SHOP MANUAL
UNIT REBUILDING

CUMMINS

J SERIES DIESEL ENGINES

BULLETIN NO. 983383

PRICE, $2.0[illegible]

CUMMINS ENGINE COMPANY, INC. • COLUMBUS, INDIANA, U.S.A.

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Foreword

This manual is applicable to all Cummins 4 and 6-cylinder J Series engines. All of the engines in this series are treated in this one manual because the repair characteristics and service procedures are either identical or similar. Where different procedures are required, they are clearly indicated. Before you attempt any engine adjustments familiarize yourself with the procedures described.

All the instructions contained herein stress the importance of cleanliness, and accurate inspection and assembly procedures. Complete instructions or references are given for engine disassembly, unit rebuilding and engine assembly.

CUMMINS ENGINE COMPANY, INC.

COLUMBUS, INDIANA, U.S.A.

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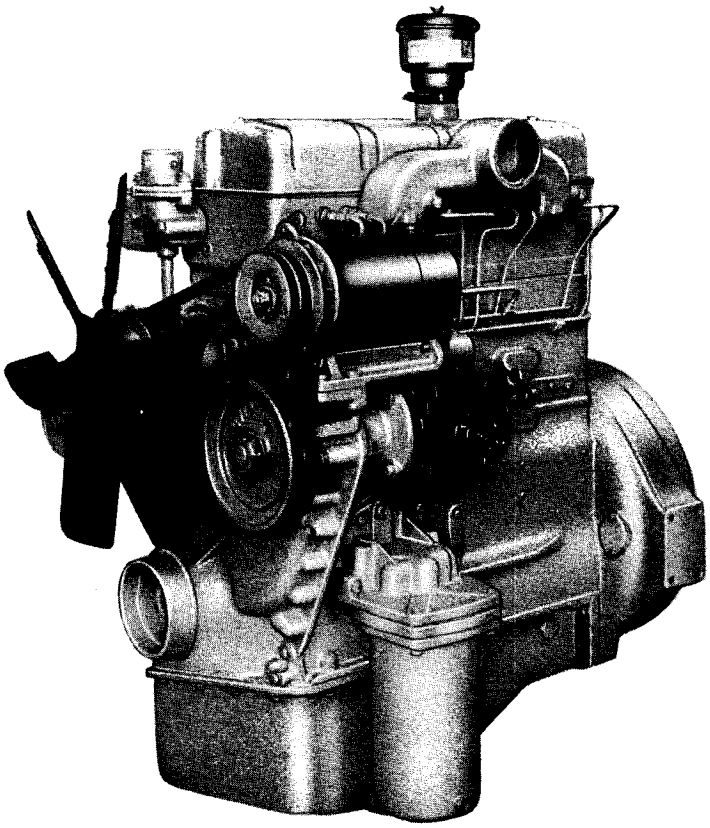


Fig. 1. Cummins J-4 Diesel Engine—Fuel Pump Side

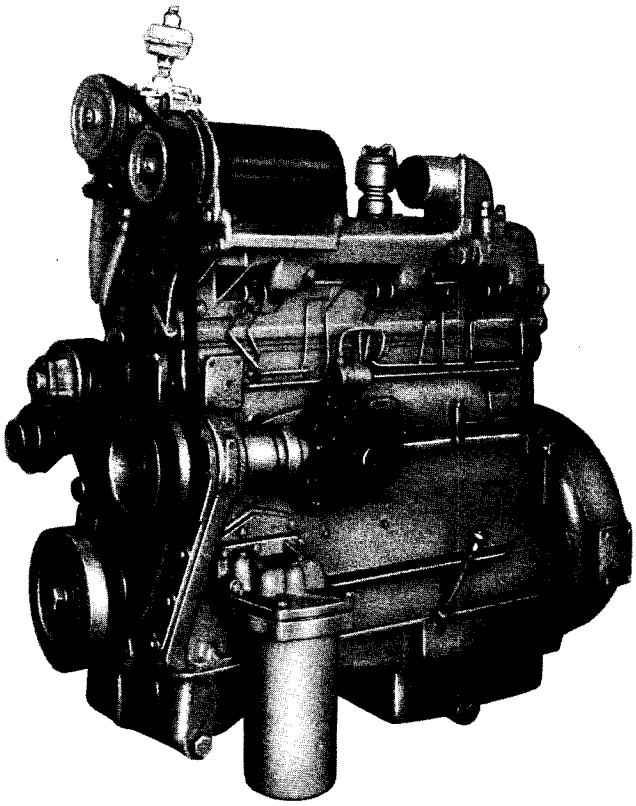


Fig. 2. Cummins JN-6 Diesel Engine—Fuel Pump Side

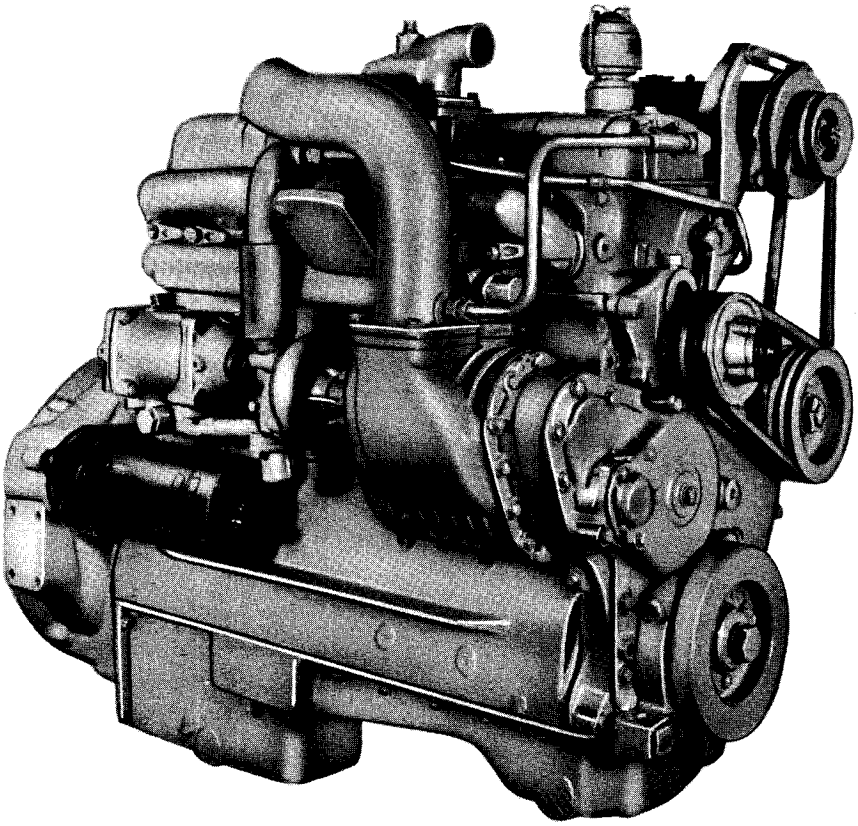


Fig. 3. Cummins JS Diesel Engine—Supercharger Side

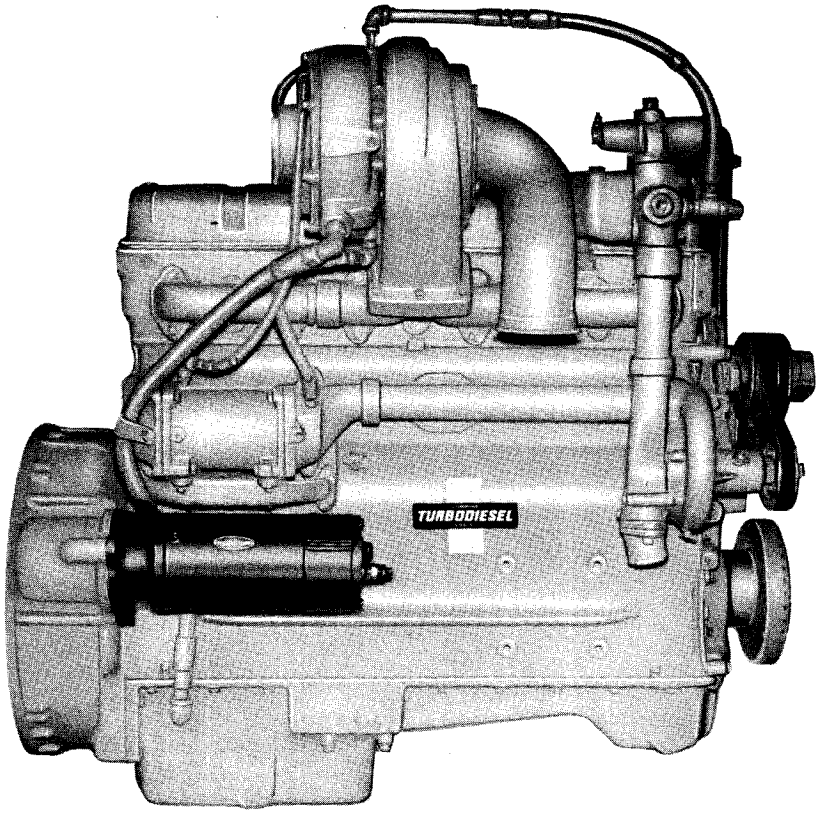


Fig. 4. Cummins JT TURBODIESEL Engine—Turbocharger Side

Introduction

As any engine operates, a certain amount of wear occurs. The amount of wear depends largely on operating conditions, maintenance procedures, and the quality of manufacture.

After some undetermined length of time (depending upon the items above), the worn parts of an engine must be replaced to keep it operating efficiently and economically. The complete inspection and parts replacement operations are called rebuilding or overhaul.

Cummins engines are designed to give long periods of service between overhauls, but like all engines they will benefit by an overhaul at the proper time.

The rebuilding job must be performed according to established standards by well-trained mechanics in a well-equipped shop. Normal shop equipment plus some special tools are necessary to properly rebuild a Cummins engine.

Your Cummins Distributor is equipped to rebuild all Cummins engines, or if you desire, you may purchase from him the tools necessary for you to perform your own rebuild. This manual is one of the "tools" necessary for a good rebuild.

NOTE: Wear limits established in this manual are *replacement limits;* i.e., a part not worn beyond the replacement limit may continue to be used for many additional hours of trouble free service.

BASIC ENGINE MODELS TREATED IN THIS MANUAL

Engine Models	Engine Breathing	Number Cylinders	Bore & Stroke	Cu. In. Displ.	Maximum HP @ RPM*
J-4	Natural	4	4 1/8 x 5	267	74 @ 2200
J-6	Natural	6	4 1/8 x 5	401	100 @ 1800
JF-6	Natural	6	4 1/8 x 5	401	110 @ 2200
JS-6	Supercharged	6	4 1/8 x 5	401	160 @ 2500
JN-6	Natural	6	4 1/8 x 5	401	130 @ 2500
JNS-6	Supercharged	6	4 1/8 x 5	401	175 @ 2500
JT-6	Turbocharged	6	4 1/8 x 5	401	175 @ 2500

* Based on 29.92" Hg. Barometric Pressure (Sea Level), 60° Fahrenheit Air Intake Temperature, Dry Air. JT-6 engines are not derated until operated at or above 12,000 feet altitude, all others derated 3% for each 1,000 feet above sea level and 1% for each 10° F. ambient temperature rise above 60° F.

Section 1

REMOVAL OF ENGINE UNITS

Remove units and parts from cylinder block group in following order and with special precautions, as noted. Place removed parts and units on ST-408 Engine Cart or equivalent for steam cleaning.

Several assemblies mentioned apply only to certain engine models.

DRAIN WATER AND OIL

1. Drain lubricating oil from oil pan and oil filter.

2. Drain fuel oil from fuel pump, fuel filters and fuel lines.

3. Drain water from cylinder block, radiator, and oil cooler.

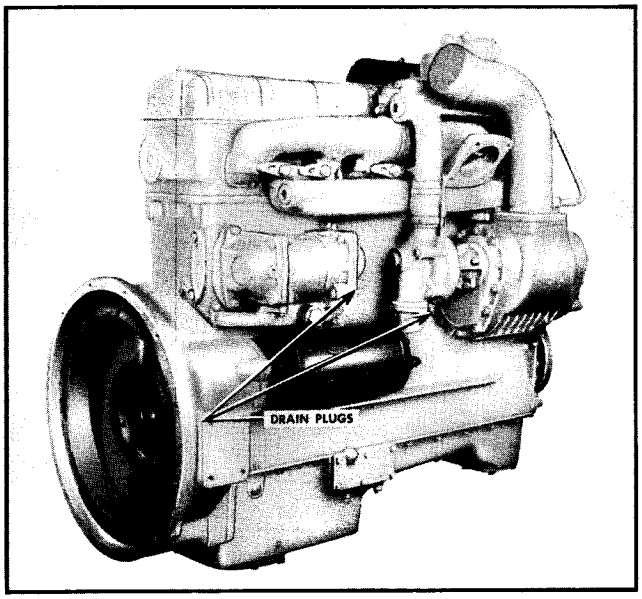


Fig. 1-1. Plugs for draining cylinder block

ELECTRICAL CONNECTIONS

1. Disconnect wire leads from terminals of generator, cranking motor, cold starting electrodes, regulator, remote controls, etc., as used.

CRANKING MOTOR

1. Remove mounting capscrews.
2. Remove cranking motor.

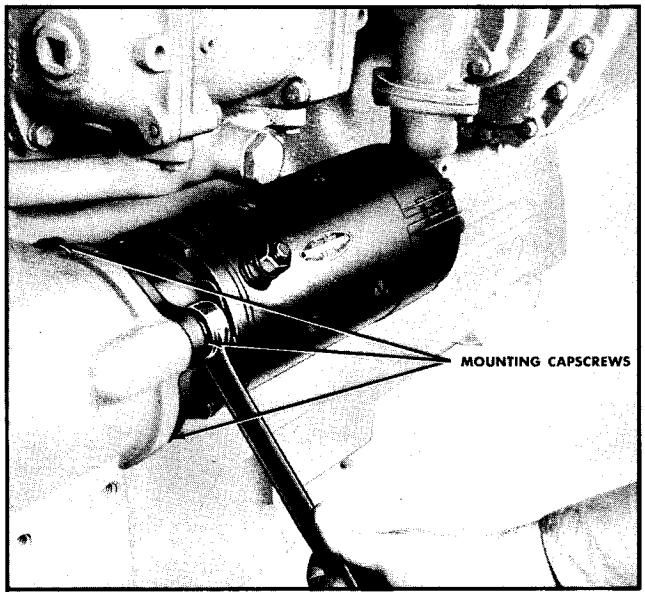


Fig. 1-2. Cranking motor removal

GENERATOR

1. Disconnect fuel inlet and drain line for No. 1 cylinder.
2. Remove mounting capscrews.
3. Remove generator.

MECHANICAL CONTROLS, WATER, AIR AND FUEL CONNECTIONS

1. Remove mechanical control linkage. (Clutch, throttle linkage, etc.)
2. Remove radiator hose.
3. Remove the flexible fuel lines from injector fuel drain manifold and pump inlet (or fuel filter inlet if so equipped), and return lines from fuel pump to fuel tank.
4. Remove hose connection, air cleaner to engine.
5. Remove outlet lines from compressor.
6. Remove air cleaner to engine piping and turbocharger or supercharger crossover.

STEAM CLEAN ENGINE EXTERIOR

A portable fuel-oil or electric heated steam cleaner is very satisfactory for general use. In addition to actual time saving effected by engine cleaning, inspections can be made during disassembly if surfaces are clean.

FAN AND PULLEY

1. Remove four capscrews.
2. Remove fan.

FAN HUB AND BRACKET

1. Loosen fan hub nut.
2. Turn adjusting screw to loosen and remove belt.
3. Remove fan hub bracket mounting capscrews.
4. Lift fan hub and bracket.

TURBOCHARGER

1. Remove water lines, turbocharger to thermostat housing, and turbocharger to oil cooler.
2. Remove oil lines from turbocharger to oil cooler and to oil pan.
3. Remove nuts from six mounting capscrews.
4. Lift turbocharger from exhaust manifold mounting flange.

ANEROID CONTROL

1. Disconnect flexible [illegible] aneroid to fuel pump on pressure side of gear pump.
2. Remove flexible [illegible] aneroid to fuel pump at inlet side of gear pump.
3. Remove air-vent hose.
4. Remove air pressure hose.
5. Remove bracket mounting capscrews.
6. Remove aneroid and bracket.

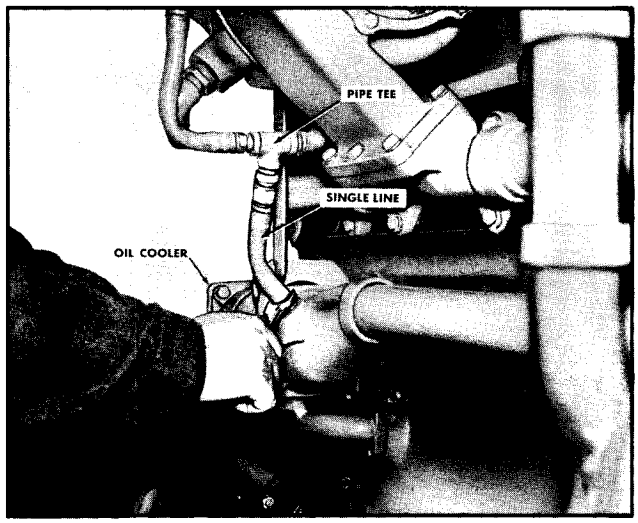


Fig. 1-3. Water line to oil cooler

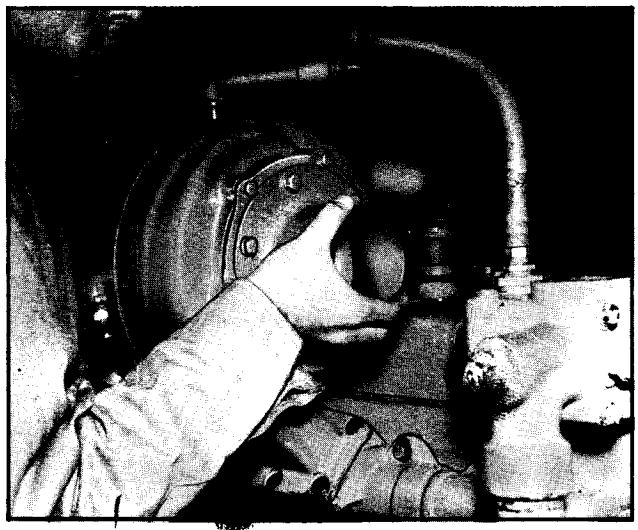


Fig. 1-4. Removing turbocharger

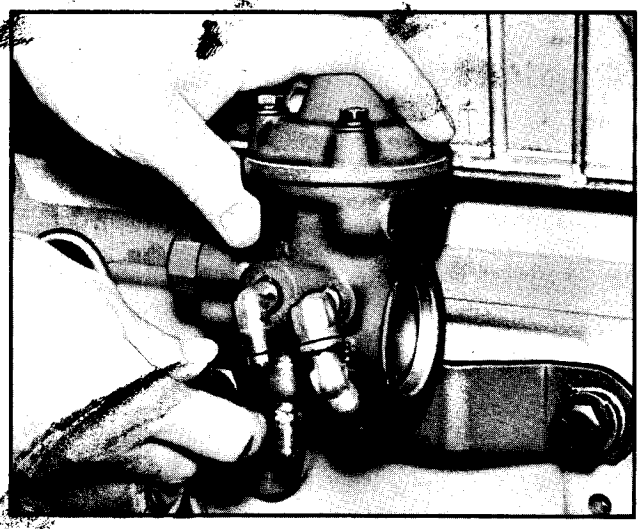


Fig. 1-5. Removing aneroid control

PT FUEL PUMP

1. Remove line from solenoid shut-off valve to inlet manifold.

2. Remove line from fuel filter (if so equipped) to pump.

3. Remove four bracket mounting capscrews.

4. Lift fuel pump and bracket.

NOTE: For flange mounted PT pump, remove four flange bolts and then remove pump.

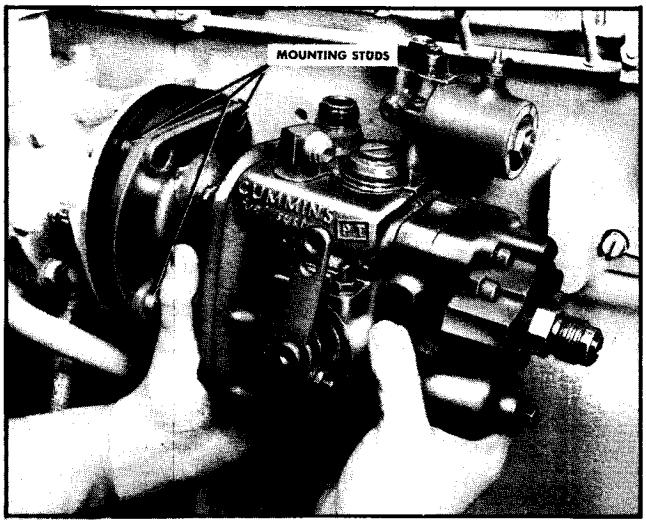


Fig. 1-6. Remove fuel pump

FUEL FILTER

1. Remove mounting capscrews.

2. Remove filter and bracket.

OIL STRAINER

1. Remove four mounting capscrews from bracket.

2. Lift strainer.

OIL BY-PASS ADAPTOR

1. Disconnect lines to oil strainer (remote mounted).

2. Disconnect tubing to compressor.

3. Remove mounting capscrews.

4. Move to engine cart.

AIR COMPRESSOR, FLANGE MOUNTED

1. Disconnect oil inlet line from air compressor drive at fuel pump flange end.

2. Remove oil drain tube from bottom of compressor.

3. Disconnect water inlet and outlet tubes.

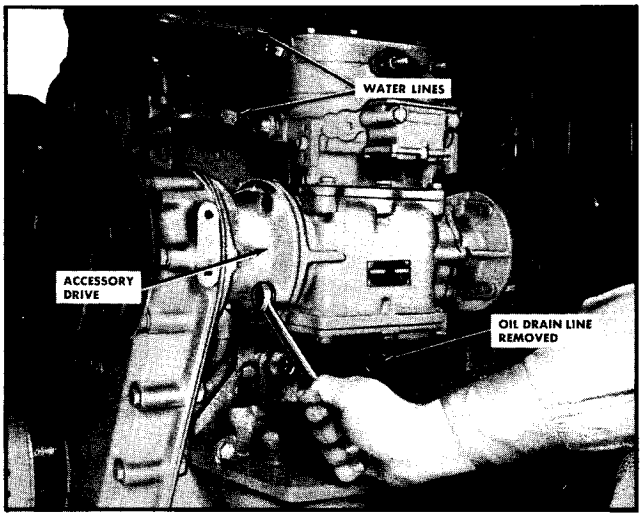


Fig. 1-7. Removal of air compressor

4. Disconnect air intake line, air compressor to intake manifold.

5. Remove bracket mounting capscrews.

6. Lift compressor from splined drive coupling.

AIR COMPRESSOR, BRACKET MOUNTED

1. Disconnect and remove air intake line.

2. Remove water and oil tubes.

3. Disconnect cotter key and pin from chain and remove.

4. Lift compressor and bracket from dowels.

AIR COMPRESSOR (J-4)

1. Disconnect oil supply line.

2. Remove bolts holding compressor to bracket; slide compressor to disengage belt.

3. Lift compressor from bracket.

4. Remove and discard gasket if it is damaged.

FUEL PUMP DRIVE

1. Remove drive pulley.
   a. Remove shaft nut and washers.
   b. Pull accessory drive pulley with ST-160.
   c. Mount puller on pulley with two capscrews.
   d. Turn center screw tight against accessory drive shaft.
   e. Tape the Woodruff Key to shaft.
   f. If seal is damaged, pull it from gear housing.
2. Remove six capscrews.
3. Lift unit and gasket.

AIR BREATHER ASSEMBLY
(Turbocharged and Supercharged Engines)

1. Remove tubing clamp.
2. Loosen pipe connection (if used), remove tube.
3. Unscrew valve.

NOTE: On some installations, it is necessary to remove pipe connection before Step 3.

OIL TRANSFER

1. Remove four capscrews.
2. Remove oil transfer.

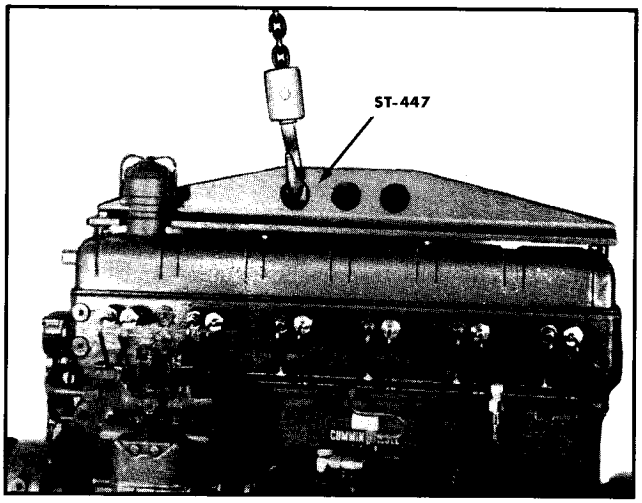


Fig. 1-8. Lifting the engine

LIFT ENGINE

1. Place ST-447 lifting fixture over cylinder head cover.
2. Tighten mounting capscrews in tapped holes provided in head.

*NOTE: When lifting a JT or JNS with ST-447, the crossover must be removed. See Turbocharger Removal, Page 1-2.

ST-464 Lifting Fixture may be used where four-valve engines are recessed under a fire wall.

1. Remove rocker lever cover.
2. Mount fixture to head with two mounting capscrews.

NOTE: Turbocharger need not be removed in most cases.

MOUNT ENGINE ON ENGINE STAND

1. Use ST-548 Engine Stand.
2. Use ST-513 Adaptor Plate.
3. Mount to fuel pump side of engine with six capscrews.

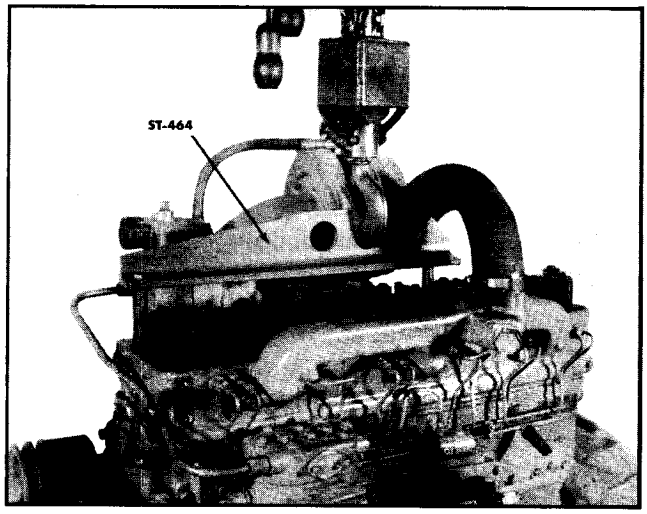


Fig. 1-9. Lifting the JT engine

MOUNT ENGINE (J-4)

1. Use ST-548 Engine Stand.
2. Use ST-549 Adaptor Plate.
3. Mount to fuel pump side of engine with six capscrews.

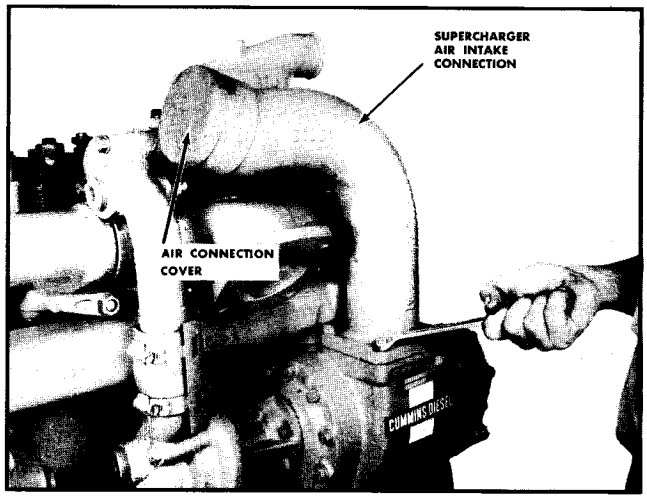


Fig. 1-10. Removing supercharger air intake connection

SUPERCHARGER AIR INTAKE CONNECTIONS

1. Remove vapor suction tube from side of air intake connection and from cylinder head cover.
2. Remove four capscrews.
3. Lift air intake connection and gasket from supercharger.

CAUTION: SUPERCHARGER AND TURBOCHARGER INLET AND OUTLET PORTS SHOULD BE COVERED WITH MASKING TAPE. DO NOT STUFF RAGS INTO PORTS TO KEEP OUT FOREIGN OBJECTS.

INTAKE MANIFOLD, FUEL PUMP SIDE

1. Remove mounting capscrews.
2. Lift manifold and gaskets.

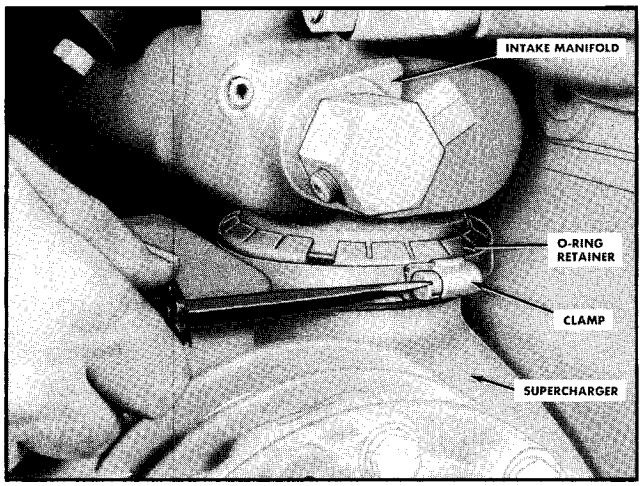


Fig. 1-11. Clamp on O-ring retainer

INTAKE MANIFOLD, EXHAUST SIDE

1. Remove band connecting supercharger to intake manifold (JS).
2. Remove stud nuts and clamps.
3. Pull away from dowels and lift intake manifold and three gaskets.

FUEL MANIFOLDS

1. Loosen injector inlet fuel manifold.
2. Loosen injector drain fuel manifold.
3. Remove mounting clamps and lines.

INLET AND DRAIN CONNECTIONS

1. Remove injector fuel drain connections.
2. Remove injector fuel inlet connection.

Turn nut closest to spring on fuel inlet connection.

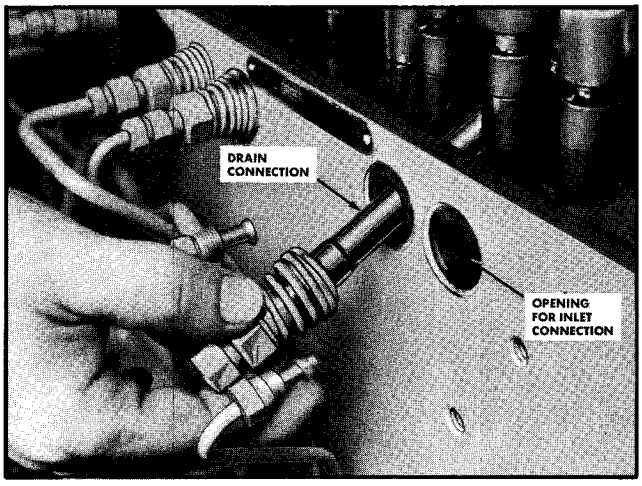


Fig. 1-12. Removing fuel drain connection

OIL COOLER

1. Remove mounting capscrews from oil cooler.
2. Remove cooler and gaskets.

DIPSTICK AND MOUNTING BRACKET

1. Remove mounting capscrews.
2. Lift dipstick and bracket.

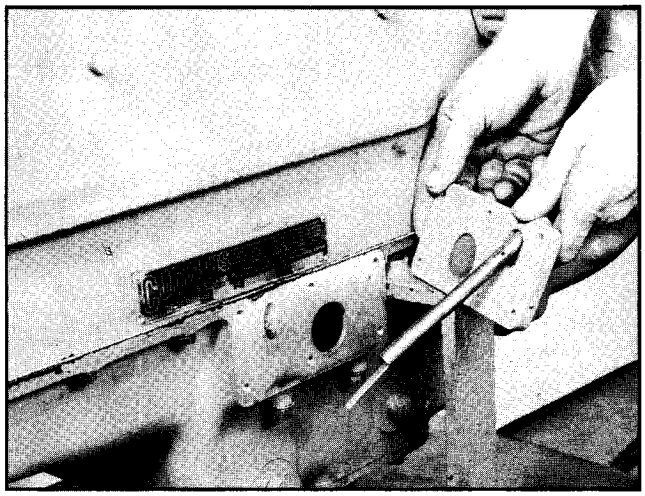


Fig. 1-13. Removing dipstick and bracket

THERMOSTAT HOUSING AND WATER BY-PASS

1. Remove water pump air bleed tubing, water pump to thermostat housing.
2. Remove two mounting capscrews.
3. Lift thermostat housing and water by-pass.

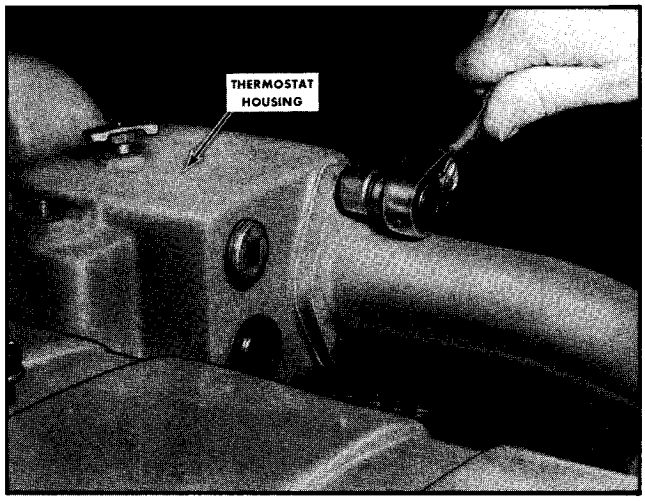


Fig. 1-14. Removing thermostat housing

THERMOSTAT HOUSING WATER BY-PASS (J-4)

1. Loosen clamps on hose connections, water pump body to thermostat housing.
2. Remove two mounting capscrews.
3. Remove housing.

EXHAUST MANIFOLD

1. Remove capscrews or stud nuts and clamps.
2. Remove manifold.

Fig. 1-15. Water pump—belt driven

WATER PUMP (Belt Driven)

1. Remove two mounting capscrews.
2. Lift pump from engine separating it from water by-pass coupling and oil cooler connection.

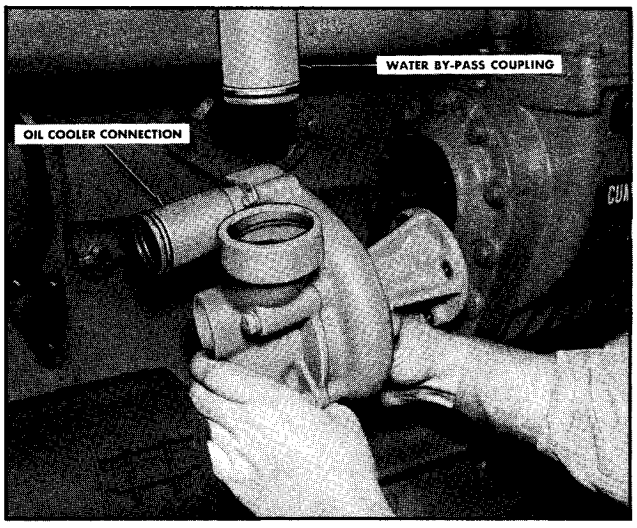


Fig. 1-16. Water pump—supercharger driven

WATER PUMP (Supercharger Driven)

1. Remove four mounting capscrews.
2. Remove unit from supercharger drive coupling.

WATER PUMP AND FAN HUB (J-4)

1. Remove seven mounting capscrews.
2. Remove water pump body, fan and water pump pulley.

SUPERCHARGER

1. Remove the seven capscrews securing supercharger to gear case.
2. Lift supercharger from gear case being careful not to damage lubricating oil ferrule in gear case close to bottom supercharger dowel.

NOTE: On JNS, remove air outlet connection to cross-over pipe.

a. Remove bracket from oil cooler.

b. Loosen band from supercharger connection.

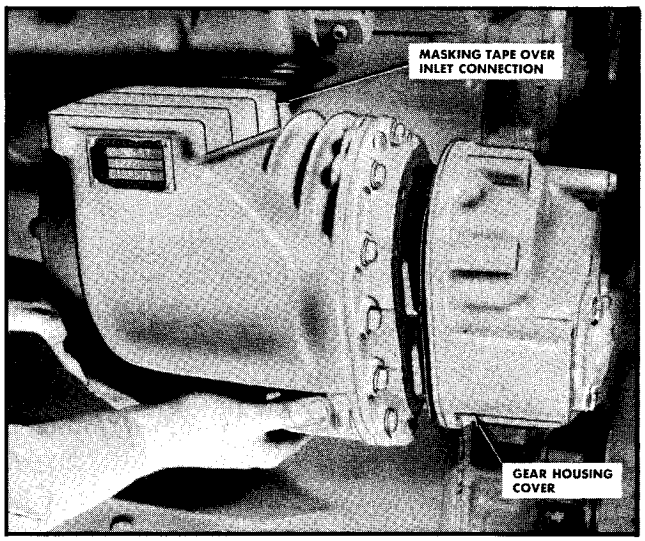


Fig. 1-17. Removing supercharger

WATER HEADER PLATE

1. Remove 2 capscrews from block.
2. Remove plate and gasket.

ROCKER LEVER COVER

1. Remove capscrews from cover.
2. Lift cover and gasket.

ROCKER LEVER ASSEMBLY

1. Remove all cylinder head capscrews.
2. Remove six oil guards from injector top housing, if used.
3. Remove capscrews which secure rocker shaft bearings. The center bearing has an oil line dowel pin.
4. Carefully, pry rocker lever assembly from dowels.
5. Using a bar or wooden slat to keep levers in position, lift and remove rocker lever assembly.

INJECTORS

1. Remove injector capscrews or stud nuts.
2. Lift each injector from cylinder head being careful not to damage injector cup tip.
3. Place injectors in a rack; number by cylinder from which they were removed.

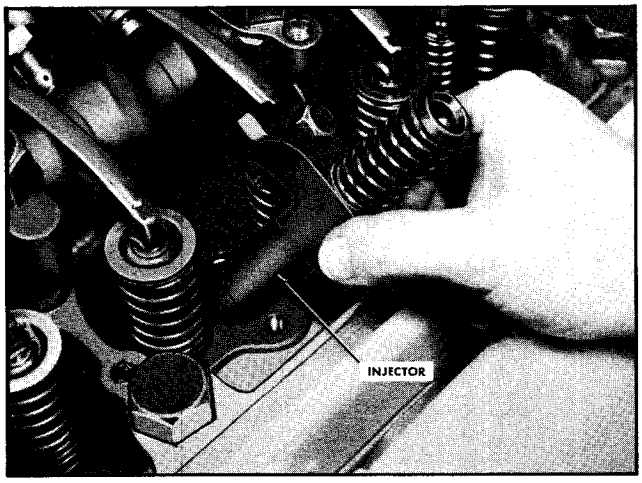


Fig. 1-18. Removing injector

PUSH RODS AND CROSSHEADS

1. Lift the push rods, 3 for each cylinder, from their sockets.
2. Lift crossheads from crosshead guides.

CYLINDER HEAD

1. Attach lifting fixture ST-447 (or some similar lifting arrangement on J-4) to cylinder head and attach hoist.
2. Raise cylinder head from block. If studs are used, the cylinder head must be kept straight and parallel with the cylinder block to prevent binding.

Do not allow the cylinder head machined surface to contact any object that may nick or scratch it. A nick or scratch may cause a blown head gasket during engine operation.

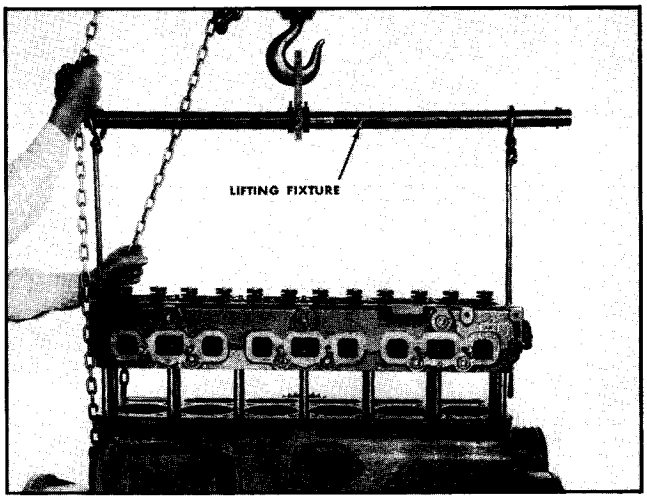


Fig. 1-19. Lifting cylinder head from block

TAPPET GUIDES AND TAPPETS

1. Cut lock wires.
2. Remove tappet guides from side of block.
3. Remove tappets from block.

FLYWHEEL

1. Remove lock wires from six capscrews, and remove capscrews.
2. Screw two studs, four or five inches long, into crankshaft flange through two holes in flywheel. The flywheel will ride on these studs when it's pulled away from its mountings.
3. Insert two ½"-13 capscrews 2½" long, threaded their entire length, into two threaded holes of the flywheel. Tighten finger tight.

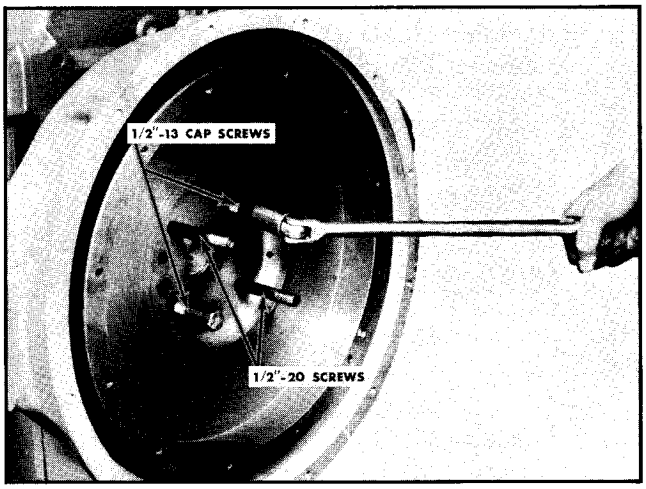


Fig. 1-20. Removing flywheel

4. Tighten ½"-13 capscrews equally against crankshaft flange to pull flywheel away from dowel pins and crankshaft flange.
5. Lift flywheel from studs.

FLYWHEEL HOUSING

1. Remove four capscrews connecting rear of flywheel housing to oil pan.
2. Remove mounting capscrews inside of housing.
3. Drive housing from dowels with light blows from block of wood or soft hammer.
4. Remove housing.

OIL PAN

1. Turn engine upside down.
2. Remove pan capscrews.
3. Lift oil pan and gasket from dowel pins.

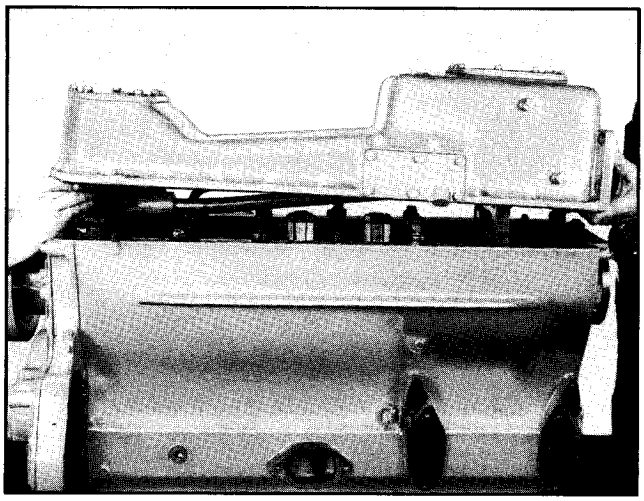


Fig. 1-21. Removing oil pan

OIL BY-PASS DRAIN LINE

1. Loosen and remove oil by-pass drain line bracket.
2. Remove line and bracket.

LUBRICATING OIL PUMP

1. Remove mounting capscrews and lockwashers from hanger straps.
2. Remove lube pump mounting capscrews.
3. Work lubricating oil pump off dowels; lift it and suction tube assembly.

VIBRATION DAMPER AND HUB

1. Remove capscrews and lock-plates.
2. Lift vibration damper and ring from hub.
3. Remove center capscrew lockwasher and retainer.
4. Use ST-564 puller to pull crankshaft flange without damaging flange. ST-564 is required only with tapered-shank crankshafts.

Do not hammer or pry the vibration damper housing.

SECOND ORDER COUNTERBALANCER (J-4)

1. Remove counterbalancer drive shaft from counterbalancer.
2. Remove four mounting capscrews.
3. Pry counterbalancer from dowels.

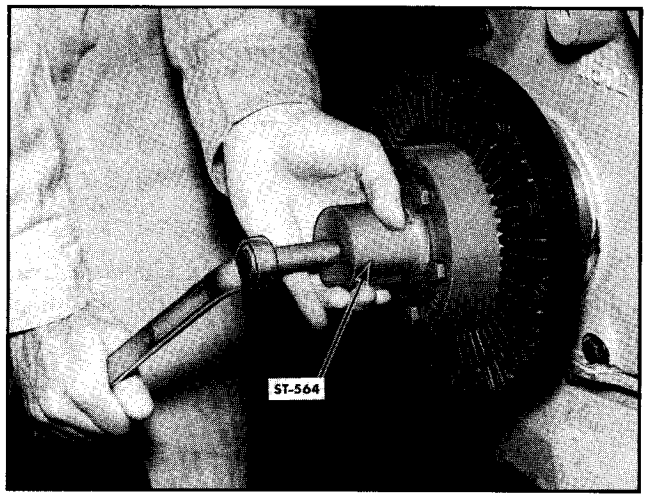


Fig. 1-22. Removing crankshaft flange

GEAR HOUSING COVER

1. Remove mounting capscrews.
2. Pry gear housing from dowels.

NOTE: JS gear housing cover has an idler spindle support screw which must be removed before Step No. 2.

SUPERCHARGER IDLER GEAR

1. Remove idler gear assembly and front and rear thrust bearings from idler shaft.

CAMSHAFT

1. Remove two or three capscrews, camshaft bearing plate to block, accessible through openings in camshaft gear.
2. Rotate camshaft gear slightly to disengage gear teeth while pulling camshaft and bearing plate.

DO NOT REMOVE GEAR FROM CAMSHAFT.

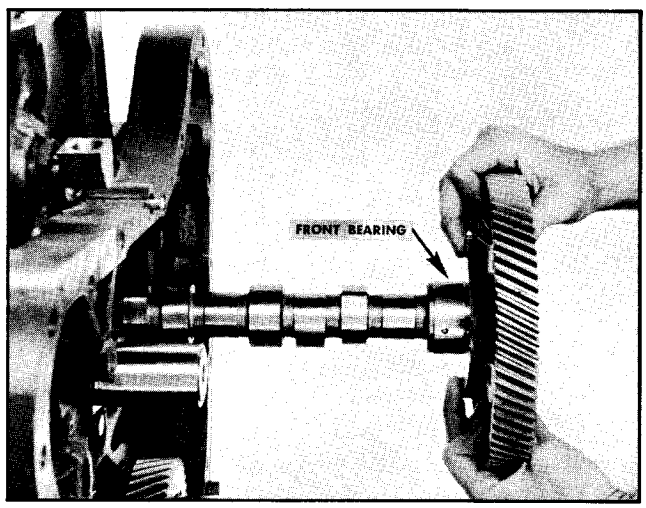


Fig. 1-23. Removing camshaft

GEAR HOUSING MOUNTING PLATE

1. Remove mounting capscrews.
2. Loosen from dowels with light blows from a lead hammer.

NOTE: Three socket head capscrews are peened in place. A special ¼" socket head wrench, with extension, must be used in order to remove these three capscrews.

ONE-PIECE REAR COVER

1. Remove six mounting capscrews.
2. Remove cover and seal.

SPLIT REAR COVER

1. Remove two nuts, lockwashers, and dowel fit bolts which hold upper half of rear cover plate to lower half.
2. Remove upper and lower rear cover plate halves.
3. Disconnect spring and remove rear cover seal with needle nose pliers or a wire hook.

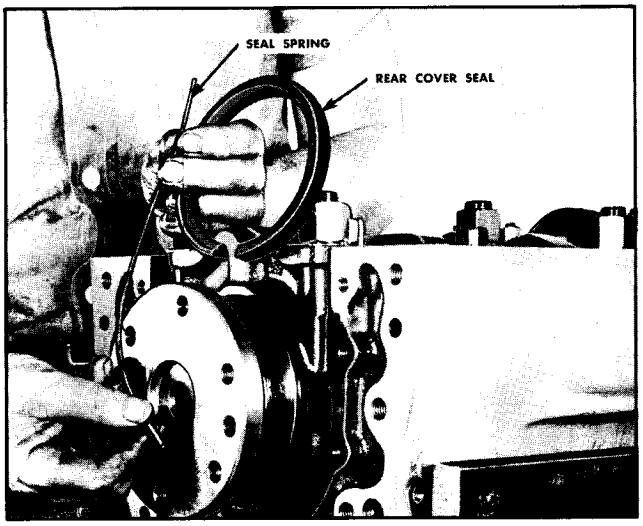


Fig. 1-24. Removing rear cover oil seal

CONNECTING ROD AND PISTON ASSEMBLIES

1. Scrape all carbon from top of cylinder liner bore. Failure to clean liners thoroughly may cause pistons to stick or score.
2. Remove connecting rod U-bolt nuts.
3. Remove cap and bearing shells.
4. Push piston and connecting rod from cylinder liner with wooden stick. Hold piston so that it will not be dropped and damaged.
5. Reassemble connecting rods, bolts, caps, and nuts as they are taken out. These parts are not interchangeable; number each assembly for identification.

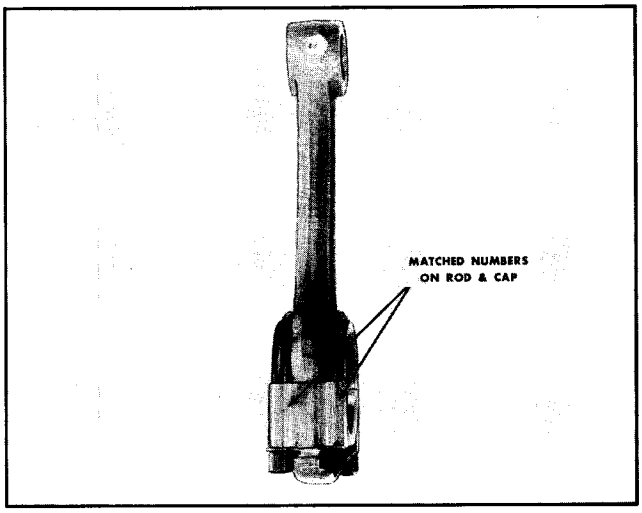


Fig. 1-25. Matched numbers on connecting rod and cap

6. Tape bearing halves together and identify by number as removed.
7. Remove piston pin snap rings.
8. Remove piston pins.

NOTE: Heat aluminum pistons in hot water before removal of piston pins. This will permit pin to be pushed out easily without distorting piston.

CRANKSHAFT AND MAIN BEARINGS

1. Loosen each main bearing capscrew until approximately five threads remain engaged in block.
2. Pry each main bearing cap loose, remove capscrews and lift cap from block.
3. Remove lower main bearings from crankshaft.

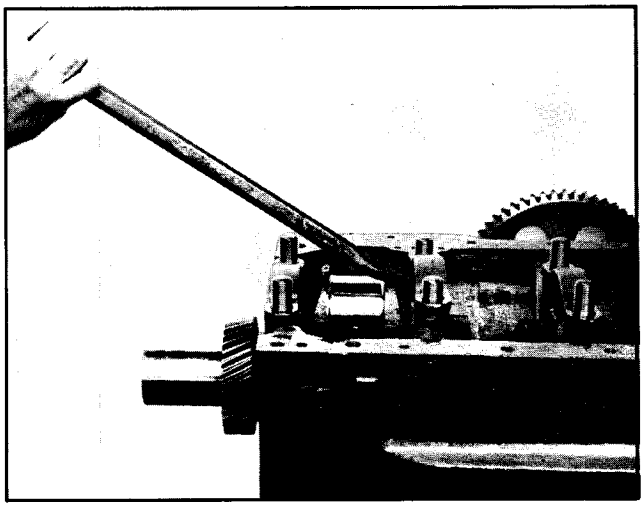


Fig. 1-26. Removing main bearing caps

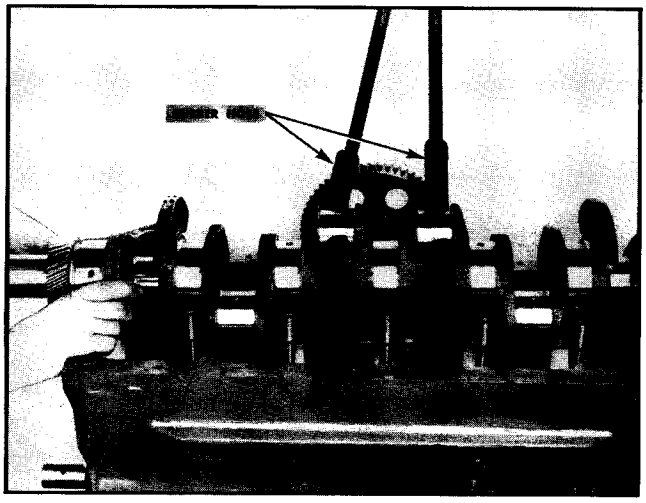


Fig. 1-27. Lifting crankshaft

4. Lift crankshaft from cylinder block with hooks covered with rubber hose to protect bearing surface or with rope at two crank throws.

5. Remove all upper main bearings.

Lower thrust half-rings are dowelled to No. 7 (No. 5, J-4) main bearing cap. Upper thrust half-rings rest in chamfer in No. 7 main bearing bore in block.

All J engines after Serial No. 113353 have grooveless lower main bearing shells and grooved upper shells.

6. Tape upper and lower main bearing shells together and identify by cylinder number.

CYLINDER LINERS

1. Pull cylinder liners from cylinder block with ST-60.

The bottom plate of tool is pivoted on central screw and is inserted through cylinder liner.

The elevated top plate straddles the liner. Tighten hex nut to pull liner loose.

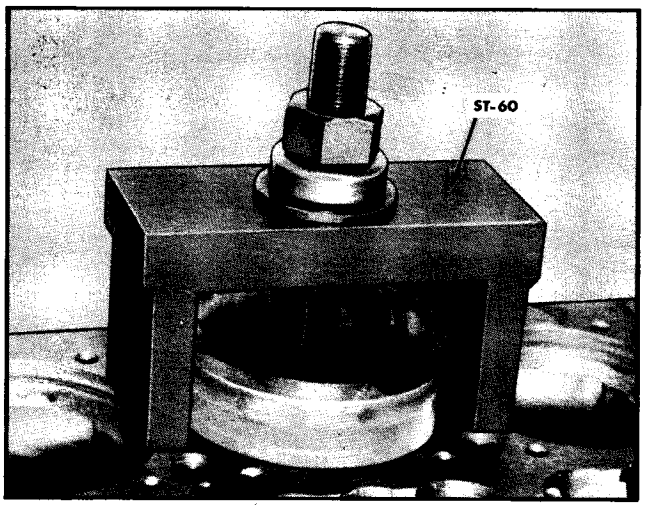


Fig. 1-28. Pulling cylinder liner

The removable wet type liners are held tight at the top by the cylinder head and gasket and at the bottom by packing rings.

STEAM CLEAN ALL UNITS

1. Steam clean all disassembled units and parts with a steam jet and dry with compressed air.

Dirt in the engine causes a high percentage of poor engine performance and costly repairs. These can be eliminated through careful cleaning—both inside and out.

Section 2

UNIT NO. 1

CYLINDER BLOCK GROUP

CYLINDER BLOCK

CHECK BLOCK FOR CRACKS

1. Paint block with oil.
2. Rub off oil.
3. Paint with chalk dust and alcohol or "whiting." When this dries, the oil seepage will discolor the chalk making the crack location readily apparent.

CHECK BLOCK FOR CORROSION

Corrosion is most likely to occur on the portions of the block which are near the cylinder liners and is evidenced by pitting.

1. Replace block if pitting will endanger effectiveness of water seals.
2. Clean liner bore in block with sandpaper, a sanding drum, and an electric drill. Emery cloth may be used on the drum if the bore contains ridges.

CAMSHAFT BUSHING

1. Use inside micrometers or dial bore gauge to gauge the camshaft bushing bore.
2. Replace bushings that are worn in excess of 1.878 inches or have been chipped badly, scored or scratched.

CLEAN OIL PASSAGES OF THE BLOCK

1. Remove oil seal plugs.
2. Clean passages with a cleaning rod and cloth or with compressed air.
3. Replace all oil seal plugs.

CHECK AIR BLEED HOLES

1. Check hole at front of No. 1 cylinder block opening into water head.
2. Check hole in cylinder head outlet connection to thermostat housing and gasket.

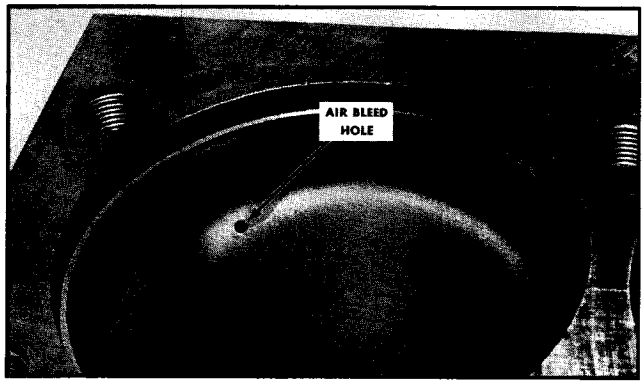


Fig. 2-1. Air bleed hole in No. 1 cylinder bore

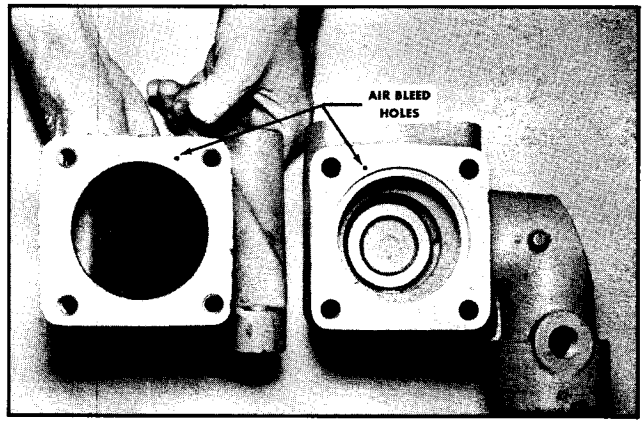


Fig. 2-2. Air bleed holes in thermostat housing

RESURFACING THE CYLINDER BLOCK

Under certain conditions, a cylinder block may be salvaged by removing a maximum of .010 inches of material from the top surface.

1. Use either a milling machine or large surface grinder.
2. Make light cuts (.001 to .003 inches deep) removing only enough material to make block usable.
3. Check distance from *centerline* of main bearing bore to top of reworked block.
   a. You may find this dimension by placing block top down on a flat surface plate and measuring from main bearing bore to plate.
   b. If surface plate is not available, insert main bearing bore checking bar and measure from bar to top of block.

      CAUTION: TOP OF BLOCK MUST BE PARALLEL TO MAIN BEARING BORE.
   c. Dimensions necessary to make check:
      (1) Main Bearing Bore Diameter— 4.124/4.125 inches
      (2) Distance Centerline of Main Bearing Bore to Top of Block— 15.122/15.124 inches (New Block) 15.112/15.114 inches (Reworked Block)
4. Finish surface to 125 micro inches.
5. Resurface counterbores to obtain proper liner protrusion.

NOTE: Cummins Engine Company assumes no responsibility for the success of this operation. It can be done only in a shop that is properly equipped for this type of operation.

CHECK CYLINDER LINER COUNTERBORE

1. Use ST-547 Gauge Block.

2. Remove all corrosion and carbon deposits which would affect readings obtained by gauge from top deck of cylinder block.

3. Zero the dial gauge located on ST-547 Gauge Block.
   a. Set gauge block on block deck.
   b. Depress indicator stem till indicator point touches deck.
   c. Set dial to "0."
   d. Position indicator in its gauge block so indicator stem moves approximately .10 to reach "0" position. This leaves maximum amount of indicator travel available.

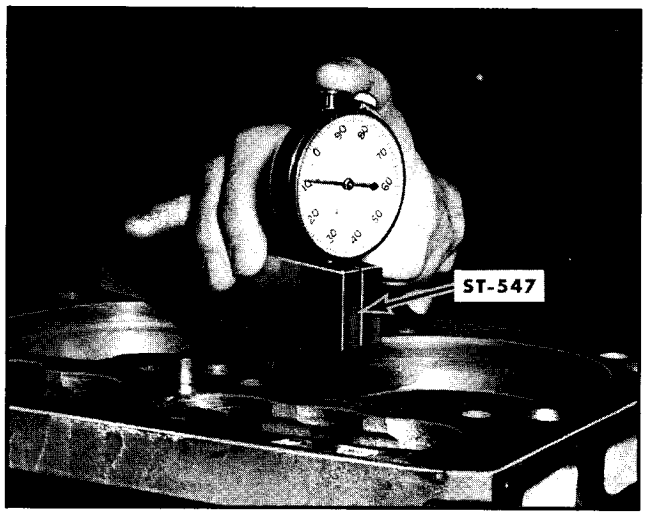


Fig. 2-3. Checking counterbore depth

4. With indicator at "0," position ST-547 on deck so that indicator stem is over liner ledge.

5. Depress indicator stem till its point contacts liner ledge.

6. Read depth of counterbore shown on indicator. (The small dial registers each .10 inch movement of stem.)

7. Check each liner ledge at four or more locations.

NOTE: The liner ledge must not be "cupped" more than .00075 inch. ("Cupped" refers to the condition where that part of the cylinder liner ledge next to the liner is the highest point of the ledge surface.) The depth must not vary more than .001 inch.

8. If readings obtained exceed the limits, mark cylinder for counterboring and determine desired depth to be obtained by counterboring operation. If depth exceeds .4035, install a new block.

RECONDITION CYLINDER LINER LEDGE

1. Insert counterbore tool (ST-541 or ST-451) into cylinder liner bore.

2. Bottom tool, then raise it approximately 1/16 inch.

3. Tighten rear adjusting screw that actuates lower locating pin until it is "snug" tight.

4. Tighten front adjusting screw, which actuates upper locating pin, "snug" tight.

5. Tighten rear adjusting screw.

6. Tighten front adjusting screw.

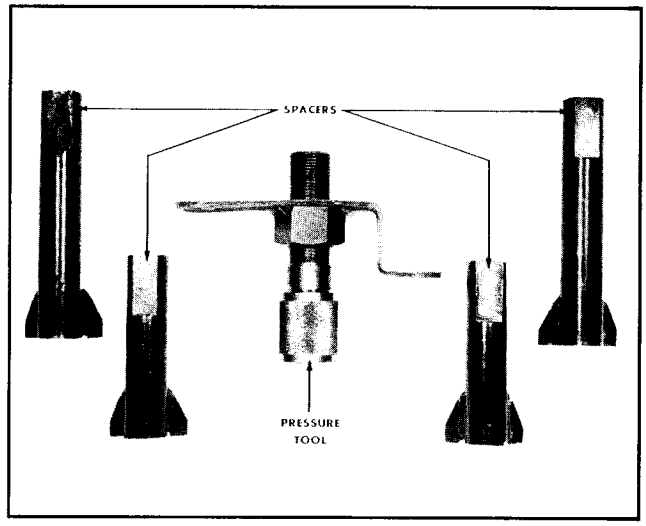


Fig. 2-4. ST-543 pressure tool and sleeves

7. Assemble ST-543 Pressure Tool.
   a. Place one short sleeve over a capscrew hole, liner hold-down pads up, and ground flats facing toward liner bore.
   b. Place one long sleeve over capscrew hole located diagonally across the cylinder bore from short sleeve.
   c. Assemble pressure mandrel; center over tool head.
   d. Assemble holding capscrews.

8. On ST-541, release knurled nut on revolving head; move arm holding tool bit to proper length.

9. Place a thrust bearing or brass washer over tool head; lubricate.

10. Screw center mandrel down until end play in tool bearings is taken up. Apply only light pressure. Make sure tool bit is retracted and is not in contact with counterbore ledge.

(If ST-451 tool is used, grind arrow from top of tool head to make top surface flat.)

11. Place a standard 5-inch extension through hollow center mandrel to engage swivel drive.

12. Turn the counterboring tool with a ratchet wrench.

13. Adjust tool bit downward until tool takes a light cut from high spot on liner ledge. Continue turning until the tool stops cutting.

NOTE: Hold center mandrel with left hand to prevent it from tightening down on counterboring tool.

14. Back off center mandrel and adjust tool bit for slightly deeper cut.

15. Apply light pressure to tool head with center mandrel.

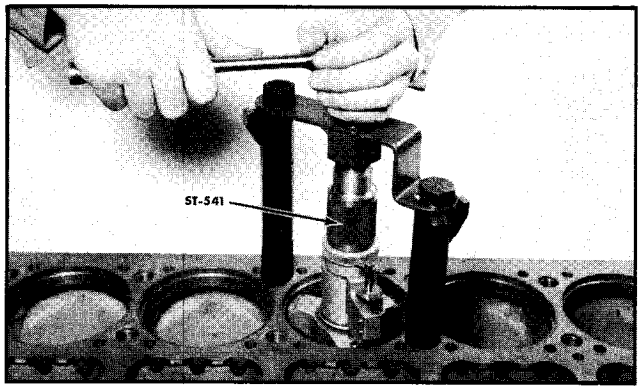


Fig. 2-5. Cutting counterbore

16. Repeat cutting operation.

17. With counterbore tool in place, check liner ledge with ST-547. Refer to CHECK CYLINDER LINER LEDGE, Step 7.

18. Repeat cutting operation until liner ledge is flat.

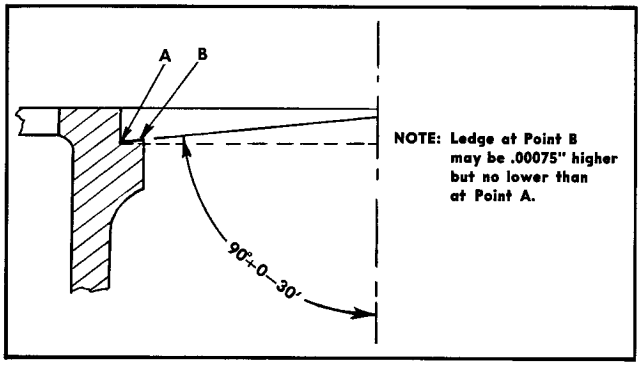


Fig. 2-6. Cross section of block counterbore

LAPPING COUNTERBORE IN BLOCK

If the cylinder liner flanges and counterbore are not perfectly smooth, the counterbore may be lapped.

1. Place Grade A grit lapping compound on counterbore ledge.

2. Insert cylinder liner.

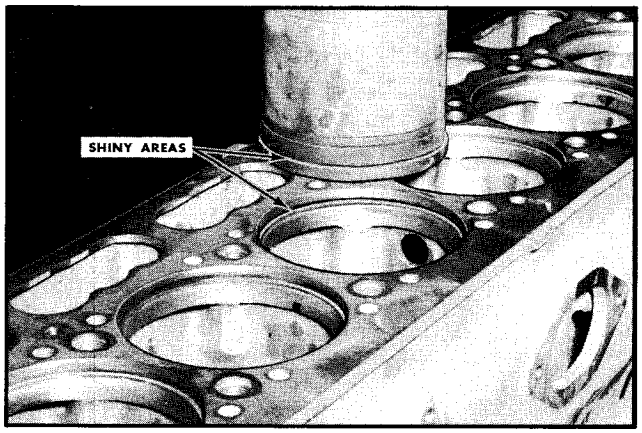


Fig. 2-7. Cylinder liner flange and counterbore after lapping

NOTE: See Cylinder Liners, Page 2-5, to see if liners may be reused.

3. Apply light and even pressure while lapping. Rotate liner one complete revolution, then lap in 30° strokes. Add a few drops of lube oil each 2 or 3 revolutions to keep lapping compound moist.

4. *Remove all lapping compound from counterbore and liner flange.*

5. Apply light coat of prussian blue and check seat. *A full seat must be indicated on both counterbore and liner flange.*

6. Repeat lapping operation as necessary.

CHECK MAIN BEARING CAP PILOT FIT

The main bearing caps have an interference fit to the block of .002 to .004 inch and must fit in the block with no perceptible clearance or "shake." The milled faces of the cap must always rest on the mating portion of the block to prevent distortion as it is tightened down. If the machined recess in the block will not hold the caps securely, the block must be scrapped.

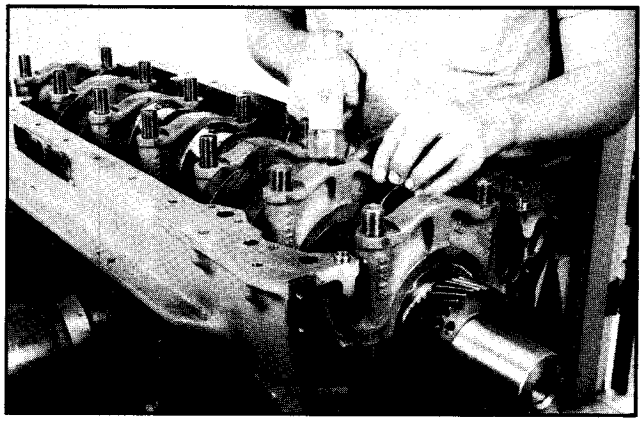


Fig. 2-8. Installing main bearing caps

CHECK MAIN BEARING BORE AND ALIGNMENT

1. Assemble main bearing caps, lock plates and capscrews in position.

2. Tighten capscrews to operating tension by template method. Page 12-2.

3. Gauge main bearing bores horizontally, vertically and diagonally with cylinder bore gage or inside micrometers properly adjusted to standards.

BORE MUST BE 4.124 TO 4.125 INCHES IN DIAMETER. If oversized, see: REDUCING OVERSIZED BORE, below.

4. Check alignment of main bearing bores with ST-409.

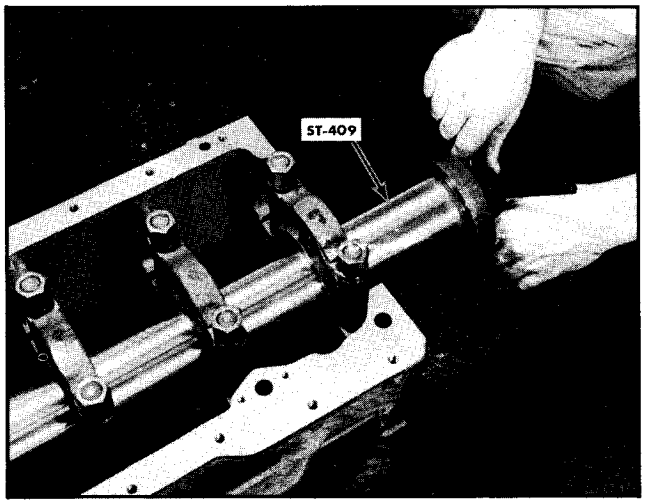


Fig. 2-9. Checking main bearing bore alignment

This closely ground checking bar is 4.1225 inches in diameter. It will pass through all seven bores and turn freely unless: (a) caps are not tightened to proper tension, (b) burrs, etc., have not been removed, (c) caps are distorted.

5. If it is definitely determined that a main bearing cap has been distorted and is preventing checking bar from passing through, mark block for reboring.

REAM MAIN BEARING BORE

CAUTION: DO NOT REAM THE MAIN BEARING BORE INDISCRIMINATELY. IT SHOULD NEVER BE NECESSARY TO REAM THE MAIN BORE UNLESS A CAP HAS BEEN DISTORTED OR REPLACED.

1. Use ST-410 main bearing bore reamer.

2. Lubricate reamer cutters and bores in block. This will help prevent reaming oversize and will contribute to a better finish.

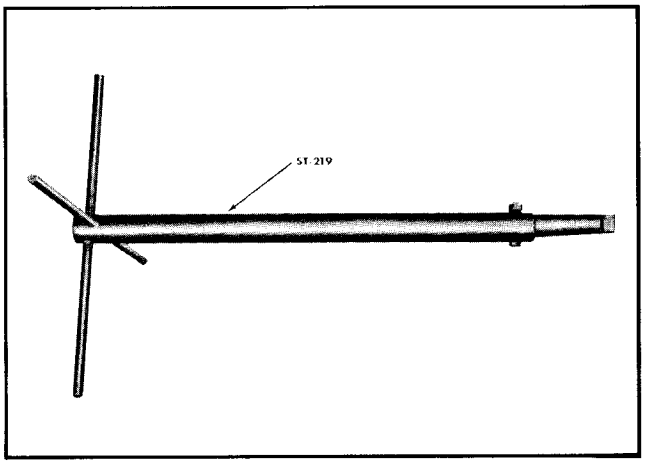


Fig. 2-10. ST-219

3. Use a special driver, ST-219.

This driver is loosely pinned to prevent up and down or side thrust of the reamer while it is being turned.

4. *Always* support reamer in two bores behind the cutters.

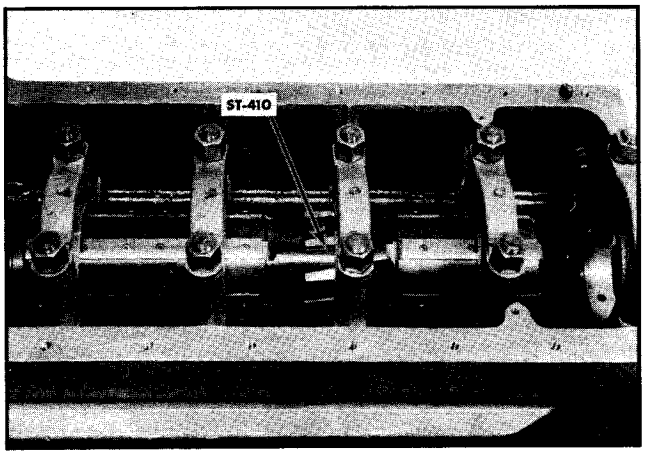


Fig. 2-11. Reaming main bearing bores

5. Run reamer through without "backing up" or reversing rotation.

6. Check alignment of reamed bore with ST-409.

7. Gauge bore diameter.

8. Clean block thoroughly.

REDUCING OVERSIZED BORE

If bore is oversized vertically and/or diagonally:

1. Remove main bearing cap.

2. Remove, by lapping or surface grinding, .002 to .003 inch stock from bottom milled main bearing cap surface.

3. Replace cap and tighten capscrews to operating tension by the template method, Page 12-2.

4. Ream main bearing bore to size. See: REAM MAIN BEARING BORE, above.

MAIN BEARING CAP REPLACEMENT

Semi-finished replacement main bearing caps are available for limited use in rebuild shops. The responsibility for the use of semi-finished caps must be assumed by the owner of the engine or by the shop which does the work.

Replacement main bearing caps have .003 inch excess material in the bore and .005 inch excess in length (pilot dimension). All other dimensions are the same as finished main bearing caps.

A No. 7 (No. 5, J-4) new replacement cap does not have cap-to-block dowel holes.

To accurately install a replacement cap:

1. Machine an equal amount of material from each end of semi-finished cap to give .002 to .004 inch interference fit in block.

2. If the new cap is a No. 7 (No. 5, J-4):

   a. Remove locating dowels from block.

   b. Locate cap so thrust faces of cap and block are flush. Use prussian blue on mating surfaces to locate dowel holes in cap.

   c. Remove cap.

   d. Drill dowel holes.

   e. Reinstall cap and ream dowel holes to smallest permissible oversize diameter.

   f. Install dowels in block.

3. Install all main bearing caps in block and tighten to operating tension. See: TEMPLATE METHOD OF TIGHTENING, Page 12-2.

4. Ream all bores. Use ST-410 main bearing bore reamer as described in REAM MAIN BEARING BORE, Page 2-4.

5. Check main bearing bore alignment; use ST-409 checking bar.

INSTALL CAMSHAFT BUSHINGS

1. Use ST-446, Camshaft Bushing Driver, to remove or install camshaft bushings.

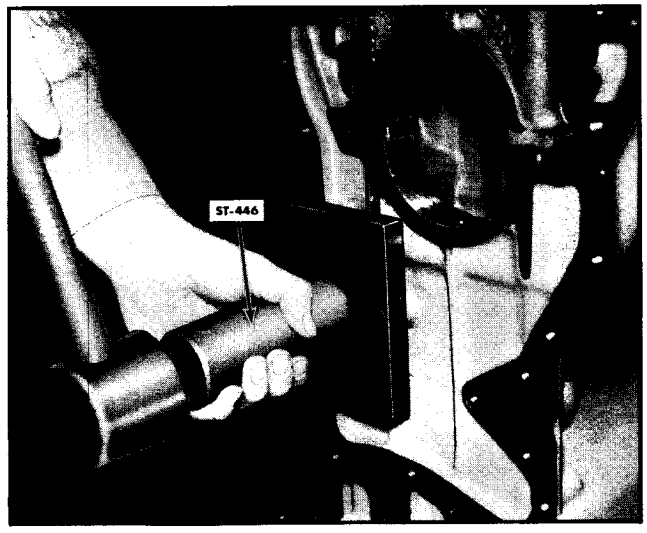


Fig. 2-12. Installing camshaft bushings

2. Locate bushing on driving mandrel during installation; align oil holes and support bushing.

3. Check oil passages to see that they are open.

4. Check installed bushing bore. If properly installed, bushing will check within limits without further machining.

PAINT CYLINDER BLOCK

1. Make sure block is cleaned thoroughly.

2. Paint the inside of the cylinder block with Sherwin-Williams No. 29064 Red Oxide Sealer.

3. Paint the outside of the cylinder block with Sherwin-Williams No. F62YC1 yellow engine paint.

CYLINDER LINERS

CHECK FOR EXCESSIVE CORROSION

1. Remove rust and scale with wire brush or by similar cleaning operation.

2. Discard any liner with excessive (1/16″ deep or more) corrosion.

3. Discard liners with dents or pits under liner flange that extend more than one-fourth way across flange in an area which cannot be located in line with cylinders and cannot be removed by lapping.

CHECK FOR CRACKS

Cracks in cylinder liners are most apt to occur: (a) just under top flange, (b) at bottom of liner, (c) above top seal ring groove.

If crack is found, replace liner.

1. Magnetic inspection.
   a. Magnetize liner.
   b. Pour solution over liner while it is still magnetized.
   (Cast iron will not hold magnetism permanently.)
2. "Whiting" inspection.
   a. Clean liner thoroughly.
   b. Dip or paint liner with lubricating or fuel oil.
   c. Wipe liner.
   d. Paint with chalk dust and alcohol or "whiting." Chalk will be discolored by oil seeping from cracks.

WORN LIMITS

Don't use liners worn more than .004 in excess of new liner maximum diameter. New liners measure 4.125 to 4.126 inches I.D.

Do not use liners with scoring marks that cannot be removed by grinding to a standard oversize.

1. Check liner bore with dial bore gauge or inside micrometer.

2. Worn liner, to be used without grinding, boring or honing, should be marked for ridge cutting or grinding. Ridge cutting is done to prevent damage to new rings.

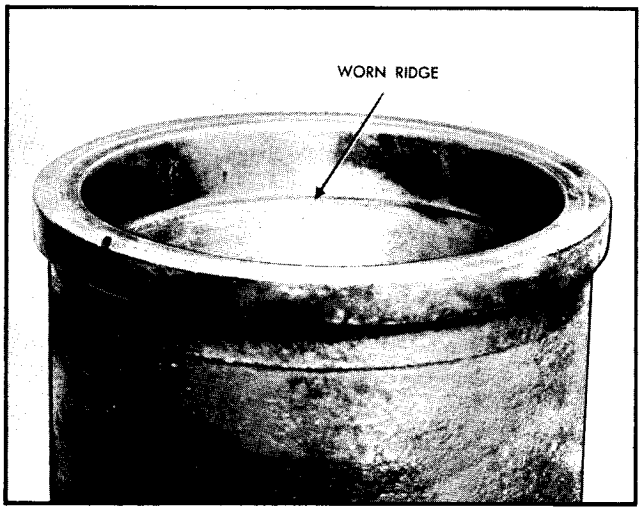


Fig. 2-13. Worn ridge in cylinder liner

HONE LINERS

1. Hone glaze from cylinder liner whose bore is within worn limits.
   a. Remove top ridge with ridge cutter.
   b. Use dry stone, Micro-Matic 3-15089 EE, or equivalent, to remove glaze.
   (Clean stone with wire brush.)
   c. Hone to 45° angle pattern.

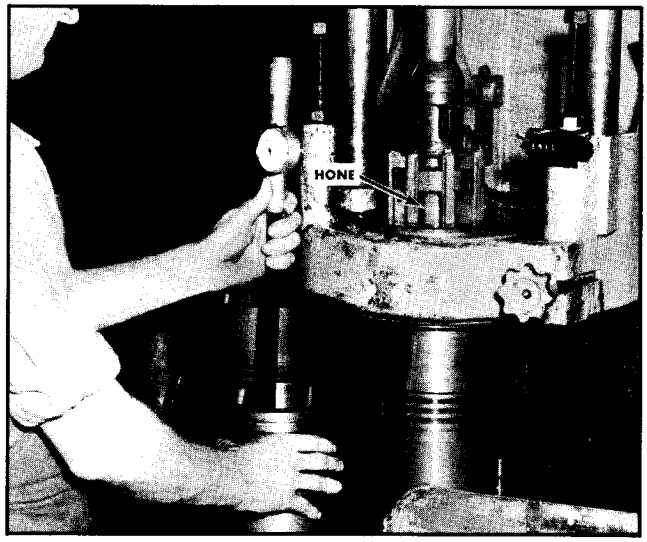


Fig. 2-14. Checking cylinder liner bore after honing

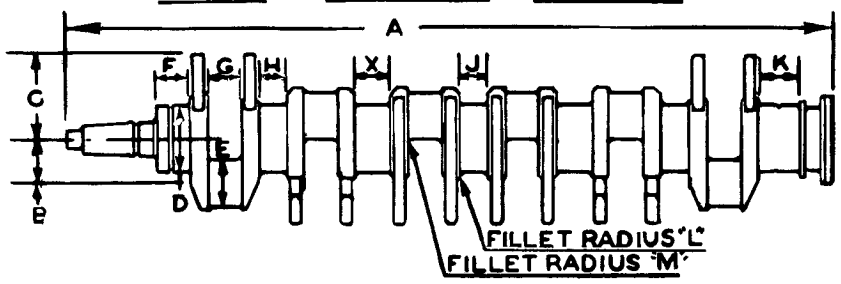
   d. Stop when glaze is removed.
   e. Coat liner I.D. with lard; use Micro-Matic 37C500HV #22 or equivalent stone to get new liner finish. (Compare finish with new liner finish.)
   f. Use soap cleaning solution to clean liner.
   g. Check liner bore with dial bore gauge.

GRIND CYLINDER LINERS

Cylinder liners should not be reused without reboring or regrinding if they exceed worn limits. J Series pistons and rings are available in .020, .030, .040 oversizes. Add oversize increments to standard dimensions to determine final oversize dimension desired.

1. Bore cast iron cylinder liners with VanNorman No. 777-4, cylinder boring bar (or equivalent).
2. Finish hone to size.

CUMMINS CRANKSHAFT DIMENSIONS



ENGINE	PART No.	A	B	C	D	E	F	G	H	X	J	K	L	M
A-4	1741	29 5/8	2 1/2	4 1/2	3.874 3.875	2.624 2.625	1 15/32	2.000 2.003	1 7/16	1 7/16	1 7/16	1.434 1.437	.09375 R .10175 R	.125 R .133 R
A 6	1740	40 1/8	2 1/2	4 1/2	3.874 3.875	2.624 2.625	1 15/32	2.000 2.003	1 7/16	1 7/16	1 7/16	1.434 1.437	.09375 R .10175 R	.125 R .133 R
J-4	112330	26.910 26.930	2.4975 2.5025	4.560 4.590	3.874 3.875	2.624 2.625	1 31/64	2.000 2.003	1.434 1.444	1.434 1.444	1.434 1.444	1.434 1.436	.141 R .164 R	.141 R .164 R
J-4	112362	29.680 29.700	2.4975 2.5025	4.560 4.590	3.874 3.875	2.624 2.625	1 31/64	2.000 2.003	1.432 1.442	1.432 1.442	1.432 1.442	1.434 1.436	.141 R .164 R	.141 R .164 R
J, JS, JT	10974	39.370 39.390	2.4975 2.5025	4 1/4	3.874 3.875	2.624 2.625	1 31/64	2.000 2.003	1.432 1.442	1.432 1.442	1.432 1.442	1.434 1.436	.141 R .164 R	.141 R .164 R
J, JS, JT	10974-1	39,370 39,390	2.4975 2.5025	4.560 4.590	3.874 3.875	2.624 2.625	1 31/64	2.000 2.003	1.432 1.442	1.432 1.442	1.432 1.442	1.434 1.436	.141 R .164 R	.141 R .164 R

Fig. 2-15. Crankshaft dimensions

CRANKSHAFT

JOURNALS

Main bearing journals of a new crankshaft are 3.874 to 3.875 inches O.D. If crankpin journals are worn more than .002 inches below low limit or are out-of-round in excess of .0015 inches, regrind crankshaft.

Crankshafts should be reground to standard undersizes to fit available standard main bearings and connecting rod bearings. Main bearings are available in .010, .020, .030, and .040 undersize. Underisze connecting rod bearings are available in corresponding undersizes.

OIL PASSAGES

1. Use a rod and rag, just as you would to clean a rifle barrel, to check and completely clean oil passages in crankshaft.

2. Replace pipe plugs.

   a. Coat threads with John Crane sealer or equivalent.

   b. Tighten to 5 ft. lbs.

   c. Stake to prevent loosening.

THRUST FLANGE

1. If crankshaft flange is worn as much as .015 or grooved as deep as .005, build up by welding and regrind to size.

Extreme wear of the crankshaft thrust flange is generally caused by careless assembly of driven units.

MAGNETIC INSPECTION

An improperly ground crankshaft can cause a great deal of trouble. A crankshaft must receive proper magnetic inspection before and after reworking.

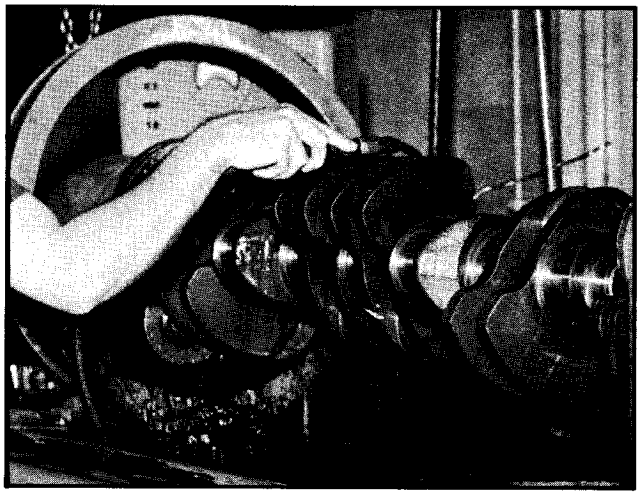


Fig. 2-16. Magnaflux inspection of crankshaft

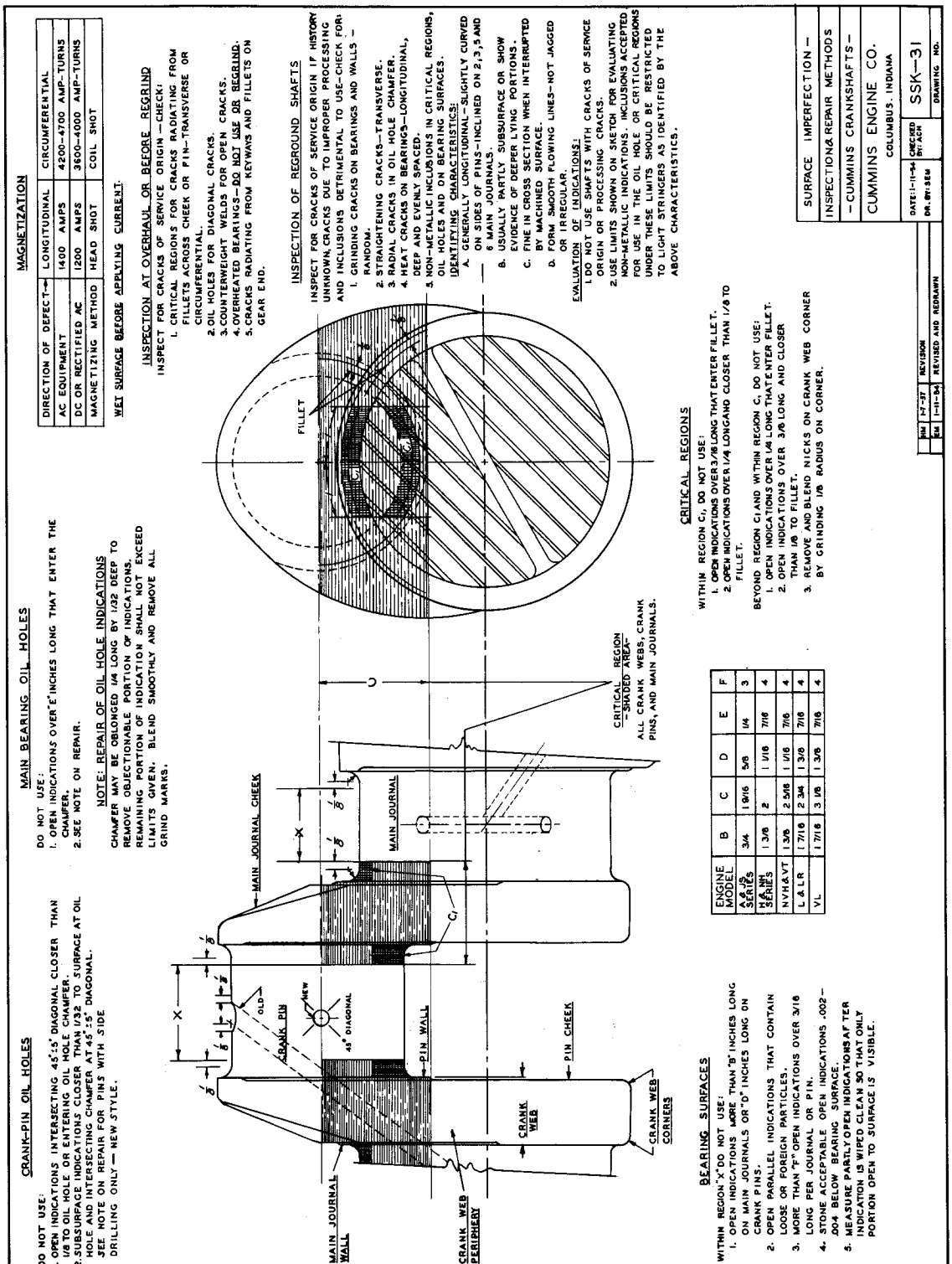


Fig. 2-17. Magnetic inspection of Cummins crankshafts

1. Wet entire surface with magnetic particle suspension before applying current.

2. To detect longitudinal indications use 1200 amperes direct or rectified alternating current, or 1400 amperes alternating current through length of shaft.

3. To detect circumferential indications use 3600 to 4000 ampere-turns direct or rectified alternating current, or 4200 to 4700 ampere-turns with alternating current.

The part under examination must be two to three inches from the inside of the coil or magnetizing surface.

Refer to Fig. 2-17 (Drawing SSK-31) for complete instructions.

FINISH

The finish should be comparable to that of a new shaft. A poorly finished journal will quickly wear away bearing metal.

DIMENSIONS

New crankshaft dimensions are shown in table, Fig. 2-15.

Reground shafts should have same dimensions, after allowing for standard regrinds, as new shafts.

Check:

1. Journal diameter.
2. Alignment.
3. Fillets.

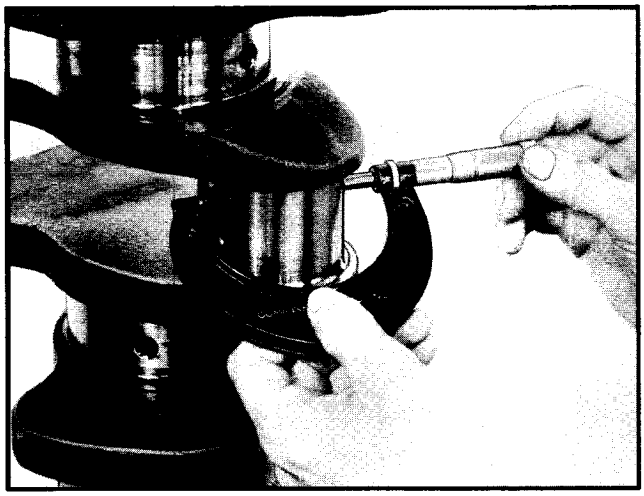


Fig. 2-18. Measuring crankshaft journal

Fillets add greatly to the strength of the crankshaft. Reducing fillet radii or undercutting subtracts materially from that strength. On the other hand, if fillets are larger than those specified, the bearing shells may be squeezed and fail very quickly.

NOTE: Current crankshafts have "rolled" fillets. These sometimes appear to be undercut; however, by close examination you can see where the metal has been "rolled" aside and is not undercut.

GRIND CRANKSHAFT

After inspection has determined that the crankshaft is worn to the point where it must be reground and magnetic inspection has shown that the crankshaft is suitable for regrinding:

1. Grind shaft to next standard undersize.
2. Hold to specifications in table, "Cummins Crankshaft Dimensions," Fig. 2-15.

CRANKSHAFT GEAR

If it is necessary to remove crankshaft gear:

1. Attach puller to gear.
2. Apply 75 to 100 ft. lbs. on puller screw.
3. Heat gear with a blow torch—not a cutting torch—to 300° F. to 400° F. The gear will expand, making it easier to pull.

To assemble gear:

1. Heat gear to 400° F.
2. Drive it on with tubing.

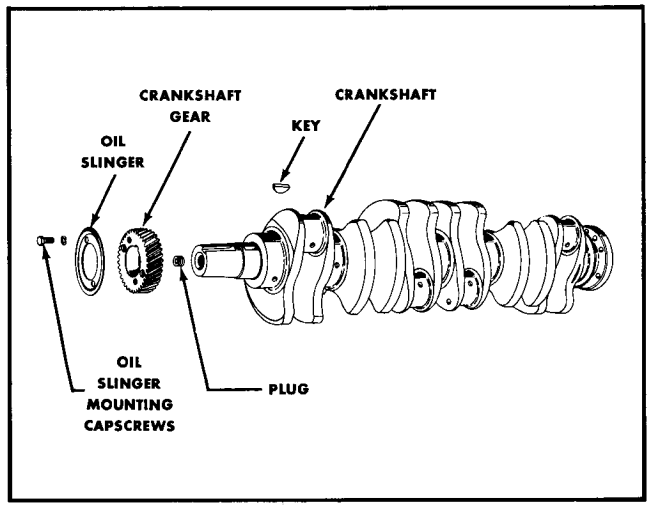


Fig. 2-19. Crankshaft gear assembly—exploded view

SECOND ORDER COUNTERBALANCER (J-4)

The balancer drive gear is the only part in the front unit that is not an operating part of the oil pump. For disassembly of the front unit, refer to "LUBRICATING OIL PUMP," Page 7-7.

Disassemble the rear unit as follows:

1. Bend lock plates and remove capscrews holding weights to their shafts.

2. Use brass rod and mallet, and tap on ends of shafts to remove them from weights and housing.

3. Gears are keyed to shafts by a ball key. Press on shaft and remove gear.

Inspection

Clean and inspect all parts thoroughly before reassembling.

Check bushings, shafts and gears for wear, and replace those parts that are excessively worn.

When new, counterbalancer parts have the following dimensions:

Balancer single-weight shaft (driven) 1.2500/1.2505 in.

Balancer double-weight shaft (driver) 1.2500/1.2505 in.

Balancer housing bushings 1.2565/1.2580 in.

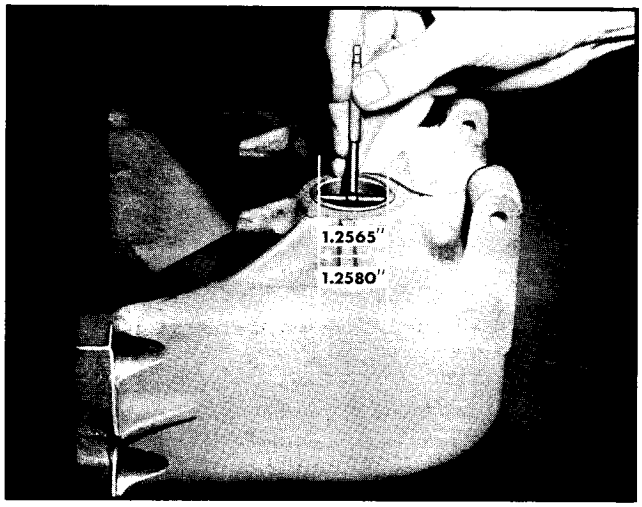


Fig. 2-20. Checking J-4 counterbalancer bushing

Reassembly

1. Assemble single-weight and double-weight shafts to their gears with ball keys.

2. Position housing so that part number is on the right.

3. Insert hollow shaft into housing through double weight.

4. Align hole in center section of double weight with ball key hole in shaft. Drop ball key into place; then drive shaft into weight. Install capscrews and lock plates.

5. Assemble single weight on shaft in same manner.

NOTE: Before driving shaft all the way into the weight, be sure that timing marks on the gear teeth are in alignment, Fig. 2-21.

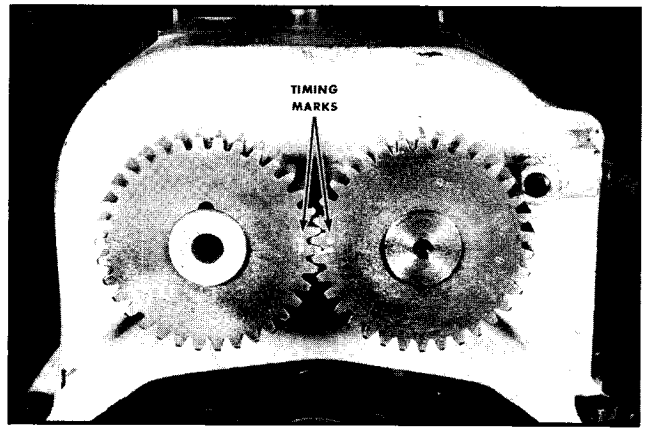


Fig. 2-21. J-4, counterbalancer timing marks

MAIN AND CONNECTING ROD BEARINGS

All Cummins main and connecting rod bearings are precision made with shell thickness, bearing material and bearing crush accurately calculated and held to close tolerances. Both standard and undersized bearings are provided with recommended clearance for the oil film. *Under no circumstances should any attempt be made to scrape or ream these bearings nor should they be lapped or filed to increase oil clearances.*

A properly fitted bearing, after a reasonable period of service, will appear dull gray, indicating it is running on an oil film. Bright spots indicate metal-to-metal contact; black spots excessive clearance.

MAIN BEARINGS

All J Series engines after Engine Serial No. 113353 have grooveless lower main bearing shells and grooved upper shells. The grooveless lower main bearing shells can be installed in engines with serial number previous to Serial No. 113353 provided the crankshaft journals do not have prominent ridges formed from wear with the grooved type lower shells. If the ridge is higher than

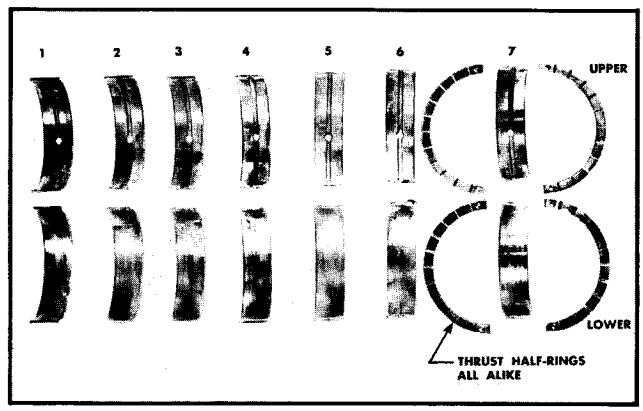


Fig. 2-22. Main bearing shells and thrust half-rings, J, JS, JT engines

.001 inch, it will be necessary to install the old-style grooved shells as both upper and lower bearings until the crankshaft is reground.

Main bearing shells are held in place by a locking tang or lip on each shell which mates with milled recesses in the block and cap opposite the camshaft side of the engine.

NOTE: If old shells are to be reused, they should be installed in the same position as removed.

Shell Thickness

New standard thickness main bearing shells are .1231 to .1236 in. thick. Standard or undersize shells that are worn more than .002 or are chipped, flaked or scored should not be reused.

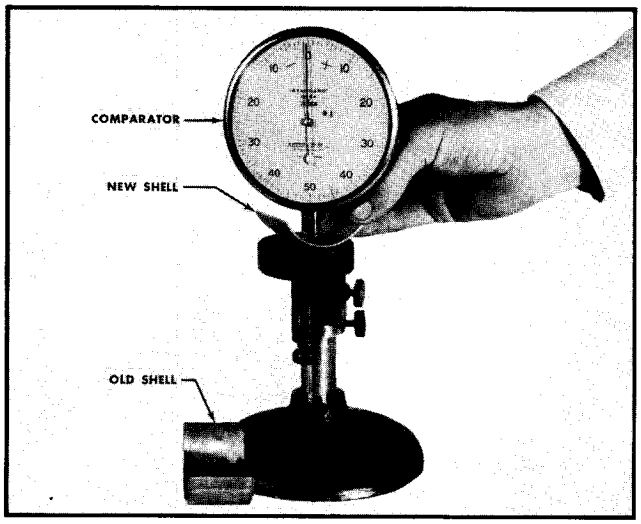


Fig. 2-23. Checking bearing shell thickness

1. Gauge shell with a ball point micrometer, dial indicator thickness gauge or comparator as shown in Fig. 2-23.

Never use lead ribbon or feeler gauge to gauge main or connecting rod bearing clearance. Doing so will result in unnecessary damage to bearing surface of shell.

If the dimensions of the main bearing bore, main bearing shells and crank journals are within permissible limits, the oil clearance will be within permissible limits also.

Thrust Bearings

The rear main bearing consists of two shells and four thrust bearing half-rings.

The thrust half-rings are interchangeable. They are held in place by dowels in the cap—two for each half-ring—and by counterbored recesses in the block and cap. The grooved babbitt faces fit next to the crankshaft flanges. Thrust half-rings are available in oversize. *They must be used in pairs.*

Crankshaft end clearances for new bearings and a new shaft will be .004 to .011. Worn shafts and thrust rings should not be reused if end clearance is in excess of .022 inch. End clearance must be checked during assembly with a dial indicator gauge.

TABLE I—BEARING AND SHAFT DATA

Part	New Dimension	Oil Clearance (New)	Worn Replacement Limit	Oil Clearance Worn Limit
Main Bearing Shell Thickness	.1231/.1236	.0018/.0048	.121	.008
Thrust Bearings—End Clearance		.004/.011		.022
Main Bearing Bore	4.124/4.125		4.124/4.125	
Crankshaft				
Main Bearing Journal	3.875/3.874	.0018/.0048	3.872	.0068
Fillet Radii	.164/.141		.131	
Connecting Rod Journal	2.625/2.624	.002/.0045	2.622	.008
Connecting Rod Shell Thickness	.07225/.07275	.002/.0045	.071	.008
Connecting Rod Bore	2.7725/2.7730			

CONNECTING ROD BEARING SHELLS

Rod bearing shells are held in place with locking tangs which correspond with milled recesses in the connecting rod and cap. Upper and lower shells are identical and interchangeable. New standard shells are .07225 to .07275 inch thick. Undersize shells are available in .005, .010, .020, .030, and .040 inch sizes.

1. Do not use shell if flaked, chipped or scored.

2. Do not reuse standard shell worn thinner than .071 inch.

3. Check connecting rod bearing shell thickness in manner described for main bearing shells. The crankpin bore for new connecting rod, with cap tightened to operating tension, is 2.773 to 2.7725 inches I.D. Crankpin journals for a new crankshaft are 2.624 to 2.625 inches O.D. This permits an oil clearance of .002 to .0045 inch between journals and shell.

CONNECTING RODS AND PISTONS

Connecting rod caps must not be interchanged, filed, lapped or turned end for end.

Matched marks stamped on connecting rods and caps are on the camshaft side of the engine. The milled recesses in both rod and cap that receive the locking lip of the bearing shells are also on the camshaft side of the engine.

CHECK ROD DIMENSIONS

1. Assemble cap to rod and tighten U-bolt nuts to operating tension as described on Page 12-7.

2. Check crankpin bore with a dial bore gauge or inside micrometers. The bore must be 2.773 to 2.7725 inches to provide correct bearing crush. Worn out-of-round limits should not exceed .002 inch.

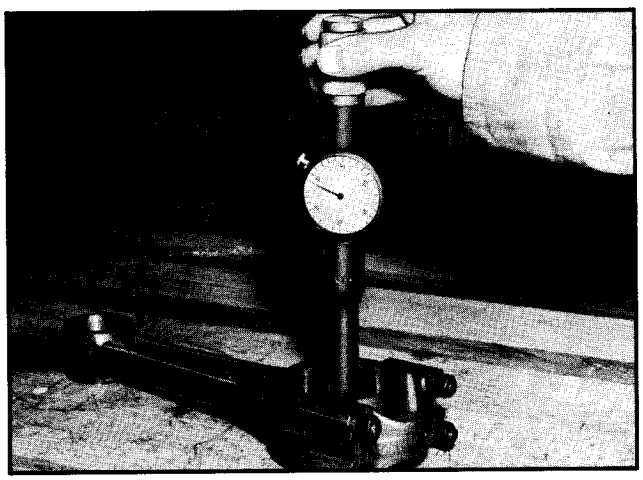


Fig. 2-24. Checking connecting rod crankpin bore

3. Check piston pin bushing with ST-504 bore gauge or inside micrometer. The upper end of a new rod is bushed with two side-by-side split bronze bushings, bored to 1.5000 to 1.5005 inch I.D. This allows a clearance of .001 to .0017 inch between the piston pin and bushing.

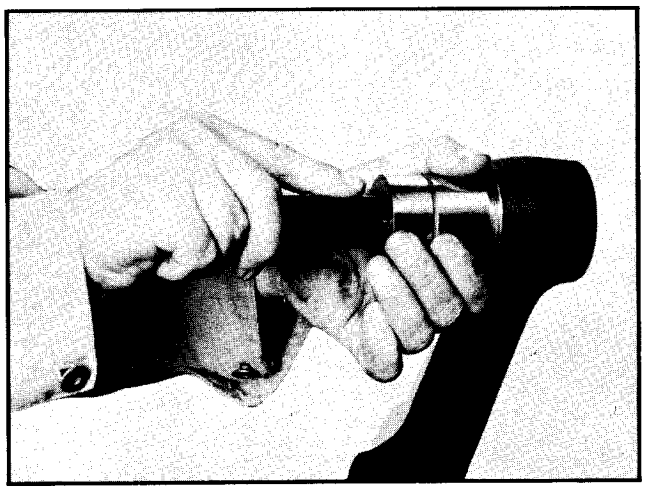


Fig. 2-25. Checking connecting rod piston pin bushing

4. Mark rod for pin bushing replacement if bore measures more than 1.5015 inches.

5. Use ST-561 Checking Fixture to check rod alignment:

a. First, calibrate checking fixture for rod size.
   (1) Take a new rod that has been checked for absolute length. (Production rods may vary from 9.498 to 9.500 inches in length.)
   (2) Assemble cap to rod and tighten U-bolt nuts to operating tension as described on Page 12-2.
   (3) Insert piston pin furnished in ST-562 Mandrel Set.
   (4) Insert and tighten ("snug" only) expanding arbor (furnished in ST-562 Mandrel Set) in crankpin bore.
   (5) Set rod in fixture as illustrated.
   (6) Move dial holder so dials indicate on piston pin.
   (7) Zero dial indicators.
   (8) Lift rod, arbor and pin assembly from fixture; turn horizontally 180°; set it back in fixture.
   (9) Readjust dial indicators to divide difference between first and second readings.

b. Check rod.
   Measurements read directly from dial indicator indicate comparative length and misalignment of bores.

(1) Assemble ST-562 Mandrel and arbor in rod.
(2) Set rod in fixture.
(3) Take readings for length and misalignment of bores.
(4) Turn rod 180 degrees. Total reading must not exceed .004 inch as shown by combined plus and minus readings of indicator. Length must read ±.001 on gauges.
(5) Measure rod twist with a feeler gauge between piston pin and dial holding plate. Twist must not exceed .010 inch.
(6) Check the center line of rod.
   a. Attach a Starrett No. 196 indicator so that it will contact the side milled surface of piston pin end of rod.
   b. Slide crankshaft end of connecting rod sideways to contact ST-561 on same side as indicator gauge. See "a."
   c. Zero indicator gauge on milled surface.
   d. Turn rod 180°, repeat all above checks. NOTE: Difference in reading not to exceed .015 inch.

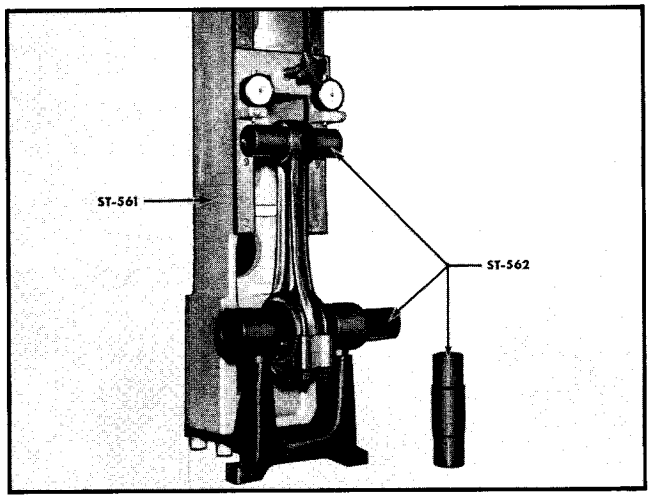


Fig. 2-26. Checking alignment of rod bores

MAGNAFLUX CONNECTING RODS

1. Check for cracks with 1000 ampere current longitudinally between plates.

2. Check for crack with 3600 to 4000 ampere-turns in a coil. Pay particular attention to shaded critical areas shown in Fig. 2-29.

3. Apply one and one-half per cent wet solution while current is ON. Make visual inspection after each application of current.

PISTON PIN BUSHING

1. Check rod dimensions, look for cracks, and perform other reconditioning operations before replacing piston pin bushings.

2. Use ST-501 Mandrel and Block in an arbor press to press out old piston pin bushings.

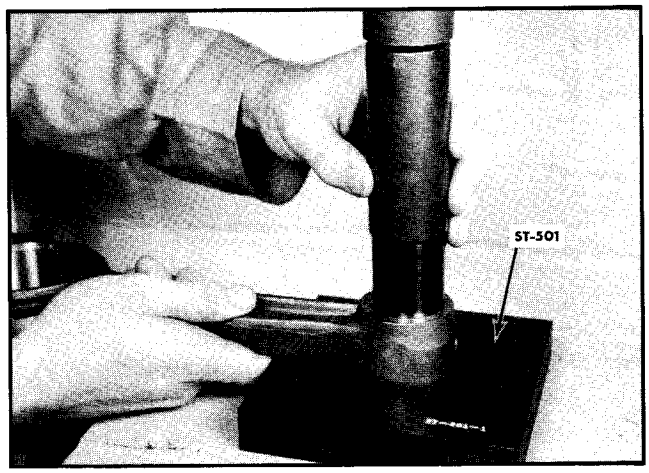


Fig. 2-27. Installing new piston pin bushing

3. Use ST-501 Mandrel to press in new bushings—one from each side of rod—to a point flush with milled side surfaces.

4. Fill lubrication holes with soap to keep shavings out.

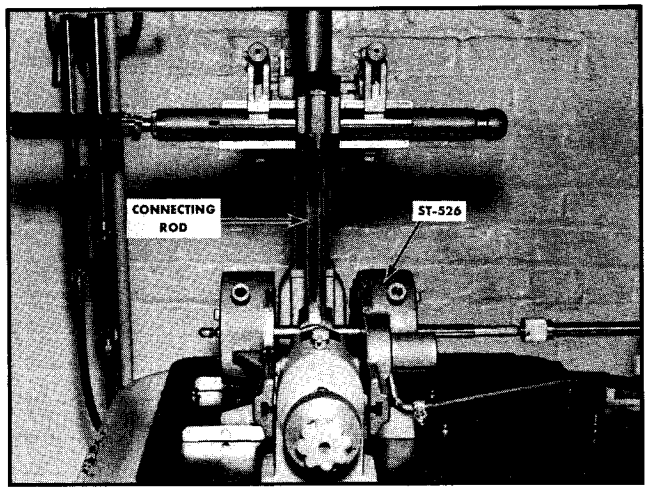


Fig. 2-28. Boring piston pin bushing

5. Mount connecting rod in ST-526 Tobin-Arp Boring Machine.

6. See instruction booklet furnished with the machine by Tobin-Arp for operating procedures.

7. Check rebushed rods in ST-561 as described in previous paragraphs.

ALWAYS TREAT ROD AND CAP AS ONE UNIT. RODS AND CAPS ARE NOT INTERCHANGEABLE

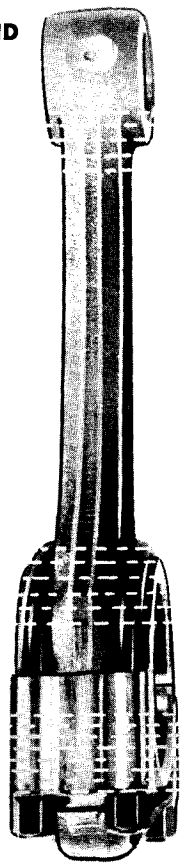
MAGNETIC INSPECTION:

1. Check with 1½% wet solution with 1000 amperes longitudinally (between plates), and circumferentially (in a coil) by magnaflux or magnaglow.

SHADED AREAS ARE CRITICAL REGIONS

NUT TIGHTENING:

1. Machining and inspection must be done with nuts tightened to operating tension by the template method.

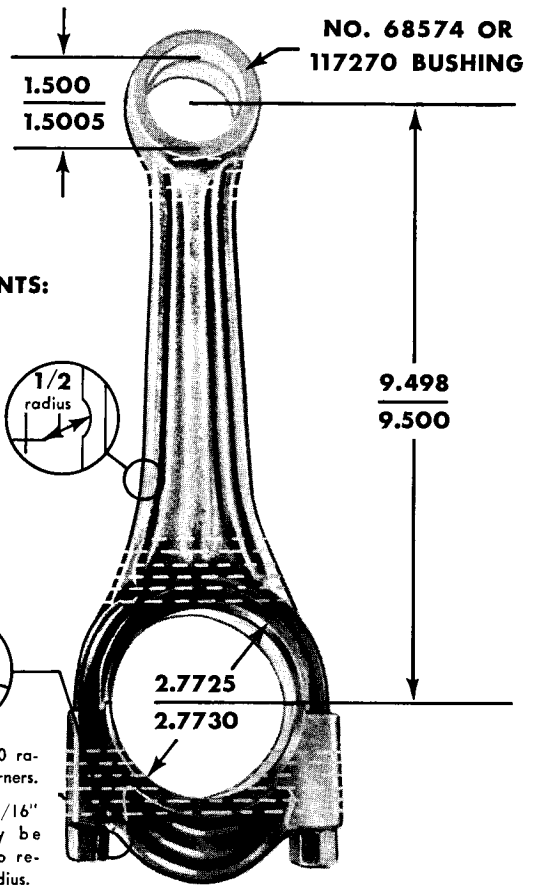


ALIGNMENT OF BORES:

1. Check on ST-561 fixture.
2. Maximum permissible misalignment:
   Bend: .004"
   Twist: .010"

NICKS AND DENTS:

1. Remove nicks and dents which are less than 1/16" deep by grinding or filing with a half-round file.
2. Radius must be ½" or more.
3. Blend radii at ends of cut.
4. Scrap rod if dents are deeper than 1/16".



1. Minimum .070 radius at all corners.
2. Maximum 1/16" metal may be milled off to restore .070 radius.

Fig. 2-29. Connecting rod specifications

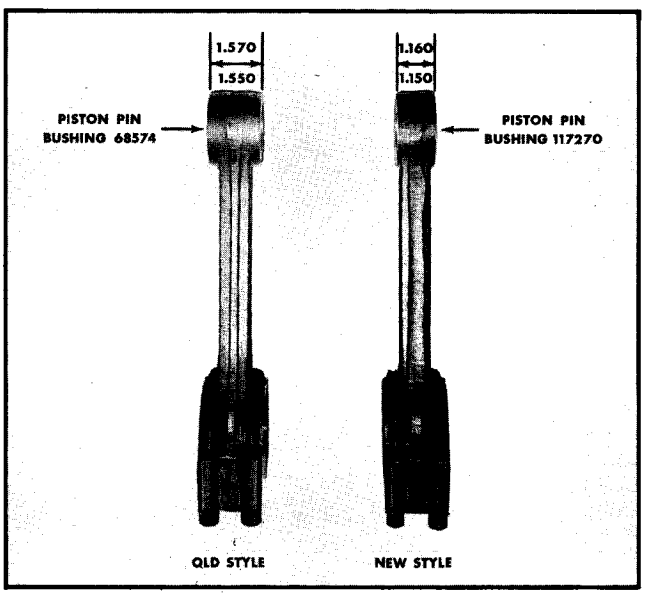


Fig. 2-30. Old and new style J connecting rods

NEW AND OLD-STYLE RODS

After Engine Serial No. 187218, all JN and JT engines have a narrow connecting rod. The difference is shown in Fig. 2-30.

1. When changing a partial set of piston and rod assemblies, remember that the new-style piston (BM-46990) and rod (BM-46825) assembly should weigh the same as the old-style assembly to maintain proper balance.

2. When reworking old-style rods (BM-20500) for use with new-style pistons:

   a. Machine piston pin end of connecting rod an equal amount on both sides until it measures 1.160 to 1.150 inches wide.

   b. Chamfer pin hole 15° by .020 to .040 deep to allow installation of bushing.

   c. Install bushings (117270).

   d. Bore new bushing.

   e. Use ST-561 to check rebushed rods.

TABLE 2—PISTON RING SPECIFICATIONS

Piston Ring Part Number	Number per Piston	Location	Type	Ring Width	Ring Gap
109410	1	Top	Compression	.1175/.1180	.013/.023
68788	2	Center	Compression	.119/.1195	.013/.023
118680	1	Bottom	Oil (U-Flex)		
113980	1	Bottom	Oil (4-Piece)		

PISTONS

1. Use ST-560 to check wear in top and second ring grooves.
   a. Shoulders of gauge *must not* touch ring groove lands if piston is to be reused. See Fig. 2-31.
   b. If shoulders touch, piston must be discarded or grooves must be machined to accept overwidth rings.
2. If ST-560 is not available, check wear with new ring and feeler gauge.
   a. Hold ring flush with land.
   b. Insert .006 in. feeler gauge.
   c. If gauge enters groove, wear is excessive.
3. A new standard piston maximum diameter is 4.1185 to 4.1195 inches measured at piston skirt at right angle to piston pin. Piston-to-liner clearance is .006 to .0075 inch for new piston and liners. A worn standard piston that measures less than 4.115 inches O.D. should not be reused.
4. Piston pin bore and piston pin O.D. are both 1.4988 to 1.499 at 70° F. The fit can be .0002 interference to .0002 clearance.

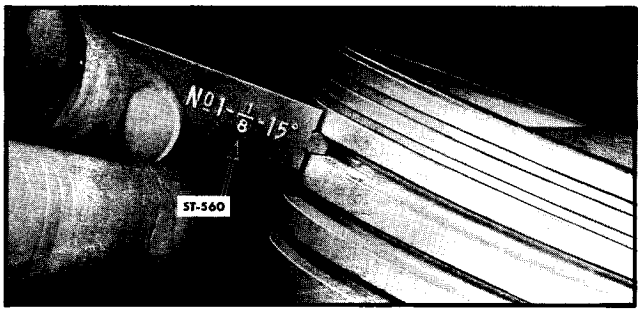


Fig. 2-31. Checking ring groove wear

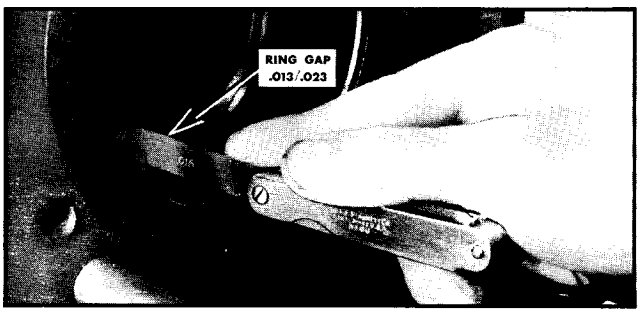


Fig. 2-32. Checking piston ring gap

Piston Rings

1. Check piston ring gap.
   a. Insert each compression ring in the mating cylinder liner until it seats squarely in operating position.
   b. Measure ring gap with feeler gauge. See Table: Piston Ring Specifications above and Fig. 2-32.
   c. If necessary, file the ends of the rings to obtain the minimum ring gap.
2. Use type ring specified for piston.
3. Pistons and rings are available in standard and .020, .030 and .040 oversizes.

CAMSHAFT

A camshaft cannot be successfully reground.

JOURNAL WEAR

New camshaft journal diameter is 1.872 to 1.873 inches. This allows for .0015 to .0045 inch oil clearances between the journal and bushing.

1. Replace camshaft if journals are smaller than 1.871 inches.
2. Replace any camshaft with scuffed, scored or cracked injector or valve lobes. Check by magnetic inspection for possible cracks.

CAMSHAFT GEAR

The interference fit camshaft gear is keyed to the camshaft. JNS engines use a standard straight Woodruff key, Part No. S-310. J, JF, JN, JS, JT engines after Engine

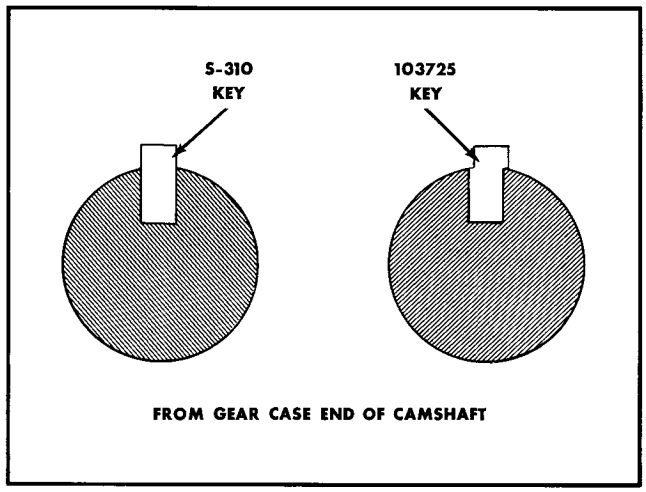


Fig. 2-33. Camshaft gear keys from gear case end

Serial No. 191030 use a special Woodruff offset key, Part No. 103725.

If inspection shows that it is necessary to replace the camshaft gear:

1. Press camshaft from gear.
2. Note type of key.
3. Replace key. See Fig. 2-33. Offset key is offset to right looking at camshaft from gear case end.
4. Press new gear on camshaft, aligning gear keyway with camshaft key.

SUPERCHARGER IDLER GEAR ASSEMBLY

It should not be necessary to rebuild this unit unless it has become noisy or loose, indicating broken leaf springs or worn bushings.

If disassembly is necessary, proceed as follows:

1. Remove capscrews and idler drive hub, blower gear, thrust washer, and spring retaining cover from assembly.
2. Carefully pry and remove idler leaf springs, 4 spring retaining rings, and separate idler driven gear from spring retainer.

Repair

1. Replace all broken or damaged idler leaf springs.
2. Check two supercharger idler gear bushings and three idler hub bushings.
   a. New idler gear bushings are 1.501 to 1.500 I.D., bushings pressed in place.
   b. New idler hub bushings are 1.501 to 1.500 I.D., idler bushings pressed in place.
   c. Idler gear shaft is 1.4985 to 1.4975 O.D.
3. Check thrust washer for wear. Replace as needed. needed.

Assembly

1. Place spring retainer over idler driven gear cam and drive idler leaf springs and four pins in place.

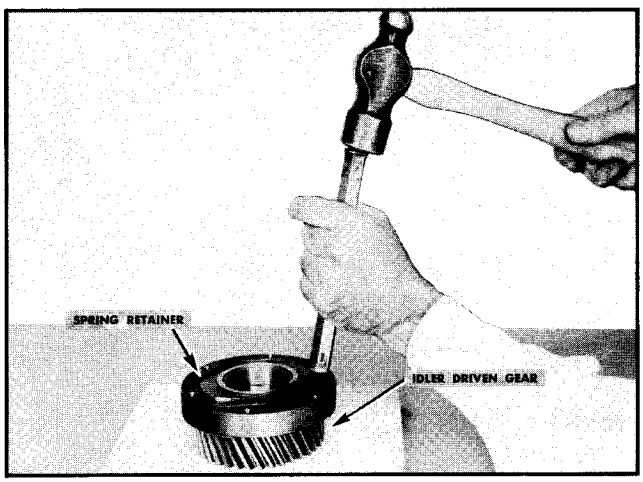


Fig. 2-34. Installing idler leaf springs

CAUTION: IDLER LEAF SPRINGS ARE MADE FROM SPRING STEEL AND COULD EASILY CAUSE A SERIOUS INJURY IF THEY ARE ALLOWED TO FLY LOOSE AS THEY ARE FORCED BETWEEN THE GEAR CAM AND SPRING RETAINER.

2. Assemble thrust washer to idler gear hub.
3. Mount retainer plate, blower gear and idler gear hub and fasten with six capscrews.
4. Peen capscrews in place.

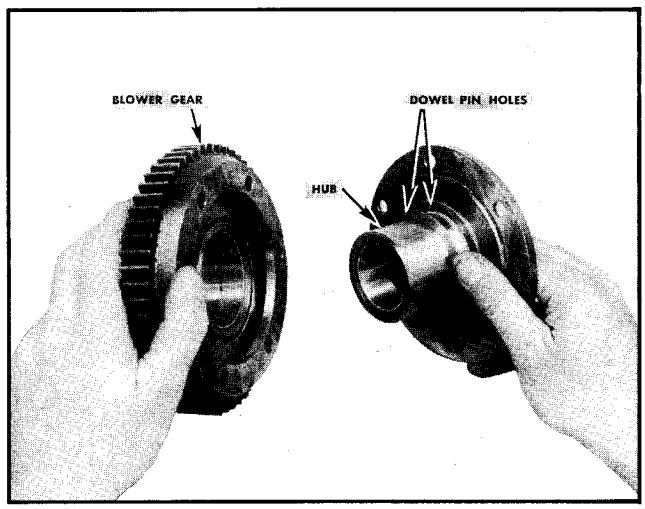


Fig. 2-35. Assembling supercharger idler gears

GEAR TRAIN

1. Check all drive and driven gears, crankshaft, camshaft, and idler gears for cracks, chipping or signs of wear.
2. Replace all gears showing visible deep wear pattern or other tooth damage.

NOTE: The extent of gear wear can be determined by checking gear backlash after all gears are assembled.

3. Wash center idler gear (JS) and water pump idler gear ball bearings in mineral spirits.
   a. Replace bearings if they are worn or rough.
   b. Pack ball bearings with ball bearing grease or lubricate with oil for initial lubrication and to prevent rusting before engine is put in service.

Section 3

UNIT NO. 2

CYLINDER HEAD

VALVES AND SPRINGS

1. Use ST-448 valve spring compressor; compress valve springs and remove half-collets.

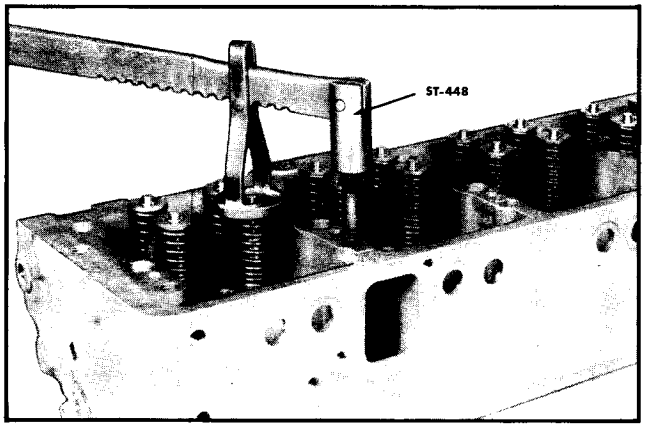


Fig. 3-1. Valve spring compressor

ST-448 is a simple lever action valve spring compressor.

a. Use a ½"-13 stud in rocker lever bearing cap-screw hole.
b. Compress one valve spring at a time.
c. Use at bench or on installed engine. If removing valve springs on an installed engine, be sure piston is up to support valves in cylinder being worked on. Replace springs before barring the engine.

CLEANING

1. 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.

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

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

4. 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 THE MACHINE SHOP OR NEAR ANY MACHINERY SUBJECT TO RUSTING. ALWAYS PROVIDE A TANK OF STRONG SODA WATER AS A NEUTRALIZING AGENT.

CHECK CYLINDER HEAD FUSE PLUG

Cylinder heads of Cummins engines after Engine Serial No. 124752 are equipped with metal-alloy center fuse plugs that melt if the engine is overheated. The part number of the plug is 70459. The screw driver slot in fuse plug distinguishes it from other plugs which are socket-head type. Fig. 3-2.

1. Examine fuse plug for signs of overheating.
2. Replace plug if metal alloy has been melted.
3. As engine disassembly proceeds, check carefully for damage from overheating.

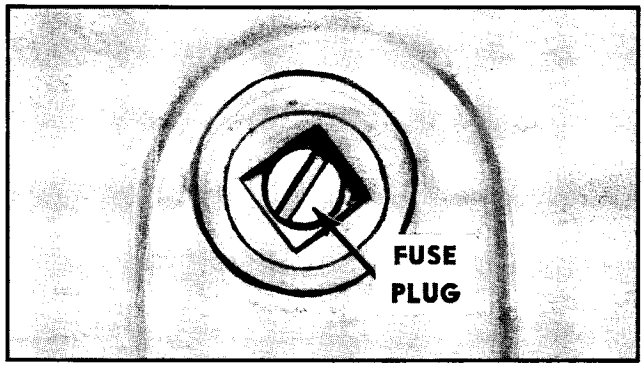


Fig. 3-2. Check fuse plug in end of head

WATER TEST CYLINDER HEAD

1. Install ST-383 injector sleeve holding tool or an old scrap injector and cup assembly in each injector sleeve.

2. Tighten to 10 to 12 foot-pounds to seal lower end of injector sleeve.

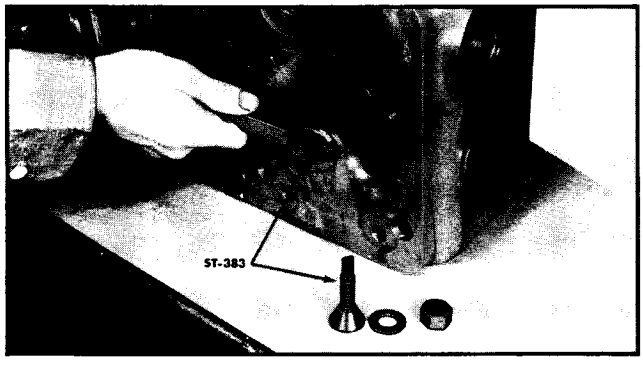


Fig. 3-3. Installing injector sleeve holding tool

3. Place cylinder head in water test fixture.

4. Test for leaks at 75 lbs. pressure and, if possible, at 170° water temperature. Check particularly 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 recommendations.

5. 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 jacket of salt, lime or sludge.

VALVE SEATS

1. Inspect the valve seats. Check for loose valve seat inserts by tapping them lightly. A slight looseness, which can be found only by tapping when head is cold and covered with film of oil, is not objectionable.

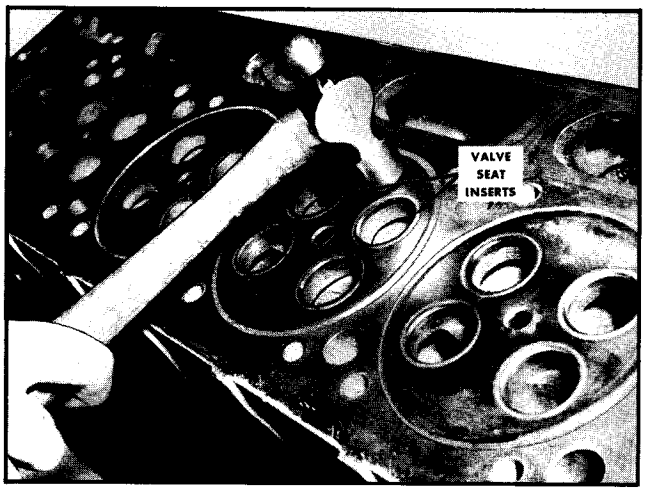


Fig. 3-4. Tapping head near valve seat inserts

2. If valve seat insert is loose enough to bounce and/or cannot be reground, mark for replacement. See: REPLACE VALVE SEAT INSERTS, Page 3-5.

3. Measure valve seat width. It should be narrowed by grinding if measurement exceeds .125 when reground. See "Grind Valve Seats," this section.

INJECTOR SLEEVES

1. Make a visual inspection of injector seat in injector sleeve for scratches.

2. Check for distortion in the sleeve and in the injector cup seat seal area. Coat new injector cup with prussian blue; rotate in sleeve with injector body.

3. Check for injector sleeve seal in head. See "Water Test Cylinder Head," Page 3-1. Do not attempt to reseal lower part of injector sleeve.

4. Check for seat depth.
   a. Install injector assembly. See INJECTORS AND CONNECTIONS, Section 12.
   b. Measure tip protrusion with dial indicator as shown in Fig. 3-5. Injector cup tips should protrude .040 to .055 beyond cylinder head milled surface. Maximum allowable protrusion is .065 inch.

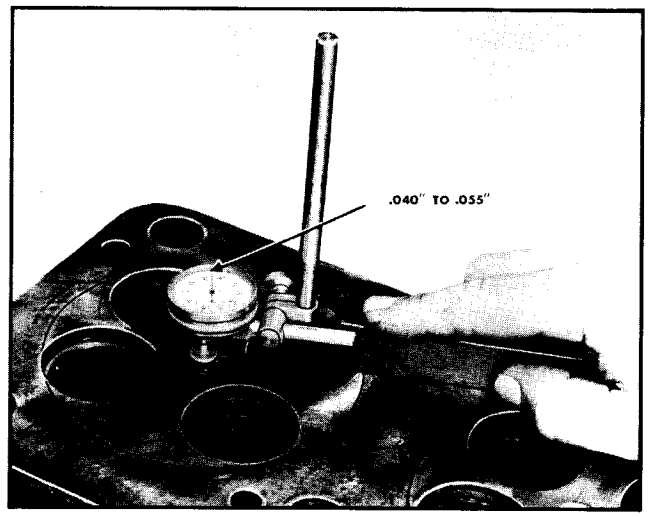


Fig. 3-5. Measuring injector tip protrusion

5. Remove worn out sleeves by cutting them from cylinder head with a 3/8" gouge chisel and driving out from lower end.

INSPECT VALVES

1. Clean valves with buffer and polish with crocus cloth.

2. Inspect, then discard if:
   a. Heads are cupped, cracked, pitted, or worn too thin to regrind within limits.
   b. Stems are scored or worn beyond replacement limits.
   c. Collet recesses are worn so new collets will not fit securely in recesses.

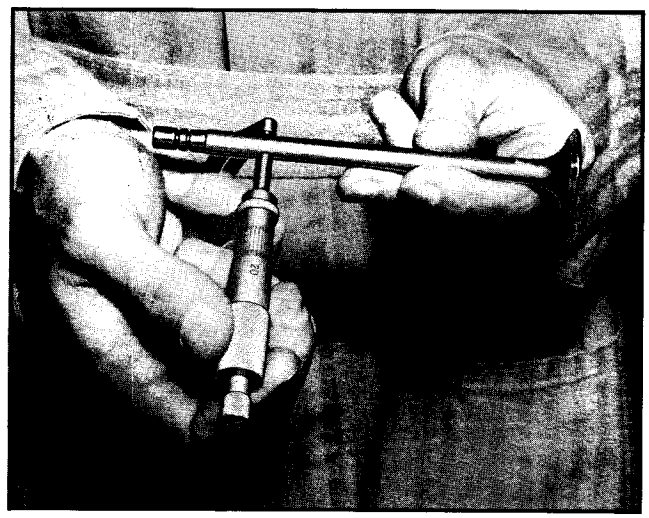


Fig. 3-6. Measuring valve stem diameter

INSPECT CROSSHEADS

1. Clean crossheads.
2. Check stem diameter. See: "Valve and Guide Data Table," Page 3-4.
3. Check for excessive wear on rocker lever and valve contact surfaces.
4. Check for cracks with Magnaflux process.

INSPECT VALVE AND CROSSHEAD GUIDES

1. Use a small bore gauge such as Starrett No. 829-D set (with accurate micrometers) .0002 inch above worn replacement limit as a "No-Go" gauge. Check for wear beyond worn replacement limits shown in Table "Valve Guide Data." Check for out-of-round holes.

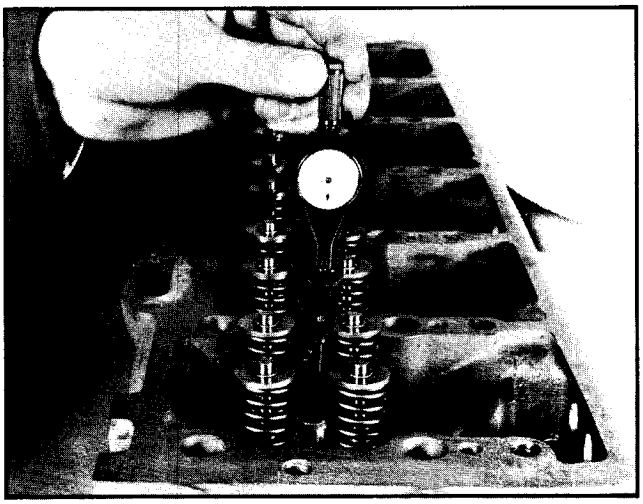


Fig. 3-7. Checking crosshead guide bore

2. Gauge hole at several points cross-wise and end-wise of head.
3. Mark guides for replacement that are not within worn replacement limits.

CAUTION: DO NOT USE A PLUG GAUGE.

VALVE SPRINGS

Weak valve springs may cause valve flutter which will cause excessive wear on both the valve and seat. Valve flutter interferes with valve timing and may cause valve to strike piston head. Warping, cracking and breaking are natural results of a weak valve spring.

1. Test on valve spring scale that is capable of very accurate measurements of spring lengths by means of standards and dial indicator gauge.
2. Use washers or spacers (maximum 1/16 inch total thickness) to make old valve springs check within load limits shown in Table "Valve Spring Data," Page 3-4.

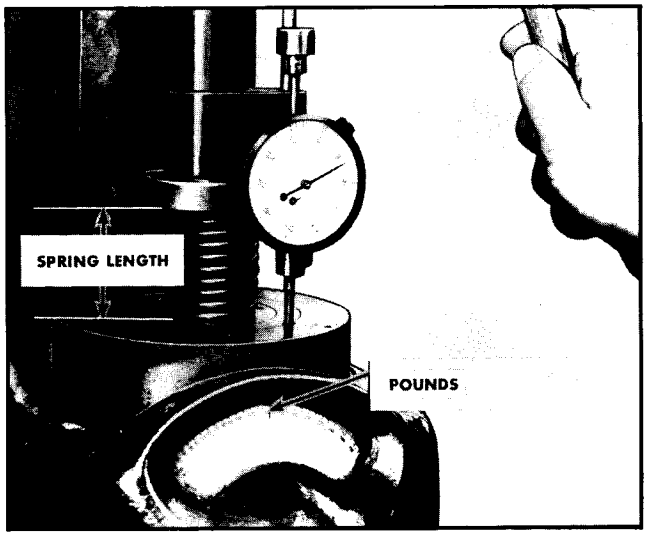


Fig. 3-8. Testing valve spring

CYLINDER HEAD RESURFACING

1. Resurface head if it has been scratched, etched or worn unevenly at point of contact with gasket sealing areas. A head warped as much as .019 inch will flatten out when tightened in position; therefore, it is not necessary to resurface only because of warping.
2. Remove no more than .030 inch total.
3. After resurface:
   a. Check head height; *it must be* at least 4.970 inches.
   b. Install new injector sleeves to maintain correct injector tip protrusion.
   c. Check overall height of assembled valve springs to see if it will be necessary to install spacers under springs to obtain correct assembled height.

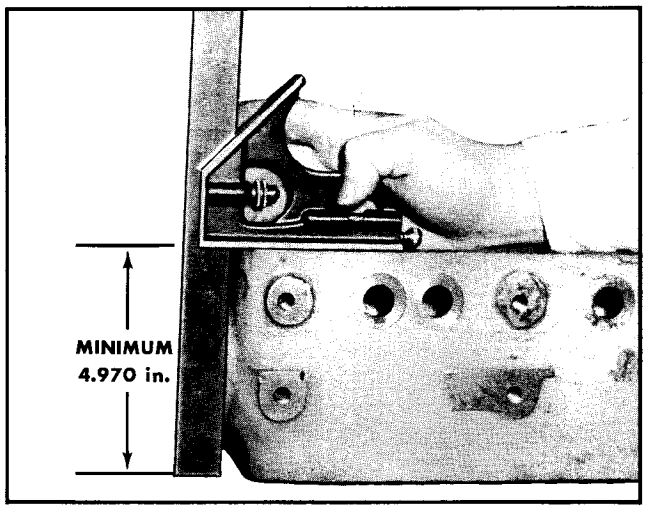


Fig. 3-9. Checking head height

TABLE 3—VALVE SPRING DATA

Engine Model	Spring Part No.	Free Length	Load Limits	Length
JN, JNS, JT	70845	2.703	69 lb. @	2.109
			136 lb. @	1.703
	106664	2.539	55 lb. @	2.079
			122 lb. @	1.673
	120089	2.364	44 lb. @	2.016
			111 lb. @	1.610
J, JF, JS	70023	2.944	91 lb. @	2.406
			187 lb. @	2.000
	105988	2.884	86 lb. @	2.346
			178 lb. @	1.940

TABLE 4—VALVE AND GUIDE DATA

Part No. and Name			Diameter New	Worn Limit Diameter	Minimum Head Thickness At Edge
68569	Intake Valve	(Stem)	.402/.403	.401	1/16"
70129	Exhaust Valve	(Stem)	.402/.403	.401	3/32"
70670	Exhaust Valve	(Stem)	.402/.403	.401	3/32"
44748	Intake Valve	(Stem)	.340/.341	.339	1/16"
113447, 44747	Exhaust Valve	(Stem)	.340/.341	.339	1/16"
105985, 60495	Valve Guide	(I.D.)	.4045/.4052	.407	
105293, 70848	Valve Guide	(I.D.)	.3425/.3432	.345	
70849	Crosshead Guide	(I.D.)	.3755/.3760	.378	
44737	Crosshead (L.H.)	(Stem)	.3708/.3713	.370	
44738	Crosshead (R.H.)	(Stem)	.3708/.3713	.370	
ST-285	Valve Guide Reamer				
	Pilot End Diameter		.4023		
	Cutting Flute Diameter		.4049/.4051		
ST-478	Valve Guide Reamer				
	Pilot End Diameter				
	Cutting Flute Diameter		.3429/.3431		

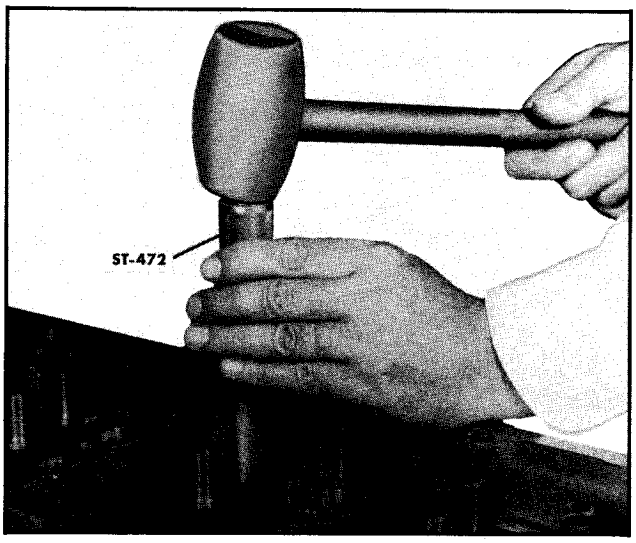


Fig. 3-10. Installing valve guide

REBUILDING

VALVE GUIDES

1. Where replacement is required, drive out valve guides from underside of cylinder head.

2. Install new valve guides with valve guide driver ST-472, for JN, JNS and JT or ST-475 for J, JF, JS engines. If ST-472 and ST-475 are not available, proper height above head surface is 1.240 to 1.260 inches for JN, JNS and JT; 1.405 to 1.435 inches for J, JF, JS engines. See Fig. 3-10.

3. Ream valve guide from bottom side of cylinder head, using a drill press and floating tool holder.

   a. Use ST-285 reamer on J, JF and JS guides.

   b. Use ST-478 reamer on JN, JNS and JT guides.

   c. Use lubricating oil or soluble oil and water solution for a good finish.

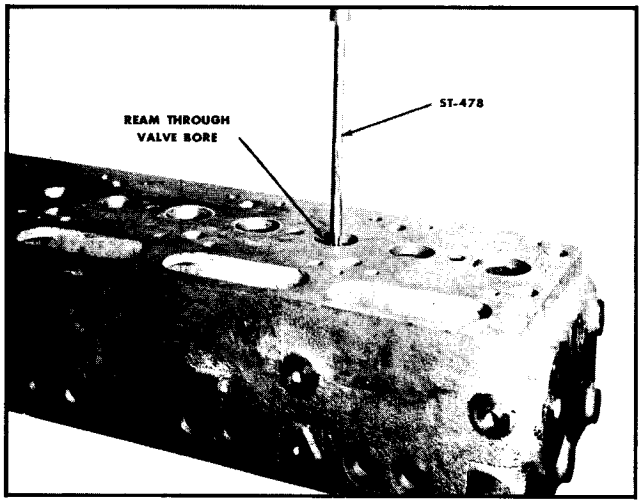


Fig. 3-11. Reaming valve guides

d. Gauge valve guide bore; see Table: "Valve and Guide Data," Page 3-4.

CAUTION: SPECIAL CARE MUST BE USED TO AVOID BREAKING CARBIDE TIPS. SHARPEN CARBIDE TIPPED TOOLS ON A DIAMOND IMPREGNATED WHEEL.

VALVE CROSSHEAD GUIDES

1. Remove guides to be replaced.
2. Press in new guides.
3. Check size with new crosshead stem.
4. If necessary, ream guide to .3755 to .3760 with bottom reamer.

INJECTOR SLEEVE INSTALLATION

1. Use ST-566 to drive in a new injector sleeve.
2. Assemble ST-383 hold-down tool.
3. Tighten nut until sleeve comes in firm contact with seat in cylinder head.

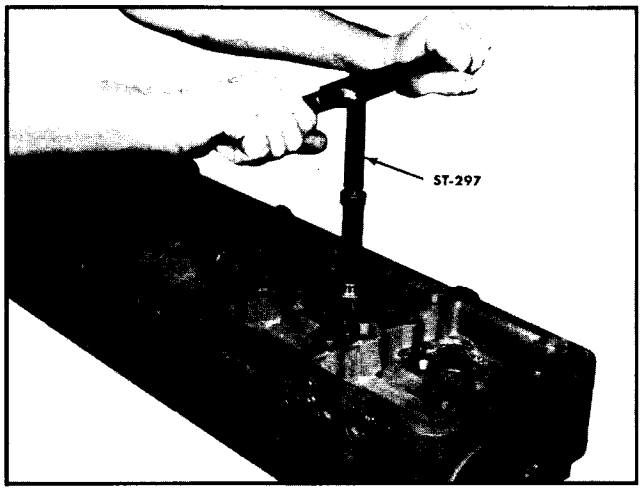


Fig. 3-12. Sealing upper end of injector sleeve

4. Seal upper part of sleeve with ST-297 expanding roller tool. To set tension on roller, screw tapered center mandrel in or out of roller head.

The upper part of the injector sleeve must be 1.380 to 1.375 I.D. to provide clearance for the injector body. Tapered mandrel can be marked to preset roller tool diameter.

Leave ST-383 hold-down tool in place to hold sleeve in position.

NOTE: If the injector sleeve protrudes above the bore, the injector will not seal. If it does protrude after rolling operation, cut off with an end cutter.

5. Remove ST-383 hold-down tool.
6. Cut injector seat.
   a. Use ST-379 seating cutter in a drill press.
   b. To determine amount of cut, insert injector and measure tip protrusion.

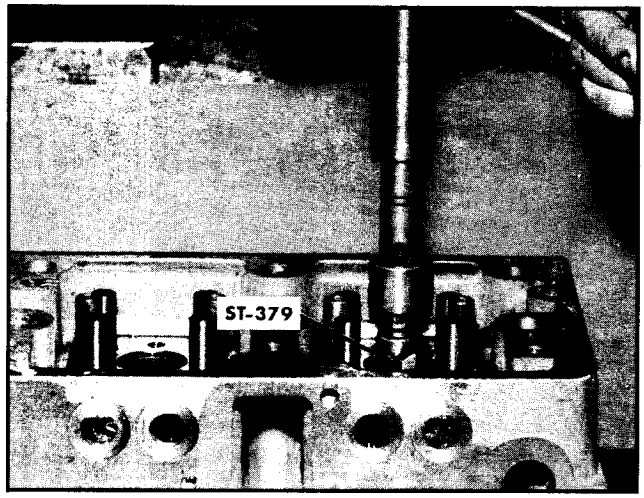


Fig. 3-13. Cutting injector seat

c. Depth of cut should provide .040 to .055 inch protrusion of injector cup tip beyond milled face of cylinder head.

REPLACE VALVE SEAT INSERTS

1. Remove loose or excessively worn valve seat inserts.
2. Enlarge counterbore to next oversize. Inserts are available in standard .005, .020, .030, and .040 oversizes as shown in table "Valve Seat Inserts," Page 3-6.
3. Use ST-257 Valve Seat Insert tool to hold and drive cutters which come in sets—ST-258 for J, JF, and JS, and ST-484 for JN, JNS and JT. This tool must be driven by an electric motor.
4. Machine counterbore .006 to .010 deeper than insert height to permit peening of head to hold insert.
5. Install valve seat insert.

6. Peen insert in head with peening tool included in ST-257 tool kit. A ¼-inch diameter round end punch may be used.

CAUTION: OVER-SWAGING AROUND INSERT MAY CRACK CYLINDER HEAD.

GRIND VALVE SEATS

Use ST-187 Valve Grinding Kit (contains parts to grind valves on all Cummins engines) or tools of equal standards.

1. Check condition of grinding equipment.
   a. Mandrels must be straight and of proper size to fit in reamed valve guides.
   b. Bushings in the grinder must be clean and must fit properly on guide mandrel.
   c. Bearings of drive unit must be in good condition.
2. Dress stone to 30° from horizontal.
3. Grind valve seats, holding seating motor as nearly vertical as possible (See Fig. 3-14).

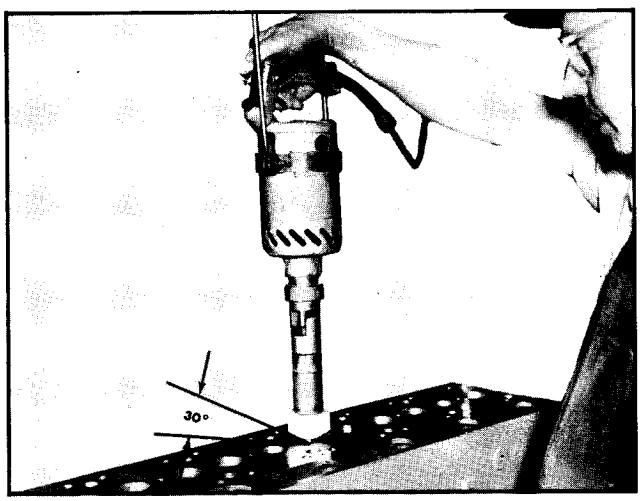


Fig. 3-14. Refacing valve seats

A severe angle will cause the seat to be out-of-true depending upon the amount of wear in the grinder bearings, mandrel, bushings, etc., even though the grinder has a universal joint.

4. Check valve seat width which should be 1/16 to ⅛ inch. See Fig. 3-15.
   a. If ground seat is wider than the maximum ⅛ inch, stock can be removed from points "A" and "B" with specially dressed valve seat grinder stones.
   b. Narrowing should not extend beyond chamfer on seat insert. Chamfer provides for peen metal.

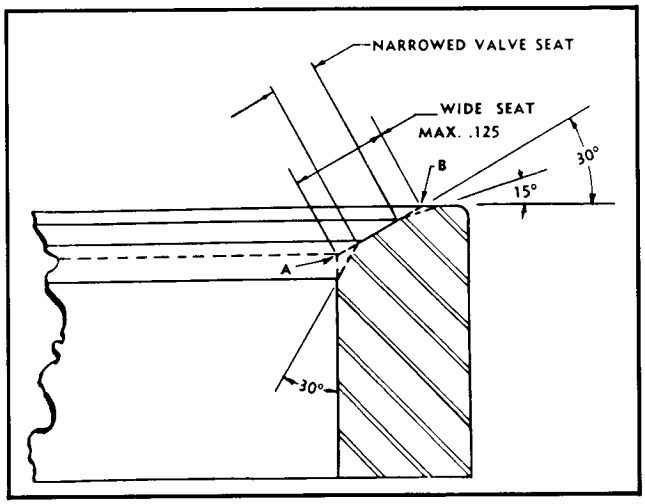


Fig. 3-15. Cross section valve seat insert

5. Dress wheel for final finish.
6. Finish grind with light touches of stone against face.
7. Check guide alignment with eccentrimeter as shown in Fig. 3-16.
   a. Run out should not exceed .001 inch.
   b. The gauge must be a perfect fit on pilot mandrel.

TABLE 5—VALVE SEAT INSERTS

Part Number	Dia.	Oversize Depth	Insert O.D.	Cylinder Head I.D.	Insert Thickness
70668	Std.	Std.	1.6905/1.6900	1.688/1.687	.258/.256
70668-A	.005	Std.	1.6955/1.6950	1.693/1.692	.258/.256
70668-B	.020	.005	1.7105/1.7100	1.708/1.707	.263/.261
70668-E	.030	.010	1.7205/1.7200	1.718/1.717	.268/.266
70668-C	.040	.015	1.7305/1.7300	1.728/1.727	.273/.271
70843	Std.	Std.	1.430/1.4305	1.428/1.427	.156/.161
103331	.005	Std.	1.435/1.4355	1.433/1.432	.156/.161
103332	.020	.005	1.450/1.4505	1.448/1.447	.166/.161
103333	.030	.010	1.460/1.4605	1.458/1.457	.171/.166
103334	.040	.015	1.470/1.4705	1.468/1.467	.176/.171

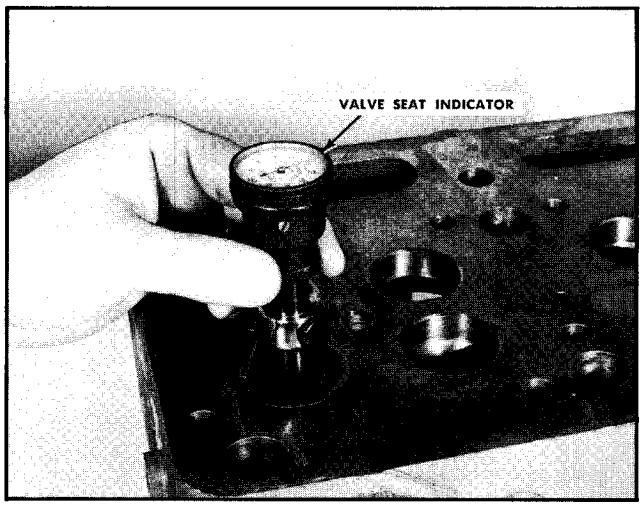


Fig. 3-16. Checking valve seat—JT head

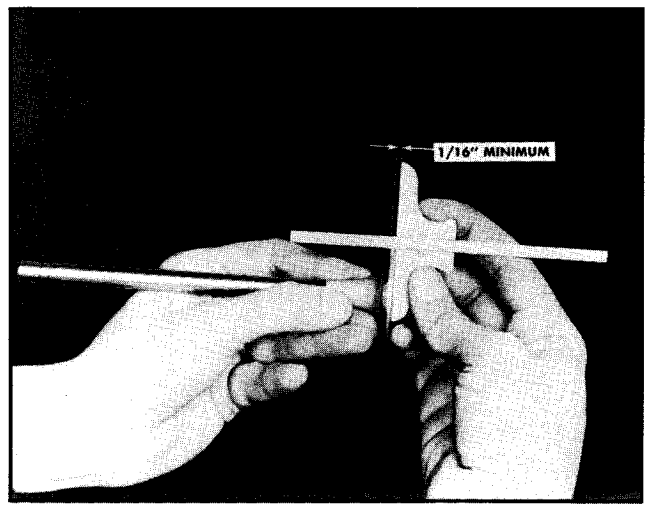


Fig. 3-17. Checking thickness of valve head rim

GRIND VALVES

Use ST-187 Valve Grinding Kits or tools of equal standards.

1. Check valve grinder setting by using a new valve and an indicator gauge.
   a. Chuck valve 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 the valve 180° from first position.
   e. Repeat "b" and "c."

If the high spots are same for both "a" and "d" positions, the valve is warped. If high spots occur in different positions, chuck is out of alignment. Runout should not exceed .001 inch.

2. Check bearings of machine.

3. The grinding wheel must be the proper grade and properly dressed to avoid chatter and grind marks.

4. Wet grind valves to an exact 30° angle from horizontal.

5. Valves and 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 vacuum test described in TEST VALVES AND SEATS FOR LEAKAGE, Page 3-8.

6. Check rim thickness as shown in Fig. 3-17. If rim is thinner than 1/16 inch, valve is not suitable for use because of the danger of burning and cupping.

7. Check valve in a finish reamed guide and against a newly ground valve seat face. Pencil mark valve as shown in Fig. 3-18, drop into position and rotate 10 degrees.

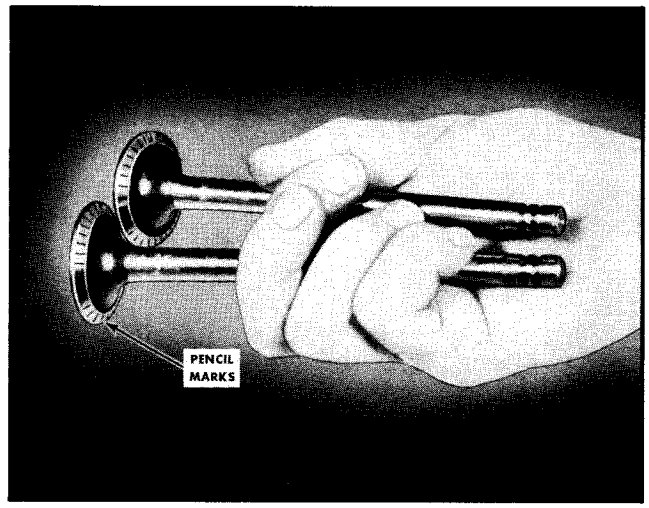


Fig. 3-18. Pencil marks on valves

8. A true seat will be indicated if all pencil marks are broken. If pencil marks are not broken, the valve seat tools need dressing or the machine has not been properly adjusted.

Conditions Of A Good Valve Seat

a. No grind or reamer marks on seating surfaces and within the guide.
b. Valve face a true 30° angle.
c. Width of grind is within limits.
d. Guide-to-stem clearance is within limits as determined from guide dimensions shown in Table 4, "Valve and Guide Data," Page 3-4.

REWORK NON-GROOVED CYLINDER HEADS

Use ST-538 to cut four grooves 4.870 to 4.880 inches in diameter and .010 to .015 inch deep to improve head gasket seal.

1. Remove tip end of scrapped J injector cup by drilling out with 11/32 inch drill.
2. Install drilled cup (Step "1") on scrapped injector body, preferably one with a class "0" plunger bore.
3. Clean carbon from cylinder head face.
4. Install injector body in cylinder head. Tighten 10 to 12 foot-pounds.
5. Install ST-538 guide pin into injector body.
6. Set adjustable cutting tool .006 to .008 inch beyond stop.

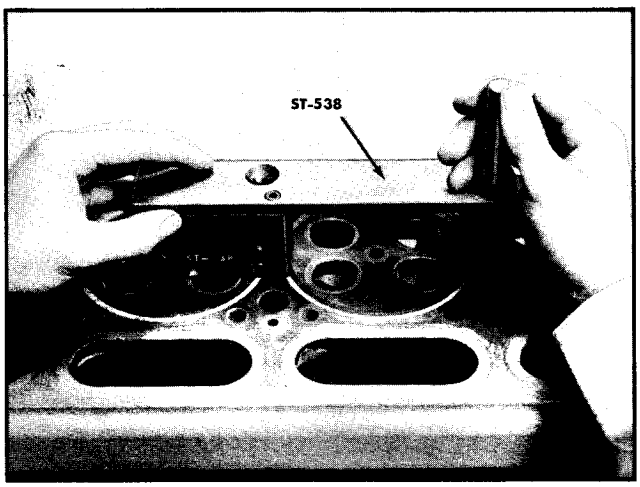


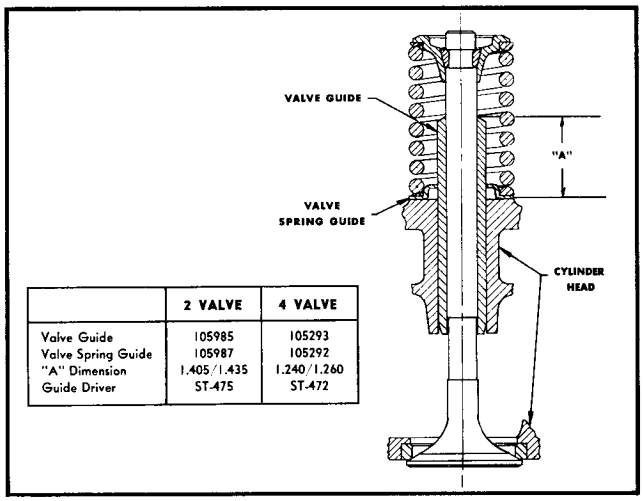
Fig. 3-19. Cutting grooves in cylinder head

7. Turn cutter in clockwise direction.

CAUTION: DO NOT ATTEMPT TO CUT DEEPER THAN THE TOOL GROOVE DEPTH. LANDS OF GROOVES SHOULD BE .005 TO .010 WIDE AND FLUSH WITH HEAD SURFACE.

ASSEMBLE VALVES AND SPRINGS

1. Insert valves.
2. Place cylinder head face down on a wooden bench to prevent marring milled surface.
3. Assemble lower valve spring guides on valve guides.
4. Assemble springs. NOTE: Reground valve heads seat deeper in cylinder head causing valve stem to protrude further above the guide. This allows valve spring to extend beyond length limits and causes weak spring action. Therefore, spacers, up to 1/16 inch total, must be used to reduce valve spring length. CAUTION: TOO MANY SPACERS WILL CAUSE THE COMPRESSED SPRING TO BECOME A SOLID SLEEVE. See Table 3, "Valve Spring Data."
5. Assemble upper valve spring guide. Insert half-collets.
6. Use ST-448 valve spring compressor to compress valve spring. Use new half-collets, Part No. 119819.



	2 VALVE	4 VALVE
Valve Guide	105985	105293
Valve Spring Guide	105987	105292
"A" Dimension	1.405/1.435	1.240/1.260
Guide Driver	ST-475	ST-472

Fig. 3-20. Valve assembly

TEST VALVES AND SEATS FOR LEAKAGE

A vacuum tester to check valves and seats for leakage is available as ST-417. It consists of a vacuum pump, vacuum gauge and suction cup. Use with any 6-volt battery source or 110-volt electrical outlet as required.

Do not install injectors.

Valves and seats must be dry and clean.

USE ST-417 VACUUM TESTER

1. Select proper vacuum cup for size valves to be tested. (Cups are furnished with each tester so that all engine models can be tested.)
2. Place suction cup over valve head. "O" ring on cup should seat on flat surface of head surrounding valve. Grease can be applied for a better seal. Keep the valve and seat dry.

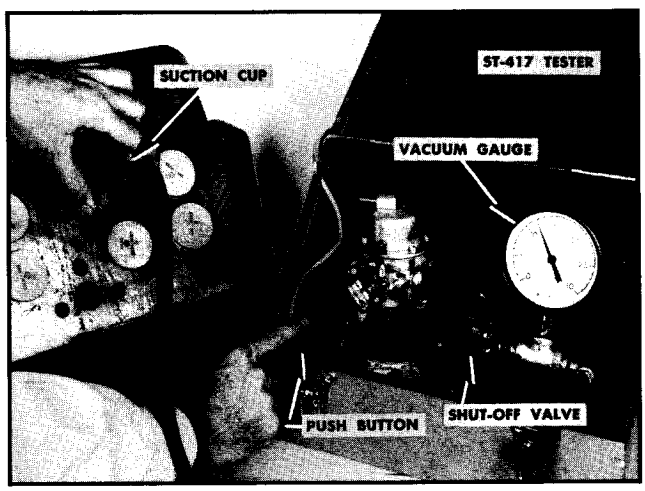


Fig. 3-21. Vacuum testing valves for leaks

3. Turn hand shut-off valve to open position; hold push button to operate vacuum pump.

4. Operate vacuum pump until hand on vacuum gauge stops climbing; 15 to 25 inches of mercury, as shown on dial.

5. Close shut-off valve; release push button to stop pump.

6. Time fall of gauge hand to test valve seat.
   a. Begin timing as soon as hand reaches "15" on the dial.
   b. Stop timing when hand reaches "12." If time is less than ten seconds, valve seal is unsatisfactory.

7. If valve seal is unsatisfactory:
   a. Check for leaking connections in tester; operate vacuum pump with suction cup against a clean window glass or any smooth flat surface; check for fall of indicator hand indicating loose connection.
   b. Make sure valve and seat are not dirty.
   c. Regrind valve and seat if necessary.

NOTE: It is possible to mistake leakage around the valve seat insert for valve seat leakage. If this type of leakage is suspected, apply grease around the outside edge of the insert to make a grease seal. Perform the vacuum test and inspect the grease seal for a break indicating air leakage between the wall of counterbore and valve seat insert. If a leak around valve seat insert is found, correction is required before continuing with the test.

PAINT

Repaint cylinder heads. New paint provides protection and means of identification.

INSTALL CROSSHEADS

1. On JN, JNS, and JT engines, insert valve crossheads in crosshead guides.

2. Install crosshead retainer to keep crosshead in position and insure correct valve-to-crosshead and rocker lever contact.

3. Assemble crosshead lock nut, tighten finger tight.

PLUG VENT HOLES

At the top of the cylinder head and at the front of every other rocker shaft bearing is a vent hole. On all supercharged and turbocharged engines the vent holes must be plugged with a ⅛ inch pipe plug.

Section 4

UNITS NO. 3 AND NO. 4

ROCKER LEVERS AND TAPPETS

ROCKER LEVERS

Disassembly

1. Slide all bearings and rocker levers from shaft.

Inspection

1. Check all rocker lever bushings. Those worn larger than 1.1265 I.D. must be replaced.

2. Test roundness of ball end of rocker lever adjusting screw with a ¼ inch radius gauge. If worn flat, they must be replaced.

3. Check injector rocker lever sockets with a radius gauge or by observation of small protrusion at bottom of socket. Replace if worn excessively.

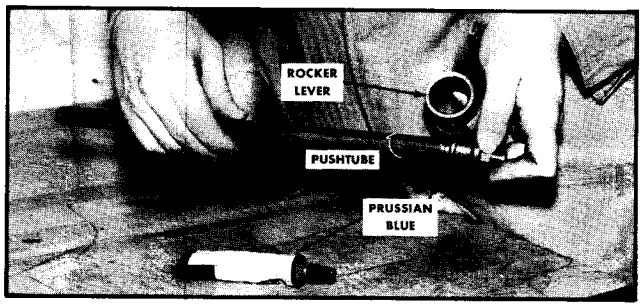


Fig. 4-1. Checking rocker lever socket wear

4. Clean all oil passages in rocker levers, rocker lever sockets, oil line dowel pin (center bearing) and rocker lever shaft.

NOTE: The oil line dowel may remain in the cylinder head.

5. Check for surface imperfections and cracks by magnetic inspection.

Rebush and Bore Rocker Lever

1. Use ST-252 mandrel and block to press out old bushings.

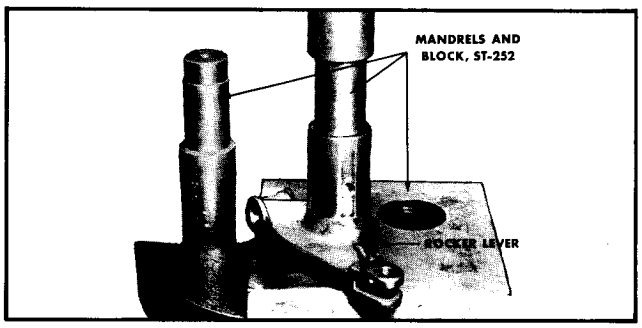


Fig. 4-2. Removing rocker lever bushings

2. Press in new bushings; use ST-252 Mandrel and Block. The sleeve will support the bushing and prevent distortion during this operation. Use hole in sleeve to align hole in bushing with lubricating oil boss of lever.

3. Use 60° cutter in slow speed drill press to chamfer each end of bushing. DO NOT CUT INTO THE LEVER.

4. Put semi-soft soap in lubricating hole of bushings to keep chips from entering and lodging.

5. Use ST-526 Tobin-Arp Boring Machine to bore rocker lever bushing. ST-294 boring machine with ST-286 fixture can also be used.

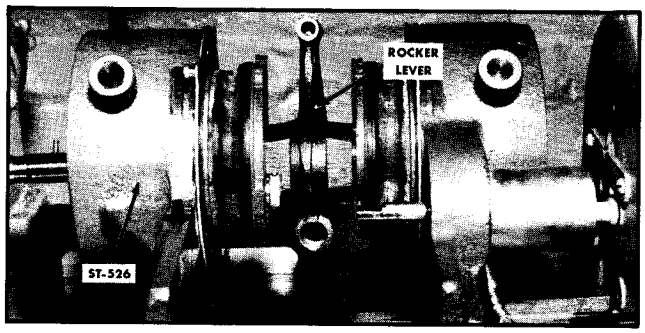


Fig. 4-3. Boring rocker lever bushings

6. Check boring operation with ST-194 "No-Go" plug gauge.

7. Blow soap from lubricating oil holes.

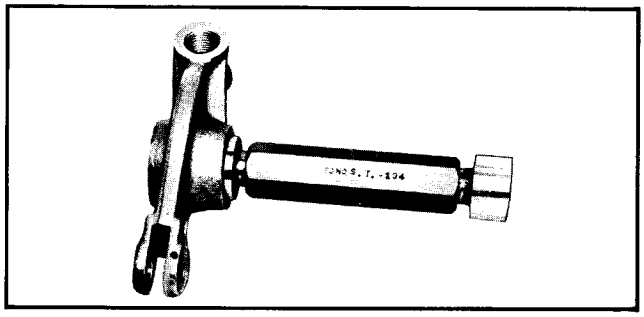


Fig. 4-4. Checking rocker lever bushing

Assembly

1. Assemble rocker levers and bearings to shaft as illustrated. Rocker lever assembly is lubricated through oil holes in shaft and in center bearing which indexes with an oil passage in block.

2. Oil line dowel pin in cylinder head indexes with center bearing.

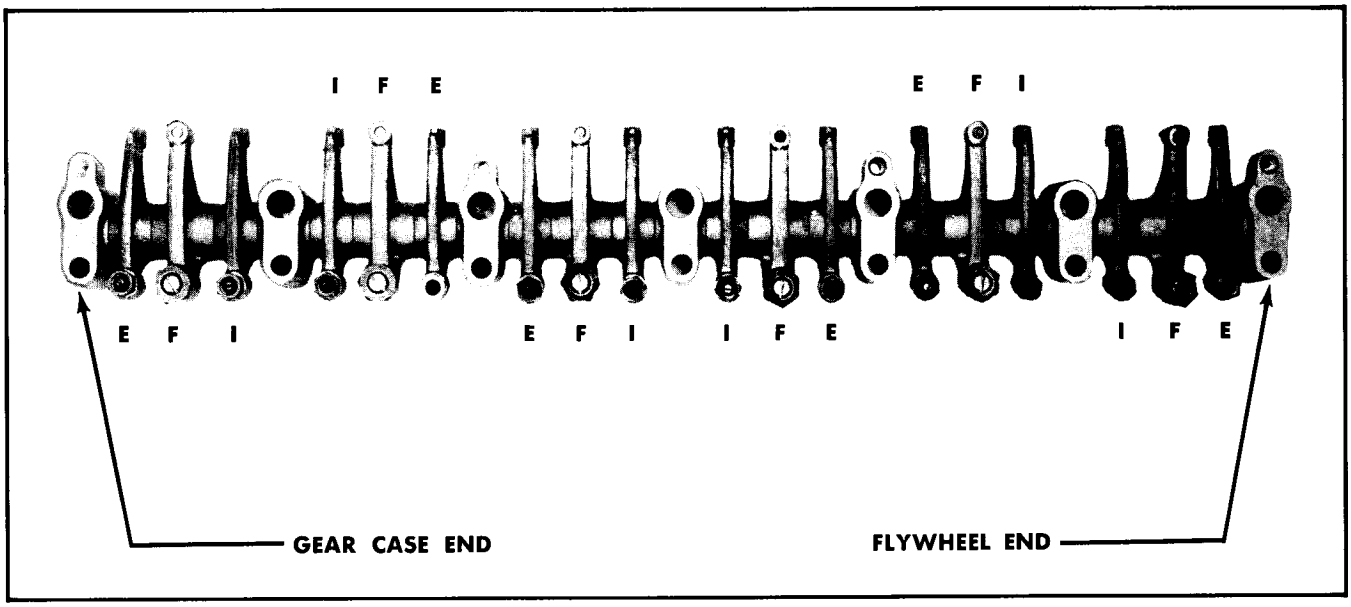


Fig. 4-5. Rocker lever assembly

3. Install rocker lever shaft plugs in shaft ends if removed.

PUSH RODS

Each cylinder has an exhaust, fuel and intake push rod.

On engines with a compression release, the intake push rods have a flange which coincides with the milled recesses in the compression release shaft. When the compression release lever is pulled upward, the intake valve is held open, permitting easy cranking.

1. Check both ends of each push rod for true spherical contours.
   a. Upper end spherical I.D. .4995 to .5005.
   b. Lower ball diameter end intake and exhaust push rods .624 to .625 inch.
   c. Lower ball diameter end injector push rod .685 to .687 with ⅛-inch diameter flat at bottom.
2. Check for signs of scratching or galling; replace if evident.

TAPPETS

1. Rollers and pins must be replaced if visibly worn.
2. Valve and injector tappet rollers are guided through machined bores in the block.

NOTE: Check Table, Tappet and Roller Data below for dimensions.

TABLE 6—TAPPET AND ROLLER DATA

Tappet Roller	
Intake	1.061/1.063 in. O.D.
Exhaust	1.061/1.063 in. O.D.
Injectors	1.123/1.125 in. O.D.
Tappets	
Valve	1.186/1.185 in. O.D.
Injector	1.311/1.310 in. O.D.

3. To obtain proper roller and tappet clearance:
   a. Place .006 inch shim stock between bottom side of roller and tappet when removing pin. This

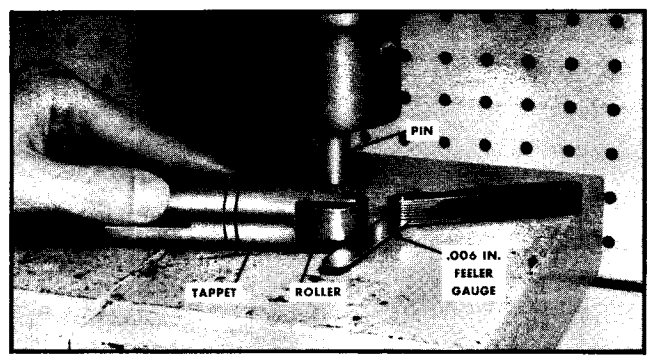


Fig. 4-6. Installing tappet roller

prevents springing in fork area of tappet.

b. At assembly, support roller in manner described in "a" above.

c. Minimum roller to tappet of .006 inch is assured by step "b" above.

4. Install steel sleeve in tappet by compressing and aligning guide slots.

There are two styles of tappets and tappet roller pins used in J Series engines.

CAUTION: MAKE CERTAIN THAT ANY ROLLER PINS THAT ARE REMOVED ARE REPLACED WITH IDENTICAL PINS. USE OF INCORRECT PIN AND TAPPET COMBINATION WILL SEAL OFF LUBRICATING OIL DRILLINGS AND LEAD TO PARTS FAILURE.

COMPRESSION RELEASE

Disassembly

1. Remove mounting stud nuts and lock washers.

2. Lift compression release housing, shaft, lever and spring from cylinder head.

3. Inspect and install a new packing gland, if necessary.

Assembly

1. Reassemble compression release to cylinder head, being careful to let one end of spring ride against housing with other end held against upper stud bolt.

2. Clamp lever in place so that open position will lift valves 1/16 inch maximum.

Section 5

UNIT NO. 5

FUEL SYSTEM

PT FUEL PUMP

Complete instructions for disassembly, rebuilding, assembly, and testing the fuel pump are given in the PT Fuel System Shop Manual, Bulletin No. 983334-A.

DISC-TYPE FUEL PUMPS

Complete instructions for disassembly, rebuilding and testing the double-disc fuel pumps used on early model JS engines are given in the Single and Double Disc Fuel System Shop Manual, Bulletin No. 983357.

Section 6

UNIT NO. 6

FUEL TUBING, CONNECTIONS AND INJECTORS

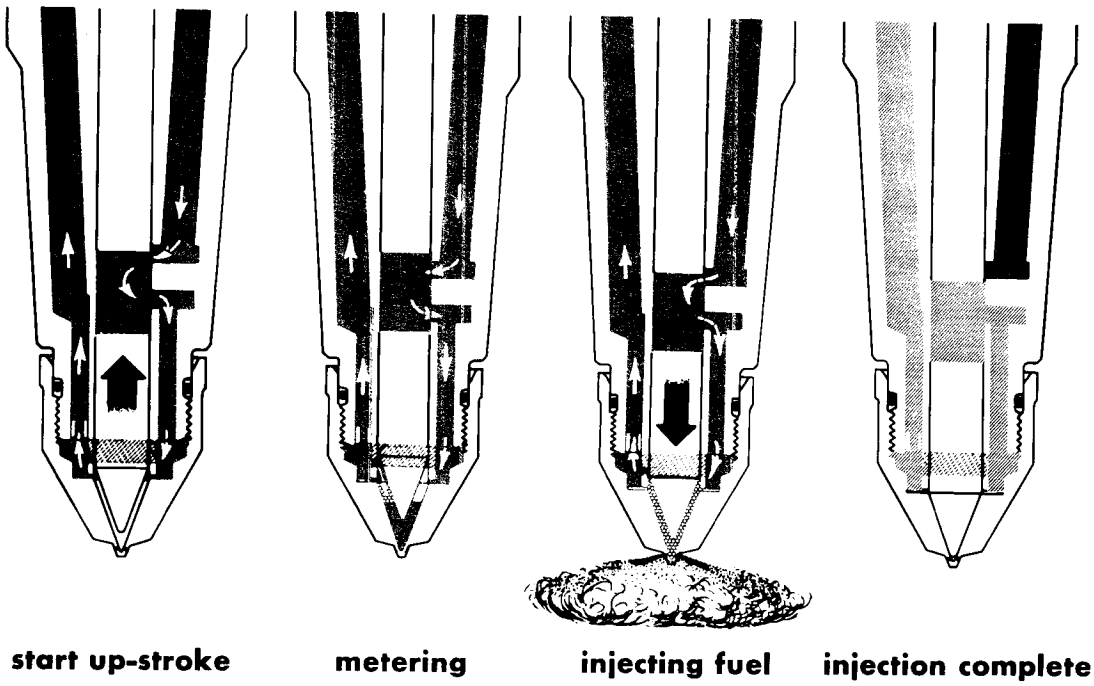


Fig. 6-1. Fuel injection cycle

The PT fuel system consists of the fuel supply tank, filters, tubing, fuel pump, inlet and drain connections, and injectors.

The fuel pump draws fuel from supply tank through tubing, filtering and delivering it at correct pressure through tubing and inlet connections to the injectors.

Fuel is metered by the injectors and injection timing is controlled by the camshaft. Excess fuel returns to the supply tank.

FUEL TUBING

1. Reject any fuel tubing or tubing connections:
   a. Not standard size or length.
   b. Twisted or bent out of shape.
   c. With damaged threads.

FUEL INLET AND DRAIN CONNECTION SCREEN

1. Remove strainer screen from inlet connection.

Fig. 6-2. Injector inlet screen

2. Clean screen in solvent.

3. Clean screen with an air jet, blowing in reverse direction to fuel flow.

4. Replace strainer screen in inlet connection.

5. Inspect threaded end of all connections; replace if threads are damaged.

INJECTORS

The injector is a simple mechanical unit which receives fuel from the fuel pump and injects it through the fine spray holes of the cup into the combustion chamber. Refer to Fig. 6-3 for parts identification.

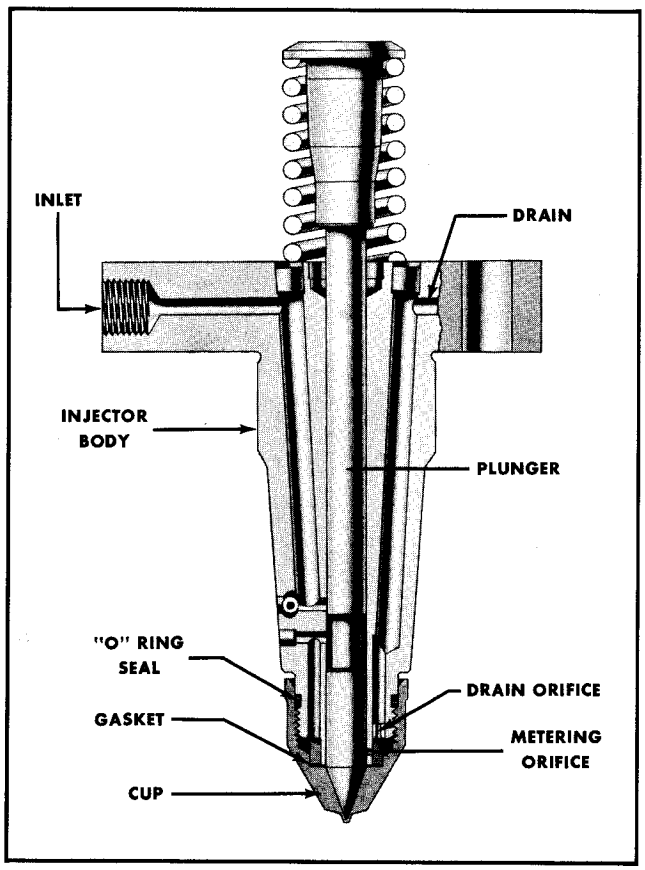


Fig. 6-3. Injector cross-section

Disassembly

1. Use ST-113 or ST-569 Holding Fixture while servicing injector. Never clamp the injector body in a vise as this may distort the body and result in a stuck injector plunger.

2. Remove bail or screw, if used, from injector body. See Fig. 6-4.

CAUTION: INJECTORS WITHOUT BAIL OR SCREW SHOULD ALWAYS BE KEPT RIGHT SIDE UP TO REDUCE POSSIBILITY OF DROPPING PLUNGER AND CAUSING DAMAGE.

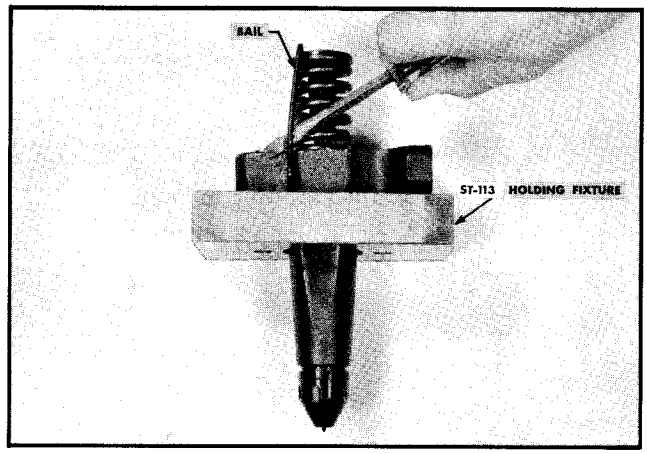


Fig. 6-4. Removing retaining bail

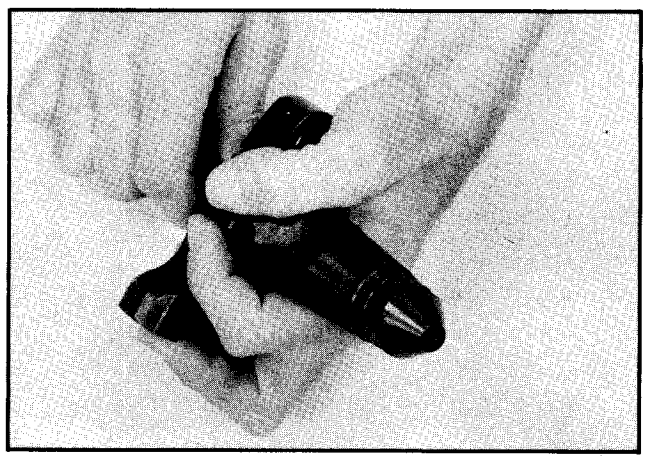


Fig. 6-5. Removing plunger and spring

3. Lift out injector plunger and spring.

4. Tag mating parts.

5. Remove injector cup with ST-499 splined wrench adaptor and proper wrench.

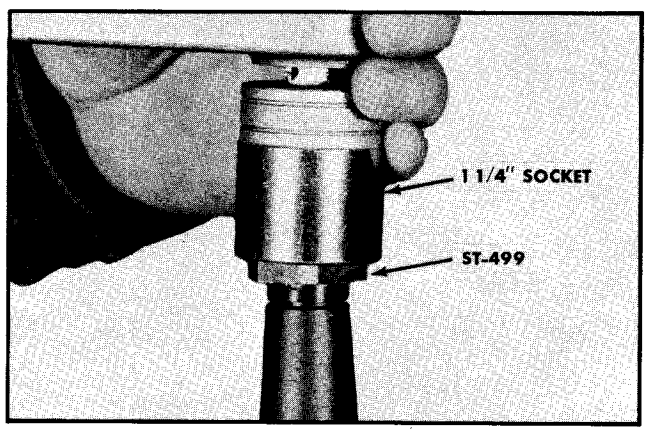


Fig. 6-6. Removing injector cup

6. Remove "O" ring.

7. Clean injector parts thoroughly of any carbon or varnish by soaking in a solvent such as "Bendix Metal Cleane" or equivalent.

8. Neutralize solvent after cleaning by dipping parts in mineral spirits.

9. Dry with clean compressed air.

Injector Cup Inspection

The accompanying illustrations show what to look for when inspecting injector cup. Use magnifying glass to determine whether or not any of the following faulty conditions exist.

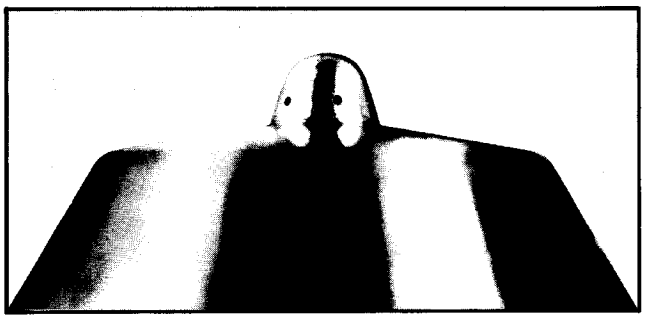


Fig. 6-7. New injector cup tip

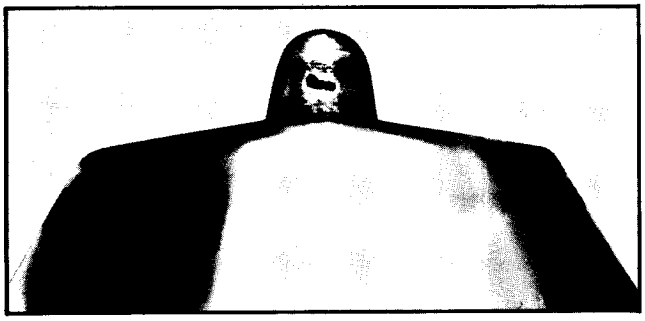


Fig. 6-8. Worn injector cup tip

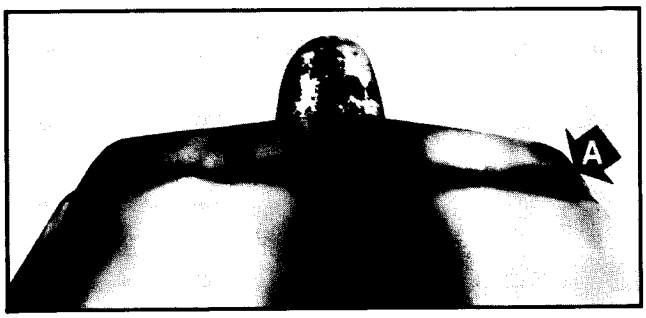


Fig. 6-9. Corroded injector cup tip

When fine abrasives such as dust get into the fuel, they have a sand blasting effect and usually cause the type of cup failure illustrated in Fig. 6-8. It is important to note that this type of wear can begin internally and cause a faulty spray pattern even though the cup exterior shows no signs of wear. *Therefore, inspect both interior and exterior.*

Faulty spray holes can be caused by the use of drills, wires, or other instruments when cleaning.

Fig. 6-9 shows the effect of high acid or sulphur content in the fuel and the effect of excessive heat caused by an overload condition. See "A"; the metal has been eaten away.

The cup is designed to inject the preheated charge of fuel into the cylinder in a fan shaped spray which brings the fuel in contact with all available air. Fig. 6-12. If one injector cup spray hole is plugged with dirt or metal, part of the available air in the cylinder chamber will not receive fuel. This results in a poor mixture which causes a falling off in power because of the slow burning. Thus, an additional burden is put on the remaining cylinders.

When some of the spray holes are closed, the remaining holes soon become enlarged. The fuel will be discharged as a liquid instead of a spray on a portion of the piston and cylinder wall. This excess fuel runs down the cylinder wall, causing piston rings to become "gummy" and "sticky" and causing dilution of the lubricating oil in the crankcase.

WARNING: *Never alter the size of the injector cup spray holes.*

Injector Body Inspection

1. Inspect injector body plunger hole for scoring. If scores are not too deep, injector body may be returned to a Cummins Distributor to be honed and fitted with oversized plunger.

2. Use strong magnifying glass to check for burrs and distorted radii in orifices. When injector orifices are damaged, the injector will not function properly.

3. Replace both body and plunger as an assembly.

Assembly

1. Install new "O" ring with ST-426 assembly tool each time cup is removed.
   a. Dip "O" ring in clean lubricating oil.
   b. Assemble ST-426 over threaded end of injector body.
   c. Slide "O" ring over tool.

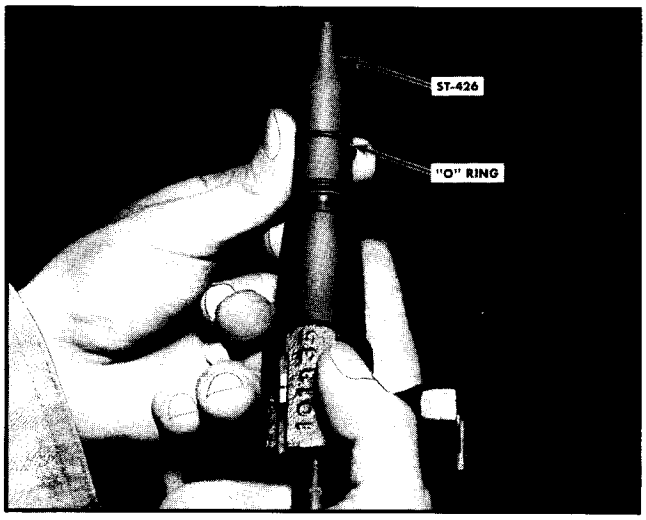


Fig. 6-10. Installing "O" ring

2. Replace injector cup gasket to avoid distortion of cup. Coat gasket with clean cup grease to hold gasket in place while mounting cup.
   a. Injector bodies which are stamped OP, 1P, 2P, or 3P use gaskets with one notch at O.D. Fig. 6-11.
   b. Injector bodies stamped OSS, 1SS, 2SS, or 3SS use gasket with two notches.
   c. Injector bodies stamped OSSS, 1SSS, 2SSS, or 3SSS use gasket with three notches.

3. Mount cup to body.
   a. Place injector body and plunger without spring upside down in T-569 holding fixture. This spring tension aligns plunger and cup when performing this operation.
   b. Use ST-499 wrench adaptor and torque wrench to tighten cup to 60 foot-pounds.

4. Replace injector plunger link if upper end shows wear which might lead to lubricating oil leakage between link and injector.
   a. Place plunger, cup end down, on soft wood.
   b. Use hammer and punch, with 1/16 inch point, to strike the "ears" on plunger link retaining ring. This will break ring and allow link to drop out.
   c. Place new retaining ring on new plunger link and press into place.
   d. Use a small screw or punch to seat retaining ring in groove in injector plunger.
   CAUTION: HANDLE INJECTOR PLUNGER CAREFULLY TO AVOID DAMAGE WHICH COULD RENDER IT USELESS.

6. To check cup spray hole openings, fill injector body two-thirds full of fuel oil and insert plunger, forcing fuel out spray holes.

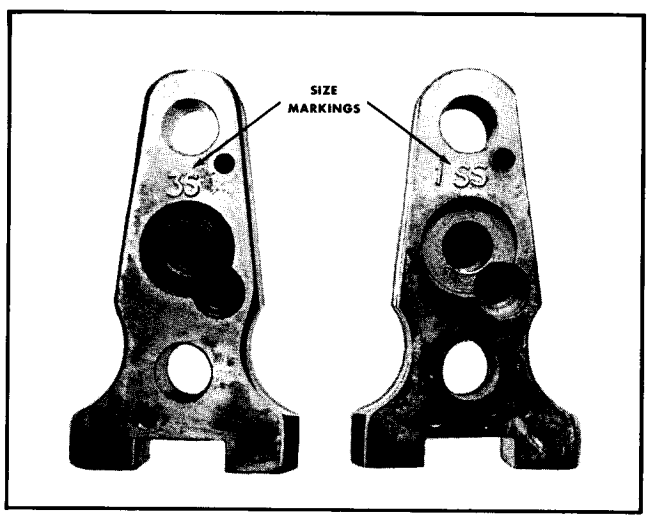


Fig. 6-11. Injector size markings

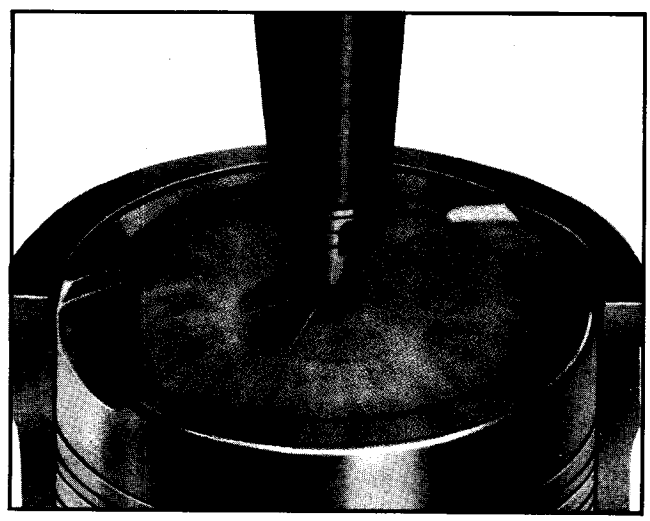


Fig. 6-12. Perfect ignition and combustion

7. Lubricate plunger with a thin coat of Molycote Type M-55.

8. Assemble plunger, spring and spacer (if used) to injector body; secure in place with bail or screw (if used).

a. Assemble seal washer to retaining screw.

b. Tighten screw to 40 inch-pounds in injector body.

9. Reface inlet and outlet seal surface if rough. Use ST-542 spot-facing tool to face seal surface to assure a better seal between connection and injector body. Fig. 6-13.

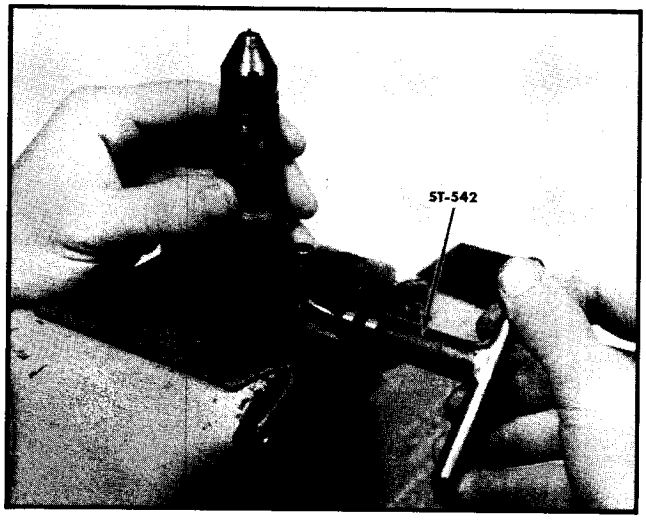


Fig. 6-13. Refacing inlet connection seal surface

INJECTOR PLUNGER SEAT TEST

After injector is assembled, the injector plunger seat should be checked by testing with ST-570. ST-570 operates from shop air pressure (approximately 85/90 psi). Fig. 6-14.

1. Place injector in ST-570. The cup fits into a tapered hole in the steel block and seats on an "O" ring while the body rests on a V block.

2. Fill inlet and drain holes in body with fuel or lube oil.

3. Press plunger into seat with pivot arm.

4. Release air pressure by pressing button on air connection cylinder. If the plunger is not seated correctly, air bubbles will appear in inlet and drain holes.

If bubbles appear, perform the following:

a. Disassemble injector and clean.

b. Reassemble injector cups with plunger in place to act as pilot. See cup installation, Page 6-4.

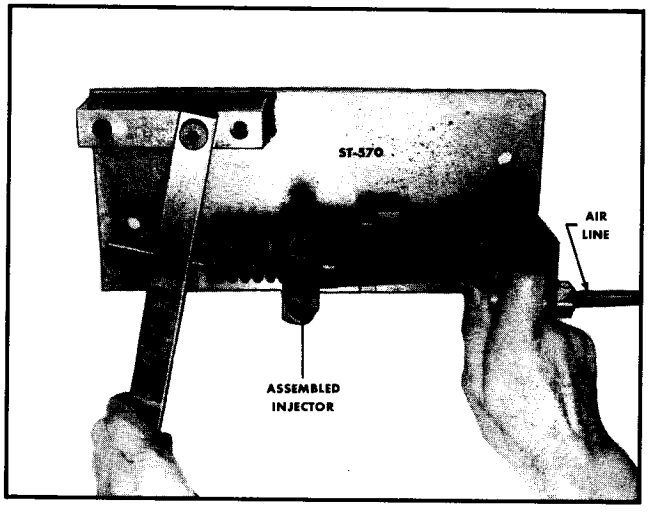


Fig. 6-14. Testing injector plunger seat

Section 7

UNIT NO. 7

LUBRICATING SYSTEM

Cummins J Series engines are pressure lubricated. The pressure is supplied by a gear type lubricating pump located in the oil pan below the crankshaft and driven by an idler gear off the pinion gear.

Oil is drawn from the pan sump through a screen and is delivered to all the working parts of the engine through lubricating oil lines and the oil header, the latter being drilled the full length of the block. Various other drillings through the block, cylinder head, crankshaft, connecting rods, and rocker levers complete the oil circulation passages.

The oil flows from pan-to-pump-to-strainer-to-cooler-to-oil header.

Lube oil is forced from the crankshaft to lubricate the main and connecting rod bearings.

Lube oil pressure is controlled by a regulator in the oil strainer head. The operating pressure at governed speed is maintained at 30 to 50 psi.

Filters, strainers and screens are provided throughout the system for proper cleaning of the lubricating oil.

Engines are equipped with oil coolers in order to maintain closer temperature regulation. Special oil pans and filters and, in some cases, a special pump are provided for certain types of installations.

LUBRICATING OIL PAN

1. Steam clean pan.

2. Clean cast iron pans in hot solvent tank.

CAUTION: MANY SOLVENT CLEANERS ARE INJURIOUS TO ALUMINUM OR OTHER NON-FERROUS METAL. MAKE SURE THAT YOUR CLEANER IS SUITABLE BEFORE USING IT ON ALUMINUM PANS, COPPER OR BRASS TUBING, OR SOLDERED PARTS.

3. Check oil pan for cracks.

4. On aluminum oil pans, check helicoil inserts. If lost or damaged, they should be replaced.

5. Determine the size hole, then use proper helicoil inserting tool to remove damaged helicoils; condition hole, and insert new helicoil.

   a. Use starting and finishing tap for helicoil inserts for new or oversize holes in aluminum. When tapping aluminum, use kerosene for lubricant to prevent tearing.

   b. After inserting helicoil, bend starting end toward center and then back toward side of hole to break off installation tip.

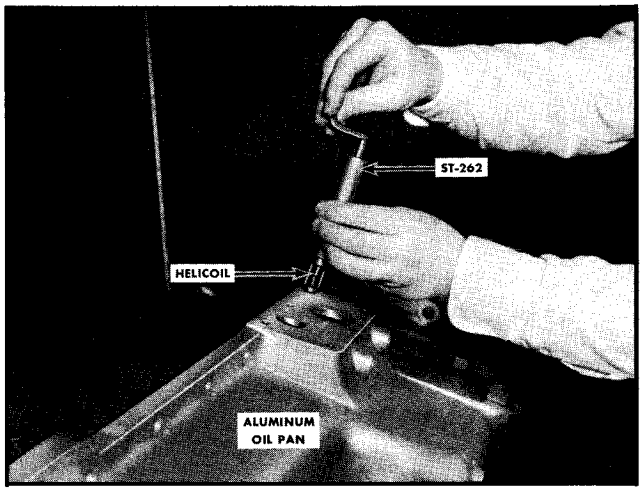


Fig. 7-1. Installing Helicoil insert in oil pan

7. Repair any small cracks in pan by welding. *Do not* weld finished surfaces.

LUBRICATING OIL STRAINER (Nugent Bag-Type)

Strainer Head

1. Remove large spring retainer cap.

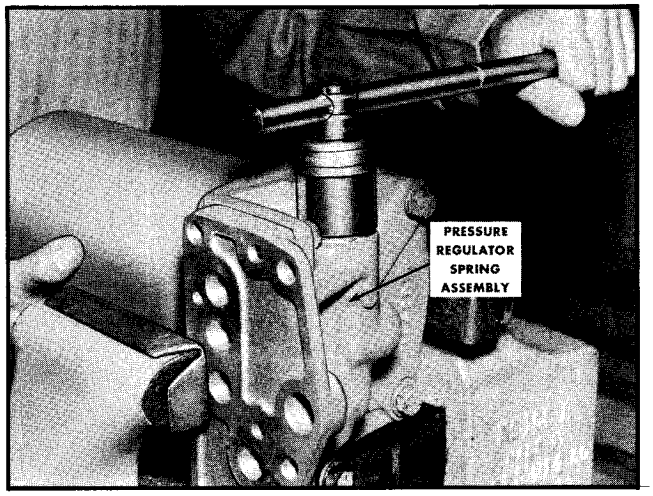


Fig. 7-2. Removing lube oil strainer retainer cap

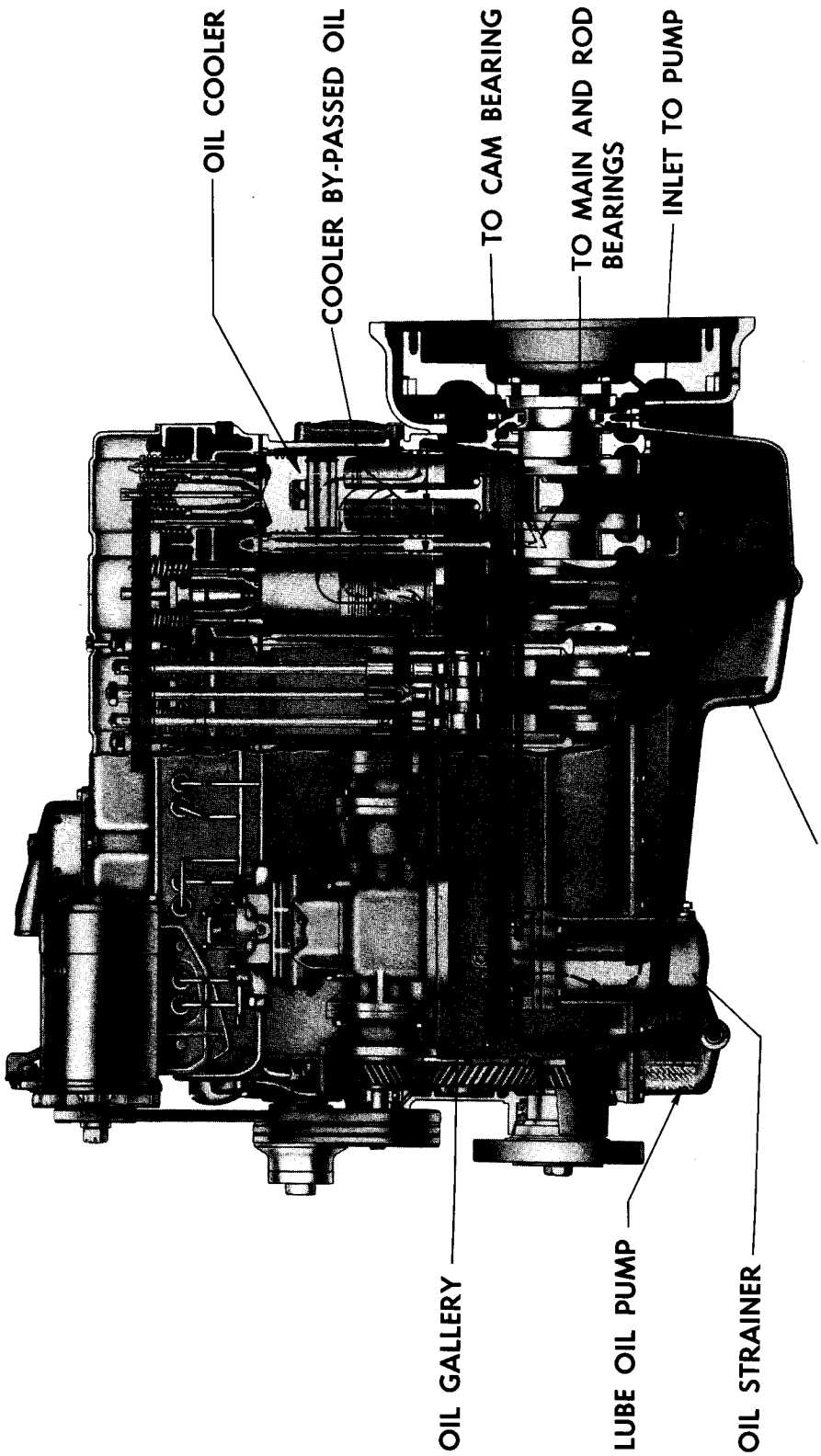


Fig. 7-3. Cross section of JS engine, side view

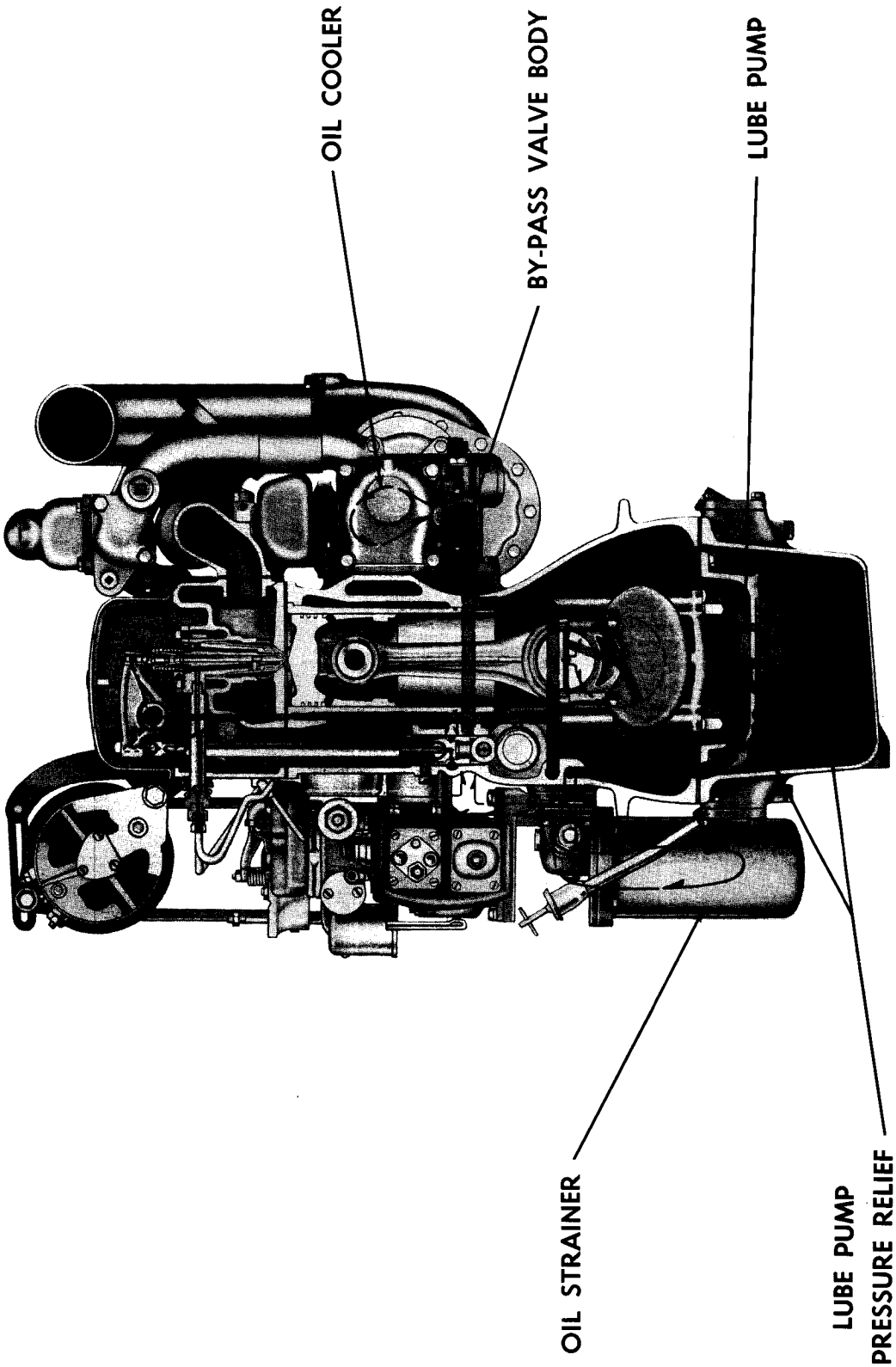


Fig. 7-4. Cross section of JS engine, end view

2. Remove relief valve spring and relief valve plunger.

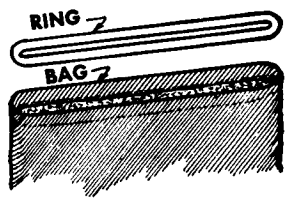
NOTE: Mark plunger and spring to assure reassembly in reverse order as removal.

3. Check the plunger for free action and wear.
4. Assemble plunger in lube oil filter head.

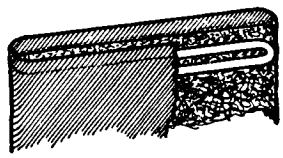
Strainer Bag

1. Remove filter head from filter assembly.
   a. Remove four capscrews.
   b. Remove Neoprene ring seal.
2. Lift filter element from housing.
3. Wipe housing with clean cloth.
4. Replace bag as illustrated in Fig. 7-6.

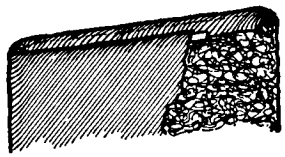
Fig. 7-5. Removing bag-type strainer element



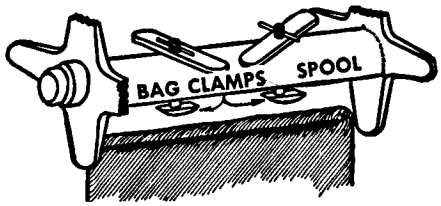
Bag and ring ready for assembling



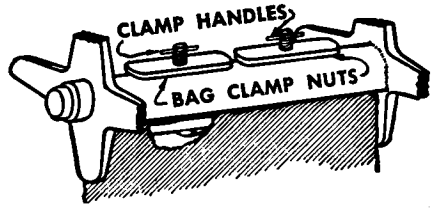
Place ring inside of bag.



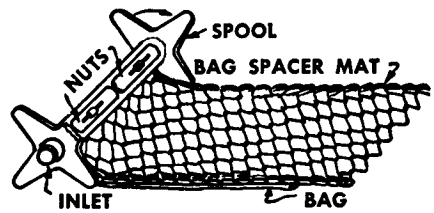
Fold top of bag inward over ring about ½" starting with the ends and then the sides.



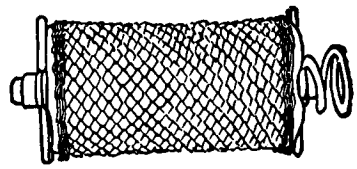
Before applying bag to spool, turn bag-clamps lengthwise so that they will enter bag opening.



Hold bag firmly against spool and give ¼ turn to bag clamp handles which brings them into lengthwise position. Hold handles thus while turning bag clamp nuts to a hand tight lengthwise position.



With inlet end facing you, place spool with bag on a clean flat surface, then lay bag spacer mat on bag making sure they are flat and that the left end of the mat comes up close to the spool. Then roll mat with bag around spool clockwise. The spacer mat must protrude 1½ to 2 inches after the mat and spool are rolled together.



Assembled filtering element ready to insert into shell.

Fig. 7-6. Changing bag of lubricating oil strainer

5. Inspect old bag for bearing metal, grit, etc. If metal is found in the bag, an inspection of connecting rod and main bearings should be made at once.

WARNING: DO NOT ATTEMPT TO WASH USED STRAINER BAGS. WASHING A BAG WILL DEPOSIT DIRT ON THE OUTSIDE OF THE BAG AND THIS, IN TURN, WILL GO THROUGH THE ENGINE'S LUBE SYSTEM.

6. Wash all other parts thoroughly.

7. Inspect gasket on spool and bag clamp. If damaged, replace.

8. Inspect spool arms for cracks or breaks. They can be broken by careless assembling of the unit.

9. Replace assembled filter element in housing.

10. Mount oil filter gasket and head to housing.

LUBE OIL STRAINER (Screen-Type)

1. Loosen capscrew at bottom of strainer and case to remove strainer assembly.

CAUTION: DO NOT LOSE THE NEOPRENE SEAL RING.

2. Lift strainer pack assembly from capscrew and case.

3. Plug open ends of strainer screen with cork stoppers to keep out dirt.

4. Inspect element for dirt, sludge, metal particles, bearing metal, grit, etc. An indication of poor operating conditions or inadequate maintenance is a strainer packed full of dirt and sludge. If the element contains any bearing metal, it is an indication of possible bearing failure in the near future. This calls for an immediate inspection of the connecting rod and main bearing shells.

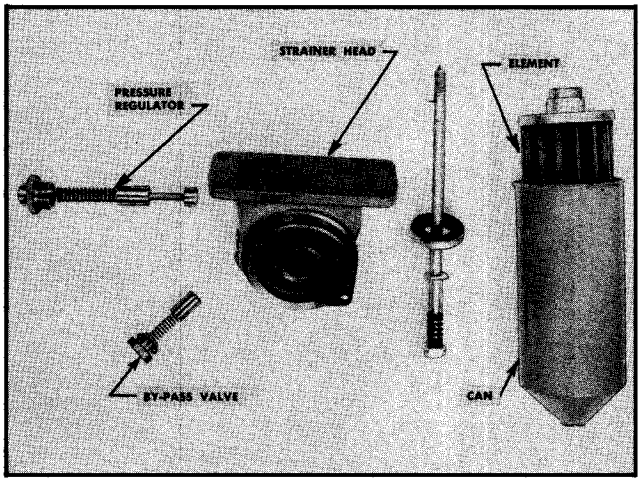


Fig. 7-7. Lubricating oil strainer head and pressure regulator

5. Clean inside of case in solvent and dry with compressed air. Do not remove the capscrew, ring, washer, or spring.

6. Clean strainer element.

NOTE: Strainer elements that are difficult to clean should be soaked overnight in Bendix carburetor cleaner or equivalent. Varnish deposits and other hard substances can then be washed free.

7. Dry with compressed air.

8. Remove cork stoppers and reassemble strainer in proper order.

9. Make sure rubber seal ring between case and cover is in good condition.

10. Fill strainer case with clean lubricating oil.

11. Tighten retainer screw to 75 to 100 inch-pounds torque.

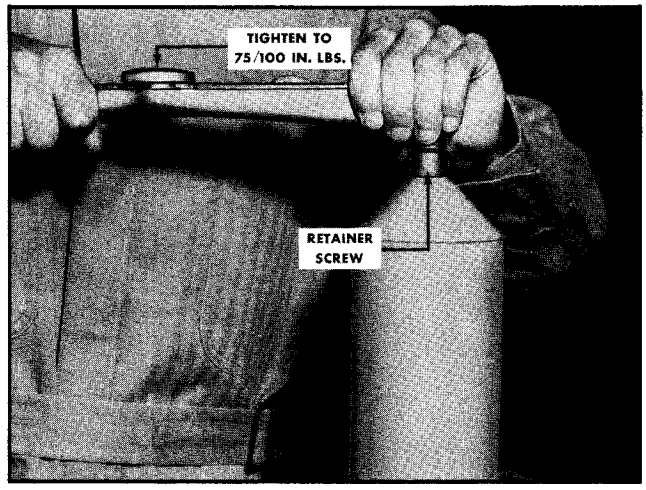


Fig. 7-8. Torquing lube strainer retaining screw

PRESSURE REGULATOR

1. Remove large retaining nuts from each side of strainer head, then remove spring and plunger.

NOTE: Mark plunger, plunger spring and retaining nut to assure reassembly in proper order.

2. Check regulating plunger for free action and wear. Replace plunger if the diameter is worn smaller than .738 inch.

3. Check pressure regulator spring. It should be 1.620 inches long under 13 lbs. load.

4. Check by-pass valve spring, ball and ball seat to see that they mate properly.

5. Replace lubricating oil pressure regulating plunger, spring retaining nut and gasket.

LUBRICATING OIL COOLER
(Tube Type, Removable Element)

This cooler consists of a cast housing, a removable element, two rubber "O" rings, a retaining ring, and a front cover. Fig. 7-9.

1. Remove front cover mounting capscrews and front cover, gasket, and steel retaining ring.

2. Install two 10/32 inch capscrews in tapped holes provided in tube bundle element.

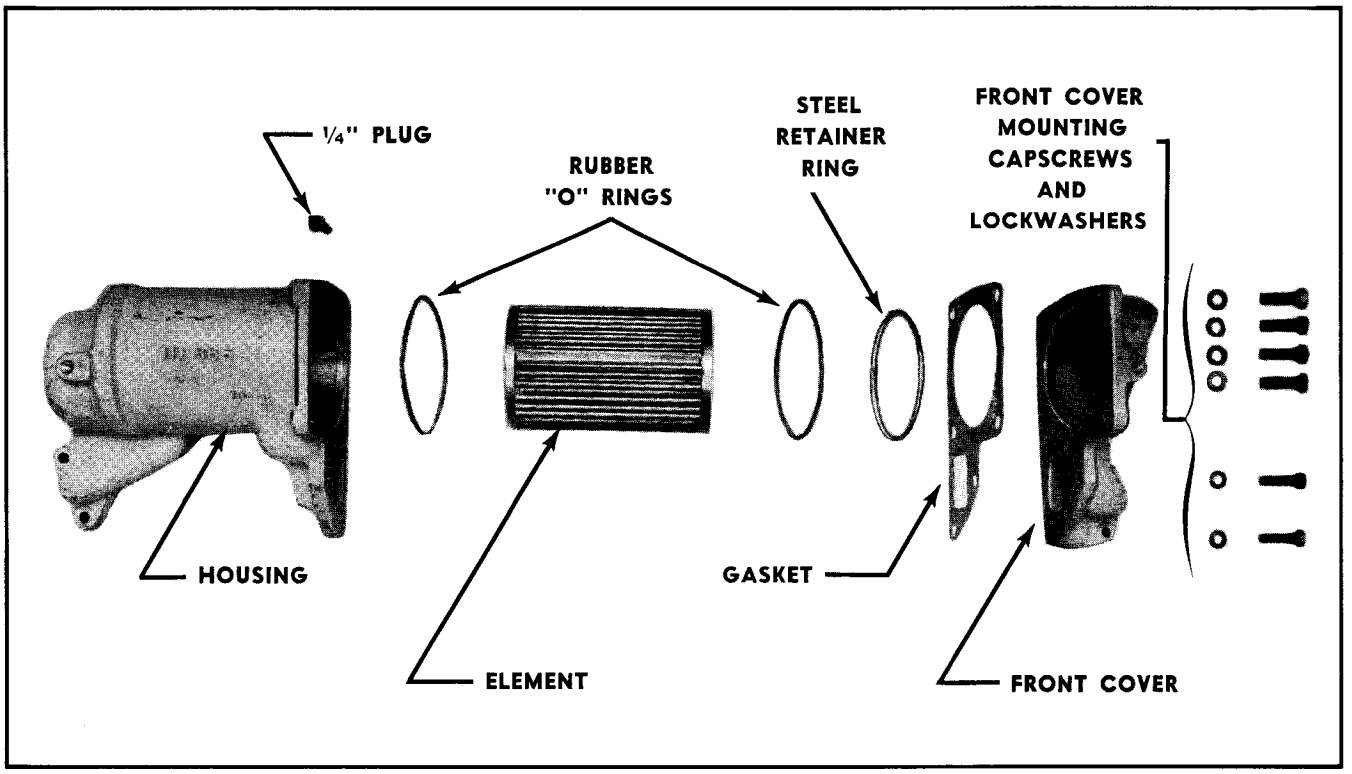


Fig. 7-9. Oil cooler—exploded view

3. Pull bundle from housing.

4. Immerse bundle in solvent that will dissolve oil film and sludge. Do not scrape bundle or use solvent that is harmful to copper.

5. Finish cleaning by blowing out bundle with compressed air.

6. Clean housing; blow out with compressed air.

7. Reassemble the unit.

   a. Place rubber "O" ring in groove at bottom of housing. CAUTION: MAKE SURE THAT THE RING IS FREE FROM CUTS, NICKS, ETC., AND IS NOT TWISTED.
   b. Lubricate ring thoroughly with a good grade of ball bearing grease.
   c. Push element into housing by hand; align index marks on housing and element.
   d. Install "O" ring on top of bundle by pressing in place with wooden block so equal pressure is applied to ring throughout its circumference.
   e. Place steel retaining ring over the rubber "O" ring.
   f. Assemble front cover and new gasket to housing.

LUBRICATING OIL COOLER

(Tube Type, Non-Removable Element)

1. Remove four capscrews and oil by-pass valve body and gaskets from side of cooler.

2. Remove eight capscrews, front and rear oil cooler heads, and gaskets.

3. Immerse core in a container of carbon tetrachloride or trichloroethlene.

4. Allow to stand in solvent for few minutes, then force cleaner through tubes with hand rubber suction cup or hand or motor driven pump in reverse direction from operating flow. Continue until clean.

CAUTION: THIS OPERATION SHOULD BE DONE IN THE OPEN AIR OR IN A WELL VENTILATED ROOM TO AVOID THE TOXIC EFFECT OF THE CHEMICALS BEING USED.

An oakite or similar alkaline solution is recommended, particularly where oil passages are badly clogged. This should be circulated through the tubes. After cleaning, flush thoroughly with hot water.

5. Flush inside of unit with clean, light oil after both oil and water sides of cooler have been cleaned.

6. Clean by-pass valve body and oil cooler heads thoroughly with steam, solvent, or both.
7. Install new gaskets.
8. Reassemble oil by-pass valve body to oil cooler.
9. Assemble front and rear oil cooler heads.

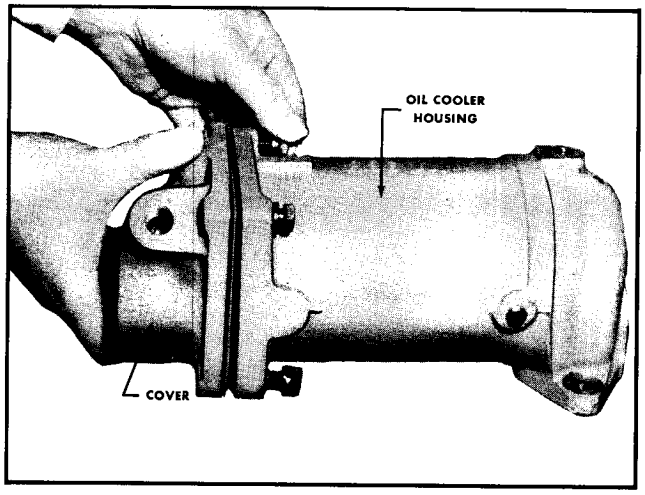


Fig. 7-10. Assembling oil cooler head

CAUTION: MAKE SURE THAT THE OIL COOLER ELEMENT IS ASSEMBLED SO THE INLET AND OUTLET ARE IN THE SAME RELATIVE POSITIONS AS BEFORE REMOVAL. THIS IS TO PREVENT ANY POSSIBILITY OF LOOSENED FLAKES BEING CARRIED INTO THE OIL STREAM.

NOTE: The by-pass valve (if used) in the by-pass body is spring loaded to open at 20 psi.

SUCTION TUBE

1. Remove the mounting capscrews from flange mounted suction tube to lube pump body.
2. Remove retaining clip and screen from suction bell.
3. Clean screen; soak in solvent, dry with compressed air.
4. Clean tube.
5. Inspect parts for damage and replace as needed.
6. Reassemble screen.
7. Where "O" rings are used on the suction tubes, install new ones.

CAUTION: "O" RINGS ON 15° TILT ENGINES MUST BE PART NO. 109080.

LUBRICATING OIL PUMP (6-Cylinder Engines)

1. Remove five capscrews and lock plates.
2. Work lubricating pump cover from dowels.
3. Lift cover, attached gears and gasket from lubricating pump body.
4. Pull lubricating pump drive gear from shaft.
5. Lift lubricating oil drive gear and shaft from cover.
6. Remove capscrews that hold idler gear retainer.
7. Lift idler gear and thrust washer from idler shaft.
8. Replace excessively worn parts.

TABLE 7—LUBRICATING OIL PUMP

Part or Location	New Dimensions Min.	Max.	Worn Replacement Limit
Idler and Driver Shaft Bushings	.6165	.6175	.6185
Idler Gear Bushings	.9925	.9935	.9945
Idler and Drive Shaft O.D.	.615	.6155	.614
Idler Gear Spindle	.990	.991	.989
Gears, O.D.	1.832	1.833	1.831
Bodies, Gear Pockets	1.840	1.842	1.843

9. Place lubricating pump driven gear over shaft with marked end to oil inlet side of body.
10. Assemble driven gear and shaft to cover; leave .002 inch clearance between gear and cover.
11. Assemble thrust washer with locking lip matching milled recess in lube oil pump cover.
12. Place idler gear over idler shaft. Fig. 7-11.

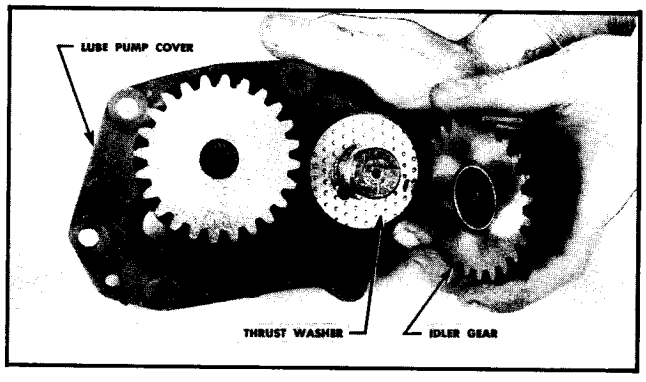


Fig. 7-11. Installing thrust washer and idler gear

13. Install; tighten idler gear straddle housing to pump cover.
14. Assemble lubricating oil pump cover and gasket to pump body with lock plates and capscrews.

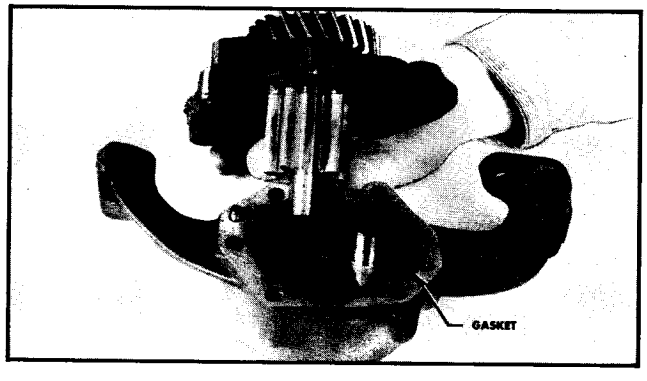


Fig. 7-12. Installing lube pump cover

LUBRICATING OIL PUMP (4-Cylinder Engines)

Disassembly:

1. Remove snap ring from idler gear shaft.

2. Slide off thrust washer and gear.

3. Remove snap ring from second order balancer drive gear shaft.

4. Lift thrust washer, drive gear and shaft assembly from oil pump cover.

5. Remove pump cover mounting capscrews.

6. Tap assembly with a plastic hammer to separate cover from body.

7. Lift pump cover and pump drive gear from pump body.

8. Press pump drive gear shaft from drive gear.

9. Remove drive gear shaft from pump cover.

10. Remove idler oil pump driven gear.

11. Remove mounting capscrews of suction and by-pass block.

12. Lift block from pump body.

13. Inspect and clean 3/32 inch bleed hole in oil pump idler gear.

14. Inspect bushings, gear shafts, and parts.

15. If necessary, replace worn parts or assemblies. Bushings and bodies should be replaced as assemblies because bushings must be properly located and line bored to new dimensions. See Table: Lube Pump Bushing Data.

16. Remove the pump driven gear from drive gear shaft with an arbor press.

17. Use arbor press to remove balancer drive gear from shaft assembly.

NOTE: Do not loss the ball key used to hold the gear on the shaft.

TABLE 8—LUBE PUMP BUSHING DATA (J-4)

	New Dimensions	Worn Replacement
Counterbalancer		
Drive Shaft Bushing.....	.8145/.8150 in.	.8170 in.
Lube Pump		
Drive Shaft Bushing.....	.6165/.6175 in.	.6195 in.

Assembly:

1. Assemble ball key in balancer shaft and press shaft into gear. Shaft should protrude .045/.050 in. beyond gear face.

2. Press oil pump drive gear onto pump drive shaft. Front of shaft should protrude .055/.060 inches.

3. Assemble pump cover to drive shaft.

4. Press pump internal drive gear, identification marks up, onto drive shaft over pump cover. Rear of shaft should protrude .850/.855 inches.

5. Place pump driven gear on idler shaft in pump body.

6. Position new gasket on body and install pump cover.

7. Install capscrews.

8. Align "B" marks on idler gear and oil pump drive gear; set idler gear in position.

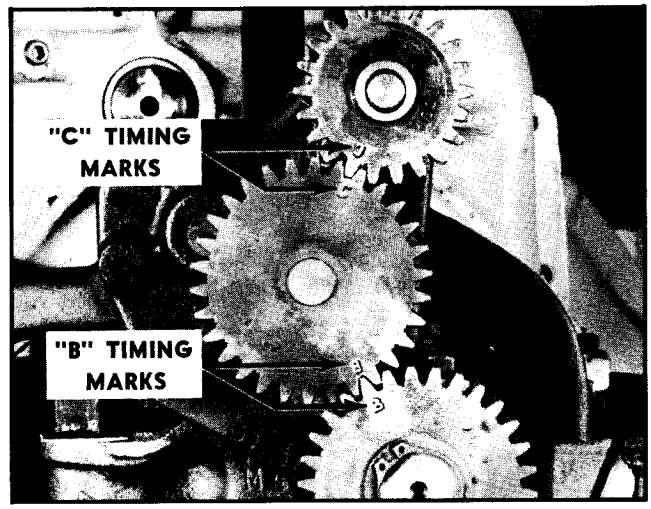


Fig. 7-13. Aligning idler gear and oil pump drive gear

9. Install thrust washer, bronze side down, and secure assembly with snap ring, flat side down.

10. Align "C" marks on balancer drive gear and oil pump drive gear; install balancer drive gear and shaft assembly.

11. Install thrust washer, bronze face down, and secure assembly with snap ring, flat side down.

12. Remount suction and by-pass block assembly.

Section 8

UNIT NO. 8

COOLING SYSTEM

WATER PUMP (J-6, Supercharger Driven)

Disassembly

1. Remove four mounting capscrews, lock washers, gasket and cover from water pump body.
2. Pull drive coupling from shaft.
3. Remove outer snap ring from coupling end of pump body.
4. Support pump body on its mounting flange in an arbor press and press out bearing and shaft assembly from impeller and pump housing.
5. Press shaft seal out of pump body.
6. Remove inner snap ring from housing.
7. Clean all parts.

Inspection

1. Inspect drive coupling for excessive wear; replace if necessary.
2. Inspect impeller seal face counterbore for wear and roughness; replace impeller if this face is not smooth and flat.
3. Replace shaft seal.

Assembly

1. Install inner snap ring.
2. Support pump body on its cover mounting face and press bearing and shaft assembly in place against inner snap ring.
3. Install outer snap ring.
4. Insert rubber washer on drive coupling end of shaft.
5. Press drive coupling onto shaft and flush with the end of shaft.
6. Support the pump on its mounting flange and assemble slinger and seal assembly to shaft.
7. Press impeller on shaft. Face of impeller hub should be 0.872 to 0.878 inch below cover mounting face on body.
8. Assemble lock washers, capscrews and new gasket to water pump cover.
9. Mount cover to pump body.
10. Turn shaft to be sure that it is free.

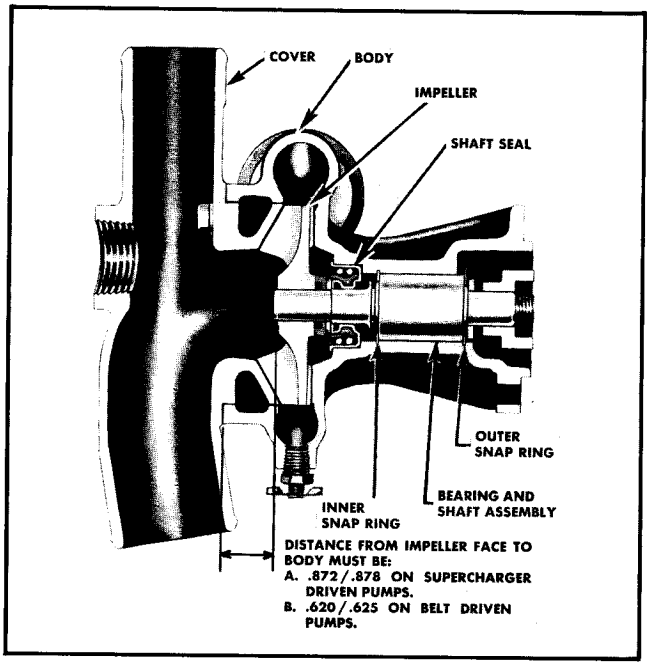


Fig. 8-1. Cross section—J-6 water pump

WATER PUMP (J-6, Belt Driven)

Disassembly

1. Remove four mounting capscrews and lock washers and lift cover and gasket from pump body.
2. Remove lock capscrew from pulley end of shaft.
3. Pull belt pulley from shaft.
4. Remove outer snap ring from pump housing.
5. Support pump on its pulley face and press shaft and bearings from pump housing and impeller.
6. Press seal assembly from housing.
7. Press two bearings, spacer and slinger from shaft.
8. Clean all parts.

Inspect

1. Inspect pulley for excessive wear.
2. Inspect impeller seal face for wear and roughness.
3. Inspect ball bearings.
4. Replace as necessary.

Assembly

1. Assemble oil slinger to shaft over pulley end of shaft.
2. Press small roller bearing, spacer and larger roller bearing on shaft.
3. Support housing on cover face and press in shaft and bearings.
4. Insert outer snap ring.
5. Support housing on pulley face.
6. Assemble a new seal assembly to shaft and housing. Press seal down to shoulder or if there is no shoulder press seal in until it is 1.530/1.550 inch below cover mounting surface.
7. Press impeller on shaft. Face of impeller hub should be .623 to .625 inches below cover face of housing.
8. Assemble lock washers, capscrews and new gasket to cover.
9. Mount cover to housing.
10. Press pulley on shaft.
11. Assemble lock washer and capscrew to shaft.

WATER PUMP (J-4)

Disassembly

1. Use ST-160 to pull pulley from water pump shaft.
2. Remove snap ring that holds bearing assembly in body.
3. Support pump body on its pulley end and press shaft and bearing assembly from impeller and pump body.
4. Remove pump seal from pump body.
5. Clean all parts.

Inspection

The shaft and bearing assembly is serviced as a unit. Inspect assembly carefully and replace if races are worn, if there is excessive end play, or if bearings do not turn freely.

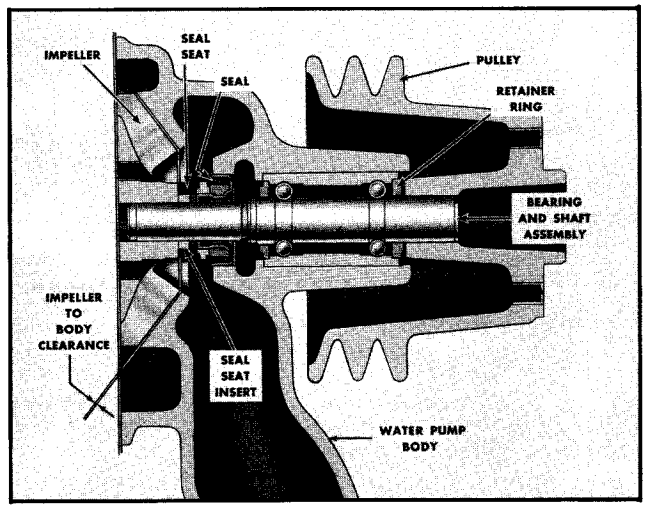


Fig. 8-2. Cross section—J-4 water pump

Assembly

1. Press shaft and bearing assembly into body to shoulder.
2. Insert snap ring.
3. Press seal into body until it seats on shoulder.
4. Place seat assembly over shaft.
5. Press impeller on shaft. A clearance of 0.010 to 0.020 inch is necessary between impeller and pump body.
6. Support shaft and press on pulley.

SEA WATER PUMP

Disassembly

1. Remove sea water pump drive gear with gear puller. Take out shaft key.

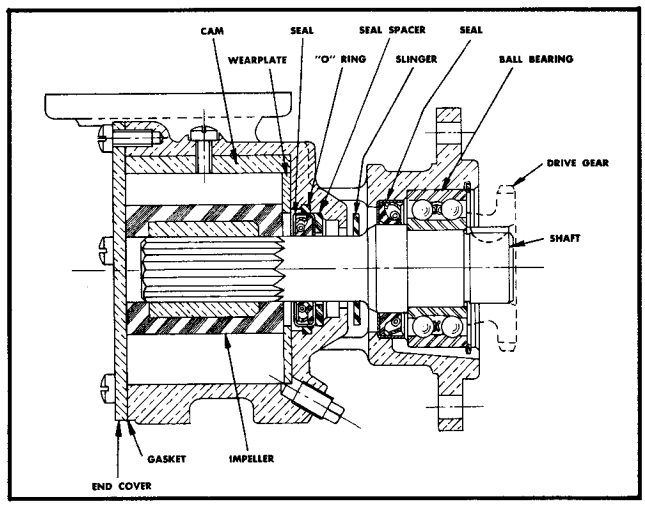


Fig. 8-3. Cross section—sea water pump

2. Remove ball bearing snap ring.

3. Take out five capscrews and remove end cover.

4. Drive out sea water pump shaft from rubber impeller end.

5. Remove oil seal, "O" ring and rubber spacer from back of impeller housing.

6. Remove rubber impeller.

7. Remove screw from side of impeller housing and take out cam and wear plate.

Rebuilding

1. Check and replace rubber impeller if it has deep scratches or cracked or torn impeller fins.

2. Check cam and wear plate surfaces to see that they are smooth and not deeply grooved.

3. Replace oil seals with new ones.

4. Check ball bearing for cracked or broken raceways, or balls. Replace new if necessary.

5. Replace new all other sea water pump parts that are worn or defective.

Assembly

1. Apply Lubriplate and press ball bearing, numbered side out, against shoulder on shaft.

2. Place drive gear end of shaft in a V-block and press key to shafts.

3. Press oil seal, Part No. S-16103, into drive gear side of housing.

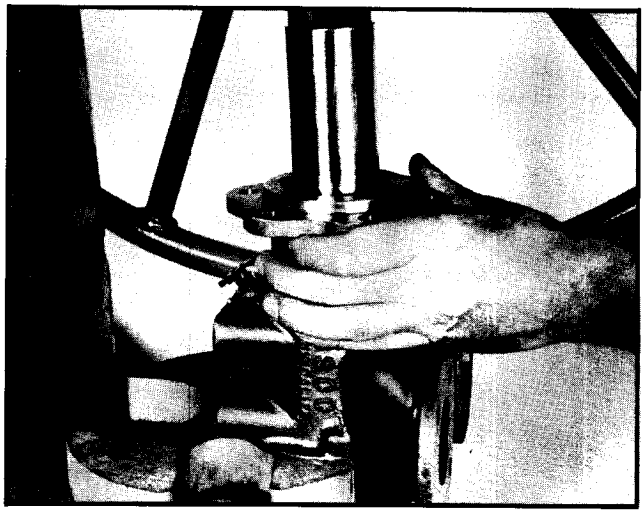


Fig. 8-4. Pressing oil seal into housing

4. Insert shaft while holding rubber slinger as shown in Fig. 8-5.

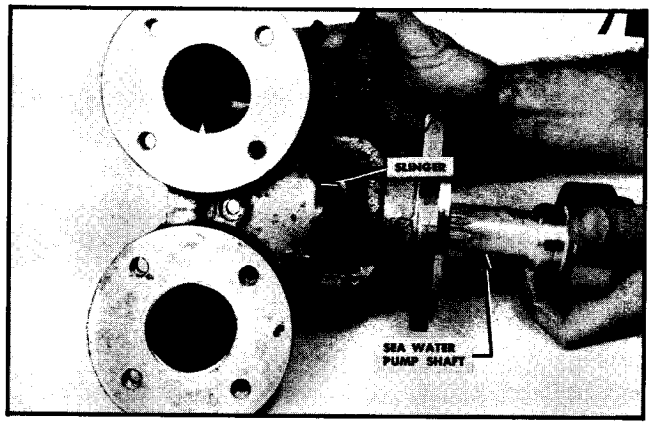


Fig. 8-5. Installing sea water pump shaft

5. Press ball bearing and shaft assembly into housing bore. Press on outer race of the ball bearing.

6. Install ball bearing retaining ring.

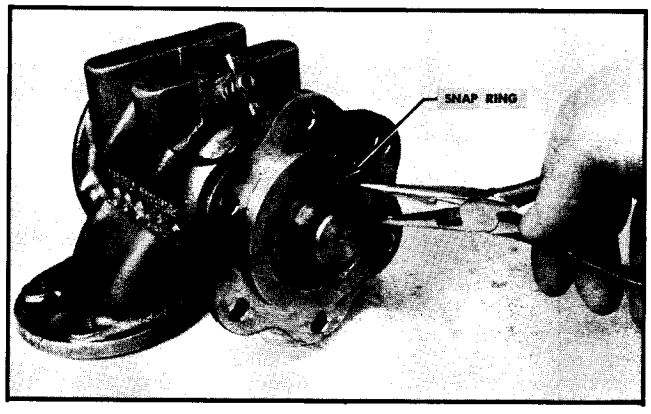


Fig. 8-6. Installing ball bearing snap ring

7. Install seal spacer and rubber "O" ring in oil seal bore of impeller housing.

8. Press oil seal, Part No. 21601-E, into impeller housing bore. The lip side of seal faces impeller.

9. Install cam and wearplate assemblies.

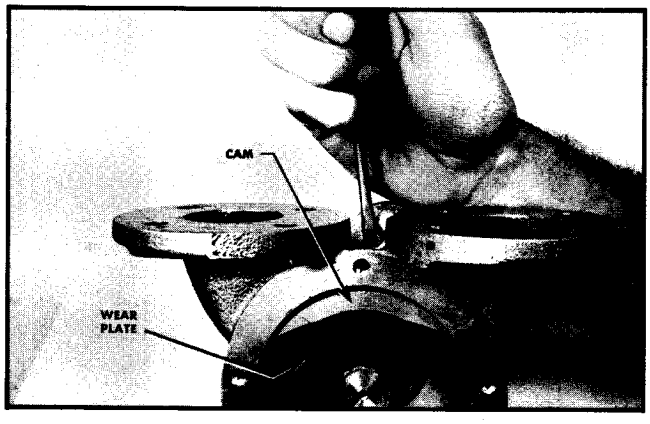


Fig. 8-7. Tightening cam to housing

10. Heat drive gear to approximately 200° F. Support impeller end of shaft and press on drive gear.

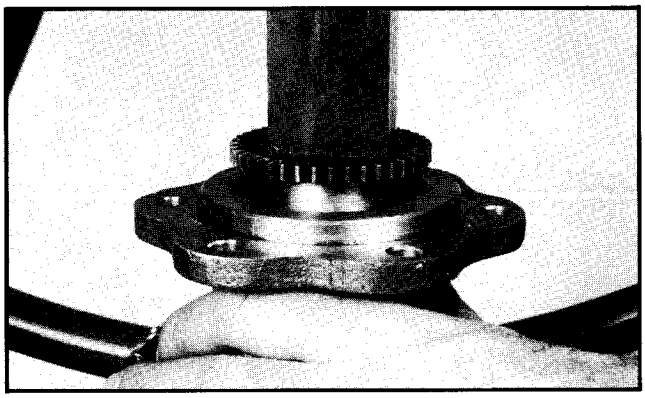


Fig. 8-8. Pressing drive gear on shaft

11. Apply glycerine or soap to impeller fins and insert impeller.

12. Install impeller for right-hand rotation. For left-hand rotation, the impeller is inserted so that rubber fins bend in reverse direction.

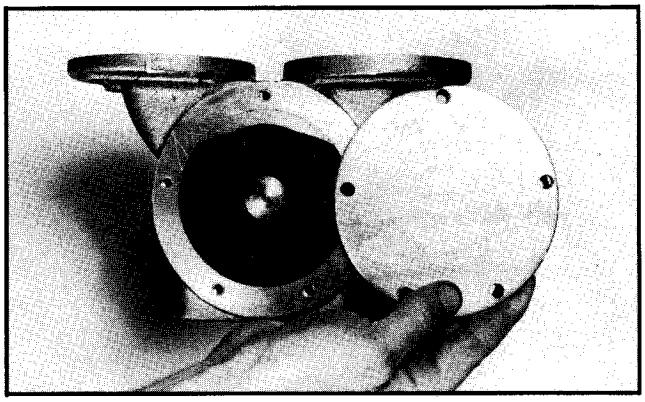


Fig. 8-9. Impeller installed for right-hand rotation

13. Install and tighten end cover and gasket.

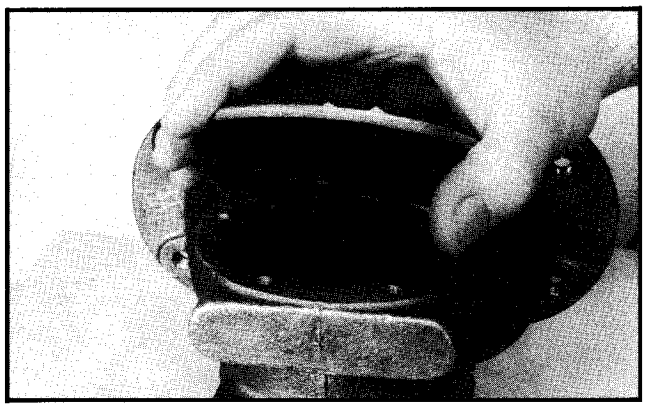


Fig. 8-10. Installing end cover

FAN HUB

(Locking Nut Behind Bracket)

Disassembly

1. Remove fan adjusting capscrew from fan bracket and fan hub shaft.
2. Remove lock nut, two washers and fan bracket from hub.
3. Remove four capscrews, lockwashers and fan pilot spacer and gasket from hub.
4. Remove cotter pin and slotted nut from shaft.
5. Take out shaft taper roller bearings and oil seal.

Rebuilding

1. Check taper roller bearings for cracked rollers, worn or indented raceways or rough operation.
2. Replace oil seal.
3. Replace any fan hub parts that are worn or defective.

Assembly

1. If the roller bearing outer-races were removed, press them back into fan hub housing roller bearing outer race into housing.
2. Coat the oil seal with ball-bearing grease, and insert seal over shaft.
3. Slide taper roller bearing inner-race over the shaft. Lower shaft, complete with oil seal and inner bearing race, into fan hub housing.

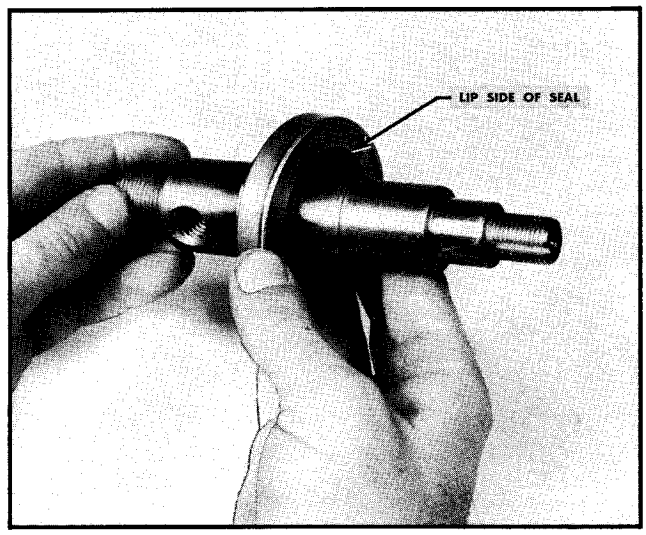


Fig. 8-11. Placing oil seal on fan hub shaft

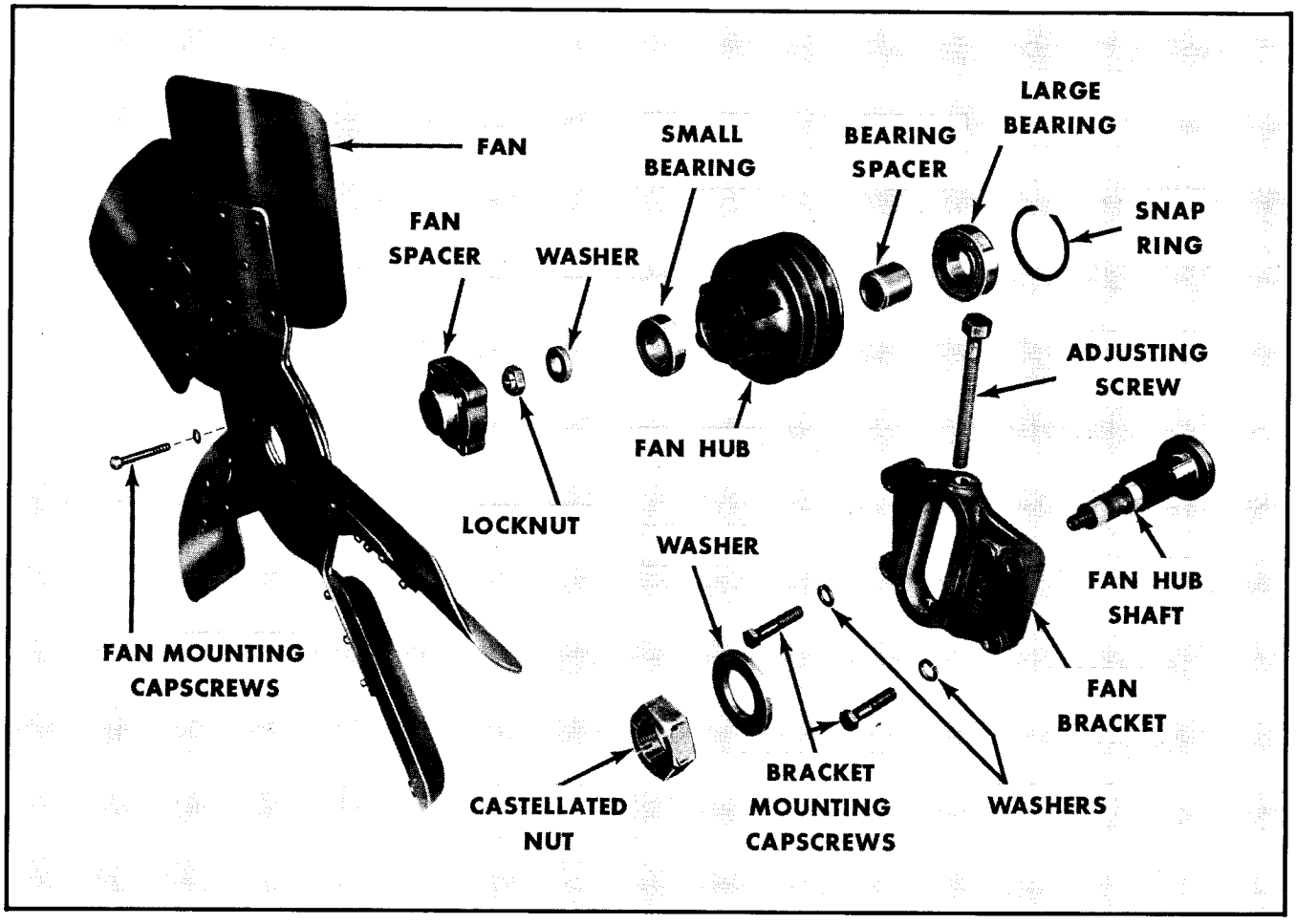


Fig. 8-12. Fan bracket and hub—exploded view

4. Place a sleeve over the shaft and press the oil seal into the fan hub housing.
5. Insert the small taper roller bearing inner-race.

FAN HUB

(Locking Nut In Front Of Bracket)

Disassembly

1. Remove 4 capscrews from fan spacer, remove spacer.
2. Remove snap ring behind spacer.
3. Pull fan hub from shaft.
4. Press off small bearing.

Assembly

1. Press small bearing into fan hub. (Shielded side "out.")
2. Assemble hubs and bearing over shafts.
3. Using shaft as a pilot, place spacer atop bearing.
4. Press large bearing over shaft into hub (shielded side out).
5. Secure assembly with snap ring.

Adjust Fan Hub Bearings

1. To adjust fan hub bearings:
   a. Tighten castellated nut at front of fan hub shaft until slight bearing drag can be noticed as fan hub is rotated.
   b. Loosen nut one hex or one castellation.
   c. Insert and lock cotter pin.
2. Install and tighten fan pilot spacer and gasket.
3. Grease fan hub through pressure relief fitting with sodium-soap base ball bearing grease.

RADIATOR

1. To remove core sections with headers, it will be necessary to remove the front screen guard and front screen guard spacers.
2. Remove bolts holding core section header casting to top and bottom tank. Then each core section may be removed from front of radiator assembly.
3. If it is necessary to service any other part of radiator assembly, remainder of assembly may be removed from unit without danger of damage to core.

4. The fan screen guard is disassembled by removal of screws attaching it to fan shroud.

5. Remove bolts holding fan shroud to side members to disassemble fan shroud.

6. Overflow tube is removed by removal of fitting in bottom of top tank and clips holding it to side member, then pulling it out of bottom of top tank.

7. Remove side members from top and bottom tanks completing disassembly operation.

Inspection and Rebuilding

1. Inspect radiator core for stoppage or leaks in same manner as described for the oil cooler.

2. Do not use anti-leak compounds to stop core leaks. If split seams or solder breaks are found, have radiator repaired at qualified radiator repair shop.

3. To reassemble radiator, reverse disassembly procedure.

HEAT EXCHANGER

Disassembly

1. Remove all flanges, hose and connections from heat exchanger.

2. Remove cover plates from oil cooler and water cooler sections of heat exchanger.

3. Remove both oil and water cooling units, or core, from housing.

Inspection and Rebuilding

1. Follow same procedure as described for oil cooler, Page 7-5.

Assembly

1. Install oil cooler and water cooler units in heat exchanger housing.

2. Replace all old gaskets with new ones. Dip new gasket in light machine oil for 1 or 2 minutes before installing.

3. Assemble covers and mounting brackets with capscrews and lock washers.

4. Replace old disintegrated zincs with new zincs.

5. Seal core outlet and core with oil or water depending upon type of core.

6. Seal inlet with fitting designed for application of an air hose and gauge.

7. Subject core to specified pressure allowing only atmospheric pressure in the casing.

8. Permit unit to stand for 15 or 20 minutes, then check pressure gauge for pressure drop which will denote a tube or header leak.

9. To test case, seal coolant outlet and seal casing with water, then follow same procedure as in the core test. A pressure drop on gauge will denote a casing leak.

10. If core is not intended for immediate use after repair and test, it should be prepared for storage.

a. Allow unit to drain thoroughly and blow out remaining liquid with air.

b. Flush light machine oil or soluble oil through tubes and drain off excess.

c. Seal all inlets and outlets to prevent entrance of dirt or foreign matter.

THERMOSTATS

1. Remove thermostat from thermostat housing.

2. Check thermostat in a container of water with an accurate thermometer.

3. Standard single-unit thermostats start to open at 160° F. and are completely open at 175° F. Check stamping on thermostat as special thermostats are sometimes used. Discard if units do not operate in correct range.

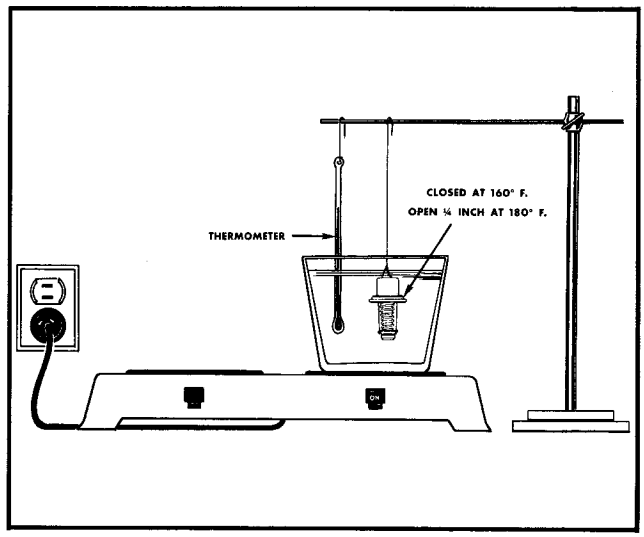


Fig. 8-13. Testing a thermostat

4. Install a new seal in the thermostat housing to insure proper by-pass of water during thermostat operation.

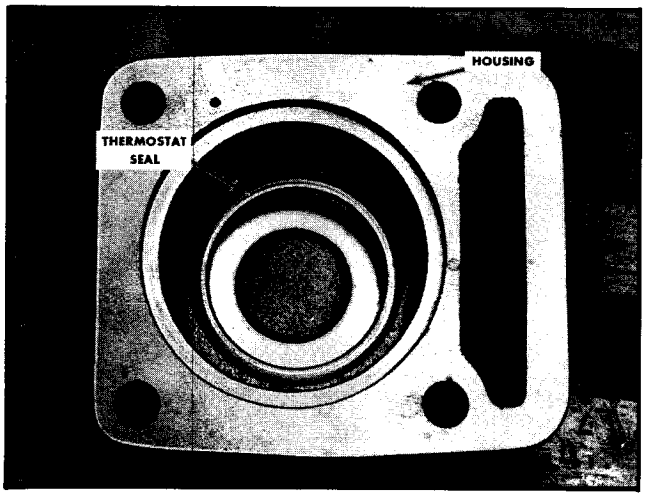


Fig. 8-14. Thermostat seal

OTHER THERMAL CONTROLS

Thermatic fans should be set to start at 185° F. and shut off at 175° F.

Shutterstats should be set to open at 180° F. and close at 172° F. when used alone. Where used with thermatic fans, shutterstats should open at 170° F. and close at 162° F.

Section 9

UNIT NO. 9

DRIVE UNITS

FUEL PUMP DRIVE

1. Clean, inspect, and lubricate fuel pump drive as a unit.
2. Disassemble if:
   a. Shaft wobble is detected.
   b. Drive gear is visibly worn or chipped.

Disassembly

1. Remove jam lock nut or capscrew and washer securing compressor coupling gear from end of shaft.
2. Use an ST-528 spline-drive gear puller to remove spider or spline-drive gear and key from shaft.

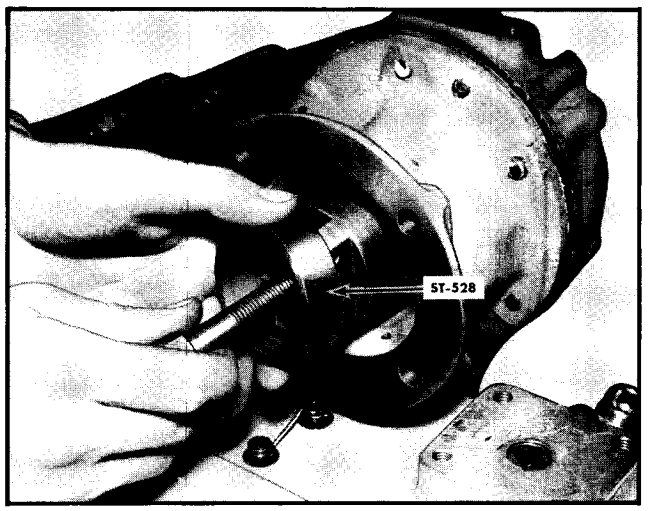


Fig. 9-1. Removing spider from fuel pump drive shaft

3. Use an arbor press to press shaft from bearing support, bearing and oil seal.
4. Remove retaining ring, bearing and oil seal from support.
5. Press shaft from drive gear.
6. Remove ¾ inch hex nut and key.
7. Press ball bearing inner race from shaft.

Assembly

1. Insert key and place drive gear over smaller threaded end of shaft. Have marked side of gear facing shaft.
2. Press gear tight against shaft flange.
3. Press shielded bearing into bearing support.
4. Secure with a retaining ring.
5. Rest end of piece of one inch I.D. heavy-wall tubing on inner race of ball bearing to press bearing and support onto shaft.
6. Install bearing spacer.
7. Install key and press spider gear or spline-drive gear onto shaft.
8. Assemble washer and pin lock nut to shaft and tighten securely.
9. Press inner race against shaft flange, pulley side.
10. Replace ¾ inch hex nut and tape pulley key to shaft. Tape will be removed during engine assembly.

BALL BEARINGS

Since ball bearings are so extensively used in drive units it is well to review some of the general rules concerning their use and handling.

1. Ball bearings should be installed or removed from housings with an arbor press and with the right size and type of mandrel or plate. Pressing should be done on the race that is press fit. When the bearing is being pressed into a housing the force should always be applied on the outer ring.
2. Work with clean tools, in clean surroundings.
3. Remove all outside dirt from housing before exposing bearings.
4. Handle with clean dry hands.
5. Treat a used bearing as carefully as a new one.
6. Use clean solvents and flushing oils.
7. Lay bearings out on clean paper.
8. Protect disassembled bearings from dirt and moisture.
9. Use clean, lint-free rags, if bearings are wiped.
10. Keep bearings wrapped in oil proof paper when not in use.

11. Clean inside of housing before replacing bearings.

12. Install new bearings as removed from the package, without washing.

13. Keep bearing lubricants clean when applying and in covered containers when not in use.

14. Pack used and washed bearings with ball bearing grease before installation.

15. Do not take new bearings apart.

16. Never press against bearing separators.

17. Never pound on a bearing or ring.

18. Do not spin bearings before cleaning. Do not spin by force of air. Hold both rings while drying with clean compressed air.

19. The following types of defects are such as to cause bearings to be rejected for further use:

a. Broken or cracked rings.

b. Dented shields or seals.

c. Cracked or broken separators.

d. Flaked areas on balls, rollers or raceways.

e. Broken or cracked balls or rollers.

f. Bearings which have been overheated. These bearings are generally darkened to brownish-blue or blue-black color.

g. Bearings whose raceways are indented or "brinelled" by impressing balls or rollers into the races.

20. Dirt causes ball bearings to fail.

OIL SEALS

1. When an oil seal fails to seal it is useless.

2. Oil seals are easily ruined by allowing them to turn while installing shafts against the sealing lip, or by keys in shafts.

3. The sealing lip must always compress *with* the pressure.

BORES IN HOUSINGS

1. Ball bearings must not turn in the housing retaining bore. If the old bearing has turned and ruined the housing, both bearing and housing must be scrapped.

2. Bore of the housing must be clean before pressing the bearing in place.

Section 10

UNITS NO. 10 AND NO. 11

INTAKE SYSTEM — EXHAUST SYSTEM

The intake system consists of air filters and silencers, turbocharger, supercharger and connections, preheater and air intake manifold.

The exhaust system consists of the exhaust manifold, exhaust piping, exhaust silencer and mufflers.

DISASSEMBLY AND CLEANING

AIR FILTERS

1. Disassemble air filters and/or air silencers.

2. Oil bath air cleaner screens should be cleaned by using steam then sloshed in fuel oil to remove any remaining dirt particles and to prevent rust. After cleaning dip in clean lubricating oil.

3. Wash breather element in a clean solvent and dip in light lubricating oil.

4. Wash out filter cases and tubes.

NOTE: The amount of intake air restriction and the exhaust back pressure must be checked after the engine has been reassembled. For this procedure see Page 13-3.

SUPERCHARGER

Preliminary Inspection

In order to eliminate any unnecessary tear down of the supercharger, it is advisable to make the following preliminary inspection on the assembled unit.

1. Make a visual check on the condition of the air outlet port. An excessive amount of oil in the air outlet port indicates that the piston ring oil seals on the rotor shaft may be worn or broken; or, oil may be coming over to the supercharger inlet through the breather line from the engine valve cover. If an inspection of this breather line does not show evidence of oil, then the supercharger should be completely disassembled for a closer inspection of the piston ring oil seals.

2. Check the radial clearance in the bearings. Clearance should not exceed .003. Fig. 10-1.

To make this inspection, it is necessary to flush the oil out of the bearings so that a reasonably accurate measurement of the clearance can be obtained. First remove the pump-end cover by removing the twelve cover capscrews. Force Diesel fuel oil under pressure through the supercharger oil inlet until the bearings are flushed free of lubricating oil.

Set up an indicator gauge on the outer diameter of the rotor timing gears. See Fig. 10-1. Measure the total radial movement as the gear is moved from one side of the bearing to the other. If this total movement is more than .003, the unit should be completely disassembled for a direct inspection of the bearings.

3. Check the end play of the rotor shaft. See Fig. 10-3.

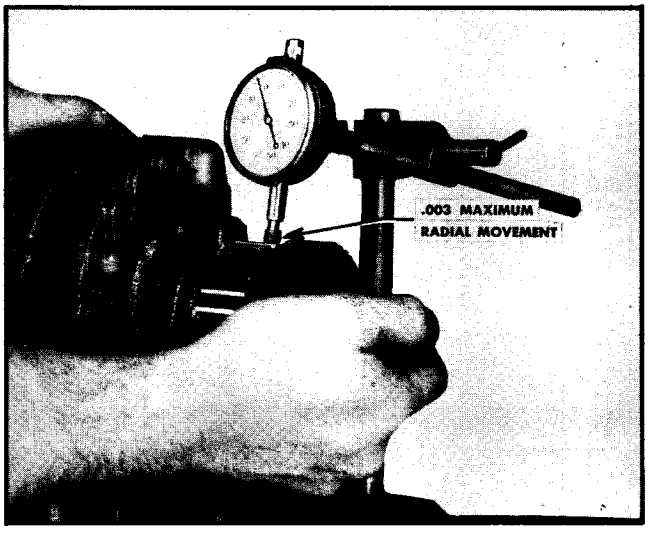


Fig. 10-1. Check radial bearing clearance

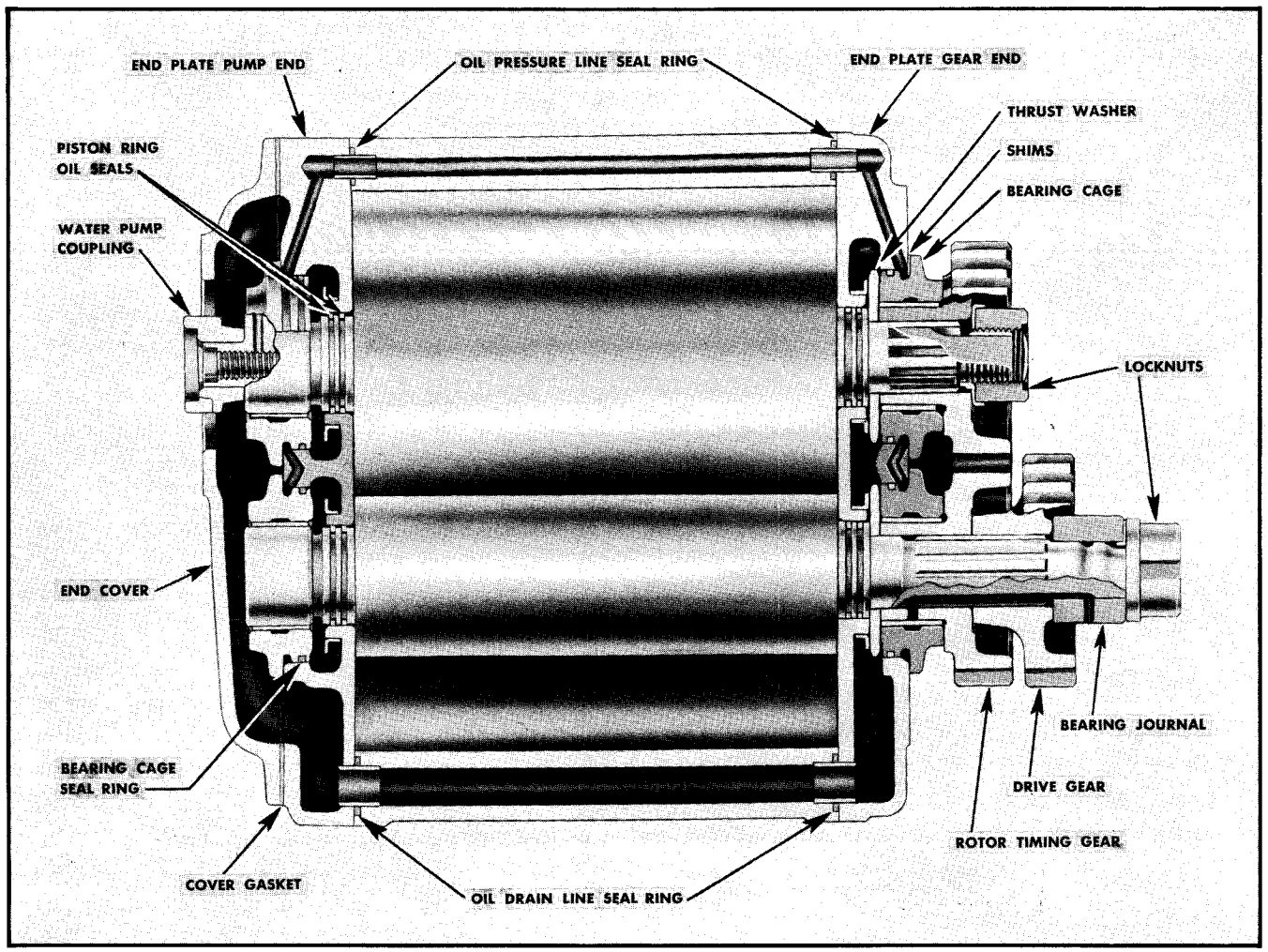


Fig. 10-2. Cross section of supercharger assembly

Set up an indicator gauge on the end of each rotor shaft and observe the total end play by pushing the shaft back and forth to the extremes of its end play. If the total end play exceeds .005, the unit should be completely disassembled for a direct inspection of the thrust faces.

4. Check the timing gear backlash.

Attach an indicator gauge to the housing and set up to measure the rotor timing gear backlash. See Fig. 10-4. If the backlash between the gears exceeds .004, replace with a new set of gears.

If none of the excessive wear conditions are noted in the above preliminary inspection, the supercharger can be replaced in the engine without any further tear-down. A new cover gasket should be used when the pump-end cover is replaced.

If one or more of the above wear conditions are noted, the supercharger should be disassembled for a closer inspection of the parts in question. For a cross section of the supercharger see Fig. 10-2.

Disassembly

1. With a small screw driver, raise the lockwasher flange clear of the slot in the rotor shaft locknut. With a special locknut wrench, remove the rotor shaft locknuts. See Fig. 10-5. Use a piece of soft metal (brass or copper) wedged between the timing gear teeth to lock the gears while loosening the locknuts.

2. Pull the water pump coupling off the idler rotor shaft.

3. Remove the pump end plate from the supercharger housing. Light taps with a rubber hammer may be necessary to break the plate loose from the dowels. (The cover

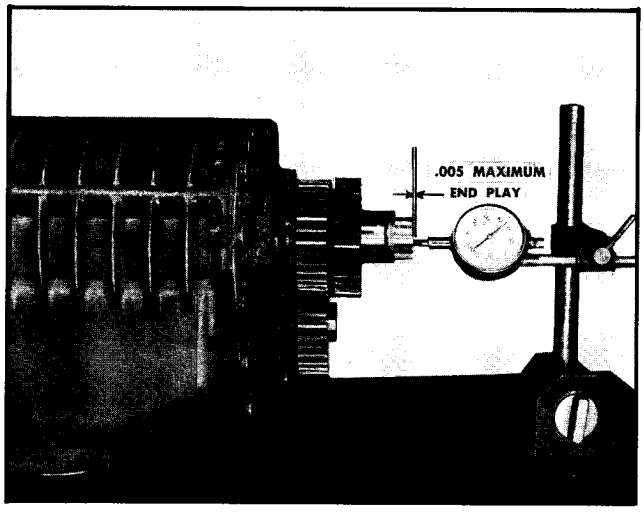


Fig. 10-3. Checking end play

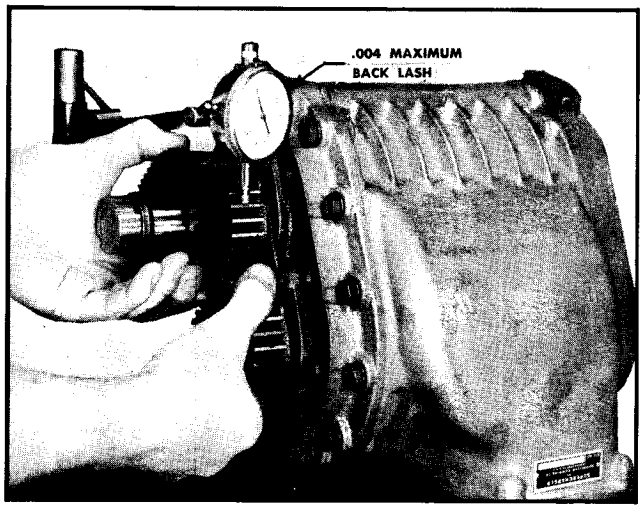


Fig. 10-4. Checking backlash

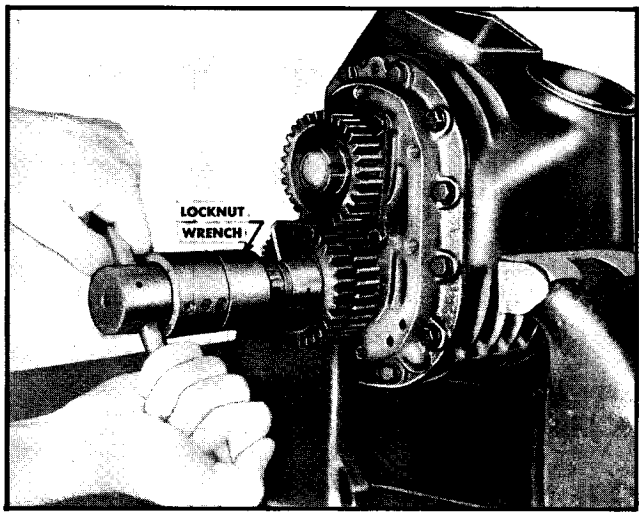


Fig. 10-5. Removing rotor shaft locknuts

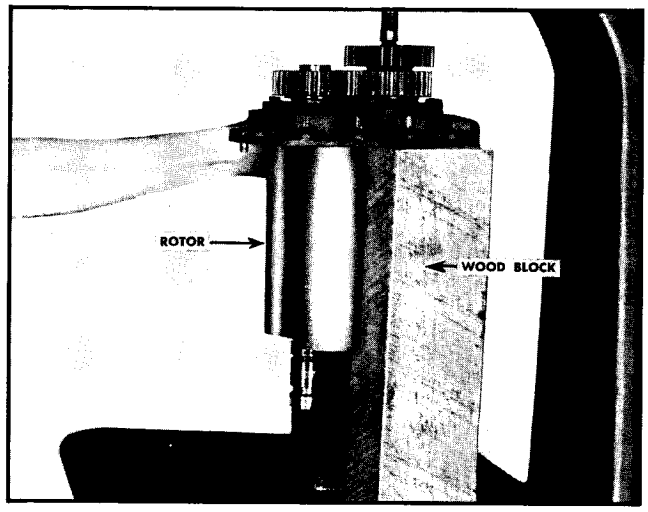


Fig. 10-6. Pressing gears off rotors

was previously removed in Step 2 of the preliminary inspection.) Care must be used in removing the end plate so as not to break the piston ring oil seals.

4. Remove the housing from the gear end plate by removing the twelve end-plate capscrews.

5. Press off the gears in an arbor press. See Fig. 10-6. Support the assembly on the under side of the end plate using wood blocks. Use two blocks of equal length with square ends. The rotors must be rotated into position where the end of the rotor being pressed out does not catch on the rotor shaft of the outer rotor.

Rebuilding

1. The piston ring seals on the rotor shafts should be inspected. Broken rings should be replaced. Clean out the ring grooves and check for excessive or visible groove wear. Use a piston ring expander for inserting the new rings.

2. Inspect the piston ring bores in the end plates. Excessive wear or roughness in these bores will not allow the piston rings to seal properly in which case the end plates should be replaced.

3. Inspect the bearing bores in each bearing cage. If the bore exceeds 1.3765 diameter the bearing cage should be replaced. The bearing cages are removed by loosening the two cage capscrews.

Note that shims are used on the gear end bearing cages under the mounting flange. These shims control the end

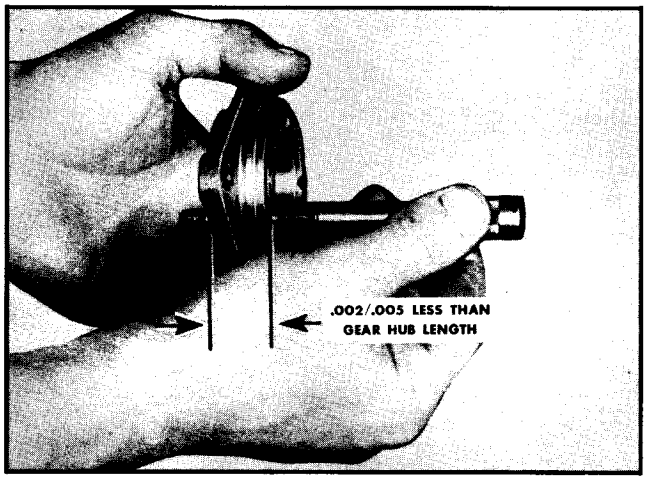


Fig. 10-7. Checking width of bearing cage

clearance of the rotors in the housing. Mark each cage so that it can be replaced in the same pocket from which it was removed and tie each set of shims with its respective bearing cage. If new bearing cages are to be used, the above precaution is not necessary.

NOTE: To simplify field repair of superchargers, .010 and .020 inch *undersize* bearing cage assemblies are available.

4. The end thrust can be checked by measuring the bearing cage width and the distance from the thrust face of the gear to the end of the gear hub. The bearing cage width must be .002 to .005 less than the length of the gear hub. Figs. 10-7 and 10-8. If the difference between these two dimensions is greater than .005, the end thrust is excessive. New gears, thrust washers, and bearing cages should be used.

5. If the water pump drive coupling on the rotor shaft shows excessive wear, replace new.

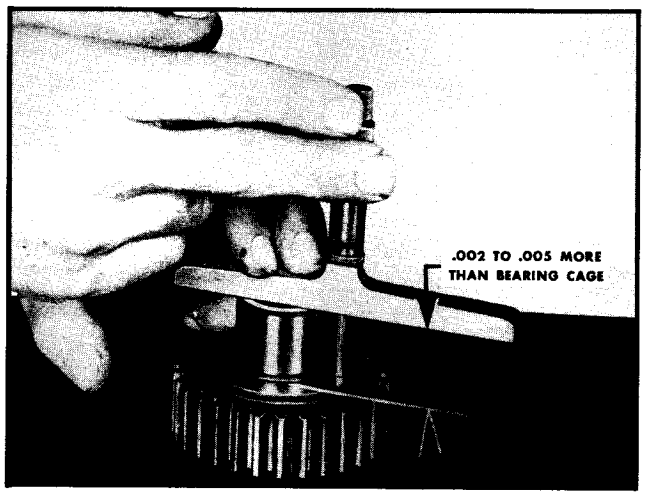


Fig. 10-8. Checking hub length for end play

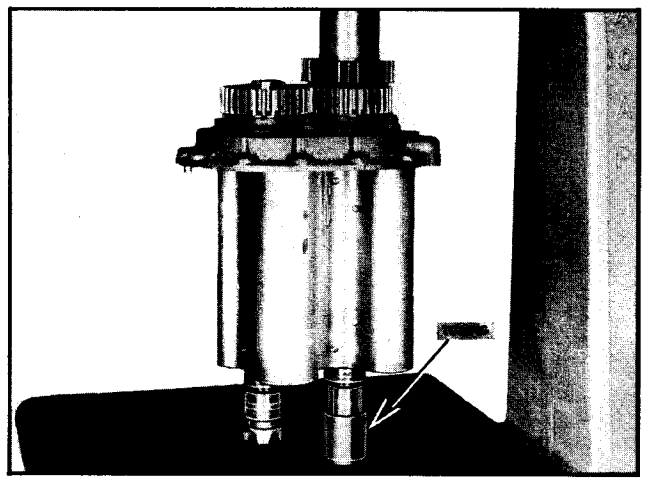


Fig. 10-9. Pressing gears on rotors

6. For other repairs such as broken or cracked rotors, shafts or housing, the supercharger should be returned to the factory for rebuilding.

All parts should be washed clean and dried. Replace defective parts with new parts. Clean conditions must be maintained during the assembly operations.

Assembly

1. Replace piston ring oil seals in grooves on rotor shafts using a ring expander.

2. Press the water pump drive coupling on the rotor shaft extension so that shaft end will be flush with the counterbore of coupling.

3. Replace thrust washers in gear end plate and replace the bearing cages. If the old bearing cages are being reused, make certain they are replaced in the same hole from which they were removed and use the same shims as originally removed with their respective cages. Use new rubber seal rings.

If new bearing cages are to be installed, use .005 total shim thickness under each bearing cage. This amount may have to be adjusted later when the rotor end clearance is checked.

Use new rubber seal rings on each bearing cage. Make certain these rubber seal rings are not left out or possible loss of oil pressure may result in burned out supercharger bearings.

4. Insert splined shaft of driving rotor through bottom hole in gear end plate. Care must be taken so that piston ring seals will not be broken as they are pressed into the end plate.

5. Support rotor on shaft at opposite end and press on the timing gear using an arbor press. See Fig. 10-9.

6. Insert idler rotor through the second hole in the gear end plate. Press on the other timing gear. Make

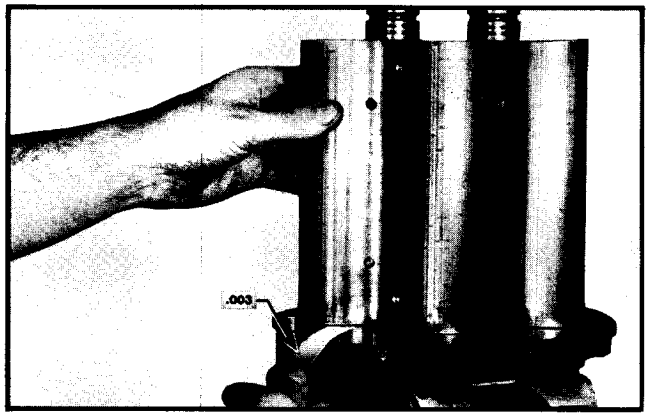


Fig. 10-10. Checking rotor end clearance

certain that the rotors are positioned 90° apart as the gears come into mesh.

7. Press drive gear on shaft up tight against timing gear.

8. Slip outboard bearing journal on shaft.

9. Replace locknut and lockwasher on each rotor shaft. Tighten securely. Wedge a piece of soft metal wire between the gear teeth to lock gear while tightening locknuts.

10. Check clearance between rotors and end plate. See Fig. 10-10. The clearance should be .003″ with rotors pushed toward gear end plate which excludes the end play.

If the end clearance is over .003″ shims will have to be added under the bearing cage mounting flange. If less than .003, shims must be removed until proper clearance is obtained. If shims have to be added or removed, remove lock nuts and gears as in previous disassembly instructions.

11. After proper end clearance is obtained, replace housing to end plate. Use new rubber seal rings on the oil pressure and drain line ferrules. See Fig. 10-11.

12. Replace pump end plate to housing using new rubber seal rings on oil pressure and drain line ferrules. Care should be taken not to break the piston ring oil seals as they are pressed into the end plate.

13. Replace cover to end plate with twelve capscrews and lockwashers. Use a new gasket between the cover and end plate.

14. Turn rotor shaft by hand to see that it rotates freely.

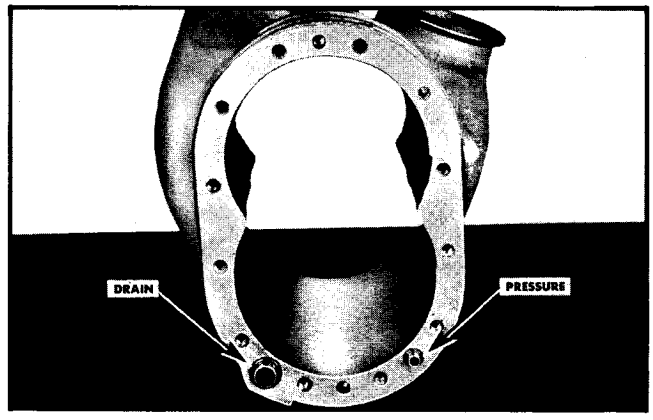


Fig. 10-11. Oil seal rings (on each end of housing)

T-506 TURBOCHARGER—JT

DISASSEMBLY FOR CLEANING AND INSPECTION

1. Clean exterior of turbocharger.
2. Attach turbocharger to ST-518 assembly stand.

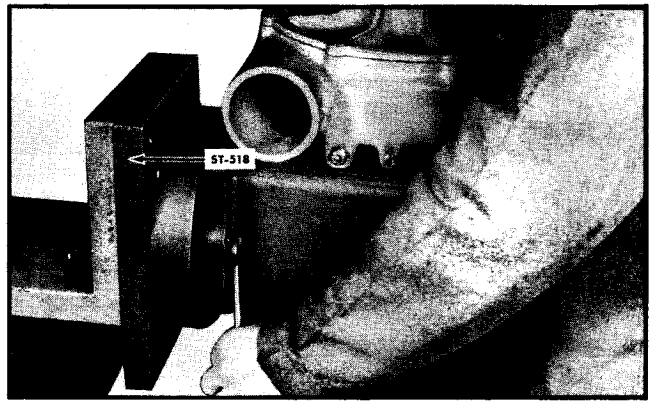


Fig. 10-12. Mounting turbo on ST-518

3. Remove capscrews and lock plates from exhaust casing on turbine end; remove exhaust casing and gasket.

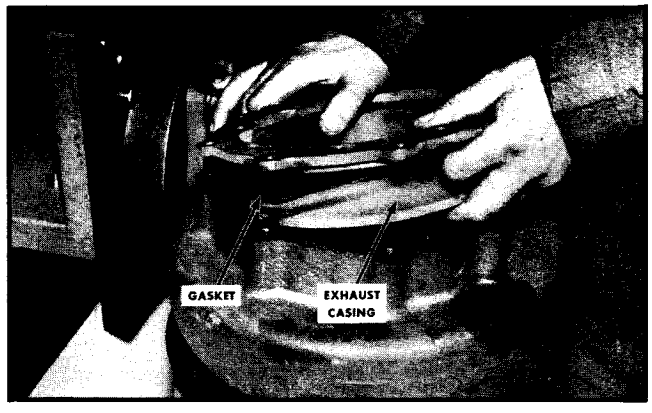


Fig. 10-13. Removing turbo exhaust casing and gasket

4. Clean impeller.
   a. Use Bendix cleaner; NEVER use a caustic solution which will attack aluminum.
   b. Use nylon or hog bristle brush; NEVER use wire brush.
   c. Immerse impeller end into cleaning solution.
   d. Dry thoroughly with compressed air.

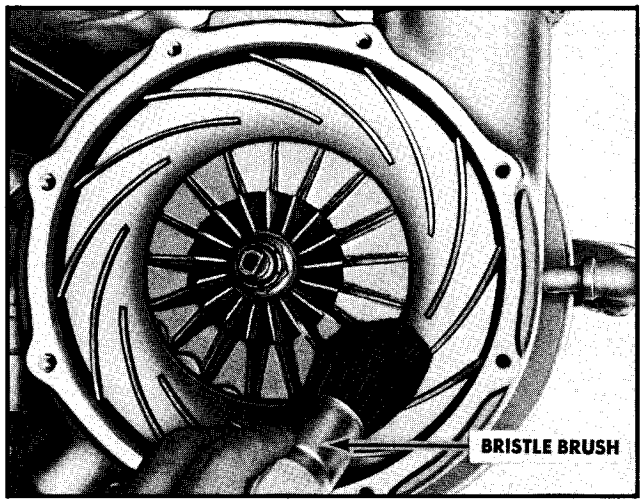


Fig. 10-14. Cleaning turbocharger impeller

Bearing Clearances

Turbocharger bearing clearances should be checked every 1,000 hours or 25,000 miles. Checks can be made without removing turbocharger. Use a dial indicator to indicate side and end-play of rotor shaft. Check as follows:

1. Remove exhaust and intake piping from turbocharger to expose both ends of rotor assembly.
2. Fasten a dial indicator to turbine casing.
3. Place indicator point against hub of turbine wheel.

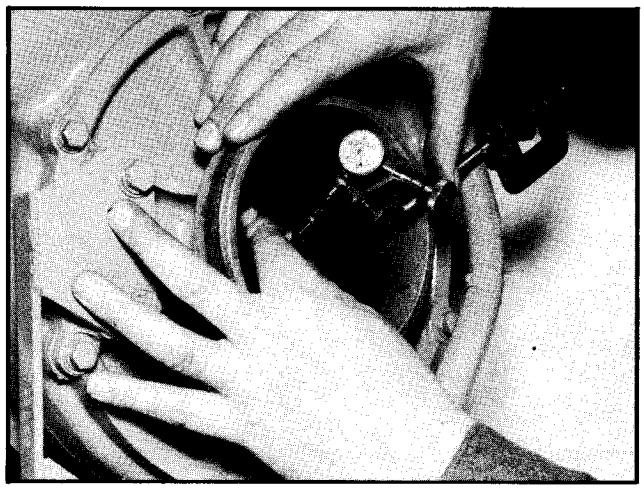


Fig. 10-15. Checking bearing clearance

4. Force turbine wheel up and down, or sidewise; note total indicator reading.
5. Remove *one* capscrew from front plate (impeller end) and replace with a long stud bolt.
6. Attach an indicator to long stud bolt and register indicator point against flat on end of rotor shaft.
7. Push shaft sidewise, making note of total indicator reading.
8. Move indicator point to end of shaft.
9. Check end-play of rotor assembly.

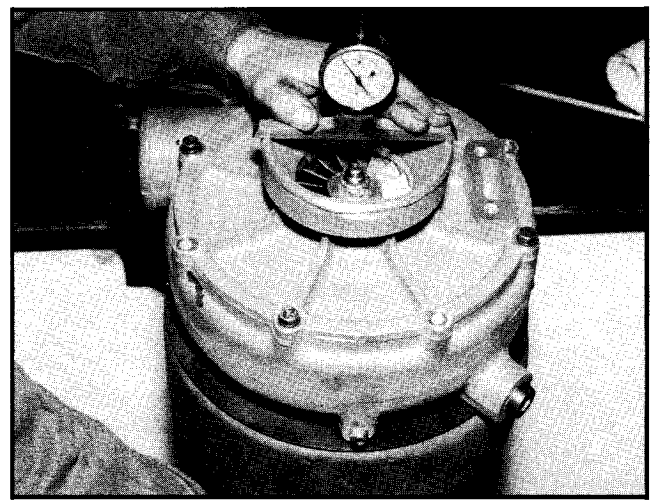


Fig. 10-16. Checking impeller end clearance

10. Compare readings with limits shown in Table 9.

TABLE 9—TURBOCHARGER BEARING DATA

Check	Min.	Max.
Radial Clearance (total indicator reading)	0.00	.010
Rotor End Play	.004	.012

If radial or end clearance exceeds the maximum limits, the turbocharger should be sent to a factory approved rebuild station for bearing replacement.

TURBOCHARGER ANEROID CONTROL

1. Remove the capscrews and lock washers and bellows cover.
2. Inspect bellows for rupture or breaks; replace as needed.
3. Replace bellows cover capscrews and lock washers.
4. Remove lever cover.
5. Inspect for excessive oil leakage indicating a worn "O" ring.
6. Pull lever from body.
7. Replace "O" ring.
8. Reassemble lever and cover.

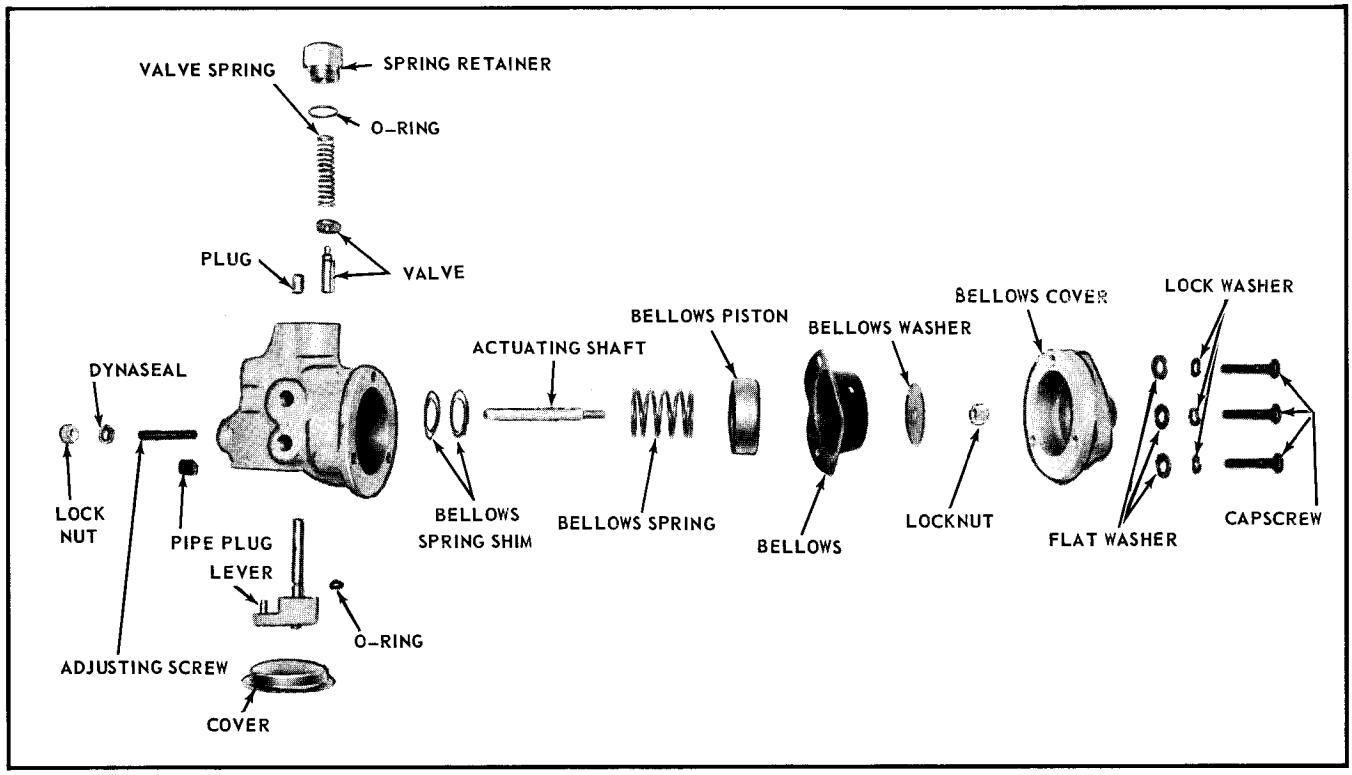


Fig. 10-17. Aneroid control—exploded view

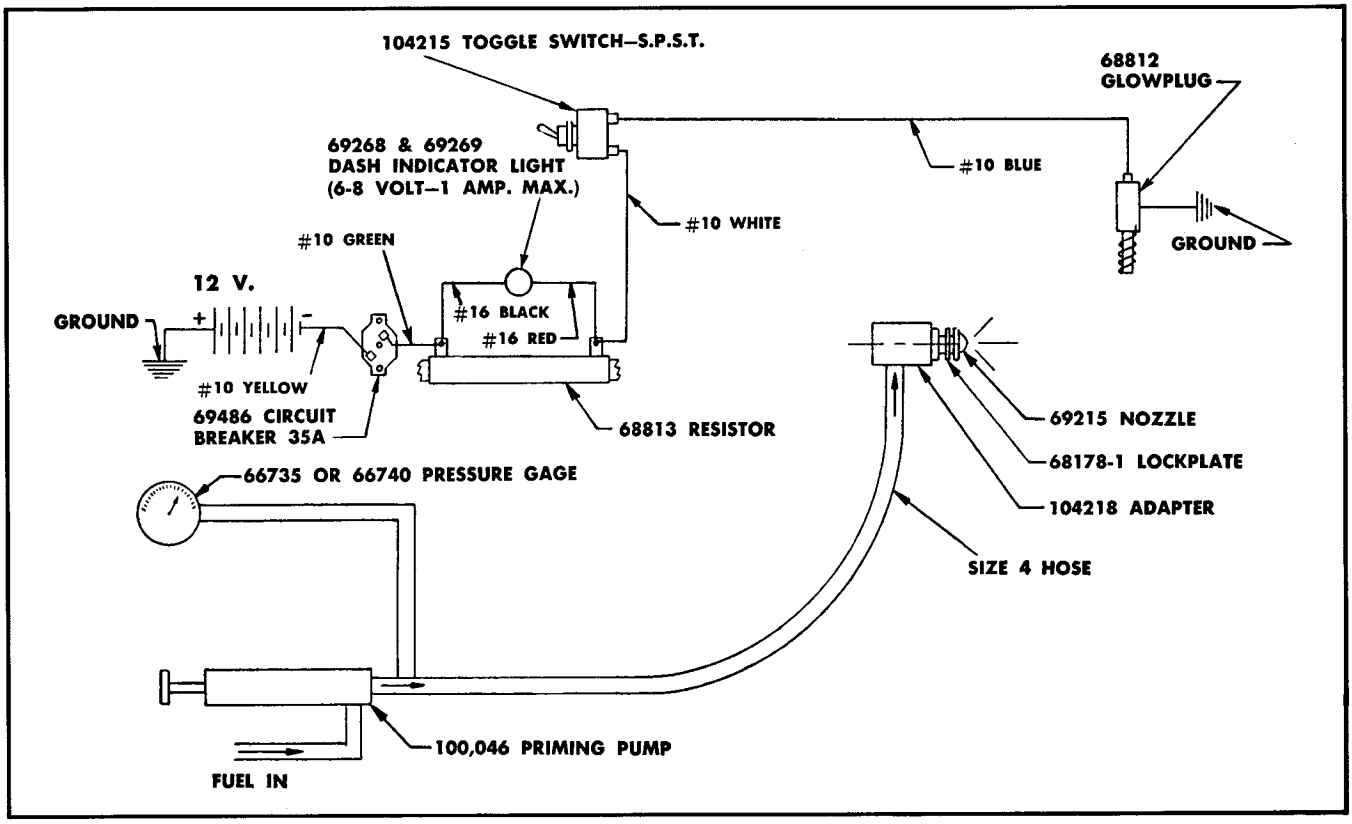


Fig. 10-18. Preheater wiring diagram

PREHEATER

Disassembly

1. Remove preheater adaptor from intake manifold.
2. Remove nozzle and clamp washer from adaptor.
3. Remove glow plug from intake manifold.

Repair

1. Clean adaptor and nozzle with Bendix carburetor cleaner, or equivalent. Be sure nozzle screen and spray hole are open and clean.
2. Check glow plug on six-volt source.

Assembly

1. Assemble clamp washer and nozzle to adaptor.
2. Tighten nozzle and bend washer over one of hexagonal sides of nozzle.
3. Install assembled adaptor in intake manifold.

NOTE: Preheater priming pump, switches and resistor are located at the instrument panel and are to be checked during engine starting.

INTAKE AND EXHAUST MANIFOLDS

1. Inspect both intake and exhaust manifolds for cracks and distortions.
2. Replace as necessary.

MANIFOLDS, J MARINE ENGINES

1. Water test water cooled exhaust manifold at 30 to 80 psi.
2. Steam clean and soak exhaust water cooled manifold in an acid tank to remove salt and lime deposits.

Section 11

UNITS NO. 12 AND NO. 13

ACCESSORY EQUIPMENT

AIR STARTING AND BRAKING

UNIT NO. 12

Equipment included under "Air Starting and Braking" includes the air compressor and vacuum pump. It is recommended that worn out air compressors be exchanged for manufacturer rebuilt units. Therefore no instructions for rebuilding equipment in Unit No. 12 will be included in this manual.

ELECTRICAL EQUIPMENT

UNIT NO. 13

This unit includes:

Electric Connections
Cranking Motor
Magnetic Switch
Starting Switch
Generator
Voltage Regulator
Solenoid and Step Controls
Engine Wiring
Electric Gauges

The information contained in this unit section is limited to a brief description of the function and operation of electric units used on Cummins engines and to simple tests and adjustments that can be made without special equipment. Wiring diagrams for installation work and parts replacement are also included.

It is recommended that repair of electric units be done in manufacturers' service stations. Their stations are well equipped and well distributed.

If this service is not available further specific information can be obtained as follows:

DELCO REMY EQUIPMENT

Electrical Equipment Operation and Maintenance Handbook DR-324 and Test Specifications DR-324-S may be purchased from the nearest United Motor Service Station, or the Service Dept. Delco-Remy Division, General Motors Corp., Anderson, Indiana.

LEECE-NEVILLE EQUIPMENT

Operation and adjustment information may be purchased from the nearest Leece-Neville distributor or the Service Dept. of the Leece-Neville Co., 5109 Hamilton Ave., Cleveland 14, Ohio.

ELECTRIC CONNECTIONS

An electric current travelling through a wire may be compared to water flowing through a hose or pipe. The voltage in the electric circuit is like the pressure behind the water in the hose. Water pressure is lost if it is allowed to leak at connections or if the hose diameter is so small that it offers resistance to flow. This loss of water pressure compares with loss of electric pressure, or voltage, because of poor connections or conductors of insufficient capacity.

Most electric units, such as switches and regulators, work around various applications of the electro-magnet which depends on the amount of voltage applied from the generator and battery. Therefore, it is important to avoid loss of voltage resulting from improper connections and wire which is too small.

Connections must be tight and splices should be soldered and insulated so no voltage loss will occur at these points.

The following practices are recommended to assure efficient operation of the electric system. They are espe-

cially necessary in cold weather when the starting requirements are higher and the battery capacity is lower than normal:

1. Generator-Regulator-Battery circuits should be two-wire circuits on all systems having 10 or more amperes generator capacity.

2. Starting motors—battery circuits should be two-wire circuits of No. 00 B & S gauge size or larger. This is especially important for cold weather starting.

3. Any accessory circuits which are of the one-wire ground-type should have ground connections as described in this Manual.

GROUND CONNECTIONS

In engine applications, a common ground connection is sometimes used. This system uses the metal of the unit as one side of the electric circuit and, as such, makes all metal which lies between the electric unit and the battery or generator, an electric conductor. So, it is advisable to make all ground connections to the same solid metal member.

An occasion may arise when the battery is grounded to one beam of the frame and it is necessary for you to make ground connections to a second beam or section of the superstructure which is jointed to the first. This can be done safely if you first bolt and sweat solder a flexible, heavy, metal strap between the two beams to bridge the joint. This has the effect of making the jointed member a part of the beam which grounds the battery. All metal joints in the circuit should be treated in this manner. This will also hold true for instrument ground connections in the cab, on the instrument panel, etc.

Many engines and cabs are installed on rubber or other flexible mountings. These mountings, in themselves, provide practically no electric connection to the frame. Even a solid-type engine mounting in which the bell housing is bolted directly to the frame makes a poor electric connection. *All ground connections from any electric unit should be made to the same solid or bridged metal member to which the battery itself is grounded.*

Corrosion, as well as oil and dirt between the two surfaces, eventually has the same effect as a resistor placed in the wiring circuit. Never bolt ground wires to a rusty, greasy or dirty surface.

Regardless of where magnetic switches, cut-out relays, and other control units are mounted, a separate ground wire should be run from the proper terminal or designated part of the unit to the same solid metal member grounding the battery. *Whenever it is possible, make ground connections directly to the battery's grounding bolt.* This will provide a dependable ground return circuit and permit an unretarded passage of the current to allow the units to function as they are intended.

The sketches shown here indicate only the proper method of grounding certain units. They are not complete wiring diagrams and, under no circumstance, should they be used as such.

To make a good electric connection between a cable terminal and the frame, you must clean and scrape the metal surfaces until they are bright and then tin these surfaces to prevent rust and corrosion. To make a completely dependable, permanent joint, after the cable is bolted to the frame, sweat solder the two together.

The heavy cables used to make ground connections from the battery, cranking motor or engine should be prevented from swinging. A single bolt connection as shown in Fig. 11-1 is unreliable. The surface of the frame

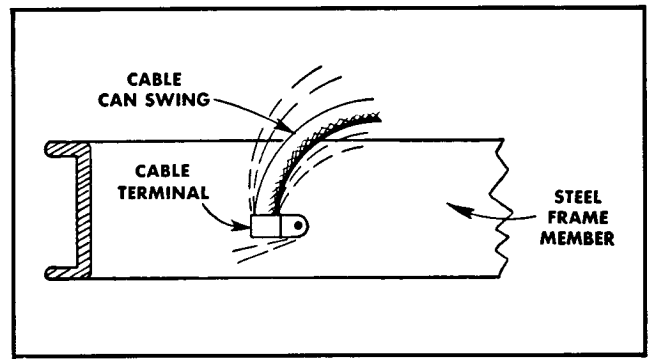


Fig. 11-1. Unreliable cable ground

at the joint is not tinned and, in addition, the heavy cable can swing back and forth to loosen the connection. Loose connections leave a space between the cable terminal and frame which may allow the entrance of dirt or moisture to form rust or corrosion.

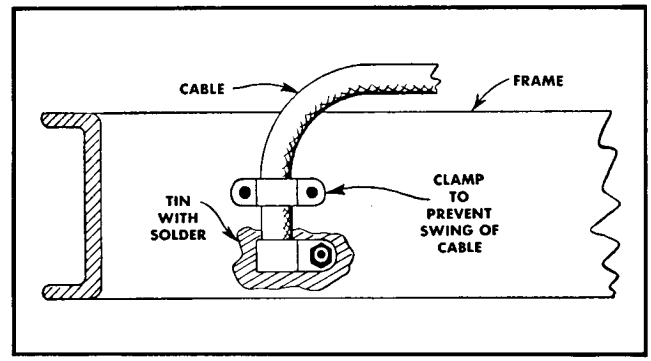


Fig. 11-2. Reliable cable ground

Recommended ground connections and methods of preventing cable swing are shown in Fig. 11-2. The surface of the frame at the connection is tinned to prevent rust and corrosion.

CRANKING MOTOR AND CONTROLS

The cranking motor used on diesel engines is a special overload motor capable of delivering a high horsepower. In order to obtain this power from the unit, it is necessary to build the cranking motor with a minimum of resistance so a large current will be taken through it. It is consequently obvious that the cranking motor should be used for short periods only—approximately 30 seconds maximum—to avoid the possibility of failure due to overheating.

CLEANING

All parts should be cleaned after disassembly. Do not clean the armature or fields in any degreasing tank, since the compounds used in this type cleaner may cause damage to mica or enamel insulation and rubber.

COMMUTATOR

1. If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper. NEVER USE EMERY CLOTH TO CLEAN COMMUTATOR.

2. All dust must be blown from the cranking motor after the commutator has been cleaned.

3. If the commutator is rough or out of round, or has high mica, remove the unit from the engine and disassemble the armature. Turn the commutator down in a lathe, removing only sufficient material to true up the commutator and remove roughness and high mica. Undercut the mica.

BRUSHES

Replace worn brushes. If brushes wear rapidly, check for incorrect brush spring tension and roughness or high mica on the commutator.

LUBRICATION

1. All bearings provided with hinge cap or ball type oilers should have 8-10 drops of light engine oil every 5,000 miles. Grey iron or bronze bearings with grease cups should have the grease cups kept filled with medium cup grease and turned down one turn every 5,000 miles.

2. Ball bearings with grease cups should have the grease cups kept filled with ball bearing grease and turned down every 5,000 miles.

3. Oil plugs should be removed every 6 months and the reservoir packed with graphite grease. On tractor, marine, and stationary applications, lubricate as above every 300 hours of operation.

4. Do not lubricate excessively, since excessive oiling may cause oil and grease to gum on the commutator and reduce the cranking ability of the motor. Never oil the commutator.

5. On some models, oil wicks are used for lubrication of the center or drive-end bearing. The wick is saturated with oil before assembly. Whenever the cranking motor is removed from the engine, the oil wick should be saturated with oil before the unit is reinstalled.

6. All oilless-type bushings should be supplied with a few drops of light engine oil whenever disassembled.

7. Lubricate cranking motor drives with a few drops of light engine oil. Avoid excessive oiling.

CRANKING MOTOR CONTROLS

1. Because of the high current flow from the battery to cranking motor during cranking, some positive means of connecting and disconnecting the battery and cranking motor must be used. The switch used must have contacts of adequate size to carry the current without burning. The manually operated switch mounted either on the floor board or the cranking motor frame, is the simplest type of switch.

2. Some applications with Bendix drive use a magnetic switch, a small electromagnet, which when energized draws in a plunger and causes a contact disc to make contact between two terminals to complete the circuit from the battery to cranking motor. The magnetic switch winding is usually energized by a dash push button.

3. Some applications with the overrunning clutch, or Dyer type drive, use a somewhat larger magnetic switch, called a solenoid switch, wherein the plunger not only thrusts against a contact disc to close the battery to cranking motor circuit, but is also linked to the shift lever so that the drive pinion is shifted into mesh with the flywheel teeth by the solenoid action. The solenoid switch is usually actuated by a dash push button.

4. Diesel engines and similar applications require a comparatively high voltage to insure adequate cranking performance. The series-parallel system is designed to provide a means of connecting two batteries in series to provide increased voltage for cranking, and reconnecting the two batteries in parallel for normal operation of the equipment after starting of the engine has been accomplished.

CRANKING MOTOR DRIVES

Friction Clutch Type Bendix Drive

1. This type of drive functions in much the same manner as other Bendix drives excepting that it uses a series of spring-loaded clutch plates which slip momentarily during the shock of engagement to relieve the shock and prevent it from being carried back through the cranking motor. The slipping stops as engagement is completed so that cranking torque is transmitted from the cranking motor armature through the drive pinion to the engine flywheel.

2. The pinion of the Bendix drive is mounted on a threaded sleeve which matches internal threads in the pinion. When the armature revolves, carrying the threaded sleeve with it, the inertia of the pinion does not allow it to pick up speed as rapidly as the armature. The result is that the threaded sleeve turns within the pinion, moving the pinion endwise and into mesh with the flywheel teeth so that cranking is accomplished. The spring-loaded clutch takes up the sudden shock of meshing. When the engine begins to operate, the flywheel drives the pinion at a higher speed than the threaded shaft is revolving. This causes the pinion to be turned relative to the threaded shaft, and in such a direction that the pinion is demeshed from the flywheel teeth.

OVERRUNNING CLUTCH DRIVE

1. The overrunning clutch is designed to provide positive meshing and demeshing of the drive pinion and flywheel ring gear. It uses a shift lever which slides the clutch and drive pinion assembly along the armature shaft so it can be meshed and demeshed as required. The clutch transmits cranking torque from cranking motor to the engine flywheel but permits the drive pinion to overrun, or run faster than, the armature after the engine is started. This protects the armature from excessive speed during the brief interval that the drive pinion remains in mesh.

2. The overrunning clutch (Fig. 11-3) consists of a shell and sleeve assembly which is splined internally to match splines on the armature shaft. Thus, both the shell and sleeve assembly and armature shaft must turn together. A pinion and collar assembly fits loosely into shell, and the collar is in contact with four hardened steel rollers which are assembled into notches cut in the inner face of the shell. These notches taper inward slightly so that there is less room in the end away from the rollers than in the end where the rollers are. The rollers are spring loaded by small plungers.

3. When the shift lever (Fig. 11-3) is operated, the clutch assembly is moved endwise along the armature shaft so that the pinion meshes with the flywheel ring gear. If the teeth should butt instead of mesh, the clutch spring compresses so that the pinion is spring loaded against the ring-gear teeth. Then, when armature begins to rotate, meshing takes place at once. Completion of the shift lever movement closes the cranking motor switch so that the armature begins to rotate. This rotates the shell and sleeve assembly causing the rollers to jam tightly in the smaller sections of the shell notches. The rollers jam between the pinion collar and the shell so that the pinion is found to rotate with the armature and crank the engine.

4. When the engine begins to operate, it attempts to drive the cranking motor armature, through the pinion,

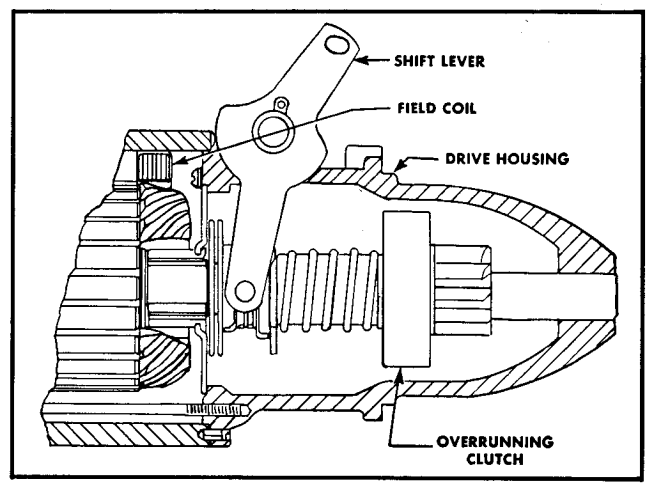


Fig. 11-3. Overrunning clutch drive assembly

faster than the armature is rotating. This causes the pinion to rotate with respect to the shell so that it overruns the shell and armature. The rollers are turned back toward the larger section of the shell notches where they are free, and thus, permit the pinion to overrun. This protects the armature until the automatic controls take over so that the shift lever is released, causing the shift lever spring to pull the overruning clutch drive pinion out of mesh from the engine flywheel ring gear. This shift lever movement also opens the cranking motor switch so that the armature stops rotating.

5. The overrunning clutch pinion requires the same ring gear as the Bendix pinion.

CHECKING AN IMPROPERLY OPERATING CRANKING MOTOR

1. If the cranking motor does not develop rated torque and cranks the engine slowly or not at all, some indication of the source of trouble may be gathered by turning on the lights and attempting to crank.

A. If the lights go out as the cranking motor switch is closed, it is probable that a poor connection exists at the battery terminals or elsewhere in the circuit.

B. If the lights dim considerably, but still burn, it is likely that the battery is run down. Or, possibly there is some mechanical trouble either in the cranking motor or in the engine which makes it difficult for cranking to take place and an excessively high current drain on the battery consequently results.

C. If the lights do not dim, it indicates that there is no current flowing to the cranking motor, due either to the cranking motor or the cranking motor switch being open.

2. The preceding checks give only an approximate idea of the source of trouble so that in an emergency it might be possible to effect a temporary repair which would bring in the vehicle. To make a systematic analysis of the cranking motor system, the first step would be to check the battery specific gravity. Then the battery connections and cables should be checked, along with the cranking motor switch.

3. If all these are in order, remove the cover band and inspect the brushes and commutator. The brushes should form good contact with the commutator and the commutator must be reasonably clean and smooth. If it is not, it should be cleaned or turned down in a lathe. If there are burned bars on the commutator, it may indicate open circuited armature coils which will prevent proper cranking.

4. If leads have been thrown out of the armature slots, the indication is that the overrunning clutch caused the armature to be spun at an excessive speed due either to a defective clutch or to the fact that the operator of the vehicle was not starting the engine in the proper manner. If the operator opens the throttle too wide on initial starting, or if he keeps the starter pedal depressed for too long after the starting has been accomplished, the overrunning clutch may overheat and partially bind so that the armature is spun at excessive speeds. In addition to ruining the armature, the overrunning clutch also will be ruined by such abuse. Evidences of excessive overrunning of the clutch are failing of the bearings, depositing of bearing material on the armature shaft, and a smooth face in the collar on the side closest to the pinion.

5. Tight, dirty or worn bearings, bent shaft or loose pole shoe screws which allow the armature to drag will reduce armature speed or prevent the armature from turning.

6. If the brushes, brush spring tension, commutator, etc., all appear in good condition, it will be necessary to remove the cranking motor for further test.

GROUND CONNECTIONS OF THE CRANKING MOTORS

In cases where the recommended two-wire system is not used on the cranking motor circuit, the ground wire should go directly from the positive terminal to the steel frame members and be grounded as shown in Fig. 11-2. The motor mounting surface should not be used for the ground circuit since the pads on the flywheel housing must carry this current to the frame and they may have paint or other highly resistant material on them.

GENERATOR

The generator is a machine which converts mechanical energy into electrical energy and it has the job of supplying current for lights, and other electrical equipment,

and keeping the battery in a charged condition by replacing, in the battery, the energy consumed by the cranking motor in starting.

The shunt generator requires some form of external current regulation, and the usual application incorporates a current regulator, voltage regulator and cut-off relay which operates together to provide control of the generator under all conditions of operation.

CLEANING

Clean the generator thoroughly of all grease and dust. Do not clean armature and field in a degreasing tank as this damages the insulation.

COMMUTATOR

1. If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper held against it with a piece of soft wood while the generator is operated. Blow out dust. NEVER USE EMERY CLOTH since emery may embed and wear the brushes rapidly.

2. If the commutator is rough, out of round, or has high mica, it must be turned down in a lathe and the mica undercut.

LUBRICATION

1. The oil reservoir in the commutator end of the generator should be kept filled with light engine oil to the overflow hole. This usually requires the addition of 8-10 drops of oil every 1,000 miles.

2. Generators with grease cups should have the grease cups turned down one turn. Keep grease cups filled with medium cup grease. Do not lubricate excessively since this might allow oil or grease to get on the commutator where it would gum and burn and reduce generator output.

CONNECTIONS

1. Check the connections and wiring in the generator-to-regulator-to-battery circuit. Check the pulley nut to be sure it is tight.

2. Make sure the mounting bolts are tight.

3. All generator installations should be checked carefully to make sure that they are properly grounded to the engine block. The generator mounting pads and mounting surfaces of the bracket and generator frame should be free of paint, oils, greases or any material resistant to electric current. To further complete the ground circuit, the engine should be grounded to the same frame member used to ground the battery, by means of a separate metal strap as shown in Fig. 11-2. This procedure must be followed on third-brush-type generators which have only one terminal, and on other generators having only one armature terminal, since the positive brushes on these generators are grounded to the generator frames.

CHECKING AND ADJUSTING OUTPUT

1. The output of the shunt generator is dependent upon the setting of the current regulator.

2. Normally, if the generator is checked with an accurate ammeter and a fully charged battery is in the circuit, the proper voltage will be developed. NEVER SET OUTPUT ABOVE SPECIFIED SETTING AS THIS WILL RESULT IN GENERATOR FAILURE.

CHECKING INOPERATIVE GENERATOR

If the generator is not performing according to specifications, and the tests outlined in the section on REGULATORS have disclosed that the generator is definitely at fault, it may be checked as follows to determine location of trouble in the generator.

No Output

When no output can be obtained from the generator, remove the cover band and check for sticking brushes, gummed or burned commutator or other causes of poor contact between commutator and brushes. If the cause of trouble is not readily apparent, remove the generator from the engine and send to generator service station for further tests and repairs.

Excessive Generator Output

Excessive generator output is usually due to either (a) a grounded field circuit or (b) a shorted field. Check the terminal insulation and if trouble cannot be corrected there, send the generator to a service station.

Unsteady or Low Output

This condition may result in any generator from:

1. Sticking brushes, low brush spring tension, or other condition which prevents good contact between brushes and commutator.

2. Commutator which is rough, out of round, dirty, or burned. Dirt in the slots or high mica also cause low or unsteady output. With these conditions, the commutator

should be turned down in a lathe and the mica undercut. Burned bars, of course, indicate an open circuit armature, and the corrections outlined above should be made.

Noisy Generator

This condition may be caused by loose mounting, or drive coupling. Worn or dirty bearings may also cause noise. Brushes improperly seated may cause noise which can be eliminated by properly seating them with a brush seating stone. A bent brush holder may cause noise and requires replacement since it is difficult to properly re-align a holder.

POLARIZING GENERATOR

1. After the generator is reinstalled on the engine, or at any time that generator or regulator tests have been made, the generator must be REPOLARIZED to make sure that it has the correct polarity with respect to the system. This must be done BEFORE THE ENGINE IS STARTED.

2. Different procedures of polarizing the generator must be used, depending on the type regulator on the application. BE SURE TO ALWAYS DETERMINE WHICH REGULATOR IS USED SO THE CORRECT PROCEDURE WILL BE FOLLOWED.

To Polarize Leece-Neville Generators

Connect a jumper lead momentarily between "G-" and "B-" connections on the regulator. This will allow a momentary surge of current from battery through generator to correctly polarize the generator.

To Polarize Delco-Remy Generators Using "1118200" and "1118300" Series Regulators

1. The Delco-Remy "1118200" and "1118300" series regulators include all Delco-Remy regulators designated by 7 digits, the first 5 of which are "11182" or "11183."

2. Connect a jumper lead momentarily between the armature (or "GEN") and battery ("BAT") terminals of the regulator. This allows a momentary surge of current to flow through the generator from the battery to correctly polarize the generator.

CAUTION: NEVER OPERATE THE GENERATOR WITH THE FIELD CIRCUITS CONNECTED AND THE "A" TERMINAL LEAD DISCONNECTED (OPEN CIRCUIT OPERATION) SINCE THIS WOULD ALLOW A HIGH VOLTAGE TO BUILD UP WITHIN THE GENERATOR WHICH WOULD DAMAGE THE FIELDS AND ARMATURE.

REGULATOR CONTROLS

Three separate magnetic switches must be used with the shunt generator in order to provide complete control at all times. These are (1) the cutout relay, (2) the voltage regulator and (3) the current regulator.

CUT-OUT RELAY

1. The cut-out relay closes the circuit between the generator and the battery when the generator voltage has built up to a value sufficient to force a charge into the battery.

2. The cut-out relay opens the circuit when the generator slows or stops and current begins to flow back from the battery into the generator.

3. The basic wiring diagram for a one-terminal, third-brush current controlled generator used with a cut-out relay is shown in Fig. 11-4. Equipment which requires low generator output, such as shovels and power units, will sometimes have this type of generator and cut-out relay.

4. This type of equipment will give satisfactory service provided the G+ B+ terminal of the relay is properly grounded to the same frame member used to ground the battery, as shown in Fig. 11-4, and provided the generator is used only for battery charging.

VOLTAGE REGULATOR

1. The voltage regulator prevents the line voltage from exceeding a predetermined value and thus protects the

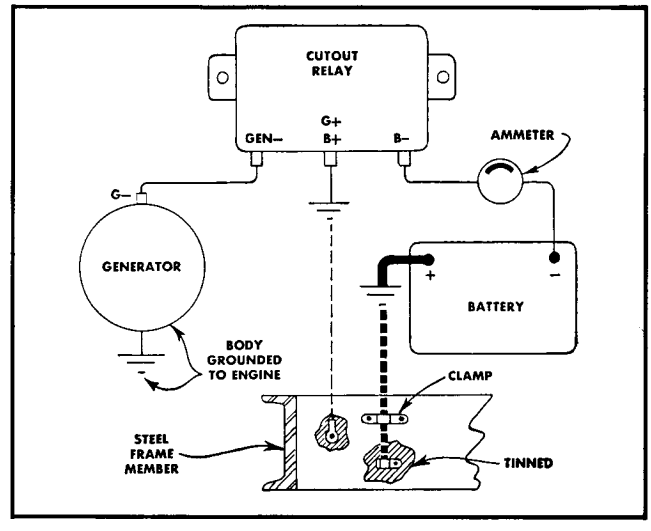


Fig. 11-4. Basic generator wiring diagram

battery and other electrical units in the system from high voltage.

2. One characteristic of batteries is that as either the specific gravity or the charging rate increases, other conditions being the same, the battery terminal voltage increases. If the terminal voltage is held constant as the battery comes up to charge (specific gravity increases), the charging rate will be reduced. The voltage regulator performs this job of holding the voltage constant and it consequently protects the electrical system from high voltage and the battery from overcharge.

CURRENT REGULATOR

1. The current regulator limits the generator output to a safe value. It is, in effect, a current limiting device which operates when the generator output has increased to its safe maximum and prevents the generator from exceeding this value.

REGULATOR OPERATING VOLTAGES

1. Regulators are factory adjusted according to the system in which they work.

2. For use in nominal 12 volt systems the regulator is adjusted to properly charge, under normal conditions, 6 cell batteries.

3. Because either 15 cell or 16 cell batteries may be used in nominal 32 volt systems, particular attention must be given to the application of regulators in a 32 volt system. These regulators are stamped "15 cell" or "16 cell" to indicate that they have been factory adjusted for use with a battery having the specified number of cells. To use a regulator stamped "15 cell" with a 16 cell battery would result in a weak-charged battery and, conversely, a "16 cell" regular would cause overcharging of a 15 cell battery.

Current and Voltage Regulator Connections

The basic diagram for Leece-Neville equipment is shown in Fig. 11-5 and is now supplied with the so-called "universal" regulator. For satisfactory operation, the steel base of the regulator must be grounded as shown because these regulators have small doughnut-type rubber shock mounts bonded to the base and depend entirely on this grounding strap and the capscrews to ground the unit.

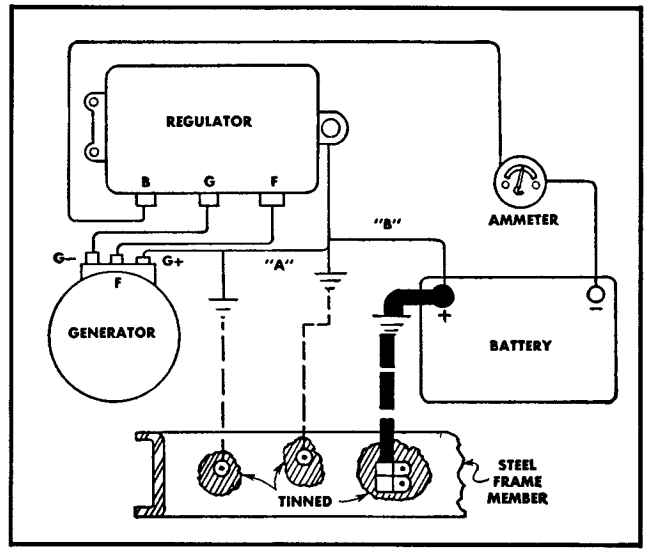


Fig. 11-5. Basic generator wiring diagram—Leece-Neville

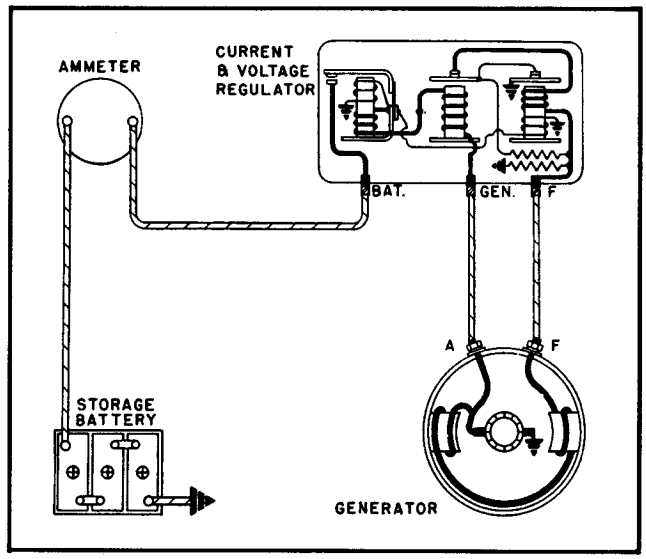


Fig. 11-6. Current and voltage regulator wiring circuit (Standard type)

Wires shown as "A" and "B" in Fig. 11-5 indicate the alternate connections necessary for the recommended two-wire system.

Some larger voltage regulation control units have cast aluminum bases and covers. These units are not grounded through their bases but by separate wires from insulated terminals. This would be indicated on the unit working diagram.

GENERATOR CUT-IN

It is advisable to check the cut-in point of the generator regulator at idling speed. On engines equipped with the low cut-in-type generator regulator, the ammeter will indicate some value of charging when the electric load is off. On other generator regulator systems, the ammeter will read "0." In either case, the ammeter should remain steady.

Erratic movement of the ammeter indicates that the regulator relay is cutting in and out frequently and this will cause an electric arc at these connections. If arcing continues, the points will eventually weld together which will leave the circuit closed at all times. This will cause an overcharge into the battery during operation and a discharge through the generator when the engine is stopped, and this will eventually burn up the generator and regulator. To overcome this condition, it will be necessary to increase the engine idling speed until the ammeter remains almost constant. Ammeter movement may indicate a loose connection.

STANDARD WIRING DIAGRAMS

Diagram No.	Fig. No.	Description	Engines Specified For
68791	11-7	12 Volt, 40/50 Amp. (560/700 Watt) Delco-Remy with Standard Three Element Regulator and P.B. Starting	J, JS, JT
102885	11-8	12 Volt, 40/50 Amp. or 24 Volt, 20 Amp. with Bendix or Dyer Drive Type Starter with Magnetic Switch	J, JS, JT
108378	11-9	30-32 Volt, 15 or 16 Cell, 10, 25, 40 or 50 Amp. with PT Pump and Glow-Plug Pre-heating	J Marine
108659	11-10	12 Volt, 50 or 100 Amp. AC System, Leece-Neville. With PT Pump and Glow-Plug Pre-heating	J, JS, JT
109244	11-11	24 Volt, 18 or 20 Amp., Negative Ground	
121995	11-12	Electric Solenoid Shut-Down Valve	All J Series

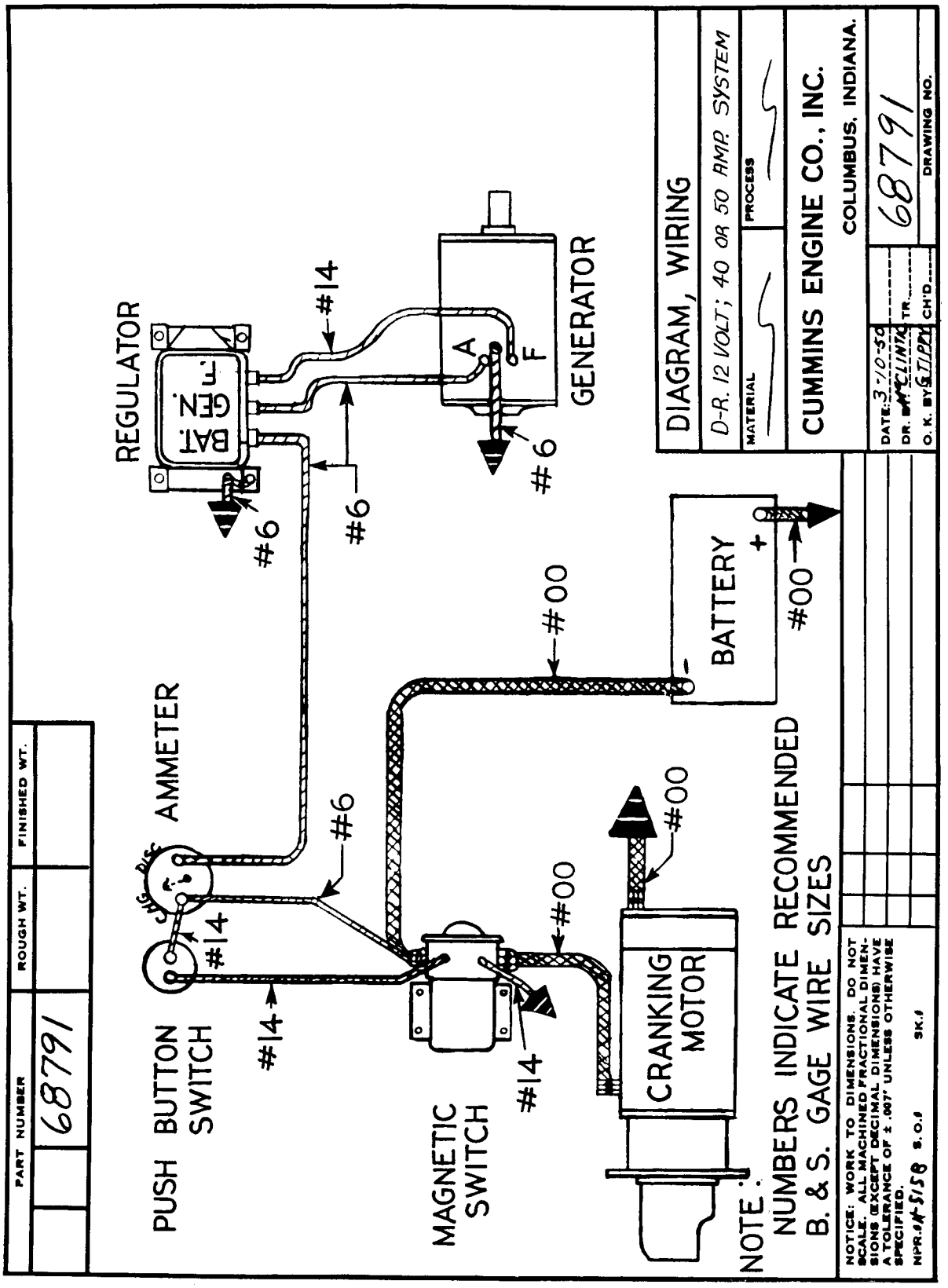


Fig. 11-7. 12 volt, 40 or 50 ampere; 560 or 700 watt Delco-Remy with Standard 3-element Regulator and P. B. Starting

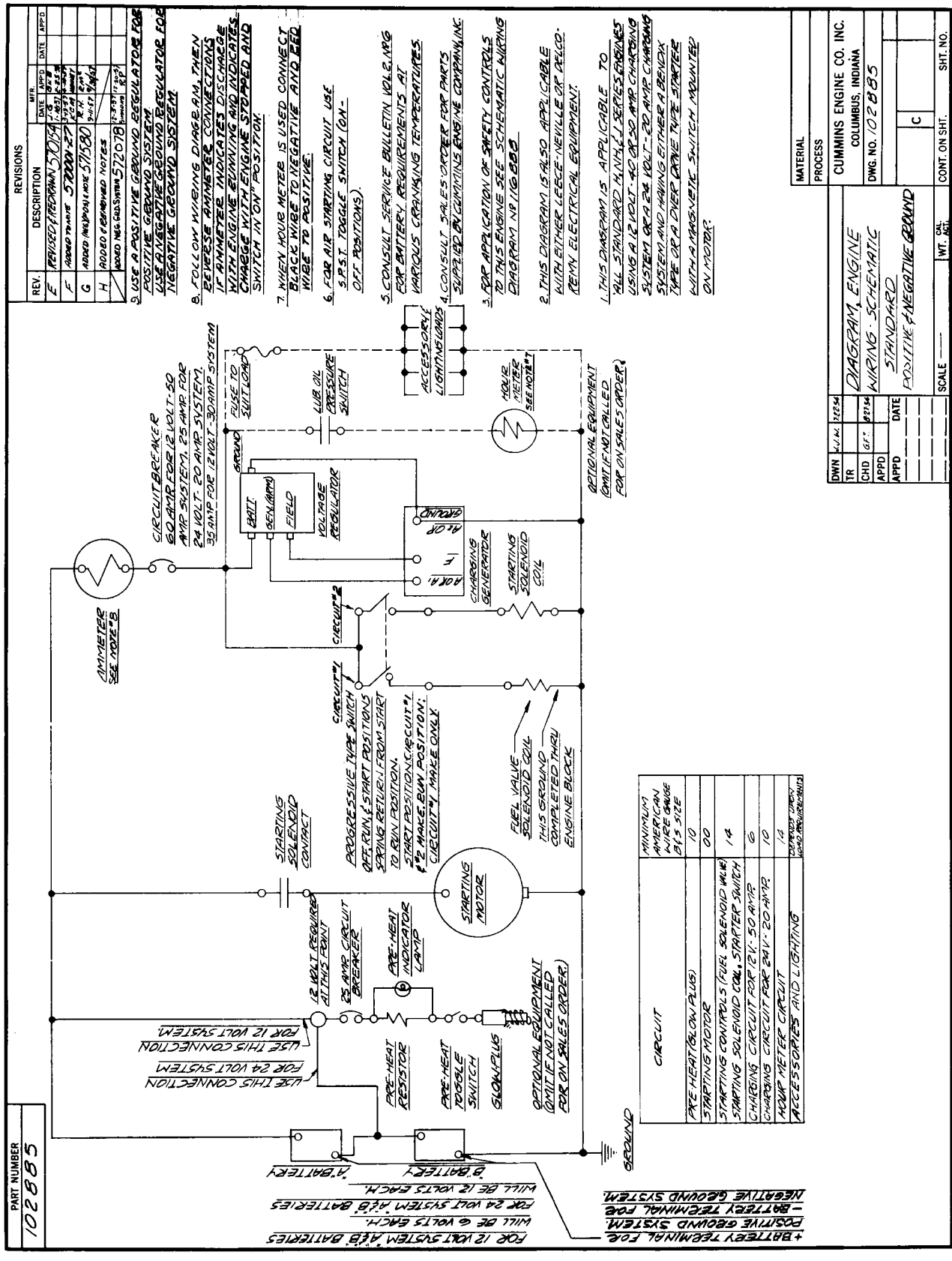


Fig. 11-8. 12 volt, 40/50 amperes or 24 volt, 20 amperes, with Bendix or Dyer Drive Type Starter with Magnetic Switch

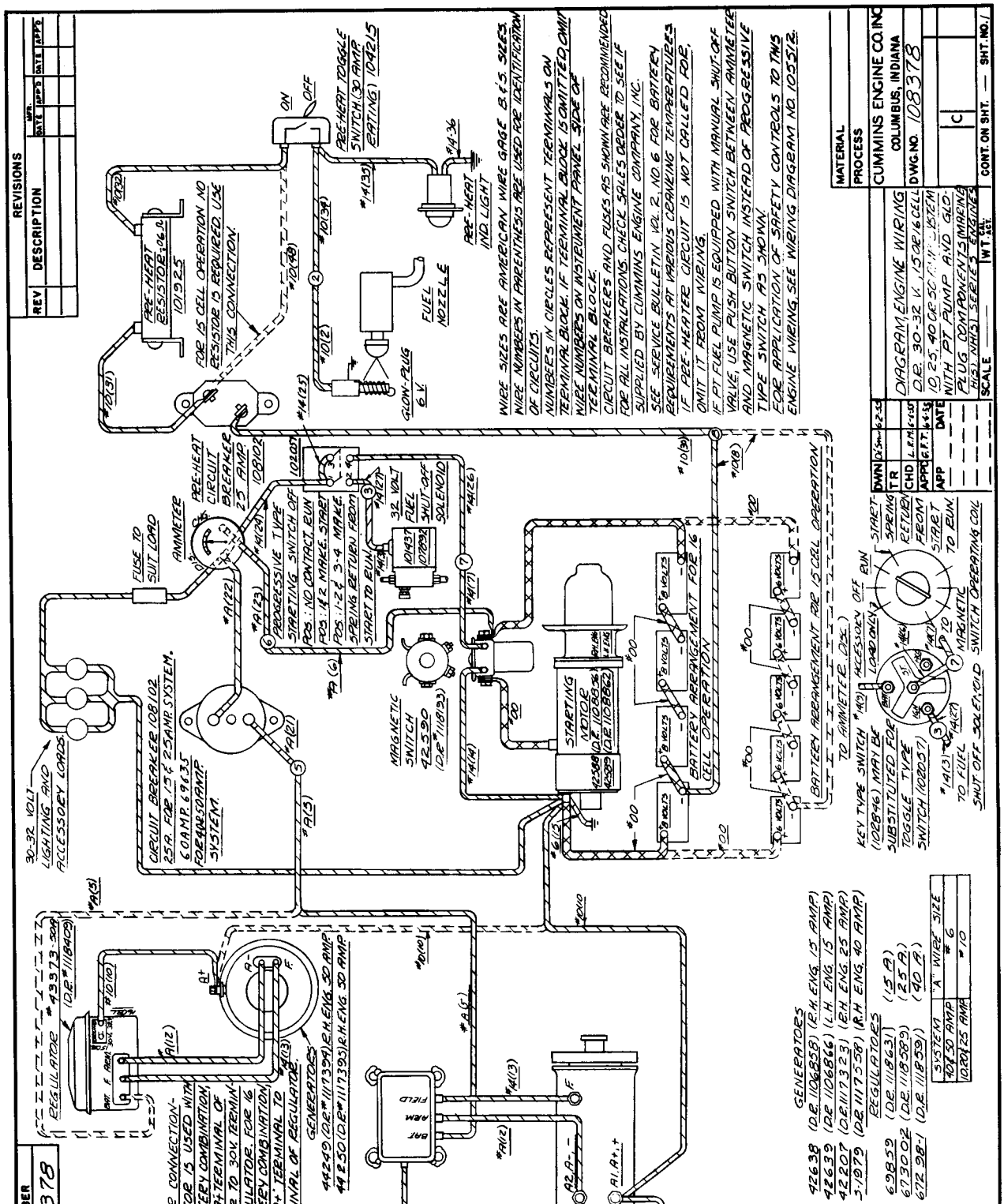


Fig. 11-9. 30/32 volt, 15 or 16 cell, 10-25-40 or 50 ampere with PT Fuel Pump and Glow-Plug Pre-heater

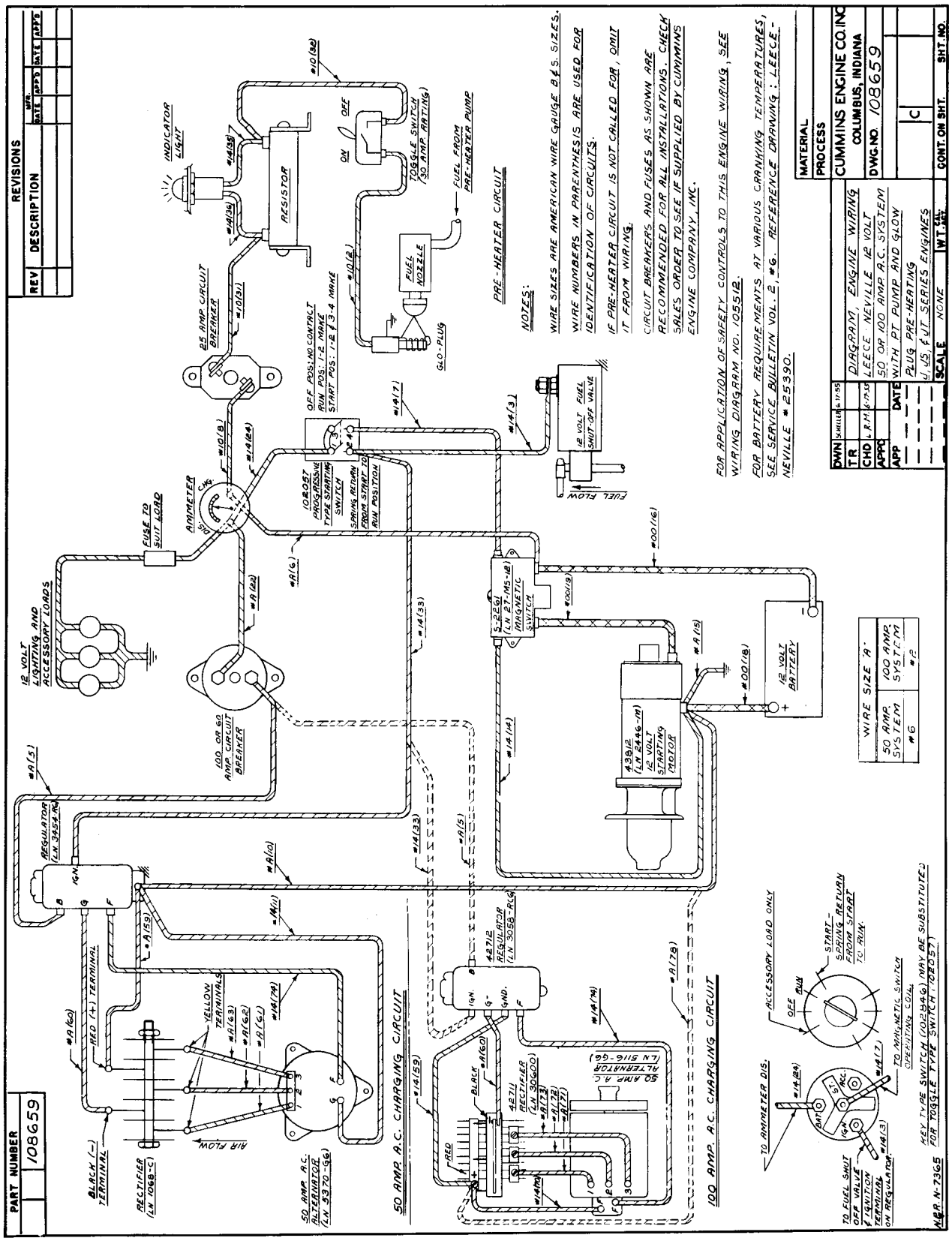


Fig. 11-10. 12 volt, 50 or 100 ampere, AC System

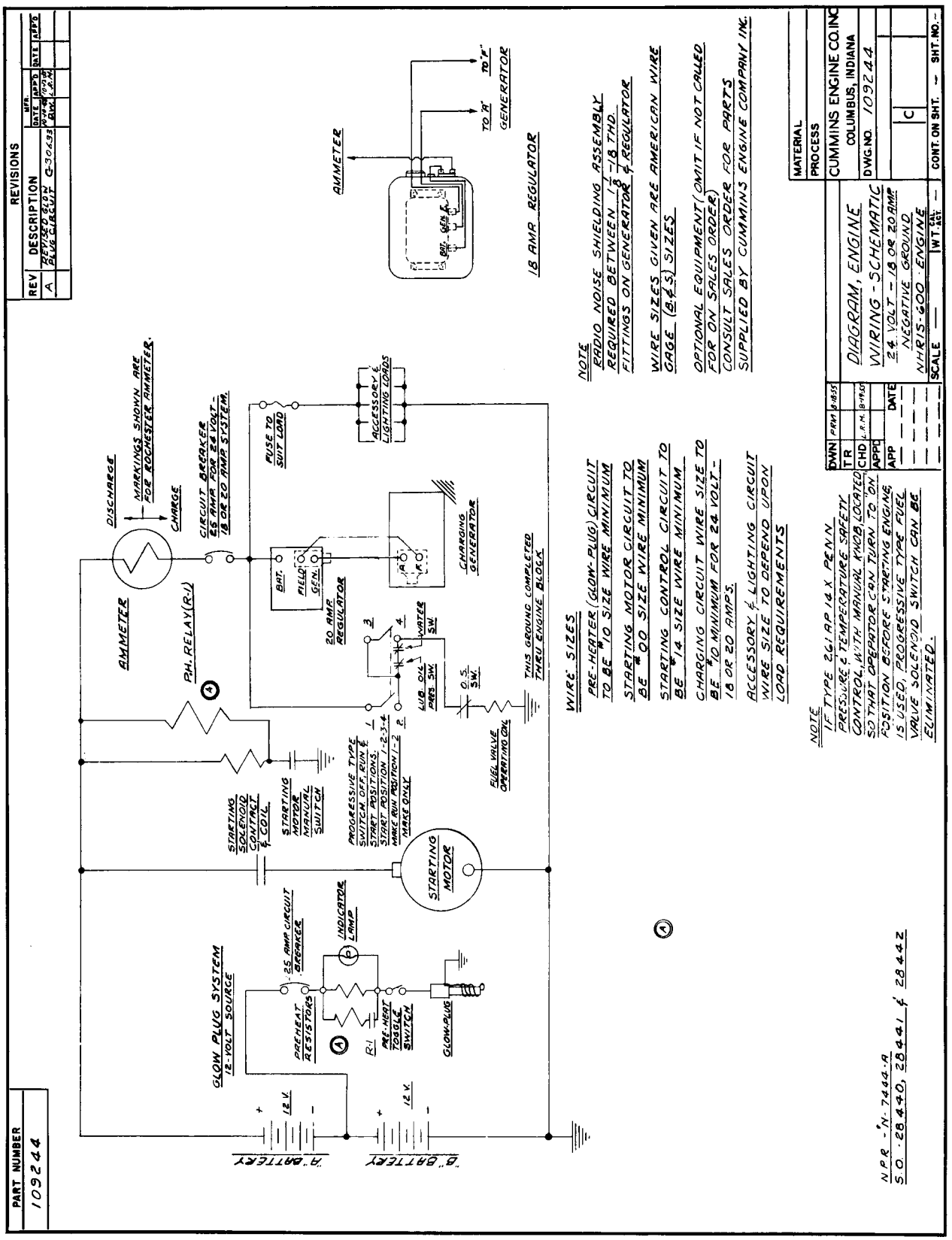


Fig. 11-11. 24 volt, 18 or 20 ampere, negative ground

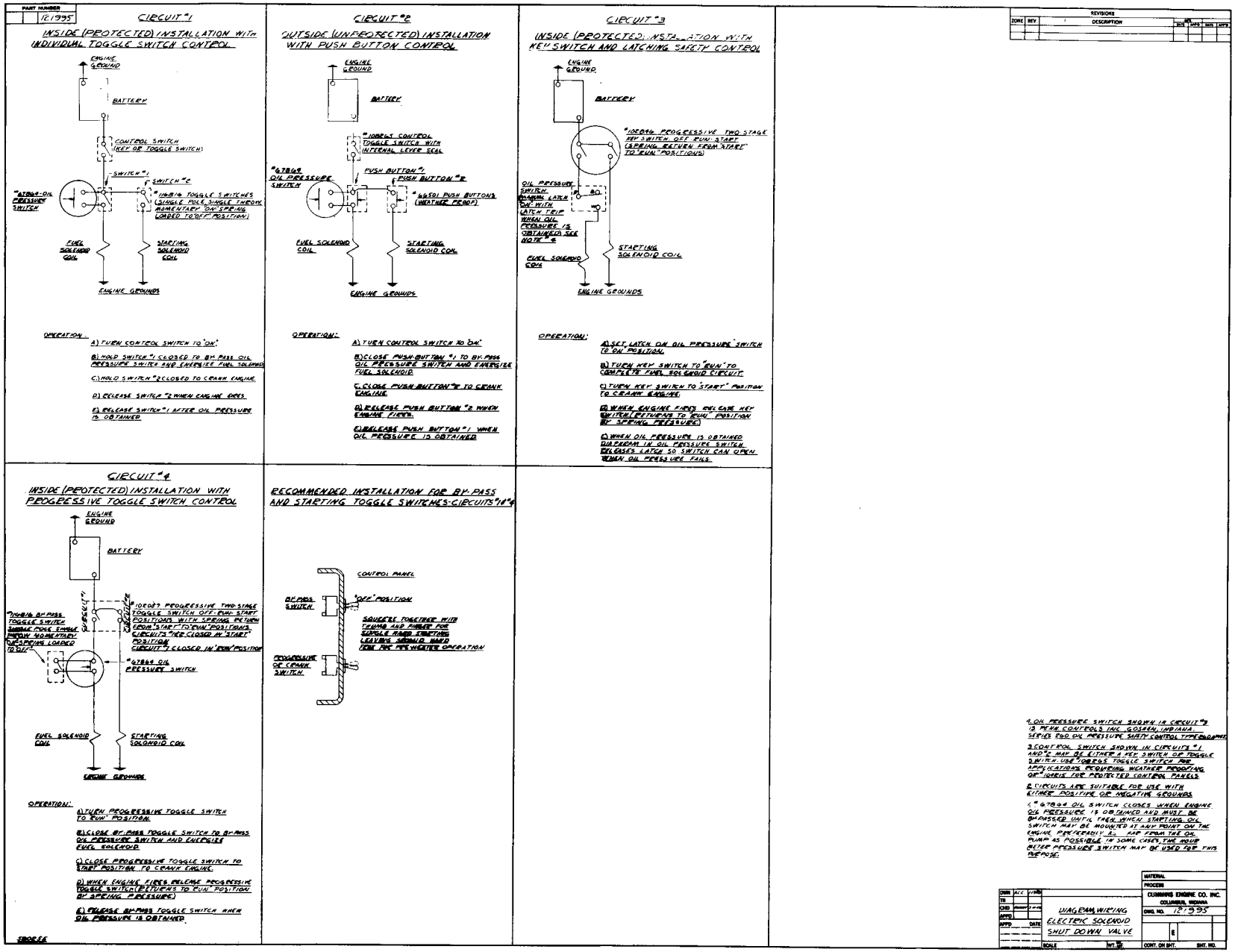


Fig. 11-12. Electric Solenoid Shut-Down Valve

Section 12

UNIT NO. 14

ENGINE ASSEMBLY AND TESTING

ENGINE ASSEMBLY

CRANKSHAFT

1. Secure cylinder block to engine stand.

2. Turn block upside down.

3. Recheck all oil passages to be sure that they are open and clean.

4. If not previously performed, check main bearing bore and alignment. See: Check Main Bearing Bore—Cylinder Block Group, Section 2.

5. Clean bearing cap, capscrew holes; remove all liquid and foreign particles.

6. Using a clean rag, wipe main bearing bores and main bearing shells.

7. Lay an upper main bearing shell in each block bore; engage locking tang with recess in block; index drilled holes in block and shell.

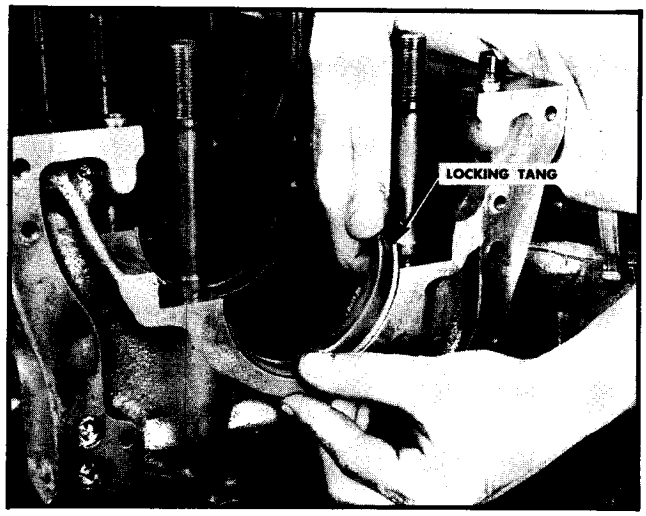


Fig. 12-1. Placing upper main bearing shells

8. Coat upper main bearing shells thoroughly with Lubriplate Type 130 AA.

9. Make sure that all crankshaft journals are thoroughly clean.

10. Lift crankshaft into position with rubber hose protected hooks.

11. Roll upper thrust half rings into position, *babbitt sides next to crankshaft flanges.*

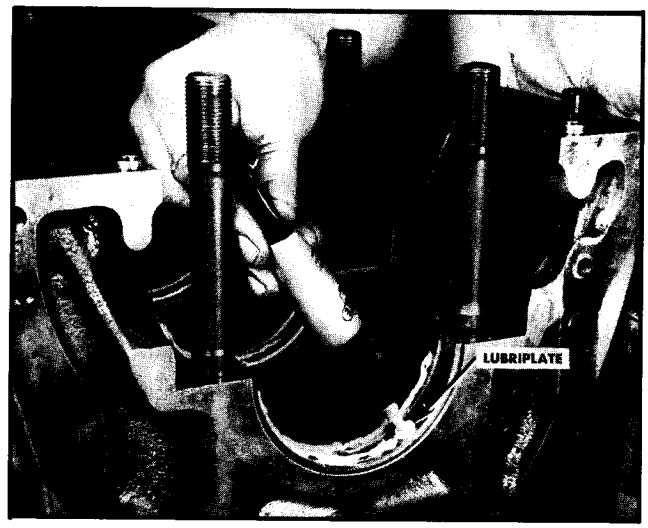


Fig. 12-2. Applying Lubriplate to upper main bearing shells

12. Snap lower main bearing shells into position in respective main bearing caps or around crankshaft. Locking tangs for both upper and lower main bearing shells are opposite camshaft side of engine.

13. Coat lower main bearing shells with Lubriplate Type 130 AA.

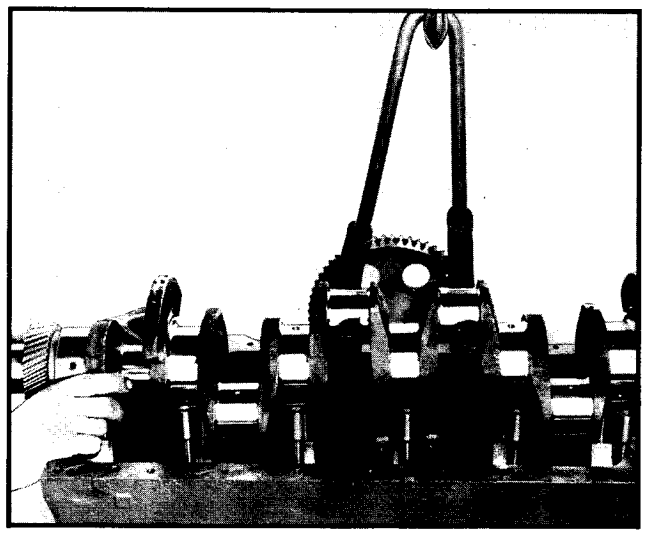


Fig. 12-3. Laying the crankshaft

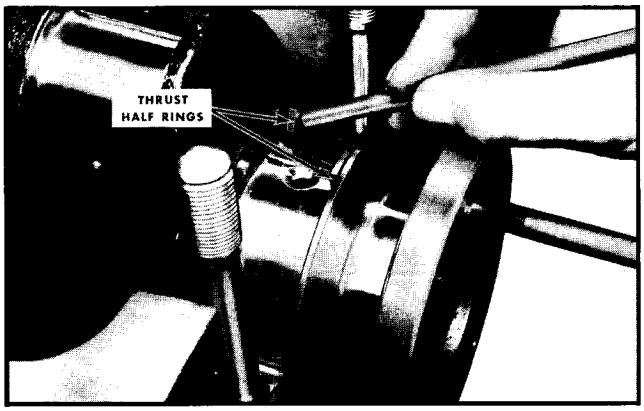


Fig. 12-4. Assembling upper thrust rings

14. Place thrust rings in counterbored recesses and secure over dowels on each side of No. 7 cap. (No. 5 cap on J-4 engines.)

Engines With Main Bearing Capscrews

1. Install capscrews and new lock plates in main bearing caps.
2. Lubricate capscrew threads with clean lubricating oil, *not Lubriplate.*
3. Place cap in position and start capscrews, engaging approximately five threads.
4. Drive caps in place; check capscrews which must turn freely in the block.
5. Tighten capscrews by template method. SEE: TEMPLATE METHOD OF TIGHTENING MAIN BEARINGS.

Engines With Main Bearing Studs

1. Drive caps in place over studs and lower shells with numbered side of cap to camshaft side of engine. Caps are 0.002 to 0.004 interference fit to the block. The recess in cap must match with bearing shell locking tang.
2. Assemble nut and new lock plate over each main bearing stud.

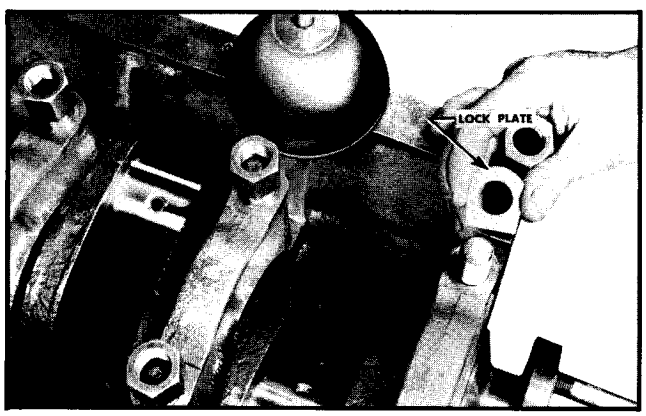


Fig. 12-5. Installing lock plates and stud nuts

3. Lubricate threads and lock plate with clean lubricating oil.
4. Tighten main bearing studs by template method. SEE: TEMPLATE METHOD OF TIGHTENING MAIN BEARINGS.

TEMPLATE METHOD OF TIGHTENING MAIN BEARING CAPSCREWS OR NUTS

1. Tighten main bearing capscrews or nuts to 160 foot-pounds with a torque wrench to set shells, caps and lock plates.

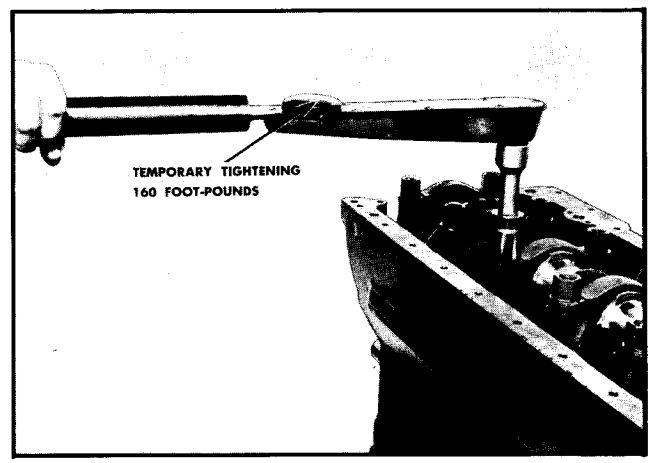


Fig. 12-6. Tightening stud nuts to 160 ft. lbs. to set caps and bearings

2. Loosen completely.
3. Retighten to 30/35 foot-pounds with a torque wrench. This is "snug" position.
4. Scribe capscrew heads or nuts with a sharp pencil to coincide with right permanent mark on cap, or scribe each cap in line with one hex corner of each main bearing capscrew.

Fig. 12-7. Snug tighten to 30-35 ft. lbs.

5. Advance 60° (one hex) from snug position described in Steps 3 and 4. This will align scribed mark (or next corner) with mark on main bearing cap. *Tighten each side of bearing a little at a time and as evenly as possible until reaching operating tension.*

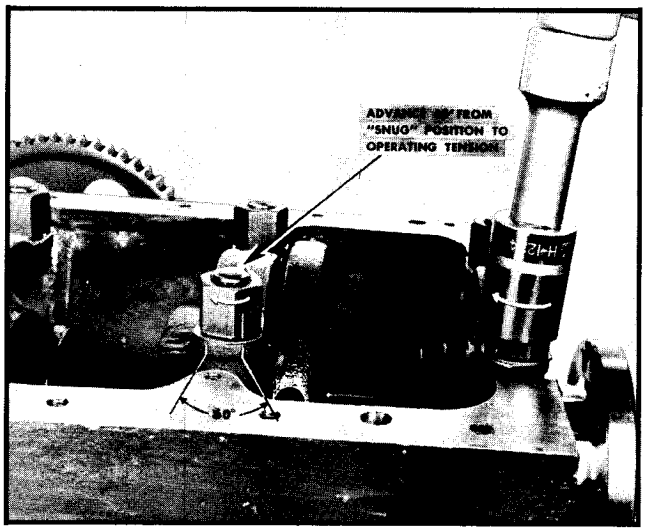


Fig. 12-8. Advancing nuts 60° from snug position to operation tension

MAIN BEARING REPLACEMENT—Crankshaft In Place

1. Remove oil pan.
2. Remove one main bearing cap and lower shell.
3. Turn crankshaft until drilled hole on main bearing journal is visible.
4. Insert a 7/32 inch by ½ inch pin with a head 3/32 inch thick into drilled hole of shaft.
5. Roll pin against shell on side opposite locking tang. Shell will turn out as crank is rotated.
6. Carefully remove all metal and clean oil passages in crankshaft and cylinder block.
7. Lay new shell in proper position on journal so when crankshaft is turned into position locking tang will fit into recess in block.
8. Use pin and rotate shaft to turn shell into position.
9. Replace lower shell and cap with locking tang in recess of cap.
10. Install a new lock plate and tighten capscrews or stud nuts by template method. See: TEMPLATE METHOD OF TIGHTENING, Page 12-2.
11. Check for free turning of crankshaft.
12. If necessary, replace remaining shells one pair at a time, in the same manner. If bearings have had considerable service, it is recommended that all be replaced so that the .002 maximum variation in oil clearance between adjacent main bearings and journals is not exceeded.
13. Check crankshaft end clearance.

CRANKSHAFT END CLEARANCE

1. Attach dial indicator securely to cylinder block with contact point of gauge resting on crankshaft flange end face.
2. With a small bar, pry crankshaft toward front end of engine, then remove pry bar.
3. Set gauge at "0."
4. Pry crankshaft towards rear of engine and remove pry bar.

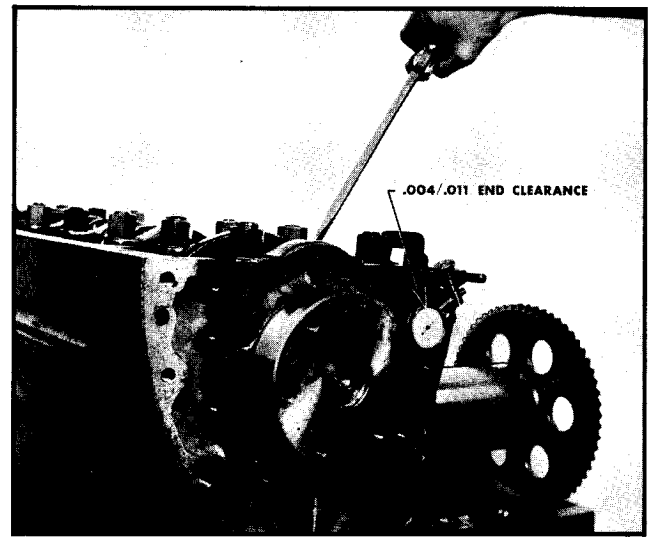


Fig. 12-9. Checking crankshaft end clearance

5. Total gauge reading should be 0.004 to 0.011 inch, with a *new* crankshaft and thrust rings.
6. If reading is less than 0.004:
   a. Loosen bearing cap capscrews slightly.
   b. Shift crankshaft first toward front and then toward rear of engine.
   c. Retighten capscrews by template method.
   d. Recheck clearance, Steps 1-5.
7. Maximum wear limit for end clearance is .022. After this, thrust bearing or crankshaft must be replaced. Ten-thousandths oversize thrust rings (Part No. 112433) may be used if necessary to obtain proper end clearance, but they must be used in pairs only.

NOTE: After checking end clearance, lock main bearing caps by bending lock plate against side of capscrew head or nut.

8. Turn crankshaft with a flywheel dowel to be sure that it's free. If it doesn't turn easily, remove crank and recheck for dirt or burrs in shells or bore. NEVER REAM OR SCRAPE MAIN BEARING SHELLS!

ONE PIECE REAR COVER

Installation

1. Coat one-piece seal with Lubriplate (Type 130 AA) or equivalent lubricant.

2. Press seal into rear cover:
   a. Use a flat plate, larger than seal outside diameter.
   b. Lay rear cover, mounting face down, on an arbor press table.
   c. Install seal "open" side down and with rear of seal flush with rear of cover.

3. Fill cavity between seal lips with Lubriplate No. 907.

4. Cement a new cover-to-cylinder block gasket on cylinder block.

5. Clean crankshaft chamfer outside diameter; a burr on the chamfer would cut seal and cause a leak.

6. Attach ST-558 Rear Seal Pilot Tool to crankshaft.

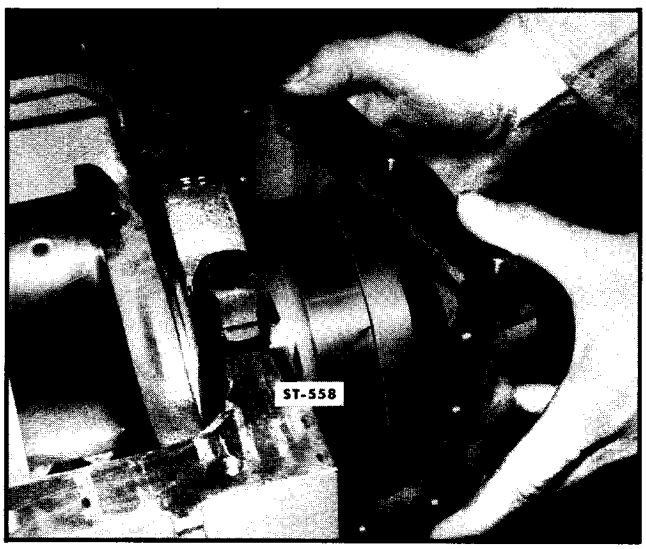


Fig. 12-10. Installing rear seal

7. Slide rear cover and seal assembly into position over tool.

8. Tighten rear cover in place so its oil pan surface is flush with pan surface cylinder block. Fig. 12-11.

9. Trim off any excess rear cover-to-block gasket.

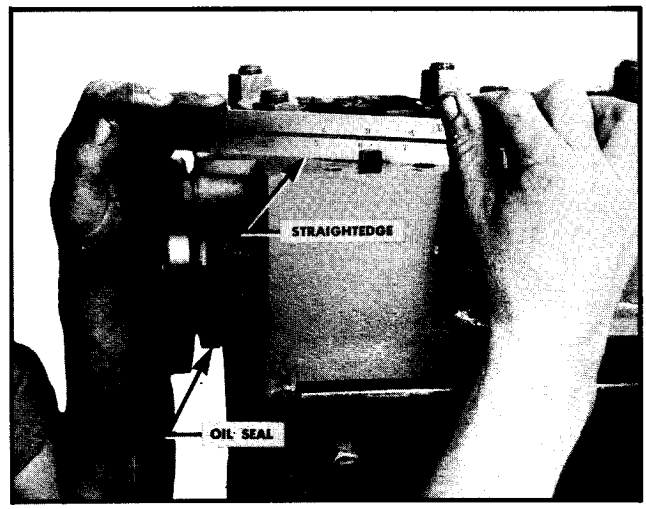


Fig. 12-11. Checking rear cover plate alignment

SPLIT-SEAL REAR COVER—Used With Crankshaft Part Nos. 11054-1 and 10974-1

1. Clean crankshaft thoroughly with crocus cloth to smooth out any rough places in seal area. Wipe with clean rag.

2. Hook spring from oil seal around crankshaft rear cover journal; use pair of needle nose pliers and do not over-stretch spring as it is installed.

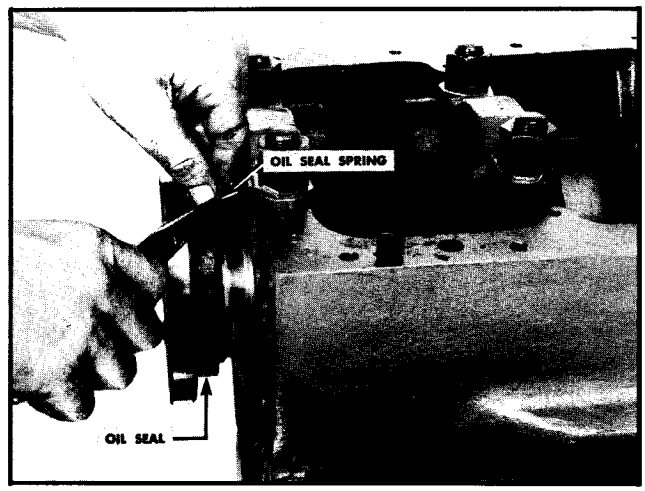


Fig. 12-12. Installing rear cover seal spring

3. Apply Lubriplate (Type 130 AA) to seal area of crankshaft and to surfaces of oil seal.

4. Assemble oil seal to crankshaft with lip side (grooved or spring side) toward block and with "split" to top of block.

5. Roll spring into position inside oil seal groove.

6. Make sure seal lip has no cuts or creases which would prevent sealing.

7. Cement new gaskets to joining surfaces of upper cover plate-half.

8. Cement a new gasket to block.

9. Install lower rear cover half; tighten capscrews only tight enough to prevent plate from slipping.

10. Check alignment of milled surface of bottom of lower plate-half with bottom surface of block. Clearance between crankshaft and rear cover with crankshaft in extreme rear position should be .004 to .006 inch. Install additional gaskets as required to obtain clearance.

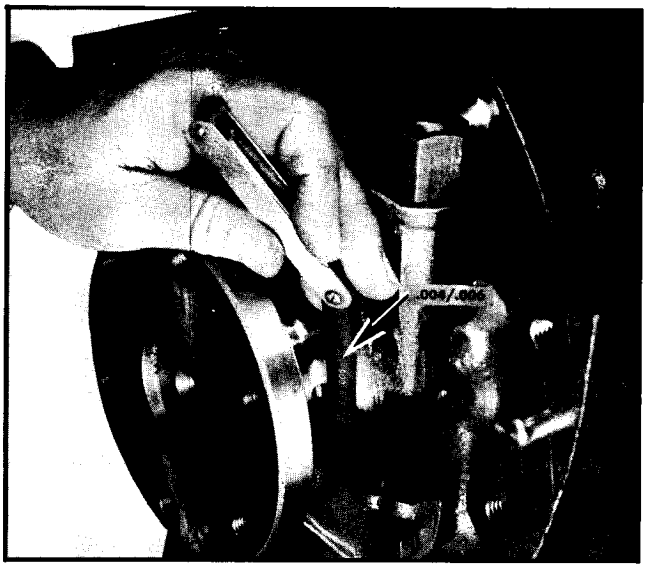


Fig. 12-13. Checking rear cover clearance

11. Assemble and tighten upper and lower rear cover plate-halves together with two dowel fit bolts, lockwashers, and nuts.

12. Repeat straight edge check to be sure bottom surfaces of cover plate and block are in alignment.

LINERS, PISTONS, RODS

LINER-BLOCK INTERFERENCE

1. Place liner, without packing rings, in block.
   a. It should drop into position.
   b. The liner must seal freely.
   c. Test for clearance by shaking.
   d. If no detectable clearance, remove liner and check for rust or corrosion on liner or block.
   e. Remove interference.

2. Check clearance around entire circumference of block counterbore and top liner flange. Minimum clearance is .0015.

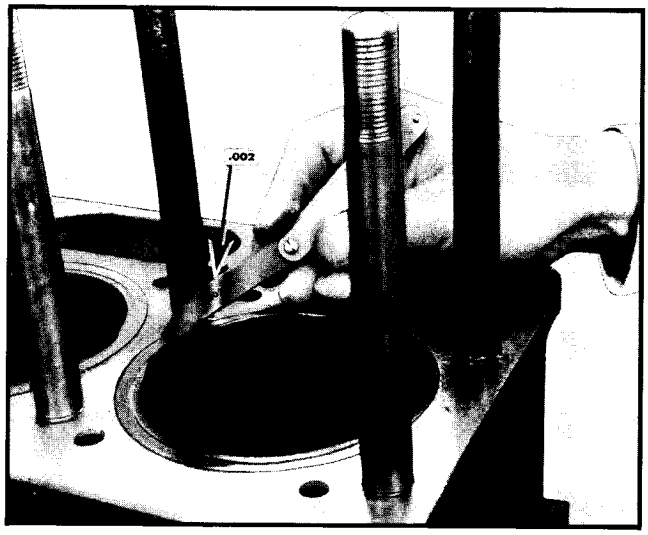


Fig. 12-14. Clearance at top of liner

   a. If clearance is not present, remove liner and scrape counterbore at points of binding until proper clearance is obtained.

3. Check cylinder liner counterbore flange seat.
   a. Apply a light coat of Prussian blue to liner flange.
   b. Check seat. A good seat should be indicated next to liner wall.
   c. If check shows a seat only on outer portion of liner flange, lap liner flange to counterbore. See Section 2.

SET LINER PROTRUSION

1. Place liner in block without shims or packing rings.

2. Place ST-547 Gauge Block across liner.

3. Depress indicator stem until point rests on flat surface of liner *outside bead.* Fig. 12-16.

4. Set indicator to "zero" with indicator point in contact with liner.

5. Move gauge block out so indicator point contacts deck about ⅛ inch from edge of liner.

6. Repeat check on liner surface inside bead.

7. Determine approximate number of shims necessary to bring liner protrusion to .0045 to .00675 inch measured from *highest point* (either inside or outside bead).

8. Remove liner.

9. Assemble shims in proper thickness.
   a. .004, .005, .006, .007, .008, .009, .020, .031 inch shims are available.
   b. Use as few shims as possible.

10. Insert liner and shims into block.

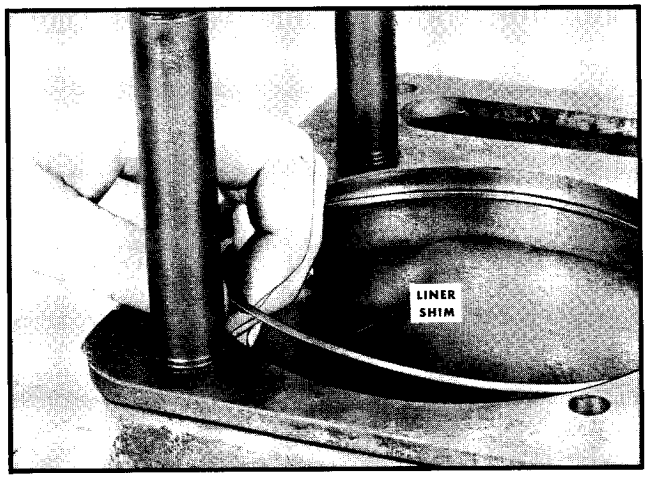


Fig. 12-15. Shims to maintain liner protrusion

11. Place four spacers from ST-543 Pressure Tool in position with liner hold-down pads against top of liner. *Make sure that pads do not contact liner bead.*
12. Assemble cylinder head capscrews and tighten to 40 foot-pounds torque.
13. Gauge liner protrusion. (Steps 2 to 7.)

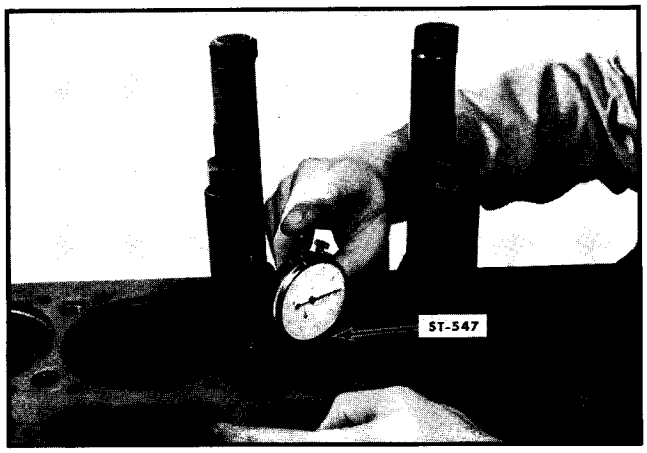


Fig. 12-16. Gauging cylinder liner protrusion

a. Check protrusion at four equidistant points to determine if liner protrusion is uniform and 0.0045 to 0.00675 inch measured from *highest* point (inside or outside the bead).
b. *Protrusion between adjacent liners should be within 0.001 inch.*

14. Remove liner from block.

CYLINDER LINER INSTALLATION

1. Assemble rubber packing rings.
   a. Lubricate packing rings with clean lubricating oil or ball bearing grease.
   b. Roll each liner ring into position.
2. Use clean lube oil to lubricate machined portions of block on which the rings seat.

JN, JNS, JT Liners or Other Liners using ST-437

1. Set liners in block with valve recesses in center. See Page 12-8.
2. Push liners into place.
3. Check liner bore with dial bore gauge. If liner is more than .001 inch out-of-round, pull liner and remove interference causing distortion.

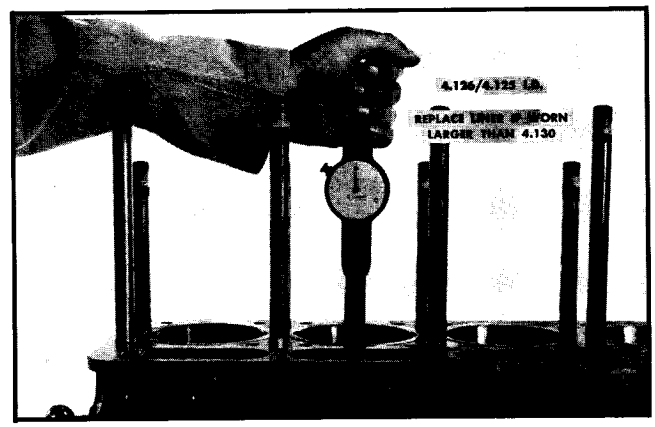


Fig. 12-17. Checking cylinder liner wear

CONNECTING RODS AND PISTONS

1. Heat piston in boiling water.
2. Push pin into place through piston and rod before piston cools.
3. Secure piston pin with snap rings at each end. Make sure rings are seated in grooves.

Fig. 12-18. Installing piston pin

PISTON RINGS

1. Lubricate pistons and rings with clean lubricating oil.
2. Assemble rings; stagger ring gaps so that they are not in line with each other or with piston pin.

PISTON, ROD ASSEMBLY

1. Lubricate pistons, rings and liners with clean lubricating oil.
2. Compress rings with band-type ring compressor.
3. Remove "U" bolts and bearing cap from connecting rod. THESE PARTS ARE NOT INTERCHANGEABLE.
4. Snap upper and lower connecting rod bearing shells into position.
5. Apply Lubriplate (Type 130 AA) to connecting rod bearing.

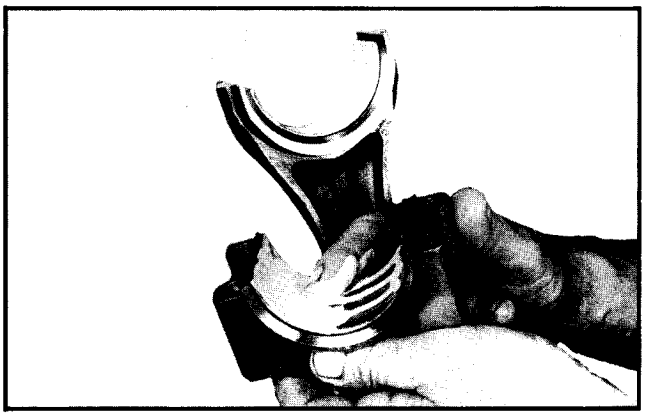


Fig. 12-19. Applying Lubriplate to rod shells

6. Push piston and rod into cylinder liner supporting connecting rod to prevent scratching.
   a. Center crankshaft throw of cylinder.
   b. Match cylinder and number stamped on rod; locate number toward the camshaft.
   c. Push rod and piston down to contact crankshaft.
   d. Avoid turning assembly in liner.
7. Assemble "U" bolts in their original position.
   a. No. 1 "U" bolt toward rear.
   b. No. 2 "U" bolt toward front.
   c. The number is to camshaft side of engine.

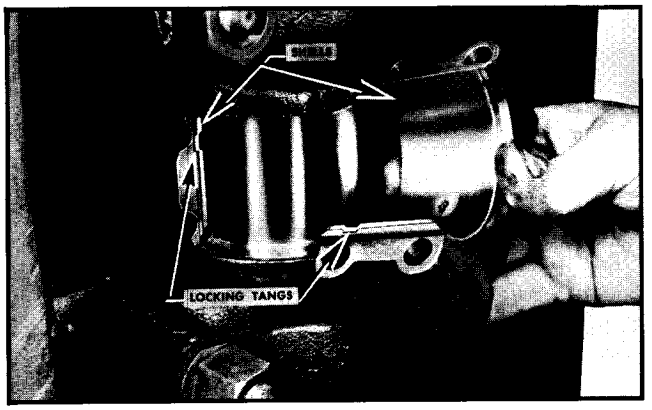


Fig. 12-20. Location of locking tangs and milled recess in rod and cap

8. Install connecting rod bearing cap so sides of rod and cap are in line.
9. Assemble "U" bolt nuts and lock plates; oil threads and lock plates with clean lubricating oil.
10. Align rod and cap.

TIGHTENING CONNECTING ROD NUTS

1. Tighten "U" bolt nuts alternately in 5 foot-pound steps to 30 foot-pounds.
2. Loosen nuts completely.
3. Retighten nuts alternately in 5 foot-pound steps 10 to 15 foot-pounds.
4. Check and align rod and cap. If necessary, strike cap a light blow with a plastic or rawhide hammer.
5. Continue tightening operation to 30 foot-pounds.

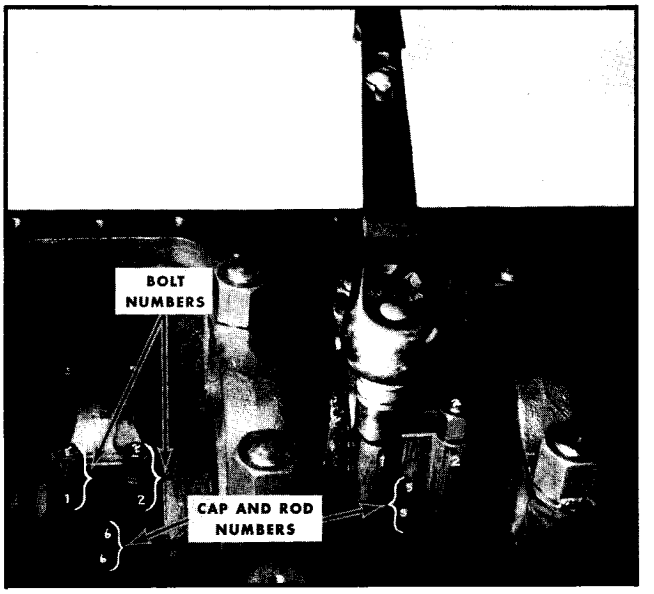


Fig. 12-21. Tightening U-bolt nuts

6. Mark nut.
7. Advance each nut 60° (one hex) in steps of 30° to prevent misalignment.
8. Check nuts in a clockwise direction with a torque wrench. If *less than* 38 foot-pounds is required to break any nut loose after above setting, replace "U" bolt.
9. Lock nuts in position with lock plates.
10. Recheck side clearance on both sides of the assembly and completely around crankshaft journal. In any case it should not be less than .006 inch. Fig. 12-22, Page 12-8.
11. Check for a minimum clearance of .020 between rod and piston boss.

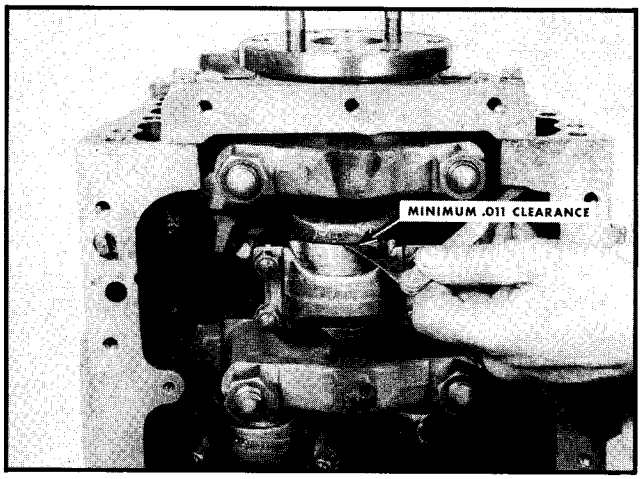


Fig. 12-22. Checking clearance between rod and crank

INSTALLING PISTON AND ROD ASSEMBLY (J, JF, JS) WITH ST-437

When available, ST-437 should be used to install JS piston and rod assemblies after the liners are in place. See Page 12-6.

1. Place ST-437 in installed liner.
2. Insert piston assembly through liner and tool.

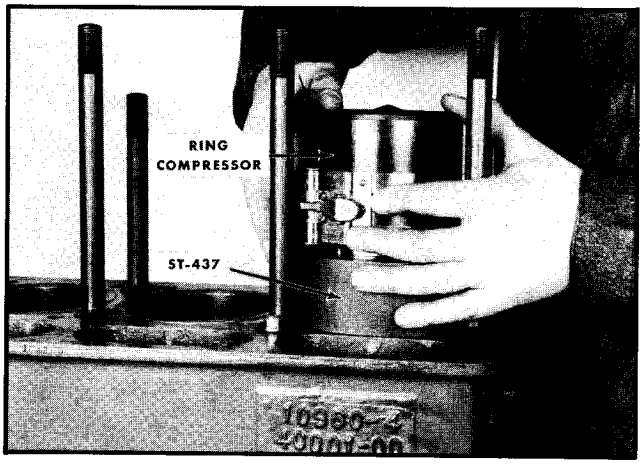


Fig. 12-23. Installing piston-rod assembly with ST-437

3. Push rod and piston to contact the crankshaft.
4. Assemble and tighten rod bearing cap and "U" bolts. See: "Tightening Connecting Rod Nuts," Page 12-7.

INSTALLING LINER, PISTON AND ROD ASSEMBLIES (J, JF, JS) WITHOUT ST-437

If ST-437 is not available the following procedure must be followed to install the piston and rod assembly and liners as a unit.

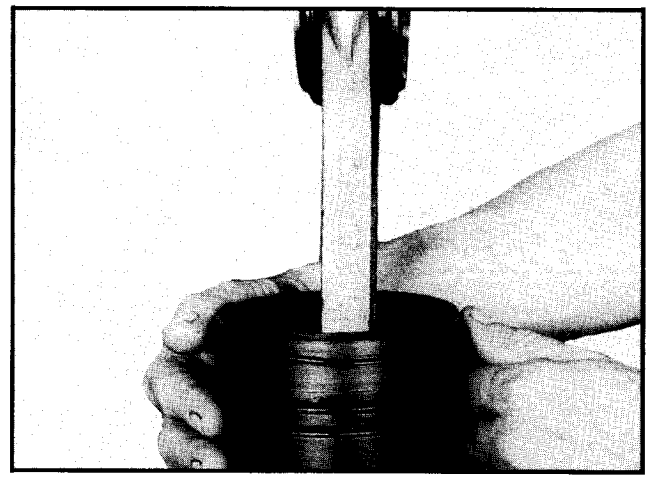


Fig. 12-24. Assembling rubber packing rings

1. Locate piston and rod in liner so that numbered side of rod is on camshaft side of engine and perpendicular to centerline of valve recesses.
2. Lubricate packing rings of liner and machined portions of block with lubricating oil.
3. Assemble packing rings.
4. Snap upper and lower connecting rod bearing shells into position in rod and cap bores.
5. Coat connecting rod bearing shells with Lubriplate.

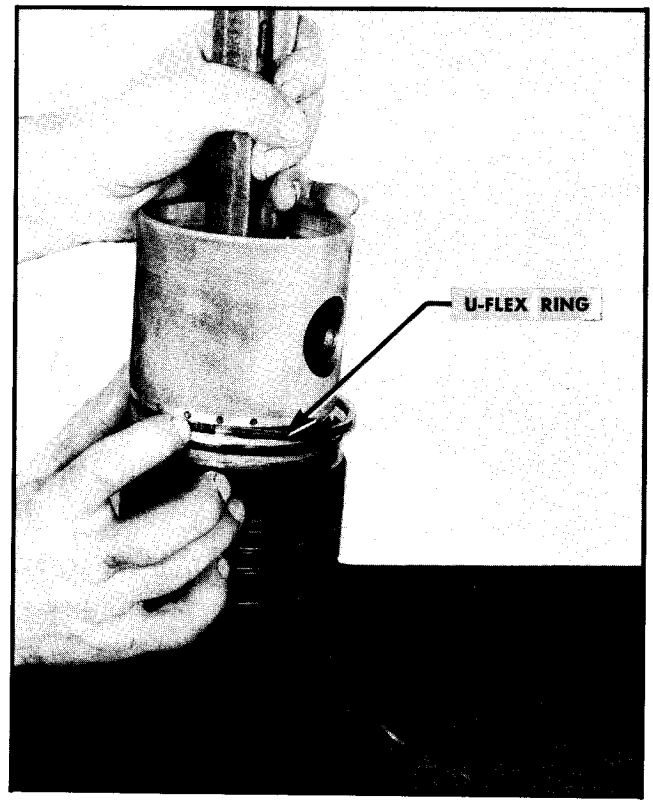


Fig. 12-25. Inserting piston into liner

6. Coat piston with lubricating oil.

7. Slide standard ring compressor over piston and rings.

8. Butt the ends of U-Flex rings together; *do not* overlap, file or grind.

9. Insert piston and rod assembly through bottom of liner.

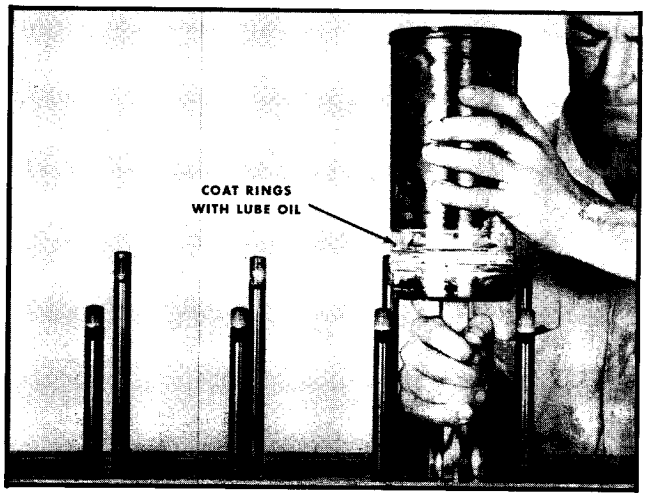


Fig. 12-26. Inserting liner, piston and rod

10. Chalk mark top of liner at center of valve recesses before pushing it into place. Center mark on liner at valve recesses with scribed line on block.

11. Push liner into position in block bore.

12. Assemble rod bearing caps. See: "Tightening Connecting Rod Nuts," Page 12-7.

GEAR CASE MOUNTING PLATE

1. Assemble a new plate-to-block gasket.

2. Mount plate over dowels.

3. Install three mounting capscrews and lock washers. Older model engines with cast iron plates must have countersunk capscrews peened in place.

4. On engines without an idler or supercharger drive gear, make sure a capscrew is installed in the "idler shaft mounting" hole which opens into an oil drilling.

IDLER SHAFT

If idler shaft is to be replaced, mount with three capscrews. Locate so oil hole indexes with drilling in block.

CAMSHAFT

1. Lubricate all cam bushings.

2. Rotate cam while installing it in block to allow lobes of cam to pass through camshaft bearings.

3. Index "0" on camshaft gear with "0" on crankshaft gear. This is Number 1 top center firing position. Fig. 12-27.

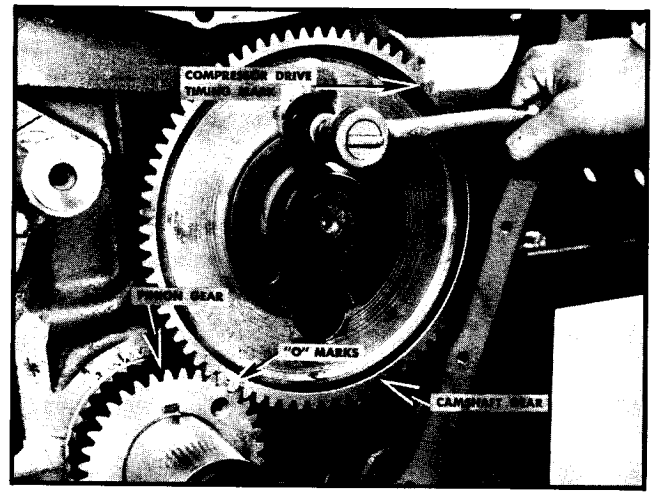


Fig. 12-27. Installing camshaft

4. Front bearing is fitted on camshaft between a shoulder on shaft and drive gear.

   a. After partially inserting camshaft in block, slip front bearing into bore of block.

   b. Tighten the two or three capscrews through openings in cam gear.

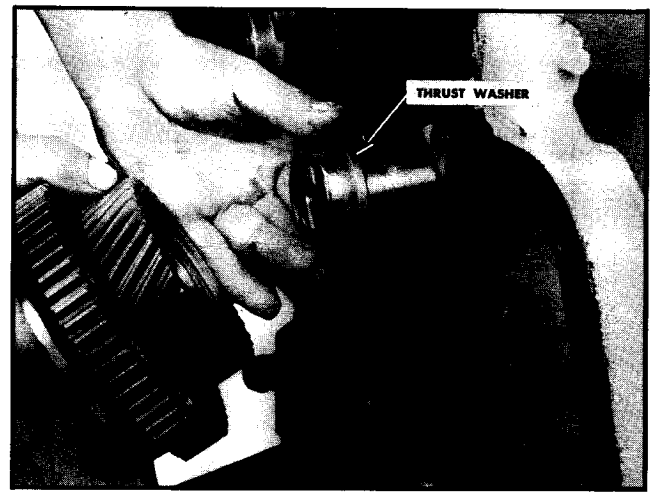


Fig. 12-28. Installing thrust washer and idler gear assembly

SUPERCHARGER IDLER GEARS (JS, JNS)

1. Install inner thrust washer.

2. Place combined supercharger idler and driven gear over idler pin.

3. Fit outer thrust washer to gear hub.

4. Bring cover washer in place by tightening capscrew over washer.

5. Check .007 to .019 clearance between thrust washer and gear.

6. Remove capscrew and cover washer; leave thrust washer in place against idler gear.

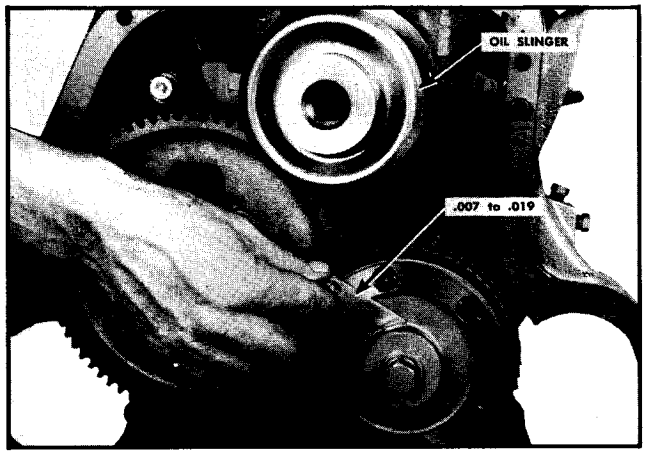


Fig. 12-29. Checking clearance between thrust washer and idler gear

OIL SLINGER

1. Mount oil slinger to crankshaft gear with two capscrews and lock plates.

2. Slinger must be cupped toward block.

CRANKSHAFT COUNTERBALANCER DRIVE GEAR (J-4)

1. Assemble counterbalancer gear to crankshaft gear; align timing marks on gears.

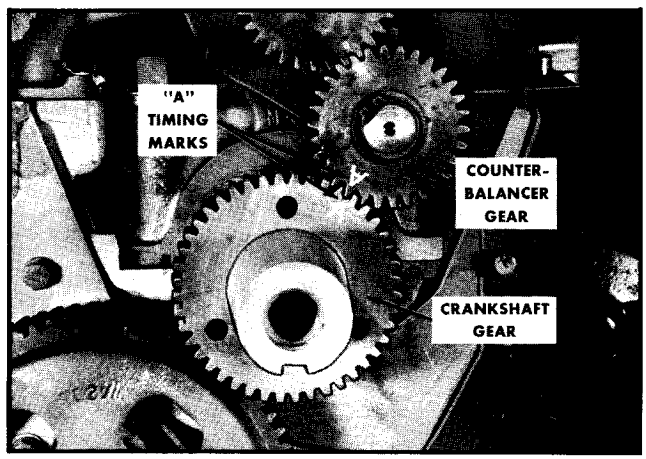


Fig. 12-30. Timing the J-4 counterbalancer

2. Tighten two capscrews; lock lockplates.

GEAR HOUSING

1. Press in steel encased double-lipped crankshaft seal with ST-480 to assure proper assembly. Coat seal with

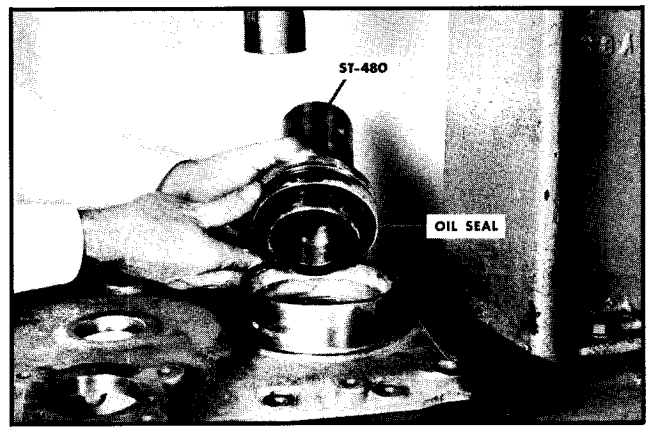


Fig. 12-31. Installing crankshaft seal in gear case cover

Lubriplate Type 130 AA; wide steel side of seal must go into bore first.

a. A leather-lip seal is used with power take-off applications and is pressed to bottom of crankshaft bore. Lubricate leather seal with lubricating oil.

b. Press fuel pump drive seal .080 to .100 below front surface.

2. Press fuel pump drive bearing into housing from back and flush with back surface.

3. Cement a new gasket to gear housing.

4. Mount housing to mounting plate; assemble capscrews and lock washers.

5. On JS gear housings, secure idler gear support washer and rubber "O" ring to idler shaft with capscrew.

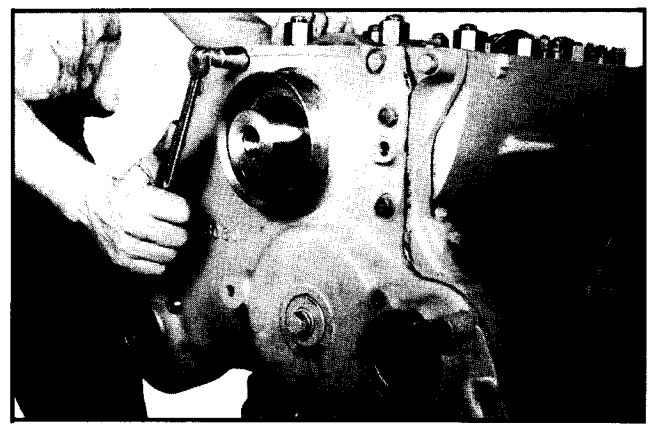


Fig. 12-32. Installing gear case cover

FUEL PUMP DRIVE GEAR

1. Remove plug from timing view hole.

2. Install fuel pump drive through gear housing oil seal and shaft bearing.

3. Align center punch mark on camshaft timing gear with the punch mark on fuel pump drive gear. Fig. 12-33.

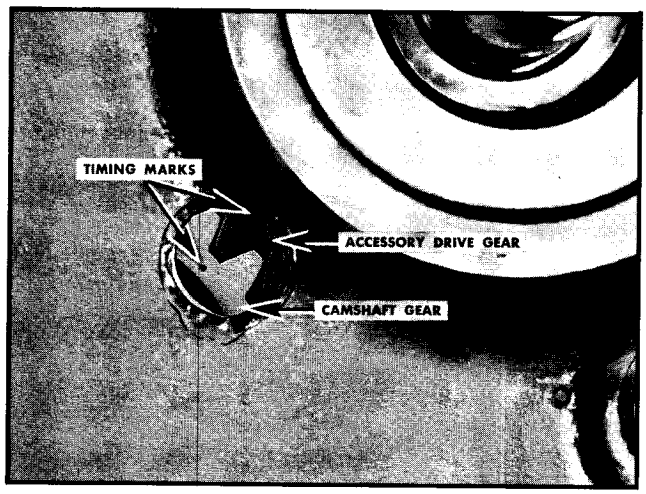


Fig. 12-33. Timing fuel pump drive gear to camshaft gear

4. Assemble mounting capscrews and lock washers; tighten.

5. Mount fuel pump drive pulley to shaft.
   a. Insert key.
   b. Drive on pulley, using lead hammer and heavy-wall tubing.
   c. Secure pulley with washer and lock nut.

VIBRATION DAMPER AND HUB

Cast Iron Flange

1. Mount flange hub to crankshaft.

2. Assemble retainer washer, lock washer, and large capscrew.

3. Tighten large capscrew 120 to 140 foot-pounds.

4. Assemble vibration damper, lock plates and capscrews to flange.

5. Tighten capscrews 35 to 45 foot-pounds.

6. Lock in place.

CAUTION: DO NOT MOUNT PULLEY ASSEMBLIES TO A CAST IRON DAMPER FLANGE OR TO ANY VIBRATION DAMPER.

Steel Flange

1. Mount vibration damper to flange.

2. Tighten capscrews 35 to 45 foot-pounds.

3. Lock capscrews in place.

4. Place key in crankshaft groove.

5. Mount damper and flange hub to crankshaft.

6. Assemble retaining washer, lock washer and larger capscrew.

7. Tighten large capscrew 120 to 140 foot-pounds.

8. Attach drive pulleys to flange. NEVER MOUNT A DRIVE TO THE DAMPER.

VALVE AND INJECTOR TAPPETS

1. Drop roller tappets into position. Injector tappets are larger and are placed between exhaust and intake tappets.

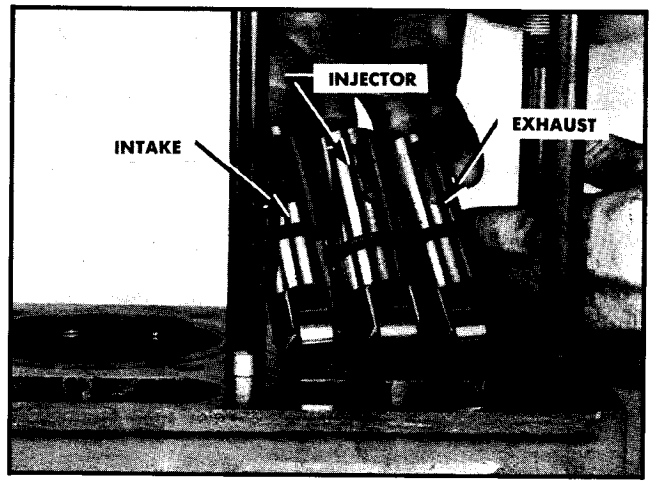


Fig. 12-34. Installing tappets

2. Align tappets and screw locking guides and copper washer into position.

3. Lock tappet guides with safety wire.

CYLINDER HEAD

1. Clean mating surfaces of cylinder block and head.

2. Check for burrs on outside edges of water and oil holes.

3. Install head gasket "TOP" up or next to cylinder head. Disregard Steps 4 and 5 if single piece gasket is installed.

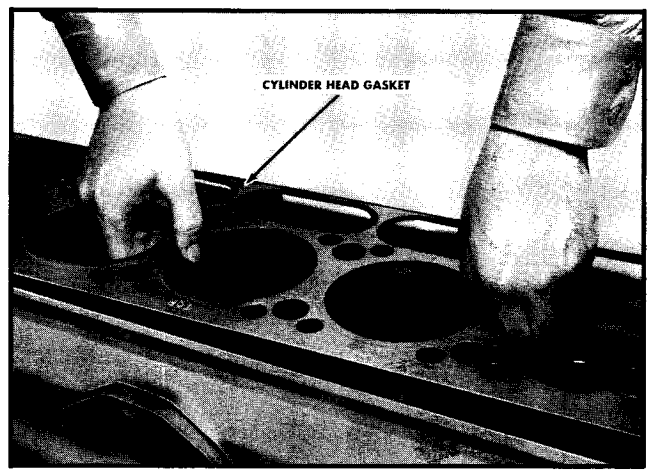


Fig. 12-35. Installing head gasket

4. Install grommets in gasket plate holes.
5. Place ferrules on grommets and center carefully.

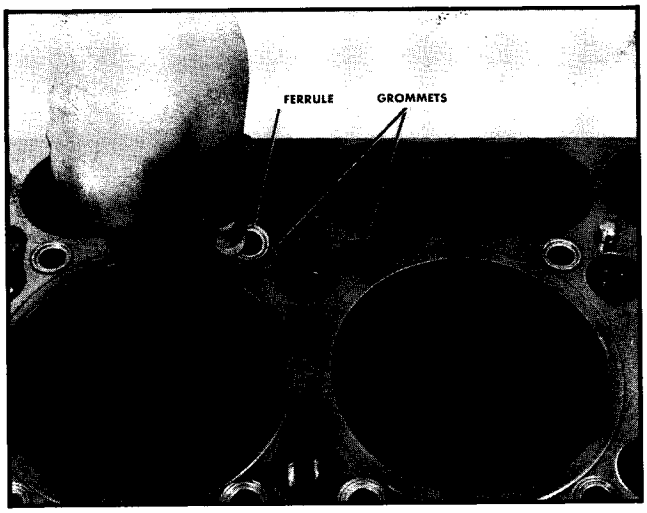


Fig. 12-36. Gaskets, grommets and ferrules

NOTE: A steel-plate gasket (6 cyl.) requires 24 grommets and ferrules.

6. Lower cylinder head over gasket and aligning dowels. Dummy stud bolts may be inserted to help align head during assembly.

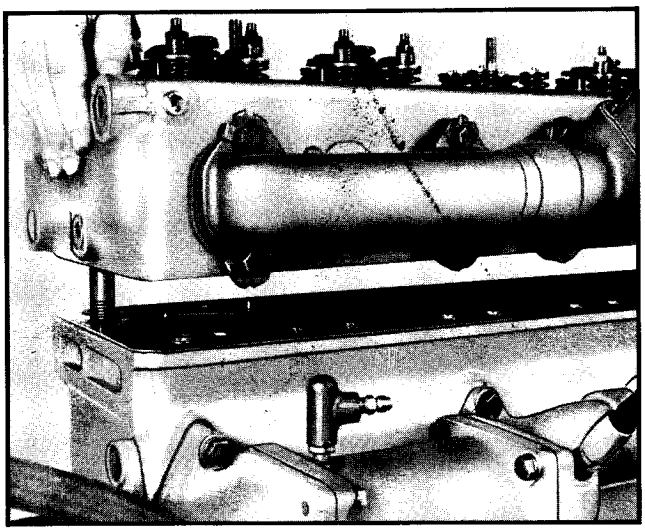


Fig. 12-37. Lowering head on gasket

7. Install oil transfer dowel. Fig. 12-38.

PUSH RODS

1. Insert push rods in tappets.

NOTE: Injector push rod is larger in diameter and is placed between the valve push rods.

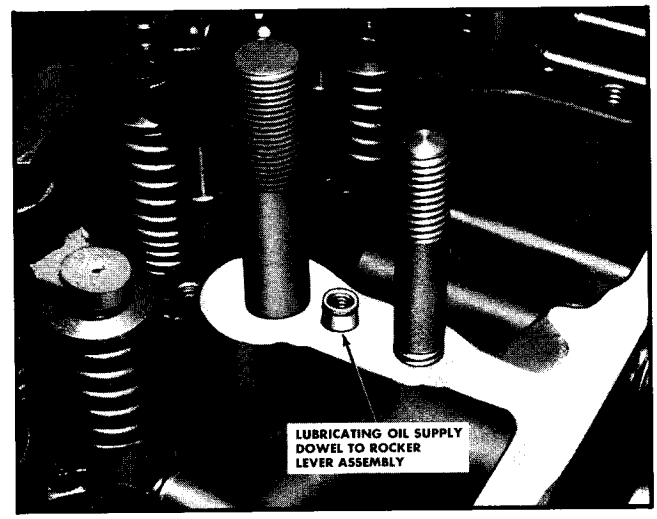


Fig. 12-38. Oil transfer dowel

2. If engine is equipped with a compression release, push rods with flanges are used at intake valves and must index with reliefs in shaft.

INJECTORS

1. Clean injector sleeves with a clean cloth wrapped around a wooden stick.

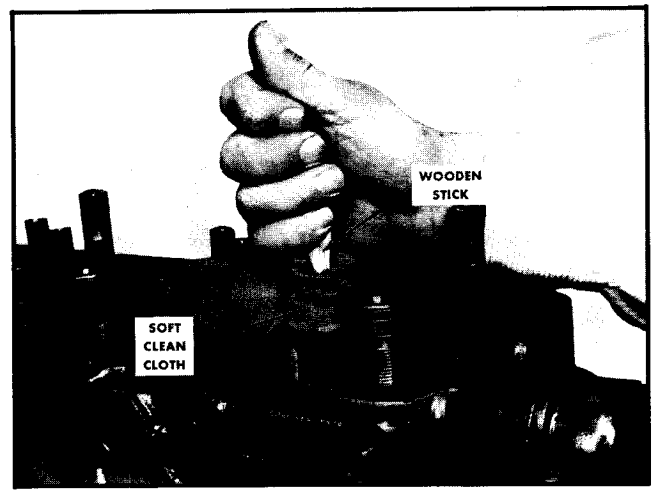


Fig. 12-39. Cleaning injector sleeves

2. Place injector in its proper position in cylinder head. CAUTION: DO NOT HIT OR BRUISE INJECTOR TIP.
3. Place new gaskets on fuel inlet and drain connections.
4. Place outlet connection in left hole.
5. Place inlet connection in right hole.
6. Start connections into injector; about three turns are needed to align injector body with fuel connections.

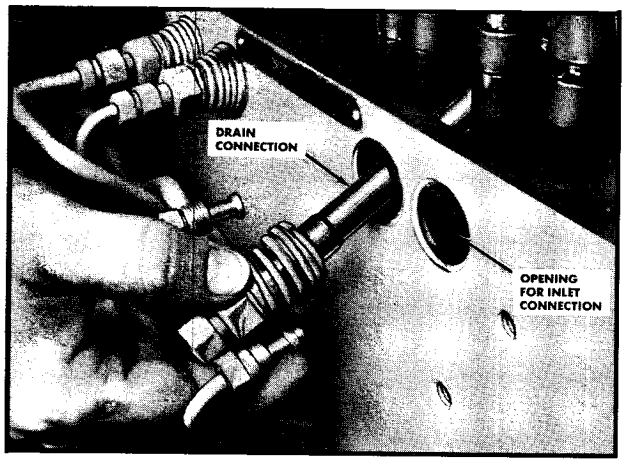


Fig. 12-40. Installing fuel drain connection

7. Install injector hold down capscrews.
8. Tighten capscrews *10* to *12* foot-pounds.

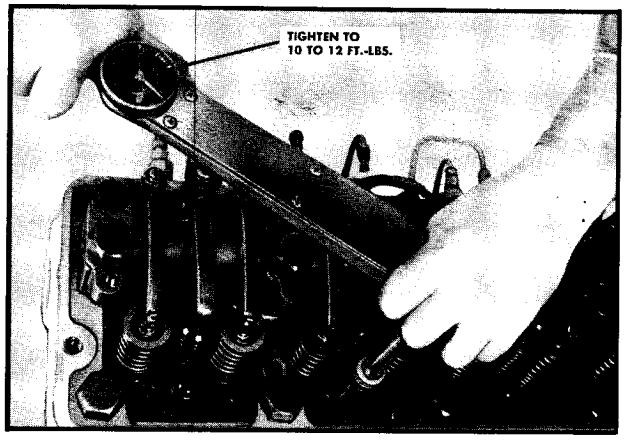


Fig. 12-41. Tightening hold-down capscrews

9. Tighten fuel inlet and drain connections *20* to *25* foot-pounds.

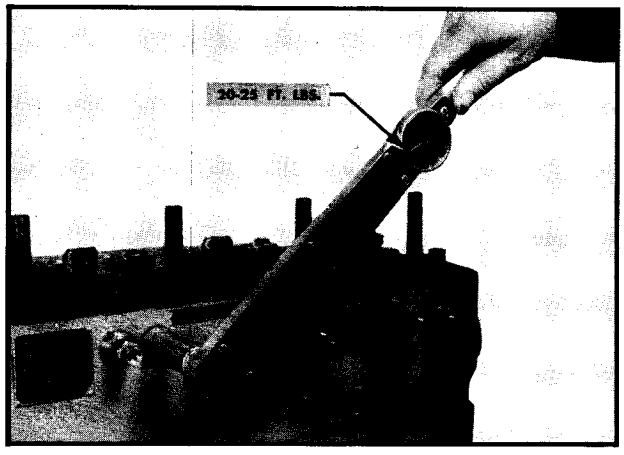


Fig. 12-42. Tightening inlet and drain connections

CROSSHEAD (JN, JNS, JT)

1. Install proper (right or left) crosshead in crosshead guide with adjusting screw to exhaust manifold side of head.

2. Install a valve crosshead retainer under crosshead adjusting screw nut.

ROCKER LEVER ASSEMBLY

1. Check center rocker shaft bearing to see that it has drilled dowel for oil transfer.

2. Mount rocker lever assembly on cylinder head; use a bar arrangement, as shown in Fig. 12-43, to hold rocker levers in place.

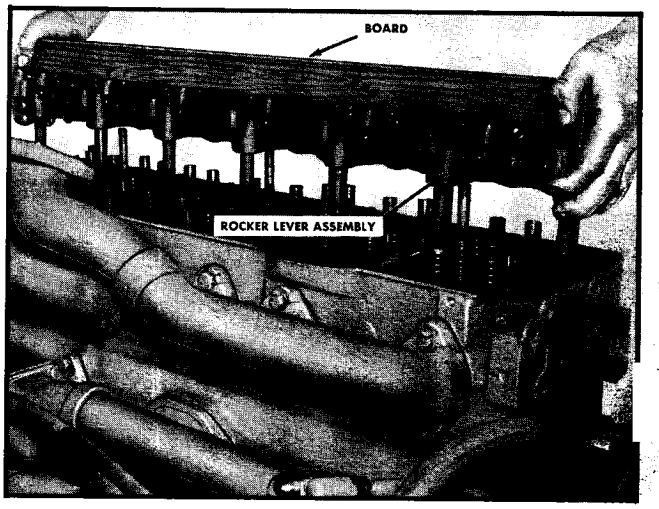


Fig. 12-43. Installing rocker lever assembly

3. Back off rocker lever adjusting screws.

4. Drive assembly over dowel pins with light blows of a soft hammer.

5. Assemble rocker lever shaft bearing capscrews and tighten securely.

CYLINDER HEAD CAPSCREWS OR STUD NUTS

3/4 Inch Capscrews or Stud Nuts

1. Lubricate capscrews or stud threads with clean lubricating oil.

2. Install washers and capscrews or stud nuts.

3. Tighten capscrews or stud nuts to 25 foot-pounds torque in sequence shown in Fig. 12-44, Page 12-14.

4. Check all rocker levers to be sure they are free.

5. Continue to tighten, in 100 foot-pound increments, to 300 foot-pounds.

6. Then, in 50 foot-pound increments, tighten to 400 foot-pounds.

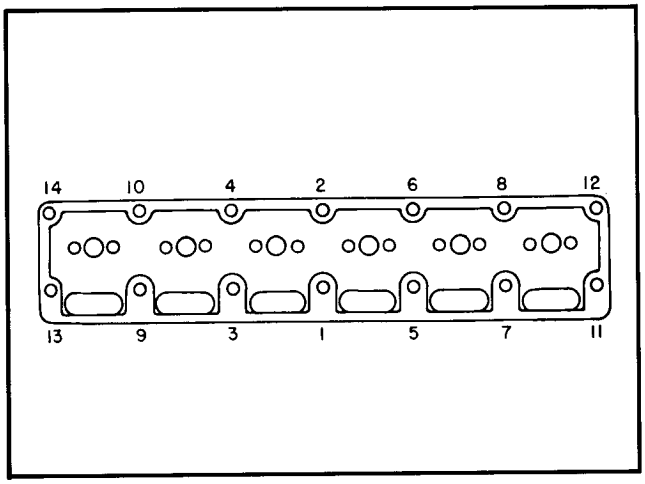


Fig. 12-44. Tightening sequence

11/16 Inch Capscrews or Stud Nuts

1. See Steps 1-4 of 3/4 INCH CAPSCREWS.

2. Continue to tighten, in 50 foot-pound increments, to 250 foot-pounds.

CAUTION: A REPLACEMENT CAPSCREW SHOULD HAVE THE SAME PART NUMBER AS THE ORIGINAL.

INJECTOR AND VALVE ROCKER LEVERS

After a cylinder head has been installed and tightened into position, check the rocker levers to make sure they are not binding. Tightening the long cylinder head capscrews sometimes shifts the rocker lever shaft bearings causing levers to bind.

Binding levers can be freed as follows:

a. Shift each set of injector and valve rocker levers toward the rear of the engine and against rocker lever shaft bearings.

b. Measure the clearance between rocker levers and rocker lever shaft bearings.

c. If the clearance is less than .009 inch, machine stock from the injector rocker lever to increase clearance to .025 inch. *Be sure to remove an equal amount of stock from each side of the lever so it will locate properly when installed on the shaft.*

d. If there is evidence that the valve rocker levers are galled, machine enough stock from both sides of the levers to smooth the surface.

e. Clean levers thoroughly of all cuttings to prevent damage to other engine parts.

SUPERCHARGER (JS, JNS)

1. Do not remove masking tape over inlet and outlet connections of supercharger until these connections are to be assembled.

2. Make sure locating dowels are in gear case.

3. Place a rubber "O" ring over oil supply ferrule.

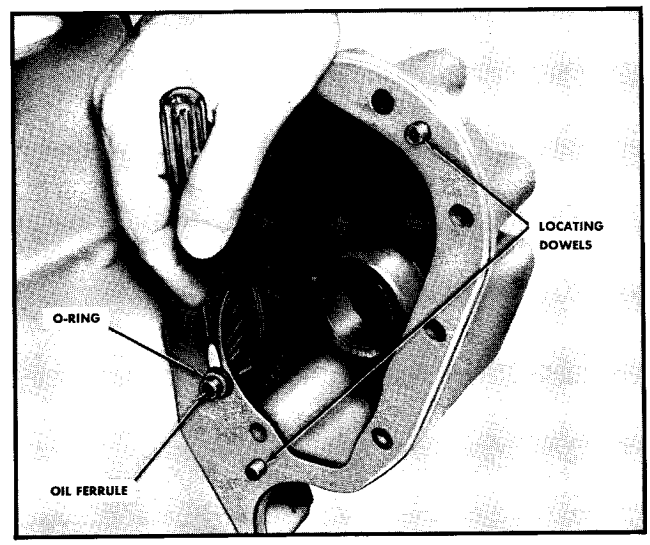


Fig. 12-45. Supercharger locating dowels and oil ferrule

4. Slip a new "O" ring over flange on intake manifold.

5. Shellac a new gasket to supercharger.

6. Lift supercharger to the back of gear housing.

7. Mesh drive gear with idler driven gear and assemble supercharger to gear housing cover.

8. Insert seven capscrews through front of gear housing and tighten securely.

INTAKE AND EXHAUST MANIFOLD (J, JS, JF)

1. On JS engines, remove masking tape from supercharger outlet connection and assemble supercharger-to-intake-manifold connecting band loosely over supercharger, Fig. 1-10, Page 1-4.

2. Install new gaskets over cylinder head port holes.

3. Assemble intake manifold over dowel pins and against head.

4. Place two manifold clamps on each side of glow plug.

5. Place exhaust manifold in its position against cylinder head.

6. Assemble remaining manifold clamps and nuts on ½-inch diameter studs between each exhaust and intake port.

7. Tighten to 45 foot-pounds in 20 foot-pound increments.

8. On JS engines, position supercharger-to-manifold connecting band.

NOTE: When washers or lock plates are used, ultimate torque must be reduced to 30 foot-pounds.

9. Tighten airplane clamp securely.

SUPECHARGER OUTLET TO CROSSOVER CONNECTION (JNS)

Mount supercharger outlet to crossover pipe to supercharger.

SUPERCHARGER AIR INTAKE

1. Remove masking tape from supercharger intake.
2. Position air intake connection to supercharger with four capscrews and lock washers.
3. Tighten capscrews securely.
4. Install vapor suction connection to air intake.

WATER PUMP (JS, JNS) (Outlet to Oil Cooler)

1. Assemble a new "O" ring on oil cooler connection.
2. Attach connection to water pump with a capscrew and lock washer.
3. Install a new rubber "O" ring on water by-pass coupling.
4. Assemble water pump and a new gasket to supercharger.

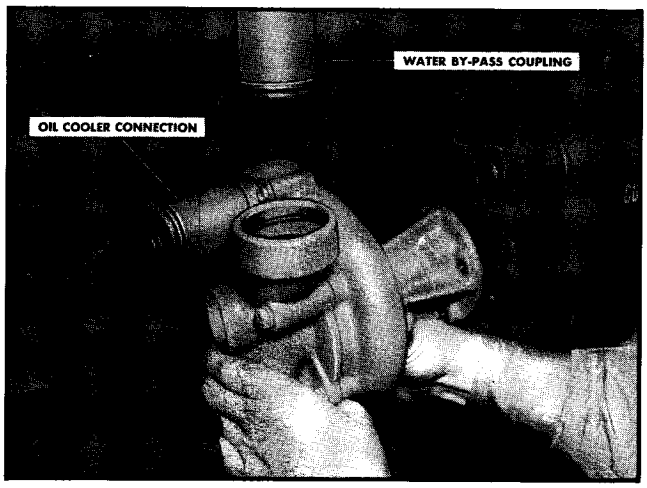


Fig. 12-46. Water pump—supercharger driven

5. Install mounting capscrews and lock washers; tighten securely.

WATER PUMP (BELT DRIVEN)

1. Lift pump into position.
2. Install mounting capscrews and lock washers that hold pump.
3. Adjust belt tension. See Page 12-27.

OIL COOLER

1. Install new "O" rings on oil cooler connection.
2. Assemble connection.
3. Position oil cooler and new gaskets to block with mounting capscrews and lock washers.
4. Tighten securely.
5. Mount oil by-pass drain line from cooler to block.

WATER PUMP AND FAN PULLEY (J-4)

1. Assemble new gasket, lock washers and capscrews to water pump.
2. Mount pump to engine.

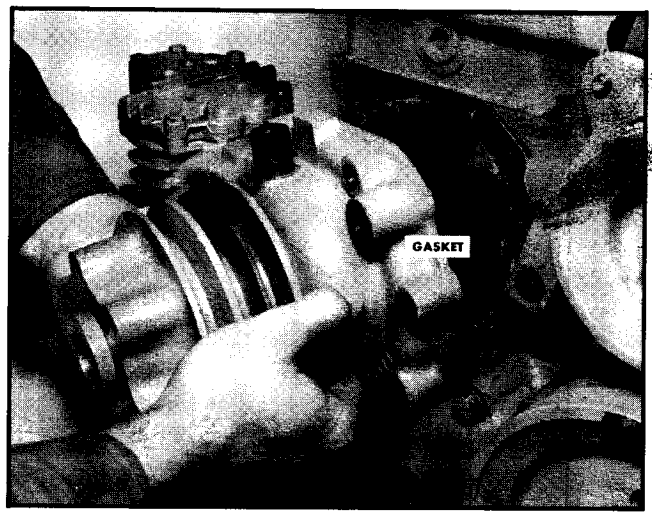


Fig. 12-47. Installing J-4 water pump

EXHAUST MANIFOLD

JN, JNS Exhaust Manifolds (7/16 Dia. Studs)

1. Install gaskets on studs and dowels.
2. Mount manifold, clamps and nuts to engine.
3. Torque all nuts to 40 foot-pounds in 20 foot-pound increments.

NOTE: When washers or lock plates are used under nuts, ultimate torque must be reduced to 25 foot-pounds.

JT EXHAUST MANIFOLDS (3/8 Mounting Capscrews)

1. Leave both manifold dowels in head.
2. Assemble washers, lock plates and capscrews to manifold.
3. Mount manifold to head; install bottom capscrews approximately two turns.
4. Drop gaskets in from top.
5. Install top capscrew to hold gasket in place.
6. Tighten all capscrews to 10 foot-pounds.
7. Alternately, tighten capscrews to 22 foot-pounds.
8. Lock capscrews into place.

JT EXHAUST MANIFOLDS (3/8 Dia. Studs)

1. Install gaskets between manifold studs.
2. Mount manifold and manifold clamps and nuts to studs.
3. Tighten nuts on each clamp to 25 foot-pounds in 10 pound increments.
4. Lock nuts in place.

THERMOSTAT HOUSING AND WATER BY-PASS

1. Install new "O" rings on water by-pass connection.
2. Assemble thermostat housing and by-pass connection to cylinder head.
3. Tighten mounting capscrews.

NOTE: The by-pass to water pump hose connection on JS engines must be assembled with a shield to protect it from the hot exhaust manifold.

4. Install air bleed line from thermostat housing to water pump.

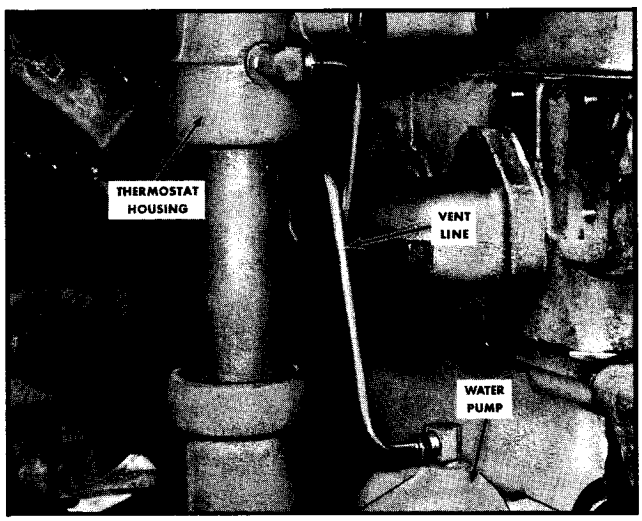


Fig. 12-48. Air bleed line from water pump to thermostat housing

OIL BY-PASS DRAIN LINE

Turn engine upside down in stand. Assemble the oil by-pass drain line and bracket to the bottom of the block on the camshaft side of the engine. Tighten the drain line and bracket with lock plates or lock wire and three capscrews. Fig. 12-49.

NOTE: Tighten the drain line to the cylinder block first and then tighten the bracket clamp screw. This eliminates the possibility of the drain line binding between the bracket and the mounting flange.

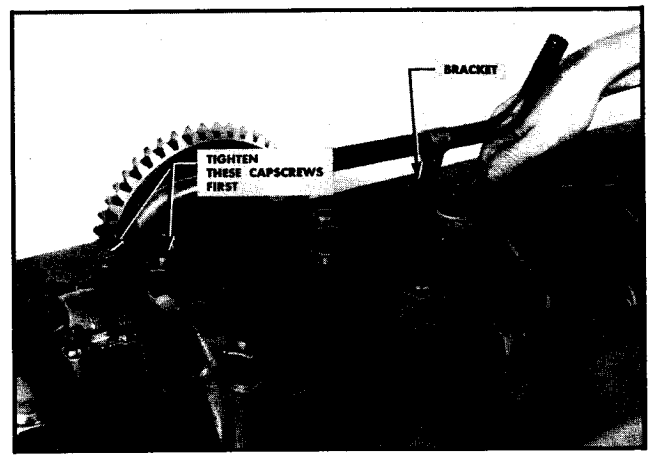


Fig. 12-49. Installing oil by-pass drain line

LUBRICATING OIL PUMP
Single Assembly

1. Assemble lock plates, capscrews and new gasket to suction tube.
2. Mount suction tube to pump; tighten capscrews finger tight.
3. Attach hanger straps to suction bell; screw lock nuts to within one turn of being tight.

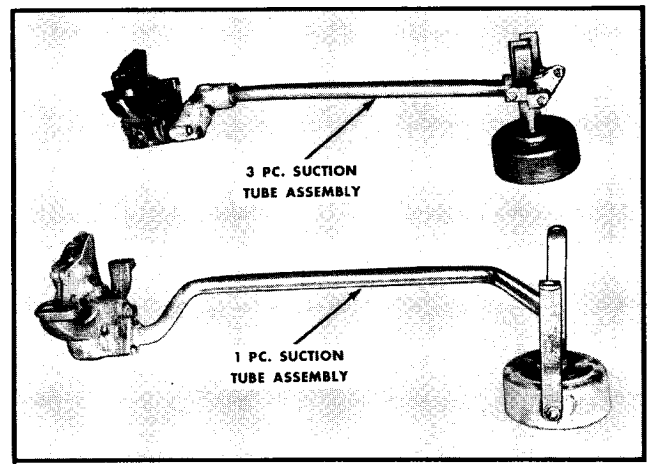


Fig. 12-50. Old and new style suction tube assemblies

4. Mount lube pump, suction tube and straps to engine.
5. Tighten three lube pump mounting capscrews securely.
6. Tighten strap-to-block capscrews finger tight.
7. Check suction tube for misalignment.
8. Tighten tube-to-pump capscrews.
9. Tighten hanger straps-to-suction tube bell lock nuts.
10. Tighten strap-to-block capscrews.
11. Check all capscrews; lock all lock plates.

Three-Piece Assembly

1. Check No. 1 main bearing cap for a ground off 1/16 inch clearance for the lube pump.
2. Mount lube oil pump to block.
   a. Mesh idler gear in place.

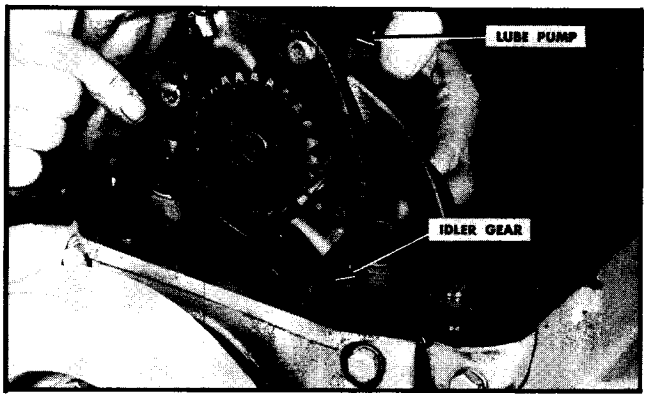


Fig. 12-51. Installing lubricating oil pump

   b. Slide pump over dowel pins.
   c. Tighen capscrews.
   d. Bend lock plates into position.
3. Mount suction tube assembly in position to cylinder block.
4. Install suction tube support and gasket to lube pump.

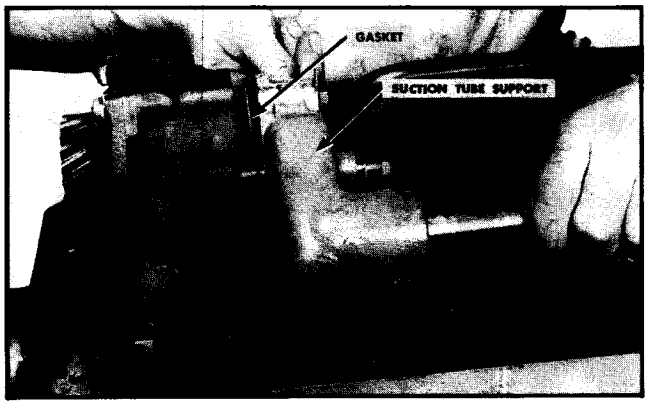


Fig. 12-52. Assembling suction tube to pump

5. Mount suction screen bracket to cylinder block.
6. Check for interference between crankshaft counterbalances and suction tube assembly.

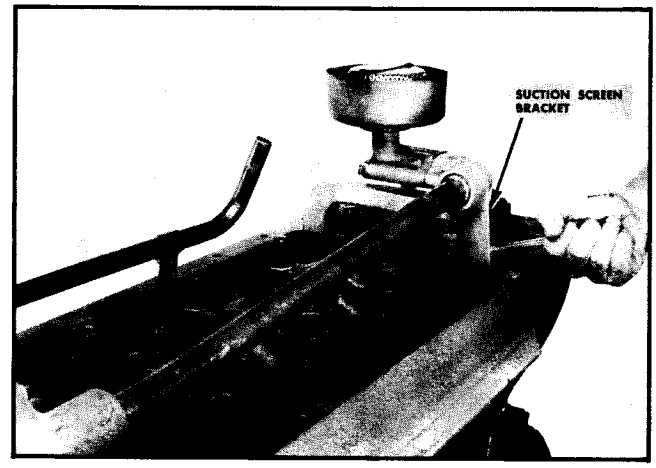


Fig. 12-53. Tightening suction screen bracket

LUBRICATING OIL PUMP (J-4)

1. Bar engine to 1/TC mark on accessory drive pulley.
2. Position housing assembly over dowels on block and install capscrews and lock plates.
3. Align timing marks of all gears on unit.

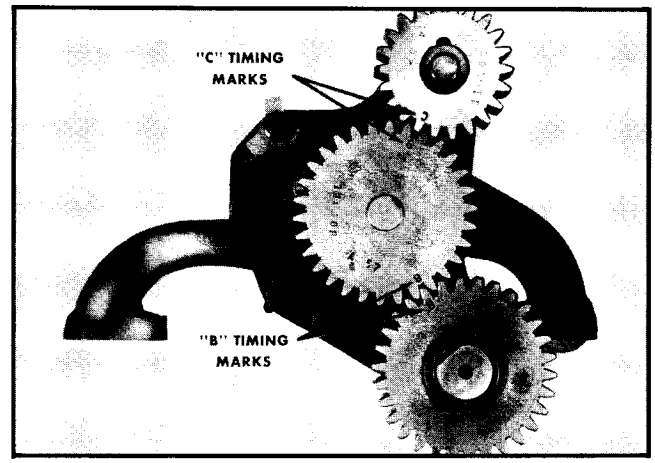


Fig. 12-54. Timing marks—J-4 lube oil pump

4. Lift unit to block, aligning "A" mark on crankshaft gear with "A" mark on oil pump idler gear. See Fig. 12-30, Page 12-10.
5. Assemble and tighten mounting capscrews and lock plates.

SECOND-ORDER COUNTERBALANCER (J-4)

1. Assemble mounting capscrews and balancer drive shaft to counterbalancer.

2. Mount counterbalancer to block, with balancer timing marks indexed and counterweights in housing; engage drive shaft to lubricating oil pump gear with splined coupling. Secure with lockwires.

CAUTION: WHEN ALIGNING TIMING MARKS, COUNTERWEIGHTS MUST BE IN "UP" POSITION WITHIN HOUSING. See Fig. 12-55.

3. Tighten capscrews.

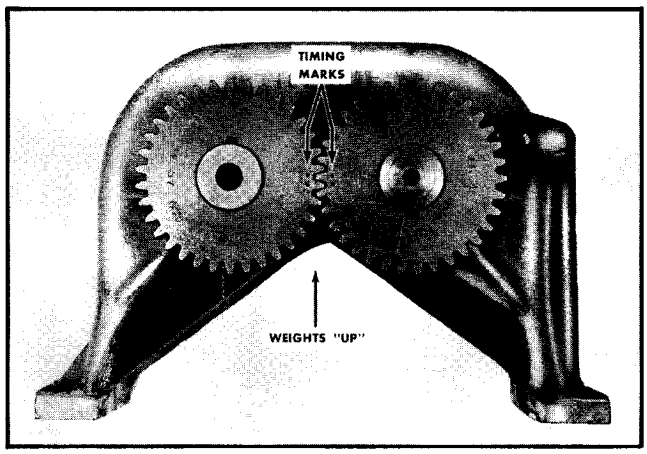


Fig. 12-55. Timing marks—J-4 counterbalancer

OIL PAN

1. Shellac a new gasket to oil pan.
2. Mount oil pan over dowel pins.
   a. Use flat washers and lock washers for aluminum pans.
   b. Tighten mounting capscrews.
3. Retighten all capscrews after break-in.

FLY WHEEL HOUSING

1. Clean the mating surfaces of the flywheel housing and the cylinder block of all dirt and burrs. Cement gasket in camshaft counterbore of flywheel housing. Fig. 12-56.

2. Inspect the dowels and, if they show evidence of wear or shearing caused by previous operation, pull them. In all cases where a new flywheel housing is being installed, the old dowels must be pulled.

3. Secure the housing to the block and oil pan with 12 capscrews and lockwashers.

4. Tighten all oil pan capscrews, if not already tightened.

Indicate Bore

1. Fasten an indicator gauge to the crankshaft flange as shown in Fig. 12-58 to indicate the bore of the housing. Make four chalk marks at points A, A^1, B and B^1 as shown in Fig. 12-59. Take readings at the four points.

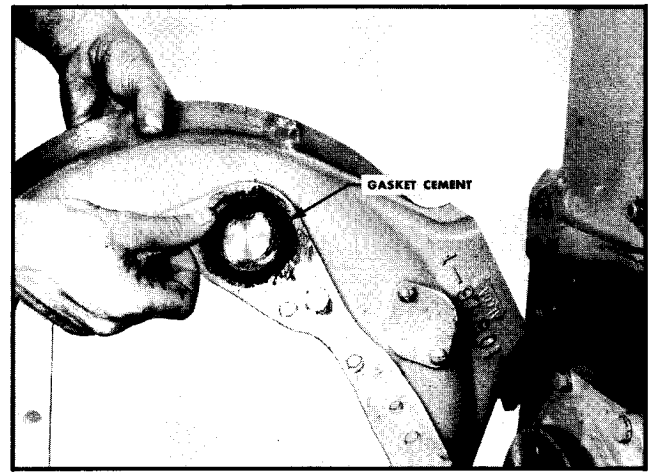


Fig. 12-56. Cementing gasket in camshaft counterbore

2. If the run-out exceeds .004, remove the flywheel housing and pull the dowels, unless they were previously removed. Loosen the capscrews just enough to allow the housing to be shifted. Use a pinch bar to shift the housing to obtain proper indicator reading. The readings at points A and A^1 should be the same and the readings at points B and B^1 should agree. Total run-out must not exceed .004.

3. After readings are within limits, tighten all the capscrews alternately, a little at a time, and recheck. If dowels were removed, redowel to smallest permissible oversize after flywheel housing and face indicate within limits.

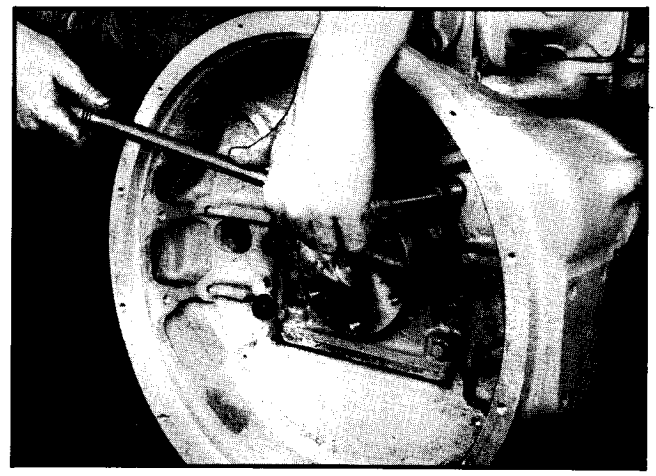


Fig. 12-57. Installing flywheel housing

CAUTION: BE SURE ALL CAPSCREWS ARE TIGHT.

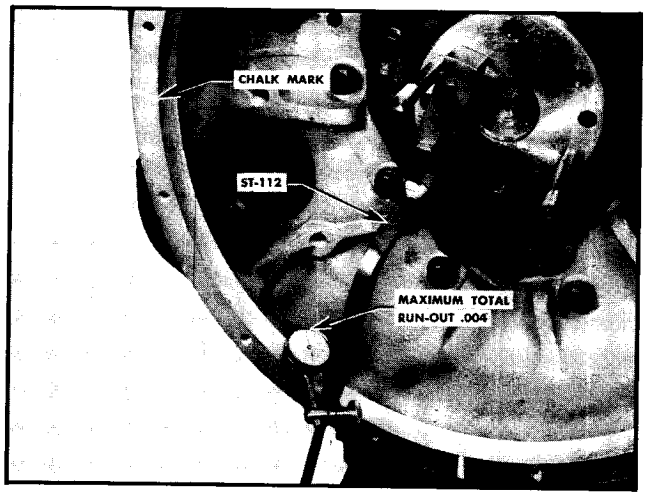


Fig. 12-58. Indicating bore of flywheel housing

Indicate Face

1. Shift the gauge to indicate the housing face. See Fig. 12-59. Turn the crankshaft to get readings at various points on the face of the housing. Each time before taking a reading, use a pinch bar between a main bearing cap and crankshaft throw to take up crankshaft end clearance. Take up end clearance the same direction each time. The readings taken at various points must not vary more than .008.

2. If the dowels were removed, ream the dowel holes in the housing and block to nearest oversize and drive in oversize dowels.

3. A drill and ream jig, ST-406, is available to locate

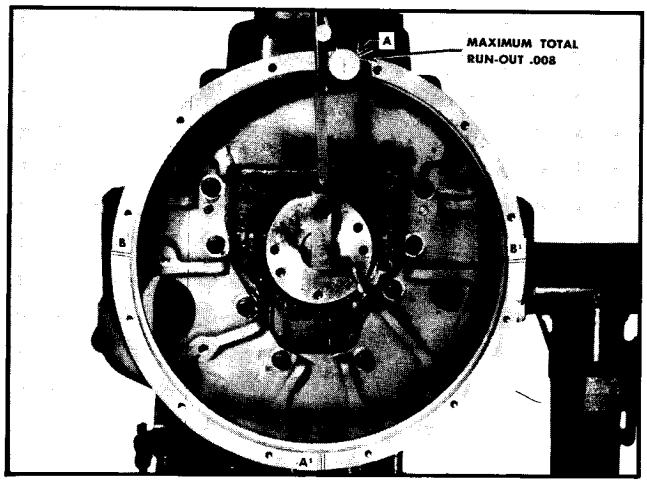


Fig. 12-59. Indicating face of flywheel housing

the drill and reamer of flywheel housing oversize dowels. After the housing is properly located, the jig can be assembled in location and various bushings used for oversize drills and reamers. Unless dowel holes are pilot reamed, the new dowels may cause the housing to shift and, if dowels are not installed straight, trouble will be experienced during next engine tear-down.

FLYWHEEL

1. Thoroughly clean the faces of the flywheel and crankshaft flange of all dirt and burrs. Inspect the dowels. If they are loose or show any signs of shearing or burrs, pull them. If a new flywheel is being installed, remove the old dowels, regardless of condition.

2. If a new flywheel is to be installed match the "O" on the flywheel with the "O" on the crankshaft flange before dowelling the flywheel to the flange.

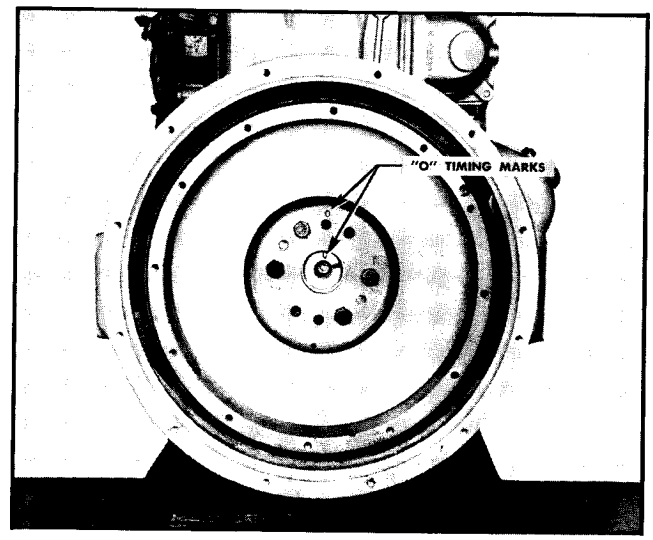


Fig. 12-60. "O" marks on flywheel and crankshaft flange

3. Screw two ½"-20 studs into the crankshaft flange as guides. Assemble the flywheel over the studs and dowels to the crankshaft flange. If dowels have been removed, match dowel holes in flywheel and crankshaft.

4. Insert the proper capscrews. Tighten them alternately, a little at a time, to pull the flywheel up evenly. Continue until all capscrews are tightened to 100/110 ft. lbs.

Indicate Bore

Attach an indicator gauge to the side of the flywheel housing to indicate the bore of the flywheel. The total run-out must not be greater than .004. Fig. 12-61.

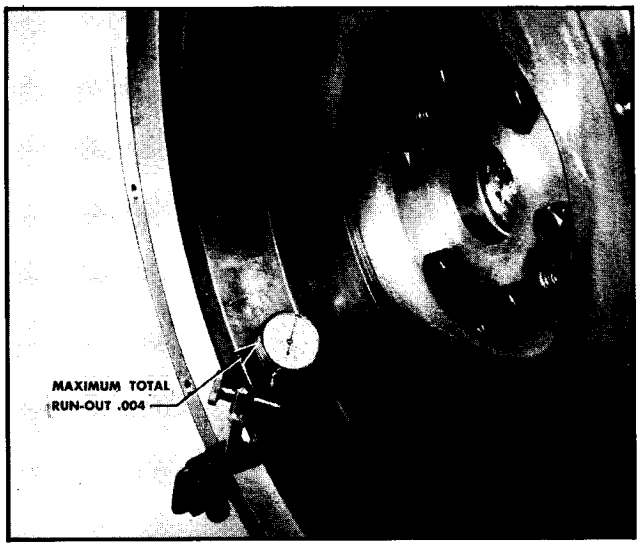


Fig. 12-61. Indicating flywheel bore

Indicate Face

1. Shift the gauge to indicate the face of the flywheel. Mark with chalk four spots equidistant on the circumference of the flywheel. Fig. 12-62.

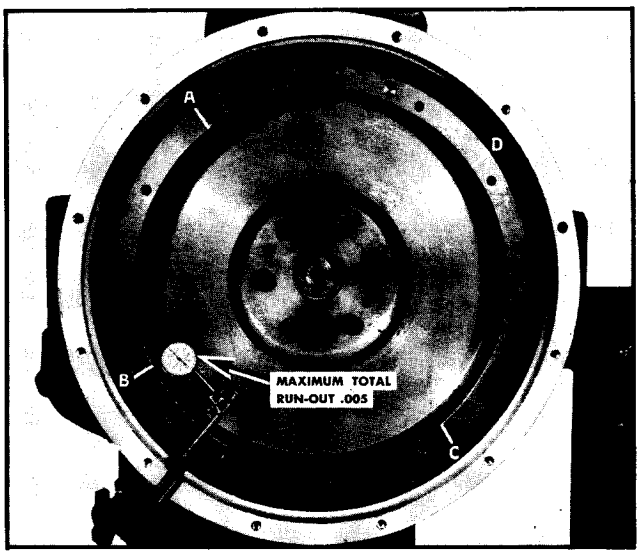


Fig. 12-62. Indicating flywheel face

2. As the crankshaft is turned to bring up each of these chalk marks even with the indicator, take up crankshaft end clearance. With the end clearance taken up, the total run-out at these four equidistant points must not exceed .005. If the run-out does exceed .005, remove the flywheel and again clean the faces of flywheel and crankshaft flange. Reinstall and check both bore and face.

3. If the old dowels have been removed, ream the dowel holes in the flywheel and flange to nearest oversize and drive in oversize dowels.

4. Lock the capscrews in pairs with lock wires.

CRANKING MOTOR

1. Mount cranking motor to flywheel housing.
2. Tighten three mounting capscrews.

FUEL INLET AND DRAIN MANIFOLDS

1. Clamp injector fuel inlet and drain manifolds to cylinder head.
2. Start line connections by hand to avoid cross threading.

INTAKE MANIFOLD (JT, JN, JNS)

1. Assemble new gaskets, mounting capscrews and lock plates to intake manifold.
2. Mount manifold to engine.
3. Tighten mounting capscrews.

ADJUST VALVES, INJECTORS AND CROSSHEADS

1. Bar engine in direction of rotation.
2. Align valve set mark on fan drive pulley with timing mark on gear case cover. Fig. 12-63.

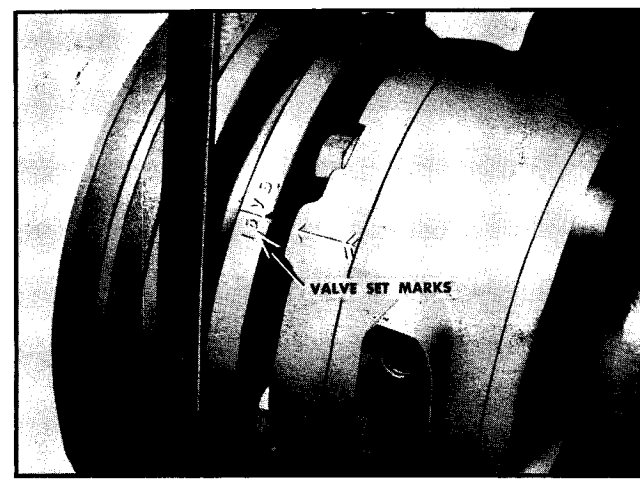


Fig. 12-63. Valve set marks

3. Check position of intake and exhaust valves of cylinder to be adjusted, valves closed, rocker levers free.
4. Adjust injector plunger.
   a. Turn adjusting screw down until plunger contacts cup; turn it an additional 15° to squeeze oil from cup.

b. Loosen adjusting screw one turn.

c. Tighten adjusting screw to 48 inch-pounds (cold setting at 70° F.). Use inch-pound torque wrench (such as Snap-On TQ 12B) and a screw driver adaptor. Lock screw in place with jam nut.

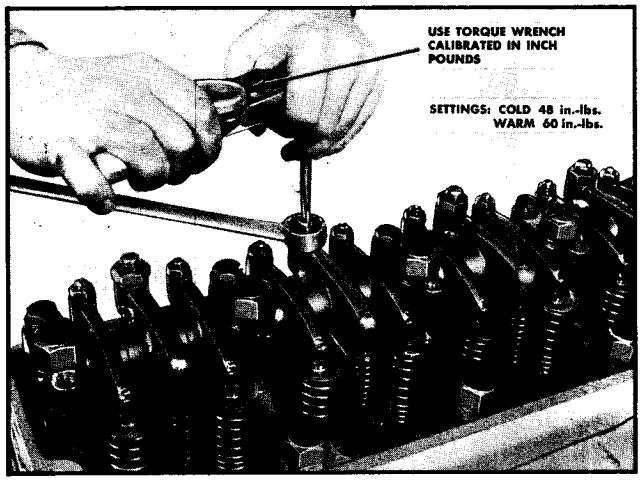


Fig. 12-64. Adjusting injector plunger

d. Make final adjustments when engine is at operating temperature (140° F.); tighten adjusting screw to 60 inch-pounds.

5. Set crosshead adjusting screw.

a. Use light finger pressure at rocker lever contact surface (A) to hold crosshead against valve stem that is nearer push rod.

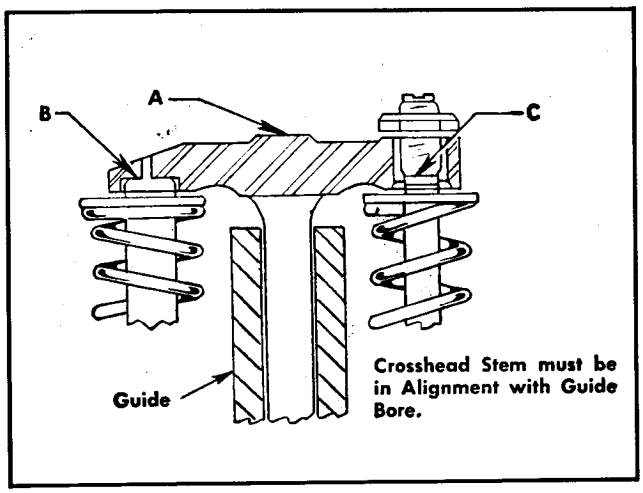


Fig. 12-65. Alignment of crosshead stem and guide

b. Turn adjusting screw down until it contacts its mating valve stem.

c. Advance adjusting screw 20° to 30° to straighten the stem in its guide and to compensate for slack in threads.

d. Hold adjusting screw in this position and tighten lock nut to 25 to 30 foot-pounds torque. An adapted socket can be used to tighten nut while holding adjusting screw in place.

To Make Adaptor:

(1) Cut a ⅜ drive from a socket or extension.

(2) Weld ⅜ inch drive to 9/16 inch socket as shown. Fig. 12-66. Square holes of both drive and socket must be parallel and flush. No spacer material is needed between drive and socket.

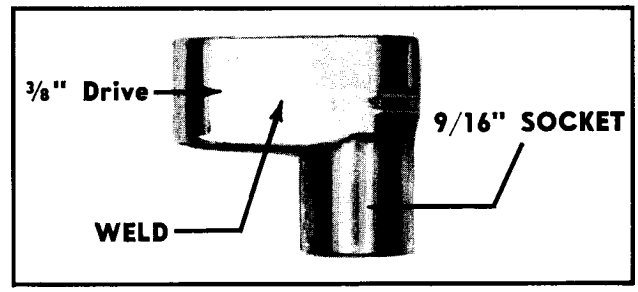


Fig. 12-66. Special adaptor for crosshead adjustment

To Use Adaptor:

(1) Place 9/16 inch socket to left of wrench to maintain torque characteristics of wrench.

(2) Insert a screwdriver through open drive hole of 9/16 inch socket to hold adjusting screw in position.

e. Check for a .020 inch minimum clearance between crosshead and valve spring retainer.

6. Adjust valve clearance. Fig. 12-67.

a. Insert feeler gauge between rocker lever and valve stem or crosshead.

Intake Valves .....015 inch
Exhaust Valves .....025 inch

b. Turn adjusting screw down until lever touches gauge.

c. Lock adjusting screw in place with jam nut.

d. Make final adjustments when engine is at operating temperature (140° F.); see "a" above.

7. Continue adjustments, each cylinder in firing order, until all cylinders are adjusted. This will require two complete revolutions of the crankshaft.

ENGINE FIRING ORDER

6 cylinder engines (right hand) 1-5-3-6-2-4
4 cylinder engines (right hand) 1-2-4-3

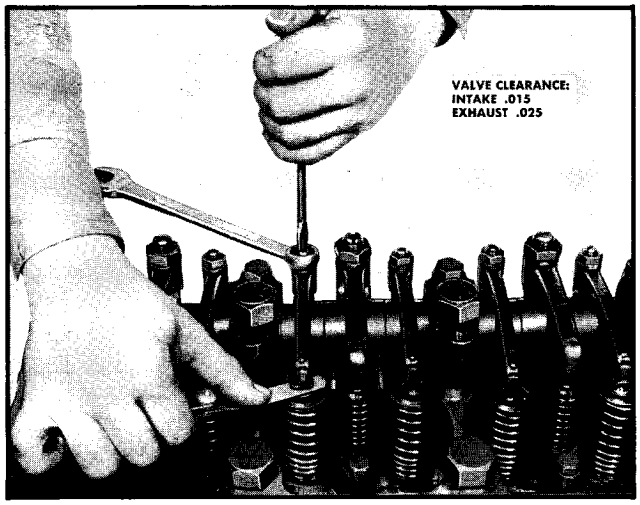


Fig. 12-67. Adjusting valves

ROCKER LEVER COVER

1. Assemble new gasket, capscrews and washers to rocker lever cover.

2. Mount cover on engine.

3. Tighten four hold-down capscrews.

4. (Supercharged engines) install vapor suction line connecting cover to supercharger air intake.

FAN HUB AND DRIVE PULLEY (J-6)

1. Assemble mounting lock washer and capscrews to fan hub bracket.

2. Mount fan hub to engine.

3. Assemble capscrews to fan.

4. Mount fan to hub.

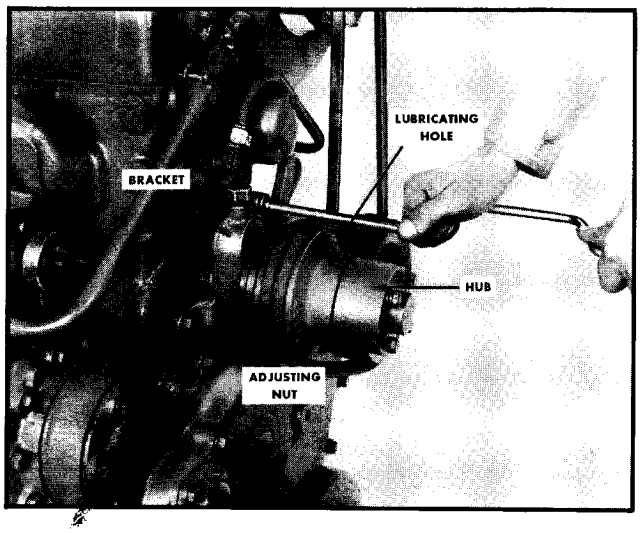


Fig. 12-68. Installing fan bracket and hub

TURBOCHARGER (JT)

1. Assemble turbocharger with lube oil drain (large boss) down or within 45° of that position when turbocharger is mounted. Fig. 12-69.

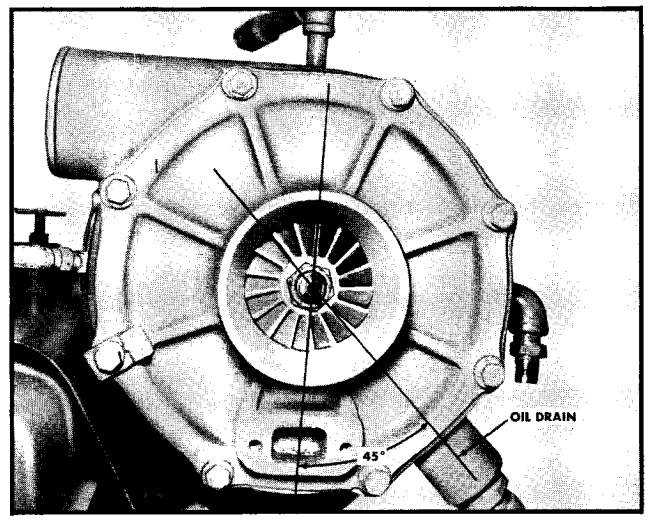


Fig. 12-69. Oil drain position

2. Assemble gasket and six capscrews and lock washers to turbocharger. (Some mounting stud bolts are used.)

3. Mount turbocharger to exhaust manifold flange.

4. Install supporting bracket between turbocharger and oil cooler. (Rear-mounting fastens to clutch housing.)

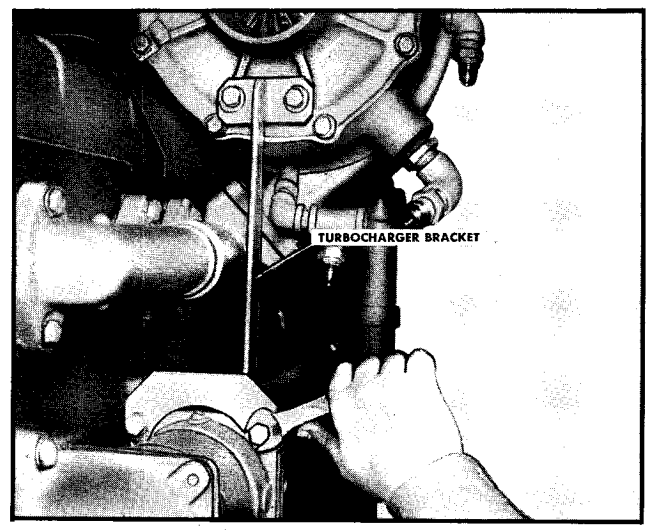


Fig. 12-70. Turbocharger support bracket

5. Install following connections:
   a. Water inlet, oil cooler-to-turbocharger.

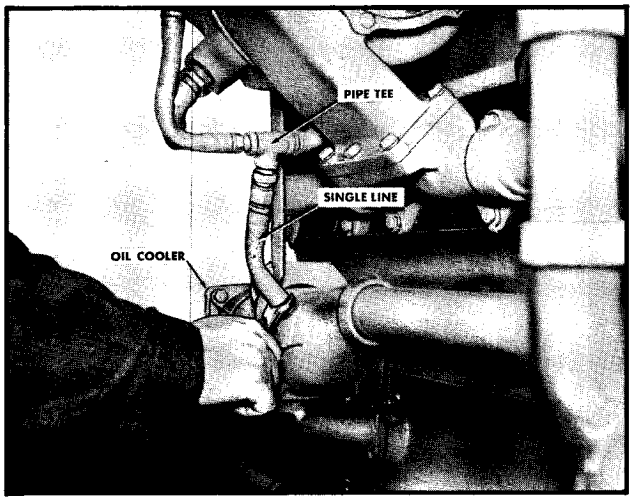


Fig. 12-71. Water line to oil cooler

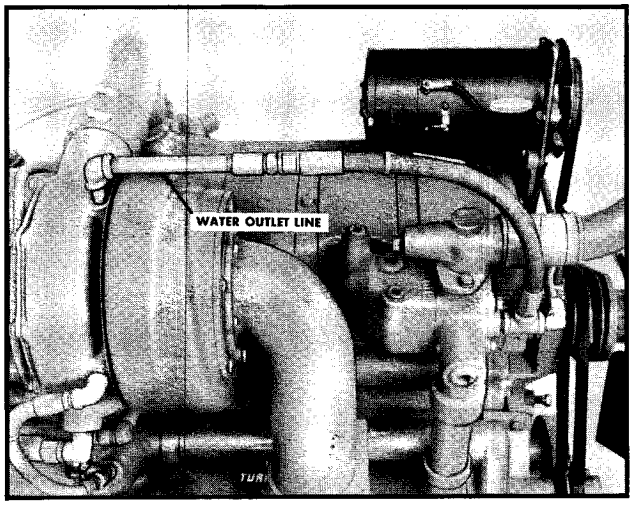


Fig. 12-72. Water outlet line from turbocharger

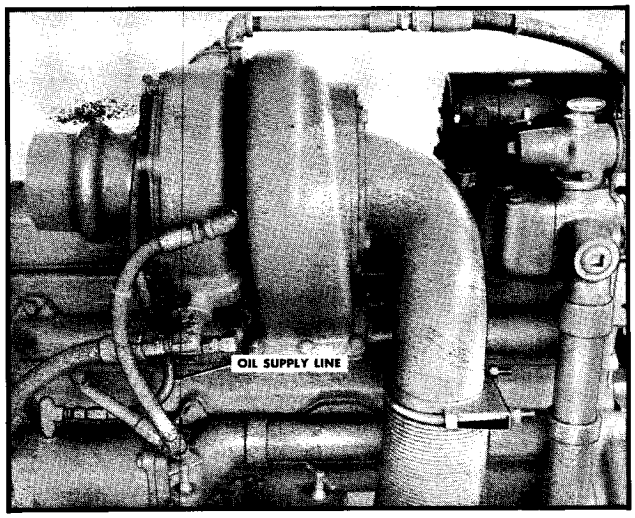


Fig. 12-73. Install oil supply line

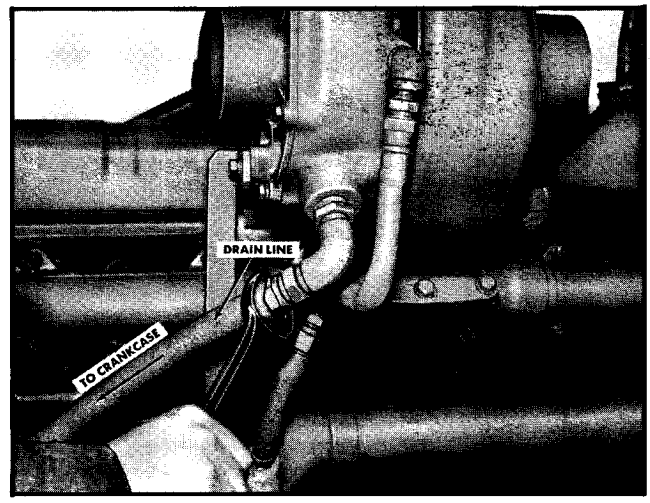


Fig. 12-74. Connect drain line

b. Water outlet, turbocharger-to-thermostat housing.

c. Oil supply line, oil cooler-to-⅛ NPT hole.

d. Oil drain, turbocharger-to-crankcase.

6. Oil and water line size:

Wire-braided flexible hose is used on all Cummins turbocharger applications for oil and water piping. The hose must be Aeroquip 1503, Strato-flex 211, Weatherhead H69, or equivalent, to meet heat resistance and pressure specifications. Hose size should be as follows:

Inside Diameter	*Location*
5/16 Inch	Water Inlet
5/16 Inch	Water Outlet
5/16 Inch	Oil Inlet
½ Inch	Oil Drain

Where pipe nipples are used to span high heat areas, nipple inside diameter should be equal to or larger than hose specifications above.

REMOVE ENGINE FROM STAND

1. See: LIFT ENGINE, Page 1-4.

2. Place it on a skid or on front and rear supports.

OIL TRANSFER CONNECTION

1. Assemble two gaskets, four lock washers and capscrews to oil transfer connection.
2. Mount connection to block.
3. Tighten capscrews.

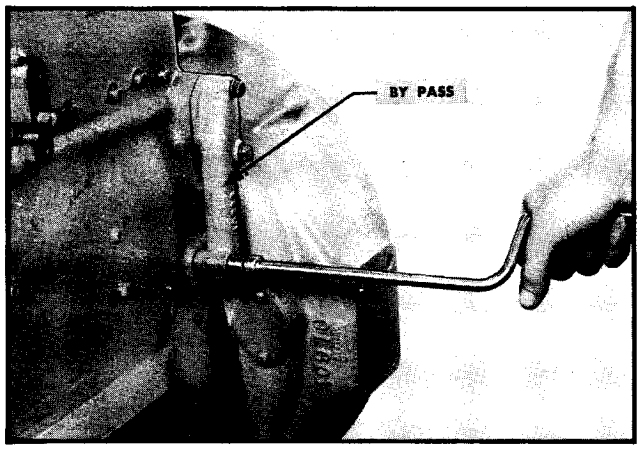


Fig. 12-75. Installing oil transfer connection

DIPSTICK TUBE AND BRACKET

1. Assemble new gasket to bracket.
2. Install bracket on oil pan.

AIR COMPRESSOR (CHAIN COUPLING)

1. Assemble gasket and two capscrews plus washers to air compressor.
2. Mount air compressor over dowels.
3. Tighten capscrews.
4. Assemble gasket, four capscrews and lock washer to oil strainer.
5. Mount oil strainer over air compressor bracket.
6. Tighten capscrews.

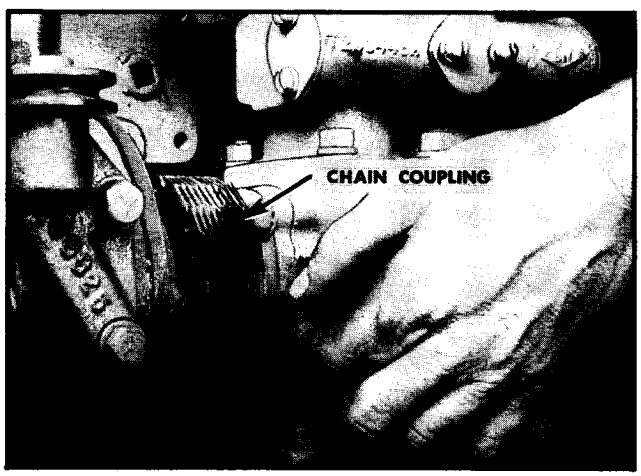


Fig. 12-76. Installing compressor drive chain

7. Link drive chain over accessory drive and spider gears.
8. Install water lines from compressor to cylinder head and block.

COMPRESSOR COUPLING ALIGNMENT

1. Check alignment of outside edges of coupling halves previous to Step No. 7, Air Compressor (Chain Coupling).
2. Chalk mark coupling at point of this first check.
3. Pry coupling halves apart to take up end play.
4. Release and gauge the space between coupling halves.
5. Rotate ¼ turn and repeat check, Steps 3 and 4.
6. Continue 5 until rotation is complete.
7. If couplings are out of alignment, readings will vary; remove old gaskets and add or remove shims at points shown. Fig. 12-77.
8. Install drive chain.
9. Check for a ⅛ inch side play.

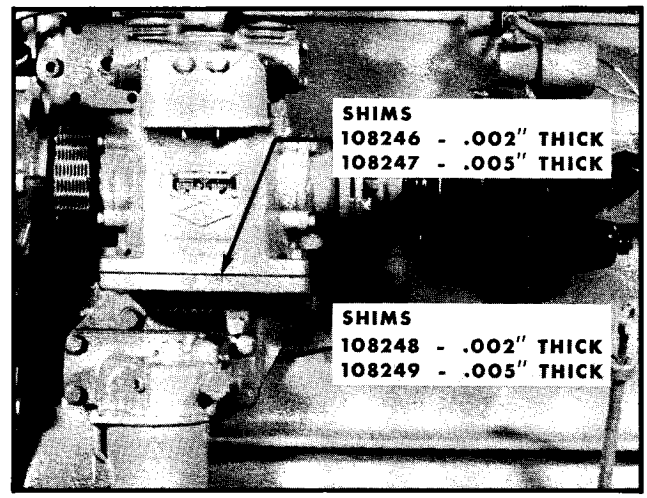


Fig. 12-77. Shim at points indicated

LUBRICATING OIL STRAINER

1. Install a new gasket on cylinder block.
2. Attach strainer assembly, or adapter where strainer is located off the engine.

AIR COMPRESSOR (SPLINE COUPLING DRIVE)

1. Assemble spline drive coupling to air compressor or accessory drive. Fig. 12-78.
2. Mount air compressor to accessory drive. Fig. 12-79.
3. Tighten four mounting capscrews.
4. Install water lines from compressor to cylinder head and block.

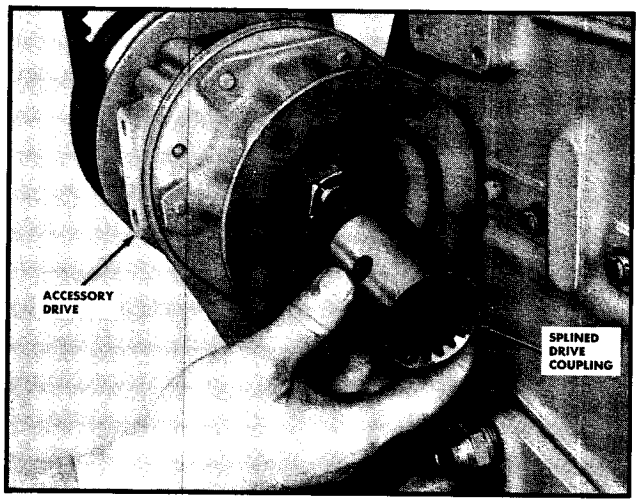


Fig. 12-78. Installing splined coupling

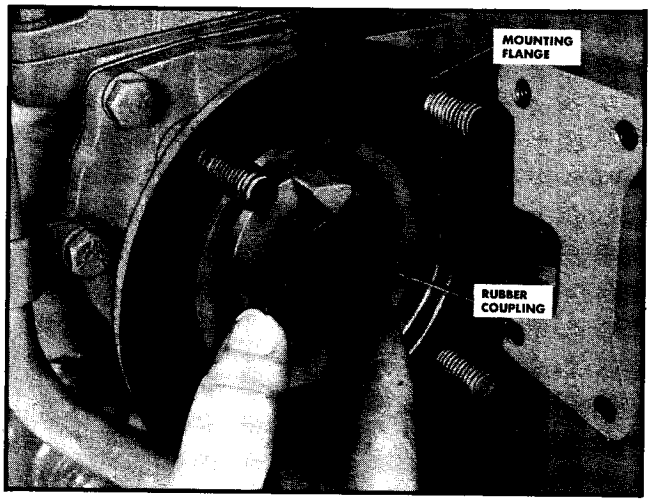


Fig. 12-80. Fuel pump drive rubber coupling

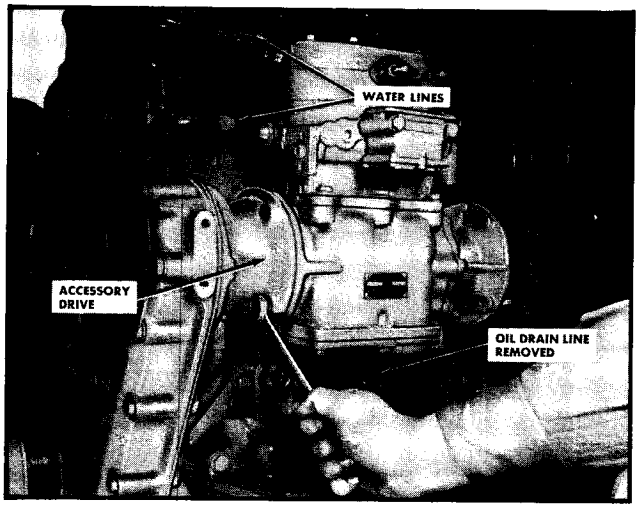


Fig. 12-79. Installing air compressor

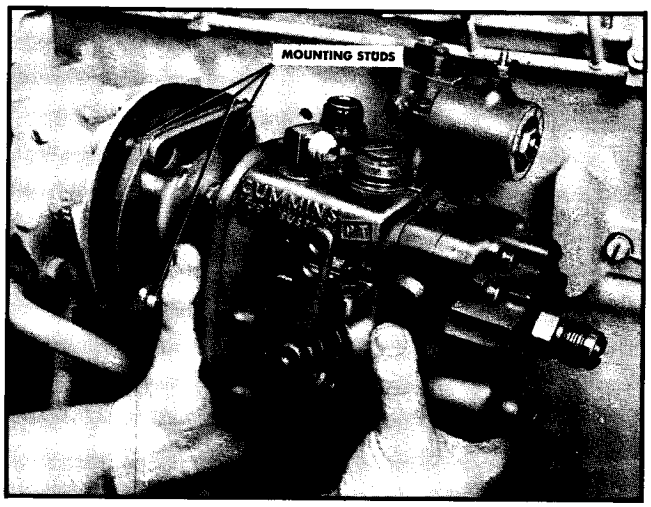


Fig. 12-81. Mounting fuel pump

5. Install oil inlet and outlet tubes.
6. Install air outlet tubes.

BRACKET MOUNTED PT FUEL PUMP

1. Assemble mounting bracket, and rubber "spider" or splined coupling to fuel pump.
2. Mount bracket to engine over the dowels.
3. Tighten four mounting capscrews.
4. Install fuel line from solenoid valve to fuel inlet manifold.

PT PUMP (FLANGE MOUNTED)

1. Assemble rubber buffer to air compressor housing. Fig. 12-80.
2. Mount PT pump to air compressor.
3. Tighten four mounting capscrews.
4. Install connection between shut-off valve and fuel manifold.

FUEL FILTER

1. Mount fuel filter to engine.
2. Install filter to fuel pump line.

GENERATOR AND BRACKET

1. Assemble three capscrews and lock washers to generator bracket.
2. Mount bracket to engine.
3. Assemble generator mounting capscrews.
4. Mount generator to bracket.

AIR COMPRESSOR, BELT DRIVEN (J-4)

1. Assemble gasket on bracket.
2. Mount compressor on bracket.
3. Assemble mounting bolts. (Tighten when adjusting belt.)

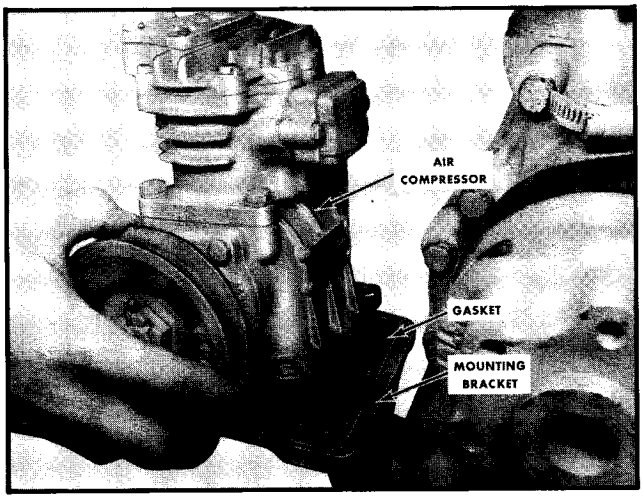


Fig. 12-82. Installing J-4 air compressor

CROSSOVER CONNECTION

1. Assemble two hose connections and four clamps to crossover pipe.
2. Install turbocharger-to-air intake manifold crossover connection. (JNS—Install supercharger crossover-to-air intake manifold connection.)
3. Tighten four clamps.

AIR BREATHER TUBE

1. Assemble tube to connection.
2. Install and tighten mounting capscrew to clamp.
3. Tighten capscrews.

ANEROID CONTROL (JT ONLY)

1. Assemble mounting bracket to aneroid control.
2. Assemble mounting capscrews and lock washers to bracket.
3. Mount aneroid and bracket as near to fuel pump as possible.
4. Install fuel pressure line from gear pump to "in" connection of control. Fig. 12-83.
5. Install return line from "out" connection of aneroid to suction side of gear pump. Fig. 12-84.
6. Install line from aneroid-to-air intake manifold. Fig. 12-85.

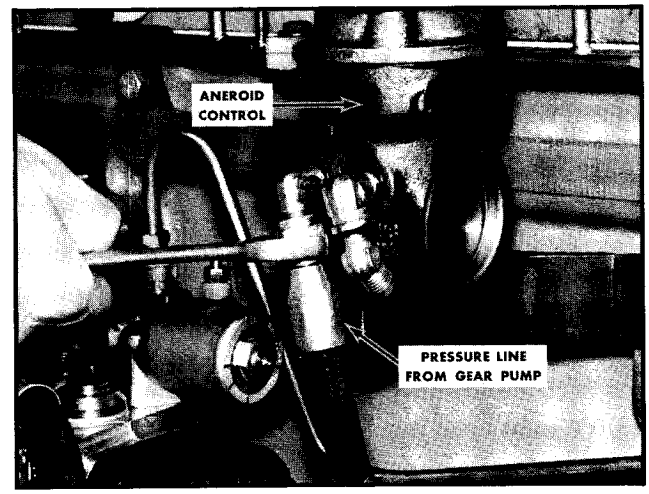


Fig. 12-83. Installing fuel pressure line from fuel pump

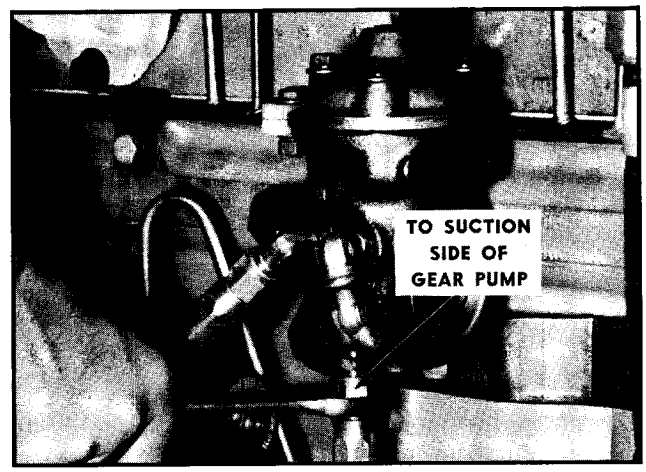


Fig. 12-84. Installing return line to fuel pump

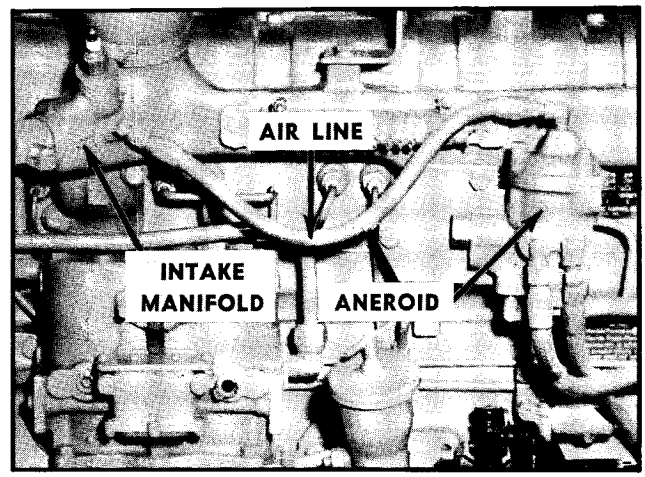


Fig. 12-85. Aneroid to air intake manifold line

7. Install aneroid vent line from aneroid to crankcase, above oil level. Fig. 12-86.

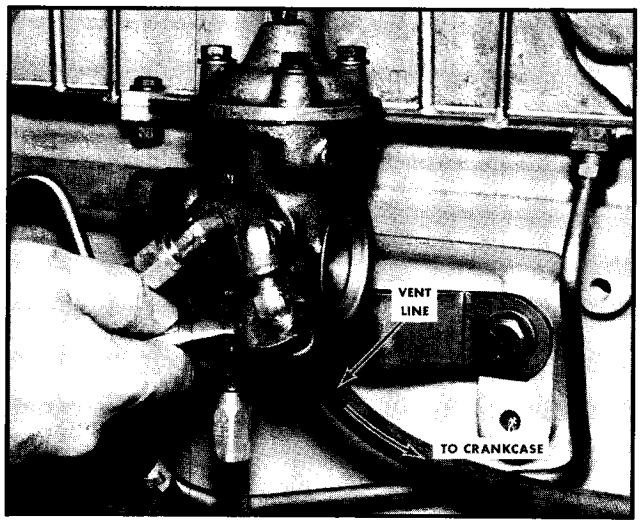


Fig. 12-86. Installing vent line to crankcase

PRIMING LUBRICATING SYSTEM

1. Remove one of Allen set screws from oil header at side of cylinder block.

2. Connect hand priming pump and source of clean SAE No. 20 lubricating oil.

3. Pump oil into oil gallery.

4. Bar engine over few times.

5. Remove pump connection; install set screw.

FILL CRANKCASE

1. Fill crankcase with SAE No. 20 lubricating oil to "H" (high) mark on bayonet gauge.

V-BELTS

1. Loosen adjustments to shorten distance between pulley centers so that belt can be installed without force.

2. Install belts over pulleys. Never roll a belt over a pulley nor pry it on with a screwdriver as this will damage belt and cause early failure.

J-6
Fuel Pump Drive-to-Generator
Fan Hub-to-Water Pump
Fuel Pump Drive-to-Fan Hub

J-4
Fuel Pump Drive-to-Generator-to-Water Pump Fan Hub
Water Pump Fan Hub-to-Air Compressor

3. Tighten belts. See: Table 10, BELT ADJUSTMENT DATA.

TABLE 10—BELT ADJUSTMENT DATA

Belt Width	Deflection per ft. of Span
1/2"	3/8"
11/16"	15/32"
3/4"	7/16"

TEST ENGINE BEFORE INSTALLATION

1. Move the engine to the engine dynamometer. See: LIFT ENGINE, Page 1-4.

2. Mount engine to dynamometer.

3. Install fuel, air and water connections.
   a. Use a standard air cleaner approved for engine model.
   b. Use a full flow lubricating oil strainer to protect against entrapped grit.

4. Connect electrical wiring to starting motor.

5. Remove all breathers or covers which would allow the blow-by gas to escape and close openings with a plain cover or masking tape.

6. Install a rocker housing cover with an ST-487 Blow-by Checking Tool adaptor consisting of a "T" connection with a .302 inch orifice to which is mounted a manometer as shown in Fig. 12-87.

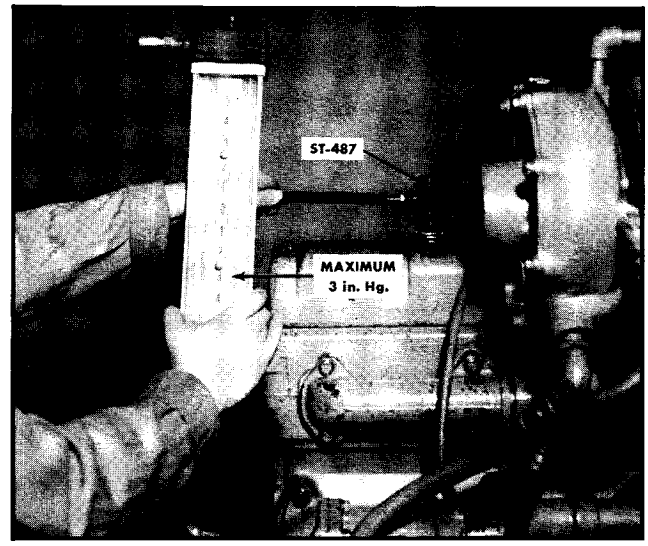


Fig. 12-87. Checking blow-by with ST-487

NOTE: To determine permissible pressure for a turbocharged or supercharged engine with new and/or worn valves and valve guides:

(1) Take manometer reading with turbocharger or

TABLE 11—BLOW-BY PRESSURES

Engine Model	Maximum Permissible Pressure: Inches of Water
J, JF, JN	1.0
JNS	1.8
JT	1.6
JS	1.8

supercharger connected and engine running at maximum governed speed, no-load.

(2) Take a manometer reading with turbocharger or supercharger outlet disconnected and engine running naturally-aspirated, at maximum governed speed, no-load.

(3) Subtract Step 2 reading from Step 1 reading; add remainder to pressure value given in Table 11, above.

a. Fill the manometer with colored water to "O" mark at middle of scale.

7. Install a water temperature gauge, oil pressure gauge, and oil temperature gauge.

8. If engine is turbocharged and has an aneroid control:

a. Remove line from pressure side of PT gear pump to aneroid control.

b. Plug line and gear pump connections.

9. Release and remove accessory drive-to-generator V-belt as a safety measure.

STARTING PROCEDURE

1. Set throttle for idle speed.

2. Open manual fuel shut-off valve (if used).

3. Pull compression release (if so equipped).

4. Start engine.

a. Press starter button, or

b. Turn switch-key to "start" position.

5. After three or four seconds of cranking, close compression release (if so equipped) and continue to crank until engine fires.

CAUTION: DO NOT CRANK THE ENGINE CONTINUOUSLY FOR MORE THAN 30 SECONDS TO AVOID DAMAGE TO THE STARTING MOTOR. IF THE ENGINE DOES NOT FIRE WITHIN THE 30 SECOND PERIOD, WAIT TWO TO FIVE MINUTES BEFORE CONTINUING.

STARTING WITH GLOW PLUG STARTING AID

1. Set throttle in idle position; *do not accelerate engine during starting procedure.*

2. Turn glow plug toggle switch to "ON" position. (Red indicator light must be on.)

3. Wait 20 seconds, then start cranking engine while operating preheater priming pump to maintain 40 to 60 psi fuel pressure. (Use of primer before 20 second interval will wet and cool glow plug below ignition temperature of fuel oil.)

4. After engine has started, continue to pump primer slowly to keep intake air warm. *(Do not accelerate engine.)*

5. When engine has warmed up and does not falter between primer strokes, stop pumping; close primer and lock.

6. Turn off glow plug toggle switch. (Red indicator light will go off.)

Break-In Run

1. Start engine and idle it at approximately 800 rpm no-load for five to ten minutes.

2. Check oil pressure and water circulation; look for leaks.

3. First Phase: (To operating temperature)

a. Operate engine at 1000 rpm.

b. Apply dynamometer load so that engine develops 25% of the rated horsepower at 1000 rpm until water temperature reaches 140° F.

c. Add lubricating oil to bring level up to "H" mark on bayonet gauge.

d. Reset valves.

e. Adjust injector plungers.

4. Second Phase: (One hour maximum)

a. Increase dynamometer load to make engine pull 50% of rated horsepower at speed shown on chart.

b. If blow-by is within limits, this phase can be limited to 30 minutes.

5. Third Phase: (One and one-half hours)

a. Operate engine at 75% rated rpm, and apply additional load to develop 75% of rated horsepower at that speed.

b. Run one and one-half hours at this rpm and load.

c. If blow-by appears to increase, reduce load to second phase specifications for 30 minutes; then return to third phase specifications.

6. Check engine governed speed and fuel rate; set if necessary.

TABLE 12—MAXIMUM AND TEST HORSEPOWER RATING

Standard Test Conditions: Temperature Not Over 60° F.: Sea Level

Derate Horsepower: 1% for Each 10° Temperature Rise Above 60° F., 3% for Each 1000 Ft. Altitude Rise Above Sea Level*

ENGINE MODEL	100% Rated @ RPM	96% @ RPM	HORSEPOWER 1st Phase	2nd Phase	3rd Phase
J-4	75 @ 2200	72 @ 2200	10 @ 1000	45 @ 2200	50 @ 1700
J-6	100 @ 1800	96 @ 1800	10 @ 1000	60 @ 1800	70 @ 1400
JF-6	110 @ 2200	105 @ 2200	15 @ 1000	70 @ 2200	80 @ 1700
JN-6	130 @ 2500	124 @ 2500	15 @ 1000	80 @ 2500	95 @ 1900
JNS-6	175 @ 2500	168 @ 2500	15 @ 1000	105 @ 2500	125 @ 1900
JS-6	160 @ 2500	153 @ 2500	15 @ 1000	95 @ 2500	110 @ 1900
JT-6	175 @ 2500	168 @ 2500	20 @ 1000	105 @ 2500	130 @ 1900

* JT engine need not be derated below 12,000 ft. altitude.

TABLE 13—FORMULA TO DETERMINE BRAKE HORSEPOWER

$$\text{BRAKE HORSEPOWER} = \frac{\text{Torque (in Foot-Pounds)} \times \text{RPM}}{5252}$$

TABLE 14—FUEL CONSUMPTION

Standard Test Conditions: Temperature Not Over 60° F.: Sea Level

Decrease Fuel Rate: 1% for Each 10° Temperature Rise Above 60° F., 3% for Each 1000 Ft. Altitude Rise Above Sea Level.

ENGINE MODEL	Max. HP @ RPM	Fuel Rate for Maximum Horsepower Lbs. Per Hour	Lbs. Per Five Minutes
J-4	75 @ 2200	33	2.7
J-6	100 @ 1800	43	3.6
JF-6	110 @ 2200	49	4.0
JN-6	130 @ 2500	55	4.6
JNS-6	175 @ 2500	76	6.3
JS-6	160 @ 2500	76	6.2
JT-6	175 @ 2500	72	6.0

Maximum Power Checks

1. Set engine rpm at maximum governed speed. See: Table 12.

2. Increase load until rpm begins to decrease; then, take horsepower reading. (A satisfactory reading must be at least 96% of maximum horsepower rating.) TIME INTERVAL UNDER FULL-LOAD NOT TO EXCEED 5 MIN.

3. Check blow-by pressure. See: Table 11, Page 12-28, for maximum permissible pressure.

4. Return to Phase 3 rpm, under no-load, for at least one minute; apply Phase 3 load for 45 minutes.

5. Repeat 1-3 after a rest period lasting at least one minute at Phase 3 rpm, no-load, until satisfactory readings, Step 2 and 3, are obtained.

6. Recheck fuel rate with ST-502 flow-rate meter or by using a beam scale to weigh fuel consumed during five minutes of maximum horsepower, governed rpm operation. See Fig. 12-88 for ST-502 hookup.

Manometer Checks During Test

1. If an increase in blow-by (as indicated by a rise in crankcase pressure) at a given speed and load is noted, reduce engine load for a few minutes, then return it to its original setting.

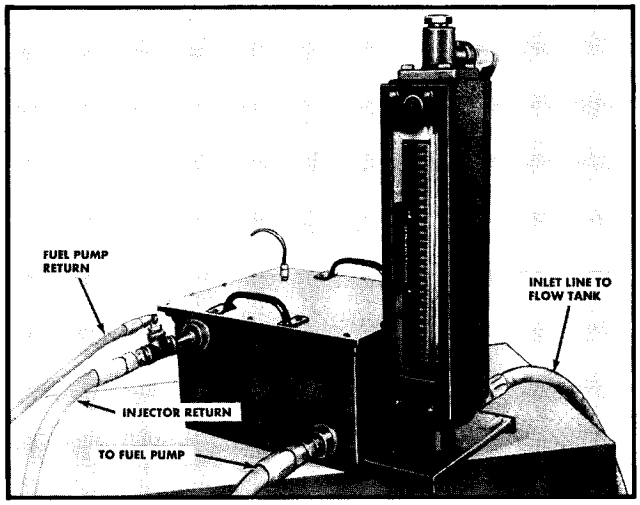


Fig. 12-88. Checking fuel rate with ST-502 meter

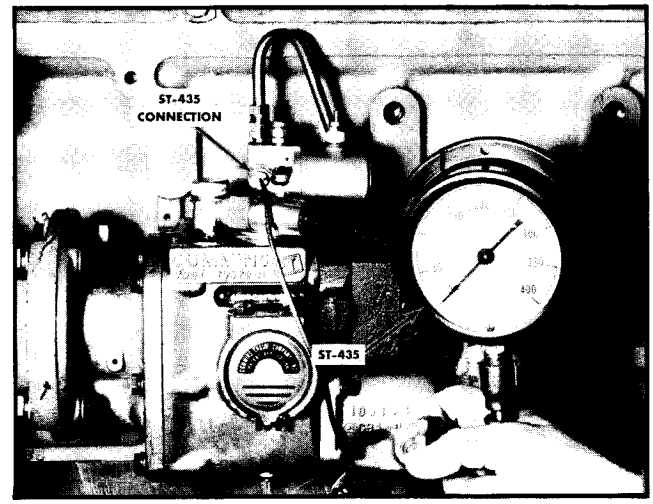


Fig. 12-89. Checking fuel pressure—aneroid disconnected

2. If an increase in blow-by is noted during a power check, more run-in is required.

3. If crankcase pressure exceeds maximum values listed in Table 11, Page 12-28, during final check, additional run-in is required.

4. Check oil level every two hours.

Shut Down Engine and Correct Cause, If:

1. Oil pressure falls off during constant load and speed operations.

2. Water temperature rises excessively above 170°.

3. Oil temperature rises sharply above 200°.

4. Unusual noises develop.

ADJUSTING THE ANEROID CONTROL (JT)

Aneroid controls on JT engines can best be adjusted while the engine is on a dynamometer. Adjust as follows:

Standard Settings. Before adjusting aneroid, the fuel pump must be calibrated. To check this:

1. Check fuel manifold pressure.
   a. Disconnect pressure line and drain line from aneroid to gear pump. Plug lines and connections to keep air out of fuel system.
   b. Use ST-435 Pressure gauge to check fuel manifold pressure. Accelerate from idle to full throttle; record maximum pressure from ST-435.
   c. Add or remove shims under fuel adjusting plunger of pressure regulator to adjust fuel pressure.

NOTE: If practical, a check of engine fuel rate with ST-502 Flow Meter may be substituted for Step 1 above. The fuel rate should be 72 pounds per hour. See Fig. 12-88.

2. After calibrating fuel pump, check air intake manifold pressure with a manometer. This pressure should be between 22 and 29 inches Mercury; a few early model T-506 turbochargers were released to operate at 19 in./hg.

3. Remove aneroid bellows cover.

4. Connect fuel pressure line from aneroid to gear pump. Start engine, warm up thoroughly. This is the only time the aneroid may be connected while checking fuel manifold pressure.

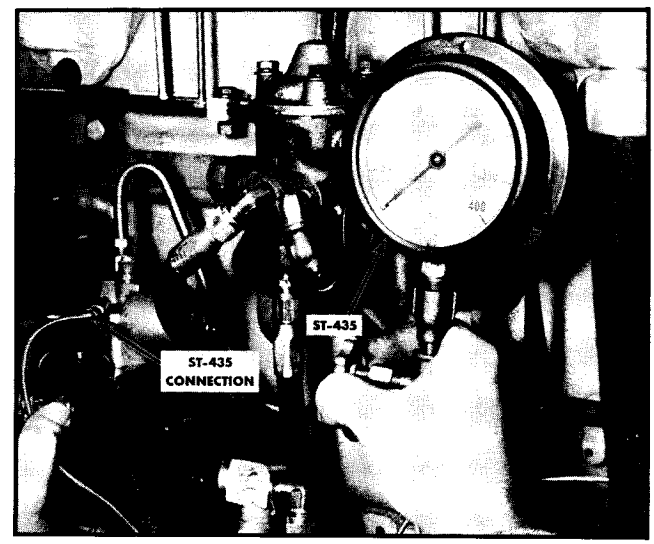


Fig. 12-90. Checking fuel pressure—aneroid connected

5. Accelerate engine from idle to full throttle; check fuel manifold pressure. It should be 90 psi with aneroid connected. Adjust fuel screw to reach this figure.

NOTE: If fuel rate method of adjustment is being used, adjust aneroid screw until fuel rate is 52 pounds per hour with the engine pulling 125 hp @ 2500 rpm.

6. Check lever action by holding actuating shaft in up position to assure contact with fuel screw at all times.

7. Lock aneroid fuel screw in position with locknut; shut down engine. Fig. 12-91.

CAUTION: ALL THE ABOVE ADJUSTMENTS MUST BE COMPLETED BEFORE PROCEEDING FURTHER.

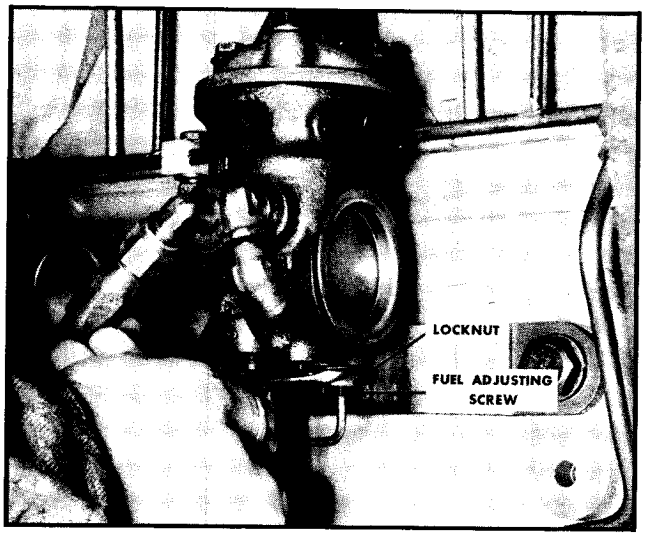


Fig. 12-91. Locking aneroid fuel adjusting screw

Special Settings. The fuel manifold pressure and fuel rate listed in Step 5 above are for automotive highway applications where smoke density must not exceed a Ringelman No. 2 rating. Where smoke regulations need not be considered, a higher setting may be used if so desired. This may be accomplished by setting the initial fuel rate approximately 15% higher than listed in Step 5 above.

CAUTION: NEVER EXCEED THE MAXIMUM FUEL RATE LISTED IN STEP 1 (72 POUNDS PER HOUR). IN HIGH ALTITUDE OPERATIONS, A 15% INCREASE IN FUEL RATE WILL CAUSE AN EXCESSIVE AMOUNT OF SMOKE AND FOR THAT REASON, CANNOT BE RECOMMENDED.

NOTE: An operator requiring a special setting must bear the expense of the adjustment and is responsible for the results.

Shimming the Bellows Spring

1. Make sure you have correct bellows spring: Part No. 124033, wire diameter .088 in., color code, green.

2. Remove bellows cover and loosen actuating shaft nut.

3. Remove bellows washer, bellows and bellows piston.

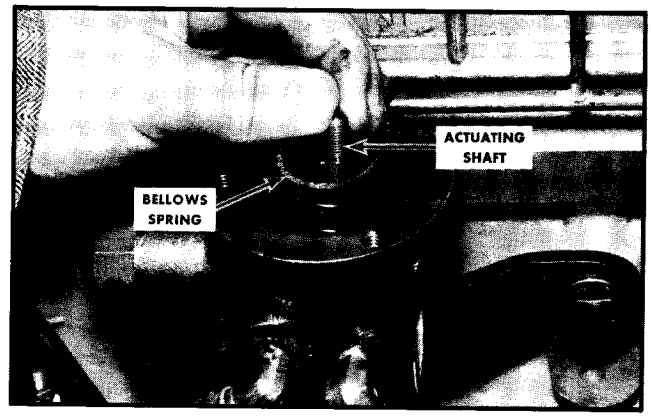


Fig. 12-92. Holding actuating shaft in "up" position

4. With bellows spring in position and with no shims under the spring, pull actuating shaft up against stop.

5. Measure distance from top of spring to shoulder on shaft. Distance should be 3/32 inch.

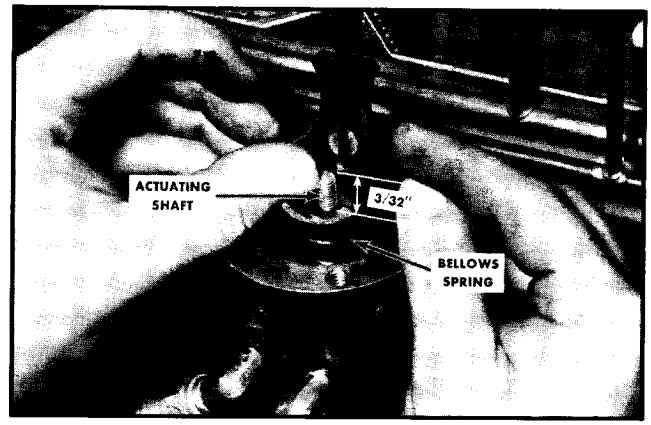


Fig. 12-93. Measuring from top of spring to shaft shoulder

a. If distance is more than 3/32 inch, 1/4 inch flat washers may be used on shaft to establish correct distance.

b. If less than 3/32 inch, shims, Part No. 114921, should be installed under spring to correct distance. Fig. 12-94.
NOTE: If shims fill spring counterbore, readjust fuel rate screw or check for wrong bellows spring.

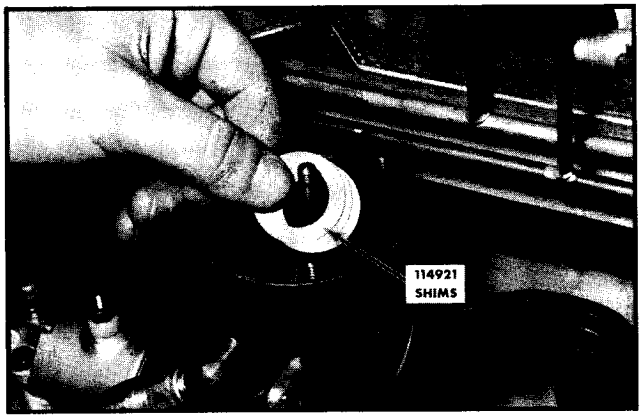


Fig. 12-94. Installing shims under spring

6. Install bellows piston, bellows and bellows washer on actuating shaft.

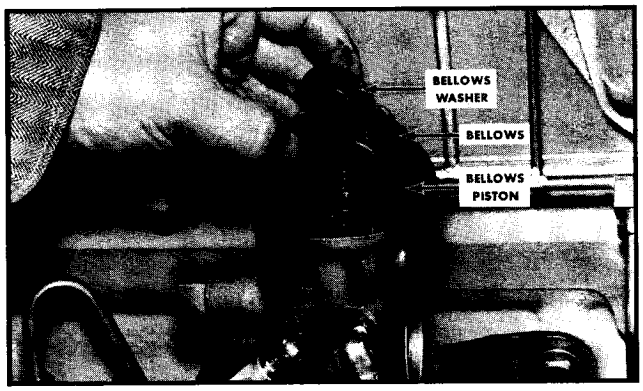


Fig. 12-95. Installing bellows piston, bellows washer and bellows

7. Align holes in bellows with capscrew holes in aneroid housing, tighten actuating shaft nut.

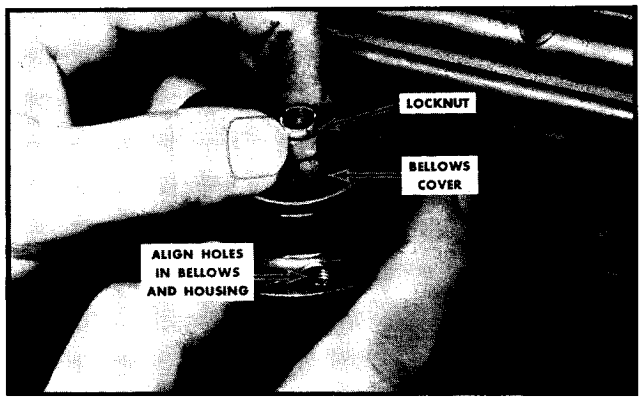


Fig. 12-96. Locking bellows cover in place

8. Install bellows cover. *Do not pinch bellows.*

9. Connect line from aneroid to air intake manifold. See Fig. 12-97.

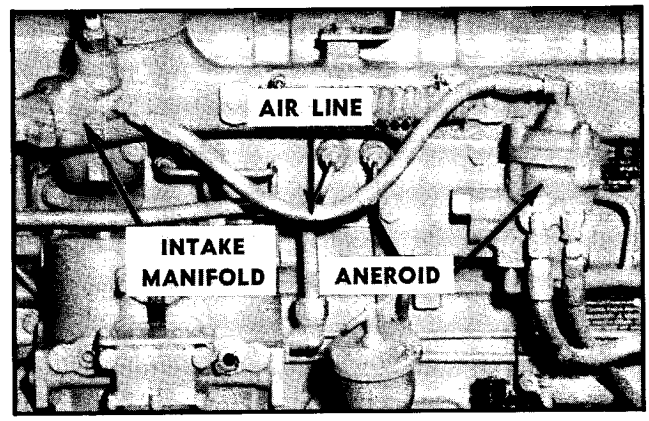


Fig. 12-97. Aneroid to air intake manifold line

Final Settings and Installation

1. Fill aneroid with clean lubricating oil.

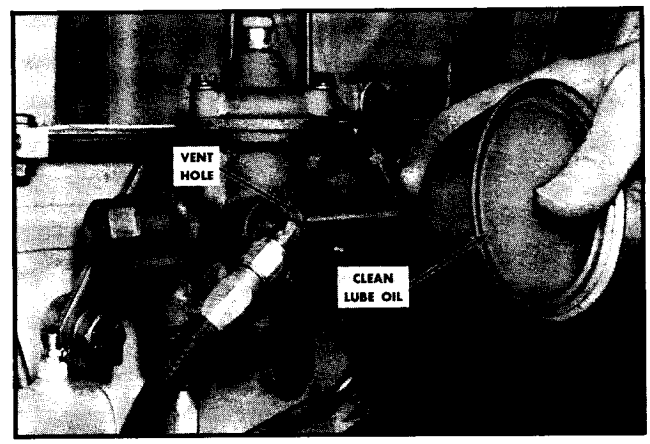


Fig. 12-98. Filling aneroid with lube oil

2. Connect vent line from aneroid to crankcase (above lube oil level). *Do not* connect this line to oil pressure or filter drain lines and *do not* install higher than vent hole in aneroid.

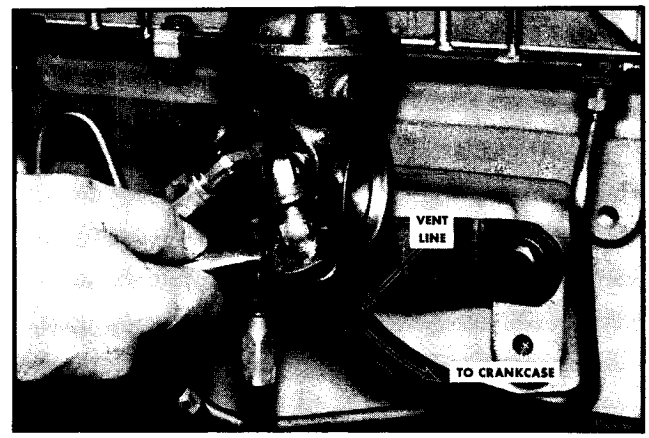


Fig. 12-99. Installing vent line to crankcase

3. Start engine, check idle speed. In most cases, idle will be low and must be adjusted upward with governor idle screw.

4. Check engine operation. If excessive smoke is present after 15 seconds of full throttle operation, the aneroid is *not* at fault. Check fuel system and turbocharger before readjusting aneroid.

5. Check smoke during acceleration by sound from idle to maximum governed speed.

a. If smoke is too heavy, back out aneroid fuel screw.

NOTE: For automotive highway application, a #4 Bacharrach or #2 Ringelman smoke density is the maximum acceptable.

b. If screw is backed out more than ½ turn, re-shim bellows spring. See Page 12-31.

c. If engine is sluggish and smoke too light, turn screw in. Re-shim bellows spring if necessary.

6. If hard starting is encountered, the aneroid pressure valve may be sticking in open position.

NOTE: The pressure valve sticking in closed position will result in excessive smoke.

Section 13

UNITS NO. 15 AND NO. 16

ENGINE MOUNTING AND ADAPTATIONS

ENGINE MOUNTING

1. Remove engine from dynamometer and move it to driven unit. See: LIFT ENGINE, Page 1-4.
2. Mount transmission to engine.
3. Mount engine to supporting brackets; check for crankshaft end clearance.
4. Mount fan to fan hub.
5. Install radiator.
6. Install all fuel and water lines.
7. Make necessary electrical connections.
8. Install mechanical control linkage.
9. Check and tighten all V-belt connections to proper tension.
10. Install air connections to air compressor, brake equipment (if used) and air cleaner.
11. Fill with fuel oil, lubricating oil and coolant. Check J Series Operation and Maintenance Manual for specifications.

ENGINE MOUNTING ADAPTATIONS

The following paragraphs set forth general policies to be followed in adapting Cummins engines to fit special applications. Each problem in mounting must be solved individually within the limits of these policies.

VIBRATION DAMPERS

Consult with Cummins engineers concerning need for vibration dampers on new or different power applications.

1. Non-viscous dampers should be examined for traces of rubber band failure or signs of excessive heat.
2. Viscous dampers should be checked for dents or cracks.

INTAKE AIR SUCTIONS

1. Air flow must be unrestricted.
2. All air must go through the air cleaner.
3. Air temperature should be maintained at 60° F. to 90° F. by the use of a "gate" on the intake air piping which allows the operator to take air from under hood in cold weather and outside hood in hot weather.
4. An engine will lose about 1% of its horsepower for each 5 degrees of temperature increase.

RADIATOR SHUTTERS

1. Shutterstats which control radiator shutters should be set to open at 180° F. and close at 172° F. when used without a thermatic fan.
2. When used with a thermatic fan, the shutters should open at 170° F. and close at 162° F.
3. Air intake must be from outside the hood when radiator shutters are used.

EXHAUST PIPING AND MUFFLERS

1. There should be no right angles or sharp bends in exhaust piping.
2. Pipe diameter throughout exhaust system must not be smaller than the exhaust manifold outlet flange.
3. There must be no restrictions or stoppages in muffler.

Check The Back Pressure

1. Tap into side of exhaust pipe at a point 1½" aft of outlet flange or manifold.

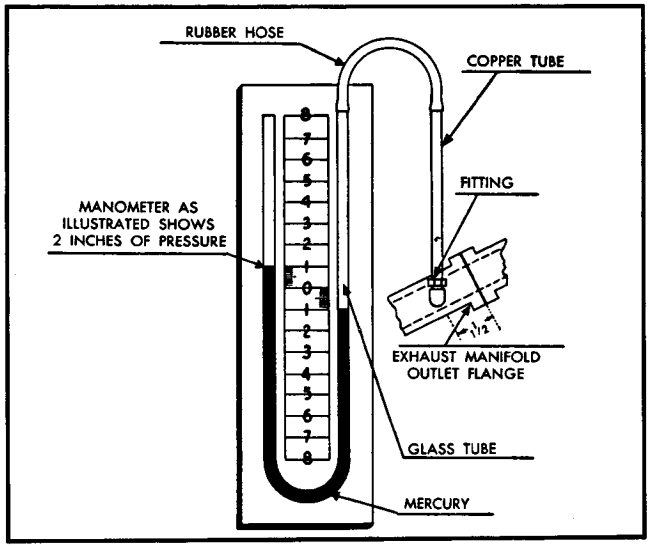


Fig. 13-1. Manometer scale and location on exhaust manifold outlet flange

2. Insert a 1/8" Weatherhead fitting flush with inside of pipe and perpendicular with it to avoid impact pressures which would give a false reading.

3. Fasten about 3 feet of copper tubing to fitting.

4. Run a rubber tube from copper tubing to one end of a water or mercury manometer.

5. Take reading when engine is developing its maximum horsepower and rpm.

NOTE: One inch of mercury or 13.6 inches of water equals .4985 pounds of back pressure per square inch.

Back Pressure Readings

J, JF, JN, J4.....Maximum: 1 inch of mercury (13.6 inches of water)

JT, JS, JNS.....Maximum: 1.5 inches of mercury (20.4 inches of water)

FUEL TANKS AND PIPING

See: Section II, PT SHOP MANUAL.

MARINE GEAR INSTALLATION

ALIGNMENT WITH CRANKSHAFT

1. Check flywheel housing to see that it is approved for use with the marine gear.

2. Check alignment of flywheel and flywheel housing.

3. Align crankshaft of engine with marine gear.

MOUNT TO THE ENGINE

1. Remove small cover plate at top of clutch housing.

2. Mount clutch housing to flywheel housing.

3. Pull bolts up uniformly and to make sure that pilot on clutch place has definitely entered into flywheel before completely tightening bolts.

4. Indicate end clearance with a dial gauge.

ASSEMBLY IN BOAT

1. Assemble marine gear before it is installed in boat.

2. Align engine and marine gear with propeller shaft; use shims where necessary.

3. Recheck and correct alignment after boat is in water.

   a. Remove bolts on propeller shaft coupling.

   b. Check spacing of two flanges on circumference. Variation should not exceed .004 inch.

POWER GENERATORS

1. The same rules given for assembly of marine gears to the engine apply to mounting of power generators.

2. Crankshaft end clearance must be maintained after assembly of generator, or any driven unit, to the engine.

CUMMINS CORROSION RESISTOR

1. Install 5/8 inch minimum I.D. hose from connection in oil cooler to corrosion resistor. A special shut-off valve, Part No. 70463, can be installed in the line if it is desired to change elements with the engine running.

2. Install 3/16 inch I.D. hose from corrosion resistor to thermostat by-pass housing. A valve should also be installed in this line if elements are changed with engine running.

3. Make sure corrosion resistor is firmly grounded to engine.

4. *Never use soluble oil in an engine equipped with a corrosion resistor.*

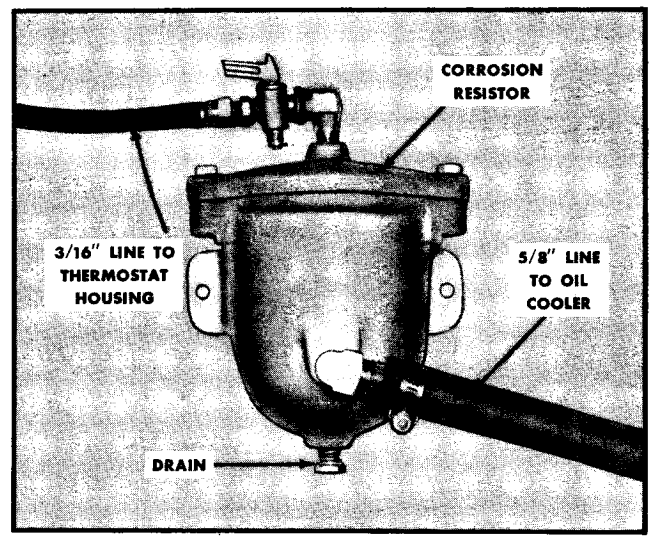


Fig. 13-2. Cummins Corrosion Resistor

Section 14

ENGINE REBUILD SPECIFICATIONS

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
	01 ENGINE BLOCK GROUP			
0101	CYLINDER BLOCK			
	Liner Counterbore Depth	.30925	.31050	.31050
	Protrusion of Liner Above Block	.0045	.00675	.004
	Main Bearing Cap in Block	–.004	–.002	.001
	Main Bearing Bore	4.124	4.125	Same
	Main Bearing Bore—Alignment	Check with ST-409		
	Main Bearing Studs in Block:			
	Tighten to 5¾"-5 $^{21}/_{32}$" height @ minimum 70 ft. lbs.			
	Camshaft Bushings I.D.	1.8745	1.8765	1.878
	Cylinder Liners—I.D.	4.125	4.126	4.130
0102	CRANKSHAFT			
	Main Journals	3.874	3.875	3.872
	Rod Journals	2.624	2.625	2.622
	Fillet Radii	.141	.164	Same
	For Other Dimensions	See Crankshaft Dimensions' Chart, P. 2-7		
	Main Bearings—Copper Lead			
	Shell Thickness	.1231	.1236	.1216
	Journal Clearance	.0018	.0048	.0068
	End Clearance	.004	.011	.022
	Tightening	Template Method, Page 12-2		
	.010, .020, .030 and .040 undersize main bearing shells are available.			
	Con. Rod Bearings—Copper Lead			
	Shell Thickness	.07225	.07275	.071
	Journal Clearance	.002	.0045	.008
	Tightening	Template Method, Page 12-7		
	.005, .010, .020, .030 and .040 undersize connecting rod shells are available.			
0103	CONNECTING ROD			
	Center to Center	9.498	9.500	Same
	Crankpin Bore	2.7725	2.7730	
	Maximum Out-of-round			.0015
	Weight Variation in Any One Engine		.03 lb.	

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
	Piston Pin Bushing	1.500	1.5005	1.5015
	Bore Misalignment—Bend	.000	.004 in 12"	.004 on ST-561 or ST-227-A
	Bore Misalignment—Twist	.000	.010 in 12°	.010 on ST-561 or ST-227-A
	Bold Fit in Rod	–.0005	.0005	.0008
	Clearance—Rod to Piston Boss	.050		.040 (Min.)
0104	PISTON			
	Ring Groove Clearance	Wedge Type Keystone Rings		
	Piston Skirt Diameter (at 70° F.) 112340	4.1195	4.1200	4.1165
	112350	4.1195	4.1205	4.1165
	117250	4.1185	4.1195	4.115
	Piston Pin Bore (at 70° F.)	1.4988	1.4990	1.500
	Piston Pin	1.4988	1.4990	1.4978
	Ring Gap Clearances (with new liners)	.013	.023	
	.010, .020, .030 and .040 oversize pistons and rings are available for J, JS, and JT engines.			
0105	REAR COVER (Asbestos Type)			
	Cover Plate to Crankshaft Clearance	.004	.006	Use Gaskets
	Bore to Crankshaft Clearance	.009	.011	
0106	CAMSHAFT			
	Journal Diameter			
	Nos. 2, 3, 4, 5, 6, 7	1.872	1.873	1.871
	Front Journal Diameter	1.747	1.748	1.746
0107	SUPERCHARGER IDLER GEAR (JS, JNS Engines Only)			
	Bushing No. 68629-1	2.125	2.126	2.127
	Bushing No. 68578	1.500	1.501	1.502
	Idler Gear Hub	2.1225	2.1235	2.1215
	Thrust Bearing No. 68631	.096	.106	.091
	Thrust Bearing No. 68632	.061	.063	.059
	Thrust Bearing No. 68633-1	.192	.194	.190
	Idler Gear to Outer Thrust Washer Clearance	.007	.019	Same

02 CYLINDER HEADS

0201	CYLINDER HEAD			
	Valve Seat Insert Counterbore (J, JS, JF)			
	Standard Depth	.256	.258	
	Standard I.D.	1.687	1.688	
	Valve Seat Insert Counterbore (JT, JNS, JN)			
	Standard Depth	.156	.161	
	Standard I.D.	1.427	1.428	
	Valve Seat Insert (J, JS, JF)			
	Valve Seat Angle	30°	30°	30°
	Insert O.D.	1.6900	1.6905	
	Oversizes	.005, .020, .030, .040		

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
	Valve Seat Insert (JT, JNS, JN)			
	Valve Seat Angle	30°	30°	30°
	Insert O.D.	1.430	1.4305	
	Oversizes	.005, .020, .030, .040		
	Valve Guide Bore (J, JF, JS)	.4045	.4052	.407
	Valve Guide Bore (JT, JNS, JN)	.3425	.3432	.345
	Intake and Exhaust Valve (J, JF, JS)			
	Seat Angle	30°	30°	30°
	Stem Diameter	.402	.403	.401
	Intake and Exhaust Valve (JT, JNS, JN)			
	Seat Angle	30°	30°	30°
	Stem Diameter	.340	.341	.339
	Crosshead Guide Bore (JT, JNS, JN)	.3755	.376	.378
	Crosshead Stem Diameter (JT, JNS, JN)	.3708	.3713	.370
	Injector Seat Angle in Sleeve	60°	60°	60°
	Injector Sleeve—Upper I.D.	1.375	1.380	
	Injector Tip Protrusion Through Head	.040	.055	.065

03 ROCKER LEVERS

0301	ROCKER LEVER HOUSING AND LEVERS			
	Shaft	1.123	1.1235	1.122
	Bushings	1.1245	1.1255	1.1265

04 VALVE AND INJECTOR TAPPETS

0401	VALVE AND INJECTOR TAPPETS			
	Injector Tappets			
	Roller O.D.	1.123	1.125	1.121
	Roller I.D.	.5655	.5665	.5675
	Roller Pin O.D.	.562	.625	.561
	Tappet O.D.	1.310	1.311	1.309
	Valve Tappets			
	Roller O.D.	1.061	1.063	1.059
	Roller I.D.	.503	.504	.505
	Roller Pin O.D.	.4995	.5000	.4985
	Tappet O.D.	1.185	1.186	1.184

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	NEW DIMENSIONS Maximum	WORN REPLACEMENT LIMIT
	07 LUBRICATING SYSTEM			
0701	Oil Pan			
	Capacity (varies with installation)	3 gal.	4 gal.	
0706	Lubricating Oil Pump			
	Impeller Drive and Impeller Shaft Bushing I.D.	.6165	.6175	.6185
	Impeller Drive and Impeller Idler Shaft O.D.	.615	.6155	.614
	Idler Gear Bushings I.D.	.9925	.9935	.9945
	Idler Gear Shaft O.D.	.990	.991	.989
	Impeller Gear O.D.	1.832	1.833	1.831
	Impeller Gear Pockets I.D.	1.840	1.842	1.843
	J-4 Balancer Drive Shaft	.8105	.8095	
	J-4 Balancer Drive Shaft Bushing	.8145	.8150	
	Idler Gear Thrust Washer	.062	.060	
	J-4 Balancer Drive Gear Thrust Washer	.062	.060	
	08 COOLING SYSTEM			
	THERMOSTATS			
	Main Line Thermostat Operating Range	160° F.	175° F.	Same
	WATER PUMP			
	(Supercharger Driven)			
	Cover Face to Impeller Hub	.872	.878	
	(Belt Driven)			
	Cover Face to Impeller Hub	.620	.625	
	(J-4 Pump)			
	Impeller to Pump Body	.010	.020	
	10 AND 11 INTAKE AND EXHAUST SYSTEMS			
1002	SUPERCHARGER			
	Clearances			
	Radial Bearing Clearance			.003
	Rotor Shaft End Play			.005
	Rotor Timing Gear Backlash			.004
	Gear Hub Protrusion over Bearing Cage	.002	.005	.006
	Rotor to Gear End Plate	.003	.003	Add or Remove Shims
	TURBOCHARGER			
	Radial Clearance	.000	.010	
	Rotor End Play	.004	.012	

UNIT NUMBER	PART OR LOCATION	NEW DIMENSIONS Minimum	Maximum	WORN REPLACEMENT LIMIT
1406	INJECTORS			
	Adjustment	Refer to Page 12-20		
1407	LUBRICATING OIL PRESSURES			
	Idling to Governed Speed	15 psi	55 psi	
	Normal at Governed Speed	30 psi	50 psi	
1414	ENGINE HORSE POWER RATINGS			
	(Sea Level and 60° F.)			
	At Maximum Speed Ratings			
	J-4 @ 2200 rpm		75 hp	
	J-6 @ 1800 rpm		100 hp	
	JF-6 @ 2200 rpm		110 hp	
	JN-6 @ 2500 rpm		130 hp	
	JNS-6 @ 2500 rpm		175 hp	
	JS-6 @ 2500 rpm		160 hp	
	JT-6 @ 2500 rpm		175 hp	
1416	EXHAUST BACK PRESSURES			
	Maximum Permissible—Inches of Mercury			
	J, JF, JN Engines		1.0	
	JNS, JS and JT Engines		1.5	
1416	FLYWHEEL HOUSING			
	Bore Run-out	.000	.004	.004
	Face Run-out	.000	.008	.008
	Clutch Pilot Bearing Bore Run-out	.000	.004	.004
	Clutch Drive Ring Pilot Bore	.000	.004	.004
	Clutch Face	.000	.005	.005
	Static Balance Tolerance—Flywheel		2 inch ounces	

TABLE 15—SPRING DATA (MISC.)

PART NUMBER	SPRING	FREE LENGTH	LOAD	@ LENGTH
9315	Injector Fuel Connection	1-21/64	40 ± 4.5#	7/8
9337	Injector Plunger Spring	1 7/8	64 ± 4#	1-47/64
62411	Injector Check Valve	.289	3.58 ± .35 oz.	.193
66507-1	Lube Oil By-Pass Valve	2.185/2.371	6.44 ± .5#	.968
69355	Lube Oil Press. Relief Valve	3.28	17.21 ± .8#	2.055

J SERIES

TORQUE SPECIFICATIONS

PART	FT./LBS. TORQUE
Cylinder Heads	
11/16 Inch Nuts or Capscrews	300
¾ Inch Nuts or Capscrews	400
Exhaust Manifold	
7/16 Inch Studs (Washers or Lockplates under Nuts)	25
7/16 Inch Studs	40
½ Inch Studs (Washers or Lockplates under Nuts)	30
½ Inch Studs	45
⅜ Inch Studs (JT Only)	25
⅜ Inch Capscrews (JT Only)	22
Main Bearing Caps	See Page 12-2
Connecting Rod Caps	See Page 12-7
Flywheel Capscrews	100/110
Injector	
Hold-down	10/12
Adjustment (140° Oil Temperature)	5
Fuel Inlet and Drain Connections	20/25
Injector Cup (With Relief)	60
Injector Cup (Without Relief)	70
PT Fuel Pump	
Bearing Cover	90/95 in./lbs.
Spring Pack Cover	90/95 in./lbs.
Screen Cover	20/25 in./lbs.
Gear Pump Cover	17
Gear Pump Mounting	9
Shut-off Valve Nut	60 in./lbs.
Pressure Regulator	20/25
Vibration Damper Capscrews	35/45
Crankshaft Flange	130/140
Crosshead Adjusting Screw Nuts	25/30
Turbocharger	
Nozzle Ring	100 in./lbs.
Main Casing	84 in./lbs.
Exhaust Casing	12
Mounting	25