Operator's Manual

for

85' AERIAL LADDER

FIRE FIGHTING TRUCK

NSN 4210-00-965-1254

HEADQUARTERSP DEPARTMENT OF THE ARMY
3 NOVEMBER 1986

COMPLETE MANUAL TABLE OF CONTENTS

COMPLETE MANUAL TABLE OF CONTENTS (Continued)

FORWORD

Descriptions, instructions and parts listing pertaining to the Model QWT 85 are discussed throughout this manual under general headings. Foldout illustrations and schematics are located at the rear of this volume. The foldout format is provided in order that illustrations may be continuously referred to while the supporting text is being examined and studied.

A detailed description is given in the Introduction of each Part of the manual to assist the user in finding the information required to operate or maintain the equipment.

Operator's Manual (TM 5-4210-227-10)

This manual is designed to provide the information necessary for a fire fighter or mechanic to properly operate the truck, the pump and the ladder.

Maintenance Manual (TM 5-4210-227-24&P)

This manual contains the information necessary for an experienced mechanic to maintain and repair all facets of the apparatus. Each volume is individually indexed for ease of reference. This manual contains all the information necessary to obtain assemblies and subassemblies or individual parts, required to repair and maintain the fire truck.

SECTION 1

1. INTRODUCTION/TABULATED DATA

1.1 INTRODUCTION

1.1.1. This manual contains all the information necessary for the safe and efficient operation of the Truck Fire Fighting Ladder 85'. Descriptions, operating instructions, safety precautions and operator maintenance are discussed under the main headings: Chassis Assembly, Pump Assembly and Ladder Assembly. Throughout the manual the complete truck assembly is referred to as the QWT 85.

1.1.2. TM 5-4210-227-24&P, Organizational, Direct Support, and General Support Maintenance Manual for 85' Aerial Ladder Fire Fighting Truck is divided into eight volumes which are further subdivided into specific sections. This manual (TM 5-4210-227-10) consists of eight separate sections. The manual is designed for use by experienced fire fighters and fire fighting techniques have been included. Although the operator may be familiar with similar fire fighting equipment, all the operating and safety instructions contained in this manual must be read and understood before attempting to operate this unit. Particular attention must be given to the "WARNINGS" and "CAUTIONS" distributed throughout the text.

1.1.3. The Operator's Manual consists of eight sections arranged as follows:

1. Introduction/Tabulated Data
2. Operating Instructions
3. Operator Maintenance
4. Illustrations
5. Operator's Manual, Series 92 Engines
6. Operator's Manual, Series V-71 Engines
7. Built-in Parts Book for Detroit Diesel Engines
8. Operator's Manual, Fire Apparatus Chassis

1.2 TABULATED DATA

a) Fire Truck

Federal Stock Number:	4210-00-965-1254
Manufacturer's Serial No.:	
Registration Nos.:	CM3653 through CM3664
Manufacturer:	Pierre Thibault Inc.
Model:	QWT 85
Contract Number:	DAAJ10-84-A218
Truck Length:	459"
Truck Width:	108"
Truck Height:	138"
Capacity or Payload:	51,000 GVWR
Shipping Weight:	43,880
Ground Clearance:	10.25"
Weight Loaded:	45,940
Front Axle	19,740
Rear Axle	26,200

b) Chassis

Manufacturer:	Duplex
I.D. Number:	I.C. 1D91 D31 D6F 1008468
Model:	D350
Wheel Base	230"

c) Engine

Manufacturer:	Detroit Diesel
Model:	8V-71 Turbo
Serial Number:	8VA437868
Fuel: Diesel	

d) Transmission

Manufacturer:	Allison
Model:	HT-740
Serial No.:	2510087501
Capacity:	7 1/2 Gals

e) Firefighting Water Pump
Manufacturer: Hale
Model: QSM FHD100
Capacity: 1000 GPM @ 150 psi

f) Front Axle
Manufacturer: Rockwell International
Model: FL 941 QX-70
Capacity: 20,000 lbs.
Serial No.: N766718

f) 1. Front Shock Absorbers
Manufacturer: Duplex
Model: 7605-1258

f) 2. Front Springs
Manufacturer: Duplex
Model: 7804-6731

g) Rear Axle
Manufacturer: Rockwell International
Model: U-170 PX-99
Capacity: 31,000 lbs.
Serial No.: NW8454892

g) 1. Rear Suspension
Manufacturer: Hendrickson
Model: Single Axle RS-SA-340

h) Alternator
Manufacturer: Delco Remy
Model: 1117152
Amp.: 145

i) Batteries
Manufacturer: Harris
Model: 7605-0670
Voltage: 12

j) <u>Battery Isolator</u>
Manufacturer: Sure Power
Model: 1602
Rated Power: 3709 BHP @ 2,100 rpm

k) <u>Steering Gear</u>
Manufacturer: Sheppard
Model: 7605-5478

l) <u>Power Steering Pump</u>
Manufacturer: Vickers
Model: 7605-5256

m) <u>Windshield Wipers</u>
Manufacturer: American Bosch
Model: WWC-12L
Type: Electric

n) <u>Radiator</u>
Manufacturer: Blackstone
Model: 7605-3950

o) <u>Air Cleaner</u>
Manufacturer: FAAR
Model: 62891-3

p) <u>Driver’s Seat</u>
Manufacturer: Bostrom
Model: Four-Way Adjustable
Type: Standard

q) <u>Wheels</u>
Front:
    Manufacturer: Firestone
    Size: 22.5 x 16.5
<u>Rear:</u>
    Manufacturer: Firestone
    Size: 20 x 8.5

r) Tires

Front:
- Manufacturer: Goodyear
- Size: 16.5 R 22.5 - 18 P.R.
- Capacity: 20,000

Rear:
- Manufacturer: Michelin
- Size: 12:00 R 20X - 18 P.R.
- Capacity: 31,000 lbs.

s) Muffler

Manufacturer: Nelson
Model: 86130-21

t) AC Inverter

Manufacturer: Dynamote
Model: A40-120

u) Siren/PA

Manufacturer: Code 3
Model: 3100

CAPABILITIES

Fire Truck

Turning Radius - Inside 31.5’ - Outside 42.25’
Rated Power: 370 BHP @ 2,100 rpm
Engine Governor Setting: No Load -,2,100; Top Speed 58 mph
Acceleration: 0 - 35 mph - 14 Seconds
Braking: 20 to 0 mph - 15 feet
Angle of Departure: Front - 15 degrees; Rear - 15 degrees

Pump

Single Stage Centrifugal
Midship Mounted
Driven by the truck engine from the output shaft of transmission
Min discharge - 1000 gpm @ 150 psi
Min discharge - 700 gpm @ 200 psi
Min discharge - 500 gpm @ 250 psi
From dry condition - take suction and discharge water in 30 sec. with a lift of 10 deg. through 20’ of 6" suction hose
12 VDC Priming Pump
Water Tank - 200 gals.

Ladder

Basic Weight - 11,560 lbs.
Outrigger Operation Speed
Lower: Front - 9 sec. Rear - 18 sec.
Raise: Front - 9 sec. Rear - 18 sec.
Complete extension, elevation and 90 degrees rotation within 60 sec.
Hydraulic Tank: 45 gals. (Imp.)

1.3 CHASSIS ASSEMBLY

The Chassis Assembly includes the cab, truck body and frame, engine, transmission, drive lines, front and rear axles, steering, fuel, brake, and electrical systems and wheels and tires. Also included with the chassis are miscellaneous items related to the operation of the truck, such as light and sound systems, power converter, bumpers, towing hooks and mirrors.

1.3.1 Controls and Instruments

The controls and instruments necessary for the road operation of the truck, for transfer of power to the pump and ladder, and for the operation of light and sound systems are located in the cab of the truck. The following sub-paragraphs provide a brief description of the function of each component in the truck cab (for component locations, refer to Figures 1-1 through 1-4).

1. Ignition Switch - When switched on, a green lamp in the switch lights, indicating the ignition system is on.

2. Headlight Switch - Operates the headlights, tail lights, instrument panel lights and running lights.

3. Air Cleaner Restriction Indicator - Turns red when the air cleaner element requires servicing.

4. Engine Coolant Temperature Gauge - Indicates the temperature of the coolant.

5. Warning Lights - Indicate a malfunction in one of five systems: low engine oil pressure, high engine coolant temperature, low air pressure in front air system, low air pressure in rear air system, and high automatic transmission fluid temperature. The warning light is mounted next to the gauge for each system being monitored. In addition to the warning light, the operator is alerted to malfunctions by a loud warning buzzer. If the malfunction is in one of the "vital circuits" (low engine oil pressure, high engine coolant temperature, or high automatic transmission fluid temperature), the buzzer will sound a steady, piercing alarm. If the malfunction is low air pressure in either the front or rear system, the buzzer will sound an intermittent alarm.

6. Voltmeter - Indicates battery conditions.

7. Ammeter - Indicates amount of charge or discharge.

8. Engine Oil Pressure Gauge - Indicates the pressure of the lubricating oil in the engine.

9. Red Parking Brake Override Button - Used in emergencies to release the parking brake when the ladder is not on its bed. Press and hold down the button and then move the truck. When the button is released, the parking brake will automatically re-set.

10. Tachometer - Indicates the engine speed in revolutions per minute.

11. Hourmeter - Indicates the number of hours the engine has operated. The hourmeter is activated by engine oil pressure. It will not register when the master switch is on unless the engine is running.

12. Turn Signal Indicator Lights - Blink to indicate the direction of turn when the Turn Signal Lever is used.

13. Parking Brake Light - Will light when the parking brake is applied. It will remain lit until the yellow park brake button (Item 23) is pushed to release the brakes.

14. Headlight High-Beam Indicator Light - Glows a bright blue when the headlights are on high-beam.

15. Speedometer/Odometer - Indicates the truck speed in miles per hour and kilometers per hour. The odometer records the total number of miles travelled.

16. Fuel Level Gauge - Indicates the amount of fuel in the fuel tank.

17. Air Pressure Gauge - Front Brakes - This gauge works in conjunction with the low-air warning lights and buzzer. Normal operating pressure is 120-125 psi.

19. Automatic Transmission Oil Temperature Gauge - Indicates the temperature of the oil in the transmission. Normal operating range is 160 degrees to 220 degrees F. Maximum allowable temperature is 250 degrees F.

20. Air Pressure Gauge - Rear Brakes - This gauge works in conjunction with the low-air warning lights and buzzer. Normal operating pressure is 120-125 psi.

22. Black Shut-off Handle - Pull out to stop engine. Push in to start.

23. Parking Brake Control (Yellow) - Controls the application and release of the spring brakes. To apply brakes, pull the button out. To release, push the button in.

24. Emergency Spring Brake Release Control - The green button will temporarily release the spring brakes.

25. Windshield Wiper Controls - Control the speed of the windshield wipers. Left-hand control is for the wiper on the driver's side; right-hand control is for the wiper on the passenger's side.

26. Heater Fan Speed Control - Provides three fan-speed positions.

27. Heater/Defroster Control - Controls the amount of air going to the adjustable flow deflectors mounted on the top of the dash.

28. Temperature Control - slides to the right to increase temperature and to the left to decrease.

29. Windshield Washer Control - Set to down position, provides washer fluid onto windscreen. The reservoir is located under the right side of the canopy (see Figure 1-2).

30. Horn Selector Switch - Selector is used to select air or electric mode of operation for the vehicle horn.

31. Pump Engaged Indicator Light - When lit, indicates the pump is engaged with the power train and the truck drive train is disengaged.

32. Pump Power Shift Control - Controls the transfer of power from the truck drive train to the Hale pump. In the OUT position, the pump is engaged; when pushed IN, the truck drive train is engaged.

33. Jacobs Brake Control Switch - Controls Jacobs engine brake.

34. Ladder PTO Switch - ENGAGED/DISENGAGED switch engages the power-take-off (PTO) controlling the ladder hydraulics.

35. Master Switch Indicator Light - Lights when the Master Battery Selector Switch is turned to "BATTERY 1".

36. Ladder PTO Indicator Light - When lit, indicates the Ladder PTO is engaged.

37. Engine Start Button - There are two engine start buttons. Either may be used to start the engine providing it has been selected by the Master Battery Selector Switch. The Master Battery Select Switch and Automatic Transmission Gear Selector are located on the floor of the cab to the right of the driver's seat (see Figure 1-3). The start button that is energized will be indicated when its associated indicator light is lit.

38. Master Switch Indicator Light - Lights when the MaSTER Battery Selector Switch is turned to "BATTERY 2".

39. Engine Start Button - Energized when Indicator Light is on.

40. Fuel Pump Switch - Controls an auxiliary fuel pump.

Two main siren switches are located on the floor, one near the base of the steering column for the driver, and one in front of the passenger position (see Figures 1-4 and 1-5).

The Cab and Canopy Lights are located in the upper left and right corners of the cab and canopy.

A pull chain, slung from the roof inside the cab, controls two air horns mounted on top of the cab roof.

1.3.2 Power Inverter

A Dynamote AC Power Inverter is located in the center of the cab. The Converter Instrument Panel includes the following gauges and controls (see Figure 1-6):

1. AC Voltage Indicator - Indicates output voltage.

2. Start and Stop Buttons - Momentary push buttons; when pushed, start and stop the operation of the Inverter.

3. Receptacles - Two 120 v convenience receptacles, a remote control receptacle and a test module receptacle are provided.

4. Fuses - Four 40 amp. input fuses, two 1!5 amp. output fuses and one 15 amp. circuit fuse are provided.

For a complete description of the Dynamote AC Power Inverter, refer to the Dynamote Power Systems Instruction Manual included in Part 2, Volume 3, Tab. 3.

1.3.3 Power Distribution

Two power distribution boxes are located on the rear cab wall above the Power Inverter. These boxes contain circuit breaker switches and control AC power distribution. The box nearest the driver controls the 125 VAC supplied to the end of the ladder. The other controls the 110 VAC supplied to each side of the truck body (see Figure 1-7).

1.4 PUMP ASSEMBLY

The pump assembly includes the Hale centrifugal, single stage pump with power shift and electric priming, and a pump control panel. Also included are miscellaneous items such as an automatic pump relief valve, a foam system, intake and output valves, and couplings and valve drains (see Figure 1-8). Power for the operation of the pump is provided by the engine through the drive shaft linkage. Power is transferred from the truck drive train to the pump by operating a pump control valve in the cab. As soon as the green indicator lamp is lit, the drive shaft has been shifted from the road to the pump position, and the transmission can then be engaged to operate the pump.

1.4.1 Pump and Valve Controls

Controls for the operation of the pump and valves are mounted on a panel on the left side of the truck body and are described in the following sub-paragraphs (for the location of gauges, instruments and controls on the Pump Control Panel, refer to Figure 1-8):

1. Pump Pressure Gauge - Indicates water pressure. The pressure is controlled by engine RPM.

2. Hydrant Pressure and Vacuum-Compound Gauge - Indicates the pressure output from the hydrant when connected to the truck, and the inches of vacuum at the priming pump when priming.

3. Engine RPM Dial - Indicates engine speed.

5. Oil Pressure Gauge - Indicates engine oil pressure.

6. Water Temperature Gauge - Indicates engine coolant temperature.

7. Hourmeter - Indicates hours of pump operation.

8. Water Tank Gauge - Lights indicate level of water in the truck water storage tank.

9. Panel Light Switch - Controls lights for illuminating the Pump Control Panel for night operations.

10. Hose Discharge Pressure Gauges - Numbered gauges indicating nozzle discharge pressure in corresponding outlets.

11. Tank Fill Control Valve - Opens the fill valve to the main storage tank.

12. Water Tower Control Valve - Controls water pump discharge from the pump to the Water Tower.

13. Tank Suction Control Valve - Controls pump suction from the Truck Water Tank to the pump.

14. 1 1/2" Control Valve - Controls the No. 2, 1 1/2" discharge control valve.

15. 1 1/2" Control Valve - Controls the No. 1, 1 1/2" discharge control valve.

16. to 19. 2 1/2" Control Valves - Control water supply to the 2 1/2" hoses.

20. Pump By-Pass Valve - Controls the pump by-pass to the main truck storage tank for pump cooling.

21. 2 1/2" Discharge Couplings - Couplings for 2 1/2" hoses for discharge outlets No. 1 and No. 2.

22. 2 1/2" Drain Valves - Drain 2 1/2" valves.

23. Pump Primer - Primes pump for initial operation.

24. 6" Suction Coupling - Coupling for 6" suction hose.

25. RPM Test Connector - Not used by operator.

26. 2 1/2" Suction Couplings - Coupling 2 1/2" suction hose to pump.

27. Hose Drain Valve - Provides for draining 2 1/2" hose.

28. Water Tower Drain Valve - Drains the water tower plumbing.

29. to 30. 1 1/2" Hose Drain Valve - Drain No. 1 and No. 2, 1 1/2" hoses respectively.

31. Relief Valve Drain - Provides for draining the Relief Valve.

32. Main Pump Drain Valve - Drains the main pump, dials, gauges and lines.

33. 2 1/2" Suction Control Valve - Controls intake for 2 1/2" suction hose.

34. Pressure Relief Valve Control - Sets pressure at which the Relief Valve will automatically operate.

35. Dump Valve - Dumps the pump suction chambers when there is a pressure overload. Factory-set at 200 lbs; adjustable to desired pumping pressure.

36. Pressure Relief Valve Indicator - When lit, indicates main pump pressure is over pre-set level and relief valve is dumping.

37. Dynamote Inverter START/STOP Switch - Controls operation of the Inverter from the pump panel.

38. Dynamote Inverter Voltage Meter - Indicates voltage output of the Inverter.

39. Foam Tank Valve - Controls movement of foam from the foam tank to the main pump.

40. Foam Metering Valve - Controls mix of water and foaming agent.

41. Throttle Control - When pulled out, increases engine RPM; counter-clockwise rotation provides fine adjustments for RPM advance, and clockwise provides fine adjustments for RPM retard.

42. Quick Release for Throttle Control - Slam button quickly reduces engine RPM.

43. Foam Flush Valve - Open to flush the foam agent out of the system.

44. Engine Cooling Valve - Controls the flow of water for engine cooling.

45. Foam Mix Valve - Introduces water to the foam educator.

46. Foam Tank Drain - When opened, drains the foaming agent from the foam tank. The Water Tank Drain Valve is located under the running board on the left side of the truck, immediately aft of the front outrigger.

47. and 48. Manufacturing Test Points - not used by operators.

49. Dynamote Pilot Light

50. Pump Engaged Indicator Lamp - When lit, indicates the drive shaft has been shifted from the road to the pump position.

Two 2 1/2" Water Tower inlet couplings with control and drain valves are located at the rear of the truck (see Figure 1-9). Two 2 1/2" discharge couplings with control valves and drain valves are located on a panel on the right side of the truck body (see Figure 1-10). The control valves for these outlets are coupled to the corresponding controls at the main panel on the left side of the truck body. This dual control feature allows these valves to be operated from either side of the truck. Also included on right side panel is a 6" suction coupling, and lights to illuminate the panel for night operation.

1.4.2 Summary of Water Suction/Discharge Couplings

6" Suction - Front 1 (provided with control valve and drain for use when receiving 6" suction under pressure).
- Left Control Panel 1
- Right Control Panel 1
Total - 3

2 1/2" Suction - Left Control Panel 2
Total - 2

2 1/2" Discharge - Left Control Panel 2
- Right Control Panel 2
Total - 4

1 1/2" Discharge - Top of Water Tank 2
Total - 2

2 1/2" Inlet - Rear of truck for Water Tower from external source

TOTAL - 2

1.5 LADDER ASSEMBLY

The Ladder Assembly (see Figure 1-11) includes three ladder sections, a sub-structure, a turntable, a control console, outriggers and a water tower. It also includes a hydraulic system for raising, lowering and turning, a plumbing system to carry water to the water tower, and a winch and cable system to extend and retract the ladder sections. Also included are miscellaneous items such as lights, intercommunication and manual controls.

The ladder hydraulics are powered by a PTO, controlled by a switch in the cab (see Figure 1-1, number 34). When the ladder PTO switch is switched to ENGAGED, the ladder hydraulics are energized and, at the same time, ladder securing clamps are automatically released. Hydraulic pressure for the ladder is controlled via engine RPM. Ladder operation is controlled at the Ladder Control Console located to the right of the ladder turntable.

Before the ladder can be deployed it is necessary to position the ladder outriggers, located on each side of the truck body. The outriggers provide a wide solid base for the ladder, giving the unit extra rigidity and strength. Large removable outrigger pads are stowed in the truck body near the outriggers for use in soft ground.

The outriggers are controlled from panels located near the rear outriggers, see Figures 1-12 and 1-13. Outriggers on each side of the truck are controlled in pairs.

1.5.1 Outrigger Controls - Left Side

For location of Left Outrigger Controls, see Figure 1-12.

1. Panel Light - Illuminates the Outrigger Control Panel for night operations.

2. Engine RPM Dial - Indicates engine RPM.

3. Engine Oil Pressure - Indicates engine oil pressure.

4. Engine Coolant Temperature - Indicates engine coolant temperature.

5. Water Pump Pressure - Indicates discharge pressure.

6. Panel Light Switch - Controls the panel light.

7. Engine Throttle Button - Controls engine RPM.

8. Electric Pump Indicator Lamp - Indicates when the electric pump is energized.
9. Manual Hydraulic Pump - Used for manual hydraulic operations.

10. Electric/PTO Pump Switch - UP position switches Electric Hydraulic Pump ON and the engine throttle button operates the pump; DOWN position for normal operation.

11. Outrigger By-Pass Switch - OFF position disables ladder movement until the outriggers are deployed. ON position, allows ladder movement without deploying outriggers.

12. Manual Hydraulic Pump Control Valve - Controls the action of the manual hydraulic pump.

13. Ladder/Outrigger Selector Control Valve - When pushed in operates ladder; when pulled out operates outrigger.

14. Outrigger Control Valve - Push down to extend the outriggers and pull up to retract.

15. Hydraulic Pressure Gauge - Indicates hydraulic pressure when outriggers are moving.

1.5.2 Outrigger Controls - Right Side

For location of Right Outrigger Controls, see Figure 1-13.

1. Engine Throttle Button - Controls engine RPM.

2. Electric Pump Indicator Lamp - Indicates when the electric pump is energized.

3. Outrigger Control Valve - Push down to extend outriggers and pull up to retract.

1.5.3 Ladder Controls

As soon as the outriggers have been positioned, the ladder may be deployed. For the location of ladder controls on the Ladder Control Console, refer to Figure 1-14.

1. Hydraulic Pressure Gauge - Indicates hydraulic pressure which will vary depending on the amount of effort required for ladder functions such as extension, elevation and rotation.

2. Console Speaker Volume Control - Controls the volume of the output from the end-of-ladder speaker.

3. Push-to-Talk Switch - When pushed, allows the operator to transmit to the end-of-ladder speaker.

4. Console PA Speaker - Allows the operator to converse with personnel at the end of the ladder.

5. End-Ladder Speaker Volume Control - Controls the volume of the output from the console speaker.

6. Ladder Load Gauge - Indicates the load on the ladder.

7. Automatic Stop Lamp - Lights automatically when the ladder is overloaded.

8. Energy On Control Light - When lit, indicates there is current to the electrically operated controls at the ladder control console.

9. Ladder Load Dial - Indicates ladder inclination in degrees (0 to 75) and suggests maximum ladder extension permissible for varying load conditions.

10. Water Tower Nozzle Pattern Select Switch - Selects spray or fog mode for the water tower nozzle delivery.

11. Water Tower Nozzle Sweep Control Switch - Controls movement of nozzle left and right.

12. Water Tower Nozzle Elevation Control Switch - Controls elevation and depression of water tower nozzle.

13. Ladder Elevation Control Joystick - Controls ladder elevation and depression.

14. Ladder Console Throttle Button - When engaged, increases engine RPM.

15. Ladder Rotation Control Joystick - Controls ladder movement left and right.

16. Emergency Override Button - When engaged, will override automatic overload stop and allow extra extension or depression of the ladder during emergencies.

17. Cut Off Button - Used to cut off current to the Ladder Control Joysticks and stop ladder movement if the ladder does not respond correctly to the actions of the Joysticks. Push down to cut off current and pull up to restore current to the Joysticks.

18. Ladder Extension Control Joystick - Controls ladder extension and retraction.

19. Engine Start Button - Allows the operator to restart a stalled engine at the Ladder Control Console.

20. Control Panel Light Switch - Controls panel illumination.

21. Ladder Extension Dial - Indicates in feet the length the ladder is extended.

22. Water Tower Pressure Gauge - Indicates water pressure to the water tower.

1.5.4 Ladder Auxiliary Controls

In the event the ladder does not respond or responds incorrectly to the actions of the Ladder Control Joysticks, the ladder can be positioned using the Ladder Auxiliary Controls located in the compartment under the Ladder Control Console, see Figure 1-15.

1. Ladder Extension Auxiliary Control Lever - Controls ladder extension and retraction. This lever is also used to extend the ladder beyond the automatic extension and retraction stops.

2. Ladder Rotation Auxiliary Control Lever - Controls ladder movement left and right.

3. Ladder Elevation Auxiliary Control Lever - Controls ladder elevation and depression.

2. OPERATING INSTRUCTIONS

2.1 INTRODUCTION

Operating instructions for the QWT 85 are described under the main headings: Chassis Operation, Pump Operation and Ladder Operation.

2.2 CHASSIS OPERATION

Before operating the truck, ensure that:

a) daily checks have been carried out (see Section 3),

b) the outriggers are stowed and properly secured,

c) the ladder is correctly positioned and secure in its bed,

d) the power-take-off (PTO) control in the cab (see Figure 1-1, number 34) is DISENGAGED (this will ensure the hydraulic oil pump is not operating and the ladder securing clamps are locked), and

e) the Pump Power Shift Control is pushed in and the "pump engaged" indicator is not lit (see Figure 1-1, number 31 and 32).

2.2.1 Starting the Engine

WARNING

All internal combustion engines emit various fumes and gases while running. Do not start or run the truck engine in a closed or poorly ventilated building where the exhaust gases can accumulate.

To start the engine:

a) Ensure the engine Shut-Off Handle is pushed in all the way (see Figure 1-1, number 22).

b) Place the Transmission Selector in neutral.

c) Turn the Master Battery Selector Switch (see Figure 1-3) to the "BOTH" position. Two clicks should be heard when the switch is turned to "BOTH".

d) Turn on the ignition switch (See Figure 1-1, number 1)

e) Push a starter button and depress the accelerator slightly.

f) After the engine starts, run at 1400 to 1600 RPM to build up air pressure quickly, and start the alternator operating.

g) Push the Parking Brake Control Button in to release the spring brakes. Wait until the red parking brake light goes off before attempting to move the vehicle.

CAUTION

When the Parking Brake Light (See Figure 1-1, number 13) is on, it indicates that the spring brakes are still applied. If the light does not go out when the yellow dash control is pushed in, DO NOT attempt to drive the truck until the malfunction is corrected.

h) The low air pressure warning light and buzzer will be on until both the front and rear brake systems have approximately 75 psi pressure.

CAUTION

If the engine does not start within 15 seconds, release the starter button and allow the starter motor to cool for 60 seconds. Then repeat steps d through f.

2.2.2 Stopping the Engine

To stop the engine:

NOTE: It is important to idle the engine three to five minutes before shutting it down. This allows lubricating oil and coolant to carry heat away from the combustion chamber, bearings, shafts, etc.

a) Bring the truck to a complete stop using the service brakes.

b) Shift the transmission selector to neutral.

c) Set the parking brakes by pulling out the Parking Brake Control Button.

d) Pull out the Shut-Off handle to stop the engine. Push the handle back in when the engine has stopped.

CAUTION

Do not turn the Master Battery Selector Switch to the OFF position until the engine has completely stopped. Switching to OFF before the engine has stopped will damage the electrical system.

e) Turn off the ignition switch.

f) Turn the Master Battery Selector Switch to the OFF position. Two clicks should be heard when the switch is turned OFF.

2.2.3 Emergency Starting

WARNING

Using jumper cables to start the truck with a battery from another vehicle requires care and caution to avoid personal injury and damage to the vehicles. Never expose a battery to open flame or electric sparks. Wear eye protection when working near a battery to avoid injury in case of explosion.

To start the engine using jumper cables:

a) Position the vehicle so the jumper cables will reach easily between the batteries. DO NOT ALLOW THE VEHICLES TO TOUCH.

b) Turn off all electric motors and accessories in both vehicles. Turn off all lights not needed to protect the vehicles or to light the work area. In both vehicles, turn off the Master Battery Selector Switch, apply the parking brake and shift the transmission to neutral.

c) Connect the first jumper cable from the positive terminal on one battery to the positive terminal on the other battery. NEVER CONNECT POSITIVE TO NEGATIVE.

d) Connect one end of the jumper cable to the negative terminal on the good battery.

e) Connect the other end of the second cable to a solid, stationary, metallic point on the vehicle with the discharged battery. Make this connection at least 18" away from the battery location.

f) With the battery cables properly attached, start the engine of the vehicle with the charged battery. Run the engine at moderate speed.

g) Start the engine in the vehicle with the discharged battery.

h) Remove the battery cables by reversing the above sequence exactly.

2.2.4 Operations Inside the Cab

Position the truck as close as possible to the desired location. Always position the truck on firm ground; the rear wheels and outriggers should never be on soft ground, over covered pits, wells or manholes. When the truck is properly positioned:

a) With the Transmission Selector in drive or reverse, switch the PTO to ENGAGED (the PTO Engaged Indicator Light indicates the Ladder Securing Clamps are released and the Hydraulic Pump is engaged.

b) Shift the Transmission Selector to Neutral and let the engine idle.

CAUTION

Do not apply the foot brake while the parking brake is applied. This may cause damage to the brakes.

c) Engage the Parking Brake Control located on the instrument panel (See Figure 1-1, number 23). To engage the brakes, pull out the button.

d) Pull the Pump Power Shift knob (see Figure 1-1, number 32) all the way out (about 3/4") and turn clockwise to lock. Wait one or two seconds for the green indicator light to come on indicating that the truck drive train has shifted from "road" to "pump". In the event of a pneumatic failure, the pump may be engaged mechanically. Insert a screwdriver or metal bar through the hole in the shaft protruding from the Pump Shift located on the left underside of the truck body, between the engine and the hydraulic pump. Move the shaft IN to engage or OUT to disengage.

e) Shift the Transmission Selector to Drive after the pump indicator light has come on.

NOTE: For a complete description of the operation of the Hale model VPS Automatic Pump Shift, refer to the "Hale Pumps Operating and Maintenance Manual", Part 2, Volume 3, Tab. 14.

f) Press the Momentary Start Button on the Dynamote AC Inverter (the Inverter can be controlled from the Pump Control Panel).

NOTE: The QWT 85 may be employed as either a Pumper Truck or a Ladder Truck or a combination of both. If only the pump is to be used, delete step a). If only the ladder is to be used, delete steps d) through e).

2.2.5 Warning Light Control Panel

The Warning Light Control Panel located to the right of the vehicle Instrument Panel (see Figure 2-1) controls the following:

1. Top left roof-mounted warning light (red).
2. Top right roof-mounted warning light (red).
3. Front left warning light (red).
4. Front center Mars light (white).
5. Front right warning light (red).
6. Rear warning lights.
7. Push-button siren brake.
8. Spare positions (two).
9. Storage compartment, door open, warning light.
10. Outriggers out of rest warning light.
11. Storage compartment lights.
12. Engine compartment light.

2.2.6 Operating the Emergency Spring Brake Release Control

WARNING

When using the Emergency Brake Release there are no service brakes. Under no circumstances should the truck be moved at speeds over 2 mph.

The release control button (see Figure 1-1, number 24) will release the spring brakes so the truck can be moved to a more convenient location for repair of a main brake failure.

To operate, push the Parking Brake Release Button. At the same time push in the yellow Parking Brake Button (see Figure 1-1, number 23). This will release the spring brakes. As soon as both buttons are pulled out, the brakes will re-set.

2.2.7 Siren/PA Control Panel

The control panel for the Code 3 siren and public-address (PA) system is mounted on the instrument panel below the Warning Light Control Panel (see Figure 2-1-1).

The Code 3 siren is electronic and is coupled with the PA system. It has a range of tones including Wail, Yelp and Hi-Lo. j

Keying the microphone stops the siren and permits use of the PA without touching the Selector Switch. The siren resumes immediately after the Microphone Switch is released.

To operate the Siren/PA system:

a) Selector-Switch - Turn the switch clockwise to select one of the various modes and to turn the system on. Selecting RADIO, rebroadcasts 2-way radio messages through the outside speaker. Outside volume is controlled by pre-adjusting the radio rebroadcast trimmer and by setting the 2-way radio volume control. Selecting SIREN, produces intermittent Wail tones when the Siren Button is depressed. The tone will stop instantly when the button is released. Selecting WAIL, produces an automatic Wail tone. Selecting YELP, produces an automatic Yelp tone. Selecting HI-LO, produces an automatic Hi-Lo tone. Turn the switch counter-clockwise to the OFF position to turn the system off.

b) OFF/VOLUME Switch - Turn the VOLUME Switch clockwise to control the volume of the PA. The volume control does not affect the loudness of the siren tone or radio rebroadcast.

c) Siren Button - Pressing the Siren Button, produces intermittent Wail when the Selector Switch is in the SIREN position. Pressing the Siren Button when the Selector Switch is in either WAIL or HI-LO will override both these automatic tones with a Yelp tone. When the Siren Button is released, the automatic tone, if previously selected, will resume.

2.2.8 Operations Outside the Cab

Before operating the pump or deploying the ladder, chock the rear wheels, fore and aft, with the chocks stored in the lower center compartments on each side of the truck body (see Figure 2-2).

2.3 PUMP OPERATION

The main controls, instruments and gauges for pump operation are located on the stainless steel panel on the left side of the truck. For component locations, refer to Figure 1-8.

2.3.1 General

The pump on the QWT 85 is designed to pump up to 300 psi. Generally, there are three modes of operation: Hydrant, Static Water Supply and Water Tank. In the Hydrant mode the suction side of the pump is connected to a hydrant source, or an external source such as a second pumper. In the Static Water mode, the suction side of the pump is connected through a suction hose to a static water supply, such as a stream,, pond or storage tank. In the Water Tank mode, the pump utilizes the water stored on the truck.

When operating in any of these modes, observe the following:

a) Ensure all drain valves, drain cocks and discharge valves are closed.

b) Ensure the Relief Valve is turned fully clockwise before setting pump pressure.

When operating in the static mode, observe the following additional points:

a) Ensure the Primer Pump Oil Tank is filled and the air breather at the oil line outlet is not plugged (see Figure 2-3).

b) Ensure all suction hose couplings and suction tube caps are tightened.

c) After each use, check the system for leaks. After closing all discharge valves, drain valves and cocks, tighten all suction caps. Prime and operate the pump until the Compound Gauge (see Figure 1-8, number 2) indicates approximately 20 inches of vacuum. If the vacuum falls more than 10 inches in 10 minutes, it indicates an air leak. Shut off the engine and listen for air escaping to locate the leak. A hydrostatic check may also be necessary to locate a leak. To test suction hoses for leaks, connect the suction hose to the pump and place a suction end cap on the other end of the hose in place of the strainer. Proceed with the vacuum check.

NOTE: Leaks in suction caps may be caused by foreign matter deposited under the rubber washers, or by faulty washers or gaskets.

2.3.2 Pumping From a Hydrant

When pumping from a hydrant:

a) Attach one end of a suction hose to the hydrant and the other end to the suction inlet of the pump (if possible, flush dirt from the hydrant first).

b) Ensure the Relief Valve is turned fully clockwise (see Figure 1-8, number 34).

c) Open the suction control valve (33)

d) Open the discharge valve or valves.

e) Increase the engine RPM with the Throttle Control on the panel (see Figure 1-8, number 41) until the desired pressure is indicated on the Pump Pressure Gauge (see Figure 1-8, number 1).

CAUTION

If the Compound Gauge indicates a vacuum before the desired pressure is reached, it is an indication that the hydrant is not able to supply sufficient water to keep up with the discharge present. The volume of discharge must be reduced or cavitation may result.

f) Turn the Relief Valve counter-clockwise until the Relief Valve Indicator Light (see Figure 1-8, number 36) comes on.

g) Turn the Relief Valve clockwise until the indicator light goes out. At this point the Relief Valve is set to operate at the pressure indicated in the Pump Pressure Gauge.

h) Open the Pump By-Pass Valve (see Figure 1-8, number 20) to prevent overheating in the event all discharge valves are closed.

j) If the Engine Temperature Gauge (see Figure 1-8, number 6) indicates the engine is overheating, open the Engine Cooler Valve (see Figure 1-8, number 44) until the correct operating temperature is reached.

2.3.3. Pumping From a Static Water Source

When pumping from a static water source:

a) Park the truck as close as possible to the water source.

NOTE: Pump capacity decreases as the vertical lift increases over ten feet.

b) Attach the suction hose to the pump. Attach the strainer to the opposite end of the suction hose and submerge in the water. The strainer end should be submerged at least two feet below the surface, to avoid air entering the system. This can happen as a result of the whirlpool effect created by the pumping operation.

c) Close all discharge valves, drain valves or drain cocks.

d) Pull the Priming Pump Handle (see Figure 1-8, number 23). In ten to thirty seconds water will enter the main pump and the Pump Pressure Gauge will indicate a rise in pressure.

e) Open a discharge valve slowly.

f) When a full, steady stream is flowing through the discharge hose, push the Priming Pump Handle.

CAUTION

If the priming pump does not discharge water within 30 seconds, do not continue to operate. Stop and check for air leaks.

g) Open the throttle slowly until the desired pressure is reached, as indicated on the Pump Pressure Gauge.

CAUTION

Cavitation can occur if the discharge volume overcomes the intake volume. Pulsating operation will take place if air leaks are present.

h) Set the Relief Valve as described under the Pumping from a Hydrant Section.

j) Open the Pump By-Pass Valve (see Figure 1-8, number 20), as necessary.

k) Employ the Engine Cooler Valve (see Figure 1-8, number 44), as necessary.

NOTE: If shut-down is required when working from a static water supply (for changing discharge hoses, etc.), reduce the discharge pressure to 30 lbs and close the discharge valves. This will prevent the pump from losing its prime if it is only a short shut-down. To resume pumping, open the discharge valve(s) and increase the engine RPM to resume operating pressure. If the pump heats up during shut-down, open a discharge valve to release a quantity of hot water.

2.3.4 Pumping From the Truck Water Tank

When pumping from the vehicle water tank:

a) Close all discharge valves, drain valves and drain cocks.

b) Pull the Tank Suction Handle (see Figure 1-8, number 13).

c) Prime the pump as described in the Pumping From a Static Water Source Section.

d) When a steady stream is flowing through the discharge hose, push in the Priming Pump Handle.

e) Set the desired discharge pressure and relief pressure as previously described.

2.3.5 Operating the Foam System

To operate the foam system, first prepare the truck for water discharge and then:

a) Pull out the Foam Mix Valve Handle (see Figure 1-8, number 45).

b) Set the Foam Metering Valve (see Figure 1-8, number 40) to the desired foam setting (operating instructions for mixing foam are inscribed on a plate mounted above the metering valve). Foam is ready to be discharged from any open discharge valve on the truck.

c) Pull out the Foam Tank Valve Handle (see Figure 1-8, number 39).

d) To stop discharging foam, push in the Foam Tank Valve Handle.

e) Open the Foam Flush Valve (see Figure 1-8, number 43) and allow water to discharge through all lines used for foam until the water runs clear.

f) Close the Foam Flush Valve.

g) Close the Foam Mix Valve.

2.3.6 Operating the Water Tower

Water can be supplied to the Water Tower at the tip of the ladder by the main pump or by hydrant pressure which are both controlled at the Pump Control Panel. Water can also be supplied by coupling a hydrant supply or another truck or pressurized water supply to the 2 1/2" suction valves located at the rear of the truck (see Figure 1-9).

The Water Tower is controlled remotely by switches on the Ladder Control Console (refer to "Ladder Operation") or directly by similar switches at the ladder tip.

To supply water to the tower, open the Water Tower Valve (see Figure 1-8, number 12). Water will discharge from the water tower nozzle until the Water Tower Valve is closed.

NOTE: If water is to be discharged from the water tower using a source other than the Vehicle Water Pump the Water Tower Valve must be kept closed.

If water is to be discharged, under control of the Pump Control Panel, through the two 2 1/2" valves at the rear of the truck, close the Water Tower Shut-Off Valve (see Figure 2-4). While this valve is closed, the water tower cannot be used.

2.4 LADDER OPERATION

The 85’ steel ladder is operated hydraulically and is controlled by a single operator from the Ladder Control Console.

2.4.1 General

The ladder assembly includes a substructure which supports the weight of the ladder in all positions. Three sections of ladder may be extended via a hydraulically driven winch. Hydraulic jacks are used to elevate the ladder from 0 degrees to 75 degrees. A ladder control console for one-man operation is part of the assembly and outriggers provide a firm, steady platform for all ladder operations. Also included are a water tower to provide remote delivery of water from the end of the ladder, a 125 VAC outlet for power tool operation and a communication system between the end of the ladder and the control console.

Before the ladder can be manipulated, the outriggers must be deployed. They are controlled from panels located in the lower compartment immediately aft of the left and right rear wheel wells. For outrigger control component locations, refer to Figures 1-12 and 1-13.

2.4.2 Lowering the Outriggers

To lower the outriggers:

a) Ensure the Outrigger Pads are deployed before lowering the outriggers if the ground is soft (see Figure 2-5).

b) Pull out the Ladder/Outrigger Selector Control Valve (see Figure 1-12, number 13).

c) Press the engine throttle button (see Figure 1-12, number 7). Pull the Outrigger Control Valve Lever (see Figure 1-12, number 14) down to deploy the outriggers. The front outrigger will deploy ahead of the rear outrigger.

d) For the right outriggers, move to the right Outrigger Control Panel. Press the engine throttle button (see Figure 1-13, number 1) and push down the Outrigger Valve Lever (see Figure 1-13, number 3).

e) Continue deploying the right outriggers until the hydraulic pressure reaches maximum and no further lifting of the truck chassis occurs.

f) Return to the left Outrigger Control Panel and repeat the lowering procedure until no further movement occurs.

NOTE: If the truck is positioned on uneven ground, deploy the outriggers on the low side first, apply pressure until the truck bed is roughly level. When the truck is level, deploy the opposite outriggers as described above. If maximum hydraulic extension is reached before the truck is level, it must be moved to more even ground.

g) Push in the Ladder/Outrigger Selector Control Valve.

2.4.3 Raising the Outriggers

To raise the outriggers:

a) Ensure the ladder is returned to its bedded position on its supports.

b) Pull out the Ladder/Outrigger Selector Control Valve.

c) Press the engine throttle button. Pull the Outrigger Control Valve Lever up to retract the outriggers. The front outrigger will retract ahead of the rear outrigger.

d) For the right outriggers, move to the right Outrigger Control Panel. Press the engine throttle button and pull up the Outrigger Control Lever to retract the outriggers. The front outrigger will retract ahead of the rear outrigger.

e) When the outriggers are fully retracted, push in the Ladder/Outrigger Selector Control Valve.

2.4.4 Ladder Movement

WARNING

Do not extend or retract the ladder with personnel standing on the ladder section, as legs and feet will be jammed between the rungs.

Ladder movement is controlled by three joysticks located on the Ladder Control Console (see Figure 1-14). The ladder can be moved when the engine is idling. However, for best operational speed, pull up the green throttle control button on the ladder control console (see Figure 1-14, number 14).

The speed at which ladder movements are performed depends on the amount of deflection of the joysticks. The joysticks control the hydraulic valves which, in turn, control the speed and movement of the ladder. Ladder movement commences the moment a deadman switch is pressed and the joystick is deflected from its neutral setting. The joysticks are spring-loaded and return to the neutral, or central, position when released. More than one joystick may be operated at the same time.

CAUTION

All joysticks must be adjusted with a slow, gentle, continuous motion until the desired speed is obtained. Avoid any fast movement, which will expose the ladder to sudden shocks. The joysticks operate somewhat like an automobile clutch pedal: i.e., a sudden movement of the joystick will cause the ladder to jerk, similar to the result of releasing the clutch pedal too fast. During night operations, it is a good practice to direct the beam of the search light, installed at the base of the ladder, to the top of the fly section so that any possible obstacles can be seen.

2.4.5 Elevating and Depressing the Ladder

To elevate or depress the ladder:

a) Pull up the green throttle control button (see Figure 1-14, number 14).

b) Press the deadman switch on top of the right joystick and pull the joystick backward to elevate, or push forward to depress. When the desired angle is reached, return the joystick to the central position and then release the deadman switch. Do not release the switch before the joystick has been returned to the central position. If the switch is released while elevating or depressing the ladder, the ladder will jerk to a stop. The angle of inclination of the ladder will be displayed in the left segment of the Ladder Load Dial, located on the Ladder Control Console (see Figure 1-14, number 9).

c) Push down the green Throttle Control Button.

CAUTION

If the ladder is extended, a relatively slow speed must be maintained when elevating or depressing. (The ladder automatically reduces speed when approaching its highest angle.)

It is vital that you do not overload the ladder. The load the ladder can support varies with the angle of inclination, the length of extension, the weight being carried and whether or not the ladder is supported. The Ladder Control Console is provided with a Ladder Load Gauge (see Figure 1-14, number 6). When the combination of ladder inclination, extention and load exceeds allowable limits, the indicator on the load gauge will register an overload, by pointing to the red section of the dial. Also, the automatic stop light will come on.

Overloading can be avoided by following the guidance parameters displayed on the Ladder Extension Dial (see Figure 1-14, number 21) and the Ladder Load Dial (see Figure 1-14, number 9) on the Ladder Control Console. The actual ladder inclination is displayed (in degrees) in the left segment of the Ladder Load Dial. The next segments indicate the safe extension of the ladder (in feet) under the load conditions: "2 MEN SUPPORTED", "1 MAN NO SUPPORT", "WATER TOWER".

The angle of inclination is normally determined by the circumstances. The guide figures on the Load and Extension Dials recommend the maximum load for a given extension, or the maximum extension for a given load, at the current inclination of the ladder. The actual extension of the ladder (in feet) is displayed on the Ladder Extension Dial.

As an example of how the guide is used: When the Ladder Inclination Dial indicates 0 degrees, it is possible to extend the ladder 71 feet with two men and the ladder supported; 58 feet with one man and the ladder not supported; or, if only the water tower is being used and is controlled remotely from the console, the ladder may be extended a maximum of 61 feet (refer to Annex A for a Ladder Load Table).

If the load indicator warns of an overload, the ladder must be retracted or elevated until the overload torque is overcome, the dial is out of the red and the automatic stop light is not lit.

2.4.6 Extending and Retracting The Ladder

To extend or retract the ladder:

a) Pull up the green Throttle Control Button (see Figure 1-14, number 14).

b) Press the deadman switch on top of the left joystick and push the joystick forward to extend, or pull to retract. When the desired length has been reached, return the joystick to the central position and release the deadman switch. Do not release the switch until the lever has been returned to the central position. If the switch is released while extending or retracting the ladder, the ladder will jerk to a stop. The length to which the ladder has been extended will be displayed in feet by the Ladder Extension Dial.

c) Push down the green Throttle Control Button.

CAUTION

To avoid shocks to the ladder start the extension and retraction operation slowly, and increase pressure on the joystick until the desired speed is obtained. Never extend the ladder more than necessary.

Generally, the ladder should be extended only after it has been elevated in the retracted position. Extension and retraction are performed by a winch, which operates at any angle of inclination. The ladder is equipped with pawls which relieve the cables from continuously supporting the entire weight of the ladder. A lever on the right side of the ladder substructure engages and releases the pawl mechanism (see Figure 2-6).

Before retracting the ladder, extend it by approximately one foot and operate the Locking Pawl Operating Lever to disengage the pawls. Perform a visual check to ensure the pawls have been disengaged before retracting the ladder. The ladder is constructed to prevent the Pawls from locking at maximum extension.

2.4.7 Rotating the Ladder

CAUTION

To avoid undue stress on the ladder, rotate to the desired position before extending. If it is necessary to rotate the ladder while it is extended, start and stop the movement slowly.

To rotate the ladder:

a) Pull up the green Throttle Control Button (see Figure 1-14, number 14).

b) Press the deadman switch on top of the center joystick and push the joystick forward to rotate the ladder counterclockwise or pull the joystick backward to rotate clockwise. When the desired position has been reached, return the joystick to the central position and release the button. Do no release the deadman switch before the joystick has been returned to the central position. If the switch is released while the ladder is rotating, the ladder will jerk to a stop.

c) Push down the green Throttle Control Button.

2.4.8 Emergency Operation

To prevent increasing an overload, the ladder is equipped with automatic controls to stop lowering and extending maneuver when it is overloaded. Automatic controls also prevent the sections from slamming against the mechanical stops when the ladder is fully extended. The mechanical stops prevent the sections from becoming disengaged from one another.

In the event of an emergency, the automatic controls may be overridden by pressing and holding down the EMERGENCY Override Button, located on the Ladder Control Console (see Figure 1-14, number 16).

To lower or extend the ladder when the automatic overload stops are engaged:

a) Retract the ladder until the hydraulic stops disengage and then lower the ladder, or

b) Press and hold down the Emergency Override Button and lower or extend the ladder using the joysticks. When the Emergency Override Button is released, the automatic overload controls will prevent further depression or extension of the ladder if the ladder is still overloaded.

CAUTION

Before pressing the EMERGENCY Override Button, ensure all joysticks are in the neutral position to prevent sudden and possibly violent movement of the ladder.

To extend the ladder beyond the automatic stops, slowly pull up the Ladder Extension Auxiliary Control Lever (see Figure 1-15, number 1) to extend the ladder until it contacts the mechanical stops. Return the lever to the central position.

NOTE: The ladder has been designed in such a way that use of the emergency facility, in cases of real emergency, will not likely have any adverse effect on the future operations or the life of the equipment. The Company reserves the right to void any warranty if it is felt there has been any abuse of the emergency facility; and that it has been employed in other than a real emergency situation and that no other normal method of operation could have saved lives or coped with the exceptional conditions encountered. The Company reserves the right to evaluate the emergency cases and act accordingly.

2.4.9 Auxiliary Operating Systems

In the event the ladder does not respond correctly to the actions of the Ladder Control Joysticks, the ladder can be positioned using the Ladder Auxiliary Controls. In the event the main hydraulic pump is inoperative, the ladder can be manipulated by an auxiliary electric hydraulic pumper, by a hand hydraulic pump or by mechanical means.

2.4.9.1 Ladder Auxiliary Controls Operation - When positioning the ladder using the Ladder Auxiliary Controls, observe the WARNINGS, CAUTIONS and NOTES in paragraphs 2.4.4 through 2.4.8.

To elevate or depress the ladder:

a) Lift up the green throttle control button (see Figure 1-14, number 14).

b) Push down the Ladder Elevation Auxiliary Control Lever (see Figure 1-15, number 3) to elevate, or pull up to depress. Return the lever to the central position when the desired angle is reached. The Ladder Load Dial (see Figure 1-14, number 9) will display the angle of inclination of the ladder.

c) Push down the green Throttle Control Button.

To extend or retract the ladder:

a) Lift up the green throttle control button (see Figure 1-14, number 14).

b) Pull up the Ladder Extension Auxiliary Control Lever (see Figure 1-15, number 1) to extend, or push down to retract. Return the lever to the central position when the desired length has been reached. The length to which the ladder is extended will be displayed in feet by the Ladder Extension Dial (see Figure 1-14, number 21).

c) Push down the green Throttle Control Button.

To rotate the ladder:

a) Lift up the green Throttle Control Button (see Figure 1-14, number 14).

b) Pull up the Ladder Rotation Auxiliary Control Lever (see Figure 1-15, number 2) to rotate the ladder counterclockwise or push down to rotate clockwise. Return the lever to the central position when the desired position is reached.

c) Push down the green Throttle Control Button.

2.4.9.2 Electric Pump Operation - The Electric Hydraulic Pump can be employed if the main hydraulic pump or PTO become inoperable. All operations possible under normal conditions can be duplicated by using the electric pump, although its main purpose is to retract the outriggers and store the ladder, if the main system fails. In an emergency, the outriggers can be extended and the ladder deployed.

To store the ladder and outriggers using the electric pump:

a) Switch the Electric Pump/PTO Pump Switch, located on the outrigger control panel, to ELECTRIC PUMP (see Figure 1-12, number 10).

b) All other operations for storing the ladder and retracting the outriggers are carried out in the normal manner, as previously described under "LADDER OPERATION".

2.4.9.3 Manual Hydraulic Pump Operation - The Manual Hydraulic Pump is used to retract the outriggers if the main and electric pumps are inoperative. The manual pump is located next to the left outrigger control panel.

To store the outriggers using the Manual Hydraulic Pump:

a) Ensure the Manual Hydraulic Pump Control Valve (see Figure 1-12, number 12) is turned fully clockwise.

b) Pull out the Ladder/Outrigger Selector Control Valve (see Figure 1-12, number 13), to select OUTRIGGER.

c) Insert the handle of the manual pump in the pump lever.

d) Move the Outrigger Control Valve (see Figure 1-12, number 14) to RETRACT, and hold in this position throughout the operation.

e) Operate the manual pump until the outriggers are retracted.

NOTE: This method is very slow and is designed for emergency use when no other hydraulic power is available.

2.4.9.4 Mechanical Operation - The ladder can be manipulated through rotation, retraction and lowering by mechanical means.

To rotate the ladder mechanically:

WARNING

Ensure all possible methods of engaging hydraulic power have been eliminated before inserting the crank into the rotating shaft. Application of hydraulic power can result in serious injury to the crank operator.

a) Insert the crank (stowed in the left outrigger hydraulic control compartment) in the rotational shaft at the rear of the turntable (see Figure 2-7).

b) Open the By-Pass Valve see Figure 2-8). Turn the crank until the ladder has arrived in the desired position.

To retract the ladder mechanically;

a) Insert the crank in the shaft located at the rear of the winch worm drive on the left side of the ladder (see Figure 2-9).

b) Open the By-Pass Valve located on the left side of the winch (see Figure 2-10).

c) Ensure the pawls are disengaged. Turn the crank until the ladder sections are fully retracted.

d) Close the By-Pass Valve.

To lower the ladder mechanically:

CAUTION

Ensure the ladder is fully retracted and is situated correctly over its travelling position before lowering. The ladder is properly positioned in rotation when the index on the ladder turntable is matched to the index on the body of the truck. (see Figure 2-11).

a) Loosen the screws on top of the two overcenter valves located on the ladder hydraulic cylinders (see Figure 2-12).

b) Pull up the Ladder Elevation Auxiliary Control Lever.

2.4.9.5 Outrigger By-Pass - If it is necessary for maintenance purposes, to operate the ladder without deploying the outriggers, the ladder disable circuit may be by-passed by switching the Outrigger By-Pass Switch (see Figure 1-12, number 11) to ON.

WARNING

Do not rotate or extend the ladder to the side of the truck without deploying the outriggers.

3. OPERATOR MAINTENANCE

Operator Maintenance for the QWT 85 is defined as: those maintenance requirements that can be carried out without the use of tools. All other maintenance is carried out by maintenance personnel during regular maintenance schedules or as required from time-to-time.

Operator maintenance consists mainly of daily checks and inspections. Faults discovered by the operator are reported to the maintenance section for repair or adjustment.

3.1 Daily Checks

To ensure the truck is ready for service, carry out the following daily inspections:

a) Make a visual inspection of the complete unit and report any deficiencies or faults.

b) Check tires for proper inflation (refer to the Vehicle Identification Plate located in the cab next to the driver's seat).

c) Check the area underneath the truck for signs of leaks and report their location.

d) Check the windshield washer fluid level and refill if needed. The fluid level in the windshield washer reservoir can be determined by looking through the engine air intake screen on the right side of the truck.

e) Check oil and coolant levels.

f) Check all lighting including high and low beams, turn signals, hazard warning flasher, brake lights, truck warning lights and spotlights.

g) Check the windshield washers and wipers.

h) After the engine has been started, check the operation of all instruments, gauges, sirens, horns and controls and report any malfunction.

j) Check the oil level in the Primer Pump Oil Tank and ensure breather hole is clear (see Figure 2-3).

k) Check the operation of the outrigger and ladder hydraulics, the hydraulic brakes and the water tower controls.

m) Check the ladder cables for damage and grease cover.

n) Before operations, ensure all drain valves and cocks are closed, all suction caps are replaced and the Pressure Relief Valve is turned fully clockwise.

p) After operations, ensure all drain valves and cocks have been opened and all water has been drained from dials, gauges, lines, valves, pumps and hoses. To avoid damage to components this procedure is particularly important in freezing weather conditions. Open the Pressure Relief Valve by turning counter-clockwise.

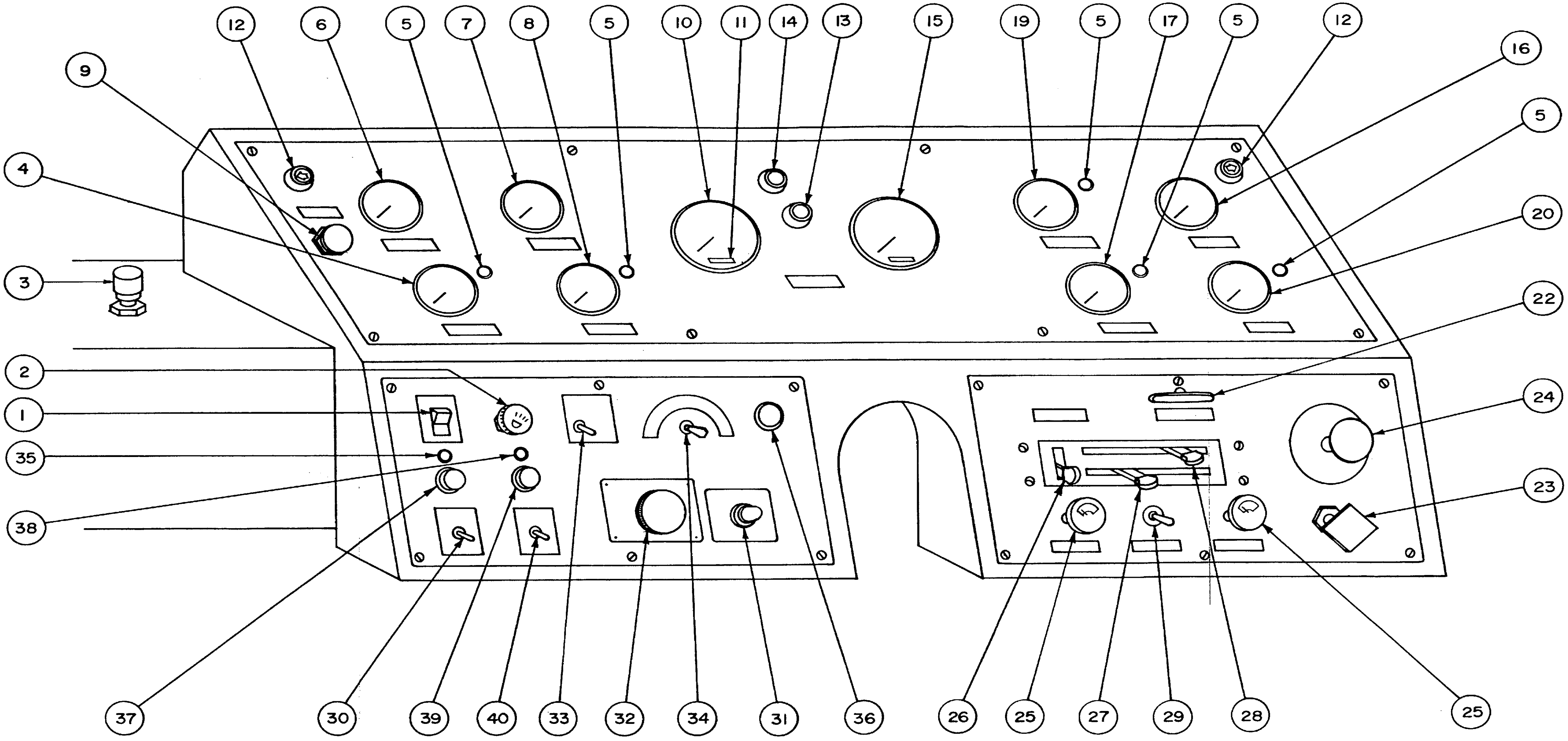
q) After pumping salt water or water containing sand or other foreign matter, couple the pump to a clean, fresh water supply and flush out the pump, gauges, valves and lines.

OPERATOR/MAINTENANCE MANUAL
PART 1
OPERATOR’S MANUAL
SECTION 4

4. ILLUSTRATIONS

4.1 General

All the illustrations and figures for the Operator’s Manual are contained in this Section. Select the desired illustration and open it out so the detail can be read. You can then turn to the supporting text and the illustration will remain in view.



See pages 7 to 11 for identification
FIGURE 1-1. Truck Instrument Panel

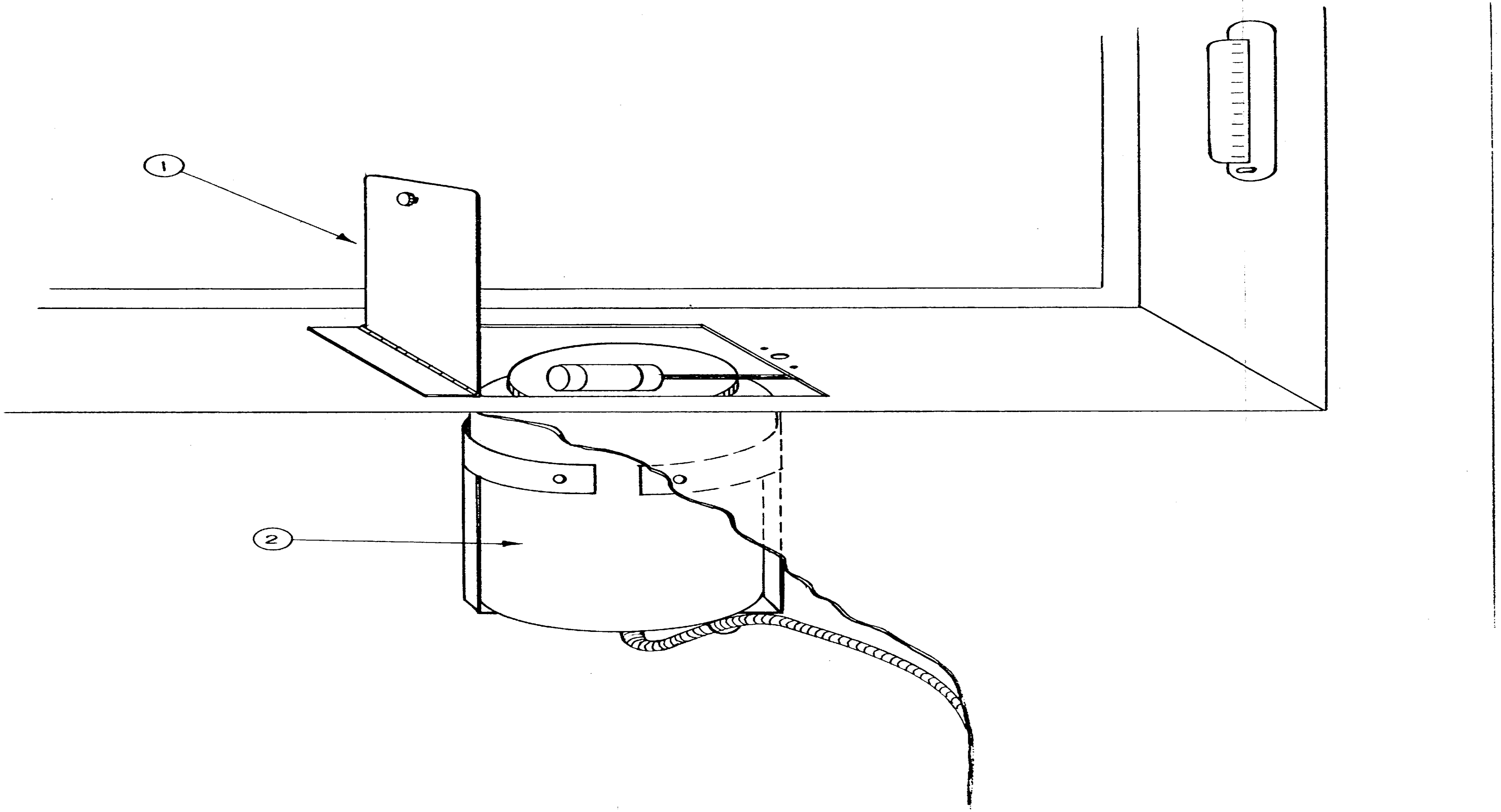


FIGURE 1-2. Windshield Washer Reservoir

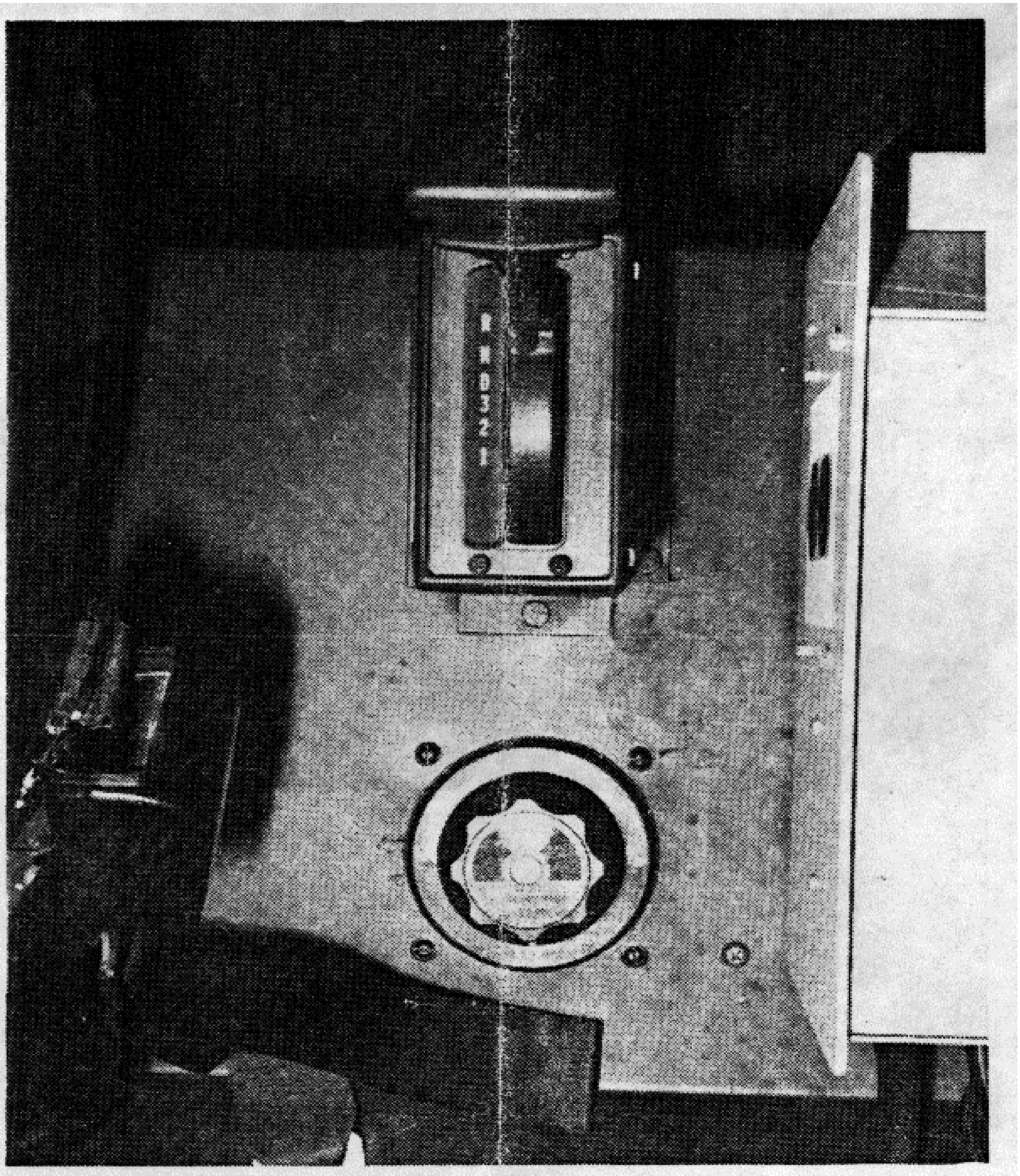


FIGURE 1-3.
Master Battery Select
Switch and Automatic
Transmission Selector
Lever

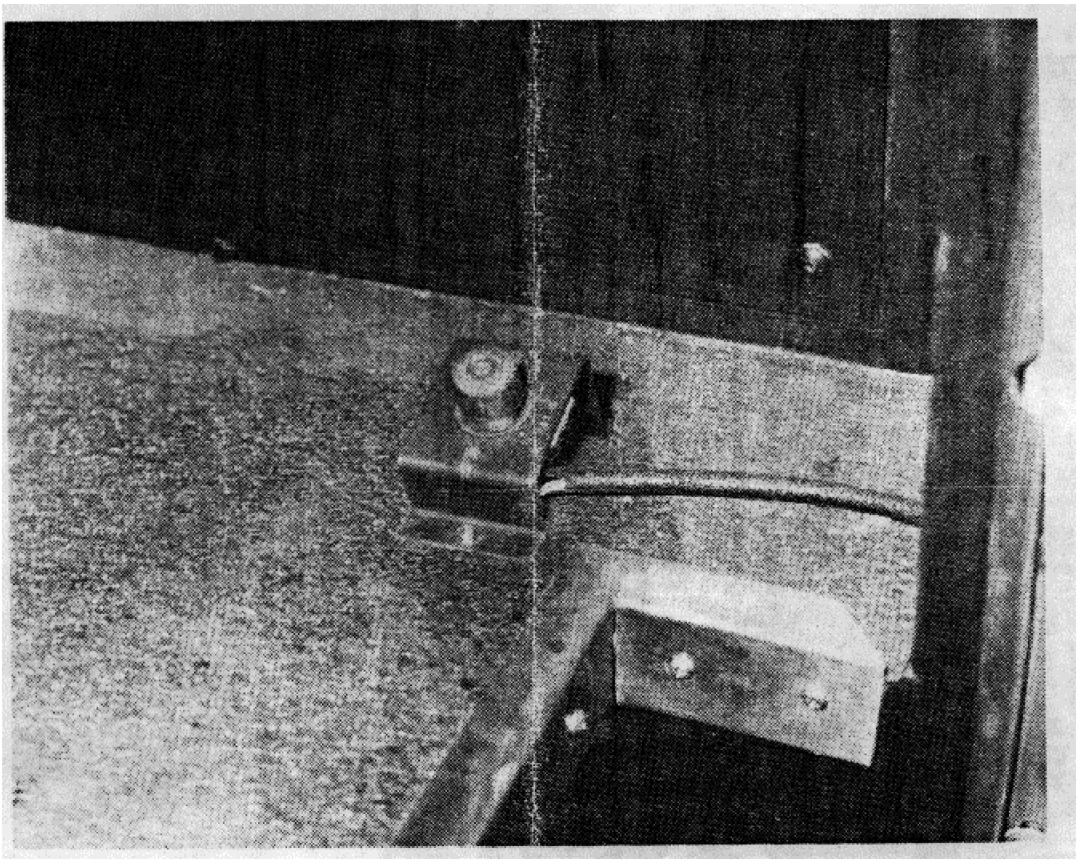


FIGURE 1-4.
Siren Switch
Side

1. Turn Signal Lever
2. Hazard Warning Indicator Light
3. Horn Button
4. Hazard Warning Flasher Switch
5. Accelerator Pedal
6. Service Air Brake Pedal
7. Headlight Hi/Low Beam Selector
8. Siren Switch

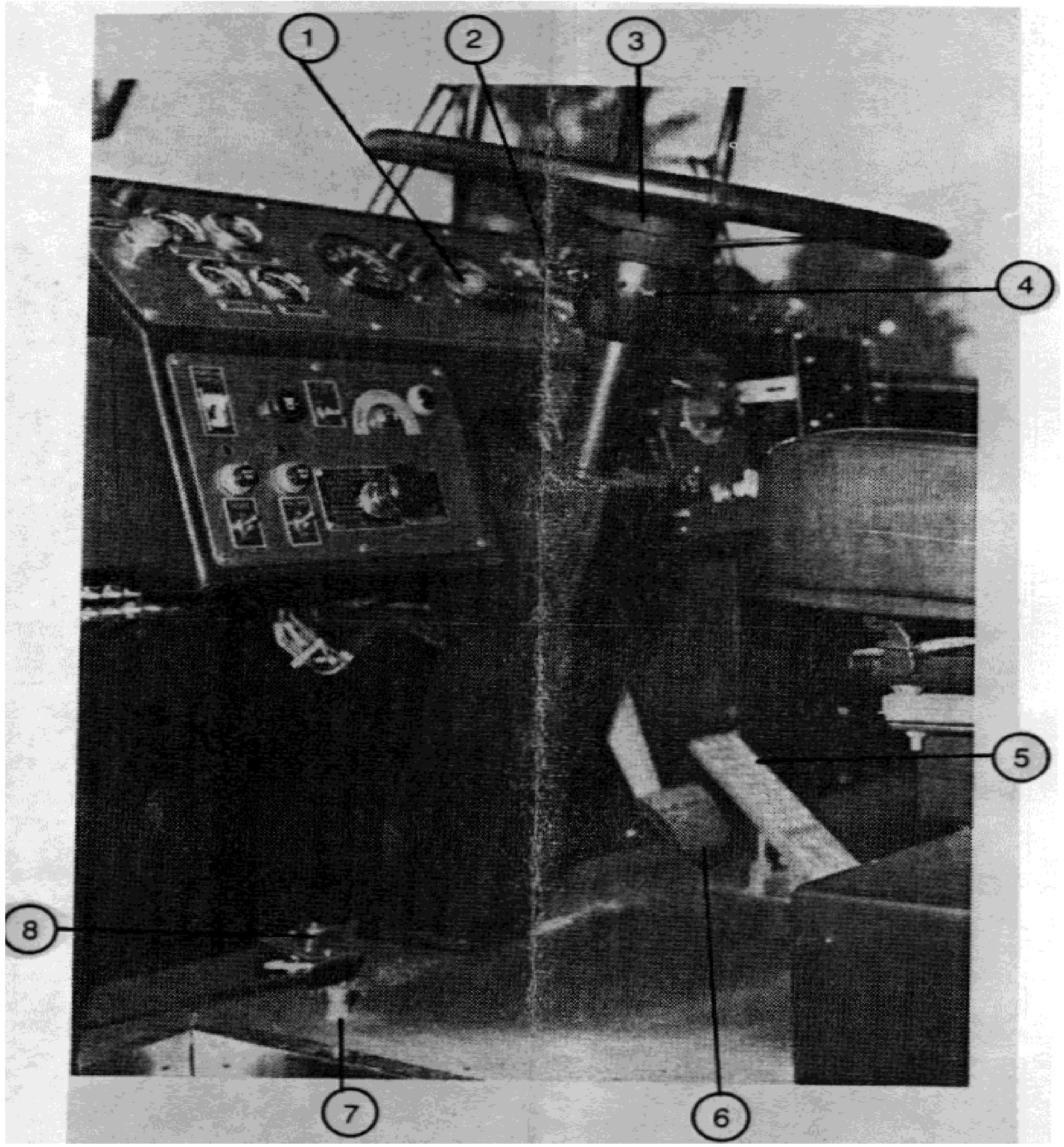


FIGURE 1-5.
Cab Interior

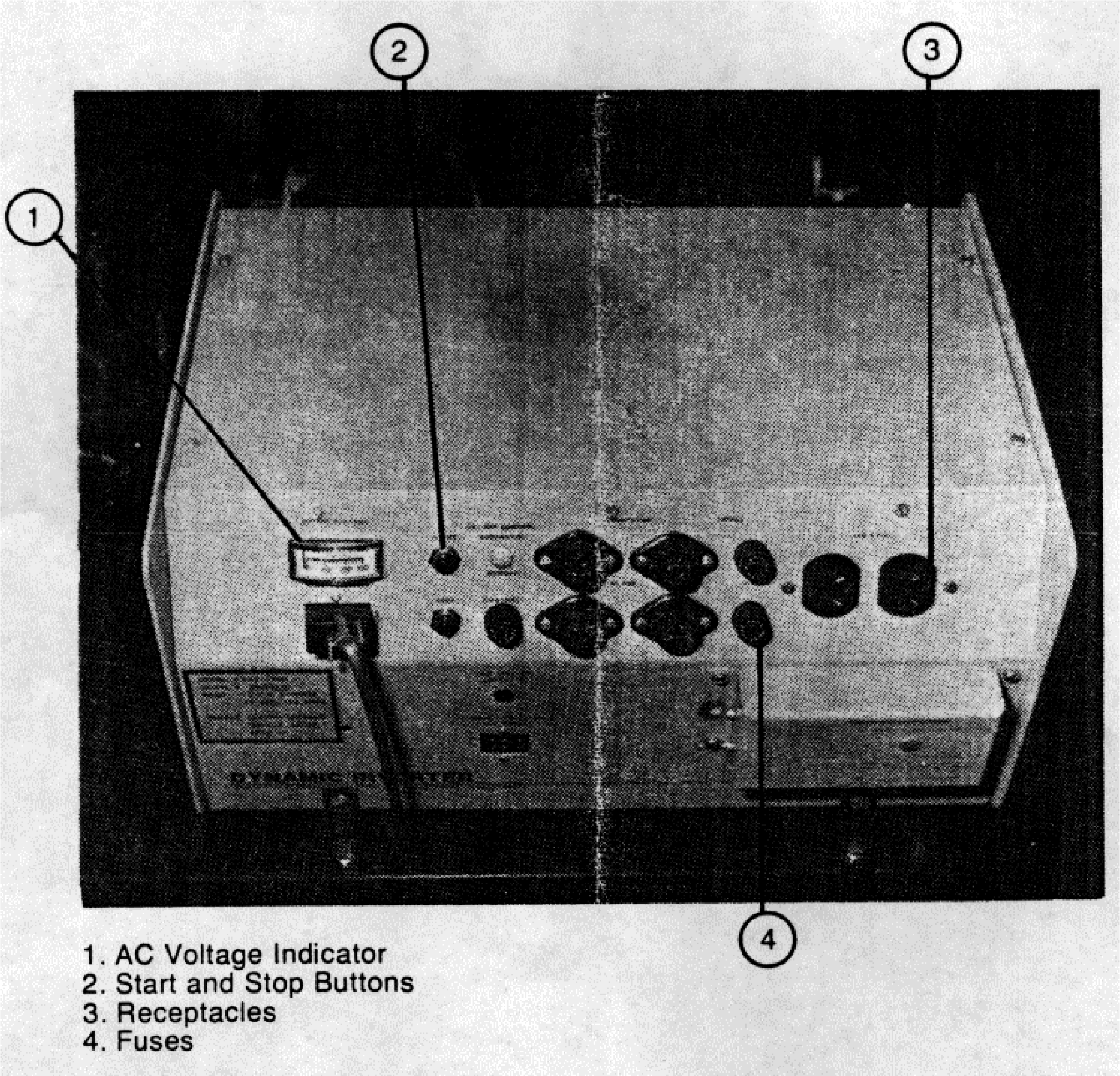


FIGURE 1-6.
Dynamote Power Inverter

1. RIGHT UPPER RECEPTACLE
2. RIGHT LOWER RECEPTACLE
3. LEFT UPPER RECEPTACLE
4. LEFT LOWER RECEPTACLE
5. FLY G.F.I. RECEPTACLE

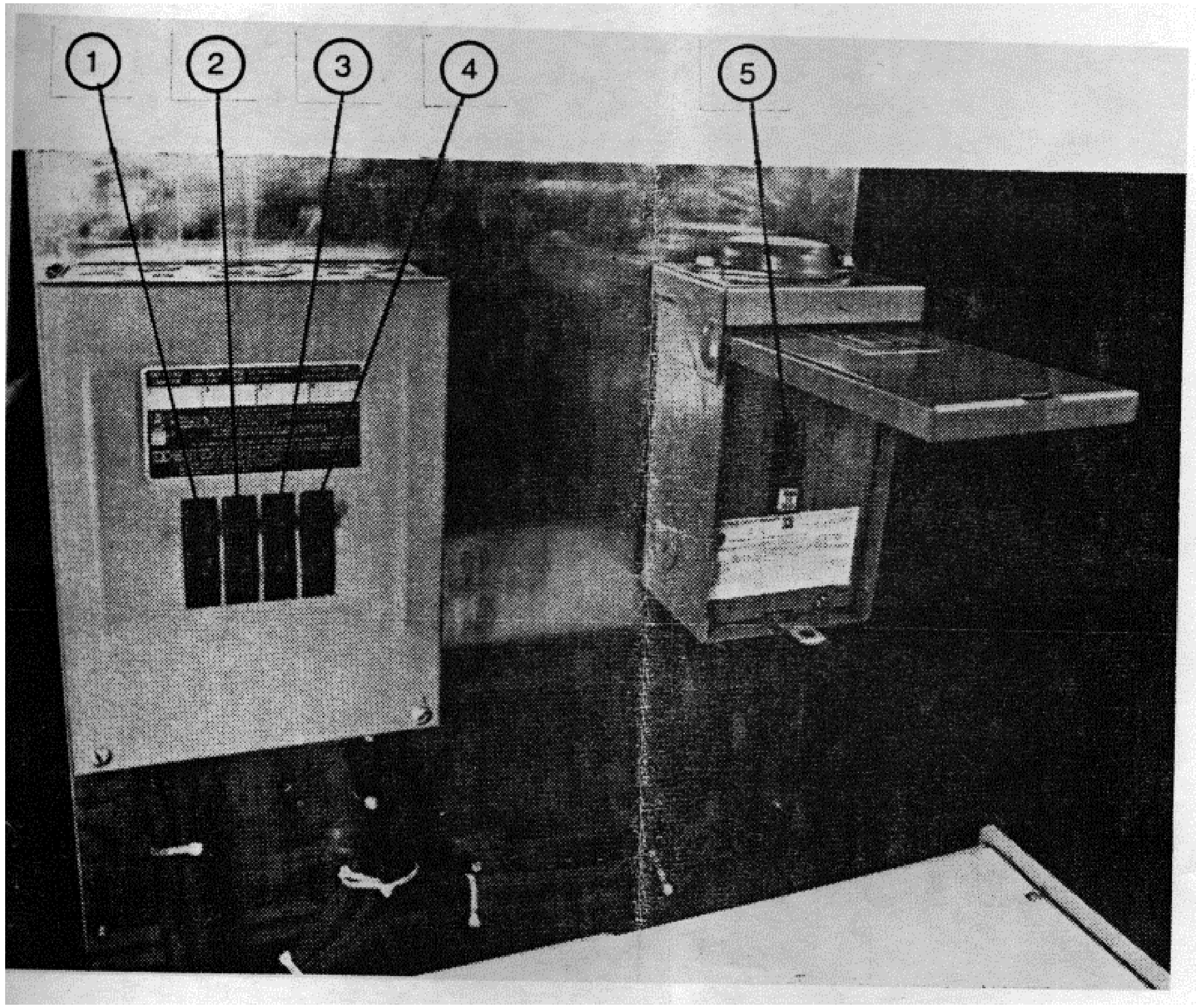
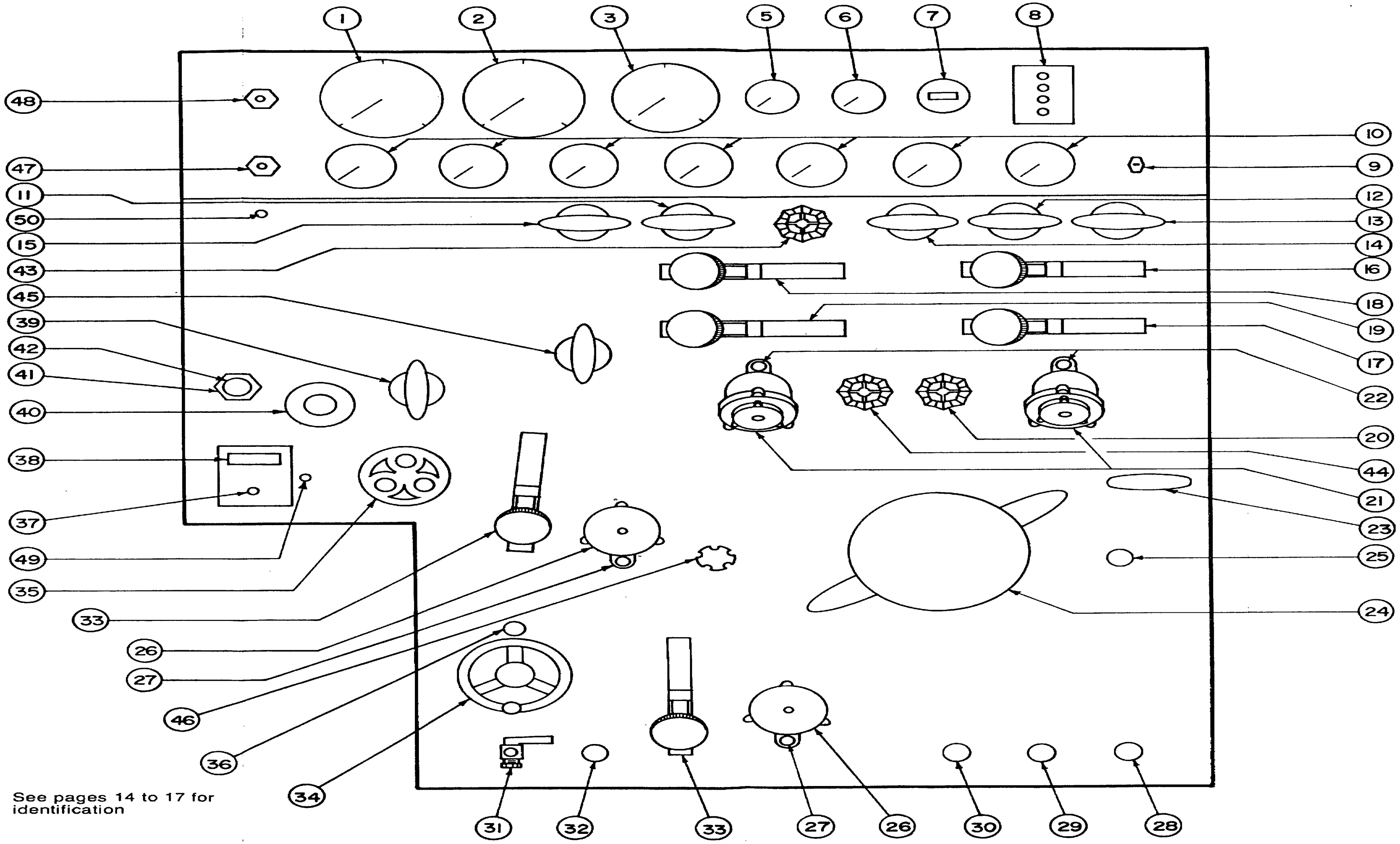


FIGURE 1-7.
Power Distribution Boxes



See pages 14 to 17 for identification

FIGURE 1-8.
Pump Control Panel
- Left Sdie

1. Cab Buzzer Switch
2. 2 1/2" Couplings
3. 2 1/2" Drain Valves
4. Battery Charging Connectors
5. Backing Siren

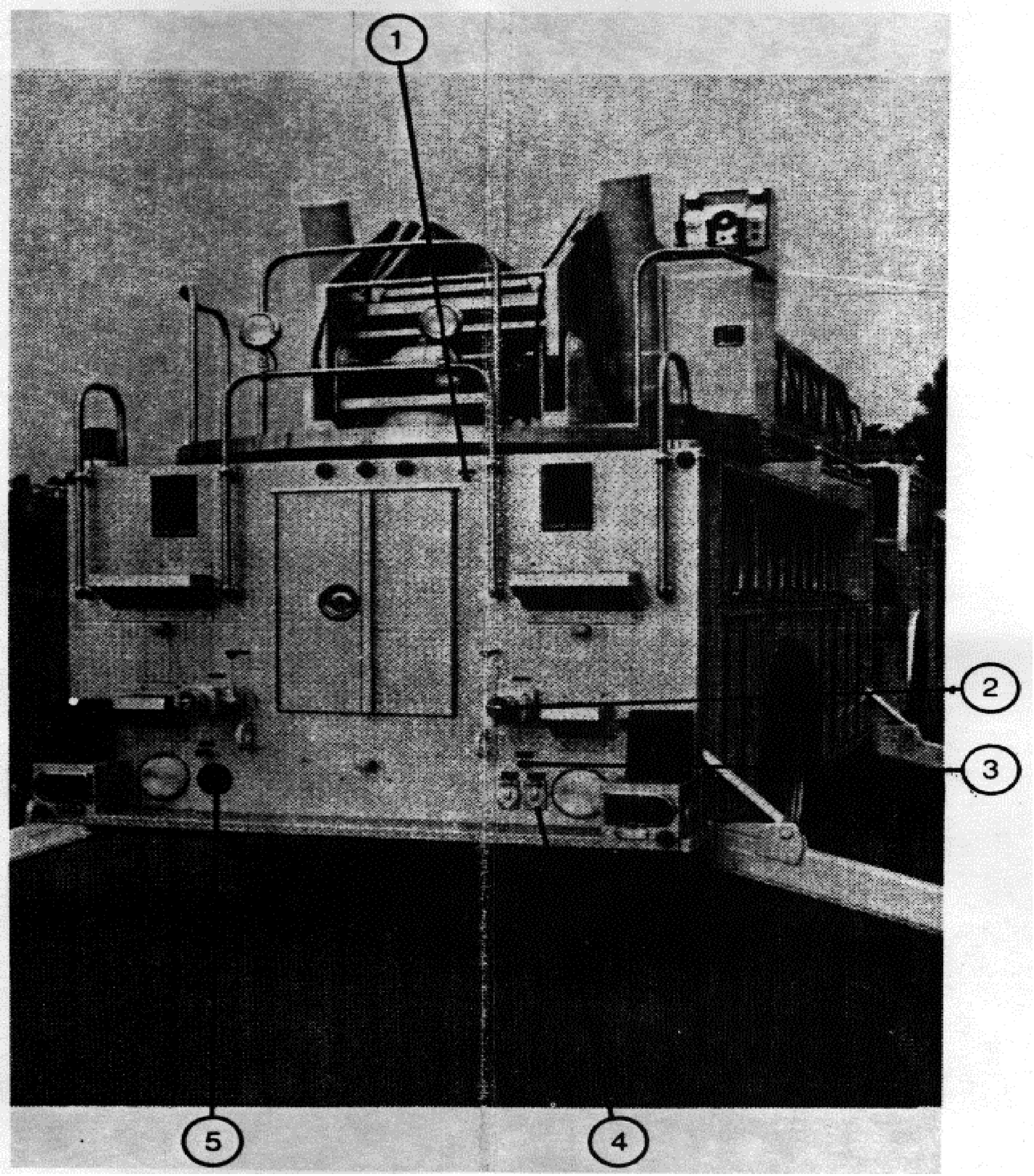


FIGURE 1-9.
Truck - Rear View

1. Panel Light
2. 2 1/2" Suction Control Valve
3. 2 1/2" Drain Valve
4. 2 1/2" Suction Coupling
5. 6" Suction Coupling

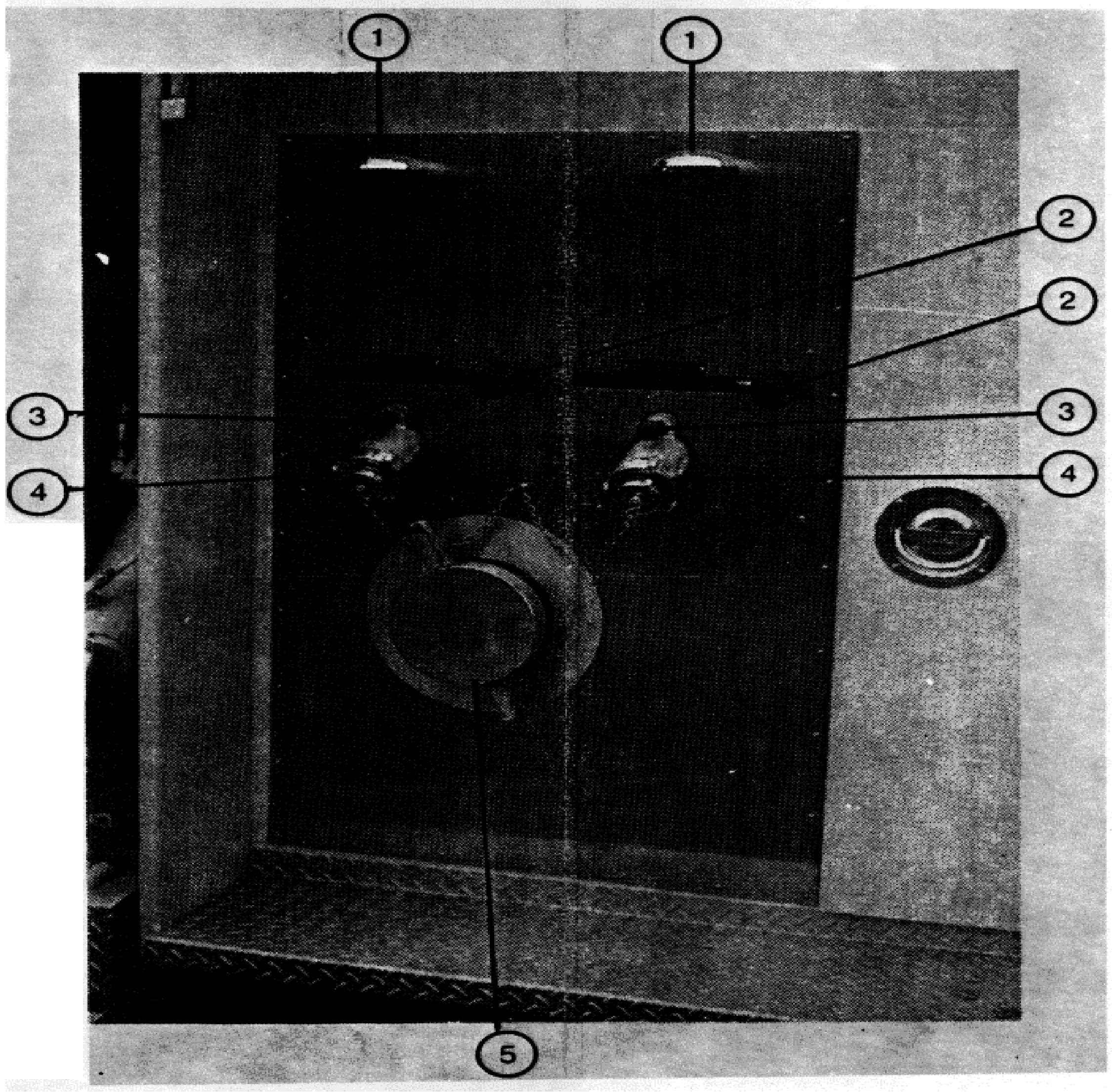


FIGURE 1-10.
Pump Control Panel
Right Side

1. Ladder Sections
2. Turntable
3. Outrigger
4. Water Tower

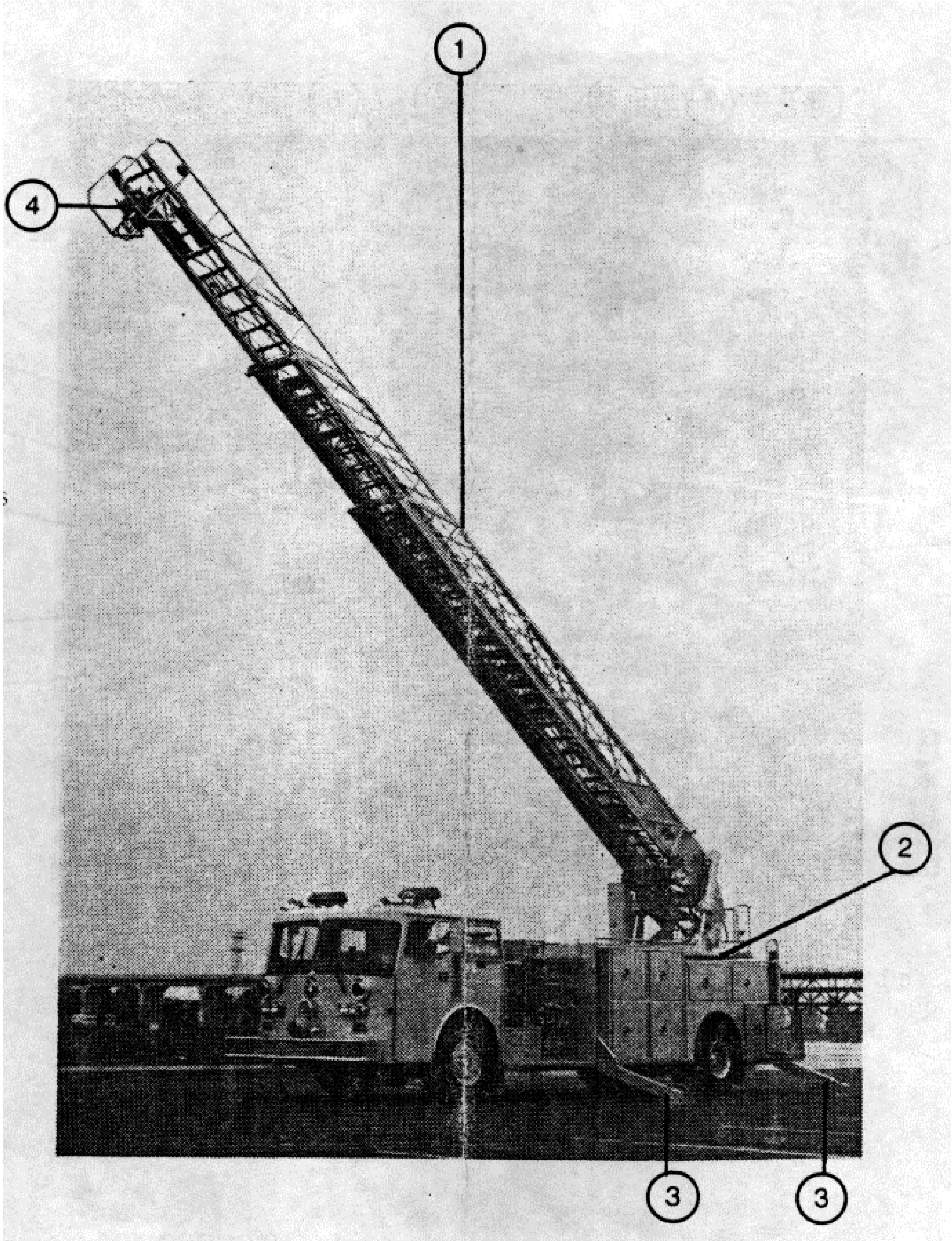
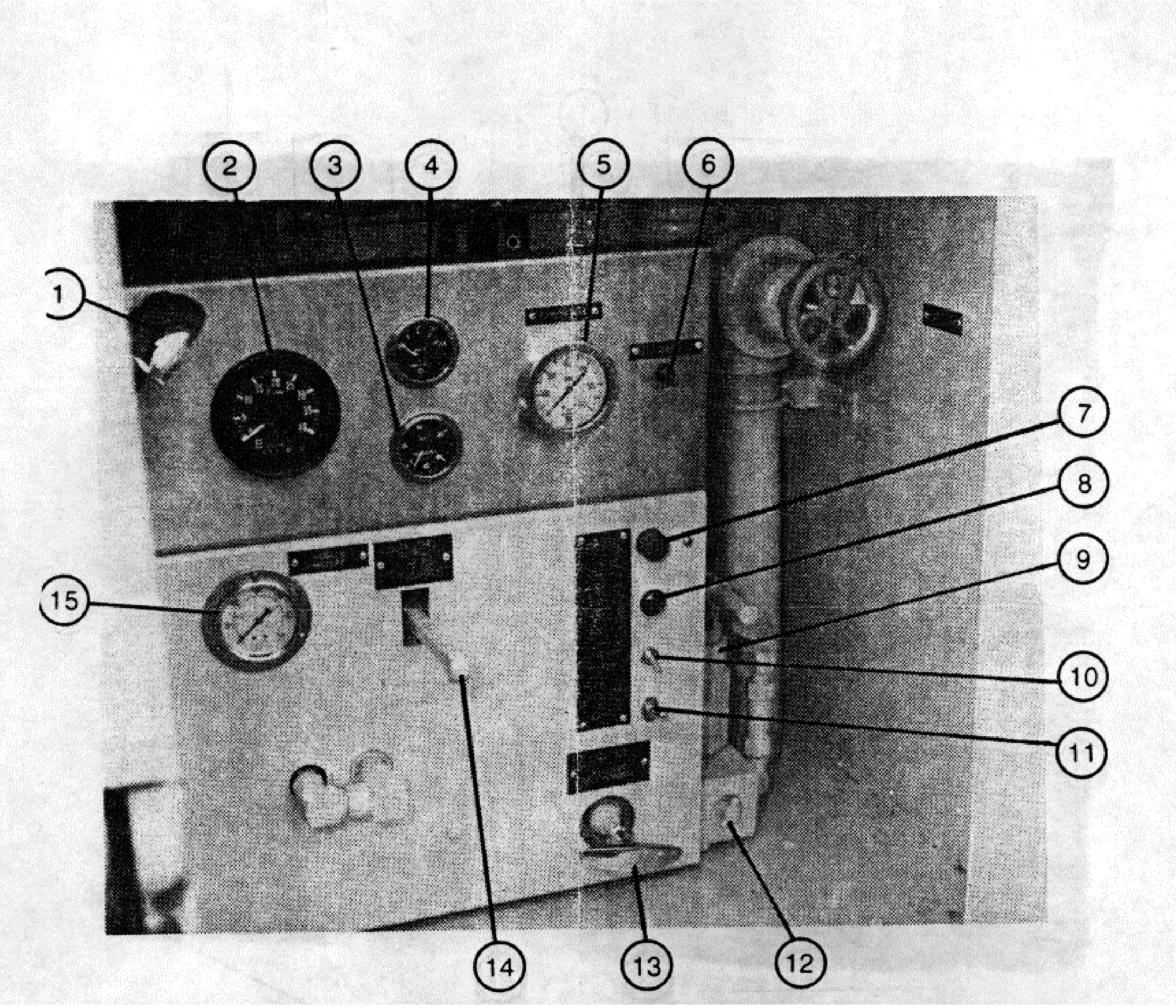


FIGURE 1-11.
Ladder Assembly



See pages 20 and 21 for identification

FIGURE 1-12.
Outrigger Control Panel
-Left Side

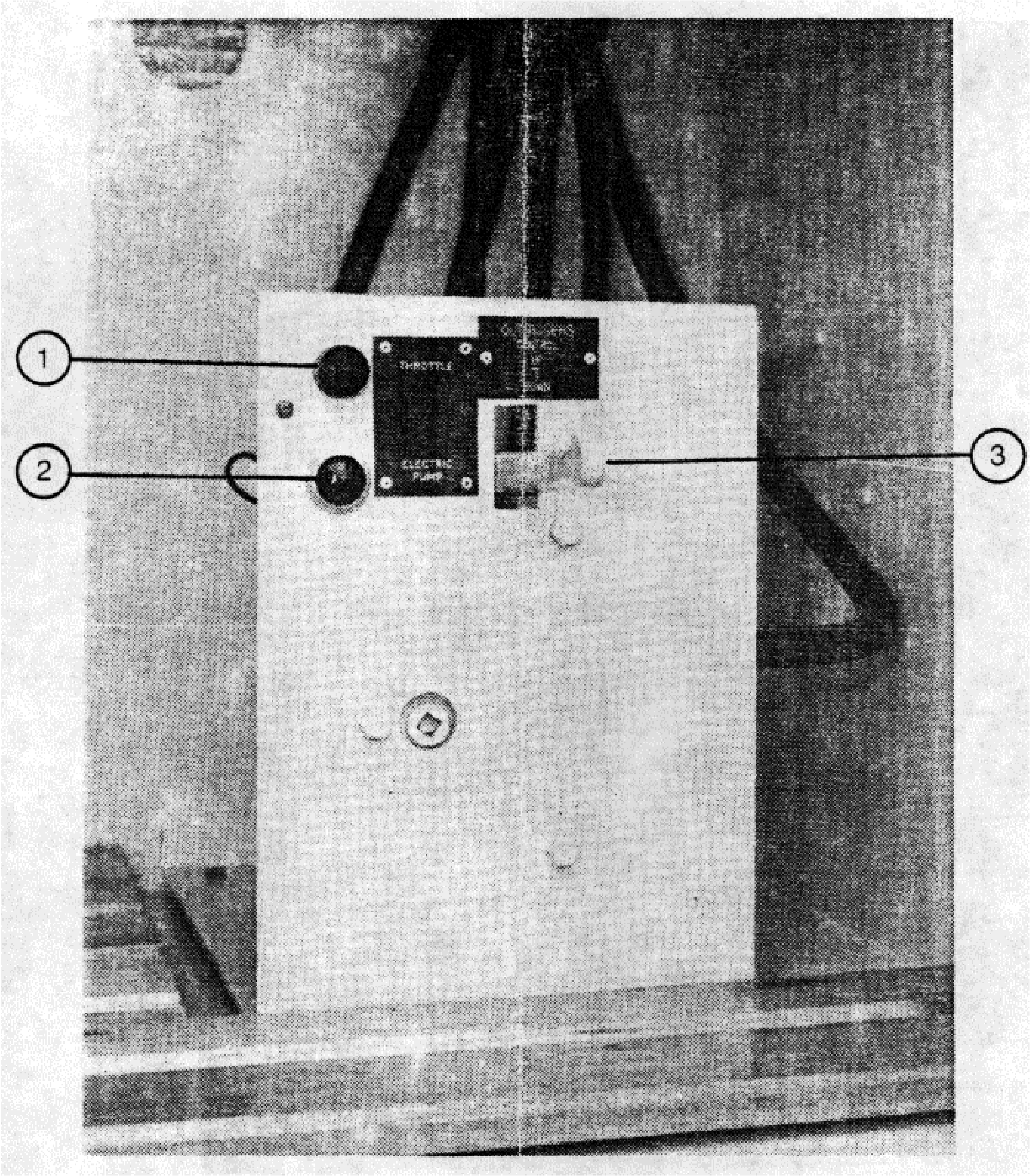


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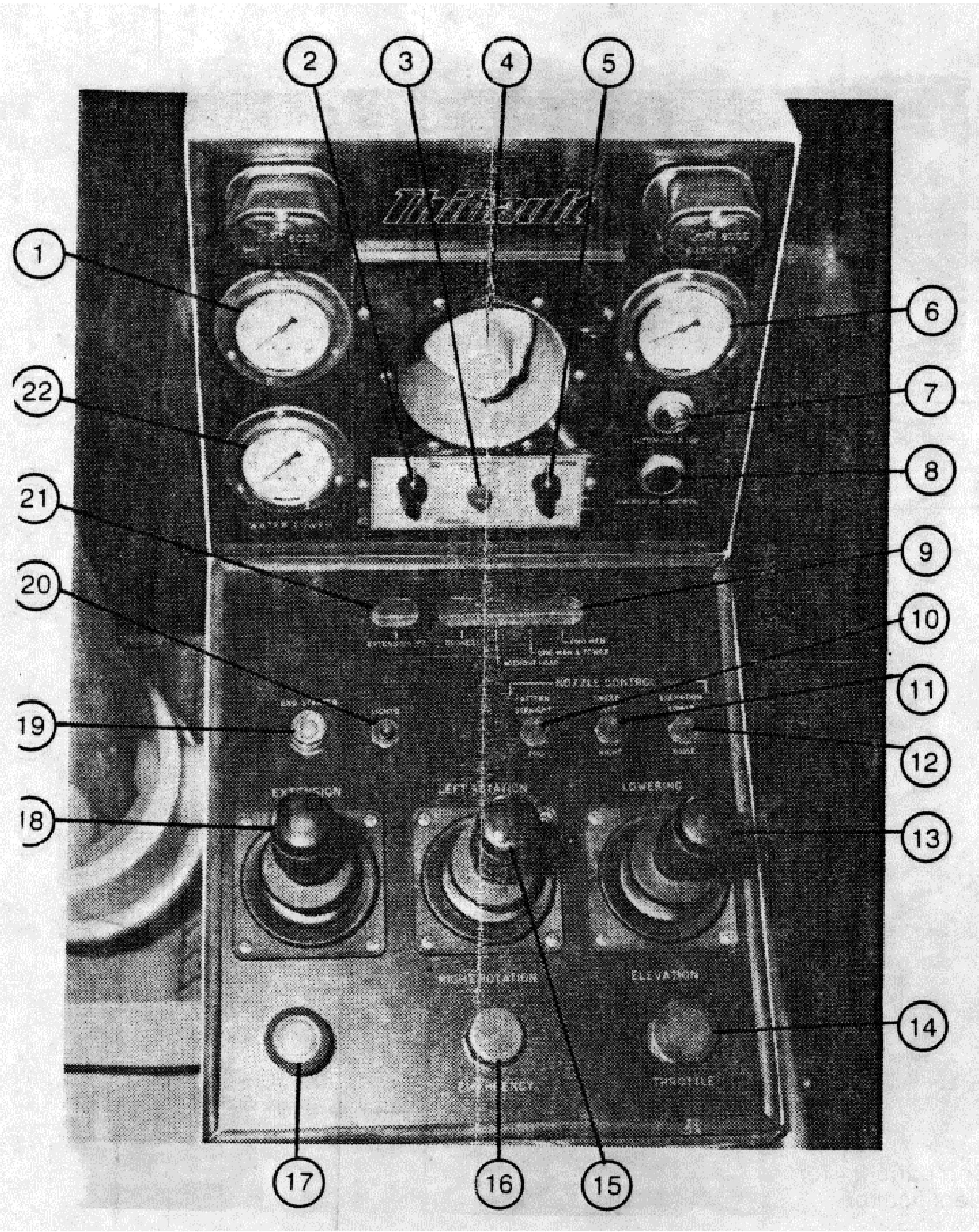
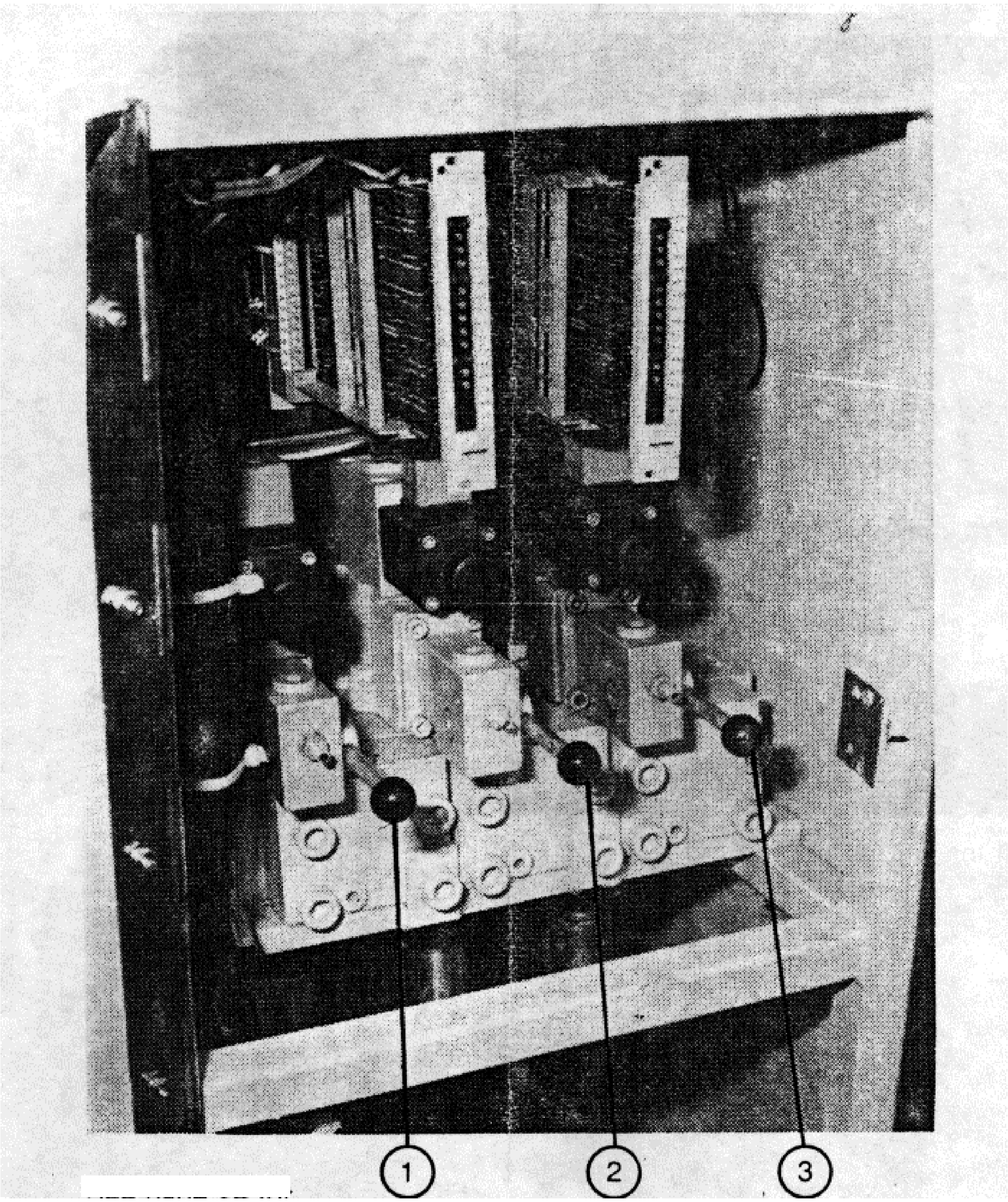
FIGURE 1-13.
Outrigger Control Panel
-Right Side



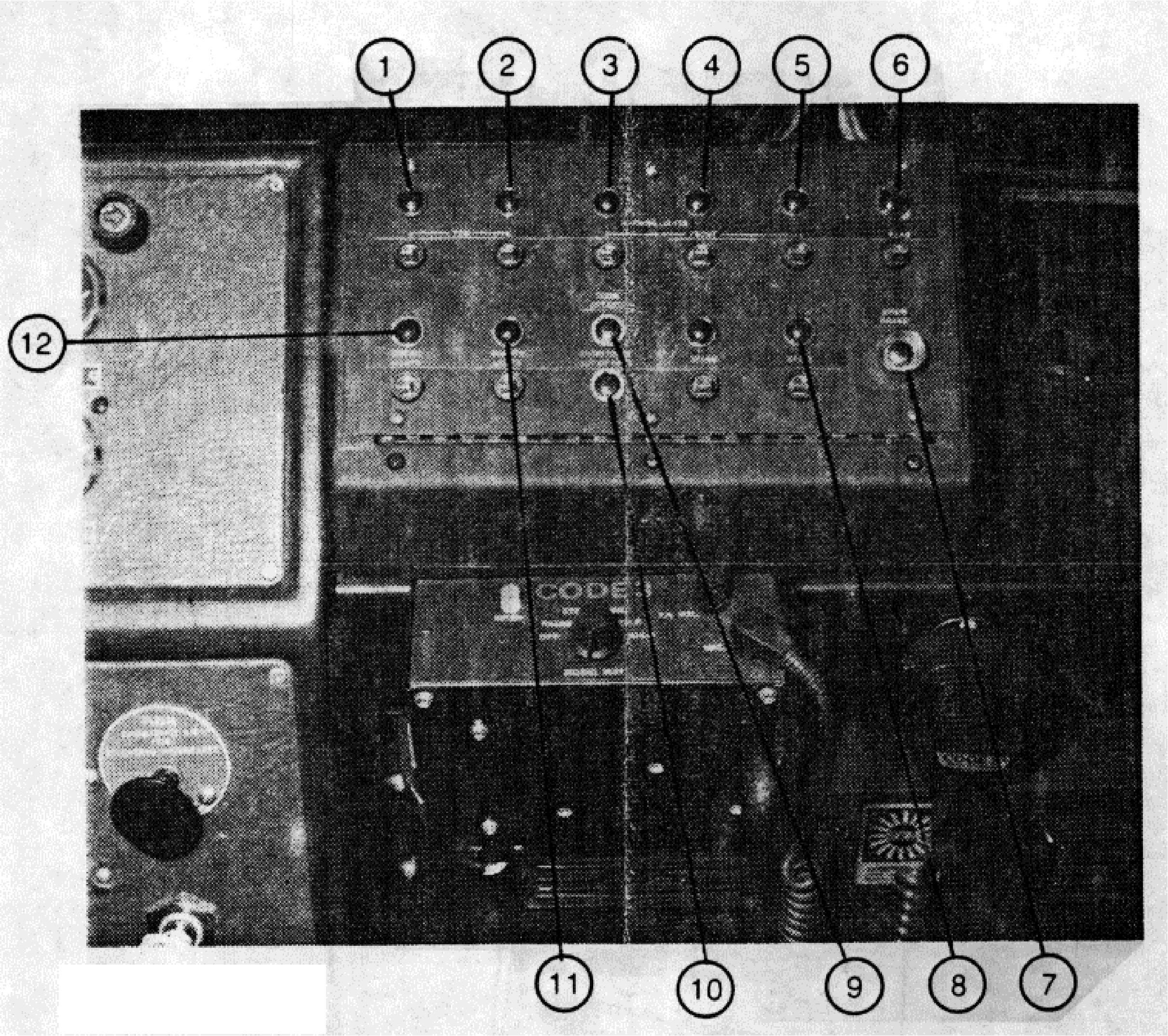
See pages 22 to 24 for Identification

FIGURE 1-14.
Ladder Control Console



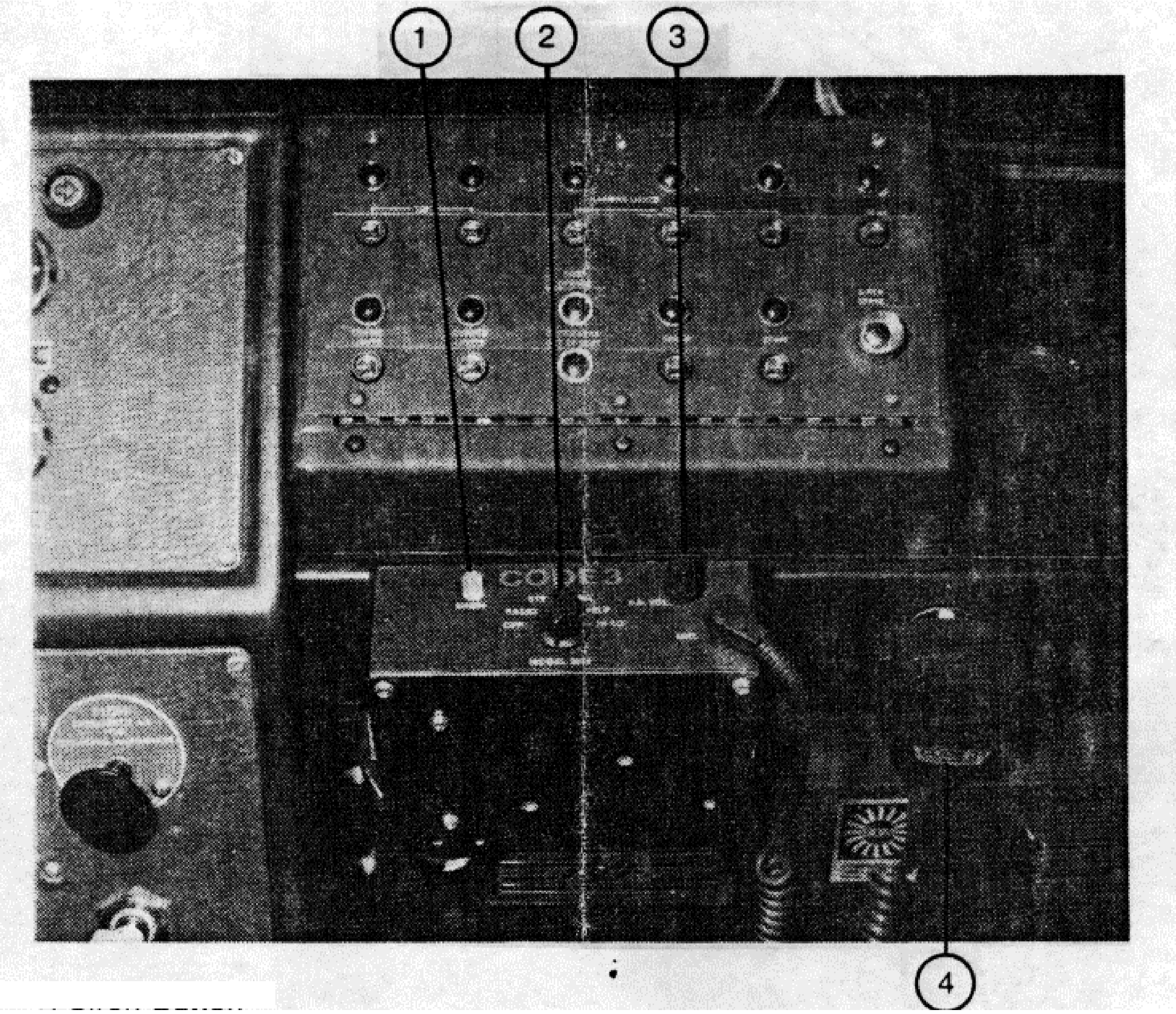
See page 24 for identification

FIGURE 1-15.
Ladder Auxiliary Controls



See page 31 for identification

FIGURE 2-1.
Warning Light Control
Panel



1. Siren Button
2. Selector Switch
3. Volume Switch
4. Microphone

FIGURE 2-1-1.
Radio Control Panel

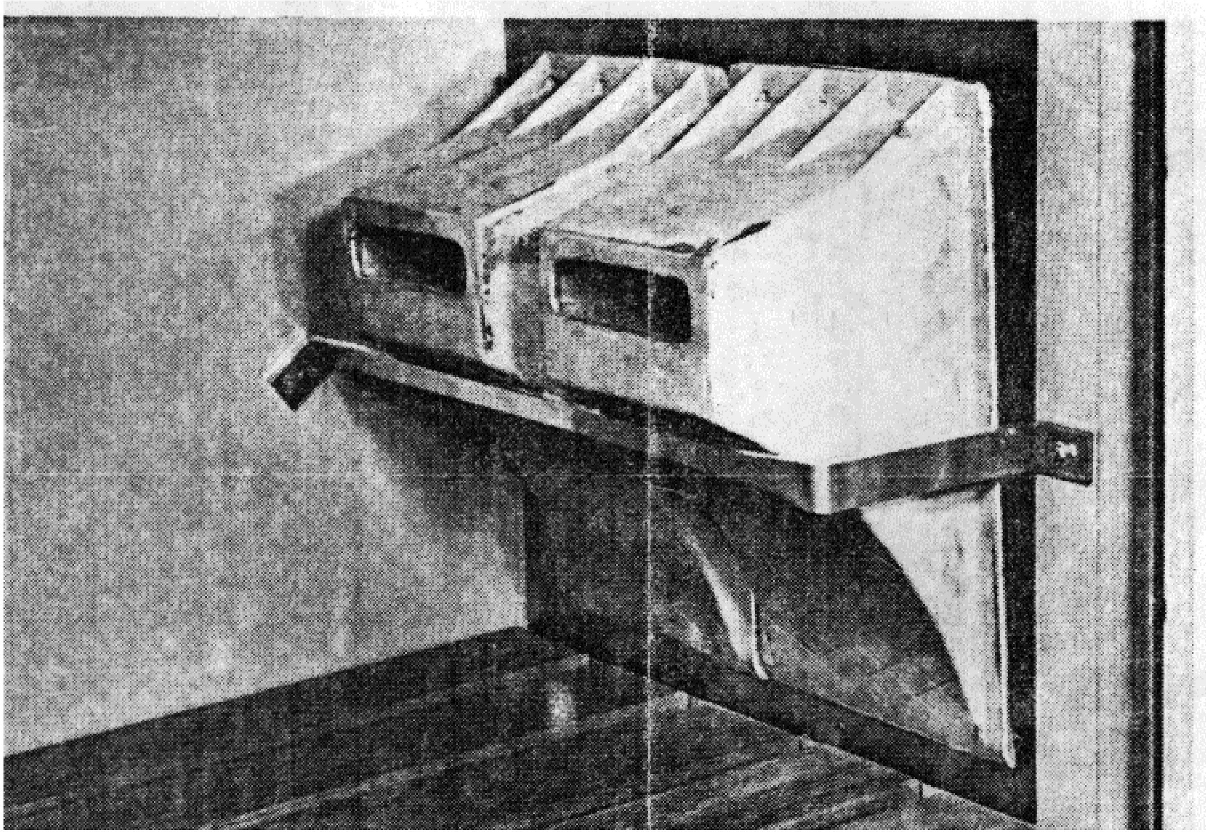
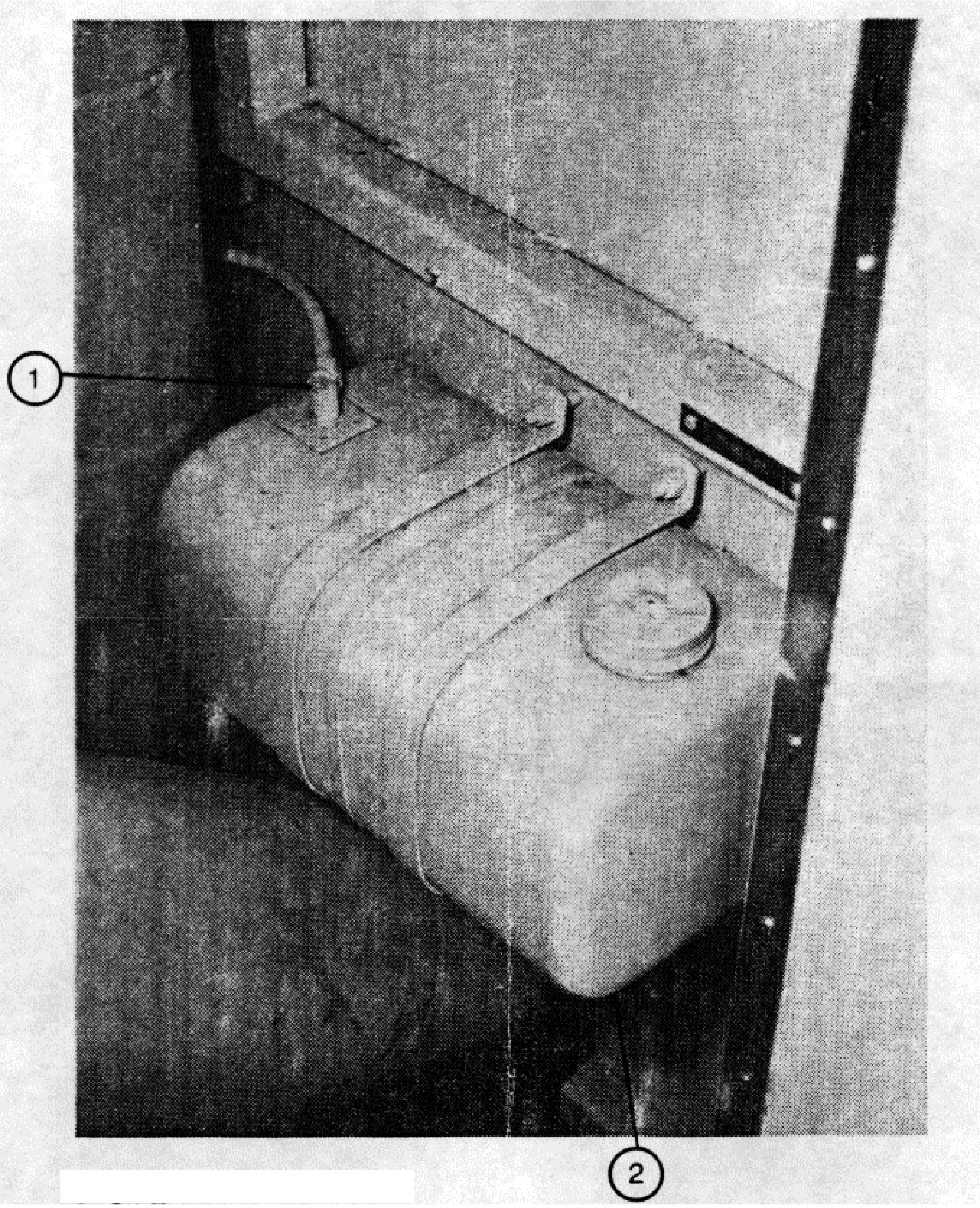


FIGURE 2-2.
Wheel Chocks - Stored



1. Oil Tank Breather Hole
2. Oil Tank

FIGURE 2-3.
Primer Pump Oil Tank

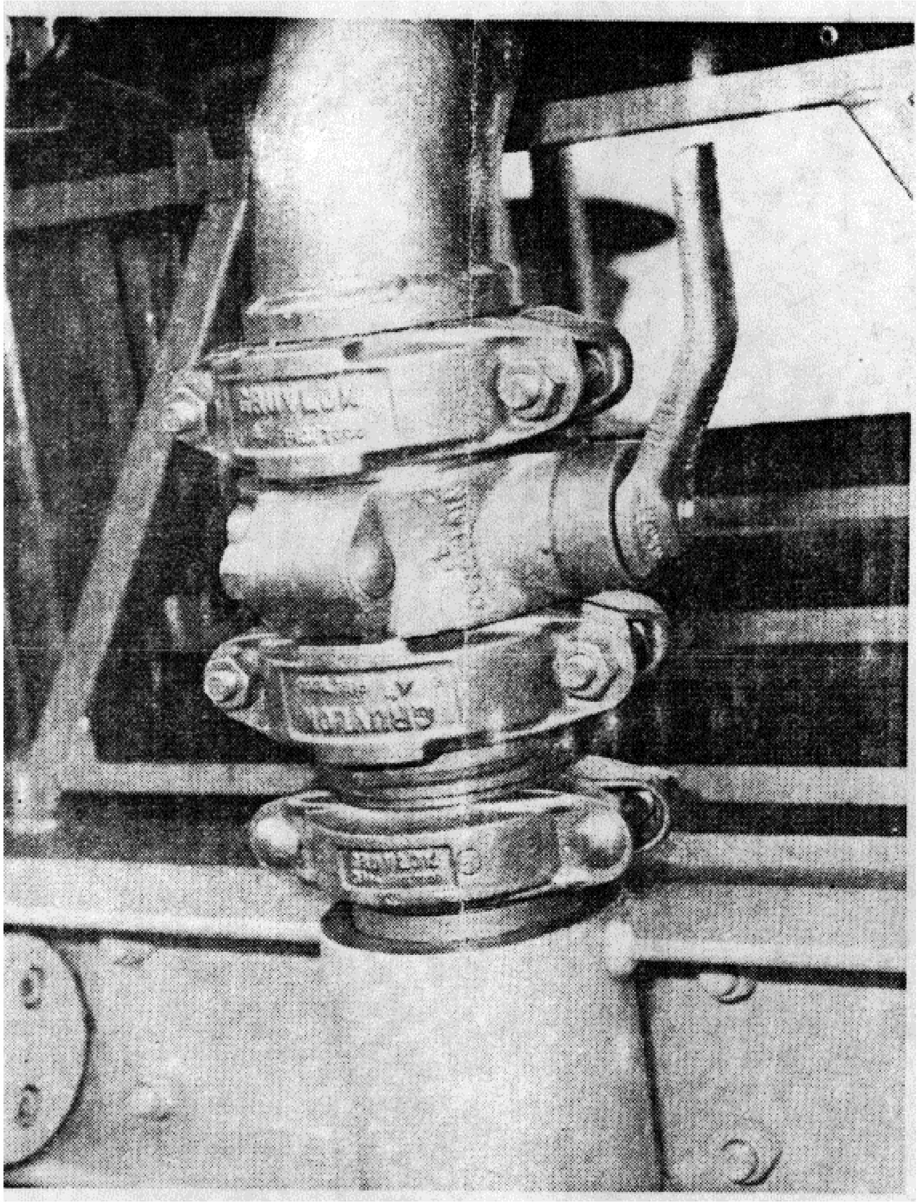


FIGURE 2-4.
Water Tower Shut-off
Valve

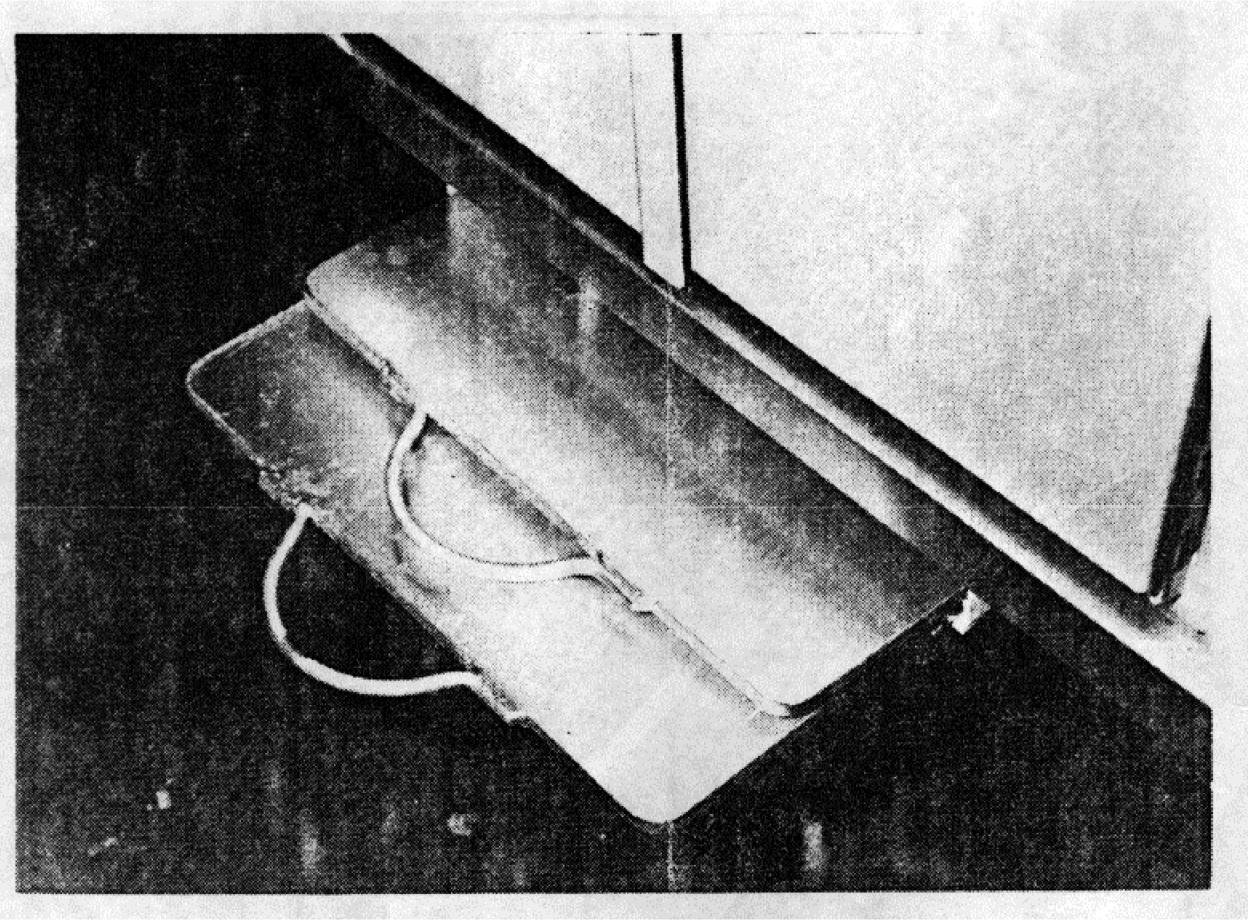


FIGURE 2-5.
Outrigger Pads

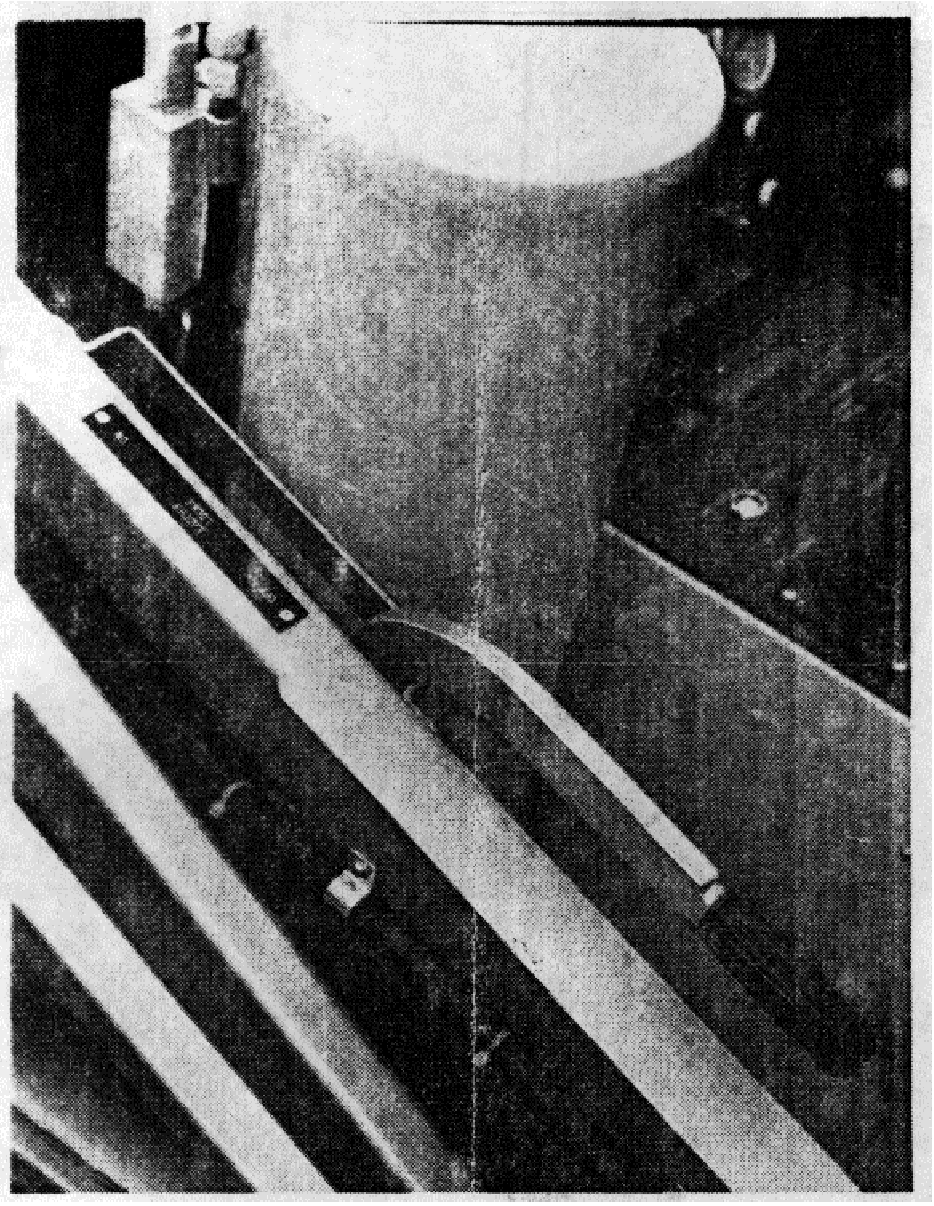


FIGURE 2-6.
Ladder Locking Lever

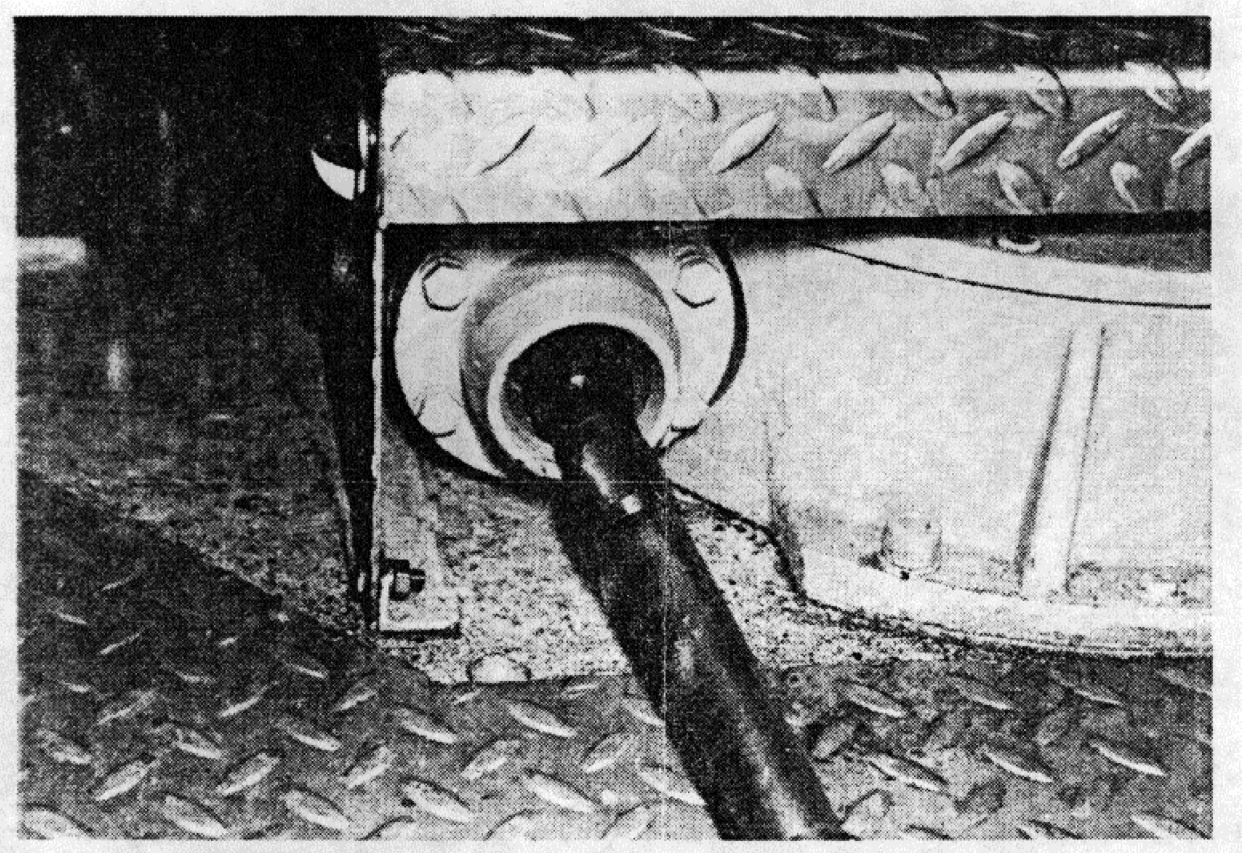
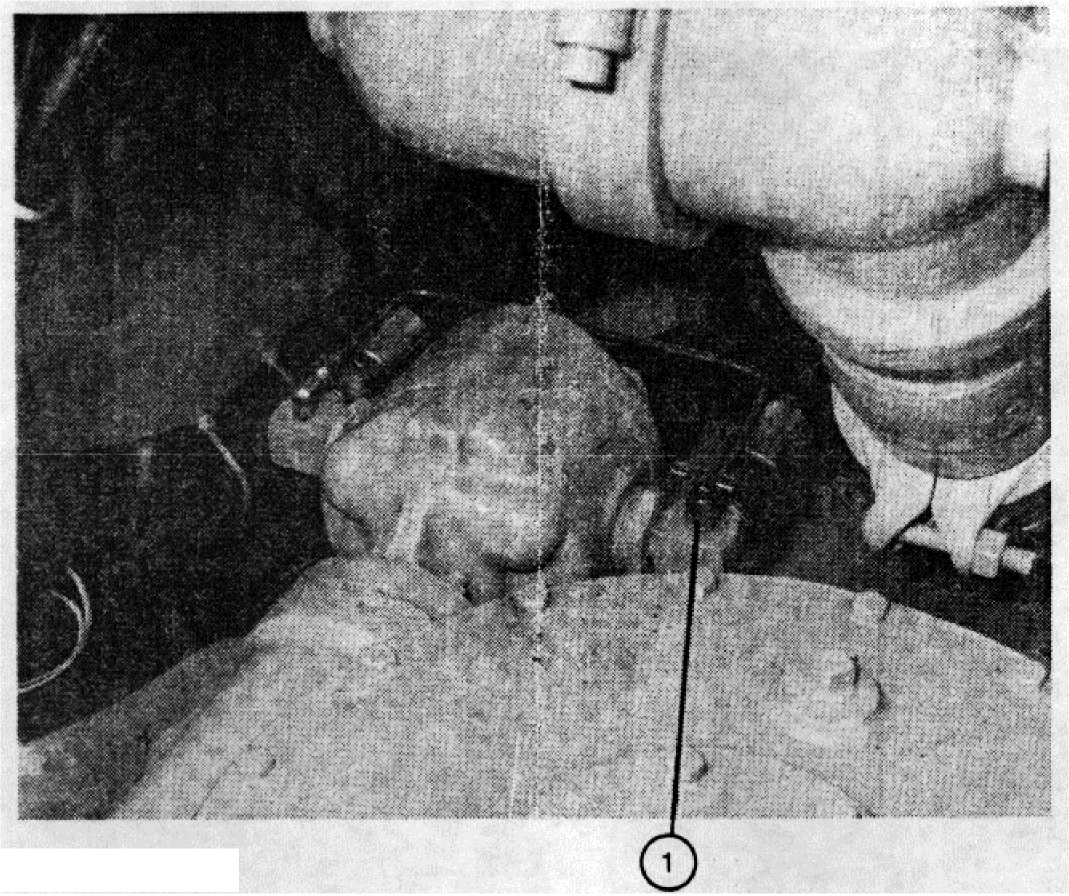


FIGURE 2-7.
Ladder Rotation Crank



1. By - Pass Valve

FIGURE 2-8.
Ladder Rotation By - Pass
Valve

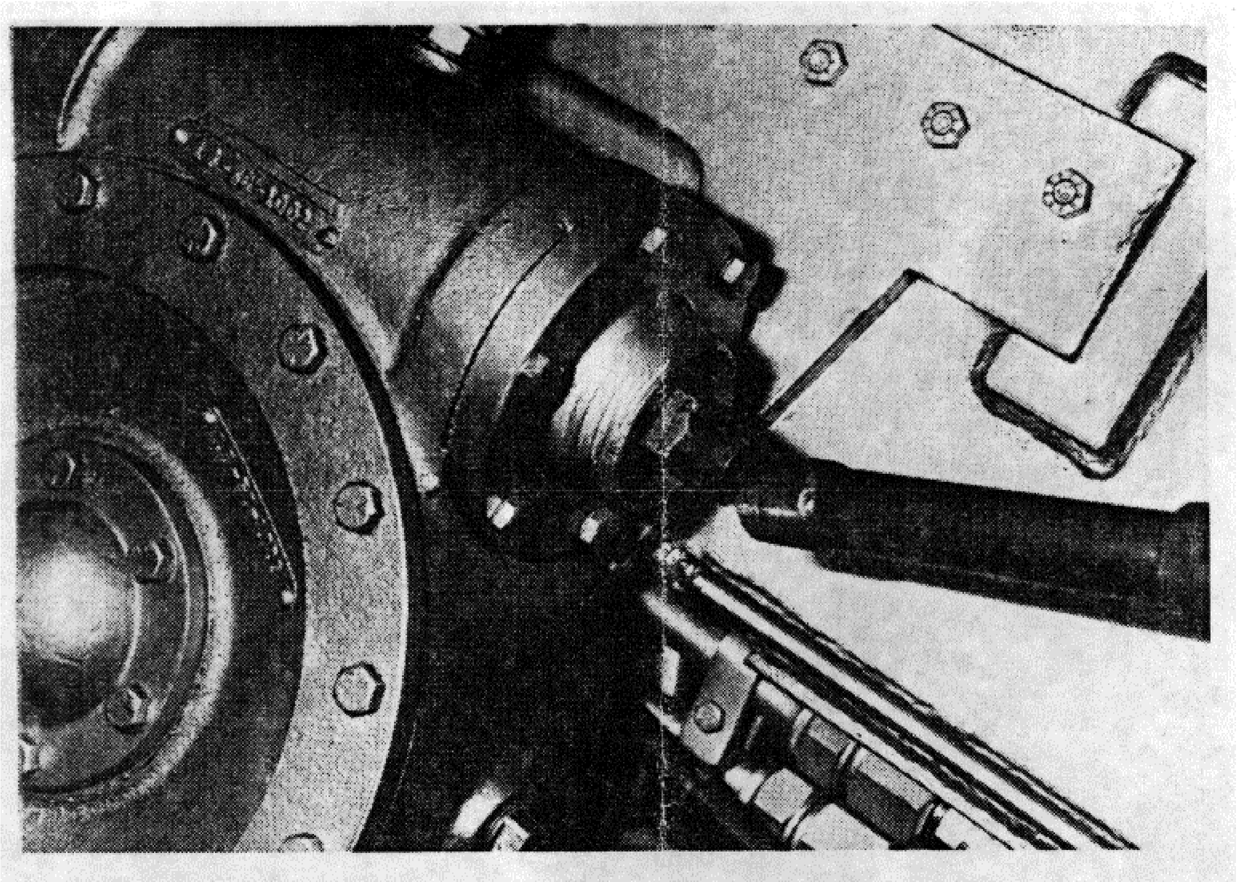
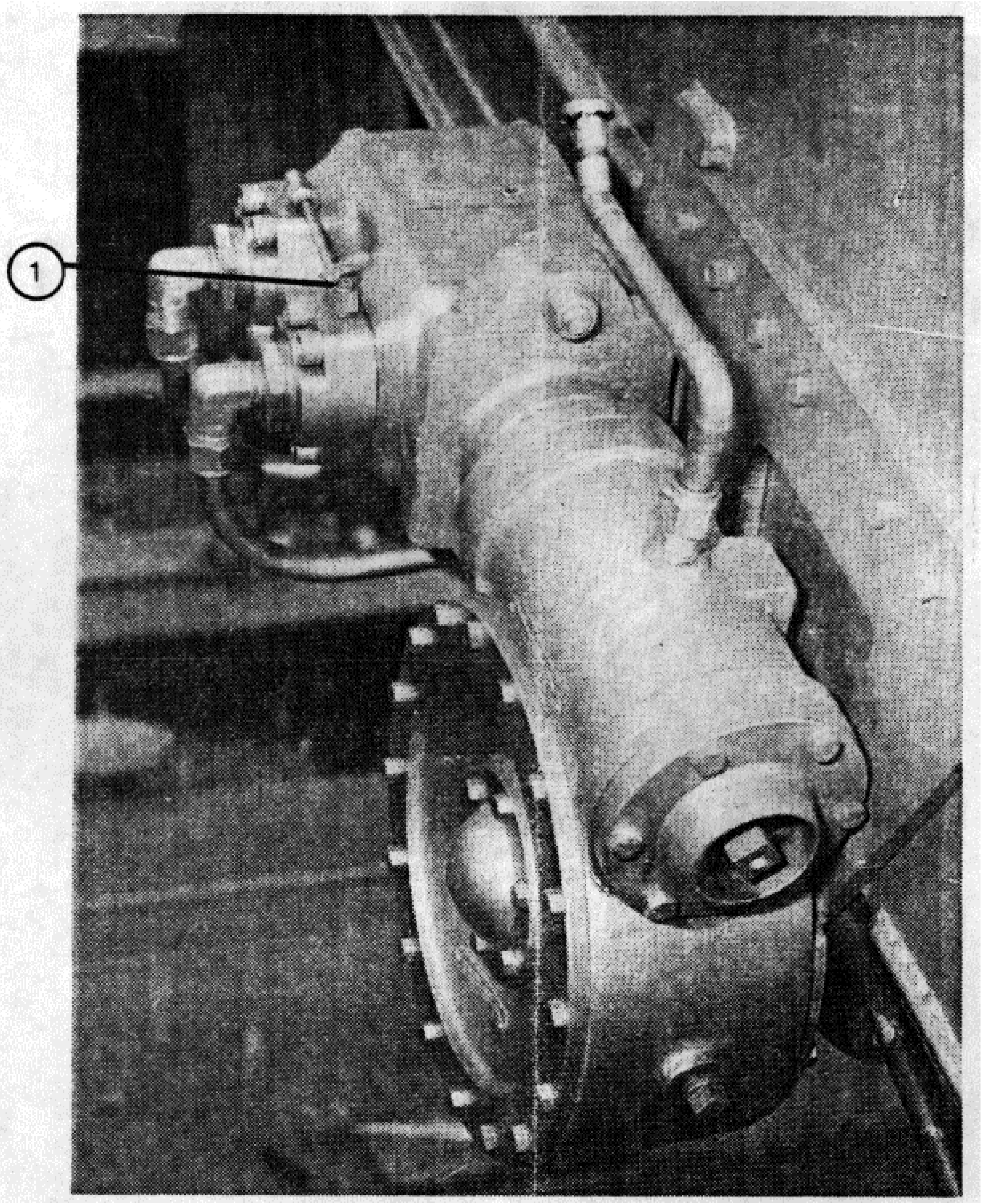


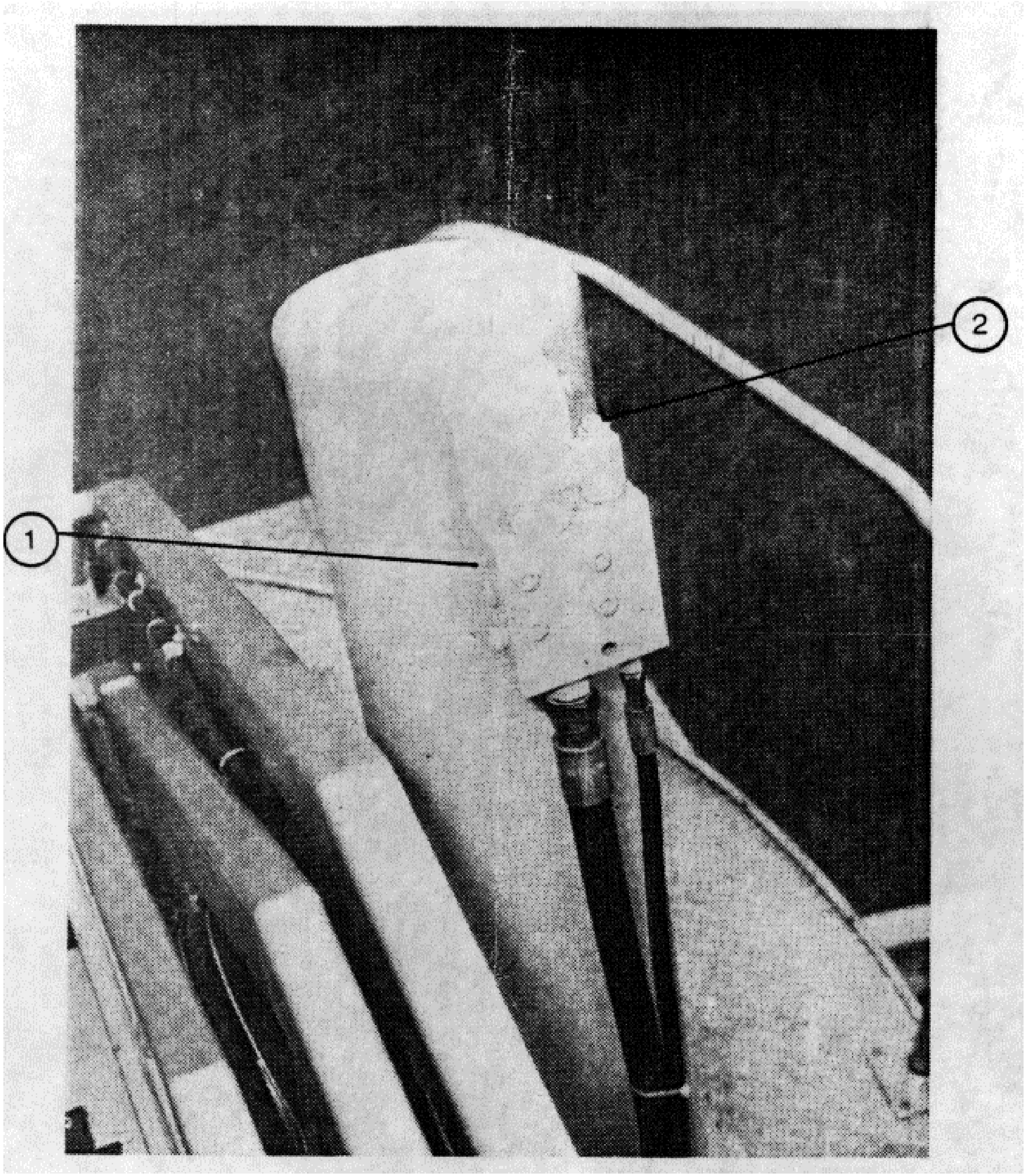
FIGURE 2-9.
Ladder Retraction Crank



1. By - Pass Valve

FIGURE 2-10.
Ladder Retraction
By - Pass Valve

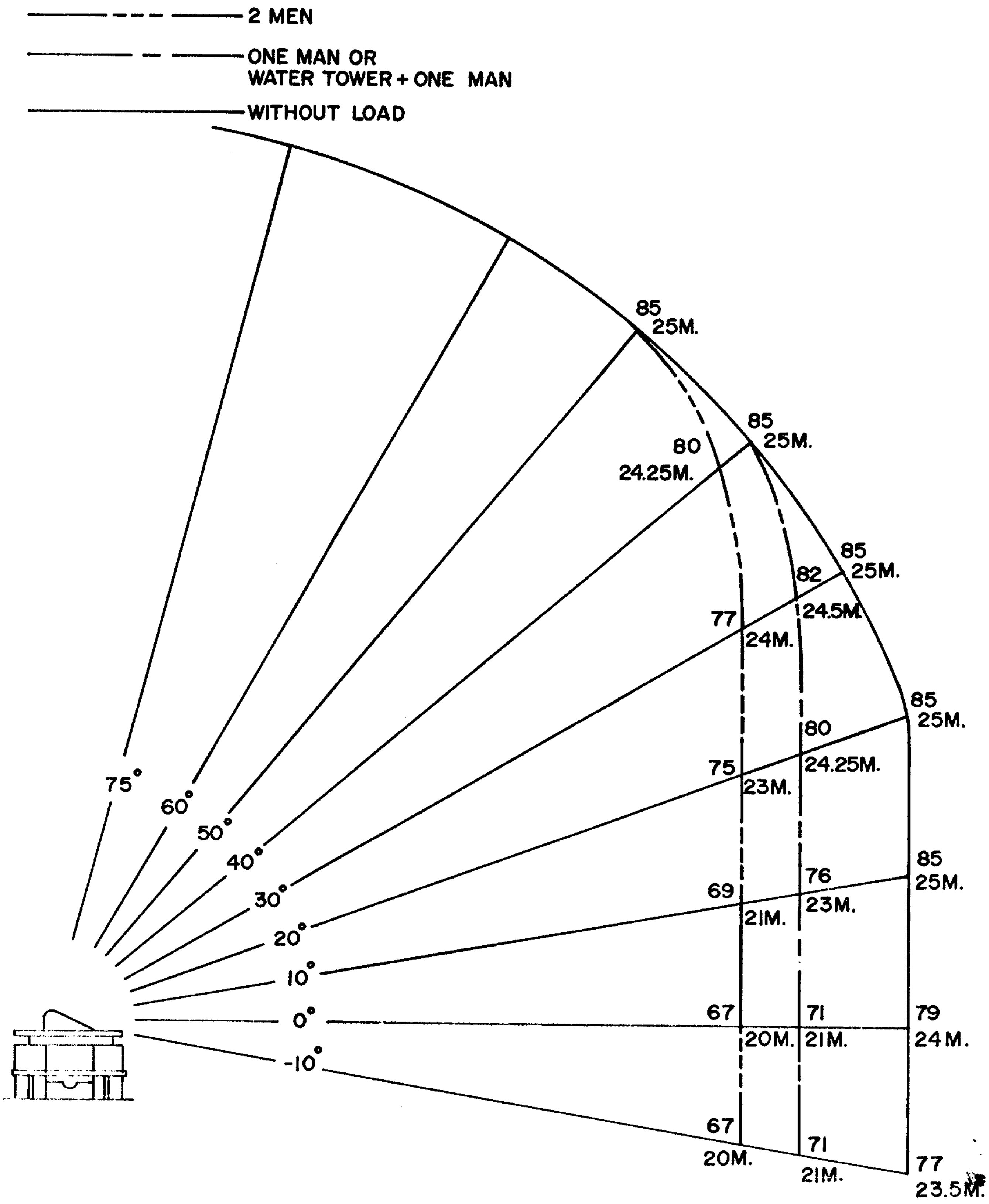
FIGURE 2-11.
Ladder Stowage - Index



1. Overcenter Valve
2. Screw

FIGURE 2-12.
Overcenter Valve

AUTOMATIC STOP CHART 85' (25M.)



ANNEX B

OPERATOR LADDER TROUBLE-SHOOTING GUIDE

PROBLEM	PROABLE CAUSE	REMEDY
1. No hydraulic pressure at either outrigger.	a. PTO not engaged.	a. Switch PTO to "engaged".
	b. Ladder/Outrigger Selector Valve pushed in.	b. Pull valve out to select outrigger.
	c. Electric/PTO pump Switch not in correct position.	c. Move switch to ‘Down’ position.
2. Outrigger fails to operate.	a. Ladder/Outrigger Selector Valve pushed in.	a. Pull valve out to select Outrigger.
3. Ladder will not elevate.	a. Ladder Bed Lock Assy not disengaged.	a. Ensure the PTO Switch is at "ENGAGED".
	b. Joystick Control faulty.	b. Inform Maintenance.
4. Ladder will not lower.	a. Ladder overloaded.	a. Reduce torque on the end of the ladder by retracting or reducing weight.
	b. Joystick Control faulty.	b. Inform Maintenance.

PROBLEM	PROABLE CAUSE	REMEDY
5. Ladder will not extend.	a. Ladder inclination angle below minimum limit.	a. Increase elevation before extending.
	b. Ladder is overloaded.	b. Reduce torque on the end of the ladder by reducing the load.
	c. Joystick Control faulty.	c. Inform Maintenance.
6. Ladder will not retract.	a. Locking Pawls are engaged.	a. Ensure Locking Pawl Lever is in the disengaged position and all locking pawls are disengaged.
	b. Ladder inclination angle too low.	b. Increase ladder elevation to reduce torque.
	c. Ladder overloaded.	c. Reduce torque on the end of the ladder by reducing the load.
7. Ladder will not rotate.	a. Turntable not level.	a. Level the truck bed with the Outriggers or by moving to more level ground.
	b. Manual by-pass valve is open.	b. Close by-pass valve.

6SE381 (Rev. 3/84)

SECTION 5

Operators Manual

SERIES 92 ENGINES

Detroit Diesel Allison

Detroit Diesel Allison
13400 Outer Drive, West
Detroit, Michigan 48239 - 4001

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

Printed in U.S.A.

SAFETY IS YOUR BUSINESS

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

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

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune, disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.

An accident can be prevented with your help.

SECTION 5
TABLE OF CONTENTS

DESCRIPTION

PRINCIPLES OF OPERATION

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

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

The Two-Cycle Principle

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

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

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

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

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

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

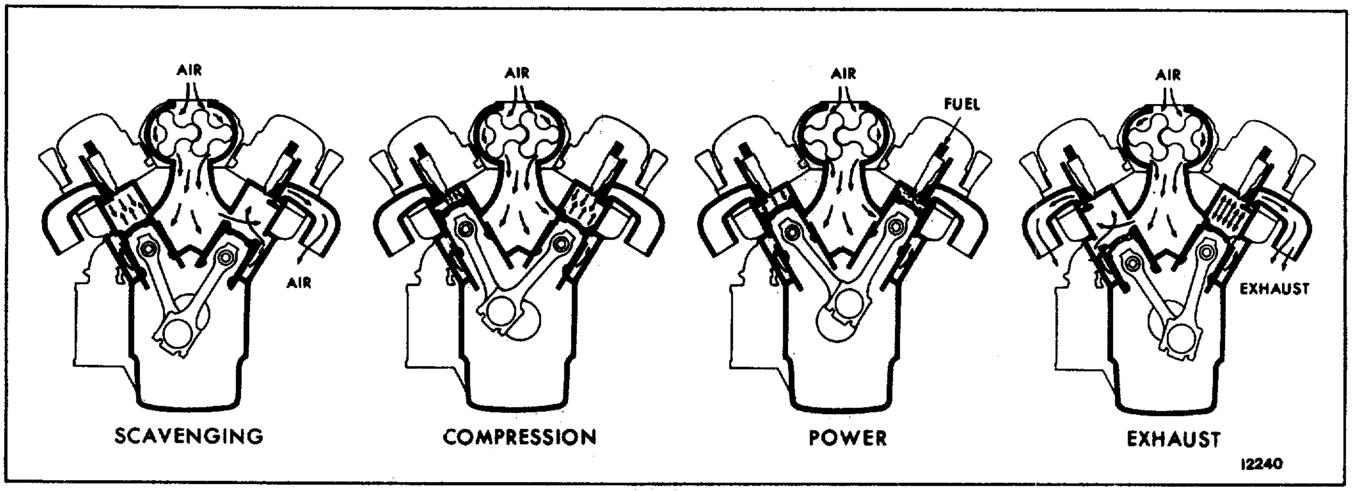


Fig. 1. The Two - Stroke Cycle

GENERAL DESCRIPTION

The Series 92 engines (6, 8, 12 and 16 cylinder models) covered by this manual have the same bore and stroke and use many of the same parts.

The engines are built with right-hand or left-hand rotation (Fig. 2). The oil cooler can be mounted only on the right-hand side of the engine. On 6V-92 and 8V-92 engines, the starter can be mounted on either the right or left side of the engine. The 12V-92 and 16V-92 engines have a starter on both the right and left side of the engine.

The meaning of each digit in the model numbering system is shown in Fig. 2. The letter L or R indicates left or right-hand engine rotation as viewed from the front of the engine. The letter A, B, C or D designates the location of the starter and oil cooler as viewed from the rear of the engine.

The engines are normally equipped with an oil cooler, lubricating oil filter(s), fuel oil strainer, fuel oil filter, air cleaner(s), governor, heat exchanger and raw water pump or fan and radiator and starting motor(s). Fuel is drawn from the supply tank through the fuel strainer by a gear-type fuel pump. It is then forced through a filter and into the fuel inlet manifolds in the cylinder heads and to the injectors. Excess fuel is returned to the supply tank through the fuel outlet manifolds and connecting lines. Since fuel is constantly circulating through the injectors, it serves to cool the injectors and carry off any air in the fuel system.

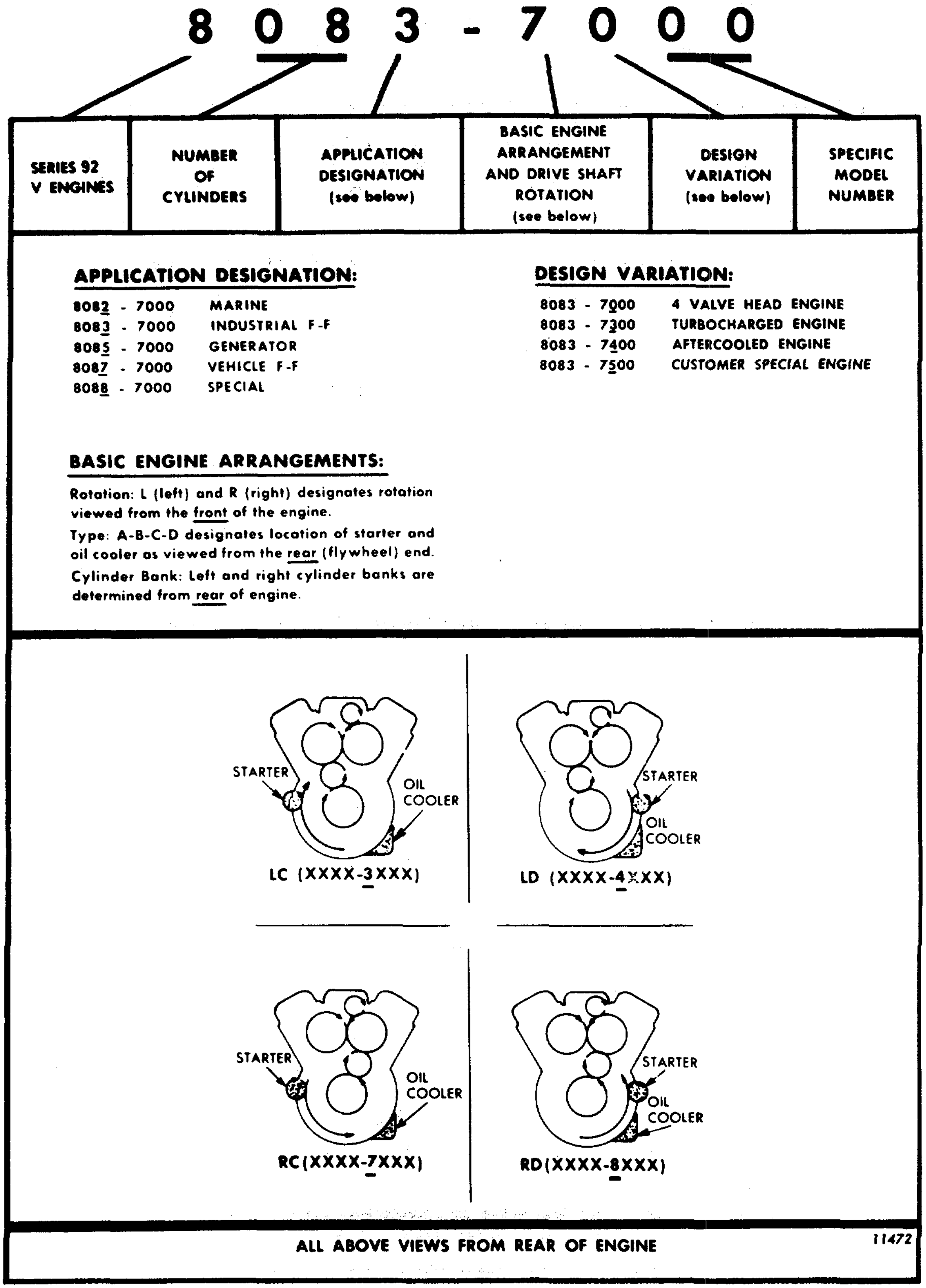
Air for scavenging and combustion is supplied by 2 blower which pumps air into the engine cylinders via the air box and cylinder liner ports. All air entering the blower first passes through an air cleaner.

Full pressure lubrication is supplied to all main connecting rod and camshaft bearings, and to other moving parts of the engine. A gear-type pump draws oi0 from the oil pan through an intake screen, through the oil filter(s), and then to the oil cooler(s). From the oil cooler(s), the oil flows through passages that connected with the oil galleries in the cylinder block and cylinder heads for distribution to the bearings, rocker arm mechanism and other functional parts.

Coolant is circulated through the engine by a centrifugal type water pump. Heat is removed from the coolant, which circulates in a closed system, by the radiator or heat exchanger. Control of the engine temperature is accomplished by thermostats that regulate the flow of the coolant within the coolant system.

Engine starting is provided by an electric starting system. The electric starting motor is energized by a storage battery. A battery-charging alternator, with a built-in voltage regulator, serves to keep the batter) charged.

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



APPLICATION DESIGNATION:

8082 - 7000	MARINE
8083 - 7000	INDUSTRIAL F-F
8085 - 7000	GENERATOR
8087 - 7000	VEHICLE F-F
8088 - 7000	SPECIAL

DESIGN VARIATION:

8083 - 7000	4 VALVE HEAD ENGINE
8083 - 7300	TURBOCHARGED ENGINE
8083 - 7400	AFTERCOOLED ENGINE
8083 - 7500	CUSTOMER SPECIAL ENGINE

BASIC ENGINE ARRANGEMENTS:

Rotation: L (left) and R (right) designates rotation viewed from the front of the engine.

Type: A-B-C-D designates location of starter and oil cooler as viewed from the rear (flywheel) end.

Cylinder Bank: Left and right cylinder banks are determined from rear of engine.

ALL ABOVE VIEWS FROM REAR OF ENGINE

Fig. 2. - Model Description, Rotation and Accessory Arrangement

GENERAL SPECIFICATIONS

	6V-92	8V-92	12V-92	16V-92
Type	2 Cycle	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	6	8	12	16
Bore (inches)	4.84	4.84	4.84	4.84
Bore (mm)	123	123	123	123
Stroke (inches)	5	5	5	5
Stroke (mm)	127	127	127	127
Comp. Ratio (Nominal) (Turbo Engines)	17 to 1	17 to 1	17 to 1	17 to 1
Comp. Ratio (Nominal) (N/A Engines)	19 to 1	19 to 1	19 to 1	19 to 1
Total Displacement - cubic inches	552	736	1104	1472
Total Displacement - liters	9.05	12.07	18.10	24.14
Number of Main Bearings	4	5	7	10

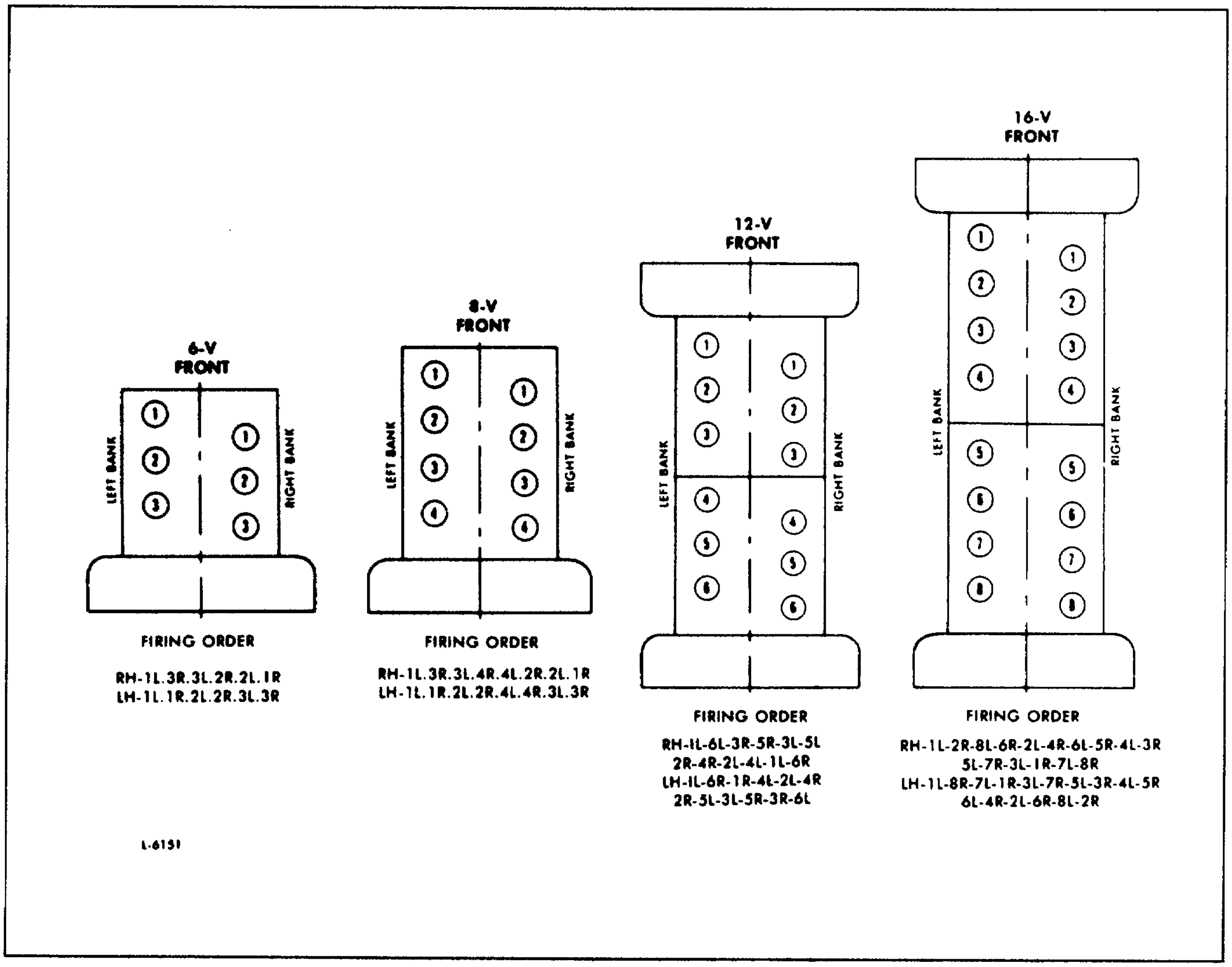


Fig. 3. - V-92 Cylinder Designation and Firing Order

Fig. 4. Typical 6V-92 and 8V-92 Engine Serial Number and Model Number as Stamped on Upper Right Front Corner of Cylinder Block

The engine serial number and the engine model number are stamped on the cylinder block (Figs. 4 and 5).

An option plate, attached to one of the valve rocker covers, carries the engine serial number and model number and, in addition, lists any optional equipment used on the engine.

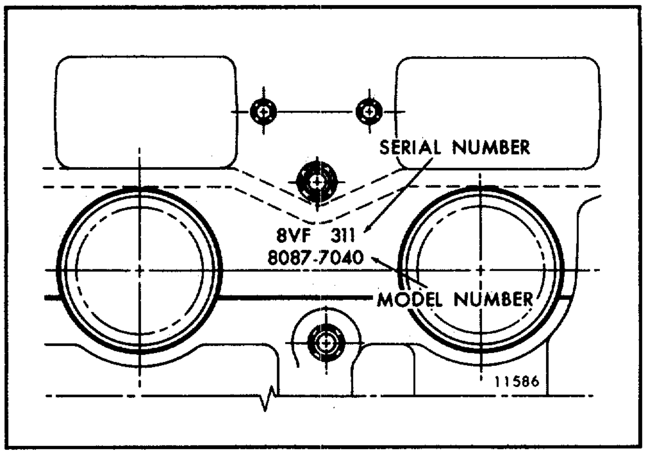


Fig. 5. - Typical 12V-92 and 16V-92 Engine Serial Number and Model Number as Stamped on Cylinder Block

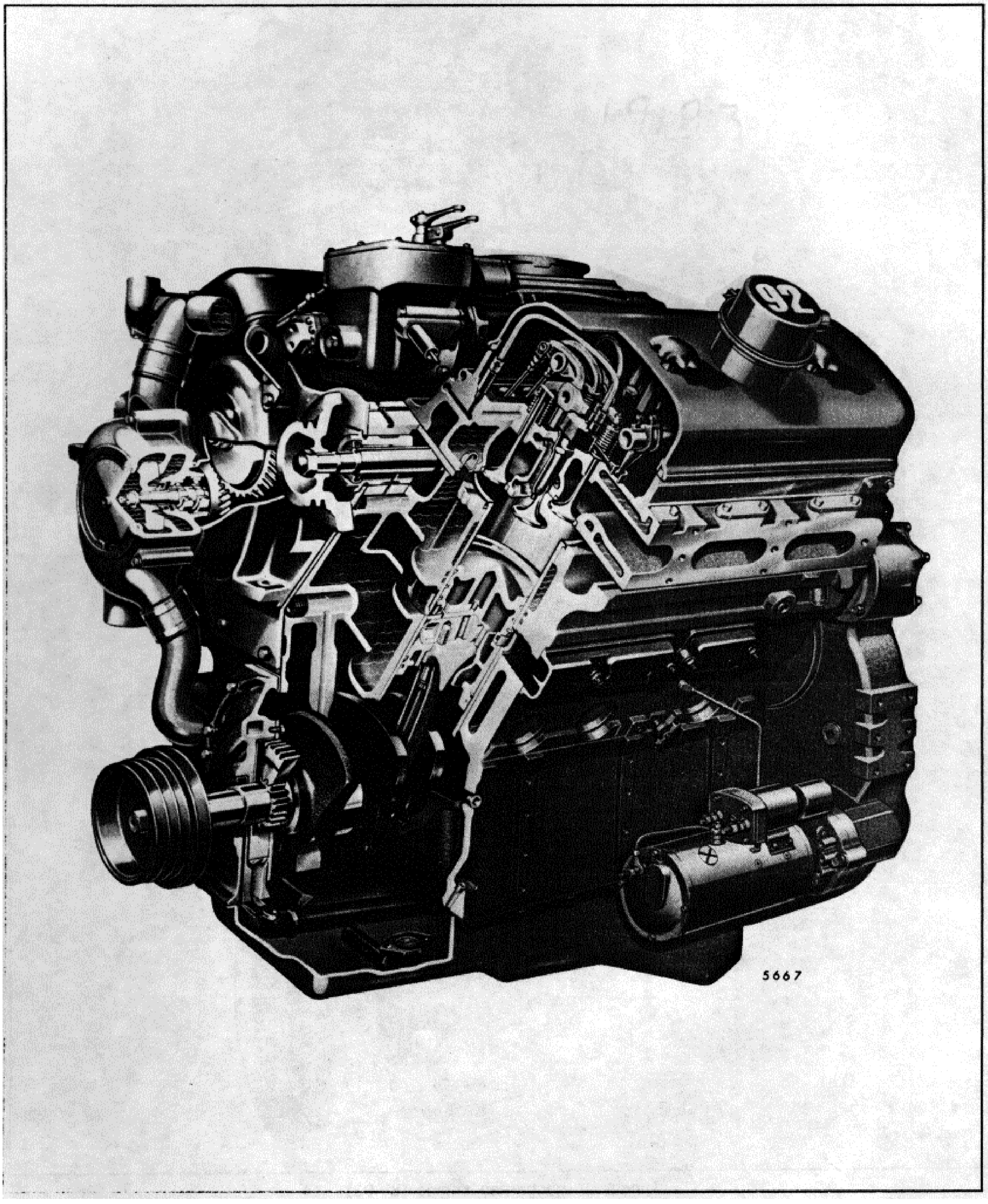
Power take-off assemblies, torque converters, marine gears, etc. may also carry name plates. The information on these name plates should be included when ordering replacement parts for these assemblies

.

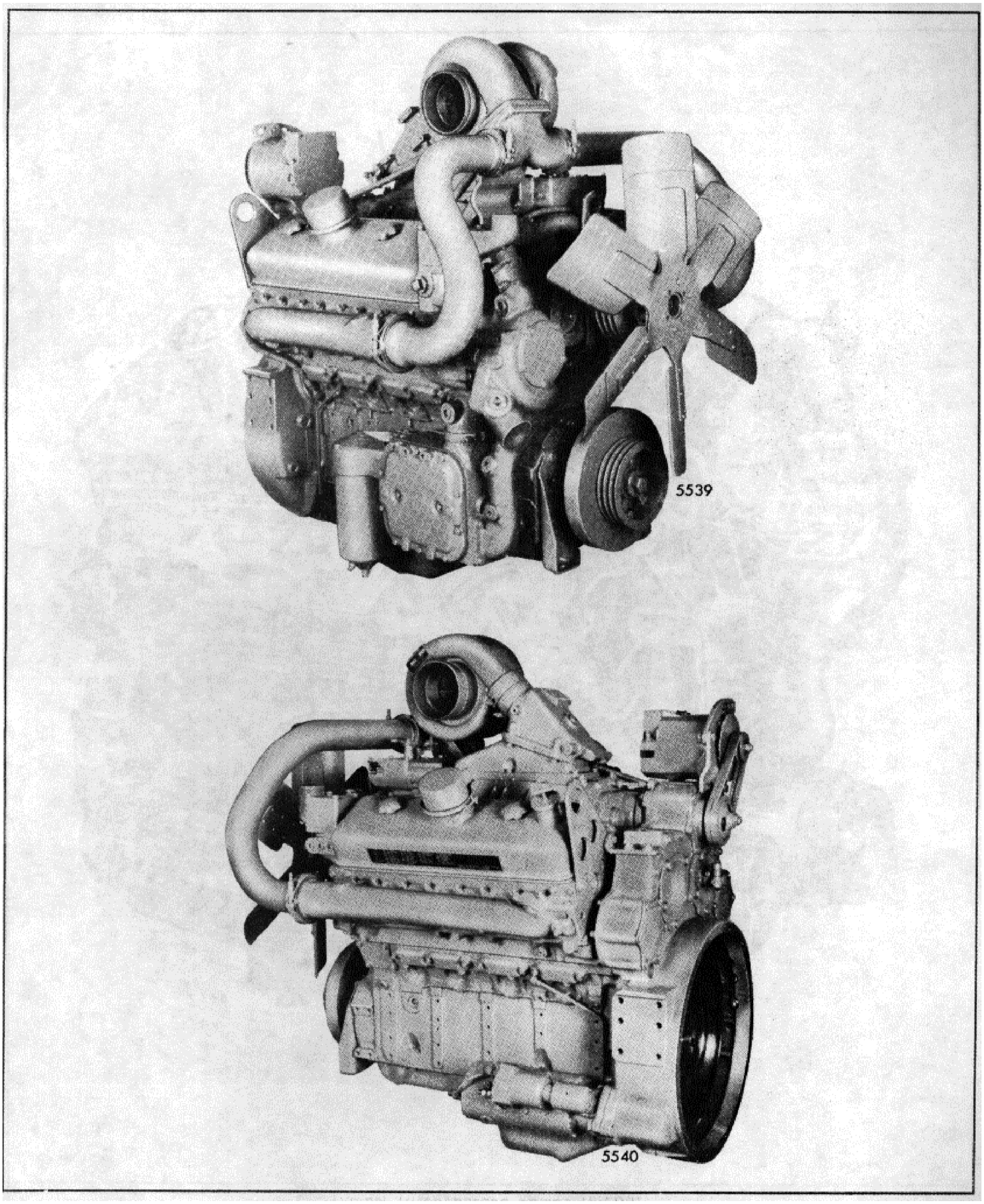
BUILT-IN PARTS BOOK

The Built-In Parts Book is a photo etched aluminum plate (option plate) that fits into a holding channel on one of the engine valve rocker covers and contains the necessary information required when ordering parts. It is recommended that the engine user read the section on the Built-In Parts Book in order to take full advantage of the information provided on the engine option plate.

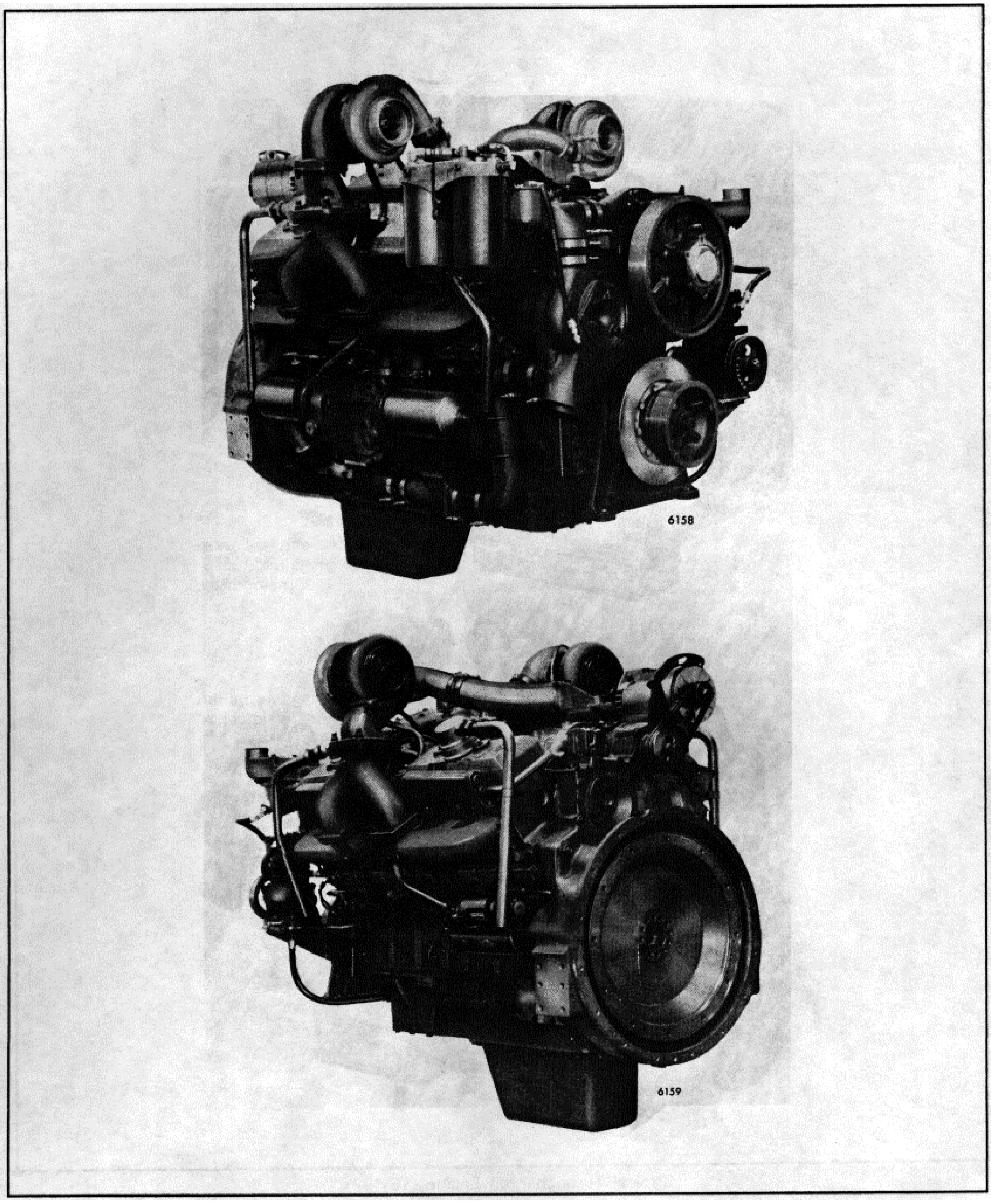
Numerous exploded view type illustrations are included to assist the user in identifying and ordering service parts.



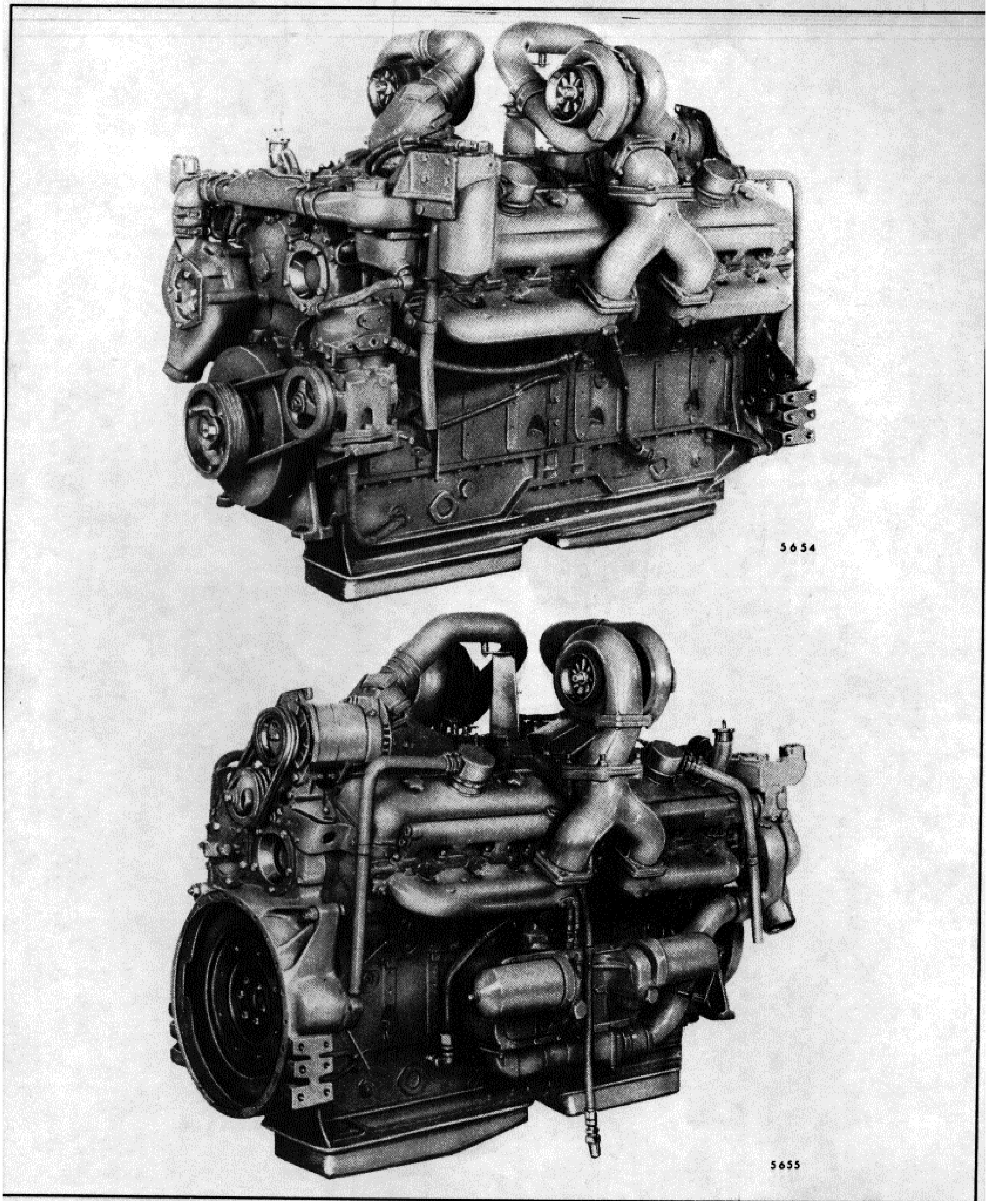
Three Quarter Cutaway View (8V-92)



Typical Turbocharged Engine (8kV-92)



Typical Turbocharged Engine (12V-92)



Typical Turbocharged Engine (16V-92)

ENGINE SYSTEMS

The Series 92 Detroit Diesel Engines incorporate four basic systems which direct the flow of fuel, air, lubricating oil and engine coolant.

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

FUEL SYSTEM

The fuel system includes the fuel injectors, fuel pipes (inlet and outlet), fuel manifolds (integral with the cylinder head), fuel pump, fuel strainer, fuel filter and fuel lines (Fig. 1).

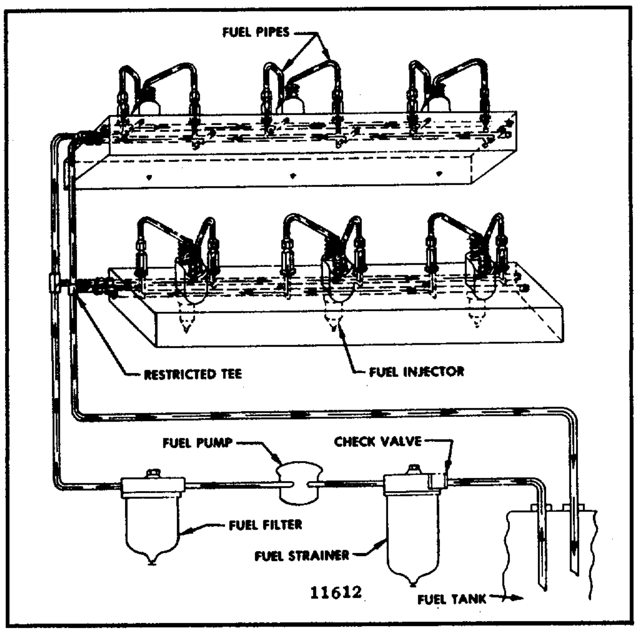


Fig. 1. - Schematic Diagram of Typical Fuel System

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Leaving the pump under pressure, the fuel is forced through the fuel filter and into the fuel inlet manifold, then through fuel pipes into the inlet side of each fuel injector.

The fuel manifolds are identified by the words "IN" (top passage) and "OUT" (bottom passage) which are cast in several places in the side of each cylinder head. This aids installation of the fuel lines.

Surplus fuel returns from the outlet side of the injectors to the fuel return manifold and then back to the supply tank.

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

All engines are equipped with a restrictive fitting in the fuel outlet manifold in one of the cylinder heads on 6V92 and 8V-92 engines or two of the cylinder heads on 12V-92 and 16V-92 engines to maintain the fuel system pressure.

A check valve may be installed in the supply line between the fuel tank and the fuel strainer to prevent the fuel from draining back when the engine is shut down.

FUEL INJECTOR

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

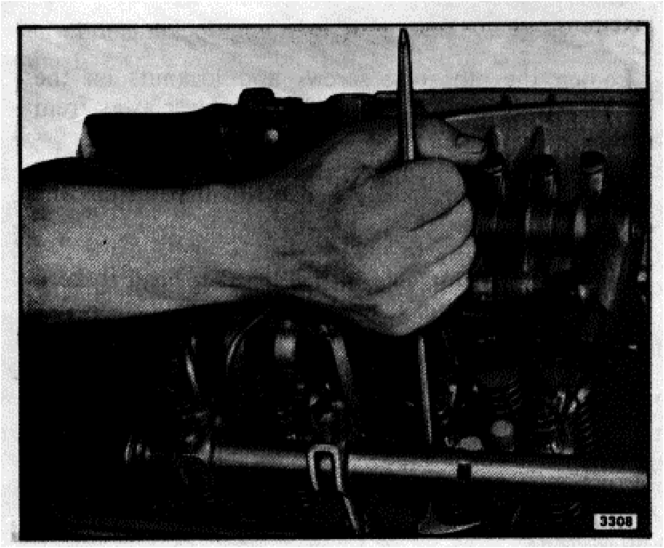


Fig. 2. - Removing Injector from Cylinder Head

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

Remove Injector

An injector may be removed in the following manner:

I. Clean and remove the valve rocker cover.

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

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

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

NOTE

: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt could be loosened. Either remove the starting motor or the pipe plug in the flywheel housing and use a pry bar against the teeth of the flywheel ring gear to turn the crankshaft.

5. Remove the two rocker shaft bracket bolts and swing the rocker arm assembly away from the injector and valves.
6. Remove the injector clamp bolt, washer and clamp.
7. Loosen the adjusting screws and locknuts on the injector rack control lever and slide the lever away from the injector.
8. Free the injector from its seat and lift it from the cylinder head (Fig. 2).

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

Install Injector

Before installing an injector, be sure the beveled seat of the injector tube is free from dirt particles and carbon deposits.
A new or reconditioned injector may be installed by reversing the sequence of operations given for removal.
Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter until it runs out the outlet filter cap.
Do not tighten the injector clamp bolt to more than 2025 lb-ft (27-34 Nm) torque as this may cause the moving parts of the injector to bind. Tighten the rocker shaft bolts to 90-100 Ib-ft (122-136 Nm) torque.
Align the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-01 and a torque wrench to tighten the fuel pipe nuts to 12-15 lbft (16-20 Nm) torque.

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

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

FUEL PUMP

A positive displacement gear type fuel pump is attached to the blower and driven off the front end of the blower.
A spring-loaded relief valve, incorporated in the pump body, normally remains in the closed position, operating only when the pressure on the outlet side (to the fuel filter) becomes excessive due to a plugged filter or fuel line.
The fuel pump incorporates two oil seals. Two tapped holes are provided in the underside of the pump body, between the oil seals, to permit draining off any leakage of oil. If fuel leakage exceeds one drop per minute, the seals must be replaced. An authorized *Detroit Diesel Allison Service* Outlet is properly equipped to replace the seals.
The fuel pump used on the V-92 engines is a left-hand rotating pump. Regardless of engine rotation, the pump will always rotate in a left-hand direction.

FUEL STRAINER and FILTER

Bolt-On Type

A replaceable element type fuel strainer and fuel filter (Figs. 1 and 3) are used in the fuel system to remove impurities from the fuel. The strainer removes the

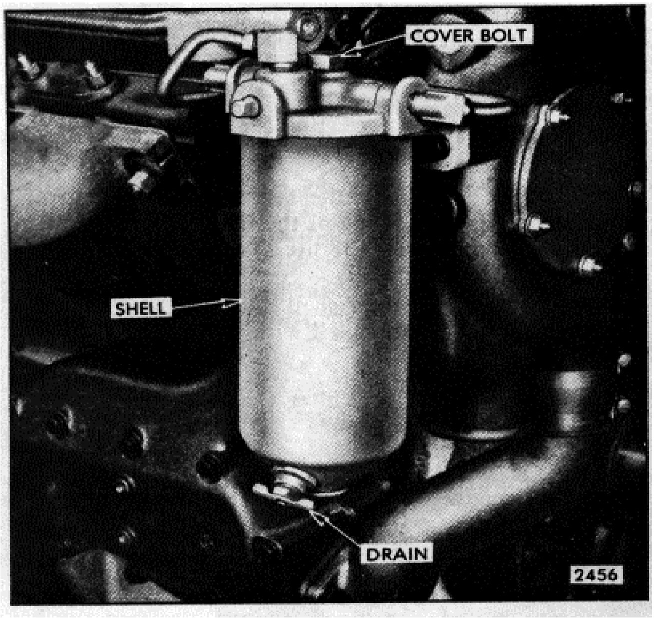


Fig. 3. - Typical Fuel Filter Mounting (Bolt-On Type)

larger foreign particles and the filter removes the small foreign particles.

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

Replace the elements as follows:

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

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

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

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

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

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

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

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

Spin-On Type

A spin-on type fuel strainer and fuel filter is used on certain engines (Fig. 4). The spin-on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly. No separate springs or seats are required to support the filters.

The filter covers incorporate a threaded sleeve to accept the spin-on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification.

No drain cocks are provided on the spin-on filters. Where water is a problem, it is recommended that a water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

A 11 diameter twelve-point nut on the bottom of the filter is provided to facilitate removal and installation.

Replace the filter as follows:

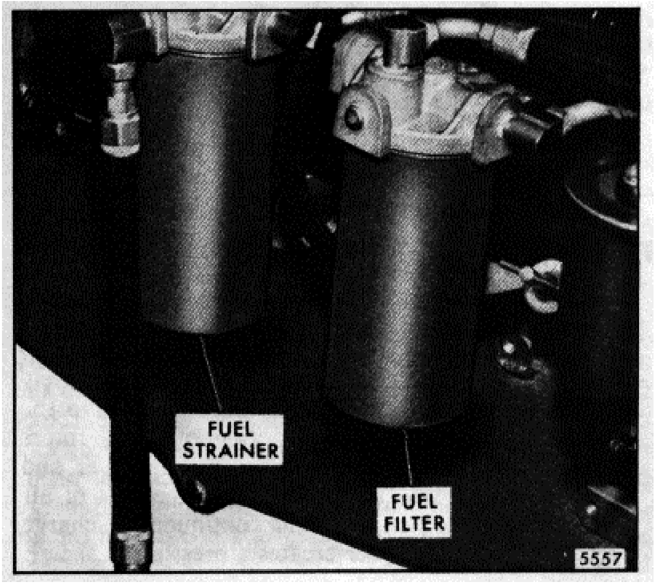


Fig. 4. - Typical Fuel Strainer and Filter Mounting (Spin-On Type)

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

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

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

4. Start the engine and check for leaks.

FUEL TANK

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

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

ENGINE OUT of FUEL

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

When an engine has run out of fuel, there is a definite procedure to follow for restarting the engine.

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

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

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

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

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

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

AIR SYSTEMS

In the scavenging system used in two-cycle engines and illustrated in Fig. 5, a charge of air, forced into the cylinders by the blower(s), sweeps all of the exhaust gases out through the exhaust valve ports, leaving the cylinders filled with fresh air for combustion at the end of each upward stroke of the pistons. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The blower(s) supplies fresh air required for combustion and scavenging. The hollow three-lobe rotors are closely fitted into the blower housing(s) which is bolted to the cylinder block. The revolving motion of these rotors pulls fresh air through the air cleaner or silencer and provides a continuous and uniform displacement of air in each combustion chamber. The continuous discharge of fresh air from the blower creates a pressure in the air box (air box pressure).

AIR CLEANERS

Several types of air cleaners are available for use with the V-92 engines. The light duty oil bath air cleaner (Fig. 6) is used with some marine models and a light or heavy-duty oil bath air cleaner (Fig. 7) is available for

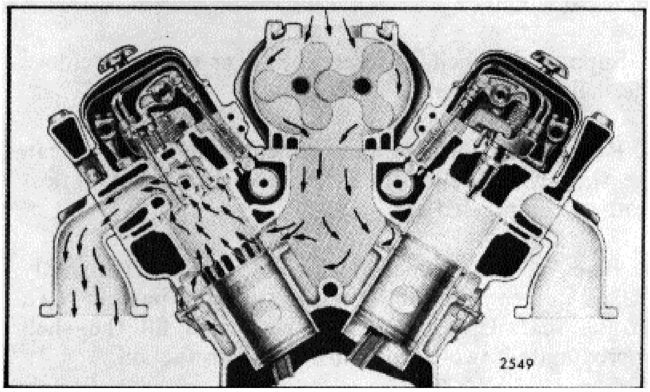


Fig. 5. - Air Intake System Through Blower and Engine

industrial engines. Some engines are equipped with a heavy-duty dry type air cleaner or a two-stage dry type air cleaner (Fig. 8). The air cleaners are designed for fast, easy disassembly to facilitate efficient servicing. Maximum protection of the engine against dust and other forms of air contamination is possible if the air cleaner is serviced at regular intervals.

Oil Bath

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

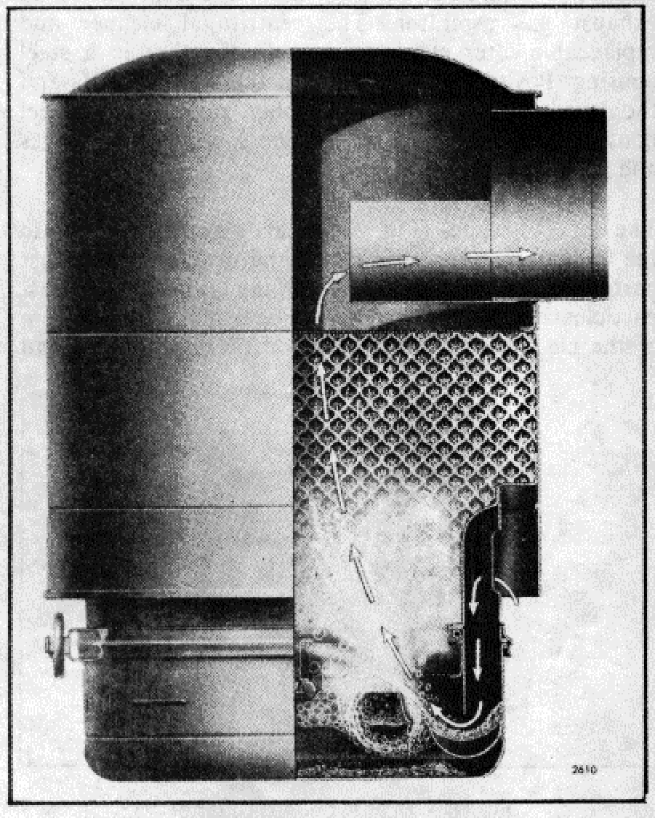


Fig. 6. - Typical Oil Bath Air Cleaner (Marine Engines)

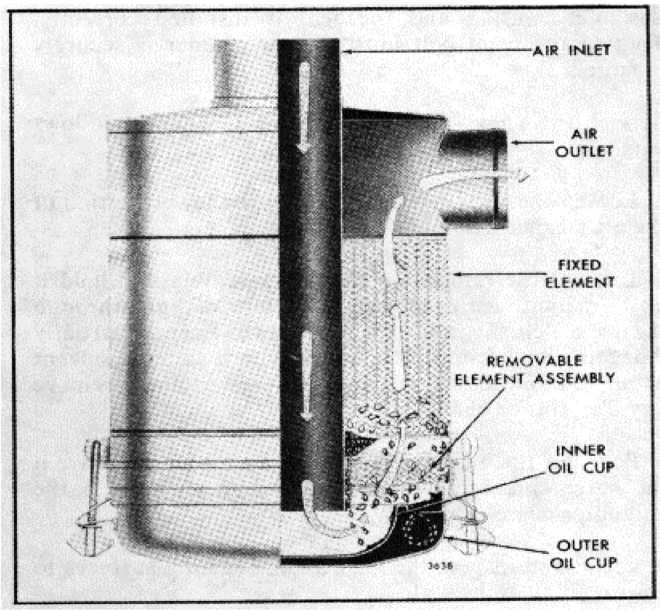


Fig. 7. - Typical Oil Bath Air Cleaner (Industrial Engines)

Service the light-duty oil bath air cleaner as follows (Fig. 6):

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing. The cleaner may then be separated into two sections; the upper section or body assembly contains the filter element and the lower section consists of the oil cup, removable inner cup or baffle, and the center tube.

2. Soak the body assembly and element in fuel oil to loosen the dirt; then flush the element with clean fuel oil and allow it to drain thoroughly.

3. Pour out the oil, separate the inner cup or baffle from the oil cup, remove the sludge and wipe the baffle and outer cup clean.

4. Push a lint-free cloth through the center tube to remove dirt or oil.

5. Clean and check all of the gaskets and sealing surfaces to ensure air tight seals.

6. Refill the oil cup to the oil level mark only, install the baffle and reassemble the air cleaner.

7. Check the air inlet housing before installing the air cleaner assembly on the engine. The inlet will be dirty if air cleaner servicing has been neglected or if dust laden air has been leaning past the air cleaner to the air inlet housing seals.

8. Make sure that the air cleaner is seated properly on the inlet housing and the seal is installed correctly. Tighten the wing bolt until the air cleaner is securely mounted.

Service the *heavy-duty* oil bath air cleaner as follows (Fig. 7):

1. Loosen the wing nuts and detach the lower portion of the air cleaner assembly.

2. Lift out the removable element assembly and hold it up to a light. An even, bright pattern of light through the wire element indicates it is clean. Even a partially plugged element must be cleaned with a suitable solvent or fuel oil and blown out with compressed air to remove any dirt, lint or chaff.

3. Pour out the oil, separate the inner cup or baffle from the outer cup, remove the sludge and wipe the baffle and outer cup clean.

4. Clean and inspect the gaskets and sealing surfaces to ensure an air tight seal.

5. Reinstall the baffle in the oil cup and refill to the proper oil level with the same grade of oil as used in the engine.

6. Inspect the lower portion of the air cleaner body and center tube each time the oil cup is serviced. If there are any indications of plugging, the body assembly should be removed and cleaned by soaking, and then flushing with clean fuel oil. Allow the unit to drain thoroughly.

7. Place the removable element in the body assembly. Install the body if it was removed from the engine for servicing.

8. Install the outer cup and baffle assembly. Be sure the cup is tightly secured to the assembly body.

Dry Type

The *dry-type* air cleaner consists of a removable cover attached to the air cleaner body which contains a replaceable paper filter cartridge and a dust cup. Air entering the air cleaner is a centrifugal precleaning by a turbine-type vane assembly. Air rotates at high speed around the filter element throwing the dust to the outside where it flows down the wall of the body and is ejected into a dust cup. The dust cup is baffled to prevent the reentry of the dust. The precleaned air passes through the paper filter and enters the engine.

Some air cleaners are equipped with an indicator which will aid in determining the servicing requirements.

Service the *dry-type* air cleaner as follows:

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing.

2. Detach the cover and wing bolt and remove the element. Then, empty and wipe the dust cup clean.

3. Clean the filter element as follows: If the element is dry and dusty, use compressed air. The air should be blown through the element opposite to the normal direction of air flow.

4. If the element is oily or has soot deposits, use a water hose (less than 40 psi or 276 kPa) and wash with warm water and a non-sudsing detergent. Dry the element thoroughly.

5. Reassemble all of the air cleaner parts, place the assembly on the air inlet housing and secure it with the wing bolts.

The two-stage dry-type air cleaner illustrated in Fig. 8 is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed. The cleaner assembly consists of a centrifugal air cleaner in series with a replaceable impregnated paper filter element. The dust collected in the centrifugal cleaner is exhausted by connecting the dust bin to an exhaust gas aspirator. The centrifugal cleaner and replaceable filter element are held together in a steel housing. Positive sealing between the two elements and the housing is provided by rubber gaskets. The steel housing incorporates filter fasteners, mounting flanges and an outlet for the filtered air.

The deflector vanes (Fig. 9) impart a swirling motion to the air entering the air cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust bin at the bottom of the cleaner by approximately 10% bleed-off air and

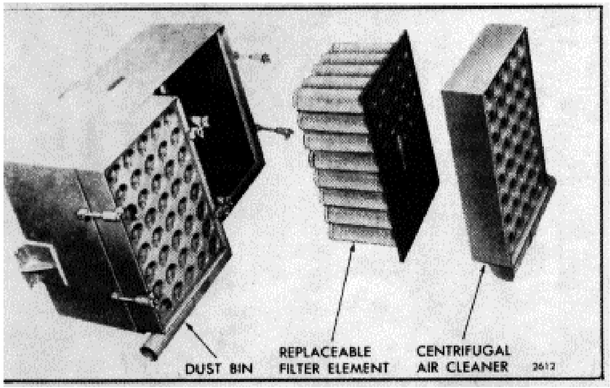


Fig. 8. - Dry Type Air Cleaner

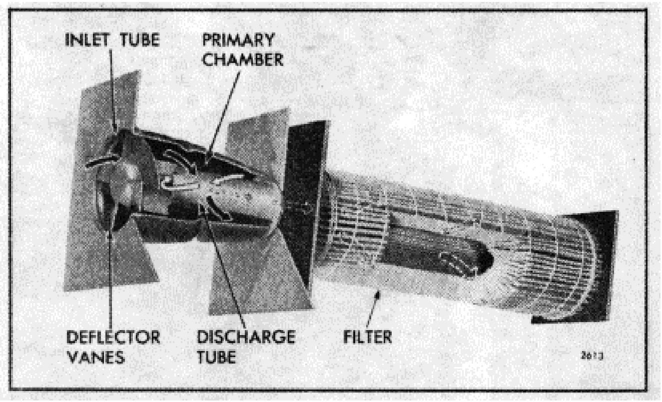


Fig. 9. - Flow of Air Through Filter Element Segment

are finally discharged into the atmosphere through an exhaust gas aspirator.

The exhaust gas aspirator is connected into the exhaust system of the engine (Fig. 10). A flexible hose carries the dust particles from the cleaner dust bin to the aspirator where the waste energy of the exhaust gases draws the dust-laden bleed off air out and discharges it into the atmosphere along with the engine exhaust gases. Approximately 90% of the total dust load is disposed of in this manner. The centrifugal air cleaner is fully effective at either high or low velocities.

The remainder of the air in the cleaner reverses direction and spirals back along the discharge tubes again centrifugally moving the air. The filtered air then reverses direction again and enters the replaceable filter element through the center portion of the discharge tubes. The air is filtered once more as it passes through the pleats of the impregnated paper element before leaving the outlet port of the cleaner housing.

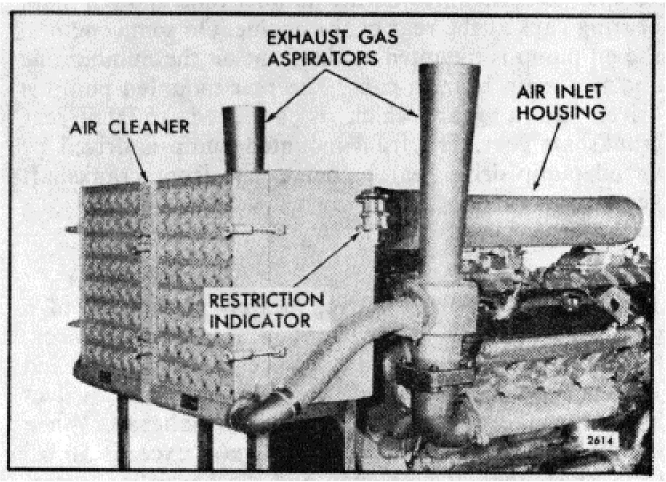


Fig. 10. - Typical Dry Type Air Cleaner Mounting

An air cleaner restriction indicator may be attached near the outlet side of the cleaner (Fig. 10). As, the restriction in the cleaner increases, suction created will pull the indicator plunger upward. A brightly colored card, attached to the plunger and visible through a small window in the indicator, will indicate the relative amount of air restriction in the cleaner. When the card is fully visible, the air cleaner should be cleaned and the indicator reset by pushing the plunger all the way up and then releasing it.

Service the *two-stage dry-type* air cleaner as follows:

The first stage centrifugal air cleaner tends to be selfcleaning due to the action of the exhaust gas aspirator. However, it should be inspected and any accumulated foreign material removed during the periodic replacement of the impregnated paper filter element. Overloading of the paper element will not cause dirt particles to bypass the filter and enter the engine, but will result in starving the engine for air.

The filter element may be replaced as follows:

1. Disconnect the flexible aspirator hose at the dust bin of the air cleaner.

2. Loosen the wing nuts on the filter fasteners and swing the retaining bolts away from the cleaner.

3. Lift the cleaner away from the housing and inspect it. Clean out any accumulated foreign material.

4. Withdraw the paper filter element and discard it.

5. Install a new filter element. New sealing gaskets are provided with the element to insure a positive air seal at all times.

6. Install the cleaner and secure it in place with the fasteners.

7. Connect the aspirator hose to the dust bin, making sure the connection is air tight.

AIR SILENCER (TURBOCHARGER)

The air silencer is attached at the outlet end of the turbocharger with a hose and clamps (Fig. 11). It is supported by a bracket attached to the flywheel housing. An air filter element of polyurethane foam is used on the air silencer inlet screen.

While no servicing is required on the air silencer, it will be necessary to remove it to perform other service operations.

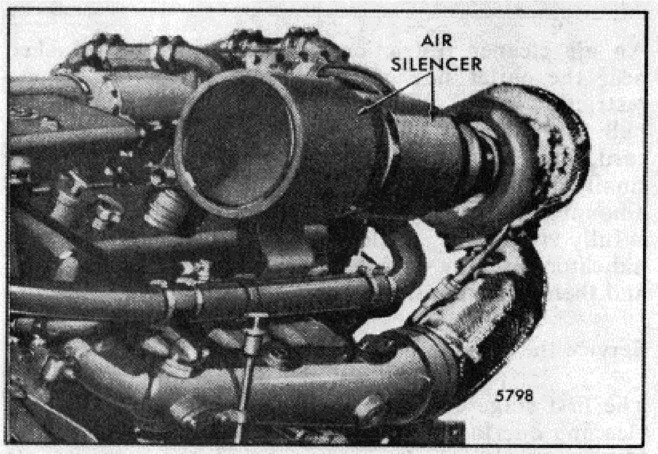


Fig. 11. - Air Silencer Mounted on 6V-92 TA Engine

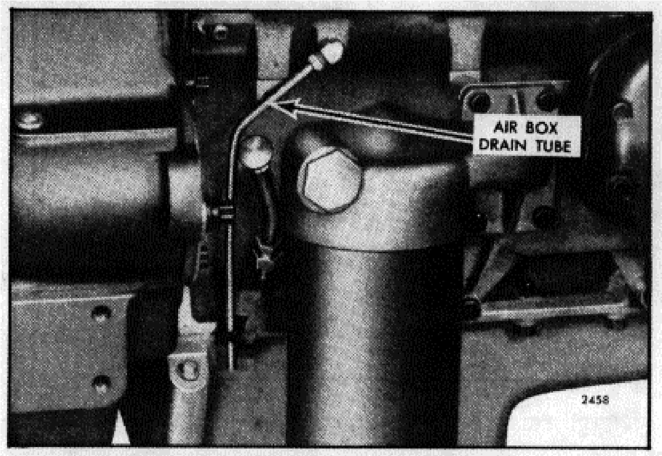


Fig. 12. - Air Box Drains

AIR BOX DRAINS

In normal operation, a slight amount of vapor from the air condenses and settles at the bottom of the air box. This condensation is drained through air box drain tubes (Fig. 12) which direct the expelled air and vapor down and away from the engine.

Air box drains must be open at all times; otherwise, water and oil may accumulate in the air box and be drawn into the cylinders with the incoming fresh air. Therefore, periodic checks should be made to ensure they are open. Remove the air box covers and examine the air box floor for oil or an accumulation of water. If oil or water is found, wipe the air box dry with clean rags and remove and clean the air box drain tubes.

CRANKCASE VENTILATION

Harmful vapors which may form within the engine are removed by a continuous ventilation system. A slight pressure is maintained within the engine by the seepage of a small amount of air past the piston rings into the crankcase. The air seepage past the piston rings is directed through a vent to the atmosphere.

LUBRICATING SYSTEM

The lubricating oil systems schematically illustrated in Figs. 13 and 14 consist of an oil pump, oil cooler, a full flow oil filter, bypass valves at the oil cooler and filter and pressure regulator valves at the pump and in the cylinder block main oil gallery. Positive lubrication is ensured at all times by this system. A bypass oil filter may also be incorporated into the lubricating system at the owner’s option.

Oil for lubricating the connecting rod bearings, piston pins and for cooling the piston head is provided through the drilled hole in the crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of oil from the camshaft pocket through a connecting passage into the flywheel housing. A certain amount of oil spills into the flywheel housing from the camshaft and idler gear bearings. The blower drive gear is lubricated from the camshaft and idler gear bearings. The blower drive gear is lubricated from the rear of the blower.

The oil pump on the 6V-92 and 8V-92 engines is driven by a pump drive hub on the front end of the crankshaft and consists of a large and small spur gear meshing in a cavity inside the crankshaft cover.

The gear-type lubricating oil pump on 12V-92 and 16V-92 engines is mounted on the number nine and ten main bearing caps at the rear of the engine. On some engines, the oil pump is mounted at the front on the number one and two main bearing caps. The rear mounted pump is driven by a gear which is attached to the rear crankshaft gear. The front mounted pump is driven by an oil pump drive gear bolted to the front crankshaft gear.

The pressure regulator valve, located at the end of a vertical oil gallery in the front of the cylinder block, maintains a stabilized oil pressure. The 12V-92 and 16V-92 engines has two pressure regulator valves located at the ends of the vertical oil galleries. When the oil pressure at the regulator valve(s) exceeds 50 psi (345 kPa), the valve(s) open and discharge the excess oil to the sump.

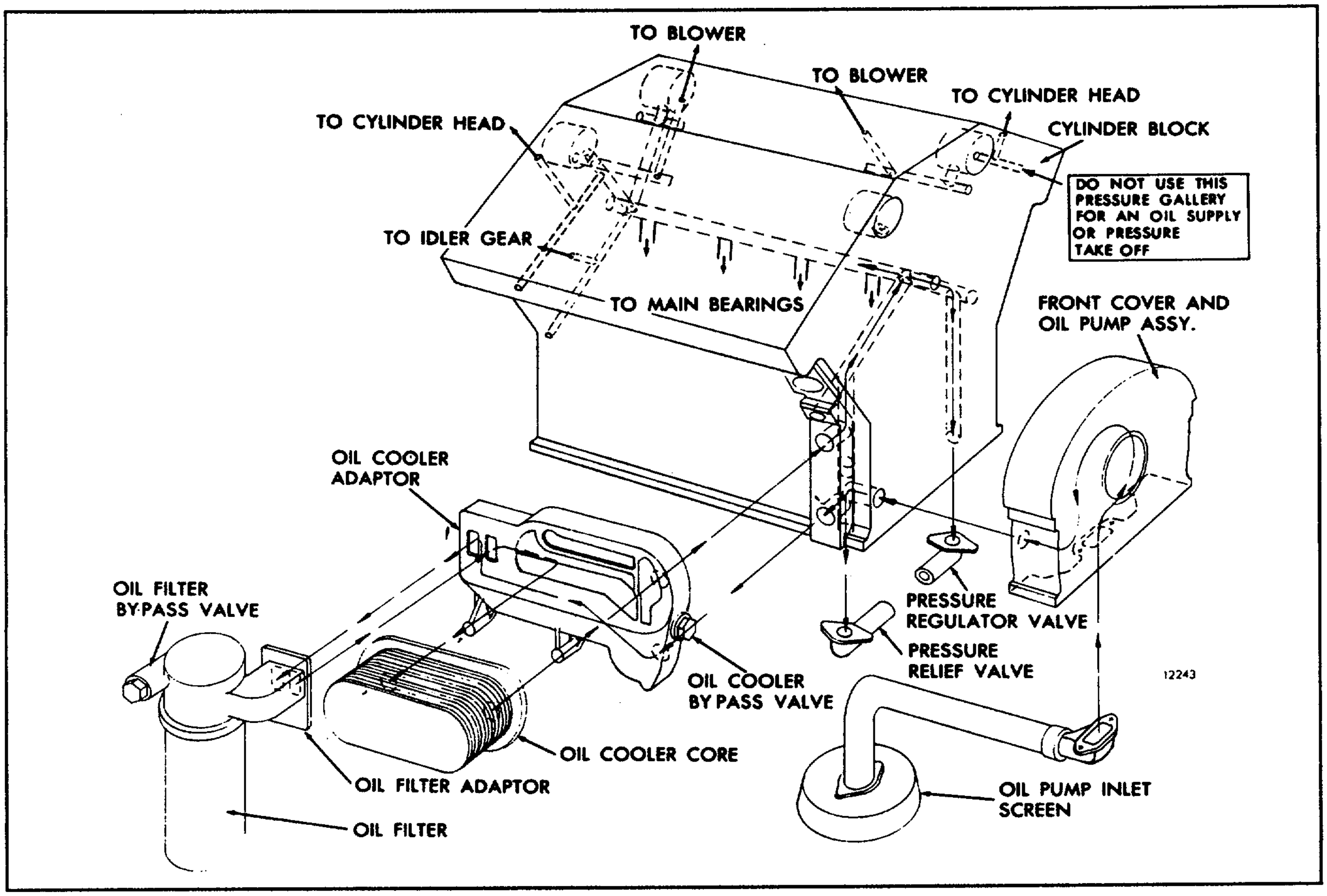


Fig. 13. - Schematic Diagram of Typical 6V-92 and 8V-92 Lubricating Systems

OIL FILTERS

Engines are equipped with a full-flow type lubricating oil filter. If additional filtering is required, a bypass type oil filter may also be installed. The full-flow filter assembly can be remotely mounted or mounted on the engine (Fig. 15). A bypass valve, which opens at 15 psi (103 kPa), is located in the filter base to ensure engine lubrication in the event the filter should become plugged.

All of the oil supplied to the engine passes through the full-flow filter that removes the larger foreign particles without restricting the normal flow of oil.

The bypass filter assembly, when used, continually filters a portion of the lubricating oil that is being bled off the oil gallery when the engine is running. Eventually all of the oil passes through the filter, filtering out minute foreign particles that may be present.

Some engines may be equipped with a bypass filter assembly consisting of two filter elements, each enclosed in a shell which is mounted on a single base. An oil passage in the filter base connects the two annular spaces surrounding both filter elements.

The full flow and bypass filter elements should be replaced, each time the engine oil is changed, as follows:

1. Remove the drain plug and drain the oil (Fig. 15).

2. The filter shell, element and stud may be detached as an assembly, after removing the center stud from the base. Discard the gasket.

3. Clean the filter base.

4. Discard the used element, wipe out the filter shell and install a new element on the center stud.

5. Place a new gasket in the filter base, position the shell and element assembly on the gasket and tighten

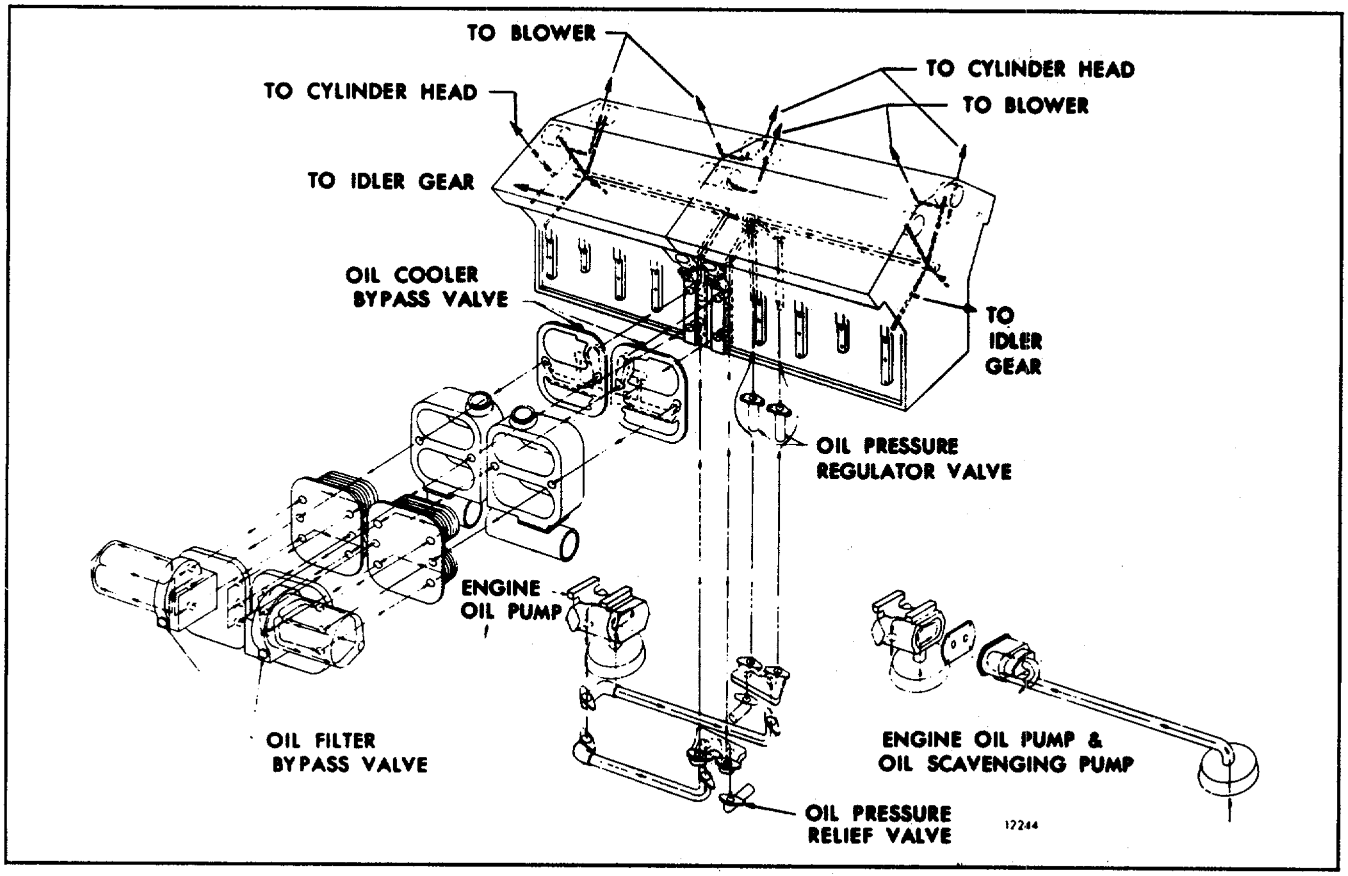


Fig. 14. - Schematic Diagram of Typical 12V-92 and 16V-92 Lubricating System

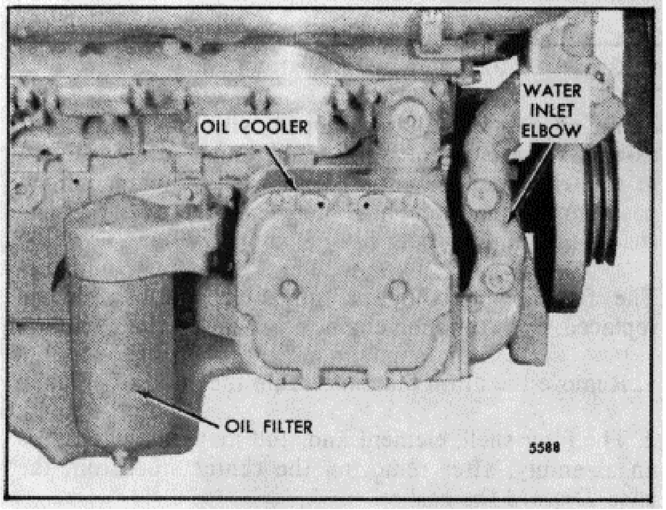


Fig. 15. - Typical Full-Flow Filter Mounting (6V-92 or 8V-92 Engine)

the center stud carefully to prevent damaging the gasket or center stud.

6. Install the drain plug and, after the engine is started, check for oil leaks.

COOLING SYSTEM

To effectively dissipate the heat generated by the engine, one of three different types of cooling systems is used on a V-92 engine; radiator and fan, heat exchanger and raw water pump, or keel cooling. Each system is provided with a centrifugal type water pump that circulates the engine coolant. Each system incorporates thermostats to maintain a normal engine operating temperature of 160-185° F (71-85° C). A typical cooling system is illustrated in Fig. 16.

RADIATOR and FAN COOLING

Coolant is drawn from the lower portion of the radiator by the water pump and is forced through the oil cooler housing and into the cylinder block. From the cylinder block the coolant passes up through the cylinder heads and, when the engine is at normal operating temperature, through the thermostat housings and into the upper portion of the radiator. Then, the coolant passes down a series of tubes where the coolant temperature is lowered by the air stream created by the revolving fan.

Upon starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostat housing and a bypass provides water circulation within the engine during the warm-up period.

HEAT EXCHANGER COOLING

In the heat exchanger cooling system, the coolant is drawn by the fresh water pump from the heat exchanger and is forced through the engine oil cooler, cylinder block, cylinder heads, exhaust manifolds and to the thermostat housings. A bypass tube from the thermostat housings to the inlet side of the water pump permits circulation of the coolant through the engine while the thermostats are closed. When the thermostats open, the coolant can flow through the heat exchanger and then, after being cooled, to the engine fresh water pump for recirculation.

While passing through the core of the heat exchanger, the coolant temperature is lowered by raw water which is drawn by the raw water pump from an outside supply. The raw water enters the heat exchanger at one side and is discharged at the opposite side.

To protect the heat exchanger element from electrolytic action, a zinc electrode is located in both the heat exchanger inlet elbow and the raw water pump inlet elbow and extends into the raw water passage.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed by the kind of coolant used in the engine and the kind of raw water used. Soft water plus a rust inhibitor or an ethylene glycol base antifreeze should be used as the engine coolant.

When foreign deposits accumulate in the heat exchanger, to the extent that cooling efficiency is impaired, such deposits can, in most instances, be removed by circulating a flushing compound through the fresh water circulating system without removing the heat exchanger. If this treatment does not restore the engine's normal cooling characteristics, contact an authorized *Detroit Diesel Allison Service Outlet*.

KEEL COOLING

In the keel cooling system, the coolant is drawn by the fresh water pump from the keel cooler and is forced through the engine oil cooler, cylinder block, cylinder heads, exhaust manifolds and to the thermostat housings. A bypass tube from the thermostat housings to the inlet side of the water pump permits circulation of coolant through the engine while the thermostats are closed. When the thermostats open, the coolant can flow through the keel cooling coils, and then to the suction side of the fresh water pump for recirculation.

The heat of the engine coolant is transferred through the coils of the keel cooler to the surrounding water.

COOLING SYSTEM MAINTENANCE

Engine Coolant

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinder, from the component parts such as exhaust valves, cylinder liners, and pistons which are surrounded by water jackets. In addition, the heat absorbed by the oil is also removed by the engine coolant in the oil-to-water cooler.

For the recommended coolant, refer to *Coolant Specifications in Section 5*

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, head, water manifold, thermostat housing and oil cooler housing) is shown in Table 1.

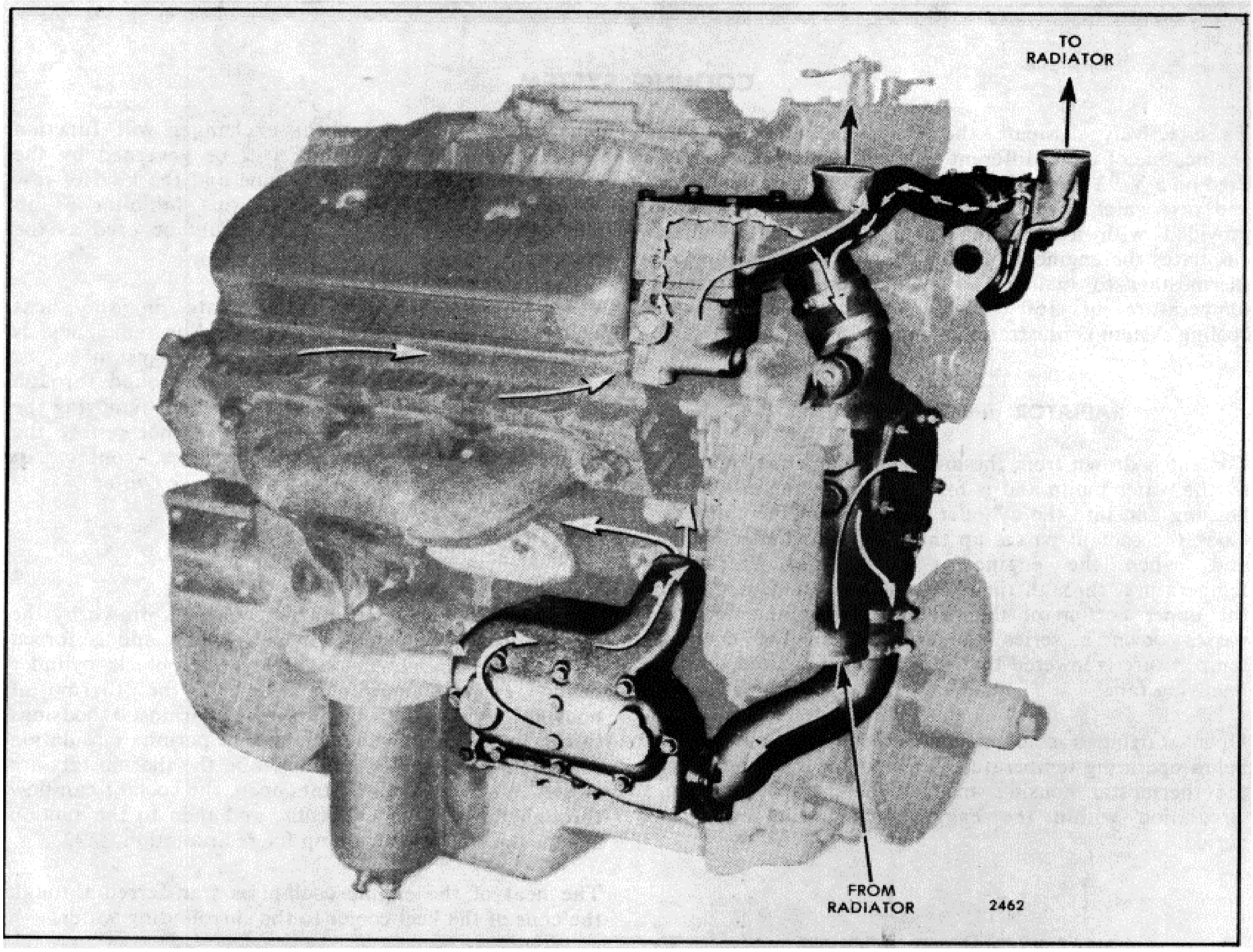


Fig. 16. - Cooling System

COOLING SYSTEM CAPACITY
(BASIC ENGINE)

Engine	Capacity	
	gallons	liters
6V-92	6	22.7
8V-92	7	26.5
12V-92	12	45.4
16V-92	14-1/2	54.9

TABLE 1.

To obtain the complete amount of coolant in the cooling system of a unit, the additional capacity of the radiator, hoses, etc. must be added to the capacity of the basic engine. The capacity of radiators and related equipment should be obtained from the equipment supplier.

Fill Cooling System

Before starting the engine, close all of the drain cocks and fill the cooling system with water. If the unit has a raw water pump, it should also be primed, since operation without water may cause impeller failure. The use of clean, soft water will eliminate the need for descaling solutions to clean the cooling system. A hard, mineral-laden water should be made soft by using water softener chemicals before it is poured into the cooling system. These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

Start the engine and, after the normal operating temperature has been reached, allowing the coolant to expand to its maximum, check the coolant level. The coolant level should be within 2’’ of the top of the filler neck.

Should a daily loss of coolant be observed, and there are no apparent leaks, there is a possibility of gases leaking past the cylinder head water seal rings into the cooling system. The presence of air or gases in the cooling system may be detected by connecting a rubber tube from the overflow pipe to a water container. Bubbles in the water in the container during engine operation will indicate this leakage. Another method for observing air in the cooling system is by inserting a transparent tube in the water outlet line.

Drain Cooling System

The engine coolant is drained by opening the cylinder block and radiator (heat exchanger) drain cocks and removing the cooling system filler cap. The removal of the cooling system filler cap permits air to enter the cooling passages and the coolant to drain completely from the system.

Drain cocks are located on each side of the cylinder block at both the front and rear of the engine. The drain cocks at the rear of the engine are below the exhaust manifold. The front surface of the cylinder block has drain cocks on each side above the engine front cover.

In addition to the drains on the block, the oil cooler housing has a drain cock at the extreme bottom. Radiators and other components that do not have a drain cock are drained through the oil cooler housing drain cock.

To ensure that all of the coolant is drained completely from a unit, all cooling system drains should be opened. Should any entrapped water in the cylinder block or radiator freeze, it will expand and may cause damage. When freezing weather is expected, drain all units not adequately protected by antifreeze. Leave all drain cocks open until refilling the cooling system.

Marine engine exhaust manifolds are cooled by the same coolant used in the engine. Whenever the engine cooling system is drained, open the exhaust manifold drain cocks.

Raw water pumps are drained by loosening the cover attaching screws and tapping the cover gently to loosen it. After the water has drained, tighten the screws.

Flushing Cooling System

The cooling system should be flushed each spring and fall. The flushing operation cleans the system of antifreeze solution in the spring and removes the summer rust inhibitor in the fall, preparing the cooling system for a new solution. The flushing operation should be performed as follows:

1. Drain the previous season's solution from the engine.

2. Refill the cooling system with soft clean water. If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.

3. Start the engine and operate it for 15 minutes to circulate the water thoroughly.

4. Drain the cooling system completely.

5. Refill the system with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats, and the fan belt tension and water level have been found to be satisfactory, clean and flush the entire cooling system. Remove scale formation by using a reputable and safe descaling solvent. Immediately after using the descaling solvent, neutralize the system with the neutralizer. It is important that the directions printed on the container of the descaler be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and reverse flush before filling the system.

Reverse Flushing

After the engine and radiator have been thoroughly cleaned, they should be reverse flushed. The water pump should be removed and the radiator and engine reverse flushed separately to prevent dirt and scale deposits clogging the radiator tubes or being forced through the pump. Reverse flushing is accomplished by hot water, under air pressure, being forced through the cooling system, in a direction opposite to the normal flow of coolant, loosening and forcing scale deposits out.

The radiator is reverse flushed as follows:

1. Remove the radiator inlet and outlet hoses and replace the radiator cap.

2. Attach a hose at the top of the radiator to lead water away from the engine.

3. Attach a hose to the bottom of the radiator and insert a flushing gun in the hose.

4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.

5. Turn on the water and, when the radiator is full, turn on the air in short blasts, allowing the radiator to fill between air blasts.

> **CAUTION**: Apply air gradually. Do not exert more than 30 psi (207 kPa) air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until only clean water is expelled from the radiator.

The cylinder block and cylinder head water passages are reverse flushed as follows:

1. Remove the thermostat and the water pump.

2. Attach a hose to the water inlet of the cylinder block to drain the water away from the engine.

3. Attach a hose to the water outlet at the top of the cylinder block and insert the flushing gun in the hose.

4. Turn on the water and, when the water jackets are filled, turn on the air in short blasts, allowing the engine to fill with water between air blasts.

5. Continue flushing until the water from the engine runs clean.

If scale deposits in the radiator cannot be removed by chemical cleaners or reverse flushing as outlined above, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate water through the radiator core from the bottom to the top during this operation.

Miscellaneous Cooling System Checks

In addition to the above cleaning procedures, the other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The cooling system hoses, thermostats and radiator pressure cap should be checked and replaced if found to be defective.

When water connection seals and hoses are installed, be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamps. All external leaks should be corrected as soon as detected.

The fan belt must be checked and adjusted, if necessary, to provide the proper tension and the fan shroud must be tight against the radiator core to prevent recirculation of air which may lower the cooling efficiency.

Water Pump

The centrifugal type water pump is mounted on the engine front cover and is driven by a front camshaft gear. This pump circulates the engine coolant through the cylinder block, cylinder head, heat exchanger or radiator and the oil cooler.

The pump consists of a bronze impeller secured to a stainless steel shaft with a locknut. A gear is pressed on the opposite end of the shaft and the shaft turns on two ball bearings. An oil seal is used ahead of the front bearing and a spring-loaded face type water seal is used in back of the impeller. The pump ball bearings are lubricated with oil splashed by the water pump gear.

Contact an authorized *Detroit Diesel Allison Service Outlet* if more information is needed.

Raw Water Pump

A positive displacement raw water pump driven by a coupling from a camshaft circulates raw water through the heat exchanger to lower the temperature of the engine coolant.

The impeller (Fig. 17) is self-lubricated by the water pumped and should be primed before starting the engine.

Rubber spline plugs have been inserted between the end of the drive shaft and cover to reduce the possibility of foreign material working into the splines and causing wear.

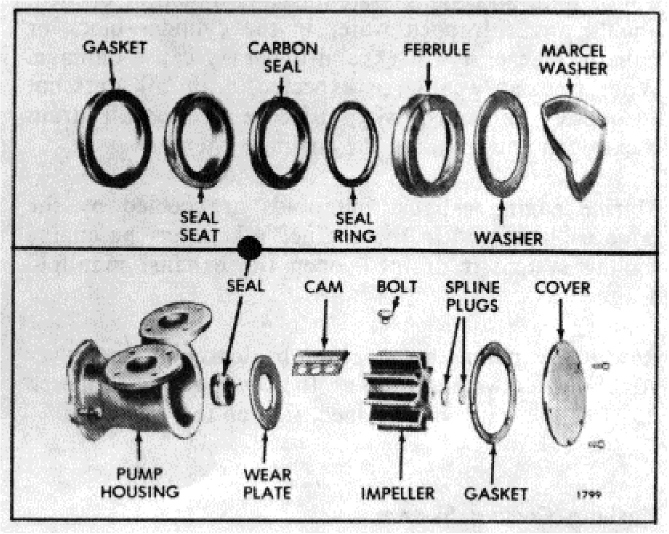


Fig. 17. - Raw Water Pump Details and Relative Location of Parts

Note that the end cover is marked to show the outlet port for RH rotation and the outlet port for LH rotation. Follow these markings when installing the raw water pump to assure proper direction of flow. Also, when installing the inlet elbow or outlet elbow, be sure to use two flat washers on the bolt being installed in the blind hole in the pump housin.

A rotary type seal assembly prevents any leakage along the shaft.

A raw water pump seal failure is readily noticeable by the leakage of water from the openings in the pump housing. These openings, which are located between the pump mounting flange and the inlet and outlet ports, must remain open at all times.

It is possible to replace seal parts and the impeller without removing the pump from the engine.

Use care to prevent scratching the lapped surface of the seal seat or that portion of the shaft which the seal contacts.

The raw water pump seal parts and impeller may be removed and replaced as follows:

1. Remove the cover screws and lift the cover and gasket from the housing (Fig. 17). Note the position of the impeller blades to facilitate reassembly.

2. Grasp a blade at each side of the impeller with pliers and pull the impeller from the shaft. The spline plugs will come out with the impeller.

3. Remove the spline plugs by pushing a screwdriver through the impeller from the opposite end.

   NOTE: If the impeller is reusable, care should be exercised to prevent damage to the splined surfaces.

4. Inspect the bond between the neoprene and the metal of the impeller. Check the impeller blades. If they have a permanent set, a new impeller should be used. If the impeller area which rides on the wear plate is damaged, the impeller should be replaced.

5. Insert two wires (each with a hook at one end) between the housing and seal, with the hooks over the edge of the carbon seal. Then, pull the seal assembly from the shaft.

6. The seal seat and gasket may be removed in the same manner.

7. Remove the cam bolt and cam.

8. Remove the wear plate and check it for wear and burrs. If the plate is worn or burred, it may be reversed.

9. Install the wear plate. There is a dowel in the pump body,and the wear plate is notched to ensure correct installation.

10. Hold the cam in position and install the cam bolt.

11. If the seal seat and gasket are removed, place the gasket and seal seat over the shaft and press them into position in the seal cavity.

12. Place the seal ring securely in the ferrule and, with the carbon seal and washer correctly positioned against the ferrule, slide the ferrule over the shaft and against the seal seat. Be sure the seal ring is correctly contained within the ferrule so that it grips the shaft.

13. Install the flat washer, and then the marcel washer.

14. Compress the impeller blades to clear the offset cam and press the impeller on the splined shaft. The impeller blades must be correctly positioned to follow the direction of rotation.

15. Turn the engine over a few revolutions to position the impeller blades properly. Install the spline plugs.

16. Use a new gasket and install the cover on the housing.

The Jabsco raw water pump is equipped with a synthetic rubber impeller. Since synthetic rubber loses its elasticity at low temperatures, impellers made of natural rubber should be installed when it is necessary to pump raw water that has a temperature below 40° F (4° C).

The synthetic rubber impeller must be used when the pump operates with water over 40° F (4° C).

ENGINE EQUIPMENT

INSTURMANT PANEL, INSTURMENTS AND CONTROLS

The instruments generally required in the operation of a diesel engine consist of an oil pressure gage, a water temperature gage, an ammeter and a mechanical tachometer (Fig. 1). Also closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine starting switch, an engine stop knob, an emergency stop knob and, on certain applications, the engine hand throttle.

Marine propulsion units are provided with an instrument panel which usually includes an engine oil pressure gage, reverse gear oil pressure gage, water temperature gage, ammeter and a tachometer. The instrument panels are generally mounted some distance from the engine. Illuminated instrument panels are provided for marine applications which require night operations.

Oil Pressure Gage

The oil pressure gage registers the pressure of the lubricating oil in the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed under Running in the Engine Operating Instructions, the engine should be stopped and the cause of low oil pressure determined and corrected before the engine is started again.

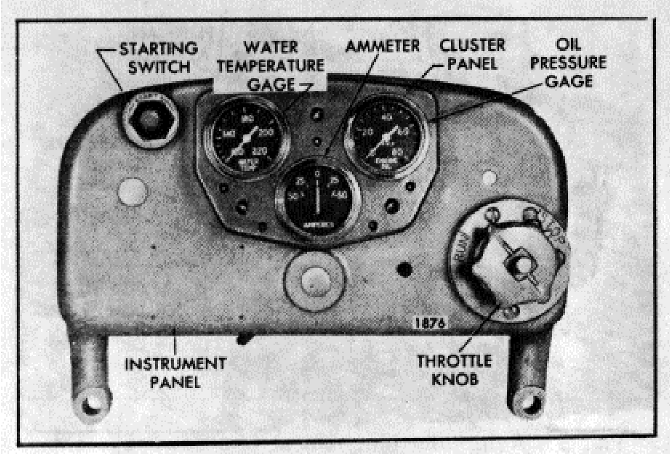


Fig. 1. - Typical Instrument Panel

Water Temperature Gage

The engine coolant temperature is registered on the water temperature gage.

Ammeter

An ammeter is wired into the electrical circuit to show the current flow to and from the battery. After starting the engine, the ammeter should register a high charge rate at rated engine speed. This is the rate of charge received by the battery to replenish the current used to start the engine. As the engine continues to operate, the ammeter should show a decline in charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery-charging alternator. If lights or other electrical equipment are connected into the circuit, then the ammeter will show discharge when these items are operating and the engine speed is reduced.

Tachometer

The tachometer, driven by the engine, registers the speed of the engine in revolutions per minute (rpm).

Engine Starting Switch

The engine starting switch is mounted on the instrument panel with the contact button extending through the front face of the panel. The switch is used to energize the starting motor. As soon as the engine starts, release the switch.

Stop Knob

A stop knob is used on most applications to shut down the engine. When stopping an engine, the speed should be reduced to idle and the engine allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine’s moving parts. Then, the stop knob should be pulled and held until the engine stops. Pulling on the stop knob manually places the injector racks in the "no-fuel" position. The stop knob should be returned to its original position after the engine stops.

NOTE: When an emergency shut down is necessary, the stop knob should be pulled immediately and held until the engine stops.

Emergency Stop Knob

(Engine with Air Shutoff Valve)

In an emergency, or if after pulling the engine stop knob the engine continues to operate, the emergency stop knob may be pulled to stop the engine. The emergency stop knob, when pulled, will trip the air shutoff valve located between the air inlet housing and the blower and shut off the air supply to the engine. Lack of air will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be push J back in after the engine stops so the air shutoff valve can be opened for restarting after the malfunction has been corrected.

Throttle Control

The engine throttle is connected to the governor speed control shaft through linkage. Movement of the speed control shaft changes the speed setting of the governor and thus the engine speed.

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN

A manually operated emergency engine shutdown device, mounted in the air shutdown housing, enables the engine operator to stop the engine in the event an abnormal condition should arise. If the engine continues to run after the engine throttle is placed in the no-fuel position, or if combustible liquids or gases are accidentally introduced into the combustion chamber causing overspeeding of the engine, the shutdown device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The device consists of a shutoff valve mounted in the air shutdown housing and a suitable operating mechanism (Fig. 2).

The air shutoff valve is retained in the open position by a latch. A Bowden wire or cable assembly is used to trip the latch. Pulling the emergency shutdown knob all the way out will stop the engine. After the engine stops, the operator must push the emergency shutdown knob all the way in and manually reset the air shutoff valve before the engine is started again.

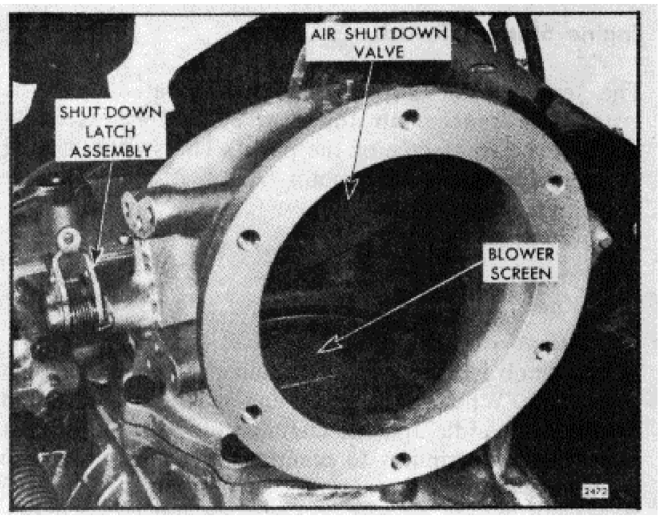


Fig. 2. - Manually Operated Emergency Engine Shutdown Valve Mounting

AUTOMATIC MECHANICAL SHUTDOWN

The automatic mechanical shutdown system (Fig. 3) is designed to stop the engine if there is a loss of oil pressure, loss of engine coolant, overheating of the engine coolant, or overspeeding of the engine. Engine oil pressure is utilized to activate the components of the system.

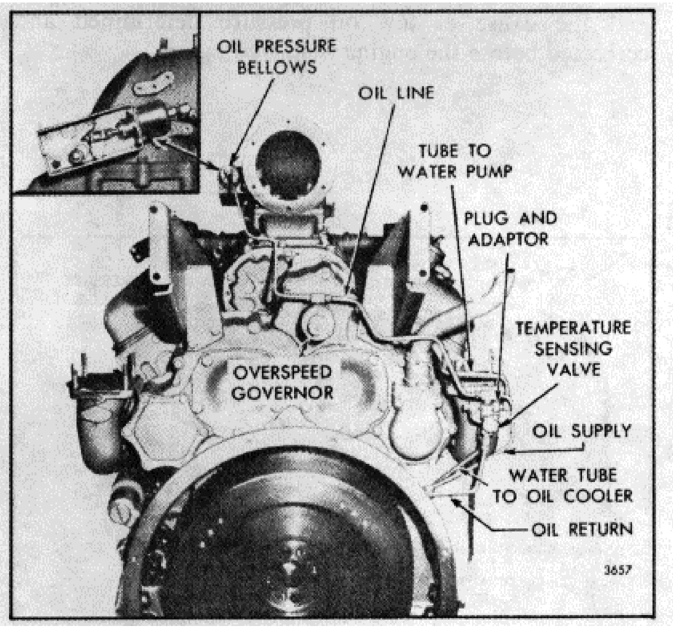


Fig. 3. - Automatic Mechanical Shutdown System Mounting

A coolant temperature-sensing valve and an adapter and copper plug assembly are mounted on the exhaust manifold outlet. The power element of the temperature-sensing valve is placed against one end of the copper plug, and the other end of the plug extends into the exhaust manifold. Engine coolant is directed through the adaptor and passes over the power element of the valve. Engine oil, under pressure, is directed through a restricted fitting to the temperature-sensing valve and to an oil pressure actuated bellows located on the air inlet housing.

The pressure of the oil entering the bellows overcomes the tension of the bellows spring and permits the latch to retain the air shutoff valve in the open position. If the oil pressure drops below a predetermined value, the spring in the bellows will release the latch and permit the air shutoff valve to close and thus stop the engine.

The over speed governor (Fig. 4), used on certain applications, consists of a valve actuated by a set of spring-loaded weights. Engine oil is supplied to the valve through a connection in the oil line between the bellows and the temperature-sensing valve. An outlet in the governor valve is connected to the engine oil sump. Whenever the engine speed exceeds the over speed governor setting, the valve (actuated by the governor weights) is moved from its seat and permits the oil to flow to the engine sump. This decreases the oil pressure to the bellows, thus actuating the shutdown mechanism and stopping the engine.

A restricted fitting, which will permit a drop in oil pressure great enough to actuate the shutdown mechanism, is required in the oil line between the cylinder block oil gallery and the shutdown sensing devices.

Operation

To start an engine equipped with a mechanical shutdown system, first manually open the air shutdown valve and then press the engine starting switch. As soon as the engine starts, the starting switch may be released, but the air shutdown valve must be held in the open position until the engine oil pressure increases sufficiently to permit the bellows to retain the latch in the open position. During operation, if the engine oil pressure drops below the setting of the pressure sensitive bellows, the spring within the bellows will release the latch and permit the air shutdown valve to close, thus stopping the engine. If the engine coolant overheats, the temperature-sensing valve will open and permit the oil in the protective system to flow to the engine crankcase. The resulting decrease in oil pressure will actuate the shutdown mechanism and stop the engine. Also, if the engine loses its coolant, the copper plug will be heated by the hot exhaust gases passing over it and cause the temperature-sensing valve to open and actuate the shutdown mechanism.

Whenever the engine speed exceeds the overspeed governor setting, the oil in the line flows to the sump, resulting in a decrease in oil pressure. The oil pressure bellows then releases the latch and permits the air shutdown valve to close.

When an engine is stopped by the action of the shutdown system, the engine cannot be started again until the particular device which actuated the shutdown mechanism has returned to its normal position. The abnormal condition which caused the engine to stop must be corrected before attempting to start it again.

AUTOMATIC ELECTRICAL SHUTDOWN

The automatic electrical shutdown system shown in Fig. 5 protects the engine against a loss of coolant, overheating of the coolant, loss of oil pressure or over speeding. In the event one of the foregoing conditions arises, a switch will close the electrical circuit and energize the solenoid switch, causing the shutdown solenoid to release the air shutdown latch and stop the engine.

Operation

The electrical circuit is de-energized under normal operating conditions. When the engine is started, one oil pressure switch opens when the oil pressure reaches approximately 10 psi (69 kPa) and the fuel oil pressure switch closes at approximately 20 psi (138 kPa) fuel pressure.

If the oil pressure drops below 10 psi (69 kPa), the oil pressure switch will close the circuit and energize the shutdown solenoid. This will activate the shutdown mechanism and stop the engine.

A loss of coolant or an increase in coolant temperature to approximately 203° F (940 C) will close the contacts in the water temperature switch, thus closing the electrical circuit and activating the shutdown mechanism.

The water temperature switch consists of a temperature-sensing element and a micro-switch. The element contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine coolant is directed over the temperature-sensing element of the switch and should the coolant temperature exceed approximately

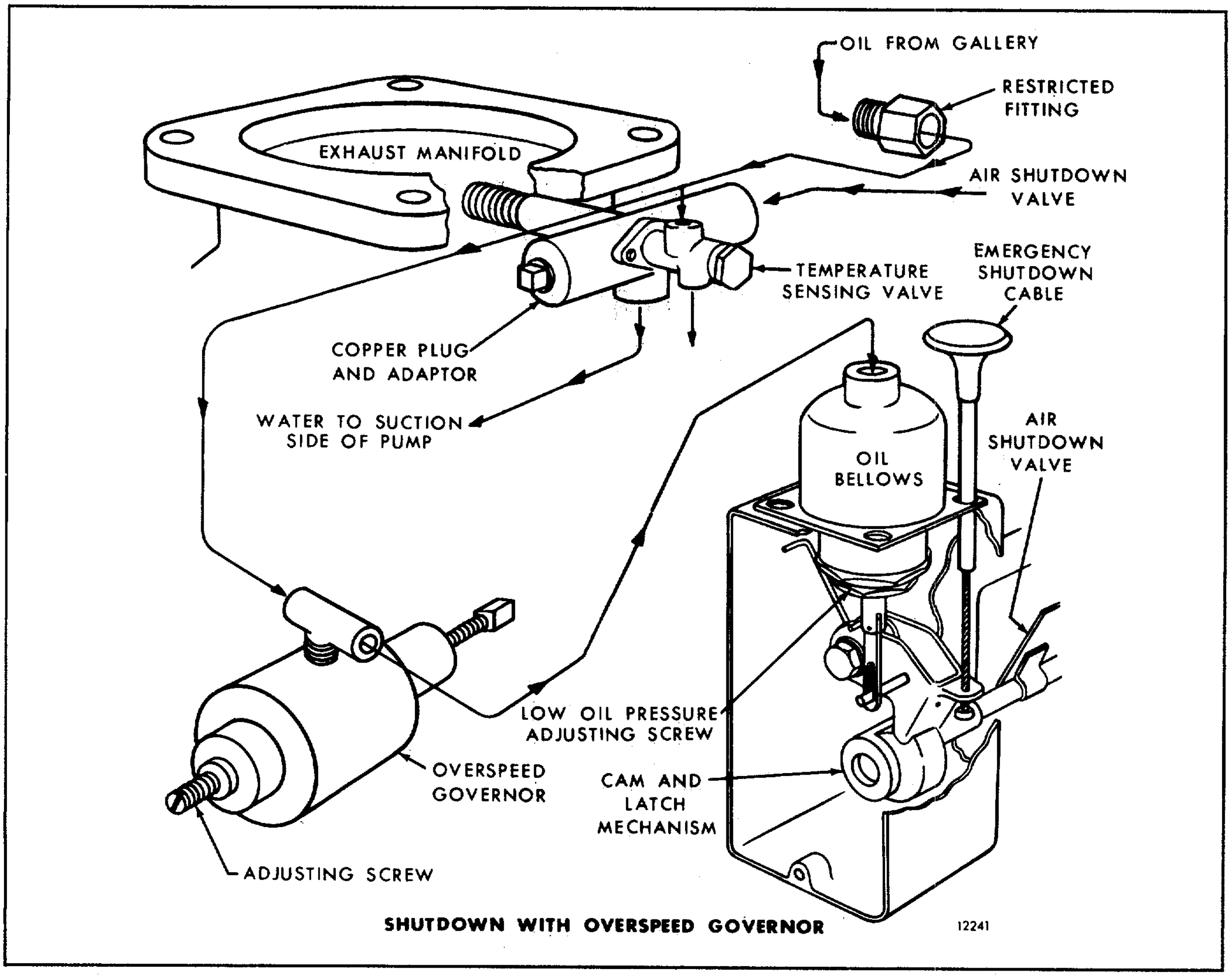


Fig. 4. - Schematic Drawing of Automatic Mechanical Shutdown System with Over speed Governor

203^0 F (94^0 C), the element will close the contacts in the micro-switch and energize the shutdown circuit. If a loss of coolant occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing element and cause the shutdown circuit to be activated.

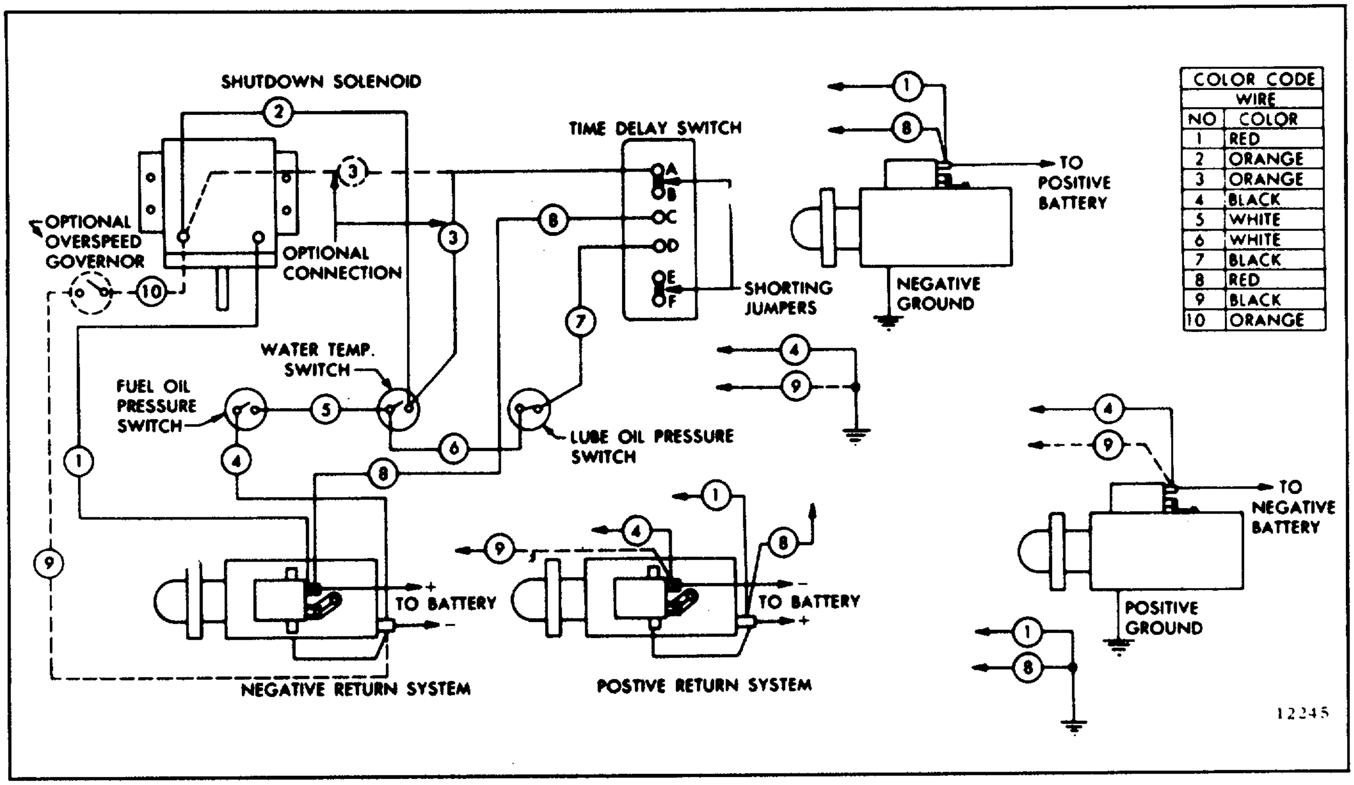
When the engine is shut down, the decrease in oil and fuel pressures will close the oil pressure switches and open the fuel pressure switch, thus de-energizing the circuit.

In the event of an automatic shutdown, the cause of the abnormal conditions must then be determined and corrected before the engine is started again. Also, the air shutdown valve must be manually reset in the open position before the engine can be started.

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a time delay switch (Fig. 5).

Since the fuel pressure builds up rapidly, the fuel oil pressure switch could close before the lubricating oil pressure switch opens, thereby effecting a shutdown of the engine. The time delay switch, however, delays operation of the solenoid for 3 to 10 seconds to enable the lubricating oil pressure to build up and open the oil pressure switch contacts.

When the lubricating oil pressure falls below 10+2 psi (69+14 k Pa), the contacts in the oil pressure switch used in this system will close and current will flow to the time delay switch. The few seconds required to heat the time delay switch provides sufficient delay to avoid an engine shut down when low oil pressure is caused by a temporary condition such as an air bubble or a



COLOR CODE WIRE	
NO	COLOR
1	RED
2	ORANGE
3	ORANGE
4	BLACK
5	WHITE
6	WHITE
7	BLACK
8	RED
9	BLACK
10	ORANGE

Fig. 5. - Automatic Electrical Shutdown System Diagram

temporary overlap in the operation of the oil pressure switch and the fuel oil pressure switch when starting or stopping the engine.

SHUTDOWN SYSTEM FOR DIRECT MOUNTED TURBOCHARGED ENGINES

With the use of a direct mounted turbocharger and the spring loaded fuel injector control racks, the air shutoff valve was eliminated from the air inlet housing. The spring loaded injector control racks enable the engine to come out of any advanced fuel position when an emergency situation arises.

When an engine is operating in an atmosphere subject to volatile fuel and is equipped with an air inlet housing without the air shutoff valve, a customer may request that the engine be equipped with an external or remote mounted emergency air shutdown assembly.

The remote mounted emergency air shutdown assembly that is equipped with the air shutoff valve can be installed upstream -of the air inlet side of the turbocharger.

Care should be taken when installing the emergency air shutdown assembly (Fig. 6) between the turbocharger and the air cleaner. Because the engine shutdown system is activated, all of the piping between the shutdown system and the engine will be subjected to an abnormally high suction which may cause some of the piping components, i.e., rubber hoses and elbows to collapse. Therefore, it is recommended that all of these components be designed to withstand the maximum suction without a failure which would allow air to reach the engine air intake.

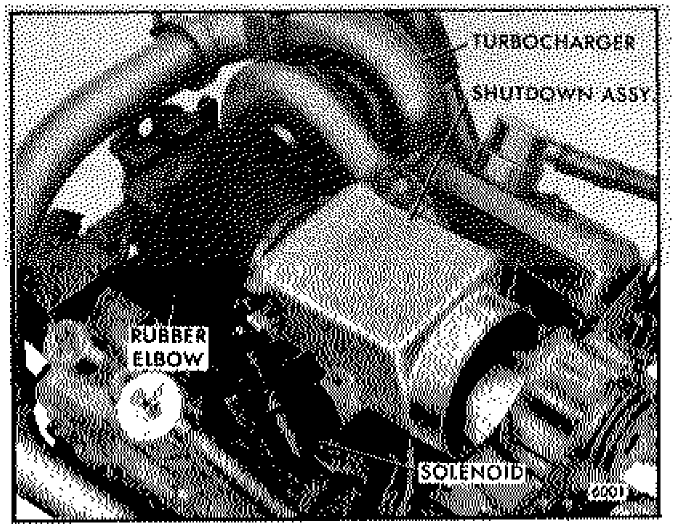


Fig. 6. - Emergency Shutdown Assembly (Direct Mounted Turbocharger)

A 7 to 5 inch diameter reducing 90^0 rubber hose or a 7 to 5 inch diameter hump hose reducer can be used to adapt the shutdown to the turbocharger.

The rubber elbow can be obtained from the manufacturer; Griffin Rubber Mills in Portland, Oregon under their part number 51759.

For the relative position of the emergency air shutdown system when installed on a Detroit Diesel engine in a direct mounted location refer to Fig. 6. The customer is also required to provide the mounting support brackets.

The emergency air shutdown assembly is manually operated. To be an automatic shutdown system, it will be necessary to install a solenoid.

ALARM SYSTEM

The alarm system shown in Fig. 7 is similar to the automatic electrical shutdown system, but uses a warning bell in place of the air shutdown valve solenoid. The bell warns the engine operator if the engine coolant overheats or the oil pressure drops below the oil pressure switch setting.

When the engine is started and the oil pressure is sufficient to open the oil pressure switch contacts (opening pressure is stamped on the switch cover), the alarm switch must be turned on manually to put the system in operation. The water temperature switch is normally open. Should the engine coolant exceed 200-2050 F (93-950 C), the water temperature switch will close the electrical circuit and sound the alarm bell. Likewise, if the oil pressure drops below the setting of the oil pressure switch, the switch will close and cause the bell to ring. The bell will continue to ring until the engine operator turns the alarm switch off. The alarm switch must also be turned off before a routine stop since the decreasing oil pressure will close the oil pressure switch and cause the bell to ring.

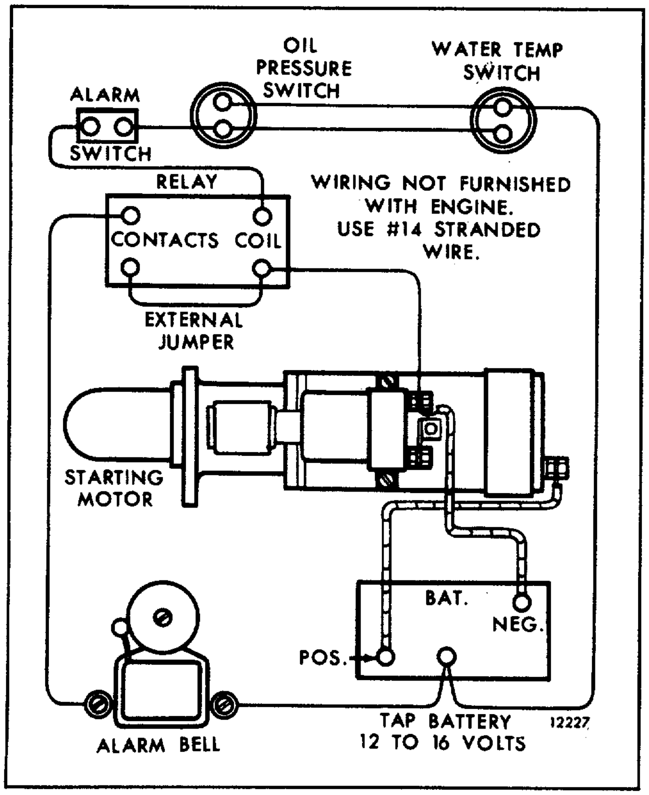


Fig. 7. - Alarm System Wiring Diagram

If the alarm bell rings during engine operation, stop the engine immediately and determine the cause of the abnormal condition. Make the necessary corrections before starting the engine again.

An alarm bell may be connected to the electrical shutdown system (Fig. 8). In this system, if an abnormal condition occurs, the engine will be stopped automatically and the alarm bell will ring to notify the operator. The bell will continue to ring until the operator pushes the reset button on the drop relay.

The alarm system illustrated in Fig. 9 utilizes the temperature-sensing switch and the low oil pressure valve.

When the engine is started, the oil pressure switch will open when the oil pressure reaches 5 psi (35 kPa) and the fuel oil pressure switch will close when the fuel pressure reaches 20 psi (138 kPa). If overheating or loss of engine coolant occurs, the temperature-sensing switch will close and complete the electrical circuit to the alarm bell. A loss of engine oil pressure will cause the oil pressure valve to open and activate the alarm system. Once the alarm system is activated, the bell will continue to ring until the engine operator stops the engine.

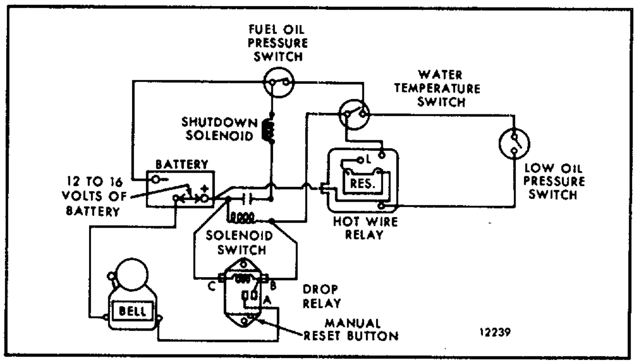


Fig. 8. - Alarm Bell Connected to Electrical Shutdown System

During a routine engine shut down, the decreasing fuel pressure causes the fuel pressure switch to open the electrical circuit before the decreasing oil pressure can activate the alarm system.

Coolant protection is also obtained through an exhaust probe and adaptor assembly and a temperature switch. In this system, the engine coolant is circulated around the switch power element to prevent the switch from being activated by the heat transfer from the exhaust probe. Therefore, an alarm will occur if coolant flow through the adaptor is interrupted for any reason. The switch will also operate when the engine coolant discharge temperature exceeds 200-205° F (93-95° C).

The oil pressure switch, mounted in the low oil pressure valve (Fig. 9), will be activated to sound the alarm when the engine oil pressure drops below the safe operating pressure. The switch will also detect an engine over speed. Engine oil is supplied to the valve. Should the engine oil pressure drop below a safe operating value, above 1,200 rpm, the valve will operate, dropping the oil pressure at the switch which completes the circuit and sounds the alarm. Below 1,200 rpm the oil pressure switch will close whenever the oil pressure is less than the oil pressure switch setting.

A relay is used to prevent damage to the pressure and temperature switches should the current to operate the alarm device be too high.

Should the alarm be activated for any reason, the engine should be stopped immediately and the cause found and corrected before the engine is started again.

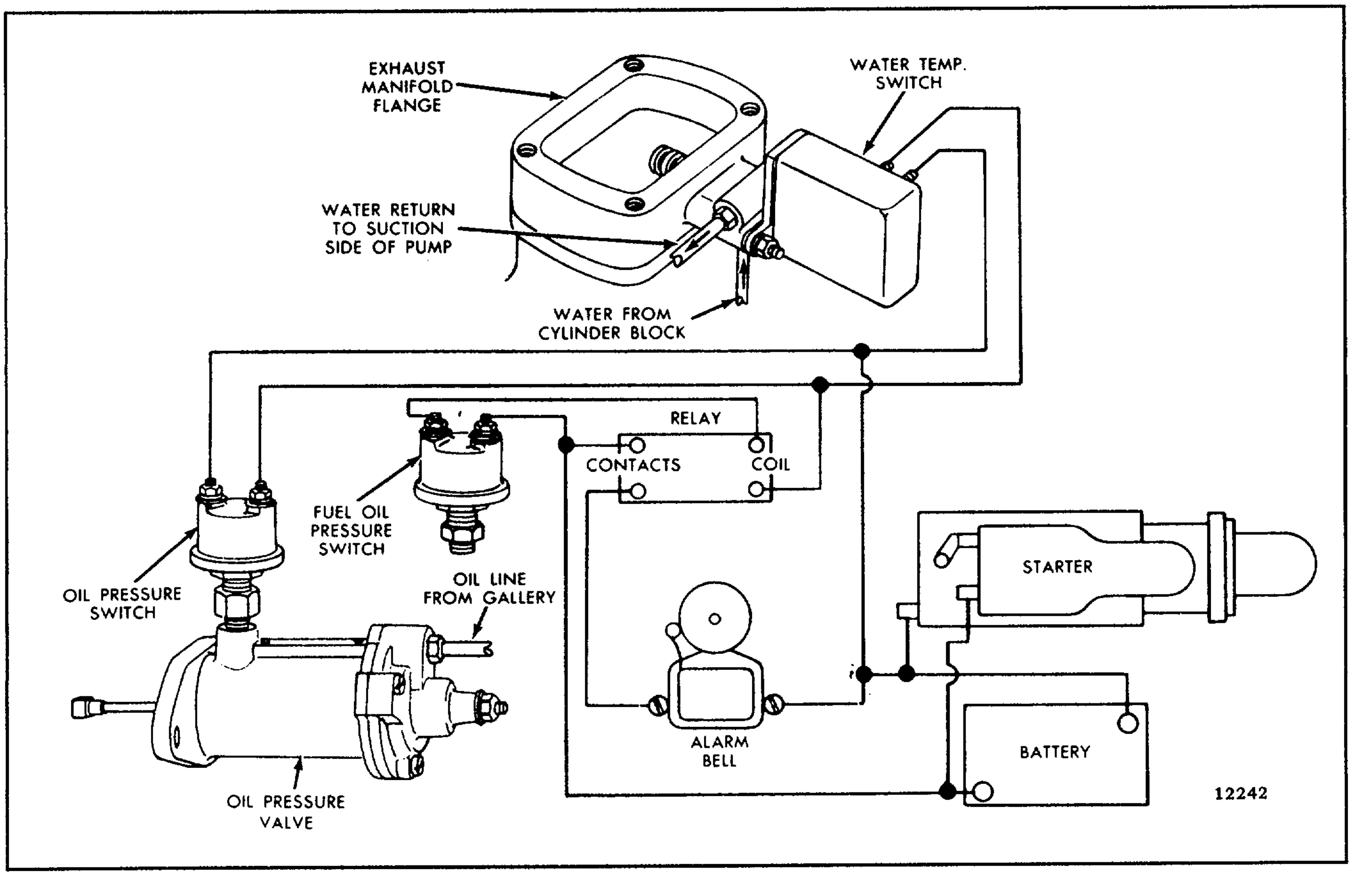


Fig. 9. - Alarm System with Mechanical Sensing Units

STARTING SYSTEM

ELECTRICAL STARTING

The electrical system on an engine generally consists of a starting motor, starting switch, battery-charging alternator, voltage regulator, storage battery and the necessary wiring. Additional electrical equipment may be installed on the engine at the option of the owner.

Starting Motor

The electric starting motor has an overrunning clutch drive or a Bendix drive assembly. Bendix drive starters are generally used on applications where automatic starting is required, such as standby generator sets. The overrunning clutch drive starters have the solenoid mounted on the starter and have a totally enclosed shifting mechanism.

Starter Switch

To start the engine, a switch is used to energize the starting motor. Release the switch immediately after the engine starts.

Battery-Charging Alternator

The battery-charging alternator is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the alternator.

Alternator Precautions

Precautions must be taken when working on or around an alternator. The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding the output wires or the field wires between the alternator and the regulator. Never run an alternator on an open circuit.

Grounding an alternator's output wire or terminals, which are always hot regardless whether or not the engine is running, and accidental reversing of the battery polarity will destroy the diodes. Grounding the field circuit will also result in the destruction of the diodes. Some voltage regulators provide protection against some of these circumstances. However, it is recommended that extreme caution be used.

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery will result in damage to the diodes, due to the momentary high voltage and current generated by the rapid collapse of the magnetic field surrounding the field windings.

In marine applications which have two sets of batteries, switching from one set of batteries to the other while the engine is running will momentarily disconnect the batteries and result in damage to the alternator diodes.

If a booster battery is to be used, the batteries must be connected correctly (negative to negative and positive to positive).

Never use a fast charger with the battery connected, or as a booster for battery output.

Never attempt to polarize an alternator. Polarization is not necessary and is harmful.

The alternator diodes are also sensitive to heat, and care must be exercised to prevent damage to them from soldering irons, etc.

If faulty operation of an alternator occurs on an engine equipped with an insulated starting motor, check to be sure that a ground strap is present and is correctly installed.

Regulator

A regulator is incorporated in the electrical system to regulate the voltage and current output of the battery-charging alternator and to help maintain a fully charged storage battery.

Storage Battery

The lead-acid storage battery is an electrochemical device for converting chemical energy into electrical energy. The battery has three major functions:

1. It provides a source of electrical power for starting the engine.

2. It acts as a stabilizer to the voltage in the electrical system.

3. It can, for a limited time, furnish current when the electrical demands of the unit exceed the output of the alternator.

The battery is a perishable item which requires periodic servicing. A properly cared for battery will give long and trouble-free service.

1. Check the level of the electrolyte regularly. Add water if necessary, but do not overfill. Over filling can cause poor performance or early failure.

2. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and reapply a light coating of grease when needed. Replace corroded, damaged parts.

4. Use the standard, quick in-the-unit battery test as the regular service test to check battery condition.

5. Check the electrical system if the battery becomes discharged repeatedly.

> **CAUTION**: Explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flame can ignite this gas causing an explosion which could shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

If the engine is to be stored for more than 30 days, remove the battery. The battery should be stored in a cool, dry place. Keep the battery fully charged and check the level of the electrolyte regularly.

The Lubrication and Preventive Maintenance section of this manual covers the servicing of the starting motor and alternator.

Consult an authorized Detroit Diesel Allison Service

Outlet for information regarding the electrical system.

GOVERNORS

Engine Governors

Horsepower requirements of an engine may vary continually due to the fluctuating loads; therefore, a means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such load fluctuations. To accomplish this control, one of three types of governors is used on the engine, depending upon the application. Installations requiring maximum and minimum speed control, together with manually controlled intermediate speeds, ordinarily use a limiting speed mechanical governor. Applications requiring a near constant engine speed, under varying load conditions that may be changed by the operator, are equipped with a variable speed mechanical governor. The hydraulic governor is used where a uniform engine speed is required, under varying load conditions, with a minimum speed droop.

Lubrication

Mechanical governors are lubricated by oil that is sprayed from an orifice in the front blower end plate. This orifice directs a stream of oil into the revolving governor weights. The weights throw the oil to all moving parts within the governor.

Surplus oil returns to the engine crankcase through connecting passages in the blower and cylinder block.

When an engine equipped with a hydraulic governor is running, oil is supplied under pressure from the engine to the governor and a portion of the oil flows past the power piston and pilot valve plunger to lubricate the moving parts in the governor housing.

Oil which collects on the floor of the governor housing drains into the drive housing, thus providing lubrication for the drive and driven shafts and their bearings. If the engine should fail to supply oil to the governor, the power piston will drop allowing the fuel rod to return to the no-fuel position; thus the hydraulic governor also acts as an automatic shutdown device.

Service

Fluctuations of the engine speed usually indicates governor malfunction. However, these fluctuations can also be caused by an excessive load on the engine, misfiring, or binding linkage. Contact an authorized Detroit Diesel Allison Service Outlet for information regarding governors.

Output Shaft Governors

On certain applications equipped with a Torqmatic Converter, it is sometimes desirable to maintain a constant output shaft speed regardless of the engine speed or load fluctuations. To acquire the necessary results, a governor driven by the output shaft is installed in conjunction with an engine governor. This governor is called an output shaft governor and may be mechanical or hydraulic.

The output shaft governor controls the engine governor (usually a limiting speed type) in the engine speed range between idle and maximum speed. The engine speed is prevented from going below idle or exceeding the maximum speed setting by the engine governor.

TRANSMISSIONS

This manual includes information on the lubrication and preventive maintenance of the transmissions. It also includes adjustment procedures covering some of the more common power transmissions. Problems relating to the repair and overhaul of these transmissions should be referred to an authorized Detroit Diesel Allison Service Outlet.

POWER TAKE-OFF ASSEMBLIES

The front and rear power take-off units are basically similar in design, varying in clutch size to meet the requirements of a particular engine application. The power take-off unit is attached to either an adaptor (front power takeoff) or the engine flywheel housing (rear power take-off). Each power take-off unit has a single or double plate clutch. The drive shaft is driven by the clutch assembly and is supported by a single roller bearing (11 1/2" clutch) or a single ball bearing(14" clutch) in the flywheel or the adaptor and by two tapered roller bearings (18" clutch) mounted in the clutch housing.

Clutch Adjustment

These instructions refer to field adjustment for clutch facing wear. Frequency of adjustment depends upon the amount and nature of the load.

To ensure a long clutch facing life and the best performance, the clutch should be adjusted before slippage occurs.

When the clutch is properly adjusted, a heavy pressure is required at the outer end of the hand lever to move the throw out linkage to the "over center" or locked position.

Adjust the 11-1/2" and 14" diameter clutches as follows:
1. Disengage the clutch with the hand lever.

2. Remove the inspection hole cover to expose the clutch adjusting ring.

Service

Refer to the Engine Tune-Up Procedures for any adjustments to the output shaft governors or contact an authorized Detroit Diesel Allison Service Outlet for information regarding output shaft governors.

3. Rotate the clutch, if necessary, to bring the clutch adjusting ring lock within reach.

4. On the 11-1/2" diameter clutch, remove the clutch adjusting ring spring lock screw and lock from the inner clutch pressure plate and adjusting ring. Then, while holding the clutch drive shaft to prevent the clutch from turning, turn the clutch adjusting ring counterclockwise (Fig. 10). Tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 13), is obtained as shown in

Clutch Dia.	Hand Lever Length	Pressure (lbs.)	(N.)	Torque Wrench (lb-ft)	(Nm)
11-1/2"	20"	65	289	94-100	127-136
14"	25"	75	334	132-149	179-202
18"	40-3/8"	90	400	278-298	377-404

TABLE 1.

5.On the 14" diameter single and double plate clutches, raise the end of the adjusting ring lock up out of the splined groove in the hub of the outer clutch pressure plate. Then, while holding the clutch drive

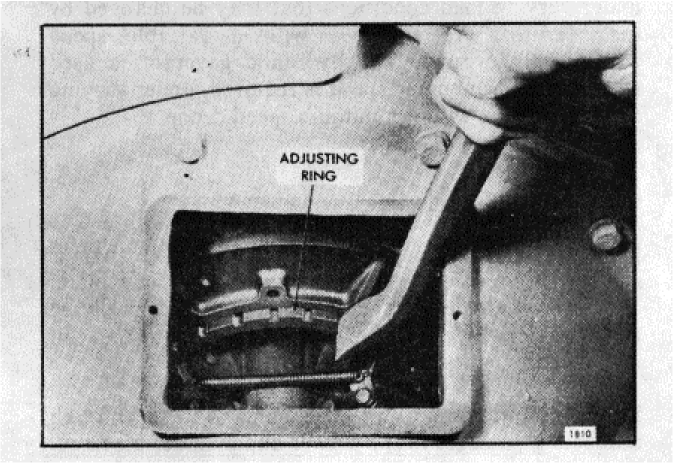


Fig. 10. - Power Take-Off Showing Typical 11-1/2" Diameter Clutch Adjustment Ring

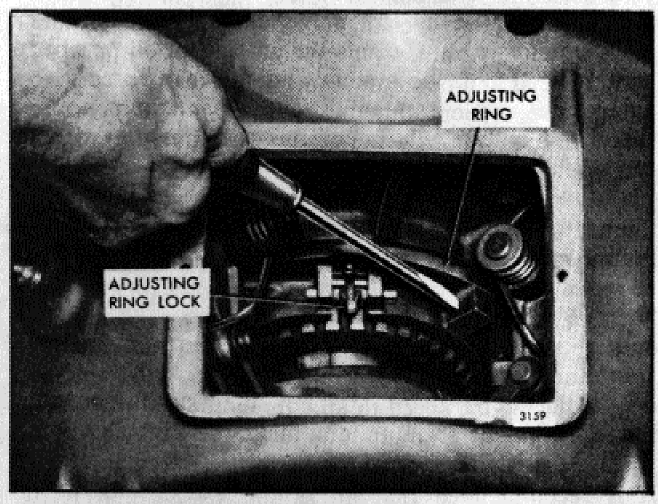


Fig. 11. - Power Takeoff Assembly Showing 14" Diameter Clutch Adjustment Ring

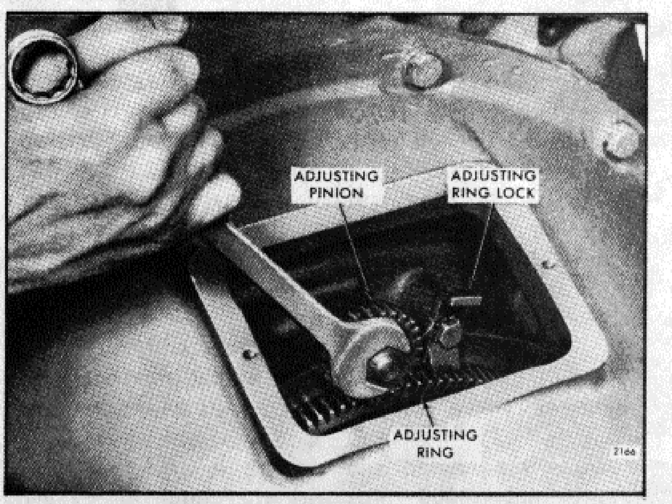


Fig. 12. - Power Take-Off Assembly Showing Method of Adjusting 18" Diameter Clutch

shaft to prevent the clutch from turning, turn the clutch adjusting ring clockwise (Fig. 11). Tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 13) is obtained as shown in Table 1.

6. Install the clutch adjusting ring spring lock on the 11-1/2" diameter clutch. The ends of the lock must engage the notches in the adjusting ring. On the 14" diameter clutch, reinstall the end of the adjusting ring lock in one of the splined grooves in the hub of the outer pressure plate. Then, install the inspection hole cover.

Adjust the 18" diameter clutch as follows:

1. Rotate the clutch, if necessary, to bring the adjustment lock and the pinion within reach through the inspection hole.

2. Loosen the lock bolt and pull the lock out of mesh with the adjusting ring; then, tighten the lock bolt to hold the lock out of the adjusting ring. While holding the clutch drive shaft to prevent the clutch from turning, turn the adjustment pinion clockwise to tighten the clutch (Fig. 12).

3. Loosen the lock bolt and move the lock so it will mesh with the teeth of the adjusting ring, then tighten the lock bolt.

When properly adjusted, the approximate pressure required at the outer end of the hand lever to engage the various diameter clutches is shown in Table 1. These specifications apply only with the hand lever which is furnished with the power take-off.

A suitable spring scale may be used to check the pounds pressure required to engage the clutch. However, a more accurate method of checking the clutch adjustment is with a torque wrench (Fig. 13).

To fabricate an adaptor, saw the serrated end off of a clutch hand lever and weld a 1-1/8" nut (across the hex) on it as shown in Fig. 13. Then, saw a slot through the nut.

When checking the clutch adjustment with a torque wrench, engage the clutch slowly and note the amount of torque immediately before the clutch engages (goes over center). The specified torque is shown in Table 1.

The facings of the clutch discs wear only along the area where they contact the pressure plates during

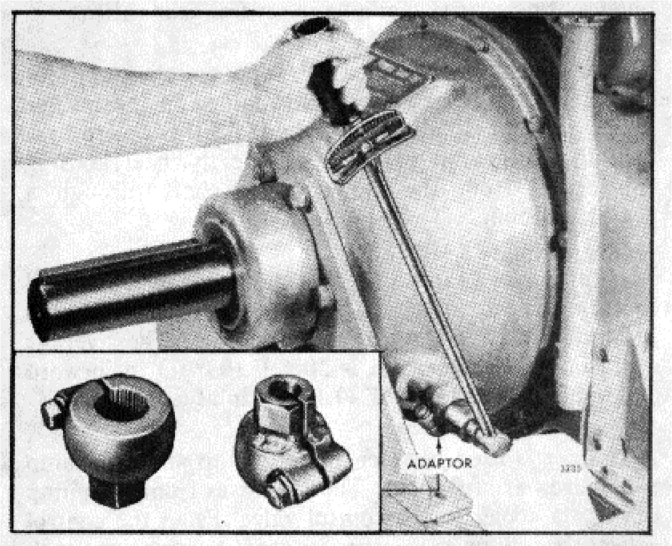


Fig. 13. - Checking Power Take-Off Clutch Adjustment with Torque Wrench and Adaptor

engagement. The area on each side of the disc beyond the pressure plates does not wear proportionately, thus resulting in a ridge. This ridge on three segment clutches can complicate the job of making an adjustment inasmuch as the top segment tends to drop down when the engine is stopped. This drop lets the ridge locate between the pressure plates. The drive ring cannot be properly adjusted to the recommended engaging pressure with the disc so positioned. The condition can result in excessive slippage and a need for early clutch facing replacement.

Make a final clutch adjustment check with the engine running, to make sure the adjustment was not made against the ridge. The procedure is outlined below:

1. Start the engine and operate it at idling speed (approximately 500 rpm) with the clutch disengaged. The speed will be sufficient to move the segments out to operating position.

2. Check the pounds pressure required to engage the clutch. The engagement pressure should be the same as that following the adjustment. If the clutch engages at a lower pressure, the adjustment was probably made against the unworn portion of the facing.

3. Stop the engine and readjust the clutch, making sure all disc segments are properly positioned. Install the inspection hole cover.

TORQMATIC MARINE GEAR

The Torqmatic marine gear is used on 6V-92 and 8V- 92 single engine marine units. The marine gear consists of a reverse gear section and a reduction gear section. Each marine gear is available in several gear ratios.

The oil for operating the hydraulic clutches and for lubricating the reverse gear is contained in the reverse gear sump and is circulated throughout the system by a hydraulic oil pump mounted on the flywheel housing and driven from the blower drive shaft through a flexible coupling.

The oil pressure ranges for the marine gear at forward operating speed are 130-155 psi (896-1068 kPa) and 110-150 psi (758-1034 kPa) in reverse. The average operating oil temperature is 2000 F (930 C) in forward and a maximum of 2500 F (1210 C) in reverse.

A strainer is used between the oil sump and the pump to remove harmful solids. The oil passes from the pump through a cooler to the control valve. From the control valve, the oil operates the forward or reverse clutch pistons and sprays oil into the reduction gear housing to lubricate the gear.

The constant flow control valve, incorporated with a pressure relief valve, controls the amount of oil pumped through the hydraulic system and is sensitive only to engine speed and operates independently of the pressure relief valve section which controls the pressure within the complete hydraulic system.

When the engine is in operation, the moving parts of the marine reverse gear are pressure lubricated while the reduction gear assembly is splash lubricated.

Shifting from forward to reverse drive through neutral may be made at any speed; however, it is advisable to shift at low engine speeds. For longest clutch life, reduce the engine speed to idle, make the shift and then increase the engine speed.

It is recommended that all sailing vessels and boats utilizing the Torqmatic marine gears (single or twin screw installations) have a locking (brake) device to prevent the propeller shaft from rotating while the sailing vessel is operating under sail, or the boat is operating with one engine shutdown or being towed.

With the engine shut down, and the marine gear oil pump not operating, it cannot circulate lubricating oil through the reverse gear. Therefore, overheating and damage to the marine gear is possible unless rotation of the propeller shaft is prevented. If the clutches cannot be engaged hydraulically, in an emergency, the forward drive may be engaged with three bolts as follows:

1. Remove the large pipe plug from the forward face of the flywheel housing.

2. With the throttle in the stop position, rotate the flywheel until one of the bolts aligns with the opening in the flywheel housing.

3. Remove the bolt from the flywheel.

4. Remove and save the jam nut. Replace the bolt finger-tight.

5. Remove and reinstall the remaining two bolts in the same manner.

6. Start at the first bolt and tighten all three bolts uniformly, thereby locking the clutch plate between the piston and the drive plate. To prevent binding between the piston and the bore in the flywheel, the emergency engagement bolts must be tightened uniformly. Do not use the reverse drive when the engagement bolts are engaged. Install the pipe plug in the flywheel housing.

NOTE: To reduce the possibility of overheating, add an additional gallon of oil if the forward clutch is engaged clutch is engaged with the emergency engagement bolts and the hydraulic pump is inoperative.

TWIN DISC MARINE GEAR

A Twin Disc marine gear is used on 16V-92 marine engines. This marine gear has two hydraulically operated multi-disc clutches to provide forward and reverse operation.

The marine gear has an oil sump capacity of approximately six gallons (23 liters). An oil pump driven by the reverse shaft operates whenever the engine is operating. This pump draws oil from the sump through a suction strainer, protecting the pump from foreign particles in the oil. The oil discharged from the pump flows through an oil cooler, mounted on the side of the engine, and then returns to the marine gear housing. The oil upon entering the gear housing passes through an integral oil filter and then to the selector valve. A bypass valve across the filter prevents the stoppage of oil flow to the selector valve in the event the filter becomes clogged.

Some units incorporate a trolling valve which is mounted between the selector valve and the forward clutch. This valve is a relief valve with manual control over the relief valve spring. Movement of the trolling valve by the operator drops the forward clutch operating pressure to a point where the multi-disc clutch plates slip. Further movement of the valve increases the slippage. This permits very low propeller speeds necessary for some fishing operations. The entire oil spill from the trolling valve, in dropping the pressure, is directed through the plates of the forward slipping clutch. This provides a film of oil on which the plates ride and removes any heat generated.

The marine gear is driven by the engine through synthetic rubber caps molded in a gear tooth form. The rubber caps are mounted on the teeth of the spider gear and mesh with the flywheel drive ring. They cushion the drive from the engine to the marine gear.

Emergency Operation

In case of emergency shifting from forward to reverse at higher than normal engine speeds, the selector and pressure regulating valve should have a 1/2 second pause in neutral so that it can control the rate of pressure rise. This causes 3/4 to 1-1/2 second delay before full pressure is applied to the selected clutch. Thus, sudden shock on the gears and shafts is reduced. Complete reversal of the propeller is recommended only at reduced engine speeds.

Emergency Engagement

Should a failure impair the hydraulic system of the marine gear, the desired clutch, either forward or reverse, can be engaged manually. The manual engagement is accomplished by removing three pipe plugs, protruding from the rear of the transmission, in line with the desired clutch to be engaged. Then bar the engine output shaft over until the three emergency engagement bolts are in line with the holes. Alternately tighten the three bolts uniformly until the clutch is locked in engagement. Reinstall the pipe plugs.

The engine, when started with the selector valve in neutral, will drive the propeller through the engaged clutch. No attempt should be made to move the selector valve from the neutral position since engagement of the other clutch may cause damage.

TORQMATIC CONVERTERS

The Torqmatic converter is a self contained unit which transfers and multiplies the torque of the prime mover. This unit transmits the power through the action of oil instead of through gears and in addition to multiplying the torque also acts as a fluid coupling between the engine and the equipment to be powered. The converter will automatically adjust the output torque to load requirements.

There are various combinations of Torqmatic converters with features such as: an automotive or industrial flange on the shaft, a hydraulically operated lock-up clutch, a manual input disconnect clutch, and an accessory drive for either a governor or tachometer.

Check the oil level daily and, if the coverter is equipped with an input disconnect clutch, additional checks and service will be necessary daily or at intervals determined by the type of operation.

Adjust the disconnect clutches as outlined under power take-off clutch adjustment.

Contact an authorized Detroit Diesel Allison Service Outlet for information on Torqmatic converters.

OPERATING INSTRUCTIONS
ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

The operator should read and follow these instructions before attempting to start the engine. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

NOTE: When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see *Daily Operations in the Lubrication and Preventive Maintenance Chart.*

Cooling System

Install all of the drain cocks in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine is so equipped.

Loosen the water return line near the top of the turbocharger (if used).

Remove the filler cap and fill the cooling system with clean, soft water or fill with an ethylene glycol base antifreeze, if the engine will be exposed to freezing temperatures (refer to *Coolant Specifications in Section 5).* Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

Close the vents, if used, after filling the cooling system.

On marine installations, prime the raw water cooling system and open any sea cocks in the raw water pump intake line. Prime the raw water pump by removing the pipe plug or electrode provided in the pump outlet elbow and pour water in the pump.

NOTE: Failure to prime the raw water pump may result in damage to the pump impeller.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time. Insufficient lubrication at start-up can cause serious damage to the engine components.

To ensure an immediate flow of oil to all bearing surfaces at initial engine start-up, DDA recommends that the engine lubrication system be charged with a commercially available pressure pre-lubricator. Use the following procedure:

1. Remove the pipe plug from the engine main oil gallery and attach the pre-lubricator hose.

2. Remove the valve rocker cover(s) and, using a positive displacement pump set at 25-35 psi (172-241 kPa), pump in the recommended grade of engine lubricating oil until it is observed flowing from the rocker arms.

3. If the engine is turbo-charged, disconnect the oil supply lines at the turbo bearing (center) housings and fill the bearing housing cavities with approximately one pint of the recommended grade of clean engine oil. Turn the rotating assemblies by hand to coat all internal surfaces with oil and reinstall the turbo oil supply lines.

4. After 20 minutes, check the crankcase oil level. Add enough oil to bring the level to the "full" mark on the dipstick. *Do not overfill*.

5. Disconnect the pre-lubricator hose, plug the main oil gallery rule and replace all components previously removed.

6. Before initial engine start-up, DDA also recommends cranking the engine with the governor in the no-fuel position until oil pressure registers on the gage.

For engine lubricating oil recommendations, see Lubrication *Specifications* in Section 5 or contact a Detroit Diesel Allison distributor.

It is recommended that the engine lubricating system be charged with a pressure prelubricator, set to supply a minimum of 25 psi (172 kPa) oil pressure, to ensure an immediate flow of oil to all bearings at the initial engine start-up. The oil supply line should be attached to the engine so that oil under pressure is supplied to the main oil gallery.

With the oil pan dry, use the pre lubricator to prime the engine with sufficient oil to reach all bearing surfaces. Use heavy-duty lubricating oil as specified under Lubrication Specifications in Section 5. Then, remove the dipstick, wipe it with a clean cloth, insert and remove it again to check the oil level in the oil pan. Add sufficient oil, if necessary, to bring it to the full mark on the dipstick. Do not overfill.

If a pressure prelubricator is not available, fill the crankcase to the proper level with heavy-duty oil as specified under *Lubrication Specifications in Section 5.* Then, prelubricate the upper engine parts by removing the valve rocker covers and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms.

Turbocharger

After installing a rebuilt or new turbocharger it is very important that all the moving parts of the turbocharger center housing be lubricated as follows:

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

1. Clean the area and disconnect the oil inlet (supply) line at the bearing (center) housing.

2. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

3. Add additional clean engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

4. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psi or 69 kPa at idle speed).

Air Cleaner

If the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. *Do not overfill.*

Transmission

Fill the transmission case, marine gear or torque converter supply tank to the proper level with the lubricant specified under *Lubrication and Preventive Maintenance.*

Fuel System

Fill the fuel tank with the fuel specified under *Fuel Specifications in Section 5.*

If the unit is equipped with a fuel valve, it must be opened.

To ensure prompt starting, fill the fuel system between the pump and the fuel return manifold with fuel. If the engine has been out of service for a considerable length of time, prime the filter between the fuel pump and the injectors. The filter may be primed by removing the plug in the top of the filter cover and slowly filling the filter with fuel.

In addition to the above, on an engine equipped with a hydrostarter, use a priming pump to make sure the fuel lines and the injectors are full of fuel before attempting to start the engine.

NOTE: The fuel system is filled with fuel before leaving the factory. If the fuel is still in the system when preparing to start the engine, priming should be unnecessary.

Lubrication Fittings

Fill all grease cups and lubricate at all fittings (except for fan hub pulley fitting -- refer to *Preventive Maintenance)* with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all of the drive belts as recommended under *Lubrication and Preventive Maintenance.*

Storage Battery

Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

NOTE: When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

Generator Set Where applicable, fill the generator end bearing housing with the same grade and viscosity lubricating oil as used in the engine.

A generator set should be connected and grounded in accordance with the applicable local electrical codes.

NOTE: The base of a generator set must be grounded.

Clutch Disengage the clutch, if the unit is so equipped.

STARTING

Before starting the engine for the first time, perform the operations listed under *Preparation for Starting Engine First Time.*

Before a routine start, see *Daily Operations in the Lubrication and Preventive Maintenance Chart.*

If a manual or an automatic shutdown system is incorporated in the unit, the control must be set in the open position before starting the engine. The blower will be seriously damaged if operated with the air shutdown valve in the closed position.

NOTE: On engines with dual air shutdown housings, both air shutoff valves must be in the open position before starting the engine.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 400 F (40 C). The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

CAUTION: Starting fluid used in capsules is highly inflammable, toxic and possesses anesthetic properties.

Initial Engine Start (Electric) Start an engine equipped with an electric starting motor as follows:

Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the *run* position. On hydraulic governors, make sure the stop knob is pushed all the way in.

Then, press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

NOTE: To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is running.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system.

Warm-Up

Run the engine at part throttle and no-load for approximately five minutes, allowing it to warm-up before applying a load.

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

Clutch

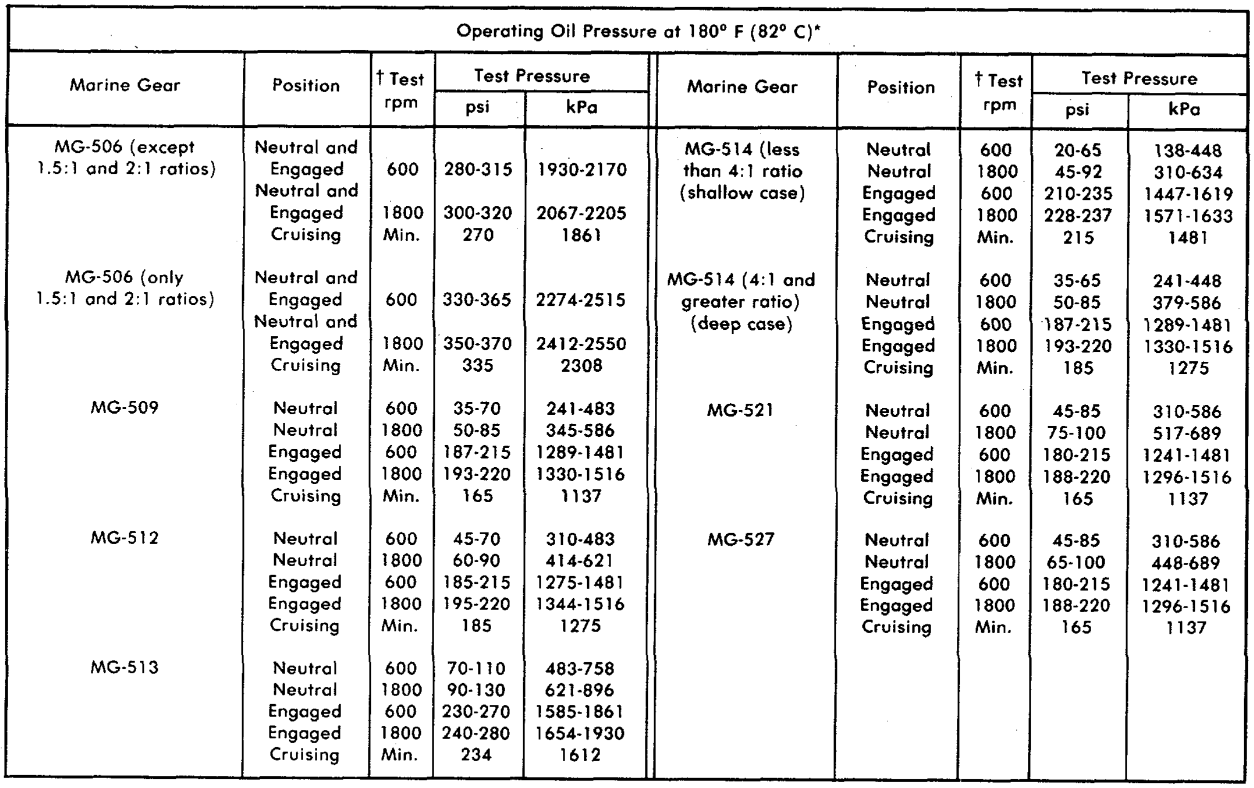
Do not engage the clutch (with a sintered iron clutch plate) at engine speeds over 850 rpm. A clutch with an asbestos or vegetable fiber material clutch plate must not be engaged at speeds over 1,000 rpm.

Inspection

While the engine is running at operating temperature, check for coolant, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Engine Temperature

Normal engine coolant temperature is 160-1850 F (71-85° C).



Operating Oil Pressure at 180° F (82° C)*

Marine Gear	Position	† Test rpm	Test Pressure	
			psi	kPa
MG-506 (except 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	280-315	1930-2170
	Neutral and Engaged	1800	300-320	2067-2205
	Cruising	Min.	270	1861
MG-506 (only 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	330-365	2274-2515
	Neutral and Engaged	1800	350-370	2412-2550
	Cruising	Min.	335	2308
MG-509	Neutral	600	35-70	241-483
	Neutral	1800	50-85	345-586
	Engaged	600	187-215	1289-1481
	Engaged	1800	193-220	1330-1516
	Cruising	Min.	165	1137
MG-512	Neutral	600	45-70	310-483
	Neutral	1800	60-90	414-621
	Engaged	600	185-215	1275-1481
	Engaged	1800	195-220	1344-1516
	Cruising	Min.	185	1275
MG-513	Neutral	600	70-110	483-758
	Neutral	1800	90-130	621-896
	Engaged	600	230-270	1585-1861
	Engaged	1800	240-280	1654-1930
	Cruising	Min.	234	1612

Marine Gear	Position	† Test rpm	Test Pressure	
			psi	kPa
MG-514 (less than 4:1 ratio (shallow case)	Neutral	600	20-65	138-448
	Neutral	1800	45-92	310-634
	Engaged	600	210-235	1447-1619
	Engaged	1800	228-237	1571-1633
	Cruising	Min.	215	1481
MG-514 (4:1 and greater ratio) (deep case)	Neutral	600	35-65	241-448
	Neutral	1800	50-85	379-586
	Engaged	600	187-215	1289-1481
	Engaged	1800	193-220	1330-1516
	Cruising	Min.	185	1275
MG-521	Neutral	600	45-85	310-586
	Neutral	1800	75-100	517-689
	Engaged	600	180-215	1241-1481
	Engaged	1800	188-220	1296-1516
	Cruising	Min.	165	1137
MG-527	Neutral	600	45-85	310-586
	Neutral	1800	65-100	448-689
	Engaged	600	180-215	1241-1481
	Engaged	1800	188-220	1296-1516
	Cruising	Min.	165	1137

*Sump or heat exchanger inlet 210° F (990 C) maximum. Normal operating range desired 140-180' F (60-820 C) minimum continuous duty.

+Sump or heat exchanger inlet 2250 F (1070 C) maximum intermittent permissible in pleasure craft.

TABLE 1. - Twin Disc Marine Gear Operating Conditions

Crankcase If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached. Allow the oil to drain back into the crankcase for approximately 20 minutes and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the heavy-duty lubricating oil specified under Lubrication Specifications in Section 5.

Cooling System

Remove the radiator or heat exchanger tank cap slowly after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or an ethylene glycol base antifreeze (refer to Coolant Specifications in Section 5).

Marine Gear

Check the marine gear oil pressure. The operating oil pressure range at operating speed is 90 to 150 psi or 621 to 1024 kPa (Allison Torqmatic gear). The operating oil pressure varies with the different Twin Disc gears as noted in the chart. Check and, if necessary, replenish the oil supply in the transmission.

Turbocharger

Make a visual inspection of the turbocharger for leaks and excessive vibration. Stop the engine immediately if there is an unusual noise in the turbocharger.

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

NOTE: When prolonged engine idling is necessary, maintain at least 800 rpm.

STOPPING

Normal Stopping

1. Release the load and decrease the engine speed. Put all shift levers in the neutral position.

2. Allow the engine to run at half speed or slower with no-load for four or five minutes, then move the stop lever to the stop position to shut down the engine.

Emergency Stopping

To stop an engine (normal or emergency) equipped with the spring-loaded (one screw) design injector control tube, pull the governor stop lever to the stop position. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected.

NOTE: The emergency shutdown system should never be used except in an emergency. Use of the emergency shutdown can cause oil to be sucked past the oil seals and into the blower housing.

The air shutoff valve, located on the blower air inlet housing, must be reset by hand and the "Emergency Stop" knob pushed in before the engine is ready to start again.

Fuel System

If the unit is equipped with a fuel valve, close it. Fill the fuel tank; a full tank reduces condensation.

Exhaust System

Drain the condensation from the exhaust line.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

Crankcase

Allow the oil to drain back into the crankcase for approximately 20 minutes and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick. Use only the heavy-duty lubricating oil specified under Lubrication Specifications in Section 5.

Transmission

Check and, if necessary, replenish the oil supply in the transmission.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to Lubrication and Preventive Maintenance and perform all of the daily maintenance operations. Also, perform the operations required for the number of hours or miles the engine has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which became apparent to the operator during the last run.

ALTERNATING CURRENT POWER GENERATOR SET OPERATING INSTRUCTIONS

These instructions cover the fundamental procedures for operating an alternating current power generator set. The operator should read these instructions before attempting to operate the generator set.

PREPARATION FOR STARTING

Before attempting to start a new or an overhauled engine or an engine which has been in storage, perform all of the operations listed under Preparation for Starting Engine First Time. Before a routine start see Daily Operations in the Lubrication and Preventive Maintenance Chart.

In addition to the Engine Operating Instructions, the following instructions also apply when operating an alternating current power generator set.

1. Before the first start, check the generator main bearing oil reservoir. If necessary, add sufficient lubricating oil of the same grade that is used in the engine crankcase to bring it to the proper level on the sight gage. Do not overfill.

2. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi or 172 kPa maximum). If there is moisture on the interior of the generator, it must be dried before the set is started. Refer to the appropriate Delco Products Maintenance Bulletin.

3. The over speed trip solenoid lever located at the air inlet housing must be in the open or reset position.

4. Refer to Fig. 1 and place the circuit breaker (10) in the off position.

5. Place the field switch (7) in the off position.

6. Place the synchronizing lamp switch (6) in the off position.

7. Place the voltage regulator switch (3) in the off or manual position.

8. Turn the field rheostat knob (8) clockwise to its lower limits.

9. Make sure the power generator set has been cleared of all tools or other objects which might interfere with its operation.

STARTING

If the generator set is operated in a closed space, start the ventilating fan or open the doors and windows, as weather permits, to supply ample air to the engine.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 400°F (4°C). The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

CAUTION: Starting fluid used in capsules is highly inflammable, toxic and possesses anesthetic properties.

Press the throttle button (15) and turn the throttle control (16) counterclockwise to a position midway between run and stop (Fig. 1). Then, press the starter button (18) firmly.

If the engine fails to start within 30 seconds, release the starter button and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

NOTE: To prevent serious damage to the starter if the engine does not start, do not press the starter switch again while the starter motor is rotating.

RUNNING

Observe the engine oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the engine lubricating system. If the oil pressure is observed to be normal, increase the throttle setting to cause the engine to run at its synchronous speed.

PREPARING GENERATOR FOR LOAD

After the engine has warmed up (or the oil pressure has stabilized), prepare the generator set for load as follows:

1. Bring the engine up to rated speed. Then place the field switch (7) in the on position (Fig. 1).

2. Turn the voltage regulator switch (3) on.

3. Turn the instrument selector switch (9) to the desired position.

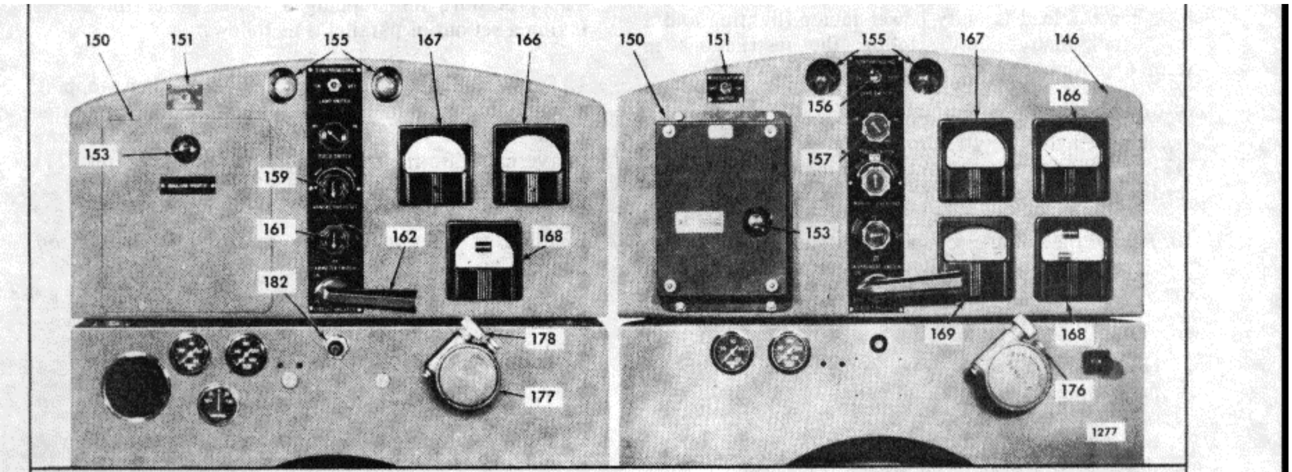
4. Turn the field rheostat (8) slowly in a counterclockwise direction to raise the voltage, while watching the voltmeter, until the rheostat reaches the end of its travel. The voltage regulator will take control of the generator voltage as the field rheostat reaches the end of its travel.

5. If the power generator unit is equipped with a frequency meter, adjust the engine speed with the vernier throttle knob (17) until the desired frequency is indicated on the meter.

6. Adjust the voltage regulator rheostat (4) to obtain the desired voltage.

7. Make sure all power lines are clear of personnel, then place the circuit breaker control (10) in the on position.

NOTE: Perform Step 7 only if the set is not being paralleled with an existing power source. If the set is being paralled with a power source already on the line, read and follow the instructions under Paralleling before turning the circuit breaker control to the on position.



146. Cabinet--Control
150. Regulator--Voltage
151. Switch--Voltage Regulator
153. Control--Voltage Regulator Rheostat
155. Lamps--Synchronizing
156. Switch--Synchronizing Lamp
157. Switch--Field
159. Control--Manual Field Rheostat
161. Switch--Selector
162. Control--Circuit Breaker
166. Ammeter
167. Voltmeter
168. Frequency Meter
169. Kilowatt Meter
176. Button--Throttle
177. Control--Throttle
178. Knob--Vernier Throttle
182. Button--Engine Starter

Fig. 1. - Typical Alternating Current Generator Control Cabinets

PARALLELING

If the load conditions require an additional set to be placed on the line, the following instructions will apply to power generator sets of equal capacity, with one set in operation on the line.

1. Prepare the set to be paralleled as outlined under Preparation for Starting, Starting, Running and Items I through 6 under Preparing Generator for Load.

2. Check the voltmeter (12) the voltage must be the same as the line voltage (Fig. 1). Adjust the voltage regulator rheostat control (4) if the voltages are not the same.

3. Place the synchronizing lamp switch (6), of the generator set to be paralleled, in the on position.

4. Turn the vernier throttle knob (17) until both sets are operating at approximately the same frequency, indicated by the slow change in the brilliancy of the synchronizing lamps.

5. When the synchronizing lamps glow and then go out at a very slow rate, time the dark interval. Then, in the middle of this interval turn the circuit breaker control to the on position. This places the incoming set on the line, with no load. The proper share of the existing load must now be placed on this set.

6. The division of the kilowatt load between the alternating current generators operating in parallel depends on the power supplied by the engines to the generators as controlled by the engine governors and is practically independent of the generator excitation. Divide the kilowatt load between the sets by turning the vernier throttle knob (17) counterclockwise on the incoming set and clockwise on the set that has been carrying the load (to keep the frequency of the sets constant) until both kilowatt meters indicate that each set is carrying its proper percentage of the total K.W. load. Refer to Item 8 if the sets are not equipped w.,h kilowatt meters.

7. The division of the reactive KVA load depends on the generator excitation as controlled by the voltage regulator. Divide the reactive load between the sets by turning the voltage regulator rheostat control on the incoming set (generally counterclockwise to raise the voltage) until the ammeters read the same on both sets and the sum of the readings is minimum.

> **NOTE**: The generator sets are equipped with a resistor and current transformer connected in series with the voltage coil of the regulator (cross-current compensation) which equalizes most but not all of

most but not all of the reactive KVA load between the generators.

8. When the load is unity power factor (lighting and a few small motors only), follow the instructions in Item 6 above until both ammeters read the same.

9. When the load is 80% power factor lagging (motor and a few lights only), turn the vernier throttle knob (17) on the incoming set until the ammeter on that set reads approximately 40% of the total current load.

10. Rotate the voltage regulator rheostat control (4) on the incoming set (generally counterclockwise to raise the voltage) until the ammeters read the same on both sets.

NOTE: If a load was not added during paralleling, the total of the two ammeter readings should be the same as the reading before paralleling. Readjust the voltage regulator rheostat (4) on the incoming set, if necessary.

11. To reset the load voltage, turn the voltage regulator rheostat controls slowly on each set. It is necessary to turn the controls the same amount and in the same direction to keep the reactive current equally divided.

Power generator sets with different capacities can also be paralleled by dividing the load proportionately to their capacity.

STOPPING

The procedure for stopping a power generator set or taking a set out of parallel is as follows:

1. Turn off all the load on the generator when stopping a single engine unit. Shift the load from the generator when taking a set out of parallel operation by turning the vernier throttle knob (17), until the ammeter (11) reads approximately zero (Fig. 1).

2. Place the circuit breaker control (10) in the off position.

3. Turn the field rheostat (8) to the fully clockwise position.

4. Turn the voltage regulator switch (3) to the off position.

5. Place the field switch (7) in the off position.

6. Press the throttle button (15) and turn the throttle control (16) to stop to shut down the engine.

NOTE: When performing a tune-up on a unit that will be operated in parallel with another set, adjust the speed droop as specified in Engine Tune-Up.

LUBRICATION AND PREVENTIVE MAINTENANCE

The Lubrication and Preventive Maintenance Schedule is intended as a guide for establishing a preventive maintenance schedule. The suggestions and recommendations for preventive maintenance should be followed as closely as possible to obtain long life and best performance from a Detroit Diesel engine. The intervals indicated on the chart are time (hours) of actual operation.

MAINTENANCE SCHEDULE EXPLANATION

The time or mileage increments shown apply only to the maintenance function described. These functions should be coordinated with other regularly scheduled maintenance.

The daily instructions pertain to routine or daily starting of an engine and not to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, carry out the instructions given under Preparation for Starting Engine First Time under Operating Instructions in Section 4.

INDUSTRIAL OFF HIGHWAY AND MARINE		TIME INTERVALS										
	HRS.	DLY.	8	50	100	150	200	300	500	700	1,000	2,000
	MILES		240	1,500	3,000	4,500	6,000	9,000	15,000	20,000	30,000	60,000
1. — Lubricating Oil		X				X						
2. — Fuel Tank		X							X	X		
3. — Fuel Lines and Flexible Hoses		X							X		X	
4. — Cooling System		X								X	X	
5. — Turbocharger		X										
6. — Battery					X							
7. — Tachometer Drive					X							
8. — Air Cleaners*			X						X			
9. — Drive Belts			X				X					
10. — Air Compressor							X			X		
11. — Throttle and Clutch Controls							X					
12. — Lubricating Oil Filter									X		X	
13. — Fuel Strainer and Filter								X				
14. — Coolant Filter and Water Pump*									X			
15. — Starting Motor*												
16. — Air System										X		
17. — Exhaust System										X		
18. — Air Box Drain Tube											X	
19. — Emergency Shutdown										X		
21. — Radiator										X		
22. — Shutter Operation										X		
23. — Oil Pressure										X		
24. — Overspeed Governor									X			
26. — Throttle Delay*												
27. — Battery-Charging Alternator							X					
28. — Engine and Transmission Mounts												X
29. — Crankcase Pressure												X
30. — Air Box Check Valves*												
31. — Fan Hub*												
32. — Thermostats and Seals										X		
33. — Blower Screen											X	
34. — Crankcase Breather											X	
36. — Engine Tune-Up*												
37. — Heat Exchanger Electrodes									X		X	
38. — Raw Water Pump		X										
39. — Power Generator					X			X				
40. — Power Take-Off			X	X					X			
41. — Marine Gear		X					X				X	
42. — Torqmatic Converter		X		X							X	
43. — Reduction Gear			X	X					X		X	

*See Item

Item 1-Lubricating Oil

Check the lubricating oil level with the engine stopped. If the engine has just been stopped, wait approximately twenty minutes to allow the oil to drain back to the oil pan. Add the proper grade oil as required to maintain the correct level on the dipstick.

> **NOTE**: Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Make a visual check for oil leaks around the filters and external oil lines.

Change the lubricating oil at the intervals shown in Table 1.

ENGINE OIL CHANGE INTERVALS

Service Application	Max. Engine Oil Change Interval		
	Diesel Fuel Sulfur Content % by Wt. Max.		
	0 to .50	0.51 to 0.75	0.76 to 1.00
Industrial & Marine	150 Hours	30 Hours	15 Hours*

*These oil change intervals are based upon worst case with chrome-faced rings. Oil change periods with plasma rings can be established by oil analysis.

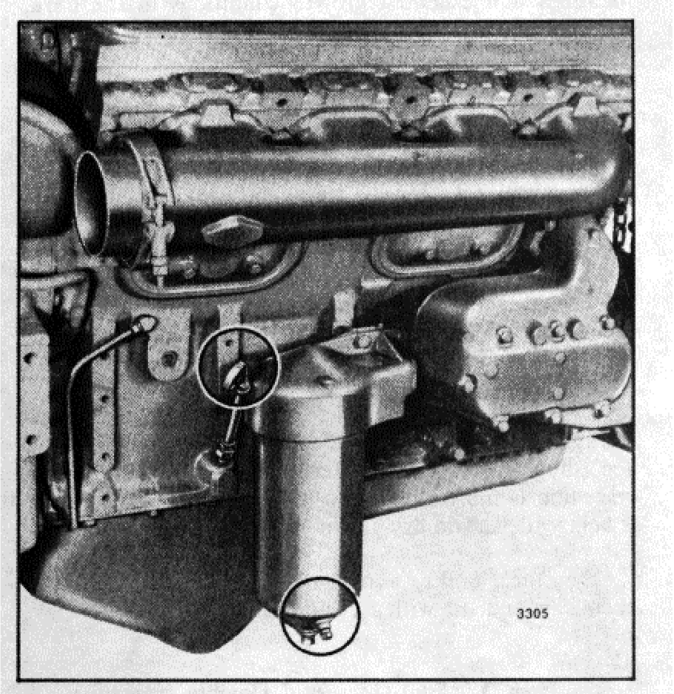
TABLE 1.

The drain interval may be established on the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the used oil sample analysis) until the most practical oil change period has been determined. Select the proper grade of oil in accordance with the instructions given in *Lubrication Specifications.*

> **NOTE**: If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and will drain readily.

Item 2-Fuel Tank

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Fuel Specifications*. Open the drain at the bottom of the fuel tank every 500 hours to drain off any water or sediment.



Items 1. and 12

Every 12 months or 700 hours tighten all fuel tank mountings and brackets. At the same time, check the seal in the fuel tank cap, the breather hole in the cap and the condition of the crossover fuel line. Repair or replace the parts, as necessary.

Diesel Fuel Contamination The most common form of diesel fuel contamination is water. Water is harmful to the fuel system in itself, but it also promotes the growth of mircobiological organisms (microbes). These microbes clog fuel filters with a "slime" and restrict fuel flow. Water can be introduced into the fuel supply through poor maintenance (loose or open fuel tank caps), contaminated fuel supply or condensation. Condensation is particularly prevalent on units which stand idle for extended periods of time, such as marine units. Ambient temperature changes cause condensation in partially filled fuel tanks. Water accumulation can be controlled by mixing isopropyl alcohol (dry gas) into the fuel oil at a ratio of one pint (.5 liter) per 125 gallons (473 liters) of fuel (or 0.10% by volume). Marine units in storage are particularly susceptible to microbe growth. The microbes live in the fuel-water interface. They need both liquids to survive. These microbes find excellent microbes find excellent growth conditions in the dark, quiet, non-turbulent nature of the fuel tank.

Microbe growth can be eliminated through the use of commerically available biocides. There are two basic types on the market.

1. The water soluble type treats only the tank where it is introduced. Microbe growth can start again if fuel is transferred from a treated to an untreated tank.

2. The diesel fuel soluble type, such as "Biobor" manufactured by U.S. Borax or equivalent, treats the fuel itself, and therefore, the entire fuel system.

Marine units, or any other application, going into storage should be treated as follows: -- Add the biocide according to the manufacturer's instructions. This operation is most effective when performed as the tank is being filled. Add dry gas in the correct proportions.

If the fuel tanks were previously filled, add the chemicals and stir with a clean rod.

Item 3-Fuel Lines and Flexible Hoses

Make a visual check for fuel leaks at the cross-over lines and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tanks.

The performance of engine and auxiliary equipment is greatly dependent on the ability of flexible hoses to transfer lubricating oil, air, coolant and fuel oil. Diligent maintenance of hoses is an important step in ensuring efficient, economical and safe operation of the engine and related equipment.

Check hoses daily as part of the pre-start up inspection. Examine hoses for leaks and check all fittings, clamps and ties carefully. Make sure that hoses are not resting or touching shafts, couplings, heated surfaces including exhaust manifolds, any sharp edges or other obviously hazardous areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them, as necessary.

Leaks

Investigate leaks immediately to determine if fittings have looseded or cracked or if hoses have ruptured or worn through. Take corrective action immediately. Leaks are not only potentially detrimental to machine operation, but they also result in added expense caused by the need to replace lost fluids. Page 4

> **CAUTION:** Personal injury and/or property damage may result from fire due to the leakage of flammable fluids such as fuel or lube oil.

Service Life A hose has a finite service life. The service life of a hose is determined by the temperature and pressure of the air or fluid within it, its time in service, its mounting, the ambient temperatures, amount of flexing and vibration it is subject to. With this in mind, all hoses should be thoroughly inspected at least every 500 operating hours (1,000 hours for the fire-resistant fuel and lube hoses and heat-insulating turbo/exhaust system blankets) and/or annually. Look for cover damage or indications of damaged twisted, worn, crimped, brittle, cracked or leaking lines. Hoses having the outer cover worn through or damaged metal reinforcement should be considered unfit for further service.

All hoses in or out of machinery should be replaced during major overhaul and/or after a maximum of five years service.

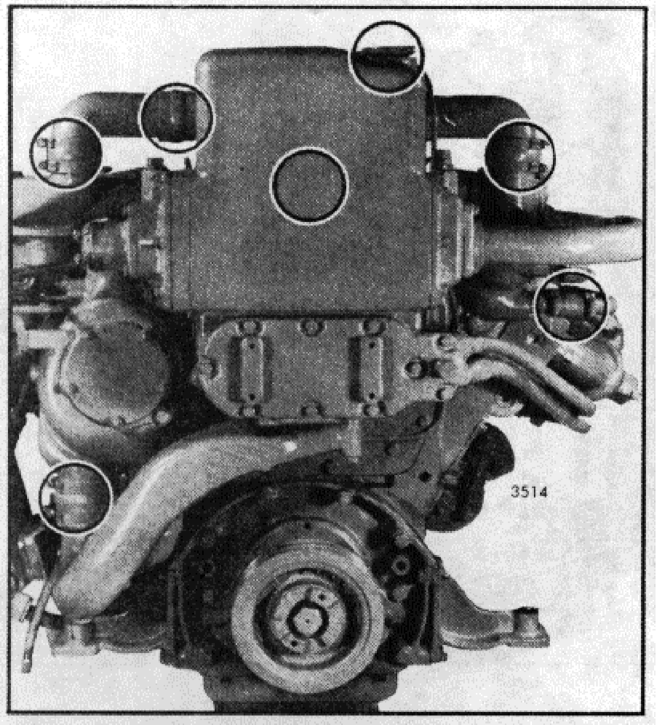
> **NOTE**: The new hose assemblies do not require automatic replacement after five years service or at major overhaul.

Item 4-Cooling System

Check the coolant level daily and maintain it near the top of the heat exchanger tank or radiator upper tank. Add coolant as necessary. Do not overfill.

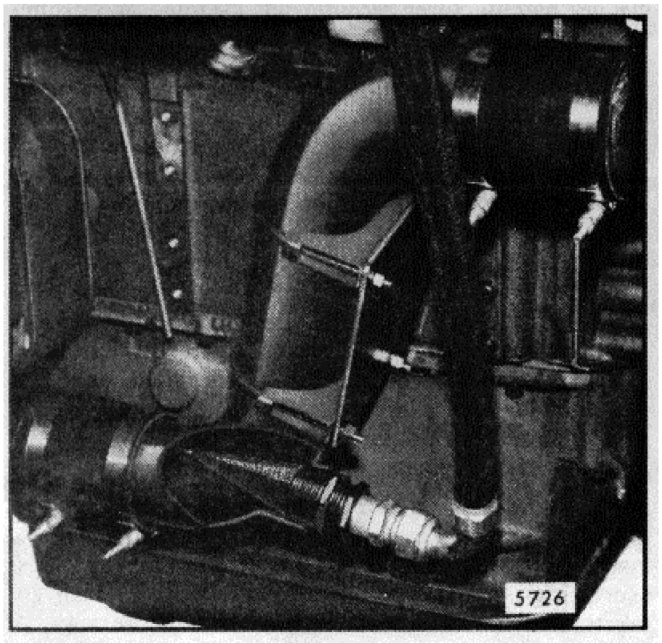
Make a visual check for cooling system leaks. Check for an accumulation of coolant beneath the vehicle during periods when the engine is running and when the engine is stopped.

Clean the cooling system every 1,000 hours using a good radiator cleaning compound in accordance with the instructions on the container. After the cleaning operation, rinse the cooling system thoroughly with fresh water. Then, fill the system with soft water, adding a good grade of rust inhibitor or an ethylene glycol base antifreeze (refer to Coolant Specifications). With the use of a proper antifreeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring or fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system. When a thorough cleaning of the cooling system is required, it should be reverse flushed.



Items 4.

The coolant circulated through the intercoolers on a turbocharged intercooler engine is protected by a 20 mesh cone-shaped water filter (screen). The filter is located at the water connection in the water pump-to-engine oil cooler tube. The filter should be inspected for damage or clogging when the cooling system is cleaned. Disconnect the flexible water hose at the water connection and remove and clean the filter. If necessary, replace the filter. Reinstall the water filter (screen) in the water connection.



Item 4.

Inspect all of the cooling system hoses at least once every 700 hours for signs of deterioration. Replace the hoses, if necessary.

Item 5-Turbocharger

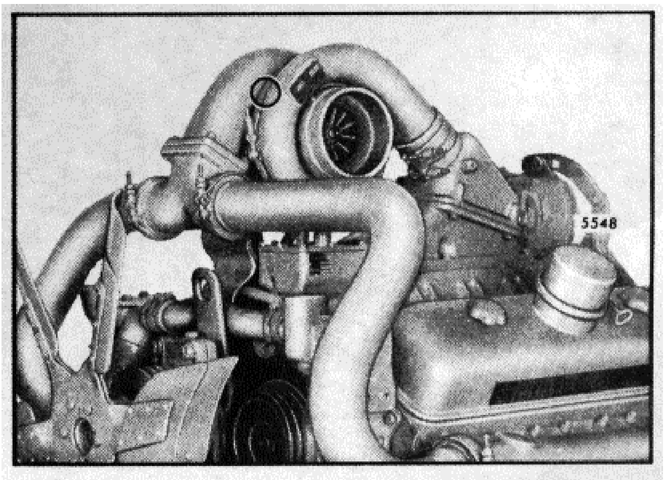
Inspect the mountings, intake and exhaust ducting and connections for leaks. Check the oil inlet and outlet lines for leaks or restrictions to oil flow. Check for unusual noise or vibration and, if excessive, remove the turbocharger and correct the cause.

Item 6-Battery

Check the specific gravity of the electrolyte in each cell of the battery every 100 hours. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.

Item 7-Tachometer Drive

Lubricate the tachometer drive every 100 hours with an all purpose grease at the grease fitting. At temperatures above +300 F (--1 C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.



Item 5.

Item 8-Air Cleaners

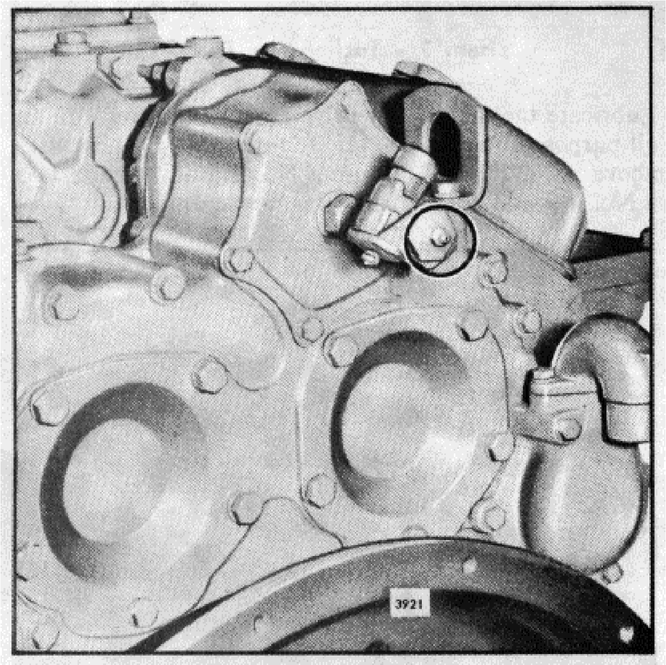
Under no engine operating conditions should the air inlet restriction exceed 25 inches of water (6.2 kPa) for non-turbocharged engines or 20 inches of water (5.0 kPa) for turbocharged engines. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

Oil Bath

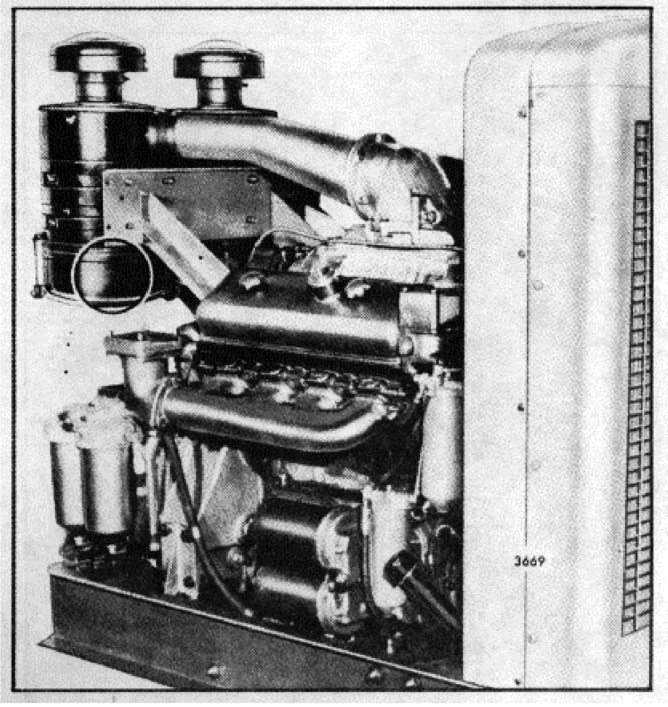
Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours, or less if operating conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark with the same grade and viscosity heavy-duty oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions. If heavy rain or snow has been encountered, check the air cleaner for an accumulation of water.

Remove and steam clean air cleaner element and baffle annually.

It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 500 hours or as conditions warrant.



Item 7.



Item 8.

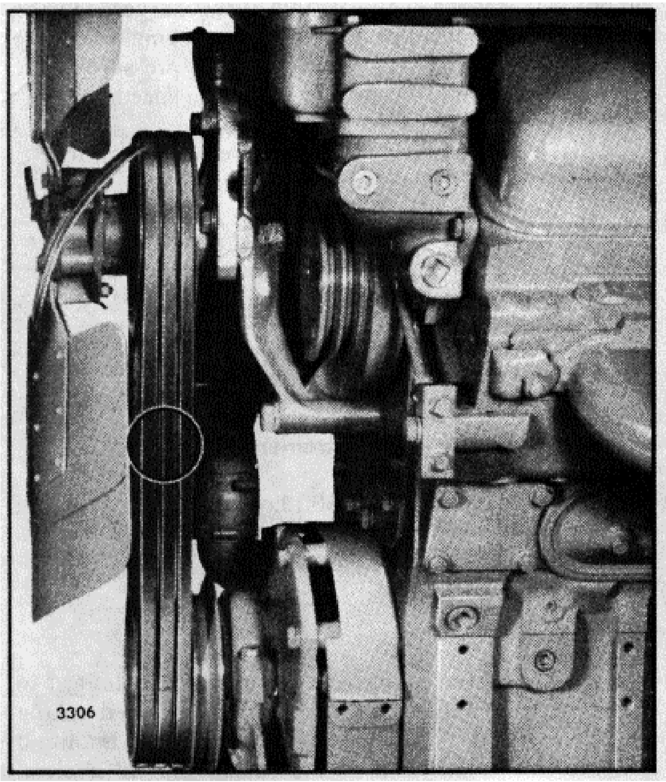
Dry Type

Secondary (safety) elements should not be cleaned or resued.

Dry type elements should be discarded and replaced with new elements after one year of service or when the maximum allowable air intake restriction has been reached, whichever comes first. In cases where the air cleaner manufacturer recommends cleaning or washing the elements, the maximum service life is still one year or maximum restriction. Cleaning, washing and inspection must be done per the manufacturer’s recommendations. Inspection and replacement of the cover gaskets must also be done per the manufacturer’s recommendations.

Item 9-Drive Belts

New standard V-belts will stretch after the first few hours of operation. Run the engine for 15 seconds to seat the belts, then readjust the tension. Check the belts and tighten the fan drive, pump drive, battery-charging alternator and other accessory drive belts after one hour and again after 8 hours of operation. Thereafter, check the tension of the drive belts every 200 hours and adjust, if necessary. Belts should be neither too tight nor too loose. Belts which are too tight impose excess loads on crankshaft, fan and/or alternator bearings, shortening both belt and bearing life. Excessively overtightened belts can result in crankshaft breakage. A loose belt will slip.



Item 9.

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set; premature belt wear can result because of belt length variation. All belts in a matched belt set are within . 032" of their specified center distances.

Adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will depress the belt 1/2" to 3/4". If belt tension gage J 23600-B or equivalent is available, adjust the belt tension as outlined in the chart. "V" and "POLY V" BELT TENSION CHART (1 lbs/beh)

	Fan Drive			Alternator or Generator Drive		
Model	10 Rib (L) Poly V Belt	2 or 3 Belts	Single Belt	Two 3/8" or 1/2" Belts	One 1/2" Belt	8 Rib (K) Poly V Belts
6, 8V-92		60- 80	80-100	40-50	50-70	110-130
16V-92	310-360	90-120		40-50	50-70	

Adjust all V-belts with belt tension gage J23600-B or equivalent.

Adjust all Poly V-Belts with belt tension gage J23586 or equivalent (Range 60-400 lbs.)

Belt tension is 60 + 10 lbs. for a single premium high capacity belt (. 785" wide) used to drive a 12 ctm air compressor.

BELT TENSION CHART (lbs/belt)

NOTE: When installing or adjusting an accessory drive belt, be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.

Adjust Poly-V Fan Belt - 16V-92

The fan belt should be neither too tight nor too loose. Carelessness in making a belt adjustment can be dangerous. Too tight a belt imposes an undue load on the fan bearings and shortens the life of the belt. Too loose a belt allows slippage and lowers the fan speed, causes excessive belt wear and leads to overheating of the cooling system.

Before a Poly-V belt is installed, it is very important that the crankshaft pulley (10 grooves) and the fan drive pulley (11 grooves) are in alignment. The extra groove in the fan drive pulley can be on the inside or the outside of the pulley, depending upon alignment requirements.

Misalignment between the crankshaft pulley and the fan drive pulley cannot be more than . 009" per inch of center line distance. A straight line can be determined by placing a straight edge on the rims of the pulleys. A spacer is available to facilitate pulley alignment, if necessary. The spacer mounts between the crankshaft pulley and the vibration damper hub.

Poly-V belts require a special procedure for proper belt tension.

1. After the belts have been initially adjusted, run the engine under a light load for one-half hour.

2. Stop the engine and check the belt tension with the belt "hot"; use belt tension gage J 23586 or equivalent, which has a range of 60 to 400 pounds.

3. If the tension value is not between 280 and 360 pounds, readjust the belt tension.

   NOTE: Because the allowable load the crankshaft bearing can carry is critical, do not exceed the maximum tension value of 360 pounds.

4. Run the engine at full load for eight hours and then recheck the belt tension.

5. If the belt tension is too tight or too loose, keep the gage in place and adjust the belt tension, to the prescribed value, at the accessory mounting or adjusting bolts. Retighten all of the bolts to the proper torque.

6. The belt tension should be rechecked every 200 hours of engine operation and readjusted, if necessary.

Item 10 - Air Compressor

Remove and clean all air compressor air intake parts every 200 hours. To clean either the hair or polyurethane type air compressor air strainer element, saturate and squeeze it in fuel oil, or any other cleaning agent that would not be detrimental to the element, until dirt free. Then, dip it in lubricating oil and squeeze it dry before placing it back in the air strainer.

For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available. Every 12 months or 700 hours tighten the air compressor mounting bolts. If the air compressor is belt driven, check the belts for proper tension.

Item 11 - Throttle and Clutch Controls

Every 200 hours lubricate the throttle control mechanism. Use an all purpose grease (No. 2 grade) at temperatures +300 F (--1° C) and above. At temperatures below this use a No. 1 grade grease. Lubricate all other control mechanisms, as required, with engine oil.

Item 12 - Lubricating Oil Filter

Install new oil filter elements and gaskets at a maximum of 500 hours or each time the engine oil is changed, whichever occurs first. Any deviation such as changing filters every other oil change, should be based on a laboratory analysis of the drained oil and the used filter elements to determine. if such practice is practical for proper protection of the engine.

Make a visual check of all lubricating oil lines for wear and chafing. If any indication of wear is evident, replace the oil lines and correct the cause. When the engine is equipped with a turbocharger:

1. Disconnect the oil inlet (supply) line at the bearing (center) housing.

2. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

3. Add additional engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

4. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psi - 69 kPa at idle speed).

> CAUTION: Do not hold the compressor wheel, for Any reason, while the engine is running. This could result in personal injury.

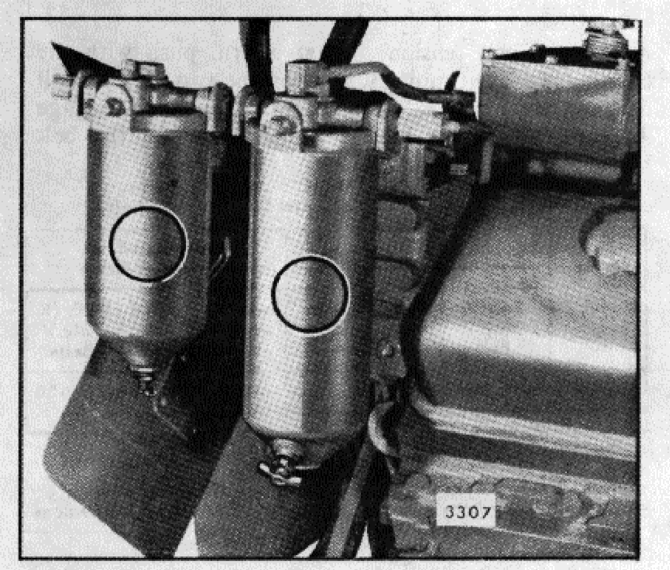
If the engine is equipped with a governor oil filter, change the element every 1, 000 hours.

Check for oil leaks after starting the engine.

Item 13 - Fuel Strainer and Filter

Install new elements every 300 hours or when plugging is indicated.

A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury. With 6V-92 and 8V-92 non-turbocharged engines, at normal operating speed and with . 080" restriction fittings, the fuel pressure is 45-70 psi (310-483 kPa). With 12V-92 and 16V-92 non-turbocharged engines, at normal operating speeds and with . 070" restriction fittings, the fuel pressure is 30-65 psi (207-448 kPa). With turbocharged engines, at



Item 13.

normal operating speeds and with either . 080" or . 070' restriction fittings, the fuel pressure is 50-70 psi (345-483 kPa). Change the fuel filter elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches (41 kPa) of mercury at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to the minimum fuel pressure shown above.

Item 14 - Coolant Filter & Water Pump

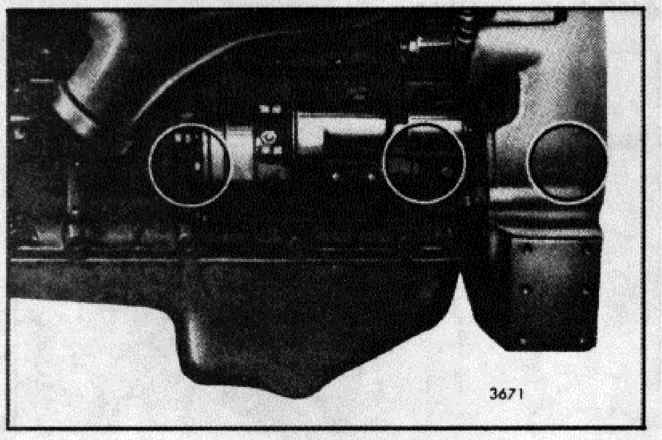
If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 500 hours. Select the proper coolant filter element in accordance with the instructions given in Coolant Specifications. Use a new filter cover gasket when installing the filter element. After replacing the filter and cover gaskets, start the engine and check for leaks.

Inspect the water pump drain hole every 6 months for plugging. If plugged, clean out the drain hole with a tool made from a front crankshaft seal, or equivalent.

Replace the water pump seal after it has been in service for 6, 000 hours.

Item 15 - Starting Motor

The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken off the engine or disassembled.



Item 15.

The Sprag overrunning clutch drive mechanism should be lubricated with a few drops of light engine oil whenever the starting motor is overhauled.

Item 16 - Air System

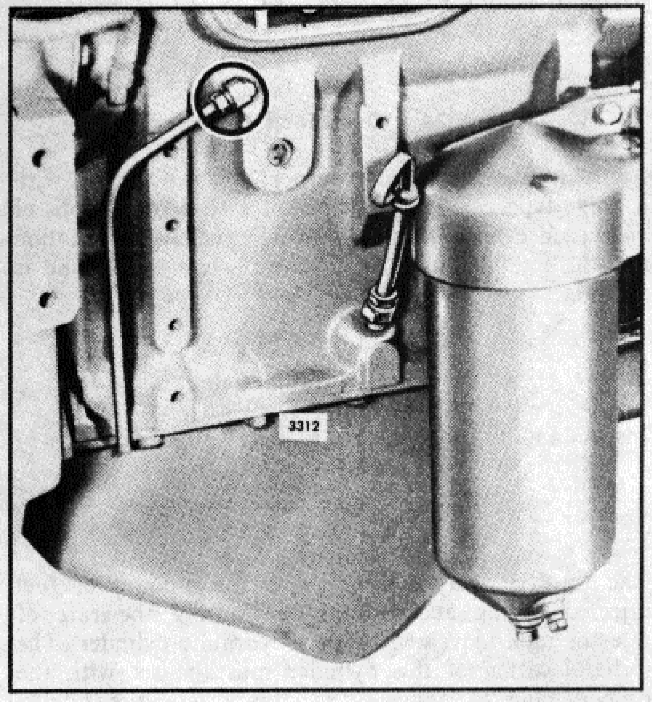
Check all of the connections in the air system to be sure they are tight. Check all hoses for punctures or other damage and replace, if necessary.

Item 17 - Exhaust System

Check the exhaust manifold retaining nuts, exhaust flange clamp and other connections for tightness. Check for proper operation of the exhaust pipe rain cap, if one is used.

Item 18 - Air Box Drain Tube

With the engine running, check for flow of air from the air box drain tubes every 1, 000 hours. If the tubes are clogged, remove, clean and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent.



Item 18.

If the engine is equipped with an air box drain tank, drain the sediment periodically.

Item 19 - Emergency Shutdown

With the engine running at idle speed check the operation of the emergency shutdown every 700 hours. Reset the air shutdown valve in the open position after the check has been made.

Item 21 - Radiator

Inspect the exterior of the radiator core every 700 hours and, if necessary, clean it with a quality grease solvent such as mineral spirits and dry it with compressed air. Do not use fuel oil, kerosene or gasoline. It may be necessary to clean the radiator more frequently if the engine is being operated in extremely dusty or dirty areas.

Item 22 - Shutter Operation

Check the operation of the shutters and clean the linkage and controls.

Item 23 - Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started. In the event the engine is equipped with warning lights rather than pressure indicators, the pressure should be checked and recorded every 700 hours.

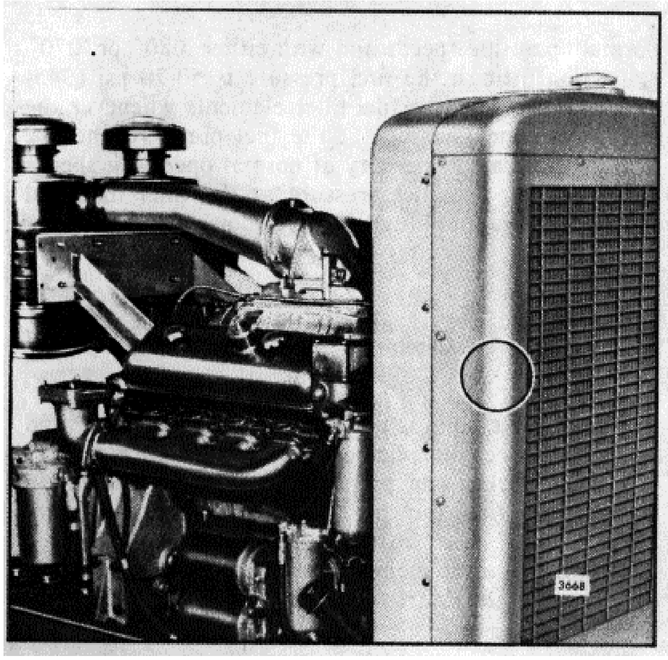
Item 24 - Overspeed Governor

Lubricate the overspeed governor, if it is equipped with a hinge-type cap oiler or oil cup, with 5 or 6 drops of engine oil every 500 hours. Avoid excessive lubrication and do not lubricate the governor while the engine is running. I

Item 26 - Throttle Delay

Inspect and adjust, if necessary, every 30 months.

The throttle delay system limits the amount of fuel injected during acceleration by limiting the rate of injector rack movement with a hydraulic cylinder. The initial location of this cylinder must be set with the proper gage to achieve the appropriate time delay
(Section 6).



Item 21.

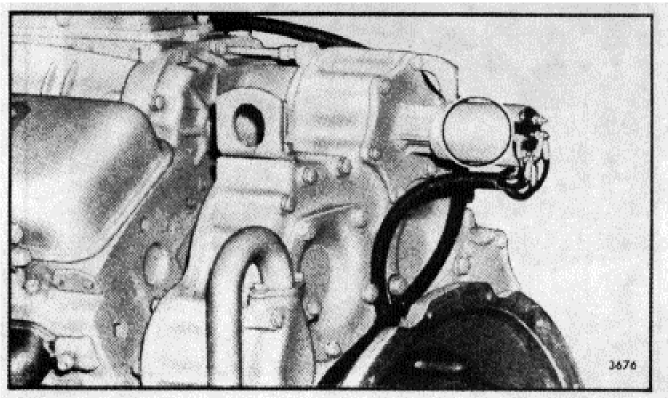
Inspect the check valve by filling the throttle delay cylinder with diesel fuel and watching for valve leakage while moving the throttle from the idle to the full-fuel position.

Item 27 - Battery-Changing Alternator

Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.

Lubricate the battery-charging alternator bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours.

Some alternators have a built-in supply of grease, while others use sealed bearings. In these latter two cases, additional lubrication is not necessary.



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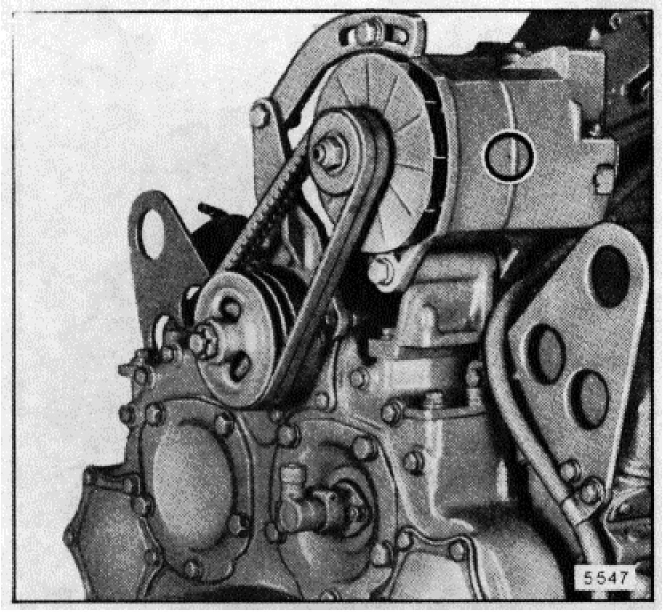


Item 27.

On alternators, the slip rings and brushes can be inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean the slip rings. Hold the polishing cloth against the slip rings with the alternator in operation and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them.

Item 28 - Engine and Transmission Mounts

Check the engine and transmission mounting bolts and the condition of the mounting pads every 2, 000 hours. Tighten and repair as necessary.

Item 29 - Crankcase Pressure

Check and record the crankcase pressure every 2, 000 hours.

Item 30 - Air Box Check Valves

Every 3, 000 hours remove, clean them in solvent and blow out the lines with compressed air. Inspect for leaks after servicing.

Item 31 - Fan Hub

If the fan bearing hub assembly is provided with a grease fitting, use a hand grease gun and lubricate the bearings with one shot of Texaco Premium RB grease, or an equivalent Lithium base multi-purpose grease, every 700 hours.

Every 4, 000 hours clean, inspect and repack the fan bearing hub assembly with the above recommended grease.

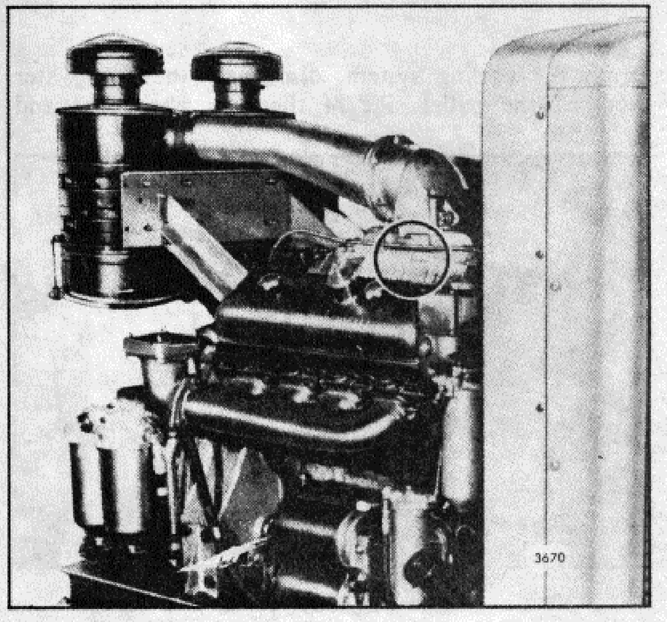
At a major engine overhaul, remove and discard the bearings in the fan hub assembly. Pack the hub assembly, using new bearings, with Texaco Premium RB grease or an equivalent Lithium base multi-purpose grease.

Item 32 - Thermostats and Seals

Check the thermostats and seals at 5, 000 hours or once a year (preferably at the time the cooling system is prepared for winter operation). The thermostats should always be replaced at overhaul. Replace the seals, if necessary.

Item 33 - Blower Screen

Inspect the blower screen and gasket assembly every 1, 000 hours and, if necessary, clean the screen in fuel oil and dry it with compressed air. Install the screen and gasket assembly with the screen side of the assembly toward the blower. Inspect for evidence of blower seal leakage.



Item 33.

Item 34 - Crankcase Breather

Remove the externally mounted crankcase breather assembly every 1, 000 hours and wash the steel' mesh pad in clean fuel oil. This cleaning period may be reduced or lengthened according to severity of service.

Clean the breather cap, mounted on the valve rocker cover, in clean fuel oil every time the engine oil is changed.

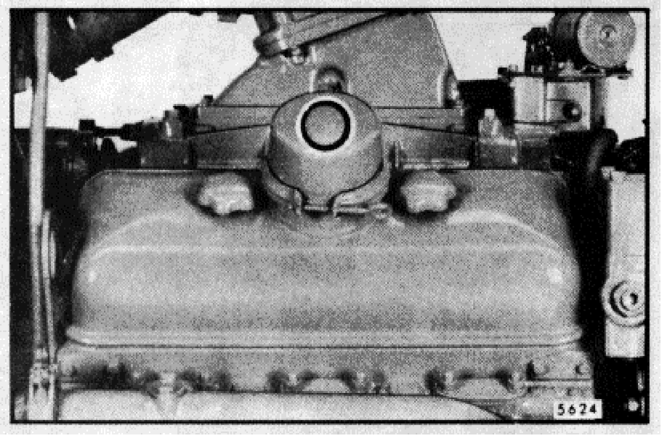
Item 36 - Engine tune-up

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

Item 37 - Heat Exchanger Electrodes and Core

Every 500 hours, drain the water from the heat exchanger raw water inlet and outlet tubes; Then, remove the zinc electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1, 000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, contact a Detroit Diesel Allison Service Outlet



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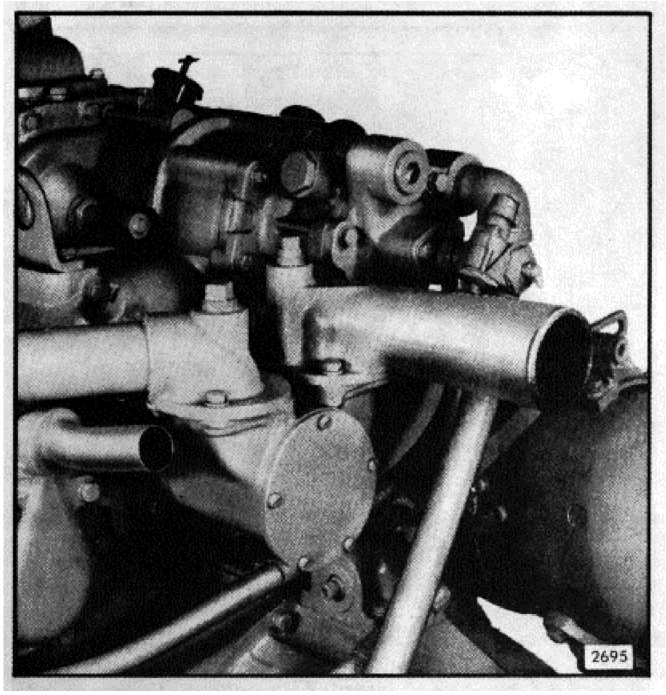


Item 37 and 38 r

Item 38 - Raw Water Pump

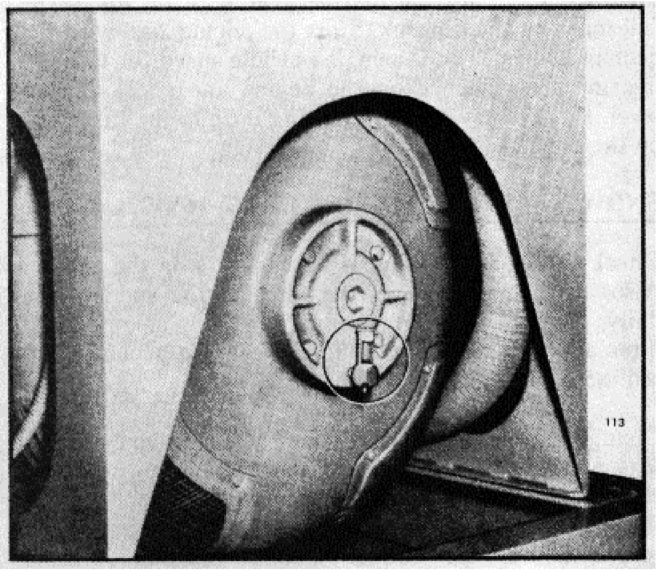
Check the prime on the raw water pump daily. The engine should not be operated with a dry pump. Prime the pump, if necessary, by removing the pipe plug provided in the pump inlet elbow and adding water. Reinstall the plug.

Item 39 - Power Generator

The power generator requires lubrication at only one point -- the ball bearing in the end frame.

If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade of oil as specified for the engine. Maintain the oil level to the line in the sight gage. Do not overfill. After adding oil, recheck the oil level after running the generator for several minutes.

If the bearing is grease lubricated, a new generator has sufficient grease for three years of normal service. Thereafter, it should be lubricated at one year intervals. To lubricate the bearing, remove the filler and relief



Item 39.

plugs on the side and the bottom of the bearing reservoir. Add grease until new grease appears at the relief plug opening. Run the generator a few minutes to vent the excess grease; then reinstall the plugs.

The following greases, or their equivalents, are recommended:

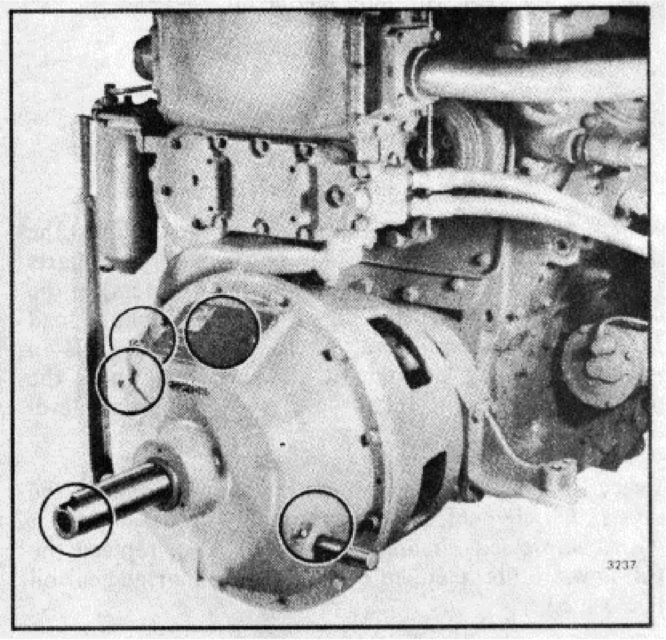
Keystone 44H	Keystone Lubrication Co.
BRB Lifetime	Socony Vacuum Oil Co.
NY and NJ926 or F927	NY and NJ Lubricant Co.

After 100 hours on new brushes, or brushes in generators that have not been in use over a long period, remove the end frame covers and inspect the brushes, commutator and collector rings. - If there is no appreciable wear on the brushes, the inspection interval may be extended until the most practicable period has been established (not to exceed six months). To prevent damage to the commutator or the collector rings, do not permit the brushes to become shorter than 3/4 inch.

Keep the generator clean inside and out. Before removing the end frame covers, wipe off the loose dirt. The loose dirt and dust may be blown out with low pressure air (25 psi or 172 kPa maximum). Remove all greasy dirt with a cloth.

Item 40 - Power Take-Off

Lubricate all of the power take-off bearings with an all purpose grease such as Shell Alvania No. 2, or equivalent. Lubricate sparingly to avoid getting grease on the clutch facings.



Item 40.

Lubricate the clutch release bearing and the disconnect mechanical rear drive shaft shielded bearing every 8 hours. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required.

Lubricate the power take-off main bearing, also the outboard bearing if the unit is so equipped, every 50 hours. Frequency of lubrication will depend on the working conditions of the bearing, shaft speeds and bearing loads. It may be necessary to lubricate this bearing more often than every 50 hours. Lubricate the front power take-off clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and lubricate the clutch release levers and link pins sparingly every 500 hours. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours.

Check the clutch facing for wear every 500 hours. Adjust the clutch, if necessary.

Item 41 - Marine Gear

<u>TORQMATIC MARINE GEAR (6V-92 and 8V-92):</u>

Check the oil level daily in the marine gear, with the controls in neutral and the engine running at idle speed. Add oil as required to bring it to the proper level on the dipstick. Use the same grade and viscosity heavy duty oil as used in the engine. Drain the oil every 200 hours and flush the gear with light engine oil.

NOTE: Series 3 oil should not be used in the marine gear.

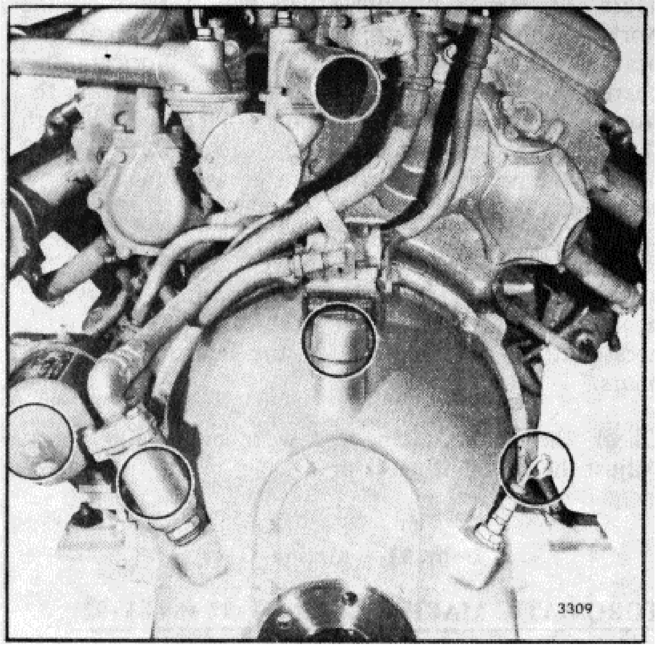
When refilling after an oil drain, bring the oil up to the proper level on the dipstick - approximately 6 quarts (5. 7 liters) in the M type and 8 quarts (7. 6 liters) in the MH type gear. Start and run the engine at light load for three to five minutes. Then, put the controls in neutral and run the engine at idle speed and check the oil level again. Bring the oil level up to the proper level on the dipstick.

Every time the marine gear oil is changed, remove the oil strainer element, rinse it thoroughly in fuel oil, dry it with compressed air and reinstall it. Also, replace the full-flow oil filter element every time the marine gear oil is changed.

TWIN DISC MARINE GEAR (16V-92):

Check the oil level daily. Check the oil level with the engine running at low idle speed and the gear in neutral. Keep the oil up to the proper level on the dipstick. Use oil of the same heavy-duty grade and viscosity that is used in the engine.

Change the oil and the oil filter element every 1, 000 hours. After draining the oil, thoroughly clean the removable oil screen and breather. Reinstall the breather and refill the marine gear with oil up to the full mark on the dipstick. Start the engine and, with the gear in neutral, run the engine at idle speed for three to five minutes. Then, stop the engine and check the oil level. If necessary, add oil to bring it up to the full mark on the dipstick.



Item 41.

SNOW NABSTEDT MARINE GEAR (16V-92):

Check the oil level daily. If' necessary, stop the engine. Also, turn the handle of the filter in the suction line daily, or more often, if necessary. This is a knife edge filter and a turn of the handle wipes the accumulated sediment from the edge of the filter discs.

Change the oil every 1, 000 hours or at the end of each season, whichever occurs first. At each oil change, remove the plug from the bottom of the filter to drain the sediment. If the filter is extremely dirty, remove the screws holding the sediment bulb to the flange at the top of the filter and remove the bulb for thorough cleaning. When replacing the bulb, be sure to tighten the screws evenly and securely to prevent air leaks in the suction line. Use oil of the same heavy duty grade and viscosity that is used in the engine.

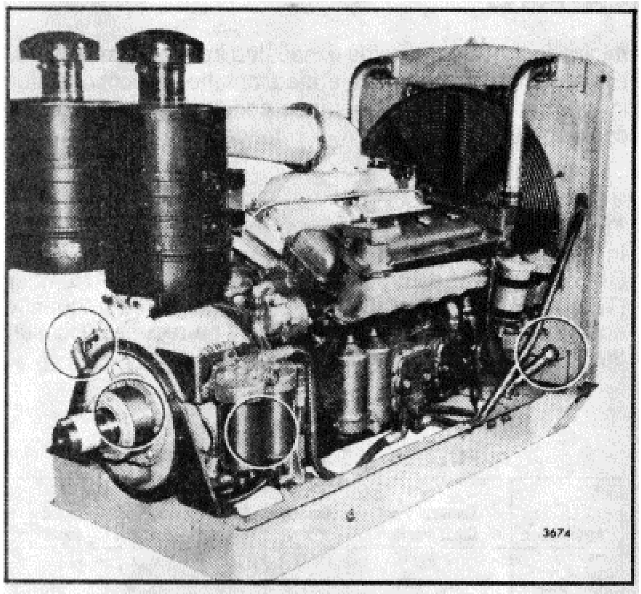
Item 42 - Torqmatic Converter

Check the oil level in the Torqmatic converter and supply tank daily. The oil level must be checked while the converter is operating, the engine idling and the oil is up to operating temperature (approximately 2000 F or 930 C). If the converter is equipped with an input disconnect clutch, the clutch must be engaged.

Check the oil level after running the unit a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" Table 2. Do not overfill the converter, as too much oil will cause foaming and high oil temperature.

Prevailing Ambient Temperature	Recommended Oil Specification
Above -10°F (-12°C)	Hydraulic Transmission Fluid, Type C-2.
Below -10°F (-12°C)	Hydraulic Transmission Fluid, Type C-2, Auxiliary preheat required to raise temperature in the sump to a temperature above -10°F (-12°C).

TABLE 2. - OIL RECOMMENDATIONS



Item 42.

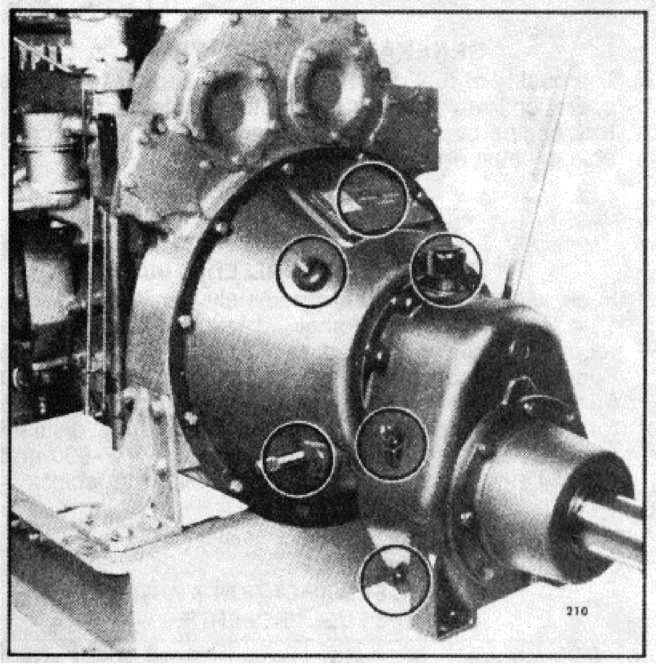
The oil should be changed every 1, 000 hours for Series 400 through 900 converters. Also, the oil should be changed whenever it shows traces of dirt or effects of high operating temperature as evidenced by discoloration or strong odor. If the oil shows metal contamination, contact an authorized Detroit Diesel Allison Service Outlet as this usually requires disassembly. Under severe operating conditions, the oil should be changed more often.

The converter oil breather, located on the oil level indicator (dipstick) should be cleaned each time the converter oil is changed. This can be accomplished by allowing the breather to soak in a solvent, then drying it with compressed air.

The full-flow oil filter element should be removed, the shell cleaned and a new element and gasket installed each time the converter oil is changed.

Lubricate the input clutch release bearing and ball bearing and the front disconnect clutch drive shaft bearing every 50 hours with an all purpose grease. Grease fittings are provided on the clutch housing. This time interval may vary depending upon the operating conditions. Over-lubrication will cause grease to be thrown on the clutch facing, causing the clutch to slip.

The strainer (in the Torqmatic transmission) and the hydraulic system filters should be replaced or cleaned with every oil change.



Item 43.

Item 43 - Reduction Gear

ROCKFORD REDUCTION GEAR:

Check the oil level in the reduction gear every 8 hours and add oil as required to bring the oil to the proper level on the dipstick. Drain the oil every 1, 000 hours, flush the housing with light engine oil, and refill to the proper level with the same grade and viscosity heavy duty oil that is used in the engine. This oil change period should be reduced under severe operating conditions.

Lubricate the clutch release bearing through the grease fitting on the side of the housing every 8 hours of operation. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required. Lubricate the front reduction clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and oil the clutch release levers and link pins sparingly every 500 hours. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours.

FUEL SPECIFICATIONS

GENERAL CONSIDERATIONS

The quality of fuel oil used for high-speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should show at least 98% by volume recovery when subjected to ASTM D-86 distillation. Fuels marketed to meet Federal Specification VV-F-800 (grades DF-1 and DF-2) and ASTM Designation D-975 (grades 1-D and 2-D) meet the completely distilled criteria. The differences in properties of VV-F-800 and ASTM D-975 fuels are shown in the following table.

FEDERAL SPECIFICATION & ASTM DIESEL FUEL PROPERTIES

Specification or Classification Grade	VV-F-800 DF-1	ASTM D-975 1-D	VV-F-800, DF-2		ASTM D-975 2-D
			NORTH AMERICA	OTHER	
Flash Point, min.	38°C 100°F	38°C 100°F	52°C 125°F	56°C 133°F	52°C 125°F
Carbon Residue (10% residuum), mass % max.	0.15	0.15	0.35	0.20	0.35
Water & Sediment, % by vol, max.	—	0.05	—	—	0.05
Ash, % by wt., max.	0.01	0.01	0.01	0.02	0.01
Distillation Temperature, 90% by vol. recovery, min.	—	—	—	—	282°C 540°F
max.	288°C 550°F	288°C 550°F	338°C 640°F	357°C 675°F	338°C 640°F
End Point max.	330°C 626°F	—	370°C 698°F	370°C 698°F	—
Viscosity					
Kinematic, cSt, min. @ 40°C	1.3	1.3	1.9	1.8@20°C	1.9
Saybolt, SUS, min. @ 100°F	—	—	—	—	32.6
Kinematic, cSt, max. @ 40°C	2.9	2.4	4.1	9.5@20°C	4.1
Saybolt, SUS, max. @ 100°F	—	34.4	—	—	40.1
Sulfur, mass % max.	0.50	0.50	0.50	0.70	0.50
Cetane No., min.	45	40.0	45	45	40.0

FUEL CLEANLINESS

Fuel' oil should be clean and free of contamination. Storage tanks and stored fuel should be inspected regularly for dirt, water or water-emulsion sludge, and cleaned if contaminated. Storage instability of the fuel can lead to the formation of varnish or sludge in the tank. The presence of these contaminants from storage instability must be resolved with the fuel supplier.

FUEL SULFUR CONTENT

The sulfur content of the fuel should be as low as possible to avoid premature wear, excessive deposit formation, and minimize the sulfur dioxide exhausted into the atmosphere. Limited amounts can be tolerated, but the amount of sulfur in the fuel and engine operating conditions can influence corrosion and deposit formation tendencies.

The detrimental effect of burning high sulfur fuel is reflected in Detroit Diesel lube oil change interval recommendations. Detroit Diesel recommends that the Total Base Number (TBN-ASTM D-664) of the lube oil be monitored frequently and that' the oil drain interval possibly be reduced. Consult the FUEL OIL SELECTION CHART. FUEL OIL SELECTION CHART

Application	General Fuel Classification	Final Boiling Point	Cetane Number	Sulfur Content	Cloud Point
		(Max.)	(Min.)	(Max.)	
City Buses	No. 1-D	550°F 288°C	45	0.30	SEE NOTES
	Winter No. 2-D*	675°F 357°C	45	0.50	
	Summer No. 2-D*	357°C	40	0.50	
All Other Applications	Winter No. 2-D	675°F 357°C	45	0.50	SEE NOTES
	Summer No. 2-D	675°F 357°C	40	0.50	

*No. 2-D diesel fuel may be used in city coach engine models that have been certified to pass Federal and California emission standards

Note 1: The cloud point should be 100F (6°C) below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

Note 2: When prolonged idling periods or cold weather conditions below 32° F (OOC) are encountered, the use of lighter distillate fuels may be more practical. The same consideration must be made when operating at altitudes above 5, 000 ft.

IGNITION QUALITY, -CETANE NUMBER

There is a delay between the time the fuel is injected into the cylinder and the time that ignition occurs. The duration of this delay is expressed in terms of cetane number (rating). Rapidly ignited fuels have high cetane numbers (50 or above). Slowly ignited fuels have low cetane numbers (40 or below). The lower the ambient temperature, the greater the need for a high cetane fuel that will ignite rapidly.

Difficult starting may be experienced if the Cretan number of the fuel is too low. Furthermore, engine knock and puffs of white smoke may be experienced during engine warm-up especially in severe cold weather when operating with a low Cretan fuel. If this condition is allowed to continue for any prolonged period, harmful fuel derived deposits will accumulate within the combustion chamber. Consult the FUEL OIL SELECTION CHART.

DISTILLATION END POINT

Fuel can be burned in an engine only after it has been vaporized. The temperature at which fuel is completely vaporized is described as the distillation endpoint (ASTM D-86). The distillation (boiling) range of diesel fuels should be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed, and load. Mediocre to poor vaporization is more apt to occur during severe cold weather and or prolonged engine idling and or light load operation. Therefore, engines will show better performance operating under the conditions described above when lower distillation end point fuels are used. Consult the FUEL OIL SELECTION CHART.

CLOUD POINT

The cloud point is that temperature at which wax crystals begin to form in diesel fuel. The selection of a suitable fuel for low temperature operability is the responsibility of the fuel supplier and the engine user. Consult the FUEL OIL SELECTION CHART.

DETROIT DIESEL FUEL OIL SPECIFICATIONS

Detroit Diesel Allison designs, develops and manufactures commercial diesel engines to operate on diesel fuels classified by the ASTM as Designation D-975 (grades 1 -D and 2-D). These grades are very similar to grades DF-1 and DF-2 of Federal Specification VV-F-800.

Burner fuels (furnace oils or domestic heating fuels) generally require an open flame for satisfactory combustion. The ignition quality (cetane rating) of burner fuels (ASTM D-396) is poor when compared to diesel fuels (ASTM D-975).

In some regions, however, fuel suppliers may distribute one fluid that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396) sometimes identified as burner, furnace, or residual fuel. Under these circumstances, the fuel should be investigated to determine whether the properties conform with those indicated in the FUEL OIL SELECTION CHART.

The FUEL OIL SELECTION CHART also will serve as a guide in the selection of the proper fuel for various applications. The fuels used must be clean, completely distilled, stable, and non-corrosive. Distillation Range, Cetane Number, Sulfur Content, and Cloud Point are four of the most important properties of diesel fuels that must be controlled to insure satisfactory engine operation. Engine speed, load, and ambient temperature all influence the selection of diesel fuels with respect to distillation range and cetane number.

All diesel fuels contain a certain amount of sulfur. Too high a sulfur content results in excessive cylinder wear. For most satisfactory engine life, fuels containing less than 0.5% sulfur should be used.

During cold weather engine operation the cloud point (the temperature at which wax crystals begin to form in diesel fuel) should be 10I F (60C) below the lowest expected fuel temperature in order to prevent clogging of the fuel filters by wax crystals.

A reputable fuel oil supplier is the only one who can assure you that the fuel you receive meets the Distillation End Point, Cetane Number, Sulfur Content, and Cloud Point property limits shown in the FUEL OIL SELECTION CHART. The responsibility for clean fuel that meets Detroit Diesel Allison specifications lies with the fuel supplier as well as the operator.

At temperatures below + 320 F (0°C) particular attention must be given to cold weather starting aids for efficient engine starting and operation.

NUMEROUS FUELS BURNED IN DETROIT DIESEL ENGINES

Numerous fuels meeting the properties shown in the FUEL OIL SELECTION CHART may be used in Detroit Diesel engines. The table (next page) shows some of the alternate fuels (some with sulfur and or cetane limits) that have been burned in Detroit Diesel engines. Among these are No. i and No. 2 diesel fuels, kerosene, aviation turbine (jet) fuels, and burner fuels.

PROPOSED ASTM D-975, GRADE 3-D

Detroit Diesel Allison does NOT recommend the use of proposed grade 3-D diesel fuel in any of its engines. This grade of fuel was proposed, but not accepted by, the ASTM. The grade 3-D which was proposed is undesirable in that it possesses poor ignition quality (i.e., lower cetane), allows greater sulfur content (up to 0.70% by weight), allows the formation of more carbon deposits (Conradson carbon residue), and allows the blending of heavier, more viscous boiling point fractions that are difficult to burn. The latter tend to increase combustion chamber deposits. This type of fuel usually manifests poor cold

FUELS BURNED IN DETROIT DIESEL ENGINES

ASTM Desig-nation	Federal Standard	Military Spec.	NATO Code	Grade	Description/Comments
D-975				1-D 2-D	Diesel Fuel
D-396				1, 2	Burner Fuel (Furnace Oil) ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. % and the Minimum Cetane No. Is 45. (See Fuel Oil Selection Chart).***
	VV-F-800		F-54	1, 2	DF-1 Winter Grade, DF-2 Regular Grade
	VV-F-800		F-56		DF-A (Arctic Grade). Limited Supply For Military.
		MIL-T-5624		JP-5	Kerosene
D-1655		MIL-T-83133	F-34	JP-8	Jet A-1, Kerosene Type Plus Special Anti-Icer
D-1655			F-35		Jet A, Kerosene
		MIL-F-16884	F-76	DFM	Diesel Fuel - Marine (DFM). ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. %.***
		MIL-F-5161		JP-6	Referee Grade JP-5 Type Jet Fuel. Limited Quantities Supplied To Military Only.

weather properties (wax formation tendencies). In addition, the poor ignition quality adversely affects noise and emission levels.

A comparison of ASTM D-975 grade 2-D and the proposed grade 3-D fuel properties is shown in the following table.

USING DRAINED LUBE OIL IN DIESEL FUEL

Detroit Diesel Allison does not recommend the use of drained lubricating oil in diesel fuel. Furthermore, Detroit Diesel Allison will not be responsible for any detrimental effects which it determines resulted from this practice.

BURNING MIXTURES OF DIESOHOL AND GASOHOL ANDIOR ADDING ALCOHOL ANDIOR GASOLINE TO DIESEL FUEL

Very small amounts of isopropyl alcohol (isopropanol) may be used to preclude fuel line freeze-up in winter months. No more than ONE PINT of isopropyl alcohol should be added to 125 GALLONS of diesel fuel for adequate protection.

Commercially marketed DIESOHOL or GASOHOL or GASOLINE should never be added to diesel fuel. An explosive and fire hazard exists if these blends are mixed and/or burned.

COMPARISON OF ASTM D-975 GRADE 2-D AND PROPOSED GRADE 3-D PROPERTIES

Property	Grade	
	Recommended 2-D	Not Recommended 3-D
Cetane No., Min.	40.0	37.0
Sulfur, WT. %, Max.	0.50	0.70
Carbon Residue On 10% Residuum, %, Max.	0.35	0.40
Viscosity @ 40° Celsius, Centistokes	1.9 - 4.1	2.0 - 7.0
Distillation		
deg. Celsius (Fahrenheit)		
90% Recovery, Max.	338 (640)	360 (680)

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpt has been taken from a policy statement of General Motors Corporation:

> "It has been and continues to be General Motors policy to build motor vehicles that will operate satisfactorily on the commercial fuels and lubricants of good quality regularly provided by the petroleum industry through retail outlets. It is accordingly contrary to the policy of General Motors to recommend the regular and continued use of supplementary additives in fuels and lubricants. "

Therefore, Detroit Diesel Allison does not recommend the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, reodorants, tune-up compounds, top oils, break-in oils, graphitizers, and friction-reducing compounds.

NOTICE: The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's fuel or lubricating recommendations may not be within the coverage of the warranty.

LUBRICATION SPECIFICATIONS

GENERAL CONSIDERATIONS

All diesel engines require heavy-duty lubricating oils. Basic requirements of such oils are lubricating quality, high heat resistance, and control of contaminants.

LUBRICATING QUALITY. The reduction of friction and wear by maintaining an oil film between moving parts is the primary requisite of a lubricant. Film thickness and its ability to prevent metal-to-metal contact of moving parts is related to oil viscosity. The optimums for Detroit Diesel engines are SAE 40 or 30 weight.

HIGH HEAT RESISTANCE. Temperature is the most important factor in determining the rate at which deterioration or oxidation of the lubricating oil will occur. The oil should have adequate thermal stability at elevated temperatures, thereby precluding formation of harmful carbonaceous and/or ash deposits.

CONTROL OF CONTAMINANTS. The piston and compression rings must ride on a film of oil to minimize wear and prevent cylinder seizure. At normal rates of consumption, oil reaches a temperature zone at the upper part of the piston where rapid oxidation and carbonization can occur. In addition, as oil circulates through the engine, it is continuously contaminated by soot, acids, and water originating from combustion. Until they are exhausted, detergent and dispersant additives aid in keeping sludge and varnish from depositing on engine parts. But such additives in excessive quantities can result in detrimental ash deposits. If abnormal amounts of insoluble deposits form, particularly on the piston in the compression ring area, early engine failure may result.

Oil that is carried up the cylinder liner wall is normally consumed during engine operation. The oil and additives leave carbonaceous and/or ash deposits when subjected to the elevated temperatures of the combustion chamber. The amount of deposits is influenced by the oil composition, additive content, engine temperature, and oil consumption rate.

OIL QUALITY is the responsibility of the oil supplier. (The term "oil supplier" is applicable to refiners, blenders, and rebranders of petroleum products). Oil quality can also be affected by handling cleanliness, contamination, dirt, water, etc.

There are hundreds of commercial crankcase oils marketed today. Obviously, engine manufacturers or users cannot completely evaluate the numerous commercial oils. The selection of a suitable lubricant in consultation with a reliable oil supplier, observance of his oil drain recommendations (based on used oil sample analysis and experience), and proper filter maintenance will provide the best assurance of satisfactory oil performance.

It should be noted that lube oil manufacturers may reformulate an oil while maintaining the same API classification, or may reformulate to a new API classification and continue the brand name designation. For example, SE oils being reformulated to SF letter code classification may perform differently after this reformulation. A close working relationship with the lube oil manufacturer should be maintained so that any reformulation can be reviewed and a decision made as to its effect on continued satisfactory performance.

COLD WEATHER OPERATION

Two important considerations relate to satisfactory operation under cold ambient temperature conditions. These are: (1) the ability to crank the engine fast enough to secure starting, and (2) providing adequate lubrication to internal wearing surfaces during starting and warm-up. Once started and warmed up, external ambient temperatures have little effect on internal engine temperatures. Both cold weather considerations can be adequately met through proper lube oil selection and the use of auxiliary heat prior to starting. Auxiliary heat can be used in the form of jacket water and oil pan heaters, hot air space heaters applied to engine compartments, or some combination of these.

Proper oil selection and oil heat can assure lubricant flow immediately upon starting. Improper oil selection and oil heat may result in starting with cold oil congealed in the oil pan, and little or no oil flow for lubricating internal parts once the engine has started.

Proper oil selection and jacket water heating can assure cranking capability by maintaining an oil film on cylinder walls and bearing surfaces in a condition which provides low friction, and hence, less cranking effort to achieve cranking speeds necessary for reliable starting. Improper oil selection and jacket water heating may result in congealed oil films on cylinder walls and bearing surfaces, which result in high friction loads and more cranking effort than is available, thus preventing sufficient cranking speeds to assure reliable starting.

LUBE OIL SPECIFICATIONS

API PERFORMANCE DESIGNATIONS, LUBE SUPPLIER, AND BRAND NAMES

Lubricants are blended to meet specific industry accepted tests developed by the American Society for Testing and Materials (ASTM). The service for which these products are intended is defined by the American Petroleum Institute (API). The lube supplier markets these products under a specific brand or trade name.

The container identification indicates whether the contents meet or exceed specific API letter code designations (example: SF, CD).

RECOMMENDATION

Lubricating oils that meet the following performance levels, viscosity grades, sulfated ash limits and zinc requirements are recommended for Detroit Diesel engines. It is also recommended that the oil supplier provide to the user evidence of satisfactory performance of his products in Detroit Diesel engines.

LUBE OIL PERFORMANCE LEVELS

Lubricants are formulated to meet all the performance criteria defined in either commercial (API) and or military specifications. Table L-1 shows the current commercial industry and military oil performance levels. The API letter designations are defined in SAE recommended practice J-183 published in the SAE Handbook. Specific oil performance level recommendations for Detroit Diesel engines are indicated in Table L-1.

TABLE L-1.
LUBE OIL PERFORMANCE LEVELS

API PERFORMANCE DESIGNATION		COMPARABLE MILITARY SPECIFICATION	RECOMMENDED FOR USE IN DDA ENGINES		COMMENTS & CURRENT API OR MILITARY QUALIFICATION STATUS
DIESEL ENGINES	GASOLINE ENGINES		2-CYCLE	4-CYCLE	
CB	—	MIL-L-2104A (Supplement 1)	YES	NO	Obsolete, still limited availability.
CC	—	MIL-L-2104B	YES	NO	Obsolete, still readily available.
CD	—	MIL-L-45199B (Series 3)	YES	NO	Still limited availability.
CC	SE	MIL-L-46152	YES	YES	Obsolete Diesel performance, intended for passenger cars burning gasoline.
CC	SF	NONE	YES	YES	Primarily for passenger cars burning gasoline.
CD	SC	MIL-L-2104C	YES	YES	Current spec. for heavy duty diesel powered military vehicles, acceptable for commercial diesel powered vehicles.
CD	SE		YES	YES	Diesel performance requirements are current. Gasoline fueled passenger cars performance requirements are obsolete.
CD	SF		YES	YES	Meet current diesel & gasoline performance requirements.
—	SF		NO	YES	Service station lubes.

VISCOSITY GRADES

Single grade SAE-40 and 30 lubricants are preferred and recommended for use in all Detroit Diesel 2-cycle engines. Table L-2 shows a viscosity grade selection chart as related to ambient temperatures. Note that 15W-40 multigrade oils are recommended as a third choice for Series 53, 71 and 92 engines only when ambient temperatures are below 320F (O°C). Multigrade oils, including 15W-40, should never be used in Series 149 engines.

TABLE L-2.
VISCOSITY - SAE GRADE SELECTION CHART

Ambient Temperature		ENGINE SERIES								
		149		92, 71, 53			8.2L			
		2-CYCLE		2-CYCLE			4-CYCLE			
		First	Second	First	Second	Third	First	Second	Third	Fourth
Deg. Fahr.	Deg. Celsius									
↕ 50	↕ 10	* * SAE 40	SAE 30	SAE 40	SAE 30	None	15W-40	10W-40	20W-40	30
↕ 32	↕ 0	SAE (40)	SAE 30 *	SAE (40)	SAE 30 *	None	* 15W-40	* 10W-40	* 20W-40	None
↕ 0	↕ −18	SAE (40)	SAE (30)	SAE (40)	SAE (30)	* 15W-40	(15W-40)	* 10W-40	(20W-40)	None
↕ −25	↕ −32	SAE (40)	SAE (30)	SAE (40)	SAE (30)	(15W-40)	(15W-40)	(10W-40)	(20W-40)	None

( ) Numbers In parentheses indicate that starting aids are required

* Usually unaided starts can be accomplished

* * SAE 50 grade lube oil is recommended if the top tank coolant temperature is 195 ◦F or above. (CAUTION: Do not use SAE-50 grade lube oil when or where cold ambient temperatures prevail.)

OTHER MULTIGRADE OILS

15W-40 oils are the only acceptable multigrade lubricants that should be considered in Series 53, 71 and 92 engines if prolonged cold ambient temperatures below 320F (0°C) are expected. Detroit Diesel Allison does not recommend the use of any multigrade oils other than 15W-40 in these 2-cycle engines. Never use any kind of multigrade oils in Series 149 engines.

OIL CHANGES

CONDITION A: THE SULFUR CONTENT OF THE DIESEL FUEL IS LESS THAN 0.50% BY WEIGHT

Table L-3 shows the initial oil drain intervals recommended for all Detroit Diesel engines. Oil drain intervals may be increased or decreased depending upon the condition of the lubricant. Used lube oil analysis guidelines, indicating contamination limits, are shown elsewhere in Table L-4. DDA recommends that if the total base number (TBN by ASTM D-664) is reduced to 1.0 or if the TBN (ASTM-2896) is reduced to 2.0, the oil should be drained immediately.

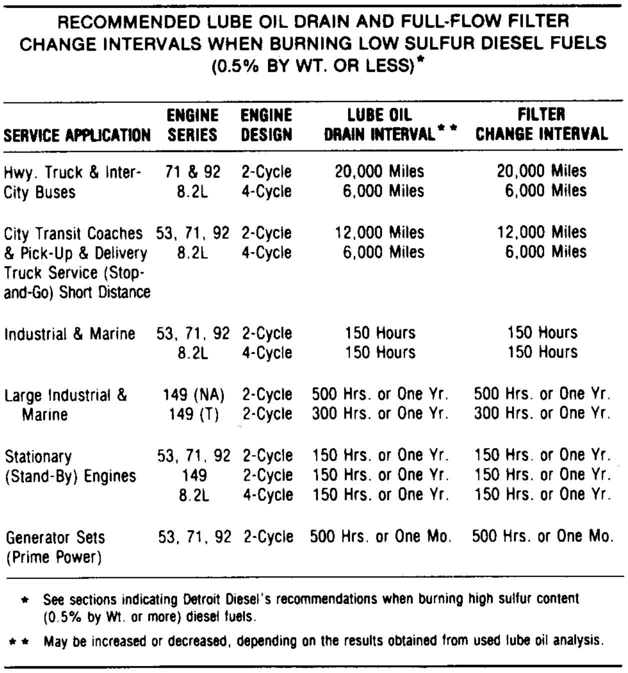
CONDITION 8: THE SULFUR CONTENT OF THE DIESEL FUEL IS GREATER THAN 0.50% BY WEIGHT

The detrimental effects of burning high sulfur fuel are known in industry. The use of high sulfur diesel fuel may be unavoidable in some locations.

The use of high TBN/ash oils (TBN greater than 10, ash up to 2.500% by weight) is recommended to counteract corrosion.

The trend manifested by extremely high TBN oils (TBN greater than 20/ash between 2.000 to 2.500% by weight) is to drop several TBN numbers and then level off. The condition of the used oil under these circumstances is that it has retained some alkaline reserve (neutralization power) but will become overloaded with suspended solids that tend to become insoluble, resulting in the formation of excessive engine deposits. Therefore, when using high TBN/ash oils, a rule of thumb for oil change intervals is to drain the oil when the TBN drops to one-half of the new oil TBN. Since lubricant composition varies from brand to brand the time and rate of TBN reduction will vary. These differences manifested by the various high TBN/ash oils will influence the drain interval.

TABLE L-3.



RECOMMENDED LUBE OIL DRAIN AND FULL-FLOW FILTER CHANGE INTERVALS WHEN BURNING LOW SULFUR DIESEL FUELS (0.5% BY WT. OR LESS)*

SERVICE APPLICATION	ENGINE SERIES	ENGINE DESIGN	LUBE OIL DRAIN INTERVAL**	FILTER CHANGE INTERVAL
Hwy. Truck & Inter-City Buses	71 & 92 8.2L	2-Cycle 4-Cycle	20,000 Miles 6,000 Miles	20,000 Miles 6,000 Miles
City Transit Coaches & Pick-Up & Delivery Truck Service (Stop-and-Go) Short Distance	53, 71, 92 8.2L	2-Cycle 4-Cycle	12,000 Miles 6,000 Miles	12,000 Miles 6,000 Miles
Industrial & Marine	53, 71, 92 8.2L	2-Cycle 4-Cycle	150 Hours 150 Hours	150 Hours 150 Hours
Large Industrial & Marine	149 (NA) 149 (T)	2-Cycle 2-Cycle	500 Hrs. or One Yr. 300 Hrs. or One Yr.	500 Hrs. or One Yr. 300 Hrs. or One Yr.
Stationary (Stand-By) Engines	53, 71, 92 149 8.2L	2-Cycle 2-Cycle 4-Cycle	150 Hrs. or One Yr. 150 Hrs. or One Yr. 150 Hrs. or One Yr.	150 Hrs. or One Yr. 150 Hrs. or One Yr. 150 Hrs. or One Yr.
Generator Sets (Prime Power)	53, 71, 92	2-Cycle	500 Hrs. or One Mo.	500 Hrs. or One Mo.

* See sections indicating Detroit Diesel's recommendations when burning high sulfur content (0.5% by Wt. or more) diesel fuels.

** May be increased or decreased, depending on the results obtained from used lube oil analysis.

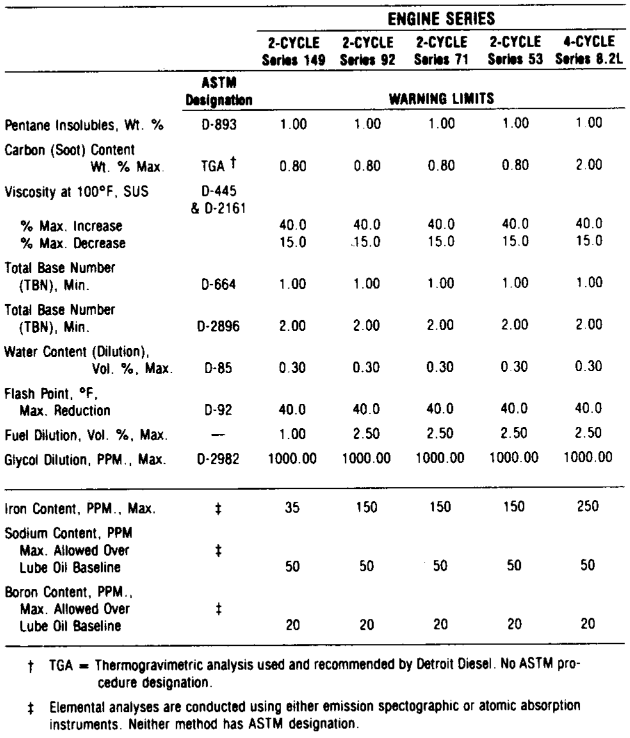
FULL-FLOW FILTER CHANGE PERIOD

Table L-3 shows the DDA recommended full-flow filter change period for the various service applications. The filter element should be changed at the same time the crankcase oil is drained. Filter life is affected by heat and vibration in addition to contaminant filtration. Filter change should not exceed 25,000 miles/500 hours maximum.

TABLE L-4.

USED LUBE OIL ANALYSIS GUIDELINES

These values indicate the need for an Immediate oil change, but do not necessarily indicate Internal engine problems requiring engine teardown. Characteristics relating to lube oil dilution should trigger corrective action to Identify and fix the source(s) of leaks, if these values are realized.



		ENGINE SERIES				
		2-CYCLE Series 149	2-CYCLE Series 92	2-CYCLE Series 71	2-CYCLE Series 53	4-CYCLE Series 8.2L
	ASTM Designation	WARNING LIMITS				
Pentane Insolubles, Wt. %	D-893	1.00	1.00	1.00	1.00	1.00
Carbon (Soot) Content Wt. % Max.	TGA †	0.80	0.80	0.80	0.80	2.00
Viscosity at 100°F, SUS	D-445 & D-2161					
% Max. Increase		40.0	40.0	40.0	40.0	40.0
% Max. Decrease		15.0	15.0	15.0	15.0	15.0
Total Base Number (TBN), Min.	D-664	1.00	1.00	1.00	1.00	1.00
Total Base Number (TBN), Min.	D-2896	2.00	2.00	2.00	2.00	2.00
Water Content (Dilution), Vol. %, Max.	D-85	0.30	0.30	0.30	0.30	0.30
Flash Point, °F, Max. Reduction	D-92	40.0	40.0	40.0	40.0	40.0
Fuel Dilution, Vol. %, Max.	—	1.00	2.50	2.50	2.50	2.50
Glycol Dilution, PPM., Max.	D-2982	1000.00	1000.00	1000.00	1000.00	1000.00
Iron Content, PPM., Max.	‡	35	150	150	150	250
Sodium Content, PPM Max. Allowed Over Lube Oil Baseline	‡	50	50	50	50	50
Boron Content, PPM., Max. Allowed Over Lube Oil Baseline	‡	20	20	20	20	20

† TGA = Thermogravimetric analysis used and recommended by Detroit Diesel. No ASTM procedure designation.

‡ Elemental analyses are conducted using either emission spectographic or atomic absorption instruments. Neither method has ASTM designation.

FREQUENCY OF LUBE OIL SAMPLES FOR ANALYSIS

The interval at which used lube oil samples may be obtained for analysis can be scheduled for the same period as when other preventative maintenance is conducted. For example, in highway truck applications, a sample may be obtained every 10,000 miles when engines are brought in for fuel and coolant filter replacement. (Reference instructions in Detroit Diesel Engine Service Manuals).

USED LUBE OIL ANALYSIS PROGRAM

A used lube oil analysis program is recommended for monitoring the condition of the crankcase oil in all engines.

Primarily, used lube oil analyses indicate the condition of the oil but not necessarily the condition of the engine.
Never tear down an engine based solely on the analysis results obtained from a single used oil sample. However, the condition of the engine should be investigated using conventional mechanical and/or electronic diagnostic instruments. Frequently, visual inspections are all that is required to detect problem areas related to engine wear.
It is also prudent to obtain another oil sample from the suspected distressed unit for analysis.

Abnormal concentrations of some contaminants such as diesel fuel, coolant, road salt, or airborne dirt cannot be tolerated for prolonged periods. Their presence will be reflected in accelerated engine wear, which can result in less than optimum engine life. The oil should be changed immediately if any contamination is present in concentrations exceeding the warning limits shown in Table L-4.

Experience in specific engine applications operating specific model engines is a prerequisite for proper interpretation of laboratory used lube oil sample analysis results. It is imperative to remember, in scrutinizing laboratory used lube oil sample results, that it is the change in value or deviation from baseline data obtained from the new oil (same brand or mixture of brands) that is significant. This is especially important to remember in investigations such as wear metal analysis, total base number and viscosity determinations.

SULFATED ASH LIMIT (ASTM D-874)
There is a performance trade-off when using either high or low ash oils. High ash oils (greater than 1.000% by weight) sometimes provide excessive exhaust valve and ring groove deposits but have shown superior anti-wear performance on compression rings and cylinder liners.
Low ash oils, historically, have shown minimal engine deposit formation tendencies but premature wear has been experienced in some applications. As indicated in the oil changes section, low ash oils do not provide sufficient neutralization capability when high sulfur diesel fuels are used.

Therefore, DDA recommends that low ash (less than 1.000% by weight) oils continue to be used where satisfactory performance has been experienced. High ash oils (2.500% by weight max.) may be used under the following circumstances:

A. At locations where high sulfur diesel fuels (greater than 0.50% by weight) are continuously used.
B. At locations, regardless of the fuel sulfur content, where the oil supplier has submitted documented, conclusive evidence to the user that the lubricant provided satisfactory field test performance in Detroit Diesel engines.

ZINC CONTENT
The zinc content (zinc diorganodithiophosphate) of all low ash (less than 1.000% by weight) lube oils recommended for use in Detroit Diesel 2-cycle and 4-cycle engines shall be a minimum of 0.07% by weight. This requirement is waived where single grade SAE-40, intermediate viscosity index lubricants qualified for use in Electro-Motive Division (EMD) diesel engines are used in Detroit Diesel engines.

Some specific high ash oils (2.500% by weight maximum) do not contain zinc additives. These oils may be used under the following circumstances:

1. Where diesel fuels with greater than 0.50% by weight sulfur content are continuously used.

2. The oil supplier has submitted documented, conclusive evidence to the user that the lubricant has provided satisfactory field test performance in Detroit Diesel engines.

EVIDENCE OF SATISFACTORY PERFORMANCE It is recommended that evidence of satisfactory lubricant performance in Detroit Diesel 2-cycle engines be obtained from the oil supplier prior to procurement. Controlled oil performance evaluations in field test engines are recommended. The type of field test used by the oil supplier depends on the series engine in which the candidate oil will be used and the service application. This information is summarized in Table L-5. The candidate test oil-operated engines should all operate for the mileage/hours indicated. Fuel and lube oil consumption should be monitored during the test period. Any serious mechanical problems experienced should be recorded. All of the oil test engines should be disassembled at the conclusion of the oil test period and inspected. The following oil performance parameters should be compared:

- Ring sticking tendencies and/or ring conditions
- Piston skirt scuffing and cylinder liner wear and scuffing
- Exhaust valve face and seat deposits
- Piston pin and connecting rod bushing wear
  (Note: Trunk pistons used in Series 53 engines)
- Overall valve train and bearing wear levels.

TABLE L-5.
INDIVIDUAL USER SERVICE APPLICATION LUBE FIELD TESTING

ENGINE SERIES	SERVICE APPLICATION	TEST DURATION	NO. ENGINES ON CANDIDATE TEST OIL	NO. SISTER ENGINES ON REFERENCE BASELINE SAE 40 or SAE 30
53	Pickup & Delivery Metro Area	50,000 Miles	5	5
71 & 92	Hwy. Truck 72,000 Lbs. GCW	200,000 Miles	5	5
149	Off Road Rear Dump 120 Ton	10,000 Hours	3*	3*

* Single Grade Only - No multigrades recommended for Series 149 engines

MIL-L.46167 ARCTIC LUBE OILS FOR NORTH SLOPE AND OTHER EXTREME SUB-ZERO OPERATIONS

Lubricants meeting this specification are used in Alaska and other extreme sub-zero locations. Generally, they may be described as 5W-20 multigrade lubricants made up of synthetic base stock and manifesting low volatility characteristics. Although they have been used successfully in some severe cold regions, Detroit Diesel Allison does not consider their use as desirable as the use of SAE-40 or SAE-30 oils with auxiliary heating aids. For this reason, they should be considered only where engine cranking is a severe problem and auxiliary heating aids are not available on the engine.

SYNTHETIC OILS

Synthetic lubricants may be used in Detroit Diesel 2-cycle engines provided the ash limit, zinc requirements, and specified oil performance levels (for example, CD/SE or MIL-L-2104B, etc.) shown elsewhere in this specification are met. Viscosity grades SAE-40 or SAE-30 are recommended.

MISCELLANEOUS FUEL AND LUBRICANT INFORMATION
ENGINE OIL CLASSIFICATION SYSTEM

The American Petroleum Institute (API), the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) jointly have developed the present commercial system for designating and identifying motor oil classifications. The table in this section shows a cross-reference of current commercial and military lube oil identification and specification systems.

CROSS-REFERENCE OF LUBE OIL CLASSIFICATION SYSTEM

API CODE LETTERS	COMPARABLE MILITARY OR COMMERCIAL INDUSTRY SPECIFICATION
CA	MIL-L-2104A
CB	Supplement 1
CC	MIL-L-2104B (See Note Below)
CD	MIL-L-45199B (Series 3)
‡	MIL-L-46152 (Supersedes MIL-L-2104B Military Only)
	MIL-L-2104C (Supersedes MIL-L-45199B for Military Only)
SA	None
SB	None
SC	Auto Passenger Car 1964 MS Oils - Obsolete System
SD	Auto Passenger Car 1968 MS Oils - Obsolete System
SE	Auto Passenger Car 1972 MS Oils - Obsolete System
SF	Auto Passenger Car 1980 Production

╪ performance meets or exceeds that of CC and SE oils

☐ performance meets or exceeds that of CD and SC oils.

NOTE :MIL-L-2104B lubricants are obsolete for military service applications only. MIL-L-2104B lubricants are currently marketed and readily available for commercial use Consult the following publications for complete descriptions'

1. Society of Automotive Engineers (SAE) Technical Report J-1 83a.
2. Federal Test Method Standard 791a.

PUBLICATION AVAILABLE SHOWING COMMERCIAL "BRAND" NAME LUBRICANTS

A list of "brand" name lubricants distributed by the majority of worldwide oil suppliers can be purchased from the Engine Manufacturers Association (EMA). The publication is titled EMA Lubricating Oils Data Book for Heavy - Duty Automotive and Industrial Engines. The publication shows the brand names, oil performance levels, viscosity grades, and sulfated ash contents of most "brands" marketed.

ENGINE MANUFACTURERS ASSOCIATION
111 EAST WACKER DRIVE
CHICAGO, ILLINOIS 60601

Upon request, the Detroit Diesel Allison Regional Office will counsel with customers in selecting a lubricating oil that will be suitable for their specific needs.

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

See statement at the end of “FUEL OILS” section.

COOLANT SPECIFICATIONS

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, the heat of combustion is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. In general, water containing various materials in solution is used for this purpose.

The function of the coolant is basic to the design and to the successful operation of the engine. Therefore, coolant must be carefully selected and properly maintained.

COOLANT REQUIREMENTS

Coolant solutions must meet the following basic requirements:

1. Provide for adequate heat transfer.

2. Provide a corrosion-resistant environment within the cooling system.

3. Prevent formation of scale or sludge deposits in the cooling system.

4. Be compatible with the cooling system hose and seal materials.

5. Provide adequate freeze protection during cold weather operation.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol based antifreeze is recommended for use in Detroit Diesel engines.

WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness and dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these. Chlorides, sulfates, magnesium and calcium are among the materials which make up dissolved solids. Water,

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

TABLE 1.

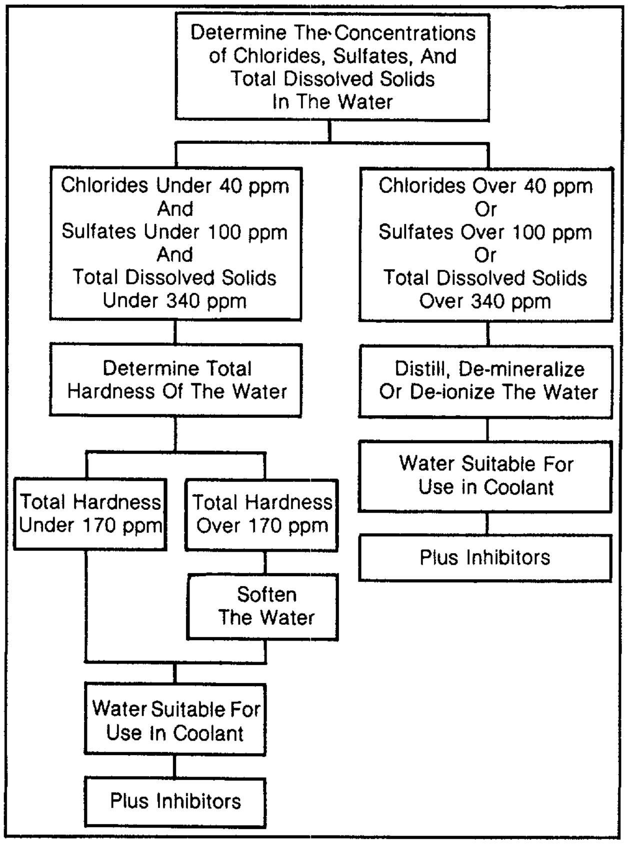


TABLE 2.

within the limits specified in Table 1 is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution is shown in Table 2.

CORROSION INHIBITORS VITAL

corrosion inhibitor is a water-soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. (Soluble oil is not recommended as a corrosion inhibitor). Depletion of all types of inhibitors occurs through normal operation. Therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, or-worse-no inhibitors at all invites the formation of rust and scale deposits within the cooling system. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a 1/16’ deposit of rust or scale on 1" of cast iron is equivalent to 4-1/4’ of cast iron in heat transferability (Fig. 1).

An engine affected in this manner overheats gradually over a period of weeks or months. Liner scuffing, scoring, piston seizure and cylinder head cracking are the inevitable results. An improperly inhibited coolant can also become corrosive enough to "eat away" coolant passages and seal ring grooves and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod. An improperly inhibited coolant can also contribute to cavitation erosion. Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

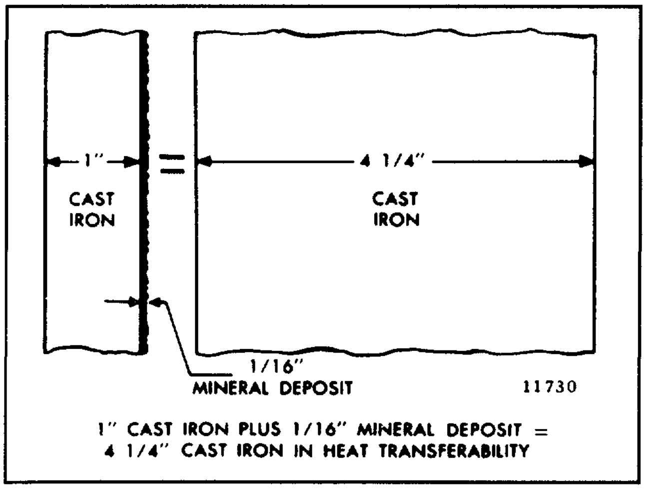


Fig. 1. - Heat Transfer Capacity

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

Chromates

Sodium chromate and potassium dichromate are two of the best and most commonly used water system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should not be used in antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages and reduces the heat transfer rate (Fig. 1) which results in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy duty descaler should be used in accordance with the manufacturer’s recommendation for-this purpose.

Soluble Oil

Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example: 1.25% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2.50% concentration raises fire deck temperature up to 15%. Soluble oil is not recommended as a corrosion inhibitor.

Non-Chromates

Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water-and-antifreeze solution.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical compounds which provide corrosion protection, pH control and water-softening ability. Corrosion protection is discussed under the heading Corrosion Inhibitors Vital. The pH control is used to maintain an acid-free solution. The water-softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives and as an integral part of antifreeze.

Coolant Filter Elements

Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which .will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.

Bulk Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant or to bulk storage tanks containing coolant solution. Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatibility with other coolant constituents.

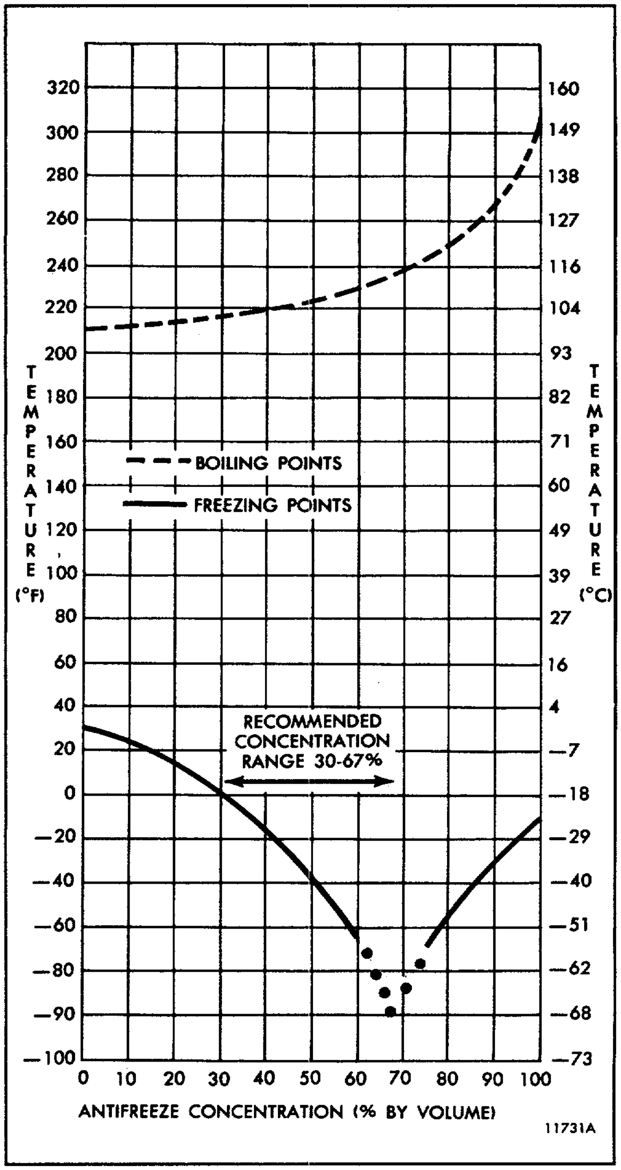


Fig. 2. - Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

Non-chromate inhibitor systems are recommended for use in Detroit Diesel engines. These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control and water softening. Some non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, require no additional hardware or plumbing.

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant at prescribed intervals to maintain original strength levels. Always follow the supplier's recommendations on inhibitor usage and handling.

TEST STRIPS

Some chemical manufacturers have developed test strips for use with their antifreeze or coolant additives.
These test strips are used to measure the freeze protection and/or inhibitor strength of ethylene glycolbased antifreeze. To avoid a false reading caused by variations in reserve alkalinity, Detroit Diesel Allison suggests using test strips that measure depletable inhibitor concentration directly. Do not use one manufacturer's test strips to measure the chemical content of another's antifreeze and/or inhibitors.
Always follow the manufacturer's recommended test procedures.

ANTIFREEZE

When freeze protection is required, an antifreeze meeting GM Specification 1899M must be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill if a minimum antifreeze, concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection. Concentrations over 67% adversely affect freeze protection and heat transfer rates (Fig. 2).

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base antifreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxy propanol base antifreeze is not recommended for use in Detroit Diesel engines due to the presence of fluoroelastomer seals in the cooling system.

Before installing ethylene glycol base antifreeze in a unit that has previously operated with Methoxy propanol, the entire cooling system should be drained, flushed with clean water, and examined for rust, scale contaminants, etc. If deposits are present, the cooling system must be chemically cleaned with a commercial grade heavy-duty descaler.

The inhibitors in antifreeze should be replenished at approximately 500 hour intervals or by test with a nonchromate inhibitor system. Commercially available inhibitor systems may be used to reinhibit antifreeze solutions.

Sealer Additives

Antifreeze containing sealer additives or the addition of sealer additive to any type coolant is not recommended for use in Detroit Diesel engines due to plugging possibilities throughout various areas of the cooling system, including cooling system bleed holes and water pump drain holes.

GENERAL RECOMMENDATIONS

All Detroit Diesel engines incorporate pressurized cooling systems which permit operation at temperatures higher than non-pressurized systems. It is essential that these systems be kept clean and leak-free, that filler caps and pressure relief mechanisms be correctly installed at all times and that coolant levels be properly maintained.

Always maintain engine coolant at the proper level. A low coolant level allows the water pump to mix air with the coolant. Air bubbles in the coolant can "insulate" the cylinder walls, preventing normal heat transfer. An abnormally low coolant level can cause the water pump to become (: air-bound," a condition in which it works feverishly but pumps nothing. Without proper heat transfer, silicone elastomer head-to-block water hole seals can deteriorate and cylinder components can expand so that pistons rapidly cut through the lubricant on the liner walls. Scuffing and piston seizure may follow.

CAUTION: Use extreme care when removing a radiator pressure control cap from an engine. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.

An engine may contain the correct amount of properly inhibited coolant, but still fail to adequately cool the engine. In cases where this occurs, other causes of low coolant flow, either engine or cooling system related, should be investigated.

1. Always use a properly inhibited coolant.

2. Do not use soluble oil.

3. Maintain the prescribed inhibitor strength.

4. Always follow the manufacturer's recommendations on inhibitor usage and handling.

5. If freeze protection is required, use a solution of water and antifreeze meeting GM Specification 1899M.

6. Reinhibit antifreeze with a recommended non-chromate inhibitor system.

Page

7. Do not use a chromate inhibitor with antifreeze.

8. Do not use methoxy propanol base antifreeze in Detroit Diesel engines.

9. Do not mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.

10. Do not use antifreeze containing sealer additives.

11. Do not use methyl alcohol base antifreeze.

12. Use extreme care when removing the radiator pressure-control cap.

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

The type of governor used depends upon the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly. The following types of governors are used:

1. Limiting speed mechanical.

2. Variable speed mechanical.

3. Hydraulic.

The mechanical engine governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double-weight limiting speed governor. A single-weight variable speed governor name plate is stamped S.W.V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor or injectors have been replaced or overhauled, then certain tune-up adjustments are required.

> **NOTE:** If a supplementary governing device, such as the throttle delay mechanism, is used, it must be disconnected prior to the tune-up. After the governor and injector rack adjustments are completed, the supplementary governing device must be reconnected and adjusted.

To tune-up an engine completely, perform all of the adjustments in the applicable tune-up sequence given below.

> **CAUTION**: To prevent the possibility of personal injury, use turbocharger inlet shield J 26554-A anytime the turbocharger inlet is exposed.

Use new valve rocker cover gaskets after the tune-up is completed.

Tune-Up Sequence for Mechanical Governors

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover, the serviceman must determine that the injector racks move to the no-fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION**: An overspeeding engine can result in engine damage which could cause personal injury.

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).
9. Adjust the supplementary governing device (if used).

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Position the injector rack control levers.
4. Adjust the governor linkage.
5. Adjust the load limit screw.
6. Compensation adjustment (PSG governors only).
7. Adjust the speed droop.
8. Adjust the maximum no-load speed.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, increased valve face wear and valve lock damage.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. Until wear occurs, no further adjustment is required on the exhaust valve bridges. When wear is evident, make the necessary adjustments as outlined below.

Valve Bridge Adjustment

1. Remove the loose dirt from the valve rocker cover and remove the cover. Remove the injector fuel pipes and the rocker arm bracket bolts. Move the rocker arms away from the exhaust valve bridge.

2. Remove the exhaust valve bridge (Fig. 1).

3. Place the valve bridge in a vise or bridge holding fixture J 21772 and loosen the locknut on the bridge adjusting screw.

> **NOTE**: Loosening or tightening the locknut with the bridge 'in place may result in bending the bridge guide or the rear valve stem.

4. Install the valve bridge on the valve bridge guide.

5. While firmly pressing straight down on the pallet surface of the bridge, turn the adjusting screw clockwise until it just touches the valve stem. Then, turn the screw an additional 1/8 to 1/4 turn clockwise and tighten the locknut finger tight (Fig. 1).

6. Remove the valve bridge and place it in a vise. Hold the screw from turning with a screwdriver and tighten the locknut on the adjustment screw. Complete the operation by tightening the locknut with a torque wrench to 20-25 lb-ft (27-34 Nm) torque, being sure that the screw does not turn.

7. Lubricate the valve bridge guide and the valve bridge with engine oil.

8. Reinstall the valve bridge in its original position.

9. Place a .0015" feeler gage (J 23185) under each end of the valve bridge. When pressing down on the pallet surface of the valve bridge, both feeler gages must be tight. If both of the feeler gages are not tight, readjust the adjusting screw as outlined in Steps 5 and 6.

10. Adjust the remaining bridges as outlined above.

11. Swing the rocker arm assembly into position being sure the valve bridges are properly positioned on the rear valve stems. This precaution is necessary to prevent valve damage due to mislocated valve bridges.

12. Tighten the rocker arm bracket bolts to 90-100 lb-ft (122-136 Nm) torque.

13. Align the fuel pipes and connect them to the injectors and the fuel connectors. Use socket J 8932 to tighten the connectors to 12-15 lb-ft (16-20 Nm) torque.

> **NOTE**: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted

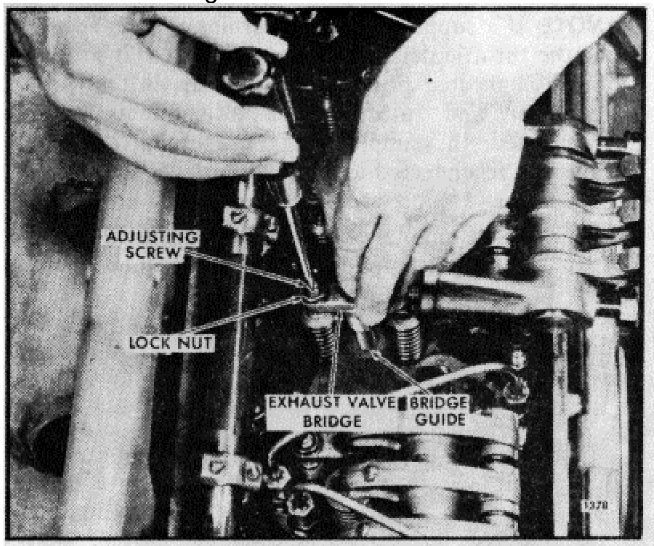


Fig. 1. - Valve Bridge Adjustment

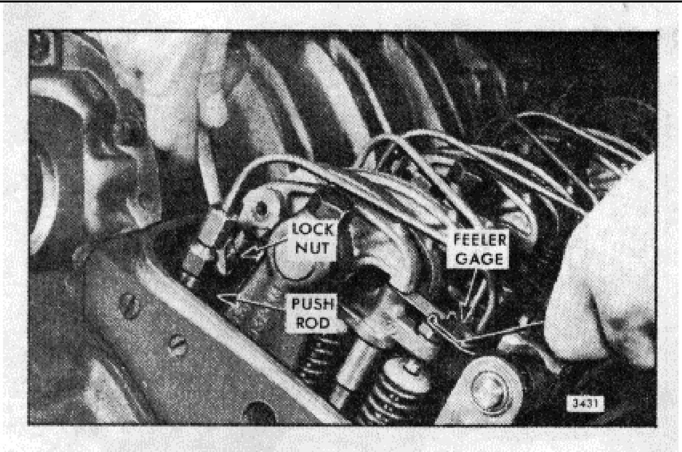


Fig. 2. - Adjusting Valve Clearance

by fuel oil can cause serious damage to the engine bearings.

The exhaust valve bridge balance should be checked when a general valve adjustment is performed. After the bridges are balanced, adjust the valve clearance at the push rod only.

Do not disturb the exhaust valve bridge adjusting screw.

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to General Specifications Section I for the engine firing order.

Valve Clearance Adjustment (Cold Engine)

1. If not done previously, clean the loose dirt from the exterior of the engine and remove the valve rocker covers. Then, cover any drain cavities in the cylinder head to prevent foreign material from entering.

2. Place the governor speed control lever in the idle speed position. If a stop lever is provided, secure it in the stop position.

3. Rotate the crankshaft, with engine barring tool J 22582 or with the starting motor, until the injector follower is fully depressed on the cylinder to be adjusted.

> **NOTE**: If a wrench or a barring tool is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt could be loosened.

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .016 feeler gage (J 9708-01) between the valve bridge and the valve rocker arm pallet (Fig. 2). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .015" gage will pass freely between the valve bridge and the rocker arm pallet, but the .017" gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as above.

Valve Clearance Adjustment (Hot Engine)

> **NOTE**: It is not necessary to make a final hot engine exhaust valve clearance adjustment after a cold engine adjustment has been performed. However, if a hot engine adjustment is desired, use the following procedure.

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance, when running at full load, may become insufficient.

> **NOTE**: Since these adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

1. With the engine at normal operating temperature (160-1850 F or 71-850 C), recheck the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .013" feeler gage will pass freely between the valve bridge and the rocker arm pallet, but the .015" feeler gage will not pass through. Readjust the push rod, if necessary.

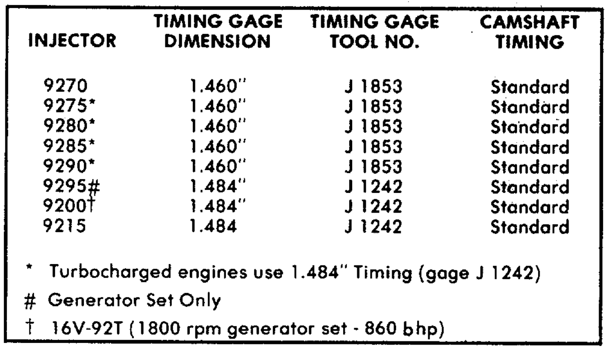
2. After the exhaust valve clearance has been adjusted, check the fuel injector timing.

Check Exhaust Valve Clearance Adjustment

1. With the engine at 1000 F (380 C) or less, check the valve clearance.

2. If a .016" feeler gage +.004" will pass between the valve stem and the rocker arm bridge, the valve clearance is satisfactory. If necessary, adjust the push rod.

FUEL INJECTOR TIMING



INJECTOR	TIMING GAGE DIMENSION	TIMING GAGE TOOL NO.	CAMSHAFT TIMING
9270	1.460"	J 1853	Standard
9275*	1.460"	J 1853	Standard
9280*	1.460"	J 1853	Standard
9285*	1.460"	J 1853	Standard
9290*	1.460"	J 1853	Standard
9295#	1.484"	J 1242	Standard
9200†	1.484"	J 1242	Standard
9215	1.484	J 1242	Standard

* Turbocharged engines use 1.484" Timing (gage J 1242)
# Generator Set Only
† 16V-92T (1800 rpm generator set - 860 bhp)

TABLE 1. - INJECTOR TIMING

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed, in firing order sequence, during one full revolution of the crankshaft. Refer to the General Specifications Section I at the front of the manual for the engine firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted, time the fuel injectors as follows:

1. Place the governor speed control lever in the idle speed position. If a stop lever is provided, secure it in the stop position.

2. Rotate the crankshaft, by using the starting motor or engine barring tool J 22582, until the exhaust valves are fully depressed on the particular cylinder to be timed.

> **NOTE**: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt could be loosened.

3. Place the small end of the injector timing gage (refer to the chart for the correct timing gage) in the hole provided at the top of the injector body with the flat of the gage toward the injector follower (Fig. 3).

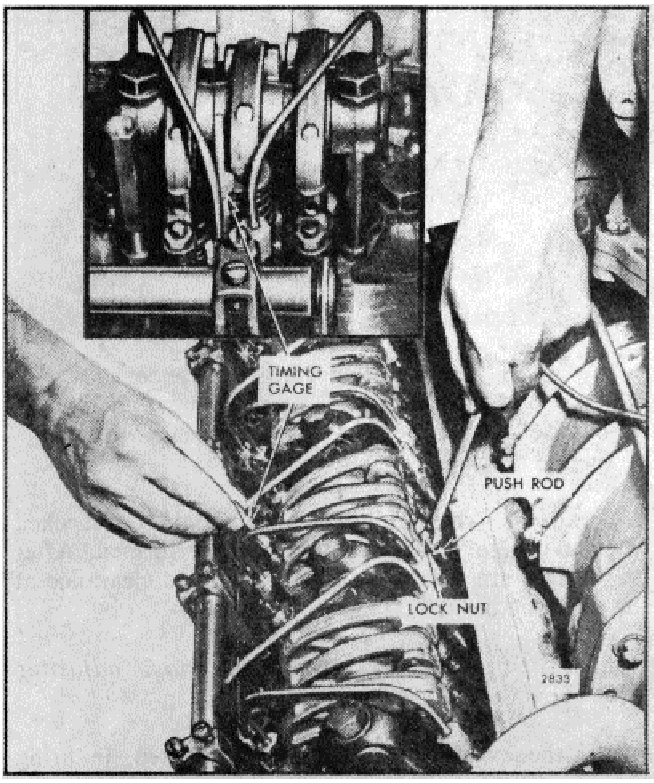


Fig. 3. - Timing Fuel Injector

4. Loosen the injector rocker' arm push rod locknut.

5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the locknut. Check the adjustment and, if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required install the valve rocker covers, using new gaskets.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6V-92 and 8V-92 ENGINES

After adjusting the exhaust valves and timing the fuel injectors, adjust the limiting speed mechanical governor and position the injector rack control levers.

> **NOTE**: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device.

Back out the external starting aid screw.

Adjust Governor Gap

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

> **CAUTION**: If the gap adjustment is to be made with the engine in the vehicle, it is suggested that the fan assembly be removed due to the closeness of the fan blades to the engine governor.

1. Remove the governor high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 9).

3. Start the engine and loosen the idle speed adjusting screw locknut. Then, adjust the idle screw to obtain the desired engine idle speed (Fig. 8). Hold the screw and tighten the locknut to hold the adjustment.

> **NOTE:** Limiting speed governors used in turbocharged engines include an external starting aid screw threaded into the governor housing.

Double Weight Governors

4. Stop the engine. Clean and remove the governor cover and lever assembly. If not previously done, remove the valve rocker cover. Discard the gaskets.

5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

> **NOTE**: Do not overspeed the engine.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 1). The gap should be .002"-.004". If the gap setting is incorrect, reset the gap adjusting screw.

7. Hold the gap adjusting screw and tighten the locknut.

8. Recheck the governor gap with the engine operating between 1100 and 1300 rpm and readjust, if necessary.

9. Stop the engine and, using a new gasket, install the governor cover and lever assembly. Tighten the screws.

Single Weight Governor

If, in going from top no-load speed to idle speed, the engine governor will not recover and the engine stalls, it may become necessary to increase the idle speed to a minimum speed of 600 rpm (Table 2).

ENGINE	INJECTOR	DROOP	IDLE SPEED
6 and 8V Turbo	90 mm	175 rpm (was 125 rpm)	600 rpm min. (was 500 rpm min.) All Injector Sizes
	Regardless of Prefix		

TABLE 2.

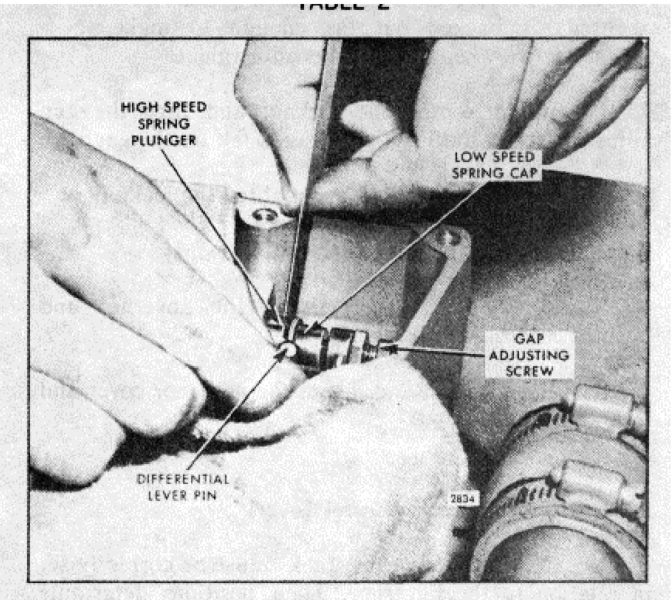


Fig. 1 - Adjusting Governor Gap - Double Weight

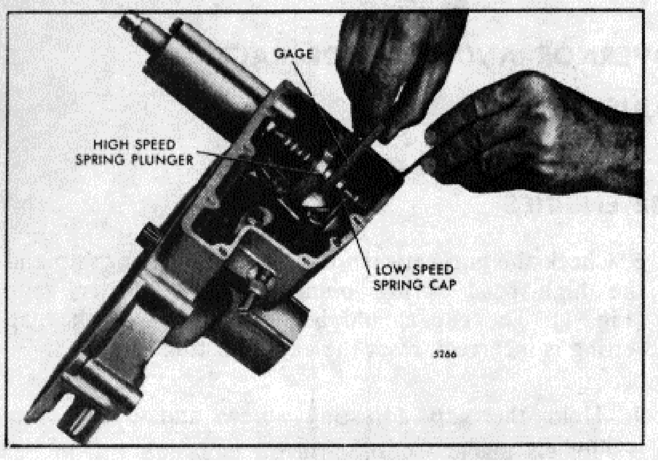


Fig. 2. - Adjusting Governor Gap - Single Weight

4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker cover. Discard the gaskets.

5. Remove the fuel rod from the differential lever and the injector control tube lever.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with gage J 23478 (.200") - (Fig. 2).

> **NOTE:** Be sure the external starting aid screw (if used) is backed out far enough to make it ineffective when making this adjustment.

7. If required, loosen the locknut and turn the gap adjusting screw until a slight drag is felt on the gage.

8. Hold the adjusting screw and tighten the locknut.

9. Recheck the gap and readjust, if necessary.

10. Install the fuel rod between the governor and injector control tube lever.

11. Use a new gasket and install the governor cover and lever assembly.

Position Injector Rack Control Levers

The positions of the injector racks must be correctly set in relation to the governor. Their positions determine the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever with one: screw and locknut to keep each injector rack properly positioned.

> **NOTE:** To ensure proper injector control rack adjustment, the injector racks must be adjusted with the yield link and governor cover that are to be used with the governor.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low-speed gap closed.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters "R" and "L" indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. IL injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the governor speed control lever.

2. Turn the idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the locknut when the nut is against the high-speed plunger. This

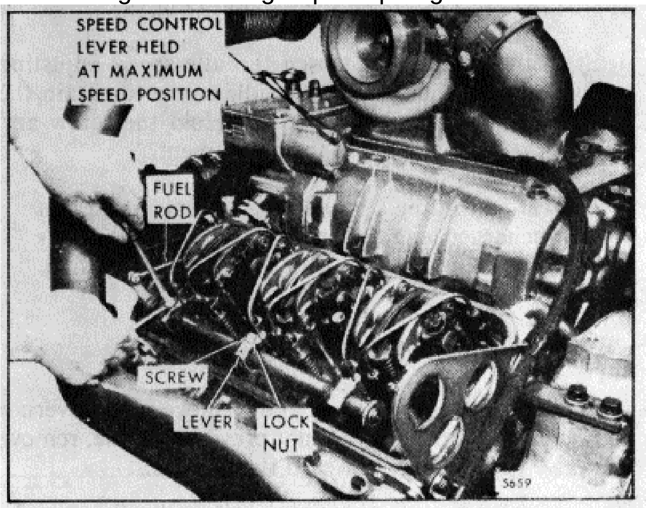


Fig. 3. - Position No. 1 Injector Rack Control Lever (One Screw and Locknut Assembly)

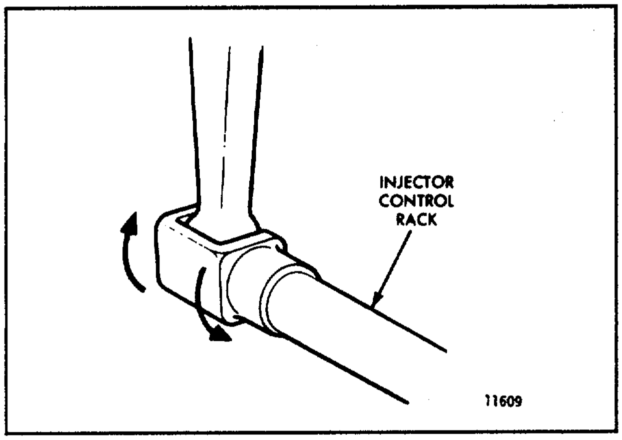


Fig. 4. - Checking Rotating Movement of Injector Control Rack

adjustment lowers the tension on the low-speed spring so it can be easily compressed. This permits closing the low-speed gap without bending the fuel rods or causing the yield mechanism springs to yield or stretch.

> **NOTE**: A false fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

Injector racks must be adjusted so the effort to move the throttle from the idle speed position to the maximum speed position is uniform. A sudden increase in effort can result from:

a. Injector rack adjusted too tight causing the yield link to separate.

b. Binding of the fuel rods.

c. Failure to back out the idle screw.

3. Back out the buffer screw approximately 5/8", if it has not already been done.

4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

5. Loosen all of the adjusting screws and locknuts on both cylinder heads. Be sure all of the injector rack control levers are free on the injector control tubes.

6. Move the speed control lever to the maximum speed position and hold it in that position with light finger pressure (Fig. 3). Tighten the adjusting screw of the No. IL injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1L injector rack in the full-fuel position.

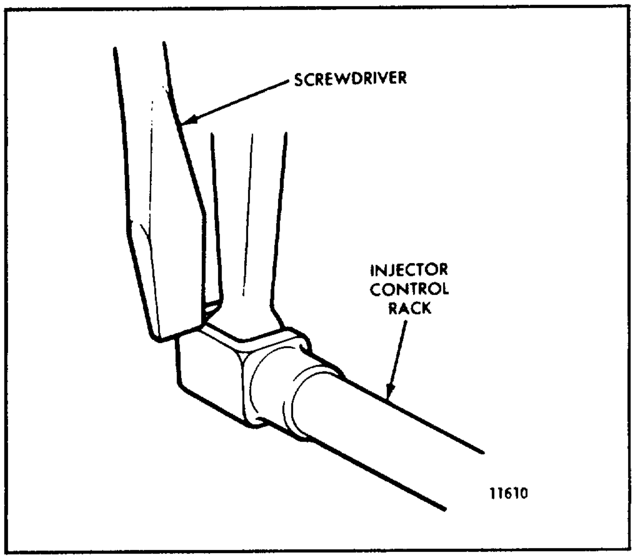


Fig. 5. - Checking Injector Control Rack "Spring"

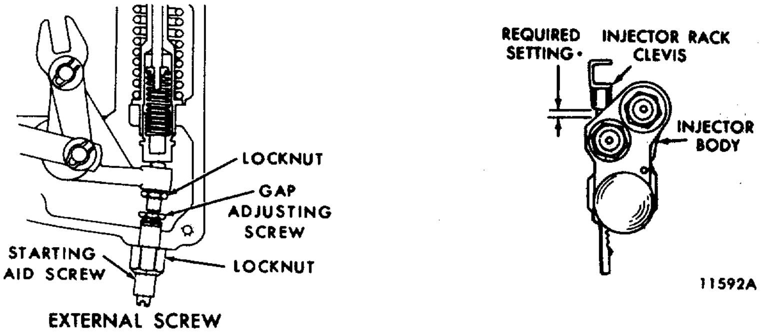
> **NOTE**: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in (3-4 Nm).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

7. To be sure of the proper rack adjustment, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack (Fig. 4). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 5).

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the speed control lever from the no-speed to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step-up in effort required to move the speed control lever to the end of its travel. To correct



INJECTOR	GAGE SETTING*	TOOL NUMBER
9280	.385"	J 24882
9285	.385"	J 24882
9290	.454"	J 23190
9295	.454"	J 23190
9200	.454"	J 23190
9215	.500"	J 23761

Fig. 6. - Starting Aid Screw Adjustment

this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

8. Remove the clevis pin from the fuel rod at the left bank injector control tube lever.

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 1R injector rack control lever as previously outlined in Steps 6 and 7 for the No. IL injector rack control lever.

10. Insert the clevis pin in the fuel rod at the left bank injector control tube lever. Verify the adjustments for the No. IL and 1R injector racks are equal. To do this, move the speed control lever to the maximum speed position. Rotate the clevis pins at the injector control tube levers and note the drag or resistance to rotate the pins. This resistance or drag should be equal for both pins. If the drag is not equal, turn the No. 1R injector rack adjusting screw clockwise to increase drag on the right bank clevis pin or counterclockwise to decrease the pin drag. Adjust No. IR adjusting screw and locknut securely to ensure equal drag for both clevis pins.

11. To adjust the remaining injector rack control levers, remove the clevis pins from the fuel rod at the injector control tube levers, hold the left bank injector control racks in the full-fuel position by means of the lever on the end of the control tube and proceed as follows:

a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE**: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in (3-4 Nm).

b. Verify the injector rack adjustment of No. 1L as outlined in Step 7. If No. IL does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. 1L injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1L and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. 1L and No. 2L injector racks are in the fullfuel position when the locknut is securely tightened.

c. Adjust the remaining injectors using the procedures outlined in Step "b" always verifying proper injector rack adjustment.

> **NOTE**: Once the No. IL and No. 1R injector rack control levers are adjusted, do not try to alter their settings. All adjustments are made on the remaining control racks.

12. When all of the injector rack control levers are adjusted, recheck their settings. With the control tube lever in the full-fuel position, check each control rack as in Step 7. All of the control racks must have the same "spring" condition with the control tube lever in the full-fuel position.

13. Insert the clevis pin in the fuel rod and the injector control tube levers.

14. Turn the idle speed adjusting screw in until it projects 3/16" from the locknut, to permit starting the engine.

15. Adjust the external starting aid screw (Turbocharged engines).

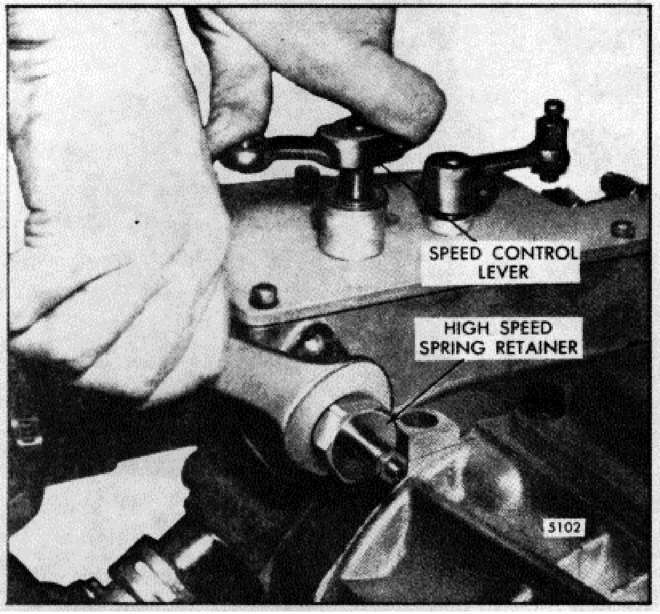


Fig. 7. - Adjusting Maximum No-Load Speed

The starting aid screw is threaded into the governor housing (Fig. 6). This screw is adjusted to position the injector racks at less than full fuel when the governor speed control lever is in the idle position. The reduced fuel makes starting easier and reduces the amount of smoke on start-up.

> **NOTE:** The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor running gap has been set and the injector racks are positioned, adjust the starting aid screw as follows:

a. With the engine stopped, place the governor stop lever in the run position and the speed control lever in the idle speed position.

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 6). Select the proper gage and measure the setting at any convenient cylinder. When the starting aid screw is properly adjusted, the gage should have a small clearance of 1/64" in the space along the injector rack shaft between the rack clevis and the injector body.

c. After completing the adjustment, hold the starting aid screw and tighten the locknut.

d. Check the injector rack clevis-to-body clearance after performing the following:

    1. Position the stop lever in the run position.
    2. Move the speed control lever from the idle speed position to the maximum speed position.
    3. Return the speed control lever to the idle speed position.

Movement of the speed control lever is to take-up the clearance in the governor linkage. The injector rack clevis-to-body clearance can be increased by turning the starting aid screw farther in against the gap adjusting screw, or reduced by backing it out.

> **NOTE**: The starting aid screw will be ineffective if the speed control lever is advanced toward wide open throttle during start-up.

16. Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks return to the no-fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION**: An overspeeding engine can result in engine damage which could cause personal injury.

17. Use new gaskets and reinstall the valve rocker covers.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option plate, set the maximum no-load speed as follows:

> **NOTE**: Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speed.

1. Loosen the spring retainer locknut and back off the high-speed spring retainer approximately five turns (Fig. 7).

2. With the engine running at operating temperature and no-load, place the speed control lever in the fullfuel speed position. Turn the high-speed spring retainer until the engine is operating at the recommended noload speed.

3. Hold the high-speed spring retainer and tighten the locknut, using spanner wrench J 5345-5.

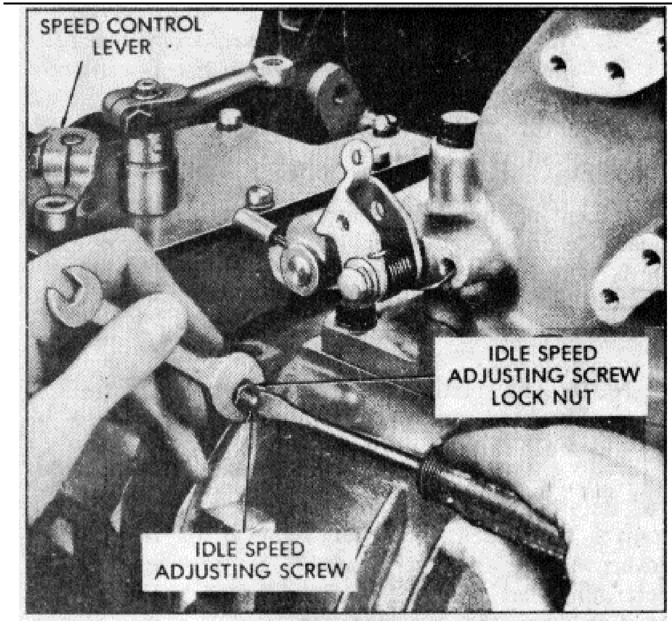


Fig. 8. - Adjusting Engine Idle Speed

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. With the engine running, at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engin6 operates at approximately 15 rpm below the recommended idle speed (Fig. 8). The recommended idle speed is 400-450 rpm, but may vary with special engine applications.

> **NOTE**: It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8").

2. Hold the idle screw and tighten the locknut.

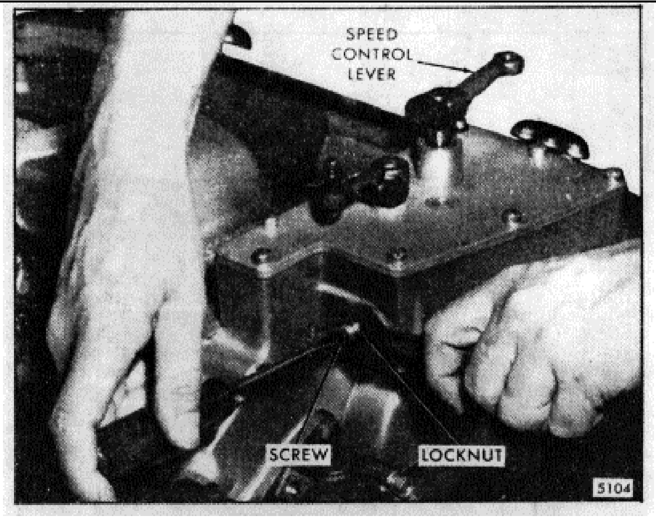


Fig. 9. - Adjusting Buffer Screw

3. Install the high-speed spring retainer cover and tighten the two bolts.

Adjust Buffer Screw

With the idle speed set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in so it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 9).

> **NOTE**: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the locknut.

12V-92 and 16V-92 ENGINES

The governor on the 12V-92 and 16V-92 engine is mounted on and driven from the front end of the rear blower (Fig. 10).

> **NOTE**: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

If the engine or governor has been overhauled, or the injector control linkage has been disturbed, the control link levers in the governor housing and auxiliary control link housing must be aligned before proceeding with the engine tune-up. Refer to Fig. 11 and position the control link levers as follows:

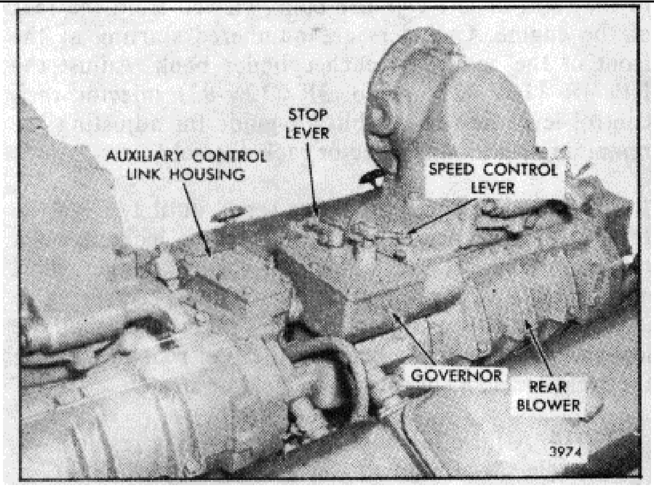


Fig. 10. - Governor Mounting

1. Disconnect the linkage to the governor speed control lever and stop lever.

2. Remove the covers from the governor housing and auxiliary control link housing.

3. Disconnect the adjustable link from the lever in the auxiliary control link housing.

4. Remove the connecting pin from the auxiliary governor control link lever.

5. Install gage J 21779 so it extends through the lever and fuel rod and into the gage hole in the bottom of the housing. With the gage in place, the auxiliary control link lever will be in the mid-travel position.

6. Remove the connecting pin from the control link lever in the governor housing and install gage J 21780. Install the gage so the pin extends through the connecting link, control lever and fuel rod and the governor housing dowel pin extends into the small hole in the gage. Then, install a governor cover bolt to lock the gage in place (Fig. 11). With gage J 21780 in place, the governor control link lever will be in the midtravel position and parallel to the auxiliary control link lever.

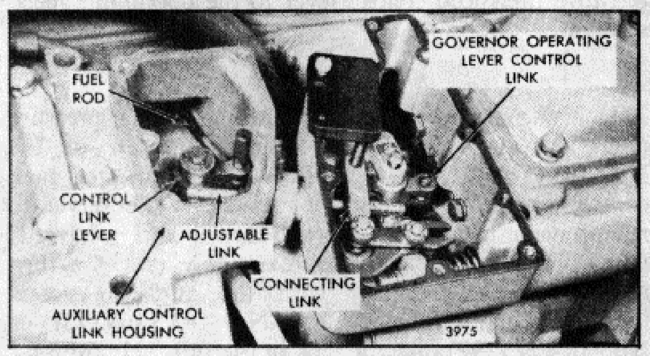


Fig. 11. - Control Link Levers in Position

7. Adjust the length of the adjustable connecting link to retain the lever positions obtained in Steps 5 and 6 and install the link.

8. Remove gages J 21779 and J 21780 and reinstall the control link lever connecting pins.

9. Install the governor housing and auxiliary control link housing covers.

Proceed with the governor and injector rack control adjustment.

Adjust the Governor Gap - Double Weight

With the engine stopped and at normal operating temperature, set the governor gap as follows:

1. Remove the governor high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 16).

3. Start the engine and loosen the idle speed adjusting screw locknut. Then, adjust the idle screw to obtain the desired idle speed (Fig. 15). The recommended idle speed is 400-450 rpm, but may vary with special engine applications. Hold the screw and tighten the locknut to hold the adjustment.

> **NOTE**: Limiting speed governors used in turbocharged engines include an external starting aid screw threaded into the governor housing.

4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker covers. Discard the gaskets.

5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

> **NOTE**: Do not overspeed the engine.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 1). The gap setting should be .002"-.004". If the gap setting is incorrect, reset the gap adjusting screw.

7. Hold the gap adjusting screw and tighten the locknut.

8. Recheck the governor gap with the engine operating between 1100 and 1300 rpm. Readjust, if necessary.

9. Stop the engine and, using a new gasket, reinstall the governor cover and lever assembly. Tighten the screws.

Position Injector Rack Control levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever with one screw and locknut to keep each injector rack properly positioned (Fig. 12).

> **NOTE**: To ensure proper injector control rack adjustment the injector racks must be adjusted with the yield link and governor cover. that are to be used on the governor.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low speed gap closed.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

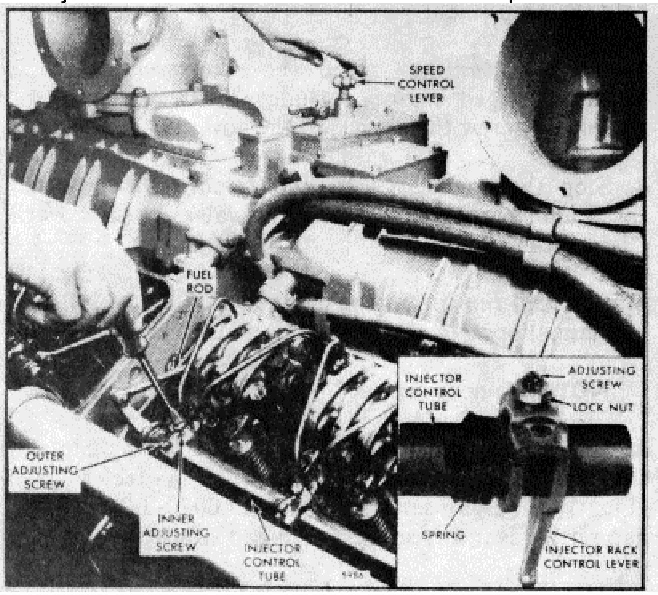


Fig. 12. - Positioning No. 4R Injector Rack Control Lever

The letters "R" and "L" indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 4R (16V-92) or No. 3R (12V-92) injector rack control lever first to establish a guide for adjusting the remaining right bank injector rack control levers.

1. Turn the idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the locknut when the nut is against the high-speed spring plunger. This adjustment lowers the tension of the low-speed spring so it can be easily compressed. This permits closing the low-speed gap without bending the fuel rods or causing the yield mechanism springs to yield or stretch.

> **NOTE**: A false full-fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

Injector racks must be adjusted so the effort to move the throttle from the idle speed position to the maximum speed position is uniform. A sudden increase in effort can result from:

a. Injector racks adjusted too tight causing the yield link to separate.

b. Binding of the fuel rods.

c. Failure to back out the idle screw.

2. Back out the buffer screw approximately 5/8", if it has not already been done.

3. Loosen all of the adjusting screws and locknuts on both cylinder banks. Be sure all of the levers are free on the injector control tubes.

4. Check for any bind in the governor control tube linkage by moving the linkage through its full range of travel.

5. Remove the clevis pins which attach the right rear bank and both left bank fuel rods to the injector control tube levers.

6. Move the speed control lever to the maximum speed position.

7. Hold the speed control lever with light finger pressure (Fig. 12) and tighten the adjusting screw of the No. 4R (16V-92) or No. 3R (1 2V-92) injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 4R (16V-92) or No. 3R (12V-92) injector rack in the full-fuel position.

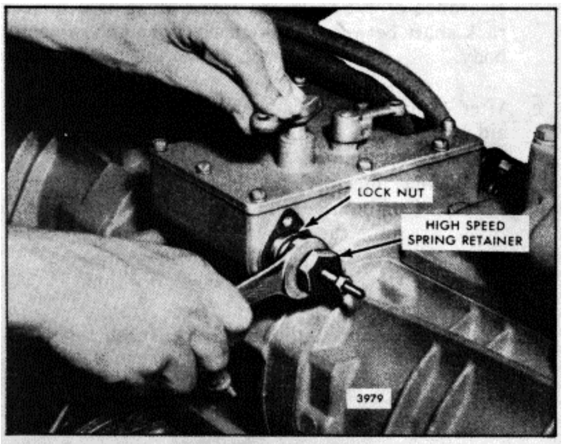


Fig. 13. - Adjusting Maximum No-Load Speed

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

8. To be sure of the proper rack adjustment, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack (Fig. 4). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward (Fig. 4) and, when the pressure of the screwdriver is released, the control rack should "spring" back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the speed control lever from the no-speed to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step-up in effort required to move the speed control lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

9. Remove the fuel rod-to-control tube lever clevis pin from the right front bank fuel rod and install it on the right rear bank fuel rod. Adjust the No. 5R (16V-92) or No. 4R (12V-92) injector rack as outlined in Steps 6, 7 and 8.

10. Repeat Step 9 for adjustment of the No. 4L and 5L (16V-92) or No. 3L and 4L (12V-92) injector racks. When the settings are correct, the No. 4R, 5R, 4L and 5L (16V-92) or 3R, 4R, 3L pd 4L (12V-92) injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

11. With the fuel rod disconnected from the injector control tube lever, adjust the remaining injector rack control levers on the right front bank. Hold the No. 4R (16V-92) or No. 3R (12V-92) injector rack in the full-fuel position by the control tube lever and proceed as follows:

a. Tighten the adjusting screw of the No. 3R (16V-92) or No. 2R (12V-92) injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 4R (16V-92) or No. 3R (12V-92) as outlined in Step 8. If No. 4R (16V-92) or No. 3R (12V-92) does not "spring" back upward, turn the No. 3R (16V-92) or No. 2R (12V-92) adjusting screw counterclockwise slightly until the No. 4R (16V-92) or No. 3R (12V-92) injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 4R and No. 3R (16V-92) or No. 3R and No. 2R (12V-92) injectors. Turn clockwise or counterclockwise the No. 3R (16V-92) or No. 2R (12V-92) injector rack adjusting screw until both No. 4R and No. 3R (16V-92) or No. 3R and No. 2R (12V-92) injector racks are in the full-fuel position when the locknut is securely tightened.

When the settings are correct, both injector racks must respond in the same manner on the ball ends of the control levers when the injector control tube lever is held in the full-fuel position.

12. Position the remaining injector rack control levers on the right front cylinder bank as outlined in Step 11.

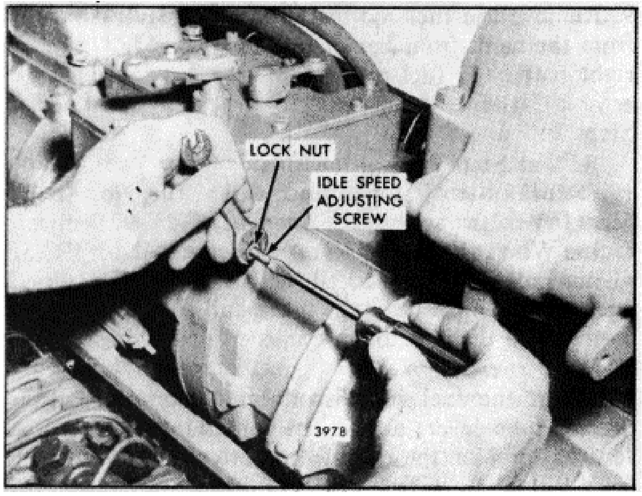


Fig. 14. - Adjusting Engine Idle Speed

13. Adjust the remaining injector rack control levers on the right rear, left front and left rear cylinder banks in the same manner as outlined in Steps 11 and 12.

14. Install the four fuel rod-to-control tube lever clevis pins and check the adjustment of the injector rack control levers.

15. Turn the idle speed adjusting screw in until it projects 3/16" from the locknut, to permit starting the engine.

16. Adjust the external starting aid screw (Turbocharged engines).

The external starting aid screw is threaded into the governor housing (Fig. 6). This screw is adjusted to position the injector racks at less than full fuel when the governor speed control lever is in the *idle* position. The reduced fuel makes starting easier and reduces the amount of smoke on start-up.

> **NOTE:** The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor *running* gap has been set and the injector racks are positioned, adjust the starting aid screw as follows:

a. With the engine *stopped*, place the governor stop lever in the run position and the speed control lever in the *idle speed* position.

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 6). Select the proper gage and measure the setting at any convenient cylinder. When the starting aid screw is properly adjusted, the gage should have a small clearance of 1/64" in the space along the injector rack shaft between the rack clevis and the injector body.

c. After completing the adjustment, hold the starting aid screw and tighten the locknut.

d. Check the injector rack clevis-to-body clearance after performing the following:

   1. Position the stop lever in the run position.

   2. Move the speed control lever from the *idle speed* position to the *maximum speed* position.

   3. Return the speed control lever to the *idle speed* position.

Movement of the speed control lever is to take-up the clearance in the governor linkage. The injector rack clevis-to-body clearance can be increased by turning the starting aid screw farther in against the gap adjusting screw, or reduced by backing it out.

> **NOTE:** The starting aid screw will be ineffective if the speed control lever is advanced toward wide open throttle during start-up.

17. Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks to the no-fuel position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION:** An overspeeding engine can result in engine damage which could cause personal injury.

18. Use new gaskets and reinstall the valve rocker covers.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the option plate, set the maximum no-load speed as follows:

> **NOTE:** Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speed.

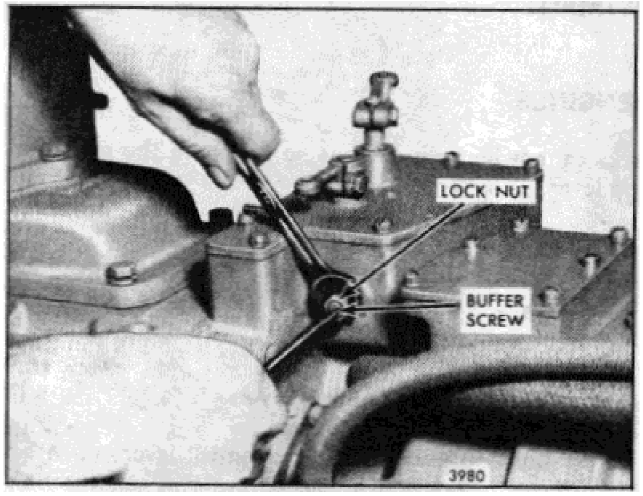


Fig. 15. - Adjusting Buffer Screw

1. Loosen the spring retainer locknut and back off the high-speed spring retainer approximately five turns (Fig. 13).

2. With the engine running at operating temperature and no-load on the engine, place the speed control lever in the full-fuel speed position. Turn the high-speed spring retainer until the engine is operating at the recommended no-load speed.

3. Hold the high-speed spring retainer and tighten the locknut using spanner wrench J 5345-5.

Adjust Idle Speed

1. With the engine running, at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine is operating approximately 15 rpm below the recommended idle speed (Fig. 14). The recommended idle speed is 400-450 rpm, but may vary with certain engine applications.

> **NOTE:** It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8").

2. Hold the idle screw and tighten the locknut.

3. Install the high-speed spring retainer cover and tighten the two bolts.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in so it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 15).

> **NOTE:** Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the locknut.

VARIABLE SPEED MECHANICAL GOVERNOR ANDINJECTOR RACK CONTROL ADJUSTMENT

6V-9.2 and 8V-92 ENGINES

The single-weight variable speed governor is mounted at the front of the engine and is driven by a blower rotor.

After adjusting the exhaust valves and timing the fuel injectors, adjust the variable speed mechanical governor and position the injector rack control levers.

> **NOTE:** Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device.

Adjust Governor Gap

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

1. Disconnect any linkage attached to the governor levers.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. Clean and remove the governor cover and valve rocker covers. Discard the gaskets.

4. Place the speed control lever in the *maximum speed* position.

5. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 1). If required, loosen the locknut and turn the adjusting screw until a slight drag is noted on the feeler gage.

6. Hold the adjusting screw and tighten the locknut. Check the gap again and, if necessary, readjust.

7. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the throttle control shaft assembly in the slot of the differential lever and the dowel pins in the housing in the dowel pin holes in the cover. Tighten the screws.

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks return to the no-fuel position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION:** An overspeeding engine can result in engine damage which could cause personal injury.

Position Injector Rack Control Levers

The position of the injector rack control levers must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever with one screw and locknut to keep each injector rack properly positioned.

Properly positioned injector rack control levers, with the engine at full load, will result in the following:

1. Speed control lever at the *maximum speed* position.

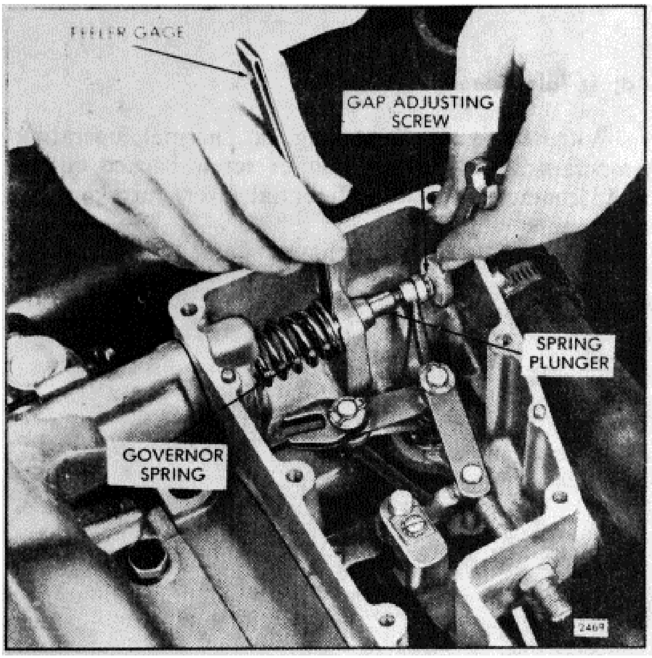


Fig. 1. - Adjusting Governor Gap

2. Stop lever in the *run* position.

3. High-speed spring plunger within .005" to .007" of its seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters "R" and "L" indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining control levers.

1. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

2. Loosen all of the adjusting screws and locknuts on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

3. Move the speed control lever to the *maximum speed* position.

4. Move the stop lever to the *run* position and hold it in that position with light finger pressure. Tighten the adjusting screw of the No. 1L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1L injector rack in the full-fuel position.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

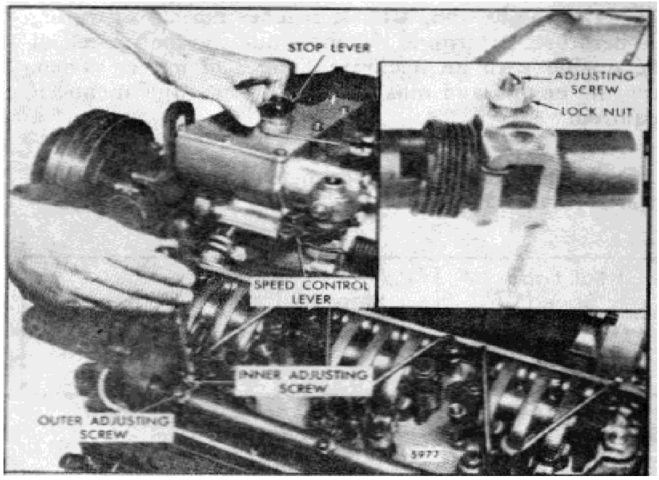


Fig. 2. - Positioning No. 1 Injector Rack Control Lever

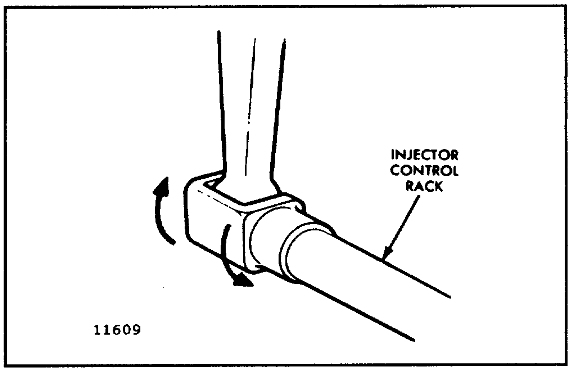


Fig. 3. - Checking Rotating Movement of Injector Control Rack

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

5. To be sure of the proper rack adjustment, hold the stop lever in the *run* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the stop lever is in the *run* position (Fig. 3). Hold the stop lever in the *run* position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and, when the

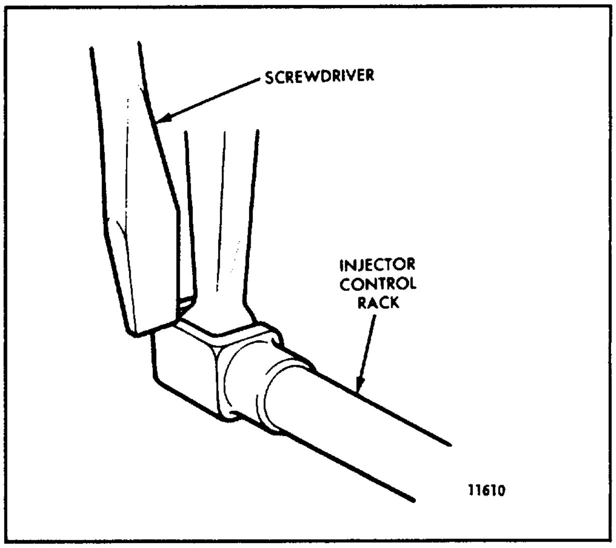


Fig. 4. - Checking Injector Control Rack "Spring"

pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 4).

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the stop lever from the *stop* to the *run* position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

6. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

7. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 1R injector rack control lever as previously outlined in Step 4.

8. Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the No. 1L and No. 1R injector rack control levers as outlined in Step 5. Carefully observe and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

9. To adjust the remaining injector rack control levers, remove the clevis pins from the fuel rods and the injector control tube levers, hold the injector control racks in the full-fuel position by means of the lever on the end of the control tube and proceed as follows:

a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1L as outlined in Step 5. If No. 1L does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. 1L injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1L and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. 1L and No. 2L injector racks are in the full-fuel position when the locknut is securely tightened.

c. Adjust the remaining injectors using the procedures outlined in Step "B" always verifying proper injector rack adjustment.

> **NOTE:** Once the No. 1L and No. 1R injector rack control levers are adjusted, do not try to alter their settings. All adjustments are made on the remaining control racks.

10. When all of the injector rack control levers are adjusted, recheck their settings. With the control tube lever in the full-fuel position, check each control rack as in Step 5. All of the control racks must have the same "spring" condition with the control tube lever in the full-fuel position.

11. Insert the clevis pins in the fuel rods and the injector control tube levers.

12. Use new gaskets and reinstall the valve rocker covers.

Adjust Maximum No-Load Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option plate, set the maximum no-load speed as outlined below.

Start the engine and, after it reaches normal operating temperature, determine the maximum no-load speed of the engine with an accurate hand tachometer. Then, stop the engine and make the following adjustments, if required:

1. Disconnect the booster spring and the governor stop lever spring.

Full Load Speed*	Stops	Shims
1200 - 1750	2	Up to .325" in Shims Maximum
1750 - 2100	1	
2100 - 2300	0	

* No-Load Speed is 150-200 rpm above the Full-Load Speed, depending on engine application.

TABLE 3.

2. Remove the variable speed spring housing and the spring retainer located inside the housing from the governor housing.

3. Refer to Table 3 and determine the stops or shims required for the desired full-load speed. The speed will increase approximately 1 rpm for each .001" in shims added.

4. Install the variable speed spring retainer and housing and tighten the two bolts.

5. Connect the booster spring. Start the engine and recheck the maximum no-load speed.

6. If required, add or remove shims to obtain the necessary operating speed. If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

> **NOTE:** Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

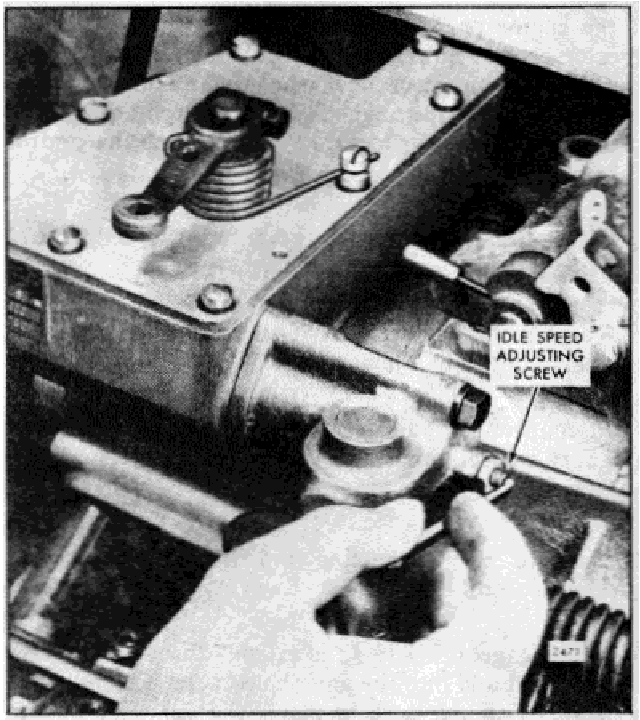


Fig. 5. - Adjusting Idle Speed

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. Place the speed control lever in the *idle* position and the stop lever in the *run* position.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the locknut and turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed (Fig. 5). The recommended idle speed is 500 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw and tighten the locknut.

Adjust Buffer Screw

1. With the engine running at normal operating temperature, turn the buffer screw *IN* so that it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 6).

> **NOTE:** Do not raise the engine idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the locknut.

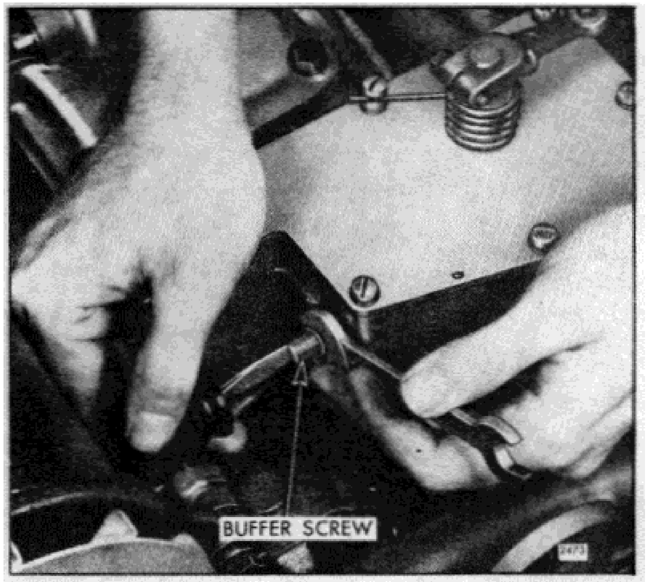


Fig. 6. - Adjusting Buffer Screw

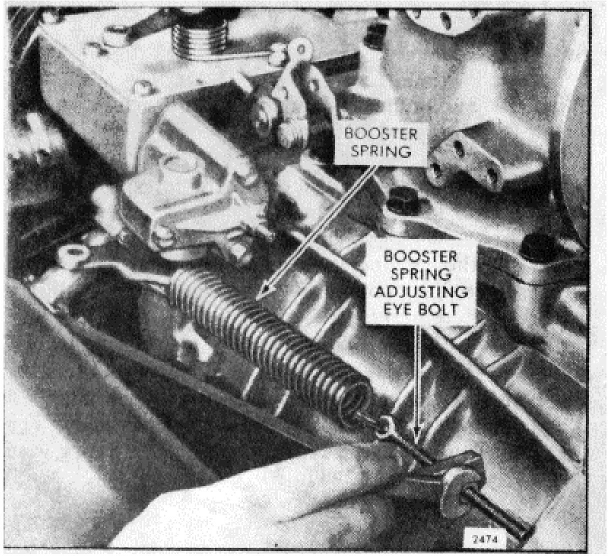


Fig. 7. - Adjusting Booster Spring

Adjust Booster Spring

With the idle speed adjusted, adjust the booster spring as follows:

1. Move the speed control lever to the *idle speed* position.

2. Refer to Fig. 7 and loosen the booster spring retaining nut on the speed control lever. Loosen the locknuts on the eyebolt at the opposite end of the booster spring.

3. With the speed control lever in the *idle* position, move the bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the *idle speed* position) of an imaginary line through the bolt, lever shaft and eyebolt. Hold the bolt from turning and tighten the locknut.

4. Start the engine and move the speed control lever to the *maximum speed* position and release it. The speed control lever should return to the *idle speed* position. If it does not, reduce the booster spring tension. If it does, continue to increase the spring tension until the point is reached that it will not return to idle. Then, reduce the spring tension until it does return to idle and tighten the locknut on the eyebolt. This setting will result in the minimum force required to operate the speed control lever.

5. Connect the linkage to the governor levers.

12V-92 and 16V-92 ENGINES

The governor on the 12V-92 and 16V-92 engines is mounted on and driven from the front end of the rear blower (Fig. 8).

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and injector rack control levers.

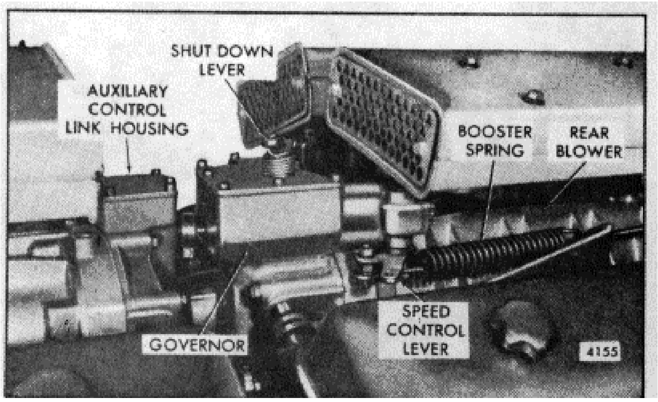


Fig. 8. - Governor Mounting

If the engine or governor has been overhauled, or the injector control linkage has been disturbed, the control link levers in the governor housing and auxiliary control link housing must be aligned before proceeding with the engine tune-up. Refer to Fig. 9 and position the control link levers as follows:

1. Disconnect the linkage to the governor speed control and stop levers.

2. Remove the covers from the governor housing and auxiliary control link housing.

3. Disconnect the adjustable link from the lever in the auxiliary control link housing.

4. Remove the connecting pin from the auxiliary governor control link lever.

5. Install gage J 21779 so it extends through the lever and fuel rod and into the gage hole in the bottom of the housing. With the gage in place, the auxiliary control link lever will be in the mid-travel position.

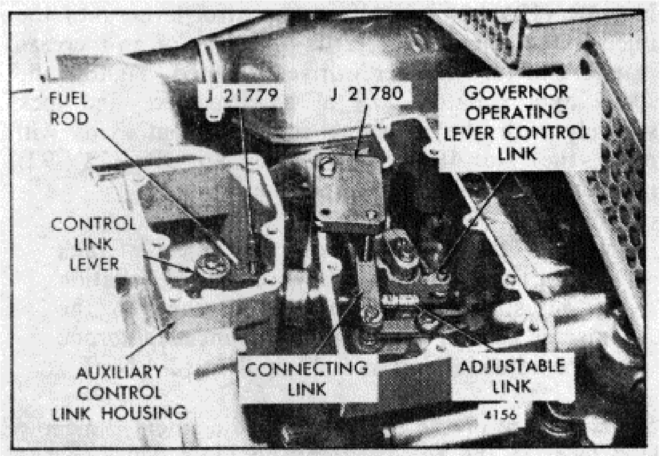


Fig. 9. - Control Link Levers In Position

6. Remove the connecting pin from the control link lever in the governor housing and install gage J 21780. Install the gage so the pin extends through the connecting link, control lever and fuel rod and the governor housing dowel pin extends into the small hole in the gage. Then, install a governor cover bolt to lock the gage in place (Fig. 9). With gage J 21780 in place, the governor control link lever will be in the mid-travel position and parallel to the auxiliary control link lever.

7. Adjust the length of the adjustable connecting link to retain the lever positions obtained in Steps 5 and 6 and install the link.

8. Remove gages J 21779 and J 21780 and reinstall the control link lever connecting pins.

9. Install the governor housing and auxiliary control link housing covers.

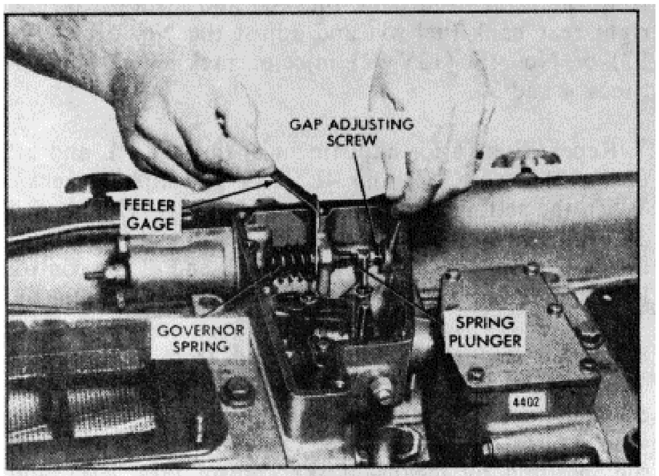


Fig. 10. - Adjusting Governor Gap

Proceed with the governor and injector rack control adjustment.

Adjust Governor Gap

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

1. Clean and remove the governor cover and the valve rocker covers. Discard the gaskets.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. Place the speed control lever in the *maximum speed* position.

4. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 10). If required, loosen the locknut and turn the adjusting screw until a slight drag is noted on the feeler gage.

5. Hold the adjusting screw and tighten the locknut. Check the gap and readjust, if necessary.

6. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the throttle control shaft assembly in the slot of the differential lever and the dowel pins in the cover. Tighten the screws.

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks return to the no-fuel position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION:** An overspeeding engine can result in engine damage which could cause personal injury.

Position Injector Rack Control Levers

The position of the injector rack control levers must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever with one screw and locknut to keep each injector rack properly positioned.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the *maximum speed* position.

2. Stop lever in the *run* position.

3. High-speed spring plunger is within .005" to .007" of its seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters "R" and "L" indicate the injector location on the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 4R injector rack control lever first to establish a guide for adjusting the remaining right bank injector rack control levers.

1. Remove the clevis pins which attach the right rear bank and both left-bank fuel rods to the injector control tube levers.

2. Loosen all of the adjusting screws and locknuts on both injector control tubes. Be sure all of the levers are free on the injector control tubes.

3. Move the speed control lever to the *maximum speed* position.

4. Move the stop lever to the run position and hold it in that position with a light finger pressure (Fig. 11).

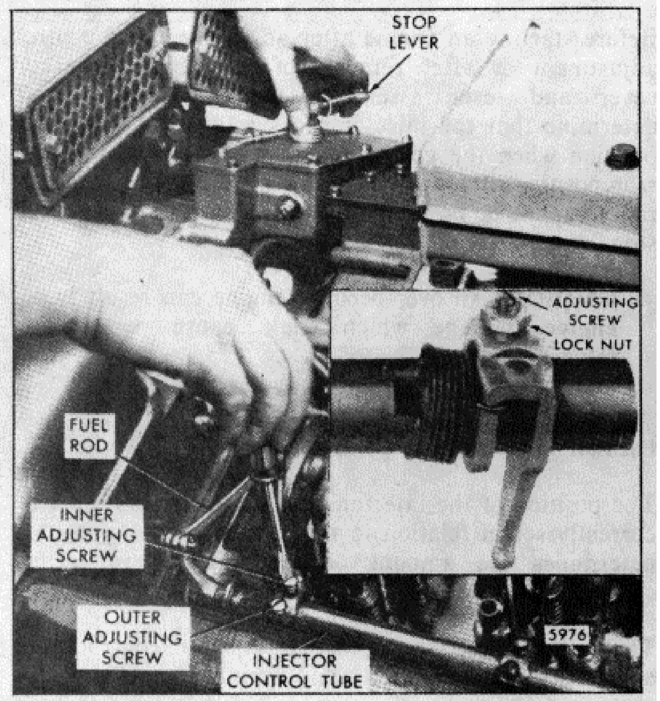


Fig. 11. - Positioning No. 4R Injector Rack Control Lever

Tighten the adjusting screw of the No. 4R (16V-92) or No. 3R (12V-92) injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 4R (16V-92) or No. 3R (12V-92) injector rack in the full-fuel position.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

5. To be sure of the proper rack adjustment, hold the stop lever in the *run* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the stop lever is in the *run* position (Fig. 3). Hold the stop lever in the *run* position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward (Fig. 4) and, when the pressure of the screwdriver is released, the control rack should "spring" back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the stop lever from the stop to the run position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

6. Remove the fuel rod-to-control tube lever clevis pin from the right front bank fuel rod and install it on the right rear bank fuel rod and adjust the No. 5R (16V-92) or No. 4R (12V-92) injector rack as outlined in Steps 4 and 5.

7. Repeat Step 6 for adjustment of the No. 4L and 5L (16V-92) or No. 3L and 4L (12V-92) injector racks. When the settings are correct, the No. 4R, 5R, 4L and SL (16V-92) or No. 3R, 4R, 3L and 4L (12V-92) injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

8. With the fuel rod disconnected from the injector control tube lever, adjust the remaining injector rack control levers on the right front bank. Hold the No. 4R (16V-92) or No. 3R (12V-92) injector rack in the full-fuel position by means of the control tube lever and proceed as follows:

a. Tighten the adjusting screw of the No. 3R (16V-92) or No. 2R (12V-92) injector rack control levler until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 4R (16V-92) or No. 3R (12V-92) as outlined in Step 5. If No. 4R (16V-92) or No. 3R (12V-92) does not "spring" back upward, turn the No. 3R (16V-92) or No. 2R (12V-92) adjusting screw counterclockwise slightly until the No. 4R (16V-92) or No. 3R (12V-92) injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify porper injector rack adjustment for both No. 4R and No. 3R (16V-92) or No. 3R and No. 2R (12V-92) injectors. Turn clockwise or counterclockwise the No; 3R (16V-92) or No. 2R (12V-92) injector rack adjusting screw until both No. 4R and No. 3R (16V-92) or No. 3R and No. 2R (12V-92) injector racks are in the full-fuel position when the locknut is securely tightened.

When the settings are correct, both injector racks must respond in the same manner on the ball ends of the control levers when the injector control tube lever is held in the full-fuel position.

9. Position the remaining injector rack control levers on the right front cylinder bank as outlined in Step 8.

10. Adjust the remaining injector rack control levers on the right rear, left front and left rear cylinder banks in the same manner as outlined in Steps 8 and 9.

11. Install the four fuel rod-to-control tube lever clevis pins and check the adjustment of the injector rack control levers.

12. Use new gaskets and reinstall the valve rocker covers.

Adjust Maximum No-Load Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option plate, set the maximum no-load speed as outlined below. Start the engine and, after it reaches normal operating temperature, determine the maximum no-load speed of the engine with an accurate hand tachometer. Then, stop the engine and make the following adjustments, if required:

1. Disconnect the booster spring and governor stop lever.

2. Remove the variable speed spring housing and the variable speed spring plunger from the governor housing.

3. Refer to Table 4 and determine the stops or shims required for the desired full-load speed. The speed will increase approximately 1 rpm for each .001" in shims added.

Full Load Speed	Stops	Shims
1200 - 1750 1750 - 2100 2100 - 2300	2 1 0	Up to .325" in Shims Maximum

No-Load Speed is 150-225 rpm above Full-Load Speed.

TABLE 4.

4. Install the variable speed spring plunger and housing and tighten the two bolts.

5. Connect the booster spring. Start the engine and recheck the maximum no-load speed.

6. If required, add or remove shims to obtain the required full-load speed. If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

> **NOTE:** Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. Place the speed control lever in the *idle* position and the stop lever in the *run* position.

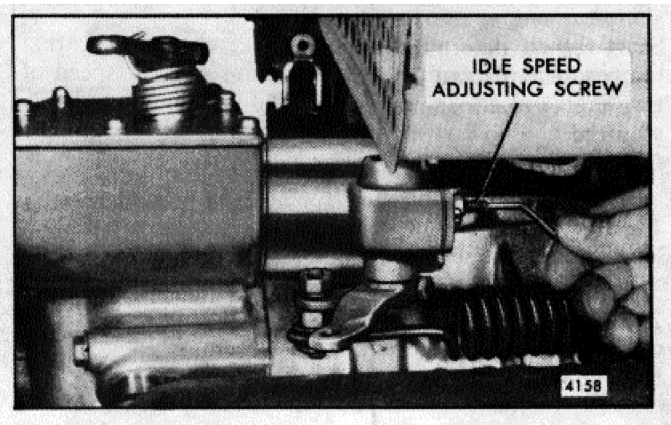


Fig. 12. - Adjusting Idle Speed

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the locknut and turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed (Fig. 12). The recommended idle speed is 550 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw from turning and tighten the locknut.

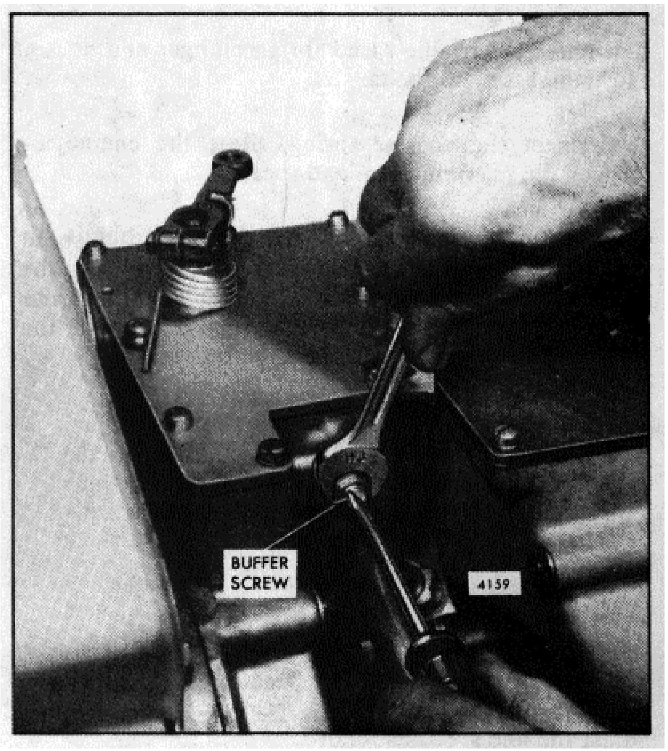


Fig. 13. - Adjusting Buffer Screw

Adjust Buffer Screw

1. With the engine running at normal operating temperature, turn the buffer screw *in* so it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 13).

   NOTE: Do not raise the idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw from turning and tighten the locknut.

Adjust Booster Spring

With the idle speed adjusted, adjust the booster spring as follows:

1. Move the speed control lever to the *idle speed* position.

2. Refer to Fig. 14 and loosen the nut on the booster spring retaining bolt on the governor speed control lever. Loosen the locknuts on the eyebolt at the opposite end of the spring.

3. Move the bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginary line through the bolt, lever shaft and eyebolt. Hold the bolt from turning and tighten the locknut.

4. Start the engine and move the speed control lever to the *maximum speed* position and release it. The speed control lever should return to the *idle speed* position. If it does not, reduce the spring tension. If the lever does return to the idle position, increase the tension of the spring until the lever will not return to idle. Then, reduce the spring tension until the lever will return to idle and tighten the locknut on the eyebolt. This setting will result in a minimum force required to operate the speed control lever.

5. Connect the linkage to the governor levers.

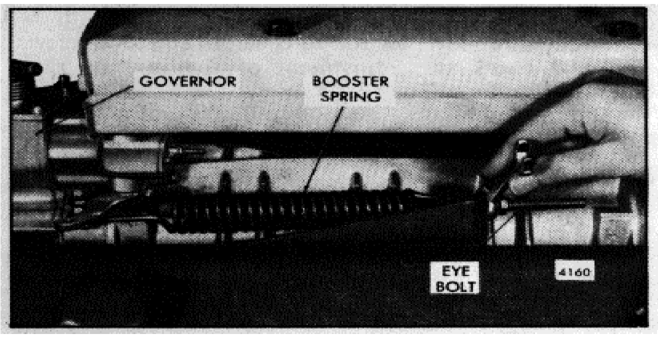


Fig. 14. - Adjusting Booster Spring

SG VARIABLE SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6V-92 and 8V-92 ENGINES

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor linkage and position the injector rack control levers (Fig. 1).

Position Injector Rack Control Levers and Adjust Governor Linkage

The position of the injector racks must be correctly set in relation to the governor. Their positions determine the amount of fuel injected into each cyoinder and ensures equal distribution of the load.

1. Clean and remove the valve rocker cover from each cylinder head. Discard the gaskets.

2. Loosen all the adjusting screws and locknuts. Be sure all control levers are free on the control tubes.

3. Disconnect the vertical link assembly from the governor operating lever and the bell crank.

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the bolt (removed from the lower end of the vertical link) through the bell crank and into the recessed hole in the drive housing (Fig. 2).

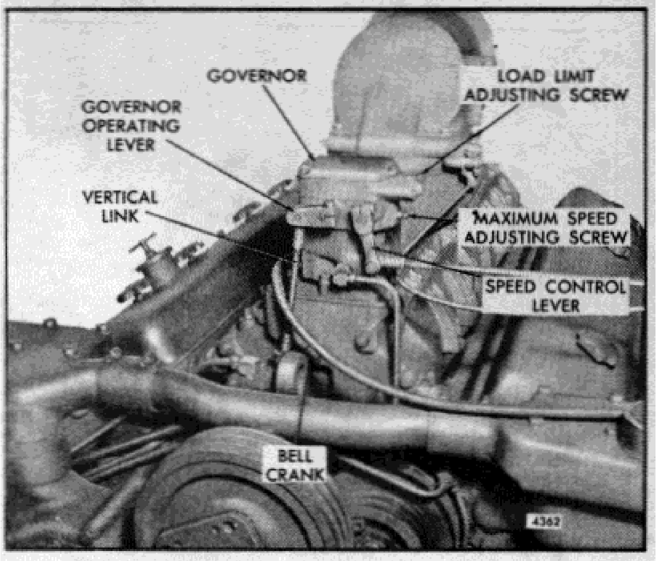


Fig. 1. - Hydraulic Governor Mounted on Engine

6. Adjust the No. 1R injector rack by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1R injector rack in the full-fuel position.

> **NOTE:** Care should be taken to avoid setting the racks too tight causing the fuel rod to bend.

7. To be sure the rack control lever is properly adjusted, the following check should be performed:

Press down on the injector rack with a screwdriver or finger tip (Fig. 3). A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns or "springs" back to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

8. Adjust the No. 1L injector rack control lever as outlined in Steps 6 and 7.

9. Check the adjustment on the No. 1R and 1L injector rack control lever. If the setting is correct, the injector racks will be in the full-fuel position and snug on the ball end of the control levers.

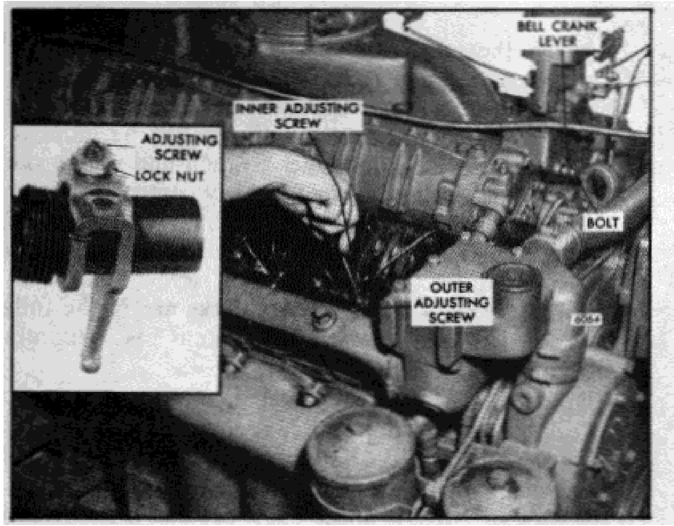


Fig. 2. - Positioning No. 1R Injector Rack Control Lever

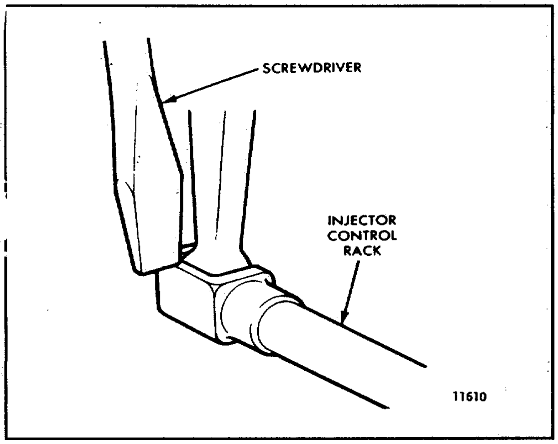


Fig. 3. - Checking Injector Rack "Spring"

10. To adjust the remaining injector rack control levers, hold the No. 1L injector rack in the full-fuel position by means of the lever on the end of the control tube assembly and proceed as follows:

a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1L as outlined in Step 7. If No. 1L does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. 1L injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1L and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. 1L and No. 2L injector racks are in the full-fuel position when the locknut is securely tightened.

Recheck the No. 1L injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while positioning the No. 2L injector rack. If the rack of No. 1L injector has become loose, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

When the settings are correct, both injector racks must respond in the same manner on the ball end of their respective rack control levers as previously outlined in Step 7.

11. Position the remaining injector rack control levers on the left and right cylinder heads as outlined in Step 10b.

When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full-fuel position.

12. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the linkage gage (Fig. 4). The type of governor (SGX or PSG) will determine the proper position of the lever.

13. Remove the gage.

14. Move the bell crank lever to the no-fuel position.

15. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 5).

16. Replace the two bolts in the levers and tighten the bolts.

17. Remove the governor cover.

18. With the load limit screw backed all the way out, retain the governor operating lever in the full-fuel position. The governor terminal lever should touch the

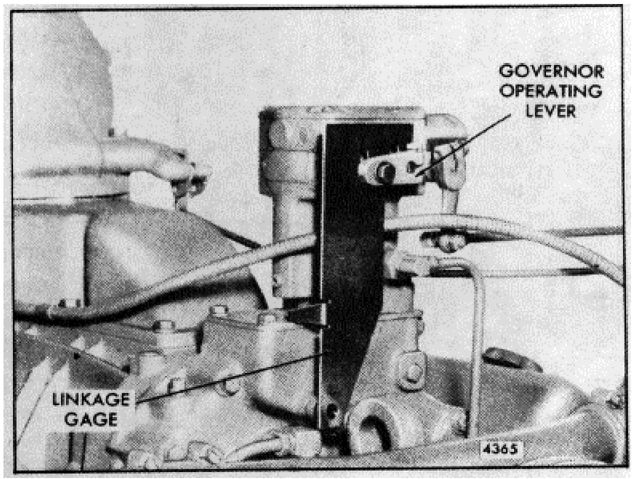


Fig. 4. - Positioning Governor Operating Lever

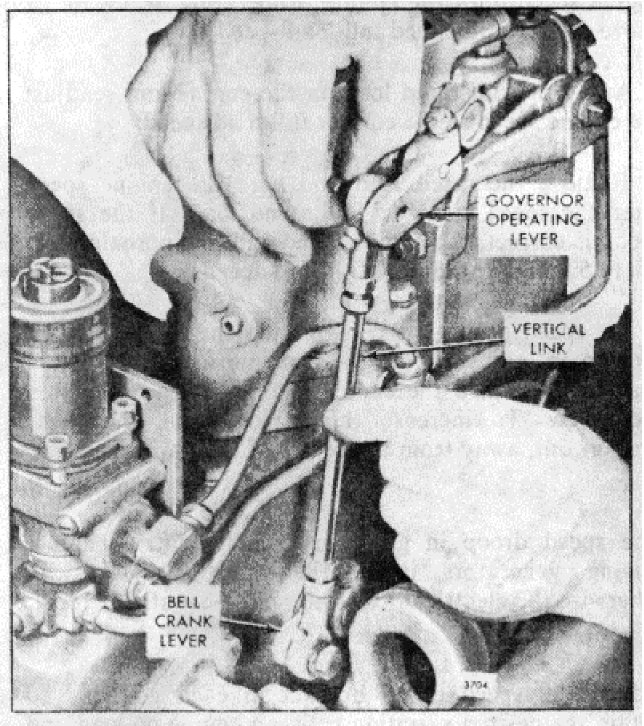


Fig. 5. - Adjusting Vertical Link

boss in the governor housing (Fig. 6). Adjust the vertical link so that all of the injector racks are in the full-fuel position, then tighten the rod end locknuts securely.

19. Use a new gasket and install a valve rocker cover on each cylinder head.

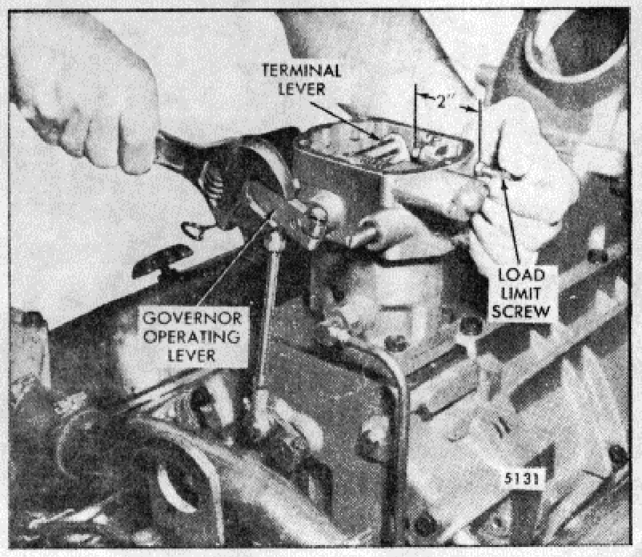


Fig. 6. - Adjusting Load Limit Screw

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Loosen the load limit screw locknut and adjust the load limit screw to obtain a distance of approximately 2" from the outside face of the boss on the governor subcap to the end of the screw. Then, place and retain the governor operating lever in the full-fuel position (Fig. 6).

NOTE: Do not overstress the linkage.

2. Turn the load limit adjusting screw until a .020" space exists between the fuel rod collar and the terminal lever. If the adjustment cannot be made with a feeler gage, turn the load limit adjusting screw (with the locknut tight enough to eliminate slack in the threads) inward until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the locknut. Then, install the governor cover and tighten the screws.

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve (without load on the engine) as follows:

1. Open the compensation needle valve (Fig. 10) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

The purpose of adjusting the speed droop is to establish a definite engine speed at no-load with a given speed at rated full load.

The governor speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

The best method of determining the engine speed is by using an accurate hand tachometer.

If a full rated load can be established on the unit, and the fuel rods, injector rack control levers and the load limit have been adjusted, set the speed droop as follows:

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

> **NOTE**: When the engine lubricating oil is cold, the governor regulation may be erratic. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8".

4. Loosen the screw and move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw (Fig. 7).

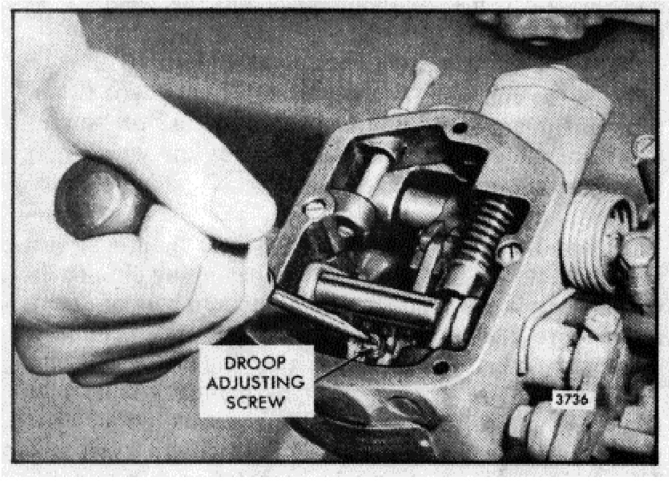


Fig. 7. - Adjusting Speed Droop

5. With the throttle in the run position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed.

6. Apply the full rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full-load speed.

If the speed droop is too high, stop the engine, loosen the droop adjusting screw and move the adjusting bracket in toward the center of the governor. Tighten the screw. To increase the speed droop, move the bracket out, away from the center of the governor.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2-1/2 cycles) for units operating at 1,500 and 1,800 rpm (Table 5). However, this speed droop recommendation may be varied to suit the individual application. Install the governor cover.

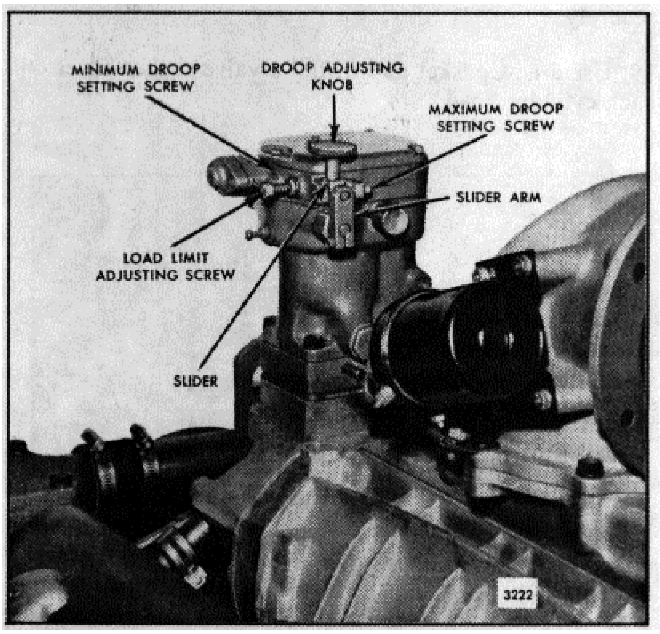


Fig. 8. - External Droop (Control on PSG Isochronous Governor

Full Load	No Load
50 cycles, 1000 rpm	52.5 cycles, 1050 rpm
60 cycles, 1200 rpm	62.5 cycles, 1250 rpm
50 cycles, 1500 rpm	52.5 cycles, 1575 rpm
60 cycles, 1800 rpm	62.5 cycles, 1875 rpm

TABLE 5.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (Fig. 8). This permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then, adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob and move the slide all the way in toward the center of the governor. Then, tighten the knob.

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed (Fig. 9).

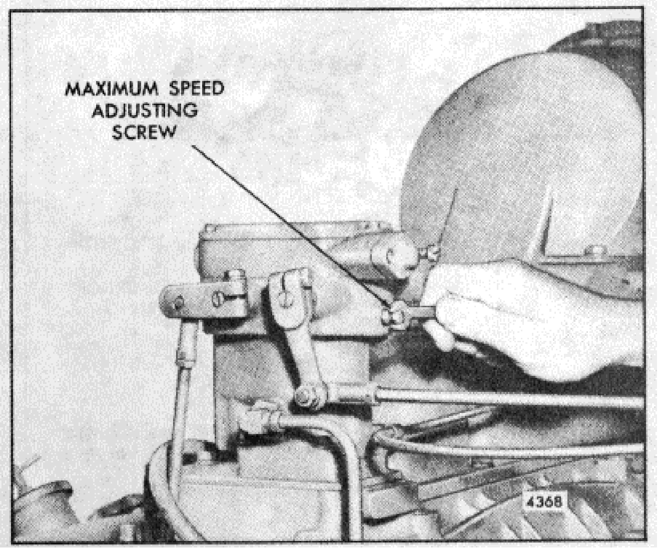


Fig. 9. - Adjusting Maximum No-Load Engine Speed

7. With the engine operating at the recommended fullload speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to fullload speed.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the locknut and turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

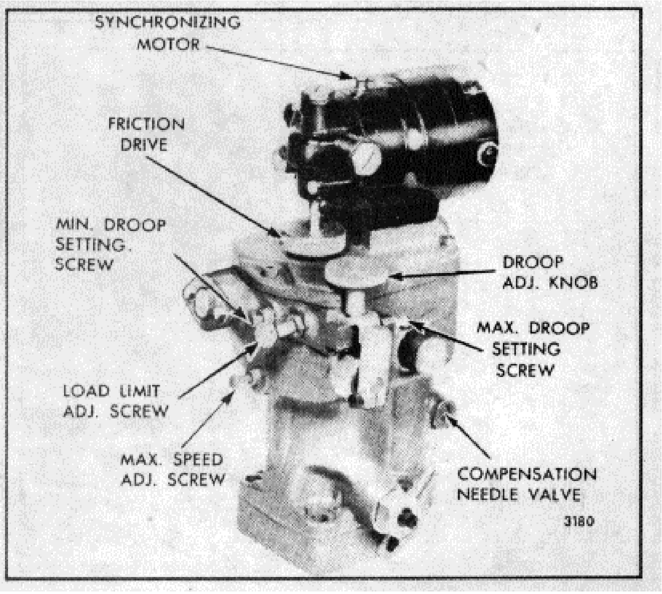


Fig. 10. - Typical Synchronizing Motor Mounting

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. With the engine operating at no load, adjust the speed until the engine is operating at approximately 8% .higher than the rated full-load speed.

2. Turn the maximum speed adjusting screw (Fig. 9) in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the locknut.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 10).

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

12V-92 and 16V-92 ENGINES

The governor on the 12V-92 and 16V-92 engine is mounted on and driven from the front end of the rear blower (Fig. 11). The governor-to-injector control tube linkage is shown in Fig. 12.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor linkage and position the injector rack control levers.

Position Injector Rack Control Levers and Adjust Governor Linkage

The position of the injector racks must be correctly set in relation to the governor. Their positions determine the amount of fuel injected into each cylinder and ensures equal distribution of the load.

1. Clean and remove the valve rocker cover from each cylinder head. Discard the gaskets.

2. Loosen all the adjusting screws and locknuts. Be sure all control levers are free on the control tubes.

3. Disconnect the vertical link assembly from the governor operating lever and the bell crank (Fig. 12).

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the bolt (removed from the lower end of the vertical link) through the bell crank and into the recessed hole in the governor drive housing (Fig. 13).

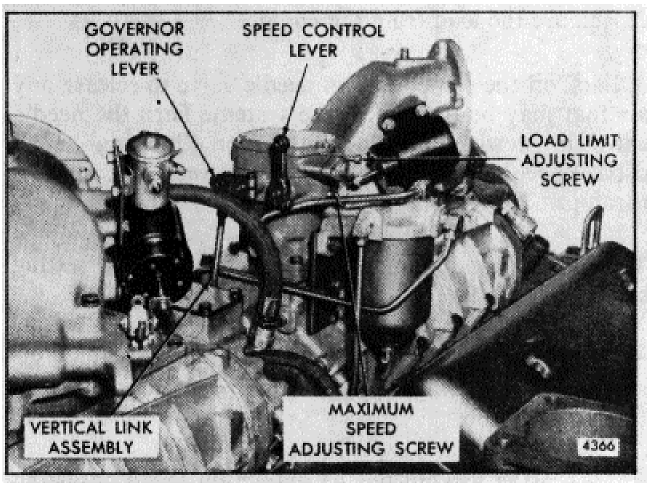


Fig. 11. - Hydraulic Governor Mounting

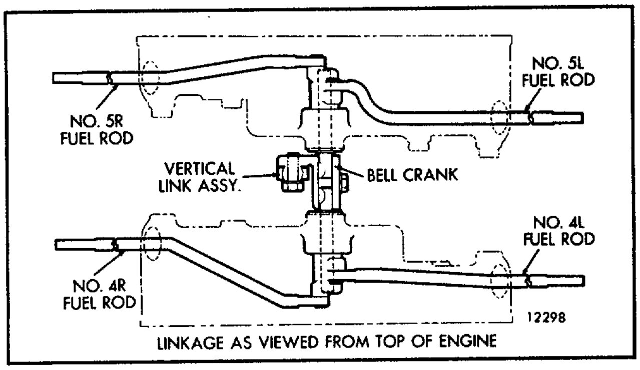


Fig. 12. - Governor to Injector Rack Control Linkage

6. Adjust the No. 4R (16V-92) or No. 3R (12V-92) injector rack by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 14). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 4R (16V-92) or No. 3R (12V-92) injector rack in the full-fuel position.

> **NOTE**: Care should be taken to avoid setting the racks too tight causing the fuel rod to bend.

7. To be sure the rack control lever is properly adjusted, the following check should be performed:

Press down on the injector rack with a screwdriver or finger tip (Fig. 3). A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns ("springs" back) to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

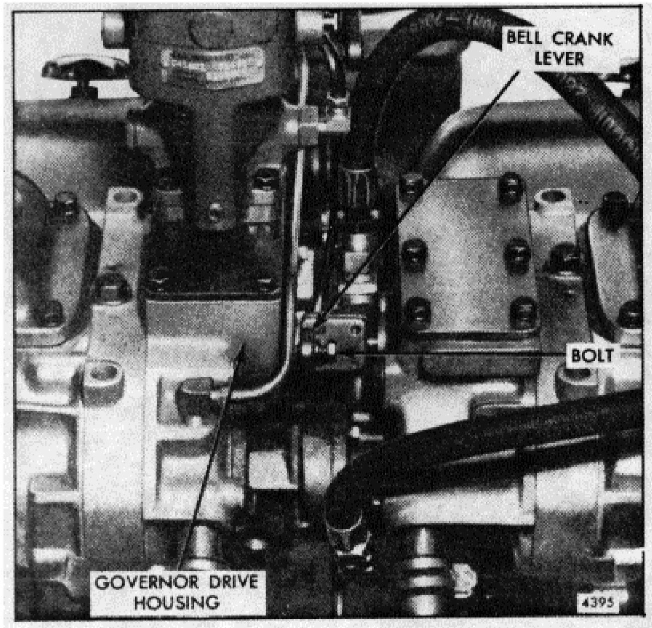


Fig. 13. - Positioning Bolt through Bell Crank Lever

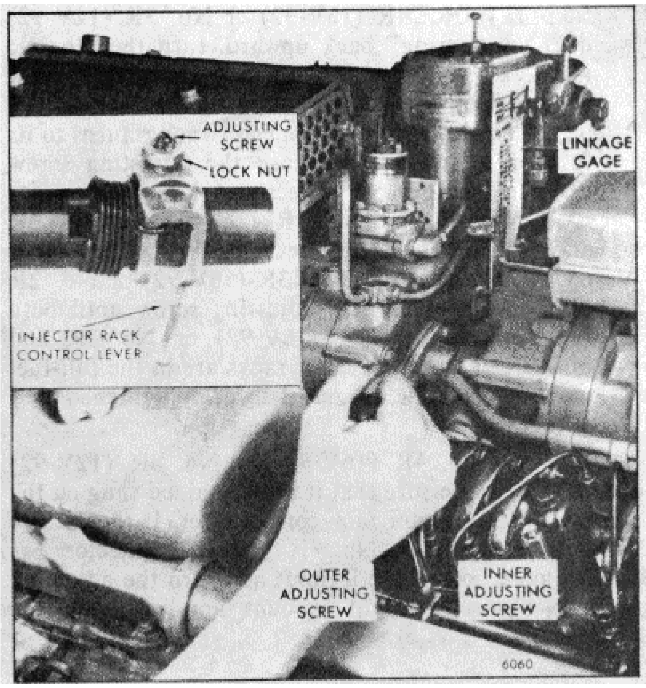


Fig. 14. - Positioning No. 4R Injector Rack Control Lever

8. Adjust the No. 5R, 4L and 5L (16V-92) or No. 4R, 3L and 4L (12V-92) injector rack control levers as outlined in Steps 6 and 7.

When the settings are correct, all four of the injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

9. To adjust the remaining injector rack control levers on the right front bank, hold the No. 4R (16V-92) or No. 3R (12V-92) injector rack in the full-fuel position by means of the lever on the control tube assembly and proceed as follows:

   a. Tighten the adjusting screw of the No. 3R (16V-92) or No. 2R (12V-92) injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE**: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in (3-4 Nm).

b. Verify the injector rack adjustment of No. 4R (16V-92) or No. 3R (12V-92) as outlined in Step 7. If No. 4R (16V-92) or No. 3R (12V-92) does not "spring" back upward, turn the No. 3R (16V-92) or No. 2R (12V-92) adjusting screw counterclockwise slightly until the No. 4R (16V92) or No. 3R (12V-92) injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 4R and No. 3R (16V-92) or No. 3R and No. 2R (12V-92) injectors. Turn clockwise or counterclockwise the No. 3R (16V-92) or No. 2R (12V-92) injector rack adjusting screw until both No. 4R and No. 3R (16V-92) or No. 3R and No. 2R (12V-92) injector racks are in the full-fuel position when the locknut is securely tightened.

Recheck the No. 4R (16V-92) or No. 3R (12V-92) injector rack to be sure that it has remained snug on the ball end of the injector rack control lever. If the rack of No. 4R (16V-92) or No. 3R (12V-92) injector has become loose, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

When the settings are correct, both injector racks must respond in the same manner on the ball ends of their respective rack control levers as previously outlined in Step 7.

10. Position the remaining injector rack control levers on the right front cylinder head as outlined in Step 9b.

When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full-fuel position.

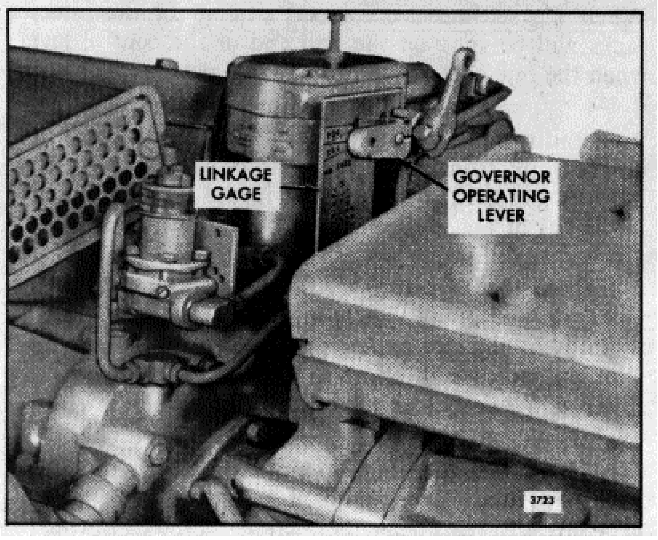


Fig. 15. - Positioning Governor Operating Lever

11. Adjust the remaining injector rack control levers on the right rear, left front and left rear cylinder heads in the same manner as outlined in Steps 9 and 10.

12. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the gage. The type of governor (SGX or PSG) will determine the proper position of the lever (Fig. 15).

13. Remove the gage.

14. Move the bell crank lever to the no-fuel position.

15. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 16).

16. Replace the two bolts in the levers and tighten the bolts.

17. Remove the governor cover.

18. With the load limit screw backed all the way out, retain the governor operating lever in the full-fuel position. The governor terminal lever should touch the boss on the governor housing. Adjust the vertical link so that all the injector racks are in the full-fuel position, then tighten the rod end locknuts securely.

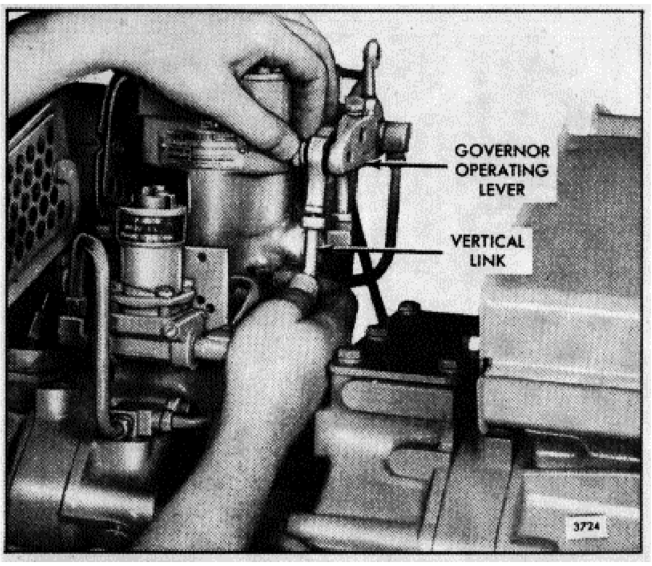


Fig. 16 - Adjusting Vertical Link

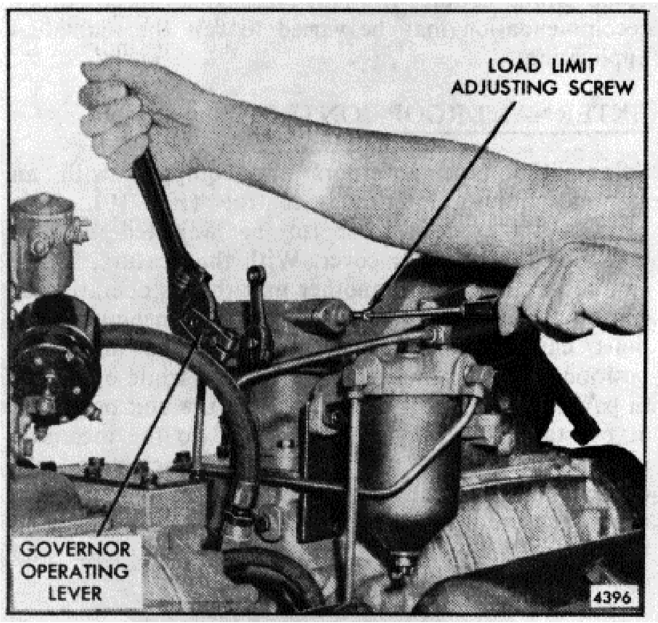


Fig. 17. - Adjusting Load Limit Screw

19. Use a new gasket and install the valve rocker cover on each cylinder head.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted. With the injector rack control levers properly adjusted, set the load limit as follows:

1. With the governor cover off and the load limit screw locknut loosened, place and retain the governor operating lever in the full-fuel position (Fig. 17).

NOTE: Do not overstress the linkage.

2. Turn the load limit adjusting screw in until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the locknut. Install the governor cover.

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve, without load on the engine, as follows:

1. Open the valve (Fig. 10) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

The purpose of adjusting the speed droop is to establish a definite speed at no load with a given speed at rated full load.

The governor speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

The best method of determining the engine speed is by using an accurate hand tachometer.

If a full rated load can be established on the unit, and the fuel rods, injector rack control levers and the load limit have been adjusted, set the speed droop as follows:

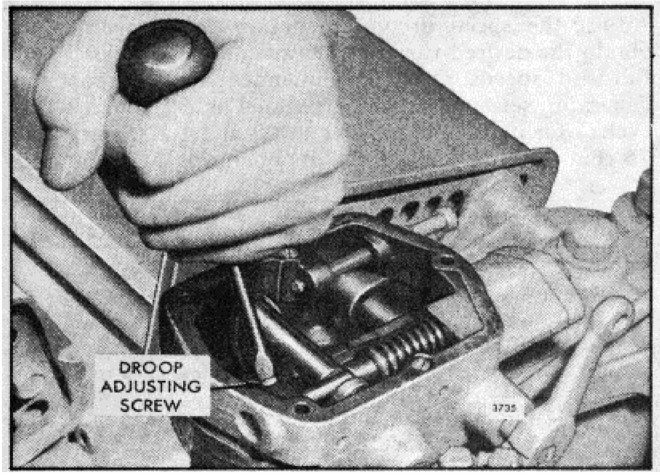


Fig. 18. - Adjusting Speed Droop

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

> **NOTE**: When the engine lubricating oil is cold, the governor regulation may be erratic. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8".

4. Loosen the droop adjusting screw (Fig. 18). Move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw.

5. With the throttle in the run. position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed.
6. Apply the full rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full-load speed. If the speed droop is too high, stop the engine, loosen the droop adjusting screw. and move the adjusting bracket in toward the center of the governor. Tighten the screw. To increase the speed droop, move the bracket out, away from the center of the governor. The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2-1/2 cycles) for units operating at 1,500 and 1,800 rpm (Table 6). However, this speed droop recommendation may be varied to suit the individual application.

Full Load	No Load
50 cycles, 1000 -rpm	52.5 cycles, 1050 rpm
60 cycles, 1200 rpm	62.5 cycles, 1250 rpm
50 cycles, 1500 rpm	52.5 cycles, 1575 rpm
60 cycles, 1800 rpm	62.5 cycles, 1875 rpm

TABLE 6.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (Fig. 10). This permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then, adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob and move the slider all the way in toward the center of the governor (Fig. 17). Then, tighten the knob.

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to full-load speed.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the locknut and turn the minimum droop setting

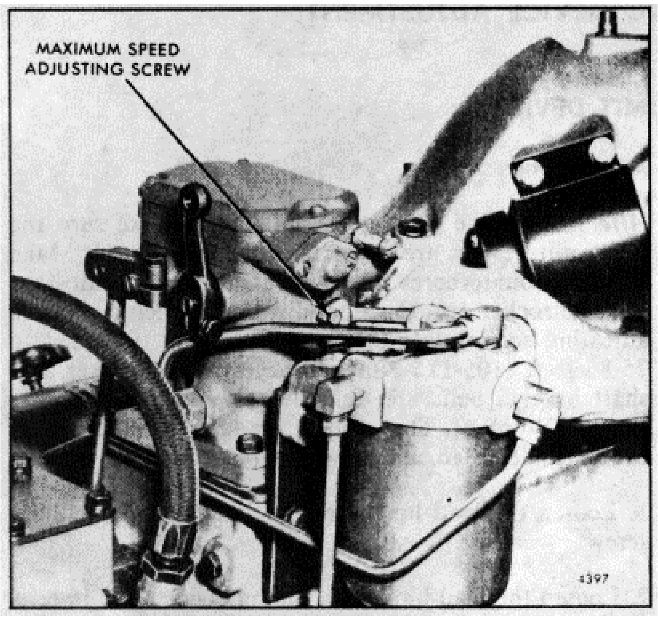


Fig. 19. - Adjusting Maximum No-Load Engine Speed

screw in until it contacts the droop linkage within the governor. This will be felt by a step up or resistance while turning the adjusting screw. Lock the adjusting screw in this position.

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw in until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. With the engine operating at no load, adjust the speed until the engine is operating at approximately 8% higher than the rated full-load speed.

2. Turn the maximum speed adjusting screw (Fig. 19) in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full load speed.

3. Hold the screw and tighten the locknut.

Governors With Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 10).

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with the external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

ENGINE LOAD LIMIT DEVICE

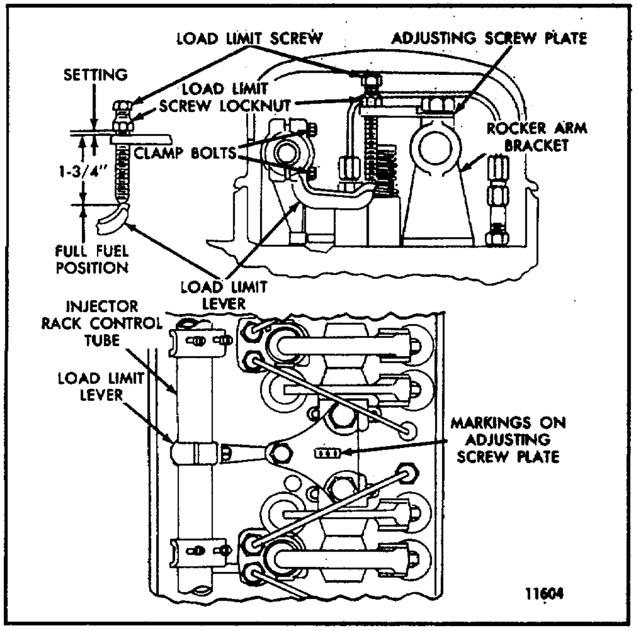


Fig. 1. - Engine Load Limit Device

Engines with mechanical governors may be equipped with a load limit device to reduce the maximum horsepower (Fig. 1).

This device consists of a load limit screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a load limit lever clamped to the injector control tube.

The load limit device is located between the No. 1 and No. 2 cylinders on each cylinder bank of a 6V-92 engine, between the No. 2 and No. 3 cylinders on each cylinder bank of an 8V-92 engine. On the 12V-92 and 16V-92 engines, four load limit devices are used (one on each cylinder head). The load limit device is located between the No. 1 and No. 2 cylinders and between the No. 4 and No. 5 cylinders (12V-92 engines) or between the No. 2 and No. 3 cylinders and between the No. 6 and No. 7 cylinders (16V-92 engines) on each cylinder bank.

When properly adjusted for the maximum horsepower desired, this device limits the travel of the injector control racks and thereby the fuel output of the injectors.

Adjustment

After the engine tune-up is completed, make sure the load limit devices are properly installed (Fig. 1). Make sure the counterbores in the adjusting screw plates are up. The rocker arm shaft bracket bolts which fasten the adjusting screw plate to the brackets are tightened to 75-85 lb-ft (105-115 Nm) torque (all other rocker arm shaft bracket bolts are tightened to 90-100 lb-ft (122136 Nm) torque). Then, adjust the load limit device, on each cylinder head, as follows:

1. Loosen the load limit screw locknut and remove the screw.

2. Loosen the load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

3. With the screw out of the plate, adjust the load limit screw locknut so the bottom of the locknut is 1 3/4" from the bottom of the load limit screw for the initial setting (Fig. 1).

4. Thread the load limit screw into the adjusting screw plate until the locknut *bottoms* against the top of the plate.

5. Hold the injector rack control tube in the full-fuel position and place the load limit lever against the bottom of the load limit screw. Then, tighten the load limit lever clamp bolts.

6. Check to ensure that the injector racks will just go into the full-fuel position -- readjust the load limit lever, if necessary.

7. Hold the load limit screw.to keep it from turning, then set the locknut until the distance between the bottom of the locknut and the top of the adjusting screw plate corresponds to the dimension (or number of turns) stamped on the plate.

> **NOTE**: If the plate is not stamped, adjust the load limit screw while operating the engine on a dynamometer test stand and note the number of turns required to obtain the desired horsepower. Then, stamp the plate accordingly.

8. Thread the load limit screw into the plate until the locknut bottoms against the top of the plate. Be sure the nut turns with the screw.

9. Hold the load limit screw to keep it from turning, then tighten the locknut to secure the setting.

THROTTLE DELAY MECHANISM

The throttle delay mechanism is used to retard full-fuel injection when the engine is accelerated. This reduces exhaust smoke and also helps to improve fuel economy.

The throttle delay mechanism is installed between the No. 1 and No. 2 cylinders on the right-bank cylinder head (Fig. 2). It consists of a special rocker arm shaft bracket (which incorporates the throttle delay cylinder), a piston, throttle delay lever, connecting link, orifice plug, ball check valve and U-bolt.

A yield link replaces the standard operating lever connecting link in the governor.

Adjustment

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be readjusted. With the engine stopped, proceed as follows:

1. Disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube (Fig. 2).

2. To provide adequate lubrication of mechanical components, fill the throttle delay reservoir with clean engine oil. The oil reservoir does not have to remain full during the entire adjustment procedure.

3. Insert gage J 25559 (.570" setting) when 9285 injectors or lower output are used, or gage J 25560 (.636" setting) when 9290 injectors or higher output are used, on the rack between the injector body and the shoulder on the injector rack clevis (Fig. 2). This is the No. 2 injector on 6V-92 and 8V-92 engines, the No. 5 injector on 12V-92 engines and the No. 6 injector on 16V-92 engines.

4. Hold the governor throttle lever in the maximum speed position. This should cause the injector rack to move toward the full-fuel position.

5. Insert pin gage J 25558 with the "go" (green, .069") end in the cylinder fill hole. If the throttle delay housing has multiple holes, use the hole indicated in Fig. 3.

6. Rotate the throttle delay lever in the direction shown in Fig. 2 until further movement is limited by the piston contacting the pin gage.

7. Tighten the U-bolt while exerting a slight pressure on the lever in the direction of rotation.

8. Check the setting as follows:

   a. Remove the pin gage.

   b. Reinsert the "go" (green, .069") end of the gage in the fill hole. If the gage will not go past the piston without resistance, increase the torque on the lower U-bolt nut. Remove the gage.

   c. Reverse the pin gage and attempt to insert the "go" (red .072") end in the fill hole. If the "no go" end of the gage enters the fill hole past the piston without resistance, increase torque on the upper U-bolt nut. It should not be possible to insert the gage past the piston without moving the injector racks toward the no-fuel position.

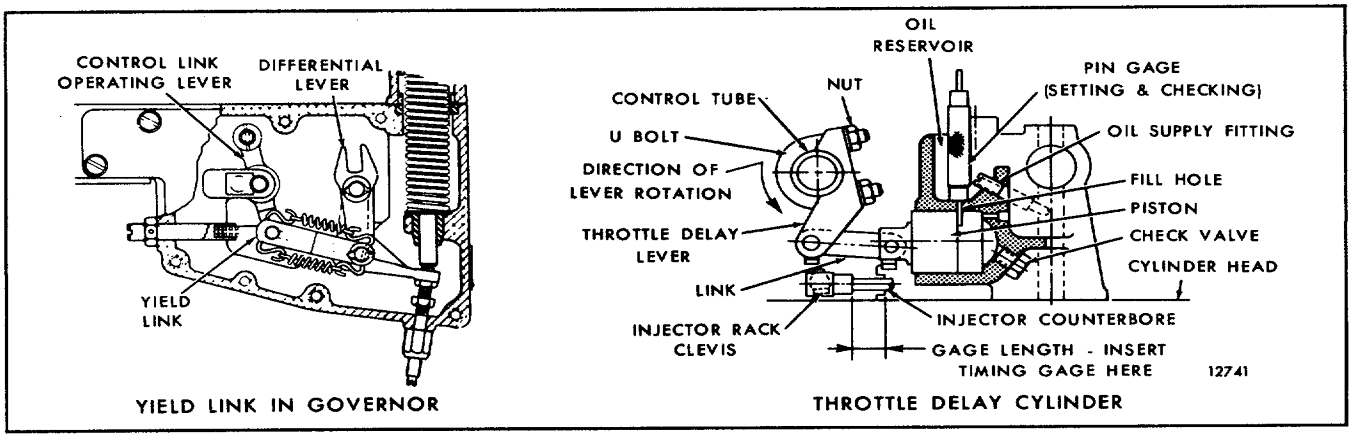


Fig. 2. - Yield Link and Throttle Delay Cylinder

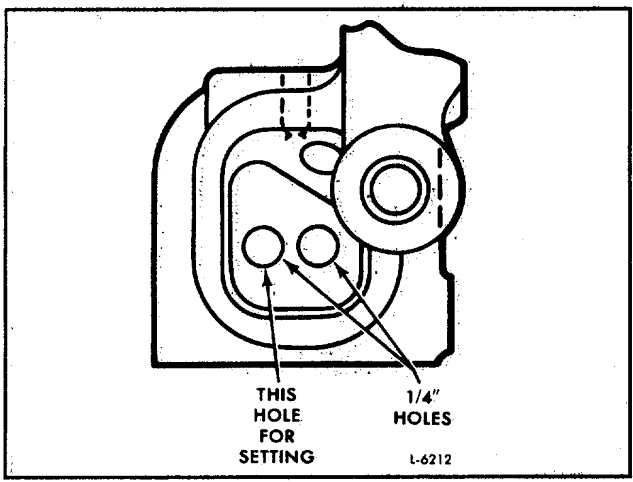


Fig. 3. - Throttle Delay with Multiple Fill Holes

9. Release the governor throttle lever and remove the timing gage and pin gage. If either U-bolt nut is tightened without the pin gage being inserted, recheck the setting.

10. Move the injector control tube. assembly between the no-fuel and the full-fuel position to make sure there is no bind.

ADJUSTMENT OF MECHANICAL GOVERNOR SHUTDOWN SOLENOID

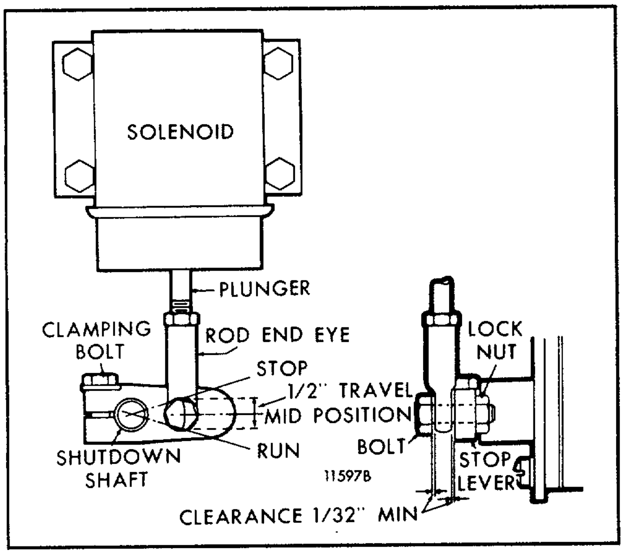


Fig. 4. - Typical Variable Speed Governor Lever Position

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor, the governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel.

The solenoid plunger can be properly aligned to the governor stop lever as follows:

1. Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs. 4 and 5). Align and clamp the lever to the shutdown shaft in such a way that, at its mid-travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible. The solenoid plunger has available 1/2" travel which is more than adequate to move the injector control racks from the full-fuel to the complete no-fuel position and shut down will occur prior to attaining complete travel.

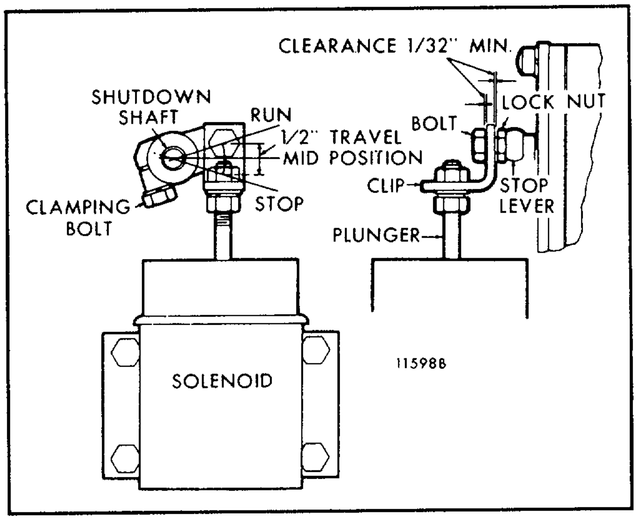


Fig. 5. - Typical Limiting Speed Governor Lever Position

2. With the stop lever in the run position, adjust the rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap, with a resultant build-up of pull-in force prior to initiating stop lever movement.

3. The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32" minimum.

   NOTE: The locknut can be either on top of or below the stop lever.

4. Move the lever to the stop position and observe the plunger for any possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger motion.

STORAGE

PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.
It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Mo8sture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 days or less)

To protect an engine for 30 days or less, proceed as follows: I. Drain the engine crankcase.

2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.

3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

> **NOTE:** Do not drain the fuel system or the crankcase after this run.

4. Check the air cleaner and service it, if necessary, as outlined under Air System Section 2. period, add an ethylene glycol base antifreeze solution

5. If freezing weather is expected during the storage in accordance with the manufacturer's recommendations. Drain the raw water system and leave the drain cocks open.

> **NOTE**: If an antifreeze solution is not to be used during this storage period, the coolant system should be flushed with a good rust inhibitor to prevent rusting of the outside diameter of the cylinder liners (refer to Coolant Specifications Section 5).

6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with compressed air.

7. Seal all of the engine openings. The material used for this purpose must be waterproof, vaporproof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission and priming the raw water pump, if used.

EXTENDED STORAGE (more than 30 days)

To prepare an engine for extended storage (more than 30 days), follow this procedure: I. Drain the cooling system and flush with clean, soft water. Refill with clean, soft water and add a rust inhibitor to the cooling system (refer to Corrosion Inhibitor under Coolant Specifications Section 5.

2. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.

3. Reinstall the injectors, time them and adjust the exhaust valve clearance.

4. Circulate the coolant by operating the engine until normal operating temperature (160-185° F or 71-85° C) is reached.

5. Stop the engine.

6. Drain the engine crankcase, then reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.

7. Fill the crankcase to the proper level with a 30 weight preservative lubricating oil MIL-L-21260C, Grade 2.

8. Drain the fuel tank. Refill with enough clean No. I diesel fuel or pure kerosene to permit the engine to operate for about ten minutes. If it isn't convenient to drain the fuel tank (i.e., marine) use a separate portable supply of the recommended fuel.

NOTE: If engines are stored where condensation of water in the fuel tank may be a problem, add pure, waterless isopropyl alcohol (isopropanol) to the fuel at a ratio of one pint (.5 liters) to 125 gallons (473 liters) of fuel or .010% by volume. Where biological contamination of fuel may be a problem, add a biocide such as Biobor JF, or equivalent, to the fuel. When using a biocide, follow the manufacturer's concentration recommendations and observe all cautions and warnings.

9 Drain and disassemble the fuel filter and strainer.

Discard the used elements and gaskets. Fill the cavity between the element and shell with No. 1 diesel fuel or pure kerosene, and reinstall on the engine. If spin-on fuel filters and strainers are used, discard the used cartridges, fill the new ones with No. 1 diesel fuel or pure kerosene, and reinstall on the engine.

10. Operate the engine for five minutes to circulate the clean fuel oil throughout the fuel system.

11. Refer to Air System Section 2 and service the air cleaner.

12**. MARINE GEAR** a. Drain the oil completely and refill with clean oil of the recommended grade and viscosity. Remove and clean or replace the strainer and filter elements.

b. Start and run the engine at 600 rpm for 10 minutes to coat all of the internal parts of the marine gear with clean oil. Engage the clutches alternately to circulate clean oil through all of the moving parts.
NOTE: The performance of this step is not necessary on torque converter units.
13 **TORQMATIC CONVERTER** a. Start and operate the engine until the temperature of the converter oil reaches 150° F (66° C).
b. Stop the engine, remove the converter drain plug and drain the converter.
c. Remove the filter element.
d. Start the engine and stall the converter for **twenty** seconds at 1,000 rpm to scavenge the oil from the converter. *Due to lack of lubrication, do not exceed the 20 second limit*.

e Install the drain plug and a new filter element.

f. Fill the converter to the proper operating level with a commercial preservative oil which meets specification MIL-L-21260C, Grade 2. Oil of this type is available from the major oil companies.

g. Start the engine and operate the converter for at least 10 minutes at a minimum of 1,000 rpm.
Engage the clutch, then stall the converter to raise the oil temperature to 225° F (1070 C).
NOTE: Do not allow the oil temperature to exceed 2250 F (1070 C). If the unit does not have a temperature gage, do not stall the converter for more than thirty seconds.

h. Stop the engine and allow the converter to cool to a temperature suitable to the touch.

i. Seal the breather and all of the exposed openings with moisture proof tape.

j. Coat all exposed, unpainted surfaces with preservative grease. Position all of the controls for minimum exposure and coat them with grease. The external shafts, flanges and scals should also be coated with grease.

14. **POWER TAKEOFF** a. Use an all purpose grease such as Shell Alvania No. 2, or equivalent, and lubricate the clutch throwout bearing, clutch pilot bearing, drive shaft main bearing, clutch release shaft and the outboard bearings (if so equipped).

b. Remove the inspection hole cover on the clutch housing and lubricate the clutch release lever and link pins with a hand oiler. Avoid getting oil on the clutch facing.

c. If the unit is equipped with a reduction gear, drain the gear box and flush with light engine oil. If the unit is equipped with a filter, clean the shell and replace the filter element. Refill the gear box to the proper level with the grade of oil indicated on the name plate.

15. **TURBOCHARGER** Since turbocharger bearings are pressure lubricated through the external oil line leading from the engine cylinder block while the engine is operating, no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture resistant tape.

16. Apply a non-friction rust preventive compound to all exposed parts. If convenient, apply the rust

preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

NOTE: Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip.

17. Drain the engine cooling system.

18. Drain the preservative oil from the engine crankcase. Reinstall and tighten the drain plug.

19. Remove and clean the battery and battery cables with a baking soda-water solution and rinse with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32° F or 0° C) dry place.

Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.

20. Insert heavy paper strips between the pulleys and belts to prevent sticking.

21. Seal all engine openings, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

22. Clean and dry the exterior painted surfaces of the engine and spray with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

23. Protect the engine with a good weather-resistant tarpaulin and store it under cover, preferably in a dry building which can be heated during the winter months.

Detroit Diesel Allison does not recommend the outdoor storage of engines (or transmission). Nevertheless, DDA recognizes that in some cases outdoor storage may be unavoidable. If units must be kept out-off-doors, follow the preparation and storage instructions already given. Protect units with quality, weather-resistant tarpaulins (or other suitable covers) arranged to provide air circulation.

NOTE
: Do not use plastic sheeting for outdoor storage. Plastic is fine for indoor storage. When used outdoors, however, enough moisture can condense on the inside of the plastic to rust ferrous metal surfaces and pit aluminum surfaces. If a unit is stored outside for any extended period of time, severe corrosion damage can result.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

PROCEDURE FOR RESTORING AN ENGINE TO SERVICE WHICH HAS BEEN IN EXTENDED STORAGE

1. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. Do not overlook the exhaust outlet.
2. Wash the exterior of the engine with fuel oil to remove the rust preventive.
3. Remove the rust preventive from the flywheel.
4. Remove the paper strips from between the pulleys and the belts.
5. Remove the drain plug and drain the preservative oil from the crankcase. Reinstall the drain plug. Then, refer to Lubrication System in the Operating Instructions Section 4 and fill the crankcase to the proper level with the recommended grade of lubricating oil.
6. Fill the fuel tank with the fuel specified under Fuel Specifications - Section 5.
7. Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, fill the cooling system with an ethylene glycol base antifreeze solution (refer to Coolant Specifications Section 5).
8. Install and connect the battery.
9. Service the air cleaner as outlined under Air System Section 2.
10. POWER GENERATOR Prepare the generator for starting as outlined under Operating Instructions Section 4.
11. MARINE GEAR Check the Marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.
12. TORQMATIC CONVERTER

a. Remove the tape from the breather and all of the openings.

b. Remove all of the preservative grease with a suitable solvent.

c. Start the engine and operate the unit until the temperature reaches 150° F (66° C). Drain the preservative oil and remove the filter. Start the engine and stall the converter for twenty seconds at 1,000 rpm to scavenge the oil from the converter.

NOTE: A Torqmatic converter containing preservative oil should only be operated enough to bring the oil temperature up to 150° F (660 C).

d. Install the drain plug and a new filter element.

e. Refill the converter with the oil that is recommended under Lubrication and Preventive Maintenance Section 5.

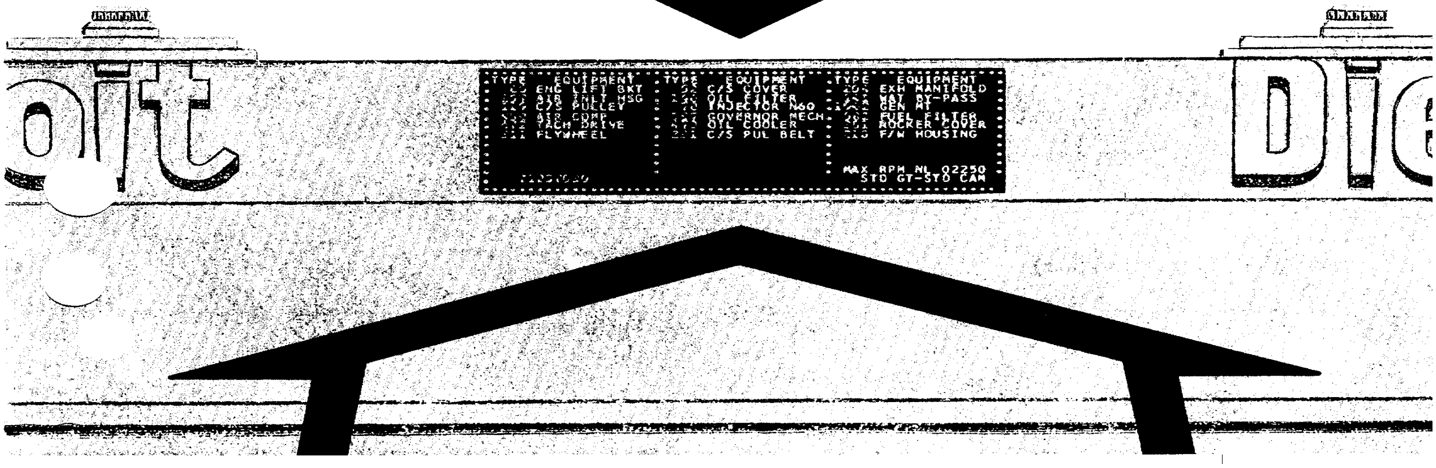
13. POWER TAKE-OFF Remove the inspection hole cover and inspect the clutch release lever and link pins and the bearing ends of the clutch release shaft. Apply engine oil sparingly, if necessary, to these areas.

14. TURBOCHARGER Remove the covers from the turbocharger air inlet and turbine outlet connections. Refer to the lubricating procedure outlined in Preparation for Starting Engine First Time under Operating Instructions Section 4.

15. After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

NOTE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

BUILT-IN
PARTS BOOK
for
DETROIT DIESEL ENGINES

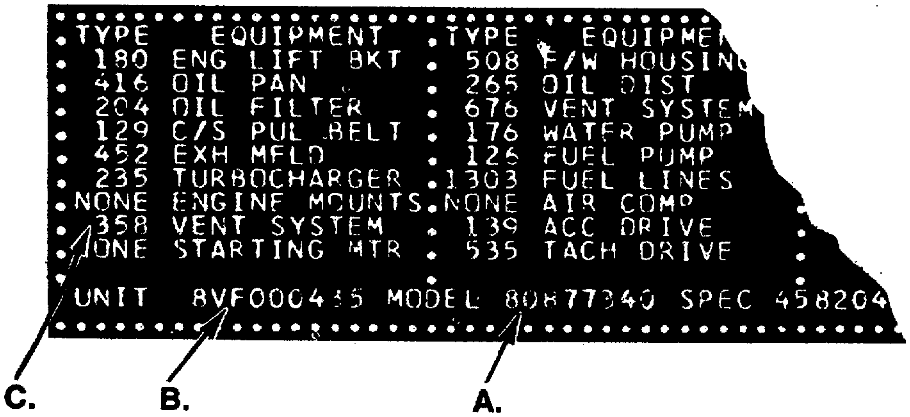


Progress in industry comes at a rapid pace. In order for the engine manufacturer to keep pace with progress he needs a versatile product for the many models and arrangements of accessories and mounting parts needed to suit a variety of equipment. In addition, engine refinements and improvements are constantly being introduced. All of this dynamic action must be documented so that the equipment can be serviced if and when it's needed. It is fully documented in the manufacturer's plant and in dealer Parts Departments with Master Files and adequate supporting records. But, what about YOU the user of this equipment? You have neither the time nor the inclination to ferret out specific part number data. What is the answer?-It is Detroit Diesel's exclusive BUILT-IN PARTS BOOK which is furnished with each engine. It takes the form of an "Option Plate" mounted on the rocker cover of the engine. With it, ordering parts becomes as simple as A, B, C. You have merely to provide the Dealer with...

A. The "Model" number

B. The "UNIT" number

C. The "TYPE" number

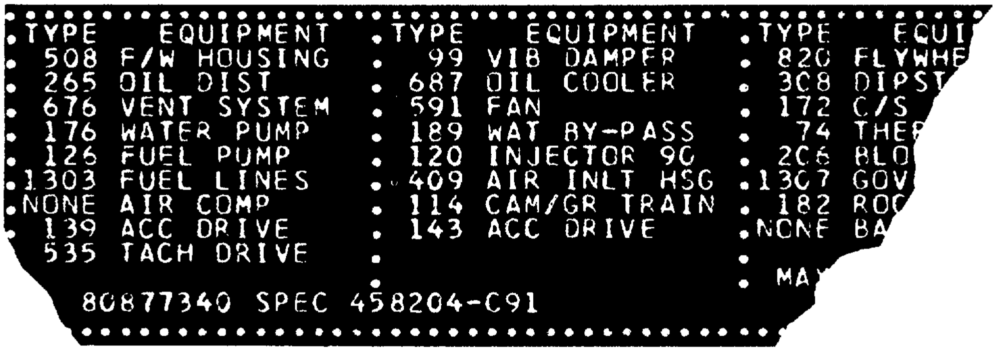


TYPE	EQUIPMENT	TYPE	EQUIPME
180	ENG LIFT BKT	508	F/W HOUSIN
416	OIL PAN	265	OIL DIST
204	OIL FILTER	676	VENT SYSTEM
129	C/S PUL BELT	176	WATER PUMP
452	EXH MFLD	126	FUEL PUMP
235	TURBOCHARGER	1303	FUEL LINES
NONE	ENGINE MOUNTS	NONE	AIR COMP
358	VENT SYSTEM	139	ACC DRIVE
NONE	STARTING MTR	535	TACH DRIVE

UNIT 8VF000435 MODEL 80877340 SPEC 458204

From that much information, the dealer with his complete records on all engine models, can completely interpret your parts requirements.

What is this "built-in" book? It is a photo etched aluminum option plate that fits into a holding channel on the engine rocker cover.



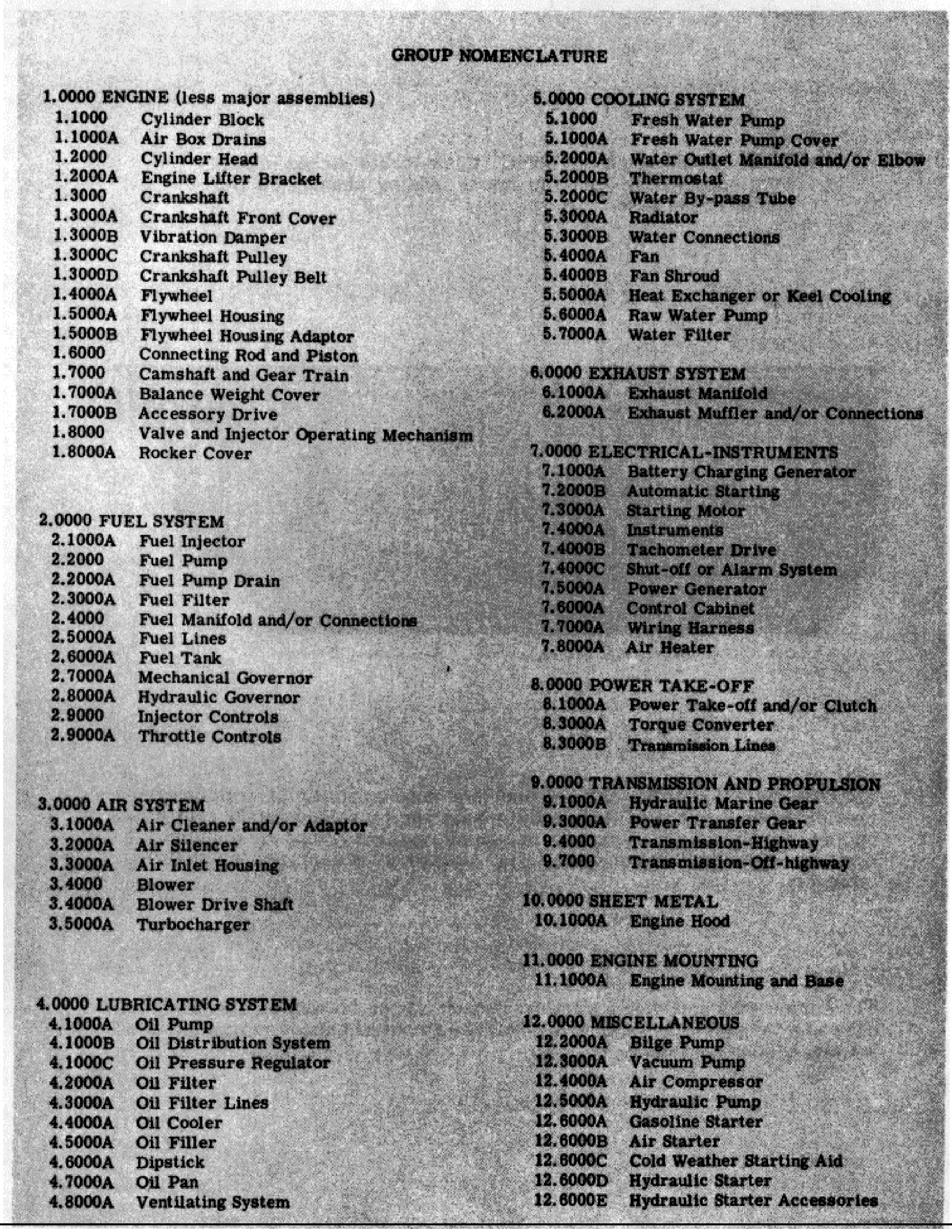
TYPE	EQUIPMENT	TYPE	EQUIPMENT	TYPE	EQUI
508	F/W HOUSING	99	VIB DAMPER	820	FLYWHE
265	OIL DIST	687	OIL COOLER	308	DIPST
676	VENT SYSTEM	591	FAN	172	C/S
176	WATER PUMP	189	WAT BY-PASS	74	THE
126	FUEL PUMP	120	INJECTOR 90	206	BLO
1303	FUEL LINES	409	AIR INLT HSG	1307	GOV
NONE	AIR COMP	114	CAM/GR TRAIN	182	ROC
139	ACC DRIVE	143	ACC DRIVE	NONE	BA
535	TACH DRIVE				
				MA	

80877340 SPEC 458204-C91

SHOWN IN COLUMNS, the type numbers and equipment descriptions represent specific groups of functionally related parts installed on the engine as optional equipment. The components making up these groups are found in the parts catalog microfiche under the "type" number of the appropriate equipment category.

The engine unit and model numbers appear at the bottom of the plate, as shown on the preceding page, along with the governed maximum rpm, no-load setting, and engine timing.

All engine components are divided into groups of functionally related parts. A complete listing of the twelve major groups and their many sub-groups is shown below.



GROUP NOMENCLATURE

1.0000 ENGINE (less major assemblies)

1.1000	Cylinder Block
1.1000A	Air Box Drains
1.2000	Cylinder Head
1.2000A	Engine Lifter Bracket
1.3000	Crankshaft
1.3000A	Crankshaft Front Cover
1.3000B	Vibration Damper
1.3000C	Crankshaft Pulley
1.3000D	Crankshaft Pulley Belt
1.4000A	Flywheel
1.5000A	Flywheel Housing
1.5000B	Flywheel Housing Adaptor
1.6000	Connecting Rod and Piston
1.7000	Camshaft and Gear Train
1.7000A	Balance Weight Cover
1.7000B	Accessory Drive
1.8000	Valve and Injector Operating Mechanism
1.8000A	Rocker Cover

2.0000 FUEL SYSTEM

2.1000A	Fuel Injector
2.2000	Fuel Pump
2.2000A	Fuel Pump Drain
2.3000A	Fuel Filter
2.4000	Fuel Manifold and/or Connections
2.5000A	Fuel Lines
2.6000A	Fuel Tank
2.7000A	Mechanical Governor
2.8000A	Hydraulic Governor
2.9000	Injector Controls
2.9000A	Throttle Controls

3.0000 AIR SYSTEM

3.1000A	Air Cleaner and/or Adaptor
3.2000A	Air Silencer
3.3000A	Air Inlet Housing
3.4000	Blower
3.4000A	Blower Drive Shaft
3.5000A	Turbocharger

4.0000 LUBRICATING SYSTEM

4.1000A	Oil Pump
4.1000B	Oil Distribution System
4.1000C	Oil Pressure Regulator
4.2000A	Oil Filter
4.3000A	Oil Filter Lines
4.4000A	Oil Cooler
4.5000A	Oil Filler
4.6000A	Dipstick
4.7000A	Oil Pan
4.8000A	Ventilating System

5.0000 COOLING SYSTEM

5.1000	Fresh Water Pump
5.1000A	Fresh Water Pump Cover
5.2000A	Water Outlet Manifold and/or Elbow
5.2000B	Thermostat
5.2000C	Water By-pass Tube
5.3000A	Radiator
5.3000B	Water Connections
5.4000A	Fan
5.4000B	Fan Shroud
5.5000A	Heat Exchanger or Keel Cooling
5.6000A	Raw Water Pump
5.7000A	Water Filter

6.0000 EXHAUST SYSTEM

6.1000A	Exhaust Manifold
6.2000A	Exhaust Muffler and/or Connections

7.0000 ELECTRICAL-INSTRUMENTS

7.1000A	Battery Charging Generator
7.2000B	Automatic Starting
7.3000A	Starting Motor
7.4000A	Instruments
7.4000B	Tachometer Drive
7.4000C	Shut-off or Alarm System
7.5000A	Power Generator
7.6000A	Control Cabinet
7.7000A	Wiring Harness
7.8000A	Air Heater

8.0000 POWER TAKE-OFF

8.1000A	Power Take-off and/or Clutch
8.3000A	Torque Converter
8.3000B	Transmission Lines

9.0000 TRANSMISSION AND PROPULSION

9.1000A	Hydraulic Marine Gear
9.3000A	Power Transfer Gear
9.4000	Transmission-Highway
9.7000	Transmission-Off-highway

10.0000 SHEET METAL

10.1000A	Engine Hood

11.0000 ENGINE MOUNTING

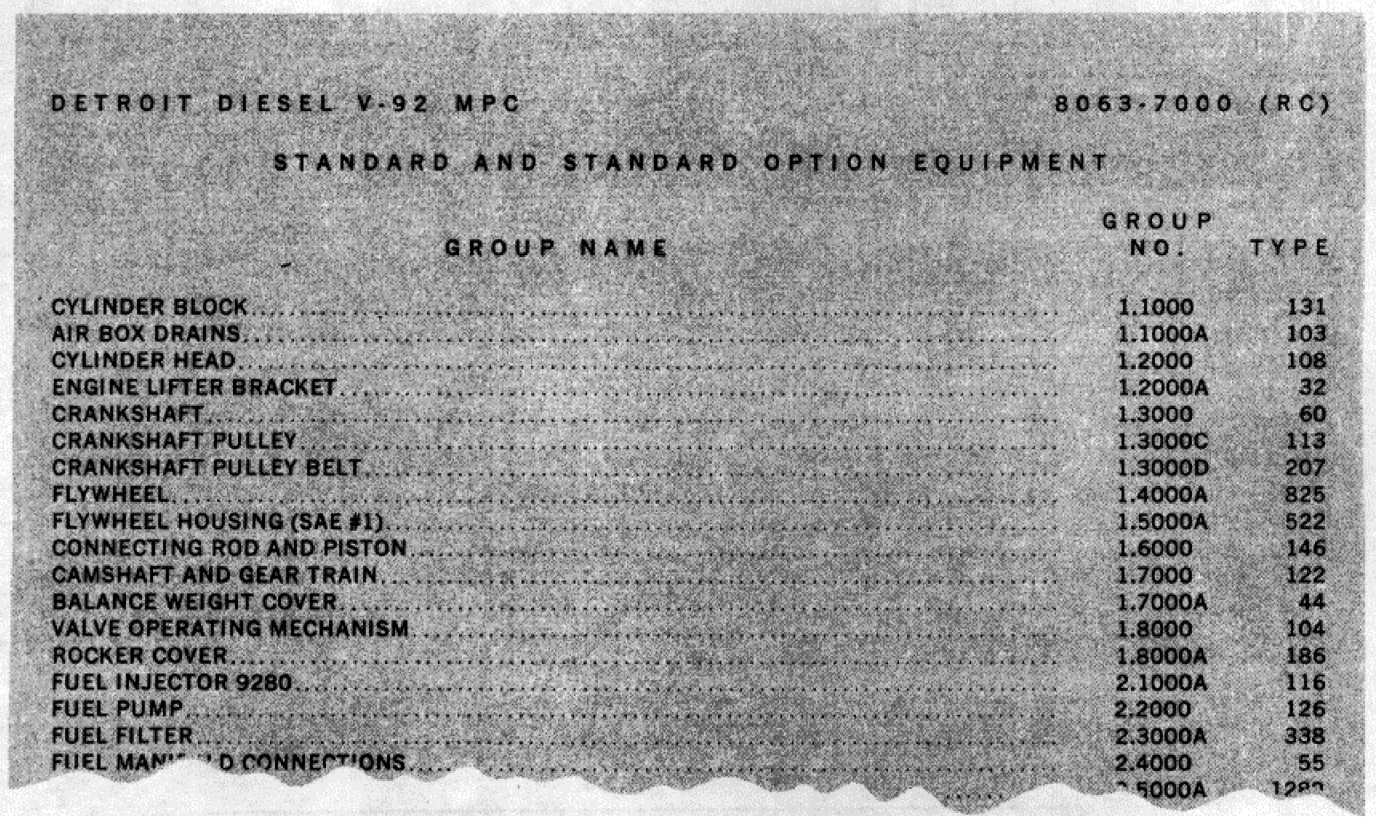
11.1000A	Engine Mounting and Base

12.0000 MISCELLANEOUS

12.2000A	Bilge Pump
12.3000A	Vacuum Pump
12.4000A	Air Compressor
12.5000A	Hydraulic Pump
12.6000A	Gasoline Starter
12.6000B	Air Starter
12.6000C	Cold Weather Starting Aid
12.6000D	Hydraulic Starter
12.6000E	Hydraulic Starter Accessories

Within each of these sub-groups, various designs of similar equipment are categorized as "Types" and identified by a Type Number.

The Distributor/Dealer has an Index for each engine model. The Index lists all of the "Standard" and "Standard Option" equipment for that model.



DETROIT DIESEL V-92 MPC 8063-7000 (RC)

STANDARD AND STANDARD OPTION EQUIPMENT

GROUP NAME	GROUP NO.	TYPE
CYLINDER BLOCK	1.1000	131
AIR BOX DRAINS	1.1000A	103
CYLINDER HEAD	1.2000	108
ENGINE LIFTER BRACKET	1.2000A	32
CRANKSHAFT	1.3000	60
CRANKSHAFT PULLEY	1.3000C	113
CRANKSHAFT PULLEY BELT	1.3000D	207
FLYWHEEL	1.4000A	825
FLYWHEEL HOUSING (SAE #1)	1.5000A	522
CONNECTING ROD AND PISTON	1.6000	146
CAMSHAFT AND GEAR TRAIN	1.7000	122
BALANCE WEIGHT COVER	1.7000A	44
VALVE OPERATING MECHANISM	1.8000	104
ROCKER COVER	1.8000A	186
FUEL INJECTOR 9280	2.1000A	116
FUEL PUMP	2.2000	126
FUEL FILTER	2.3000A	338
FUEL MAN[illegible]D CONNECTIONS	2.4000	55
[illegible]	[illegible]5000A	128[illegible]

NOTE The Distributor/Dealer uses his model index to interpret the standard equipment. The plate, therefore, lists only the non-standard or choice items.

So, from the plate, give the dealer the

A-Model No.
B-Unit No.
*C-Type No.
*(If not shown, indicate "NONE". The dealer knows the "standard" for the model).

FOR READY REFERENCE, Transfer the information on the Option Plate to this record.

MODEL NO.________________________ UNIT NO________________.

EQUIPMENT	TYPE	EQUIPMENT	TYPE	EQUIPMENT	TYPE
Engine Base		Water Bypass Tube		Battery Chrg. Generator	
Engine Lifter Brkt.		Thermostat		Starter	
Flywheel Housing		Water Filter		Hyd. Starter Acces.	
Vibration Damper		Exhaust Manifold		Starting Aid	
Flywheel		Air Cleaner or Silencer		Marine Gear	
Flywheel Hsg. Adptr.		Fuel Pump		Torque Converter	
Oil Pan		Injector		Torque Converter Lines	
Oil Pump		Blower		Muffler & Conn.	
Oil Distribution		Blower Drive Shaft		Engine Hood	
Dipstick		Fuel Filter		Wiring Harness	
Oil Pan Drain Tube		Fuel Lines		Instruments	
Oil Filler Tube or Cap		Air Inlet Housing		Tach. Drive	
Oil Cooler		Alarm or Shutoff		Radiator	
Oil Filter		Overspeed Governor		Heat Ex. or Keel Cooling	
Oil Lines		Throttle Controls		Raw Water Pump	
Ventilating System		Injector Controls		Power Generator	
Crankshaft Cover		Governor Mech or Hyd		Control Cabinet	
Balance Wgt. Cover		Engine Mounts		Cylinder Head	
Fan		Power Take-off		Conn Rod & Piston	
Crankshaft Pulley		Hydraulic Pump		Valve Mechanism	
Crankshaft Pulley Belt		Air Compressor		Fuel Manifold Conn	
Fan Shroud		Camshaft & Gear Train			
Water Connections		Rocker Cover			
Water Pump Cover		Accessory Drive			
Water Manifold					

OTHER USEFUL INFORMATION:

Each fuel and lube oil filter on your engine has a decal giving the service package part number for the element. It is advisable to have your own personal record of these part numbers by filling in the chart provided below:

TYPE	LOCATION	PACKAGE PART NO.
Fuel Strainer		
Fuel Filter		
Lube Oil Filter Ful1-Flo		
Lube Oil Filter By-Pass*		

*Not Standard

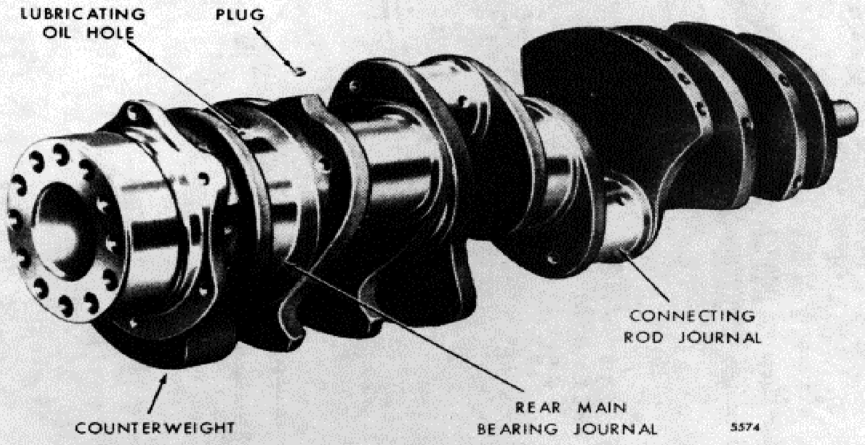
AIR CLEANER

If dry-type, indicate make and number of filter element:

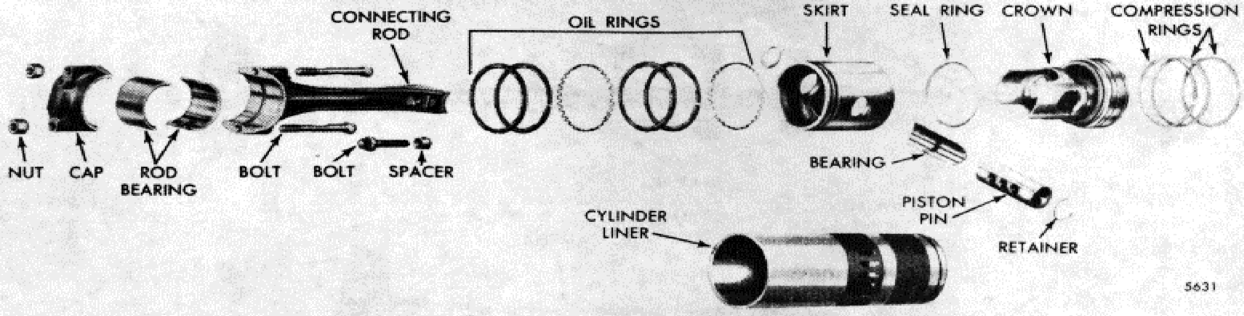
____

____

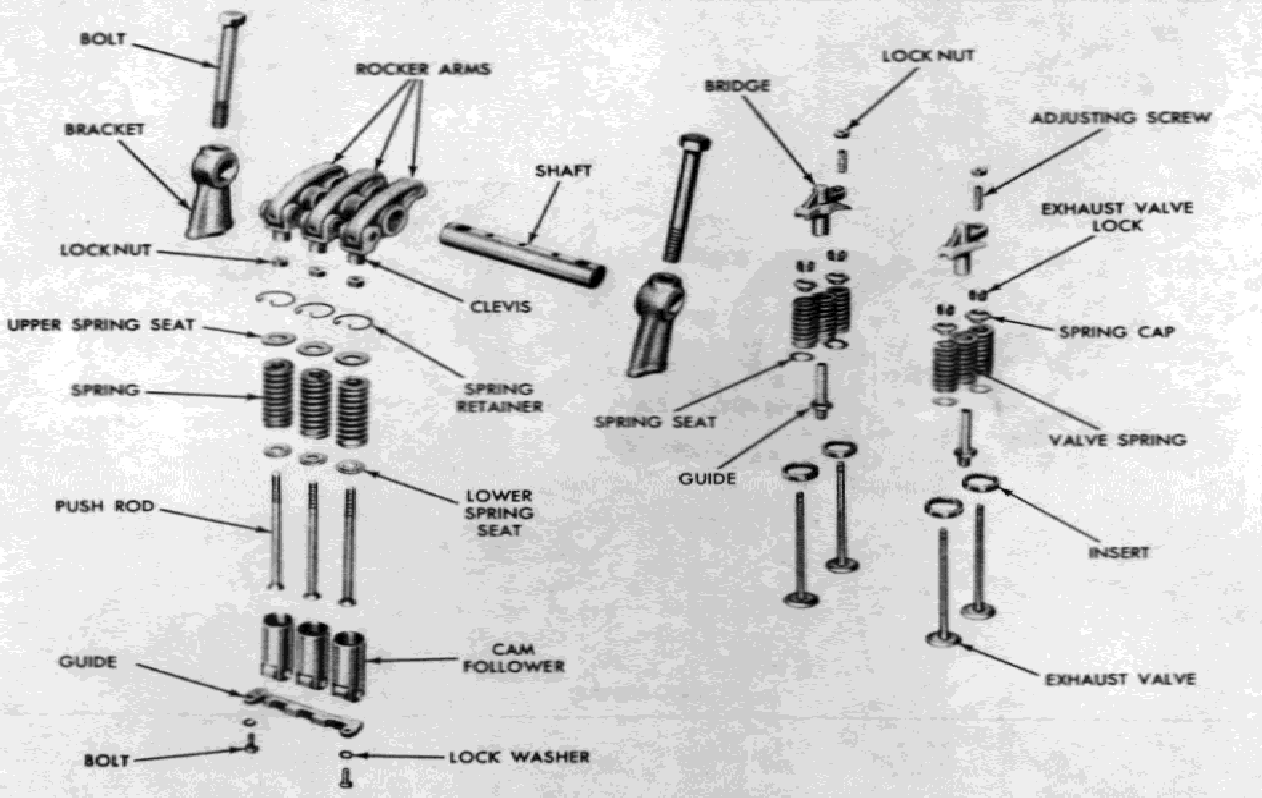
Wet type, indicate capacity__________ qts.



CRANKSHAFT

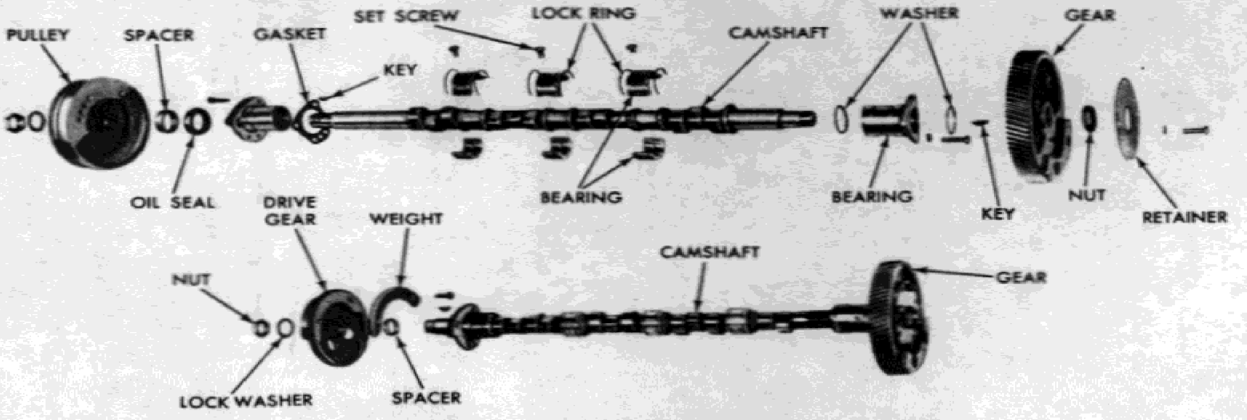


CONNECTING ROD, PISTON AND LINER



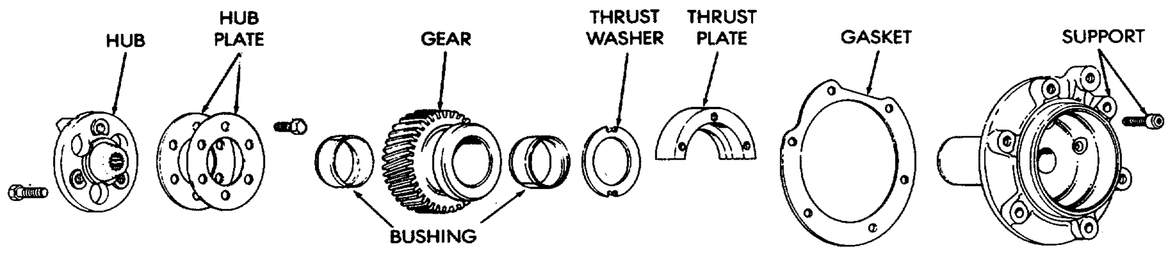
VALVE OPERATING MECHANISM (4 VALVE)

P 600A

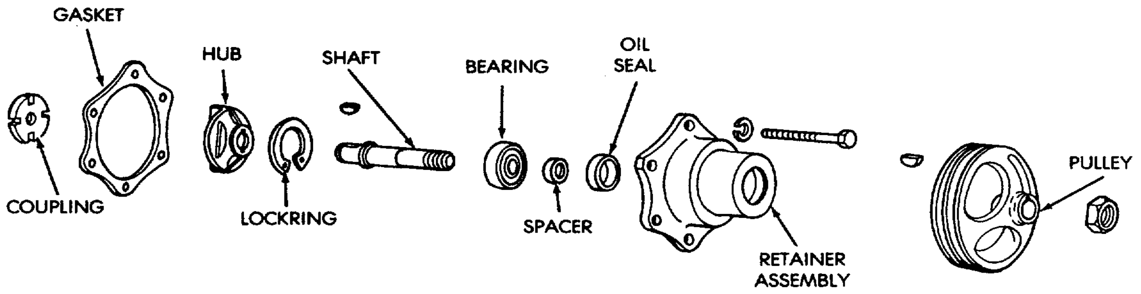


CAMSHAFT AND GEARS

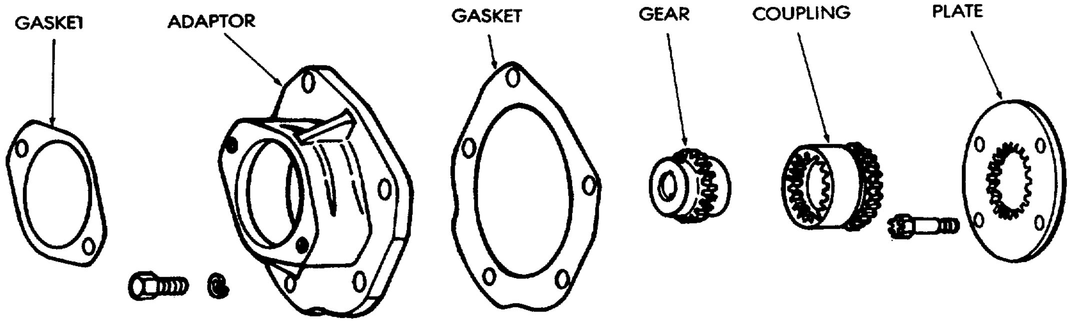
P 600



BLOWER DRIVE GEAR

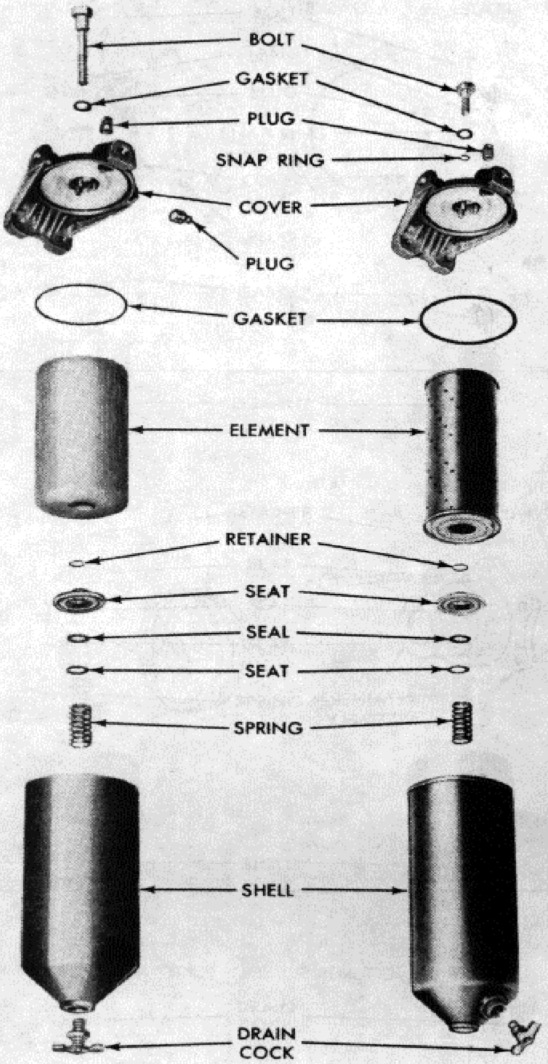


ACCESSORY DRIVE



ACCESSORY DRIVES

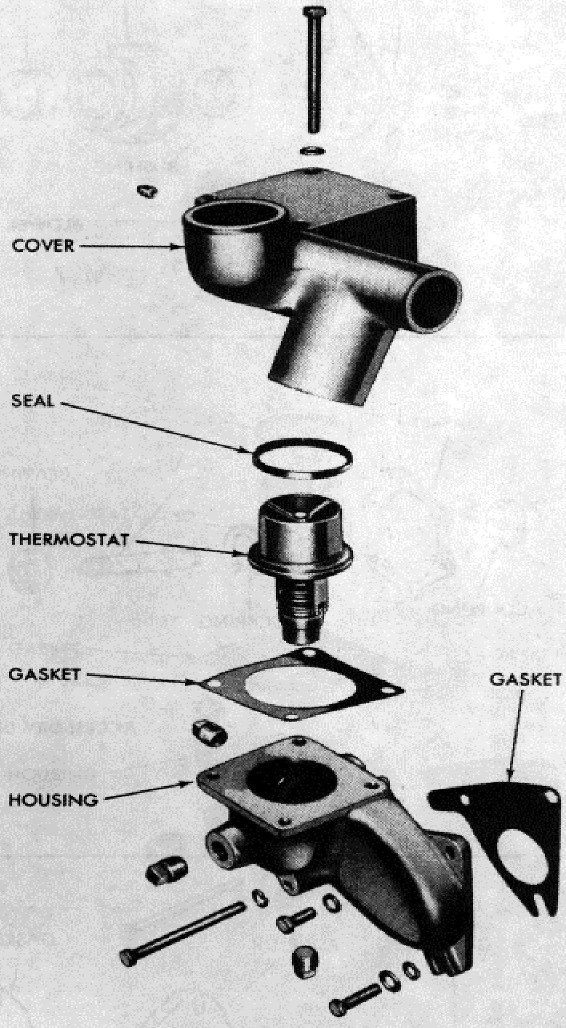
L-6370



TYPICAL FUEL OIL STRAINER

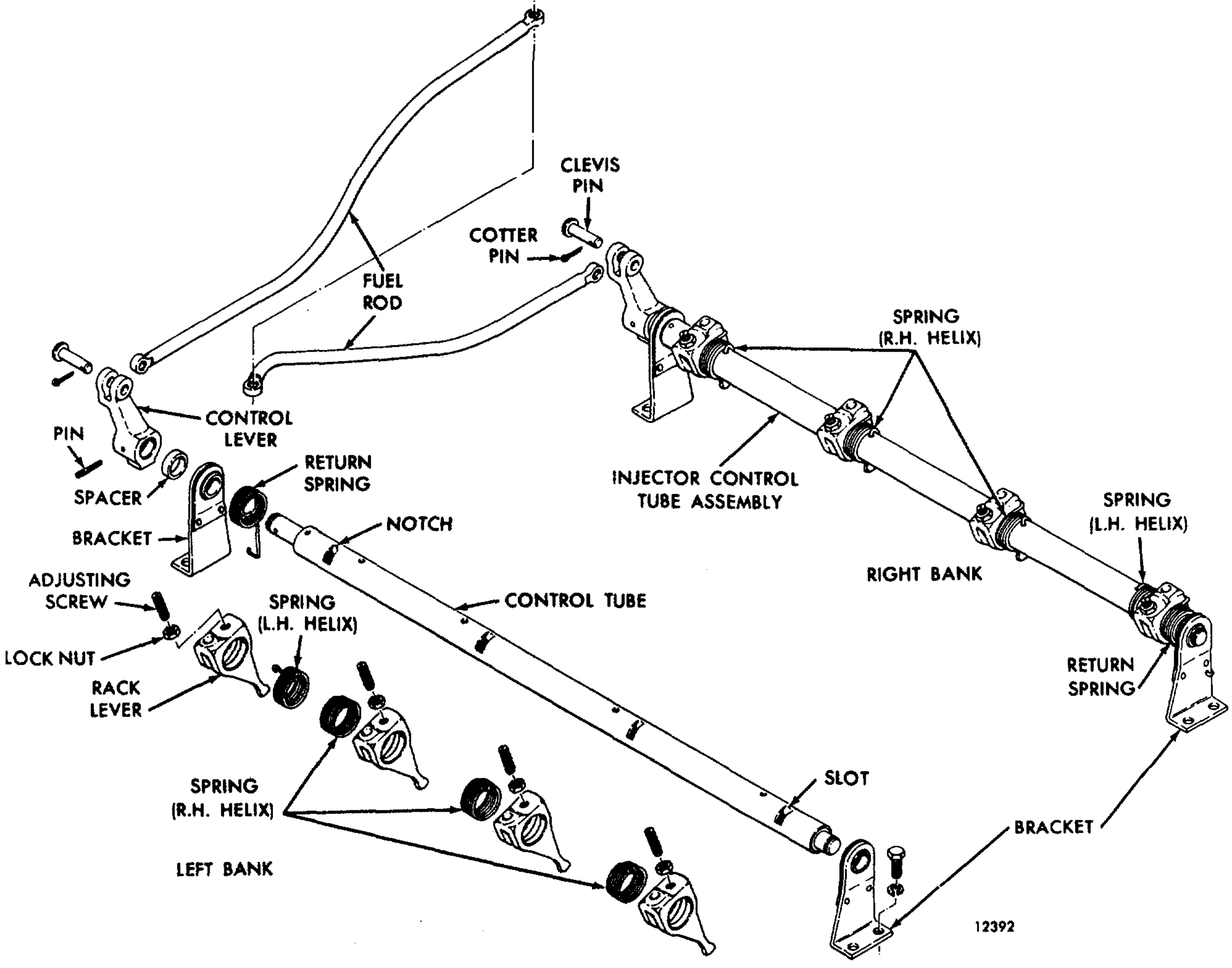
TYPICAL FUEL OIL FILTER

P 601A

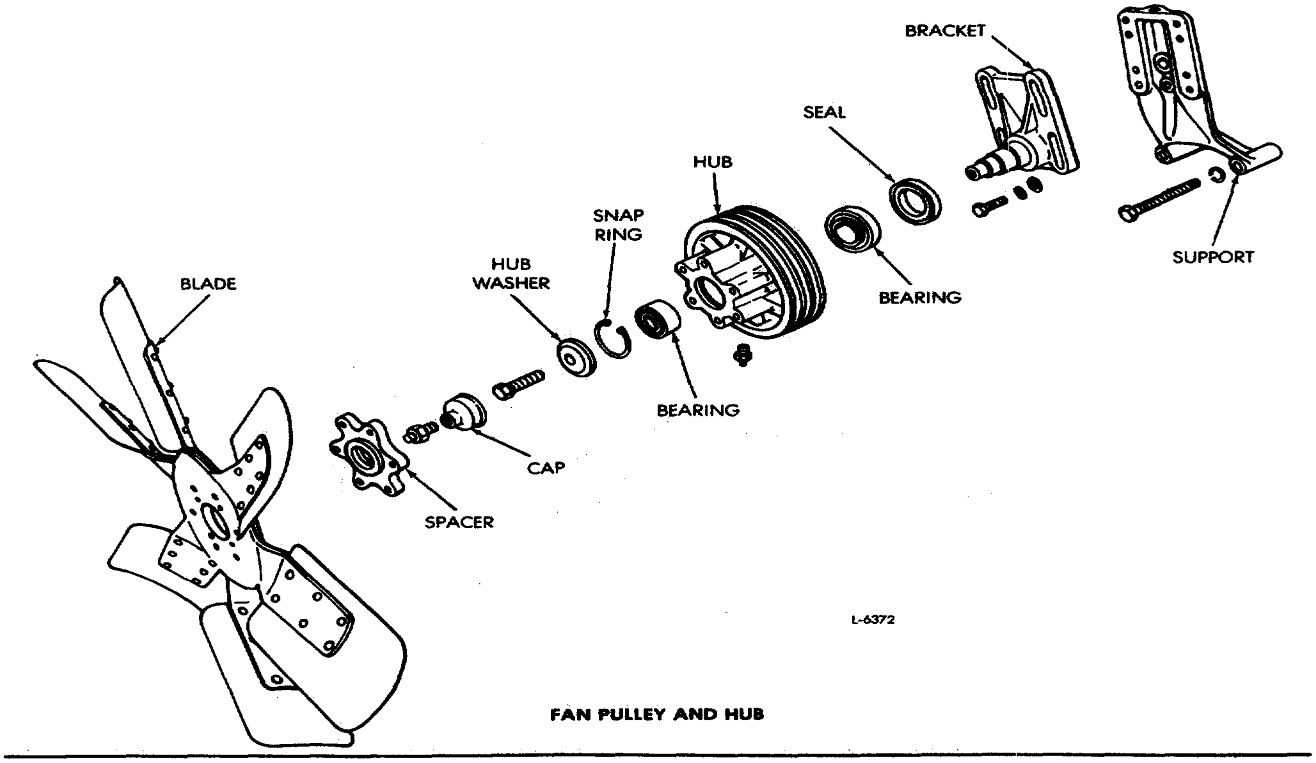


THERMOSTAT HOUSING

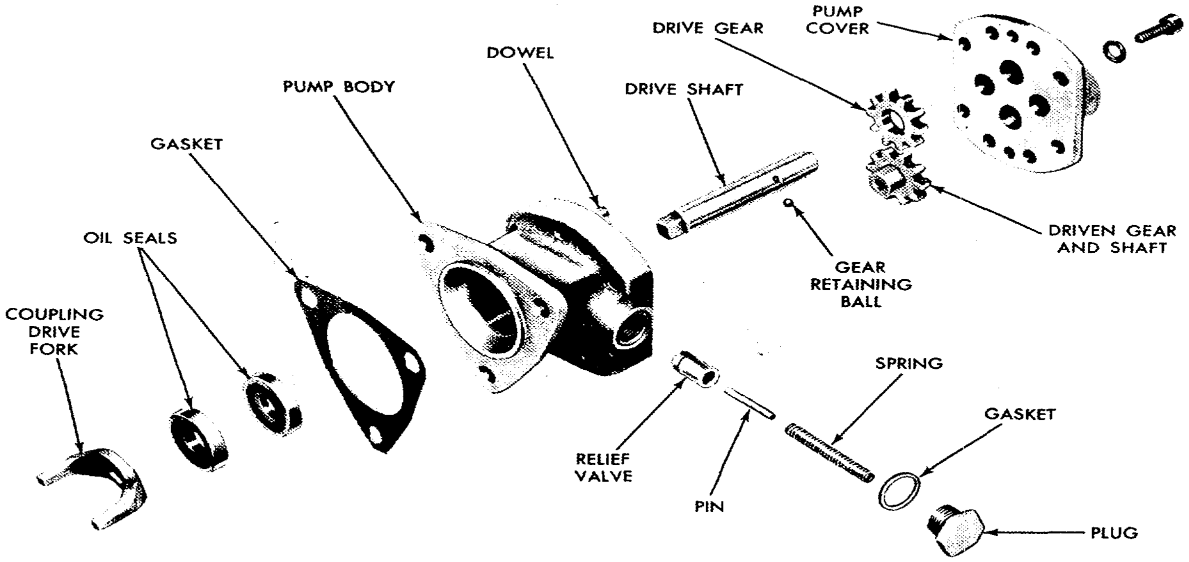
P 601



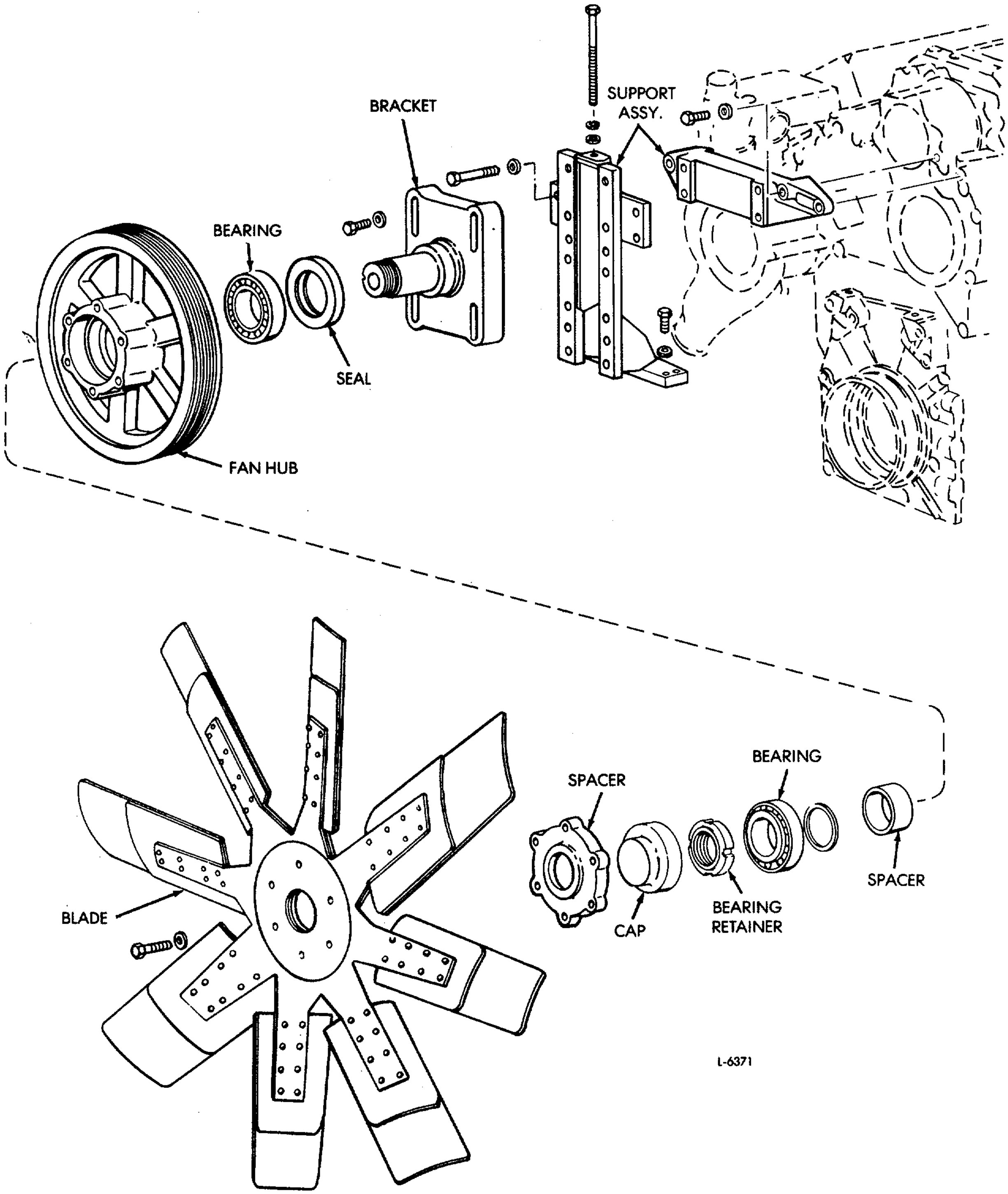
INJECTOR CONTROLS
(Spring-Loaded)



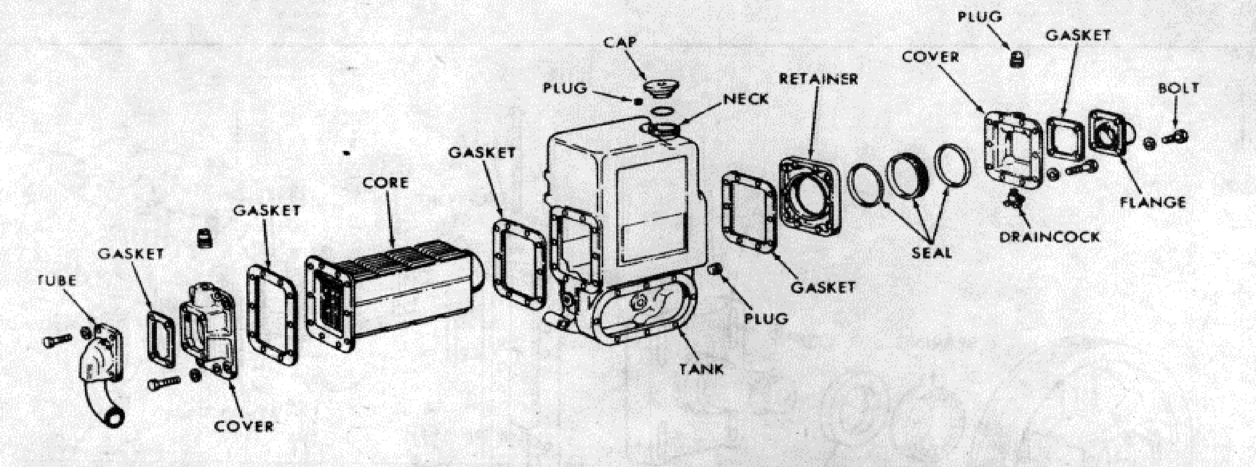
FAN PULLEY AND HUB

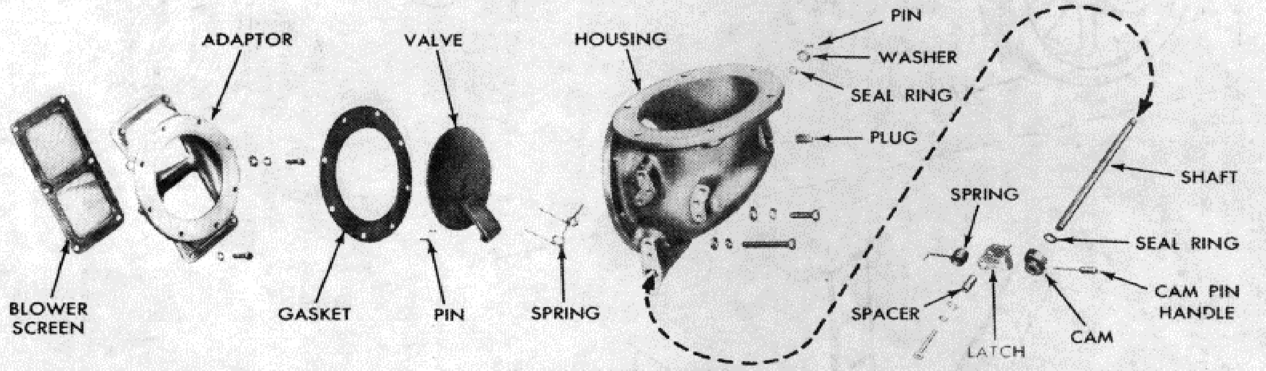


TYPICAL FUEL PUMP



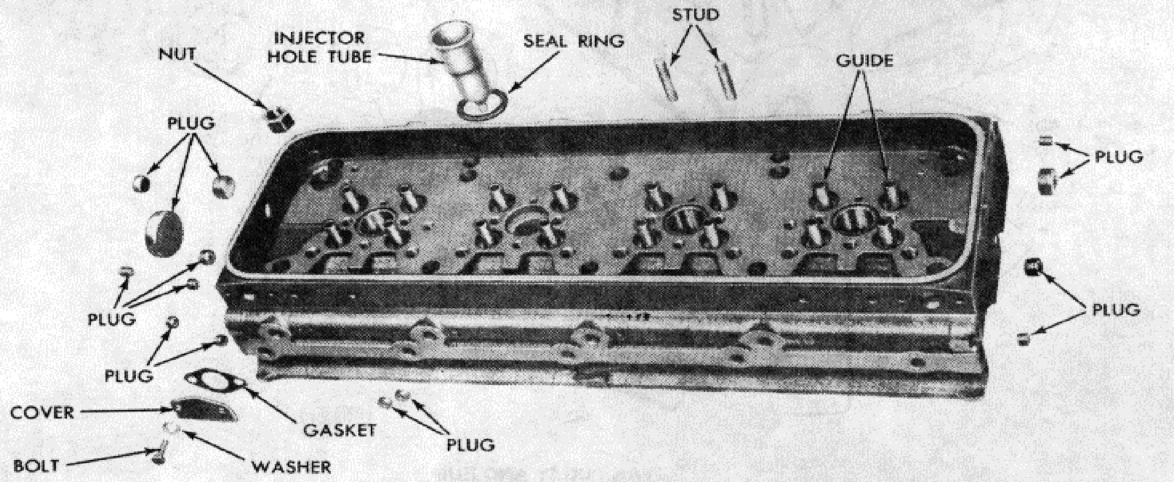
FAN PULLEY AND HUB





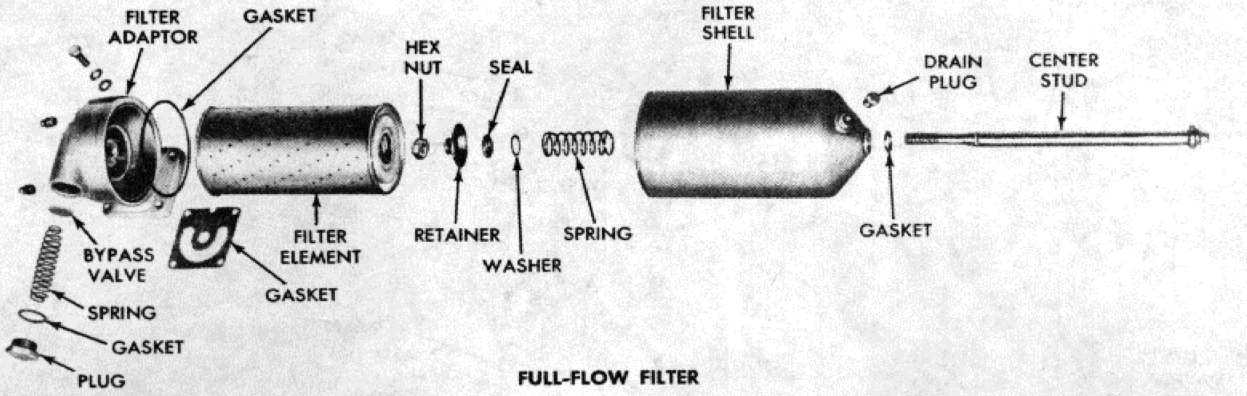
AIR SHUT DOWN HOUSING

P 604A



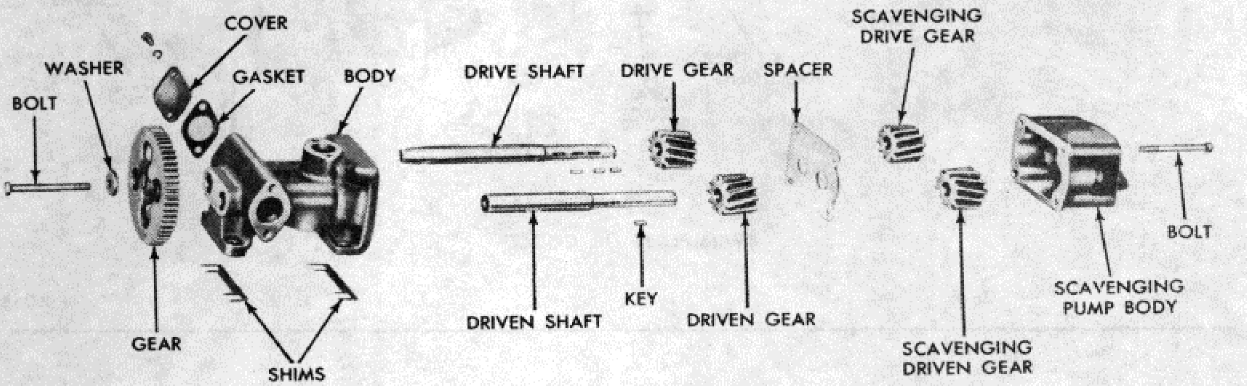
4 VALVE CYLINDER HEAD

P 604



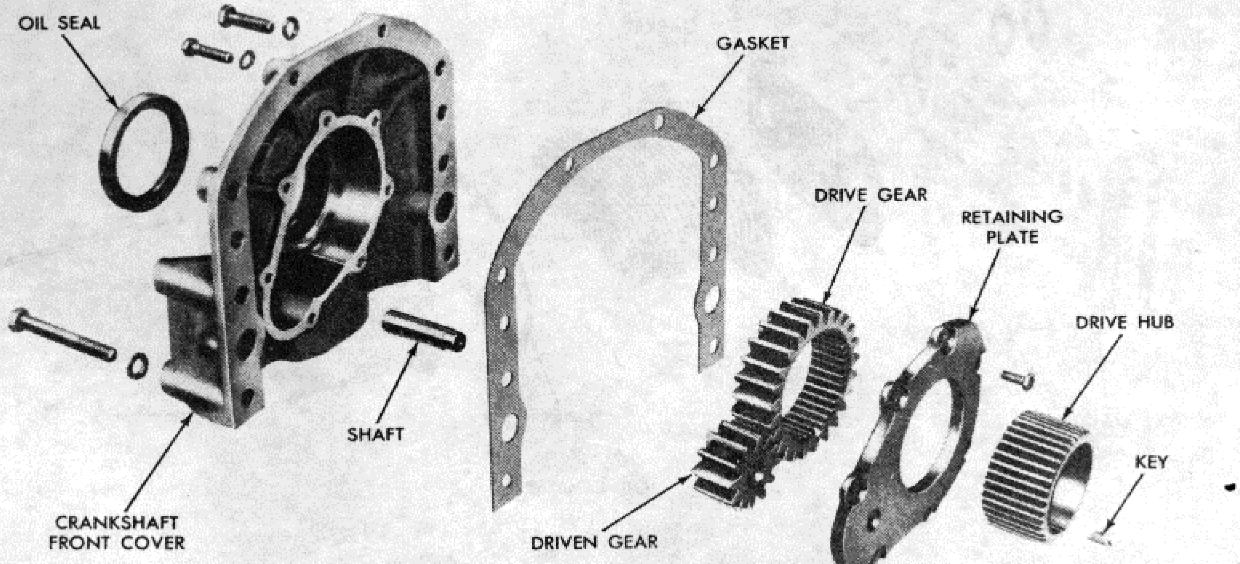
FULL-FLOW FILTER

P 605B



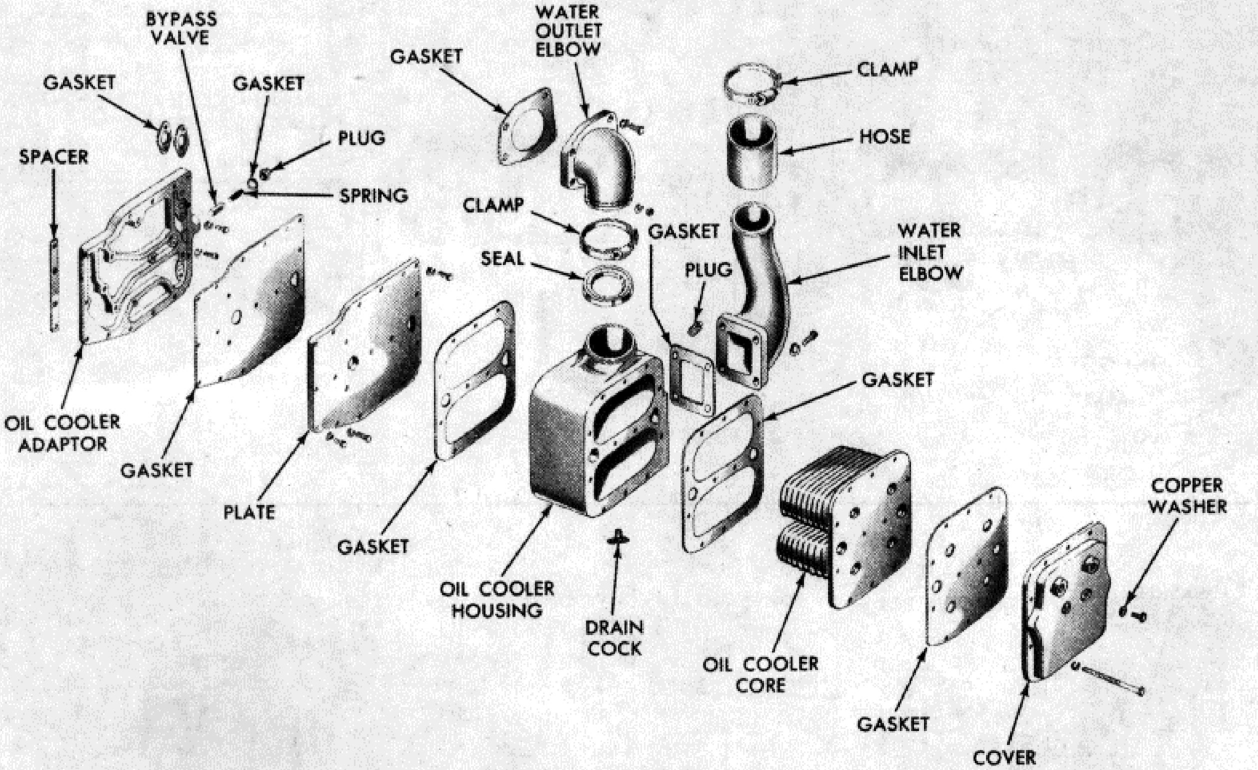
LUBRICATING OIL PUMP

P 605A



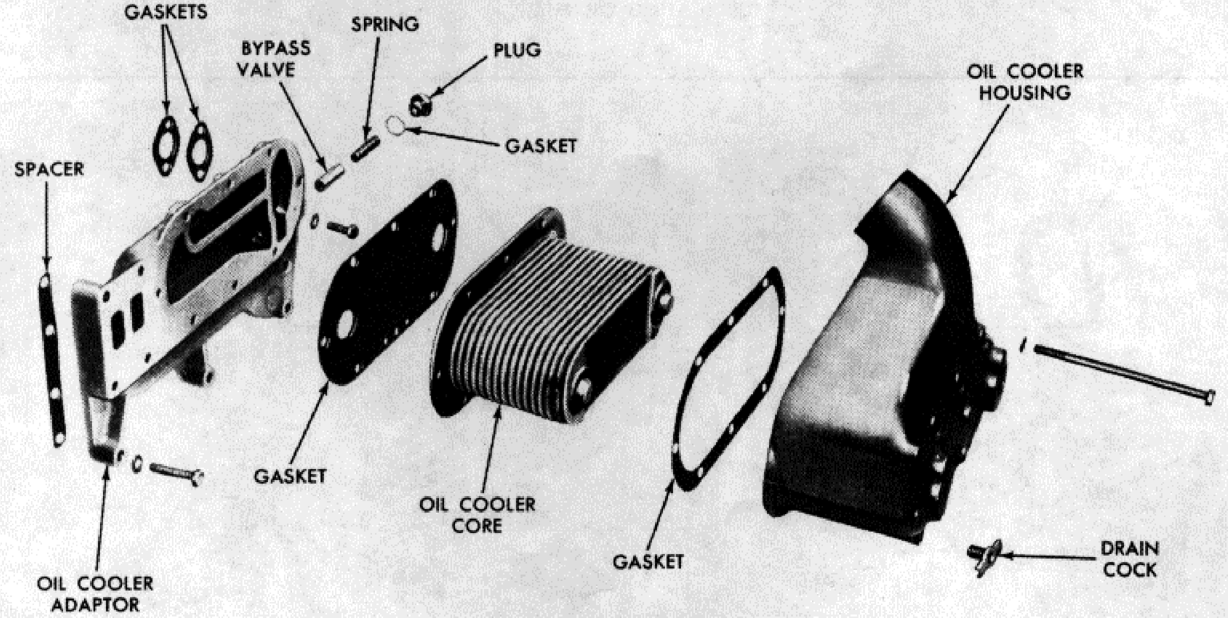
LUBRICATING OIL PUMP (6V OR 8V ENGINES)

P 605



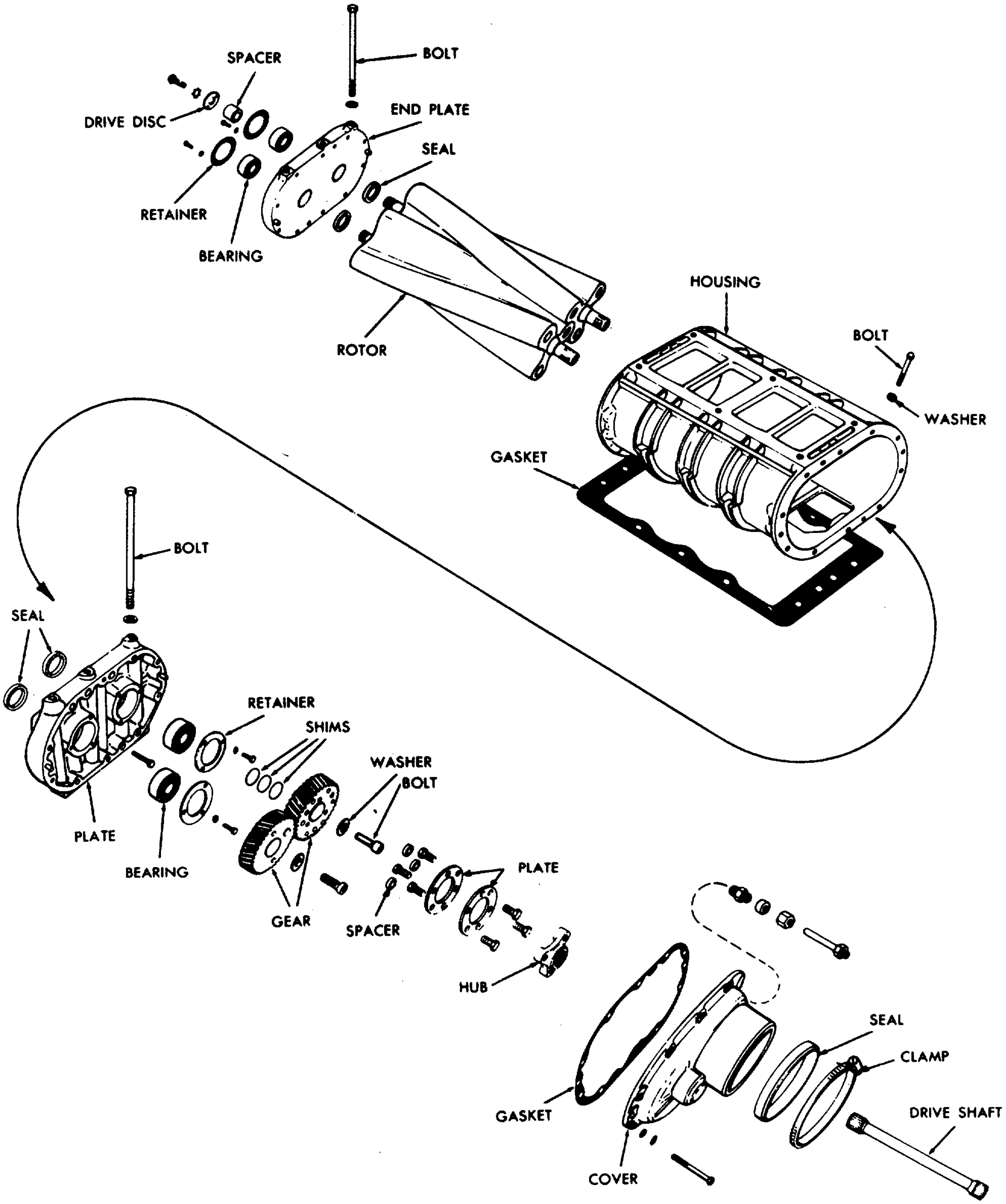
TWIN PLATE OIL COOLER

P 608B

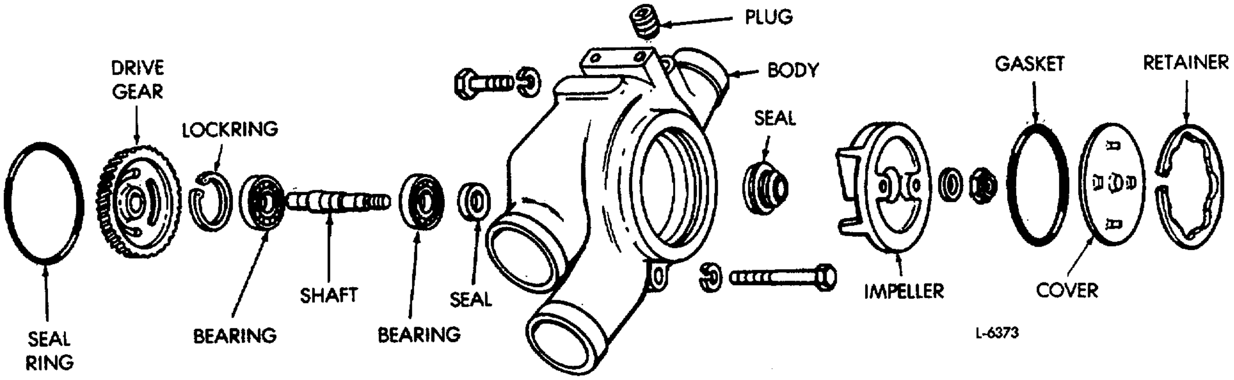


OIL COOLER

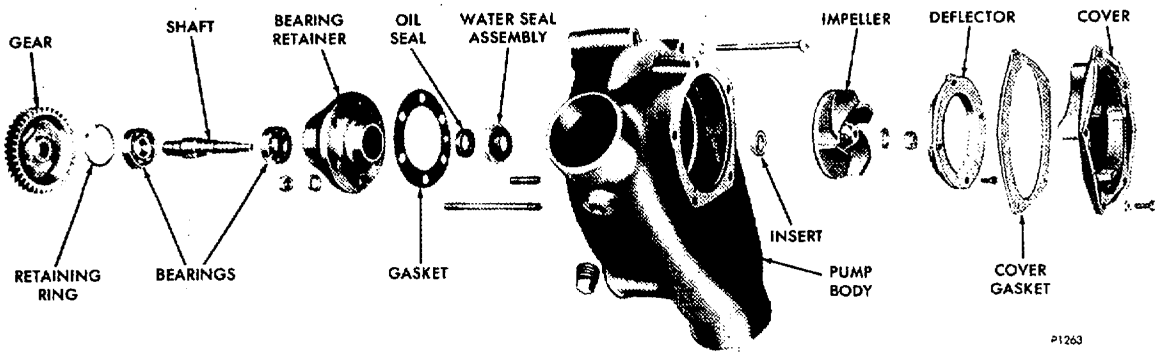
P 608


SPACER
BOLT
DRIVE DISC
END PLATE
SEAL
RETAINER
BEARING
HOUSING
ROTOR
BOLT
WASHER
GASKET
BOLT
SEAL
RETAINER
SHIMS
WASHER
BOLT
PLATE
BEARING
GEAR
SPACER
PLATE
HUB
SEAL
CLAMP
DRIVE SHAFT
GASKET
COVER

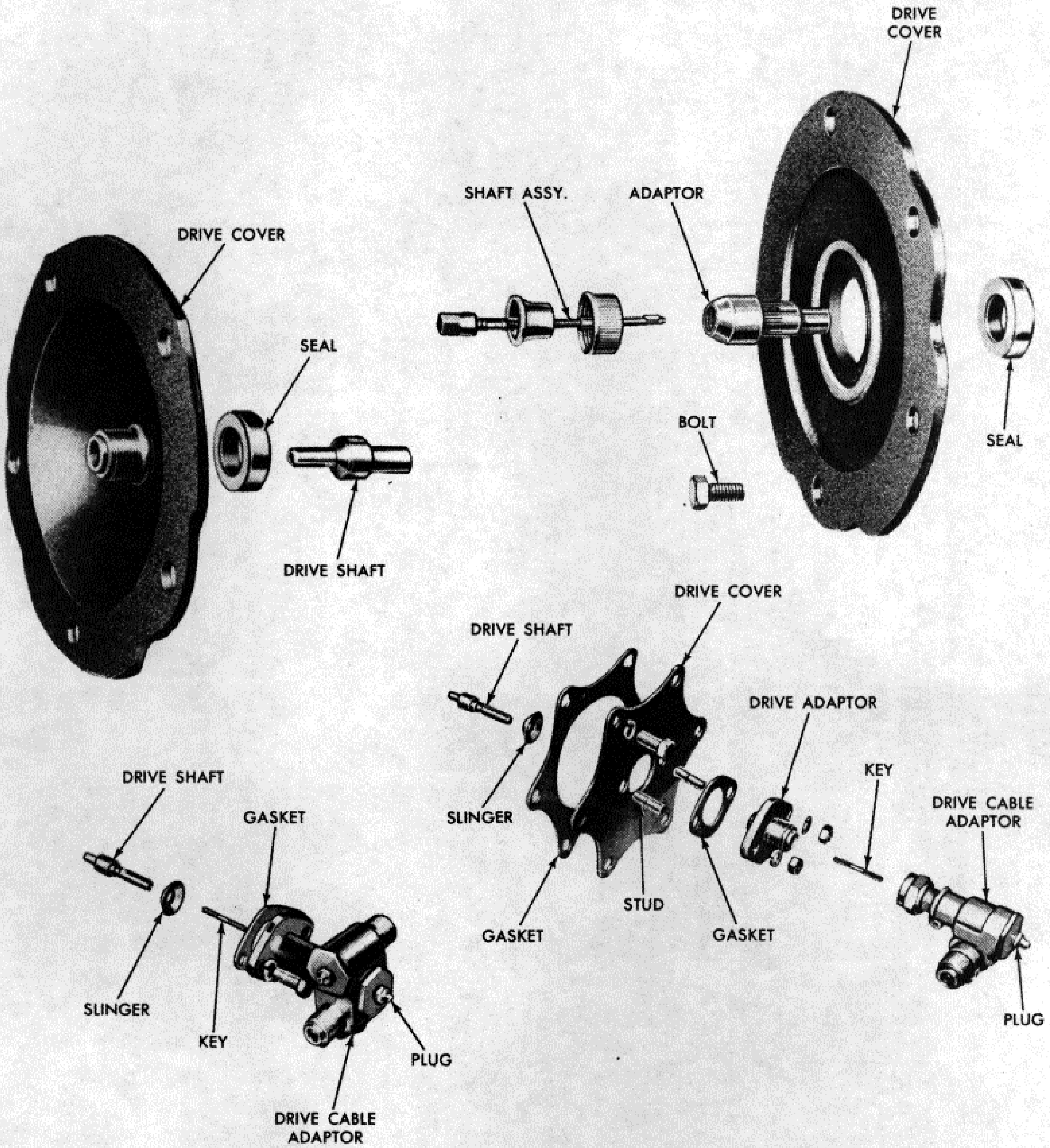
BLOWER



WATER PUMP (6V-92 and 8V-92)



WATER PUMP (12V-92 and 16V-92)



TACHOMETER DRIVE COVERS AND ADAPTORS

OWNER ASSISTANCE

The satisfaction and goodwill of the owners of Detroit Diesel engines are of primary concern to Detroit Diesel Allison and its authorized service outlets. We recognize, however, that despite the best intentions of everyone concerned, misunderstandings may occur. Normally, any such situation that arises in connection with the sale, operation or service of your engine will be handled by the authorized service outlets in your area (check the Yellow Pages for the Detroit Diesel Allison Service Outlet nearest you).

To further assure your complete satisfaction, we have developed the following three-step procedure to be followed in the event you have a problem that has not been handled satisfactorily.

Step One - **Discuss your problem with a member of management from the authorized service outlet.** Frequently, complaints are the result of a breakdown in communication and can quickly be resolved by a member of management. If you have already discussed the problem with the Sales or Service Manager, contact the General Manager. If your problem originates with a dealer, explain the matter to a management member of the distributorship with whom the dealer has his service agreement.

Step Two - When it appears that your problem cannot readily be resolved at the distributor level without additional assistance, **contact the responsible Detroit Diesel Allison Regional Office in your area** listed below:

Eastern Region
9 Sylvan Way
P. O. Box 3001
Parsippany, New Jersey 07054, U. S. A.
Phone: (201) 993-4046

Great Lakes Region
Suite 365 - New Center One
3031 General Motors Blvd.
Detroit, Michigan 48202, U. S. A.
Phone: (313) 556-5800

Southwestern Region
General Motors Bldg.
130 E. Carpenter Freeway
Irving, Texas 75062, U. S. A.
Phone: (214) 659-5070

Latin America Region
Detroit Diesel Allison
Gables Center - Suite 321
95 Merrick Way
Coral Gables, Florida 33144, U. S. A.
Phone: (305) 446-4900

Pacific Region
Detroit Diesel Allison
Div. of GM - Holden's Ltd.
Princes Highway, P. O. Box 163
Dandenong, Victoria 3175
Australia
Phone: 03-797-01111

Southeastern Region
5730 Glenridge Drive N. E.
Atlanta, Georgia 30328, U. S. A.
Phone: (404) 257-3640

Midwestern Region
475 Alexis R. Shuman Blvd.
Naperville, Illinois 60566, U. S. A.
Phone: (312) 961-6750

Western Region
Suite 2700
39465 Paseo Padre Parkway
Fremont, California 94538, U. S. A.
Phone: (415) 498-5200

Canada
Diesel Division - GM of Canada Ltd.
P. O. Box 5990
London, Ontario N6A 4L6, Canada
Phone: (519) 452-5000
Telex: 064-5850

European Region
Detroit Diesel Allison - Europe
Div. of GM Continental, S. A. Nederland
Parmentierplein 1, 3088 GN Rotterdam
Mail: P. O. Box 5061
3008 AB Rotterdam, Netherlands
Phone: 010-290-000

Asia Region
Detroit Diesel Allison
Division of GM Overseas Dist. Corp.
15 Benoi Sector
Jurong Town
Singapore 2262
Phone: 265-4697

Middle East/Africa Region
Detroit Diesel Allison
Athens Towers
Messoghion 2/4
Athens 610, Greece
Phone: 1-7785-344 or 1-7706-669
or 1-7787-281

Prior to this call, have the following information available:

- * Name and location of distributor or dealer.
- * Type and make of equipment.
- * Engine model and serial number.
- * Engine delivery date and accumulated miles or hours of operation.
- * Nature of problem.
- * Chronological summary of unit's history.

Step Three - If you are still not satisfied, present the entire matter in writing or by phone to the **Product Headquarters:**

Diesel Operations - Manager Customer Services, Detroit Diesel Allison, 13400 W. Outer Drive, Detroit, Michigan 48239, Phone (313) 592-5608.

The inclusion of all pertinent information will assist the product headquarters in expediting the handling of the matter. If an additional review by the product headquarters of all the facts involved indicates that some further action can be taken, the Regional Office will be so instructed.

If at this point your problem is still not resolved to your satisfaction, call or write:

Manager, Diesel Engine Service, Detroit Diesel Allison, 13400 W. Outer Drive, Detroit, Michigan 48239, U. S. A. Phone: (313)592-7279.

When contacting the Regional Office or product headquarters, please keep in mind that ultimately your problem will likely be resolved at the distributorship or dealership using their facilities, equipment and personnel. Therefore, it is suggested that you follow the above. steps in sequence when experiencing a problem.

Your purchase of a Detroit Diesel Allison product is greatly appreciated, and it is our sincere desire to assure complete satisfaction.

6SE323 (REV. 4/82)

SECTION 6

Operators Manual

V-71 Engines

Detroit Diesel Allison
13400 W. Outer Drive
Detroit, Michigan 48239

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

Printed in U.S.A.

TO THE OPERATOR

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

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

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

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

WARRANTY

The applicable engine warranty is contained in the form entitled WARRANTY INFORMATION on DETROIT DIESEL ENGINES, available from authorized Detroit Diesel Allison Service Outlets.

SAFETY IS YOUR BUSINESS

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

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

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune, disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.

An accident can be prevented with your help.

SECTION 6
TABLE OF CONTENTS

DESCRIPTION

PRINCIPLES OF OPERATION

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

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

The Two-Cycle Principle

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

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

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

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

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

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

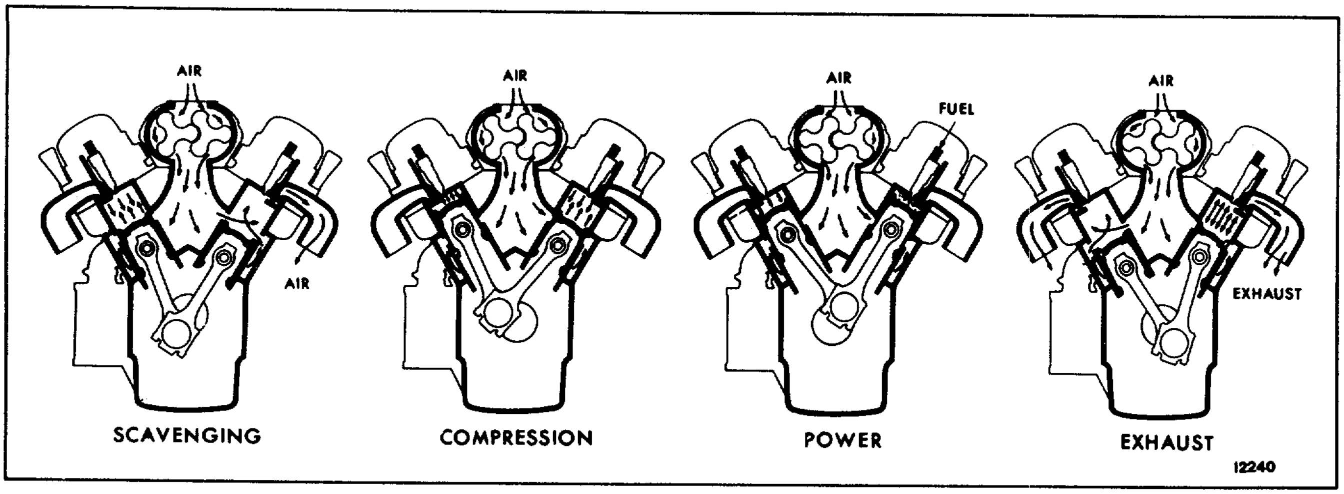


Fig. 1. - The Two-Stroke Cycle

GENERAL DESCRIPTION

The V-71 engines (6, 8, 12 and 16 cylinder models) covered by this manual have the same bore and stroke and use many of the same parts.

All cylinder blocks are symmetrical in design thus permitting oil cooler or starter installation on the same side or on opposite sides of the engine, depending upon the installation requirements. The engines are built with right-hand or left-hand crankshaft rotation. For example, the crankshaft in an RC engine, viewed from the flywheel end, will rotate counterclockwise, the oil cooler will be mounted on the right-hand side of the engine and the starter will be on the left-hand side of the engine (Fig. 2).

There are eight basic engine models. The letter L or R indicates left or right-hand engine rotation as viewed from the front of the engine. The letter A, B, C or D designates the location of the starter and oil cooler as viewed from the rear (flywheel) end. For the meaning of each digit in the model numbering system, refer to Fig. 2.

The engines are normally equipped with an oil cooler, lubricating oil filter(s), fuel oil strainer, fuel oil filter, air cleaner(s) or silencer(s), governor, heat exchanger and raw water pump or fan and radiator and a starter.

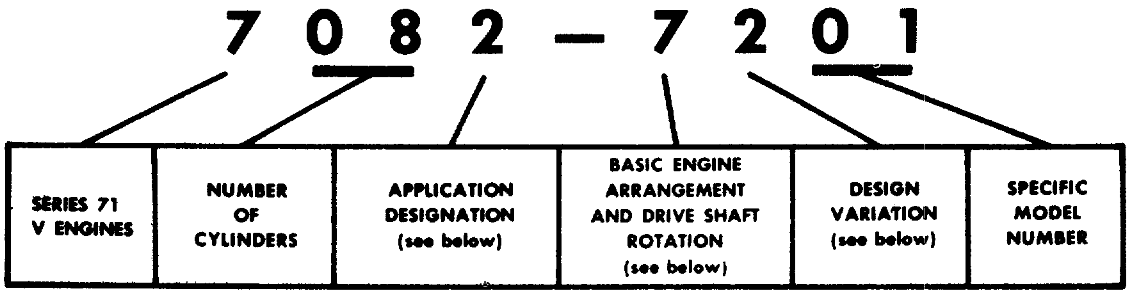
Fuel is drawn from the supply tank and through a strainer by a gear-type fuel pump, then it is forced through the filter and the fuel inlet manifolds in the cylinder heads to the injectors. Excess fuel is returned to the supply tank via the return fuel manifolds and connecting lines. Since fuel is constantly circulating through the injectors, it serves to cool the injectors and carry off any air in the fuel system.

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

Full pressure lubrication is supplied to all main, connecting rod and camshaft bearings, and to other moving parts of the engine. A gear-type pump draws oil from the oil pan through an intake screen and delivers it to the oil filter(s) and then to the oil cooler(s). From the oil cooler(s) the oil flows through passages that connect with the oil galleries in the cylinder block and cylinder heads for distribution to the bearings, rocker arm mechanism and other functional parts.

Coolant is circulated through the engine by a centrifugal type water pump. Heat is removed from the coolant, which circulates in a closed system, by either a radiator or heat exchanger. Control of the engine temperature is accomplished by thermostats that regulate the flow of the coolant within the cooling system.

Engine starting is provided by either a hydraulic or an electrical starting system. Engine speed is controlled by a governor. Some engines have a mechanical limiting speed governor, some a mechanical variable speed governor, and other engines use a limiting speed or a variable hydraulic governor. The engine application determines which type of governor is used.



APPLICATION DESIGNATION:

7082-7200	MARINE
7083-7200	INDUSTRIAL F-F
7084-7200	POWER-BASE
7085-7200	GENERATOR
7087-7200	VEHICLE F-F
7088-7200	SPECIAL

DESIGN VARIATION:

7082-7000	V-71 "N" ENGINE
7082-7100	2 VALVE HEAD ENGINE
7082-7200	4 VALVE HEAD ENGINE
7082-7300	TURBOCHARGED ENGINE
7082-7400	AFTERCOOLED ENGINE
7082-7500	CUSTOMER SPEC. ENGINE

BASIC ENGINE ARRANGEMENTS:

Rotation: L (left) and R (right) designates rotation viewed from the front of the engine.

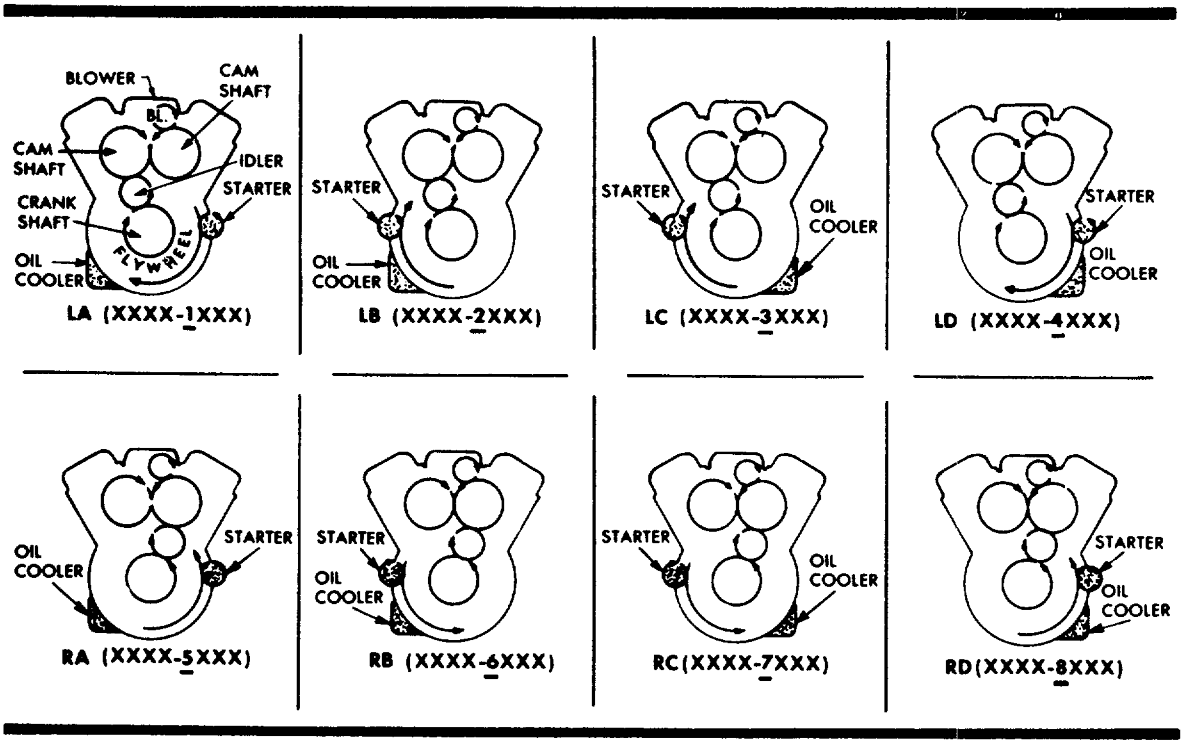
Type: A-B-C-D designates location of starter and oil cooler as viewed from the rear (flywheel) end.

Cylinder Bank: Left and right cylinder banks are determined from rear of engine.

DRIVE SHAFT ROTATION:

7242-0200	LEFT-HAND
7242-9200	RIGHT-HAND

Drive shaft rotation: shaft rotation on multiple units is determined from the rear of the unit.



ALL ABOVE VIEWS FROM REAR OF ENGINE 11473

Fig. 2. - Model Description, Rotation, and Accessory Arrangement

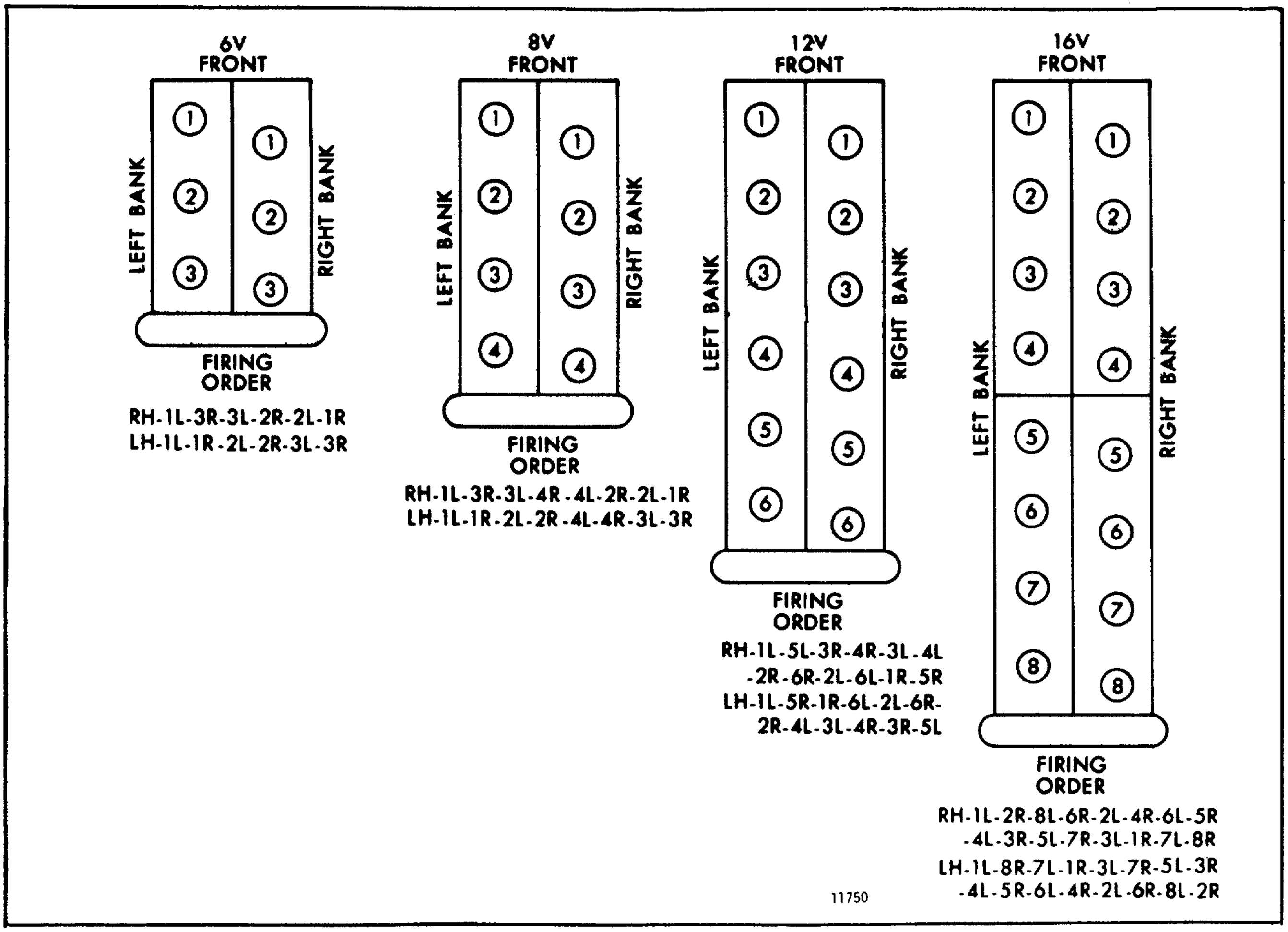


Fig. 3. - V-71 Cylinder Designation and Firing Order

GENERAL SPECIFICATIONS

	6V	8V	12V	16V
Type	2 Cycle	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	6	8	12	16
Bore (inches)	4.25	4.25	4.25	4.25
Bore (mm)	108	108	108	108
Stroke (inches)	5	5	5	5
Stroke (mm)	127	127	127	127
Compression Ratio (Nominal) (Standard Engines)	17 to 1	17 to 1	17 to 1	17 to 1
Compression Ratio (Nominal)("N" Engines)	18.7 to 1	18.7 to 1	18.7 to 1	18.7 to 1
Total Displacement - cubic inches	426	568	852	1136
Total Displacement - liters	6.00	9.32	13.97	18.63
Number of Main Bearings	4	5	7	10

ENGINE MODEL AND SERIAL NUMBER DESIGNATION

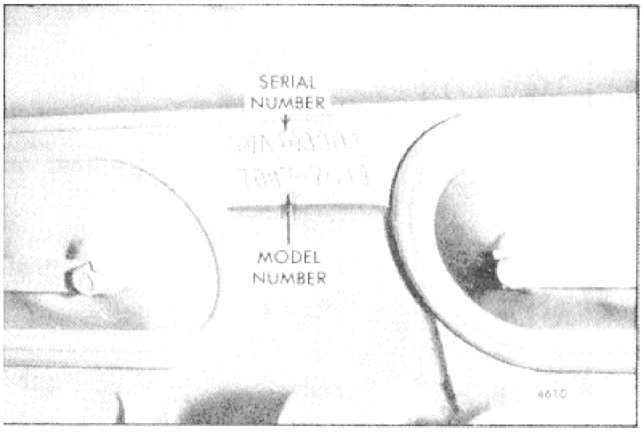


Fig. 4. - Typical Engine Serial Number and Model Number as Stamped on Cylinder Block

The engine serial number and model number are stamped on the right-hand side of the cylinder block (Fig. 4).

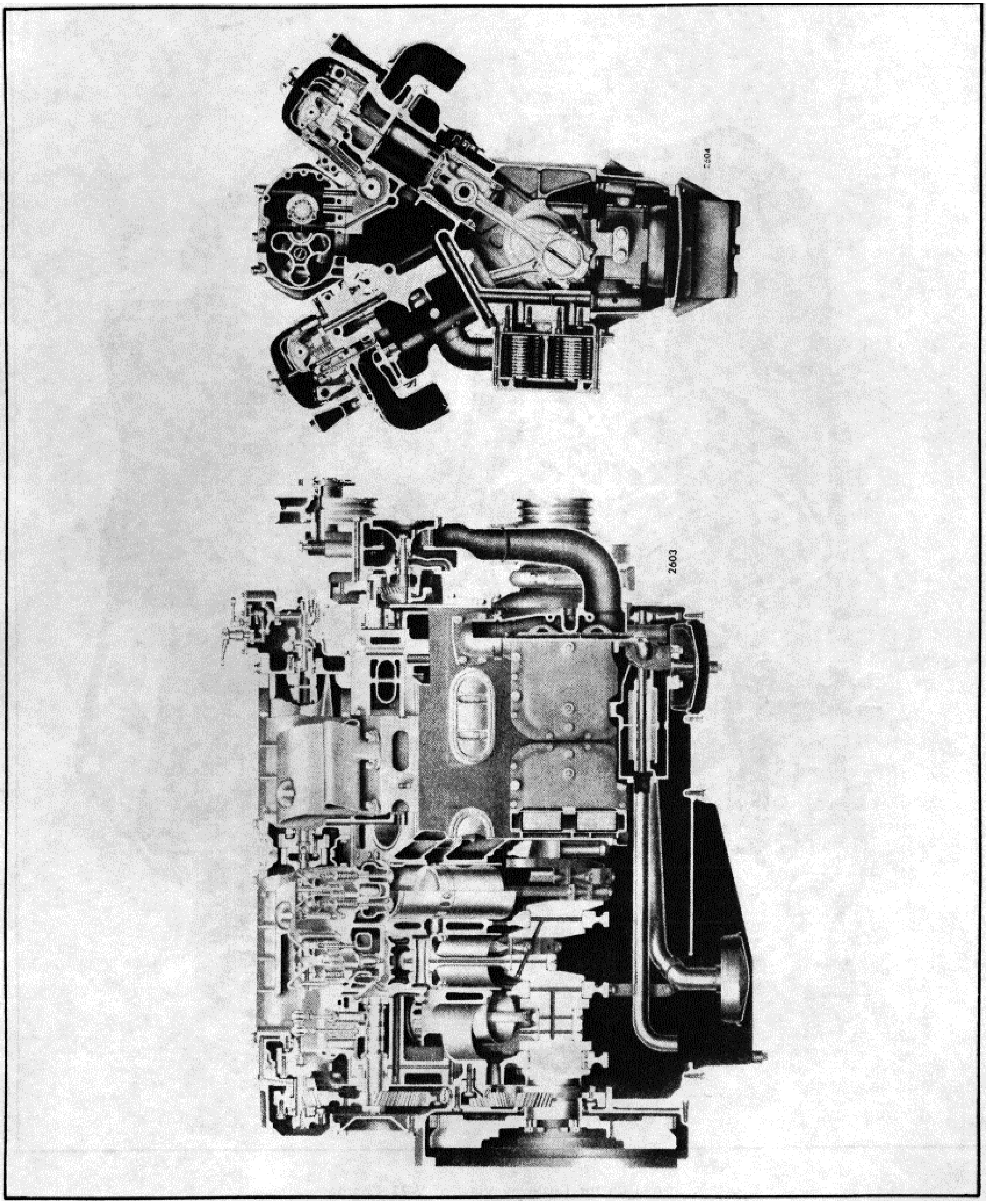
Engines with optional equipment have an option plate attached to one of the valve rocker covers. The engine serial number and model number are also stamped on this plate.

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

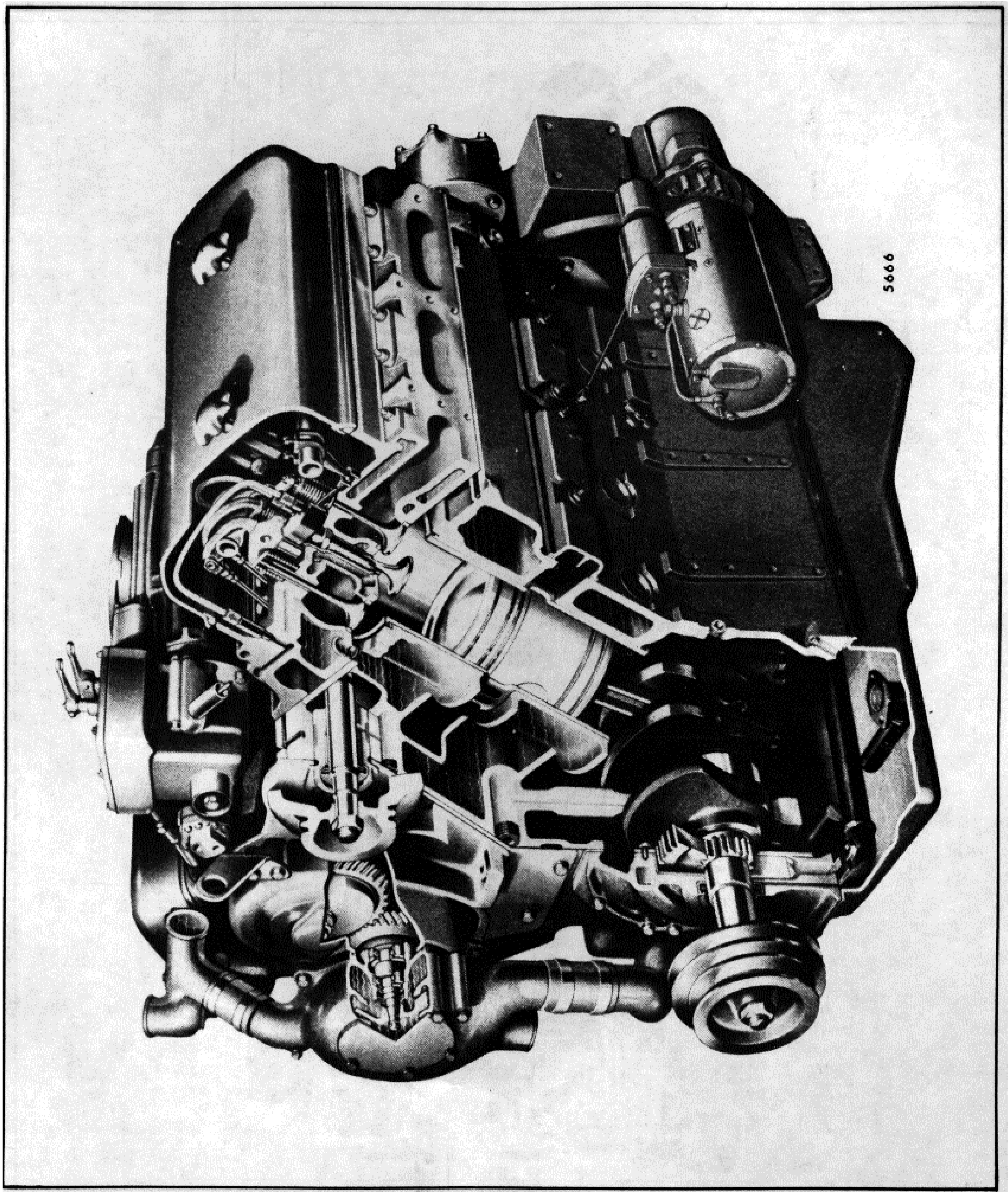
BUILT-IN PARTS BOOK

The *Built-in Parts Book* is a photo etched aluminum plate (option plate) that fits into a holding channel on one of the engine valve rocker covers and contains the necessary information required when ordering parts. It is recommended that the engine user read the section on the *Built-In Parts Book* in order to take full advantage of the information provided on the engine option plate.

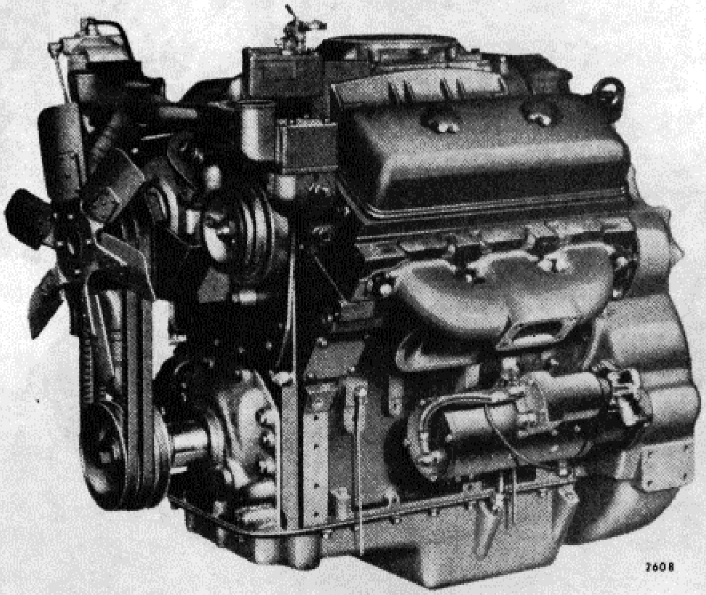
Numerous exploded view type illustrations are included to assist the user in identifying and ordering service parts.



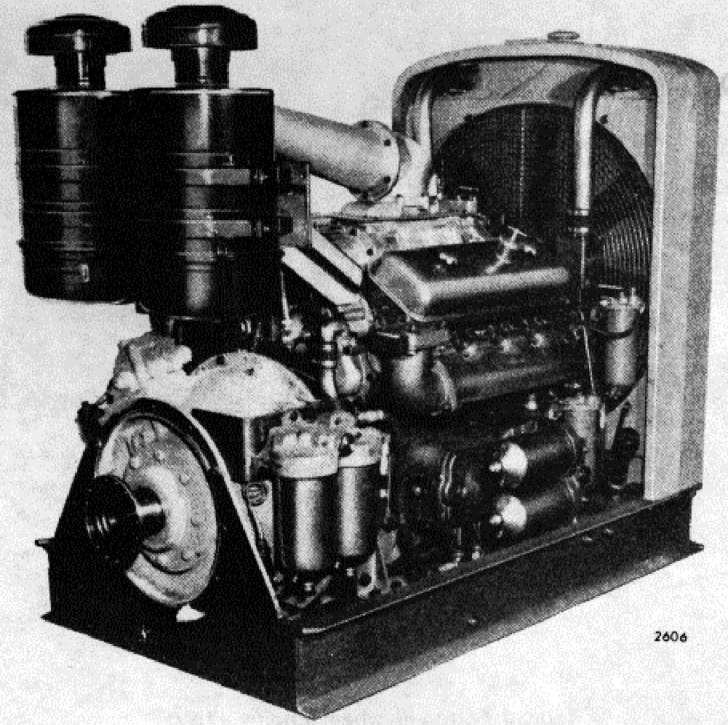
Cross Section Views of a typical V-71 Engine



Three-Quarter Cutaway view of V-71 Engine

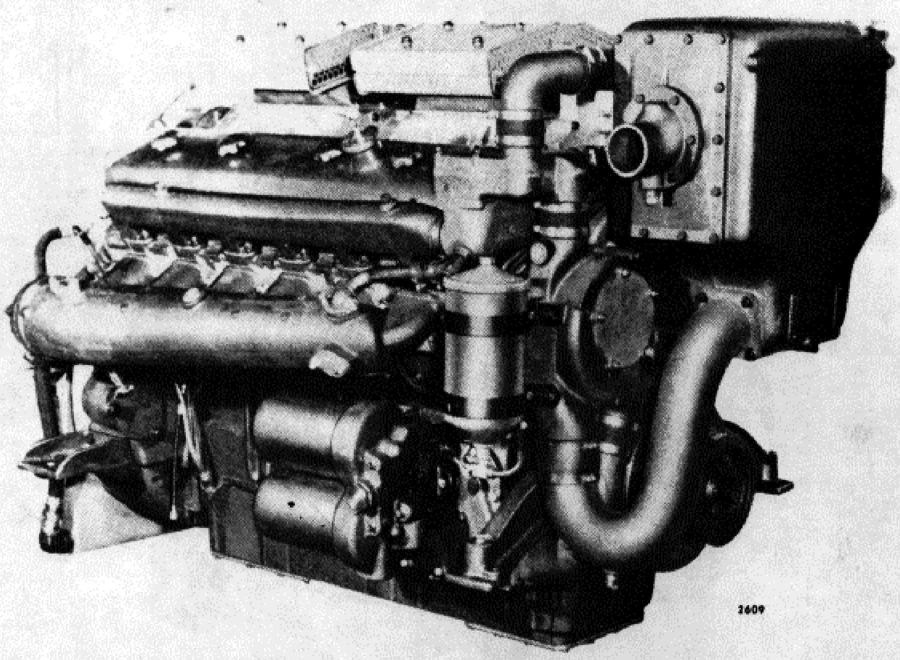


Typical Fan-to-Flywheel Unit (6V)

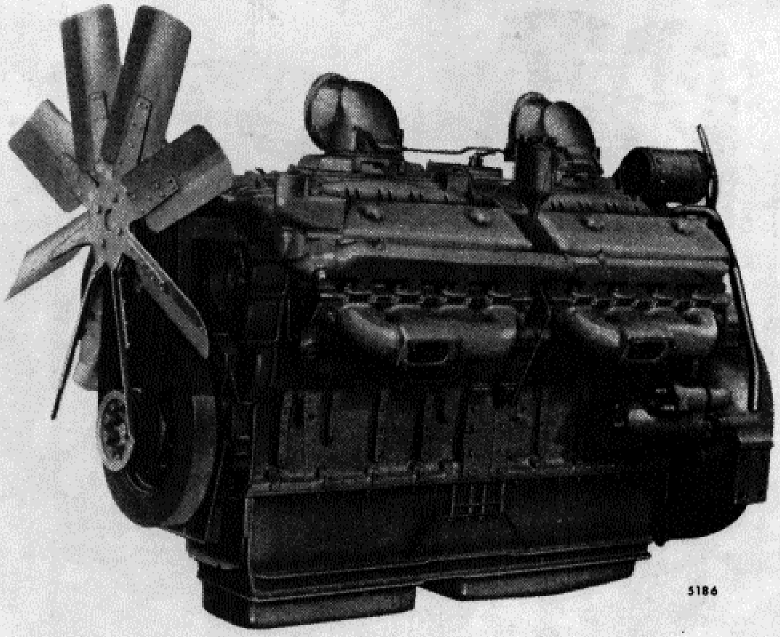


Typical Industrial Torque Converter Unit (8V)

Typical Industrial Torque Converter Unit (8V)



Typical Marine Propulsion Engine (12V)



Typical Fan-to-Flywheel Engine (16V)

ENGINE SYSTEMS

The V-71 Detroit Diesel engines incorporate four basic systems which direct the flow of fuel, air. Lubricating oil and engine coolant.

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

FUEL SYSTEM

The fuel system (Fig. I) consists of the fuel injectors, fuel pipes, fuel pump, fuel strainer, fuel filter and the necessary connecting fuel lines.

A restricted fitting is located in the outlet passage in one of the cylinder heads on 6, 8 and 12V engines to maintain pressure in the fuel system. Two of the cylinder heads on 16V engines have a restricted fitting.

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

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

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

Fuel Injector

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

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

Remove Injector

An injector may be removed in the following manner:

1. Remove the valve rocker cover.

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

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

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

> **NOTE**: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation

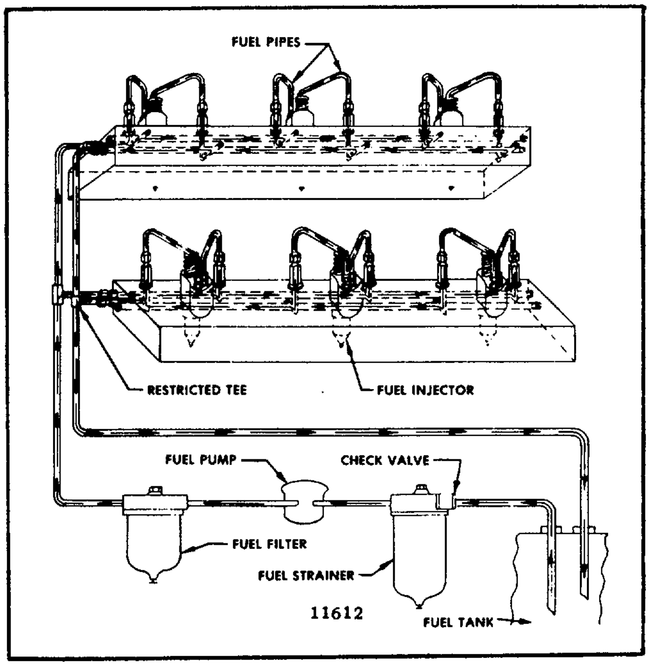


Fig. 1. - Schematic Diagram of Typical Fuel System

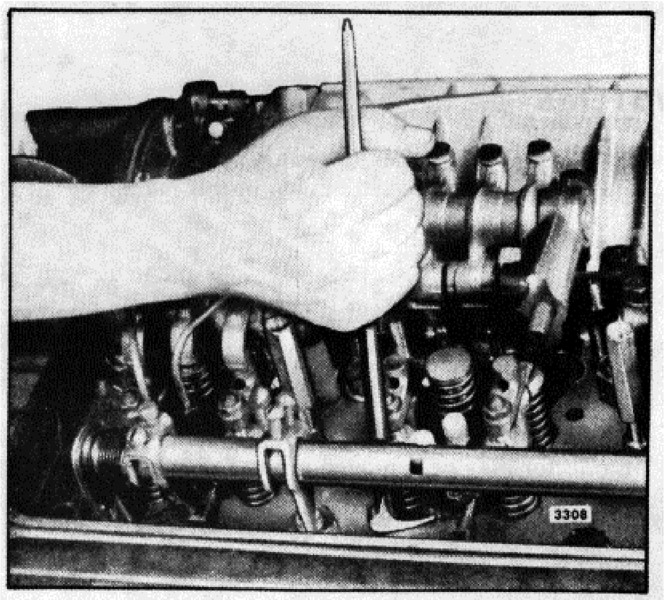


Fig. 2. - Removing Injector from Cylinder Head

because the bolt may be loosened. Either remove the starting motor or the pipe plug in the flywheel housing and use a pry bar against the teeth of the flywheel ring gear to turn the crankshaft.

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

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

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

8. Free the injector from its seat as shown in Fig. 2 and lift it from the cylinder head.

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

Install Injector

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

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

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

Do not tighten the injector clamp bolt to more than 20-25 lb-ft (27-34 Nm) torque, as this may cause the moving parts of the injector to bind. Tighten the rocker shaft bolts to 90-100 lb-ft (122-136 Nm) torque.

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

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

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

Fuel Pump

A positive displacement gear type fuel pump is attached to the blower and driven off the front end of the blower.

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

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

The fuel pump used on the V-71 engines is a left-hand rotating pump. Regardless of engine rotation, the pump will always rotate in a left-hand direction.

Fuel Strainer and Fuel Filter

A replaceable element type fuel strainer and fuel filter are used in the fuel system to remove impurities from the fuel (Figs. I and 3) The strainer removes the larger foreign particles and the filter removes the small foreign particles.

The fuel strainer and fuel filter are basically identical in construction, both consisting of a cover, shell and replaceable element. Since the fuel strainer is placed between the fuel supply tank and the fuel pump, it

Fig. 3. - Typical Fuel Filter Mounting

functions under suction; the fuel filter, which is installed between the fuel pump and the fuel inlet manifold in the cylinder head, operates under pressure.

Replace the elements as follows:

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

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

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

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

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

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

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

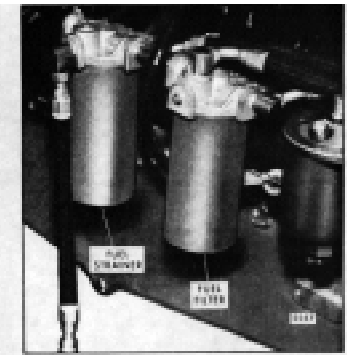


Fig. 4. - Typical Spin-On Fuel Filter Mounting

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

Spin-On Type Fuel Filter

A spin-on type fuel strainer and fuel filter is used on certain engines (Fig. 4). The spin-on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly. No separate springs or seats are required to support the filters.

The filter covers incorporate a threaded sleeve to accept the spin-on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification.

No drain cocks are provided on the spin-on filters. Where water is a problem, it is recommended that a water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

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

Replace the filter as follows:

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

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

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

4. Start the engine and check for leaks.

Fuel Tank

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

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

Engine Out of Fuel

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

When an engine has run out of fuel, there is a definite procedure to follow for restarting the engine.

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

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

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

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

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

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

AIR SYSTEM

In the scavenging system used in two-cycle engines and illustrated in Fig. 5, a charge of air, forced into the cylinders by the blower(s), sweeps all of the exhaust gases out through the exhaust valve ports, leaving the cylinders filled with fresh air for combustion at the end of each upward stroke of the pistons. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The blower(s) supplies fresh air required for combustion and scavenging. The hollow three-lobe rotors are closely fitted into the blower housing(s) which is bolted to the cylinder block. The revolving motion of these rotors pulls fresh air through the air cleaner or silencer and provides a continuous and uniform displacement of air in each combustion chamber. The continuous discharge of fresh air from the blower creates a pressure in the air box (air box pressure).

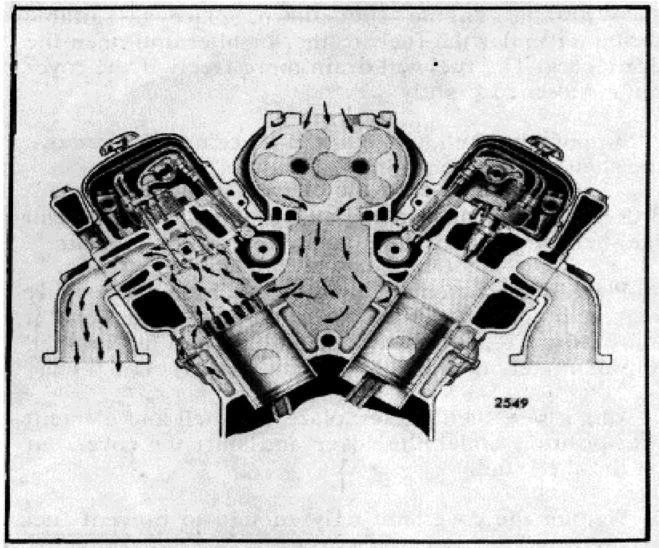


Fig. 5. - Air Intake System Through Blower and Engine

AIR CLEANERS

Several types of air cleaners are available for use with the V-71 engines. The light duty oil bath air cleaner (Fig. 6) is used with some marine models and a light or heavy-duty oil bath air cleaner (Fig. 7) is available for industrial engines. Some engines are equipped with a heavy-duty dry type air cleaner or a two-stage dry type air cleaner (Fig. 8). The air cleaners are designed for fast, easy disassembly to facilitate efficient servicing. Maximum protection of the engine against dust and other forms of air contamination is possible if the air cleaner is serviced at regular intervals.

Oil Bath Air Cleaners

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

Service the *light-duty* oil bath air cleaner (Fig. 6) as follows:

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing. The cleaner may then be separated into two sections; the upper section or body assembly contains the filter element and the lower section consists of the oil cup, removable inner cup or baffle and the center tube.

2. Soak the body assembly and element in fuel oil to loosen the dirt; then flush the element with clean fuel oil and allow it to drain thoroughly.

3. Pour out the oil, separate the inner cup or baffle from the oil cup, remove the sludge and wipe the baffle and outer cup clean.

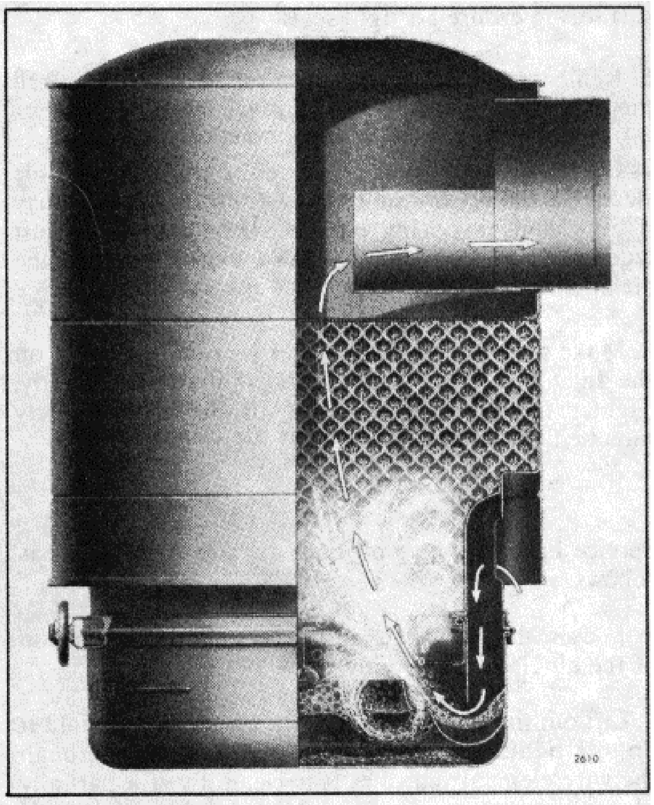


Fig. 6. - Typical Light-Duty Air Cleaner

4. Push a lint-free cloth through the center tube to remove dirt or oil.

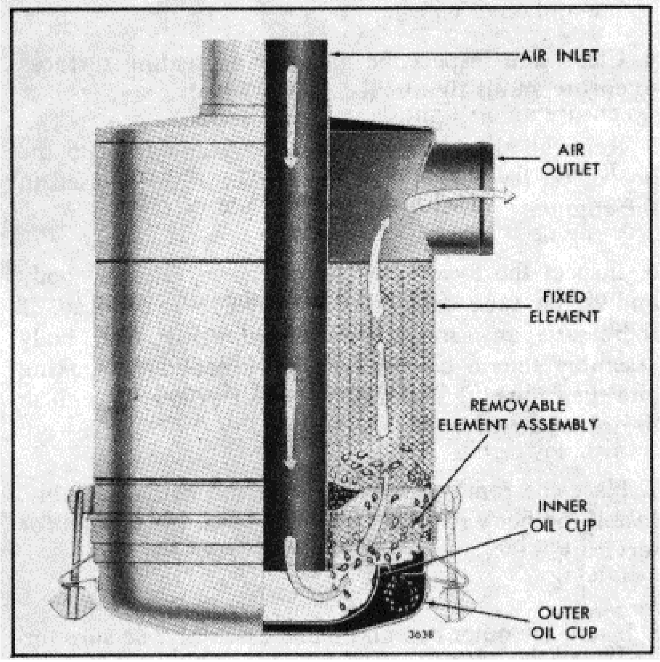


Fig. 7. - Heavy-Duty Oil Bath Air Cleaner

5. Clean and check all of the gaskets and sealing surfaces to ensure air tight seals.

6. Refill the oil cup to the oil level mark only, install the baffle and reassemble the air cleaner.

7. Check the air inlet housing before installing the air cleaner assembly on the engine. The inlet will be dirty if air cleaner servicing has been neglected or if dust laden air has been leaking past the air cleaner to the air inlet housing seals.

8. Make sure that the air cleaner is seated properly on the inlet housing and the seal is installed correctly. Tighten the wing bolt until the air cleaner is securely mounted.

Service the *heavy-duty* oil bath air cleaner (Fig. 7) as follows:

1. Loosen the wing nuts and detach the lower portion of the air cleaner assembly.

2. Lift out the removable element assembly and hold it up to a light. An even, bright pattern of light through the wire element indicates it is clean. Even a partially plugged element must be cleaned with a suitable solvent or fuel oil and blown out with compressed air to remove any dirt, lint or chaff.

3. Pour out the oil, separate the inner cup or baffle from the outer cup, remove the sludge and wipe the baffle and outer cup clean.

4. Clean and inspect the gaskets and sealing surfaces to ensure an air tight seal.

5. Reinstall the baffle in the oil cup and refill to the proper oil level with the same grade of oil as used in the engine.

6. Inspect the lower portion of the air cleaner body and center tube each time the oil cup is serviced. If there are any indications of plugging, the body assembly should be removed and cleaned by soaking and then flushing with clean fuel oil. Allow the unit to drain thoroughly.

7. Place the removable element in the body assembly. Install the body if it was removed from the engine for servicing.

8. Install the outer cup and baffle assembly. Be sure the cup is tightly secured to the assembly body.

Dry-Type Air Cleaner

The *dry-type* air cleaner consists of a removable cover attached to the air cleaner body which contains a replaceable paper filter cartridge and a dust cup. Air entering the air cleaner is given a centrifugal precleaning by a turbine-type vane assembly. Air rotates at high speed around the filter element throwing the dust to the outside where it flows down the wall of the body and is ejected into a dust cup. The dust cup is baffled to prevent the reentry of the dust. The precleaned air passes through the paper filter and enters the engine.

Some air cleaners are equipped with an indicator which will aid in determining the servicing requirements.

Service the *dry-type* air cleaner as follows:

1. Loosen the wing bolt and remove the air cleaner assembly from the air inlet housing.

2. Detach the cover and wing bolt and remove the element. Then empty and wipe the dust cup clean.

3. Clean the filter element as follows: If the element is dry and dusty, use compressed air. The air should be blown through the element opposite to the normal direction of air flow.

4. If the element is oily or has soot deposits, use a water hose (less than 40 psi or 276 kPa) and wash with warm water and a non-sudsing detergent. Dry the element thoroughly.

5. Reassemble all of the air cleaner parts, place the assembly on the air inlet housing and secure it with the wing bolts.

The two-stage dry-type air cleaner illustrated in Fig. 8 is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed. The cleaner assembly consists of a centrifugal air cleaner in series with a replaceable impregnated paper filter element. The dust collected in the centrifugal cleaner is exhausted by connecting the dust bin to an exhaust gas aspirator. The centrifugal cleaner and replaceable filter element are held together in a steel housing. Positive sealing between the two elements and the housing is provided by rubber gaskets. The steel housing incorporates filter fasteners, mounting flanges and an outlet for the filtered air.

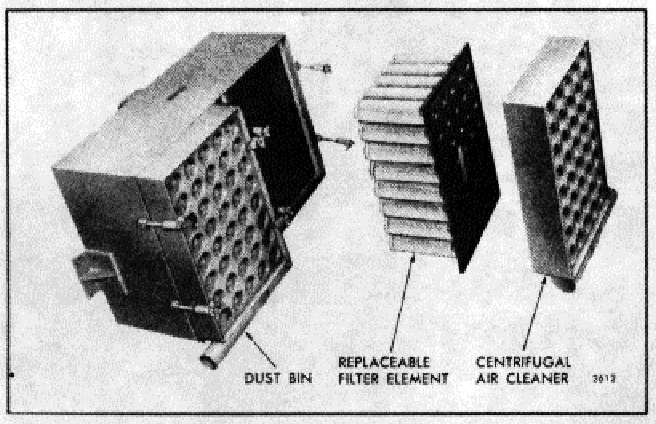


Fig. 8. - Dry Type Air Cleaner

The deflector vanes (Fig. 9) impart a swirling motion to the air entering the air cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust bin at the bottom of the cleaner by approximately 10% bleed-off air and are finally discharged into the atmosphere through an exhaust gas aspirator.

The exhaust gas aspirator is connected into the exhaust system of the engine (Fig. 10). A flexible hose carries the dust particles from the cleaner dust bin to the aspirator where the waste energy of the exhaust gases draws the dust-laden bleed-off air out and discharges it into the atmosphere along with the engine exhaust gases. Approximately 90% of the total dust load is disposed of in this manner. The centrifugal air cleaner is fully effective at either high or low velocities.

The remainder of the air in the cleaner reverses direction and spirals back along the discharge tubes again centrifugally moving the air. The filtered air then reverses direction again and enters the replaceable filter element through the center portion of the discharge tubes. The air is filtered once more as it passes through the pleats of the impregnated paper element before leaving the outlet port of the cleaner housing.

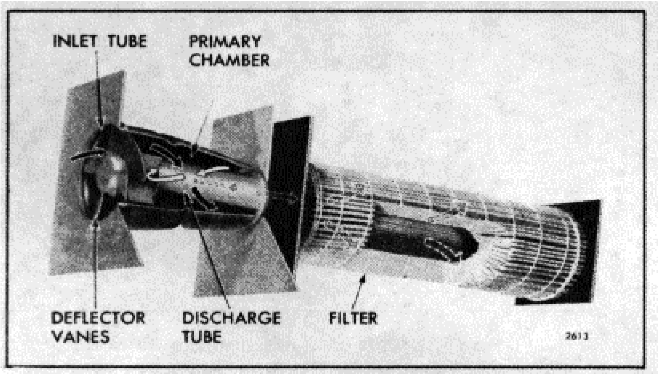


Fig. 9. - Flow of Air Through Filter Element Segment

An air cleaner restriction indicator (Fig. 10) may be attached near the outlet side of the cleaner. As the restriction in the cleaner increases, suction created will pull the indicator plunger upward. A brightly colored card, attached to the plunger and visible through a small window in the indicator, will indicate the relative amount of air restriction in the cleaner. When the card is fully visible, the air cleaner should be cleaned and the indicator reset by pushing the plunger all the way up and then releasing it.

Service the *two-stage dry-type* air cleaner as follows:

The first stage centrifugal air cleaner tends to be selfcleaning due to the action of the exhaust gas aspirator. However, it should be inspected and any accumulated foreign material removed during the periodic replacement of the impregnated paper filter element. Overloading of the paper element will not cause dirt particles to bypass the filter and enter the engine, but will result in starving the engine for air.

The filter element may be replaced as follows:

1. Disconnect the flexible aspirator hose at the dust bin of the air cleaner.

2. Loosen the wing nuts on the filter fasteners and swing the retaining bolts away from the cleaner.

3. Lift the cleaner away from the housing and inspect it. Clean out any accumulated foreign material.

4. Withdraw the paper filter element and discard it.

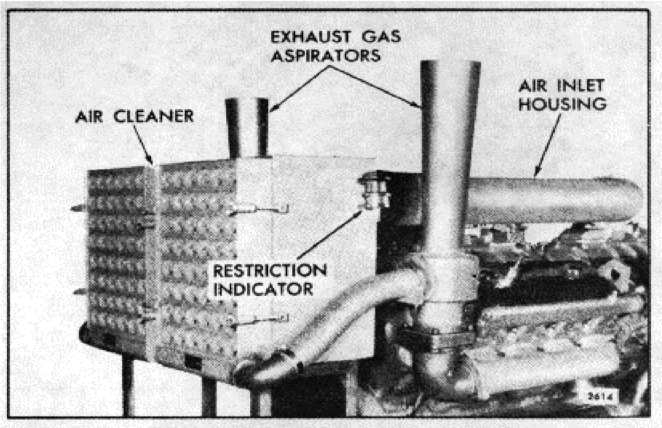


Fig. 10. - Typical Dry Type Air Cleaner Mounting

5 Install a new filter element. New sealing gaskets are provided with the element to insure a positive air seal at all times.

6. Install the cleaner and secure it in place with the fasteners.

7. Connect the aspirator hose to the dust bin, making sure the connection is air tight.

AIR SILENCER

The air silencer (Fig. 11), used on some marine models, is bolted to the air intake side of the blower housing. The silencer has a perforated steel partition welded in place parallel with the outside faces, enclosing flame proof, felted cotton waste which serves as a silencer for air entering the blower. While no servicing is required on the air silencer proper, it may be removed when necessary to replace the air intake screen. This screen is used to filter out any large foreign particles which might seriously damage the blower assembly.

AIR BOX DRAINS

In normal operation, a slight amount of vapor from the air condenses and settles at the bottom of the air box. This condensation is drained through air box drain tubes (Fig. 12) which direct the expelled air and vapor down and away from the engine.

Air box drains must be open at all times, otherwise water and oil may accumulate in the air box and be drawn into the cylinders with the incoming fresh air. Therefore, periodic checks should be made to ensure they are open. Remove the air box covers and examine the air box floor for oil or an accumulation of water. If oil or water is found, wipe the air box dry with clean rags and remove and clean the air box drain tubes.

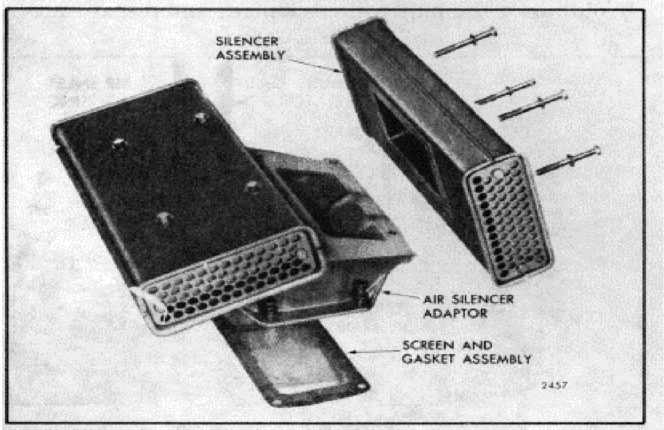


Fig. 11. - Silencer Assembly

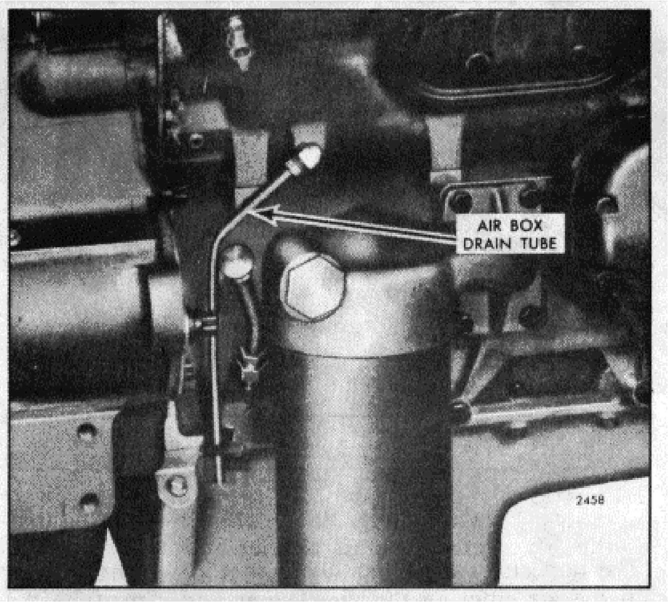


Fig. 12. - Air Box Drains

CRANKCASE VENTILATION

Harmful vapors which may be formed within the engine are removed from the crankcase. gear train. and valve compartment by a continuous pressurized ventilation system.

Breathing is through two openings in the rear main bearing bulkhead of the crankcase, which connects to a chamber. Two crimped-steel mesh breather pads, which cover the openings (Fig. 13), filter out the oil as the vapors pass into the chamber.

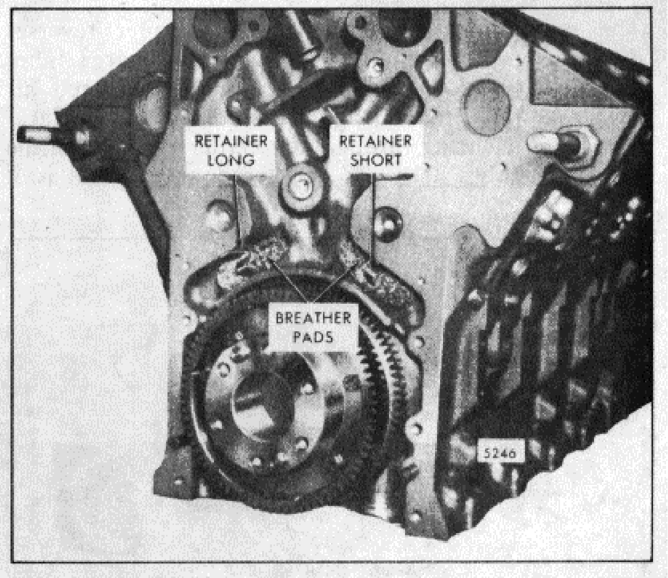


Fig. 13. - Breather Pads and Retainers Installed in Cylinder Block

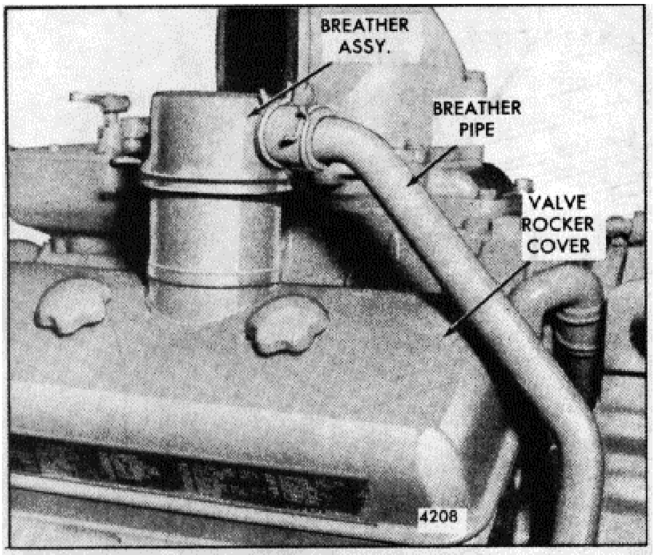


Fig. 14. - Typical Mounting of Breather Assembly on Valve Rocker Cover

A breather pipe is pressed into or flange mounted on top of the cylinder block to provide an exit for the crankcase vapors.

Some engines have an additional breather assembly mounted on the flywheel housing or on one of the valve rocker covers (Fig. 14).

LUBRICATING SYSTEM

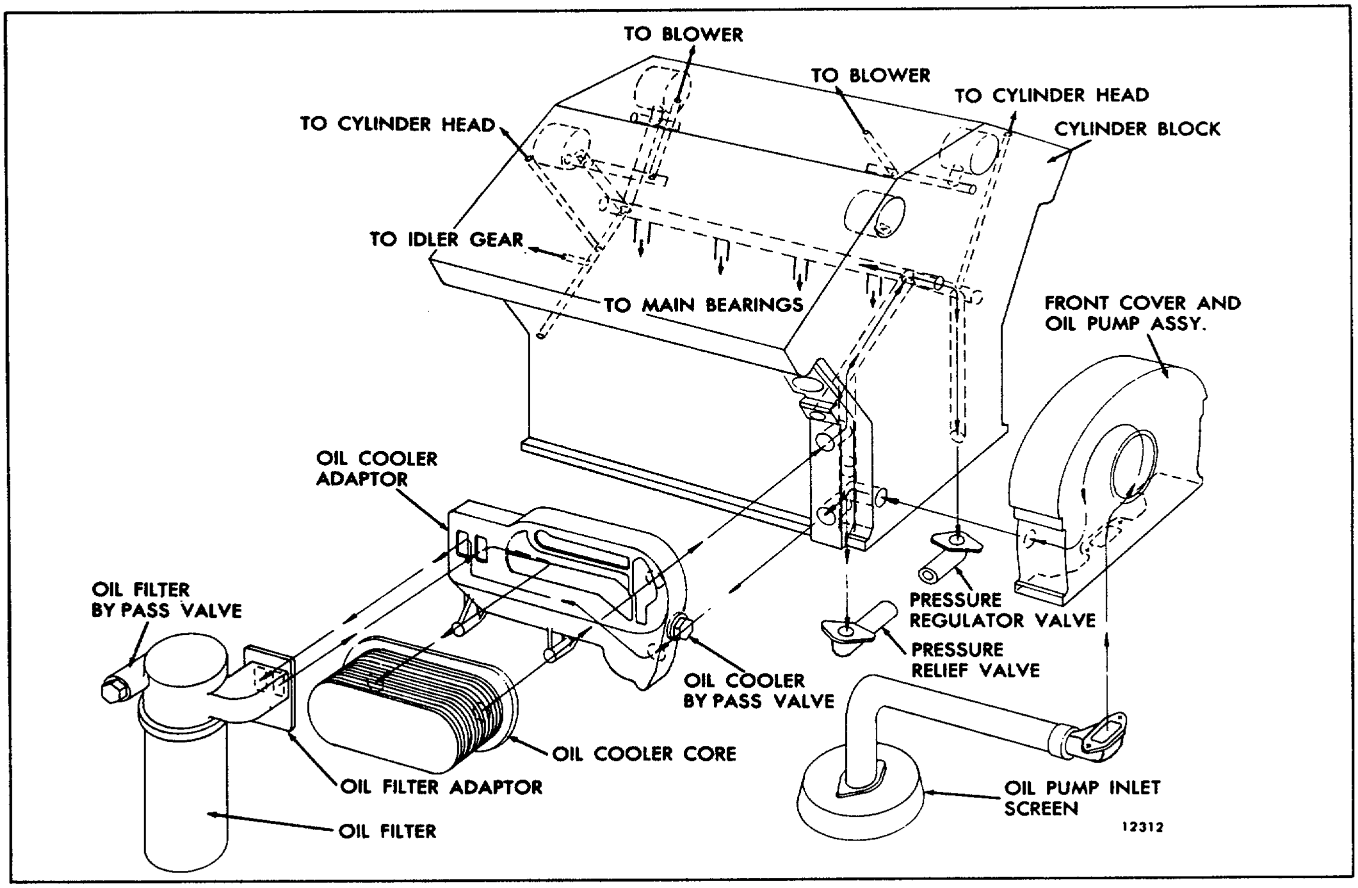


Fig. 15. - Schematic Diagram of Typical 6V and 8V Lubricating Systems

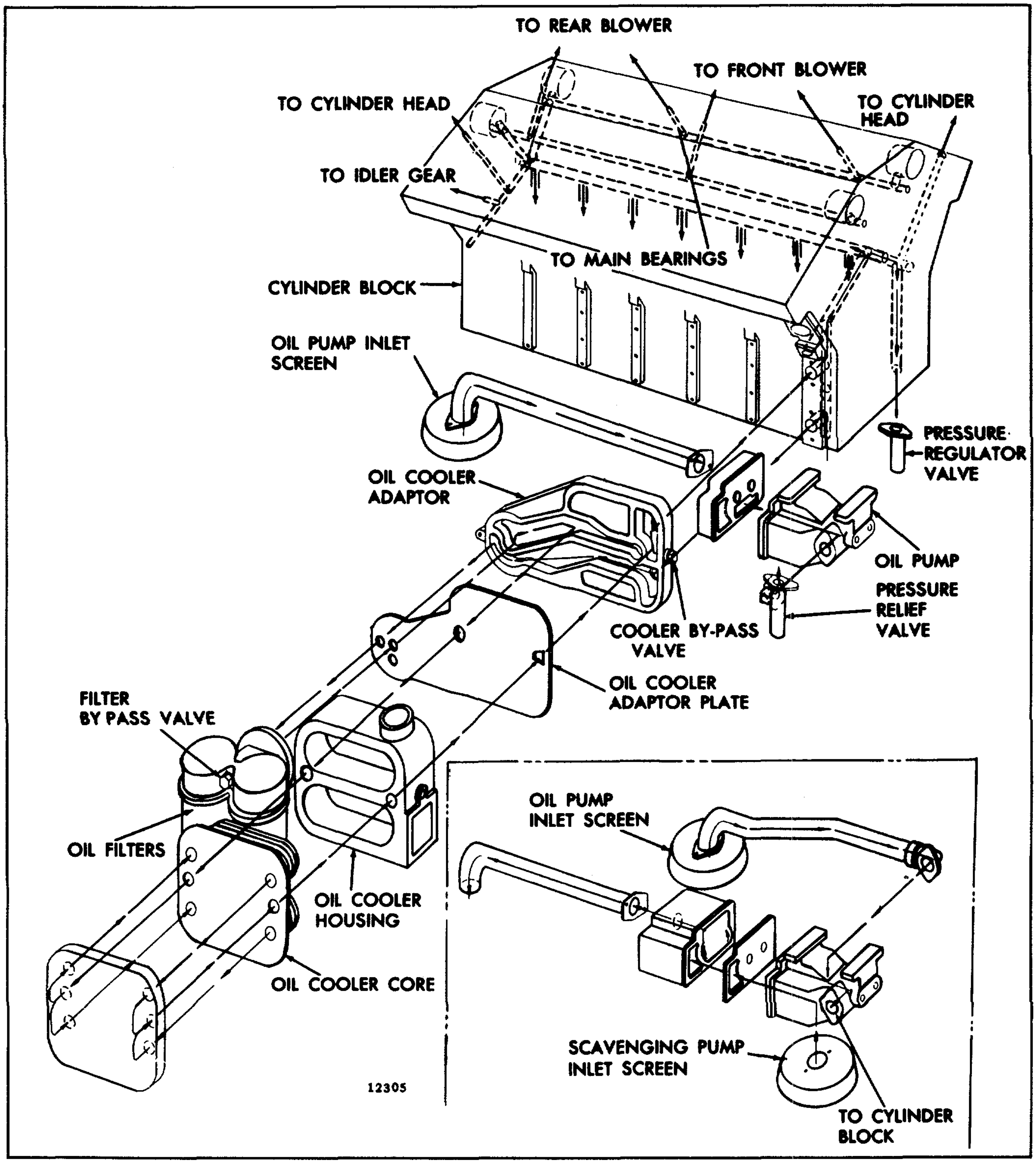


Fig. 16. - Schematic Diagram of Typical 12V Lubricating Systems

The lubricating oil systems schematically illustrated in Figs. 15, 16 and 17 consist of an oil pump, oil cooler, a full-flow oil filter, bypass valves at the oil cooler and filter and pressure regulator valves at the pump and in the cylinder block main oil gallery. Positive lubrication is ensured at all times by this system. A bypass oil filter may also be incorporated into the lubricating system at the owner’s option.

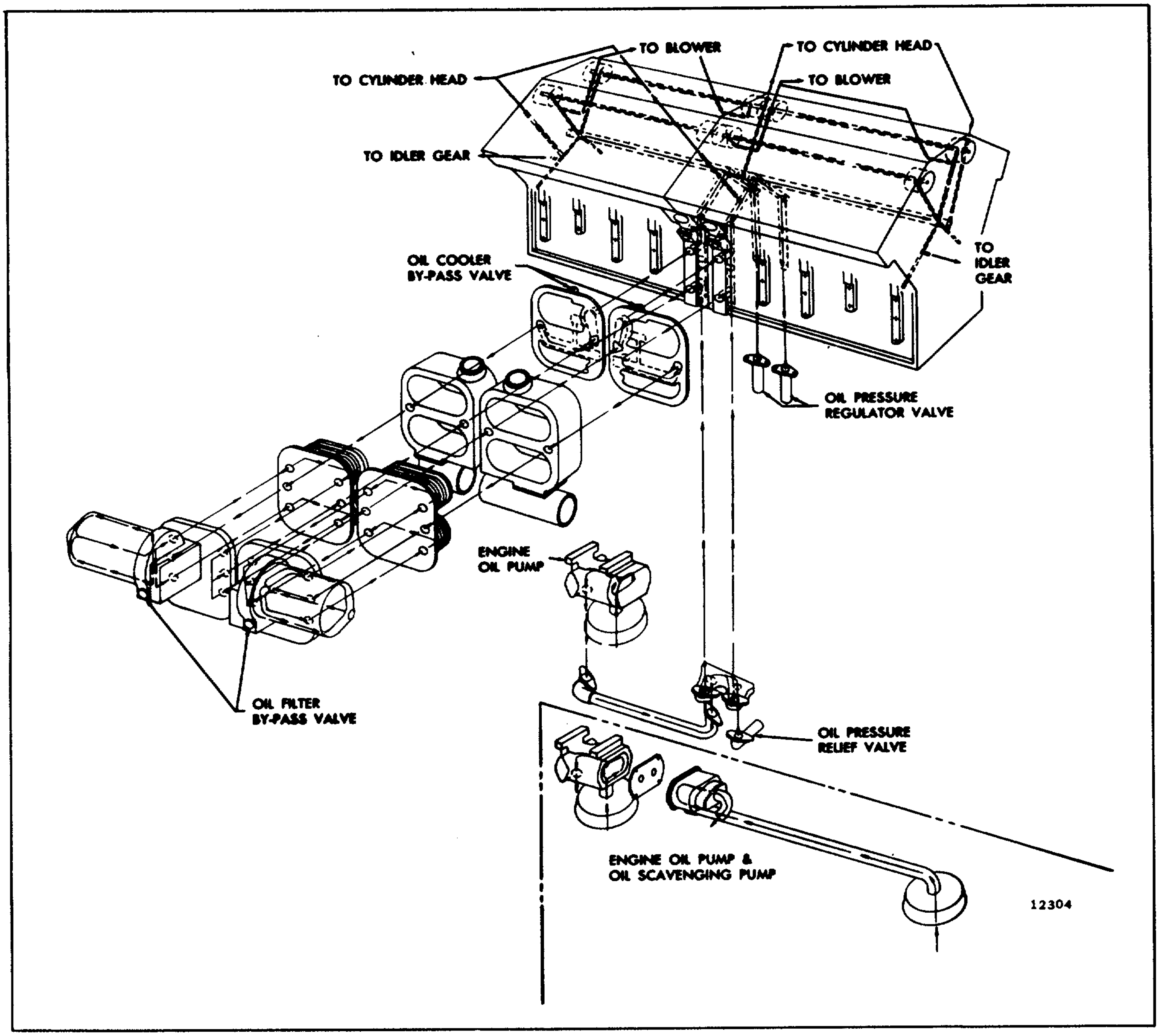


Fig. 17. - Schematic Diagram of Typical 16V Lubrication System

Oil for lubricating the connecting rod bearings and piston pins and for cooling the piston head is provided through the drilled hole in the crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of oil from the camshaft pocket through a connecting passage into the flywheel housing. A certain amount of oil spills into the flywheel housing from the camshaft and idler gear bearings. The blower drive gear is lubricated from the rear of the blower.

The oil pump on the 6 and 8V engines is driven by a pump drive hub on the front end of the crankshaft and consists of a large and small spur gear meshing in a cavity inside the crankshaft cover.

The gear-type oil pump used on the 12 and 16V engines is mounted on the main bearing caps. The pump on the 12V engine is driven from the front end of the crankshaft and on the 16V engine the pump, which is mounted on the No. 9 and 10 main hearing caps. is driven from the rear end of the crankshaft.

The pressure regulator valve, located at the end of a vertical oil gallery in the front of the cylinder block. maintains a stabilized oil pressure. The 16V engine

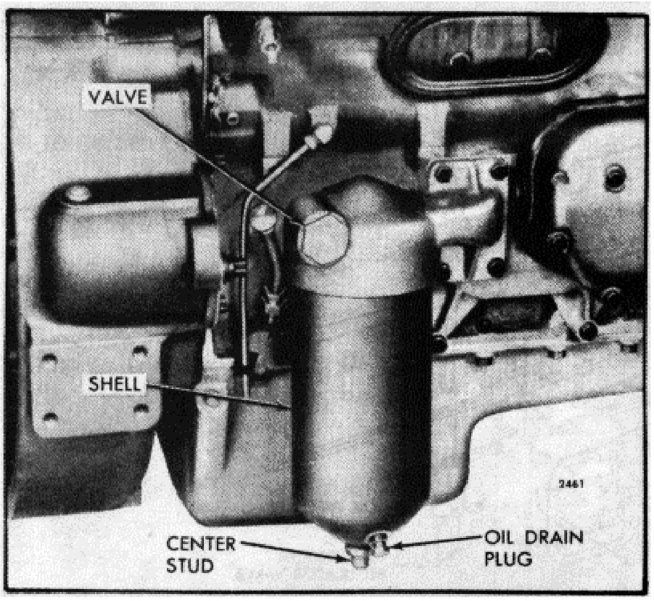


Fig. 18. - Typical Full-Flow Filter Mounting

has two pressure regulator valves located at the ends of the vertical oil galleries. When the oil pressure at the regulator valve(s) exceeds 50 psi (345 kPa). the valve(s) open and discharge the excess oil to the sump.

Oil Filters

Engines are equipped with a full-flow type lubricating oil filter. If additional filtering is required, a bypass type oil filter may also be installed. The full-flow filter assembly can be remotely mounted or mounted on the engine as shown in Fig. 18. A bypass valve, which opens at 15 psi (103 kPa), is located in the filter base to ensure engine lubrication in the event the filter should become plugged.

All of the oil supplied to the engine passes through the full-flow filter that removes the larger foreign particles without restricting the normal flow of oil.

The bypass filter assembly, when used, continually filters a portion of the lubricating oil that is being bled off the oil gallery- when the engine is running. Eventually all of the oil passes through the filter, filtering out minute foreign particles that may be present.

Some engines may be equipped with a bypass filter assembly consisting of two filter elements, each enclosed in a shell which is mounted on a single base. An oil passage in the filter base connects the two annular spaces surrounding both filter elements. The full flow and bypass filter elements should be replaced, each time the engine oil is changed, as follows:

1. Remove the drain plug and drain the oil (Fig. 18).

2. The filter shell, element and stud may be detached as an assembly, after removing the center stud from the base. Discard the gasket.

3. Clean the filter base.

4. Discard the used element, wipe out the filter shell and install a new element on the center stud.

5. Place a new gasket in the filter base, position the shell and element assembly on the gasket and tighten the center stud carefully to prevent damaging the gasket or center stud.

6. Install the drain plug and, after the engine is started, check for oil leaks.

COOLING SYSTEM

To effectively dissipate the heat generated by the engine, one of three different types of cooling systems is used on a V-71 engine; radiator and fan, heat exchanger and raw water pump, or keel cooling. Each system is provided with a centrifugal type water pump that circulates the engine coolant. Each system incorporates thermostats to maintain a normal engine operating temperature of 160-185°F (71-85° C). A typical cooling system is illustrated in Fig. 19.

Radiator and Fan Cooling

Coolant is drawn from the lower portion of the radiator by the water pump and is forced through the oil cooler housing and into the cylinder block. From the cylinder block the coolant passes up through the cylinder heads and, when the engine is at normal operating temperature, through the thermostat housings and into the upper portion of the radiator. Then the coolant passes down a series of tubes where the coolant temperature is lowered by the air stream created by the revolving fan.

Upon starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostat housing and a bypass provides water circulation within the engine during the warm-up period.

Heat Exchanger Cooling

In the heat exchanger cooling system, the coolant is drawn by the fresh water pump from the heat exchanger and is forced through the engine oil cooler, cylinder block, cylinder heads, exhaust manifolds and to the thermostat housings. A bypass tube from the thermostat housings to the inlet side of the water pump permits circulation of the coolant through the engine while the thermostats are closed. When the thermostats open, the coolant can flow through the heat exchanger and then, after being cooled, to the engine fresh water pump for recirculation.

While passing through the core of the heat exchanger, the coolant temperature is lowered by raw water which is drawn by the raw water pump from an outside supply. The raw water enters the heat exchanger at one side and is discharged at the opposite side.

To protect the heat exchanger element from electrolytic action, a zinc electrode is located in both the heat exchanger inlet elbow and the raw water pump inlet elbow and extends into the raw water passage.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed by the kind of coolant used in the engine and the kind of raw water used. Soft water plus rust inhibitor or an ethylene glycol base antifreeze should be used as the engine coolant.

When foreign deposits accumulate in the heat exchanger, to the extent that cooling efficiency is impaired, such deposits can, in most instances, be removed by circulating a flushing compound through the fresh water circulating system without removing the heat exchanger. If this treatment does not restore the engine's normal cooling characteristics, contact an authorized Detroit Diesel Allison Service Outlet.

Keel Cooling

In the keel cooling system, the coolant is drawn by the fresh water pump from the keel cooler and is forced through the engine oil cooler, cylinder block. cylinder heads, exhaust manifolds and to the thermostat housings. A bypass tube from the thermostat housings to the inlet side of the water pump permits circulation of coolant through the engine while the thermostats are closed. When the thermostats open. the coolant can flow through the keel cooling coils and then to the suction side of the fresh water pump for recirculation.

The heat of the engine coolant is transferred through the coils of the keel cooler to the surrounding water.

ENGINE COOLING SYSTEM MAINTENANCE

Engine Coolant

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinder, from the component parts such as exhaust valves, cylinder liners, and pistons which are surrounded by water jackets. In addition, the heat

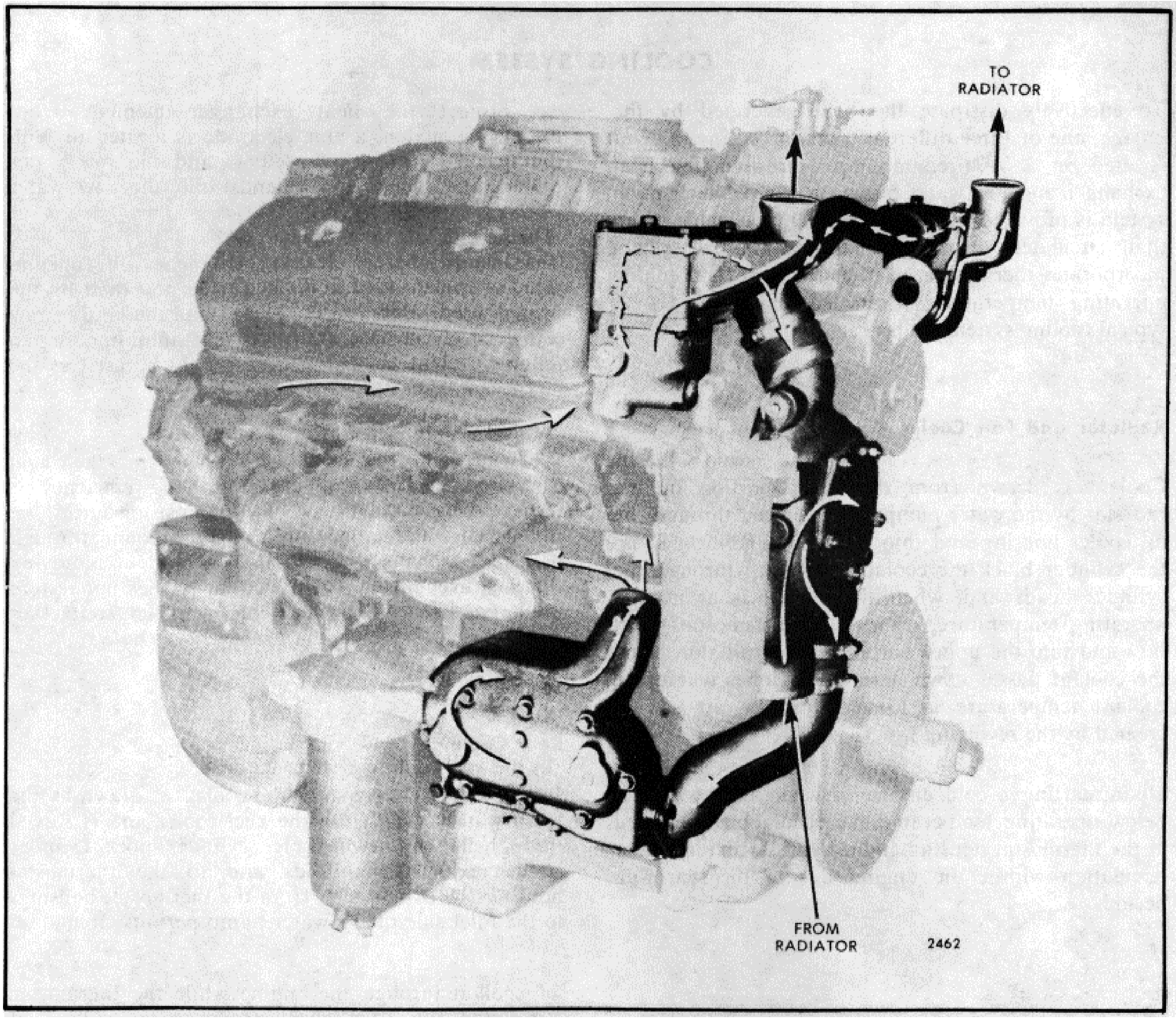


Fig. 19. - Cooling System

absorbed by the oil is also removed by the engine coolant in the oil-to-water cooler.

For the recommended coolant, refer to the section on *Engine Coolant.*

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, head, water manifold, thermostat housing and oil cooler housing) is shown in Table 1.

To obtain the complete amount of coolant in the cooling system of a unit, the additional capacity of the radiator, hoses, etc, must be added to the capacity of the basic engine. The capacity of radiators and related equipment should be obtained from the equipment supplier.

Fill Cooling System

Before starting the engine, close all of the drain cocks and fill the cooling system with water. If the unit has a raw water pump, it should also be primed, since operation without water may cause impeller failure. The use of clean, soft water will eliminate the need for descaling solutions to clean the cooling system. A hard, mineral-laden water should be made soft by using water softener chemicals before it is poured into the cooling system. These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

Start the engine and, after the normal operating temperature has been reached, allowing the coolant to expand to its maximum, check the coolant level. The coolant level should be within 2" of the top of the filler neck.

COOLING SYSTEM CAPACITY
(BASIC ENGINE)

	*WBP Block	
† Engine	gallons	litres
6V	7	27
BV	7-3/4	29
12V	13-3/4	52
16V	19-3/4	75
** 16VTI	22	83

* Water-below-port cylinder block
** Estimated
† Cylinder block water jacket capacity -
3.5 gal. (13.2 liter) - 6V or 7.0 gal. (26.4 liter) - 12V
4.4 gal. (16.9 liter) · 8V or 8.8 gal. (33.8 liter) - 16V

TABLE 1.

Should a daily loss of coolant be observed, and there are no apparent leaks, there is a possibility of gases leaking past the cylinder head water seal rings into the cooling system. The presence of air or gases in the cooling system may be detected by connecting a rubber tube from the overflow pipe to a water container. Bubbles in the water in the container during engine operation will indicate this leakage. Another method for observing air in the cooling system is by inserting a transparent tube in the water outlet line.

Drain Cooling System

The engine coolant is drained by opening the cylinder block and radiator (heat exchanger) drain cocks and removing the cooling system filler cap. The removal of the cooling system filler cap permits air to enter the cooling passages and the coolant to drain completely from the system.

Drain cocks are located on each side of the cylinder block at both the front and rear of the engine. The drain cocks at the rear of the engine are below the exhaust manifold. The front surface of the cylinder block has drain cocks on each side above the engine front cover.

In addition to the drains on the block, the oil cooler housing has a drain cock at the extreme bottom. Radiators and other components that do not have a drain cock are drained through the oil cooler housing drain cock.

To ensure that all of the coolant is drained completely from a unit, all cooling system drains should be opened. Should any entrapped water in the cylinder block or radiator freeze, it will expand and may cause damage. When freezing weather is expected, drain all units not adequately protected by antifreeze. Leave all drain cocks open until refilling the cooling system.

Marine engine exhaust manifolds are cooled by the same coolant used in the engine. Whenever the engine cooling system is drained, open the exhaust manifold drain cocks.

Raw water pumps are drained by loosening the cover attaching screws and tapping the cover gently to loosen it. After the water has drained, tighten the screws.

Flushing Cooling System

The cooling system should be flushed each spring and fall. The flushing operation cleans the system of antifreeze solution in the spring and removes the summer rust inhibitor in the fall, preparing the cooling system for a new solution. The flushing operation should be performed as follows:

1. Drain the previous season's solution from the engine.

2. Refill the cooling system with soft clean water. If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.

3. Start the engine and operate it for 15 minutes to circulate the water thoroughly.

4. Drain the cooling system completely.

5. Refill the system with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats, and the fan belt tension and water level have been found to be satisfactory, clean and flush the entire cooling system. Remove scale formation by using a reputable and safe descaling solvent. Immediately after using the descaling solvent, neutralize the system with the neutralizer. It is important that the directions printed on the container of the descaler be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and reverse flush before filling the system.

Reverse Flushing

After the engine and radiator have been thoroughly cleaned, they should be reverse flushed. The water pump should be removed and the radiator and engine reverse flushed separately to prevent dirt and scale deposits clogging the radiator tubes or being forced through the pump. Reverse flushing is accomplished by hot water, under air pressure, being forced through the cooling system in a direction opposite to the normal flow of coolant, loosening and forcing scale deposits out.

The radiator is reverse flushed as follows:

1. Remove the radiator inlet and outlet hoses and replace the radiator cap.

2. Attach a hose at the top of the radiator to lead water away from the engine.

3. Attach a hose to the bottom of the radiator and insert a flushing gun in the hose.

4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.

5. Turn on the water and, when the radiator is full, turn on the air in short blasts, allowing the radiator to fill between air blasts.

> **NOTE**: Apply air gradually. Do not exert more than 30 psi (207 kPa) air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until only clean water is expelled from the radiator.

The cylinder block and cylinder head water passages are reverse flushed as follows:

1. Remove the thermostat and the water pump.

2. Attach a hose to the water inlet of the cylinder block to drain the water away from the engine.

3. Attach a hose to the water outlet at the top of the cylinder block and insert the flushing gun in the hose.

4. Turn on the water and, when the water jackets are filled, turn on the air in short blasts, allowing the engine to fill with water between air blasts.

5. Continue flushing until the water from the engine runs clean.

If scale deposits in the radiator cannot be removed by chemical cleaners or reverse flushing as outlined above, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate water through the radiator core from the bottom to the top during this operation.

Miscellaneous Cooling System Checks

In addition to the above cleaning procedures, the other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The cooling system hoses, thermostats and radiator pressure cap should be checked and replaced if found to be defective.

When water connection seals and hoses are installed, be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamps. All external leaks should be corrected as soon as detected.

The fan belt must be checked and adjusted, if necessary, to provide the proper tension and the fan shroud must be tight against the radiator core to prevent recirculation of air which may lower the cooling efficiency.

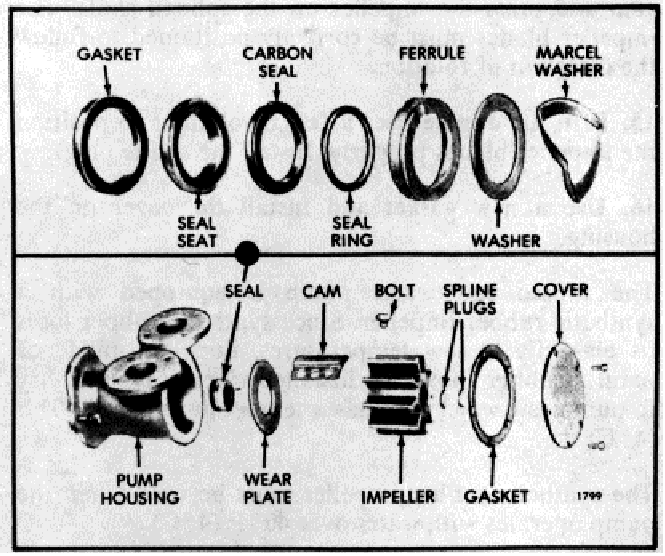


Fig. 20. - Raw Water Pump Details and Relative Location of Parts

Water Pump

The centrifugal type water pump is mounted on the engine front cover and is driven by a front camshaft gear. This pump circulates the engine coolant through the cylinder block, cylinder head, heat exchanger or radiator and the oil cooler.

The pump consists of a bronze impeller secured to a stainless steel shaft with a locknut. A gear is pressed on the opposite end of the shaft and the shaft turns on two ball bearings. An oil seal is used ahead of the front bearing and a spring-loaded face type water seal is used in back of the impeller. The pump ball bearings are lubricated with oil splashed by the water pump gear.

Contact an *authorized Detroit Diesel Allison Service Outlet* if more information is needed.

Raw Water Pump

A positive displacement raw water pump driven by a coupling from a camshaft circulates raw water through the heat exchanger to lower the temperature of the engine coolant.

The impeller (Fig. 20) is self-lubricated by the water pumped and should be primed before starting the engine.

Rubber spline plugs have been inserted between the end of the drive shaft and cover to reduce the possibility of foreign material working into the splines and causing wear.

Note that the end cover is marked to show the outlet port for RH rotation and the outlet port for LH rotation. Follow these markings when installing the raw water pump to assure proper direction of flow. Also, when installing the inlet elbow or outlet elbow, be sure to use two flat washers on the bolt being installed in the blind hole in the pump housing.

A rotary type seal assembly prevents any leakage along the shaft.

A raw water pump seal failure is readily noticeable by the leakage of water from the openings in the pump housing. These openings, which are located between the pump mounting flange and the inlet and outlet ports, must remain open at all times.

It is possible to replace seal parts and the impeller without removing the pump from the engine.

Use care to prevent scratching the lapped surface of the seal seat or that portion of the shaft which the seal contacts.

The raw water pump seal parts and impeller may be removed and replaced as follows:

1. Remove the cover screws and lift the cover and gasket from the housing (Fig. 20). Note the position of the impeller blades to facilitate reassembly.

2. Grasp a blade at each side of the impeller with pliers and pull the impeller from the shaft. The spline plugs will come out with the impeller.

3. Remove the spline plugs by pushing a screw driver through the impeller from the opposite end.

> **NOTE**: If the impeller is reusable, care should be exercised to prevent damage to the splined surfaces.

4. Inspect the bond between the neoprene and the metal of the impeller. Check the impeller blades. If they have a permanent set, a new impeller should be used. If the impeller area which rides on the wear plate is damaged, the impeller should be replaced.

5. Insert two wires (each with a hook at one end) between the housing and seal, with the hooks over the edge of the carbon seal. Then pull the seal assembly from the shaft.

6. The seal seat and gasket may be removed in the same manner.

7. Remove the cam bolt and cam.

8. Remove the wear plate and check it for wear and

burrs. If the plate is worn or burred, it may be reversed.

9. Install the wear plate. There is a dowel in the pump body, and the wear plate is notched to ensure correct installation.

10. Hold the cam in position and install the cam bolt.

11. If the seal seat and gasket are removed, place the gasket and seal seat over the shaft and press them into position in the seal cavity.

12. Place the seal ring securely in the ferrule and, with the carbon seal and washer correctly positioned against the ferrule, slide the ferrule over the shaft and against the seal seat. Be sure the seal ring is correctly contained within the ferrule so that it grips the shaft.

13. Install the flat washer and then the marcel washer.

14. Compress the impeller blades to clear the offset cam and press the impeller on the splined shaft. The impeller blades must be correctly positioned to follow the direction of rotation.

15. Turn the engine over a few revolutions to position the impeller blades properly. Install the spline plugs.

16. Use a new gasket and install the cover on the housing.

The Jabsco raw water pump is equipped with a synthetic rubber impeller. Since synthetic rubber loses its elasticity at low temperatures, impellers made of natural rubber should be installed when it is necessary to pump raw water that has a temperature below 40° F (4°C).

The synthetic rubber impeller must be used when the pump operates with water over 40°F (4° C).

ENGINE EQUIPMENT

INSTRUMENT PANEL, INSTRUMENTS AND CONTROLS

The instruments (Fig. 1) generally required in the operation of a diesel engine consist of an oil pressure gage, a water temperature gage, an ammeter and a mechanical tachometer. Also, closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine starting switch, an engine stop knob, an emergency stop knob and, on certain applications, the engine hand throttle.

Marine propulsion units are provided with an instrument panel which usually includes an engine oil pressure gage, reverse gear oil pressure gage, water temperature gage, ammeter and a tachometer. The instrument panels are generally mounted some distance from the engine. Illuminated instrument panels are provided for marine applications which require night operations.

Oil Pressure Gage

The oil pressure gage registers the pressure of the lubricating oil in the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed *under Running in the Engine Operating Instructions*, the engine should be stopped and the cause of low oil pressure determined and corrected before the engine is started again.

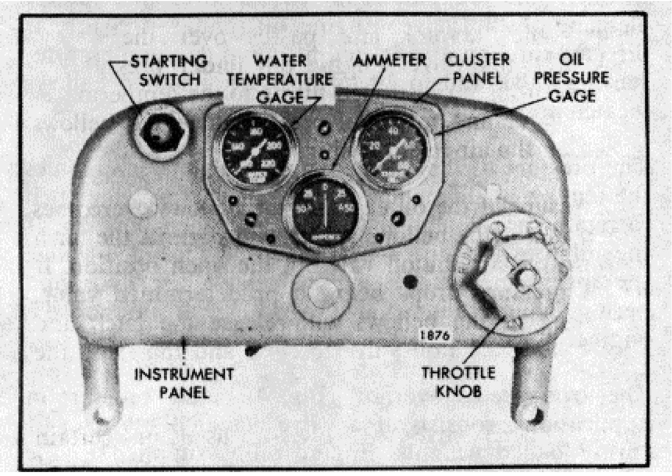


Fig. 1. - Typical Instrument Panel

Water Temperature Gage

The engine coolant temperature is registered on the water temperature gage.

Ammeter

An ammeter is incorporated into the electrical circuit to show the current flow to and from the battery. After starting the engine, the ammeter should register a high charge rate at rated engine speed. This is the rate of charge received by the battery to replenish the current used to start the engine. As the engine continues to operate, the ammeter should show a decline in charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery-charging alternator. If lights or other electrical equipment are connected into the circuit, then the ammeter will show discharge when these items are operating and the engine speed is reduced.

Tachometer

A mechanical tachometer is driven by the engine and registers the speed of the engine in revolutions per minute (rpm).

Engine Starting Switch

The engine starting switch is mounted on the instrument panel with the contact button extending through the front face of the panel. The switch is used to energize the starting motor. As soon as the engine starts, release the switch.

Stop Knob

A stop knob is used on most applications to shut the engine down. When stopping an engine, the speed should be reduced to idle and the engine allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine’s moving parts. Then the stop knob should be pulled and held until the engine stops. Pulling on the stop knob manually places the injector racks in the "no-fuel" position. The stop knob should be returned to its original position after the engine stops.

NOTE: When an emergency shut down is necessary, the stop knob should be pulled immediately and held until the engine stops.

Emergency Stop Knob (Engine with Air Shutoff Valves)

In an emergency, or if after pulling the engine stop knob the engine continues to operate, the emergency stop knob may be pulled to stop the engine. The emergency stop knob, when pulled, will trip the air shutoff valve located between the air inlet housing and the blower and shut off the air supply to the engine. Lack of air will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine stops so the air shutoff valve can be opened for restarting after the malfunction has been corrected.

Throttle Control

The engine throttle is connected to the governor speed control shaft through linkage. Movement of the speed control shaft changes the speed setting of the governor and thus the engine speed.

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN

A manually-operated emergency engine shutdown device, mounted in the air shutdown housing, enables the engine operator to stop the engine in the event an abnormal condition should arise. If the engine continues to run after the engine throttle is placed in the no-fuel position, or if combustible liquids or gases are accidentally introduced into the combustion chamber causing overspeeding of the engine, the shutdown device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The device consists of a shutdown valve mounted in the air shutdown housing and a suitable operating mechanism (Fig. 2).

The air shutoff valve is retained in the open position by a latch. A wire or cable assembly is used to trip the latch. Pulling the emergency shutdown knob all the way out will stop the engine. After the engine stops, the operator must push the emergency shutdown knob all the way in and manually reset the air shutoff valve before the engine is started again.

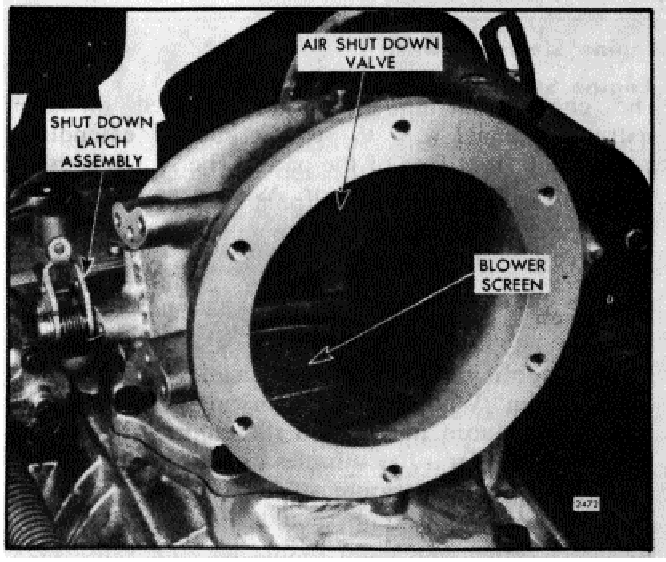


Fig. 2. - Manually Operated Emergency Engine Shutdown Valve Mounting

AUTOMATIC MECHANICAL SHUTDOWN

The automatic mechanical shutdown system (Fig. 3) is designed to stop the engine if there is a loss of oil pressure, loss of engine coolant, overheating of the engine coolant, or overspeeding of the engine. Engine oil pressure is utilized to activate the components of the system.

A coolant temperature-sensing valve and an adaptor and copper plug assembly are mounted on the exhaust manifold outlet. The power element of the temperature-sensing valve is placed against one end of the copper plug, and the other end of the plug extends into the exhaust manifold. Engine coolant is directed through the adaptor and passes over the power element of the valve. Engine oil, under pressure, is directed through a restricted fitting to the temperature sensing valve and to an oil pressure actuated bellows located on the air inlet housing.

The pressure of the oil entering the bellows overcomes the tension of the bellows spring and permits the latch to retain the air shutoff valve in the open position. If the oil pressure drops below a predetermined value, the spring in the bellows will release the latch and permit the air shutoff valve to close and thus stop the engine.

The overspeed governor (Fig. 4), used on certain applications, consists of a valve actuated by a set of spring-loaded weights. Engine oil is supplied to the valve through a connection in the oil line between the

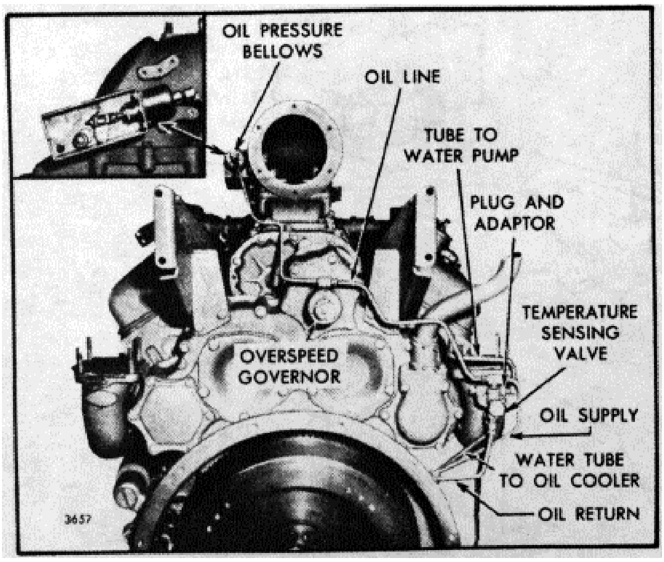


Fig. 3. - Automatic Mechanical Shutdown System Mounting

bellows and the temperature-sensing valve. An outlet in the governor valve is connected to the engine oil sump. Whenever the engine speed exceeds the overspeed governor setting, the valve (actuated by the governor weights) is moved from its seat and permits the oil to flow to the engine sump. This decreases the oil pressure to the bellows, thus actuating the shutdown mechanism and stopping the engine.

A restricted fitting, which will permit a drop in oil pressure great enough to actuate the shutdown mechanism, is required in the oil line between the cylinder block oil gallery and the shutdown sensing devices.

Operation

To start an engine equipped with a mechanical shutdown system, first manually open the air shutoff valve and then press the engine starting switch. As soon as the engine starts, the starting switch may be released, but the air shutoff valve must be held in the open position until the engine oil pressure increases sufficiently to permit the bellows to retain the latch in the open position.

During operation, if the engine oil pressure drops below the setting of the pressure sensitive bellows, the spring within the bellows will release the latch and permit the air shutoff valve to close, thus stopping the engine.

If the engine coolant overheats, the temperature-sensing valve will open and permit the oil in the protective system to flow to the engine crankcase. The resulting decrease in oil pressure will actuate the shutdown mechanism and stop the engine. Also if the engine loses its coolant, the copper plug will be heated up by the hot exhaust gases passing over it and cause the temperature-sensing valve to open and actuate the shutdown mechanism.

Whenever the engine speed exceeds the overspeed governor setting, the oil in the line flows to the sump, resulting in a decrease in oil pressure. The oil pressure bellows then releases the latch and permits the air shutoff valve to close.

When an engine is stopped by the action of the shutdown system, the engine cannot be started again until the particular device which actuated the shutdown mechanism has returned to its normal position. The abnormal condition which caused the engine to stop must be corrected before attempting to start it again.

AUTOMATIC ELECTRICAL SHUTDOWN

The automatic electrical shutdown system shown in Fig. 5 protects the engine against a loss of coolant, overheating of the coolant, loss of oil pressure, or overspeeding. In the event one of the foregoing conditions arises, a switch will close the electrical circuit and energize the solenoid switch, causing the shutdown solenoid to release the air shutdown latch and stop the engine.

Operation

The electrical circuit is de-energized under normal operating conditions. When the engine is started, one oil pressure switch opens when the oil pressure reaches approximately 5 psi (35 kPa) and the fuel oil pressure switch closes at approximately 20 psi (138 kPa) fuel pressure. As the engine speed increases, the second oil pressure switch opens at approximately 27 psi (186 kPa) and at 1000-1100 rpm, the No. 1 switch in the overspeed governor will close. The water temperature switch remains open.

If the oil pressure drops below 27 psi (186 kPa), the oil pressure switch will close the circuit and energize the shutdown solenoid. This will activate the shutdown mechanism and stop the engine.

A loss of coolant or an increase in coolant temperature to approximately 203°F (94°C) will close the contacts in the water temperature switch, thus closing the electrical circuit and activating the shutdown mechanism.

The water temperature switch consists of a temperature-sensing valve and a micro-switch. The valve

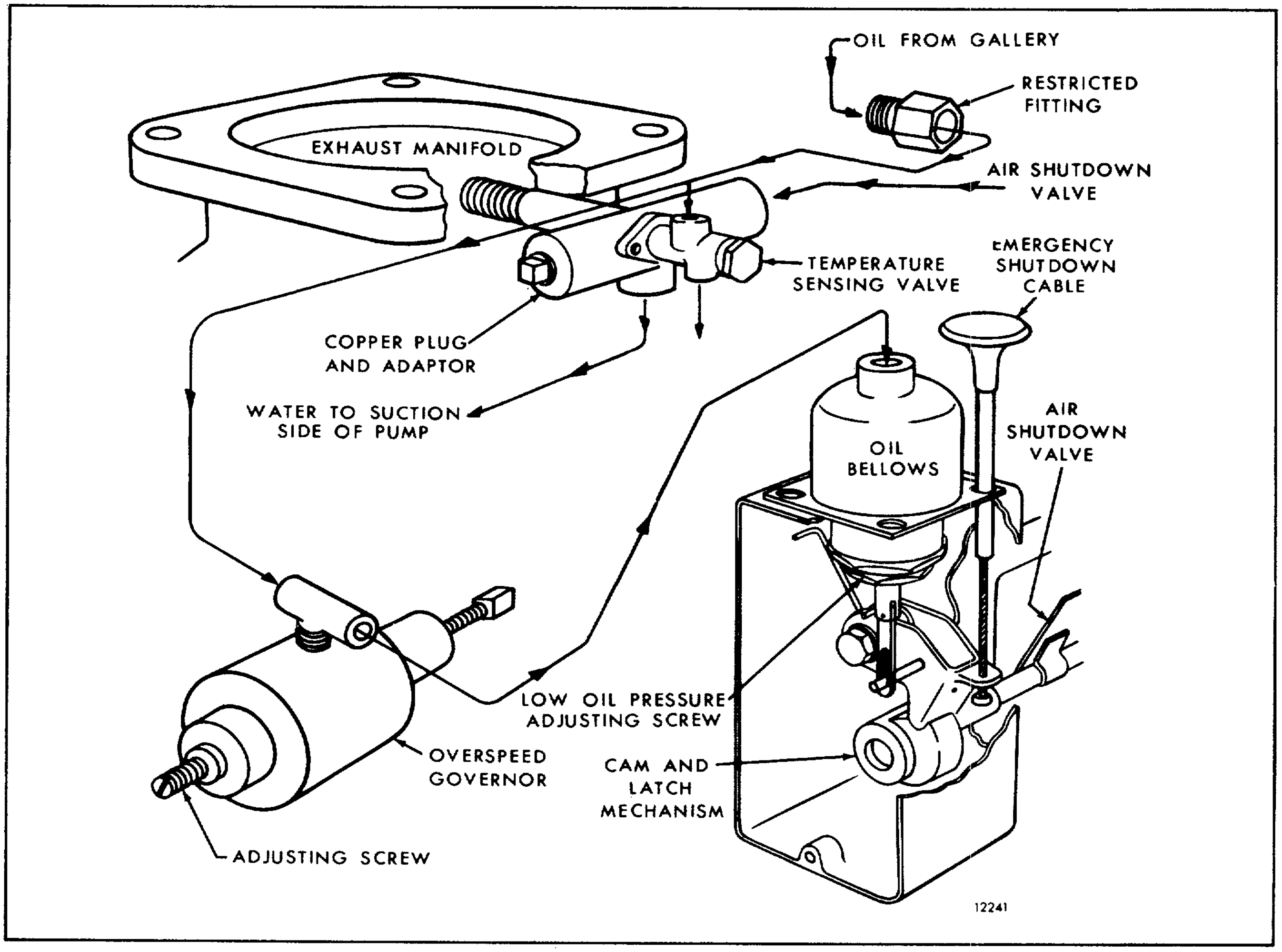


Fig. 4. - Schematic Drawing of Automatic Mechanical Shutdown System with Overspeed Governor

contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine water is directed over the power element of the valve and should the water temperature exceed approximately 203°(94°C), the valve will close the contacts in the microswitch and energize the shutdown circuit. If a loss of water occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing valve and cause the shutdown circuit to be activated.

If the engine speed exceeds the high speed setting of the overspeed governor, the No. 2 governor switch will close and activate the shutdown mechanism.

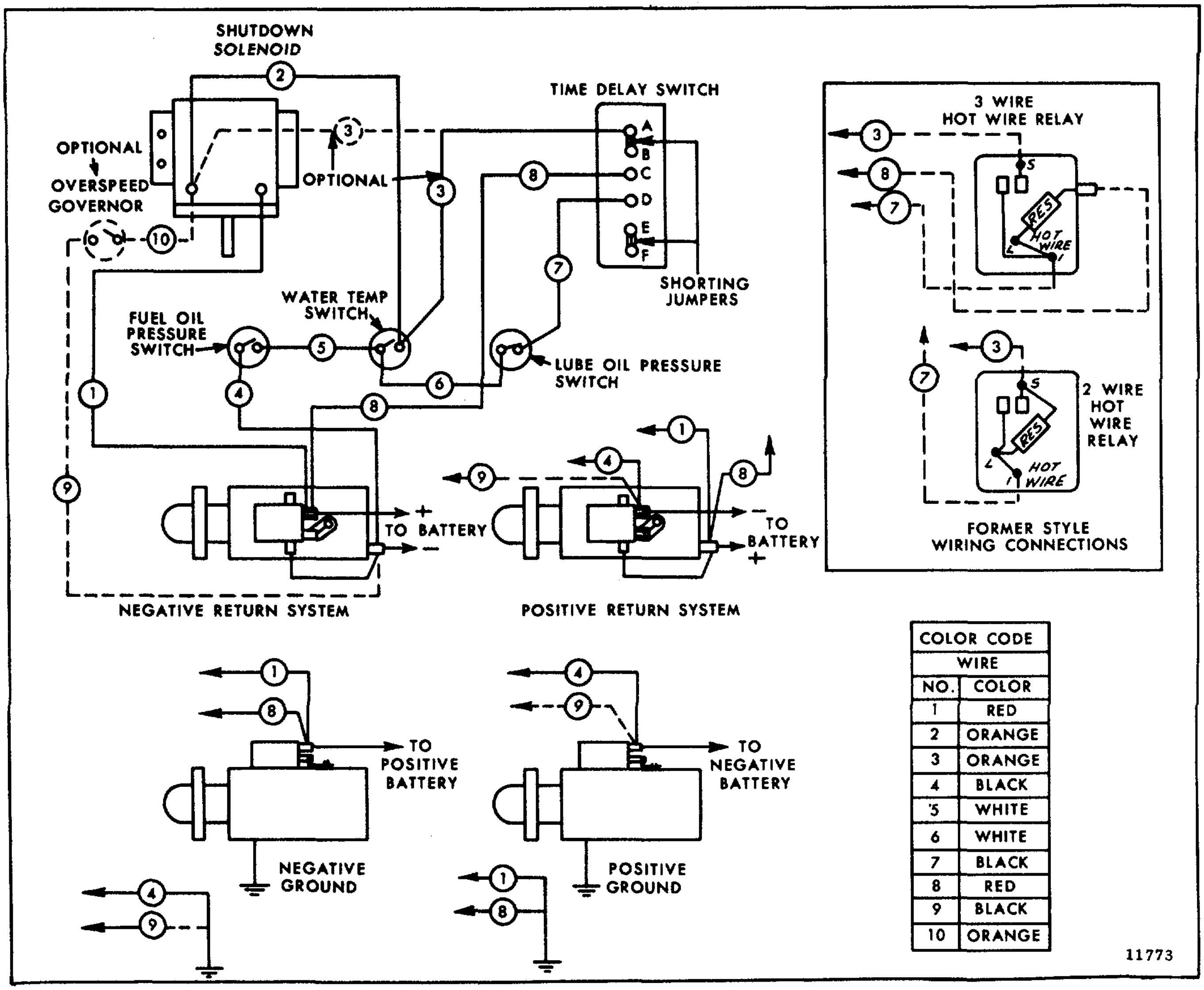
When the engine is shut down, the decrease in speed will open the governor switches and the decrease in oil and fuel pressures will close the oil pressure switches and open the fuel pressure switch, thus de-energizing the circuit.

The cause of the abnormal conditions must then be determined and corrected before the engine is started again. Also, the air shutoff valve must be manually reset in the open position before the engine can be started.

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a hot wire relay and one oil pressure switch (Fig. 5).

Since the fuel pressure builds up rapidly, the fuel oil pressure switch could close before the lubricating oil pressure switch opens, thereby effecting a shut down of the engine. The hot wire relay, however, delays the closing of the fuel oil pressure switch for 3 to 10 seconds to enable the lubricating oil pressure to build up and open the oil pressure switch contacts.

When the lubricating oil pressure falls below 10±2



COLOR CODE	
WIRE	
NO.	COLOR
1	RED
2	ORANGE
3	ORANGE
4	BLACK
5	WHITE
6	WHITE
7	BLACK
8	RED
9	BLACK
10	ORANGE

Fig. 5. - Automatic Electrical Shutdown System Diagram

psi (69 i 14 kPa), the contacts in the oil pressure switch used in this system will close and current will flow to the hot wire relay. The few seconds required to heat the hot wire relay provides sufficient delay to avoid an engine shut down when low oil pressure is caused by a temporary condition such as an air bubble or a temporary overlap in the operation of the oil pressure switch and the fuel oil pressure switch when starting or stopping the engine.

Depending upon the particular shutdown system used, the high water temperature switch may be installed in one of the openings in the water manifold, or the temperature-sensing valve and micro-switch unit may be installed in the exhaust manifold outlet.

In some electrical shutdown applications, the temperature-sensing valve and the copper plug used in the mechanical shutdown system is utilized. The lubricating oil pressure switch is installed in the oil line to the valve. When an increase in water temperature causes the valve to open and permits the oil to flow back to the crankcase, the resulting decrease in oil pressure will close the oil pressure switch and energize the electrical shutdown circuit. Low engine oil pressure will also cause the contacts in the oil pressure switch to close and energize the shutdown circuit.

SHUTDOWN SYSTEM FOR DIRECT MOUNTED TURBOCHARGED ENGINES With the use of a direct mounted turbocharger and the spring loaded fuel injector control racks, the air shutoff valve was eliminated from the air inlet housing. The spring loaded injector control racks enable the engine to come out of any advanced fuel position when an emergency situation arises.

When an engine is operating in an atmosphere subject to volatile fuel and is equipped with an air inlet housing without the air shutoff valve, a customer may request that the engine be equipped with an external or remote mounted emergency air shutdown assembly.

The remote mounted emergency air shutdown assembly that is equipped with the air shutoff valve can be installed upstream of the air inlet side of the turbocharger.

Care should be taken when installing the emergency air shutdown assembly (Fig. 6) between the turbocharger and the air cleaner. Because the engine shutdown system is activated, all of the piping between the shutdown system and the engine will be subjected to an abnormally high suction which may cause some of the piping components, i.e., rubber hoses and elbows to collapse. Therefore, it is recommended that all of these components be designed to withstand the maximum suction without a failure which would allow air to reach the engine air intake.

A 7 to 5 inch diameter reducing 90 ° rubber hose or a 7 to 5 inch diameter hump hose reducer can be used to adapt the shutdown to the turbocharger.

The rubber elbow can be obtained from the manufacturer; Griffin Rubber Mills in Portland, Oregon under their part number 51759.

For the relative position of the emergency air shutdown system when installed on a Detroit Diesel engine in a direct mounted location refer to Fig. 6.

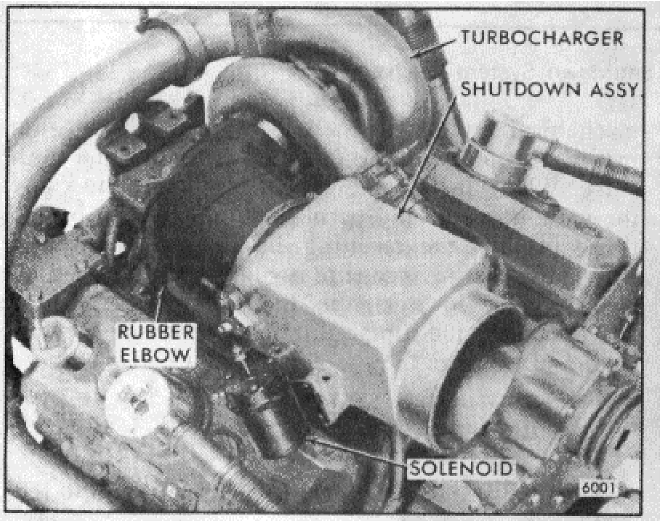


Fig. 6. - Emergency Shutdown Assembly (Direct Mounted Turbocharger)

The customer is also required to provide the mounting support brackets.

The emergency air shutdown assembly is manually operated. To be an automatic shutdown system, it will be necessary to install a solenoid.

ALARM SYSTEM

The alarm system shown in Fig. 7 is similar to the automatic electrical shutdown system, but uses a warning bell in place of the air shutoff valve solenoid.

The bell warns the engine operator if the engine coolant overheats or the oil pressure drops below the safe operating limit.

When the engine is started and the oil pressure is sufficient to open the oil pressure switch contacts (opening pressure is stamped on the switch cover), the alarm switch must be turned on manually to put the system in operation. The water temperature switch is normally open. Should the engine coolant exceed 200205 F (93-95 C), the water temperature switch will close the electrical circuit and sound the alarm bell.

Likewise, if the oil pressure drops below the setting of the oil pressure switch, the switch will close and cause the bell to ring. The bell will continue to ring until the engine operator turns the alarm switch off. The alarm

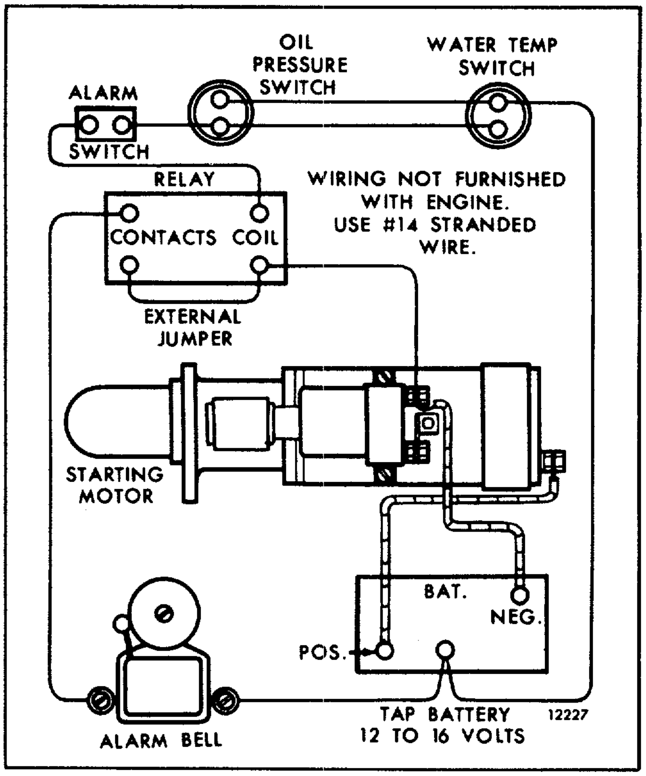


Fig. 7. - Alarm System Wiring Diagram

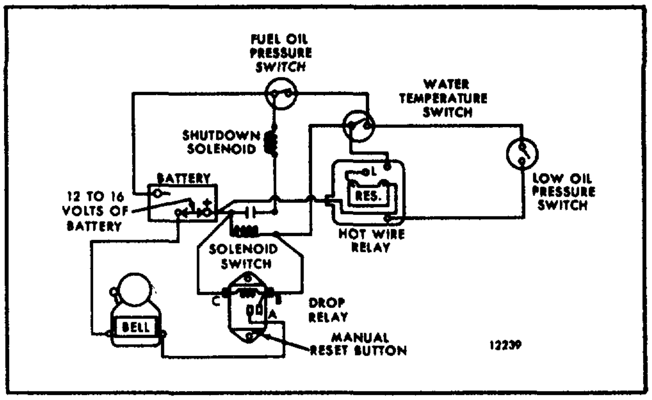


Fig. 8. - Alarm Bell Connected to Electrical Shutdown System

switch must also be turned off before a routine stop since the decreasing oil pressure will close the oil pressure switch and cause the bell to ring.

If the alarm bell rings during engine operation, stop the engine immediately and determine the cause of the abnormal condition. Make the necessary corrections before starting the engine again.

An alarm bell may be connected to the electrical shutdown system as shown in Fig. 8. In this system, if an abnormal condition occurs, the engine will be stopped automatically and the alarm bell will ring to notify the operator. The bell will continue to ring until the operator pushes the reset button on the drop relay.

The alarm system illustrated in Fig. 9 utilizes the temperature-sensing valve and the low oil pressure and overspeed valve used in the mechanical shutdown system.

When the engine is started, the oil pressure switch will open when the oil pressure reaches 10 psi (69 kPa) and the fuel oil pressure switch will close when the fuel pressure reaches 20 psi (138 kPa). If overheating or loss of engine coolant occurs, the temperature-sensing valve will open and permit the oil to flow to the crankcase. The resulting drop in oil pressure will permit the contacts in the oil pressure switch to close and complete the electrical circuit to the alarm bell. A loss of engine oil pressure or overspeeding of the engine will cause the oil pressure and overspeed valve to open and activate the alarm system. Once the alarm system is activated, the bell will continue to ring until the engine operator stops the engine.

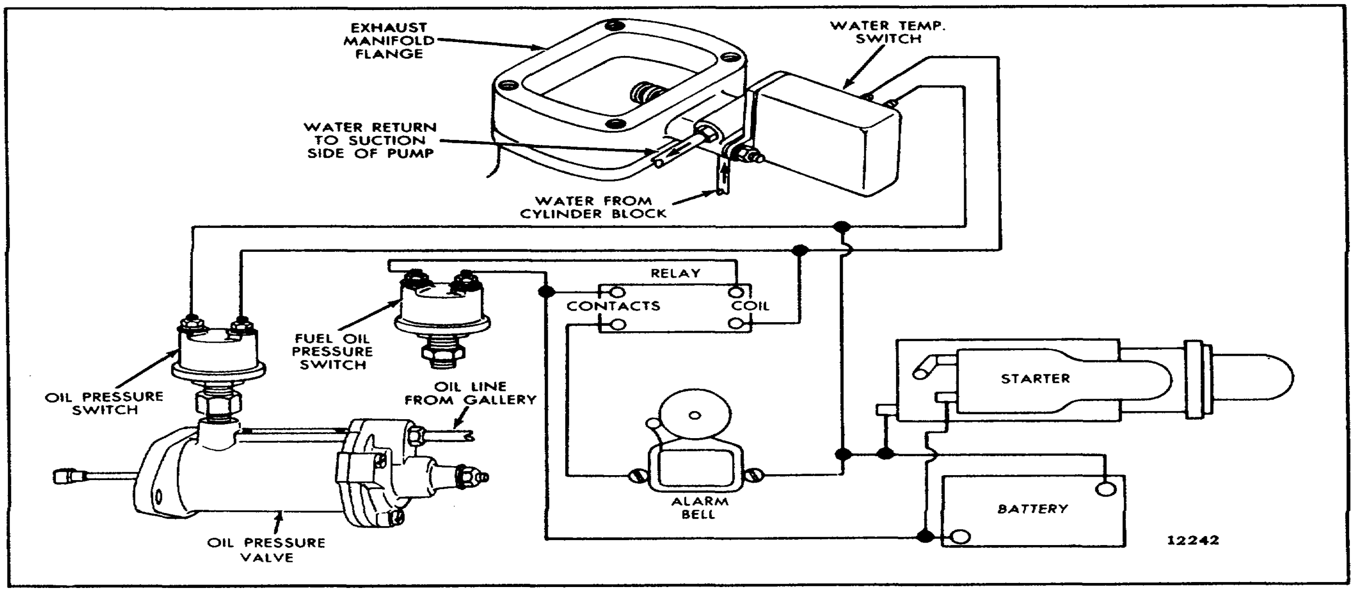


Fig. 9. - Alarm System with Mechanical Sensing Units

During a routine engine shut down, the decreasing fuel pressure causes the fuel pressure switch to open the electrical circuit before the decreasing oil pressure can activate the alarm system.

On 16V-71 engines, coolant protection is also obtained through an exhaust probe and adaptor assembly and a temperature switch. In this system, the engine coolant is circulated around the switch power element to prevent the switch from being activated by the heat transfer from the exhaust probe. Therefore, an alarm will occur if coolant flow through the adaptor is interrupted for any reason. The switch will also operate when the engine coolant discharge temperature exceeds 200-205 °F (93-95 ° C).

The oil pressure switch, mounted in the low oil pressure and overspeed valve (Fig. 9), will be activated to sound the alarm when the engine oil pressure drops below the safe operating pressure. The switch will also detect an engine overspeed. Engine oil is supplied to the valve. Should the engine oil pressure drop below a safe operating value, above 1200 rpm, the valve will operate, dropping the oil pressure at the switch which completes the circuit and sounds the alarm. Below 1200 rpm the oil pressure switch will close whenever the oil pressure is less than the switch setting.

Engine overspeed is detected by the operation of the valve which results in the oil switch closing. The travel of the piston in the valve, which is adjustable, controls the overspeed setting.

The relay is used to prevent damage to the pressure and temperature switches should the current to operate the alarm device be too high.

Should the alarm be activated for any reason, the engine should be stopped immediately and the cause found and corrected before the engine is started again.

STARTING SYSTEMS

ELECTRICAL STARTING

The electrical system on an engine generally consists of a starting motor, starting switch, battery-charging alternator, voltage regulator, storage battery and the necessary wiring. Additional electrical equipment may be installed on the engine at the option of the owner.

Starting Motor

The electric starting motor has an overrunning clutch drive or a Bendix drive assembly. Bendix drive starters are generally used on applications where automatic starting is required, such as standby generator sets.

The overrunning clutch drive starters have the solenoid mounted on the starter and have a totally enclosed shifting mechanism.

Starter Switch

To start the engine, a switch is used to energize the starting motor. Release the switch immediately after the engine starts.

Battery-Charging Alternator

A battery-charging alternator is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the alternator.

Alternator Precautions

Precautions must be taken when working on or around an A.C. generator (alternator). The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding the output wires or the field wires between the alternator and the regulator. Never run an alternator on an open circuit.

Grounding an alternator's output wire or terminals, which are always hot regardless whether or not the engine is running, and accidental reversing of the battery polarity will destroy the diodes. Grounding the field circuit will also result in the destruction of the diodes. Some voltage regulators provide protection against some of these circumstances. However, it is recommended that extreme caution be used.

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery will result in damage to the diodes, due to the momentary high voltage and current generated by the rapid collapse of the magnetic field surrounding the field windings.

In marine applications which have two sets of batteries, switching from one set of batteries to the other while the engine is running will momentarily disconnect the batteries and result in damage to the alternator diodes.

If a booster battery is to be used, the batteries must be connected correctly (negative to negative and positive to positive).

Never use a fast charger with the battery connected, or as a booster for battery output.

Never attempt to polarize an alternator. Polarization is not necessary and is harmful.

The alternator diodes are also sensitive to heat, and care must be exercised to prevent damage to them from soldering irons, etc.

If faulty operation of an alternator occurs on an engine equipped with an insulated starting motor, check to be sure that a ground strap is present and is correctly installed.

Regulator

A regulator is incorporated in the electrical system to regulate the voltage and current output of the batterycharging alternator and to help maintain a fully charged storage battery.

Storage Battery

The lead-acid storage battery is an electrochemical device for converting chemical energy into electrical energy.

The battery has three major functions: I. It provides a source of electrical power for starting the engine.

2. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and reapply a light coating of grease when needed. Replace corroded, damaged parts.

4. Use the standard, quick in-the-unit battery test as the regular service test to check battery condition.

5. Check the electrical system if the battery becomes discharged repeatedly.

CAUTION: Explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flame can ignite this gas causing an explosion which could shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

If the engine is to be stored for more than 30 days, remove the battery. The battery should be stored in a cool, dry place. Keep the battery fully charged and check the level of the electrolyte regularly.

The Lubrication and Preventive Maintenance section of this manual covers the servicing of the starting motor and alternator.

Consult -an authorized Detroit Diesel Allison Service Outlet for information regarding the electrical system.

GOVERNORS

Engine Governors

Horsepower requirements of an engine may vary continually due to the fluctuating loads: therefore, a means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such load fluctuations. To accomplish this control, one of three types of governors is used on the engine, depending upon the application. Installations requiring maximum and minimum speed control.

together with manually controlled intermediate speeds, ordinarily use a limiting speed mechanical governor.

Applications requiring a near constant engine speed, under varying load conditions that may be changed by the operator, are equipped with a variable speed mechanical governor. The hydraulic governor is used where a uniform engine speed is required, under varying load conditions, with a minimum speed droop.

Lubrication

Mechanical governors are lubricated by oil that is sprayed from an orifice in the front blower end plate.

This orifice directs a stream of oil into the revolving governor weights. The weights throw the oil to all moving parts within the governor.

Surplus oil returns to the engine crankcase through connecting passages in the blower and cylinder block.

When an engine equipped with a hydraulic governor is running, oil is supplied under pressure from the engine to the governor and a portion of the oil flows past the power piston and pilot valve plunger to lubricate the moving parts in the governor housing.

Oil which collects on the floor of the governor housing drains into the drive housing, thus providing lubrication for the drive and driven shafts and their bearings. If the engine should fail to supply oil to the governor, the power piston will drop allowing the fuel rod to return to the no-fuel position; thus the hydraulic governor also acts as an automatic shutdown device.

Service

Fluctuations of the engine speed usually indicates governor malfunction. However, these fluctuations can also be caused by an excessive load on the engine, misfiring or binding linkage. Contact an authorized Detroit Diesel Allison Service Outlet for information regarding governors.

Output Shaft Governors

On certain applications equipped with a Torqmatic converter, it is sometimes desirable to maintain a constant output shaft speed regardless of the engine speed or load fluctuations. To acquire the necessary results, a governor driven by the output shaft is installed in conjunction with an engine governor. This governor is called an output shaft governor and may be mechanical or hydraulic.

The output shaft governor controls the engine governor (usually a limiting speed type) in the engine speed range between idle and maximum speed. The engine speed is prevented from going below idle or exceeding the maximum speed setting by the engine governor.

Service

Refer to the Engine Tune-Up Procedures for any adjustments to the output shaft governors or contact an authorized Detroit Diesel Allison Service Outlet for information regarding output shaft governors.

TRANSMISSIONS

This manual includes information on the lubrication and preventive maintenance of the transmissions. It also includes adjustment procedures covering some of the more common power transmissions.

Problems relating to the repair and overhaul of these transmissions should be referred to an authorized Detroit Diesel Allison Service Outlet.

POWER TAKE-OFF ASSEMBLIES

The front and rear power take-off units are basically similar in design, varying in clutch size to meet the requirements of a particular engine application.

The power take-off unit is attached to either an adaptor (front power take-off) or the engine flywheel housing (rear power take-off). Each power take-off unit has a single or double plate clutch. The drive shaft is driven by the clutch assembly and is supported by a pilot bearing in the flywheel or the adaptor and by two tapered roller bearings mounted in the clutch housing.

Clutch Adjustment

These instructions refer to field adjustment for clutch facing wear. Frequency of adjustment depends upon the amount and nature of the load.

To ensure a long clutch facing life and the best performance, the clutch should be adjusted before slippage occurs.

When the clutch is properly adjusted, a heavy pressure is required at the outer end of the hand lever to move

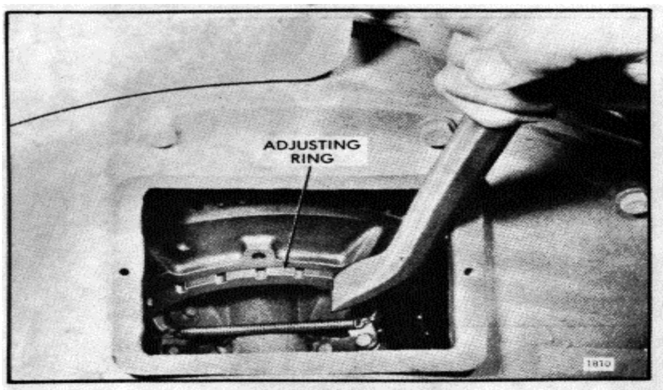


Fig. 10. - Power Take-Off Showing Typical 8 and 11-1/2 Inch Diameter Clutch Adjustment Ring

the throwout linkage to the "over center" or locked position.

Adjust the 8", 11-1/2" and 14" diameter clutches as follows: 1. Disengage the clutch with the hand lever.

2. Remove the inspection hole cover to expose the clutch adjusting ring.

3. Rotate the clutch, if necessary, to bring the clutch adjusting ring lock within reach.

4. On the 8" and 11-1/2" diameter clutches, remove the clutch adjusting ring spring lock screw and lock from the inner clutch pressure plate and adjusting ring. Then, while holding the clutch drive shaft to prevent the clutch from turning, turn the clutch adjusting ring counterclockwise as shown in Fig. 10 and tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 13), is. obtained as shown in Table 1.

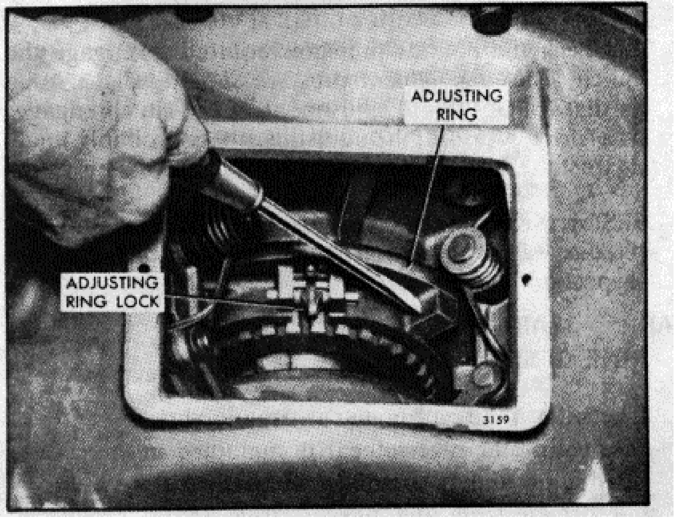


Fig. 11. Power Take-Off Assembly Showing 14 Inch Diameter Clutch Adjustment Ring

5. On the 14" diameter single and double plate clutches, raise the end of the adjusting ring lock up out of the splined groove in the hub of the outer clutch pressure plate. Then, while holding the clutch drive shaft to prevent the clutch from turning, turn the clutch adjusting ring clockwise as shown in Fig. 11 and tighten the clutch until the desired pressure on the outer end of the hand lever, or at the clutch release shaft (Fig. 13), is obtained as shown in Table 1.

6. Install the clutch adjusting ring spring lock on the 8" and 11-1/2" diameter clutches. The ends of the lock must engage the notches in the adjusting ring. On the 14" diameter clutch, reinstall the end of the adjusting ring lock in one of the splined grooves in the hub of the outer pressure plate. Then install the inspection hole cover.

Adjust the 18" diameter clutch as follows:

I. Rotate the clutch, if necessary, to bring the adjustment lock and the pinion within reach through the inspection hole.

2. Loosen the lock bolt and pull the lock out of mesh with the adjusting ring; then, tighten the lock bolt to hold the lock out of the adjusting ring. While holding the clutch drive shaft to prevent the clutch from turning, turn the adjustment pinion clockwise to tighten the clutch as shown in Fig. 12.

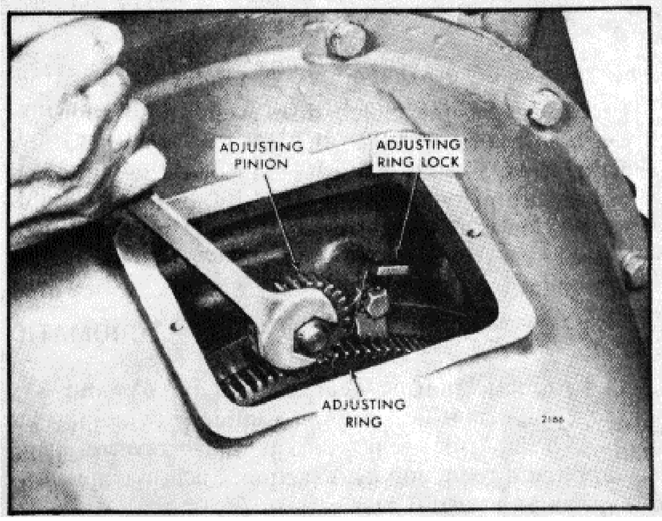


Fig. 12. - Power Take-Off Assembly Showing Method of Adjusting 18 Inch Diameter Clutch

3 Loosen the lock bolt and move the lock so it will mesh with the teeth of the adjusting ring. then tighten the lock bolt.

When properly adjusted, the approximate pressure required at the outer end of the hand lever to engage the various diameter clutches is shown in the table.

These specifications apply only with the hand lever which is furnished with the power take-off.
A suitable spring scale may be used to check the pounds pressure required to engage the clutch.
However, a more accurate method of checking the clutch adjustment is with a torque wrench as shown in Fig. 13.
To fabricate an adaptor, saw the serrated end off of a clutch hand lever and weld a 1-1/8" nut (across the hex) on it as shown in Fig. 13. Then saw a slot through the nut.
When checking the clutch adjustment with a torque wrench, engage the clutch slowly and note the amount of torque immediately before the clutch engages (goes over center). The specified torque is shown in Table 1.

Clutch	Hand Lever	Pressure		Torque	
Dia.	Length	psi	kPa	Ib-ft	Nm
8"	20"	40	276	56-63	76-85
11-1/2"	20"	65	448	94-100	127-136
14"	25"	75	517	132-149	179-202
18"	40-3/8"	90	621	278-298	379-404

TABLE 1.

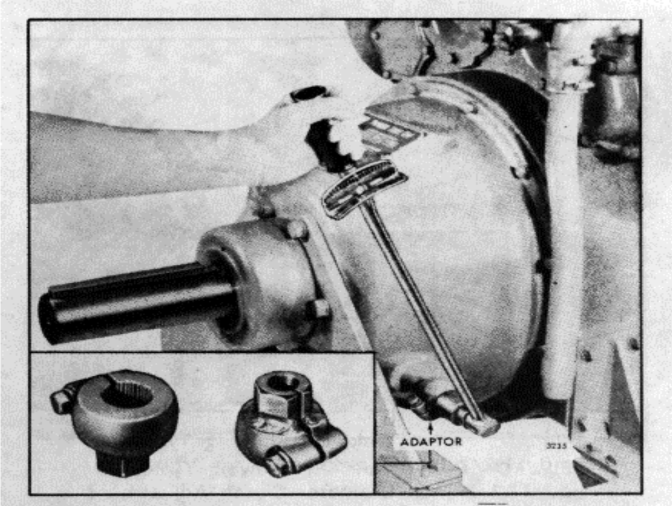


Fig. 13 · Checking Power Take-Oft Clutch

Fig. 13. - Checking Power Take-Oft Clutch

The facings of the clutch discs wear only along the area where they contact the pressure plates during engagement. The area on each side of the disc beyond the pressure plates does not wear proportionately, thus resulting in a ridge. This ridge on three segment clutches can complicate the job of making an adjustment inasmuch as the top segment tends to drop down when the engine is stopped. This drop lets the ridge locate between the pressure plates. The drive ring cannot be properly adjusted to the recommended engaging pressure with the disc so positioned. The condition can result in excessive slippage and a need for early clutch facing replacement.

Make a final clutch adjustment check with the engine running, to make sure the adjustment was not made against the ridge. The procedure is outlined below: I.
Start the engine and operate it at idling speed (approximately 500 rpm) with the clutch disengaged.

The speed will be sufficient to move the segments out to operating position.

2. Check the pounds pressure required to engage the clutch. The engagement pressure should be the same as that following the adjustment. If the clutch engages at a lower pressure, the adjustment was probably made against the unworn portion of the facing.

3. Stop the engine and readjust the clutch, making sure all disc segments are properly positioned. Install the inspection hole cover.

TORQMATIC MARINE GEAR

The Torqmatic marine gear is used on 6V and 8V single engine marine units and tandem twin marine units. The marine gear consists of a reverse gear section and a reduction gear section. Each marine gear is available in several gear ratios.

The oil for operating the hydraulic clutches and for lubricating the reverse gear is contained in the reverse gear sump and is circulated throughout the system by a hydraulic oil pump mounted on the flywheel housing and driven from the blower drive shaft through a flexible coupling.

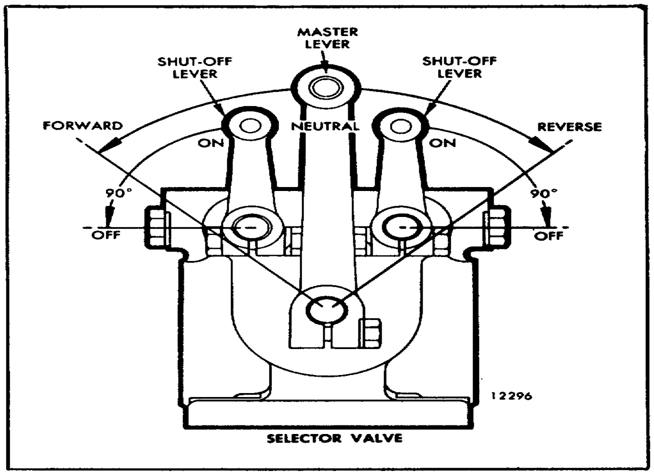


Fig. 14. - Lever Arrangement on Tandem Twin Engine Marine Gear Selector Valve

The oil pressure ranges for the marine gear at forward operating speed are 130-155 psi (896-1068 kPa) and 110-150 psi (758-1034 kPa) in reverse. The average operating oil temperature is 200 F (93 ° C) in forward and a maximum of 250 ° F (121 ° C) in reverse.

A strainer is used between the oil sump and the pump to remove harmful solids. The oil passes from the pump through a cooler to the control valve. From the control valve, the oil operates the forward or reverse clutch pistons and sprays oil into the reduction gear housing to lubricate the gear.

The constant flow control valve, incorporated with a pressure relief valve, controls the amount of oil pumped through the hydraulic system and is sensitive only to engine speed and operates independently of the pressure relief valve section which controls the pressure within the complete hydraulic system.

When the engine is in operation, the moving parts of the marine reverse gear are pressure lubricated while the reduction gear assembly is splash lubricated.

Shifting from forward to reverse drive through neutral may be made at any speed; however, it is advisable to shift at low engine speeds. For longest clutch life, reduce the engine speed to idle, make the shift and then increase the engine speed.

The marine gear selector control valve assembly on the tandem twin marine engine unit is provided with several levers (Fig. 14). The master control lever engages both marine gears in forward or reverse simultaneously. The smaller levers, one for each engine, operate the shutoff control valves for controlling the flow of oil to each individual engine marine gear. These levers are normally set in a vertical position ("on" position). To shut down one engine for service work or to conserve on power in a light load situation, place the master control lever in the neutral position and then turn the shutoff lever for that engine to the "off' position (90 degrees toward the engine). With the shutoff lever in the "off' position, the marine gear for that engine is locked out of engagement. The other engine can then continue to supply power to the gear box.

CAUTION: When the shutoff lever is turned to the off position, lock it in that position by wire or some other means to prevent vibration from moving it back up to the on position. This caution applies particularly when work is being done on the engine.

It is recommended that all sailing vessels and boats utilizing the Torqmatic marine gears (single or twin screw installations) have a locking (brake) device to prevent the propeller shaft from rotating while the sailing vessel is operating under sail, or the boat is operating with one engine shut down or being towed.

With the engine shut down, and the marine gear oil pump not operating, it cannot circulate lubricating oil through the reverse gear. Therefore, overheating and damage to the marine gear is possible unless rotation of the propeller shaft is prevented.

If the clutches cannot be engaged hydraulically, in an emergency, the forward drive may be engaged with three bolts as follows:

1. Remove the large pipe plug from the forward face of the flywheel housing.

2. With the throttle in the stop position, rotate the flywheel until one of the bolts aligns with the opening in the flywheel housing.

3. Remove the bolt from the flywheel.

4. Remove and save the jam nut, and replace the bolt finger-tight.

5. Remove and reinstall the remaining two bolts in the same manner.

6. Start at the first bolt and tighten all three bolts uniformly, thereby locking the clutch plate between the piston and the drive plate. To prevent binding between the piston and the bore in the flywheel, the emergency engagement bolts must be tightened

uniformly. Do not use the reverse drive when the engagement bolts are engaged. Install the pipe plug in the flywheel housing.

NOTE: To reduce the possibility of overheating, add an additional gallon of oil if the forward clutch is engaged with the emergency engagement bolts and the hydraulic pump is inoperative.

TWIN DISC MARINE GEAR

A Twin Disc marine gear is used on certain V-71 marine engines. This marine gear has two hydraulically operated multi-disc clutches to provide forward and reverse operation.

The marine gear has an oil sump capacity of approximately six gallons (23 liters). An oil pump driven by the reverse shaft operates whenever the engine is operating. This pump draws oil from the sump through a suction strainer, protecting the pump from foreign particles in the oil. The oil discharged from the pump flows through an oil cooler, mounted on the side of the engine, and then returns to the marine gear housing. The oil upon entering the gear housing passes through an integral oil filter and then to the selector valve. A bypass valve across the filter prevents the stoppage of oil flow to the selector valve in the event the filter becomes clogged.

Some units incorporate a trolling valve which is mounted between the selector valve and the forward clutch. This valve is a relief valve with manual control over the relief valve spring. Movement of the trolling valve by the operator drops the forward clutch operating pressure to a point where the multi-disc clutch plates slip. Further movement of the valve increases the slippage. This permits very low propeller speeds necessary for some fishing operations. The entire oil spill from the trolling valve, in dropping the pressure, is directed through the plates of the forward slipping clutch. This provides a film of oil on which the plates ride and removes any heat generated.

The marine gear is driven by the engine through synthetic rubber caps molded in a gear tooth form.

The rubber caps are mounted on the teeth of the spider gear and mesh with the flywheel drive ring. They cushion the drive from the engine to the marine gear.

Emergency Operation

In case of emergency shifting from forward to reverse at higher than normal engine speeds. the selector and pressure ,regulating valve should have a 1/2 second pause in neutral so that it can control the rate of pressure rise. This causes 3/4 to I 1/2 second delay before full pressure is applied to the selected clutch. Thus, sudden shock on the gears and shafts is reduced. Complete reversal of the propeller is recommended only at reduced engine speeds.

Emergency Engagement

Should a failure impair the hydraulic system of the marine gear, the desired clutch, either forward or reverse, can be engaged manually. The manual engagement is accomplished by removing three pipe plugs, protruding from the rear of the transmission, in line with the desired clutch to be engaged. Then bar the engine output shaft over until the three emergency engagement bolts are in line with the holes. Alternately tighten the three bolts uniformly until the clutch is locked in engagement. Reinstall the pipe plugs.

The engine, when started with the selector valve in neutral, will drive the propeller through the engaged clutch. No attempt should be made to move the selector valve from the neutral position since engagement of the other clutch may cause damage.

TORQMATIC CONVERTERS

The Torqmatic converter is a self contained unit which transfers and multiplies the torque of the prime mover. This unit transmits the power through the action of oil instead of through gears and in addition to multiplying the torque also acts as a fluid coupling between the engine and the equipment to be powered. The converter will automatically adjust the output torque to load requirements.

There are various combinations of Torqmatic converters with features such as: an automotive or industrial flange on the shaft, a hydraulically operated lock-up clutch, a manual input disconnect clutch, and an accessory drive for either a governor or tachometer.

Check the oil level daily and, if the converter is equipped with an input disconnect clutch, additional checks and service will be necessary daily or at intervals determined by the type of operation.

Adjust the disconnect clutches as outlined under power take-off clutch adjustment.

Contact an authorized *Detroit Diesel Allison Service Outlet* for information on Torqmatic converters

OPERATING INSTRUCTIONS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow the instructions listed below and in the *Engine Tune-Up Procedure*. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

NOTE

: When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see Daily Operations in the *Lubrication and Preventive Maintenance Chart.*

Cooling System Install all of the drain cocks or plugs in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine is so equipped.

Loosen the water return line near the top of the turbocharger (if used).

Remove the filler cap and fill the cooling system with clean, soft water or a protective solution consisting of an ethylene glycol base antifreeze, if the engine will be exposed to freezing temperatures (refer to Engine Coolant). Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

Close the vents, if used, after filling the cooling system.

Tighten the turbocharger water return line.

On marine installations, prime the raw water cooling system and open any sea cocks in the raw water pump intake line. Prime the raw water pump by removing the pipe plug or electrode provided in the pump outlet elbow and pour water in the pump.

NOTE

: Failure to prime the raw water pump may result in damage to the pump impeller.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time.

It is recommended that the engine lubricating system be charged with a pressure prelubricator, set to supply a minimum of 25 psi (172 kPa) oil pressure, to ensure an immediate flow of oil to all bearings at the initial engine start-up. The oil supply line should be attached to the engine so that oil under pressure is supplied to the main oil gallery.

With the oil pan dry, use the prelubricator to prime the engine with sufficient oil to reach all bearing surfaces. Use heavy-duty lubricating oil as specified under Lubrication Specifications. Then remove the dipstick, wipe it with a clean cloth, insert and remove it again to check the oil level in the oil pan. Add sufficient oil, if necessary, to bring it to the full mark on the dipstick. Do not overfill.

If a pressure prelubricator is not available, fill the crankcase to the proper level with heavy-duty lubricating oil as specified under Lubrication Specifications. Then pre-lubricate the upper engine parts by removing the valve rocker covers and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms.

Turbocharger

After installing a rebuilt or new turbocharger it is very important that all the moving parts of the turbocharger center housing be lubricated as follows: 1.

Disconnect the oil inlet (supply) line at the bearing (center) housing.

2. Fill the bearing housing cavity with clean engine oil.

Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

3. Add additional engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

4. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all the moving parts are

getting lubrication is when the oil pressure gage registers pressure (10 psi or 69 kPa at idle speed).

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running.

This could result in personal injury.

Air Cleaner

the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. Do not overfill.

Transmission

Fill the transmission case, marine gear or torque converter supply tank to the proper level with the lubricant specified under Lubrication and Preventive Maintenance.

Fuel System

Fill the fuel tank with the fuel specified under Fuel Specifications.

If the unit is equipped with a fuel valve, it must be opened.

To ensure prompt starting, fill the fuel system between the pump and the fuel return manifold with fuel. If the engine has been out of service for a considerable length of time, prime the filter between the fuel pump and the injectors. The filter may be primed by removing the plug in the top of the filter cover and slowly filling the filter with fuel.

In addition to the above, on an engine equipped with a hydrostarter, use a priming pump to make sure the fuel lines and the injectors are full of fuel before attempting to start the engine.

NOTE: The fuel system is filled with fuel before leaving the factory. If the fuel is still in the system when preparing to start the engine, priming should be unnecessary.

Lubrication Fittings

Fill all grease cups and lubricate at all fittings with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all drive belts as recommended under Lubrication and Preventive Maintenance.

Storage Battery

Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

NOTE: When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

Generator Set

Where applicable, fill the generator end bearing housing with the same lubricating oil as used in the engine.

A generator set should be connected and grounded in accordance with the applicable local electrical codes.

NOTE: The base of a generator set must be grounded.

Clutch

Disengage the clutch, if the unit is so equipped.

STARTING

Before starting the engine for the first time, perform the operations listed under *Preparation For Starting Engine First Time.*

Before a routine start, see *Daily Operations in the Lubrication and Preventive Maintenance Chart.*

If a manual or an automatic shutdown system is incorporated in the unit, the control must be set in the open position before starting the engine. The blower will be seriously damaged if operated with the air shutoff valve in the closed position.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40° F (4°C).

NOTE: On engines with dual air shutdown housings, both air shutoff valves must be in the open position before starting the engine.

Initial Engine Start (Electric) Start an engine equipped with an electric starting motor as follows: Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the run position; on hydraulic governors, make sure the stop knob is pushed all the way in. Then press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

NOTE: To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is running.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system. The pressure should not fall below 25 psi (172 kPa) at 1200 rpm or 30 psi (207 kPa) at 2100 rpm and normal operating pressure should be higher.

Warm-Up

Run the engine at part throttle and no-load for approximately five minutes, allowing it to warm-up before applying a load.

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

Inspection

While the engine is running at operating temperature, check for coolant, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Engine Temperature

Normal engine coolant temperature is 160-185°F (7185 C).

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached, allow the oil to drain (approximately 20 minutes) back into the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the *heavy duty* lubricating oil specified under *Lubrication Specifications*.

Clutch

Do not engage the clutch (with a sintered iron clutch plate) at engine speeds over 850 rpm. A clutch with an asbestos or vegetable fiber material clutch plate must not be engaged at speeds over 1000 rpm.

Cooling System

Remove the radiator or heat exchanger tank cap slowly after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or a high boiling point type antifreeze.

Transmission

Check the marine gear oil pressure. The operating oil pressure range at operating speed is 130-155 psi (8961068 kPa) (Allison Torqmatic gear). The operating oil pressure varies with the different Twin Disc gears as noted in Table 1. Check and, if necessary, replenish the oil supply in the transmission.

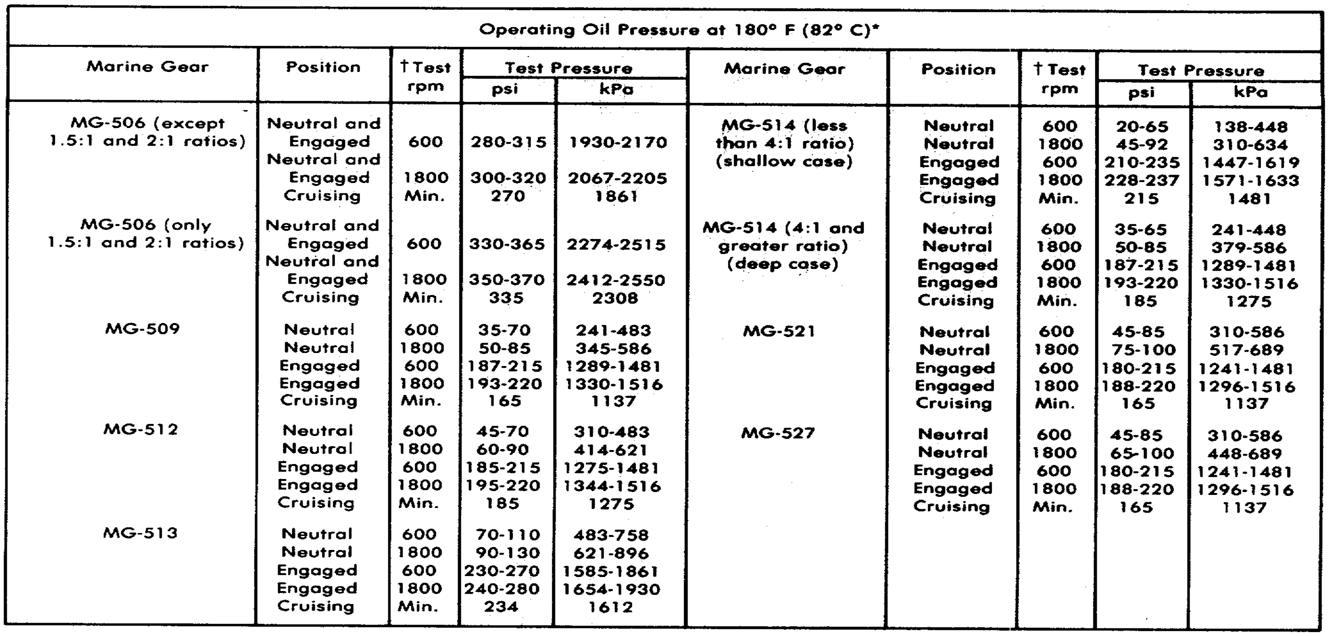
Turbocharger

Make a visual inspection of the turbocharger for leaks and excessive vibration. Stop the engine immediately if there' is an unusual noise in the turbocharger.

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

> **NOTE:** When prolonged engine idling is necessary, maintain at least 800 rpm.



Operating Oil Pressure at 180° F (82° C)*

Marine Gear	Position	† Test rpm	Test Pressure	
			psi	kPa
MG-506 (except 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	280-315	1930-2170
	Neutral and Engaged	1800	300-320	2067-2205
	Cruising	Min.	270	1861
MG-506 (only 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	330-365	2274-2515
	Neutral and Engaged	1800	350-370	2412-2550
	Cruising	Min.	335	2308
MG-509	Neutral	600	35-70	241-483
	Neutral	1800	50-85	345-586
	Engaged	600	187-215	1289-1481
	Engaged	1800	193-220	1330-1516
	Cruising	Min.	165	1137
MG-512	Neutral	600	45-70	310-483
	Neutral	1800	60-90	414-621
	Engaged	600	185-215	1275-1481
	Engaged	1800	195-220	1344-1516
	Cruising	Min.	185	1275
MG-513	Neutral	600	70-110	483-758
	Neutral	1800	90-130	621-896
	Engaged	600	230-270	1585-1861
	Engaged	1800	240-280	1654-1930
	Cruising	Min.	234	1612

Marine Gear	Position	† Test rpm	Test Pressure	
			psi	kPa
MG-514 (less than 4:1 ratio) (shallow case)	Neutral	600	20-65	138-448
	Neutral	1800	45-92	310-634
	Engaged	600	210-235	1447-1619
	Engaged	1800	228-237	1571-1633
	Cruising	Min.	215	1481
MG-514 (4:1 and greater ratio) (deep case)	Neutral	600	35-65	241-448
	Neutral	1800	50-85	379-586
	Engaged	600	187-215	1289-1481
	Engaged	1800	193-220	1330-1516
	Cruising	Min.	185	1275
MG-521	Neutral	600	45-85	310-586
	Neutral	1800	75-100	517-689
	Engaged	600	180-215	1241-1481
	Engaged	1800	188-220	1296-1516
	Cruising	Min.	165	1137
MG-527	Neutral	600	45-85	310-586
	Neutral	1800	65-100	448-689
	Engaged	600	180-215	1241-1481
	Engaged	1800	188-220	1296-1516
	Cruising	Min.	165	1137

** Sump or heat exchanger inlet 210° F (990 C) maximum. Normal operating range desired 140-1800 F (60-820 C) minimum continuous duty.*

t Sump or heat exchanger inlet 2250 F (1070 C) maximum intermittent permissable in pleasure craft.

TABLE 1. - Twin Disc Marine Gear Operating Conditions

STOPPING

Normal Stopping

1. Release the load and decrease the engine speed. Put all shift levers in the neutral position.

2. Allow the engine to run at half speed or slower with no load for four or five minutes, then move the stop lever to the stop position to shut down the engine.

Emergency Stopping

To stop an engine (normal or emergency) equipped with the spring-loaded (one screw) design injector control tube, pull the governor stop lever to the stop position. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected.

NOTE : The emergency shutdown system should never be used except in an emergency. Use of the emergency shutdown can cause oil to be sucked past the oil seals and into the blower housing.

Fuel System

If the unit is equipped with a fuel valve, close it. Fill the fuel tank; a full tank minimizes condensation.

Exhaust System

Drain the condensation from the exhaust line or silencer.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

Crankcase

Check the oil level in the crankcase. Add oil, if necessary, to bring it to the proper level on the dipsticks.

Transmission

Check and, if necessary, replenish the oil supply in the transmission.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to *Lubrication and Preventive Maintenance* and perform all of the daily maintenance operations. Also perform the operations required for the number of hours or miles the engine has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which became apparent to the operator during the last run.

ALTERNATING CURRENT POWER GENERATOR SET

OPERATING INSTRUCTIONS

These instructions cover the fundamental procedures for operating an alternating current power generator set. The operator should read these instructions before attempting to operate the generator set.

PREPARATION FOR STARTING

Before attempting to start a new or an overhauled engine or an engine which has been in storage, perform all of the operations listed under Preparation for Starting Engine First Time. Before a routine start see *Daily Operations in the Lubrication and Preventive Maintenance Chart.*

In addition to the *Engine Operating Instructions*, the following instructions also apply when operating an alternating current power generator set.

1 Before the first start, check the generator main bearing oil reservoir. If necessary, add sufficient lubricating oil of the same grade that is used in the engine crankcase to bring it to the proper level on the sight gage. *Do not overfill*.

2. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi or 172 kPa maximum). If there is moisture on the interior of the generator, it must be dried before the set is started. Refer to the appropriate Delco Products Maintenance Bulletin.

3. The overspeed trip solenoid lever located at the air inlet housing must be in the open or reset position.

4. Refer to Fig. 1 and place the circuit breaker (10) in the o*ff* position.

5 Place the field switch (7) in the off position.

6 Place the synchronizing lamp switch (6) in the *off* position.

7 Place the voltage regulator switch (3) in the off or manual position.

8. Turn the field rheostat knob (8) clockwise to its lower limits.

9. Make sure the power generator set has been cleared of all tools or other objects which might interfere with its operation.

STARTING

If the generator set is operated in a closed space, start the ventilating fan or open the doors and windows, as weather permits, to supply ample air to the engine.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40° F (4°C).

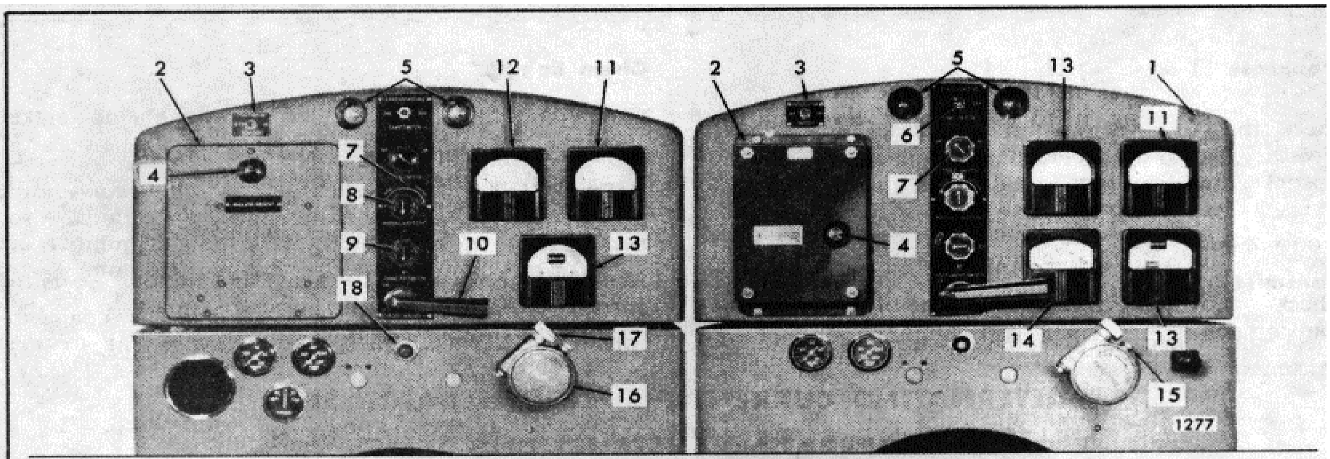
Press the throttle button (15) and turn the throttle control (16), Fig. 1, counterclockwise to a position midway between run and stop. Then press the starter button (18) firmly.

If the engine fails to start within 30 seconds, release the starter button and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

> **NOTE :** To prevent serious damage to the starter if the engine does not start, do not press the starter switch again while the starter motor is rotating.

RUNNING

If the oil pressure is observed to be normal, increase the throttle setting to cause the engine to run at its synchronous speed.



1. Cabinet--Control
2. Regulator--Voltage
3. Switch--Voltage Regulator
4. Control--Voltage Regulator Rheostat
5. Lamps--Synchronizing
6. Switch--Synchronizing Lamp
7. Switch--Field
8. Control--Manual Field Rheostat
9. Switch--Selector
10. Control--Circuit Breaker
11. Ammeter
12. Voltmeter
13. Frequency Meter
14. Kilowatt Meter
15. Button--Throttle
16. Control--Throttle
17. Knob--Vernier Throttle
18. Button--Engine Starter

1.

Fig. 1. - Typical Alternating Current Generator Control Cabinets

PREPARING GENERATOR FOR LOAD

After the engine has warmed up (or the oil pressure has stabilized), prepare the generator set for load as follows:
I. Bring the engine up to rated speed. Then place the field switch (7), Fig. 1, in the on position.

2. Turn the voltage regulator switch (3) on.

3. Turn the instrument selector switch (9) to the desired position.

4. Turn the field rheostat (8) slowly in a counterclockwise direction to raise the voltage, while watching the voltmeter, until the rheostat reaches the end of its travel. The voltage regulator will take control of the generator voltage as the field rheostat reaches the end of its travel.

5. If the power generator unit is equipped with a frequency meter, adjust the engine speed with the vernier throttle knob (17) until the desired frequency is indicated on the meter.

6. Adjust the voltage regulator rheostat (4) to obtain the desired voltage.

7. Make sure all power lines are clear of personnel, then place the circuit breaker control (10) in the on position.

NOTE: Perform Step 7 only if the set is not being paralleled with an existing power source. If the set is being paralled with a power source already on the line, read and follow the instructions under Paralleling before turning the circuit breaker control to the on position.

PARALLELING

If the load conditions require an additional set to be placed on the line, the following instructions will apply to power generator sets of equal capacity, with one set in operation on the line.

I. Prepare the set to be paralleled as outlined under Preparation for Starting, Starting, Running and Items I through 6 under Preparing Generator for Load.

2. Check the voltmeter (12), Fig. 1; the voltage must be the same as the line voltage. Adjust the voltage regulator rheostat control (4) if the voltages are not the same.

3. Place the synchronizing lamp switch (6), of the generator set to be paralleled, in the on position.

4. Turn the vernier throttle knob (17) until both sets are operating at approximately the same frequency, indicated by the slow change in the brilliancy of the synchronizing lamps.

5. When the synchronizing lamps glow and then go out at a very slow rate, time the dark interval. Then, in

the middle of this interval turn the circuit breaker control to the on position. This places the incoming set on the line, with no load. The proper share of the existing load must now be placed on this set.

6 The division of the kilowatt load between the alternating current generators operating in parallel depends on the power supplied by the engines to the generators as controlled by the engine governors and is practically independent of the generator excitation.

Divide the kilowatt load between the sets by turning the vernier throttle knob (17) counterclockwise on the incoming set and clockwise on the set that has been carrying the load (to keep the frequency of the sets constant) until both kilowatt meters indicate that each set is carrying its proper percentage of the total K.W.

load. Refer to Item 8 if the sets are not equipped with kilowatt meters.

7. The division of the reactive KVA load depends on the generator excitation as controlled by the voltage regulator. Divide the reactive load between the sets by turning the voltage regulator rheostat control on the incoming set (generally counterclockwise to raise the voltage) until the ammeters read the same on both sets and the sum of the readings is minimum.

> **NOTE** : The generator sets are equipped with a resistor and current transformer connected in series with the voltage coil of the regulator (cross-current compensation) which equalizes most but not all of the reactive KVA load between the generators.

8. When the load is unity power factor (lighting and a few small motors only), follow the instructions in Item 6 above until both ammeters read the same.

9 When the load is 80% power factor lagging (motor and a few lights only), turn the vernier throttle knob (17) on the incoming set until the ammeter on that set reads approximately 40% of the total current load.

10. Rotate the voltage regulator rheostat control (4) on the incoming set (generally counterclockwise to raise the voltage) until the ammeters read the same on both sets.

> **NOTE** : If a load was not added during paralleling, the total of the two ammeter readings should be the same as the reading before paralleling. Readjust the voltage regulator rheostat (4) on the incoming set, if necessary.

11. To reset the load voltage, turn the voltage regulator rheostat controls slowly on each set. It is necessary to turn the controls the same amount and in the same direction to keep the reactive current equally divided.

Power generator sets with different capacities can also be paralleled by dividing the load proportionately to their capacity.

STOPPING

The procedure for stopping a power generator set or taking a set out of parallel is as follows: I. Turn off all the load on the generator when stopping a single engine unit. Shift the load from the generator when taking a set out of parallel operation by turning the vernier throttle knob (17), Fig. I, until the ammeter (11) reads approximately zero.

2 Place the circuit breaker control (10) in the off position.

3. Turn the field rheostat (8) to the fully clockwise position.

4. Turn the voltage regulator switch (3) to the off position.

5 Place the field switch (7) in the off position.

6. Press the throttle button (15) and turn the throttle control (16) to stop to shut down the engine.

> **NOTE** : When performing a tune-up on a unit that will be operated in parallel with another set, adjust the speed droop as specified in Engine Tune-Up.

LUBRICATION AND PREVENTIVE MAINTENANCE

The Lubrication and Preventive Maintenance Schedule is intended as a guide for establishing a preventive maintenance schedule. The suggestions and recommendations for preventive maintenance should be followed as closely as possible to obtain long life and best performance from a Detroit Diesel engine. The intervals indicated on the chart are time or miles (in thousands) of actual operation.

MAINTENANCE SCHEDULE EXPLANATION

The time or mileage increments shown apply only to the maintenance function described. These functions should be coordinated with other regularly scheduled maintenance.

The daily instructions pertain to routine or daily starting of an engine and not to a new engine or one that has not been operated for a considerable -period of time. For new or stored engines, carry out the instructions given under Preparation for Starting Engine First Time under Operating Instructions in Section 4.

INDUSTRIAL OFF HIGHWAY AND MARINE	TIME INTERVALS										
HRS.	DLY.	8	50	100	150	200	300	500	700	1,000	2,000
MILES		240	1,500	3,000	4,500	6,000	9,000	15,000	20,000	30,000	60,000
1. — Lubricating Oil	X				X						
2. — Fuel Tank	X							X	X		
3. — Fuel Lines	X										
4. — Cooling System	X								X	X	
5. — Turbocharger	X										
6. — Battery				X							
7. — Tachometer Drive				X							
8. — Air Cleaners		X						X			
9. — Drive Belts		X				X					
10. — Air Compressor						X			X		
11. — Throttle and Clutch Controls						X					
12. — Lubricating Oil Filter								X		X	
13. — Fuel Strainer and Filter							X				
14. — Coolant Filter								X			
15. — Starting Motor*											
16. — Air System									X		
17. — Exhaust System									X		
18. — Air Box Drain Tube										X	
19. — Emergency Shutdown									X		
21. — Radiator									X		
22. — Shutter Operation									X		
23. — Oil Pressure									X		
24. — Overspeed Governor								X			
26. — Throttle Delay*											
27. — Battery-Charging Alternator						X					
28. — Engine and Transmission Mounts											X
29. — Crankcase Pressure											X
30. — Air Box Check Valves*											
31. — Fan Hub*									X		
32. — Thermostats and Seals									X		
33. — Blower Screen										X	
34. — Crankcase Breather										X	
36. — Engine Tune-Up*											
37. — Heat Exchanger Electrodes								X		X	
38. — Raw Water Pump	X										
39. — Power Generator				X			X				
40. — Power Take-Off		X	X					X			
41. — Marine Gear	X					X				X	
42. — Torqmatic Converter	X		X					X		X	
43. — Reduction Gear (Single Engine)		X	X					X		X	
44. — Reduction Gear (Multiple-Ind.)	X									X	
45. — Reduction Gear (Multiple-Marine)	X					X					

*See Item

Item 1 - Lubricating Oil

Check the lubricating oil level with the engine stopped.
If the engine has just been stopped. wait approximately twenty minutes to allow the oil to drain back to the oil pan. Add the proper grade oil as required to maintain the correct level on the dipstick.

> **NOTE:** Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Make a visual check for oil leaks around the filters and external oil lines.

Change the lubricating oil at the intervals shown in Table 1.

ENGINE OIL CHANGE INTERVALS

	Max. Engine Oil Change Interval			
Service Application	Diesel Fuel Sulfur Content % by Wt. Max.			
		O to .50	0.51 to 0.75 0.	76 to 1.00
Industrial & Marine		150 Hours	30 Hours	15 Hours’

*These oil change intervals ore based upon worst case with chrome-faced rings. Oil change periods with plasma rings can be established by oil analysis.

TABLE 1.

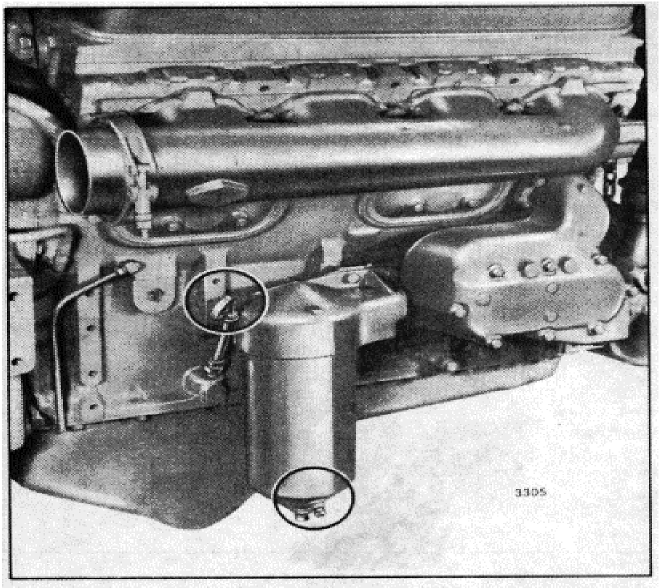
The drain interval may be established on the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the used oil sample analysis) until the most practical oil change period has been determined. Select the proper grade of oil in accordance with the instructions given in *Lubrication Specifications*.

NOTE : If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and will drain readily.

Item 2 Fuel Tank

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Fuel Specifications*. Open the drain at the bottom of the fuel tank every 500 hours or 15,000 miles to drain off any water or sediment.

Every 12 months or 20,000 miles (700 hours) tighten all fuel tank mountings and brackets. At the same time, check the seal in the fuel tank cap. the breather hole in the cap and the condition of the crossover fuel line. Repair or replace the parts as necessary.



Items 1 and 12

Diesel Fuel Contamination

The most common form of diesel fuel contamination is water. Water is harmful to the fuel system in itself, but it also promotes the growth of mircobiological organisms (microbes). These microbes clog fuel filters with a "slime" and restrict fuel flow.

Water can be introduced into the fuel supply through poor maintenance (loose or open fuel tank caps), contaminated fuel supply or condensation.

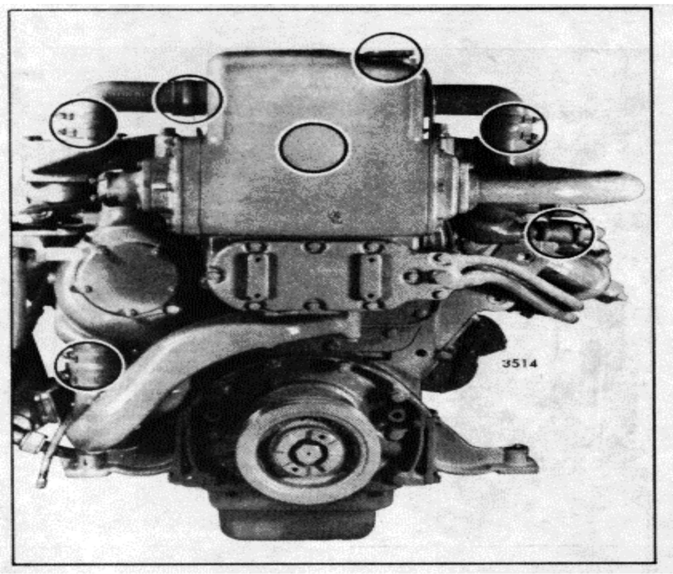
Condensation is particularly prevalent on units which stand idle for extended periods of time. such as marine units. Ambient temperature changes cause condensation in partially filled fuel tanks.

Water accumulation can be controlled by mixing isopropyl alcohol (dry gas) into the fuel oil at a ratio of one pint per 125 gallons fuel (or 0.10% by volume).

Marine units in storage are particularly susceptible to mircobe growth. The mircobes live in the fuel-water interface. They need both liquids to survive. These microbes find excellent growth conditions in the dark.

quiet, non-turbulent nature of the fuel tank.

Microbe growth can be eliminated through the use of



Items 4.

commerically available biocides. There are two basic types on the market: I. The water soluble type treats only the tank where it is introduced. Microbe growth can start again if fuel is transferred from a treated to an untreated tank.

2. The diesel fuel soluble type, such as "Biobor" manufactured by U.S. Borax or equilvalent, treats the fuel itself and therefore the entire fuel system.

Marine units, or any other application, going into storage should be treated as follows: Add the biocide according to the manufacturer’s instructions. This operation is most effective when performed as the tank is being filled. Add dry gas in the correct proportions.

If the fuel tanks were previously filled. add the chemicals and stir with a clean rod.

Item 3 Fuel Lines

Make a visual check for fuel leaks at the cross-over lines and at the fuel tank suction and return lines.

Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tanks.

Item 4 - Cooling System

Check the coolant level daily and maintain it near the top of the heat exchanger tank or radiator upper tank.

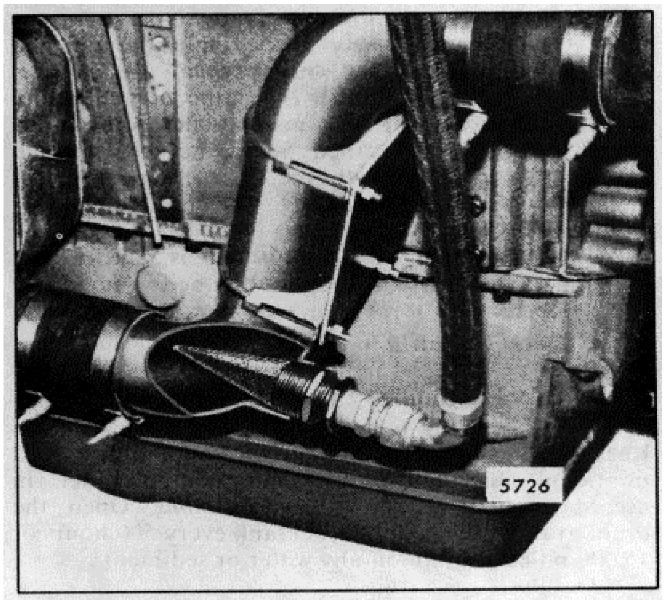
Add coolant as necessary. Do not overfill.

Make a visual check for cooling system leaks. Check for an accumulation of coolant beneath the vehicle during periods when the engine is running and when the engine is stopped.

Clean the cooling system every 1,000 hours or 30,000 miles using a good radiator cleaning compound in accordance with the instructions on the container.

After the cleaning operation, rinse the cooling system thoroughly with fresh water. Then fill the system with soft water, adding a good grade of rust inhibitor or a high boiling point type antifreeze (refer to Engine Coolant). With the use of a proper antifreeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring or fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system. When a thorough cleaning of the cooling system is required, it should be reverse flushed.

The coolant circulated through the intercoolers on a turbocharged intercooler engine is protected by a 20 mesh cone-shaped water filter (screen). The filter is located at the water connection in the water pump-to engine oil cooler tube. The filter should be inspected for damage or clogging when the cooling system is cleaned. Disconnect the flexible water hose at the



Item 4.

water connection and remove and clean the filter. If necessary, replace the filter. Reinstall the water filter (screen) in the water connection.

Inspect all of the cooling system hoses at least once every 700 hours or 20,000 miles for signs of deterioration. Replace the hoses if necessary.

Item 5 Turbocharger

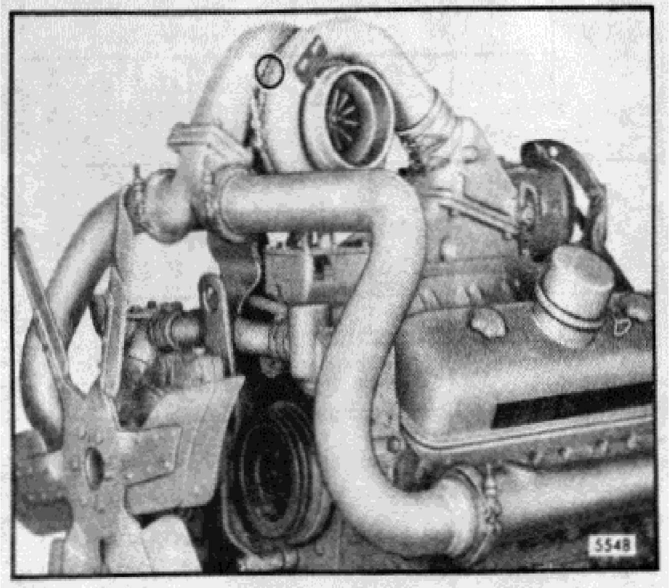
Inspect the mountings, intake and exhaust ducting and connections for leaks. Check the oil inlet and outlet lines for leaks or restrictions to air flow. Check for unusual noise or vibration and, if excessive, remove the turbocharger and correct the cause.

Item 6 Battery

Check the specific gravity of the electrolyte in each cell of the battery every 100 hours or 3,000 miles. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.

Item 7 Tachometer Drive

Lubricate the tachometer drive every 100 hours or 3,000 miles with an all purpose grease at 'the grease fitting. At temperatures above +30°F (-I C). use a No. 2 grade grease. Use a No. I grade grease below this temperature.



Item 5.

Item 8 Air Cleaners

Under no engine operating conditions should the air inlet restriction exceed 25 inches of water (6.2 kPa) for non-turbocharged engines or 20 inches of water (5.0 kPa) for turbocharged engines. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

Oil Bath

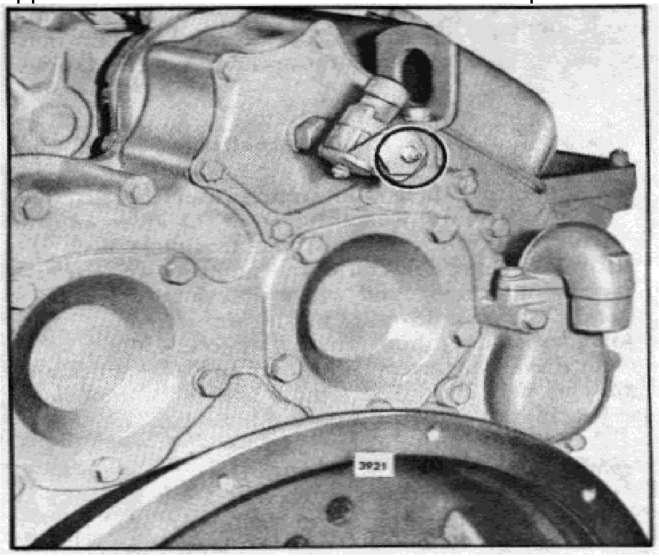
Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours or 240 miles, or less if operating conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark and viscosity heavy-duty oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions. If heavy rain or snow has been encountered, check the air cleaner for an accumulation of water.

Remove and steam clean air cleaner element and baffle annually.

It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 500 hours, 15,000 miles or as conditions warrant.

Dry Type

Secondary (safety)elements should not be cleaned or reused. Dry type elements used in off-highway applications should be discarded and replaced with



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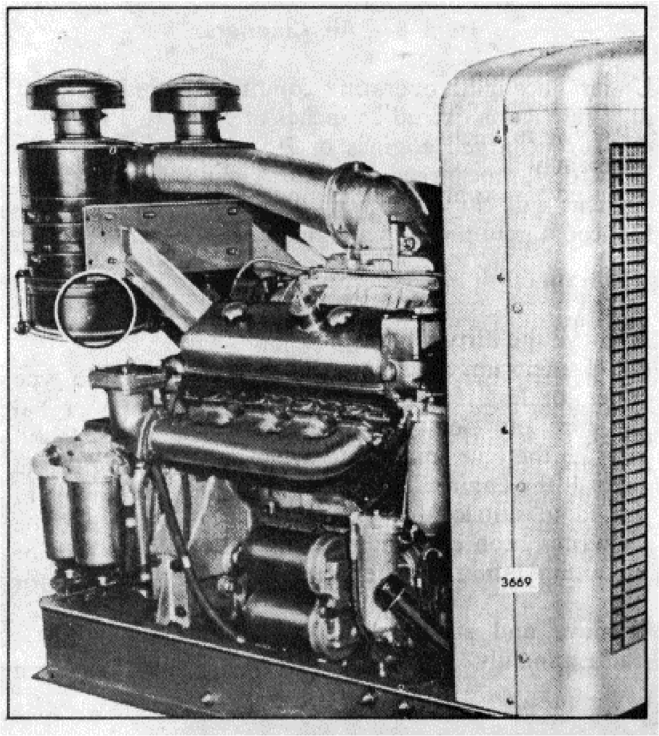


Item 8.

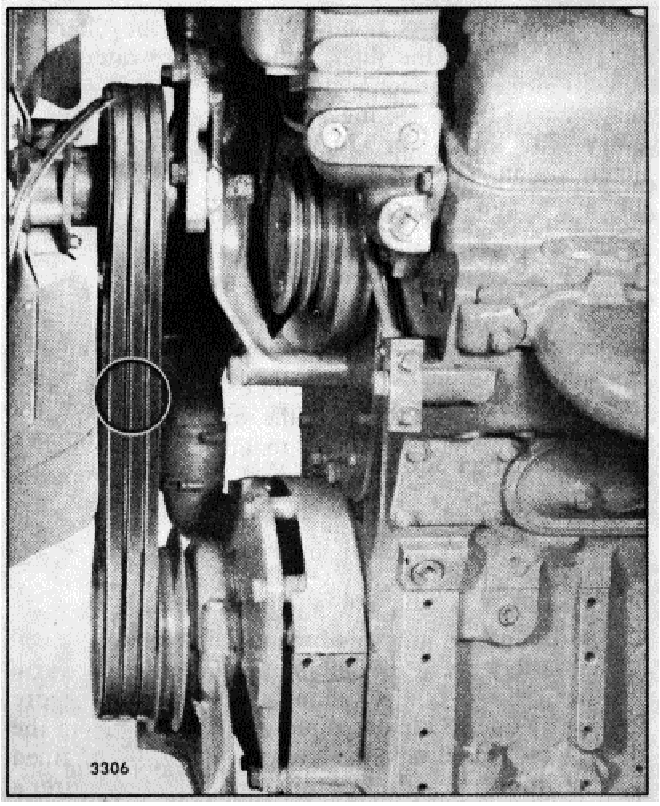
new elements after one year of service or when the maximum allowable air intake restriction has been reached (see Section 13.2). whichever comes first. In cases where the air cleaner manufacturer recommends cleaning or washing off-highway elements. the maximum service life is still one year or maximum restriction. Cleaning, washing and inspection must be done per the manufacturer's recommendations.

Inspection and replacement of the cover gaskets must also be done per the manufacturer's recommendations.

Item 9 Drive Belts

New standard V-belts will stretch after the first few hours of operation. Run the engine for 15 seconds to seat the belts, then readjust the tension. Check the belts and tighten the fan drive. pump drive. Battery charging alternator and other accessory drive belts after 1/2 hour or 15 miles and again alter 8 hours or 240 miles of operation. Thereafter. check the tension of' the drive belts every 200 hours or 6.00() miles and adjust. if necessary. Too tight a belt is destructive to the bearings of the driven part: a loose belt will slip.

Replace all belts in a set when one is Worn. Single belts of similar size should not be used as a substitute for a matched belt set, premature belt wear can result because of belt length variation. All belts in a matched belt set are within .032" of their specified center distances.



Item 9.

Adjust the belt tension so that a firm push with the thumb. at a point midway between the two pulleys, will depress the belt 1/2" to 3/4". If belt tension gage BT-33-73FA. J 23600-B or equivalent is available, adjust the belt tension as outlined in the chart.

NOTE: When installing or adjusting an accessory drive belt. be sure the bolt at the accessory "V' and

"POLY V" BELT TENSION TABLE (1 lbs/belt)

		Fan Drive			Alternator or Generator Drive	
model	10 Rib (L) Poly V	2or3 Belts	Single Belt	Two 3/8" or ½" Belts	One ½" Belt	8 Rib (K Poly Belts
6, 8V-71		60-80	80-100	40-50	50-70	110-130
		70-90		40-50	50-70	
1 2V-71		90-120		40-50	50-70	
16V-71						
310-360						

Belt tension is 50-70 for a single premium high capacity belt (.785" wide) used to drive a 12 cfm air compressor.

Adjust all V-belts with belt tension gage BT-33-73 FA, J23600-B or equivalent.

Adjust all Poly V-belts with belt tension gage BT-33-AE6-40A, J23586 or equivalent. (Range 60-400 lbs.) BELT TENSION CHART (lbs/belt) adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.

Adjust Poly-V Fan Belt-16V

The fan belt should be neither too tight nor too loose. Carelessness in making a belt adjustment can be dangerous. Too tight a belt imposes an undue load on the fan bearings and shortens the life of the belt. Too loose a belt allows slippage and lowers the fan speed, causes excessive belt wear and leads to overheating of the cooling system.

Before a Poly-V belt is installed, it is very important that the crankshaft pulley (10 grooves) and the fan drive pulley (11 grooves) are in alignment. The extra groove in the fan drive pulley can be on the inside or the outside of the pulley, depending upon alignment requirements.

Misalignment between the crankshaft pulley and the fan drive pulley cannot be more than . 009" per inch of center line distance. A straight line can be determined by placing a straight edge on the rims of the pulleys. A spacer is available to facilitate pulley alignment, if necessary. The spacer mounts between the crankshaft pulley and the vibration damper hub.

Poly-V belts require a special procedure for proper belt tension.

1. After the belts have been initially adjusted, run the engine under a light load for one-half hour.

2. Stop the engine and check the belt tension with the belt "hot"; use belt tension gage BT-33-86AE6-40A, J 23586 or equivalent, which has a range of 60 to 400 pounds.

3. If the tension value is not netween 280 and 360 pounds, readjust the belt tension.

> **NOTE**: Because the allowable load the crankshaft bearing can carry is critical, do not exceed the maximum tension value of 360 pounds.

4. Run the engine at full load for eight hours and then recheck the belt tension.

5. If the belt tension is too tight or too loose, keep the gage in place and adjust the belt tension, to the prescribed value, at the accessory mounting or adjusting bolts. Retighten all of the bolts to the proper torque.

6. The belt tension should be rechecked every 200 hours or 6, 000 miles of engine operation and readjusted, if necessary.

Item 10 - Air Compressor

Remove and clean all air compressor air intake parts every 200 hours or 6, 000 miles. To clean either the hair or polyurethane type air compressor air strainer element, saturate and squeeze it in fuel oil, or any other cleaning agent that would not be detrimental to the element, until dirt free. 'Then dip it in lubricating oil and squeeze it dry before placing it back in the air strainer.

For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available. Every 12 months or 20, 000 miles (700 hours) tighten the air compressor mounting bolts. If the air compressor is belt driven, check the belts for proper tension.

Page &Item 11 - Throttle and Clutch Controls

Every 200 hours or 6, 000 miles lubricate the throttle control mechanism. Use an all purpose grease (No. 2 grade) at temperatures +30°F (-1 °C) and above. At temperatures below this use a No. 1 grade grease.

Lubricate all other control mechanisms, as required, with engine oil.

Item 12 - Lubricating Oil Filter

Install new oil filter elements and gaskets at a maximum of 500 hours or each time the engine oil is changed, whichever occurs first. Any deviation such as changing filters every other oil change, should be based on a laboratory analysis of the drained oil and the used filter elements to determine if such practice is practical for proper protection of the engine.

Make a visual check of all lubricating oil lines for wear and chafing. If any indication of wear is evident, replace the oil lines and correct the cause.

When the engine is equipped with a turbocharger:

1. Disconnect the oil inlet (supply) line at the bearing (center) housing.

2. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

3. Add additional engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

4. Start and run the engine at idle until oil pressure

and supply has reached all of the turbocharger moving parts. A good indicator that all the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psi - 69 kPa at idle speed).

> CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

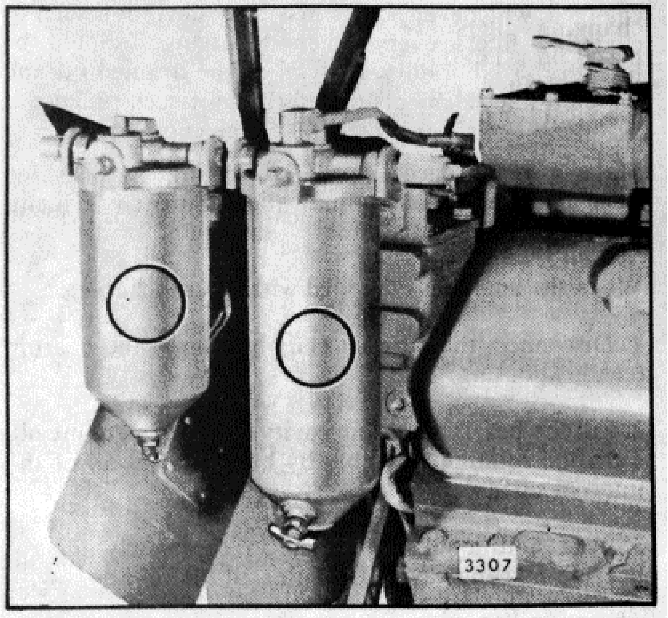
If the engine is equipped with a governor oil filter, change the element every 1, 000 hours or 30, 000 miles.

Check for oil leaks after starting the engine.

Item 13 - Fuel Strainer and Filter

Install new elements every 300 hours or 9, 000 miles or when plugging is indicated.

A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury (20. 3 kPa). With 6 and 8V non-turbocharged engines, at normal operating speed and with . 080" restriction fittings, the fuel pressure is 45-70 psi (310-483 kPa). With 16V non-turbocharged engines, at normal operating speeds and with . 070" restriction fittings, the fuel pressure is 30-65 psi (207-448 kPa). With turbocharged engines, at normal operating speeds and with either . 080" or . 070" restriction fittings, the fuel pressure is 50-70 psi (345-483 kPa). Change the fuel filter elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches of mercury (41 kPa) at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to the minimum fuel pressure shown above. Refer to the chart.



ITEM 13.

Item 14 - Coolant Filter

If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 500 hours or 15, 000 miles. Select the proper coolant filter element in accordance with the instructions given in Engine Coolant in this section. Use a new filter cover gasket when installing the filter element. After replacing the filter and cover gaskets, start the engine and check for leaks.

Item 15 - Starting Motor

The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken off the engine or disassembled.

The Sprag overrunning clutch drive mechanism should be lubricated with a few drops of light engine oil whenever the starting motor is overhauled.

Item 16 - Air System

Check all of the connections in the air system to be sure they are tight. Check all hoses for punctures or other damage and replace, if necessary.

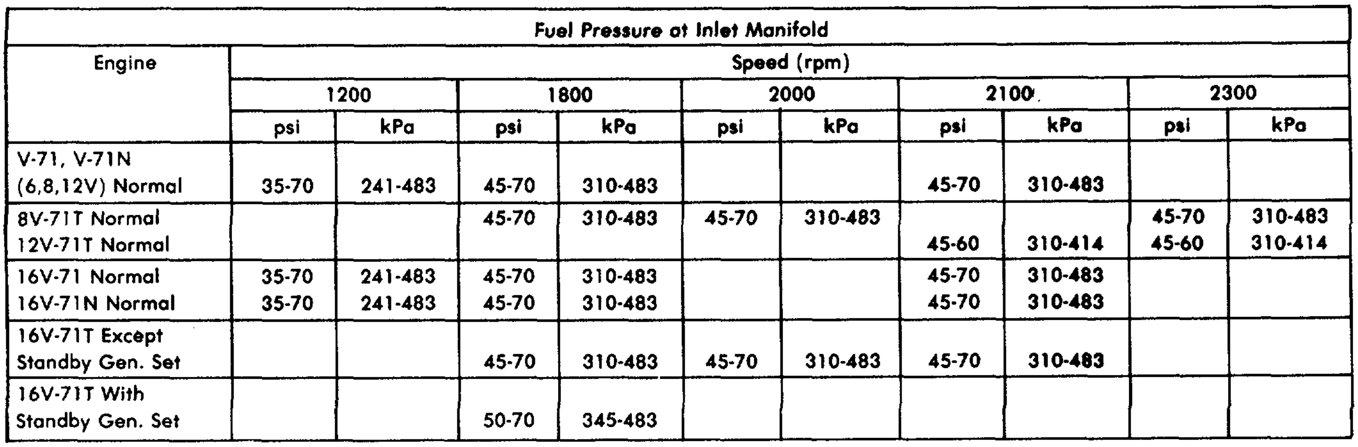
Item 17 - Exhaust System

Check the exhaust manifold retaining nuts, exhaust flange clamp and other connections for tightness. Check for proper operation of the exhaust pipe rain cap, if one is used.

Item 18 - Air Box Drain Tube

With the engine running, check for flow of air from the air box drain tubes every 1, 000 hours or 30, 000 miles. If the tubes are clogged, remove, clean and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent.

If the engine is equipped with an air box drain tank, drain the sediment periodically.



Fuel Pressure at Inlet Manifold

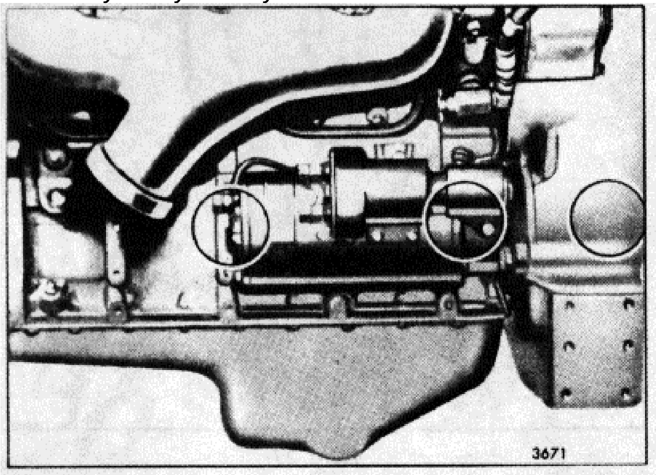
Engine	Speed (rpm)									
	1200		1800		2000		2100		2300	
	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa
V-71, V-71N (6,8,12V) Normal	35-70	241-483	45-70	310-483			45-70	310-483		
8V-71T Normal			45-70	310-483	45-70	310-483			45-70	310-483
12V-71T Normal							45-60	310-414	45-60	310-414
16V-71 Normal	35-70	241-483	45-70	310-483			45-70	310-483		
16V-71N Normal	35-70	241-483	45-70	310-483			45-70	310-483		
16V-71T Except Standby Gen. Set			45-70	310-483	45-70	310-483	45-70	310-483		
16V-71T With Standby Gen. Set			50-70	345-483						

Item 19 - Emergency Shutdown

With the engine running at idle speed check the operation of the emergency shutdown every 700 hours or 20, 000 miles. Reset the air shutdown valve in the open position after the check has been made.

Item 21 - Radiator

Inspect the exterior of the radiator core every 700 hours or 20, 000 miles and, if necessary, clean it with a quality grease solvent such as mineral spirits and dry it with compressed air. Do not use fuel oil, kerosene or gasoline. It may be necessary to clean the radiator more frequently if the engine is being operated in extremely dusty or dirty areas.



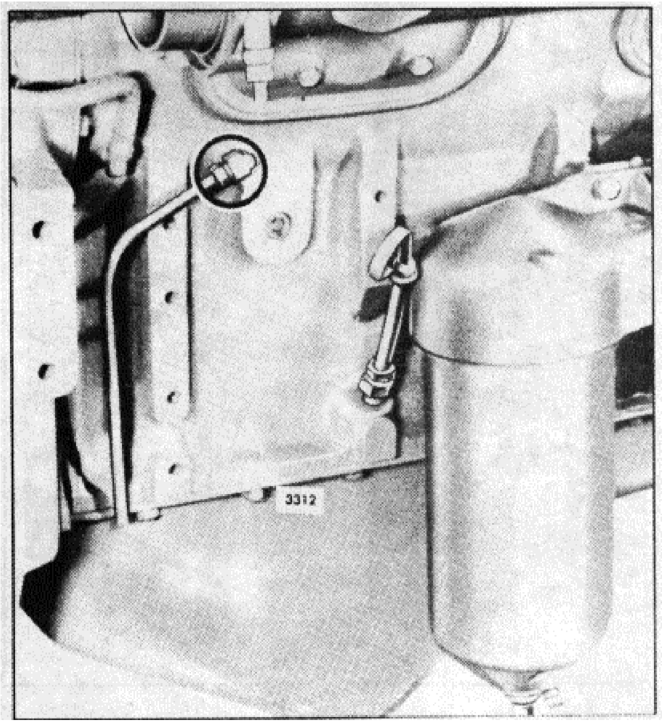
Item 15.

Item 22 - Shutter Operation

Check the operation of the shutters and clean the linkage and controls.

Item 23 - Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started. In the event the engine is equipped with warning lights rather than pressure



Item 18.

indicators, the pressure should be checked and recorded at the interval indicated.

Item 24 - Overspeed Governor

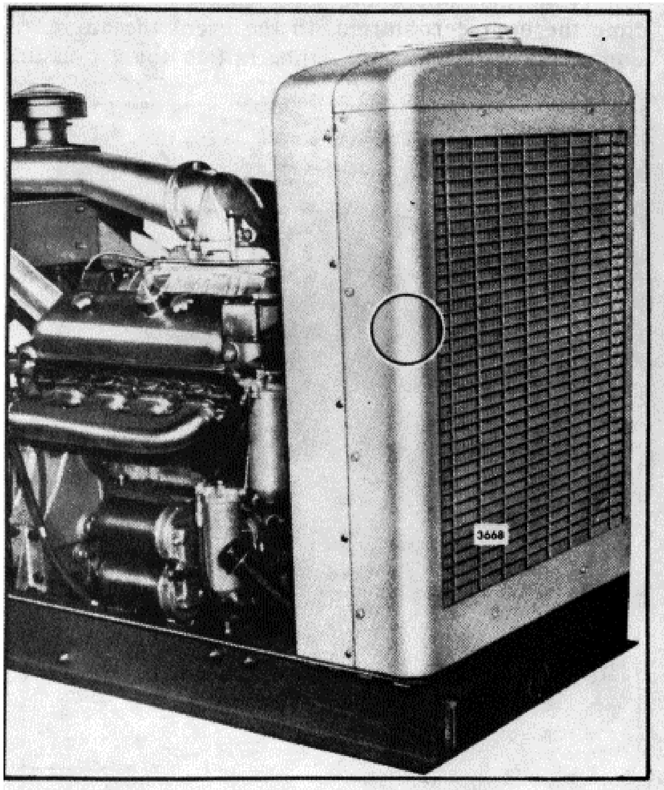
Lubricate the overspeed governor, if it is equipped with a hinge-type cap oiler or oil cup, with 5 or 6 drops of engine oil every 500 hours or 15, 000 miles. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Item 26 - Throttle Delay

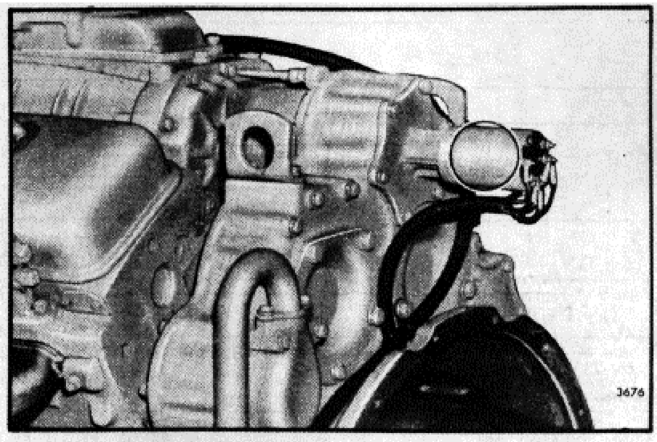
Inspect and adjust, if necessary.

The throttle delay system limits the amount of fuel injected during acceleration by limiting the rate of injector rack movement with a hydraulic cylinder. The initial location of this cylinder must be set with the proper gage to achieve the appropriate time delay (Section 6).

Inspect the check valve by filling the throttle delay cylinder with diesel fuel and watching for valve leakage while moving the throttle from the idle to the. full-fuel position.



Item 21.

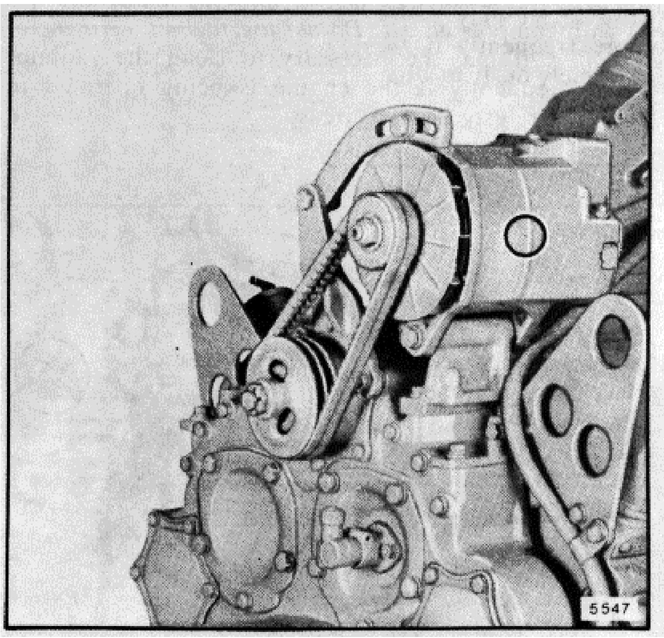


Item 24.

Item 27 - Battery-Changing Alternator

Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.

Lubricate the battery-charging alternator bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours or 6, 000 miles. Some alternators have a built-in supply of grease, while others use sealed bearings. In these latter two cases, additional lubrication is not necessary. On alternators, the slip rings and brushes can be inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean the slip rings. Hold the polishing cloth against the slip



Item 27.

rings with the alternator in operation and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them.

Item 28 - Engine and Transmission Mounts

Check the engine and transmission mounting bolts and the condition of the mounting pads every 2, 000 hours or 60, 000 miles. Tighten and repair as necessary.

Item 29 - Crankcase Pressure

Check and record the crankcase pressure every 2, 000 hours or 60, 000 miles.

Item 30 - Air Box Check Valves

Every 100, 000 miles or approximately 3, 000 hours remove, clean them in solvent and blow out the lines with compressed air. Inspect for leaks after servicing.

Item 31 - Fan Hub

If the fan bearing hub assembly is provided with a grease fitting, use a hand grease gun and lubricate the bearings with one shot of Texaco Premium RB grease, or an equivalent Lithium base multi-purpose grease, every 20, 000 miles (700 hours).

Every 4, 000 hours or 120, 000 miles clean, inspect and repack the fan bearing hub assembly with the above recommended grease.

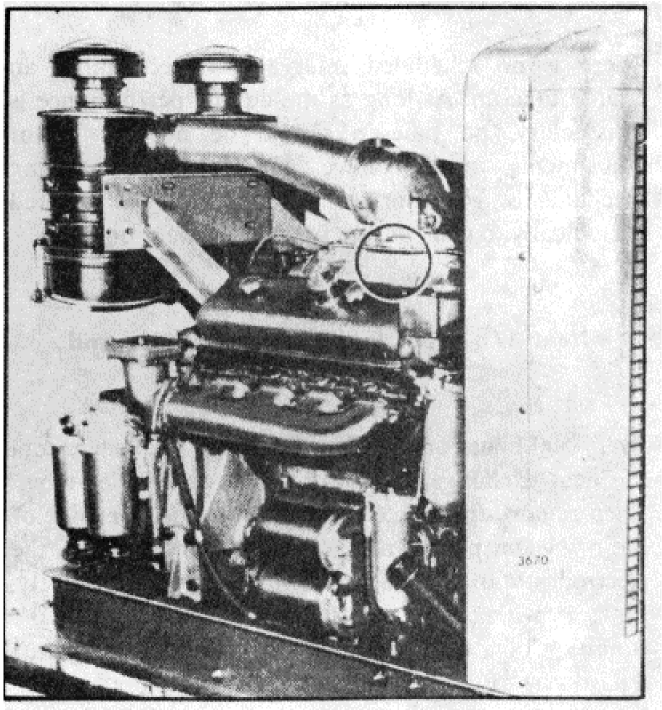
At a major engine overhaul, remove and discard the bearings in the fan hub assembly. Pack the hub assembly, using new bearings, with Texaco Premium RB grease or an equivalent Lithium base multi-purpose grease.

Item 32 - Thermostats and Seals

Check the thermostats and seals (preferably at the time the cooling system is prepared for winter operation). Replace the seals if necessary.

Item 33 - Blower Screen

Inspect the blower screen and gasket assembly every 1, 000 hours or 30, 000 miles and, if necessary, clean the screen in fuel oil and dry it with compressed air. Install the screen and gasket assembly with the screen side of the assembly toward the blower. Inspect for evidence of blower seal leakage.

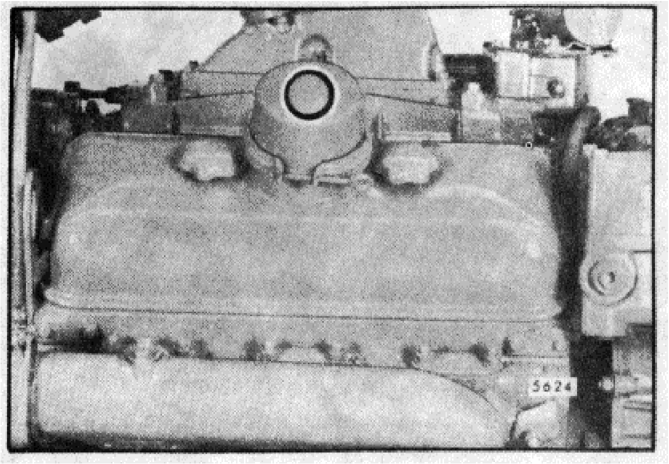


Item 33.

Item 34 - Crankcase Breather

Remove the externally mounted crankcase breather assembly every 1, 000 hours or 30, 000 miles and wash the steel mesh pad in clean fuel oil. This cleaning period may be reduced or lengthened according to severity of service.

Clean the breather cap, mounted on the valve rocker cover, in clean fuel oil every time the engine oil is changed.



Item 34.

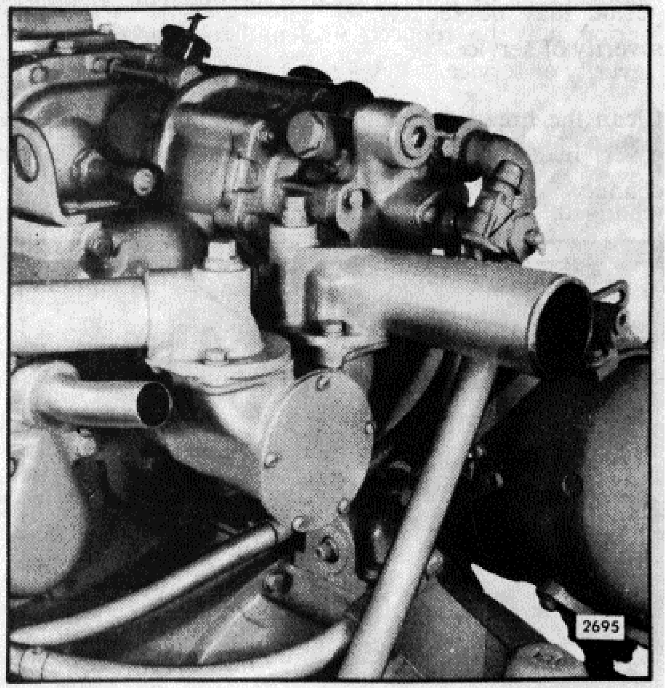
Item 36 - Engine tune-up

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

Item 37 - Heat Exchanger Electrodes and Core

Every 500 hours or 15, 000 miles, drain the water from the heat exchanger raw water inlet and outlet tubes. Then remove the zinc electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1, 000 hours or 30, 000 miles and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, contact a *Detroit Diesel Allison Service Outlet.*



Item 37 and 38

Item 38 - Raw Water Pump

Check the prime on the raw water pump; the engine should not be operated with a dry pump. Prime the pump, if necessary, by removing the pipe plug provided in the pump inlet elbow and adding water. Reinstall the plug.

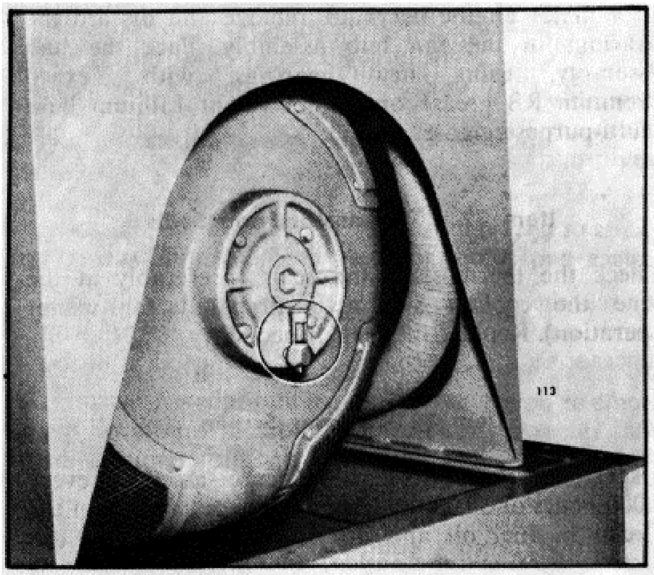
Item 39 - Power Generator

The power generator requires lubrication at only one point -the ball bearing in the end frame. If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade of oil as specified for the engine. Maintain the oil level to the line in the sight gage. Do not overfill. After adding oil, recheck the oil level after running the generator for several minutes.

If the bearing is grease lubricated, a new generator has sufficient grease for three years of normal service. Thereafter, it should be lubricated at one year intervals. To lubricate the bearing, remove the filler and relief plugs on the side and the bottom of the bearing reservoir. Add grease until new grease appears at the relief plug opening. Run the generator a few minutes to vent the excess grease; then reinstall the plugs.

The following greases, or their equivalents, are recommended:

Keystone 44H	Keystone Lubrication Co.
BRB Lifetime	Socony Vacuum Oil Co.



Item 39.

NY and NJ926 or F927..............NY and NJ Lubricant Co.

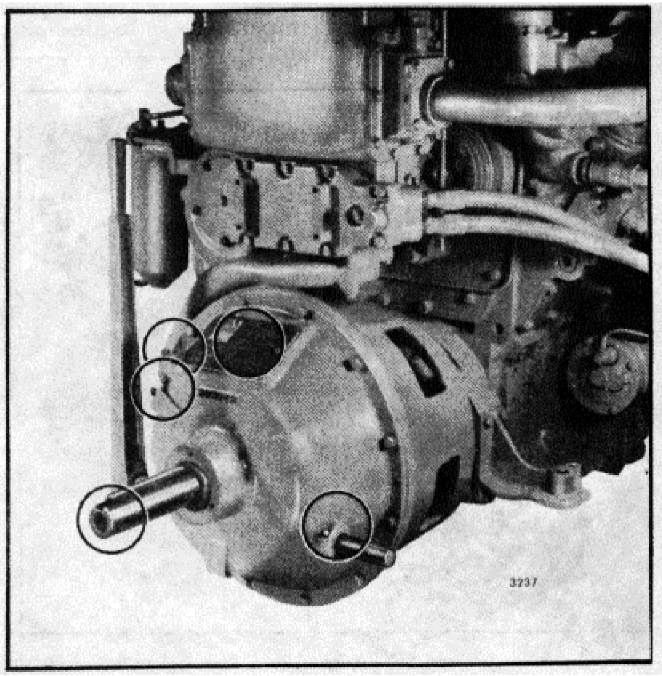
After 100 hours or 3, 000 miles on new brushes, or brushes in generators that have not been in use over a long period, remove the end frame covers and inspect the brushes, commutator and collector rings. If there is no appreciable wear on the brushes, the inspection interval may be extended until the most practicable period has been established (not to exceed six months). To prevent damage to the commutator or the collector rings, do not permit the brushes to become shorter than 3/4 inch.

Keep the generator clean inside and out. Before removing the end frame covers, wipe off the loose dirt. The loose dirt and dust may be blown out with low pressure air (25 psi or 172 kPa maximum). Remove all greasy dirt with a cloth.

Item 40 - Power Take-Off

Lubricate all of the power take-off bearings with an all purpose grease such as Shell Alvania No. 2, or equivalent. Lubricate sparingly to avoid getting grease on the clutch facings.

Lubricate the clutch release bearing and the disconnect mechanical rear drive shaft shielded bearing every 8 hours. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required.



Item 40.

Lubricate the power take-off main bearing, also the outboard bearing if the unit is so equipped, every 50 hours or 1, 500 miles. Frequency of lubrication will depend on the working conditions of the bearing, shaft speeds and bearing loads. It may be necessary to lubricate this bearing more often than every 50 hours or 1, 500 miles. Lubricate the front power take-off clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours or 1, 500 miles. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and lubricate the clutch release levers and link pins sparingly every 500 hours or 15, 000 miles. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours or 15, 000 miles.

Check the clutch facing for wear every 500 hours or 15, 000 miles. Adjust the clutch if necessary.

Item 41 - Marine Gear

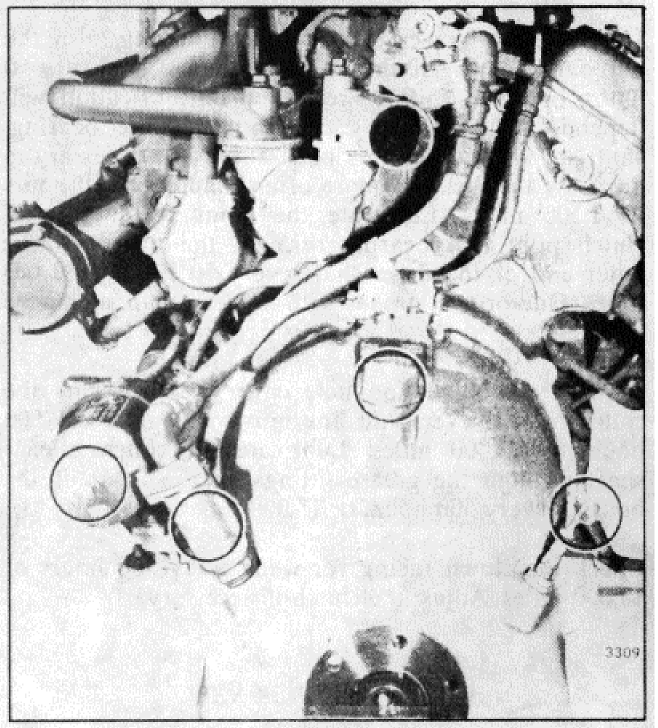
TORQMATIC MARINE GEAR (6 and 8V): Check the oil level daily in the marine gear, with the controls in neutral and the engine running at idle speed. Add oil as required to bring it to the proper level on the dipstick. Use oil of the same heavy 'duty grade and viscosity that is used in the engine. Drain the oil every 200 hours or 6, 000 miles and flush the gear with light engine oil.

> **NOTE**: Series 3 oil should not be used in the marine gear.

When refilling after an oil drain, bring the oil up to the proper level on the dipstick approximately 6 quarts (5. 7 liters) in the M type and 8 quarts (7. 6 liters) in the MH type gear. Start and run the engine at light load for three to five minutes. Then put the controls in neutral and run the engine at idle speed and check the oil level again. Bring the oil level up to the proper level on the dipstick.

Every time the marine gear oil is changed, remove the oil strainer element, rinse it thoroughly in fuel oil, dry it with compressed air and reinstall it. Also replace the full-flow oil filter element every time the marine gear oil is changed.

TWIN DISC MARINE GEAR (16V):
Check the oil level daily. Check the oil level with the engine running at low idle speed and the gear in neutral. Keep the oil up to the proper level on the dipstick. Use oil of the same heavy-duty grade and viscosity that is used in the engine.



Item 41.

Change the oil and the oil filter element every 1. 000 hours or 30, 000 miles. After draining the oil. thoroughly clean the removable oil screen and breather. Reinstall the breather and refill the marine gear with oil up to the full mark on the dipstick. Start the engine and, with the gear in neutral. run the engine at idle speed for three to five minutes. Then stop the engine and check the oil level. If necessary. add oil to bring it up to the full mark on the dipstick.

SNOW NABSTEDT MARINE GEAR (16V):

Check the oil level daily. If necessary. stop the engine. Also turn the handle of the filter in the suction line daily, or more often if necessary. This is a knife edge filter and a turn of the handle wipes the accumulated sediment from the edge of the filter discs.

Change the oil every 1, 000 hours (30. 000 miles) or at the end of each season, whichever occurs first. At each oil change, remove the plug from the bottom of the filter to drain the sediment. If the filter is extremely dirty. remove the screws holding the sediment bulb to the flange at the top of the filter and remove the bulb for thorough cleaning. When replacing the bulb. be sure to tighten the screws evenly and securely to prevent air leaks in the suction line. Use oil of the same heavy duty grade and viscosity that is used in the engine

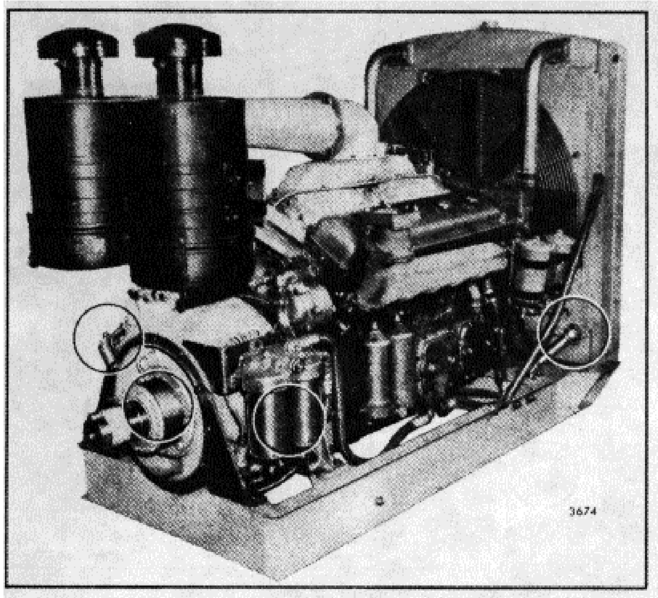
Item 42 - Torqmnatic Converter

Check the oil level in the Torqmatic converter and supply tank daily. The oil level must be checked while the converter is operating, the engine idling and the oil is up to operating temperature (approximately 200°F or 93°C). If converter is equipped with an input disconnect clutch, the clutch must be engaged.

Check the oil level after running the unit a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" (see chart). Do not overfill the converter, as too much oil will cause foaming and high oil temperature.

Prevailing Ambient Temperature	Recommended Oil Specification
-100F (-230C)	Hydraulic Transmission Fluid, Type C2
Below -10F (123°C) -	Hydraulic Transmission Fluid, Type c-2. Auxiliary preheat required to raise temperature in the sump to a temperature above --100F (-230C)

The oil should be changed every 1. 000 hours or 30, 000 miles for Series 400 through 900 converters. Also, the oil should be changed whenever it shows traces of dirt or effects of high operating temperature as evidenced



Item 42.

by discoloration or strong odor. If the oil shows metal contamination, contact an authorized Detroit Diesel Allison Service Outlet as this usually requires disassembly. Under severe operating conditions, the oil should be changed more often.

The converter oil breather, located on the oil level indicator (dipstick) should be cleaned each time the converter oil is changed. This can be accomplished by allowing the breather to soak in a solvent, then drying it with compressed air.

The full-flow oil filter element should be removed, the shell cleaned and a new element and gasket installed each time the converter oil is changed.

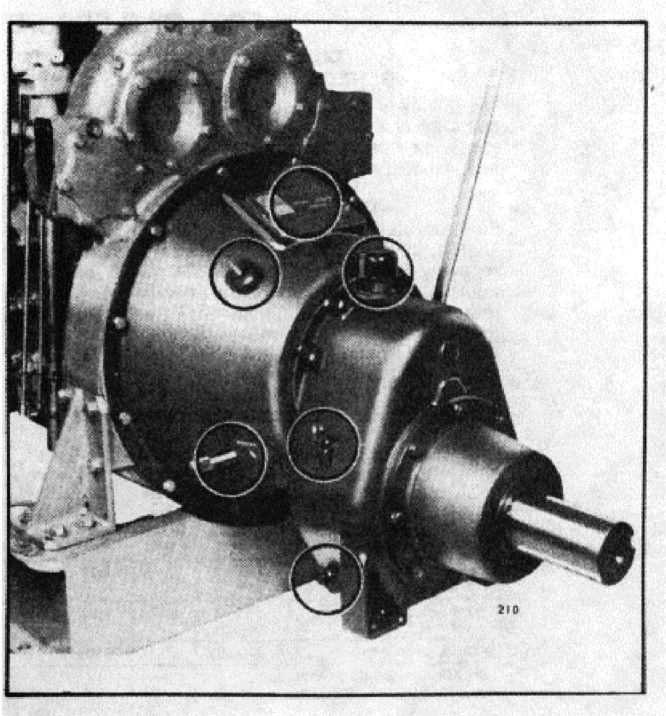
Lubricate the input clutch release bearing and ball bearing and the front disconnect clutch drive shaft bearing every 50 hours or 1, 500 miles with an all purpose grease. Grease fittings are provided on the clutch housing. This time interval may vary depending upon the operating conditions. Over-lubrication will cause grease to be thrown on the clutch facing, causing the clutch to slip.

The strainer (in the Torqmatic transmission) and the hydraulic system filters should be replaced or cleaned with every oil change.

Item 43 - Reduction Gear

ROCKFORD REDUCTION GEAR:

Check the oil level in the reduction gear every 8 hours or 240 miles and add oil as required to bring the oil to the proper level on the dipstick. Drain the oil every 1, 000 hours or 30, 000 miles, flush the housing with light engine oil, and refill to the proper level with the same grade and viscosity heavy duty oil that is used in the engine. This oil change period should be reduced under severe operating conditions.



Item 43.

Lubricate the clutch release bearing through the grease fitting on the side of the housing every 8 hours or 240 miles of operation. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required. Lubricate the front reduction clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours or 1, 500 miles. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and oil the clutch release levers and link pins sparingly every 500 hours or 15, 000 miles. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours or 15, 000 miles.

FUEL OILS FOR DETROIT DIESEL ENGINES

DIESEL FUEL OILS

GENERAL CONSIDERATIONS

The quality of fuel oil used for high-speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material That Is, the fuel should show at least 98% by volume recovery when subjected to ASTM D-86 distillation Fuels marketed to meet Federal Specification VV-F-800 (grades DF-1 and DF-2) and ASTM Designation D-975 (grades 1-D and 2-D) meet the completely distilled criteria The differences in properties of VV-F-800 and ASTM D-975 fuels are shown In the following table;

FEDERAL SPECIFICATION & ASTM DIESEL FUEL PROPERTIES

Specification or Classification Grade	VV-F-800 DF-1	ASTM D-975 1-D	VV-F-800 DF-2	ASTM D-975 2-D
Flash Point, min.	104°F 40°C	100°F 38°C	122°F 50°C	125°F 52°C
Carbon Residue (10% residuum), % max.	0.15	0.15	0.20	0.35
Water & Sediment, % by vol, max.	0.01	trace	0.01	0.05
Ash, % by wt., max.	0.005	0.01	0.005	0.01
Distillation Temperature, 90% by vol. recovery, min.	—	—	—	540°F (282°C)
max.	572°F (300°C)	550°F (288°C)	626°F (330°C)	640°F (338°C)
End Point, max.	626°F (330°C)	—	671°F (355°C)	—
Viscosity 100°F (38°C)				
Kinematic, cSt, min.	1.4	1.4	2.0	2.0
Saybolt, SUS, min.	—	—	—	32.6
Kinematic, cSt, max.	3.0	2.5	4.3	4.3
Saybolt, SUS, max.	—	34.4	—	40.1
Sulfur, % by wt., max.	0.50	0.50	0.50	0.50
Cetane No.	45	40	45	40

FUEL CLEANLINESS

Fuel oil should be clean and free of contamination Storage tanks and stored fuel should be Inspected regularly for dirt, water or water-emulsion sludge, and cleaned If contaminated Storage Instability of the fuel can lead to the formation of varnish or sludge in the tank The presence of these contaminants from storage instability must be resolved with the fuel supplier

FUEL SULFUR CONTENT

The *sulfur content* of the fuel should be as low as possible to avoid premature wear, excessive deposit formation, and minimize the sulfur dioxide exhausted into the atmosphere. Limited amounts can be tolerated, but the amount of sulfur In the fuel and engine operating conditions can influence corrosion and deposit formation tendencies

The deleterious effect of burning high sulfur fuel Is reflected In Detroit Diesel lube oil change Interval recommendations. Detroit Diesel recommends that the Total Base Number (TBN-ASTM D-664) of the lube oil be monitored frequently and that the oil drain Interval be drastically reduced Consult the FUEL OIL SELECTION CHART

IGNITION QUALITY-CETANE NUMBER

There Is a delay between the time the fuel is injected into the cylinder and the time that ignition occurs The duration of this delay is expressed in terms of *cetane number* (rating) Rapidly ignited fuels have high cetane numbers, e g. 50 Slowly ignited fuels have low cetane numbers, e g, 40 or less The lower the ambient temperature, the greater the need for a fuel that will ignite rapidly, i e, high cetane Difficult starting may be experienced If the cetane number of the fuel is too low Furthermore, engine knock and puffs of white smoke may be experienced during engine warm-up especially In severe cold weather when operating with a low cetane fuel If this condition is allowed to continue for any prolonged period, harmful fuel derived deposits will accumulate within the combustion chamber Consult the FUEL OIL SELECTION CHART

DISTILLATION END POINT

Fuel can be burned in an engine only after It has been vaporized The temperature at which fuel is completely vaporized is described as the ***distillation end*** *point* (ASTM D-86) The distillation (boiling) range of diesel fuels should be low enough to permit complete vaporization at combustion chamber temperatures The combustion chamber temperature depends on ambient temperature, engine speed, and load Mediocre to poor vaporization is more apt to occur during severe cold weather and/or prolonged engine Idling and/or light load operation Therefore, engines will show better performance operating under the conditions described above when lower distillation end point fuels are used Consult the FUEL OIL SELECTION CHART

CLOUD POINT

The *cloud point* is that temperature at which wax crystals begin to form In diesel fuel The selection of a suitable fuel for low temperature operability is the responsibility of the fuel supplier and the engine user Consult the FUEL OIL SELECTION CHART

FUEL OIL SELECTION CHART

Application	General Fuel Classification	Final Boiling Point	Cetane Number	Sulfur Content	Cloud Point
		(Max.)	(Min.)	(Max.)	
City Buses	No. 1-D	550°F 288°C	45	0.30	SEE NOTE 1
	Winter No. 2-D*	675°F 357°C	45	0.50	
	Summer No. 2-D*	357°C	40	0.50	
All Other Applications	Winter No. 2-D	675°F 357°C	45	0.50	SEE NOTE 1
	Summer No. 2-D	675°F 357°C	40	0.50	

*No 2-D diesel fuel may be used in city coach engine models that have been certified to pass Federal and California emission standards

Note 1 The cloud point should be 10F (60C) below the lowest e expected fuel temperature to prevent clogging of the fuel filters by wax crystals

Note 2 When prolonged idling periods or cold weather conditions below 320 F (O°C) are encountered, the use of lighter distillate fuels may be more practical The same consideration must be made when operating at altitudes above 5,000 ft

DETROIT DIESEL FUEL OIL SPECIFICATIONS

Detroit Diesel Allusion designs, develops and manufactures commercial diesel engines to operate on diesel fuels classified by the ASTM as Designation D-975 (grades 1 -D and 2-D). These grades are very similar to grades DF-1 and DF-2 of Federal Speclflcation VV-F-800

Burner fuels (furnace oils or domestic heating fuels) generally require an open flame for satisfactory combustion The ignition quality (cetane rating) of burner fuels (ASTM D-396) is poor when compared to diesel fuels (ASTM D-975)

In some regions, however, fuel suppliers may distribute one fluid that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396) sometimes identified as burner, furnace, or residual fuel Under these circumstances, the fuel should be Investlgated to determine whether the properties conform with those indicated in the FUEL OIL SELECTION CHART. The FUEL OIL SELECTION CHART also will serve as a guide in the selection of the proper fuel for various applications. The fuels used must be clean, completely distilled, stable, and non-corrosive. Distillation Range, Cetane Number, Sulfur Content, and Cloud Point are four of the most Important properties of diesel fuels that must be controlled to insure satisfactory engine operation. Engine speed, load, and ambient temperature all influence the selection of diesel fuels with respect to distillation range and cetane number All diesel fuels contain a certain amount of sulfur. Too high a sulfur content results in excessive cylinder wear. For most satisfactory engine life, fuels containing less than 0 5% sulfur should be used.

During cold weather engine operation the cloud point (the temperature at which wax crystals begin to form In diesel fuel) should be 10°F (6°C) below the lowest expected fuel temperature in order to prevent clogging of the fuel filters by wax crystals

A reputable fuel oil supplier is the only one who can assure you that the fuel you receive meets the Distillation End Point, Cetane Number, Sulfur Content, and Cloud Point property limits shown in the FUEL OIL SELECTION CHART The responsibility for clean fuel and fuel that meets Detroit Diesel Allison specifications lies with the fuel supplier as well as the operator.

At temperatures below + 32° F (0°C) particular attention must be given to cold weather starting aids for efficient engine starting and operation

NUMEROUS FUELS BURNED IN DDA ENGINES

Numerous fuels meeting the properties shown in the FUEL OIL SELECTION CHART may be used in Detroit Diesel engines The table (top, right) shows some of the alternate fuels (some with sulfur and/or cetane limits) that have been burned in Detroit Diesel engines. Among these are No. 1 and No. 2 diesel fuels, kerosene, aviation turbine (let) fuels, and burner fuels.

FUELS BURNED IN DETROIT DIESEL ENGINES

ASTM Desig-nation	Federal Standard	Military Spec.	NATO Code	Grade	Description/Comments
D-975				1-D 2-D	Diesel Fuel
D-396				1, 2	Burner Fuel (Furnace Oil) ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. % and the Minimum Cetane No. Is 45. (See Fuel Oil Selection Chart).***
	VV-F-800		F-54	1, 2	DF-1 Winter Grade, DF-2 Regular Grade
	VV-F-800		F-56		DF-A (Arctic Grade). Limited Supply For Military.
		MIL-T-5624		JP-5	Kerosene
D-1655		MIL-T-83133	F-34	JP-8	Jet A-1, Kerosene Type Plus Special Anti-Icer
D-1655			F-35		Jet A, Kerosene
		MIL-F-16884	F-76	DFM	Diesel Fuel - Marine (DFM). ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. %.***
		MIL-F-5161		JP-6	Referee Grade JP-5 Type Jet Fuel. Limited Quantities Supplied To Military Only.

PROPOSED ASTM D-975, GRADE 3-D Detroit Diesel Allison does NOT recommend the use of proposed grade 3-D diesel fuel in any of its engines This grade of fuel has been proposed to, but not accepted by, the American Society for Testing and Materials (ASTM)

The proposed grade 3-D is undesirable In that it possesses poor Ignition quality (i.e., lower cetane), allows greater sulfur content (up to 0.70% by weight), allows the formation of more carbon deposits (Conradson carbon residue), and allows the blending of heavier, more viscous boiling point fractions that are difficult to burn The latter tend to increase combustion chamber deposits This type of fuel usually manifests poor cold weather properties (wax formation tendencies) In addition, the poor Ignition quality adversely affects noise and emission levels

A comparison of ASTM D-975 grade 2-D and the proposed grade 3-D fuel properties is shown in the following table;

COMPARISON OF ASTM D-975
GRADE 2-D AND PROPOSED GRADE 3-D PROPERTIES

ASTM Desig-nation	Federal Standard	Military Spec.	NATO Code	Grade	Description/Comments
D-975				1-D 2-D	Diesel Fuel
D-396				1, 2	Burner Fuel (Furnace Oil) ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. % and the Minimum Cetane No. Is 45. (See Fuel Oil Selection Chart).***
	VV-F-800		F-54	1, 2	DF-1 Winter Grade, DF-2 Regular Grade
	VV-F-800		F-56		DF-A (Arctic Grade). Limited Supply For Military.
		MIL-T-5624		JP-5	Kerosene
D-1655		MIL-T-83133	F-34	JP-8	Jet A-1, Kerosene Type Plus Special Anti-Icer
D-1655			F-35		Jet A, Kerosene
		MIL-F-16884	F-76	DFM	Diesel Fuel - Marine (DFM). ***Caution: If Used, The Max. Sulfur Content Allowed Is 0.50 WT. %.***
		MIL-F-5161		JP-6	Referee Grade JP-5 Type Jet Fuel. Limited Quantities Supplied To Military Only.

USING DRAINED LUBE OIL IN DIESEL FUEL

Detroit Diesel Alllson does not recommend the use of drained lubricating oil in diesel fuel Furthermore, Detroit Diesel Allison will not be responsible for any detrimental effects which it determines resulted from this practice

BURNING MIXTURES OF ALCOHOL, GASOLINE, GASOHOL OR DIESOHOL WITH DIESEL FUEL

Alcohol, gasoline, gasohol, or dlesohol should never be added to diesel fuel An explosive and fire hazard exists if these blends are mixed and/or burned See DIESEL FUEL LINE DE-ICER below

DIESEL FUEL LINE DE-ICER

Very small amounts of isopropyl alcohol (isopropanol) may be used to preclude fuel line freeze-up in winter months. No more than ONE PINT of isopropyl alcohol should be added to 125 GALLONS of diesel fuel for adequate protection

LUBRICATING OILS FOR DETROIT DIESEL ENGINES

DIESEL LUBRICATING OILS GENERAL CONSIDERATIONS

All diesel engines require heavy-duty lubricating oils.

Basic requirements of such oils are lubricating quality, high heat resistance, and control of contaminants

LUBRICATING QUALITY. The reduction of friction and wear by maintaining an oil film between moving parts is the primary requisite of a lubricant. Film thickness and Its ability to prevent metal-to-metal contact of moving parts is related to oil viscosity. The optimums for Detroit Diesel engines are SAE 40 or 30 weight.

HIGH HEAT RESISTANCE. Temperature is the most important factor in determining the rate at which deterioration or oxidation of the lubricating oil will occur. The oil should have adequate thermal stability at elevated temperatures, thereby precluding formation of harmful carbonaceous and/or ash deposits

CONTROL OF CONTAMINANTS. The piston and compression rings must ride on a film of oil to minimize wear and prevent cylinder seizure. At normal rates of consumption, oil reaches a temperature zone at the upper part of the piston where rapid oxidation and carbonization can occur In addition, as oil circulates through the engine, It is continuously contaminated by soot, acids, and water originating from combustion Until they are exhausted, detergent and dispersing additives aid in keeping sludge and varnish from depositing on engine parts But such additives in excessive quantities can result In detrimental ash deposits. If abnormal amounts of insoluble deposits form, particularly on the piston in the compression ring area, early engine failure may result.

0IL that is carried up the cylinder liner wall is normally consumed during engine operation. The oil and additives leave carbonaceous and/or ash deposits when subjected to the elevated temperatures of the combustion chamber. The amount of deposits is influenced by the oil composition, additive content, engine temperature, and oil consumption rate OIL QUALITY is the responsibility of the oil supplier.

(The term "oil supplier" is applicable to refiners, blenders, and rebranders of petroleum products, and does not include distributors of such products).There are hundreds of commercial crankcase oils marketed today Obviously, engine manufacturers or users cannot completely evaluate the numerous commercial oils. The selection of a suitable lubricant in consultation with a reliable oil supplier, observance of his oil drain recommendations (based on used oil sample analysis and experience), and proper filter maintenance will provide the best assurance of satisfactory oil performance.

It should be noted that lube oil manufacturers may reformulate an oil while maintaining the same API classification, or may reformulate to a new API classification and continue the brand name designation. For example, SE oils being reformulated to SF letter code classification may perform differently after this reformulation. A close working relationship with the lube oil manufacturer should be maintained so that any reformulation can be reviewed and decision made as to its affect on continued satisfactory performance.

^

COLD WEATHER OPERATION

Two important considerations relate to satisfactory operation under cold ambient temperature conditions. These are: (1) the ability to crank the engine fast enough to secure starting, and (2) providing adequate lubrication to internal wearing surfaces during starting and warm-up. Once started and warmed up, external ambient temperatures have little effect on internal engine temperatures. Both cold weather considerations can be adequately met through proper lube oil selection and the use of auxiliary heat prior to starting. Auxiliary heat can be used in the form of jacket water and oil pan heaters, hot air space heaters applied to engine compartments, or some combination of these.

Proper oil selection and oil heat can assure lubricant flow immediately upon starting. Improper oil selection and oil heat may result in starting with cold oil congealed in the oil pan, and little or no oil flow for lubricating internal parts once the engine has started.

Proper oil selection and jacket water heating can assure cranking capability by maintaining an oil film on cylinder walls and bearing surfaces in a condition which provides low friction, and hence, less cranking effort to achieve cranking speeds necessary for reliable starting. Improper oil selection and jacket water heating may result in congealed oil films on cylinder walls and bearing surfaces, which result in high friction loads and more cranking effort than is available, thus preventing sufficient cranking speeds to assure reliable starting.

LUBE OIL SPECIFICATIONS

Detroit Diesel Allison lubricant recommendations are based on general experience with current lubricants of various types and give consideration to the commercial lubricants presently available.

RECOMMENDATION

Detroit Diesel 2-cycle engines have provided optimum performance and experienced the longest service life operating with lubricating oils meeting the following ash limits, zinc requirements, oil performance levels, viscosity grades, and evidence of satisfactory performance.

Sulfated Ash Limit (ASTM D-874) The sulfated ash content of the lubricant shall not exceed 1.000% by weight, except lubricants that contain only barium detergent-dispersing salts where 1.5% by weight is allowed. Lubricants having a sulfated ash content between 0.55% and 0.85% by weight, have a history of excellent performance in Detroit Diesel engines. Lubricants having a sulfated ash content exceeding 0.85% by weight, are prone to produce greater deposit levels in the piston ring grooves, exhaust valve faces and seats

Zinc Content

The zinc content (zinc diorgano dithiophosphate) of all the lubricants recommended for use in Detroit Diesel 2-cycle engines shall be a minimum of 0.07% by weight. This requirement is waived where single grade **SAE 40,** intermediate viscosity index lubricants qualified for use in Electro-Motive Division (EMD) diesel engines are used.

VISCOSITY GRADE AND OIL PERFORMANCE LEVEL

Single Grade SAE 40 & SAE 30 Lubricants Single grade SAE **40** and SAE 30 grade lubricants are preferred and recommended for use in all Detroit Diesel 2-cycle engines provided they meet the sulfated ash and zinc content requirements indicated above and any of the oil performance levels shown in Table L-1. EVIDENCE OF SATISIFACTORY PERFORMANCE (see section under this title) is desired where new formulation SAE 40 or SAE 30 oils will be used. Selection of the appropriate viscosity grade is shown in Table L-2

Multigrade Lubricants

Multigrade oils have not provided performance comparable to SAE-40 or SAE-30 lubricants in some engine service applications. Because of this experience, the use of 15W-40 and all other Multigrade oils is not recommended for Series 149 engines, and restrained usage in Series 53, 71 and 92 engines is advised. If the use of a 15W-40 Multigrade oil in Series 53, 71 or 92 engines is being considered, it must meet the CD/SE oil performance level shown in Table L-1. Table L-2 indicates that 15W-40 multigrades may be selected when ambient temperatures are at, or less than, freezing. However, because our experience has disclosed that the performance of straight grade oils has been superior to Multigrade oils in some service applications, Detroit Diesel recommends that the user obtain proven service experience and evidence of satisfactory performance supplied by the lube oil manufacturer or follow the guidelines in the section entitled, "EVIDENCE OF SATISFACTORY PERFORMANCE." Upon request, the Detroit Diesel Allison Regional Office will counsel with customers in selecting a lubricating oil that will be suitable for their specific needs.

Other Multigrade Oils

Detroit Diesel Allison *does not recommend* the use of 1 OW-30, 1 OW-40, 20W-40 or any other Multigrade oils in 2-cycle engines. As previously indicated, 15W-40 oils are the only lubricants that should be considered if prolonged severe cold, ambient temperatures, are expected.

EVIDENCE OF SATISFACTORY PERFORMANCE

It is recommended that evidence of satisfactory lubricant performance in Detroit Diesel 2-cycle engines be obtained from the oil supplier prior to procurement. Controlled oil performance evaluations in field test engines are recommended. The type of field test used by the oil supplier depends on the Series engine in which the candidate oil will be used and the service application. This information is summarized in Table L-3. The candidate test oil-perated engines should all operate for the mileage/hours indicated. Fuel and lube oil consumption should be monitored during the test period. Any serious mechanical problems experienced should be recorded. All of the oil test engines should be disassembled at the conclusion of the oil test period and inspected. The following oil performance parameters should be compared:

- Ring sticking tendencies and/or ring conditions
- Piston skirt scuffing and cylinder liner wear and scuffing
- Exhaust valve face and seat deposits
- Piston pin and connecting rod bushings (Note' Trunk
- pistons used in Series 53 engines)
- Overall valve train and bearing wear levels.

USED LUBE OIL ANALYSIS PROGRAM A used lube oil analysis program should be conducted in conjunction with the oil performance field test In order to determine the condition of the lube oil that will prevail when subjected to various engine operational modes in specific service applications, it is recommended that frequent oil samples be investigated. This subject is more comprehensively addressed in the OIL CHANGES section below.

OIL CHANGES

Table L-4 shows the initial oil drain intervals for all Series 2-cycle engines used in the various service applications Oil drain intervals in all service applications may be increased or decreased with experience using a specific lubricant. Detroit Diesel Allison recommends the use of a controlled, used lube oil analysis monitoring program.

This is especially prudent when extended oil drain intervals (e.g., 100,000 miles) are being considered. The frequency at which used lube oil samples are obtained may be scheduled for the same period as when other preventive maintenance is conducted. For example, a used lube oil sample for analysis may be obtained every 10,000 miles when engines are brought in for fuel and coolant filter replacement. Table L-5 shows the routine specific laboratory tests that are recommended. Sometimes further confirmatory tests are required, especially when fuel and/or coolant dilution is suspected. Table L-5 indicates the routine and confirmatory tests recommended. The lube oil should be drained if any of the maximum tolerable warning limits are exceeded.

THE INFLUENCE OF DIESEL FUEL SULFUR CONTENT ON LUBE OIL CHANGE INTERVALS

Table L-4 shows the reduced oil drain intervals that are recommended if the use of high sulfur fuel is unavoidable. The use of diesel fuels having a sulfur content exceeding 0.50% by weight can have a negative effect on piston ring life and lube oil deposit levels. For this reason, it is recommended that oil drain intervals be drastically shortened to minimize the adverse effect of acid build-up in the lubricant. These relatively short oil drain intervals may be altered If a lubricant with high alkaline reserve (i.e., high TBN ASTM D-664) and low sulfated ash (i.e., less than 1.000% by weight ASTM D-874) can be obtained. Table L-5 indicates that the TBN of the used oil should never be less than 1 0 (ASTM D-664). If laboratory analysis reveals that the TBN is less than 1.0, this is an indication that the acceptable drain interval has been exceeded.

MIL-L-46167 ARCTIC LUBE OILS FOR NORTH SLOPE AND OTHER EXTREME SUB-ZERO OPERATIONS

Lubricants meeting this specification are used in Alaska and other extreme sub-zero locations. Generally, they may be described as 5W-20 Multigrade lubricants made up of synthetic base stock and manifesting low volatility characteristics. Although they have been used successfully In some severe cold regions, Detroit Diesel Allison does not consider their use as desirable as the use of SAE-40 or SAE-30 oils with auxiliary heating aids For this reason, they should be considered only where engine cranking is a severe problem and auxiliary heating aids are not available on the engine.

EMD (RR) OILS

Lubricants qualified for use In Electro-Motive Division (EMD) diesel engines may be used in Detroit Diesel 2-cycle engines provided the sulfated ash (ASTM D-874) content does not exceed 1 000% by weight. These lubricants are frequently desired for use In applications where both Detroit Diesel and Electro-Motlve powered units are operated. These fluids may be described as SAE-40 lubricants that possess medium Viscosity Index properties and do not contain any zinc additives

SYNTHETIC OILS

Synthetic lubricants may be used in Detroit Diesel 2-cycle engines provided the ash limit, zinc requirements, and specified oil performance levels (for example, CD/SE or MIL-L-2104B, etc) shown elsewhere In this specification are met. Viscosity grades SAE-40 or SAE-30 are recommended

LUBE OIL FILTER CHANGE INTERVAL

Full-Flow Filters

A full-flow filtration system is used in all Detroit Diesel 2-cycle engines To ensure against physical deterioration of the filter element, it should be replaced at a maximum of 25,000 miles for on-highway vehicles. For all other applications, the filter should be replaced at a maximum of 500 hours

By-Pass Filters

Auxiliary by-pass lube oil filters are not required on Detroit Diesel 2-cycle engines

OIL CHANGE INTERVAL
BASED ON SURVEY OF SATISFIED END USERS

A number of successful Detroit Diesel (2-cycle engine) customers in numerous service applications do not utilize oil analysis procedures. They prefer conservative lube oil drain and filter change intervals

Lubricant and filters were changed based on experience, and the customer felt he saved money in eliminating costly lube oil analysis programs Naturally, Detroit Diesel supports the lube oil and filter change practices used in these successful service operations.

Highway Truck Service Application

011 Change Interval	20,000 Miles
Filter Change Interval	20,000 Miles

Large 149 Series Engines Powering Off-Road Equipment (Construction & Mine Site Service Applications)

011 Change Interval	1 50 Hours
Filter Change Interval	300 Hours

City Transit Coaches

Oil Change Interval	12,500 Miles
Filter Change Interval	25,000 Miles

Pickup & Delivery Metro Area Truck Service

Oil Change Interval	12,000 Miles
Filter Change Interval	24,000 Miles

Stationary (Usually Stand By) Engines

Oil Change Interval	150 Hours or One Year
Filter Change Interval	300 Hours or One Year

LUBE OIL PERFORMANCE LEVELS

API Letter Code Service Classification	Military Specification	SAE Grade
CB	MIL-L-2104A (Supplement 1)	40 or 30
CC	MIL-L-2104B	40 or 30
CD	MIL-L-45199B (Series 3)	40 or 30
CC/SE	MIL-L-46152	40 or 30
CD/SC	MIL-L-2104C	40 or 30
Numerous Combinations of Above	Single Grade Universal No MIL- Spec.	40 or 30
CD/SE	Multigrade Universal No MIL- Spec.	15W-40

TABLE L-1.

VISCOSITY GRADE SELECTION

AMBIENT TEMPERATURE		RECOMMENDATIONS		
degrees Celsius	degrees Fahrenheit	PRIMARY	SECONDARY	THIRD
↑ 10	↑ 50	SAE 40	SAE 30	None
10 ↕ 0	50 ↕ 32	SAE 40 Plus Starting Aids	SAE 30 Usually Unaided	None
0 ↕ 18	32 ↕ 0	SAE 40 Plus Starting Aids	SAE 30 Plus Starting Aids	15W-40 Usually Unaided
18 ↑	0 ↑	SAE 40 Plus Starting Aids	SAE 30 Plus Starting Aids	15W-40 Plus Starting Aids

TABLE L-2.

Table L-2

INDIVIDUAL USER SERVICE APPLICATION LUBE FIELD TESTING

Engine Series	Service Application	Test Duration	No. Engines on Candidate Test Oil	No. Sister Engines on Reference Baseline SAE 40 or SAE 30
53	Pickup & Delivery Metro Area	50,000 Miles	5	5
71 & 92	Hwy. Truck 72,000 Lbs. GCW	200,000 Miles	5	5
149	Off Road Rear Dump 120 Ton	10,000 Hours	3*	3

*Single Grade Only - No Multigrades Recommended For Series 149 Engines

TABLE L-3.

LUBE OIL DRAIN INTERVAL

Service Application	Engine Series	Max. Lube Oil Drain Interval*		
		Diesel Fuel Sulfur Content Wt. %		
		0 to 0.50	0.51 to 0.75	0.76 to 1.00
Hwy. Truck (Long Distance Hauls) and Inter-City Buses	71 & 92	100,000 Miles**	20,000 Miles	10,000 Miles
City Transit Coaches and Pickup and Delivery Truck Service (Stop-And-Go Short Distance	53, 71, 92	12,500 Miles	2,500 Miles	1,250 Miles
Industrial and Marine	53, 71, 92	150 Hours	30 Hours	15 Hours +
Large Industrial and Marine	149	(NA) 500 Hours	100 Hours	50 Hours +
		(T) 300 Hours	60 Hours	30 Hours +

*Maximum lube oil drain intervals must be based on the laboratory test results obtained from used lube oil samples.

**If supported by oil analysis at 10,000 mile intervals or when recommended fuel filter maintenance is performed.

+These oil change intervals are based upon worst case with chrome-faced rings. Oil change periods with plasma-faced rings can be established by oil analysis.

TABLE L-4.

USED LUBE OIL ANALYSIS WARNING VALUES

	ASTM Designation	Limits	Routine Or Confirmatory
Pentane Insolubles, Wt. %, Max.	D-893	1.00	Routine
TGA Carbon (Soot) Content, Wt. %, Max.	None	0.80	Routine
Viscosity at 100°F, SUS	D-445		Routine
% Max. Increase	&	40.00	
% Max. Decrease	D-2161	15.00	
Iron Content, PPM., Max.	None	150.00	Routine
Total Base Number (TBN), Min.	D-664	1.00	Routine
Water Content, Vol. %, Max.	D-95	0.30	Confirmatory
Flash Point, °F, Max. Reduction	D-92	40.00	Confirmatory
Fuel Dilution, Vol. %, Max.	—	2.50	Confirmatory
Glycol Dilution, PPM., Max.	D-2982	1000.00	Confirmatory
Sodium Content, PPM., Max. Allowed Over Lube Oil Baseline	—	50.00	Routine
Boron Content, PPM., Max. Allowed Over Lube Oil Baseline	—	20.00	Routine

TABLE L-5.

MISCELLANEOUS FUEL AND LUBRICANT INFORMATION

ENGINE OIL CLASSIFICATION SYSTEM

The American Petroleum Institute (API), the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) jointly have developed the present commercial system for designating and identifying motor oil classifications. The table in this section shows a cross-reference of current commercial and military lube oil identification and specification systems.

PUBLICATION AVAILABLE SHOWING COMMERCIAL "BRAND" NAME LUBRICANTS

A list of "brand" name lubricants distributed by the majority of worldwide oil suppliers can be purchased from the Engine Manufacturers Association (EMA). The publication is titled *EMA Lubricating Oils Data Book for Heavy-Duty Automotive and Industrial Engines.* The publication shows the brand names, oil performance levels, viscosity grades, and sulfated ash contents of most "brands" marketed.

ENGINE MANUFACTURERS ASSOCIATION
111 EAST WACKER DRIVE
CHICAGO, ILLINOIS 60601

Upon request, the Detroit Diesel Allison Regional Office will counsel with customers in selecting a lubricating oil that will be suitable for their specific needs.

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpt has been taken from a policy statement of General Motors Corporation:

> *"It has been and continues to be General Motors policy to build motor vehicles that will operate satisfactorily on the commercial fuels and lubricants of good quality regularly provided by the petroleum industry through retail outlets."*

Therefore, Detroit Diesel Allison does not recommend the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, reodorants, tune-up compounds, top oils, break-in oils, graphitizers, and friction-reducing compounds.

NOTICE: The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's fuel or lubricating recommendations may not be within the coverage of the warranty.

CROSS REFERENCE OF LUBE OIL CLASSIFICATION SYSTEM

API CODE LETTERS	COMPARABLE MILITARY OR COMMERCIAL INDUSTRY SPECIFICATION
CA	MIL-L-2104A
CB	Supplement 1
CC	MIL-L-2104B (See Note Below)
CD	MIL-L-45199B (Series 3)
‡	MIL-L-46152 (Supersedes MIL-L-2104B Military Only)
□	MIL-L-2104C (Supersedes MIL-L-45199B for Military Only)
SA	None
SB	None
SC	Auto Passenger Car 1964 MS Oils - Obsolete System
SD	Auto Passenger Car 1968 MS Oils - Obsolete System
SE	Auto Passenger Car 1972 MS Oils - Obsolete System
SF	Auto Passenger Car 1980 Production

‡ Oil performance meets or exceeds that of CC and SE oils.

□ Oil performance meets or exceeds that of CD and SC oils.

NOTE: MIL-L-2104B lubricants are obsolete for military service applications only.
MIL-L-2104B lubricants are currently marketed and readily available for commercial use.

Consult the following publications for complete descriptions:

1. Society of Automotive Engineers (SAE) Technical Report J-183a.
2. Federal Test Method Standard 791a.

ENGINE COOLANT

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, the heat of combustion is conveyed through the cylinder walls and the cylinder head into the coolant.

Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. In general, water containing various materials in solution is used for this purpose.

The function of the coolant is basic to the design and to the successful operation of the engine. Therefore, coolant must be carefully selected and properly maintained.

COOLANT REQUIREMENTS

Coolant solutions must meet the following basic requirements:

1. Provide for adequate heat transfer.

2. Provide a corrosion-resistant environment within the cooling system.
3. Prevent formation of scale or sludge deposits in the cooling system.
4. Be compatible with the cooling system hose and seal materials.
5. Provide adequate freeze protection during cold weather operation.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol-based antifreeze is recommended for use in Detroit Diesel engines.

WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness and dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

TABLE 1.

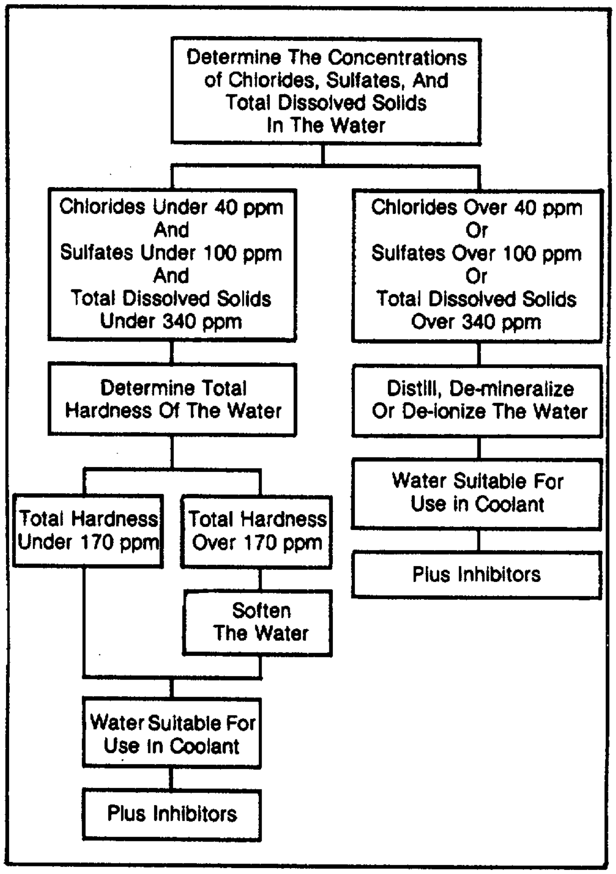


TABLE 2.

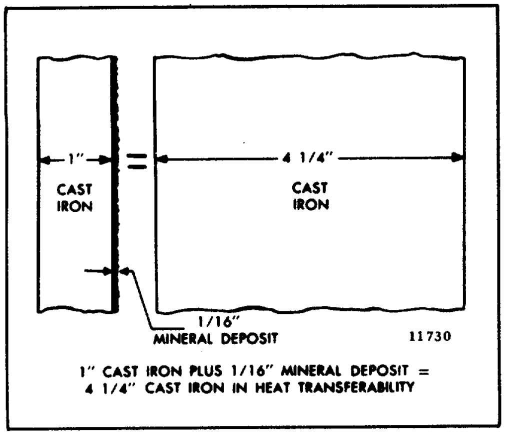


Fig. 1. Heat Transfer Capacity

of these. Chlorides, sulfates, magnesium and calcium are. among the materials which make up dissolved solids. Water, within the limits specified in Table 1 is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution is shown in Table 2.

CORROSION INHIBITORS VITAL

A corrosion inhibitor is a water-soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil.

(Soluble oil is not recommended as a corrosion inhibitor). Depletion of all types of inhibitors occurs through normal operation. Therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, 'or-worse-no inhibitors at all invites the formation of rust and scale deposits within the cooling system.. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a 1/16" deposit of rust or scale on I" of cast iron is equivalent to 4-1/4" of cast iron in heat transferability (Fig. 1).

An engine affected in this manner overheats gradually over a period of weeks or months. Liner scuffing, scoring, piston seizure and cylinder head cracking are the inevitable results. An improperly inhibited coolant can also become corrosive enough to "eat away" coolant passages and seal ring grooves and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod. An improperly inhibited coolant can also contribute to cavitation erosion. Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

Chromates

Sodium chromate and potassium dichromate are two of the best and most commonly used water system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should not be' used in antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages and reduces the heat transfer rate (Fig. 1) which results in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

Soluble Oil

Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example: 1.25% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2.50% concentration raises fire deck temperature up to 15%. Soluble oil is not recommended as a corrosion inhibitor.

Non-Chromates

Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water-and-antifreeze solution.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical compounds which provide corrosion protection, pH control and water-softening ability. Corrosion protection is discussed under the heading Corrosion Inhibitors Vital. The pH control is used to maintain an acid-free solution. The water-softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives and as an integral part of antifreeze.

Coolant Filter Elements

Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.

Bulk Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant or to bulk storage tanks containing coolant solution.

Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatibility with other coolant constituents.

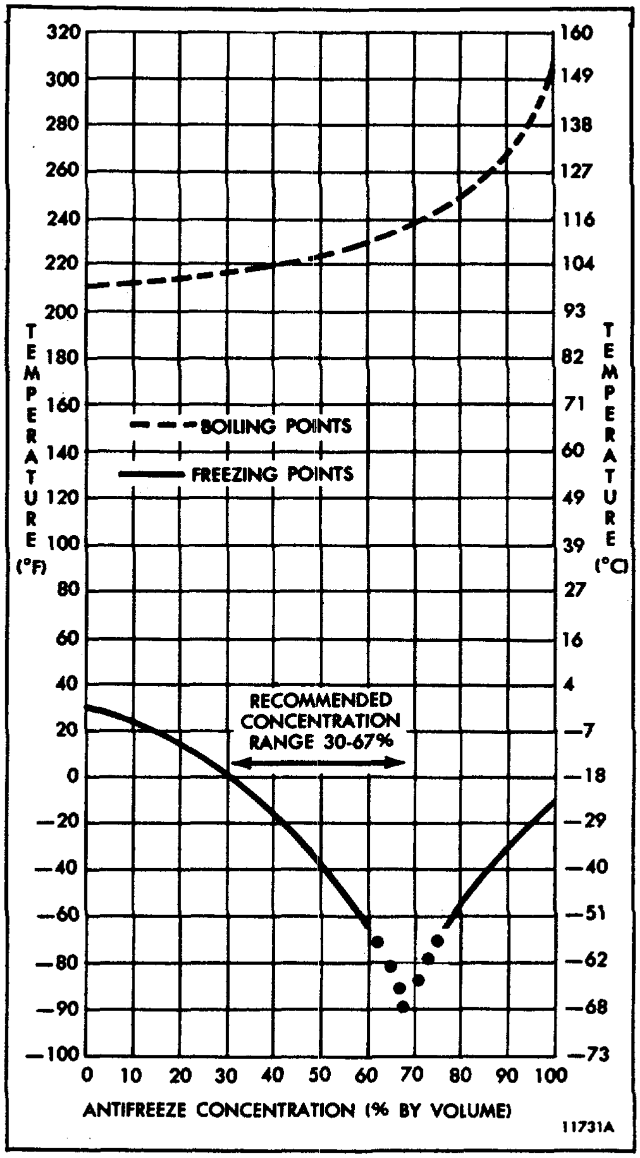


Fig. 2. - Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

Non-chromate inhibitor systems are recommended for use in Detroit Diesel engines. These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control and water softening. Some non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, require no additional hardware or plumbing.

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant at prescribed intervals to maintain original strength levels. Always follow the supplier's recommendations on inhibitor usage and handling.

TEST STRIPS

Some chemical manufacturers have developed test strips for use with their antifreeze or coolant additives.

These test strips are used to measure the freeze protection and/or inhibitor strength of ethylene glycol-based antifreeze. To avoid a false reading caused by variations in reserve alkalinity, Detroit Diesel Allison suggests using test strips that measure depletable inhibitor concentration directly. Do not use one manufacturer's test strips to measure the chemical content of anther's antifreeze and/or inhibitors. Always follow the manufacturer's recommended test procedures.

ANTIFREEZE

When freeze protection is required, an antifreeze meeting GM specification 1899M must be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill if a minimum antifreeze concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection.
Concentrations over 67% adversely affect freeze protection and heat transfer rates (Fig. 2).

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base anti-freeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxypropanol base antifreeze is not recommended for use in Detroit Diesel engines due to the presence of fluoro-elastomer seals in the cooling system.

Before installing ethylene glycol base antifreeze in a unit that has previously operated with Methoxypropanol, the entire cooling system should be drained, flushed with clean water, and examined for rust, scale contaminants, etc. If deposits are present, the cooling system must be chemically cleaned with a commerical grade heavy-duty descaler.

The inhibitors in antifreeze should be replenished at approximately 500 hour intervals or by test with a non-chromate inhibitor system. Commercially available inhibitor systems may be used to re inhibit antifreeze solutions.

Sealer Additives

Antifreeze with sealer additives is not recommended for use in Detroit Diesel engines due to plugging possibilities throughout various areas of the cooling system, including cooling system bleed holes and water pump drain holes.

GENERAL RECOMMENDATIONS

All Detroit Diesel engines incorporate pressurized cooling systems which permit operation at temperatures higher than non-pressurized systems. It is essential that these systems be kept clean and leak free, that filler caps and pressure relief mechanisms be correctly installed at all times and that coolant levels be properly maintained.

Always maintain engine coolant at the proper level. A low coolant level allows the water pump to mix air with the coolant. Air bubbles in the coolant can "insulate" the cylinder walls, preventing normal heat transfer. An abnormally low coolant level can cause the water pump to become (: air-bound," a condition in which it works feverishly but pumps nothing.

Without proper heat transfer, silicone elastomer head to-block water hole seals can deteriorate and cylinder components can expand so that pistons rapidly cut through the lubricant on the liner walls. Scuffing and piston seizure may follow.

CAUTION
Use extreme care when removing a radiator pressure-control cap from an engine.

The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.
An engine may contain the correct amount of properly inhibited coolant, but still fail to adequately cool the engine. In cases where this occurs, other causes of low coolant flow, either engine or cooling system related, should be investigated.

1. Always use a properly inhibited coolant.
2. Do not use soluble oil.
3. Maintain the prescribed inhibitor strength.
4. Always follow the manufacturer's recommendations on inhibitor usage and handling.
5. If freeze protection is required, use a solution of water and antifreeze meeting GM specification 1899M.
6. Re-inhibit antifreeze with a recommended non-chromate inhibitor system.

7. Do not use a chromate inhibitor with antifreeze.

8. Do not use methoxy propanol base antifreeze in Detroit Diesel engines.

9. Do not mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.

10. Do not use antifreeze containing sealer additives.

11. Do not use methyl alcohol base antifreeze.

12. Use extreme care when removing the radiator pressure-control cap.

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

Four types of governors are used. Since each governor has different characteristics, the tune-up procedure varies accordingly. The four types are:

1. Limiting speed mechanical.

2. Variable speed mechanical.

3. Limiting speed hydraulic.

4. Variable speed hydraulic.

The mechanical engine governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double-weight limiting speed governor. A single weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings.

However, if the cylinder head, governor or injectors have been replaced or overhauled. then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine.

NOTE
If a supplementary governing device, such as the throttle delay mechanism, is used, it must be disconnected prior to the tune-up.

After the governor and injector rack adjustments are completed, the supplementary governing device must be reconnected and adjusted.

To tune-up an engine completely, all of the adjustments, except the valve bridge adjustment on four valve cylinder heads, are made by following the applicable tune-up sequence given below, after the engine has reached normal operating temperature.

Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.
NOTE: The exhaust valve bridges on the four valve cylinder head are adjusted at the time the cylinder head is installed on the engine and, until wear occurs, no further adjustment is required. When wear is evident, perform a complete valve bridge adjustment as outlined on the following pages.

The tune-up procedures apply to the individual engines of multiple engine units as well as to the single engine units. However, the throttle linkage of multiple engine units must be adjusted after the individual engines have been tuned up.

Use new valve rocker cover gaskets after the tune-up is completed.

Tune-Up Sequence for Mechanical Governors

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover, the serviceman must determine that the injector racks move to the no-fuel position when the governor stop lever is placed in the stop position.

Engine over speed will result if the injector racks cannot be positioned at no-fuel with the governor stop lever.
CAUTION: An over speeding engine can result in engine damage which could cause personal injury.
I. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).
9. Adjust the supplementary governing device (if used).

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor linkage.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Compensation adjustment (PSG governors only).
7. Adjust the governor speed droop.
8. Adjust the maximum no-load speed.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

ENGINES WITH TWO VALVE CYLINDER HEADS

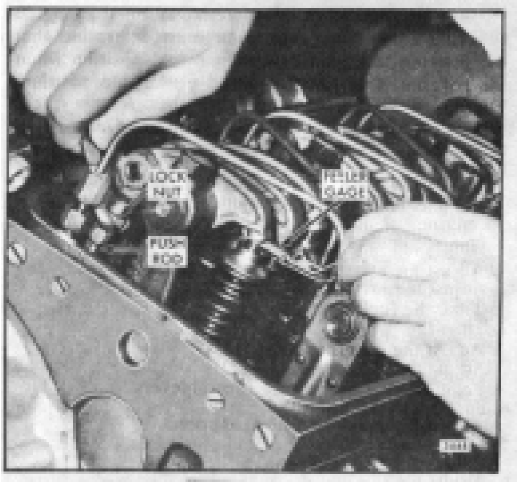


Fig. 1. - Adjusting Valve Clearance

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the General Specifications at the front of the manual for the engine firing order.

Valve Clearance Adjustment (Cold Engine) 100°F (38°C) or less

1. Remove the loose dirt from the valve rocker covers and remove the covers.

2. Place the governor speed control lever in the idle speed position. If a stop lever is provided, secure it in the stop position.

3. Rotate the crankshaft, with the starting motor or engine barring tool J 22582, until the injector follower is fully depressed on the cylinder to be adjusted.

NOTE
If a wrench is used on the crankshaft or camshaft bolt at the front of the engine, do not turn the engine in a left-hand direction of rotation because the bolt may loosen.

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .012" +\-.004" feeler gage (J 9708-01) between the valve stem and the rocker arm bridge (Fig. 1). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .011" feeler gage will pass freely between the valve stem and the rocker arm, but the .013" feeler gage will not pass through. Readjust the push rod, if necessary.

8. Check and adjust the remaining exhaust valves in the same manner as outlined above.

Valve Clearance Adjustment (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become insufficient.

With the engine at normal operating temperature (160-185°F or 71-85°C), recheck the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .008" feeler gage will pass freely between the end of the valve stem and the rocker arm and the .010" feeler gage will not pass through. Readjust the push rod, if necessary.

ENGINES WITH FOUR VALVE CYLINDER HEADS

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. Until wear occurs, no further adjustment is required on the exhaust valve bridges. When wear is evident, make the necessary adjustments as outlined below.

Exhaust Valve Bridge Adjustment 1. Remove the loose dirt from the valve rocker covers and remove the covers. Remove the injector fuel pipes and the rocker arm bracket bolts. Move the rocker arms away from the exhaust valve bridge.

2. Remove the exhaust valve bridge (Fig. 2).

3. Place the valve bridge in a vise or bridge holding fixture J 21772 and loosen the locknut on the bridge adjusting screw.

NOTE

: Loosening or tightening the locknut with the bridge in place may result in bending the bridge guide or the rear valve stem.

4. Install the bridge on the bridge guide.

5. While firmly pressing straight down on the pallet surface of the bridge, turn the adjusting screw clockwise until it just touches the valve stem. Then turn the screw an additional 1/8 to 1/4 turn clockwise and tighten the locknut finger tight.

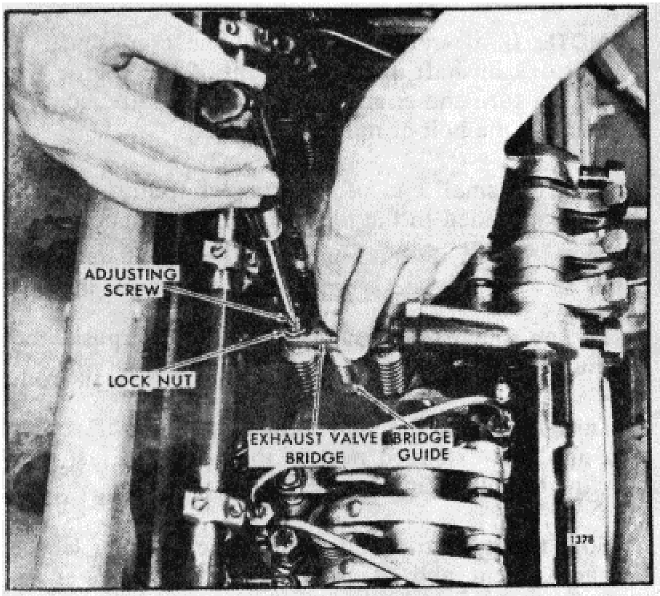


Fig. 2. - Bridge Balancing Adjustment

6. Remove the valve bridge and place it in a vise. Use a screwdriver to hold the adjustment screw from turning and tighten the locknut to 25 lb-ft (34 N m) torque.

7. Lubricate the valve bridge guide and the valve bridge pilot with engine oil.

8. Reinstall the valve bridge in its original position.

9. Place a .0015" feeler gage under each end of the bridge. When pressing down on the pallet surface of the bridge, both feeler gages must be tight. If both feeler gages are not tight, readjust the screw as outlined in Steps 5 and 6.

10. Adjust the remaining valve bridges as outlined above.

11. Swing the rocker arm assembly into position being sure the bridges are properly positioned on the rear valve stems. This precaution is necessary to prevent valve damage due to mis-located bridges.

12. Tighten the rocker arm bracket bolts to 90-100 lb ft (122-136 N m) torque.

13. Align the fuel pipes and connect them to the fuel injectors and connectors. Use socket J 8932 to tighten the connectors to 12-15 lb.-ft (16-20 N m) torque. Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks.

Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

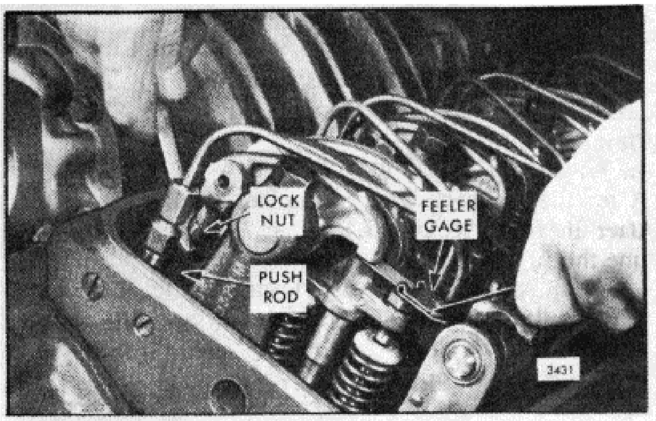


Fig. 3. - Adjusting Valve Clearance

Valve Clearance Adjustment (Cold Engine) 100°F (38°C) or less

All of the exhaust valves may be adjusted, in firing order sequence, during one full revolution of the crankshaft. Refer to the General Specifications at the front of the manual for the engine firing order.

1. Remove the loose dirt from the valve rocker covers and remove the covers.

2. Place the governor speed control lever in the idle speed position. If a stop lever is provided, secure it in the stop position.

NOTE
On certain 12V turbo-charged engines, it is necessary to remove the air inlet housing to remove the rocker covers.

3. Rotate the crankshaft, with the starting motor or engine barring tool J 22582, until the injector follower is fully depressed on the cylinder to be adjusted.

NOTE
If a wrench is used on the crankshaft or camshaft bolt at the front of the engine, do not turn the engine in a left-hand direction of rotation because the bolt may loosen.

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .016" =\-.004" feeler gage (J 9708-01) between the valve bridge and the valve rocker arm pallet (Fig. 3). Adjust the push rod to obtain a smooth "pull" on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

7. Recheck the clearance and adjust the push rod, if necessary.

8. Check and adjust the remaining valves in the same manner as outlined above.

Valve Clearance Adjustment (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final valve clearance adjustment. If the engine is allowed to cool off before setting any of the valves, the clearance when running at full load may become insufficient.

1. With the engine at normal operating temperature (160-185°F or 71-85°C), recheck the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .013" feeler gage will pass freely between the valve stem and the valve bridge adjusting screw, but the .015" feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing.

TIMING FUEL INJECTOR

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed, in firing order sequence, during one full revolution of the crankshaft.

Refer to the General Specifications at the front of the manual for the engine firing order.

Use the proper timing gage as indicated in Table 1.

Time Fuel Injector

After the exhaust valve clearance has been adjusted, time the fuel injectors as follows: 1. Place the speed control lever in the idle speed position. If a stop lever is provided, secure it in the no fuel position.

2. Rotate the crankshaft, by using the starting motor or engine barring tool J 22582, until the exhaust valves are fully depressed on the particular cylinder to be timed.

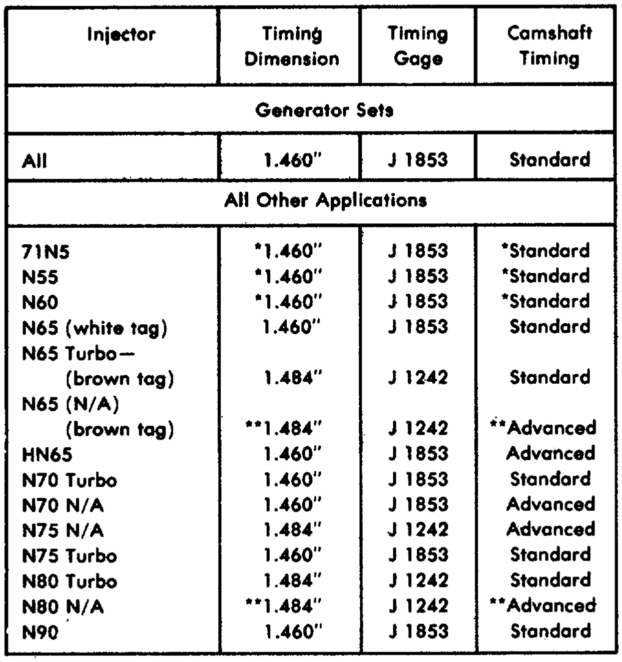
NOTE
If a wrench is used on the crankshaft bolt or camshaft nut at the front of the engine, do not turn the engine in a left-hand direction because the bolt or nut may loosen.

3. Place the small end of the injector timing gage in the hole provided in the top of the injector body, with the flat of the gage toward the injector follower (Fig. 4).

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the locknut. Check the adjustment and, if necessary, readjust the push rod.



Injector	Timing Dimension	Timing Gage	Camshaft Timing
Generator Sets			
All	1.460"	J 1853	Standard
All Other Applications			
71N5	*1.460"	J 1853	*Standard
N55	*1.460"	J 1853	*Standard
N60	*1.460"	J 1853	*Standard
N65 (white tag)	1.460"	J 1853	Standard
N65 Turbo—(brown tag)	1.484"	J 1242	Standard
N65 (N/A) (brown tag)	**1.484"	J 1242	**Advanced
HN65	1.460"	J 1853	Advanced
N70 Turbo	1.460"	J 1853	Standard
N70 N/A	1.460"	J 1853	Advanced
N75 N/A	1.484"	J 1242	Advanced
N75 Turbo	1.460"	J 1853	Standard
N80 Turbo	1.484"	J 1242	Standard
N80 N/A	**1.484"	J 1242	**Advanced
N90	1.460"	J 1853	Standard

N/A-Naturally aspirated engines.

*Use 1.484" timing gage (J1242) when engine has advanced camshaft timing. Correct to standard camshaft timing and 1.460" injector timing at first opportunity to be consistent with current production build.

**Use 1.460" timing gage (J 1853) when engine has standard camshaft timing. Correct to advanced camshaft timing and 1.484" injector timing at first opportunity.

NOTE Advanced camshaft timing is indicated by "ADV-CAM TIMING" stamped on lower right-hand side of option plate.

TABLE 1.

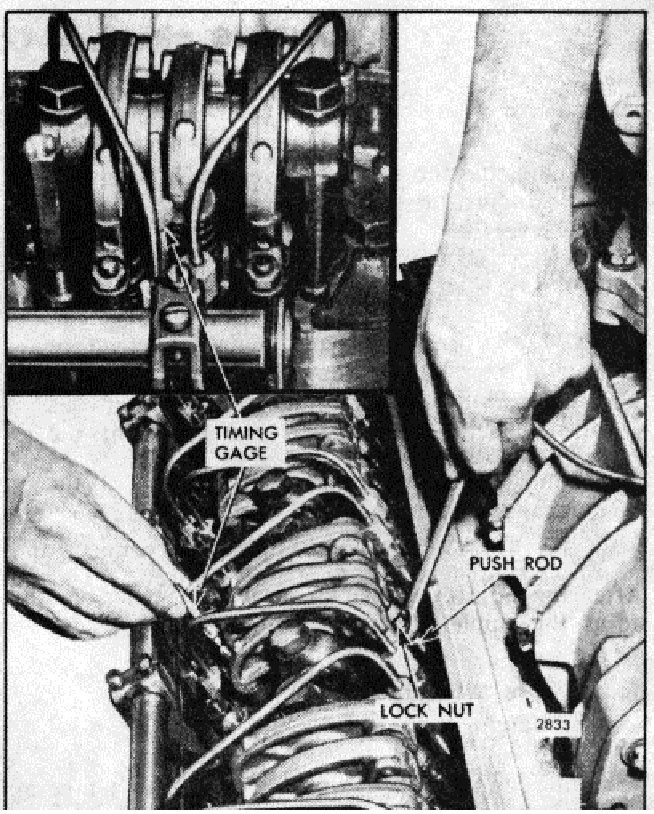


Fig. 4. - Timing Fuel Injector

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required, use new gaskets and install the valve rocker covers.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V ENGINES

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor gap and the injector rack control levers.

NOTE Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. such as throttle delay mechanism and back out the starting aid screw.

After the adjustments are completed. reconnect and adjust the supplementary governing device.

Adjust Governor Gap Double Weight Governor

With the engine stopped and at operating temperature, adjust the governor gap as follows:

CAUTION If the governor gap adjustment is to be made with the engine in the unit, it is suggested that the fan assembly be removed due to the closeness of the fan blades to the engine governor.

1. Remove the high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 8).

3. Start the engine and loosen the idle speed adjusting screw locknut. Then adjust the idle screw to obtain the desired engine idle speed. Hold the screw and tighten the locknut to hold the adjustment.

NOTE Limiting speed governors used in turbo charged engines include a starting aid screw threaded into the governor housing.

4. Stop the engine, clean and remove the governor cover and lever assembly and the valve rocker covers.

Discard the gaskets.

5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

NOTE: Do not over speed the engine.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 1). The gap setting should be .002"-.004".

7. On governors without the starting aid screw, hold the gap adjusting screw and tighten the lock nut.

8. Recheck the gap with the engine running between 1100 and 1300 rpm and readjust if necessary.

9. Stop the engine and, using a new gasket, install the governor cover and lever assembly. Tighten the screws.

Adjust Governor Gap Single Weight Governor With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

CAUTION: If the gap adjustment is to be made with the engine in the unit, it is suggested that the fan assembly be removed due to the

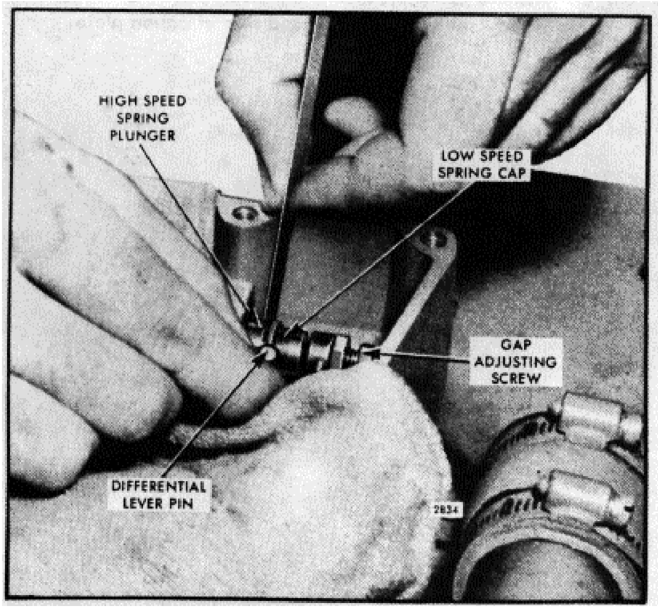


Fig. 1. - Adjusting Governor Gap

closeness of the fan blades to the engine governor.

1. Remove the governor high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 8).

3. Start the engine and loosen the idle speed adjusting screw locknut. Then adjust the idle screw to obtain the desired engine idle speed. Hold the screw and tighten the locknut to hold the adjustment.

> **NOTE** Limiting speed governors used in turbocharged engines include an external starting aid screw threaded into the governor housing.

If in going from top no-load speed to idle speed, the engine governor will not recover and the engine stalls, it may become necessary to increase the idle speed to a minimum speed of 600 rpm (see Chart).

ENGINE	INJECTOR	DROUP	IDLESPEED
6, 8 and 12V Turbo	All	Unchanged	600 rpm min. (was 500 rpm min.) All Injector Sizes
6, 8 and 12V Not. Asp	7E65 mm	175 rpm (was 150 rpm)	Unchanged

4. Stop the engine. Clean and remove the governor cover and lever assembly and valve rocker cover. Discard the gaskets.

5. Remove the fuel rod from the differential lever and the injector control tube lever.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with gage J 23478 (.200") as shown in Fig. 1.

> **NOTE** Be sure the external starting aid screw (if used) is backed out far enough to make it ineffective when making this adjustment.

7. If required, loosen the locknut and turn the gap adjusting screw until a slight drag is felt on the gage.

8. Hold the adjusting screw and tighten the locknut.

9. Recheck the gap and readjust if necessary.

10. Install the fuel rod between the governor and injector control tube lever.

11. Use a new gasket and install the governor cover and lever assembly.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever with one screw and locknut to keep each injector rack properly positioned.

> **NOTE** To ensure proper injector rack control adjustment, the injector racks must be adjusted with the yield link and governor cover that are to be used with the governor.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low-speed gap closed.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. IL injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the governor control lever.

2. Turn the idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the locknut when the nut is against the high-speed plunger. This adjustment lowers the tension of the low-speed spring so it can be easily compressed. This permits closing the low-speed gap without bending the fuel rods or causing the yield mechanism springs to yield or stretch.

> **NOTE** A false fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

Injector racks must be adjusted so the effort to move the throttle from the idle speed position to the

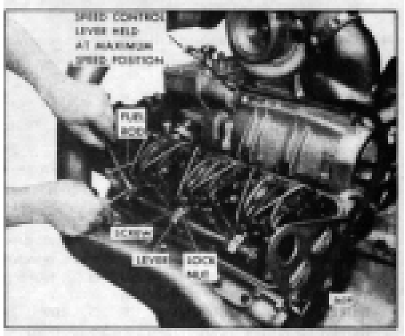


Fig.2. - Positioning No. 1 Injector Rack Control Lever (One Screw and Lock Nut Assembly)

maximum speed position is uniform. A sudden increase in effort can result from:

a. Injector racks adjusted too tight causing the yield link to separate.

b. Binding of the fuel rods.

c. Failure to back out idle screw.

3. Back out the buffer screw approximately 5/8", if it has not already been done.

4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

5. Loosen all of the adjusting screws and locknuts on both cylinder heads. Be sure all of the injector rack control levers are free on the injector control tubes.

6. Move the speed control lever to the maximum speed position and hold it in that position with light finger pressure (Fig. 2). Tighten the adjusting screw of the No. I L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. IL injector rack in the full-fuel position.

Over tightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in(3-4 Nm).

> **NOTE:** The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

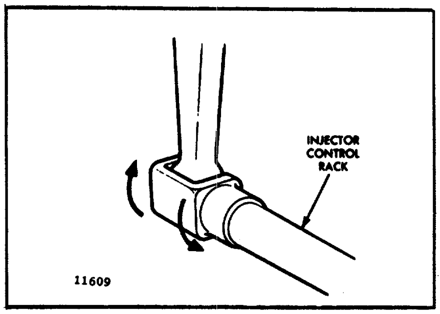


Fig.3. - Checking Rotating Movement of the Injector Control Rack

7. To be sure of the proper rack adjustment, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack (Fig. 3). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 4).

If the rack does not return to its original position, it is

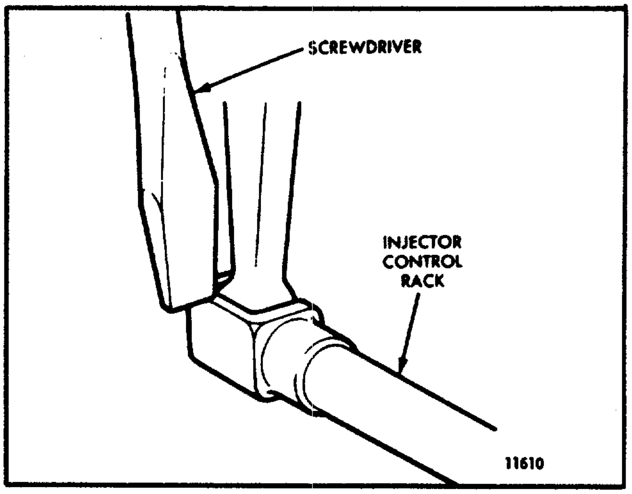


Fig. 4. - Checking Injector Control Rack "Spring".

too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the speed control lever from the no-speed to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover).

This will result in a step-up in effort required to move the speed control lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. IR injector rack control lever as previously outlined in Steps 6 and 7 for the No. IL injector rack control lever.

10. Insert the clevis pin in the fuel rod at the left bank injector control tube lever. Verify the adjustments for the No. IL and IR injector racks are equal. To do this, move the speed control lever to the maximum speed position. Rotate the clevis pins at the injector control tube levers and note the drag or resistance to rotate the pins. This resistance or drag should be equal for both pins. If the drag is not equal, turn the No. I R injector rack adjusting screw clockwise to increase drag on the right bank clevis pin or counterclockwise to decrease the pin drag. Adjust No. IR adjusting screw and lock securely to ensure equal drag for both clevis pins.

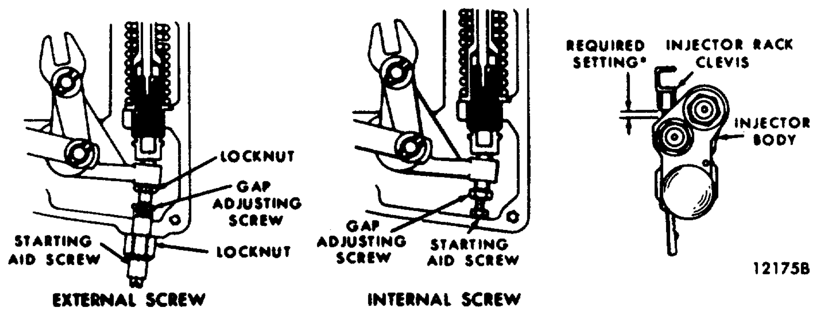
11. To adjust the remaining injector rack control levers, remove the clevis pins from the fuel rod at the injector control tube levers, hold the left bank injector control racks in the full fuel position by means of the lever on the end of the control tube and proceed as follows: a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE Over tightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in(3-4 N m).

b. Verify the injector rack adjustment of No. IL as outlined in Step 7. If No. IL does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. IL injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. IL and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. IL and No. 2L injector racks are in the full fuel position when the locknut is securely tightened.

c. Adjust the remaining injectors using the procedures outlined in Step "B" always verifying proper injector rack adjustment.

NOTE Once the No. IL and No. IR injector rack control levers are adjusted, do not try to alter their settings. All adjustments are made on the remaining control racks.



INJECTOR	GAGE SETTING*	TOOL NUMBER
S80	.345"	J 24889
N60	.345"	J 24889
N65	.385"	J 24882
N70	.385"	J 24882
N75	.385"	J 24882
N80	.385"	J 24882
N90	.454"	J 23190
C65	.385"	J 24882
C80	.385"	J 24882

See V-71 Service Manual for other injector gage settings

Fig. 5. Starting Aid Screw Adjustment

12. When all of the injector rack control levers are adjusted, recheck their settings. With the control tube lever in the full-fuel position, check each control rack as in Step 7. All of the control racks must have the same "spring" condition with the control tube lever in the full-fuel position.

13. Insert the clevis pin in the fuel rod and the injector control tube levers.

14. Turn the idle speed adjusting screw in until it projects 3/16" from the locknut, to permit starting the engine.

15. Adjust the starting aid screw (Turbo-charged engines).

The starting aid screw is threaded into the governor housing (Fig. 5). This screw is adjusted to position the injector racks at less than full fuel when the governor speed control lever is in the idle position. The reduced fuel makes starting easier and reduces the amount of smoke on start-up.

> **NOTE:** The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor running gap of .002"-.004" has been set and the injector racks positioned, adjust the starting aid screw as follows: a. With the engine stopped, place the governor stop lever in the run position and the speed control lever in the idle speed position.

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 5).

Select the proper gage and measure the setting at any convenient cylinder. When the starting aid screw is properly adjusted, the gage should have a small clearance of 1/64" in the space along the injector rack shaft between the rack clevis and the injector body.

c. After completing the adjustment, hold the starting aid screw and tighten the locknut.

d. Check the injector rack clevis-to-body clearance after performing the following: I. Position the stop lever in the run position.

2. Move the speed control lever from the idle speed position to the maximum speed position.

3. Return the speed control lever to the idle speed position.

Movement of the speed control lever is to take-up the clearance in the governor linkage. The injector rack clevis-to-body clearance can be increased by turning the starting aid screw farther in against the gap adjusting screw, or reduced by backing it out.

> **NOTE**The starting aid screw will be ineffective if the speed control lever is advanced toward wide open throttle during start-up.

Affix a new gasket to the top of the governor housing.

Place the governor cover assembly on the governor housing with the pin in the throttle control shaft assembly in the slot of the differential lever and the dowel pins in the housing in the dowel pin holes in the cover. Tighten the screws.

> **NOTE** Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks move to the no fuel position when the governor stop lever is placed in the stop position. Engine over speed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

CAUTION An over speeding engine can result in engine damage which could cause personal injury.

16. Use new gaskets and replace the valve rocker covers.

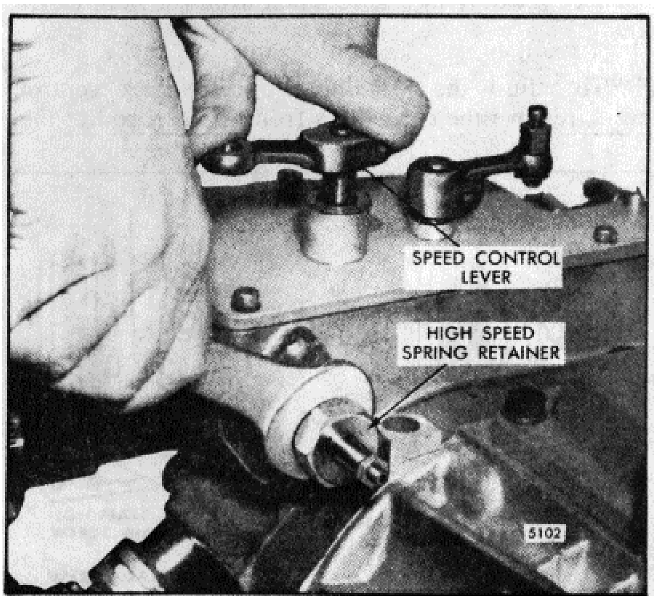


Fig. 6. Adjusting Maximum No-Load Speed

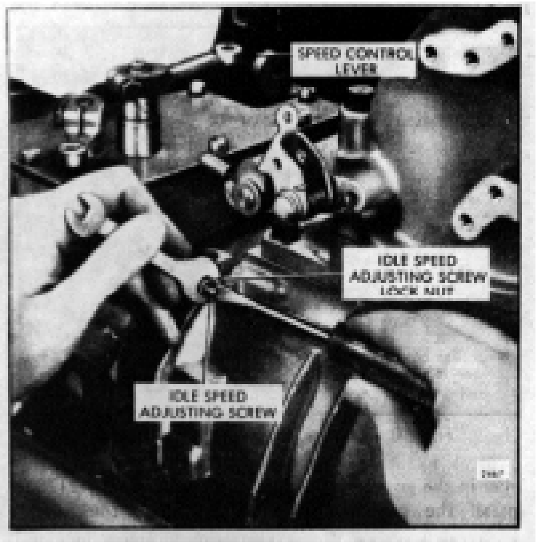


Fig. 7. - Adjusting Engine Idle Speed

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option plate, set the maximum no-load speed as follows:

> **NOTE** Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speed.

1. Loosen the spring retainer locknut (Fig. 6) and back off the high-speed spring retainer approximately five turns.

2. With the engine running at operating temperature and no-load on the engine, place the speed control lever in the maximum speed position. Turn the high speed spring retainer until the engine is operating at the recommended no-load speed.

3. Hold the high-speed spring retainer and tighten the lock nut, using spanner wrench J 5345-5.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

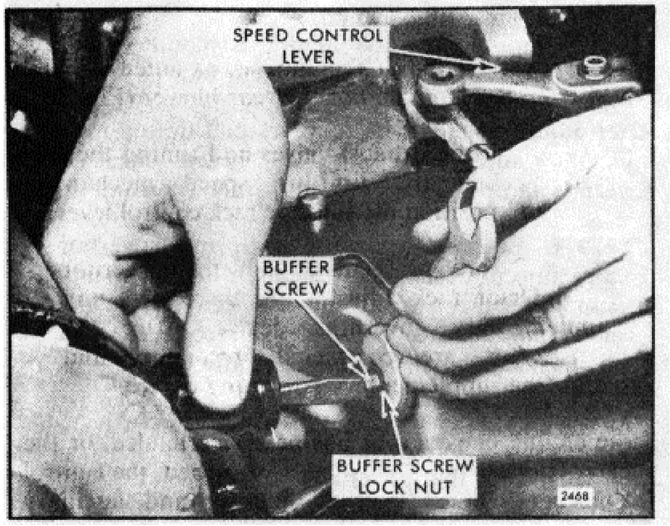


Fig. 8. Adjusting Buffer Screw

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine operates at approximately 15 rpm below the recommended idle speed (Fig. 7).

> **NOTE** It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8").

2. Hold the idle screw and tighten the locknut.

3. Install the high-speed spring retainer cover and tighten the two bolts.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw IN so it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 8).

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back out the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the locknut.

16V ENGINES

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 9).

After adjusting the exhaust valves and timing the fuel injectors, adjust the limiting speed mechanical governor and position the injector rack control levers.

NOTE Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device.

If the engine or governor has been overhauled, or the injector control linkage has been disturbed, the control link levers in the governor housing and auxiliary control link housing must be aligned before proceeding with the engine tune-up. Refer to Fig. 10 and position the control link levers as follows:

1. Disconnect the linkage to the governor speed control lever and stop lever.

2. Remove the covers from the governor housing and auxiliary control link housing.

3. Disconnect the adjustable link from the lever in the auxiliary control link housing.

4. Remove the connecting pin from the auxiliary governor control link lever.

5. Install gage J 21779 so it extends through the lever and fuel rod and into the gage hole in the bottonm of the housing. With the gage in place, the auxiliary control link lever will be in the mid-travel position.

6. Remove the connecting pin from the control link

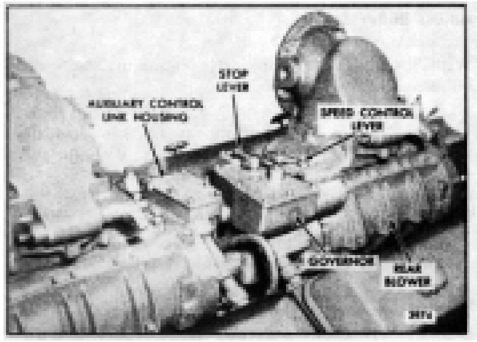


Fig. 9. Governor Mounting

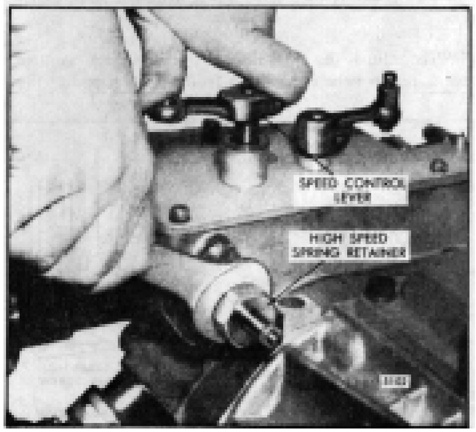


Fig. 10. Control Link Levers in Position lever in the governor housing and install gage J 21780.

Install the gage so the pin extends through the connecting link, control lever and fuel rod and the governor housing dowel pin extends into the small hole in the gage. Then install a governor cover bolt as shown in Fig. 10 to lock the gage in place. With gage J 21780 in place, the governor control link lever will be in the mid-travel position and parallel to the auxiliary control link lever.

7. Adjust the length of the adjustable connecting link to retain the lever positions obtained in Steps 5 and 6 and install the link.

8. Remove gages J 21779 and J 21780 and reinstall the control link lever connecting pins.

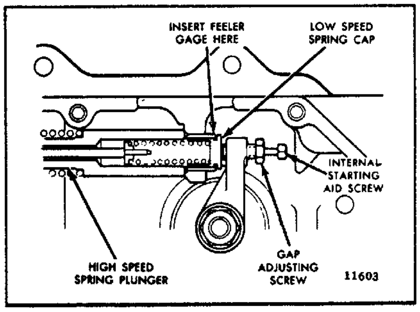


Fig. 11. Governor Gap Adjustment

9. Install the governor housing and auxiliary control link housing covers.

Proceed with the governor and injector rack control adjustment.

Adjust the Governor Gap

With the engine stopped and at operating temperature, adjust the governor gap as follows:

1. Remove the governor high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 15).

3. Start the engine and loosen the idle speed adjusting screw locknut. Then adjust the idle screw to obtain the desired idle speed (Fig. 14). Hold the screw and tighten the locknut to hold the adjustment. The recommended idle speed is 400-450 rpm. but may vary with special engine applications.

> **NOTE** Limiting speed governors used in turbo-charged engines include a starting aid screw threaded into the governor housing.

4. Stop the engine. Clean and remove the governor cover and lever assembly. If not previously done, remove the valve rocker covers. Discard the gaskets.

5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

> **NOTE** Do not over speed the engine.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 11). The gap setting should be .002"-.004". If the gap setting is incorrect, reset the gap adjusting screw.

7. On governors without the internal starting aid screw, hold the gap adjusting screw and tighten the locknut.

8. Recheck the governor gap with the engine operating between 1100 and 1300 rpm. Readjust, if necessary.

9. Stop the engine and, using a new gasket, reinstall the governor cover and lever assembly. Tighten the screws.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.
The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever and one screw and locknut to keep each injector rack properly positioned (Fig. 12).

> **NOTE** To ensure proper injector control rack adjustment the injector racks must be adjusted with the yield link and governor cover that are to be used on the governor.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low speed gap closed.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 4R injector rack control lever first to establish a guide for adjusting the remaining right bank injector rack control levers.

1.Turn the idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the locknut when the nut is against the high-speed spring plunger.

This adjustment lowers the tension of the low-speed spring so it can be easily compressed. This permits closing the low-speed gap without bending the fuel Fig. 12 - Positioning No. 4L Injector Rack
Control Lever

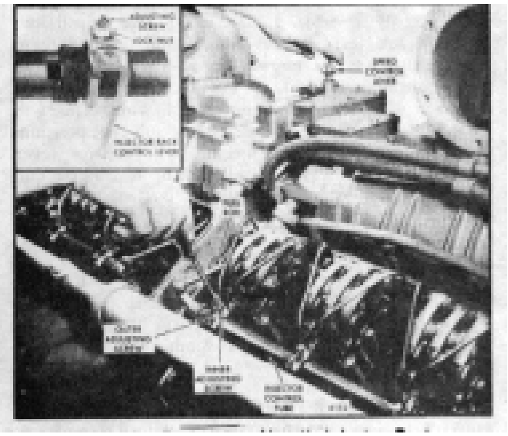


Fig. 12. Positioning No. 4L Injector Rack Control Lever

rods or causing the yield mechanism springs to yield or stretch.

NOTE A false fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

Injector racks must be adjusted so the effort to move the throttle from the idle speed position to the maximum speed position is uniform. A sudden increase in effort can result from:
a. Injector racks adjusted too tight causing the yield link to separate.

b. Binding of the fuel rods.

c. Failure to back out the idle screw.

2. Back out the buffer screw approximately 5/8", if it has not already been done.

3. Loosen all of the adjusting screws and locknuts on both cylinder banks. Be sure all of the levers are free on the injector control tubes.

4. Check for any bind in the governor control tube linkage by moving the linkage through its full range of travel.

5. Remove the clevis pins which attach the right rear bank and both left bank fuel rods to the injector control tube levers.

6. Move the speed control lever to the maximum speed position.

7. Hold the speed control lever with light finger pressure (Fig. 12) and tighten the adjusting screw of the No. 4R injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 4R injector rack in the full-fuel position. Over tightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in(3-4 N m).

NOTE The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

8. To be sure of the proper rack adjustment, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note "rotating" movement of the injector control rack (Fig. 3). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward (Fig. 4) and when the pressure of the screwdriver is released, the control rack should "spring" back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the speed control lever from the no-speed to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover).This will result in a step-up in effort required to move the speed control lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

9. Remove the fuel rod-to-control tube lever clevis pin from the right front bank fuel rod and install it on the right rear bank fuel rod. Adjust the No. 5R injector rack as outlined in Steps 6, 7 and 8.

10. Repeat Step 9 for adjustment of the No. 4L and 5L injector racks. When the settings are correct, the No. 4R, 5R, 4L and 5L injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

11. With the fuel rod disconnected from the injector control tube lever, adjust the remaining injector rack control levers on the right front bank. Hold the No. 4R injector rack in the full-fuel position by the control tube lever and proceed as follows:

a. Tighten the adjusting screw of the No. 3R injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE Over tightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in(3-4 N m).

b. Verify the injector rack adjustment of No. 4R as outlined in Step 8. If No. 4R does not "spring" back upward, turn the No. 3R adjusting screw counterclockwise slightly until the No. 4R injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 4R and No. 3R injectors. Turn clockwise or counterclockwise the

No. 3R injector rack adjusting screw until both No. 4R and No. 3R injector racks are in the full fuel position when the locknut is securely tightened.

c. Adjust the remaining injectors using the procedures outlined in Step "b" always verifying proper injector rack adjustment.

12. Recheck the No. 4R injector rack to be sure it has remained snug on the ball end of the injector rack control lever. If the rack of the No. 4R injector has become loose, loosen the locknut on No. 3R and turn the adjusting screw counterclockwise a slight amount and retighten the locknut. When the settings are correct, both injector racks must respond in the same manner on the ball ends of the control levers when the injector control tube lever is held in the full-fuel position.

13. Position the remaining injector rack control levers on the right front cylinder bank as outlined in Steps 11 and 12.

14. Adjust the remaining injector rack control levers on the right rear, left front and left rear cylinder banks in the same manner as outlined in Steps 11, 12 and 13.

15. Install the four fuel rod-to-control tube lever clevis pins and check the adjustment of the injector rack control levers.

16. Turn the idle speed adjusting screw in until it projects 3/16" from the locknut, to permit starting the engine.

17. Adjust the starting aid screw (Turbo-charged engines).

The starting aid screw (Fig. 5) is threaded into the governor housing. This screw is adjusted to position the injector racks at less than full fuel when the governor speed control lever is in the idle position. The reduced fuel makes starting easier and reduces the amount of smoke on start-up.

NOTE

: The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor running gap of .002 "-.004" has been set and the injector racks positioned, adjust the starting aid screw as follows: a. With the engine stopped, place the governor stop lever in the run position and the speed control lever in the idle speed position.

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 5).

Select the proper gage and measure the setting at any convenient cylinder. When the starting aid screw is properly adjusted, the gage should have a small clearance of 1/64" in the space along the injector rack shaft between the rack clevis and the injector body.

c. After completing the adjustment, hold the starting aid screw and tighten the locknut.

d. Check the injector rack clevis-to-body clearance after performing the following:

1. Position the stop lever in the run position.
2. Move the speed control lever from the idle speed position to the maximum speed position.
3. Return the speed control lever to the idle speed position.

Movement of the speed control lever is to take-up the clearance in the governor linkage. The injector rack clevis-to-body clearance can be increased by turning the starting aid screw farther in against the gap adjusting screw, or reduced by backing it out.

NOTE The starting aid screw will be ineffective if the speed control lever is advanced toward wide open throttle during start-up.

Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor

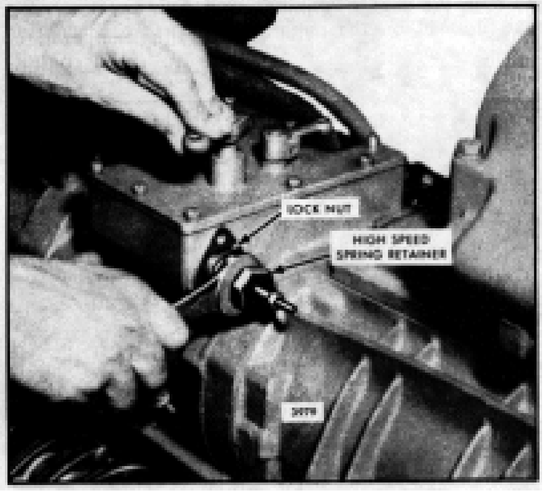


Fig. 13. Adjusting Maximum No-Load Speed

housing with the pin in the throttle control shaft assembly in the slot of the differential lever and the dowel pin holes in the cover. Tighten the screws.

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks to the no fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

CAUTION An overspeeding engine can result in engine damage which could cause personal injury.

18. Use new gaskets and replace the valve rocker covers.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the option plate, the maximum no-load speed may be set as follows:

> **NOTE** Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speed.

1.Loosen the spring retainer locknut and back off the high-speed spring retainer approximately five turns (Fig. 13).

2. With the engine running at operating temperature and no-load on the engine, place the speed control lever in the maximum speed position. Turn the high speed spring retainer until the engine is operating at the recommended no-load speed.

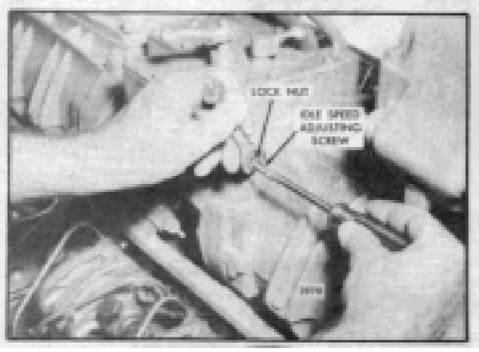


Fig. 14. Adjusting Engine Idle Speed

3. Hold the high-speed spring retainer and tighten the locknut.

Adjust Idle Speed

Adjust the idle speed as follows:

1. With the engine running, at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine is operating approximately 15 rpm below the recommended idle speed (Fig. 14). The recommended idle speed is 400450 rpm, but may vary with certain engine applications

> **NOTE** It may be necessary to use the buffer screw to eliminate the engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8").

2. Hold the idle screw and tighten the locknut.

3. Install the high-speed spring retainer cover and tighten the two bolts.

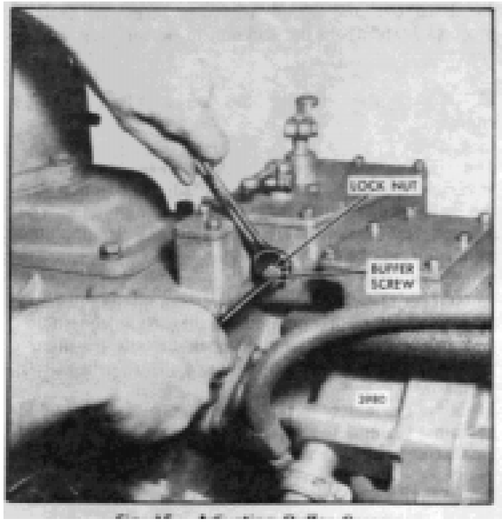


Fig. 15. Adjusting Buffer Screw

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in so it contacts the differential lever as lightly as possible and still eliminates the engine roll (Fig. 15).

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the locknut.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V ENGINES

The single-weight variable speed governor is mounted on the front of the engine and is driven by the blower rotor.

After adjusting the exhaust valves and timing the fuel injectors, adjust the variable speed mechanical governor and injector rack control levers.

> **NOTE**: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device.

Adjust Governor Gap

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

1. Disconnect any linkage attached to the governor levers.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. Clean and remove the governor cover and valve rocker covers. Discard the gaskets.

4. Place the speed control lever in the maximum speed position.

5. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 1). If required, loosen the locknut and turn the adjusting screw until a slight drag is noted on the feeler gage.

6. Hold the adjusting screw and tighten the locknut. Check the gap again and, if necessary, readjust.

7. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the throttle control shaft assembly in the slot of the differential lever and the dowel pins in the housing in the dowel pin holes in the cover. Tighten the screws.

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks return to the no fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION**: An overspeeding engine can result in engine damage which could cause personal injury.

Position Injector Rack Control Levers

The position of the injector control rack levers must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever with one screw and locknut to keep each injector rack properly positioned.

Properly positioned injector rack control levers, with the engine at full load, will result in the following:

1. Speed control lever at the maximum speed position.

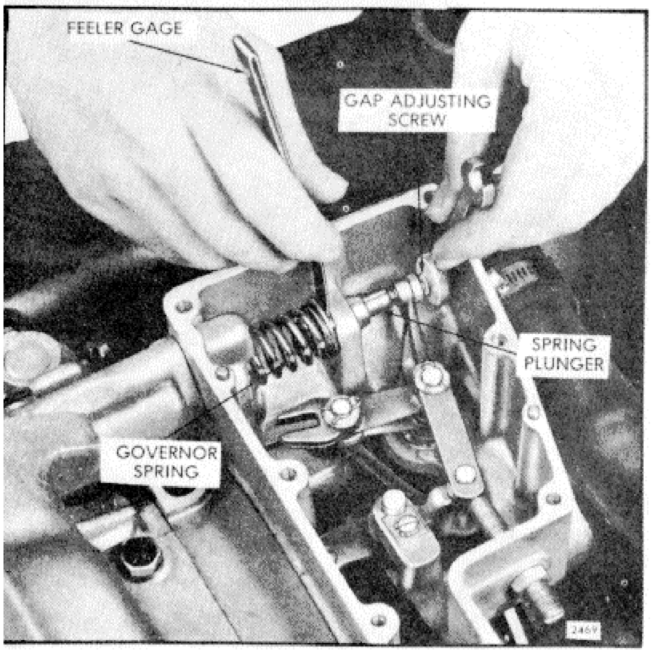


Fig. 1. - Adjusting Governor Gap

2. Stop lever in the run position.

3. High speed spring plunger is within .005" to .007" of its seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. The cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining control levers.

1. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

2. Loosen all of the adjusting screws and locknuts on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

3. Move the speed control lever to the maximum speed position.

4. Move the stop lever to the run position and hold it in that position with light finger pressure. Tighten the adjusting screw of the No. 1L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1L. injector rack in the full-fuel position.

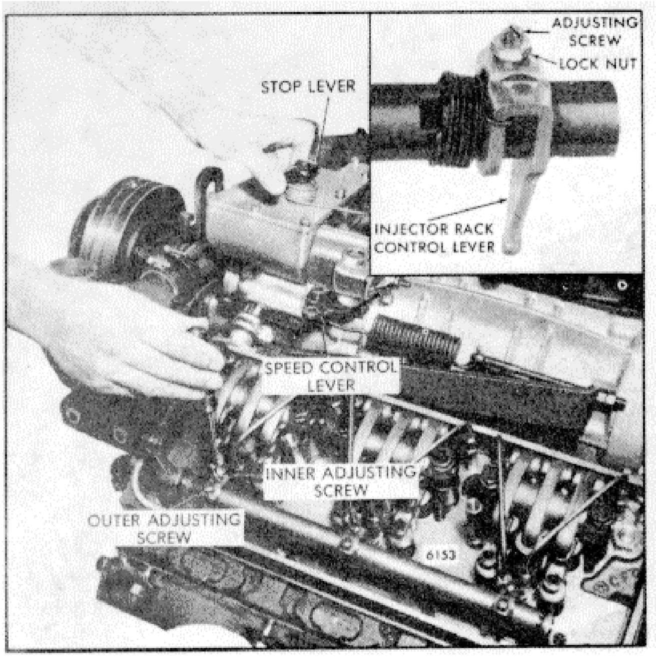


Fig. 2. - Positioning No. 1 Injector Rack Control Lever

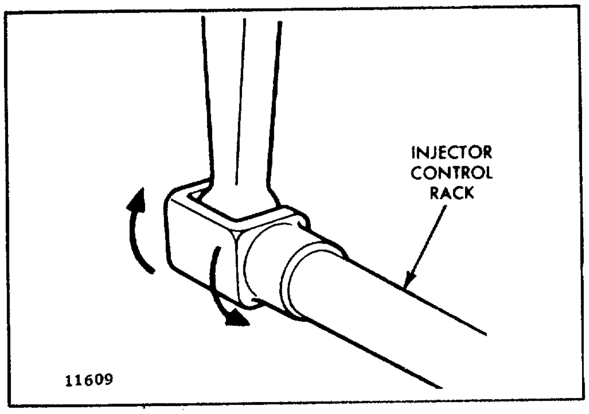


Fig. 3. - Checking Rotating Movement of Injector Control Rack

> **NOTE**: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in**(3-4 Nm).

5. To be sure of the proper rack adjustment. hold the stop lever in the run position and press down on the injector rack with a screwdriver or finger tip and note "rotating" movement of the injector control rack when the stop lever is in the run position (Fig. 3). Hold the stop lever in the run position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and, when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 4).

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the stop lever from the stop to the run position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

6. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

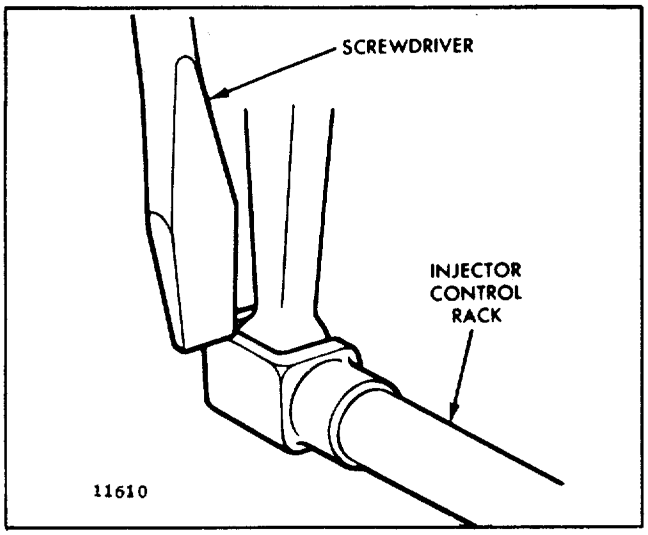


Fig. 4. - Checking Injector Control Rack "Spring"

7. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 1R injector rack control lever as previously outlined in Step 4.

8. Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the No. 1L and No. 1R injector rack control levers as outlined in Step 5. Carefully observe and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

9. To adjust the remaining injector rack control levers, remove the clevis pin from the fuel rods and the injector control tube levers, hold the injector control racks in the full-fuel position by means of the lever on the end of the control tube and proceed as follows:

   a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

   NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in**(3-4 Nm).

   b. Verify the injector rack adjustment of No. 1L as outlined in Step 5. If No. 1L does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. 1L injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1L and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. 1L and No. 2L injector racks are in the full-fuel position when the locknut is securely tightened.

   c. Adjust the remaining injectors using the procedures outlined in Step "B" always verifying proper injector rack adjustment.

   NOTE: Once the No. 1L and No. 1R injector rack control levers are adjusted, do not try to alter their settings. All adjustments are made on the remaining control racks.

10. When all of the injector rack control levers are adjusted, recheck their settings. With the control tube lever in the full-fuel position, check each control rack as in Step 5. All of the control racks must have the same "spring" condition with the control tube lever in the full-fuel position.

11. Insert the clevis pin in the fuel rods and the injector control tube levers.

12. Use new gaskets and reinstall the valve rocker covers.

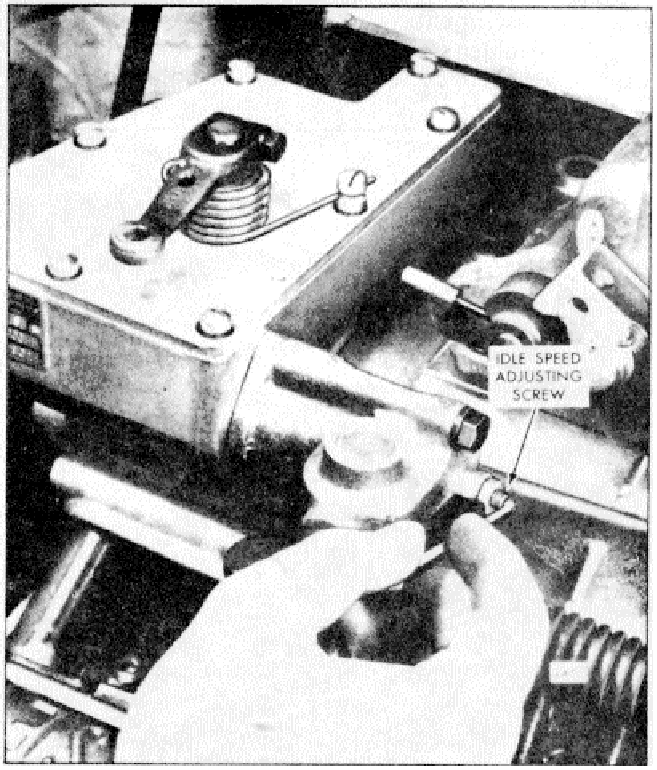


Fig. 5. - Adjusting Idle Speed

Adjust Maximum No-Load Speed

The maximum no-load speed on engines equipped with variable speed governors must not be more than 150 to 250 rpm above the recommended full-load speed as given on the engine option plate.

Start the engine and, after it reaches normal operating temperature, determine the maximum no-load speed of the engine with an accurate hand tachometer. Then stop the engine and make the following adjustments, if required:

1. Disconnect the booster spring and the stop lever spring.

2. Remove the variable speed spring housing and the spring retainer located inside the housing from the governor housing.

3. Refer to Table 1 and determine the stops or shims required for the desired full-load speed. The speed will increase approximately 1 rpm for each .001" in shims added.

Variable Speed Governor Adjustment		
Full-Load Speed*	Stops	Shims
1200-1750	2	Up to .325" in shims maximum
1750-2100	1	
2000-2300	0	

*No-load speed is 125-200 rpm above full-load speed depending upon engine application.

TABLE 1

4. Install the variable speed spring retainer and housing and tighten the two bolts.

5. Connect the booster spring. Start the engine and recheck the maximum no-load speed.

6. If required, add or remove shims to obtain the necessary operating speed. If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

> **NOTE**: Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

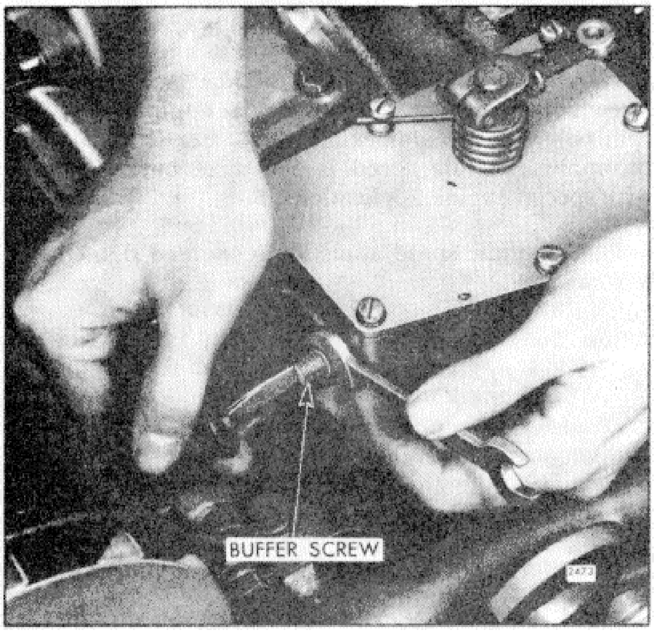


Fig. 6. - Adjusting Buffer Screw

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. Place the speed control lever in the idle position and the stop lever in the run position.

2. With the engine running at normal operating

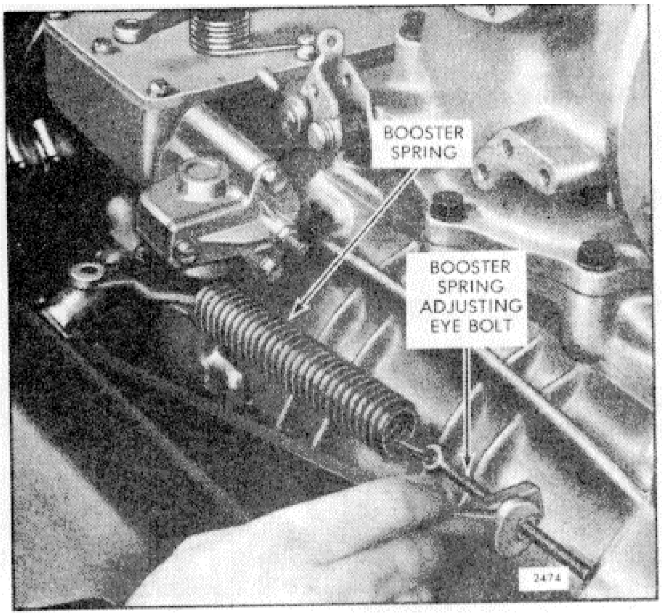


Fig. 7. - Adjusting Booster Spring

temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the locknut and turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed (Fig. 5)..The recommended idle speed is 500 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw and tighten the locknut.

Adjust Buffer Screw

1. With the engine running at normal operating temperatures, turn the buffer screw IN so that it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 6).

> **NOTE**: Do not raise the engine idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the locknut.

Adjust Booster Spring

With the idle speed adjusted, adjust the booster spring as follows:

1. Move the speed control lever to the *idle speed* position.

2. Refer to Fig. 7 and loosen the booster spring retaining nut on the speed control lever. Loosen the locknuts on the eye bolt at the opposite end of the booster spring.

3. Move the bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginary line through the bolt, lever shaft and eye bolt. Hold the bolt and tighten the locknut.

4. Start the engine and move the speed control lever to the *maximum speed* position and release it. The speed control lever should return to the *idle speed* position. If it does not, reduce the tension on the booster spring. If it does, continue to increase the spring tension until the point is reached that it will not return to idle. Then reduce the tension until it does return to idle and tighten the locknut on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.

5. Connect the linkage to the governor levers.

16V ENGINES

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 8).

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and injector rack control levers.

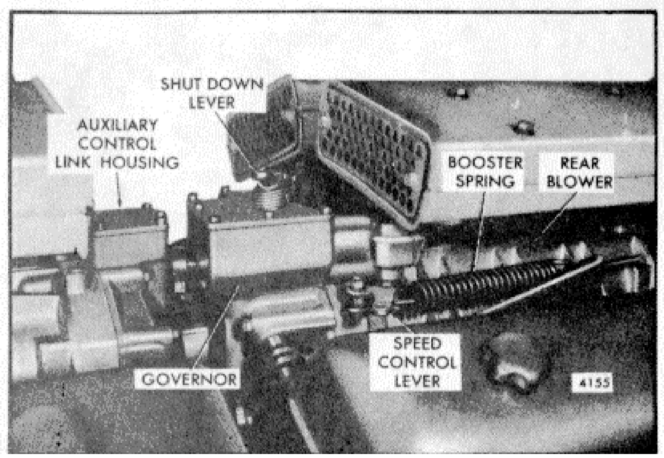


Fig. 8. - Governor Mounting

If the engine or governor has been overhauled, or the injector control linkage has been disturbed, the control link levers in the governor housing and auxiliary control link housing must be aligned before proceeding with the engine tune-up. Refer to Fig. 9 and position the control link levers as follows:

1. Disconnect the linkage to the governor speed control and stop levers.

2. Remove the covers from the governor housing and auxiliary control link housing.

3. Disconnect the adjustable link from the lever in the auxiliary control link housing.

4. Remove the connecting pin from the auxiliary governor control link lever.

5. Install gage J 21779 so it extends through the lever

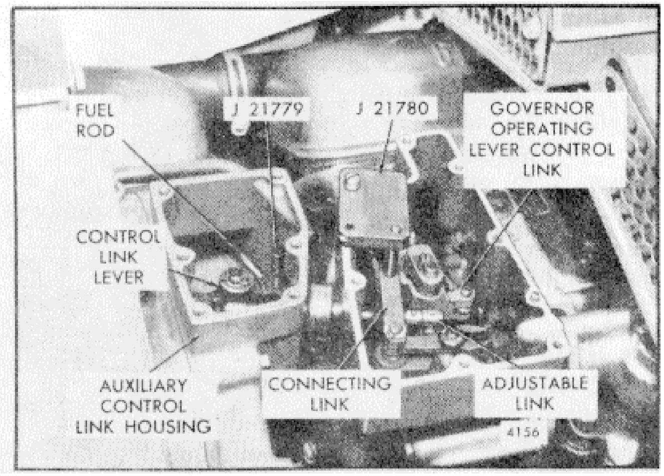


Fig. 2. - Control Link Levers In Position

and fuel rod and into the gage hole in the bottom of the housing. With the gage in place, the auxiliary control link lever will be in the mid-travel position.

6. Remove the connecting pin from the control link lever in the governor housing and install gage J 21780. Install the gage so the pin extends through the connecting link, control lever and fuel rod and the governor housing dowel pin extends into the small hole in the gage. Then install a governor cover bolt as shown in Fig. 9 to lock the gage in place. With gage J 21780 in place, the governor control link lever will be in the mid-travel position and parallel to the auxiliary control link lever.

7. Adjust the length of the adjustable connecting link to retain the lever positions obtained in Steps 5 and 6 and install the link.

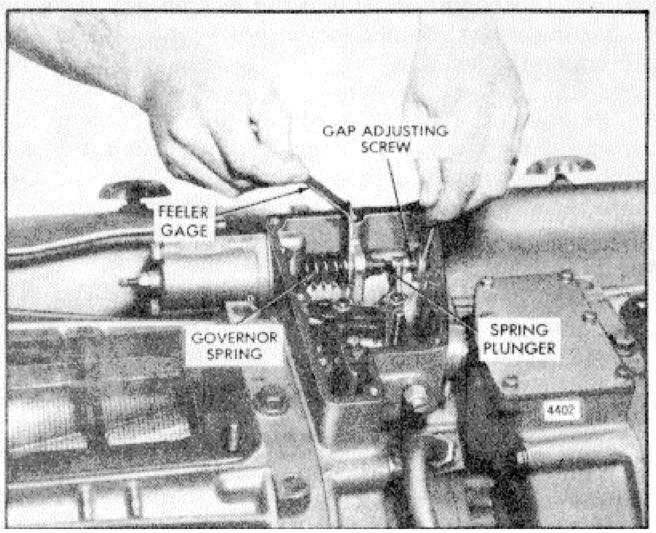


Fig. 10. - Adjusting Governor Gap

8. Remove gages J 21779 and J 21780 and reinstall the control link lever connecting pins.

9. Install the governor housing and auxiliary control link housing covers.

Proceed with the governor and injector rack control adjustment.

Adjust Governor Gap

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

1. Clean and remove the governor cover and the valve rocker covers. Discard the gaskets.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. Place the speed control lever in the maximum speed position.

4. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 10). If required, loosen the locknut and turn the adjusting screw until a ,slight drag is noted on the feeler gage.

5. Hold the adjusting screw and tighten the locknut. Check the gap and readjust, if necessary.

6. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the throttle control shaft assembly in the slot of the differential lever and the dowel pins in the cover. Tighten the screws.

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks return to the no-fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION**: An overspeeding engine can result in engine damage which could cause personal injury.

Position Injector Rack Control Levers

The position of the injector rack control levers must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The engines use spring-loaded injector control tube assemblies which have a yield spring at each injector rack control lever with one screw and locknut to keep each injector rack properly positioned.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Stop lever in the run position.

3. High speed spring plunger is within .005" to .007" of its seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 4R injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Remove the clevis pins which attach the right rear bank and both left bank fuel rods to the injector control tube levers.

2. Loosen all of the adjusting screws and locknuts on both cylinder banks. Be sure all of the levers are free on the injector control tubes.

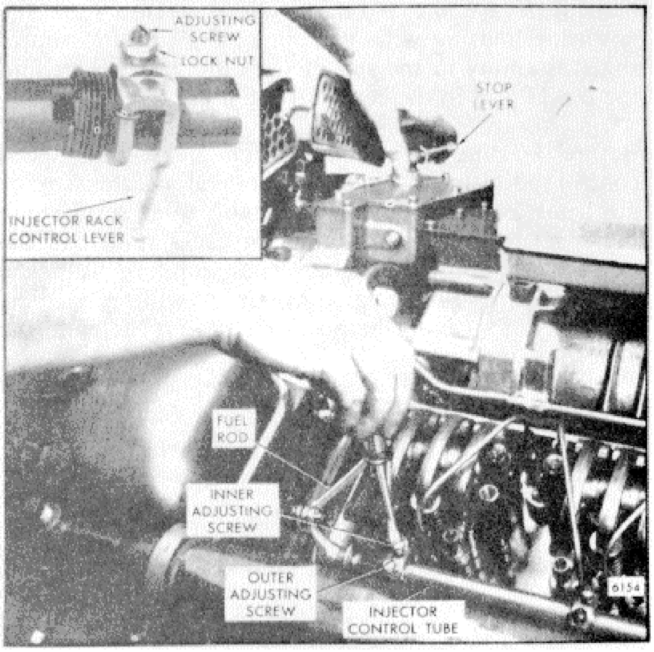


Fig. 11. - Positioning No. 4R Injector Rack Control Lever

3. Move the speed control lever to the maximum speed position.

4. Move the stop lever to the run position and hold it in that position with a light finger pressure (Fig. 11). Tighten the adjusting screw of the No. 4R injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 4R injector rack in the full-fuel position.

> **NOTE**: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in**(3-4 Nm).

5. To be sure of the proper rack adjustment, hold the stop lever in the run position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the stop lever is in the run position (Fig. 3). Hold the stop lever in the run position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward (Fig. 4) and when the pressure of the screwdriver is released, the control rack should "spring" back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the stop lever from the stop to the run position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step-up in effort required to move the stop lever to the end of its travel. To correct this condition, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

6. Remove the fuel rod-to-control tube lever clevis pin from the right front bank fuel rod and install it on the right rear bank fuel rod and adjust the No. 5R injector rack as outlined in Steps 4 and 5.

7. Repeat Step 6 for adjustment of the No. 4L and 5L injector racks. When the settings are correct, the No. 4R, 5R, 4L and 5L injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

8. With the fuel rod disconnected from the injector control tube lever, adjust the remaining injector rack control levers on the right front bank. Hold the No. 4R injector rack in the full-fuel position by means of the control tube lever and proceed as follows:

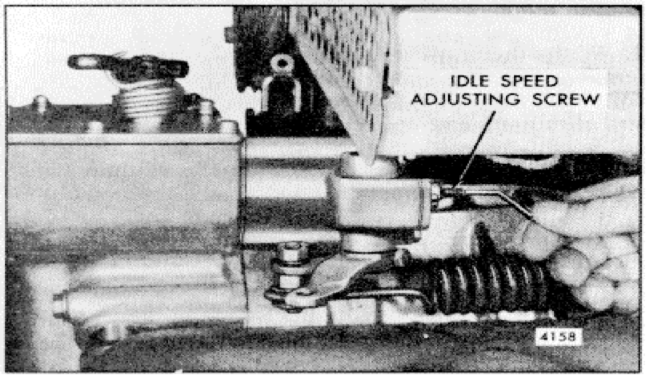


Fig. 12. - Adjusting Idle Speed

a. Tighten the adjusting screw of the No. 3R injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the. screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in**(3-4 Nm).

b. Verify the injector rack adjustment of No. 4R as outlined in Step 5. If No. 4R does not "spring" back upward, turn the No. 3R adjusting screw counterclockwise slightly until the No. 4R injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 4R and No. 3R injectors. Turn clockwise or counterclockwise the No. 3R injector rack adjusting screw until both No. 4R and No. 3R injector racks are in the full-fuel position when the locknut is securely tightened.

c. Adjust the remaining injectors using the procedures outlined in Step "B" always verifying proper injector rack adjustment.

9. Recheck the No. 4R injector rack to be sure it has remained snug on the ball end of the injector rack control lever. If the rack of the No. 4R injector has become loose, loosen the locknut on No. 3R and turn the adjusting screw counterclockwise a slight amount and retighten the locknut. When the settings are correct, both injector racks must respond in the same manner on the ball ends of the control levers when the injector control tube lever is held in the full-fuel position.

10. Position the remaining injector rack control levers on the right front cylinder bank as outlined in Steps 8 and 9.

11. Adjust the remaining injector rack control levers on the right rear, left front and left rear cylinder banks in the same manner as outlined in Steps 8, 9 and 10.

12. Install the four fuel rod-to-control tube lever clevis pins and check the adjustment of the injector rack control levers.

13. Use new gaskets and reinstall the valve rocker covers.

Adjust Maximum No-Load Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine option plate, set the maximum no-load speed as outlined below.

Start the engine and, after it reaches normal operating temperature, determine the maximum no-load speed of the engine with an accurate hand tachometer. Then stop the engine and make the following adjustments, if required:

1. Disconnect the booster spring and the stop lever spring.

2. Remove the variable speed spring housing and the spring retainer located inside the housing from the governor housing.

3. Refer to Table 2 and determine the stops or shims required for the desired full-load speed. For each .001" shim added the speed will increase approximately 1 rpm.

Variable Speed Governor Adjustment		
Full-Load	Stops	Shims
Speed* 1200-1750 1750-2100 2000-2300	 2 1 0	 Up to .325" in shims maximum

*No-load speed is 150-225 rpm above full-load speed depending upon engine application.

TABLE 2.

4. Install the variable speed spring plunger and housing and tighten the two bolts.
5. Connect the booster spring. Start the engine and recheck the maximum no-load speed.

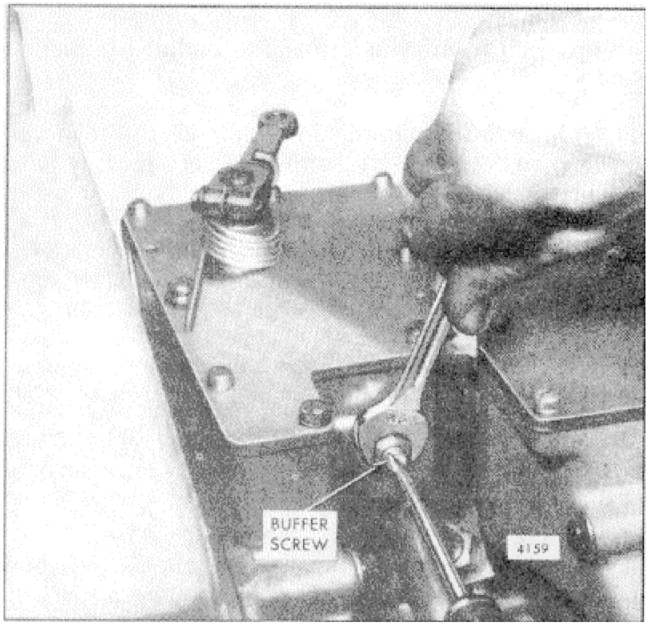


Fig. 13. - Adjusting Buffer Screw

6. If required, add or remove shims to obtain the necessary operating speed. If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

> **NOTE**: Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. Place the speed control lever in the *idle* position and the stop lever in the run position.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the locknut and turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed (Fig. 12). The recommended idle speed is 550 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw from turning and tighten the locknut.

Adjust Buffer Screw

1. With the engine running at normal operating temperature, turn the buffer screw IN so that it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 13).

> **NOTE**: Do not raise the idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw from turning and tighten the locknut.

Adjust Booster Spring

With the idle speed adjusted, adjust the booster spring as follows:

1. Move the speed control lever to the *idle speed* position.

2. Refer to Fig. 14 and loosen the nut on the booster spring retaining bolt on the governor speed control lever. Loosen the locknuts on the eye bolt at the opposite end of the booster spring.

3. Move the bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginery line through the bolt, lever shaft and eye bolt. Hold the bolt from turning and tighten the locknut.

4. Start the engine and move the speed control lever to the *maximum speed* position and release it. The speed control lever should return to the idle speed position. If it does not, reduce the spring tension. If the lever does return to the idle position, increase the tension of the spring until the lever will not return to idle. Then reduce the tension until the lever will return to idle and tighten the locknut on the eye bolt. This setting will result in a minimum force required to operate the speed control lever.

5. Connect the linkage to the governor levers.

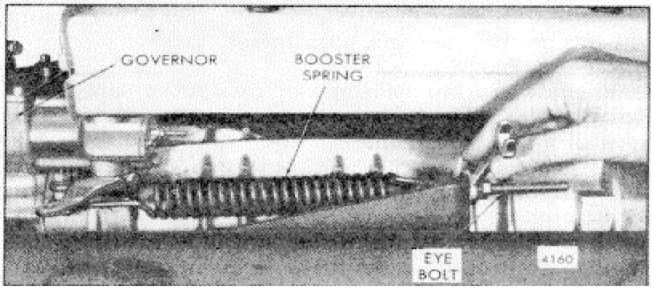


Fig. 14. - Adjusting Booster Spring

LIMITING SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

16V ENGINES

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 1). The governor to injector rack control linkage is shown in Fig. 2.

The objectives of the tune-up are:

1. To adjust the linkage so the injector racks will be at the full-fuel position when the terminal lever shaft pointer indicates exactly 18 .

2. To set the band-level so the governor will place the pointer at exactly 18°just below full-load speed.

3. To adjust the speed droop, idle speed and maximum no-load speed.

Prior to starting the tune-up, remove the governor control housing cover and turn the buffer screw out until it clears the differential lever approximately 1/4 inch, when the speed control lever is in the idle position. Then hold the speed control lever in the maximum speed position and move the governor operating lever to check the travel of the terminal shaft lever as indicated by the pointer.

The pointer should move from 0°to 36°(on some governors, the pointer may not quite reach 36°). Next, check to be sure that the pointer is exactly at zero when the linkage is in the no-fuel position. If not, adjust the pointer or the terminal lever shaft position indicator plate (scale).

The pointer is attached to a metal ring which is secured to the terminal shaft by a set screw (Fig. 3). To make the zero adjustment, loosen the set screw and, with the linkage in the no-fuel position, set the pointer at exactly zero. Then tighten the set screw.

After the zero adjustment is completed, to make sure the shaft is assembled correctly, reach in behind the differential lever in the governor control housing and force the governor operating lever upward until the pointer is aligned exactly with the 18°mark (Fig. 6).

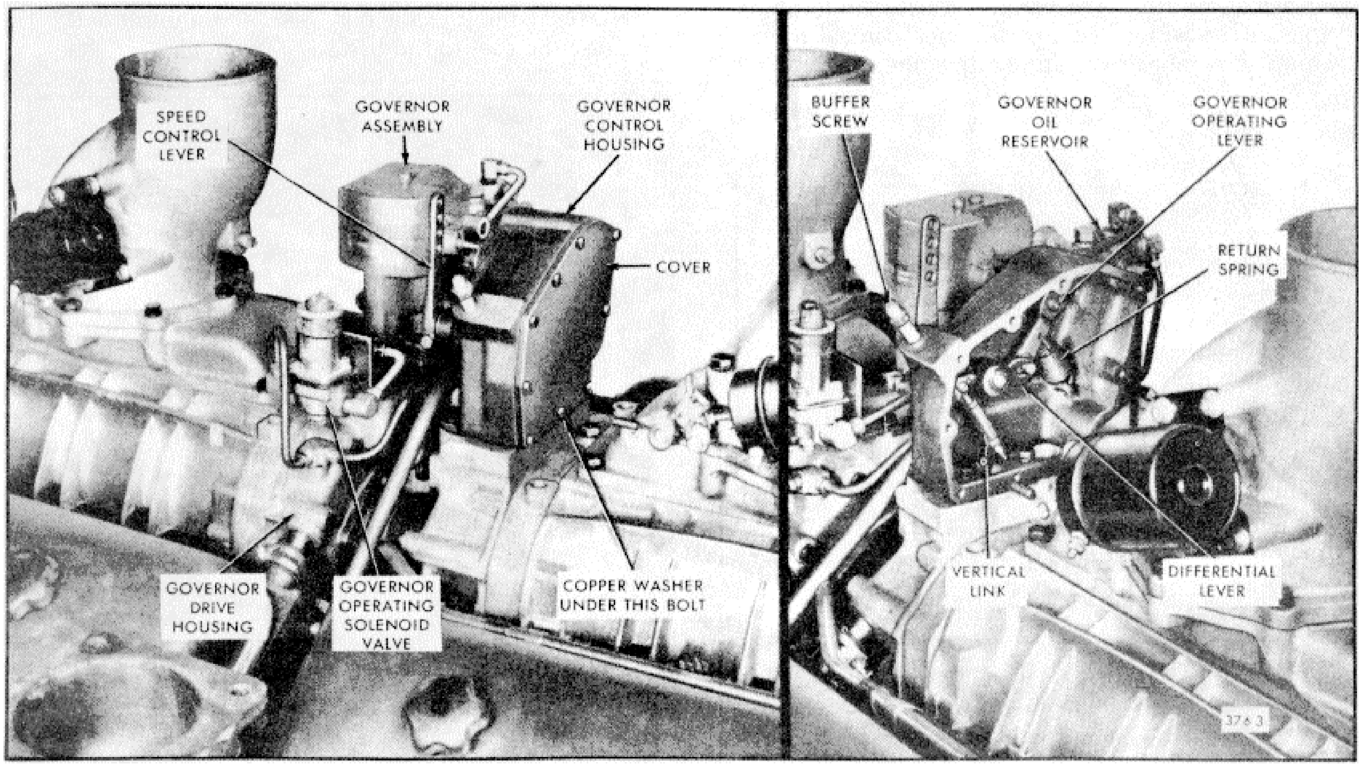


Fig. 1. - Governor Mounting and Linkage in the Control Housing

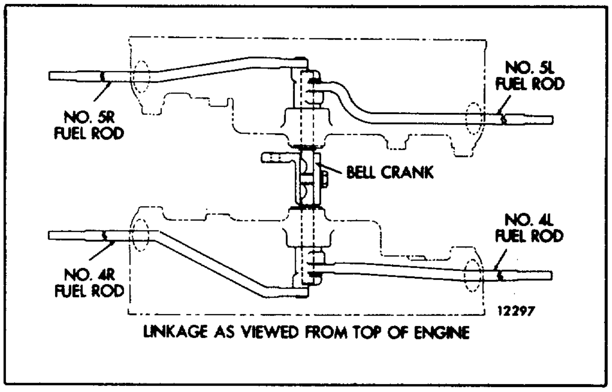


Fig. 2. - Governor-to-Injector Rack Control Linkage

The pointer should be vertical; if it is approximately 1/16" off vertical, the shaft is probably out one serration. To make the necessary correction. remove the sub-cap (refer to Adjust Maximum No-Load Speed), then remove the cotter pin from the shaft and make a careful visual check of the alignment of' the holes in the terminal lever and the shaft. If they are not in alignment, remove the shaft and reinstall it so the holes are in perfect alignment. Then install the cotter pin and sub-cap.

Then, after adjusting the exhaust valves and timing the injectors, position the injector rack control levers. adjust the governor linkage and adjust the governor.

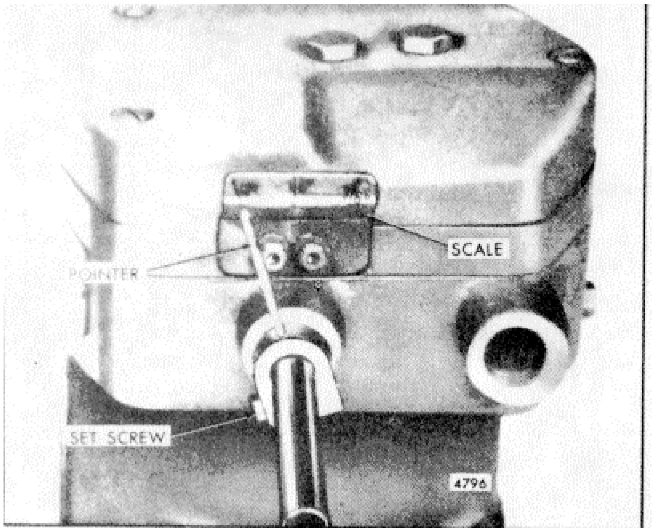


Fig. 3. - Governor Pointer and Scale

Adjust Governor Linkage and Position

Injector Rack Control Levers

1. Clean and remove the valve rocker cover from each cylinder head.

2. Loosen all of the adjusting screws and locknuts. Be sure all of the control levers are free on the control tubes.

3. Disconnect the upper end of the adjustable vertical link (Fig. 1) from the differential lever pin.

> **NOTE**: Stuff a clean rag in the opening to prevent the clip or washer from dropping into the engine.

4. Place linkage gage J 21351 in position so the pin in the gage enters the hole in the bell crank lever and the tangs on each side of the gage rest on top of the governor drive housing cover (Fig. 4). The gage holds the linkage in the full-fuel position while the injector racks are being adjusted.

5. Adjust the No. 4R injector rack by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 5). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 4R injector rack in the full-fuel position.

> NOTE: If the injector rack is set too tight, it will cause the fuel rod to bend.

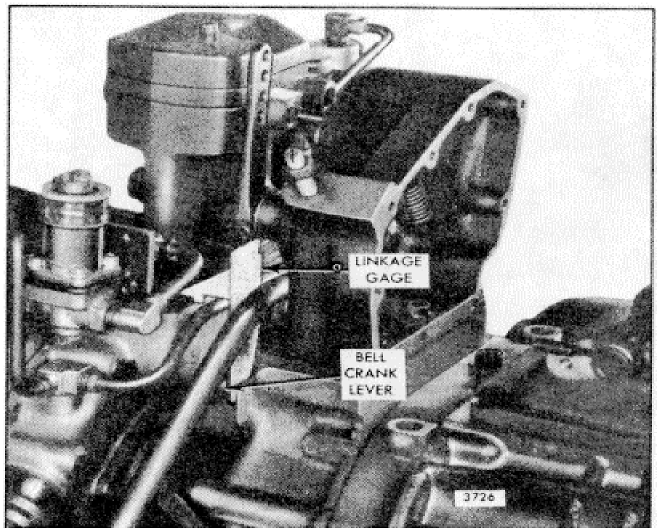


Fig. 4. - Linkage Gage in Position

6. To be sure the injector rack control lever is properly adjusted, press down on the injector rack with a screwdriver or finger tip. A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

7. Adjust the No. 5R, 4L and 5L injector rack control levers as outlined in Steps 5 and 6. When the settings are correct, all four of the injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position. The linkage gage may be removed at this time.

8. To adjust the remaining injector rack control levers on the right front bank, hold the No. 4R injector rack in the full-fuel position, by means of the lever on the control tube assembly and proceed as follows:

   a. Tighten the adjusting screw of the No. 3R injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

   NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in(3-4 Nm).

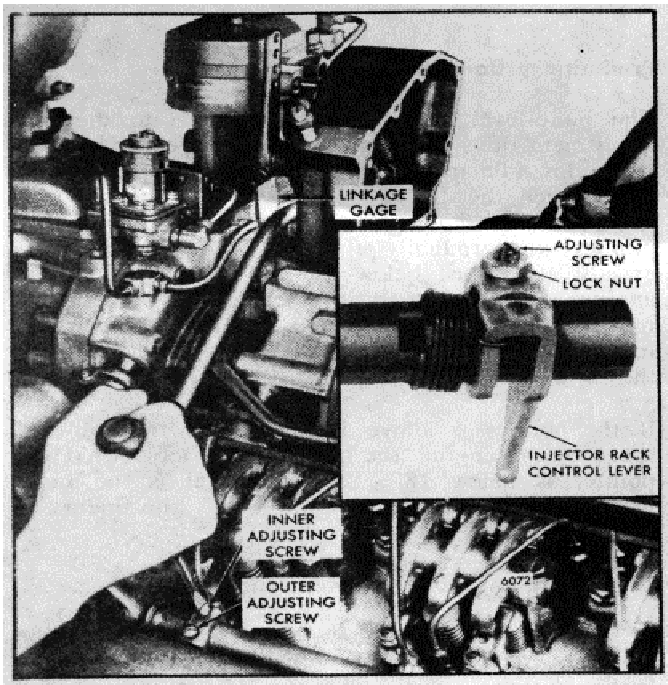


Fig. 5. - Positioning No. 4R Injector Rack Control Lever

   b. Verify the injector rack adjustment of No. 4R as outlined in Step 7. If No. 4R does not "spring" back upward, turn the No. 3R adjusting screw counterclockwise slightly until the No. 4R injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 4R and No. 3R injectors. Turn clockwise or counterclockwise the No. 3R injector rack adjusting screw until both No. 4R and No. 3R injector racks are in the full-fuel position when the locknut is securely tightened.

Recheck the No. 4R injector rack to be sure it has remained snug on the ball end of the injector rack control lever. If the No. 4R injector rack has become loose, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

When the settings are correct, both injector racks must respond in the same manner on the ball ends of their respective rack control levers as previously outlined in Step 7.

9. Position the remaining injector rack control levers on the right front cylinder head as outlined in Step 8b.

When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full-fuel position.

10. Adjust the remaining injector rack control levers

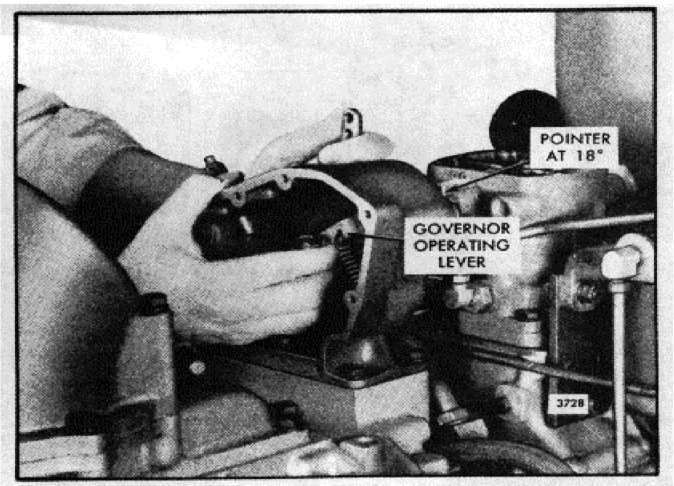


Fig. 6. - Moving Operating Lever

on the right rear, left front and left rear cylinder heads in the same manner as in Steps 8 and 9.

11. Reconnect the upper end of the adjustable vertical link on the differential lever pin and secure it in place with the washer and clip.

12. To be sure that the governor flyweights will be in the vertical position throughout the intermediate speed range (between idle speed and full-load speed), adjust the vertical link as follows.

a. Loosen and back off the two turnbuckle locknuts two or three turns.

b. Secure the speed control lever in the maximum speed position.

c. Reach in behind the differential lever in the governor control housing and force the governor operating lever upward until the governor pointer is aligned exactly with the 18° mark (Fig. 6). Hold the lever in this position.

NOTE: It is very important that the force to move the pointer to 18°be applied to the governor operating lever rather than to the differential lever. This is necessary to ensure that the terminal lever pin is tight against the upper side of the slot in the differential lever just as it is when the engine is running under governor control.

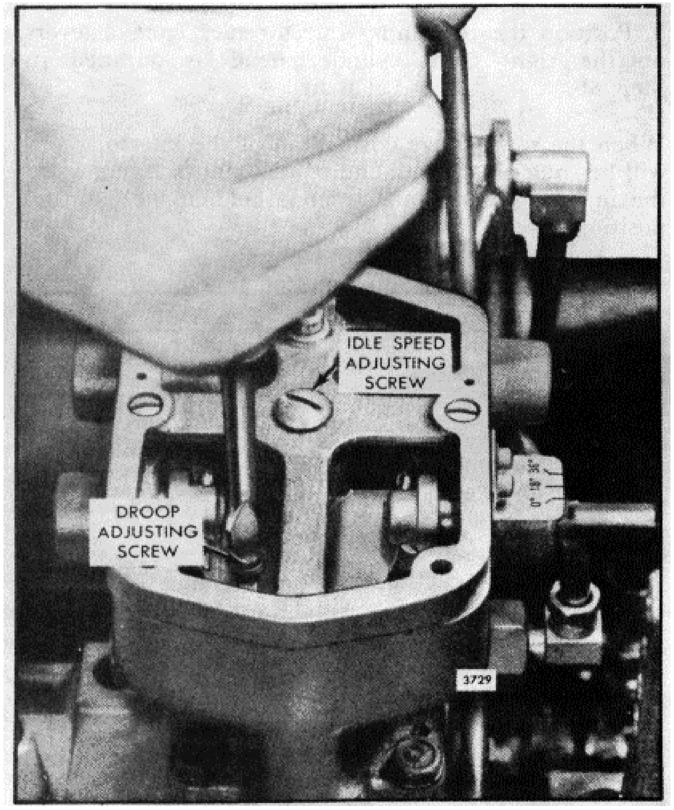


Fig. 7. - Adjusting Speed Droop

d. Adjust the length of the vertical link, by means of the turnbuckle, so the injector racks are in the full-fuel position. Then tighten the locknuts.

e. Recheck to determine if the pointer still points to exactly 18°when the injector racks are at the full-fuel position. Readjust the vertical link, if necessary.

f. Release the speed control lever. With the lever in the idle speed position, the pointer should be at approximately 18°.

13. Use a new gasket and install the valve rocker cover on each cylinder head.

Adjust Governor Speed Droop

1. Remove the governor cover.

2. Set the governor speed droop bracket at its mid-position (Fig. 7). After the other adjustments are made, the speed droop may be increased if the engine speed is unstable.

Preliminary Band-Level Adjustment

The band-level adjustment corresponds to the gap adjustment on a mechanical limiting speed governor.

In the low idle speed range, the governor pointer will be between the 18°and 36°marks. As the speed is increased, by moving the speed control lever, the pointer will gradually approach 18°and should be exactly at 18°just below the full-load speed of the engine. After full load is reached, the pointer will move rather rapidly until at the no-load speed it will indicate a position approximately half way between the 18° and 18° marks.

If the pointer is above 18°just below the full-load speed of the engine, the band-level is too low; if the pointer is below 18°, the band-level is too high. Perform a preliminary band-level adjustment as follows:

1. Hold the linkage so the pointer indicates 18.

2. With a long thin screw driver, pry one of the flyweights outward with a light force (Figs. 8 and 9). It should reach a vertical position. If not, proceed with Step 3.

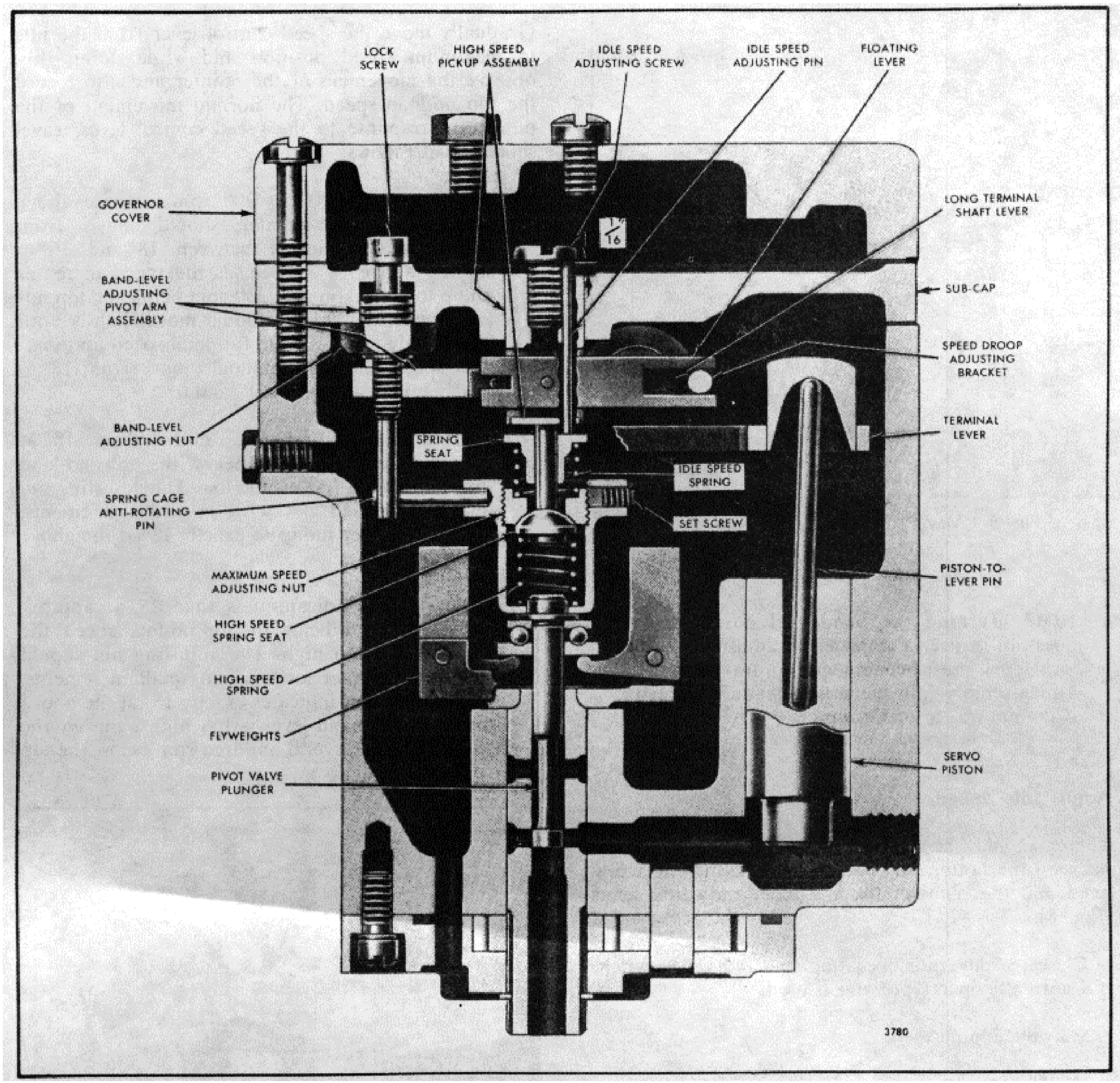


Fig. 8. - Cross-Section of Limiting Speed Hydraulic Governor for 16V Engine

NOTE: The position of the flyweights determines the position of the pilot valve plunger, which controls the flow of oil to the servo piston. If the flyweights are too far in, the plunger will not close off the ports and oil will flow to the servo piston. This will cause the terminal lever to move the pointer beyond 18° and result in excessive speed when the engine is started. When the flyweights are too far out, the plunger moves up and dumps the oil from the servo piston. This causes the terminal lever to drop below the 18° position and will result in difficulty in starting the engine or in attaining speed.

3. Loosen the band-level pivot arm lock screw and turn the band-level adjusting nut clockwise to raise the band-level or counterclockwise to lower the band-level (Figs. 8 and 10). Tighten the lock screw to draw the pivot arm assembly in place. Then check the adjustment as described in Step 2. Readjust the band-level, if necessary.

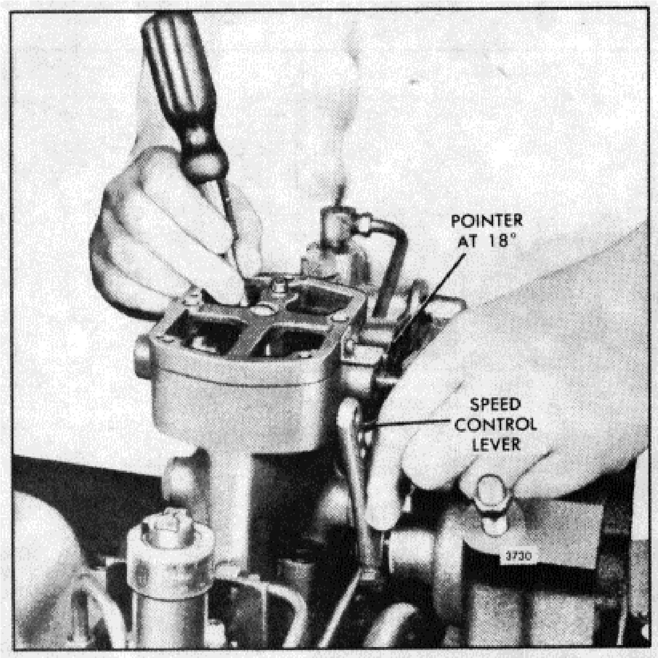


Fig. 9. - Moving Flyweight with Screwdriver

NOTE: Turning the band-level adjusting nut does not in itself complete the adjustment. The lock screw must be tightened to draw the pivot arm assembly into the new position, especially if the nut was turned down.

Adjust Idle Speed

There should be approximately 1/16" clearance between the bottom of the idle speed adjusting screw head and the plunger directly under the screw head (Fig. 8).

1. Close the governor operating solenoid valve switch, if a normally open type valve is used.

2. Start the engine.

   NOTE: Stop the engine if the speed starts to increase above idle speed while the speed control lever is in the idle position. Raise the band-level again until the speed remains at idle.

3. If the engine stalls with the speed control lever in the idle position, turn the idle screw down (clockwise) 1/4 turn or until the engine will continue running.

4. Hold the speed control lever in the idle position. Then turn the idle speed adjusting screw in or out until the desired idle speed is obtained (Figs. 8 and 10).

Set Band-Level at 18°

Gradually move the speed control lever from the idle to maximum speed position and while doing this, observe the movement of the pointer and also record the top no-load speed. The normal movement of the pointer in response to the speed control lever travel should be as follows:

a. During the first 100 or 200 rpm increase above idle speed, the pointer should move from approximately midway between 18°and 36°to slightly above 18°. Then, as the speed increases on up to approximately 300 rpm below the top noload speed, the pointer should move slightly until it is exactly at 18°. From full-load speed up to noload speed, the pointer should move from 18° to nearly midway between 18° and 0°.

b. If the pointer indicates more than 18 at approximately 300 rpm below the top no-load speed, the band-level is too low. The adjusting nut should be turned clockwise, in small increments, until the pointer indicates exactly 18° at the above speed.

c. If the pointer indicates less than 18°at approximately 300 rpm below the top no-load speed, the band-level is too high. The adjusting nut should be turned counterclockwise, in small increments, until the pointer indicates exactly 18° at the above speed. If the band-level is too high , the engine speed may fall several hundred rpm below the top

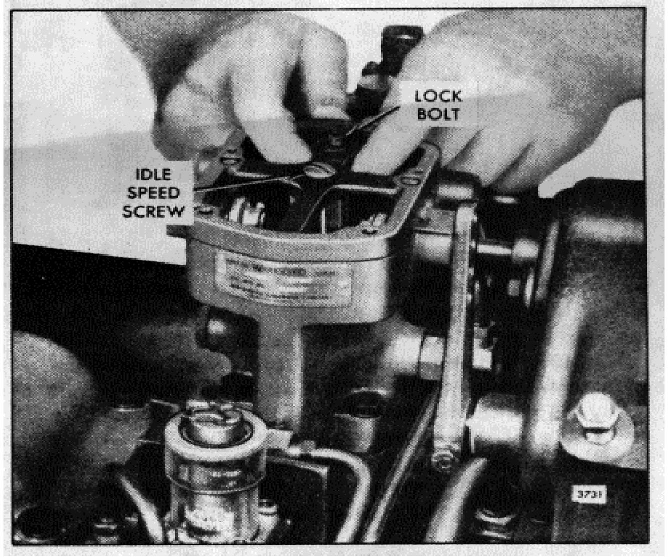


Fig. 10. - Adjusting Band-Level

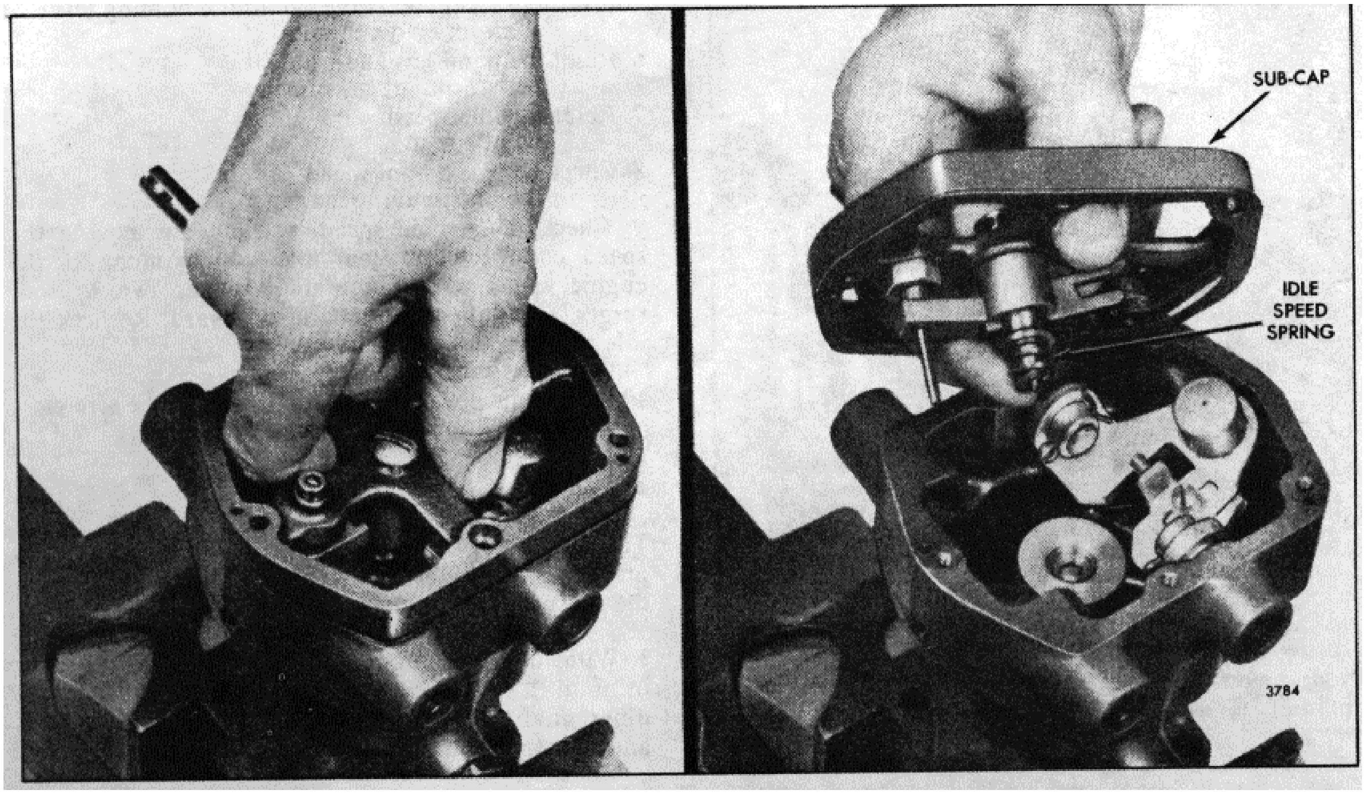


Fig. 11. - Removing or Installing Governor sub-Cap Assembly

no-load speed even though the speed control lever is in the maximum speed position.

d. Reset the idle speed, if the band-level has been changed.

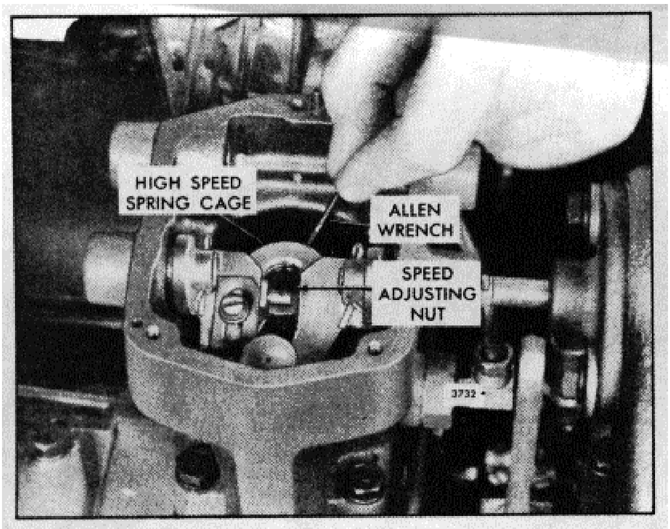


Fig. 12. - Loosening Allen Screw on Spring Cage

Adjust Maximum No-Load Speed

1. Remove the sub-cap assembly, including the idle speed spring. Since the sub-cap is dowelled to the governor housing, removal will be made easier by moving the linkage so the pointer is near the 36 ° mark.

> **NOTE**: Hold the idle speed spring seat or spring with your finger, as shown in Fig. 11, to prevent it from falling into the governor housing.

2. Loosen the small set screw (on the side opposite the anti-rotating pin) in the high speed spring cage with a 5/64" Allen wrench (Figs. 8 and 12).

3. Turn the high speed adjusting nut up to decrease or down to increase the speed (Fig. 13).

> **NOTE**: A 1/6th turn of the nut changes the speed 30-40 rpm. Use a 1/4" Allen wrench (the end of the wrench should be ground flat or slightly concave).

4. Tighten the small set screw to lock the adjusting nut in place.
5. Check to make sure the idle speed adjusting pin is in position and place the idle speed spring against the

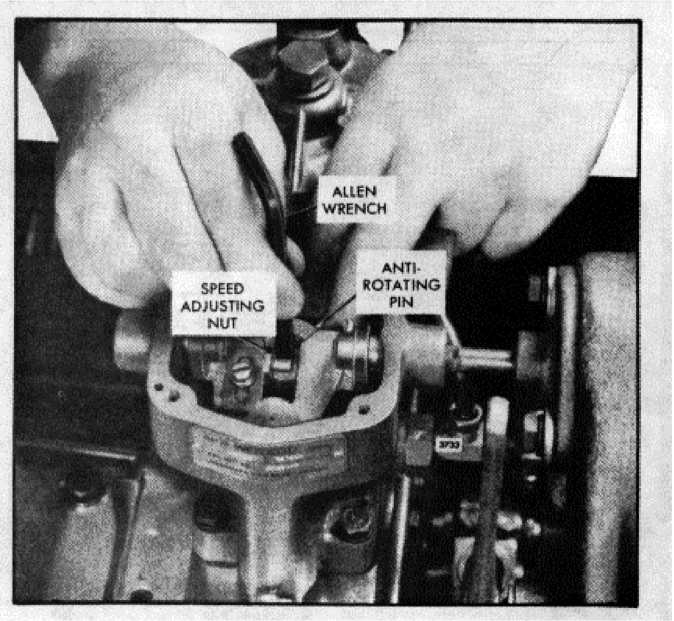


Fig. 13. - Turning High Speed Adjusting Nut

spring seat. Then, holding the spring in place with your finger (Fig. 11) and holding the linkage so the pointer is near the 36°mark, install the sub-cap assembly. Make sure the pin in the speed droop adjusting bracket enters the slot in the floating lever.

6. Reset the band-level adjustment.

7. Reset the idle speed.

8. Check the maximum speed.

9. Check the engine speed by suddenly moving the speed control lever from idle to maximum. If the engine speed does not stabilize after two to four surges, move the droop bracket outward. Recheck the idle and maximum speeds.

10. Install the governor cover and tighten the screws.

Adjust Buffer Screw

The purpose of the buffer screw adjustment is to prevent the injector racks from going all the way to the no-fuel position and causing the engine to stall.

1. With the warm engine at idle, turn the buffer screw in until it just touches the lower left end of the differential lever. Then, back off three complete turns and tighten the locknut.

2. Install the cover on the governor control housing.

VARIABLE SPEED HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V ENGINES

After adjusting the exhaust valves and timing the fuel injectors. adjust the governor linkage and position the injector rack control levers (Fig. I).

Adjust Governor Linkage and Position Injector Rack Control Levers

1. Clean and remove the valve rocker cover from each cylinder head. Discard the gaskets.

2. Loosen all of the adjusting screws and locknuts. Be sure all of the control levers are free on the control tubes.

3. Disconnect the vertical link assembly from the governor operating lever and the bell crank.

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the bolt (removed from the lower end of the vertical link) through the bell crank and into the recessed hole in the governor drive housing (Fig. 2).

6. Adjust the No. 1R injector rack by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. I R injector rack in the full-fuel position.

> **NOTE**: Care should be taken to avoid setting the racks too tight and causing the fuel rod to bend.

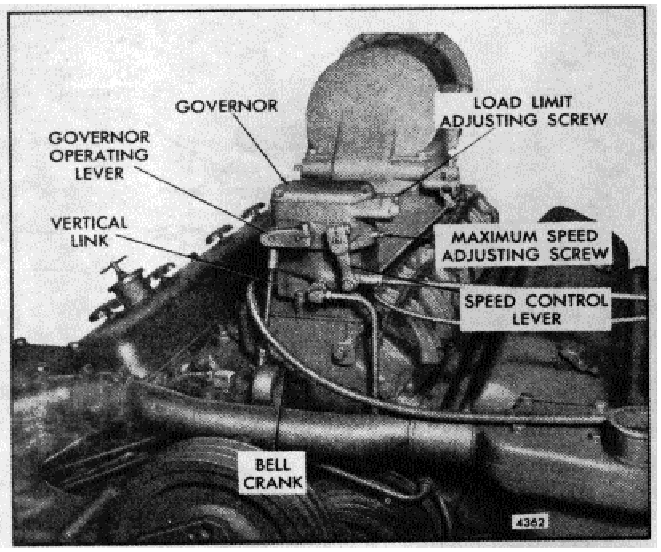


Fig. 1.- Hydraulic Governor Mounted on Engine

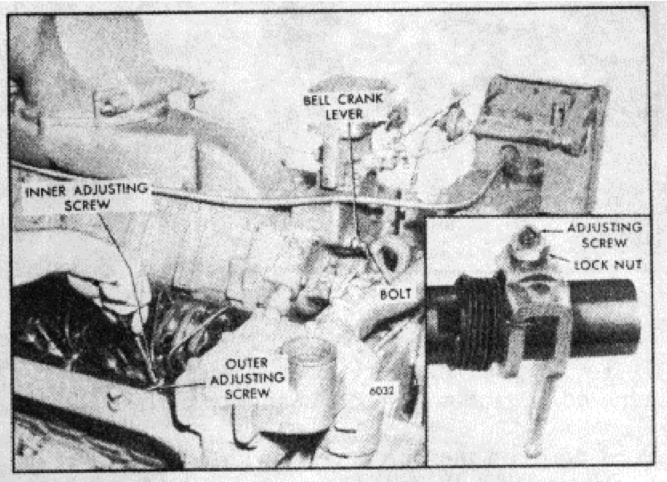


Fig. 2. - Positioning No. 1R Rack Control Lever

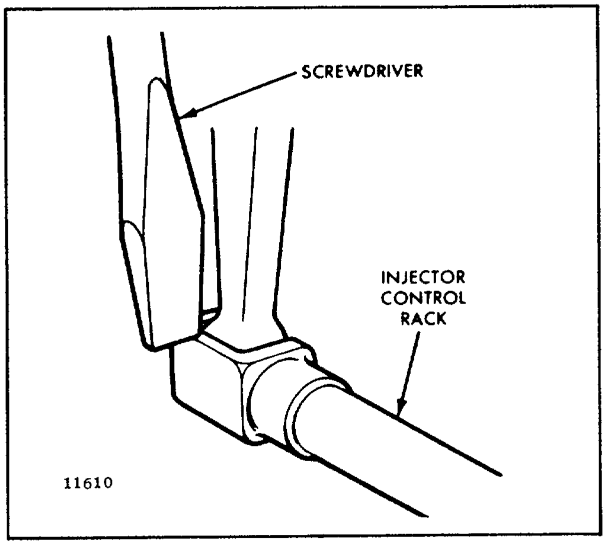


Fig. 3. - .Checking Injector Rack "Spring"

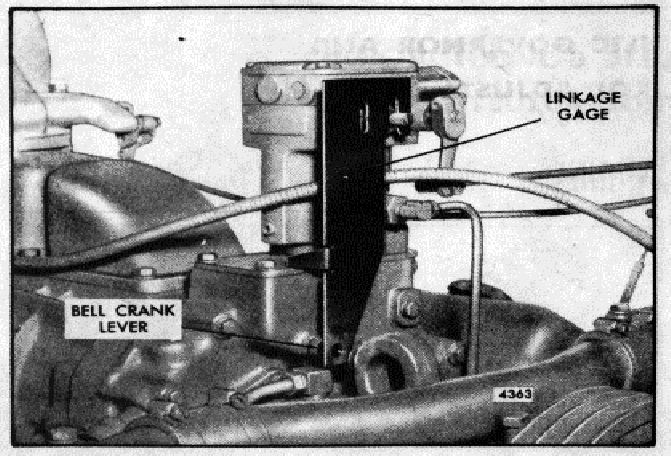


Fig. 4. - Linkage Gage in Position

7. To be sure the rack control lever is properly adjusted, the following check should be performed: Press down on the injector rack with a screwdriver or finger tip (Fig. 3). A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns or springs back to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

8. Adjust the No. 1L injector rack control lever as outlined in Steps 6 and 7.

9. Check the adjustment on the No. 1R and 1L injector rack control levers. If the setting is correct, the injector racks will be in the full-fuel position and snug on the ball end of the control levers.

10. To adjust the remaining injector rack control levers, hold the No. IL injector rack in the full-fuel position by means of the lever on the end of the control tube assembly and proceed as follows:

   a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

   NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in (3-4 Nm).

   b. Verify the injector rack adjustment of No. 1L as outlined in Step 7. If No. 1L does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. 1L injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. IL and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. 1L and No. 2L injector racks are in the full-fuel position when the locknut is securely tightened.

Recheck the No. L injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while positioning the No. 2L injector rack. If the rack of the No. 1L injector has become loose, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

When the settings are correct, both injector racks must respond in the same manner on the ball end of their respective rack control levers as previously outlined in Step 7.

11. Position the remaining injector rack control levers on the left and right cylinder heads as outlined in Step 10b.

When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full-fuel position.

12. Remove the bolt from the recessed hole in the drive housing and install linkage gage J 21304 (Fig. 4).

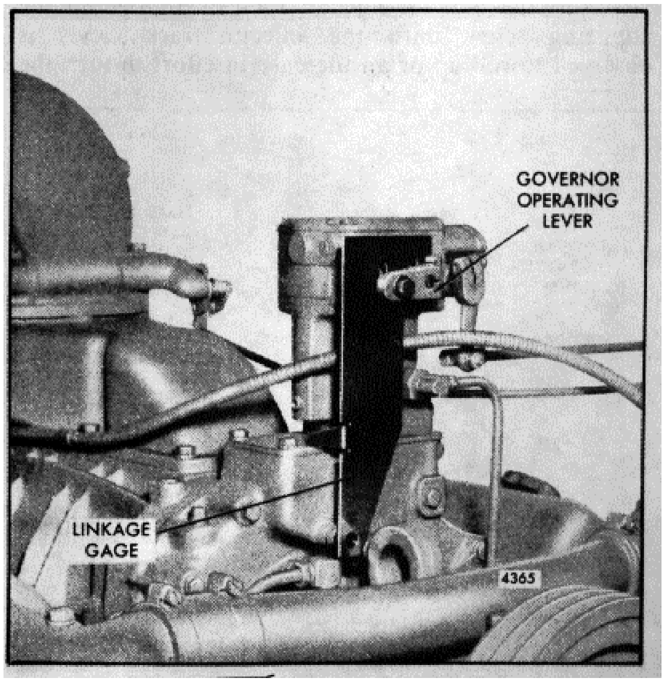


Fig. 5. - Governor Operating Lever in Position

13. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the gage (Fig. 5). The type of governor (SGX or PSG) will determine the proper position of the lever.

14. Remove the gage.

15. Move the bell crank lever to the no-fuel position.

16. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 6).

17. Replace the two bolts in the levers and tighten the bolts.

18. Remove the governor cover.

19. With the load limit screw backed all the way out, retain the governor operating lever in the full-fuel position. The governor terminal lever should touch the boss in the governor housing (Fig. 7). Adjust the vertical link so that all of the injector racks are in the full-fuel position, then tighten the rod end locknuts securely.

20. Use a new gasket and install a valve rocker cover on each cylinder head.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, set the load limit as follows:

1. Loosen the load limit screw locknut and adjust the load limit screw to obtain a distance of approximately 2" from the outside face of the boss on the governor sub-cap to the end of the screw. Then place and retain the governor operating lever in the full-fuel position as shown in Fig. 7.

NOTE: Do not overstress the linkage.

2. Turn the load limit adjusting screw until a .020" space exists between the fuel rod collar and the terminal lever. If the adjustment cannot be made with a feeler gage, turn the load limit adjusting screw (with the locknut tight enough to eliminate slack in the threads) inward until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the locknut. Then install the governor cover and tighten the screws.

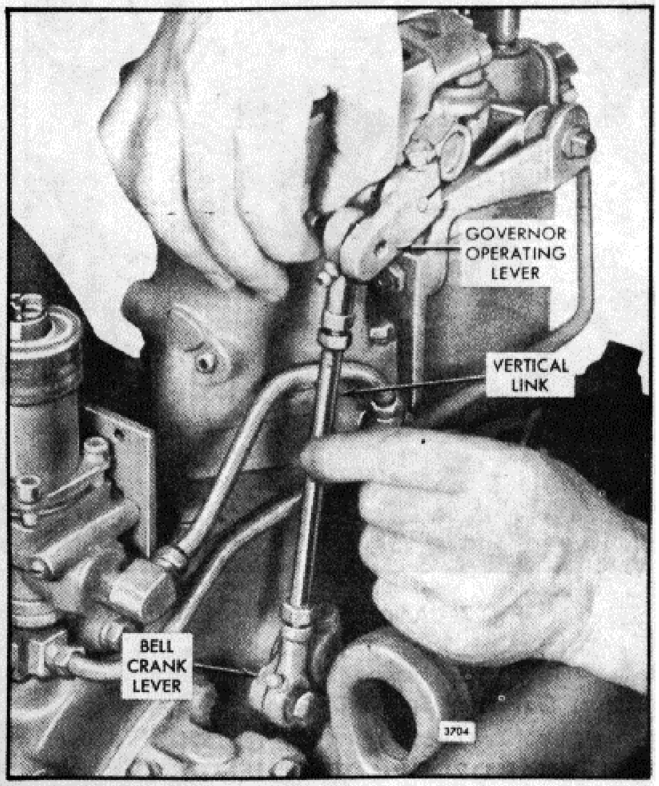


Fig. 6. - Adjusting Vertical Link

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve (without load on the engine) as follows:

1. Open the compensation needle valve (Fig. 11) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which the "hunting" stopped.

Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

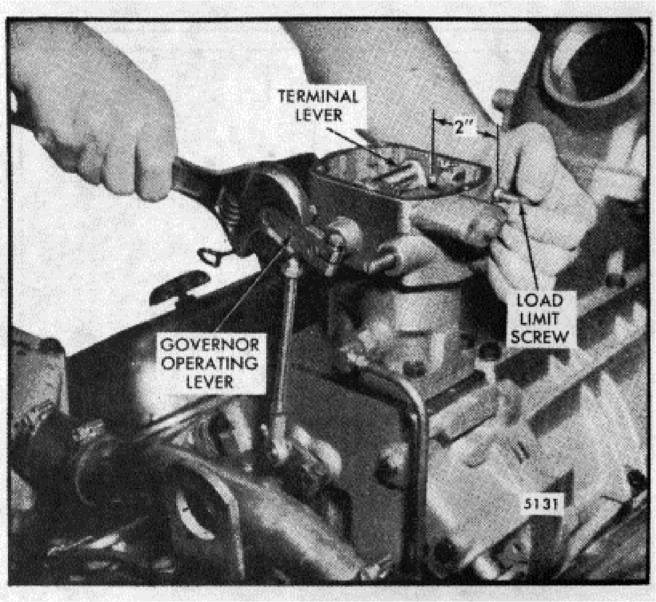


Fig. 7. - Adjusting Load Limit Screw

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

The purpose of adjusting the speed droop is to establish a definite engine speed at no-load with a given speed at rated full load.

The governor speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled, the speed droop must be readjusted.

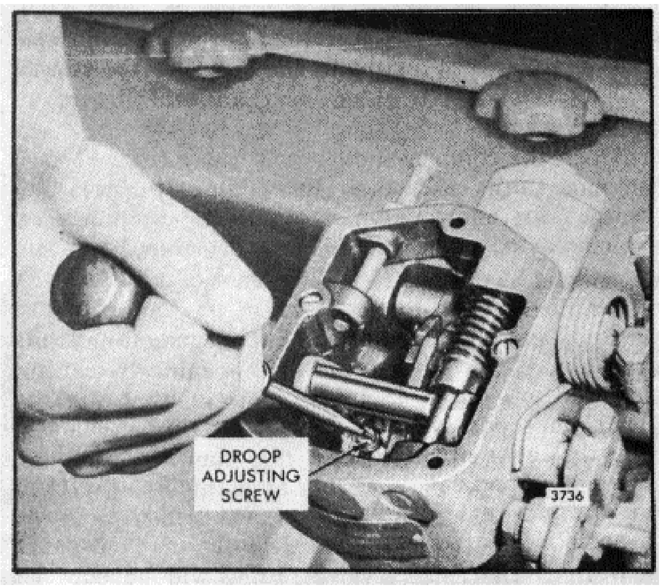


Fig. 8. - Adjusting Speed Droop

The best method of determining the engine speed is by using an accurate hand tachometer.

If a full rated load can be established on the unit, and the fuel rods, injector rack control levers and the load limit have been adjusted, set the speed droop as follows:

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

   NOTE: When the engine lubricating oil is cold, the governor regulation may be erratic. Regulation will become increasingly stable as the temperature of the oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8".

4. Loosen the droop adjusting screw. Move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw (Fig. 8).

5. With the throttle in the run position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed.

6. Apply the full rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed stabilizes under no-load. If the speed

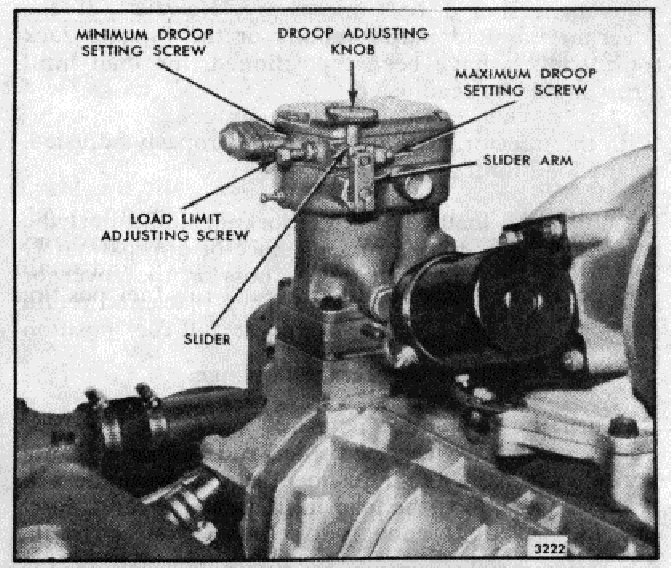


Fig. 9. - External Droop Control on PSG Isochronous Governor

droop is correct, the engine speed will be approximately 3% to 5% higher than the full-load speed.

If the speed droop is too high, stop the engine, loosen the droop adjusting screw and move the adjusting bracket IN toward the center of the governor. Tighten the screw. To increase the speed droop, move the bracket OUT, away from the center of the governor.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (21/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2-1/2 cycles) for units operating at 1,500 and 1,800 rpm (Table 1). However, this speed droop recommendation may be varied to suit the individual application.

Full Load	No Load
50 cycles, 1000 rpm	52.5 cycles, 1050 rpm
60 cycles, 1200 rpm	62.5 cycles, 1250 rpm
50 cycles, 1500 rpm	52.5 cycles, 1575 rpm
60 cycles, 1800 rpm	62.5 cycles, 1875 rpm

TABLE 1.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (Fig. 9). This permits the speed droop to be adjusted without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop). Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob and move the slider all the way in toward the center of the governor. Then tighten the knob.

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed (Fig. 10).

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to full-load speed.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the locknut and turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step-up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

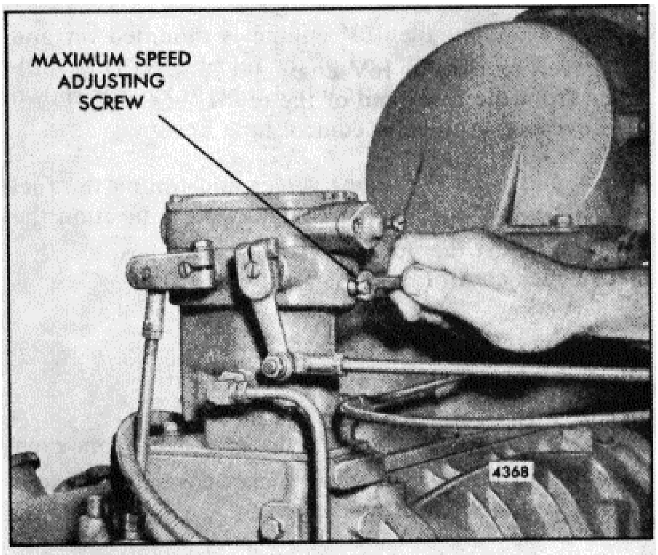


Fig. 10. - Adjusting Maximum No-Load Engine Speed

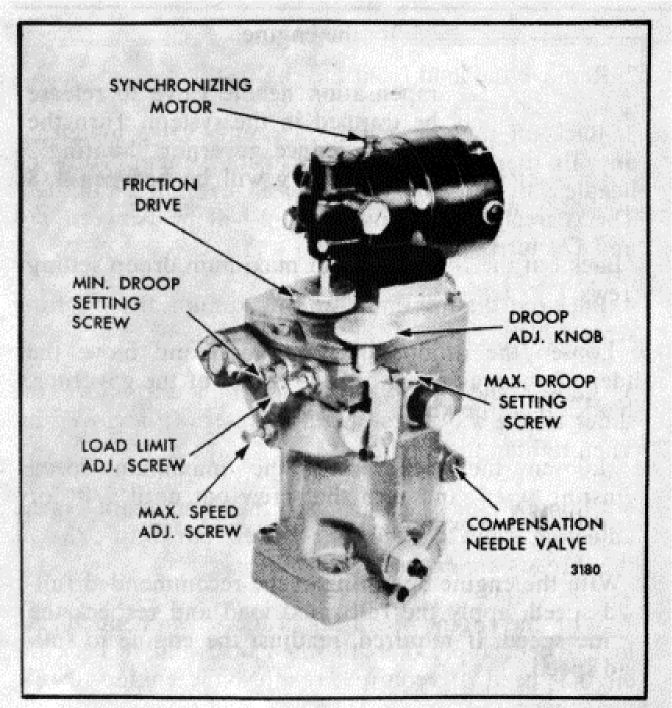


Fig. 11. - Typical Synchronizing Motor Mounting

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum ’speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. With the engine operating at no load, adjust the speed until the engine is operating at approximately 8% higher than the rated full-load speed.

2. Turn the maximum speed adjusting screw (Fig. 10) in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the locknut.

Governors with Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 11).

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with an external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

16 V ENGINES

The governor on the 16V engine is mounted on and driven from the front end of the rear blower (Fig. 12). The governor-to-injector control tube linkage is shown in Fig. 13.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor linkage and position the injector rack control levers.

Adjust Governor Linkage and Position Injector Rack Control Levers

1. Clean and remove the valve rocker cover from each cylinder head. Discard the gaskets.

2. Loosen all of the adjusting screws and locknuts. Be sure all of the control levers are free on the control tubes.

3. Disconnect the vertical link assembly from the governor operating lever and the bell crank lever (Fig. 13).

4. Loosen the bolt and slide the governor operating lever from the serrated shaft.

5. Place the bolt (removed from the lower end of the vertical link) through the bell crank and into the recessed hole in the governor drive housing (Fig. 14).

6. Adjust the No. 4R injector rack by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 15). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 4R injector rack in the full-fuel position.

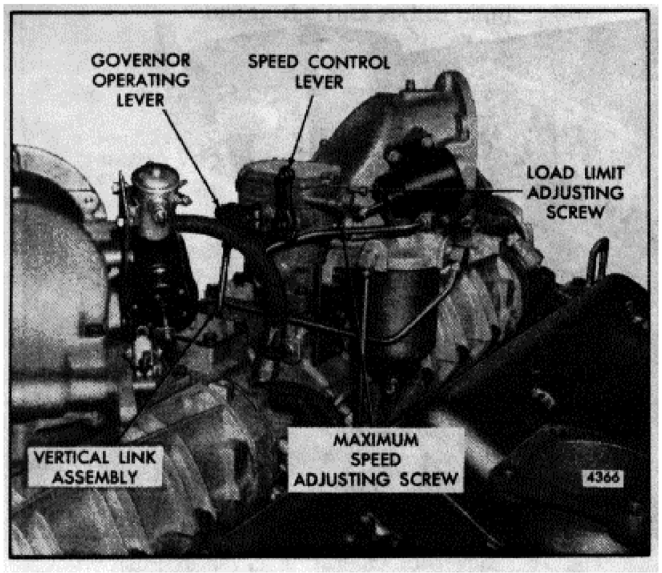


Fig. 12. - Hydraulic Governor Mounting

> **NOTE**: Care should be taken to avoid setting the racks too tight, causing the fuel rod to bend.

7. To be sure the rack control lever is properly adjusted, press down on the injector rack with a screwdriver or finger tip (Fig. 3). A light pressure should cause the rack to rotate. The rack is sufficiently tight if the rack returns ("springs" back) to its original position when the pressure is removed. The rack is too tight if a heavy pressure is required to rotate the rack.

8. Adjust the No. 5R, 4L and 5L injector rack control levers as outlined in Steps 6 and 7.

When the settings are correct, all four of the injector racks will be snug on the ball end of the control levers when the injectors are in the full-fuel position.

9. To adjust the remaining injector rack control levers on the right front bank, hold the No. 4R injector rack in the full-fuel position by means of the lever on the control tube assembly and proceed as follows:

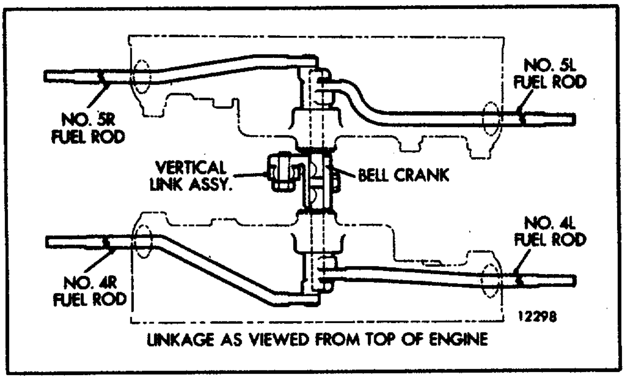


Fig. 13. - Governor to Injector Rack Control Linkage

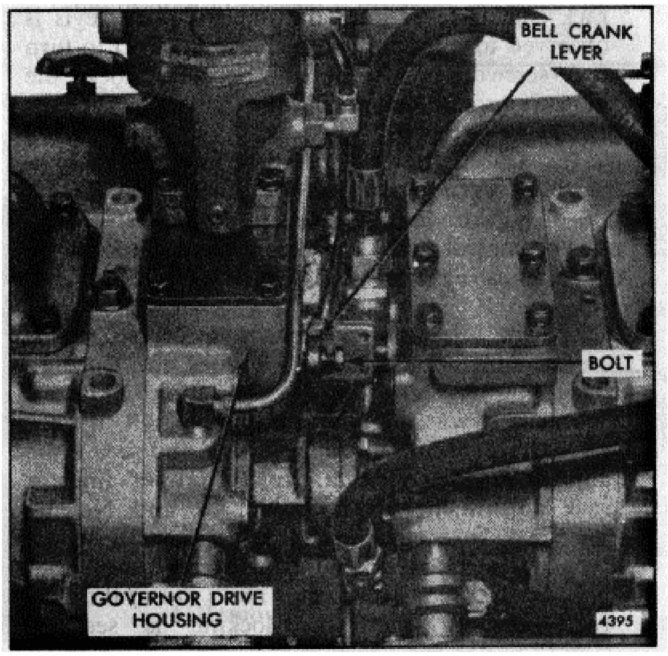


Fig. 14. - Bolt in Position through Bell Crank Lever

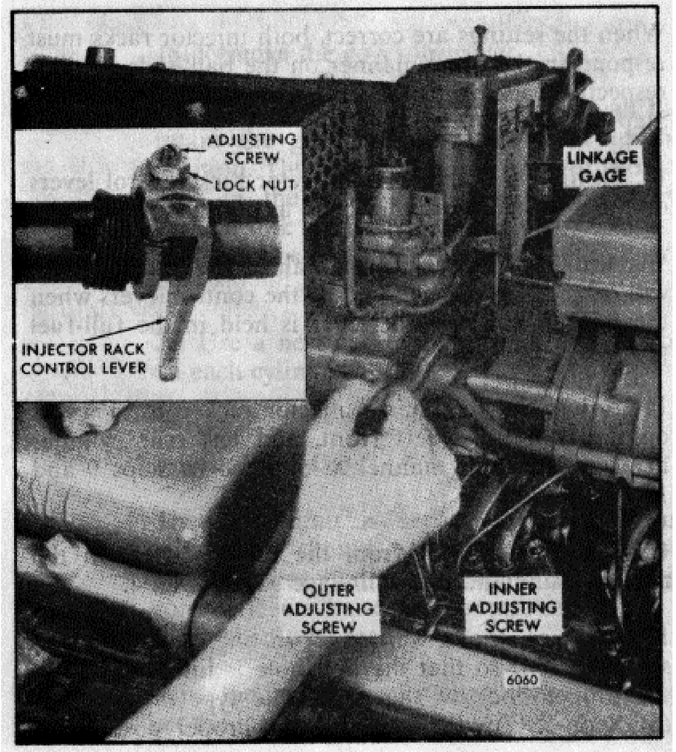


Fig. 15. - Positioning No. 4R. Injector Rack Control Lever

a. Tighten the adjusting screw of the No. 3R injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in(3-4 Nm).

b. Verify the injector rack adjustment of No. 4R as outlined in Step 7. If No. 4R does not "spring" back upward, turn the No. 3R adjusting screw counterclockwise slightly until the No. 4R injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 4R and No. 3R injectors. Turn clockwise or counterclockwise the No. 3R injector rack adjusting screw until both No. 4R and No. 3R injector racks are in the full fuel position when the locknut is securely tightened.

Recheck the No. 4R injector rack to be sure that it has remained snug on the ball end of the injector rack control lever. If the rack of No. 4R injector has become loose, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

When the settings are correct, both injector racks must respond in the same manner on the ball ends of their respective rack control levers as previously outlined in Step 7.

10. Position the remaining injector rack control levers on the right front cylinder head as outlined in Step 9.

When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube lever is held in the full-fuel position.

11. Adjust the remaining injector rack control levers on the right rear, left front, and left rear cylinder heads in the same manner as outlined in Steps 9 and 10.

12. Remove the bolt from the recessed hole in the drive housing and install linkage gage J 21304.

13. Replace the governor operating lever on the serrated shaft so that the bolt hole is lined up within the proper lines on the gage. The type of governor (SGX or PSG) will determine the proper position of the lever (Fig. 16).

14. Remove the gage.

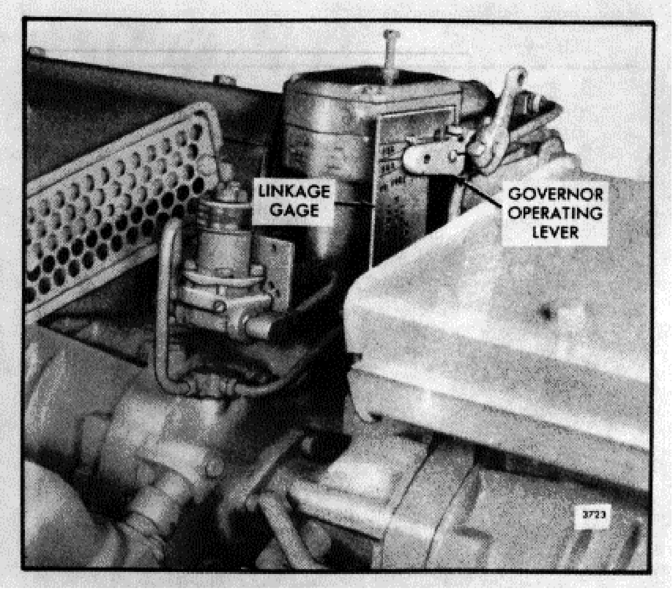


Fig. 16. - Governor Operating Lever in Position

15. Move the bell crank lever to the no-fuel position.

16. Adjust the length of the vertical link so that the bolt holes of the levers and the centers of the rod end bearings are lined up (Fig. 17).

17. Replace the two bolts in the levers and tighten the bolts.

18. Remove the governor cover.

19. With the load limit screw backed all the way out, retain the governor operating lever in the full-fuel position. The governor terminal lever should touch the boss on the governor housing. Adjust the vertical link so that all of the injector racks are in the full-fuel position, then tighten the rod end locknuts securely.

20. Use a new gasket and install the valve rocker cover on each cylinder head.

Adjust Load Limit

The load limit is set at the factory and any further adjustment should be unnecessary. However, if the governor has had major repairs or the injector control rack levers have been repositioned the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, set the load limit as follows:

1. With the governor cover off and the load limit screw lock nut loosened, place and retain the governor operating lever in the full-fuel position as shown in Fig. 18.

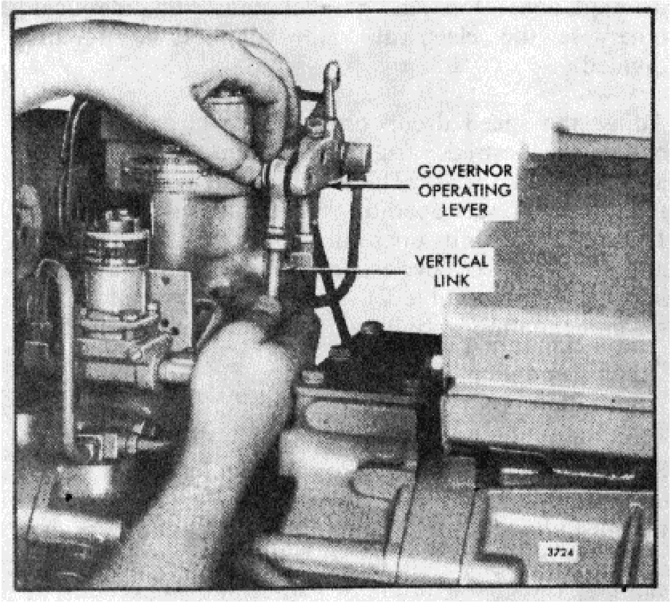


Fig. 17. - Adjusting Vertical Link

NOTE: Do not overstress the linkage.

2. Turn the load limit adjusting screw until a .020" space exists between the fuel rod collar and the terminal lever. If the adjustment cannot be made with a feeler gage, turn the load limit adjusting screw (with the locknut tight enough to eliminate any slack in the threads) in until the injector racks just loosen on the ball end of the control levers.

3. Release the governor operating lever and hold the adjusting screw while tightening the locknut. Then install the governor cover and tighten the screws.

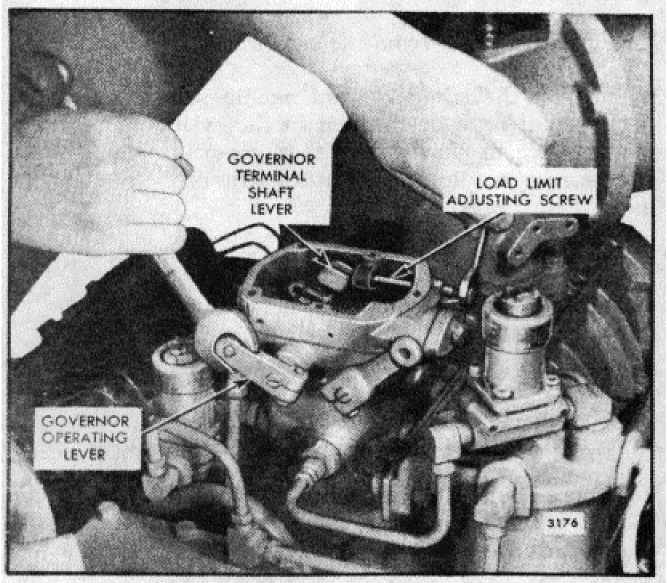


Fig. 18. - Adjusting Load Limit Screw

Compensation Needle Valve Adjustment (PSG Governor)

Start the engine and, after the engine reaches normal operating temperature, adjust the governor compensation needle valve, without load on the engine, as follows:

1. Open the valve (Fig. 11) two or three turns and allow the engine to "hunt" or "surge" for about one-half minute to bleed any air which may be trapped in the governor oil passages.

2. Gradually close the valve until the "hunting" just stops. Check the amount of valve opening by closing the valve completely and noting the number of turns required to close it. Open the valve to the previously determined position at which, the "hunting" stopped. Test the action of the governor by manually disturbing the engine speed. The engine should return promptly to the original steady speed with only a small overshoot. The correct valve setting will be between 1/8 and 1/2 turn open. Closing the valve farther than necessary will make the governor slow in returning the engine to normal speed after a load change.

Adjust Governor Speed Droop

INTERNAL DROOP ADJUSTMENT

The purpose of adjusting the speed droop is to establish a definite speed at no-load with a given speed at rated full-load.

The governor speed droop is set at the factory and further adjustment should be unnecessary. However, if the governor has been overhauled. the speed droop must be readjusted.

The best method of determining the engine speed is by using an accurate hand tachometer.

If a full rated load can be established on the unit, and the fuel rods, injector rack control levers and the load limit have been adjusted, set the speed droop as follows:

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

> **NOTE**: When the engine lubricating oil is cold, the governor regulation may be erratic. Regulation will become increasingly stable as the temperature of the oil increases.

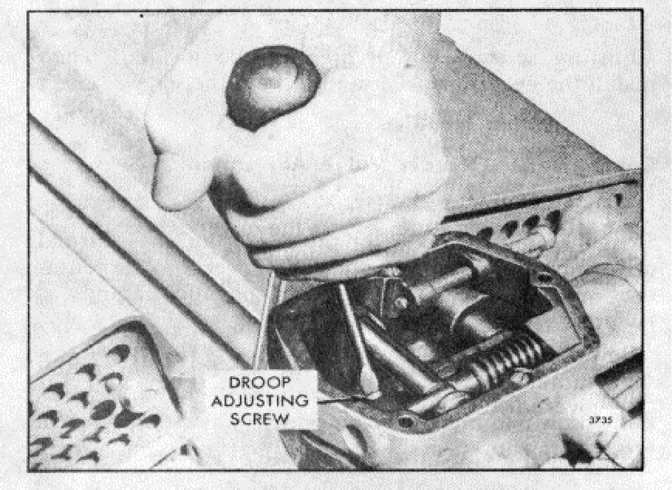


Fig. 19. - Adjusting Speed Droop

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8".

4. Loosen the droop adjusting screw (Fig. 19). Move the droop bracket so that the screw is midway between the ends of the slot in the bracket. Tighten the screw.

5. With the throttle in the run position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed.

6. Apply the full rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full-load speed.

If the speed droop is too high, stop the engine, loosen the droop adjusting screw and move the adjusting bracket IN toward the center of the governor. Tighten the screw. To increase the speed droop. move the bracket OUT, away from the center of the governor.

Full Load	No Load
50 cycles, 1000 rpm	52.5 cycles, 1050 rpm
60 cycles, 1200 rpm	62.5 cycles, 1250 rpm
50 cycles, 1500 rpm	52.5 cycles, 1575 rpm
60 cycles, 1800 rpm	62.5 cycles, 1875 rpm

TABLE 2.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each governor to obtain the desired variation between engine no-load and full-load speeds. The recommended speed droop for generator sets operating in parallel is 50 rpm (21/2 cycles) for units operating at 1,000 and 1,200 rpm, and 75 rpm (2-1/2 cycles) for units operating at 1,500 and 1,800 rpm (Table 2). However, this speed droop recommendation may be varied to suit the individual application.

EXTERNAL DROOP CONTROL

Some PSG type governors are equipped with an external adjustable droop control (Fig. 11). This permits the speed droop to be adjusted. without removing the governor cover. With this feature, a unit can be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit must have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, shift the load to the incoming unit and move the governor droop bracket to zero droop. Then adjust the outgoing unit to maximum droop, remove it from the line and stop the engine. The incoming unit will now be carrying the load and operating at constant frequency (zero droop).

Adjust the governor speed droop as follows:

1. Start the engine and run it at approximately one-half of the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the compensation needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor "hunting". The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob and move the slider all the way in toward the center of the governor. Then tighten the knob.

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the

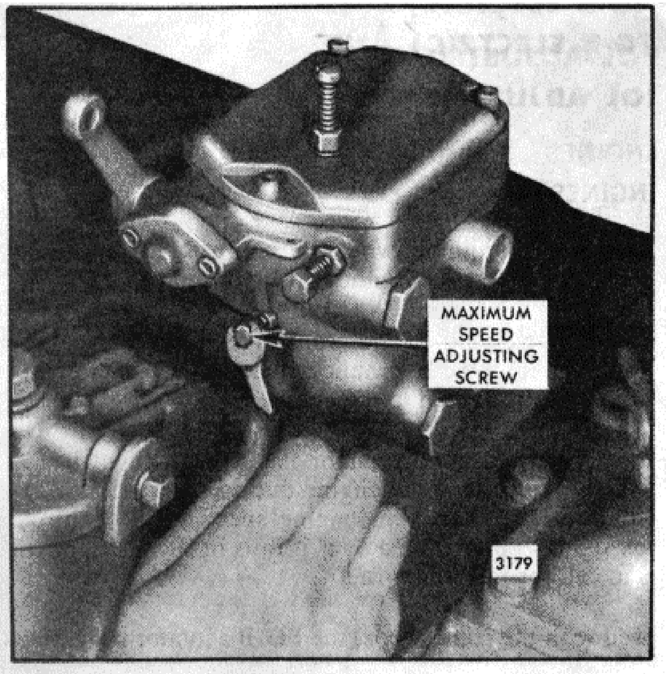


Fig. 20. - Adjusting Maximum No-Load Engine Speed

engine speed. If required, readjust the engine to full load speed.

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the droop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the locknut and turn the minimum droop setting screw in until it contacts the droop linkage within the governor. This will be felt by a step up of resistance while turning the adjusting screw. Lock the adjusting screw in this position.

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum speed droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw in until it contacts the droop slider arm. Lock the adjusting screw in this position.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are obtained.

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. With the engine operating at no-load, adjust the speed until the engine is operating at approximately 8% higher than the rated full-load speed.

2. Turn the maximum speed adjusting screw (Fig. 2()) in until the screw contacts the throttle linkage internally, limiting the maximum speed of the engine at 8% above the rated full-load speed.

3. Hold the screw and tighten the locknut.

Governors with Synchronizing Motor

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 11).

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. However, the governor cover and motor assembly must be removed when setting the engine speed droop (except on a governor equipped with the external droop adjustment). The cover and motor must be reinstalled to check the speed droop.

HYDRAULIC GOVERNOR (EG-B ELECTRIC) AND INJECTOR RACK CONTROL ADJUSTMENT

6, 8 and 12V ENGINES

The Woodward EG-B2C series governor is of the electric type (Fig. 1). It can be operated as an isochronous (zero speed droop) governor or as a speed droop governor. As an isochronous governor installed on an engine operating alone, it will maintain a constant speed for all loads within the capacity of the engine, except momentarily at the time a load change occurs. Paralleled with other EG-governors, it will render proportional load division with isochronous control. Paralleled with dissimilar governors or with an infinite bus (i. e., commercial power), the EG-B2C governor can be operated as a conventional speed droop governor and the load carried by the engine will be a function of the governor speed setting and speed droop setting.

The governor consists essentially of three separate assemblies: a control box, a speed adjusting potentiometer and a hydraulic actuator. A resistor box assembly is required when the control box receives load signals from an engine driven alternator.

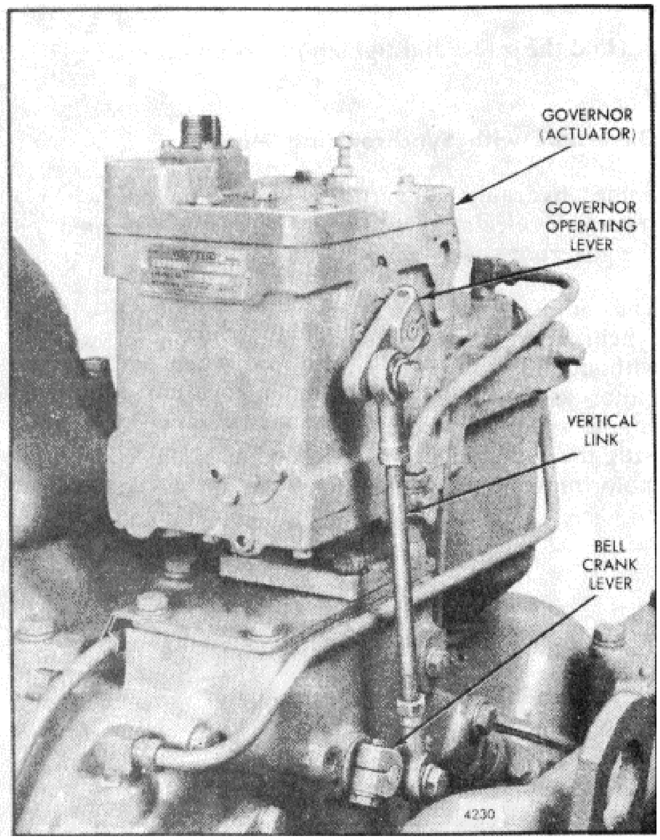


Fig. 1. Governor Mounted on Engine

The output signal of the control box serves as the input signal to the hydraulic actuator; the actuator in turn controls the fuel to the engine.

The EG-B hydraulic actuator has a centrifugal head assembly to control the engine during starting; also, it will limit the maximum engine speed if the control box signal is interrupted or if it fails in such a manner as to call for maximum fuel.

Used with the control box, the EG-B actuator provides, in effect, two governors in one: an electric governor and a centrifugal governor, each independently capable of positioning the terminal (output) shaft. During normal operation, the electric governor controls fuel to the engine. The actuator is adjusted so that, if the electric control signal is interrupted, the electric section moves the fuel linkage to maximum fuel. When the speed reaches the level for which the centrifugal governor is set (always a level higher than that for which the electric governor is set), this section assumes and maintains control of the engine. Speed can then be reduced, if desired, by lowering the speed setting on the centrifugal governor. Should the control box fail in such a way as to emit a continuous signal calling for a decrease in fuel, the unit would shut down.

The essential element of the electric section of the actuator is an electro-hydraulic transducer which directs pressure oil to and from the power piston which actuates the fuel mechanism. The transducer consists of a polarized magnet to which is attached the pilot valve plunger controlling oil flow to and from the power piston. The solenoid responds to the push-pull output of the electric control box and, in so doing, moves the pilot valve plunger up or down. Through connecting linkage, the power piston moves the terminal (output) shaft of the actuator. The engine fuel linkage attaches to the actuator terminal shaft.

The governor (actuator) uses oil from the engine lubrication system.

For more detailed information on the electrical section and on servicing the EG-B2C governor, refer to the Woodward Governor Company's Bulletins 37709 and 37706 (also 37702 for type EG-BI governor).

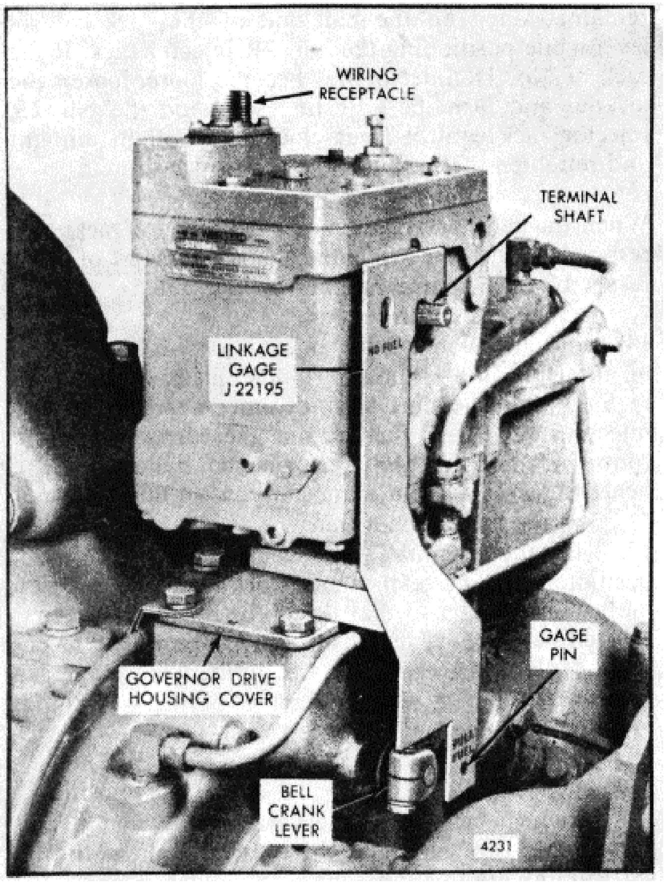


Fig. 2. Linkage Gage in Position

Adjust Governor Linkage and Position Injector Rack Control Levers

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor linkage and position the injector rack control levers.

The position of the injector control racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

The letters R and L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1R injector rack control lever first to establish a guide for adjusting the remaining levers.

1. Clean and remove the valve rocker covers. Discard the gaskets.

2. Loosen all of the adjusting screws and locknuts on both injector control tubes. Be sure all of the injector rack control levers are free on the control tubes.

3. Remove the vertical link assembly from the governor operating lever and the bell crank lever (Fig. 1).

4. Loosen the clamping bolt and slide the governor operating lever from the governor terminal shaft.

5. Place the linkage gage J 22195 over the governor terminal shaft and insert the gage pin in the bell crank lever bolt hole (Fig. 2). The tang on the side of the gage should just touch the top of’ the governor drive housing when the gage is properly positioned. The gage will hold the injector control racks in the full-fuel position while the levers are being adjusted.

6. Remove the clevis pin from the fuel rod and the left cylinder bank injector control tube lever.

7. Adjust the No. 1R injector rack control lever by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 3). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1R injector rack in the full-fuel position.

> **NOTE**: Avoid setting the rack too tight, causing the fuel rod to bend.

8. To be sure the control lever is properly adjusted, press down on the injector rack with a screwdriver or finger tip. The setting is sufficiently tight if the rack returns or "springs" back to its original position when the pressure is released. The rack is too tight it’ a heavy pressure is required to rotate the rack.

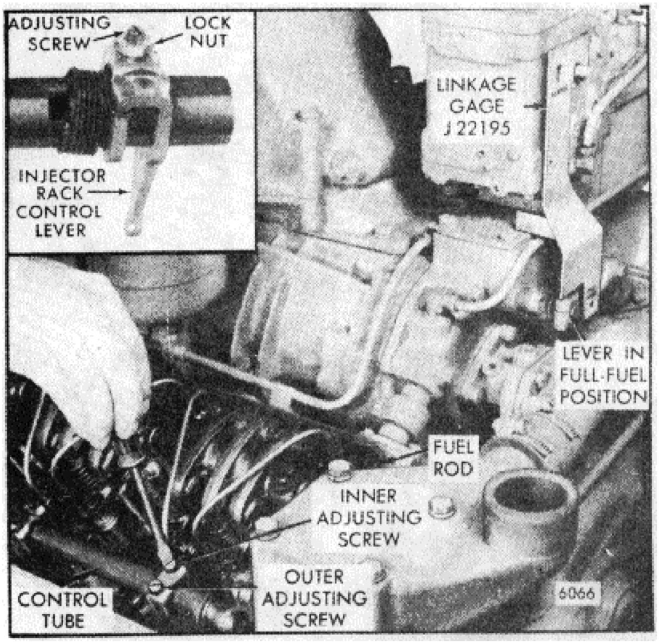


Fig. 3. - Positioning No. 1R Injector Rack Control Lever

9. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

10. Install the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Then position the No. 1L injector rack control lever as outlined in Steps 7 and 8.

11. Install the clevis pin in the fuel rod and the right cylinder bank injector control tube lever. Recheck the No. 1 R and IL injector rack control levers as in Step 8 Check for and eliminate any deflection in the fuiel rods. If the settings are correct, both injector racks will be in the full-fuel position and snug on the ball end of the control levers.

12. Manually hold the No. 1 R injector rack in the full fuel position by means of the injector control tube lever (Fig. 3). Tighten the adjusting screw of the No. 2R injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 lb-in(3-4 Nm).

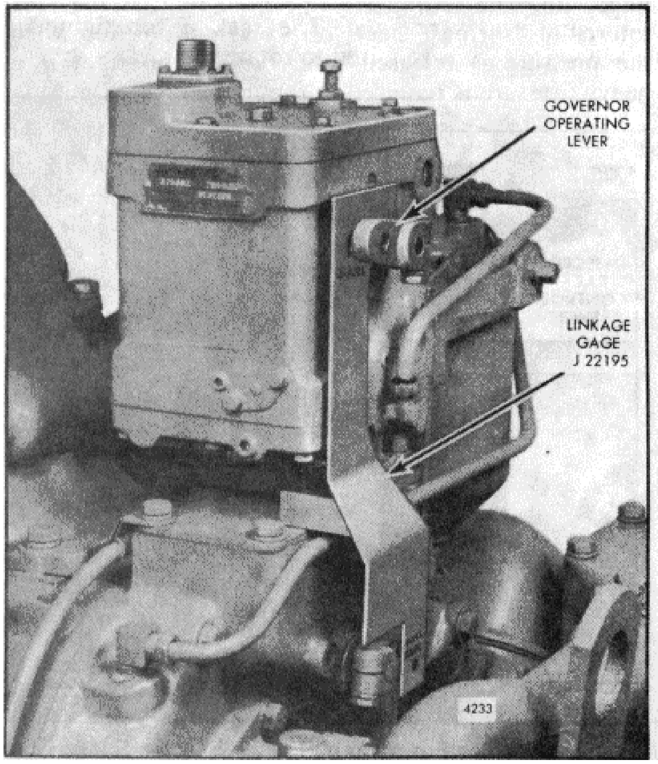


Fig. 4. - Governor Operating Lever In Position

13. Recheck the No. 1R injector rack to be sure it has remained snug on the ball end of the rack control lever while positioning the No. 2R injector rack. If the rack of No. 1R injector has become loose, loosen the locknut and turn the adjusting screw on the No. 2R injector rack control lever clockwise a slight amount and retighten the locknut.

When the settings are correct, both injector racks will respond in the same manner on the ball end of their respective rack control levers.

14. Position the remaining injector rack control levers on the right and left bank cylinder heads as outlined in Step 12. When the settings are correct, all of the injector racks will be snug on the ball end of the control levers when the injector control tube levers are held in the full-fuel position.

15. Turn the terminal shaft clockwise to the no-fuel position. Then place the governor operating lever on the terminal shaft so that the bolt hole in the lever is aligned with the center of the slot in the linkage gage (Fig. 4). Remove the gage and tighten the clamping bolt on the lever.

16. Move the bell crank lever to the no-fuel position.

17. Adjust the length of the vertical link so the bolt holes in the two levers and the rod end bearings in the, vertical link are in alignment.

18. Install and tighten the vertical link attaching bolts.

19. As an additional check, the governor operating lever should be in a position indicating maximum on the dial indicator (Fig. 6), when the injector rack control levers are in the full-fuel position. If not, readjust the vertical link.

20. Use a new gasket and install the valve rocker cover on each cylinder head.

Governor Adjustments

The centrifugal governor section of the actuator has three operating adjustments.

1. Speed setting: An external adjustment used to set the speed at which the centrifugal governor will control.

2. Speed droop: An internal adjustment used to permit parallel operation of units controlled by the centrifugal governor.

3. Needle Valve: An external adjustment used to stabilize the centrifugal governor.

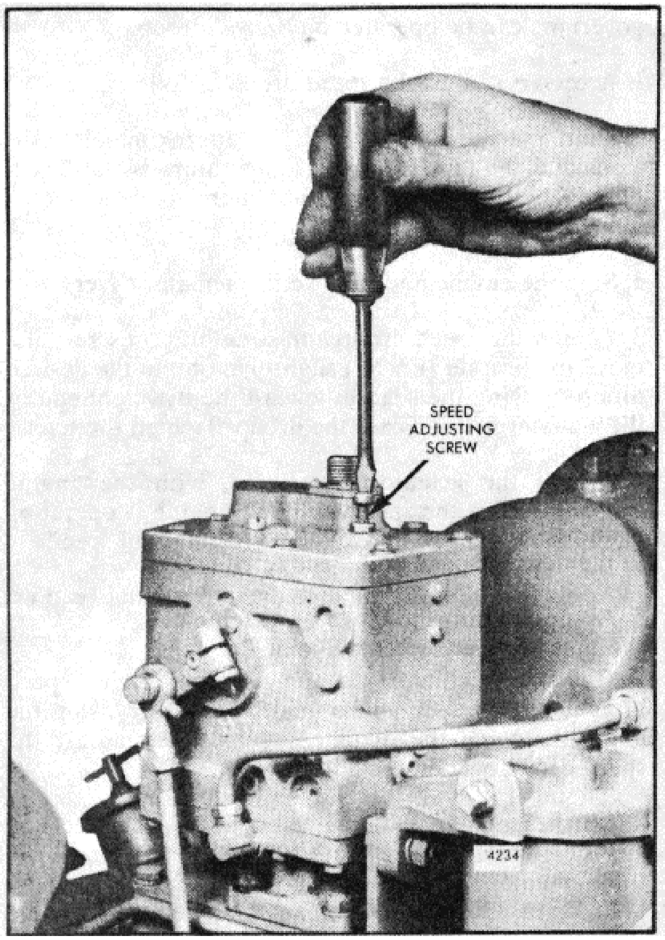


Fig. 5. - Adjusting Maximum No-Load Engine Speed

Once set, these adjustments do not usually require further adjustment.

Adjust Maximum No-Load Speed

When shipped from the factory, the speed adjusting screw is set for a speed approximately 4-1/2% above rated speed at no-load (the usual factory droop setting of 3% will reduce the speed to approximately 1-1/2% above rated speed at full travel of the centrifugal governor power piston). With the speed adjusting screw at this setting during normal operation (i. e., with the electric section controlling), the centrifugal governor power piston will be held in its maximum fuel position.

If adjustment of the maximum no-load speed is required, proceed as follows:

1. Disconnect the wiring at the receptacle on the governor cover.

2. Start the engine and run it at no-load.

3. Turn the speed adjusting screw until the desired speed is obtained (Fig. 5). Turning the screw counterclockwise will decrease the speed setting.

Adjust Needle Valve

When starting the engine for the first time, eliminate any air which may be trapped in the actuator oil passages as follows:

1. Open the needle valve of the centrifugal governor section until the engine hunts or surges (Fig. 6). After a half minute, gradually close the needle valve until the engine speed just stabilizes. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change. Never close the needle valve tight.

2. Test the action by manually disturbing the speed of the engine. The engine should promptly return to its original steady-state speed with only a small overshoot or undershoot.

Speed Droop Adjustment

The governor is set with approximately 3% droop when shipped from the factory. When the electric governor section is controlling the engine, the speed droop adjustment has no effect on operation and

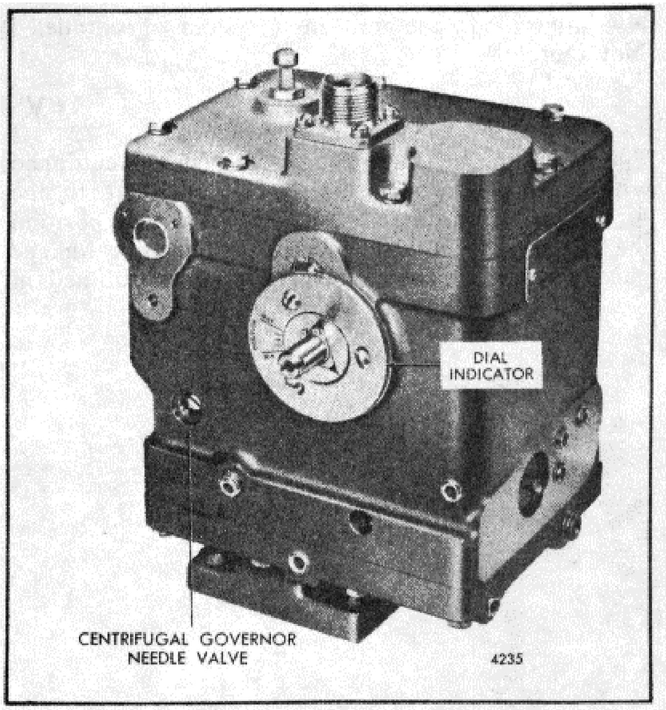


Fig. 6. - Location of Centrifugal Governor Needle Valve

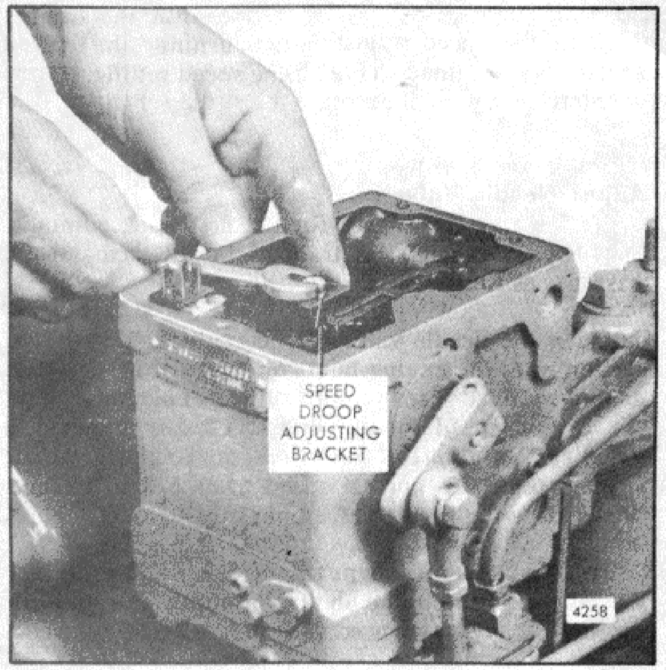


Fig. 7. - Adjusting Speed Droop

should be left as factory set. When, for some reason, the centrifugal governor section is controlling the engine, the speed droop setting can be adjusted, if necessary, to suit the operating requirements. The governor should never be set at "zero" droop unless the unit is maintaining the frequency of paralleled alternators or is operating as a single, isolated unit. Not more than one unit in a system of paralleled alternators with engines controlled by centrifugal governors can be operated on "zero" droop.

If necessary, adjust the speed droop as follows:

1. Start the engine and run it at approximately halfload until the lubricating oil temperature is stabilized; governor regulation will become more stable as the oil temperature increases.

2. Stop the engine and remove the actuator cover.

3. Loosen the speed droop adjusting bracket screw and move the bracket (Fig. 7) slightly to obtain the desired droop; moving the bracket toward the flyweight end of the actuator will increase the droop. Tighten the screw.

4. Install the actuator cover and, with the engine running, adjust the speed until the engine is operating at the desired speed above the rated full-load speed.

5. Apply the full rated load on the engine and readjust the speed to the correct full-load speed.

6. Remove the rated load and note the engine speed after it stabilizes under no load. If necessary, stop the engine, remove the actuator cover and readjust the speed droop bracket.

After the engine tune-up is completed, reconnect the electrical circuit of the governor at the receptacle on the actuator cover. If necessary, refer to the Woodward Governor Company's Bulletin 37709 for the procedures to be followed in checking the electrical system.

16V ENGINE

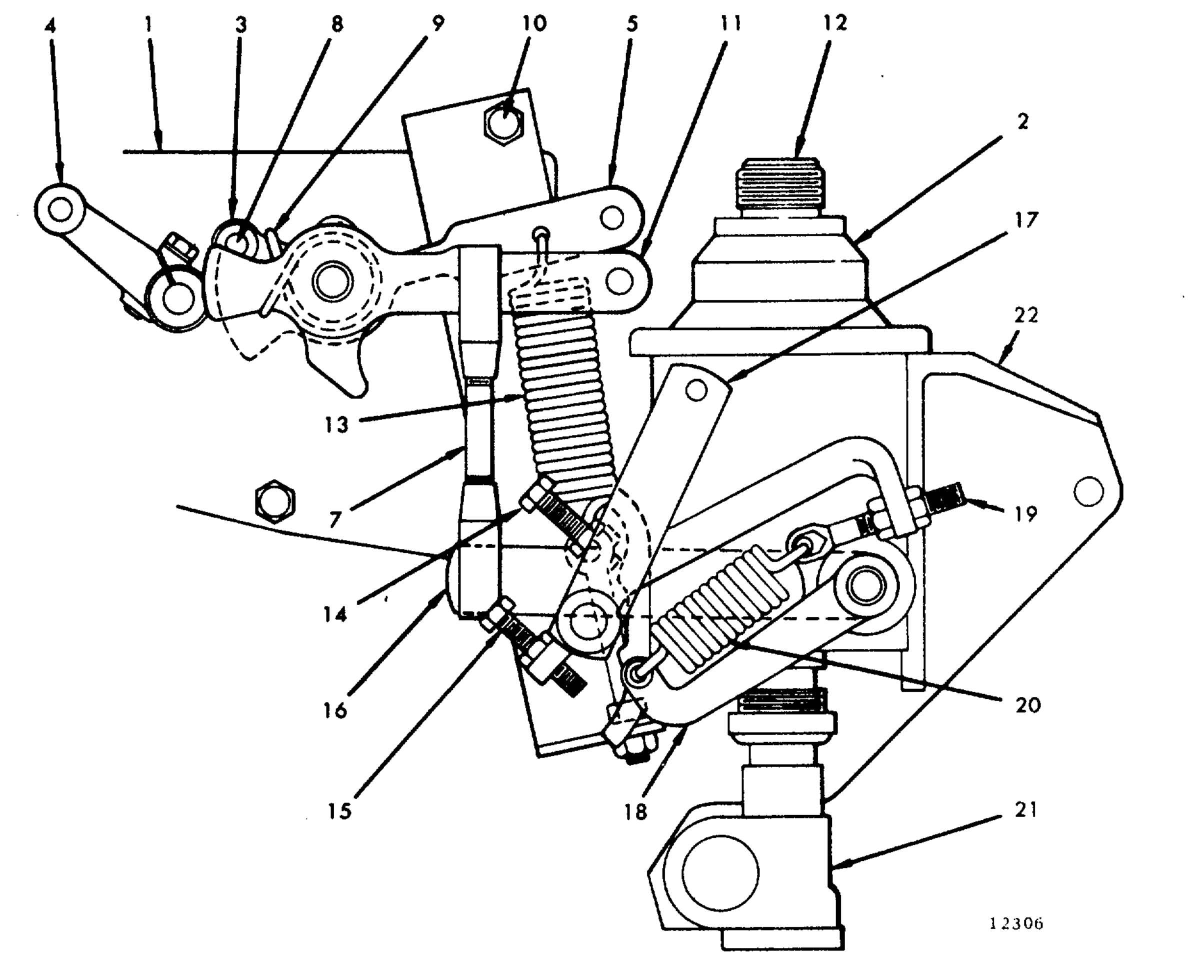
The tune-up procedure for a 16V engine equipped with the EG-B electric governor is similar to the procedure used on the 6, 8 or 12V engines. To position the injector rack control levers, use the same linkage gage (J 22195) but follow the procedure outlined in the variable speed hydraulic governor (6, 8 and 12V) or in the variable speed hydraulic governor (16V). The governor adjustments, however, are the same as on the 6, 8 and 12V engines.

MECHANICAL OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A Pierce mechanical governor is used to maintain a near constant output shaft speed on engines equipped with a torque converter. The governor is mounted at the front of the engine (Fig. 1) and driven by a flexible shaft from the converter output shaft.

The output shaft governor is lubricated by engine oil contained within the governor housing. The governor sump is filled through the hinged cap oiler until the oil begins to drip out of the oil level hole. After filling, a plug is installed in the oil level hole to prevent leakage. The oil level should be checked every 8 service hours and changed every 500 hours (15, 000 miles).

The output shaft governor is connected to the engine governor by control rods and levers as illustrated in Fig. 1. The control rod end ball joints are sealed assemblies and do not require lubrication. Other moving parts of the



1. Governor--Engine
2. Governor--Output Shaft
3. Lever--Throttle Control
4. Lever--Shutdown
5. Lever--Engine Governor Operating
7. Rod--Output Shaft Governor
8. Pin--Stop
9. Spring--Torsion
10. Bolt (Stop)
11. Lever--Output Shaft Governor
12. Drive--Flexible Shaft
13. Spring--Governor Lever Return
14. Bolt--Minimum Speed Adjusting
15. Bolt--Maximum Speed Adjusting
16. Lever--Rocker Shaft
17. Lever--Speed Adjusting
18. Lever--Spring
19. Eyebolt--Droop Adjusting
20. Spring--Speed Adjusting
21. Drive--Tachometer
22. Bracket--Output Shaft Governor Mounting

Fig. 1. Mechanical Output Shaft Governor and Linkage

control linkage should be lubricated with engine oil.

The centrifugal force of the revolving output shaft governor flyweights is converted into linear motion which is transmitted through a riser, thrust bearing, operating fork, and rocker shaft to an external speed adjusting spring. The speed of the torque converter output shaft is governed by the tension of the speed adjusting spring. This spring tension is established by the operator when he moves the output shaft governor speed adjusting lever to the desired speed setting.

The engine governor operating lever is positioned by the operator to limit the maximum fuel input to the engine. For most purposes, such as drag line and shovel operation, the lever is advanced to its maximum position to permit the output shaft governor to obtain full power from the engine. The lever may be used as an overrule lever when performing such jobs as laying of structural steel. A spring is used to return the lever to the idle position. Travel of the governor operating lever is limited by a stop (bolt).

The engine governor throttle control lever is pinned to the throttle shaft. The engine governor operating lever is mounted below the throttle control lever and rides on the throttle shaft boss on the governor cover. The output shaft governor lever is mounted above the throttle control lever and is retained on the shaft by a snap ring. A stop pin, pressed into the throttle control lever, transmits movement of the output shaft governor lever and/or engine governor operating lever through the throttle control lever to the injector racks. The torsion spring, used to retain the throttle control lever stop pin against the output shaft governor lever, yields to permit the governor operating lever to move the throttle control lever toward the idle position, regardless of the position of the output shaft governor lever. A slot in the underside of the governor cover hub limits the travel of the throttle control lever in both its maximum and minimum speed positions.

Movement of the output shaft governor speed adjusting lever is limited by the maximum and minimum speed adjusting bolts.

The engine shutdown lever is connected through a shaft to another lever, under the governor cover, which bears against the pin in the differential lever. To stop the engine, the shutdown lever is used to move the differential lever to the no-fuel position.

Operation

When the output shaft governor speed adjusting lever is advanced, the tension on the speed adjusting spring is increased. The force resulting from the increased spring tension is transmitted through the rocker shaft lever and control linkage to the throttle control lever which advances the injector racks. Engine speed increases, as a result of the increased fuel, until the output shaft governor weight force is sufficient to balance the increased spring tension. The weights then move against the spring and reduce the injector rack fuel setting to an amount sufficient to maintain the higher engine speed setting.

If the operator moves the speed adjusting shaft lever to a decreased speed position, the tension on the speed adjusting spring will decrease and the governor weights will overcome the spring tension and move the rocker shaft lever to a decreased fuel position. The engine speed will be reduced until the force of the output shaft governor weights equals the tension of the speed adjusting spring. The engine will then operate at the desired reduced engine speed.

When a load is applied to the unit, the output shaft slows down and the force exerted by the governor flyweights is reduced, allowing the spring to move the rocker shaft lever to an increased fuel position to provide sufficient power to equal the new load.

When the load on the unit is removed, the output shaft speed will increase and the force exerted by the governor flyweights will increase, overcoming the spring tension and moving the rocker shaft lever to a decreased fuel position to reduce the power to match the reduced load.

Tune-Up

Adjust the exhaust valve clearance, time the fuel injectors and adjust the engine and output shaft governors as follows:

1. Adjust the exhaust valve clearance and time the injectors.

2. Disconnect the output shaft governor rod and the linkage to the engine governor operating lever. Then adjust the engine governor as outlined under Limiting Speed Mechanical Governor and Injector Rack Control Adjustment.

> **NOTE:** Set the No-Load engine speed to that specified on the engine option plate. The No Load speed varies with the converter used and the maximum output shaft speed setting.

3. Reconnect the linkage to the governor operating lever and check the total travel of the operating lever. The lever should move the stop (bolt) in one direction and the governor lever return spring should move the lever, in the other direction, until the throttle control lever reaches the end of its travel.

4. Move the governor operating lever to the maximum speed position (against the stop bolt).

5. Move the output shaft governor rocker shaft lever to the maximum fuel position and retain it by moving the speed adjusting lever to the full-speed position. Then move the output shaft governor lever and the throttle control lever together to the maximum speed position and retain there.

> **NOTE:** This operation closes the low speed gap which may require more torque than is available from the torsion spring between the above two levers. Thus, it is important that they be held together, permitting no space between the throttle control lever pin and the arm of the output shaft governor lever.

6. Adjust the output shaft governor rod length until it will just slide into the inner hole of the output shaft governor lever (Fig. 1). Then, increase the length of the rod until there is approximately. 020" clearance between the stop pin and the output shaft governor lever. Tighten the adjustment.

7. Adjust the governor operating lever return spring by retaining the rocker shaft lever in the full-speed position and increasing the tension on the spring by adjusting the eye bolt and nuts, until the tension of the torsion spring is overcome and the throttle control lever is moved against its stop in the idle position.

8. Move the output shaft governor speed adjusting lever to the minimum speed position and start the engine.

9. Advance the output shaft governor speed adjusting lever to the desired maximum output shaft speed and adjust the maximum speed adjusting bolt to retain the lever.

10. Move the output shaft governor speed adjusting shaft lever to the desired minimum speed position and adjust the minimum speed adjusting bolt to retain the lever.

11. Recheck the output shaft maximum and minimum speeds and readjust the position of, the speed adjusting bolts, if necessary.

12. To check the unit for stability as affected by governor speed droop, move the speed adjusting shaft lever, with the engine operating at no load, to the maximum speed position. Then move the output shaft governor rod to cause a speed decrease of several hundred rpm. Release the rod and check for hunting when the governor returns the engine to the maximum speed setting. If the engine stabilizes in less than three surges, the droop may be set too high; if the engine does not stabilize in five surges, the droop may be set too low. Set the speed droop as follows:

a. If the engine hunts less than three surges, back off the inner speed adjusting spring eye bolt nut one full turn and tighten the inner nut one turn to retain the adjustment. If the engine hunts more than five surges, back off the outer speed adjusting spring eye bolt nut one full turn and tighten the outer nut one turn to retain the adjustment.

> **NOTE**: The eye of the bolt must be in a horizontal plane to avoid twisting the spring.

b. Reset the maximum engine no-load speed, if necessary, as outlined in Steps 9 and 10.

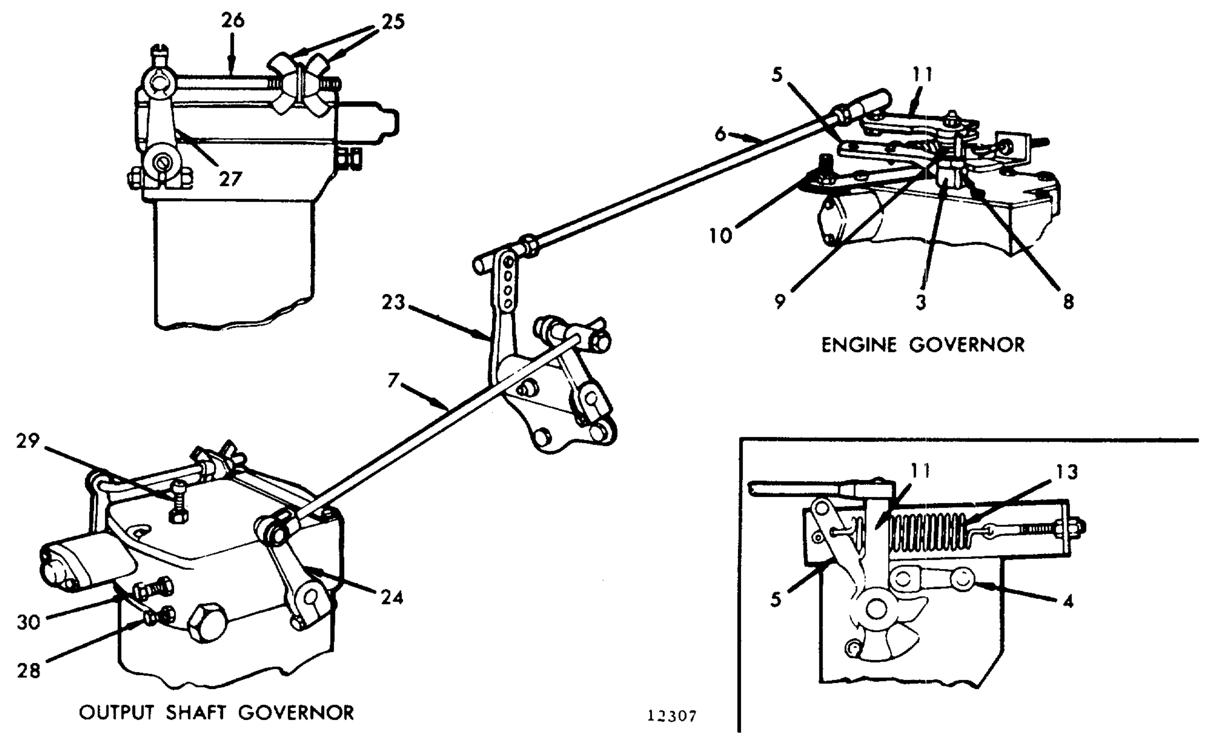
c. Recheck the speed droop. The engine speed should be stable when the governor droop is 7-1/2% to 10% of the full-load speed. For example, at an output shaft speed setting of 1800 rpm full load, the output shaft speed droop should be 150 to 200 rpm. Therefore, the no-load output shaft speed should be set at 1950 to 2000 rpm.

HYDRAULIC OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A hydraulic governor is used to maintain a near constant output shaft speed on engines equipped with a Series 500 or larger Torqmatic converter. The governor is mounted on the converter and gear driven from the output shaft.

The output shaft governor is connected to the engine governor by control rods and levers (Fig. 1). The control rod end ball joints are sealed assemblies and do not require lubrication. Other moving parts of the control linkage should be lubricated with engine oil.

In most applications, such as drag line and shovel operation, it is desirable to have the output shaft governor control the fuel input to maintain a relatively constant output shaft speed. The output shaft speed will be constant up to full power of the engine, except for the amount of governor droop. The speed setting of the engine governor must be sufficiently higher than the speed setting of the output shaft governor so the engine governor will not reduce the fuel input to the engine before full power is required by the output shaft governor. As load is applied to the output shaft, the output shaft speed will decrease gradually up to the amount of the output shaft governor droop at full



3. Lever--Throttle Control
4. Lever--Shutdown
5. Lever--Engine Governor Operating
6. Rod--Engine Governor
7. Rod--Output Shaft Governor
8. Pin--Stop
9. Spring--Torsion
10. Bolt (Stop)
11. Lever--Output Shaft Governor
13. Spring--Governor Lever Return
23. Lever--Throttle Control Rear Cross Shaft
24. Lever--Output Shaft Governor Control
25. Wing Nut--Speed Adjusting
26. Link--Sliding
27. Lever--Speed Control
28. Screw--Maximum Speed Limit Adjusting
29. Screw--Minimum Speed Limit Adjusting
30. Screw--Maximum Fuel Adjusting

Fig. 1. - Hydraulic Output Shaft Governor and Linkage

load. At the same time, the engine speed will gradually increase until full load is reached.

In some types of operation, such as laying of structural steel, it is desirable to operate the unit with a very low output shaft speed. This speed could be so low that the output shaft governor ball head assembly would not actuate the governor pilot valve and spring seat assembly. In such applications, the engine governor operating lever, used as an overrule lever, can be moved toward the idle speed position sufficiently to provide the desired low output shaft speed. Output shaft speeds down to zero can be obtained through this type of engine governor control. The engine governor would maintain control unless the output shaft speed increased to the speed setting of the output shaft governor.

Adjustments

The engine governor throttle control lever is pinned to the throttle shaft (Fig. 1). The engine governor operating lever is mounted below the throttle control lever and rides on the throttle shaft boss on the governor cover. The output shaft governor lever is mounted above the throttle control lever and is retained on the shaft by a snap ring. A stop pin, pressed into the throttle control lever, transmits movement of the output shaft governor lever and/or engine governor operating lever through the throttle control lever to the injector racks. The torsion spring, used to retain the throttle control lever stop pin against the output shaft governor lever, yields to permit the governor operating lever to move the throttle control lever toward the idle position, regardless of the position of the output shaft governor control lever. A slot in the underside of the governor cover hub limits the travel of the throttle control lever in both the maximum and minimum speed positions.

The engine shutdown lever is connected through a shaft to another lever, under the governor cover, which bears against the pin in the differential lever. To stop the engine, the shutdown lever is used to move the differential lever to the no-fuel position.

The following linkage and governor adjustments should be made with the engine stopped and after the limiting speed engine governor has been adjusted.

1. Connect the linkage to the governor operating lever and check the total travel of the lever. The lever should move to the stop bolt in one direction and the governor lever return spring should move the lever, in the other direction, until the throttle control lever reaches the end of its travel.

2. Move the governor operating lever to the maximum speed position (against the stop bolt).

3. Move the output shaft governor control lever to the full-fuel position and retain it by moving the speed control lever to the maximum speed position. Then move the output shaft governor lever (on the engine governor cover) and the throttle control lever together to the maximum speed position and retain there.

> **NOTE:** This operation closes the low speed gap (in the engine governor) which may require more torque than is available from the torsion spring between the two levers. Thus, it is important that they be held together, permitting no space between the throttle control lever pin and the arm of the output shaft governor lever.

4. To adjust the linkage between the output shaft governor and the engine governor, loosen the output shaft governor rod clamping bolt in the ball joint in the rear cross-shaft lever. Next, move the output shaft governor rod until there is approximately . 020" clearance between the stop pin and the output shaft governor lever. Then tighten the clamping bolt securely.

> **NOTE:** The engine governor control rod is connected to the outer bolt hole in the outputshaft governor lever.

5. To adjust the governor operating lever return spring, retain the output shaft governor control lever in the full-fuel position and increase the tension on the spring by adjusting the eye bolt and locknuts until the tension of the torsion spring is overcome and the throttle control lever is moved against the stop in the idle speed position.

Final Adjustments

Move the output shaft governor lever in the idle speed position and start the engine.

After the engine reaches normal operating temperature, advance the output shaft governor speed control lever to the maximum speed position and check the Torqmatic converter output shaft speed. This speed will vary depending upon engine application.

If it is necessary to adjust the output shaft speed, loosen the wing nuts on the sliding link and move the speed control lever to increase or decrease the speed as needed.

The output shaft governor is driven through the converter and there is a high droop. Therefore, the no load speed setting should be at least 150 rpm higher than the desired full-load speed setting. Tighten the wing nuts after completing the adjustment.

> **NOTE:** Do not set the Torqmatic converter output shaft speed in excess of the speed specified by the equipment manufacturer, to prevent damage to the driven machinery.

It will be noted during engine operation that the minimum droop will vary between 150 and 175 rpm. If the droop requires adjustment, move the droop bracket (inside the output shaft governor) to decrease or increase the amount of droop

> **NOTE:** To compensate for the output shaft speed droop, the engine no-load speed must be set approximately 175 rpm above the required engine full-load speed.

Move the output shaft governor speed control lever to the idle speed position and adjust the idle speed by means of the minimum speed limit adjusting screw.

The maximum fuel adjusting screw and the maximum speed limit adjusting screw are not used and should be backed out to prevent interference.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

ENGINE LOAD LIMIT DEVICE

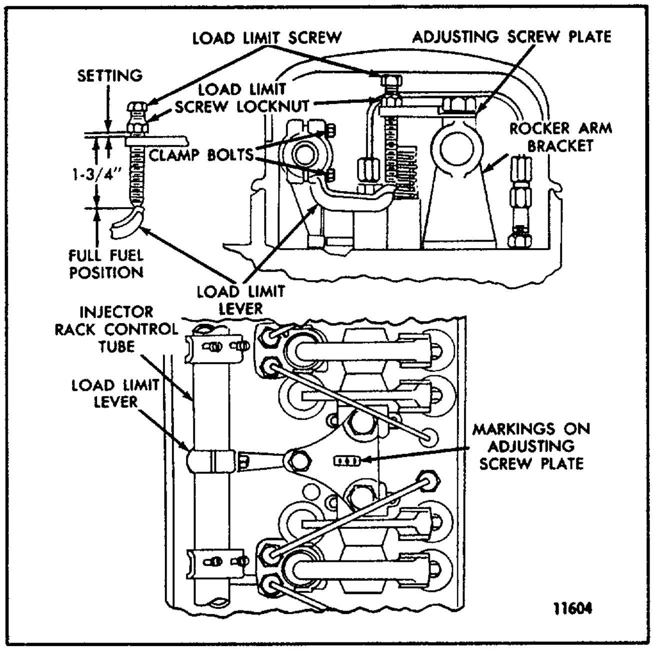


Fig. 1. - Engine Load Limit Device

Engines with mechanical governors may be equipped with a load limit device (Fig. 1) to reduce the maximum horsepower.

This device consists of a load limit screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a load limit lever clamped to the injector control tube.

The load limit device is located between the No. 1 and No. 2 cylinders on each cylinder bank of a 6V engine, between the No. 2 and No. 3 cylinders on each cylinder bank of an 8V engine, or between the No. 3 and No. 4 cylinders on each cylinder bank of a 12V engine. On the 16V engine, four load limit devices are used (one on each cylinder head): between the No. 2 and No. 3 cylinder and between the No. 6 and No. 7 cylinder on each bank.

When properly adjusted for the maximum horsepower desired, this device limits the travel of the injector control racks and thereby the fuel output of the injectors.

Adjustment

After the engine tune-up is completed, make sure the load limit devices are properly installed as shown in Fig. 1. Make sure the counterbores in the adjusting screw plates are up. The rocker arm shaft bracket bolts which fasten the adjusting screw plate to the brackets are tightened to 75-85 lb-ft (102-115 Nm) torque (all other rocker arm shaft bracket bolts are tightened to 90-100 lb-ft or 122-136 Nm torque). Then adjust the load limit device, on each cylinder head, as follows:

1. Loosen the load limit screw locknut and remove the screw.

2. Loosen the load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

3. With the screw out of the plate, adjust the load screw locknut so the bottom of the locknut is 1 3/4" from the bottom of the load limit screw for the initial setting (Fig. 1).

4. Thread the load limit screw into the adjusting screw plate until the locknut bottoms against the top of the plate.

5. Hold the injector rack control tube in the full-fuel position and place the load limit lever against the bottom of the load limit screw. Then tighten the load limit lever clamp bolts.

6. Check to ensure that the injector racks will just go into the full-fuel position -- readjust the load limit lever, if necessary.

7. Hold the load limit screw to keep it from turning, then set the locknut until the distance between the bottom of the locknut and the top of the adjusting screw plate corresponds to the dimension (or number of turns) stamped on the plate.

NOTE: If the plate is not stamped, adjust the load limit screw while operating the engine on a dynamometer test stand and note the number of turns required to obtain the desired horsepower. Then stamp the plate accordingly.

8. Thread the load limit screw into the plate until the locknut bottoms against the top of the plate. Be sure the nut turns with the screw.

9. Hold the load limit screw to keep it from turning, then tighten the locknut to secure the setting.

THROTTLE DELAY MECHANISM

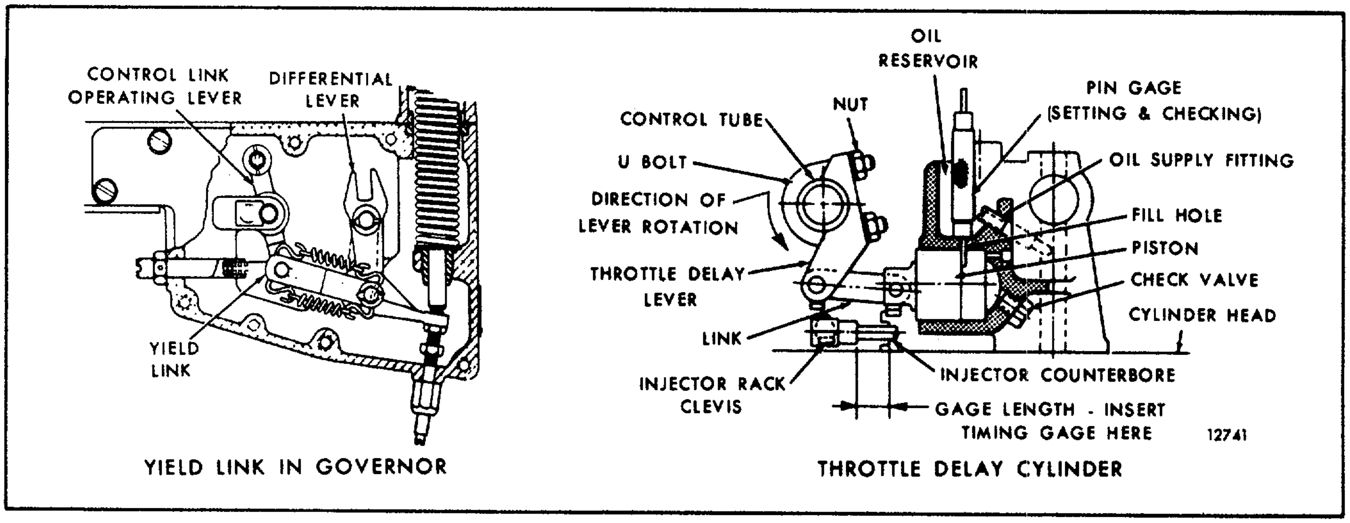


Fig. 2. - Throttle Delay Cylinder and Yield Link

The throttle delay mechanism is used to retard fullfuel injection when the engine is accelerated. This reduces exhaust smoke and also helps to improve fuel economy.

The throttle delay mechanism is installed between the No. 1 and No. 2 cylinders on the right-bank cylinder head (Fig. 2). It consists of a special rocker arm shaft bracket (which incorporates the throttle delay cylinder), a piston, throttle delay lever, connecting link, orifice plug, ball check valve and U-bolt.

A yield link replaces the standard operating lever connecting link in the governor.

Adjustment

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be readjusted. With the engine stopped, proceed as follows:

1. Refer to Fig. 3 and insert the timing gage between the injector body and the shoulder on the injector rack clevis of the injector nearest the throttle delay cylinder. (570" setting J 25559 with the, 069" and, 072" pin gage-J 25558).

2. Hold the governor throttle in the maximum speed position. This should cause the injector rack to move toward the full-fuel position and against the gage.

3. Insert the pin gage J 25558 (. 072" diameter setting end) in the cylinder fill hole.

4. Rotate the throttle delay lever in the direction shown in Fig. 3 until further movement is limited by the piston contacting the pin gage.

5. Tighten the U-bolt nuts while exerting a slight amount of torque on the lever; in the direction of rotation. Be careful not to bend the gage or damage the piston by using excessive force.

6. Check the setting as follows:

   a. Remove the pin gage.

   b. Attempt to reinstall the pin gage. It should not be possible to reinsert the gage without moving the injector racks toward the no-fuel position.

   c. Reverse the pin gage to the 069" diameter end and insert it in the cylinder fill hole. It should enter the cylinder without resistance.

NOTE: If the 072" diameter end of the pin gage enters the fill hole (Step 6b), increase the torque on the upper U-bolt nut. If the 069" diameter will not enter the fill hole (Step 6c) without resistance, increase the torque on the lower U-bolt nut.

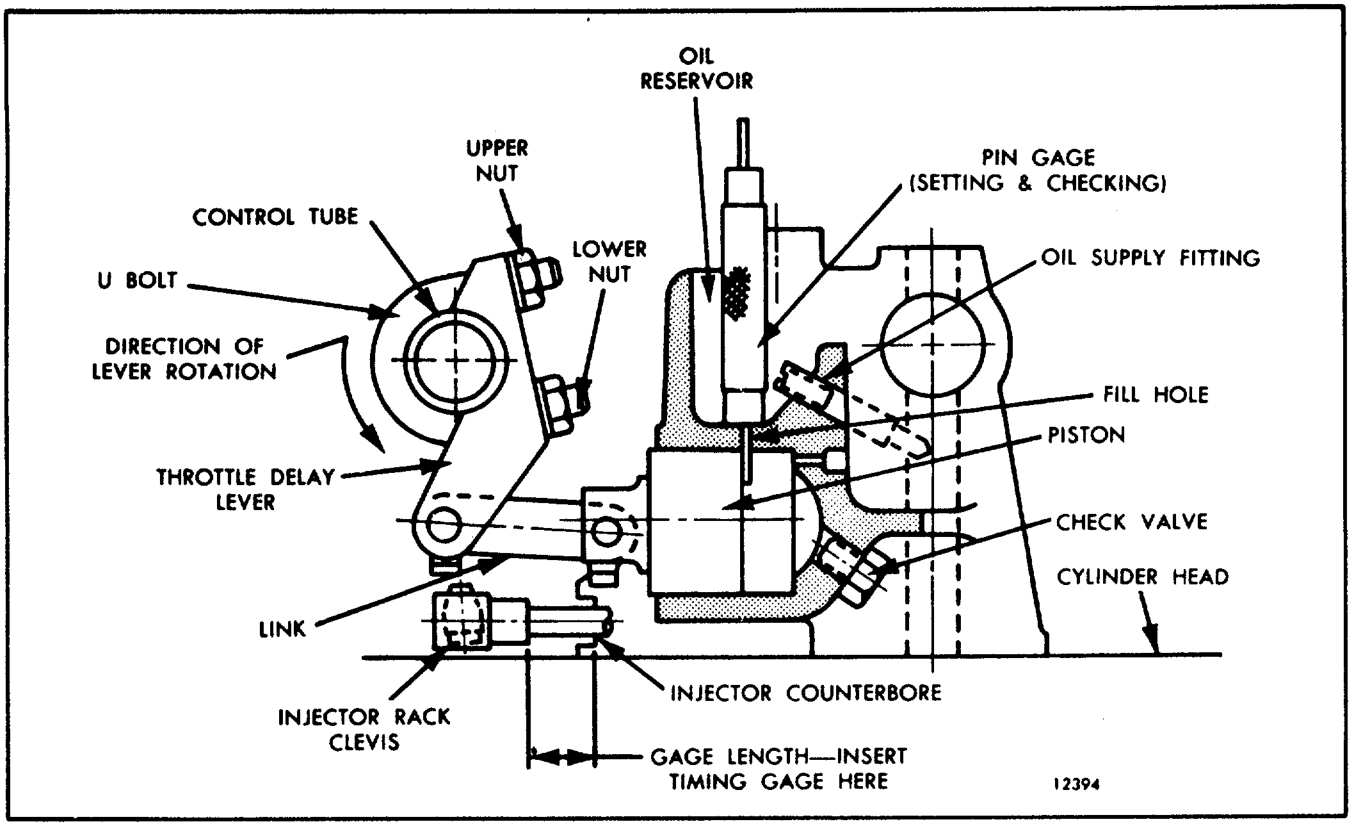


Fig. 3. - Adjusting Throttle Delay Cylinder

7. Release the governor throttle and remove the timing gage and pin gage.

8. Move the injector control tube assembly from the no-fuel to the full-fuel position to make sure there is no bind.

ADJUSTMENT OF MECHANICAL GOVERNOR SHUTDOWN SOLENOID

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor. the governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel.

The solenoid plunger can be properly aligned to the governor stop lever as follows:

I. Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs. 4 and 5). Align and clamp the lever to the shutdown shaft in such a way that, at its mid-travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible. The solenoid plunger has available 1/2" travel which is more than adequate to move the injector control racks from the full-fuel to the complete no-fuel position and shutdown will occur prior to attaining complete travel.

2. With the stop lever in the run position, adjust the

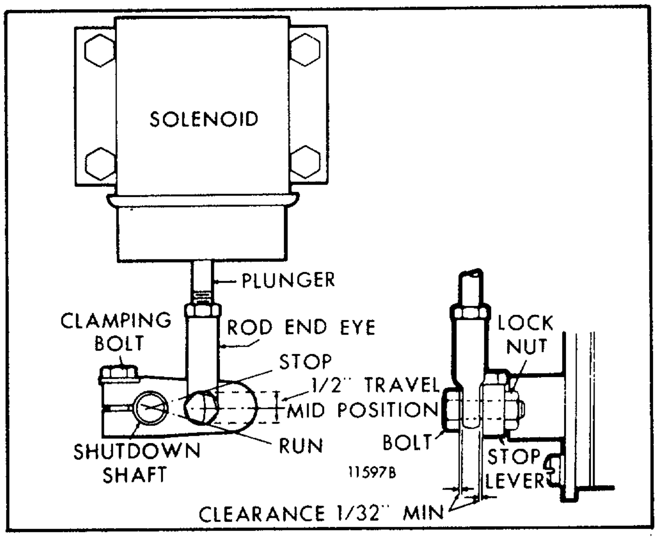


Fig. 4. - Typical Variable Speed Governor Lever Position

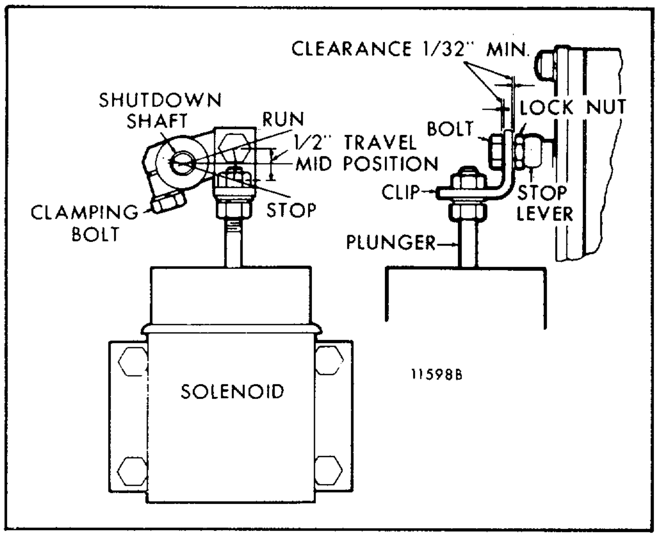


Fig. 5. - Typical Limiting Speed Governor Lever Position

rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap. with a resultant build-up of the pull-in force prior to initiating stop lever movement.

3. The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32" minimum.

NOTE: The locknut can be either on top of or below the stop lever.

4. Move the lever to the stop position and observe the plunger for any possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger motion.

STORAGE

PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 days or less)

To protect an engine for a temporary period of time, proceed as follows:

1. Drain the engine crankcase.

2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.

3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

> **NOTE**: Do not drain the fuel system or the crankcase after this run.

4. Check the air cleaner and service it, if necessary, as outlined under Air System-Section 2.

5. If freezing weather is expected during the storage period, add an ethylene glycol base antifreeze solution in accordance with the manufacturer’s recommendations. Drain the raw water system and leave the drain cocks open.

6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with air.

7. Seal all of the engine openings. The material used for this purpose must be water proof, vapor proof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission and priming the raw water pump, if’ used.

EXTENDED STORAGE (more than 30 days)

To prepare an engine for extended storage, (more than 30 days), follow this procedure:

1. Drain the cooling system and flush with clean, soft water. Refill with clean, soft water and add a rust inhibitor to the cooling system (refer to Corrosion Inhibitor under Engine Coolant-Section 5).

2. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.

3. Reinstall the injectors, time them and adjust the exhaust valve clearance.

4. Circulate the coolant by operating the engine until normal operating temperature is reached (160-185 F or 71-85 ° C).

5. Stop the engine.

6. Drain the engine crankcase, then reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.

7. Fill the crankcase to the proper level with a 30-weight preservative lubricating oil MIL-L-21260B, Grade 2.

8. Drain the fuel tank. Refill with enough clean fuel oil to permit the engine to operate for about ten minutes.

9. Drain and disassemble the fuel filter and strainer. Discard the used elements and gaskets. Wash the shells in clean fuel oil and insert new elements. Fill the cavity between the element and shell about two-thirds full of fuel oil and reinstall on the engine. If spin-on

fuel filters and strainers are used, discard the used cartridges, fill the new ones two-thirds full of fuel oil and reinstall on the engine.

10. Operate the engine for five minutes to circulate the clean fuel oil throughout the engine.

11. Refer to Air System-Section 2 and service the air cleaner.

12. MARINE GEAR

a. Drain the oil completely and refill with clean oil of the recommended grade and viscosity. Remove and clean or replace the strainer and filter element.

b. Start and run the engine at 600 rpm for 10 minutes to coat all of the internal parts of the marine gear with clean oil. Engage the clutches alternately to circulate clean oil through all of the moving parts.

13. TORQMATIC CONVERTER

a. Start and operate the engine until the temperature of the converter oil reaches 150 OF (66 ° C).

b. Stop the engine, remove the converter drain plug and drain the converter.

c. Remove the filter element.

d. Start the engine and stall the converter for twenty seconds at 1000 rpm to scavenge the oil from the converter. Due to lack of lubrication, do not exceed the 20 second limit.

e. Install the drain plug and a new filter element.

f. Fill the converter to the proper operating level with a commercial preservative oil which meets Government specifications MIL-L-21260B, Grade 2. Oil of this type is available from the major oil companies.

g. Start the engine and operate the converter for at least 10 minutes at a minimum of 1000 rpm. Engage the clutch, then stall the converter to raise the oil temperature to 225 ° F (107' C).

NOTE: Do not allow the oil temperature to exceed 225°F (107°C). If the unit does not have a temperature gage, do not stall the converter for more than thirty seconds.

h. Stop the engine and allow the converter to cool to a temperature suitable to the touch.

i. Seal the breather and all of the exposed openings with moisture proof tape.

j. Coat all exposed, unpainted surfaces with preservative grease. Position all of the controls for minimum exposure and coat them with grease. The external shafts, flanges and seals should also be coated with grease.

14. POWER TAKE-OFF

a. Use an all purpose grease such as Shell Alvania No. 2, or equivalent, and lubricate the clutch throwout bearing, clutch pilot bearing, drive shaft main bearing, clutch release shaft and the outboard bearings (if so equipped).

b. Remove the inspection hole cover on the clutch housing and lubricate the clutch release lever and link pins with a hand oiler. Avoid getting oil on the clutch facing.

c. If the unit is equipped with a reduction gear, drain the gear box and flush with light engine oil. If the unit is equipped with a filter, clean the shell and replace the filter element. Refill the gear box to the proper level with the grade of oil indicated on the name plate.

15. TURBOCHARGER

Since turbocharger bearings are pressure lubricated through the external oil line leading from the engine cylinder block while the engine is operating, no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture resistant tape.

16. Apply a non-friction rust preventive compound to all exposed parts. If convenient, apply the rust preventive coupound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

NOTE: Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip. 17. Drain the engine cooling system.

18. Drain the preservative oil from the engine crankcase. Reinstall and tighten the drain plug.

19. Remove and clean the battery and battery cables with a baking soda-water solution and rinse them with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32 F or O ° C) dry place.

Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.

20. Insert heavy paper strips between the pulleys and belts to prevent sticking.

21. Seal all engine openings, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

22. Clean and dry the exterior painted surfaces of the engine and spray with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

24. Protect the engine with a good weather-resistant tarpaulin and store it under cover, preferably in a dry building which can be heated during the winter months.

Detroit Diesel Allison does not recommend the outdoor storage of engines (or transmission). Nevertheless, DDA recognizes that in some cases outdoor storage may be unavoidable. If units must be kept out-off-doors, follow the preparation and storage instructions already given. Protect units with quality, weather-resistant tarpaulins (or other suitable covers) arranged to provide air circulation.

> **NOTE:** Do not use plastic sheeting for outdoor storage. Plastic is fine for indoor storage. When used outdoors, however, enough moisture can condense on the inside of the plastic to rust ferrous metal surfaces and pit aluminum surfaces. If a unit is stored outside for any extended period of time, severe corrosion damage can result.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

PROCEDURE FOR RESTORING AN ENGINE TO SERVICE WHICH HAS BEEN IN EXTENDED STORAGE

1. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. Do not overlook the exhaust outlet.

2. Wash the exterior of the engine with fuel oil to remove the rust preventive.

3. Remove the rust preventive from the flywheel.

4. Remove the paper strips from between the pulleys and the belts.

5. Remove the drain plug and drain the preservative oil from the crankcase. Reinstall the drain plug. Then refer to Lubrication System in the Operating Instructions Section 4 and fill the crankcase to the proper level with the recommended grade of lubricating oil.

6. Fill the fuel tank with the fuel specified under Fuel Specifications-Section 5.

7. Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, add an ethylene glycol base antifreeze solution to the cooling system (the antifreeze contains a rust inhibitor).

8. Install and connect the battery.

9. Service the air cleaner as outlined under Air System-Section 2.

10. POWER GENERATOR

Prepare the generator for starting as outlined under Operating Instructions-Section 4.

11. MARINE GEAR

Check the Marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.

12. TORQMATIC CONVERTER

a. Remove the tape from the breather and all of the openings.

b. Remove all of the preservative grease with a suitable solvent.

c. Start the engine and operate the unit until the temperature reaches 150°F (660C). Drain the preservative oil and remove the filter. Start the engine and stall the converter for twenty seconds at 1000 rpm to scavenge the oil from the converter.

> **NOTE:** A Torqmatic converter containing preservative oil should only be operated enough to bring the oil temperature up to 150°F (66 o C).

d. Install the drain plug and a new filter element.

e. Refill the converter with the oil that is recommended under Lubrication and Preventive Mainte- nance-Section 5.

13. POWER TAKE-OFF

Remove the inspection hole cover and inspect the clutch release lever and link pins and the bearing ends of the clutch release shaft. Apply engine oil sparingly, if necessary, to these areas.

14. TURBOCHARGER

a. Thoroughly clean the area around the turbo charger air inlet tube and the oil inlet line.

b. Disconnect the air inlet tube from the compressor housing.

c. Disconnect the oil inlet line from the top of the center housing.

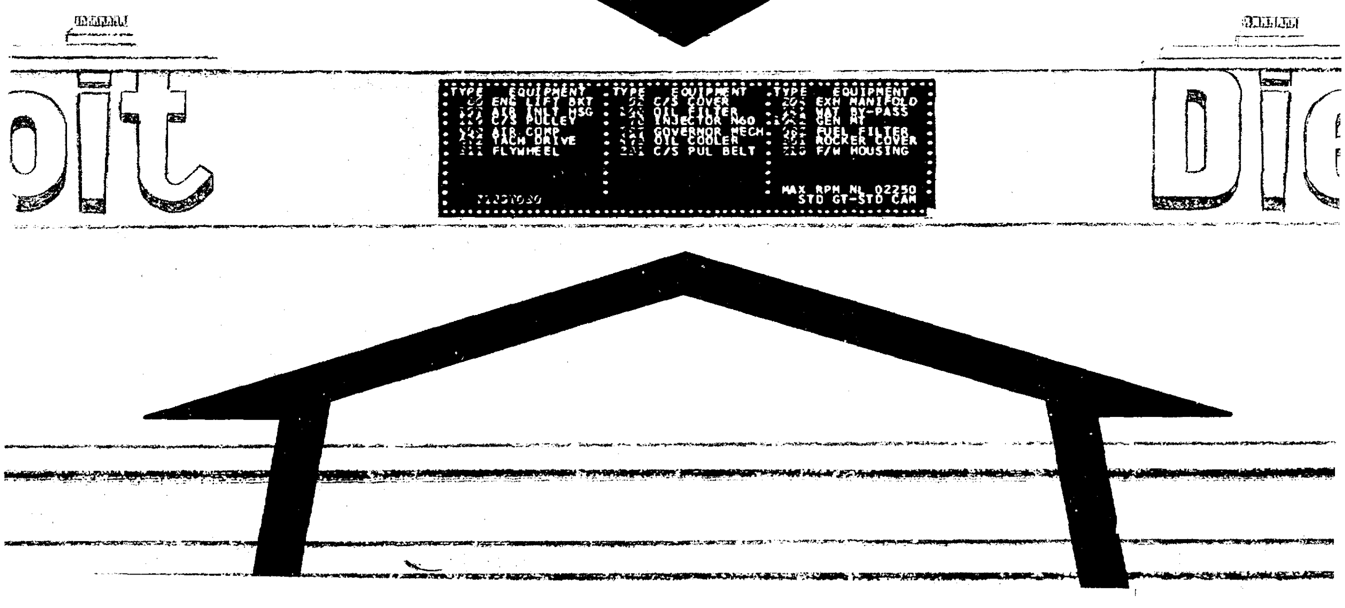
d. Pour approximately four ounces of lubricating oil in the oil inlet opening of the center housing. Reach in through the air inlet opening in the compressor housing and turn the rotating assembly by hand to coat the bearings, thrust ring and thrust washer with oil. Then fill the oil inlet line with engine oil.

e. Connect the oil inlet line to the top of the center housing. Then connect the air inlet tube to the compressor housing.

15. After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

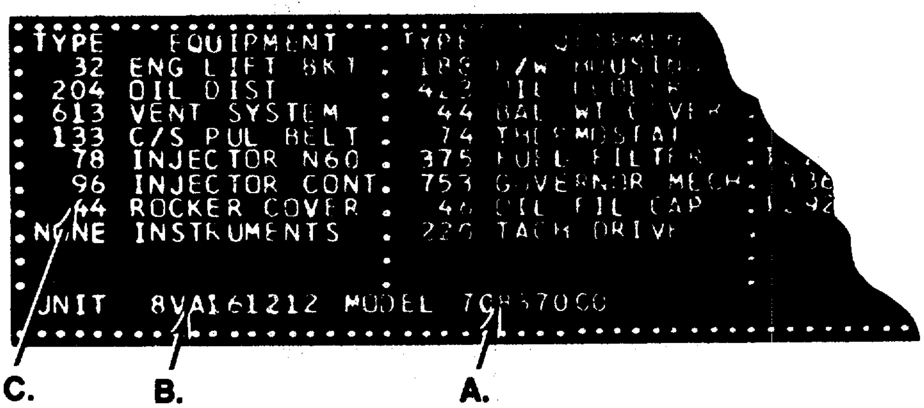
NOTE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

BUILT-IN PARTS BOOK for DETROIT DIESEL ENGINES



Progress in industry comes at a rapid pace. In order for the engine manufacturer to keep pace with progress he needs a versatile product for the many models and arrangements of accessories and mounting parts needed to suit a variety of equipment. In addition, engine refinements and improvements are constantly being introduced. All of this dynamic action must be documented so that the equipment can be serviced if and when it's needed. It is fully documented in the manufacturer's plant and in dealer Parts Departments with Master Files and adequate supporting records. But, what about YOU the user of this equipment? You have neither the time nor the inclination to ferret out specific part number data. What is the answer?-It is Detroit Diesel's exclusive BUILT-IN PARTS BOOK which is furnished with each engine. It takes the form of an "Option Plate" mounted on the rocker cover of the engine. With it, ordering parts becomes as simple as A, B, C. You have merely to provide the Dealer with . . .

A. The "Model" number B. The "UNIT" number C. The "TYPE" number

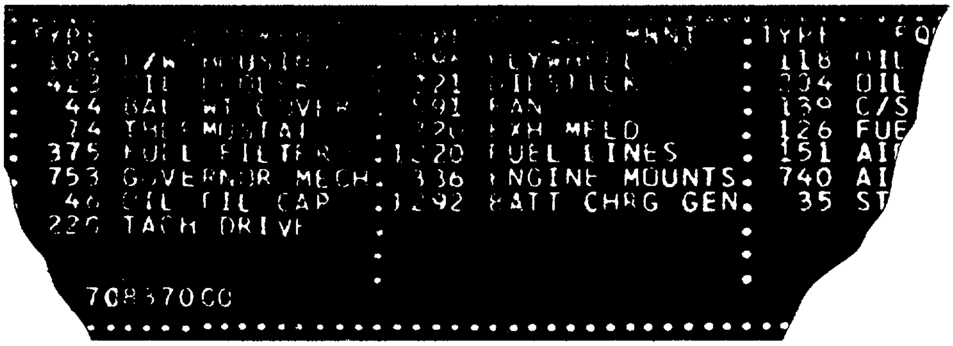


TYPE	EQUIPMENT	TYPE	EQUIPMENT
32	ENG LIFT BKT	188	F/W HOUSING
204	OIL DIST	423	OIL COOLER
613	VENT SYSTEM	44	BAL WT COVER
133	C/S PUL BELT	74	THERMOSTAT
78	INJECTOR N60	375	FUEL FILTER
96	INJECTOR CONT	753	GOVERNOR MECH
44	ROCKER COVER	46	OIL FIL CAP
NONE	INSTRUMENTS	220	TACH DRIVE

UNIT 8VA161212 MODEL 70857000

From that much information, the dealer with his complete records on all engine models, can completely interpret your parts requirements.

What is this "built-in" book? It is a photo etched aluminum option plate that fits into a holding channel on the engine rocker cover.



SHOWN IN COLUMN'S, the type numbers and equipment descriptions represent specific groups of functionally related parts installed on the engine as optional equipment. The components making up these groups are found in the parts catalog microfiche under the "type" number of the appropriate equipment category.

The engine unit and model numbers appear at the bottom of the plate, as shown on the preceding page, along with the governed maximum rpm, no-load setting, and engine timing.

All engine components are divided into groups of functionally related parts. A complete listing of the twelve major groups and their many sub-groups is shown below.

GROUP NOMENCLATURE

1.0000 ENGINE (less major assemblies)

1.1000	Cylinder Block
1.1000A	Air Box Drains
1.2000	Cylinder Head
1.2000A	Engine Lifter Bracket
1.3000	Crankshaft
1.3000A	Crankshaft Front Cover
1.3000B	Vibration Damper
1.3000C	Crankshaft Pulley
1.3000D	Crankshaft Pulley Belt
1.4000A	Flywheel
1.5000A	Flywheel Housing
1.5000B	Flywheel Housing Adaptor
1.6000	Connecting Rod and Piston
1.7000	Camshaft and Gear Train
1.7000A	Balance Weight Cover
1.7000B	Accessory Drive
1.8000	Valve and Injector Operating Mechanism
1.8000A	Rocker Cover

2.0000 FUEL SYSTEM

2.1000A	Fuel Injector
2.2000	Fuel Pump
2.2000A	Fuel Pump Drain
2.3000A	Fuel Filter
2.4000	Fuel Manifold and/or Connections
2.5000A	Fuel Lines
2.6000A	Fuel Tank
2.7000A	Mechanical Governor
2.8000A	Hydraulic Governor
2.9000	Injector Controls
2.9000A	Throttle Controls

3.0000 AIR SYSTEM

3.1000A	Air Cleaner and/or Adaptor
3.2000A	Air Silencer
3.3000A	Air Inlet Housing
3.4000	Blower
3.4000A	Blower Drive Shaft
3.5000A	Turbocharger

4.0000 LUBRICATING SYSTEM

4.1000A	Oil Pump
4.1000B	Oil Distribution System
4.1000C	Oil Pressure Regulator
4.2000A	Oil Filter
4.3000A	Oil Filter Lines
4.4000A	Oil Cooler
4.5000A	Oil Filler
4.6000A	Dipstick
4.7000A	Oil Pan
4.8000A	Ventilating System

5.0000 COOLING SYSTEM

5.1000	Fresh Water Pump
5.1000A	Fresh Water Pump Cover
5.2000A	Water Outlet Manifold and/or Elbow
5.2000B	Thermostat
5.2000C	Water By-pass Tube
5.3000A	Radiator
5.3000B	Water Connections
5.4000A	Fan
5.4000B	Fan Shroud
5.5000A	Heat Exchanger or Keel Cooling
5.6000A	Raw Water Pump
5.7000A	Water Filter

6.0000 EXHAUST SYSTEM

6.1000A	Exhaust Manifold
6.2000A	Exhaust Muffler and/or Connections

7.0000 ELECTRICAL-INST.RUMENTS

7.1000A	Battery Charging Generator
7.2000B	Automatic Starting
7.3000A	Starting Motor
7.4000A	Instruments
7.4000B	Tachometer Drive
7.4000C	Shut-off or Alarm System
7.5000A	Power Generator
7.6000A	Control Cabinet
7.7000A	Wiring Harness
7.8000A	Air Heater

8.0000 POWER TAKE-OFF

8.1000A	Power Take-off and/or Clutch
8.3000A	Torque Converter
8.3000B	Transmission Lines

9.0000 TRANSMISSION AND PROPULSION

9.1000A	Hydraulic Marine Gear
9.3000A	Power Transfer Gear
9.4000	Transmission-Highway
9.7000	Transmission- Cff-highway

10.0000 SHEET METAL

10.1000A	Engine Hood

11.0000 ENGINE MOUNTING

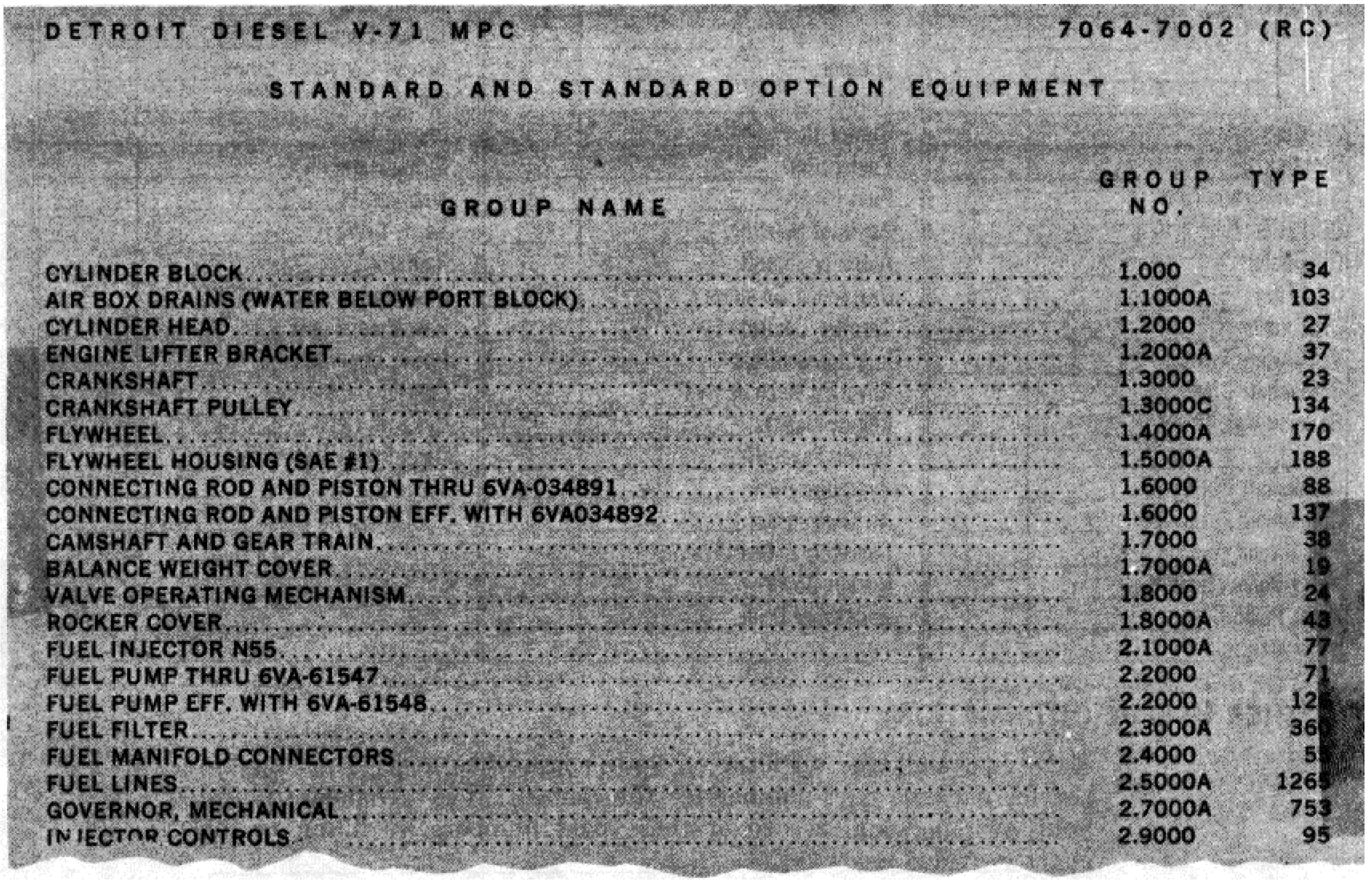
11.1000A	Engine Mounting and Base

12.0000 MISCELLANEOUS

12.2000A	Bilge Pump
12.3000A	Vacuum Pump
12.4000A	Air Compressor
12.5000A	Hydraulic Pump
12.6000A	Gasoline Starter
12.6000B	Air Starter
12 6000C	Cold Weather Starting Aid
12 6000D	Hydraulic Starter
12.6000E	Hydraulic Starter Accessories

Within each of these sub-groups, various designs of similar equipment are categorized as "Types" and identified by a Type Number.

The Distributor/Dealer has an Index for each engine model. The Index lists all of the "Standard" and "Standard Option" equipment for that model.



DETROIT DIESEL V-71 MPC 7064-7002 (RC)

STANDARD AND STANDARD OPTION EQUIPMENT

GROUP NAME	GROUP NO.	TYPE
CYLINDER BLOCK	1.000	34
AIR BOX DRAINS (WATER BELOW PORT BLOCK)	1.1000A	103
CYLINDER HEAD	1.2000	27
ENGINE LIFTER BRACKET	1.2000A	37
CRANKSHAFT	1.3000	23
CRANKSHAFT PULLEY	1.3000C	134
FLYWHEEL	1.4000A	170
FLYWHEEL HOUSING (SAE #1)	1.5000A	188
CONNECTING ROD AND PISTON THRU 6VA-034891	1.6000	88
CONNECTING ROD AND PISTON EFF. WITH 6VA034892	1.6000	137
CAMSHAFT AND GEAR TRAIN	1.7000	38
BALANCE WEIGHT COVER	1.7000A	19
VALVE OPERATING MECHANISM	1.8000	24
ROCKER COVER	1.8000A	43
FUEL INJECTOR N55	2.1000A	77
FUEL PUMP THRU 6VA-61547	2.2000	71
FUEL PUMP EFF. WITH 6VA-61548	2.2000	12
FUEL FILTER	2.3000A	36
FUEL MANIFOLD CONNECTORS	2.4000	5
FUEL LINES	2.5000A	126
GOVERNOR, MECHANICAL	2.7000A	753
INJECTOR CONTROLS	2.9000	95

NOTE The Distributor/Dealer uses his model index to interpret the standard equipment. The plate, therefore, lists only the non-standard or choice items.

So, from the plate, give the dealer the

A - Model No. _________
B - Unit No. _________
*** C - Type No.** _________
*(If not shown, indicate "NONE". The dealer knows the "standard" for the model).

FOR READY REFERENCE, Transfer the information on the Option Plate to this record.

MODEL NO. **UNIT NO.**

EQUIPMENT	TYPE	EQUIPMENT	TYPE	EQUIPMENT	TYPE
Engine Base		Water Bypass Tube		Battery Chrg. Generator	
Engine Lifter Brkt.		Thermostat		Starter	
Flywheel Housing		Water Filter		Hyd. Starter Acces.	
Vibration Damper		Exhaust Manifold		Starting Aid	
Flywheel		Air Cleaner or Silencer		Marine Gear	
Flywheel Hsg. Adptr.		Fuel Pump		Torque Converter	
Oil Pan		Injector		Torque Converter Lines	
Oil Pump		Blower		Muffler & Conn.	
Oil Distribution		Blower Drive Shaft		Engine Hood	
Dipstick		Fuel Filter		Wiring Harness	
Oil Pan Drain Tube		Fuel Lines		Instruments	
Oil Filler Tube or Cap		Air Inlet Housing		Tach. Drive	
Oil Cooler		Alarm or Shutoff		Radiator	
Oil Filter		Overspeed Governor		Heat Ex. or Keel Cooling	
Oil Lines		Throttle Controls		Raw Water Pump	
Ventilating System		Injector Controls		Power Generator	
Crankshaft Cover		Governor Mech or Hyd		Control Cabinet	
Balance Wgt. Cover		Engine Mounts		Cylinder Head	
Fan		Power Take-off		Conn Rod & Piston	
Crankshaft Pulley		Hydraulic Pump		Valve Mechanism	
Crankshaft Pulley Belt		Air Compressor		Fuel Manifold Conn	
Fan Shroud		Camshaft & Gear Train			
Water Connections		Rocker Cover			
Water Pump Cover		Accessory Drive			
Water Manifold					

OTHER USEFUL INFORMATION:

Each fuel and lube oil filter on your engine has a decal giving the service package part number for the element. It is advisable to have your own personal record of these part numbers by filling in the chart provided below:

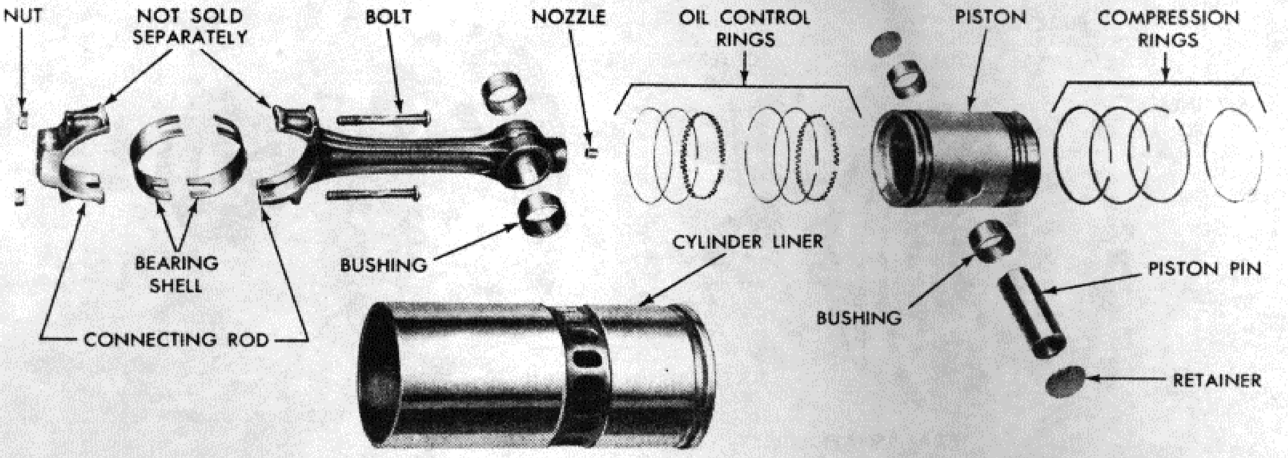
TYPE	LOCATION	PACKAGE PART
Fuel Strainer		
Fuel Filter		
Lube Oil Filter Full-Flo		
Lube Oil Filter By-Pass*		

*Not Standard

AIR CLEANER

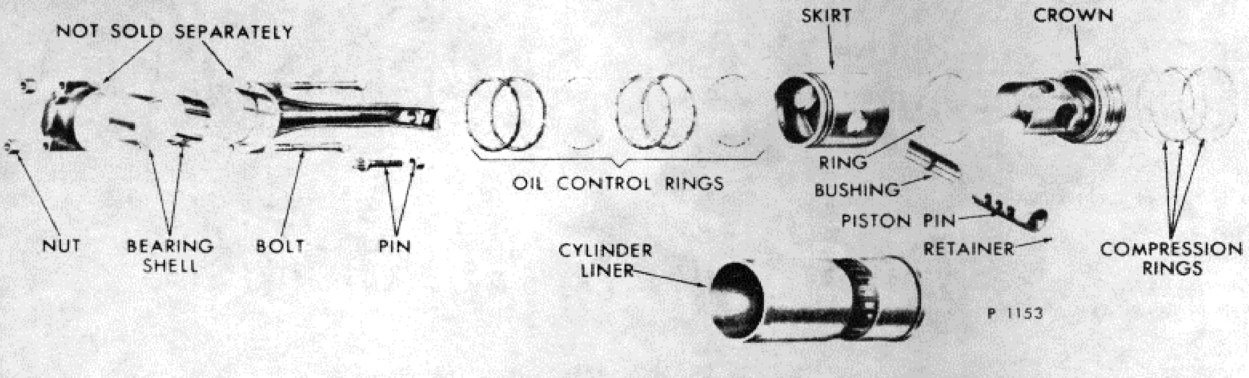
If dry-type, indicate make and number of filter element:

Wet type, indicate capacity ________qts.

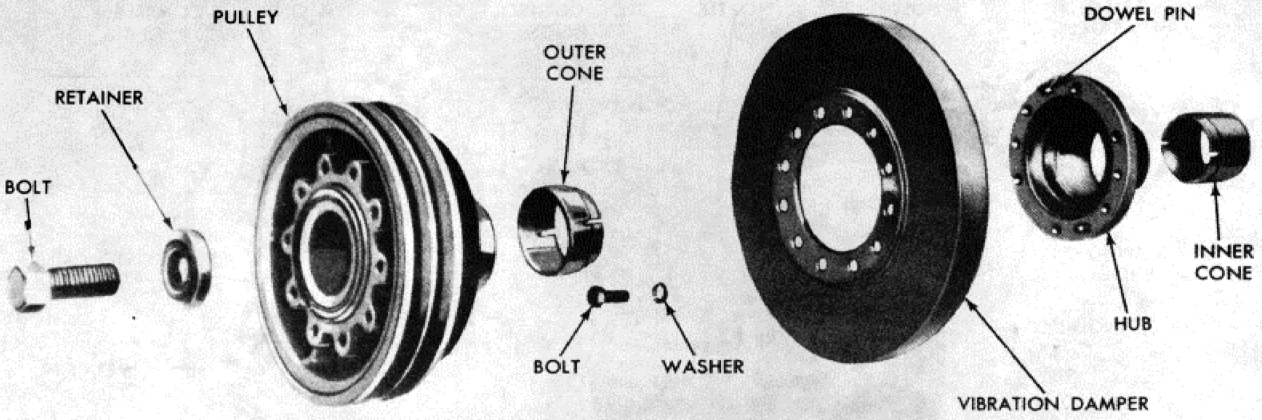


CONNECTING ROD AND PISTON

P 607B

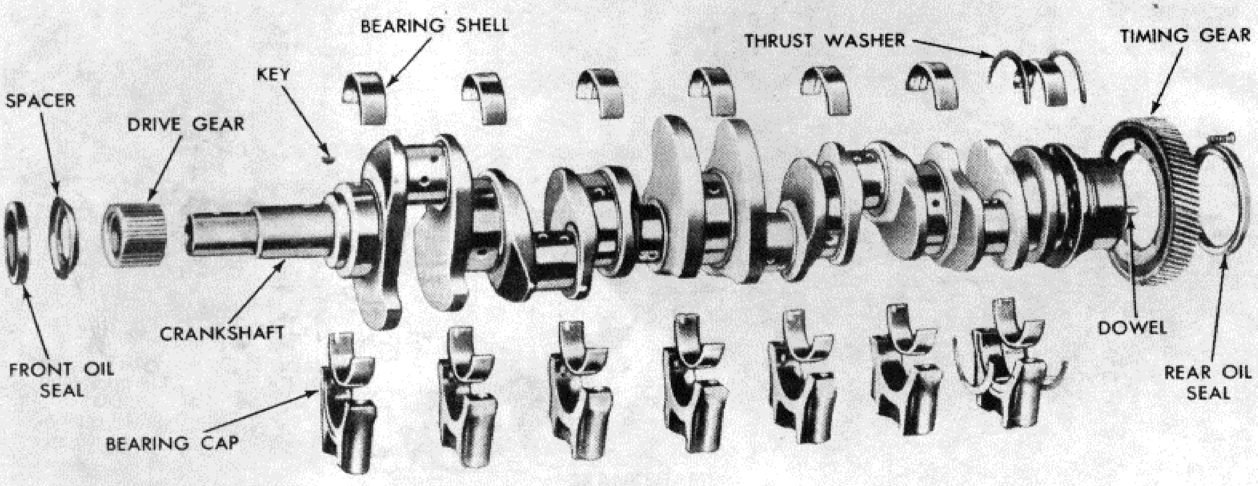


P 1153



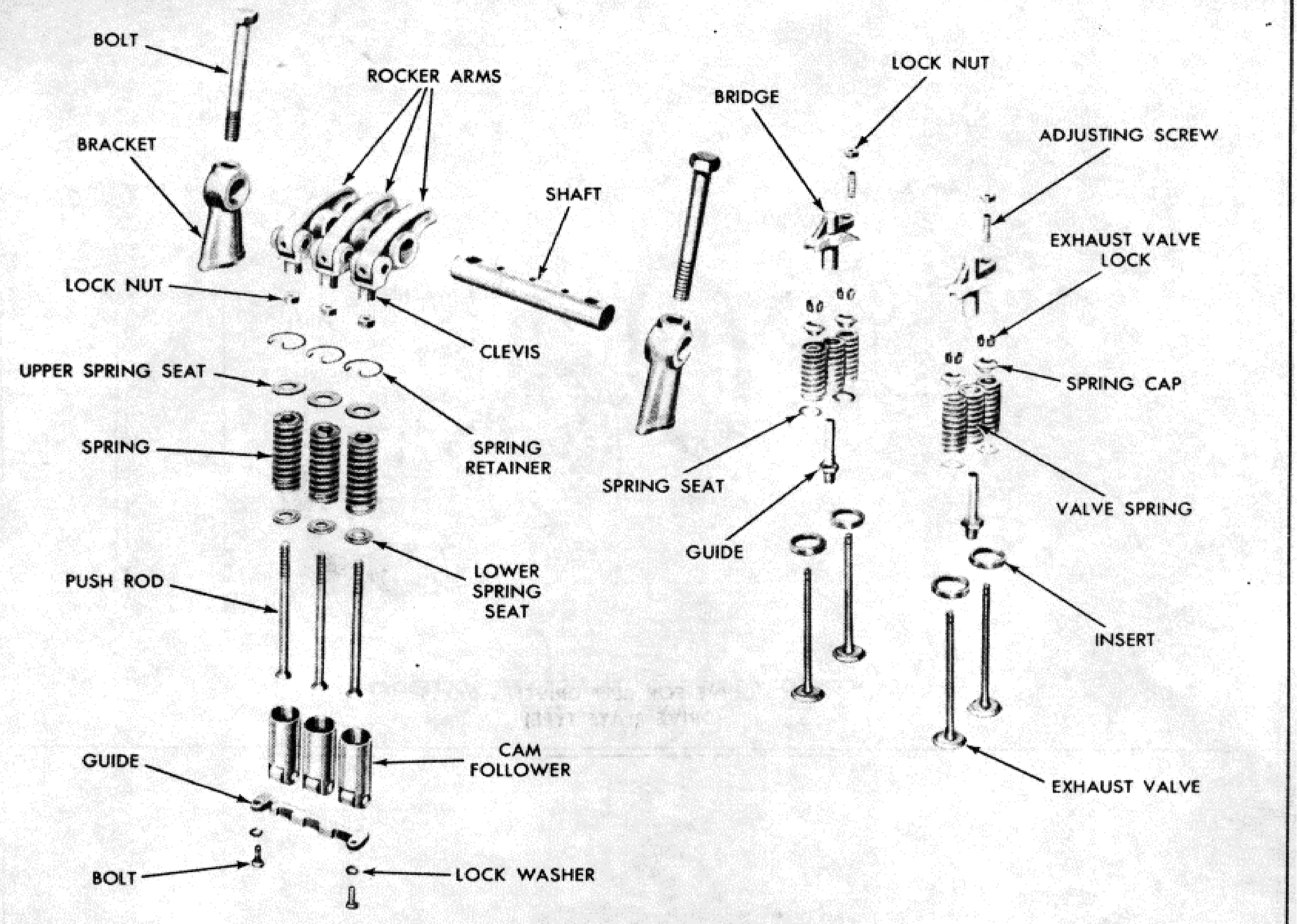
CRANKSHAFT PULLEY, VIBRATION DAMPER AND HUB

P 607A



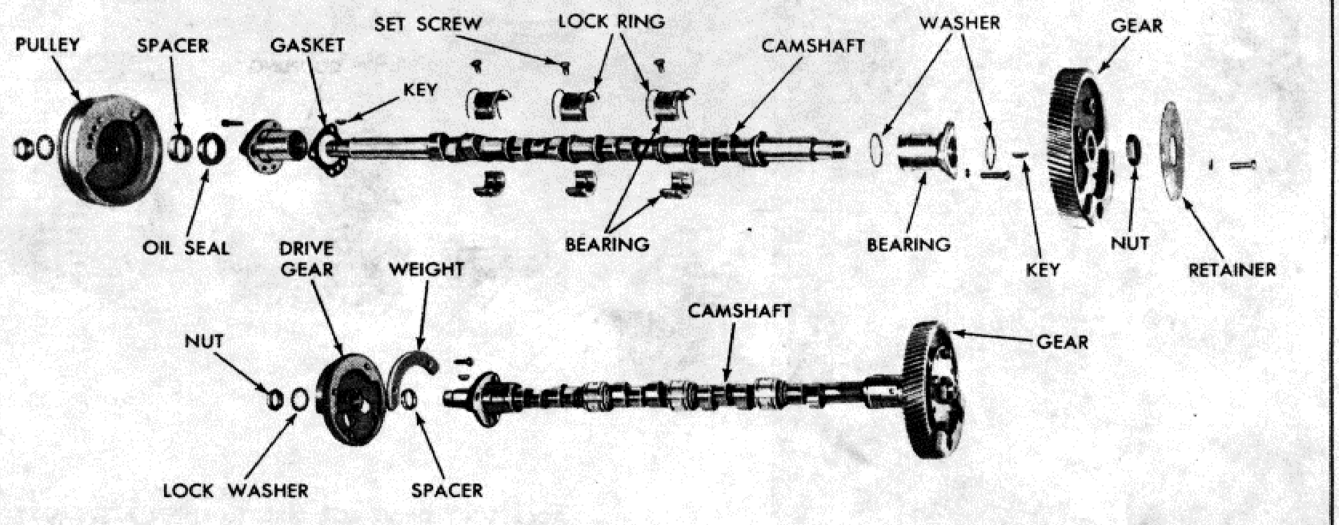
CRANKSHAFT

P 607



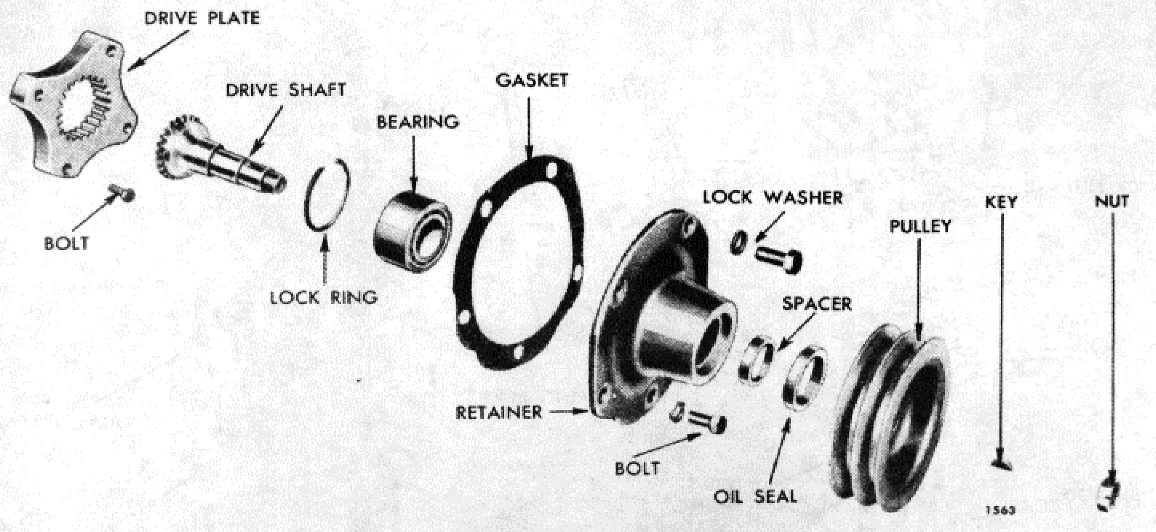
VALVE OPERATING MECHANISM (4 VALVE)

P 600A

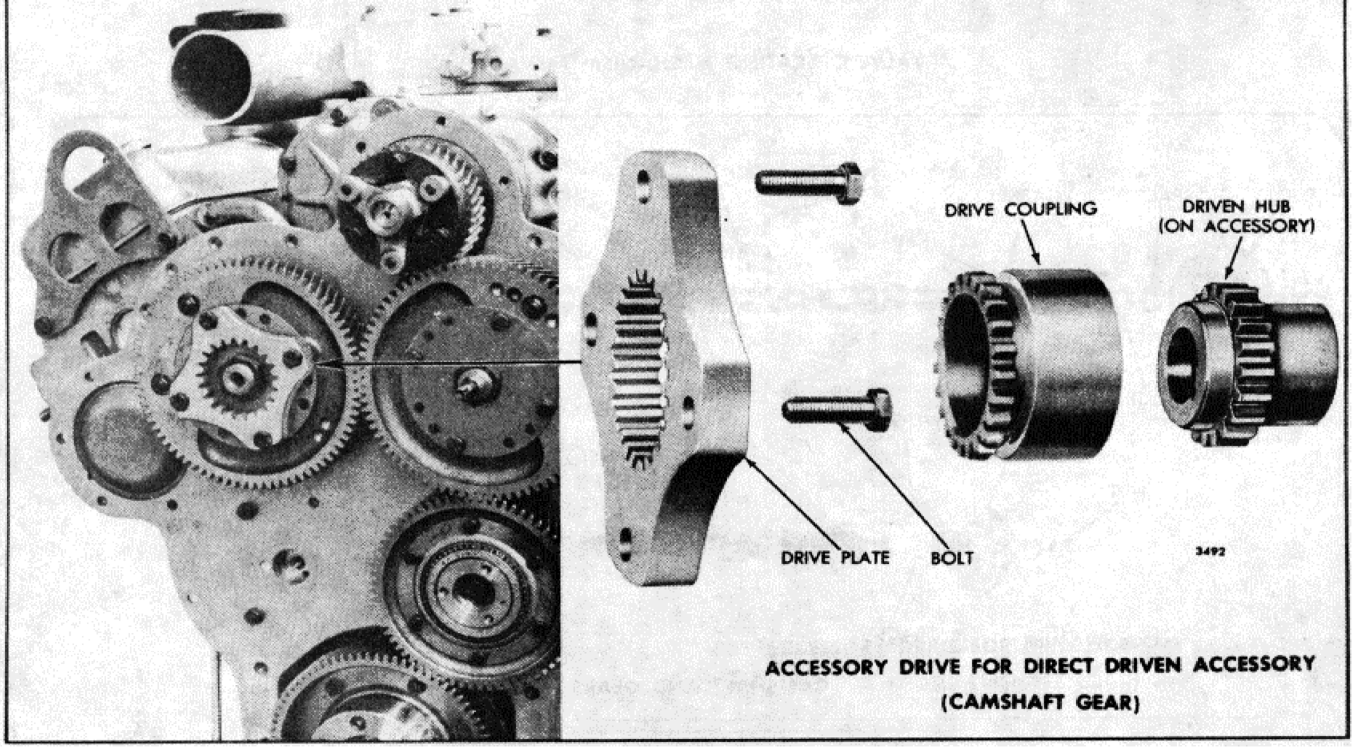


CAMSHAFT AND GEARS

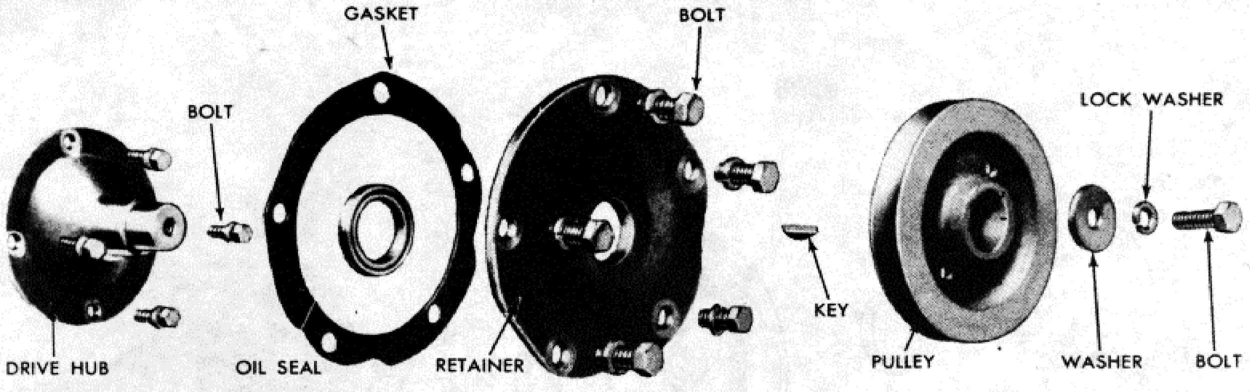
P 600



ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY
(DRIVE PLATE TYPE)

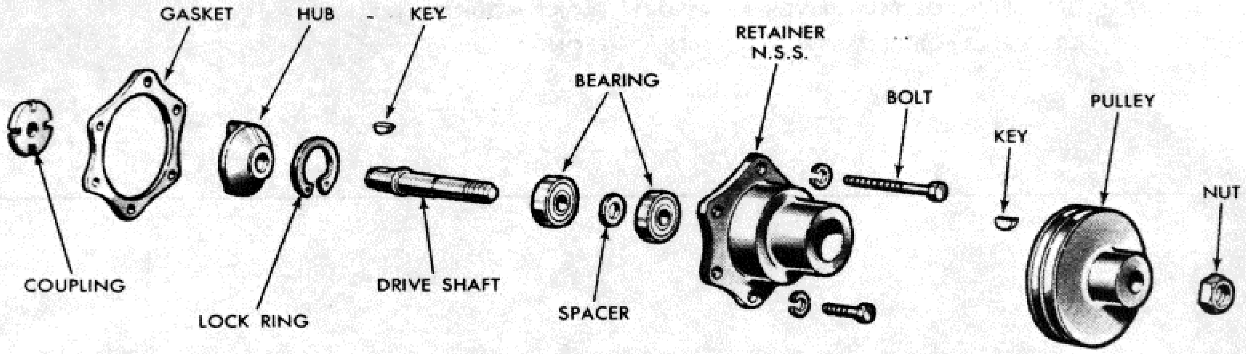


ACCESSORY DRIVE FOR DIRECT DRIVEN ACCESSORY
(CAMSHAFT GEAR)



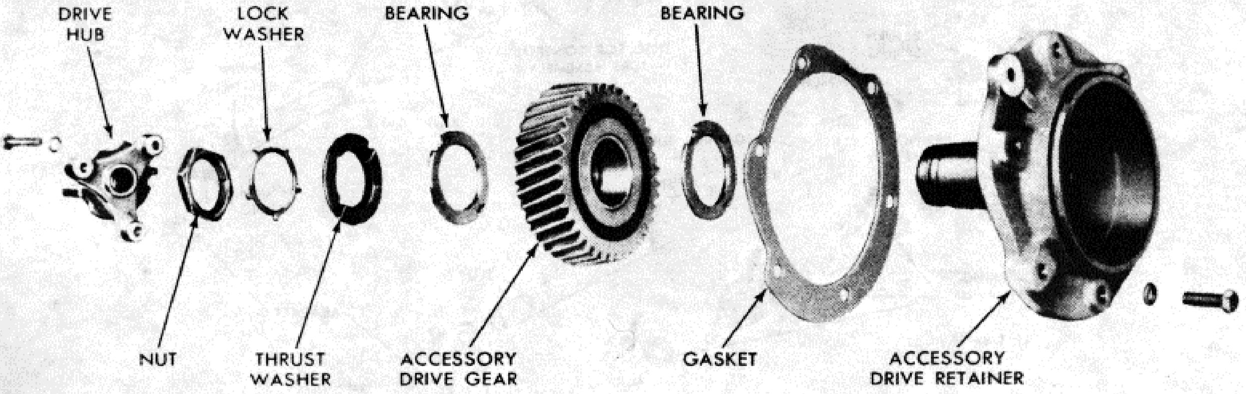
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (DRIVE HUB TYPE)

P 603B



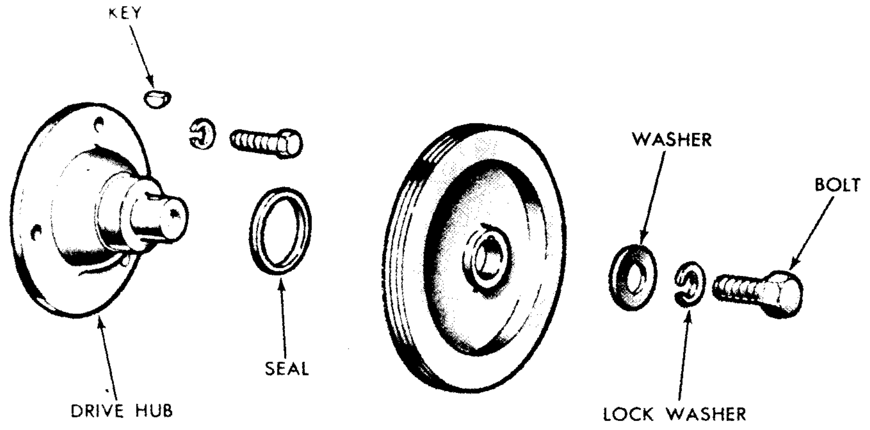
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (DRIVE DISC COUPLING TYPE)

P 603A



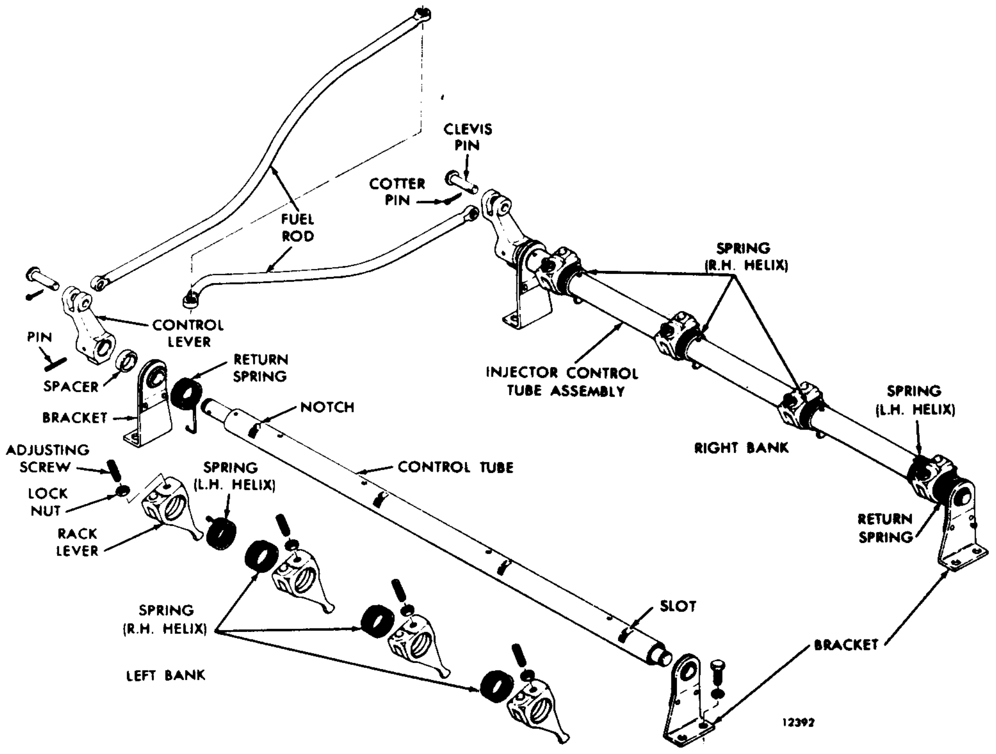
ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (ACCESSORY GEAR)

P 603

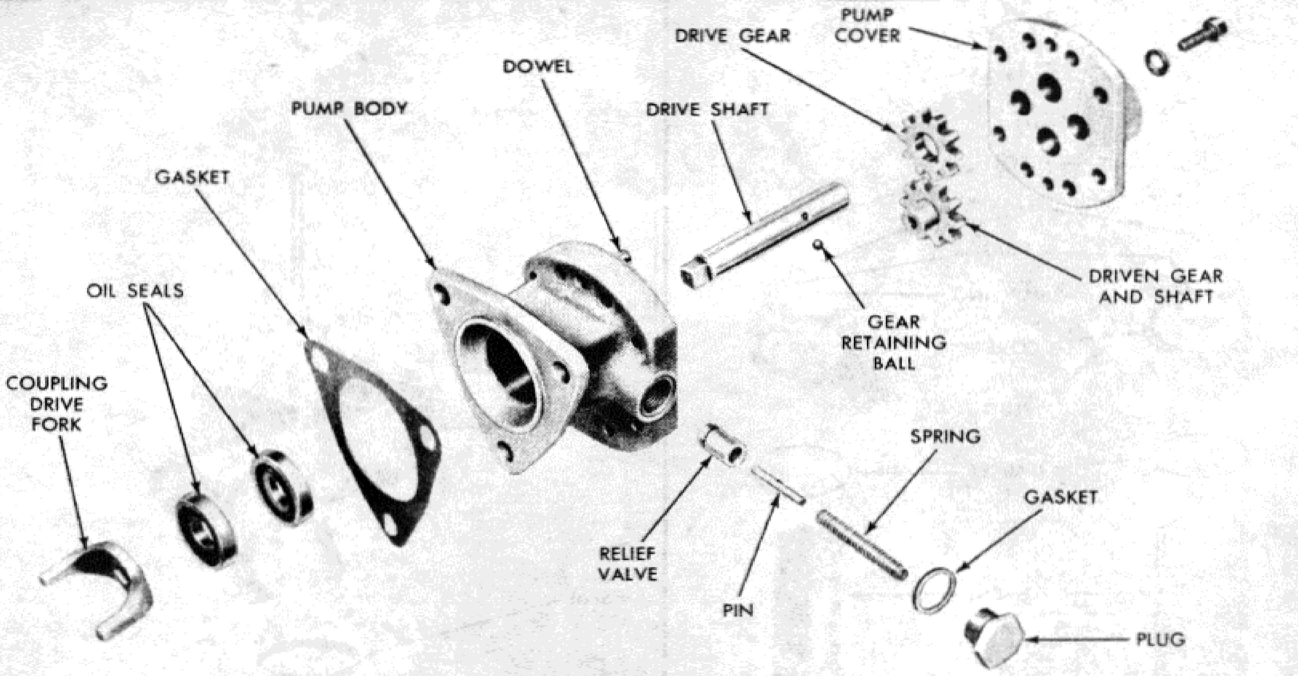


ACCESSORY DRIVE FOR BELT DRIVEN ACCESSORY (FRONT MOUNTED TYPE)

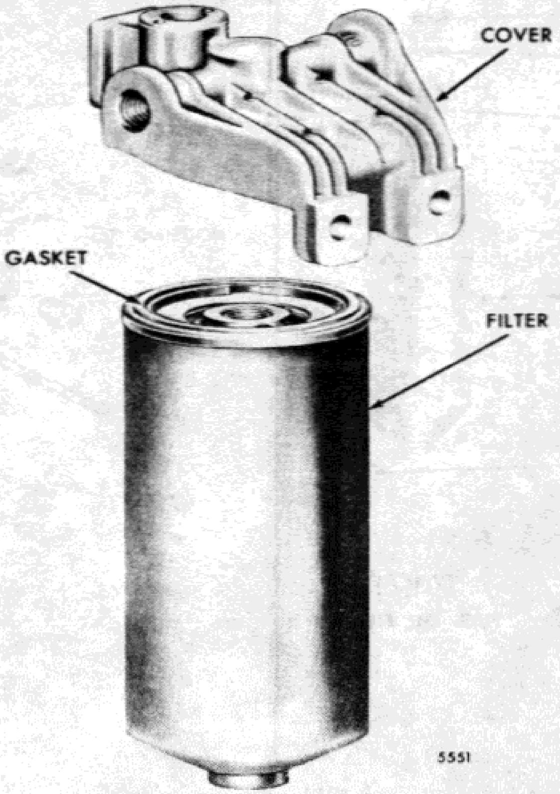
P 609B



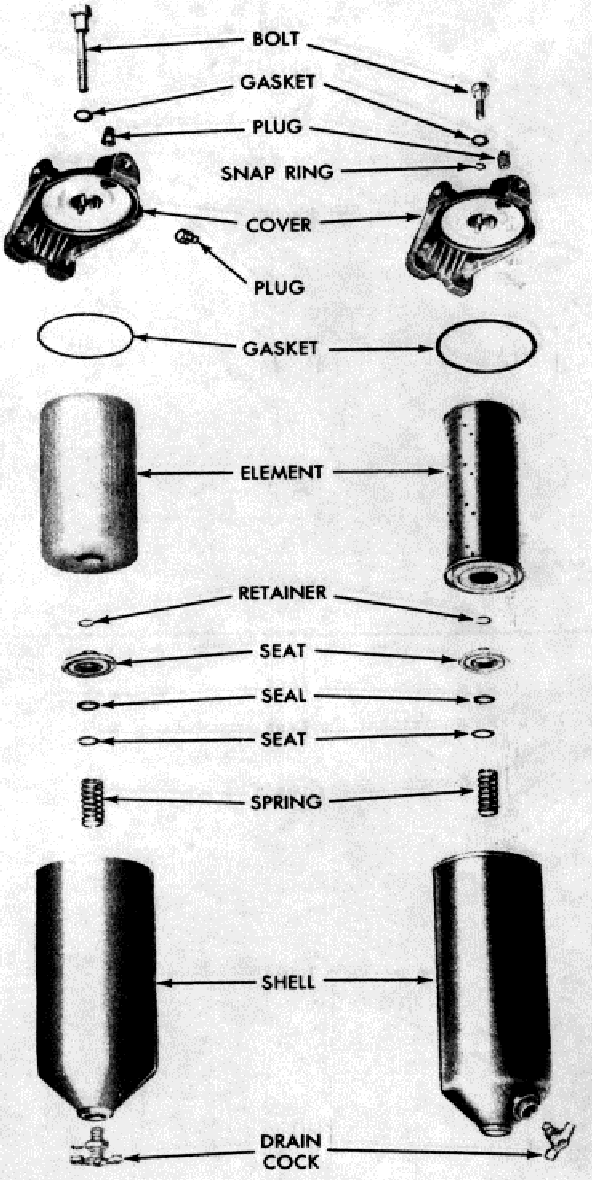
Spring- Loaded Injector Controls



TYPICAL FUEL PUMP



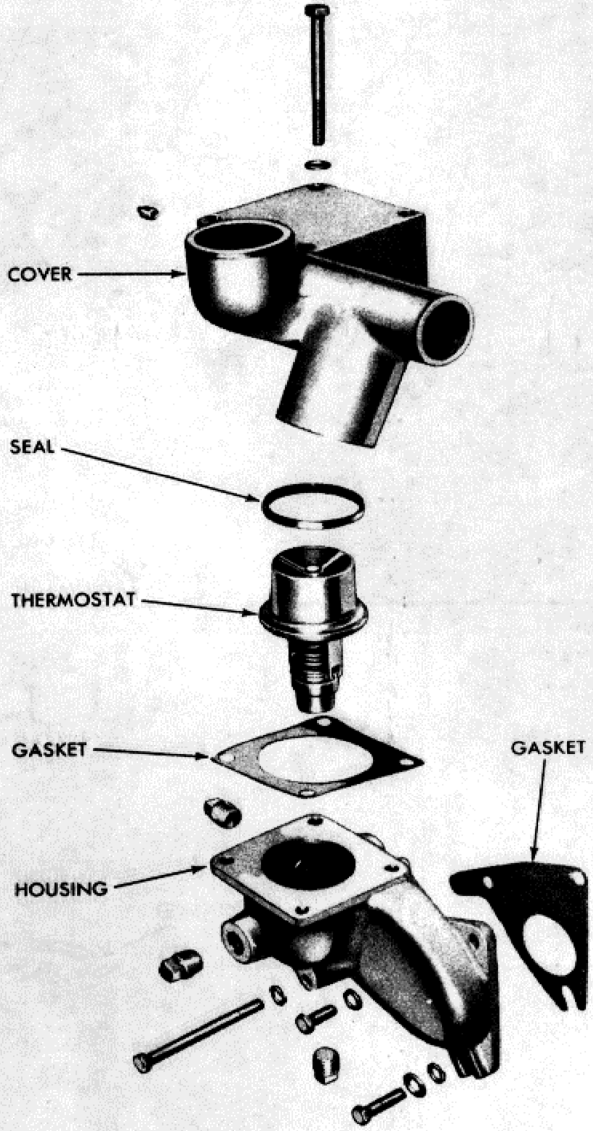
Spin-On Filter



TYPICAL FUEL OIL STRAINER

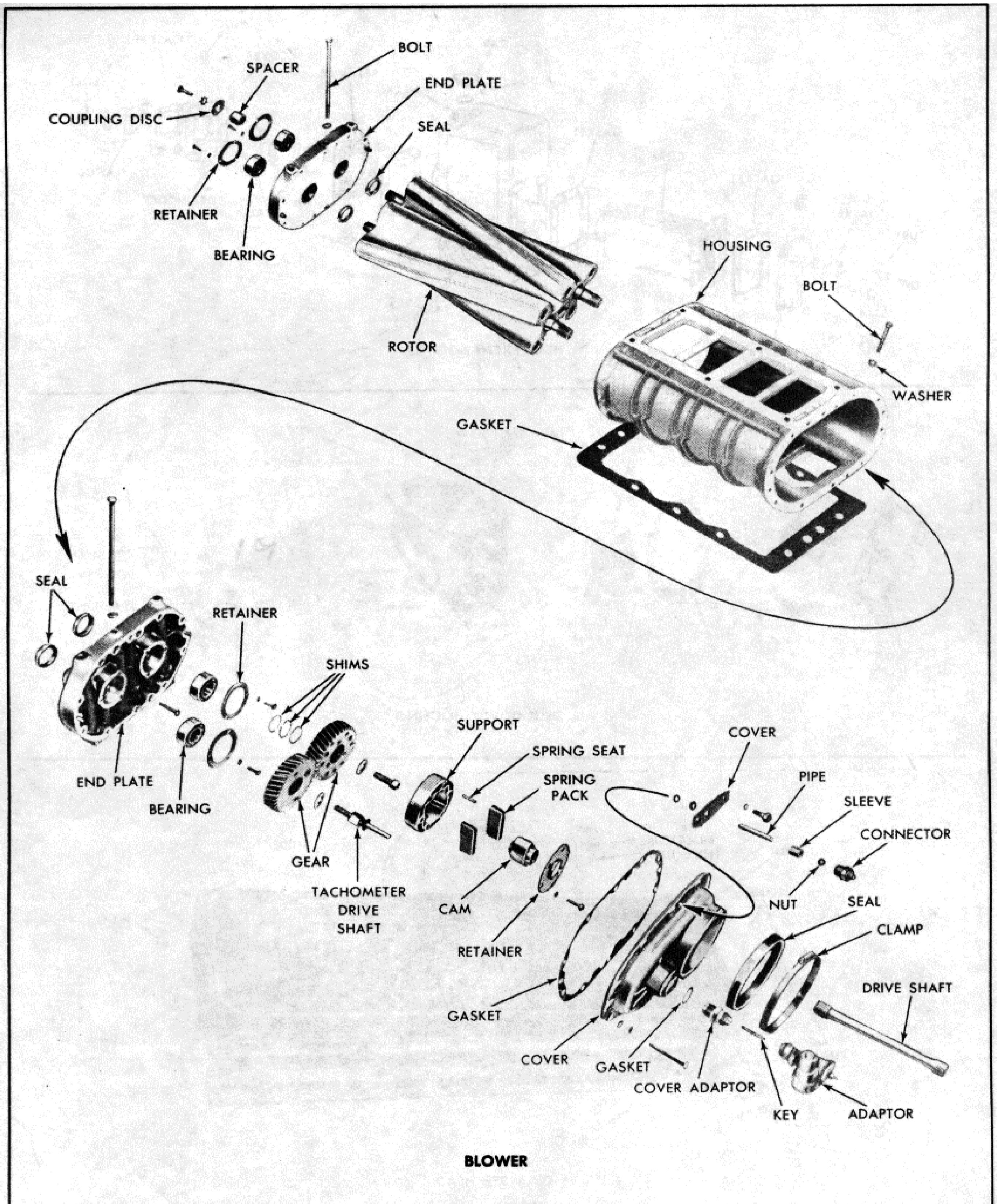
TYPICAL FUEL OIL FILTER

P 601A

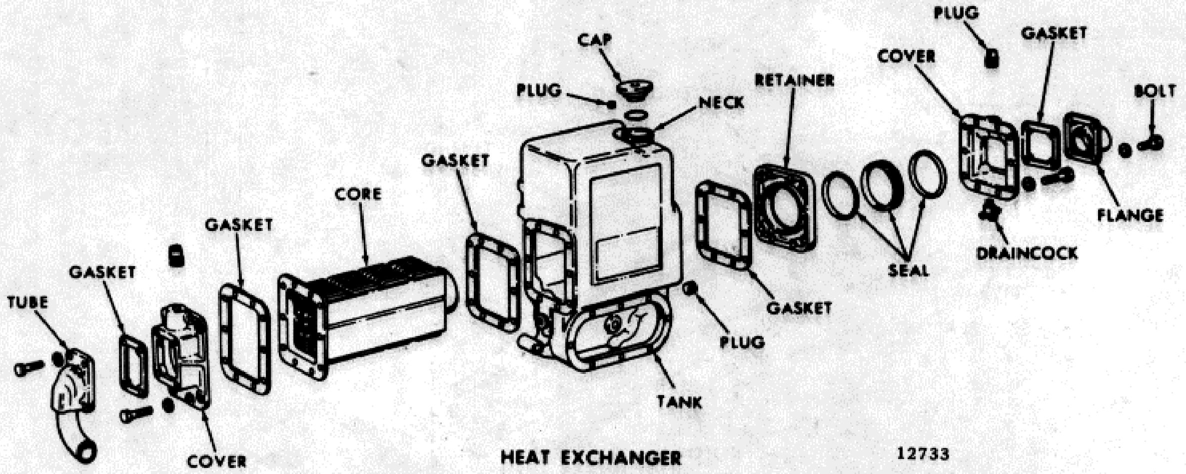


THERMOSTAT HOUSING

P 601

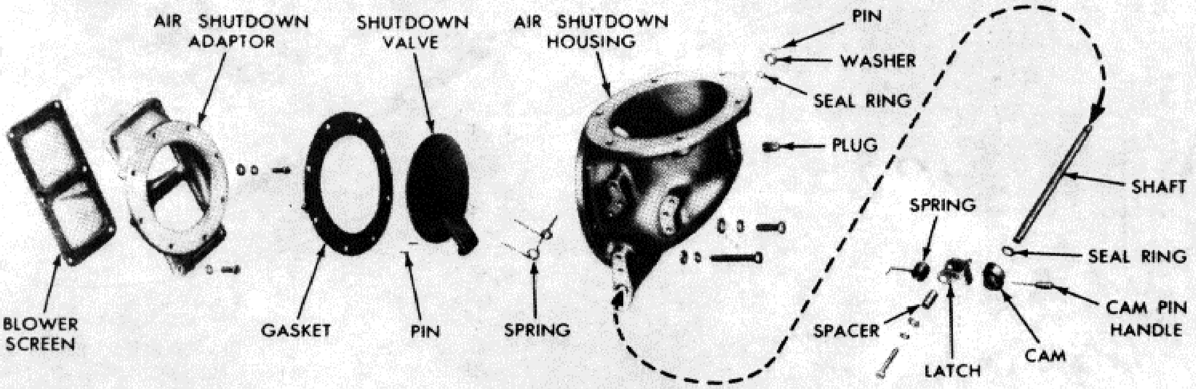

BOLT
SPACER
END PLATE
COUPLING DISC
SEAL
RETAINER
BEARING
HOUSING
BOLT
ROTOR
WASHER
GASKET
SEAL
RETAINER
SHIMS
SUPPORT
COVER
SPRING SEAT
SPRING PACK
PIPE
END PLATE
SLEEVE
BEARING
CONNECTOR
GEAR
TACHOMETER DRIVE SHAFT
CAM
NUT
SEAL
CLAMP
RETAINER
DRIVE SHAFT
GASKET
COVER
GASKET
COVER ADAPTOR
KEY
ADAPTOR
P 606

BLOWER



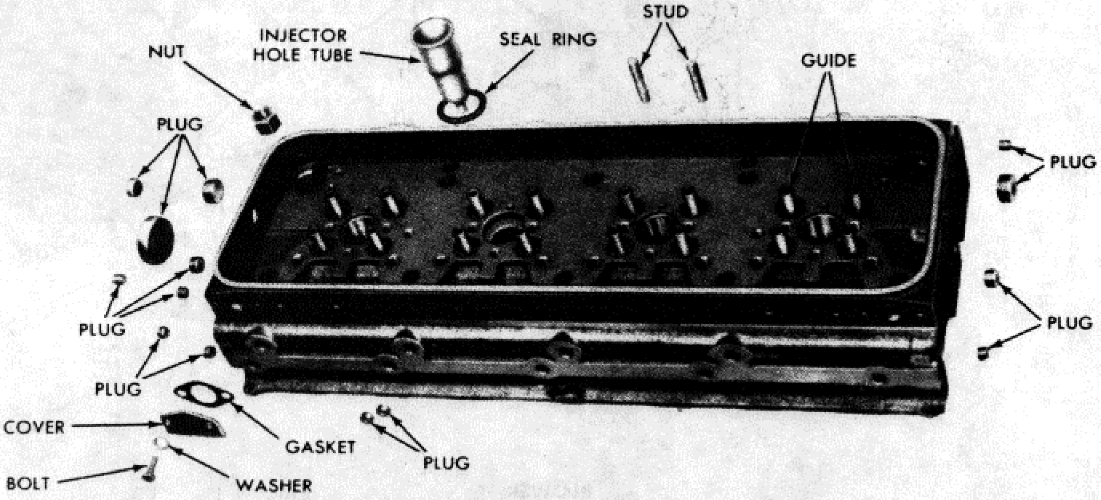
HEAT EXCHANGER

12733



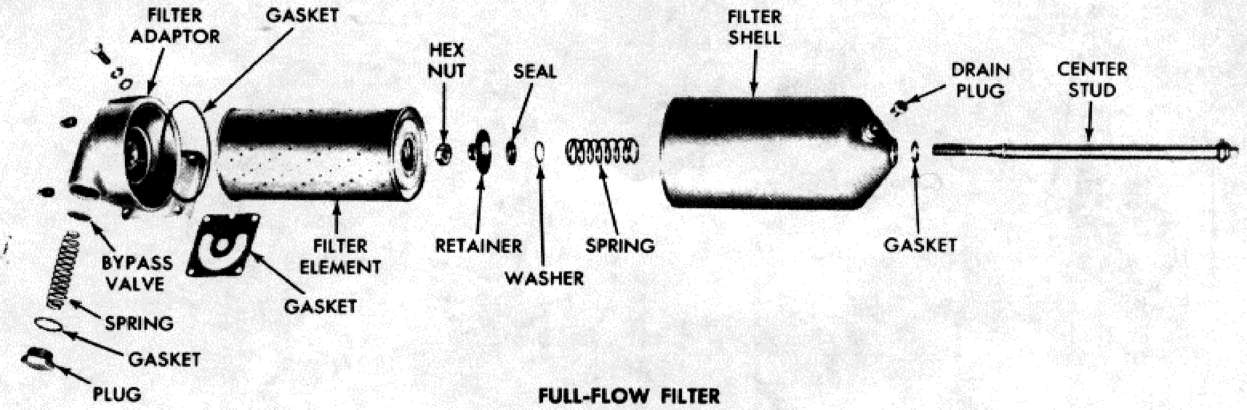
AIR SHUT-DOWN HOUSING

P 604A



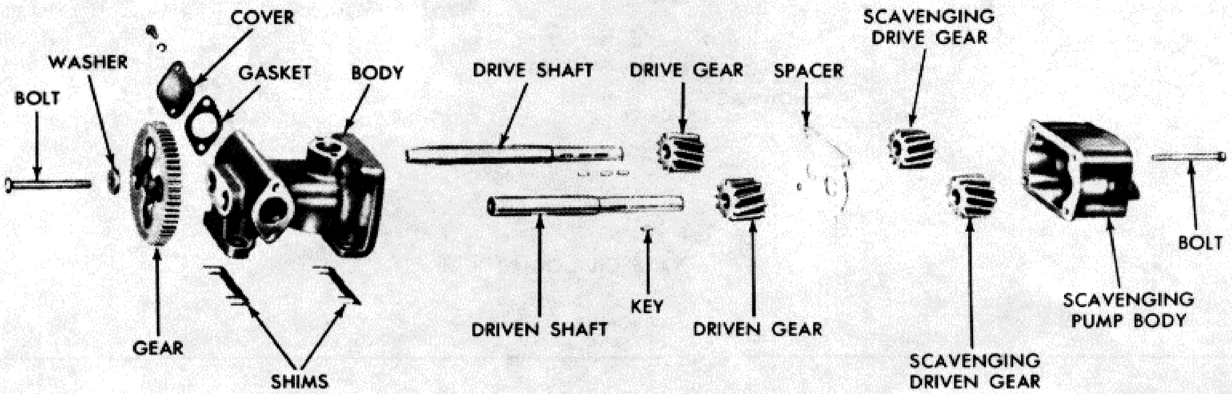
4 VALVE CYLINDER HEAD

P 604



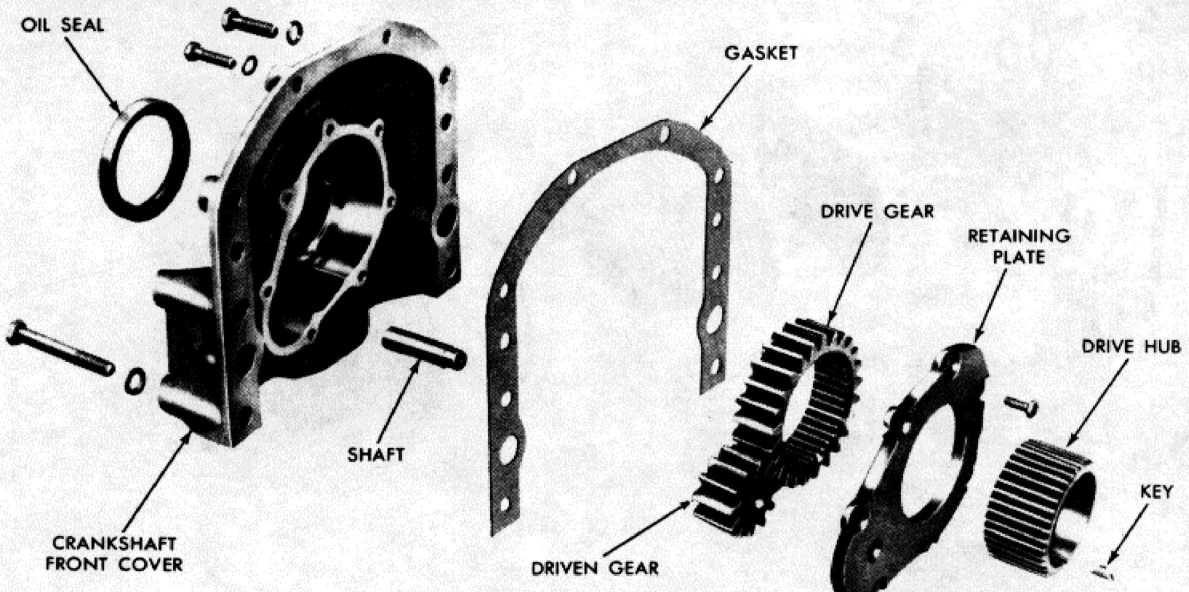
FULL-FLOW FILTER

P 605B



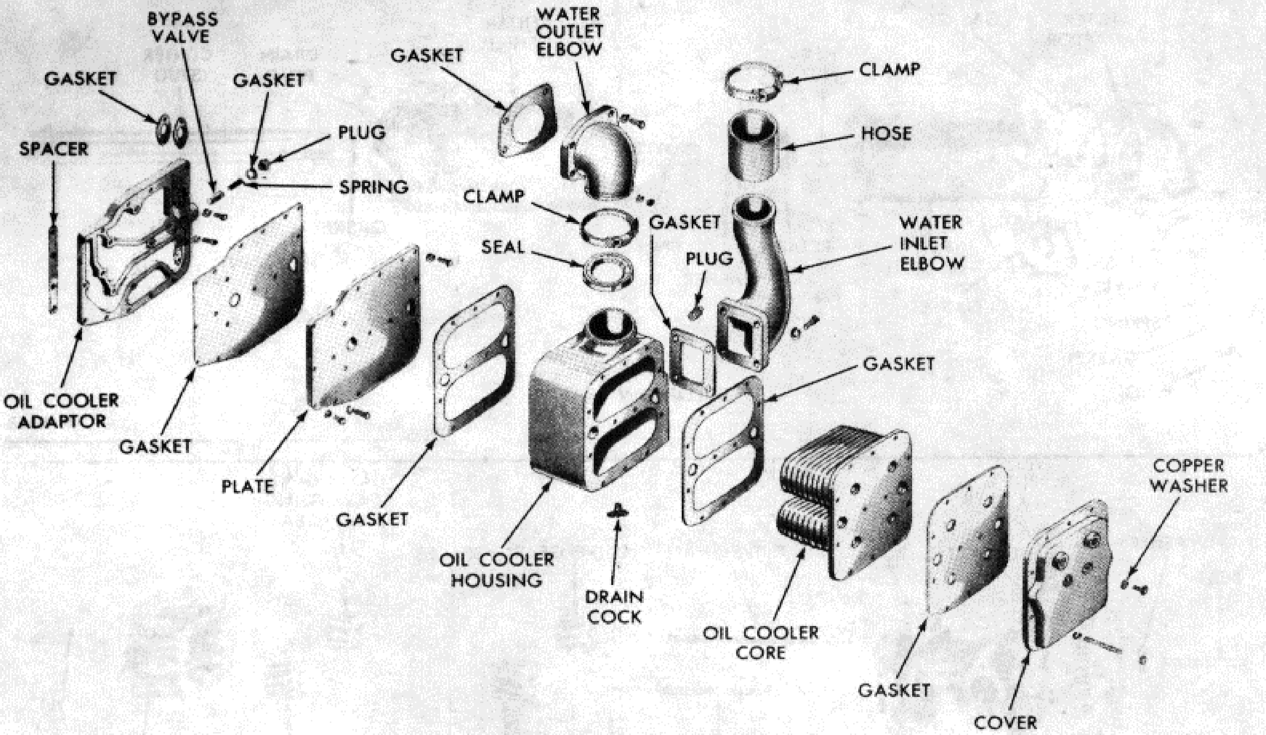
LUBRICATING OIL PUMP

P 605A



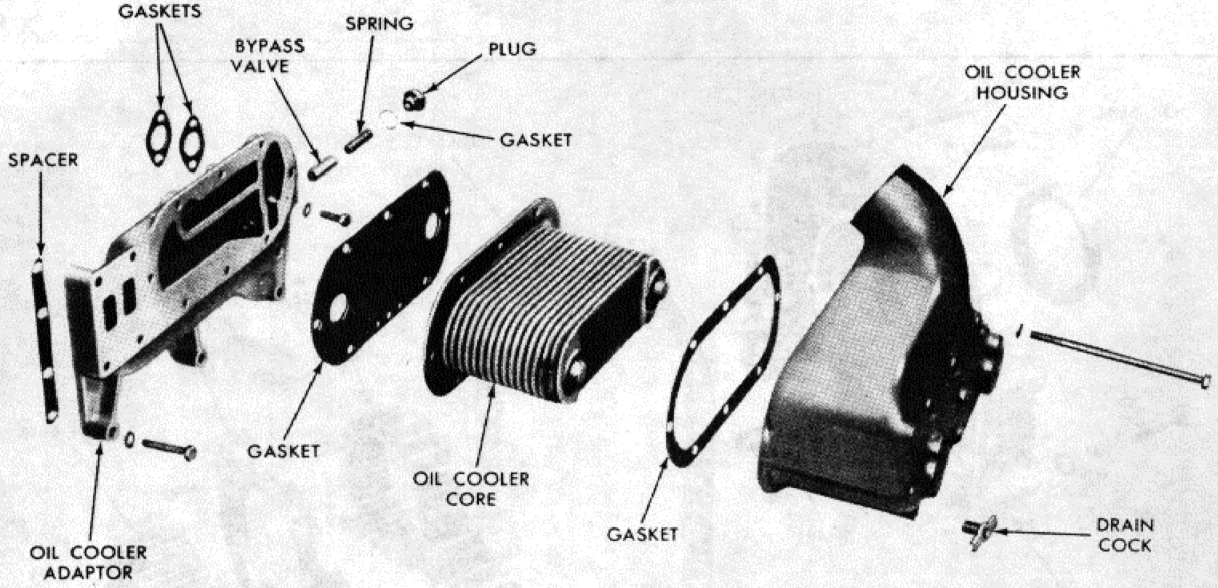
LUBRICATING OIL PUMP (6V OR 8V ENGINES)

P 605



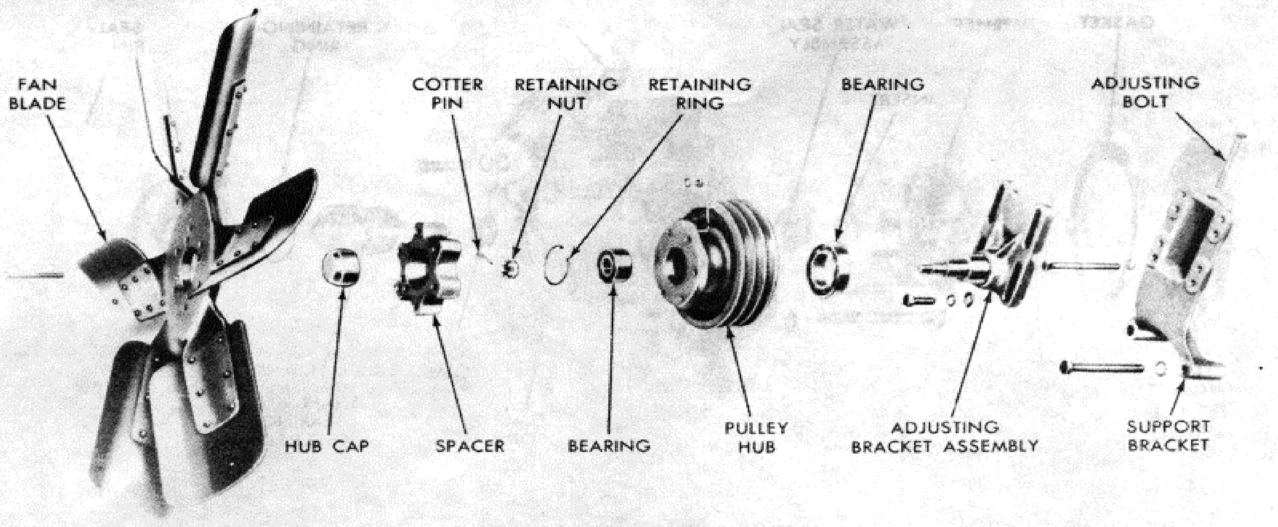
TWIN PLATE OIL COOLER

P 608B



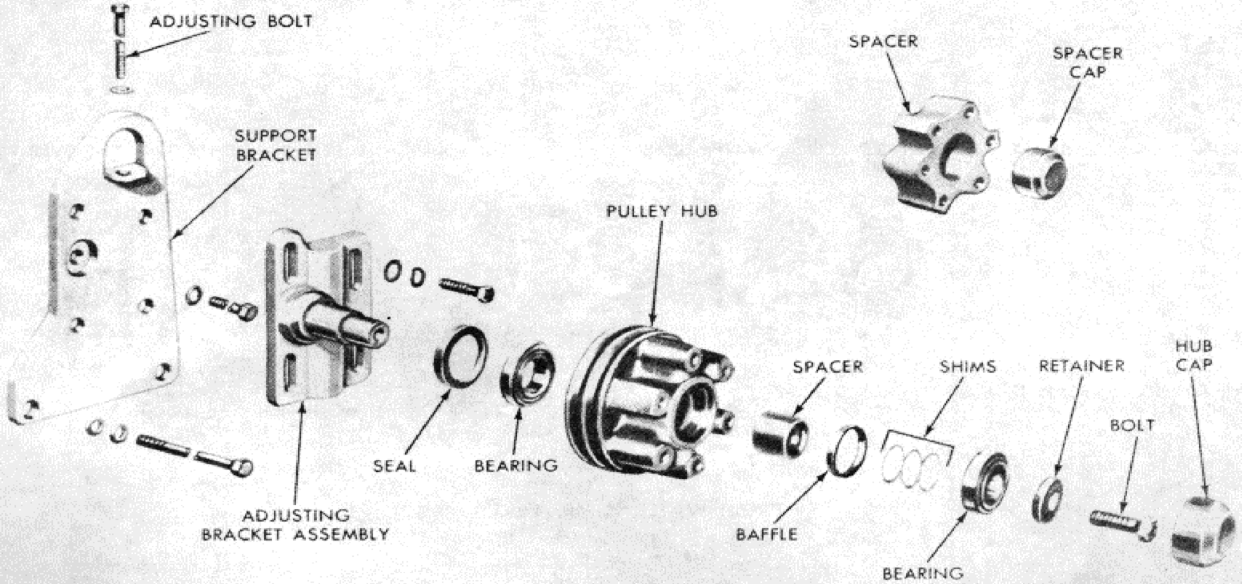
OIL COOLER

P 608



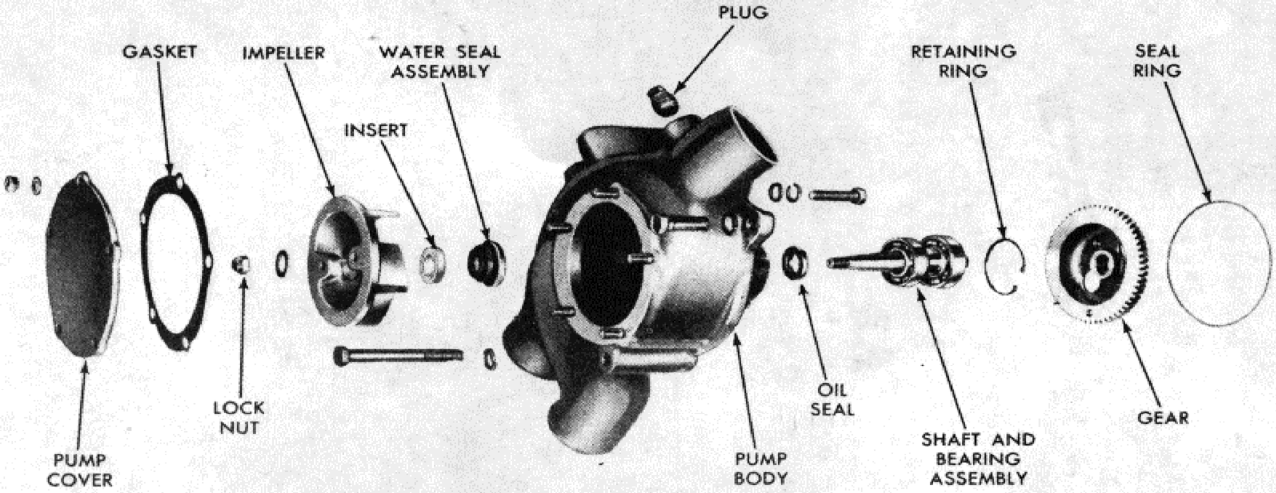
FAN ASSEMBLY

P 610A



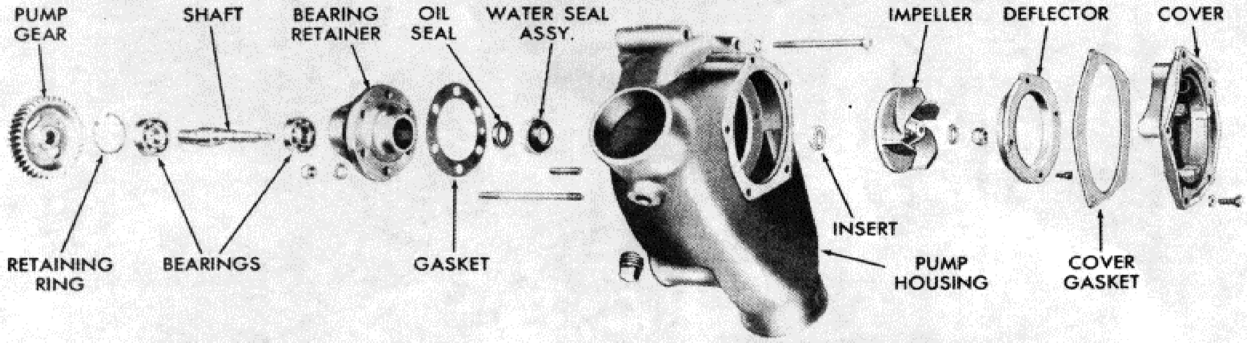
FAN MOUNT

P 610



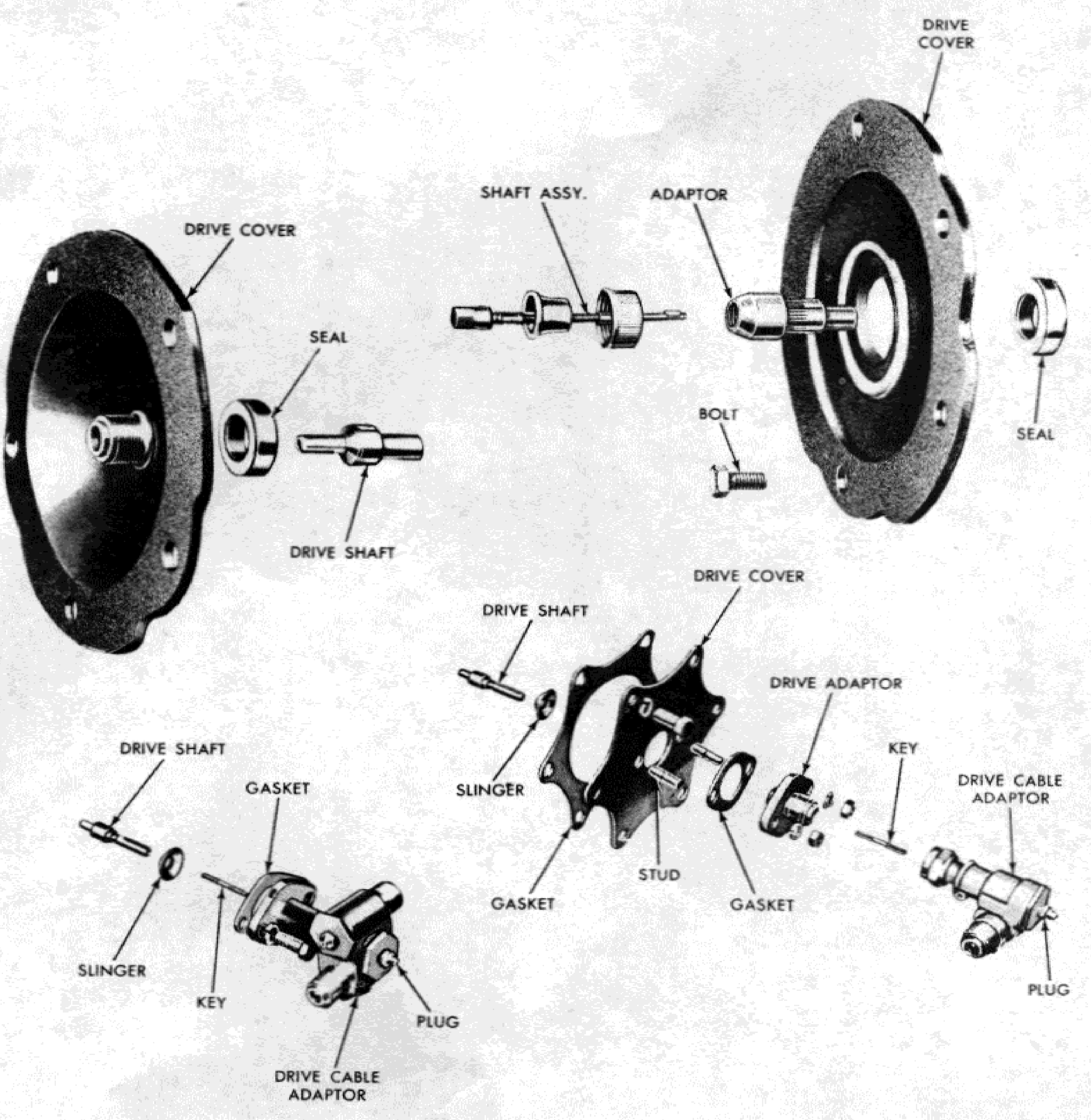
FRESH WATER PUMP (6, 8, 12V)

P 612A



FRESH WATER PUMP (16V)

P 612



TACHOMETER DRIVE COVERS AND ADAPTORS

P 611

OWNER ASSISTANCE

The satisfaction and goodwill of the owners of Detroit Diesel engines are of primary concern to Detroit Diesel Allison and its authorized service outlets. We recognize, however, that despite the best intentions of everyone concerned, misunderstandings may occur. Normally, any such situation that arises in connection with the sale, operation or service of your engine will be handled by the authorized service outlets in your area (check the Yellow Pages for the Detroit Diesel Allison Service Outlet nearest you).

To further assure your complete satisfaction, we have developed the following three-step procedure to be followed in the event you have a problem that has not been handled satisfactorily.

Step One- **Discuss your problem with a member of management from the authorized service outlet**. Frequently, complaints are the result of a breakdown in communication and can quickly be resolved by a member of management. If you have already discussed the problem with the Sales or Service Manager, contact the General Manager. If your problem originates with a dealer, explain the matter to a management member of the distributorship with whom the dealer has his service agreement.

Step Two -When it appears that your problem cannot readily be resolved at the distributor level without additional assistance**, contact the responsible Detroit Diesel Allison Regional Office in your area** listed below:

Eastern Region
Suite 202
10 Parsonage Road
Edison, New Jersey 08817, U.S.A.
Phone: (201) 246-5070
Regional Manager: S. F. Zappia
Service Manager: D. P. Friedrich

Great Lakes Region
Garrison Place
19855 West Outer Drive
Dearborn, Michigan 48124, U.S.A.
Phone: (313) 565-0411
Regional Manager: E. C. Enlow
Service Manager: R. Schwaller

Southwestern Region
General Motors Bldg.
130 E. Carpenter Freeway
Irving, Texas 75062, U.S.A.
Phone: (214) 659-5070
Regional Manager: E. A. Wilson
Service Manager: W. C. Kaphengst

Western Region
Suite 232
2659 Townsgate Road
Westlake Village, California 91361, U.S.A.
Phone: (213) 997-5405
Regional Manager: G. J. Dunneback
Service Manager: W. K. Clark, Jr.

Southeastern Region
5730 Glenridge Drive, N.E.
Atlanta, Georgia 30328, U.S.A.
Phone: (404) 252-3310
Regional Manager: L. R. Kirby
Service Manager: B. D. Robison, Jr.

Midwestern Region
Suite 618
2021 Spring Road
Oakbrook, Illinois 60521, U.S.A.
Phone: (312) 654-6619
Regional Manager: C. O. Zimmerman
Service Manager: R. A. Galloway

Northwestern Region
Suite 2700
39465 Paseo Padre Parkway
Fremont, California 94538, U.S.A.
Phone: (415) 498-5200
Regional Manager: C. G. Good, Jr.
Service Manager: J. T. Hunt

Canada
Diesel Division - GM of Canada Ltd.
P.O. Box 5990
600 Clarke Road
London, Ontario N5V 3K5, Canada
Phone: (519)452-5000
Telex: 064-5850
TWX; 610-352-0269
Manager: W. Bedford
Service Manager: H. Marienfeldt

Asia/Pacific Region
Detroit Diesel Allison - Australia
Div. of GM - Holden’s Ltd.
Princes Highway, P.O. Box 163
Dandenong, Victoria 3175
Australia
Phone: 03-792-01111
Telex: 30792, Melbourne
Regional Manager: J. McGranaghan
Sales & Service Manager: T. E. Kendrick

Latin America Region
Detroit Diesel Allison
Gables Center, Suite 321
95 Merrick Way
Coral Gables, Florida 33144, U.S.A.
Phone: (305)446-4900
Telex: 810-848-9061
Regional Manager: R. D. Daugherty
Sales & Service Manager: J. O. Wine

European Region
Detroit Diesel Allison - Europe
Div. of GM Cotinental, S.A. Nederland
Parmentierplein 1, 3088 GN4 Rotterdam
Mail: P.O. Box 5061
3008 AB Rotterdam, Netherlands
Phone: 010-290-000
Telex: 28355 GMCNL
Regional Manager: H. Veldhuizen
Service Manager: T. F. Chope

Middle East/Africa Region
Detroit Diesel Allison
Athens Towers, Messoghion 2/4
Suite 705
Athens 610, Greece
Phone: 7785-344 or 7706-669 or 7787-281
Telex: 215759 DDA
Regional Manager: R. L. Riddell
Service Manager: R. B. Golding

Prior to this call, have the following information available:

- Name and location olf distributor or dealer.
- Type and make of equipment.
- Engine model and serial number.
- Engine delivery date and accumulated miles or hours of operation.
- Nature of problem.
- Chronological summary of unit’s history.

Step Three If you are still not satisfied. **present the entire matter in writing or by phone to the Product Headquarters:**

Diesel Operations -J. E. Frederickson. Manager Customer Services, Detroit Diesel Allison, 13400 W. Outer Drive, Detroit, Michigan 48239, Phone (313) 592-5608.

The inclusion of all pertinent information will assist the product headquarters in expediting the handling of the matter. If an additional review by the product headquarters of all the facts involved indicates that some further action can be taken, the Regional Office will be so instructed.

If at this point your problem is still not resolved to your satisfaction, call or write:

J. P. Lewis, Manager, Diesel Engine Service. Detroit Diesel Allison, 13400 W. Outer Drive. Detroit, Michigan 48239, USA, Phone: (313)592-7279.

When contacting the Regional Office or product headquarters, please keep in mind that ultimately your problem will likely be resolved at the distributorship or dealership using their facilities, equipment and personnel.

Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

Your purchase of a Detroit Diesel Allison product is greatly appreciated, and it is our sincere desire to assure complete satisfaction.

SECTION 8

OPERATOR’S MANUAL

FIRE

APPARATUS

CHASSIS

FIRE

Introduction

This manual contains essential information to familiarize you with safe operating procedures for your Duplex custom chassis. Careful attention to these instructions will add to the performance, reliability, and life of the unit. Even though you may be familiar with similar units, you must read and understand this manual before operating the truck.

Safe operation depends on the use of proper operating procedures. Following the recommended operation procedures will help you to avoid unsafe practices. Performing the checks and services described in this manual will help to keep your chassis in good condition.

Warning* and Caution* notes have been included throughout this manual to help you avoid injury and/or damage to the chassis. These notes are not intended to cover all possibilities; it is impossible to anticipate and evaluate all possible methods of operation. It is important that any procedure not specifically recommended in this manual be thoroughly evaluated from the standpoint of safety before it is implemented.

Additional manuals are available at a nominal charge.

⚠ *Pay special attention where you see this symbol. It indicates areas where the safety of yourself and others is concerned.

Truck Identification

VEHICLE IDENTIFICATION PLATE (V.I.N.) - Fig. 1

When ordering parts for your chassis or in any correspondence about your truck, be sure to specify your Duplex Vehicle Identification Number (V.I.N.).

The identification plates shown below are mounted either on the riser for the driver's seat or on the firewall between the driver's seat and the door (Fig. 3).

Older trucks have a serial number instead of a V.I.N.

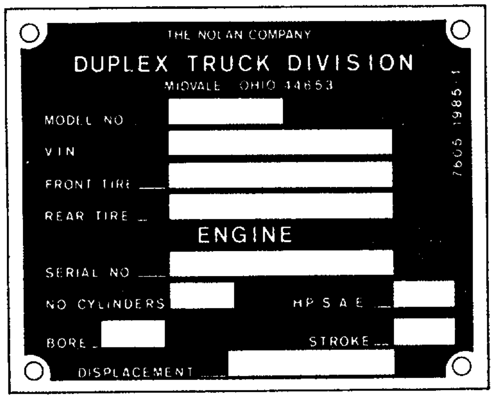


Fig. 1.

WEIGHT RATINGS PLATE (W.R.P.) - Fig. 2

This plate contains the Certified Gross Vehicle Weight Rating (GVWR) and the Gross Axle Weight Rating (GAWR). The GVWR is the maximum total vehicle weight including the chassis, water, hose, personnel and miscellaneous equipment. DO NOT EXCEED MAXIMUM GVWR.

The GAWR is the load-carrying capacity of a single axle system. The GAWR is developed on the basis of the minimum component rating, be it axle, suspension, tires, or wheels.

For assistance in understanding your vehicle weight carrying capacity, contact your apparatus salesman or Duplex.

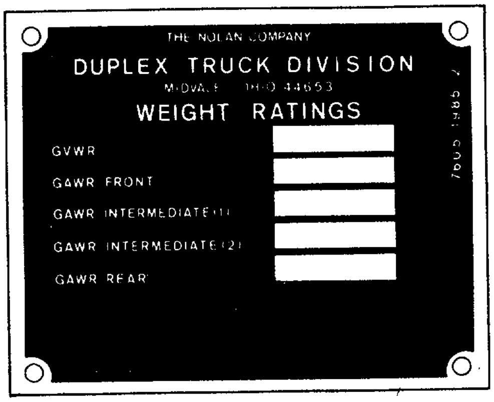


Fig. 2.

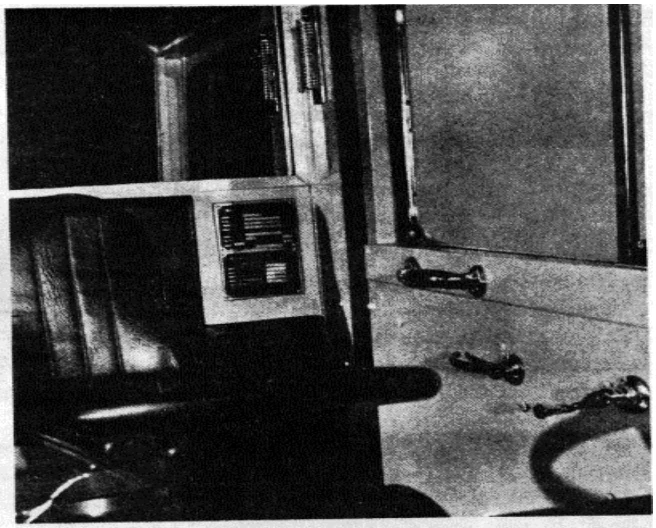


Fig. 3. - The V.I.N. and W.R.P. plates are usually mounted on the firewall between the driver's seat and the door.

Table of Contents

THINK SAFETY FIRST!

Safety Precautions

Look for this symbol which points out important safety precautions. It means ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED! A Never smoke while refueling, servicing the fuel system, or working with batteries.

Always use a non-flammable solvent for cleaning component parts. Avoid gasoline or other flammable substances.

Storage batteries give off highly explosive hydrogen gas when being charged. Keep them away from sparks and open flames. Wear eye protection when working with batteries.

If battery electrolyte contacts skin or clothing, flush immediately and thoroughly with water.

Keep hands, feet and loose clothing away from fan belts, fans, pulleys and driveshafts when engine is running.

Keep working area as clean as possible at all times to prevent slips and falls. Wipe up oil spills immediately.

When working on the hydraulic or air system, be sure to relieve all pressure in the lines before removing component.

Always deflate tires before removing them from the truck for servicing. Tire and wheel assemblies can come apart with an explosive force if not handled properly. Block vehicle before jacking.

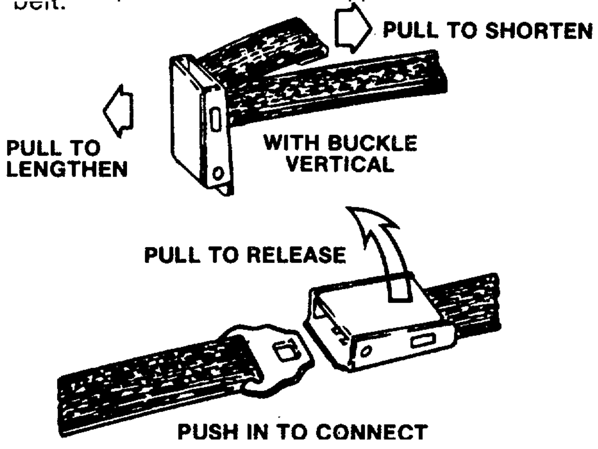
When servicing the cooling system, be sure to relieve pressure in the system. See page 26.

Safety Features

SEAT BELTS (TYPICAL) Before fastening the seat belt, always adjust the seat to the position you will use.

For greater safety and comfort: 1. Be sure the belt is snugly fitted around the hips (not waist) and that there are no twists in the belt.

2. Only one person should be strapped in each seat belt.



To lengthen the belt, tip the buckle end downward (as shown) and pull the buckle until the belt ends can be joined. Join ends of both belts together. Release the belts by pulling upward on the top half of the buckle.

If your unit has seat belt retractors, pull the belt completely out before adjusting and fastening.

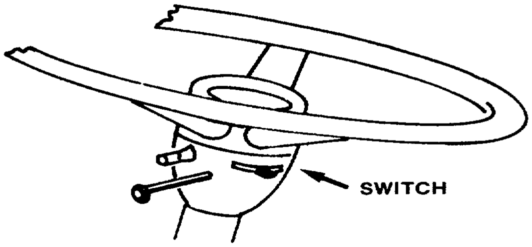
Seat belts should receive the same care as the best fabric. Clean with mild soap; do not use cleaning solvents or abrasives.

WARNING: Do not bleach or re-dye color of webbing, as this may cause a severe loss of tensile strength. Keep belts flat to avoid twisting and roping when not being used. Do not place heavy or sharp objects on belts. The entire belt assembly should be inspected monthly for corrosion, wear, fraying or weak spots. The belt mounting bolts should be tight at all times. Any belt severely strained in an accident should be replaced immediately. All belts should be replaced at least every five years.

HAZARD WARNING

FLASHER SWITCH The red switch located on the left side of the steering column will activate both front and rear turn signals.

This should be used to indicate an emergency situation or vehicle in distress. Push in to flash all turn indicators simultaneously; pull out to turn off.



Be sure the turn signal lever is in the center or "off" position before pulling out the hazard warning flasher switch.
The flasher lights will operate for some time with the engine off providing that the batteries are in good condition.

Truck Start-Up and Shut-Down Procedures

To make sure your fire truck is ready for service, make the following daily inspection.

DAILY CHECKS

Before starting each day, check or inspect the following to assure trouble-free performance.

1. Make visual inspection of entire unit.

2. Check tires for proper inflation (see pgs. 28-29).

3. Check all air reservoir drains and close any that may be open.

4. Check the area underneath the truck for signs of leaks. If noted, check hoses and lines for leaks.

Correct the condition causing the leak.

5. Check the windshield washer fluid level and refill if needed.

6. Check all oil and coolant levels.

SAFETY CHECKS

Equally important as the pre-starting checks is a complete safety check of your vehicle.

1 Make a check of all lighting including high and low beams, turn signals, hazard warning flasher, brake lights and warning lights. Repair any defective lights.

2. Check the windshield washers and wipers.

3. Check the operation of all instruments, gauges, and controls.

After performing the pre-starting checks and safety checks, you are ready to operate the vehicle. Start engine and make sure all systems are functioning.

NOTE: Safety on the road depends on you as well as your equipment. Observe weather and road conditions, and drive accordingly. Be physically and mentally alert.

STARTING THE ENGINE

WARNING: All internal combustion engines give off various fumes and gases while running. DO NOT start or run the truck engine in a closed or poorly ventilated building where the exhaust gases can accumulate.

Before operating the truck, the driver should be familiar with the Operator's Manual furnished by the engine manufacturer for procedures and recommendations on engine starting and use.

1 Before starting engine:
  a. With Shut-Off Handle: Make sure handle is pushed in all the way.
  b. With Fuel Switch: Place switch in the ON position.

2. Place transmission in NEUTRAL position.

3. Turn Battery Selector Switch to BOTH position.

4. Push both starter buttons and depress the accelerator slightly.

5. After the engine starts, run engine at 1200 to 1600 rpm to quickly build up air pressure, if necessary, to release the parking brake.

6 Push the Parking Brake Control Button IN to release the spring brakes. Wait until the red Parking Brake Light goes off before attempting to move the vehicle.

7. The Lo-Air Pressure Warning Light and Buzzer will be on until both the front and rear systems have approximately 75 psi pressure.

NOTE : Upon starting, rev the engine to 1350-1400 rpm to energize the alternator. Once the alternator is energized, it will charge at any engine speed.

CAUTION: If the engine does not start within 15 seconds, release the starter buttons and allow the starter motor to cool for 60 seconds. Then repeat steps 1 through 5.

STOPPING THE ENGINE

Read the Engine Operating Manual furnished by the engine manufacturer for recommended procedures.

1 Bring the truck to a complete stop using the service brakes.

2. Shift transmission into NEUTRAL.

3. Set parking brakes by pulling out Parking Brake Control (yellow button).

4. Shut down engine as follows:
  a With Handle: Pull out Shut-Off Handle to stop engine. Push handle back in when engine has stopped.

  b. With Fuel Switch: Put Fuel Switch in OFF position.

5. Turn Battery Selector Switch to OFF position.

CAUTION
: DO NOT turn Battery Selector Switch to OFF position until engine has completely stopped.

Switching to OFF before the engine has stopped WILL damage the electrical system.

IDLE ENGINE BEFORE SHUT-DOWN

It is important to idle an engine 3 to 5 minutes before shutting it down. This allows the lubricating oil and coolant to carry heat away from the combustion chamber, bearings, shafts, etc. This is especially Important with turbocharged engines.

The turbocharger contains bearings and seals that are subject to the high heat of combustion exhaust gases. While the engine is running, this heat is carried away by normal oil circulation. If the engine is stopped suddenly, the turbocharger temperature may rise as much as 1000F (560C). The results of extreme heat may be seized bearings or loose oil seals.

EMERGENCY STARTING

⚠ **WARNING: Using jumper cables to start your truck with the battery from another vehicle requires care and caution to avoid personal injury and damage to the vehicles involved. Be sure to observe these precautions.**

1. Never expose a battery to open flame or electric sparks.

2. Never smoke near a battery.

3. Wear eye protection when working near a battery to avoid injury In case of an explosion.

Do not allow battery fluid to contact eyes, skin, fabrics or painted surfaces because battery fluid is a corrosive acid. Flush any contacted area with water immediately and thoroughly. Get medical, help if eyes are affected.

To reduce the risk of a short circuit, remove rings, metal watchbands and other metal jewelry. Do not allow metal tools to make contact with the positive battery terminal while at the same time making contact with any other metal part on the truck.

Most trucks have a 12 volt negative ground electrical system. Before using jumper cables, make sure the other vehicle also has a negative ground system (negative terminal attached to a metal part of the vehicle). If unsure of the other vehicle's voltage or ground, do not try to jump start, as personal injury or severe damage to the electrical system may result.

Procedure for using jumper cables:

1. Position the vehicles so the jumper cables will reach easily between the batteries. DO NOT ALLOW THE VEHICLES TO TOUCH.

2. Turn off all electric motors and accessories in both vehicles. Turn off all lights not needed to protect the vehicles or to light the work area. In both vehicles, stop the engine, turn off the master switch, apply the parking brake and shift the transmission to NEUTRAL.

3. Connect the first jumper cable from the positive (+) terminal on one battery to the positive (+) terminal on the other battery. NEVER CONNECT POSITIVE TO NEGATIVE.

4. Connect one end of the second jumper cable to the negative (-) terminal on the good battery.

5. Connect the other end of the second cable to a solid, stationary, metallic point on the vehicle with the discharged battery. Make this connection at least 18 inches (450mm) away from the battery.

6. With the jumper cables properly attached, start the engine of the vehicle with the good (charged) battery. Run the engine at moderate speed.

7. Start the engine in the vehicle with the discharged battery.

8. Remove the battery cables by reversing the above sequence exactly.

Instrument Panel

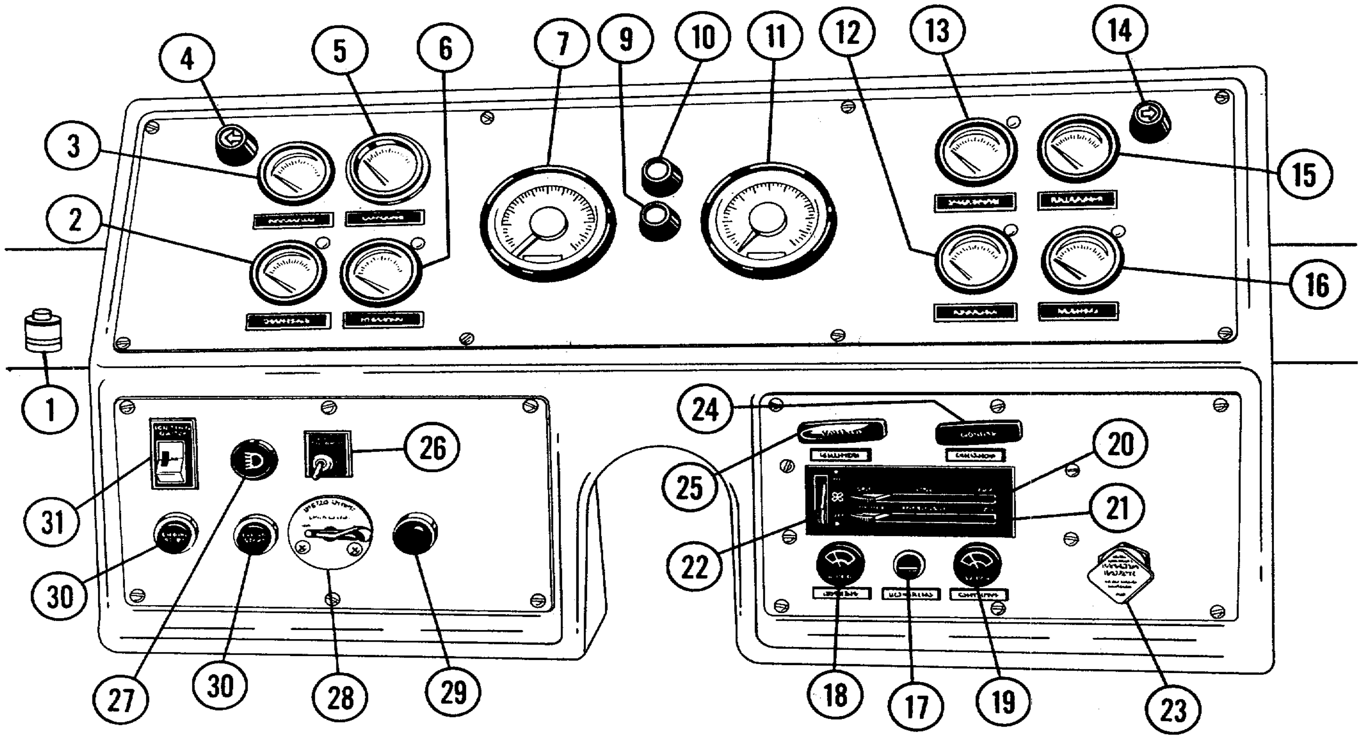


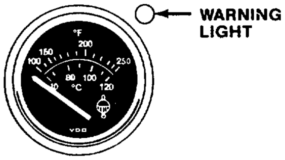
Fig. 4.

1. Air Cleaner Restriction Indicator
2. Engine Coolant Temperature Gauge
3. Voltmeter
4. Left Turn Signal Light
5. Ammeter
6. Engine Oil Pressure Gauge
7. Tachometer with Engine Hour Meter
8. Pump Hour Meter - Not Shown (Optional)
9. Parking Brake Light
10. Headlight Hi-Beam Indicator Light
11. Speedometer with Odometer
12. Air Pressure Gauge - Front Brakes
13. Automatic Transmission Oil Temperature Gauge
14. Right Turn Signal Light
15. Fuel Gauge
16. Air Pressure Gauge - Rear Brakes
17. Windshield Washer Control
18. Left Hand Windshield Wiper Control
19. Right Hand Windshield Wiper Control
20. Heater Temperature Control
21. Heater/Defroster Control
22. Heater/Defroster Fan Speed Control
23. Parking Brake Set/Release Button
24. Black Engine Stop Handle
25. Red Emergency Stop Handle (Some Units)
26. Jacobs Brake Control Switch (Optional)
27. Headlight Switch
28. Interaxle Differential Control - Tandem Axle Units Only
29. Differential Lockout Control Indicator Light - Tandem Axle Units Only
30. Engine Start Buttons
31. Ignition Switch

Instrument Functions

1. **Air Cleaner Restriction Indicator** Turns red when the air cleaner element should be serviced.
See page 18 for details.

2. **Engine Coolant Temperature Gauge** Indicates the temperature of the engine coolant. See the Engine Manual for normal and maximum operating temperatures.

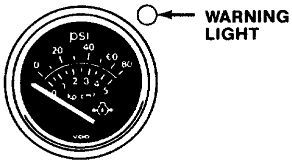


3. **Voltmeter** Indicates battery condition.

4. **Left Turn Signal Light** Blinks when turn signal lever on steering column is pulled toward driver to indicate left turn.

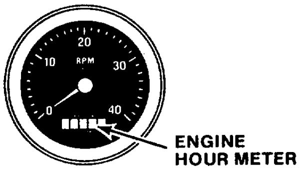
5. **Ammeter** Indicates amount of charge or discharge.

6. **Engine Oil Pressure Gauge**-Indicates the pressure of the lubricating oil in the engine.



Normal Oil Pressure @ Idle ....10 20 psi
Normal Oil Pressure.................. ....50 psi

7. **Tachometer with Engine Hour Meter**-Indicates the engine speed in revolutions per minute. It serves as a guide for shifting gears to maintain engine speed in the proper operating range.



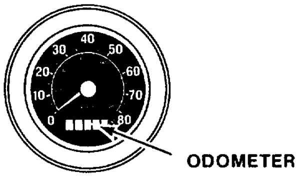
8. **Pump Hour Meter** (Optional/Not Shown) Registers hours of pump operation.

9. **Parking Brake Light**-Will light when the parking brake is applied. It will remain lit until the yellow Parking Brake Button (Item 23) is pushed to release the brakes.

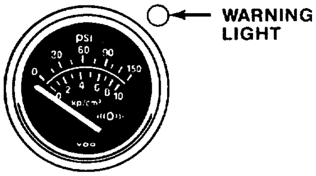
CAUTION: When the Parking Brake Light is on, it indicates that the spring brakes are still applied. If the light does not go out when the yellow dash control is pushed in, DO NOT attempt to drive the truck until the malfunction is corrected.

10. **Headlight Hi-Beam Indicator Light** Glows a bright blue when the headlights are on hi-beam.

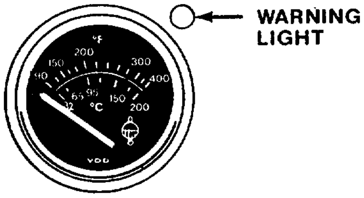
11 **Speedometer with Odometer** Indicates the truck speed in miles per hour (mph) and kilometers per hour (kph). The odometer registers the total number of miles traveled.



12 & 16. **Air Pressure Gauges (front supply & rear supply)** These gauges work in conjunction with the lo-air warning lights and buzzer. Normal operating pressure is 120 to 125 psi. (See pgs. 12-13 for further explanation of air system.)

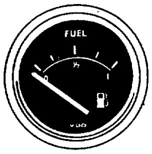


13 **Automatic Transmission Oil Temperature Gauge (automatic transmission only)** Indicates the temperature of the oil in the transmission. Normal operating range is 160° to 2200 F. Maximum allowable temperature is 2500 F. If the oil temperature exceeds 2500, shut down and correct malfunction before driving. (See Transmission Manual for troubleshooting')



14 **Right Turn Signal Light** Blinks when turn signal lever on steering column is pushed away from the driver to indicate a right turn.

15 **Fuel Level Gauge** Indicates amount of fuel in the fuel tank.



Instrument Functions CONTINUED

16 See Number 12, Page 9.

17 Windshield Washer Control Push down and hold toggle switch for washer fluid. Release toggle to shut off. Turn wipers on to clean windshield. Keep the fluid reservoir full at all times. The reservoir is located behind the air intake screen. It can be filled through an opening behind the jump seat. Windshield washer solvent added to the water will aid in cutting road film and grease on the windshield.

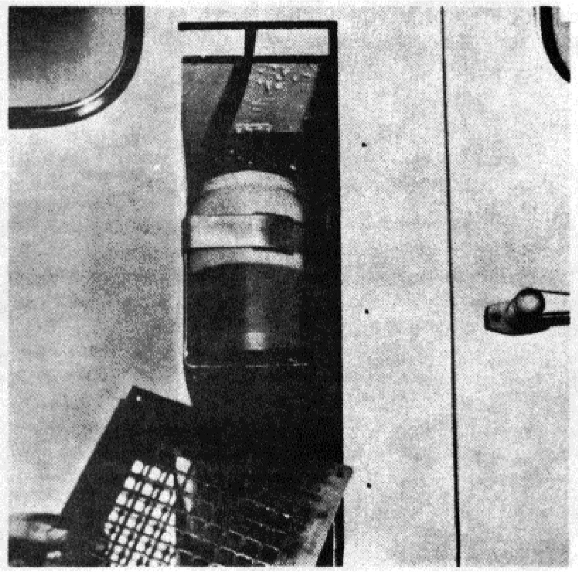


Fig. 5.

18 & 19. Windshield Wiper Controls Turn clockwise to turn on wipers. Turn counterclockwise to turn off wipers.

CAUTION

: To avoid damage to the mechanisms of the wipers, DO NOT MOVE THE WIPERS BACK AND FORTH BY HAND. Lift the blade outward when cleaning the windshield.

20 Heater Temperature Control Slide lever to right to increase air temperature. Slide to left to lower temperature.

21. Heater/Defroster Control Controls amount of air going to the adjustable flow deflectors mounted on top of the dash.

22 Heater/Defroster Fan Speed Control Push lever up to increase fan speed, down to decrease fan speed.

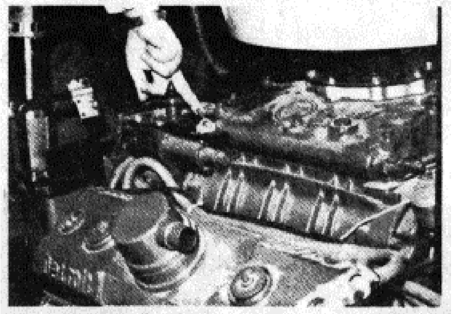
23 Parking Brake Set/ Release Button (yellow) - Controls the application and release of the spring brakes. To apply brakes, pull the button out. To release, push the button in.

CAUTION: Do not apply the foot brake while the parking brake is applied. This may cause damage to the brakes.

24. Black Engine Stop Handle Pull out and hold until engine stops.

25 Red Emergency Stop Handle (Some Units) Controls a diaphragm located in the air intake system of some detroit Diesel engines. This diaphragm shuts off air flow to the engine. Pull handle out to stop engine.

NOTE: The diaphragm must be manually re-set at the engine. See your engine manual for details.



Typical re-set of diaphragm

CAUTION: Do not use this control for normal engine shut-down. This control should only be used if the black Engine Stop Handle (Item 25) does not stop the engine.

26 Jacobs Brake Control Switch (Optional) Controls Jacobs Engine Brake. See manual for details.

27. Headlight Switch Operates the headlights, tail lights, instrument panel lights and running lights. Pull switch out to first position for tail lights and running lights. Pull to second position for headlights. Rotate knob clockwise to dim instrument panel lights, counterclockwise to brighten instrument panel lights.

28. Interaxle Differential Control -This is provided only on tandem axles, and locks both rear axles together to provide more efficient operation and control. Control provides both "Lock" and "Unlock" positions. See operating instructions in the service manual for additional information.

⚠ **WARNING: The interaxle differential lock is not recommended for extended use in the "lock" position. DO NOT use the "lock" position for city driving or on roads with sharp curves. Its use under these conditions may be dangerous. DO NOT move the control into the "lock" position when one or both of the tandems are spinning, as this could cause serious damage to the axles**.

29. Differential Lockout Control Light Comes on when the interaxle differential control is in the lock position.

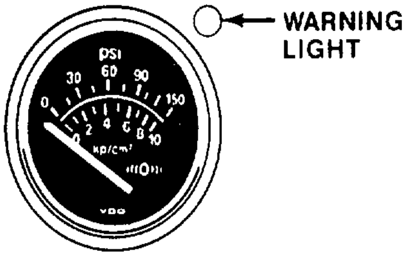
30 Engine Start Buttons Depress both buttons to start engine.

31. Ignition Switch Disconnects power to starter buttons and warning system. Truck will not start unless switch is on.

Instrument Functions CONTINUED

WARNING LIGHTS

Red lights are located next to all the following vital instruments. When a light comes on, it indicates a malfunction in that system.



1. Engine Oil Pressure Gauge - Pressure too low.
2. Engine Coolant Temperature Gauge - Temperature too high.
3. Air Pressure Gauge (Front System) - Pressure too low.
3. Air Pressure Gauge (Rear System) - Pressure too low.
5. Automatic Trans. Oil Temperature Gauge - Temperature too high.

In addition to the warning lights, the machine operator is alerted to a malfunction by a loud warning buzzer.

Cab Controls

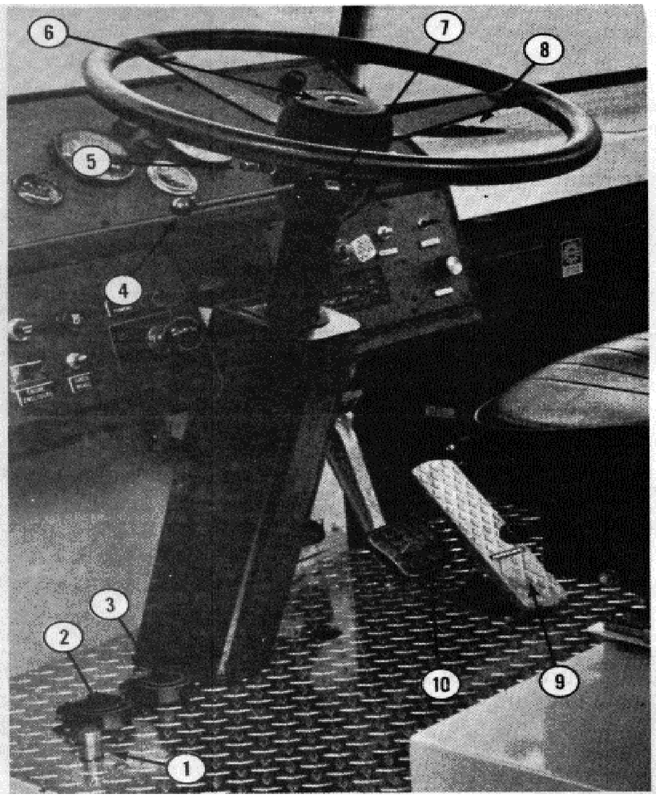


Fig. 6.

1. Headlight Hi/Lo Beam Switch
2. Horn Foot Pedal (Optional)
3. Siren Foot Pedal (Optional)
4. Turn Signal Lever
5. Hazard Warning Indicator Light
6. Horn Button
7. Hazard Warning Flasher Switch
8. Defroster Louver
9. Accelerator Pedal
10. Air Brake Pedal (Treadle Valve)

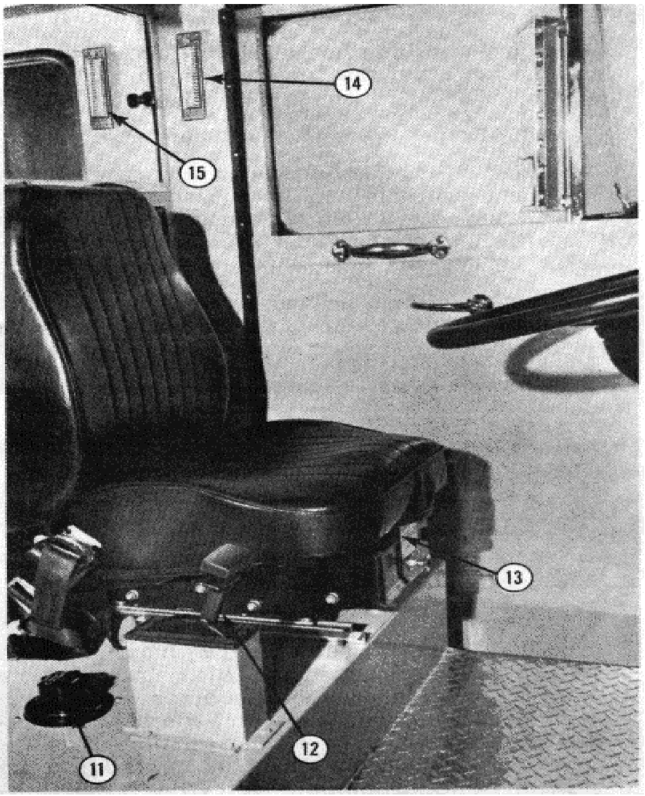


Fig. 7.

11. Battery Selector Switch
12. Automatic Transmission Gear Selector
13. Viking T-Bar Driver's Seat - Standard (Not Shown)
    Air Suspension Driver's Seat - Optional (Shown)
14. Cab Light (One or Two)
15. Canopy Light (One or Two)

Cab Controls CONTINUED

1. Headlight HI/Lo Beam Control Controls hi-beam and lo-beam of the headlights. Depress to change. When the hi-beams are on, a blue indicator light on the instrument panel will glow.

2. **Horn Foot Pedal** (Optional) Foot pressure sounds the air horns. Release and horns stop. A lanyard suspended from the roof in the center of the cab will also sound the air horns (not shown).

3. Siren Foot Pedal (Optional) Foot pressure turns on siren. Release and siren will-wind down. To stop siren faster, use Siren Brake Button on the instrument panel. A second pedal is on the passenger's side of the cab (not shown).

4. Turn Signal Lever Pull toward driver to signal a left turn. Push away (or up) to signal right turn.

5. Hazard Warning Indicator Light When lit, this light indicates that the truck's warning lights are flashing.

6. Horn Button Press to sound electric horn.

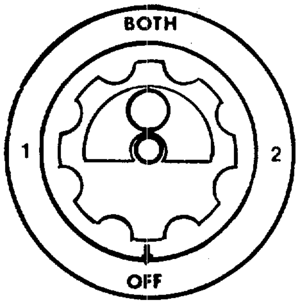
7. Hazard Warning Flasher Switch Located on the left side of the steering column. Push in to make all the turn signals flash simultaneously. Pull out to turn off. The turn signal lever must be in the center of OFF position for flashers to work.

8. Defroster Louvers Two louvers on top of the dash can be turned to direct the flow of air onto the windshield.

9. Accelerator Pedal Controls the speed of the truck.

10. Air Brake Pedal (Treadle Valve) Controls the application of the service brakes.

11. Battery Selector Switch-This is a four position Master Electrical Control Switch. It must be turned to the "Both" position before the truck can be started. This energizes the entire electrical system. This switch will route the charging current to the left battery (Position 1), both batteries (Position Both), or the right battery (Position 2). The truck will not start with the selector switch in "Off"'



CAUTION: After the engine is stopped, turn selector switch to OFF position. DO NOT turn Battery Selector Switch to OFF position until the engine is shut down. Turning switch to OFF while the engine is running may damage the electrical system.

12. Automatic Transmission Gear Selector Selector is used to select one of several forward gears or reverse. (See page 15 for details.)

13. Viking T-Bar Driver's Seat-Adjustable for: seat back angle, seat fore and aft, driver's weight, and ride level. See manufacturer's manual for details.

14 & 15. Cab and Canopy Lights There is one light on each side of the driver's compartment and one light next to each jump seat under the canopy. Each light has its own switch.

Dual Air Brake System

Duplex fire chassis are equipped with a dual brake system that provides a means of braking the vehicle even when one of the systems becomes inoperative. The brake system complies with Federal Motor Vehicle Safety Standards in effect at the time of manufacture. This system may have, integrated into the design, an optional computerized Wheel Lock Control system which automatically prevents wheel lock-up during a maximum braking effort (panic stop).

The dual brake system separates the front and rear brakes into two systems and provides an air pressure gauge for each system. As a safety measure, a red Lo-Air Pressure Warning Light and an audible Signal Buzzer come on whenever the air pressure in either system is below 60 psi. Normal operating pressure for both systems is 120-125 psi. If the air pressure in both systems falls below 45 psi, the rear axle spring brakes will automatically apply.

The spring-set Parking Brakes are applied by pulling out the yellow button on the instrument panel (Item 23, pg. 8). The parking brakes are released by pushing in the yellow button. This control will not stay depressed and the spring brakes will not be fully released until the rear system pressure reaches approximately 60 psi. The red Parking Brake Light (Item 9, pg. 8) remains on until the spring brakes are fully released. Once this light goes out, the truck may be driven. It should be noted that the Lo-Air Warning light and buzzer may still be on, since both systems (front and rear) must reach approximately 75 psi before the light and buzzer go off.

Dual Air Brake System CONTINUED

If the Lo-Air Pressure warning light or signal buzzer comes on indicating that the pressure in one or both of the systems is below 75 psi, maintain a check on the air gauges to see that the air pressure rebuilds.
If you experience a continuing loss of pressure, you should pull the truck off the road and take corrective action.

⚠ : **If the air pressure in both systems drops below 45 psi, the spring brakes will automatically apply. Care should be taken to prevent this from happening while the truck is being driven**.

To provide fast release of the rear spring brakes, the brake system has been designed to build up air pressure in the rear system first. If air pressure in the rear system is down, accelerate the engine to approximately 1400 rpm or more. This gives you maximum output from the compressor and will build up the rear system pressure quickly. Once the rear system is pressurized to approximately 60 psi, the spring brakes can be released. The truck may be driven, and the front system will start to charge. When both systems reach approximately 75 psi, the Lo-Air Pressure warning light and buzzer will go off and the pressure in both systems will continue to build to 120-125 psi.

⚠ : **Do not release the spring brakes until you have a minimum of 60 psi in the rear system. Excessive use of air operated accessories without adequate air pressure may result in automatic application of the spring brakes.**

When applying the service brakes during normal operation, do not pump (fan) the air brake pedal. The best way to make a stop is to apply the brakes as hard at first as the road and other conditions permit, gradually reducing the pressure so that, at the end of the stop, there is sufficient air pressure to hold the vehicle. Improper application of brakes will glaze the brake lining. This will cause squealing and/or chattering.

Checking the Air Brake System

CHECKING LOW AIR WARNING BUZZER

With the air system charged, reduce the air pressure by moderate brake applications or by opening the drain cocks on the air reservoirs. Observe the pressure at which the low air warning buzzer and light come on.

If the low air pressure warning light and buzzer do not come on when 60 psi is reached, replace the low pressure switch. If the buzzer and light do not remain on below 60 psi, determine cause and repair.

CHECK AIR PRESSURE LEAKS

Acceptable air pressure losses are described by two standards.

1. ANSI Standard D7-1973.

2. NFPA 1901 Standard for Automotive Fire Apparatus.

Both, of these list as cause for rejection:

   1. "Air brake pressure drop of more than 2 psi in one minute for single vehicles or more than 3 psi in one minute for vehicle combinations, with engine stopped and service brakes released."
   2. "Air pressure drop of more than 3 psi in one minute for single vehicles or more than 4 psi in one minute for vehicle combinations, with engine stopped and service brakes fully applied."

These are the only standards that apply to air loss.
If air loss exceeds these limits, find and correct the problem.

CHECKING THE AIR PRESSURE GOVERNOR

1. Charge the air system to its maximum capacity, observing the pressure on the air gauges.
2. Determine if the governor has cut out.
3. With the engine running, make a series of brake applications and observe the pressure on the air gauges.
4. Determine when the governor cuts in.
5. If the governor does not cut out at 120-125 psi, determine the cause of malfunction and repair. If the governor does not cut in when pressure is below 80 psi, determine the cause of malfunction and repair.

CHECKING AIR PRESSURE RECOVERY TIME

1. Charge the airsystem until the governor cuts out.
2. Make a brake application and note air pressure reading on gauges.
3. Continue making brake applications until you are 20 psi below the governor cut-in pressure.
4. Run the engine at maximum rpm and determine the time required to increase the air pressure from the level achieved after one brake application to governor cut-out pressure.
5. If the time required is more than 30 seconds, determine cause of malfunction and repair.

Checking the Air Brake System CONTINUED

MANUAL RELEASE OF SPRING BRAKES

In the event of complete air pressure loss, the spring brakes can be released manually. See Service Manual for details.

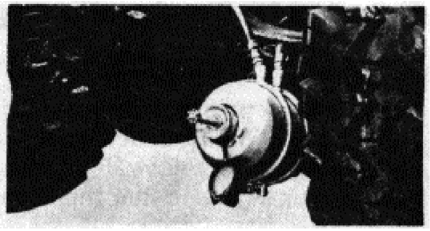


Fig. 8. -Typical Installation

DO NOT release spring brakes unless vehicle is properly blocked so that it will not move.

Transmissions

MANUAL TRANSMISSIONS

Shifting Gears (Spicer SST or Fuller Manual Transmission)

1. With transmission in neutral, start the engine. Release parking brake and hold the truck with the service brake.
2. Depress the clutch fully and move the shift lever into first gear position. While releasing the clutch pedal slowly, remove foot from the treadle valve and depress the accelerator gradually to increase engine speed. If performed properly, the truck will move forward smoothly.
3. With the truck moving forward smoothly, release the accelerator while depressing the clutch and move the gear shift lever into neutral position. Release the clutch pedal.
4. Depress the clutch again and move the shift lever to second gear position. Release the clutch smoothly while depressing the accelerator. Shift to the higher gears by using the above procedure. This method for upshifting is known as "double clutching".
5. To stop the truck, release the accelerator and apply the service brake. Depress the clutch and shift to neutral just before the truck comes to a stop.

Downshifting

1. Release the accelerator pedal while depressing the clutch. Shift to neutral and release the clutch.
2. Depress the accelerator briefly to increase engine speed to approximately 85% of governed rpm. Release the accelerator while depressing the clutch and then move the shift lever to the next lower gear position.
3. Depress the accelerator to maintain approximately 85% of governed rpm while releasing the clutch smoothly.

CAUTION : Never downshift when truck speed will cause the engine to overspeed in the next lower gear. Serious damage to the engine may result. Use service brakes to slow truck to proper speed for downshift if necessary.

Shifting Gears (Spicer CM-50 and CM-60 Transmissions)

1. With the transmission in neutral, start the engine. Release the parking brake and hold the truck by using service brake.
2. Depress the clutch and move the shift lever into first gear position. While releasing the clutch pedal slowly, remove your foot from the brake treadle and depress the accelerator gradually to increase engine speed. If performed properly, the truck will move forward smoothly.
3. With the truck moving forward smoothly, release the accelerator while depressing the clutch. Move the gear shift lever into the next higher gear position. Release the clutch pedal.
4. Shift to higher gears by depressing the clutch pedal, moving the shift lever through neutral to the next higher gear and releasing the clutch pedal.
5. To stop the truck. release the accelerator and apply the service brake. Depress the clutch and shift to neutral just before the truck comes to a stop.

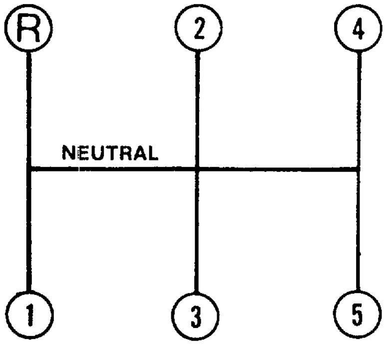
Downshifting

1. Release the accelerator while depressing the clutch. Shift through neutral to the next lower gear. Release the clutch while depressing the accelerator.

2. Downshift to the lower gears using the same method.

NOTE : To downshift to first gear, you must double clutch. See "Shifting Gears (Spicer SST)" for explanation of double clutching.

Sample Shift Pattern for Manual Transmission (see decal on cab dash for exact pattern)



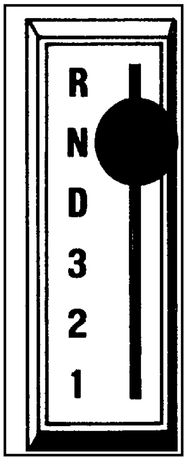
Transmissions CONTINUED

AUTOMATIC TRANSMISSION (MT-643, MT-644 & HT-740)

The automatic has four (4) forward speeds and one (1) reverse. Shifting within any of the forward drive ranges selected is fully automatic. See Fig. 9 for gear selector pattern.

: **WARNINGAny time the engine is to be left running while the operator is not at the controls, SHIFT THE TRANSMISSION INTO NEUTRAL AND SET THE PARKING BRAKE**.

Fig. 9.



(R) Use this for backing the vehicle. The vehicle should be completely stopped before shifting from a forward gear to reverse or from reverse to forward. Reverse has only one gear. Reverse operation also provides the greatest tractive advantage.

(N) Use this position when you start the engine. If the engine starts in any other position, the neutral start switch is malfunctioning.

(D) Use this gear for all normal driving conditions. The vehicle will start in first gear, and as you depress the accelerator, the transmission will upshift to second gear, third gear and fourth gear, automatically. As the vehicle slows down, the transmission will downshift to the correct gear, automatically.

(3) and (2) Occasionally, the road, load, or traffic conditions will make it desirable to restrict the automatic shifting to a lower range. When the conditions improve, return the range selector to the normal driving position. These positions also provide progressively greater engine braking power (the lower the gear range, the greater the braking effect).

(1) This is low gear for use when pulling through mud and snow or diving up steep grades. This position provides maximum engine braking power.

In the lower ranges (1, 2, and 3), the transmission will not upshift above the highest gear selected unless the recommended engine governed speed for the gear is exceeded.

NOTE: Some chassis may be equipped with five speed transmissions. On these transmissions, gear selection no. 1 is the creeper gear. Select this gear for off-highway operation. Use the creeper for pulling through mud or snow. This gear provides the greatest tractive effort. It is not recommended that full-power Upshifts from 1 to 2-3 be made.

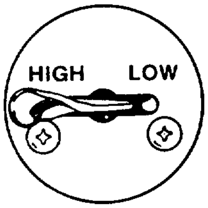
CAUTION: Allowing your vehicle to coast in neutral is not recommended. This practice can result in severe transmission damage. Also, no engine braking is available.

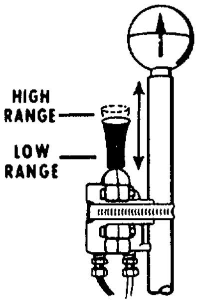
PARKING

When parking your truck, shift the transmission gear selector into neutral and apply the parking brake or chock the wheels.

: **WARNING: Never leave your parked truck in gear. If the truck should roll, the engine could start by heat of compression.**

Two-Speed Rear Axle (Optional)





A switch attached to the transmission selector on the dashboard permits selection of either the high or low axle ratio. When this control is pushed in or set on "low" position, the rear axle is in low (power) ratio. When this control is pulled out or set on "high" position, the rear axle is in high (speed) ratio.

SHIFTING THE TWO-SPEED AXLE MANUAL TRANSMISSION

Shifting Into the Low (Power) Ratio

On level grades or at high truck speeds:

1. Keep accelerator pedal depressed and push the control in or set to "low" position.
2. To complete the shift, release the accelerator pedal and then depress the accelerator again as quickly as possible. Do not operate the clutch.

On upgrades or at slow truck speeds:

1. Keep the accelerator depressed and push the control switch in or set on "low" position.
2. To complete the shift, keep the accelerator depressed and disengage and re-engage the clutch as quickly as possible.

Two-Speed Rear Axle (Optional) CONTINUED

On downgrades against the engine:

1. Release the accelerator and push the switch in or set to "low" position.
2. To complete the shift, press down on accelerator enough to synchronize the gears, then immediately release the accelerator. Do not operate the clutch.

Shifting Into the High (Speed) Ratio

On downgrades against the engine:

1. Release the accelerator and pull the control switch out or set to the "high" position.
2. To complete the shift, disengage and re-engage the clutch with the accelerator pedal released.

At any time except on downgrades against the engine:

1. Keep accelerator depressed and pull the control switch out or set to "high" position.
2. Gradually release the accelerator pedal to complete the shift. Do not depress the accelerator until the shift is completed.

SPLIT SHIFTING

To shift to the next higher gear and at the same time from the high to low speed axle, shift the transmission in the usual way and push the control switch in or set to "low" position before engaging the clutch. To shift to the next lower gear in the transmission and at the same time from the low to high speed axle, pull the control switch out to set to "high" position and release the accelerator, then complete your shift in the normal way. Always start and park in low range.

SHIFTING THE TWO-SPEED AXLE AUTOMATIC TRANSMISSION

The following shift procedure must be followed:

Going from Slow to Fast speed ratio:

1. Move selector switch to FAST position.
2. Release accelerator.
3. Pause with accelerator released until the shift is completed.
4. Resume accelerator pressure.

Going from Fast to Slow speed ratio:

1. Move selector switch to SLOW position.

2. Release accelerator.

3. Depress accelerator.

CAUTION: Do not attempt to shift from fast to slow under any circumstances until the speed of the vehicle has been reduced to a speed of at least 5 miles per hour less than the maximum truck speed at the governed engine RPM in the slow axle ratio.

TOWING

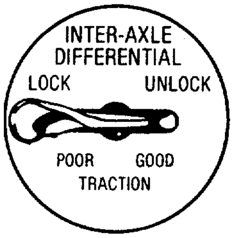
CAUTION: Unless the drive shafts are disconnected from the axles, towing can seriously damage the transmission mainshaft and mainshaft gears, since they will be starved of lubrication.

Inter-Axle Differential (Optional)

SHIFTING THE INTER-AXLE DIFFERENTIAL

Correctly used, the inter-axle differential provides for necessary differential action between the axles of a tandem drive unit. This allows the wheels of either axle to revolve faster or slower than the wheels of the other axle in order to compensate for cornering, uneven road surfaces and slightly different tire sizes.

When encountering soft or slippery road conditions, the driver can lock out the inter-axle differential, eliminating any differential action between the axles. Each axle then receives full power, giving the vehicle more get-up-and-go in rugged off-road operations and better control on slippery surfaces.

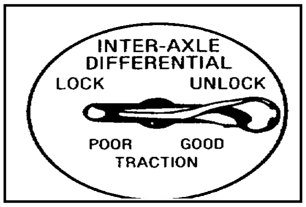


To Lock or Engage:

To lock the inter-axle differential and achieve maximum pulling power when approaching slippery or poor road conditions, follow these three steps:

1. Flip driver's control switch to "lock" position while maintaining vehicle speed before encountering the poor road condition.
2. Let up momentarily on the accelerator to engage the differential lock.
3. Proceed over the poor road conditions cautiously.

Inter-Axle Differential (Optional) CONTINUED



To Unlock or Disengage:

When the poor road conditions have passed, follow these next three steps for unlocking the inter-axle differential:

1. Flip the driver's control switch to "unlock" while maintaining vehicle speed after leaving the poor road conditions.
2. Let up momentarily on the accelerator to allow the shift.
3. Resume driving at normal speed.

CAUTIONS

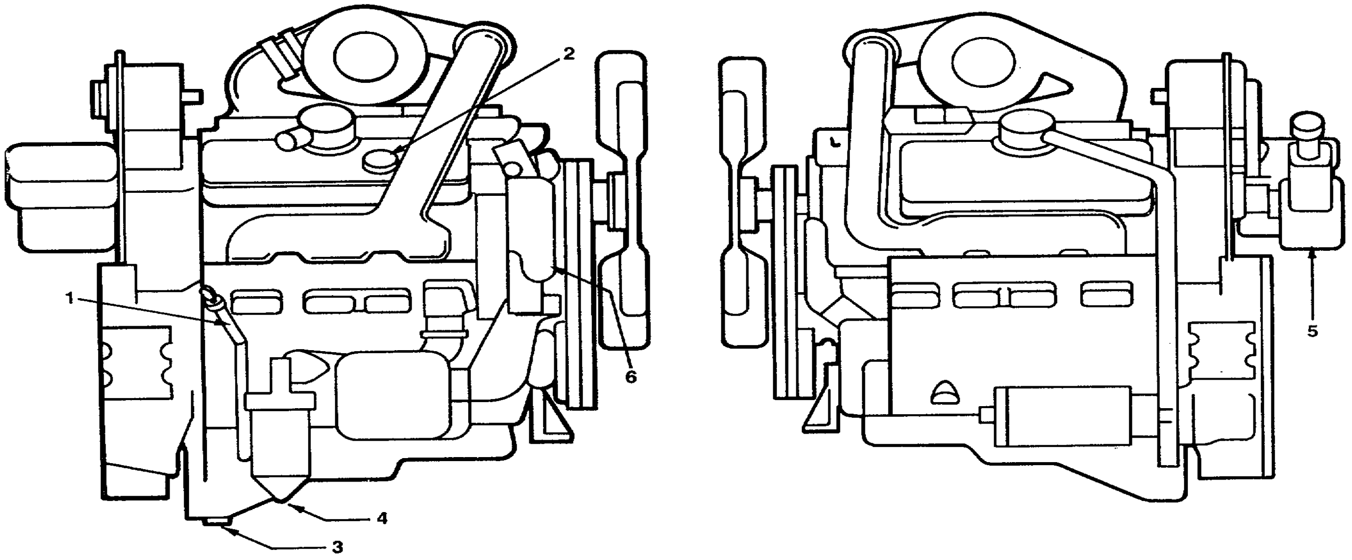
Do not actuate the inter-axle differential control switch while wheels are slipping. This can result in axle gearing damage.

Do not spin the wheels with the inter-axle differential unlocked. Rear axle gearing damage can result.

Do not wait until you've lost traction and your wheels are spinning before you lock the inter-axle differential. This could result in damage to the axle gearing.

Do not operate the vehicle continuously with the inter-axle differential in lock position during extended periods of good road conditions. This could result in excessive tire and gear wear.

Typical Engine Maintenance Diagram



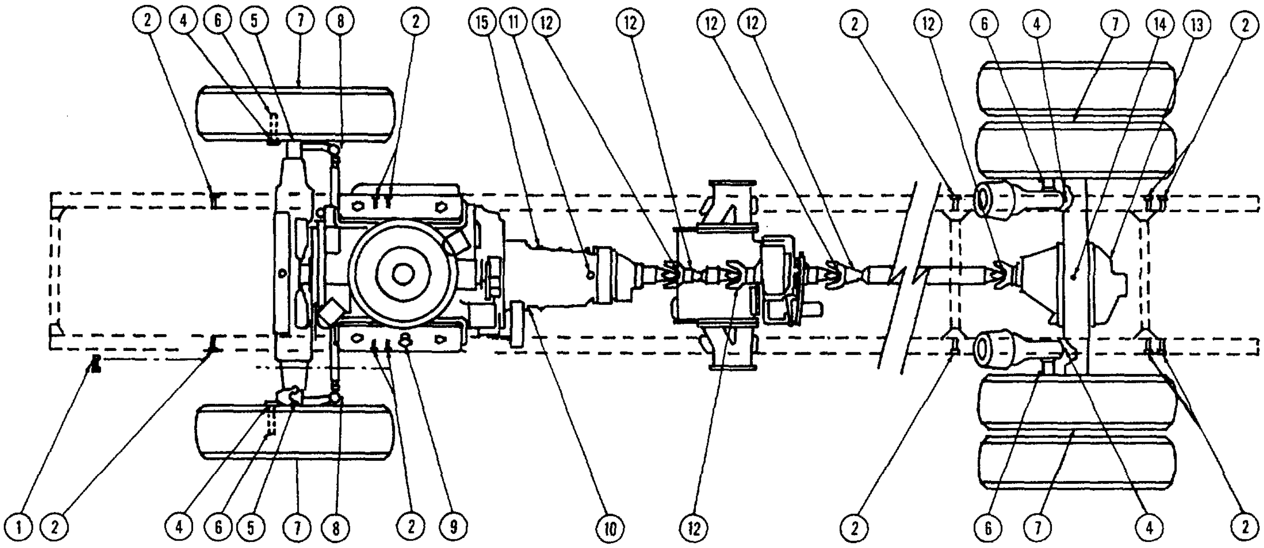
Item	Lube Symbol	Detroit Diesel
1. Crankcase Dipstick (check level)	EO	Daily/10 Hrs.
2. Crankcase Fill (fill to level on dipstick as required)	EO	As Req'd.
3. Crankcase Drain (drain and refill) (initial change for new or rebuilt engines should be made at 25 hours of operation)	EO	Monthly/150 Hrs.
4. Oil Filter (discard old element, clean housing and install new element at each oil change)	--	Monthly/150 Hrs.
5. Steering Pump Reservoir (check with wheels straight - fill to level as required)	EO	Daily/10 Hrs.

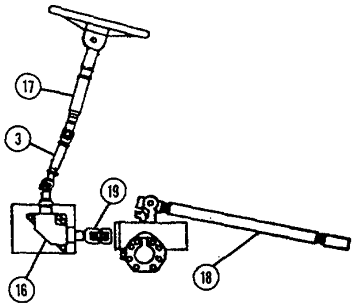
See lubrication symbols on chassis lubrication diagram.

Maintenance Schedule

Description	Check	Clean	Lube	Replace	Adjust
DAILY OR EVERY 10 HOURS					
Engine Oil Level	●				
Radiator Coolant Level	●				
Tire Pressure	●				
Drain Air Reservoirs	●				
Windshield Washer Fluid Level	●				
Windshield Washer Operation	●				
Signs of Oil, Water and Air Leaks	●				
Operation of Instruments, Gauges and Controls	●				
Transmission Oil Level	●				
Power Steering Fluid Level	●				
WEEKLY OR EVERY 50 HOURS					
Engine	See Engine Manual				
Wheel Lugs (torque)	●				
Battery Fluid Level	●				
Diesel Fuel Filter	●			●	
Belt Tension and Condition (fan, power steering and pump)	●				●
Radiator Fins	●	●			
Differential and Axle	●				
Radiator and Connections	●				
Lubrication Fittings	See Lubrication Chart				
MONTHLY OR EVERY 150 HOURS					
Engine Oil and Filter				●	
Engine Components	See Engine Manual				
Axle Components	See Axle Manual				
Air Cleaner Element	Replace when restriction indicator shows entirely red				
Clutch			●		●
Axle Mounting U Bolts	●				●
Body Mounting Brackets	●				●
All Bolts and Nuts	●				●
Tightness of All Joints on Muffler System	●				●
Steering Linkage	●				●
Tire Condition	●				
SEMI-ANNUALLY OR EVERY 1500 HOURS					
Engine Components	See Engine Manual				
Wheel Bearings	See Axle Manual				
Automatic Transmission Oil				●	
Clutch Pedal Travel	●				●
Radiator Shutter Linkage			●		
Differential Lubricant				●	
Electric Lines for Cracks or Wear	●				
Air Line System	●				
ANNUALLY					
Manual Transmission Oil				●	
Brake Linkage, Controls, Linings and Rubber Parts	●				
Radiator Filler Neck Seat, Cap Gasket and Cap Relief Valve	●			●	
Radiator Coolant	Drain and flush				
Air Cleaner Secondary Element and Dust Unloader (if applicable)		●		●	

Maintenance Schedule
Lubrication Chart (Typical Chassis)





Lubrication Symbols:
CG — Grease, high temperature
GO — Gear oil
ATF — *Automatic transmission fluid*
EO — Engine oil

Item	No of fittings	Description	Schedule	Symbol
1	1	Clutch pedal assembly (if applicable)	Weekly/50 Hrs	CG
2	12	Spring pin	Weekly/50 Hrs	CG
3	3	Shaft-steering gear to miter box	Weekly/50 Hrs	CG
4	4	Slack adjuster	Weekly/50 Hrs	CG
5	4	King pin	Weekly/50 Hrs	CG
6	4	Brake cam shaft	Weekly/50 Hrs	CG
7	-	Wheel bearings	See axle manual	GO
8	2	Tie rod ball joints	Weekly/50 Hrs	CG
9	-	Engine	See engine manual	See engine manual
10	1	Clutch throwout bearing (if applicable)	Weekly/50 Hrs	CG
11	1	Man. trans drain plug (drain & refill)	Semi-annually	GO
11	1	Auto. trans drain plug (drain & refill)	Semi-annually	ATF
12	6	"U" joints; slip shaft	Weekly/50 Hrs	CG
13	1	Differential fill plug	See axle manual	GO
14	1	Differential drain plug	See axle manual	---
15	1	Man. Trans. fill plug (check &fill to level)	Daily/10 Hrs	GO
15	1	Auto. Trans. fill plug (check & fill to level)	Daily/10 Hrs	ATF
16	1	Miter box	Weekly/50 Hrs	CG
17	1	Steering column	Weekly/50 Hrs	CG
18	2	Draglink	Weekly/50 Hrs	CG
19	3	Shaft-miter box to steering gear	Weekly/50 Hrs	CG

Anti-Freeze Chart

	Gallons of Ethylene-Glycol Base Anti-Freeze Required									
Cooling System Capacity in Gallons	5	6	7	8	9	10	11	12	13	14
10	-34°	-62°								
11	-23°	-47°	-62°							
12	-15°	-34°	-57°							
13	-9°	-25°	-45°	-62°						
14	-5°	-18°	-34°	-54°						
15	0°	-12°	-26°	-43°	-62°					
16	2°	-8°	-19°	-34°	-52°	-62°				
17	5°	-4°	-14°	-27°	-42°	-58°				
18	7°	0°	-10°	-21°	-34°	-50°	-62°			
19	9°	2°	-7°	-16°	-28°	-42°	-56°			
20	10°	4°	-3°	-12°	-22°	-34°	-48°	-62°		
21	12°	6°	0°	-9°	-17°	-28°	-41°	-54°	-62°	
22	13°	8°	2°	-6°	-14°	-23°	-34°	-47°	-59°	
23	14°	9°	4°	-3°	-10°	-19°	-29°	-40°	-52°	-62°
24	15°	10°	5°	0°	-8°	-15°	-24°	-34°	-46°	-58°
25	16°	12°	7°	1°	-5°	-12°	-20°	-29°	-40°	-52°

Degrees of Temperature in Fahrenheit

NOTE: 60% Ethylene-Glycol Base Anti-Freeze and 40% water by volume gives maximum protection.
NEVER use concentrated Ethylene-Glycol Base Anti-Freeze, as it will freeze at approximately 0° F.

Calculate Anti-Freeze

Determine cooling system capacity by consulting engine capacity chart. Refer to above table to determine amount of anti-freeze needed for protection desired.

Engine Capacities

Engine	Cooling System Capacity
6V-53T	13.25 Gals.
6-71N	15.25 Gals.
6-71T	15.25 Gals.
8V-71N	17.50 Gals.
8V-71TA	18.00 Gals.
6V-92TA	16.75 Gals.
8V-92TA	18.00 Gals.
VT-225	13.75 Gals.
PT-240	14.75 Gals.
PT-270	14.75 Gals.

Engine	Cooling System Capacity
NTC-300	14.75 Gals.
NTC-350	15.75 Gals.
VT-350	15.75 Gals.
NTC-400	15.75 Gals.
3406 DIT - 280 H.P	18.25 Gals.
3406 DIT CAL - 300 H.F	18.25 Gals.
3406 DIT - 325 H.P	18.25 Gals.
3406 PCTA CAL - 375 H.P	19.25 Gals.
3406 DITA - 380 H.P	19.25 Gals.

Regular Maintenance

ENGINE OIL

Check daily to be sure the oil level in the crankcase is between the ADD and FULL marks on the oil dipstick. When checking the oil level, the dipstick must be withdrawn and wiped clean, then inserted all the way and withdrawn again for a true reading.

Never check the oil level with the engine running, since a false level reading will be obtained.

See Engine Manufacturer's Manual for instructions on changing filters.

NOTE: The lubricating oil in a diesel engine becomes dark in color after short periods of operation. This discoloration is not harmful as long as the oil and oil filter are changed at regular intervals. (See page 18.)

FUEL FILTERS

Dirt of any kind must be kept from reaching the injection pump and injectors, or operating problems will result. A fuel filter or filters are used to protect the fuel system.

The life of the filter elements depends on the amount of dirt, water and sediments they must remove. These elements cannot be cleaned, and should not be disturbed except to replace them.

See Engine Manufacturer's Manual for details on filter change.

POWER STEERING RESERVOIR

Check weekly. To check the fluid level, remove fill cover and dipstick. If level is below FULL mark, add recommended fluid. The engine should be running at idle and the wheels centered when checking or adding fluid.

Use care in checking or adding fluid to keep dirt and foreign matter out of the system. If contamination is found, the system must be drained, flushed and refilled.

The location of the reservoir will vary depending on the engine in your truck.

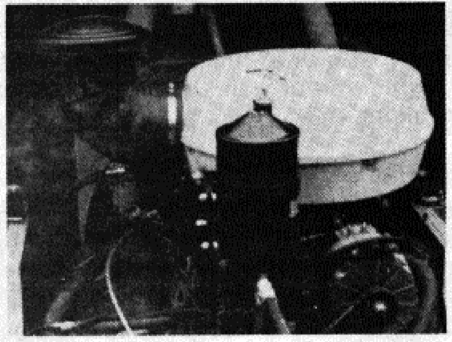


Fig. 10.

A typical power steering reservoir installation.

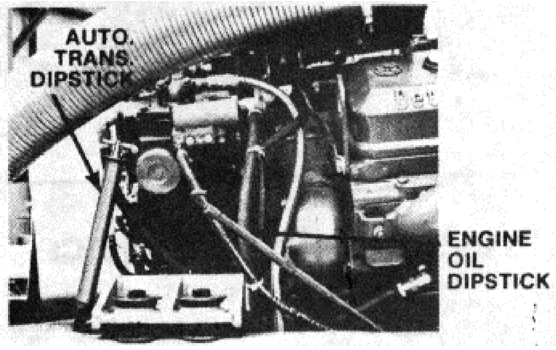
CLUTCH: MANUAL TRANSMISSION UNITS

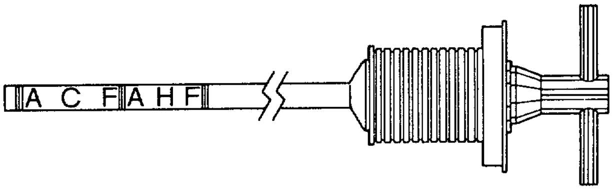
The clutch is located between the engine and transmission. If equipped with a grease fitting, it should be greased monthly or every 150 hours with MultiPurpose grease.

AUTOMATIC TRANSMISSION

Check oil level daily or every 10 hours, whichever occurs first. Drain and refill transmission and change filters annually or every 1500 hours (see Transmission Service Manual for further information).

When checking the transmission fluid level in an automatic transmission, the engine should be running at idle. Use the proper marking, hot or cold, depending on transmission temperature.





MANUAL TRANSMISSION

Check oil level weekly or every 50 hours, whichever occurs first. If level is low, add oil through the check plug opening (Fig. 12). Drain and refill annually (see Transmission Service Manual for further information). Make all checks of oil levels with engine off.

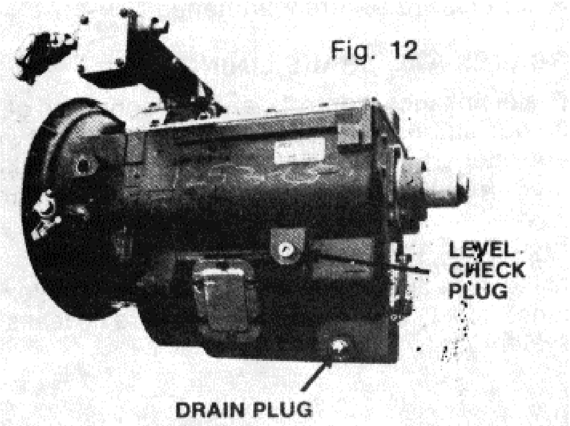


Fig. 12

Regular Maintenance
CONTINUED

DIFFERENTIAL

The differential is located in the center of the rear axle. Check lubricant level weekly or every 50 hours. Check and fill plugs are located on the differential housing (Fig. 13). Drain and refill once a year or every 1500 hours, whichever occurs first. The drain plug is located at the bottom of the housing (see Axle Manual for further information).

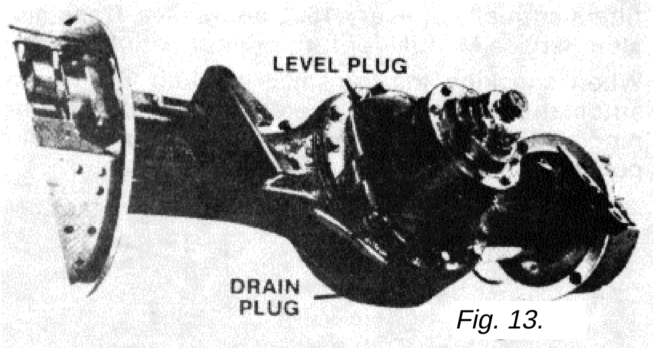


Fig. 13.

FUEL TANK

Our fuel tank is located behind the rear axle, and is bolted to the chassis frame with removable straps (Fig. 14). Always use clean fuel. Keep the tank full. This will prevent condensation and sweating, and will help to keep moisture out of the fuel system. See Engine Manual for fuel recommendations.

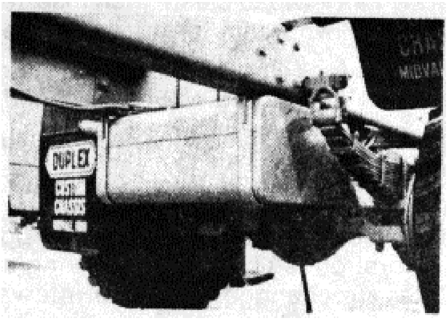


Fig. 14.

⚠ **WARNING:**: **Never fill fuel tank near an open flame. Shut off engine when refueling truck. Do not smoke when refueling.**

Preventive Maintenance

Every effort is made to be sure your Duplex Chassis is engineered and manufactured to provide continued dependable service. However, the continuation of safe, trouble-free operation of your truck depends on proper maintenance of the chassis and the immediate repair or replacement of parts that have deteriorated through use. Lubrication intervals present a good opportunity to inspect the entire vehicle. It is also a good practice to make an inspection of the running gear at least once a year. We recommend that the following items be checked at every lubrication or as indicated.

AXLES, BODY AND CHASSIS COMPONENTS

Check to be sure that axle mounting U-bolt nuts are properly torqued and body mounting brackets and chassis components (attaching or mounting bolts and nuts) are securely tightened.*

BRAKES AND BRAKE LININGS

Brake linkages, controls, and the condition of brake linings should be inspected at least once a year. If your department has a history of severe brake use, more frequent inspections should be scheduled.

ENGINE EXHAUST SYSTEM

Make sure all joints are tight* on mufflers, exhaust pipes, etc. Check to be sure there are no leaks in the system.

ELECTRICAL SYSTEM

Replace loose, weathered, cracked or broken wires to safeguard against breakdown or possible shorts.

PIPES AND HOSES

Check all air, water and hydraulic lines and hoses for leaks. Make sure they are not pushed against exhaust pipes, the engine or next to moving parts that can damage them. Replace all cracked, weathered or deteriorated hoses.

LINKAGES

Clutch, transmission and brake rods, clevis pins and lock pins should be in good repair and properly adjusted.

RUBBER PARTS

Rubber is subject to deterioration wherever it is used. Regularly check all such parts and replace as required. This is especially important for rubber parts in the brake system.

STEERING

Check tie-rod and drag-link end clamp bolts. They must be tight.* Minor adjustments could head off future problems.

WHEELS, RIMS AND TIRES

Check condition of and tighten wheel and rim bolts and nuts. Examine condition of tires. Keep tires inflated properly (see pages 27-29).

*See Service Manual for recommended torque limits.

Air Intake System

An average diesel truck engine will take in over 267,000 cubic feet of air during every hour of operation. If there are any air leaks in the tubing and connections between the air cleaner and the engine (and if nothing is done to correct the leaks), dust laden air will cause expensive damage to internal parts.

Air leaks develop when heat, deterioration and vibration fatigue combine to generate cracks in the tubing and elbow connectors. This condition can be accelerated if vibration and road shock further loosen fasteners, brackets and clamps. This is pointed out to stress the logic that if time and money are spent installing an air cleaner to protect the internal parts of an engine, then regular inspection and maintenance of the air intake tubing and connections is important to prevent any unfiltered air from entering the engine.

Always inspect a new air cleaner cartridge for shipping damage before installing it in the air cleaner housing. Inspect the old element for soot or oil If there is soot inside the element, check for (1) leaks in the engine exhaust system, (2) exhaust "blow back" into air intake, or (3) exhaust from other equipment. If the element appears "oily", check for fumes escaping from crankcase breather. Excessive oil mist shortens the life of any element. Troubleshooting before a new element is placed in the air cleaner can appreciably lengthen element life.

The following schedule is strongly recommended:

At Each Chassis Lubrication

Visually inspect the intake system, from the air cleaner to the intake manifold, with special attention to the following:

1. Check the air cleaner housing for cracks caused by distortion or vibration.
2. Check air cleaner mounting for loose fasteners and cracks.
3. Check all air tubing supports. Loose or broken supports can cause excessive vibration, and open cracks in the system.
4. Check all connecting clamps for dents, bends and tightness.
5. Wipe all tubing and elbow connectors clean, then check thoroughly for cracks.
6. Check for chafing of cables, control rods, hoses or lines against tubing and connectors. Correct as necessary.
7. If the air intake manifold or the compressor intake flange are suspected of being loose, consult the Engine Manufacturer's Manual for torque values and tighten retaining nuts to specifications.

AIR CLEANERS

Several makes of air cleaners are used on Duplex fire chassis. All should be serviced or replaced when restriction reaches the maximum allowable limit set by the engine manufacturer. A restriction indicator on the dash is provided as standard equipment on Duplex chassis. These are factory preset to a restriction limit. They will gradually change color as the air cleaner loads with dirt. When the indicator is solid red, the air cleaner should be cleaned or replaced. After changing the cartridge, re-set the indicator by pushing the re-set button.

Restriction Indicator

The restriction limits differ for various engines as follows:

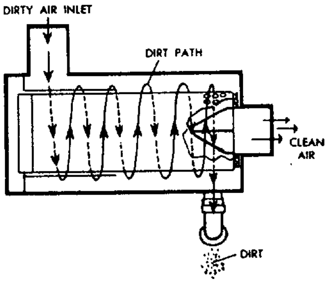
Detroit Diesel Engines	
Naturally aspirated	25" H20
Turbocharged	20" H20
Cummins Engines	
Turbocharged	25" H20
Caterpillar Engines	
Turbocharged	30" H20

CANISTER DRY TYPE AIR CLEANER

As outside air is drawn into the air cleaner, it is automatically set into circular action. This positive spinning of the dirty air throws out the heavier particles of dust and dirt, where they are collected in the dust port and then expelled through the dust unloader. Centrifuging continues even during low air intake at engine idle speeds.

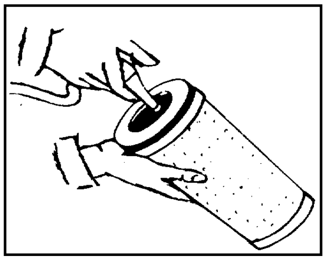
The air then passes through a washable filter element. One end is completely closed off with a metal cap. The other end is gasket-sealed against the outlet butt plate.

Paper pleats are chemically treated to resist oil and water, and provide the largest possible filtering area. Over 32 pounds of airborne dirt can be handled before maintenance is necessary. Maintenance of the canister type air cleaner is positive and simple. The elements may be cleaned by compressed air or by washing.

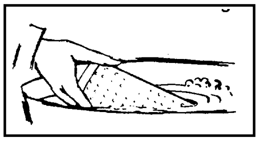


Air Intake System CONTINUED

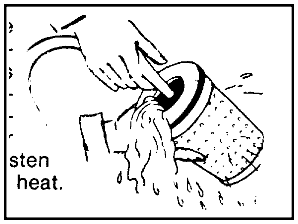
Cleaning With Air Only
Compressed air can be used to clean the dry-type element. Direct dry, clean air up and down the length of the element. If possible, use a garage-type nozzle and be sure the air pressure at the nozzle does not exceed 100 psi. Maintain a distance of several inches between the nozzle and the element. Be sure not to concentrate the air blast, since this can fracture or rip the element. The compressed air must be directed at the clean side of the element (i.e. a flow direction which is opposite to the normal flow of air through the element). Under no circumstances should the air be directed at the dirty side of the element.



Cleaning By Washing
Extreme dust conditions, recirculated exhaust soot and blow-by gases, or oil laden air shorten element life. Cleaning by the compressed air method A not remove these deposits satisfactorily. Warm with a low-suds detergent can be used to good advantage. First rinse with fresh water, or use compressed air to remove excess dirt from the cartridge.

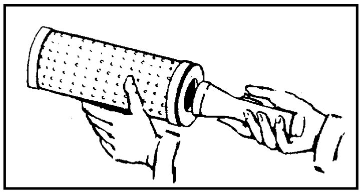


Soak the element in a solution of warm water and low-suds detergent for a period of from 15 minutes to several hours, depending on the quantity and type of contamination. Maintain a temperature of 100-125° for best results.



Using clean water, rinse the entire cartridge un-till the drain water i, clear. Air dry the element in a clean atmosphere. A fan or ail draft may be used to ha drying, but do not use

Under no circumstances should any form of solvent, fuel oil or gasoline be used for the purpose of washing elements, nor should any attempt be made to scrub, scrape, brush or rub off contamination from the element.



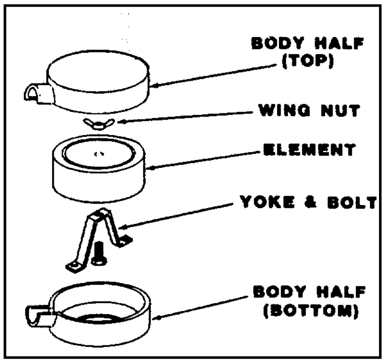
Carefully inspect the element to make sure there no rips, fractures pinholes. Check be certain that intact. The use of a drop light using a 150 watt bulb provides a handy and quick way to check the condition of the element. Insert the bulb in the element and slowly rotate the element. Rays from the bulb visible from the outside of the element may denote a break or fracture.

Duplex recommends that the element be replaced after four cleaning cycles, regardless of appearance.

The secondary, or safety element's function is to increase the effectiveness and maintenance dependability of the system. The safety element should not be cleaned, but should be replaced once a year or whenever it becomes plugged.

The automatic dust unloader should be replaced as needed, or at least once a year.

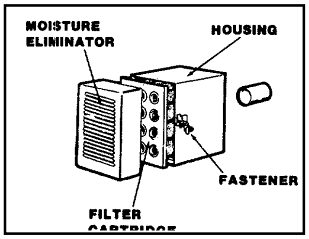
DONALDSON DRY TYPE AIR CLEANER



1. Loosen nuts joining the top and bottom halves of air cleaner housing. Remove the top half.
2. Remove cleaner element by loosening wing nut, and discard old element. Do not re-use.
3. Wipe out any dirt that may have gotten into the filter housing and install a new filter element. Make sure that the V-shaped gasket is in place on top of the element and the nylon washer is in place under the wing nut. Tighten the wing nut securely.

Place the assembled filter in the housing and reinstall the cover, making sure that the retaining nuts are tight.

TUBE TYPE AIR CLEANER

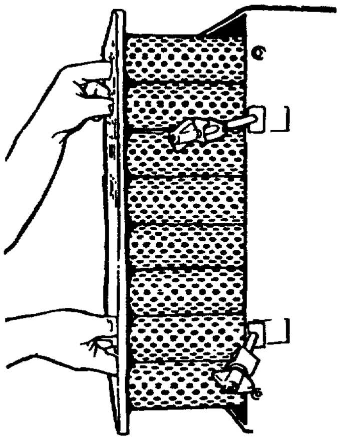


1. Loosen wing nuts on air cleaner housing and remove moisture eliminator (and guard, if used).
2. Remove Pamic tridge and discard. Do not re-use.
3. Inspect the inside of the air cleaner housing to be sure it is free of all foreign material.

Air Intake System CONTINUED

Installation of the Tube Type Cartridge

To install a new Pamic cartridge, hold the cartridge in the same manner as when removing it from the housing. Insert the new cartridge into the housing. Avoid hitting the cartridge tubes against the sealing flange on the edges of the air cleaner housing.



Since the tube type air cleaner does not require separate seals or gaskets, care must be taken to make sure the cartridge is seated properly within the air cleaner housing. Firmly press all edges and corners of the cartridge with your fingers to effect a positive air seal against the sealing flanges of the housing. Under no circumstances should the cartridge be pounded or punched in the center with a fist to effect a seal.

Lock cartridge in place by installing pre-cleaner (on two stage) or moisture eliminator (on single stage). Tighten wing nuts evenly at opposite corners first. After tightening by hand, wing nuts should be turned 11/2 to 2 more turns with a small wrench. If hex nuts are used, tighten to a torque of 15 in. lbs.

If intake adaptors or rain guards are used, follow the same procedure. Tighten all nuts again two or' three days after a clean cartridge is installed.

CAUTION: During operation, care should be taken to keep the air cleaner intake unobstructed. Do not expose the air cleaner to temperatures over 2000 F.

FARR ECOLITE FILTER

When the dash mounted restriction indicator shows maximum allowable restriction, replace the entire air cleaner assembly.

Cooling System

The cooling system of every internal combustion engine performs a vital function --the dissipation of heat in order to maintain normal engine operation. Internal combustion engines develop power through the conversion of fuel into heat,' and then into mechanical energy applied at the output shaft. Only one-third of this heat is converted into power, while another third goes out the engine's exhaust system. This still leaves one-third of the heat to contend with. Its elimination is the job of the cooling system.

WHAT PREVENTS PROPER HEAT DISSIPATION

The two major deterrents to proper heat dissipation are coolant passage deposits and aerated coolant.
Both act as an insulator.

DEPOSITS

Coolant passage deposits fall into four general categories:

1. Scale from water-borne minerals.
2. Products of corrosion.
3. Products of chemical incompatibility.
4. Petroleum contaminants.

Scale deposits twelve thousandths (.012) of an inch thick will cut heat dissipation by up to 40%.

The most common product of chemical incompatibility is chromium hydroxide (commonly called "green slime"). This is a green oxidation product formed by using chromate type inhibitors with permanent anti-freeze. Petroleum contaminants such as lube oil or soluble oil in the system will also reduce the heat dissipation efficiency of the coolant.

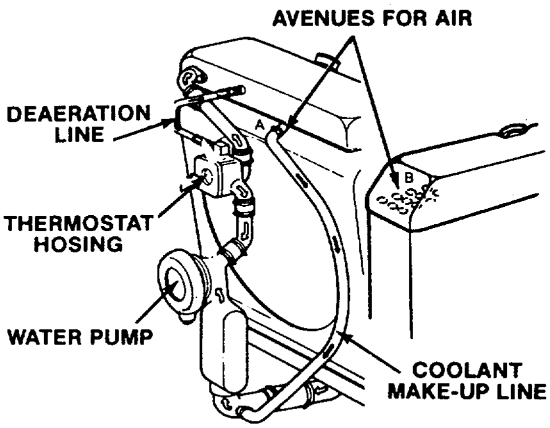
AERATED COOLANT

The presence of air bubbles in the coolant reduces pump efficiency and the heat capacity of the coolant. The cooling system is designed to remove a certain amount of entrapped air from the coolant. Pockets of air that are trapped in the engine during fill are removed to the top tank of the radiator, normally within minutes of start-up. However, conditions such as a low coolant level or a leaking gasket or hose on the suction side of the water pump can introduce more air into the cooling system than it can handle.

Cooling System CONTINUED

PRESERVATION OF HEAT DISSIPATION

In order to maintain optimum heat dissipation within the engine, the cooling system should contain an inhibited coolant that will keep water jacket surfaces clean and deposit-free. The fundamental requirements for an air-free coolant are the proper coolant level and the repair or replacement of components necessary to preserve an airtight, leakproof system.



The engine water pump can draw air as well as coolant when the coolant level drops below the coolant make-up line connection at the radiator (A) or the top of the radiator core (B).

MECHANICAL COMPONENTS OF THE COOLING SYSTEM

Another aspect of the cooling system requiring attention is the mechanical side. The radiator and pressure cap, the cooling fan and driving belts, the thermostat, the water pump, the hoses and connecting hardware, must be maintained in good working order.

COOLANT PRESSURE CONTROL CAP

The cooling system is pressurized to permit high altitude operation without loss of coolant and to prevent coolant after-boiling following engine shutdown. The standard pressure cap used in Duplex chassis cooling systems maintains seven (7) psi. Radiator cap testers can confirm if the pressure valve in the cap is releasing at its proper setting. If it is not, the cap should be replaced.

Replacement caps must be of the same setting (usually stamped on the cap) as the one replaced. Under-pressurizing a system is inviting coolant loss. Over-pressurizing a system overloads hoses, radiator seams and heater parts. This could lead to rupturing of these parts.

There is a second valve in the radiator cap that opens under vacuum. This prevents the collapse of hoses and other parts. Inspect the vacuum relief valve to be sure it is not stuck on its seat.

To insure that the cap is going to seal properly, check the radiator filler neck seat and radiator cap gasket for defects every 12 months. Replace the cap if the gasket shows deterioration.

HOSES

Inhibited coolants protect against corrosion and scale, but do not prevent hoses from deteriorating. Make sure both upper and lower coolant hoses are pliable. Replace hoses that show signs of hardening, cracking, weakening or ballooning. Avoid sharp bends that may kink the hose.

Hose clamps may become loose occasionally from the hoses taking a set. Re-tighten clamps as necessary. Do not over-tighten. Be sure that there is nothing rubbing against any of the hoses.

SCHEDULED MAINTENANCE

Check coolant level in radiator daily. The coolant level should be within 2" of the top of the filler neck.

⚠ WARNING: **Removal of a radiator cap on a warm engine will cause hot coolant to spray out and may result in serious injury. If it is necessary to check coolant level in a hot radiator, shut off the engine and relieve radiator pressure before removing the cap. Relieve pressure by holding the cap with rags and turning to the left until pressure begins to escape. Wait until the escaping pressure has stopped and remove the cap cautiously**.

If coolant level is consistently low, check for leaks in the radiator or hoses. If no leaks are found, check for air in the system, possibly caused by a leaky head gasket. Check fan belts for frays, proper alignment and tension. Drain and flush the cooling system once a year.

CAUTION: If coolant is to be added or refilled when the engine is warm, add coolant slowly to prevent rapid cooling and possible cracking or distortion of the engine block.

When shipped from the factory, the cooling system is filled with a permanent type anti-freeze solution of 1/2 water and 1/2 ethylene glycol base anti-freeze. Any high boiling point - type anti-freeze marketed today works equally well.

CAUTION: Anti-freeze with sealer additives is not recommended for use with diesel engines due to plugging problems which can develop throughout the cooling system.

CORROSION INHIBITORS

A non-chromate type inhibitor is recommended for use with either water or the ethylene glycol base anti-freeze solution to retard rust and scale buildup. All corrosion inhibitors, no matter what type you use, dissipate under normal operating conditions.

They should be replenished at approximately 500 hour intervals. See the Duplex Service Manual or the engine manufacturer's Service Manual for further information.

Batteries

It is important to keep all batteries at full charge, especially for cold weather. Check fluid level weekly. Water loss that occurs at a rate above normal is an indication that a short exists, and the complete battery charging and electrical system should be inspected.

WARNING:Electric storage batteries give off highly inflammable hydrogen gas when charging, and continue to do so for some time afterwards. Keep open flame or sparks away from the batteries. To lessen the risk of injury in case of explosion, wear eye protection when working near a battery. Battery electrolyte is a corrosive acid. DO NOT ALLOW IT TO CONTACT EYES, SKIN, FABRICS, OR PAINTED SURFACES. Thoroughly flush any contacted area immediately with water. Get medical assistance if eyes are affected.

RECOMMENDATIONS FOR BATTERY PROTECTION

Here are some suggestions for protecting battery efficiency and life:

1. Make cable connections as corrosion resistant as possible by coating the connection with a heavy general purpose grease. Tighten the cable clamps to the battery posts before applying the grease. This prevents the grease from getting between the clamps and the posts, and thereby restricting the flow of electrical current.

CAUTION: Do not use a non-porous material such as shellac or a plastic sealer instead of grease on battery connections. The material should be able to "breathe"; otherwise, greater corrosive action may occur under the surface of the coating.

2. Keep the battery clean. It can be cleaned with a brush dipped in a baking soda or ammonia solution. Make sure the battery caps are tight to prevent the solution from entering the battery. After cleaning, flush with water. Clean battery terminals with steel wool or a wire brush. Keep terminals clean and tight. Make sure vent holes in the battery caps are open.
3. Maintain the battery electrolyte level above the plates. Add clean water (distilled or tap water). Never add water from a questionable source such as a creek or stream. Raw water impurities can impair the action of the battery electrolyte.

CHARGING BATTERIES

Always disconnect battery leads while charging batteries. A fast charger should never be used as a booster for starting the engine. Always connect battery charger leads to vehicle battery leads of the same sign. Check ground or return circuit polarity visually (or with a voltmeter) before connecting batteries or other voltage producing components into the system.

GROUND

Do not ground the field circuit at the regulator or the alternator. Do not ground the alternator output terminal.

OPEN CIRCUIT

Do not operate alternators on open circuit; that is, with output wire disconnected from terminal and with field circuit externally energized. Do not turn master switch to OFF position while engine is running.

SHORT

Do not short across any terminals on the regulator.

CAUTION: Disconnect batteries before doing any welding on truck. The alternator is very sensitive to changes in current polarity and voltage spikes. In all alternators, the diode of the rectifier acts as a check valve and allows current to travel in only one direction. The opposite action of the welding polarity (feeding through the ground cable of the battery) burns up the diode. Even if the polarity is correct, the high voltage will produce the same results.

Wheels

WHEEL AND RIM MOUNTING NUTS - CAST WHEELS

On cast type wheels, the rim clamp nuts should be inspected weekly to assure that they are tight. The rim and tire alignment, in relation to the wheel, should also be inspected to be sure the tire is running true. Keep the rim clamps tight. Refer to torque chart for nut size and torque.

RIM CLAMP NUT TORQUE

Thread Size	**Torque (lbs. foot)**
5/8-11	160-175
3/4-10	175-190

WHEEL AND RIM MOUNTING NUTS - DISC WHEELS

1. Mounting faces of the hub, wheel and nut must be free from dirt or excess paint. Mounting faces that are damaged must be replaced.

2. Right hand threads are used on the right side of the vehicle and left hand threads on the left side.

WARNING: **DO NOT use right hand threads on left side and vice versa. The wheel could become disengaged from the vehicle.**

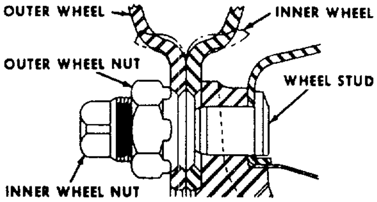
3. Tighten the single wheel nuts alternately.

Wheels CONTINUED

4. Tighten the wheel mounting stud nuts to 450-500 pounds foot torque.

5. On dual wheels, loosen the outer nuts before attempting to tighten the inner nuts. Tighten inner nuts to 500 pounds foot torque and outer nuts to 450 pounds foot torque.

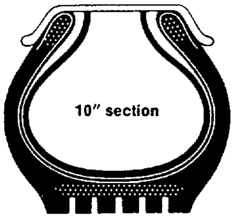
NOTE: Always tighten the inner nuts 50 pounds foot more than the outer nuts. Never let the outer nuts get below 400 pounds foot torque. The wheel nuts should be tightened daily during the first 500 miles of service: (1) on new trucks, and (2) whenever wheels have been removed and repaired. Torque of the nuts should be checked weekly thereafter

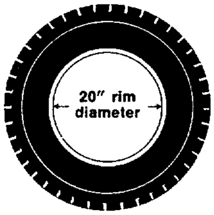


Tires

LOAD RANGE/PLY RATING CONVERSION CHART

Load Range	Ply Rating
F	12
G	14
H	16
J	18
L	20





TIRE DATA

This illustration shows how a truck tire is measured. The first number in any tire size is the measurement between the sidewalls taken at the widest point when the tire is inflated but not under load.

The second number is the measurement from bead to bead (rim diameter). The letter "R" designates radial construction.

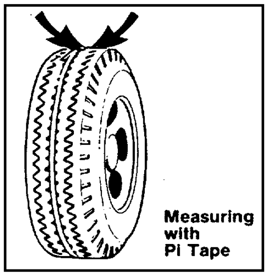
Example: 11.00 x 20-Load Range H This is a bias belted non-radial tire with 11" dimension outside to outside and a 20" measurement from bead to bead with a 16 ply rating. 11.00R20-Load Range H This is a radial construction tire with the same measurements and ply rating as the above.

MATCHING AND SPACING OF DUALS

If the tires on a dual assembly are not closely matched in size, the smaller tire suffers from fast, irregular wear as it scuffs against the road. The larger tire is often subjected to an overload and excessive flexing which may lead to overheating, internal damage, and possible blow-out.

Problems are likely to result if tires on a dual assembly differ by more than 1/2 inch in diameter.

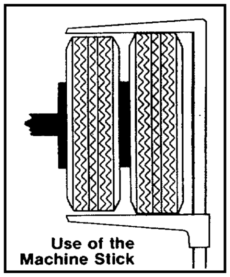
If a slight mismatch does occur, the smaller of the two tires should be installed on the inside. The most accurate way to measure an inflated tire before it is on the vehicle is to use a steel pi tape. Wait at least 24 hours after initial inflation before measuring. On vehicle measurement can be made with the other devices illustrated.


Measuring with Pi Tape

Tire spacing between duals is also important. If too close, sidewalls will rub to-gether when the vehicle is heavily loaded. If too far apart, the outside tire will suffer from excessive scuf-fing when the vehicle makes a turn.

TIRE INFLATION

Proper inflation is vital! Underinflation is a tire's worst enemy. Inflation pressure should be checked daily. "Thumping" with a so-called tire bar is not a satisfactory method to use when checking pressure.


Use of the Machine Stick

The practice of "bleeding" tires (reducing inflation pressure) to attain a softer ride is extremely hazardous, especially when steer axle tires are involved. Underinflation causes excessive flexing within the tire, resulting in heat build-up which can cause a blow-out. An underinflated tire running at highway speeds and under heavy load can cause severe handling problems.

Underinflation can also result in general deterioration of the tire body, including separation of the

Tires CONTINUED

tread from the body or fatigue breaks in the body cords. Remember, if one tire on a dual assembly is severely underinflated, the other tire is prone to failure from overloading.

Overinflation detracts from a tire's ability to endure road shocks. The tire is more rigid, resulting in carcass and bead failures. Overinflated tires often exhibit groove cracking and rapid center tread wear, and are more likely to be cut or punctured.

Excessive pressure build-up resulting from overloading or high speed can cause the rim to fail. Remember that the load carrying capacity of a tire cannot be increased over the maximum rated load by increasing the inflation pressure. See Master Truck Record for the proper tire inflation.

A tire which has become hot from normal use will have a higher pressure than specified in your owner's manual. Never bleed a hot tire!

CAUTION: On 4 x 4 or 6 x 6 vehicles, tires of the same size and specification must be installed on both front and rear driving axles. If different size tires are used, when the vehicle is operated with both axles engaged, a torque build-up between the axles, caused by the different size tires, will result in excessive tire wear and strain on the entire drive unit.

Warranty

The Duplex Warranty is a typical automotive type that covers workmanship and materials. Many items such as engine, transmission, axles, tires, and batteries are warranted by the manufacturers of these products. In all cases, warranty claims on any part of the chassis should be made to the apparatus manufacturer who produced and delivered the complete fire truck to your department.

ITEMS NOT COVERED BY WARRANTY

Certain services and expenses in connection with the repair and maintenance of Duplex trucks are not reimbursable. Examples of such items are (but are not limited to) the following:

1. Towing and road calls.
2. Services required due to vehicle misuse, negligence or accident for which the owner is responsible, and over which the manufacturer has no control, including use or operation different from that for which the truck was designed, or loading beyond capacity.
3. Failures caused by modifications not authorized by Duplex.
4. Incidental expenses such as fuel, telephone, traveling, lodging, and loss or damage of personal property.
5. All tires, inner tubes and wheels are warranted by their respective manufacturers.
6. Service required due to improper storage, protection or handling of new vehicle prior to final delivery, including damage to batteries, cooling system, paint, tires, trim or bright metal parts due to inadequate protection of stored vehicle, or services due to loss or damage to vehicle in transit.
7. Normal diagnosis and test services.
8. Front end alignment.
9. Failures resulting from lack of normal maintenance as described in the Duplex Maintenance Manual.
10. Replacement or adding of lubricant or coolant.
11. Unnecessary replacement rather than repair of unit.
12. Any service not authorized by Duplex.

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

R. L. DILWORTH
Brigadier General, United States Army
The Adjutant General

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THE METRIC SYSTEM AND EQUIVALENTS

LINEAR MEASURE

1 Centimeter 10 Millimeters 0 01 Meters 0 3937 Inches
1 Meter 100 Centimeters 1000 Millimeters 39 37 Inches
1 Kilometer 1000 Meters 0 621 Miles

WEIGHTS

1 Gram 0 001 Kilograms 1000 Milligrams 0 035 Ounces
1 Kilogram 1000 Grams 2 2 Lb
1 Metric Ton 1000 Kilograms 1 Megagram 1 1 Short Tons

LIQUID MEASURE

1 Milliliter 0 001 Liters 0 0338 Fluid Ounces
1 Liter 1000 Milliliters 33 82 Fluid Ounces

SQUARE MEASURE

1 Sq Centimeter 100 Sq Millimeters 0 155 Sq Inches
1 Sq Meter 10 000 Sq Centimeters 10 76 Sq Feet
1 Sq Kilometer 1 000 000 Sq Meters 0 0386 Sq Miles

CUBIC MEASURE

1 Cu Centimeter 1000 Cu Millimeters 0 06 Cu Inches
1 Cu Meter 1,000,000 Cu Centimeters 35 31 Cu Feet

TEMPERATURE

5/9 (F 32) C
212 Fahrenheit is equivalent to 100 Celsius
90 Fahrenheit is equivalent to 32 2 Celsius
32 Fahrenheit is equivalent to 0 Celsius
9/5 C + 32 F

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2 540
Feet	Meters	0 305
Yards	Meters	0 914
Miles	Kilometers	1 609
Square Inches	Square Centimeters	6 451
Square Feet	Square Meters	0 093
Square Yards	Square Meters	0 836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0 405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29 573
Pints	Liters	0.473
Quarts	Liters	0.946
Gallons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0 907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubit Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
Liters	Gallons	0.264
Grams	Ounces	0.035
Kilograms	Pounds	2.205
Metric Tons	Short Tons	1 102
Newton-Meters	Pound-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
Kilometers per Liter	Miles per Gallon	2.354
Kilometers per Hour	Miles per Hour	0.621

TEAR ALONG PERFORATED LINE

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS

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