DIESEL ENGINES

ANDORIA

4C90 and 4CT90-1

REPAIR MANUAL

A/4C90/R/a

Rok wydania 1998

WYTWÓRNIA SILNIKÓW WYSOKOPRĘŻNYCH „ANDORIA" S.A.
ul. Krakowska 140
34-120 ANDRYCHÓW
Telefon (033) 75-32-40 do 47
Fax (033) 75-32-50; (033) 75-16-06
Telegraf „ANDORIA"
Telex 035 46 81

CONTENTS

INTRODUCTION

Engines specification

Engine model	**4C90**	**4CT90-1**
Engine type	Diesel, 4-stroke, with an indirect injection into the turbulence chamber	Diesel, 4-stroke, turbocharged with an indirect injection into the turbulence chamber
Number and arrangement of cylinders	4 cylinders, in line, vertical	
Cylinder bore	90 mm	
Piston stroke	95 mm	
Total cylinder volume	2417 cm^3	
Compression ratio	21.1 : 1	
Rated power, acc. To BSAU 141a:1971	51.5 kW (70HP)	66 kW (90 HP)
Rated power speed	4200 rpm	4100 rpm
Maximum torque (at 2500 rpm)	145 N · m (14.9 kgfm)	195 N · m (19.9 kgfm)
Idling speed	800 ± 20 rpm	
Specific fuel consumption, acc. to BSAU 141a:1971 (after complete run in 50 h)	299 g/kWh	295 g/kWh
Crankshaft revolution direction	Anticlockwise, seeing from flywheel side	
Engine starting	Electric, with heater plugs	
Oil consumption (after complete run in 50 h)	Max. 0.125 kg/h	Max. 0.178 kg/h
Oil pressure at rated rpm (engine heated up)	0.38 ... 0.50 MPa	
Oil pressure at min. idling speed (engine heated up)	Min. 0.1 MPa	
Engine sump capacity — „max" on oil level indicator — „min" on oil level indicator	 5.9 l 4.0 l	
Injection advance angle shifter capacity	0.25 l	
Timing gear type	OHV with camshaft placed in the cylinder head	
Inlet and exhaust valve clearance (for cold engine)	0.2 mm	
Injection type	Indirect (into the turbulence chamber RICARDO COMET VB)	
Injection nsequence	1-3-4-2	
Injection pressure	15^{+1} MPa	
Injection pressure (minimal value during work)	Min. 14 MPa	
Angle of fuel injection start (static)	8° ± 2° before TDC	
Engine dry mass	Appr. 230 kg	Appr. 247 kg

1. ENGINES 4C90 AND 4CT90-1 — CONSTRUCTION

Lublin trucks are equipped with 4-stroke diesel engines 4C90 and 4CT90-1 (turbocharged) (Fig. 2a, b, 3 and 4), manufactured by WSW Andoria. Both models of engines are water-cooled, with indirect injection into the turbulence chamber.
Engines specification see in Introduction. Engine performance curves are shown in Fig. 1a, b.
The basic difference in construction between naturally aspirated and turbocharged engine is a use of turbocharger mounted on the exhaust manifold and injection pump equipped with pressure corrector placed on the speed governor in 4CT90-1. Additionally turbocharged engine has special nozzles, which spray the oil on bottom side of piston crown. Crankshaft of turbocharged engine is nitride case hardened. Crankshaft of naturally aspirated engine is hardened. Heater plugs placed in cylinder head enable engine start. Their heating elements are inside turbulence chambers.
Camshaft, placed in the head flange, is driven from crankshaft by toothed belt.
Multi-cylinder injection pump, in line type, is driven by toothed belt through an injection advance device and driving shaft, located in the pump holder. Water pump and alternator are driven from crankshaft by V-belt. A cooling fan is fixed to the water pump pulley. Fan has a viscous coupling which changes fan speed in relation to the temperature of air stream passing through the radiator. Special rubber insert between pulley rim and hub operates as a vibration damper.
Both engines have vacuum pump for vacuum assisted brake system. Vacuum pump is located on the head flange and is camshaft driven. Oil pump is driven directly from crankshaft (it is located in the front of crankshaft).

2. TYPES OF ENGINE REPAIRS AND ENGINE EVALUATION FOR REPAIR

There are three types of engine repairs.

1. Running repair enclosing emergency repair of easy accessible outer assemblies, e.g. replacement of a head flange gasket, replacement of an injection pipe. During running repair it is not necessary to dismantle the whole engine. It is also not necessary to use special tools. User is often able to perform running repair.
2. Medium repair, during which are repaired one or more assemblies. In such case there is necessary partial dismounting of an engine and general inspection of assemblies.
3. Major overhaul, during which the whole engine is dismantled. All parts are inspected and revised. Worn or defective parts are replaced (see the table of allowed clearances).

In case of unexpected defect should be performed properly repair beside to the earlier foreseen medium or major repair. A time between overhauls depends mainly on suitable service and use of an engine. Improper and inaccurate engine service could be reason of significant defects and premature parts wear.

After 75 000 km, an overhaul comprises:
— Visual inspection of the whole engine,
— Tightening of bolts and nuts,
— Testing and adjustment of injectors,
— Testing of alternator,
— Testing of starter,
— Testing of battery,
— Checking of engine work parameters.

After 150 000 km, a medium repair comprises:
— An overhaul and repair of all main subassemblies of an engine,
— Checking of valve tightness, removing any leakage if occurs,
— Replacement of piston rings in case of an oil overconsumption.

After run 225 000 km follow an overhaul as after 75 000 km.

After 300 000 km, a major overhaul comprises:
— Total dismantling of an engine to assemblies, subassemblies and parts,
— Replacement of cylinders and pistons,
— Checking of crankshaft journals and grinding to the suitable undersize or replacement of crankshaft,
— Replacement of crankshaft journals bearings,
— Replacement of sealings and gaskets,
— Checking of all remaining parts or subassemblies, repair or replacement if necessary,
— Assembly of an engine, adjustments and checking in engine test bench.

It can be decided if an engine suits for further use or should be repaired after:

- Study of engine control documents informing about:
  — Truck mileage,
  — Fuel and oil consumption,
  — Performed overhauls and repairs.
- Checking and adjustment of valve clearances, checking of injectors and adjustment of an injection pump (fuel injection start).

An engine should be qualified as for a major overhaul if the following indications are present even after suitable adjustments:

- Excessive oil pressure drop (oil pressure in the heated engine is below allowed values):
  — Minimum oil pressure at the smallest idling speed 0.049 MPa,
  — Minimum oil pressure at the maximum rpm 0.29 MPa.
  Before testing of an oil pressure be sure that:
  — Oil filter insert is clear and in good condition,
  — Engine is filled with a suitable oil (type and category),
  — Overflow valve is tight.

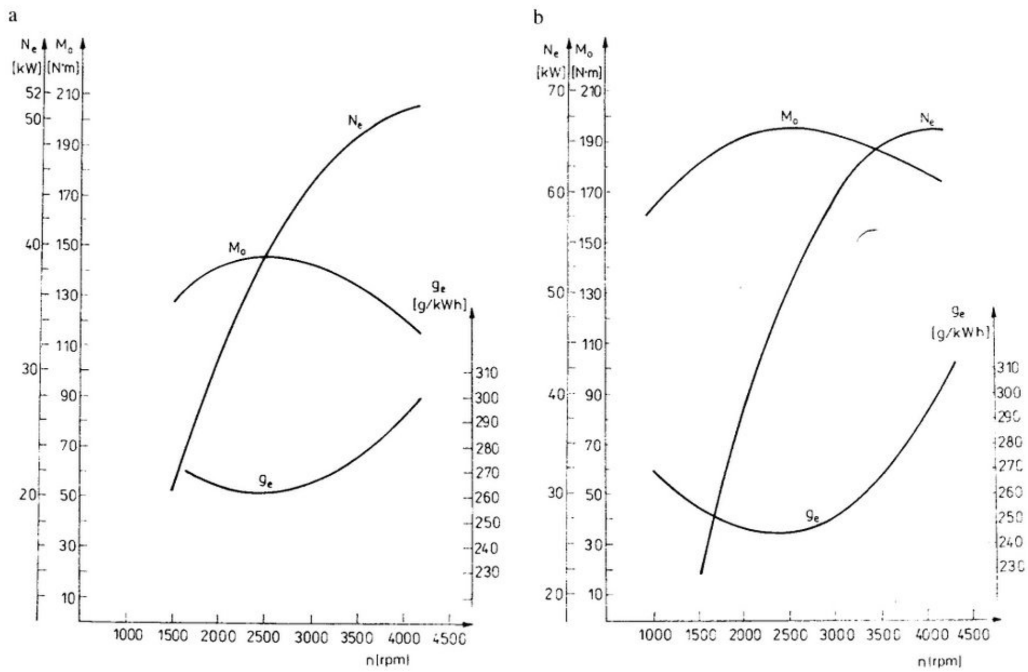


Fig. 1. Engines performance curves
a — engine 4C90, *b* — engine 4CT90-1

- An oil consumption is greater than:
  - 0.186 kg/h for 4C90,
  - 0.240 kg/h for 4CT90-1.
- Compression pressure at speed 200 ... 250 rpm is lower than 2.45 MPa. The difference between compression pressures should be not greater than 0.5 MPa. Pressure should be measured when an engine is hot. Crankshaft should be revolved with starter, fuel supply closed, and battery of good condition. Compression pressure for brand new engine is 3 MPa. Above values refer to measurements made with tester SPC-50. In case of use of another tester, the tester should be calibrated on the new engine. For example for a tester PSWo-60 KFM a compression pressure for brand new engine is about 2.6 MPa a minimum compression pressure is 2.1 MPa. During measurements all injectors should be removed and an injection pump lever should be in a STOP position.
- Operating fuel consumption is 10% greater than a value foreseen for a particular truck.
- Horse power drop is 10% in relation to rated horse power in spite of proper adjustment of fuel system.
- Excessive exhaust gases emission from oil sump. Amount of gases emission is about 40 dm^3/min for 4C90 and 60 dm^3/min for 4CT90-1.
- Abnormal noise during an engine operation.

Engine 4C90 defects, their probable reasons and methods of repair are given in the Table 1.

3. ENGINE REMOVING FROM TRUCK

In case of any more serious repairs it is necessary to remove from the truck an engine together with a clutch and a gearbox. Particular it is necessary in case of:
- Engine replacement,
- Engine major overhaul,
- Cylinder block replacement,
- Crankshaft replacement.

For an engine dismounting it is not necessary to remove the cab. You only need to remove all engine accessories and engine mounting elements.
To achieve that you should do, as follows:
- Place a truck over a service channel.
- Drain a cooling liquid from a cooling system.
- Drain an oil from engine.
- Unscrew front bumper.
- Dismount a front panel of cab.
- Dismount a radiator, together with rubber hoses.
- Disconnect electric cables, of:
  - Starter,
  - Alternator,

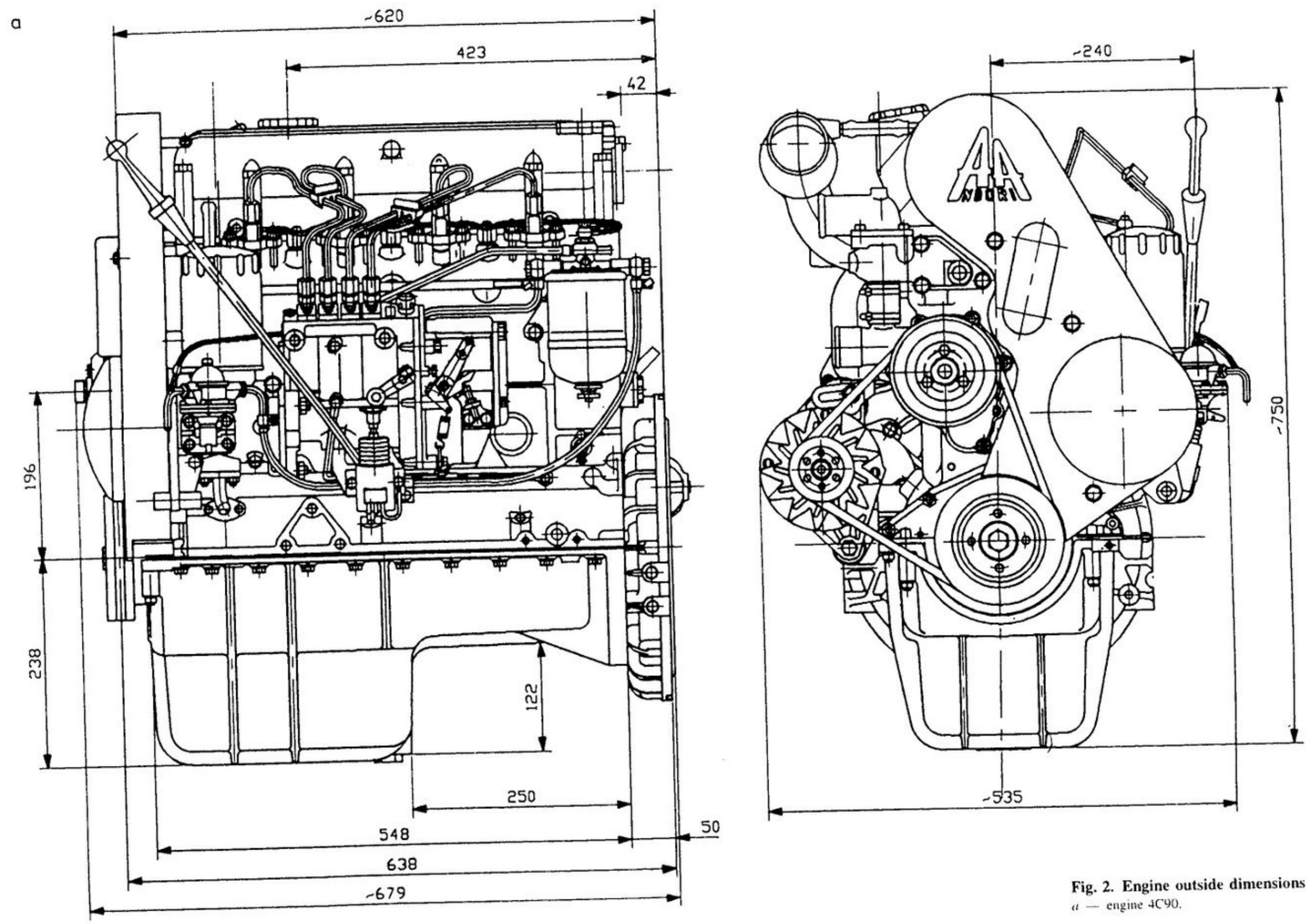
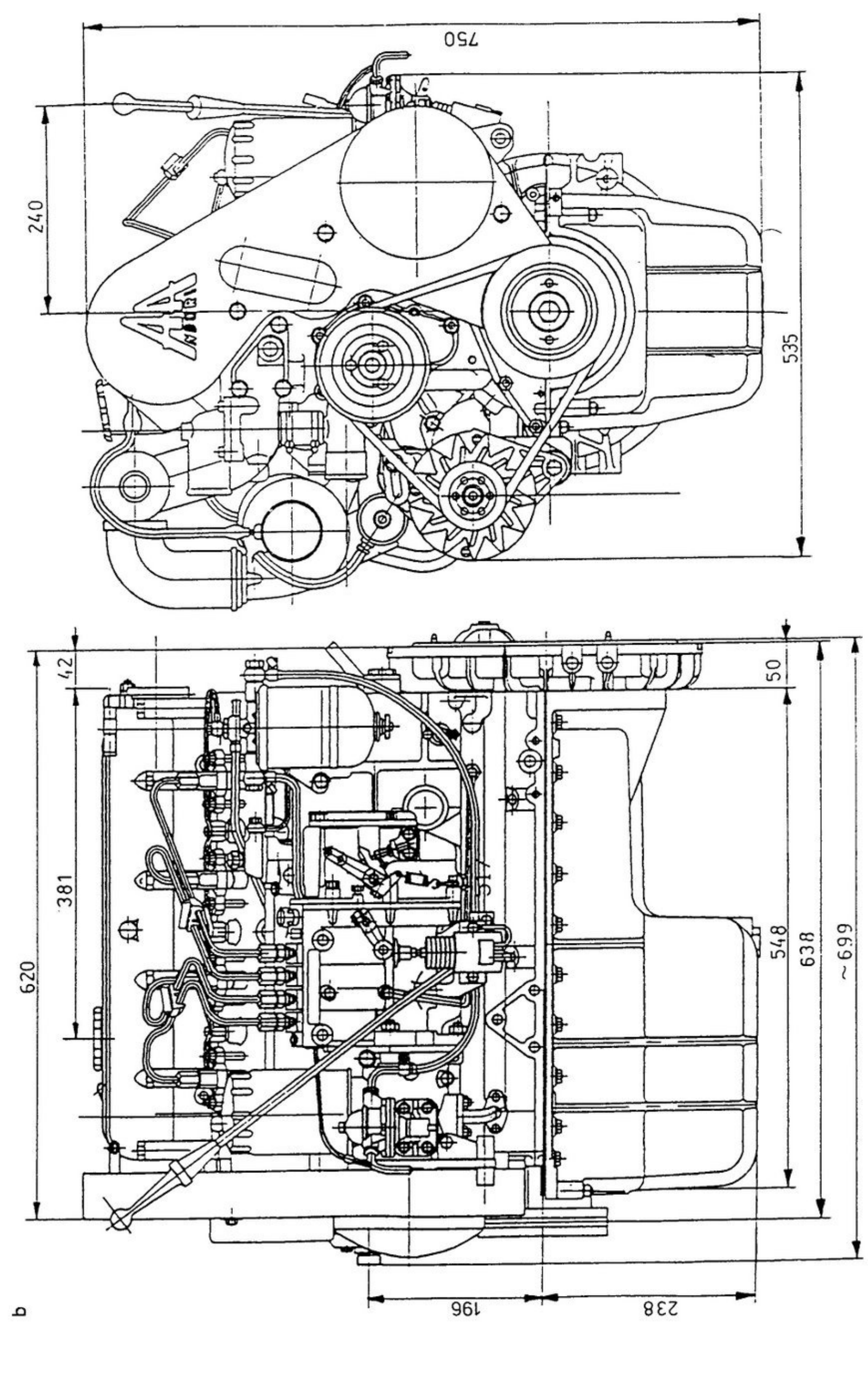


Fig. 2. Engine outside dimensions
a — engine 4C90.



b — engine 4CT90-1

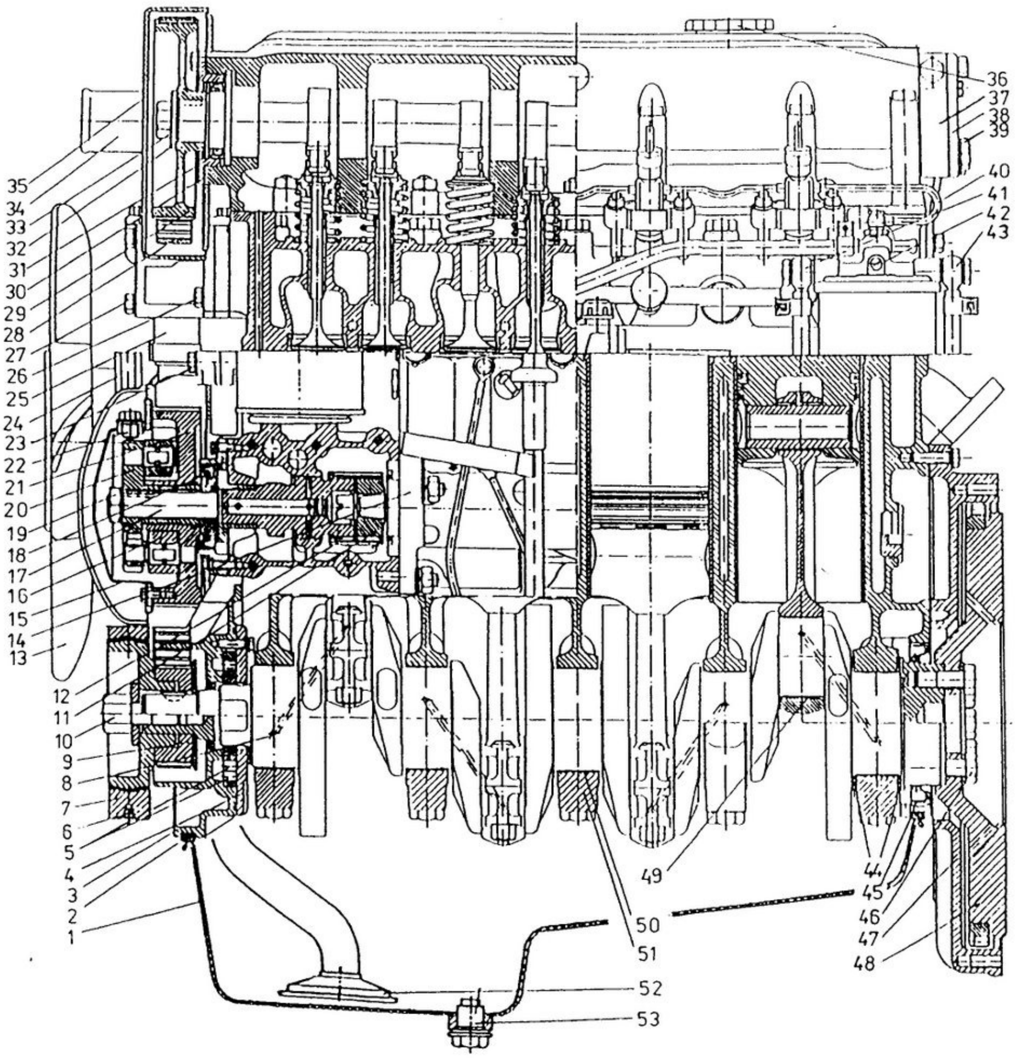


Fig. 3. Engine 4C90 — longitudinal section

1 — oil sump, 2 — oil sump gasket, 3 — oil pump body, 4 — oil pump cover, 5 — oil pump rotors, 6 — V-belt, 7 — pulley with vibration damper, 8 — crankshaft, 9 — crankshaft gear, 10 — bolt, 11 — injection pump gear, 12 — coupling bush, 13 — fan, 14 — injection pump, 15 — cover of an injection advance angle shifter, 16 — weight, 17 — injection pump drive shaft, 18 — sealing ring, 19 — M16 nut, 20 — hub, 21 — injection pump driving gear, 22 — plug, 23 — bolt, 24 — water pump pulley, 25 — toothed belt cover, 26, 27 — M8 bolts, 28 — toothed belt, 29 — camshaft gear, 30 — sealing rings bush, 31 — sealing ring, 32 — special washer, 33 — M16 bolt, 34 — thermostat housing (upper part), 35 — toothed belt front cover, 36 — oil filler plug, 37 — vacuum pump, 38 — pump cover, 39 — M8 bolt and nut, 40 — overflow pipe, 41 — fuel pipe, 42 — bleeding screw, 43 — fuel pipe, 44 — lower thrust ring, 45 — sealing ring, 46 — bolt, 47 — flywheel housing, 48 — flywheel, 49 — connecting rod halfshell, 50 — main bearing halfshell, 51 — main bearing cap, 52 — oil pump strainer, 53 — oil drain plug

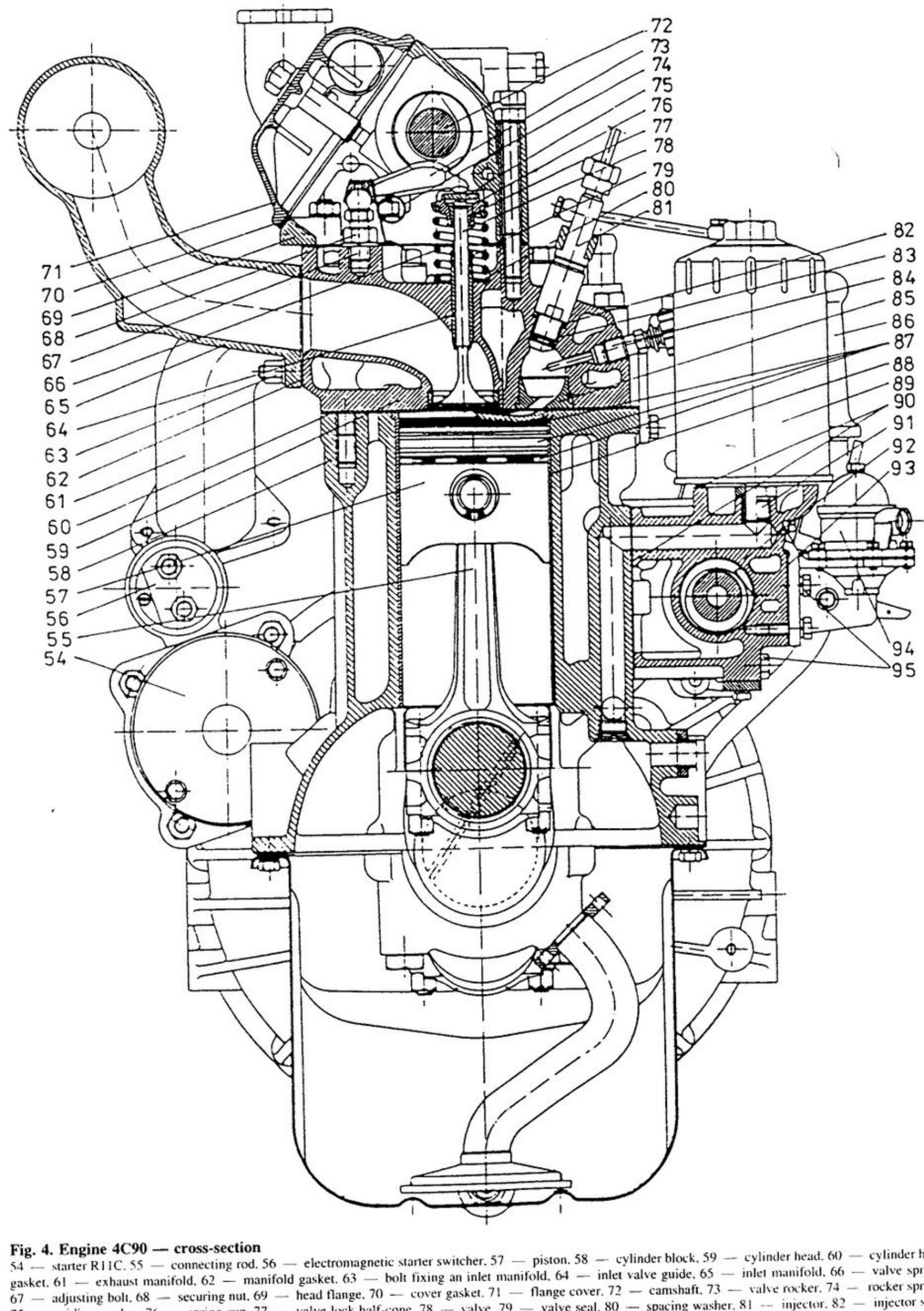


Fig. 4. Engine 4C90 — cross-section
54 — starter R11C. 55 — connecting rod. 56 — electromagnetic starter switcher. 57 — piston. 58 — cylinder block. 59 — cylinder head. 60 — cylinder head gasket. 61 — exhaust manifold. 62 — manifold gasket. 63 — bolt fixing an inlet manifold. 64 — inlet valve guide. 65 — inlet manifold. 66 — valve spring. 67 — adjusting bolt. 68 — securing nut. 69 — head flange. 70 — cover gasket. 71 — flange cover. 72 — camshaft. 73 — valve rocker. 74 — rocker spring. 75 — guiding washer. 76 — spring cup. 77 — valve lock half-cone. 78 — valve. 79 — valve seal. 80 — spacing washer. 81 — injector. 82 — injector seal. 83 — insulating bush. 84 — heater plug. 85 — chamber insert. 86 — oil level indicator. 87 — piston rings. 88 — cylinder liner. 89 — oil filter. 90 — gasket. 91 — filter connector. 92 — injector pump support. 93 — gasket. 94 — fuel supply pump. 95 — bolt

Engine malfunctions

Table 1

Symptoms	Probably reasons	Repair indications	Remarks
1	2	3	4
A. Engine does not start	Discharged battery Loose electrical wires connectors Broken electrical wire Motor starter is out of order Ignition switch is out of order Heat plug is out of order Wrong operation of heater plug controller	Charge the battery Clean and clamp the wire connectors Replace the wire Repair or replace the motor starter Replace the ignition switch Replace the heater plug Check an operation of the heater plug controller and plug wiring	Electrical installation
	Empty fuel tank or an air in the fuel supply system Injection pump is switched off Clogged or worn injector Clogged fuel filter, feeding pump or fuel pipes Speed governor stoppage Leakage of fuel pipes Feeding pump out of order Injection pump out of order	Fill the tank deaerate the fuel supply system Switch on the injection pump Replace the injector Clean the fuel filter, feeding pump and fuel pipes, replace the filter cartridge Dismount the governor and remove a reason of stoppage Seal or replace the fuel pipes Repair or replace the feeding pump Repair or replace the injection pump	Fuel supply system
	Valve clearances to small Cylinder head gasket damaged Leaky valves Valve spring(s) broken Inlet or outlet valve suspended Significant piston leakage	Adjust valve clearances to 0.2 mm (cold engine) Replace the cylinder gasket Perform valve grinding Replace the valve spring(s) Use kerosene or diesel oil for achieving of freely movement of valve Remove a carbon deposit from piston rings or replace the piston rings if necessary	Timing system
B. Engine suddenly stops	Fuel does not flow to an injection pump Fuel filter clogged Fuel feeding pump out of order Improper fuel injection advance angle Piston seizing in cylinder Valve seizing Toothed belt for timing system drive is broken	Check presence of fuel in the fuel tank, check the fuel pipes Replace the fuel filter cartridge Repair the feeding pump Adjust an advance angle of a fuel injection Replace the piston and cylinder liner Repair the valves Send the engine for repair	
C. Engine does not achieve a full power	Fuel supply pipe is clogged Fuel feeding pump out of order Fuel filter clogged Fuel supply system aerated Injection pump out of order Injector out of order Improper fuel injection advance angle Improper valve clearances Cylinder head gasket damaged Improper fuel Cold engine Cylinder liners worn Piston rings worn	Clean the fuel supply pipe Repair the fuel feeding pump Replace oil filter cartridge Deaerate fuel supply system Repair or replace the injection pump Replace the injector Adjust an advance angle of injection Adjust valve clearances to 0.2 mm (cold engine) Replace cylinder head gasket Use proper fuel Wait until engine will be properly warm Replace cylinder liners Replace piston rings	
D. Engine overheating	Not enough of coolant in the cooling system Loosen V-belt driving water pump Thermostat defective Thermal switch of an electromagnetic clutch is out of order Defected brush of an electromagnetic clutch Delay of fuel injection Radiator cooling air ducts are clogged Clogged cooling system Engine overloaded To low an engine oil level in the sump Excessive clutch clearance Water pump defective	Stop the engine, wait for cooling and fill up the cooling system with coolant Tension the belt Replace the thermostat Replace the thermal switch Replace the brush Adjust advance angle of the fuel injection Clean the air ducts Remove boiler scale out of system Decrease an engine load Fill up the oil Adjust the clearance Repair the pump	

Tablica I cd.

1	2	3	4
E. Too low an engine oil pressure	To low an engine oil level in the sump	Fill up a lubrication system with an oil	
	Oil filter is clogged	Replace oil filter cartridge	
	Oil pump strainer clogged	Clean the oil pump strainer	
	Oil pump out of order	Repair or replace the oil pump	
	Leakage in an engine lubrication system	Remove any leakage	
	Defected oil pressure indicator	Replace the oil pressure indicator	
	Presence of fuel or oil in the lubrication system	Remove the leakage cause and replace the oil	
	Damaged or leaky an oil pump overflow valve	Tighten up or replace an overflow valve	
	Crankshaft bearing damaged	Send the engine for repair	
F. Exhaust gases are black	Air cleaner clogged	Clean filter cartridge or replace it	
	Injection nozzle clogged or an injector does not operate properly	Clean injection nozzle or replace injector	
	Wrong adjustment of an advance angle (injection to late)	Adjust the injection advance angle	
	Improper valve clearances	Adjust valve clearances to 0.2 mm (cold engine)	
	Maximum dose of fuel is excessive	Decrease the fuel dose	
	Inlet and outlet valves are not tight	Perform the valve grinding	
	Cylinder head gasket is damaged	Replace the cylinder head gasket	
	Suspended inlet or outlet valve	Use kerosene or diesel oil for achieving of freely movement of valve	
G. Exhaust gases are blue	Excessive amount of oil in oil sump	Remove excess of an oil	
	Clogged piston rings	Loose piston rings — remove carbon deposit from grooves	
	Piston rings are worn or broken	Replace the piston rings	
	Too long idling of an engine	Avoid excessive idling of an engine	
	Piston grooves eroded	Replace the piston	
H. Knocking during an engine operation	Poor injectors condition	Replace injectors	
	Crank system bolts loosen	Replace the bolts, check bearings, replace the bearing shells if necessary	
	Improper injection advance angle	Adjust the injection advance angle	
	Improper timing adjustment	Adjust timing	
	Suspended valves	Remove cause of valve suspension	
	Valve rocker broken	Replace valve rocker	
	Improper valve clearance	Adjust the valve clearances	
	Improper fuel	Use the proper fuel	
	Valve spring broken	Replace the valve spring	
I. Excessive fuel consumption	Air cleaner clogged	Replance the air cleaner carttidge	
	Injection pump damaged	Repair or replace the injection pump	
	Injector damaged	Replace the injector	
	Improper injection advance angle	Adjust the injection advance angle	
	Improper valve clearances	Adjust valve clearance for 0.2 mm	
	To low compression ratio	Remove cause of leakage	
	Improper fuel	Use proper fuel	
	Limited capacity of exhaust pipe	Remove the cause	
	Cylinder head gasket damaged	Replace the cylinder head gasket	
	Seizing of valves	Repair valves, see A	
	Cylinder liners worn	Replace cylinder liners	
	Piston rings worn	Replace the piston rings	

— Engine temperature gauge,
— Connection between an engine and truck mass,
— Oil pressure gauge,
— Heat plugs.

- Disconnect an injection pump control lever, wiring of stop light switch and clutch release lever.
- Disconnect air cleaner hose and vacuum servo buster hose.
- Disconnect lubrication oil pipes.
- Disconnect fuel supply pipes.
- Unscrew exhaust pipe from engine exhaust manifold.
- Unscrew propeller shaft and speedometer drive cable from gearbox.
- Disconnect gear change lever from gear box.
- Unscrew the front frame cross member.
- Unscrew bolts fixing the front engine supporting members on the rubber pads.
- Place the special fitting on the roller pneumatic lift located in the service channel and slide it under an engine.
- Unscrew the rear cross member of an engine hanging from a truck frame and remove it.
- Move forward an engine supported on a lift.
- Relocate an engine (driving assembly) with a hoist (capacity up to 3000 kg) to an assembly stand and fix it to the special supporting device.

4. ENGINE CLEANING

Before starting repair the engine should be carefully cleaned and washed. Dismount an alternator and starter before washing. These assemblies should be cleaned separately.

Plug all holes before cleaning of an engine, to avoid inside penetration of dirt and cleaning means. It is possible to wash an engine in a special washing device with hot water sprinklers. If such device is not available wash an engine in direct strong stream of water. If there is an oil or grease on the outer surface of engine use special mean for removing oil and grease or diesel fuel before washing with water. After washing dry an engine with a compressed air.

For parts washing use chemical bath. It is necessary to keep strictly all indications of proper use. In contrary it the damage of parts is possible especially those which are from aluminium.

Parts should be washed in sump with double bottom. Upper bottom should be made from wire grid or steel sheet with holes, which allows dirt sinking to the lower bottom. The same means should be used for washing of an oil channels under the pressure. If it is impossible to use pressure you can use special bore brushes. After washing in chemical solution parts should be washed with a hot water and dried with a compressed air. In case the ready prepared chemical means are not available you can use solutions given below.

For washing of steel and grey iron parts use water solution of caustic soda in relations 30 ... 35 g of soda per 1 dm^3 of water. In such solution heated up to temperature about 80°C parts should be kept for a 10 ... 15 minutes, then washed with hot water and dried with a compressed air.

For washing parts made from aluminium use water solution which composition is given in the Table 2. Washing procedure is the same as for steel parts.

Water solution for washing of aluminium parts Table 2

Component	Amount of component in g/dm^3 of water
Green soap	40
Sodium carbonate	70
Potassium hydroxide	30

Above solutions do not remove carbon deposit, which should be removed in the mechanical manner or in chemical in the special baths. Mechanical removing is performed with hand or mechanical brushes, scrapers or a compressed air with a bone meal (with device similar as for sand blasting).

Mechanical removing of carbon deposit should be performed very carefully. Scratches could damage parts. It is possible to remove carbon deposit from steel and iron parts with solution which composition is given in the Tabele 3.

Dip the parts which need to be cleaned in solution warmed up to 80 ... 90°C and keep them for about 2 ... 3 minutes. Remaining deposit can be easy removed with a brush. After such treatment the parts should be washed with a hot water and dried with a compressed air.

Water solution for removing of carbon deposit from steel or iron parts Table 3

Component	Amount of component in g/dm^3 of water
Caustic soda	25
Calcined soda	33
Water glass	1.5
Green soap	8.5

It is possible to remove carbon deposit from aluminium parts with solution as given in the Table 4. Procedure of removing is the same as for steel and iron parts.

Water solution for removing of carbon deposit from aluminium parts Table 4

Component	Amount of component in g/dm^3 of water
Calcined soda	20
Green soap	10
Water glass	8
Potassium dichromate	5

Removing of boiler scale

In case of excessive boiler scale inside of channels of cylinder head or cylinder block in result of use a „hard" water, to remove it follow the below indications:

— Prepare solution with composition: 1 ... 1.5 kg of caustic soda per 10 dm^3 of water,
— Warm up the solution to temperature 60 ... 90°C,
— Dip a cylinder head or cylinder block in warmed solution and keep it for about 30 to 45 minutes,
— Remove cylinder head or cylinder block from the solution, wash with a hot water and next with a cold water.

Attention. Caustic soda is aggressive. Use gloves for protection. Avoid spilling of solution outside the tank.

5. ENGINE DISASSEMBLY

During engine disassembly and assembly follow the below indications:

— Use proper universal and special tools,
— Note special signs made on parts and assemblies which inform how parts and assemblies should be positioned,

— Removing parts fixed with bolts keep the bolts in their locations,
— All parts of engine should be carefully cleaned to remove an oil or carbon deposit,
— Mating parts should be marked for keeping proper positioning during assembly,
— Blow with compressed air the water channels of cylinder head to avoid any water penetration to the cylinders of an engine,
— For assembly use parts clean and of good condition,
— During assembly lubricate any sliding surfaces with a thin film of an engine oil,
— Keep clean the toothed belt,
— After unscrew of a fuel pipe or injection pipe protect the ends against dirt, place covers on an injection pump connections,
— For a complete disassembly and later assembly of engines 4C90 and 4CT90-1 use special revolving stand if available (part No. 029901). If not both operations could be done on a work-bench,
— Assembly station should be equipped with suitable hoist with hook.

Operation sequence during the total disassembly is as follows:

- Unscrew bolts fixing an alternator and remove alternator together with V-belt.
- Unscrew the motor starter and remove it together with holder (if used).
- Clean the engine outside.
- Unscrew the drain plug and drain an oil. Remove the fuel from fuel filter. Unscrew the head of a drain plug of the fuel deposit container. Drain the transmission oil from an advance angle controller (unscrew two plugs located in the cylindrical cap). Unscrew the oil filter with a special wrench (Fig. 5).

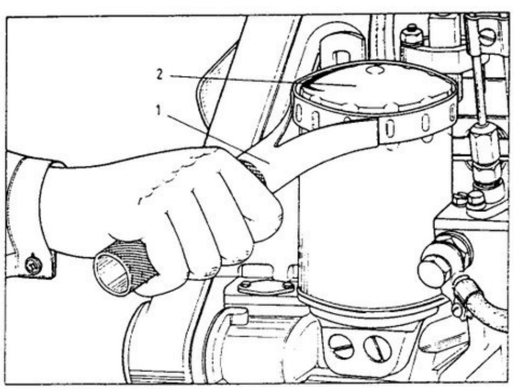


Fig. 5. Oil filter disassembly
1 — special tool, 2 — oil filter

- Unscrew clutch together with housing.
- Unscrew the turbocharger pipes (for engine 4CT90-1).
- Unscrew inlet and outlet manifolds and remove them (together with a turbocharger, for engine 4CT90-1).

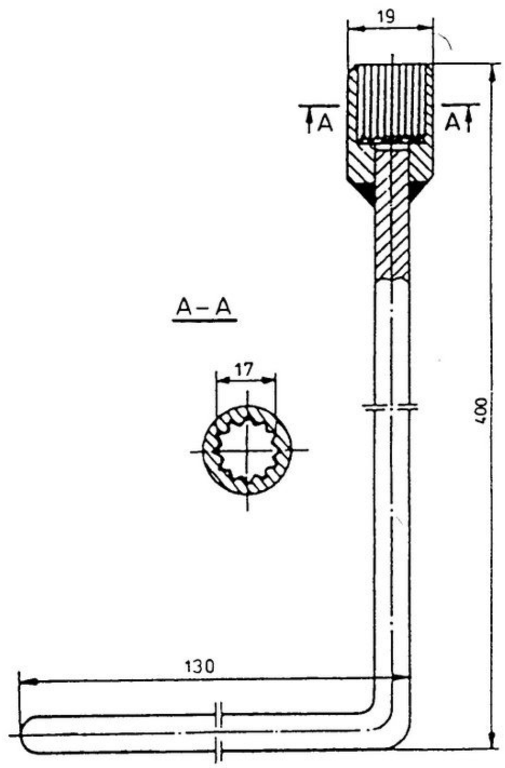


Fig. 6. Special wrench for mounting of an injection pump

- Unscrew and remove injection pipes from injectors, pump and clamps. Protect all holes against dirt.
- Unscrew the following fuel pipes:
  — An overflow pipe, fuel filter — injectors
  — A pipe, fuel filter — injection pump,
  — A pipe, fuel filter — feeding pump,
- Screw in bolts of connecting element, all washers together with securing parts keep in a proper locations.
- Unscrew bolts fixing the fuel filter together with a holder, remove the fuel filter together with a holder.
- Unscrew bolts fixing the feeding pump and remove the pump.
- Unscrew and remove the oil pipe, connecting an injection pump with cylinder block and the fuel pipe, connecting an injection pump with suction pipe of a feeding pump.
- Unscrew nuts fixing an injection pump, remove an injection pump. For a nut located at cylinder block side use a special wrench (Fig. 6).
- Unscrew and remove injectors.
- Unscrew and remove the toothed belt housing.
- Place a crankshaft in position when all pistons are in the middle of their stroke (after achieving TDC turn the shaft anticlockwise for 90°).

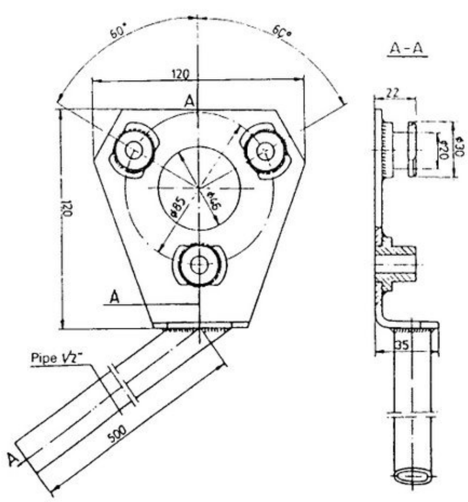


Fig. 7. Device for blocking of a camshaft gear

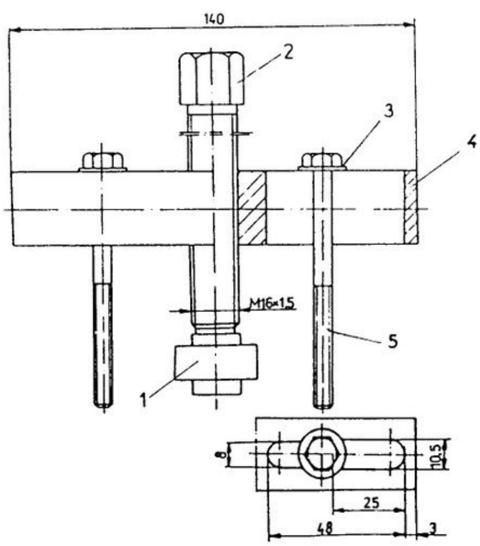


Fig. 8. Puller for camshaft gears disassembly
1 — bolt thrust collar, 2 — M16×1.5 bolt, 3 — washer, 4 — beam, 5 — bolt

- Loose nuts fixing tensioner rollers, release tensioner pushing the roller left and remove toothed belt of timing drive.
- Unscrew the bolt fixing pulley with vibration damper and remove it.
- Unscrew the bolt fixing camshaft gear (use a special device for gear blocking — Fig. 7) and remove it from a camshaft using a puller (Fig. 8).
- Unscrew nuts fixing head flange cover and remove the cover together with breathing pipe.

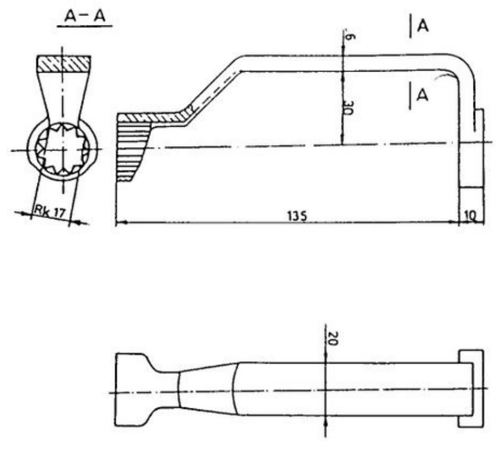


Fig. 9. Special wrench for bolts of a head flange

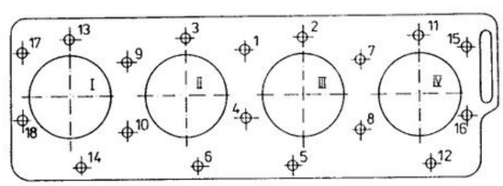


Fig. 10. Tightening sequence for nuts fixing a cylinder head

- Unscrew and remove vacuum pump together with clutch and non-return valve. Protect a clutch against falling it into the engine (refers to engines equipped with vacuum pump fixed with three bolts).
- Unscrew the thermostat case, remove pipes and disconnect them from the water pump after removal of pump and disassembly of the pipe clamps.
- Unscrew and remove the water pump together with fan and thermostat housing.
- Unscrew and remove the rear cover (upper part).
- Unscrew the head flange. At first loose nuts located inside the flange, and then the remaining bolts. Remove the flange together with a camshaft. Use special device for unscrewing (Fig. 9).
- Unscrew nuts fixing cylinder head (engines produced up to the middle of an April 1997) or bolts (engines produced since the middle of an April 1997) in the opposite sequence as shown in Fig. 10. Remove the cylinder head using special device (Fig. 11). Remove a gasket and clean upper inner surfaces of cylinder liners (to remove a carbon deposit), it will make easy to remove the pistons.
- Unscrew and remove a guide of an oil level indicator together with an indicator.
- Unscrew and remove the flywheel together with a washer.
- Unscrew and remove flywheel housing.

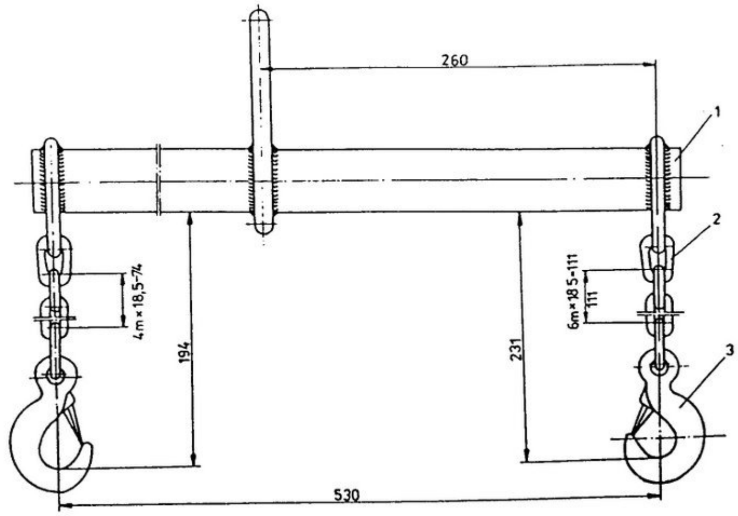


Fig. 11. Device for lifting an engine
1 — beam, 2 — chain, 3 — hook

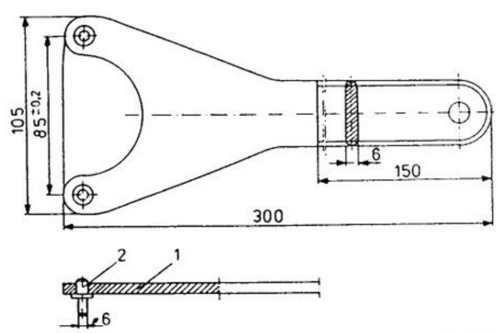


Fig. 12. Special tool for blocking an injection advance angle shifter
1 — tool, 2 — dowel

- Unscrew and remove a cap of an injection advance angle controller.
- Unscrew and remove an injection advance angle controller (using a special puller, Fig. 8), remove a key. For unscrewing use a flat wrench (Fig. 12) to block an injection pump driving shaft.
- Remove the clutch bush together with an injection pump driving shaft.
- Unscrew the fixing bolts and remove an oil sump.
- Unscrew and remove the oil suction pipe together with washers.
- Unscrew the fixing bolts and remove the oil pump together with a gasket.
- Unscrew nuts of the first connecting rod cap, remove the big end cap together with a halfshell.
- Push upward the first connecting rod together with a piston and remove them from cylinder. Connect the cap with connecting rod and fix with bolts. Keep the former position of bolts and nuts. Follow the same procedure for the remaining connecting rods.
- Unscrew and remove the main bearing caps together with the bolts.
- Remove the crankshaft out of cylinder block. Main bearing caps place back in their locations and fix them with bolts.
- Remove sealing ring from crankshaft.
- Unscrew and remove the alternator holder and tensioner.

6. VERIFICATION OF PARTS

The engine parts after disassembly, are shown in Fig. 13, 14, 15.
The parts verification should be divided into two stages:
— Primary verification
— Detailed verification.
The primary verification means visual inspection of all parts and elimination of parts worn or defected, which can be not used or which can not be repaired. The detailed verification means check up of parts and measurement of them with suitable measuring instruments.
Technician performing the detailed verification of parts decides if the part can be used again (considering the proper repair).
In case of major overhaul of engines for further use can be classified only the parts which ensure achieving the nominal clearances (factory clearances). Parts which ensure only allowable clearances can be used only in case of the running repair.

Parts which need to be machined or balanced together

The following parts of an engine are machined or balanced together:

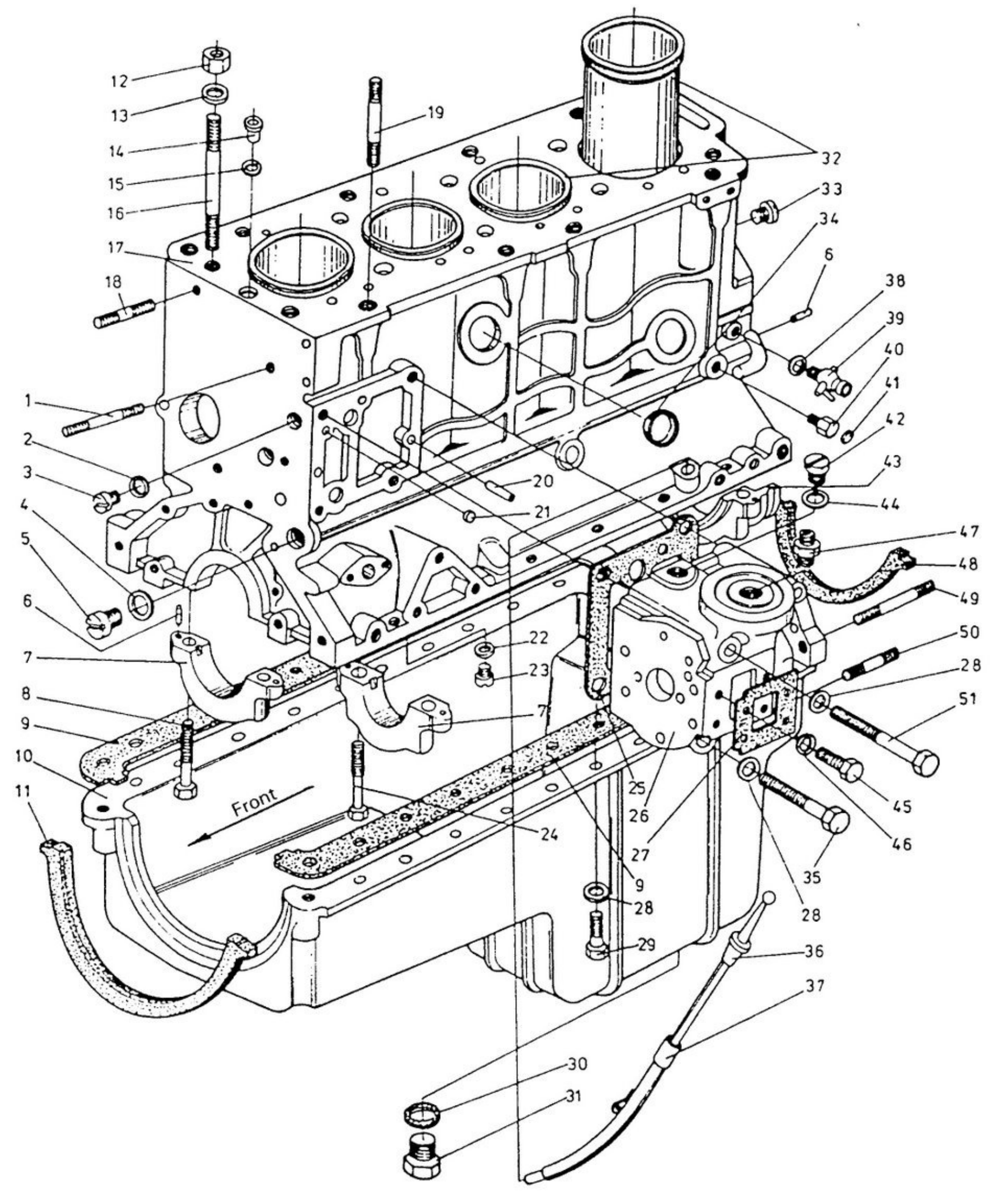


Fig. 13. Parts of a cylinder block and of an oil sump
1 — stud-bolt, 2 — seal, 3, 5 — plugs, 4 — sealing ring, 6 — 8n6 × 16 pin, 7 — main bearing cap, 8, 24 — bearing cap bolts, 9 — oil sump gasket, 10 — oil sump, 11 — sump rubber seal, 12 — nut, 13 — washer, 14 — bush, 15 — sealing ring, 16, 19 — stud-bolts fixing a cylinder head, 17 — cylinder block, 18 — stud-bolt, 20 — location dowel, 21 — hole plug, 22 — seal, 23 — plug, 24 — bolt, 25 — support gasket, 26 — injection pump support, 27 — fuel supply pump gasket, 28 — spring washer, 29 — bolt, 30 — seal, 31 — oil drain plug, 32 — cylinder liner, 33 — plug, 34 — plug, 35 — M8 × 85 bolt, 36 — oil sump, 37 — indicator guide, 38 — seal, 39 — cooling liquid drain cock, 40 — oil pressure gauge seat, 41 — seat plug, 42 — plug, 43 — thrust main bearing cap, 44 — seal, 45 — M8 × 16 bolt, 46 — spring washer, 47 — oil filter connector, 48 — sump rubber seal, 49 — M10 × 35 bolt, 50 — M10 × 28 bolt, 51 — M8 × 105 bolt

— Crankshaft main bearing caps, which are machined together with a cylinder block,
— Connecting rod, machined together with a big end cap,
— Piston pin bush, machined after pressing into the connecting rod small end,
— Flywheel, dynamic balanced together with toothed ring, with tolerance of 35 gcm,
— Pulley of the V-belt driving water pump and alternator. It is dynamic balanced together with vibration damper, with tolerance of 6.4 gcm,
— Oil pump rotors, creating a set considering of a between teeth play, are selected in pairs already during machining.

Table 5

Table of clearances for engines 4C90 and 4CT90-1

Clearance location and description	Clearance in mm	
	Nominal	Admissible
Radial clearance of the crankshaft main bearing	0.040 ... 0.098	0.15
Axial clearance of the crankshaft fixing bearing shell	0.080 ... 0.280	0.35
Radial clearance of the connecting rod bearing shell	0.040 ... 0.092	0.15
Axial clearance of the connecting rod bearing shell	0.180 ... 0.350	0.40
Radial clearance of the piston pin in the bush of the small end of connecting rod	0.030 ... 0.042	0.10
Radial clearance of the piston pin in the piston (when cold)	0.003 ... 0.013	0.07
Projection of the liner flange over the cylinder block surface	0.01 ... 0.10	0.01 ... 0.10
Projection of the piston over the cylinder block surface	0.185 ... 0.515	0.185 ... 0.515
Clearance of the piston ring in the axial direction (in the groove) 1. piston ring 2. piston ring 3. piston ring	 0.050 ... 0.090 0.040 ... 0.078 0.045 ... 0.085	 0.30 0.25 0.25
Clearance of the piston ring lock, 1. compression ring	0.30 ... 0.55	2.5
Clearance of the piston ring lock, 2. oil scraper ring	0.40 ... 0.65	2.5
Clearance of the piston ring lock, oil scraper ring	0.30 ... 0.60	2.5
Axial clearance of the camshaft	0.120 ... 0.270	0.30
Radial clearance of the camshaft bearings	0.050 ... 0.144	0.20
Axial clearance of the injection pump driving shaft	0.100 ... 0.250	0.30
Radial clearance of the injection pump driving shaft bearings Front Rear	 0.020 ... 0.062 0.025 ... 0.075	 0.10 0.10
Valve clearance, cold engine, checked between a cam and valve rocker Inlet valve Exhaust valve	 0.20 0.20	 0.20 0.20
Radial clearance between the valve stem and guide	0.010 ... 0.055	0.15
Radial clearance of the hub advance device in the gear of the injection pump driving shaft	0.040 ... 0.094	0.12
Radial clearance of the pin in the plunger bush of the hub advance device	0.032 ... 0.077	0.12
Radial clearance of the pin in the advance device spring seat	0.025 ... 0.062	0.12
Axial clearance of the vacuum pump rotor	0.10 ... 0.22	0.25
Radial clearance of the rotor journal in the bearing hole of the vacuum pump rotor	0.032 ... 0.077	0.12
Between teeth clearance of the oil pump rotors	0.03 ... 0.15	0.20
Bearing of turbocharger assembly TB25.61 Radial clearance Axial clearance	 0.056 ... 0.127 0.0254 ... 0.084	

Attention

Values of nominal clearances are calculated on the basis of dimensions of mating parts. These should be achieved during an engine assembly in the factory and during an engine assembly when the major overhaul is performed.

Clearances given in the column three are not allowed for an engine under the major overhaul. It refers especially to the following parts: liner — piston, crankshaft — crankshaft bearing shells, piston pin — pin bearing bush located in the small end of connecting rod and piston rings — piston — liner.

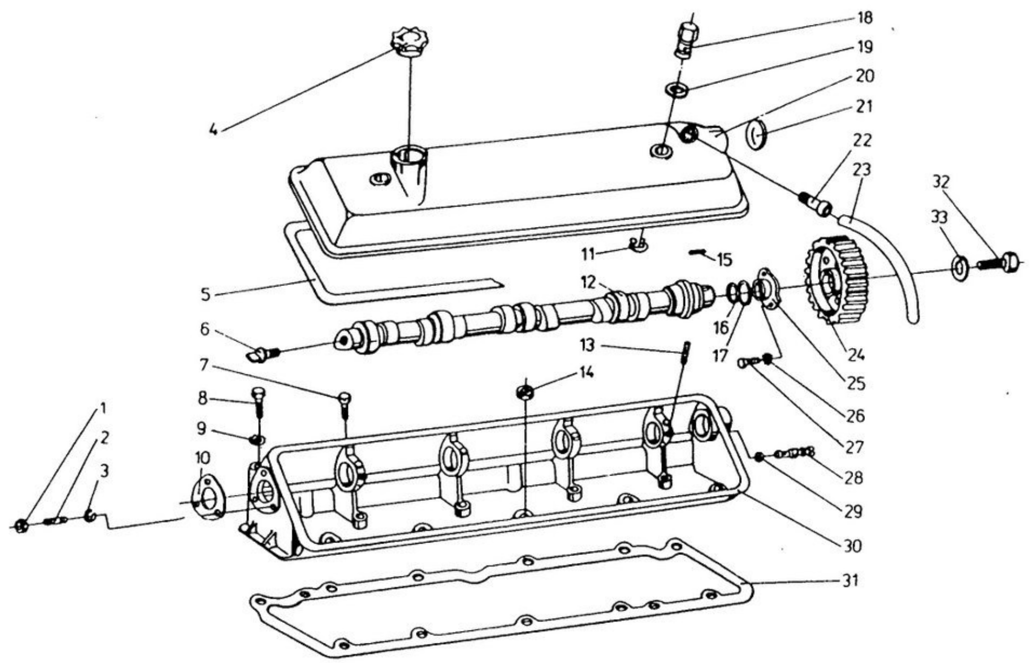
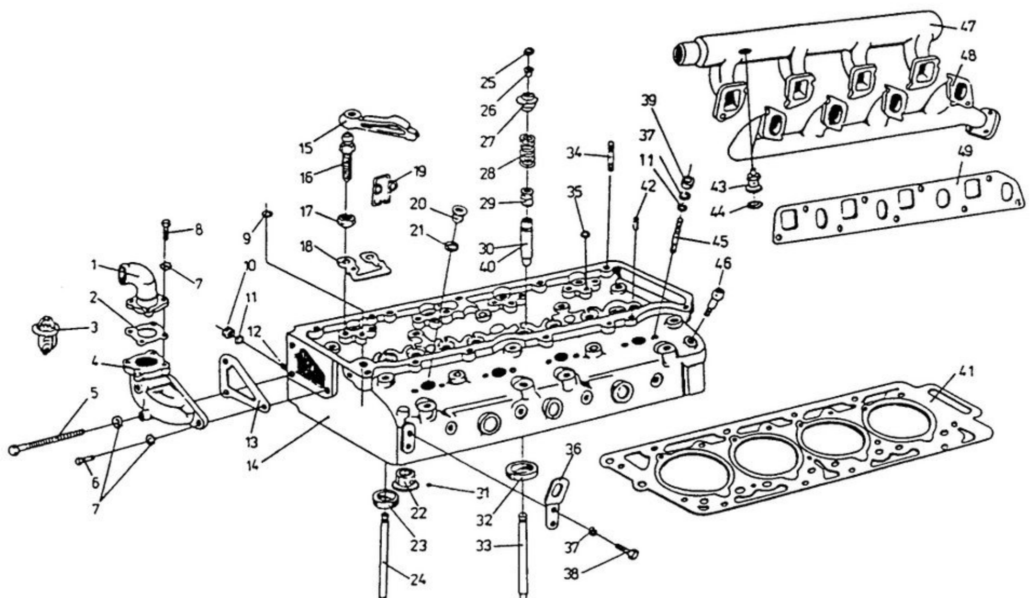


Fig. 14. Parts of a head flange and of a camshaft

1 — M8 nut, 2 — M8 × 40 stud-bolt, 3 — spring washer, 4 — oil filler plug, 5 — cover gasket, 6 — blade, 7 — M10 × 85 bolt, 8 — M10 × 95 bolt, 9 — washer, 10 — gasket, 11 — ring 14Z, 12 — camshaft, 13 — stud-bolt, 14 — M10 nut, 15 — A6 × 6 × 14 key, 16 — A40 × 55 × 10 sealing ring, 17 — sealing ring, 18 — nut, 19 — sealing ring, 20 — head flange cover, 21 — B32-ZN plug, 22 — connector, 23 — rubber pipe, 24 — camshaft gear, 25 — sealing rings bush, 26 — washer, 27 — M8 × 22 bolt, 28 — nozzle, 29 — sealing ring 6.3 × 2.4, 30 — head flange, 31 — gasket, 32 — spacing washer, 33 — sealing ring



Verification of gaskets and sealing rings

Only new sealing elements should be used during a major overhaul. It refers especially to cylinder head gasket. Sealing ring, O- type, can be used once more if they are flexible and their surfaces are not worn. Sealing rings of Simmer type should be replaced if they are not enough flexible or damaged. Particularly important is condition of crankshaft sealing rings. Both parts of flat gasket of an oil sump should be replaced. It is recommended to replace also the rubber sealing rings of an oil sump if there are any permanent deformations. In case they are flexible enough they can be used further.

7. ENGINE REPAIR

7.1. Cylinder block

The engine block (17, Fig. 13) is machined together with caps of crankshaft main bearings (7). Mentioned parts are suitable marked to enable identification during disassembly and assembly. On all caps, and on cylinder block surface in proper locations are capital letters (A, B, C, D, E). It means that main bearings caps are not interchangeable. Surfaces of retaining bearing cap which are in contact with cylinder block should be coated with Loctite paste on width of the sealing ring.
In the engine block are inserted thin-walled, removable, liners of dry type. Liners which are worn up to the limit should be replaced.

Cylinder block repair

- Carefully check a cylinder block. Special attention should be paid to surfaces contacting with a cylinder head and an oil sump, surfaces contacting with the crankshaft main bearing shells and to all threaded holes and bolts.
- A cylinder block should be replaced in case when:
  - — Surface of contact with a cylinder head shows any defects or scratches (tightness is impossible),
  - — Damaged are surfaces contacting with main bearing shells. The diameter of bearing seats should be 74.000 ... 74.019 mm. It should be measured after tightening of securing bolts with a torque 147 ... 157 N·m,
  - — Fractured walls which could cause a leakage of a coolant or an oil.
- Replace cylinder liners showing deep scratches, fractures or excessive wear. To check the wear should be measured an inner diameter and should be located places in which the wear is the greatest. Such places are usual in the top part of liner, about 20 mm far from the upper flange surface in the plane perpendicular to a crankshaft axis. If a diameter of at least one liner is greater than 90.08 mm all liners should be replaced. For this purpose:
  - — Extract liners with a press. Extracting force should be applied from side of crankshaft. Use a special device shown in Fig. 16,
  - — Carefully clean cylindrical and plane surfaces of cylinder block holes, before placing of the new liners;
  - — Carefully clean outer surfaces of liners before insertion;
  - — Place the liners with press. The required minimum force is 6280 N;
  - — Check cylinder liner bores with a special gauge (Fig. 17). The gauge should ease go through the whole length of a liner. If this requirement is not fulfilled the liner should be removed and replaced by another. In case the gauge shown in a Fig. 17 is

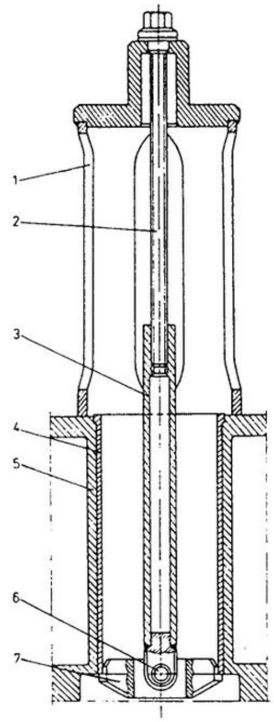


Fig. 16. Device for pressing cylinder liners
1 — body, 2 — bolt, 3 — pipe, 4 — cylinder liner, 5 — cylinder block, 6 — pin, 7 — plate

Fig. 15. Parts of cylinder head
1 — thermostat housing (upper part), 2 — thermostat housing gasket, 3 — thermostat, 4 — thermostat housing (lower part), 5 — M8×85 bolt, 6 — M8×20 bolt, 7 — washer, 8 — M8×22 bolt, 9 — sealing ring, 10 — M8 nut, 11 — washer, 12 — M8×28-5D bolt, 13 — thermostat housing gasket, 14 — cylinder head with plugs, 15 — valve rocker, 16 — adjusting bolt, 17 — securing nut, 18 — special washer, 19 — valve rocker spring, 20 — insulating bush, 21 — bush washer, 22 — chamber insert, 23 — exhaust valve seat, 24 — exhaust valve, 25 — guiding insert, 26 — valve lock half-cones, 27 — valve spring cup, 28 — valve spring, 29 — valve seal, 30 — exhaust valve guide, 31 — ball, 32 — inlet valve seat, 33 — inlet valve, 34 — M10×28-5D head flange bolt, 35 — spacing washer, 36 — engine lifting eye, 37 — washer, 38 — M8×18 bolt, 39 — M8 nut, 40 — inlet valve guide, 41 — cylinder head gasket, 42 — locating dowel, 43 — connector, 44 — seal, 45 — M8×55-8G injector fixing bolt, 46 — connector, 47 — inlet manifold, 48 — exhaust manifold, 49 — manifold gasket

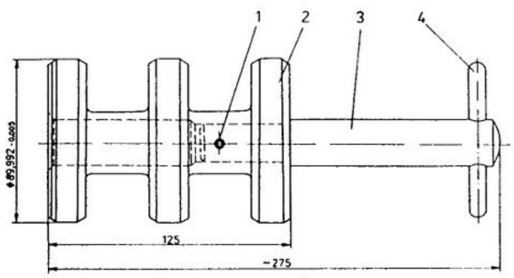


Fig. 17. Gauge for checking of holes of cylinder liners
1 — pin, 2 — gauge, 3 — mandrel, 4 — cross pin

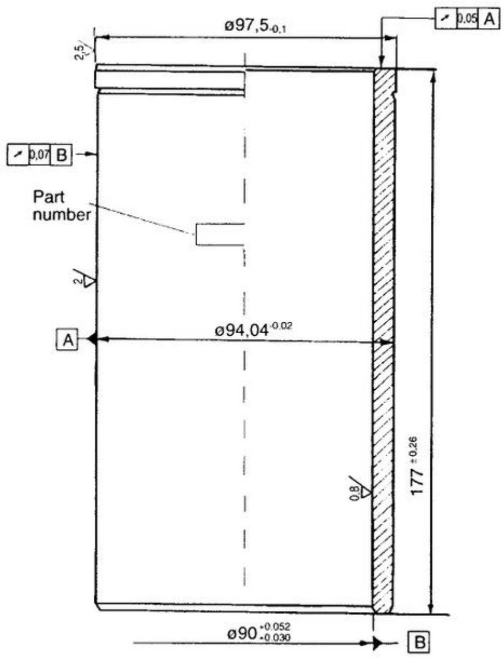


Fig. 18. Cylinder liner dimensions

not available the liners holes should be measured with rod gauge equipped with dial device. The liner inner diameters should be within limits shown in Fig. 18 and in Table 6;

- Measure a height of cylinder liner protrusion over a cylinder block surface; it should be 0.01 ... 0,015 mm (Fig. 19). A cylinder head gasket rests on the protruding part of cylinder liner.
- Replace the front bearing bush of an injection pump driving shaft if a diameter of bush is greater than 24.021 mm (in particular cases 24.04 mm). For this purpose remove two screws securing a liner flange, together with spring washers. Then strike out a bush using a special dowel. Outside diameters of bushes and their seats in the cylinder block are given in Table 7.

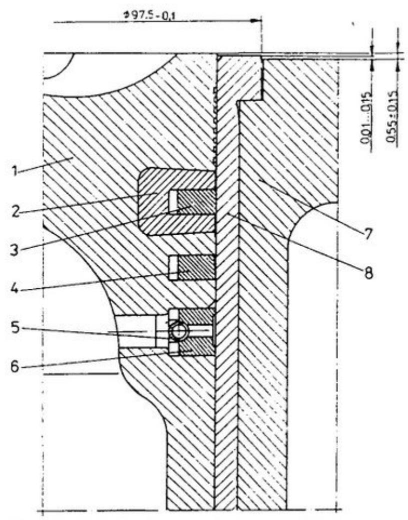


Fig. 19. Cylinder liner and piston position over a cylinder block upper surface
1 — piston, 2 — grey iron insert protecting a piston ring against overheating, 3 — 1st compression ring, 4 — 2nd compression ring, 5 — ring spring, 6 — scraper ring, 7 — cylinder block, 8 — cylinder liner

- Using a special dowel press in a front bush ensuring that a hole in flange and lubrication hole in a bush are in proper location in relation to the holes in cylinder block. It refers to all engines produced before January 1, 1995. After this date lubrication of an injection pump driving shaft is performed from the side nearer of an injection pump. The front bush has no any lubrication hole.
- Tighten with screws a flange of a front bearing bush of an injection driving shaft.

Diameter limits for cylinder liners and their seats in cylinder block (in mm) Table 6

Diameter of liner seat in the cylinder block	Diameter limits		
	Cylinder liner outer diameter	Cylinder liner inner diameter	
		Before pressing	After pressing into the block
94.000	94.020	90.030	90.000
94.010	94.040	90.052	90.022

Bush diameters (in mm) Table 7

Bearing bush	Seat diameter	Bush outer diameter	Clearance
Front bearing bush of an injection pump driving shaft	32.000 ... 32.025	31.984 ... 32.000	0.000 ... 0.041

Check if holes of both bearing bushes of an injection pump driving shaft are coaxial. Do it with a checking shaft. It may be a new diving shaft. A shaft should easy turn inside both bearing bushes (there is allowed a use of scraper to improve the movement freedom). Since an August 1, 1997, it means starting from an engine number 51846, are used pressed front bearing bushes of an injection pump driving shaft. During a repair a new bush should be pressed up to the inner surface of a hub. Inner diameter after pressing should be $24^{+0.021}_{-0.030}$ mm.

- In case of replacement of damaged stud bolts, securing a cylinder head, the new bolts should be at first screwed in to home and then tighten with a torque 49 ... 54 N · m. Four shorter bolts should be screwed in from the side of an injection pump.
- Screw in two plugs closing an oil pipe and two plugs closing an oil channels from and to filter. Than clean carefully the whole cylinder block with a compressed air. Pay special attention to an oil main channel and remaining oil channels.
- Place the main bearing caps, keeping in mind the marks. Lightly screw cap fixing bolts in a cylinder block.
- Replace all worn halfshells of the main bearings (Fig. 20).

Halfshells can be used further if:

— Their work surface is in good condition,

— Wall thickness a on the whole circumference is within limits given in Table 8.

Shells should be also replaced when crankshaft journals have been machined.

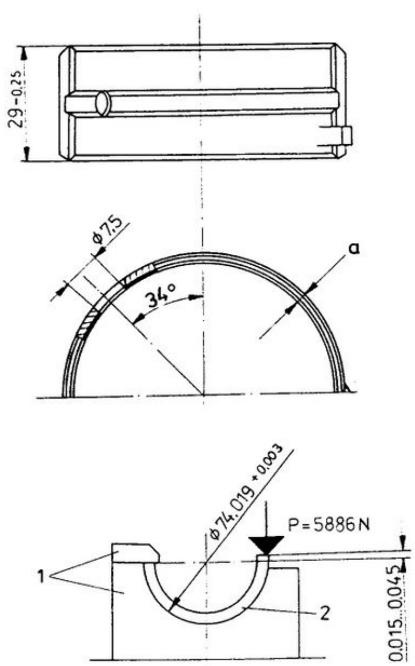


Fig. 20. Main bearing half shell
1 — half shell seat in a checking device, 2 — half shell

Selection of the main halfshells in relation to the diameters (in mm) of crankshaft main journals Table 8

Halfshell size	Main journal limit diameters C (see Fig. 22 and Table 11)	Wall thickness „a" limits (Fig. 20)
Nominal	69.981 ... 70.000	1.970 ... 1.980
1. undersize	69.731 ... 69.750	2.095 ... 2.105
2. undersize	69.481 ... 69.500	2.220 ... 2.230
3. undersize	69.231 ... 69.250	2.345 ... 2.355

Selection of connecting rod halfshells in relation to crank pin diameters (in mm) Table 9

Halfshell size	Crank pin limit diameters E (see Fig. 22 and Table 11)	Wall thickness „a" limits (Fig. 28)
Nominal	54.981 ... 55.000	1.720 ... 1.730
1. undersize	54.731 ... 54.750	1.845 ... 1.855
2. undersize	54.481 ... 54.500	1.970 ... 1.980
3. undersize	54.231 ... 54.250	2.095 ... 2.105

Limit deviations (in mm) for halfshells Table 10

Halfshell	Force P (N)	Limit deviations	Fig. No.
Main	5885	0.015 ... 0.045	20
Connecting rod	3924	0.020 ... 0.045	28

- Replace retaining rings of retaining bearing (retaining half rings, upper and lower) if they have excessively worn surfaces when it is impossible to achieve the proper axial play of crankshaft (see Table 5 and Fig. 21a, b).

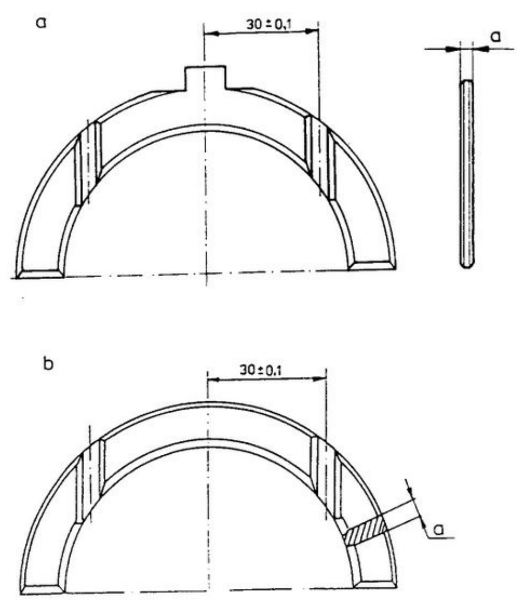


Fig. 21. Thrust rings
a — lower, *b* — upper

Attention. To ensure that water jacket walls and oil channels are tight the tightness test should be performed. For the test of water jacket walls tightness is used water with room temperature. A water should be kept for two minutes under the pressure 196 kPa. No any leakage through the walls is allowed.Water with a room temperature is also used for testing tightness of the oil channels. A water should be kept for two minutes under the pressure 540 kPa. No any leakage through the channel walls is allowed.

7.2. Crankshaft and flywheel

In the engine 4C90 the main journals, crank pins and cylindrical surface of the crankshaft flange mating with a sealing ring as well as the shaft end mating with an oil pump rotor are induction hardened.
Crankshaft of the engine 4CT90-1 (Fig. 22) is nitrogen hardened. The cylindrical surface of a crankshaft flange mating with a flywheel is polished by the oscillation method. Machining traces should be in clockwise direction to ensure an oil throwing out to the oil sump. Traces inclination to the crankshaft axis should be 70°. Such machining method ensures proper sealing of crankshaft from the flywheel side.

Verification and repair of crankshaft

- Clean the crankshaft carefully.
- Check the key groove in a front end of crankshaft. Replace a crankshaft if the groove is so increased that its width is greater than 5.00 mm or if it is so damaged that the proper placing of key is no longer possible.
- Check the thread M12 × 1.25 condition in eight holes of a flange and condition of the inner thread M16 in the front end of a crankshaft. Replace the crankshaft if already the thread of two coils is damaged.
- Check the crankshaft with an eddy-current flow detector against fractures. There are not allowed any fractures of a crankshaft. A crankshaft in which no fractures were found should be demagnetised.

Limit sizes of a crankshaft journals and pins (in mm) Table 11

Crankshaft size	Crank-shaft pin diameter E	Crank-shaft pin length F	Journal diameter C	Journal length: Front journal D_l	Journal length: Fixing journal D_V	Journal length: Remaining journals D
Nominal	54.981 55.000	32.000 32.100	69.981 70.000	35.500 36.500	36.000 36.050	36.000 36.250
1. undersize	54.731 54.750	32.000 32.100	69.731 69.750	35.500 36.500	36.000 36.050	36.000 36.250
2. undersize	54.481 54.500	32.000 32.000	69.481 69.500	35.500 36.500	36.000 36.050	36.000 36.250
3. undersize	54.231 54.250	32.000 32.100	69.231 69.250	35.500 36.500	36.000 36.050	36.000 36.250

Attention. If resistant surfaces of a fixing journal (mating with resistant rings) are damaged, the length of a fixing journal (D_V) should be increased up to size 36.300 ... 36.350 mm. In such case should be used oversized repair halfrings (Table 12).

Resistant rings selection (sizes in mm) Table 12

Ring	Description	Halfring thickness a (Fig. 21a, b)
Nominal size	Resistant ring bottom Resistant ring top	2.400 ... 2.450
Repair size	Resistant ring bottom Resistant ring top	2.550 ... 2.600

- Perform:
  - Measurement of the main journals and connecting rod pins (according to Table 11) and determine to which size a crankshaft journals and pins should be machined (common size for all journals or pins);
  - Measurement of the fixing journal length; check a resistant surfaces condition, determine if there is necessary to grind these surfaces to achieve the nearest undersize. The nominal length of a fixing journal D_V is 36.000 ... 36.050 mm. Foreseen is only one machining of the resistant surfaces to a size 36.000 ... 36.350 mm and available is only one set of oversized rings (Table 11 and 12).
  - Checking of the sealing surfaces of a crankshaft flange; if they are worn (a circumferential groove on the flange) the not expected axial movement of a sealing ring is possible.
- All journals and pins should be induction hardened (min HRC 54). In case of an engine 4CT90-1 they should be nitrogen hardened. After heat treatment journals and pins should be checked with an eddy-current flow detector, demagnetised and then carefully washed. Oil channels should be dried with a compressed air.

Attention. Any repair of a crankshaft should be made in a workshop equipped with a special grinder for crankshafts, special device for an induction hardening and nitrogen hardening (in case of a turbocharged engine) and an eddy-current flow detector.
A flywheel (1, Fig. 23) has a toothed ring (2) placed with a shrink. A location of a ring is fixed with a dowel. A flywheel is fixed on the crankshaft flange with eight bolts M12××1.25. The flywheel surface mating with a clutch disc should be plane and smooth. When it is not plane or not smooth enough and cooperation with a clutch disc is not proper the mating surface should be ground. The permissible material layer for remove is a 1.5 mm.
A machining should ensure that the surface will be plane with tolerance 0.07 mm and maximum run-out 0.1 mm (measured on diameter about 280 mm) in relation to the reference surfaces *A* and *B*. In case of any damage of teeth the flywheel ring should be replaced. Replacement needs removing of the old ring with a press and placing of a new one. Before positioning of a new ring the mating surfaces of both these parts should be carefully cleaned. The ring should be heated up to temperature 150 ... 220°C and evenly pressed on a flywheel. Properly located tooth ring should be in contact with resistant surface of a flywheel.

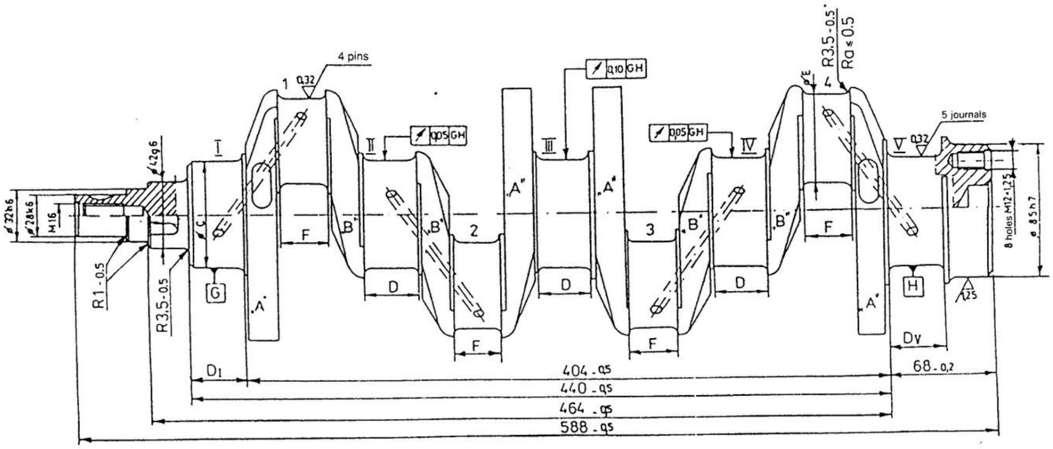


Fig. 22. Engine crankshaft

A — counterweights, B — crank web, C — main journal diameter, D — main journal width, D_I — front main journal width, D_{II} — thrust main journal width, E — crank pin diameter, F — crank pin width

* Refers to all main journals and crank pins

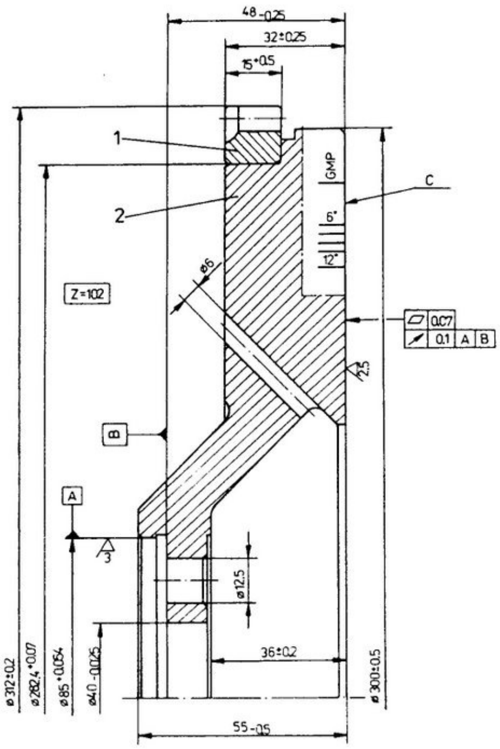
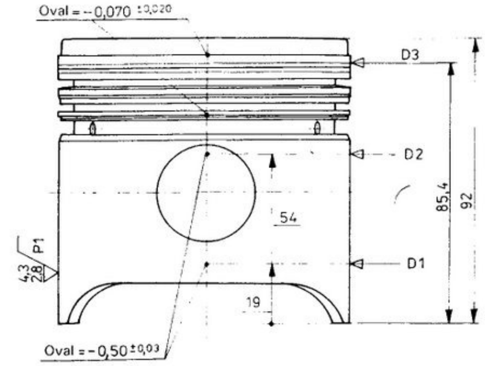


Fig. 23. Flywheel
1 — flywheel, 2 — ring gear



Piston diameters (in mm) Table 13

h (min)	Piston diameter D	Tolerance	Oval	Tolerance
19	$D_1 = 89.960$	±0.009	0.50	±0.030
54	$D_2 = 89.849$	±0.007	0.50	±0.030
85.4	$D_3 = 89.461$	±0.012	0.07	±0.020

Piston ring play in a groove (in mm) Table 14

Play in the axial direction		
Ring	Play	
	Nominal	Permissible
1st compression ring	0.050 ... 0.090	0.30
2nd compression ring	0.040 ... 0.078	0.25
Scraper ring	0.045 ... 0.085	0.25

7.3. Pistons and connecting rods

The engine pistons (1, Fig. 24) are made of an aluminium alloy. The piston skirt is shaped as an ovalised barrel which changes during heating to a cylindrical. It ensures the proper mating of piston with its liner. In the first period of manufacturing of an engine 4C90 were used a nominal pistons which part number was 1.7.0540. For these pistons clearance between a liner and a piston skirt, for a cold engine, should be 0.15 mm.

Since the October 1, 1992, are used pistons with a control thermal expansion (part No. 1.7.1775). For these pistons a clearance between a liner and a piston skirt is 0.04 mm and it is constant during the engine work. There are used special inserts which are placed inside an inner surface of a piston. The piston diameters are given in Table 13.

The pistons with a controlled thermal expansion ensure lower noise generating and an oil consumption. The first compression ring with trapezoidal shape in section is placed in groove made in an iron insert poured in the piston. The purpose of use of a mentioned insert is to improve the heat carrying away from a ring. It helps to avoid the piston ring blocking in the groove.

The second compression ring has a little inclined face surface (anglo 45' ± 15''). It allows for a fast fitting of a piston to a cylinder liner.

Surfaces of the first compression ring and scraper ring are chromium plated. For repair use the pistons of a same type. It is recommended a use of pistons with a controlled thermal expansion (No. 1.7.1775) for the positive results. The permissible difference of masses of connecting rods used in an engine is about 25 g. During weighting the connecting rod should be supported in line of an axis of the small end hole. Connecting rods belonging to the one selection group are marked with a figure from 1 to 8 on the proper place of cap (place *a*). Since May 15, 1996, number of the selection group is located on the connecting rod stem (place a_1).

Repair of piston-connecting rod set

- Using pliers remove compression rings and a scraper ring from a piston (1, Fig. 24).
- Remove retaining springs (5), securing the piston pin.
- Place the piston on a plate made from an aluminium or a hard wood and knock out the piston pin (6), using a hammer and a jumper. The plate should have a cylindrical seat with a radius minimum 45 mm (a half of the piston diameter) and a hole with a diameter 32 mm, for a piston pin, perpendicular to a seat. A diameter of a jumper should be 29 mm with a pivot

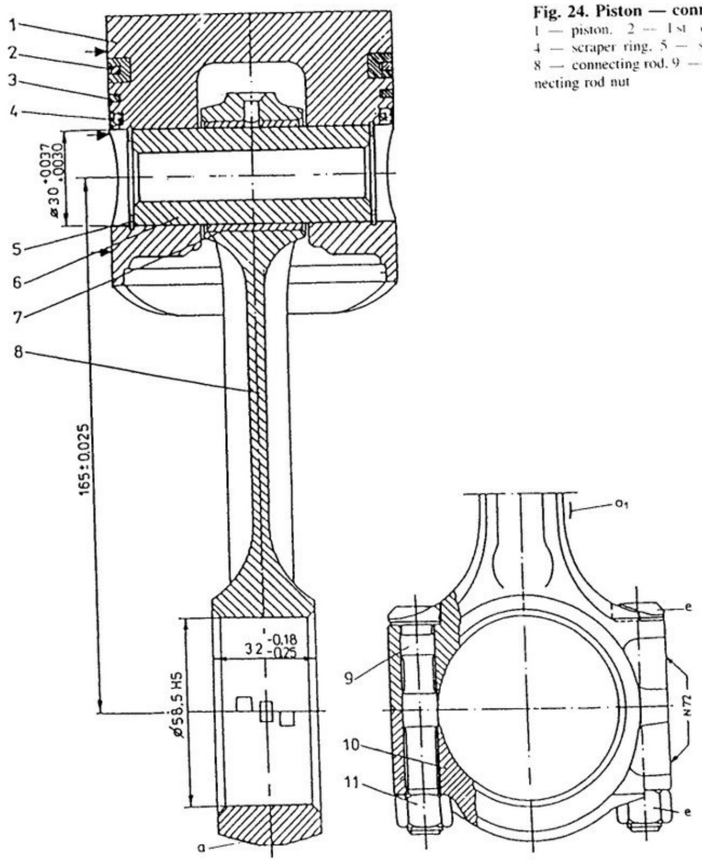


Fig. 24. Piston — connecting rod subassembly
1 — piston. 2 — 1st compression ring. 3 — 2nd compression ring. 4 — scraper ring. 5 — spring ring. 6 — piston pin. 7 — small end bush. 8 — connecting rod. 9 — connecting rod bolt. 10 — big end cap. 11 — connecting rod nut

diameter 17 mm, guiding a jumper in the piston pin hole. In case of any troubles with removing of the piston pin heat up a piston to a temperature about 70°C in the oil or water bath.

- Remove the connecting rod (8) from a piston (1).
- Unscrew nuts (11), remove the big end cap and screw nuts in their former location.
- Replace piston if there are found:
  — Deep scratches or fracture of a piston crown;
  — Excessive wear of skirt surface; measuring of piston should be performed in a perpendicular plane to an axis of pin for hole in the distance of 73 mm from an upper surface of crown; piston diameter should be not below 89,959 mm (exceptionally 89,93 mm for a piston with a controlled thermal expansion); in the distance of 81,5 mm from an upper surface of the piston crown the diameter should be not below 89,84 mm (exceptionally 89,83 for a standard piston);
  — Excessive wear of the piston pin hole; its diameter, measured in a parallel plane to the piston axis, should be not greater than 30.008 mm.
- Replace piston rings which show an excessive wear of surface mating with a cylinder liner. In result of wear increases also a slot in the piston ring. Permissible slots are given in the Table 15.
- Replace an expanding spring of a scraper ring if it is broken or shows traces of wear on the surface mating with a ring.

Slot of piston lock sizes (in mm) Table 15

Ring	Slot size	
	Nominal	Permissible
1st compression ring	0.35 ... 0.55	2.50
2nd compression ring	0.40 ... 0.65	2.50
Scraper ring	0.39 ... 0.60	2.50

- Replace the piston pin if fractured and also when its diameter is smaller than 29.985 mm in result of wear (exceptionally 29.980). Pin should be tested with eddy-current flow detector against fractures.
- Replace the connecting rod if the big end hole diameter is greater than 58.50 ... 58.513 mm. Before measuring of a diameter place a cap and tighten the nuts up to the matching of marks made on a nut and connecting rod bolt. Permissible is overtightening

for 15° (pay an attention on identifying marks N72, Fig. 24).

- Replace the worn bush of a connecting rod small end. Diameter of the bush, after pressing in the hole of a connecting rod small end, should be 30.030 ... 30.037 mm (exceptionally up to 30.08).
  To remove the bush follow as below:
  — Extract with a press the worn bush;
  — Clean a hole in the connecting rod small end; diameter for the hole and outer diameter of the bush are given in Table 16;
  — Press a new bush in such a manner that the contact surface of coiled bush edges will be on side of marks N72 (Fig. 24) and the lubrication holes of bush and connecting rod will match. Permissible is a shift of hole maximum 1 mm;
  — Ream the inner hole in the bush to diameter 30.030 ... 30.037 mm, according to the following:

(All sizes in mm) Table 16

Diameter of the hole in a small end of connecting rod	Bush outer diameter	Interference
34.000 ... 34.025	34.090 ... 34.093	0.065 ... 0.093

a) Surface roughness after machining should be $R_a = 0.63$ µm;
b) An axis of the bush hole and an axis of big end hole should be parallel; permissible is difference of dimensions $a - b = 0.025$ mm and skews $c = 0.05$ mm (Fig. 26). Measurements should be performed with special drift mandrels length 100 mm pressed in both holes of a connecting rod.

- Replace the connecting rod bolts and nuts following as below:
  — Make marks on the bolt head and on the nut side;
  — Measure and note the real length *L* of both bolts (Fig. 27). It should be within limits 69.75 ... 70.00 mm;
  — Place the bolts in the connecting rod holes screw on the nuts and tighten them up to the bolt elongation 0.11 ... 0.140 mm (tightening torque about 70 ... 75 N · m);
  — Make marks with a punch on the bolt and nut faces, according to an item *e* of Fig. 24.

Attention. During a disassembly and an assembly of connecting rod the bolts and nuts should be placed in the same holes. Each connecting rod foreseen as a spare part has marked all suitable indications referring to bolts and nuts.

- Replace the connecting rod halfshells (Fig. 28) if they are excessively worn or have a deep scratches on their working surfaces in result of seizing.
  Halfshells can be used repeatedly if:
  — Working surface is in good condition;
  — Wall thickness on the whole circumference is within limits given in Table 9
  Shells should be replaced also in case when the crankshaft pins were machined to the undersize.

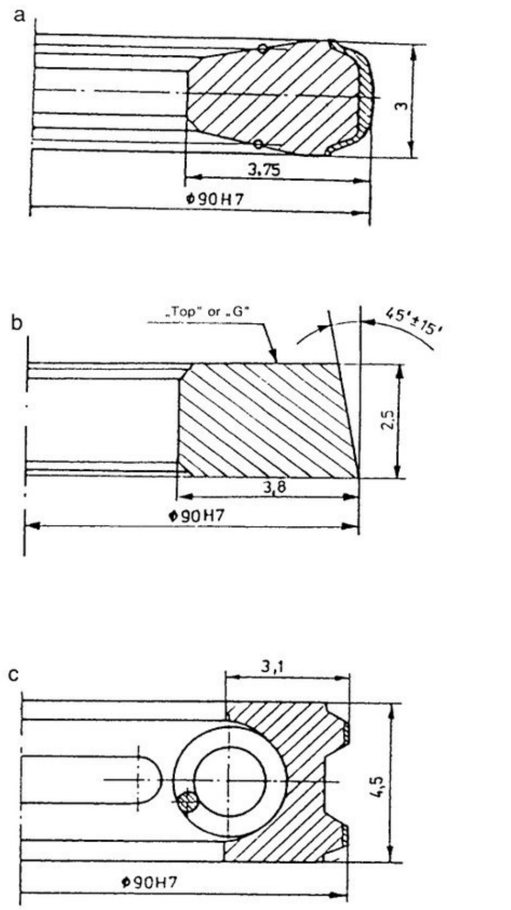


Fig. 25. Piston rings
a — the first compression ring, *b* — the second compression ring, *c* — scraper ring

- Assembly the set piston-connecting rod following as below:
  — Prepare all parts which belong to a subassembly; elasticity resistance of the piston rings should be according to values given in a Fig. 25 a, b, c.
  — Place one retaining spring ring into the groove in the piston hole for a pin;
  — Heat up the piston up to the temperature 70°C in the oil or water bath;
  — Place a connecting rod to the warmed piston then slide in a pin into the holes in a piston and a bush of the small end of connecting rod up to the contact with a spring ring; connecting rod should be placed in the manner that identifying marks will match with recess in the pi ston crown;
  — Place the second spring ring to the groove in the piston hole for pin;

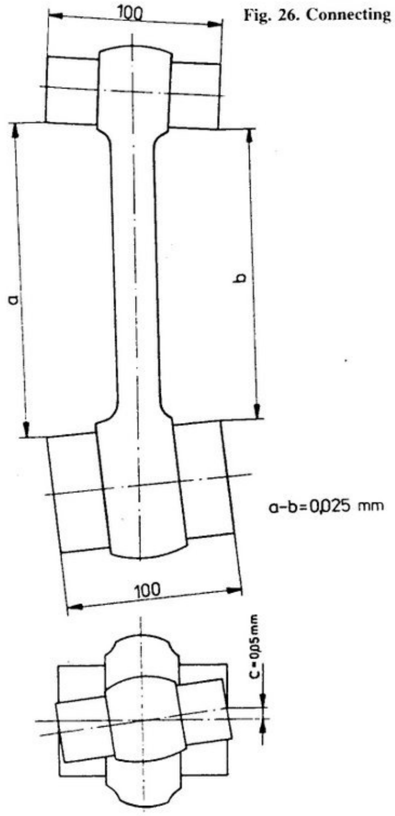


Fig. 26. Connecting rod inspection

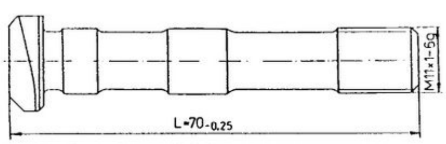


Fig. 27. Connecting rod bolt

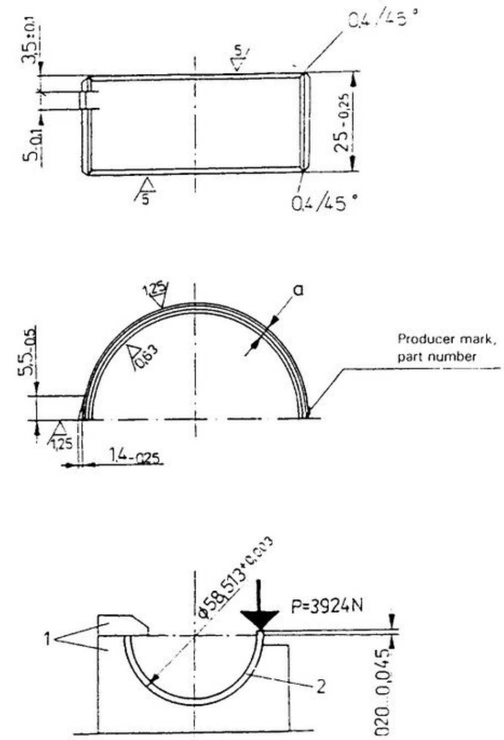


Fig. 28. Connecting rod half shell
1 — half shell seat in a checking device, 2 — half shell

— Place the scraper ring with expanding spring on the piston. The ends of a spring should be located on the opposite side in relation to the ring lock (see position *a*, Fig. 25c);
— Place the second compression ring in the second piston groove. The mark *TOP* or *G*, punched on the face surface of ring should be positioned on the piston crown side;
— Place the first piston ring in the groove;
— Place the piston rings in such manner that ring locks will be located every 120°.

7.4. Cylinder head

The complete cylinder head (Fig. 29) comprises casting of the head (28), valve seats (33), valve guides (32), valves (18) with valve springs and locks (15), valve rockers (9) and turbulence chamber inserts. Cylinder head is a casting made of a cast iron.

Seats of an inlet and outlet valves are made of the special sort of an iron. They are positioned in the cylinder head after earlier cooling in the liquid nitrogen.
Tapered working seat surfaces are ground for achieving of the proper width and position in relation to valve guides.
Valve guides (32), made of special sort of an iron, are pressed with a press into the cylinder head. An outlet valve face is surfaced by welding with a heat-resistant alloy. Valve shanks have surfaces coated with hard alloy, resistant for a wear.
On the valves placed in their guides are set seals (17) which protect cylinders against an oil penetration.
In the cylinder head there are made a turbulence chambers one for each cylinder. In each turbulence chamber is placed an injector (23) and heat plug (27). The upper part of a turbulence chamber is made in the head castings. The lower part of a chamber is a separate element made of a special heat-resistant alloy, pressed into the cylinder head.
To achieve a proper location of the chamber lower part on an outer cylindrical surface is made a special seat for a 3 mm ball located in the groove in cylinder head.
Valve rockers (9) are held and pressed with springs to valves and adjustment bolts. In the head holes made for injectors are pressed special elements with seals (24) which insulate injectors nozzles against heat.

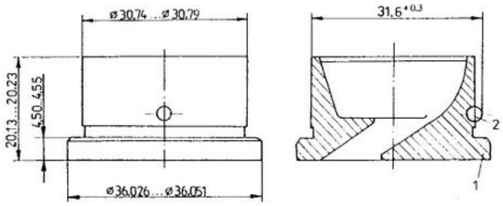


Fig. 30. Chamber insert with a ball
1 — insert, 2 — ball

permissible cylinder head surface roughness is 2.5 µm. Thickness of an removed material layer should be below 0.3 mm.

- Replace the valve seats if their working surface wear makes impossible any regeneration. Seat can be extracted with a special tool.
  Placing of a valve seat in the head:
  — Clean a hole for the valve seat with a compressed air,
  — Place a valve seat, with premachined working surface, into the cooling device with a liquid nitrogen. After cooling down to $-180°$ punch a valve seats using a special mandrel. In Table 17 are given diameters of holes in a cylinder head for valve seats, outside diameters of the valve seats and suitable interferences.

Sizes of valve seats (in mm) Table 17

Valve seat	Diameter of hole in a cylinder head	Outer diameter of a valve seat	Interference
Inlet	44.000 ... 44.025	44.070 ... 44.086	0.045 ... 0.086
Exhaust	37.000 ... 37.025	37.060 ... 37.076	0.035 ... 0.076

Attention. During taking the cooled valve seats out from cooling device and placing them to the head should be used pliers and gloves.
For knocking seats is necessary a mandrel with guiding part inserted in the valve guide. In Table 18 are given the main dimensions for mandrels used for knocking of valve seats.

Dimensions of mandrels used for knocking of valve seats (in mm) Table 18

Valve seat	Mandrel diameter	Guiding hole diameter		Guiding part length
		In guide	In the head hole	
Inlet	43	7.9	13.9	60
Exhaust	36	7.9	13.9	60

- Replace the valve guide if a clearance between a valve stem and the guide hole is greater than 0.090 mm (exceptionally 0.15 mm); for measuring use a new valve.
  Replacement of the valve guides:
  — Extrude the valve guide from a cylinder head using a mandrel with an outer diameter 13.9 mm with piloting part diameter 7.9 mm; perform extruding from side of the valve seat (Fig. 31);
  — Clean a hole for the valve guide;
  — Grease an outer surface of the valve guide with Lanolin or oil grade MS-20 and then press it into a hole in cylinder head. The guide should protrude for 18 ± 0.1 mm over the resistant surface for a spring; interference, the same for both valve guides, is 0.010 ... 0.046 mm. Note that the inlet valve guide is 59.5 ... 60 mm long and the outlet valve guide is 63.5 ... 64 mm long;

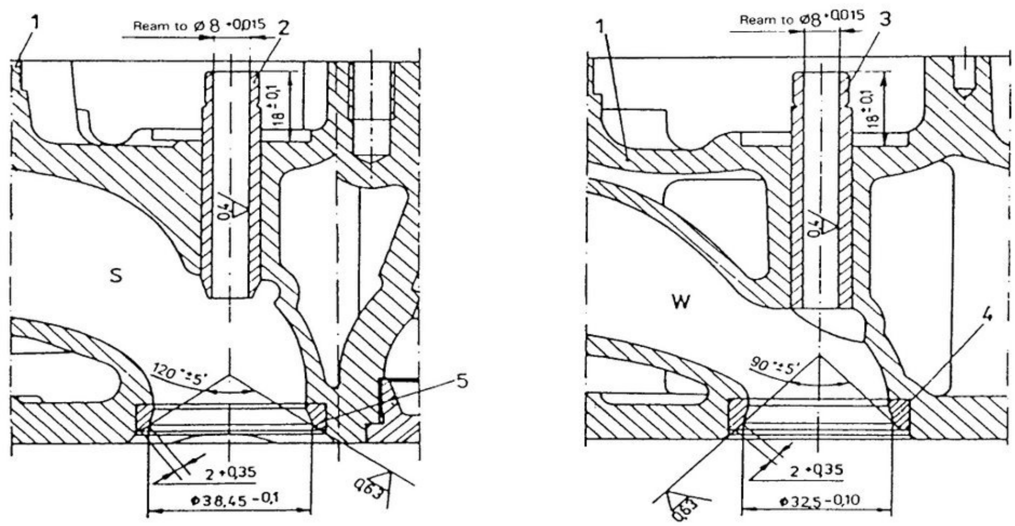


Fig. 31. Valve seats and valve guides
1 — cylinder head, 2 — inlet valve guide, 3 — exhaust valve guide, 4 — exhaust valve seat, 5 — inlet valve seat

— Using a gauge with diameter 7.980 ... 8.010 mm check holes in all valve guides; if in any guide the hole will be to small it should be reamed to size 8.000 ... 8.015 mm.

- Grind the valve seat working surfaces for width of 2.00 ... 2.35 mm. This operation should be done with a special grinder enabling achieving of angles given in Table 19 and in Fig. 31 and surface roughness $R_a = 0.63$ mm. Run out of this surface in relation to the guide hole should not greater than 0.05 mm.
- Perform the tightness test for the valve seats using a compressed air with pressure of 0.07 MPa. Used device for mentioned test should have the checking tip for the inlet and outlet valves. Tightness is proper when developed pressure will drop to zero within about 15 seconds.

Angles of valve working surfaces Table 19

Valve seat	Angle of the seat cone
Inlet	120° ± 5′
Exhaust	90° ± 5′

- If there is an excessive wear of valve working surface, valve head, stem if there are pits or fractures the valve should be replaced (Fig. 32).

For ensure a proper clearance of the inlet valve and outlet valve the stem diameter for both should be 7.925 ... 7.940 mm.

Attention

1. The valve seats with small pits or wear not significantly can be regenerated (grinding of working surfaces). The nominal caving *a* for valves should be 0.8 ... 1.1 mm, the permissible maximum is 1.3 mm (Fig. 29). To achieve the necessary working surface width (2.00 ... 2.35 mm) the seat should be milled from the upper side with a face mill, diameter 43.9 ... 44 mm for an inlet valve seat and 36.9 ... 37.0 for an outlet valve seat. From the bottom side milling should be performed with an angle mill with an apex angle 30°. In both cases the mill should be located in the mandrel with piloting part placed in the valve guide. The piloting part diameter is 7.940 ... 7.980 mm.
2. Valve seats for valves which are qualified for further use should bee ground with a special grinder, according to requirements given in Table 20 and Fig. 32. Run out of the working surface of valve in relation to the valve stem should be not greater than 0.013 mm.
3. In case when a grinder is not available a valve seat working surface can be lapped jointly with a valve head working surface. Achieve earlier such size of the working surface of a valve seat as are given in the item 1, then you can start lapping. For premachining of a valve seat working surface use a cone mill with apex angle 120° for an inlet valve seat and 90° for an outlet valve seat.

- Valve springs which are broken, with corrosion and scratches on coils (check with magnifying glass), which do not satisfy requirements given in Table 21, should be replaced.

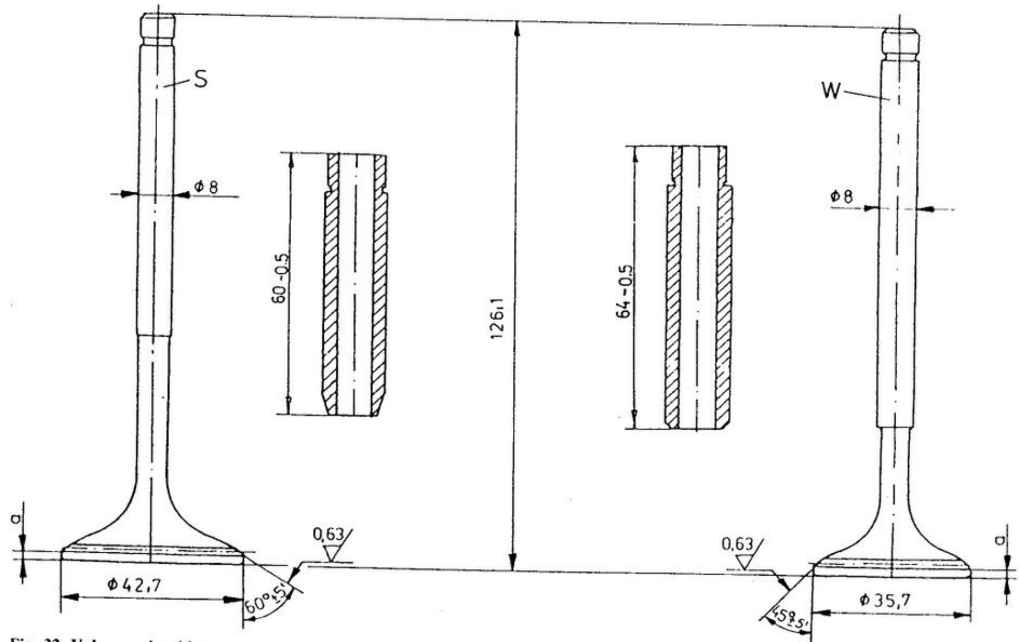


Fig. 32. Valves and guides
S — inlet valve, W — exhaust valve

Permissible height of a cylindrical part of a valve head (in mm)

Table 20

Valve	Inclination angle of the valve working surface	Permissible height a of a cylindrical part (Fig. 32)
Inlet	60° ± 5′	0.8
Exhaust	45° ± 5′	0.8

Requirements for valve springs

Table 21

Spring length (mm)			Force (N)	
In free state		Length during test	Minimum	Permissible
New	Old			
51.5	50.5	35	787	670

- Valve rockers which show an excessive wear on surfaces mating with cams of a camshaft, with adjusting bolts and guiding inserts, should be replaced.
- Adjusting bolts showing an excessive wear of the spherical surface mating with a valve rockers should be replaced.
- Turbulence chamber inserts (31, Fig. 29) which are fractured or which have significant pits should be replaced. Check also condition of the heat protecting bushes for an injector nozzles.
  Chamber inserts replacement follows as below:
  — Knock out an insert operating from an injector hole side and using a mandrel;
  — Knock out a heat protecting bush operating from the bottom side:
  — Clean a holes for a chamber insert and for a protective bush;
  — Place a ball, diameter 3 mm, to the side hole of a chamber insert (Fig. 30) using a thick grease then put in a cylinder head a chamber insert together with a ball: the ball should be in position suiting the groove in a hole, then knock in a chamber insert using a mandrel, diameter 35 mm, made of a soft steel;
  A chamber insert flange is pressed into the hole with interference 0.004 ... 0.051, cylindrical part of an insert is put with a clearance 0.33 ... 0.48 mm;
  — Check a position of an insert in the cylinder head; a maximum caving or protrusion of an insert over a chamber inner surface can not be greater than 0.05 mm;
  — Press a nozzle protection bush together with a washer into a hole for an injector.
  A chamber insert washer fit is from −0.009 (interference) up to +0.033 mm (clearance).
- Mount valves into a cylinder head:
  — Lubricate a working surface of a valve head and stem surface with an engine oil and slide a valve into a valve guide;
  — Press a cover on a valve guide up to retaining surface;
  — Put a valve spring together with a valve cup washer; press a spring in a special tool and place a half cones of a valve lock into a spring cup washer;
  — Remove a special tool, note if cones of a valve lock are in proper position
  — Check cavity of a valve head bottom surface; it should be 0.8 ... 1.1 mm for a new valve and a new valve seat; in the same manner place the remaining valves then check tightness of working surfaces using cosmetic kerosene, according to standard BN-74/0533-10; any leakage during two minutes test is not allowable.
- Screw in adjustment bolts together with lock nuts and special washers.
- Place a guiding inserts into a spring cup washers then put valve rockers on an adjustment bolts and guiding inserts then place valve rocker springs.
- Screw stud bolts (for fixing manifolds, injectors, a head flange and a water pipe connector) into a cylinder head.
- Knock in a locating pins for a head flange.

Attention. It is possible to check a cylinder head tightness dipping the head into a water for a 1 minute and using a compressed air with pressure 0.2 MPa. Any leakages are not allowable. Before connection to an air close all bottom channels with a steel plate and a gasket. A front channel close with a pipe connector with a seal. In case when safety plugs will be not tight they should be removed, clean holes and knock in new safety plugs using a stag paste and repeat a tightness test. If leakages are caused by head wall fractures a cylinder head should be replaced.

7.5. Cylinder head flange and camshaft

A camshaft is located in a cylinder head flange. A shaft supporting bearings are holes made directly in the flange. On the front end of a camshaft is located a gear driven from a crankshaft with a toothed belt. A camshaft is lubricated with an oil supplied by an oil pump through a channel made in a cylinder block and cylinder head. From a channel in a cylinder head an oil is delivered to the main channel located lengthwise in a head flange. Small channels, diameter 6 mm, deliver an oil from a main channel to bearings of a camshaft. Another channels, diameter 1 mm, deliver an oil to cams of a camshaft In the front part of a main channel is located a nozzle with a filter. It directs increased amount of an oil to the first bearing of a camshaft (from a drive side) which is loaded mostly (in relation to remaining bearings). A filter protects a 1 mm channels against clogging.
In the rear end of a camshaft is a thread hole for mounting a blade which drives a vacuum servo pump of a brake system.
Operation sequence during disassembly and repair of a camshaft is as follows:

- Unscrew two bolts together with spring washers which secure a sealing ring bush and remove a bush.
- Carefully remove a camshaft, avoid damage of journals and bearings.
- Unscrew an oil nozzle together with sealing ring. Since the March 1, 1993, are used nozzles with two sealings rings.
- Remove sealing rings from a bush and nozzle.

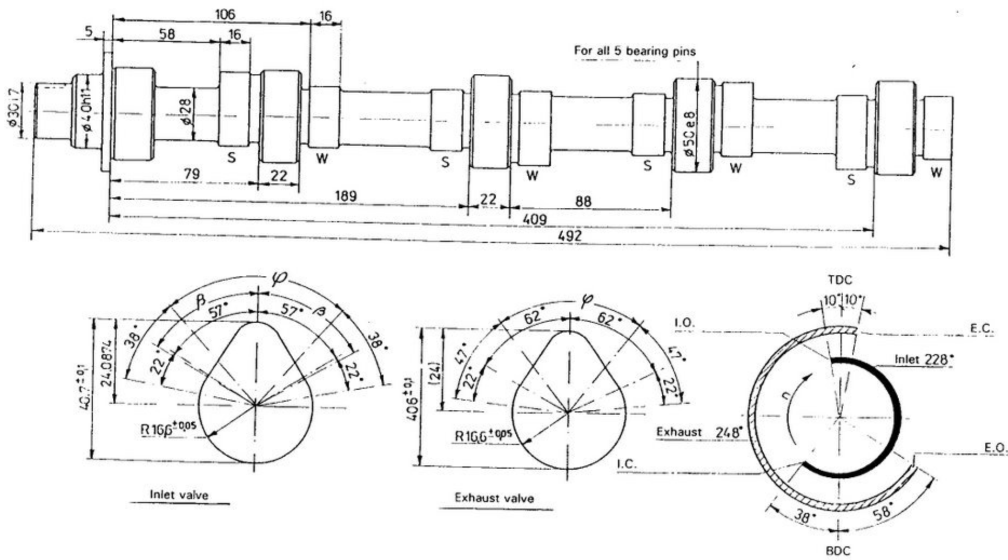


Fig. 33. Camshaft

- Wash all parts.
- Inspect all parts of a head flange. Parts damaged or worn (sealing rings, bolts and washers) should be replaced.
- Replace a head flange if:
  - — There is excessive wear of bearing holes; their diameter should be not greater than 50.025 mm (exceptionally 50.050 mm);
  - — There is an excessive warp of the surfaces contacting with a cylinder head; allowable warp is 0.05 mm; a warp can be decreased by lapping of fractures, which could cause a leakages of an oil;
- Screw off a driving blade for a vacuum pump drive and replace it in case of an excessive wear.
- Replace a camshaft if:
  - — There could be seen a deep and uneven wear of cams;
  - — There are deep scratches on journal surfaces;
  - — Fractures;
  - — Key groove damaged;
  - — Damaged is a thread of hole for screwing in a blade;
  - — There is an excessive wear of journals; journal diameter should be not smaller than 49.91 mm (exceptionally 49.85 mm);
  - — There is an excessive wear of cams; it means if a difference between a cam height *h* and its diameter *d* for an inlet valve is smaller than 7.3 mm and for an outlet valve is smaller than 7.4 mm.
- Replace an oil nozzle if it has a damaged thread or filter grid.
- Place a cylinder head flange.
- Clear all parts; a particular attention pay to oil channels in a flange; the main channel supplying an oil and channels supplying an oil to bearing could be cleaned with a special bore brush, diameter about 6 mm; eight small channels, diameter 1 mm, supplying an oil to cams should be cleaned using a soft wire (copper); avoid a damage of channels.
- After cleaning blow a head flange with a compressed air, screw in two stud-bolts for securing head flange cover:
  - — Place a camshaft in a vice (use soft pads made of an aluminium) and screw in a driving blade, up to a seizing of thread;
  - — Lubricate a camshaft bearings with an engine oil; carefully place a camshaft into a head flange and check if it turns free;
  - — Press a sealing ring into a bush; put carefully sealing ring „O" type on a bush; lubricate sealing rings with an engine oil and press a complete bush to a head flange and secure it with bolts and spring washers;
  - — Put a sealing ring on a nozzle and screw it in until increased resistance;
  - — Check an axial clearance of a camshaft; it should be 0.080 ... 0.260 mm.

A head flange cover

- Screw off an oil drain plug.
- Remove an old cover gasket.
- Carefully check visually all parts of cover.
- Replace damaged or worn sealing rings, securing nuts, retaining rings, oil drain plug and breathing connector.

- Join a new gasket with glue, for example with butapren, with flange cleaned and blown with a compressed air.
- Screw in an oil drain plug.

7.6. Engine lubrication system

During an engine work a rotor type oil pump (1, Fig. 34) sucks an oil from an oil sump (16) through a pipe ended with a strainer and delivers an oil to an oil filter (4). Primary cleaning ensures a pump strainer. An accurately cleaning ensures an oil filter. From a filter an oil is delivered to an oil main channel (14) from which it is supplied to crankshaft bearings (15), camshaft (6), injection pump driving shaft and vacuum pump. Excess of an oil flows through an overflow channel (2) and returns to the suction side of an oil pump. An overflow valve (Fig. 35) is located in a pump body and serves for a control of an oil pressure in an engine lubrication system.

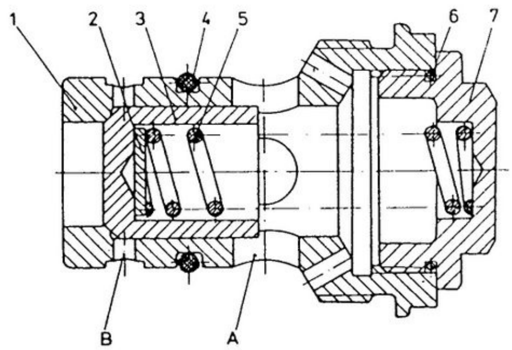


Fig. 35. Overflow valve of an oil pump
1 — valve body, 2 — adjusting washer, 3 — plunger, 4, 6 — sealing ring, 5 — spring, 7 — plug, A, B — channels

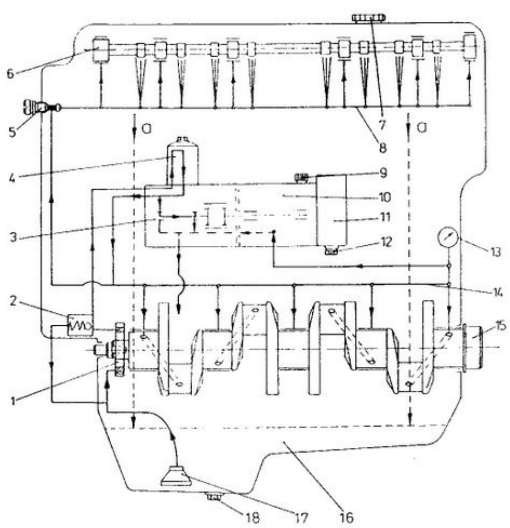


Fig. 34. Engine lubrication system
1 — oil pump, 2 — overflow valve, 3 — injection pump support, 4 — oil filter, 5 — nozzle, 6 — camshaft, 7 — oil filler plug, 8 — oil channel, 9 — oil filler plug, 10 — injection pump, 11 — speed governor, 12 — oil drain plug, 13 — gauge, 14 — oil channel, 15 — crankshaft, 16 — oil sump, 17 — strainer, 18 — oil drain plug

Oil pump

In an engine is used an oil pump of a rotor type with outer and inner toothed gears (Fig. 36). A pump output at 800 rpm and pressure of 0.1 MPa is 10 dm^3/min and at 4200 rpm and pressure 0.5 MPa is 60 dm^3/min.

Oil pump is directly driven from a front end of a crankshaft (it is located on the front end of a crankshaft).

The operation sequence during an oil pump repair is as follows:

- Unscrew bolts M6 securing a cover.
- After removing of cover remove rotors.

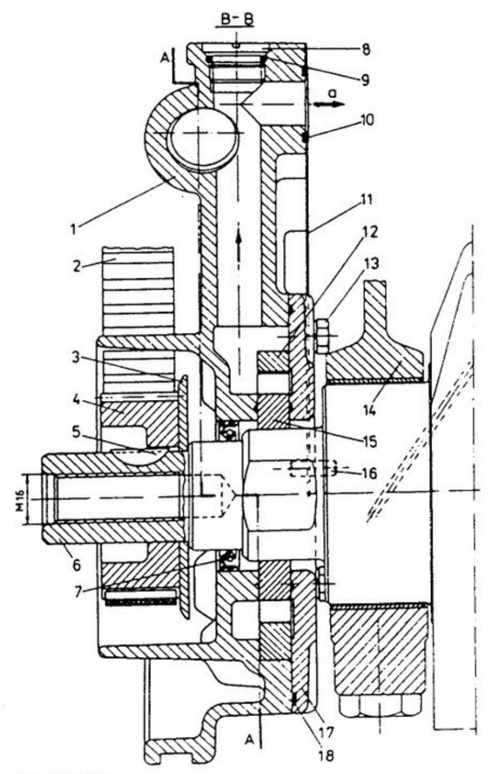


Fig. 36. Oil pump
1 — pump body, 2 — toothed belt, 3 — guiding disc, 4 — crankshaft gear, 5 — key, 6 — crankshaft, 7, 9, 10 — sealing rings, 8 — plug, 11 — oil pump gasket, 12 — pump rotor outer, 13 — bolt fixing pump cover, 14 — cylinder block, 15 — pump rotor inner, 16 — locating pin, 17 — pump cover, 18 — sealing ring

- Wash parts of a pump with a clean gasoline and check them.
- Rotors which show results of seizure or chipping should be replaced; always replace both rotors.
- Sealing ring GZD 35×47×7 or A35×47×7 RDR-FMP (used since the beginning of 1997) with worn or damaged sealing lip should be replaced. It should be also replaced if its elasticity is significant decreased.
- Sealing ring of „O" type A120×3 should be replaced if its shape is changed or if it is not enough elastic.
- The pump body which is mechanically damaged should be replaced.
- Screw off an overflow valve plug (valve is screwed in a pump body) and remove a spring and a piston.
- If a piston shows significant wear or significant wear shows a valve body what can cause leakages, both elements should be replaced.
- Spring which is fractured or shows an excessive wear on its outer surface should be replaced.
- Assembly a pump performing all operations in the opposite sequence; pay a attention if the outer rotor is properly located in a pump body; a chamfer should be inside a pump body. A new oil pump should be filled with an engine oil (about 1 cm^3) before mounting to an engine. Priming a pump should be done through a suction channel. Turn a pump rotor.

7.7. Engine cooling system

A centrifugal type pump causes a circulation of a liquid which cools an engine. The pump is driven with a V-belt from a crankshaft. When an engine is not enough warm a thermostat closes a „small" cooling system. Cooling liquid can not flow through a radiator. It ensures an even and a fast heating of an engine.
After heating an engine to a proper temperature thermostat opens a valve and a full liquid stream flows through the radiator. When liquid temperature will be about 92°C, and a temperature of an air flowing through a radiator will be about 60°C a visco type clutch starts to drive a fan. Fan switching on causes cooling liquid temperature drop to the operational level. Then fan switches off and rotates only by inertia.

Cooling liquid pump

In the pump body (5, Fig. 37) is located a rotor shaft (9) together with a bearing (4). A ball bearing is filled with a special grease and is closed from both sides. It does not need any service. A sealing element (8) ensures the pump tightness from the rotor side. It is pressed into the pump body. Sealing element has a spring pressing it to the pump rotor (7). Such solution ensures a proper tightness. If there are any leakages it means that a sealing element is already worn or damaged. On the other end of a shaft is located a hub (1) to which is fixed a pulley (3) with a bolt (2) and a fan with visco clutch which is secured on the hub with nut with a left hand thread. It prevents loosing of nut during an engine operation.

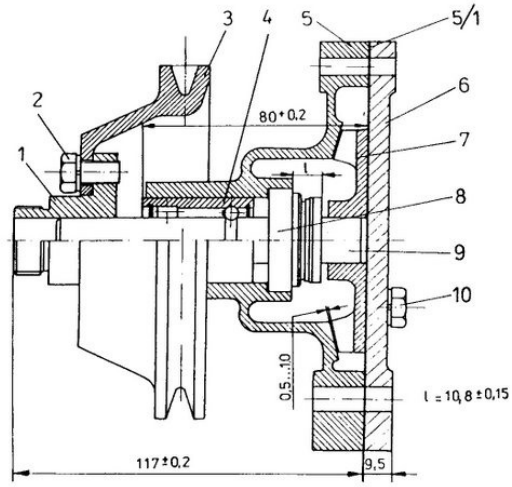


Fig. 37. Water pump with pulley
1 — hub, 2 — bolt, 3 — pulley, 4 — bearing, 5 — pump body, 5/1 — pump cover gasket, 6 — cover, 7 — rotor, 8 — sealing ring, 9 — shaft, 10 — bolt

Cooling liquid pump repair

- Unscrew a visco clutch together with a fan (1, Fig. 38) using a flat wrench 32 (clutch has a left hand thread).
- Unscrew securing bolts (2) and remove a pulley (4).
- Unscrew band clips and remove rubber hoses.
- Unscrew nuts (13, 15) and remove a pump.
- Remove a pulley hub (6) using a puller (Fig. 39) from a shaft (7).
- Screw off a screw (25) and bolts (23) and remove a cover (20) together with a gasket (19).
- Using a press squeeze out a shaft (7) together with a sealing element (17) and a rotor (18); force should be applied toward a rotor.
- Using a press squeeze a rotor (18) out from the pump shaft and remove a sealing element (17).
- A fractured or damaged pump body should be replaced.
- A damaged or excessively worn rotor should be replaced.
- A worn surface mating with sealing element can be ground and lapped; surface roughness after machining should be not greater than $R_a = 0.2$ µm and its run out in relation to the rotor hole should be not greater than 0.05 mm.
- Replace a sealing element (Fig. 40) if:
  - — A spring (4) and a sealing ring (1) are damaged;
  - — A sealing disc (3) is broken or has a deep scratches on its surface.

  Sealing element should be 19±0.3 mm long. After pressing it to 15±0.4 mm applied force should be 69 ... 88 N. After releasing a sealing disc (3) should return back without any jamming to a resistance surface of a sealing element housing.

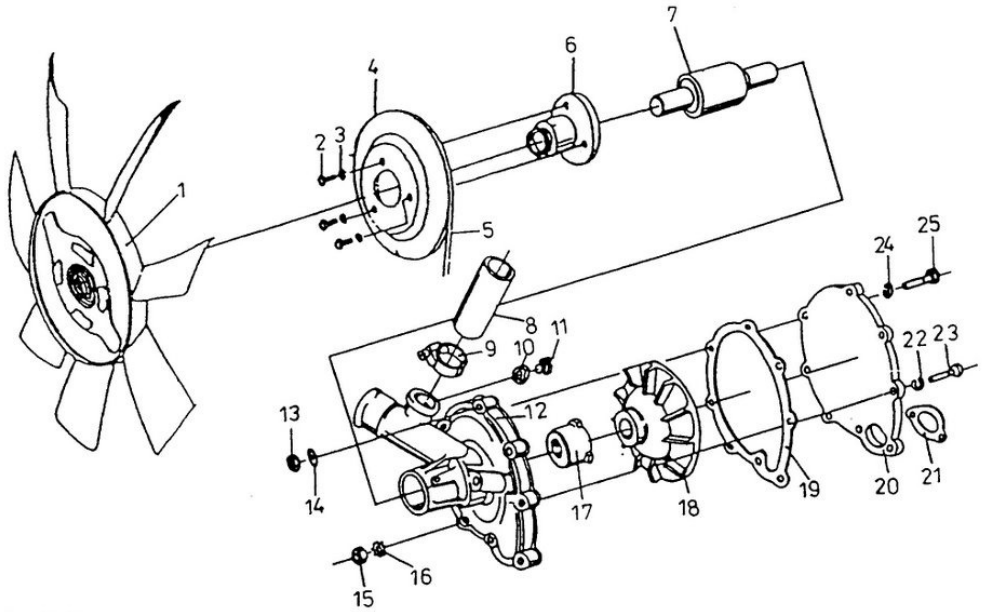


Fig. 38. Water pump parts
1 — fan (Eaton). 2 — bolt. 3 — spring washer. 4 — pulley. 5 — V-belt (Morathon). 6 — hub. 7 — shaft with a bearing. 8 — hose. 9 — band clip. 10 — washer. 11 — plug. 12 — pump body. 13 — nut. 14 — washer. 15 — nut. 16 — spring washer. 17 — sealing element. 18 — rotor. 19 — gasket. 20 — pump cover. 21 — gasket. 22 — washer. 23 — bolt. 24 — washer. 25 — screw

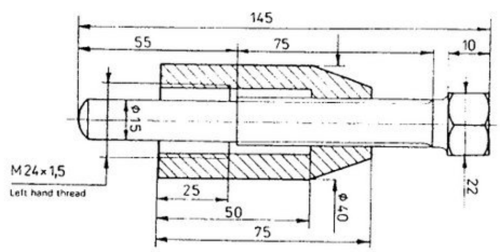


Fig. 39. Puller for dismounting of a water pump pulley hub

- If a bearing is very noisy during operation or a clearance of a bearing side shield is greater than 0.12 mm a shaft should be replaced together with a bearing.

Assembly of a cooling liquid pump

- Press a sealing element (8, Fig. 37) into a pump body (12, Fig. 38) using a mandrel with diameter 45 mm and check a distance „l" (it should be about 10.8 mm) between a sealing element (8) and a seat edge.
- Slide a shaft to a pump body (from a visco clutch side); a bearing face surface should be 80±0.2 mm from a rear surface of a pump body. Bearing fit in a pump body: interference = ±0.015 mm.
- Place a rotor on a pump shaft using a press, to achieve a clearance 0.5 ... 1.0 mm between a rotor blades and a pump body.

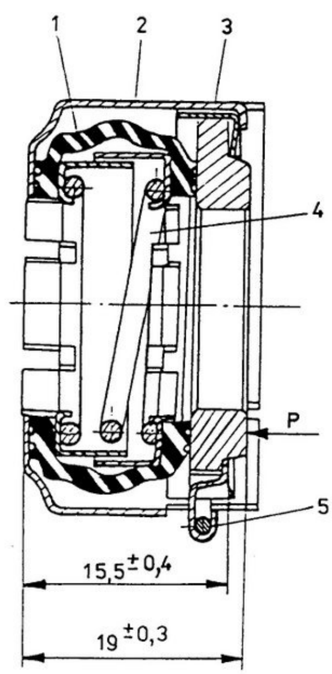


Fig. 40. Water pump shaft sealing element
1 — sealing ring. 2 — sealing element housing. 3 — sealing plate 4 — spring. 5 — connection

Attention. A fit of a rotor and a pump shaft is 0.005 ... 0.050 mm. After pressing a pulley hub on a pump shaft mount a pump cover (6).

Fan clutch — construction and operation

In engines 4C90 and 4CT90-1 is used a servicefree visco clutch of Eaton for transmitting a torque from a cooling liquid pump shaft to a fan.
A visco clutch operation is based on existence of a liquid viscosity resistance. A drive torque is transmitted through an input shaft firmly connected with a clutch disc. A clutch housing consisting a two parts is connected with a fan and is a clutch part which is driven. Between these two precisely matched parts is a small gap filled with silicon liquid. This liquid is used for transmission of driving torque from an input shaft to a housing connected with a fan. There not any contact between a clutch disc and a housing; the only connection is through a thin layer of a silicon liquid.
A clutch housing rotates with a smaller velocity than a driving shaft. When a driving shaft rotational velocity increases the difference between velocities of both elements and a clutch slip decrease up to achieving of a maximum fan velocity. Since this moment it is impossible to increase a fan velocity because of a viscosity resistance force. A use of a special valve enabling a flow of liquid from a tank to a clutch chamber allows an additional increase of a fan velocity.
Bimetallic spring element controls opening and closing of a valve. It is of a spiral shape and is located in a front part of a clutch. The bimetallic element is sensitive for any changes of temperature of an air which flows through a radiator and reaches a fan. As a temperature of an air increases also a rotational velocity of a fan.
Eaton visco clutch has automatic limitation of a maximum rotational fan velocity. The limit is about 3500 rpm in spite of greater velocity of a driving shaft. It is a result of a slip at this velocity. The purpose of a mentioned limitation is to decrease a noise. A 3500 rpm is a limit for a fan of this size. Above this limit there is significant increase of noise produced by fan blades.
Attention. A visco clutch can not be repaired. It should be checked and when found defective should be replaced. An operation of an engine with a damaged visco clutch is forbidden.

Thermostat

Thermostat (Fig. 41) is located in a housing fixed to a front wall of a cylinder head.
It is responsible for a control of a cooling liquid flow to a radiator. When temperature reaches 74 ± 2°C a thermostat begins to open a valve. The full opening is reached at a temperature 86 ± 2°C.
In case when it is necessary to dismantle a thermostat from an engine follow as below:

- Partially drain a cooling liquid from a cooling system to achieve a liquid mirror lever below a hole in a cylinder head through which liquid flows to a thermostat.
- Loose a band clip and remove a hose from an upper connection of a thermostat housing.

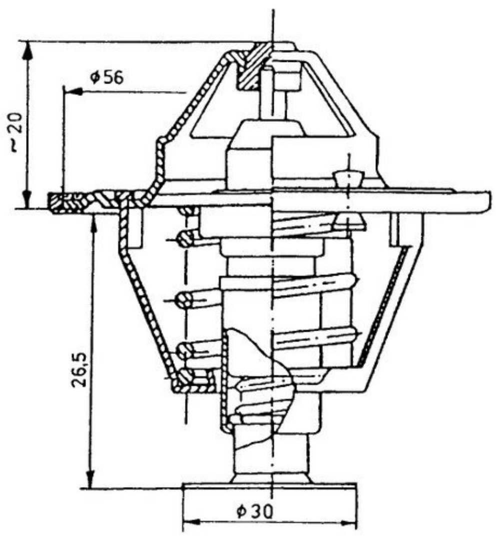


Fig. 41. Thermostat of 4C90 engine

- Unscrew three bolts and remove washers.
- Remove a cap and remove a thermostat.

Visually check a thermostat and particularly pay an attention to surfaces of a valve and a valve seat in a housing. Any damages can cause a bad operation of a thermostat and when found the thermostat should be replaced.
A damage of a bimetallic sensor causes closing of a valve and a cooling liquid can not flow through a radiator. Such case can be easy noticed because a cooling liquid reaches a high temperature (in a summer season it leads to an engine overheating). Thermostat is preadjusted in a factory and there is not possible to adjust it later.
A thermostat operation can be checked in a following manner:

— Hang a thermostat in a vessel filled with water and heat it controlling a temperature with a thermometer; A valve should start an opening at 72 ... 76°C;
— Continue heating an check a temperature when it will be fully open; it should be at 84 ... 88°C.

In case of faulty operation a thermostat should be replaced.

7.8. Fuel supply system

A fuel supply system (Fig. 42) has a plastic tank (1), supply pump (2), fuel filter (14), injection pump (4), fuel pipes and injection pipes (5) and injectors (6) located in a cylinder head.
For a proper operation of a whole fuel supply system is necessary a regular service of a fuel filter and a supply pump. It ensures a delivery of a clean fuel to an injection pump. During an engine operation a supply pump (2) sucks a fuel from a tank and delivers it through a fuel filter (14) to an injection pump (4). An injection pump delivers

a fuel through a high pressure pipes (5) to injectors. An excessive amount of fuel delivered by an injection pump and from injectors and filter is taken off with an overflow pipes to a tank. Fuel tank is located on the left side of a truck and its capacity is 85 dm^3. A broken or damaged fuel tank should be replaced.

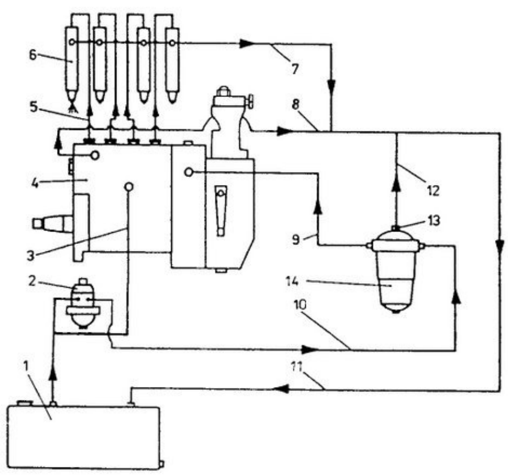


Fig. 42. Fuel supply system
1 — fuel tank, 2 — fuel supply pump, 3, 7, 8, 11, 12 — overflow pipes, 4 — injection pump, 5 — high pressure pipes, 6 — injectors, 9, 10 — supply pipes, 13 — overflow pipe, 14 — fuel filter

Supply pump

An eccentric of a shaft driving an injection pump drives a membrane type fuel supply pump (Fig. 43).
For repair a supply pump follow as below:

- Screw off a bolt (8) fixing a cover (7) to a pump head (4); remove a cover and a grid strainer with a gasket (5).
- Screw off screws (6) fixing a head to a pump housing (1) and part both elements.
- Press a membrane (3) and then rotate it clockwise or anticlockwise for 90° and remove it together with a spring; in case of an excessive clearance between a rocker (13) priming a pump membrane and its spindle (11) which is pressed into a pump support or in case of an excessive wear of the end surface of a rocker matching with an eccentric on the injection pump driving shaft knock out a rocker spindle (11) and replace both parts.
- Wash carefully all parts in a kalibrol oil or in a diesel oil, clean a grid strainer (5) and parts of an inlet and outlet valve.
- Damaged grid strainer should be replaced.
- Damaged valves (which are located in a head (4)) should be replaced.
- Fractured membrane and a spring showing a wear should be replaced.

Assembly a pump following all steps in a opposite sequence.

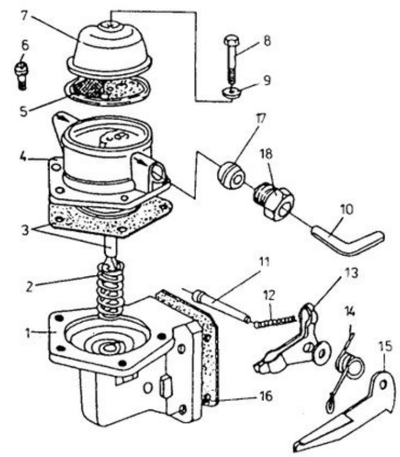


Fig. 43. Fuel supply pump parts
1 — housing lower part, 2 — membrane spring, 3 — membrane, 4 — housing upper part, 5 — filter grid, 6 — screw, 7 — decanter cover, 8 — bolt, 9 — washer, 10 — fuel pipe, 11 — rocker shaft, 12 — spring, 13 — rocker inner, 14 — rocker spring, 15 — hand operated lever, 16 — gasket, 17 — pipe end, 18 — pipe connection

Fuel filter

Periodically rotate anticlockwise (6, Fig. 44) a valve head to drain a fuel mixed with a water and impurities. Then tighten a valve. A filter cartridge (1) should be replaced every 20 000 km. To perform this operation unscrew a bolt (7), remove a cap (9) and remove a filter cartridge (1). A strainer (3) should be washed with a diesel oil. After inserting a new filter cartridge (1) assembly a fuel filter tightening a bolt (7) and breath a fuel supply system. A repair of a fuel filter means a replacement of worn or damaged parts.

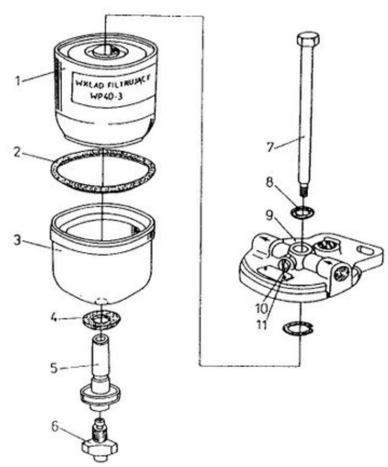


Fig. 44. Fuel filter
1 — filter cartridge, 2, 8, 11, 13, 14 — seal, 3 — decanter, 5 — valve body, 6 — valve tap, 7 — bolt, 9 — cover, 10 — breather, 12 — bolt with hole

Injection pump

Engines 4C90 and 4CT90-1 are equipped with an injection pump, in-line type, produced in Czech Republic — Motorpal Jihlava (Fig. 45).

An injection pump is driven with a toothed belt from a crankshaft through an injection angle shifter placed on a shaft supported in a cylinder block. An injection pump is coupled with a driving shaft through a splined bush. There is removed one tooth in a gear of an injection pump and in a gear of a driving shaft. It enables a proper setting of an injection pump in relation to a crankshaft and a camshaft.

An injection pump should be regulated on a special test stand equipped with nozzles KDOP 115 S 530-4376 in injectors NC 57A 1304 adjusted to a opening pressure 17 MPa and with an overflow valve adjusted for a pressure 0.015 ... 0.030 MPa. Diameter of an injection pipes is 6 and 8 mm and length 750 mm. Regulation should be performed according to an instruction edited by Motorpal Jihlava.

Numbers of injection pumps used in engines produced by WSW Andoria:

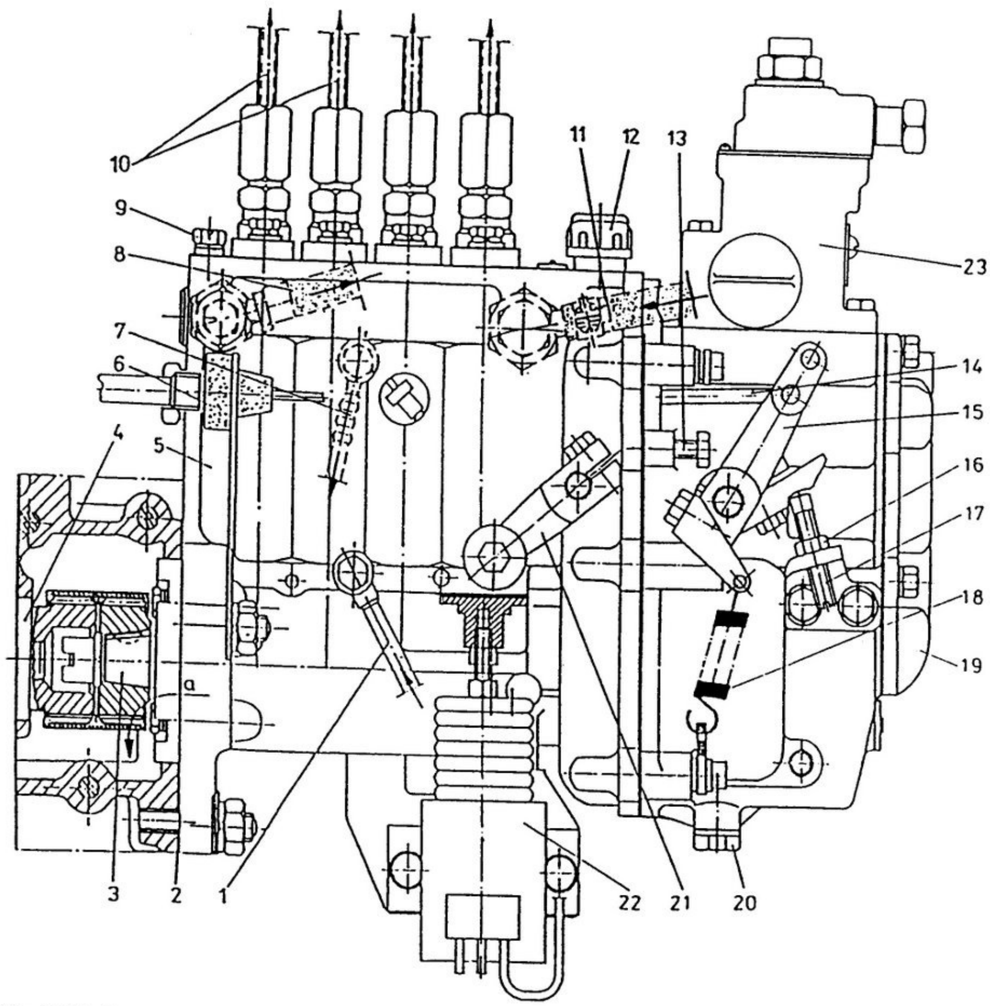


Fig. 45. Injection pump

1 — oil pipe, 2 — gasket, 3 — injection pump driving shaft, 4 — support, 5 — pump body, 6 — cable armour, 7, 8 — overflow pipes, 9 — breather, 10 — injection pipes, 11 — supply pipe, 12 — engine oil filler plug, 13 — thrust bolt, 14 — control lever, 15 — injection pump control lever, 16 — securing nut, 17 — idling speed adjusting screw, 18 — pulling spring, 19 — governor cover, 20 — oil drain plug, 21 — engine stop lever, 22 — electromagnetic mover switching off an injection pump and an engine, 23 — overpressure pluga — oil flow direction

Attention: Engine idling speed adjustment (800 rpm) is performed with a screw (17) after loosing of a securing nut (16). After setting tighten a nut.

Engine 4C90

Cv 5135 M for pumps PP4M7Ple 3083 (without a STOP lever);
Cv 5954 M for pumps PP4M7Plg 3175 (with a STOP lever).

Engine 4CT90-1

Cv 5929 M for pumps PP4M7Ple 3073 (without a STOP lever);
Cv 5953 M for pumps PP4M7Plg 3176 (with a STOP lever).
A pump regulation should be performed by an authorised workshop equipped with suitable devices and instruments. The workshop should be also authorised by Motorpal Jihlava. Some basic data taken from a regulation instruction are in Tables 22 and 23. An injection pump for a turbocharged engine (3176) has additionally an overpressure corrector (23, Fig. 45) mounted on the speed governor. Its operation is similar to operation of a negative corrector it means it decreases a fuel dose when decreases an engine speed. It decreases an emission of smoke. This corrector serves also as a limiter of a fuel dose at sudden acceleration when a turbocharger supplies a small amount of an air because of a low engine speed. Injection pumps used for an engines 4C90 have not any overpressure corrector.
A lubricating oil delivered under pressure to a corrector makes impossible switching on a start up dose during an engine operation. Pressure fluctuations of air conducted from an inlet manifold over a pressure corrector membrane are transmitting by a double-arm lever to a tooth of a control rod rack cable. It is a way enabling a control of a fuel dose in relation to a charging pressure.
In case of a pump wrong operation an injection pump should be adjusted or repaired.

Attention. A repair and regulation of a pump after repair should be performed by a specialistic workshop according to a producer repair manuals.
Considering a precision of a pump manufacturing and a role of pump in an engine assembly a damaged injection pump deliver for repair to a workshop which is authorised by Motorpal Jihlava.

An injection pump (and an engine) can be switched off by pulling (towards) a cable handle by slightly depressed an acceleration pedal. A released control lever (14, Fig. 45) moving beyond idle speed position shifts an angle lever, a free lever and a control rod rack in a rear extreme position STOP.
Since the February 1, 1996, injection pumps are equipped with a STOP lever (21, Fig. 45) controlled by an electromagnetic mover (servo) (22).
After switching an ignition switch on to a starter terminal „50" and to an electromagnetic servo pulling winding (white wire) delivered is simultaneously the same voltage. After drawing a servo core (to a position shown in Fig. 45) an inner microswitch switches a voltage of an ignition switch to a supporting winding (red wire). It ensures that after switching an engine on and after return of a key to a position „I" a mover remains switched on and a STOP lever remains in position „WORK" (as it is shown in Fig. 45). To stop an engine it is necessary to turn a key to position „O". It causes disconnection of voltage and an inner spring will shift a STOP lever in a „stop" position.

Regulation data for an injection pump PP4M7Plg 3175

Table 22

Operation	Pump shaft rotational speed rpm	Injection number	Output dose (cm^3)	Permissible dose deviation (cm^3)
Beginning of a speed governor operation	2180 ... 2200		Time of a dose decrease	
	Max. 2500		End of dosage	
Nominal dose	2100	400	15.8 ... 16.2	±0.6
Corrector dose	1250	400	18.1 ... 18.6	±0.4
Start dose	150	100	Min. 6 ... 7	±0.5

Attention. For an injection pump adjustment use a test oil Kalibrol according to standard ISO 4113-1978.

Regulation data for an injection pump PP4M7Plg 3176

Table 23

Operation	Pump shaft rotational speed rpm	Injection number	Output dose (cm^3)	Permissible dose deviation (cm^3)
Beginning of a speed governor operation	2140 ... 2160		Time of a dose decrease	
	Max. 2600		End of dosage	
Nominal dose	2050	400	20.3 ... 20.7	±0.6
Corrector dose	1250	400	Increase of a medium dose by 2.2 ... 2.7 cm^3 at 400 injections in relation to a nominal dose	±0.4
Start dose	150	100	Min. 6 ... 7	±0.5

Attention. For an injection pump adjustment use a test oil Kalibrol according to standard ISO 4113-1978.

To ensure a proper work of a mover (servo) and an injection pump, during adjustment of a mover follow as below:

- Remove a STOP lever from a pump.
- Loose a solenoid washer screwing a solenoid in up to the resistance (down).
- Loose a nut located on a mover core screwing it in up to the resistance (down).
- Press a solenoid to a position „switched on" (when under voltage).
- Mount à STOP lever with a bearing on a pump in such position that a clearance between a bearing and a washer is a minimal and it is still possible to mount a lever on a pump (position „stop" with one tooth below horizontal position).
- Cancel a clearance between a lever bearing and a washer.

- Screw off a washer four revolutions up.
- Tighten nuts.

In case of wrong mover operation it should be checked:
— Electric wiring; remove any dirt from connectors, check all connections against any breaks or faulty connections;
— Freedom of movement of a mover core; remove any reasons of jamming.

A governor lever mechanism is lubricated with a engine oil. An oil circulation system is connected to a pump lubrication system which is connected to an engine lubrication system. Both Inlet and drain holes are closed with plugs located in a housing and in a speed governor cover. Speed governor can be repaired only by a specialised workshop.

Injectors

Up to January 10, 1994, it means to a S/N 12920 were used injectors type WNS-13/2.73.027. Since January 10, 1994, it means from S/N 12921 to September 27, 1994, it means up to S/N 16454 were used injectors type WNS-19/2.73.070. Since September 27, 1994, it means from S/N 16455 are used injectors type WNS-21/2.73.072. Since June 15, 1996, are used as a replacement part injectors produced by Motorpal Jihlava type VA 42 S 390 2698.

Injectors are located in seats of cylinder head. A separate clamp (1) and a two stud-bolts with nuts M8 secure each one. To protect a nozzles against an excessive heating there are pressed a protective bushes into a holes of cylinder head. Between an injector and protecting bush is located a copper washer (14) and between a bottom of a protective bush and a nozzle is located a wavy sealing washer (15) made of a steel. Both washers are only for a single use it means they can not be used again after a disassembling and an assembling of an injector.

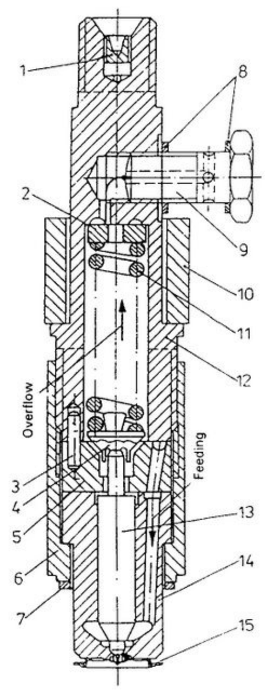


Fig. 47. Injector section
1 — filter, 2 — adjusting washer, 3 — dowel 3n6, 4 — cup lower, 5 — washer, 6 — nozzle nut, 7, 8 — copper seals, 9 — connector bolt, 10 — beam, 11 — spring, 12 — injector body, 13 — needle, 14 — nozzle body, 15 — steel seal

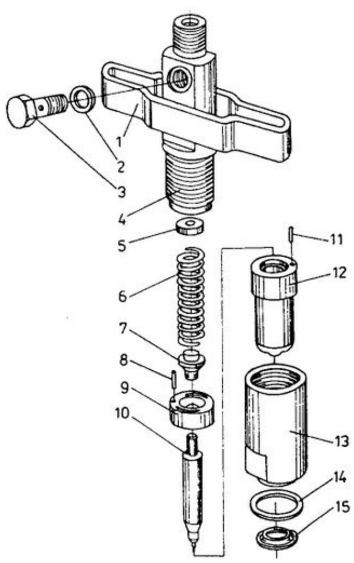


Fig. 46. Injector parts
1 — fixing beam, 2 — seal, 3 — connecting bolt, 4 — injector body, 5 — adjusting washer, 6 — spring, 7 — cup lower, 8 — dowel 2n6, 9 — adjusting washer, 10 — needle, 11 — dowel 3n6, 12 — nozzle body, 13 — nozzle nut, 14 — injector copper seal, 15 — injector steel seal (waved)

Probably reasons of wrong operation of an injector:
— Decrease of an opening pressure; after first 5000 km this decrease should be not greater than 10% of the primary opening pressure.
— Break or bending of retaining dowels (8, 11, Fig. 46) caused by improper disassembly or assembly of an injector (it refers to injectors type WNS-13 only);
— Use of a second washer without removing the worn one;
— Fuel leakages on surfaces critical for tightness of an injector;
— An excessive wear of an insert face in result of knocking of an injector needle valve; as a result increases a needle valve stroke and disturbances in dosage;
— Damage of a cone thread in an injector housing from side of a fuel pressure pipe connection;
— A lack of tightness between a needle valve and its seat;

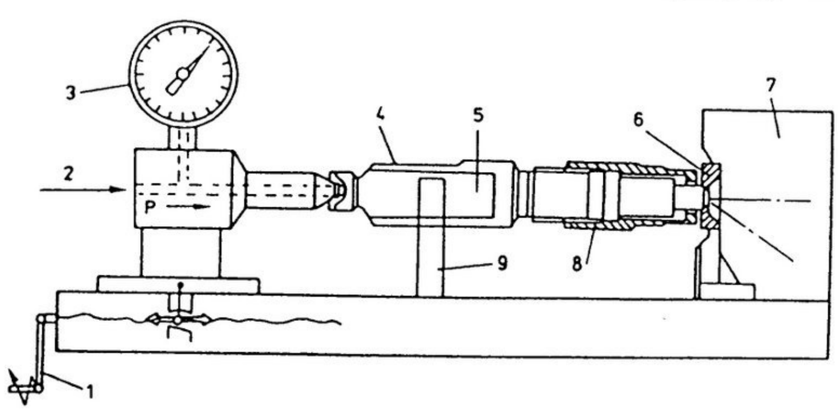


Fig. 48. Device used for assembly and testing of injectors
1 — force developing system (P = 19 ... 22 kN). 2 — fuel supply. 3 — manometer. 4 — injector under test. 5 — injector flattening. 6 — eye support. 7 — vessel. 8 — tightening surfaces. 9 — device yoke

— Hanging of a needle valve;
— Broken spring.

Conditions of a proper operation of an injector:
— Use of a clean fuel;
— Disassembly and assembly of an injector performed by an authorised workshop; during a travel in a road condition an injector can be only replaced;
— During a pressure adjustment use at least two adjusting washers (5, Fig. 47);
— For assembly and checking of an injection use only a device shown in Fig. 48;
— Before mounting an injector together with a copper washer a seat and protective bush in a cylinder head should be carefully cleaned;
— Tighten all thread connections with indicated torque: a nozzle nut 50 ... 70 N · m, a nut of an injection fuel pipe 15 ... 25 N · m, a nut of a securing clamp 10 ... 20 N · m.

Inspection and replacement of an injector

An inspection of an injector on an engine is limited. Without any instruments it is possible only to notice if all moving parts have freedom of movement and if a needle valve is not hanged.
To evaluate injectors operation loose a nut of a fuel pipe connection of this injector which does not operate (you can not feel with fingers a pressure pulsation inside an injector fuel pipe) and watch an operation of an engine. If any difference can not be noticed it means that an injector is defected and should be replaced or repaired.

Remarks

1. In case of replacement of injectors type WNS-13 for WNS-19 or WNS-21 and WNS-19 for WNS-21 replaced should be a set of injectors.
2. In case of replacement of injectors for a new type also replace the whole set.
3. Stipulations of items 1 and 2 refer to an optimal engine operation conditions. In special cases a replacement of one injector or use of injectors of different types is allowed but only to reach a nearest workshop.
4. Because of difference in length of nozzles BDNOSCP 6389 (used in injectors WNS-13) in relation to nozzles DNOSD 265 (used in injectors WNS-19) and also DNOSD 256 and DNOSD 256A (used in injectors WNS-21) in case of replacement of injectors of type BDNOSCP 6389 for a new type should be replaced complete injectors. Nozzles DNOSD 256 and DNOSD 256A are fully interchangeably.
5. For engines 4C90 and 4CT90-1 are especially recommended nozzles DNOSD 256 and DNOSD 256A. They ensure the best results in reference to noise level, durability and toxicity of exhaust gases.

Recommended workshop equipment for injectors repair (without nozzles regeneration)

1. Hand operated checking device for example PRW-3, produced by WSK Kraków for checking and adjustment of injectors. With this device it is possible to check:
   — Tightness of cone surface of nozzle during static test;
   — Tightness of guiding surfaces of an injector;
   — Quality of an atomised fuel;
   — An injector bleeding during dynamic test;
   — An injector opening pressure.
2. Special device for inspection of inner surfaces of nozzle to estimate a wear.
3. Device for disassembly and assembly of an injector (Fig. 48) which enables:
   — To tighten of an injector nut;
   — To check an opening pressure;
   — To check an injector tightness.
4. Trays for washing an injector parts.
5. Set of tools for cleaning of hardly accessible injector surfaces:
   — Special rod scrapers for cleaning of a cone seat in

a nozzle, for removing of a carbon deposit and others from a pressure chamber of an injector;
— Holders with wolfram needles for cleaning of nozzle openings.

6. Torque wrenches.
7. Vice with soft clamps.
8. Universal measure instruments.
9. Brushes for cleaning injector parts.

Improvised repair of an injector

A repair which relays on a replacement of worn or damaged parts and on washing and cleaning of parts which can be used further.
For parts washing use an Antykor kerosene. For cleaning use means listed in a workshop equipment specification.

A. Injector disassembly
Operation sequence:
— Fix an injector in a device (Fig. 48),
— Unscrew an injector nut (13, Fig. 46),
— Remove: nozzle holder (4), insert, spring cup (7) and adjustment washer (9).

Attention. In case when a special device for disassembly is not available it can be used a vice with soft clamps. Clamp an injector on a flat place of an injector body (width 14 mm).

B. Verification of injector parts
- In majority of cases damaged is a nozzle. Check it carefully with a special device for inspection of inner surfaces:
  — Check a cone seat and guiding surface in an injector body;
  — Check if there are any metallic deposits, scratches if atomising holes (main and additional) are clogged. Two holes has only nozzle type BDNOSPC 6389 (Pintaux) remaining nozzles have one hole per nozzle.
- Furthermore check if:
  — A cone edge of a nozzle needle valve is not blunted;
  — Guiding surfaces of a needle valve and of a nozzle are not damaged;
  — There is spalled a face surface of a needle valve; if a body and a needle valve are in good state, check freedom of movement of a needle valve in a nozzle body; it should be done in the following manner: wash a body and a needle valve in the pure Kalibrol oil or in the diesel oil and then draw a needle valve for 1/3 of its height out (7 ... 10 mm) keeping a nozzle body in position declined for 30° to a vertical; a needle valve should freely come into a nozzle body, down to a seat, in each rotational position; such test perform several times.

C. Injection assembly
- Injector should be assembled in a special device (Fig. 48) which ensures that:
  — Retaining dowels will be not bent or broken. There will not arise any leakages between an injector body and a nozzle body;
  — Proper adjustment washers will be chosen;
  — It is possible to check an injection pressure an there is an easy access to all injector connections for checking a tightness.
- Injector assembly operation sequence:
  — Wash and dry with an air all parts;
  — Insert an adjustment washer (9, Fig. 46) into an injector body. It should be of the same width as one which was removed during a disassembly;
  — Put into a body (12) a spring (6), a spring cup (7), an insert (5) with two retaining dowels from the side of an injector body and with two retaining dowels from the side of a nozzle body; then screw in a nozzle nut to a light resistance; retaining dowels are used only in injectors type WNS-13 with nozzles BDNOSCP 6389;
  — Fix an injector in a device (Fig. 48) and using a crank press a nozzle to a body (with force of 19 ... 22 kN).

Injector checking in a device

- Connect a testing instrument PRW3 or similar to a device and then make a single injections (using a lever) to a device vessel and check:
  — Tightness of contact between: injector body – insert – nozzle body;
  — Opening pressure value; which for repaired injector should be of 14 ... 14.5 MPa; if a pressure is different replace an adjustment washer, note that for each 0.1 mm of washer width increase you achieve an opening pressure increase of 1 MPa; there is allowed to use two adjustment washers together; there are foreseen the following adjustment washers: 0.8, 0.9, 0.95, 1.0, 1.1, 1.35, 1.6, 1.65 mm;
  — If there is not any bleeding during injection inside the device vessel (continues fuel streams), drops, hanging of a needle valve; during a test the device lever should be operated with frequency 1 to 4 movements down per a second; if a test is passed tighten a nozzle nut with a torque wrench; torque value 50 ... 70 N · m.

Attention. In case when device shown in Fig. 48 is not available to tighten an nozle nut clamp an injector in vice with soft pads. Apply to an injector a torque operating in the opposite direction in relation to this one which is necessary for tightening of a nut.

Testing of an injector with a tester PRW3 or similar

- Clamp an injector in a tester, connect a tester injection pipe to an injector and check:
  — Opening pressure value, which for injector after repair should be 14 ... 14.5 MPa, and for a brand new injector 14.5 ... 15.5 MPa;
  — Tightness of a seat; after reaching of an opening pressure (an injector needle performs short strokes and an oil flows out from nozzle openings) stop pumping and wait till a pressure drops for 2 MPa. Then dry a face surface of a nozzle and keep a pressure 1 ... 1.5 MPa lower then an opening pressureor for next 10 secunds. A nozzle seat is

enough tight if no any oil appears on the face surface of a needle valve.

Attention. Seat of a used injector is tight enough if at a pressure lower for 1.5 ... 2.5 MPa in relation to an opening pressure, within 10 seconds, will be not any drops of a fuel.

— Tightness of an injector high pressure circuit: pump a fuel and after achieving an opening pressure stop a pumping, wait to a pressure decrease to $P_1 = 11$ MPa, then pump to alevel of 12 MPa, wait once more to a pressure decrease to $P_1 = 11$ MPa and from this moment measure time for a pressure decrease down to $P_2 = 8$ MPa; if the measured time is within limits 4 ... 25 seconds it can be stated that a tightness of a high pressure circuit is satisfactory.

— Injector operation: pump a fuel with frequency of one movement down per 2 to 3 seconds, up to the moment when will be achieved an opening pressure; will appear an injection of a well atomised fuel stream through an additional hole, accompanied by a silent, soft hoarsing; from a main hole will escape a stream of a bad atomised fuel; at the and of a lever move it can arise a sporadic flow on a fuel from a main hole of a nozzle; it is allowed if a nozzle has enough tight a cone seat. At least at a frequency 4 to 6 movements of a lever per a second both holes of an injector operate properly, hoarsing is at high level of a tone and from a main hole escapes a stream of good atomised fuel.

Above remarks concern to an injector WNS 13 with a nozzle BDNOESPC 6389.

A test for injectors WNS 19 and WNS 21 is performed with frequency of pumping at least 2 injections per a second: an escaped fuel should be in a form of a fog.

7.9. Camshaft and injection pump driving system

A camshaft an injection pump driving shaft are driven from a crank shaft with a toothed belt. A spring tensioner mounted on an engine block ensures a toothed belt tension.

A shaft driving an injection pump is located in a support in such a way that one end drive through a teeth coupling an injection pump and on the other end is located an ignition advance angle shifter (Fig. 49). A shaft driving an injection pump has an eccentric cam driving a fuel supply pump.

Cooling liquid pump and a fan are driven with a separate V-belt. Pushing away of an alternator enables reaching of a proper tension of a V-belt.

A crankshaft toothed gear of a toothed belt

- Check teeth of a hole surface diameter 28H7 and a grove for a key (Fig. 50). Replace a teethed gear if a whole diameter is greater than 28.025 mm or if a groove width is greater than 5.00 mm. A key and guiding disc should be replaced when they are damaged. A key width should be 4.964 ... 5.000 mm.

An injection pump driving shaft

- Replace a shaft (Fig. 51) when:
  - — There are a deep scratches or uneven and excessive wear of a cam (7) which drives a fuel pump;
  - — An outer spline is worn;
  - — Dowel (2) diameter is smaller than 23.960 mm (in particular cases 23.940 mm);
  - — Dowel (3) diameter is smaller than 44.950 mm (in particular cases 44.930 mm);
  - — Shaft (1) diameter is smaller than 17.983 or key groove width is greater than 5.000 mm.

Increase of mentioned sizes can be caused by a vibration of a hub of an injection advance angle shifter in result of not proper tightening of a nut securing a shifter hub. Replace also a key if its width is smaller than 4.970 mm.

Injection advance angle shifter

- Remove cover and unscrew a nut fixing a shifter on a pump driving shaft (Fig. 49).
- Remove four springs (15) together with adjustment washers (16).
- Remove a hub (5) from a gear together with parts fixed to it.
- Remove a sealing ring (12) from seat in a gear hub.
- Take retaining rings (11) off hub dowels (3) and then remaining parts placed on dowels.
- Replace a gear (10) together with dowels if a hole diameter is greater than 28.021 mm (exceptionally 28.040 mm) or in case of an excessive wear of teeth.
- Replace a hub (5) together with dowels if a diameter of surface contacting with bearings is smaller than 27.927 mm (exceptionally 27.920 mm).
- Measure a maximal distances L between thrust surfaces of spring seats (6) and a hub firstly without adjustment washers and then put adjustment washers on dowels (17) and springs. The washer thickness should be greater for 0.5 mm than difference of a free spring length.

Camshaft gear

- Replace a gear when teeth are excessively worn or in case when:
  - — A key groove width is increased, this width should be 5.970 ... 6.000 mm, a key width should be not smaller than 5.970 mm;
  - — A hub hole diameter is increased; this diameter should be 30.000 ... 30.073 mm.

Toothed belt tensioner (Fig. 52)

- Replace a damaged spring (3).
- Replace bearings (12), if they are too noisy.

Attention. Bearings have their own portion of grease and they do not need any periodical greasing.

Pulley driving a cooling system pump and alternator

Pulley has a hub and a disc. Between them is located (pressed) a rubber insert which works as a vibration damper. There should be checked a rubber insert, a key

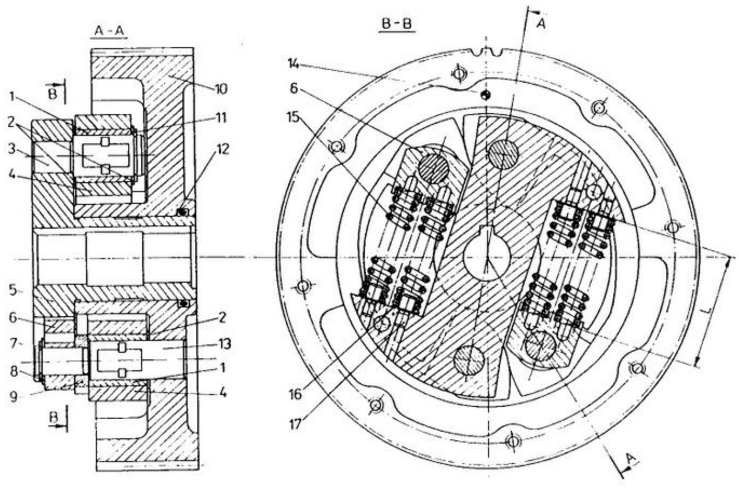


Fig. 49. Injection advance angle shifter
1 — weight bush, 2 — washer, 3 — hub pin, 4 — weight, 5 — hub, 6 — spring seat, 7 — spring ring, 8 — washers, 9 — washer, 10 — gear, 11 — spring ring, 12 — sealing ring, 13 — gear pin, 14 — location hole, 15 — spring, 16 — adjusting washer, 17 — dowel
L — distance without adjusting washer

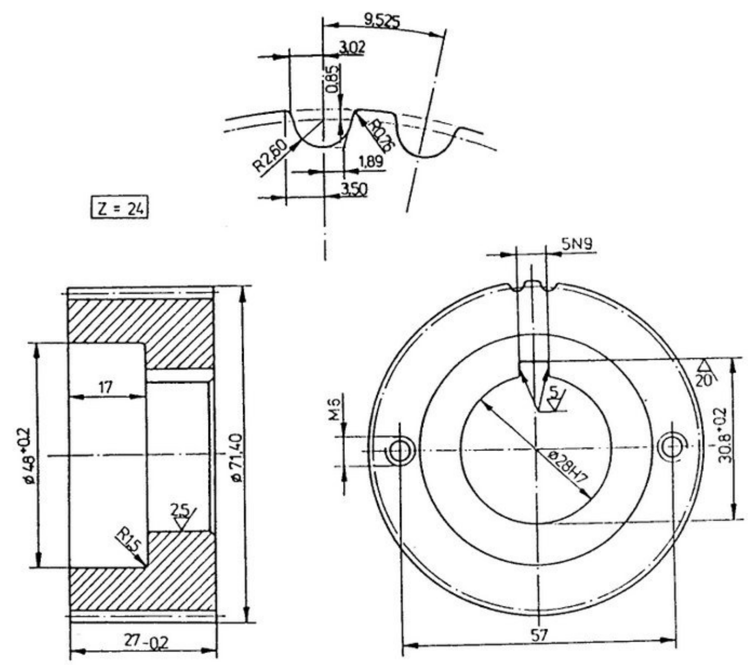


Fig. 50. Crankshaft gear

groove and a hole in a hub. If a rubber insert is fractured, a groove is wider than 8.000 mm and a hub hole diameter is greater than 32.025 mm, replace a pulley.

7.10. Turbocharger

For an engine 4CT90-1 is used a turbocharger made in France, a radial flow type with an exhaust gases overflow valve (Fig. 53).

A turbocharger basic data

Model and type: Allied Signal France TB 2561.

Overpressure (charging pressure): 0.08 MPa.

A description given below consists a basic information necessary for use, maintenance, defects diagnosis during a charger work on an engine, and a trouble shooting table enabling to diagnose any malfunctions on basis of watching of an engine and turbocharger work.

Attention. Because a producer does not foreseen any repair of turbocharger by an user or typically equipped workshop below description gives no any information concerning repair. In case of any malfunctions qualifying a turbocharger for repair and which need a disassembly of

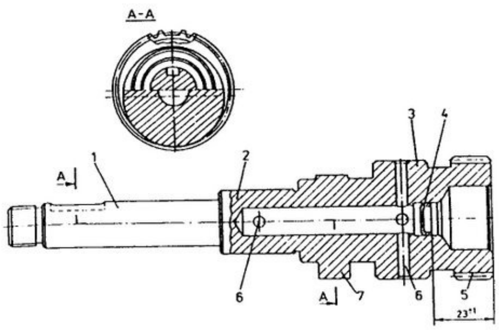


Fig. 51. Injection pump driving shaft
1 — shaft end for location of an injection advance angle shifter, 2 — front bearing journal, 3 — rear bearing journal, 4 — plug, 5 — coupling gear, 6 — oil channels, 7 — fuel pump driving cam

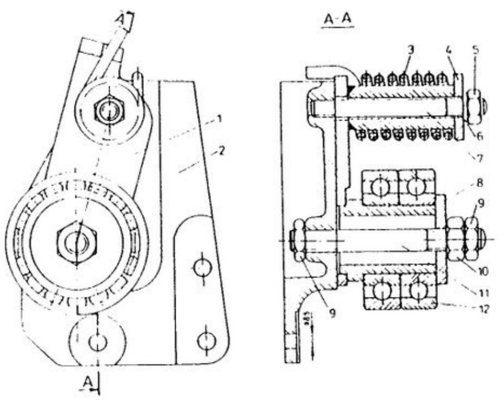


Fig. 52. Toothed belt tensioner
1 — lever, 2 — support, 3 — spring, 4 — washer, 5 — nut, 6 — spring washer, 7 — M8 bolt, 8 — washer, 9 — securing nut, 10 — M10 nut, 11 — stud-bolt, 12 — ball bearing 6206-2RS

unit such operation leave to a specialised workshop authorised for a turbocharger repairs.

Turbocharger – description and operation

A turbocharger is mounted on an exhaust manifold. It delivers an air to cylinders with a proper pressure and with suitable amount. Turbocharger has an exhaust gases overflow valve (18, Fig. 53) which ensures automatic adjustment of an air pressure. This pressure increases from the idling speed to a maximum torque speed (it means 2500 rpm) and then its value is constant.
The use of turbocharger causes increase of amount of a drawn air which ensures increase of an engine output. The basic parts of a turbocharger are: turbine and a charger housing which are fixed to a central housing. A turbocharger is located on an exhaust manifold in such manner that an exhaust gases escaping from an engine drive a turbine which is located on a common shaft with a compressor. During compressor rotation an air is sucked, compressed and delivered to engine cylinders.

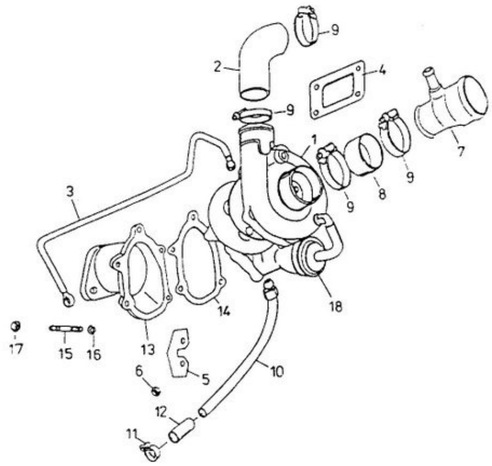


Fig. 53. Turbocharger parts
1 — turbocharger, 2 — elbow, 3 — oil supply pipe, 4 — gasket, 5 — tab washer, 6 — fixing bolt nut, 7 — connector, 8 — hose, 9 — band clamp 10 — oil overflow pipe, 11 — band clamp, 12 — pipe with textile armour 13 — exhaust elbow, 14 — elbow gasket, 15 — stud-bolt fixing exhaust elbow, 16 — washer, 17 — nut, 18 — exhaust gases valve

Lubrication of a turbocharger

Turbocharger is lubricated with an engine oil delivered under pressure through a special pipe (3, Fig. 53). Oil flows back to an engine through another pipe (10). To ensure a proper oil return an outlet hole axis should be in vertical or near vertical position. Such position protects against an excessive oil consumption. A return pipe should not be bent.
After switching an engine on wait for a couple minutes before increasing of an engine speed. Let an engine idling. It is necessary because of hydrodynamic bearings of an assembly turbine/compressor which usually rotates with a speed of 120 000 rpm and oil comes to bearings wit a delay.

Preventive maintenance

- Often check all manifold connections and gaskets if there are not any leakages. Immediately perform all necessary repairs to avoid decrease of an engine output and overheating.
  Wrong filtration of a delivered air causes increase of impurities amount inside a turbocharger. It can also cause a decrease of an engine output and overheating. If compressor will suck impurities it can be a reason of a serious damage of a compressor and an engine.
- Follow all recommendation given in an engine manual in reference to maintenance, recommended oils grades and strictly follow a schedule of an oil replacement. It ensures a normal operation of bearings.
- It should be ensured that an engine will work a few minutes with an idling speed, to enable an oil flow to a turbocharger bearings. It is especially important in the winter season or when an engine did not work through a long period of time.

Troubleshooting – inspection on an engine

A. Engine does not work

- Inlet system connections — tighten when necessary.
- Air cleaner — replace any damaged part and a cleaner insert according to recommendation given in a service manual.
- Compressor connection with an engine inlet manifold — tighten when necessary.
- Turbine connection with an outlet manifold - tighten when necessary (a colour changes or exhaust deposit may indicate that there are leakages in an exhaust system).
- The whole compressor assembly — look for any leakages from a central housing and rotating assembly and from a compressor and turbine. Leakages inform about improper situation in an engine.
- The central housing oil pipes connections — inlet connector tighten with a torque 27 ... 33 N · m and an outlet connector with a torque 32 ... 48 N · m.
- Oil return pipe — if it is possible remove a pipe and look into a hole. Check if there are any deposits on a shaft and in a turbine hole.
- Turbine and compressor rotors — remove inlet pipe for a turbine and outlet pipe for an exhaust gases. Turn a rotating assembly with a hand and check if there is any resistance or jamming. Press the assembly applying side force during rotation and check if rotors are in contact and wipe each other.
- A radial play for a rotor bearing is 0.056 ... 0.127 mm.
- An axial play for a rotor is 0.0254 ... 0.084 mm.

B. Engine during operation

Attention. Turbocharger operates with a great rotational speed and at high temperature. Keep hands, tools and another things apart prom holes and avoid a contact with a hot surfaces and connecting parts.

- After 4 seconds of idling an oil pressure should achieve 0.07 MPa. Check if for a maximal torque speed and higher an oil pressure is at least 0.21 MPa. In case of an abnormal noise and vibration an engine should be immediately stopped. Check if a shaft and turbocharger rotors are damaged. A cyclical noise level changes can indicate that an air cleaner is clogged, flow resistance in a hose air cleaner — compressor, significant dirt sedimentation in a compressor housing or on a compressor rotor. A high tone noise can mean that there is a leakage between an air cleaner and an engine or between an exhaust manifold and an inlet to a turbocharger.
- Detecting of a turbocharger malfunctions and their reasons:
  - — Probably malfunction reasons are given in Table 24,
  - — Troubleshooting manual gives Table 25.

Air cleaner

In truck is used an air cleaner of a dry type (Fig. 54) with a replaced paper cartridge. Every 5000 km an air cleaner should be cleaned with a compressed air and should be turned for 180° to achieve better air cleaning. Every

Reasons of a turbocharger malfunctions Table 24

	A probable malfunction reason, according to a code number
1.	Air cleaner insert clogged
2.	Crankcase breathers closed
3.	Air cleaner insert is missing, is perforated or not tight, turbocharger connections are loosen
4.	A pipe delivering air to a turbocharger is bent or closed
5.	Clogged or damaged pipe turbocharger — inlet manifold
6.	There is any object between an exhaust filter and a turbocharger
7.	Any object in an exhaust system of an engine (check an engine)
8.	Loosen flanges, clamp or turbocharger bolts
9.	An inlet manifold is broken — gaskets are not tightened or they are missing — loosen connections
10.	An exhaust manifold is broken, burned, gaskets are not tightened
11.	An exhaust system is closed
12.	An oil flow to a turbocharger is delayed
13.	Lubrication not efficient
14.	A lubrication oil contains dirt or another particles
15.	A not proper oil is used
16.	An oil delivery channel is closed
17.	An oil exit channel is closed
18.	Damaged or clogged a turbocharger housing
19.	A turbocharger is not tight
20.	Bearing journals are worn
21.	An excessive amount of deposits in a turbocharger housing
22.	An excessive amount of a carbon deposit behind a turbine
23.	An excessive acceleration after an engine start
24.	An engine heating up period is to short
25.	A wrong operation of a fuel feed pump
26.	Injectors are worn, damaged
27.	A wrong valve timing
28.	Valves overheated, burned
29.	Piston rings are worn
30.	Pistons are overheated, burned
31.	Pipes delivering an oil are not tight
32.	An excessive lubrication before an engine start
33.	To long idling
34.	There is too much dirt and a carbon deposit in a central housing
35.	Wrong operation of an oil pump
36.	An oil filter is clogged
37.	An air cleaner is wet: a) A clogged cartridge, b) An oil is sucked, c) Viscosity of an oil is to low, d) Viscosity of an oil is too high

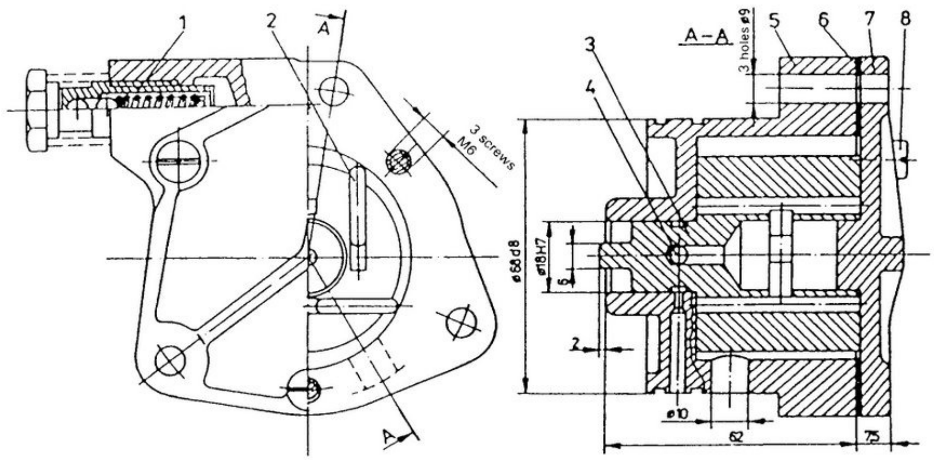


Fig. 55. Vacuum pump of a brake system servo
1 — overflow valve, 2 — blade, 3 — rotor, 4 — oil channel, 5 — pump housing, 6 — gasket, 7 — cover, 8 — screw

56.2 mm in relation to an axis of a hole in a pump housing can be maximum 0.1 mm;
- — An axial clearance for a rotor should be within 0.1 ... 0.22 mm.

- A pump after assembly should be tested on a special inspection stand ensuring:
  - — Supply oil pressure 0.24 ... 0.38 MPa;
  - — Oil viscosity 9.4 ... 12.6 mm²/s at temperature 100°C;
  - — Oil temperature during test 90°C;
  - — Rated rotor rotational speed 2100 rpm.
- A pump should ensure:
  - — Maximum negative pressure 91 kPa;
  - — Maximum time for emptying of a tank of capacity 1.4 dm³ to a negative pressure 39 ... 78 kPa should be 4 s.

Above description refers to an old type of vacuum pump used up to February 20, 1996 (fixed with three bolts). Since February 20, 1996 is used another type of vacuum pump (fixed with two bolts). A new model has better features, it means a maximum time of emptying a tank of capacity 2500 cm³ up to a negative pressure 0 ... 75 kPa is 13 s.

Also changed is construction of an overflow valve which ensures now a full tightness and protects a system against an engine oil penetration. According to producer, ZSM Praszka, a new model of pump is not for repair. In case of any troubles a pump should be replaced.

8. ENGINE ASSEMBLY

Assembly an engine according to Fig. 3 and 4. An operation sequence is as follows:

- Unscrew bearing caps, clean caps and sets in a cylinder block, put halfshells and coat them with an engine oil. Check if an oil channels in a crankshaft are free. Place a thrust half rings, lubricate journals and place caps together with halfshells. Check if there are proper marks on a cap and on a block. Tighten caps of main bearings with a torque wrench. Tightening torque should be 147 ... 157 N·m. Check if a crankshaft rotates free without any jamming. A crankshaft axial clearance should be 0.10 ... 0.30 mm.
- Clean cylinder liners. Coat their inner surfaces with an engine oil and insert pistons together with connecting rods into cylinders using a device shown in Fig. 56.

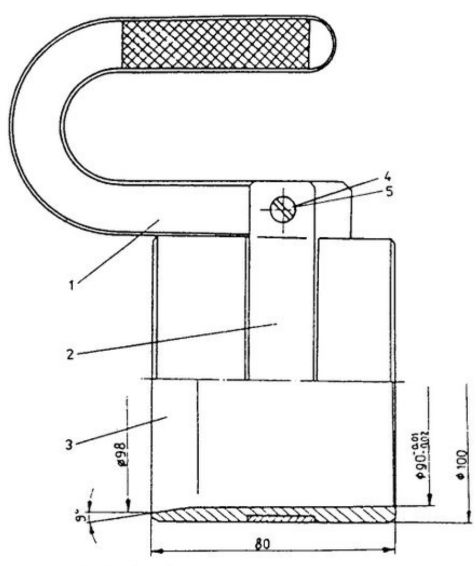


Fig. 56. Device for piston mounting
1 — handle, 2 — band, 3 — bush, 4 — screw, 5 — nut

During piston rings assembly remember that their locks should be located every 120° on the piston circumference. Arrows made on piston crowns should be directed towards an engine front. Numbers on connecting rods should be from side of an injection pump.

- Lubricate connecting rod halfshells with an engine oil, place caps and tighten them up matching of marks on nut and connecting rod bolt (torque about 70 ... 75 N · m). Nuts (marked with a puncher on side surfaces) should have their marks from side of a connecting rod numbers. Avoid mixing of nuts. A piston crown upper surface in a TDC position should be 0.144 ... 0.450 mm above cylinder block surface, for engines produced up to February 1, 1995, and 0.40 ... 0.70 mm for engines produced after February 1, 1995. An axial play in a connecting rod bearing should be 0.180 ... 0.350 mm.
- Place an injection pump driving shaft (Fig. 51) in the cylinder block after lubricating its pins with an engine oil.
- Place a distance ring on an injection pump driving shaft.
- Place a gasket (1.9.0423) and coat it with sealant. Tighten a sealing ring housing together with sealing ring (A42 × 62 × 10) with M6 bolts and washers.
- Place a gasket (1.9.1103) between an oil pump and a cylinder block. Use a sealant. Mount a complete oil pump together with two rubber sealing rings (O-type) 18.3 × 2.4 on the front end of shaft. Use an assembly mandrel (to avoid damage of a sealing ring GZD 35 × 47 × 7) and tighten a pump with M8 bolts. Use a copper seal KN6-1 under the lowermost bolt (there is made a special hole to an oil chamber). Place a gasket and join a suction pipe with a pump. Since June 1, 1994, in place of a flat seal is used a sealing ring MVQ 70 N-25.2 × 3.
- Place a drain plug washer and screw in a plug in a hole of an oil sump.
- A cylinder block surface contacting with an oil sump should be wiped with a cloth and coat with sealant (silicon) all corners between a thrust bearing cap and a block and in a pump body a groove for a gasket. Connect a sump with a cylinder bolt and fix it with twenty two bolts and spring washers. Tighten bolts diagonally starting from a middle.
- Coat with a sealant block surfaces and thrust bearing caps in neighbourhood of contact between block and a cover (about 1 cm width). Place a flywheel housing and fix it on cylinder block with bolts.
- Press a sealing ring on a crankshaft from the flywheel side (A85 × 115 × 15) using mandrels (Fig. 59 and 60). Since January 1, 1996, is used a sealing ring BAUM6 × 7 85 × 110 × 12.
- Place a flywheel on a crankshaft. A locating pin should come in a suitable hole in a flywheel. Place a washer and tighten a flywheel with eight bolts using a torque wrench. Tightening torque for bolts is 127.5 ... 136 N · m.
- Fix an engine lifting eyes to a cylinder head with M8 bolts with spring washers.
- Put a cylinder head gasket and a bush with a seal (1.9.0046-PL606597) place a head (using a hoist with slings) on a cylinder block and fix it with eighteen nuts and washers. Tighten nuts according to sequence shown in Fig. 10. Tightening torque for head nuts is 93 ... 98 N · m.

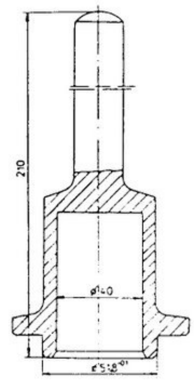


Fig. 57. Mandrel for knocking of sealing ring in an oil pump housing

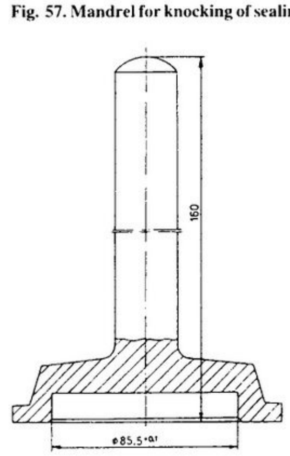


Fig. 58. Mandrel for knocking of sealing ring in a cylinder block (flywheel side)

Tightening should be performed in three steps:

— Light,
— Tightening with torque 10 N · m,
— Final tightening with a torque 93 ... 98 N ·m.

Since the half of April 1997 in place of stud-bolts and nuts are used bolts Before placing a cylinder head gasket screw in two special bolts a gasket position and guiding a cylinder head during assembly. Bolt thread should be lubricated with an engine oil. Bolts tightening sequence is the same as for nuts.

- Single arm valve rockers lubricate with an engine oil.
- Put a disc guiding toothed belt on a crankshaft, place a key in a groove and press a gear on a crankshaft using a mandrel (Fig. 59). Place a damper of torsion vibration.

- Put a sealing ring (1.9.0033-PL6015 62) into a cylinder head, coat with sealant a head surface contacting with a head flange gasket (1.9.0629), place a gasket and then a cylinder head flange. Below its central supports place a distance washers (1.9.0633).
  Before tightening of a flange place a TDC mark of a flywheel before a suitable mark on a housing. Then turn a flywheel for 90° anticlockwise to avoid rocker damage during tightening of a flange. After such preparation you can start with tightening of a head flange. Perform this operation in three steps, an initial and a final tightening of peripheral bolts, and then tightening of central nuts, using a special tool (Fig. 60). Tightening torque for bolts and nuts should be 34 ... 44 N·m. Lubricate a camshaft cams with an engine oil.

Attention. Any rotation of a crankshaft before putting a toothed belt and valve timing adjustment is strictly forbidden.

- Screw in two supports of a cover and fix a rear cover (upper and lower part) with six M6 bolts one M8 bolt and one M8 nut. Use spring washers. Fix an upper and lower parts of a cover with two M5 bolts.
- Knock in a key into a groove in an injection pump driving shaft and place a gear together with an injection advance shifter. Place a tab washer, tighten a nut with torque 78.5 ... 88 N·m. Performing it stop a shifter with a special flat wrench. Bend a tabwasher. An axial play for a shaft should be 0.10 ... 0.25 mm. Check if a pump driving mechanism operates without any jamming.
- Place a gasket of a shifter cover (1.9.0422) after coating it with a sealant. Place a cover and fix it with eight M6 bolts. Use spring washers. Screw in a drain plug. Fill a shifter with a transmisssion oil Hipol 15 (0.25 l) pouring it through an intake hole. Screw in a filler plug together with a washer.
- Fix a shifter together with PT indicator with M8 nuts and screw in a cover support with a spring washer.
- Press a key into a groove in a camshaft, knock in a driving gear, place a special washer and tighten a M10 bolt with a torque 186 ... 196 N·m after placing a gear blocking device (Fig. 7).
- Adjust timing in the following manner (Fig. 61):
  a) Position a camshaft gear according to marks made on gear and on a head flange (Fig. 61, item 7);
  b) Position TDC mark in a proper place in relation to a scratch made on a flywheel housing. Doing it rotate a flywheel clockwise (item 3);
  c) Position a shifter gear so that its mark will show an indicator arrow (item 4);
  d) Shift a tensioner lever to left and stop it by tightening of a nut;
  e) Place a toothed belt and tension it keeping a timing setting as in items a, b, c; it is recommended to place a belt on a crankshaft gear at first then tensioning slightly place its teeth in grooves of shifter and then place it on a camshaft gear (checking if proper is a gear position). At last place a belt on roller of a tensioner lever;

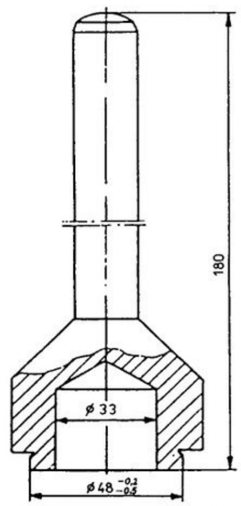


Fig. 59. Mandrel for knocking a gear on a crankshaft

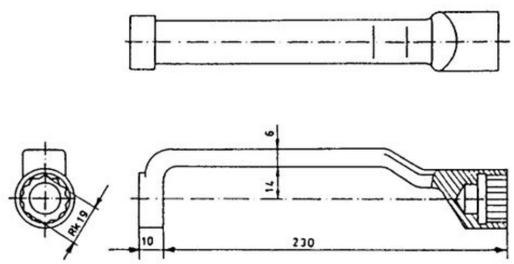


Fig. 60. Special wrench

  f) Loosen a nut fixing a tensioner lever; a spring should shift a lever causing a belt tension (if the tension is to low because of movement resistance increase, shift a lever with your hand);
  g) Tighten slightly nuts fixing a tensioner lever;
  h) Make two full turns of a crankshaft, clockwise (viewing from front) and check if adjusting marks are matched (if not repeat toothed belt placing);
  i) Tighten nuts fixing a tensioner lever; toothed belt is tensioned properly if it bends for a 5 mm when applied a force 11.8 ... 12.7 N in the middle between a camshaft gear and an injection advance angle shifter gear;
  j) Set a valve clearance 0.2 mm for all valves (measured between a cam circle and a rocker); adjustment is possible by rotation of an adjusting bolt, with using of delivered flat wrenches (Fig. 62, 63); after adjustment tighten securing nut.
- Place a pulley together with a vibration damper and screw in a bolt with a washer using. a special torque wrench. Tightening torque 186 ... 198 N·m. During tightening keep a crankshaft stopped.
- Place an injection pump gasket 1.9.0967. before placing coat tightening surfaces with sealant excluding a pump surface and a gasket surface which contacts with a pump.

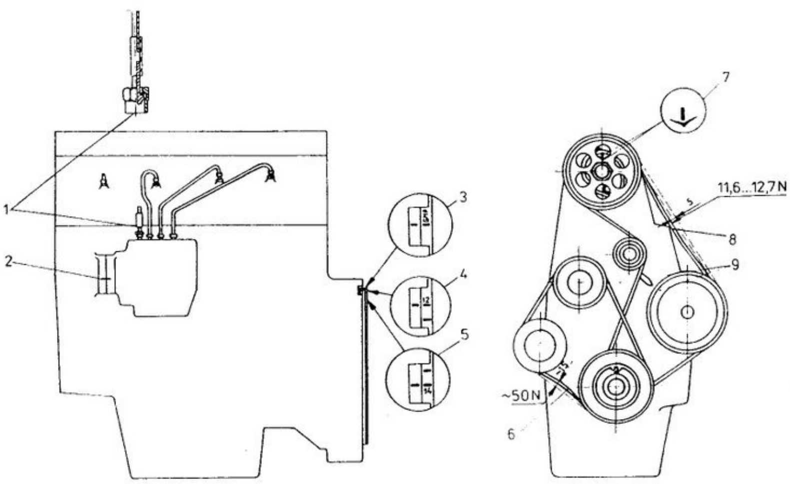


Fig. 61. Setting marks on an engine
1 — capillary for checking of an injection start. 2 — injection pump setting marks. 3 — setting marks for TDC of the first cylinder. 4 — setting marks for an injection start 8° before TDC. 5 — setting marks for an injection start 10° before TDC. 6 — V-belt. 7 — setting marks for a camshaft gear. 8 — toothed belt 9 — setting marks of an injection pump driving gear

Following this indications enables adjustment of an angle of a delivery start and protects a gasket against any damage. Since July 1, 1996, in place of a flat gasket is used a sealing ring MVQ70N 63 × 5, placed in an injection pump groove.

- Place an injection pump and fix it with a cylinder block Position its shaft in such a manner that the missing tooth of an injection pump gear will match with double tooth of a coupling bush inner split. Correct setting of gear ensures easy placing of an injection pump gear on a pin of a driving shaft. Tighten three nuts fixing an injection pump. Use spring washers. Under each nut use two washers, a flat one and a spring one. Place a pump in such a manner that a mark on an outside part of a pump flange was matched with a suitable mark on cylinder block (Fig. 61, item 2). Such positioning ensure reaching of a proper fuel delivery start angle. Tighten nuts fixing a pump. For nut adjacent to a block use a special wrench (Fig. 6).
- Coat contacting surfaces of a fuel feed pump and a block with a sealant, place a gasket (1.9.0631) and fix a pump with four M8 bolts with copper seals.
- Fix a front cover with two M8 bolts, nuts and washers.
- Coat with a sealant a surfaces of a cooling liquid pump which contact with a cylinder block and place a gasket (1.9.0417). Place a spacer washer 1.9.0418, place a pump and fix with M8 bolts, nuts and washers.
- Place a hose: water pump — thermostat housing, secure clamping bands (one after fixing of a thermostat housing).
- Slightly tighten a fan (left-hand thread!).
- Screw in heater plugs. Place a brass rod connecting heater plugs and tighten nuts.
- Place a vacuum pump in a head flange after meshing of a dog coupling. Pump housing gasket coat with a sealant and tighten a pump with M8 nuts with spring washers. In a new model of pump gasket is not used.
- Thermostat housing gasket coat with a sealant and place a whole assembly in a cylinder head. Then tighten it with three bolts. Tighten a hose clamp band. Place a thermostat in a housing. After placing a gasket

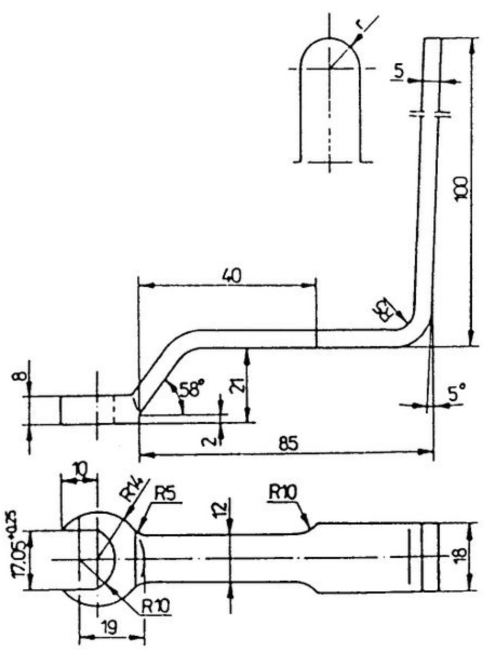


Fig. 62. Special wrench RK 17 for valve clearance adjustment

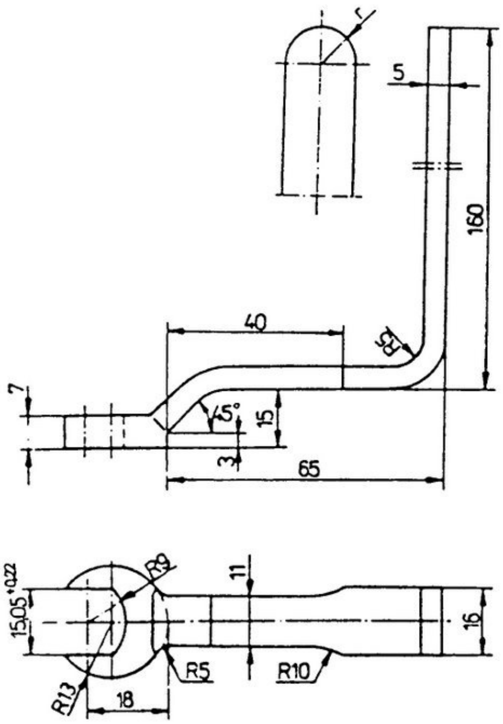


Fig. 63. Special wrench RK 15 for valve clearance adjustment

and coating it with a sealant put an upper part of a thermostat housing.

- Put a sealing washers on injectors (OS-33-6-A) and sealing washers for nozzles (1.2.0662) securing them with grease.

A nozzle washer should be placed in a such manner that its edges are in contact with a nozzle. Put a usual washers and spring washers on bolts fixing injectors. Tighten nuts with a torque 10 ... 20 N·m using a torque wrench.

- Fix a fuel filter support with two bolts M10 with spring washers.
- Fix a fuel filter to a support with two bolts with washers.
- Connect fuel pipes to an injection pump and injectors.
- Place stiffing elements on fuel pipes.
- Fix fuel pipes with joining bolts and washers in a following sequence:
  - — Overflow pipe, fuel filter — injectors; for injectors VA 42 S 390 2698 overflow pipes are placed on injector terminals;
  - — Pipe fuel filter — injection pump;
  - — Pipe fuel filter — fuel supply pump;
  - — Overflow pipe, injection pump — fuel filter.

Place handling element on pipe, fuel supply pump — filter, and fix it to a cylinder block with a M8 bolt with a spring washer.

Fill an injection pump PP4M7 „Motorpal" with an engine oil (capacity 0.2 dm^3) and connect to pump following pipes:

- — Oil pipe, block — injection pump;
- — Overflow pipe, injection pump — tee connection on a fuel supply pump.

- Screw in a connection and fix an oil filter (PP-8.2) with wrench (Fig. 5).
- Put an oil level indicator guide into a hole in cylinder block and screw it with a M6 bolt to an acceleration pedal cable support.
- Put an oil level indicator into a guide.
- Screw a starter shield to an engine block. In case of use a starter with an inner gear mentioned shield is not used.
- Place a manifold gasket and screw an inlet and outlet manifolds using M8 nuts with washers.
- Mount a turbocharger, screw hoses and connections (engine 4CT90-1).
- Place a crankcase breathing hose connecting it with an end of an inlet manifold and with a head flange cover.
- Screw a head flange cover.
- Screw an alternator support together with a bush using two M10 bolts and spring washers.
- Screw an alternator tensioner using two M8 nuts and spring washers.
- Screw an alternator to support member using a bolt M12, nut and washer. Place a V-belt SPZ947 on a pulley mounted at the end of a crankshaft and remaining pulleys of a water pump and alternator. Screw initially a bolt M10 and nut of alternator to a tensioner then decline an alternator to tension a belt; V-belt is tensioned properly if under a finger pressure (50 N) it will be bent for about 15 mm (Fig. 61).
- Screw a draining cock of a cooling liquid system.
- Screw a starter together with a support member to a flywheel housing using three M10 nuts and washers. During mounting check if a support matches properly with a fixing surface. In case of use a starter with an inner gear the additional starter support is not used.
- Secure an inlet manifold hole with a plastic cap.
- Screw an engine supporting members.
- Using a special device (Fig. 11) remove an engine from an assembly stand and deliver it to the store.

9. PARTS AND ASSEMBLIES REPLACEMENT

9.1. Replacement of V-belt driving water pump and alternator (1.1.2831/SPZ947)

If a V-belt is damaged or excessively long (there is no longer possibly to adjust a belt tension) it should be replaced:

- Loosen a nut securing an upper alternator connection with a tensioner and a nut of a bolt of a lower support.
- Remove an old belt and place a new one.
- Push alternator away from an engine and after achieving a proper belt tension tighten a nut fixing an

alternator to tensioner and a nut of a lower support; belt is tensioned properly if under pressure of finger in the middle of belt it bends for about 15 mm.

9.2. Replacement of toothed belt driving camshaft (1.9.1069/58159) 25 mm wide

Sequence of operations is as below:
- Remove a V-belt driving a water pump.
- Unscrew and remove a front cover.
- Position a TDC mark on flywheel according to a mark in a flywheel housing window (Fig. 61); a mark on a camshaft gear place before a mark made on a head flange; place a mark on an injection pump driving gear on a arrow.
- Loosen a securing nut and nut fixing a tensioner roller, push the roller left up to release of a toothed belt; tighten a tensioner nut.
- Remove a worn toothed belt.
- Place a new toothed belt (58150) and adjust timing.
- Screw a front cover.
- Place a V-belt.

9.3. Replacement of crankshaft rear sealing ring (from side of a flywheel)

Sealing ring GZS 85 × 115 × 15 (1.9.1560), and since January 1 BAUM 85 × 110 × 12 (2.90.001):
- Remove gear box and a complete clutch (it refers to an engine in a truck).
- Unscrew bolts securing a flywheel together with a washer.
- Remove a sealing ring.
- Clean a ring seat and place a new ring inside; before placing lubricate a crankshaft journal with an engine oil; if a journal surface shows wear in place of contact with a sealing ring shift a ring within allowed axial play limits. Remember to secure a proper ring position. It should be positioned in a plane perpendicular to a journal axis. For positioning of ring use a mandrel shown in Fig. 60.
- Mount a flywheel together with a washer. A bolt tightening torque is 127.5 ... 136 N · m.
- Mount a clutch and a gear box.

9.4. Replacement of valve rocker (1.6.0133) and guiding insert (1.4.0544)

In case of an excessive valve rocker wear or when it is broken it should be replaced. When a replacement is caused by break then check at first a valve timing and find a reason of damage. After removing a reason start with a rocker replacement and operate as follows:
- Unscrew a head flange cover.
- Unscrew an inlet manifold (if necessary).
- Place a camshaft in such position that a cam for which we remove a rocker is positioned in such a manner that a top of cam is upside.
- An adjusting bolt of a rocker which is under disassembly screw into a head after loosening of a securing nut with a flat wrenches (Fig. 62 and 63).
- Remove a rocker from an adjusting bolt and after a spring releasing slide a rocker outside.
- Place a new rocker. After a proper rocker locating in a guiding insert and on an adjustment bolt and after spring assembly adjust a valve clearance (0.2 mm); lubricate a rocker and a cam with an engine oil.
- Screw a head flange cover together with a breathing hose.
- If necessary replace also a guiding insert (1.4.0744).

9.5. Replacement of oil pump (2.17.046 or 2.17.052)

For an oil pump replacement remove an oil sump and eventually replace an oil sump gasket. Estimate a state of gaskets, change of a shape of a rubber half rings. Each time replace a side gaskets of an oil sump. For replacement of an oil pump follow as below:
- Remove a V-belt by loosing a belt tension and turning a bolt securing an alternator.
- Remove a timing gear cover (plastic part).
- Unscrew a bolt securing a pulley together with a vibration damper and remove a pulley using a pulling device.
- Adjust a valve timing.
- Loosen nuts securing a toothed belt tensioner lever and shift the lever to left.
- Remove a toothed belt.
- Remove a gear from a crankshaft using a puller.
- Unscrew bolts securing an oil sump and remove an oil sump.
- Screw off from a pump housing two M6 bolts (or M8 for pump 2.17.052) which secure an inlet pipe.
- Unscrew six M8 bolts which fix an oil pump to the engine block.
- Clean all sealing surfaces of a cylinder block and an oil sump and a surface between pump and block, replace a pump gasket.
- Perform an assembly working in an opposite order.

9.6. Replacement of camshaft sealing ring in head flange (1.1.2148 3A40 × 55 × 10 PN-72/M86962)

Sealing ring
- Remove a V-belt, unscrew a toothed belt cover.
- Adjust a valve timing.
- Remove a toothed belt only from a camshaft driving gear.
- Unscrew a bolt securing a camshaft gear using a stopping device as shown in Fig. 7, remove a gear with a puller (Fig. 8).
- Unscrew bolts fixing a sealing rings bush, remove a bush.
- Knock out a sealing ring (3A40 × 55 × 10).
- Replace also a sealing ring 63 × 2, if necessary.
- Place a new sealing ring 3A40 × 55 × 10 in a bush; in case will be found an excessive wear of a camshaft face in place of contact with a sealing edge of above ring, shift a new ring within limits of allowable axial play.

Secure a proper location of a sealing ring. It means it should be perpendicular to a shaft axis and its sealing edge should contact with not worn surface. Lubricate it with an engine oil. Screw bushes with sealing rings to a head flange.

- After placing a key mount a gear on a camshaft, using a blocking device (Fig. 7). Bolt tightening torque is 186 ... 196 N·m.
- Place a toothed belt and adjust a valve timing (Fig. 61).
- Screw a front cover.
- Place a V-belt.

9.7. Replacement of head flange and camshaft

If a head flange is not tight or cams of a camshaft are worn disassembly a head flange and a camshaft.

- Remove a V-belt.
- Remove a toothed belt from a gear of a camshaft.
- Remove a gear and bushes of sealing rings; by unscrewing a gear use a blocking device (Fig. 7) and a puller (Fig. 8).
- Unscrew an upper part of a rear cover.
- Unscrew a cover then a head flange and remove it together with a camshaft.
- Remove a camshaft from a head flange together with coupling of a vacuum pump.
- Unscrew a vacuum pump and remove it from a head flange (for a flange replacement only).
- Clean a contact surfaces of a head flange and on a vacuum pump and prepare them for assembly (put sealings).
- Insert a camshaft into a head flange after earlier lubricating a bearing pins with an engine oil.
- Place sealing rings (3A40×55×10 and 63×2) on a bush.
- Screw a head flange.
- Screw a rear cover.
- Place a key, screw a gear on a camshaft using a locking device according to Fig. 7. Tightening torque 186 ... 196 N·m.
- Place a toothed belt and adjust valve timing (Fig. 61).
- Screw a front cover.
- Place a V-belt.
- Screw a head flange cover together with breathing system hose.

9.8. Replacement of injection pump (3175)

Operation sequence is as follows:

- Unscrew fuel pipes; supplying and overflow pipes.
- Screw in back connecting bolts after putting on them securing rings and unscrew an oil pipe (lower) and a pipe through which comes back a fuel from pump leakages. Connecting bolts (with holes) should be protected and screwed into pump. Protect also pipe ends against dirt.
- Unscrew injection pipes and release nuts fixing the pipes to injectors. Bend pipes away from a pump and protect connections with caps.
- Disconnect control rods from a governor lever and electric cables of an electromagnetic valve STOP (in case when an engine is mounted in a truck).
- Unscrew three nuts fixing a pump, using a wrench as shown in Fig. 6 and remove pump.
- In case when is necessary to replace an injection pump gear 1.4.0771 use special wrenches (Fig. 64 and 65).

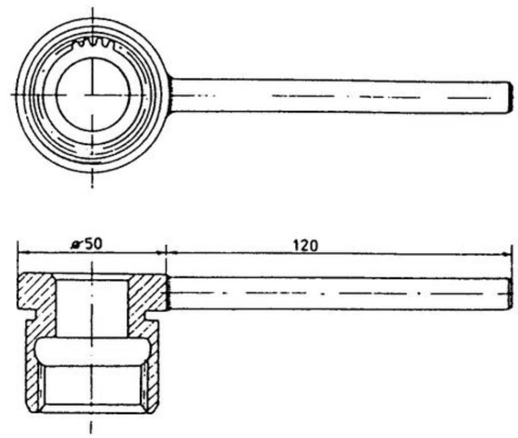


Fig. 64. Special wrench for blocking of an injection pump gear

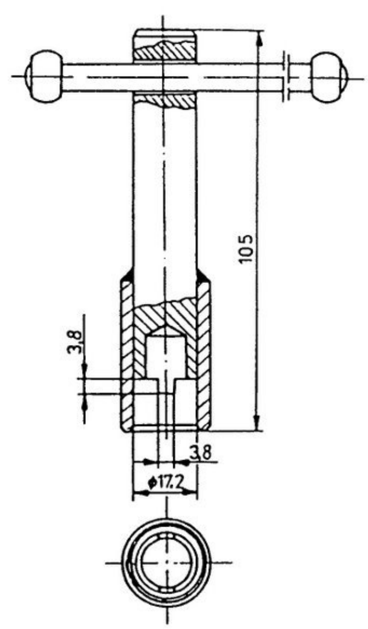


Fig. 65. Special wrench for tightening of an injection pump gear

9.9. Replacement of cylinder head and cylinder head gasket

Operation sequence is as follows:
- Remove V-belt and a front cover.
- Remove a toothed belt from a timing gear.
- Unscrew an upper part of a rear cover.
- Unscrew a flange cover and a head flange and remove it together with a camshaft.
- Unscrew fuel injection pipes and protect connections on an injection pump and on injectors.
- Unscrew an overflow pipe from a fuel filter.
- Unscrew a thermostat housing from a cylinder head.
- Unscrew nuts fixing a cylinder head. Operate in an opposite sequence as shown in Fig. 10. Remove a head together with manifolds (preferred use of a hoist). If a head is to be replaced unscrew also manifolds.
- Remove a head gasket and clean a surface of a cylinder block; if necessary replace sealing ring of an oil channel.
- After repair mount a cylinder head together with a new gasket, then tighten with nuts and washers (18 pieces).

Nuts fixing a cylinder head should be tighten in three steps:

1. Tightening with hands,
2. Initial tightening with a torque wrench using a torque 68 ... 78 N·m (remember the tightening sequence).
3. Final tightening with a torque wrench with torque 93 ... 97 N·m (remember the tightening sequence).

Since half of an April 1997 in place of stud-bolts and nuts are used bolts with head. Before placing a cylinder head gasket screw into a block two special bolts locating a gasket position and guiding a head during assembly. A bolt thread coat with an engine oil.

Tightening sequence is the same as for nuts.

4. Screw a thermostat housing.

- Screw a head flange together with a camshaft, gear and a rear cover.
- Join a rear cover (an upper part with a lower one).
- Place a toothed belt an adjust a valve timing (Fig. 61).
- Screw a front cover. Connect a fuel injection pipes together with clamping elements.
- Screw an overflow pipe to a fuel filter.
- Screw a flange cover together with a breathing system hose.
- Place a V-belt.

9.10. Replacement of injector

Operation sequence is as follows:
- Unscrew an injection pipe from an injector and an injection pump. Protect connections with caps.
- Unscrew an overflow pipe and remove (for injectors type VA 42 S 390 push pipes away from connections).
- Unscrew nuts fixing an injector, remove an injector together with washers from a cylinder head.
- Put washers (1.2.0662 and OS-33-6-A) on an injector (regenerated or new one) and place a set into cylinder head. Use a grease for fixing washers with an injector during this operation.
- Tighten initially an overflow pipe together with washers (for injectors VA 42 S 390 put an overflow pipe on a connection).
- Put flat washers and spring washers on bolts fixing an injector and tighten bolts with a torque 15...20 N·m.
- Tighten an injection pipe and put a pipe clamp.

9.11. Replacement of injection pump driving shaft

Operation sequence is as follows:
- Remove an injection pump from a support.
- Remove a V-belt.
- Remove a front cover.
- Place a flywheel in TDC position according to suitable marks. Place also a camshaft gear according to a mark (Fig. 61). Release a tensioner roller and remove toothed belt from a gear of an injection advance angle shifter.
- Unscrew drain plugs and drain an oil from a shifter.
- Unscrew a nut blocking a shifter with a wrench (Fig. 12) and remove a shifter. It is possible to use a puller (Fig. 8). Remove a key from a pump driving shaft.
- Remove an injection pump driving shaft.
- Replace a sealing ring (3A42×60×10) if necessary.
- Prepare a new shaft (plug a hole) and place it to an injection pump support. Shaft pins coat with an engine oil.
- Place a key; press a gear together with an injection angle advance shifter and tighten a fixing nut with a torque 78 ... 88 N·m. During this operation stop a shifter with a wrench (Fig. 12). Secure a nut and screw a cover. Fill a shifter with a gear oil (Hipol 15F, amount 0.25 dm^3).
- Place a toothed belt and adjust a valve timing.
- Screw an injection pump.
- Screw injection pipes and put clamps.
- Connect fuel pipes with a pump (supplying pipe and overflow one).
- Screw an oil pipe to a pump.
- Screw a front cover.
- Place a V-belt.

9.12. Replacement of piston

Operation sequence for replacement of a piston 2.31.033 (used up to September 30, 1992) or 2.31.077 (used since October 1, 1992, from an engine serial number 8457) is as follows:
- Remove a toothed belt of timing gear.
- Unscrew and remove a cylinder head flange.
- Unscrew and remove a cylinder head. Unscrew nuts in an opposite sequence to this which is shown in Fig. 10.
- Drain an oil and disassembly an oil sump.
- Unscrew connecting rod nuts and remove big end cap together with a halfshell.
- Push upward a connecting rod together with a piston and remove them from a cylinder. Connect a cap with a connecting rod (keep a former position of bolts and nuts). Last two steps perform also for the remaining pistons.

- After replacement of defective or worn elements (piston rings, pistons, piston pins, connecting rod) prepare for assembly necessary subassemblies piston — connecting rod.
- Mount pistons and connecting rods to an engine.
- Clean connecting surfaces of a cylinder block and an oil sump.
- Place a new cylinder head gasket.
- Mount a cylinder head.
- Tighten nuts fixing cylinder head according to Fig. 10.
- Mount remaining elements performing all operations in an opposite sequence as during disassembly.

10. ENGINE TEST AFTER A MAJOR OVERHAUL

A test is performed in three steps.

1. Inspection if an assembly was performed correctly and if all subassemblies operate properly.
2. Running-in of an engine.
3. Checking of an engine parameters.

Recommended test procedure:

- Place an engine on a test stand and check if it is complete.
- Connect an engine with a test stand:
  - — Fix an engine to a stand base,
  - — Connect a flywheel with a brake shaft using a universal coupling, protect it with a shield,
  - — Connect an exhaust manifold with an exhaust installation,
  - — Connect an inlet and outlet of an engine cooling system with a cooling system of a test stand (plug a connecting element in a cylinder head),
  - — Connect an engine lubrication system with an oil cooler using a special washer (Fig. 66) which should be placed under an oil filter PP8.7.2,
  - — Connect an air cleaner with an inlet manifold after previous removing of a plastic insert.

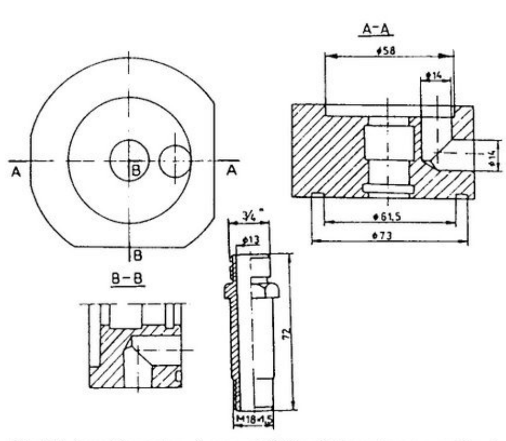


Fig. 66. Special washer for an oil filter (oil cooler connection in a brake stand)

- Connect measuring and control instruments to an engine:
  - — Connect an oil pressure gauge,
  - — Connect a cooling liquid temperature gauge,
  - — Connect an oil temperature gauge, connect an exhaust gases temperature gauge,
  - — Connect a gas flow-meter to a breathing hole (in a flange cover) for measurement of escaping gases (scavenge),
  - — Connect a „U"-pipe of vacuometer to an underpressure hole of vacuum pump (if this measurement is not performed a pump inlet should be closed).
- Prepare an engine for a start:
  - — Fill a sump and an oil cooler with an engine oil,
  - — Check if an injection pump is filled with an oil; if not fill it pouring 0.25 dm3 of an engine oil,
  - — Fill a cooling system of an engine and a cooling system of a stand with cooling liquid,
  - — Deaerate the whole system,
  - — Supply a fuel to an engine and deaerate the fuel supply system,
  - — Connect an electrical installation (12V, DC),
  - — Connect an engine control system.
- Start an engine according to a service manual and perform a test of idling. Check an oil pressure, presence of any leakages, lubrication of valve rockers and cams of a camshaft (after removing of a flange cover); in case of arising any knocks or a noise, indicating improper engine operation stop an engine and remove a reason. Also remove any leakages.
- Engine running-in: during running-in watch if an engine operates properly. In the running-in chart notice (at the end of an operation period, for each load) as follows: time of consumption of 200 cm^3 of fuel, an oil pressure, an oil temperature, a cooling medium temperature, an exhaust gases temperature. Running-in should follow according to Table 26. During running-in a time of consumption of 200 cm^3 of fuel can be shorter (for 5%).

Engine running-in schedule Table 26

Operation time (min)	Engine speed (rpm)	Time of consumption of 200 cm^3 of fuel (s)	Measured output (kW)
20	2100	131.4	13.7
30	2500	103.5	17.5
30	3000	85.0	22.5
30	3300	71.0	26.4
30	3800	53.7	32.3
30	4000	47.0	38.0
30	4100	40.1	42.0

- An engine preparation for braking parameters measurement:
  - — Remove a flange cover and tighten nuts fixing a cylinder head with a torque 93 ... 98 N·m, using a special tool (Fig. 60); tightening sequence according to Fig. 10.