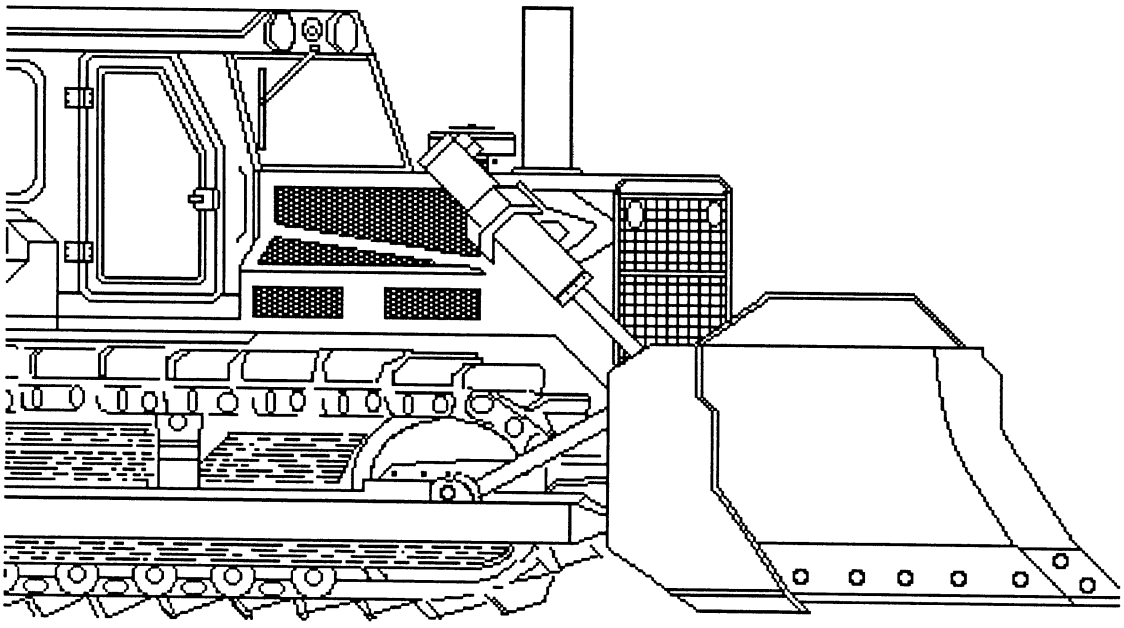
8215
ENGINE

SERIVCE MANUAL



FORM 60406190
8/92 REPRINT

SUPPLEMENT No. 1
8215 ENGINE SERVICE MANUAL
604.06.190

(5-88)

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Page 9 (Revised May, 1988)
Page 10 (No Change)

8215 Engine

service manual

Form 604.06.190 English

⚠ WARNING

STUDY THE OPERATION AND MAINTENANCE INSTRUCTION MANUAL THROUGH BEFORE STARTING, OPERATING, MAINTAINING, FUELING OR SERVICING THIS MACHINE.

⚠ The Operation and Maintenance Instruction Manual provides the instructions and procedures for starting, operating, maintaining, fueling, shutdown and servicing that are necessary for properly conducting the procedures for overhaul of the related components outlined in this Service Manual.

⚠ This symbol is your safety alert sign. It MEANS ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED.

⚠ Read and heed all safety instructions carrying the signal words WARNING and DANGER.

⚠ Machine mounted safety signs have been color coded yellow with black borders and lettering for warning and red with white borders and lettering for danger points.

SAFETY RULES

GENERAL

Study the Operation and Maintenance Instruction Manual before starting, operating, maintaining, fueling, or servicing machine.

Read and heed all machine-mounted safety signs before starting, operating, maintaining, fueling or servicing machine.

Machine-mounted safety signs have been color coded yellow with black borders and lettering for warning and red with white borders and lettering for danger points.

Do not allow unauthorized personnel to service or maintain this machine. Do not perform any work on equipment that is not authorized. Follow the Maintenance and Service procedures. Study the Operation and Maintenance Instruction Manual before starting, operating, maintaining, fueling or servicing this machine.

Always wear safety glasses with side shields.

Do not wear rings, wrist watches, jewelry, or loose or hanging apparel, such as ties, torn clothing, scarves, unbuttoned, or unzipped jackets that can catch on moving parts. Wear proper safety equipment as authorized for the job. Examples: hard hats, safety shoes, heavy gloves, ear protectors, safety glasses or goggles, reflector vests, or respirators. Consult your employer for specific safety equipment requirements.

Do not use controls or hoses as handholds when climbing on or off machine. Hoses and controls are movable and do not provide a solid support. Controls may also be inadvertently moved causing accidental machine or equipment movement.

Do not jump on or off machine. Keep two hands and one foot, or two feet and one hand, in contact with steps and grab-rails and handles at all times.

Machine should not be serviced with anyone in the operator's seat unless they are qualified to operate the machine and are assisting in the servicing.

Keep operator's compartment, stepping points, grab-rails and handles clean of foreign objects, oil, grease, mud or snow accumulation to minimize the danger of slipping or stumbling. Clean mud or grease from shoes before attempting to mount or operate the machine.

Never attempt to operate the machine or its tools from any other position than seated in the operator's seat.

Keep operator's compartment clear of loose objects.

If movement of an attachment by means of the machine's hydraulic system is required for service or maintenance, do not raise or lower attachments from any position other than when seated in the operator's seat. Before starting machine or moving attachment or tool, make sure to set brakes, sound horn and call for an all clear. Raise attachment slowly.

Always block with external support any linkage or part on machine that requires work under the raised linkage, parts, or machine per OSHA requirements. Never allow anyone to walk under or be near unblocked raised equipment. Avoid working or walking under raised blocked equipment unless you are assured of your safety.

Never place head, body, limbs, fingers, feet or hands into an exposed portion between uncontrolled or unguarded scissor points of machine without first providing secure blocking.

Never lubricate, service or adjust a machine with the engine running, except as called for in the Operation and Maintenance Instruction Manuals. Do not wear loose clothing or jewelry near moving parts.

When servicing or maintenance requires access to areas that cannot be reached from the ground, use a ladder or step platform that meets OSHA requirements to reach the service point. If such ladders or platforms are not available, use the machine handholds and steps as provided. Perform all service or maintenance carefully.

Shop or field service platforms and ladders used to maintain or service machinery should be constructed and maintained according to local or national requirements.

Disconnect batteries and TAG all controls according to OSHA requirements to warn that work is in progress. Block the machine and all attachments that must be raised per OSHA requirements.

Never check or fill fuel tanks, storage batteries or use starter fluid near lighted smoking materials or open flame due to the presence of flammable fluid.

Brakes are inoperative when manually released for servicing. Provision must be made to maintain control of the machine by blocking or other means.

Always place the fuel nozzle against the side of the filler opening before starting and during fuel flow. To reduce the chance of a static electricity spark, keep contact until after fuel flow is shut off.

Use only designated towing or pulling attachment points. Use care in making attachment. Be sure pins and locks as provided are secure before pulling. Stay clear of drawbars, cables or chains under load.

To move a disabled machine, use a trailer or low boy truck if available. If towing is necessary, provide warning signals as required by local rules and regulations and follow operation and maintenance instruction manual recommendations. Load and unload on a level area that gives full support to the trailer wheels. Use ramps of adequate strength, low angle and proper height. Keep trailer bed clean of clay, oil and all materials that become slippery. Tie machine down securely to truck or trailer bed and block tracks (or wheels) as required by the carrier.

Never align holes with fingers or hands. Use the proper aligning tool.

Remove sharp edges and burrs from reworked parts.

Use only grounded auxiliary power source for heaters, chargers, pumps and similar equipment to reduce the hazards of electrical shock.

Lift and handle all heavy parts with a lifting device of proper capacity. Be sure parts are supported by proper slings and hooks. Use lifting eyes if provided. Watch out for people in the vicinity.

Never place gasoline or diesel fuel in an open pan.

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

When using compressed air for cleaning parts use safety

Safety Rules

GENERAL (Continued)

glasses with side shields or goggles. Limit the pressure to 30 psi according to local or national requirements.

Do not smoke or permit any open flame or spark near when refueling, or handling highly flammable materials.

Do not use an open flame as a light source to look for leaks or for inspection anywhere on the machine.

Be sure all mechanic's tools are in good condition. DO NOT use tools with mushroomed heads. Always wear safety glasses with side shields.

Move carefully when under, in or near machine or implements. Wear required protective equipment, such as hard hat, safety glasses, safety shoes, ear protectors.

When making equipment checks that require running of the engine, have an operator in the operator seat at all times with the mechanic in sight. Place the transmission in neutral and set the brakes and lock. Keep hands and clothing away from moving parts. Shut off engine and disengage the Power Take-Off lever before attempting adjustments or service.

Never use the bucket as a man lift.

The articulation point between frames will not clear a person. Stay clear when engine is running. Support, using device provided when servicing. Return support to carry position and secure before moving machine after servicing. See Operation and Maintenance Instruction Manual.

For field service, move machine to level ground if possible and block machine. If work is absolutely necessary on an incline, block machine and its attachments securely. Move the machine to level ground as soon as possible.

Guard against kinking chains or cables. Do not lift or pull through a kinked chain or cable. Always wear heavy gloves when handling chain or cable.

Be sure cables are anchored and the anchor point is strong enough to handle the expected load. Keep exposed personnel clear of anchor point and cable or chain. DO NOT PULL OR TOW UNLESS OPERATOR'S COMPARTMENTS OF MACHINES INVOLVED ARE PROPERLY GUARDED against accidental cable or chain backlash.

Keep maintenance area CLEAN and DRY. Remove water or oil slicks immediately.

DO NOT pile oily, greasy rags — they are a fire hazard. Store in a closed metal container.

Before starting machine or moving attachment check and adjust and lock operator's seat. Be sure all personnel in the area are clear before starting or moving machine and any of its attachments. Sound horn.

Rust inhibitors are volatile and flammable. Prepare parts in well-ventilated place. Keep open flame away — DO NOT SMOKE. Store container in a cool well-ventilated place secured against unauthorized personnel.

Do not carry loose objects in pockets that might fall unnoticed into open compartments.

Keep clutches and brakes on machine and attachments such as Power Control Units, winches and master clutches adjusted according to Operation and Maintenance Instruction Manuals of the manufacturer at all times. DO NOT adjust machine with engine running except as specified.

Wear proper protective equipment such as safety goggles or safety glasses with side shields, hard hat, safety shoes, heavy gloves when metal or other particles are apt to fly or fall.

Wear welder's protective equipment such as dark safety glasses, helmets, protective clothing, gloves and safety shoes when welding. Wear dark safety glasses near welding. DO NOT LOOK AT ARC WITHOUT PROPER EYE PROTECTION.

Know your jacking equipment and its capacity. Be sure the jacking point used on the machine is appropriate for the load to be applied. Be sure the support for the jack at the machine and under the jack is appropriate and stable. Any equipment up on a jack is dangerous. Transfer load to appropriate blocking as a safety measure before proceeding with service or maintenance work according to local or national requirements.

Wire rope develops steel slivers. Use authorized protective equipment such as heavy gloves, safety glasses when handling.

Handle all parts with extreme care. Keep hands and fingers from between parts. Wear authorized protective equipment such as safety glasses, heavy gloves, safety shoes.

Inspect your seat belt at least twice a year for signs of fraying, wear, or other weakness that could lead to failure.

Where it is necessary to use diesel fuel as a lubricant make sure all smoking material and open flames are extinguished or that no sparks are near. Place all parts in a closed container of clear diesel fuel for use as needed.

To minimize dangers of fire and explosion, it is recommended that before any welding is done on a fuel tank, the tank be completely drained of fuel, fuel lines disconnected and the ends closed to protect them, and the tank be steam cleaned. All traces of fuel must be removed before welding is started. Flood the tank with carbon dioxide (CO_2) before and during welding. Caps must be removed and vents and other openings left open during welding.

Dry ice (solid carbon dioxide) is extremely cold and will freeze flesh on contact. Use care to prevent contact with skin, eyes, or other parts of the body to avoid personal injury.

When work is required under or between components, block with an external support capable of holding the components in place according to local or national requirements.

START UP

Do not run the engine of this machine in closed areas without proper ventilation to remove deadly exhaust gases.

Do not place head, body, limbs, feet, fingers, or hands near a rotating fan or belts. Be especially alert around a pusher fan.

STARTING FLUID IS FLAMMABLE. Follow the recommendations as outlined in the Operation and Maintenance Instruction Manual and as marked on the containers. Store containers in cool, well-ventilated place secure from unauthorized personnel. DO NOT PUNCTURE OR BURN CONTAINERS. Follow the recommendation of the manufacturer for storage and disposal.

Safety Rules

ENGINE

Turn radiator cap slowly to relieve pressure before removing. Add coolant only with engine stopped or idling if hot. See Operation and Maintenance Instruction Manual.

Do not run engine when refueling and use care if engine is hot due to the increased possibility of a fire if fuel is spilled.

Never attempt to check or adjust fan belts when engine is running.

Do not adjust engine fuel pump when the machine is in motion.

Never lubricate a machine with the engine running.

Avoid running engine with open unprotected air inlets. If such running is unavoidable for service reasons, place protective screen over all inlet openings before servicing engine.

ELECTRICAL

Be sure to connect the booster cables to the proper terminals (+ to +) and (- to -) at both ends. Avoid shorting clamps. Follow the Operation and Maintenance Instruction Manual procedure.

Always turn the master switch (key switch if so equipped) to the off position when maintaining or servicing machine.

BATTERY GAS IS HIGHLY FLAMMABLE. Leave battery box open to improve ventilation when charging batteries. Never check charge by placing metal objects across the posts. Keep sparks or open flame away from batteries. Do not smoke near battery to guard against the possibility of an accidental explosion.

Check for fuel or battery electrolyte leaks before starting service or maintenance work. Eliminate leaks before proceeding.

Do not charge batteries in a closed area. Provide proper ventilation to guard against an accidental explosion from an accumulation of explosive gases given off in the charging process.

Disconnect batteries before working on electrical system or repair work of any kind.

HYDRAULIC

Fluid escaping under pressure from a very small hole can almost be invisible and can have sufficient force to penetrate the skin. Use a piece of cardboard or wood to search for suspected pressure leaks. DO NOT USE HANDS. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.

Shut off engine and be sure all pressure in system has been relieved before removing panels, housings, covers, and caps. See Operation and Maintenance Instruction Manual.

When making pressure checks use the correct gage for expected pressure. See Operation and Maintenance Instruction Manual or Service Manual for Guidance.

ATTACHMENTS

Keep head, body, limbs, feet, hands and fingers away from blade, bucket or ripper when in raised position. Use authorized blocking as a safety measure before proceeding with service or maintenance per OSHA requirements.

If movement of an attachment by means of the machine's hydraulic system is required for service or maintenance do not raise or lower attachments from any position other than when seated in the operator's seat. Before starting machine or moving attachments or tools, make sure to set brakes, sound horn and call for an all clear. Raise attachment slowly.

Do not use machine to carry loose objects by means other than attachments for carrying such objects.

Never use any gas other than dry nitrogen to charge accumulators. See Operation and Maintenance Instruction Manual.

Keep clutches and brakes on machine and attachments such as power control units, winches and master clutches adjusted according to Operation and Maintenance Instruction Manuals of the manufacturer at all times. DO NOT adjust machine with engine running except as specified.

TIRES (APPLICABLE MACHINES)

Be sure tires are properly inflated to the manufacturer's specified pressure. Inspect for damage periodically.

Stand to one side when changing inflation of tires.

Check tires only when the machine is empty and tires are cool to avoid overinflation. Do not use reworked wheel parts. Improper welding, heating or brazing weakens them and can cause failure.

Never cut or weld on the rim of an inflated tire. Inflate a spare tire only enough to keep rim parts in place — a fully inflated tire might fly apart when it is not installed on a machine.

Use care if you must transport (haul) a fully inflated tire.

When servicing tires block the machine in front and back of all wheels. After jacking up, place blocking under machine to protect from falling per OSHA requirements.

Deflate tires before removing objects from the tread.

Never inflate tires with flammable gases. Explosion and personal injury could result.

Foreword

This manual contains service instructions for parts common to class 8215 engines shown in the table below

Engine type	Application
8215.22.520	FL 20 - Crawler loader
8215.22.531	FD 20 - Crawler tractor
8215.02.542	FR 20 - Wheel loader

Service and overhaul procedures given herein are valid for all engine applications shown in table. Any differences are indicated by the specific engine type number concerned. For engine type number interpretation see 1.1.1.

For fluid capacities see the operator's manual provided with the machine to which engine is fitted.
The following subjects are not dealt with in this manual, as they differ from machine to machine:

— Starter
— Alternator
— Air cleaner
— Turbocharger (where used)
— Air compressor (where used)
— Injection pump
— Engine removal/installation
— Oil pan removal with engine on vehicle.

See the "engine related components" module of the various machine models for information regarding these subjects.

IMPORTANT

The information in this manual was current at the time of publication. It is our policy to constantly improve our product and to make available additional optional items. These changes may affect procedures outlined in this manual. If variances are observed, verify the information through your Dealer.

NOTE

Additional publications pertaining to this model and to all other Fiat-Allis products are available through Fiat-Allis dealers. Publications are generally available in several languages. Refer to Service Publications Index for all such publications; this index is available free from Fiat-Allis.

TABLE OF CONTENTS

1. GENERAL

1.1 ENGINE IDENTIFICATION

Each engine is identified by means of two numbers, the engine type number and the serial number, stamped on L.H. side of engine block as shown in fig. 1.

Engine type and serial numbers identify exact engine composition, and should always be specified when ordering spares.

1.1.1 ENGINE TYPE

All engines installed on a given type of machine carry the same "engine type number", which is to be interpreted as follows:

1st digit: 8 = "engine"
2nd and 3rd digits: identify engines of substantially similar design
4th digit: 5 = indicates that engine is installed on earth moving machinery
5th digit: indicates a design feature of engine through code below —
0 = naturally aspirated engine
2 = turbocharged engine
6th digit: identifies series to which engine belongs within the same project
7th, 8th, 9th digits: indicate engine variant.

1.1.2 ENGINE SERIAL NUMBER

Engine serial number is a progressive number given to each engine during production.

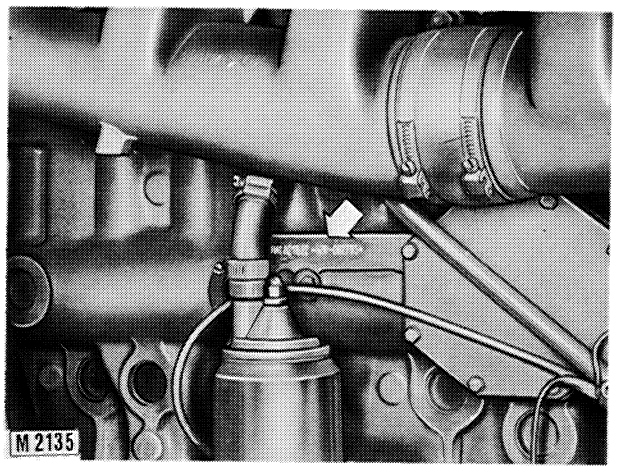


Fig. 1 - Engine identification data.

1.2 DIESEL ENGINE OPERATION

1.2.1 GENERAL

In diesel engines, fuel and air is mixed directly in the combustion chamber. As a result of the high pressure to which the air is subjected, its temperature increases to the point where the air/fuel mixture ignites spontaneously.
In fact, when the air is brought rapidly to a pressure of 30 bar or 435 psi, its temperature reaches 700°C (1290°F), sufficient to cause spontaneous combustion.
During the intake stroke, only air enters the cylinder. Naturally, an effective air cleaner must be placed at the end of the intake manifold to prevent dust and impurities from entering the cylinder, thus causing irreparable damage to engine components.
Air entering the cylinder may be drawn directly from the outside atmosphere during piston downstroke, as occurs in naturally aspirated engines, or it may be precompressed by an exhaust gas activated turbocharger, as in superchargered engines.
After being drawn into the cylinder, the air is compressed and, as a result, heated to a temperature high enough to ignite the fuel spontaneously.
Fuel is introduced directly into the cylinder (direct injection) towards the end of the compression stroke, and slightly before piston top dead center.
At the start of injection, atomized fuel is sprayed from the injector nozzle at high pressure (approximately 200 bar), and penetrates the compressed air in the combustion chamber. Part of the fuel then begins to burn rapidly as a result of the high air temperature. This part of the fuel burns so rapidly that it can be considered to explode. The resulting great increase of temperature in the combustion chamber, together with the rapid swirling motion imparted to the air,

M 2646

Fig. 2 - Longitudinal section through 8215 engine.

combine to permit complete ignition of the fuel which continues to enter the combustion chamber from the injector.
The operating cycle is completed by the power and exhaust strokes, and is repeated every two revolutions of the crankshaft.

1.2.2 INJECTION REQUIREMENTS

Correct injection, and hence optimum engine performance, depend on:

a) Injection timing. - For proper functioning, injection should always take place at the same point of the operating cycle. This point may, if necessary, be modified in accordance with engine speed by means of an automatic advance device, for example.

b) Amount of fuel injected. - In order for the engine to develop the required power, the amount of fuel injected must remain constant and be the same for all cylinders. This amount of fuel must be carefully determined in accordance with the engine requirements and, obviously, must be able to vary with the load applied to the engine.

c) Method of injection. - The fuel spray must:

— Be sufficiently atomized to permit immediate combustion
— Fully penetrate the compressed air
— Spread in all directions so that the greatest possible amount of air in the cylinder can be used in combustion.

The injection system, and in particular the pump and injectors, perform all these functions.
When adjusting injection pump timing, care should be taken that injection advance is as prescribed to avoid causing irreparable damage to engine and injection system. Care should also be taken when adjusting injection pump calibration to ensure that the maximum limit is not exceeded. Never try to increase engine power by increasing pump output, as this would cause permanent damage to the engine. Also check injector calibration and spray characteristics.

1.3 SPECIFICATION, ENGINE 8215

1.3.1 TYPE (Fig. 2)

6 cylinder in-line vertical diesel engine.
Engine internal structure and characteristics are shown in fig. 2.

Cycle	Diesel
Aspiration	
Engine 8215.02	Natural
Engine 8215.22	Turbocharged
Strokes	Four
Injection	Direct
Number of cylinders	6
Bore	137 mm or 5.39 in
Stroke	156 mm or 6.14 in
Displacement	13,798 cm^3 or 841,95 cu.in
Compression ratio	
Engine 8215.02	16 to 1
Engine 8215.22	15 to 1
Main bearings	7
Crankshaft rotation (seen from fan side)	Clockwise
Maximum power, full load, at	2100 rpm
Maximum torque at	1200 rpm
Maximum speed, no load	2350 rpm
Minimum speed, no load	800 to 850 rpm
Engine weight (without fluids):	
Engine 8215.02	approx. 1240 kg or 2734 lbs
Engine 8215.22	approx. 1280 kg or 2822 lbs

Valve gear

Valves	Overhead, 2 per cylinder, pushrod operated
Valves open:	
— Inlet	16° BTDC
— Exhaust	58° BBDC
Valves close:	
— Inlet	52° ABDC
— Exhaust	18° ATDC

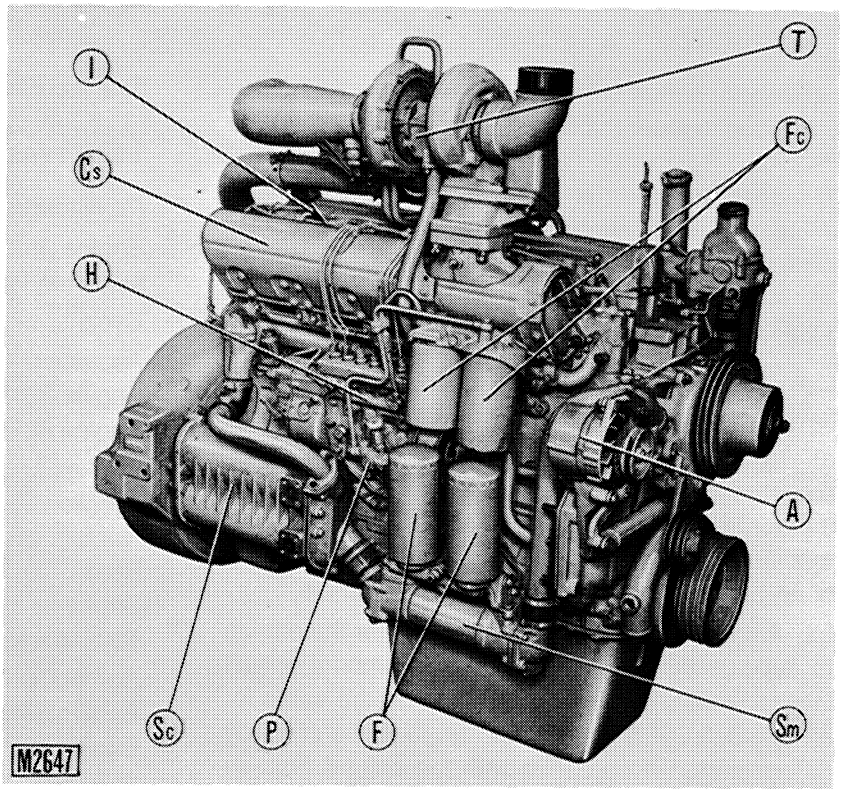


Fig. 3 - RH view of engine 8215.22. ...

A. Alternator - **Cs.** Exhaust manifold - **F.** Oil filters - **Fc.** Fuel filters - **H.** Injection pump - **I.** Injectors - **P.** Feed pump - **Sc.** Converter oil heat exchanger - **Sm.** Engine oil heat exchanger - **T.** Turbocharger.

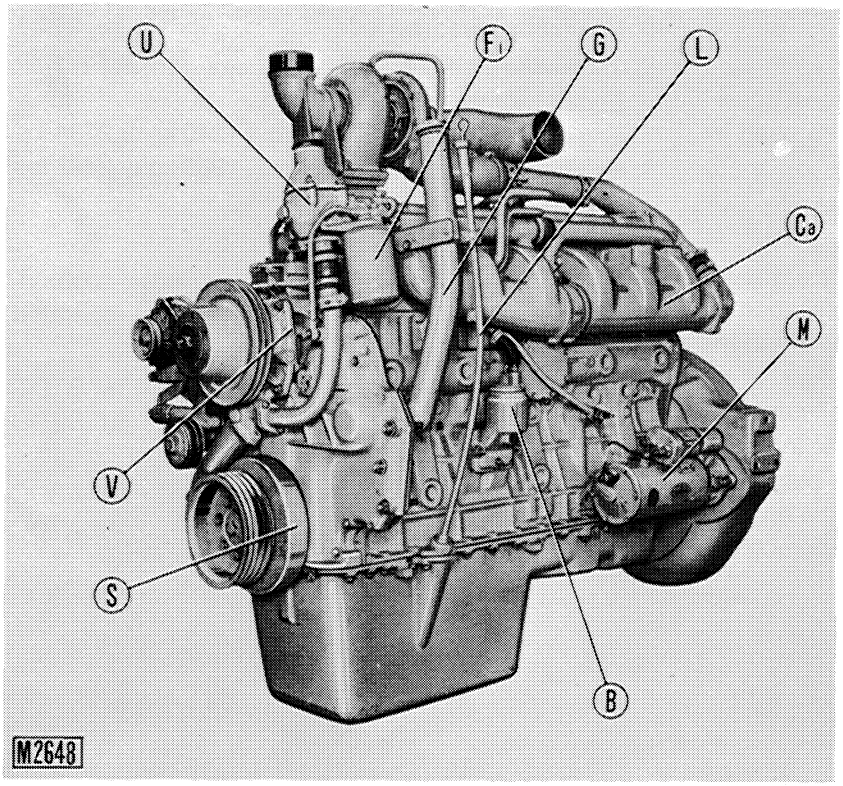


Fig. 4 - LH view of engine 8215.22. ...

B. Vent - **Ca.** Intake manifold - **Fi.** Corrosion inhibiting filter - **G.** Oil filler tube - **L.** Dipstick - **M.** Starter - **S.** Crankshaft damper - **U.** Cooling system thermostats - **V.** Water pump.

Fuel system

Fuel filters ..... Two, series mounted, cloth and replaceable paper elements
Injection system ..... See specific "engine related components" manual section
Air cleaner ..... See specific "engine related components" manual section
Injection timing ..... 22° BTDC
Firing order ..... 1 - 5 - 3 - 6 - 2 - 4

Lubrication system

Type ..... Forced feed
Oil Pump ..... Double, gear, feed and scavenge
Oil filters
— Suction ..... Gauze on both pumps
— Outlet ..... Twin, paper cartridge
Oil Cooler ..... Heat exchanger to engine cooling system

Cooling system

Type ..... Water
Pump ..... Centrifugal
Thermostat ..... Two, side by side
Filter ..... Corrosion inhibiting filter

1.3.2 VIEW OF EXTERNAL ENGINE COMPONENTS, R.H. SIDE (Figs. 3 and 5)

— Exhaust manifold (**Cs**)
— Fuel lift pump (**P**)
— Injection pump (**H**)
— Injectors (**I**)
— Oil filters (**F**)
— Fuel filters (**Fc**)
— Engine oil heat exchanger (**Sm**)
— Converter oil heat exchanger (**Sc**)
— Alternator (**A**)
— Turbocharger (engine 8215.22 only) (**T**)

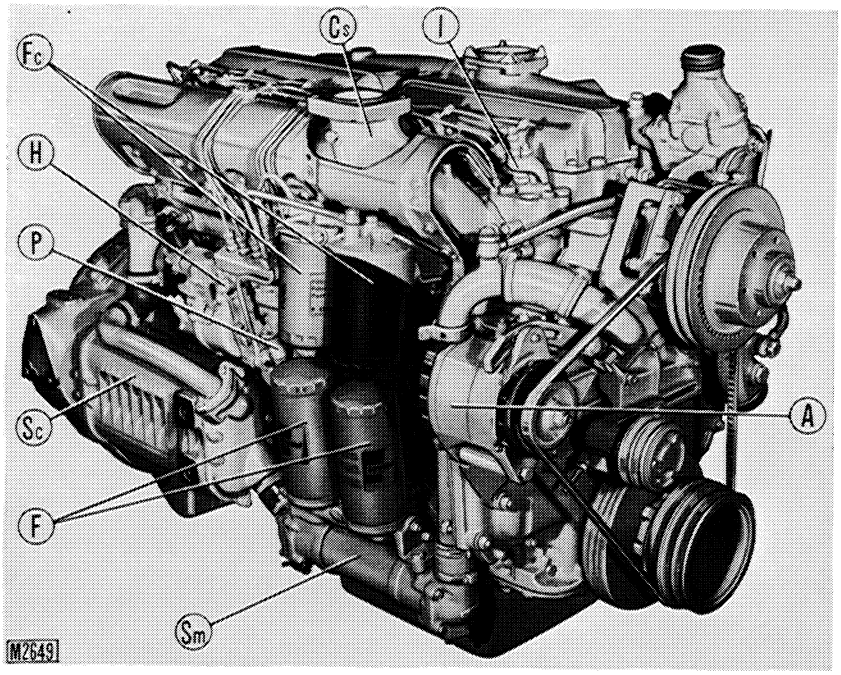


Fig. 5 - RH view of engine 8215.02.542

A. Alternator - **Cs.** Exhaust manifold - **F.** Oil filters - **Fc.** Fuel filters - **H.** Injection pump - **I.** Injectors - **P.** Feed pump - **Sc.** Converter oil heat exchanger - **Sm.** Engine oil heat exchanger.

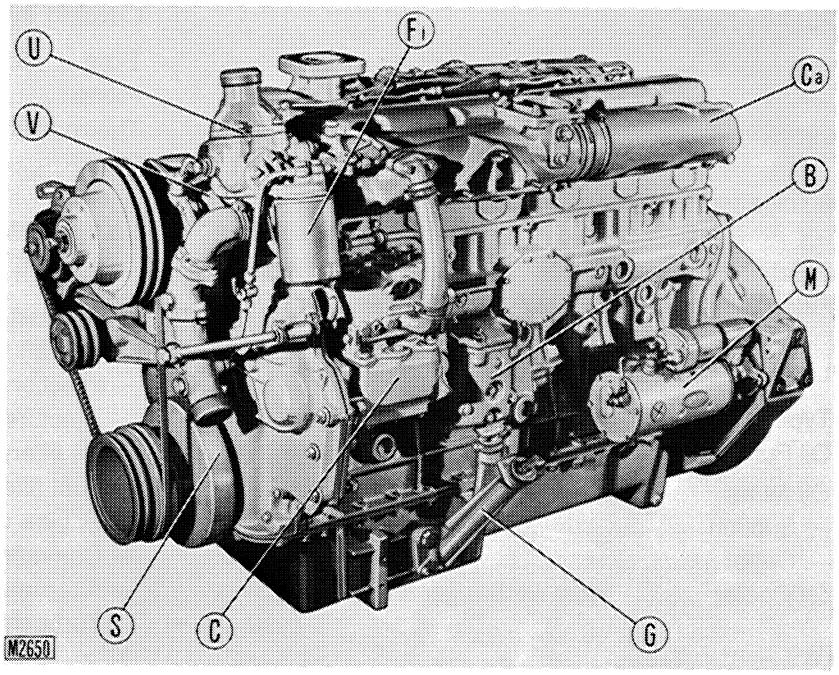


Fig. 6 - LH view of engine 8215.02. ...

B. Vent - **C.** Air compressor - **Ca.** Intake manifold - **Fi.** Corrosion inhibiting filter - **G.** Oil filler tube and dipstick - **M.** Starter - **S.** Crankshaft damper - **U.** Cooling system thermostats - **V.** Water pump.

L.H. side (figs. 4 and 6)

— Intake manifold (**Ca**)
— Engine oil inlet (**G**)
— Engine vent (**B**)
— Cooling system corrosion inhibitor (**Fi**)
— Starter (**M**)
— Air compressor (engine 8215.02.542 only) (**C**)
— Water pump (**V**)
— Cooling system thermostat (**U**)

2. ENGINE BLOCK AND CYLINDER HEADS

2.1 CYLINDER BLOCK AND SLEEVES

The cylinder block is cast in one piece in special cast iron. Main oilway passes through L.H. side of block. Other oilways supply main bearings, camshaft bushings and cylinder heads. Housings for cylinder sleeves, main bearings, camshaft bushings and tappets are integral with cylinder block.
The finish machined cylinder sleeves are heat-treated before being press-fitted into the block. After press fitting, sleeves are classified into grades A and B (see figure 7) and require no further processing.
The grade identification letters are stamped in the top of the block adjacent to the sleeves.

2.1.1 SLEEVE RENEWAL

Inspect the sleeves for wear as follows:

— Check the sleeve bore over the working length (X, fig. 7) swept by the piston rings.
— The diameter reading should be taken in both the upper and lower part of the working length in plane (**c**) parallel to the crankshaft and in plane (**d**) at right angles to it.
— Compare the readings to establish the amount of sleeve out-of-round and taper.

To assess the piston working clearance check the sleeve bore diameter in lower part (**Z**) in plane (**d**) only.
If out-of-round or taper in excess of .15 mm or .0006 in is detected, cylinder sleeves should be renewed, as oversize pistons are not available.

WARNING

Lift and handle all heavy parts with a lifting device of proper capacity. Be sure parts are supported by proper slings and hooks. Use lifting eyes if provided. Watch out for people in the vicinity.

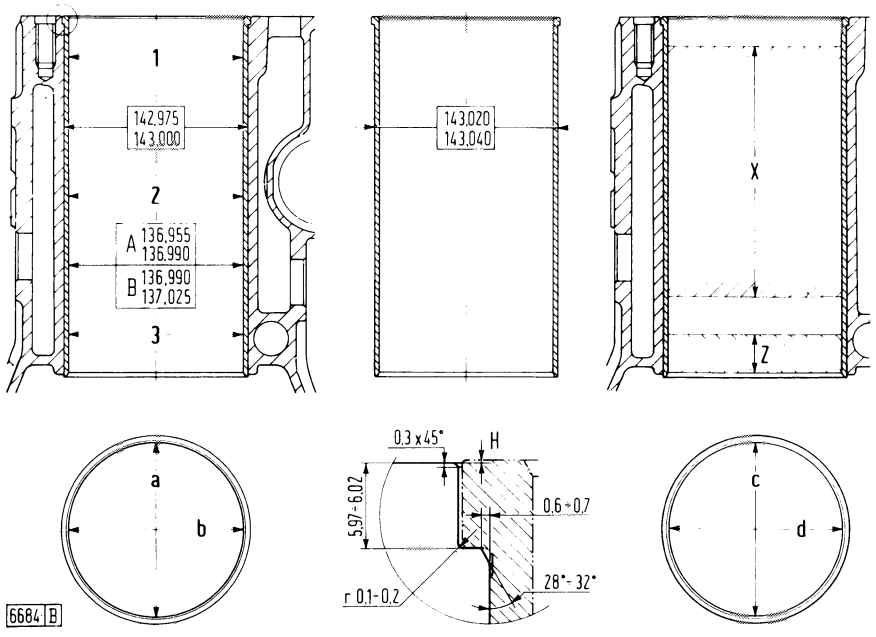


Fig. 7 - Sleeve and block dimensions and inspection data.

A/B. New sleeve grades after fitting - **H.**= -.020 to .055mm (-.0008 to .0022in) sleeve stand-in or stand-out - **Z**. Sleeve bore inspection area on plane (**d**) to determine piston working clearance - **X**. Working length for assessment of sleeve bore wear on planes (**c** and **d**) (corresponding to swept area) - **1/2/3**. New sleeve bore measurement point at right angle to planes (**a** and **b**).

To replace sleeves, engine must be removed from machine, all parts connected to cylinder block disassembled, and a hydraulic press used.
Withdraw the cylinder sleeves from the bottom of the cranckcase using plate **75292884**.

WARNING

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

When installing replacement sleeves proceed as follows:

— Thoroughly clean both the sleeves and the block bores.

— Apply a coat of oil to block bore and to sleeve outer surface.

— Press each sleeve into the crankcase from cold using a suitable press and plate **75291611**.

— When the sleeve is 100 mm or 4 in in (see **L**, fig. 8) the load (**P**) required to press the sleeves fully home should be between 400 and 4500 daN or 882 to 9922 lbs.

— A load lower than 400 daN or 882 lb indicates insufficient interference, while one higher than 4500 daN or 9922 lbs means excessive interference. Replacement sleeves should be installed so that load (**P**) is within the stated range.

NOTE - If it is impossible to obtain the correct fit owing to a block bore diameter in excess of nominal value, maximum allowance being .05 mm or .002 in, adopt .05 mm or .002 oversize sleeves.

— With the sleeve fully seated, check the sleeve bore by placing a suitable dial gauge set to zero on planes (**a** and **b**, fig. 7), subsequently repeating the readings in three points (1, 2 and 3) at different heights.

— Also check that sleeve stand-in or stand-out (**H**) is − .020 to .055 mm or − 0008 to .0022 in.

— Where necessary, stamp the grade identification letters to which pistons must be matched (see para. 4.3) to the cylinder block (see fig. 7).

If in the course of overhaul block bore out-of-round is found to be in excess of .1 mm or .004 in, the bores should be opened out by .25 mm or .010 in (see data table, chapter 10).
After opening out the block recut the lead-in chamfer according to the dimensions given in fig 7.

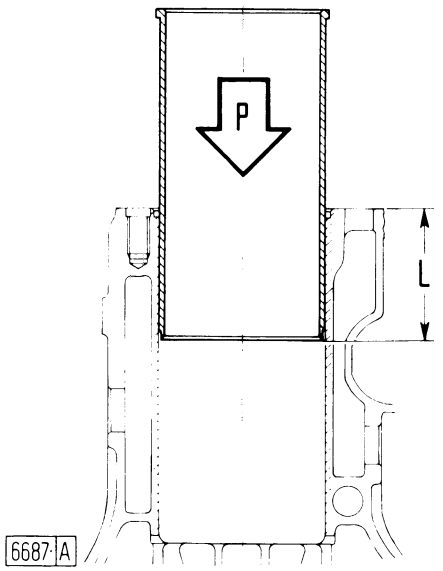


Fig. 8 - Pressing the sleeves in the engine block.

L = 100 mm (4 in) lead-in depth prior to load application (**P**) - **P** = 400 to 4500 daN or 882 to 9922 lbs sleeve installation load.

WARNING

Wear proper safety equipment such as hard hat, safety shoes, heavy gloves, safety glasses or goggles where particles might fly.

If the block top needs grinding (which should be done with the sleeves removed) also restore the original depth of counterbore and lead-in chamfer according to the dimensions shown in fig. 7 to obtain fitted sleeve dimension (**H**) as prescribed.

NOTE - The sleeve bore is surface-hardened and must not be ground, honed or dressed at all after installation. Owing to their low interference, these sleeves can be removed and put back several times without any adverse effect.

2.2 OIL PAN

See specific "engine related components" manual section for oil pan removal with engine in the machine.
To install the oil pan proceed as follows:

— Always replace the complete gasket.

WARNING

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

— Thoroughly clean gasket mating surfaces.
— Using jointing compound, apply the gasket assembly to the pan ensuring that the holes are correctly aligned and the rear end of the gasket protrudes by 1 to 1.5 mm or .04 to .06 in. If necessary, cut off the excess material.
— Coat gasket seams (**A**, fig. 9) and ends (**B**) with jointing compound.
— Place the pan in position and turn in screws (**2**) a few turns.
— Fully tighten screws (**1**) and turn screws (**3**) to 3/4 of their full depth.
— Slightly slacken screws (**1**) and fully tighten screws (**3**).
— Fully tighten screws (**2**) in a staggered sequence.
— Check that screws (**3**) are adequately tight and tighten the screws (**1**). See chapter 9 for tightening torques.

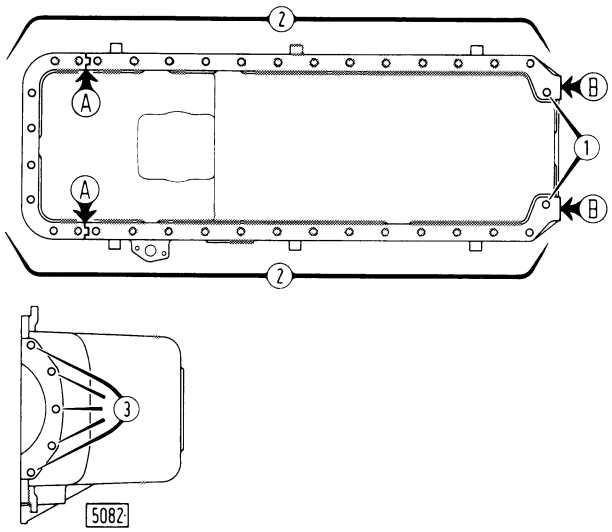


Fig. 9 - Engine oil pan tightening diagram.

(See instructions in Chapter 2.2).

2.3 CYLINDER HEADS

WARNING

Always wear safety glasses with side shields when machining or grinding metal, or performing any task where particles might fly.

Check head flatness by placing each cylinder head on a surface plate smeared with carbon black and, if necessary, re-dress by scraping or grinding if the amount of distortion is in excess of .15 mm or .006 in.

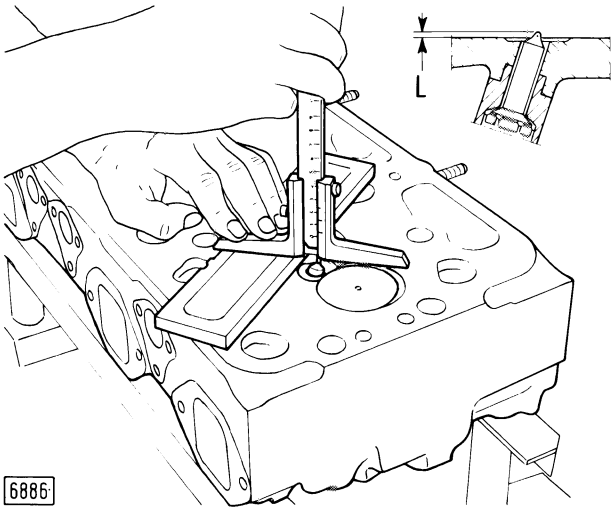


Fig. 10 - Checking injector stand-out from cylinder head.

L = 1.5 to 2 mm or .06 to .08 in nozzle stand-out.

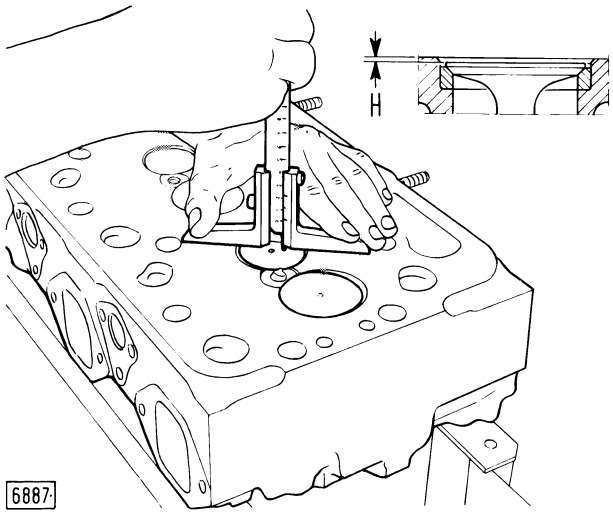


Fig. 11 - Checking valve stand-in from cylinder head.

H = 1.3 to 1.9 mm or .05 to .07 in valve stand-in.

When grinding, the maximum amount of material which can be removed should not exceed .5 mm or .02 in. If valve seat recutting is also necessary the maximum allowance will be 1 mm or .04 in.
Remember that new cylinder head thickness should be 139.750 to 140.000 mm or 5.5108 to 5.5118 in.
After installing the fuel injectors and the valves, ensure that:

— Fuel injector protrusion (**L**) is as specified in fig. 10.

— Valve depth (**H**) is as specified in fig. 11.

If injector protrusion is less than prescribed grind the taper seat in the sleeve using cutter **75291339**. If excessive stand-out is detected, replace the sleeve.
To replace fuel injector sleeves, use the set of taps **75290687** for tapping, and puller **75290633** to remove from the heads.
Install the new injector sleeves using the hand press and expand their top end using punch **75291350**.
Check for leaking core plugs and fuel injector sleeves.
In case of doubt, replace all suspect parts. Injector sleeve leakage can often be stopped by means of punch **75291350**.

To obtain a good seal between injector and sleeve bottom, dress the taper seat using cutter **75291339**.

WARNING

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

Wear safety glasses with side shields or goggles when using compressed air for cleaning to reduce the danger of personal injury from flying particles. Limit the pressure to 2.1 bar (30 psi) according to local or national requirements.

Wash cylinder heads carefully after all overhaul operations to remove all traces of abrasive particles.
When installing the head gaskets make sure that the side marked ALTO is "UP"; before installing, smear the gasket surfaces with carbon black.

Tighten self-locking cylinder head retaining screws as directed in fig. 12. Correct tightening torque is given in chapter 9.

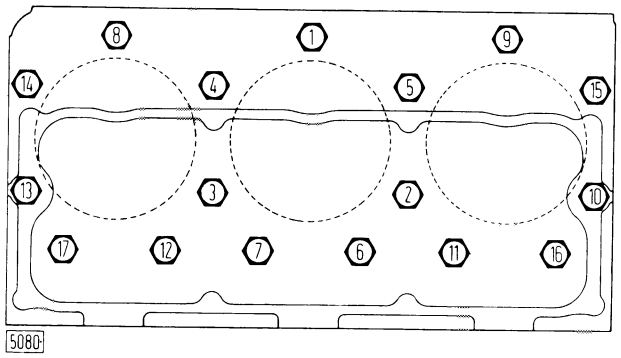


Fig. 12 - Cylinder head tightening diagram.

Note - The prescribed tightening torque should be reached in at least 3 successive stages adopting the sequence indicated above.

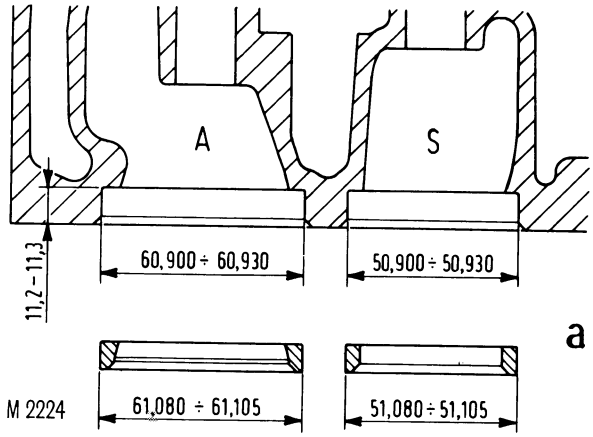
2.3.1 VALVE SEAT RECUTTING

Use tool **75291113** to rest the cylinder heads on, and support **75291112** to position the valves.
For valve seat recutting, use universal hand cutter **75292913** proceeding as follows:

WARNING

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

— Remove all deposits and carefully clean the valve guide bore prior to inserting the cutter pilot.
— Attach the tool to the associated support and place in position.



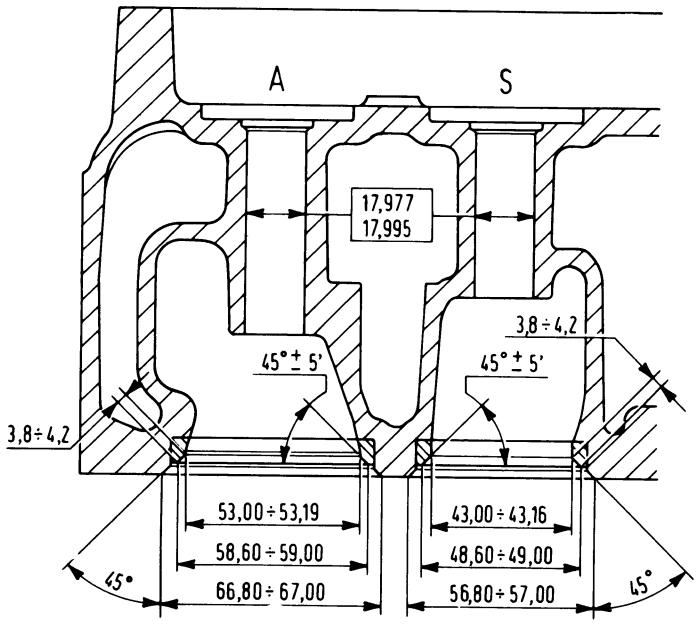


Fig. 13 - Valve seat and guide housing details.

a. Valve seat insert details - **A.** Inlet - **S.** Exhaust.

Note - Valve seat insert oversize, .20 mm or .008 in on outside diameter (see data table, Chapter 10).

— Zero the cutter on the valve seat center line.
— Take .1 mm or .004 in cuts until a complete new seat is obtained.
— Take a .05 mm or .002 in finish cut.

The tool provided enables the seat width to be reduced to the value prescribed in fig. 13.
Should the universal hand cutter not be available for any reason, satisfactory results can be obtained by means of set of cutters and handles **75291610** bearing in mind the following points:

— Universal hand cutter machined seats do not necessitate grinding-in of new valves.
— Seats machined with set of cutters and handles must be ground-in together with the valves.

After the seats have been recut several times, when valve depth below the cylinder head face exceeds the prescribed allowance (see fig. 11), the cylinder head can be reconditioned by adopting valve seat inserts (see Data Table, Chapter 10, and Fig. 13).

3. VALVE GEAR

3.1 CAMSHAFT

To replace the camshaft bushings, remove the retaining screws and proceed as follows:

— For front and rear bushings, remove the rear engine mounting and use universal puller **75292909**.

— For intermediate bushings, use drift **75292797**.

To take out the camshaft preferably remove the engine assembly. Engine removal is always necessary for camshaft bushing replacement.

To reinstall the camshaft bushings proceed as follows:

— Reposition the bushings so that the retaining screws register with the associated holes and ensure that holes (**B** and **G**, Fig. 15) coincide with the block lubricating ports (**b** and **g**) respectively.

— Reposition the two intermediate bushings first, starting from the front of the engine block using drift **75292797**.

— For front and rear bushings, use drift **75292796**.

— After assembly, the bushings do not need reaming.

NOTE - Prior to starting an overhauled engine, lubricate the camshaft by introducing 1 kg or 1 3/4 pints of oil through each cylinder head.

3.1.1 TO INSPECT CAMSHAFT AND BUSHINGS

Check both camshaft journals and bushings (Fig. 15) for wear and excessive running clearance (see Data Table, Chapter 10).

Bushings are not supplied with undersize inside diameter. If the running clearance is found to exceed .20 mm or 0.0078 in, the bushings should be replaced if necessary together with the camshaft itself.

Check the driven gear flange for runout as follows:

— Place the camshaft with two end journals over V-blocks and rest the stylus of a dial gauge on the flange face at approximately 37 mm or 1.5 in from the centerline (**C**, Fig. 15).

— Rotate the shaft and check that over one revolution the recorded runout does not exceed .01 mm or .0004 in.

— Place the stylus over spigot surface (**D**) and check that over one full revolution the amount of out-of-round does not exceed .01 mm or .0004 in.

Also check for shaft distortion by placing the stylus of the dial gauge over the two center journals; maximum eccentricity should not exceed .10 mm or .0004 in over one revolution. If necessary, straighten the camshaft using a suitable press.

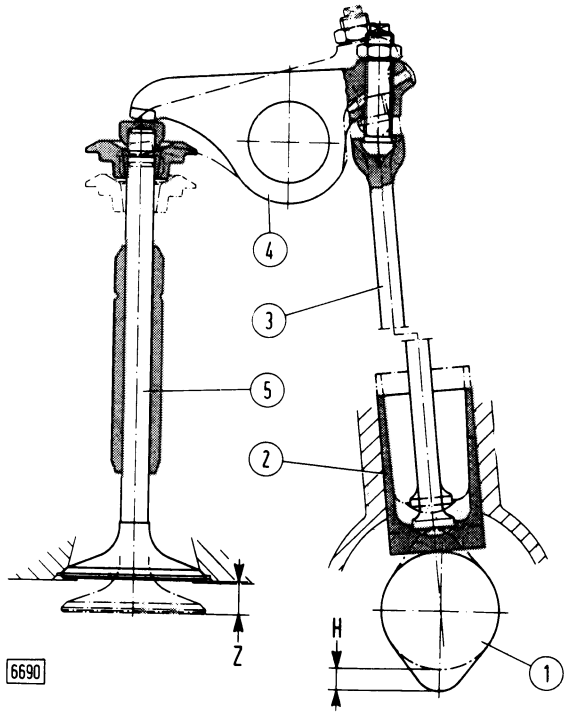


Fig. 14 - Valve gear mechanism.

H. Cam lift: inlet 7.921 mm or 0.312 in, exhaust 8.000 mm or 0.315 in - **Z.** Max. valve lift: inlet 13.862 mm or 0.546 in, exhaust 14.0 mm or 0.551 in - **1.** Cam - **2.** Tappet - **3.** Pushrod - **4.** Rocker - **5.** Valve.

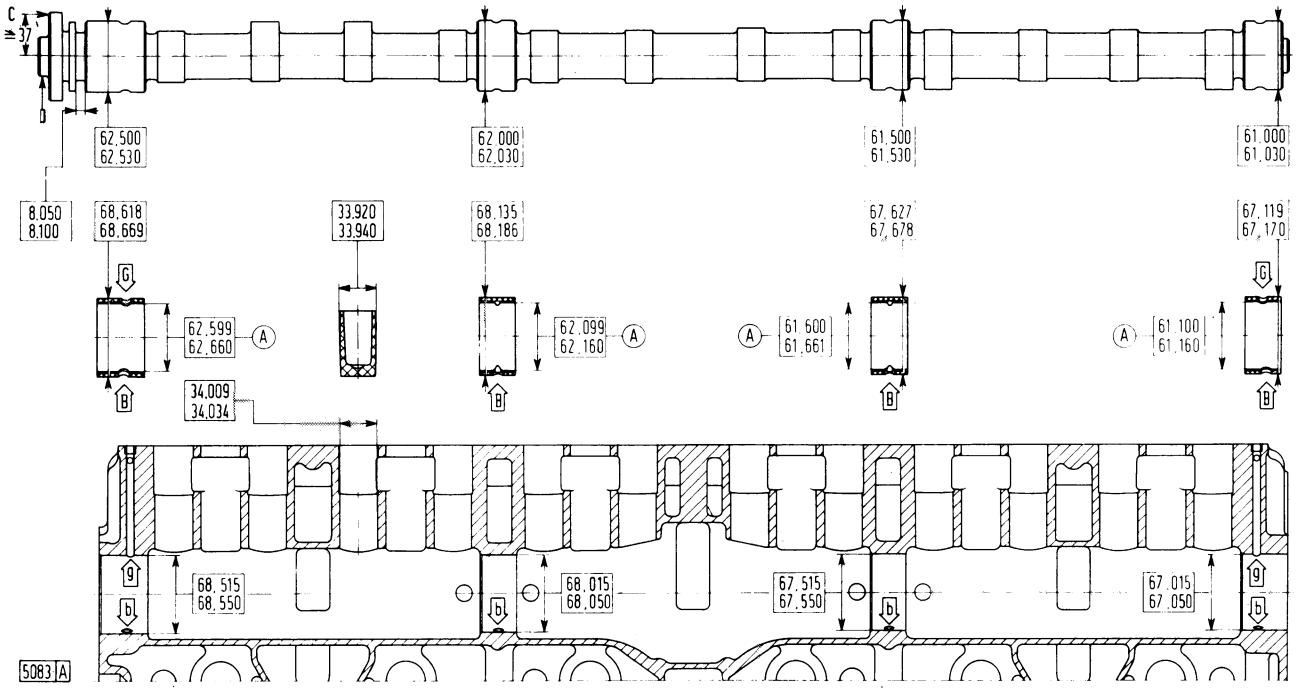


Fig. 15 - Camshaft, bushing, tappet and housing details.

A. Bushing installed I.D. - **C/D.** Flange runout stylus position - **b/g** and **B/G.** Lubricating ports and ways for camshaft journals and bushings.

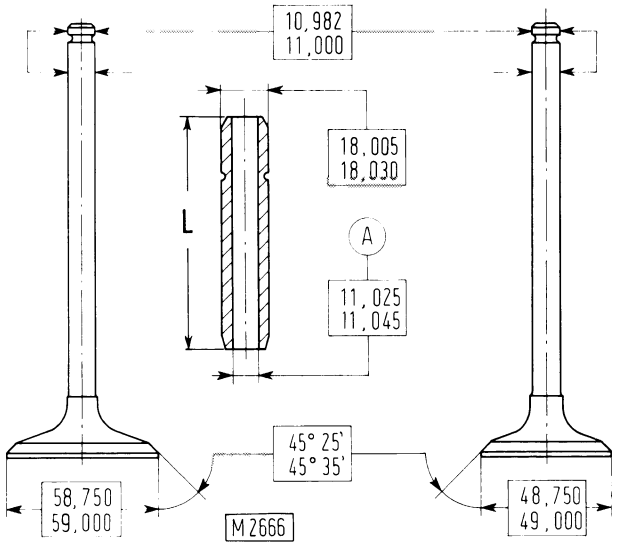


Fig. 16 - Valve and guide details.

A. Installed diameter after reaming - **L.** Valve guide length: inlet 86 mm or 3.39 in, exhaust 76 mm or 2.99 in.

3.2 VALVES AND GUIDES

To remove the valves use tool **75291050**.

Maximum valve stem working clearance is .20 mm or .008 in.

Check valve stems and guides for size using a micrometer gauge and kit **75292867**. If the clearance recorded is excessive, replace the valves in question. If following valve replacement, the clearance still exceeds the specified value, also replace the valve guides.

To install the guides use drift **75291496**, together with a suitable press. Work from the underside of the heads to remove, and from the top to reinstall.

When checking the guides, note the following points:

— Each guide should have a retaining ring.

— The guides should be tight in their seats in the heads, otherwise install oversize guides (see Data Table, Chapter 10).

— After installation each guide should be reamed using reamer **75291265**.

Exhaust guides are 10 mm or .394 in shorter than inlet valve guides (see **L**, Fig. 16).

After reassembly, check that valve depth below cylinder head is 1.3 to 1.9 mm or .05 to .07 in as shown in Fig. 11.

3.2.1 TO ADJUST VALVE CLEARANCE

For valve clearance adjustment, use wrench **75290886** and a feeler gauge. The correct clearance is .30 mm or .012 in for inlet valves and .40 mm or .016 in for exhaust valves.

Cylinder matching for valve clearance adjustment is 1-6, 2-5 and 3-4. Bring the valves of the first cylinder of each pair in a condition of balance to adjust the valves of the second cylinder of the same pair and vice versa.

3.3 TAPPETS AND ROCKERS

Tappet withdrawal necessitates cylinder head removal.

Check tappet working clearance; if in excess of .20 mm or .008 in, fit oversize tappets and open out the associated bores in the engine block (see Data Table, Chapter 10).

Check the rocker shaft and rocker bushings for wear and play.

When bushing replacement is necessary, install as directed in Fig. 17. After installation, the bushings should be reamed to dimensions shown in Fig. 18 by means of expanding blade reamer **75290001**.

WARNING

Always wear safety glasses with side shields when machining or grinding metal, or performing any task where particles might fly.

Inspect the rocker toes. When regrinding becomes necessary, remember that the depth of case (hardened layer) is 1.2 to 2 mm or .047 to .079 in, in the center of the toe.

Reinstall the rocker shaft as indicated in Fig. 19, noting the following points:

— Lubricating ports (**7**, **8** and **9**) should be clear.

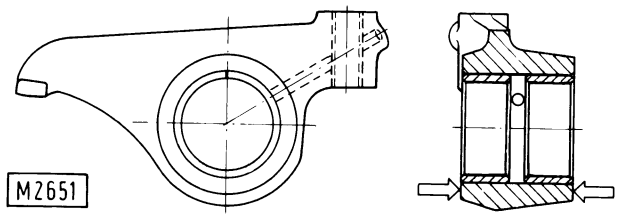


Fig. 17 - Bushing position on rockers.

Note - Bushings must be flush with arrowed planes on rockers.

— Position the shafts so that the machined dimples line up with the stud holes drilled in brackets (**4**) to obtain correct alignment of lubricating ports (**8**).

— The thickness of spring plates (**5**) should be 1.5 mm or .059 in.

— End washers (**6**) are available in three different thicknesses, namely 1.5 mm, 2 mm and 2.5 mm or .060 in, .080 in and .100 in. Use the correct thickness in order to reduce the end float of the end rockers to a minimum.

3.4 VALVE TIMING

To install the valve gear proceed as follows:

— Provisionally adjust the valve clearance (on both inlet and exhaust valves) to .5 mm or .020 in on cylinders 1 and 6.

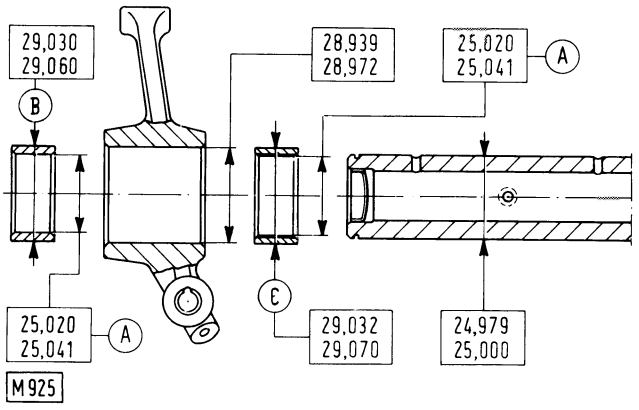


Fig. 18 - Rocker, bushing and shaft details.

A. Installed diameter after reaming - **B.** Bronze bushing - **C.** White metal lined steel shell.

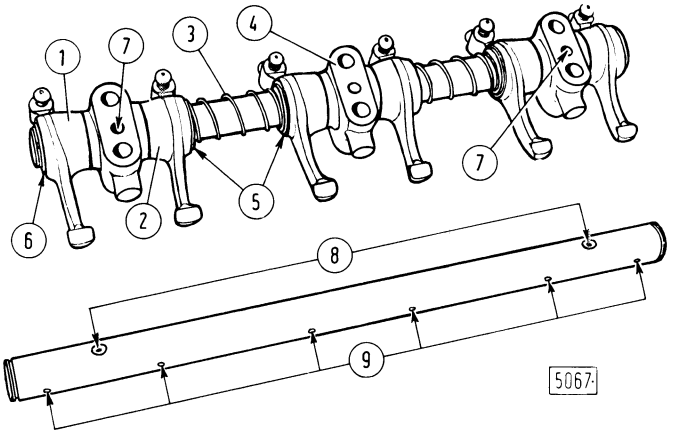


Fig. 19 - Refitting rocker assemblies.

1. Inlet valve rockers - **2.** Exhaust valve rockers - **3.** Spacer springs - **4.** Rocker brackets - **5.** Spring plates - **6.** End washers - **7/8/9.** Lubrication ports.

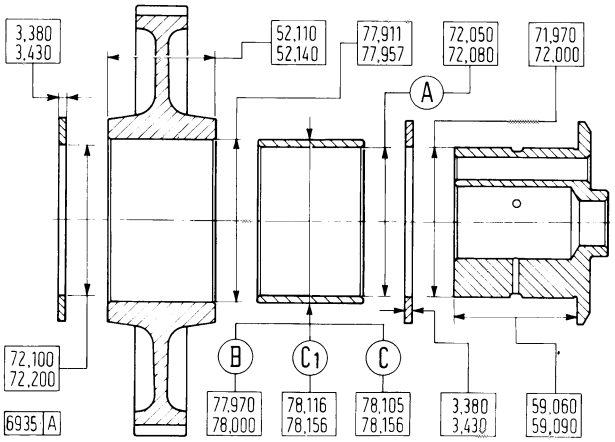


Fig. 20 - Idler gear and jackshaft details.

A. Bushing installed diameter - **B.** Bronze bushing - **C.** White metal lined steel shell (Vandervell type) - **C_1.** White metal lined steel shell (Clevite type).

— Loosen the fuel injectors and rotate the crankshaft until reference mark P.M.S. 1-6 (stamped on flywheel periphery) lines up with the associated fixed timing pointer (see Detail **a**, Fig. 21).

— Reposition the gears over their shafts taking care to align reference marks 1-1, 2-2 and 3-3 shown in Fig. 21, installing the idler gear last. This is necessary because the other two timing gears have their assembly position restricted by dowels (1 and 2).

— Retighten the retaining screws.

— Turn the crankshaft through a few degrees in either direction to ensure that piston no. 1 is on the firing stroke; consequently, the associated valves should be closed while the valves of cylinder no. 6 should be open and in a condition of balance within the prescribed angular setting.

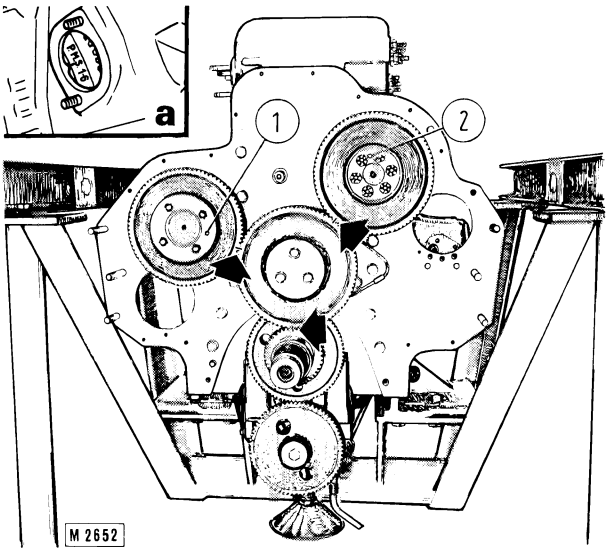


Fig. 21 - Valve timing.

a. Camshaft gear timing mark detail.

1. Injection pump gear dowel - **2.** Camshaft gear dowel.

Note - Valve timing marks **1-1**, **2-2** and **3-3** arrowed.

4. CRANKGEAR

4.1 CRANKSHAFT

To remove the crankshaft remove the engine and place on rotary overhaul stand noting the following points:

— Remove the crankshaft vibration damper hub using puller **75291504** (Fig. 22).
— Remove flywheel housing.
— Remove cylinder heads.
— Remove pistons and connecting rods.
— Remove main bearing caps.
— Remove crankshaft.
— Wash and inspect carefully. Any signs of cracks will necessitate replacement.

Check both main journals and crankpins:

— Scratches and evidence of pick up may be eliminated using a zero grade emery clotch.
— Score marks, out of round or taper errors in excess of .05 mm or .002 in require journal re-grinding to the nearest undersize dimension (see Data Table, Chapter 10).

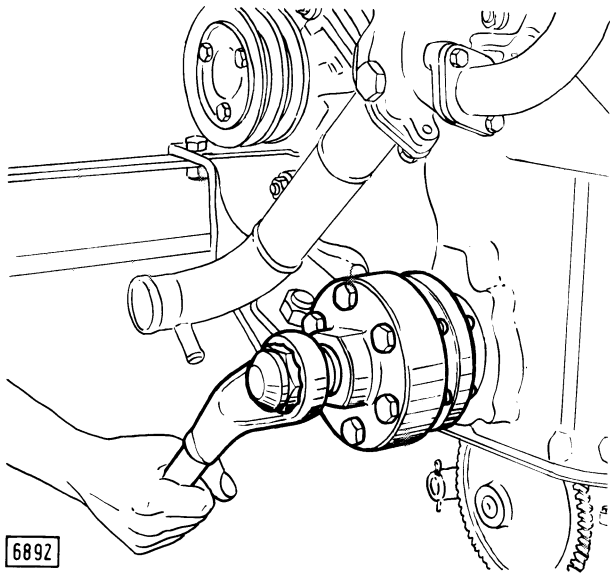


Fig. 22 - Removing crankshaft damper hub using puller 75291504.

WARNING

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

Always wear safety glasses with side shields when machining or grinding metal, or performing any task where particles might fly.

After re-grinding, blend the journal fillets and chamfer the lubricating holes as shown in Fig. 23.
Check the crankshaft noting the following points:

— Out of round of the journals should not exceed .008 mm or .0003 in.
— Taper of each journal should be lower than .012 mm or .0004 in.
— Maximum misalignment with the shaft over V-blocks and cranks 1 and 6 at the top, should be .05 mm or .002 in (**D**, Fig. 24).
— Maximum misalignment of each pair of crankpins with respect to the main journals should not exceed ± .25 mm or .010 in when measured as shown in Fig. 24.
— The allowance on the distance from top of cranking to crankshaft rotational axis should not exceed ± .10 mm or .004 in.
— Run-out as measured with the dial gauge stylus in (**A**, Fig. 24) at the outside of the crankshaft flange should not exceed .02 mm or .0008 in. Eccentricity in (**B**) should not exceed .04 mm or .0001 in.

WARNING

Wear proper safety equipment as hard hat, safety shoes, heavy gloves, safety glasses or goggles where particles might fly.

Check the core plugs for leakage using oil, at 10 bar or 145 psi. In case of replacement, press the new plugs fully home and stake in position. Re-check the circuit with oil under pressure.

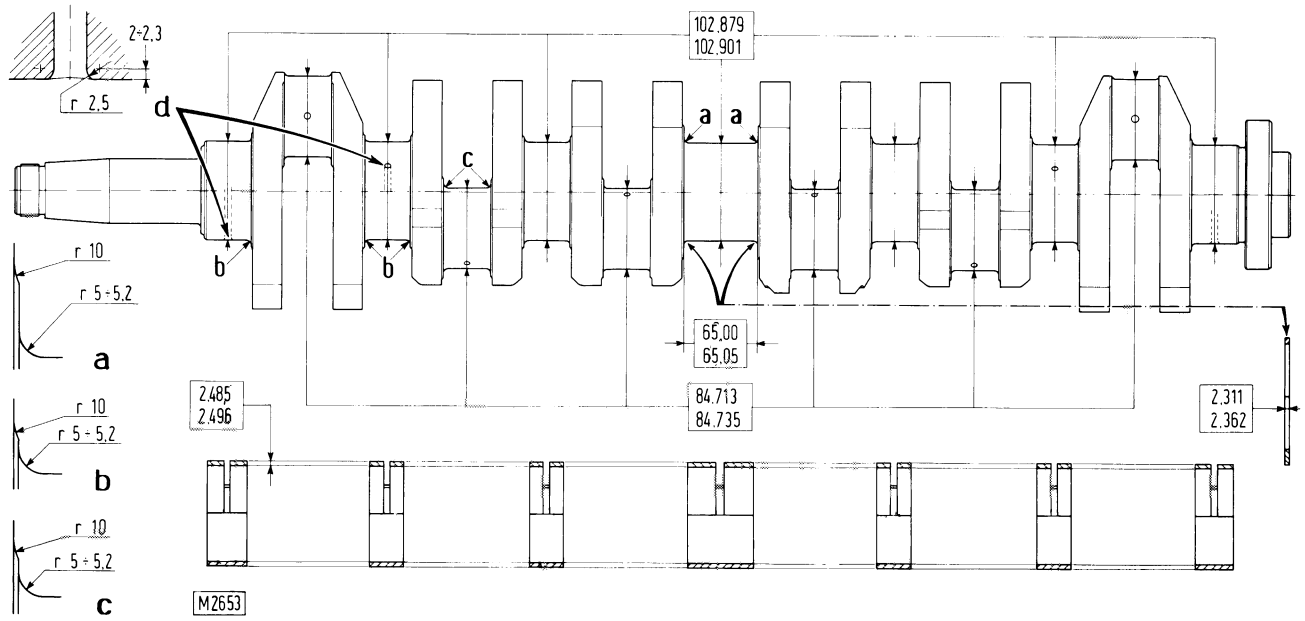


Fig. 23 - Crankshaft journal, bearing and thrust washer details.

a/b/c. Journal fillet radius details - **d.** Lubrication port chamfer details.

4.2 MAIN AND BIG-END BEARINGS

The white-metal-lined thin-shell bearings do not need any adjustment and should be replaced whenever their working surfaces are found to be scored or worn (see Data Table, Chapter 10).
Check the bearing running clearance as follows:

WARNING

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

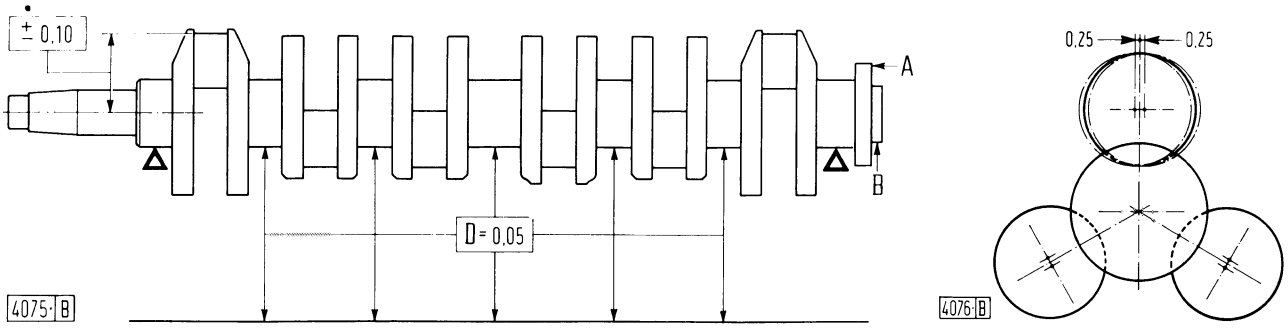


Fig. 24 - Checking main journal and crankpin alignment.

A/B. Flange runout stylus positions - **D.** Maximum main journal misalignment.

— Carefully clean the journals, the bearings and the bearing housings.
— Place a length of Perfect Circle Plastigage, type PR-1 or PB-1 calibrated wire over the bearing at approximately 6 mm or 1/4 in from the centerline. (See Fig 25).
— Install the bearing cap with attached calibrated wire and tighten to the prescribed torque.
— Remove the cap and compare the width of the compressed calibrated wire with the reference scale printed on the wire container.

In the course of this measurement, remember the following:
— The reading represents the amount of clearance.
— Uneven wire width is evidence of journal taper, the amount of which may be assessed by taking a measurement at either end of the wire and subtracting the lower value from the other.

When replacing the main bearings and their caps note the following points (see Fig. 26):
— Bearings **c** and **d** of 2nd, 3rd, 5th and 6th housings are identical.

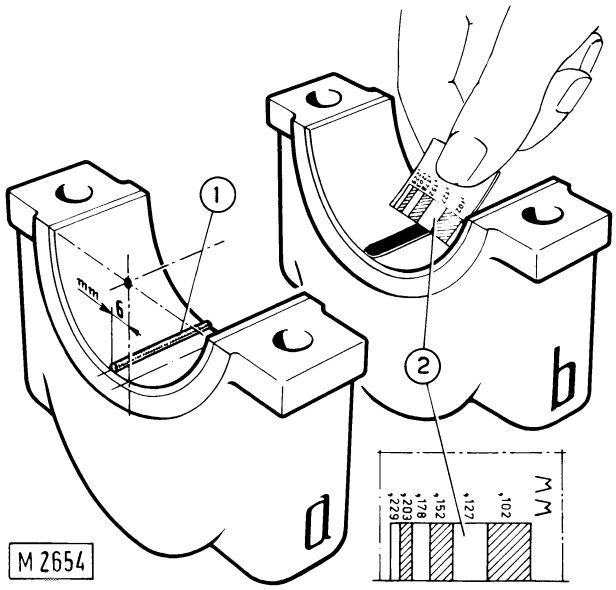


Fig. 25 - Checking bearing running clearance.

a. Calibrated wire position for installing cap - **b.** Measuring calibrated wire compression after removing cap - **1.** Perfect Circle Plastigage type PB1 calibrated wire - **2.** Reference scale on wire container.

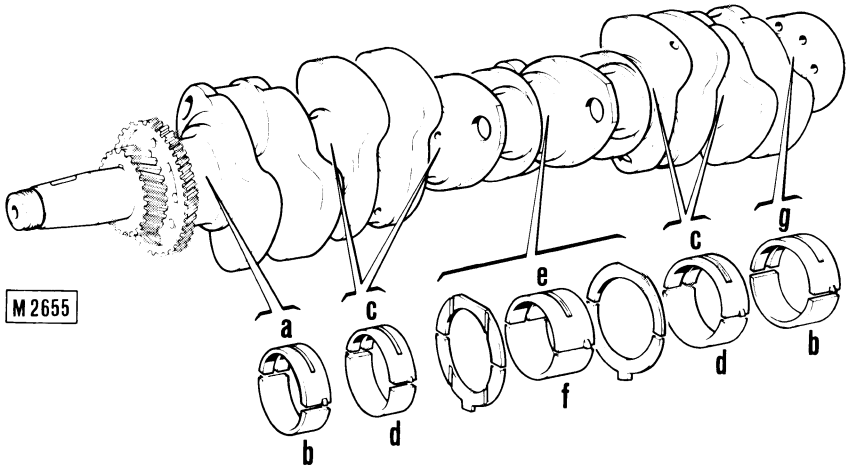


Fig. 26 - Assembling main bearings.

a. Front main bearing top half - **b.** Front and rear main bearing bottom halves - **c.** Intermediate main bearing top halves - **d.** Intermediate main bearing bottom halves - **e.** Center main bearing top half - **f.** Center main bearing bottom half - **g.** Rear main bearing top half.

Note - The complete set of main bearings consists of the following:

Bearing halves	**a**	**b**	**c**	**d**	**e**	**f**	**g**
Quantity	1	2	4	4	1	1	1