# TECHNICAL MANUAL

# OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS INFORMATION AND SUPPLEMENTAL MAINTENANCE AND REPAIR PARTS INSTRUCTIONS) FOR PAVING MACHINE BITUMINOUS MATERIEL CRAWLER MOUNTED DED MODEL BSF-400 (NSN 3895-01-063-7891) WITH DETROIT DIESEL ENGINE (SERIES 53) IOWA MANUFACTURING COMPANY

HEADQUARTERS, DEPARTMENT OF THE ARMY

**JANUARY 1981**

## **IMPORTANT NOTICE**!

Federal, State and Local Safety Regulations must be complied with to prevent possible danger to person(s) or property, from accidents or harmful exposure. This equipment must be used in accordance with all operation and maintenance instructions.

(1) Read all warning, caution and instruction signs. Know what guards and protective devices are included and see that each item is in place. Additional guards and protective devices, that may be required due to proximity to related equipment, must be installed by the user (owner) before operating.
(2) NEVER LUBRICATE OR ADJUST EQUIPMENT WHEN IT IS IN MOTION!
(3) Always establish a positive lockout of the involved power source and block parts if necessary to prevent motion before performing maintenance, cleaning, adjusting or repair work. Secure the power source lockout to prevent start-up by other persons.
(4) Wear a protective mask whenever harmful air pollution exists.
(5) Use ear plugs wherever the noise level is above established acceptable limits.

## **SAFETY IS YOUR BUSINESS**

Safety, based on technical skill and years of experience, has been carefully built into your Detroit Diesel engine. Time, money and effort have been invested in making your diesel engine a safe product. The dividend you realize from this investment is your personal safety.

It should be remembered, however, that power-driven equipment is only as safe as the man who is at the controls. You are urged, as the operator of this diesel engine, to keep your fingers and clothing away from the revolving "V" belts, gears, blower, fan, drive shafts, etc.

An accident can be prevented with your help.

## SAFETY RECOMMENDATIONS

CEDARAPIDS Equipment is designed with the safety of all personnel in mind. Guards, covers and shields are added whenever necessary to prevent accidental injury to operators and others working on or near the equipment.

The following basic safety recommendations should be followed:

1. All guards and covers should be replaced after adjustment or maintenance of equipment.

2. Make sure handrails and walkways are on good repair and clear of tools, spare parts and obstructions.

3. Never adjust or lubricate equipment while it is operating.

4. Stand clear of hauling equipment that is dumping material into the hopper.

5. Always look around equipment before start-up to make sure no one is near moving parts, making inspection or adjustment.

6. Do not drop material or tools from walkways or ladders without being positive that no one is below.

7. Blocking under-and around plants must be suitable material and properly placed to support the structure. Periodically check blocking for signs of failure or shifting that could allow structure to fall.

8. Electricians should handle any kind of work on electrical equipment. Avoid touching any loose or misplaced electrical wires. Consider them all dangerous.

9. Mark all inflammable materials; such as, oils, greases, and gasoline. Store these materials in an incombustible building situated away from the operating plant. NO SMOKING while handling flammable material.

10. Proper clothing while on the job is important. Wear shoes with safety toes to protect your toes from falling objects. Do not wear loosely hanging clothes or neck ties on the job. This type of clothing will get caught in moving parts of the equipment and-generally hinders work. The use of hard hats and safety glasses or goggles are definite safety protective equipment and are required by many safety conscious contractors.

11. Think safety! If you have and maintain an attitude of safety on the job, then the chances of being injured are very greatly reduced. Point out hazards and instruct new employees on safety.

## GUIDE TO GROUNDING SAFEGUARDS

## ON ELECTRICALLY POWERED EQUIPMENT

1. Each electric drive motor must have its frame electrically bonded to its controlling starter. This is to be by a conductor of equal size to the conductors feeding power to the motor. The bonding shall be by the junction box mounting bolt at the motor end, and by a starter mounting bolt at the starter end. The bonding must be by tight connection of clean metal to clean metal.

2. All electric motor starters on a unit (separate piece of equipment) must have their cases (enclosures) bonded to each other, and to the metal structure of the unit.

3. All individually mounted push button units (not mounted on the starter covers) must have their cases (enclosures) bonded to the starter enclosure or encloses.

4. When electric drives are used on one or more portable units (separate pieces of equipment) in an installation, the metallic supporting structures of all units used in that installation must be bonded to each other by a bonding wire having a size rating of not less than #6AWG, and equal in size to the largest power supplying conductor. It is especially important that portable units using no electric drives be bonded to electrically driven units.

5. The starter or group of starters on each unit must have their cases (enclosures) bonded to the main power supply disconnect case (enclosure). This may be by a grounding conductor or conductors in the power supply cable(s).

6. The main power disconnect case (enclosure) must be bonded to the ground approved by the power supply company when electric energy is purchased, or to the generator common-ground when electric energy is being generated by one or more engine-generator sets.

7. Each generator of engine-generator installations must have its case (frame) bonded to the neutral connection of the generator power windings. This connection we refer to as the "common generator ground".

8. The common generator ground(s) must, wherever possible, be connected to a driven or plate earth ground in accordance with Article 250, Section H, of the 1962 National Electric Code.

9. In addition to the earth ground at the common generator grounds(s), there must also be at least one earth ground of the driven rod type or plate type to which the metallic supporting structures of the units are bonded. When operating a group of. highly portable units, such as in a quarry installation, the portable unit or units nearest the moist earth (quarry face) and nearest the metallic mounted equipment (track mounted shovel, etc.) shall have earth grounds.

10. When plugs and receptacles are used as a means of disconnecting power supplying or distributing lines, the plugs and receptacles shall have separate connections for the bonding wire(s). Wherever possible, these connections should be by separate pins rather than by the plug and receptacle cases.

11. Damaged electric power supply cables and damaged electric power distribution cables are hazardous. All exposed electric power supply conductors or exposed electric terminals must be guarded against accidental contact by operating personnel.

12. Manufacturers of equipment using electrical products cannot be responsible for owners and operators safety unless the above recommendations are followed...Play Safe ...Electrical Currents Can Kill.

## INTRODUCTION

**To The Owner and Operator:**
In this manual we have tried to provide information which will give you a clear understanding of equipment construction, function, capabilities and requirements. The details are compiled from the knowledge and experience of highly qualified people at our factory and in our field organizations. By reading and using this information we believe you can better obtain the highest degree of performance efficiency, the maximum service life from normal wear-absorption parts, and the lowest possible maintenance expense. It is our strong recommendation that all persons directly involved with the equipment, be familiar with the contents of this manual.

Respectfully,
IOWA MANUFACTURING COMPANY

## TO THE OPERATOR

This manual contains instructions on the operation and preventive maintenance of your Detroit Diesel engine. Sufficient descriptive material, together with numerous illustrations, is included to enable the operator to understand the basic construction of the engine and the principles by which it functions. This manual does not cover engine repair or overhaul.

Whenever possible, it will pay to rely on an authorized *Detroit Diesel Allison Service Outlet* for all your service needs from maintenance to major parts replacement. There are over 1500 authorized service outlets in the U.S. and Canada. They stock factory original parts and have the specialized equipment and personnel with technical knowledge to provide skilled and efficient workmanship.

The operator should familiarize himself thoroughly with the contents of the manual before running an engine, making adjustments, or carrying out maintenance procedures.

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

## WARRANTY

The applicable engine warranty is contained in the form entitled POLICY ON OWNER SERVICE, available from authorized Detroit Diesel Allison Service Outlets.

**TM 5-3895-355-14&P**

TECHNICAL MANUAL
No. 5-3895-355-14&P

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *26 January 1981*

# Operator's,. Organizational, Direct Support and General Support Maintenance Manual (Including Repair Parts Information and Supplemental 'Maintenance and Repair Parts Instructions) For PAVING MACHINE BITUMINOUS MATERIEL CRAWLER MOUNTED DED MODEL BSF-400 (NSN 3895-01-063-7891) WITH DETROIT DIESEL ENGINE (SERIES 53) IOWA MANUFACTURING COMPANY

**REPORTING OF ERRORS**

You can help improve this manual. If you find any mistake or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Tank-Automotive Command, ATTN: DRSTA-MB, Warren, MI 48090. A reply will be furnished to you.

**NOTE**

This manual is published for the purpose of identifying an authorized commercial manual for the use of the personnel to whom the paving machine is issued.
Manufactured by: Detroit Diesel Allison, Division of General Motors Corp.
Iowa Manufacturing Company
Procured under Contract Nos: DSA 700-77-C-8481 and DAAE07-79-C5795

This technical manual is an authentication of the manufacturers' commercial literature and does not conform with the format and content specified in AR 310-3, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

**PART I. OPERATOR'S INSTRUCTIONS**
**For Series 53 Engines**
**TABLE OF CONTENTS**

## DESCRIPTION

## 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 pons.

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 injected fuel 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 halfway down, allowing the burned gases to escape into the exhaust manifold as shown in Fig. I (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".

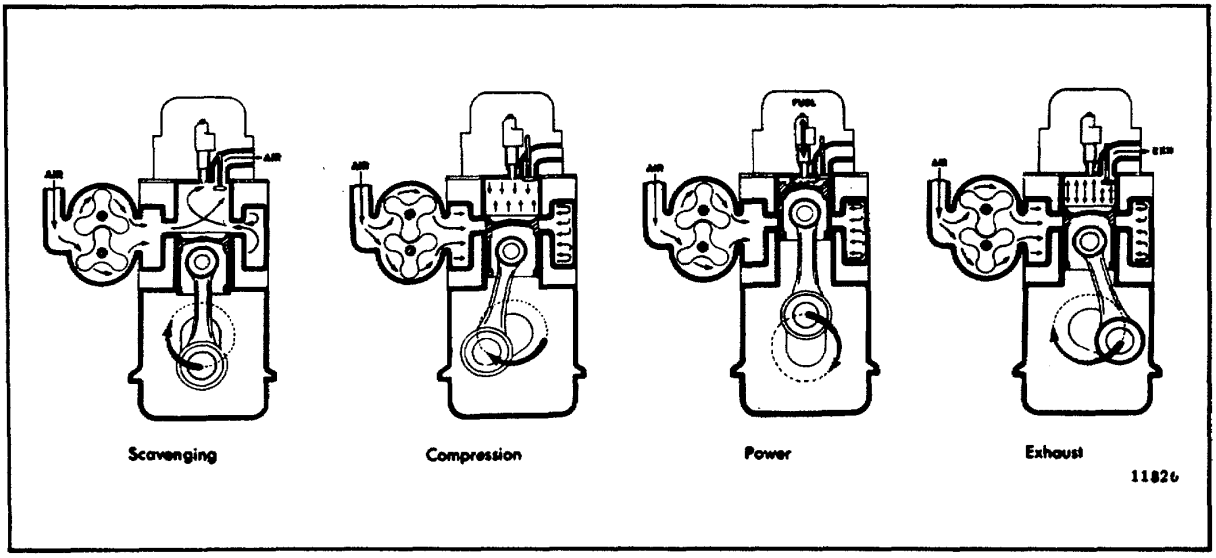



Fig. 1 - The Two-Stroke Cycle

## GENERAL DESCRIPTION

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

The In-line engines, including the inclined marine models, include standard accessories such as the blower, water pump, governor and fuel pump, which, on some models, may be located on either side of the engine regardless of the direction the crankshaft rotates. Further flexibility in meeting installation requirements is achieved with the cylinder head which can be installed to accommodate the exhaust manifold on either side of the engine.

The V-type engine uses many In-line engine parts, including the 3-53 cylinder head. The blower is mounted on top of the engine between the two banks of cylinders and is driven by the gear train. The governor is mounted on the rear end of the 6V-53 blower.

The meaning of each digit in the model numbering system is shown in Figs. 2 and 3. The letter L or R indicates left or right-hand engine rotation as viewed from the front of the engine. The letter A,B,C or D designates the blower and exhaust manifold location on the In-line engines as viewed from the rear of the engine while the letter A or C designates the location of the oil cooler and starter on the 6V-53 engine.

Each engine is equipped with an oil cooler, replaceable element type lubricating oil filter, fuel oil strainer, fuel oil filter, an air cleaner or air silencer, a governor, a heat exchanger and raw water pump or a fan and radiator, and a starting motor.

Full pressure lubrication is supplied to all main bearings, connecting rod bearings, and camshaft bearings, and to other moving parts.

Oil is drawn by suction from the oil pan through the intake screen and pipe to the oil pump where it is pressurized and delivered to the oil filter and the oil cooler. From the oil cooler, the oil enters oil galleries in the cylinder block and cylinder head for distribution to the main bearings, connecting rod bearings, camshaft bearings, rocker arm mechanism and other functional parts.

The cooling system has a centrifugal water pump which circulates the engine coolant through the oil cooler and water jackets. The engine temperature is regulated by a thermostat(s).

Fuel is drawn from the supply tank through the fuel strainer and enters a gear type fuel pump at the inlet side. Upon leaving the pump under pressure, the fuel is forced through the fuel filter into the inlet manifold where it passes through fuel pipes into the inlet side of the fuel injectors. The fuel is filtered through elements in the injectors and then atomized through small spray tip orifices into the combustion chamber. Excess fuel is returned to the fuel tank through the fuel outlet galleries and connecting lines.

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 or air silencer.

The engine may be started by either a hydraulic or an electric starting system.

The engine speed is regulated by a mechanical or hydraulic type engine governor, depending upon the engine application.

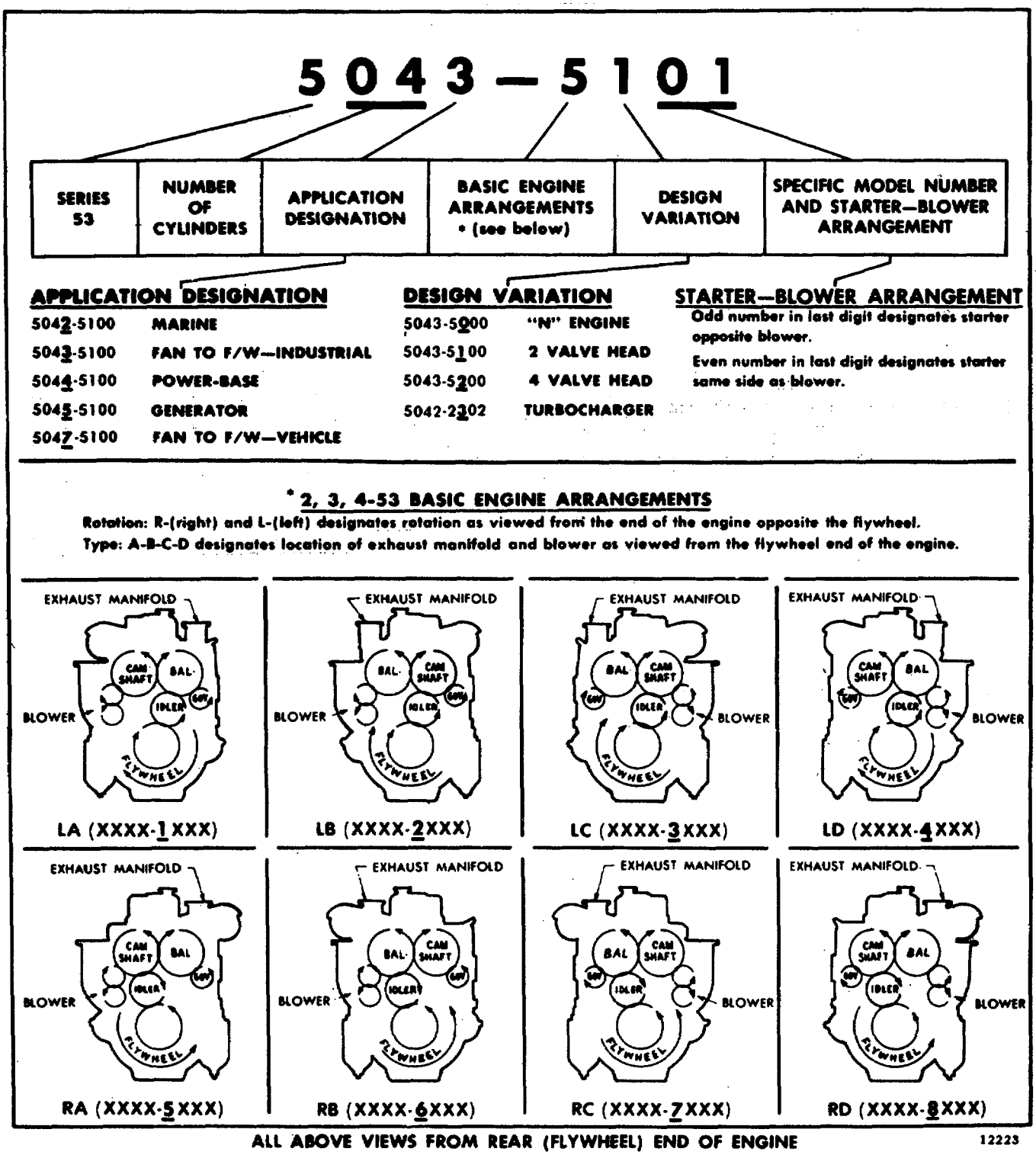



Fig. 2 - In-Line Engine Model Description, Rotation and Accessory Arrangement

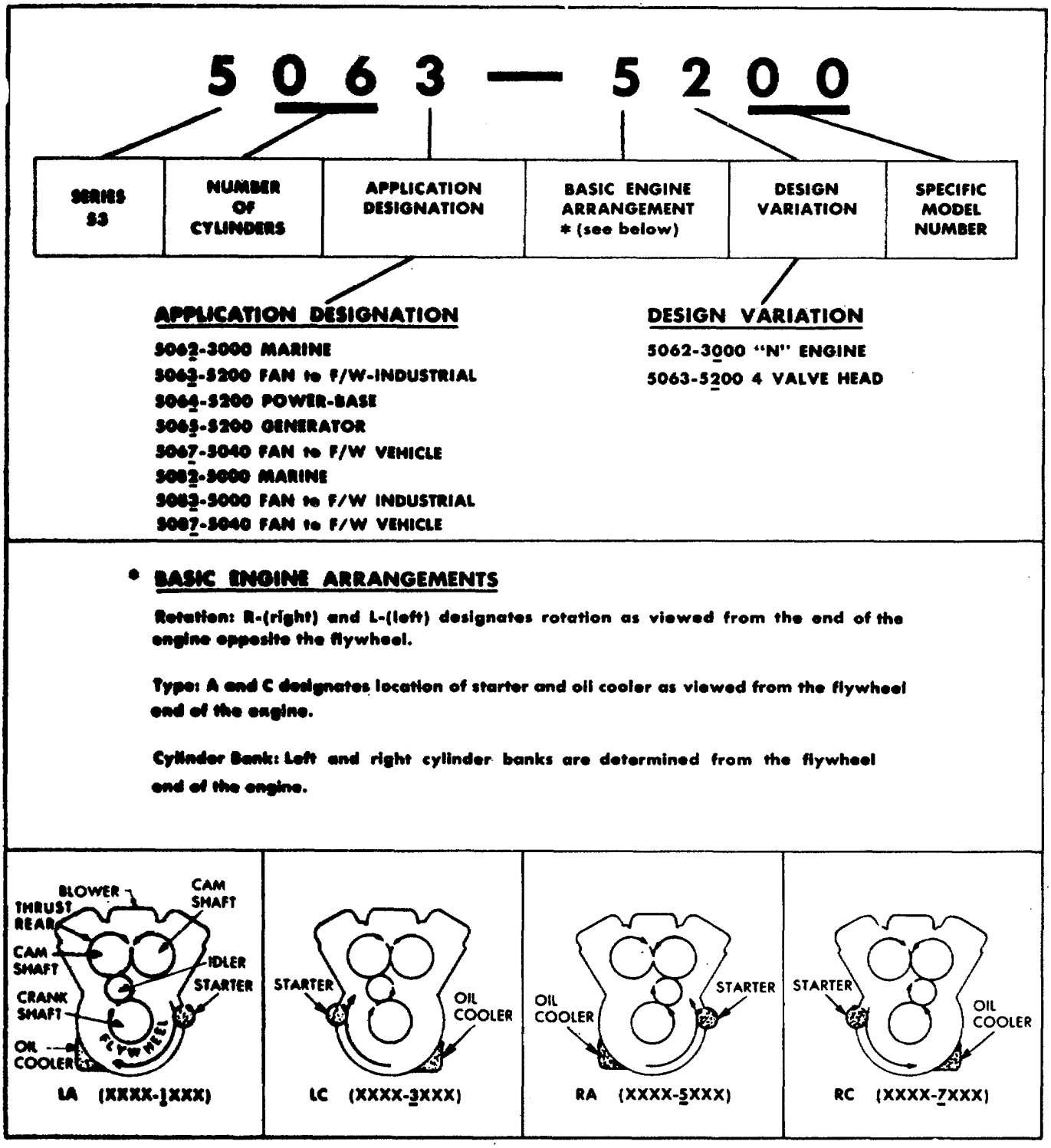



Fig. 3 · 6V Engine Model Description, Rotation and Accessory Arrangement

## GENERAL SPECIFICATIONS

| | 3-53 | 4-53 | 6V-53 |
|---|---|---|---|
| Type | 2 Cycle | 2 Cycle | 2 Cycle |
| Number of cylinders | 3 | 4 | 6 |
| Bore (inches) | 3.875 | 3.875 | 3.875 |
| Bore (mm) | 98 | 98 | 98 |
| Stroke (inches) | 4.5 | 4.5 | 4.5 |
| Stroke (mm) | 114 | 114 | 114 |
| Compression Ratio (nominal)(standard engines) | 17 to 1 | 17 to 1 | 17 to 1 |
| Compression Ratio (nominal)("N" engines) | 21 to 1 | 21 to 1 | 21 to 1 |
| Total Displacement - cubic inches | 159 | 212 | 318 |
| Total Displacement - litres | 2.61 | 3.48 | 5.22 |
| Number of main bearings | 4 | 5 | 4 |

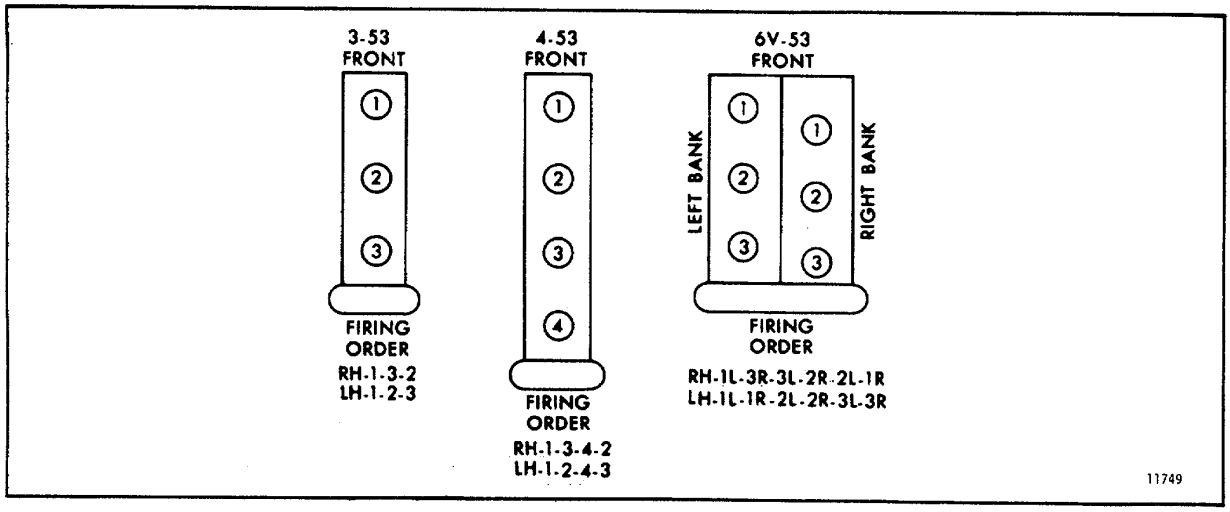



Fig. 4. Series 53 Cylinder Arrangement

## ENGINE MODEL AND SERIAL NUMBER DESIGNATION

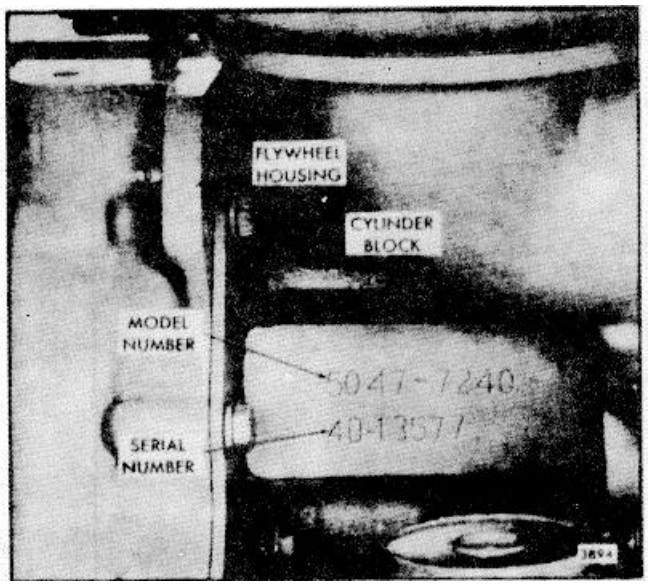



Fig. 5 - Typical Model and Serial Numbers as Stamped on Cylinder Block (In-Line Engine)

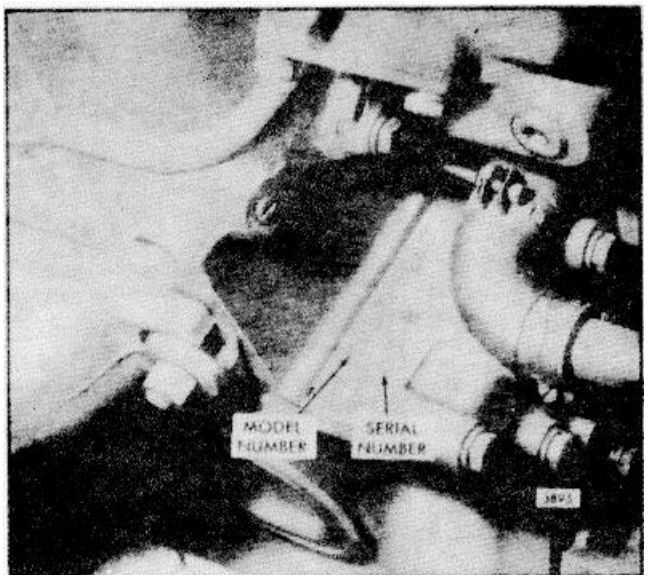



Fig 6 - Typical Model and Serial Numbers as Stamped on Cylinder Block (6V Engine)

On the In-line engines, the model number and serial number are stamped on the right-hand side of the cylinder block in the upper rear corner (Fig. 5). The model number and serial number on the V-type engine is located on the top right-hand front corner of the cylinder block, as viewed from the rear of the engine (Fig. 6).

An option plate, attached to the valve rocker cover, is also stamped with the engine serial number and model number and, in addition, lists any optional equipment used on the engine (Fig. 7).

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.

Power take-off assemblies, torque converters, hydraulic marine gears, etc. may also carry name plates pertaining to the particular assembly to which they are attached. The information on these name plates is useful when ordering parts for these assemblies.

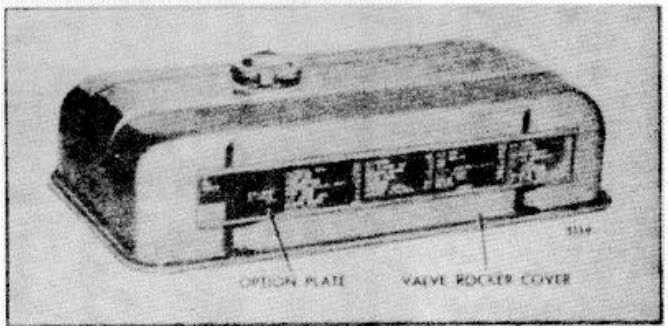
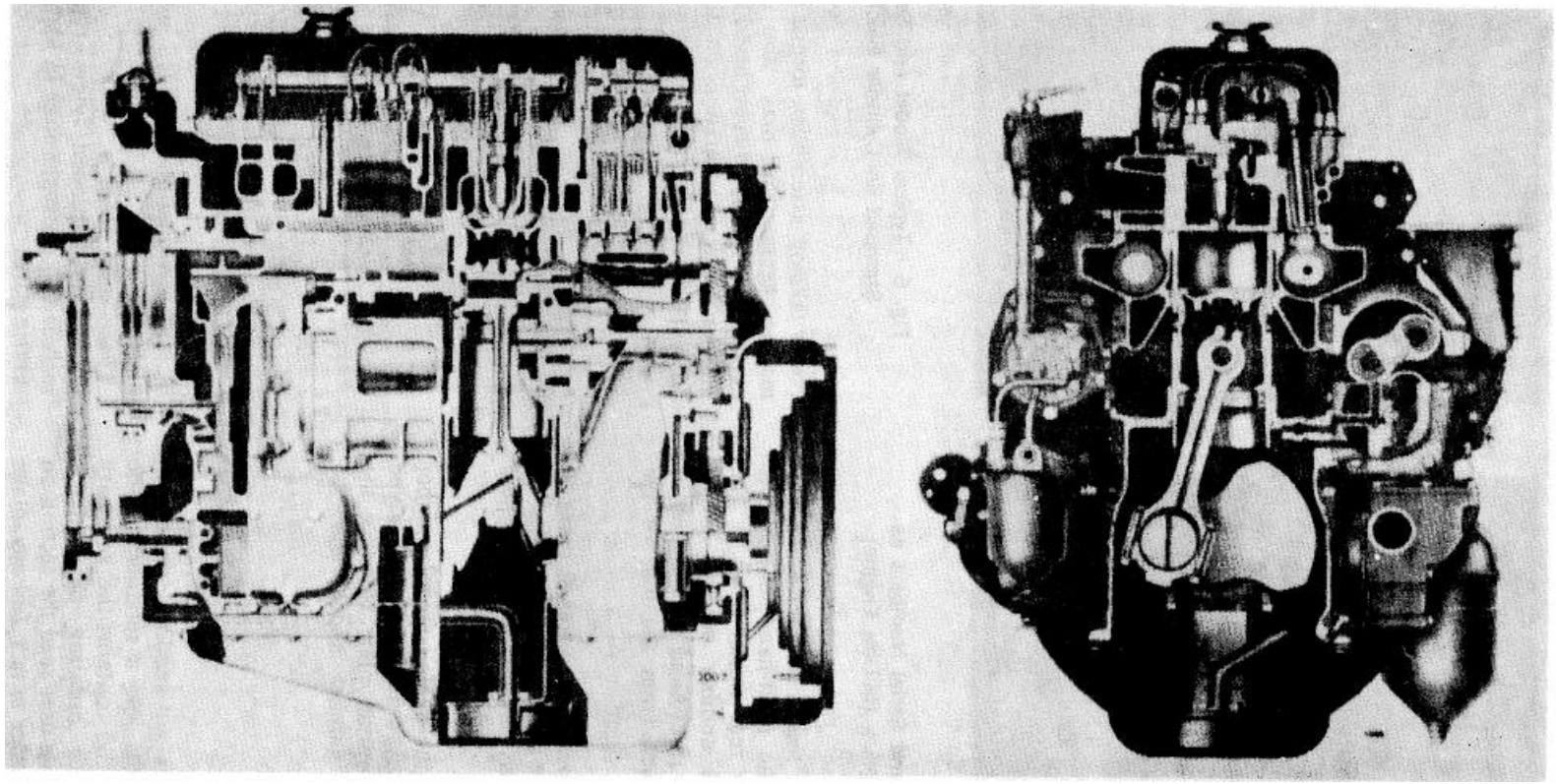



Fig. 7 - Option Plate

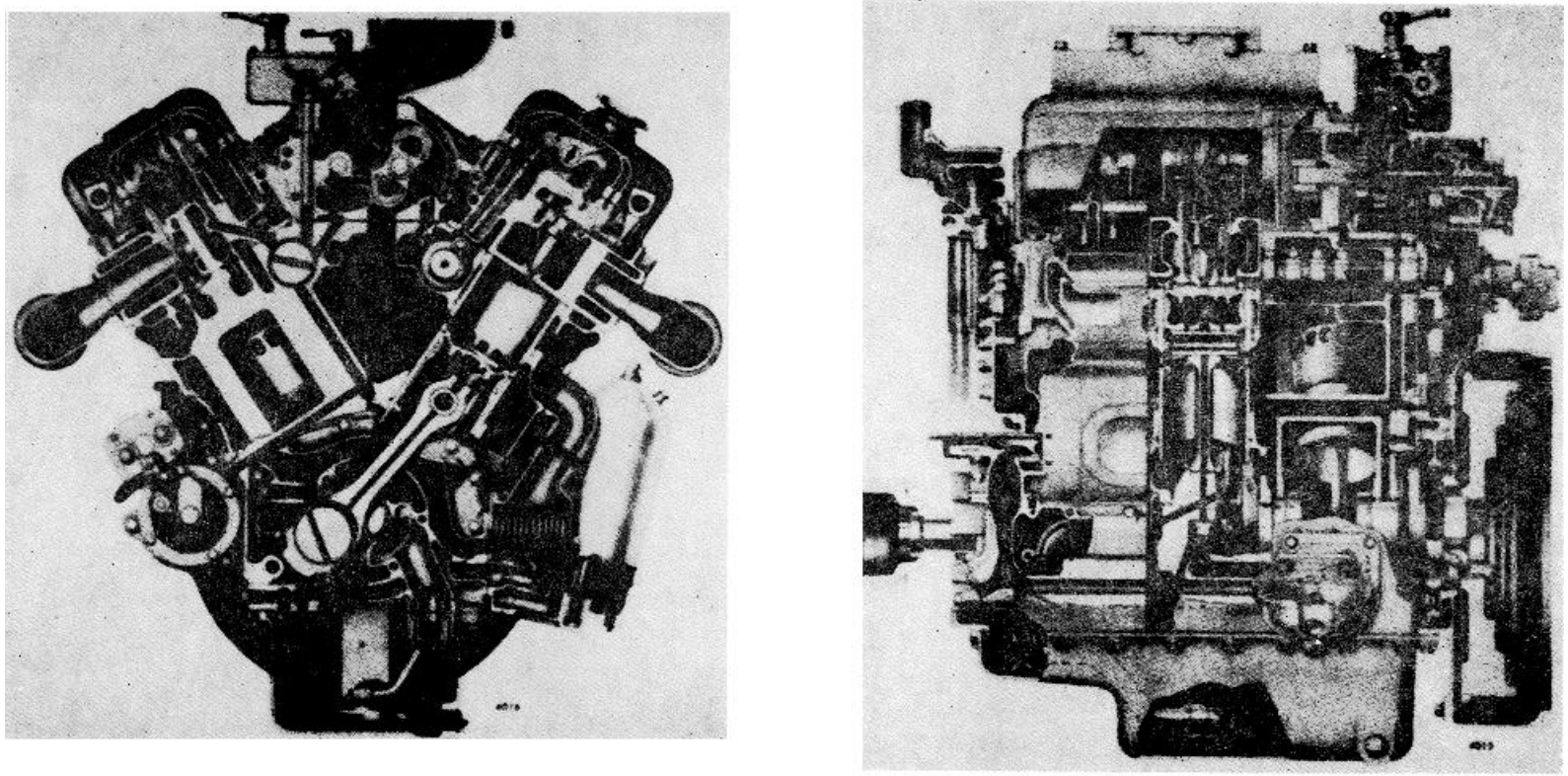
## BUILT-IN PARTS BOOK

The *Built-In Parts Book* is an anodized aluminum plate (Option Plate) that fits into a retainer on the engine valve rocker cover and contains the necessary information required when ordering parts. It is recommended that the engine user read the section on t*he Built-In Parts Book* in order to take full advantage of the information provided on the engine option plate.

Numerous exploded view type illustrations are included to assist the user in identifying and ordering service parts.



Cross Section Views of a Typical In-Line Engine



Cross Section Views of a Typical 6V-53 Engine

## ENGINE SYSTEMS

The Series 53 Detroit Diesel engines incorporate four basic systems which direct the flow of fuel, air, lubricating oil, and engine coolant.

A brief description of each of these systems and their components, and the necessary maintenance and adjustment procedures are given in this manual.

## FUEL SYSTEM

The fuel system (Figs. I and 2) consists of the fuel injectors, fuel pipes, fuel manifolds (integral with the cylinder head), fuel pump, fuel strainer, fuel filter and the necessary connecting fuel lines.

On In-line engines, a restricted fitting is located in the cylinder head fuel return manifold outlet to maintain pressure within the fuel system. On V-type engines, this restricted fitting is located in the left-bank cylinder head.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Upon leaving the pump under pressure, the fuel is forced through the fuel filter and into the fuel inlet manifold where it passes through fuel pipes into the inlet side of each fuel injector. The fuel is filtered through elements in the injectors and atomized through small spray tip orifices into the combustion chamber. Surplus fuel, returning from the injectors, passes through the fuel return manifold and connecting fuel lines back to the fuel tank.

The continuous flow of fuel through the injectors helps to cool the injectors and remove air from the fuel system.

A check valve may be installed between the fuel strainer and the source of supply as optional equipment to prevent fuel drain back when the engine is not running.

**Fuel Injector**

The fuel injector combines in a single unit all of the parts necessary to provide complete and independent fuel injection at each cylinder. The injector creates the high pressure necessary for fuel injection, meters the proper amount of fuel, atomizes the fuel and times the injection into the combustion chamber.

Since the injector is one of the most important and carefully constructed parts of the engine, it is recommended that the engine operator replace the injector as an assembly if it is not operating properly. Authorized *Detroit Diesel Allison Service Outlets* are properly equipped to service injectors.

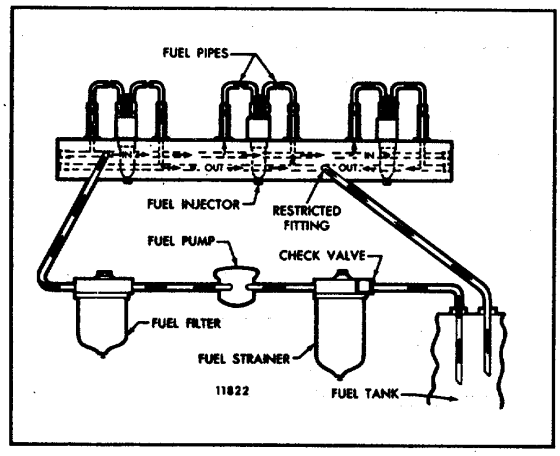



Fig. 1 - Schematic Diagram of Typical Fuel System - In-Line Engine

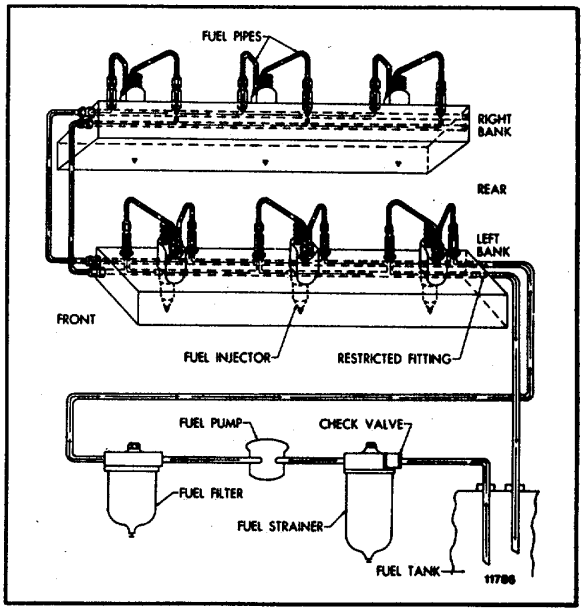



Fig. 2 - Schematic Diagram of Typical Fuel System - V-type Engine

**Remove Injector**
An injector may be removed in the following manner:

1. Clean and remove the valve rocker cover.

2. Disconnect the fuel pipes from both the injector and the fuel connectors.

3. Immediately after removing the fuel pipes, cover the injector inlet and outlet fittings with shipping caps to prevent dirt from entering.

4. Turn the crankshaft manually in the direction of engine rotation or crank the engine with the starting motor, if necessary, until the rocker arms for the particular cylinder are aligned in a horizontal plane.

   **CAUTION:** If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation as the bolt will be loosened. Remove the starting motor and use a pry bar against the teeth of the flywheel ring gear to turn the crankshaft.

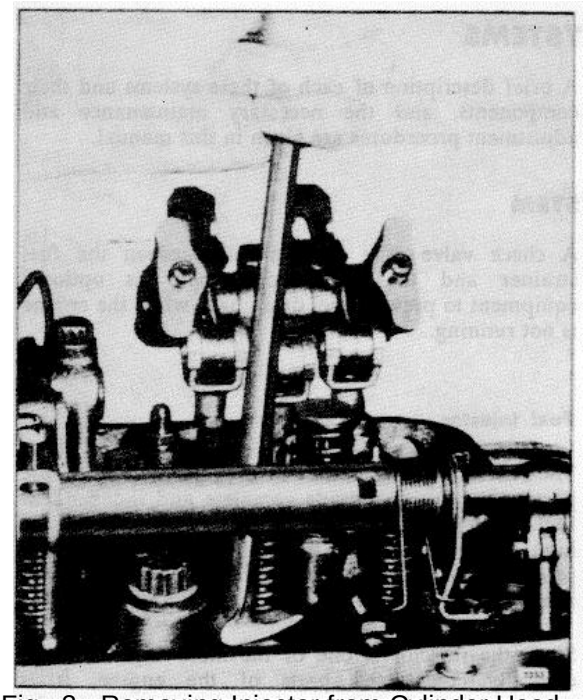


Fig. 3 - Removing Injector from Cylinder Head

5. Remove the two rocker shaft bracket bolts and swing the rocker arm assembly away from the injector and valves.

6. Remove the injector clamp bolt, washer and clamp.

7. Loosen the inner and outer adjusting screws on the injector rack control lever and slide the lever away from the injector.

8. Free the injector from its seat as shown in Fig. 3 and lift it from the cylinder head.

9. Cover the injector hole in the cylinder head to keep foreign particles out of the cylinder.

**Install Injector**
Before installing an injector, be sure the beveled seat of the injector tube is free from dirt particles and carbon deposits.

A new or reconditioned injector may be installed by reversing the sequence of operations given above for removal.

Be sure the injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter until it runs out the outlet filter.

**CAUTION:** On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridge is not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Therefore, note the position of the exhaust valve bridge before, during and after tightening the rocker shaft bracket bolts.

Do not tighten the injector clamp bolt to more than 20-25 lb-ft (27-34 Nm) torque, as this may cause the moving parts of the injector to bind. Tighten the rocker shaft bolts to *50-55* lb-ft (68-75 Nm) torque.

Align the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-01 and a torque wrench to tighten the fuel pipe nuts to 12-15 lb-ft (16-20 Nm) torque.

**CAUTION:** Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

Time the injector, position the injector rack control lever and adjust the exhaust valve clearance (cold setting) as outlined in the engine tune-up procedure. If all of the injectors have been replaced, perform a complete tune-up on the engine.

**Fuel Pump**

A positive displacement gear-type fuel pump is attached to the governor or blower on the In-line engines and to the flywheel housing on the V-type engines.

A spring-loaded relief valve, incorporated in the pump body, normally remains in the closed position, operating only when the pressure on the outlet side (to the fuel filter) becomes excessive due to a plugged filter or fuel line.

The fuel pump incorporates two oil seals. Two tapped holes are provided in the underside of the pump body, between the oil seals, to permit a drain tube to be attached. If fuel leakage exceeds one drop per minute, the seals must be replaced. An authorized *Detroit Diesel Allison Service Outlet* is properly equipped to replace the seals.

Fuel pumps are furnished in either left or right-hand rotation, according to the engine model, and are stamped RH or LH. These pumps are not interchangeable and cannot be rebuilt to operate in an opposite rotation.

**Fuel Strainer and Fuel Filter**

A replaceable-element type fuel strainer and fuel filter (Fig. 4) are used in the fuel system to remove impurities from the fuel. The strainer removes the larger particles and the filter removes the small foreign particles.

The fuel strainer and fuel filter are basically identical in construction, both consisting of a cover, shell and replaceable element. Since the fuel strainer is placed between the fuel supply tank and the fuel pump, it functions under suction; the fuel filter, which is installed between the fuel pump and the fuel inlet manifold in the cylinder head, operates under pressure.

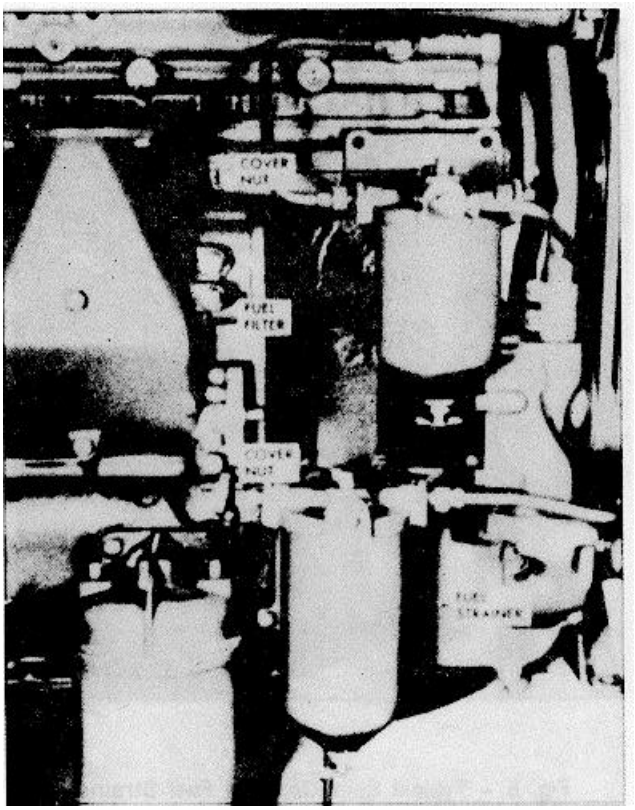



Fig. 4 - Typical Fuel Strainer and Filter Mounting

Replace the elements as follows:

1. With the engine shut down, place a suitable container under the fuel strainer or filter and open the drain cock. The fuel will drain more freely if the cover nut is loosened slightly.

2. Support the shell, unscrew the cover nut and remove the shell and element.

3. Remove and discard the element and gasket. Clean the shell with fuel oil and dry it with a cloth or compressed air.

4. Place a new element, which has been thoroughly soaked in clean fuel oil, over the stud and push it down on the seat. Close the drain cock and fill the shell approximately two-thirds full with clean fuel oil.

5. Affix a new shell gasket, place the shell and element into position under the cover and start the cover nut on the shell stud.

6. Tighten the cover nut only enough to prevent fuel leakage.

7. Remove the plug in the strainer or filter cover and fill the shell with fuel. Fuel system primer J 5956 may be used to prime the fuel system.

8. Start and operate the engine and check the fuel system for leaks.

**Spin-On Type Fuel Filter**

A spin-on fuel strainer and fuel filter (Fig. 5) is used on certain engines. The spin-on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly. No separate springs or seats are required to support the filters.

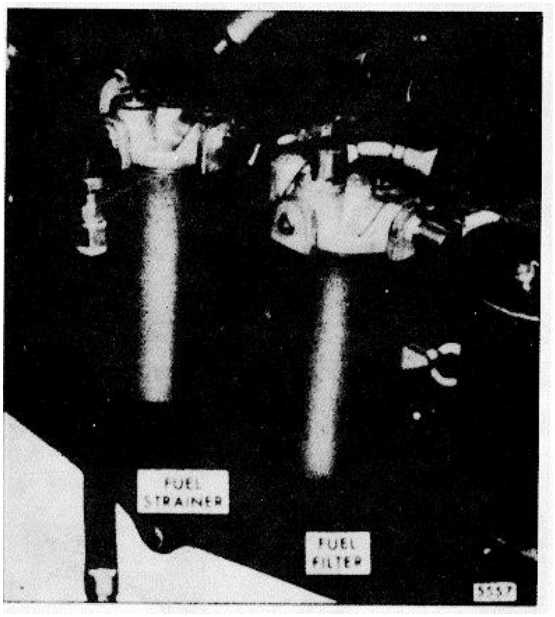



Fig. 5 - Typical Spin-On Type Fuel Strainer and Fuel Filter Mounting

The filter covers incorporate a threaded sleeve to accept the spin-on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification. No drain cocks are provided on the spin-on filters. Where water is a problem, it is recommended that a water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

A 1" diameter twelve-point nut on the bottom of the filter is provided to facilitate removal and installation.

Replace the filter as follows:

1. Unscrew the filter (or strainer) and discard it.

2. Fill a new filter replacement cartridge about two-thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.

3. Install the new filter assembly and tighten it to two-thirds of a turn beyond gasket contact.

4. Start the engine and check for leaks.

**Fuel Tank**

Refill the fuel tank at the end of each day's operation to prevent condensation from contaminating the fuel.

> **CAUTION:** A galvanized steel tank should never be used for fuel storage because the fuel oil reacts chemically with the zinc coating to form powdery flakes which quickly clog the fuel strainer and filter and damage the fuel pump and the fuel injectors.

**Engine Out of Fuel**

The problem in restarting the engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is then pumped from the primary fuel strainer and sometimes partially removed from the secondary fuel filter before the fuel supply becomes insufficient to sustain engine firing. Consequently, these components must be refilled with fuel and the fuel pipes rid of air in order for the system to provide adequate fuel for the injectors.
When an engine has run out of fuel, there is a definite procedure to follow for restarting the engine.

1. Fill the fuel tank with the recommended grade of fuel oil. If only partial filling of the tank is possible, add a minimum of ten gallons (38 litres) of fuel.

2. Remove the fuel strainer shell and element from the strainer cover and fill the shell with fuel oil. Install the shell and element.

3. Remove and fill the fuel filter shell and element with fuel oil as in Step 2.

4. Start the engine. Check the filter and strainer for leaks.

> **NOTE:** In some instances, it may be necessary to remove a valve rocker cover and loosen a fuel pipe nut in order to bleed trapped air from the fuel system. Be sure the fuel pipe is retightened securely before replacing the rocker cover.

Primer J 5956 may be used to prime the entire fuel system. Remove the filler plug in the fuel filter cover and install the primer. Prime the system. Remove the primer and install the filler plug.

## Air System

In the scavenging system used in two-cycle engines, illustrated in Figs. 6 and 7, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burned gases through the exhaust valve ports. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The air, entering the blower from the air silencer or air cleaner, is picked up by the blower rotor lobes and carried to the discharge side of the blower. The continuous discharge of fresh air from the blower enters the air chamber of the cylinder block and sweeps through the intake ports of the cylinder liners.

The angle of the ports in the cylinder liner creates a uniform swirling motion to the intake air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

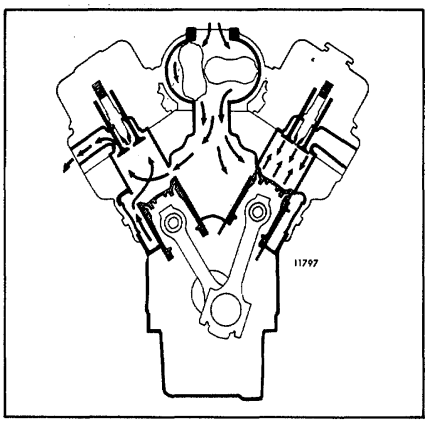



Fig. 7 - Air Intake System Through Blower and Engine (6V-53 Engine)

### Air Cleaners

Several types of air cleaners are available for use with industrial engines. The light-duty oil bath air cleaner is used on most models. However, a heavy-duty oil bath type or a dry type air cleaner may be installed where the engine is operating in heavy dust concentrations.

The air cleaners are designed for fast, easy disassembly to facilitate efficient servicing. Maximum protection of the engine against dust and other forms of air contamination is possible if the air cleaner is serviced at regular intervals.

The *light-duty oil bath type air cleaner* (Fig. 8) consists of a metal wool cleaning element supported inside of a housing which contains an oil reservoir. A chamber beneath the oil reservoir serves as a silencer for the incoming air to the blower. Air is drawn into the cleaner by the blower and passes over the top of the oil bath, where a major portion of the dirt is trapped, then up through the metal wool, where the finer particles are removed, and then down the central duct to the blower.

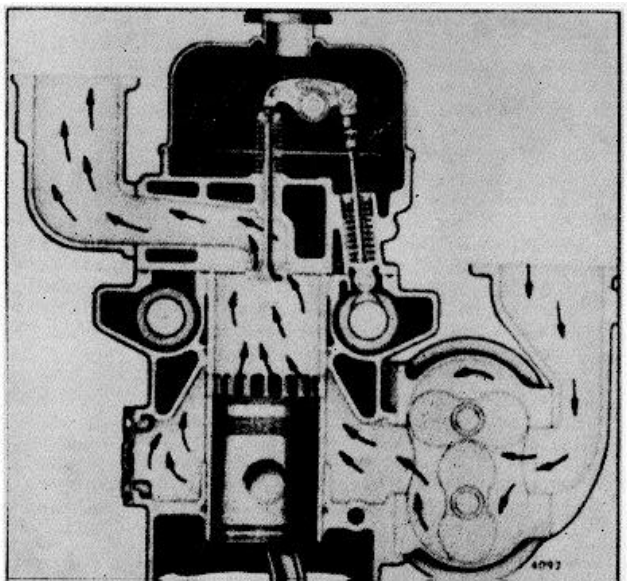


Fig. 6 - Air Intake System Through Blower and Engine (In-line Engine)

The *heavy-duty oil bath type air cleaner* (Fig. 9) consists of the body and fixed filter assembly which filters the air and condenses the oil from the air stream so that only dry air enters the engine. The condensed oil is returned to the cup where the dirt settles out of the oil and the oil is recirculated. A removable element assembly removes a major part of the dust from the air stream thereby decreasing the dust load to the fixed element. An inner cup, which can be removed from the outer (oil cup), acts as a baffle in directing the oil-laden air to the element and also controls the amount of oil in circulation and meters the oil to the element. The oil cup supports the inner cup and is a reservoir for oil and a settling chamber for dirt.

Service the *light-duty oil bath air cleaner* as follows: