SERVICE MANUAL

Loader

500
W5
W5A

9-76231

1. Trim along dashed line.
2. Slide into pocket on Binder Spine.

TYPE 1-4

SERVICE MANUAL
Loader
500
W5
W5A
9-76231
1. Trim along dashed line.
2. Slide into pocket on Binder Spine.
TYPE 1-4

SERVICE MANUAL
Loader
500
W5
W5A
9-76231
1. Trim along dashed line.
2. Slide into pocket on Binder Spine.
TYPE 1-4

SERVICE MANUAL
Loader
500
W5
W5A
9-76231
1. Trim along dashed line.
2. Slide into pocket on Binder Spine.
TYPE 1-4

500/W5/W5A
Service Manual 9-76231
Table of Contents

SECTION

C

SPECIFICATIONS FOR 188 DYNACLONIC DIESEL AND 188 SUPR-TORQ GASOLINE ENGINES

Rac. 9-76053

PRINTED IN U.S.A.

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
188 ---------- 3-13/16 Inches

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

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

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

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

Method of Starting Diesel Engine ---------- Engine Starts on Diesel Fuel (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 Pressure	400 PSI	389 PSI	373 PSI	359 PSI	346 PSI	332 PSI

Allowable Variance Between Cylinders
20 Pounds Pressure at 200 RPM Cranking Speed

CYLINDER SLEEVES

Type ---------- Replaceable Wet Type; Two Rubber "O"Ring seals carried on each sleeve.

Inside Diameter of Sleeve Bore
188 ---------- 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)
188 ---------- .002 to .005 Inch

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

PISTON AND PISTON PINS

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

Piston Weight(Less Pin)
188 ---------- 2.224 to 2.233 Pounds

Diameter of Piston at Top of Skirt (Below Oil Ring)
188 ---------- 3.804 to 3.807 Pounds

Diameter of Piston at Bottom of Skirt
188 ---------- 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
188 ---------- 3.147 to 3.167 Inches

Piston Pin Diameter
188 ---------- 1.2497 to 1.2498 Inches

Piston Pin Fit in Piston
188 ---------- .0001 to .0004 Inch

Piston Pin Fit in Connecting Rod Bushing
188 ---------- .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 188 ---------- .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.
188 ---------- Use 1.2500 to 1.2502 Reamer

Piston Pin Hole Diameter in Rod (Without Bushing)
188 ---------- 1.312 to 1.313 Inches

Inside Diameter of Piston Pin Bushing in Rod
188 ---------- 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 ---------- 1.00 to 1.980 Inches

Width Between Crankshaft Main Bearing Cheeks

A.5th ---------- 1.745 to 1.755 Inches

B. 2nd, 4th ---------- 1.185 to 1.189 Inches

C. 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 Inches

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

Bushing Lubrication(Front Bushing)
Pressure Lubricated from Oil Pump

Bushing Lubrication (2nd,3rd and 4th)
Lubricated by Gravity Flow

Bushing Lubrication (5th)
Pressure Lubricated with Rear Oil Metering

Diameter of Camshaft at Each Bearing Surface
188 ---------- 1.749 to 1.750 Inches

Inside Diameter of Each Bushing
(Measured When in Place in Block)
188---------- 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 Inches

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

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

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

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

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

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
188---------- .561 to .562 Inch

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

VALVES

Valve Tappet Clearance

*188(Intake and Exhaust) ---------- .014 Inch, Engine Hot

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

*Hot Settings Are Made At Low Idle After The Engine Has Operated At Thermostat Control Temperature For At Least Fifteen Minutes.

Exhaust Valve Seat Insert

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

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

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

Outside Diameter of Insert
188---------- 1.445 to 1.4505 Inches

Inside Diameter of Insert
188---------- 1.245 to 1.255 Inches

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

Intake Valves

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

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

Minimum 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

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 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 Inches, 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

Spring Pressure at Compressed Height of
1.500 Inches ---------- 105 Pounds or Less, Replace Spring

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
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

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 Injectors ---------- C.A.V. Long Stem Multi-Hole Type Opening Pressure 2225 PSI to 2275 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

188 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 ---------- 3-13/16 Inches

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

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

Compression Ratio ---------- 7.34 to 1

Maximum Compression at Cranking Speed (200 RPM)
Engine Warmed Up to Operating Temperature ------ 125 PSI at Sea Level

Allowable Variance Between Cylinders ---------- 10 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 to Sleeve Bore ------- 3.8130 to 3.8145 Inches. Replace Sleeve When Inside Diameter Below Top Ring Ridge Exceeds 3.822 Inches.

Piston Clearance in Sleeve (At Skirt) ---------- .0025 to .0055 Inch

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

PISTON AND PISTON PINS

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

Diameter of Piston at Top of Skirt ---------- 3.809 to 3.8105 Inches

Diameter of Piston at Bottom of Skirt ---------- 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 ---------- 2.995 to 3.005 Inches

Piston Pin Diameter ---------- .9991 to .9992 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 3.8125 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 ---- .0020 to .0035 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 3.8125 Inch Cylinder ---------- .010 to .018 Inch

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

CONNECTING RODS

Piston Pin Bushing ---------- Replaceable Bronze Bushing
Ream in Place Use .9995 to .9997 Reamer

Piston Pin Hole Diameter
Rod (Without Bushing) ---------- 1.062 to 1.063 Inches

Inside Diameter of Piston
Pin Bushing in Rod ---------- .9995 to .9997 Inches: Install New Bushing if Inside Diameter Exceeds 1.0027 Inches

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

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

Allowable Connecting
Rod Bearing End Play ---------- .006 Inch

CRANKSHAFT AND MAIN BEARINGS

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

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 Center Main If End Play Exceeds .012 Inch

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

Main Bearing Journal Diameter ---------- 2.8730 to 2.8740 Inches

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

Inside Diameter of Main Bearing Liners
(In Place and Capscrews Tight) ---------- 2.8748 to 2.8768 Inches

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

Width of 1st Main Bearing Liner ---------- 1.286 Inches

Width of 2nd Main Bearing Liner ---------- 1.371 to 1.373 Inches

Width of 3rd Main Bearing Liner ---------- 1.567 Inches

Width Between Crankshaft Center
Main Bearing Cheeks ---------- 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 -- 2.8530 to 2.8540 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 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 ---------- 4

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

Front Bushing Lubrication ------ Pressure Lubricated from Oil Pump

2nd, 3rd and 4th Bushings are Drip Lubricated from the Top

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 & 3 Bushing Length ---------- .490 to .500 Inch

No.4 (Rear) Bushing Length ---------- 1.213 to 1.223 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 Hot
*Exhaust ---------- .014 Inch, Engine Hot

Exhaust Valves

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

Valve Length ---------- 5.714 to 5.704 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 ---------- 1.408 to 1.398 Inches

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

Exhaust Valve Seat

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

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

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

Intake Valves

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

Valve Length ---------- 5.714 to 5.704 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 ---------- 1.524 to 1.514 Inches

*Hot Settings Are Made At Low Idle After The Engine Has Operated At Thermostat Control Temperatures For At Least Fifteen Minutes.

Intake Valve Seat

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

Seat Width ---------- .055 to .070 Inch

Exhaust Valve Guides

Length ---------- 2.843 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 --------- .937 Inch Press Fit

Intake Valve Guides

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

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

Inside Diameter---------- .3429 to .3439 Inch
Replace Guide When Inside Diameter Exceeds ---------- .3459 Inch

Valve Stem Clearance in Guide----------.0032 to .0050 Inch

Distance Above Head Guide Must Protrude ------ 1.937 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
Spring Pressure at Compressed Height of 1.750 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 24 to 32 Pounds Oil Pressure (Oil Warm, Engine Operating at Full Governed Speed.

Relief Valve Spring
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 ---------- Zenith Model No.267

Float Level 1.156 Inch from Machined Surface of Cover to Top of Float

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

Venturi Size ---------- .866 Inch Dia. Throat

Flange ---------- SAE 1-1/4 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) ---------- 95-100 Ft. Lbs.

Cylinder Head Capscrews (Diesel) ---------- 110-115 Ft. Lbs.

Cylinder Head Studs w/Flange Nuts (Diesel) ---------- 95-100 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 Nut ---------- 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 ---------- 5-8 Ft. Lbs.

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

Section

2013

CYLINDER HEAD AND VALVES

148, 159, 188 AND 201 SPARK IGNITION ENGINES

TABLE OF CONTENTS

CASE CORPORATION Rac. 9-80512 PRINTED IN U.S.A.

SPECIFICATIONS

		Maximum Limit Including Wear
CYLINDER HEAD		
Warpage		.006″
SPARK PLUG		
Gap Setting (18mm)	.025″	
EXHAUST VALVE		
Tappet Clearance (COLD)	.020″	
(HOT)	.014″	
Face Angle	44°	
Face Run-out		.002″
Length (188 and 201)	5.824″ to 5.844″	
Length (148 and 159)	5.309″ to 5.334″	
O.D. of Head (188 and 201)	1.398″ to 1.408″	
O.D. of Head (148 and 159)	1.265″ to 1.275″	
O.D. of Stem	.3382″ to .3390″	.002″
Insert Seat Angle	45°	
Seat Contact Width (188 and 201)	.072″ to .085″	
Seat Contact Width (148 and 159)	.090″ to .100″	
Seat Run-Out		.002″
Insert Height (188 and 201)	.2475″ to .2525″	
Insert Height (148 and 159)	.198″ to .203″	
O.D. of Insert (188 and 201)	1.4495″ to 1.4505″	
O.D. of Insert (148 and 159)	1.3765″ to 1.3775″	
I.D. of Insert (188 and 201)	1.245″ to 1.255″	
I.D. of Insert (148 and 159)	1.074″ to 1.084″	
INTAKE VALVE		
Tappet Clearance (HOT AND COLD)	.014″	
Face Angle	29°	
Face Run-Out		.002″
Length (188 and 201)	5.796″ to 5.816″	
Length (148 and 159)	5.275″ to 5.300″	
O.D. of Stem	.3406″ to .3414″	
O.D. of Head (188 and 201)	1.514″ to 1.524″	
O.D. of Head (148 and 159)	1.410″ to 1.420″	
Seat Angle	30°	
Seat Run-out		.002″
Seat Contact Width (188 and 201)	.055″ to .070″	
Seat Contact Width (148 and 159)	.045″ to .060″	
EXHAUST VALVE GUIDE		
Length (188 and 201)	2.843″	
Length (148 and 159)	2.438″	
O.D.	.6565″ to .6575″	
I.D. (Installed and Reamed)	.3422″ to .3432″	.002″
Protrusion Above Cylinder Head (188 & 201)	1.000″	
Protrusion Above Cylinder Head (148 & 159)	.844″	

SPECIFICATIONS (Continued)

		Maximum Limit Including Wear
INTAKE VALVE GUIDE		
Length (188 and 201)	3.125″	
Length (148 and 159)	2.688″	
O.D.	.6565″ to .6575″	
I.D. (Installed and Reamed)	.3422″ to .3432″	.002″
Protrusion Above Cylinder Head	1.000″	
VALVE SPRING (Exhaust Valve)		
Color Code	Silver Stripe Full Length	
Free Length	2-3/16″	
Total Coils	7-3/4	
Wire Diameter	.162″	
I.D.	.970″ to .990″	
Compressed to 1.332″ (Valve Open)	110 to 118 lbs.	
Compressed to 1.686″ (Valve Closed)	53 to 59 lbs.	
VALVE SPRING (Intake Valve)		
Free Length	2-3/8″	
Total Coils	8-1/4	
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 Rocker Arm (Installed and Reamed on 148 and 159)	.624″ to .625″	
Shaft Spring (188 and 201):		
Free Length	2-1/2″	
I.D.	11/16″	
Wire Diameter	.072″	
Compressed to 1-3/4″	7.5 to 8.5 lbs.	
Shaft Spring (148 and 159):		
Free Length	1-3/16″	
Total Coils	7	
I.D.	11/16″	
Wire Diameter	.072″	
Compressed to 11/16″	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 Flanged Nuts (188 and 201)	90 to 100 ft. lbs.
Cylinder Head Stud Nuts (148 and 159)	95 to 105 ft. lbs.
Intake and Exhaust Manifold Stud Nuts	25 to 30 ft. lbs.
Rocker Arm Bracket Stud Nuts and Bolts	25 to 30 ft. lbs.
Valve Cover Stud Nuts	5 to 8 ft.lbs.
Water Pump Stud Nuts	20 to 25 ft. lbs.
Spark Plugs	32 to 35 ft. lbs.

CHECKING COMPRESSION PRESSURE

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

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

3. Only the cranking method is advised to be used when checking compression pressure. **NOTE:** The engine must be at operating temperature at the time of compression checking.

4. With the engine at operating temperature, shut the engine off. Close the fuel needle valve at the fuel tank. This will prevent excessive fuel from entering the cylinder and washing of the cylinder walls. Disconnect all high tension spark plug wires. Remove all spark plugs to provide minimum load on the starting motor and battery.

5. Check the compression pressure, using a reliable gauge and suitable adapter to fit in a 18 mm thread plug hole. Refer to chart on Page 5.

6. Two common types of compression gauge equipment used are the remote control and the ignition switch operation type.

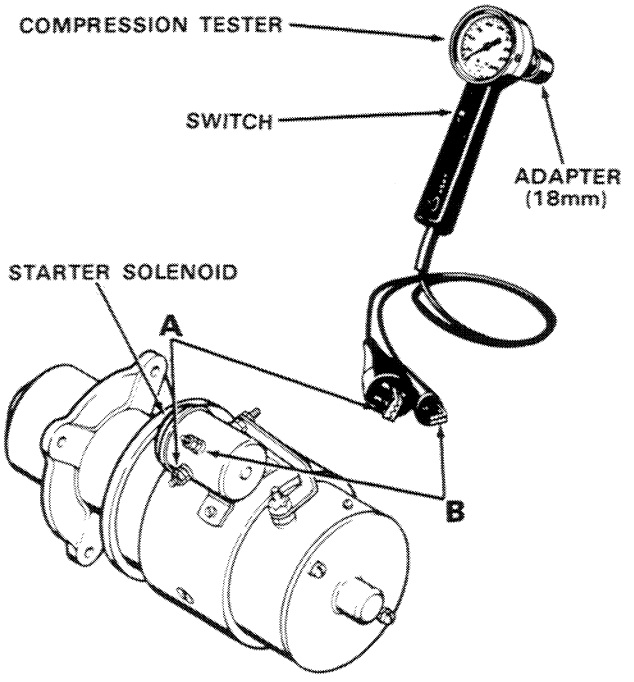

Figure 1

A. When using the remote control type of compression tester, Figure 1, make sure the wires are correctly attached to the starter terminals. Incorrect attaching of wires will cause damage to the testing equipment, Figure 1.

B. When using the ignition switch operation type of compression tester, Figure 2, be sure the carburetor throttle plate (butterfly) valve is held in the wide open position. Drain the carburetor to prevent fuel from entering the cylinders.

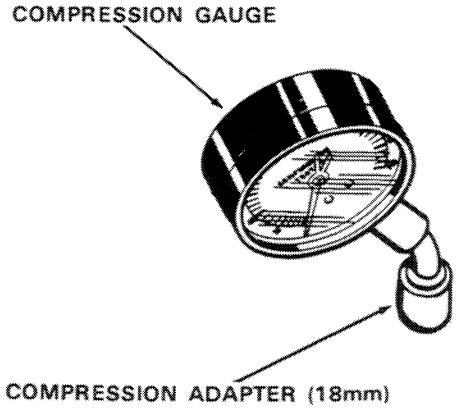

Figure 2

7. It is very important that all cylinder pressures be approximately alike. For the allowable compression pressure variation, refer to the chart on Page 5.

8. If the compression 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: Always take a second set of readings for an accurate check. This will also indicate how much the loss of cranking speed, due to battery discharge, is affecting the compression pressure reading.

CHECKING COMPRESSION PRESSURE (Continued)

9. Before installing the spark plugs, clean them thoroughly and check them for burned electrodes or cracked insulation. Replace them if necessary. Regap all plugs to .025″ setting, Figure 3.

10. Replace all spark plug gaskets, Figure 3, before installing for proper seating and sealing. Install the spark plugs finger tight. Using the exact size spark plug wrench or a thin wall deep socket, torque the spark plugs 32 to 35 ft. lbs.

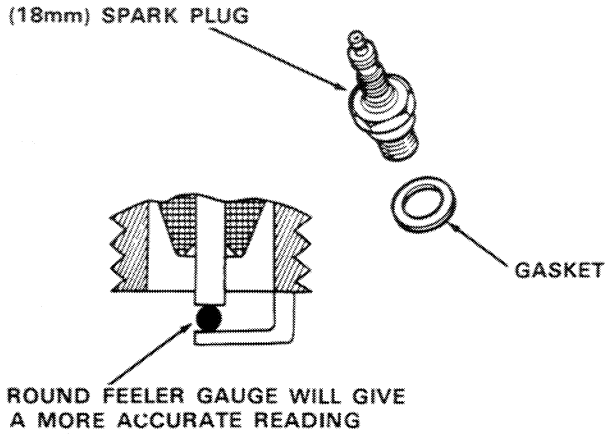

Figure 3

	ENGINE SPEED APPROXIMATELY	NORMAL COMPRESSION PRESSURE	ALLOWABLE VARIATION BETWEEN CYLINDERS
CRANKING	(148) 150 RPM	140 PSI*	20 PSI
	(159) 150 RPM	125 PSI*	20 PSI
	(188) 150 RPM	125 PSI*	20 PSI
	(201) 150 RPM	150 PSI*	20 PSI

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

CYLINDER HEAD AND COMPONENTS

148 AND 159

(Refer to Figure 4)

Disassembly

Remove the muffler and hood from the vehicle. Steam clean the entire engine area where service works is to be performed. Disconnect and remove the air cleaner system.

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.

2. Remove the hose from the the thermostat housing (1). Remove the thermostat housing (1) and gasket (2). Discard the gasket. **NOTE;** If the thermostat is to be serviced, refer to Section 23.

3. Disconnect the linkage and fuel lines from the carburetor (3). Remove the carburetor assembly (3) and gasket (4). Discard the gasket. Disconnect the high tension wires from the spark plugs and remove the spark plugs (5) and gaskets (6).

4. Remove the bolts that connect the intake manifold (7) to the exhaust manifold (8). Remove the intake manifold (7) and exhaust manifold (8). Remove manifold gasket (9) and discard.

5. Remove the valve cover (10), gasket (11) and breather tube (12). Discard the gasket.

6. Remove the rocker arm bracket bolts (13) and the stud nuts (14). Remove the rocker arm assembly (19). See Page 14 and 15 for servicing of the rocker arm assembly.

7. Remove the push rods (15) and tag them so they can be installed in their proper location when reassembling.

8. Remove the cylinder head stud nuts (16) and the cylinder head (17). Remove the cylinder head gasket (18) and discard the gasket.

Inspection

1. Replace all gaskets and worn or defective parts.

2. Clean the top surface of the cylinder block and sleeve flange carefully. The top of the pistons may be cleaned with a power driven wire brush. **NOTE:** The pistons must be at top dead center when being cleaned. All traces of carbon and other deposits must be removed. During cleaning, the use of a clean lint free cloth dampened in solvent is recommended.

3. Clean all bolt and stud threads.

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

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

6. Clean the valve cover and flush out the breather tube.

7. Clean and check the spark plugs. If replacement is required, regap the spark plugs to .025 setting.

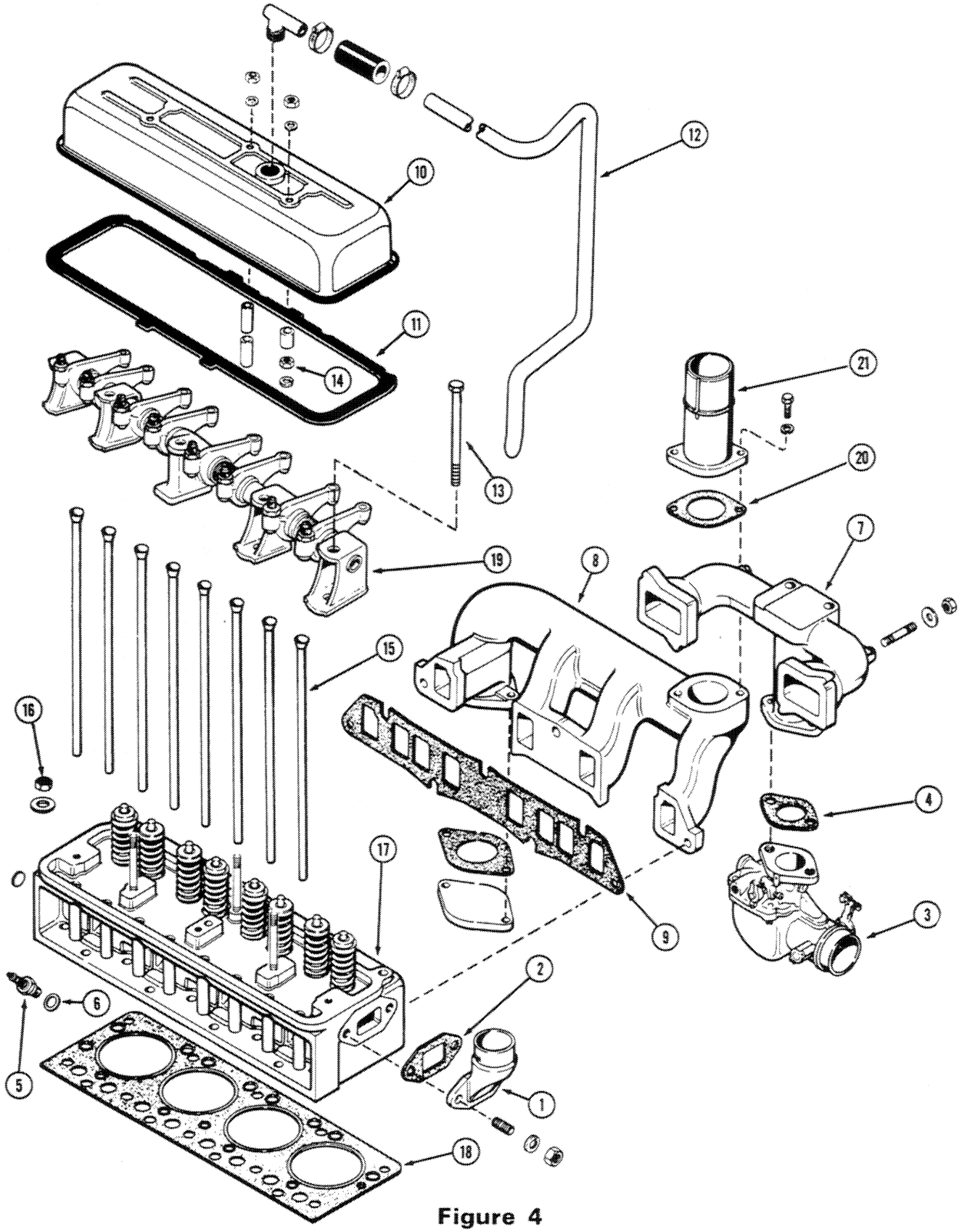

Figure 4

CYLINDER HEAD AND COMPONENTS (Continued)

148 AND 159

(Refer to Figure 5)

Assembly

1. Install new cylinder head gasket (18) with the TOP mark up.

2. Install the cylinder head (17) and stud nuts (16), tighten the stud nuts (16) finger tight.

3. Install new intake and exhaust manifold gasket (9). Install the exhaust manifold (8) and intake manifold (7), leaving the stud nuts finger tight.

4. Install the thermostat housing (1) and new gasket (2), leaving stud nuts finger tight.

5. Torque the cylinder head stud nuts to 60 ft. lbs. and then to 95 - 105 ft. lbs. **NOTE:** Lubricate threads with clean engine oil prior to torquing and use the tightening sequence shown in Inset A.

6. Torque the exhaust manifold and intake manifold stud nuts 25 - 30 ft. lbs. Torque the thermostat housing stud nuts 20 - 25 ft. lbs.

7. Coat the push rods (15) with clean engine oil and install them in their original location.

8. Install the rocker arm assembly (19). Make sure all of the push rods (15) are engaged with the adjusting screws on the rocker arms. Torque the mounting bolts (13) and stud nuts (14) 25 - 30 ft. lbs.

9. Adjust the valve tappet clearance, refer to Page 26.

10. Install the exhaust stack (21) and new gasket (20), if it was removed. Torque the mounting bolts 35 to 42 ft. lbs.

11. Install the carburetor (3) with a new gasket (4) to the intake manifold (7). Torque the mounting bolts 35 - 42 ft. lbs. Reconnect the linkage and fuel line to the carburetor.

12. Reconnect the hose to the thermostat housing (1) and clamp securely. Make sure the drain valves are closed and refill the cooling system. Reinstall the air cleaner system making sure all connections are tight. Install the spark plugs (5) with new gaskets (6) and torque 32 - 35 ft. lbs. Reconnect all of the high tension wires to the spark plugs.

13. 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 and seat the head gaskets.

14. Shut the engine off. Back off each stud nut individually 1/4 turn and retorque to 95 - 105 ft. lbs. in the proper sequence, Inset A. **NOTE:** DO NOT BACK OFF ALL THE STUD NUTS AT THE SAME TIME. Recheck the torque to make sure all stud nuts have retained their proper torque. Recheck the rocker arm stud nuts and mounting bolts to make sure they have retained the 25-30 ft. lbs. torque.

15. Install a new valve cover gasket (11) and valve cover (10). Torque the cover nuts 5 to 8 ft. lbs. Do not over torque the cover nuts. Install the breather tube (12).

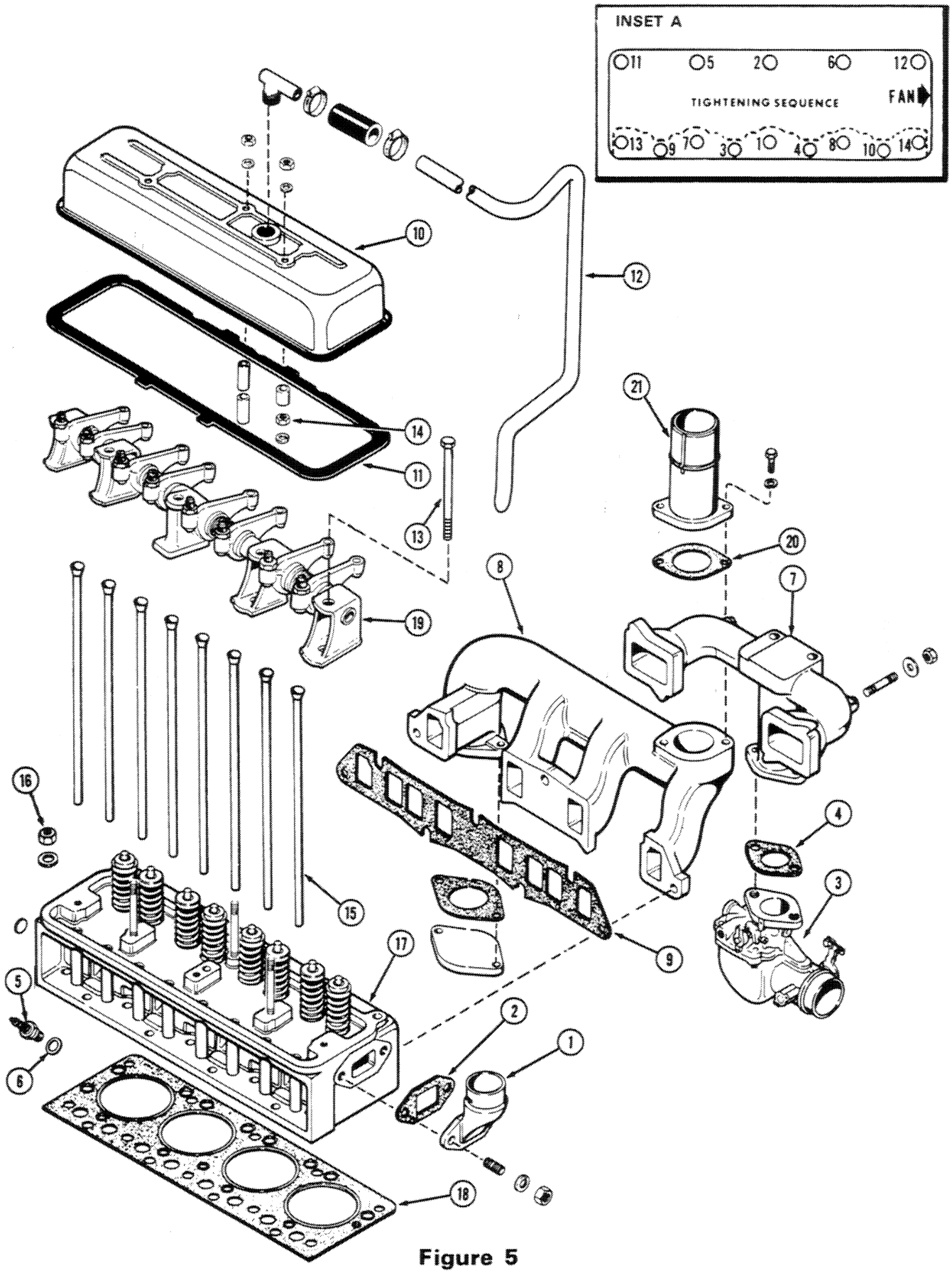
INSET A
11
5
2
6
12
TIGHTENING SEQUENCE
FAN
13
9
7
3
1
4
8
10
14
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

Figure 5

CYLINDER HEAD AND COMPONENTS (Continued)

188 AND 201

(Refer to Figure 6)

Disassembly

Remove the muffler and hood from the vehicle. Steam clean the entire engine area where service work is to be performed. Disconnect and remove the air cleaner system.

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.

2. Remove the hose from the the thermostat housing (1). Remove the thermostat housing (1) and gasket (2). Discard the gasket. **NOTE;** If the thermostat is to be serviced, refer to Section 25.

3. Disconnect the linkage and fuel lines from the carburetor (3). Remove the carburetor assembly (3) and gasket (4). Discard the gasket. Disconnect the high tension wires from the spark plugs and remove the spark plugs (5) and gaskets (6).

4. Remove the bolts that connect the intake manifold (7) to the exhaust manifold (8). Remove the intake manifold (7) and exhaust manifold (8). Remove manifold gasket (9) and discard.

5. Remove the valve cover (10), gasket (11) and breather tube (12). Discard the gasket.

6. Remove the rocker arm bracket bolts (13). Remove the rocker arm assembly (19). See Page 16 and 17 for servicing of the rocker arm assembly.

7. Remove the push rods (15) and tag them so they can be installed in their proper location when reassembling.

8. Remove the cylinder head stud nuts (16) and the cylinder head (17). Remove the cylinder head gasket (18) and discard the gasket.

Inspection

1. Replace all gaskets and worn or defective parts.

2. Clean the top surface of the cylinder block and sleeve flange carefully. The top of the pistons may be cleaned with a power driven wire brush. **NOTE:** The pistons must be at top dead center when being cleaned. All traces of carbon and other deposits must be removed. During cleaning, the use of a clean lint free cloth dampened in solvent is recommended.

3. Clean all bolt and stud threads.

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

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

6. Clean the valve cover and flush out the breather tube.

7. Clean and check the spark plugs. If replacement is required, regap the spark plugs to .025 setting.

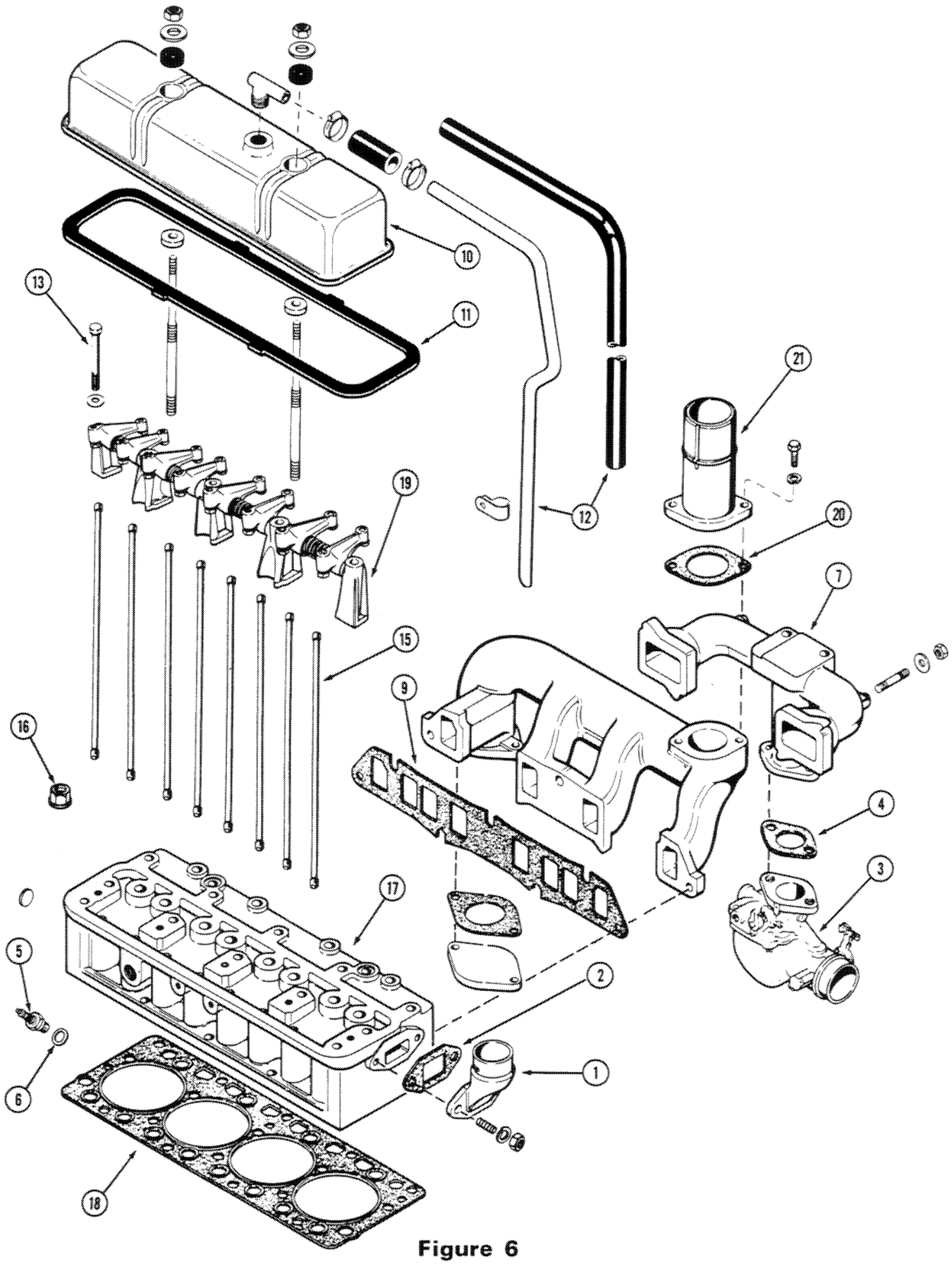

Figure 6

CYLINDER HEAD AND COMPONENTS (Continued)

188 AND 201

(Refer to Figure 7)

Assembly

1. Install new cylinder head gasket (18) with the TOP mark up.

2. Install the cylinder head (17) and stud nuts (16), tighten the stud nuts (16) finger tight.

3. Install new intake and exhaust manifold gasket (9). Install the exhaust manifold (8) and intake manifold (7), leaving the stud nuts finger tight.

4. Install the thermostat housing (1) and new gasket (2), leaving stud nuts finger tight.

5. Torque the cylinder head flanged nuts to 60 ft. lbs. and then to 90-100 ft. lbs. **NOTE:** Lubricate threads with clean engine oil prior to torquing and use the tightening sequence shown in Inset A.

6. Torque the exhaust manifold and intake manifold stud nuts 25 - 30 ft. lbs. Torque the thermostat housing stud nuts 20 - 25 ft. lbs.

7. Coat the push rods (15) with clean engine oil and install them in their original location.

8. Install the rocker arm assembly (19). Make sure all of the push rods (15) are engaged with the adjusting screws on the rocker arms. Torque the mounting bolts (13) 25-30 ft. lbs.

9. Adjust the valve tappet clearance, refer to Page 26.

10. Install the exhaust stack (21) and new gasket (20), if it was removed. Torque the mounting bolts 35 to 42 ft. lbs.

11. Install the carburetor (3) with a new gasket (4) to the intake manifold (7). Torque the mounting bolts 35 - 42 ft. lbs. Reconnect the linkage and fuel line to the carburetor.

12. Reconnect the hose to the thermostat housing (1) and clamp securely. Make sure the drain valves are closed and refill the cooling system. Reinstall the air cleaner system making sure all connections are tight. Install the spark plugs (5) with new gaskets (6) and torque 32 - 35 ft. lbs. Reconnect all of the high tension wires to the spark plugs.

13. 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 and seat the head gaskets.

14. Shut the engine off. Back off each cylinder head flanged nut individually 1/4 turn and retorque to 90-100 ft. lbs. in the proper sequence, Inset A. **NOTE:** DO NOT BACK OFF ALL THE FLANGED NUTS AT THE SAME TIME. Recheck the torque to make sure all flanged nuts have retained their proper torque. Recheck the rocker arm bolts to make sure they have retained the 25-30 ft. lbs. torque.

15. Install a new valve cover gasket (11) and valve cover (10). Torque the cover nuts 5 to 8 ft. lbs. Do not over torque the cover nuts. Install the breather tube (12).

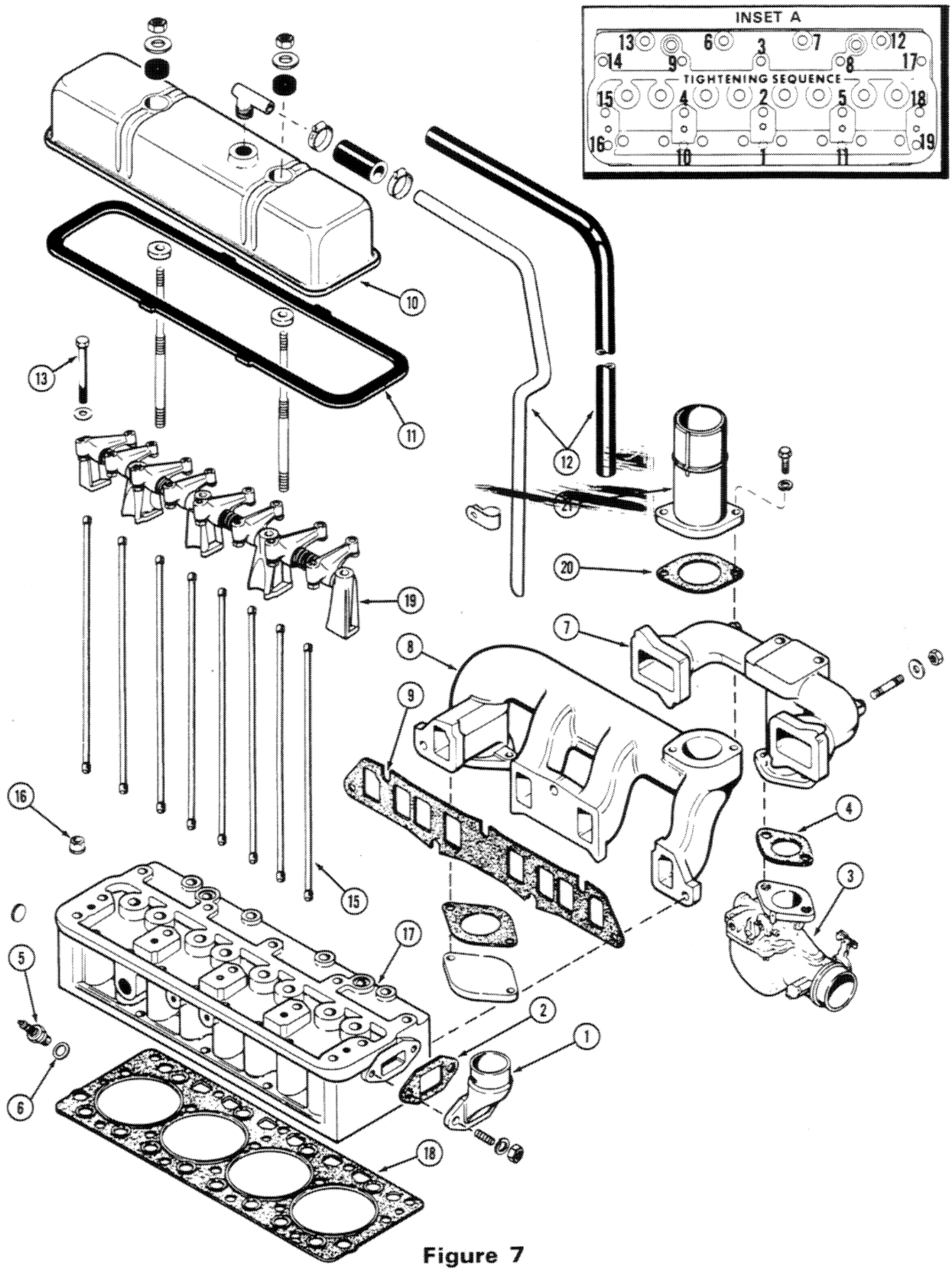
INSET A
13
6
3
7
12
14
9
8
17
TIGHTENING SEQUENCE
15
4
2
5
18
16
19
10
1
11
10
13
11
12
21
20
19
7
8
9
16
4
3
15
17
5
2
1
6
18

Figure 7

ROCKER ARM ASSEMBLY

148 AND 159

(Refer to Figure 8)

Disassembly

1. Remove the rocker arm shaft bracket bolts (1) and studs (9). **NOTE:** The center bracket is drilled for oil passge to the rocker arm shafts.
2. Remove and tag each rocker arm bracket (2 & 10) for proper location when assembling. **NOTE:** The end brackets will have to be moved outward slightly in order to remove the retainer pins (4) from the shafts (5) before the end brackets can be removed.
3. Remove the shaft springs (8) and spacers (11) from the shafts (5). Tag the front and rear shafts (5) for proper location when assembling.
4. Remove the tappet adjusting screws (12) from the rocker arms. Remove the push rods and tag them for proper location.

Inspection

Check the shaft springs for damage and proper tension.

SPRING SPECIFICATIONS

Free Length	1-3/16
Wire Diameter	.072"
I.D.	11/16"
Compressed to 11/16"	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 shaft. Replace the shaft if any of these conditions exists.

Inspect the rocker arms by installing each rocker arm on the shafts in its proper location. The rocker arm must be free on the shaft without any side wobble. If any is noted, replace the rocker arm bushing. Clean the oil passage in the rocker arms, Inset A, 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 passage in the tappet adjusting screws.

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

Clean and check the oil passage in the center rocker arm bracket, Inset B.

Assembly

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

1. Install the plugs (3) in to the outer ends of the shafts (5), if they were removed, to a point which will allow the retainer pins (4) to be installed and not block any oil holes. **NOTE:** If the plugs (3) are installed too far they will block the flow of oil to one or more rocker arms.
2. Install the end brackets (2) part way on the shafts (5) so the retaining pins (4) can be installed in shaft. Tap the end brackets further on the shafts so the pin engages the slot in the bracket and the oil holes in the shaft are toward the valve side of the bracket.
3. Install new rocker arm bushing (13) in to the rocker arms (6 & 7) if they are being replaced. **NOTE:** The bushing (13) must be pressed into the rocker arm and reamed to .624"-.625", Inset A.
4. Starting with the front shaft install a rear rocker arm (7), spring (8), front rocker arm (6), intermediate bracket (2), spacer (11), rear rocker arm (7), spring (8) and front rocker arm (6).
5. Starting with the rear shaft install a front rocker arm (6), spring (8), rear rocker arm (7), intermediate bracket (2), spacer (11), front rocker arm (6), spring (8) and rear rocker arm (7).
6. Install these two rocker arm shaft assemblies into the center bracket (10) and wire the complete assembly together.
7. Install the tappet adjusting screws (12) into the rocker arms (6 & 7) as far as possible.
8. Install the push rods in their proper location. Install the rocker arm assembly to the cylinder head with the bracket bolts (1) and studs (9). Torque the bracket bolts and stud nuts 25-30 ft. lbs.
9. Adjust the tappets, refer to Page 26.

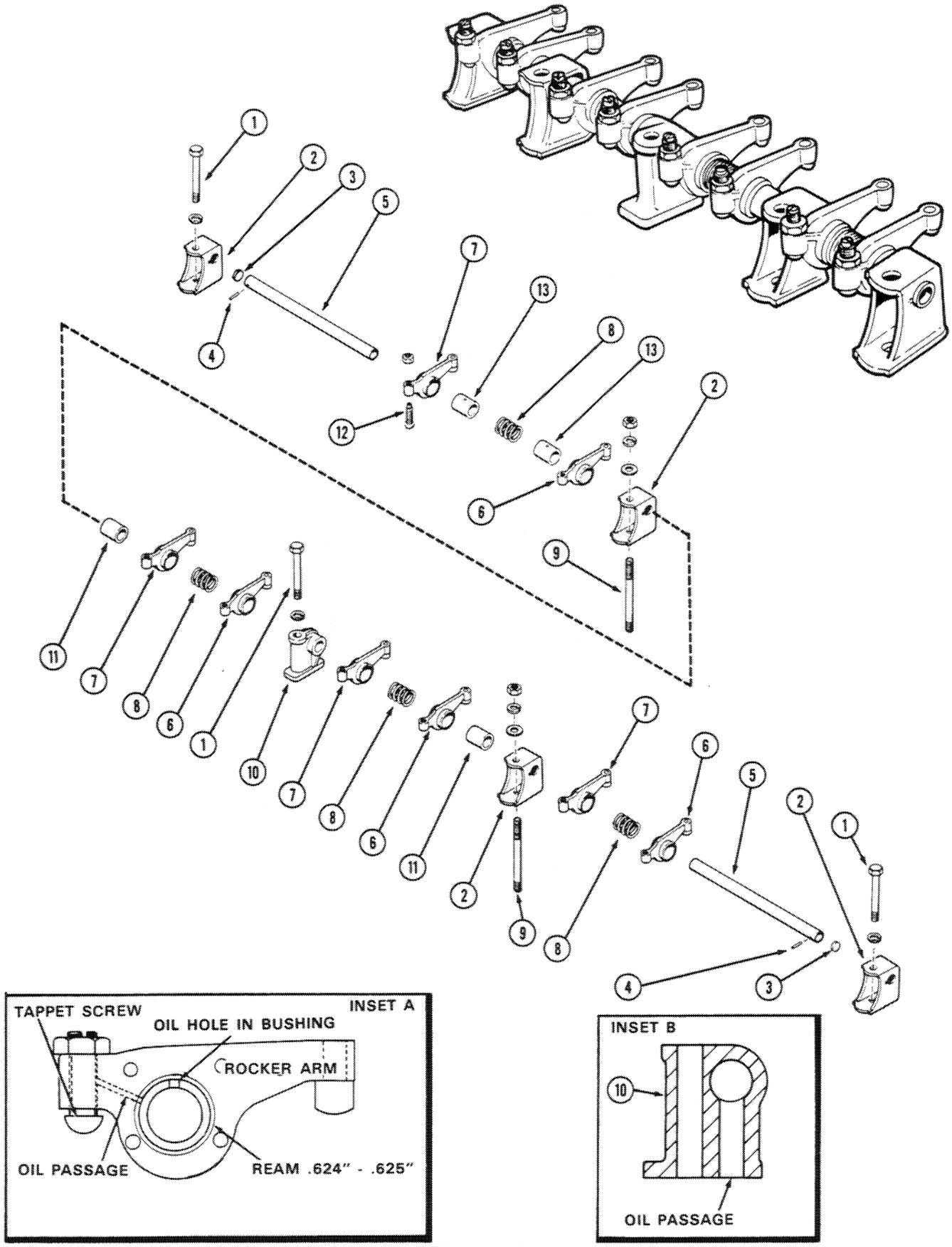
INSET A
TAPPET SCREW
OIL HOLE IN BUSHING
ROCKER ARM
OIL PASSAGE
REAM .624" - .625"
INSET B
OIL PASSAGE

Figure 8

ROCKER ARM ASSEMBLY (Continued)

188 AND 201

(Refer to Figure 9)

Disassembly

1. Remove the rocker arm shaft bracket bolts (1 & 9). **NOTE:** The center 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 shaft. Replace the shaft if any of these conditions exists.

Inspect the rocker arms by installing each rocker arm on the shafts in its proper location. The rocker arm must be free on the shaft without any side wobble. If any is noted, replace the rocker arm. 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 passage in the tappet adjusting screws, Inset A, and the center bracket retaining bolt (1).

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 center oil passage in the head, see Inset C. Install the rocker arm assembly to the cylinder head with bracket bolts (1 & 9), making sure the center bracket drilled bolt (1) is installed in the cylinder head oil passage hole. Torque the bracket bolts 25-30 ft. lbs.

7. Adjust the tappets, refer to Page 26.

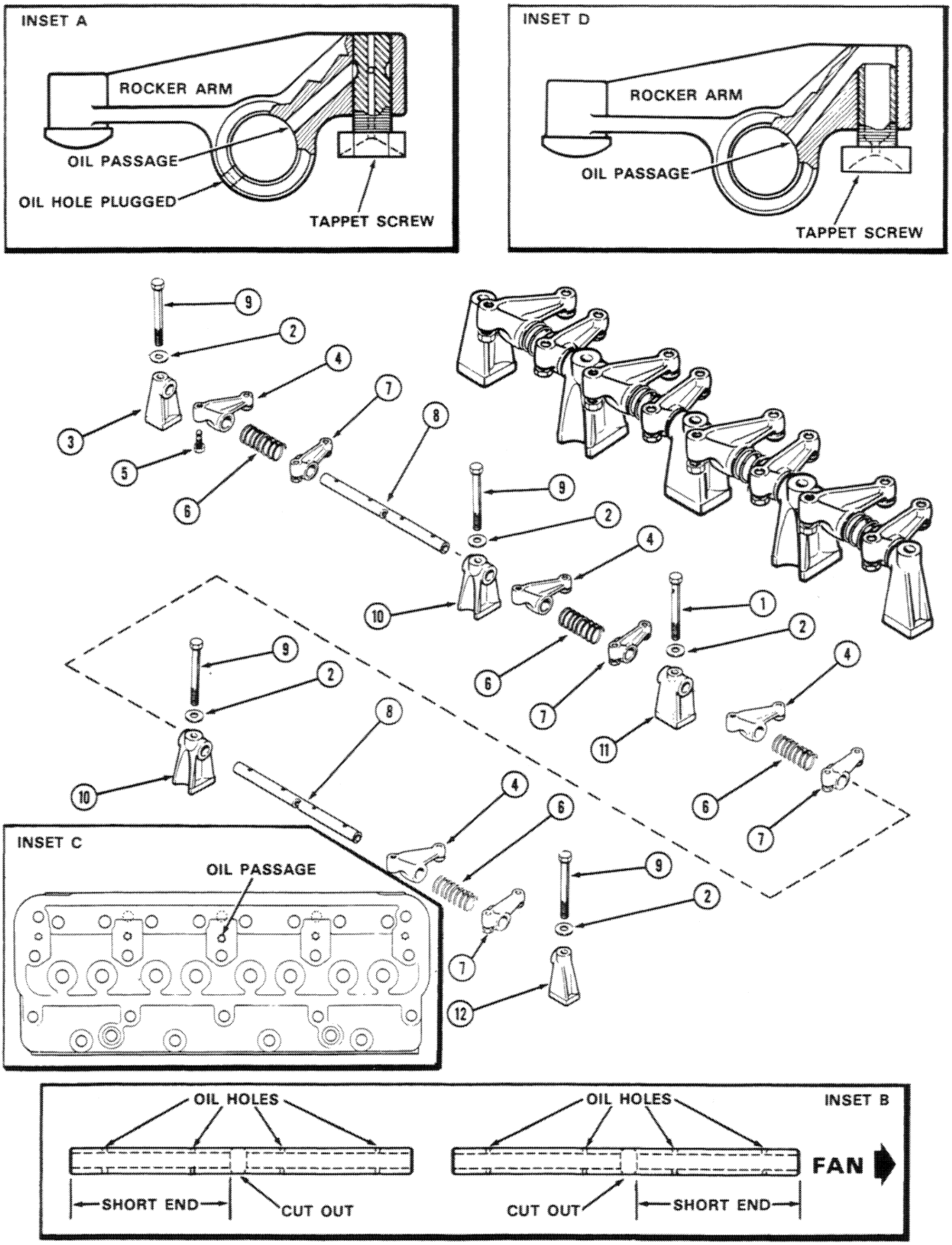
INSET A
ROCKER ARM
OIL PASSAGE
OIL HOLE PLUGGED
TAPPET SCREW
INSET D
ROCKER ARM
OIL PASSAGE
TAPPET SCREW
INSET C
OIL PASSAGE
INSET B
OIL HOLES
SHORT END
CUT OUT
OIL HOLES
CUT OUT
SHORT END
FAN

Figure 9

CYLINDER HEAD ASSEMBLY

148 AND 159

(Refer to Figure 10)

Disassembly

1. Using a valve spring compressor, compress the valve spring (1) enough to remove the valve retainer locks (2). Release the spring compressor and remove the intake valve seals (3), intake valve retainers (4) and the exhaust valve rotators (5). Remove the springs (1).
2. Remove any carbon from the valve stems before they are removed from the cylinder head. Remove the intake valves (6) and exhaust valves (7) from the cylinder head (9) and set them in a rack or holder. **NOTE:** Mark the valves on removal so they can be installed in their original location.
3. Remove the intake valve guides (10) and the exhaust valve guides (11) by driving them down through the cylinder head (9) using an arbor.
4. Remove the exhaust valve seats (8) from the cylinder head (9) using 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. Remove the push rod tubes (12) from the cylinder head (9) by driving them down through the head. Remove the push rod tube "O" rings (13) and discard them.
6. To remove the expansion plug (14) from the cylinder head (9) it must be drilled and pryed out.

   NOTE: Refer to Inspection and Servicing on Pages 22,23, 24 and 25 prior to Assembly.

Assembly

1. If the valve guides are being replaced, install new guides (10 & 11) in the cylinder head 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 - 1.000" and exhaust - .844"), Inset A. After the guides have been pressed into place, they must be reamed to .3422" - .3432", Inset A.
2. To install new exhaust valve seats (8), clean the recess in the cylinder head (9). 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. Install new push rod tube "O" rings (13) in the cylinder head recesses. Lubricate the push rod tubes (12) with clean engine oil and install them into the cylinder head. **NOTE:** The tubes must be installed from the top with the tapered end down. Be sure they DO NOT protrude below the cylinder head, See Inset C.
4. Lubricate the intake valves (6) and exhaust valves (7) with clean engine oil and install them in their original location.
5. Install valve springs (1) with closed coil end toward head, and valve retainers (4) on the intake valves (6). Compress the valve springs so that the intake valve seals (3) can be installed in the lower groove on the valve stems. Install the valve retainer locks (2) and remove the spring compressor carefully.
6. Install the valve springs (1) and the exhaust valve rotators (5) on the exhaust valves (7). Compress the valve springs so that the valve retainer locks (2) can be installed. Remove the spring compressor carefully.
7. Install new expansion plug (14) if it was removed. The plug must be pressed in place and firmly seated against the retaining ridge in the cylinder head.

NOTE: When engine assembly is complete, a check of the operation of the rotators must be made. It is impossible to determine whether or not the rotator is turning without an identifying mark.

Place a dab of white paint on each of the rotators and note it's position. Start the engine and observe whether or not the rotator is turning. DO NOT attempt repairs on rotators. There is not a set speed at which the rotators should turn. Some rotators will turn faster than others. As long as the rotator is turning the valve, it is functioning properly.

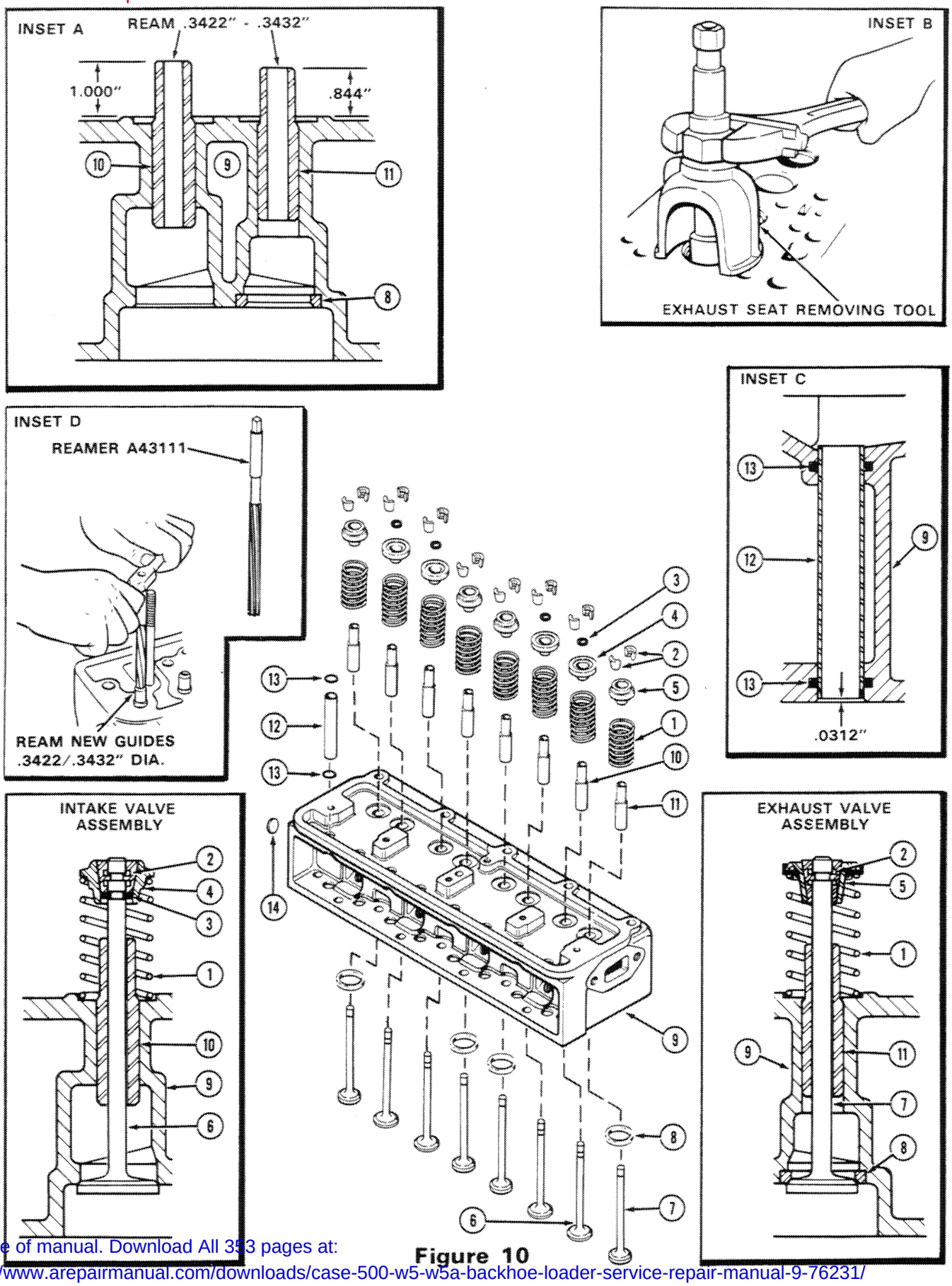

Figure 10