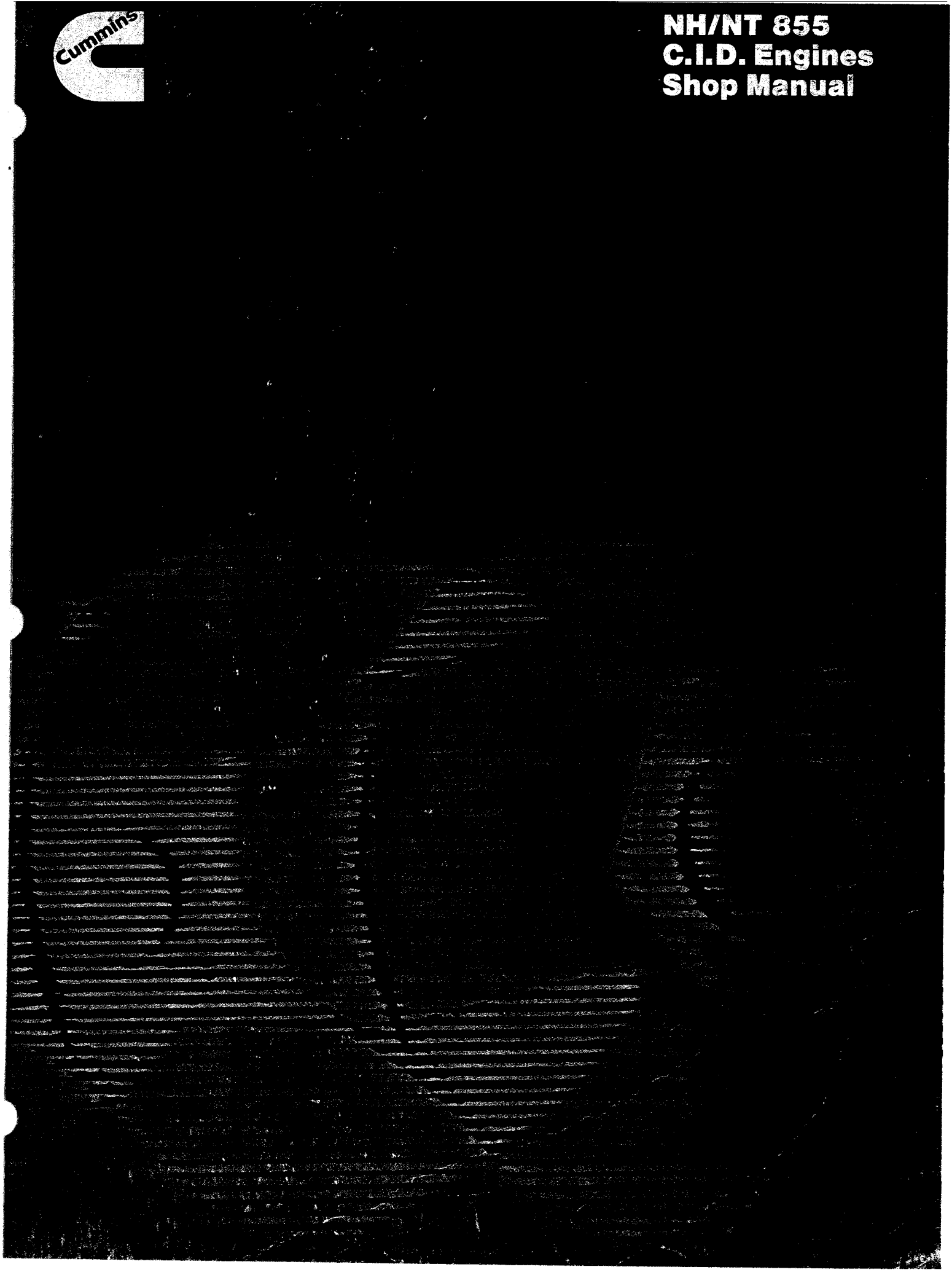
NH/NT 855 C.I.D. Engines Shop Manual



Shop Manual

Cummins Diesel NH/NT 855 C. I. D. Engines

Bulletin No. 3379076-04, Printed 1-79

Foreword

This unit rebuild manual was written for service personnel who repair or service 855 C.I.D. (cubic inch displacement) series engines and their accessories.

For model identification of an engine, check the dataplate, the letter and number code indicates breathing (naturally aspirated except when letter "T" for turbocharged is present), cubic inch displacement, application and maximum rated horsepower.

Examples:

NTA-855-400
N = 4 valve head
T = Turbocharged
A = Aftercooled
400 = Maximum rated horsepower

When calling a distributor about any field problem, have engine data ready. The distributor may want to know engine model, serial number, S.O. number, or C.P.L. number. These numbers are all found on the engine dataplate. Have these as well as any pertinent part numbers ready to assist in obtaining desired information.

For convenience of those using tools calibrated in metric measurements, all wear limits and specifications have been converted to millimeters or other metric units.

All repair and rebuild services described herein are available at Cummins Distributor and/or many Dealer locations.

Cummins Engine Company, Inc.
Columbus, Indiana U.S.A.

Table of Contents

The contents of this manual are based on information in effect at time of printing and are subject to change without notice.

Introduction

The Manual and its Arrangement

This manual covers the basic 855 Cubic Inch Displacement Engine Series built by Cummins Engine Company, Inc., Columbus, Indiana and its subsidiaries. These engines are used in many applications and have gained worldwide recognition for their dependability and simplicity of design.

Loose Leaf Manual

If it is desired to remove pages or groups from a bound manual, bend manual back at beginning and end of group and pull out. The cover is glued in place and pages can be removed quite easily.

Page Numbers

Page numbers within the group are numbered consecutively, starting with a new Page 1 at the beginning of each group, 0-1, 1-1, 2-1, etc.

Parts Dimensions, Wear Limits and Torque Specifications

An exploded view of components and pertinent specifications are listed in a table contained in each Group. Worn limits are listed where applicable. Torque specifications are within the text or tabulated the same as parts dimensions.

Near the end of the manual is Group 18, a complete tabulation of parts dimensions, worn limits and torque specifications.

Worn Limits

Worn limits, as stated in this manual, indicate that the part may be reused if it is at the worn limit. Discard only if it exceeds the worn limit. Of course, the reuse of any part is partially the responsibility of the person making the inspection, as it could well be damaged in an area not listed as a worn limit, thus making it unfit for further use.

Universal Units

Units such as fuel pumps, injectors, air compressors and turbochargers are also used on other models of Cummins Engines. These group sections are in separate manuals and written so they may be used with other engine shop manuals. These units are covered in full detail to make the information as useful and universally applicable as possible. For Bulletin Numbers, see back page or contact the nearest Cummins Distributor. Bulletin Numbers describing other available publications are identi fied in the individual Groups.

Auxiliary Equipment

Units such as hydraulic governors, exhaust brakes, thermatic fans, etc. are sometimes used on Cummins Engines. These special units are listed in the group in which they operate (hydraulic governors with Fuel Pump Group, etc.), information not contained in this or separate Cummins manuals must be obtained from the manufacturer.

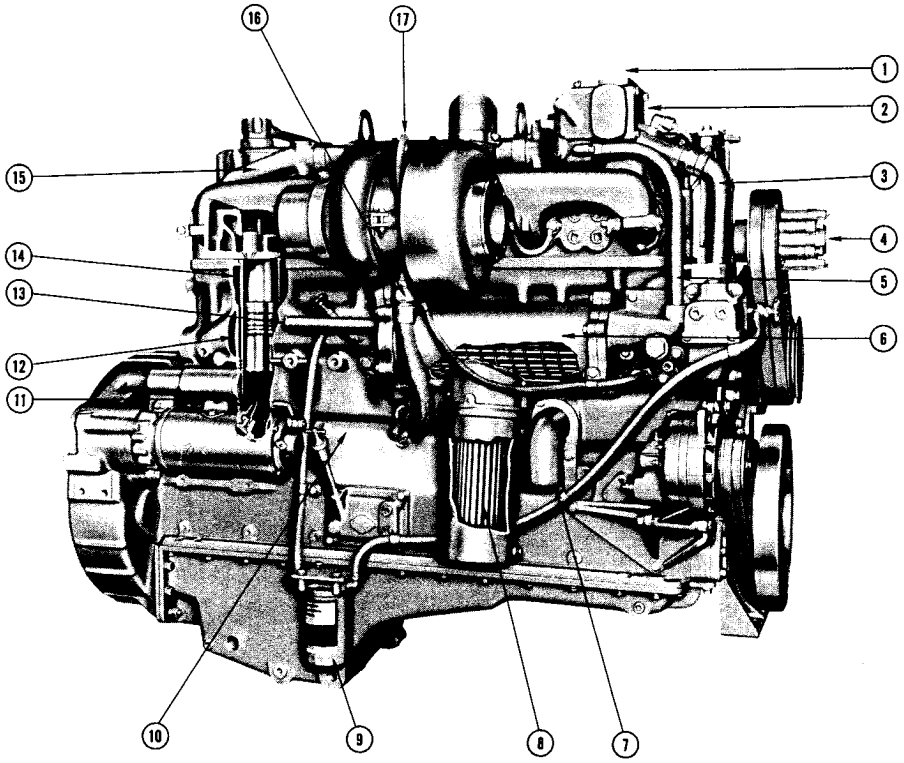
Service Tools

The average repair shop does not have all the factory facilities to do machining; however, it must be equipped with sufficient tooling to duplicate factory standards if the rebuilt unit is to do a good job.

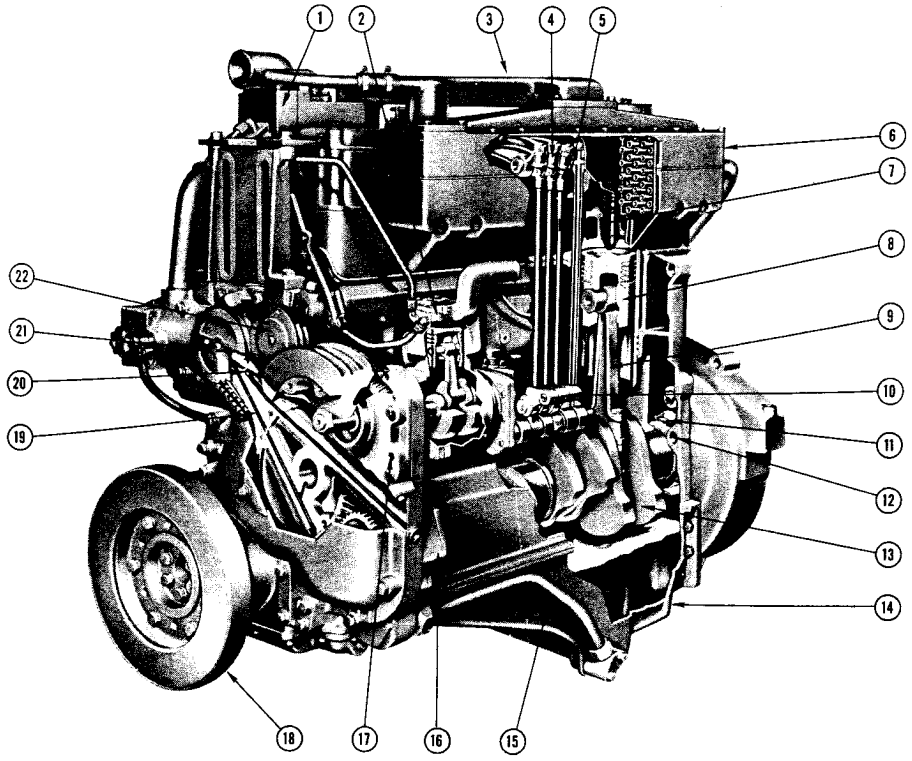
Cummins Service Tools are listed at the beginning of each group and described as those required and those which are desirable. Procedures for use of those Service Tools that are most difficult to use are described at the end of each group. Cummins Service Tools may be ordered through Cummins Distributors.

Additional Information

Cummins Engine Company, Inc. is constantly improving its products and Cummins Distributors and Dealers are kept fully abreast of these improvements, and where possible the instructions to apply the improvements to engines already in service at the lowest possible cost to the engine owners. Information on improvements and changes are released and arranged using the group number system so the Distributor or Dealer has a ready cross reference between manuals, new information and parts. Complete new products as released will be applied to the engine group within which it is used or, if necessary, a new group will be established.



1. WATER TO RADIATOR
2. THERMOSTAT HOUSING
3. WATER BY–PASS
4. FAN HUB
5. WATER FROM COOLER TO THERMOSTAT HOUSING
6. LUBRICATING OIL COOLER
7. WATER FROM RADIATOR
8. LUBRICATING OIL FILTER
9. CORROSION RESISTOR
10. LUBRICATING OIL HEADER
11. PISTON COOLING OIL
12. WATER HEADER
13. WATER TO COOLER FROM BLOCK
14. WATER JACKET
15. WATER MANIFOLD
16. TURBOCHARGER OIL DRAIN
17. TURBOCHARGER OIL SUPPLY



1. THERMOSTAT
2. AIR COMPRESSOR
3. INTAKE AIR CROSSOVER
4. ROCKER LEVERS
5. PUSH TUBES
6. AFTERCOOLER
7. INJECTOR
8. PISTON
9. CONNECTING ROD
10. CAM FOLLOWERS
11. CRANKSHAFT OIL SEAL
12. MAIN OIL PASSAGE
13. CRANKSHAFT
14. OIL PAN
15. OIL SUPPLY TUBE
16. LUBRICATING OIL PUMP
17. OIL TO ACCESSORY DRIVE
18. VIBRATION DAMPER
19. OIL FROM COOLER
20. OIL TO COOLER
21. WATER PUMP
22. IDLER PULLEY

855 C.I.D. Engine Models (Worldwide)

855 Series Engines* Automotive	Construction	Industrial	Locomotive
NH-230	N-855-C190	N-855-P190	N-855-L1
NTC-230	N-855-C220	N-855-P220	N-855-L2
NTC-230-S	N-855-C235	N-855-P235	NT-855-L1
NHF-240	N-855-C250	N-855-P250	NT-855-L2
NHC-250	NT-855-C250	NT-855-P280	NT-855-L3
NTC-250	NT-855-C280	NT-855-P310	NT-855-L4
NTC-250-S	NT-855-C310	NT-855-P335	NTA-855-L1
NHH-250	NT-855-C335	NTA-855-P360	NTA-855-L2
NTF-255	NTA-855-C360	NT-855-P380	
NHF-265	NTA-855-C380	NTA-855-P400	
Power Torque 270	NTA-855-C400		**Rail Car**
NTC-290	NTA-855-C420		N-855-R
NTCE-290			NT-855-R1
NTF-295			NT-855-R2
NTFE-295	**Fire Pump**	**Marine**	
Power Torque 300-D	N-855-F	N-855-M	**Generator Set**
Power Torque 330-D	NT-855-F1	NT-855-M1	NH-230-GS/GC
NTC-335	NT-855-F2	NT-855-M2	NH-250-GS/GC
NHHTC-335			NT-270-GS/GC
NTC-350			NT-310-GS/GC
NTCE-350			NT-335-GS/GC
NTCC-350			NT-400-GS/GC
NTF-365			N-855-GS/GC
NTA-400			NT-855-GS/GC
			NTA-855-GS/GC

***Includes both the standard and new Big Cam versions.**

Keep in close contact with the nearest Distributor or Dealer to remain current with the advances in design and release of new Cummins products.

Group 0

Unit removal is a simple operation, time and labor will be saved if the necessary steps are followed. A few precautions are included that will help prevent accidents and/or damage to the parts.

Engine Disassembly

The following service tools or tools of equal quality are considered necessary to disassemble the 855 C.I.D. (Cubic Inch Displacement) Series Cummins Diesel Engines.

Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
ST-125	Lifting Fixture
ST-548, 1317 or 3375193	Engine Rebuild Stand
ST-805 or 3375013	Engine Stand Adapter
3375049	Filter Wrench (Spin-On)

Desirable (Or Equivalent) Service Tools

ST-163	Engine Support
ST-647	Puller (Pulley)
ST-845	Fan Hub Wrench
ST-887	Crankshaft Flange Puller
ST-893	Fan Hub Wrench
ST-1297 or 3375161	Injector Removal Tool
ST-1178	Main Bearing Cap Puller
ST-1201	Liner Puller Bridge
ST-1202	Liner Puller Assembly
ST-1259	Seal Mandrel

Standard Tools -- Obtain Locally

	Hoist (Power or Chain)
	Steam Cleaner
	Cleaning Tank
	Rinsing Tank
	Impact Wrench
	Glass Bead Cleaner

Unit Removal and Cleaning

Before disassembly of an engine or any unit used on the engine inspection of the over-all condition should be made. This will furnish a great deal of information concerning necessary repair.

Inspection of each unit and tagging of electrical wires and components, bearing shell positions and other parts identification will help insure correct assembly.

Remove units and parts from cylinder block in a convenient order by removing mounting hardware, such as clamps, brackets, capscrews, washers, drive belts, etc. Mark or identify mounting components, as removed, for mounting location. Place parts and units (except electrical parts) on a rack or cart for cleaning. Discard gaskets and lockplates.

Engine Serial Number Plate

Engine serial number plate is located on the gear case mounting flange. Always refer to serial number and model designation when ordering parts or assemblies.

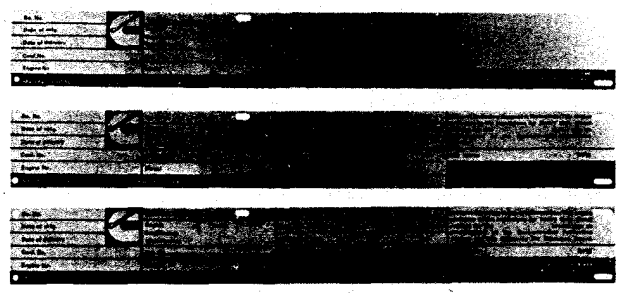


Fig. 0-1. Engine serial dataplates

Note: Engine serial dataplates shown in Fig. 0-1 are: (1) Non-certified engine serial dataplate, applies to current non-certified engines. (2) Certified engine serial dataplate applies to engines conforming to the Federal (U.S.A.) Clean Air Act. (3) California engine serial dataplate applies to engines conforming to California Air Resources Board standards as well as to the Federal Clean Air Act. Engine serial dataplate may not be changed without consent and approval of Cummins Engine Company, Inc.

Drain Water and Oil

1. Drain lubricating oil from oil pan, oil filter, oil cooler, hydraulic governor (if used) and air compressor.

2. Drain fuel oil from fuel pump, fuel filter(s) and fuel lines.

3. Open vent cocks and drain water from cylinder block, radiator, oil cooler, heat exchanger and air compressor (as applicable).

4. Bleed compressed air system, when used.

Engine Disassembly

Prior to steam cleaning and mounting engine on engine stand remove the following:

Electrical Connections

1. Disconnect and tag wire leads from terminals of generator, cranking motor, cold starting aids, fuel pump shut-down valve, regulator, remote controls, control panels, etc. as used.

2. Remove all other electric controls and wiring.

Oil Gauge

1. Remove capscrews and lockwasher securing bracket to block. Fig. 0-2.

2. Lift oil gauge bracket from block.

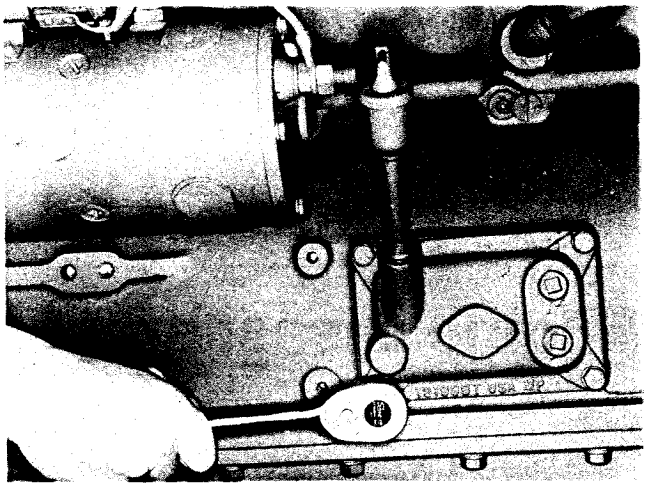


Fig. 0-2, (N10073). Removing oil gauge bracket

Electric Cranking Motor

1. Disconnect leads from cranking motor terminals (if not previously removed).

2. Remove capscrews and lockwashers holding cranking motor and spacer to flywheel housing. Fig. 0-3.

3. Slide cranking motor forward and remove.

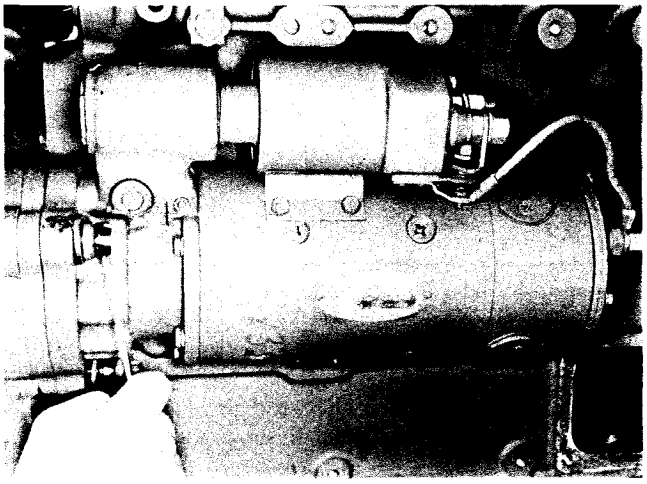


Fig. 0-3, (N10074) Removing electric cranking motor

Air Starter

1. Bleed air system.

2. Disconnect air supply from cranking motor.
3. Depress starter handle to bleed air.
4. Uncouple union between starter valve and motor.
5. Remove capscrews and lockwashers holding motor to flywheel housing. Fig. 0-4.
6. Support motor and slide out.

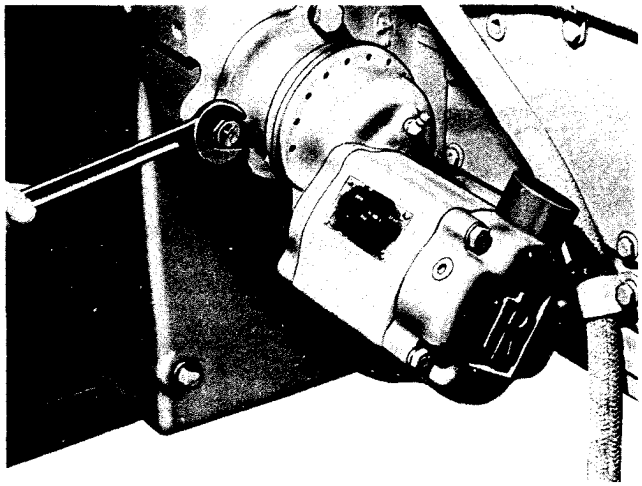


Fig. 0-4, (N10004) Removing air starter

Generator or Alternator

1. Remove adjusting screw and flatwasher securing generator to adjusting bar.
2. Remove capscrews and flatwasher securing adjusting bar to engine. Remove adjusting bar.
3. Loosen mounting bolts. Move generator toward engine and remove drive belt(s). Let belt hang around drive pulley until water pump belts are removed; alternator/generator must be removed before steam cleaning engine.
4. Remove capscrews and flatwashers or spacers securing generator to mounting blocks or bracket (Fig. 0-5), and lift away generator.
5. Remove capscrews, lockwashers and flatwashers securing mounting blocks or bracket to engine. Remove blocks or bracket.

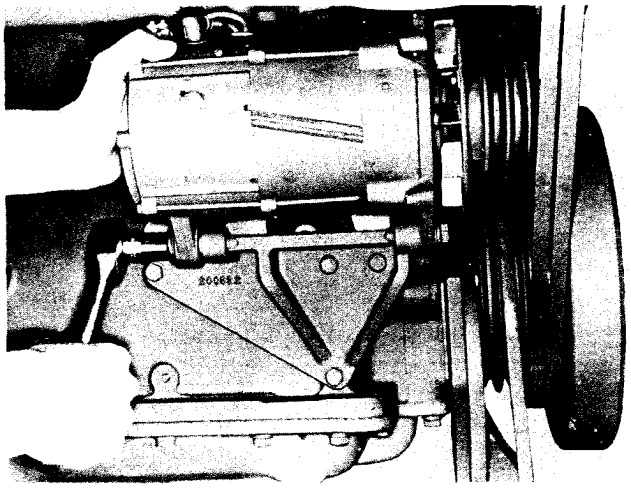


Fig. 0-5, (N10075). Removing generator

Water Filter

1. Close shut-off valves on inlet and drain lines.
2. Unscrew element and discard. Fig. 0-6.
3. Disconnect inlet and outlet lines.
4. Remove capscrews, lockwashers and flatwashers securing water filter head or bracket to block.

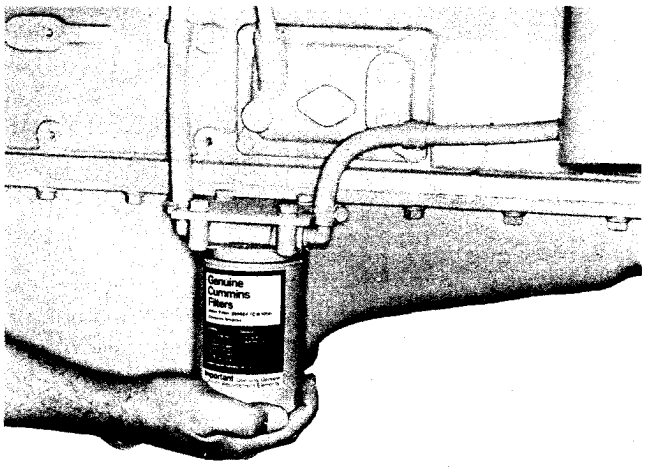


Fig. 0-6, (N11976). Removing spin-on water filter

Mechanical Controls, Water, Air and Fuel Connections

1. Remove mechanical control linkage, (Clutch, throttle linkage, etc.).

2. Remove water connections (radiator hose, water by-pass tubes, etc.).

3. Remove flexible fuel lines from injector fuel drain and pump inlet (and fuel filter if so equipped) and return lines from fuel pump to fuel tank.

Note: Engines used as Dual Diesels will be equipped with two sets of fuel lines and additional fuel control valves so four cylinders can be used for compressor pumping.

4. Remove air and lubricating oil lines from compressor.

5. Remove air cleaner to engine piping and turbocharger.

Caution: Inlet and outlet to turbocharger should be kept covered with plates or gummed paper to keep out foreign objects.

Steam Clean Engine Exterior

Prior to steam cleaning cover all openings with water proof tape.

In addition to actual time-saving affected by engine cleaning, inspections can be made more quickly and accurately during disassembly if surfaces are clean.

A heavy-duty steam cleaner is preferred; however, any model for general use is satisfactory.

Aftercooler

1. Disconnect air connections between turbocharger and aftercooler/intake manifold. Fig. 0-7.

2. Disconnect water supply and return hose from aftercooler and termination points.

Turbocharger

1. Remove oil drain line from turbocharger and side of block, remove oil supply line from turbocharger and oil cooler or termination point.

2. Remove capscrews and lockwashers or lockplates securing turbocharger bracket (if used) to turbocharger and cylinder block; remove bracket.

Note: If used, heat blankets or heat shields must be removed prior to turbocharger removal.

3. Remove locknuts securing turbocharger to exhaust manifold and lift turbocharger from exhaust manifold mounting flange.

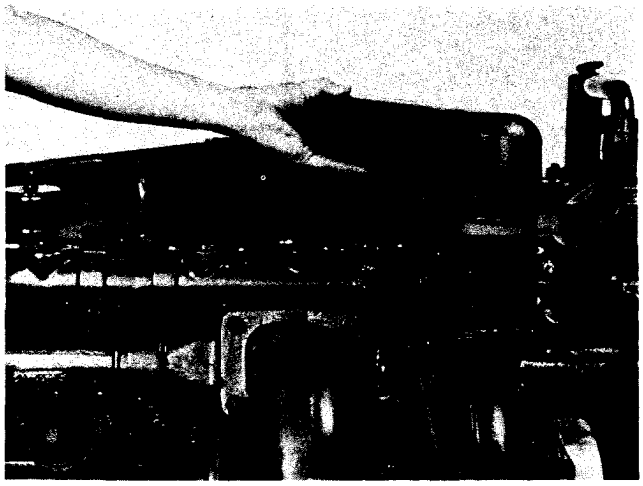


Fig. 0-7, (N100139). Removing air crossover connection

Crankcase Vent

1. On turbocharged engines, remove capscrews and lockwashers securing vent tube flange to breather, some vent tubes attach to breather by short hose and clamps.

2. Remove capscrews and lockwashers securing tube clip to engine.

3. Remove tube and bracket from engine.

Oil Spray Nozzles

On engines equipped with oil cooled pistons, an internal oil drilling running full length of cylinder block (exhaust side) provides oil to six spray nozzles used for cooling pistons. Nozzles are replaceable from outside cylinder block.

Remove slotted screw or capscrews securing each nozzle flange to block; remove nozzles. Fig. 0-8.

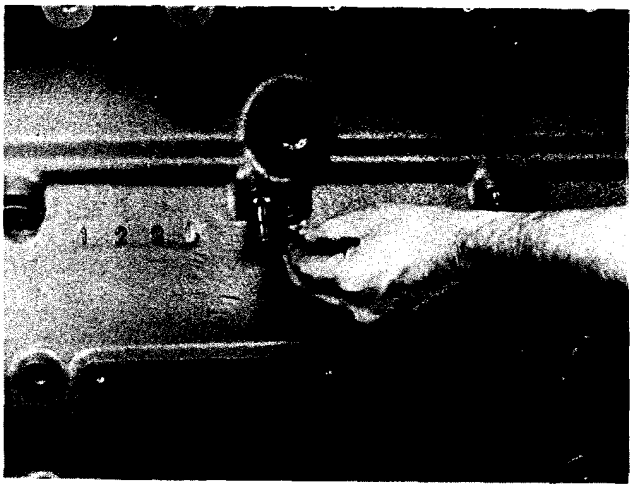


Fig. 0-8, (N100140).Removing oil spray nozzle

Water Transfer Tube – NTA Series

1. Remove capscrew securing tube to water manifold.

2. Remove capscrew securing tube support to block, if used.

3. Slip end of water transfer from end of water manifold, then slip end of tube from cooler housing. Discard "O" rings.

Oil Cooler and Filter Assembly

1. Remove and discard filter.

2. Remove by-pass tube and water header cover plate (Fig. 0-9) discard "O" rings.

Fig. 0-9, (N100141). Removing by-pass tube and water header

3. Remove capscrew, lockwasher and flatwasher securing cooler mounting bracket to block.

4. Remove capscrews and lockwashers securing cooler assembly support to cylinder block, lift cooler assembly from block and by-pass connection, discard gasket.

Water Pump, Idler and Fan Hub

1. Remove capscrew and lockwasher securing water inlet assembly bracket to block.

2. Remove capscrews and lockwashers securing inlet assembly to water pump; discard gasket. Fig. 0-10.

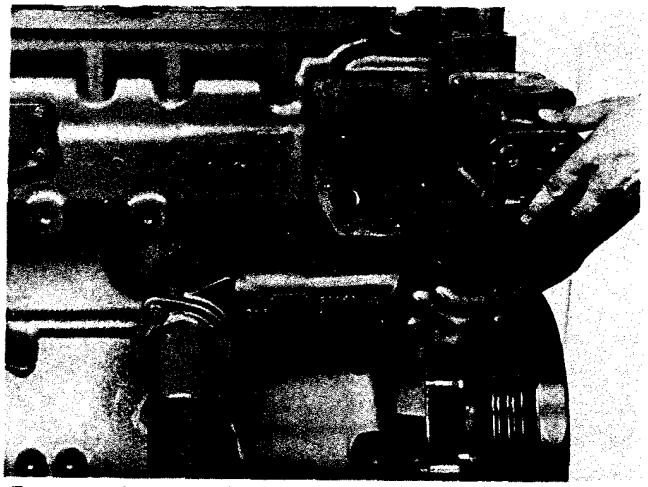


Fig. 0-10, (N100142). Removing water inlet assembly

3. Loosen clamps securing water transfer tube to thermostat housing. Remove transfer tube, discard "O" ring. Fig. 0-11.

4. Remove fan hub adjusting screw; lift off belts.

5. Remove capscrews and lockwashers securing fan hub support to rocker housing and fan hub adjusting bracket; remove support.

6. Remove capscrews and lockwashers securing fan hub adjusting bracket to water pump housing. Fig. 0-12. Remove fan hub and adjusting bracket assembly.

7. Loosen nut securing idler pulley. Using adjusting screw depress idler pulley, remove belts if not previously removed.

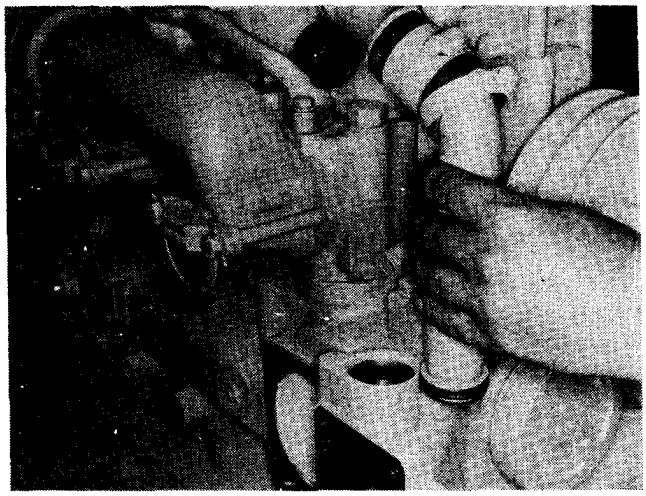


Fig. 0-11, (N100119). Removing water transfer tube

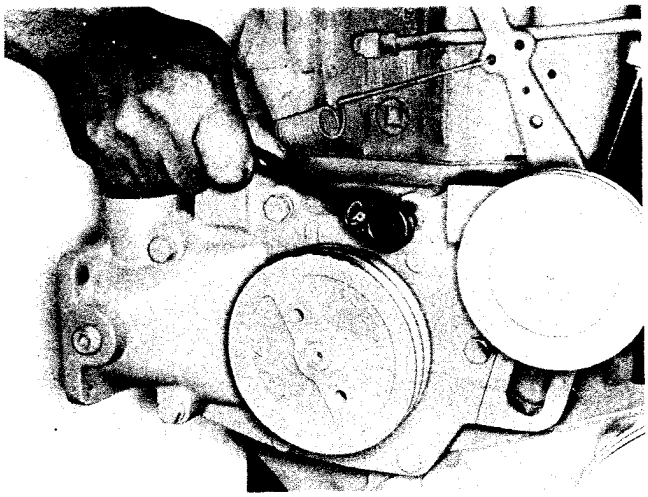


Fig. 0-13, (N100121). Removing water pump assembly

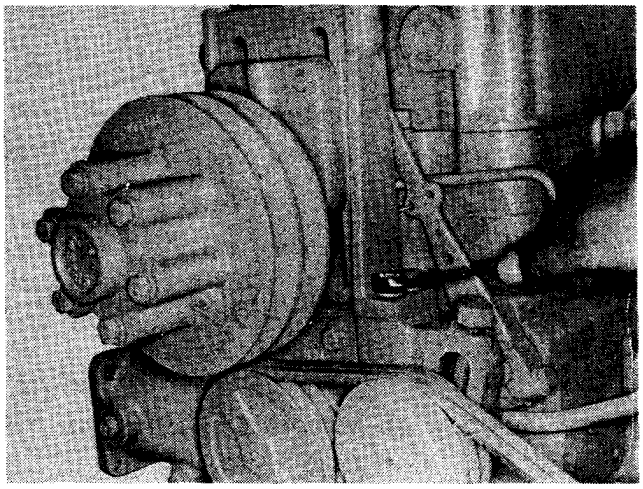


Fig. 0-12, (N100120). Removing fan hub assembly

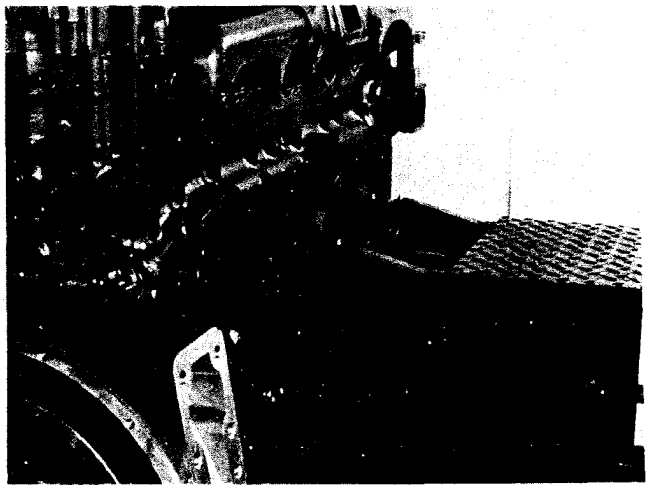


Fig. 0-14, (N100143). Engine mounted on stand

8. Remove capscrews and lockwashers securing water pump assembly to block. Fig. 0-13. Remove water pump assembly; discard gasket.

Mount Engine on Engine Stand

Replace water header cover plates with mounting adapter plates. Secure engine stand adapters to engine rebuild stand. Position engine to stand; secure with capscrews and lockwashers.

With engine mounted securely to roll-over stand (Fig. 0-14), remove the following:

Compression Release Lever

Remove spring link, bracket and lever from compression release shaft.

Vibration Damper and Flange

1. When removing rubber element type damper from flange, it may be necessary to tap damper with a soft hammer to loosen.

2. Prevent crankshaft from turning when removing self-locking capscrew from flange.

3. Pull flange from crankshaft with ST-887 Flange Puller.

Vibration Damper and Pulley

Vibration damper and pulley combination may be removed as an assembly by removing capscrews securing pulley to crankshaft. Fig. 0-15. Lock flywheel to break capscrews loose.

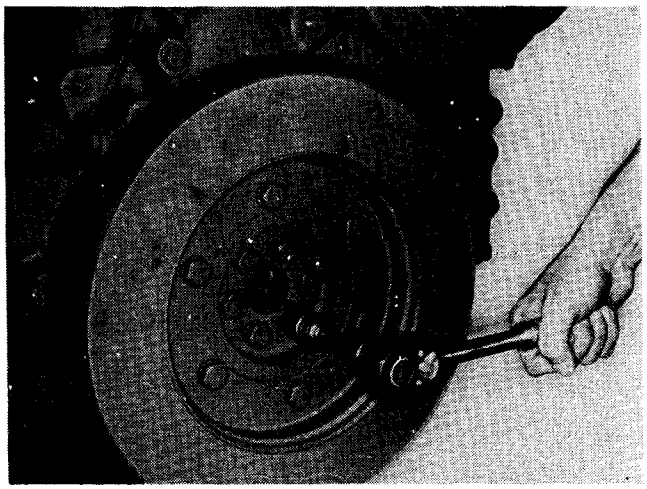


Fig. 0-15, (N10093). Removing viscous vibration damper

Caution: Do not resort to pounding or prying when removing the viscous type damper. Denting the outer shell may render the damper ineffective.

Front Engine Support

Two types of front engine supports are used on 855 C.I.D. Engines. Trunnion supports are normally left in the engine chassis. Pad type supports should remain with the engine and be removed after vibration damper and pulley removal.

Accessory Drive Pulley

After removing locking nut and washer, use ST-647 Puller to remove pulley. Remove shaft key or pin and oil slinger.

Aneroid Control

Disconnect air and fuel lines. Aneroid and mounting bracket may be removed as an assembly, if so desired.

Fuel Pump

1. Remove fuel supply and drain lines from fuel pump and cylinder head.

2. Remove fuel pump from hydraulic governor drive or air compressor. Lift out drive buffer or splined coupling as used.

3. Cover fuel pump connections to prevent entrance of dirt.

Air Compressor or Hydraulic Governor

Remove air compressor and/or hydraulic governor; lift out splined drive. Fig. 0-16.

Fuel Pump/Compressor Drive

After removing capscrews it may be necessary to tap assembly lightly with a soft hammer or wooden block to loosen; remove drive. Fig. 0-17.

Lubricating Oil Filter

Lubricating Oil Pump

1. Remove and tag all oil inlet and outlet lines (as used).

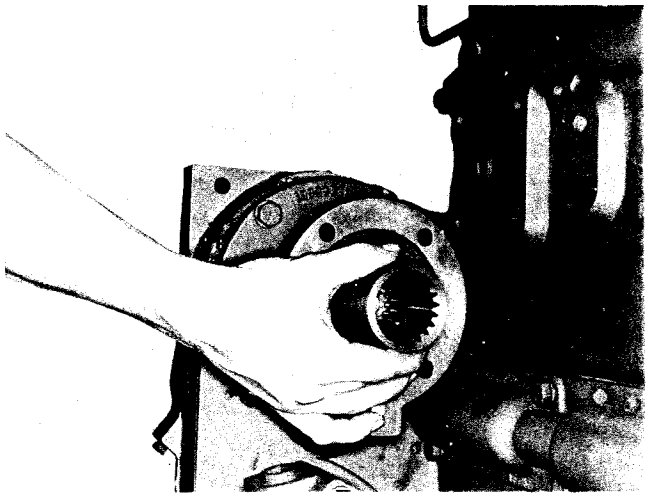


Fig. 0-16, (N100102). Removing splined coupling

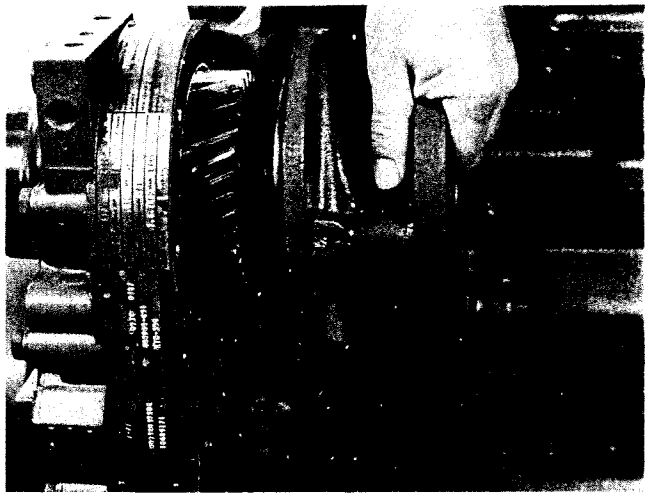


Fig. 0-17, (N100144). Removing fuel pump/compressor drive

2. Loosen and remove capscrews and lockwashers (Fig's. 0-18 and 0-19) securing lubricating oil pump to gear case.

3. Disengage pump driving gear and pull pump from gear case.

Intake Manifold/Aftercooler

1. Remove air inlet connections.

2. Remove air lines and air compressor intake line (if used) from intake manifold.

3. Remove capscrews, lockwashers and flatwashers at each intake port; lift off intake manifold and discard gaskets. Fig. 0-20.

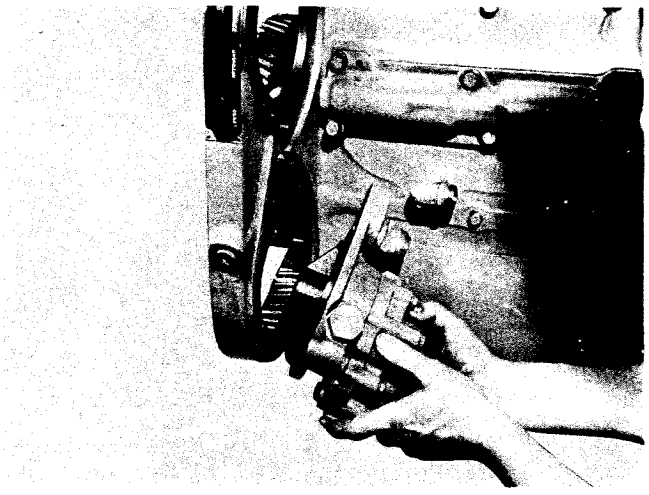


Fig. 0-18, (N10029). Removing lubricating oil pump

Fig. 0-19, (N100104). Removing lubricating oil pump (NTA Series)

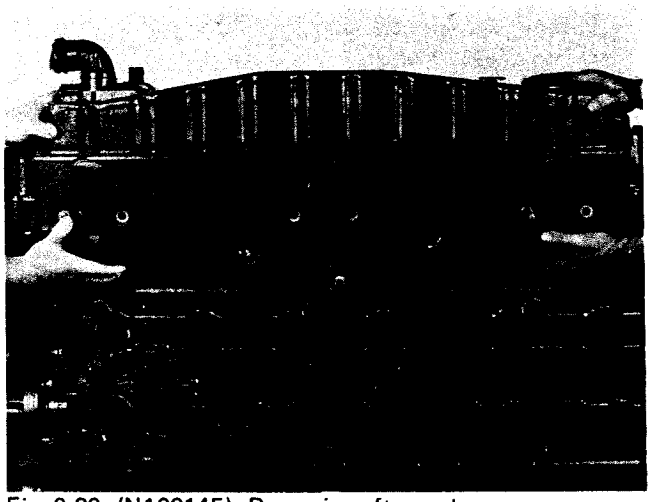


Fig. 0-20, (N100145). Removing aftercooler

Rocker Housing Covers and Rocker Housings

1. Remove rocker housing covers and discard gaskets. Fig. 0-21.

2. Loosen valve and injector adjusting screw locknuts and back out all adjusting screws one to two turns.

3. Remove rocker housing assembly and discard gaskets. Fig. 0-22.

Note: Rocker housing mounting capscrews also secure engine lifting brackets.

Push Tubes

Lift all push tubes from sockets. It is recommended push tubes, rocker housing and cam follower housing be marked for position so if they are reused they can be replaced in same mating cam followers. Due to the wear seat established more accurate adjustments will result from this practice.

Valve Crossheads

Remove all valve crossheads from cylinder heads.

Injectors

Remove injector hold-down plate; use ST-1297 Injector Removal Tool to remove injectors from cylinder head. Top Stop injectors require 3375161. Fig. 0-23.

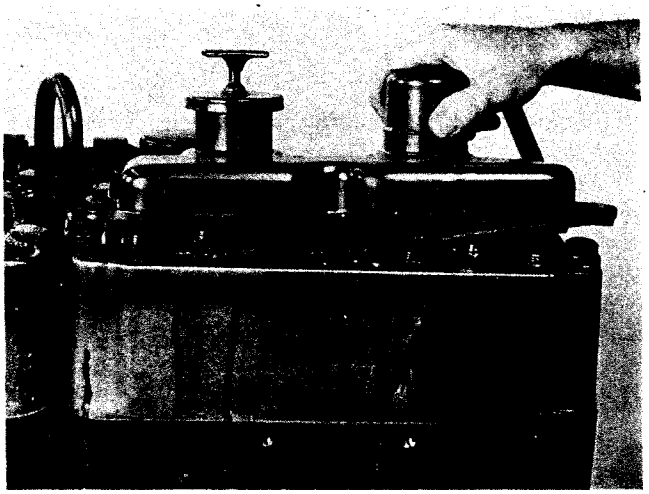


Fig. 0-21, (N100146). Removing rocker housing covers

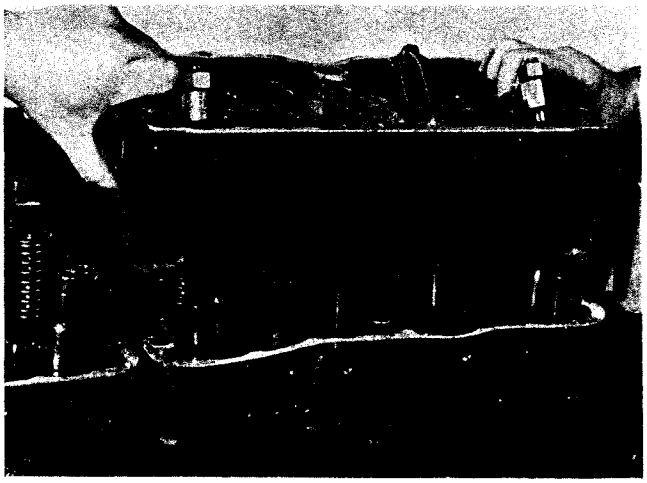


Fig. 0-22, (N100147). Removing rocker housing assembly

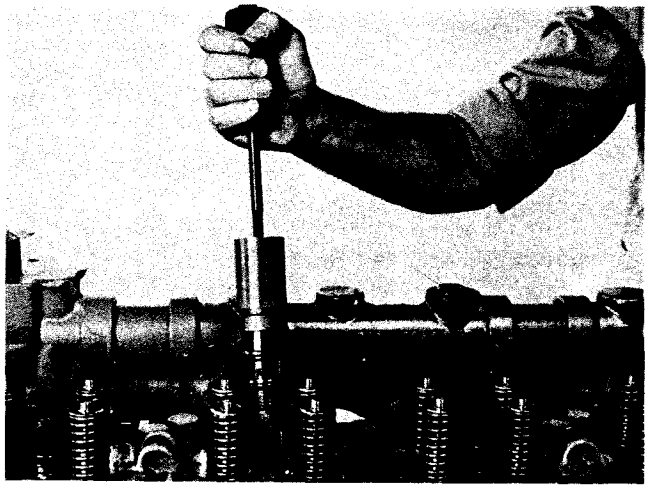


Fig. 0-23, (N100148). Removing injectors

Note: To avoid dropping plunger, do not turn injector upside-down. Place injectors in a rack for protection. Number by cylinder from which removed.

Fuel Connector

Remove slotted screws securing fuel crossover connectors to cylinder heads. Fig. 0-24. Lift off connectors and discard "O" rings.

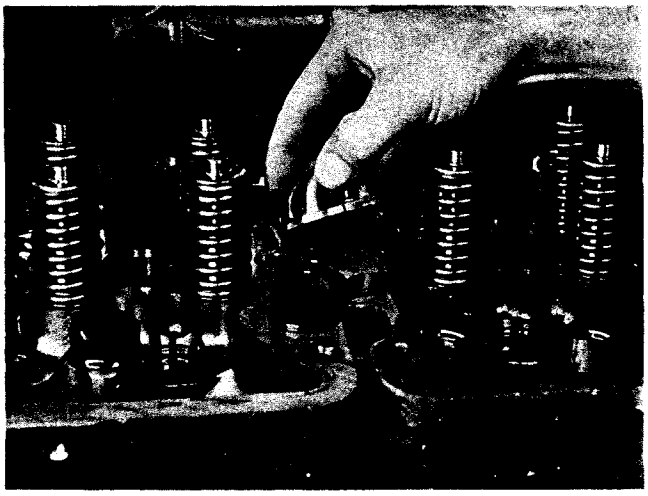


Fig. 0-24, (N100149). Removing fuel crossover

Exhaust Manifold

1. Remove heat shield, if used.
2. Bend back tabs on exhaust manifold lockplates.
3. Remove exhaust manifold.

Water Manifold/Thermostat Housing

Remove air compressor line and vent line (if not previously removed). Lift manifold assembly from engine. Fig. 0-25. See Page 0-10. Discard "O" Rings.

Cylinder Heads

1. Remove cylinder head capscrews in opposite order of torquing sequence and lift each cylinder head assembly from cylinder block. Fig. 0-26. See Page 0-10.
2. Remove and discard gaskets.

Compression Release Shaft

Remove shaft lockscrew and copper washer at rear

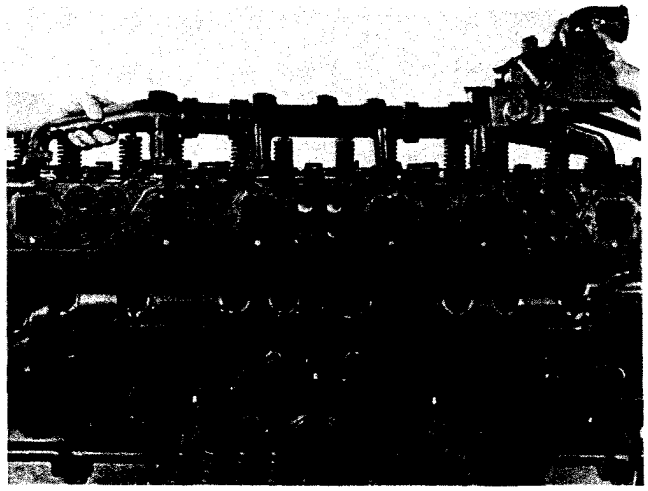


Fig. 0-25, (N100150). Removing water manifold

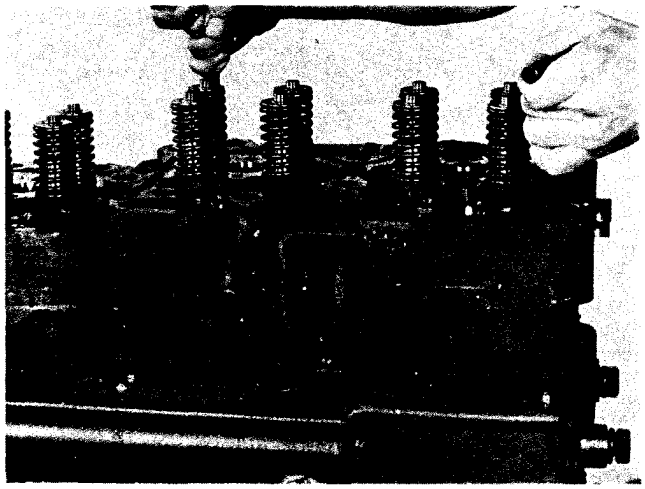


Fig. 0-26, (N100151). Removing cylinder head

of cylinder block. Pull shaft through block from lever end.

Note: Do not remove stop pin from cylinder block unless damaged.

Cam Follower Housings

Note: Do not discard metal spacer used on some engines. Measure and record total thicknesses of gasket(s) then discard gasket(s). Total thickness of gasket(s) varies spacing cam followers to establish injection timing.

Flywheel

1. Cut lockwires (if used) and remove flywheel capscrews. Insert two 5/8"-18 thread studs, 6 inch [152.4000 mm] long, in two opposite holes in flywheel. Screw studs into crankshaft flange. These will provide support for flywheel during removal.

2. In two holes provided, place 1/2"-13 capscrews, threaded their entire length, to act as jack-screws. Turn in capscrews alternately to pull flywheel from crankshaft. Fig. 0-27.

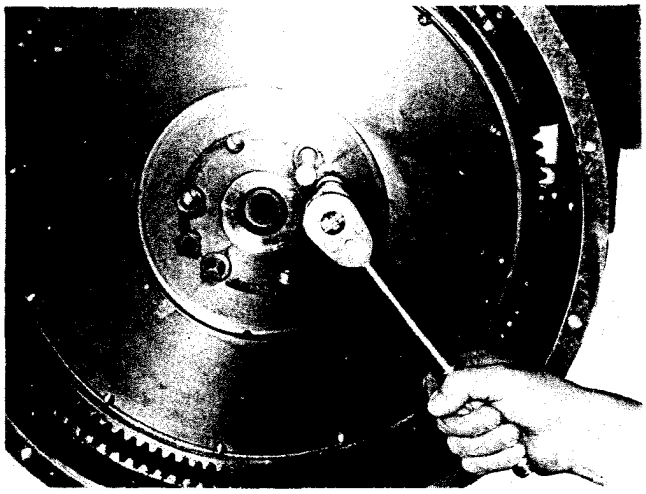


Fig. 0-27, (N100113). Removing flywheel

Flywheel Housing

1. Remove capscrews, flatwashers and lockwashers (if used) securing oil pan to housing from each side and bottom of pan.

2. Remove capscrews, lockwashers and flatwashers (Fig. 0-28) securing flywheel housing to cylinder block; drive housing from dowels with block of wood or soft hammer.

Oil Pan

1. Remove all mounting bolts and capscrews, flatwashers and lockwashers (if used) securing oil pan to cylinder block and gear case cover.

Note: Two bolts through oil pan and cylinder block flange at flywheel end of engine may be dowel fit. Remove nuts and drive out dowel bolts with soft hammer or soft punch and hammer.

2. Remove capscrews from rear of pan and rear seal cover.

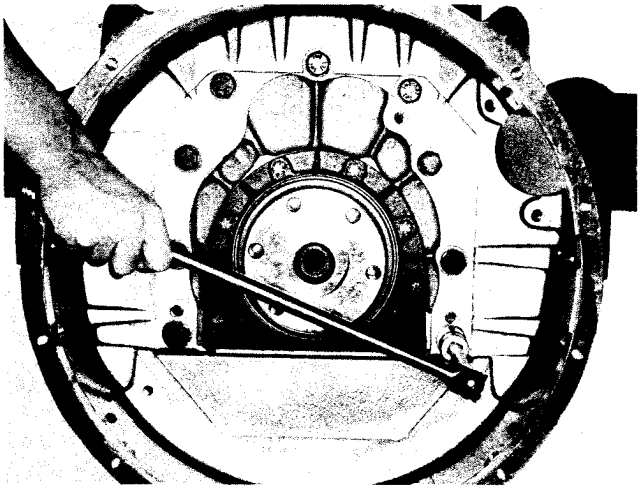


Fig. 0-28, (N100114). Removing flywheel housing

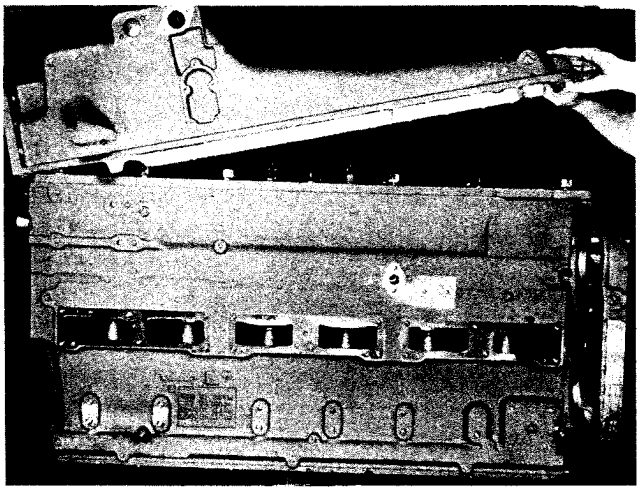


Fig. 0-29, (N100115). Removing oil pan

3. Remove oil pan (Fig. 0-29); discard gasket.

Rear Cover and Seal

When wet-type flywheel housings are used; remove and discard "O" ring. Pull cover and seal from crankshaft flange.

Oil Seal Removal

1. Secure ST-1259 Tool to nose of crankshaft with three vibration damper mounting capscrews. Tighten securely.

2. Install the three special seal puller screws into tool. Continue to turn in the special screws until screws penetrate the seal casing sufficiently for puller threads to engage the seal casing. Screws will "bottom out" against seal casing. Exercise care when "bottoming out" to prevent mutilating screws. Anti-seize or equivalent lubricant is recommended on the threads of all puller screws.

Note: The special puller screws have a drill point on end followed by No. 10-16 sheet metal screw threads. These features are used to drill through and thread into the seal casing by turning the screws (having 1/4"-20 threads) into the base tool.

3. Remove the three vibration damper mounting capscrews. Install the center puller screw and continue to turn center puller screw until seal is removed from gear cover.

4. Inspect area of seal location on crankshaft and remove any shavings that might have dropped onto crankshaft. These are minimal, but should be removed so they do not get into the engine or cause damage to the new seal.

ST-1263 Rear Oil Seal Expander is available to install Teflon oil seal on rear end of crankshaft; tool is similar to ST-1260.

Gear Case Cover

If gear case cover is equipped with outboard bearing at camshaft, remove from cover. Place two (2) guide studs 4 inches [101.6 mm] long, one on each side of cover to support cover during removal. Fig. 0-30.

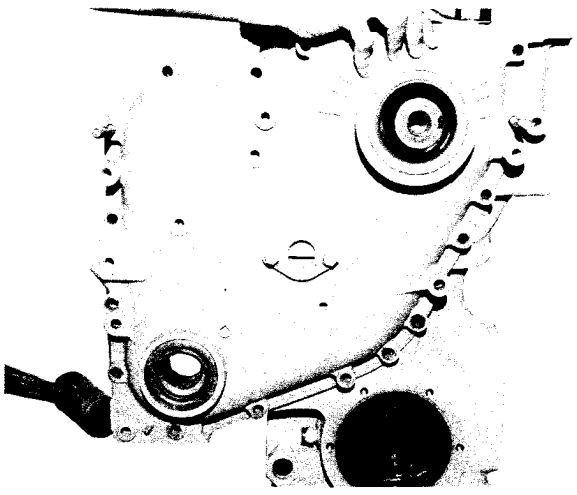


Fig. 0-30, (N10039). Removing gear case cover

Camshaft and Gear

Rotate camshaft gear slightly while pulling camshaft from engine. Do not remove gear from camshaft.

Note: On 2-1/2 Inch Cam Engines, install 3375268 Camshaft pilot to prevent damage to camshaft journals or bearings. Fig. 0-31. Remove cup plug seal at rear of camshaft bore.

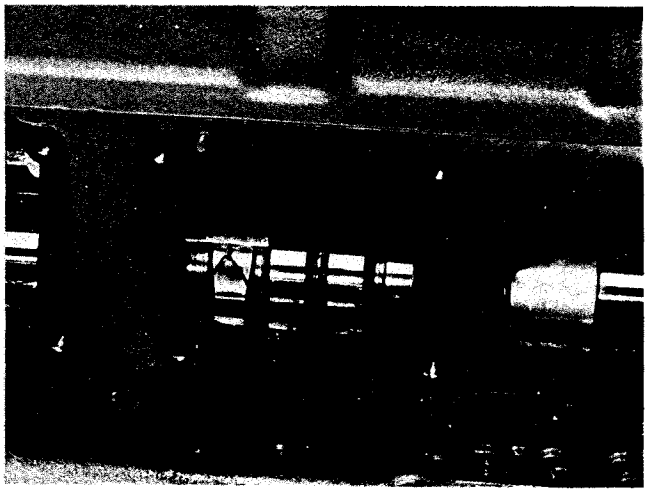


Fig. 0-31, (N100152). Removing camshaft with 3375268 Pilots

Connecting Rod and Piston Assemblies

1. Turn engine right-side-up and clean all carbon from upper inside wall of each cylinder liner and polish with fine emery cloth. Do not damage liner finish. Clean area thoroughly. Fig. 0-32.

2. Remove connecting rod caps:

   a. On two capscrew rods, loosen capscrews about 3/8 inch [9.5 mm]. Tap on capscrew heads with a soft hammer to pull caps from dowels. Remove capscrews and connecting rod caps.

Caution: Do not pry or hammer on connecting rod cap.

   b. On two bolt rods, remove bolt nuts and washers; pull caps and bearing shells from connecting rods. Using a soft hammer, drive rod bolts from rod.

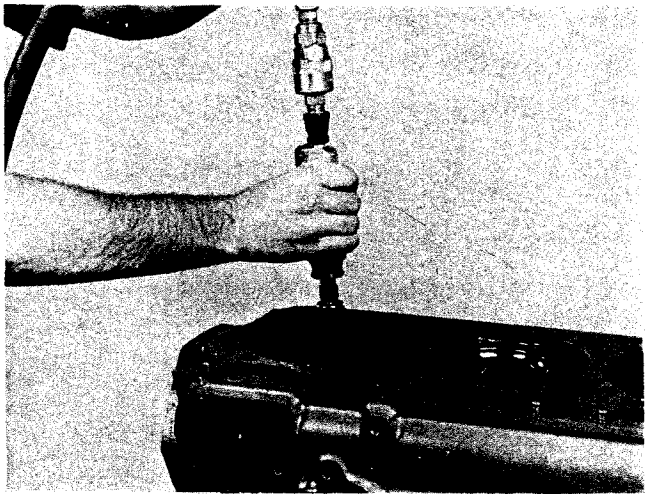


Fig. 0-32, (N100153). Removing carbon from cylinder liner

3. Push connecting rod and piston assemblies from cylinder liners. Fig. 0-33. Use care not to damage cylinder liners as connecting rods are withdrawn. Check each rod and cap as removed to be sure it is stamped or labeled. Reassemble each connecting rod cap to mating rod, tape mating bearing shells together and label by cylinder.

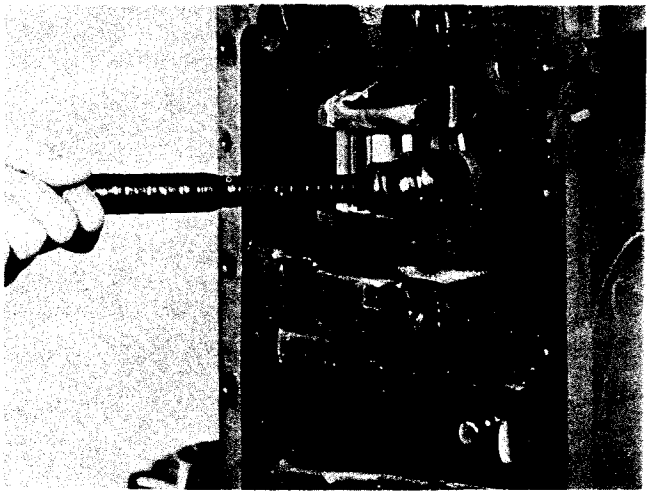


Fig. 0-33, (N100154). Removing piston and rod assembly

4. Remove and discard piston rings; remove snap rings.

5. To facilitate removal of piston pins, first heat piston in boiling water; then push pin from piston, using finger pressure or other suitable method.

Caution: Do not drive or otherwise force pin from piston.

Crankshaft and Main Bearings

1. Using ST-1178 Main Bearing Cap Puller, loosen main bearing caps from dowels. Fig. 0-34. Lift caps and rear thrust rings from block. Make sure all bearing caps are marked so they can be installed in their original locations.

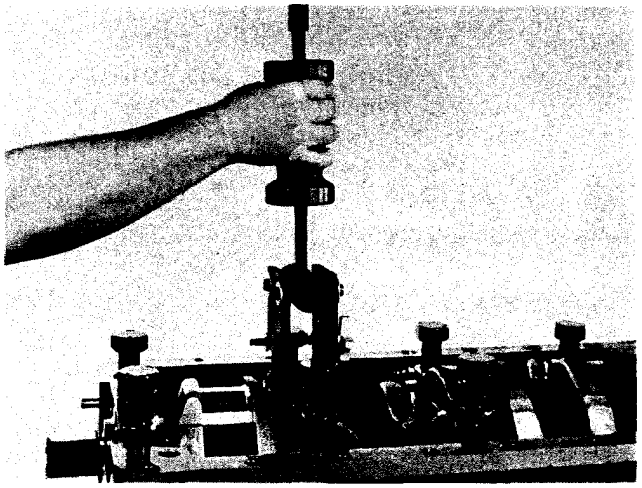


Fig. 0-34, (N100155). Removing main bearing caps

2. Remove lower main bearing shells from main bearing caps or crankshaft.

3. Remove crankshaft using hooks protected by rubber hose. Handle crankshaft with care to avoid possible damage to finished surface.

4. Remove upper main bearing shells and ring dowels from cylinder block. Tape mating halves of bearing shells together and identify from position removed.

Note: Crankshaft gear can be pulled without removing oil pan or heating gear by using 3375074 Crankshaft Gear Removal Tool and 3375077 Puller Jaw.

Cylinder Liners

Use ST-1201 Liner Puller Bridge and ST-1202 Liner Puller Assembly with an impact wrench or rachet to remove cylinder liners. Discard "O" rings and crevice seals. Fig. 0-35.

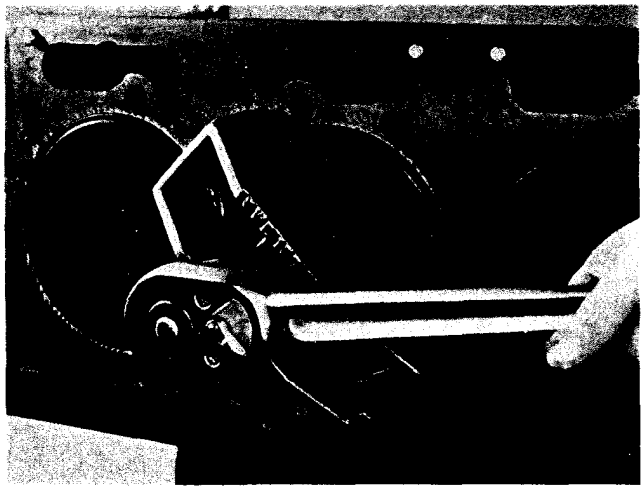


Fig. 0-35, (N100156). Removing cylinder liner

Cleaning

Glass Bead Cleaning

Glass bead cleaning has been proven most effective for pistons, valves, cylinder heads, etc. The nature and degree of treatment is controlled by the size of glass beads used, operating pressure and exposure time.

1. Bead Size – for pistons and other similar parts, use U.S. sieve size No. 70. For general purpose cleaning use No. 60.

2. Operating Pressure – 90 psi [620 kPa] for pistons, etc. For general cleaning, pressures from 90 to 125 psi [620 to 862 kPa] may be used.

3. Do not expose the part being cleaned to the bead blast any longer than absolutely necessary. This is particularly true when cleaning soft material such as aluminum.

4. The only additional cleaning required is to wash with solvent and dry with compressed air. Be sure all foreign material has been removed from parts before reassembling.

Steam Cleaning

Steam clean all disassembled units and parts (except those that might be damaged by steam or moisture) with a steam jet and dry with compressed air. All units such as oil coolers, oil pan, heat exchanger, etc. should be cleaned as quickly

as possible to prevent hardening and drying of accumulated foreign substances.

Solvent/Acid Cleaning

Several solvent and acid type cleaners are effective cleaning solutions, always follow manufacturers recommendations as to concentration and use.

Caution: Solvent cleaners may damage bearing shells and aluminum parts, check with manufacturer before cleaning these parts in solvent.

Remove all gasket material and deposits of sludge, carbon, etc., with a wire brush or scraper, from units such as cylinder heads, oil pan, rocker lever housing and cover, etc. before submerging them in wash tank.

Caution: Do not damage gasket surfaces.

1. Solvent solution should be heated to approximately 180 to 200°F [82 to 93°C] and kept in constant agitation. With sufficient heat, the agitation can be accomplished by built-in baffle plates.

2. After unit disassembly, put all small parts in wire mesh baskets, steam clean, then immerse in cleaning tank for as long as necessary. Larger parts can be lowered directly by chain hoist into tank.

3. Cylinder block must have all pipe plugs removed from oil and water passages, etc. Run rods with brushes or swabs through all oil passages, clean air vent hole (No. 1 cylinder) that opens into water pump cavity. Scrape liner counterbore lightly to remove scale, sand lower liner bore or use emery cloth to remove any nicks or burrs that might damage packing rings as liner is installed.

Note: Piston cooling oil passage may have a spring and plug under pipe plug that must be removed before cleaning.

4. To remove heavy deposits of lime, use circulated acid type cleaner.

Warning: The use of acid may be extremely dangerous to workman and injurious to machinery. Always provide a tank of strong soda water as a neutralizing agent.

5. Rinse all parts in hot water and dry with compressed air, blow cleaning fluid or water from capscrew holes to prevent damage when capscrews are tightened.

6. Replace piston cooling passage spring and plug and pipe plugs removed for cleaning when used. Torque to specifications.

Note: If rebuild machining is required, replace pipe plugs and reclean affected area after machining is completed.

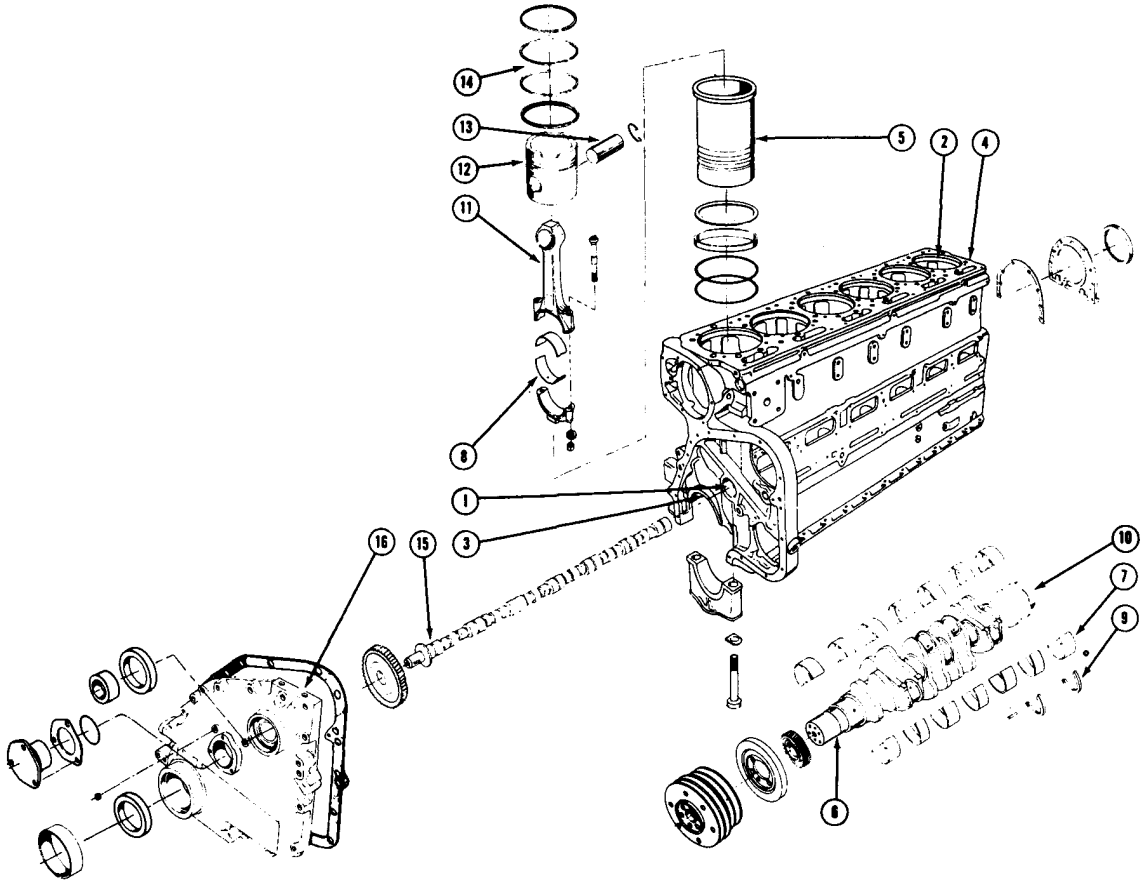
7. If parts are not to be reused immediately after cleaning, dip them in a suitable rust proofing compound.

Note: Rust proofing compound must be removed before installing parts in engine.

Group 1

The cylinder block group consists of cylinder block, cylinder liners, crankshaft, bearing shells, vibration damper, connecting rods, pistons, rear cover, camshaft and gear cover.

Cylinder Block



1. Camshaft Bushing Bore
2. Cylinder Liner Counterbore
3. Main Bearing Bore
4. Cylinder Block
5. Cylinder Liner
6. Crankshaft
7. Main Bearings
8. Rod Bearings
9. Crankshaft Thrust Ring
10. Crankshaft End Clearance
11. Connecting Rod
12. Piston
13. Piston Pin
14. Piston Ring
15. Camshaft
16. Gear Case Cover

Fig. 1-1, (N101113). Cylinder block – exploded view

The service tools or tools of equal quality listed are considered necessary to repair and/or rebuild the cylinder block as outlined in this section.

Cylinder Block

Inspection

Before any parts are discarded or used again a careful inspection must be performed. The inspection should include wearing surfaces and general over-all conditions.

Note: Inspection of cylinder block must be performed on a flat surface to prevent distortion; do not leave on engine stand.

Using Dye Penetrants to Locate Flaws

Use dye penetrant method for locating cracks, porosity, leaks, etc. Clean suspected defective area with kerosene or other grease-removing cleaner.

Apply dye penetrant allowing time for it to dissolve or enter into the defect (usually about fifteen minutes); do not "force" dry. Remove all excess penetrant and apply developer so defect will stand out; cracks usually show up as a solid or dotted line; however, caution must be observed as this can be a non-damaging forging lap. Porosity usually shows up as dots in local areas. The wider the area spreads, the larger the defect.

Corrosion

Corrosion most frequently occurs on portions of block nearest cylinder liners and is evidenced by pitting. Discard block if area cannot be cleaned, or if area is distorted and cannot be repaired by sleeving as outlined under "Parts Replacement and Repair" following.

Camshaft Bushings

Use inside micrometers or dial bore gauge to measure camshaft bushing inside diameter. Mark bushings for replacement if worn larger than "Worn Limit" (Table 1-1) (1) or are chipped, scored or scratched. If bushings have turned in block bore, check block bore size; see Table 1-1 (1). Make certain oil passages between bushings and block oil holes are properly aligned. If bushing replacement is necessary, see "Parts Replacemant and Repair".

Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
3375115	Boring Machine
ST-1010	Counterboring Tool (Water Hole)
ST-1295	Counterboring Tool (Cylinder Liner)
ST-1295-18	Adapter Plate
ST-1065	Tool Holder
ST-1287	Boring Tool (Lower Cylinder Liner Bore)
ST-1168	Counterbore Salvage Tool
ST-1177	Boring Tool (Main Bearing Bore)
ST-1228	Camshaft Bushing Drive Kit
3375154	2-1/2" Cam Bushing Drive Kit
ST-1250	Cylinder Liner Bore Salvage Tool
ST-1252	Concentricity Gauge
ST-1272	Head Capscrew Thread Salvage Tool
3375153	2-1/2" Cam Cup Plug Driver
3375268	2-1/2" Cam Installation Sleeve
3375151	Oil Seal Installation Tool

Desirable (Or Equivalent) Service Tools

ST-205	Plug Gauge (Connecting Rod)
ST-547	Gauge Block
ST-560	Ring Groove Gauge
ST-561	Checking Fixture (Connecting Rod)
ST-563	Locating Mandrel (Connecting Rod)
ST-598	Bushing Mandrel (Gear Cover)
ST-861	Chamfering Tool (Connecting Rod)
ST-896	Ring Gauge (Connecting Rod)
ST-897	Ring Guage (Connecting Rod)
ST-903	Ring Gauge (Main Bearing Bore)
ST-1171	Bushing Mandrel (Accessory Drive)
ST-1178	Puller (Main Bearing Cap)
ST-1184	Cylinder Liner Hold Down Tool
ST-1242	Mandrel Set
ST-1259	Front Oil Seal and Wear Sleeve Driver/Puller
3375151	Oil Seal Expander
3375053	Thrust Surface Cutter
3375361	Heating Oven
3375840	Gear Puller

Cylinder Liner Counterbore

1. Check upper liner counterbore and remove burrs, dirt, etc., so liner will enter without distortion. If counterbore exceeds limits listed in Table 1-1 (2) for the top 0.250 inch [6.35 mm] depth, mark blocks for counterbore repair. The counterbore ledge must be smooth and perpendicular to the liner bore to within 0.005 inch [0.13 mm] total indicator reading. Use a straight edge to check flatness of top of block. Refer to "Top Surface Refinishing".

2. Check counterbore depth so installed liner will be assembled to correct protrusion and to determine if refinish of counterbore surface is necessary. Depth of counterbore on a new block is listed in Table 1-1 (2). If worn to or beyond limit, the cylinder block must be salvaged using ST-1295 or 1065 Cylinder Liner Bore Salvage Tool or replaced. If worn less than worn limit, the surface can be refinished and shims installed under the cylinder liner to restore proper protrusion.

3. Installed cylinder liners must protrude 0.003 to 0.006 inch [0.08 to 0.15 mm] above block. To check for proper protrusion without installing a liner:

   a. Measure liner flange thickness with micrometer. Do not include bead on top of liner flange in taking measurement. See Fig. 1-2.

   b. Measure block counterbore depth with dial indicator depth gauge or ST-547 Gauge Block. Always measure counterbore depth on ledge at the edge of liner bore. See Fig. 1-3.

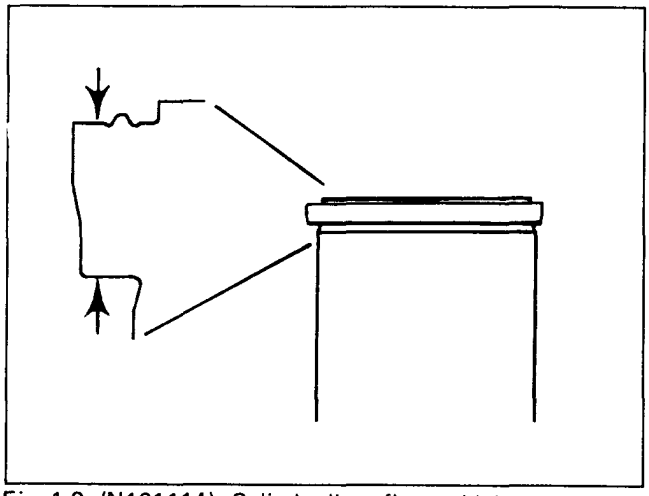
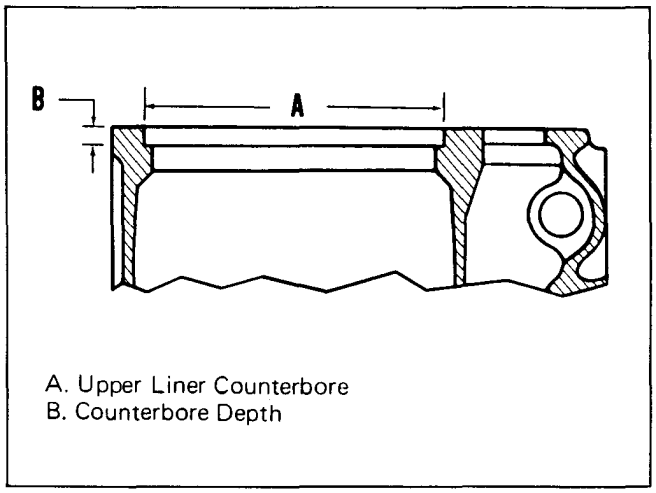


Fig. 1-2, (N101114). Cylinder liner flange thickness measuring point



A. Upper Liner Counterbore
B. Counterbore Depth

Fig. 1-3, (N10103). Cylinder liner counterbore depth

   c. Check depth at four equidistant locations. Ledge must not be "cupped" more than 0.0014 inch [0.036 mm]. Depth must not vary more than 0.001 inch [0.03 mm] throughout counterbore circumference.

   d. Counterbore must always be resurfaced if it slants downward toward the center or if dimensions do not meet standards. See "Parts Replacement and Repair".

   e. Subtract counterbore depth from liner flange thickness to determine amount of shims and depth of counterbore cut that must be used to provide 0.003 to 0.006 inch [0.08 to 0.15 mm] liner protrusion. 0.007 inch [0.18 mm] shims are thinnest available. If material to be removed will result in a counterbore depth exceeding worn limit, block cannot be reused, unless a sleeve can be installed.

4. The most accurate method of checking protrusion is as follows:

   a. Install liner in block with proper number of liner shims beneath the flange. Shims are available from 0.007 to 0.068 inch [0.18 to 1.73 mm]. Use ST-1005 or ST-1184 Cylinder Liner Hold-Down Tool. Tool should be

spaced so even load will be applied. Torque capscrews to 50 ft-lbs [68 N• m].

b. Use ST-547 Gauge Block and check liner protrusion above the cylinder block at four equidistant points outside the bead. Add or remove shims from beneath the liner flange as needed to reach 0.003 to 0.006 inch [0.08 to 0.15 mm] protrusion.

c. With liner installed, check for out-of-round as described under "Install Liner in Block", Group 14.

Cylinder Liner Lower Bore

1. Install a new cylinder liner in the block without packing rings or crevice seal.

2. Desirable clearance between liner and block should be as listed, but liner contact with block is permissible as long as it does not cause liner out-of-round.

3. If clearances do not fall within limits, recheck after counterboring; limits do not apply with cylinder head installed and tightened to operating torque. If clearance is not correct, check lower block packing ring bore inside diameter.

4. Lower liner bore concentricity should be checked with ST-1252. If a piston seizure has occurred or after counterboring the cylinder block, check the counterbore to lower cylinder liner bore concentricity. Follow Service Tool Instructions. Liner bore should be concentric within 0.005 inch [0.13 mm] total indicator reading.

Main Bearing Caps

Caps must fit in block with no perceptible clearance or "shake". Milled faces of cap must always rest on mating portion of block to prevent distortion during tightening.

Replacement caps are available as service parts.

Main Bearing Bore

1. Assemble main bearing caps to block in operating position. Tighten capscrews to operating tension. See Table 1-1.

2. Gauge main bearing bores horizontally, vertically and diagonally with dial bore gauge or inside micrometers properly adjusted to ST-903 Ring Gauge. See Table 1-1 (3) for dimensions.

ST-1177 Boring Tool may also be used to check main bearing bore alignment; see Service Tool Instructions. If it is definitely determined that a main bearing cap has been distorted, mark block for repair.

Water Passages

1. Check all water passages to make sure they are open and for eroded water holes which may prevent proper seating of head gasket.

2. Water holes not eroded more than 1/16 inch [1.59 mm] from edge of hole can be sleeved.

3. Check for erosion within 1/32 to 3/32 inch [0.79 to 2.38 mm] from liner counterbore; if not too deep, block may be resurfaced. Block must clean up before removing a maximum of 0.010 inch [0.25 mm] material.

Parts Replacement and Repair

After a thorough inspection of cylinder block, bushings and main bearing caps, the decision must be made whether to install a new or reconditioned block assembly, replace bushings or caps and how much can be done to rebuild or recondition the reusable parts.

Camshaft Bushing Replacement

Bushings may be removed and installed with 3375154 or ST-1228 Camshaft Bushing Driver Kit. Oil holes in camshaft bushings must align with oil holes in block.

Both 2-1/2 inch and 2 inch camshaft cylinder blocks are machined with the same tooling causing the oil drain hole on No. 7 journal, which lies further inboard, to be partially covered when 215570 Bushing is installed. 3007689 Bushing corrects this problem. When oil holes in bushing are properly aligned, the orientation notch will align with the oil drain hole. See Fig. 1-4.

Main Bearing Cap Replacement

1. Replacement main bearing caps have 0.015 inch [0.38 mm] material in bore. Other dimensions

are the same as finished main bearing caps. No. 7 replacement cap does not have cap-to-block dowel holes and must be machined to block width.

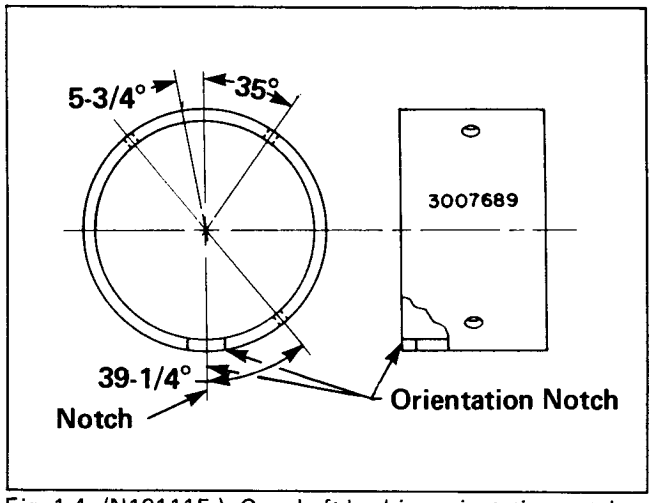


Fig. 1-4, (N101115). Camshaft bushing orientation notch

2. Main bearing caps provide 0.0015 to 0.0045 inch [0.040 to 0.114 mm] interference fit in block.

3. If the cap is a rear cap (No. 7):

   a. Remove locating dowels from block. Locate cap so thrust faces of cap and block are flush. Use Prussian Blue on block surface to locate dowel holes in cap.

   b. Remove cap, drill dowel holes. Reinstall cap and ream dowel holes to the smallest permissible oversize. Install dowels in block.

4. Install all caps on block and machine bore as described in Service Tool Instructions, this section.

Sleeve Eroded Water Holes

The cylinder block surfaces around the water holes must be free of any erosion scratches or blemishes which are more than 0.003 inch [0.08 mm] deep in the area 1/16 to 3/32 inch [1.59 to 2.38 mm] from edge of water holes. Use ST-1010 Water Hole Counterboring Tool to enlarge hole for sleeve. See Service Tool Instructions, this section.

1. To install water passage sleeve Part No. 190079:

   a. Slide sleeve onto stop end of ST-1010-9 Bushing Driver.

   b. A sealant may be used to coat sleeve before installation, if desired.

   c. Align sleeve in top of water passage hole and drive sleeve in with a hammer until it bottoms. Sleeve will protrude above surface of block.

2. If block is to be resurfaced, see "Top Surface Refinishing". If not to be resurfaced, file bushing flush with top of block, using a wide, flat mill file.

Top Surface Refinishing

If necessary, a cylinder block may be salvaged by removing a maximum of 0.010 inch [0.25 mm] of material from the top surface with a large surface grinder.

1. Use either a milling machine or large surface grinder, locate block on main bearing pads.

2. Remove dowels from head mounting surface and make light cuts of 0.001 to 0.003 inch [0.03 to 0.08 mm] deep, removing only enough material to make block usable.

3. Check distance from centerline of main bearing bore (1, Fig. 1-5) to top of block. See Table 1-1 (4).

   a. Find this dimension by placing block, top down, on a flat surface plate and measuring from main bearing bore centerline to plate.

   b. An alternate method is to check distance from installed main bearing bore alignment bar to top surface of block (2, Fig. 1-5).

   c. Distance from head surface to main bearing bore centerline must not vary more than 0.002 inch [0.05 mm] throughout length of block. Head surface flatness must not vary over 0.002 inch [0.05 mm].

4. Finish surfaces to 125 R.M.S.

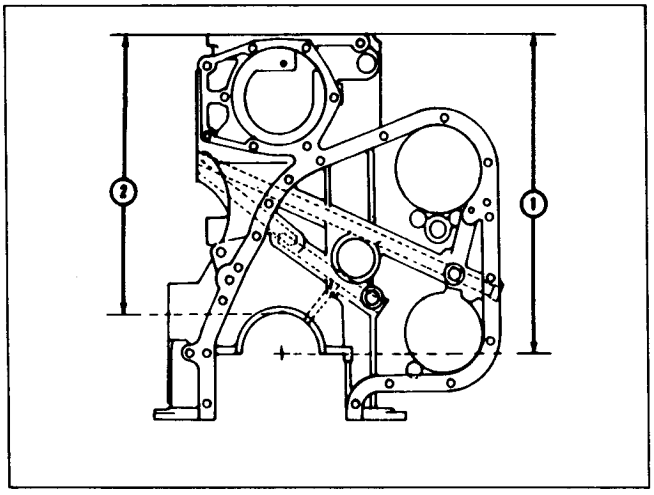


Fig. 1-5, (N10181). Cylinder block height check location

5. Resurface counterbore to obtain proper liner protrusion. Check liner to block contact in crevice seal area.

Lower Liner Packing Ring Bore Repair — Installation of Cast Iron Sleeve

Use ST-1287 Boring Tool as indicated in Service Tool Instructions, this section, when installing 195778 or ST-1287-41 Cast Iron Sleeves in lower bore of block.

Machining Lower Bore Entry Chamfer

If the lower bore or the lower bore entry chamfer is beyond the tolerances, pitted, or eroded, one of the following operations may be performed to salvage the cylinder block.

If the erosion has occurred only on the entry chamfer and not in the packing ring sealing area, the chamfer may be "built-up" by the use of a plastic steel compound such as Devcon Plastic Steel, Type "A". The manufacturer's directions should be followed for this salvage procedure. Check the chamfer depth after this operation and resurface the chamfer if beyond acceptable tolerances. Follow Service Tool Instructions, this section.

Cylinder Liner Counterbore

Resurface cylinder liner counterbore if block has been resurfaced, ledge is uneven or where liner protrusion is incorrect. ST-1295 Counterbore Tool with ST-1065 Adapter Plate can be used for this operation. See Service Tool Instructions, this section.

Rebuilding Cylinder Liner Counterbores

ST-1168 Cylinder Liner Counterbore Salvage Tool will enable salvaging a block which has a damaged or cracked counterbore ledge. ST-1166 Magnetic Crack Detecting Tool may be used to determine the extent of cracks. The bores can be enlarged and a new sleeve installed. See Service Tool Instructions, this section.

The new counterbore salvage sleeve Part No. 202226 is a precision sleeve. No inside diameter cutting is required except cutting the counterbore ledge to depth. When installed 0.005 inch [0.13 mm] to 0.010 inch [0.25 mm] must be cut from the counterbore ledge to meet specifications, Table 1-1 (2).

Cylinder Head Capscrew Threads

If cylinder head capscrew threads are damaged, they may be repaired by using ST-1272. ST-1272 installs solid bushing-type thread inserts and insures their correct alignment. See Service Tool Instructions, this section.

Main Bearing Capscrew Threads

If threads are damaged, block may be repaired by installing Heli-Coil insert using ST-1230 Heli-Coil Kit as follows:

1. Drill out old threads with a 1-1/32 inch drill to a depth of 2.675 to 2.705 inches [68.16 to 68.74 mm] from the main bearing cap pad.

2. Tap drilled hole with Tap No. 9193-16H4 to a depth of 2.425 to 2.455 inches [61.60 to 62.36 mm].

3. Install insert Part No. 3591-16CN-1.500 with inserting tool No. 535-16 until insert is to a depth of 0.860 to 0.890 inch [21.84 to 22.61 mm] below cap mounting pad.

4. Break off tang using tang break-off tool No. 1196-16. (Do not use inserting tool.)

Cylinder Liners

Cummins cylinder liners form combustion chamber walls and are in direct contact with coolant for

efficient cooling. Coolant is sealed in block by accurately machined surfaces at liner flange and by packing rings and crevice seal at lower end of liner.

Inspection

1. Check for cracks in cylinder liners just under top flange, at bottom of liner, or above top seal ring groove as follows:

   a. Magnetic Method.

   b. Dye Penetrants.

2. Discard any liner with excessive corrosion or erosion and pits 1/16 inch [1.59 mm] deep or more, or if dents, pitting or fretting on underside of liner flange cannot be removed by lapping.

3. Check worn liners with dial bore gauge. Replace if worn more than Worn Limit as shown in Table 1-1 (5).

Cleaning

The recommended procedure for preparing new or used liners (after removing heavy carbon deposit and inspecting used liners for wear and surface deterioration) is as follows:

1. Wash liners with detergent soap and warm water using a bristle (not wire) scrub brush.

2. Rinse thoroughly – preferably with steam.

3. Blow liners dry with compressed air.

4. Coat liner bores generously with clean engine lubricating oil and let stand for 5 or 10 minutes.

5. Use white paper towels to wipe lubricating oil from liner bores. Note gray or black residue that appears with oil on white towels. Repeat application of lubricating oil and wipe off with towels until residue no longer shows.

6. Oil lightly with clean engine lubricating oil and store in a clean, dry location.

Crankshaft

Crankshafts are steel forgings with accurately machined and hardened main and connecting rod journals. Each shaft is balanced for proper weight distribution to ensure even forces during rotation.

Disassembly and Inspection

1. If crankshaft gear is chipped, cracked, broken or worn, remove lockplate and nut (if used).

Note: If crankshaft gear condition is satisfactory, do not remove gear.

2. Attach a circular-type puller behind the crankshaft gear.

3. Apply 75 to 100 ft-lbs [102 to 136 N• m] on puller screw.

4. If gear removal is necessary, use 3375840 Gear Puller. Remove gear and discard gear key.

5. Inspect crankshaft visually for scratches, nicks, cracks and obvious wear pattern and measure crankshaft journals with micrometers. See Table 1-1 (6).

6. Check crankshaft for out-of-round condition. Crankshafts should be reground if main bearing or crankpin journals are worn out-of-round more than 0.002 inch [0.05 mm].

Clean Drillings in Crankshaft

1. Remove all pipe plugs; clean all drilled oil passages with a stiff, nylon bristle brush and a quick drying solvent. Flush oil holes with solvent and dry with compressed air.

2. Lubricate threads with clean SAE 20W or 30W lubricating oil; install and tighten plugs to 60 to 95 in-lbs [6.8 to 10.9 N• m].

Inspect Crankshaft Journals and Thrust Flange

1. Carefully examine crankshaft journals and thrust flange at No. 7 main bearing. If surfaces are scored or scratched, crankshaft should be reground and undersize rod and main bearings or oversize thrust rings installed.

2. Reground crankshafts or those used with undersize rod and main bearings and/or oversized thrust rings should be marked so correct bearing

shells and thrust rings can be installed in proper position. Fig's. 1-6 and 1-7.

3. The marking for undersize rod and main bearings should be on front counterweight, oversize thrust ring size on rear counterweight. Both thrust ring size and ring location must be included in stamping as shown in Fig. 1-7.

Example: Front – 0.010 inch [0.25 mm] and rear – 0.020 inch [0.51 mm].

Assembly

Install crankshaft gear, if removed.

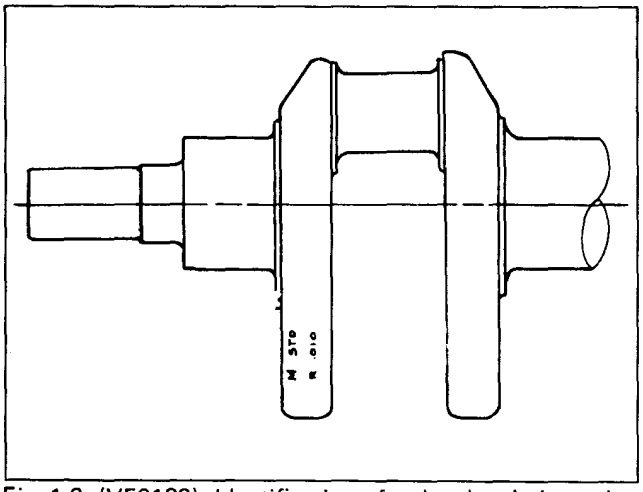


Fig. 1-6, (V50138). Identification of rod and main journal size

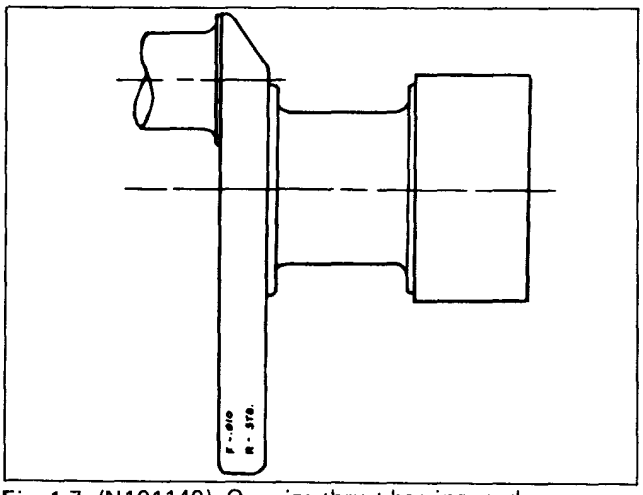


Fig. 1-7, (N101140). Oversize thrust bearing mark on crankshaft

Note: Check parts catalog for correct gear part number.

1. Install key in shaft.

2. Heat gear in a pre-heated oven at 400°F [205°C] for a minimum period of (1) hour before installation.

Note: Special care must be taken when heating crankshaft gears for installation, to prevent hot spots and overheating; overheating will remove the hardness from the gear.

3. Lubricate flange with high pressure grease and drive gear onto shaft with piece of tubing.

Bearing Shells

Main and connecting rod bearings (or shells) are two-piece units with one unit containing an oil hole for lubrication. Thrust rings are used at the rear main bearing.

Inspect Bearing Shells

1. Gauge shell with ball point micrometer, dial indicator thickness gauge, or comparator. Discard shells that are worn more than 0.001 inch [0.03 mm] or if chipped, flaked, or scored. See Table 1-1 (7-8) for thickness of standard shells.

2. Total worn maximum oil clearance should not vary more than 0.002 inch [0.05 mm] between adjacent main bearings. See Table 1-1 (7-8).

Note: Under no circumstances should an attempt be made to scrape bearing shells, nor should they be lapped or filed to increase oil clearances. A properly fitted bearing will appear dull gray after a reasonable period of service, indicating it is running on an oil film. Bright spots indicate metal-to-metal contact and black spots indicate excessive clearance.

Crankshaft Thrust Rings

1. The best measurement of wear on crankshaft thrust rings is the crankshaft end clearance check. See "Engine Assembly", Group 14 and Table 1-1 (9-10).

2. Oversize thrust rings are available; be sure to use same size (thickness) half-ring on both upper

and lower portions. Stamp crankshaft rear counterweight indicating size used.

Note: Allowable amount of wear on thrust ring depends upon wear of crankshaft surfaces. Installed in a cylinder block, crankshaft end clearance should not exceed 0.022 inch [0.56 mm] at rebuild; however, at the maintenance check, when engine is operating satisfactorily, end clearance is allowable to maximum of 0.035 inch [0.89 mm].

Vibration Damper

The vibration damper is a unit which counteracts twisting or torsional vibrations of crankshaft. The damper is engineered to match engine model on which it is used. To prevent failures make sure it is operative at all times. Two types of vibration dampers are used on Cummins engines — rubber element and viscous.

Cleaning

1. Rubber element dampers should be cleaned in household detergent.

2. Viscous dampers should be cleaned of rust, dirt or grease with a suitable solvent cleaner.

Dampers are not subject to field repair; therefore, if inspection shows them to be defective, install new dampers.

Rubber Element Damper

Most engines use rubber element dampers, which are tuned to the engine's natural system frequency. These are made of metal units separated by rubber compound material. The dampers are designed to provide adequate protection for the engine when normal power transmitting components are connected in a suitable manner.

1. Inspect rubber element damper for cracks, and elastic member for deterioration that will impair its effectiveness.

2. Check for alignment of index marks (3, Fig. 1-8) on damper hub (1) and inertia member (2). If out of alignment more than 1/16 inch [1.59 mm], discard damper.

3. Check for damper wobble on inner ledge of inertia "outer" member; wobble should not exceed 0.0025 inch per inch [25.4 mm] of diameter at point of measurement. Discard unserviceable damper. See "Crankshaft Flange and Vibration Damper Installation", Group 14.

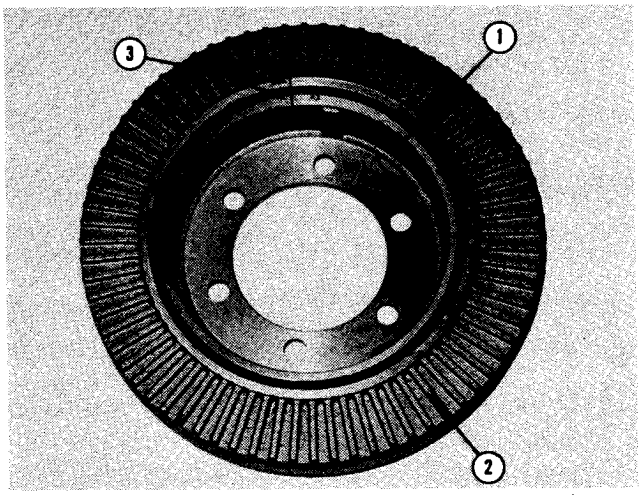


Fig. 1-8, (N10146). Vibration damper alignment marks

Viscous Dampers

Viscous dampers operate on a different principle and are not as critical in their operation. Due to design, operation over a greater variation in load and mass is possible.

1. Spray damper with Spotcheck Developer, Type SKD-NF, or equivalent. Place damper in oven heated to 200°F [93°C]. Allow damper to reach oven temperature.

2. Remove damper from oven and inspect for oil smudges or fluid leakage. If oil smudges appear, discard vibration damper.

3. Remove the paint and accumulated dirt and grime from both the front and rear surfaces of the damper in four (4) equally spaced areas, as shown in Fig. 1-9 (avoid areas with stamped lettering). This will allow for precise measurement of the damper's thickness with micrometer.

Caution: Coarse emery cloth or scraper should not be used as they may remove excess material from the surfaces of the damper. Use only a good paint solvent and fine (240 grit) emery cloth.

4. Measure and record the thickness of the damper

at each of the four (4) equally spaced areas approximately 0.125 inch [3.18 mm] from the outside edge of the front cover plate as shown in Fig. 1-10.

5. Replace the damper if the variation in the four (4) thickness dimensions exceeds 0.010 inch [0.25 mm].

Vibration Damper Mounting Flange

1. Check damper mounting capscrew hole threads.

2. Maximum eccentricity of mounting flange, measured on outside diameter of pilot, should not exceed 0.004 inch [0.10 mm] total indicator reading. Wobble of flange, measured at 2-3/4 inch [69.85 mm] radius, should not exceed 0.003 inch [0.08 mm]. The above readings are to be taken after assembly to engine. Crankshaft must be kept to front or rear thrust limit while wobble is checked.

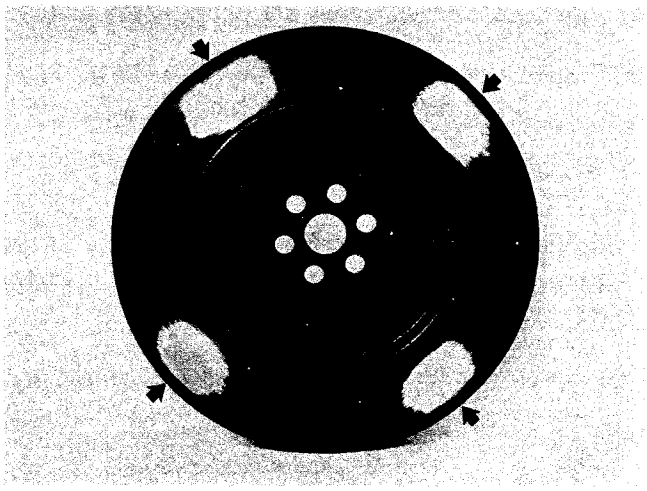


Fig. 1-9, (N101116). Damper prepared for measuring

Fig. 1-10, (N10117). Measuring damper

Connecting Rod

Inspection

1. Magnaglo all connecting rods, caps, capscrews and bolts; discard if cracks are detected. Not all indications are cracks. Forging lines and surface imperfections may show as indications. These lines do not affect connecting rod strength.

Note: Be sure rod and cap are kept mated at all times.

2. Assemble cap to rod and alternately tighten capscrews or nuts to prescribed torque as described in Table 1-1 (19). See Fig. 1-11 for sequence.

3. Check crankpin bore with dial bore gauge.

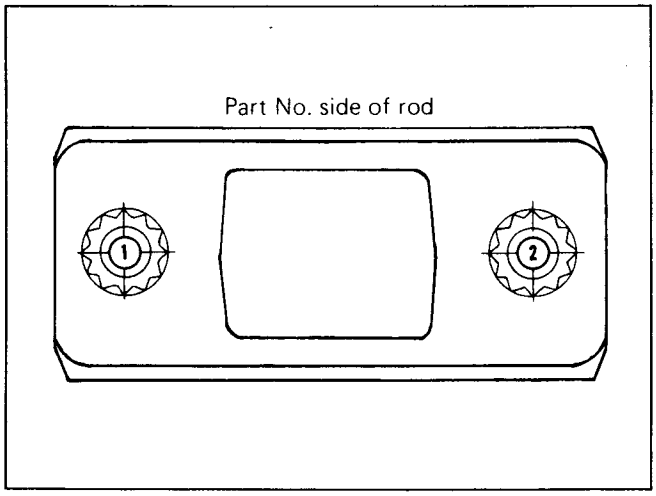


Fig. 1-11, (N114222) Connecting rod torquing sequence

a. On 2 inch camshaft engines the connecting rod bore diameter must be within 3.2722 to 3.2736 inch [83.114 to 83.149 mm] up to 30 degrees on either side of parting line. Fig. 1-12.

b. On 2-1/2 inch camshaft engines the connecting rod bore diameter must be within 3.3157 to 3.3171 inch [84.219 to 84.254

mm] up to 30 degrees on either side of parting line. Fig. 1-12.

c. On 2 inch camshaft engines the connecting rod bore diameter must be within 3.2722 to 3.2732 inch [83.114 to 83.139 mm] beyond 30 degrees on either side of parting line. See Fig. 1-12.

d. On 2-1/2 inch camshaft engines the connecting rod bore diameter must be within 3.3157 to 3.3167 inch [84.219 to 84.244 mm] beyond 30 degrees on either side of parting line. See Fig. 1-12.

e. If either specification is not met, the rod must be resized.

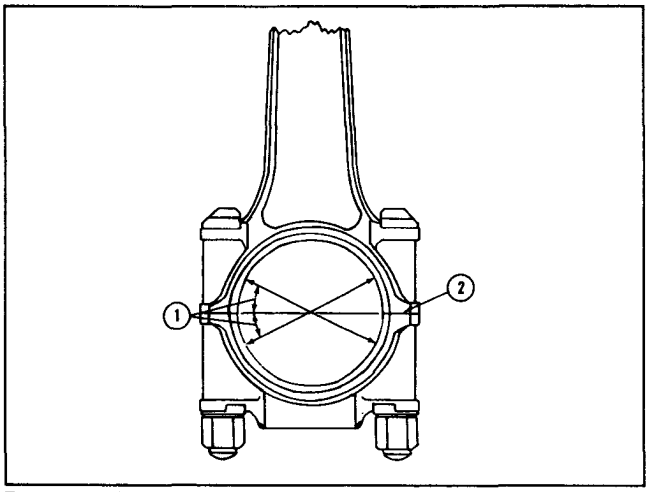


Fig. 1-12, (N10194). Connecting rod measuring points

4. Gauge piston pin bushing diameter with dial bore gauge. See Table 1-1 (11).

5. Use ST-561 Checking Fixture and ST-563 Locating Mandrel to check rod alignment.

6. Scrap rods with nicks or dents in excess of 1/32 inch [0.80 mm] deep on the I beam.

Calibrate ST-561 Checking Fixture for Rod Size

1. Select a new rod that has been checked for correct absolute center to center length, 12 inch [304.80 mm] between centers. Production rods may vary from 11.998 to 12.000 inch [304.75 to 304.80 mm].

2. Assemble cap to rod as described in Step 2 under Inspection. Bolts must press into bore sufficiently to resist, without dislocation, a 5 pound minimum longitudinal force applied to the threaded end of the bolt.

3. Insert piston pin arbor, furnished in ST-800 Mandrel Set, in piston pin bore. Insert and tighten ("snug" only) expanding arbor in crankpin bore.

4. Set master rod in fixture and move dial holder so dials indicate on piston pin. Zero dial indicators.

5. Lift rod, arbor and pin assembly from fixture, turn horizontally 180 degrees; set back in fixture. Readjust dial indicators to read half way between second readings and zero. Fixture is now calibrated.

Check Rod Bend, Twist and Center to Center Distance

Measurements read directly from dial indicator indicate comparative length and misalignment of bores. Measurements apply with or without bushing installed. See Fig. 1-13.

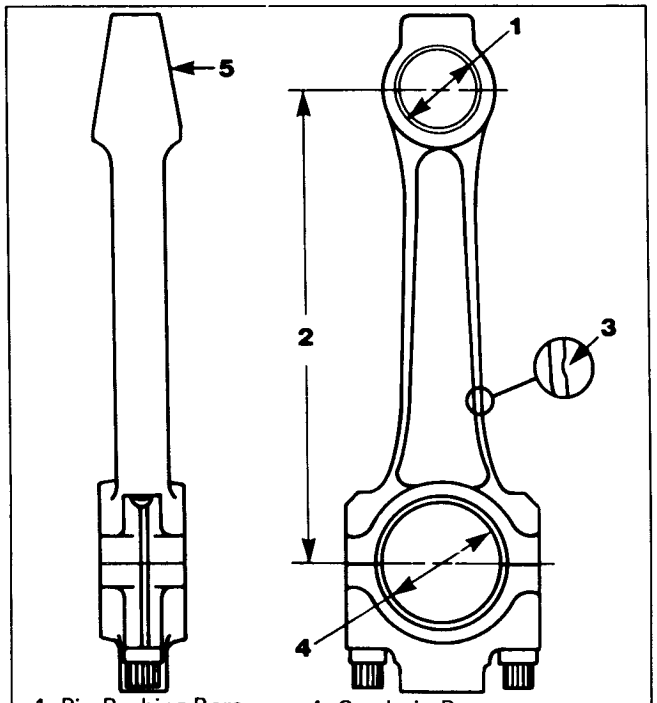
1. Assemble proper mandrel in rod to be checked and set rod in fixture. Be sure pin in mandrel is down and locked in position in center line of rod.

2. Record readings from right and left dial indicators to determine length and bend.

   a. To determine length, add right and left indicator reading (noting plus and minus readings) and divide by two. This gives the amount shorter or longer than the master rod.

   b. To determine bend, subtract the smaller reading from the larger (again noting plus and minus readings).

3. Length must be no longer than the master rod and not more than 0.002 inch [0.05 mm] shorter. Bend must not exceed 0.004 inch [0.10 mm] without bushing or 0.0015 inch [0.038 mm] with bushing installed.



1. Pin Bushing Bore
2. Rod Length
3. Defect in Rod
4. Crankpin Bore
5. Rod Taper

Fig. 1-13, (V40114). Connecting rod specifications

4. Measure rod twist with a feeler gauge between piston pin and dial holding plate. When measuring connecting rod twist in ST-561 and rod does not contain piston pin bushing, twist must not exceed 0.007 inch [0.18 mm]. Twist must not exceed 0.004 inch [0.10 mm] with bushing in place and bored to size.

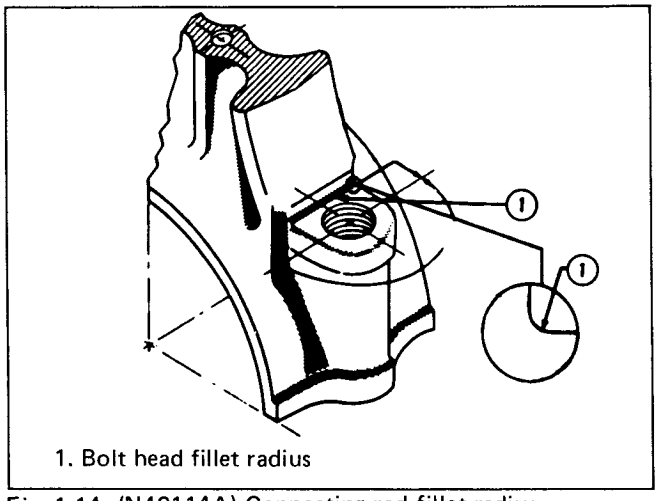
Check Bolts, Bolt Holes and Bolt Pads

1. If connecting rod bolts have been tightened excessively, they may be permanently stretched, in which case they must be discarded. Discard bolts if smallest diameter is less than listed in specifications.

2. Discard all bolts and nuts that have distorted threads.

3. Check rod bolt hole pilot inside diameter in rod and cap. If diameter exceeds wear limit or is smaller than new standard, discard rod and cap.

4. Check bolt pad radius for dents and nicks. See (1, Fig. 1-14).



1. Bolt head fillet radius

Fig. 1-14, (N40114A) Connecting rod fillet radius

Repair

Restore Fillet

1. All 2-bolt rods must have a fillet radius of 0.045 to 0.055 inch [1.14 to 1.40 mm]. Fig. 1-14. Maximum 1/16 inch [1.59 mm] depth of metal may be milled off the pad to restore radius. Break sharp edges around pad.

2. Polish fillet to 16 micro-inch.

Resize Crankpin Bore

Resize if crankpin bore is outside limits given in Table 1-1 (11) or if parting faces are damaged.

1. Remove old piston pin bushing with ST-870 Mandrel and Block. Install cap and tighten nuts to prescribed torque.

2. Recheck rod length on ST-561 Checking Fixture. If rod length is 11.991 inch [304.57 mm] or less, rod cannot be resized and must be discarded.

Note: A maximum of 0.009 inch [0.23 mm] may be machined from the cap and rod. Equal stock must be removed from cap and rod. Rod must measure 12.000 inch [304.80 mm] in length to remove 0.009 inch [0.23 mm] from mating surfaces. Center to center length must be 11.991 inch [304.57 mm] following grinding and lapping.

   a. Parts must be clamped securely during mating face grinding operation to ensure proper

contact of engine mating surfaces and proper alignment of bores for rod bolts when assembled. Bolt holes must remain perpendicular to machined mating faces.

b. Lap rod and cap mating surfaces. After grinding and lapping, "blue" machine surfaces; seating or flatness pattern must show a minimum 75 percent contact with surface plate, non-contact area must not be in area outside bolt centerline (area farthest from bore centerline); this area should indicate 100 percent contact.

3. The rod cap must be reassembled to rod and tightened to prescribed torque. On 2 inch camshaft engines line bore or grind crankpin bore to 3.2725 to 3.2730 inch [83.122 to 83.134 mm] inside diameter. On 2-1/2 inch camshaft engines, line bore or grind crankpin to 3.3160 to 3.3165 inch [84.226 to 84.239 mm]. A fixture is required to maintain alignment of bores.

Note: The above measurement is boring dimension before rod and cap separation.

4. Check bend and twist on ST-561. See "Check Rod Alignment".

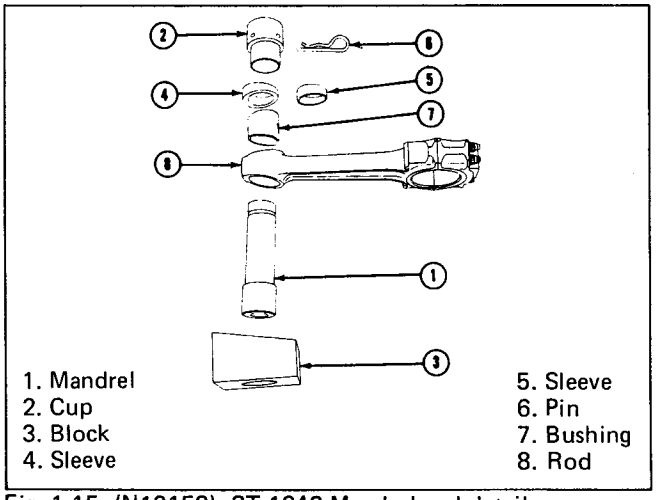
Note: ST-294 Boring Machine is not suitable for this job. Use ST-526, a milling machine or cylindrical grinder with a precision fixture. Finished surface must be to 75 micro-inch or better to ensure proper contact with connecting rod bearing shells.

5. Install and bore new heavy-wall piston pin bushing as described under "Replace Piston Pin Bushing". Heavy-wall special bushing must be used. Bore piston pin bushing off-center to restore rod to original 11.998 to 12.000 inch [304.75 to 304.80 mm] length.

Replace Piston Pin Bushing

1. Remove worn bushings with ST-1242 Mandrel and Detail 5 (Fig. 1-15); remove tool.

2. To install standard size bushing (7) in rod, assemble bushing (7) on mandrel (1), position sleeve (4) then cup (2) on mandrel (1). Secure with locking pin (6).



1. Mandrel
2. Cup
3. Block
4. Sleeve
5. Sleeve
6. Pin
7. Bushing
8. Rod

Fig. 1-15, (N10158). ST-1242 Mandrel and details

3. Place connecting rod on block (3) and support in horizontal position.

4. Insert mandrel with all components listed in Step 2 into connecting rod bushing bore.

5. Align detail (4) with middle of boss on rod.

Note: Be sure to line up oil holes.

6. Using an arbor press, press bushing into bore until detail (4) contacts side of rod pin boss.

7. Check oil hole alignment. A 1/8 inch rod must pass freely through rod and bushing.

Bore Rod Piston Pin Bushing

1. Fill lubricating holes with soap to keep out shavings.

2. Mount connecting rod in ST-526 Tobin-Arp Boring Machine or equivalent.

Note: Lower mandrel should have only the two horizontal blades in place to properly locate the side position of the piston pin end of rod.

3. See instruction booklet furnished with ST-526 for operating procedure.

4. Bore bushing to 2.001 to 2.0015 inch [50.83 to 50.838 mm] inside diameter. Remove rod from ST-526 and check size with dial bore gauge.

5. Remove sharp edges with a scraper.

6. Remove shavings and soap, wash in mineral spirits and dry with compressed air.

7. Check all dimensions on rebushed and rebored rods on ST-561 Checking Fixture as previously described.

Note: All connecting rods used in an engine should be the same part number. Never attempt to interchange caps.

Chamfer Piston Pin Bore

1. ST-861 Chamfering Tool is used to chamfer piston pin bushing bore, if not chamfered.

2. Install proper bushing tool detail by use of flat-head screw.

3. Set the guide screw holder in position; there are three notches, so guide screw will follow on face of bore.

4. Adjust tool bit until point just clears guide screw and tighten in position with two set-screws.

5. Install unit into bore.

6. Adjust the guide screw (up or down) until tool bit just engages bore.

Note: A slight pressure is required against guide screw. To obtain this pressure, tighten setscrew in end of holder against guide screw.

7. Insert drive ratchet and turn tool one complete turn to clean up edge of bore.

8. Loosen guide screw and again turn tool one or more complete turns to give a clean cut.

Note: Repeat until a uniform chamfer of 0.020 to 0.030 inch [0.51 to 0.76 mm] depth is reached.

9. Remove tool from bore, turn rod over and chamfer other side of bore.

10. With both sides chamfered, remove tool.

11. Use emery cloth to remove any sharp edges which may have been left on chamfer.

12. Wash rod before bushing installation.

Pistons and Piston Rings

Piston Rings

New rings should be checked in cylinder liner in which they are to be used to make sure the gaps are correct.

1. Insert each ring in mating cylinder liner; position with head of piston so it is seated squarely in ring travel area of liner.

2. Measure ring gap with a feeler gauge. Gap should fall within limits given in Table 1-1 (14).

3. Never file or stone chrome-plated rings and never use chrome-plated rings in chrome-plated cylinder liners.

4. Check current parts catalogs and service literature to assure use of proper ring/piston combination. When used, chrome-plated compression ring is always installed in top piston ring groove.

Pistons

Inspection

1. Check top and second ring grooves with ST-560 Ring Groove Gauge. Shoulders of gauge must not touch ring groove lands if piston is to be reused. If shoulders touch, discard piston.

2. If ST-560 is not available, check wear with a segment of a new ring and a feeler gauge.

   a. Hold ring in groove, flush with land and insert 0.006 inch [0.15 mm] feeler gauge.

   b. If gauge enters groove without forcing or disengaging ring, wear is excessive and piston should not be used.

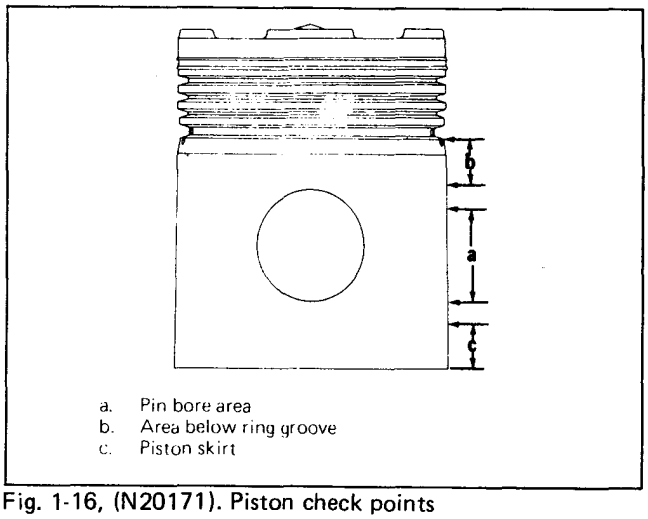
3. Measure piston skirt diameter with micrometer at right angle to piston pin bore (A, Fig. 1-16 for barrel-ground pistons); measure straight or tapered ground pistons at Point B, 1 inch [25.4 mm] below ring groove and C, 1 inch [25.4

mm] above bottom of piston. Pistons should not be reused if worn more than 5.483 inch [39.27 mm].

4. Pistons should be checked at temperature of 70 to 90°F [21 to 32°C]. After measuring piston and comparing with liner inside diameter, piston-to-liner clearance may be computed if desired.

5. Piston pin bore checked at 70°F [21.1°C] should fall within limits shown in Table 1-1; and 0.0005 inch [0.013 mm] per 10°F [−12°C] up to 90°F [32°C].

6. Check piston pin outside diameter with micrometer. Pins should not be reused if out-of-round more than 0.001 inch [0.03 mm] or worn smaller than indicated in Table 1-1 (13). Reboring of piston pin bores and use of oversize pins is not practical because the misalignment that results from such practice will cause seizure of piston or failure of connecting rod bearings.



a. Pin bore area
b. Area below ring groove
c. Piston skirt

Fig. 1-16, (N20171). Piston check points

Piston-to-Connecting Rod Assembly

1. Pistons are machined to a very close weight tolerance; therefore, as long as the same part number piston is used throughout the engine, weight does not affect engine operation. 218520 Four Ring Pistons may be intermixed with 214870 Five Ring Pistons.

2. Be sure rod and cap are stamped with cylinder number from which removed before disassembly to prevent mixing parts.

3. Install one piston pin snap ring in groove of piston pin bore.

4. Heat aluminum pistons in boiling water or in an oven at or below 210°F [98.9°C] and install pin through piston and connecting rod pin bores before piston cools; at 70°F [21°C] the pin fit is 0.0001 to −0.0003 inch [0.003 to −0.008 mm] which prevents pin assembly unless piston is heated. Secure pin with second snap ring in groove at opposite end of pin bore.

Caution: Never drive piston pin in pistons. Driving may cause distortion of piston, causing piston seizure in cylinder liner.

Rear Cover

The rear cover is a unit subject to replacement of seals only. Damaged housings require replacement by a new assembly or installation of thread insert for stripped threads; these are only items of repair.

Alignment during engine assembly is the biggest factor for proper performance of the rear cover unit. See Group 14.

Camshaft

Inspection

Check camshaft bushing journals with micrometers. Replace camshaft if journals are worn beyond limits given in Table 1-1.

Replace camshafts that have scuffed, scored, or cracked injector or valve lobes. Check by magnetic inspection for possible cracks.

Cummins Engine Company, Inc., does not recommend regrinding of camshaft lobes.

Camshaft Support

If cast iron support is used, inspect bushing in support; remove if damaged or worn smaller than 1.370 inch [34.80 mm]; press in new bushing flush with inner bore. New dimensions are 1.3725 to 1.3755 inch [34.862 to 34.938 mm]. Replace aluminum support.

Thrust Bearing

Inspect thrust bearing for flaking, burrs, distortion and wear; discard if damaged or worn smaller than 0.083 inch [2.11 mm]. New dimensions are 0.093 to 0.098 inch [2.36 to 2.49 mm].

Gear

1. Remove gear if chipped, cracked or visibly worn. Gear is press-fit on camshaft.

2. Place camshaft in a press between V blocks. Support hub area with V blocks or equivalent spacers.

Caution: At anytime a crankshaft or camshaft gear is to be reused do not apply heat with a torch during removal or assembly. If a heating torch is used for gear removal, a new gear must be installed to avoid future gear failure.

3. Press camshaft from gear; remove key.

4. Remove pipe plug from drive end of camshaft; clean oil passages as required.

Note: On engines not equipped with outboard bearing, camshaft contains an orifice plug 68193. Do not mix with other 1/8 inch orifice plugs. This may produce a slight reduction of engine oil pressure.

5. Install pipe plug in drive end of camshaft, if removed. Torque pipe plug to 5 to 10 ft-lbs [7 to 14 N• m].

6. Heat camshaft gear in preheated oven at 400°F [205°C] for a minimum period of one (1) hour before installation. Maximum clearance between camshaft flange and gear face is 0.0015 inch [0.038 mm]; check with feeler gauge.

7. Place camshaft in press; insert new key in camshaft. Press on camshaft gear while hot.

8. On all turbocharged and aftercooled engines, a retainer ring must be pressed in place after the camshaft gear. Heat retainer to 450°F [232°C] in same manner as gear and press against gear. This requires use of special camshaft support bushing in front cover.

Note: Always check timing when a new camshaft or gear is installed in an engine.

Gear Cover

Inspection

1. Remove and discard all oil seals. See Service Tool Instructions this section, for in-frame repair and seal replacement.

2. Check trunnion and/or bushing for wear; replaceable bushing is available to "rebuild" outside diameter of trunnion which was not originally equipped with bushing.

3. Check thrust plates for deep scores or wear beyond point where removal of gaskets will now allow establishment of correct camshaft end play. See Camshaft Installation, Group 14.

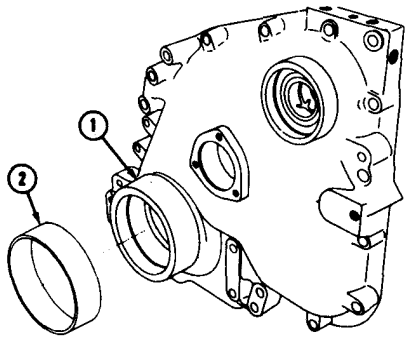
Parts Replacement and Repair

Gear Cover Trunnion

If gear trunnion on cover is to be "bushed", install as follows:

1. Machine gear case trunnion (1, Fig. 1-17) to 4.747 to 4.750 inch [120.57 to 120.65 mm] outer diameter.

2. Press bushing (2) (Part No. 68226-1) over machined trunnion with chamfered side of bushing toward gear case.



1. Gear Case Trunion
2. Bushing

Fig. 1-17, (N10145). Gear case cover and trunnion bushing

Camshaft Support

1. Front camshaft supports are used in gear cover of some turbocharged engines and are one piece aluminum.

2. Check inside diameter, per wear limits in Table 1-1; discard unserviceable parts.

Accessory Drive Bore Bushing

1. Check bore of accessory (fuel pump and compressor) drive; if worn larger than 1.571 inch [39.90 mm], replace.

2. If accessory drive shaft is worn enough to allow use of oversize bore bushing (maintain minimum clearance of 0.003 inch [0.08 mm] between shaft and bushing), use as listed in Table 1-1.

3. Press in new bushing using ST-598 Mandrel. Oil hole alignment must be such that a 0.156 inch [3.96 mm] diameter rod will pass through the bushing.

Accessory Drive Bore Bushing (NTA)

1. Check bore of accessory (fuel pump and compressor) drive bushing; if worn larger than 1.7585 inch [44.666 mm] replace.

2. Press in new bushing using ST-1171 Bushing Mandrel. Refer to Parts Catalogs for correct part number. Oil hole alignment must be such that a 0.156 inch [3.96 mm] rod will pass through the bushing.

Service Tool Instructions

ST-1010 Water Hole Counterboring Tool

See Service Tool Instructions, Cylinder Heads, Group 2.

ST-1295 Cylinder Liner Counterboring Tool

ST-1295 and ST-1065 Tool Holder are used in this operation. Assemble tools as follows:

Install ST-1065 Tool Holder (3, Fig. 1-18) onto driver unit (1). Fasten holder onto drive unit with capscrew (5).

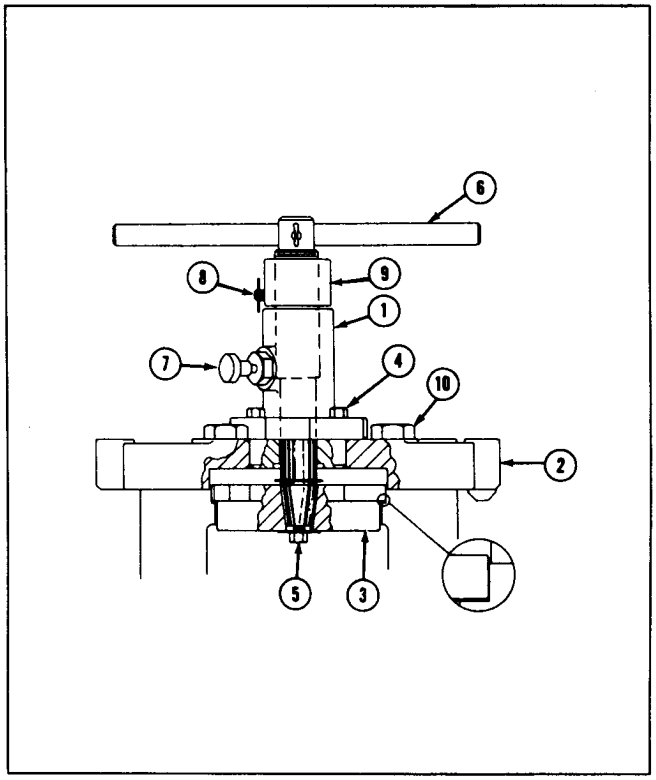


Fig. 1-18, (V40156). ST-1295 Counterbore Tool

Presetting Tool Bit

1. Loosen thumb screw and push adjusting pin back into housing. Tighten thumb screw.

2. Place tool bit setting gauge (if used) onto tool holder with dowel pins, engaging smaller diameter of tool holder and holding locating surfaces of housing against flat surface of tool holder.

3. While holding tool bit setting gauge in the above position, loosen thumb screw allowing adjusting pin to engage larger diameter of tool holder. Tighten thumb screw.

4. Install tool bit into tool holder. Set point of tool bit below larger diameter of tool holder and tighten one setscrew.

5. Place tool bit setting gauge with dowel pins engaging smaller diameter of tool holder, holding locating surfaces of housing against flat surface of tool holder.

6. Position adjusting pin over point of tool bit. Loosen setscrews allowing tool bit point to rest

against locating point of adjusting pin. Tighten setscrews.

Installation and Operation

1. Pull out on handle (6) until plunger (7) will hold tool holder (3) in the up position. Place unit on cylinder block with hold-down holes matching in cylinder block.

2. Hold onto handle (6) and pull out on plunger (7). Slowly lower tool holder into counterbore. Engaging larger diameter of holder, allow tool bit to rest on counterbore ledge.

3. Loosen locking screw (8) and rotate adjusting nut (9) in clockwise direction until tool bit clears counterbore ledge. Tighten locking screw.

4. Assemble hold-down capscrews and washers (10) through adapter plate into cylinder block finger tight; then torque to 50 to 75 ft-lbs [68 to 102 N• m].

Note: Tool holder must rotate freely.

5. To measure depth of counterbore:

   a. Install depth gauge into gauging hole of adapter plate. Loosen capscrew and push down on dial indicator to end of travel.

   b. Pull dial indicator 0.010 to 0.020 inch [0.25 to 0.51 mm] off bottom. (End of travel.) Tighten capscrew.

   c. Set dial indicator to zero.

   d. Rotate tool holder until red indicator line matches red line on adapter plate.

   e. Place depth gauge on four counterbore measuring holes. The average of the four readings will be the present depth of counterbore. See Table 1-1 (2) for counterbore depth.

6. To operate counterboring tool:

   a. Loosen locking screw. Rotate adjusting nut in counterclockwise direction until tool bit is resting on lowest part of counterbore ledge and there is clearance between housing and adjusting nut.

Note: The distance between housing and adjusting nut equals amount of material that will be removed from counterbore ledge.

   b. To set the depth of cut, place a feeler gauge of required thickness between adjusting nut and top of housing. For example: if 0.005 inch [0.13 mm] of material is to be removed from counterbore ledge, use 0.005 inch [0.13 mm] feeler gauge. Make sure there is no grease or dirt between adjusting nut and top of housing.

   c. Rotate adjusting nut until feeler gauge is just held between adjusting nut and top of housing. Tighten locking screw. Remove feeler gauge.

   d. Hold down on handle applying more pressure on tool bit side and rotate handle in a clockwise direction until unit turns freely and is bottomed out between adjusting nut and top of housing.

   e. Measure depth of counterbore as described in Step 5.

ST-1252 Concentricity Gauge

Check the cylinder liner counterbore to lower bore concentricity as follows:

1. Place gauge flat on top deck of cylinder block with bumper pins against counterbore inside diameter.

2. Raise or lower bar to position indicator in area of lower bore to be checked.

3. Holding gauge bumper pins firmly against counterbore inside diameter, zero indicator.

4. Release pressure; reposition gauge to check indicator reading. Rezero indicator if necessary.

5. Place gauge 180 degrees from original setting position, hold bumper pins firmly against counterbore inside diameter, record indicator reading.

6. Move gauge 90 degrees and repeat procedure.

Note: Indicator readings recorded are two (2) times actual shift of bore.

Example: Indicator reading – 0.002 inch [0.05 mm]. Actual shift from center of bore – 0.001 inch [0.03 mm].

ST-1168 Cylinder Liner Counterbore Salvage Tool

This tool is used to enlarge damaged counterbores for the installation of salvage sleeve 202226 or bores that have been reworked to maximum depth.

Assembly of Tool

1. Assemble and secure adapter plate (ST-1168-28), (Fig. 1-19) to main body.
2. Assemble tool holder (ST-1168-39) on shaft of main body (1168) and secure with nut (ST-1168-33) and washer (ST-1168-34).

Machining the Block

1. Remove cutting tool from (ST-1168-39) holding plate.
2. Place boring machine on cylinder block above bore to be cut and hand start mounting capscrews. Capscrew spacers (ST-1168-29 or 40) must be on capscrews.
3. Lower tool holder into bore by pulling up on orifice retractor knob (ST-1168-14) while pushing down on set collar (ST-1168-12).
4. Tool holder lower diameter is used to center machine in counterbore inside diameter. Push tool holder lower locating diameter into counterbore and tighten four mounting capscrews alternately to 25 to 35 ft-lbs [34 to 47 N• m] torque.
5. Retract tool holder by pulling up on orifice retractor knob (ST-1168-14).
6. Loosen setscrew (ST-1168-23) in back end of tool bit and push adjustable set pin (ST-1168-21) all the way in. Lock setscrew.
7. Adjust micrometer (ST-1168-25) to 6.750 inch [171.45 mm].
8. Place tool bit (ST-1168-19) in tool bit gauge and hold firmly against stop and hardened pad (ST-1168-27). Loosen setscrew and allow adjustable set pin to come out against micrometer spindle. Lock setscrew.
9. As a further check, back off thimble on micrometer and recheck tool bit length again.
10. Insert tool bit into tool holder and tighten lockscrew (ST-1168-20). Tool bit must be held all the way in against tool holder.
11. Turn tool holder until tool bit recess is at large opening in (ST-1168-28) adapter plate.
12. Place a 0.004 inch [0.10 mm] feeler gauge between block and tool bit and lower tool bit onto feeler gauge by pulling up on retractor knob while pushing down on set collar.
13. Loosen set collar setscrew and back off collar counterclockwise until salvage sleeve can be placed between collar and boring machine main body as a depth indicator. Tighten setscrew in set collar. Remove feeler gauge.

Note: This spaces the set collar to cut a depth 0.004 inch [0.10 mm] less than total height of salvage sleeve to be used.

14. Place 1/2 inch drive flex adapter (ST-1168-48) in a 1/2 or 3/4 inch heavy duty (10 amperes or more) hand drill.

Caution: Do not use drill rated less than 10 amperes or over 450 rpm.

15. With drill on half inch drive of boring tool (ST-1168-3), bore hole until drill freewheels. About half way down during cut, tool bit begins cutting out old counterbore ledge; operator should have a firm grip on drill to be prepared for increased load on drill from added metal being cut. Stop immediately when drill freewheels.
16. Retract tool holder by pulling up on retractor knob. Remove tool bit from tool holder. Clean

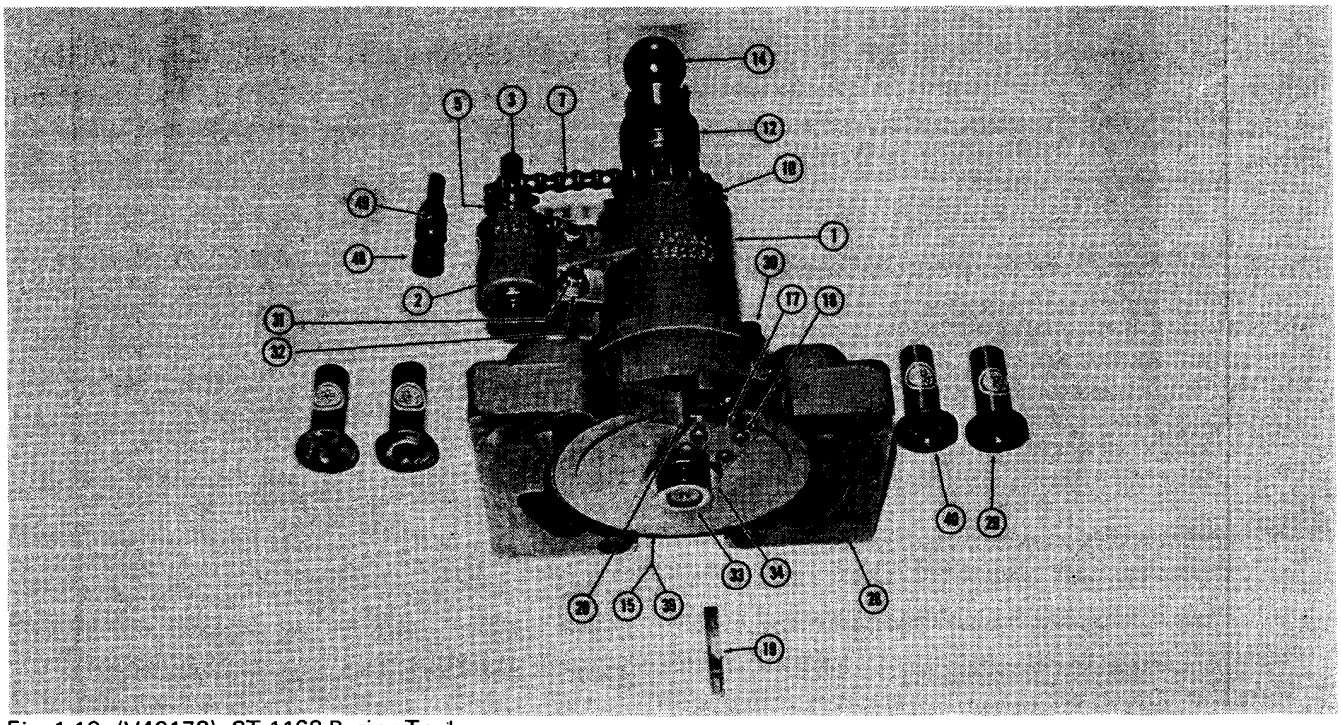


Fig. 1-19, (V40172). ST-1168 Boring Tool

1. Body
2. Drive Bracket
3. Drive Shaft
5. Drive Sprocket
7. Drive Chain
10. Driven Sprocket
12. Depth Collar
14. Knob
15. Guide Plate
17. Tool Locating Plate
18. Capscrews
19. Tool Bit
20. Adjusting Pin
28. Base Plate
29. Spacer
30. Capscrew
31. Bolt
32. Nut
33. Jam Nut
34. Washer
39. Guide Plate
40. Adapter
48. Universal Joint
49. Roll Pin

away all shavings and deburr bore with emery cloth.

Installing Salvage Sleeve

1. Clean bore thoroughly with a non-petroleum base solvent or cleaner.

2. Coat outside of sleeve lightly with a suitable sealant and drive sleeve into bore with driver until it bottoms (see ST-1168-36 through 46). A solid sound can be heard when sleeve bottoms.

3. The sleeve will protrude above the top of block by 0.004 inch [0.10 mm] and must be filed even with the top of block. Remove all burrs with emery cloth.

4. The salvage sleeve is designed to be 0.005 to 0.010 inch [0.13 to 0.25 mm] above required counterbore depth. Check depth and cut to specifications listed in Table 1-1 (2).

ST-1177 Main Bearing Boring Tool

This tool is designed to perform both the boring and checking functions. Before boring operation, allow tool and block to stabilize to room temperature.

Assembly to Block

1. Remove two undamaged main bearing caps, preferably one from each end of block or as far apart as possible.

2. Insert proper centering rings, with oiler up, in two bores and tap top of centering ring with plastic hammer to seat.

3. Reinstall main bearing caps and torque to

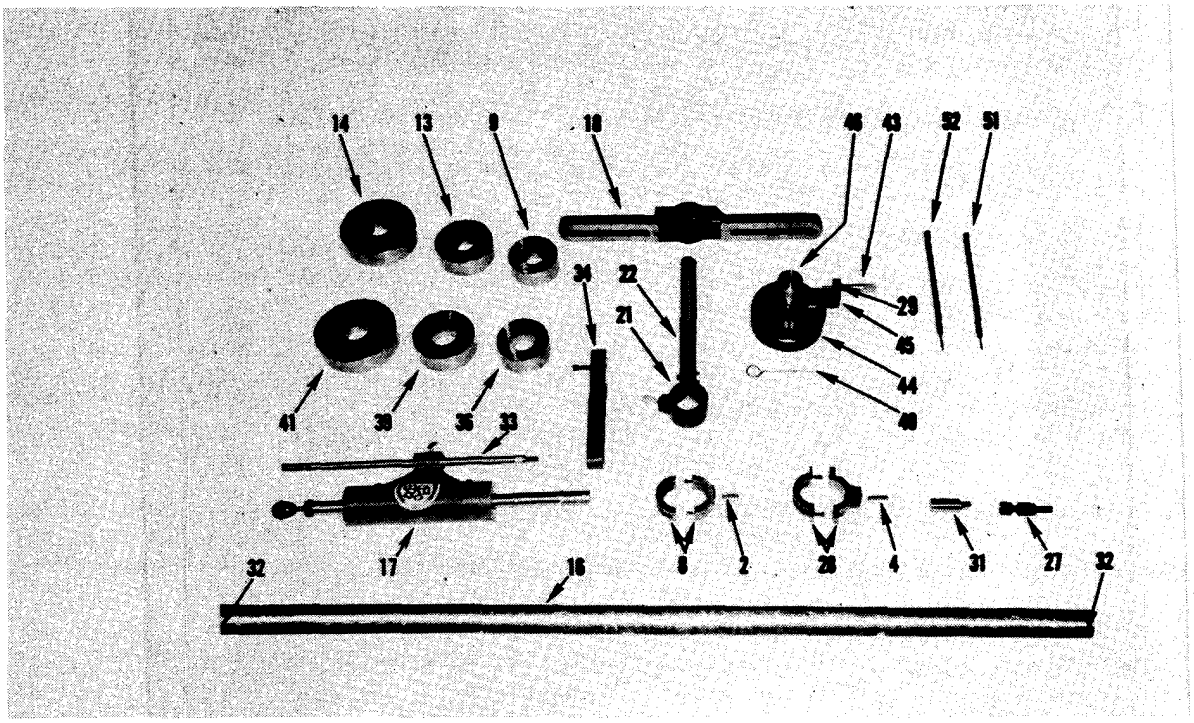


Fig. 1-20, (ST-1177). Exploded view of ST-1177 Boring Tool

2. Cutting Tool
4. Cutting Tool
8. Cutter Holder
9. Checking
13. Checking Ring
14. Checking Ring
16. Bore Bar
17. Bore Feed Assembly
18. Bore Bar Bridge
21. Bearing Bridge
22. Bearing Bar
27. Swivel Joint
28. Cutter Holder
29. Capscrew
31. Drive Adapter
32. Capscrew
33. Torsion Bar
34. Bracket
36. Centering Ring
39. Centering Ring
41. Centering Ring
43. Micrometer
44. Micrometer Base
45. Micrometer Bracket
46. Micrometer Shaft
49. Cutter Pin
51. Allen Wrench
52. Allen Wrench

required specifications, following steps in Table 1-1 (18).

Note: If centering ring must be installed in journals which have had caps replaced by semi-finished caps, limit torque to 10 ft-lbs [14 N• m].

4. Oil centering ring bores and boring bar, install boring bar (ST-1177-16), (Fig. 1-20) through centering rings rotating slowly. Bar should spin free. Slide bar out one end until appropriate checking ring can be installed in bar. Oil outside diameter of checking ring.

5. Using light finger pressure against checking ring (ST-1177-13) on both sides of bar, push checking ring through each bore. Bar must be turned during this check.

   a. Check bore for burrs if checking ring will not pass through bore.

   b. A 0.003 inch [0.08 mm] feeler gauge (not over 1/2 inch [12.70 mm] wide) can be used in detecting irregularities in the bore.

   c. Attempt to insert feeler gauge between bore and bar or slip ring as used on ST-1177 Boring Tool. Run gauge completely around bar or slip ring on each side of bore. Evaluate as follows:

      1) Gauge does not enter at any point, bar rotates freely – standard bore.

      2) Gauge enters on one side and not on opposite – slight misalignment. No problem if bar rotates freely.

      3) Gauge loose – oversize bore.

      4) Gauge enters on front and not on rear of bore – tapered bore.

6. Mark bores to be salvaged.

Assembling Micrometer Tool Bit Setting Gauge and Tool Bit

1. Place micrometer base shaft (ST-1177-46) through bore of micrometer bracket (ST-1177-45) and thread into micrometer base (ST-1177-44). Tighten securely.

2. Tighten the socket head screw (ST-1177-29) in the micrometer bracket until the bracket is tight on the micrometer base shaft; micrometer hole in micrometer bracket must be in alignment with cutting tool hole in micrometer base shaft.

3. Install centering ring (ST-1177-39) over micrometer base shaft and micrometer (ST-1177-43) in micrometer bracket:

   a. Adjust micrometer thimble to value stamped on centering ring.

   b. Hold micrometer spindle against centering ring and tighten socket head screw in micrometer bracket. Check to see that micrometer spindle turns free.

4. Remove centering ring and install appropriate cutter holder over micrometer shaft.

5. Align tool bit hole in cutter holder with hole through micrometer base shaft and tighten cutter holder socket head screws. Scribed lines are used on the base shaft and cutter holder for this purpose. Keep even gaps between two halves of cutter holder.

6. Insert appropriate cutting bit in tool holder. Tool must be short enough so it does not extend into the bore of the tool holder. When adjusting micrometer or tool cutter, be careful to "just contact" tool to prevent damage.

7. With cutter key (ST-1177-49) adjust tool bit against micrometer spindle and tighten tool bit retaining screw in cutter holder, back off micrometer and check tool bit setting.

Note: Do not tighten micrometer spindle against tool bit point or carbide may be chipped. Do not sweep micrometer spindle across carbide cutter for it will chip cutting edge.

8. Back off micrometer and remove holder from micrometer base shaft.

Cutting Bores

1. Install bore feed assembly (ST-1177-17) in one end of boring bar and tighten socket head screw (ST-1177-32).

2. Install torsion bar (ST-1177-33), threaded end first, through bore feed assembly, (ST-1177-17) start threads into end hole of torsion bracket (ST-1177-34). The flats on bar can be used to secure it to bracket.

3. Locate tapped hole in end of block and secure torsion bracket to block with a suitable capscrew and washer.

4. Pull out on plastic knob of feed assembly until pin is free of slot and turn one-fourth (1/4) turn, then pull complete feed assembly back all the way to the knob and tighten wing setscrew in feed assembly to secure on torsion bar.

5. Install square head set bolt in second threaded hole of torsion bracket end and tighten snug against cylinder block to stabilize torsion assembly.

6. Turn plastic knob on drive assembly one-fourth (1/4) turn until pin seats in groove.

7. Install adapter; (ST-1177-31) in other end of boring bar with one-half (1/2) inch square drive out. Lock with socket head setscrew.

8. Lock swivel joint (ST-1177-27) in a 1/2 inch drill chuck. These instructions assume use of a right hand rotation drill.

9. Install tool bit holder on boring bar, next to journal to be cut. When operating, boring bar will feed toward feed assembly. Make sure tool bit cutting edge is turned in direction of drill rotation.

10. With swivel joint on boring bar adapter, bore the journal. Keep boring bar well lubricated during all boring operations.

Caution: Do not use drill rated less than 10 amperes or over 450 rpm.

11. To cut next journal:

    a. Remove cutter holder from boring bar.

    b. Pull out on plastic knob on feed assembly and turn one-fourth (1/4) turn.

    c. Push in on feed shaft (the knob) until it stops against feed assembly.

    d. Turn plastic knob one-fourth (1/4) turn, until pin seats in slot.

    e. Repeat Steps 9 and 10.

12. Clean block and check size of bore with a dial bore gauge and alignment with checking ring.

Use of the Bridges

The bridges and bearings are intended for additional support of boring bar and are designed to compensate for any distortion of block oil pan surface. It is not necessary to use bridges if centering rings are located equally apart.

Example: If No. 1, 3, 4, 5 or 7 journals are to be bored and centering rings are in 2 and 6 journals, bridges are not necessary.

1. Assemble bearing bar (ST-1177-22) on bearing bridge (ST-1177-21) with hexagon head capscrew (ST-1177-23) finger tight.

2. Slide bearing over boring bar at point where support is needed. Allow room for cutter holder, if next to journal being cut.

3. Lower line bore bridge (ST-1177-18) over bearing bar and secure to oil pan rails.

4. Tighten socket head screw (ST-1177-25) in bearing until bearing is snug on boring bar; do not restrict bar from turning.

5. Tighten hexagon head capscrew (ST-1177-25) in bearing bar and socket head capscrew (ST-1177-19) in bridge.

6. Turn boring bar to see that it is free.

3375053 Thrust Surface Cutter

The ability to line bore the main bearing bore of Cummins Engines using ST-1177 Boring Bar is a big advantage in salvaging engine blocks. The one job required to make the tool complete was a means to cut the thrust surface. The 3375053 Thrust Surface Cutting Tool (Fig. 1-21 and Table 1) used in conjunction with the ST-1177 Boring Bar provides this ability.

Instructions for Using 3375053 Thrust Cutter

1. Install centering rings in No. 1 main bearing and thrust bearing saddles. The centering ring in the thrust saddle should be centered in saddle (Fig. 1-22) such that it will clear tool holder when cutting thrust bearing surface.

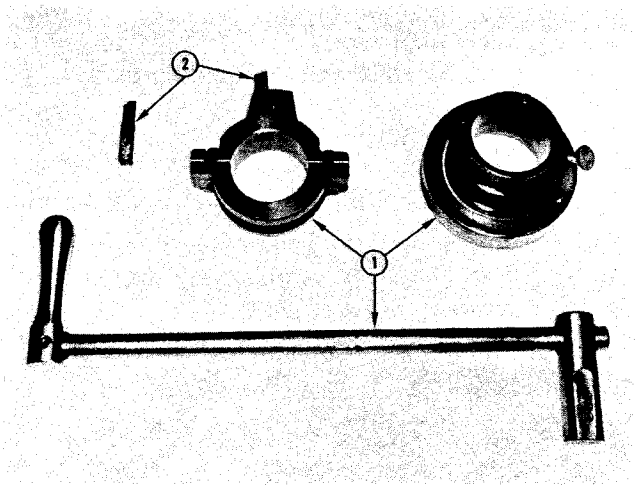


Fig. 1-21, (N101118). 3375053 Thrust Surface Cutter

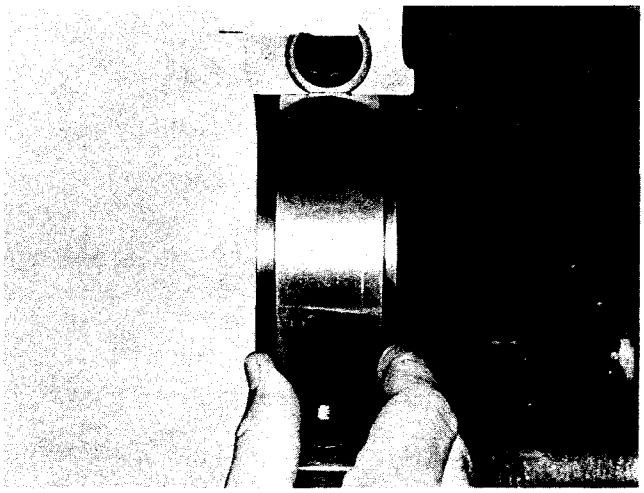


Fig. 1-22, (N101119). Installing centering ring

2. Install main bearing caps over center rings and torque to specifications.

3. Install boring bar in centering rings.

4. Install depth set collar on boring bar on opposite side of thrust surface to be cut.

5. Install T-handle drive assembly in end of boring bar. Secure with setscrew.

6. Install cutter holder and adjust cutting tool to cut the full thrust bearing surface. Fig. 1-23. The tool should be installed so it cuts when shaft is turned in clockwise rotation.

7. Set depth set collar so cutting tool is making light contact with surface to be cut and tighten setscrews securely. Fig. 1-24.

8. Turn boring bar clockwise a few revolutions to check tool bit cutting depth and pattern.

9. Adjust tool cutting depth by loosening thumb screw and rotating depth set collar clockwise (each line on collar is 0.001 inch [0.03 mm]).

Caution: Tool should be rotated very slowly during cutting operation to avoid chatter.

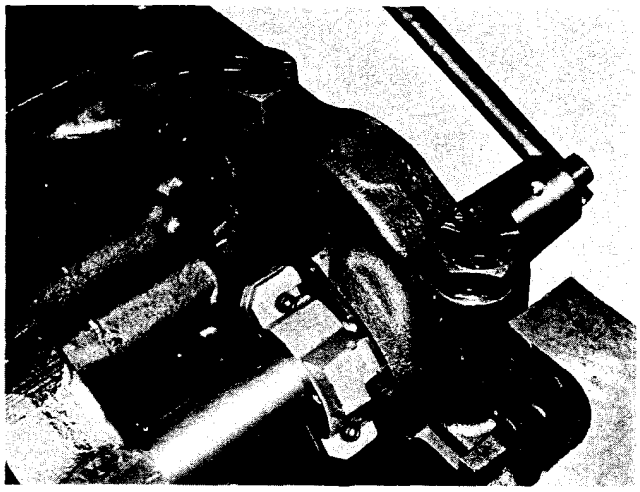


Fig. 1-23, (N101120). Cutter in position

Cylinder Head Capscrew Thread Salvage Tool

If cylinder head capscrews in the cylinder block are stripped or thread area is cracked slightly, blocks may be repaired by using a special (solid bushing-type) thread insert and appropriate tools to insure alignment and location. Special thread insert, ST-1272-15, is threaded internally and externally and also features a counterbore on one end same as capscrew hole in the block. Internal threads are same size as original threads in the block. Operations may be performed "in frame" with minimum effort on part of mechanic.

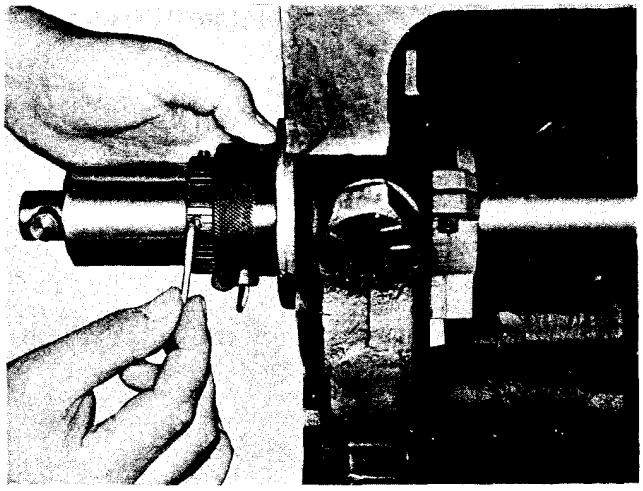


Fig. 1-24, (N101121). Setting depth set collar

ST-1272 Head Capscrew Thread Salvage Tool, to repair NH, NT-855 Engines with 11/16-16 threads in cylinder block is now available. See Fig. 1-25.

Notes:

1. To order additional thread inserts, detail 15 contains 10 thread inserts. If 20 inserts are desired, order two detail 15 thread inserts, etc.

2. Details 3, 4 and 14 are not available for service replacement, use local standard hardware source.

General Instructions (Refer to Fig. 1-25)

1. Assemble reamer guide bar (2) to base plate (1). Secure base plate to block with capscrews and spacers included.

2. Place tapered locator stem (5) through guide bar into hole to be salvaged. Tighten capscrew (3) securing guide bar to base plate.

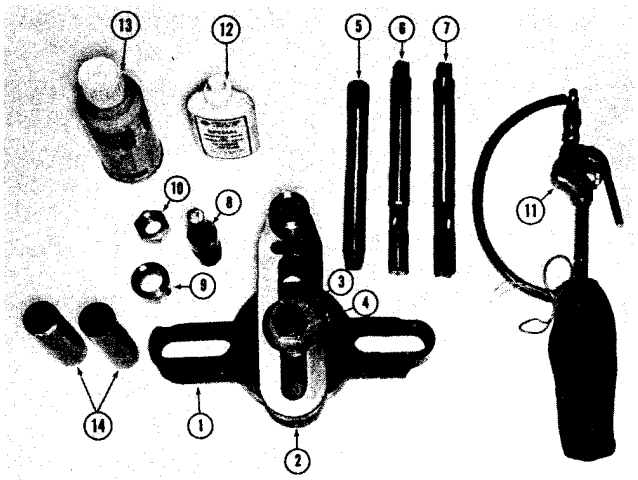


Fig. 1-25, (N101122). ST-1272 Repair Kit

1. Base Plate
2. Reamer Guide Bar
3. Capscrew (standard 5/8-18 x 3)
4. Flatwasher (standard 5/8 I.D.)
5. Locator
6. Reamer – special
7. Tap – special
8. Flex Drive Adapter
9. Stop Collar
10. Nut – special
11. Chip Remover
12. Loctite Retaining Compound
13. Loctite Primer (Grade T)
14. (2) Spacers (standard 4 inches long)
15. (10) Threaded Inserts

3. Remove tapered locator. Install special reamer (6) in pilot bushing.

4. Install flex-drive adapter (8) into heavy duty 1/2 or 5/8 inch electric drill.

5. Ream hole until reamer "bottoms out". Remove reamer and remove shavings with special shaving remover (11) gun. Fig. 1-26.

6. Reinstall reamer to ensure reamer "bottoms out" in bore.

7. Remove reamer. Install special tap in pilot bushing. Tap will sit on top of block. Fig. 1-27. Place thread insert between pilot bar and stop collar on tap. Adjust stop collar to rest on top of insert and scure collar.

8. Using electric drill and drive swivel, tap hole until stop collar is 1/8 to 1/4 inch [3.175 to 6.35 mm] from "bottoming out" on pilot bar.

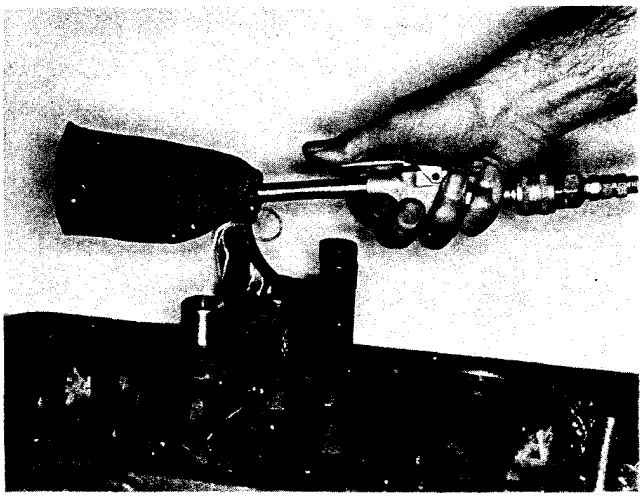


Fig. 1-26, (N101123) Removing shavings

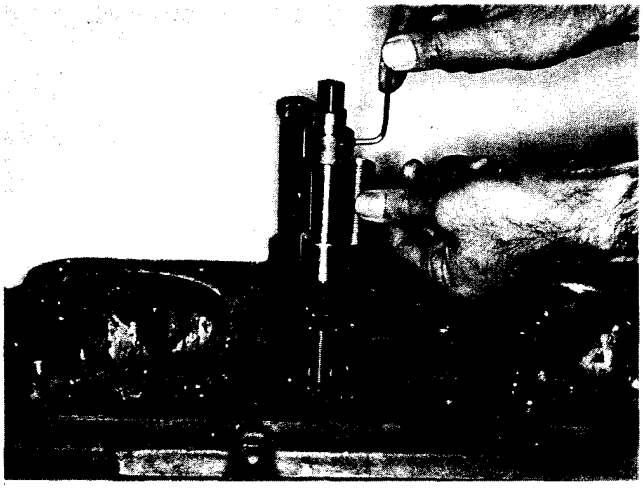


Fig. 1-27, (N101124). Adjusting stop collar

9. Remove tap, clean all shavings from hole. Fig. 1-26. Reinstall tap to 1/8 to 1/4 inch [3.175 to 6.35 mm] from bottom. Tap remainder of depth, with tap handle or suitable wrench until stop collar bottoms out.

10. Remove tap and tool. Thoroughly clean hole.

11. Install special nut on standard head capscrew.

12. Install thread insert on head capscrew against special nut. Fig. 1-28.

13. Clean external threads of insert with Loctite

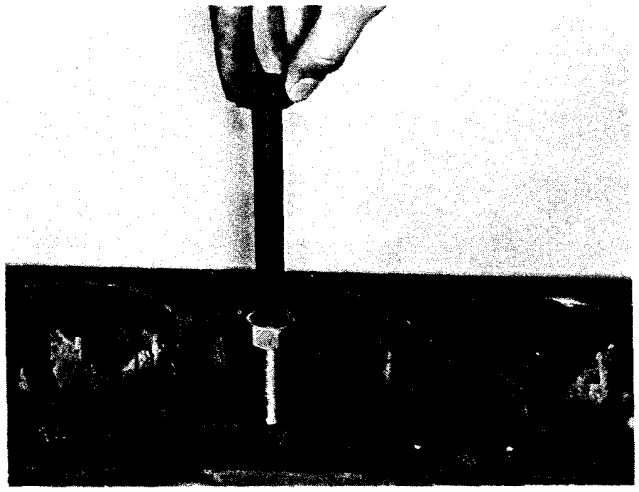


Fig. 1-28, (N101125). Installing thread insert

Primer T Cleaner to remove all foreign material. Allow to dry.

14. Apply light coat of Loctite Sealer to external threads and install in block until insert is flush with block deck.

15. Hold head bolt and back off nut 1/4 turn. Remove bolt from insert.

16. If required, file off any excess stock so insert is flush with block.

ST-1287 Boring Tool (Lower Cylinder Liner Bore)

ST-1287 (Fig. 1-29) is used in this operation. This tool features tapered locator centering ring to positively locate tool in counterbore, a special gauge rod to preset boring depth and a micrometer set-block to preset cutting tool bit.

Tool Operating Instructions

1. Select proper centering ring. Remove "O" ring and install centering ring onto tool with taper toward cutter. Install "O" ring to keep ring from coming off.

2. Preset tool bit with micrometer set block.

   a. Check micrometer calibration with special "standard". Micrometer should read five (5) inches when measuring "standard". If off, loosen socket head capscrew and move micrometer in or out as required.

   b. Place tool bit in set block. Loosen setscrew in tool bit, depress plunger as required to be in general range. Preset micrometer to proper value. Loosen setscrew allowing plunger to contact micrometer. Tighten setscrew securely.

   c. Back off micrometer and recheck value. Readjust as required.

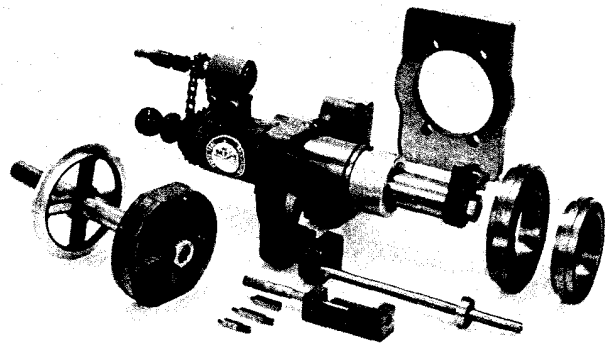


Fig. 1-29, (N101126). ST-1287 Boring Tool

3. Place tool bit in tool holder, until it bottoms against drive shaft. Tighten setscrews securing tool bit.

4. Adjust depth set collar on special gauge rod to engine model to be bored.

5. Attach gauge rod on bottom side of base plate with capscrew provided.

6. Loosen round knob on top and push drive shaft down until tool bit barely contacts preset collar. Adjust depth set collar on spline shaft to "bottom out" on top of boring machine. Tighten setscrews.

Note: Gauge rod is not marked for 195778 Sleeve. This sleeve is approximately 0.100 inch [2.54 mm] shorter than ST-1287-41 and 42. If 195778 Sleeve is used, adjust stop collar as required to avoid boring too deep.

7. Remove gauge rod.

8. Pull upward on round knob to raise boring bar all the way up.

9. Remove all nicks or burrs from counterbore in block. Clean thoroughly. Deck must be flat and free from rough area that would cause machine misalignment with lower bore.

10. Install tool in counterbore, lower unit into counterbore with tapered centering ring engaging counterbore. Fig. 1-30.

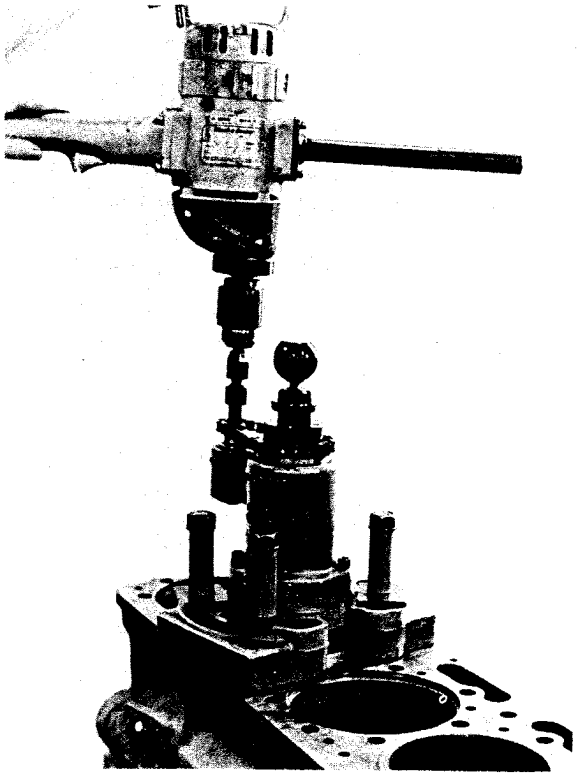


Fig. 1-30, (N101127). Boring tool installed

11. Secure base plate to block with capscrews and spacers. Tighten securely to approximately 50 ft-lbs [68 N• m].

12. Push downward on round knob slowly until tool bit touches lower bore area. Raise up boring bar approximately 1 inch [25.4 mm].

13. Tighten round knob; this engages the automatic feed mechanism. Rotate shaft by hand to be sure it rotates freely.

14. Install flexible coupling drive in a heavy duty drill. Recommended drill size is 1/2 to 3/4 inch, 10 amperes or more, 450 rpm.

15. Place drill and flex coupling on drive shaft. Bore until stop collar "bottoms out". (A noticeable change in drill speed will be observed.)

16. Loosen round knob; pull drive shaft all the way up. Tighten knob.

17. Remove boring bar.

18. Inspect bore; measure bore. Clean thoroughly and remove rough edges with emery cloth.

Install Repair Sleeve Into Cylinder Block

1. Thoroughly clean bore area with compressed air; wipe clean.

2. Clean the block bore and outside diameter of the sleeve with Loctite Primer. Apply narrow band of Loctite Bushing Mount, or equivalent, completely around the sleeve outside diameter.

3. Set repair sleeve on top of counterbore.

4. Push sleeve through upper bore.

5. Install proper sleeve driver into sleeve. (Inside diameter chamfer of sleeve must be positioned upward toward top of deck.)

6. Install upper locator over driver handle and into counterbore.

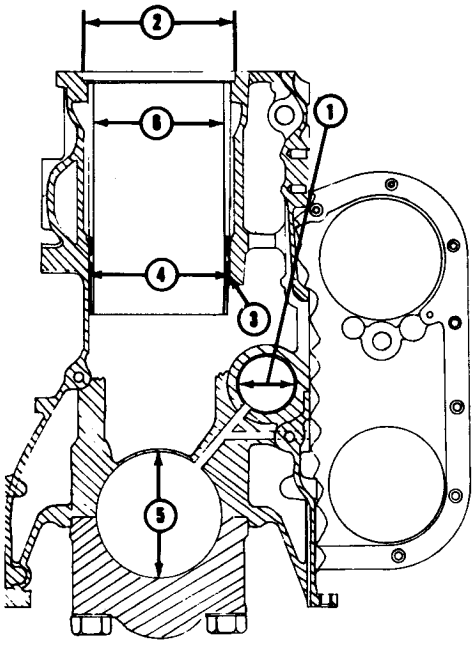
7. Tap gently on driver handle to position sleeve in bore.

8. With suitable hammer (preferred rawhide mallet) drive sleeve into place. When sleeve is positioned, sleeve driver should rotate freely for removal; remove tool.

9. Wipe clean excess Loctite compound from around sleeve entrance.

Table 1-1: Cylinder Block Specifications – Inch [mm] (Reference Fig. 1-0)

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	2 Inch Cam Engines New Minimum	2 Inch Cam Engines New Maximum	2-1/2 Inch Cam Engines Specifications not listed are the same as 2 Inch Cam Engines Worn Limit	2-1/2 Inch Cam Engines New Minimum	2-1/2 Inch Cam Engines New Maximum
1.	**Camshaft Bushing**						
	Inside Diameter	**2.0015 [50.838]**	1.999 [50.775]	2.0005 [50.813]	**2.5008 [63.520]**	2.4983 [63.457]	2.4998 [63.495]
	Camshaft Bushing Bore						
	Inside Diameter	**2.1305 [54.115]**	2.1285 [54.064]	2.1295 [54.089]	**2.6265 [66.721]**	2.6245 [66.662]	2.6255 [66.688]
2.	**Cylinder Liner Counterbore**						
	Inside Diameter		6.5615 [166.662]	6.5635 [166.713]			
	Depth	**0.412 [10.46]**	0.350 [8.89]	0.352 [8.94]			
3.	**Liner to Block Clearance**						
	Lower Bore		0.002 [0.05]	0.006 [0.15]			
4.	**Lower Liner Bore**						
	Inside Diameter		6.124 [155.55]	6.126 [155.60]			
5.	**Main Bearing Bore**						
	Inside Diameter	**4.7505 [120.663]**	4.7485 [120.612]	4.750 [120.650]			
	Block Ref. Fig. 1-5						
	Height from Main Bearing Centerline	**18.994 [482.45]**	19.003 [482.68]	19.007 [482.78]			
	Height from Installed Alignment Bar	**16.619 [422.12]**	16.628 [422.35]	16.632 [422.45]			
	Cylinder Liner						
	Inside Diameter	**5.505 [139.83]**	5.4995 [139.687]	5.501 [139.73]			



Note: New cylinder liners dimensions at 60 to 70°F [16 to 21°C]; may be 0.0002 to 0.0006 inch [0.005 to 0.015 mm] smaller than indicated due to lubrite coating.

	Protrusion (Installed)		0.003 [0.08]	0.006 [0.15]			
6.	**Crankshaft**						
	Connecting Rod Journal Outside Diameter	**3.122 [80.30]**	3.1235 [79.337]	3.125 [79.38]			
	Main Bearing Journal Outside Diameter	**4.4975 [114.237]**	4.4985 [114.262]	4.500 [114.30]			
	Thrust Bearing Surface to Rear Counterweight	**3.006 [76.35]**	3.001 [76.23]	3.003 [76.28]			
	Main and Rod Journals Out-of-round T.I.R.**	**0.002 [0.05]**					
	Main and Rod Journal Taper (Length of Journal)	**0.0005 [0.013]**					

**T.I.R. – Total Indicated Runout

**Also available in 0.010, 0.020, 0.030 and 0.040 inch undersize.

Table 1-1: Cylinder Block Specifications – Inch [mm] (Reference Fig. 1-0) (Cont'd.)

		2 Inch Cam Engines			2-1/2 Inch Cam Engines Specifications not listed are the same as 2 Inch Cam Engines		
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum	Worn Limit	New Minimum	New Maximum
7.	**Main Bearings****						
	Shell Thickness	**0.1215**	0.123	0.1238			
		[3.086]	[3.12]	[3.145]			
	Journal Clearance	**0.007**	0.0015	0.005			
		[0.18]	[0.038]	[0.13]			
8.	**Rod Bearings****						
	Shell Thickness	**0.071**	0.0724	0.0729	**0.093**	0.0942	0.0947
		[1.80]	[1.839]	[1.852]	**[2.393]**	[2.393]	[2.405]
	**Also available in 0.010, 0.020, 0.030 and 0.040 inch undersize.						
9.	**Crankshaft Thrust Ring**						
	157280 Std.						
	Thickness	*	0.245	0.247			
			[6.22]	[6.27]			
	157281 0.010 O.S.						
	Thickness [0.25]	*	0.255	0.257			
			[6.48]	[6.53]			
	157282 0.020 O.S.						
	Thickness [0.51]	*	0.265	0.267			
			[6.73]	[6.78]			
	*Use Crankshaft End Clearance						
10.	**Crankshaft End Clearance**						
	End Clearance	**0.022**	0.007	0.017			
	(Installed)	**[0.56]**	[0.18]	[0.43]			
11.	**Connecting Rod**						
	Crankpin Bore Inside Diameter		3.2725	3.2730		3.3160	3.3165
			[83.122]	[83.134]		[84.226]	[84.239]
	Center to Center Length		11.998	12.000			
			[304.75]	[304.80]			
	Piston Pin Bushing						
	Inside Diameter	**2.0022**	2.001	2.0015			
		[50.856]	[50.83]	[50.838]			
	Connecting Rod						
	Bend	**0.008**		0.008			
	Without Bushing	**[0.20]**		[0.20]			
	Bend	**0.004**		0.004			
	With Bushing	**[0.10]**		[0.10]			
	Twist	**0.020**		0.020			
	Without Bushing	**[0.51]**		[0.51]			
	Twist	**0.010**		0.010			
	With Bushing	**[0.25]**		[0.25]			
	Connecting Rod Bolt						
	Minimum Outside Diameter	**0.540**	0.541	0.545			
		[13.72]	[13.74]	[13.84]			

Table 1-1: Cylinder Block Specifications — Inch [mm] (Reference Fig. 1-0) (Cont'd.)

		2 Inch Cam Engines			2-1/2 Inch Cam Engines Specifications not listed are the same as 2 Inch Cam Engines		
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum	Worn Limit	New Minimum	New Maximum
	Pilot Outside Diameter	**0.6242 [15.855]**	0.6245 [15.862]	0.6250 [15.875]			
	Connecting Rod Capscrew						
	Outside Diameter	**0.583 [14.81]**	0.584 [14.83]	0.590 [14.99]			
	Pilot Outside Diameter	**0.637 [16.18]**	0.638 [16.21]	0.643 [16.33]			
	Bolt Hole Pilot (2 Bolt Rods)						
	Rod	**0.6249 [15.872]**	0.6243 [15.857]	0.6248 [15.870]			
	Cap	**0.6252 [15.880]**	0.6246 [15.865]	0.6251 [15.878]			
	Dowel and Pilot (2 Capscrew Rod)						
	Dowel Diameter		0.3127 [7.943]				
	Rod Dowel Hole		0.3128 [7.945]	0.3133 [7.958]			
	Dowel Protrusion		0.220 [5.59]	0.250 [6.35]			
	Dowel Press Fit In Cap		0.0001 [0.003]	0.0006 [0.015]			
12.	**Piston**						
	Skirt Diameter at 70°F [21°C]	**5.483 [139.27]**	5.487 [139.37]	5.488 [139.40]			
	Piston Pin Bore						
	Inside Diameter at 70°F [21°C]	**1.999 [50.775]**	1.9985 [50.762]	1.9989 [50.772]			
13.	**Piston Pin**						
	Outside Diameter	**1.9985 [50.762]**	1.9988 [50.770]	1.9990 [50.775]			
14.	**Piston Ring**						
	Part No. 147670						
	Gap in Ring Travel Area of Liner	*	0.023 [0.58]	0.033 [0.84]			
	132880						
	Gap in Ring Travel Area of Liner	*	0.019 [0.48]	0.029 [0.74]			
	214730						
	Gap in Ring Travel Area of Liner	*	0.019 [0.48]	0.029 [0.74]			
	218732						
	Gap in Ring Travel Area of Liner	*	0.010 [0.25]	0.025 [0.64]			

*Add 0.003 inch [0.08 mm] ring gap to new maximum limit for each 0.001 inch [0.03 mm] wear in cylinder liner wall.

Table 1-1: Cylinder Block Specifications – Inch [mm] (Reference Fig. 1-0) (Cont'd.)

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	2 Inch Cam Engines New Minimum	2 Inch Cam Engines New Maximum	2-1/2 Inch Cam Engines Specifications not listed are the same as 2 Inch Cam Engines Worn Limit	2-1/2 Inch Cam Engines New Minimum	2-1/2 Inch Cam Engines New Maximum
15.	**Camshaft Journal**						
	Outside Diameter	**1.996 [50.70]**	1.997 [50.72]	1.998 [50.75]	**2.495 [63.37]**	2.496 [63.40]	2.497 [63.42]
	Thrust Bearing						
	Thickness	**0.083 [2.11]**	0.093 [2.36]	0.098 [2.49]			
	Support Bushing						
	Inside Diameter	**1.370 [34.80]**	1.3725 [34.862]	1.3755 [34.938]			
	Outboard Bearing Support						
	Inside Diameter	**1.757 [44.63]**	1.751 [44.48]	1.754 [44.55]			
16.	**Gear Case Cover Accessory Drive Bushing Part No. 213820 Std.**						
	Inside Diameter	**1.571 [39.90]**	1.565 [39.75]	1.569 [39.85]			
	213821 0.010 U.S. [0.25]						
	Inside Diameter	**1.561 [39.65]**	1.555 [39.50]	1.559 [39.60]			
	213822 0.020 U.S. [0.51]						
	Inside Diameter	**1.551 [39.40]**	1.545 [39.24]	1.549 [39.34]			
	200822 Std. (NTA Series)						
	Inside Diameter	**1.7585 [44.666]**	1.7525 [44.513]	1.7565 [44.615]			

Torque Specifications ft-lbs [N•m]

	Pipe Plug Size	Minimum	Maximum
	1/8	15 [20]	20 [27]
	1/4	30 [41]	35 [47]
	3/8	35 [47]	45 [61]
	1/2	45 [61]	55 [75]
	3/4	60 [81]	70 [95]
	1-1/4	75 [102]	85 [115]
	1-1/2	90 [122]	100 [136]
18.	**Main Bearing Capscrews**		
	Step 1. Tighten to	140 [190]	150 [203]
	Step 2. Advance to	300 [407]	310 [420]
	Step 3. Loosen	All	All
	Step 4. Tighten to	140 [190]	150 [203]
	Step 5. Advance	300 [407]	310 [420]

Table 1-1: Cylinder Block Specifications – Inch [mm] (Reference Fig. 1-0) (Cont'd.)

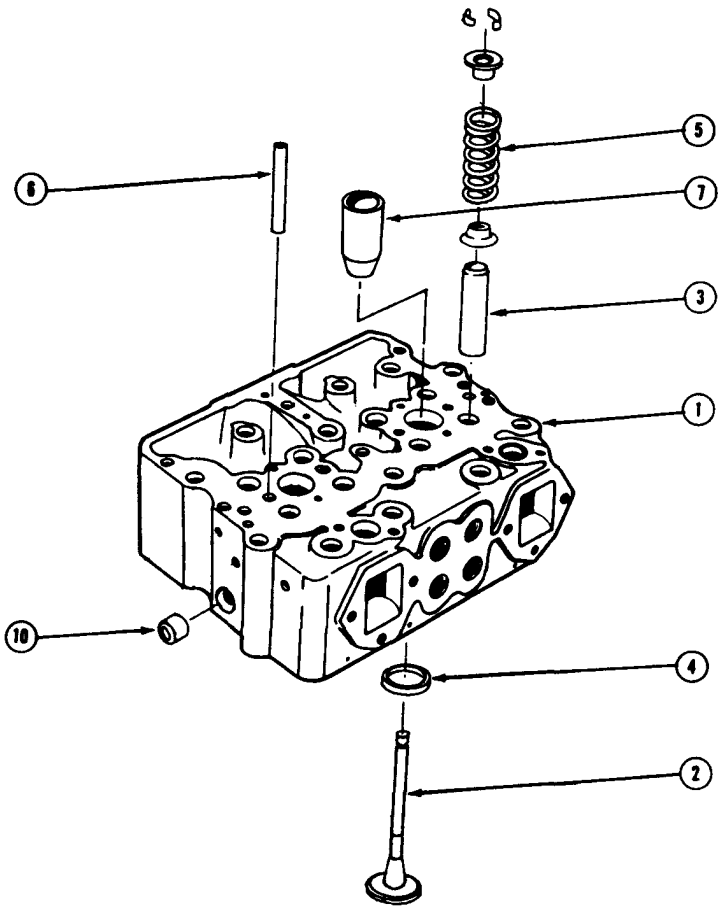
	2 Inch Cam Engines		2-1/2 Inch Cam Engines Specifications not listed are the same as 2 Inch Cam Engines
Torque Specifications ft-lbs [N•m]	**Minimum**	**Maximum**	
19. Connecting Rod Nuts or Capscrews*			
Step 1. Tighten to	70 [95]	75 [102]	
Step 2. Advance to	140 [190]	150 [203]	
Step 3. Loosen	All	All	
Step 4. Tighten to	25 [34]	30 [41]	
Step 5. Tighten to	70 [95]	75 [102]	
Step 6. Advance to	140 [190]	150 [203]	

*For torquing sequence see Fig. 1-11.

Group 2

Cylinder head group covers inspection, repair and assembly of cylinder head, valves and guides, crossheads and guides, valve seats, injector sleeves and valve springs.

Cylinder Head



1. Cylinder Head
2. Valve
3. Valve Guide
4. Valve Seat Insert
5. Spring
6. Crosshead Guide
7. Injector Sleeve
8. Valve Spring Retainer
9. Half Collets
10. Pipe Plug

Fig. 2-1, (N10295). Cylinder head – exploded view

The service tools or tools of equal quality listed are considered necessary to repair and/or rebuild the cylinder head as outlined in this section.

Cylinder Head

Cylinder head assemblies have been standardized for use on 2 inch cam and 2-1/2 inch cam engines.

Measurements

All dimensions (with exception of engine cylinder bore size, used to identify engine models) in this group are listed in both U.S. and Metric units. The metric units are enclosed in brackets [ ].

Disassembly

1. Steam clean complete head assembly and dry with compressed air.
2. Place cylinder head in ST-583 Head Holding Fixture or equivalent.
3. Remove valves and springs. Use ST-448 Valve Spring Compressor (1, Fig. 2-2) to compress valve springs. ST-448 may be used at bench or on installed engine.
4. Screw stud (2) from ST-448 in rocker lever housing mounting capscrew hole.

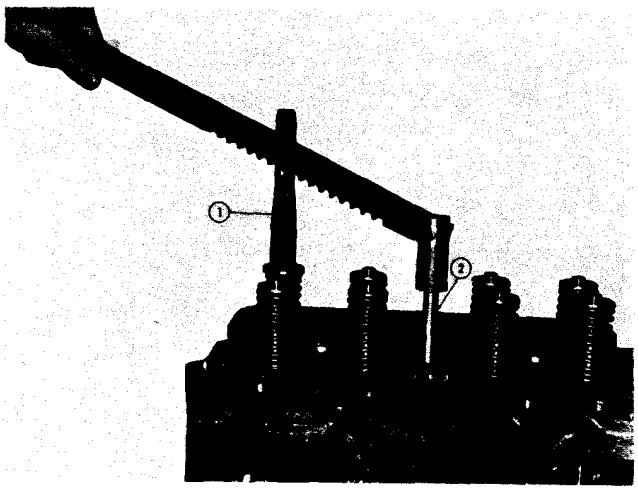


Fig. 2-2, (N10276). Compression valve spring with ST-448

Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
ST-257	Valve Seat Insert Tool
ST-646	Valve Guide Reamer
ST-662	Valve Seat Insert Cutter Set
ST-663	Valve Guide Arbor Set
ST-684	Valve Facing Machine
ST-685	Valve Seat Grinding Machine
ST-788	Bead Cutting Tool
ST-880	Injector Sleeve Expander
ST-884	Injector Sleeve Cutter
ST-913	Cylinder Head Grooving Tool
ST-1010	Water Hole Counterboring Tool
ST-1012	Hydrostatic Tester
ST-1013	Hydrostatic Tester Base Plate
ST-1134	Dowel Pin Extractor
ST-1179	Injector Sleeve Holding Tool
ST-1217	Valve Guide Mandrel
ST-1227	Injector Sleeve Installation Mandrel
ST-1257 A or D	Vacuum Tester
3375190	3/4" Cup Plug Driver
3375191	1" Cup Plug Driver
3375192	1-1/4" Cup Plug Driver

Desirable (Or Equivalent) Service Tools

ST-448	Valve Spring Compressor (Single)
ST-547	Gauge Block
ST-583	Head Holding Fixture
ST-633	Crosshead Guide Mandrel
ST-876	Cleaning Brush
ST-1022	Valve Spring Compressor Stand (Used with multiple compressor plate)
ST-1026	Valve Spring Compressor Plate (Compress 8 springs in one operation)
ST-1122	Staking Tool Driver
ST-1124	Valve Seat Insert Staking Tool
ST-1279	Valve Seat Extractor
ST-1166	Magnetic Crack Detector
ST-1187	Valve Guide Reamer 0.015 inch [0.38 mm] Oversize
ST-1188	Valve Guide Reamer 0.010 inch [0.25 mm] Oversize
ST-1244	Injector Sleeve Puller
ST-1247	Injector Sleeve Puller Impact Wrench Socket
3375155	Injector Protrusion Gauge
3375067	Loctite Cup Plug Sealer
3375182	Valve Spring Tester

Standard Tools — Obtain Locally

0-1 Micrometers
Small Bore Gauge
Vernier Depth Gauge

Caution: If removing valve springs on an installed engine, be sure piston is up to support valves in cylinder. Replace springs before barring the engine or valve will drop into cylinder necessitating cylinder head removal to retrieve valve.

Note: High volume head rebuild shop may use ST-1026 Valve Spring Compressor Plate with ST-1022 Stand, or equivalent arbor press, to remove all valve springs from cylinder heads in one operation.

5. Compress one valve spring at a time. Fig. 2-1. Tap valve head lightly to loosen; then remove half collets. A small magnet may be used as an aid in removing half collets.

6. Withdraw valves, valve springs and retainers (and valve spring guides, if used). Remove oil seals from intake valve guides, if used. Discard seals. Place valves on a numbered valve board for inspection.

7. Remove 1/8 inch pipe plugs that plug vent holes on turbocharged engines. Naturally aspirated engines are open.

8. Remove pipe plugs from fuel connector holes at top rear of number 3 cylinder head and top front on number 1 cylinder head.

9. Remove all pipe plugs from fuel passages in each end of cylinder head.

Inspection and Cleaning

Air Pressure Test of Cylinder Head

1. Lay head on intake manifold side of head.

2. Install ST-384, ST-923 or ST-1179 Injector Sleeve Holding Tool or scrap injector assembly in each sleeve. Fig. 2-3.

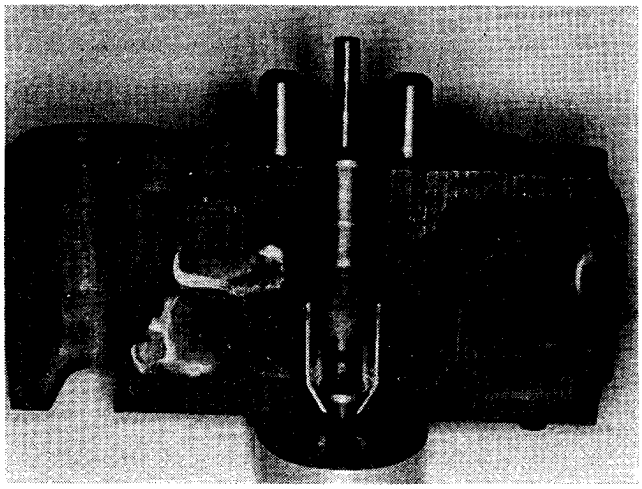


Fig. 2-3, (N10278). ST-1179 Injector Sleeve Holding Tool

3. Tighten sleeve holding tool to seal lower end of injector sleeve, or install injectors and secure with capscrew, torque to 10 to 12 ft-lbs [14 to 16 N• m].

4. Install ST-1012 Hydrostatic Tester, using proper ST-1013 Base Plate to clamping device. Fig. 2-4.

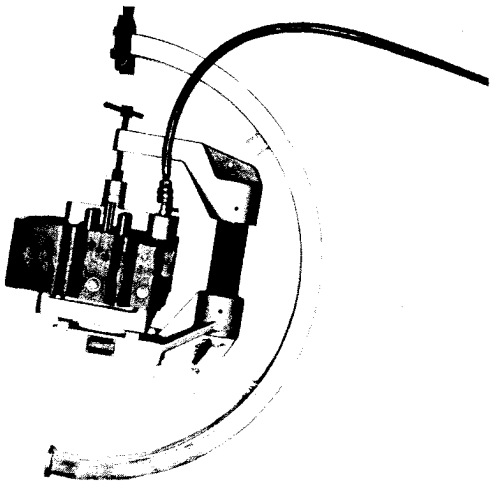


Fig. 2-4, (N10282). Using ST-1012 Hydrostatic Tester

   a. Pin carrier to the quadrant in to center position.

   b. Engage locator of base plate into proper cylinder head water holes.

   c. Install water header locators into the water

manifold holes; tighten clamping screw against water header.

d. Use a hoist or suitable lifting device to position head over water tank and connect air line with quick coupler; adjust air pressure regulator 30 to 40 psi [207 to 276 kPa].

e. Lower head into tank approximately 1/2 inch below water surface.

f. Check exhaust ports for leaks.

g. Remove pin, rotate head and check lower sleeve area for leaks.

h. Rotate head 180 degrees to upright and check upper sleeve sealing area.

i. Rotate head back to center position and install pin.

j. Lift cylinder head from tank. Disconnect quick coupling that supplies air pressure and lower head to bench top.

k. Release clamping screw and remove water header.

l. Lift quadrant and base plate away from cylinder head.

Water Test Cylinder Head

1. Install ST-384, ST-923 or ST-1179 Injector Sleeve Holding Tool, or a discarded injector assembly in each injector sleeve.

2. Tighten sleeve holding tool to 10 to 12 ft-lbs [14 to 16 N• m] to seal lower end of injector sleeve, or install injectors and secure with capscrews torqued to 10 to 12 ft-lbs [14 to 16 N• m].

3. Place cylinder heads in water-test fixture ST-1012. Test cylinder heads for leaks at 35 to 85 psi [241 to 586 kPa] and, if possible, at 180 to 200°F [82 to 93°C] water temperature. Check carefully around valve seats and injector sleeve seats for any cracks, even though such cracks might not show water leakage. This type crack is caused when injector capscrews are tightened beyond factory torque recommendation. Discard head if cracked.

4. Open water outlet valve of test fixture; check for free water circulation through cylinder head. If restriction is evident, remove plugs and injector sleeves; clean water jackets of salt, lime or sludge as follows:

   a. Remove all cup plugs and pipe plugs from cylinder head.

      1) Using a small drift pin or punch and hammer, tap cup plug near outside diameter until cocked crosswise in opening.

      2) Remove cup plug with pliers or small pry bar.

   b. After steam cleaning and disassembly, submerge head in tank of cleaning solution heated to near boiling temperature. Use Turko or Wyandotte "G" solvent or equivalent; follow manufacturer's recommendations as to use.

   c. Circulate solvent to increase effectiveness on salt or lime deposits, grease, etc.

   d. Clean valves, valve springs and collets by submerging in solvent.

   e. To remove heavy deposits of lime, use circulated acid-type cleaner.

Caution: The use of acid is extremely dangerous to workmen and injurious to machinery. Acid should never be used in machine shop or near any machine subject to rusting. Always provide a tank of strong soda water as a neutralizing agent.

5. Clean internal fuel passages with ST-876 or similar type brush. Flush passages with solvent to remove deposits.

6. Check lubricating oil passage (1, Fig. 2-5) to be sure it is open.

7. After drying with compressed air, using orbital sander, sand cylinder head surface lightly, just enough to shine the finish. This will allow a

more complete inspection of mating surfaces.

Caution: Do not use disc sander. Serious damage could result to the sealing surface of the head.

8. Air test fuel line passage as follows:

   a. Install "discarded" injectors in head.

   b. Block fuel outlet and attach an air pressure gauge.

   c. Install air fittings in fuel inlets and apply air pressure of 80 to 100 psi [550 to 690 kPa].

   d. Close air inlet valve and inspect passage for leaks.

   e. Check air gauge; there must be no drop in pressure for 15 seconds. Discard an unserviceable head.

   f. Optional additional test to detect suspected weakness due to thin walls or porosity is as follows:

      Apply 500 psi [3450 kPa] hydraulic pressure to fuel lines. No drop in pressure should occur in 15 seconds.

Magnetic Crack Detection

Inspect head for cracks using ST-1166 Magnetic Crack Detector in valve and injector port areas as follows:

1. Remove keeper bar from magnet poles.

2. Place magnet on area being inspected.

3. Spray a moderate amount of powder onto area to be checked. Fig. 2-6. Blow off excess powder with low pressure air. Powder will remain in cracks, and show as a white line.

Note: When dispensing powder, hold thumb partially over spray head to keep cap from blowing off.

Valve Seats

1. Check for loose valve seat inserts by lightly tapping cylinder head near insert, if valve seat is loose enough to bounce, mark for replacement. A slight looseness found only by tapping when head is cold and covered with a film of oil is not objectionable.

2. If seat area width (2, Fig. 2-7) exceeds 0.125 inch [3.18 mm] at any point and cannot be narrowed sufficiently (1) during regrind, mark for replacement.

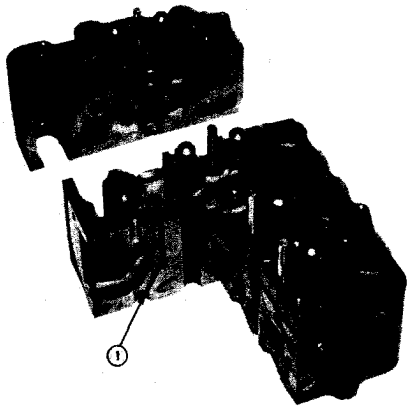
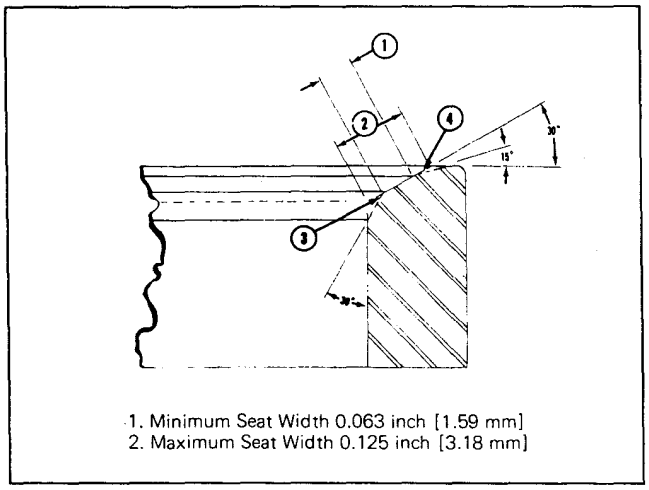


Fig. 2-5, (N10266). Rocker lever oiling hole

Fig. 2-6, (N10279). Magnetic crack detection check with ST-1166

Injector Sleeves

Note results of pressure test. Leaks indicate need for replacement of injector sleeves. Visually check sleeves, which pass pressure test, for scratches on



1. Minimum Seat Width 0.063 inch [1.59 mm]
2. Maximum Seat Width 0.125 inch [3.18 mm]

Fig. 2-7, (N10228). Valve seat insert – cross section

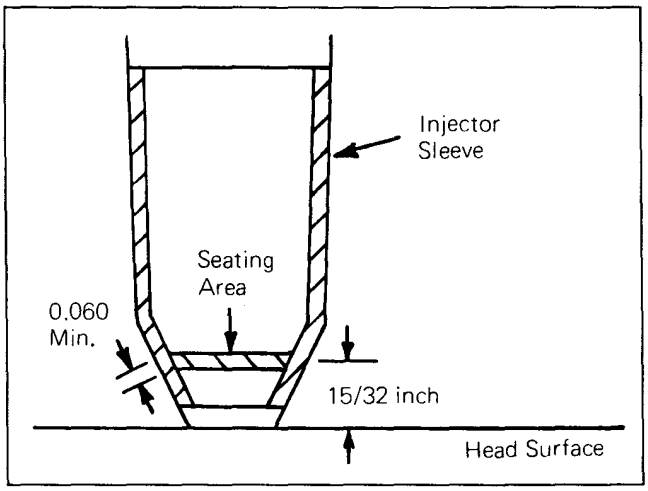


Fig. 2-8, (N10298). Injector sleeve sealing width

cup seat area. If seat area is scratched, mark for replacement.

Injector Tip Protrusion

Injector sleeves that have passed the above tests must further be checked for injector tip protrusion (seat depth) and seating pattern.

1. Lightly coat injector cup with Prussian Blue; install injector assembly into sleeve. Torque to 10 to 12 ft-lbs [14 to 16 N• m]. Remove and check seat pattern. Bluing band must be 0.060 inch [1.52 mm] minimum in width and located approximately 15/32 inch [11.91 mm] from bottom of head surface. If indicated seat width does not meet these specifications, mark sleeve for replacement. See Fig. 2-8.

2. Install injector assembly; torque to 10 to 12 ft-lbs [14 to 16 N• m]. Measure tip protrusion with ST-547 Dial Indicator. Fig. 2-9. Tip protrusion must be 0.060 to 0.070 inch [1.52 to 1.78 mm]. See Service Tool Instruction.

Valve Crosshead Guides and Crossheads

1. Check guide outside diameter with micrometers. See Table 2-1 (6) for worn replacement limits.

2. Check guide for straightness. It should be at right angles with milled surface of head. Mark guides for replacement if not straight or worn beyond replacement limits.

3. Check crossheads for cracks with Magnaglo process.

4. Check bore inside diameter (3, Fig. 2-10) using a small bore gauge set at 0.4402 inch [11.181 mm]. Use as a "No Go" gauge to check for wear beyond worn replacement limit.

5. Check for out-of-round holes; gauge at several points 90 degrees apart. Do not use plug gauge for this operation.

6. Visually check for excessive wear on rocker lever (1) and valve stem contact surface (2). Check adjusting screw and crosshead threads (4) for wear or distortion. Mark for replacement if excessive wear is found.

Valve Guides

1. Check guide inside diameter; using a small bore gauge, set at 0.4552 inch [11.562 mm]. Use bore gauge as a "No Go" gauge. Table 2-1 (3).

2. Check for out-of-round holes; gauge at several points crosswise and endwise of head full length of guide. Do not use a plug gauge for this operation. Visually check valve guides for chips, cracks or burrs. Mark for replacement any guides showing excessive wear or damage.

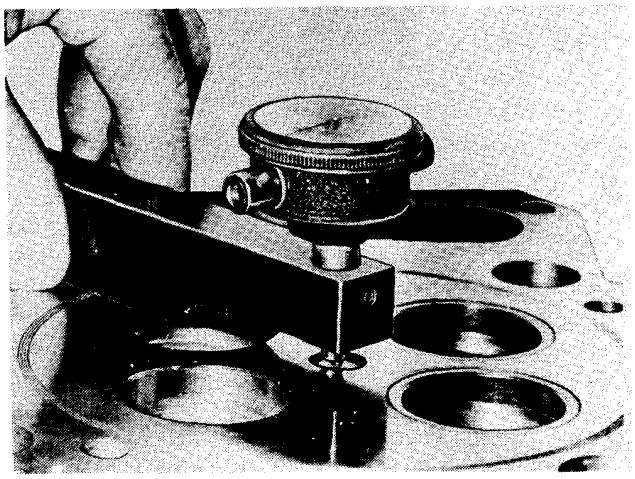
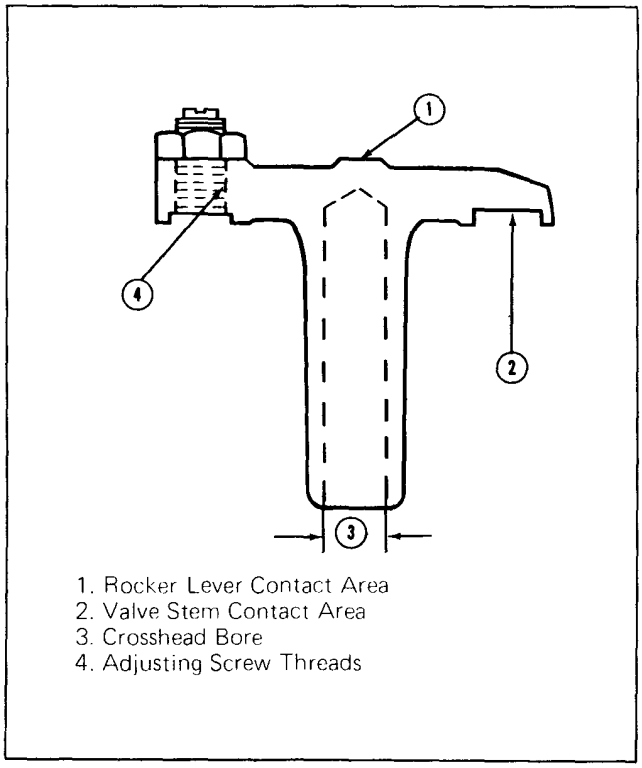


Fig. 2-9, (N10206). Measuring injector tip protrusion



1. Rocker Lever Contact Area
2. Valve Stem Contact Area
3. Crosshead Bore
4. Adjusting Screw Threads

Fig. 2-10, (N10299). Crosshead wearpoints

Valves

Visual

Clean valves with a buffer and polish with crocus cloth.

Inspect, then discard if:

Heads are cupped, cracked, pitted or worn too thin to regrind within limits. Check valve head rim thickness (A, Fig. 2-11), it should be a minimum of 0.105 inch [2.67 mm]. Stems scored or worn beyond worn replacement limit as listed in Table 2-1 (2), should be discarded. If collet recesses are worn so new collets will not fit securely in recesses (discard).

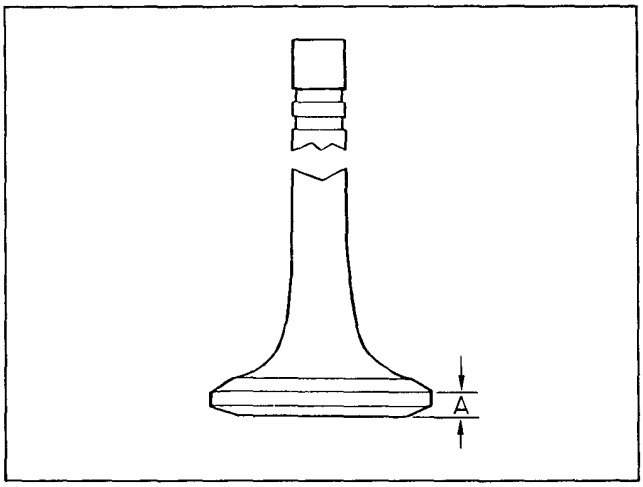


Fig. 2-11, (N10231). Minimum valve head rim thickness

Magnetic Method

1. Surface to be inspected must be cleaned to remove all foreign material which could give false indications or react in any way with penetrant or developer. Vapor degreasing is recommended.

2. Welded valves which have two types of metal, may be Magnaglo inspected. However, due to change of metal at weld, there will be magnetic leakage at this point. This will be indicated by a broad fuzzy pattern of magnetic particles. For this reason, such valves should be magnetized in coil at low amperage, at 100 to 200 amps, and then inspected residually with Magnaglo. A crack at, or near, the weld would show as a sharp bright fluorescent line.

3. Valves with only one type of metal can be inspected in normal way. Magnetize and inspect in two directions. Coil magnetization, use 100 to 300 amps. Inspect with residual Magnaglo.

Defects found after this magnetization will be in a transverse direction. Follow by headshot magnetization, at 500 to 700 amps, use residual Magnaglo. Defects by this magnetizing method will be radial.

4. Magnetic indications should be as follows: Reference Fig. 2-12.

   a. No magnetic indication over 1/2 inch [12.70 mm] in length or more than 5 indications spaced closer than 1/8 inch [3.18 mm] can be accepted in area (1).

   b. No visible or magnetic indication acceptable in area (2).

   c. No visible or circumferential magnetic indications are acceptable in areas (3) and (4).

   d. No visible or magnetic indication is acceptable in area (5).

Note: "Visible" means indication can be seen by use of a 3 power magnifying glass after removing magnetic particle suspension.

5. Demagnetize all acceptable parts.

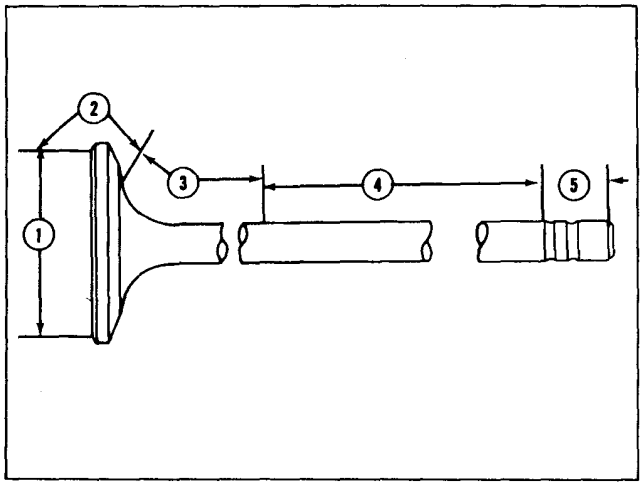


Fig. 2-12, (N10269). Magnetic indications of Magnaglo

Rebuilding

Sleeve Eroded Water Holes

Cylinder head surface around water holes must be free of any erosion, pits, scratches or blemishes which are more than 0.003 inch [0.08 mm] deep in the area 1/16 to 5/32 inch [1.59 to 3.97 mm] from edge of water hole. Use ST-1010 Water Hole Counterboring Tool to enlarge hole for sleeve. See Service Tool Instructions.

1. Coat sleeve, Part No. 191078, (1, Fig. 2-13) with sealant, align sleeve in top of water passage hole and drive into position using bushing driver (2) and hammer.

2. Use a flat mill file to file sleeve flush with top of cylinder head. Do not damage head surface. Remove burrs from inside diameter of sleeve, clean all cuttings and filings from water passages.

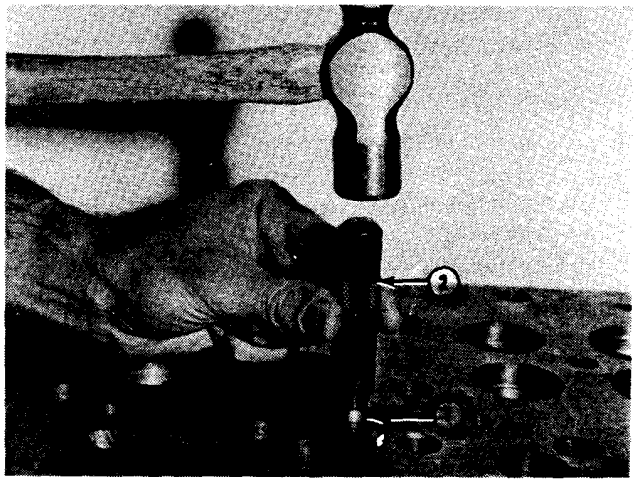


Fig. 2-13, (N10264). Driving bushing into hole

3. If proper sleeve is not available, heavy wall copper tubing may be used. Tubing must provide 0.002 to 0.005 inch [0.05 to 0.13 mm] press fit. Overall length should be approximately 1/2 inch [12.70 mm]; inside diameter must be 7/16 inch [11.11 mm] to allow proper water flow through head.

Resurface Cylinder Head

If cylinder head has been scratched, etched or is uneven at point of contact in gasket sealing area, head may be milled or surface ground. Maintain 125 AA finish.

1. Use ST-1279 Valve Seat Extractor, remove all

valve seat inserts.

2. After resurfacing check head height, use micrometer or Vernier depth gauge. Do not remove more than indicated as worn limit. See Table 2-1 (1).

3. Rework valve seat insert counterbore, remove amount of stock equal to that removed during cylinder head resurfacing.

Replace Valve Guides

1. Drive out guides marked for replacement from underside of cylinder head. Install new valve guide with 3375282 Mandrel or if valve guide bore in cylinder head has been damaged, install oversize guides as follows:

   a. Using ST-1188 Reamer, ream defective valve guide bore in head to 0.760 to 0.761 inch [19.30 to 19.33 mm]. Ream through, remove all burrs. Corner break should not exceed 0.015 inch [0.38 mm].

   b. Using ST-1217 Mandrel, press oversize valve guide, Part No. 3006457, into cylinder head.

Note: If damaged valve guide bore does not clean up, use ST-1187 Reamer. Ream 0.765 to 0.766 inch [19.43 to 19.46 mm] and use oversize valve guide, Part No. 3006458. Repeat Steps a and b above. It may be necessary to ream valve spring guide hole to 0.768 to 0.773 inch [19.51 to 19.63 mm] to accommodate oversize valve guides.

2. If proper valve guide mandrel is not available, press guide into head. See Table 2-1 (3).

3. Normally valve guide inside diameter does not require reaming. Insert valve stem into guide and check for freedom of movement.

4. If reaming is necessary: Ream valve guide from bottom side of cylinder head using ST-646 Reamer. Use lubricating oil or soluble oil and water solution for proper finish. Do not ream valve guide larger than 0.4532 inch [11.511 mm].

Replace Crosshead Guides

1. Remove crosshead guides marked for replacement using ST-667 or ST-1134 Dowel Puller.

2. Using ST-633 Crosshead Guide Mandrel, press new guides into cylinder head. If mandrel is not available, press new guides into head to obtain protrusion as listed in Table 2-1 (6).

3. Oversize crosshead guides may be installed as follows:

   a. Drill guide bore in head to original depth with a 29/64 inch [11.51 mm] drill.

   b. Lubricate and ream bore with 15/32 inch [11.91 mm] reamer.

   c. Install oversize guide, Part No. 161527, as per Step 2 above.

Replace Valve Seat Insert

1. If cylinder head has not been resurfaced, use ST-1133 Valve Seat Extractor to remove valve seat inserts that are marked for replacement.

2. Enlarge counterbore to next oversize. Inserts are available in standard oversizes as listed in Table 2-1 (8).

3. Use ST-663 Valve Guide Arbor and ST-257 Valve Seat Insert Tool Driver (Fig. 2-14) to hold and drive ST-662 Valve Seat Insert Cutter when cutting valve seat insert counterbore.

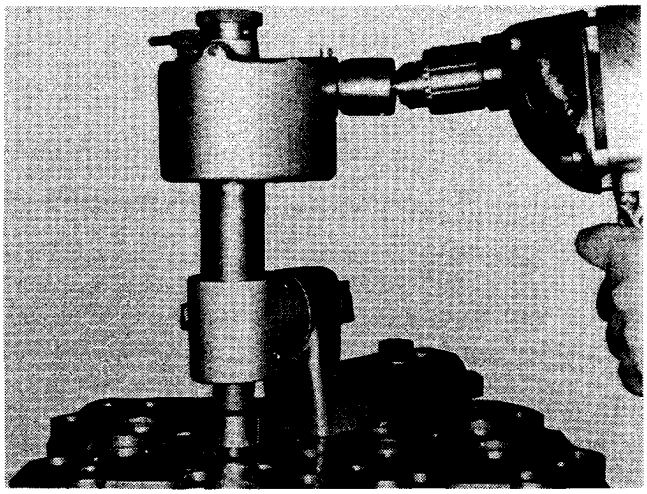


Fig. 2-14, (N10288). Counterboring for valve seat with ST-257

4. Cut counterbore 0.006 to 0.010 inch [0.15 to 0.25 mm] deeper than insert thickness to permit staking or peening of head to hold insert. Allow cutter to dwell upon reaching proper depth to ensure a flat seating surface.

5. Install valve seat insert and stake insert in head using ST-1122 Tool Driver over shaft of ST-1124 Insert Staking Tool. A 1/4 inch [6.35 mm] diameter round end punch may be used if staking tool is not available.

Caution: Over-swaging around insert may crack cylinder head.

Grind Valve Seats

1. Use ST-685 Valve Seat Grinder and correct arbor from ST-663 Valve Guide Arbor Set.

2. Check valve seat width, it should be 0.063 to 0.125 inch [1.59 to 3.18 mm], see (1 or 2, Fig. 2-6).

3. If seating area (1) is wider than 0.125 inch [3.18 mm] maximum, stock can be removed from points (3) and (4) with specially dressed stones. Narrowing should not extend beyond chamfer on valve seat insert. Chamfer provides metal for staking or peening.

4. Check valve seat concentricity with valve seat indicator. Total run-out should not exceed value listed in Table 2-1 (4).

Replace Injector Sleeves

Remove injector sleeves marked for replacement with ST-1244 Injector Sleeve Puller and ST-1247 Impact Socket Wrench or equivalent. See Service Tool Instructions.

Sleeve Installation

1. Coat new "O" rings with clean engine lubricating oil. Install "O" ring into groove of head injector sleeve bore. See Fig. 2-15.

2. Using ST-1227 or equivalent Injector Sleeve Installation Mandrel, push new injector sleeve into bore of cylinder head until it bottoms. Do not strike mandrel with hammer during this step. Remove mandrel.

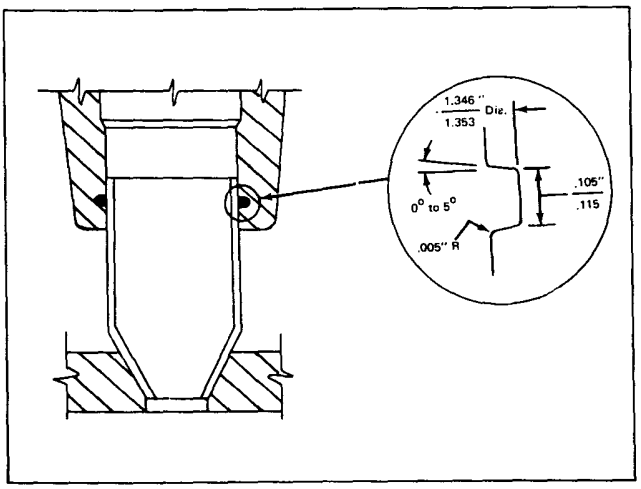


Fig. 2-15, (V40244). "O" ring groove in head

3. Install ST-1179 Injector Sleeve Holding Tool. Tighten nut to 35 to 40 ft-lbs [47 to 54 N• m] torque.

4. Insert mandrel into sleeve bore, strike mandrel two moderate blows with hammer to ensure that injector sleeve is properly seated. Retighten injector sleeve holding tool to 35 to 40 ft-lbs [47 to 54 N• m] torque.

5. Roll top 1/2 inch [12.70 mm] area of sleeve with ST-880 Expanding Roller. Fig. 2-16. Use in-lbs torque wrench to turn ST-880; turn mandrel until a 75 in-lbs [8.5 N• m] maximum torque reading is obtained on torque wrench.

Caution: Over-rolling of injector sleeve will cause deformation of sleeve into "O" ring groove.

6. Cut injector seat to provide proper seat and injector tip protrusion. To determine amount of cut, insert injector and torque to specifications, then measure tip protrusion. Depth of cut must provide 0.060 to 0.070 inch [1.52 to 1.78 mm] protrusion of injector cup tip beyond milled face of cylinder head when injector is installed at proper torque.

7. Use ST-884 Injector Sleeve Cutter in a drill press with pilot, using a solid stream of good cutting oil to allow cutter to cut freely without grabbing, etc.

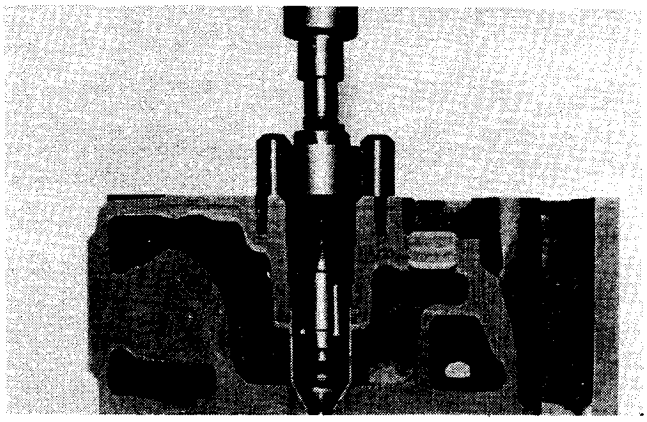


Fig. 2-16, (N10222). ST-880 in upper injector sleeve bores

8. Sleeve must "blue in" with Prussian Blue 360 degrees around injector seat when injector is installed in cylinder head. Bluing band must be 0.060 inch [1.52 mm] minimum width.

9. Water test cylinder head.

Grind Valves

1. Check valve grinder setting by using a new valve and an indicator gauge:

   a. Check valve in valve grinder on guide area of stem. Relieved portions on both ends of guide area are not necessarily concentric to guide area of stem.

   b. Indicate on ground face of valve.

   c. Turn valve and mark high spot on head of valve.

   d. Rechuck valve 180 degrees from first position.

   e. Repeat (b) and (c). If high spots are same for both (a) and (d) position, valve is warped. If high spots occur in different positions, chuck is out of alignment. Runout should not exceed 0.001 inch [0.03 mm].

2. Wet-grind valves to an exact 30 degree angle from horizontal. Check rim thickness as shown in Fig. 2-11. If rim is less than 0.105 inch [2.67 mm], valve is not suitable for reuse.

3. Pencil mark valve face as shown in Fig. 2-17, position in valve guide against a newly ground valve seat, rotate valve 10 degrees. A good seat will be indicated if all pencil marks are broken. If pencil marks are not broken, tools need dressing or machine has not been properly adjusted; final check should be made with a vacuum tester.

4. Valve seats properly ground with precision equipment should not require lapping to effect an air-tight seal; however, a small amount of lapping is permissible if necessary in order to pass Valve Seating (vacuum) Test.

5. Conditions of a good valve seat:

   a. No grinding of reamer marks on seating surfaces and within guide.

   b. Valve face a true 30 degree angle.

   c. Width of grind is within limits.

   d. Guide-to-stem clearance is within limits as determined from dimensions of stem and guide.

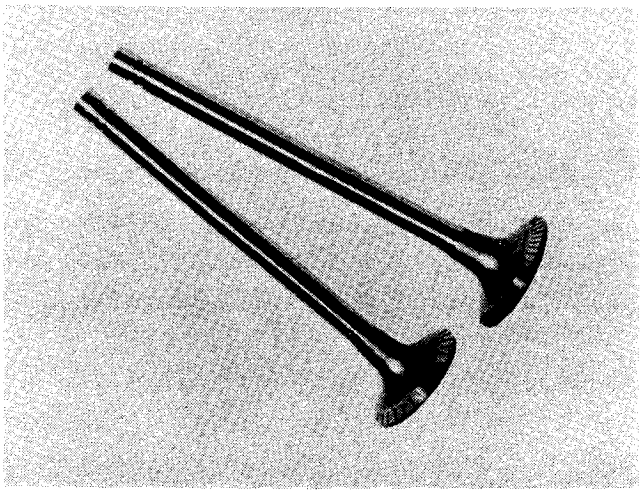


Fig. 2-17, (N20217). Pencil marks on valves

Valve Springs

Weak valve springs may cause valve flutter resulting in excessive wear on both valve and seat. Valve

flutter interferes with valve timing and may cause valve to strike top of piston.

1. Test valve spring on spring tester that is capable of accurate measurement of valve spring length, apply required load for length as listed in Table 2-1 (9). If valve springs compress to dimensions shown, at less than load indicated under "worn limit", discard valve spring.

2. Spacers should be used under valve spring when insert and valve have been refaced more than a total of 0.030 inch [0.76 mm]. A maximum of two (2) Part No. 68803-A Spacers may be used under valve springs.

Assembly

1. Install pipe plugs, fuel inlet and drain fittings in same position as removed from fuel passages. Coat threads with Teflon sealing tape or use liquid lead sealer to prevent leakage. Torque plugs to values listed in Table 2-1 (10).

2. To install cup plugs coat outside diameter of cup plug and inside diameter of water passage with a light coat of 3375068 Cummins Cup Plug Lock 'N Seal.

3. Using appropriate cup plug driver, see Table 2-1 (11), install cup plug.

Note: If cup plug driver is not available, install cup plug flush to 0.090 inch [2.29 mm] below bore chamfer with a suitable mandrel. See Fig. 2-18.

Do not bottom cup plugs against counterbores.

Note: Cylinder heads contain breather or vent holes that must be "plugged" on turbocharged engines and "open" on naturally aspirated engines. Vent holes are located above air intake port on cylinder head. Current turbocharged engine cylinder heads do not have the vent hole drilled.

4. Dip valve stems into clean engine lubricating oil, insert into valve guides. Place cylinder head face down on wooden bench or protective surface to prevent marring finish surface.

5. Place lower valve spring guides over valve guides.

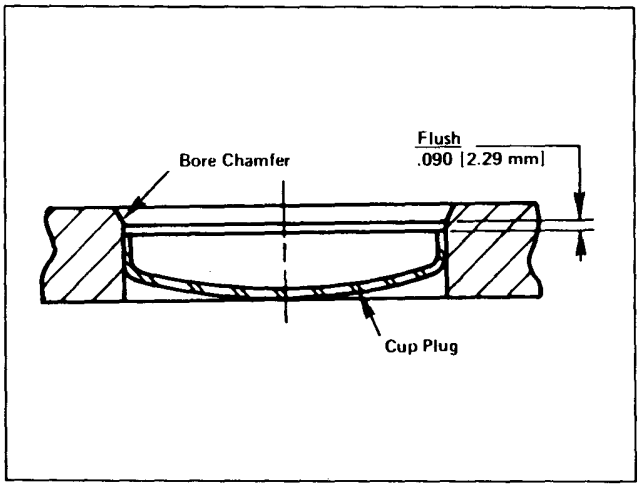


Fig. 2-18, (N102100). Cup plug installed in bore below chamfer

Caution: See current Parts Catalog for correct spring and guide combination; certain valve springs and spring guides must not be mixed under a given crosshead.

6. Intake valve guide seals are not being used on factory built engines and may be omitted or installed as desired. Use of seals has no effect on valve guide wear limits and may not be used as a substitute for new guides.

7. Assemble spring, spring seats, and spring spacers as required. Place upper valve spring retainer over springs, compress with ST-448 Valve Spring Compressor, install half-collets.

8. Cylinder heads with double exhaust valve springs (inner and outer), have a heavy-duty spring retainer at the top and two (2) spring wear plates at the head surface. Refer to Parts Catalog for part numbers.

Note: New valve collets should always be used during cylinder head rebuild.

Valve Seating Test

ST-1257-A Valve Vacuum Tester is used for testing valve seating. ST-1257-A consists of vacuum pump, gauge, and cups and operates on 110 volts AC. Use ST-1257-D with 220 volt systems.

Caution: Never vacuum test cylinder head with injectors installed. Installation of injectors while head is removed from block could cause misalignment of valves in valve seat area and result in leakage during testing which would not necessarily occur during actual engine operation.

1. Operate vacuum pump until hand on vacuum gauge (Fig. 2-19) reaches 18 to 25 inches vacuum. Close shut-off valve, release push button to stop pump.

2. Time fall of gauge hand as follows:

   a. Begin timing as soon as hand reaches "18" on dial.

   b. Stop timing when hand reaches "8".

   c. If elapsed time is less than ten seconds, valve seat is unsatisfactory.

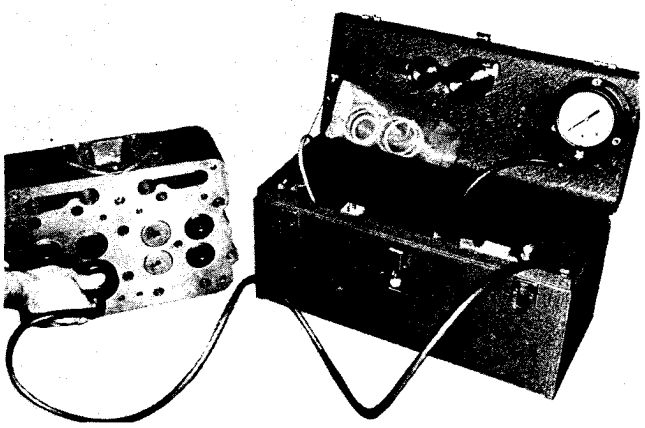


Fig. 2-19, (N10297). Vacuum test valves for leaks

3. Tap stem end of valve with a soft-faced mallet and retest. If valve seat is unsatisfactory:

   a. Check for leaking connections in tester; operate vacuum pump against a clean window glass or any smooth flat surface; fall of indicator hand indicates a loose connection.

   b. Check valve and seal face area to be sure they are free of dirt particles.

4. Regrind seat and reface valve if necessary; however, it is possible to mistake leakage around valve seat insert for valve seat leakage. If this type leakage is suspected, apply grease around outside edge of insert to make a grease seal.

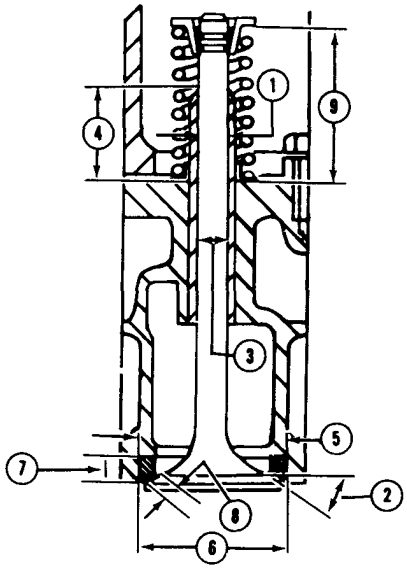
5. Perform vacuum test and inspect grease seal for a break indicating air leakage between wall of counterbore and valve seat insert. If leak around valve seat insert is found:

   a. Stake or peen insert, vacuum test.

   b. Remove insert, counterbore for next smallest oversize. See "Replace Valve Seat Insert".

Table 2-1: Specifications — Inch [mm] (Reference Fig. 2-1)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
1.	**Cylinder Head**			
	Height	**4.340 [110.24]**	4.370 [111.00]	4.380 [111.25]
2.	**Valve, Stem**			
	Outside Diameter	**0.449 [11.41]**	0.450 [11.43]	0.451 [11.46]
	Face Angle		30 degree	30 degree
3.	**Valve Guide**			
	Inside Diameter	**0.455 [11.56]**	0.4525 [11.494]	0.4532 [11.511]
	Assembled Height		1.270 [32.26]	1.280 [32.51]
4.	**Valve Seat Insert***			
	Outside Diameter		2.0025 [50.864]	2.0035 [50.889]
	Cylinder Head			
	Inside Diameter		1.9995 [50.787]	2.0005 [50.813]
	Insert Height		0.278 [7.06]	0.282 [7.16]
	Run Out in 360 Degrees	**0.002 [0.05]**		
	Refaced Seat Width		0.063 [1.59]	0.125 [3.18]
5.	**Valve Spring****			
	Assembled Height			2.250 [57.15]



*See Ref. No. 8 for oversize valve seat inserts.
**See Ref. No. 9 for valve spring data.

6.	**Crosshead Guide**			
	Outside Diameter	**0.432 [10.97]**	0.433 [11.00]	0.4335 [11.011]
	Assembled Height		1.860 [47.24]	1.880 [47.75]
	Crosshead Bore	**0.440 [11.18]**	0.434 [11.02]	0.436 [11.07]
7.	**Injector Sleeve**			
	Tip Protrusion		0.060 [1.52]	0.070 [1.78]

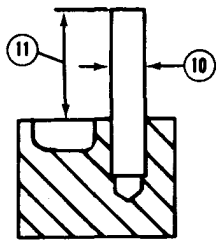


Table 2-1: Specifications – Inch [mm] (Reference Fig. 2-1) (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum

8. Valve Seat Insert

Part No.	Oversize Diameter	Oversize Depth	Insert O.D.	Cylinder Head I.D.	Insert Thickness
127935	0.005	Std.	2.0075/2.0085 [50.991/51.016]	2.0045/2.0055 [50.914/50.940]	0.278/0.282 [7.06/7.16]
127931	0.010	Std.	2.0125/2.0135 [51.118/51.143]	2.0095/2.0105 [51.041/51.067]	0.278/0.282 [7.06/7.16]
127932	0.020 [0.50]	0.005 [0.13]	2.0225/2.0235 [51.372/51.397]	2.0195/2.0205 [51.295/51.321]	0.283/0.282 [7.19/7.29]
127933	0.030 [0.76]	0.010 [0.25]	2.0325/2.0335 [51.626/51.651]	2.0295/2.0305 [51.549/51.575]	0.288/0.292 [7.32/7.42]
127934	0.040 [1.02]	0.015 [0.38]	2.0425/2.0435 [51/880/51.905]	2.0395/2.0405 [51/803/51.829]	0.293/0.297 [7.44/7.54]

Be sure to measure insert before machining head or installing insert in head.

9. Valve Spring Data

Valve Spring Part No.	Approximate Free Length Inch [mm]	No. Coils	Wire Diameter Inch [mm]	Length Inch [mm]	Required Load for Length Lb [N] Worn Limit	Lb [N] New Minimum	Lb [N] New Maximum
211999	2.685 [68.20]	9	0.177 [4.50]	1.724 [43.79]	**143 [636]**	147.25 [655]	162.75 [724]
178869	2.290 [74.17]	9.5	0.177 [4.50]	1.765 [44.83]	**150 [667]**	155 [689]	189 [841]

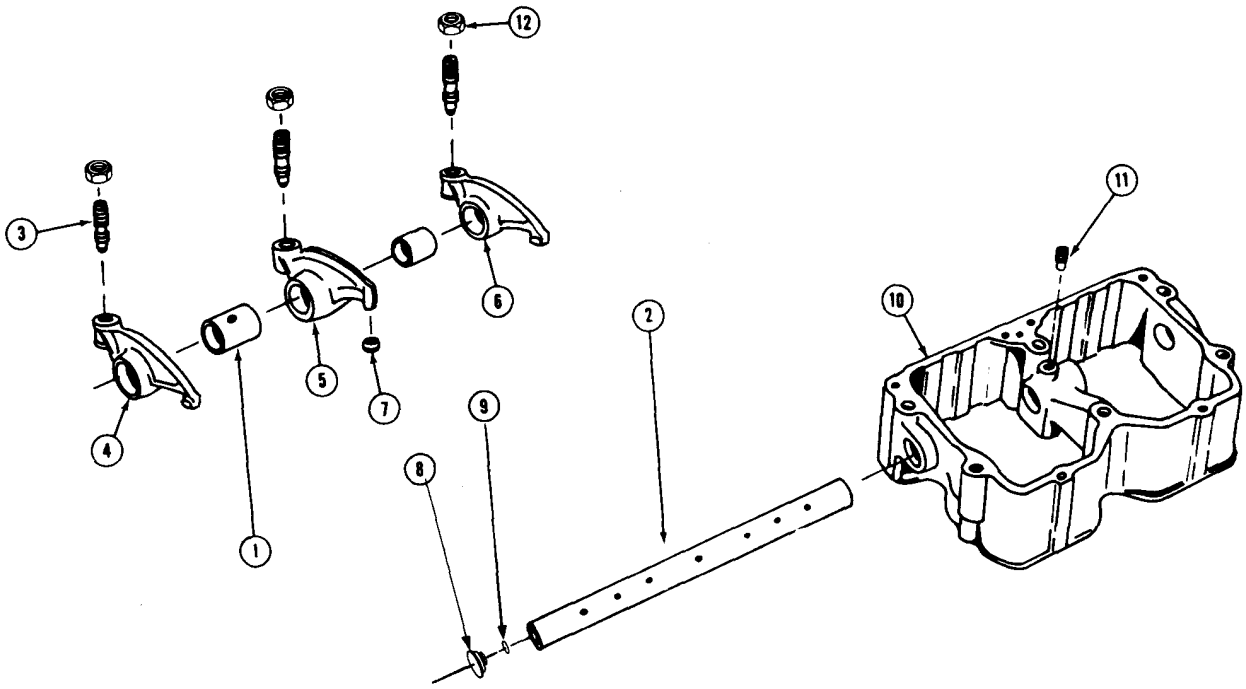
10. Cylinder Head Pipe Plug Torque – ft-lbs [N•m]

Plug Size	Minimum	Maximum
1/16 Inch	3 [4]	6 [8]
1/8 Inch	5 [7]	10 [14]
3/8 Inch	35 [47]	45 [61]
1/2 Inch	60 [81]	70 [95]
3/4 Inch	65 [88]	75 [102]
1 Inch	135 [182]	145 [197]

Group 3

Rocker lever group consists of rocker levers, rocker lever shafts, rocker lever covers, crankcase breathers and rocker lever housings.

Rocker Levers



1. Bushing
2. Shaft
3. Adjusting Screw
4. Intake Lever
5. Injector Lever
6. Exhaust Lever
7. Injector Lever Socket
8. Housing Plug
9. Shaft Plug
10. Rocker Lever Housing
11. Shaft Setscrew
12. Adjusting Screw Locknut

Fig. 3-1, (N10329). Rocker lever shaft and housing

Service Tools (Or Equivalent) Required	
Service Tool Number	**Tool Name**
ST-691	Mandrel and Block
ST-863	Mandrel
ST-1053	Driver
ST-1182	Alignment Tool (80 degree tilt engine)
Standard Tools — Obtain Locally	
	Small Bore Gauge Micrometers (1 to 2 inch) Radius Gauge (1/4 inch [6.35 mm])

Rocker Lever Housing

Disassembly and Inspection

1. Tag rocker levers for position, as removed and remove adjusting screws and nuts from all levers.

2. Remove setscrew or spray nozzle and jam nut (80 degree tilt engines) positioning rocker lever shaft in housing.

3. Use a flat or drift punch to drive or press shaft through housing.

4. Remove "O" rings from solid type plugs and discard. Solid plugs may be removed by placing plug end in vise and rocking shaft. Discard plugs as press fit is destroyed during removal. Clean drilling in shaft with a bottle brush.

5. Visually inspect all capscrew holes for damaged threads and inspect all levers, housings and covers for cracks, chips or breaks.

6. Inspect entrance of shaft bore for sharp edges, nicks or burrs, entrance of bore should have a slight radius. Sharp edges can be removed by using 240 grit aluminum oxide paper over a split rod, rotating in an electric drill.

7. Check breather vent hole (1, Fig. 3-2) to make sure it is free of dirt or other deposits.

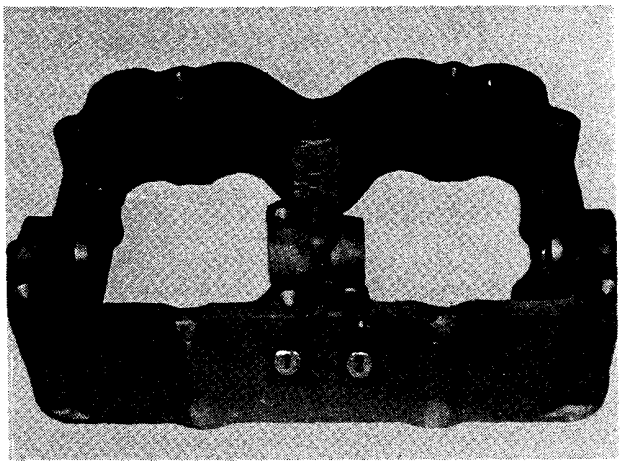


Fig. 3-2, (N10318-A) Breather vent hole

8. Check rocker lever shaft bore of housing inside diameter. Dimensions should be 1.1238 to 1.1246 inch [28.545 to 28.565 mm]. If shaft bore does not meet these dimensions, discard housing and replace. See Parts Catalog for correct part number.

Rocker Levers

Inspection and Repair

1. Check for surface imperfections by magnetic inspection. Apply coil magnetization, amperage at 300 to 500 with residual Magnaglo. See Fig. 3-3 for most likely areas. Demagnetize after checking.

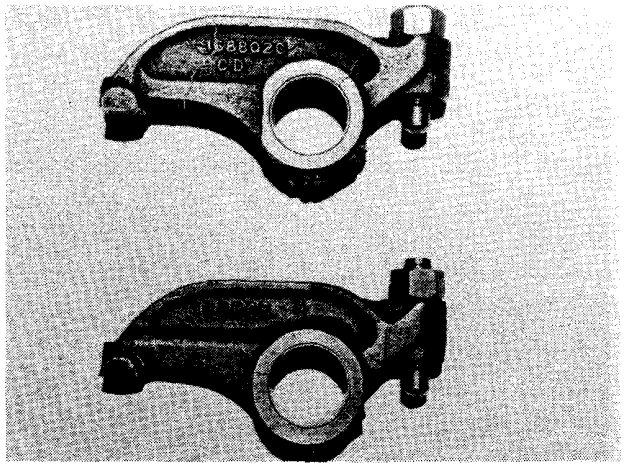


Fig. 3-3, (V40305). Magnetic inspection crack indication

2. The ball end of rocker lever adjusting screw must be a true sphere. Check with 1/4 inch [6.35 mm] radius gauge. Fig. 3-4. Replace if flat at bottom or there is evidence of scratching or galling. Check thread condition on all screws and in levers. Check closely for threaded distortion at assembly position of locknut. Screws must run freely through levers.

3. Examine injector rocker lever sockets for scuffing, galling or wear. Wear can be determined by bluing in with a 0.500 inch [12.70 mm] diameter gauge ball or new injector link. Blue pattern should coat at least 80 percent of seat area. Socket with unacceptable blue patterns should be replaced.

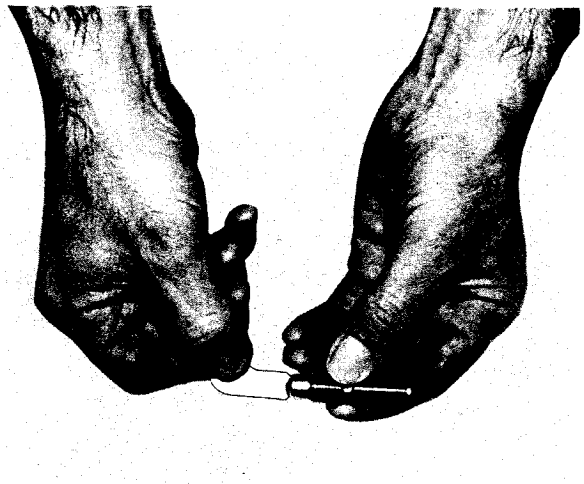


Fig. 3-4, (N20305). Checking rocker lever adjusting screw ball end

4. If socket must be replaced, drill a small hole in lever above socket and drive out worn socket. Stake plug in hole and replace socket.

5. Check rocker lever bushings for scratches, pitting or scoring. Check rocker lever bushing inside diameter with inside micrometers or small bore gauge. Fig. 3-5. If bushing exceeds 1.1286 inch [28.664 mm], press out bushing with ST-691 Mandrel and Block. Clean lever thoroughly and dry with compressed air. See Parts Catalog for current replacement bushing part numbers.

6. Install new bushing with ST-691 and arbor press. Fig. 3-6.

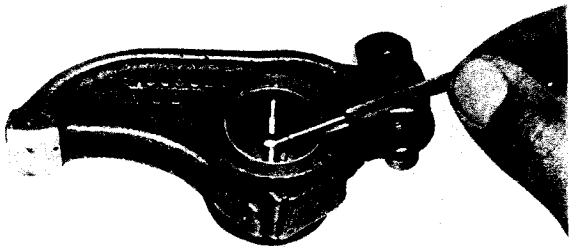


Fig. 3-5, (V40306). Checking rocker lever bushing inside diameter

   a. On injector and exhaust valve levers, install bushings so oil holes to crosshead nose or injector link and adjusting screw are open for oil flow.

   b. On intake valve levers with oil drilling to crosshead nose end, install bushing so "nose" hole is closed and so bushing "slot hole" is in line with adjusting screw oil hole. Do not bore steel bushings.

7. Check intake and exhaust rocker lever-to-crosshead contact surfaces. Replace if worn or damaged.

8. Check rocker lever shaft for wear or scoring. If

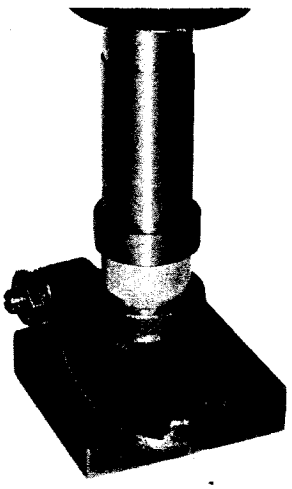


Fig. 3-6, (N20306). Installing rocker lever bushing

shaft has shoulders or ridges due to rocker lever action on shaft, replace with new rocker lever shaft. See Table 3-1 (2) for shaft dimensions. Flush out shaft bore and dry thoroughly.

Assembly – Aluminum Housings

Solid plugs can be used in any rocker lever housing and should be used in all aluminum housings. Solid plugs can be used to replace cup plug seals with no changes to the shaft or housing.

1. Install new plugs in shaft until plug bottoms. Plugs may be pressed in simultaneously with an arbor press.

2. Install adjusting screws and locknuts in rocker levers.

3. Start shaft into housing and install levers as shaft is pushed through. See Fig. 3-7, for correct position of levers.

   a. Install exhaust (1), injector (2) and intake (3) levers.

   b. Install intake (4), injector (5), and exhaust (6) levers.

4. Push shaft until 1/2 inch protrudes from housing. Install lightly oiled "O" ring in groove in shaft assembly.

5. Push shaft until other end protrudes and install second "O" ring.

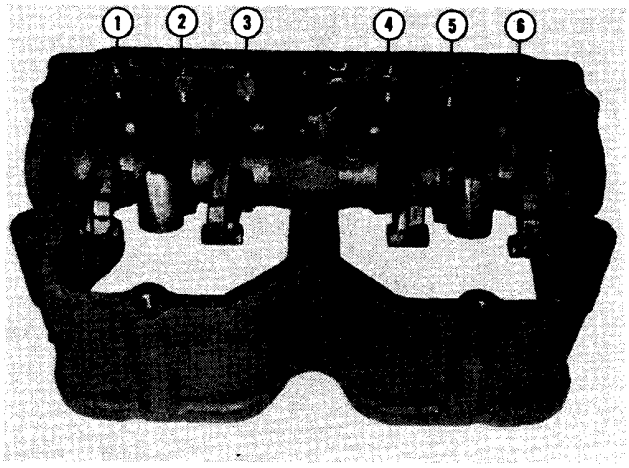


Fig. 3-7, (N10326). Rocker lever assembly

6. Center and align shaft and housing locking hole by squeezing two rocker levers to rotate shaft. Secure with setscrew or oil spray nozzle. Check levers for freedom of movement.

Note: Oil spray nozzles are used on 80 degree tilt engines. Use ST-1182 Alignment Tool to obtain proper alignment of oil spray holes in nozzle to permit oil flow from rocker lever shaft to valve mechanism. Secure spray nozzle in desired position with jam nut.

Crankcase Breather

Different types of crankcase breathers are used on 855 C.I.D. Engines. Mesh element with vapor barrier, mesh element, paper element, foam element and screen element.

1. Remove cover, screens and baffle or element from breather body; discard paper element.

2. Clean vent tube, screens and baffle foam, or mesh element in an approved cleaning solvent. Wipe out breather housing.

3. Assemble baffle, screens or element and new gasket in body. Replace cover.

Note: Current engines using rocker lever cover with baffle plate installed do not have baffle or screens in crankcase breather body.

Rocker Housing Cover

There are two types of rocker lever housing covers: plain and breather type.

Inspection

Remove all gasket material from sealing edge of cover. Inspect for cracks, dents and distorted sealing areas; discard unserviceable parts. Inspect for cracks around all capscrew holes and breather port area.

Assembly

If a new breather-type cover is used, press in new breather neck; install new or reconditioned breather body (breather must be pressed in straight). After installation of breather body, or breather neck, check closely for cracks around press-fit area.

Table 3-1: Specifications – Inch [mm]

Ref. No.	Measurement	2 Inch Cam Engines			2-1/2 Inch Cam Engines		
		Worn Limit	New Minimum	New Maximum	Worn Limit	New Minimum	New Maximum
1.	**Bushing**						
	Inside Diameter	**1.1286 [28.664]**	1.1245 [28.562]	1.1275 [28.639]	**1.1286 [28.664]**	1.1245 [28.562]	1.1275 [28.639]
2.	**Shaft**						
	Outside Diameter	**1.122 [28.50]**	1.123 [28.52]	1.124 [28.55]	**1.122 [28.50]**	1.123 [28.52]	1.124 [28.55]

Group 4

Cam followers are used in the 855 C.I.D. Engines to transmit movement from the camshaft lobes through push tubes and rocker levers to actuate injectors and valves.

Cam Followers

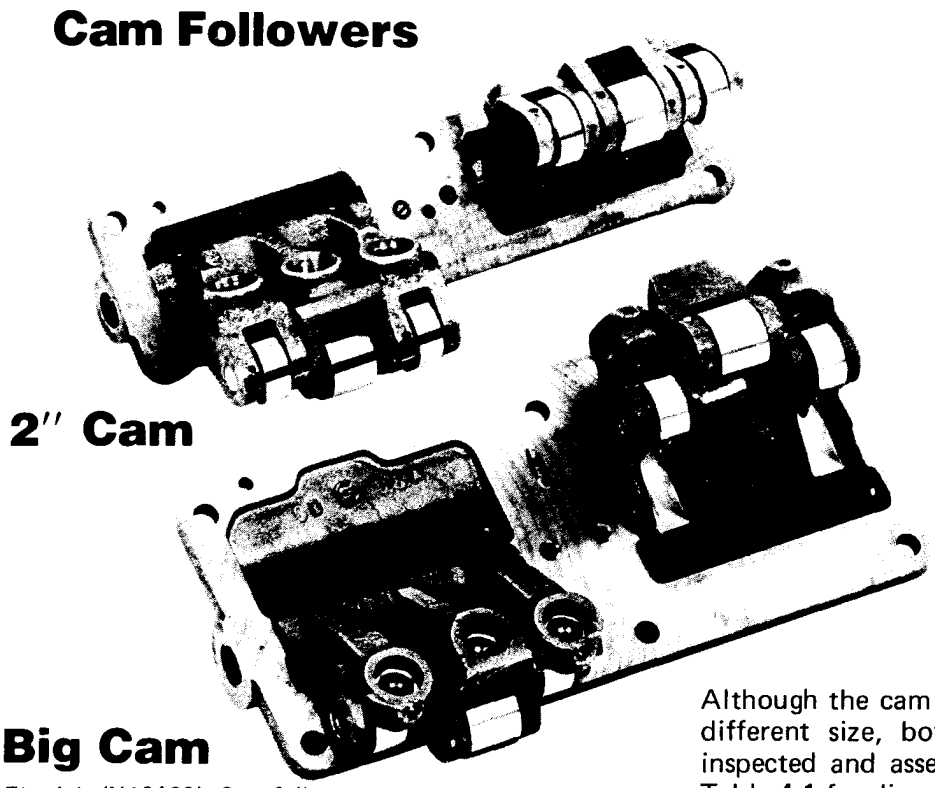


Fig. 4-1, (N10420). Cam followers comparison

Although the cam followers and push tubes are of different size, both assemblies are disassembled, inspected and assembled in like manner. Refer to Table 4-1 for dimensions.

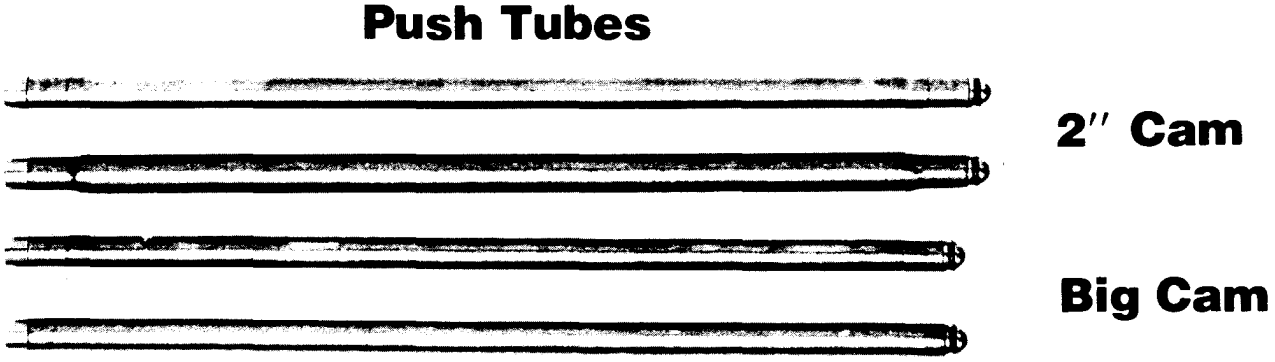
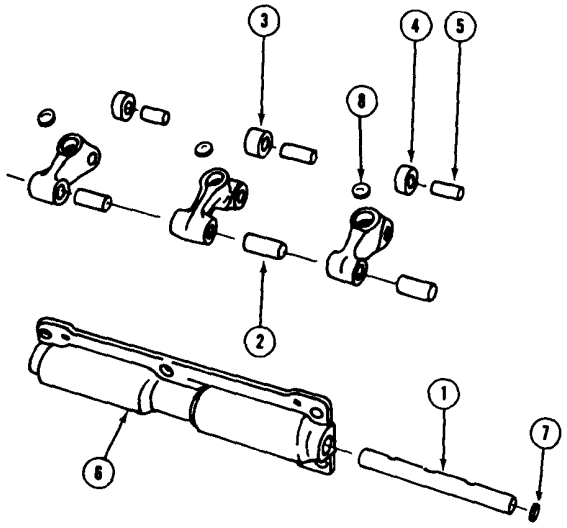
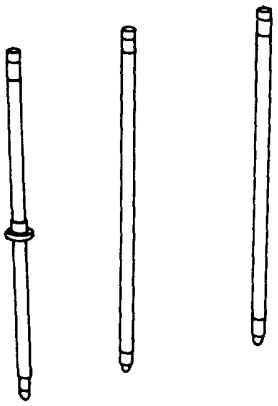


Fig. 4-2, (N10421). Push tubes comparison





1. Shaft
2. Bushing
3. Injector Cam Roller
4. Valve
5. Valve Cam Roller Pins
6. Housing
7. Shaft Plug
8. Insert

Fig. 4-3, (N10419). Cam followers and push tubes

The following service tools or tools of equal quality are considered necessary to repair and/or rebuild the cam follower assembly as outlined in this group.

Service Tools Used in Cam Follower Group

Service Tool Number	Tool Name
ST-195	Plug Gauge
ST-249	Mandrel and Block
ST-970	Plug Driving Mandrel
ST-1053	Plug Driving Mandrel
Standard Tools – Obtain Locally	
	Small Bore Gauge
	Micrometer (0 to 1 inch)
	Micrometer (1 to 2 inch)
	Snap Ring Pliers
	Feeler Gauge

Disassembly

1. Remove gaskets if not previously removed.
2. Remove lockscrews holding shafts in housing. Fig. 4-4.
3. Remove cup plugs by using a sharp pointed driver and punch a hole in center of plug. Tap one side of plug to force other side of plug out of hole. Remove with pliers. Using proper

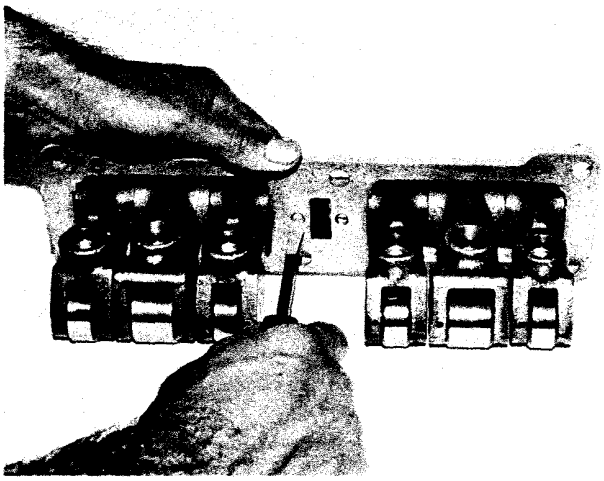


Fig. 4-4, (N10401). Removing shaft lockscrews

mandrel, press both shafts out opposite end forcing cup plug out of hole.

4. Remove cam follower levers from housings.

5. Mark or tag cam follower levers for position, as removed, to prevent confusion during assembly.

Cleaning

1. Dip cam follower shafts in mineral spirits and blow out with compressed air.

2. Clean other parts in solvent and dry thoroughly.

Caution: Clean small oil passages in levers.

Inspection

1. Measure O.D. of shaft with micrometers. Fig. 4-5. Dimensions should be 0.7485 to 0.749 inch [19.012 to 19.02 mm]. If worn smaller than 0.748 inch [19.00 mm] mark for replacement.

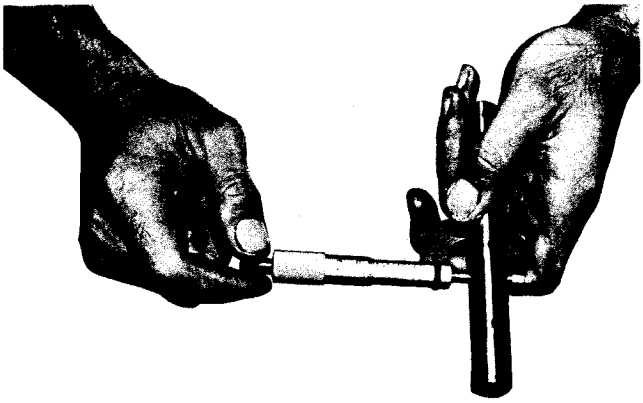


Fig. 4-5, (N10411). Measuring cam follower shaft

Note: Check cam follower shafts very carefully around lockscrew end to make sure grooves are clean.

Visually inspect cam rocker housing for cracks or mating surface imperfections. Discard unserviceable parts.

2. Check cam follower bushings for scratches, pitting or scoring. Check bushing inside diameter with inside micrometers. Fig. 4-6. Dimensions should be 0.7501 to 0.7511 inch [19.053 to 19.078 mm]. If worn larger than 0.752 inch [19.10 mm] mark for replacement.

3. Check for surface imperfections by magnetic inspection. Apply coil magnetization, amperage at 300 to 500 with residual Magnaglo. See Fig. 4-7 for most likely areas.

4. Inspect edges of cup plug holes in cam box housing for sharp edges or nicks. If damage during removal of cup plug is evident, use a 240 grit aluminum oxide paper and clean hole with a steel rod which has been split for placing a small strip of 240 grit paper. Chamfer the

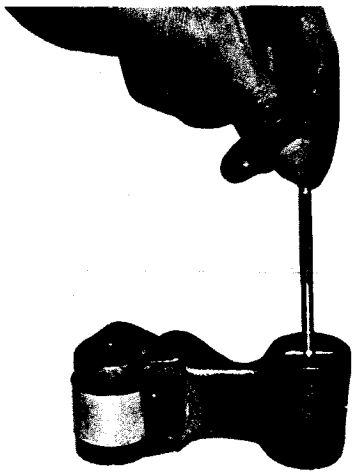


Fig. 4-6, (N10402). Measuring cam follower bushing

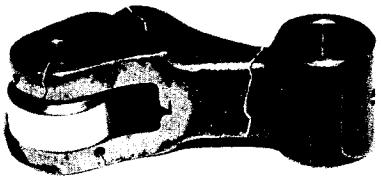
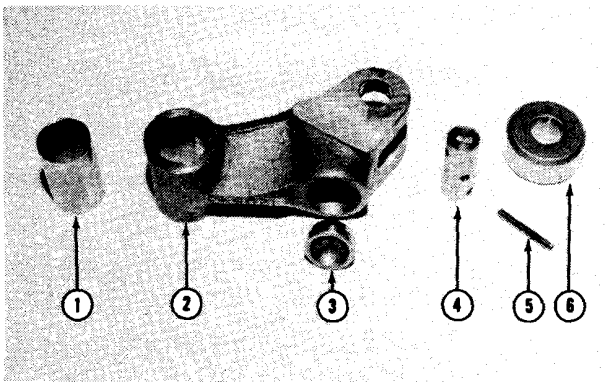


Fig. 4-7, (N10410). Magnetic crack detection check

entrance of this hole to form a slight radius and break sharp edges to aid the installation of cup plug without damaging sealing surface.

5. Cam follower levers have a removable insert (3, Fig. 4-8). These must be replaced if scored or extremely worn. Check with a new push tube ball or 0.625 inch [15.88 mm] checking ball and Prussian Blue. Fig. 4-9. This area must "blue in" 80 percent blue. Replace insert if match is in anyway doubtful.

6. Remove cam roll pins (5, Fig. 4-8), roller pins (4) and rollers (6) from cam follower levers (2).



1. Bushing
2. Lever
3. Insert
4. Roller Pin
5. Roll Pin
6. Roller

Fig. 4-8, (N10412). Cam follower – exploded view

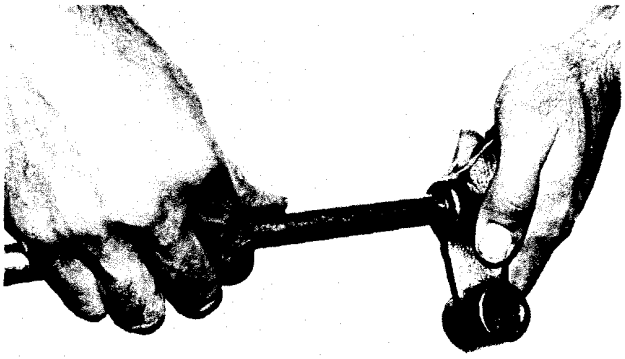


Fig. 4-9, (N10413). Checking cam follower insert with push tube

7. Inspect cam rollers. Set small bore gauge (such as Starrett No. 829-D) 0.0002 inch [0.005 mm] above worn replacement limit. Use as a "No Go" gauge in bore to check wear beyond replacement limits. Check for out-of-round holes. Fig. 4-10.

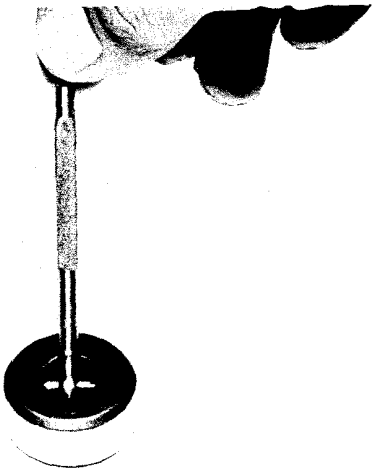


Fig. 4-10, (N10414). Measuring cam roller I.D.

8. Refer to Table 4-1 (3) for injector cam roller dimensions, and Table 4-1 (4) for valve cam roller dimensions. If measurements exceed worn limits, mark for replacement.

9. Use micrometers to check O.D. or rollers. Fig. 4-11. Refer to Table 4-1 for dimensions.

10. On all rollers the I.D. must be concentric with

Fig. 4-11, (N10415). Measuring cam roller O.D.

Table 4-1: Specifications – Inch [mm]

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	2 Inch Cam Engines New Minimum	2 Inch Cam Engines New Maximum	2-1/2 Inch Cam Engines Worn Limit	2-1/2 Inch Cam Engines New Minimum	2-1/2 Inch Cam Engines New Maximum
1.	**Shaft**						
	Outside Diameter	**0.748 [19.00]**	0.7485 [19.012]	0.749 [19.02]	**0.748 [19.00]**	0.7485 [19.012]	0.749 [19.02]
2.	**Bushing**						
	Inside Diameter	**0.752 [19.10]**	0.7501 [19.053]	0.7511 [19.078]	**0.752 [19.10]**	0.7501 [19.053]	0.7511 [19.078]
3.	**Injector Cam Roller**						
	Inside Diameter	**0.505 [12.83]**	0.503 [12.78]	0.504 [12.80]	**0.705 [17.91]**	0.703 [17.86]	0.704 [17.88]
	Outside Diameter	**1.2485 [31.71]**	1.2495 [31.73]	1.2505 [31.76]	**1.2485 [31.71]**	1.2495 [31.73]	1.2505 [31.76]
4.	**Valve Cam Rollers**						
	Inside Diameter	**0.503 [12.78]**	0.5005 [12.713]	0.5015 [12.738]	**0.503 [12.78]**	0.5005 [12.773]	0.5015 [12.708]
	Outside Diameter	**1.248 [31.71]**	1.2495 [31.73]	1.2505 [31.76]	**1.2485 [31.71]**	1.2495 [31.73]	1.2505 [31.76]
5.	**Cam Roller Pin Diameter**						
	Valve	**0.497 [12.62]**	0.4995 [12.687]	0.500 [12.70]	**0.497 [12.62]**	0.4995 [12.687]	0.500 [12.70]
	Injector	**0.497 [12.62]**	0.4995 [12.687]	0.500 [12.70]	**0.697 [17.70]**	0.6995 [17.767]	0.7000 [17.780]

the O.D. within 0.002 inch [0.05 mm]. Sides must be square to bore and parallel to each other within 0.004 inch [0.10 mm]. Check cam roller pins. Fig. 4-12. Refer to Table 4-1 for dimensions. If measurements exceed worn limits, mark for replacement.

11. If rollers were scored or galled, make careful inspection of camshaft lobes for damage.

Repair

1. If cam follower with bushing is worn beyond that listed in Table 4-1, remove bushing with ST-249 Mandrel and Block. Fig. 4-13.

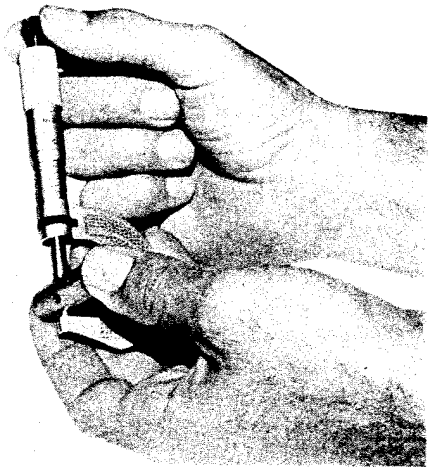


Fig. 4-12, (N10416). Measuring cam roller pin

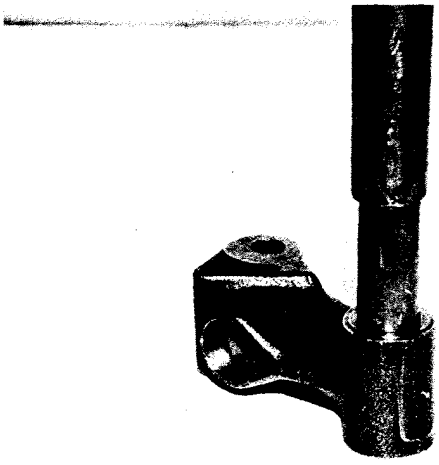


Fig. 4-13, (N10403). Removing cam follower bushing

2. Blow out oil passages with compressed air.

3. Install new cam follower bushings using ST-249 Mandrel. When installing one-piece bushing, care must be taken to align oil hole in bushing with hole in cam follower.

4. Chamfer each end of bushing with 60 degree angle cutter in a slow speed drill press.

5. Fill oil hole in bushing with semi-soft soap to prevent chips from entering oil passage during boring operation.

6. Bore bushings to 0.7501 to 0.7511 inch [19.053 to 19.078 mm].

7. Check bored bushings with ST-195 Plug Gauge.

8. Blow soap from oil holes and clean lever in an approved solvent. Dry with compressed air.

Assembly

1. If previously removed, press in new lever insert. Make sure insert is securely seated.

Caution: If new insert is installed, a new push tube must also be used.

2. Install rollers with 0.006 inch [0.15 mm] feeler stock beneath roller and next to lever as a support. Press pins through rollers and levers, then remove feeler stock. Fig. 4-14. Secure with roll pins.

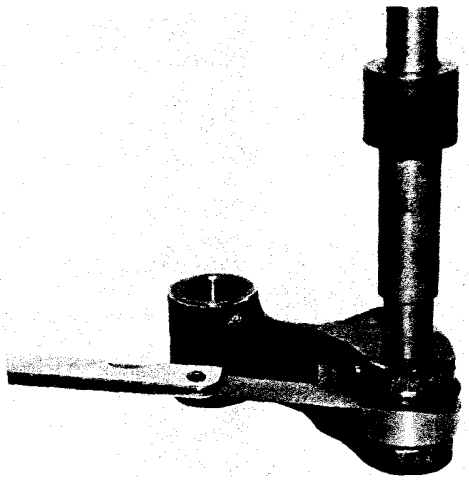


Fig. 4-14, (N10406). Installing cam follower roller pin

3. Assemble levers and shafts in housing. Make sure injector lever is in center position of each assembly. Fig. 4-15.

Note: Cam rocker levers must be installed in housing with push tube sockets and housing dowel pin holes topside. See Fig. 4-15.

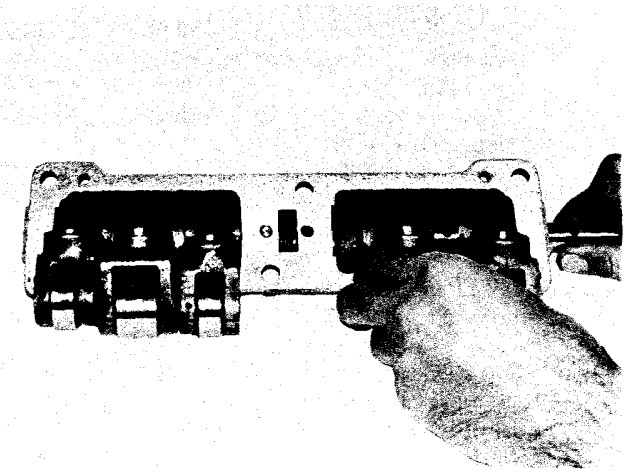


Fig. 4-15, (N10407). Assembling cam follower assembly

4. Install "dummy" screw in shaft. A "dummy" screw is used at this point to prevent lockscrew breakage. Screws have a tendency to break due to close shaft-housing fit, causing plug to act as hydraulic ram when driven in place.

5. Use No. 3 Permatex sealant and lightly coat bore in each end of housing before plugs are pressed in. Use proper service tool to press plugs into hole. Use ST-1053 Plug Driving Mandrel with end marked 175831 to press in new cup plug until it is flush to 0.010 inch [0.25 mm] below edge of hole. Fig. 4-16.

6. Remove "dummy" screw and install shaft lock-screws.

Push Tubes

Each cylinder has exhaust, injector and intake push tubes. Injector push tube is largest and fits in middle socket. On engines equipped with compression release, exhaust push tube is equipped with collar to match with milled recess in compression release shaft; the remaining push tubes are plain. On engines without compression release, intake and exhaust push tubes are both plain.

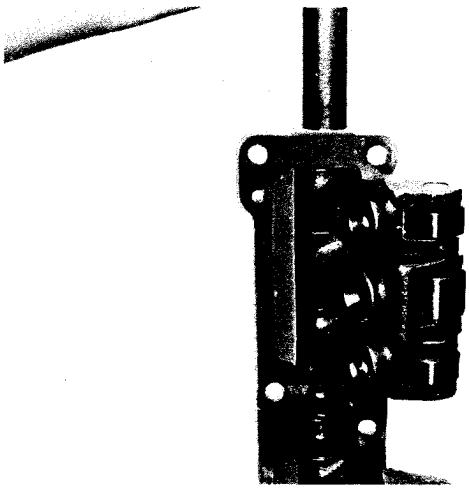


Fig. 4-16, (N10409). Installing new cup plugs

Fig. 4-18, (N20309). Checking push tube ball end with radius gauge

Cleaning and Inspection

1. Clean push tubes (Fig. 4-17) in mineral spirits or an approved solvent.

2. Check injector and valve push tube ball end for wear with radius gauge. Fig. 4-18. Ball end diameter of push tubes is 0.619 to 0.625 inch [15.72 to 15.88 mm].

3. Check socket of push tube with ball end of a new rocker lever adjusting screw (Fig. 4-19) or with a 1/2 inch [12.70 mm] check ball which should "blue in" 80 percent of seat area, spherical inside diameter new is 0.510 to 0.520 inch [12.95 to 13.21 mm].

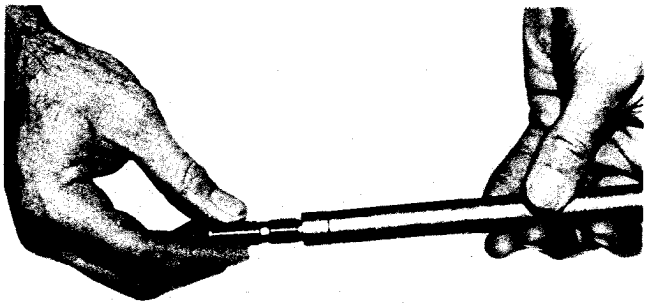


Fig. 4-19, (N20310). Checking push tube socket with adjusting screw

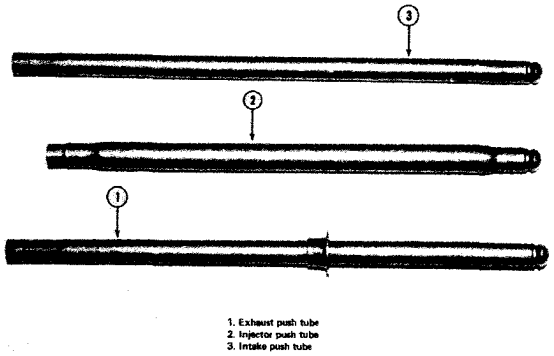


Fig. 4-17, (V40309). Push tubes

4. Extreme wear on either end of push tube will result in loss of lubricating oil pressure and may interfere with correct injector or valve adjustment.

5. Check push tubes to see if they are bent; out-of-round. Tubes should not be out-of-round more than 0.035 inch [0.89 mm] when located in centers of socket and ball.

6. Push tubes with worn balls should never be installed in new cam follower sockets.

Table 4-1: Specifications – Inch [mm]

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	2 Inch Cam Engines New Minimum	2 Inch Cam Engines New Maximum	2-1/2 Inch Cam Engines Worn Limit	2-1/2 Inch Cam Engines New Minimum	2-1/2 Inch Cam Engines New Maximum
1.	**Shaft**						
	Outside Diameter	**0.748 [19.00]**	0.7485 [19.012]	0.749 [19.02]	**0.748 [19.00]**	0.7485 [19.012]	0.749 [19.02]
2.	**Bushing**						
	Inside Diameter	**0.752 [19.10]**	0.7501 [19.053]	0.7511 [19.078]	**0.752 [19.10]**	0.7501 [19.053]	0.7511 [19.078]
3.	**Injector Cam Roller**						
	Inside Diameter	**0.505 [12.83]**	0.503 [12.78]	0.504 [12.80]	**0.705 [17.91]**	0.703 [17.86]	0.704 [17.88]
	Outside Diameter	**1.2485 [31.71]**	1.2495 [31.73]	1.2505 [31.76]	**1.2485 [31.71]**	1.2495 [31.73]	1.2505 [31.76]
4.	**Valve Cam Rollers**						
	Inside Diameter	**0.503 [12.78]**	0.5005 [12.713]	0.5015 [12.738]	**0.503 [12.78]**	0.5005 [12.773]	0.5015 [12.708]
	Outside Diameter	**1.248 [31.71]**	1.2495 [31.73]	1.2505 [31.76]	**1.2485 [31.71]**	1.2495 [31.73]	1.2505 [31.76]
5.	**Cam Roller Pin Diameter**						
	Valve	**0.497 [12.62]**	0.4995 [12.687]	0.500 [12.70]	**0.497 [12.62]**	0.4995 [12.687]	0.500 [12.70]
	Injector	**0.497 [12.62]**	0.4995 [12.687]	0.500 [12.70]	**0.697 [17.70]**	0.6995 [17.767]	0.7000 [17.780]

Table 4-2: Push Tube Length – Inch [mm]

	2 Inch Cam	2-1/2 Inch Cam
Injector	18.290 [464.57]	17.775 [451.49]
	18.320 [465.32]	17.805 [452.25]
Valve	18.360 [466.34]	17.880 [454.15]
	18.390 [467.11]	17.910 [454.91]

Group 5

The PT fuel system is used exclusively on Cummins Diesels, it was developed by Cummins Engine Company. The identifying letters "PT" are an abbreviation for pump functions of supplying fuel pressure at the proper time "pressure-time".

Fuel System

PT Fuel Pumps

Three models of PT fuel pumps are used: The PT (type G), PT (type R) and PT (type G) AFC. The PT (type G) indicates that fuel pressure regulation is a part of the governor function. The PT (type R) refers to fuel pressure regulation as a function of a regulator assembly. The PT (type G) AFC fuel pump indicates that the air fuel control is an integral part of the fuel pump.

1. Repair of pumps and calibration instructions is described in Bulletin No. 3379084 or revisions.

2. Bulletin No. 3379101 covers calibration of the PT (type R) pumps as used on Cummins engines.

3. Bulletin No. 3379068 covers calibration specifications of the PT (type G) pumps as used on Cummins engines.

4. For Air Fuel Control, aneroid adjustment and calibration refer to Fuel Pump Calibration manuals.

5. The CPL (Control Parts List) Manual, Bulletin No. 3379133, is a listing of basic engine parts and timing specifications which are necessary to produce a given engine performance. By reference to CPL numbers stamped on engine nameplate, this list may be used to identify parts within an engine. These parts then determine whether a fuel pump calibration is suitable for that engine.