# 480 LOADER

# TABLE OF CONTENTS




CASE CORPORATION

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C-2

## 188 ENGINE SPECIFICATIONS

Type ---------- CASE Full Diesel,4 Cylinder 4 Stroke Cycle Valve-in-Head Engine.

No. of Cylinder Heads ---------- 1

Firing Order ---------- 1-3-4-2

Bore ---------- 3-13/16 Inches

Stroke ---------- 4-1/8 Inches

Piston Displacement ---------- 188 Cubic Inches

Compression Ratio ---------- 17.5 to 1

Oil Filter, Crankcase ---------- Replaceable Full Flow Element Type.

Method of Starting Diesel Engine ---------- Electric Starting Motor.

### Maximum Compression Pressures

ENGINE WARMED UP TO OPERATING TEMPERATURE
CRANKING AT APPROXIMATELY 200RPM

| Altitude | Sea Level | 1000 ft. | 2000 ft. | 3000 ft. | 4000 ft. | 5000 ft. |
|---|---|---|---|---|---|---|
| Compression | 400 PSI | 389 PSI | 373 PSI | 359 PSI | 346 PSI | 332 PSI |

Allowable Variance Between Cylinders ---------- 20 Pounds

## CYLINDER SLEEVES

Type ---------- Replaceable Wet Type; Two Rubber "O" Ring Seals Carried on Each Sleeve.

Inside Diameter of Sleeve Bore ------ 3.8110 to 3.8120 Inches. Replace Sleeve When Inside Diameter Below Top Ring Ridge Exceeds 3.819 Inches.

Piston Clearance in Sleeve (At Skirt) ---------- .002 to .005 Inch

Cylinder Sleeve Protrusion Above Block ---------- .002 to .005 Inch

## PISTON AND PISTON PINS

Piston Material ---------- Aluminum

Piston Weight (Less Pin) ---------- 2.224 to 2.233 Pounds

Diameter of Piston at Top of Skirt (Below Oil Ring Perpendicular to Pin) ---------- 3.805 to 3.806 Pounds

Diameter of Piston at Bottom of Skirt (Perpendicular to Pin) ---------- 3.807 to 3.808 Inches

Piston Pins ---------- Full Floating Type; Held in Position With Snap Rings in Piston. Replaceable Bronze Bushing in Connecting Rod.

Piston Pin Length ---------- 3.147 to 3.167 Inches

Piston Pin Diameter ---------- 1.2497 to 1.2498 Inches

Piston Pin Fit in Piston ---------- .0001 to .0004 Inch

Piston Pin Fit in Connecting Rod Bushing ---------- .0002 to .0005 Inch

## PISTON RINGS

Rings Per Piston ---------- 3 (2 Compression and 1 Oil)

Compression Rings

- Width of Ring-Top (Keystone) ---------- .1225 to .124 Inch
- 2nd ---------- .0930 to .0935 Inch
- Ring End Gap When Compressed in 3.8125 Inch Cylinder ---------- .015 to .025 Inch
- Side Clearance in Groove of 2nd Ring ---------- .0035 to .005 Inch

Oil Ring ---------- To Install Replacement Ring, Follow Instructions Packed With Rings.

- Width of Ring ---------- .1825 to .1885 Inch
- Side Clearance in Groove ---------- .0000 to .007 Inch

## CONNECTING RODS

Connecting Rod Bushing ------- Replaceable Bronze Bushing. Replacement Bushing Must be Reamed. Use 1.2500 to 1.2502 Reamer.

Piston Pin Hole Diameter in Rod(Without Bushing)-1.312 to 1.313 Inches

Inside Diameter of Piston Pin Bushing in Rod ------- 1.2500 to 1.2502 Inches; Install New Bushing If Inside Diameter Exceeds 1.2507 Inches.

Connecting Rod Bearing ----------Replaceable Precision, Steel Backed Aluminum Liners

Connecting Rod Capscrews -------- Self Locking Type, No Lock Wires Required; May Be Used More Than Once.

Connecting Rod Length (Center to Center Between Pin Hole and Bearing Journal Hole) --- 7.0029 to 7.0039 Inches

Bearing Liner Width ---------- 1.125 Inches

Diameter of Crankshaft Journal Hole in Rod (Without Liner) ---------- 2.1870 to 2.1875 Inches

Inside Diameter of Bearing Liner (Standard Liner in Place in Rod and Capscrews Tight) ----2.0625 to 2.0640 Inches

Diameter of Crankshaft Rod Journal ----------2.0605 to 2.0615 Inches

Clearance Between Rod Bearing and Crankshaft Journal ---------- .001 to .0035 Inch; Install New Bearing Liners When Clearance Exceeds .006 Inch.

Undersize Bearing Liners Available for Service ----------.002, .010, .020, .030 Inch

Allowable Connecting Rod Bearing End Play ----------.005 to .011 Inch

## CRANKSHAFT AND MAIN BEARINGS

Crankshaft ---------- Balanced; Drilled to Provide Pressure Lubrication to Main and Connecting Rod Bearings.

Type Main Bearings ---------- Replaceable, Precision, Steel Backed Aluminum Liners.

Bearing Capscrews ---------- Self Locking Type; No Lock Wires Required. May Be Used More Than Once

Bearing Taking End Thrust ---------- Center

Crankshaft End Play (Measured at Center Main Bearing) ---------- .001 to .006 Inch; Install New Bearing If End Play Exceeds .012 Inch.

Main Bearing Journal Diameter ---------- 2.873 to 2.874 Inches

Crankshaft Main and Connecting Rod Journal Bearings out of Round ---------- Maximum .002 Inch

Inside Diameter of Main Bearing Liners (In Place and Capscrews Tight)---------- 3.8748 to 3.8768 Inches

Clearance Between Main Bearing Liner and Journal ---------- .0008 to .0038 Inch; Install New Bearing Liner When Clearance Exceeds .006 Inch.

Width of 1st Main Bearing Liner (Front) --------- 1.276 to 1.286 Inches

Width of 2nd and 4th Main Bearing Liners ----------.980 to 1.000 Inches

Width of 3rd (Center) Main Bearing Liner --------1.371 to 1.373 Inches

Width of 5th (Rear) Main Bearing Liner --------1.5575 to 1.5675 Inches

Width Between Crankshaft Main Bearing Cheeks

- 5th ---------- 1.745 to 1.755 Inches
- 2nd, 4th ---------- 1.185 to 1.189 Inches
- 3rd (Center)---------- 1.374 to 1.377 Inches

Width Between Crankshaft Rod Bearing Journal Cheeks ----------1.3105 to 1.3145 Inches

Undersize Main Bearing Liners Available for Service ----------.002, .010, .020, .030 Inch

Crankshaft Main Bearing Journals
Should Be Ground to
2.863 to 2.864 Inches for .010 Inch Undersize Bearing
2.853 to 2.854 Inches for .020 Inch Undersize Bearing
2.843 to 2.844 Inches for .030 Inch Undersize Bearing

Undersize Connecting Rod Bearing
Shells Available for Service ----------.002, .010, .020,. 030 Inch

Connecting Rod Crankshaft Journals Should
Be Ground to
2.0505-2.0515 Inches for .010 Inch Undersize Bearing
2.0405-2.0415 Inches for .020 Inch Undersize Bearing
2.0305-2.0315 Inches for .030 Inch Undersize Bearing

## CAMSHAFT AND BUSHINGS

Number of Bearing Surfaces on Camshaft ----------5

Type Bushing ---------- Replaceable, Precision, Steel Backed Babbitt

Diameter of Camshaft at Each Bearing Surface --- 1.749 to 1.750 Inches

Inside Diameter of Each Bushing
(Measured When in Place in Block) ----------1.752 to 1.753 Inches

No. 1 (Front) Bushing Length ----------1.213 to 1.223 Inches

No. 2 and 4 Bushing Length ---------- .490 to .500 Inch

No. 3 Bushing Length ----------.713 to .723 Inch

No. 5 Bushing Length ---------- 1.213 to 1.223 Inches

Camshaft End Play ---------- Taken Up By Thrust Plate

Camshaft Thrust Plate Thickness ---------- .147 to .149 Inch

Camshaft End Clearance ----------.003 to .007 Inch

## TIMING GEARS

Total Gear Train Backlash (From Crankshaft to Injection Pump
Drive Gear)-Measured at Injection Pump Drive Gear --- Max. .030 Inch

Backlash Between Oil Pump Drive Gear
and Crankshaft Gear ----------.003 to .007 Inch

## VALVE PUSH ROD LIFTERS

Type ----------Mushroom Type

Outside Diameter of End That Projects into Block ---- .561 to .562 Inch

Diameter of Bore in Block for Lifter ---------- .5625 to .5635 Inch

## VALVES

### Valve Tappet Clearance

Intake and Exhaust ----------.014 Inch, Engine Cold
Intake and Exhaust ----------.014 Inch, Engine Hot
Hot Settings Are Made At Low Idle After The Engine Has Operated At Thermostat Control Temperature For At Least Fifteen Minutes.

### Exhaust Valves

Angle of Valve Face ---------- 44 Degrees

Valve Length ---------- 6.339 to 6.364 Inches

Maximum Valve Face Runout -------.002 Inch as Determined with a Dial Indicator

Diameter of Valve Stem --.3399 to .3409 Inch Install New Valve If There is More Than .002 Inch Difference in Diameter At Any Point on Stem

Diameter of Valve Head ----------1.403 Inches

### Exhaust Valve Seat Insert

Seat Angle ---------- 45 Degrees

Seat Width ----------.072 to .085 Inch

Insert Height ---------- .2475 to .2525 Inch

Outside Diameter of Insert ---------- 1.445 to 1.4505 Inches

Inside Diameter of Insert ---------- 1.245 to 1.255 Inches

Maximum Allowable Seat Runout ---------- .002 Inch as Determined with a Dial Indicator

### Exhaust Valve Guides

Length ---------- 3.125 Inches

Outside Diameter ---------- .6565 to .6575 Inch

Inside Diameter ---------- .3429 to .3439 (After Assembly)

Valve Stem Clearance in Guide ----------.002 to .004 Inch

Distance Above Head Guide Must Protrude --------.875 Inch, Press Fit

### Intake Valves

Angle of Valve Face ---------- 44 Degrees

Valve Length ---------- 6.334 to 6.369 Inches

Maximum Valve Face Runout ---------- .002 Inch as Determined with a Dial Indicator

Diameter of Valve Stem ----------.3409 to .3419 Inch. Install New Valve if there is More Than .002 Inch Difference in Diameter at any Point on Stem.

Diameter of Valve Head ---------- 1.604 Inches

### Intake Valve Seat

Seat Angle ---------- 45 Degrees

Seat Width ----------.082 to .094 Inch

Maximum Allowable Seat Runout ----------.002 Inch As Determined With a Dial Indicator.

### Intake Valve Guides

Length ----------3.250 Inches

Outside Diameter ---------- .6565 to .6575 Inch

Inside Diameter ----------.3429 to .3439 Inch (After Assembly)

Valve Stem Clearance in Guide ---------- .001 to .003 Inch

Distance Above Head Guide Must Protrude ------- .875 Inch, Press Fit

## VALVE SPRINGS

Free Length ---------- Approximately 2.375 Inches

Spring Pressure at Compressed Height of
1.516 Inches (Valve Open) ----------110-118 Pounds

Spring Pressure at Compressed Height of
1.875 Inches (Valve Closed) ---------- 53-59 Pounds

## ROCKER ARM ASSEMBLY

Rocker Arm Bushing ---------- Replaceable Precision Bronze Bushing

Number of Bushings ----------8

Lubrication ---------- Engine Lubricated

Outside Diameter of Rocker Arm Shaft ---------- .622 to .623 Inch

Inside Diameter of Rocker Arm Bushing (Installed) --- .624 to .625 Inch

Rocker Arm Shaft Spring Pressure at Compressed Height of
1.750 Inches ---------- 8 Pounds; Install New Spring If Pressure is Less Than 7.500 Pounds.

## OIL PUMP

Type ---------- Positive Displacement, Gear Type Pump; Driven Off Crankshaft

Pressure Relief Valve ---------- Maintains 50 to 75 Pounds Full Pressure (Oil Warm, Engine Operating at Full Governed Speed).

Relief Valve Spring Pressure At Compressed Height of
1.438 Inches ---------- 18.4 Pounds

Radial Clearance of Gears
(Clearance Between Gears and Housing) ---------- .002 to .005 Inch

Gear End Clearance
(Clearance Between Gears and Cover) ----------.0015 to .0055 Inch

## WATER PUMP AND THERMOSTAT

Type of System ---------- Pressurized Thermostat Controlled Forced Circulation (Pump).

Type Pump ---------- Impeller Vane Type

Temperature Control ----------Butterfly Type Thermostat

## FUEL SYSTEM

Injection Pump ---------- Roosa Master, Model DB. Single Cylinder, Opposed Plunger, Inlet Metering. Distributor Type.

Direction of Pump Rotation ---------- Counter-Clockwise (as Viewed from Drive End).

Pump Mounting ---------- Left Side of Engine

Pump Drive ----------Gear Driven from Pump Drive Idler Gear

Injection Pump Idler Gear End Clearance ----------.003 Inch

Injection Pump Drive Lubrication ---------- Crankcase Oil Through Timing Gear Train.

Injection Pump Drive Shaft End Play ---------- Automatically Taken Up By a Spring Loaded Thrust Button in Front End of Pump Drive Shaft.

Timing Marks on Engine Flywheel ----------40° BTDC to 10° ATDC in One Degree Increments

Fuel Injection ---------- C. A. V. Long Stem Multi-Hole Type Opening Pressure 2250 PSI.

Fuel Transfer Pump -------Vane Type; Integral Part of Injection Pump

Governor ---------- Mechanical, Fly-Weight Integral Part of Injection Pump

Fuel Filters

Fuel Tank Air Breather ---------- Vented Tank Filler Cap

Fuel Tank Water Trap ---------- Located in Base of Fuel Tank

1st Stage Fuel Filter ---------- Replaceable Element Type

2nd Stage Fuel Filter ----------Replaceable Sealed "Can" Type

## 148 ENGINE SPECIFICATIONS

Type ---------- CASE 4 Cylinder, 4 Stroke Cycle, Valve in Head Engine.

No. of Cylinder Heads ---------- 1

Firing Order ---------- 1-3-4-2

Bore ---------- 3-3/8 Inches

Stroke ---------- 4 Inches

Piston Displacement ---------- 148 Cubic Inches

Compression Ratio ---------- 7.1 to 1

Maximum Compression at Cranking Speed 200 RPM
Engine Warmed Up to Operating Temperature ---- 115 PSI at Sea Level

Allowable Variance Between Cylinders ---------- 20 Pounds Pressure

Oil Filter, Crankcase ---------- Replaceable Cartridge Type

Exhaust Valve Rotators ---------- Positive Type

Ignition ---------- Distributor

## CYLINDER SLEEVES

Type ---------- Replaceable Wet Type; Two Rubber "O" Ring Seals Carried on Each Sleeve.

Inside Diameter of Sleeve Bore ------ 3.3750 to 3.3765 Inches. Replace Sleeve When Inside Diameter Below Top Ring Ridge Exceeds 3.384 Inches.

Piston Clearance in Sleeve (At Skirt) ---------- .001 to .002 Inch

Cylinder Sleeve Protrusion Above Block ---------- .002 to .005 Inch

## PISTON AND PISTON PINS

Piston Material ---------- Aluminum

Diameter of Piston at Top of Skirt
(Below Oil Ring Perpendicular to Pin) ---------- 3.3715 to 3.373 Inches

Piston Pins ---------- Full Floating Type; Held in Position with Snap Rings in Piston; Replaceable Bronze Bushing in Connecting Rod.

Piston Pin Length ---------- 2.750 to 2.740 Inches

Piston Pin Diameter ---------- .8592 to .8593 Inch

Piston Pin Fit in Piston ---------- .0000 to .0003 Inch

Piston Pin Fit in Connecting Rod Bushing ---------- .0002 to .0006 Inch

## PISTON RINGS

Rings Per Piston ---------- 4-(3 Compression and 1 Oil)

Compression Rings (Top 3)

Width of Rings (All 3) ---------- .0930 to .0935 Inch

Ring End Gap (All 3) When Compressed
in 3.375 Inch Cylinder ---------- .010 to .020 Inch

Side Clearance in Groove of 1st (Top) Ring ------.003 to .0045 Inch

Side Clearance in Groove of 2nd and 3rd Rings ---.0025 to .004 Inch

Oil Ring ---------- To install Replacement Ring, Follow Instructions Packed with Rings.

Width of Ring ---------- .2485 to .2490 Inch

Ring End Gap When Compressed in
3.375 Inch Cylinder ---------- .010 to .020 Inch

Side Clearance in Groove ---------- .001 to .0025 Inch

## CONNECTING RODS

Piston Pin Bushing ---------- Replaceable Bronze Bushing Ream in Place. Use .8596 to .8598 Reamer

Piston Pin Hole Diameter in
Rod (Without Bushing) ---------- .9045 to .9055 Inch

Inside Diameter of Piston
Pin Bushing in Rod ---------- .8596 to .8598 Inch; Install New Bushing if Inside Diameter Exceeds .863 Inch

Connecting Rod Bearing ---------- Replaceable, Precision Steel Backed, Aluminum Liners.

Connecting Rod Capscrews ---------- Self Locking Type, No Lock Wire Required - May Be Used More Than Once

Connecting Rod Length (Center to Center Between
Pin Hole and Bearing Journal Hole) ---------- 6.998 to 7.002 Inches

Bearing Liner Width ---------- 1.120 to 1.130 Inches

Diameter of Crankshaft Journal Hole
in Rod (Without Liner) ---------- 2.1870 to 2.1875 Inches

Inside Diameter of Bearing Liner (Standard
Liner in Place in Rod and Capscrews Tight) ----2.0620 to 2.0630 Inches

Diameter of Crankshaft Rod Journal ---------- 2.0605 to 2.0615 Inches

Clearance Between Rod Bearing
and Crankshaft Journal --------.0005 to .0025 Inch; Install New Bearing Liners When Clearance Exceeds .006 Inch

Undersize Bearing Liners
Available for Service ---------- .002, .010, .020, .030 Inch

Allowable Connecting Rod Bearing End Play ---------- .005 to .011 Inch

## CRANKSHAFT AND MAIN BEARINGS

Crankshaft ---------- Balanced; Drilled to Provide Pressure Lubrication to Main and Connecting Rod Bearings

Type Main Bearings ---------- Replaceable, Precision, Steel Backed, Copper Lead Liners.

Bearing Capscrews ---------- Self Locking Type, No Lock Wires Required - May Be Used More Than Once

Bearing Taking End Thrust ---------- Center

Crankshaft End Play (Measured
at Center Main Bearing) ----------.001 to .006 Inch; Install New Center Main If End Play Exceeds .010 Inch

Connecting Rod Journal Diameter ---------- 2.0605 to 2.0615 Inches

Main Bearing Journal Diameter ---------- 2.623 to 2.624 Inches

Crankshaft Main and Connecting
Rod Journal Bearing Out-of-Round ---------- .002 Inch

Inside Diameter of Main Bearing Liners
(In Place and Capscrews Tight) ---------- 2.6245 to 2.626 Inches

Clearance Between Main Bearing
Liner and Journal ---------- .005 to .003 Inch; Install New Bearing Liners When Clearance Exceeds .003 Inch

Width of 1st Main Bearing Liner ---------- 1.437 Inches

Width of 2nd Main Bearing Liner ---------- 1.500 Inches

Width of 3rd Main Bearing Liner ---------- 1.562 Inches

Width Between Crankshaft Center
Main Bearing Cheeks ---------- 1.499 to 1.502 Inches

Width Between Crankshaft Rod
Bearing Journal Cheeks ---------- 1.3105 to 1.3145 Inches

Undersize Main Bearing Liners
Available for Service ---------- .002, .020, .040 Inch

Crankshaft Main Bearing Journals Should
be ground to -----2.603 to 2.604 Inches for .020 Inch Undersize Bearing
2.583 to 2.584 Inches for .040 Inch Undersize Bearing

Undersize Connecting Rod Bearing
Shells Available for Service ---------- .002, .010, .020, .030 Inch

Connecting Rod Crankshaft Journals Should
be ground to ---2.0505 to 2.0515 Inches for .010 Inch Undersize Bearing
2.0405 to 2.0415 Inches for .020 Inch Undersize Bearing
2.0305 to 2.0315 Inches for .030 Inch Undersize Bearing

## CAMSHAFT AND BUSHINGS

Number of Bearing Surfaces on Camshaft ---------- 3

Type Bushing ---------- Replaceable, Precision, Steel Backed Babbitt

Diameter of Camshaft at Each Bearing Surface --- 1.749 to 1.750 Inches

Inside Diameter of Each Bushing
(Measured When in Place in Block) ---------- 1.752 to 1.753 Inches

No. 1 (Front) Bushing Length ---------- 1.307 to 1.317 Inches

No. 2 (Center) Bushing Length ---------- .713 to .723 Inch

No. 3 (Rear) Bushing Length ---------- 1.177 to 1.197 Inches

Camshaft End Play ---------- .003 to .007 Inch

Camshaft Thrust Plate Thickness ---------- .147 to .149 Inch

## TIMING GEARS

Backlash Between Oil Pump Drive Gear
and Crankshaft Gear ---------- .005 to .010 Inch

Backlash Between Crankshaft and Camshaft Gear ----- .003 to .007 Inch

## VALVE PUSH ROD LIFTERS

Type ---------- Mushroom Type

Outside Diameter of End That
Projects into Block ---------- .5615 to .5620 Inch

Diameter of Bore in Block for Lifter ---------- .5625 to .5635 Inch

## VALVES

### Valve Tappet Clearance

Intake ---------- .014 Inch, Engine Cold
Exhaust ---------- .020 Inch, Engine Cold
Intake and Exhaust ---------- .014 Inch, Engine Hot
Hot Settings Are Made At Low Idle After The Engine Has Operated At Thermostat Control Temperatures For At Least Fifteen Minutes.

### Exhaust Valves

Angle of Valve Face ---------- 44 Degrees

Valve Length ---------- 5.166 to 5.191 Inches

Maximum Valve Face Runout ---------- .002 Inch as Determined with a Dial Indicator

Diameter of Valve Stem ---------- .3382 to .3390 Inch; Install New Valve if There is More Than .002 Inch Difference in Diameter at any Point on Stem.

Diameter of Valve Head ---------- 1.198 to 1.1208 Inches

Valve Rotators ---------- Positive Type

### Exhaust Valve Seat

Seat Angle ---------- 45 Degrees

Seat Width ---------- .090 to .100 Inch

Maximum Allowable Seat Runout ---------- .002 Inch as Determined With a Dial Indicator

### Intake Valves

Angle of Valve Face ---------- 29 Degrees

Valve Length ---------- 5.166 to 5.191 Inches

Maximum Valve Face Runout ---------- .002 Inch as Determined with a Dial Indicator.

Diameter of Valve Stem ---------- .3406 to .3414 Inch. Install a New Valve If There is More Than .002 Inch Difference in Diameter at any Point or Stem.

Diameter of Valve Head ---------- 1.323 to 1.333 Inches

### Intake Valve Seat

Seat Angle ---------- 60 Degrees

Seat Width ---------- .045 to .060 Inch

### Exhaust Valve Guides

Length ---------- 2.688 Inches

Outside Diameter ---------- .6565 to .6575 Inch

Inside Diameter ---------- .3422 to .3432 Inch
Replace Guide When Inside Diameter Exceeds .3452 Inch

Valve Stem Clearance in Guide ---------- .0032 to .005 Inch

Distance Above Head Guide Must Protrude ---------- .968 Inch, Press Fit

### Intake Valve Guides

Length ---------- 2.688 Inches

Outside Diameter ---------- .6565 to .6575 Inch

Inside Diameter ---------- .3422 to .3432 Inch
Replace Guide When Inside Diameter Exceeds .3452 Inch

Valve Stem Clearance in Guide ---------- .0008 to .0026 Inch

Distance Above Head Guide Must Protrude ---------- 1.031 Inch, Press Fit

## VALVE SPRINGS

### Intake

Free Length ---------- Approx. 2.375 Inches

Spring Pressure at Compressed Height of
1.521 (Valve Open) ---------- 110 to 118 Pounds; Install New Spring if Pressure is Less Than 102 Pounds.

Spring Pressure at Compressed Height of
1.875 Inches (Valve Closed) ----- 53 to 59 Pounds: Install New Spring if Pressure is Less Than 50 Pounds.

### Exhaust

Free Length ---------- Approx. 2.188 Inches

Spring Pressure at Compressed Height of
1.332 Inches (Valve Open) ----- 110 to 118 Pounds; Install New Spring if Pressure is Less Than 102 Pounds.

Spring Pressure at Compressed Height of
1.688 Inches (Valve Closed) ------ 53 to 59 Pounds; Install New Spring if Pressure is Less Than 50 Pounds.

## ROCKER ARM ASSEMBLY

Rocker Arm Bushings ---------- Replaceable Precision Bronze Bushing

Number of Bushings ---------- 8

Lubrication ---------- Pressure Lubricated; Crankcase Oil To Rocker Arms Full Pressure

Oil Holes in Rocker Arm Shaft ---------- Oil Holes Must Face Downward. Shaft Cannot Be Rotated

Positioning of Exhaust Valve
Rocker Arms ---------- Spacer Washers Position Exhaust Valve Rocker Arm and Eliminates End Play Without Binding.

Outside Diameter of Rocker Arm Shaft ---------- .622 to .623 Inch

Inside Diameter of Rocker Arm Bushing ---------- .624 to .625 Inch

Rocker Arm Shaft Spring Pressure at Compressed Height of
.687 Inch ---------- 8 Pounds; Install New Spring if Pressure is less than 7.500 Pounds.

## OIL PUMP

Type ---------- Positive Displacement, Gear Type Pump Driven Off Crankshaft.

Pressure Relief Valve ---------- Maintains 28 to 32 Pounds Oil Pressure (Oil Warm, Engine Operating at Full Governed Speed).

Relief Valve Spring Pressure at Compressed Height of
1.438 Inches ---------- 18.4 Pounds

Radial Clearance of Gears
(Clearance Between Gears and Housing) ---------- .002 to .005 Inch

Gear End Clearance
(Clearance Between Gears and Cover) ---------- .0015 to .0055 Inch

## WATER PUMP AND THERMOSTAT

Type of System ---------- Thermostat Controlled, Forced Circulation (Pump).

Type Pump ---------- Impeller Vane Type

Radiator ---------- Heavy Duty Fin and Tube Type

Temperature Control ---------- By-Pass Type Thermostat

## FUEL SYSTEM

Type of System ---------- Gravity Flow

Carburetor ---------- Marvel Schebler TSX635

Float Level ---------- 1/4 Inch from Gasket to Nearest Surface of Float.

Load Jet ---------- Adjustable

Venturi Size ---------- .776 to .786 Inch Dia. Throat

Flange ---------- SAE 1 Inch

## SPECIAL TORQUE SPECIFICATIONS

### For Torques Not Listed Below Use Torque Chart on Following Page

Camshaft Nut ---------- 80-90 Ft. Lbs.

Connecting Rod Nut ---------- 45-50 Ft. Lbs.

Connector Bolts (High Pressure Line to Injection Pump) - 33-36 Ft. Lbs.

Crankshaft Nut ---------- 125-135 Ft. Lbs.

Cylinder Head Capscrew(In Water Pump Housing)-Maximum 30 Ft. Lbs.

Cylinder Head Nuts (Gasoline) ---------- 95-105 Ft. Lbs.

Cylinder Head Nuts (Diesel) ---------- 110-120 Ft. Lbs.

Engine to Torque Tube ---------- 150-160 Ft. Lbs.

Engine to Front Support ---------- 120-135 Ft. Lbs.

Flywheel Capscrews ---------- 65-70 Ft. Lbs.

Governor Control Rod to Engine Block ---------- 15 Ft. Lbs.

Heat Plug ---------- 25-30 Ft. Lbs.

High Pressure Fuel Line Nuts to Injector ---------- 15 to 20 Ft. Lbs.

Injection Nozzle Cap Nut ---------- 50 Ft. Lbs.

Injector Stud Nuts (To Cylinder Head) ---------- 12-15 Ft. Lbs.
(To Avoid Distorting Nozzle Holder the Two Nuts must Be Tightened Simultaneously)

Injector Spring Cap Nut ---------- 75 Ft. Lbs.

Injector Pump Drive Shaft ---------- 35-40 Ft. Lbs.

Main Bearing Place Bolts ---------- 90-100 Ft. Lbs.

Manifold Stud Nuts ---------- 25-30 Ft. Lbs.

Oil Pan Capscrews ---------- 10-12 Ft. Lbs.

Oil Seal Retainer Capscrews ---------- 6-8 Ft. Lbs.

Oil Pump Cover Capscrews ---------- 6-8 Ft. Lbs.

Push Rod Adjustable Screw ---------- Minimum 30 In. Lbs.

Screen Assembly at Injection Pump Inlet ---------- 12 Ft. Lbs.

Spark Plugs ---------- 32-35 Ft. Lbs.

Timing Window Cover Screw on Injection Pump ---------- 1-2 Ft. Lbs.

Valve Cover Stud Nuts ---------- 5-6 Ft. Lbs.

Water Pump Stud Nuts ---------- 20-25 Ft. Lbs.

## GENERAL TORQUE SPECIFICATION TABLE (Revised 5-64)

**USE THE FOLLOWING TORQUES WHEN SPECIAL TORQUES ARE NOT GIVEN**

**NOTE:** These values apply to fasteners as received from supplier, dry, or when lubricated with normal engine oil. They do not apply if special graphited or moly-disulphide greases or other extreme pressure lubricants are used. This applies to both UNF and UNC threads.

| SAE Grade No. | 5 | | 8 * | |
|---|---|---|---|---|
| Bolt head identification marks as per grade Note: Manufacturing Marks Will Vary |  | |  | |
| | Torque Foot Pounds | | Torque Foot Pounds | |
| Bolt Size | Min. | Max. | Min. | Max. |
| 1/4" | 9 | 11 | 12 | 15 |
| 5/16 | 15 | 18 | 24 | 28 |
| 3/8 | 35 | 40 | 45 | 50 |
| 7/16 | 54 | 60 | 70 | 80 |
| 1/2 | 80 | 90 | 110 | 125 |
| 9/16 | 110 | 120 | 160 | 180 |
| 5/8 | 150 | 165 | 220 | 240 |
| 3/4 | 260 | 280 | 380 | 420 |
| 7/8 | 360 | 400 | 600 | 660 |
| 1" | 540 | 600 | 900 | 1000 |
| 1-1/8 | 720 | 800 | 1280 | 1440 |
| 1-1/4 | 1000 | 1100 | 1800 | 2000 |
| 1-3/8 | 1460 | 1680 | 2380 | 2720 |
| 1-1/2 | 1940 | 2200 | 3160 | 3560 |

* Thick nuts must be used with Grade 8 bolts

## TIMING CHART

| ENGINE | FULL LOAD GOVERNED ENGINE SPEED | NUMBER OF DEGREES |
|---|---|---|
| 188D (480) | 1750 | 8°BTDC |
| 148G (480) | 1750 | 4° BTDC (Static) 25° BTDC (Running at Full Load RPM) |

## VALVE TIMING

With valve clearances set correctly, dial indicator mounted above valve stem reading taken with valve .040" off its seat.

188D Inlet Valve (No. 1 Cyl.) ---------- 3° 30' ATC

148G Exhaust Closing (No.1 Cyl. ---------- 10° BTC

**NOTE** "Inlet opening" and "Exhaust closing" are the only positions on these engines that can be checked by the flywheel timing marks. Use the degree marks already on the flywheel for measurement. If this position is correct, it can be assumed that the timing gears are correctly marked and properly assembled.

# Section 22

# CYLINDER HEAD AND VALVES 188 DIESEL ENGINES

## SPECIFICATIONS

| | | Maximum Limit Including Wear |
|---|---|---|
| CYLINDER HEAD | | |
| Warpage | | .006" |
| EXHAUST VALVES | | |
| Tappet Clearance (Hot and Cold) | .014" | |
| Face Angle | 44° | |
| Face Run-Out | | .002" |
| O.D. of Head | 1.398" to 1.408" | |
| O.D. of Stem | .3399" to .3409" | .002" |
| Length | 6.339" to 6.364" | |
| Insert Seat Angle | 45° | |
| Seat Face Width | .0415" | |
| Seat Run-Out | | .002" |
| Insert Height | .2475" to .2525" | |
| O.D. of Insert | 1.4450" to 1.4505" | |
| I.D. of Insert | 1.245" to 1.255" | |
| INTAKE VALVES | | |
| Tappet Clearance (Hot and Cold) | .014" | |
| Face Angle | 44° | |
| Face Run-Out | | .002" |
| O.D. of Head | 1.599" to 1.609" | |
| O.D. of Stem | .3409" to .3419" | .002" |
| Length | 6.339" to 6.364" | |
| Seat Angle | 45° | |
| Seat Run-Out | | .002" |
| Seat Width | .082" to .094" | |

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## SPECIFICATIONS (Continued)

| | | Maximum Limit Including Wear |
|---|---|---|
| EXHAUST VALVE GUIDES | | |
| Length | 3.125" | |
| O.D. | .6565" to .6575" | |
| I.D. (Installed and Reamed) | .3429" to .3439" | .001" |
| Valve Stem Clearance in Guide | .002" to .004" | |
| Protrusion Above Cylinder Head | .875" | |
| INTAKE VALVE GUIDES | | |
| Length | 3.250" | |
| O.D. | .6565" to .6575" | |
| I.D. (Installed and Reamed) | .3429" to .3439" | .001" |
| Valve Stem Clearance in Guide | .001" to .003" | |
| Protrusion Above Cylinder Head | .875" | |
| VALVE SPRING | | |
| Free Length | 2.375" | |
| Total Coils | 8.25 | |
| Wire Diameter | .162" | |
| I.D. | .958" to .978" | |
| Compressed to 1.521" (Valve Open) | 110 to 118 lbs. | |
| Compressed to 1.875" (Valve Closed) | 53 to 59 lbs. | |
| ROCKER ARM ASSEMBLY | | |
| O.D. of Shaft | .622" to .623" | |
| I.D. of Arm Bore | .624" to .625" | |
| Shaft Spring | | |
| Free Length | 2.5" | |
| Wire Diameter | .072" | |
| Compressed to 1.75" | 7.5 to 8.5 lbs. | |
| Lubrication | Engine oil, camshaft metering | |
| Shaft Oil Holes | Toward valve side of engine, shaft cannot be rotated. | |

## SPECIAL TORQUES

| | |
|---|---|
| Cylinder Head Studs w/Flange Nuts | 90 to 100 ft. lbs. |
| Intake and Exhaust Manifold Stud Nuts | 25 to 30 ft. lbs. |
| Cylinder Head Valve Cover Stud Nuts | 5 to 8 ft. lbs. |
| Rocker Arm Bracket Bolts | 25 to 30 ft. lbs. |

## CHECKING COMPRESSION PRESSURE

1. Clean the engine thoroughly, preferably by steam cleaning.

2. Before cranking the engine make sure all operating controls are in neutral, brakes are set and the wheels are securely blocked.

3. There are two methods of checking compression pressure - the cranking method and the engine running method. **NOTE:** The engine must be at operating temperature for either method used.

A. CRANKING METHOD - Close the needle valve at the fuel tank. Disconnect all high pressure fuel lines and leak-off lines between injectors. Remove all of the injectors. Refer to the chart on Page 3.

# CHECKING COMPRESSION PRESSURE (Continued)

B. RUNNING METHOD - Disconnect the high pressure fuel line and leak-off line from number one injector. Using an appropriate length of tubing or hose, route the fuel from these lines back to the fuel tank or a clean container. Refer to chart below.

4. Clean the injector bores of loose carbon and residue. Replace the compression seal in the injector bore of the cylinder to be checked and install a Bacharach 70-314 (D-558). Compression Gauge Adapter, Figure 1. Secure with an original injector clamp assembly and spacer, Figure 1, Inset A. Tighten bolt to 20 ft. lbs. Connect Case No. CD-504 Compression Gauge to the adapter, Figure 2.

**IMPORTANT:** It is very important that all cylinder pressure be approximately alike. For the allowable compression pressure variation refer to chart below.

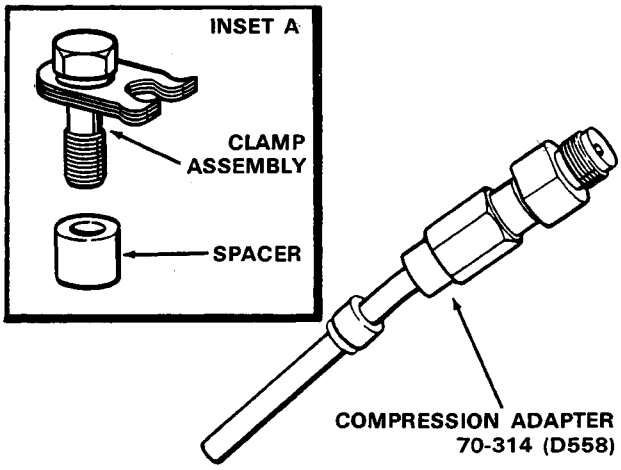


**Figure 1**

5. If the compression is greater than the figure mentioned, carbon deposits are indicated. If the reading is below these figures, leaking valves or excessive ring clearance is indicated. **NOTE:** To make a simple check when a compression leak is indicated, squirt a small amount (a teaspoon) of oil into the cylinder and recheck the compression. If the pressure rises to near normal, compression loss is past the rings. Very little change in compression indicates leakage past the valves. A low pressure reading will cause difficulty in starting particularly at low temperatures.

**NOTE:** Take several compression reading on each cylinder. This is done by pressing the vent valve button, Figure 2, to relieve gauge pressure. When the button is released the gauge will again indicate compression pressure.

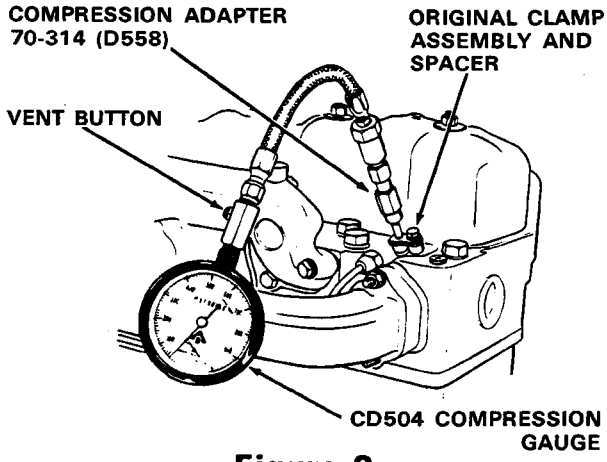


**Figure 2**

**IMPORTANT:** Replace the compression seal on all injectors at the time of installation, Figure 3.

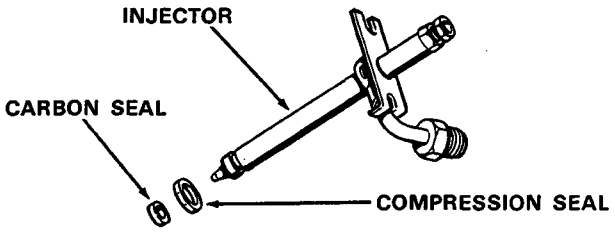


**Figure 3**

| | ENGINE SPEED | NORMAL COMPRESSION PRESSURE | ALLOWABLE VARIATION BETWEEN CYLINDERS |
|---|---|---|---|
| CRANKING | Approximately 200 RPM | 400 PSI* | 25 PSI |
| RUNNING | 800 RPM | 480 PSI* | 20 PSI |

**NOTE:** *A 4% reduction in PSI must be allowed for every 1000 ft. above sea level.

# CYLINDER HEAD AND COMPONENTS

## (Refer to Figure 4)

## Disassembly

Remove the muffler and hood from vehicle. Disconnect the exhaust system and air cleaner from the manifolds. Loosen the alternator adjusting bolt and remove the fan belt. Remove the water pump and all stud nuts securing water manifold to cylinder head. Steam clean the entire area where service work is to be performed.

1. Drain the cooling system. **CAUTION:** If the engine is hot, do not remove the radiator cap until the coolant has had sufficient time to cool. Loosen the cap to the first stop carefully to relieve any excess pressure before removing it completely. Remove the upper radiator and water pump hoses.
2. Disconnect the high pressure fuel lines from the injectors and the leak-off tubes. Cap them to prevent any foreign particles from entering. Remove the injectors as described in Section 33 of the Service Manual.
3. Remove the breather tube (1).
4. Remove the intake elbow (2) and gasket (3), and discard the gasket.
5. Remove the intake manifold (4) and discard the gaskets (5).
6. Remove the exhaust stack (6) and gasket (7).
7. Remove the exhaust manifold (8) and discard the gaskets (9).
8. Remove the valve cover (10) and cover gasket (11). Discard gasket.
9. Remove the bolts and washers (12), and the rocker arm assembly (13). Remove the push rods (14) and tag them for proper reassembly.
10. Remove the flanged nuts (15). Remove the cylinder head assembly (16), fire rings (17) and head gasket (18). Discard the fire rings and head gasket.
    **NOTE:** Refer to Inspection and Servicing on Page 6 and 7 prior to assembly.

## Assembly

1. Place new cylinder head gasket (18) on the engine block. **NOTE:** Be sure the two dowel rings are installed in their proper location, Inset A.
2. Install the new fire rings (17) with either side up. **NOTE:** The fire rings must be installed dry.
3. Install new gasket (19) between timing cover and cylinder head, coating it with a sealer.
4. Install the cylinder head (16) and flanged nuts (15). Lubricate threads with clean engine oil prior to torquing. Torque the flange nuts to 60 ft. lbs. and then to 90-100 ft. lbs. using the torquing sequence shown in Inset B.
5. Install the water pump and a new gasket, coating the gasket with a sealer. Torque the water pump stud nuts 20-25 ft. lbs. Install the fan belt and adjust.
6. Coat the push rods (14) with clean engine oil and install them in their original location.
7. Install the rocker arm assembly (13). **NOTE:** The rear mounting bolt is drilled for oil passage to the rocker arm shafts. Torque the bolts (12) to 25-30 ft. lbs. Adjust the valve tappet clearance, refer to Page 16.
8. Install the intake (4) and exhaust (8) manifolds using new gaskets (5 & 9). Torque the stud nuts and bolts 25-30 ft. lbs.
9. Install the intake elbow (2) using new gasket (2). Install the exhaust stack (6) using new gasket (7).
10. Reinstall the air cleaner system and exhaust system. Refill the cooling system. Reconnect the high pressure fuel lines to the injectors and the leak-off tubes.
11. Apply clean engine oil to the rocker arm assembly and start the engine. Check that the rocker arms are receiving lubricating oil. Operate the engine for approximately one hour, (under load if possible) to thoroughly warm up the engine seat the head gaskets.
12. Shut the engine off. Back off each cylinder head flanged nut individually 1/4 and retorque to 100 ft. lbs. **NOTE:** DO NOT BACK OFF ALL THE FLANGED NUTS AT THE SAME TIME.
13. Install new valve cover gasket (11) and valve cover (10). Torque the valve cover stud nuts 5-8 ft. lbs. Install breather tube (1).

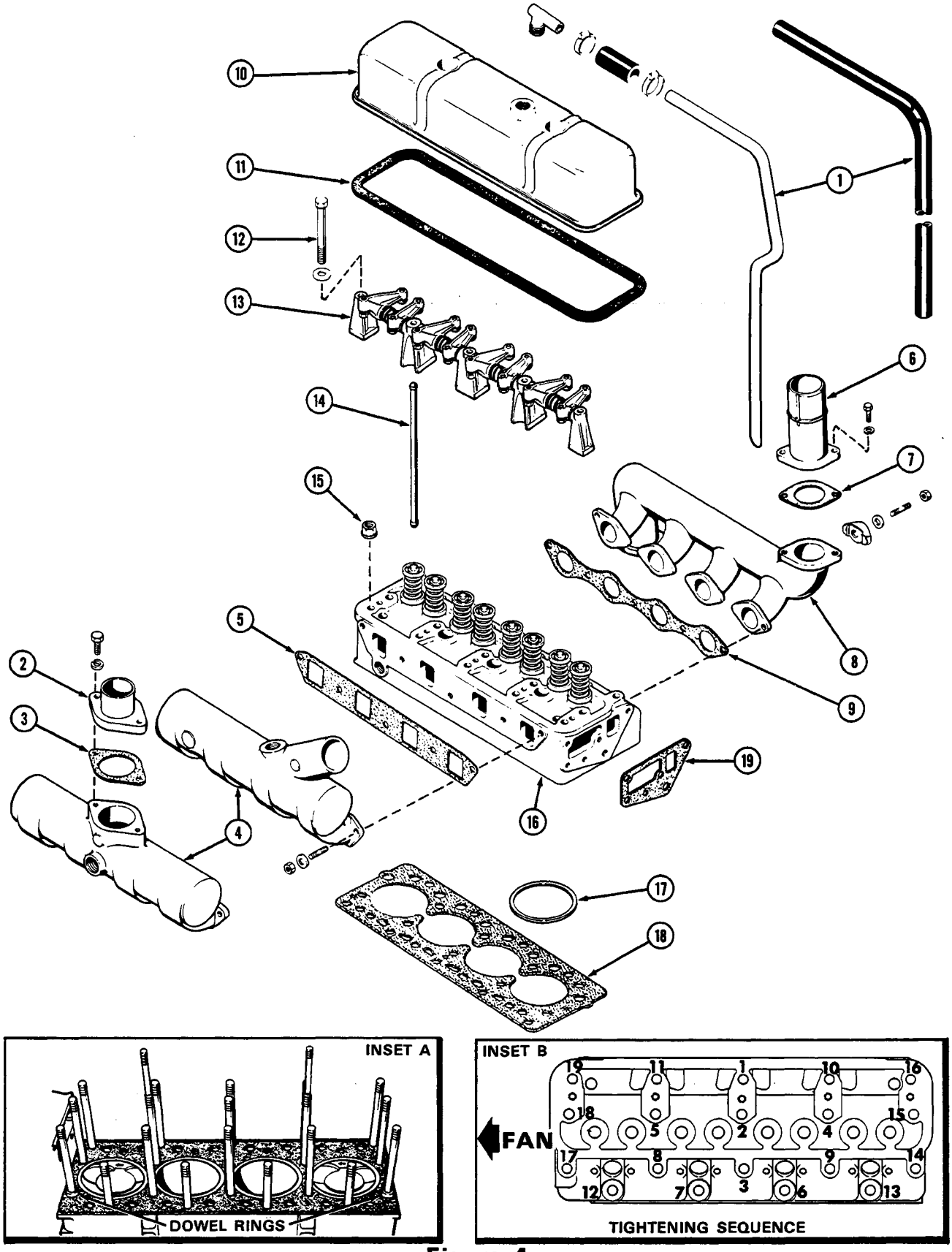
10
11
12
13
14
15
1
6
7
8
9
5
2
3
4
16
19
17
18
INSET A
DOWEL RINGS
INSET B
FAN
19 11 1 10 16
18 5 2 4 15
17 8 9 14
12 7 3 6 13
TIGHTENING SEQUENCE

**Figure 4**

# CYLINDER HEAD AND COMPONENTS (Continued)

## Inspection

Replace all gaskets, seals and worn or defective parts.

1. Clean the top surface of the block and sleeve flange carefully. All traces of carbon and other deposits must be removed. During cleaning, the use of a rag dampened in solvent is recommended.

2. Using extreme care not to scratch surfaces. Remove any small burrs in the areas to be measured so accurate readings can be obtained.

3. Sleeve protrusion must be checked to determine which fire ring is used, Figure 5. Make sure the correct fire ring is used. **NOTE:** Only the standard size fire ring is included in the valve grind gasket kit. However, a thicker fire ring is available if the protrusion chart indicates a need for it. The thicker fire ring can be identified by a black marking stripe. Either a magnetic base dial indicator or a depth micrometer can be used to determine the cylinder sleeve protrusion as indicated in Figure 6. Measure cylinder sleeve protrusion at points A,B,C and D. Using ball (A28312), clamping bar (A40682) and plate (OTC 970-7), clamp the cylinder sleeve in place, Figure 7. **NOTE:** The plate OTC 970-7 is available through local Owatonna Tool dealers or the Owatonna Tool Co., Owatonna, Minnesota. Torque the hold down capscrews to 50 ft. lbs.

4. Clean and inspect the cylinder head thoroughly. If evidence of fretting or erosion exists in the area of fire-ring contact or if the head is warped more than .006", the head must be resurfaced or replaced.

5. Inspect push rods for straightness, cracked or worn ends. Replace if necessary.

6. Clean all bolt and stud threads.

7. Clean the rocker arm cover and discard the old gasket.

8. Replace all hoses if cracks and deterioration is found. Replace hose clamps to assure a tight connection.

| CYLINDER SLEEVE PROTRUSION | USE STANDARD FIRE RINGS | USE OVERSIZE (THICKNESS) FIRE RINGS |
|---|---|---|
| MORE THAN .003"* | X | |
| .001" - .003"* | X | |
| LESS THAN .001"* | | X |

**Figure 5**

*If sleeve protrusion varies more than .003" around circumference, change that sleeve and check again. If sleeve shows severe erosion, replace the sleeve. **NOTE:** Cylinder head warpage should not exceed .006" (maximum) measuring from end to end.

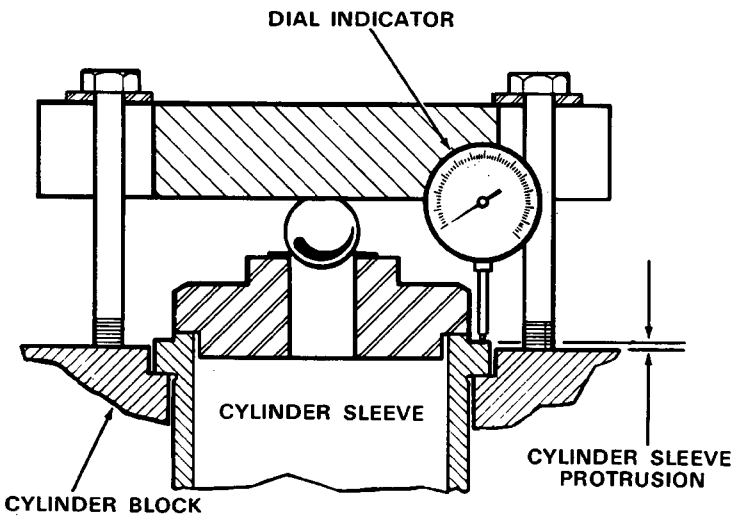


**Figure 6**

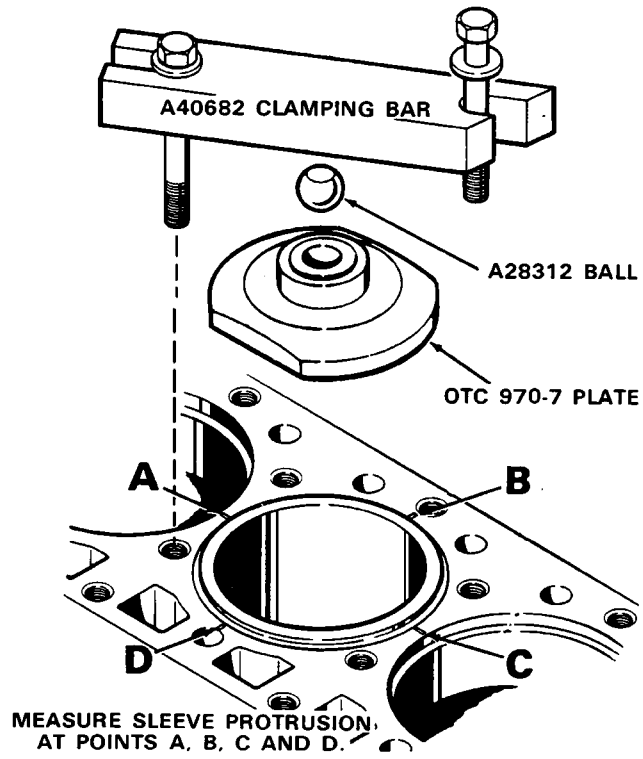


**Figure 7**

# ROCKER ARM ASSEMBLY

## (Refer to Figure 8)

## Disassembly

1. Remove the rocker arm shaft bracket bolts (1 & 9). **NOTE:** The rear bracket bolt is drilled for oil passage to the rocker arm shafts.

2. Remove and tag each rocker arm (4 & 7) and bracket (3, 10, 11 & 12) for proper location when assembling.

3. Remove the shaft springs (6) and tag the front and rear shafts (8).

4. Remove each tappet adjusting screw (5) from each rocker arm, refer to Inset A.

## Inspection

Check the shaft springs for damage and proper tension.

SPRING SPECIFICATIONS

| | |
|---|---|
| Free Length | 2.5" |
| Wire Diameter | .072" |
| Compressed to 1.75" | 7.5 to 8.5 lbs. |

Flush the shafts to remove any residual material. Inspect the shafts for excessive wear or worn spots on the bottom side of the shafts.

Inspect the rocker arm shaft passages for wear. The maximum clearance between the shaft and rocker arm is .010". Replace the shaft and rocker arms when wear is beyond this point.

Clean the oil passage in the rocker arms to insure free oil flow. Inspect the valve stem contact area on the rocker arm for wear. Replace if worn.

Clean and check the oil passages in the tappet adjusting screws and the rear bracket bolt.

Inspect the push rods for straightness, cracked or worn ends, replace if these conditions exist.

## Assembly

With all component parts cleaned thoroughly and worn parts replaced, coat them with clean engine oil.

1. Install the intermediate brackets (10) on the shafts (8), starting with the front shaft. The front shaft is installed with the short end of the shaft (from the cut-out) toward the front of the engine, see Inset B. The rear shaft is installed with the short end of the shaft (from the cut-out) toward the rear of the engine.

2. Insert the bracket bolt (9) into the intermediate bracket (10) - it must line up with the cut-out in the shaft.

3. Install the tappet adjusting screws (5) into the rocker arms (4 & 7), make sure the screws are turned into the rocker arms as far as possible.

4. Install the rocker arms (4 & 7) and springs (6) on the rocker arm shafts (8).

5. Install the center bracket (11) to the long end (from the cut-out) of the shafts (8). Install the front (12) and rear (3) brackets to the shafts (8).

6. Before installing the rocker arm assembly on the cylinder head, crank the engine (fuel injectors removed) with the starting motor (approximately 1 to 3 minutes) until oil appears at the rear oil passage in the head, see Inset C. Install the rocker arm assembly to the cylinder with bracket bolts (1 & 9), making sure the rear bracket drilled bolt (1) is installed the cylinder head oil passage hole.

7. Adjust the tappets, refer to Page 16.

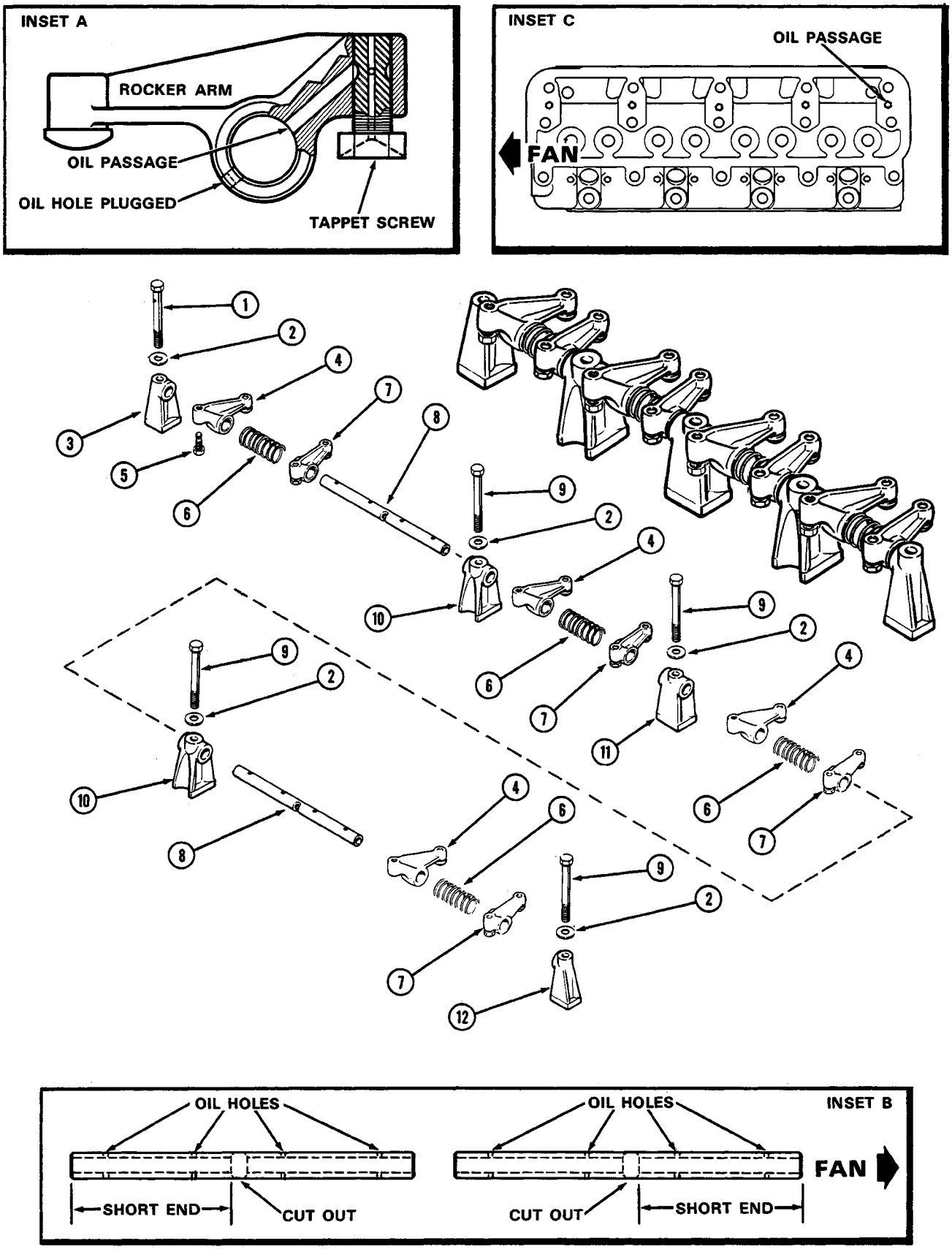
INSET A
ROCKER ARM
OIL PASSAGE
OIL HOLE PLUGGED
TAPPET SCREW
INSET C
OIL PASSAGE
FAN
1
2
3
4
5
6
7
8
9
10
11
12
INSET B
OIL HOLES
OIL HOLES
FAN
SHORT END
CUT OUT
CUT OUT
SHORT END

**Figure 8**

# CYLINDER HEAD ASSEMBLY

## (Refer to Figure 9)

## Disassembly

1. Using a valve spring compressor, compress the spring (1) enough to remove the valve retainer locks (2). Release the spring compressor and remove the valve spring retainer (3). Remove the valve spring (1), valve stem oil seals (4) and valve spring seats (5). Remove any carbon from the valve stems before they are removed from the cylinder head.

2. Remove the intake valves (6) and the exhaust valves (7) from the cylinder head (13) and set them in a rack or holder. **NOTE:** Mark them on removal so they may be installed in their original location.

3. Drive the intake valve guide (8) and exhaust valve guide (9) down through the head using an arbor.

4. The exhaust valve seats (10) can be removed with a special seat removing tool, Inset B. **NOTE:** Never attempt to remove a valve seat with a center punch, cold chisel or pry bar.

5. To remove the cup plugs (11) or expansion plug (12) they must be drilled and pryed out.

**NOTE:** Refer to Inspection and Servicing on Pages 12,13,14 and 15 prior to assembly.

## Assembly

1. If the valve guides have been replaced, install the new guides (8 & 9) using an arbor. Press the guides into the head from the top of the cylinder head. The guides must protrude above the cylinder head (intake and exhaust) .875", Inset A.

2. To install new exhaust valve seats (10) clean the recess in the cylinder head. Place the valve seats in dry ice to shrink them. Insert the valve seats in the head and press them in place, using a suitable press.

3. Lubricate the intake valves (6) and exhaust valves (7) with clean engine oil and install them in their original locations.

4. Install the valve spring seats (5), valve springs (1), the valve retainers (3). Compress the valve springs so the valve stem seals (4) can be installed in the lower grooves of the valve stems. Install the valve retainer locks (2). Remove the spring compressor carefully.

5. Install new plugs (11 & 12) if they were removed. **NOTE:** The cup plug (11) lip must be flush with the top of the cylinder head. The expansion plug (12) must be firmly seated against the ridge in the cylinder head.

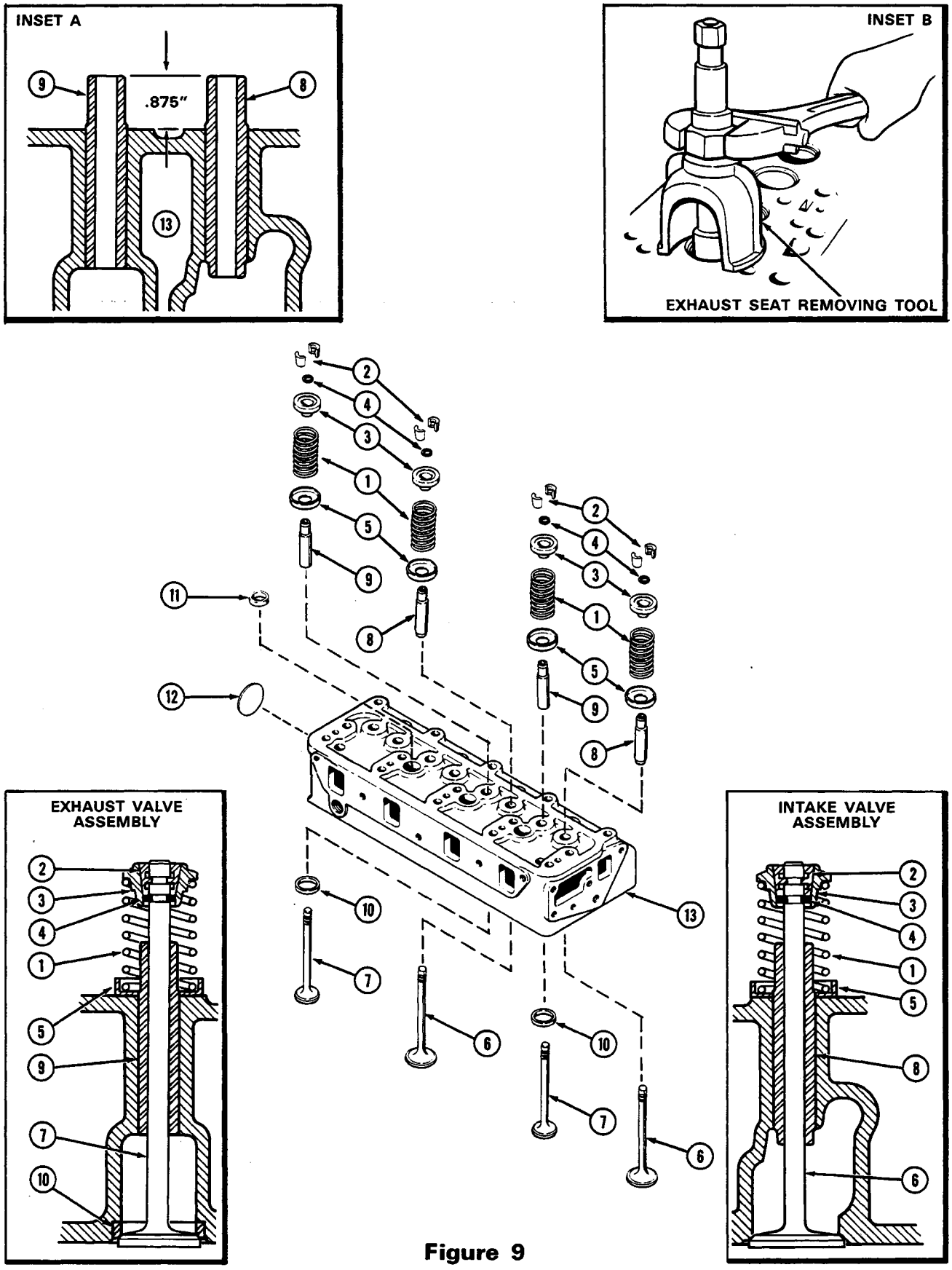
INSET A
.875"
INSET B
EXHAUST SEAT REMOVING TOOL
EXHAUST VALVE ASSEMBLY
INTAKE VALVE ASSEMBLY

**Figure 9**

# INSPECTION OF VALVES, GUIDES, HEAD AND SPRINGS

Clean the cylinder head completely. Remove all traces of carbon and other deposits. Check for cracks and any evidence of fretting or erosion existing in the area of fire ring contact. Check the head for evidence of warpage. If warpage exists and is more than .006", the cylinder head must be resurfaced or replaced.

Valve springs should be checked for flat squared ends, broken coils and correct spring pressure. Use a Valve Spring Tester referring to the spring specifications below:

Free Length ---------- 2.375"
Total Coils ---------- 8.25"
Wire Diameter ---------- .162"

| Valve Position | Compressed Height | Spring Pressure | Replace if Less than |
|---|---|---|---|
| Valve Open | 1.521" | 114 lbs. | 110 lbs. |
| Valve Closed | 1.875" | 56 lbs. | 53 lbs. |

Remove all carbon from the bore of the valve guides with a fine wire brush and blow clean with compressed air. Valve guides can be checked for wear by using a bore gauge and micrometer, refer to Figure 10, Inset A. The valve guides should be checked at the top, middle and bottom of the guide bore for wear, Figure 10. If the diameter is greater than .3440" at any point along the bore, the guide must be replaced. Use an arbor equal to the inside diameter of the valve guide to keep the guide from collapsing when pressed into place. Press in from the top of the head until the guide (Intake and Exhaust) protrudes a distance of .875" above the head, refer to Figure 9, Inset A, Page 11. Replacement guides must be reamed after installation. Ream the guide .3429" to .3439" diameter.

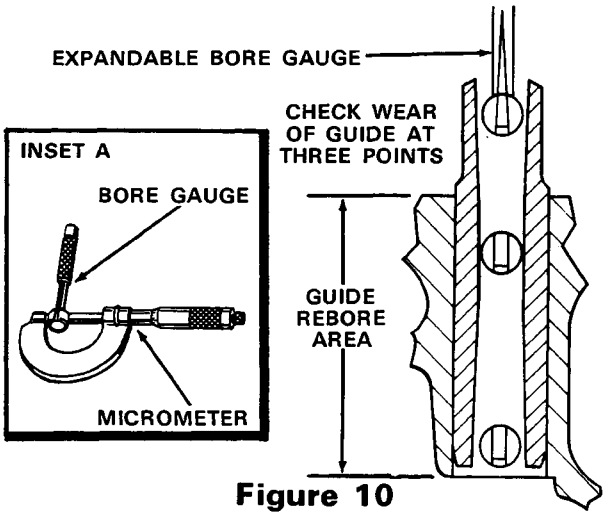


**Figure 10**

Clean the valves with a power driven fine wire brush, being very careful not to scratch the valve stems. Refer to Figure 11 for valve nomenclature.

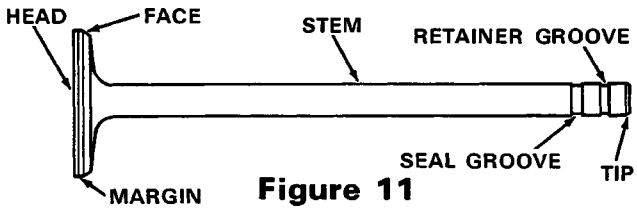


**Figure 11**

Inspect the valves for excessive wear or necked stems, Figure 12. This can be caused by lack of lubrication, plugged water passages or operating the engine under continuous overload at excessive engine RPM. Replace valves if this condition exists.

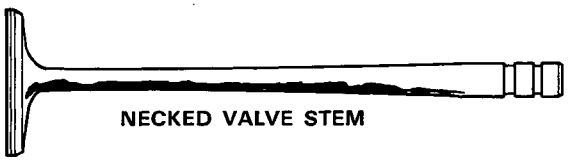


**Figure 12**

Inspect the valves for deep grooves in the face, Figure 13. This can be caused by abrasives entering the engine through the intake system or not servicing the air cleaner regularly. If grinding the valve face will not correct this condition, replace the valve.

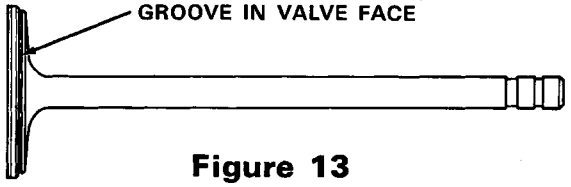


**Figure 13**

Inspect the valve face and stem for rust or pitting, Figure 14. Rust or pitting can usually be removed by grinding the valve face. If rust or pitting on the valve stem exists, replace the valve. These conditions can be caused by using poor quality engine oil or fuel that does not meet the specification given in Section 11 and by improper storing of the engine.

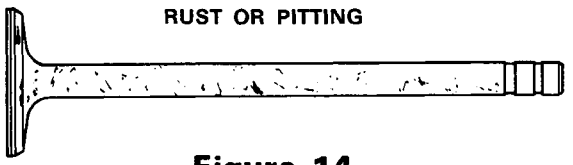


**Figure 14**

# INSPECTION OF VALVES, GUIDES, HEAD AND SPRINGS (Cont'd)

Heavy carbon or varnish deposits on the valves, Figure 15, should be removed before valves are ground. This condition is usually caused by worn piston rings and sleeves which allow too much oil to reach the combustion chamber. This conditions could also be caused by worn valve guides or bad seals on the valves. Low operating temperature is still another cause.

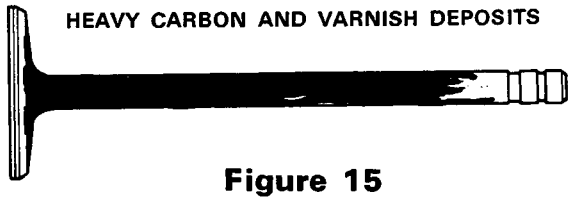


**Figure 15**

Inspect the valve head for dishing and the valve face for deep burned spots, Figure 16. These conditions cannot be corrected by grinding the valves. The valves must be replaced. These conditions are usually caused by running the engine under excessive loads at high engine temperatures.

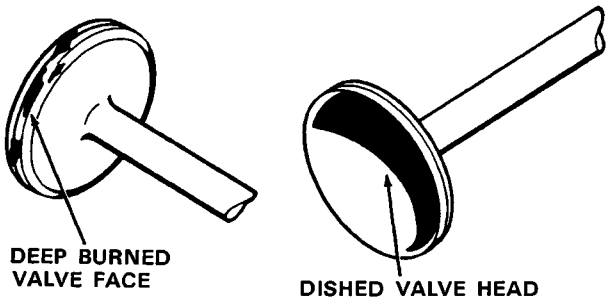


**Figure 16**

Valves with worn keeper grooves or if the stem tip is worn or dished beyond the chamfer, replace the valves, Figure 17.

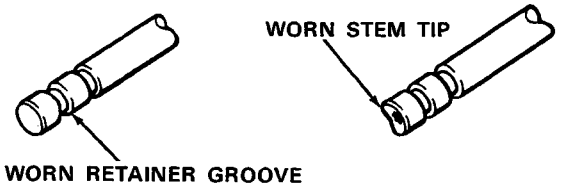


**Figure 17**

The checking of the valve stem diameter can be best be done with a good, accurate micrometer, Figure 18. The valve stem being straight, should be measured at three points along the stem, Figure 18. Wear limit must not exceed .002" at all points of measurement. If the wear is greater, replace the valve.

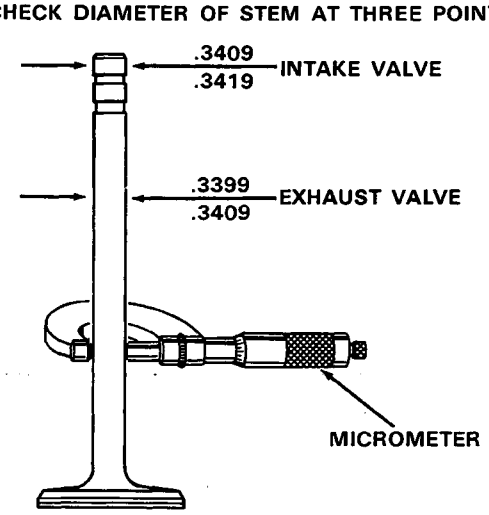


**Figure 18**

The checking of the valve face runout should be done after the valves have been ground. A Vee block type holder with a dial indicator, Figure 19 can be used to check the valve face and stem runout. The valve face runout should not exceed more than .002". The valve stem runout should not exceed .002". If the valve face and/or valve stem runout is greater, the valve must be replaced.

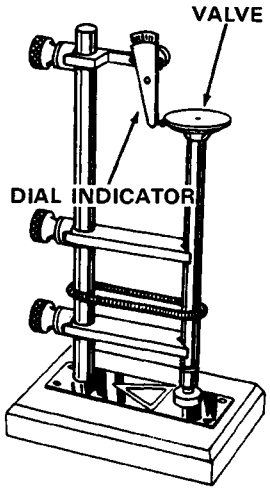


**Figure 19**

**NOTE:** Small amounts of very fine pitting, Figure 20, may be found on the surfaces of the valves faces and seats after the valves are cleaned. These are normal and will not affect engine performance. This fine pitting is caused by a normal oxidation process and can happen on any engine during the run-in period. It is not necessary to grind valves or seats if this fine pitting is found as the pitting will generally reoccur after the engine is run for a few hours.

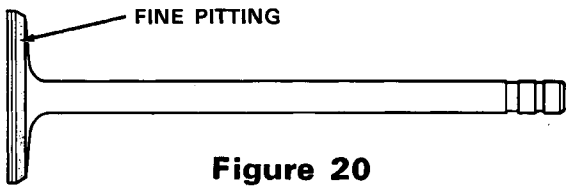


**Figure 20**

# REFACING INTAKE AND EXHAUST VALVES

Before refacing the valves, they should be wire brushed, cleaned and inspected. A 44° angle is the correct valve face grinding angle. Set the refacing machine protractor at this angle. Be sure the chuck of the machine is clean before installing the valve. Dress the grinding wheel before starting to reface the valves. Take only light cuts as the valve is refaced. The last cut must be very fine so the valve face will have a polished finish.

**IMPORTANT:** Replace any valve that has a thin edge or margin, Figure 21. If the margin on the ground valve is less than half the margin on a new valve, replace the valve.

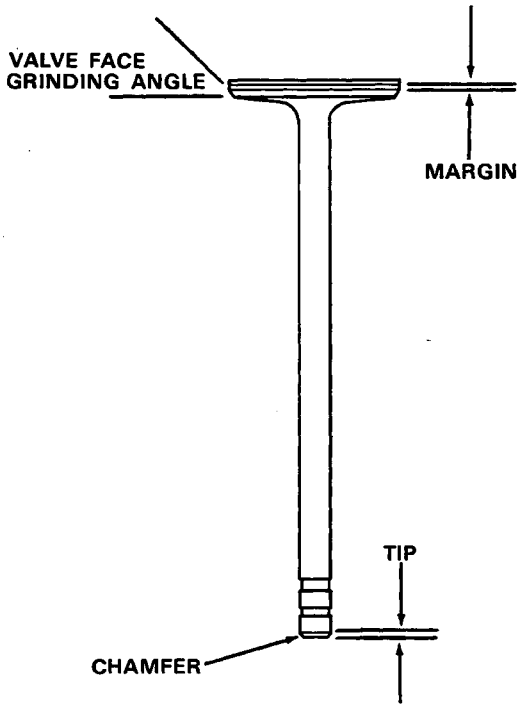


**Figure 21**

The tip end of the valve should be checked for roughness or wear. Usually this can be removed with some very light cuts against the side of the grinding wheel and will square up the end. Never grind off the valve stem end beyond the chamfer.

Correct refacing of intake and exhaust valves and valve seats will provide a 1° interference angle. This angle is important since it aids in cutting carbon and helps seat the valves.

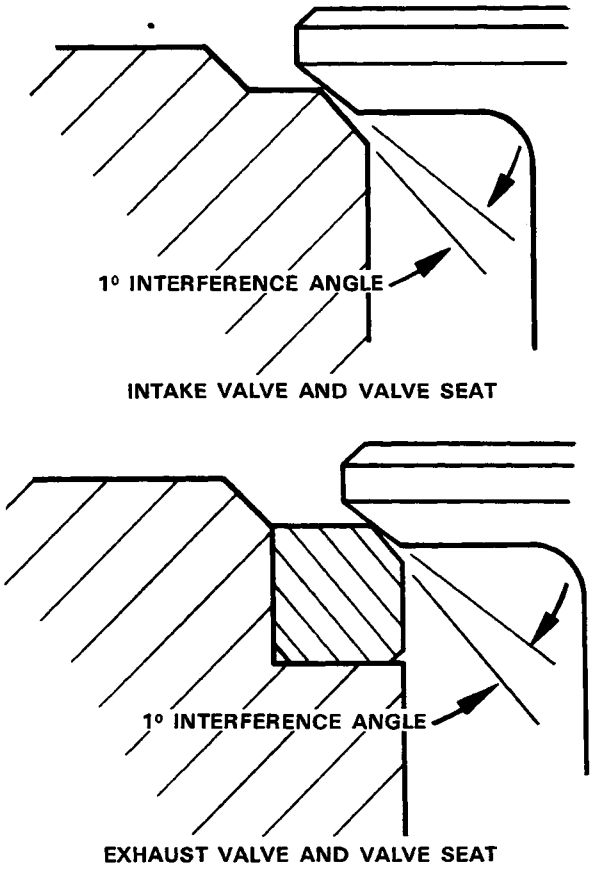


**Figure 22**

When the top edge of the contact area is too high or low on the valve face, the seat contact area must be moved. This is done by using the narrowing stones. Refer to Page 15. The contact area width should never exceed the specified dimension of .0608" to .0962" (exhaust valve) and .704" to .1057" (intake valve).

# GRINDING INTAKE AND EXHAUST VALVE SEATS

Always use a precision seat grinder. Take very light cuts with the grinding stones so just enough metal is removed to end up with a good smooth seat finish.

The proper angle of grind is 45° for exhaust valve and intake valve seats, Figure 23. The seat grinding angle of the stone should be dressed frequenctly on a stone dresser to maintain a clean accurate surface.

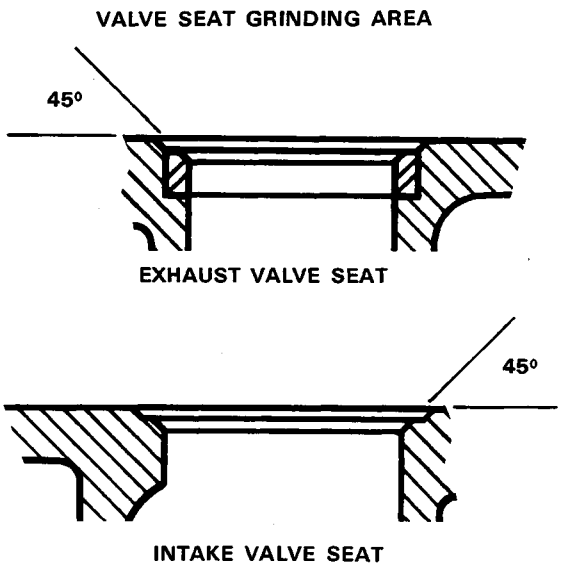


**Figure 23**

**IMPORTANT:** The valve seat runout should be checked after finish grinding with a dial indicator and seat grinding pilot, Figure 24. The runout of the valve seat must not exceed .002" .

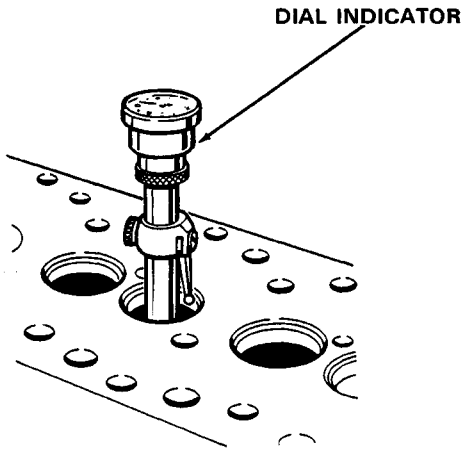


**Figure 24**

The valve seat contact area width and location can be changed by using the 30° and 60° narrowing stones, Figure 25.

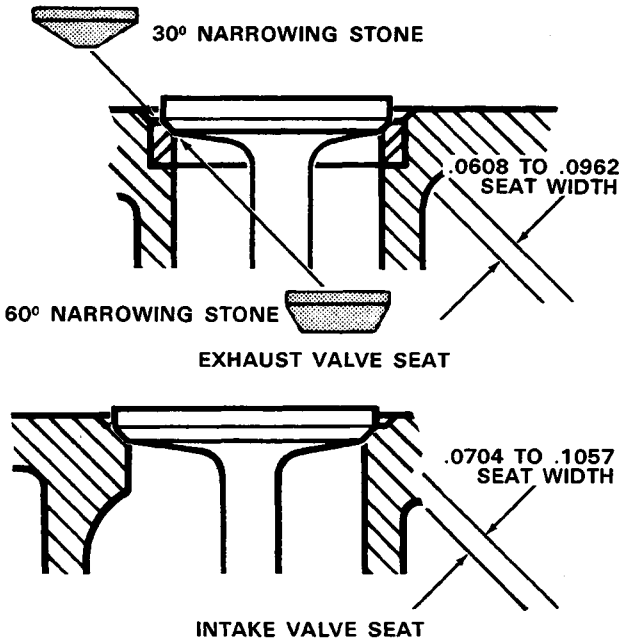


**Figure 25**

**NOTE:** If the valve head has receded more than .010" (exhaust valve and intake valve) below the cylinder head surface, Figure 26, the valve or valve insert or both should be replaced to keep the compression ratio equal between cylinders for an efficient running engine.

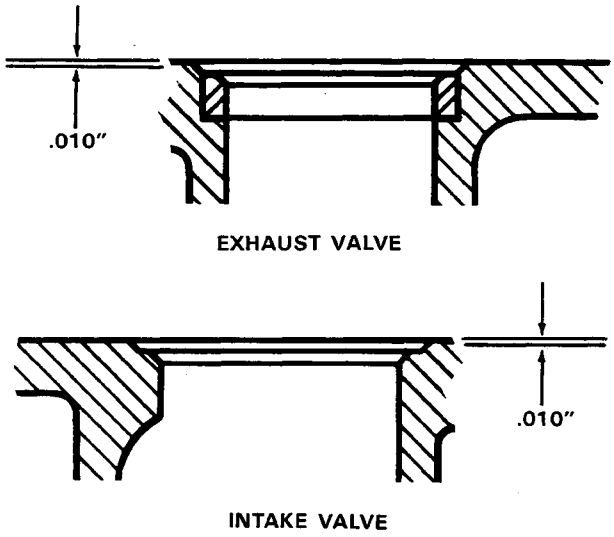


**Figure 26**

# LOCATING TOP DEAD CENTER AND TAPPET ADJUSTMENTS

FIRING ORDER ---------- 1-3-4-2

The Top Dead Center position of number 1 and 4 cylinders is indicated by the TDC mark on the flywheel. Refer to Figure 27

The tappet adjustments can be done in two steps as described in the following manner.

## COLD SETTING

STEP 1 - Remove the valve cover. Crank the engine until the timing pointer is aligned with the TDC timing mark on the flywheel, Figure 27. Check the push rods on No. 1 cylinder for looseness. If the push rods are loose, No. 1 cylinder is at TDC on the compression stroke. If the push rods are tight, crank the engine one complete revolution and align the pointer and the TDC mark on the flywheel, Figure 27.

Check and adjust the following valve clearances; intake valve at .014" clearance on cylinders 1 and 2, and the exhaust valves on cylinders 1 and 3 at .014" clearance, Figure 28.

STEP 2 - Crank the engine one complete revolution and align the timing pointer and the TDC mark on the flywheel, Figure 27. Cylinder No. 4 should be at TDC on the compression stroke. Check the push rods on No. 4 cylinder for looseness.

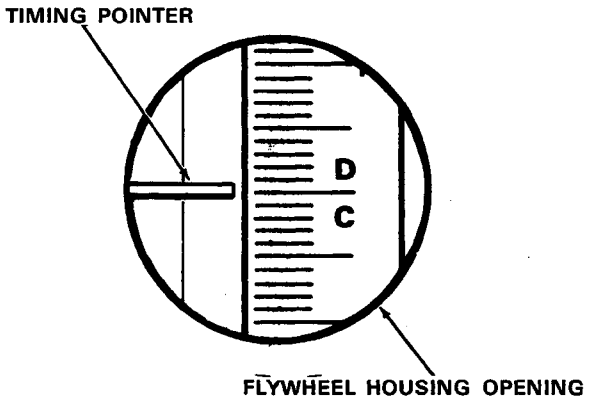


**Figure 27**

Check and adjust the following valve clearances; intake valves at .014" clearance on cylinders 3 and 4, and the exhaust valves on cylinders 2 and 4 at .014" clearance, Figure 28.

## HOT SETTING

Follow steps 1 and 2 while the engine is hot. The tappet clearances for hot settings are .014" for the intake valves and .014" for the exhaust valves.

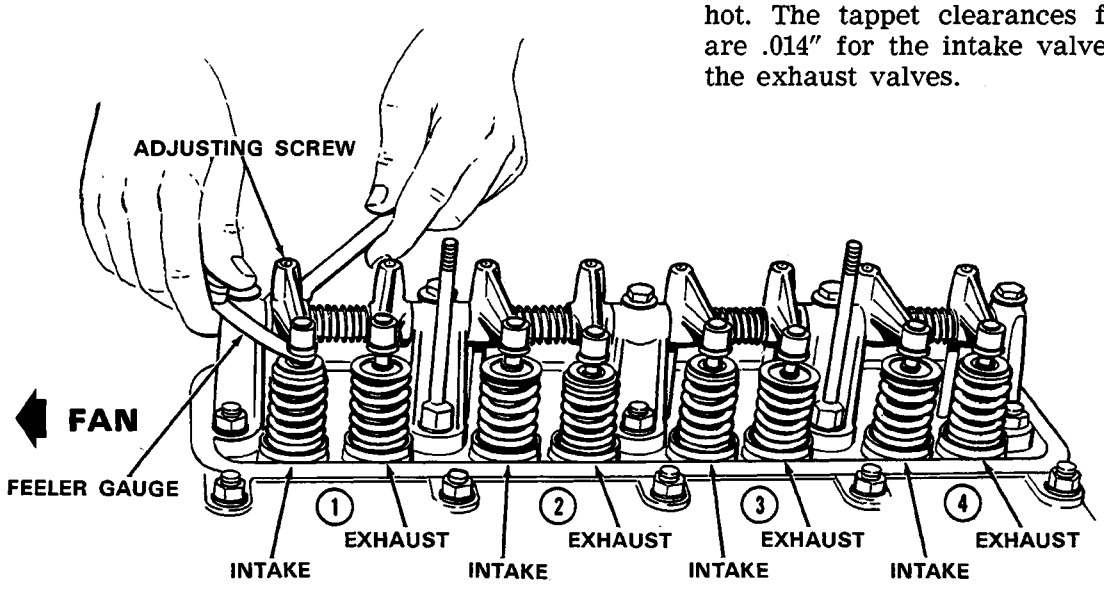


**Figure 28**

**IMPORTANT:** The valve tappet clearance is a critical adjustment.

The entire combustion system of the engine will be seriously affected by adjusting the valve tappet clearance to any other setting.

Excessive clearance will change the valve timing and could result in overheating, power loss and possible valve breakage.

Insufficient clearance would allow the valves to remain open and be burned by the hot exhaust gases.

# Section

# 23

## ENGINE BLOCK ASSEMBLIES

## 188D DIESEL AND 188G, 159G, 148G SPARK IGNITION ENGINES

### TABLE OF CONTENTS




Rac. Form 9-80431

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# SPECIFICATIONS

**NOTE:** All dimensions are given in inches. Specifications apply to all engines unless noted.

| | | Maximum Limit Including Wear |
|---|---|---|
| CYLINDER SLEEVES | | |
| I.D. of sleeve (159G) | 3.5013 to 3.5028 | .005 |
| (188D) | 3.8115 to 3.8125 | .005 |
| (188G) | 3.8130 to 3.8145 | .005 |
| (148G) | 3.3745 to 3.3765 | .005 |
| Sleeve out-of-round | | .004 |
| Clearance to bottom of piston skirt (188D) | .0035 to .0055 | |
| (188G) | .0025 to .0035 | |
| (159G) | .0015 to .0045 | |
| (148G) | .0030 to .0035 | |
| Taper | | .001 |
| PISTON | | |
| Type | Cam Ground | |
| Material | Aluminum Alloy | |
| O.D. at bottom of skirt: 90° to piston pin (188G) | 3.8090 to 3.8105 | |
| (188D) | 3.8070 to 3.8080 | |
| (159G) | 3.4983 to 3.4998 | |
| (148G) | 3.3735 to 3.3750 | |
| I.D. of piston pin bore (188D) | 1.2500 to 1.2503 | .001 |
| (188G, 159G) | .9992 to .9994 | .001 |
| (148G) | .8592 to .8594 | .001 |
| Width of 1st ring groove (188D) | Keystone Type | |
| (188G, 159G, 148G) | .0965 to .0975 | |
| Width of 2nd ring groove (188D) | .097 to .098 | |
| (148G, 159G, 188G) | .0955 to .0965 | |
| Width of 3rd ring groove (188D) | .1895 to .1885 | |
| (188G, 159G, 148G) | .0955 to .0965 | |
| Width of 4th ring groove (188G, 159G, 148B) | .250 to .251 | |
| PISTON RINGS | | |
| No. 1 Compression (188D) | Chrome Grooved Keystone | |
| (188G, 159, 148G) | Tapered Face | |
| Width (188D) | Not measureable | |
| (188G, 159G, 148G) | .0930 to .0935 | |

# SPECIFICATIONS (Cont'd)

| PISTON RINGS (Continued) | Maximum Limit Including Wear |
|---|---|
| End gap in 3.812 I.D. sleeve (188D) | .015 to .025 |
| 3.375 I.D. sleeve (148G) | .010 to .020 |
| 3.500 I.D. sleeve (159G) | .010 to .020 |
| 3.812 I.D. sleeve (188G) | .010 to .020 |
| Side clearance (188D) | Not measureable |
| (188G, 159G, 148G) | .0030 to .0045 |
| No. 2 Compression (188G, 159G, 148G) | Tapered Face |
| (188D) | Grooved |
| Width (188G, 159G, 148G) | .0930 to .0935 |
| (188D) | .0925 to .0935 |
| End Gap in 3.812 sleeve (188D) | .015 to .025 |
| 3.375 sleeve (148G) | .010 to .020 |
| 3.500 sleeve (159G) | .010 to .020 |
| 3.812 sleeve (188G) | .010 to .020 |
| No. 2 Compression | |
| Side clearance (188D) | .0035 to .0055 |
| (188G,159G,148G) | .0020 to .0035 |
| No. 3 Compression (188G,159G,148G) | Tapered Face |
| Width | .0930 to .0935 |
| End gap in 3.812 sleeve (188G) | .010 to .020 |
| 3.375 sleeve (148G) | .010 to .020 |
| 3.500 sleeve (159G) | .010 to .020 |
| Side clearance | .0020 to .0035 |
| OIL RINGS | |
| Width (188D) | .1825 to .1888 |
| (188G,159G,148G) | .2485 to .2490 |
| Side clearance (188D) | .000 to .007 |
| (188G,159G,148G) | .0010 to .0015 |
| End gap in 3.812 I.D. sleeve (188G) | .010 to .018 |
| 3.375 I.D. sleeve (148G) | .010 to .018 |
| 3.500 I.D. sleeve (159G) | .010 to .018 |
| Rail end gap in 3.812 I.D. sleeve (188D) | .015 to .055 |

# SPECIFICATIONS (Cont'd)

| | | Maximum Limit Including Wear |
|---|---|---|
| **PISTON PIN** | | |
| Type | Full Floating | |
| O.D. of pin (188D) | 1.2497 to 1.2498 | |
| (188G, 159G) | .9991 to .9992 | |
| (148G) | .8592 to .8593 | |
| Fit in piston (188D) | .0002 to .0006 | |
| (188G, 159G) | .0000 to .0003 | |
| (148G) | .0000 to .0002 | |
| Fit in rod bushing (188D) | .0002 to .0006 | |
| (188G,159G,148G) | .0003 to .0006 | |
| **CONNECTING ROD** | | |
| Bushing | Replaceable Bronze | |
| Bushing I.D. installed (reamed to size) | | |
| (188G,159G) | .9995 to .9997 | .001 |
| (188D) | 1.2502 to 1.2504 | .001 |
| (148G) | .8596 to .8598 | .001 |
| Bushing out-of-round | | .0015 |
| Bearing Liners | Replaceable | |
| Bearing liner width | 1.120 to 1.130 | |
| Rod width at crank end | 1.3035 to 1.3055 | |
| Journal I.D. without bearing liners | 2.1870 to 2.1875 | |
| Bearing oil clearance | .0010 to .0035 | .006 |
| Undersize bearings for service | .002,.010,.020,.030 | |
| Side clearance | .005 to .011 | |
| Cap bolts | Self locking type | |
| **CRANKSHAFT** | | |
| Type | Balanced | |
| Main bearing liners | Replaceable | |
| End play, center main bearing cap | .001 to .006 | |
| Thrust spacer std. thickness | .092 to .098 | |
| Connecting rod journal std. O.D. | 2.0605 to 2.0615 | |
| Grind to .010" O.D. undersize | 2.0505 to 2.0515 | |
| .020" O.D. undersize | 2.0405 to 2.0415 | |
| .030" O.D. undersize | 2.0305 to 2.0315 | |
| Connecting rod journal maximum taper | | .002 |

# SPECIFICATIONS (Cont'd)

| | Maximum Limit Including Wear |
|---|---|
| CRANKSHAFT (Continued) | |
| Journals out-of-round | .001 |
| Main bearing liner width 1st, (188D, 188G) | 1.276 to 1.286 |
| Main bearing liner width 1st, (159G, 148G) | 1.870 to 1.880 |
| Main bearing liner width 3rd (188D) | 1.371 to 1.373 |
| Main bearing liner width 2nd (188G) | 1.371 to 1.373 |
| Main bearing liner width 2nd and 4th (188D) | .950 to 1.000 |
| Main bearing liner width 5th (188D), (188G 3rd.) | 1.557 to 1.567 |
| Undersize main bearing liners for service | .002,.010,.020,.030 |
| Main bearing oil clearance | .0012 to .0042 |
| Main bearing journal std. O.D. (188G, 188D) | 2.8730 to 2.8740 |
| (159G,148G) | 2.6230 to 2.6240 |
| Grind to: | |
| .010" O.D. undersize, (188G, 188D) | 2.8630 to 2.8640 |
| .020" O.D. undersize, (188G, 188D) | 2.8530 to 2.8540 |
| .030" O.D. undersize, (188G, 188D) | 2.8430 to 2.8440 |
| .010" O.D. undersize, (159G, 148G) | 2.6130 to 2.6140 |
| .020" O.D. undersize, (159G, 148G) | 2.6030 to 2.6040 |
| .030" O.D. undersize, (159G, 148G) | 2.5930 to 2.5940 |
| Main journal bore I.D. w/o liners (188D, 188G) | 3.066 to 3.067 |
| (159G,148G) | 2.816 to 2.817 |
| Main journal width between cheeks: | |
| 2nd (159G, 148G) | 1.499 to 1.502 |
| 2nd and 4th (188D) | 1.185 to 1.189 |
| 2nd (188G) | 1.3770 to 1.3740 |
| 3rd (188D) | 1.3740 to 1.3770 |
| 3rd (159G,148G) | 1.741 to 1.751 |
| 5th (188D) | 1.745 to 1.755 |
| Connecting rod journal width between cheeks | 1.3105 to 1.3145 |
| CAMSHAFT | |
| Type | Parabolic |
| Bushings (188D) | 5, Replaceable |
| Bushings (188G) | 4, Replaceable |
| Bushings (159G, 148G) | 3, Replaceable |
| Oil Clearance | .002 to .005 |

# SPECIFICATIONS (Cont'd)

| | | Maximum Limit Including Wear |
|---|---|---|
| **CAMSHAFT (Continued)** | | |
| Bushing lubrication: | | |
| Front bushing | Pressure lubricated from oil pump. | |
| Intermediate bushing | Gravity flow lubricated | |
| Rear bushing (188D Only) | Pressure lubricated with rear oil metering. | |
| Oil clearance | .002 to .005 | .007 |
| I.D. of bushing installed | 1.752 to .1753 | |
| Bushing width: | | |
| 1st (front) (159G,148G) | 1.307 to 1.317 | |
| 1st (front) (188D,188G) | 1.213 to 1.223 | |
| 2nd (159G,148G) | .713 to .723 | |
| 2nd, 3rd & 4th (188D) | .490 to .500 | |
| 2nd, & 3rd. (188G) | .490 to .500 | |
| 3rd (rear) (148G, 159G) | 1.177 to 1.197 | |
| 4th (rear) (188G) | 1.213 to 1.223 | |
| 5th (rear) (188D) | 1.213 to 1.223 | |
| O.D. of each bearing surface (159G,188D) | 1.749 to 1.750 | .004 |
| O.D. of each bearing surface (148G,188G) | 1.749 to 1.750 | .004 |
| Thrust plate thickness | .149 to .147 | |
| Camshaft end play | Taken up by thrust plate | |
| Camshaft end clearance | .003 to .007 | |
| **VALVE PUSH ROD LIFTERS** | | |
| Type | Mushroom | |
| Body O.D. std. | .5615 to .5620 | |
| I.D. of block bore, std. | .5625 to .5635 | .0015 |
| **GEAR TRAIN** | | |
| Backlash: | | |
| Crankshaft gear to camshaft gear | .0002 to .006 | |
| Camshaft gear to idler gear (Diesel) | .0004 to .006 | |
| Idler gear to fuel pump gear (Diesel) | .0005 to .007 | |
| Crankshaft gear to oil pump gear | .002 to .008 | |
| Crankshaft gear to fuel pump gear (Diesel) | Maximum .019 | |

# SPECIFICATIONS (Cont'd)

| | | Maximum Limit Including Wear |
|---|---|---|
| IDLER GEAR | | |
| O.D. of idler gear journal (Diesel) | 1.3740 to 1.3755 | .0005 |
| I.D. of idler gear w/bushing (Diesel) | 1.376 to 1.377 | |
| Thrust washer shims (Diesel) | .005,.006,.007,.009 | |
| Idler gear end play (Diesel) | | .003 |
| OIL PUMP FRONT MOUNTED | | |
| Positive displacement pump | Gear Type | |
| Pump gears to oil pump cover clearance | .0015 to .0055 | |
| Pump gears radial clearance | .002 to .005 | |
| Drive gear to body clearance (188G,159G,148G) | .003 to .006 | |
| Drive gear to body clearance (188D) | .0035 to .0065 | |
| Relief valve spring: | | |
| Wire thickness (188D) | .0625 | |
| Maximum O.D. (188G,159G,148G) | .469 | |
| Maximum O.D. (188D) | .4844 | |
| Free length (188G,159G,148G) | 2 | |
| Free length (188D) | 2-1/8 | |
| Load at 1.38 inches (188G,159G,148G) | 6-3/4 to 7-1/4 lbs. | |
| Load at 1.44 inches (188D) | 18 to 19 lbs. | |
| Oil pressure (188G,159G,148G) | 24 to 32 PSI | |
| Oil pressure (188D) | 50 to 75 PSI | |
| Backlash, crankshaft drive gear and oil pump gear | .002 to .008 | |

# SPECIAL TORQUES

| | |
|---|---|
| Camshaft nut | 80 to 90 Ft. lbs. |
| Connecting rod nuts | 45 to 55 Ft. lbs. |
| Crankshaft nut | 125 to 135 Ft. lbs. |
| Flywheel to crankshaft bolt | 65 to 70 Ft. lbs. |
| Main bearing cap bolts | 90 to 100 Ft. lbs. |
| Oil pan capscrews (Stamped steel) | 10 to 12 Ft. lbs. |
| Oil pan capscrews (Cast iron) | 24 to 28 Ft. lbs. |
| Oil pan to seal retainer | 15 to 20 Ft. lbs. |
| Oil pan drain plug | 18 to 20 Ft. lbs. |
| Oil pump cover capscrews | 6 to 8 Ft. lbs. |
| Oil seal retainer bolts (Grade 8 bolts) | 12 to 15 Ft. lbs. |
| Fuel pump drive gear nut (Diesel) | 35 to 40 Ft. lbs. |

# ENGINE LUBRICATION

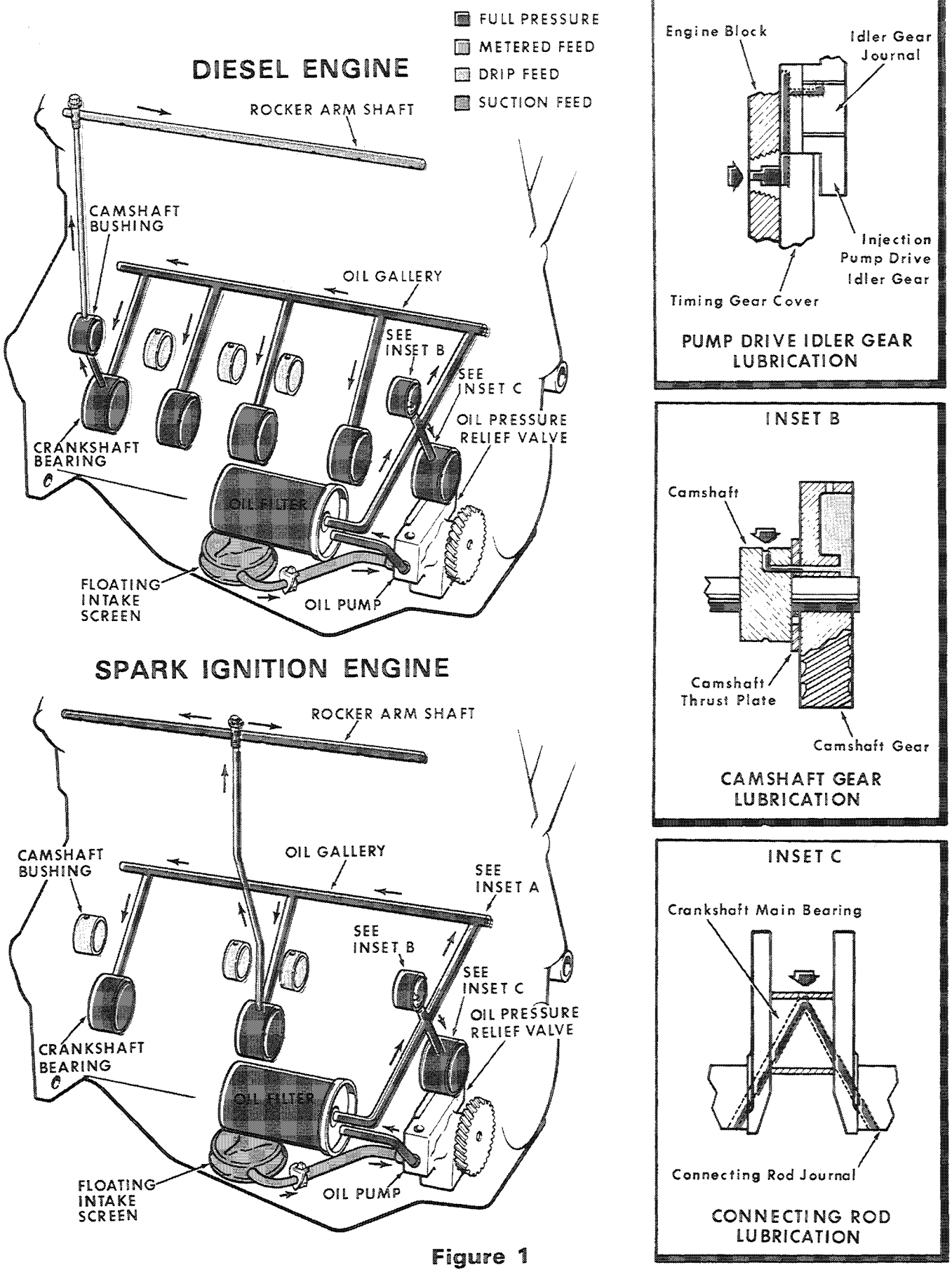



**Figure 1**

# ENGINE LUBRICATION

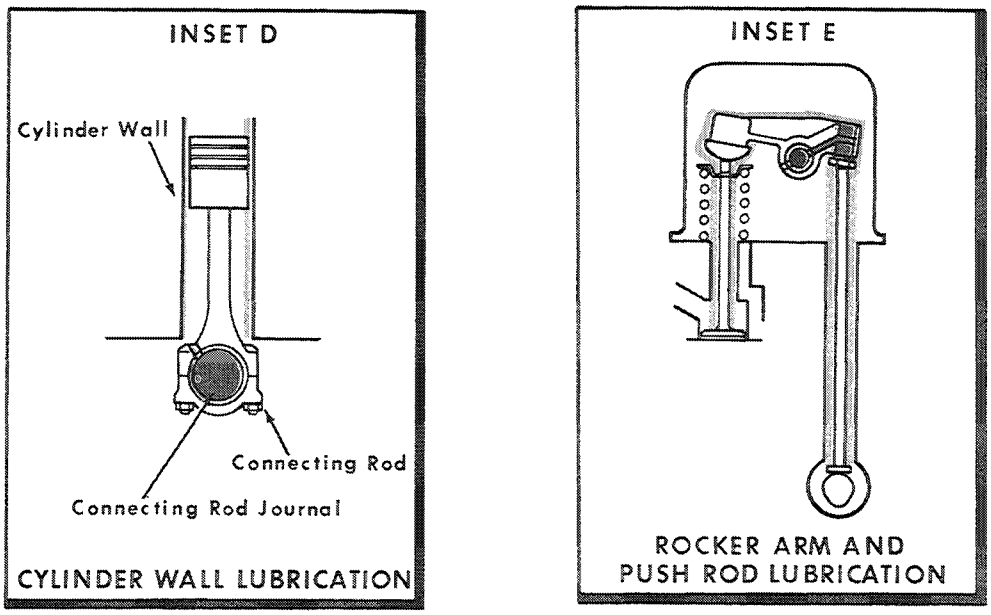
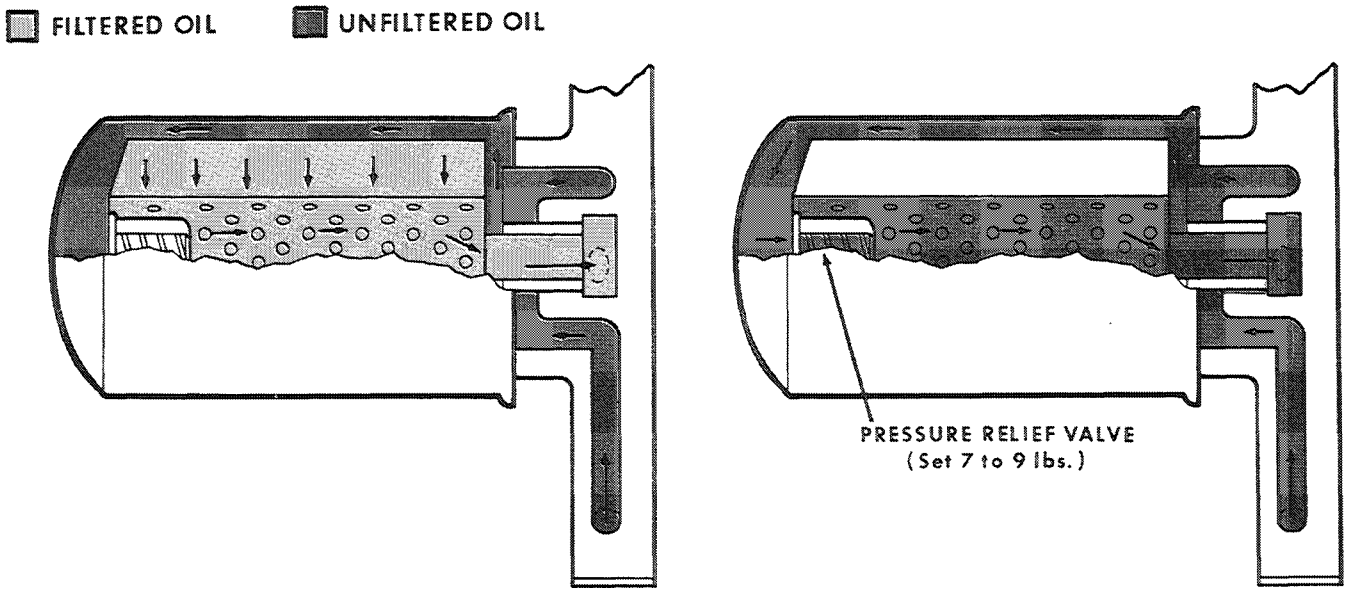



Figure 2

# OIL FILTER




CLEAN OIL FILTER

PLUGGED OIL FILTER

Figure 3

# FLYWHEEL, OIL PAN, SEAL RETAINER AND OIL FILTER

## (Refer to Figure 4)

## Disassembly

1. Remove the oil pan drain plug (1) with gasket (2) to drain the engine and remove the engine oil filter (6) and discard.

2. Remove the oil pan bolts (13) and gasket (14). Remove all the gasket material from block and oil pan.

3. Remove the dipstick (3), extension tube (2), "O" ring and clamp (4) if equipped, and the dipstick socket (5) if it needs replacing.

4. Remove adapter (8) and plug (7) if adapter requires replacement.

**NOTE:** On engines equipped with the timing marks on the flywheel it is advisable to rotate the flywheel until the TDC mark is lined up with timing pointer. Then scribe a mark on the front crankshaft pulley and timing cover.

5. Remove the flywheel mounting bolts (15) or (18) and flywheel assembly (16 or 19) and output hub (29) (Hydrostatic Tractor Only). If the ring gear (17 or 20) is worn or damaged, it must be driven or broken off the flywheel to be removed.

6. For dry clutch tractor flywheel, Inset A, remove oil seal (21), snap ring (23) and "O" ring (22). Press bearing (24) out of flywheel.

7. Remove the rear oil seal retainer (26) and gasket (27). Press seal (28) from retainer (26).

8. Remove any cup plugs from block that need replacing by drilling a hole in them and pulling them out.

9. To remove the Diesel tachometer drive (30), a puller can be made from an old tachometer drive cable. Cut off the end that screws into the drive and weld a stud to it. With this tool, pull the tachometer drive.

## Inspection

Replace all damaged or worn parts, oil seals, gaskets, "O" rings and oil filter.

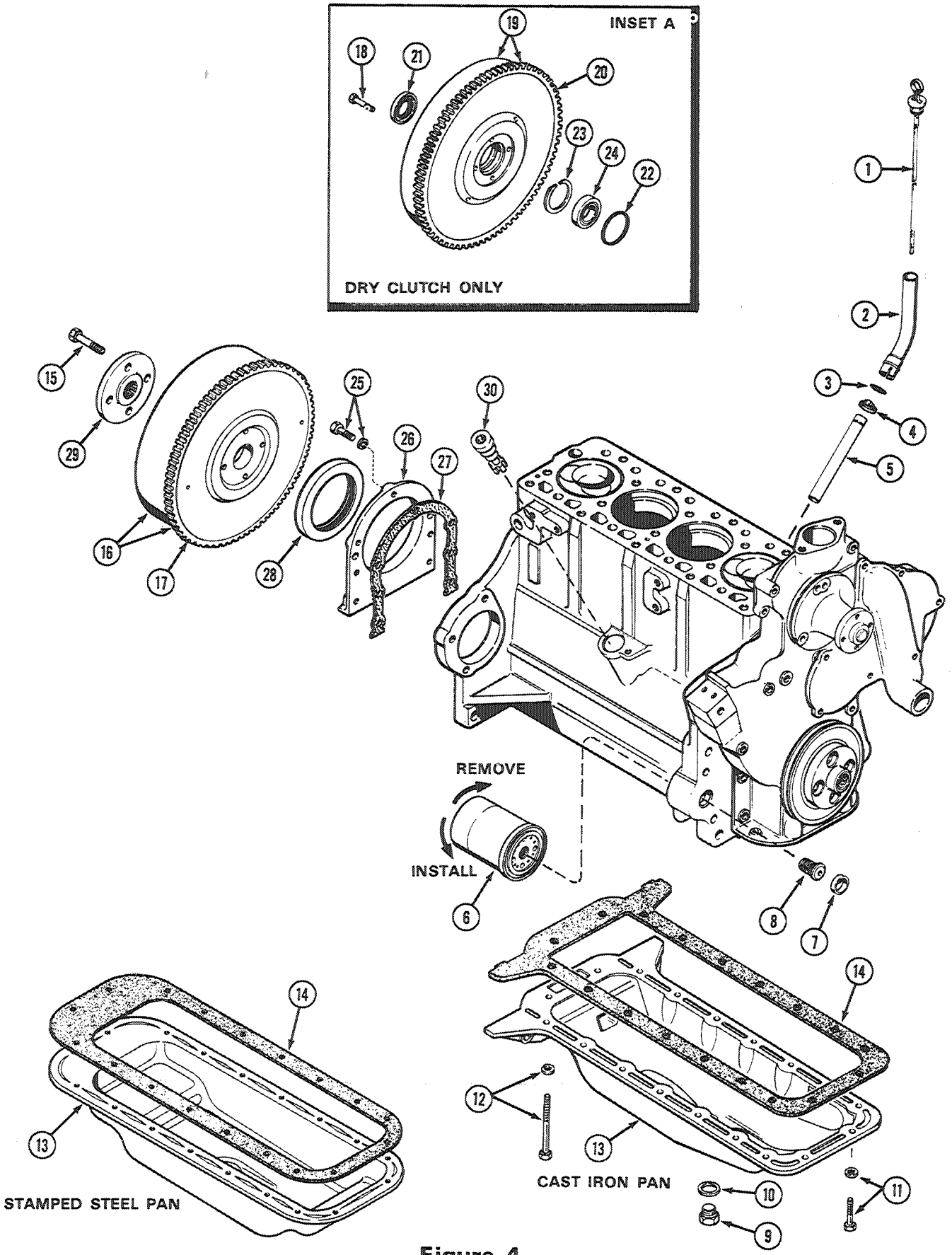

INSET A
DRY CLUTCH ONLY
REMOVE
INSTALL
STAMPED STEEL PAN
CAST IRON PAN

**Figure 4**

# FLYWHEEL, OIL PAN, SEAL RETAINER AND OIL FILTER

## (Refer to Figure 5)

## Assembly

1. To install new cup plugs, coat the bore with Gasolia or equivalent and install the cup plugs until the outer edge is even with the inner edge of the chamfer in the bore. Install the tachometer drive (30) (Diesel only) into the block, engaging the gear on the camshaft.

2. Press in new rear oil seal (28) into the retainer (26) (seal lip in toward block) flush with rear of retainer, Inset A. Assemble gasket (27) to retainer and lay a bead of Permatex No. 2 on both sides of the gasket.

3. Using a Case No. G15028 Sleeve, Inset C, slide the oil seal (28) and retainer (26) onto the crankshaft.

4. Remove the sleeve and install a Case No. G13506 Aligning Tool, Inset D with the tool pins in the aligning pin holes in the flange, refer to Inset G, below. The tool must be installed over the flange on the crankshaft.

5. Install the two bottom and the top bolts (25). Tighten the bolts slightly then remove the aligning tool.

6. Install the remaining bolts and lockwashers (25), then torque 12 to 15 ft. lbs.

7. Preheat the new flywheel ring gear (17 or 20) 400 to 450°F., either in oil or an oven. Do not use a torch. Install the ring gear with the large chamfer toward the flywheel, Inset E.

8. On dry clutch tractor flywheel (19), Inset B, install snap ring (23) in groove of flywheel. Press bearing (24) in until seated against the snap ring from the gear side of flywheel. Install new oil seal (21) from rear side with lip inward until seated against the snap ring. Install new "O" ring (22). Lubricate the oil seal and "O" ring with drive-way oil.

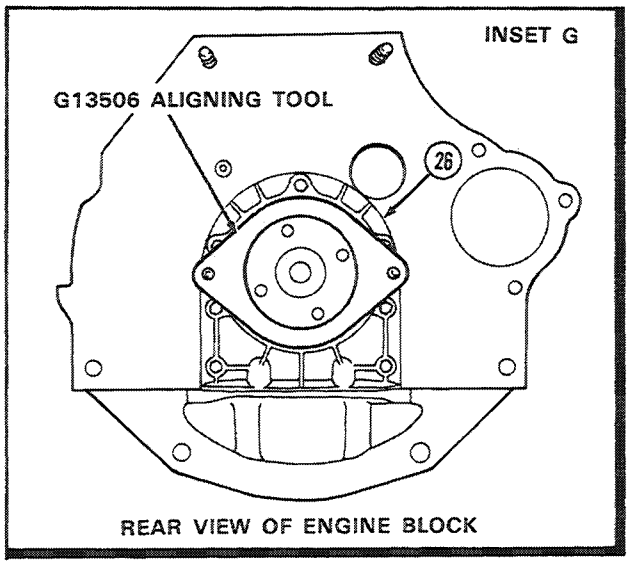
9. Install the flywheel assembly (19 or 16) to the crankshaft with output hub (29) (Hydrostatic Tractor only). **IMPORTANT:** Prior to installing output hub (29), lubricate the spline hole and face of hub liberally with #2 Moly Disulfide Grease. Torque the retaining bolts 65 to 70 ft. lbs.

10. Install dipstick socket (5) into the block to the depth shown in Inset F.

11. Press the filter adapter (8) into the block flange until seated. Press plug (7) in until seated against the adapter. Apply a thin coat of new oil or grease to the gasket of new oil filter (6) and install turning clockwise until gasket contact is made. Hand tighten 1/2 of a turn and loosen filter. Retighten until gasket contact is made and hand tighten 1/2 to 3/4 of a turn to obtain the proper sealing without damaging the filter.

12. Install a new oil pan gasket (14) and oil pan (13) to block with the long bolts to the rear. Torque the bolts 24 to 28 ft. lbs. for cast iron pan, 10 to 12 ft. lbs. for stamped steel oil pan. Torque the rear bolts 15 to 20 ft. lbs.

13. Install the oil pan drain plug (9) with new gasket (10). Torque 18 to 20 ft. lbs. Refill the engine crankcase with the proper amount of oil.



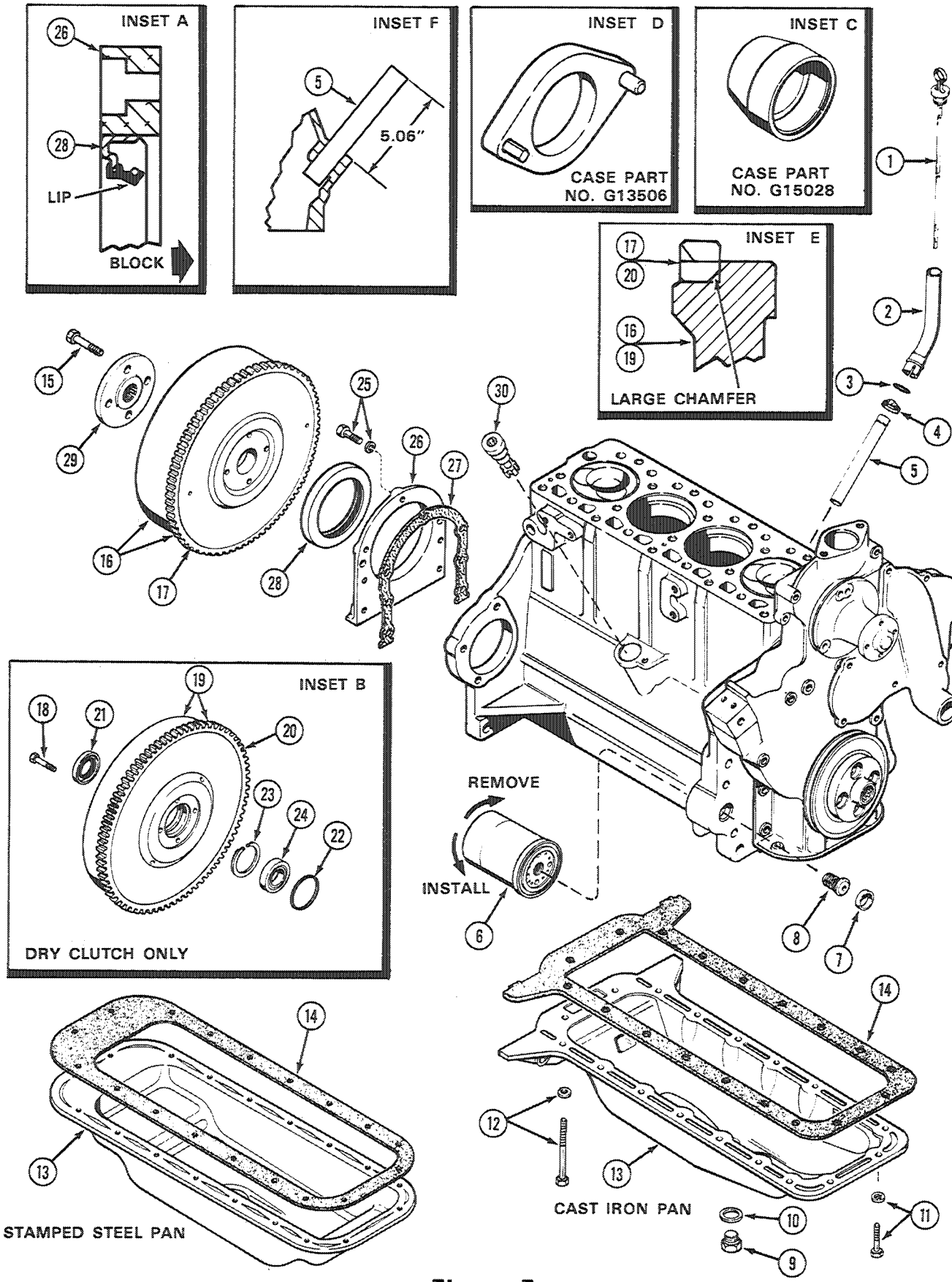

INSET A
26
28
LIP
BLOCK
INSET F
5
5.06"
INSET D
CASE PART
NO. G13506
INSET C
CASE PART
NO. G15028
INSET E
17
20
16
19
LARGE CHAMFER
1
2
3
4
5
15
29
16
17
25
26
27
28
30
INSET B
19
18
21
20
23
24
22
DRY CLUTCH ONLY
REMOVE
INSTALL
6
8
7
14
12
13
CAST IRON PAN
10
11
9
14
13
STAMPED STEEL PAN

**Figure 5**

# DIESEL TIMING GEAR COVER, GEARS AND WATER PUMP

## (Refer to Figure 6)

## Disassembly

1. Remove fan blade (1), pulley (2), water pump (3) and gasket (4).

2. Remove the pump drive cover (5), gasket (6), plunger (7) and spring (8). Remove nut and lockwasher (9) and pump drive gear (10).

3. Remove lock plate pointer (11), thrust plate (12), shims (13), idler gear (14) and journal (15).

4. Remove bolt and washer (16), (17), bushing (18) and flexible coupler (if equipped). Remove pulley retainer nut (20), and pull the crankshaft pulley (21) with key (22).

5. Remove the timing gear cover (23) and gasket (24) and (30). Press the seal (25) from the timing gear cover.

6. Remove the nut (26) and lockwasher (27). Pull the camshaft gear (28) with key (29).

## Inspection

Clean all parts thoroughly before inspecting

Inspect the gears for chipped teeth, burrs, or excessive wear. Light burrs and nicks can be removed with a hone or crocus cloth. Replace if damaged or worn.

Using an inside micrometer or a bore gauge and micrometer, check the inside diameter of the pump drive idler gear bushing. The maximum allowable inside diameter is 1.378″. Replace the entire idler gear if the bushing exceeds this dimension or is otherwise damaged.

Inspect the idler gear journal for a plugged oil hole. Blow out with compressed air.

Check the end of the thrust plunger for excessive wear. Make sure the plunger is free in the bore of the injection pump drive shaft. Replace if necessary.

Inspect the idler gear journal with a micrometer, as shown in Inset A. The minimum outside dimension is 1.374″. Replace the journal if this dimension is less.

Inspect the pump drive shaft for stripped or damaged threads, burrs, nicks or other damage. Rethread slightly damaged threads; burrs and nicks may be removed with a hone or crocus cloth.

Inspect the oil passage in the engine block which mates with pump drive idler gear journal oil groove. This passage must be free of dirt or other foreign particles.

Inspect the thrust spring for the following specifications:

| | |
|---|---|
| Free length | 1.22″ |
| O.D. | .255″ |
| Total coils | 15 |
| Wire diameter | .038″ |
| Compressed to .950″ | 6 lbs. 4 oz. |

Inspect the water pump for leaks or worn bearings. If these conditions exist, replace the pump assembly.

Check the fan pulley for wear and the fan blade for damage. Replace them if these conditions exist.