Detroit Diesel Engines

In-Line 71 Highway Vehicle Service Manual

IMPORTANT SAFETY NOTICE

Proper service and repair is important to the safe, reliable operation of all motor vehicles. The service procedures recommended by Detroit Diesel Allison and described in this service manual are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the purpose. The special tools should be used when and as recommended.

It is important to note that some warnings against the use of specific service methods that can damage the vehicle or render it unsafe are stated in this service manual. It is also important to understand these warnings are not exhaustive. Detroit Diesel Allison could not possibly know, evaluate and advise the service trade of all conceivable ways in which service might be done or of the possible hazardous consequences of each way. Consequently, Detroit Diesel Allison has not undertaken any such broad evaluation. Accordingly, anyone who uses a service procedure or tool which is not recommended by Detroit Diesel Allison must first satisfy himself thoroughly that neither his safety nor vehicle safety will be jeopardized by the service method he selects.

6SE250 (Rev. 8 83)

Service Manual

Detroit Diesel Engines

IN-LINE 71

HIGHWAY VEHICLE

Detroit Diesel Allison
13400 West Outer Drive
Detroit, Michigan 48239

NOTE:
Additional copies of this service manual may be purchased from Detroit Diesel Allison Distributors. See your yellow pages—under Engines, Diesel.

Printed in U.S.A.

FOREWORD

This manual contains instructions on the overhaul, maintenance and operation of the basic Series 71 In-Line Detroit Diesel Engines.

Full benefit of the long life and dependability built into these engines can be realized through proper operation and maintenance. Of equal importance is the use of proper procedures during engine overhaul.

Personnel responsible for engine operation and maintenance should study the sections of the manual pertaining to their particular duties. Similarly, before beginning a repair or overhaul job, the serviceman should read the manual carefully to familiarize himself with the parts or sub-assemblies of the engine with which he will be concerned.

The information, specifications and illustrations in this publication are based on the information in effect at the time of approval for printing. This publication is revised and reprinted periodically. It is recommended that users contact an authorized *Detroit Diesel Allison Service Outlet* for information on the latest revisions. The right is reserved to make changes at any time without obligation.

TABLE OF CONTENTS

July, 1983

SCOPE AND USE OF THE MANUAL

This manual covers the basic Series 71 In-line on-highway vehicle diesel engines built by the Detroit Diesel Allison Division of General Motors Corporation. Complete instructions on operation, adjustment (tune-up), preventive maintenance and lubrication, and repair (including complete overhaul) are covered. The manual was written primarily for persons servicing and overhauling the engine and, in addition, contains all of the instructions essential to the operators and users. Basic maintenance and overhaul procedures are common to all Series 71 In-line engines, and therefore, apply to all engine models.

The manual is divided into numbered sections. The first section covers the engine (less major assemblies). The following sections cover a complete system such as the fuel system, lubrication system or air system. Each section is divided into subsections which contain complete maintenance and operating instructions for a specific subassembly on the engine. For example, Section 1, which covers the basic engine, contains subsection 1.1 pertaining to the cylinder block, subsection 1.2 covering the cylinder head, etc. The subjects and sections are listed in the Table of Contents on the preceding page. Pages are numbered consecutively, starting with a new Page 1 at the beginning of each subsection. The illustrations are also numbered consecutively, beginning with a new Fig. 1 at the start of each subsection.

Information regarding a general subject, such as the lubrication system, can best be located by using the Table of Contents. Opposite each subject in the Table of Contents is a section number which registers with a tab printed on the first page of each section throughout the manual. Information on a specific subassembly or accessory can then be found by consulting the list of contents on the first page of the section. For example, the cylinder liner is part of the basic engine, therefore, it will be found in Section 1. Looking down the list of contents on the first page of Section 1, the cylinder liner is found to be in subsection 1.6.3. An Alphabetical Index at the back of the manual has been provided as an additional aid for locating information.

SERVICE PARTS AVAILABILITY

Genuine Detroit Diesel Allison service parts are available from authorized Detroit Diesel Allison distributors and service dealers throughout the world. A complete list of all distributors and dealers is available in the World Wide Parts and Service Directory, 6SE280. This publication can be ordered from any authorized distributor.

CLEARANCES AND TORQUE SPECIFICATIONS

Clearances of new parts and wear limits on used parts are listed in tabular form at the end of each section throughout the manual. It should be specifically noted that the "New Parts" clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still assure satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgment of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the paragraph entitled *Inspection* under *General Procedures* in this section.

Bolt, nut and stud torque specifications are also listed in tabular form at the end of each section.

PRINCIPLES OF OPERATION

The diesel engine is an internal combustion power unit, in which the heat of fuel is converted into work in the cylinder of the engine.

In the diesel engine, air alone is compressed in the cylinder; then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

The Two-Cycle Principle

In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes respectively as shown in Fig. 1. In contrast, a four-cycle engine requires four piston strokes to complete an operating cycle; thus, during one half of its operation, the four-cycle engine functions merely as an air pump.

A blower is provided to force air into the cylinders for expelling the exhaust gases and to supply the cylinders with fresh air for combustion. The cylinder wall contains a row of ports which are above the piston when it is at the bottom of its stroke. These ports admit the air from the blower into the cylinder as soon as the rim of the piston uncovers the ports as shown in Fig. 1 (scavenging).

The unidirectional flow of air toward the exhaust valves produces a scavenging effect, leaving the cylinders full of clean air when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is subjected to compression as shown in Fig. 1 (compression).

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion chamber by the unit fuel injector as shown in Fig. 1 (power). The intense heat generated during the high compression of the air ignites the fine fuel spray immediately. The combustion continues until the fuel injected has been burned.

The resulting pressure forces the piston downward on its power stroke. The exhaust valves are again opened when the piston is about half way down, allowing the burned gases to escape into the exhaust manifold as shown in Fig. 1 (exhaust). Shortly thereafter, the downward moving piston uncovers the inlet ports and the cylinder is again swept with clean scavenging air. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft, or, in other words, in two strokes; hence, it is a "two-stroke cycle".

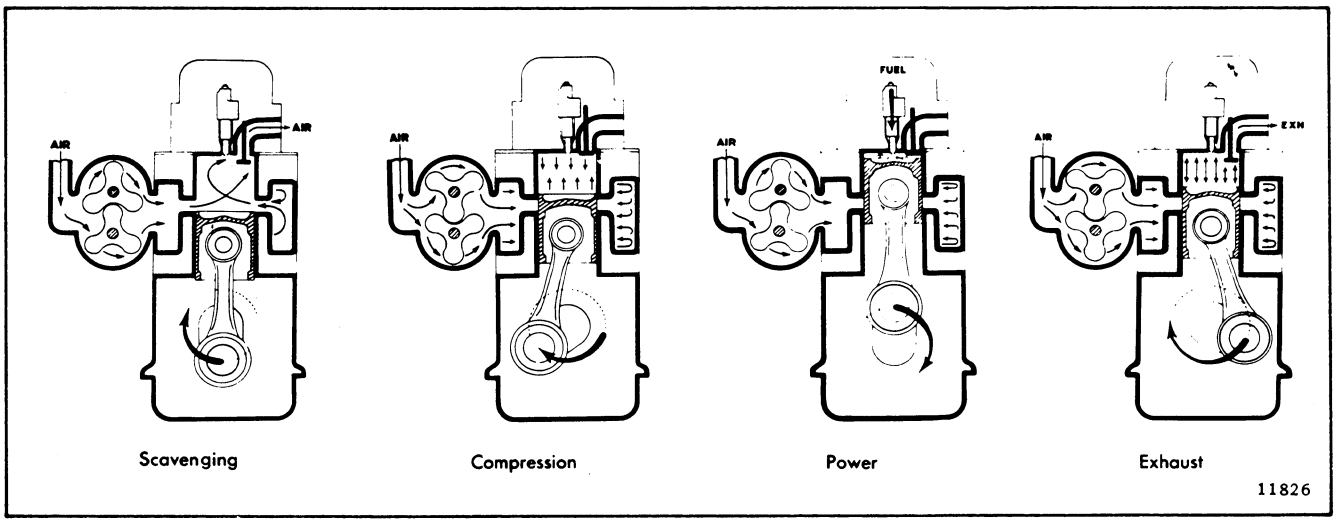


Fig. 1 - The Two-Stroke Cycle

GENERAL DESCRIPTION

The two-cycle diesel engines covered in this manual are produced in 3, 4 and 6 cylinder models having the same bore and stroke and many of the major working parts such as injectors, pistons, connecting rods, cylinder liners and other parts that are interchangeable.

The blower, water pump, governor and fuel pump form a group of standard accessories which can be located on either side of the engine. Further flexibility in meeting installation requirements can be had by placing the exhaust manifold and the water outlet manifold on either side of the engine (Fig. 2). This flexibility in the arrangement of parts is obtained by having both the cylinder block and the cylinder head symmetrical at both ends and with respect to each other.

Each engine is equipped with an oil cooler, full-flow lubricating oil filter, fuel oil strainer, fuel oil filter, air cleaner, governor, fan and radiator and starting motor.

Full pressure lubrication is supplied to all main, connecting rod and camshaft bearings, and to other moving parts within the engine. A gear-type pump draws oil from the oil pan through an intake screen, through the oil filter and then to the oil cooler. From the oil cooler, the oil enters a longitudinal oil gallery in the cylinder block where the supply divides; a portion entering the bypass filter, if used, and then draining back into the oil pan, part going to the cam and balance shaft end bearings and cylinder head, with the remainder going to the main bearings and connecting rod bearings via the drilled crankshaft.

Coolant is circulated through the engine by a centrifugal-type water pump. Heat is removed from the coolant, which circulates in a closed system, by the radiator. Control of the engine temperature is accomplished by a thermostat which regulates the flow of the coolant within the cooling system.

Fuel is drawn from the supply tank through the fuel strainer by a gear-type fuel pump. It is then forced through a filter and into the fuel inlet manifold in the cylinder head and to the injectors. Excess fuel is returned to the supply tank through the fuel outlet manifold and connecting lines. Since the fuel is constantly circulating through the injectors, it serves to cool the injectors and also carries off any air in the fuel system.

Air for scavenging and combustion is supplied by a blower which pumps air into the engine cylinders via the air box and cylinder liner ports. All air entering the blower first passes through an air cleaner.

Engine starting is provided by an electric starting motor energized by a storage battery. A battery-charging generator, with a suitable voltage regulator, or an alternator serves to keep the battery charged.

Engine speed is controlled by a mechanical governor.

GENERAL SPECIFICATIONS

	3-71	4-71	6-71
Type	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	3	4	6
Bore (inches)	4.25	4.25	4.25
Bore (mm)	108	108	108
Stroke (inches)	5	5	5
Stroke (mm)	127	127	127
Compression Ratio (Nominal) (Std & Turbo)	17 to 1	17 to 1	17 to 1
Compression Ratio (Nominal) ("N" Engines)	18.7 to 1	18.7 to 1	18.7 to 1
Total Displacement - cubic inches	213	284	426
Total Displacement - litres	3.49	4.66	6.99
Firing Order - R.H. Rotation	1-3-2	1-3-4-2	1-5-3-6-2-4
Number of Main Bearings	4	5	7

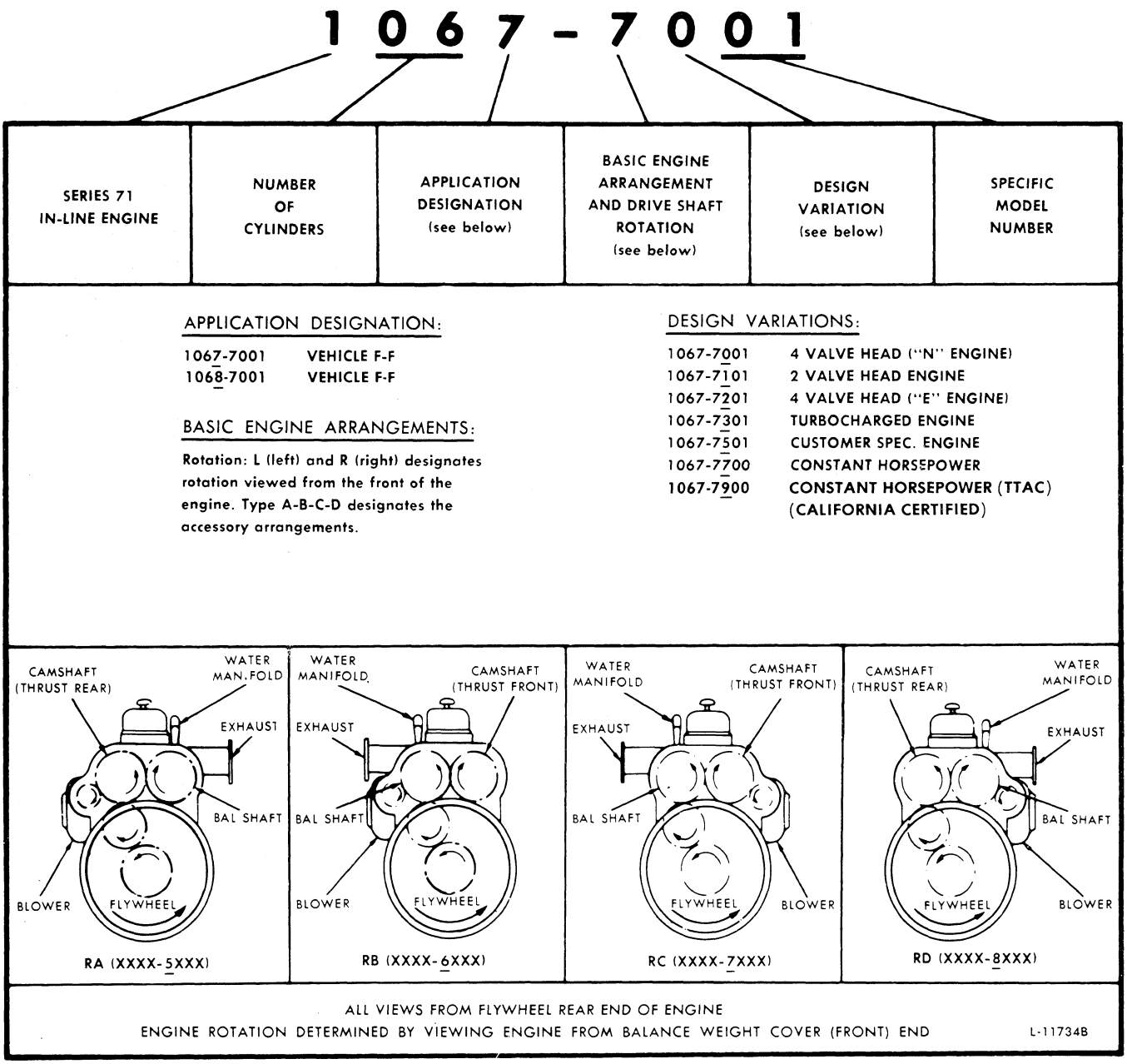


Fig. 2 - Model Numbering (Current Engines), Rotation and Accessory Arrangements

ENGINE MODEL, SERIAL NUMBER AND OPTION PLATE

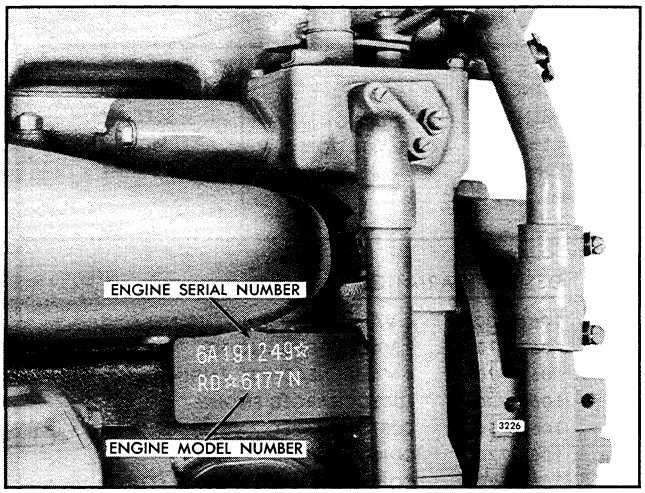


Fig. 3 - Typical Engine Serial Number and Model Number as Stamped on Cylinder Block (Former Engines)

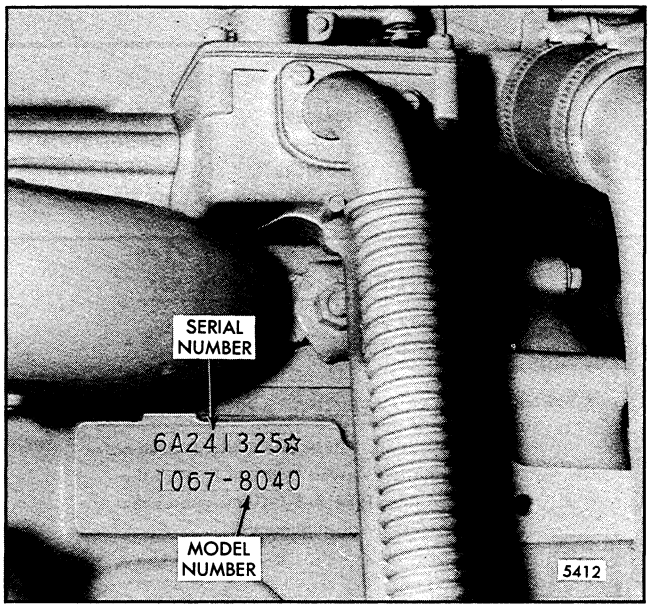


Fig. 4 - Typical Engine Serial Number and Model Number As Stamped on Cylinder Block (Current Engines)

Engine Model and Serial Numbers

On all current Series 71 engines, the engine serial number and the engine model number are stamped on the cylinder block (Figs. 3 and 4). The engine serial number and model number are also stamped on the Option Plate (when used) attached to the valve rocker cover.

The engine serial number is prefixed by numerals indicating the number of cylinders and the letter "A" which designates a Series 71 engine.

Current Series 71 engines are identified by an eight digit model number (Fig. 2). The engine model number 1067-7001 illustrated is interpreted as follows: Series 71 In-line engine (1), six-cylinder (06), vehicle engine (7), right-hand rotation with "C" accessory arrangement (7), four-valve head "N" engine (0) and specific model variation No. 1 (01).

Option Plate

An option plate, attached to the valve rocker cover, carries the engine serial number and model number and, in addition, lists any optional equipment used on the engine (Fig. 5). An exhaust emission certification label, separate from the option plate, is mounted permanently in the option plate retainer. The current label includes information relating to an engine family for the maximum fuel injector size and maximum speed. *Due to Federal regulations, the exhaust emission plate should not be removed from the rocker cover.* Refer to Section 14 for further information regarding emission regulations.

With any order for parts, the engine model number and serial number must be given. In addition, if a type number is shown on the option plate covering the equipment required, this number should also be included on the parts order.

All groups of parts used on an engine are standard for the engine model unless otherwise listed on the option plate.

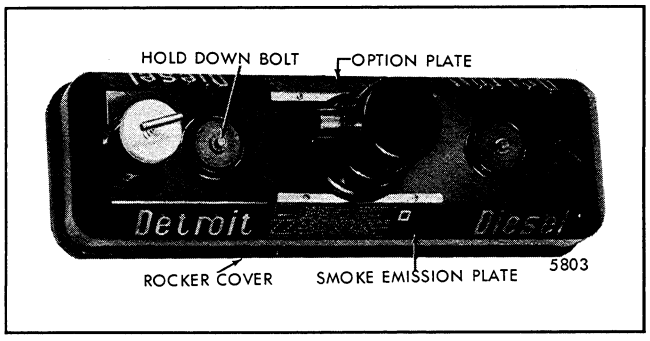


Fig. 5 - Option Plate

GENERAL PROCEDURES

In many cases, a serviceman is justified in replacing parts with new material rather than attempting repair. However, there are times where a slight amount of reworking or reconditioning may save a customer considerable added expense. Crankshafts, cylinder liners and other parts are in this category. For example, if a cylinder liner is only slightly worn and within usable limits, a honing operation to remove the glaze may make it suitable for reuse, thereby saving the expense of a new part. Exchange assemblies such as injectors, fuel pumps, water pumps and blowers are also desirable service items.

Various factors such as the type of operation of the engine, hours in service and next overhaul period must be considered when determining whether new parts are installed or used parts are reconditioned to provide trouble-free operation.

For convenience and logical order in disassembly and assembly, the various subassemblies and other related parts mounted on the cylinder block will be treated as separate items in the various sections of the manual.

DISASSEMBLY

Before any major disassembly, the engine must be drained of lubricating oil, water and fuel. Lubricating oil should also be drained from any transmission attached to the engine.

To perform a major overhaul or other extensive repairs, the complete engine assembly, after removal from the vehicle and transmission, should be mounted on an engine overhaul stand; then the various subassemblies should be removed from the engine. When only a few items need replacement, it is not always necessary to mount the engine on an overhaul stand.

Parts removed from an individual engine should be kept together so they will be available for inspection and assembly. Those items having machined faces, which might be easily damaged by steel or concrete, should be stored on suitable wooden racks or blocks, or a parts dolly.

CLEANING

Before removing any of the subassemblies from the engine (but after removal of the electrical equipment), the exterior of the engine should be thoroughly cleaned. Then, after each subassembly is removed and disassembled, the individual parts should be cleaned. Thorough cleaning of each part is absolutely necessary before it can be satisfactorily inspected. Various items of equipment needed for general cleaning are listed below.

The cleaning procedure used for all ordinary cast iron parts is outlined under *Clean Cylinder Block* in Section 1.1; any special cleaning procedures will be mentioned in the text wherever required.

Steam Cleaning

A steam cleaner is a necessary item in a large shop and is most useful for removing heavy accumulations of grease and dirt from the exterior of the engine and its subassemblies.

Solvent Tank Cleaning

A tank of sufficient size to accomodate the largest part that will require cleaning (usually the cylinder block) should be provided and provisions made for heating the cleaning solution to 180° -200° F (82° -90° C).

Fill the tank with a commercial heavy-duty solvent which is heated to the above temperature. Lower large parts directly into the tank with a hoist. Place small parts in a wire mesh basket and lower them into the tank. Immerse the parts long enough to loosen all of the grease and dirt.

Rinsing Bath

Provide another tank of similar size containing hot water for rinsing the parts.

Drying

Parts may be dried with compressed air. The heat from the hot tanks will quite frequently complete the drying of the parts without the use of compressed air.

Rust Preventive

If parts are not to be used immediately after cleaning, dip them in a suitable rust preventive compound. The rust preventive compound should be removed before installing the parts in an engine.

INSPECTION

The purpose of parts inspection is to determine which parts can be used and which must be replaced. Although the engine overhaul specifications given throughout the text will aid in determining which parts should be replaced, considerable judgment must be exercised by the inspector.

The guiding factors in determining the usability of worn parts, which are otherwise in good condition, is the clearance between the mating parts and the rate of wear on each of the parts. If it is determined that the rate of wear will maintain the clearances within the specified maximum allowable until the next overhaul period, the reinstallation of used parts may be justified. Rate of wear of a part is determined by dividing the amount the part has worn by the hours it has operated.

Many service replacement parts are available in various undersize and/or oversize as well as standard sizes. Also, service kits for reconditioning certain parts and service sets which include all of the parts necessary to complete a particular repair job are available.

A complete discussion of the proper methods of precision measuring and inspection are outside the scope of this manual. However, every shop should be equipped with standard gages, such as dial bore gages, dial indicators, and inside and outside micrometers.

In addition to measuring the used parts after cleaning, the parts should be carefully inspected for cracks, scoring, chipping and other defects.

ASSEMBLY

Following cleaning and inspection, the engine should be assembled using new parts as determined by the inspection.

Use of the proper equipment and tools makes the job progress faster and produces better results. Likewise, a suitable working space with proper lighting must be provided. The time and money invested in providing the proper tools, equipment and space will be repaid many times.

Keep the working space, the equipment, tools and engine assemblies and parts clean at all times. The area where assembly operations take place should, if possible, be located away from the disassembly and cleaning operation. Also, any machining operations should be removed as far as possible from the assembly area.

Particular attention should be paid to storing of parts and subassemblies, after removal and cleaning and prior to assembly, in such a place or manner as to keep them clean. If there is any doubt as to the cleanliness of such parts, they should be recleaned.

When assembling an engine or any part thereof, refer to the table of torque specifications at the end of each section for proper bolt, nut and stud torques.

To ensure a clean engine at time of rebuild, it is important that any plug, fitting or fastener (including studs) that intersects with a through hole and comes in contact with oil, fuel or coolant must have a sealer applied to the threads.

A number of universal sealers are commercially available. It is recommended that Loctite J 26558-92 *pipe sealer with teflon*, or equivalent, be used.

> **NOTE:** Certain plugs, fittings and fasteners available from the Parts Depot already have a sealer applied to the threads. This pre-coating will not be affected when the pipe sealer with teflon is also applied.

The sealer information above must not be confused with International Compound No. 2, which is a lubricant applied before tightening certain bolts. Use International Compound No. 2 only where specifically stated in the manual.

WORK SAFELY

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune, take these precautions before starting to work on an engine:

1. Disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.

2. Make sure the mechanism provided at the governor for stopping the engine is in the stop position. This will mean the governor is in the no-fuel position. The possibility of the engine firing by accidentally turning the fan or by being bumped by another vehicle is minimized.

Some Safety Precautions To Observe When Working On The Engine

1. Consider the hazards of the job and wear protective gear such as safety glasses, safety shoes, hard hat, etc. to provide adequate protection.

2. When lifting an engine, make sure the lifting device is fastened securely. Be sure the item to be lifted does not exceed the capacity of the lifting device.

3. Always use caution when using power tools.

4. When using compressed air to clean a component, such as flushing a radiator or cleaning an air cleaner element, use a safe amount of air. Recommendations regarding the use of air are indicated throughout the manual. Too much air can rupture or in some other way damage a component and create a hazardous situation that can lead to personal injury.

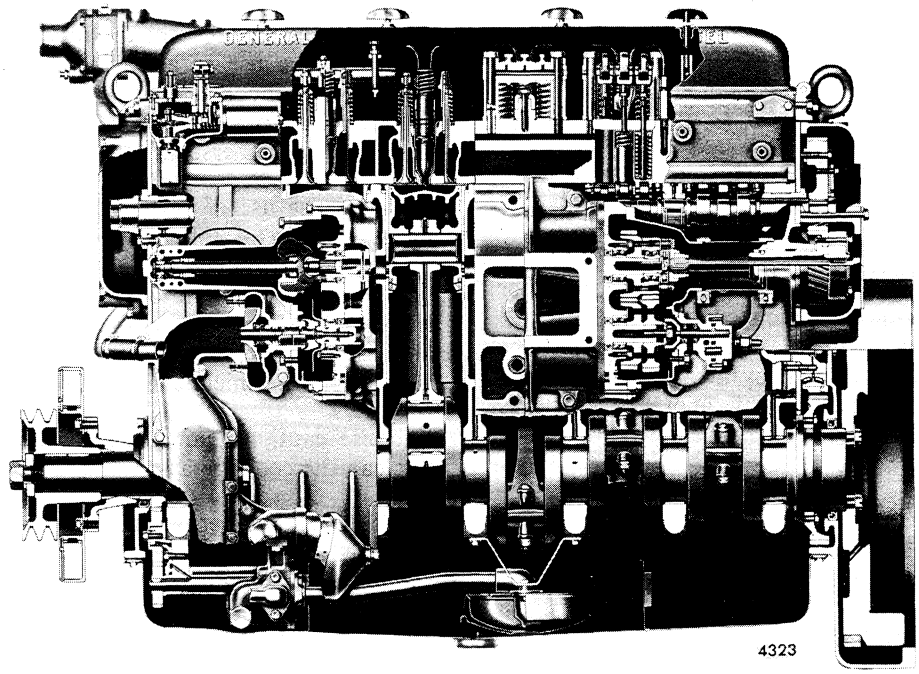
5. Avoid the use of carbon tetrachloride as a cleaning agent because of the harmful vapors that it releases. Use perchlorethylene or trichlorethylene. However, while less toxic than other chlorinated solvents, use these cleaning agents with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield and an apron.

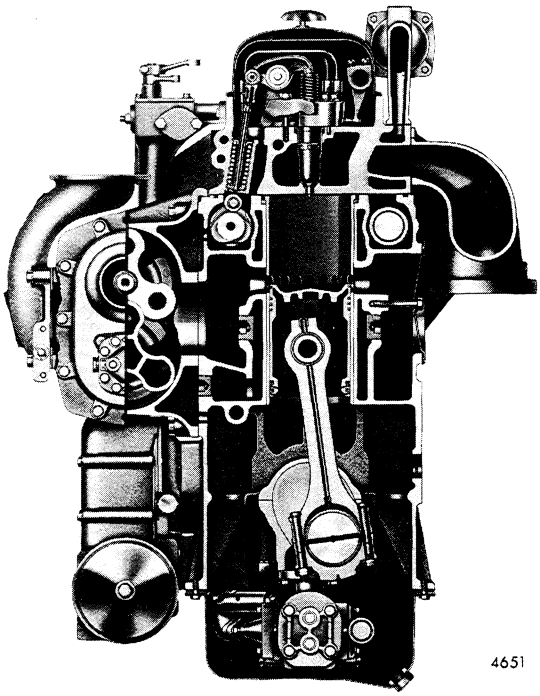
Exercise caution against burns when using oxalic acid to clean the cooling passages of the engine.

6. Use caution when welding on or near the fuel tank. Possible explosion could result if heat build-up inside the tank is sufficient.

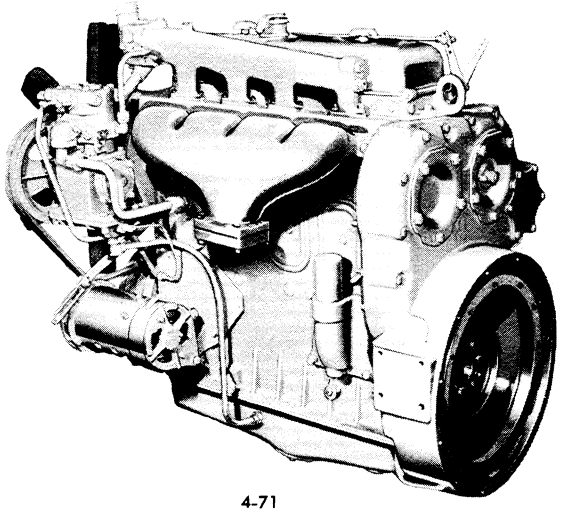
7. Avoid excessive injection of ether into the engine during start attempts. Follow the instructions on the container or by the manufacturer of the starting aid.

8. When working on an engine that is running, accidental contact with the hot exhaust manifold can cause severe burns. Remain alert to the location of the rotating fan, pulleys and belts. Avoid making contact across the two terminals of a battery which can result in severe arcing.

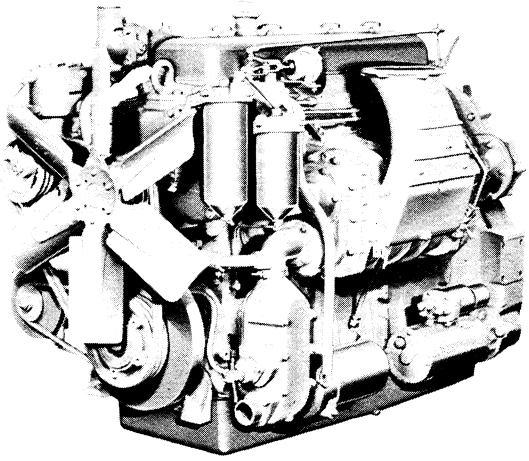




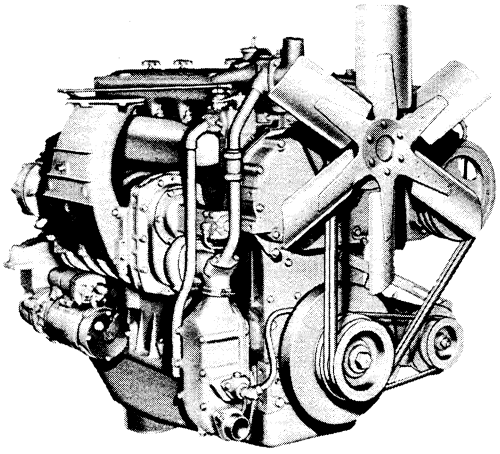
Cross-Sections of Typical Series 71 Engine



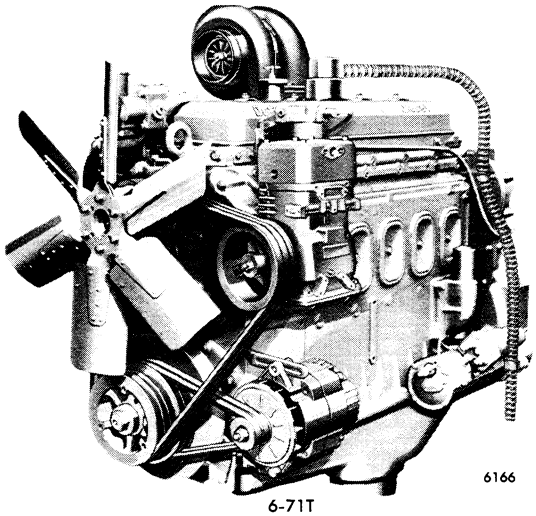
4-71



6-71E



6-71N



6166

6-71T

Typical Engine Models

SECTION 1

ENGINE (less major assemblies)

CONTENTS

CYLINDER BLOCK

The cast iron cylinder block (Figs. 1 and 2) serves as the main structural part of the engine. Transverse members, cast integrally, provide rigidity and strength and ensure alignment of the block bores and bearings under load. Cylinder blocks for the four and six-cylinder engines are identical in design and dimensions except for length. The two ends of the block are similar, so the flywheel housing and gear train can be assembled to either end.

The block is bored to receive replaceable cylinder liners. Water jackets, which extend the full length of the bores, are divided into upper and lower sections which are connected by hollow struts (Fig. 2). Coolant from the pump enters at the bottom of each water jacket and leaves at the top of the block through holes which register with corresponding openings in the cylinder head.

An air box (Fig. 2) surrounding the water jackets conducts the air from the blower to the air inlet ports in the cylinder liners. Air box openings (Fig. 3) on the side of the block opposite to the blower provide access to the air box and permit inspection of the pistons and compression rings through the air inlet ports in the cylinder walls. The six-cylinder block has two additional air box openings on the blower side.

The camshaft and balance shaft bores are located on opposite sides near the top of the block.

The upper halves of the main bearing supports are cast integral with the block. The main bearing bores are line-bored with the bearing caps in place to ensure longitudinal alignment. Drilled passages in the block carry the lubricating oil to all moving parts of the engine, eliminating the need for external piping.

The perimeter of the top surface of the cylinder block is grooved, outside of the cam pockets, to accommodate a block-to-head oil seal ring. The top surface of the block is also counterbored at each water or oil passage to accommodate individual seal rings (Fig. 4).

Each cylinder liner is retained in the block by a flange at its upper end. The liner flange rests on a cast iron insert located in the counterbore in the block bore. An individual compression gasket is used at each cylinder.

When the cylinder head is installed, the gaskets and seal rings compress sufficiently to form a tight metal-to-metal contact between the head and block.

New service replacement cylinder block assemblies include the main bearing caps and bolts, dowels and the necessary plugs.

Since the cylinder block is the main structural part of the engine, the various sub-assemblies must be removed from the cylinder block when an engine is overhauled.

The hydraulically operated overhaul stand (Fig. 5) provides a convenient support when stripping a cylinder block. The engine is mounted in an upright position. It may then be tipped on its side, rotated in either direction 90 ° or 180 ° where it is locked in place and then, if desired, tipped back with either end or the oil pan side up.

Remove and Disassemble Engine

Before mounting an engine on an overhaul stand, it must be removed from the vehicle and disconnected from the transmission. Details of this procedure will vary from one application to another. However, the following steps will be necessary.

1. Drain the cooling system.

2. Drain the lubricating oil.

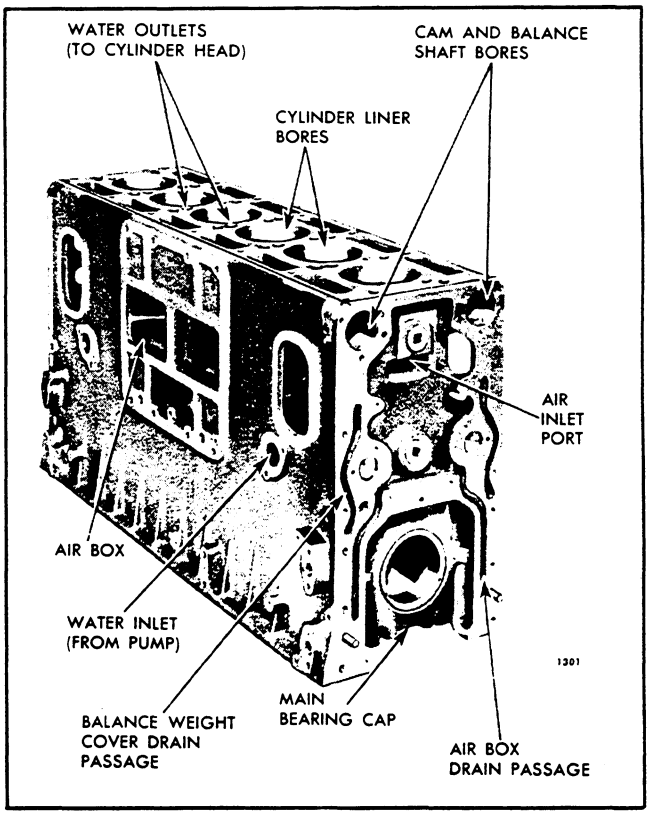


Fig. 1 - Typical Cylinder Block

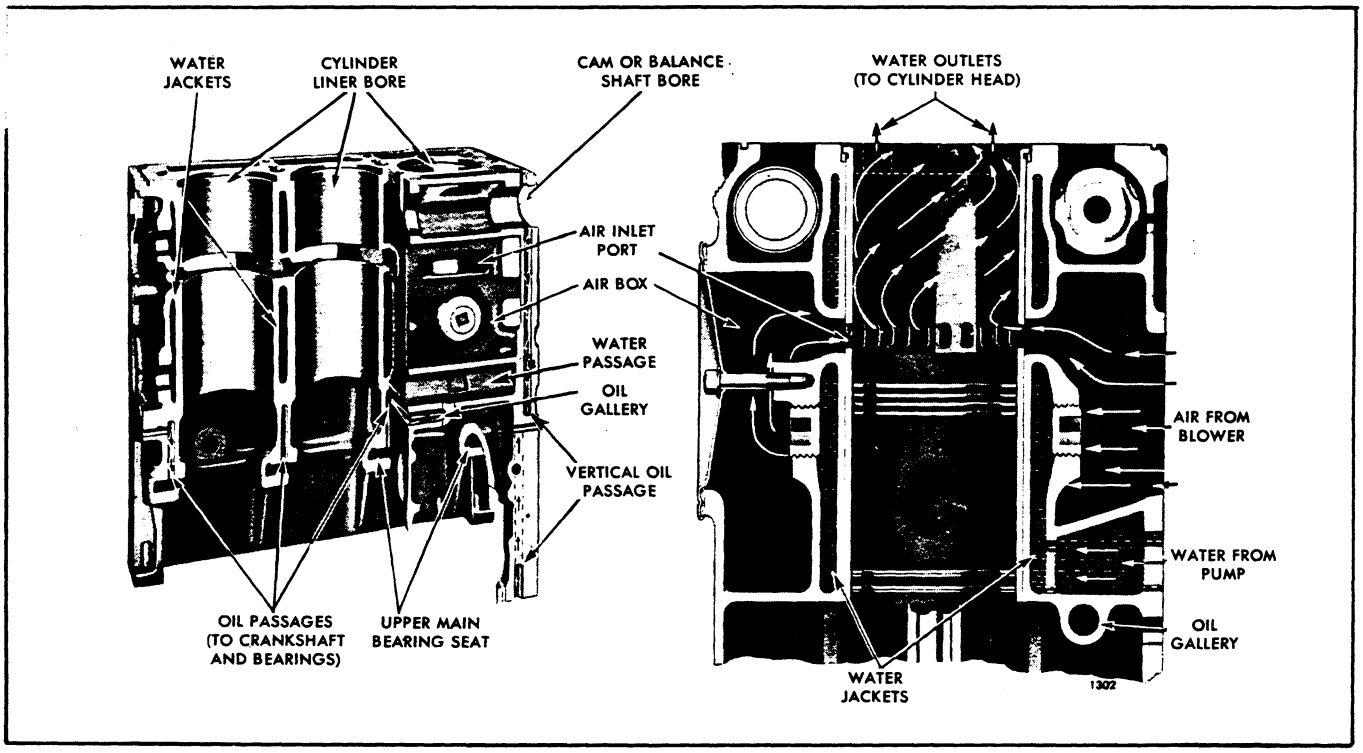


Fig. 2 - Cutaway View of Cylinder Block Showing Air and Water Passages

3. Disconnect the fuel lines.

4. Remove the air cleaner and mounting bracket.

5. Remove the turbocharger, if used.

6. Disconnect the exhaust piping and remove the exhaust manifold.

7. Disconnect the throttle controls.

8. Disconnect and remove the starting motor, battery-charging generator and other electrical equipment.

9. Remove the air compressor, if used.

10. Remove the radiator and other related cooling system parts.

11. Remove the air box covers.

12. Disconnect any other lubricating oil lines, fuel lines or electrical connections.

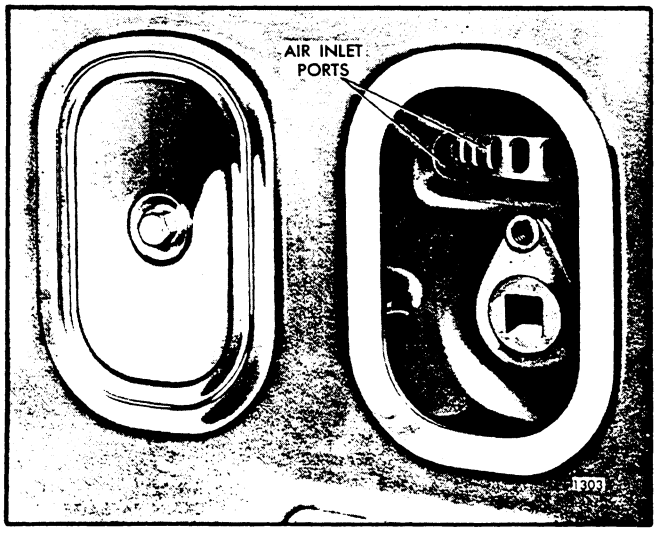


Fig. 3 - Air Box Covers and Air Inlet Ports

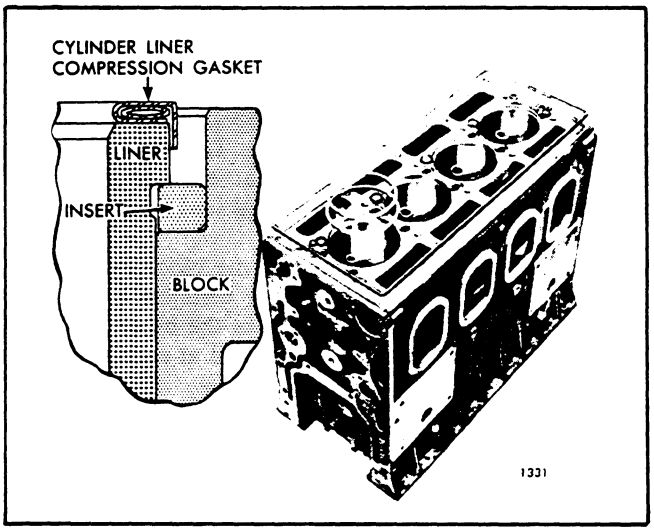


Fig. 4 - Sealing Arrangement of Cylinder Block

13. Separate the engine from the transmission.

14. Remove the engine mounting bolts.

15. Use a spreader bar with a suitable sling and adequate chain hoist to lift the engine from its base (Fig. 6). To prevent bending of the engine lifter brackets the lifting device should be adjusted so the lifting hooks are vertical. To ensure proper weight distribution, all engine lifter brackets should be used to lift the engine.

NOTE: Do not lift an engine by the webs in the air inlet opening of the cylinder block.

16. Locate the center lug of the overhaul stand adaptor plate in the proper air box opening on the side of the block opposite the blower. The center lug is located in the number two opening of four cylinder engines and in the number four opening of six cylinder engines.

The adaptor plate, used with the hydraulic engine overhaul stand, must be attached to the mounting plate on the overhaul stand with six spacers and bolts (Fig. 5). Long spacers and bolts are used with the four cylinder engines and short spacers and bolts are used with the six cylinder engines. The spacers provide the necessary clearance for the front balance weight cover and the flywheel housing when the engine is tipped on its side and rotated.

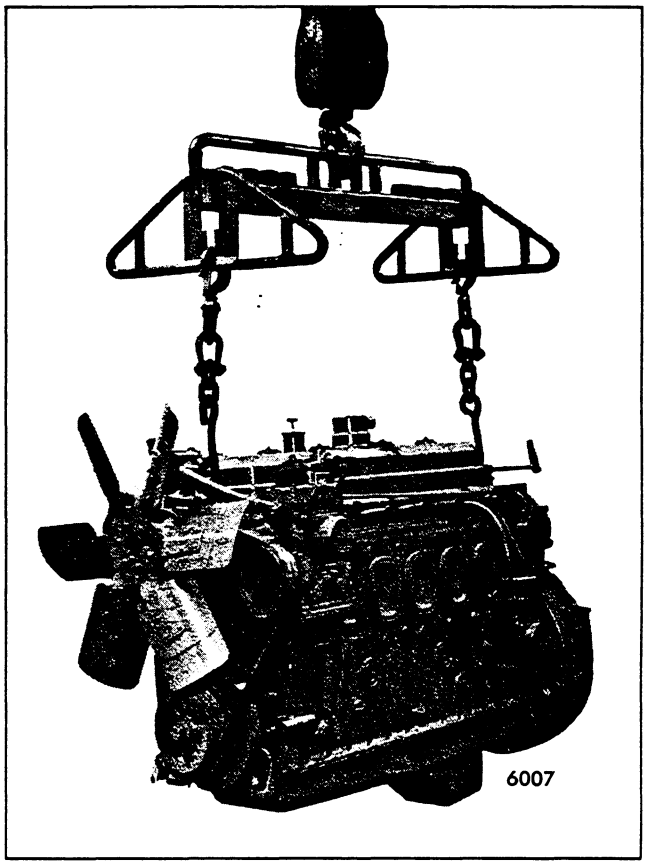


Fig. 6 - Lifting Engine with Spreader and Sling

17. Loosen the locknuts on the two holding lugs on the adaptor plate and lower the engine while guiding the lugs into the air box openings.

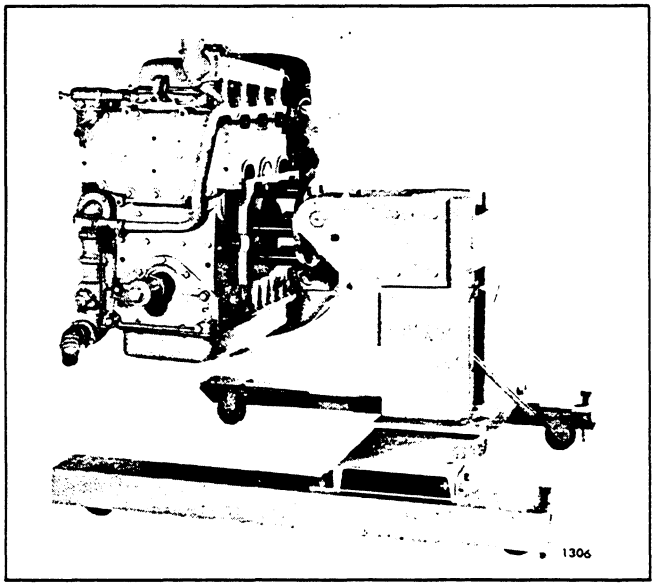


Fig. 5 - Engine Mounted on Overhaul Stand (J 6837-C) and Adaptor (J 8196)

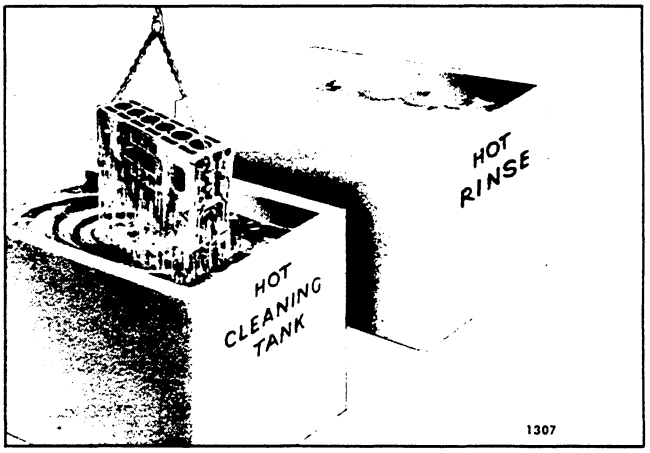


Fig. 7 - Cleaning Cylinder Block

18. Turn the holding lugs crosswise in the air box openings and tighten the locknuts, drawing the engine tight against the adaptor plate.

19. To be sure the engine does not shift on or break away from the overhaul stand, insert a 7/16"-14 x 2" bolt, with a plain washer under the head of the bolt, through the hole in the adaptor plate and into the pad on the cylinder block.

CAUTION: Be sure the engine is securely mounted to the overhaul stand before releasing the lifting sling. Severe injury to personnel and destruction of engine parts will result if the engine breaks away from the overhaul stand.

20. With the engine mounted on the overhaul stand, remove all of the remaining subassemblies and parts from the cylinder block. The procedure for removing each subassembly from the cylinder block, together with disassembly, inspection, repair and reassembly of each, will be found in the various sections of this manual.

After stripping, the cylinder block must be thoroughly cleaned and inspected.

Clean Cylinder Block

Scrape all gasket material from the cylinder block. Then remove all oil gallery plugs and core hole plugs (except cup plugs) to allow the cleaning solution to contact the inside of the oil and water passages. This permits more efficient cleaning and eliminates the possibility of the cleaning solution attacking the aluminum core hole plug gaskets.

If a core hole plug is difficult to remove, hold a 3/4" drift against the plug and give it a few sharp blows with a one-pound hammer. With a 1/2" flexible handle and a short extension placed in the countersunk hole in the plug, turn the plug slightly in the direction of tightening. Then turn it in the opposite direction and back the plug out.

Clean the cylinder block as follows:

1. Remove the grease by agitating the cylinder block in a hot bath of commercial heavy-duty alkaline solution (Fig. 7).

2. Wash the block in hot water or steam clean it to remove the alkaline solution.

3. If the water jackets are heavily scaled, proceed as follows:

a. Agitate the block in a bath of inhibited commercial pickling acid.

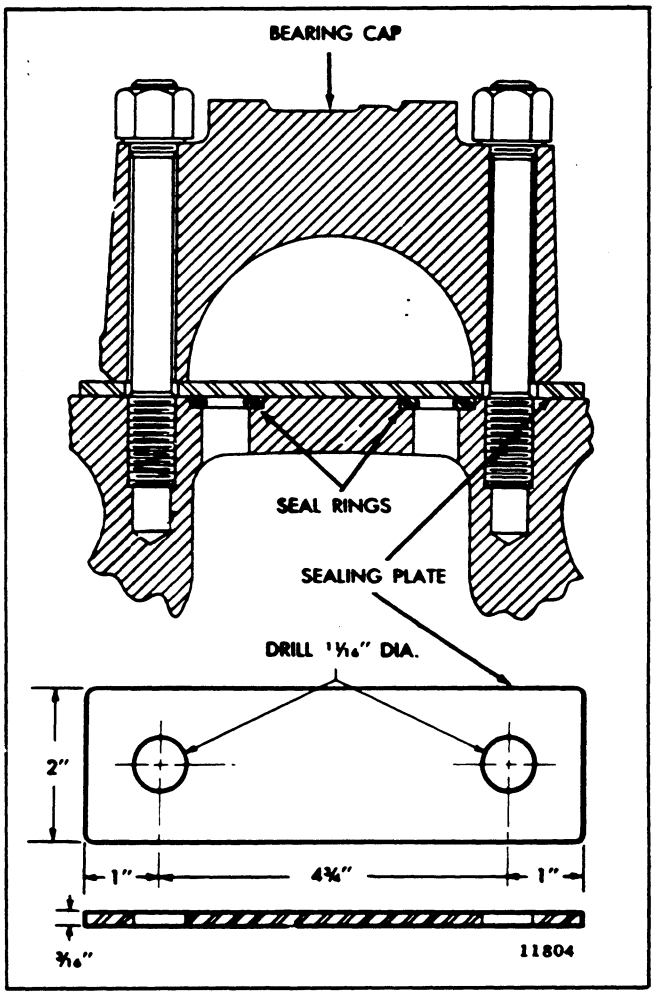


Fig. 8 - Sealing Plate Details for Pressure Testing Cylinder Block

b. Allow the block to remain in the acid bath until the bubbling action stops (approximately 30 minutes).

c. Lift the block, drain it and reimmerse it in the same acid solution for 10 minutes.

d. Repeat Step "c" until all scale is removed.

e. Rinse the block in clear hot water to remove the acid solution.

f. Neutralize the acid that may cling to the casting by immersing the block in an alkaline bath.

g. Wash the block in clean water or steam clean it.

4. Dry the cylinder block with compressed air.

5. Make certain that all water passages, oil galleries and air box drain holes have been thoroughly cleaned.

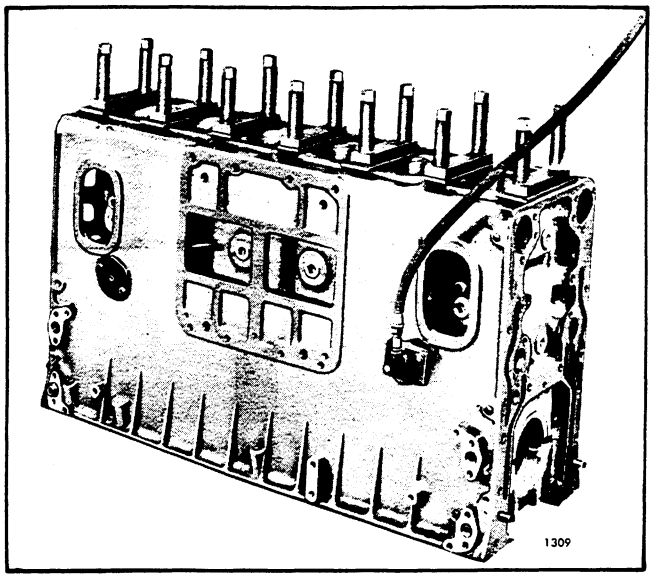


Fig. 9 - Cylinder Block Prepared for Pressure Test

NOTE: The above cleaning procedure may be used on all ordinary cast iron and steel parts of the engine. Mention will be made of special cleaning procedures whenever necessary.

After the cylinder block has been thoroughly cleaned and dried, reinstall the core hole plugs. Coat the threads of the plugs with sealant. Install the core hole plugs in the sides of the block from 2" to 2-1/4" below the machined surface of the block. They must be water tight. The core hole plugs in the ends of the block are flanged to provide a positive stop against the counterbore of the hole, thus preventing the plugs from entering the water jacket and restricting the flow of water. Soft aluminum gaskets are used with the plugs. Coat the threads of the end plugs with sealant and, using new gaskets, reinstall the plugs and tighten them to 150-180 lb-ft (204-244 Nm) torque.

NOTE: Excessive torque applied to the core hole plugs may result in cracks in the water jacket.

Pressure Test Cylinder Block

Extremely tight fitting cylinder liners, severe scoring of the liners and overheating of the engine may result in cracks in the cylinder bores. Overheating of the engine may also result in cracks between the water jackets and the oil passages.

The cylinder block may be pressure tested for cracks or leaks by either one of two methods. In either method, it will be necessary to make plates (Fig. 8) to seal the water openings in the top of the block. Main

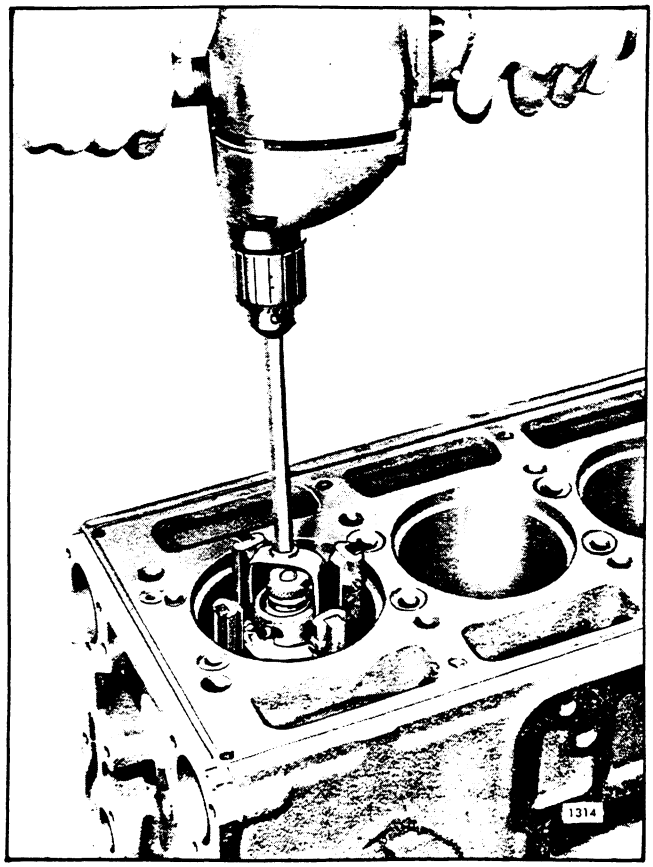


Fig. 10 - Honing Bore of Cylinder Block with Tool J 5902-01

bearing caps may be used to secure the plates to the block with the cylinder head bolts or studs and nuts. Cylinder head seal rings may be used as gaskets between the plates and the block. It will also be necessary to use water hole cover plates and gaskets to cover the water pump inlet openings in the block. Drill and tap one cover plate to provide a connection for an air line (Fig. 9).

With the cylinder block prepared in the above manner, the core hole plugs installed and the plugs removed from the oil passages, test the block as follows:

METHOD "A"

This method may be used when a large enough water tank is available and the cylinder block is completely stripped of all parts.

1. Immerse the block for twenty minutes in a tank of water heated to 180-200° F (82-93° C).

2. Apply 40 psi (276 kPa) air pressure to the water jacket and observe the water in the tank for bubbles which indicate the presence of cracks or leaks in the

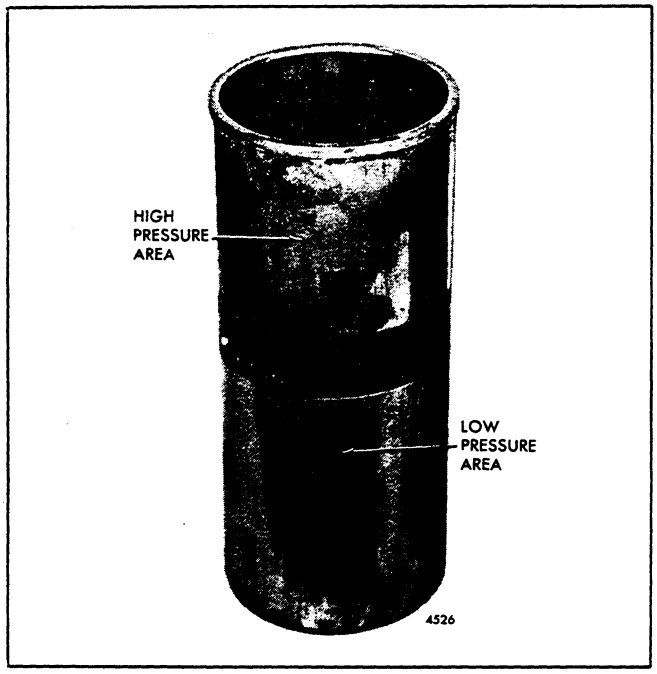


Fig. 11 - High Pressure Areas on Cylinder Liner

block. A cracked cylinder block must be replaced by a new block.

3. After the pressure test is completed, remove the block from the water tank. Then remove the plates and gaskets and dry the block with compressed air.

METHOD "B"

This method may be used when a large water tank is unavailable, or when it is desired to check the block for cracks without removing the engine from the vehicle. However, it is necessary to remove the cylinder head, blower, oil cooler, air box covers and oil pan.

1. Attach sealing plates and gaskets as in Method "A". However, before attaching the last sealing plate, fill the water jacket with a mixture of water and one gallon of an ethylene glycol base antifreeze. The antifreeze will penetrate small cracks and its color will aid in detecting their presence.

2. Install the remaining sealing plate and tighten it securely.

3. Apply 40 psi (276 kPa) air pressure to the water jacket and maintain this pressure for at least two hours to give the water and antifreeze mixture ample time to work its way through any cracks which may exist.

4. At the end of the test period, examine the cylinder bores, air box, oil passages, crankcase and exterior of the block for presence of the water and antifreeze

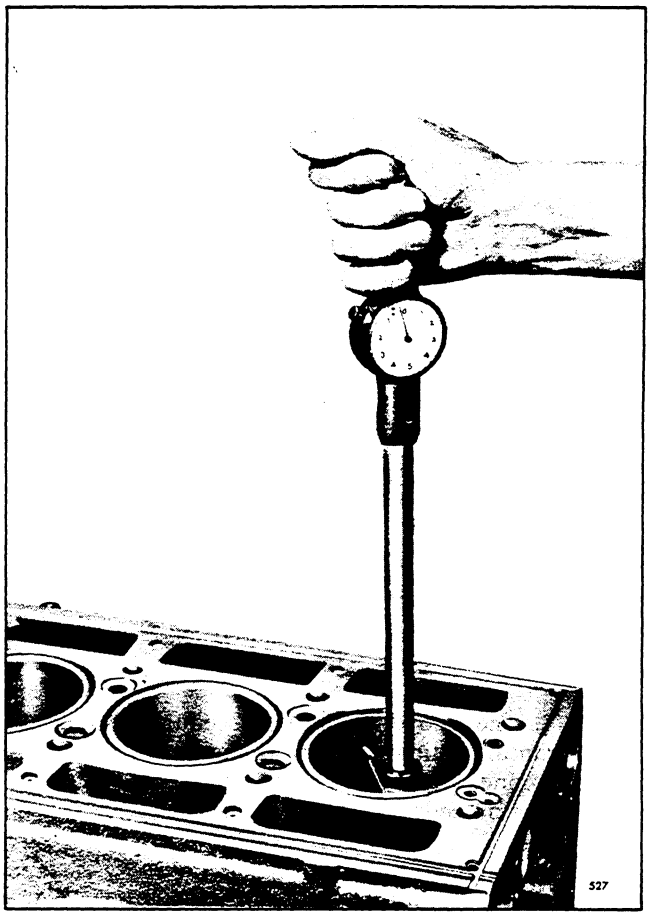


Fig. 12 - Checking Bore of Cylinder Block with Tool J 5347-01

mixture which will indicate the presence of cracks. A cracked cylinder block must be replaced by a new block.

5. After the test is completed, remove the plates, drain

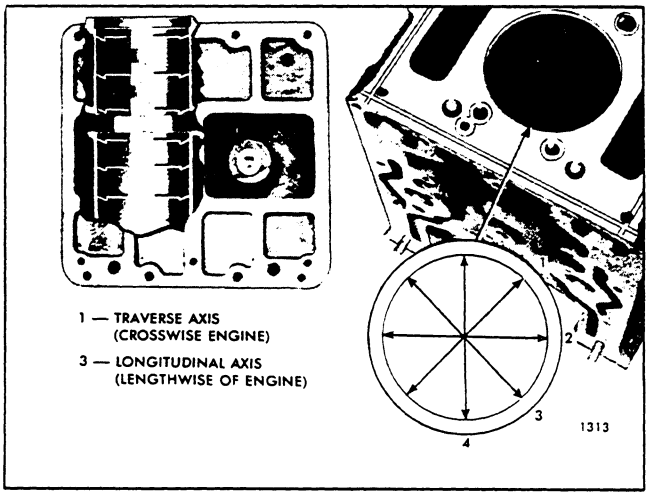


Fig. 13 - Cylinder Bore Measurement Diagram

	Trans.	45°	Long.	45°
	1	2	3	4
A				
B				
C				
Port Belt	X	X	X	X
D				
E				
F				

Fig. 14 - Block Bore Measurement Record Form

the water jacket and blow out all of the passages in the block with compressed air.

Inspect Cylinder Block

After cleaning and pressure testing, inspect the cylinder block.

Since most of the engine cooling is accomplished by heat transfer through the cylinder liners to the water jacket, a good liner-to-block contact must exist when the engine is operating. Whenever the cylinder liners are removed from an engine, the block bores must be inspected.

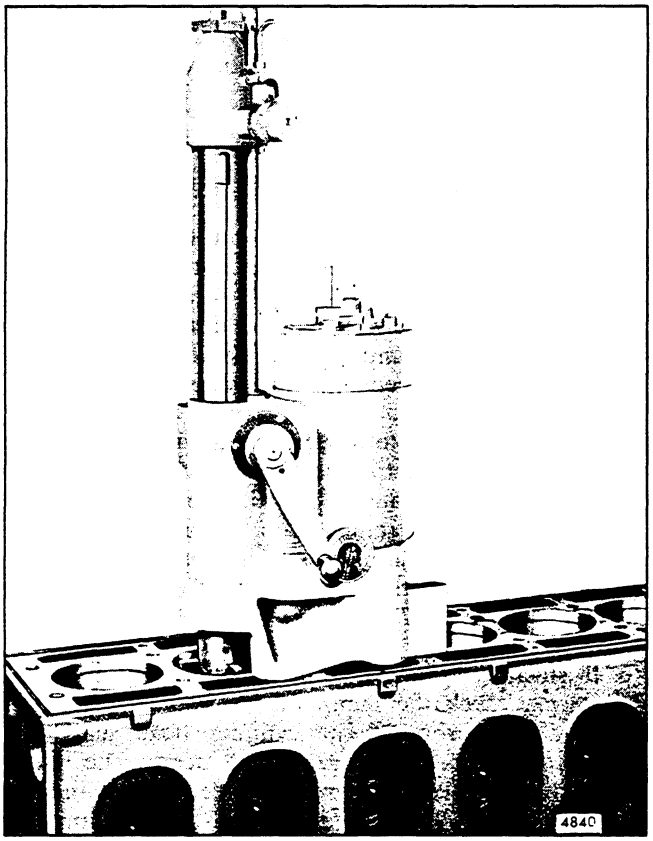


Fig. 15 - Boring Cylinder Block with Portable Boring Bar

NOTE: Before attempting to check the block bores, hone them throughout their entire length until about 75% of the area above the ports has been "cleaned-up".

1. Hone the block bores as follows:

   a. Use a hone (J 5902-01) in which the cutting radius of the stones can be set in a fixed position to remove irregularities in the bore rather than following the irregularities as with a spring-loaded hone. Clean the stones frequently with a wire brush to prevent stone loading. Follow the hone manufacturer's instructions regarding the use of oil or kerosene on the stones. Do not use such cutting agents with a dry hone. Use 120 grit stones J 5902-14.

   b. Insert the hone in the bore (Fig. 10) and adjust the stones snugly to the narrowest section. When correctly adjusted, the hone will not shake in the bore, but will drag freely up and down when the hone is not running.

   c. Start the hone and "feel out" the bore for high spots which will cause an increased drag on the stones. Move the hone up and down the bore with short overlapping strokes about 1" long. Concentrate on the high spots in the first cut. As these are removed, the drag on the hone will become lighter and smoother. Do not hone as long at the air inlet port area as in the rest of the bore because this area, as a rule, cuts away more rapidly. Feed lightly to avoid an excessive increase in the bore diameter. Some stones cut rapidly even under low tension.

   d. When the bore is fairly clean, remove the hone, inspect the stones and measure the bore. Determine which spots must be honed most. Moving the hone from the top to the bottom of the bore will not correct an out-of-round condition. To remain in one spot too long will cause the bore to become irregular. Where and how much to hone can be judged by feel. A heavy cut in a distorted bore produces a steady drag on the hone and makes it difficult to feel the high spots. Therefore, use a light cut with frequent stone adjustments.

   e. Wash the cylinder block thoroughly after the honing operation is completed.

2. The cylinder liner is alternately expanding and

contracting, during engine operation, due to temperature variations. This may result in irregularities in the block bores (out-of-round and taper), the effects of which will be seen as high pressure areas on the outside diameter of the cylinder liner (Fig. 11). A slight increase in block bore size is normal with high mileage or long periods of engine operation.

a. Visually check the contact area as revealed by the honed surface. There must not be any low spots which are larger in area than a half dollar.

b. Measure the entire bore of each cylinder with cylinder bore gage J 5347-01 (Fig. 12) which has a dial indicator calibrated in .0001" increments. The standard block bore is 4.6260" to 4.6275". Place the bore gage in the master ring gage J 8386-01 which has an I.D. of 4.6270" and set the dial to zero. Take measurements on the cleaned-up surface only at positions A, B, C, D, E and F in the bore on axes 45° apart (Fig. 13). Read the measurements from the zero mark on the gage. The readings may be recorded on a form similar to the one illustrated in Fig. 14.

NOTE: Dial bore gage setting master tool J 23059-01 may be used in place of the master ring gage.

3. The liner-to-block clearance with new parts is zero to .0015". With used parts, the maximum clearance is .0025". After measuring the block bores, measure the outside diameter of the cylinder liners (Section 1.6.3). Then determine the block-to-liner clearance (refer to Section 1.0 for the specified clearance) and whether it will be necessary to bore the block for oversize liners.

4. If necessary, bore the cylinder block as follows:

a. Each bore in a used block must not be out-of-round or tapered more than .002". If the average block bore is over 4.6285", the block should be bored oversize (refer to Tables 1 and 2).

b. A typical commercially available portable boring bar is illustrated in Fig. 15. Instructions on correct use of the boring bar are provided by the manufacturer.

For Average Block Bore I.D. Size	Use Liner O.D. Size	For Liner-to-Block Clearance
	CAST IRON BLOCK	
4.6260" / 4.6275"	Standard	.000" to .0025"
4.6270" / 4.6285"	.001" Oversize	.000" to .0025"

TABLE 1

Block Boring Dimensions	Liner O.D. Size	Max. Block Bore I.D. on Used Block
	CAST IRON BLOCK	
4.6310" / 4.6320"	.005" Oversize	4.6325"
4.6360" / 4.6370"	.010" Oversize	4.6375"
4.6460" / 4.6470"	.020" Oversize	4.6475"
4.6560" / 4.6570"	.030" Oversize	4.6575"

TABLE 2

c. After boring the block for an oversize cylinder liner, check the bore finish to be sure it is smooth (120 RMS). Heat transfer from the cylinder liner to the block will be adversely affected if the block bore isn't smooth.

d. Wash the block thoroughly after the boring operation.

e. When an oversize liner is used, stamp the size of the liner on the top deck of the block adjacent to the liner counterbore. An oversize liner insert must be installed whenever an oversize liner is used (Section 1.6.3).

5. Check the top of the block for flatness with an accurate straight edge and a feeler gage (Fig. 16).

a. The top surface of the block must not vary more than .003" transversely and not over .007" or .009" longitudinally on the 4 and 6 cylinder blocks respectively. It will be difficult to prevent water, oil and compression leaks if the top surface of the block exceeds these tolerances.

b. If it is necessary to machine the top surface of the block to correct for the above conditions, do not remove more than .008" of metal. Stamp the amount of stock removed on the face of the block. The distance from the centerline of the crankshaft to the top of the block must not be less than 16.176" (Fig. 17).

c. If stock is removed from the top surface of the block, check the depth of the seal ring grooves and counterbores. The cylinder head seal strip grooves must be .092"-.107" deep. The large water hole counterbores (between the cylinders) must be .109"-.120" deep, and the combination water and oil hole counterbores and small water hole counterbores must be .087"-.098" deep. If necessary, deepen the grooves or counterbores to

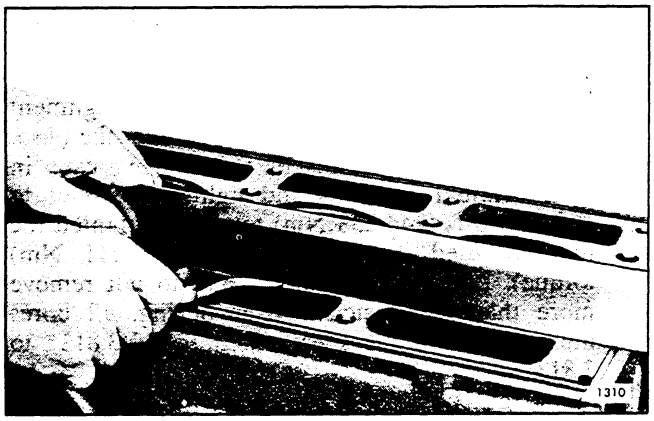


Fig. 16 - Checking Top Face of Cylinder Block

the specified limits to retain the proper "crush" on the seal rings. It is not necessary to deepen the counterbores for the cylinder liners since .004" and .008" undersize thickness inserts are available for adjusting the liner position as outlined in Section 1.6.3 under *Fitting Cylinder Liner in Block Bore.*

6. Make sure the cylinder liner counterbores in the block are clean and free of dirt. Then check the depth (Fig. 18). The depth must be .4770" to .4795" and must not vary more than .0015" throughout the entire circumference. The counterbored surfaces must be smooth and square with the cylinder bore within .001" total indicator reading. There must not be over .001" difference between any two adjacent cylinder counterbores when measured along the cylinder longitudinal centerline of the cylinder block.

7. Check the main bearing bores as follows:

a. Check the bore diameters with the main bearing caps in their original positions. Apply a small quantity of International Compound No. 2, or equivalent, to the threads on the bolts or studs and nuts and to the bolt head (or nut) contact area. Main bearing cap bolts are especially designed for this purpose and must not be replaced by ordinary bolts. Install and tighten the bolts to 165-175 lb-ft (224-238 Nm) torque or stud nuts to 140-155 lb-ft (190-211 Nm) torque. The specified bore diameter is 3.812" to 3.813". If the bores do not fall within these limits, the cylinder block must be rejected.

NOTE: Bearing caps are numbered to correspond with their respective positions in the cylinder block. It is imperative that the bearing caps are reinstalled in their original positions to maintain the main bearing bore alignment. The number of the front main bearing cap is stamped on the face of the oil pan mounting flange of the cylinder block, adjacent to its permanent location in the engine as established at the time of manufacture. The No. 1 main bearing cap is always located at the end opposite the flywheel end of the cylinder block (Fig. 19), regardless of engine rotation or

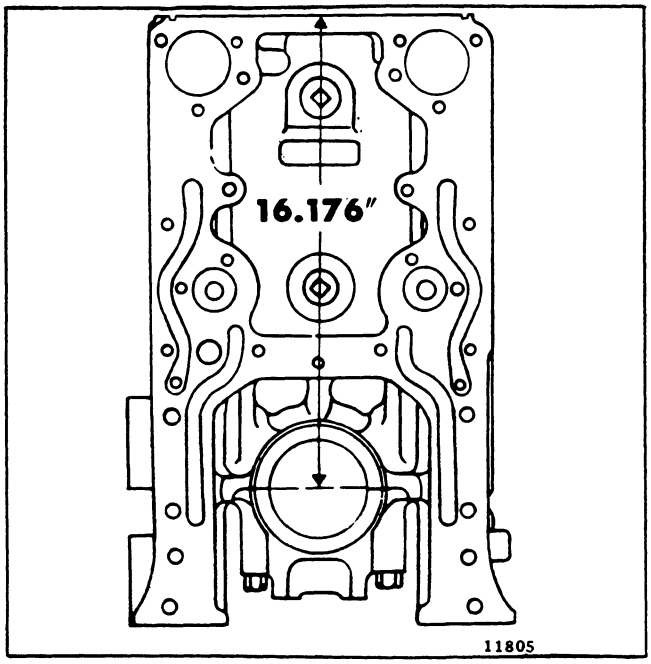


Fig. 17 - Minimum Distance from Center Line of Crankshaft to Top of Cylinder Block

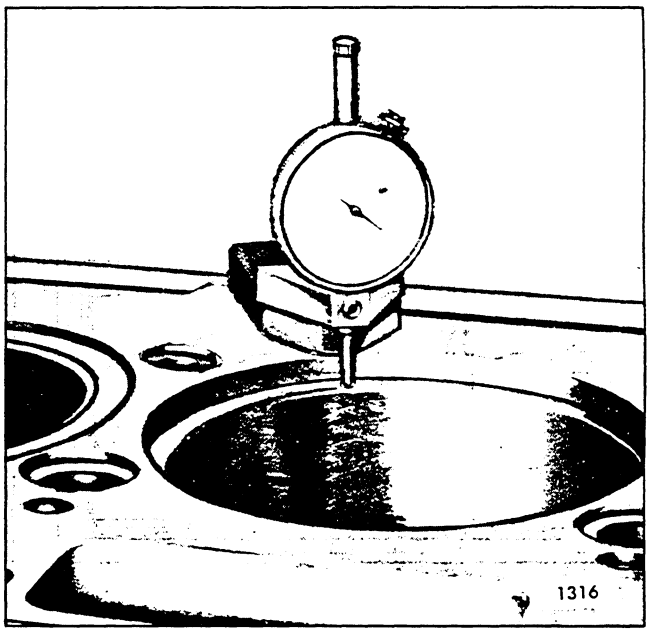


Fig. 18 - Checking Depth of Counterbore for Cylinder Liner with Tool J 22273

accessory arrangement. As originally manufactured, the main bearing caps are installed with the numbered side facing the blower side of the engine. Machining of the cylinder block and main bearing caps is such that the mating parts are "offset" to prevent installation of the bearing caps 180° from their correct position. However, if an engine has been converted for a new application and the cylinder and bearing numbering sequence has been reversed, the bearing caps must be reinstalled in the original positions regardless if the block and bearing caps have or have not been renumbered.

b. Finished and unfinished main bearing caps are available for replacing broken or damaged caps. When fitting a *finished* replacement bearing cap, it may be necessary to try several caps before one will be found to provide the correct bore diameter and bore alignment. If a replacement bearing cap is installed, be sure to stamp the correct bearing position number on the cap.

NOTE: Use the unfinished bearing caps for the front and intermediate bearing positions. The finished bearing caps, machined for the crankshaft thrust washers, are to be used in the rear bearing position.

c. Main bearing bores are line-bored with the bearing caps in place and thus are in longitudinal alignment. Bearing bores may be considered properly aligned with one another if the crankshaft can be rotated freely by hand after new bearing shells have been installed and lubricated and the bearing caps have been secured in place and the bolts tightened as specified in Section 1.3.4. If a main bearing bore is more than .001" out of alignment, the block must be line-bored or scrapped. Misalignment may be caused by a broken crankshaft, excessive heat or other damage.

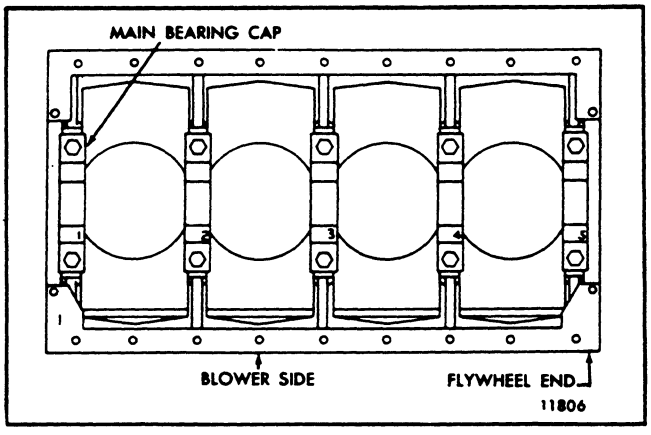


Fig. 19 - Cylinder Block Markings

d. If the main bearing bores are not in alignment when a replacement bearing cap is used, the block must be line-bored. Install the bearing caps in their original positions and tighten the bolts to 165-175 lb-ft (244-238 Nm) torque (or tighten the nuts, if used, to 140-155 lb-ft (190-211 Nm) torque). Line-bore the block, but do not remove more than .001" stock. After boring, all bores must be within the specified limits of 3.812" to 3.813".

8. Refer to the *Cylinder Block Plugging Charts* at the end of this manual and install the necessary plugs and dowels.

9. Replace loose or damaged dowel pins. The dowels at the ends of the cylinder block must extend .625" from the face of the block.

The dowels used to retain the crankshaft thrust washers on the rear main bearing cap must extend .110" to .120" from the surface of the bearing cap.

NOTE: A stepped dowel pin is available to replace loose pins in the rear main bearing cap. Before installing the stepped pins, rebore the dowel holes in the bearing cap with a No. 11 (.1910") or No. 12 (.1890") drill. After pressing the pins into the bearing cap, remove all burrs from the base of the dowel pins to ensure proper seating of the thrust washers.

10. Replace main bearing cap studs, if used, which are damaged or broken. Install new studs to a height of 4" ± 1/32" above the upper bearing seat at a torque of 35-75 lb-ft (47-102 Nm).

11. If used, replace damaged or broken cylinder head studs. Install and drive a new stud to a height of 4 3/8" ± 1/32" at a minimum torque of 75 lb-ft (102 Nm).

12. Examine the tapped bolt holes for the cylinder head or main bearing cap bolts and, if the threads are damaged, "clean-up" the threads or install a helical thread insert. The tapped holes may be tapped with a 5/8"-11 UNC3B tap. All cylinder head bolt or stud holes must have the threads extending 1.84" below the block surface.

NOTE: The current service replacement cylinder blocks use a special cylinder head bolt in all positions.

13. Check the drive pins (which plug the vertical oil

galleries) in the corners of the block to be sure they are flush with or below the top surface of the block.

14. Check the remaining cylinder block surfaces and threaded holes. Check all of the mating surfaces, or mounting pads, for flatness, nicks and burrs. The flatness of the blower mounting pad must not vary more than .004". Clean-up damaged threads in tapped holes with a tap or install helical thread inserts, if necessary.

15. After inspection, if the cylinder block is not to be used immediately, spray the machined surfaces with engine oil. If the block is to be stored for an extended period of time, spray or dip it in a polar type rust preventive such as Valvoline Oil Company's "Tectyl 502-C", or equivalent. Castings free of grease or oil will rust when exposed to the atmosphere.

Assemble and Install Engine

After the cylinder block has been cleaned and inspected, assemble the engine as follows:

> **NOTE:** Before a reconditioned or new service replacement cylinder block is used, steam clean it to remove the rust preventive and blow out the oil galleries with compressed air.

1. Mount the cylinder block on the overhaul stand.

2. If a new service replacement block is used, stamp the engine serial number and model number on the pad located in the upper right-hand corner on the blower side of the block. Also stamp the position numbers on the main bearing caps (Fig. 19) and the position of the No. 1 bearing on the oil pan mounting flange of the block.

3. Install all of the required cylinder block plugs and drain cocks. Use a good grade of non-hardening sealant on the threads of the plugs and drain cocks. Install the plugs flush with or below the surface of the block.

4. Clean and inspect all engine parts and subassemblies and, using new parts as required, install them on the cylinder block by reversing the sequence of disassembly. The procedures for inspecting and installing the various parts and subassemblies are outlined in the following sections of this manual.

5. Use a chain hoist and suitable sling to transfer the engine to a dynamometer test stand.

6. Complete the engine build-up by installing all remaining accessories, fuel lines, electrical connections, controls etc.

7. Operate the engine on a dynamometer, following the *run-in* procedure outlined in Section 13.2.1.

8. Reinstall the engine in the vehicle.