

# 480 LOADER

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# diesel engine

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## 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

**Thanks very much for your reading,  
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**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. Dis-  
tributor 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

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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"

## SPECIFICATIONS (Continued)

	Maximum Limit Including Wear
<b>EXHAUST VALVE GUIDES</b>	
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"
<b>INTAKE VALVE GUIDES</b>	
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"
<b>VALVE SPRING</b>	
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.
<b>ROCKER ARM ASSEMBLY</b>	
O.D. of Shaft .....	.622" to .623"
I.D. of Arm Bore .....	.624" to .625"
<b>Shaft Spring</b>	
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.

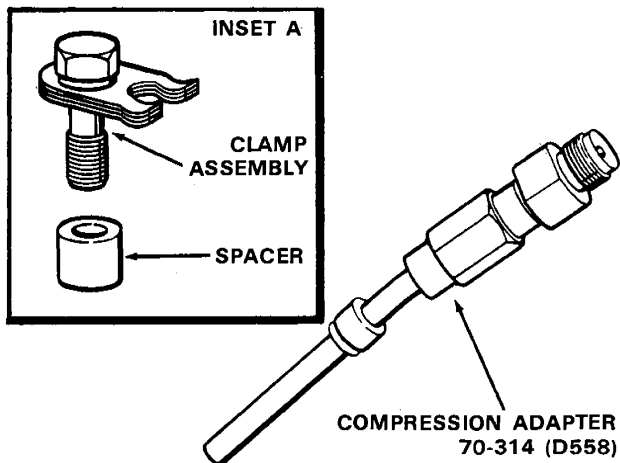
**A. CRANKING METHOD** - Close the needle valve at the fuel tank. Disconnect all high pressure fuel lines and leak-off lines between injectors. Remove all of the injectors. Refer to the chart on Page 3.

## 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.

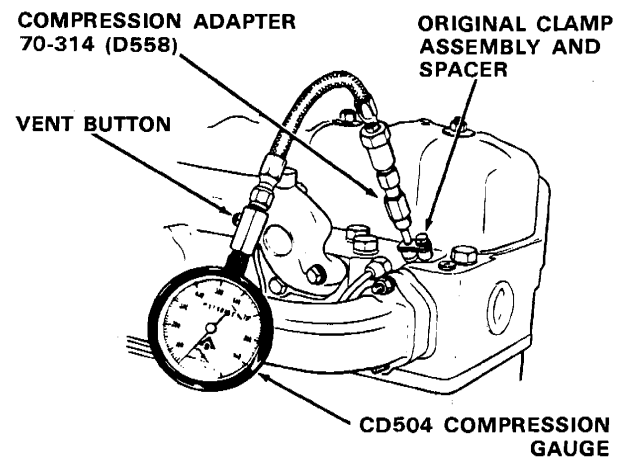


**Figure 1**

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

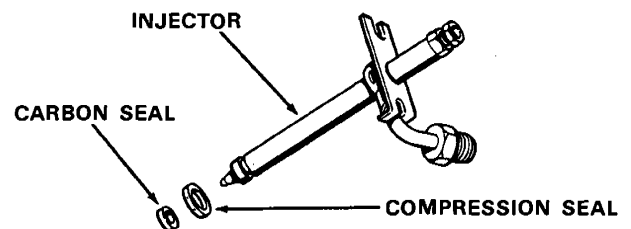
a small amount (a teaspoon) of oil into the cylinder and recheck the compression. If the pressure rises to near normal, compression loss is past the rings. Very little change in compression indicates leakage past the valves. A low pressure reading will cause difficulty in starting particularly at low 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 re-assembly.
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 re-torque 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).

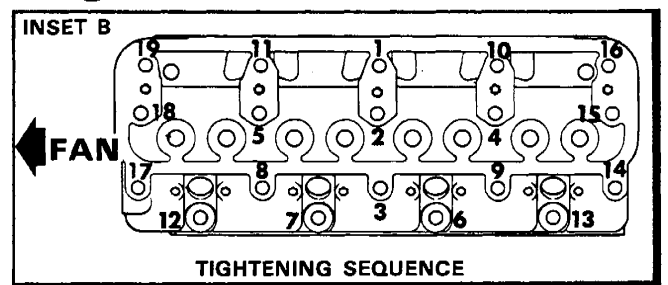
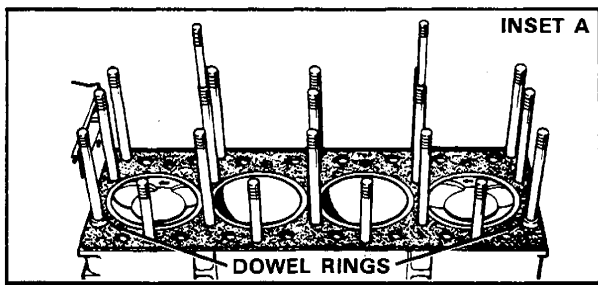
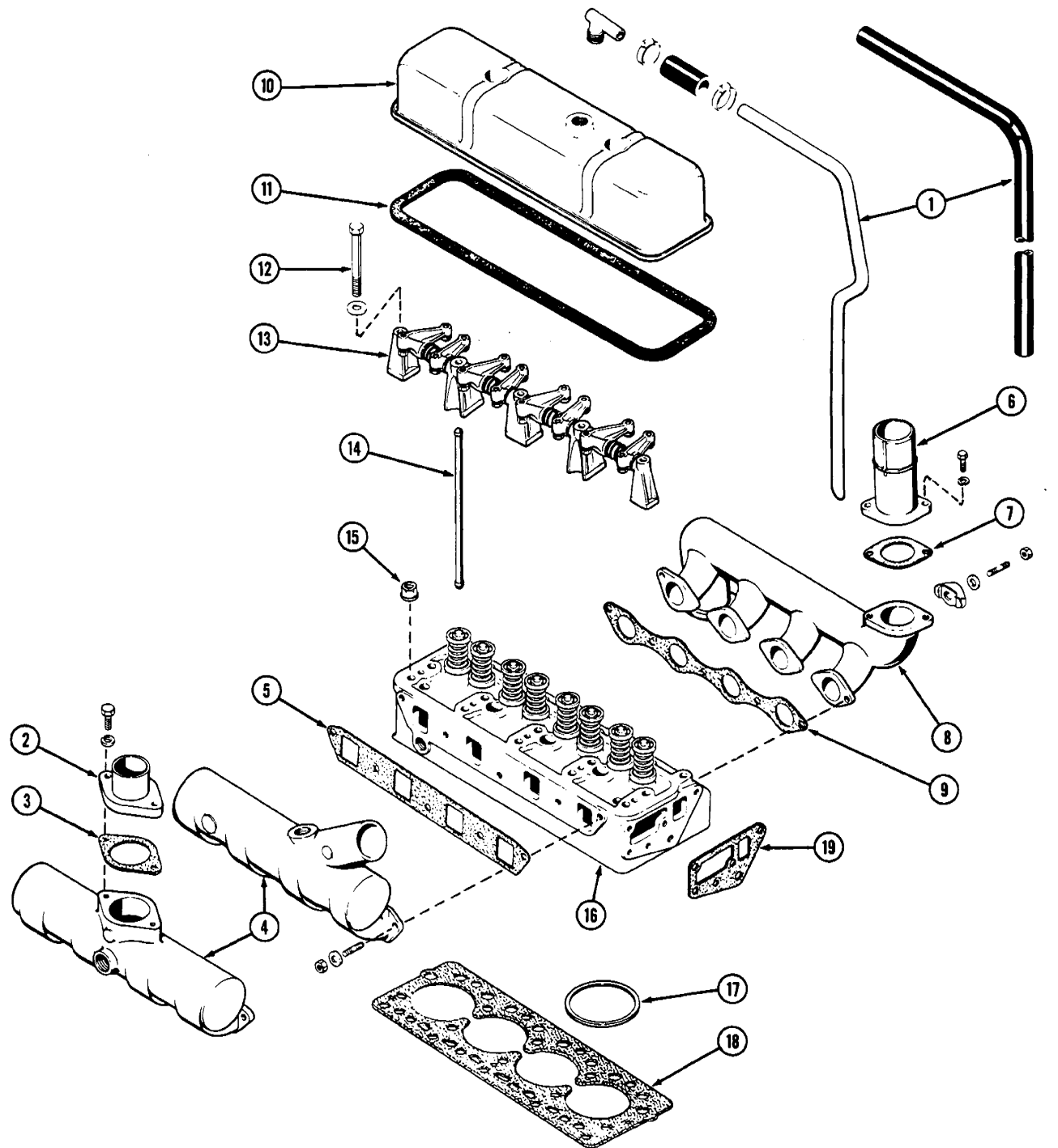


Figure 4



## CYLINDER HEAD AND COMPONENTS (Continued)

### Inspection

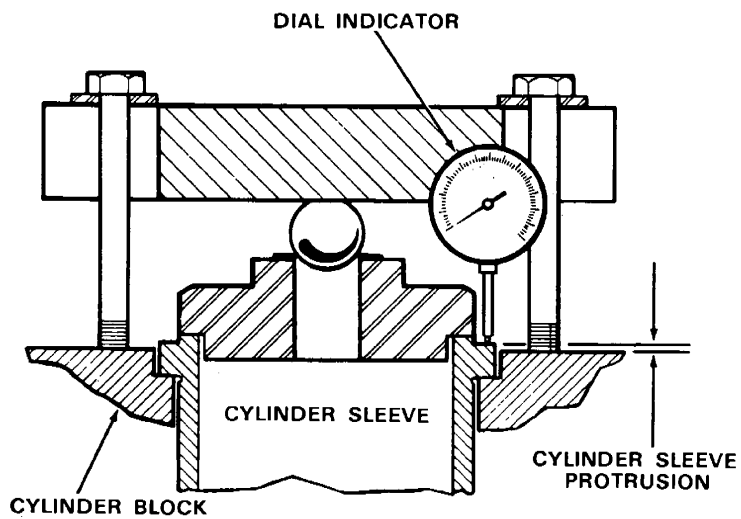
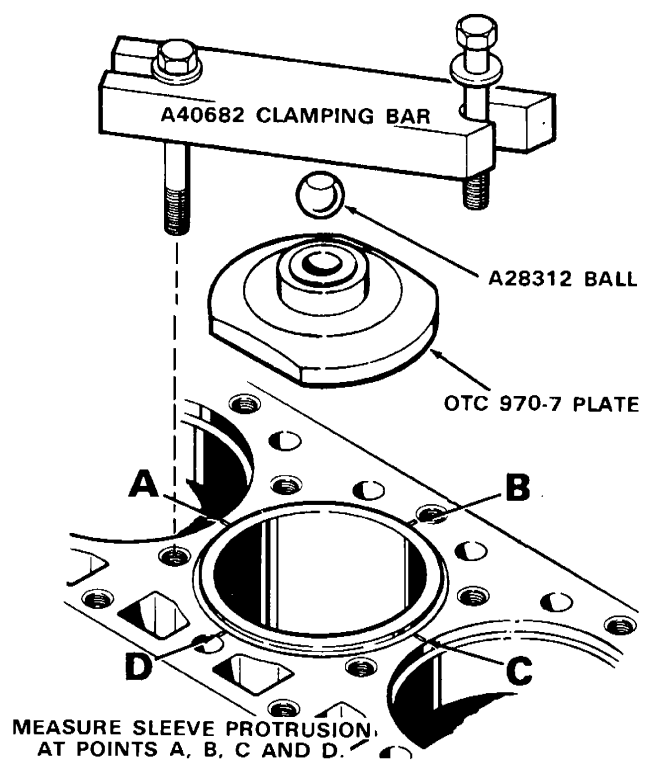
Replace all gaskets, seals and worn or defective parts.

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"	<b>X</b>	
.001" - .003"	<b>X</b>	
LESS THAN .001"		<b>X</b>

**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.

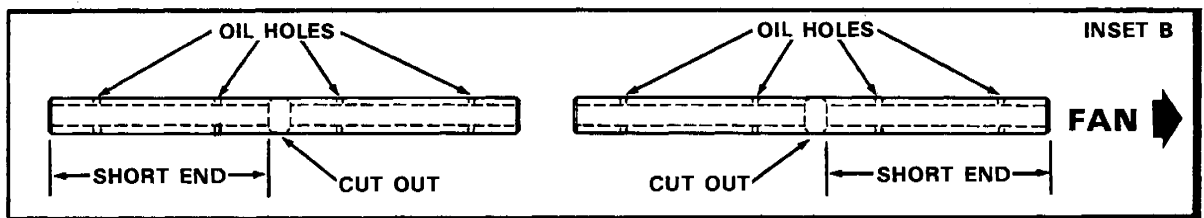
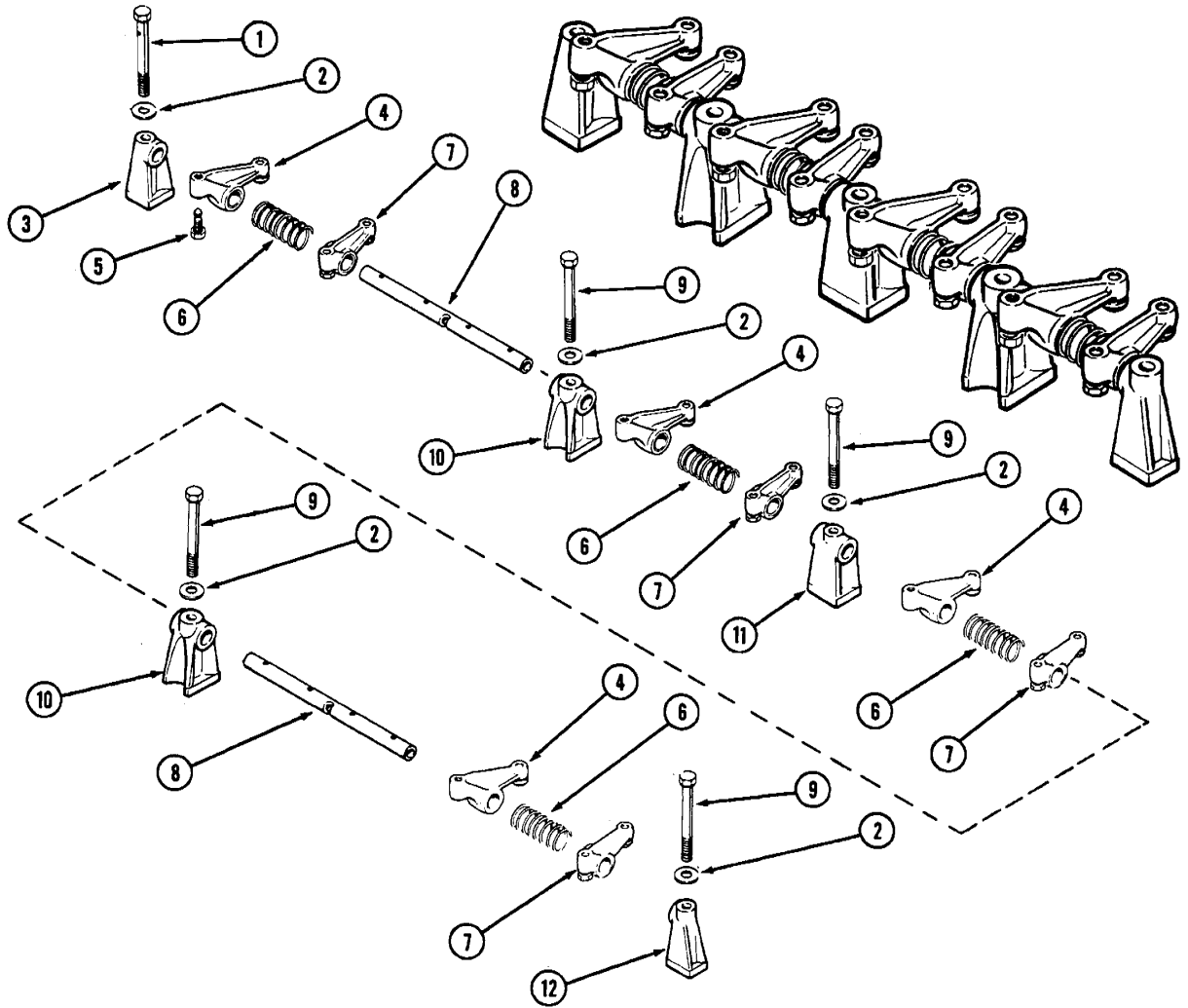
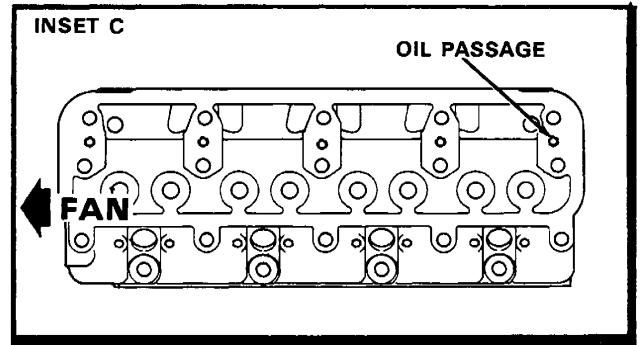
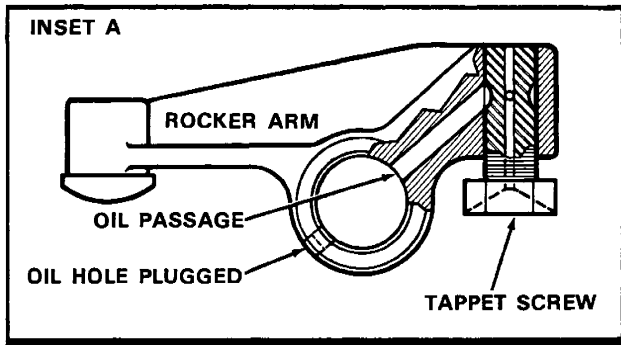
Clean and check the oil passages in the tappet adjusting screws and the rear bracket bolt.

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.



**Figure 8**

## CYLINDER HEAD ASSEMBLY

(Refer to Figure 9)

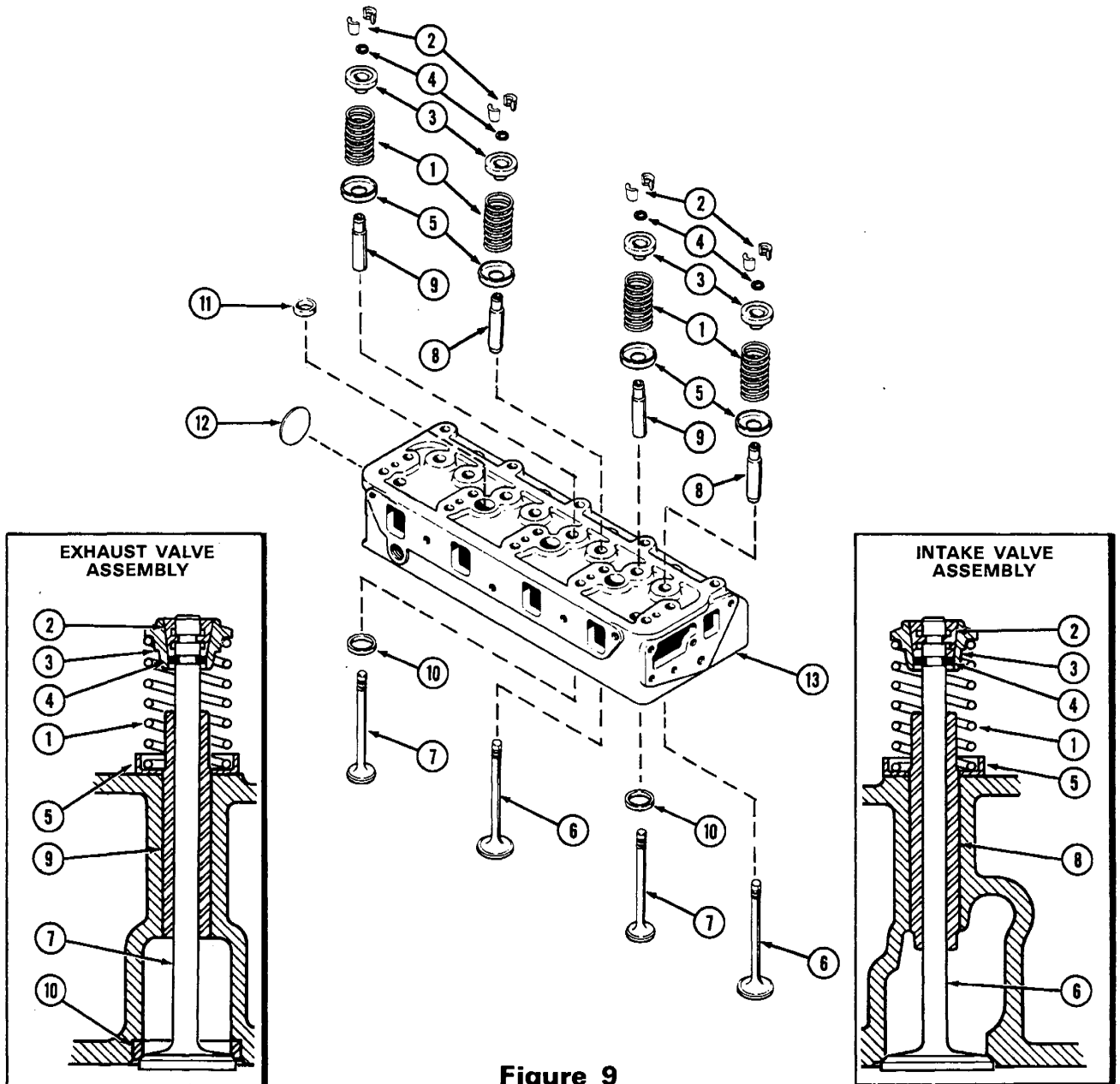
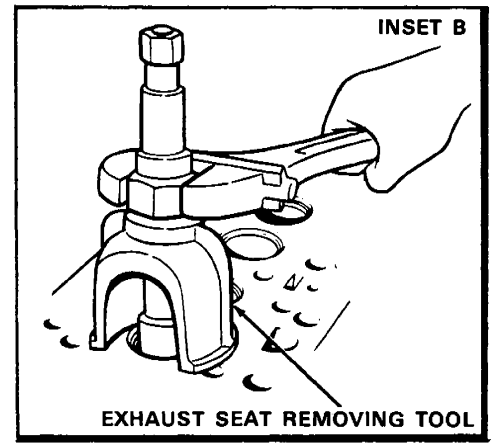
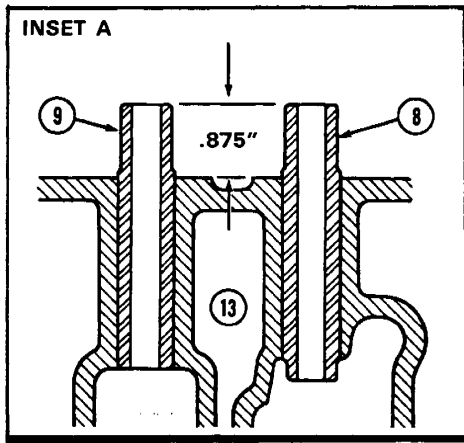
### Disassembly

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.



**Figure 9**