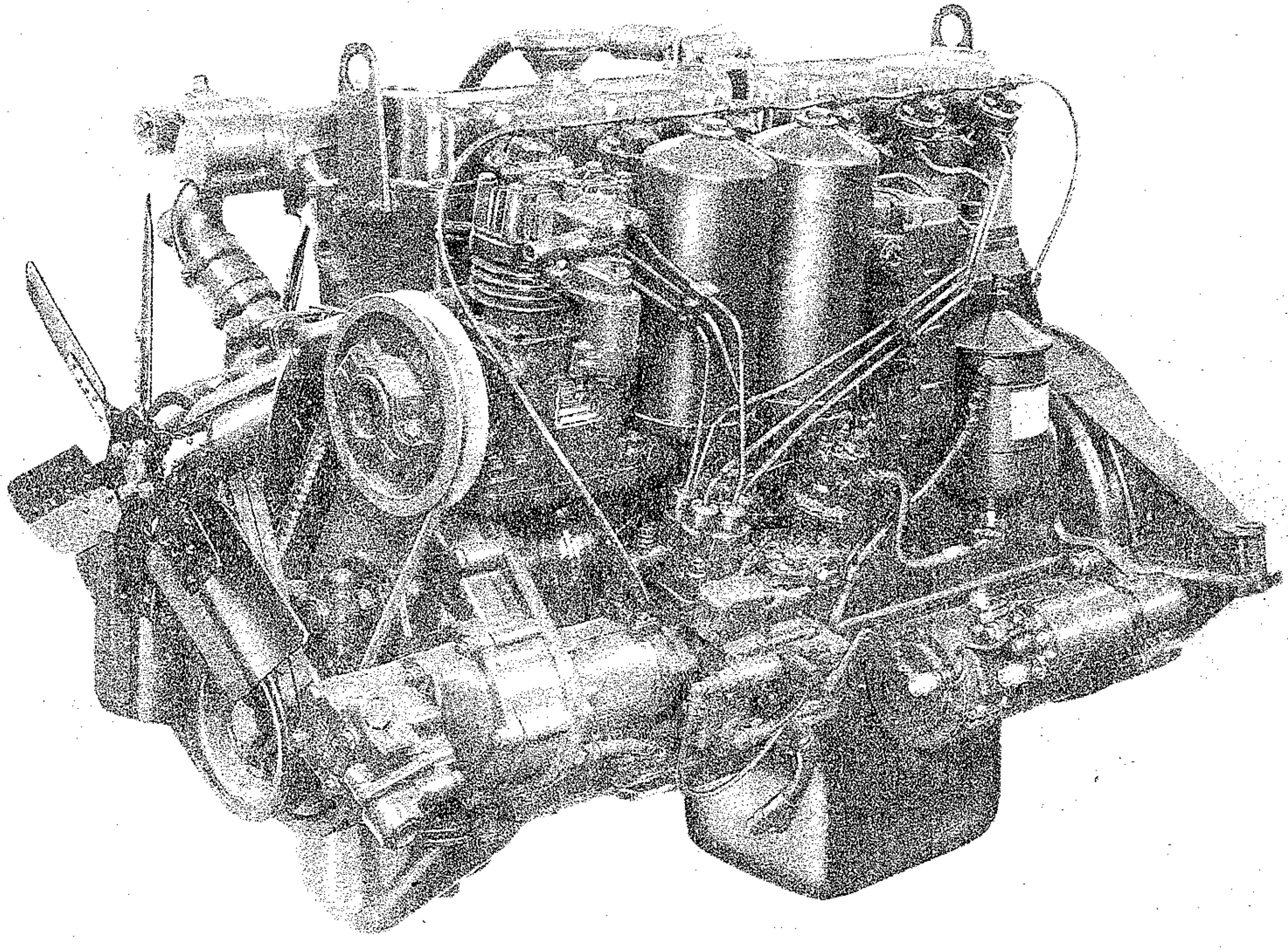
Trouble Shooting Manual
LDS-465-1 Multifuel Engine



JUNE 1968

OFFICE OF THE PROJECT MANAGER
MULTIFUEL ENGINE

CONTINENTAL AVIATION AND ENGINEERING CORPORATION
DETROIT, MICHIGAN 48215

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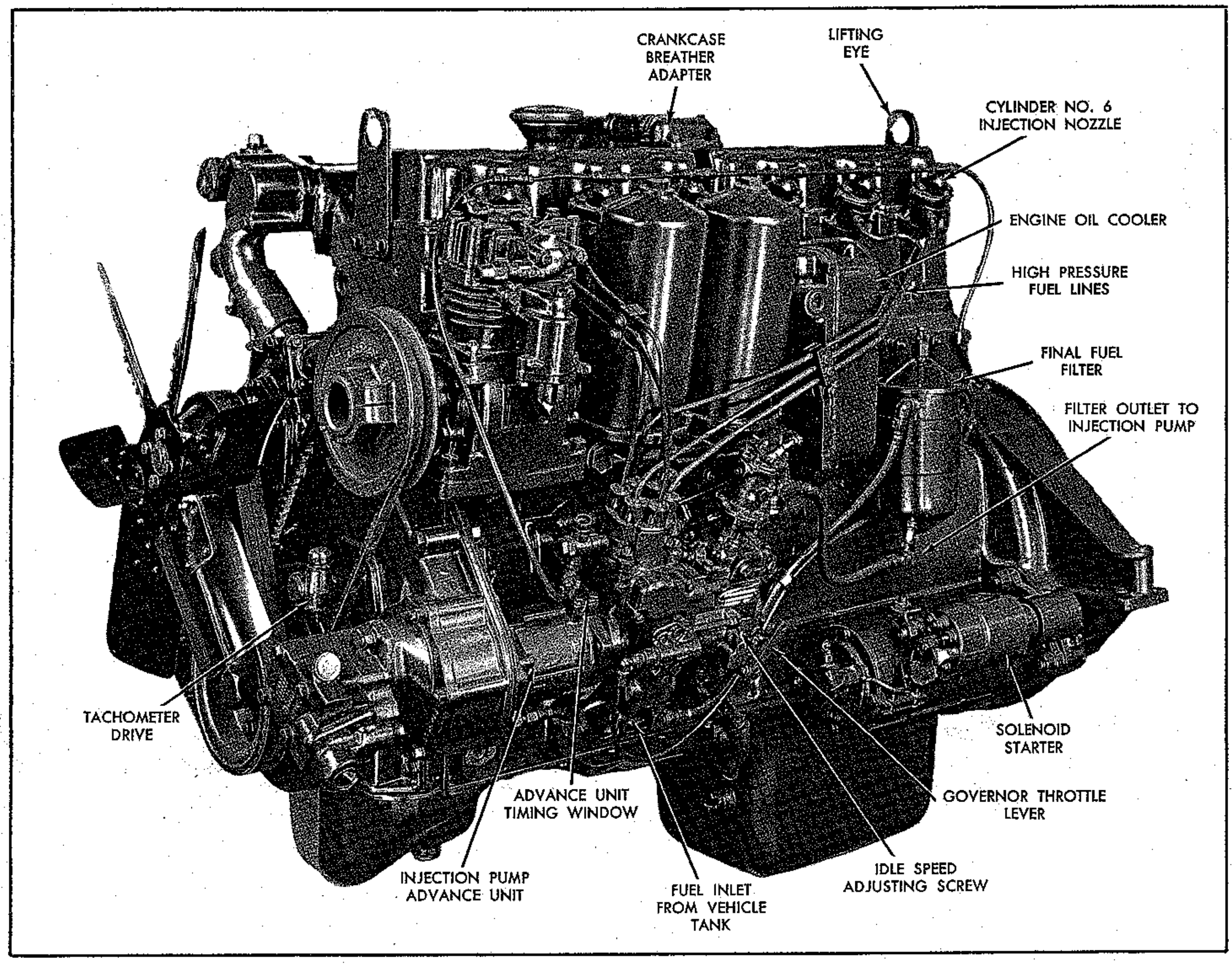
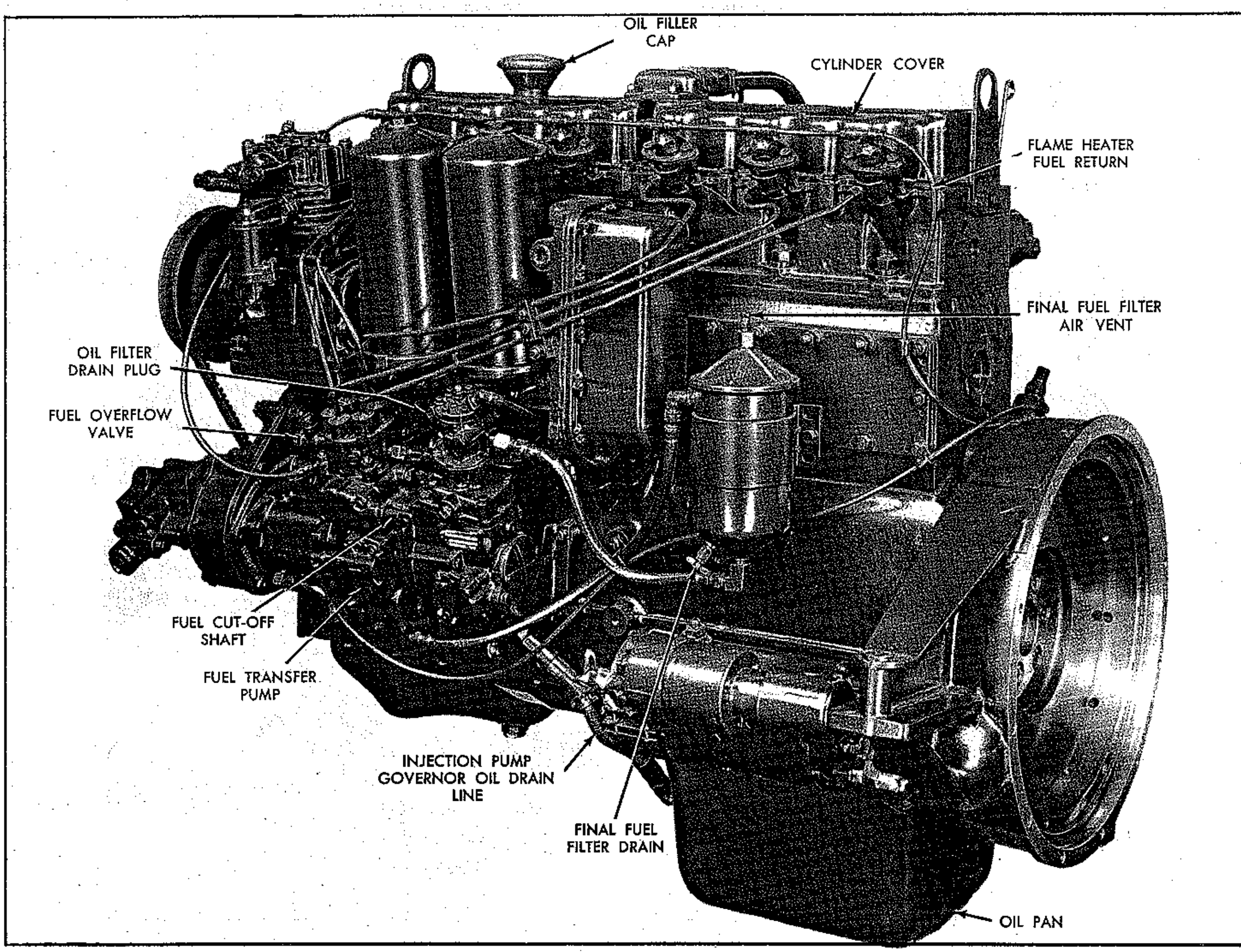
FOREWORD

Whenever an engine leaves the factory it has been adjusted to deliver its designed torque and brake horsepower under all loads and conditions. The engine is then installed in a vehicle and attachments made to the various vehicle components, i.e., battery, fuel supply, air intake. As long as engine adjustments stay within specifications and vehicle mounted attachments remain in a serviceable condition, the engine will continue to give its all for a long time; however, adjustments will fall by the wayside for a number of reasons and components will become dirty or unserviceable. For these reasons there must be a procedure laid down to find out which adjustment fell by the wayside, or which component requires servicing so the vehicle can be returned to service with the least amount of delay. This manual establishes trouble shooting procedures for the LDS-465-1 Multifuel Engine. This manual was written to cover all the possible causes of low engine power. If you start at the beginning and follow each procedure step by step, as laid out in the manual, you might never have to perform all the steps covered, since the problem may be corrected early in the procedure.

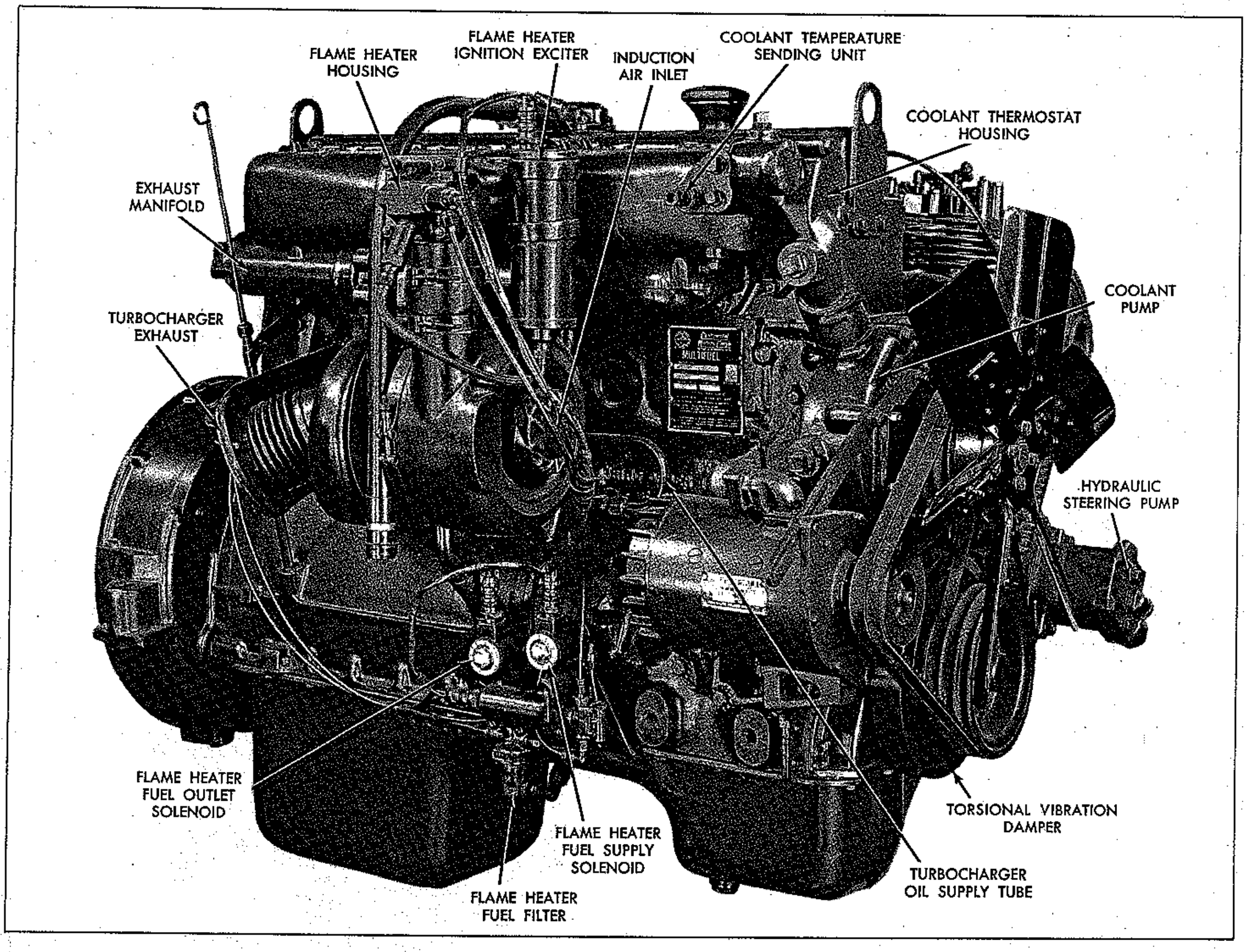
Remember an engine, like other pieces of equipment in our machine age, is only as good as the men that operate and maintain it. So take your time, follow the procedures and do a good job the first time so that the second time will be a long time in coming.



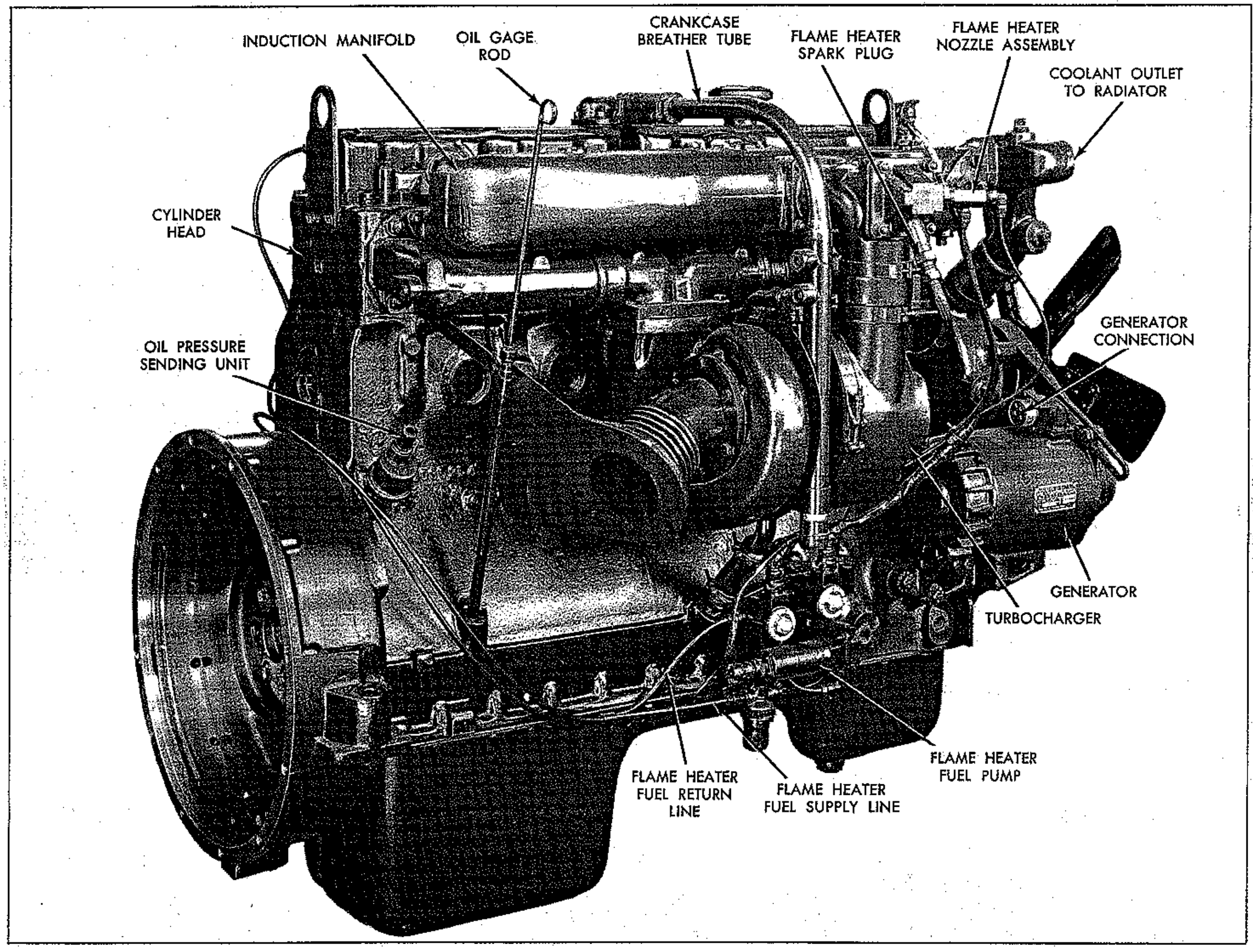
LDS-465-1 Engine - Left Fan End



LDS-465-1 Engine - Left Flywheel End



LDS-465-1 Engine - Right Fan End



LDS-465-1 Engine - Right Flywheel End

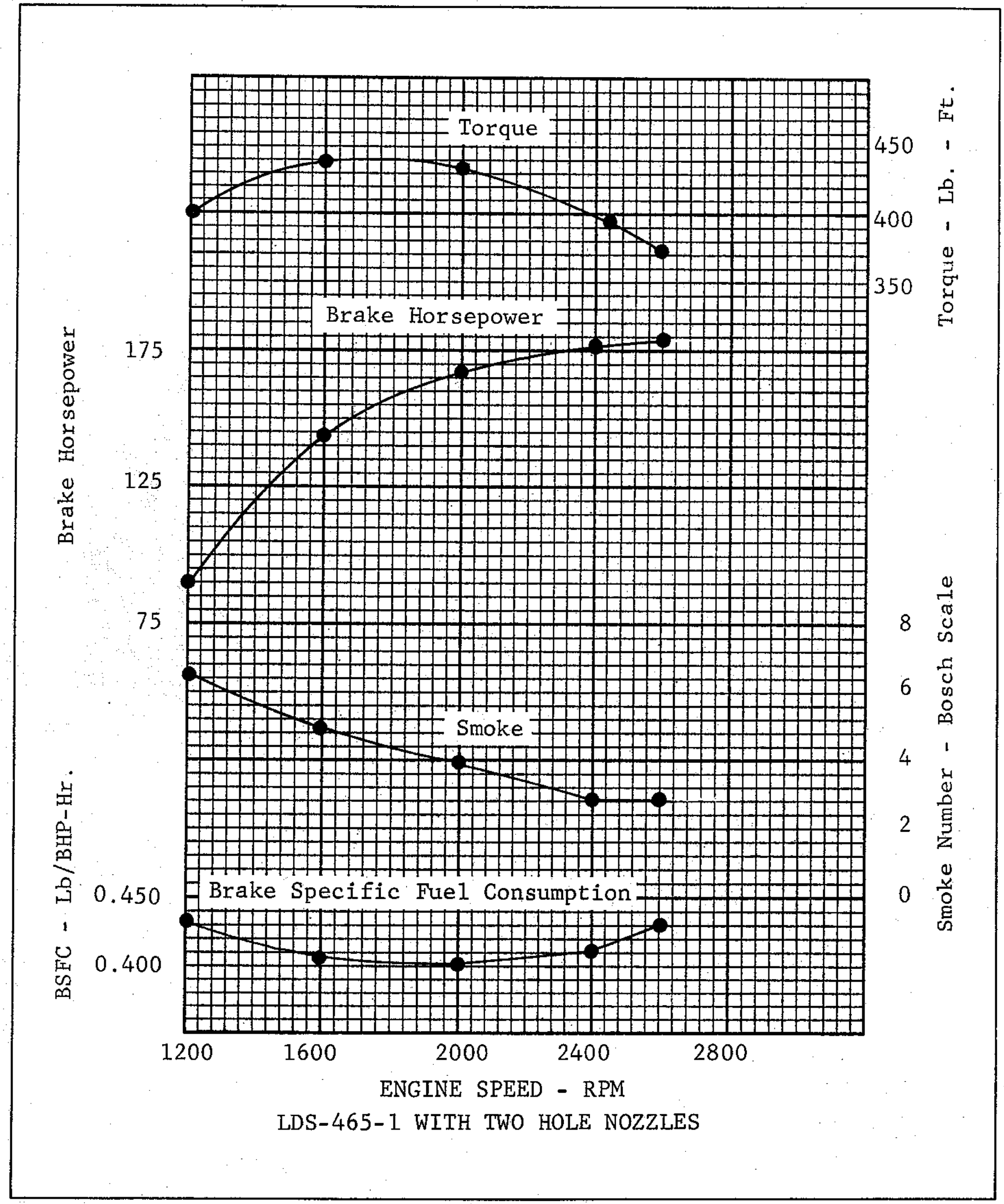


Figure 1. Performance Curve, LDS-465-1 Engine With Two Hole Nozzles

PART I - GENERAL

1. INTRODUCTION.

The LDS-465-1 is a six-cylinder, in-line, liquid-cooled, compression-ignition engine rated at 180 brake horsepower at 2600 rpm. This engine employs the Hypercycle multifuel combustion system which permits the use of various grades of fuels while still preserving a low rate of fuel consumption. A fuel sensory device is provided on the fuel-injection pump to automatically maintain constant full-rack power regardless of the type or mixtures of fuels being employed. The engine has been developed to meet the stringent requirements of Ordnance service.

The LDS-465-1 engine can be operated successfully on any of the following fuels: diesel oil (VV-F-800), compression-ignition & turbine engine (Referee) (MIL-F-45121B), compression ignition engine (MIL-F-46005) and automotive combat gasoline (MIL-G-3056B).

Figure 1 is a typical performance curve of the LDS-465-1 engine operating on diesel oil (VV-F-800), compression-ignition & turbine engine (Referee) fuel (MIL-F-45121B), and automotive combat gasoline (MIL-G-3056B) with two-hole nozzles.

2. POINTS OF REFERENCE.

a. Fan End and Flywheel End. The end of the engine where the fan is mounted is designated as the "Fan End"; the other as the "Flywheel End."

b. Right and Left. "Right" and "Left" sides of the engine are determined when the engine is viewed from the flywheel end.

c. Parts Position Identification. Cylinder bores, liners, pistons, connecting rods, and connecting rod bearings are identified by their respective position from the fan end of the engine. For example: the first fan-end cylinder bore is designated as No. 1 cylinder.

d. Crankshaft Rotation. Crankshaft rotation is clockwise as viewed from the fan end.

e. Camshaft Rotation. Camshaft rotation is counterclockwise as viewed from the fan end.

3. GENERAL INFORMATION.

The LDS-465-1 engine represents a further development of the production Ordnance LDS-427-2 engine. Consequently, a considerable number of component parts are interchangeable between the two engines.

a. Crankcase. The LDS-465-1 engine is a six-cylinder in-line design with a cast iron crankcase and two interchangeable cast iron cylinder heads. Each cylinder head covers three cylinders. Replaceable "dry" cast iron cylinder liners are used in the cylinder bores. The crankcase is designed for maximum rigidity by extending the sides of the crankcase below the centerline of the crankshaft. The main bearing caps are provided with maximum support by recessing them into transverse webs which are cast integrally with the crankcase. The integrally-cast water jacket provides a uniform transfer of the cylinder heat rejection to the coolant.

The crankshaft is a one-piece unit of forged and Tocco-hardened steel. A flange is provided on one end for mounting the flywheel. The other end of the crankshaft has a machined hub with a key slot to mount the accessory drive gear and torsional vibration damper and accessory drive V-belt pulley.

The seven replaceable main bearings are of the split, precision type, and are steel-backed with a copper-lead alloy bearing surface. The center main bearing is double-flanged with bearing material to control crankshaft end thrust.

A simple helical gear train located at the fan end of the engine drives the camshaft, oil pumps and the fuel-injection pumps. The generator, coolant pump and fan, and air compressor are belt-driven from the accessory drive pulley on the fan end of the crankshaft.

b. Connecting Rods and Pistons. The connecting rods are tapered I-beam section steel forgings. The bearing caps are split at 45° to enable removal of the piston and rod assembly through the top of the cylinder block. A bronze-lined, steel-backed bushing is pressed into the piston pin end of the rod. The connecting rod bearings are of the precision, steel-backed, copper-lead alloy, split-type.

The pistons are cam ground and tapered to provide an accurate fit in the cylinder bore at operating temperatures. The spherical shape of the combustion chamber is machined into the top of the piston. Each piston is fitted with three compression rings and one oil control ring (lowest position). The hollow steel piston pins are held in the piston pin bosses by retaining rings.

c. Camshaft and Valve Train. A single, solid, forged steel camshaft mounted in the crankcase actuates the valve gear train. The camshaft is supported in four steel-backed, copper-lead alloy bearings pressed into the crankcase. A thrust plate located between the camshaft gear and crankcase is bolted to the crankcase to control camshaft end play. The valve train consists of solid valve lifters, tubular push rods, valve rockers, valves and springs. Each valve has two springs, one located within the other. The intake and exhaust valves are equipped with positive rotators. An adjusting screw at the push rod end of each rocker permits the maintenance of proper clearance in the valve train.

d. Lubrication System. (Figure 2) The LDS-465-1 engine incorporates a full-pressure lubricating system. The design of the oil pan, in conjunction with a scavenge pump system, ensures a continuous supply of oil to the pressure oil pump pickup even at extreme attitudes of engine operation. The crankshaft main bearings and the camshaft bearings are lubricated through passages in the engine block. An annulus in each main bearing provides an oil supply to each crankpin bearing. A drilled passage within the crankshaft cheek feeds oil to the no-load side of crankpin journal.

The valve rocker arm bearings and other components of the valve train in the cylinder heads are lubricated with metered oil fed through passages leading from a camshaft bearing. Suitable drain passages return the oil from the cylinder heads to the oil pan.

Filtration of the lubricating oil is accomplished by two replaceable-element-type filters. A coolant-jacketed oil cooler is provided to perform two functions. The first is to transfer heat from the coolant to the lubricating oil to speed the warm-up of the lubricating oil during cold starts. The second is to maintain the lubricating oil temperatures at an acceptable level during normal operation.

To maintain proper piston temperature, oil is taken from a separate oil gallery and directed to the underside of the pistons by means of suitable oil jets. A pressure-sensing valve is provided to control the amount of piston cooling oil.

e. Coolant System. (Figure 3) A balanced water manifold type of coolant system is another important feature of this engine. Coolant is circulated by the belt-driven coolant pump through the oil cooler, and hence, through the crankcase block water jacket where it flows around the cylinder walls and then into the cylinder heads. After circulating through the cylinder heads it flows into the water header manifold. The function of the water header manifold is to maintain an equal distribution of the coolant around each cylinder head, thereby eliminating any "hot spots" or unequal thermal stresses. The coolant then flows from the water header manifold to the jacket of the intake manifold and finally to the bypass thermostat housing where the thermostat controls the coolant flow to the radiator. The six-bladed fan, mounted on the pump shaft, provides the proper air circulation through the coolant radiator.

f. Fuel-Injection System. (Figure 4) The LDS-465-1 engine is equipped with an American Bosch PSB-6A model fuel-injection pump of the single-plunger distributor-type design. A centrifugal advance device is provided between the injection pump and the injection pump mounting pad to provide an 8° advance in the start of fuel injection throughout the engine speed range. An overspeed governor is an integral part of the pump. A fuel sensory device is provided on the fuel-injection pump to automatically maintain constant full-rack power regardless of the type of mixtures of fuels being employed.

The fuel supply pump, which delivers fuel under pressure to the injection pump, is mounted on the side of the injection pump and is driven internally from the injection pump. A fine fuel filter is installed between the supply pump and the injection pump. Inasmuch as dirt is a primary cause of fuel-injection system malfunctions, breaking of the connection between the fuel-injection pump and this final fuel filter should be avoided.

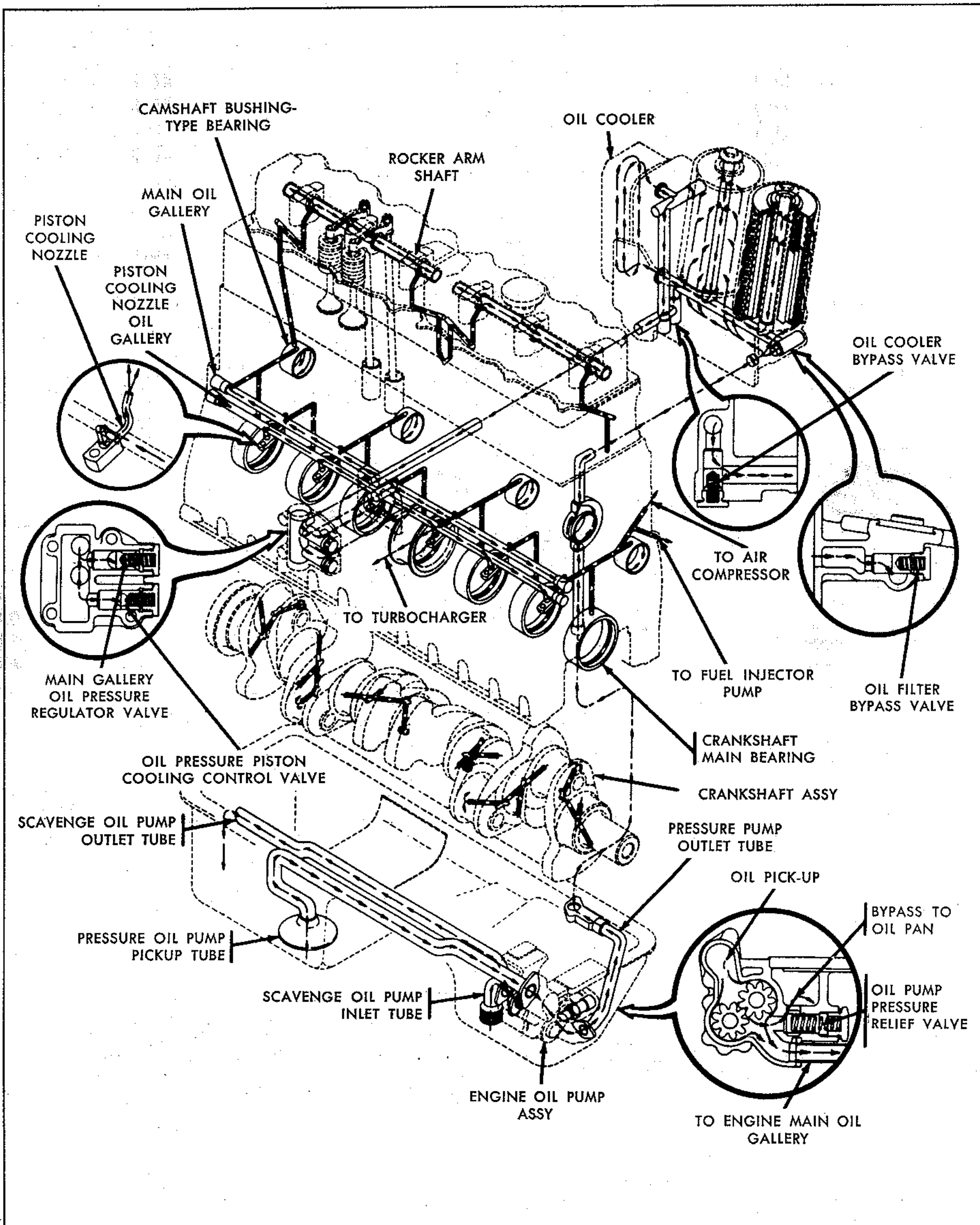


Figure 2. LDS-465-1 Engine Lubrication System Diagram

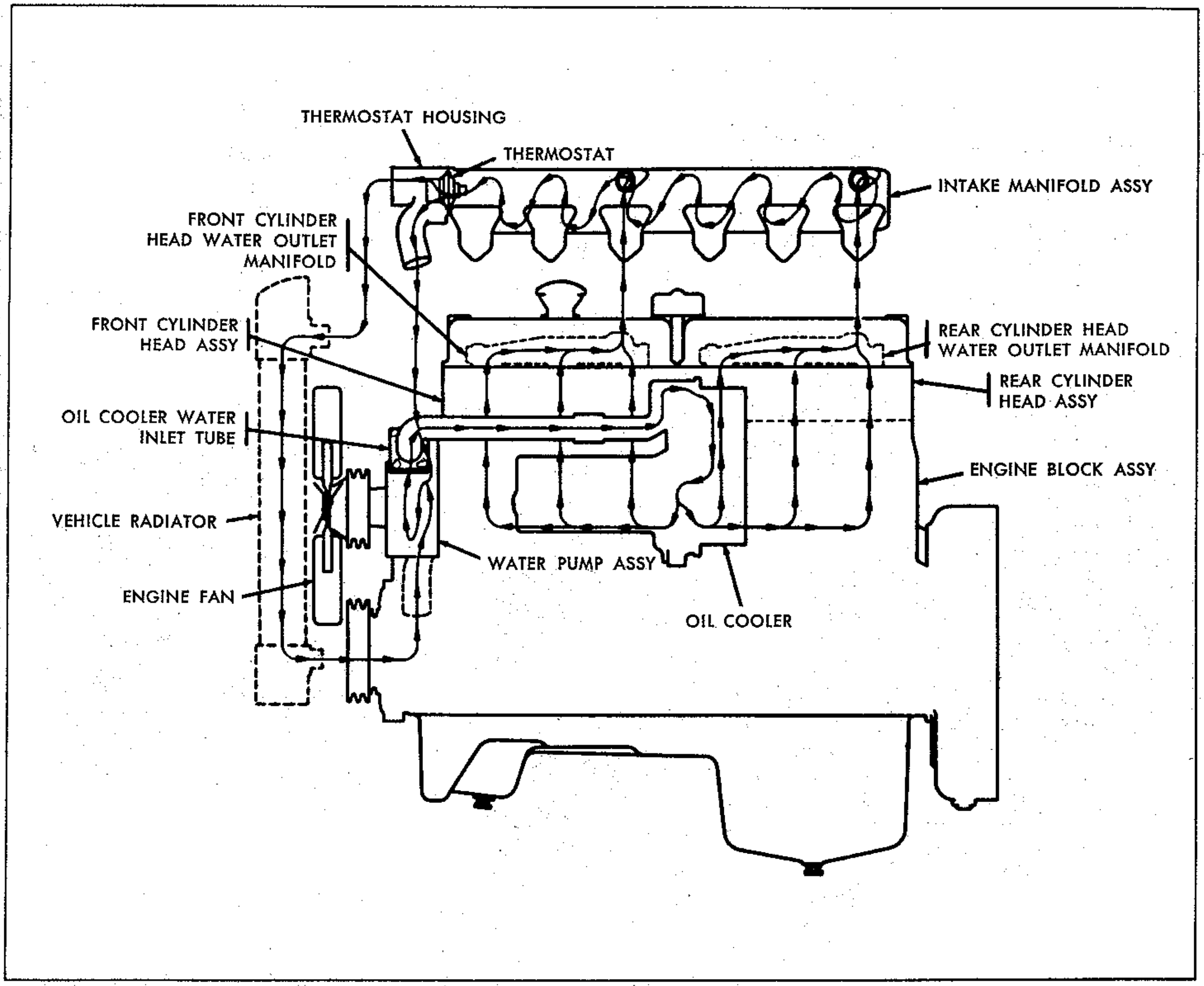


Figure 3. LDS-465-1 Engine Cooling System Diagram

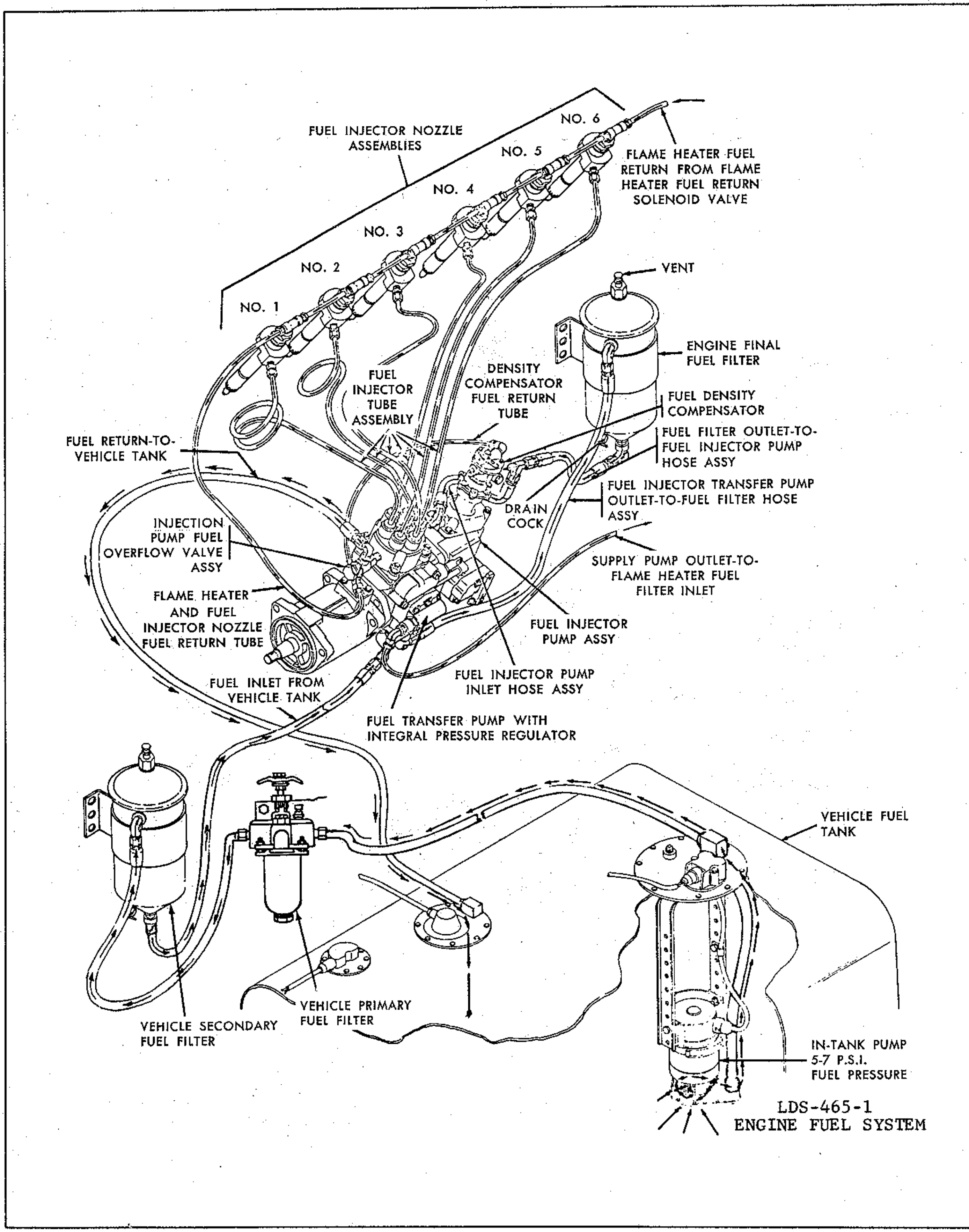


Figure 4. LDS-465-1 Engine Fuel System Diagram

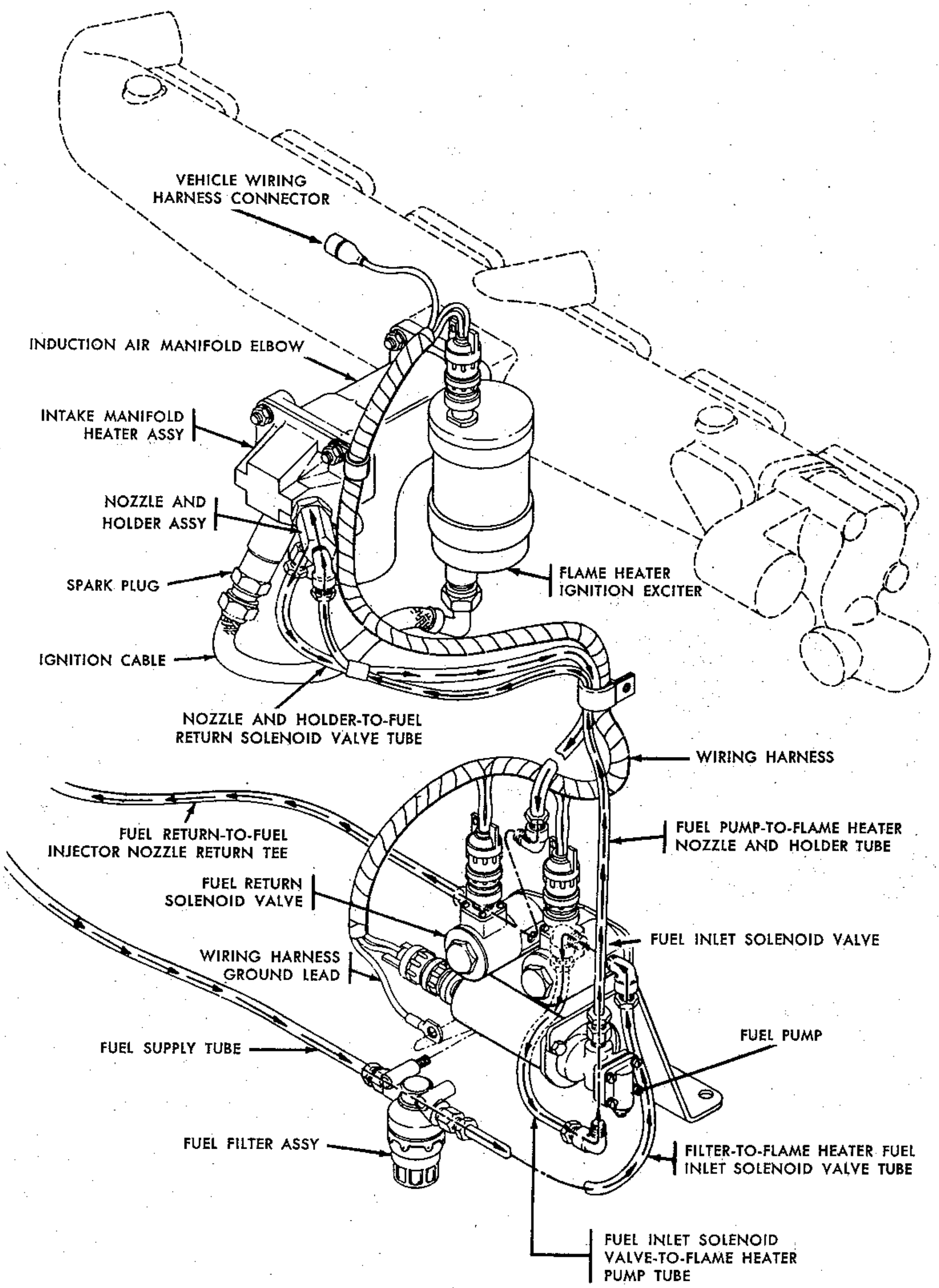


Figure 5. LDS-465-1 Engine Flame Heater System Diagram

All of the fuel-injection lines are approximately the same length and are made of 0.250-inch O.D., 0.063-inch I.D., soft-annealed steel tubing. Each nozzle and nozzle holder assembly can be replaced without removing the rocker covers. The nozzles are American Bosch ADB two-hole type. A special copper gasket, 0.070-inch thick, is used to seal the nozzle in the cylinder head.

g. Induction System. The LDS-465-1 engine is supercharged by an exhaust-driven, Schwitzer-manufactured turbocharger. External oil lines are provided to supply and drain the necessary lubricating oil. The air outlet from the turbocharger routes the supercharged induction air to a jacketed, runner-type induction manifold. Coolant is circulated through the jacket, and heat thus transferred to the induction air improves the cold weather combustion characteristics of the engine.

h. Intake Manifold Heater. (Figure 5) The LDS-465-1 engine is equipped with a flame-type intake manifold heater for heating the induction air during cold weather starting and warm-up operation. Since the heater will operate on all fuels specified for the engine, fuel is taken directly from the vehicle fuel tank. The system is energized by operating a momentary on-off toggle switch on the vehicle instrument panel. An electrical rotary pump delivers filtered fuel through the nozzle supply solenoid valve to the nozzle in the heater body and fuel is sprayed into the intake manifold. At the same time, the heater ignition coil and spark plug are energized and a flame is started in the manifold. The quantity of fuel sprayed into the manifold is controlled by the return flow nozzle which ensures an optimum fuel-air mixture in the manifold.

i. The Hypercycle Combustion Process. (Figure 6) The Hypercycle combustion process enables the LDS-465-1 engine to perform successfully with a wide variety of fuels having

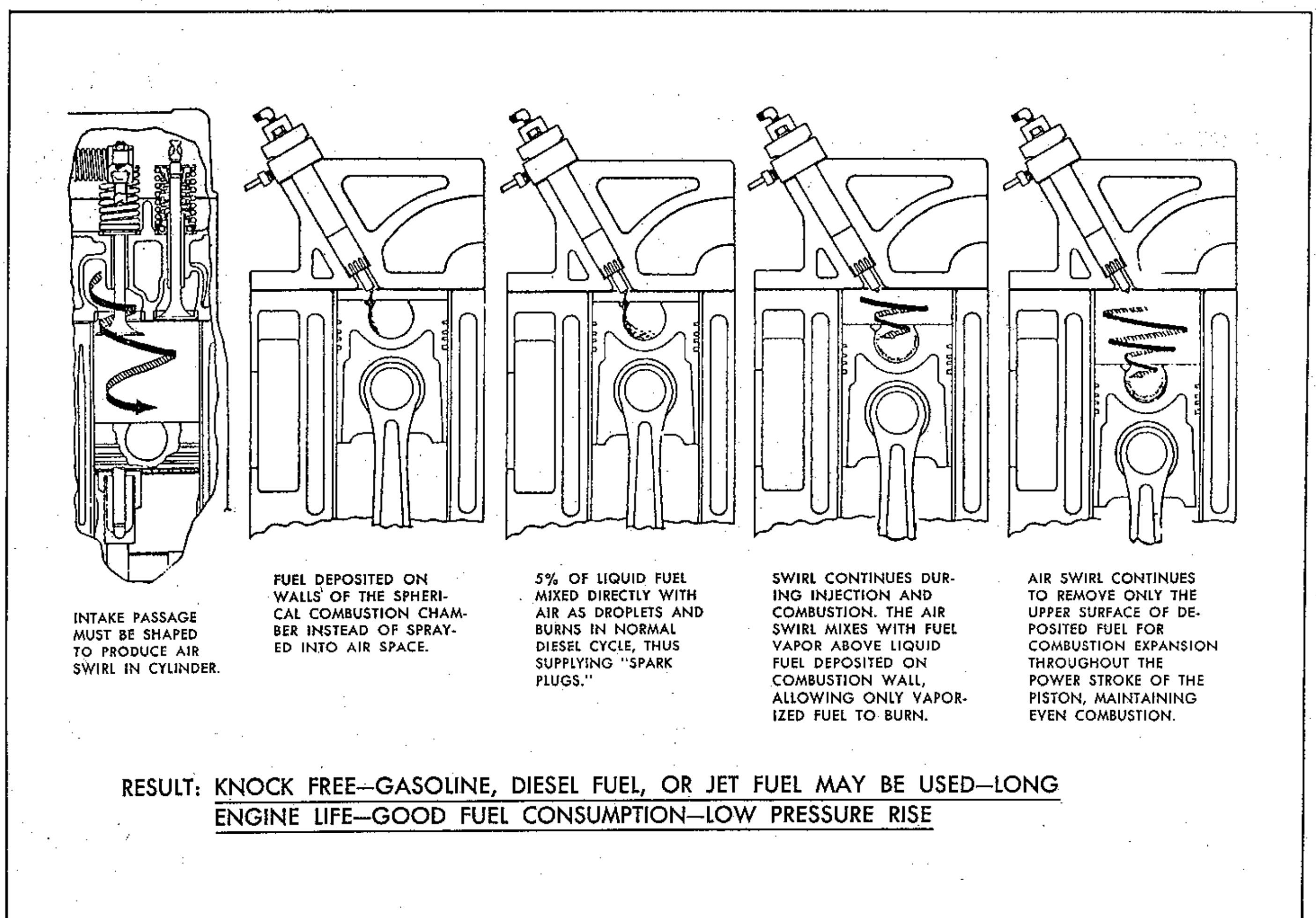


Figure 6. Continental Hypercycle Multifuel Combustion Principle

cetane ratings from 18 to 60 without encountering "diesel knock."

The Hypercycle combustion principle differs from the normal direct-injection systems where the fuel is sprayed directly into the combustion air. In this case, the fuel is sprayed against the wall of a combustion chamber machined into the top of the piston. Here, the rate of evaporation is controlled by the piston temperature. Through the use of a special intake port, a swirl is induced in the induction air which scrubs the fuel from the combustion chamber wall and continuously supplies oxygen to the slowly evaporating fuel; the swirling air provides the correct mixture for burning. This process prevents the fuel molecules from reaching the cracking temperatures before a correct fuel-to-air ratio mixture is reached; thus, it prevents knock from occurring while operating on low cetane fuels such as gasoline and turbine fuels.

4. ENGINE SPECIFICATIONS.

a. General.

Make and Type	Continental 6-cylinder, in-line, liquid-cooled, multifuel, compression-ignition engine
Model	LDS-465-1
Horsepower, Gross at Rated Speed (2600 rpm)	170-185 bhp
Idle Speed	700-750 rpm
Torque, Maximum Gross	440-lb-ft. at 1800 rpm
Bore and Stroke (Inches)	4.56 x 4.87 in. stroke
Displacement	478 cubic in.
Number of Cylinders	6
Compression Ratio	22:1
Firing Order	1-5-3-6-2-4
Crankshaft Rotation	Clockwise, viewed from fan end
Over-All Dimensions	
Length	48.09 inches
Width	29.48 inches
Height	39.96 inches
Engine Weight	
Complete Engine (dry)	1561 lbs.
Bare Engine (dry) (Complete Engine less oil cooler, water pump and fan, generator, electric starter, air compressor, injection pump and power steering pump)	1326 lbs.
Valves	Overhead type, two per cylinder, actuated by a single camshaft
Cooling System	Thermostatically-controlled, pump-circulated, liquid-cooling, with a balanced water manifold. Six-bladed fan for radiator air circulation.
Induction System	Supercharged by a Schwitzer exhaust-driven turbocharger
Fuel Metering System	American Bosch PSB fuel-injection equipment. Includes fuel sensing device to maintain constant full-rack performance.

b. Injection Timing.

Static setting with injection advance in full retard	20° BTC

c. Accessory Drive Ratios and Rotation as Viewed from Fan End.

Water Pump and Fan	1.35:1 clockwise
Tachometer	0.50:1 counterclockwise
Generator	2.00:1 clockwise
Starting Motor	11.5:1 counterclockwise
Injection Pump	1.00:1 clockwise
Air Compressor	0.86:1 clockwise
Oil Pump	1.22:1 clockwise
Power Steering Pump	1.37:1 clockwise

d. Accessories.

Type	Make	Federal Stock No. or Ordnance No.
25-Ampere Generator	Delco Remy Autolite Prestolite	7355736 7524310 10950808
Starter (Solenoid)	Delco Remy Leece-Neville Prestolite	10911018-1 10935376 10951385
Fuel Filter Element	Purolator P-91	5702684
Oil Filter Element	Purolator	8748329
Fuel-Injection Pump	American Bosch (PSB-6A)	10951115
Nozzle and Holder Assembly	American Bosch (ADB)	10935284
Air Compressor	Midland-Ross	10899038
Intake Manifold Heater	Bendix-Scintilla	7748871
Power Steering Pump	Vickers	10935271

e. Fuel.

Type	Specification
Diesel Oil	VV-F-800 DF-A Arctic DF-1 Winter DF-2 Regular
Automotive Combat Gasoline	MIL-G-3056B
Compression Ignition Engine	MIL-F-46005
Compression-Ignition & Turbine Engine (Referee)	MIL-F-45121B

f. Lubricating Oil.

Engine Capacity
Filters Dry .... 22 Quarts
Filters Full .... 18 Quarts

Ambient Temperature	Oil Specification
+20°F to +115°F	SAE 30 (MIL-L-2104)
-10°F to + 50°F	SAE 10 (MIL-L-2104)
-65°F to + 20°F	Arctic (MIL-O-10295)

g. Coolant Specification.

Refer to vehicle manufacturer's recommendation.

h. Nut and Bolt Torque Specifications.

Note. Use SAE 30 Oil on all Threads.

Critical Nuts and Bolts	Lb.-Ft.	Lb.-In.
Rod Bolt	100	1200
Cylinder Head Nut Sequence 1.	40	
2.	80	
3.	110	
4.	130	
Torsion Damper (Press to 17.5 Tons)		425
Pulley and Damper to Crankshaft	225 - 250	
Flywheel Bolts	120	
Main Bearing Bolts	92	1100
Nozzle Hold Down Bolts	12 - 15	150 - 175
Hydraulic Pump Gear Retaining Nut	45 - 50	550 - 600
Rocker Cover Bolts		30 - 60
Camshaft Gear Retaining Nut	400 - 425	
Oil Filter Can Centerbolt	60	
Turbocharger to Exhaust Manifold Bolts	23 - 27	
Injection Pump Hub Nut	66 - 71	800 - 850
Fuel Filter Center Bolt	15	180
Oil Pump Gear Nut	50	600
Oil Pump Mounting Bolts	50	600

Standard Bolt Torques	Lb.-Ft.	Lb.-In.
1/4 In.	6 - 8	75 - 100
5/16 In.	12 - 15	150 - 175
3/8 In.	23 - 27	275 - 325
7/16 In.	33 - 43	400 - 500
1/2 In.	46 - 50	550 - 600
9/16 In.	66 - 71	800 - 850

i. Performance.

Gross Fuel Consumption at Rated Power .... 80 lb/hr - . 43 lb/bhp-hr
Gross Fuel Consumption at Idle Speed .... 2 lb/hr at 700/750 rpm
Normal Oil Temperature
After Cooler .... 200°F at 60°F ambient
Maximum Oil Temperature
After Cooler .... 260°F
Lubrication Oil Pump Capacity .... 22 gpm
Normal Oil Pressure .... 60 psi at 2800 rpm with 200°F oil temperature.
(10 psi minimum at idle)
Induction Airflow at Rated Power .... 550 cfm
No-Load High-Speed Governor Setting .... 2850 - 2900 rpm

PART II - TROUBLESHOOTING

5. GENERAL.

In trouble shooting an engine of this type while in the vehicle, the main concern is clean fuel, proper fuel pressures, proper fuel delivery and proper air induction. Without these, the engine will not reach the RPM required to develop its maximum torque and brake horsepower and will be low on power. To trouble shoot these conditions, two engine RPM tests are required; one a maximum no-load speed test, and the other a full-load speed test.

The procedures set down in this manual are based on the fact that to find the cause of any trouble you always start at the beginning. So when you are trouble shooting, go step by step and do not skip a step because the one you skip might be the one that would have corrected the trouble.

The example engine used to explain this trouble shooting procedure contained most of the known reasons that would cause an LDS-465-1 engine to be underpowered.

6. MAXIMUM NO-LOAD SPEED TEST.

If, after completing any of the steps for maximum no-load speed testing, the engine performs within specifications, stop at that point and conduct the engine full-load test.

a. A check of engine maximum no load speed and maximum fuel pressure can tell you

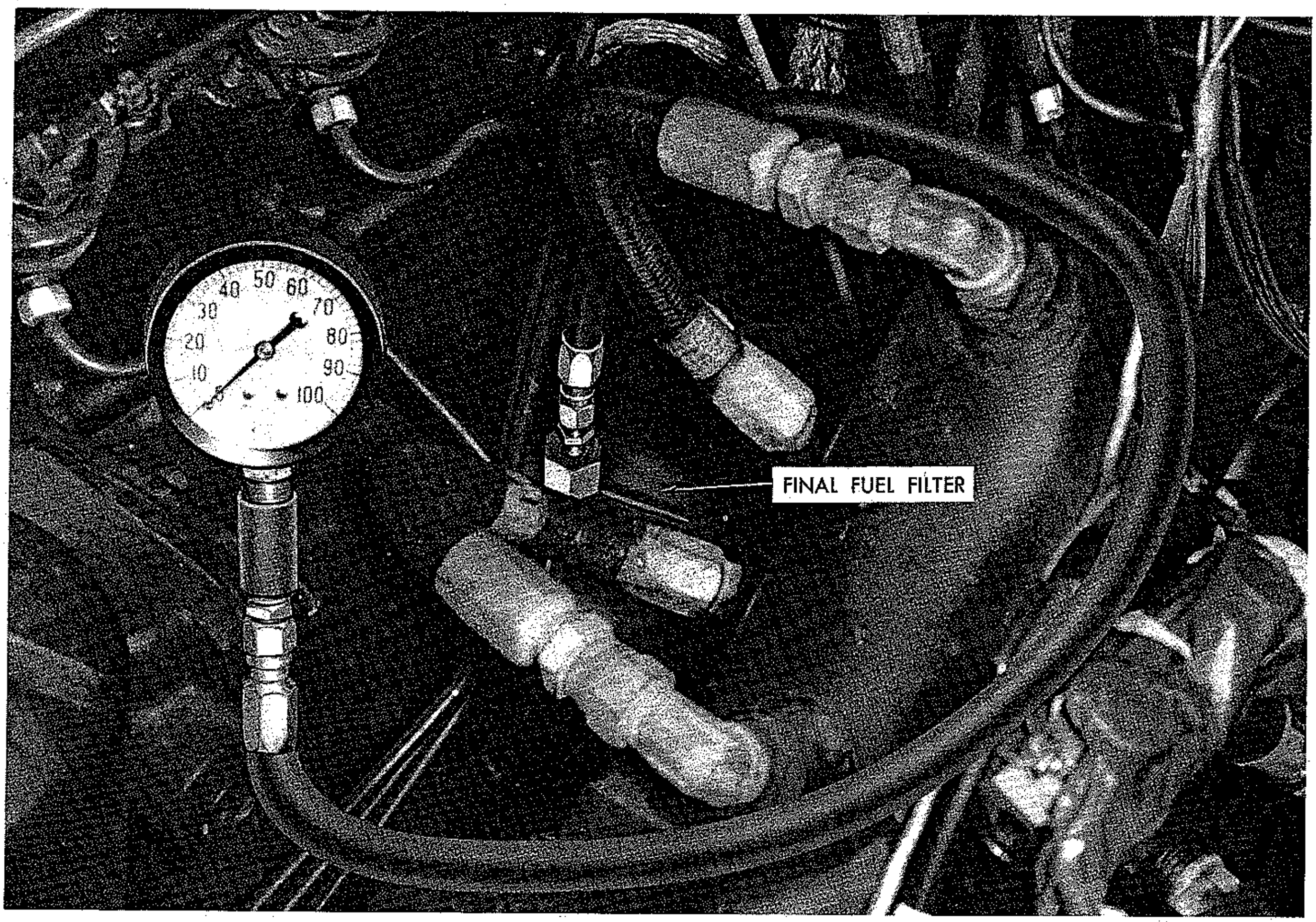


Figure 7

a great deal about how the engine is performing. One of the main reasons for low power on an LDS-465-1 engine is low fuel pressure. Low fuel pressure results in the engine not being able to produce its maximum torque and horsepower when operating under full-load conditions. Since there is no fuel pressure gage installed on the vehicle it will be necessary to install a 100 PSI fuel pressure gage at the engine final fuel filter housing, Figure 7, before performing any speed or fuel pressure checks.

b. The following fuel pressures, at engine speeds indicated, are required for normal engine performance:

(1) Fuel pressure supplied from the vehicle fuel tank electric boost pump--5 - 7 PSI.

(2) Fuel pressure with engine speed at 700 - 750 RPM low idle speed--30 - 35 PSI.

(3) Fuel pressure with engine at maximum no load speed of 2850 - 2900 RPM--65 - 75 PSI.

(4) Figure 8 is a chart showing normal engine operating fuel pressures for various engine speeds.

REQUIRED ENGINE FUEL PRESSURES THROUGH ENGINE SPEED RANGES

A difference in engine fuel pressure will be encountered when using different type fuels. Fuel pressure will be higher when using Diesel fuel and lower when using Automotive Combat gasoline. Pressure should be within the limits listed below regardless of the type of fuel used.

ENGINE SPEED RPM	ENGINE FUEL PRESSURE	
	Minimum	Maximum
700 - 750	30	35
1200	48	57
1600	57	64
2000	63	69
2400	65	73
2600	65	75
High Idle (2850 - 2900)	65	75

Figure 8

c. Initial Test - Check No. 1

(1) Start engine and allow it to warm up to normal operating temperature.

(2) Depress accelerator pedal slowly to full throttle position.

(3) Observe engine speed (RPM) and fuel pressure gage.

(4) The following readings should exist for a properly adjusted and normal performance engine:

(a) Engine speed ..... 2850-2900 RPM

(b) Fuel pressure .... 65 - 75 PSI

(5) Return engine speed to an idle (700 - 750 RPM) and observe fuel pressure. Normal fuel pressure at this speed should be 30 - 35 PSI.

(6) Example of possible readings obtained indicating a low performance engine (Check No. 1):

(a) Engine maximum no-load speed .... 1600 RPM

(b) Engine maximum fuel pressure .... 45 PSI

(c) Engine low idle fuel pressure .... 25 PSI

d. In the above cited example (Check No. 1), all readings are too low for a normal performance engine. As was stated before, to find the cause of any trouble you must start at the beginning. The beginning for a compression-ignition engine is AIR and lots of it. So the first system to inspect is the air induction system. A dirty or plugged induction air filter element will cause an engine to operate at less than maximum power. When operating under full load conditions engine speed will be low, fuel pressures will be low and heavy black smoke will be observed coming from the vehicle exhaust pipe.

e. Inspection of the Engine Induction Air System.

(1) An air filter element restriction indicator gage is mounted in the right

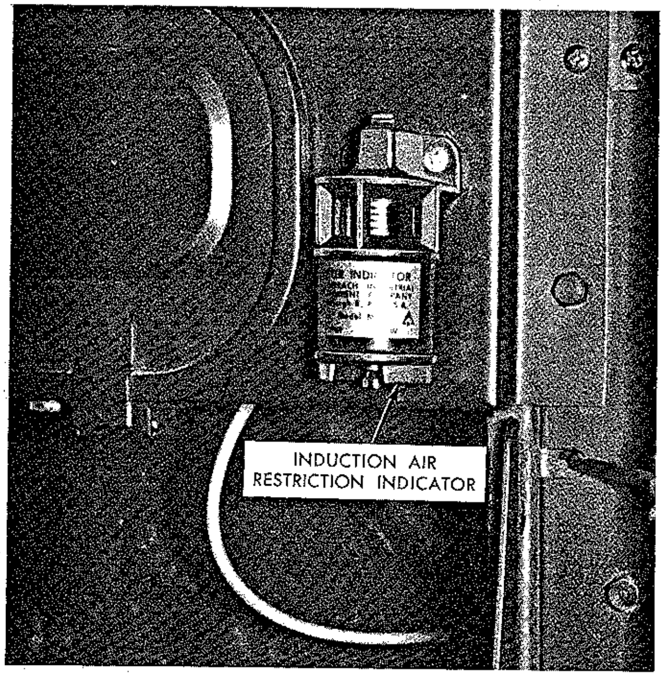


Figure 9

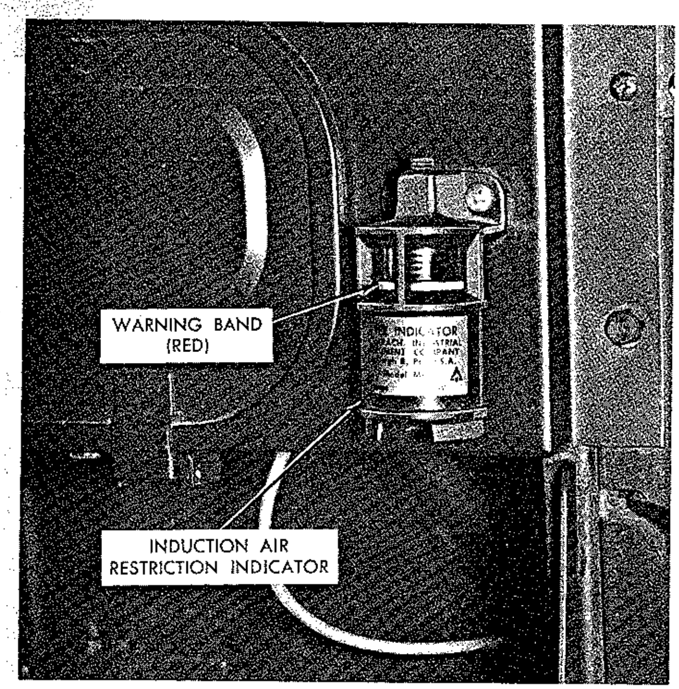


Figure 10

hand corner of the vehicle dash panel, Figure 9. This restriction indicator gage should be observed every time a driver operates the vehicle. When the air filter becomes partially restricted with dirt, a RED BAND rises into view on the indicator gage, Figure 10.

(2) When operating the vehicle, drivers

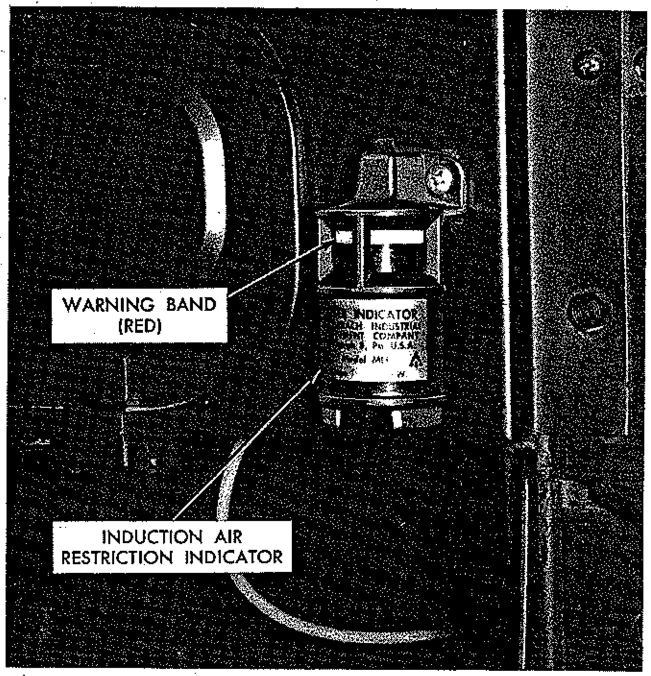


Figure 11

should watch the indicator gage for any sign of the RED BAND. When the red band is observed, just starting to rise, service the air filter element. DO NOT WAIT UNTIL THE RED BAND IS COMPLETELY IN VIEW, AND LOCKS INTO POSITION, Figure 11.

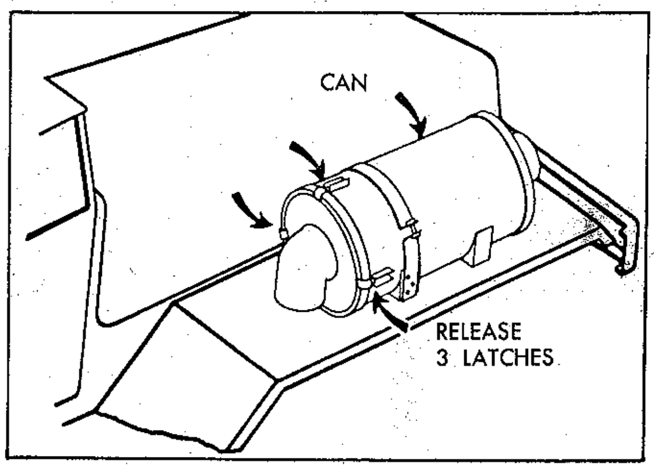
(3) Servicing of the air filter housing and element is done as shown in Figures 12 and 13.

(4) After cleaning the air filter housing and air filter element, the air restriction indicator should be reset to the non-restricted position (out of sight below window) by pushing upward on the plunger at the bottom of the gage housing.

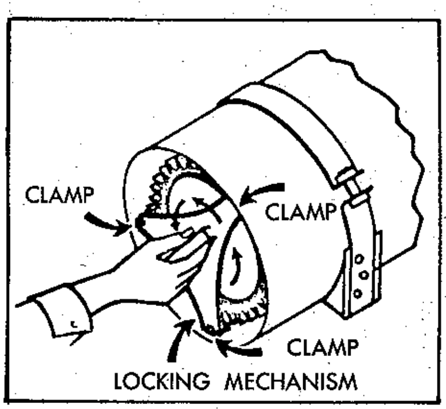
Caution: Do not operate a vehicle without an air filter element installed. Operation of an engine without an air filter element results in an engine being dust gutted. In short, the cylinder liners, turbocharger, and piston rings would be completely worn out in a very short period of time.

(5) After servicing the air filter housing and element, inspect all induction air tubes and hose connections to the inlet side of the turbocharger, Figure 14.

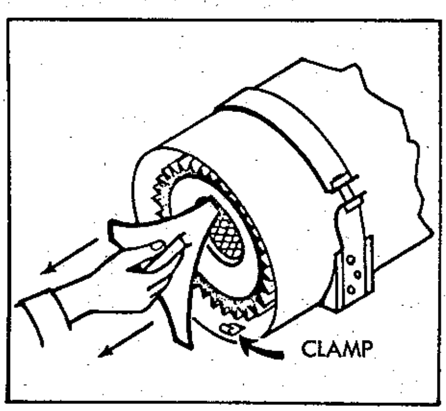
AIR CLEANER MAINTENANCE ON M39-A2, 5-TON VEHICLES WITH LDS-465-1 OR LDS-465-1A ENGINES INSTALLED



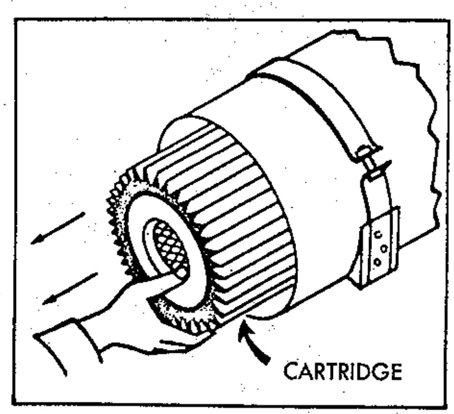
A. Remove cover by unlatching the three assemblies that hold the cover to the can.



B. Release locking mechanism by turning handle counter clockwise and turn until mechanism is disengaged from clamps.

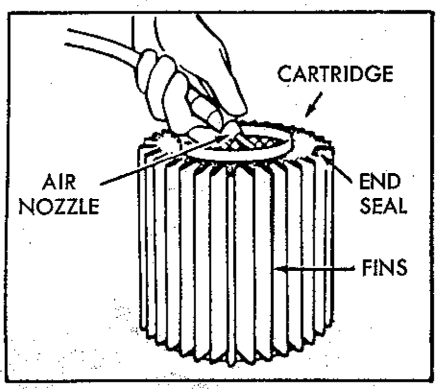


C. Pull out locking mechanism.

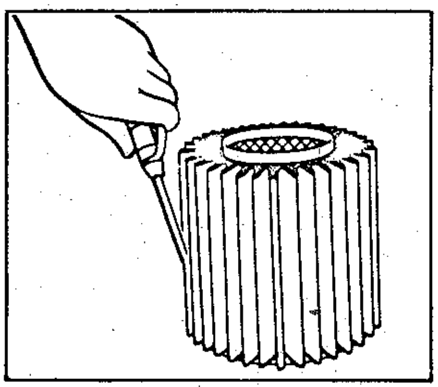


D. Remove cartridge from the can.

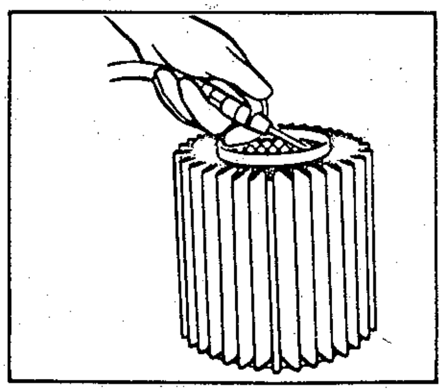
Figure 12



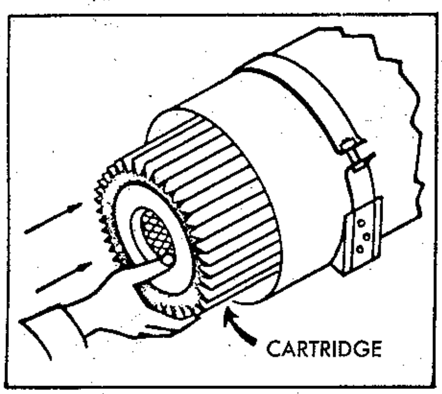
E. Blow off the inside of the cartridge with 100 lbs. compressed air.



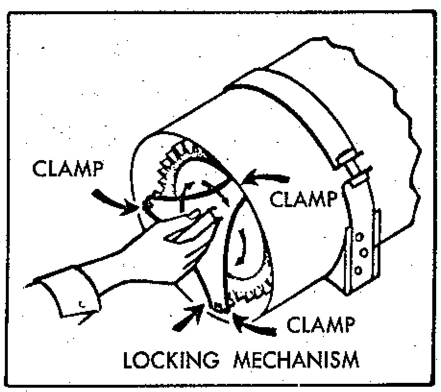
F. Blow off the outside of the cartridge with 100 lbs. compressed air.



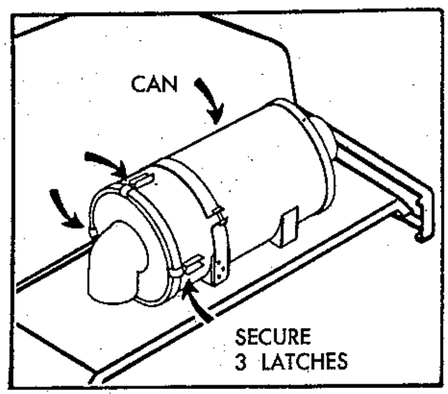
G. Blow off the inside of the cartridge again to remove any dirt on the clean air side that may have blown through when outside was cleaned.



H. Replace cartridge in can. Caution: Clean inside of can before replacing cartridge.



J. Replace locking mechanism by turning mechanism to engage under clamps. Tighten by turning handle clockwise.



K. Replace cover on can by securing the (3) latches.

If compressed air is not available, emergency cleaning of the cartridge in the field can be accomplished by gently beating the cartridge fins with the hands and tapping the ends of the cartridge on a flat metal surface to remove the dirt.

It is not necessary to pound the cartridge as enough dirt will be removed by gently beating and tapping to allow the vehicle to proceed to a source of compressed air.

Cartridge can be cleaned in soap and water. DO NOT CLEAN IN GAS OR SOLVENTS as these will damage plastic cartridge end seals making the cartridge useless. Do not install cartridge when dripping wet. Dry with compressed air.

Figure 13

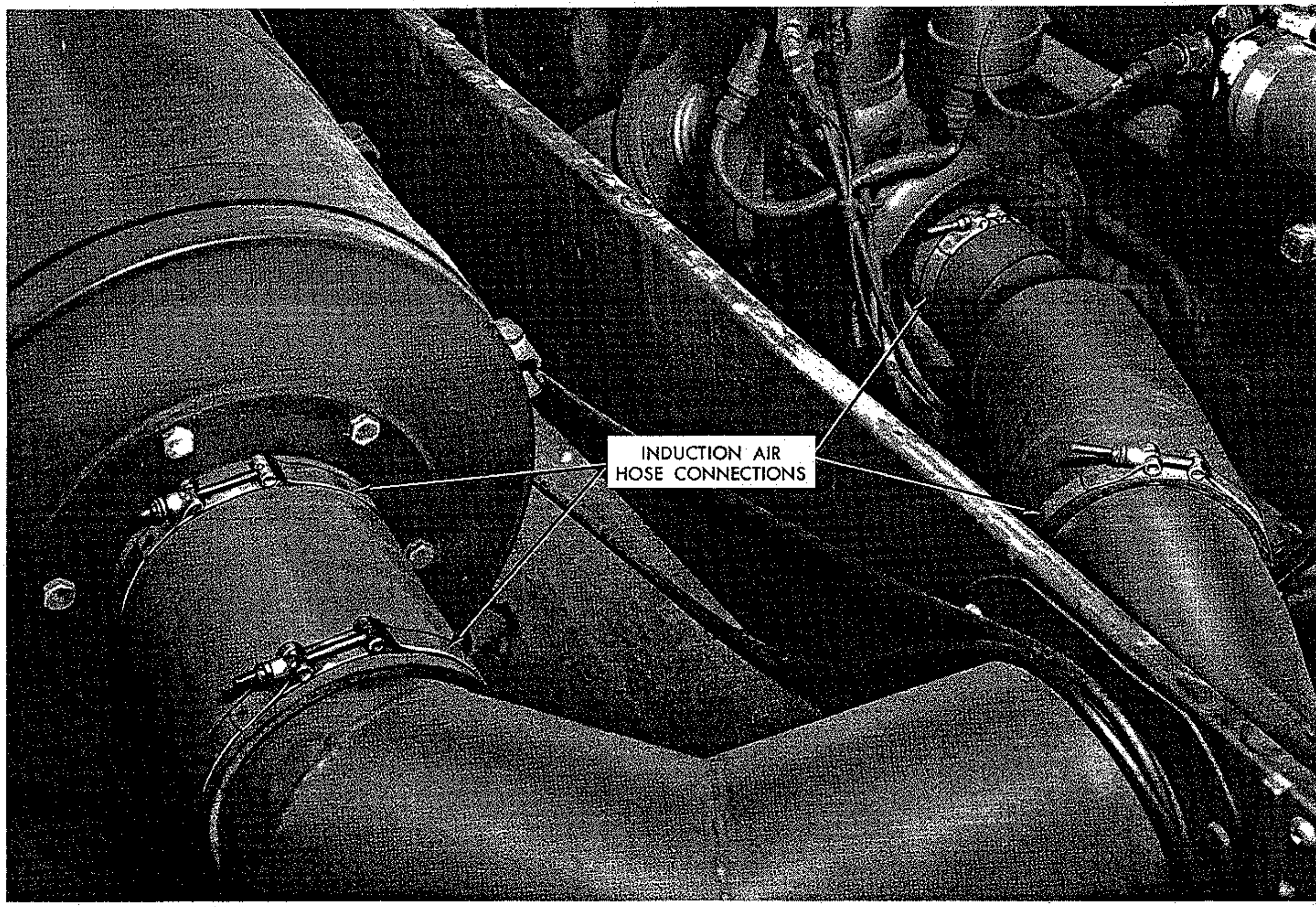


Figure 14

Make sure there are no loose connections. Tighten all connections as needed to prevent unfiltered air from entering the induction air system. Remove and replace worn induction air tubes and hoses.

f. Recheck Engine Maximum No-Load Speed - Check No. 2.

(1) After inspecting and servicing the engine induction air system, start up engine and recheck maximum no-load speed as outlined for Initial Test.

(2) Example of possible readings obtained (Check No. 2):

(a) Engine maximum no-load speed .... 2000 RPM

(b) Engine maximum fuel pressure .... 47 PSI

(c) Engine low idle speed fuel pressure .... 25 PSI

g. In the above cited example (Check No. 2), the maximum no-load speed and maximum fuel pressure have been increased with low idle speed fuel pressure remaining the same. However, all readings are still too low. As fuel is the second most important thing to a compression-ignition engine the cause of low fuel pressure must be determined and corrected next.

h. To check for low fuel pressure you must start at the beginning or source of fuel supply to the engine, the vehicle in-tank fuel pump, then each fuel filter in its respective order, primary, secondary and final. Make checks as follows:

(1) With the fuel pressure gage installed, turn on the vehicle master switch, Figure 15. This will activate the electric fuel supply pump located in

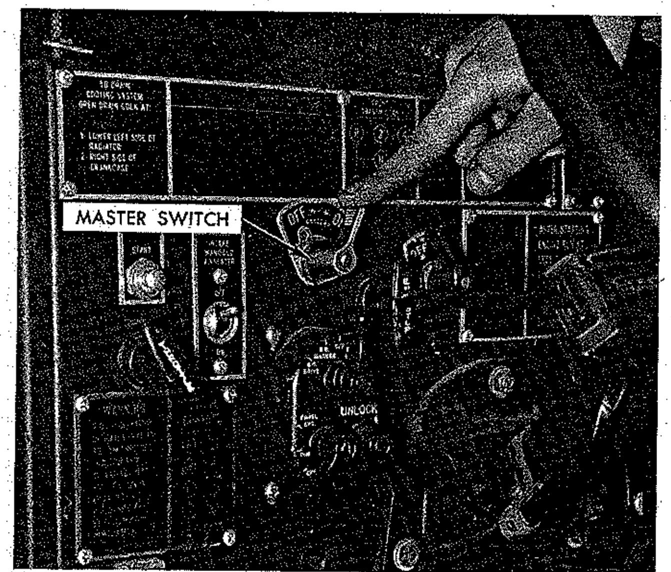


Figure 15

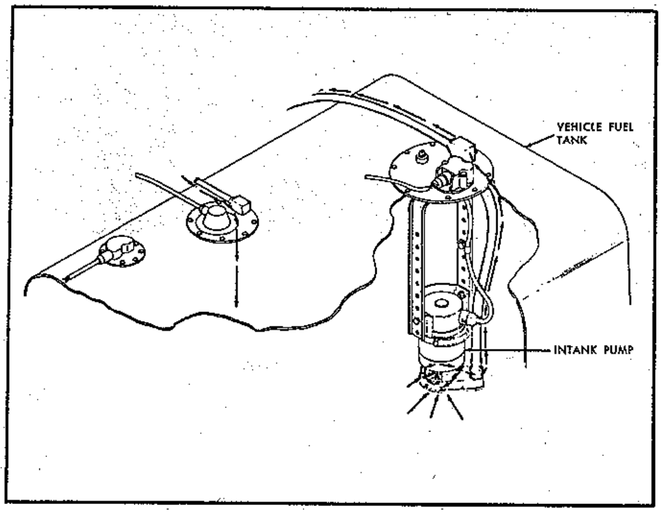


Figure 16

the fuel tank, Figure 16.

(2) A 5-7 PSI fuel pressure on the gage should be observed. Should no fuel pressure register on the gage, check to see if the in-tank fuel pump is operating. If it is inoperative, inspect the following vehicle electrical system components:

(a) In-tank pump electrical connections for looseness.

(b) Vehicle battery voltage output to the in-tank pump.

(3) If electrical connections and battery voltage output are correct, but the pump is still inoperative, remove and replace the in-tank fuel pump, as an inoperative vehicle fuel tank supply pump will result in the following.

(a) Engine hard to start due to lack of fuel supply pressure to engine.

(b) Engine unable to develop maximum torque and horsepower. The LDS-465-1 engine when operating under full-load conditions, demands that a positive fuel pressure be delivered to the inlet of the injection pump fuel transfer boost pump. Positive supply pressure allows the injection pump fuel transfer pump to produce the required fuel pressures and fuel quantities to the injector pump hydraulic head, resulting in the engine being able to develop maximum torque and horsepower as required.

(4) If the fuel tank supply pump is found to be operative but the fuel pressure gage shows only 2-4 PSI, inspect the vehicle primary (scraper type) fuel filter for restrictions, draining the filter and observing the drained fuel for signs of water, dirt, black-in-color dirty fuel, or foreign materials, Figures 17 and 18.

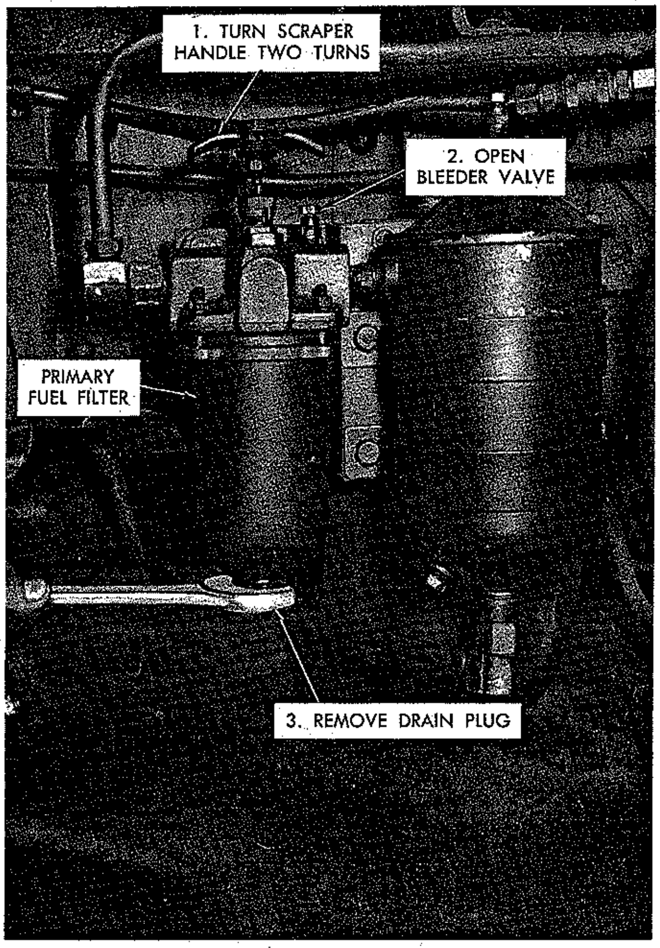


Figure 17

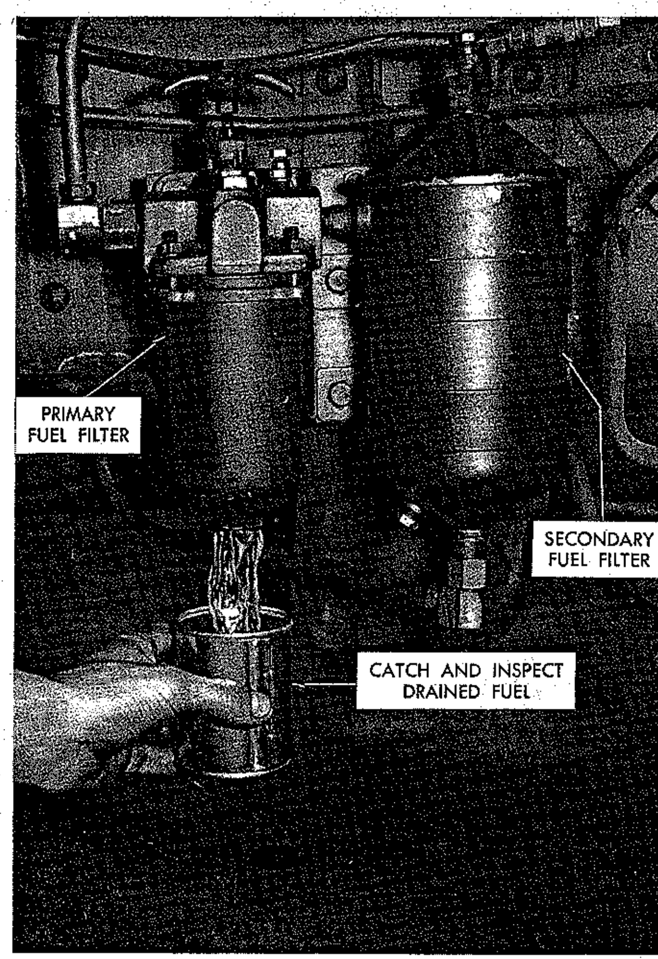


Figure 18

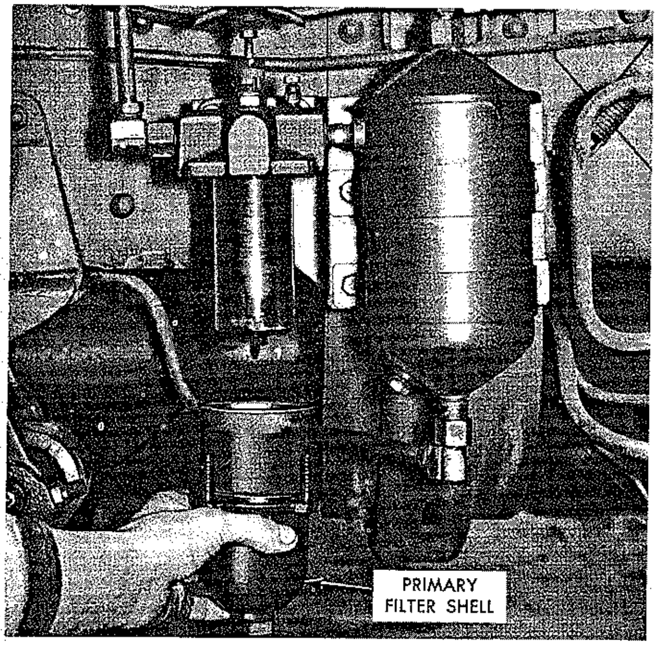


Figure 19

(5) Should any of these conditions be observed, remove the filter shell and clean the strainer element, Figure 19.

(6) If any of the three conditions were found in the draining of fuel from the primary fuel filter, proceed to inspect the secondary fuel filter for contamination.

(7) Drain the secondary fuel filter, observing the fuel for any signs of water, dirt, or black-in-color dirty fuel, Figures 20 and 21. Normally, a very small amount of dirt found in this secondary fuel filter would not plug the replaceable fuel filter element, but if any signs of water or black-in-color dirty fuels are found, then remove and replace the filter element, as both of these conditions tend to rapidly plug the element, Figures 22, 23 and 24.

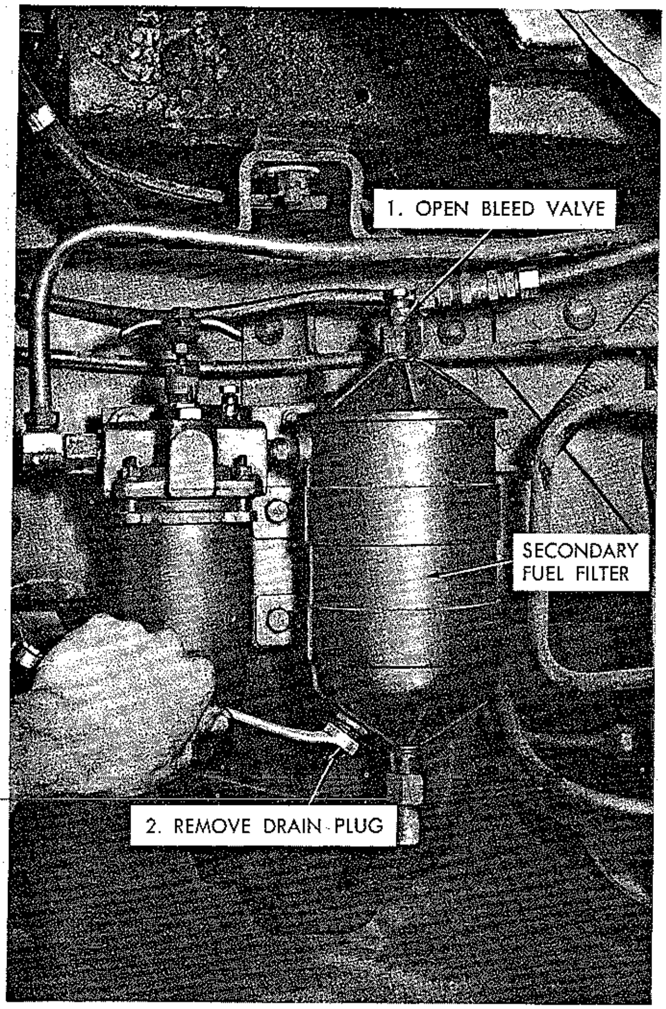


Figure 20

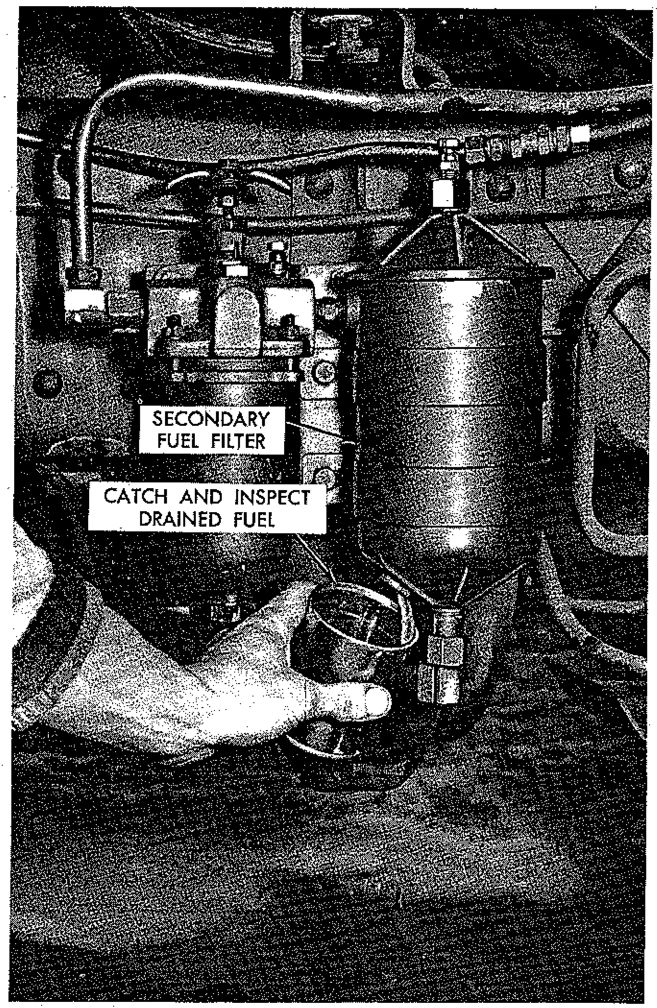


Figure 21

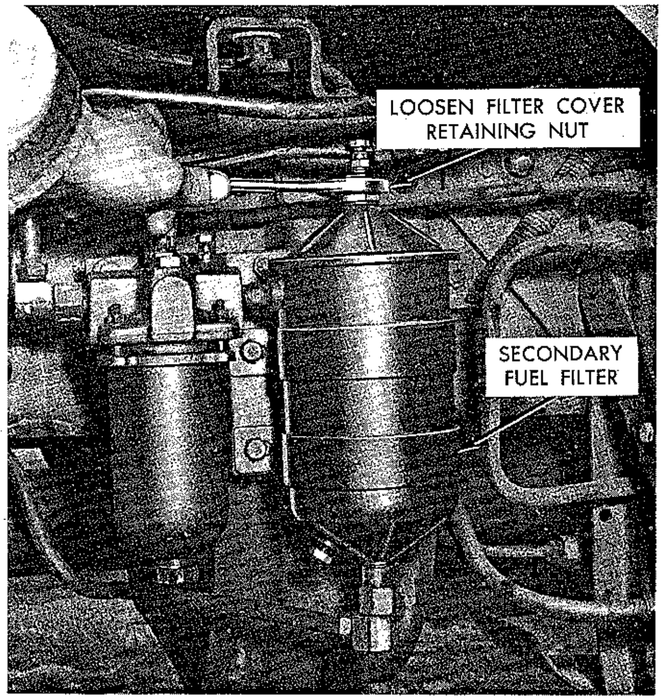


Figure 22

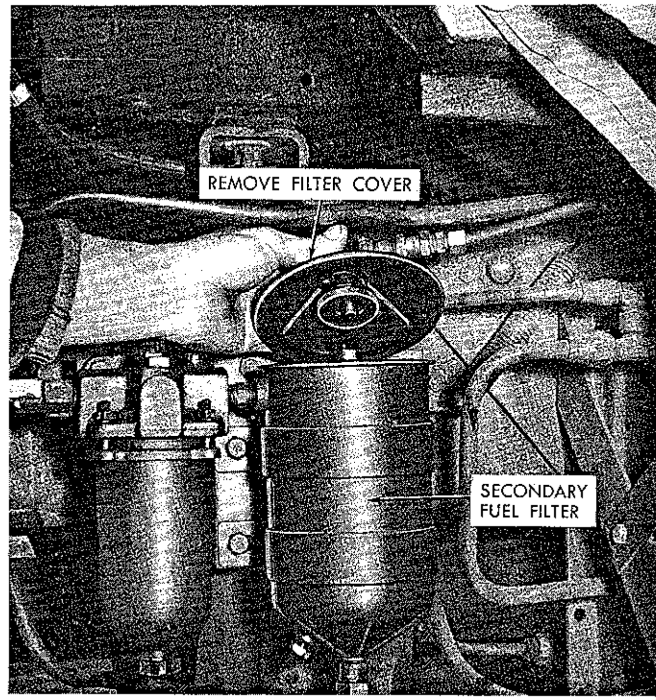


Figure 23

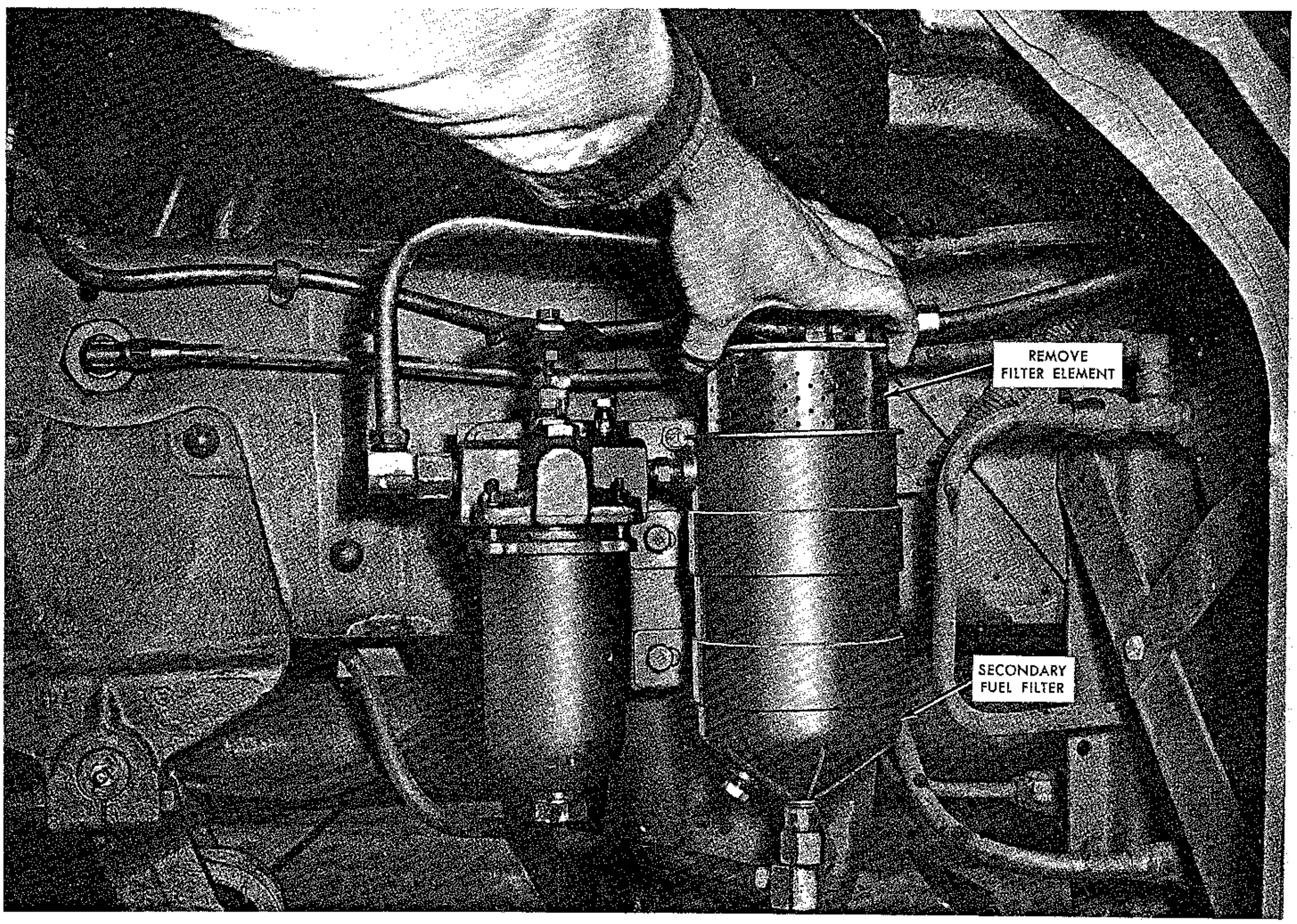


Figure 24

(8) Here again, if any water or black-in-color dirty fuel was found in the vehicle secondary fuel filter, you must also inspect the engine final fuel filter for contamination.

(9) Drain the engine final fuel filter assembly observing the drained fuel for any signs of water or black-in-color dirty fuel, Figure 25. Should either or both types of contaminated fuel be found, clean the filter housing and replace the filter element. The procedure used for replacement of this filter element is shown in Figures 26, 27 and 28.

(10) Now that all fuel filters are cleaned and new elements installed, drain the vehicle fuel tank if contaminated fuel was found, and replenish it with clean fuel.

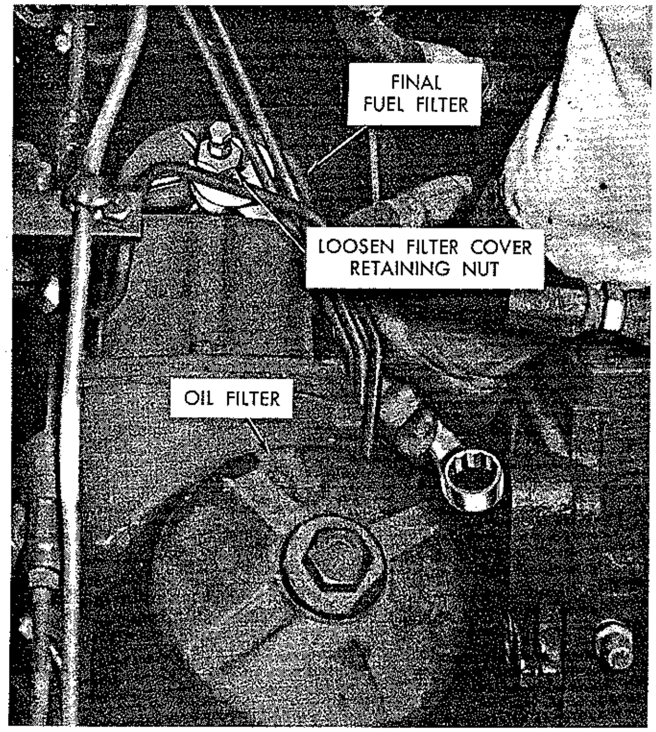


Figure 26

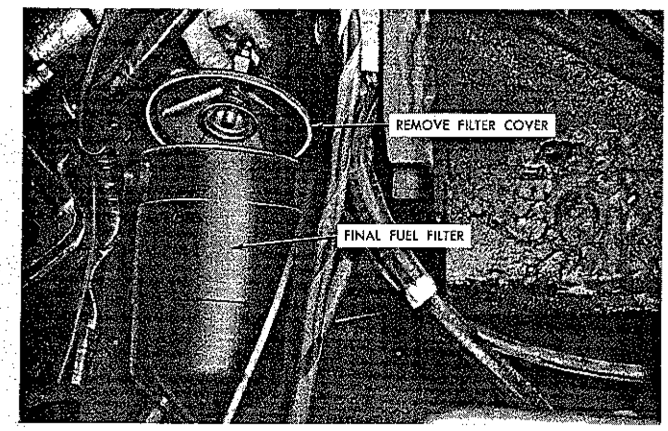


Figure 27

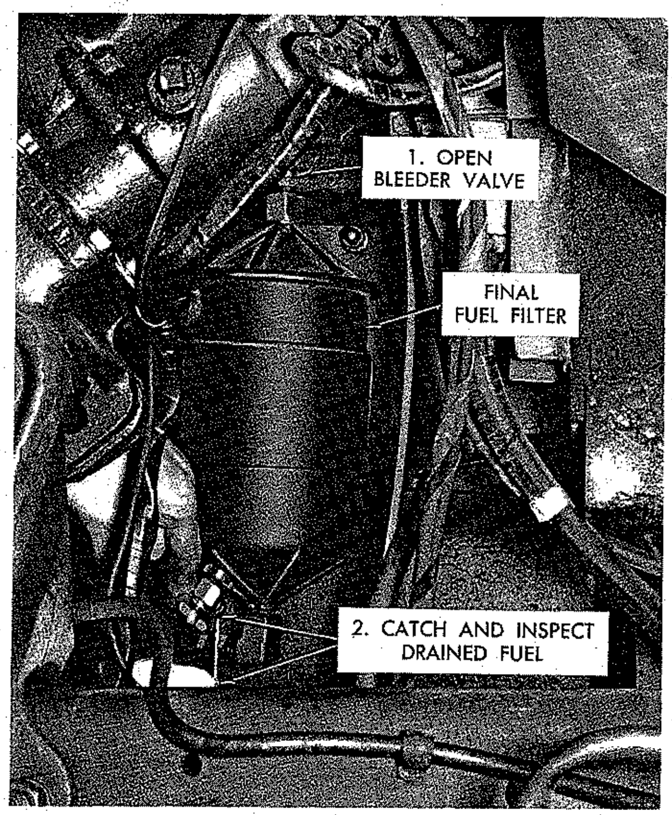


Figure 25

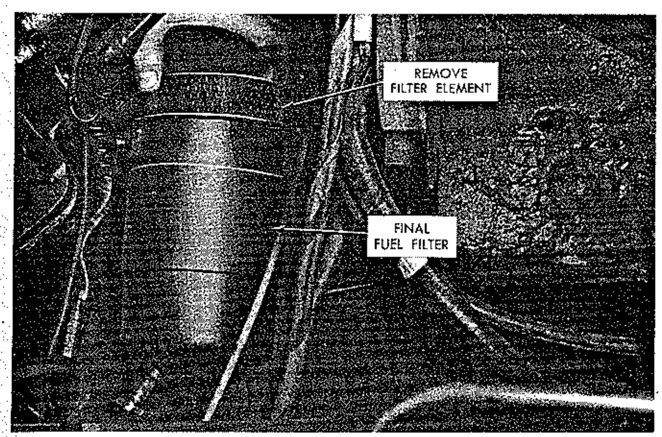


Figure 28

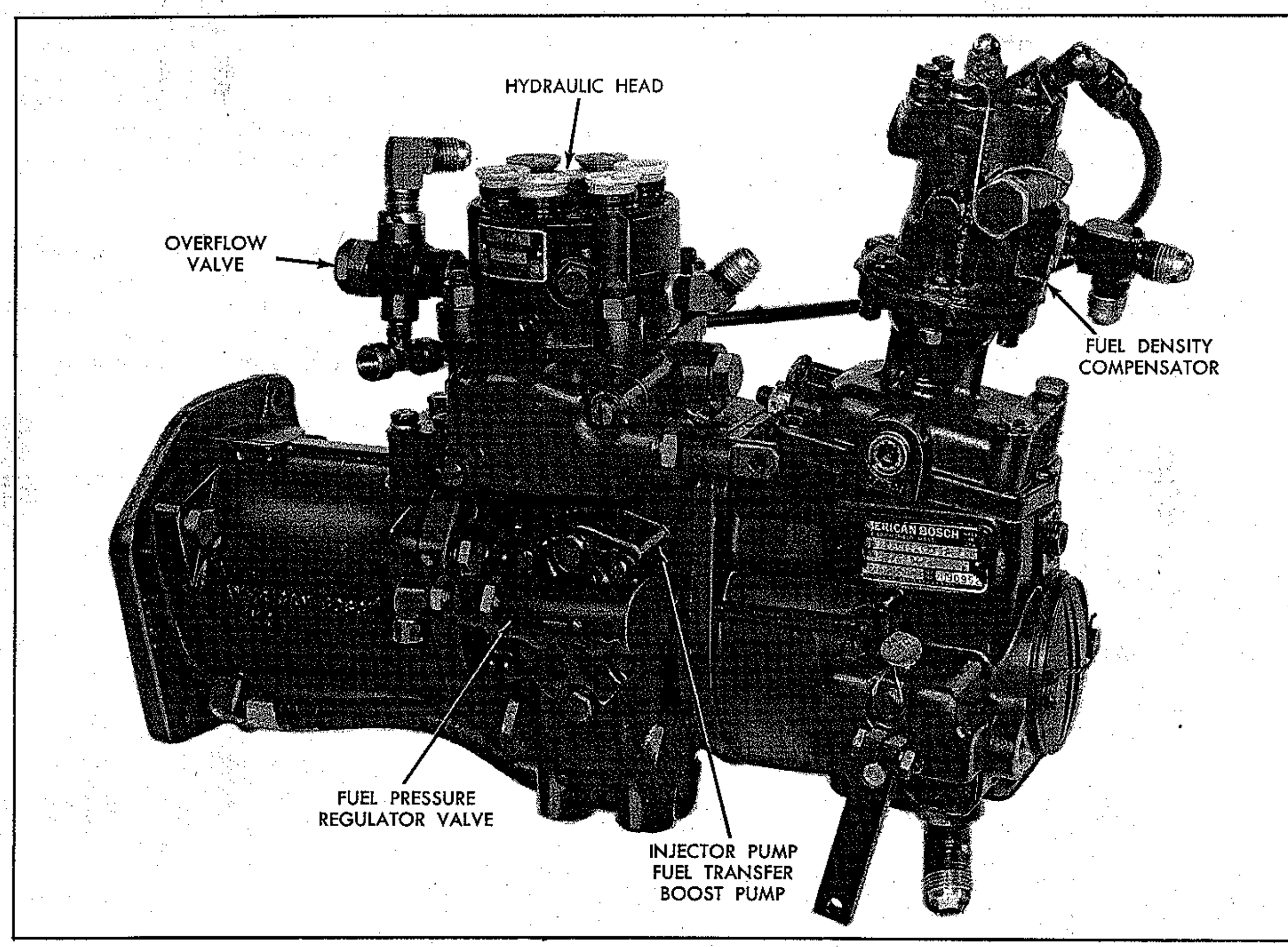

HYDRAULIC HEAD
OVERFLOW VALVE
FUEL DENSITY COMPENSATOR
FUEL PRESSURE REGULATOR VALVE
INJECTOR PUMP FUEL TRANSFER BOOST PUMP

Figure 29

Caution: Do not start up the engine with contaminated fuel, as the fuel system will again be restricted in a very short time.

(11) With all engine and vehicle fuel filters inspected and elements replaced as needed, and clean fuel in the tank, turn on the vehicle fuel in-tank pump and recheck the supply pressure. If the original low fuel pressure of 2-4 PSI still shows on the fuel pressure gage, then you can assume that the fuel tank pump is not operating properly to deliver the required 5-7 PSI fuel pressure.

Note. In most cases, after installing new fuel filters and clean fuel, you will see 5-7 PSI on pressure gage during recheck.

i. Recheck Maximum No-Load Speed - Check No. 3.

(1) After servicing the engine and vehicle fuel filters, start the engine up and recheck the engine maximum no-load speed using the same procedure as outlined for Initial Test.

(2) Example of possible readings obtained (Check No. 3):

(a) Engine maximum no-load speed .... 2200 RPM

(b) Engine maximum fuel pressure .... 55 PSI

(c) Engine low idle speed fuel pressure .... 35 PSI

j. In the above cited example (Check No. 3), the engine maximum no-load speed has been increased from 2000 RPM to 2200 RPM, but still below the required 2850 to 2900 RPM. Maximum fuel pressure has been increased from 47 PSI to 55 PSI, but it also is still below the required 65 - 75 PSI. Low engine idle speed fuel pressure has been increased from 25 PSI to 35 PSI which brings it within the required limits of 30 - 35 PSI at 700 - 750 RPM. The engine and vehicle fuel system has been serviced and has clean fuel and elements, eliminating any chance of low fuel pressure due to a restriction. The problem of low fuel pressure now lies within the fuel pressure system itself.

k. The fuel transfer pump, mounted to and driven by the fuel injection pump, contains the engine fuel pressure regulator valve assembly, Figure 29. This fuel pressure regulator valve assembly works in conjunction with the fuel pressure overflow valve assembly to develop the required engine operating fuel pressures. The fuel pressure overflow valve is located on the fuel outlet side of the fuel injection pump hydraulic head, Figure 29. The fuel pressure regulator valve starts to open at approximately 60 PSI and regulates the engine fuel pressure between 65 and 75 PSI. At any pressure above 75 PSI, the valve will open further to bypass the supply fuel back into the fuel inlet side of the transfer boost pump. Check fuel pressure regulator as follows:

(1) Remove the fuel pressure regulator valve and spring, located in the cover plate of the fuel transfer boost pump, Figure 30. Inspect the valve and spring assembly for evidence of sticking due to dirt or rust caused by water and/or contaminated fuel.

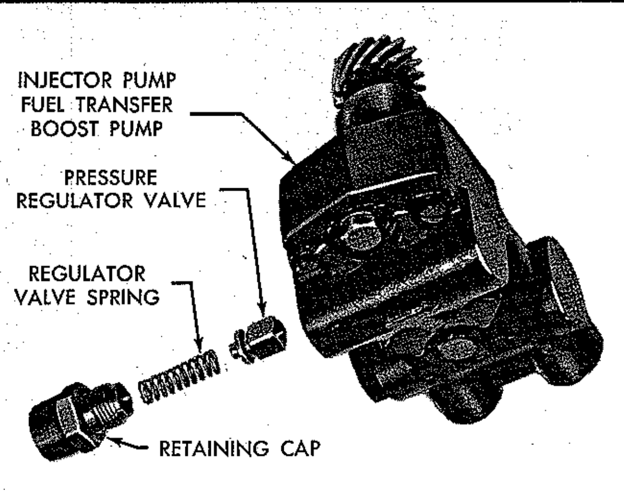


Figure 30

(2) Recondition the fuel pressure regulator valve assembly and housing to prevent sticking of the valve assembly.

(3) Replace the complete valve assembly and cover plate, if necessary, to obtain a proper operating fuel pressure. A sticking valve in the housing cover

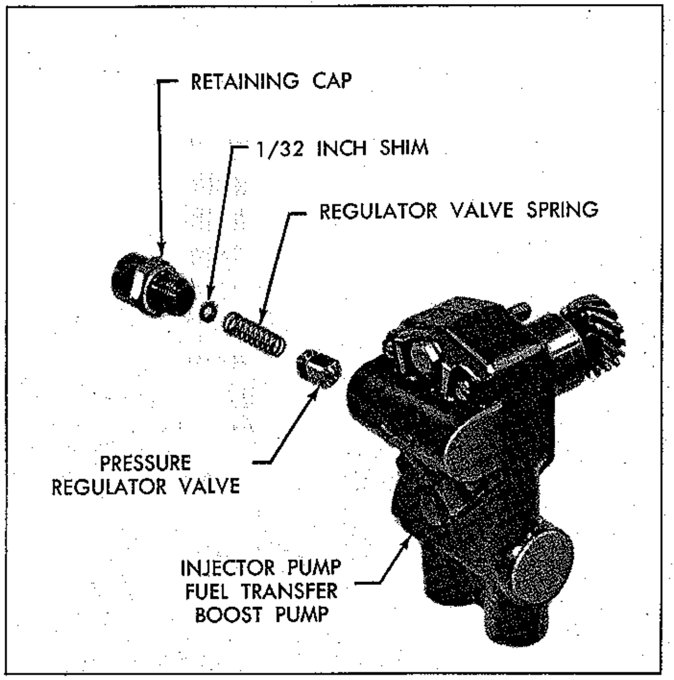


Figure 31

plate will cause low fuel pressure and low engine fuel pressure results in low engine power.

(4) Should the fuel pressure regulator valve and housing cover plate show no signs of sticking and valve operates freely, install a 1/32-inch shim behind the valve spring at the cap position, Figure 31. Shims are sometimes required to bring the engine operating fuel pressure back up to normal, due to the regulator valve spring taking a set in tension.

(5) Reassemble the valve assembly back into position in the housing cover plate.

l. Retest Maximum No-Load Speed - Check No. 4.

(1) After servicing the fuel pressure regulator, start the engine up and recheck the engine maximum no-load speed using the same procedure as outlined for Initial Test.

(2) Example of possible readings obtained (Check No. 4):

(a) Engine maximum no-load speed .... 2400 RPM

(b) Engine maximum fuel pressure .... 70 PSI

(c) Engine low idle speed fuel pressure .... 35 PSI

m. In the above cited example (Check No. 4), the engine maximum no-load speed has been increased from 2200 to 2400 RPM, but is still below the required 2850 to 2900 RPM. Engine maximum fuel pressure has been increased from 55 to 70 PSI which brings it within the required limits of 65 - 75 PSI. Engine low idle speed fuel pressure remains within limits so the fuel system is functioning properly. The next step is to check the fuel injection nozzle assemblies for proper operation.

n. Fuel Injection Nozzle Inspection and Testing.

(1) Remove the six fuel injection nozzle assemblies from the engine.

(a) When the nozzle assemblies are removed, the nozzle tips must be inspected for type, Figure 32. If it is found that a mixed set of nozzle tips or one-hole type were installed, this condition must be corrected by installing a complete set of two-hole type.

(b) Installation of the two-hole orifice type is covered by MWO 9-2815-210-30/2. Federal Stock Number and Ordnance part numbers for the two-hole orifice type are as follows:

1. Nozzle and Holder Assembly:

a. FSN No. 2910-861-1408

b. Ordnance P/N 7748863

2. Nozzle Tip

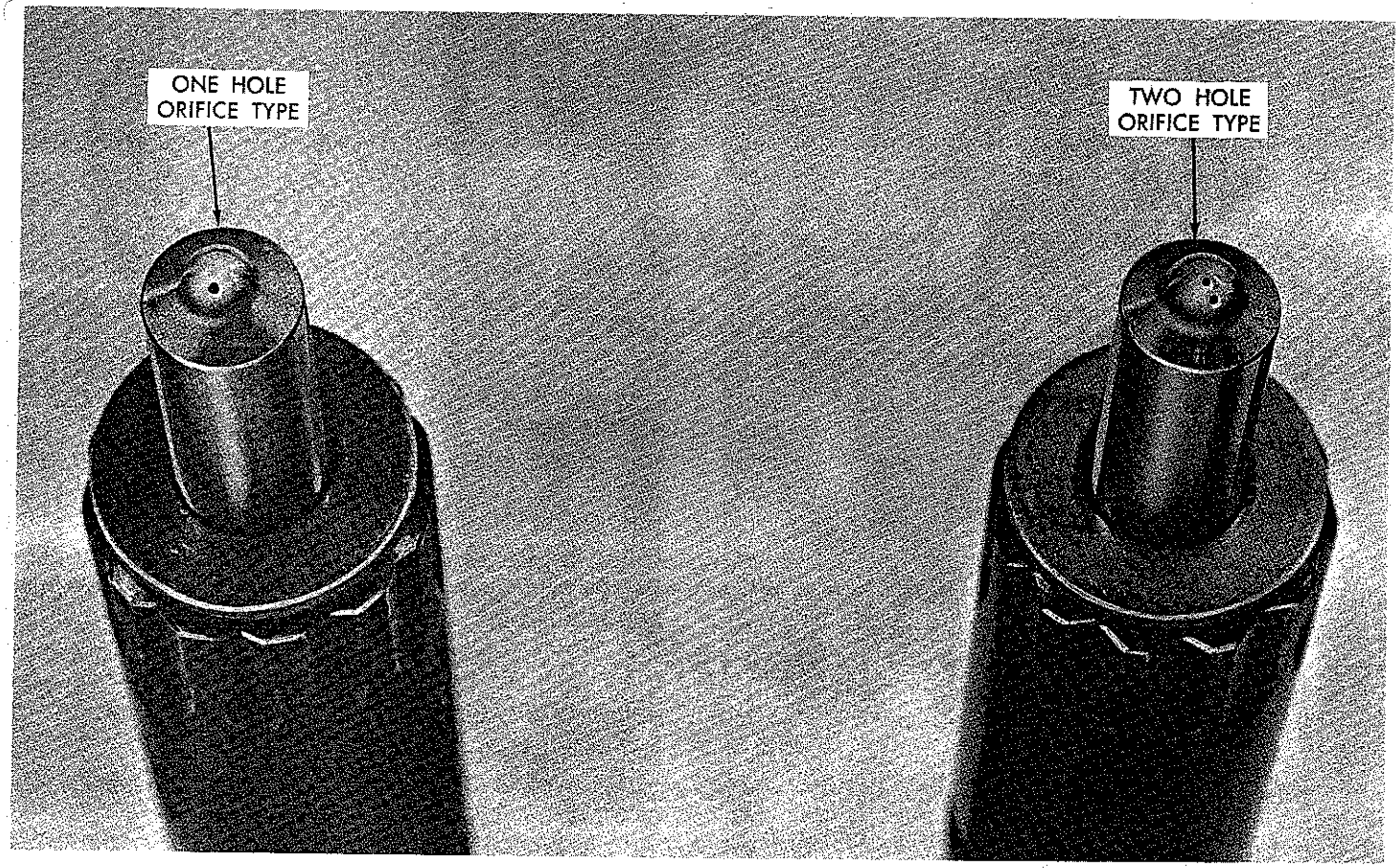


Figure 32

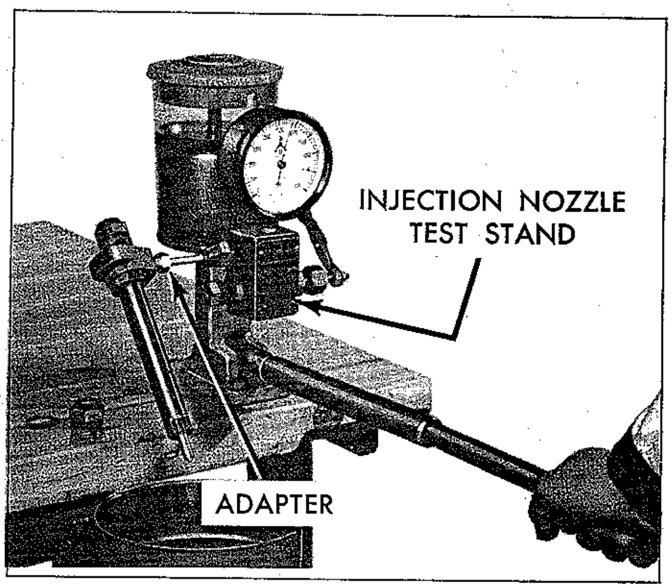


Figure 33

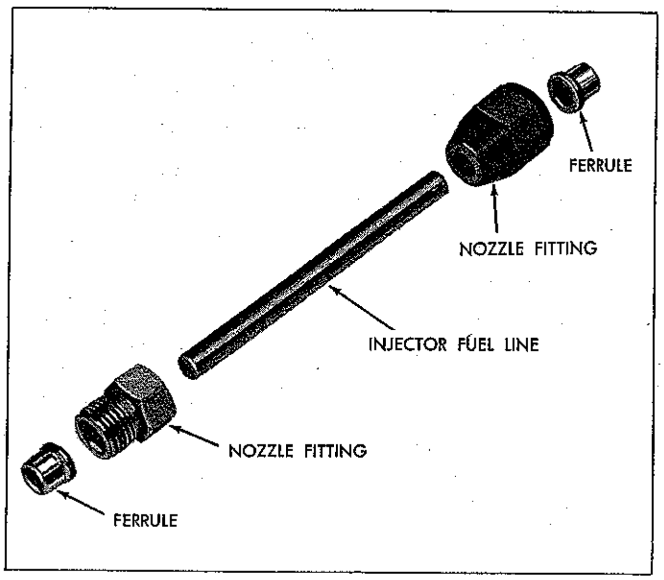


Figure 34

a. FSN No. 2910-860-2336

b. Ordnance P/N 774882.

(2) Connect Injector Nozzle to Fuel Injector Nozzle Hand Test Stand, FSN No. 4910-255-8641, Figure 33. If a connecting adapter fitting is not available, one can be fabricated, Figure 34, to fit nozzles from the LDS-465-1, LDS-465-1A, LD-465-1 or LDS-427-2 engines using the following items:

(a) A spare or broken fuel injection line from a LDS-465-1, LDS-465-1A, LD-465-1 or LDS-427 engine.

(b) A nozzle connection fitting and unused ferrule fitting from an LDS-465-1, LDS-465-1A, LD-465-1 or LDS-427 engine.

(c) A fuel injection line nozzle connection fitting and ferrule from a spare fuel injection line that is used on the AVDS-1790-2 engine used in the M60 Tank.

Warning: The penetrating power of atomized fuel oil under hand test stand pressure is sufficient to puncture the skin and may cause blood poisoning. Therefore, KEEP HANDS AWAY FROM A SPRAYING NOZZLE.

(3) Fill nozzle tester container with clean fuel. There are a number of different types of fuels that may be used, but because of the location of your Maintenance Unit the most accessible type would be Diesel fuel.

(4) Close the pressure gage valve and actuate the pump handle 20 - 25 times to remove all air from the nozzle and holder assembly.

(5) Open pressure gage valve and actuate pump handle slowly to build up pressure. As the correct opening pressure of 2800 - 2850 PSI is approached, observe the spray orifice hole or holes of the nozzle tip. If drops of fuel can be observed to form on the nozzle tip at 100 PSI below opening pressure or if fuel seems to just flow from the tip in a solid stream, the nozzle is leaking and must be disassembled and cleaned in clean Diesel fuel. After disassembly and cleaning, recheck nozzle. Should the same condition appear, replace the nozzle tip or complete nozzle and holder assembly.

(6) If the nozzle passes the leakage test and opens within the required limits of 2800 - 2850 PSI, the spray pattern should be checked as follows:

(a) Actuate pump handle at a rate of approximately 15 strokes per minute.

(b) Nozzle chatter must be distinct and regular. A sharp pitch sound is desirable, but an occasional skip or variation in the chatter pitch is acceptable.

(c) Spray formation should be sharp with a rather solid pattern and the angles formed by the spray or sprays uniform.

(d) Usually the spray or sprays will be satisfactory if the valve seat is tight, the valve is free and all spray orifices are clean. If the spray pattern is not satisfactory, the nozzle must be disassembled, cleaned and spray pattern rechecked. If the spray pattern does not improve after cleaning, the tips must be replaced.

(7) If nozzle opening pressure does not fall within the limits of 2800 - 2850, it must be either adjusted, rebuilt or replaced.

(8) When rebuilding a nozzle holder assembly and using a new nozzle spring, set valve opening pressure to 3000 - 3050 PSI because the new spring will take a working set when the nozzle is operating in the engine.

(9) Nozzle Opening Pressure Adjustment

Note. There are presently two types of nozzle holder assemblies in the Army supply system for the LDS-465-1 engine. The only difference between these nozzle holder assemblies lies in the manner for adjusting nozzle valve opening pressure.

(a) The first type nozzle holder assembly, Figure 35, contains a screw adjustment for increasing or decreasing the nozzle valve opening pressure. By removing the cap from the upper section of the holder assembly and loosening the adjustment screw locknut, you can increase the valve opening pressure by turning the adjustment screw clockwise. By turning the adjustment screw counterclockwise, you decrease the valve opening pressure.

(b) On the second type, Figure 36, to increase or decrease nozzle opening pressure, you add or remove shims to the cap assembly behind the spring. Whenever you have to scrap one of these nozzle holder assemblies, remove the shims and save them for future use.

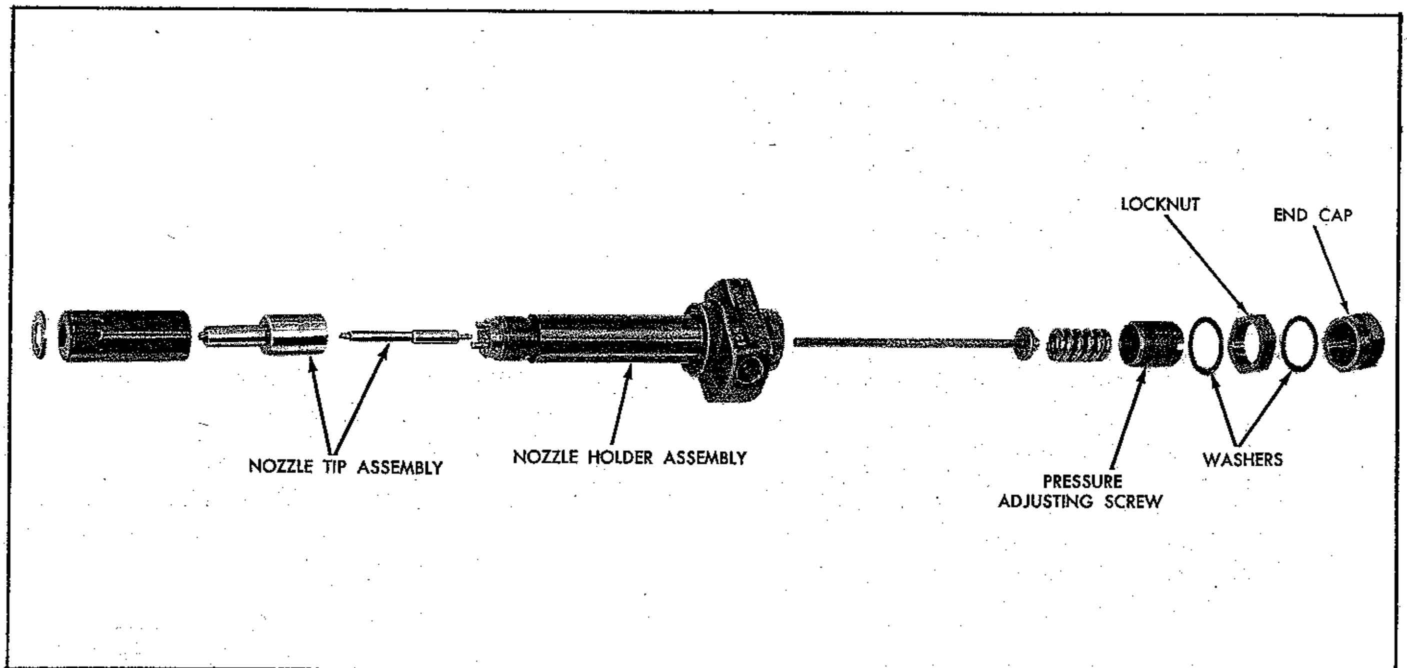


Figure 35

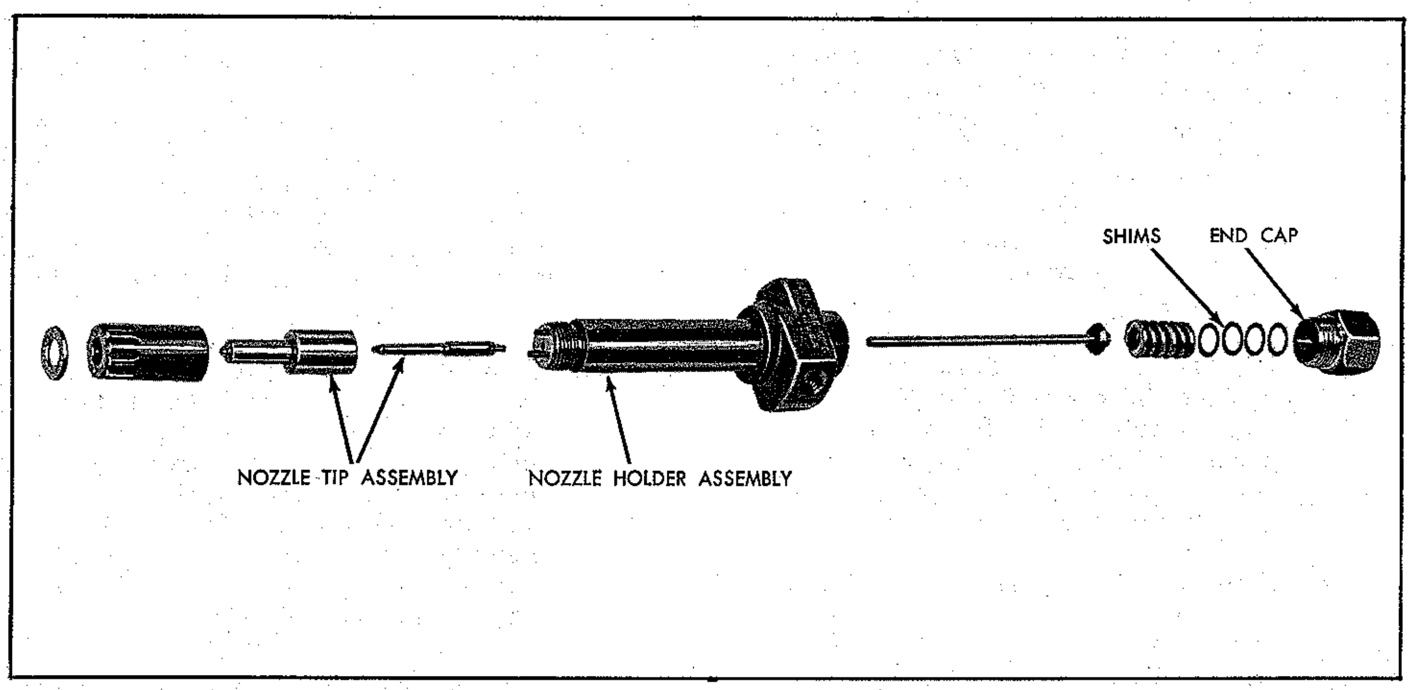


Figure 36

NOZZLE SERVICE ADJUSTMENTS

Irregularity	Cause	Remedy
1. Nozzle opening pressure	a. Pressure adjusting screw or nozzle shims incorrectly set. b. Nozzle valve seized in nozzle body. c. Nozzle valve stuck in nozzle body due to lacquer formation. d. Spray holes clogged.	a. Adjust pressure adjusting screw or shim correctly and secure setting with lock nut. b. Replace nozzle tip assembly. c. Replace nozzle tip assembly. d. Replace nozzle tip assembly.
2. Nozzle opening pressure too low	a. Pressure adjusting screw or shims incorrectly set. b. Pressure adjusting screw or nozzle broken or damaged. c. Valve stuck in nozzle body due to lacquer formation.	a. Adjust pressure adjusting screw or add additional shims and secure setting with lock nut. b. Replace pressure adjusting screw. c. Replace nozzle tip assembly.
3. Dripping of nozzle	Nozzle valve leaking due to damaged seat or stuck valve due to lacquer formation.	Replace nozzle tip assembly.
4. Fuel spray distorted	Nozzle tip partially plugged or nozzle valve damaged.	Replace nozzle tip assembly.
5. Nozzle fails to chatter	a. Nozzle valve stuck or seized. Valve seat leaking. b. Nozzle holder cap nut damaged internally through frequent changing of the nozzle, causing nozzle to cock.	a. Replace nozzle tip assembly. b. Replace nozzle holder cap nut.
6. Excessive overflow from leak-off connection of nozzle holder.	a. Too much play in nozzle valve. b. Cap nut insufficiently tightened. c. Dust, grit or scale from tubing between the lapped surfaces of nozzle body and nozzle holder shank.	a. Replace nozzle tip assembly. b. Tighten cap nut. c. Remove nozzle tip assembly and thoroughly clean the lapped surfaces with testing fluid and compressed air.
7. Nozzle valve turns blue after service in engine.	Nozzle tip is being overheated.	Replace nozzle tip assembly. Engine is probably being overfueled - Correct injection pump calibration.

o. Recheck Maximum No-Load Speed - Check No. 5.

(1) After the fuel injection nozzles have been serviced and you are sure that a complete set of two-hole orifice type have been installed, start up engine and recheck maximum no-load speed as outlined for Initial Test.

(2) Example of possible readings obtained (Check No. 5):

(a) Engine maximum no-load speed .... 2600 RPM

(b) Engine maximum fuel pressure .... 70 PSI

(c) Engine low idle speed fuel pressure .... 35 PSI

p. In the above cited example (Check No. 5) the engine maximum no-load speed has been increased from 2400 to 2600 RPM, but is still below the required 2850 - 2900 RPM. Fuel pressures remain within limits so the fuel system is still functioning properly. The next step is to check the engine and vehicle throttle linkage.

q. Engine and Vehicle Throttle Linkage Operation.

(1) In order for the engine injection pump governor to give the engine the required amount of fuel during vehicle and engine operation, the throttle linkage must move through its correct travel limits, Figure 37-A.

(2) When the vehicle driver steps down on the foot accelerator pedal, moving it to full throttle position against throttle stop on vehicle cab floorboard, the engine injection pump governor throttle shaft arm must move to the full throttle position, placing the throttle shaft speed stop plate against the high speed adjustment screw.

(3) In order to check the throttle linkage travel, a mechanic must get under the engine, installed in vehicle, and place a short narrow strip of paper between the engine governor throttle speed stop plate, and the high speed adjustment screw, as shown in Figure 37-B.

(4) At this time, with the paper strip in position, another mechanic slowly depresses the vehicle cab accelerator pedal, until it is in the maximum full throttle position.

(5) With the throttle linkage at full throttle position, the governor throttle speed stop plate should be contacting the high speed adjustment screw, holding the paper strip in position, Figure 37-C, so that the mechanic cannot pull the paper strip out. If the mechanic can pull the paper strip out from between the governor throttle speed stop plate and high speed adjustment screw, then the accelerator rod, shown in Figure 37-A, must be shortened in length in order to increase the governor throttle speed plate travel. Adjustment is as follows:

(a) Disconnect throttle accelerator rod return spring, so you can move the governor operating lever shaft freely.

(b) Disconnect the accelerator rod from the governor operating lever shaft.

(c) To shorten the accelerator rod, loosen the lock nut of the accelerator rod to ball joint at the bell crank connection.

(d) Screw the accelerator rod into the ball joint connection until the retaining pin hole of the detent spring assembly of the accelerator rod, just goes past the mating pin hole in the governor operating lever shaft with the arm held in full throttle position, see Figure 38.

(6) When the accelerator rod has been adjusted correctly and reconnected, recheck to be sure the governor throttle speed stop plate contacts the high speed adjustment screw, retaining the paper strip when pulled. DO NOT, "REPEAT", DO NOT remove the governor operating lever shaft from the shaft and reposition shaft lever to the shaft to obtain the correct travel of the operating lever shaft speed stop

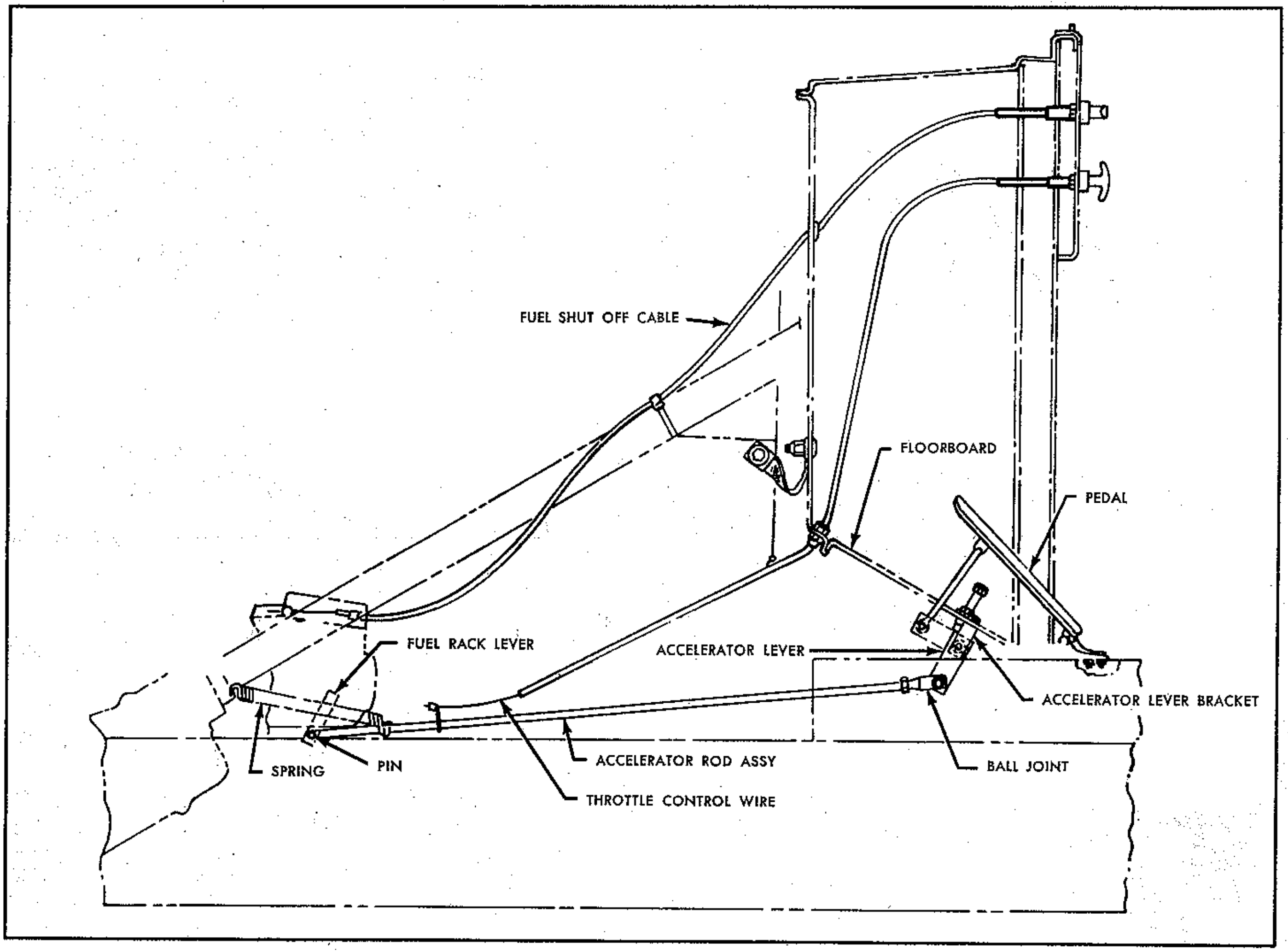


Figure 37-A

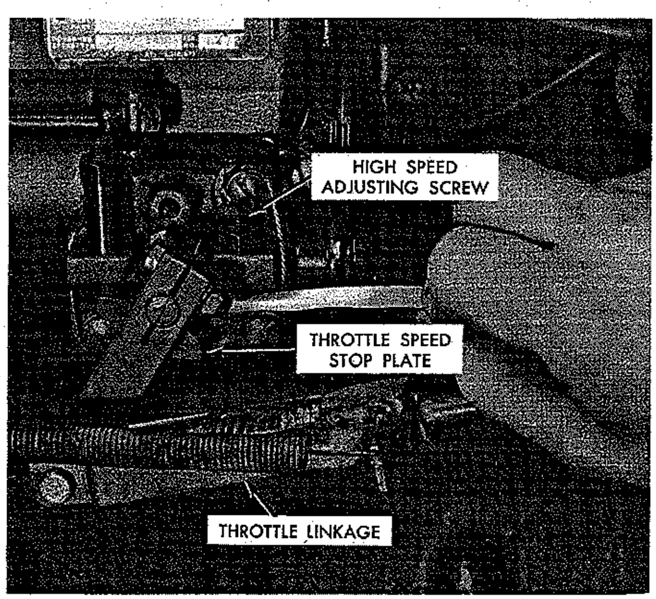


Figure 37-B

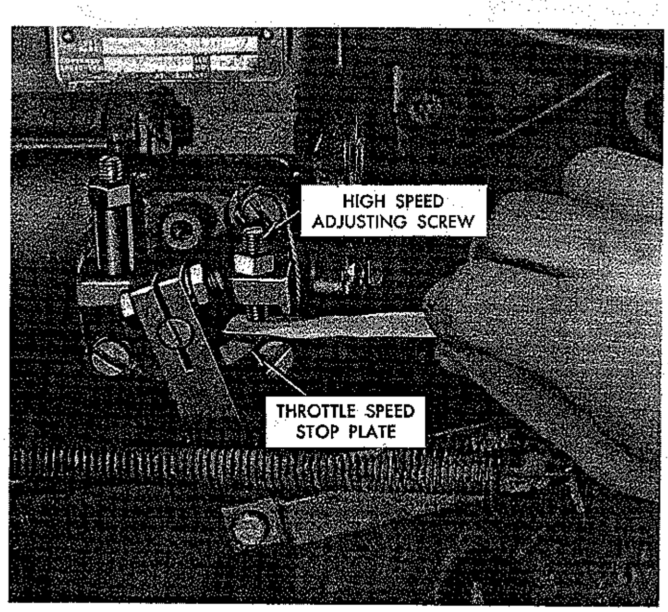


Figure 37-C

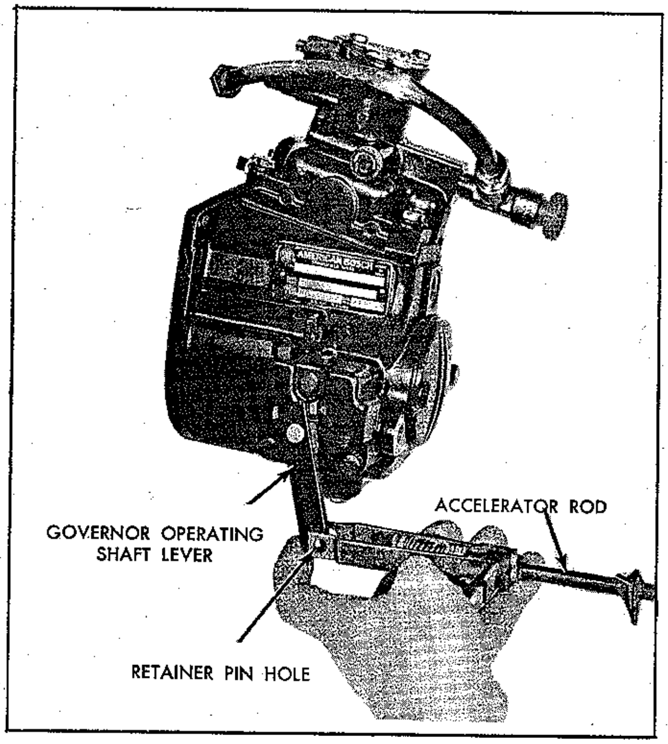


Figure 38

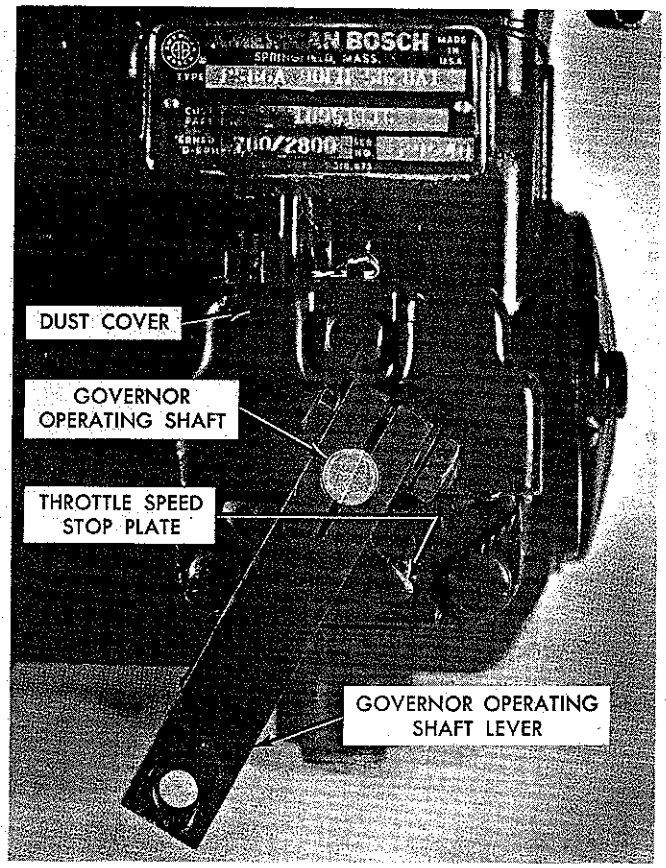


Figure 39

plate. The governor speed operating lever shaft is installed in the correct position when the injection pump is calibrated, as shown in Figure 39. Any repositioning of this operating lever shaft will not allow the injection pump the ability to deliver the required calibrated amount of fuel to the engine through the engine speed range.

r. Recheck Engine Maximum No-Load Speed - Check No. 6.

(1) After adjusting the engine and vehicle throttle linkage, start up the engine and recheck maximum no-load speed as outlined for Initial Test.

(2) Example of possible readings obtained (Check No. 6):

(a) Engine maximum no-load speed .... 2800 RPM

(b) Engine maximum fuel pressure .... 70 PSI

(c) Engine low idle speed fuel pressure .... 35 PSI

s. In the above cited example (Check No. 6) the engine maximum no-load speed has been increased from 2600 to 2800 RPM, but is still below the required 2850 - 2900 RPM. Fuel pressures remain within the required limits so the fuel system is still functioning properly. The next step is to check the fuel injection pump governor high speed screw adjustment.

t. Fuel Injection Pump Governor High Speed Screw Adjustment.

(1) Remove the dust cover from the governor operating shaft stop plate assembly, Figure 39. This will provide access to the high speed screw for adjustment.

Note. A 7/16-inch open end wrench and screw driver are needed to make an adjustment of the high speed screw, Figure 40.

(2) Loosen the high speed screw lock nut holding the high speed screw in position. DO NOT allow the high speed screw to turn when loosening lock nut.

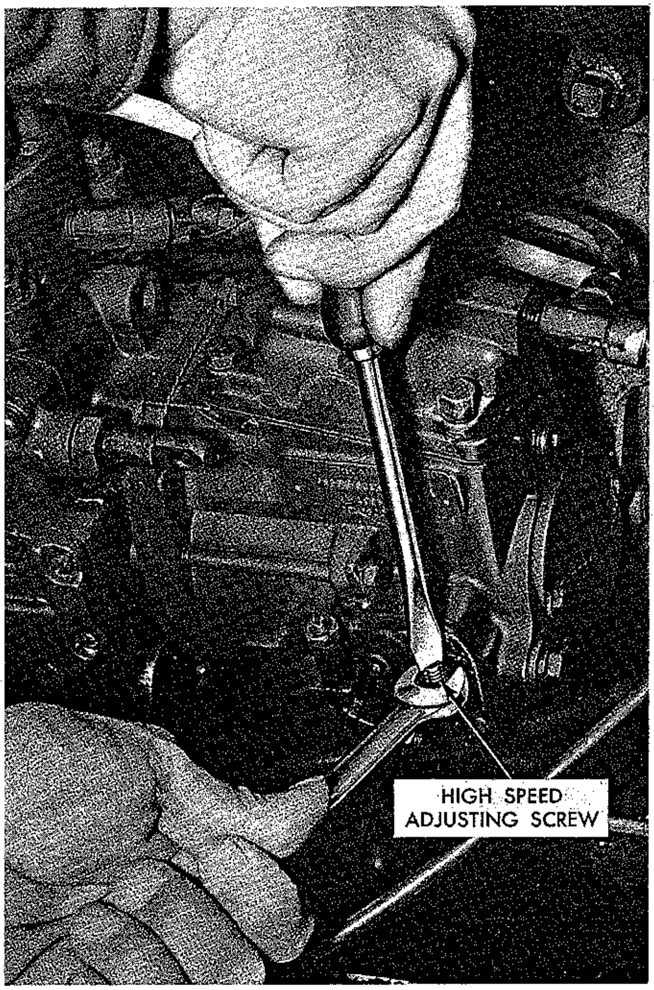


Figure 40

(3) In this case you want to slightly increase the engine maximum no-load speed from 2800 RPM to 2850 - 2900 RPM. To increase the engine maximum no-load speed, turn the high speed screw counterclockwise.

(4) Start by making a one-half (1/2) turn counterclockwise.

(5) Recheck the engine maximum no-load speed and see how much the one-half (1/2) turn has increased the engine speed. The next adjustment may not require a full half turn to bring the engine speed up to 2850 - 2900 RPM.

(6) Each time the high speed screw is turned counterclockwise to increase the engine speed, before starting the engine up, check to see if the throttle speed stop plate is still contacting the high speed screw in the full throttle position. If it is not, re-adjust the throttle linkage so that it does.

u. Final Test - Check No. 7.

(1) You have completed the engine maximum no-load speed test. You should obtain the following engine speeds and fuel pressures:

(a) Engine maximum no-load speed . . . . 2850 - 2900 RPM

(b) Engine maximum fuel pressure . . . . 65 - 75 PSI

(c) Engine low idle speed fuel pressure . . . . 30 - 35 PSI

(2) With these engine speeds and fuel pressures, the vehicle is ready for a full load performance test.

7. ENGINE FULL-LOAD PERFORMANCE TEST

a. Never conduct a full-load performance test before an engine maximum no-load test has been conducted. To do so will only result in false and misleading full-load test readings.

b. When an engine operates correctly under no-load conditions it does not always mean that the engine will develop maximum torque and horsepower under full-load conditions. If this turns out to be the case, then additional adjustments or replacement of engine accessories will be required.

c. For an engine to operate properly under full-load conditions, engine manifold pressure must be within certain limits for a given RPM, nozzle tip and fuel. Manifold pressure varies with the amount of fuel delivered to and consumed by the engine, the more fuel the higher the manifold pressure, the less fuel the lower the manifold pressure. For the engine to operate at its best throughout all speeds and loads the manifold pressure must be checked and fuel delivery set at two different RPM's. Looking at Figure 41, you will notice that these checks and settings are made at 2400 RPM (Maximum Fuel) and 1600 RPM (Droop Screw Setting). Maximum fuel setting is always checked and set first, then the droop screw setting.

d. Since manifold pressure will vary de-

FIELD PERFORMANCE SETTINGS FOR LDS-465-1 ENGINE WITH 2-HOLE NOZZLES			
	MAXIMUM FUEL SETTING		
TYPE FUEL	MANIFOLD PRESSURE	ENGINE SPEED	ENGINE LOAD
Gasoline	21-23" Hg Gage Pressure	2400 RPM	Full Load
Diesel	18-20" Hg Gage Pressure	2400 RPM	Full Load
	DROOP SCREW SETTING		
TYPE FUEL	MANIFOLD PRESSURE	ENGINE SPEED	ENGINE LOAD
Gasoline	8-10" Hg Gage Pressure	1600 RPM	Full Load
Diesel	8-10" Hg Gage Pressure	1600 RPM	Full Load

Figure 41

pending on the type of nozzle tips (Figure 32) that are installed and the type of fuel being used, these two factors must be determined before a full-load performance test can be conducted. If the nozzle assemblies had to be removed during the maximum no-load test, you already know what type of nozzle tips are installed; if not, nozzle assemblies must be removed and the TWO-HOLE type nozzle tips installed. The only type of fuel to be used is either Diesel fuel or Automotive Combat gasoline, be sure of this and record the type being used.

e. Placing the engine under full-load conditions with the vehicle moving is accomplished by applying the vehicle brakes, therefore, you must be sure that the vehicle brake system is in good operating condition. The use of vehicle brakes during the engine performance test is only for a short period of time, and does not have an adverse effect on the vehicle braking system.

f. Two men are needed to conduct an engine full-load performance test, one man to operate the vehicle and the second to observe and record manifold pressure readings.

g. Install Engine Manifold Pressure Gage.

(1) Remove the 1/8 NPT plug from the engine intake manifold elbow, Figure 60.

(2) Install a 1/8 NPT to 1/4-inch hose flair 90° elbow fitting, Figure 61.

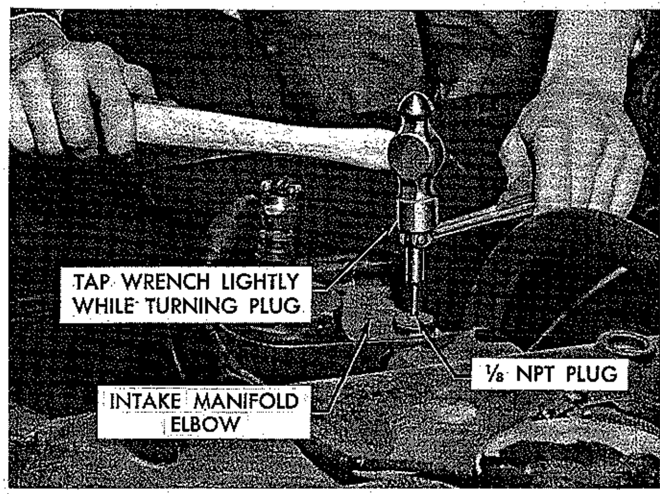


Figure 42

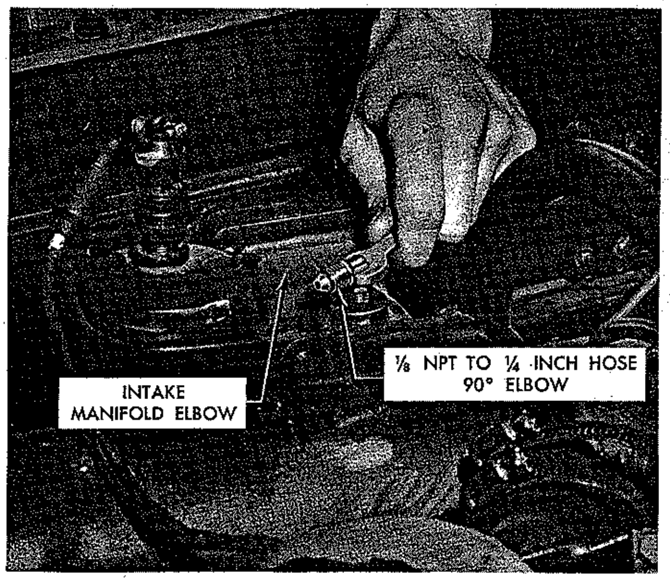


Figure 43

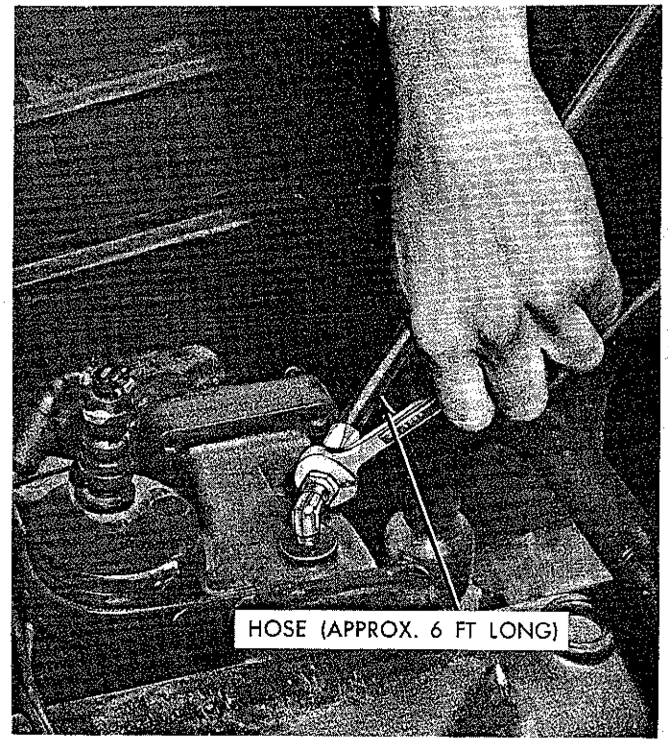
(3) Connect a pressure hose, to the 90° elbow, of sufficient length to permit observance of pressure gage from vehicle cab (approximately 6 feet), Figure 44.

(4) Connect a manifold pressure gage, having a range of 0 - 50 In. Hg (Mercury) gage pressure, to the pressure hose.

h. Vehicle Driver and Observer Instructions:

(1) Vehicle Driver:

(a) With the engine started and running at idle speed, place the transmission



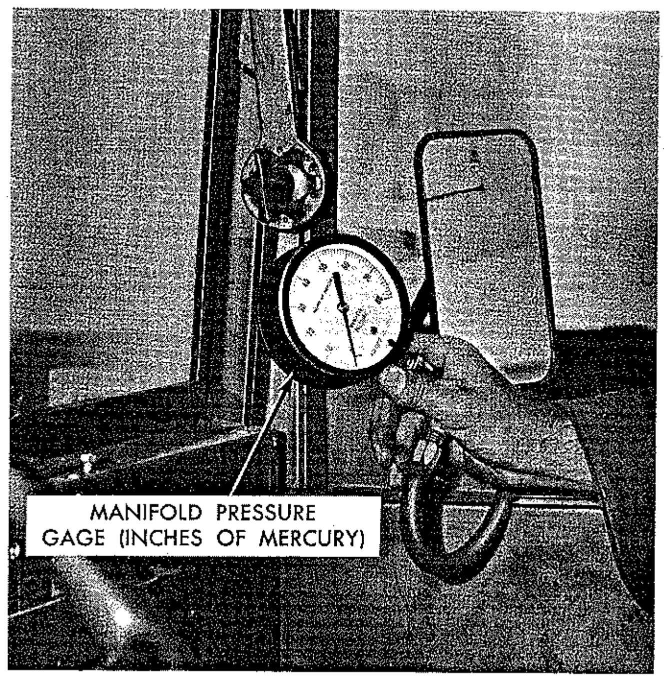


Figure 44

in first gear high range. The complete engine test will be made with the vehicle moving and the transmission in first gear high range.

(b) Move the vehicle out in first gear. With the vehicle moving, push the foot accelerator pedal to the maximum full throttle position, Figure 45.

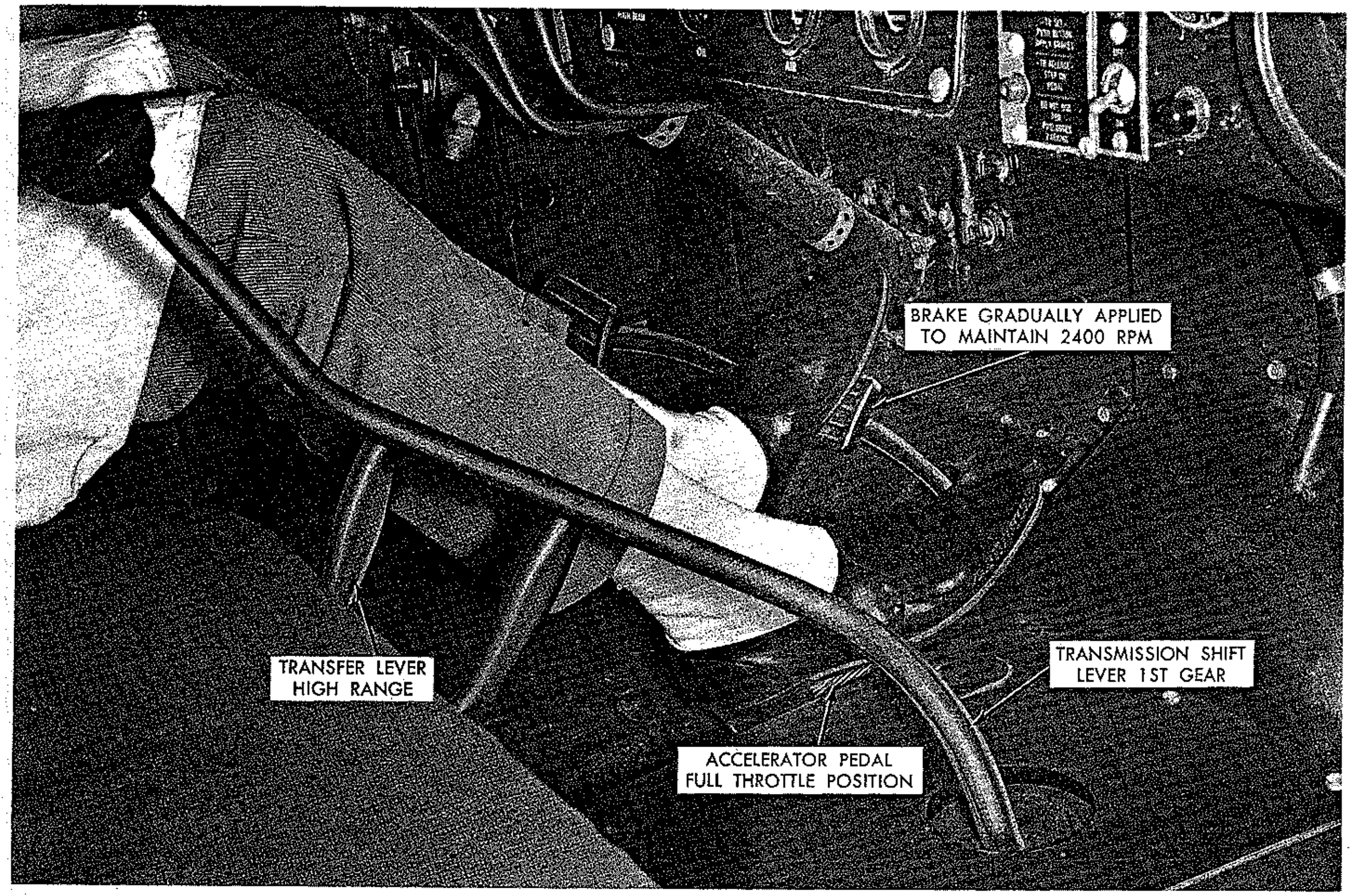


Figure 45

(c) When the engine speed reaches 2600 RPM, place your left foot on the vehicle foot brake pedal, Figure 63, and gradually apply the brakes until the engine speed drops to 2400 RPM, Figure 46. Hold the engine speed at a constant 2400 RPM with the vehicle brakes and with the accelerator pedal at full throttle.

(d) Upon reaching this constant 2400 RPM full load engine speed, and the speed is stable, call out to the observer to record the manifold pressure.

(e) Conduct as many runs as necessary to assure correct pressure readings at 2400 RPM full load conditions. Each time upon reaching a stabilized 2400 RPM full load speed, the driver should call out to the observer to record the gage pressure observed.

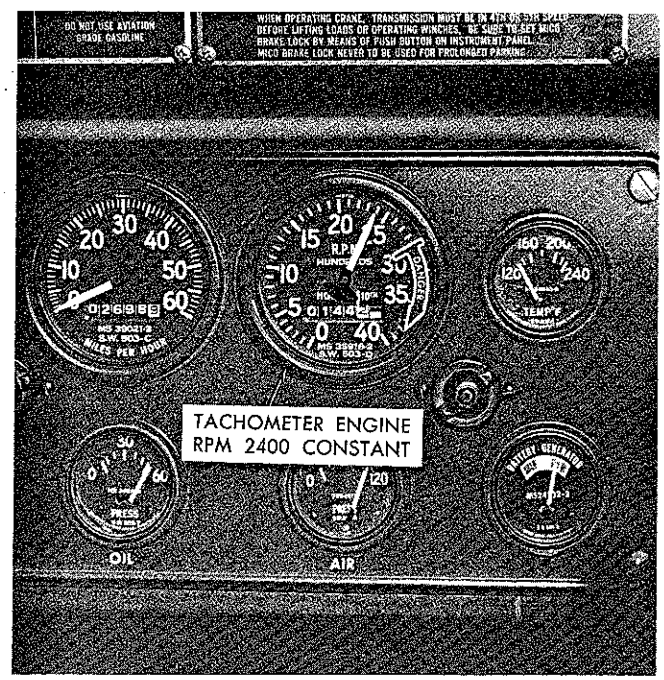


Figure 46

(f) When conducting the full load engine performance test, should the engine speed continue to decrease after reaching 2400 RPM, without applying additional pressure on the vehicle brakes, the condition may be caused by the vehicle brake system grabbing, thus causing an additional load to be applied to the engine.

(g) If this condition should occur, release the brake pedal and allow the engine speed to increase to about 2600 RPM. Gradually reapply pressure on the brake pedal to slowly increase the load until the engine speed drops to 2400 RPM.

(h) If the engine speed continues to decrease without applying additional brake pressure, and you are sure that the vehicle brake system is not at fault, then the cause for the continued loss of engine speed lies within the engine fuel injection pump governor. Governor operation has become faulty or incorrect adjustments have been made to the governor settings. In either case, the injection pump should be replaced.

(2) Vehicle Observer.

(a) After the vehicle driver puts the vehicle into motion, and the engine is under full load condition at 2400 RPM engine speed, he will call out to record manifold pressure.

EXAMPLE

ENGINE FULL LOAD PERFORMANCE

TEST IN VEHICLE

READING NO.	MANIFOLD PRESSURE AT 2400 RPM	MANIFOLD PRESSURE AT 1600 RPM
1	14.5 inch Hg. Gage	12.0 inch Hg. Gage
2	15.5 inch Hg. Gage	11.5 inch Hg. Gage
3	15.0 inch Hg. Gage	12.0 inch Hg. Gage
4	15.5 inch Hg. Gage	12.5 inch Hg. Gage
5	14.5 inch Hg. Gage	12.0 inch Hg. Gage
	AVERAGE MANIFOLD PRESSURE = 15.0 inch Hg. Gage	AVERAGE MANIFOLD PRESSURE = 12.0 inch Hg. Gage

Type Fuel Used: Diesel

Type Nozzle Tip: Two (2) Hole

Driver: ____________________

Observer: ____________________

Figure 47

(b) During this time, you observe the manifold pressure gage. When the vehicle driver calls out to "RECORD", note the maximum manifold pressure on the gage and record the information on a previously prepared engine performance data sheet, Figure 47. The driver should repeat this test enough times to insure correct readings. Each time he calls out "RECORD", you will observe the manifold pressure on the gage and then record the observed manifold pressure.

i. Engine Full Load Performance Test Readings 2400 RPM.

(1) Suppose that you have just conducted a full load engine performance test at 2400 RPM. The LDS-465-1 engine contained two-hole orifice nozzle tips and the test was conducted on Diesel fuel. The average manifold gage pressure from five test runs at 2400 RPM is 15 inches Hg.

(2) The average 15 inches Hg manifold pressure is lower than the 19 inches Hg manifold pressure obtained on an engine giving excellent performance under the same conditions. (See Figure 41 for Field Performance Settings for LDS-465-1 engine.)

(3) As a result of this low manifold pressure reading the following inspections must be made FIRST, before any adjustments are made to the fuel injection pump to increase the engine manifold pressure:

(a) Visual inspection of the injection pump governor fuel density compensator for proper functional operation.

(b) Fuel injection pump timing to the engine.

(c) Engine turbocharger assembly.

j. Fuel Density Compensator Inspection.

(1) Remove the four mounting cap screws.

(2) Lift the density compensator up enough so that it can be rotated and suspended at an angle of about 45 degrees above the injection pump governor housing, Figure 66.

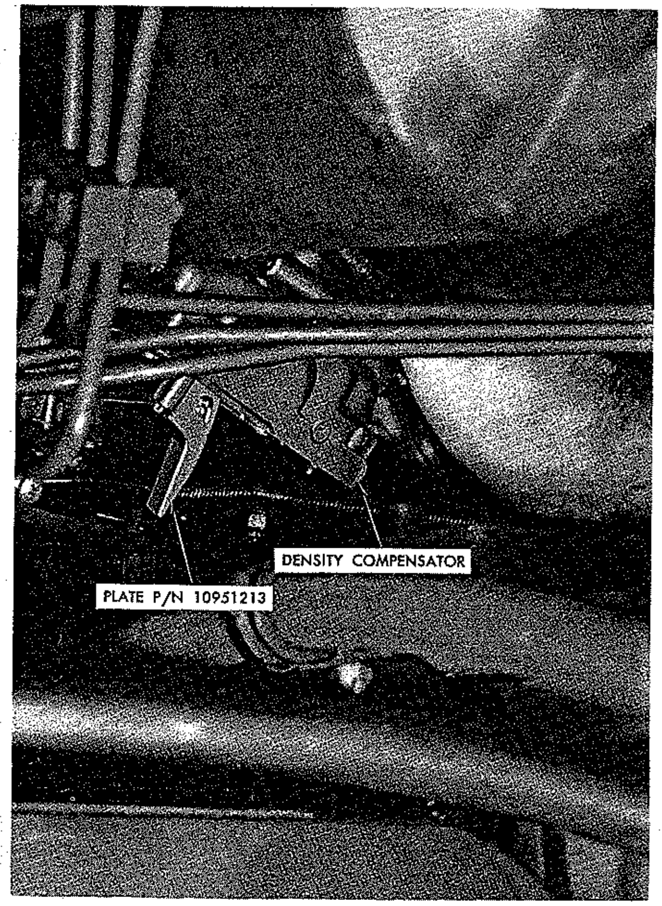


Figure 48

Caution: Do not disconnect the density compensator fuel lines.

(3) While holding the compensator in this position, start the engine and accelerate to approximately 1200 RPM.

(4) When starting the engine the plate, Part No. 10951213 (Figure 49), should move from the maximum extended position to the operating range for the type of fuel being used.

(5) While the engine is operating at 1200 RPM, push the plate upward to its maximum retracted position.

(6) Release the plate, it should move downward to the operating position for the type of fuel being used.

(7) Stop engine, the plate should move

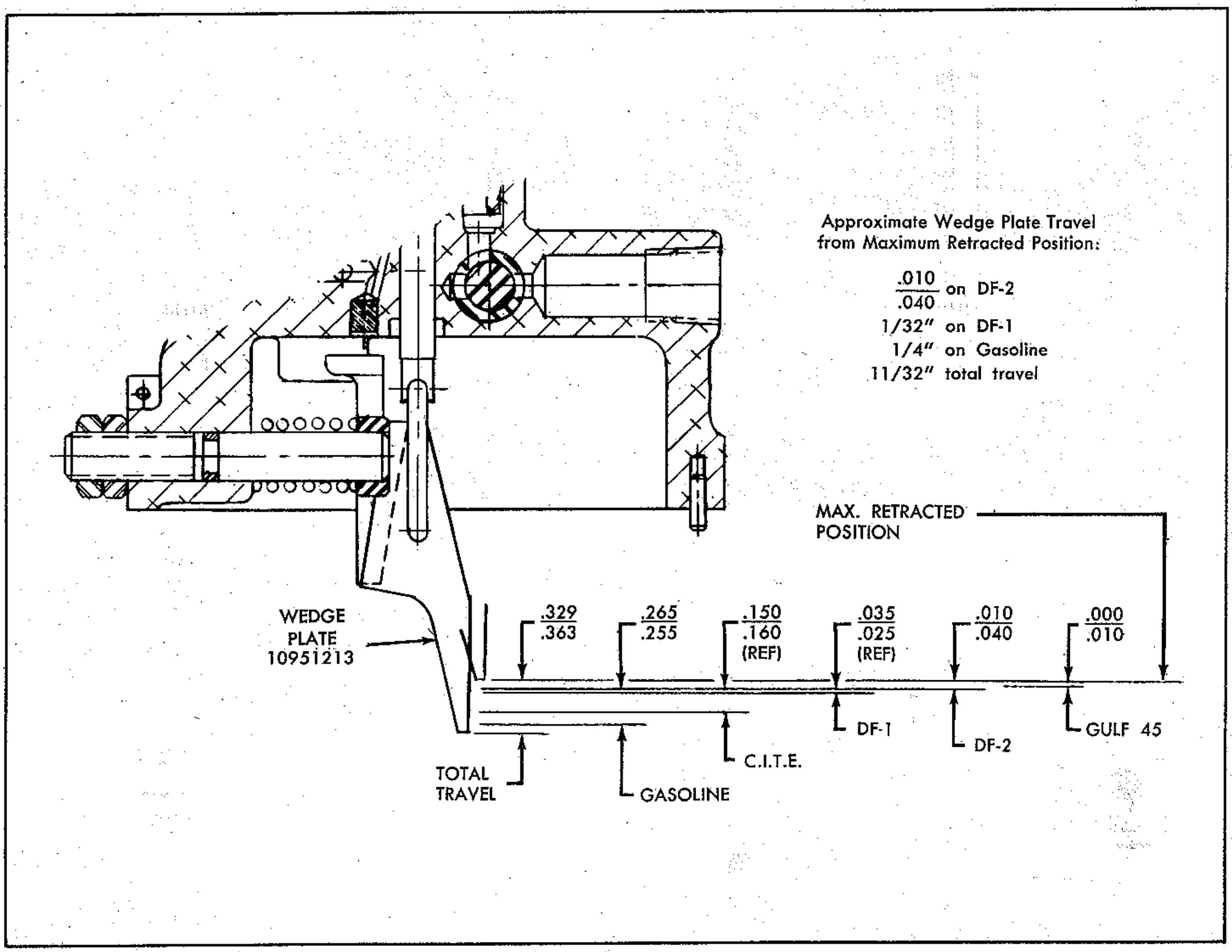


Figure 49

downward to the static mechanical stop (full travel).

(8) If there is no movement of the plate during this inspection, the fuel injection pump must be replaced and turned in for rebuild.

(9) If movement of the plate is observed and the operating position established for the type of fuel being used, it is certain that the control is functioning and the source of trouble causing low manifold pressure is elsewhere. Reinstall compensator.

k. Fuel Injection Pump Timing to Engine Inspection.

(1) Remove the injection pump advance unit timing inspection cover plate, Figure 50.

(2) Pull engine fuel shut-off out to maximum position, Figure 51.

(3) Rotate the crankshaft in its direction of rotation (clockwise as viewed from front of engine), and align the crankshaft damper timing mark for LDS-465-1 engine to timing pointer, Figure 52.

(4) With the LDS-465-1 injection pump timing mark on the crankshaft damper aligned to the timing pointer, check to see if the timing mark on the advance unit hub is aligned to its timing pointer,

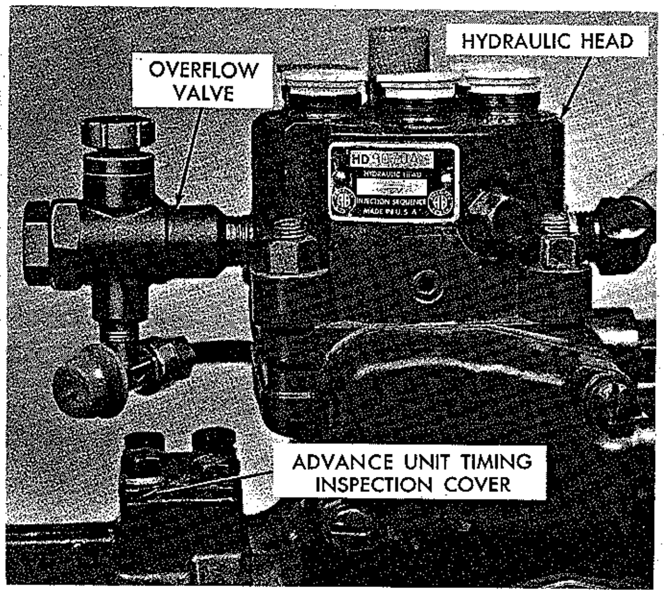


Figure 50

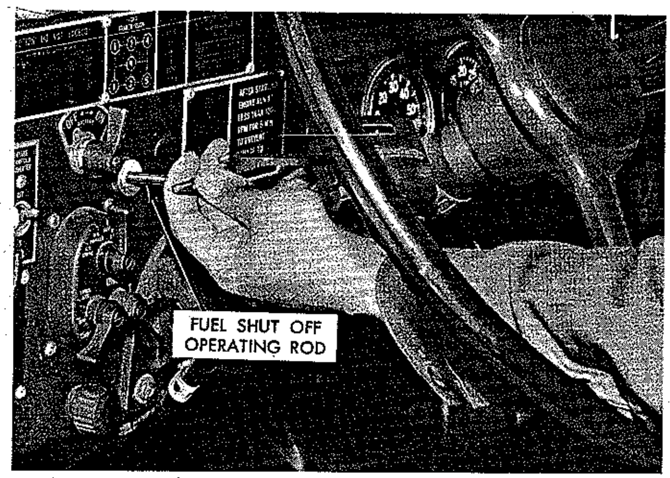


Figure 51

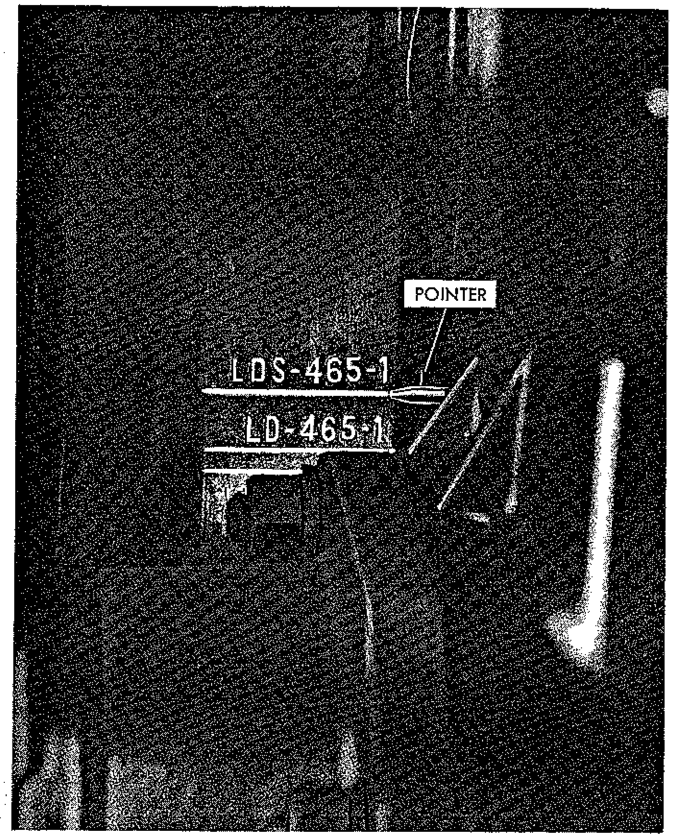


Figure 52

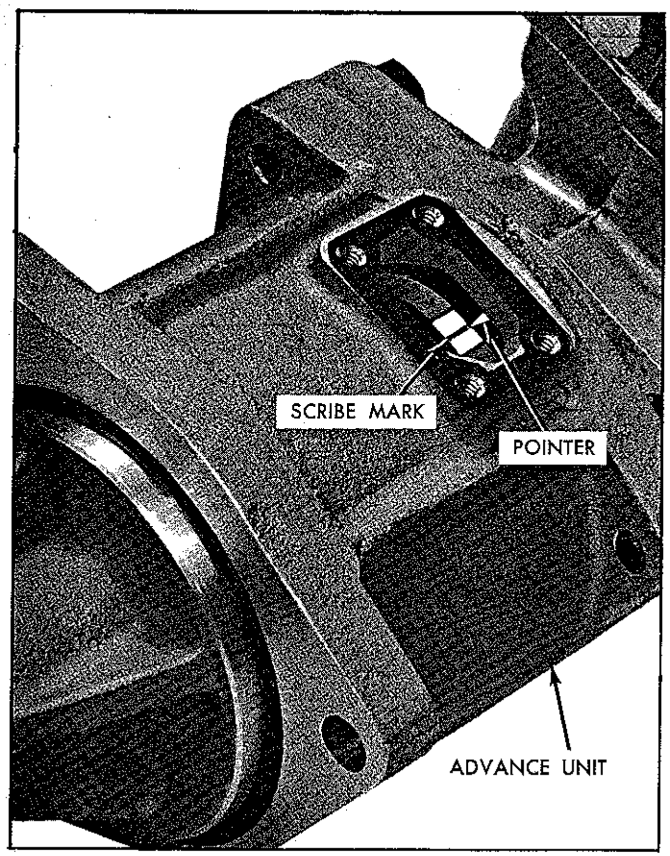


Figure 53

Figure 53. If these two timing marks are aligned remove the fuel shut-off cover from the injection pump, Figure 54, and look to see if the red painted scribed gear tooth on the hydraulic head can be seen, Figure 55. If the red painted scribed tooth can be seen, the injection pump is timed correctly to the engine.

(5) If the red painted scribed tooth cannot be seen, then the engine or injection pump may be on the wrong timing stroke.

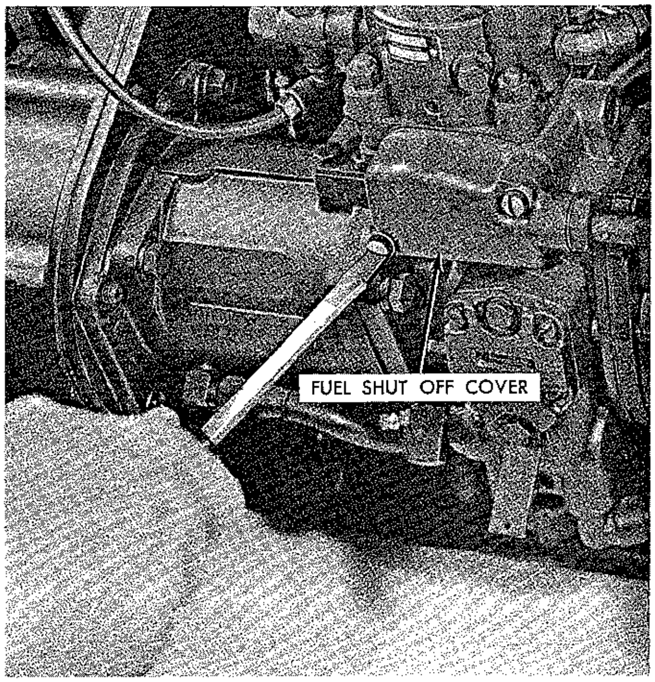


Figure 54

(6) Turn the engine over in its direction of rotation, 360 degrees and realign the crankshaft damper LDS-465-1 injection pump timing mark to the timing pointer. You should now be able to see both the advance unit timing mark aligned to the timing pointer and the hydraulic head red painted scribed gear tooth.

(7) Should you still not be able to set all three timing marks together, recheck the timing again, but this time remove the engine front cylinder head rocker cover. Turn the engine over in its direction of rotation observing the number one cylinder intake and exhaust valves open and close.

(8) After the intake valve closes, align the crankshaft damper LDS-465-1 injection pump timing mark with the pointer.

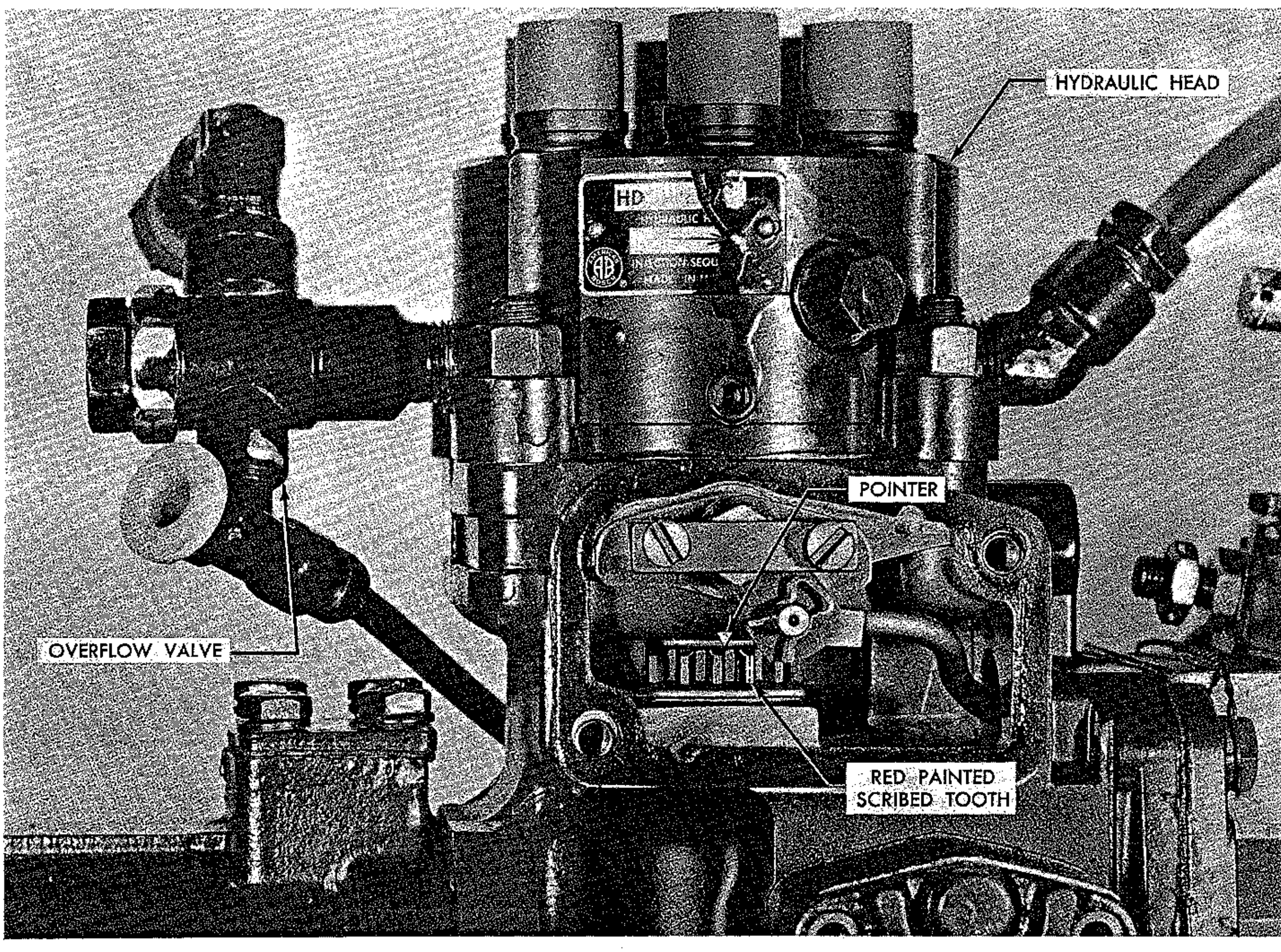


Figure 55

(9) The engine is now on the correct timing stroke and the injection pump timing mark in the advance unit should be aligned to the timing pointer and the hydraulic head red painted and scribed gear tooth should be observable.

(10) With the engine on the correct timing stroke, if the injection pump timing marks are not observed in their correct position, remove and retime the fuel injection pump, as the pump is not calibrated correctly.

(11) If you found the injection pump correctly timed to the engine, you may now proceed to inspect the turbocharger.

l. Turbocharger Assembly Inspection.

(1) Remove the induction air inlet hose from the turbocharger compressor housing.

(2) Spin the turbine wheel. There should be no drag on the shaft caused by the turbine impeller wheel rubbing the compressor housing.

(3) If you feel or hear any rubbing, remove and replace the turbocharger.

m. Increasing the Engine Manifold Pressure at 2400 RPM.

(1) Since increasing the engine manifold pressure is accomplished by increasing the amount of fuel the engine is consuming, you must adjust the engine main fuel adjustment screw shaft, located on the injection pump governor fuel density compensator.

Caution: Instructions for adjusting the engine main fuel adjustment screw shaft must be followed very carefully, with strict attention to procedures. Failure to do so could result in an engine being overfueled, ending in an engine failure.

(2) When observing the main fuel adjustment screw shaft, you will notice that there are two retaining nuts having six flat sides holding the screw shaft in position, Figure 56. The outer nut is a locknut and the inner nut is the fuel adjusting nut. Fuel adjustments, whether to increase or decrease fuel are to be made by turning the fuel adjustment nut ONE flat, REPEAT, ONE flat, at a time. To increase manifold pressure, turn the inner adjustment nut clockwise. To decrease manifold pressure, turn the inner adjustment nut counterclockwise.

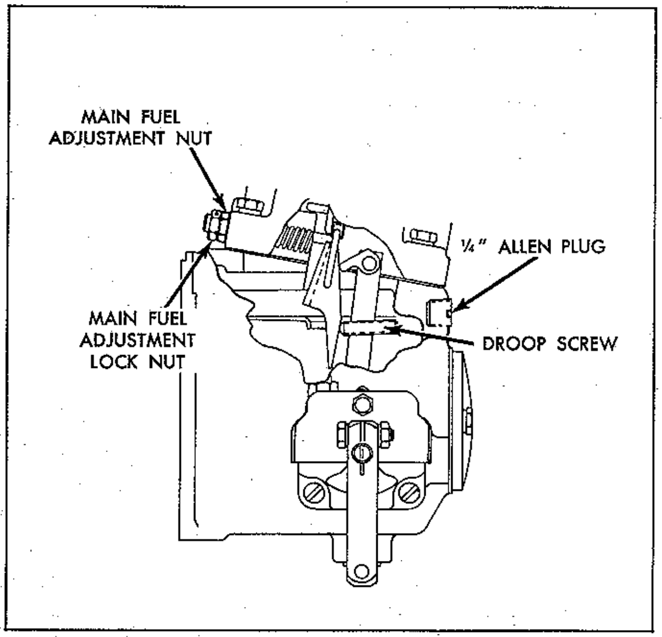


Figure 56

(3) Remove the factory safety wire and seal.

Note. Because the two retaining nuts are very thin, two very thin 1/2-inch open end wrenches are required to make a fuel adjustment, Figure 57.

(4) Loosen locknut (outer nut) using two wrenches. This is done so that you DO NOT move the inner adjustment nut, as any movement will change the fuel setting that gave you the 15 inches Hg reading during the full load test.

(5) The reading of 15 inches Hg that was obtained at 2400 RPM full load indicates you must increase engine fuel delivery to bring the manifold pressure up to 18 - 20 inches Hg. Increase fuel flow by turning fuel adjustment nut (inner nut) ONE flat clockwise.

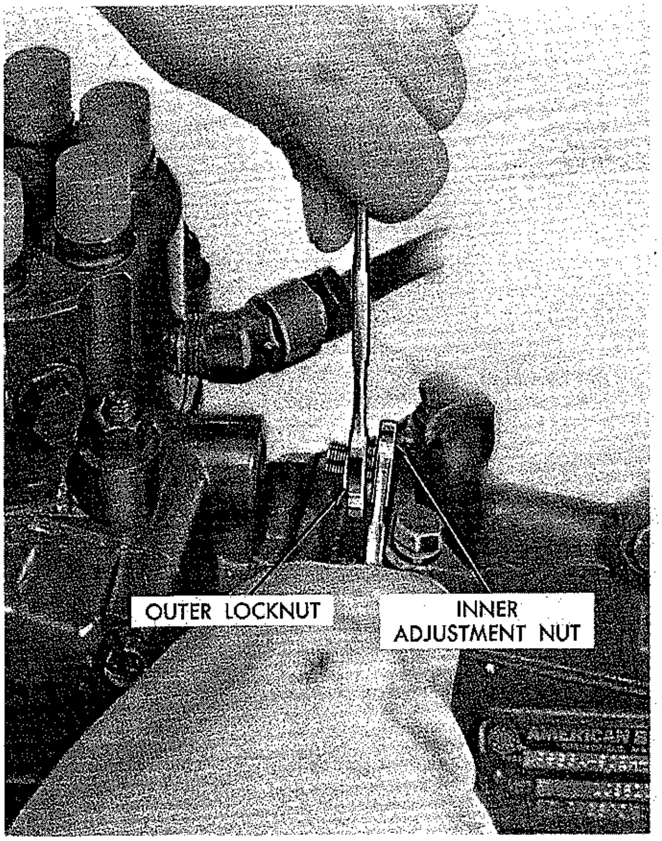


Figure 57

(6) Position the locknut up next to the adjustment nut, but not real tight as you might have to make another adjustment after rechecking the engine full load performance.

(7) Recheck engine full load performance at 2400 RPM, as previously described.

Note. By turning the adjustment nut clockwise one flat you will notice an increase of approximately one-inch of manifold pressure, i. e., with a previous reading of 15 inches Hg on the recheck test manifold pressure will be approximately 16 inches Hg.

(8) With manifold pressure still below the normal limits, increase fuel flow again by turning the adjustment nut one flat clockwise and recheck full load performance. Continue this operation until you bring the manifold pressure within the limits outlined in Figure 41 for the type of nozzle tip installed and type of fuel being used.

(9) The example used in this instruction was for an engine with low manifold pressure, however, if in your case the manifold pressure was too high, the procedure remains the same except you must decrease fuel flow by turning the adjustment nut counterclockwise.

(10) Upon reaching the desired manifold pressure at 2400 RPM, tighten the outer locknut up tight against the inner adjustment nut. Be careful not to move adjusting nut in doing so.

(11) Recheck full load performance at 2400 RPM to insure that fuel adjustment nut did not move and that you are still within normal limits.

(12) Safety wire and seal the fuel adjustment and locknut to the fuel density compensator housing to prevent loosening.

n. After increasing or decreasing the injection pump fuel delivery at 2400 RPM, whichever the case may be, the fuel delivery at 1600 RPM will also be changed, and must be checked and reset. This adjustment is accomplished by means of a droop screw located inside of the injection pump governor on the fulcrum lever assembly, Figure 56. The droop screw setting controls fuel delivery to the engine up to approximately 2000 RPM.

o. Check droop screw setting using the same procedure as outlined for check at 2400 RPM, only this time load the engine and maintain a constant 1600 RPM. Remember, engine speed must be stable when manifold pressure is recorded.

p. Engine Full Load Test Reading 1600 RPM.

(1) Suppose after 5 test runs the average manifold pressure reading was 12 inches Hg.

(2) Still using the same engine as an example, having two-hole orifice nozzle tips installed and using Diesel fuel, this average reading is 2 inches Hg higher than the required 8 - 10 inches Hg.

(3) This time it will be necessary to decrease fuel flow to bring the manifold pressure within limits.

q. <u>Decreasing Engine Manifold Pressure at 1600 RPM.</u>

(1) To gain access to the droop screw, remove the 1/4-inch Allen plug from the rear of the injection pump governor housing, Figure 58.

<u>Note</u>. A 1/4-inch Allen wrench may be used, or a removal tool as shown in Figure 58 can be fabricated.

(2) Insert a 1/8-inch Allen wrench or a fabricated droop screw adjusting wrench, Figure 59, into the droop screw. As this must be done strictly by feel, you may have a little trouble here so take your time and insure that the wrench is fully bottomed in the adjusting screw.

(3) To decrease manifold pressure the droop screw must be turned clockwise. Since this is the case in this example, turn the droop screw clockwise 45 degrees or 1/8 of a full turn. A little bit here goes a long way. If manifold pressure must be increased, turn the droop screw counterclockwise.

(4) Remove wrench and re-install Allen plug, but not too tight as further adjustment may be required.

(5) Recheck engine performance at 1600 RPM. Here again, engine performance must be checked each time you make a fuel adjustment.

(6) Suppose this time the average test reading is 10.5 inches Hg manifold pressure. This is still too high and further adjustment is required.

(7) Adjust droop screw clockwise but this time turn it only 20 degrees or 1/16 of a full turn.

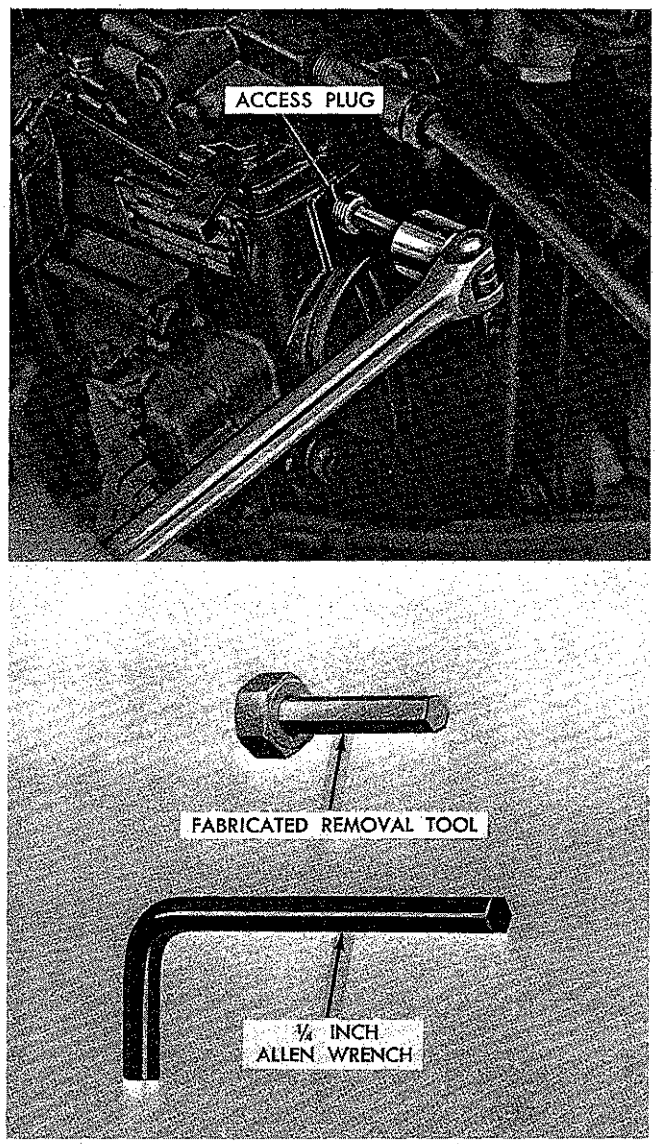


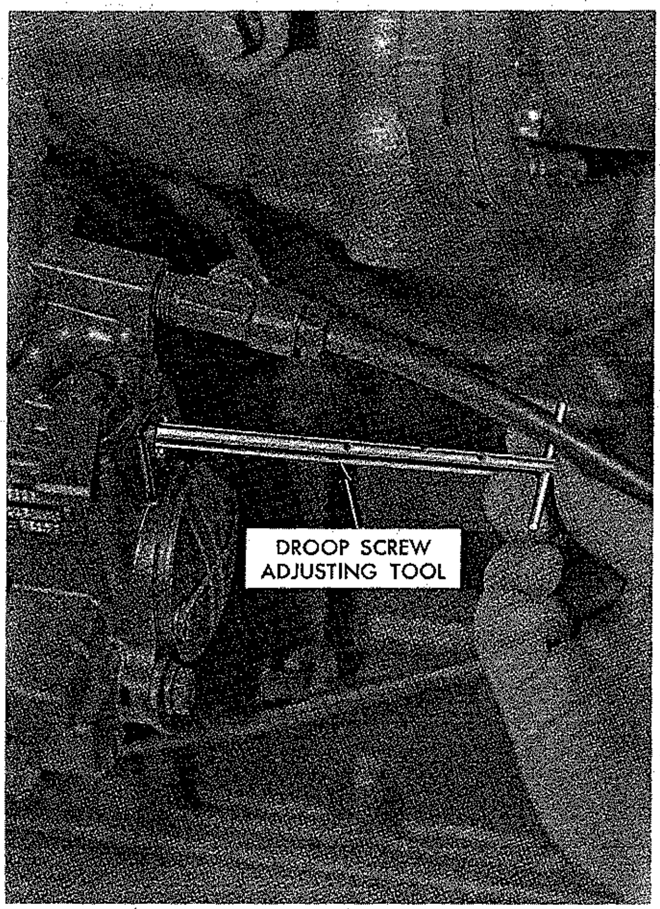
Figure 58

(8) Remove wrench, re-install Allen plug and recheck engine performance at 1600 RPM.

(9) Suppose the average test reading this time is 9.75 inches Hg manifold pressure. This reading is within the required limits of 8 - 10 inches Hg, therefore adjustment is completed.

(10). Tighten 1/4 inch Allen plug.

With both manifold pressures set within the required limits, the engine full load performance test is completed. Original factory engine performance has been restored and the engine is ready to do the job it was designed to do.



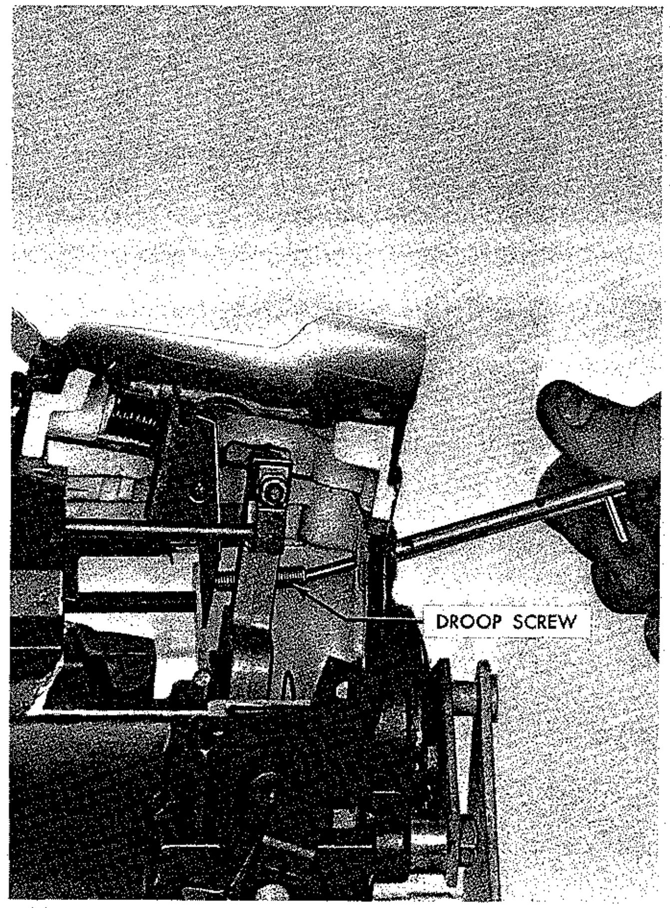


Figure 59

PART III - CRITICAL MAINTENANCE AREAS

8. TIMING FUEL INJECTION PUMP TO ENGINE

a. To set injection pump on correct pumping stroke:

(1) Place the injection pump on a clean work bench and remove advance unit timing cover inspection window.

(2) Remove injection pump shut-off cover.

(3) Turn the injection pump drive shaft in its normal direction of rotation (clockwise as viewed from front of pump). As you are turning the pump drive shaft, observe advance unit hub through the inspection window. When you first see the white paint on the advance unit hub coming into view, stop turning the injection pump drive shaft. Look to see if the scribed red tooth on the hydraulic head plunger drive gear is in view, Figure No. 60.

(4) If the white paint on the advance unit hub and the scribed red tooth of the hydraulic head plunger drive gear can be seen, the injection pump is on the pumping stroke for Number 1 fuel port. This does not mean that the pump is timed; it has only been placed on the correct pumping stroke, and is now ready to be installed on the engine and timed.

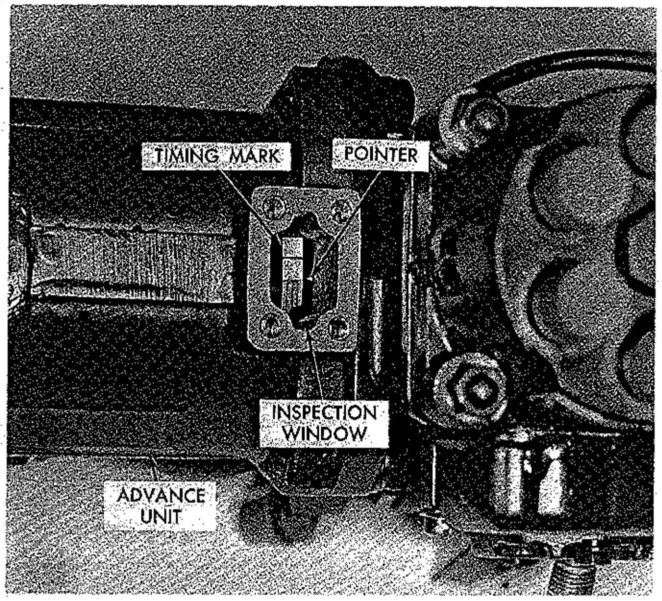
b. Timing Injection Pump to Engine.

Note. Correct injection pump timing is essential to engine performance and durability. A mistimed pump can cause hard starting, poor performance and possible engine destruction. Therefore, the following procedure should be closely adhered to:

(1) Remove engine front cylinder head cover.

(2) Rotate crankshaft clockwise as viewed from fan end of engine (normal direction of rotation) until number one cylinder intake valve closes.

(3) When the intake valve closes, align the LDS-465-1 timing mark on crankshaft damper (third timing mark) to the timing pointer. With the engine in this position, you should be able to feel free movement of the intake and exhaust valve rocker arms. If either



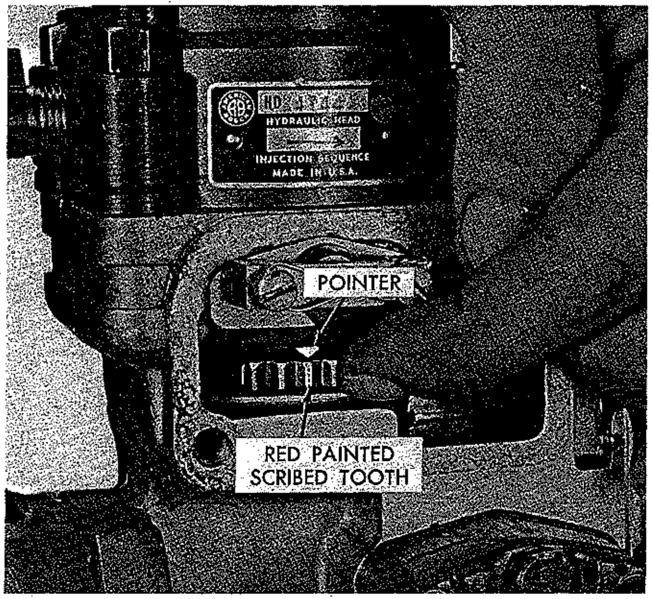


Figure 60

rocker arm is tight (without valve lash) the engine is not on the correct stroke and it will be necessary to repeat the procedure.

(4) Install injection pump to the engine.

(5) Install pump drive gear on the pump hub in the position shown in Figure No. 61. If the gear is not in the position illustrated, you will not be able to rotate the pump shaft sufficiently to the correct timing point.

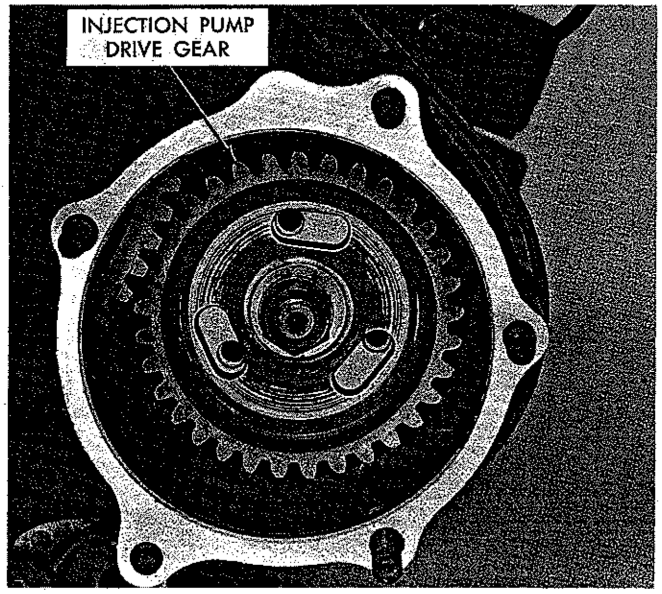


Figure 61

(6) Place the gear retaining plate in position and turn the three locking cap screws in finger tight.

(7) Rotate pump drive shaft in its normal direction of rotation (clockwise) until the timing mark on the advance unit hub is aligned with the timing pointer. Holding this position, tighten the three 9/16-inch locking screws, Figure No. 62.

(8) Recheck pump timing by rotating the engine crankshaft counterclockwise a short distance and then turn it clockwise until the LDS-465-1 timing mark is realigned with timing pointer. The pump advance unit hub timing mark should also be aligned with its timing pointer. If it is not, loosen the three cap screws and reset the advance unit

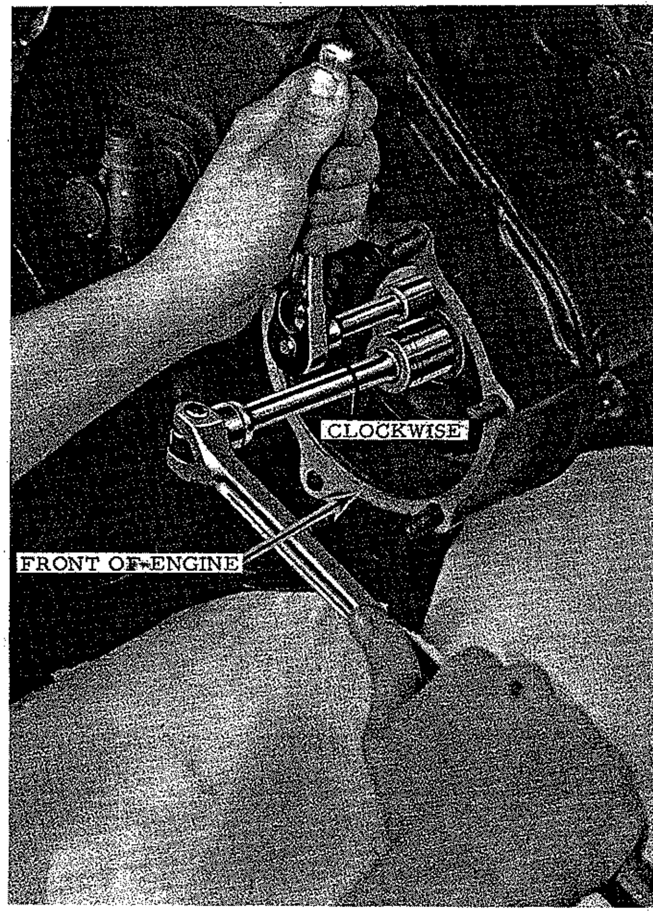


Figure 62

hub timing mark to the pointer. Repeat the timing and recheck procedure until both the damper timing mark and the pump advance unit hub timing mark align with their pointers.

(9) When crankshaft damper and advance unit hub timing marks are correct, inspect hydraulic head plunger drive gear. The scribed red tooth should have moved approximately one tooth away from its original position.

9. INSTALLATION OF HIGH PRESSURE FUEL INJECTION LINES

a. Incorrect installation of fuel injection lines will result in fuel being distributed to the cylinders in an improper firing sequence, causing piston burning and eventual destruction of the engine.

b. Correct metering discharge sequence of the injection pump hydraulic head is 1-5-3-6-2-4- as numbered counterclockwise from number one port outlet, located at the 10 o'clock

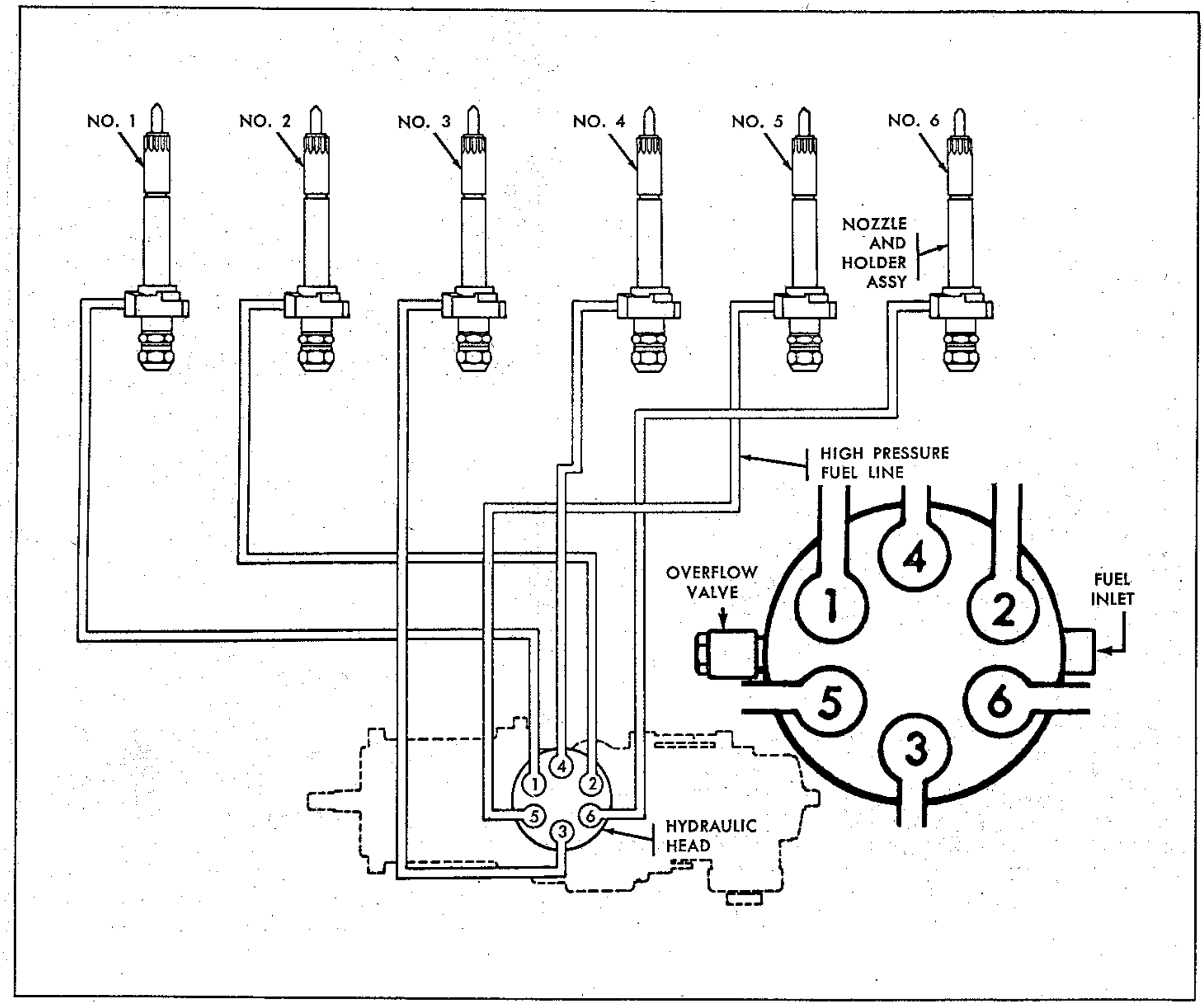


Figure 63

position. As a reference point, the overflow valve should be considered to be in the 9 o'clock position, Figure No. 63.

c. When installing fuel injection lines between injection pump and injection nozzles, they should be installed as called out in Figure No. 63.

d. Position lines in correct firing sequence.

e. Loosely assemble nozzle end and pump end nuts.

f. Tighten brackets and line clamps.

g. Tighten line nuts at each end.

10. OIL AND OIL FILTER CHANGE

Note. Under normal operating conditions changing of engine lubrication oil for the LDS-465 engine is recommended every 3,000 miles or three months, whichever occurs first. However, under extremely dusty conditions it is necessary to change oil and filters more frequently.

a. Drain engine oil while engine is at normal operating temperatures. This aids in removing a certain amount of sediment that is suspended in warm oil.

b. Remove oil filter housing drain plug and drain housing.

c. Remove filter elements.

Caution: Do not remove filter can, center post, and element as an assembly. To do so will allow accumulated sediment and sludge to enter center oil passage in the filter base and oil galleries of the engine block. Remove filter can and center post first. Remove sediment and sludge from around filter base then remove the element.

d. Clean filter element cans. Wash in cleaning solvent or diesel fuel.

e. Install new sealing gasket. Carefully position gasket so that the best possible seal will be obtained.

f. Install new filter elements.

g. Install and tighten filter can center post.

Caution: Do not allow filter can to turn when tightening center post, as this will cause cutting of the gasket.

11. CYLINDER HEAD GASKETS

Three types of cylinder head gaskets, shown in Figure 64, have been used on LD/LDS-465 and LDS-427-2 engines. The top gasket, P/N 7748879, was the only one used on LDS-427-2 engines and on original production LDS-465-1 engines. When head gasket problems first occurred on LDS-465-1 engines using this gasket, head gasket P/N 10951161, center gasket Figure No. 64, was used in very limited quantity to correct the problems. These head gaskets are now obsolete and should not be installed on any LD/LDS-465 or LDS-427-2 engines.

Continued development by Continental Aviation and Engineering Corporation resulted in release of a multi-piece, vented head gasket, P/N 10951428, bottom gasket Figure No. 64. This gasket is presently being used in production and is being installed on LDS-465-1 engines in the field under MWO 9-2815-210-35/1. This gasket is also recommended for use on LDS-427-2 engines.

12. INSTALLATION OF MULTI-PIECE VENTED HEAD GASKET ON THE LDS-465-1 ENGINE

a. Remove cylinder heads as outlined in the appropriate technical manual.

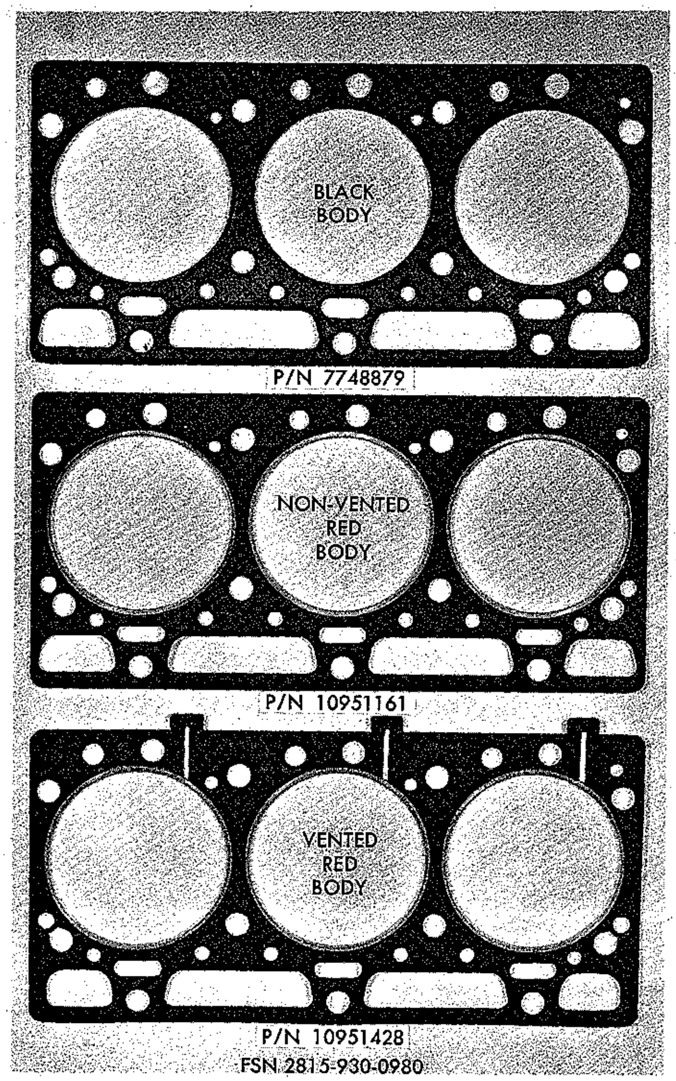


Figure 64

b. Before installing new head gaskets, the following inspection of cylinder heads and engine block head surfaces must be made.

(1) Cylinder head gasket surfaces must be clean and free of any carbon build up. If surfaces require cleaning, exercise extreme caution when cleaning. Any deep scratches or gouges in gasket surfaces can cause a head gasket failure.

(2) Inspect heads for cracks. Cracks are frequently found in two areas, between the intake and exhaust valve seats and extending out radially from the injection nozzle inlet, Figure 65. Cracks do not necessarily mean that the head is unserviceable. When cracks are found, pressure check the head to find

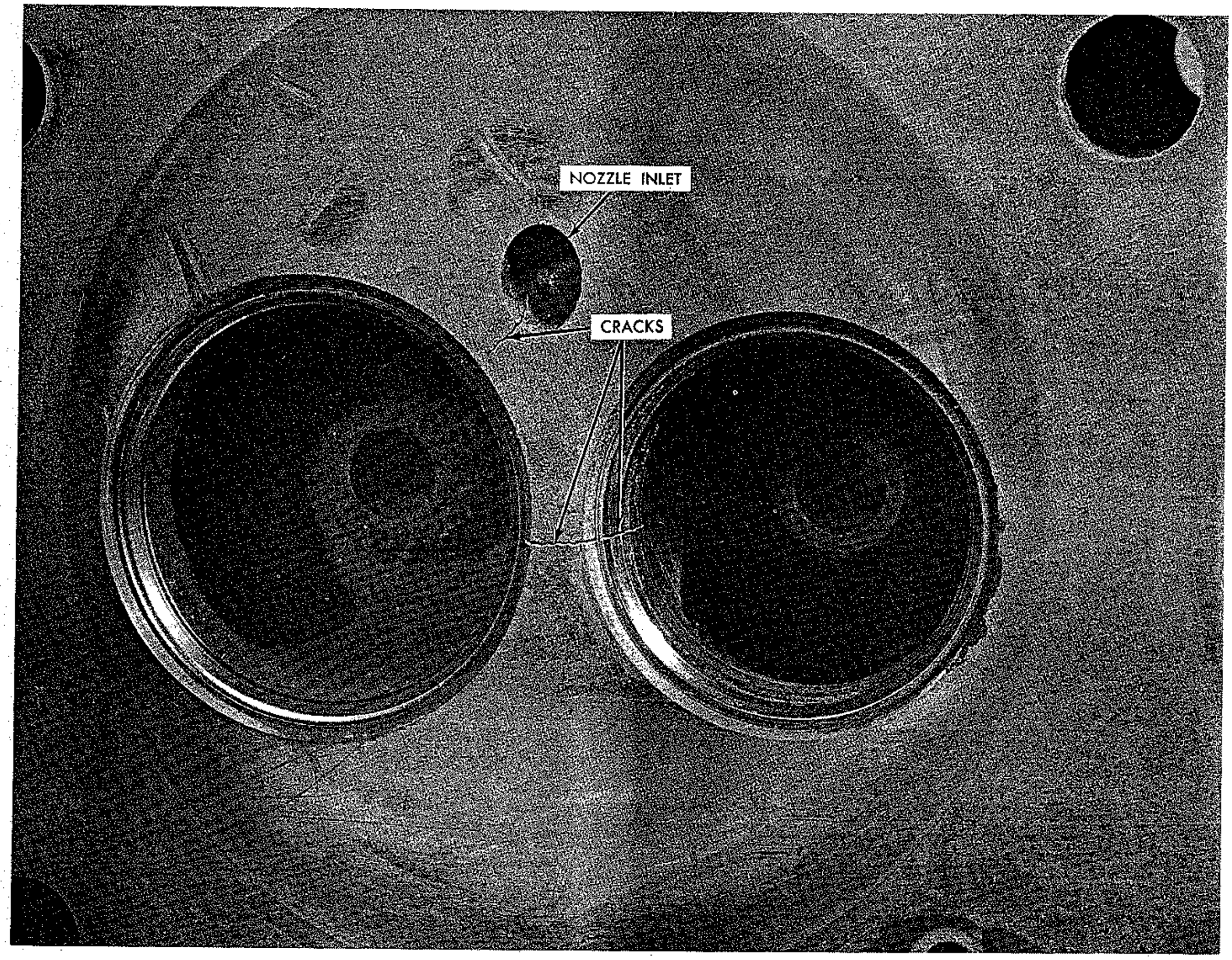


Figure 65

out if cracks extend into the water jacket. If cracks do not leak, the head is serviceable. Cracked valve seat inserts must be replaced.

(3) When removing cylinder heads, water, dirt and oil will accumulate on the top of the cylinder block and pistons as well as in the cylinder bores; these areas must be clean. DO NOT allow any core sand from the cylinder head water passages to get into the cylinder bores. This will cause piston ring and cylinder bore scratching, ending in a possible engine failure.

(4) Check cylinder bore liner height. Tolerance is .0005 to .005 inches above block head gasket surface. Use a flat parallel bar or straight edge and feeler gage. If liner height exceeds .005-inch, remove liner and clean any carbon or dirt that may have lodged between the liner lip and block bore.

c. Coat both sides of the gasket with No. 572 Permatex, as shown in shaded area of Figure No. 66.

d. Install gasket body on cylinder block with part number facing up.

e. Install fire rings. Either side of the fire ring can face up.

f. Install cylinder heads.

g. Install cylinder stud washers and nuts. Lubricate cylinder head stud threads, nuts and washers prior to installing washers and nuts,

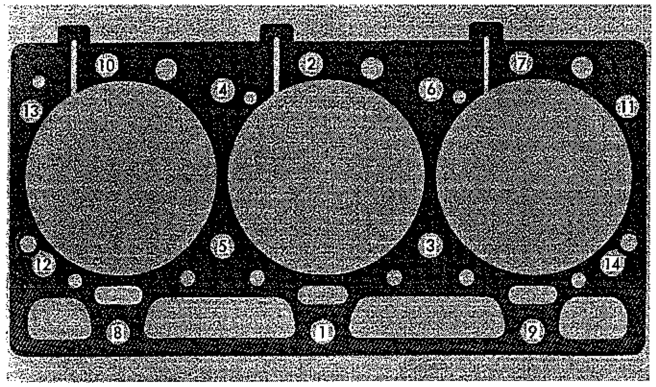


Figure 66

Figure No. 67, using engine oil. DO NOT USE THREAD LUBE of any kind.

h. Tighten cylinder head nuts to each of the following four torque values using the sequence shown in Figure No. 66 for each torque value.

First	40 Pound-Feet
Second....................	80 Pound-Feet
Third....................	110 Pound-Feet
Fourth..................	130 Pound-Feet

Note. To insure proper torquing, two special wrenches must be used. Without these, torque values may be incorrect resulting in a very possible head gasket failure. The longer wrench, P/N 10951484 (Figure No. 68), is used on all nuts when the rocker arm assembly is not assembled to the engine. The shorter wrench, P/N 10951485 (Figure No. 69), is used on the nuts under the rocker arm assembly when it is assembled to the engine.

j. Install push rods and rocker arm assemblies and set valve lash (.010-inch intake and .025-inch exhaust).

k. Complete assembly of the engine.

l. Start engine and operate vehicle until engine reaches operating temperature, 175 degrees minimum.

m. Shut down engine.

n. Retorque cylinder head nuts to 130 pound-feet in sequence shown in Figure No. 66. Nuts must be retorqued immediately after engine shut down. Engine coolant must not be less than 160 degrees during the hot retorque period. Nuts must be retorqued to 130 pound-

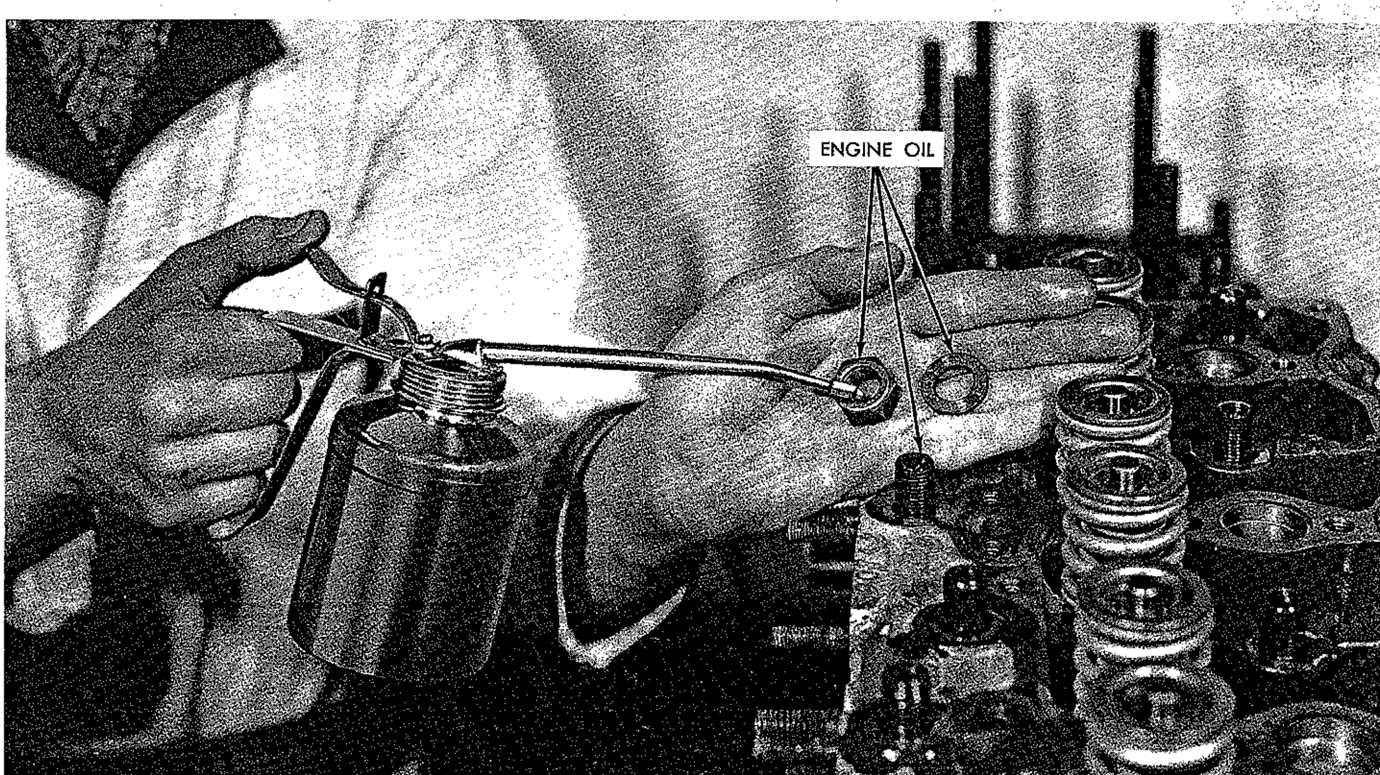


Figure 67

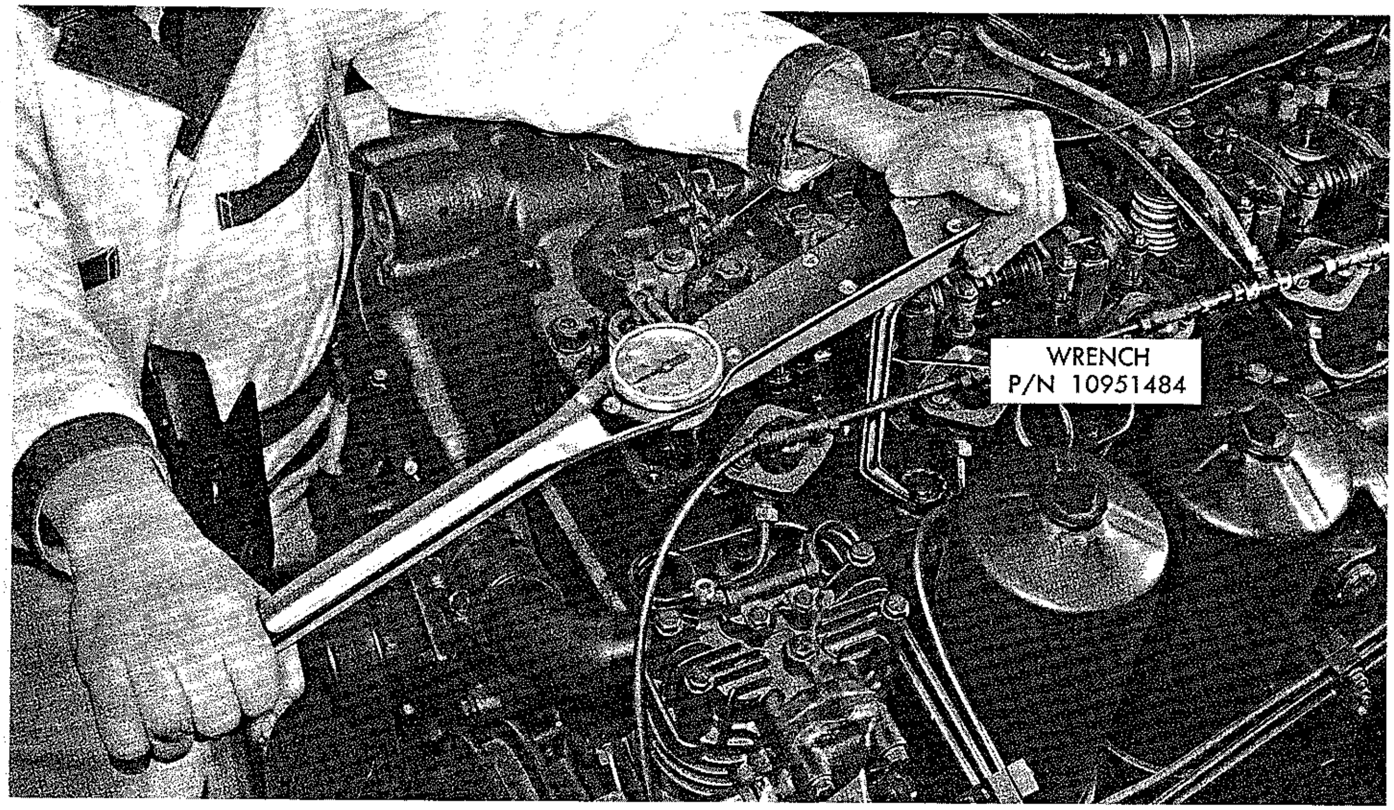


Figure 68

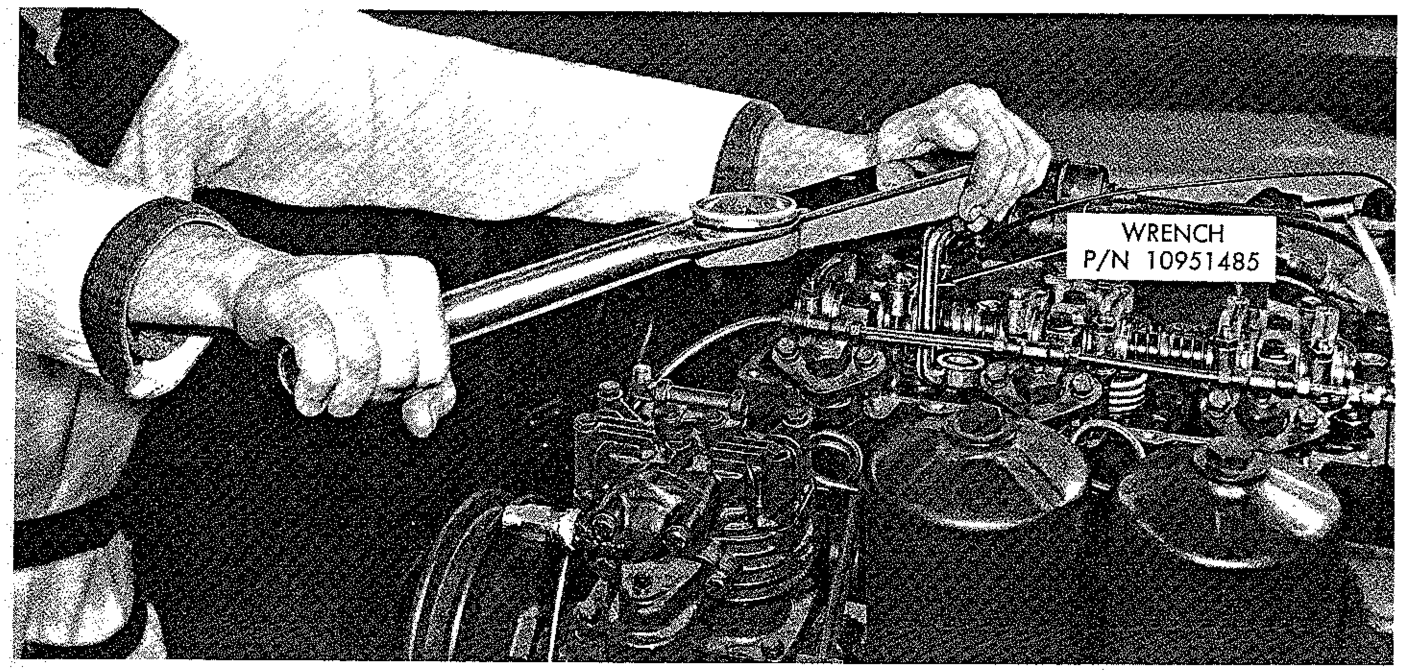


Figure 69

feet with the nut turning. If the nut does not turn, it must be backed off, stud and nut re-oiled, and retorqued to 130 pound-feet, with the nut moving, before proceeding to the next nut in the sequence.

13. SETTING VALVE LASH

Valve lash setting is the same for all LD/ LDS-465 and LDS-427-2 engines, INTAKE .010-inch and EXHAUST .025-inch. Settings are the same either hot or cold. The following procedure enables adjustment of valve lash on all twelve valves by just rotating the engine twice.

Note. Place transfer case in neutral and transmission in fifth gear so the engine can be turned over manually by rotating the drive shaft between the transmission and transfer case.

a. Rotate drive shaft until No. 1 cylinder intake valve is in the maximum open position, Figure No. 70. Adjust the following valves:

(1) INTAKE .... No. 2, 3 and 6

(2) EXHAUST .... No. 1, 2 and 4

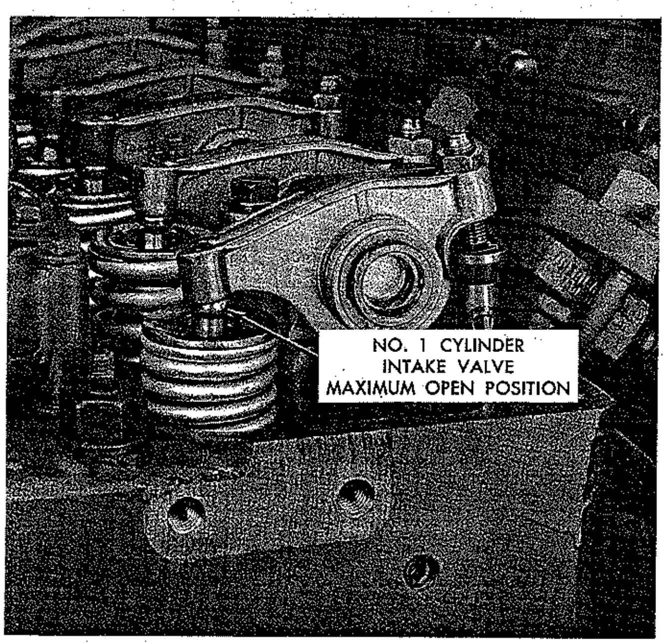


Figure 70

b. Rotate drive shaft until No. 6 cylinder intake valve is in the maximum open position, Figure No. 71. Adjust the following valves:

(1) INTAKE .... No. 1, 4 and 5

(2) EXHAUST .... No. 3, 5 and 6

14. CHECKING CAMSHAFT TIMING ON LD/LDS-465 ENGINES

a. Using the prescribed procedure, set the number one cylinder exhaust valve lash to .125 inch.

b. Rotate the engine crankshaft in its normal direction (clockwise as viewed from fan end) until the No. 1 exhaust valve closes.

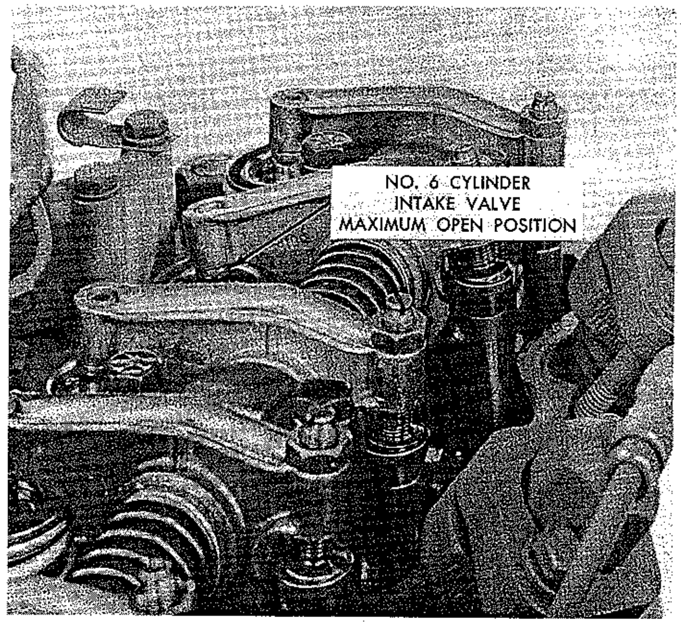


Figure 71

c. Observe the crankshaft damper timing pointer. It should indicate 21° BTC, which is approximately 1/16 inch past the LDS-465-1 mark in the direction of the other timing marks stamped in the damper.

d. If the camshaft timing does not appear to be correct, the camshaft gear to camshaft assembly should be inspected.

15. VALVE SPRING RETAINERS

The machined type upper valve spring retainer, P/N 10889832, Figure No. 72, was first

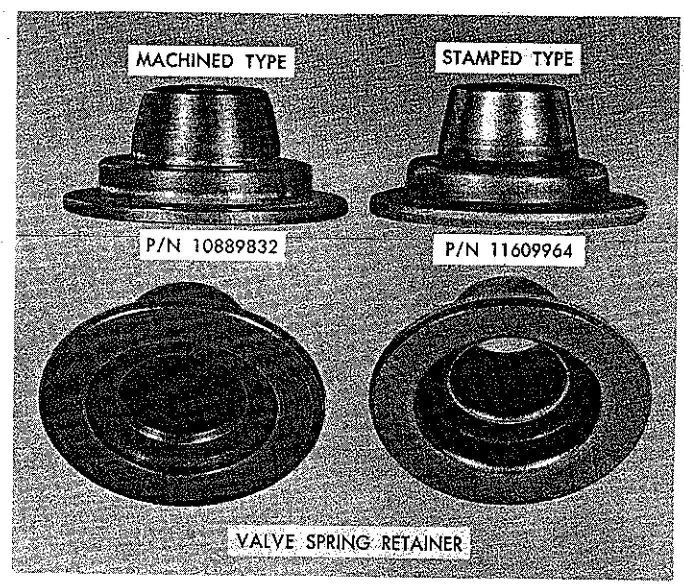


Figure 72

used on LDS-427-2 engine, then on LDS-465-1 engines. This retainer is subject to failure when overspeeding the LDS-465-1 engine, causing extensive damage to the engine. As a result, the machined type retainer has been replaced by a new stamped type retainer, Figure No. 72, which has a new part number (11609964).

All LDS-465-1A and LD-465-1 engines use the new stamped type retainer. Replacement of the machined type retainer on LDS-465-1 is authorized by MWO 9-2815-210-35/1.

16. PISTON PINS

There are two types of piston pins, hollow and solid, in use today on LD/LDS-465 engines, shown in Figure No. 73. The hollow type, P/N 10889939, is used in LDS-465-1 engines. The solid type, P/N 10951222, is used in LD-465-1 and LDS-465-1A engines. Both type piston pins can be used in all three engines, but only as a complete set throughout the engine. NEVER INSTALL A MIXED SET OF HOLLOW AND SOLID TYPE PINS IN AN ENGINE.

17. ENGINE STARTERS

All three starters, Delco-Remy, Prestolite and Leece-Neville, are interchangeable between the LD/LDS-465 engines. Before installing a starter on a given engine you must be sure the starter nose housing is indexed properly for the given engine. Figure No. 74 shows proper indexing for each engine and starter.

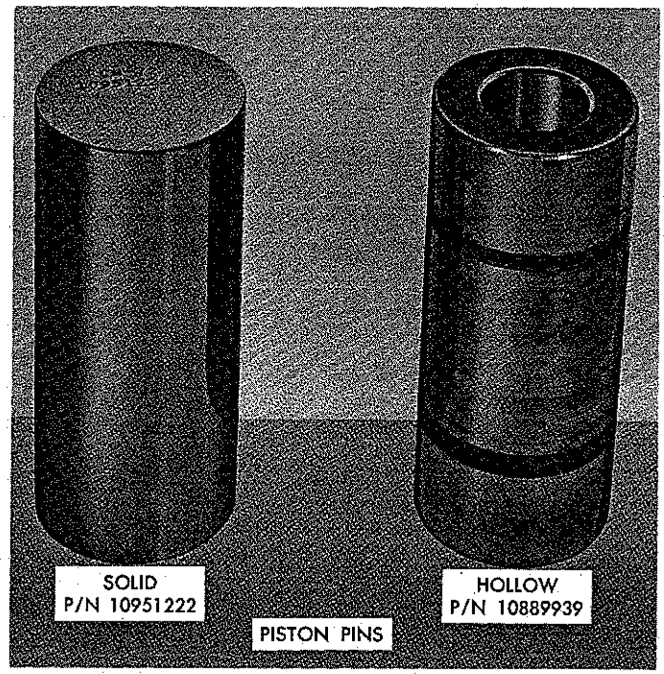
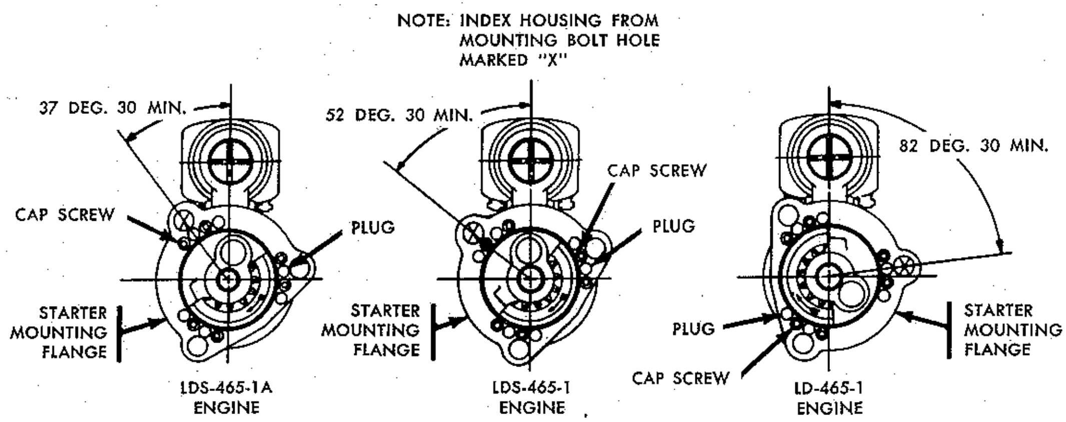
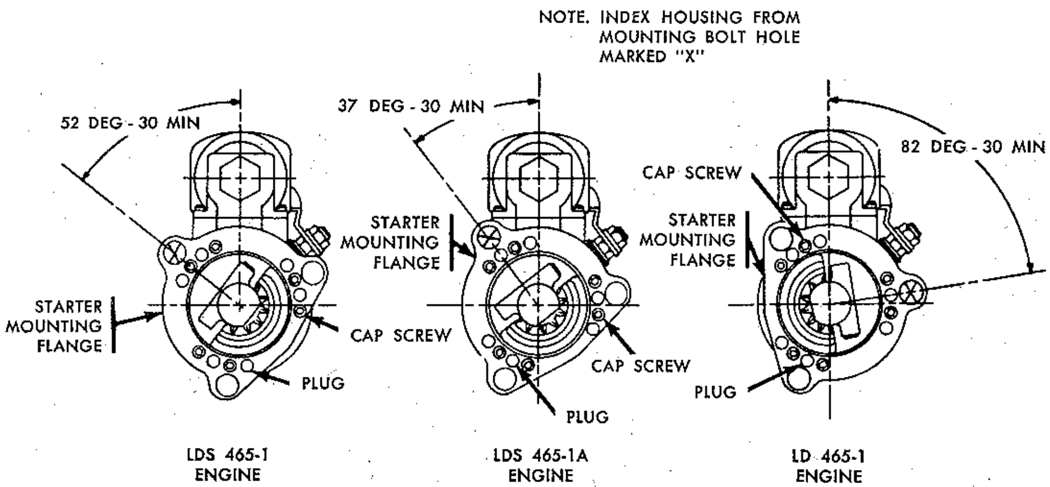


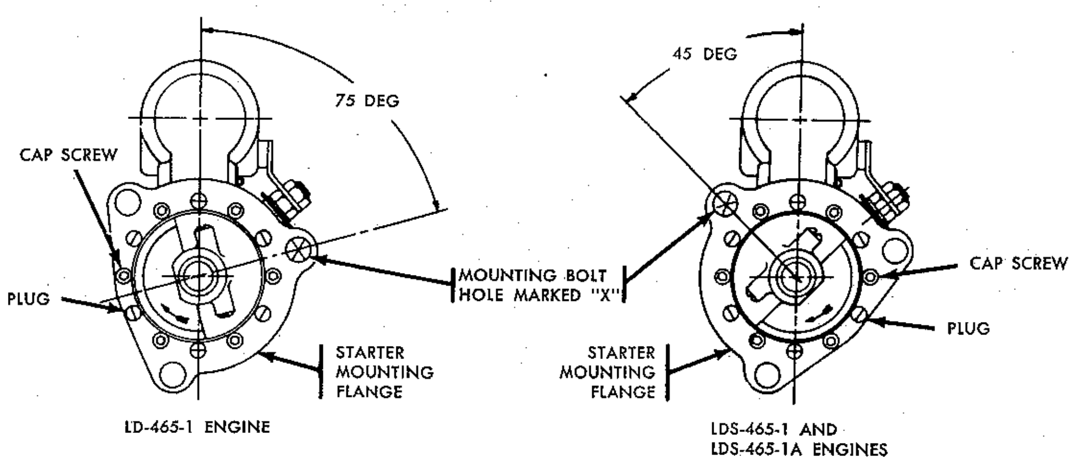
Figure 73



DELCO-REMY STARTERS (10911018 AND 10911018-1)



PRESTOLITE STARTER (1951385)



LEECE NEVILLE STARTER (10935376)

Figure 74