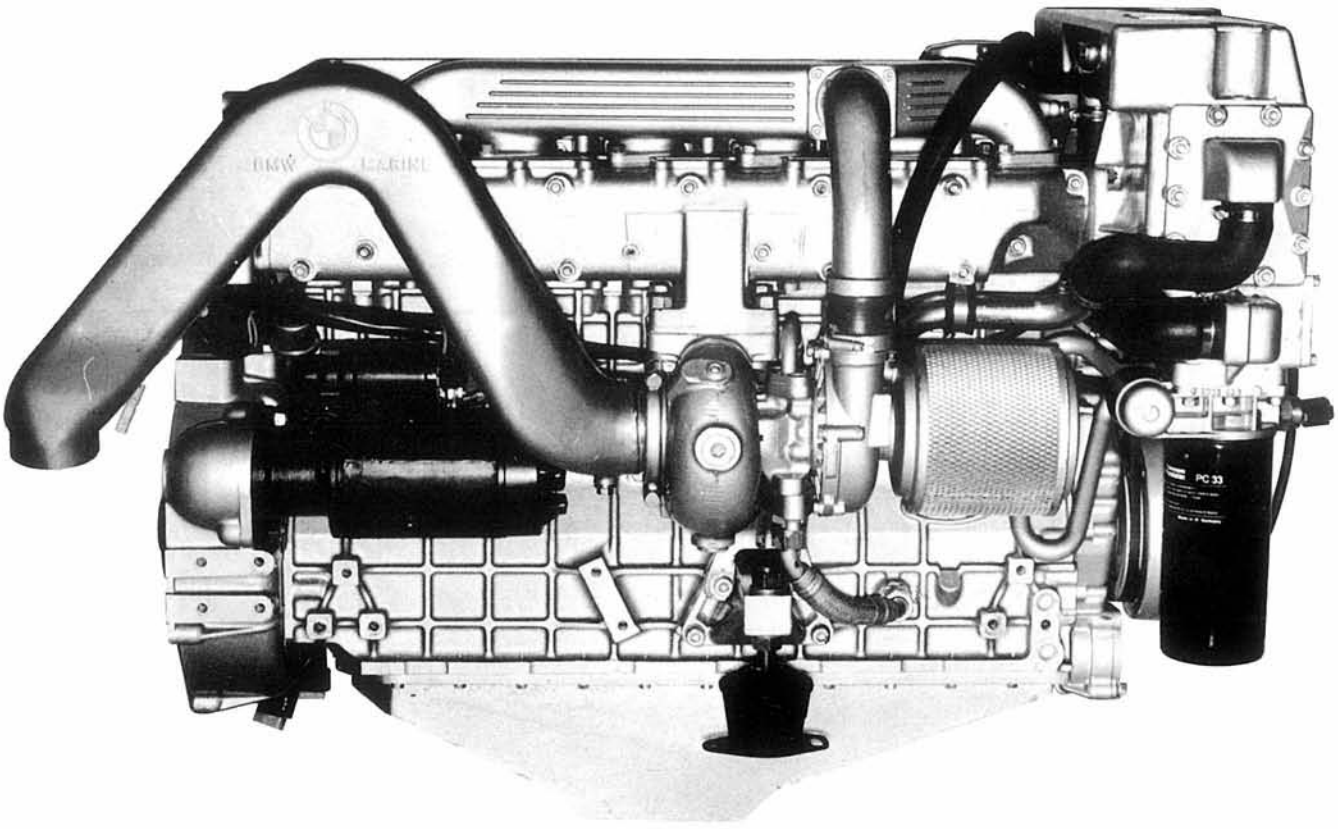
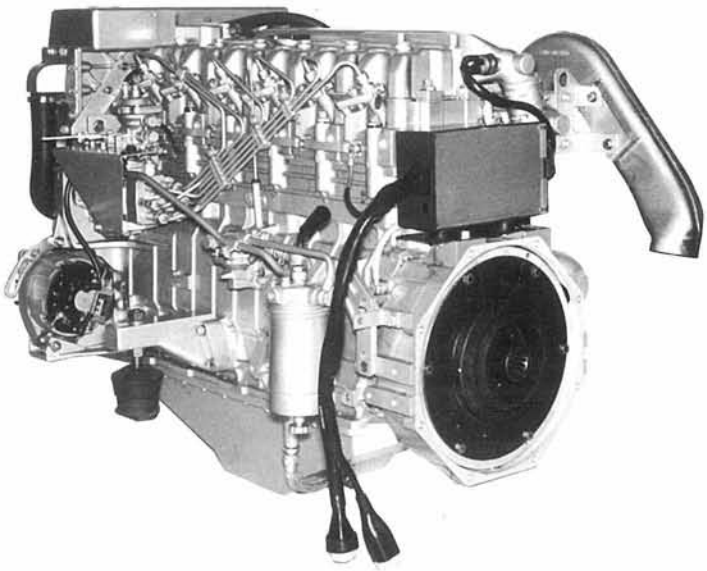
Workshop Manual
BMW D 150



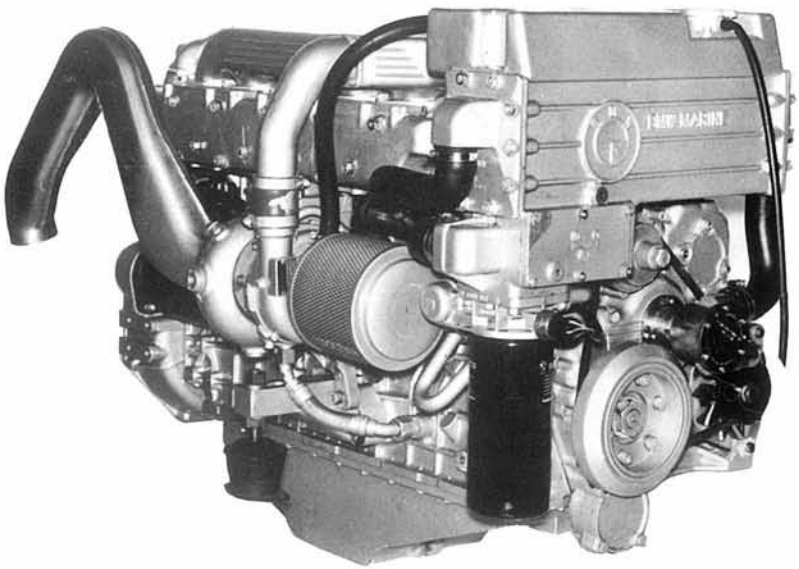
BMW Marine Engines

ENGINE DESCRIPTION

The BMW D 150 is a water-cooled, four stroke, six cylinder diesel engine with indirect injection and turbocharger. It has a dual circuit cooling system, whereby radiator, oil cooler, thermostats and expansion tank are integrated in one unit. The coolant circulating pump is driven off of the crankshaft with the same drive belt used for the alternator, while the raw water pump is driven direct off of the camshaft. The camshaft is located in the side of the engine block and is gear driven. The charge pressure controlled Bosch injection system, in conjunction with the turbocharger and a large volume air cleaner, guarantees optimal fuel/air mixture and consequently economical as well as low-emission operations in all speed ranges.



Left Rear View of Engine



Right Front View of Engine

GENERAL INFORMATION

This manual describes repair operations on a removed BMW D 150 engine. All removal and installation as well as repair operations are compiled in chapters, which are designated according to the pertinent construction groups. The sequence of chapters conforms with the procedures for disassembly of the engine. If the engine is not removed or when the engine does not have to be completely disassembled, the preliminary jobs required for removal (repair) of a pertinent construction group (part) are listed at the beginning of each chapter additionally.
The sequence of assembly for the entire engine are listed in abbreviated form with notes concerning pertinent chapters under the title „assembly".
Designations „front, rear, right, left" refer to the engine's installed position in forward direction.

LIST OF CONTENTS

Description

LIST OF CONTENTS

SERVICE AND MAINTENANCE

Regular service and maintenance operations are listed in the following table.

Job Description	Intervals								
	Daily Before Departing	Every 14 Days	Every 50 Hours or Annually	Every 100 Hours or Annually	Every 200 Hours	Every 500 Hours	Every 1000 Hours	As Required	Instructions for Job on Page
Fuel tank — cleaning					X				
Raw filter — cleaning			X					X	
Oil/water heat exchanger — cleaning								X	36
Water/water heat exchanger — cleaning								X	36
Cylinder head bolts — tightening			X						66
Air filter — cleaning		X							
Fuel filter — cleaning		X							
Engine oil level — checking	X								
Battery acid level — checking		X							
Valve play — checking				X					59
Injection pressure — checking						X			59
Drive belt tigthness — checking		X							
Water level — checking	X								
Turbocharger — checking				X					41
Fuel lines — tigthening				X					
Engine oil — replacing*				X					
Fuel filter — replacing									
Air filter — replacing							X		
Oil filter cartridge — replacing*					X or annually				
Drive belts — replacing						X			
Hose clamps — tightening				X					
* First time with new engine after 50 hours									

OPERATIONS FOR 10 HOUR INSPECTION

On Cold Engine:

1. Checking oil level in outdrive or reversing gearbox.
2. Checking for oil leaks.
3. Check battery acid level.
4. Checking function of power trimm/tilt system.
5. Checking coolant level in fresh water circuit.
6. Draining water and residue in fuel filter.
7. Checking engine oil level.
8. Checking drive belt tigthness for alternator and water pump.
9. Tightening all hose clamps.
10. Tightening all bolts and nuts for engine and outdrive installation.
11. Checking indicator and warning lamps.
12. Tigthening cylinder heads (outside 80 Nm, inside 160 Nm), manifold pipes and turbocharger.
13. Adjusting valves.

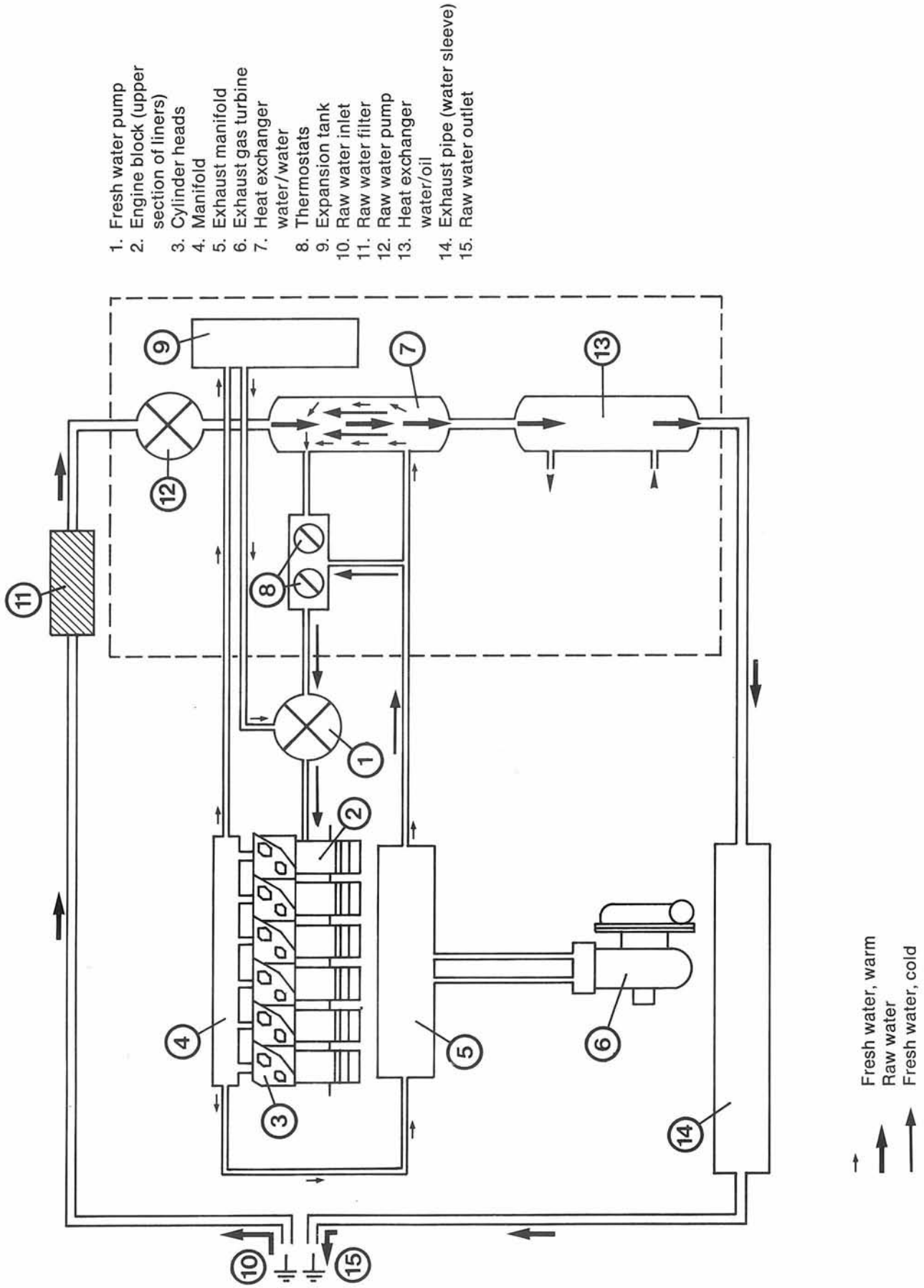
On Running Engine With Operating Temperature:

14. Checking charge voltage of alternator.
15. Checking idle speed (both circuits).
16. Checking cooling system for leaks.
17. Checking exhaust system for leaks.
18. Checking fuel system for leaks.
19. Visual inspection of entire engine for leaks.

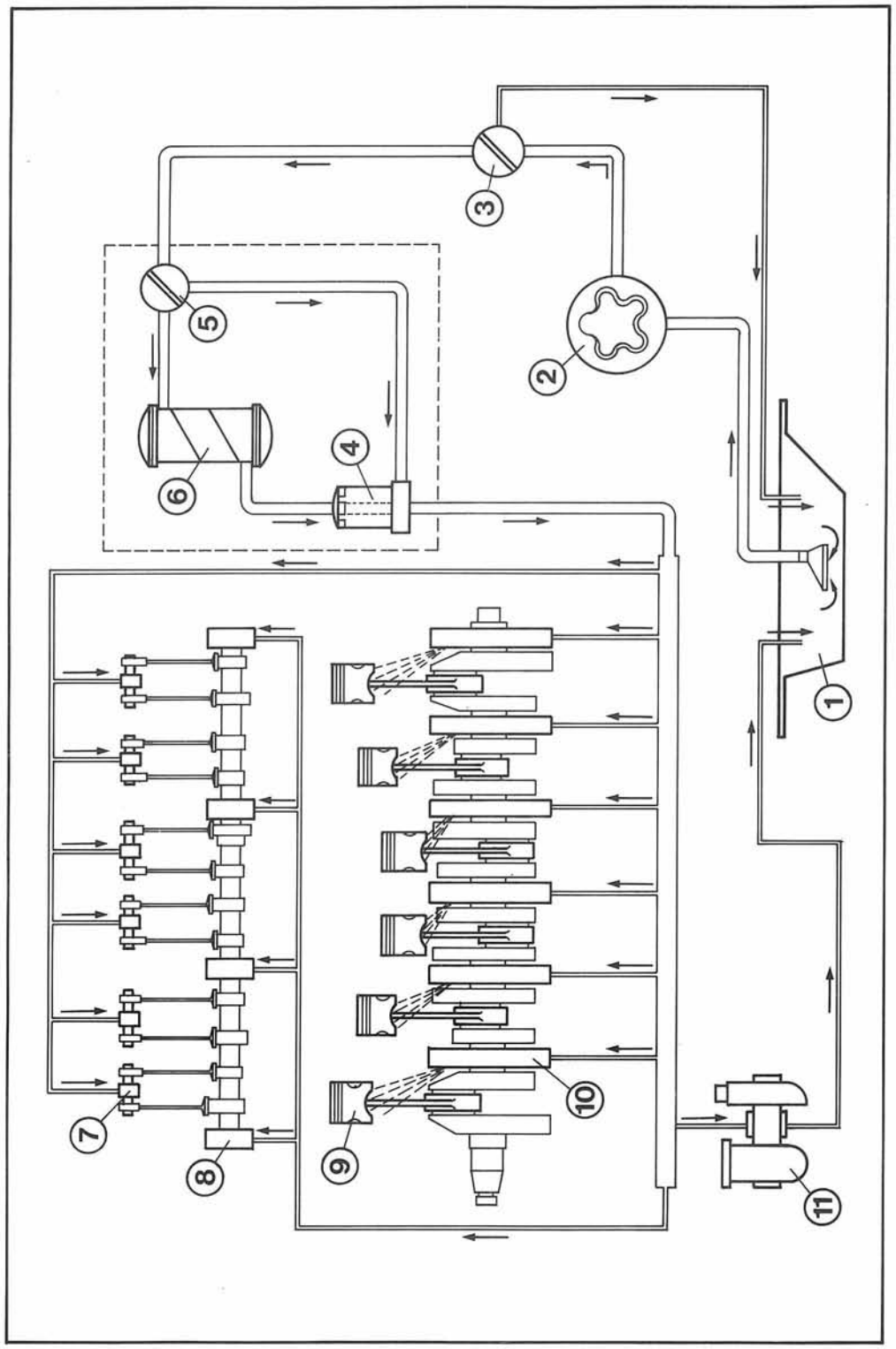
Trial Run:

20. Checking function of remote control.
21. Checking propeller tuning.
22. Checking function of power trimm/tilt system.

COOLING SYSTEM

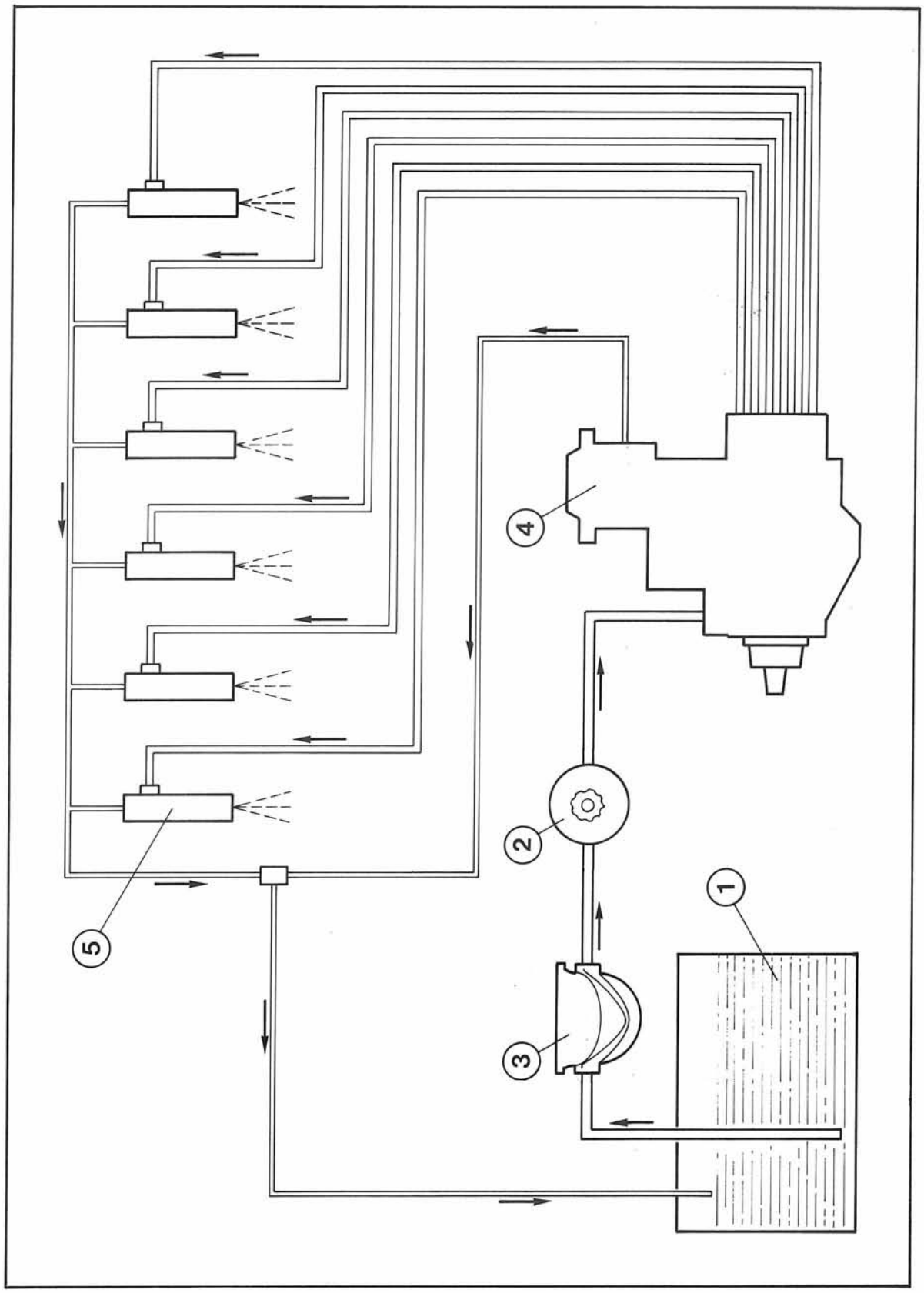


ENGINE LUBRICATION LAYOUT DRAWING

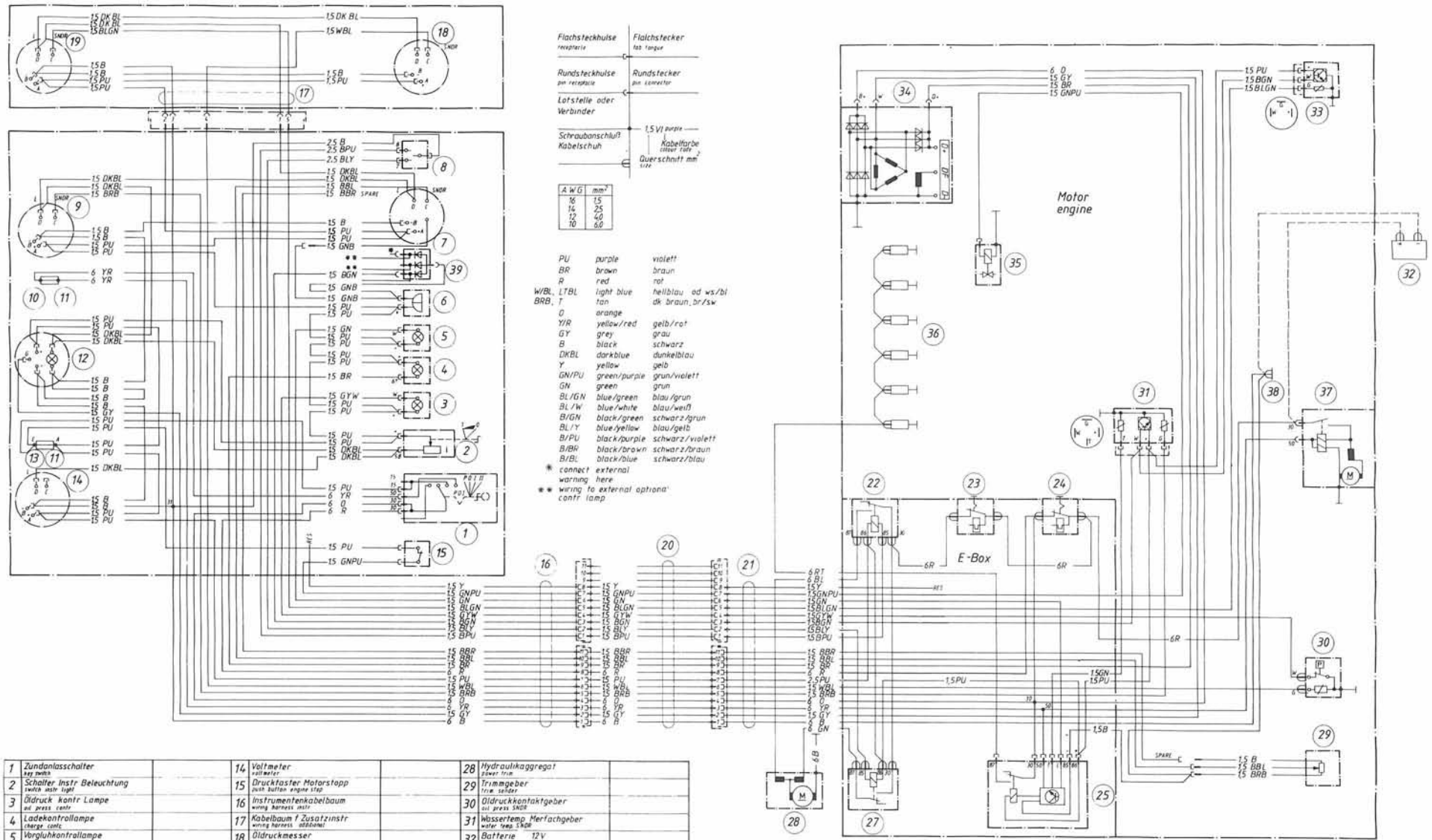


1. Oil pan
2. Oil pump
3. Pressure relief valve
4. Oil filter
5. Oil thermostat
6. Oil/water heat exchanger
7. Rocker arm
8. Camshaft bearings
9. Pistons
10. Crankshaft main bearings and connecting rod bearings
11. Turbocharger

FUEL SYSTEM LAYOUT DRAWING



1. Fuel tank
2. Fuel filter
3. Fuel pump with manual operation
4. Bosch injection pump
5. Fuel injectors
6. Fuel return line



1	Zundanlasschalter key switch		14	Voltmeter voltmeter		28	Hydraulikaggregat power trim	
2	Schalter Instr Beleuchtung switch instr light		15	Drucktaster Motorstopp push button engine stop		29	Trimmgeber trim sender	
3	Öldruck kontr Lampe oil press contr		16	Instrumentenkabelbaum wiring harness instr		30	Öldruckkontaktgeber oil press SNDR	
4	Ladekontrollampe charge contr		17	Kabelbaum f Zusatzinstr wiring harness additional		31	Wassertemp Merfachgeber water temp SNDR	
5	Vorgluhkontrollampe glow contr		18	Öldruckmesser oil press gauge		32	Batterie 12V starter battery	
6	Summer buzzer		19	Ölthermometer oil temp gauge		33	Öltemperaturkontaktgeber oiltemp sender	
7	Trimminstrument trim gauge		20	Verlangerungskabelbaum wiring harness extention		34	Generator 14V 75A alternator	
8	Trimm Taster trim switch		21	Kabelbaum Motor wiring harness engine		35	Kraftstoffventil elektr valve injektor	
9	Wassertherмometer watertemp gauge		22	Relais heben relay lift		36	Glukerzen glow plug	
10	Feinsicherung US Norm 15A trage melting fuse 1½ + ½ time lag		23	Sicherungsautomat 40A circuit breaker		37	Anlasse 12V 2,7 kW starter	
11	Sicherungshalter fuse holder US-Standard		24	Sicherungsautomat 60A circuit breaker		38	Masse Motor GRND engine	
12	Drehzahlmesser mit Betriebsstundenzähler 0–4200/min tacho w hourmeter		25	Vorglührelais pre glow relay		39	Trenndrode f warning isolator diode f warning	
13	Schmelzsicherung 8A trage melting fuse 1½ + ½ time lag		26					
			27	Relais senken relay lower				

Schaltplan
electric diagram

Motor +Instrumente
engine and instruments

REMOVING AND INSTALLING ELECTRIC BOX

Removing Electric Box

Figure 6

Disconnect all electric wires on engine and run wire harness back to electric box (6/1). Unscrew four phillips screws (6/2) and take off cover (6/3) on electric box.

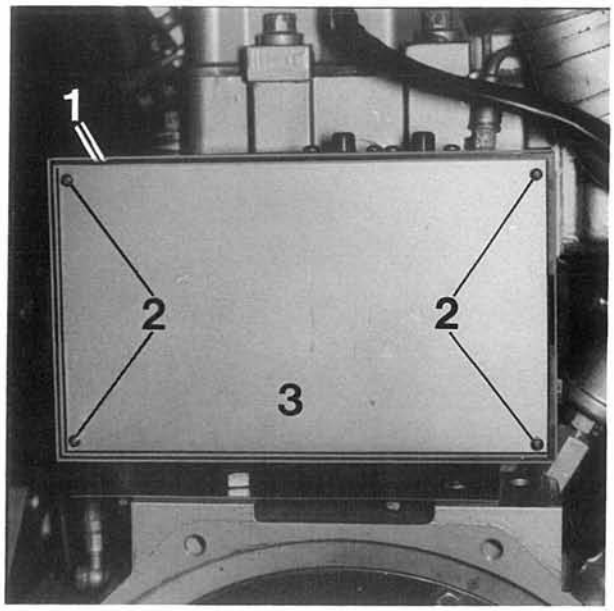


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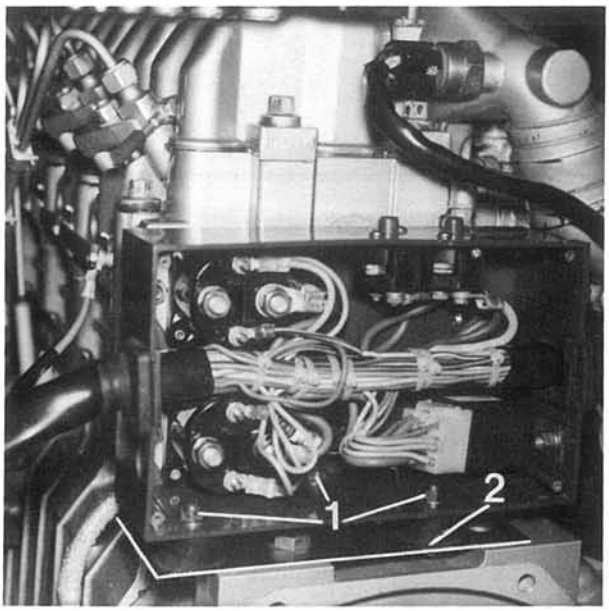
Figure 7

Unscrew three hexagon nuts (7/1) and take off complete electric box from holder (7/2) on the flywheel housing.



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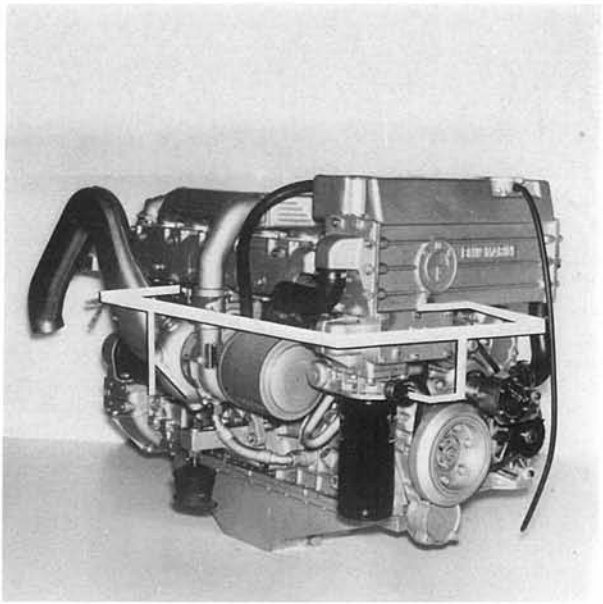
Installing Electric Box

Figure 8

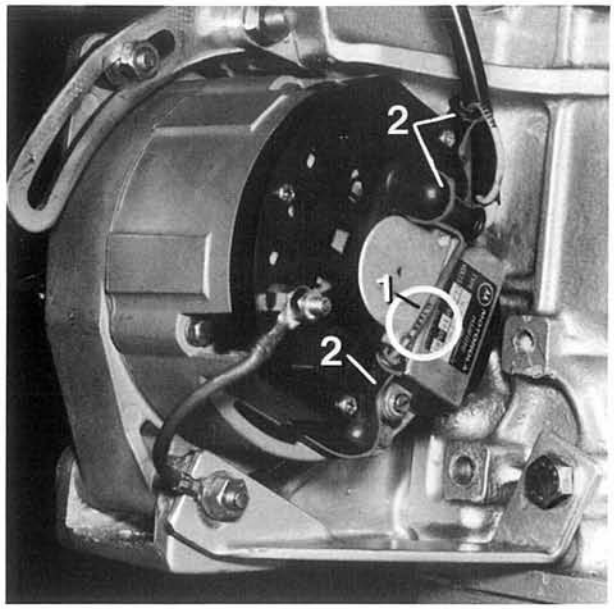
Place electric box on holder (7/2) on flywheel housing and screw down with three hexagon nuts (7/1). Route wire harness below turbocharger on right side of engine forward and then left behind the cooling system to the alternator.



8

Figure 9

Connects wires for alternator and solenoid of fuel injection pump.
Note: Check marks (9/1) on ends of wires. Slide a rubber protection cap (9/2) over each connection.



9

Figure 10

Connect plug on oil thermometer (10/1). Connect starter (10/2) and engine ground (10/3). Slide on rubber protection caps.
Note: Check marks on ends of wires for starter.

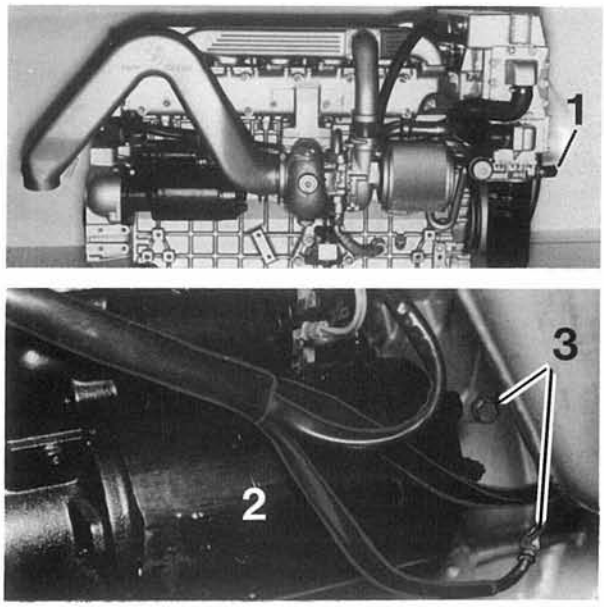


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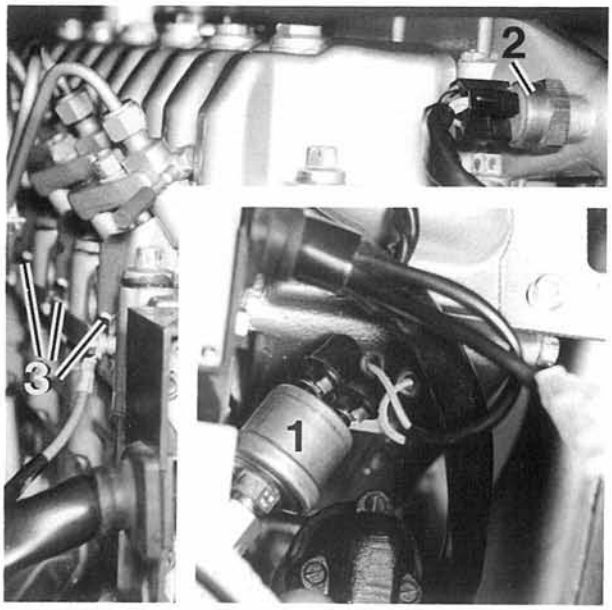
Figure 11

Connect oil pressure gauge (11/1), coolant temperature gauge (11/2) and flame-heated plugs (11/3). Install and mount electric box cover with four phillips screws.



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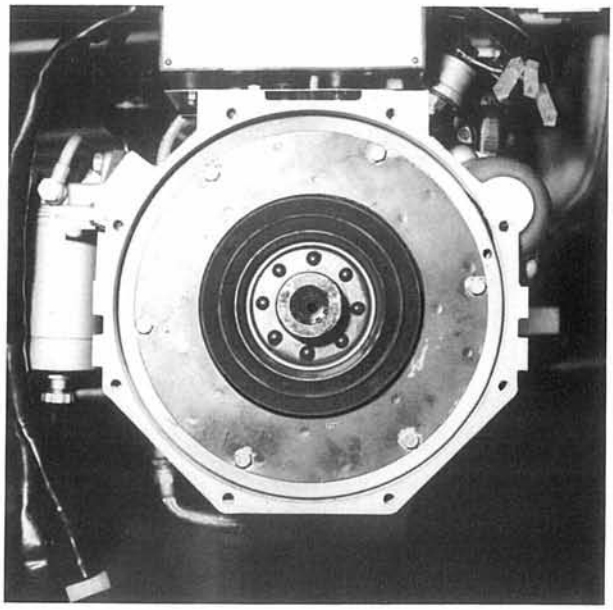
REMOVING AND INSTALLING RUBBER COUPLING

Removing Rubber Coupling

Figure 12

Unscrew six mounting bolts and press rubber coupling off of flywheel with a screwdriver.

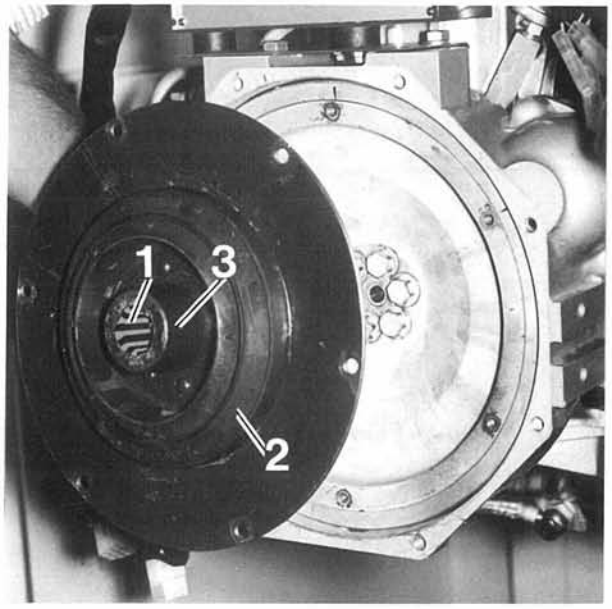


12

Installing Rubber Coupling

Figure 13

Note: Check, whether drive gear (13/1) and rubber damper (13/2) are in good condition, or install a new rubber coupling if necessary.
Place rubber coupling with support (13/3) toward rear on flywheel, align with bores and install and tighten bolts.



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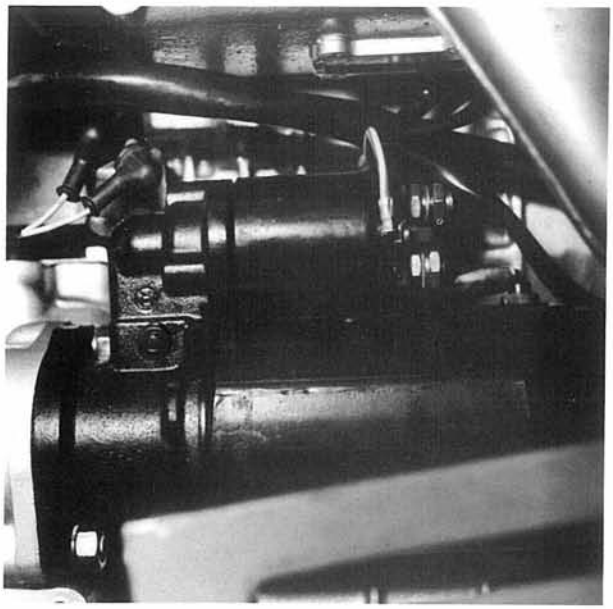
REMOVING AND INSTALLING STARTER

Removing Starter

— Disconnect electric wires, see „Electric Box".

Figure 14

Unscrew two mounting nuts and lift starter out of holder on flywheel housing.
Note: If defective, always replace complete starter.



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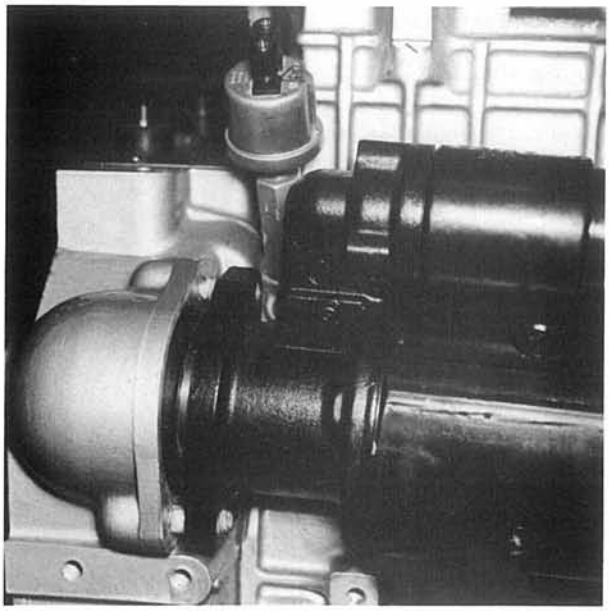
Installing Starter

Figure 15

Place starter in holder on flywheel housing, screw on and tighten two mounting nuts.



— Connect eclectric wires, see „Electric Box".

15

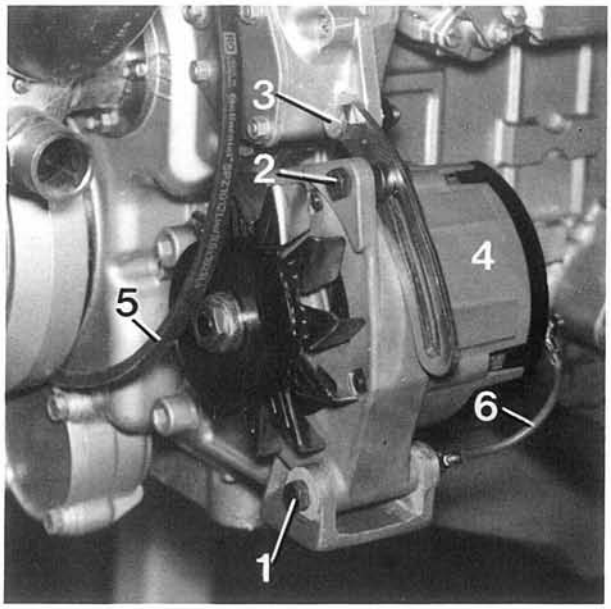
REMOVING AND INSTALLING ALTERNATOR

Removing Alternator

— Disconnect electric wires, see „Removing Electric Box".

Figure 16

Loosen three bolts (16/1, 2, 3), swing alternator (16/4) toward engine and take off drive belt (16/5). Unscrew bolts (16/2 and 3), take off ground wire (16/6) and take alternator out of holder.



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Installing Alternator

Figure 17

Install alternator in holder and screw in lower mounting bolt (17/1).

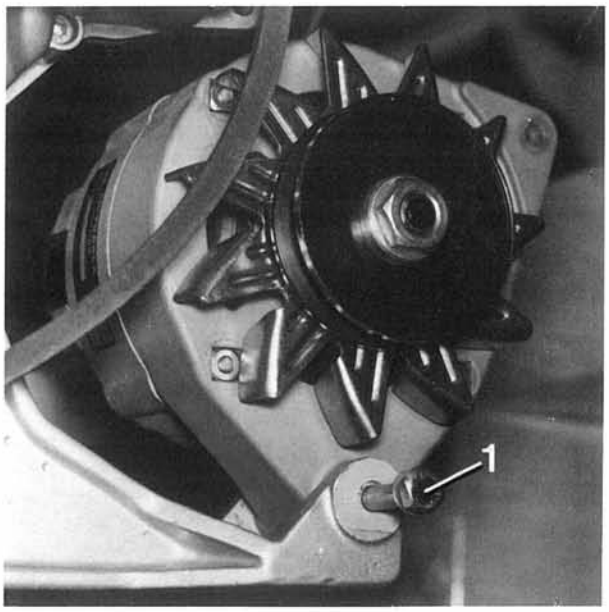

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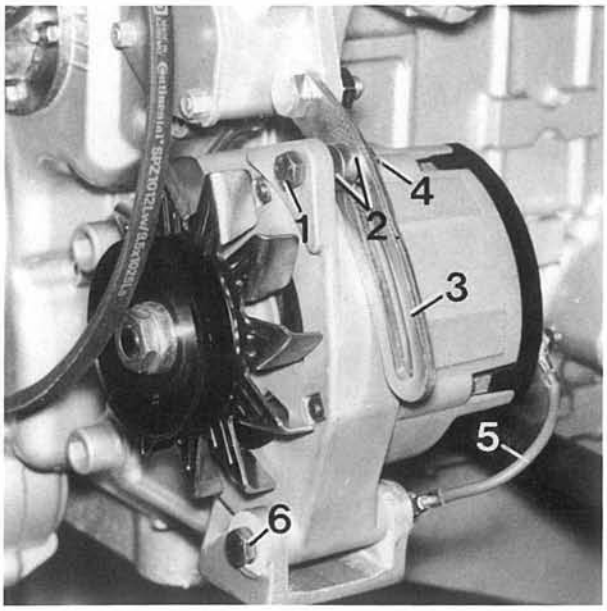
Figure 18

Insert upper mounting bolt (18/1) in alternator, install two spacers (18/2) and mount bracket (18/3) by tightening nuts (18/4) finger tight. Install ground wire (18/5) on lower mounting bolt (18/6) and secure by tightening mounting nut finger tight.
Install and tighten drive belt. Tighten all mounting bolts and nuts.



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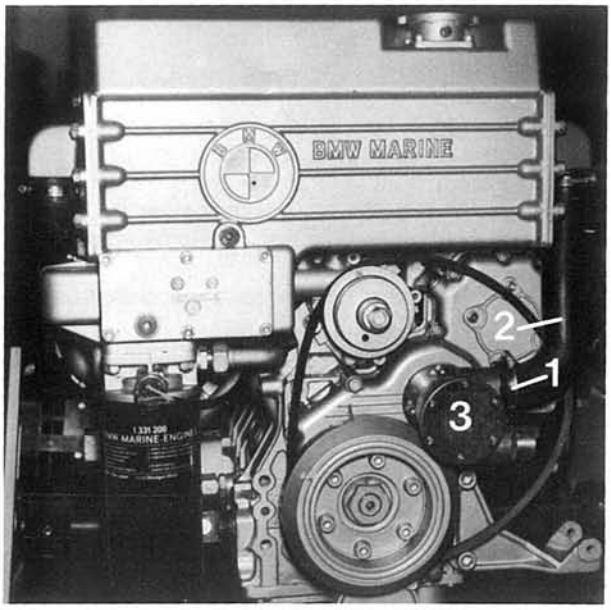
REMOVING AND INSTALLING, DISASSEMBLING AND ASSEMBLING RAW WATER PUMP

Removing Raw Water Pump

Figure 19

Unscrew hose clamp (19/1) and pull off water hose (19/2) for heat exchanger on raw water pump. Unscrew four hexagon nuts (19/3) and remove raw water pump on engine.



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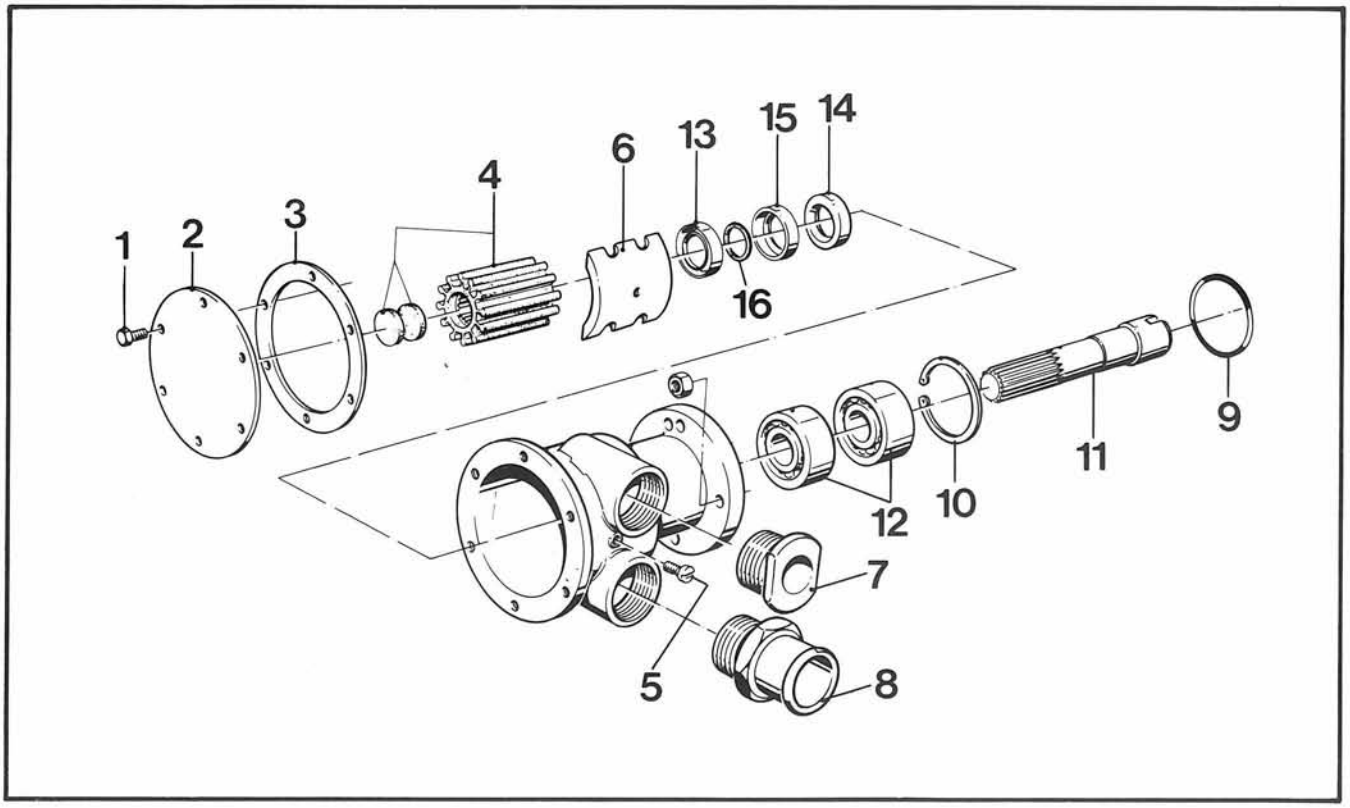
DISASSEMBLING AND ASSEMBLING RAW WATER PUMP

Disassembling Raw Water Pump

Figure 20

Clamp raw water pump in a vise. Unscrew six slotted head bolts (20/1) on cover (20/2). Remove cover and gasket (20/3). Press impeller (20/4) off of pump shaft with two screwdrivers. Unscrew mounting bolt (20/5) and take comb (20/6) out of pump housing. Unscrew adapter (20/7). Heat seat of adapter to about 500° C to remove adapter (20/8). Turn water pump around in vise, take off O-ring (20/9) and remove circlip (20/10) from groove with a circlip pliers. Knock pump drive shaft (20/11) out of pump housing with a mandrel and remove shaft complete with two ball bearings (20/12) from raw water pump. Press pump shaft out of ball bearings. Press shaft seals (20/13 and 14) complete with thrust ring (20/15) and O-ring (20/16) out of pump housing.



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Assembling Raw Water Pump

Figure 21

Press new shaft seal (20/14) into pump housing from behind. Insert thrust ring (20/15) in raw water pump from front and place against shaft seal. Install new O-ring (20/16). Press in new shaft seal (20/13) from front against stop. Press two bearings (21/1) on pump shaft (21/2).
Note: Sealing lips of shaft seals always face away from thrust ring.

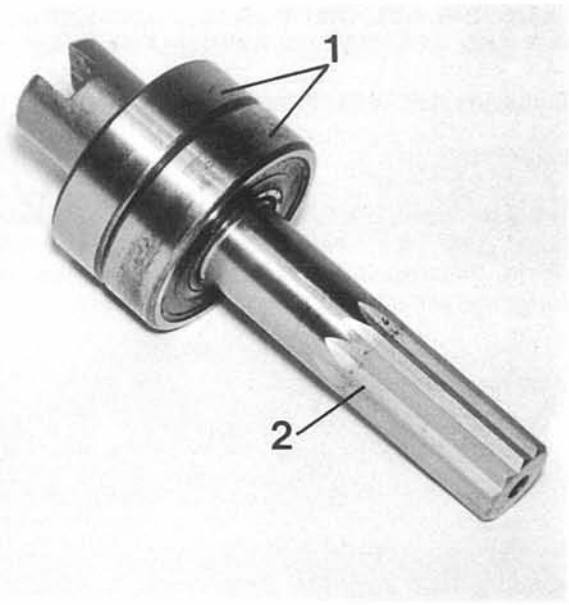

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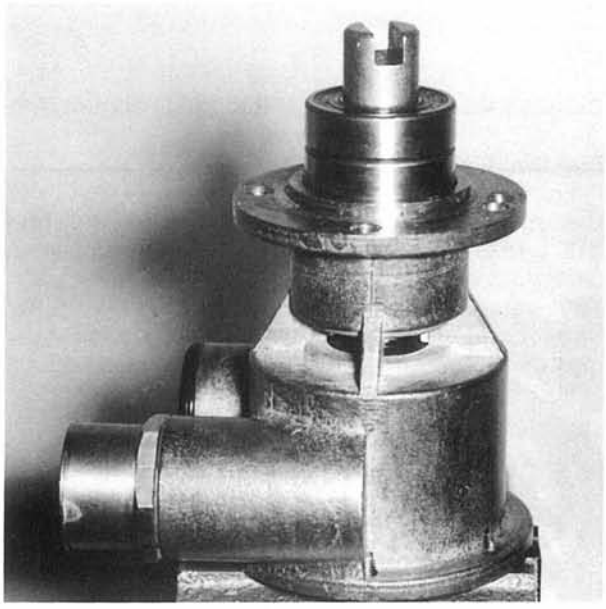
Figure 22

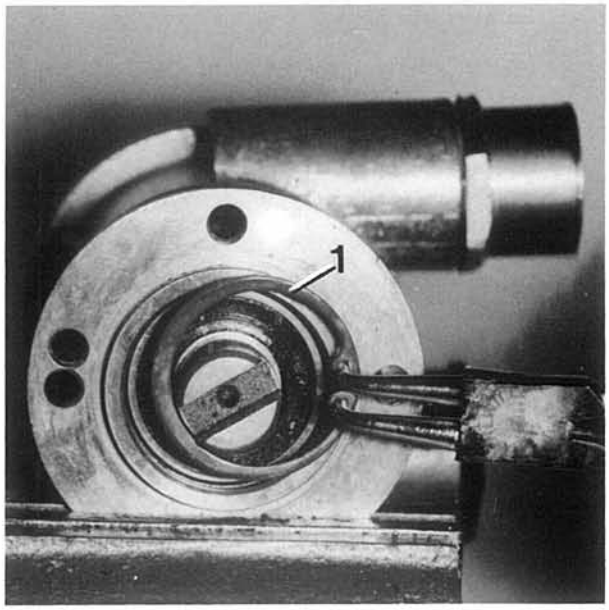
Install pump shaft complete with bearings in pump housing from behind. Make sure that the O-ring (20/16) between the shaft seals is not damaged.



22

Figure 23

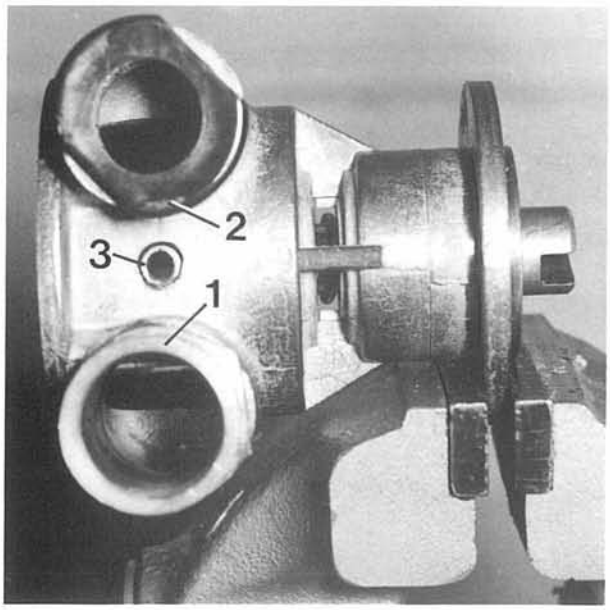
Install circlip (23/1) in groove with a circlip pliers.



23

Figure 24

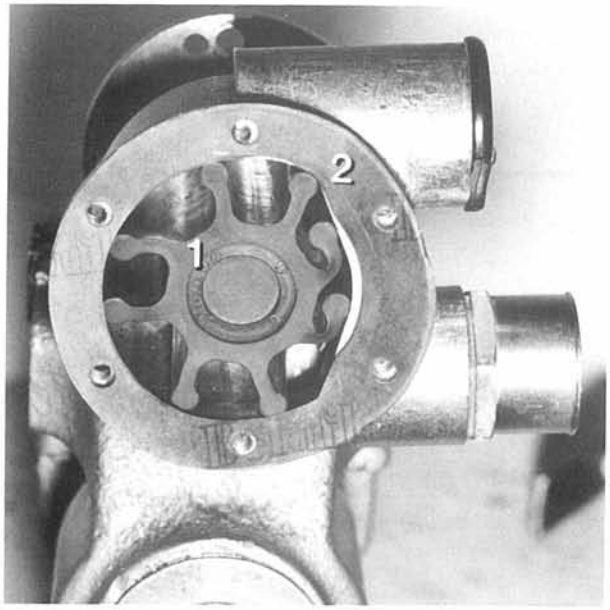
Coat threads of adapter (24/1) with Loctite and screw adapter in pump housing.
Screw in and tighten plastic adapter (24/2).
Insert comb (20/6) from front and secure with mounting bolt (24/3).



24

Figure 25

Push impeller (25/1) on to pump shaft, install new gasket (25/2) (wide side faces comb), mount cover and tighten six slotted head bolts.



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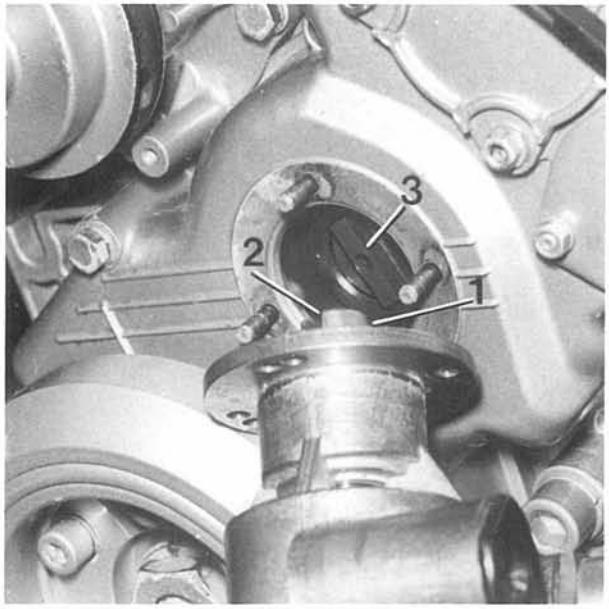
Installing Raw Water Pump

Figure 26

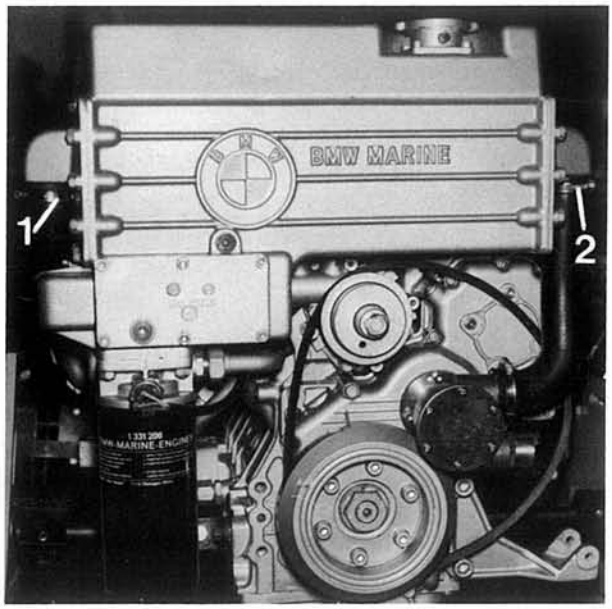
Use new O-ring (26/1). Align groove of pump shaft (26/2) with drive key (26/3) of cramshaft. Slide raw water pump on to staybolts, screw on and tighten four hexagon nuts.



26

Figure 27

Connect water hose (27/1) for heat exchanger on pump outlet and tighten with a hose clamp.
Note: Attach drive belt before connecting the water hose.



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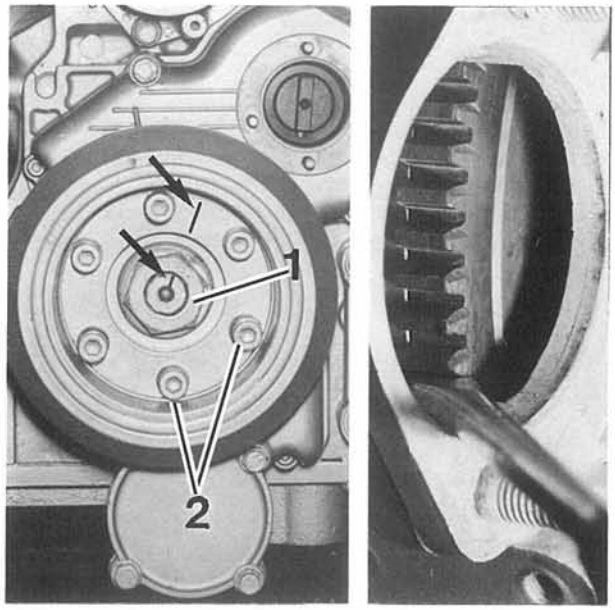
REMOVING AND INSTALLING VIBRATION DAMPER WITH PULLEY

Removing Vibration Damper with Pulley

Figure 28

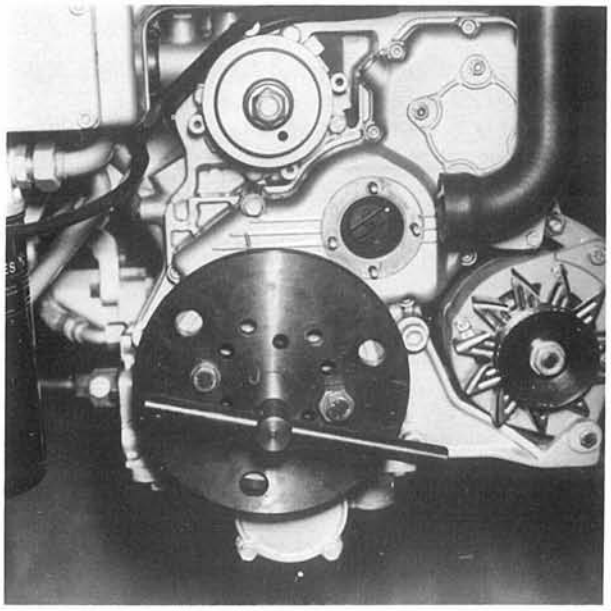
Mark position of vibration damper to crankshaft. To remove mounting nut (28/1), hold flywheel with a screwdriver and unscrew mounting nut. Unscrew three socket head screws (28/2) (offset) in vibration damper and pulley.



28

Figure 29

Bolt Special Tool 7464 1 333507 on vibration damper with three bolts. Pull vibration damper and pulley off of crankshaft.

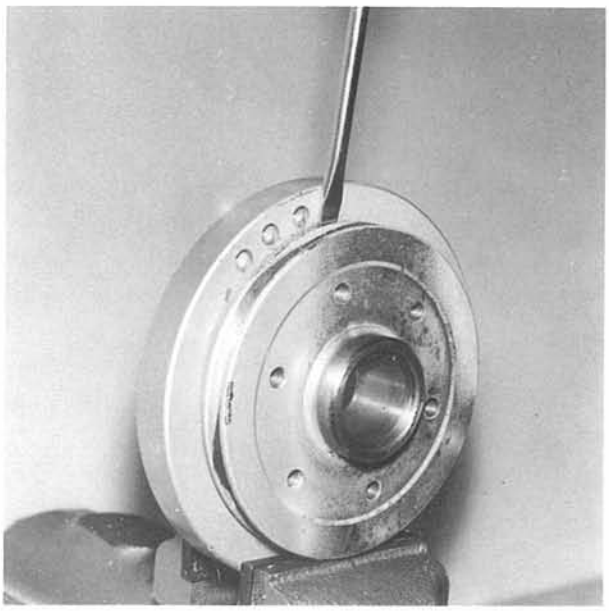


29

Disconnecting Vibration Damper and Pulley

Figure 30

Clamp vibration damper in a vise and press pulley off vibration damper with a screwdriver.

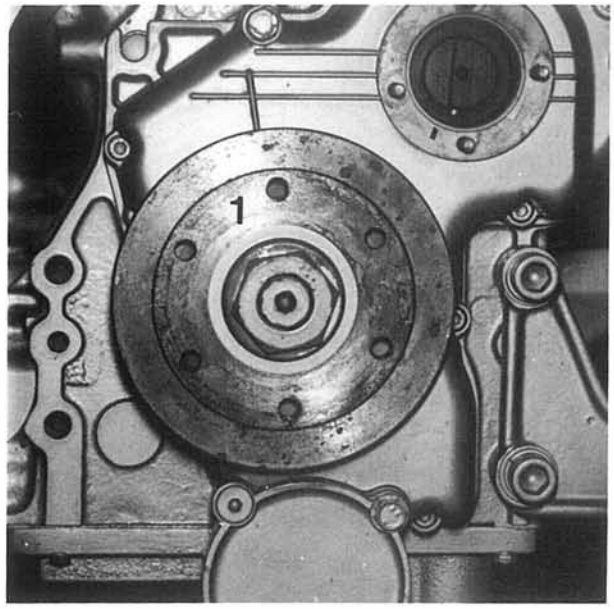


30

Installing Vibration Damper and Peulley

Figure 31

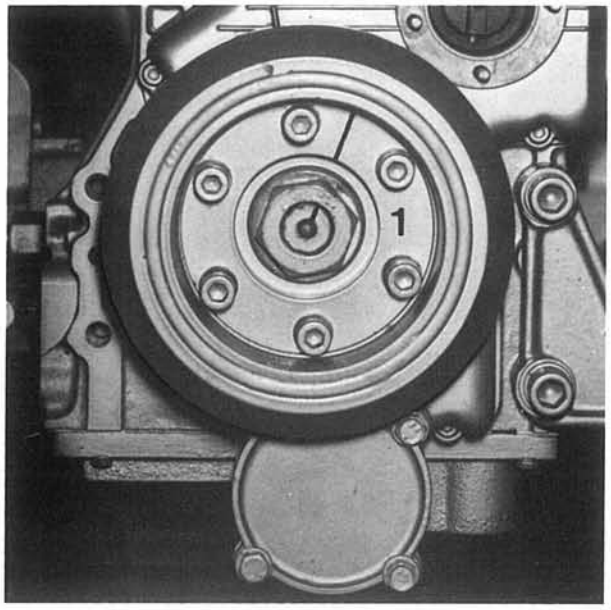
If pulley and vibration damper had been separated, first install pulley (31/1) on crankshaft and secure with mounting nut (Nm 230 to 280).
Note: If pulley and vibration damper had not been separated, install both on crankshaft and tighten nuts.



31

Figure 32

Then place vibration damper (32/1) on pulley and tighten the six socket head screws.
Note: Check mark on crankshaft.
— Hold on gear ring of flywheel to tighten the mounting nut.



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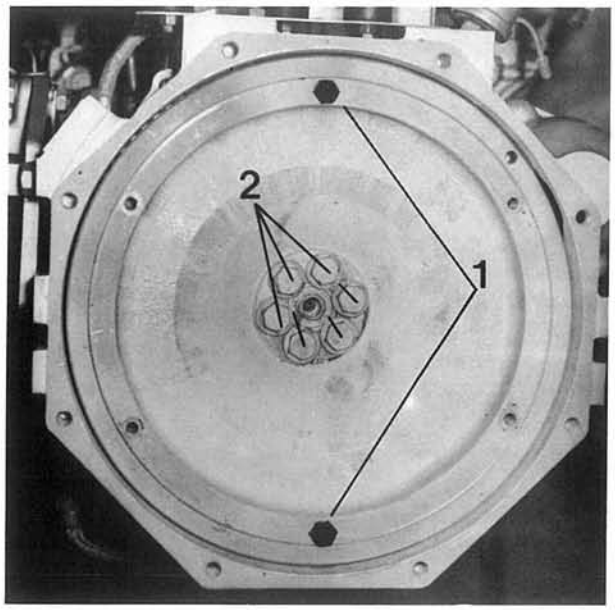
REMOVING AND INSTALLING FLYWHEEL

Removing Flywheel

— Remove rubber coupling.
— Remove starter.

Figure 33

Insert two bolts (33/1) in bores for rubber coupling. Unscrew six mounting bolts (33/2) and pull flywheel out of flywheel housing on the two inserted bolts.

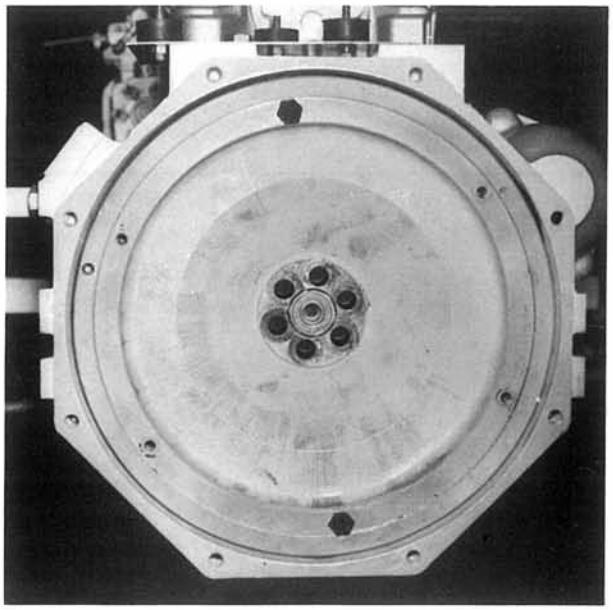


33

Installing Flywheel

Figure 34

Place flywheel in flywheel housing, align with bore in bearing race, lubricate, screw in and tighten mounting bolts to 110 Nm torque.
Note: Use new flywheel bolts (expansion bolts).



34

Measure lateral runout of flywheel, see Figure 39.

Replacing Starter Gear Ring

— Remove starter.
— Remove rubber coupling.
— Remove flywheel.

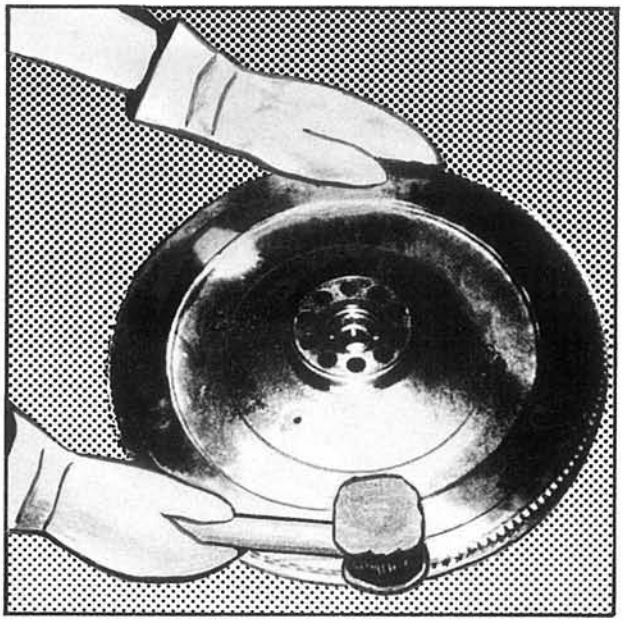
Figure 35

Drill hole in and break starter gear ring, being careful not to damage the flywheel.

35

Figure 36

Heat new starter gear ring to 220° C (428° F) and press on against the stop.

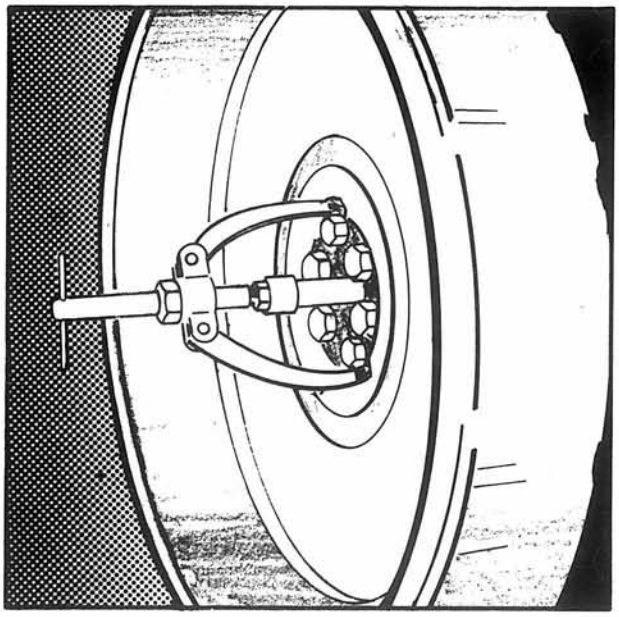


36

Replacing Drive Shaft Bearings

Figure 37

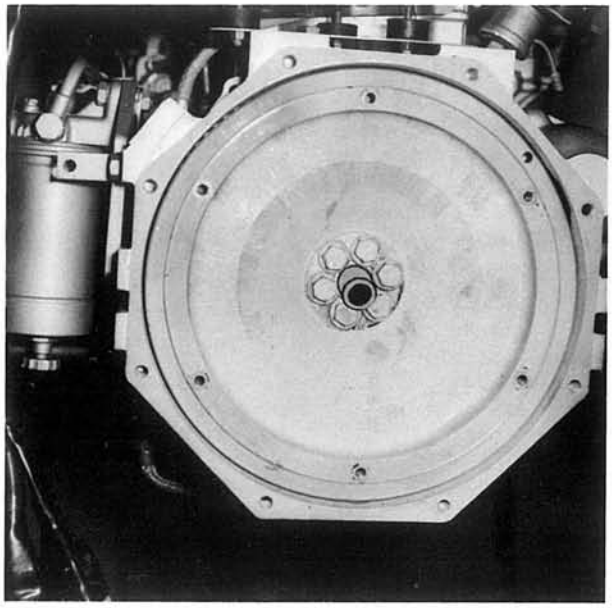
Pull drive shaft bearings out of flywheel with a suitable internal claw extractor.



37

Figure 38

Knock in new drive shaft bearings against stop with a suitable piece of pipe applied on the bearing outer race.

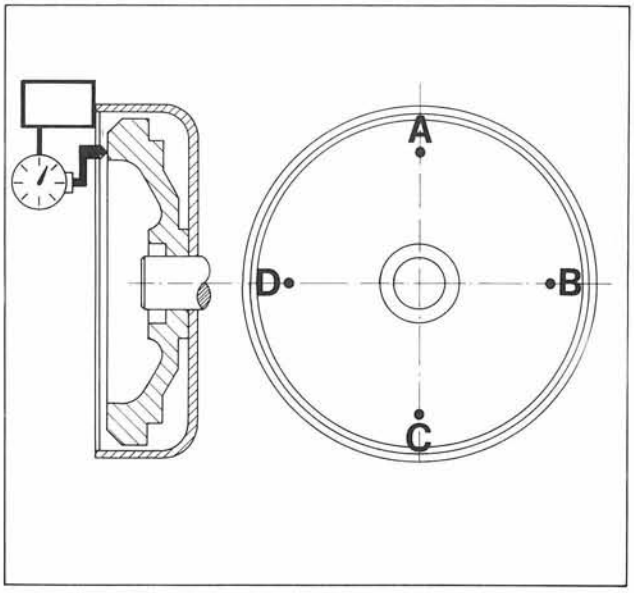


38

Measuring Flywheel Lateral Runout

Figure 39

Apply dial gauge holder on flywheel housing. Apply dial gauge with pre-load on face of flywheel and set to „zero". Press crankshaft against stop for measuring to make sure of always having the same distance. Turn crankshaft and measure runout every 90°. The difference between the highest and deepest point of all four measurements must not exceed 0.10 mm.



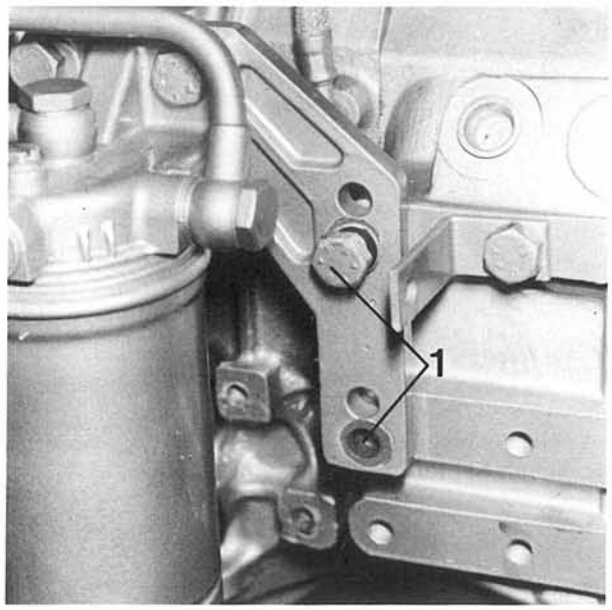
39

REMOVING AND INSTALLING FLYWHEEL HOUSING AND REPAIRING CRANKSHAFT MAIN BEARINGS

Removing Flywheel Housing

Figure 40

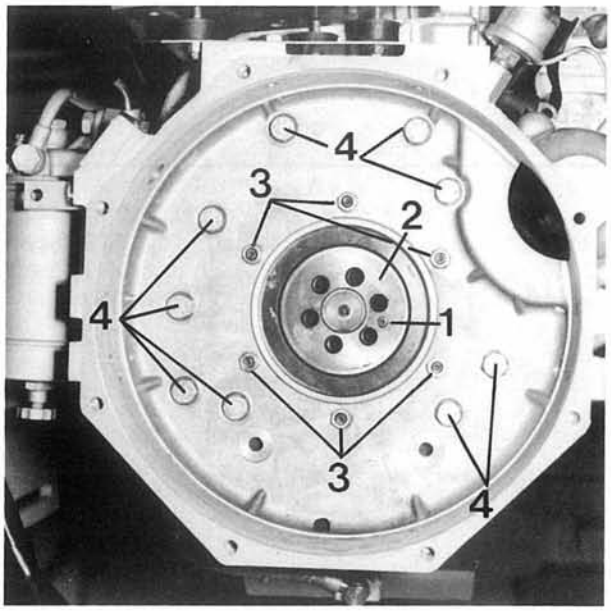
Unscrew two bolts (40/1) of bracket for fuel filter and oil scavenging pump in flywheel housing.



40

Figure 41

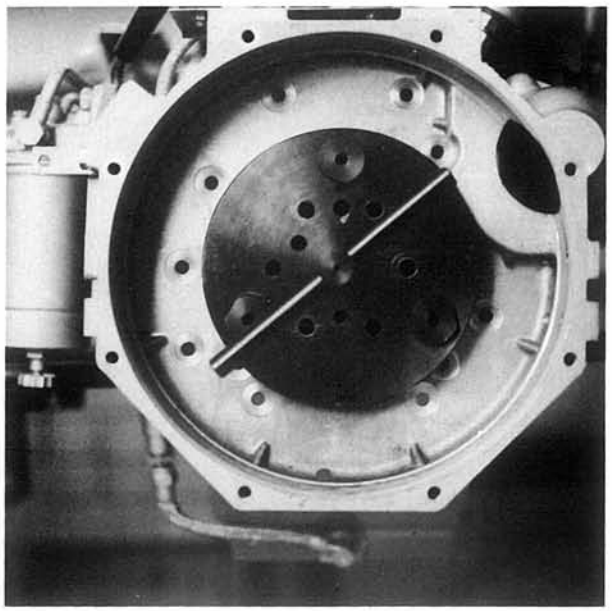
Unscrew socket head cap screw (41/1) and pull bearing race (41/2) out of crankshaft main bearing. Unscrew six hexagon nuts (41/3) of crankshaft main bearing and nine mounting bolts (41/4) of flywheel housing (41/5).



41

Figure 42

Apply Special Tool 7464 1 333507 and pull off flywheel housing complete with rear crankshaft main bearing.

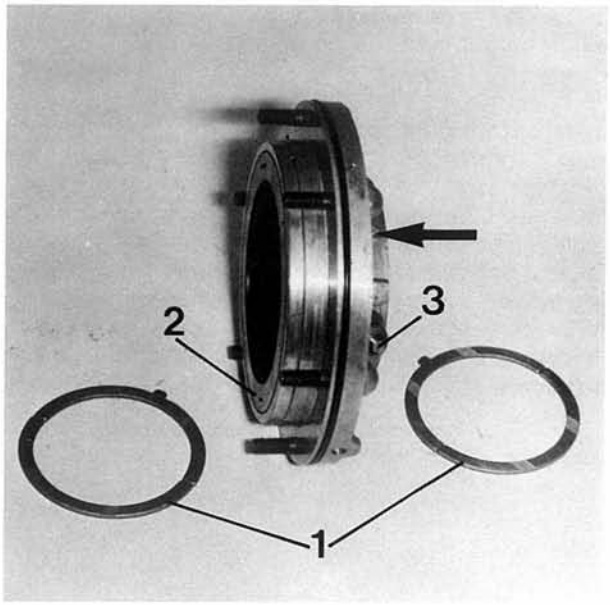


42

Repairing Crankshaft Main Bearing

Figure 43

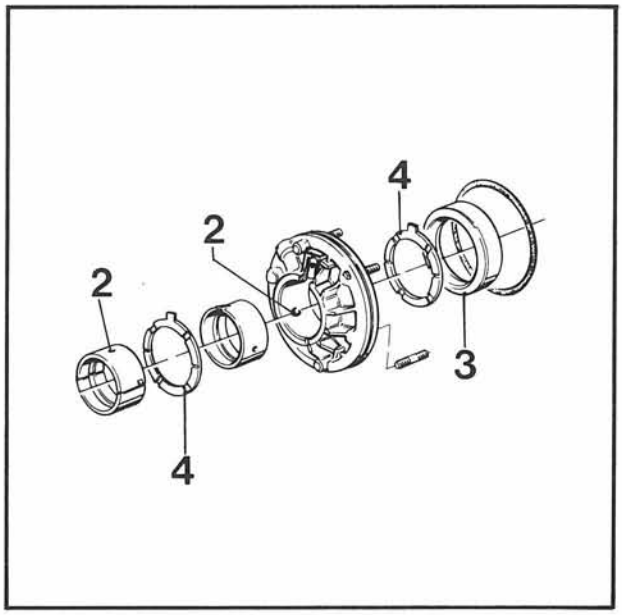
Remove crankshaft main bearing on flywheel housing. Remove thrust washers (43/1). If necessary, press shaft seal (43/2) out of main bearing flange from behind (arrow). If applicable, replace oil spray jet (43/3).



43

Figure 44

Check bearing shells (44/1) for damage and replace, if necessary. Check oil bore (44/2). If removed, press in a new shaft seal (44/3). Lubricate thrust washers (44/4) with grease and install with lettering facing out.

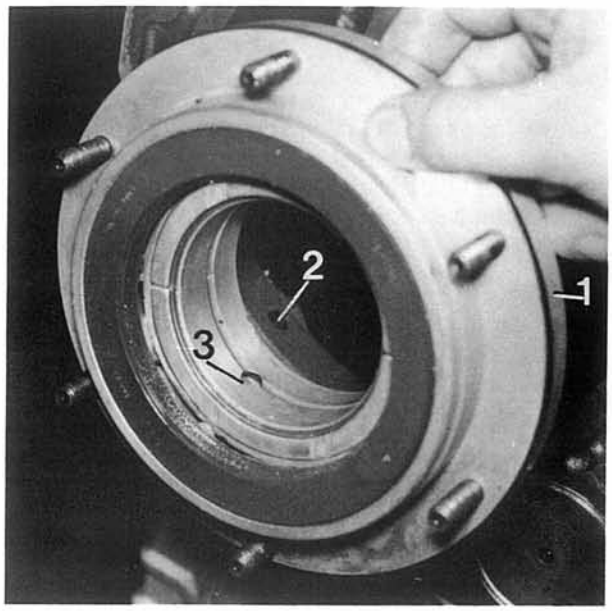


44

Installing Flywheel Housing

Figure 45

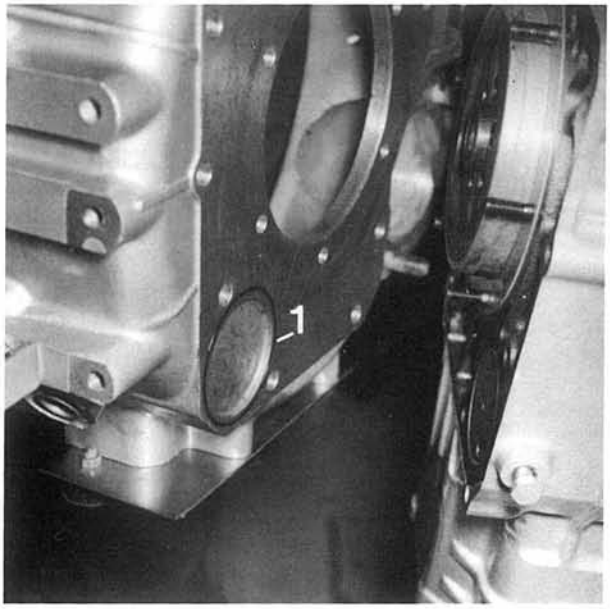
Install crankshaft main bearing in engine block with oil spray jet facing forward. Use a new O-ring (45/1).
Important! Bores for lubrication in bearing seat (45/2) and bearing flange (45/3) must be aligned.
Insert bearing race in rear crankshaft main bearing with chamfered side facing shaft seal.
Align bore for socket head cap screw with bore in crankshaft, screw in and tighten socket head cap screw.



45

Figure 46

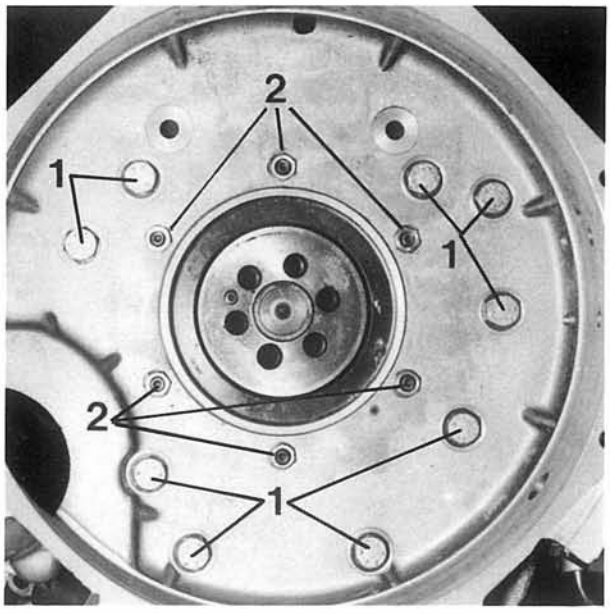
Mount flywheel housing on engine block, using a new O-ring (46/1).



46

Figure 47

Screw in and torque nine mounting bolts (48/1) to 50 Nm. Screw six mounting nuts (47/2) of crankshaft main bearing on staybolts and tighten. Mount bracket for fuel filter and oil scavenging pump on flywheel housing with two bolts.



47

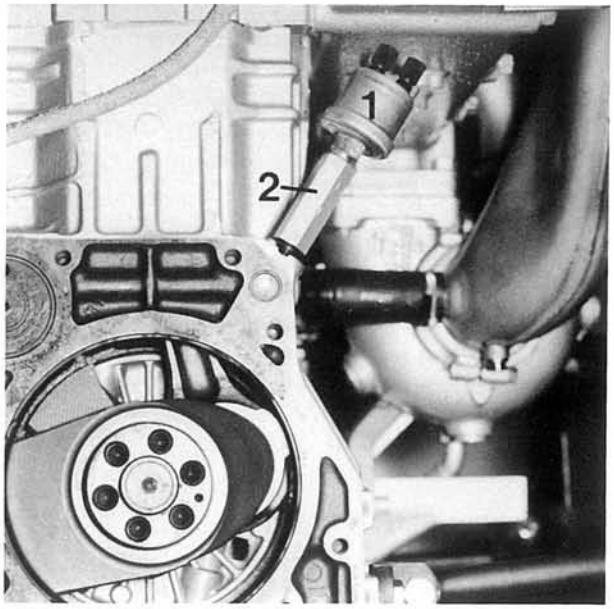
REMOVING AND INSTALLING OIL PRESSURE TRANSMITTER

— Disconnect electric wires, see „Removing Electric Box".

Figure 48

Unscrew oil pressure transmitter (48/1) with adapter (48/2) in engine block (disconnect oil pressure transmitter and adapter to replace transmitter).
Screw new oil pressure transmitter on adapter and screw both in engine block.

— Connect electric wires, see „Installing Electric Box".



48

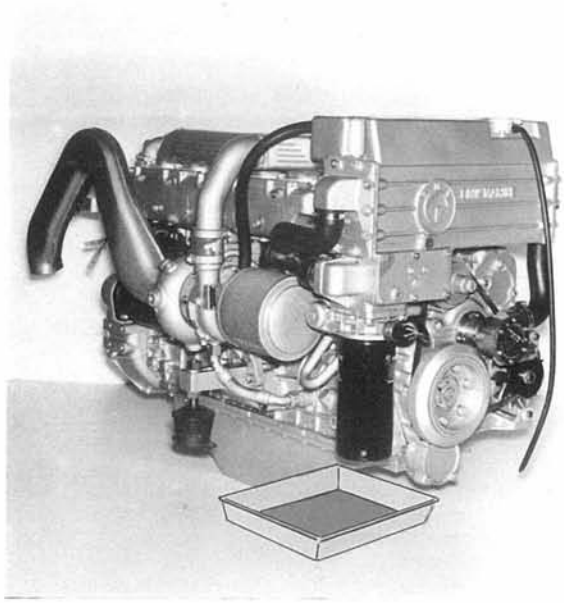
REMOVING AND INSTALLING, DISASSEMBLING AND ASSEMBLING RAW WATER COOLING CIRCUIT

Raw Water Cooling Circuit

— Pull off plug on oil thermostat.

Figure 49

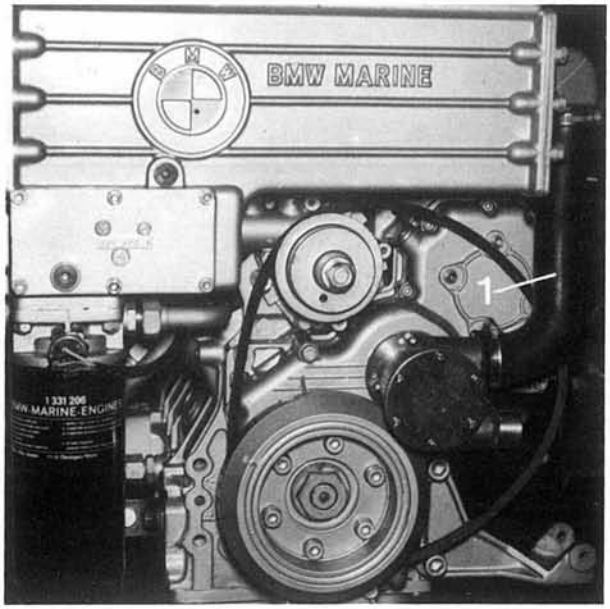
Place container in position. Unscrew socket head bolt (49/1) and drain oil from heat exchanger. Unscrew socket head bolt (49/2), take off cap on expansion tank and drain fresh water from cooling system.



49

Figure 50

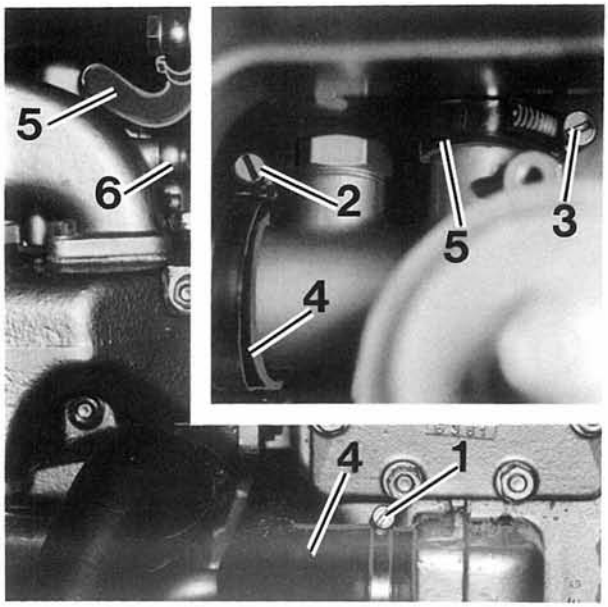
Unscrew hose clamps (50/1 and 2) and pull off hoses on heat exchangers to drain the raw water.



50

Figure 51

Unscrew hose clamps (51/1 to 3) and pull off hoses (51/4 and 5) on cooling system. Unscrew connector (51/6) and take off pressure relief line (51/7) on cooling system.



51

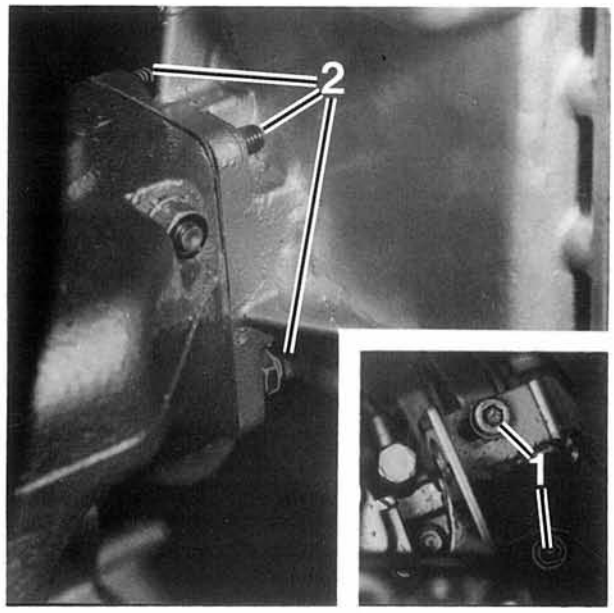
Figure 52

Unscrew four coupling nuts (55/1) and remove two oil lines (52/2) between raw water cooling circuit and central oil supply connection (52/3).

52

Figure 53

Unscrew two socket head cap screws (53/1) from cooling system holder. Unscrew four mounting nuts (53/2) on cooling system flange and take cooling system off of engine.

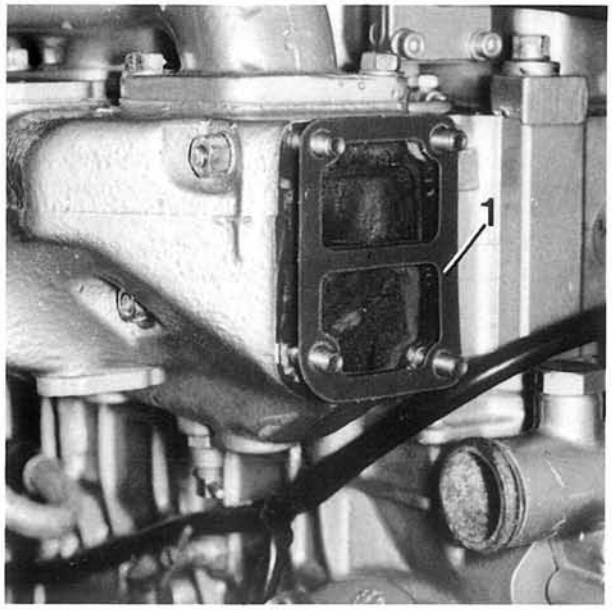


53

Installing Raw Water Cooling Circuit

Figure 54

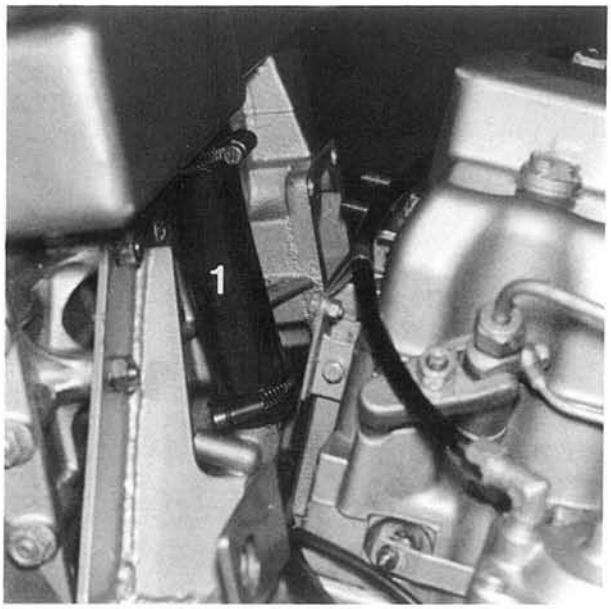
Coat new gasket (54/1) with a liquid sealing compound and install on exhaust manifold.



54

Figure 55

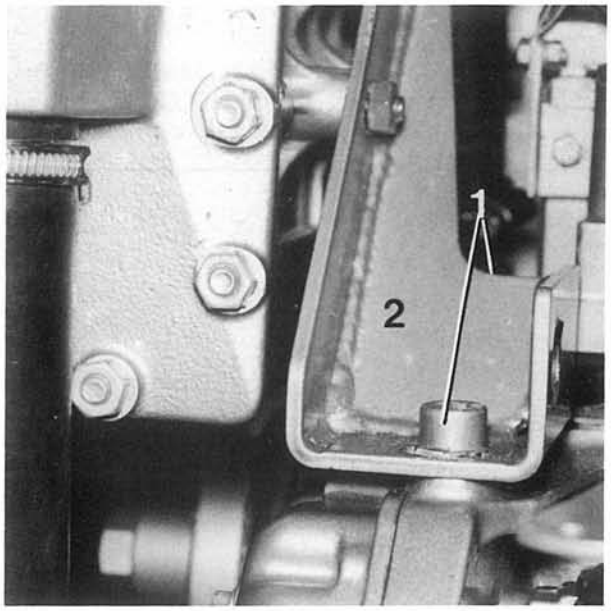
Place raw water cooling circuit on exhaust manifold flange, guiding hose (55/1) above water pump connection. Mount raw water cooling circuit on exhaust manifold with four hexagon nuts.



55

Figure 56

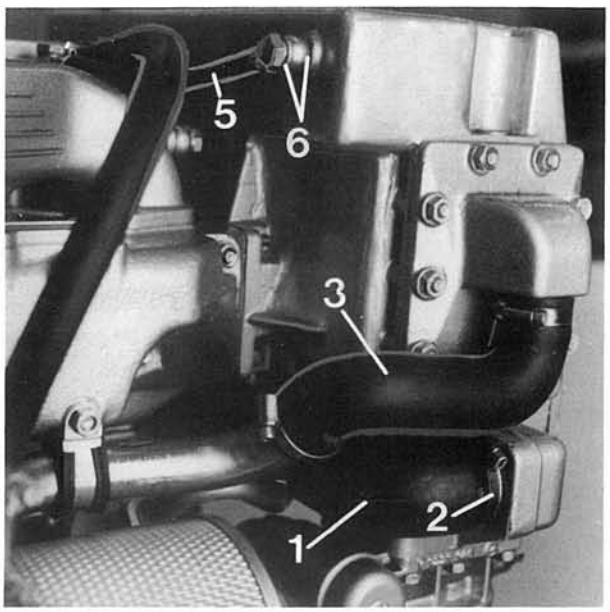
Screw two socket head cap screws (56/1) in support (56/2) and torque to 50 Nm.



56

Figure 57

Push on two hose clamps, install hose (57/1) between raw water colling circuit and water pump, and tighten hose clamp (57/2). Push one hose clamp on raw water line (57/3), connect raw water line on raw water drain (57/4) of cooling system and tighten hose clamp. Attach pressure relief line (57/5) of manifold plate on expansion tank. Use one each seal (57/6) on both ends of hollow union bolt connector.



57

Figure 58

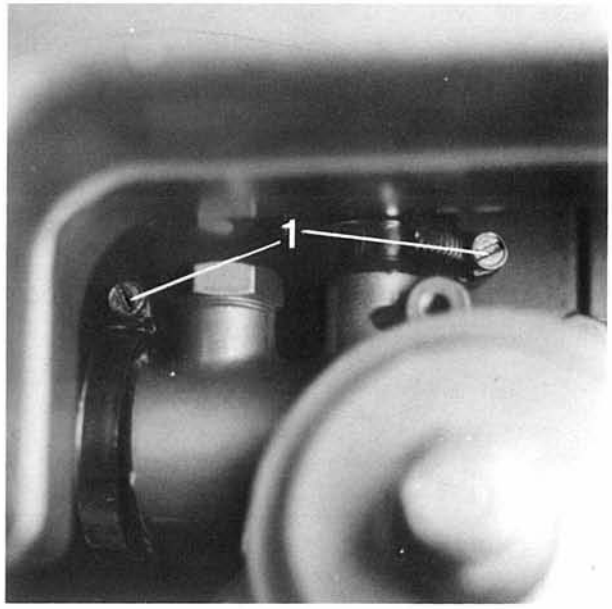
Attach two oil lines (58/1) between engine and cooling system. Conect plug on oil thermometer, see „Installing Electric Box".

58

Figure 59

Tighten two hose clamps (59/1) on water pump.

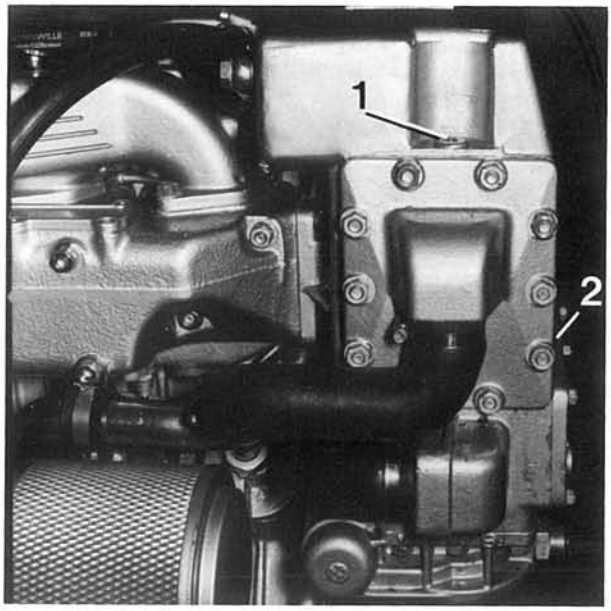
— Connect raw water line on raw water pump, see „Removing and Installing Raw Water Pump".



59

Figure 60

Fill cooling system with coolant. Unscrew socket head bolt (60/1), fill oil/water heat exchanger with engine oil and screw in bolt again. Refer to „Technical Data" for filling capacities.
Note: Before filling the cooling system, check that both socket head bolts (60/2) are installed tight in front of cooling system.



60

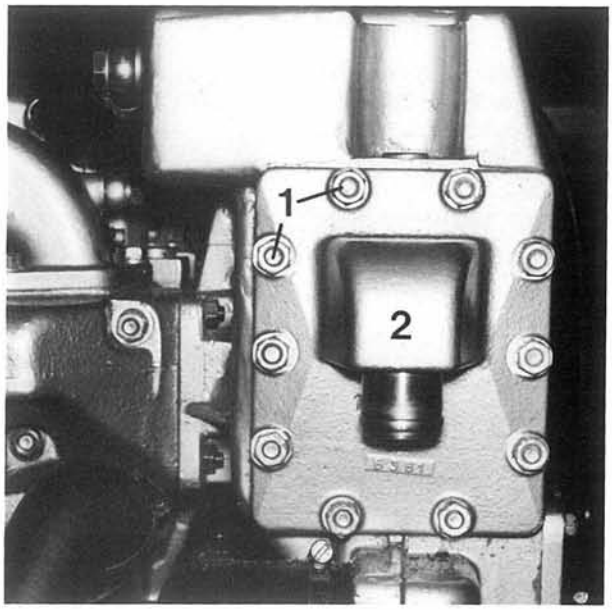
DISASSEMBLING AND ASSEMBLING RAW WATER COOLING CIRCUIT

Removing Heat Exchangers

— Drain oil and water, see „Removing Raw Water Cooling Circuit".
— Detach raw water lines on covers of cooling system.

Figure 61

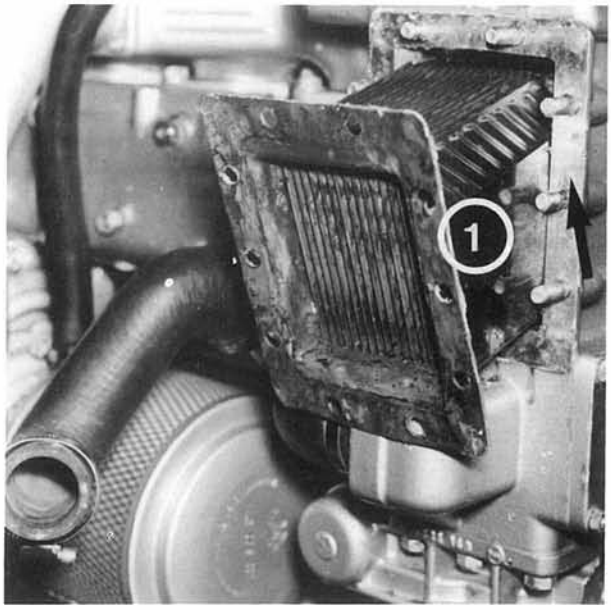
Unscrew ten hexagon nuts (61/1) on right side of side cover (61/2) and take off side cover.



61

Figure 62

Scrape off bearing surface (arrow) of heat exchanger flange on cooling system housing flange with a sharp knife. Pry heat exchanger (62/1) out of housing carefully with a screwdriver and remove.
Note: Be careful not to damage heat exchanger flange while prying out.
Remove water/water heat exchanger in same manner.
Note: Always first remove the oil/water heat exchanger.



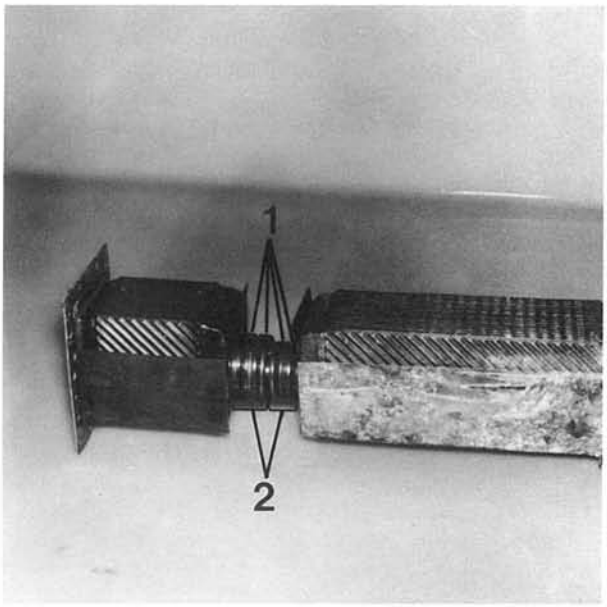
62

Installing Heat Exchangers

Clean heat exchangers and seats in cooling system prior to installation.
Note: Always first install the oil/water heat exchanger.

Figure 63

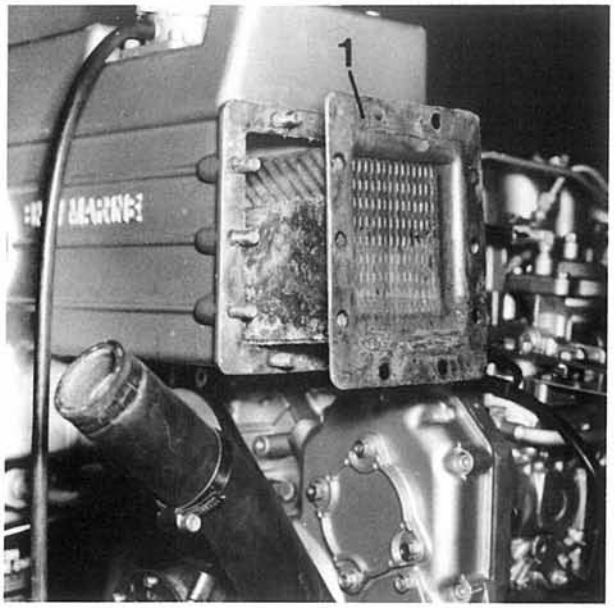
Use new O-rings (62/1) and lubricate connection (63/2) from heat exchanger to heat exchanger with grease.



63

Figure 64

Place oil/water heat exchanger in cooling system housing, install and mount cover with ten mounting nuts. Connect hose.
Install water/water heat exchanger (64/1), lift slightly and push in firmly. Bolt on cover and connect hose for raw water pump.
Fill cooling system with water and oil, see „Installing Raw Water Cooling Circuit".



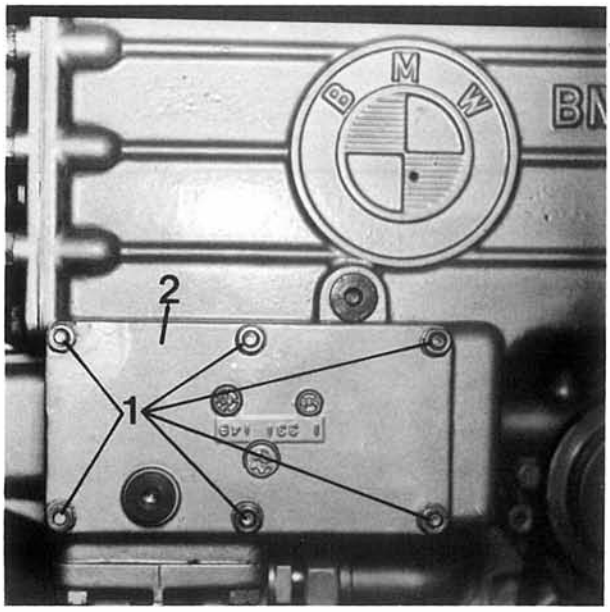
64

Replacing Thermostats

— Drain water, see „Removing Raw Water Cooling Circuit".

Figure 65

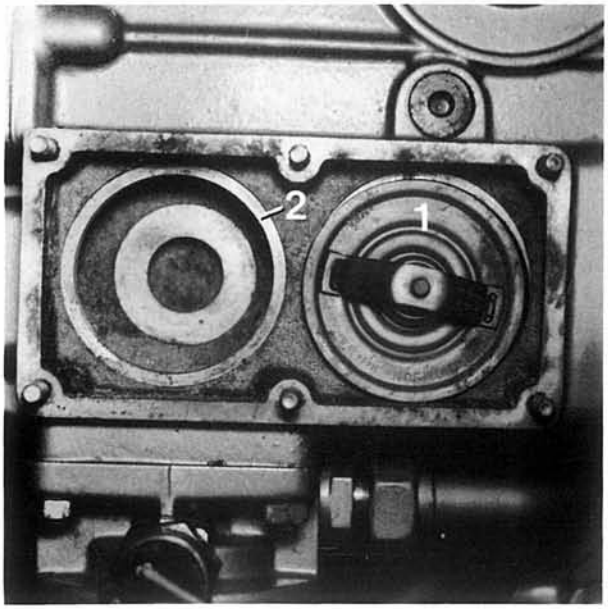
Unscrew six nuts (65/1) and take off cover (65/2) with gasket on thermostat housing. Remove gasket remaining on cover and housing with a steel brush.



65

Figure 66

Remove thermostat(s) (66/1). Install new thermostat(s) in housing, making sure that rubber seal fits correctly in groove (66/2). Coat new gasket with a liquid sealing compound and place gasket on thermostat housing. Install and mount cover with six nuts. Use a washer under each nut.



66

Replacing Oil Thermostat

— Drain oil in oil cooler, see „Removing Raw Water Cooling Circuit".

Figure 67

Detach oil line (67/1) .Unscrew adapter (67/2) and remove with seal from oil thermostat housing. Install new thermostat (lettering faces out), place a new seal on adapter and screw in the adapter. Attach oil line.

— Fill oil/water heat exchanger with oil, see „Installing Raw Water Cooling Circuit".

67

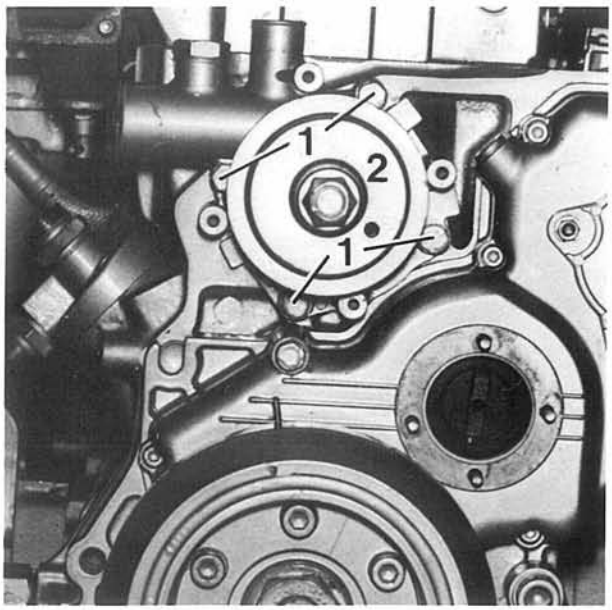
REMOVING AND INSTALLING WATER PUMP

Removing Water Pump

— Take off drive belt.
— Detach two hoses, see „Removing Raw Water Cooling Circuit".

Figure 68

Unscrew four mounting bolts (68/1) and take water pump (68/2) off of engine.



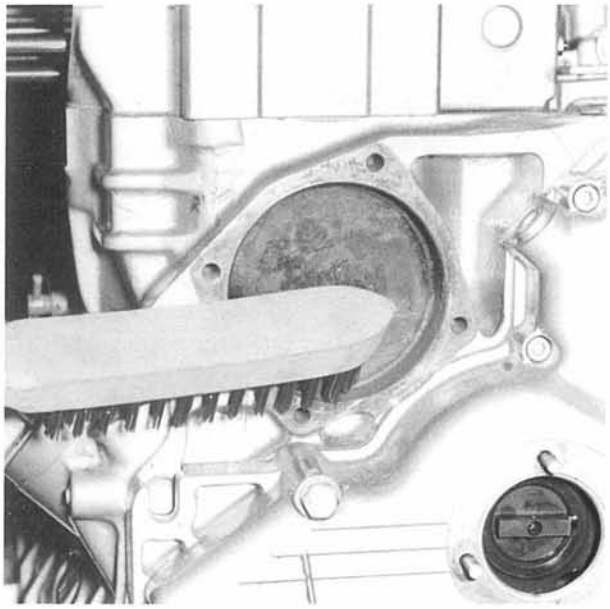
68

Installing Water Pump

Figure 69

Remove remainders of old gasket on water pump seat and flange by cleaning with a steel brush. Coat new gasket with a liquid sealing compound and place on water pump. Place water pump on water pump seat (see Figure 68) and mount with four hexagon head bolts (68/1).

— Attach hoses, see „Installing Raw Water Cooling Circuit".
— Install and tighten drive belt, see „Installing Alternator".



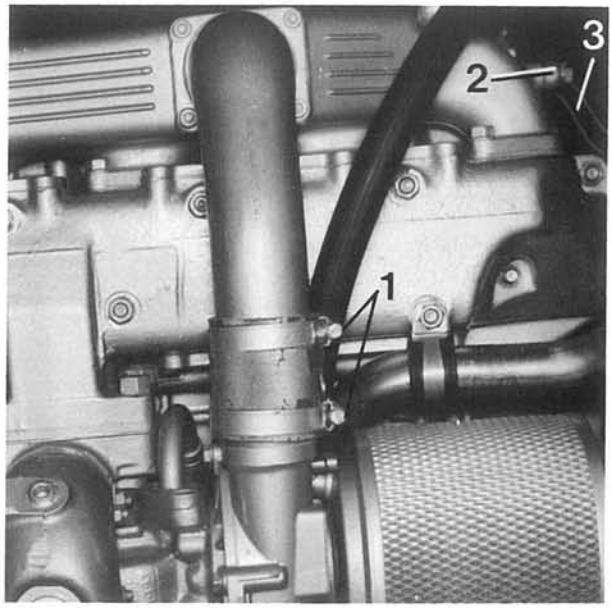
69

REMOVING AND INSTALLING INTAKE MANIFOLD

Removing Intake Manifold

Figure 70

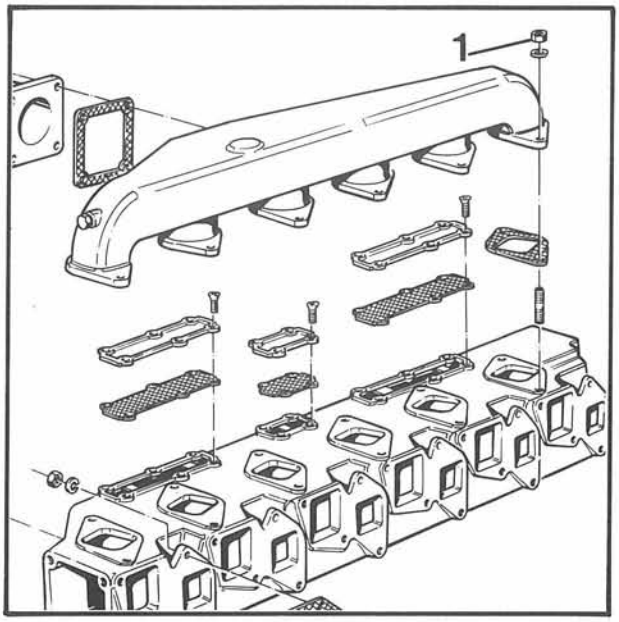
Unscrew two hose clamps (70/1) on turbocharger. Unscrew connector (70/2) and remove pressure line for injection rate control (70/3) on intake manifold.



70

Figure 71

Unscrew twelve mounting nuts (71/1) and remove nuts and washers. Take intake manifold off of exhaust manifold.

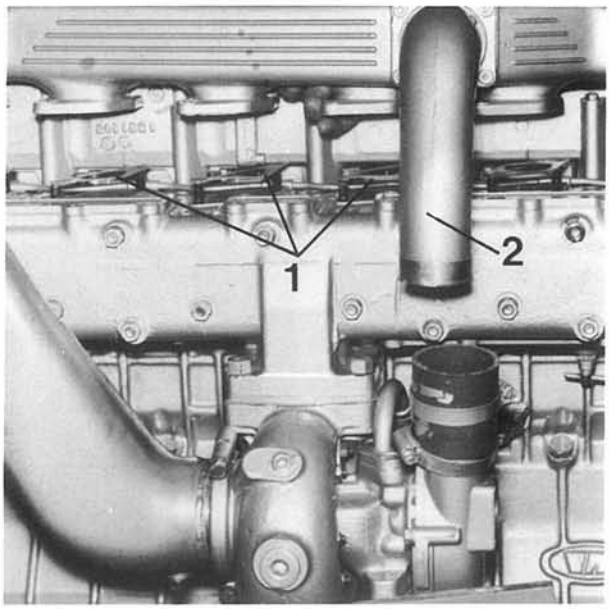


71

Installing Intake Manifold

Figure 72

Remove remainders of old gasket on intake manifold flange and exhaust manifold. Install new gaskets (72/1) and place intake manifold on exhaust manifold. Use a washer under each mounting nut and mount intake manifold with twelve mounting nuts.
Note: Push intake pipe (72/2) into connecting hose for turbocharger while mounting the intake manifold.



72

REMOVING AND INSTALLING TURBOCHARGER

Note: The chapter on removal and installation of the turbocharger is described twice,

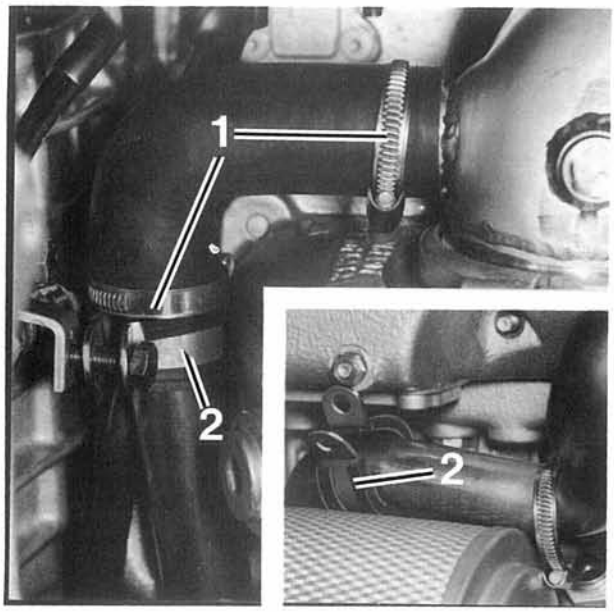
a) when disassembling the entire engine and
b) when only removing the turbocharger alone.

a) Removing Turbocharger Complete with Exhaust Manifold and Pipe

— Remove intake manifold.
— Remove air cleaner.

Figure 73

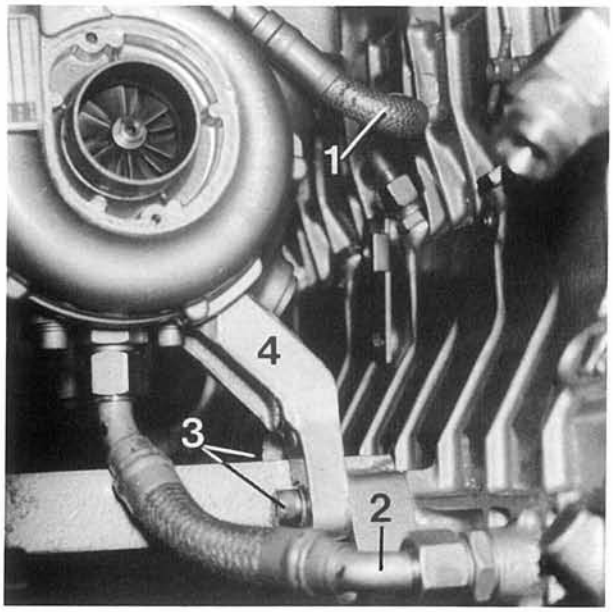
Unscrew two hose clamps (73/1). Unscrew two pipe clamps (73/2) on engine and remove complete raw water line from cooling system to exhaust pipe.



73

Figure 74

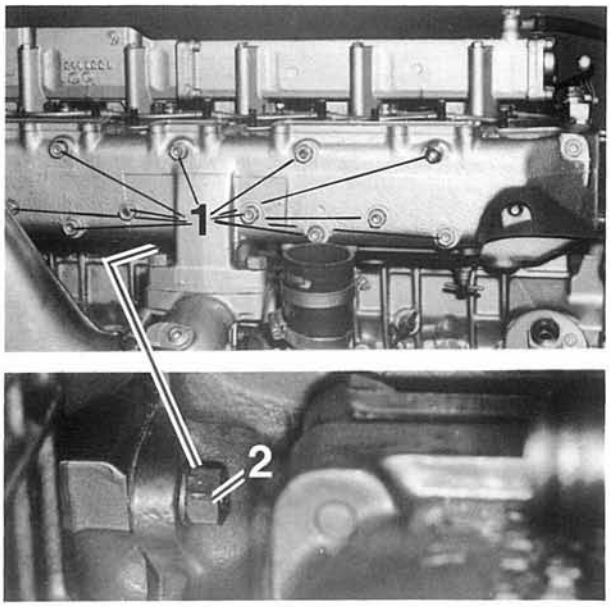
Unscrew oil pressure line (74/1) and oil return line (74/2) on engine block. Unscrew two socket head cap screws (74/3) in turbocharger support (74/4).



74

Figure 75

Unscrew all mounting nuts (75/1) of exhaust manifold and remove washers.
Remove entire assembly from engine.
Important! Check whether lower mounting nut (75/2) of exhaust manifold behind the turbocharger has been unscrewed.

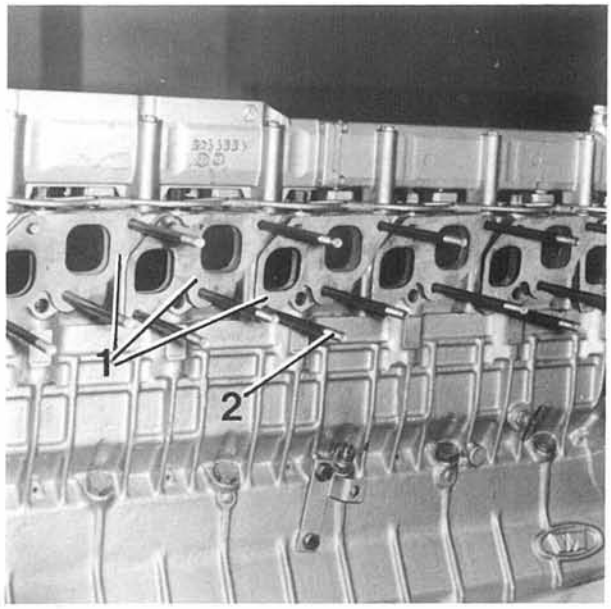


75

Installing Turbocharger Complete with Exhaust Manifold

Figure 76

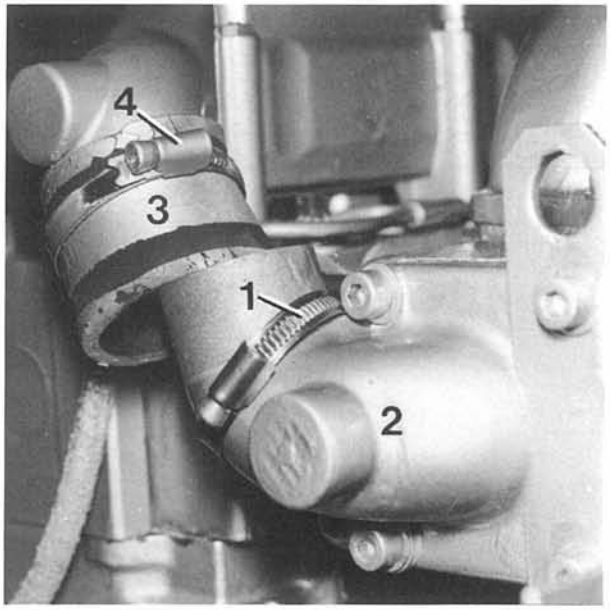
Place new gaskets (76/1) over studs (76/2) and install on cylinder head flange.



76

Figure 77

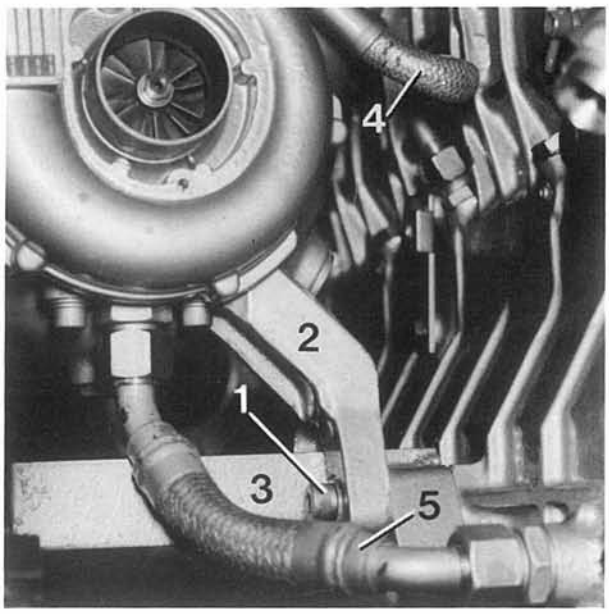
Connect one hose clamp (77/1) above elbow (77/2) on cover of exhaust manifold. Place turbocharger complete with exhaust manifold and exhaust pipe over studs (76/2). Guide hose (77/3) for water collection plate above elbow on exhaust manifold. Use a washer under each nut and screw on and tighten all mounting nuts of exhaust manifold. Tighten hose clamps (77/1 and 4).



77

Figure 78

Guide two socket head cap screws (78/1) into support (78/2) and engine brace (78/3) and torque to 50 Nm. Connect oil pressure line (78/4) and return line (78/5) on engine block.



78

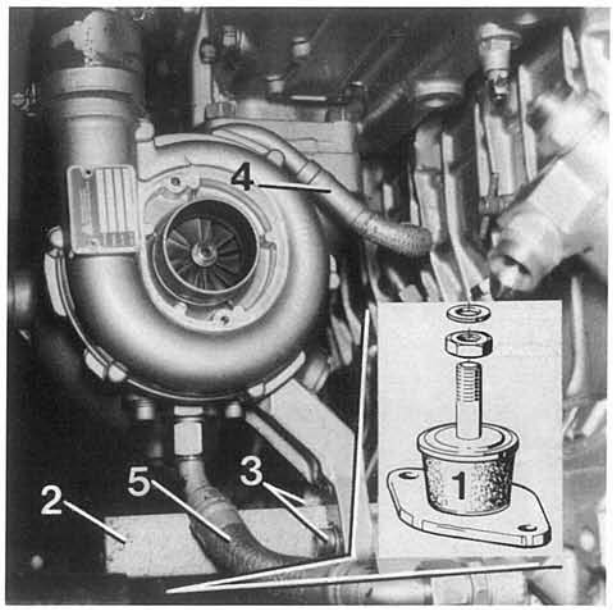
— Install intake manifold.
— Install air cleaner.

b) Removing Turbocharger Separately

— Remove air cleaner.

Figure 79

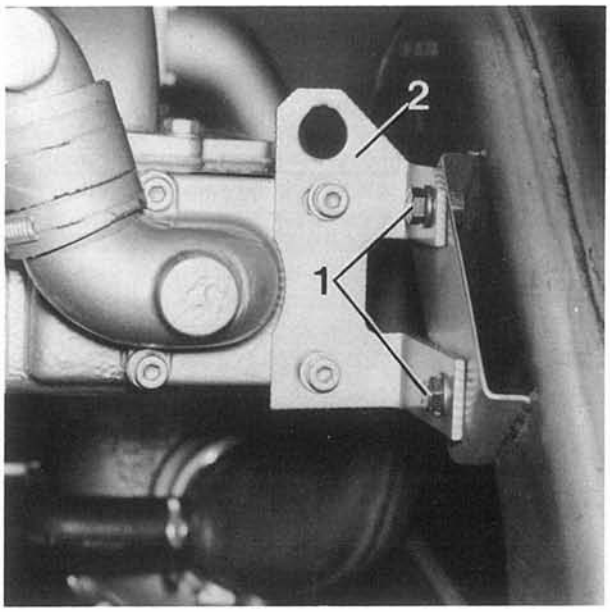
Support engine from underneath. Unscrew two mounting bolts of right mount (79/1) in bearing seat and unscrew mount on engine brace (79/2). Unscrew four socket head cap screws (79/3) in engine brace and remove engine brace. Unscrew oil pressure line (79/4) and return line (79/5) of turbocharger on engine.



79

Figure 80

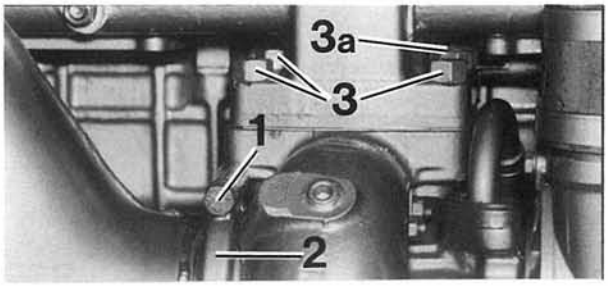
Unscrew two exhaust pipe connecting bolts (80/1) on bracket (80/2) and remove nuts, washers and bolts.

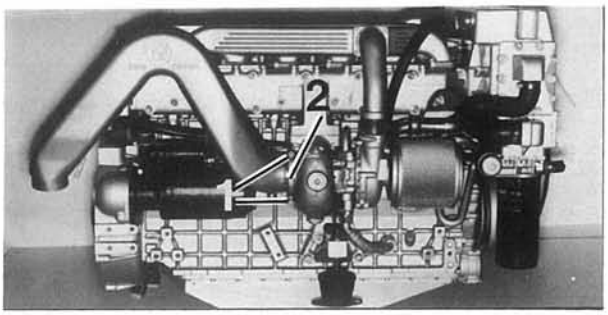


80

Figure 81

Unscrew two hose clamps on exhaust manifold. Unscrew two bolts (81/1) of exhaust pipe mounting clamp (81/2) and remove clamp, exhaust pipe and gasket on turbine outlet. Apply pressure from bottom of turbocharger, unscrew four hexagon nuts (81/3) and take turbocharger with gaskets off of exhaust manifold from below.
Note: Use a ground off open-end wrench to unscrew the rear, right nut (81/3a).



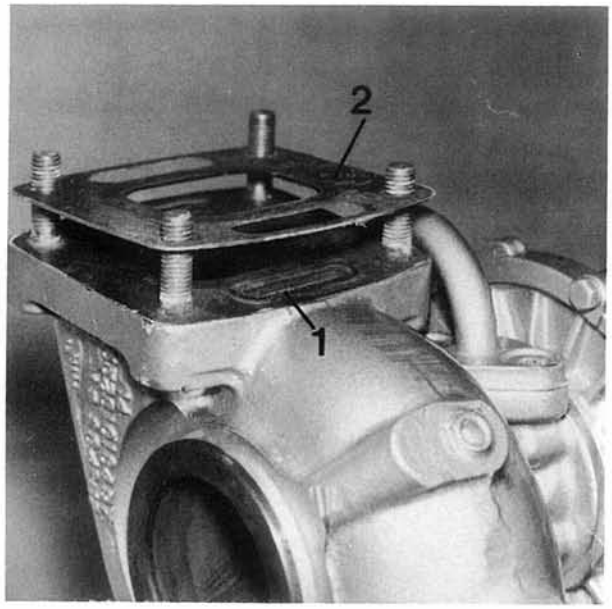


81

Installing Turbocharger

Figure 82

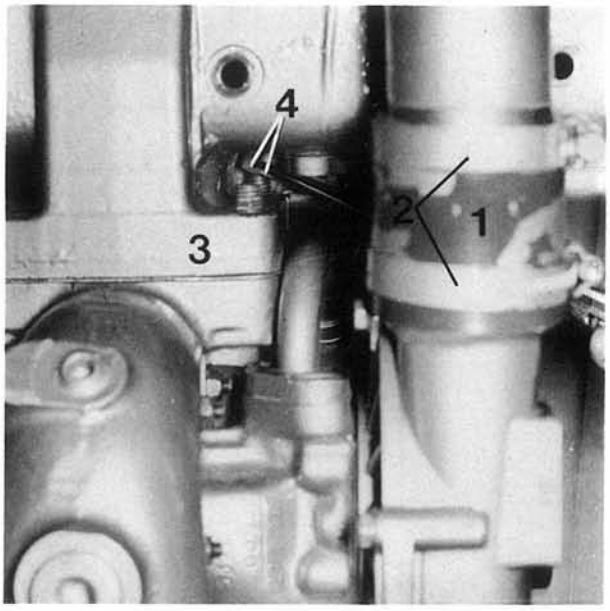
Place new seals (82/1) in openings of water ports and new gasket (82/2) on turbocharger flange.



82

Figure 83

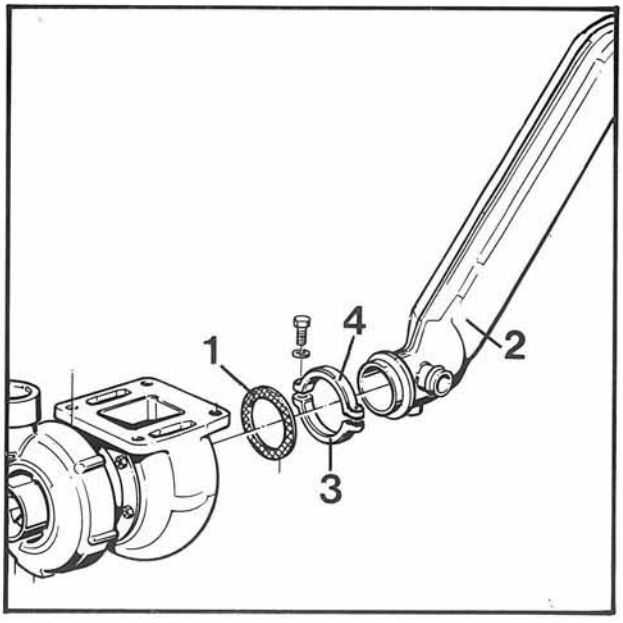
Connect hose (83/1) on compressor outlet with two hose clamps (83/2).
Place turbocharger on flange (83/3) of exhaust manifold and push hose on elbow of intake manifold. Install rear, right mounting nut (83/4) on stud with a pliers (if necessary lower turbocharger slightly for better accessability) and tighten with a ground off open-end wrench (25 to 28 Nm). Install and tighten remaining three mounting nuts (25 to 28 Nm). Tighten two hose clamps (83/2).



83

Figure 84

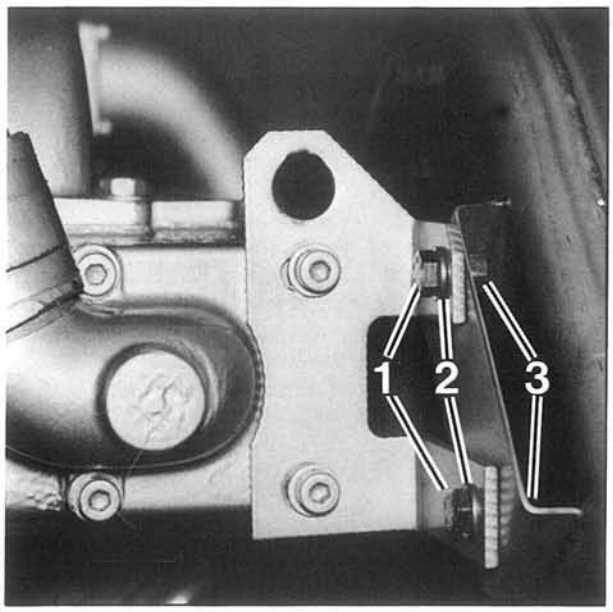
Install new gasket (84/1) on exhaust pipe (84/2) and insert exhaust pipe in turbine outlet against stop. Slide both sections (84/3 and 4) of mounting clamp on collar of exhaust pipe and turbine, insert two bolts and pull clamp uniformly by tightening the bolts alternately. Tighten bolts to torque of 30 to 35 Nm.



84

Figure 85

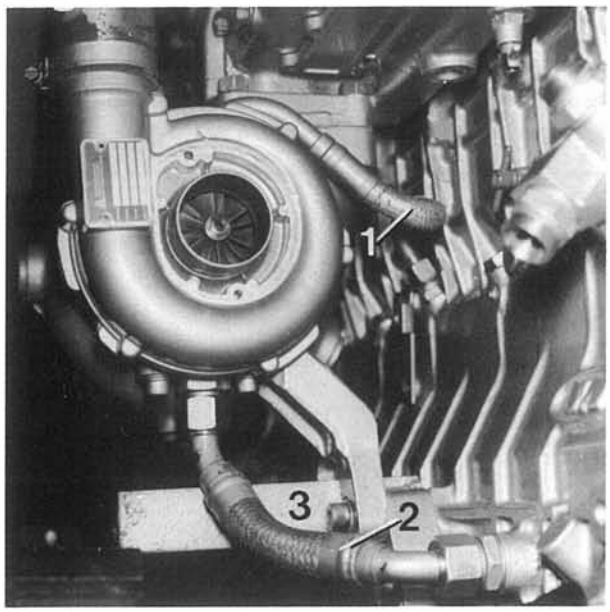
Bolt exhaust pipe on support with two hexagon head bolts (85/1), hexagon nuts (85/2) and one each washer (85/3) under the heads of bolts.



85

Figure 86

Connect oil pressure line (86/1) and return line (86/2) on engine. Place engine brace (86/3) on flange from below, screw in and tighten four socket head cap screws to 50 Nm. Screw a hexagon nut on mount, install a washer and insert stud of mount in slot of engine brace from below. Align mount with bores in mount seat and bolt on mount seat. Screw on lower hexagon nut against stop on engine brace. Place second washer on stud, screw on locknut and lock with lower hexagon nut.



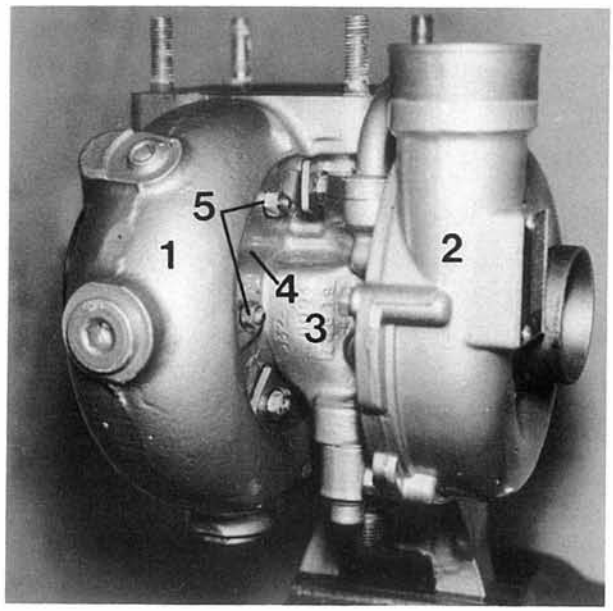
86

DISASSEMBLING AND ASSEMBLING TURBOCHARGER MEASURING AXIAL AND RADIAL PLAY

Disassembling Turbocharger

Figure 87

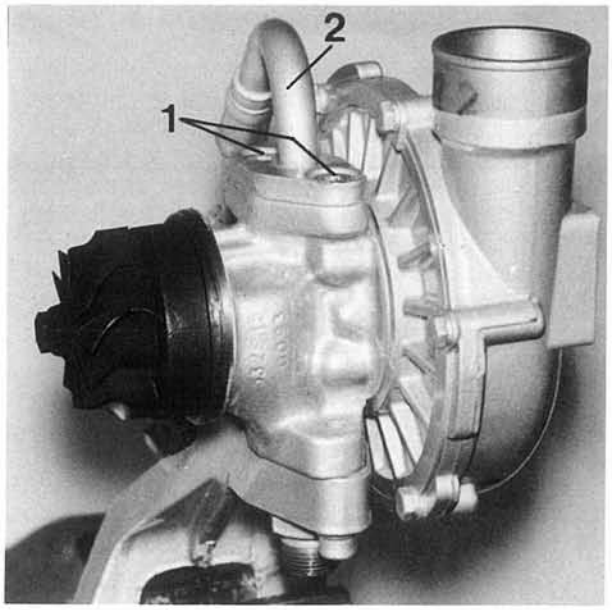
Clamp turbocharger in a vise on the support. Mark position of turbine housing (87/1) and compressor housing (87/2) to bearing housing (87/3). Unscrew two mounting nuts (87/5) for each clamping ring (87/4), take three clamping rings off of turbine housing and pull off turbine housing.



87

Figure 88

Unscrew two socket head cap screws (88/1) and take oil pressure line (88/2) with gasket off of bearing housing.

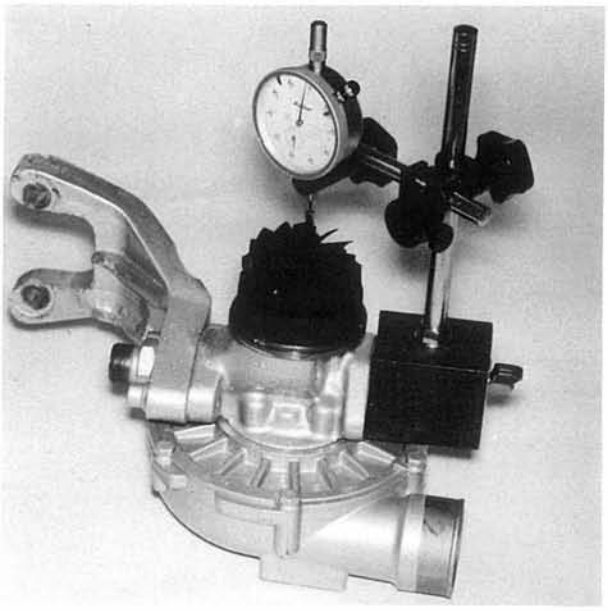


88

Measuring Axial Play

Figure 89

Apply dial gauge holder with dial gauge as shown and apply dial gauge on face of turbine shaft with pre-load. Press rotor shaft against dial gauge, read and note the value.
Press rotor shaft in opposite direction, read and note the value. The difference of both values is the axial play.
Max. axial play = 0.15 mm.
Replace turbocharger when play is exceeded.

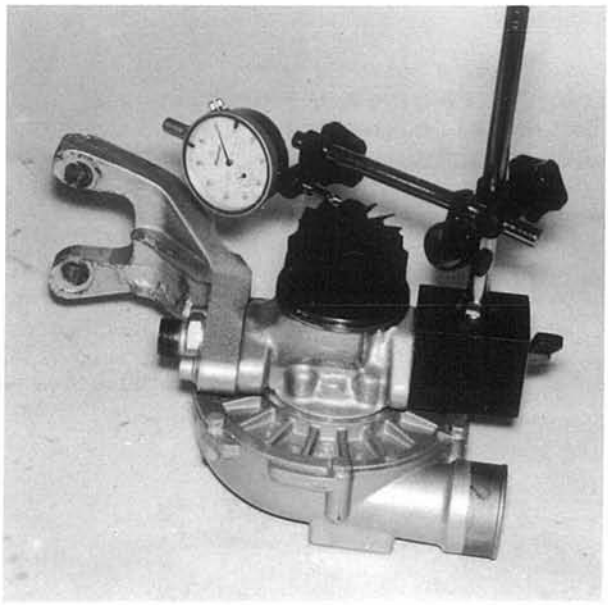


89

Measuring Radial Play

Figure 90

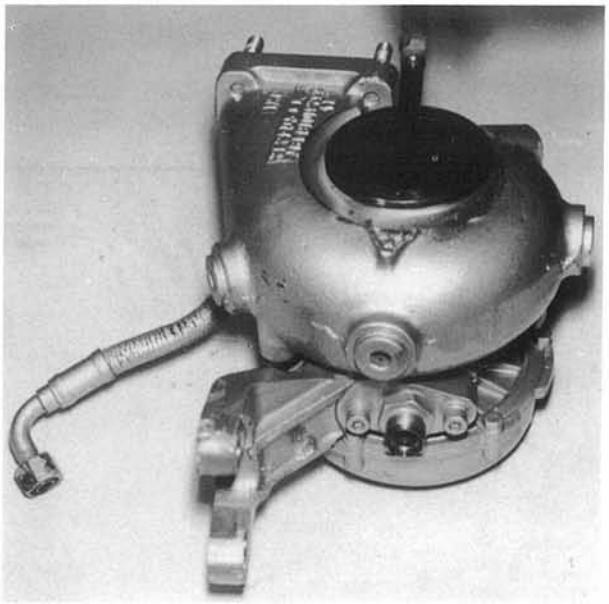
Radial play is measured only on the turbine end with a dial gauge or feeler gauge.
Dial Gauge: Apply tip of dial gauge on face of hub, press turbine down, read and note the value. Press turbine in opposite direction, read and note the value. The difference of both values is the radial play. Max. radial play must not exceed 0.55 mm.



90

Figure 91 (Turbine Housing Attached)

Feeler Gauge: Press turbine to final position and measure clearance between turbine housing and turbine. Press turbine to opposite final position and measure clearance. Difference of both measured distances is the radial play. Max. radial play must not be exceeded. Measure at two different points. If play is exceeded, replace the turbocharger.
Note: The radial play can be measured with a feeler gauge also when turbocharger is installed.

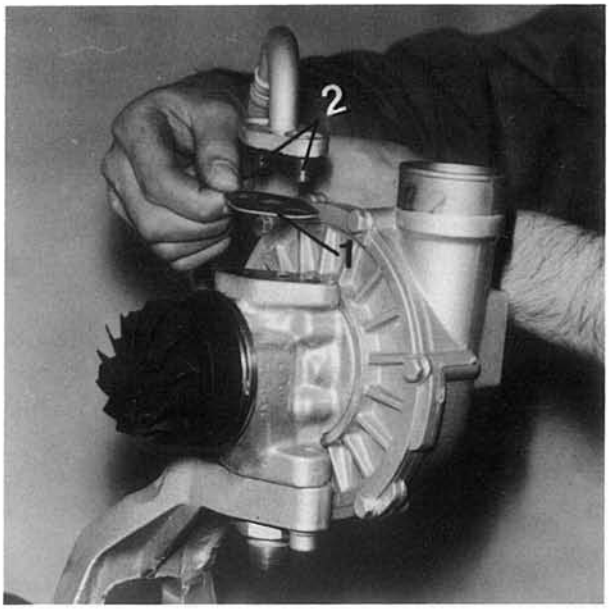


91

Assembling Turbocharger

Figure 92

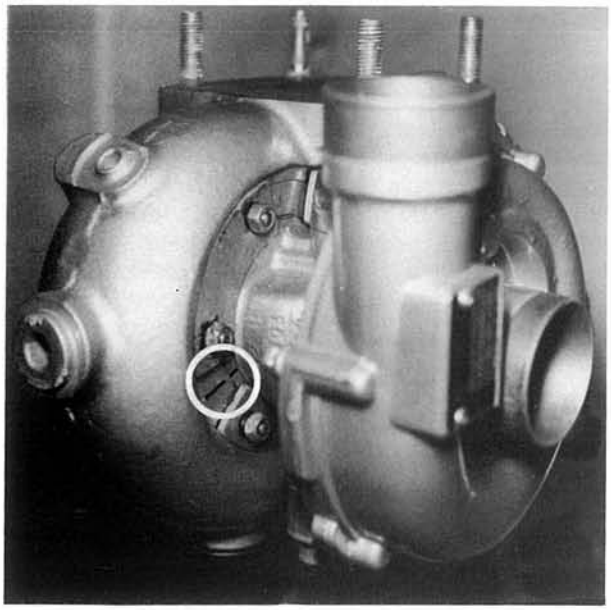
Place a new gasket (92/1) on bearing housing flange, install oil pressure line and secure with two socket head cap screws (92/2).



92

Figure 93

Install turbine housing, apply clamping rings, screw two hexagon nuts on each clamping ring housing and compressor housing with those on and tighten finger tight. Align marks on turbine boarding housing. Tighten nuts of clamping rings to a torque of 30 Nm.



93

TROUBLESHOOTING TURBOCHARGER

Possible Malfunctions on Turbocharged Engines

If engine malfunctions, always first conform with the instructions on the injection system before checking the following points.

Condition	Possible Cause	Correction
Unusual exhaust gas opacity and power drop	Generally because of insufficient air with low charge pressure	Replace air cleaner
	Clogged air cleaner (excessive vacuum ahead of compressor; possibly oil leak on conpressor end)	Replace air cleaner
	Exhaust gas line behind turbocharger clogged or damaged (pressure behind turbocharger too high)	Clean or repair
Unusual exhaust gas opacity and power drop in conjunction with unusual noise	Leakage on connections and flanges or air and exhaust gas lines	Check connections and flanges; replace gaskets if necessary
	Rotor scraping	After removal of lines on turbine and compressor ends check housings for traces of scraping; check bearing play according to instructions if necessary.
Rotor scraping	Normally due to excessive bearing play; this could be caused by occasional interruption of oil supply, foreign particles or residue in oil lines and oil ports, defective or clogged oil filters, poor oil quality due to exceeding change intervals, leaks on oil pressure line to turbocharger, extremely fast starting on very cold engine (avoid quick loads after starting).	Replace turbocharger with an exchange turbocharger. Only run engine at partial load until turbocharger is replaced to avoid further damage, with orientation on exhaust gas opacity.

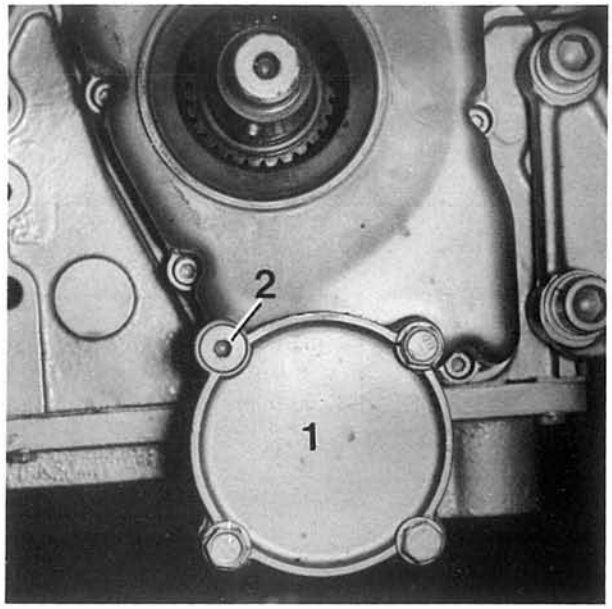
B e f o r e attaching the turbocharger, the compressor inlet, exhaust gas line from engine to turbine and the oil line to the turbocharger must be checked very conscientiously for foreign particles and other contamination to avoid premature damage on the turbocharger. Fill oil before connecting the oil feed line.

REMOVING AND INSTALLING TIMING CASE COVER

— Remove raw water pump.
— Remove vibration damper with pulley.
— Remove water pump.

Figure 94

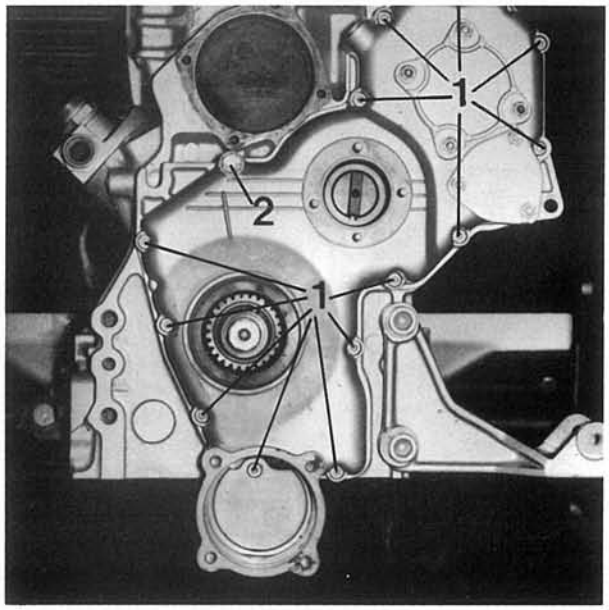
Unscrew drive case cover (94/1) on timing case cover and remove with gasket.



94

Figure 95

Unscrew all socket head bolts (95/1) and one hexagon head bolt (95/2) in timing case cover. Take timing case cover with gasket off of engine block.

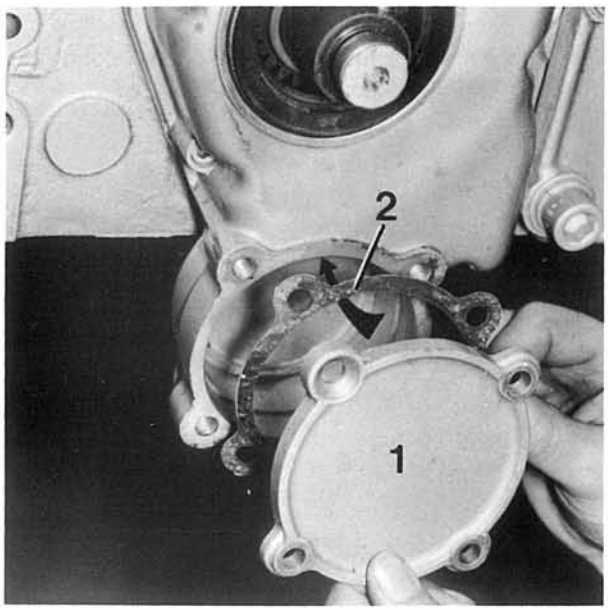


95

Installing Timing Case Cover

Figure 96

Install timing case cover with new gasket on engine block. Screw in all socket head bolts (95/1). Note bolt on output case (arrow). Screw in one hexagon head bolt (95/2) with washer. Install and bolt drive cover (96/1) with new gasket (96/2) on timing case cover.
Note: Left, upper bolt in drive cover is a countersunk, socket head screw (94/2), while the other three are hexagon head bolts.



96

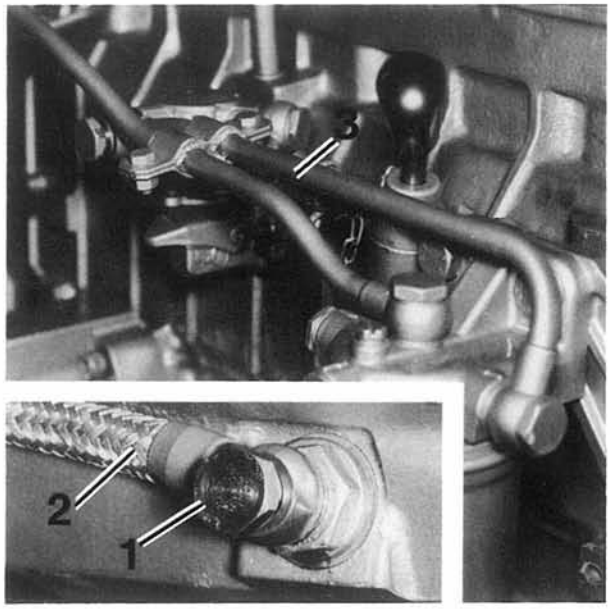
REMOVING AND INSTALLING OIL SCAVENGING PUMP WITH FUEL FILTER

Removing Oil Scavenging Pump with Fuel Filter

— Pump out oil.
— Unscrew holder on flywheel housing, see „Removing and Installing Flywheel Housing".

Figure 97

Unscrew connector (97/1) and take oil line (97/2) with seals off of oil pan. Unscrew fuel line (97/3) on fuel pump and remove with seals. Remove fuel line (99/2) with seals on injection pump after unscrewing connector (99/3).

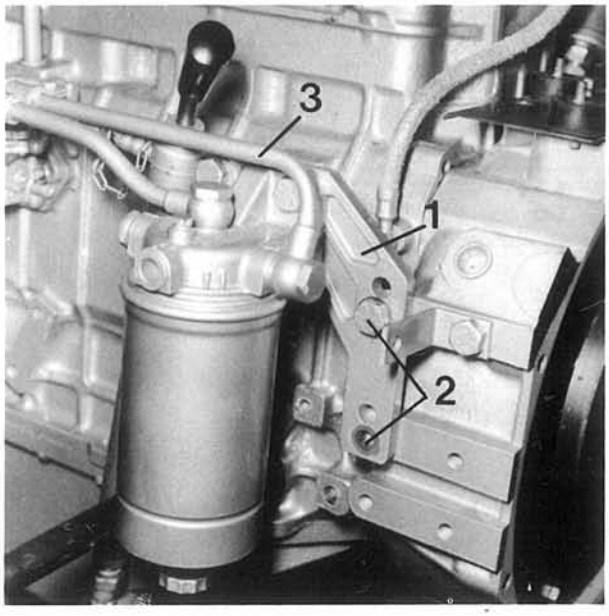


97

Installing Oil Scavenging Pump with Fuel Filter

Figure 98

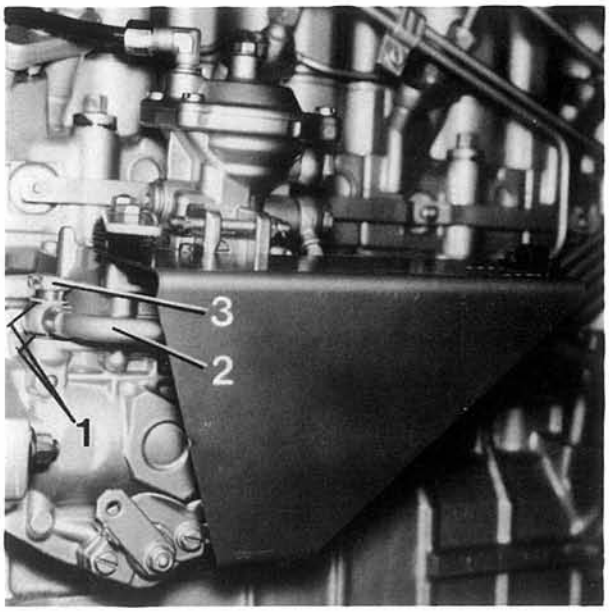
Install fuel filter and oil scavenging pump with bracket (98/1) on flywheel housing and mount with two hexagon head bolts (98/2). Install fuel line (98/3) on fuel pump, place two copper seals in connector and tighten connector.



98

Figure 99

Insert two seals (99/1) and screw fuel line (99/2) on injection pump with connector (99/3). Bolt oil line (97/2) of scavenging pump on oil pan with two seals.
— Add engine oil (see Technical Data for filling capacity).
— Bleed fuel system.



99

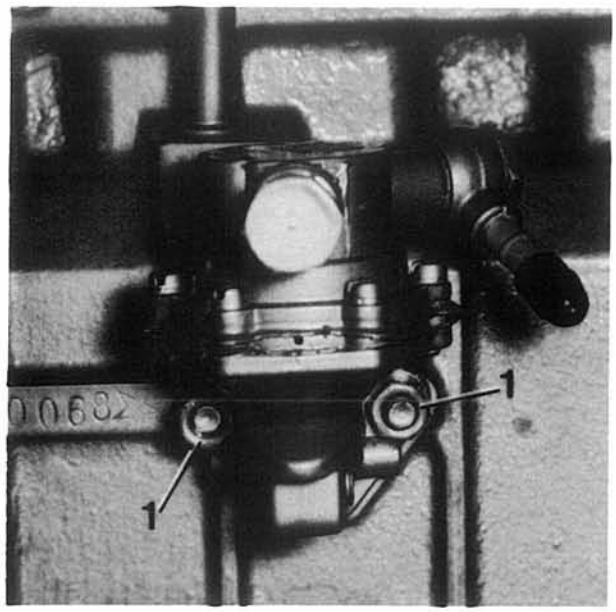
REMOVING AND INSTALLING FUEL PUMP

Removing Fuel Pump

— Disconnect fuel feed line and insert plug.
— Remove fuel delivery line to fuel filter, see „Removing and Installing Injection Pump".

Figure 100

Unscrew two mounting nuts (100/1) and take fuel pump off of engine.

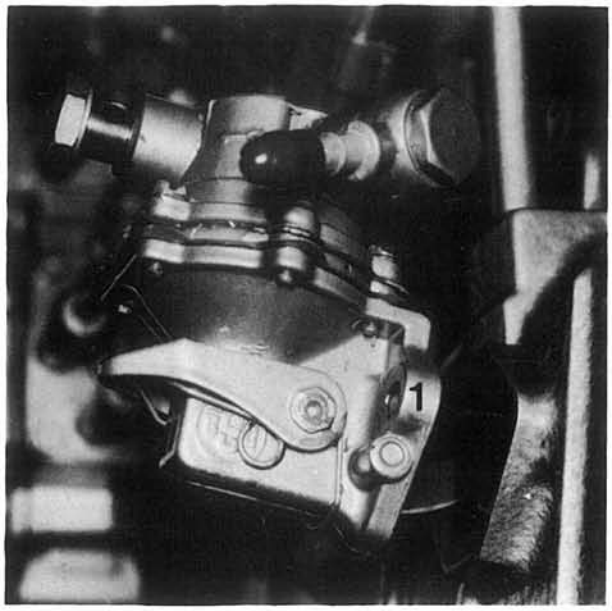


100

Installing Fuel Pump

Figure 101

Insert new O-ring in fuel pump flange (101/1), place fuel pump on engine and mount with two nuts and washers.
— Connect fuel lines.
— Bleed fuel system.

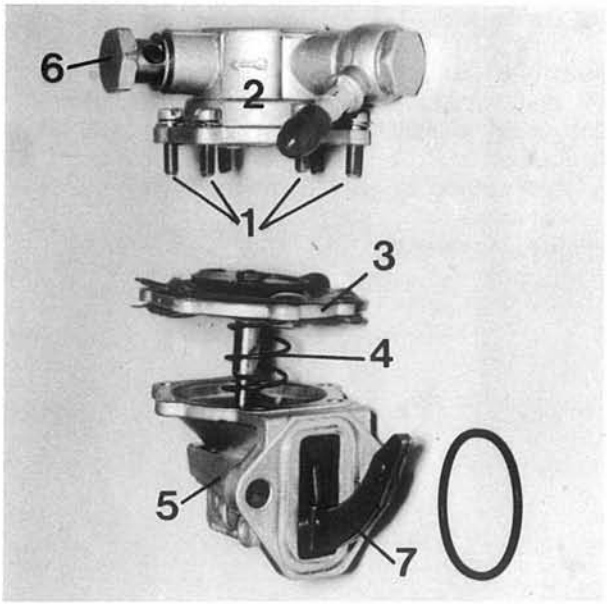


101

REPLACING DIAPHRAGM

Figure 102

Unscrew six slotted head screws (102/1) and remove case cover (102/2). Press diaphragm (102/3) down and turn counterclockwise about 90°. Take diaphragm and spring (102/4) out of fuel pump housing (102/5). Install spring on diaphragm piston.
Install new diaphragm with spring, press down and turn clockwise about 90° until bores of diaphragm are aligned with bores of case. Release diaphragm carefully.
Install case cover with connection (102/6) for delivery line to fuel filter offset to pump operating lever (102/7) by 180° and mount with six slotted head bolts.



102

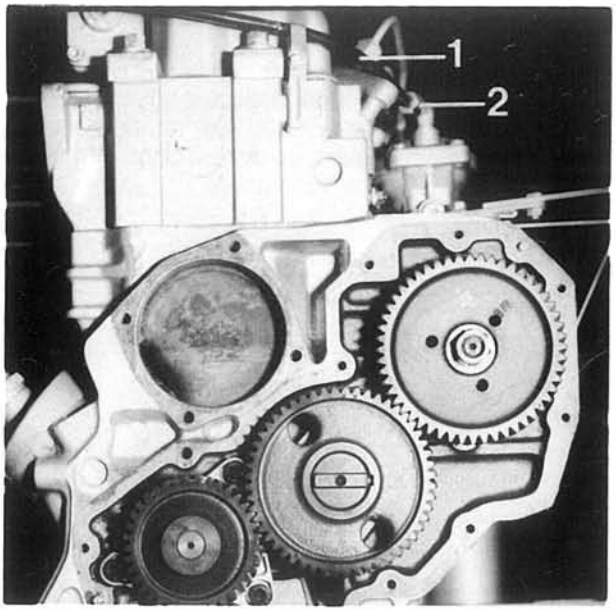
REMOVING AND INSTALLING, ADJUSTING INJECTION PUMP

Injection pump removal and installation as well as adjustment are described twice,
a) when engine has to be disassembled and assembled and
b) when only injection pump has to be removed.

a) Removing Injection Pump

Figure 103

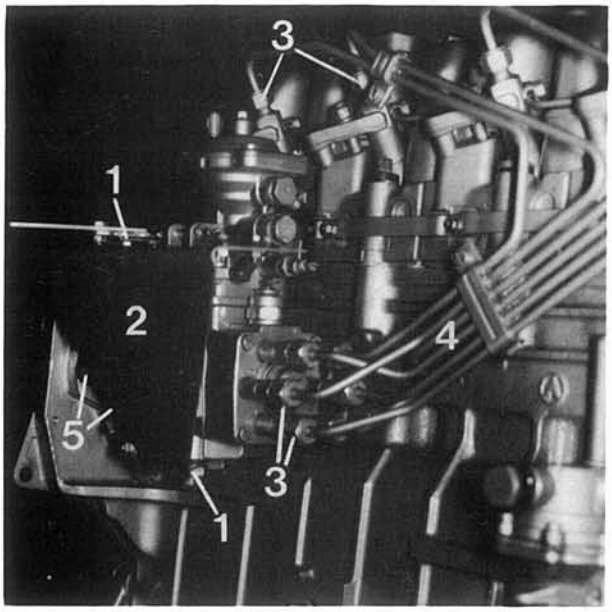
Unscrew charge pressure line (103/1). Unscrew mounting nut (103/2) and pull drive gear off of pump shaft, watching out for woodruff key in pump shaft.



103

Figure 104

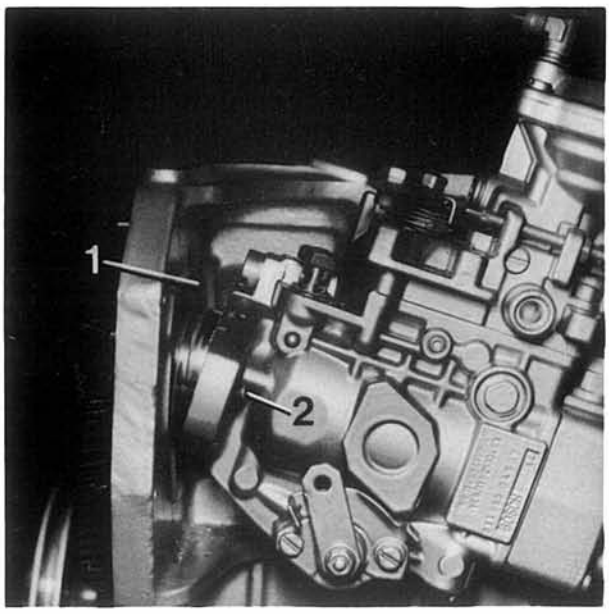
Unscrew two hexagon head bolts (104/1) and remove holder (104/2). Unscrew coupling nuts (104/3) on injection pump and fuel injectors, and take off six injection lines (104/4). Unscrew two mounting nuts (104/5), remove one each washer and pull back injection pump off of engine.



104

Figure 105

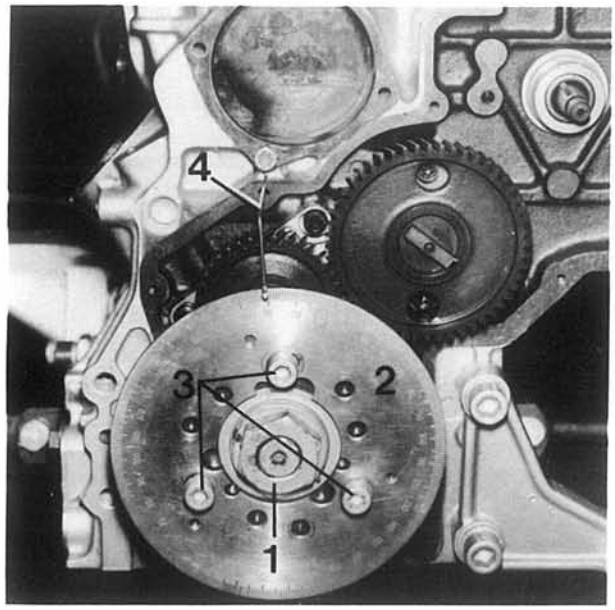
Install injection pump with new gasket (105/1) on engine block, screw two nuts with washers on studs (105/2) and tighten finger tight.



105

Figure 106

Place pulley on crankshaft and secure with mounting nut (106/1). Bolt adjusting disc (106/2), No. 7464 1 333505, on pulley with three socket head bolts (106/3). Make up an indicator (106/4) from a piece of wire and apply on engine as shown.

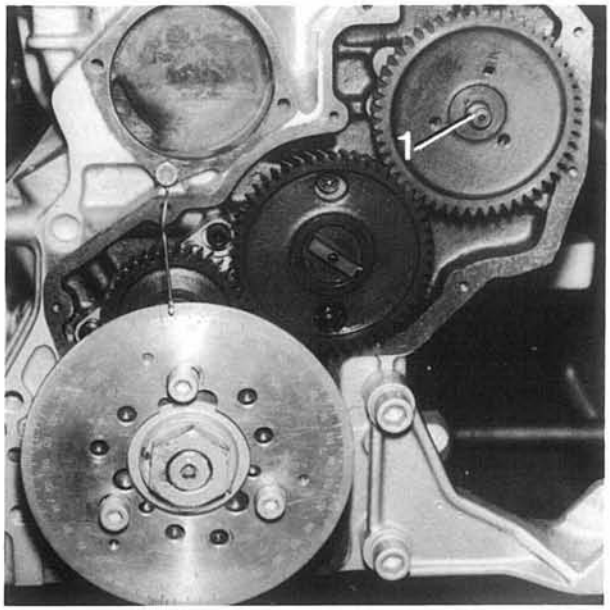


106

Adjusting Injection Pump

Figure 107

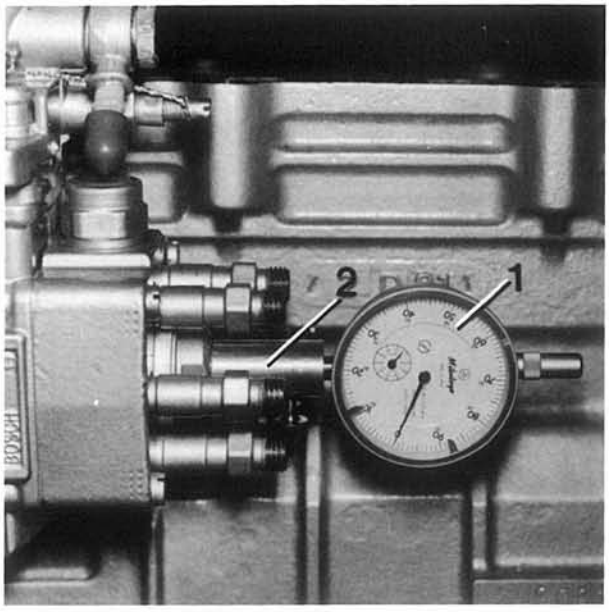
Set first cylinder to TDC (compression cycle) and mark position of adjusting disc to indicator. Install injection pump gear on pump shaft (watch woodruff key) and turn crankshaft until woodruff key groove (107/1) is aligned with opening of first pump piston „A". Pull off drive gear. Set first cylinder to 25—30° before TDC. Install injection pump gear on pump shaft again.
Continue as described in b) text for Figure 113.



107

Figure 108

Remove dial gauge (108/1) and adapter (108/2) on injection pump and screw in bleeder screw (114/1) with a new seal.



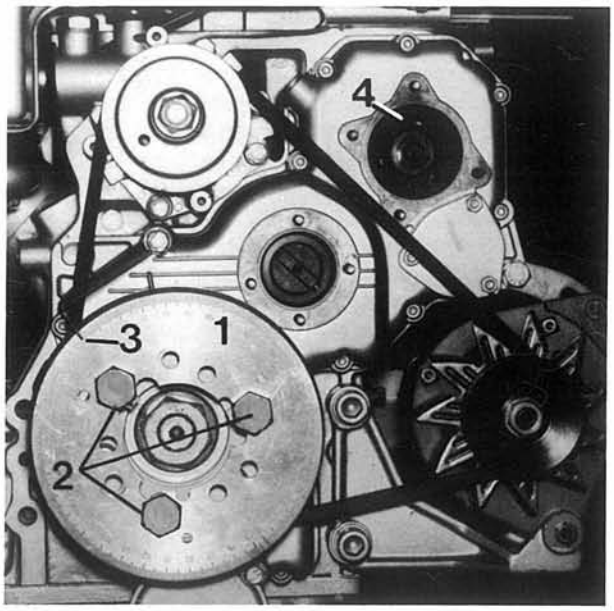
108

b) Removing Injection Pump

— Remove raw water pump.
— Disconnect electric wires of alternator and injection pump, see „Removing and Installing Electric Box".

Figure 109

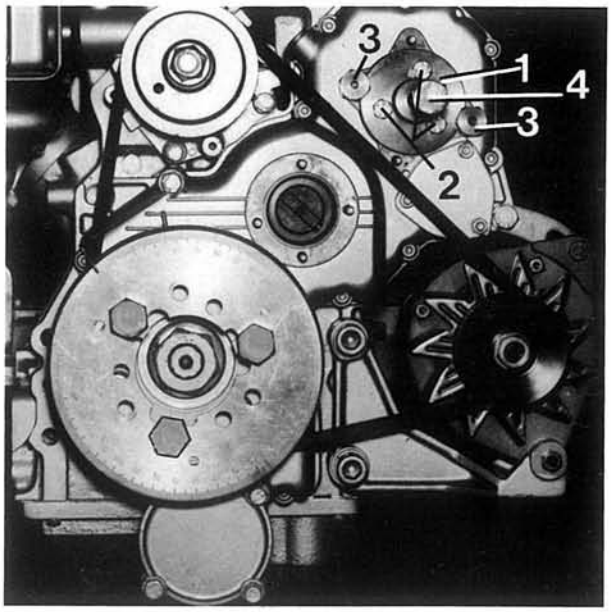
Unscrew three vibration damper socket head bolts. Mount adjusting disc (109/1), No. 7464 1 333500, on vibration damper with three hexagon head bolts (109/2). Take off valve cover of sixth cylinder and set first cylinder and set first cylinder to TDC (compression cycle) — (valves of 6th cylinder will overlap). Make up an indicator (109/3) from a piece of wire and apply as shown in Figure 109. Mark TDC position of adjusting disc to indicator and turn crankshaft counterclockwise 25 to 30°. Unscrew four hexagon nuts and take off front cover on injection pump seat (109/4).



109

Figure 110

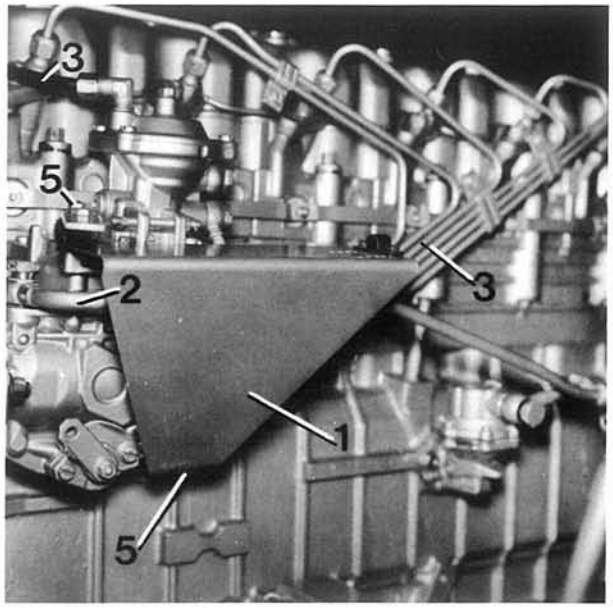
Apply Special Tool 7464 1 333505 (110/1) on injection pump drive gear and secure with three hexagon head bolts (110/2). Hold special tool and gear with two collar nuts (110/3).



110

Figure 111

Take holder (111/1), fuel feed line (111/2), injection lines (111/3) and charge pressure line (111/4) off of injection pump. Unscrew two hexagon head bolts (111/5) and remove washers (also refer to „a") removal text for Figures 103 and 104). Turn hexagon head bolt (110/4) of Special Tool 7464 1 333505 to press off injection pump. Remove pump toward rear.
Note: Return pressing off bolt (110/4) to its original position immediately after pressing off, since otherwise pump shaft cannot engage when installing again.

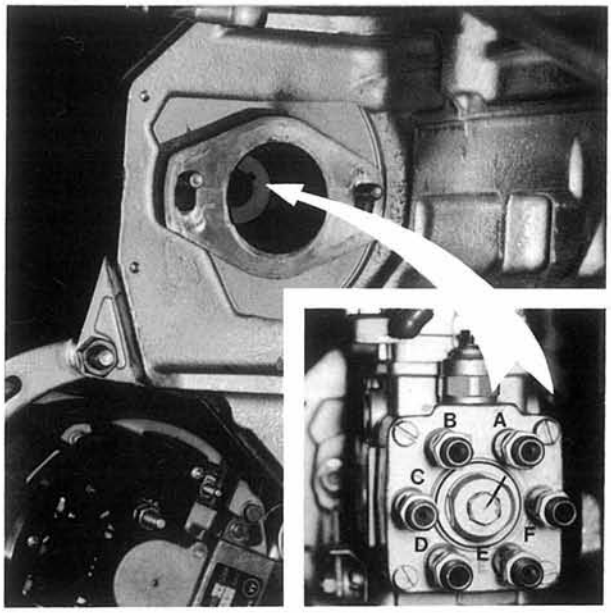


111

Installing and Adjusting Injection Pump

Figure 112

Turn drive shaft of injection pump in direction of rotation until woodruff key is aligned with front outlet „A" (PO = pump zero position). Place injection pump on engine, screw on two nuts with washers and tighten finger tight. Remove Special Tool 7464 1 333505 and screw mounting nut with washer on pump shaft and tighten finger tight. Make sure that pump shaft is not turned.



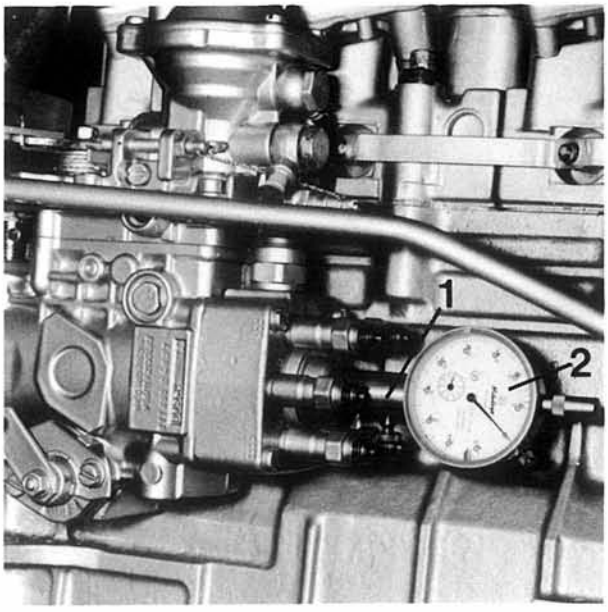
112

Figure 113

Adjusting Injection Pump

Unscrew bleeder screw and screw in dial gauge adapter (No. 7465 1 333510). Place dial gauge (113/2) with extension in adapter, pre-load dial gauge and set to zero. Tun crankshaft in direction of rotation until dial gauge displays 0.50 mm = pump stroke.
The degree scale on the adjusting disc (109/1) should now show 4° before TDC. If not, turn crankshaft to this value. Then correct injection pump in slots by turning on the pump flange until dial gauge again displays 0.50 mm. Tighten two mounting nuts and be careful not to displace the pump stroke. Remove adjusting disc and screw in the three vibration damper socket head bolts.

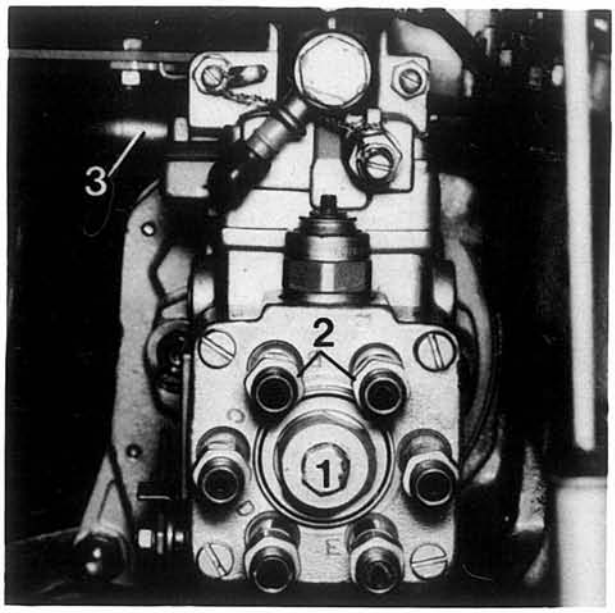
0,74 mm @ TDC



113

Figure 114

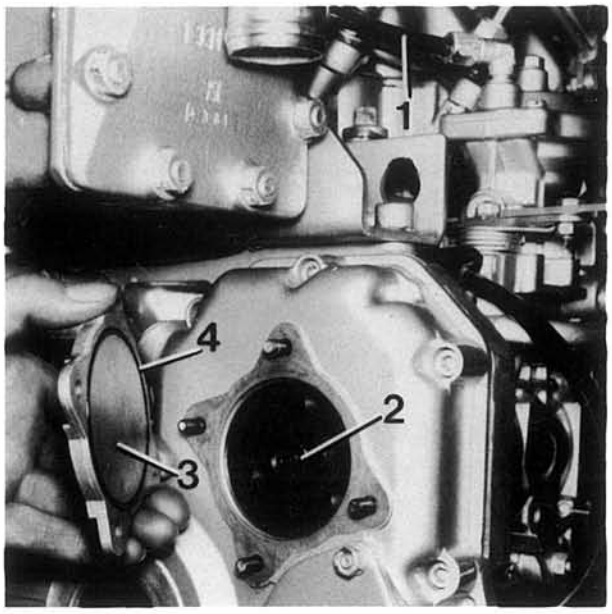
Unscrew dial gauge and adapter in injection pump and screw in bleeder screw (114/1) with a new seal. Attach injection lines on fuel injectors and connect on injection pump outles (114/2). Connect fuel line (114/3).



114

Figure 115

Connect charge pressure line (115/1). Tighten mounting nut (115/2) on pump shaft to torque of 90 Nm. Install cover (115/3) with new O-ring (115/4) on injection pump seat in timing case cover and secure with four hexagon nuts and washers. Attach holder (111/2).



115

— Connect electric wires on alternator and injection pump, see „Removing and Installing Elextric Box".
— Install raw water pump.

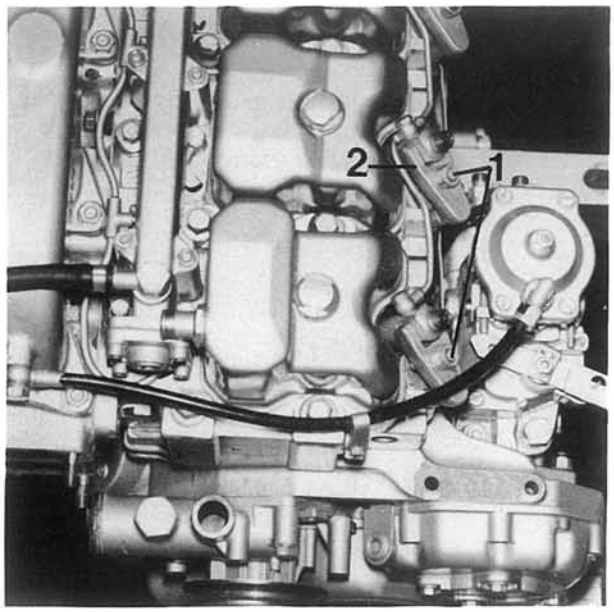
REMOVING AND INSTALLING FUEL INJECTORS

Removing Fuel Injectors

— Remove injection lines, see „Installing Injection Pump".

Figure 116

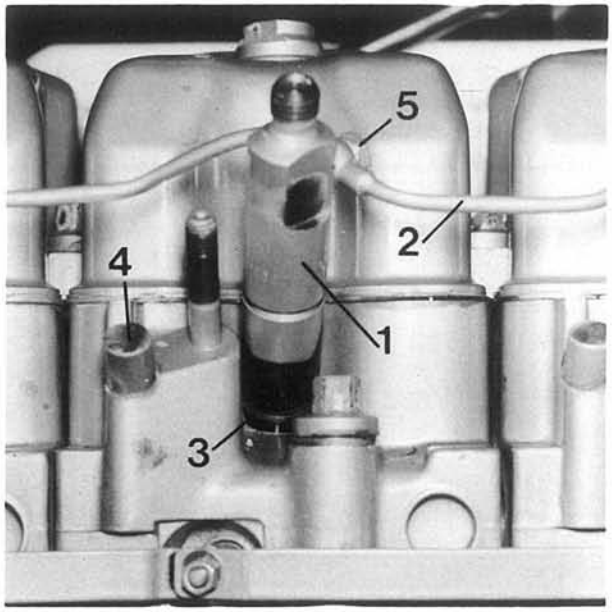
Unscrew one hexagon nut (116/2) for each clamp (116/1) and remove with spring washer and plain washer. Remove clamps.



116

Figure 117

Take six fuel injectors (117/1) together with pressure relief return line (117/2) off of cylinder heads. Remove one seal (117/3) from injector seat for each fuel injector. Remove six spacers (117/4).
Note: If only one fuel injector is removed, first take off pertinent valve cover to be able to unscrew coupling (117/5) of return line.

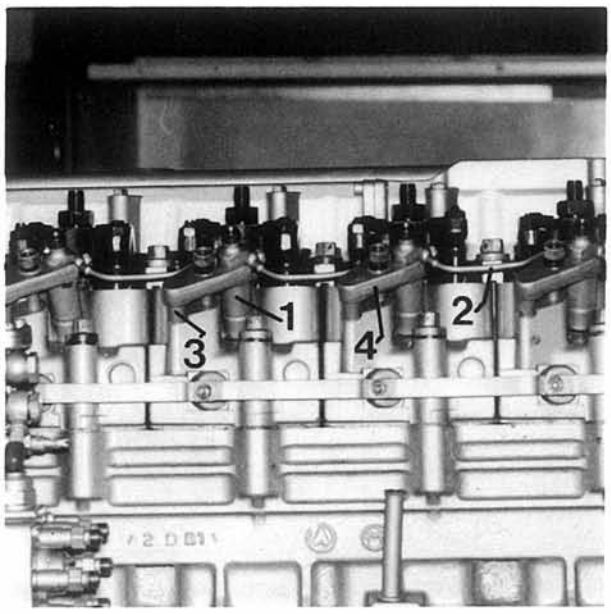


117

Installing Fuel Injectors

Figure 118

Place a new seal for each fuel injector (118/1) in cylinder head and install fuel injectors complete with pressure relief line (118/2).
Install spacers (118/3) in bores of cylinder head. Place six clamps (119/4) on studs, install one each plain washer and spring washer, and screw on hexagon nuts (118/5).
Note: If only one fuel injector had been removed, connect pressure relief line with a coupling (117/5) and mount valve cover.
— Attach injection line.

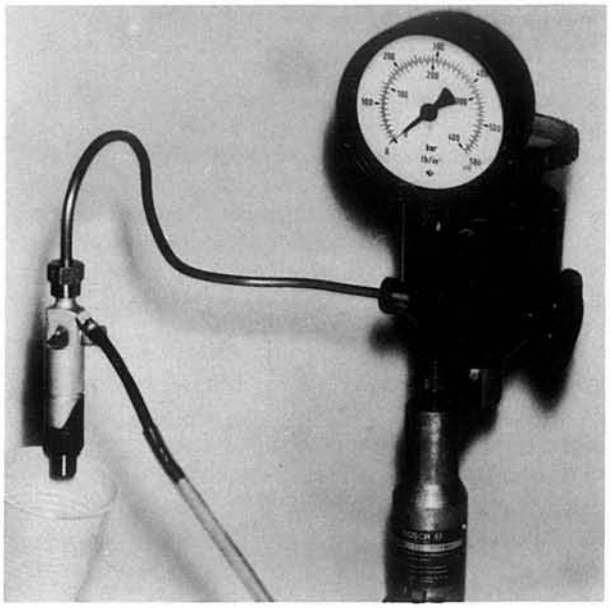


118

CHECKING FUEL INJECTORS

Figure 119

Fuel injectors are checked for opening pressure (ejection pressure), leaks and spray pattern with the injector tester. Pure test oil or pure diesel fuel is used for testing. Clean and check injectors for wear before testing.



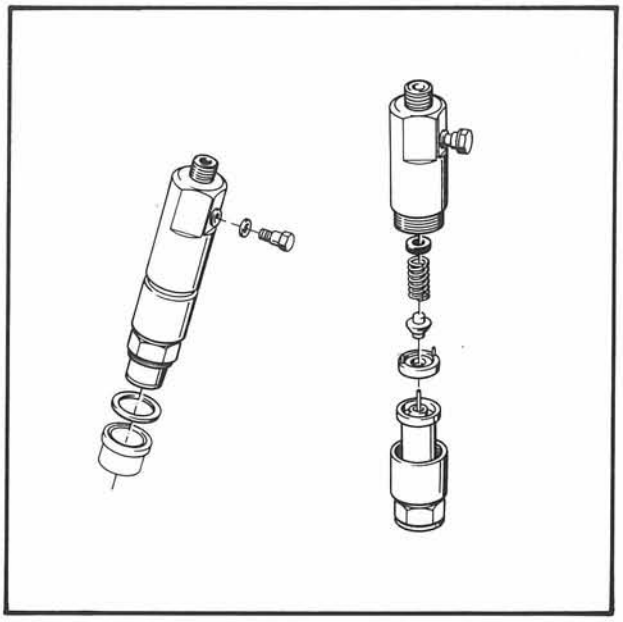
119

Figure 120

Check injector with matching injector holder. Connect feed connection of injector on pressure line of tester.

1. Checking Opening Pressure:
With pressure gauge switched on push back manual lever slowly until injector ejects fuel with a light grinding noise. Read opening pressure (155 to 160 bar) on pressure gauge.

2. Checking Spray Pattern:
With pressure gauge switched off make fast movements and check whether spray pattern is tight. Injector's running noise must be heard, which indixates that jet needle is still moving easily and atomization for start conditions will still be sufficient.



120

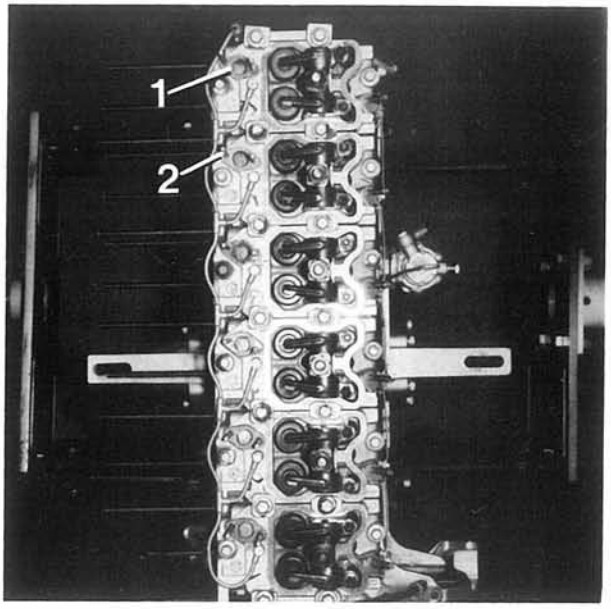
REMOVING AND INSTALLING WATER COLLECTION PLATE

Removing Water Collection Plate

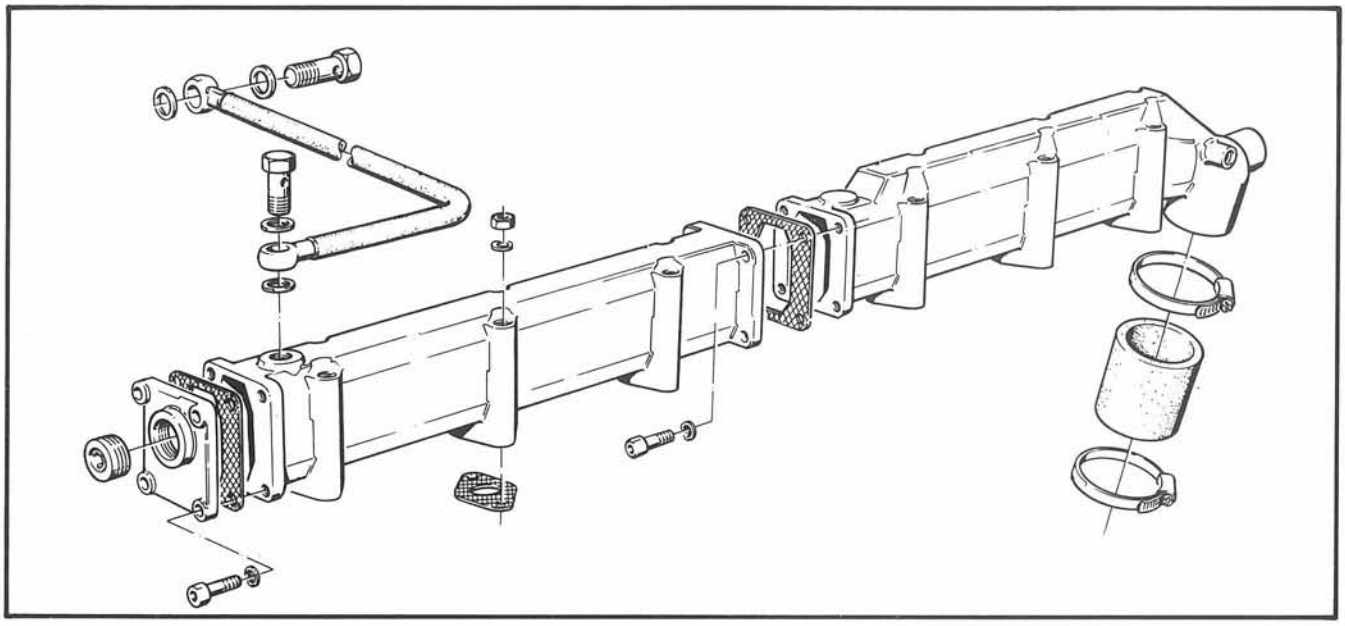
— Disconnect hose to elbow on exhaust manifold, see „Removing Turbocharger".
— Unscrew pressure relief return line on expansion tank, see „Removing Raw Water Cooling Circuit".

Figure 121

Unscrew all mounting nuts (121/1) on water collection plate (121/2) and pull water collection plate with gaskets off of cylinder heads.



121



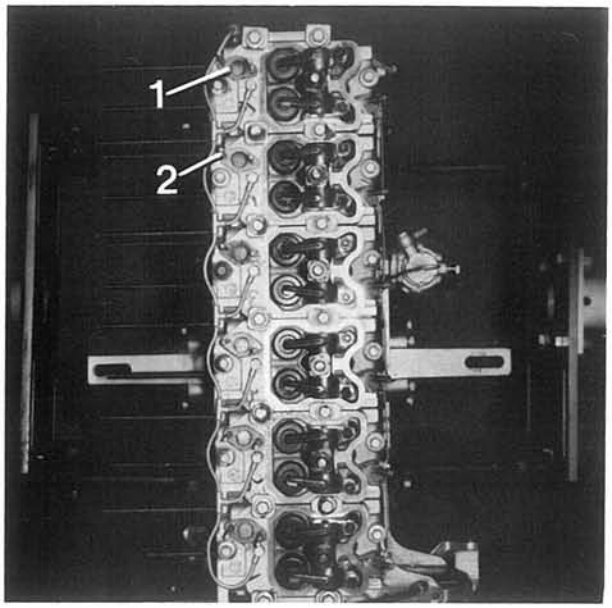
Installing Water Collection Plate

Figure 122

Inspect water collection plate for dirt, cracks, deformation or damaged theads before installing. Replace parts which cannot be reused. Make sure sealing surfaces of collection plate are not distorted or scratched. To guarantee level sealing surfaces of cylinder heads, it could be necessary to grind all flange face surfaces.

Figure 123

Place new gaskets (123/1) on cylinder heads, push on water collection plate, install one washer on each stud (123/2) and bolt down with twelve mounting nuts.



123

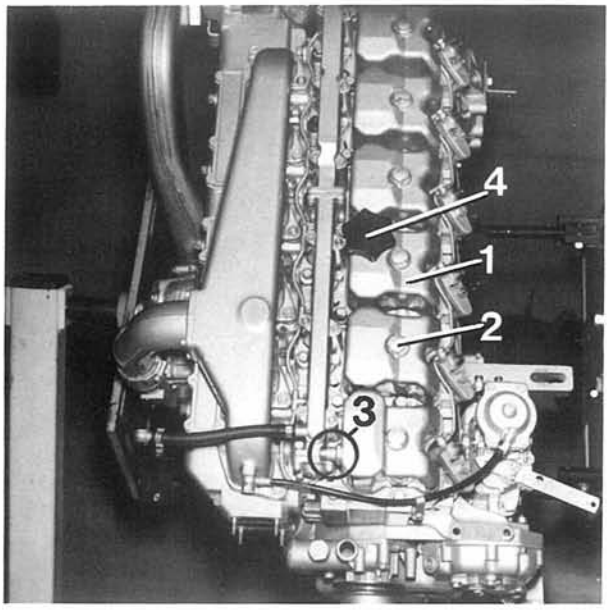
— Connect pressure relief return line on expansion tank, see „Installing Raw Water Cooling Circuit".
— Tighten hose on exhaust manifold, see „Installing Turbocharger".

REMOVING AND INSTALLING VALVE COVERS

Removing Valve Covers

Figure 124

Unscrew one cap nut (124/2) on each valve cover (124/1) and take off six valve covers with gaskets from cylinder heads.
Note: Remove engine breather hose on valve cover (124/3) of first cylinder.

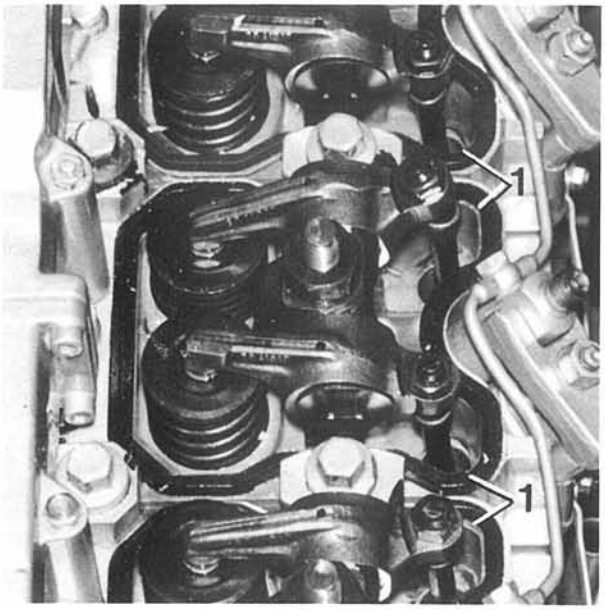


124

Installing Valve Covers

Figure 125

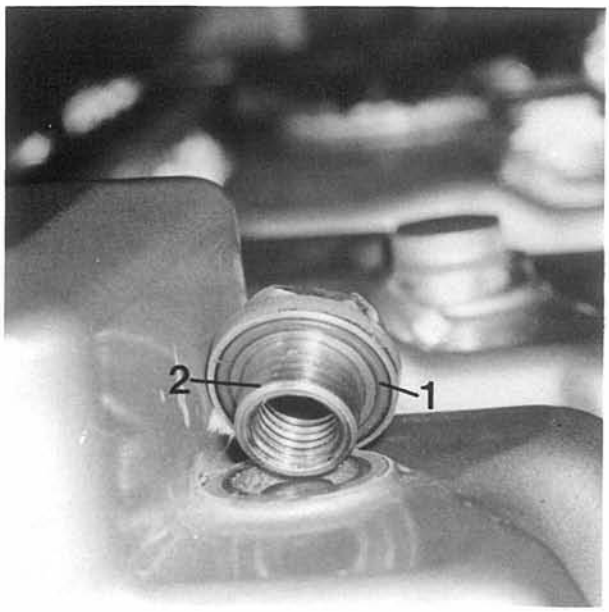
Place new valve cover gaskets (125/1) on cylinder heads.



125

Figure 126

Mount valve covers on cylinder heads, place new seal (126/1) in mounting nut (126/2) and tighten each valve cover with one mounting nut. Connect engine breather hose on valve cover.
Note: Mount valve cover (124/3) with engine breather connection on first cylinder and valve cover (124/4) with oil filler opening on third cylinder.



126

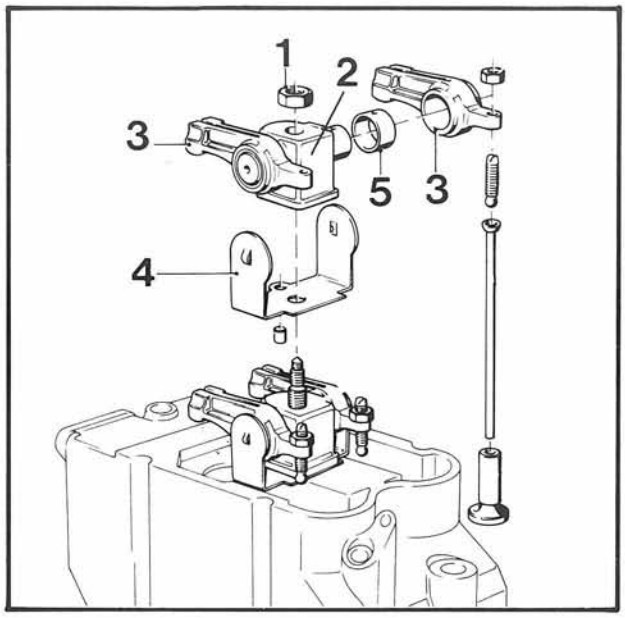
REMOVING AND INSTALLING ROCKER ARMS

Removing Rocker Arms

— Remove valve covers.

Figure 127

Unscrew hexagon nut (127/1) and take rocker arm bracket (127/2) complete with rocker arms (127/3) off of cylinder head. Pull off bracket (127/4) from below and take rocker arms off of bracket from side.



127

Installing Rocker Arms

Check bearing sleeve (127/5) for damage and, if necessary, replace. Clean all parts thoroughly with a solution, remove residue in oil ports and clean oil ports with compressed air.
Refer to „Technical Data" for installation distances.
Give rocker arms (127/3) a light coat of oil, slide on to rocker arm bracket (127/2) and push on holder (127/4). Mount rocker arm bracket on cylinder head an tighten hexagon nut (127/1) to 110 Nm.

— Adjust valves.
— Install valve covers.

REMOVING AND INSTALLING CYLINDER HEADS

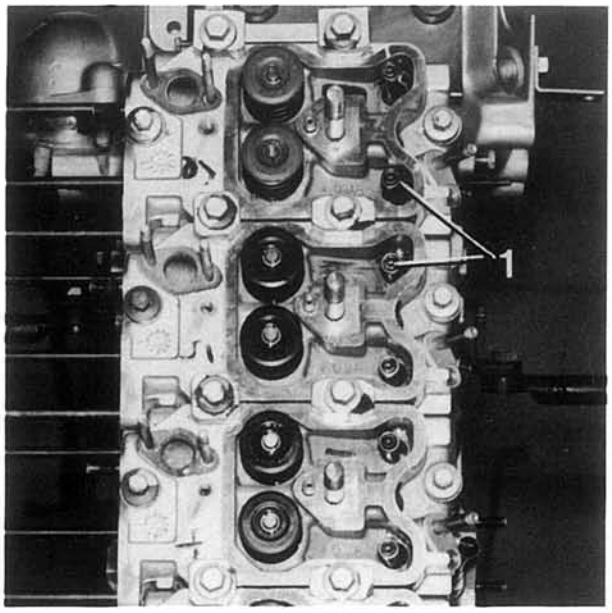
Removing Cylinder Heads

— Disconnect electric wires on water collection plate and flame-heated plugs, see „Removing Electric Box".
— Remove turbocharger with exhaust manifold.
— Remove water collection plate.
— Remove fuel injectors.
— Remove valve covers.
— Remove rocker arms.

Caution! Never detach cylinder heads on a hot engine to avoid distortion of sealing surfaces!

Figure 128

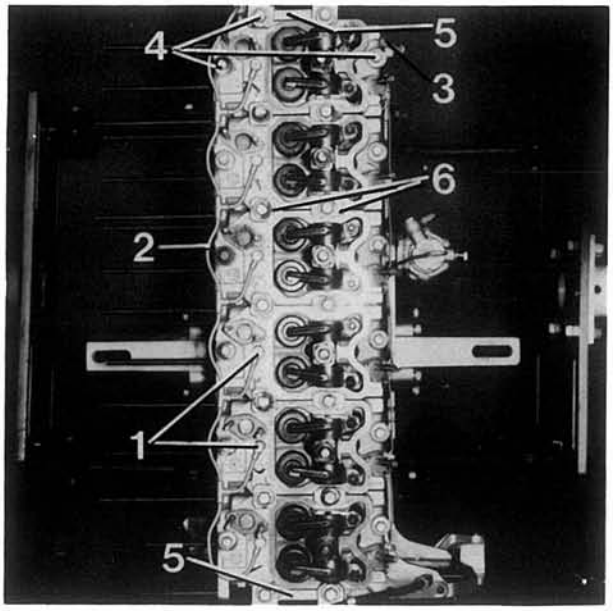
Remove push rods (128/1) from cylinder heads. Detach ground bridges of flame-heated plugs. Mark installing sequence of cylinder heads by stamping numbers.



128

Figure 129

Unscrew six couplings (129/1) of oil pressure line (129/2) for rocker arm lubrication. Unscrew one coupling for hose (129/3) and take oil pressure line with seals off of cylinder heads.
Unscrew and remove cylinder head bolts (129/4) in reverse sequence of tightening (see Figure 132). Remove two spacers (129/5) and all clamps (129/6). Remove cylinder heads with flame-heated plugs and gaskets from crankcase, beginning with sixth cylinder.



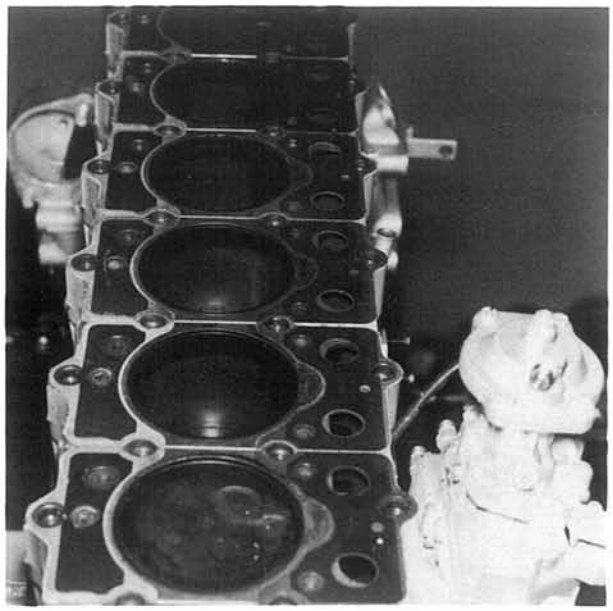
129

Installing Cylinder Heads

Note: Clean tapped bores in crankcase with compressed air prior to installation. Clean sealing surfaces on cylinder heads and crankcase. Surface finish peak-to-valley depth must be sufficient after grinding sealing surfaces.
Max. material removal through grinding is 0.20 mm. If more material is removed, replace cylinder head.

Figure 130

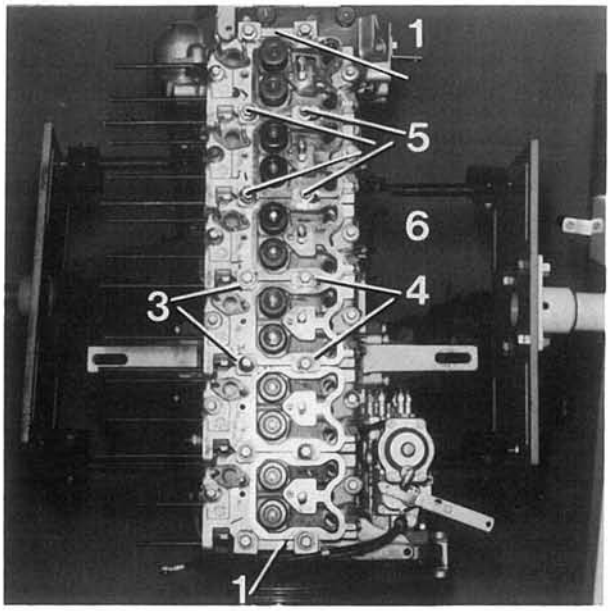
Place new dry cylinder head gaskets on crankcase. Refer to „Measuring Piston Protrusion" for determination of gasket thickness and make sure hole patterns match.



130

Figure 131

Mount cylinder heads complete with flame-heated plugs and valves on crankcase, watching marks and beginning with first cylinder. Install spacers (131/1 and 2) (spacer 131/1 with charge pressure control line at front). Install clamps (131/3 and 4) as shown in Figure 131, lubricate cylinder head bolts (131/5) and side bolts (131/6) with oil and screw in.
Note: To avoid distortion between cylinder heads and manifolds, mounts cylinder heads, tighten cylinder head bolts finger tight, align cylinder heads with a steel ruler and bolt exhaust manifold to specified torque (see „Installing Turbocharger with Exhaust Manifold").



131

Tighten cylinder heads bolts in the sequence shown in Figure 132 in steps, first with 40, then 100 and finally 160 Nm. Tighten side bolts with 80 Nm (Figure 132/11).

— Install exhaust manifold.

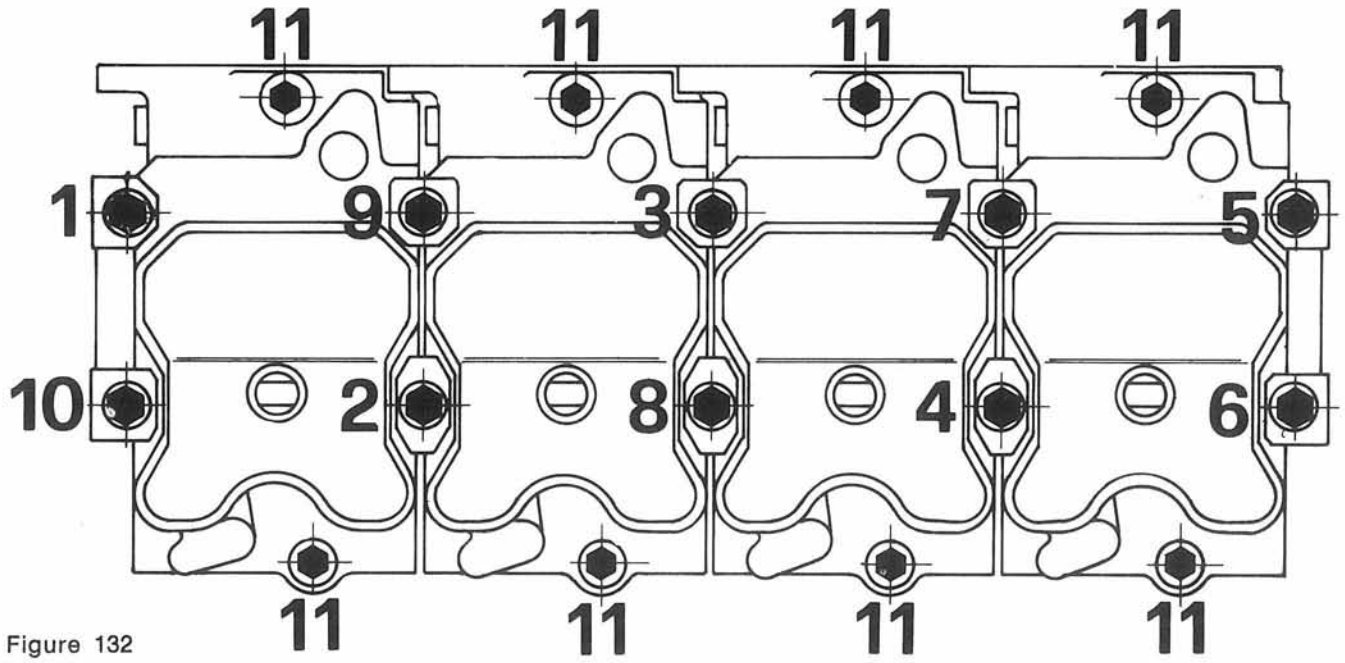


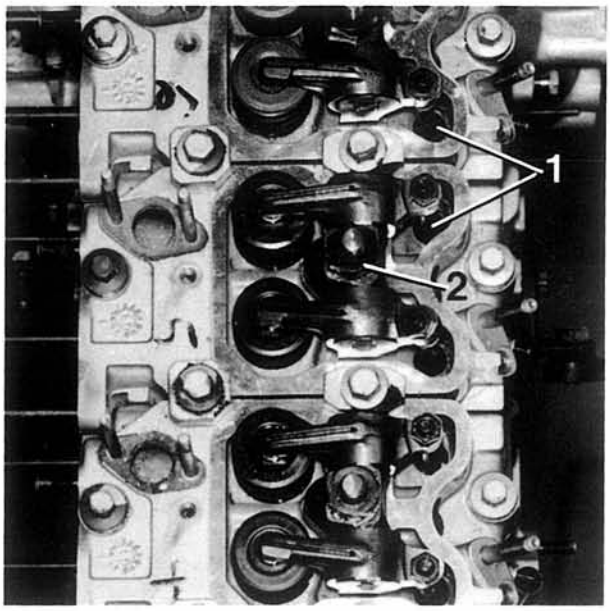
Figure 132

Figure 133

Check push rods (133/1) for distortion. Install push rods and mount rocker arm bracket (133/2) with rocker arms. Tighten mounting nuts only finger tight and align rocker arms with valves. Tighten mounting nuts with a torque of 110 Nm.
Adjust valves.

— Install valve covers.
— Install fuel injectors.
— Install water collection plate.
— Install turbocharger with exhaust manifold.
— Connect electric wires.

Important! After breaking-in period tighten cylinder head bolts in steps to 160 Nm and side bolts to 80 Nm.



133

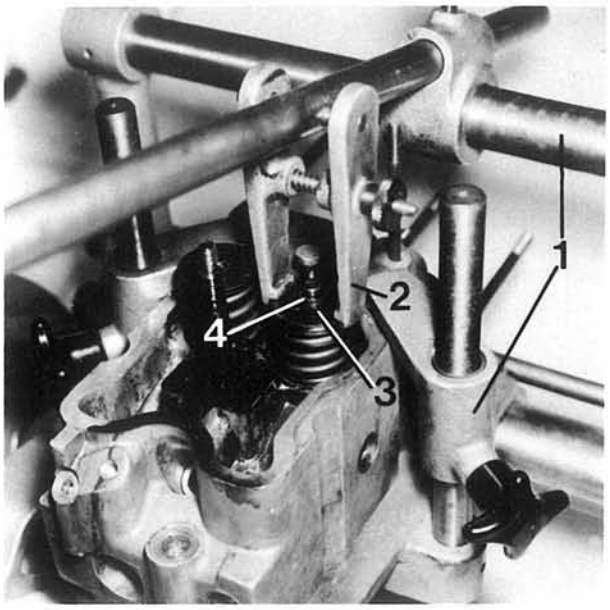
REMOVING AND INSTALLING VALVES

Removing Valves

— Remove cylinder head.

Figure 134

Mount cylinder head on valve lifter (134/1). Press down on valve spring retainer (134/3) with fork (134/2). Take off collets (134/4), lift fork and remove vaive spring retainer, valve springs and discs.



134

Figure 135

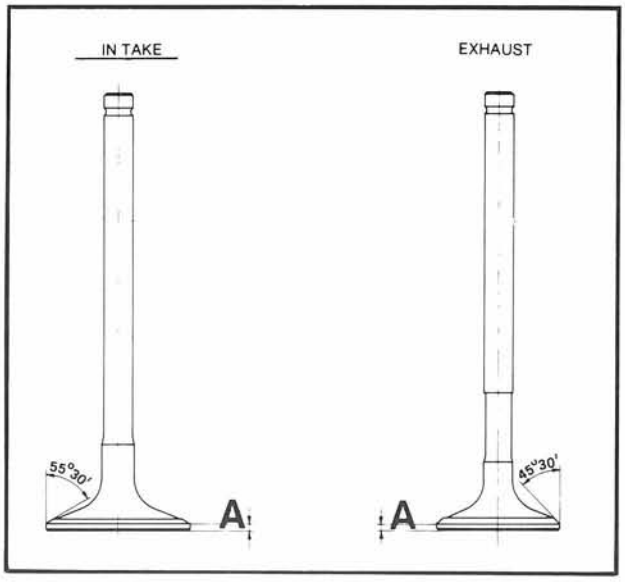
Turn cylinder head around, remove valves and lay aside in installed order or mark.

135

Figure 136

Clean valves. Damaged valves or valves, which no longer have distance „A" (Figure 136), may no longer be installed.

„A" =	Exhaust	Intake
	1.78 mm	1.90 mm



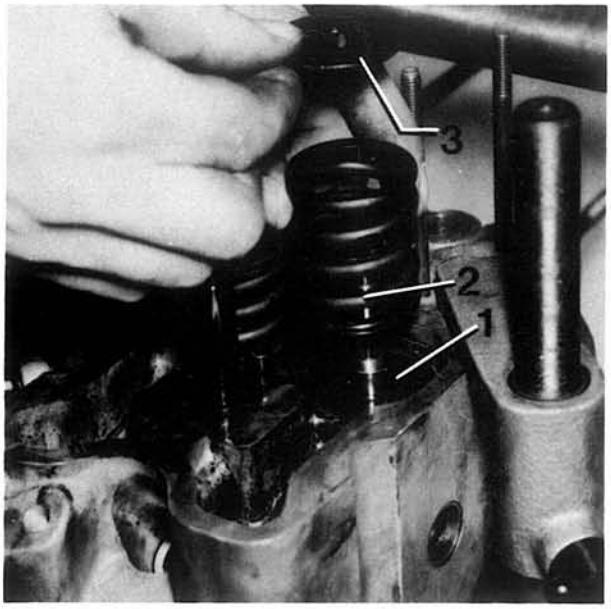
136

Installing Valves

Figure 137

Insert valves in cylinder head from combustion chamber side (check marked order). Turn cylinder head around and clamp in valve lifter. Insert disc (137/1), valve spring (137/2) and valve spring retainer (137/3). Press down on valve springs with fork and install collets.

— Install cylinder head.
— Adjust valves.



137

Adjusting Valves

— Remove valve covers.

Important! Only adjust valves on cold engine.

Figure 138

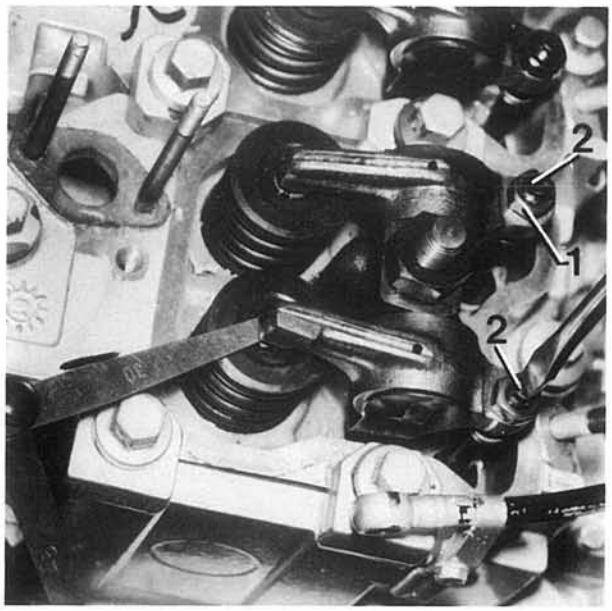
Turn engine until piston of cylinder being adjusted is at TDC and rocker arms are released. Valves of synchronous cylinder will overlap.

Zylinder in OT	
Cylinder in TDC	1-5-3-6-2-4
Zylinder in Überschneidung	
Cylinder in overlap position	6-2-4-1-5-3

138

Figure 139

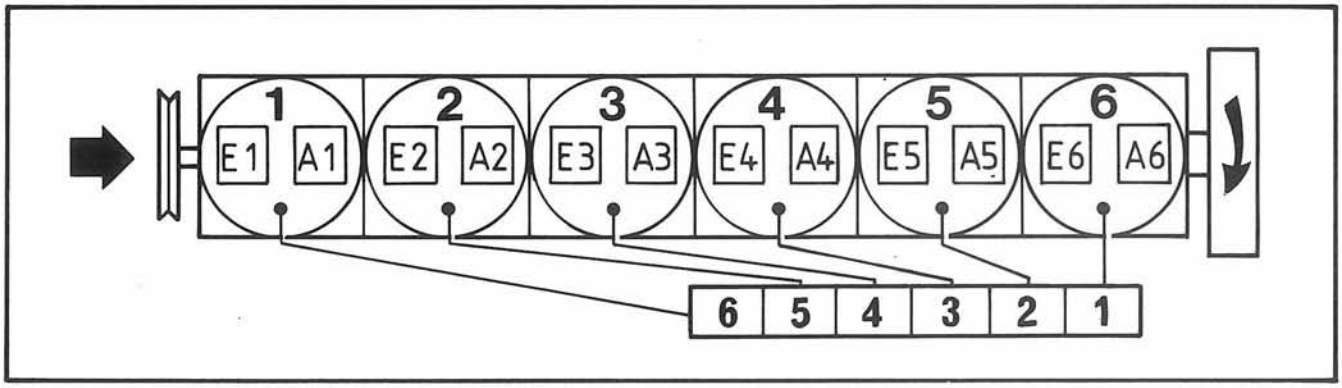
Slide feeler gauge blade between valve stem and rocker arm. Loosen locknut (139/1) and turn adjusting screw (139/2) until feeler gauge blade can be pulled out with slight resistance. Recheck valve play. Install valve cover with a new gasket.
See „Technical Data" for valve play.



139

Figure 140

Layout Drawing of Valve Arrangement



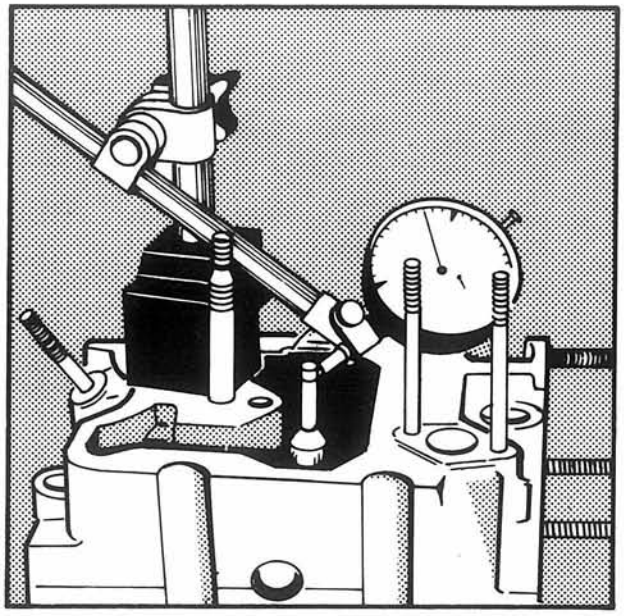
140

REMOVING AND INSTALLING VALVE GUIDE

Figure 141

Note: Visually inspect valve guides for dirt, cracks and burnt spots. Check valve guide bore for damage from seizure, oil carbon deposits or wear. Replace valve guide if necessary. Clean valve guides with a solution and steel brush. Measure play between valve stem and valve guide as shown in Figure 141. It must be as specified below.

Intake 0.040 to 0.073 mm
Exhaust 0.060 to 0.093 mm
If not, replace valve guide.



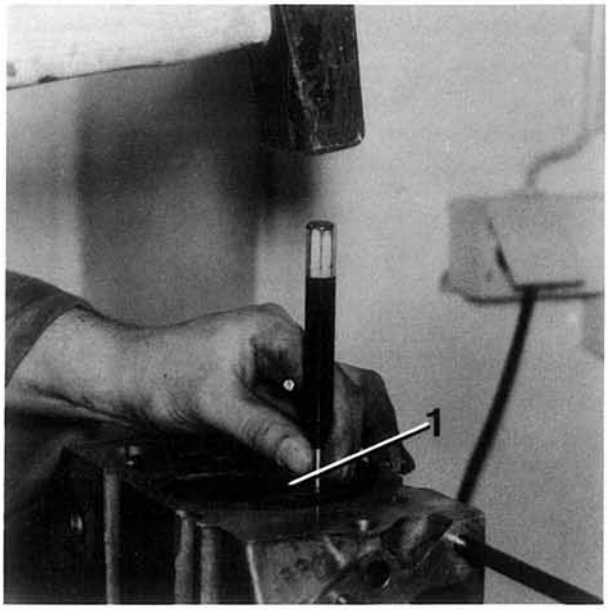
141

Removing Valve Guide

— Remove valves.

Figure 142

Heat cylinder head in an oven or water bath to 80—90° C (176 to 194° F). Knock out a damaged valve guide (142/1) from below with a suitable punch.



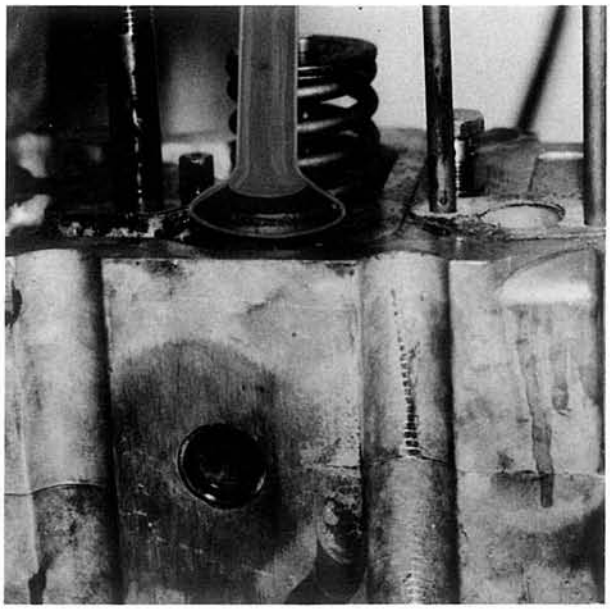
142

Installing Valve Guide

Figure 143

Heat cylinder head to 80—90° C (176 to 194° F). Press new valve guide into cylinder head from above. Check distance between upper end of valve guide and valve spring disc bore. See „Technical Data".

— Install valves.



143

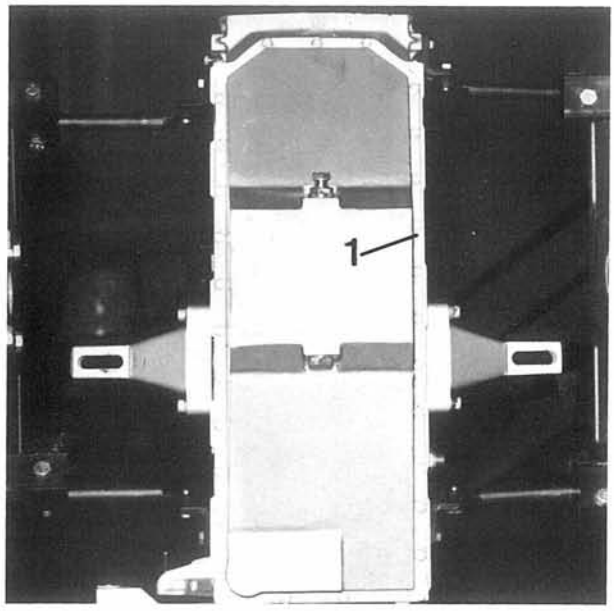
REMOVING AND INSTALLING OIL PAN

Removing Oil Pan

— Drain oil.
— Remove oil dipstick.
— Detach line of scavenging pump.

Figure 144

Swing engine 180°.
Unscrew mounting bolts (141/1) and remove with washers. Take off oil pan and gasket on crankcase.

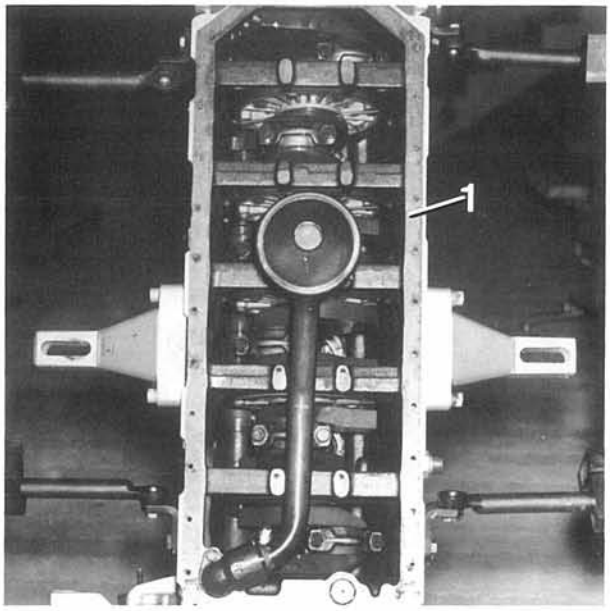


144

Installing Oil Pan

Figure 145

Place new gasket (145/1) on crankcase flange, mount oil pan, use a washer on each mounting bolt, screw in and tighten 29 mounting bolts to torque of 10 to 12 Nm.
— Attach line of scavenging pump.
— Install oil dipstick.
— Fill engine oil.



145

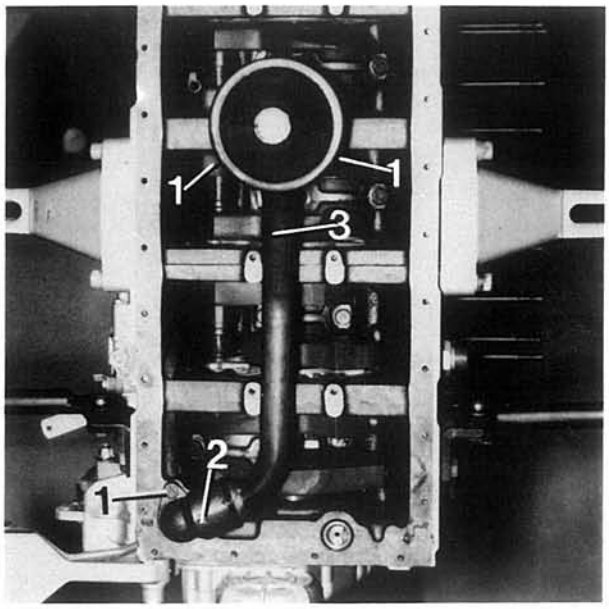
REMOVING AND INSTALLING OIL INTAKE PIPE WITH ELBOW

Removing Oil Intake Pipe with Elbow

— Remove oil pan.

Figure 146

Unscrew three mounting bolts (146/1) and remove with washers. Take off elbow (146/2) and oil intake pipe (146/3) on crankcase.

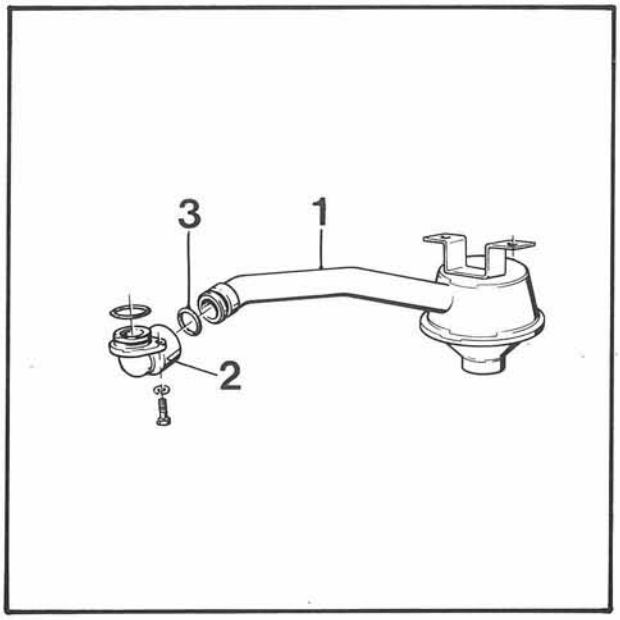


146

Installing Oil Intake Pipe with Elbow

Figure 147

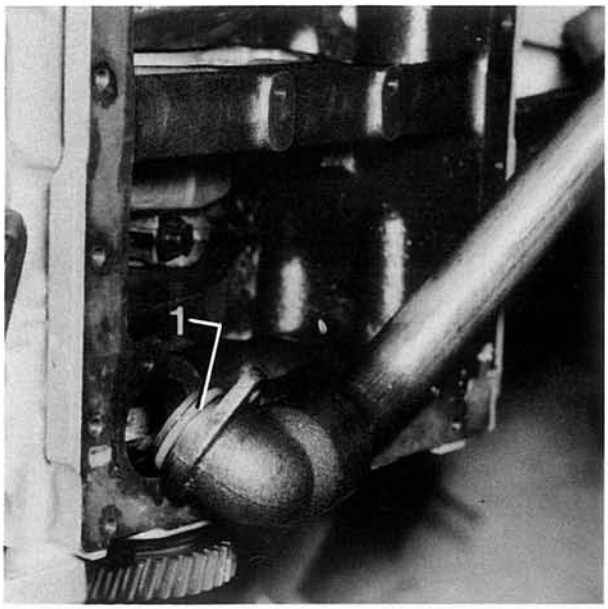
Inspect oil intake pipe (147/1) and elbow (147/2) for damage, deposits and dirt. Replace O-ring (147/3) before assembling oil intake pipe and elbow.



147

Figure 148

Install oil intake pipe complete with elbow on crankcase. Use a new O-ring (148/1). Use a washer on each bolt and mount oil intake pipe and elbow with three hexagon head bolts.



148

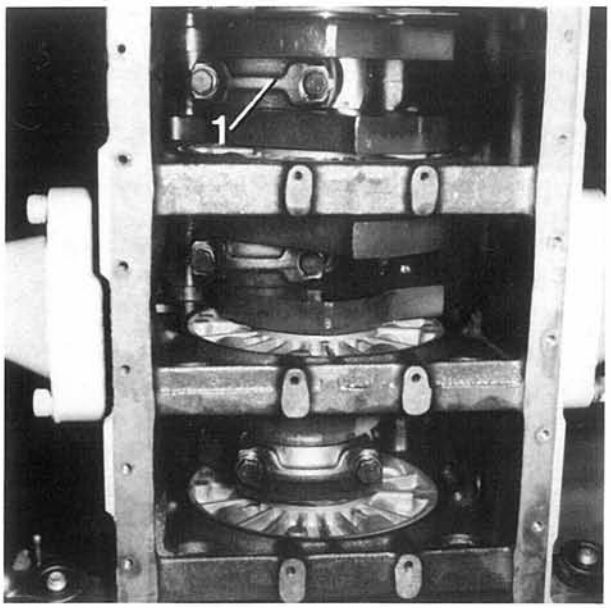
REMOVING AND INSTALLING PISTONS WITH CONNECTING RODS

Removing Pistons with Connecting Rods

— Remove cylinder heads.
— Remove oil pan.
— Remove oil intake pipe with elbow.

Figure 149

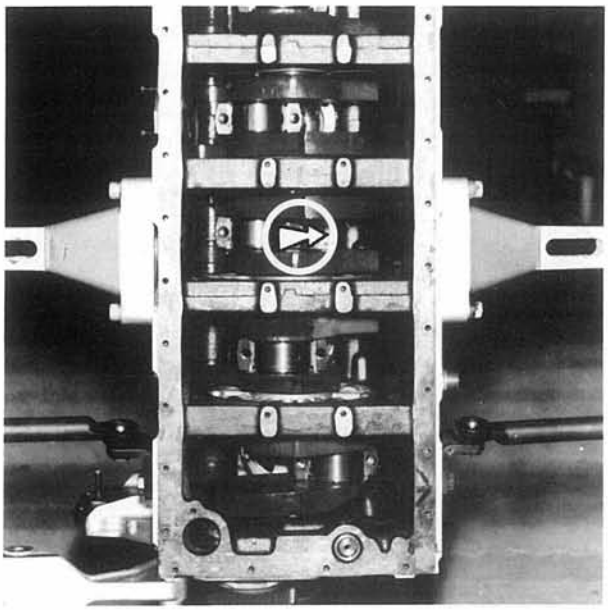
Unscrew and remove connecting rod cap bolts. Remove connecting rod cap (149/1) with bearing shells.



149

Figure 150

Remove combustion residue on upper edge of cylinder liner (be careful not to damage bearing surface). Press out connecting rod with piston downward (arrow).

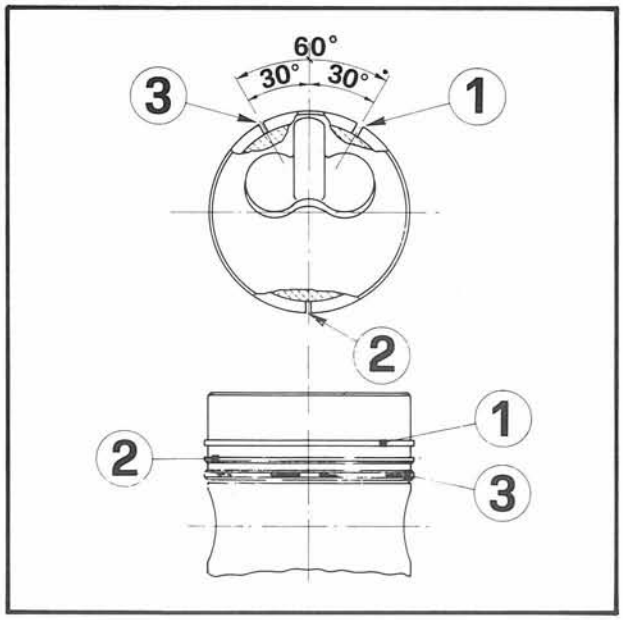


150

Installing Pistons with Connecting Rods

Figure 151

Use piston ring compressor to install new piston rings. Upper ring is a compression ring (151/1). Second ring is a tapered face ring (151/2) and is installed with scraping edge facing piston crown. Third ring is an oil scraper ring (151/3) (bevelled-edge) ring with rubber-lined spring). Ring gaps must be offset as shown in Figure 151 before installing.



151

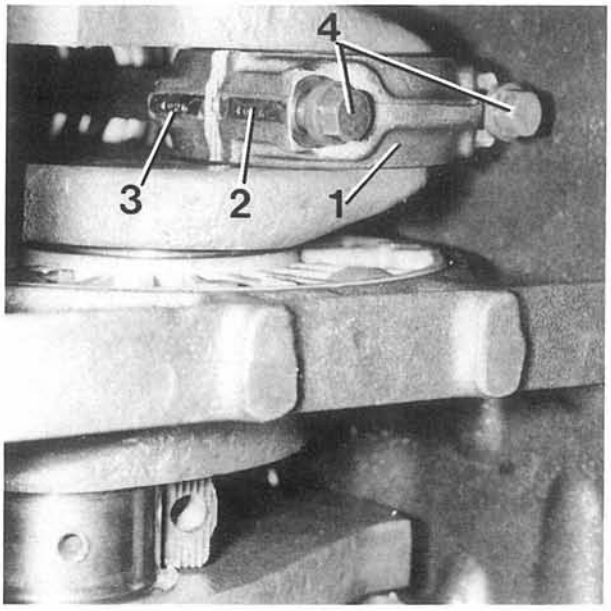
Figure 152

Lubricate piston and cylinder liner with oil. Install piston ring clamping sleeve (152/1) on cylinder liner. Guide piston (152/2) with connecting rod (152/3) into cylinder liner.
Important! Number (152/4) in end of connecting rod must face the camshaft.
Note: Install all parts in same position as prior to removal.

152

Figure 153

Install and lightly lubricate new connecting rod bearing shells with oil.
Install connecting rod cap (153/1) (number 153/2) on same side as on connecting rod (153/3) and tighten connecting rod cap bolts (153/4) in steps to a torque of 80 to 85 Nm.
Note: Lubricate bolt threads with oil before installing. Use new bolts.

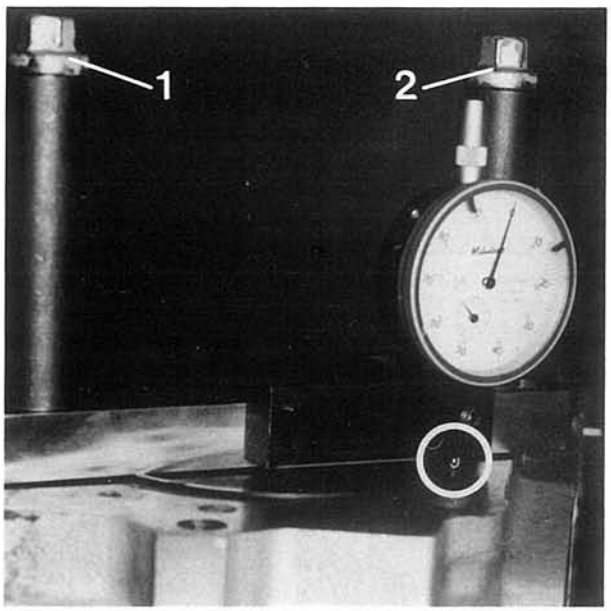


153

Measuring Piston Protrusion

Figure 154

Set first piston to TDC. Mount Special Tool 7464 1 333509 on crankcase as shown. Tighten bolts (154/1 and 2) to 30 Nm. Apply dial gauge tip on outer edge of liner and set dial gauge to zero.



154

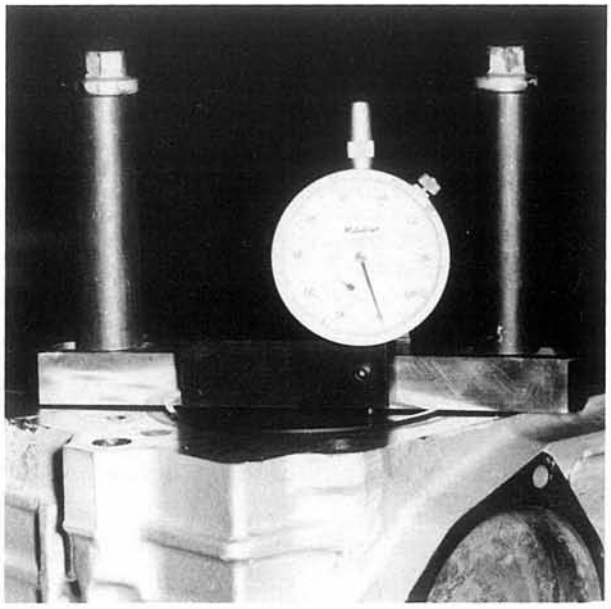
Figure 155

Apply dial gauge tip on piston and read displayed value. Select correct gasket from following table.

Measured Value (mm)	Gasket Thickness (without load) (mm)	Gasket Thickness (installed) (mm)	Piston Protrusion (mm)
0.065 to 0.20	1.70	1.45	1.25 to -.385
0.21 to 0.335	1.85	1.60	1.265 to 1.39

Installed gasket thickness minus measured distance equals the piston protrusion.
Example:

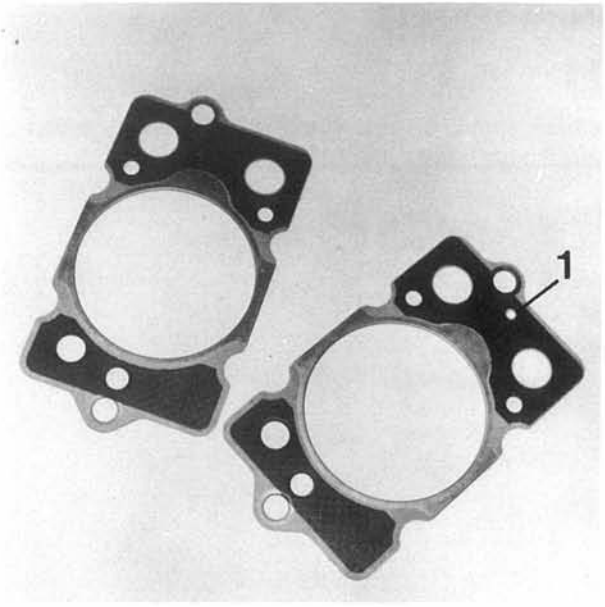
Gasket thickness	1.60 mm
Measured distance	— 0.335 mm
Piston protrusion	1.265 mm



155

Figure 156

Thicker cylinder head gasket can be identified by additional bore (156/1).



156

REMOVING AND INSTALLING CAMSHAFT

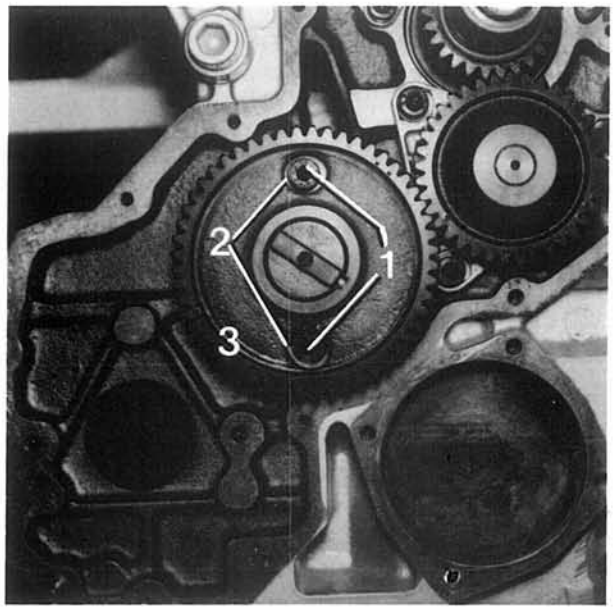
Removing Camshaft

— Remove flywheel.
— Detach timing case cover.
— Remove rocker arms and push rods.

Note: If camshaft bearings have to be replaced, remove the crankshaft.

Figure 157

Turn camshaft until mounting bolts (157/1) are accessible through bores (157/2) in camshaft drive gear (157/3). Unscrew two socket head cap screws (157/1) and pull camshaft out of crankcase carefully.

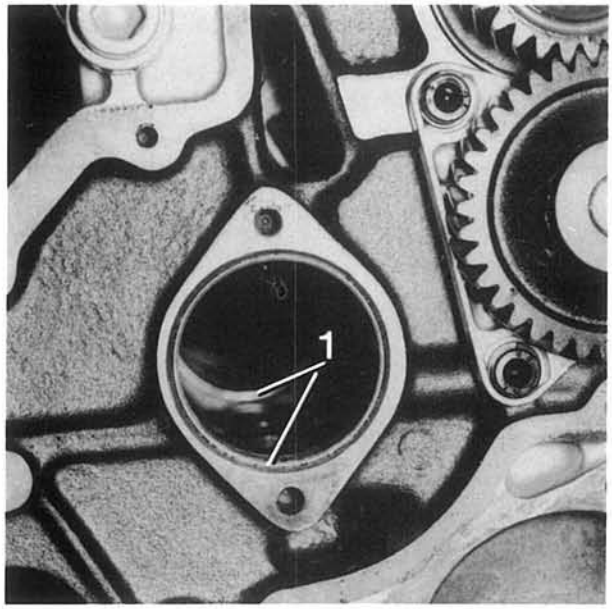


157

Installing Camshaft

Figure 158

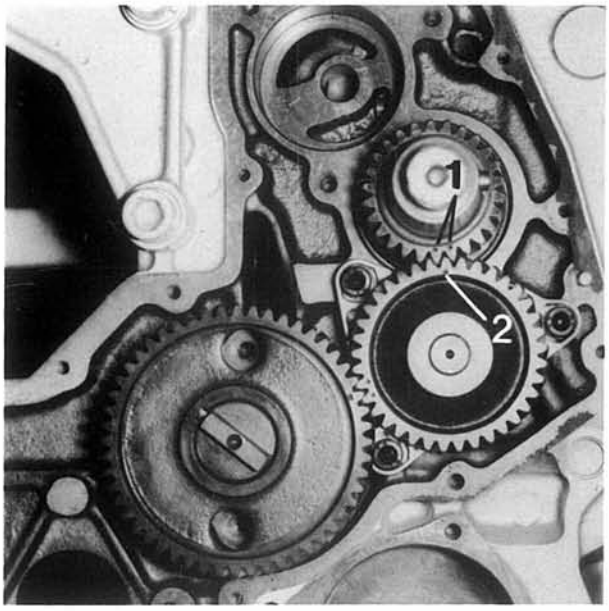
Check camshaft bearings (158/1) for wear, replacing if necessary.



158

Figure 159

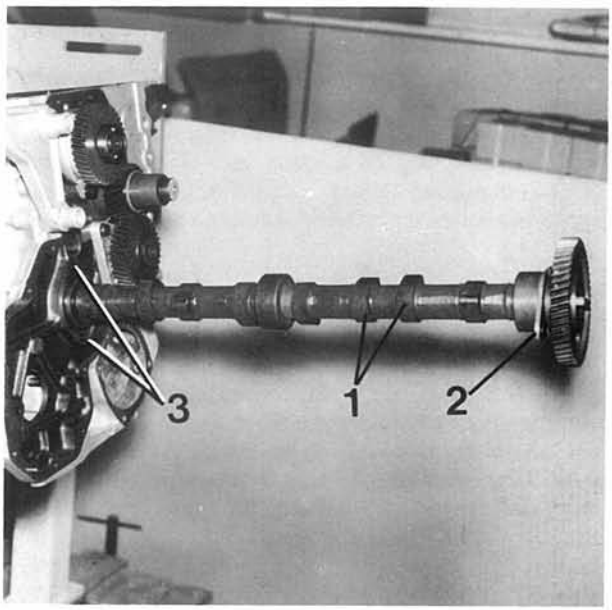
Align marks (159/1) on crankshaft gear with mark (159/2) on pinion.



159

Figure 160

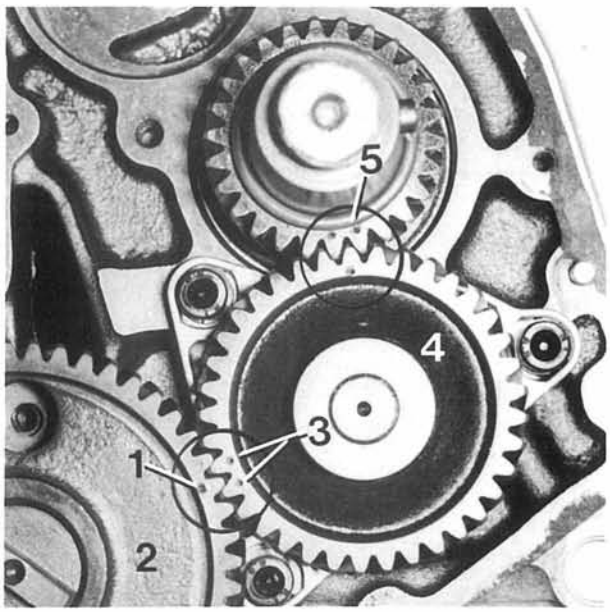
Give cams (160/1) a light coat of clean engine oil and insert camshaft in crankcase, being careful not to damage the hardened camshaft bearing surfaces. Align bores in camshaft flange (160/2) with bores (160/3) in crankcase.



160

Figure 161

When installing camshaft have marks (161/1) on gear (161/2) engage with marks (161/3) on pinion (161/4). Use a washer on each socket head cap Screw. Install two socket head cap screws in camshaft flange and bolt camshaft.
Important! Marks (161/5) on pinion and crankshaft sprocket must mesh as shown.
If a sprocket is replaced or not marked, proceed as described in „Adjusting TDC and Engine Timing".



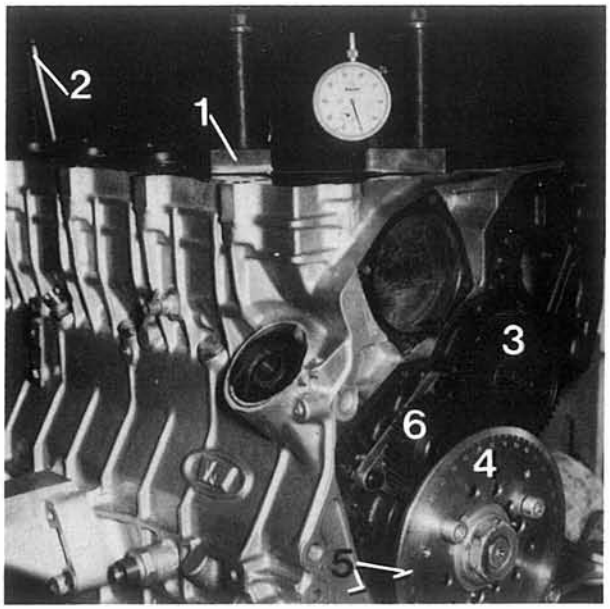
161

Adjusting TDC and Engine Timing

Manufacturer has marked the timing gears that engine timing will be automatically correct, when conforming with instructions referring to them when assembling. If a gear is not marked, the TDC and engine timing can be adjusted according to the following procedures.

Figure 162

Attach pulley and screw on adjusting disc No. 7464 1 333500 (162/1). Place two push rods (162/2) in the sixth cylinder. Turn crankshaft until overlapping point of sixth cylinder is reached. Guarantee accurate overlapping point by using a steel ruler. Mark position of any tooth (162/3) on camshaft to crankcase. Mount Special Tool 7464 1 333509 (162/4) on crankcase at first cylinder. Dial gauge tip a middle of piston. Turn crankshaft and observe dial gauge needle. TDC is reached at the moment in which the needle changes its direction of movement. Make sure that the adjusting disc is mounted securely. Mark position of adjusting disc to crankcase (162/5). Remove pinion (162/6) and turn camshaft until sprocket mark is aligned with mark on crankcase. Align mark on adjusting disc with appropriate mark on crankcase and install pinion again.



162

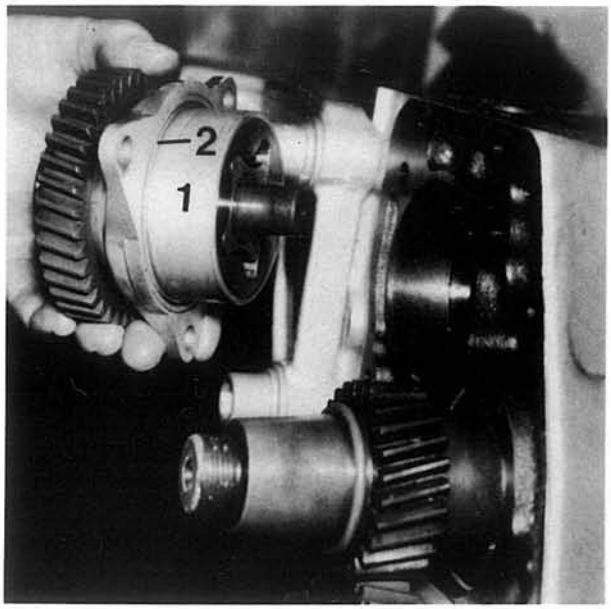
REMOVING AND INSTALLING OIL PUMP

Removing Oil Pump

— Detach timing case cover.

Figure 163

Unscrew three socket head bolts and remove with washers. Remove oil pump (163/1) complete from seat in crankcase.

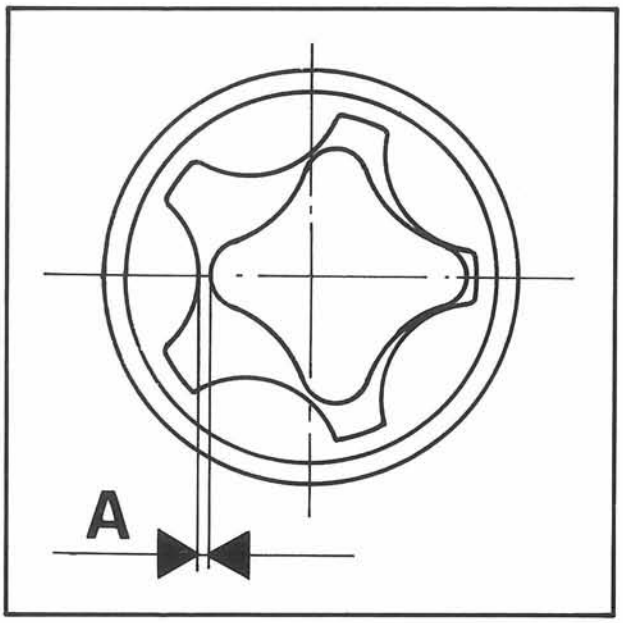


163

Installing Oil Pump

Figure 164

Clean oil pump in a solution bath and check for damage or wear.
Install new O-ring (163/2), place oil pump on crankcase, install a washer on each mounting bolt, insert three socket head bolts in pump flange and tighten to 25 Nm. Check backlash.
See „Technical Data" for specifications.



164

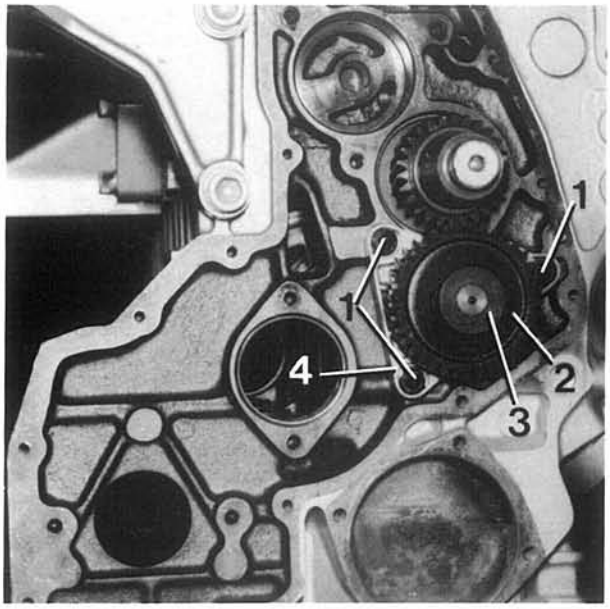
REMOVING AND INSTALLING CRANKSHAFT REPLACING CRANKSHAFT BEARINGS

Removing Crankshaft

— Remove flywheel.
— Remove flywheel housing.
— Remove timing case cover.
— Remove cylinder heads.
— Remove oil pan.
— Remove camshaft.
— Remove pistons.
— Remove oil pump.

Figure 165

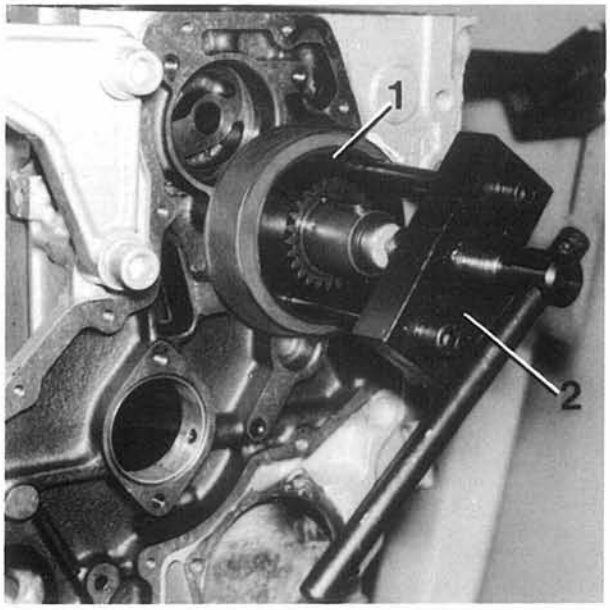
Unscrew three socket head bolts (165/1) and remove pinion (165/2) on crankcase. Unscrew coupling (165/3) and remove with cover (165/4).



165

Figure 166

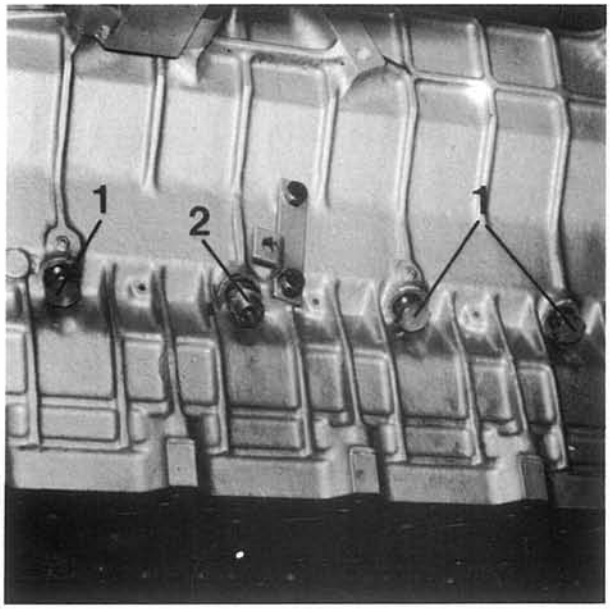
Only when damaged, pull crankshaft sprocket (166/1) off crankshaft with puller (166/2), No. 7464 1 333503.



166

Figure 167

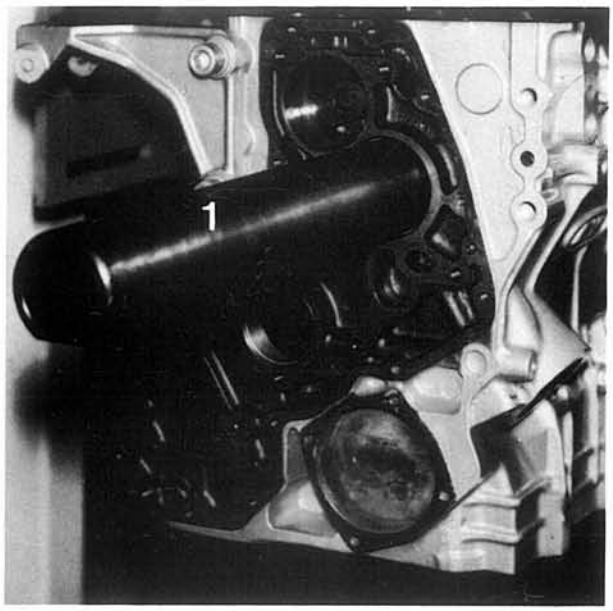
Unscrew five locating bolts (167/1) in crankcase and lift crankshaft out of crankcase.



167

Figure 168

If crankshaft is removed with the crankshaft sprocket, apply Special Tool 7464 1 333504 (168/1) and pull out crankshaft. Remove plunger.

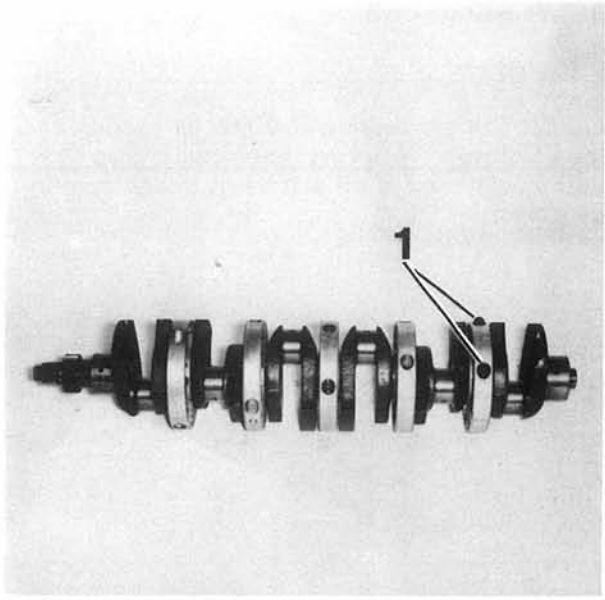


168

Replacing Crankshaft Bearings

Figure 169

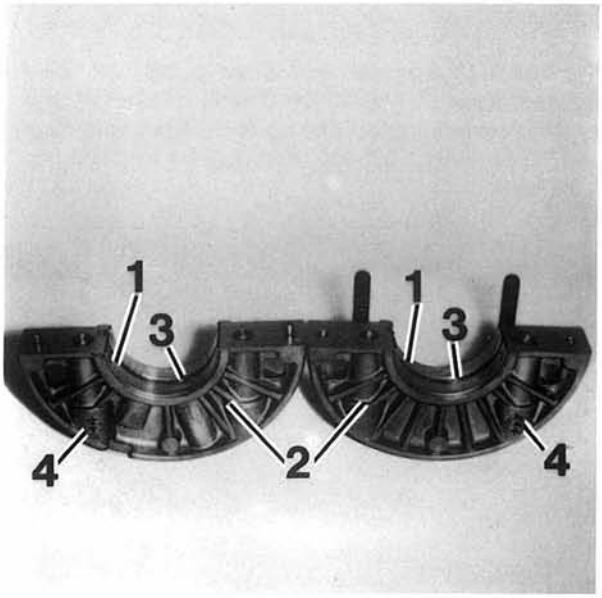
Unscrew two socket head bolts on each inner main bearing flange and take bearing flanges off of crankshaft. Clean crankshaft with a solution and oil passages with compressed air.
Visually inspect crankshaft for scratches, notches, wear and distortion.
If necessary, replace crankshaft.



169

Figure 170

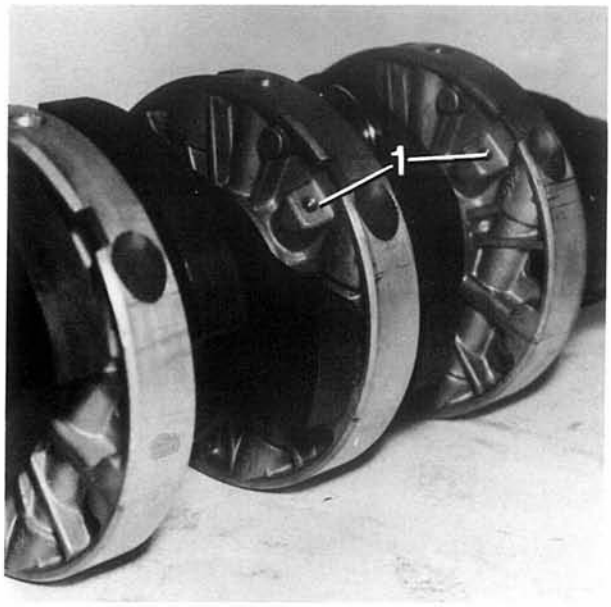
Remove bearing shells (170/1) in flange sections (170/2). Install new shells in flange sections while watching oil lubrication bores (170/3) (see „Technical Data") and attach flange sections on crankshaft. Touque bearing flange bolts to 40—45 Nm.
Note: The numbers (170/4) on both flange sections must be on same side after assembling.



170

Figure 171

Important! Oil spray jets (171/1) must face crankshaft tip (= front of engine) after installation.

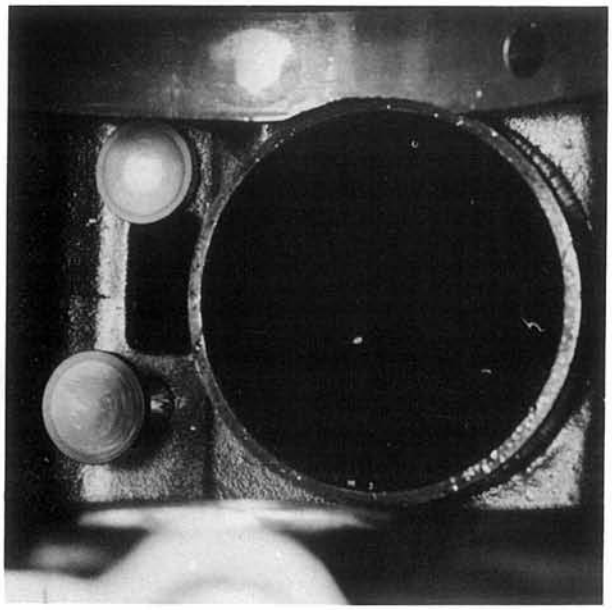


171

Installing Crankshaft

Figure 172

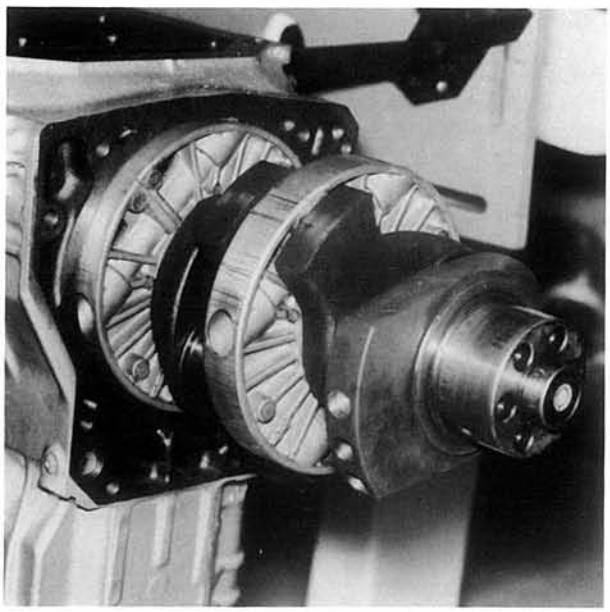
Inspect plunger bearing surfaces for scoring and traces of wear, replacing if necessary. Give plungers a light coat of oil and insert in bores in engine block.



172

Figure 173

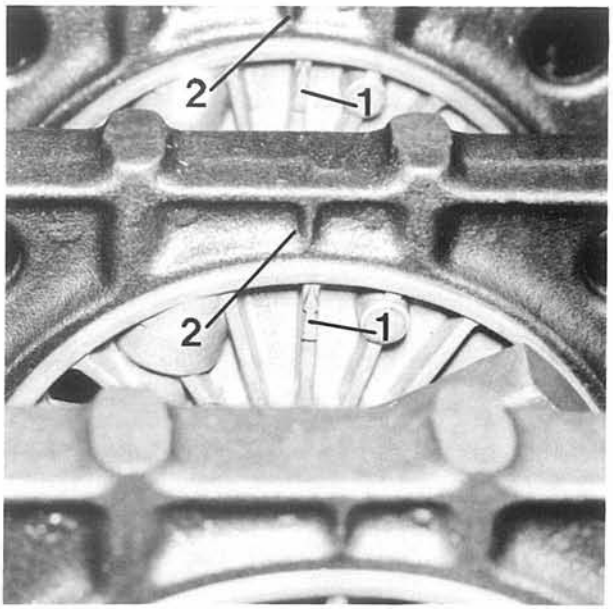
If crankshaft spocket had been pulled off, heat new sprocket to 180—200° C (356 to 392° F) and press on crankshaft. Take up crankshaft with Special Tool 7464 1 333504 and guide into engine from rear.



173

Figure 174

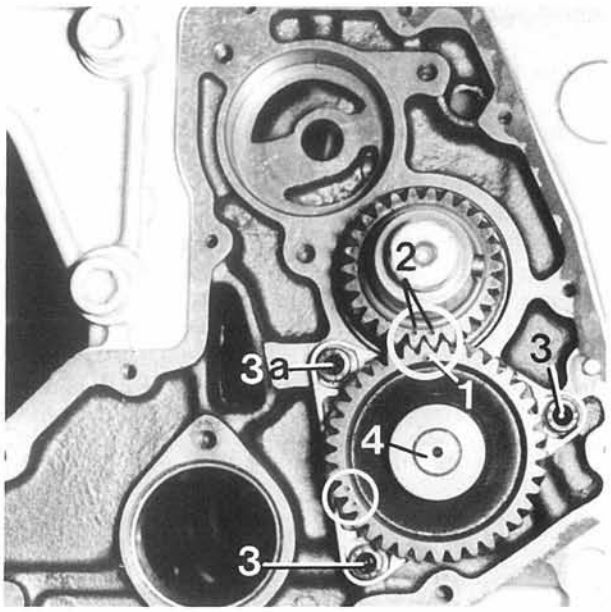
Align arrows (174/1) on bearing flanges with marks (174/2) on crankcase. Screw in five locating bolts 167/1) (hollow bolt 167/2) for turbocharger lubrication in middle). Place a new O-ring in cover (165/4) and mount cover on crankcase with hollow bolt (165/3).



174

Figure 175

Install pinion that mark (175/1) of pinion meshes in marks (175/2) of craankshaft sprocket. Tighten three socket head bolts (175/3) with a torque of 25 Nm. Install new O-ring (175/4) on crankshaft.
Important! Bolt (175/3a) must not be longer than 16 mm, since otherwise oil port in engine block would be plugged.

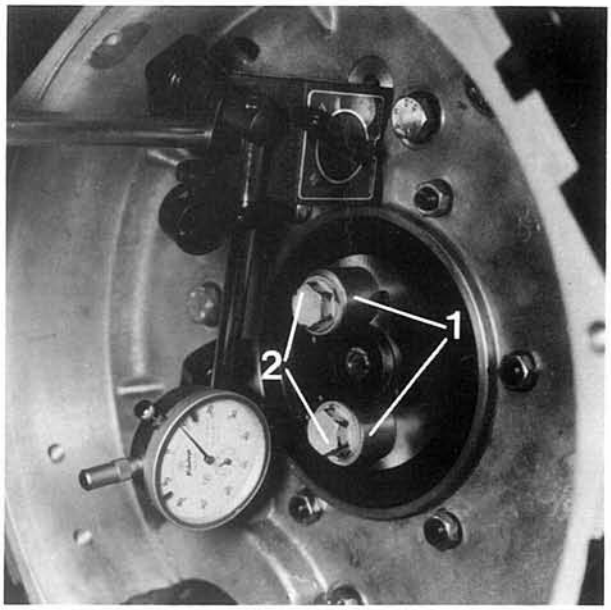


175

Figure 176

— Install camshaft.
— Install rear crankshaft main bearing.
— Install flywheel housing.

Mount two spacers (176/1), which conform with thickness of flywheel, with two flywheel mounting bolts (176/2) and tighten bolts with 50 to 60 Nm. Apply dial gauge holder with dial gauge on bearing race of flywheel housing, place dial gauge tip on bearing race and measure crankshaft axial play.
It must not exceed 0.121 to 0.323 mm. If axial play is greater than specified, install thicker thrust washers (see „Technical Data").



176

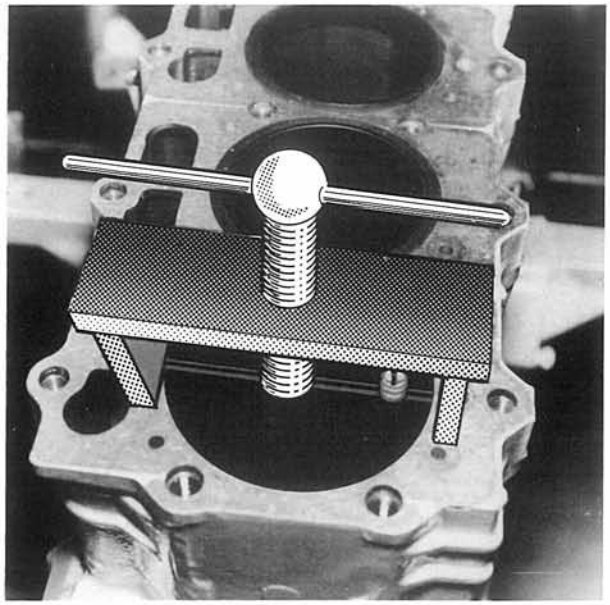
REMOVING AND INSTALLING CYLINDER LINERS

Removing Cylinder Liners

— Remove crankshaft.

Figure 177

Move engine to normal position. Pull cylinder liners out of engine block with Special Tool 7464 1 333502.

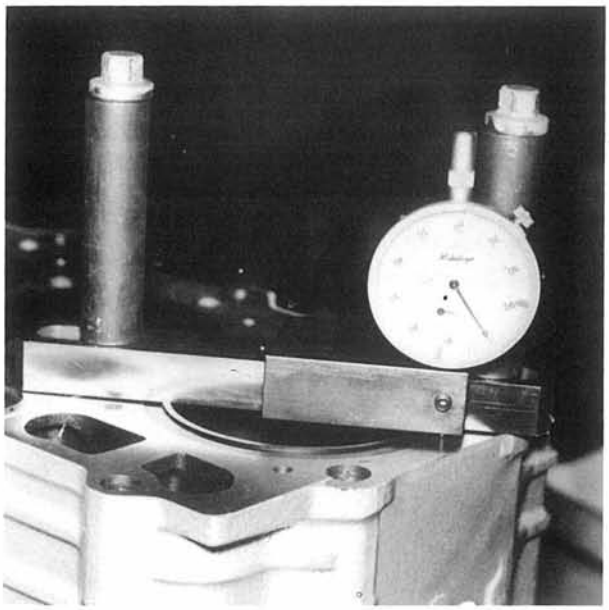


177

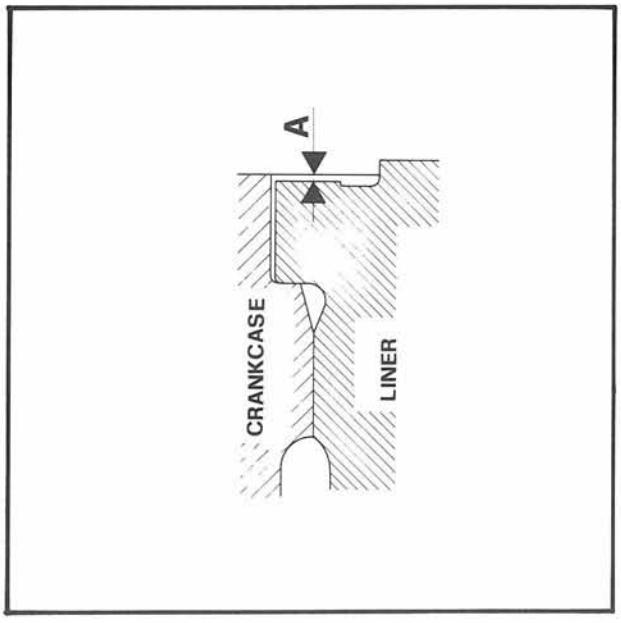
Installing Cylinder Liners

Figure 178

Clean cylinder liners. Inspect bearing surfaces for scoring, scratches or other damage (irregularities). Clean bearing surfaces of liner flanges in crankcase. Install cylinder liners without O-rings, mount Special Tool 7464 1 333509 and tighten two bolts to 30 Nm. Apply dial gauge tip on outer edge of liner on pre-chamber side, set dial gauge to zero and proceed with gauge tip on engine block. Read value.
Cylinder liner protrusion (Figure 179/A) should be 0.00 to 0.05 mm. If necessary, install appropriate shims (see „Technical Data").



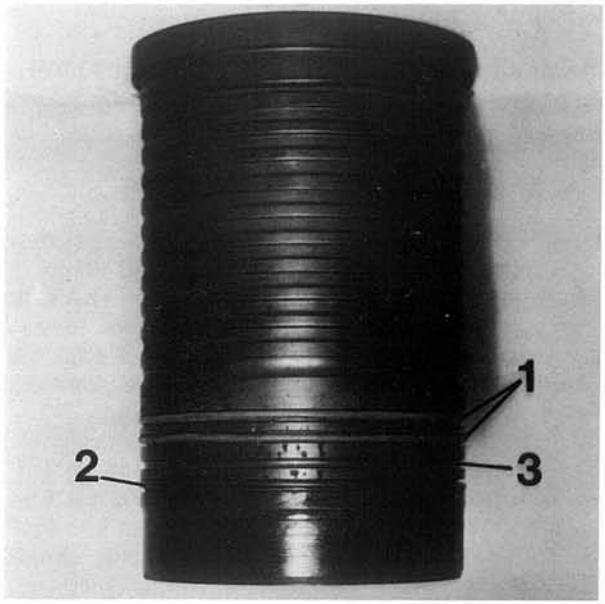
178



179

Figure 180

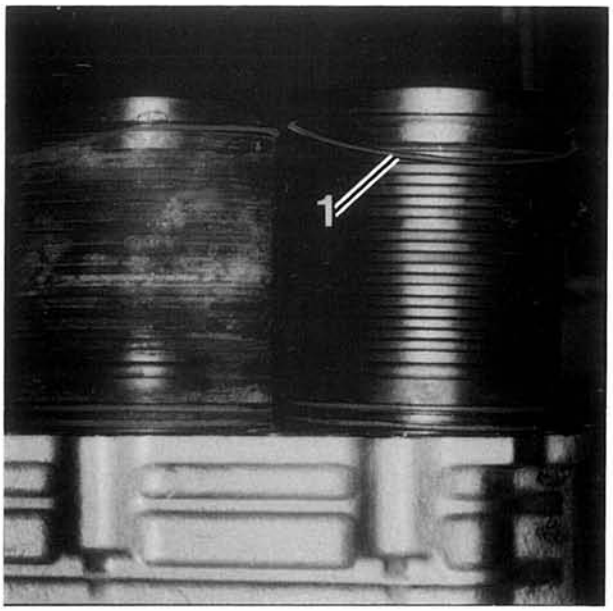
Use new O-rings (180/1 and 2). Place two red O-rings (180/1) in both upper grooves as water seals. Place one black O-ring (180/2) in lower groove as an oil seal. Second groove from bottom (180/3) is without an O-ring. Give O-rings a light coat of engine oil.



180

Figure 181

Coat bearing surface of liner flange with Loctite. Install cylinder liner in crankcase with a suitable shim (181/1) as determined in Figure 178.
Note: When installing make sure that O-rings are not damaged. If there is noticeable resistance when installing, O-rings are no longer in correct position. Correct position of O-rings and guide in liners again.

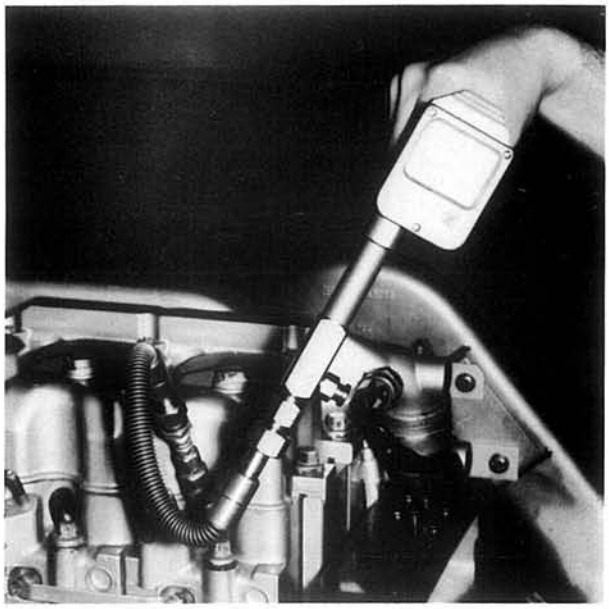


181

Checking Compression Pressure

Figure 182

Remove all fuel injectors. Install new seals. Apply compression pressure tester with adapter in fuel injector bore and crank engine with starter so long, until needle of compression pressure tester stops rising. Repeat procedures for each cylinder. Requirement: battery charge condition okay.



182

CHECKING ENGINE TIMING

Mount adjusting disc, Special Tool 7464 1 333507, and indicator.
Adjust valve play of first cylinder to following values.

Intake	0.53 mm
Exhaust	0.68 mm

Turn crankshaft so long until valves of first cylinder overlap. To check motion of intake valve, apply dial gauge with dial gauge tip on spring retainer (see Figure 182). Turn crankshaft counterclockwise about 30 to 35° to set the piston before TDC. Turn crankshaft clockwise slowly and observe dial gauge. Note displayed value of adjusting disc as soon as indicator begins to deflect. Place dial gauge indicator stops. Note new value of adjusting disc. Both values must conform with those in Figure 183 (intake opens, exhaust closes). The other cylinders need not be checked, since the camshaft is produced precisely according to the timing. Carry out the following procedures, if values in Figure 183 cannot be reached.

— Remove rocker arms and push rods.
— Unscrew camshaft mounting bolts and set first cylinder to TDC.
— Mark gears to each other and pull out camshaft, making sure position of gears is not changed.
— To delay timing turn camshaft sprocket counterclockwise one tooth or clockwise by one tooth to advance the timing.
— Install camshaft, push rods and rocker arms.
— Recheck timing.
— If timing is correct, adjust valve play to correct value (see „Technical Data")

IMPORTANT!

Do not offset position of crankshaft and camshaft when installing the pinion.
This then completes the adjustment of engine timing. The first cylinder will be at TDC in compression cycle and the sixth at overlap.

Note: Some of the camshaft springing back can be caused by the cam followers. If this is applicable, swing engine 180° and turn back crankshaft one full turn. If marks are matched again, swing back engine block and continue with adjusting procedures.

ENGINE ASSEMBLY PROCEDURES

— Install cylinder liners.
— Install cam followers.
— Install crankshaft.
— Install locating bolts.
— Install pinion.
— Install rear main bearing.
— Install bearing race.
— Install camshaft.
— Install flywheel housing.
— Measure crankshaft axial play.
— Install oil pump.
— Install pistons.
— Install connecting rod caps.
— Install oil intake pipe and elbow.
— Install oil pan.
— Turn engine 180° (normal position).
— Check and adjust valve timing.
— Adjust TDC and engine timing.
— Measure piston protrusion and calculate cylinder head gasket thickness.
— Install injection pump.
— Adjust injection pump.
— Install cylinder heads.
— Install push rods.
— Install rocker arms with rocker arm brackets.
— Adjust valves and check engine timing.
— Mount oil supply cover with hollow bolt.
— Mount timing case cover.
— Install water pump.
— Install flywheel.
— Install rubber coupling.
— Install oil pressure transmitter.
— Attach oil line for rocker arm lubrication.
— Attach ground bridges on flame- heated plugs.
— Install water collection plate.
— Install turbocharger together with exhaust manifold.
— Attach oil return line between turbocharger and engine block.
— Install fuel injectors.
— Install valve covers.
— Install injection lines.
— Install fuel pump.
— Mount guide for throttle cable on injection pump.
— Mount pulley.
— Bolt vibration damper on pulley.
— Install starter.
— Mount fuel filter complete with holder and oil scavenging pump.
— Install electric box.
— Attach raw water cooling circuit.
— Install raw water pump.
— Install alternator.
— Install raw water line.
— Install air cleaner.

TECHNICAL DATA

Engine

Design	In-line, upright
Principle	—
Strokes	4
Operation	Diesel operation with indirect injection and turbocharger
No. of cylinders	6
Displacement	3590 cm³
Stroke	90 mm
Bore	92 mm
Compression ratio	21:1
Power to DIN 6270B	KW/HP 100/136 at 3800 rpm
Max. torque	Nm 290 at 3000 rpm
Firing order	1 - 5 - 3 - 6 - 2 - 4
Lubrication by	Gear ring pump
Max. oil temperature	100° C (176° F)
Oil temperature briefly	110° C (230° F)
Cooling system	Dual circuit, fresh water/natural water pump
By	Impeller pumps
Coolant temperature	80 to 85° C (176 to 185° F)
Engine weight (dry)	365 kg

Filling Capacities

Oil	
Engine total	10 ltr.
Drain oil of oil pan	8 ltr.
of filter	1 ltr.
of oil cooler	1 ltr.
Fresh water	12 ltr.
Max. axial installation angle	15°

Crankcase

Crankshaft bearing seat, front	67.670 to 66.687 mm

Pistons

Piston dia. (measured 15 mm from lower edge of piston)

Version	Standard Size	Fisrt Oversize
A	91.900 to 91.910 mm	92.530 to 92.540 mm
B	91.910 to 91.920 mm	92.540 to 92.550 mm

Max. piston wear	0.1 mm
Max. piston pin bore out-of-true	0.05 mm
Piston running clearance	0.5 mm
Max. weight difference of pistons in one engine	5 grams
Piston protrusion from upper edge of crankcase	1.250 to 1.385 mm 1.265 to 1.390 mm
Piston ring height	
1st compression ring	2.075 to 2.095 mm
2nd compression ring	1.978 to 1.990 mm
Oil scraper ring	3.978 to 3.990 mm
Width of piston ring grooves	
1st compression ring	2.106 mm
2nd compression ring	2.06 to 2.08 mm
Oil scraper ring	4.02 to 4.04 mm
Piston ring end clearance	
1st compression ring	0.40 to 0.65 mm
2nd compression ring	0.40 to 0.65 mm
Oil scraper ring	0.25 to 0.58 mm

TECHNICAL DATA

Piston bushing protrusion	0.01 to 0.05 mm
Version: white	
Standard size	92.000 to 92.010 mm
1st oversize	92.600 to 92.610 mm
Version: red	
Standard size	92.010 to 92.020 mm
1st oversize	92.610 to 92.620 mm
Max. out-of-true	0.100 mm
Max. conicity from wear	0.100 mm

Connecting Rods

Piston pin outside dia.	29.990 to 29.996 mm
Piston pin bearing inside dia.	30.030 to 30.045 mm
Piston pin radial play in connecting rod	0.024 to 0.045 mm
Wear tolerance	0.100 mm
Crank journal bore	57.563 —0.02 to 57.582 +0.02 mm
Distortion of connecting rod and bore deviation 100 mm from axial axis of piston pin	0.05 mm
Max. difference in weight of connecting rods	10 grams
Connecting rod weight	
sky blue	1120 to 1130 grams
white	1130 to 1140 grams
yellow	1140 to 1150 grams
red	1150 to 1160 grams
green	1160 to 1170 grams
blue	1170 to 1180 grams

Crankshaft

Front main bearing	
Main bearing journal dia.	
Standard size	62.980 to 63.000 mm
1st undersize (0.25 mm)	62.730 to 62.750 mm
2nd undersize (0.50 mm)	62.480 to 62.500 mm
Bearing shell inside dia.	
Standard size	63.060 to 63.110 mm
1st undersize (0.25 mm)	62.810 to 62.860 mm
2nd undersize (0.50 mm)	62.560 to 62.610 mm
Bearing shell width	31.750 to 32.250 mm
Crankshaft radial play	0.060 to 0.130 mm
Wear tolerance	0.200 mm
Inner main bearing	
Bearing journal diameter	
Standard size	62.980 to 63.000 mm
1st undersize (0.25 mm)	62.730 to 62.750 mm
2nd undersize (0.50 mm)	62.480 to 62.500 mm
Bearing shell inside dia.	
Standard size	63.050 to 63.093 mm
1st undersize (0.25 mm)	62.800 to 62.843 mm
2nd undersize (0.50 mm)	62.550 to 62.593 mm
Bearing shell width	29.750 to 30.000 mm
Play between bearing shell and bearing journal	0.050 to 0.113 mm
Wear limit	0.200 mm

TECHNICAL DATA

Rear main bearing	
Bearing journal diameter	
Standard size	69.980 to 70.000 mm
1st undersize (0.25 mm)	69.730 to 69.750 mm
2nd undersize (0.50 mm)	69.480 to 69.500 mm
Bearing shell inside dia.	
Standard size	70.060 to 70.110 mm
1st undersize	69.810 to 69.860 mm
2nd undersize	69.560 to 69.610 mm
Bearing shell width	31.750 to 32.250 mm
Play between bearing shell and bearing journal	0.060 to 0.130 mm
Wear limit	0.200 mm
Conrod bearing journal dia.	
Standard size	53.920 to 53.940 mm
1st undersize (0.25 mm)	53.670 to 53.690 mm
2nd undersize (0.50 mm)	53.420 to 53.440 mm
Conrod bearing shell inside dia. (meafured with removed conrod caps and bolts torqued to 80—85 Nm)	
Standard size	53.975 to 54.014 mm
1st undersize	53.725 to 53.764 mm
2nd undersize	53.475 to 53.514 mm
Conrod bearing shell width	22.750 to 23.250 mm
Play between bearing shell and bearing journal	0.035 to 0.094 mm
Wear limit	0.200 mm
Radius on main bearing and conrod bearing journals	2.7 to 3.0 mm
Radius on rear main bearing journal	2.5 mm
Surface finish of main and conrod bearing journals	0.12 mm
Axial play of crankshaft	0.121 to 0.323 mm
Bearing race thickness	7.9 to 8.1 mm
Bearing race outside dia.	89.960 to 90.000 mm
Max. deviation between bearing race bearing surfaces	0.01 mm
Rear crankshaft main bearing housing	
Max. permissible deviation in out-of-true to crankshaft bearing center line	0.03 mm
Flywheel housing seat outside dia. of bearing housing	131.965 to 131.990 mm
Housing bore for main bearing seat	75.005 to 75.030 mm
Housing bore for shaft seal	120.000 to 120.030 mm
Thickness of thrust washers	
Standard size	2.311 to 2.362 mm
1st oversize	2.411 to 2.462 mm
2nd oversize	2.511 to 2.562 mm

Flywheel

Max. permissible lateral runout	0.10 mm
Max. permissible radial runout	0.10 mm
Gear ring installing temp.	220° C

Flywheel Housing

Max. permissible lateral deviation on face surface to end of crankshaft	0.20 mm
Max. permissible radial deviation of inside diameter to center line of crankshaft	0.20 mm

TECHNICAL DATA

Cylinder Heads and Valves

Thickness of cylinder head gasket before installing	
Standard size	1.70 mm
1st oversize	1.85 mm
Thickness of cylinder head gasket after installing and tightening bolts	
Standard size	1.45 mm
1st oversize	1.60 mm
Cylinder head height	
Height of cylinder head spacers	91.40 to 91.50 mm
Valve retrusion	
Intake	0.800 to 1.100 mm
Exhaust	0.790 to 1.090 mm
Valve guide protrusio above valve spring seat plane	13.5 to 14.00 mm
Valve springs	
Relaxed length	43.20 mm
Spring force for 37 mm length (valve closed)	31 to 37 mm
Spring force for 26.61 mm length (valve open)	88 to 94 mm

Timing

Rocker arm bearing journal dia.	21.979 to 22.000 mm
Rocker arm bushing inside dia.	22.020 to 22.041 mm
Rocker arm radial play	0.020 to 0.062 mm
Wear limit	0.200 mm
Valve tappet stem dia.	14.965 to 14.985 mm
Housing bore for valve tappet	15.010 to 10.035 mm
Valve tappet clearance	0.035 to 0.077 mm
Cam height	
Intake	45.14 mm
Exhaust	44.76 mm
Cam width	
Intake	37.88 mm
Exhaust	37.12 mm
Wear limit	0.05 mm
Camshaft bearing journal dia.	
Standard size	53.480 to 53.500 mm
1st undersize (0.25 mm)	53.20 to 53.250 mm
Camshaft bushing inside dia.	
Standard size	53.540 to 53.590 mm
1st undersize (0.25 mm)	53.290 to 53.340 mm
Camshaft bushing outside dia.	57.111 to 57.161 mm
Camshaft bearing seat bore in crankcase	57.005 to 57.030 mm
Camshaft radial play	0.040 to 0.110 mm
Max. permissible runout	0.05 mm
Wear limit	0.200 mm
Thickness of thrust ring	3.950 to 4.050 mm
Valve stem diameter	
Intake	7.942 to 7.960 mm
Exhaust	7.922 to 7.940 mm

TECHNICAL DATA

Valve radial play	
Intake	0.040 to 0.073 mm
Exhaust	0.060 to 0.093 mm
Valve seat angle	
Intake	55° 30′
Exhaust	45° 30′
Valve seat insert basic bore in cylinder head	
Intake	41.962 to 41.985 mm
Exhaust	35.964 to 35.988 mm
Valve insert height	
Intake	7.00 to 7.05 mm
Exhaust	7.00 to 7.05 mm
Valve insert outside dia.	
Intake	42.076 to 42.086 mm
Exhaust	36.068 to 36.084 mm
Valve insert retrusion	
Intake	3.11 mm
Exhaust	3.00 mm
Valve play	
Intake	0.30 mm
Exhaust	0.45 mm
Timing (with normal valve play)	
Intake opens	30° before TDC
Exhaust closes	32° before TDC

Engine Lubrication

Oil pressure at idle speed	1.5 to 2.5 bar
Oil pressure at rated speed	3.5 to 6.5 bar
Operating limit at idle speed	1 bar
Oil temperature	100 to 110° C (176 to 230° F)
Briefly	120° C (244.4° F)
Valve opening pressure	
Pressure relief valve in bottom of crankcase	4 to 4.5 bar
Pressure valve of oil spray jets	1.5 to 2 bar
Backlash between crankshaft sprocket and oil pump drive gear	0.10 to 0.45 mm

Oil Pump

Rotor housing bore depth	32.403 to 32.406 mm
Rotor length/width	32.487 to 32.500 mm
Max. play of inner rotor to rotor chamber	0.152 mm
Distance between rotor face surface and housing cover	0.081 to 0.097 mm
Outer rotor housing dia.	58.105 to 58.130 mm
Distance between pump body and gear	0.050 to 0.070 mm
Outer rotor radial play	0.105 to 0.160 mm
Wear limit	0.500 mm
Rotor axial play (installed in crankcase)	0.130 to 0.185 mm
Oil pump delivery rate	
at 1500 rpm	19 ltr.
at 2200 rpm	28 ltr.
at 3200 rpm	40 ltr.
at 4200 rpm	52 ltr.

TECHNICAL DATA

Cooling System

Speed ratio between engine and water pump	1 to 1.49 mm
Water pump delivery rate	
at 1342 rpm engine speed and 2000 rpm pump speed	70 ltr.
at 2013 rpm engine speed and 3000 rpm pump speed	113.3 ltr.
at 2684 rpm engine speed and 4000 rpm pump speed	158.3 ltr.
at 3355 rpm engine speed and 5000 rpm pump speed	197.5 ltr.
at 4026 rpm engine speed and 6000 rpm pump speed	238.3 ltr.
at 4228 rpm engine speed and 6300 rpm pump speed	246.7 ltr.
Speed ratio between engine and natural water pump	2 to 1
Natural water pump delivery rate	
at 1000 rpm engine speed and 500 rpm pump speed	27.7 ltr.
at 2000 rpm engnie speed and 1000 rpm pump speed	55 ltr.
at 3000 rpm engine speed and 1500 rpm pump speed	80 ltr.
at 4000 rpm engine speed and 2000 rpm pump speed	102 ltr.
Opening temperature of thermostats	77 to 81° C

Compression Pressure Test

Good between	24 and 26 bar
Max. pressure difference	5 bar

Electrical System

Starter (Bosch)	Solenoid type
Nominal voltage	12 V
Nominal power	2.7 KW
Alternator (Motorola)	Alternating current
Generating voltage	14 V
Max. current	75 A
Power	1000 W
Battery	12 V 110 Ah

Fuel System

Ejection pressure of fuel injectors	155 bar
Opening pressure of overflow valve on injection pump	1.4 to 1.5 bar
Fuel injector type	Throttling pin injector
Make/designation	Bosch/DNOSD 1510
Spray hole dia.	1.0 mm
Spray angle	neutral = 0°
Injection pump type	Distributor type injection pump VE with charge pressure controlled full throttle stop
Make	Bosch
Delivery begins	4° before TDC
Governor type	Centrifugal governor
Injection System	
Explanation of codes	
V	Distributor injection pump
E	Power
6	Number of outlets
11	Piston diameter in mm
F	Centrifugal governor
2100	Max. adjusted full throttle speed

TECHNICAL DATA

L	Rotation direction L = left R = right
63	Version code
Fuel delivery pump type	Diaphragm pump
Drive	Off of camshaft
Turbocharger	
Make	KKK
Type	26
Max. vacuum in air intake line	0.05 bar (500 mm WS)
Min. engine oil pressure ahead of turbocharger	
at speed of 4300 rpm	bar
at idle speed	bar
Max. axial play of rotor shaft	0.15 mm
Max. radial play of rotor shaft	0.55 mm

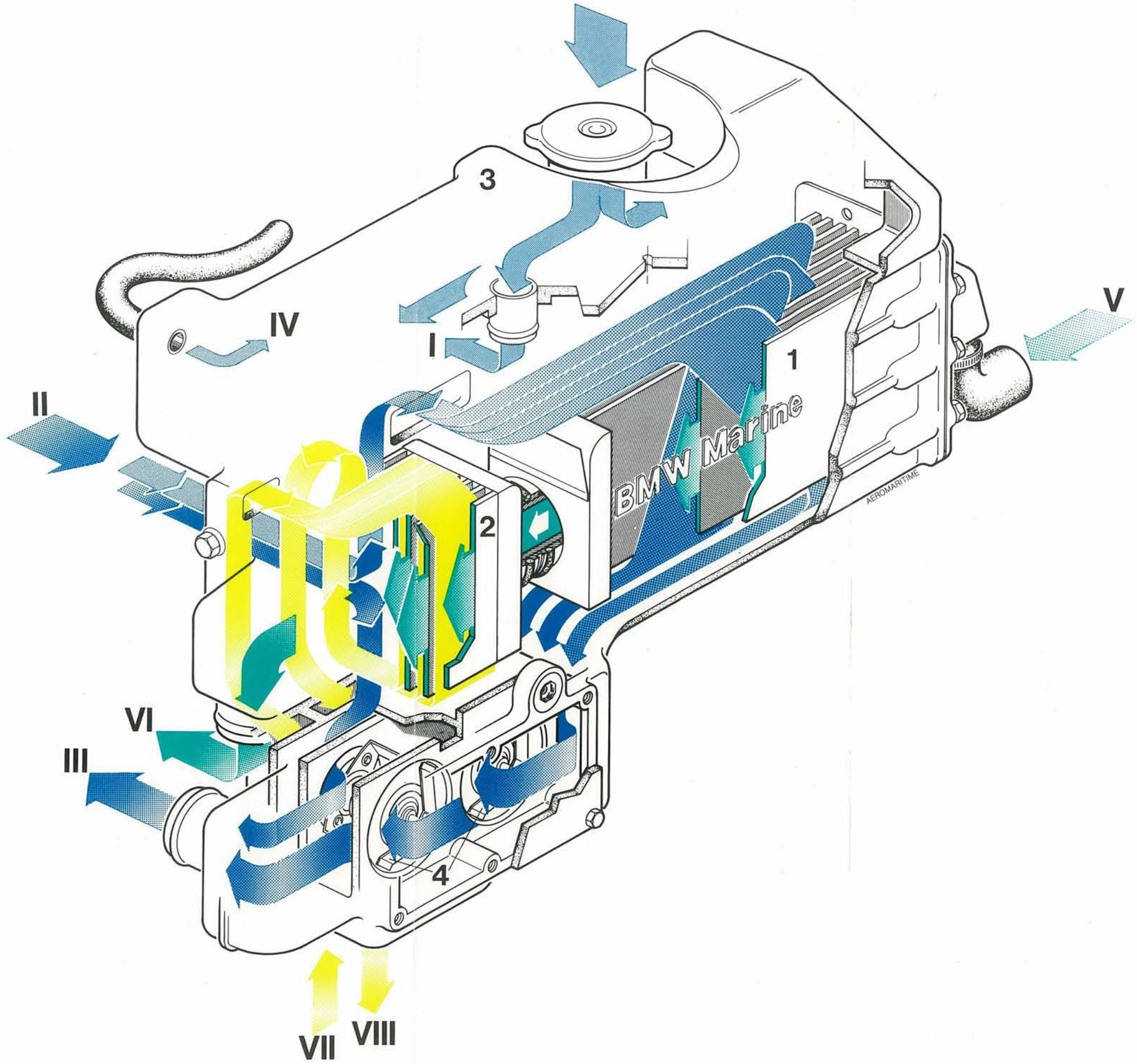
TIGHTENING TORQUE SPECIFICATIONS IN NM

Cylinder head bolts	160
Side bolts	80
Rocker arm brackets	110
Connecting rods	80 to 85
Flywheel	110
Pulley nut, crankshaft	150 to 160
Oil drain plug	80
Engine suspension	50
Oil pump	25 to 30
Rear main bearing housing	25 to 30
Flywheel housing	50
Fuel injector nut	25 to 30
Injection line couplings	15 to 20
Exhaust manifold	30 to 35
Intake manifold	30 to 35
Main bearing flanges	40 to 45
Valve covers	10
Oil pan	10 to 12
Water collection plate	8 to 10
Turbocharger	23 to 25
Oil supply lines between cooler and crankcase	45 to 50
Oil thermostat	7 to 8
Injection pump gear	90
Plugs	23 to 25
Injection pump mounting nuts	30 to 32
Exhaust clamp	25 to 30
Alternator, pulley mounting nut	55 to 60
Alternator bolt, lower	50 to 55
Alternator bolt, upper	100 to 110
Alternator armature	45 to 50

Special Tools

BMW Part No.	Description
74 64 1 333 500	Degree disc
74 64 1 333501	Cylinder head guide pin
74 64 1 333 502	Liner extractor
74 64 1 333 503	Crankshaft sprocket extractor
74 64 1 333 504	Crankshaft installing tool
74 64 1 333 505	Injection pump gear extractor
74 64 1 333 506	Flywheel holder
74 64 1 333 507	Bearing cap/pulley extractor
74 64 1 333 508	Bearing bushing extractor
74 64 1 333 509	Liner gauge
74 64 1 333 510	Bosch injection pump adjusting tool

BMW D 150



FLUID CIRCLE OF FRESH-WATER COOLING

dark blue	=	fresh water, cold
pale blue	=	fresh water, warm
green	=	raw water
yellow	=	engine oil

1	heat exchanger water/water
2	heat exchanger oil/water
3	expansion tank
4	thermostats

I	to the water-pump caster
II	from exhaust plenum chamber
III	to the water-pump
IV	from water manifold (pressure return pass)
V	from seawater pump
VI	to exhaust gas end pipe
VII	from oil temperature transmitter
VIII	to the oil filter

FLÜSSIGKEITSKREISLAUF DER FRISCHWASSERKÜHLUNG

dunkelblau	=	Frischwasser, kalt
hellblau	=	Frischwasser, warm
grün	=	Seewasser
gelb	=	Motoröl

1	Wärmetauscher Wasser/Wasser
2	Wärmetauscher Öl/Wasser
3	Ausgleichsbehälter
4	Thermostate

I	zum Wasserpumpenvorlauf
II	vom Abgassammler
III	zur Wasserpumpe
IV	von der Sammelleiste (Überdruckrücklauf)
V	von der Seewasserpumpe
VI	zum Abgasrohr
VII	vom Ölthermostat
VIII	zum Ölfilter

KEY-WORD INDEX

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