SECTION VIII ENGINE REPAIR AND OVERHAUL

This section includes instructions for repairs and overhaul of the component units of Continental Red Seal six cylinder over-head valve engines.

Provide a clean place to work and clean the engine exterior before you start disassembling — dirt causes engine failures.

Many shop tools have been developed to save time and assure good workmanship; these should be included in your equipment.

Use only genuine Red Seal parts in Continental over-head valve engines as years of development and testing have gone into these specifications to assure maximum life and performance.

CYLINDER HEAD

The cylinder head is an important part of the engine assembly since it contains the combustion chamber, valves, and cored passages for air, exhaust and water flow.

REMOVING THE CYLINDER HEAD

1. Drain water from engine and disconnect radiator or heat exchanger hoses.

2. Remove cylinder head covers by taking out the screws holding them to the rocker arm supports.

3. Remove rocker arm shaft assemblies and push rods. Grip the push rods and snap them sideways out of the tappet sockets as shown in the illustration. This method serves to break the hydraulic connection and permits lifting the push rods out and leaving the tappets in place. (If tappets are lifted out of the guides they will have to be reassembled through the opening in the block if only the cylinder head is removed for servicing.) Tappets in the R - S and U models are of the mushroom type and will not lift out.

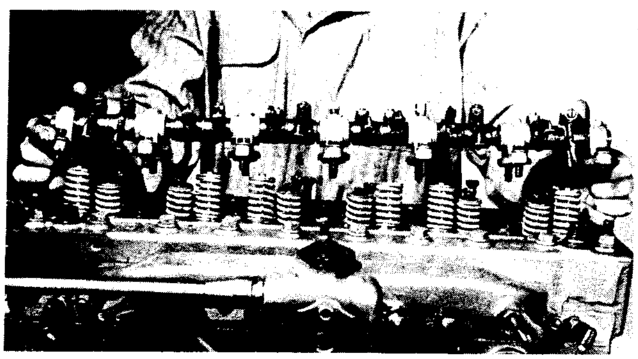


Figure 122
Removing Rocker Arm Assembly

Figure 123
Snapping Push Rod out of Ball Socket of Tappet on T Series

4. Loosen and remove the nuts holding the cylinder head to the block.

5. Lift the cylinder head off the engine and carry to a clean bench for further disassembly.

DISASSEMBLY OF CYLINDER HEAD

1. Remove all carbon from combustion areas using scraper and wire brush.

2. Using a C type valve spring compressor, remove the valve spring retainer locks, retainers, springs and oil seals on intake valve stems — placing all parts in a container of solvent.

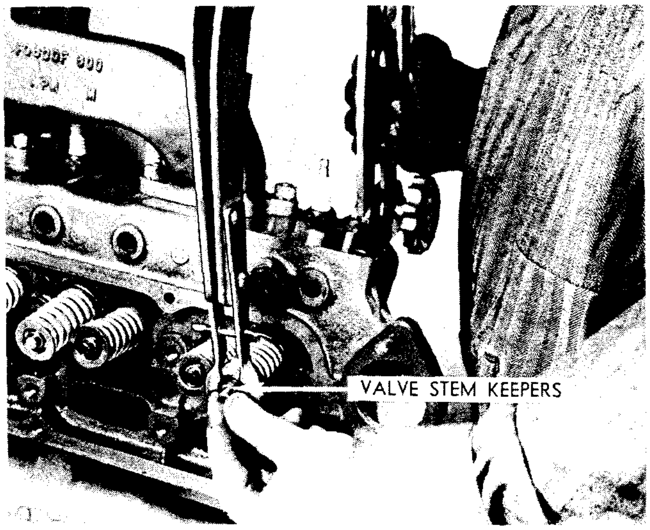


Figure 124
Removing Valve Springs

3. Remove the valves and place them in order in a rack with holes numbered for both intake and exhaust so they will not be mixed in handling.

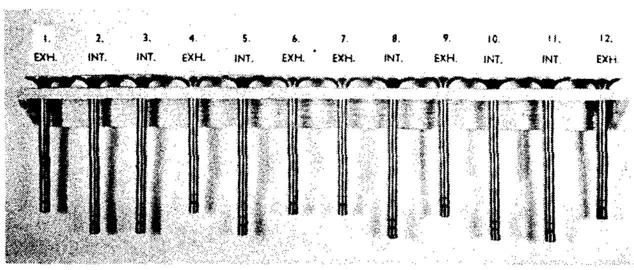


Figure 125
Valves in Rack

4. Clean the cylinder head thoroughly with a solvent or degreasing solution and blow it off with air pressure. Inspect carefully for cracks.

On the R Series, make sure that holes in the three rocker arm support studs (figure 126) are clean and open as they are oil passages to the rocker arm system.

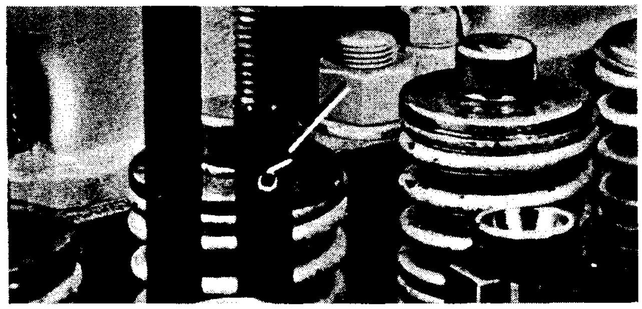


Figure 126
Studs Drilled for Oil Passages to Rocker Arms (R600 Series)

VALVE GUIDES

1. Clean the valve stem guides, removing lacquer or other deposits. Do not use tools that remove metal.

2. Check guides for wear by using a telescope gage and 1" micrometer. Replace all guides that are worn bell-mouthed and have increased .0015 in diameter. See Limits and Clearance Section for maximum diameter permissible to determine actual amount it has increased. Remove all valve guides when necessary by pressing them out from the combustion chamber side.

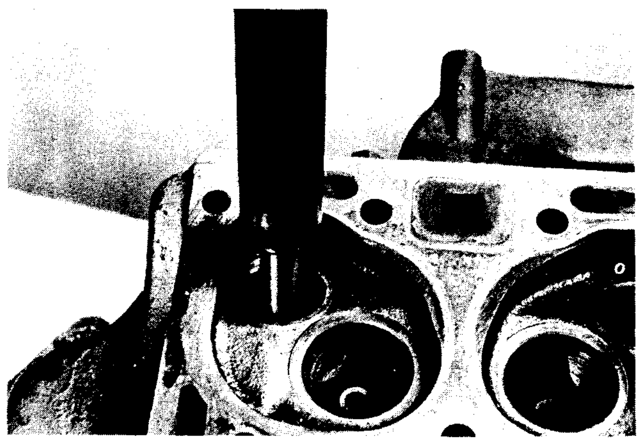


Figure 127
Removing Valve Guides from Combustion Chamber Side

3. Replace worn guides as required by pressing in new guides from the combustion chamber side to the correct depth below the valve seat face as given in the Chart.

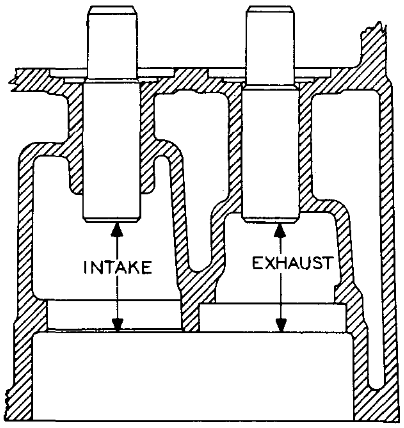


Figure 128 — Diagram showing Valve Guide location, R600

	Intake	Exh.
FO	1 3/32	1 11/32
K	1 13/32	1 19/32
T	1 3/4	1 3/8
U	1 7/8	1 7/8
R	1 5/8	1 5/8
S-749	1 17/32	1 1/2
S-820	1 27/32	1 1/2

Diagram Showing Valve Guide Location Valve Seat Face to Top of Guide

4. Ream new valve stem guides only when *not* Ferrox coated to size given in Limits and Clearance Chart, using a straight reamer ground to correct size and having a pilot which will properly locate it and keep it from wandering from the original reamed hole.

> **CAUTION: When replacing guides that are ferrox coated do not ream since these are all pre-reamed before being ferrox coated—any further reaming will remove the coating.**

VALVE SEAT INSERTS

1. Valve seat inserts are used *only* for the exhaust valves, and are held in place by a shrink fit.

Inspect all exhaust valve inserts in the head and replace any that are loose, cracked or otherwise damaged. Use puller for removing faulty insert as shown below.

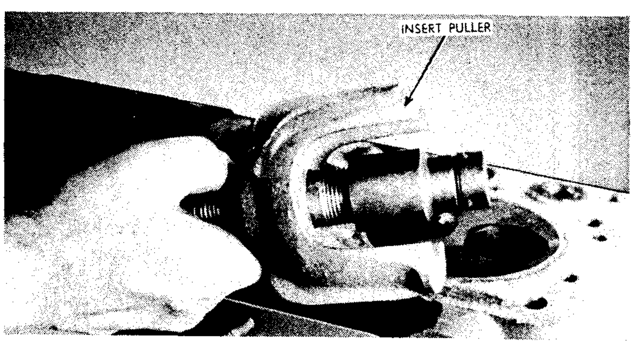


Figure 129
Exhaust Valve Seat Insert Removal Tool

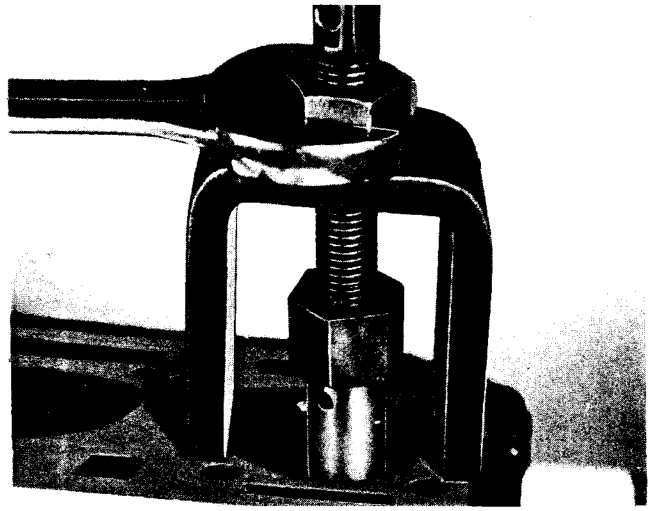


Figure 130
Removing Exhaust Valve Seat Insert

2. Continental does not recommend installing new inserts having the same outside diameter as the one removed. When required to replace an insert clean and re-machine counterbore for a .010 larger insert than the one removed, using a tool with a correct fitting pilot.

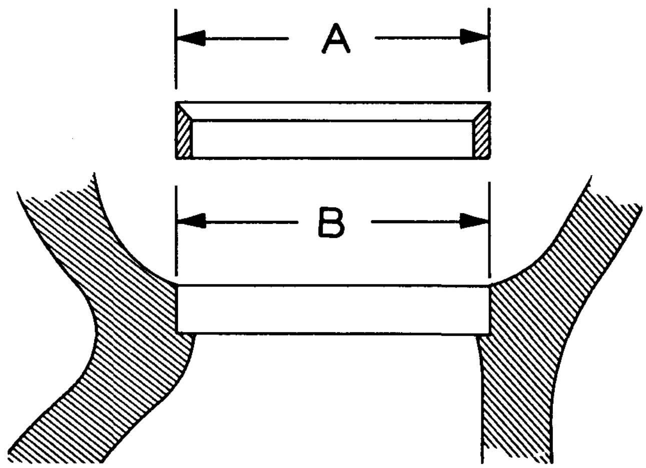


Figure 131
Insert and Counterbore

When machining the counterbore, be sure to go deep enough with the tool to clean up the bottom so that the insert will have full contact to carry away the heat.

The following chart shows the dimensions of standard inserts and counterbores:

Engine Model	Outside Dia. of Insert A	Inside Dia. of C'bore B	Press Fit
FO	1.5775/1.5785	1.5745/1.5735	.003 -.005
K	1.816 /1.815	1.813 /1.812	.002 -.004
T	1.8785/1.8775	1.8755/1.8745	.002 -.004
U	1.9815/1.9805	1.976 /1.975	.0045-.0065
R	2.1905/2.1915	1.188 /2.187	.0025-.0045
S	2.504 /2.503	2.5005/2.4995	.0025-.0045

When OVERSIZE inserts are used, dimensions of the insert and counterbore increase proportionately (.010, .020, .030 — depending on the oversize.

New insert installation should have press fit. Chill insert in container with dry ice for 20 minutes before assembling.

Insert may then be installed in the counterbore using a piloted driver, tapping in place with very light hammer blows, without the possibility of shearing the side walls. This assures it being seated firmly on the bottom of the counterbore after which it should be rolled or peened in place.

VALVES

1. Inspect valves for condition and replace any that are "necked", cracked or burned, also any on which valve stems are bent or worn more than .002. Reface or replace all valves.

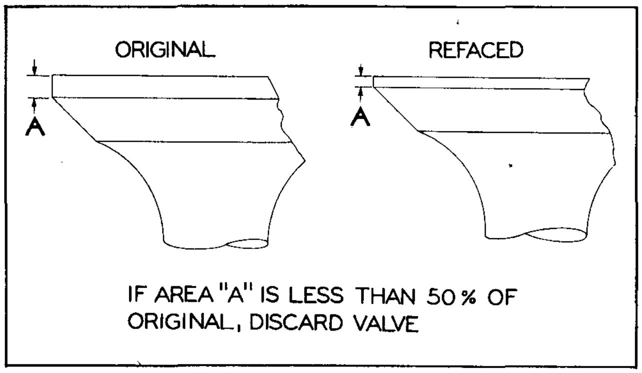


Figure 132
Allowable Head Thickness of Refaced Valves

2. All valves having less than 50% margin thickness (outer edge of valve head) after refacing has been completed must be replaced. To check this dimension, compare the refaced valve with a new valve.

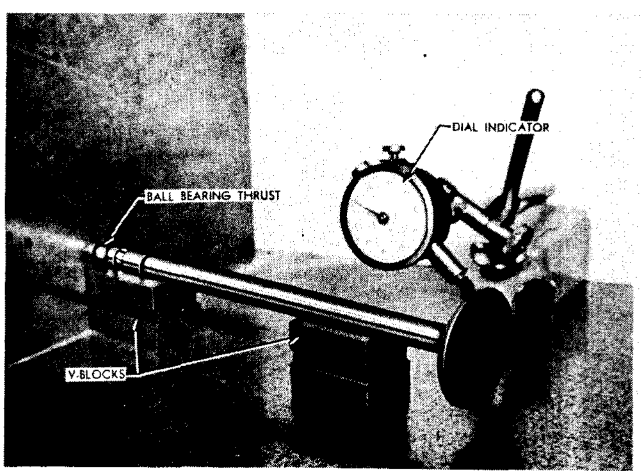


Figure 133
Checking Valve Face in V-Blocks

3. Check all refaced or new valves in V-blocks with indicator to determine if the contact face is true with the stem within .002. If not, repeat the refacing operation.

4. Grind the intake and exhaust valve seats in the head in accordance with instructions in your limits and clearance chart.

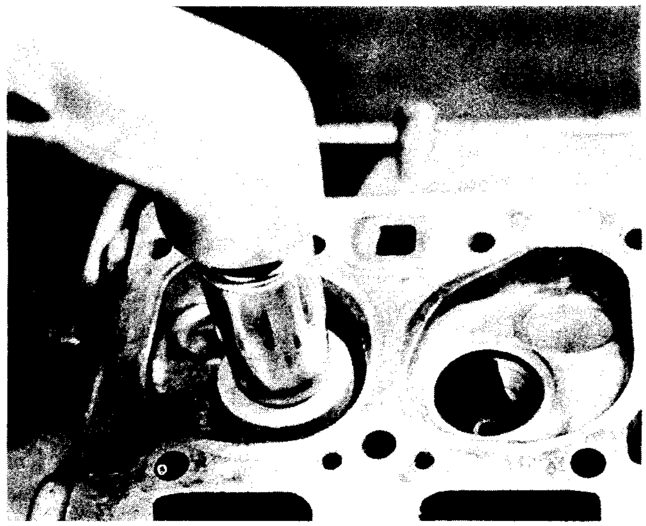


Figure 134
Grinding Intake Valve Seats

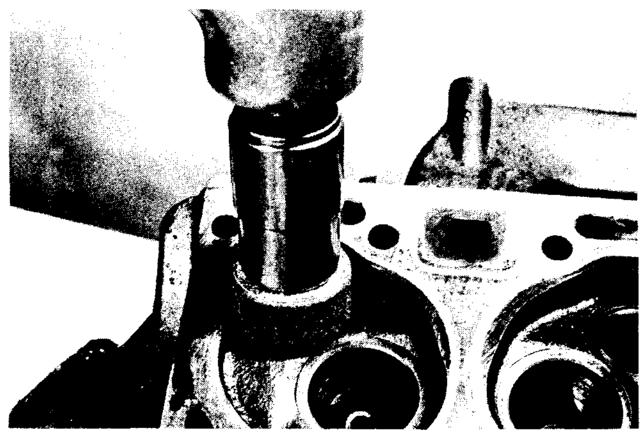


Figure 135
Grinding Exhaust Valve Seat

Before removing the arbor, indicate the seat. Total indicator reading must not be more than .002″.

Use a pilot preferably having a solid stem with a long taper, as all valve seats must be ground concentric and square with either new or worn valve stem guide holes.

5. After the valves and seats have been refaced and reground, coat the seat lightly with Prussian blue and drop the valve into position, oscillating it slightly to transfer the blue pattern to the valve face. This should show a contact width of 1/16″ to 3/32″ and should fall well within

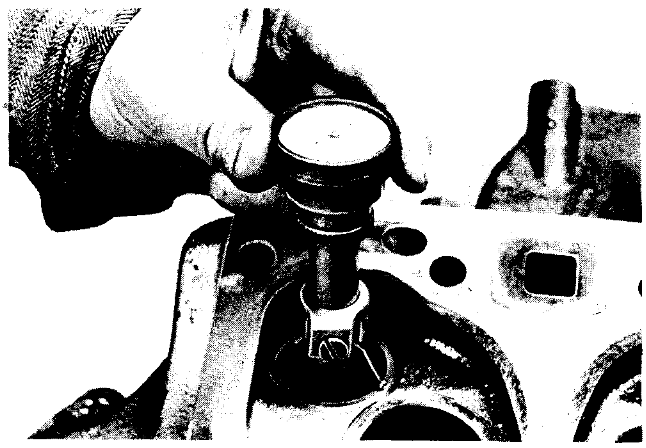


Figure 136
Checking Exhaust Valve Seat Run-out

the width of the valve face, leaving at least 1/64″ on either side where the blue does not show.

If the contact is too wide, the seat in the head may be narrowed by using a 15° stone to reduce the outside diameter or using a 60° or 75° stone to increase the inside diameter.

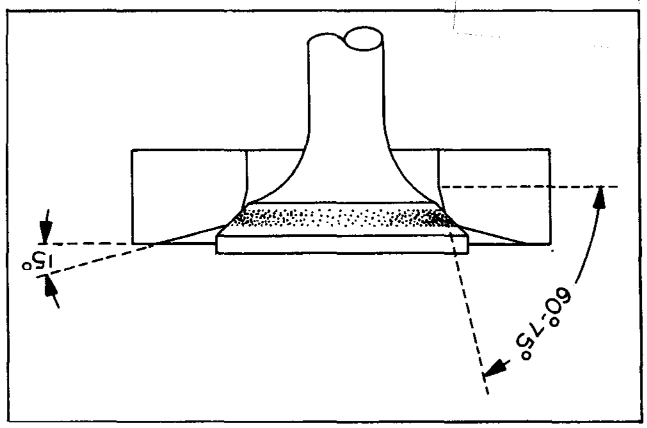


Figure 137
Method of Narrowing Valve Seats

Never allow valves to set down inside the seat.

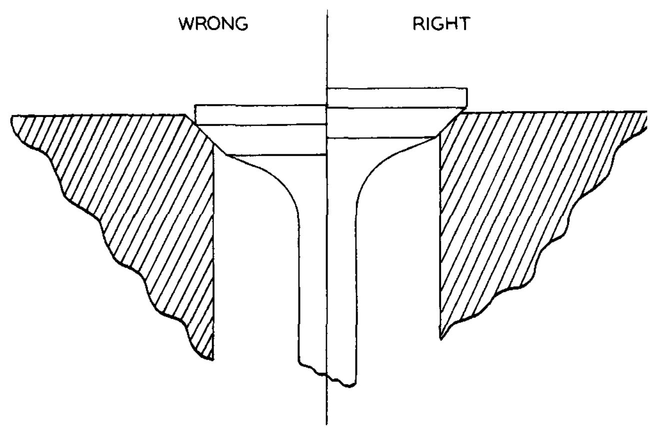


Figure 138
Valve Position in Head

After the narrowed-down seat is brought within specifications, it should be retouched lightly with the original stone to remove burrs or feathered edge.

"A poor valve grinding job cannot be corrected by lapping with grinding compound."

6. Coat the valve stem with a light film of engine oil.

VALVE SPRINGS

1. Check all valve springs on a spring tester to make sure they meet specifications regarding weight and length.

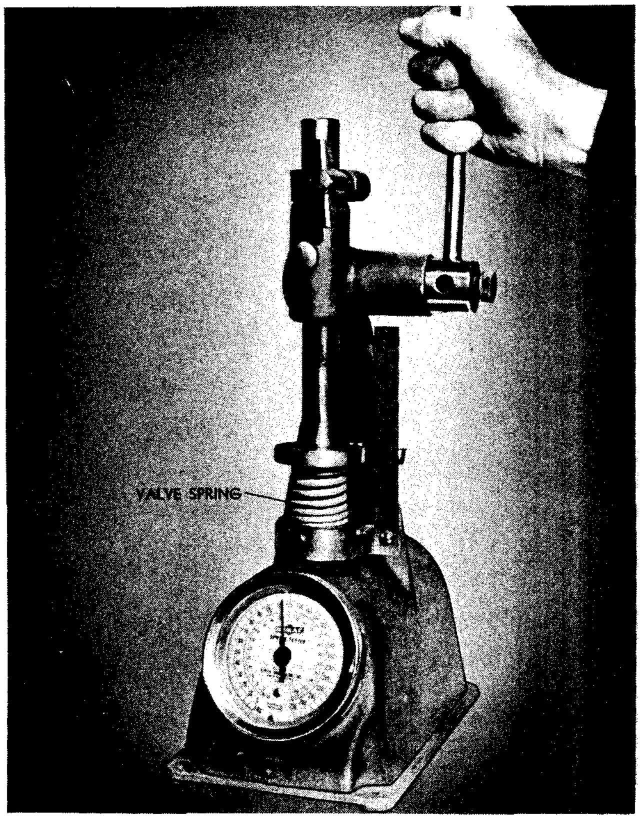


Figure 139
Valve Spring Tester

Springs, when compressed to the "valve open" or "valve closed" length, must fall within the specifications shown on the Limits and Clearance chart when new, and must not show more than 10% loss to re-use.

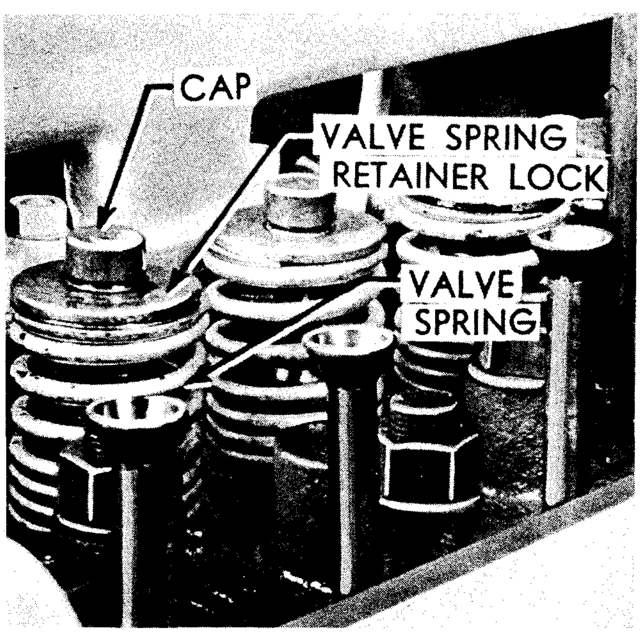


Figure 140
Valve Assembly
Note: Close Wound Coils Contact Head

2. Reassemble the valves and springs in the head with the retainer and retainer lock. *The close wound coils of the valve spring should contact the cylinder head.*

ROCKER ARMS

1. Inspect the rocker arm shaft for wear. If the shaft has "shoulders" on it due to wear, replace. Blow out oil holes with air.
2. Examine rocker arms for cracks, condition of valve contact surface and worn bushings. Replace all defective rocker arms or any having over .005 clearance between shaft and arm.
3. Inspect the rocker arm brackets for cracks or other damage.

VALVE PUSH RODS

1. Inspect push rods for bends or twists and examine the ball and cup ends for excessive wear. Replace rods that are faulty or excessively worn..
2. To prevent damage to push rods, replace after the cylinder head is installed.

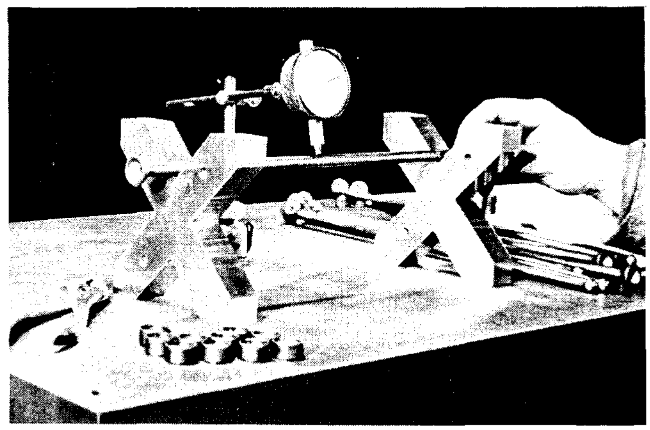


Figure 141
Push Rod Inspection for Runout

INSTALLING HEAD

1. Make sure that gasket contact surfaces on the head and block are clean, smooth and flat. Check flatness with straight edge and feeler gauge in three positions lengthwise and five crosswire. The maximum permissible on dual heads is .004 low in the center lengthwise, while on the single heads .006 is acceptable, gradually decreasing towards the ends. Crosswise or in localized low spots maximum should not exceed .003. The Cylinder head or block must be resurfaced if these limits are exceeded.

Figure 142
Checking Cylinder Head Flatness

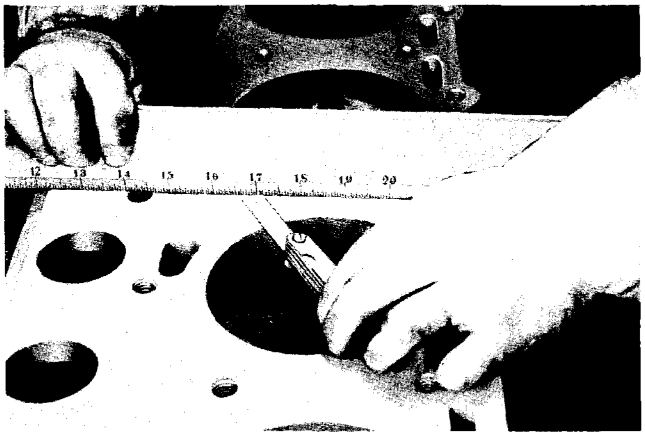


Figure 143
Checking Cylinder Head Flatness Crosswise

2. Use new cylinder head gasket, which is precoated, thus no cement is required.

3. Using a chain hoist, lower the cylinder head assembly evenly over the studs, then pull all cylinder head cap screws up snug with speed wrench.

4. Tighten with torque wrench in recommended sequence to the correct torque shown in Chart *by going over them two times before pulling them down to the final torque specification on the third round.*

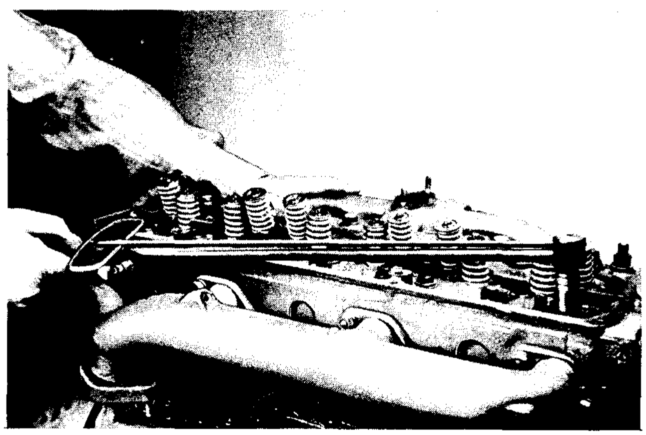


Figure 144
Torquing Cylinder Head Nuts

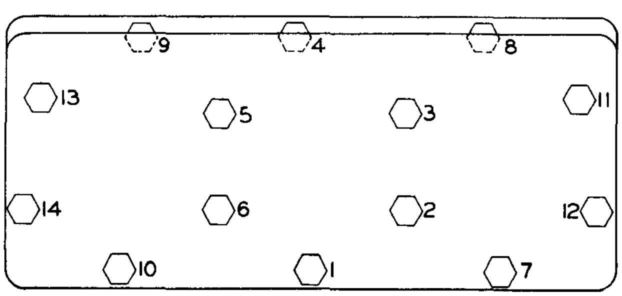
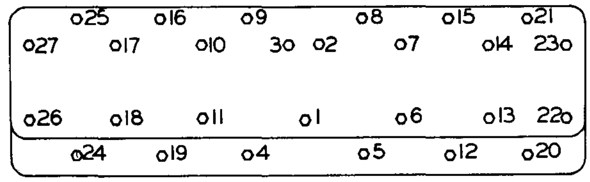
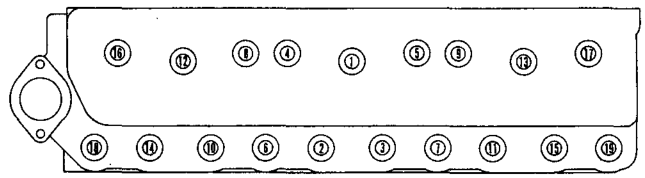


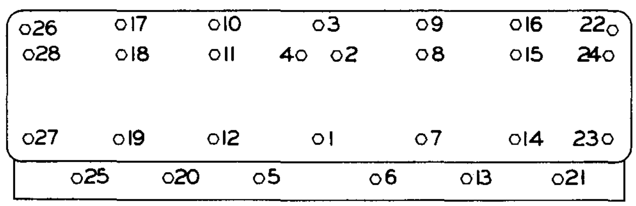
Figure 145
S Series
Cylinder Head Tightening Sequence



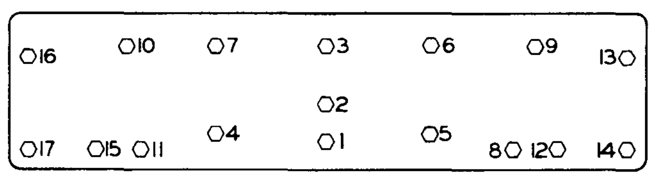
K Series



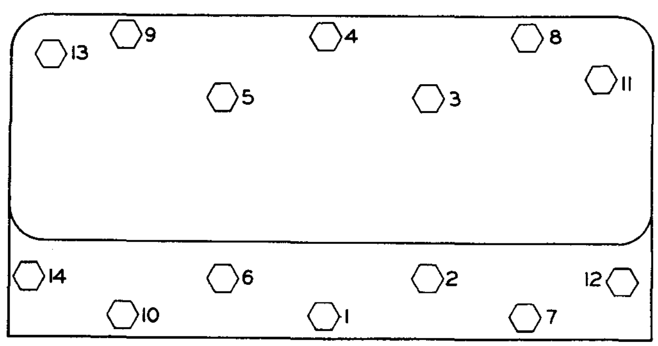
FO Series



T Series



U Series



R Series

CYLINDER BLOCK

Continental six-cylinder overhead valve engines have the cylinder bores machined in the cylinder block casting.

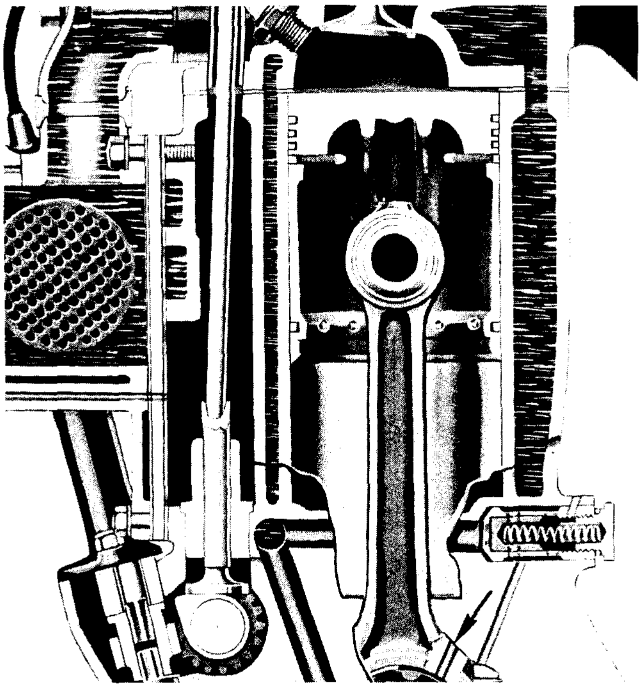


Figure 146
Sectional View of Cylinder

When cylinder bore wear is less than .008 — a set of service rings may be used to restore the engine to satisfactory operating condition.

If the bore wear is over .008 — it must be rebored to have oversize pistons.

CHECKING BORE WEAR

1. Clean the ring of carbon from around the top of the cylinder bore formed above the travel of the top ring.

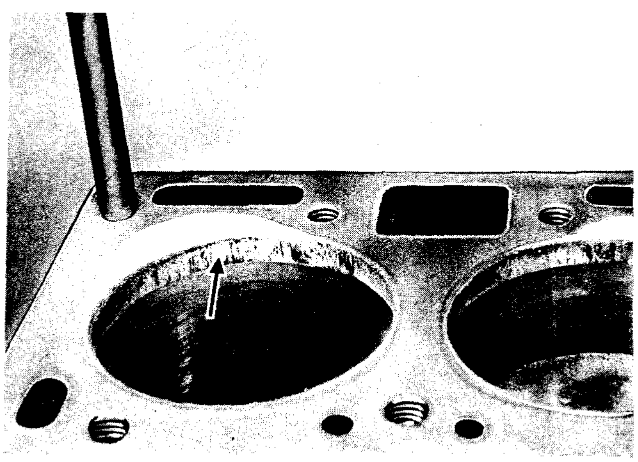


Figure 147
Deposits on Cylinder Before Cleaning

2. Determine the original diameter of the cylinder bore by checking this unworn area with a pair of inside micrometers at intervals of approximately 45°.

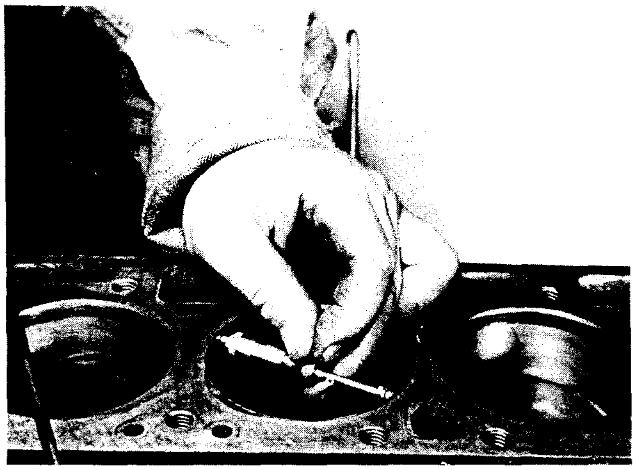


Figure 148
Measuring Original Diameter of Bore (on R and S)

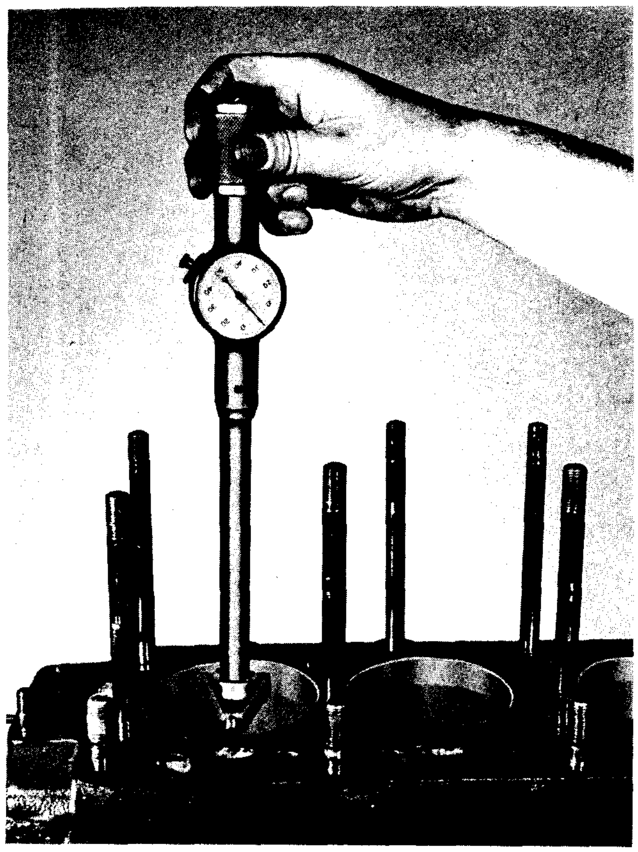


Figure 149
Measuring Original Diameter of Bore with Bore Gauge

3. Check in same manner the top of the ring travel area aproximately ¼" below the shoulder.

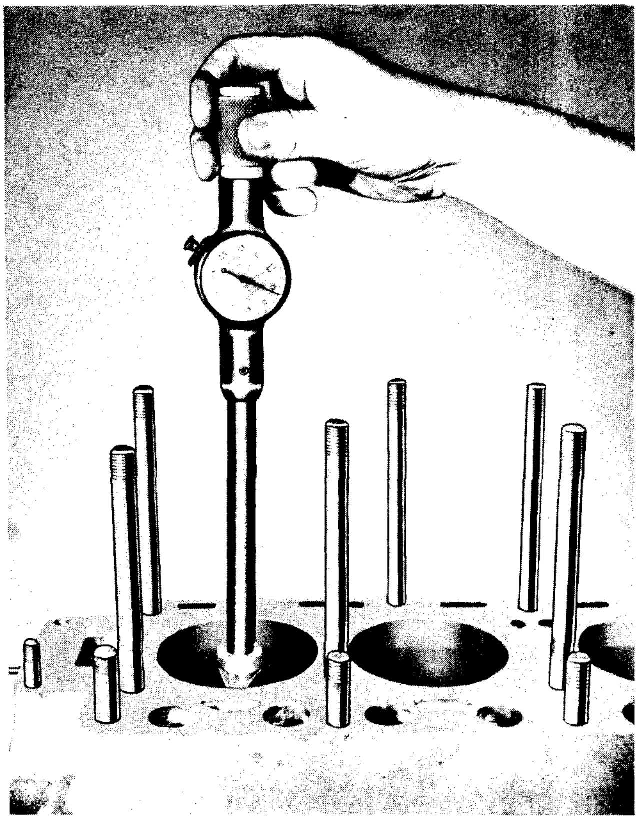


Figure 150
Measuring Bore Wear ¼" Below Shoulder

4. The maximum difference in the above checks, indicates the amount of cylinder bore wear. If less than .008, reringing will be suitable and if over .008 reboring is required.

RE-RINGING (*For bore wear less than .008*)

1. Ridge ream the cylinders to remove the unworn area at the top so that the new rings when assembled will not bump and distort both themselves and the piston lands.

Several good makes of ridge reamers are available which will ream the top of the bore in direct relation to be worn area so that should the worn area be off center slightly there will be no partial ridge remaining.

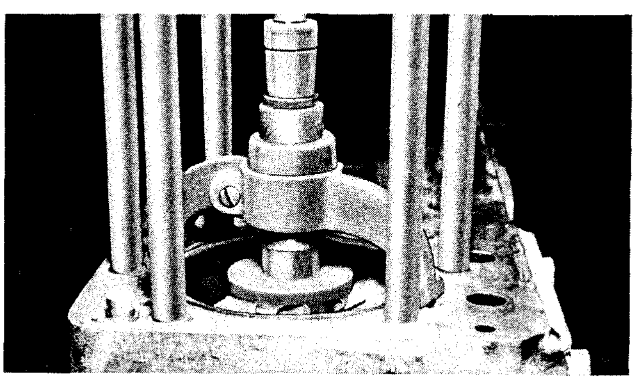


Figure 151
Ridge Reaming Top of Cylinders

2. Drain the crankcase and remove the oil pan.

3. Remove cotter pins and nuts from the connecting rod bolts, permitting removal of caps. Keep the caps and bolts in numerical order so that when the pistons and rods are removed from the engine, the cap can be reassembled and kept with its mating part. If not already numbered, do so at this time.

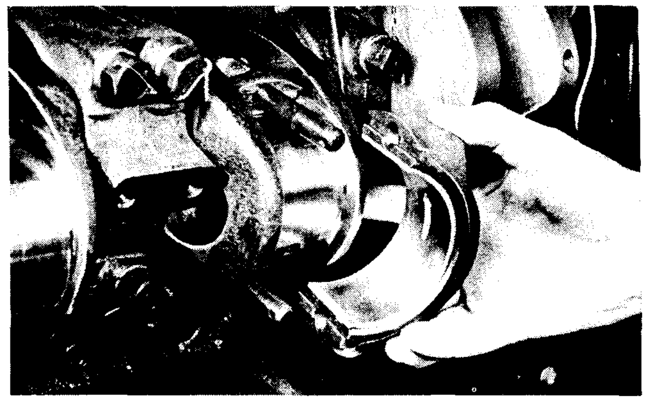


Figure 152
Removing Connecting Rod Cap

4. Push the pistons and connecting rods up through the top of the cylinder, carrying with them all the carbon and metal chips left from the cleaning and ridge reaming operation. When doing this, every precaution must be taken to prevent damage to cylinder bores by the sharp corners and rough edges of the connecting rods and bolts.

5. Break the glaze on the cylinder bores by using a glaze-breaker or other means in order to assure quick seating of the new piston rings — protect the crankshaft with oily (not dirty) rags during the glaze breaking operation.

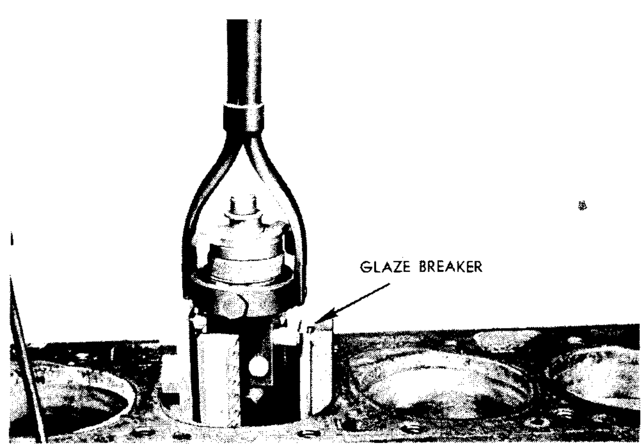


Figure 153
Breaking Cylinder Wall Glaze

The glaze breaker may be run up and down the cylinder bore while turned with an electric drill until the shiny surface is removed, after which these surfaces must be thoroughly cleaned by wiping with a clean oiled rag which will pick up the small particles of dust that are embedded in the pores of the iron.

Failure to do this cleaning carefully, raises one of the big objections to using a glaze breaker or other means for roughing up the cylinder bores so the new rings will seat. If the glaze is not removed, we have no assurance as to when the rings will begin to function properly and control the oil; therefore, *we must recommend that this be done — but done with care — and the bores thoroughly cleaned afterwards.*

6. In many cases, the top ring land has a cast insert or a thin steel ring in a groove above the ring — which materially reduce top ring land wear.

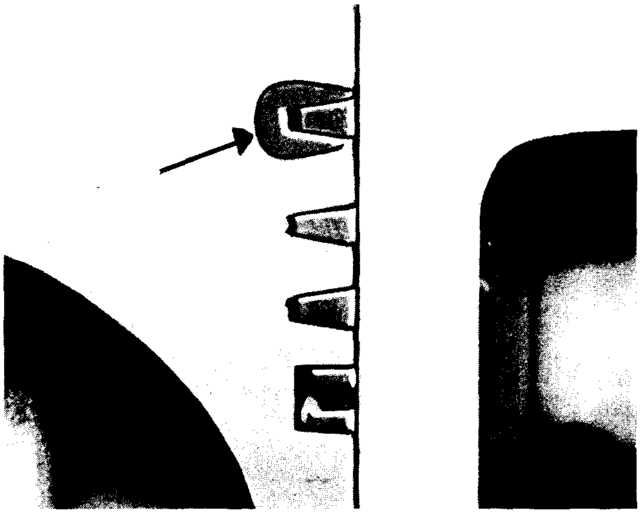


Figure 154
Cast in Insert

Worn ring grooves on the conventional piston can be salvaged by installing a ring groove insert as furnished by several piston ring manufacturers, as shown below.

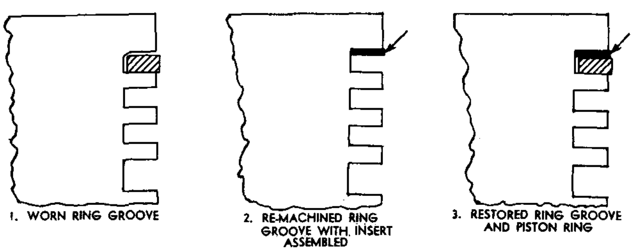


Figure 155
Ring Groove Insert

Some of them provide tools so that this job can be done manually in a shop not equipped with machines for this purpose.

7. After the honing or glaze breaking operations are completed, clean the cylinder bores and crankcase thoroughly with a solution of water and one of the many detergents available.

8. Blow off with compressed air, then wipe with clean, oiled rag to protect the finished surface.

PISTON FIT

Check the piston fit in the bore using a half-inch wide strip of feeler stock, of the thickness specified in the Limits and Clearance Chart, the feeler being attached to a small scale of approximately 15 lbs. capacity.

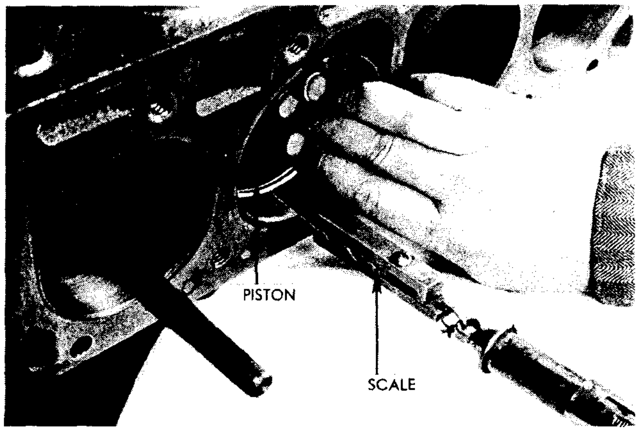


Figure 156
Checking Piston Fit in Bore

When the correct fit is obtained you must be able to withdraw the feeler with a pull of 5-10 pounds on the scale, the feeler inserted between the piston and the cylinder midway between the piston pin bosses where the diameter of the piston is the greatest. Check the fit of the piston when it is *approximately 2" down* in the cylinder bore in an inverted position.

Piston Fit With 5 to 10# Pull					
FO	6226	—.0015	R	513 / 6513	—.005
K	330 / 6330	—.005	R	572 / 6572	—.005
K	363 / 6363	—.002	R	602 / 6602	—.006
T	427 / 6427	—.004	S	749 / 6749	—.008
U	501 / 6501	—.005	S	820 / 6820	—.008

PISTON RINGS

Check all piston rings in the cylinders for gap regardless of whether you are using (1) a re-ring set of piston rings in cylinder bores which have been ridge reamed or (2) a standard set with new cylinder sleeves or (3) an oversize set for cylinders that have been rebored.

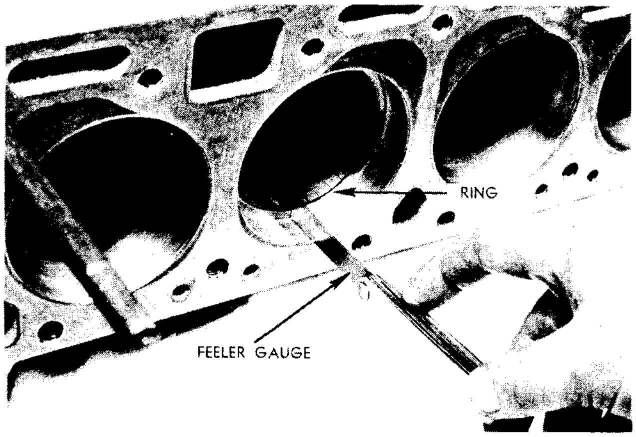


Figure 157
Checking Ring Gap

To do this, insert a piston in the cylinder bore in an inverted position and then insert each ring one at a time *about 2" down in the bore* and bring the bottom edge of the piston up against the ring to square it up in the cylinder bore.

PISTON RING GAPS

Check the gap between the ends of the ring with a feeler gauge in accordance with specifications shown in the Limits and Clearance chart. If any of the rings do not have enough gap, they may be filed either in a ring filing fix-

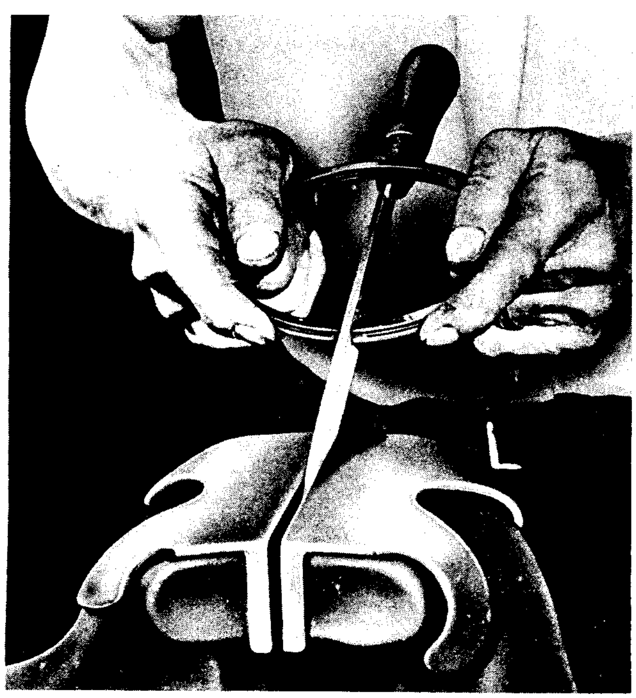


Figure 158
Filing Piston Ring to Increase Gap

ture or by clamping the file in a vise and holding the two ends against opposite sides of the file as shown above.

PISTON PINS

Check the bushing in the upper end of the connecting rod for wear. If worn and you are using the original pistons with a service set of rings, an oversize piston pin may be obtained in .003 or .005" oversize.

The piston pin hole in the piston and the bushing in the connecting rod may be honed to in-

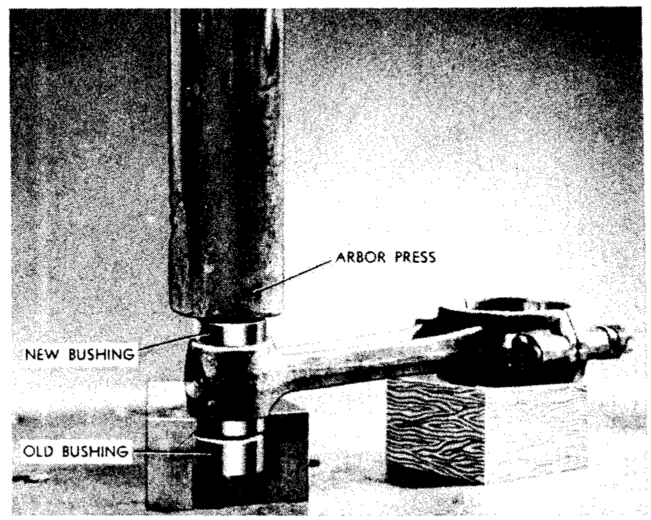


Figure 159
Pressing in Piston Pin Bushing

crease their diameter to obtain the desired fit as shown in your Limits and Clearance Chart.

> *Note that while the chart specifies a light push fit of the pin in the piston, there is a definite clearance of the piston pin in the connecting rod.*

CONNECTING ROD

Replace the bushing in the connecting rod if new pistons or pins are used. Using an arbor press, press out the old bushing and press in the new one — after which the bushing must be honed to obtain the correct fit of the pin in the bushing as shown on Limits and Clearance Chart.

If there is an excess of stock in the piston pin bushing, it may be reamed first, then honed. In any event, the final operation should be done with a hone to obtain the desired fit with better than 75% bearing area on the pin.

PISTON AND CONNECTING ROD ASSEMBLY

1. Assemble the piston on the connecting rod by first heating them in some form of oven or in hot water to a minimum temperature of 160°F.

With the piston heated, the pin will enter the piston very easily and can be pushed on through the connecting rod and into place without distorting the piston.

The snap rings must be assembled in the grooves, making sure they are fully seated in place.

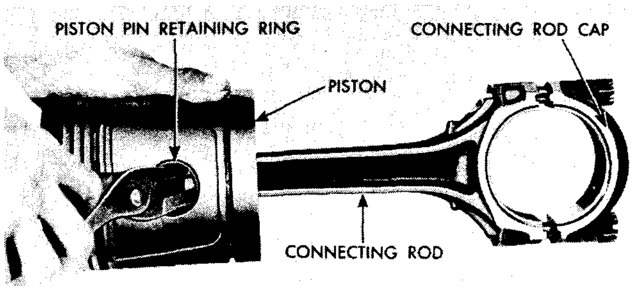


Figure 160
Installing Snap Ring

2. The piston pin hole in the connecting rod must be parallel to and in plane with, the large bore in the bearing end of the connecting rod.

This may be checked on a fixture with the piston pin assembled in the rod before assembling the piston; but regardless of this preliminary check, the completed piston and rod assembly must be rechecked and there must not be more than .002" twist or out of squareness checked over a spread of approximately 4 inches.

The connecting rod can be carefully bent or twisted to meet this specification.

Pistons are cam and taper ground, and this must be taken into consideration when checking alignment of the assembly, since the diameter in line with the piston pin would be less at the top of the skirt than at the bottom.

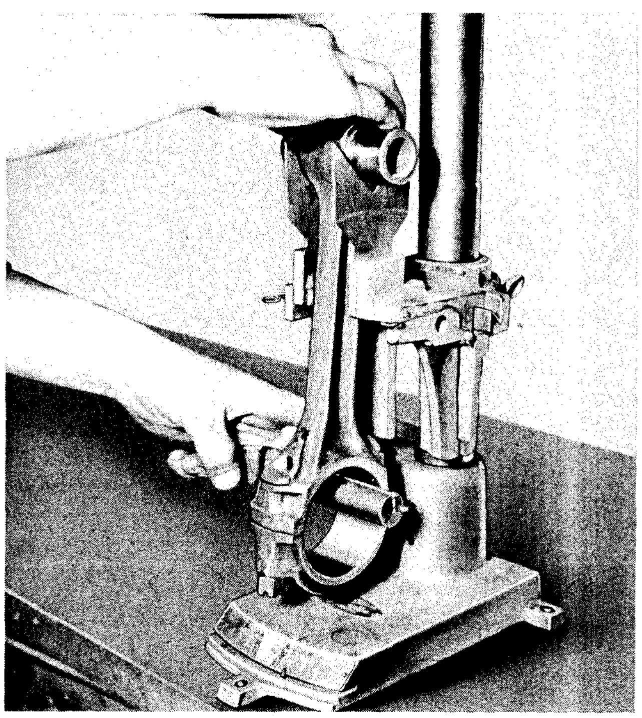


Figure 161
Checking Connecting Rod for Twist

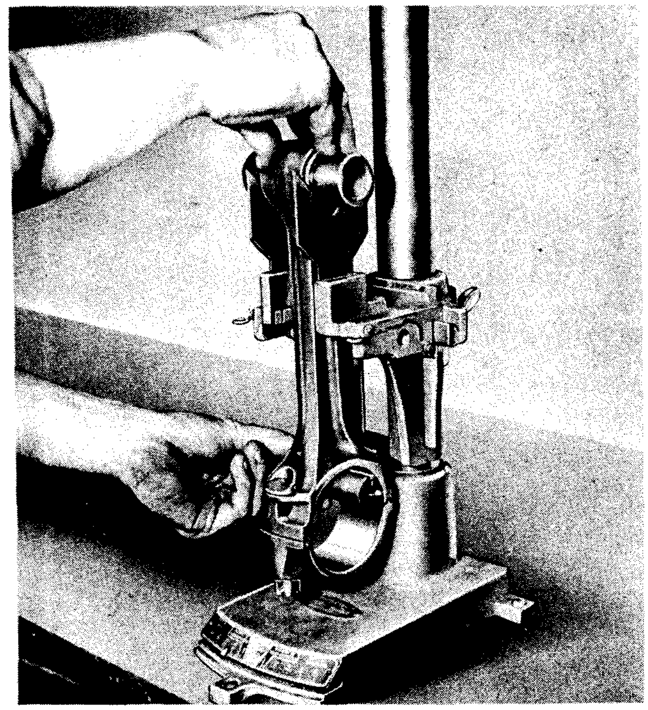


Figure 162
Checking Connecting Rod for Alignment

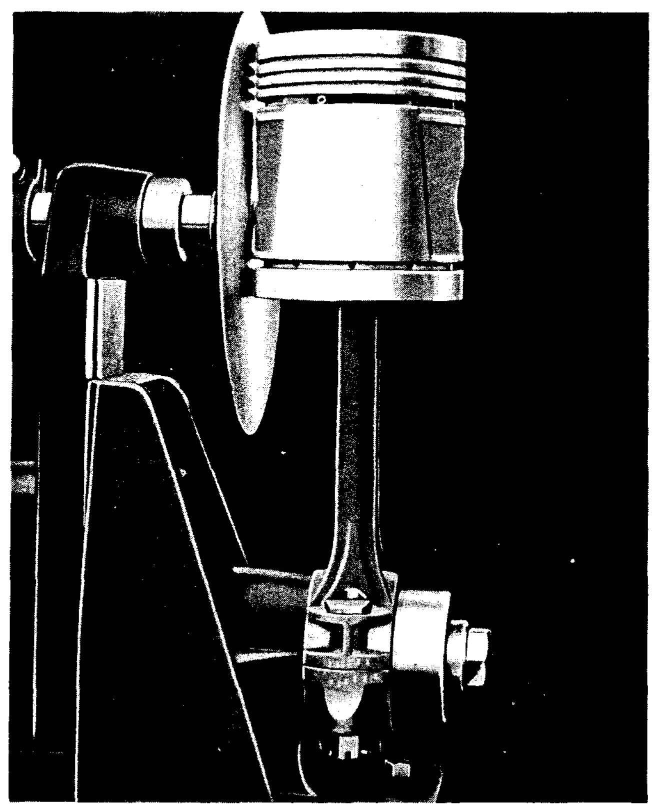


Figure 163
Checking Piston and Rod Assembly for Squareness and Twist

RECOMMENDED METHOD OF INSTALLING PISTON RINGS

1. Grip the connecting rod in a vise with lead lined jaws to hold the piston firmly and roll each of the straight side rings in its groove to be sure there are no burrs or other interference with the free action of the ring in the groove.

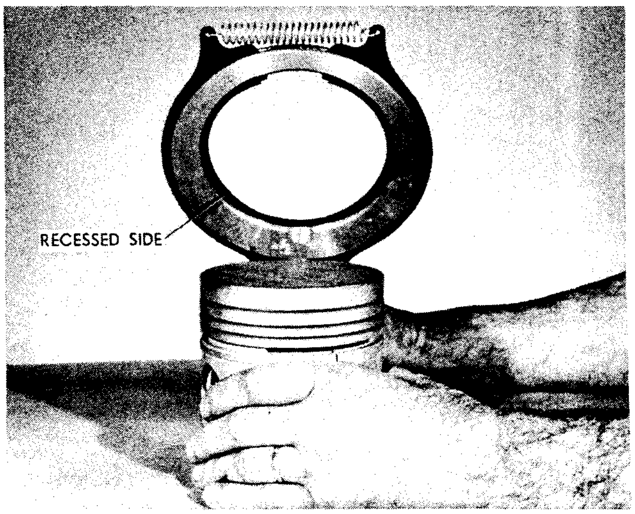


Figure 164
Installing Rings with Ring Expander Tool

2. Hold the ring tool with **recess** side up and place the ring in with the bottom side up. **Start with the lowest ring first.**

Some piston rings are taper faced. These are clearly marked "TOP" or "T" on the side to be *up* when assembled on piston, see Fig. 165.

3. Position ring in the tool so the expanding fingers will fully engage both ends.

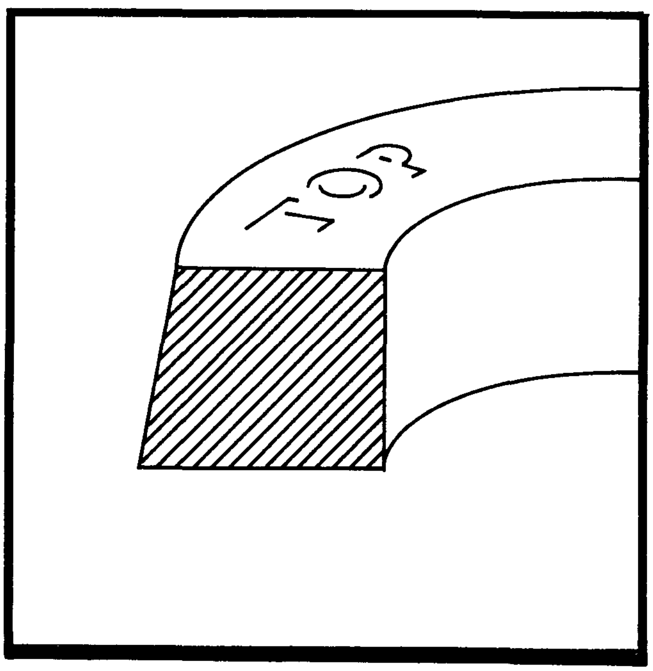


Figure 165
Install Tapered Rings with "Top" Side Up

4. Apply pressure on handles so ring is completely expanded. Pass the expanded ring and tool **recessed side down** over the piston to the proper groove.

5. Check the ring side clearance at various positions with a feeler in accordance with the tolerances shown on the Limits and Clearance Chart.

Figure 166
Checking Ring Clearance in Groove

If any of the rings lack clearance in the grooves — check grooves for nicks or damage. If the grooves are good, the rings may be lapped on a plate, using crocus cloth to narrow them down to obtain the desired clearance.

CRANKSHAFT AND MAIN BEARINGS

1. Remove vibration dampener from crankshaft pulley. Remove starting jaw lock and starting jaw nut and washer. Using a puller, remove pulley from crankshaft.

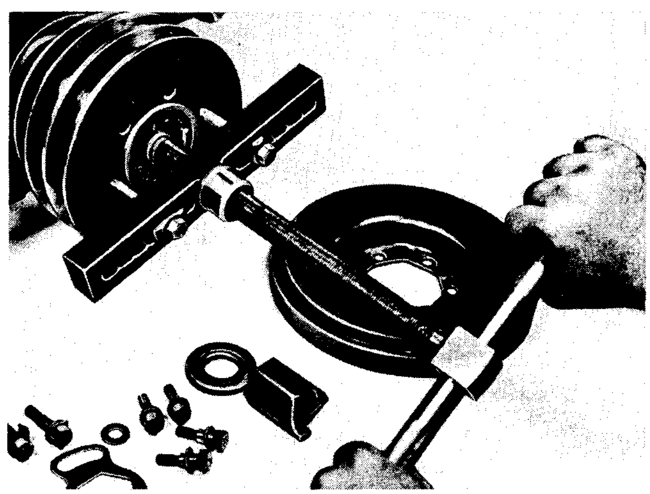


Figure 167
Removing Vibration Damper

2. Take out screws and remove gear cover.

3. Drop the oil pump, by removing nut or cap screws holding pump to center main bearing cap.

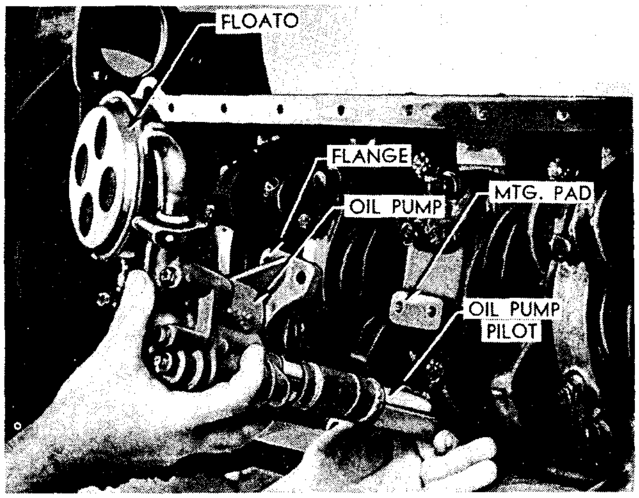


Figure 168
Removing Oil Pump

4. Remove each main bearing cap, one at a time, and inspect the bearing and crankshaft journal.

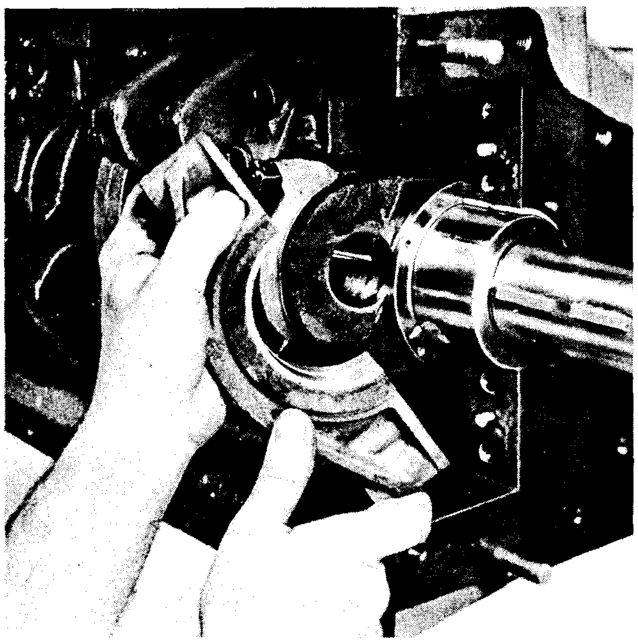


Figure 169
Removing Bearing Cap

If there is any indication of flaking out, scoring or actual wear, — **they must be replaced.**

While the lining of these bearings when new is smooth and highly polished, *a very few hours of operation will change their appearance completely.*

The bearing surface becomes a leaden gray in color and develops minute craters, almost cellular in appearance as indicated in the photograph, which follow the pattern of the matrix.*This appearance is a natural characteristic of this type bearing and in no way indicates failure.*

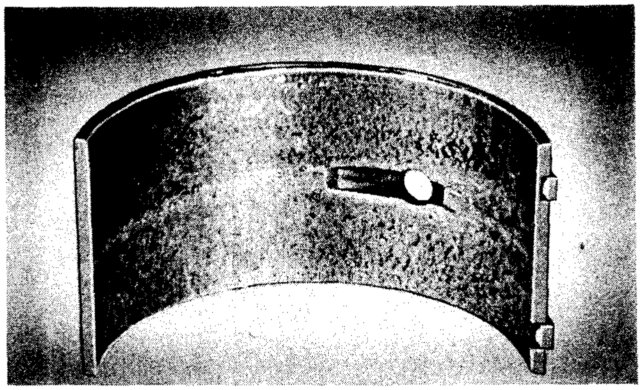


Figure 170
Appearance of a Good Bearing

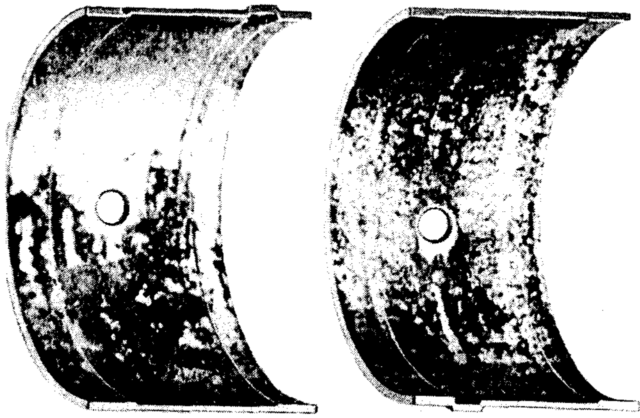


Figure 171
Bearing Damage Due to Corrosion

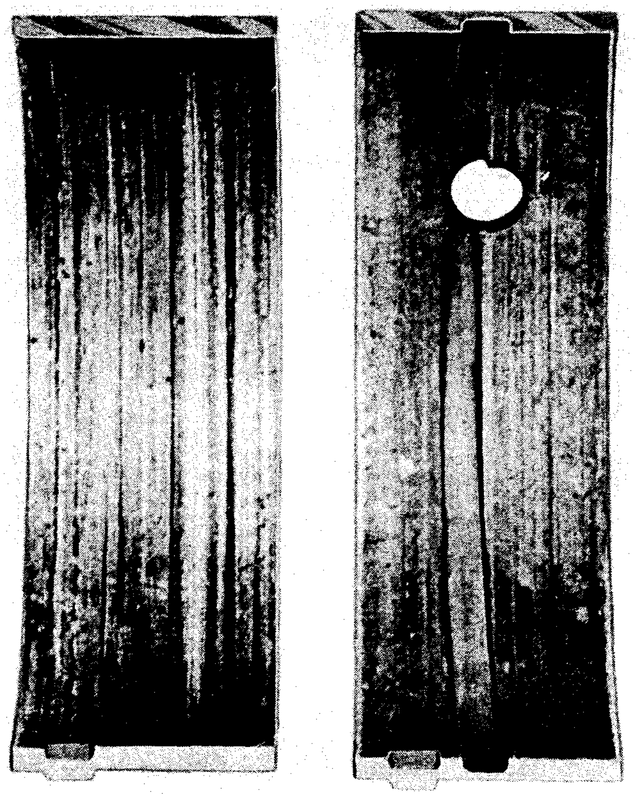


Figure 172
Scored Bearings Due to Dirt or Lack of Oil

5. If the visual inspection appears satisfactory, they should be removed and checked for thickness using a ball micrometer.

To remove the upper half of the bearing shell use a special tool obtainable at most parts houses, which is a pin with an angular head. It may be inserted in the oil hole of the crankshaft and as

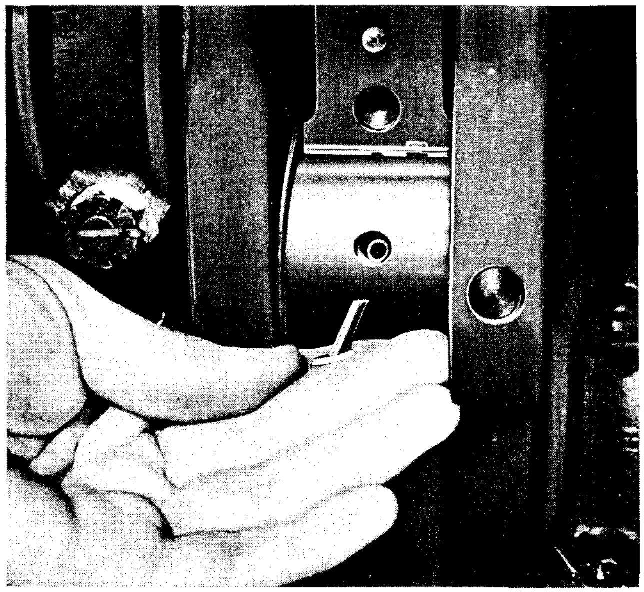


Figure 173
Removing Bearing

the crankshaft is turned in a clockwise direction, the head of this pin picks up the bearing shell and forces it out of the bore in the block.

Figure 174
Measuring Bearing Thickness

The thickness of the bearing shells are given in the Limits and Clearance Chart, and if this thickness has been reduced more than .0005, the bearing shell must be replaced.

6. The crankshaft is Tocco-hardened or scientifically heat treated and is subject to very little wear and is normally safe to use unless it is scored or cut from lack of lubrication.

If visual inspection of the crankshaft shows no indication of excessive wear or scoring, the clearance of the bearing should be checked, using a piece of feeler stock ½" wide and approx-

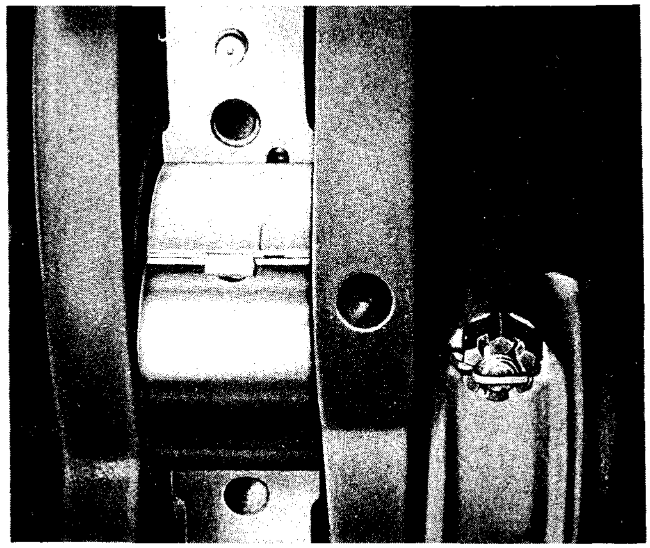


Figure 175
Replacing Bearing

imately ⅛" shorter than the length of the bearing, dressing all edges carefully to be sure there are no burrs to mark the bearing.

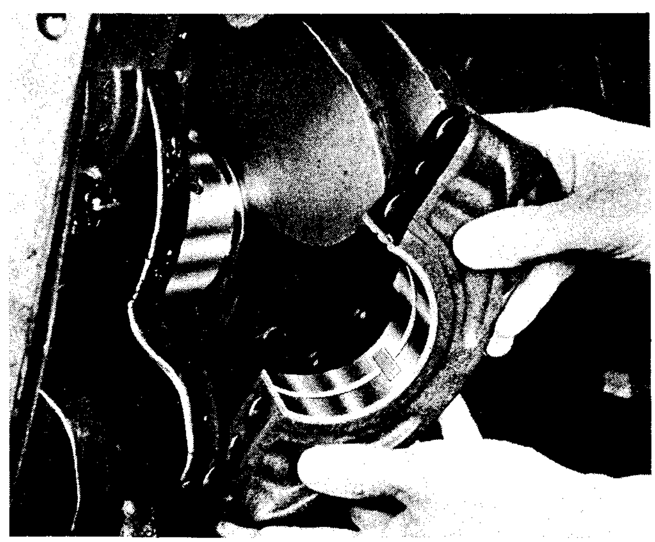


Figure 176
Checking Bearing Clearance

7. Check each bearing, one at a time, by laying the above piece of feeler stock (the thickness of which should be equivalent to the maximum clearance permissible in the bearing) lengthwise, in the bearing shell, on a film of oil. Assemble the bearing cap and tighten the screws, torquing them to the specifications, — then try to turn the crankshaft by hand to determine whether or not you can feel a drag.

If a definite drag is felt and the piece of feeler stock is equivalent to, but no more in thickness than the maximum clearance specified, you may be sure that neither the crankshaft nor bearing are worn excessively as far as clearance is concerned.

When using new bearings and the crankshaft is not worn, checking with a piece of feeler stock as outlined above should lock up the crankshaft, making it possible to turn only by use of a bar or wrench.

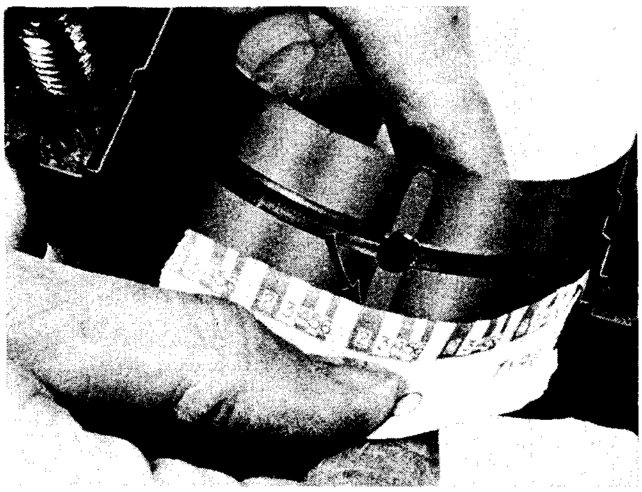


Figure 177
Checking Bearing Clearance with Plastigage

The same check can be made by using a piece of Plastigage of the diameter specified to check certain clearances.

By placing this Plastigage in the bearing and tightening it in place, the width of the Plastigage after crushing determines the bearing clearance as shown above.

> **CAUTION**
> *When using this method DO NOT TURN the crankshaft as that would destroy the plastigage.*

If crankshaft is scored, or worn enough so that new bearings will not fit with the required clearance, it should be removed and reground.

Tocco-hardened crankshafts may be reground to decrease the diameter a maximum of .040. A reduction of more than .040 reduces the hardened area beyond limits of safety.

Before shaft is reground, it must be checked for straightness and straightened if necessary to be within .002 indicator reading. When reground, fillet radii must be within dimensional limits and must be perfectly blended into thrust and bearing surfaces.

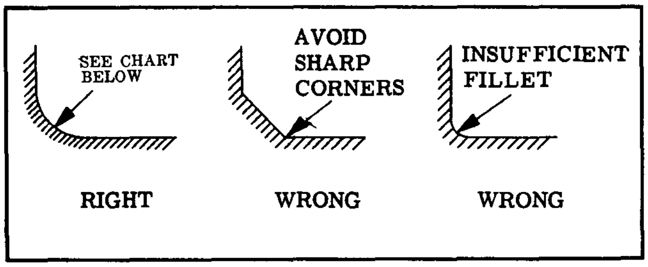


Figure 178

FO	Mains — .093 $^{+.000}_{-.015}$R Crankpins — 3/32 ± .015R
K	Mains — 3/32 ± 1/16R on all except rear main Rear Main — 1/8 ± 1/64R Crankpins — 3 3/32 ± 1/64R
T	Mains — 3/32 ± 1/64R Crankpins — 3 3/32 ± 1/64R
U	#1 Main — 3/64 ± 1/64R Other Mains — 3/32 ± 1/64R Crankpins — 3 3/32 ± 1/64R
R	Mains — 3/32 ± 1/64R Crankpins — 3/32 ± 1/64R
S	Mains — 5/32 $^{+0}_{-1/32}$ Crankpins — 5/32 $^{+0}_{-1/32}$

8. Connecting rod bearings and crank pins may be checked in the same manner with one exception; instead of trying to turn the crankshaft when the connecting rod bearing is tightened on it with a piece of feeler gauge assembled, try to move the connecting rod from side to side.

When the connecting rod is perfectly free, it will have from .006 to .010″ side play and can be moved by a light touch of the fingers. With feeler stock assembled having a thickness equal to the maximum specified clearance, enough drag should be felt so as to require pressure to move the rod from side to side.

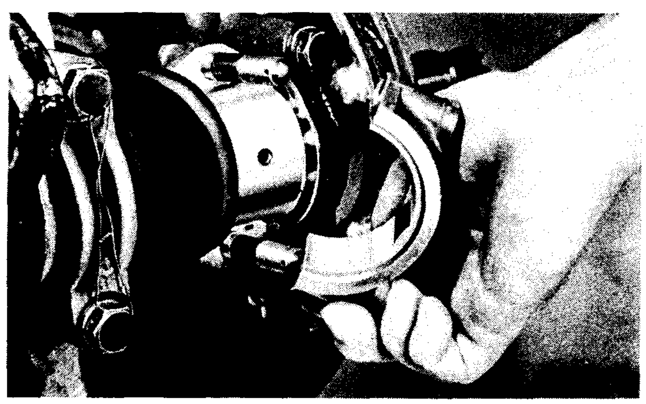


Figure 179
Checking Rod Bearings with Feeler Stock

Using new bearing shells and feeler stock equivalent to the specified clearance in thickness, if the crank pin is not worn you will quite probably have to use a hammer to move the rod from side to side, indicating that the clearance is well within the specification range.

CAMSHAFT

1. Using a puller, remove the cam and crank gears, except on the FO series which require removal of timing chain and sprockets.

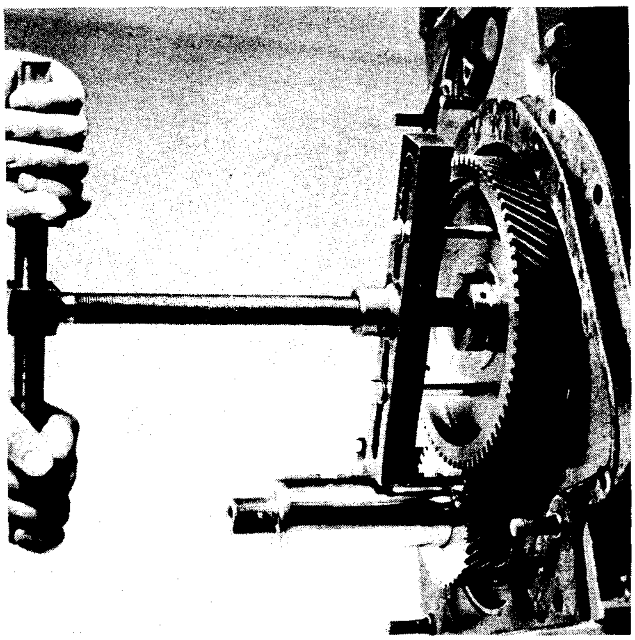


Figure 180
Pulling Cam Gear

2. Removė the screws holding the camshaft thrust plate to the front of the cylinder block, which makes it possible to pull the camshaft forward out of the bearings.

3. Remove push rods and unless engine is laying on its side, tappets must be removed or lifted before camshaft can be pulled.

4. Tappet chamber covers or side plates, which, on many of these engines includes the Oil Cooler Assembly, must also be removed.

5. Tappets on the FO - K and T series can then be lifted out and lined up in sequence, for installation in the same location unless inspection shows that they require replacement.

6. On the R and U series, the tappets and guides can be lifted out by removing the crabs holding the guides in place. These assemblies should be lined up in the same order in which they were in the engine, so they can be reassembled in the same location after thorough inspection.

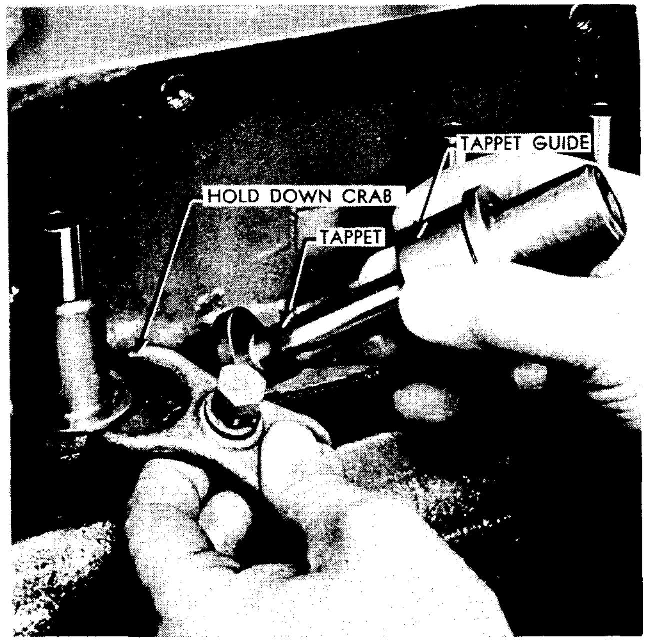


Figure 181
Removing Tappets, R & U Series

7. Tappets on the S series cannot be removed from the top, but must be lifted as high as possible in the guides, then held in this position.

This can be done by using magnetized rods long enough to reach down and lift the tappets, at the same time extending high enough above the cylinder block to permit holding in this position.

The present push rods with the ends cleaned, then coated with a tacky fibrous grease will also serve to lift the tappets and can be used to hold them up, away from the camshaft.

Either the magnetized rods or the push rods can then be held up by gripping them, in pairs, with rubber bands, or by using copper or soft wire wound tightly to hold them firmly against the push rod hole.

Another method is to use a piece of copper or soft iron wire in a similar manner, except that both ends have to be fastened with the wire stretched tightly. (With engine out of the installation and laid on its side, tappets can be pushed back, from cam, the latter pulled, then tappets removed for inspection.)

8. In either case before pulling the camshaft completely, check the clearance of the bearing journals in the bushing. To do this use strips of feeler stock 1/4″ wide with edges dressed with a stone to eliminate any burrs or feathered edges.

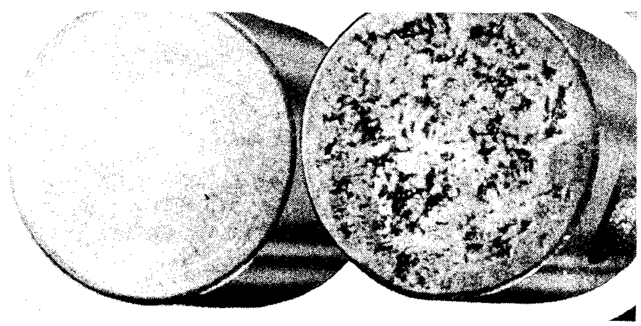
9. If clearance is equal to or greater than the amount indicated under wear limits, check the diameter of the camshaft journals to determine

the next step. Excess wear at these positions require replacement of the shaft.

If wear is found to be in the bushings instead, these must be replaced using precision service bushings, available for that purpose, which require no reaming, only care in assembly, to line up oil holes, and not to damage the bushings as they are being pressed in.

TAPPETS AND TAPPET GUIDES

1. Tappets must be inspected visually for scores or damage to the contact face. Two or three small pits in the latter is acceptable, more than that calls for replacement of the tappet.
2. Check the outside diameter with micrometers to determine if replacement is necessary because of wear.
3. Tappet guides or guide bushings may be checked for wear with a plug gauge or preferably with a telescope gauge and micrometers and are replaceable in every case.



ACCEPTABLE NOT ACCEPTABLE

Figure 182

FO TIMING CHAIN DRIVE SERVICING

The following procedure should be followed when removing or replacing FO series engine timing chains:

1. Remove fan belt, crank pulley and vibration damper.
2. Remove timing chain cover and oil slinger.
3. Remove nut and locking plate on cam chain sprocket, then pull chain sprockets from crankshaft, and camshaft evenly — (chain will follow) this can be done by use of small pry bars, being careful not to damage sprockets or chain.
4. To replace, reverse above instructions but be sure to have chain timed properly to chain sprockets.

Sprockets each have a letter "O" below the proper tooth.

There should be nine (9) chain links (or 10 pins) between the two "O" marks. No. 6 piston should be in top dead center firing position. Then slide sprockets and chain on to camshaft and crankshaft evenly.

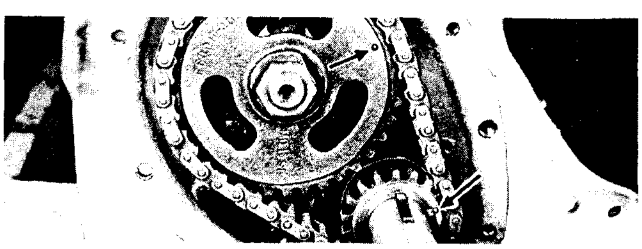


Figure 183 — FO Timing Chain

> *CAUTION: Be sure to hold camshaft forward by installing pry bar in fuel pump opening; failure to do this may loosen plug in rear of cylinder block, causing oil leaks. Torque cam sprocket nut to specified torque: 70 - 80 ft./lbs.*

TIMING GEARS

1. Timing gears and timing gear fits must be checked carefully while the engine is being overhauled. To check the fit, use a screw driver to force the mating teeth as far apart as possible and check this clearance with a feeler gauge. If this clearance is .002" or greater, or if the gear teeth are badly scuffed and worn, the gear must be replaced. *Timing gears must be replaced in pairs.*

Gears marked similar to the original as far as sizes are concerned should be used as replacements.

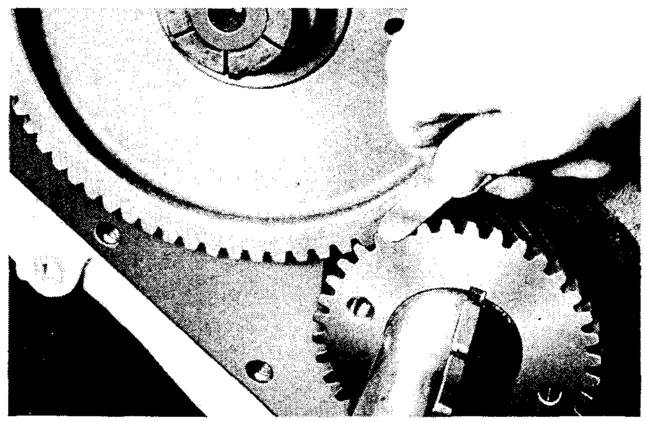


Figure 184
Checking Backlash in Timing Gears

2. Examine the camshaft thrust plate carefully for scoring and wear and if any indication of either shows, a new thrust plate should be assembled without question.

3. Assemble the cam gear or chain sprocket to the camshaft by driving or pressing it on, at the same time holding the camshaft forward so there is no possibility of the camshaft bumping the expansion plug at the rear end and forcing it out of position, thus causing an oil leak.

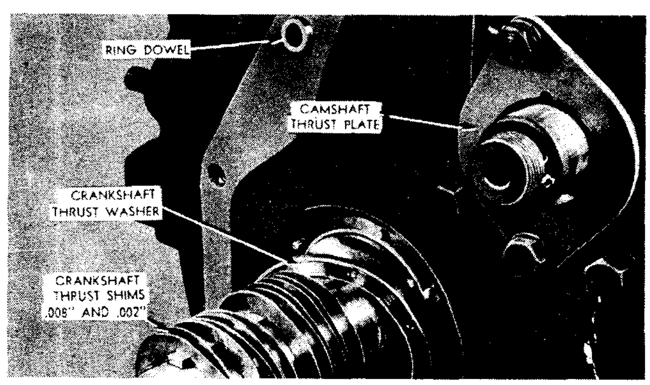


Figure 185
Crankshaft Shims and Thrust Washer

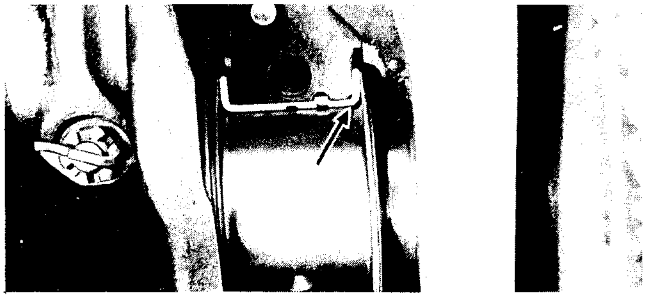


Figure 185A — FO Rear Bearing Controls Crankshaft End Play

4. Inspect crankshaft thrust washers for wear and scoring. Replace if necessary before reassembling gear.

FO thrust is on rear bearing and if crankshaft end play is excessive — replace rear main bearing shells and recheck.

5. Drive the crank gear on the shaft making sure that the marked teeth on the cam gear straddle the marked tooth on the crank gear, which assures you of the crankshaft and camshaft being in time — except FO series as mentioned previously.

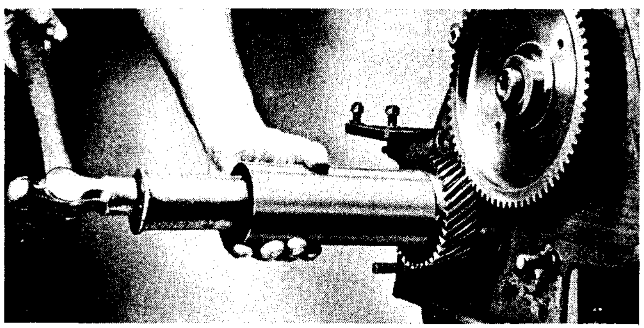


Figure 186
Assembling Crank Gear

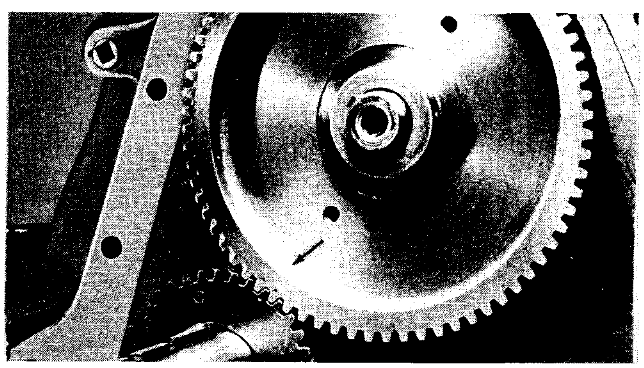


Figure 187
Timing Marks

6. Check for clearance with the above gears assembled in place, since it may be possible that it is not within specifications. Repeat the operation previously outlined. Using a screwdriver pry the teeth as far apart as possible and check the clearance with a feeler gauge. If a .0015" feeler will not enter the gap the clearance is not excessive.

To be certain that there is enough clearance, hold your finger at the junction of the two gears and with a light hammer tap the rim of the cam gear and note if there is vibration felt at this point.

If there is vibration and a .0015" feeler gauge will not enter the gap between the two gear teeth, the gear fit is within specifications.

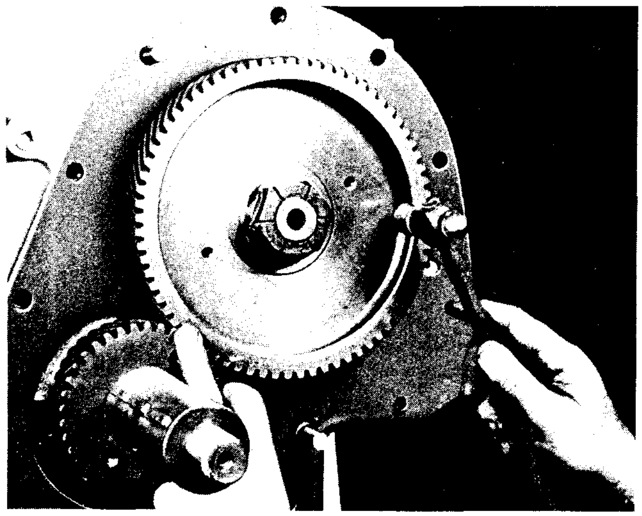


Figure 188
Checking Gear Fit

7. Crankshaft gears and camshaft gears are furnished in standard and under and over sizes. Gears marked "S" are standard; if they are marked with figures "1" or "2" in a letter "U" this signifies undersize. If they are marked with figures in the letter "O" this signifies oversize.

Gears can be selected to give the desired fit. Always assemble a new lock and tighten the cam nut firmly, drawing up to specified torque shown in Section X. Turn the lock over so that the nut is firmly held in place.

Check end play which should be within specified limits. If correct, turn the lock over so that the nut is firmly held in place.

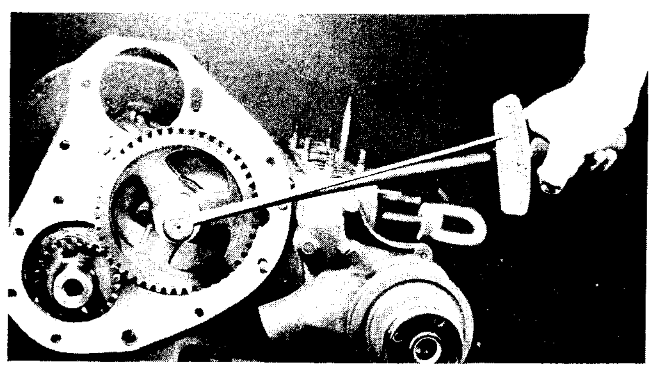


Figure 189
Torquing Cam Gear

CRANKSHAFT END PLAY

1. Check the crankshaft end play before replacing the gear cover. All engines except the FO

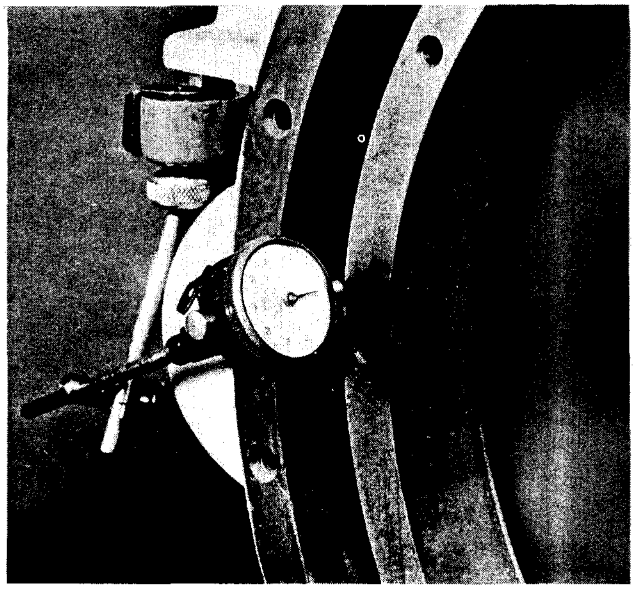


Figure 190
Checking End Play with Indicator

series have a shim pack containing shims of .002" and .008" thickness incorporated in the assembly between the front end of the main bearing journal and the crank gear and by removing or adding shims, this end play can be corrected to fall within the specifications.

The FO series end play is controlled by the rear main bearing thrust.

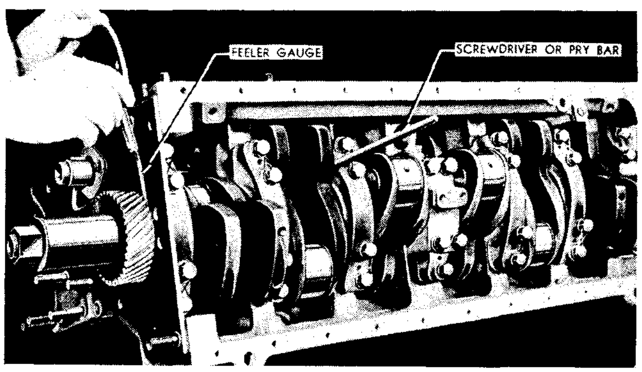


Figure 191
Checking End Play with Screwdriver

At all times when checking end play, the crank gear must be tightened firmly against the shim pack, which can be done by using a sleeve or the regular pulley, slipping it over the crankshaft and using the standard assembly parts to tighten the pulley and gear in place.

FRONT OIL SEAL

Check the front oil seal carefully to determine whether or not it is damaged. If it has been damaged, replace it.

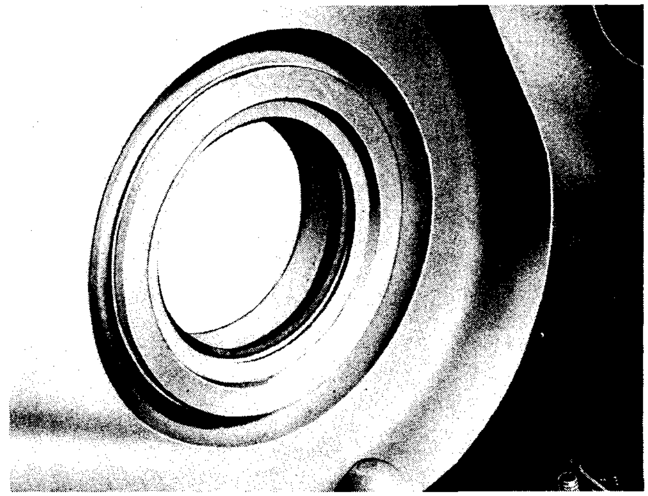


Figure 192
Crankshaft Front Oil Seal (inside view)

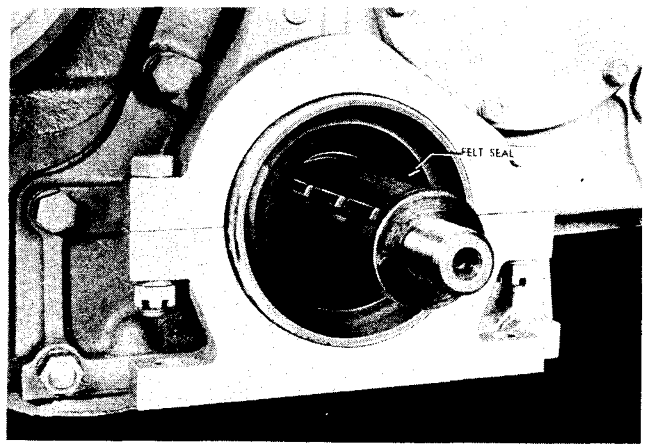


Figure 193
Front Oil Seal (outside view)

If the oil seal is in new condition and shows no sign of cuts or excessive wear, it may serve satisfactorily through another period of operation provided the contact surface on the crankshaft pulley is in good condition.

Examine this surface very carefully since any roughness or scratches of any kind will cause an oil leak and eventually damage the seal.

If the surface is damaged and the pulley is otherwise satisfactory, it may be salvaged by building up the damaged surface and the contact area by brazing, then turning the surface again to the specified size and polishing it very carefully.

Another method of salvaging the fan drive pulley hub is to turn the surface down in diameter and shrink on a steel sleeve, finishing the O.D. to the original specification and carefully polishing it.

If this is done, make certain there are no rough edges left to damage the seal during as-

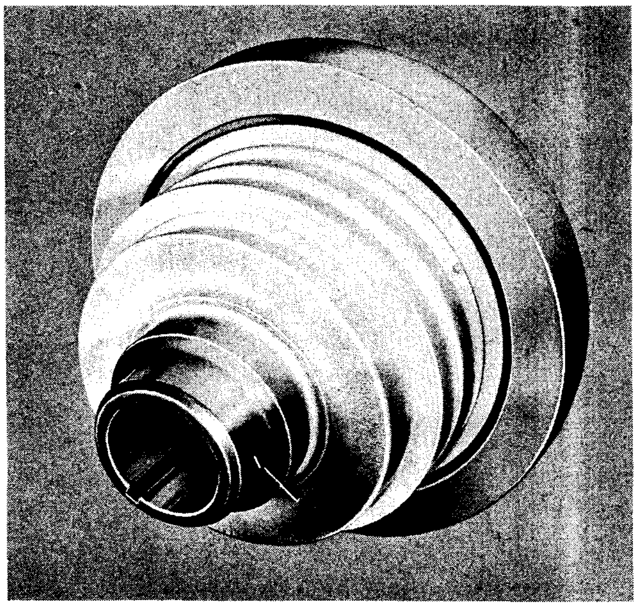


Figure 194
Seal Surface on Pulley

sembly. If the belt surfaces in the pulley are damaged, replace the pulley without question.

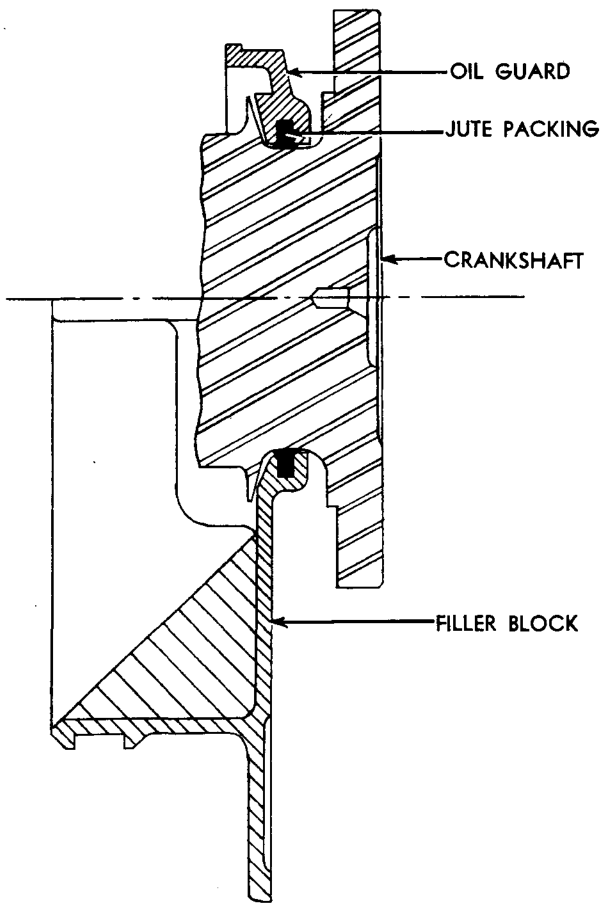


Figure 195
Rear Oil Seal

REAR CRANKSHAFT OIL SEALS (FO - T - K)

The T - K and FO series engines use the jute packing type of rear seal, which, if properly assembled, effectively seals against any possibility of oil leaks at the rear end of the crankshaft.

To replace this packing and reassemble this rear seal, it is necessary to follow instructions very carefully, otherwise your efforts may be useless.

1. The first step is to remove the filler block and oil guard, the latter being the semi-circular die casting which fits in the cylinder block, in a groove machined just to the rear of the rear main bearing.

2. Clean all surfaces and grooves thoroughly. If a scraper or wire brush is used, be very careful not to scratch or gouge the sealing surfaces. All dried cement or other material must be removed from these surfaces. Check filler block contact faces for flatness — Replace if warped.

3. The jute packing, as it is received, has a diameter approximately one-third greater than the width of the grooves. This must be crushed in a vice or otherwise flattened narrow enough to be inserted in the grooves.

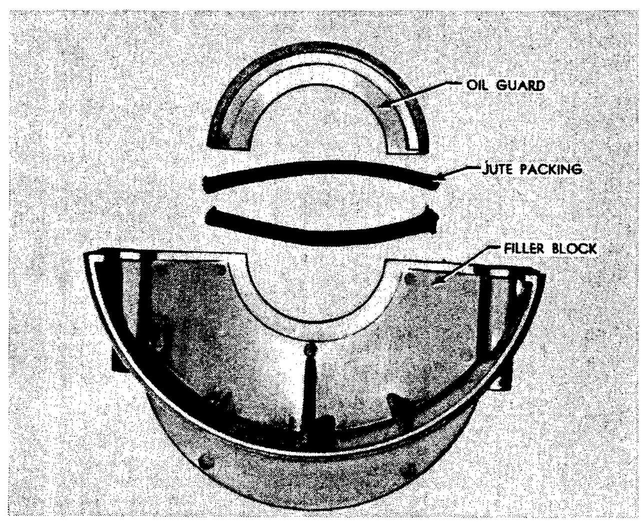


Figure 196
Rear Crankshaft Oil Seal
FO - K - T

4. Next, press it into the grooves of both the filler block and oil guard as well as possible by hand. Then, using a piston pin, smooth hammer handle or some other tool with a smooth, rounded surface, iron this packing into the groove so that it is seated firmly and expanded to grip the sides.

You will find that the packing is long enough to protrude from the groove at either end in varying amounts.

5. With a sharp knife or razor blade, cut this off parallel to the surface of the casting, allowing it to protrude $\frac{1}{32}$ of an inch.

6. You are now ready to reassemble these parts in the engine. To do so, coat the outer or sealing surface of the oil guard with a non-hardening cement. Slide it into place around the crankshaft, if engine is still assembled or directly into the recess, if crankshaft is out.

When the assembly is made as outlined, and completed with a new oil pan gasket and the filler block assembled and properly tightened in place, there is no possibility of oil leaks developing at this point.

REAR CRANKSHAFT OIL SEALS (U - R - S)

The U - R and S series engines have an oil resistant synthetic rubber seal molded over a steel plate, which permits its assembly to the rear end of the cylinder block and filler block with small round head screws.

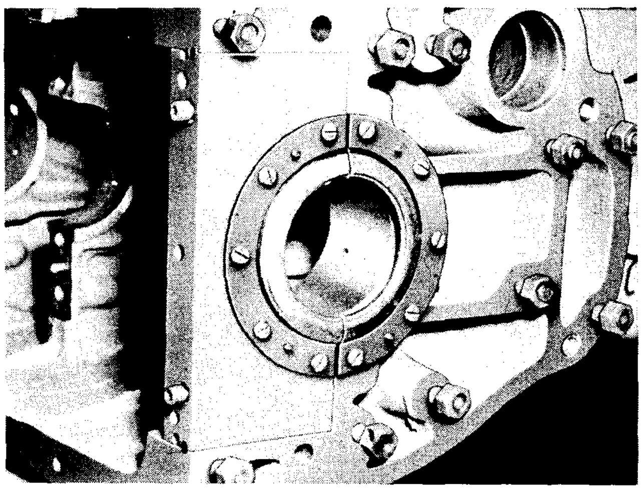


Figure 197
Seal Assembly on U - R - S

These are made in semi-circular form and two pieces are used to complete the assembly. Small dowel pins, two for each section, assure postive location in relation to the crankshaft.

Since the crankcase of these engines extends well below the crankshaft, the opening at the rear end must be filled flush with the bottom surface to complete the oil pan contact surface.

This opening is completely machined to have a flat contact surface and parallel sides so that a filler block with similar machined surfaces can be assembled.

The filler block becomes an integral part of the cylinder block, by being bolted and doweled

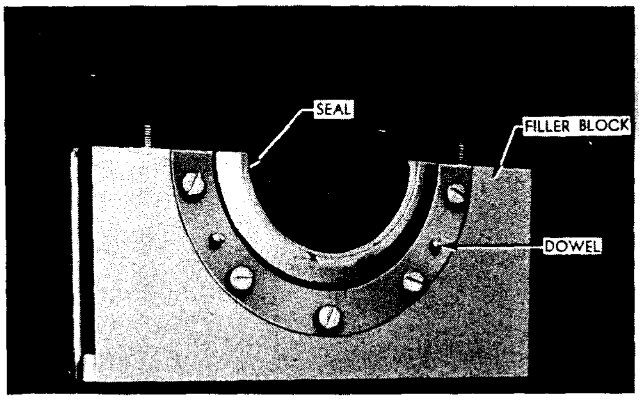


Figure 198
Seal and Retainer Gasket in Place on Filler Block

in position before the rear end of the block has the final machining operation making it flat and square with the bearing bore.

A gasket is assembled between the filler block and its seat in the block, on each side of the crankshaft sealing this contact area against oil leakage.

The sides of the filler block, where it fits into the milled slot in the cylinder block, are sealed, oil tight, by candlewick packing driven into a semi-cylindrical groove machined in the filler block.

Use a packing tool made of $\frac{3}{16}$ or $\frac{1}{4}''$ rod with one side ground off for clearance, this section to be slightly longer than the depth of the filler block.

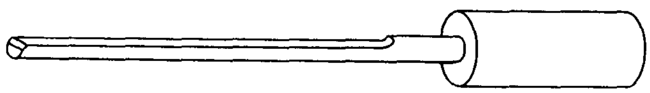


Figure 199
Packing Tool

First dip the packing tool in National Oil Seal Cement, or equal, and coat the groove full length with cement.

Twist the candle-wick tight and make a "pigtail" twist and force in groove with tool.

Every 4 twists, dip the tool in cement and using a hammer — drive the packing in solidly as far as it will go.

Repeat this operation until the groove is completely filled — without voids — then wipe off excess cement on filler block.

CAUTION

If you try packing this all in one operation, you will have areas where the packing is not solid and leaks will occur.

As outlined previously, the rear crankshaft seal fastens to the rear of the cylinder block and filler block with small round head screws. The two halves are located in position by 2 dowel pins in each section.

A gasket is cemented to the cylinder block and filler block, before assembling the seal. Next, lightly coat each end of both synthetic rubber seals with Minnesota Mining and Manufacturing Company's EC847 Rubber Cement and allow to dry from 3 to 6 minutes or until it becomes tacky.

Coat the inside surface of the metal with Permatex #3 Aviation Gasket Cement. This will be the side from which the seal protrudes approximately 1/8 inch.

Assemble the seals in place, this 1/8" projection located freely in the bore in the cylinder block and filler block, the sheet metal in place over the dowels. The ends butting together will seal and make a complete circle of the two pieces.

Assemble 5 screws in each section and tighten.

By following the foregoing procedure in every detail, a leak-proof rear end seal is assured.

OIL PUMPS

All of the six cylinder over-head valve engines except the FO series, have the oil pump assembled to the center main bearing.

The FO series engines have the oil pump mounted externally on the RH side of the cylinder block with five capscrews.

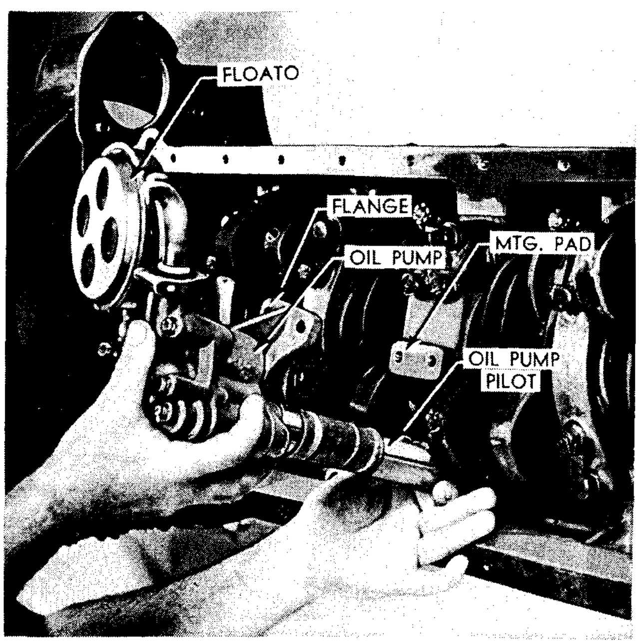


Figure 200
U - R - S Oil Pump Assembly

A gear assembled to the upper end of this shaft is driven by a mating gear cut on the camshaft and drives the oil pump gear which is assembled to the lower end of the pump shaft.

The pump shaft is carried in two bronze bushings assembled in the cast iron housing, which is also a part of the oil distributing system, transmitting oil to the drilled passages.

The gear type pump has a capacity well in excess of that required by the engine. The K and T series engines dump this surplus into the oil pan by the pressure relief — while the FO - R - U and S series engines have a by-pass type relief valve built into the pump so that the surplus is recirculated through the pump.

When the pump is removed, examine the drive gear carefully for wear, inspecting the gear on the camshaft at the same time. If scored or torn or worn deeply, both the camshaft and the gear on the pump must be replaced.

Examine the pick-up screen, which is the floating (Float-O) type to be sure it is not damaged. It must move freely when it is inserted in the pump body so it can follow the level of the oil.

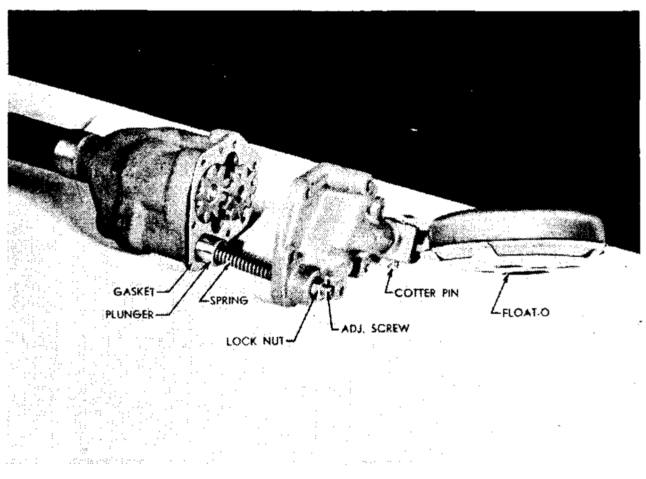


Figure 201
U - R - S Oil Pump Disassembled

Remove the cover, being careful not to damage the lead gasket which acts as a spacer as well as a gasket to seal the joint.

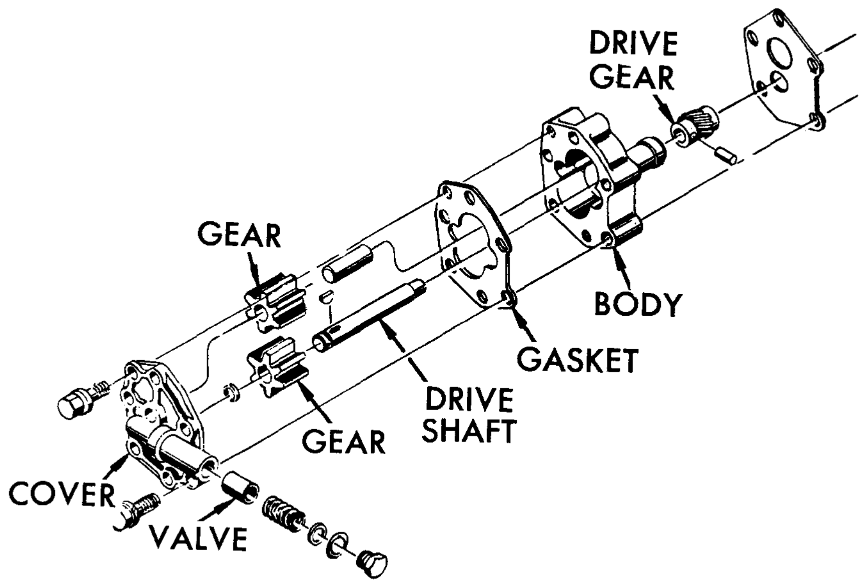


Figure 202
FO Oil Pump Exploded View

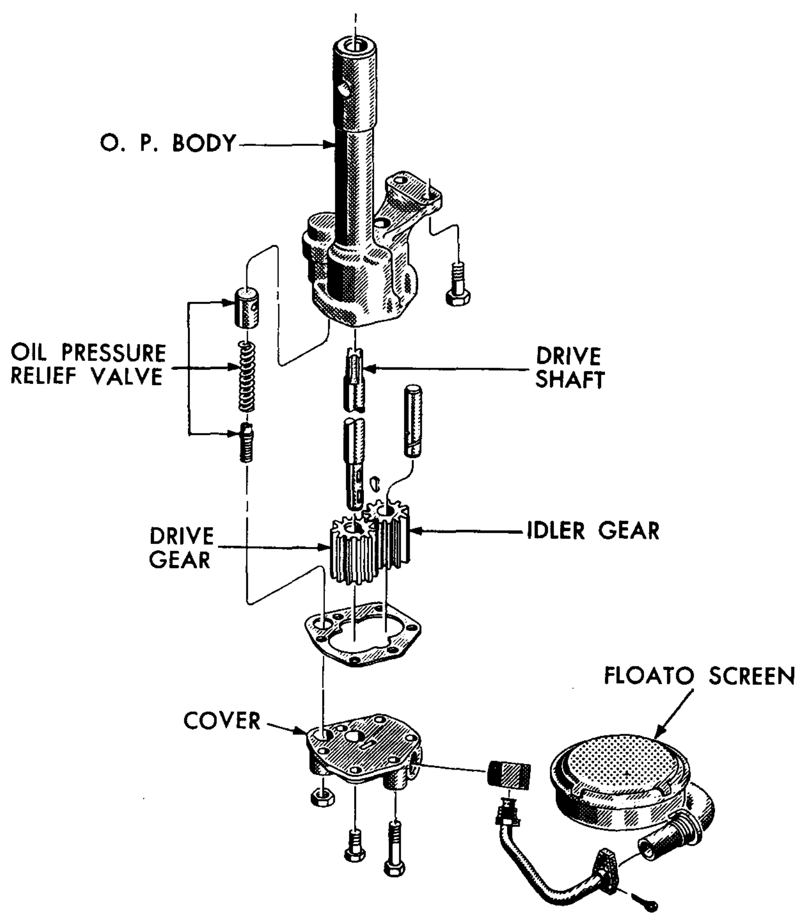


Figure 203
U - R - S Oil Pump Exploded View

Examine the gears and pump body for any sign of wear indicating lack of clearance. The gears should have from .001 to .003 clearance in the chamber and should make no contact with the walls.

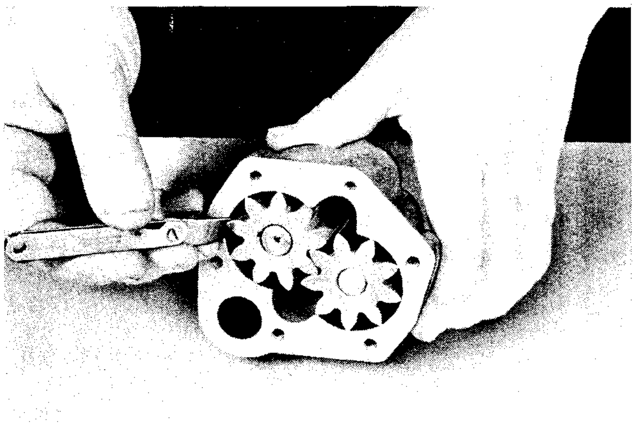


Figure 204
Checking Clearance in Gears

Inspect the cover and face of the gears for excessive wear or scoring. With the gasket assembled to the body there should be .0015 - .006 clearance between the gears and the cover.

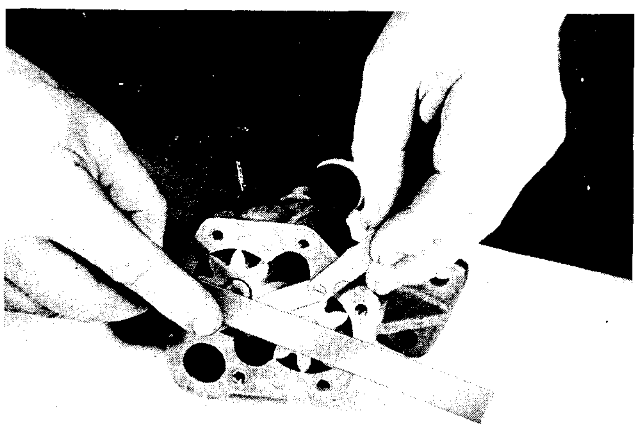


Figure 205
Checking End Play

Worn or scored gears can be replaced, as can a worn cover. If the body shows wear in the chamber, it can be replaced, but in a case like this, a new pump would be the most economical.

Engine oil pressure must be maintained within specified limits for satisfactory engine life.

Normal oil pressures under operating conditions are:

FO	Series — 30-40 pounds
K - T	Series — 40-50 pounds
U - R - S	Series — 55-65 pounds

At idle, the oil pressure should not fall below 7 pounds.

Pressure is controlled by a plunger and spring — the spring having a definite range. The only adjustment variation is either to change springs

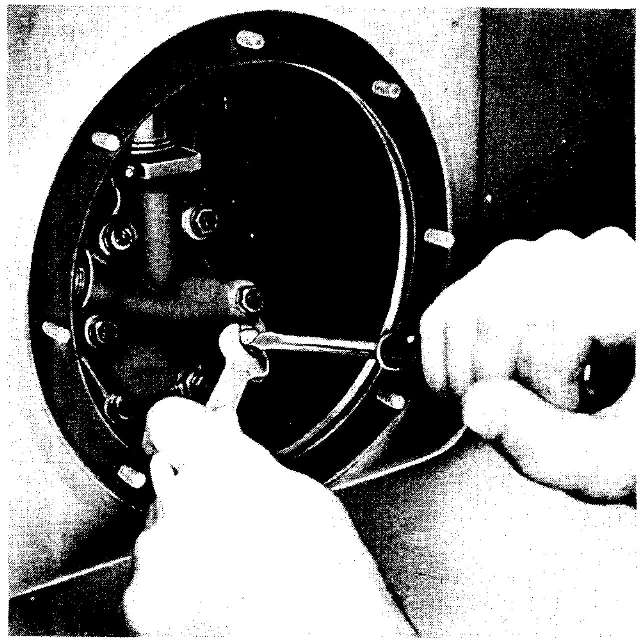


Figure 206
Adjusting Oil Pressure on R - U & S Series

or assemble or remove washers from behind the present spring — *up to four washers are permissible.*

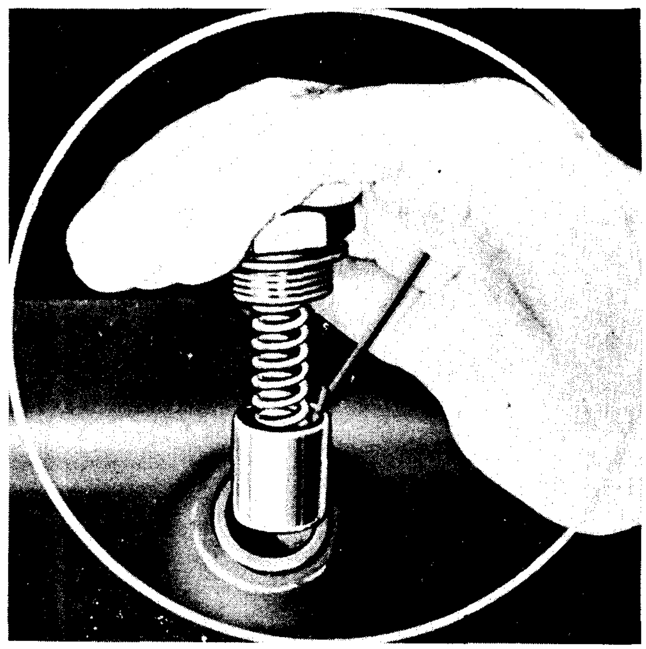


Figure 207
Oil Pressure Relief Valve T & K Series

The adjustment of the FO series is made externally on the pump cover.

The T and K series have the pressure relief adjustment externally on the LH side of the block near the oil pan flange at the center.

The R - U and S series engines have the oil pressure adjusting screw on the oil pump cover — which requires adjusting inside the oil pan. Turning the screw clockwise or "IN" increases the pressure and "OUT" reduces the pressure.

FLYWHEEL AND FLYWHEEL HOUSING

The flywheel is machined and balanced so that the clutch face and locating counterbore will run true with its axis.

To be sure that the crankshaft flange has not been sprung or otherwise damaged or that the counterbore in the flywheel, which locates it on the crankshaft, is not damaged, mount an indicator on the flywheel housing and check the flywheel for runout.

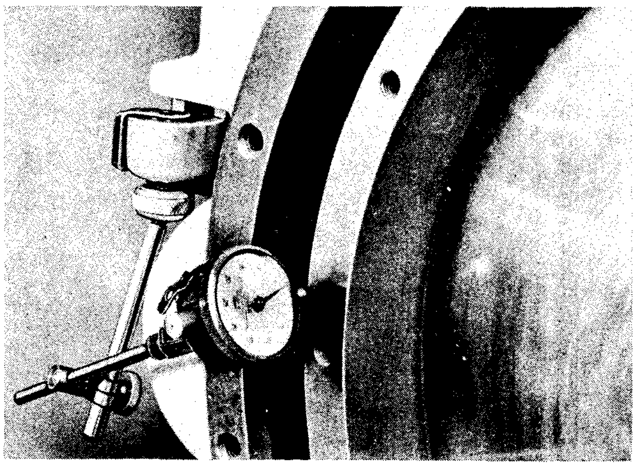


Figure 208
Checking Flywheel Runout

The indicator should be set up so that it contacts the clutch face or the vertical surface of the clutch counterbore, then turn the flywheel at least one full revolution at the same time holding against the crankshaft to offset the possibility of end play.

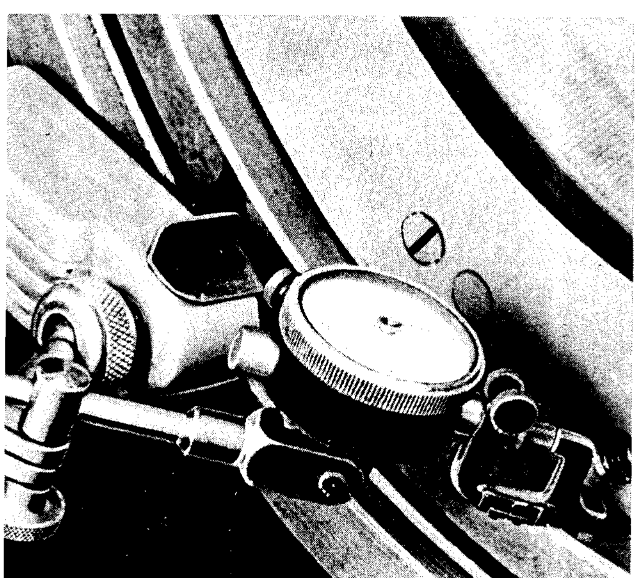


Figure 209
Checking Flywheel Counterbore

Excessive runout of the flywheel, in either position, is probably caused by dirt in or damage to counterbore locating the flywheel on the crankshaft flange.

Re-locate the indicator to check the inside diameter of the counterbore. In both cases the maximum indicator reading must not be more than .008.

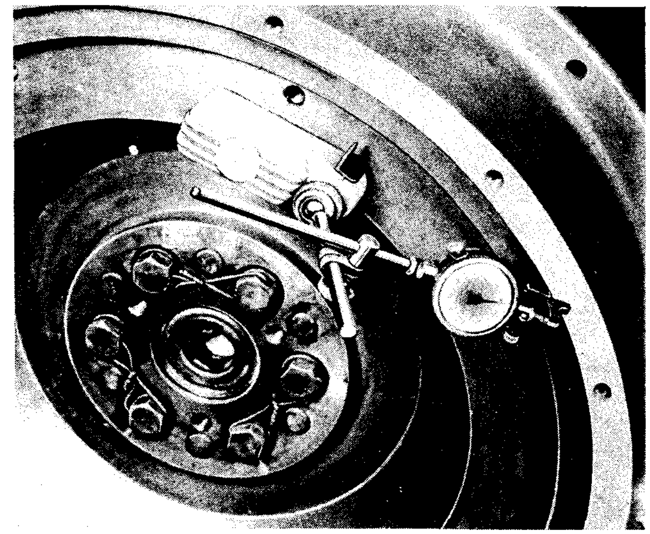


Figure 210
Checking Flywheel Housing Face Runout

When assembled, mount the indicator on the flywheel so that it contacts the housing face and turn the crankshaft, at the same time holding against it to counteract end play. The maximum indicator reading must not exceed .008.

Re-locate the indicator to contact the housing bore and check this in the same manner. The same run-out limits prevail.

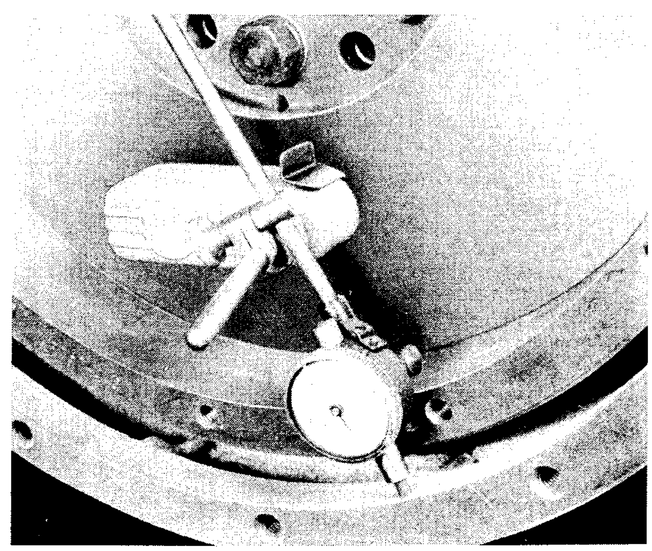


Figure 211
Checking Housing Bore

If more than one engine is being rebuilt at a time, the housing should be identified with its original cylinder block and should be reassembled to that block in the rebuilding process.

FLYWHEEL DOWELS

Check if flywheel to crankshaft dowels indicate any looseness — if so they should be reamed out to use .003 or .010 oversize dowels with a .0015 - .022 *interference fit — requiring driving in place.*

Standard Size Dowels must be only used with a new crankshaft and a new flywheel — reaming the dowel holes to a .0015 - .002 interference fit (undersize).

Oversize Dowels must be used when assembling a new flywheel on an old shaft or a new crankshaft with an old flywheel — using .003 or .010 oversize dowels, reamed to .0015-.002 interference fit.

> *WARNING*: Dowel holes must be .0015-.002 undersize so that the dowels *drive in* and do not fit loose.

REASSEMBLING ENGINE

In the foregoing, we have outlined procedures for checking, repairing or replacing the many wearing parts in the engine.

In most cases, the instructions have covered the reassembly of parts or subassemblies made up of several parts.

When reassembling pistons and connecting rods, use a good ring compressor and oil the bores thoroughly. A hammer handle may be used to bump the pistons out of the ring compressor into the cylinder bore.

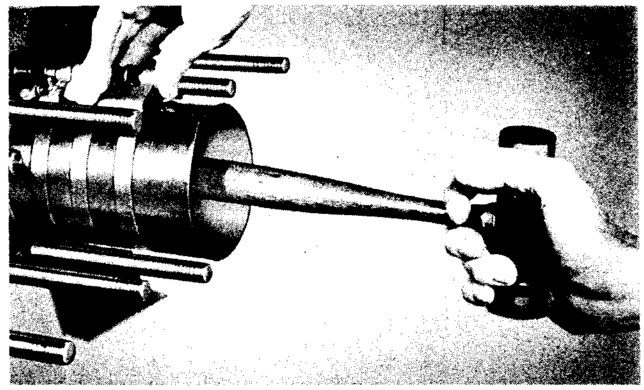


Figure 212
Assembling Piston in Cylinder

Once more, we call attention to care demanded to prevent connecting rods damaging the cylinder bore finish and at the same time as they are assembled over the crank pin, locate them carefully in order to protect the bearing surfaces.

Always lubricate the bearings with clean engine oil when assembling, and tighten them to the torque specified. Use lockwires, cotter pins or lockwashers as required to prevent nuts and screws from loosening.

Before assembling the oil pan with new gaskets make certain that gasket surfaces are flat and clean. Tighten screws in accordance with limits prescribed in torque chart — to avoid looseness or overstressing.

SECTION IX
TROUBLE SHOOTING

A preventive maintenance system including inspection, lubrication and adjustment as recommended in our Maintenance Section will prevent the greater portion of gasoline engine troubles.

Failure of a gasoline engine to start is mainly due to two things: ignition trouble or failure in the fuel system.

Operators handling the same engine every day, soon develop a sense of impending trouble when abnormal operation occurs. Immediate attention to these danger signals can prevent major failures, insure dependable operation and increase the life of the engine.

Operators should depend on their well-developed senses of **feeling, hearing, seeing** and **smelling** and replace their sense of taste in this type of work — with a generous amount of "Common-Sense".

A good rule to follow in locating trouble is to never make more than **one** adjustment at a time — then locate the trouble by a process of elimination. Remember the cause is usually **Simple** — rather than mysterious and complicated.

Following are listed some of the normal complaints encountered in routine operation of all gasoline engines and the probable causes.

A — STARTING MOTOR — WILL NOT CRANK ENGINE:

1 — Weak or dead battery.
2 — Poor ground connection.
3 — Faulty starting switch or relay.
4 — Defective starting motor.
5 — Internal engine seizure — turn engine manually to determine cause.

B — ENGINE CRANKS — BUT DOES NOT START:

Disconnect one spark plug wire, turn ignition on with starter cranking engine and free end of wire 1/8" from cylinder head — note spark.

1 — **NO SPARK:**

(A) — **If Ammeter Shows No Discharge** — it indicates an open primary circuit due to:

1 — Points not closing.
2 — Open primary wires.
3 — Defective ignition switch.
4 — Faulty coil.

(B) — **Normal Ammeter Reading (2-5 Amps)** — this indicates that primary circuit is OK — trouble may be in secondary circuit due to:

1 — Broken or grounded high tension wire from coil to distributor.
2 — Wet high tension wires.
3 — Faulty distributor cap or rotor.
4 — Broken secondary winding of coil.

(C) — **Excessive Ammeter Reading (over 5 Amps)** — indicates a "short" in the primary winding which may be due to:

1 — Shorted or grounded primary winding.
2 — Distributor points not opening.
3 — Grounded breaker point arm.
4 — Defective condenser.

2 — **WEAK SPARK** — may be caused by:

(A) Loose ignition wiring connections.
(B) Burned or pitted distributor points.
(C) Wet spark plug wires.
(D) Defective condenser.
(E) Cracked distributor cap.
(F) Weak ignition coil.

3 — **GOOD SPARK AT EACH PLUG** — indicates that ignition system is OK and trouble is in fuel system — which may be due to:

(A) **No Gas in Carburetor** — which may be due to:

1 — No gas in tank.
2 — Clogged filter or lines.
3 — Faulty fuel pump.
4 — Leaky fuel line from tank.
5 — Plugged vent in fuel tank cap.

(B) **Gas in Carburetor** — which may be flooded due to:

1 — Too much choking — plugs are wet.
2 — Wrong float level.
3 — Choke not operating correctly.
4 — Water in Gas.

C — ENGINE RUNS WITH CONTINUOUS MIS-FIRING: Due to:

1 — Uneven compression.

2 — Wet or deteriorated high tension wires.

3 — Cracked distributor cap.

4 — Faulty spark plugs—if spark plug porcelain is white when removed, use **Colder** plug — if light brown OK — if Black or oily use **Hotter** plug.

D — ENGINE RUNS UNEVENLY

1 — **At Idling Speed**—which may be due to:

(A) Too wide spark plug gaps.

(B) Poor Carburetor idle adjustment.

(C) Wrong float level.

(D) Carburetor or intake manifold air leaks.

(E) Leaky cylinder head gasket.

2 — **At High Speed** — which may be due to:

(A) Wide breaker points.

(B) Weak distributor breaker arm spring

(C) Weak valve springs.

(D) Spark plug of wrong type or incorrect gap.

E — ENGINE RUNS IMPROPERLY

1 — **Back-Firing into Manifold** — indicates **Too Rich** a fuel mixture; into carburetor indicates **Too Lean** a mixture—may be due to:

(A) Late Ignition Timing.

(B) Clogged Air Cleaner.

(C) Fuel line restrictions.

(D) Clogged carburetor jets.

(E) Sticking Valves.

(F) Weak or broken valve springs.

2 — **Excessive Ping (Detonation)**—Results in damaged pistons and bearings and is caused by pre-ignition or using inferior grade of gas, or ignition timing too far advanced.

3 — **Engine Idles Too Fast** — indicates improper throttle adjustment or weak throttle return springs; slight vacuum leak.

4 — **Engine Dies When Idling** — which indicates incorrect speed or mixture adjustment; clogged idling circuit in carburetor or wrong choke adjustment, or air leaks in intake manifold.

5 — **Engine "Stumbles" on Acceleration** — which may be due to defective accelerator pump or air in fuel lines.

6 — **Defective Spark Plugs.**

F — LACK OF POWER — which may be due to:

1 — Poor Compression.

2 — Wrong Timing.

3 — Throttle control not opening fully.

4 — Air leak in fuel system.

5 — Restriction in air cleaner — should have vacuum less than 10″ water.

6 — Exhaust line obstructed — should have back pressure of not more than 20″ water.

7 — Poor fuel.

8 — Piston rings sticking or worn.

G — POOR COMPRESSION—check with compression gauge — if irregular, seal the piston with a teaspoonful of engine oil poured through the spark plug hole, and take a second reading; if pressure does not increase this will indicate that poor seating of valves are at fault.
Poor compression may be due to:

1 — Valves holding open — no tappet clearance.

2 — Leaky cylinder head gasket.

3 — Broken or weak valve springs.

4 — Burned or sticking valves.

5 — Badly worn, broken or stuck piston rings.

6 — Wrong valve timing.

H — OVERHEATING

1 — Lack of water in radiator.

2 — Fan belts slipping.

3 — Thermostat sticking or inoperative.

4 — Radiator clogged or leaky.

5 — Late ignition timing.

6 — Back pressure in exhaust line.

7 — Defective water pump.

8 — Overloading of engine.

I — LOW OIL PRESSURE

1 — Low Oil level.

2 — Oil pressure gauge or line faulty.

3 — Oil too light — diluted.

4 — Suction screen plugged.

5 — Dirt in relief valve or broken spring.

6 — Worn bearings.

7 — Worn or damaged oil pump gears.

8 — Worn Cam Bushings.

J — HIGH OIL PRESSURE—should not exceed recommended pressures except when engine is starting up cold. Abnormally high oil pressure is not desirable because it increases oil consumption — possible causes of high oil pressures are:

1 — Engine oil too heavy.

2 — Stuck relief valve.

3 — Obstruction in distributing line.

4 — Faulty oil pressure gauge.

K — HIGH OIL CONSUMPTION

1 — Oil leaks.

2 — Too high oil level.

3 — Incorrect grade of oil used.

4 — Clogged crankcase breather.

5 — Oil pressure too high — stuck relief valve.

6 — Piston rings not run-in, due to too smooth cylinder bore finish or glazed condition.

7 — Worn, broken or stuck piston rings and clogged oil control rings.

8 — Worn pistons and sleeves.

9 — Worn bearings.

10 — Worn valve guides.

(Manifold may be removed for visual inspection.)

L — ENGINE KNOCKS AND OTHER NOISES

1 — Operating Knocks — which may be due to:

(A) **Pre-Ignition** — Most common cause is due to wrong type plugs which are too hot.

(B) **Carbon** — noticeable when engine is accelerated while hot — clean head and pistons.

(C) **Timing**—early timing causes knocks similar to carbon — but may tend to kick back when starting.

(D) **Fuel** — detonation knock caused by poor gas.

(E) **Overloads** — particularly at lower operating speeds.

2 — **Mechanical Knocks**—result from wear, abuse or improper adjustments — which may be due to:

(A) **Crankshaft and Main Bearings:**

(1) **Worn or burned-out Main Bearings** — A heavy, dull knock when accelerating under load. Locate by shorting out plugs on both sides of the bad bearing.

(2) **Crankshaft End-Play** — excessive end-play is indicated by an intermittent knock which will come and go when the load is released and engaged.

(B) **Connecting Rod Bearings**

(1) **Worn or Burned-out Bearings** — The worst condition, a light pound or metallic knock, is noted at idling and to about ⅔ maximum speed. Bad bearings can be determined by shorting out plugs.

(C) **Pistons and Wrist-Pins**

(1) **Loose Wrist Pins** — noise doubles when the correct plug is shorted out — most noticeable at idling speed.

(2) **Piston Loose in Cylinder** — "Piston-Slap" is noted by metallic knocking at low speed under load; but disappears at high speed — also most noticeable when starting cold —test by shorting out plugs.

(D) **Broken Piston Ring or Pin**
sharp clicking noise that won't short out.

(E) **Valves**

(1) **Burned Valves and Seats** — engine misses, especially at low speeds, or acceleration under load.

(2) **Weak or Broken Valve Springs** — missing at low or high speeds when under load.

(3) **Sticking Valves** — loss of power and popping sound when bad.

(4) **Tappet noise** — excessive clearances cause noise when cold — which diminishes at normal operating temperature.

(F) **Camshaft** — Noise due to loose bearings or end play — usually occurs at half engine speed.

(G) **Timing Gear Noise** — Loose or worn gears rattle or knock — tight gears hum.

3 — **Vibration Originating at Engine** — The most common sources of vibration originating in or on the engine, as distinguished from causes created outside the engine are as follows:

(A) Misfiring

(B) Misalignment of engine

(C) Bent or off-center coupling

(D) Engine loose on bed and type of mountings.

(E) Out of balance condition of flywheel and clutch assembly.

SECTION X
TORQUE SPECIFICATIONS

Continental Overhead-Valve gasoline engines have many studs, bolts, and cap screws of special materials and sizes and it is very important that special care be exercised to replace all studs and bolts in their respective locations during assembly of engine.

The torque specifications, foot pounds, listed below, **MUST** be followed in order to have the assembled engine conform to the original specifications:

Size-Diameter	1/4″	5/16″	3/8″	7/16″	1/2″	9/16″	5/8″
Cyl. Heads - C.I.	--------	--------	35-40	70-75	100-110	130-140	145-155
Cyl. Heads - Alum.	--------	--------	30-35	--------	--------	--------	--------
Main Brg. Caps	--------	--------	35-40	70-75	85-95	110-120	140-150
In Alum. Blocks	--------	--------	--------	--------	60-70	--------	--------
Connecting Rods	--------	20-25	40-45	55-60	90-100	110-120	--------
Flywheels	--------	20-25	35-40	70-75	85-95	100-110	145-155
Flywheel Housings	--------	15-20	25-30	50-55	80-90	115-125	--------
*Manifolds	--------	15-20	25-30	40-50	50-60	50-60	60-70
Gear Covers, Water Pumps, Front and Rear End Plates	8-10	15-20	25-30	50-55	80-90	--------	--------
Oil Pans	--------	12-16	12-16	--------	--------	--------	--------
Rocker Supports and Die Castings	6-8	10-15	20-25	35-40	50-55	--------	--------
Misc. Accessories and Brackets	8-10	15-20	25-30	50-55	80-90	115-125	
Camshaft Nut							
Thread Size	¾″	⅞″	1″	1⅛″	1¼″		
Steel and C.I. Shafts	65-70	70-80	95-100	125-130	145-150		
Spark Plugs							
Thread Size	10MM.	14MM.	18MM.	⅞-18			
Torque Setting	14	30	34	37			

* 7/16″ to 5/8″ Manifold End Nuts — 35# Torque

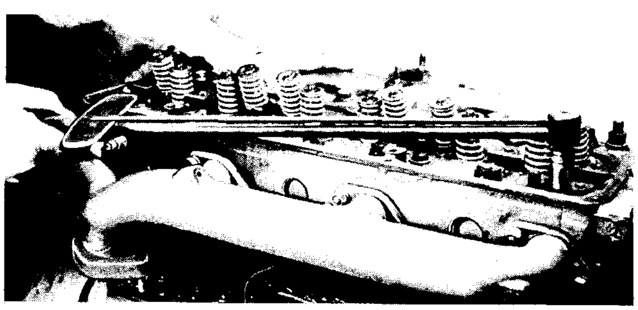


Figure 213
Torquing Cylinder Head Nuts

SECTION XI
LIMITS AND CLEARANCE DATA

NOTE: DIMENSIONS SHOWN ARE FOR STANDARD ENGINES

ENGINE SERIES	FO-6226	K330—6330 K363—6363	T-427—6427	U-501—6501	R513—6513 R572—6572 R602—6602		S749—6749 S820—6820	
INTAKE VALVE GUIDE								
							S749 S6749	S820 S6820
Length	2 5/16	2 29/32	2 7/8	2 9/16	3 3/16		3 3/16	3 3/8
Outside Dia.	.6575/.6565	.814/.813	.814/.813	.752/.751	.8765/.8755		.8765/.8755	
Stem Hole Dia. in Head	.3432/.3422	.4370/4360.	.4370/.4360	.4370/.4360	.4990/.4985		.4995/.4985	
*Wear Limits—Max. Dia.	.3442	.4380	.4380	.4380	.5005		.5005	
Distance—Valve Seat Face to Top of Guide	1 3/32	1 13/32	1 3/4	1 7/8	1 5/8		1 17/32	1 27/32
EXHAUST VALVE GUIDE								
Length	2 5/16	2 5/8	3 1/4	2 9/16	3 3/16		4 1/8	
Outside Dia.	.6575/.6565	.814/.813	.814/.813	.752/.751	.8765/.8755		.8765/.8755	
Stem Hole Dia. in Head	.3432/.3422	.4370/.4360	.4370/.4360	.4370/.4360	.4990/.4985		.4995/.4985	
*Wear Limits—Max. Dia.	.3442	.4380	.4380	.4380	.5005		.5005	
Distance—Valve Seat Face to Top of Guide	1 11/32	1 19/32	1 3/8	1 7/8	1 5/8		1 1/2	
VALVES, INTAKE								
					IND.	TRANS.	S749 S6749	S820 S6820
Overall Length	4.9461	6.068	6.2625	6.6665	6.5232	6.662	7.2915	7.278
Stem Dia.	.3410/.3402	.4352/.4344	.4352/.4344	.4352/.4342	.495/.494	.494/.493	.4977/.4969	
*Wear Limits—Min. Dia.	.3382	.4324	.4324	.4322	.492	.4912	.4949	
Head Dia.	1.781	1.990	2.083	2 9/64	1.891		2.556	2.622
Angle of Valve Face	30°	15°	15°	30°	44°		15°	
Stem Clearance Limit	.0012/.0032	.0008/.0026	.0008/.0026	.0008/.0028	.0035/.005	.0045/.0058	.0008/.0026	
*Wear Limits—Max. Cl.	.0052	.0046	.0046	.0048	.007	.0078	.0046	
Desired Stem Cl.	.002	.0015	.0015	.0015	.004	.005	.0015	
VALVES, EXHAUST								
Overall Length	5.409/5.384	5.688	6.206	6.716	6.5232	6.662	7.328	
Stem Dia.	.339/.338	.4325/.4315	.4325/.4315	.4325/.4315	.495/.494	.494/.493	.496/.495	
*Wear Limits—Min. Dia.	.336	.4295	.4295	.4295	.492	.4912	.493	
Head Dia.	1.427/1.417	1.641	1.641	1.88	1.891		2.1406	
Angle of Valve Face	44°	44°	44°	29°	44°		44°	
Stem Clearance Limit	.0032/.0052	.0035/.0055	.0035/.0055	.0035/.0055	.0035/.005	.0045/.006	.0025/.0045	
*Wear Limits—Max. Cl.	.0072	.0075	.0075	.0075	.0078		.0065	
Desired Stem Cl.	.004	.004	.004	.004	.004	.005	.004	
OUTER VALVE SPRING								
Free Length	2 1/8	1.902	1.902	2.625	2.602		3 1/16	
Outside Dia.	1.156	1.614	1.614	1.624	1.820		1.887	
Wire Gauge	.172	.182	.182	.187	.207		.225	
Length—Valve Closed	1.817	1.548	1.548	1.931	2.117		2.750	
Load—Valve Closed	76#	58.5#	58.5#	72#	67#		71#	
*Wear Limits—Min.	68#	52#	52#	65#	60#		64#	
Length—Valve Open	1.405	1.077	1.077	1.427	1.617		2.0937	
Load—Valve Open	175#	136.4#	136.4#	142#	160#		221#	
*Wear Limits—Min.	158#	122#	122#	128#	144#		200#	

LIMITS AND CLEARANCE DATA

ENGINE SERIES	FO-6226	K-330—6330 K-363—6363	T427—6427	U501—6501	R513—6513 R572—6572 R602—6602	S749—6749 S820—6820
INNER VALVE SPRINGS						
Free Length		1.748	1.748	2.250	2.232	$2\frac{15}{16}$
Outside Dia.		1.135	1.135	1.135	1.655	1.375
Wire Gauge	NO	.135	.135	.135	.156	.172
Length—Valve Closed	INNER	1.453	1.453	1.837	1.867	2.594
Load—Valve Closed	SPRING	30.4#	30.4#	30#	38#	45#
*Wear Limits—Min.		27#	27#	27#	34#	41#
Length—Valve Open		.982	.982	1.333	1.367	1.9375
Load—Valve Open		79#	79#	80#	90#	136#
*Wear Limits—Min.		71#	71#	72#	81#	123#
CAMSHAFT						
#1 Brg. Journal Dia.	1.8735/1.8725	2.8850/2.1840	2.2430/2.2420	2.3705/3.3695	2.1225/2.1215	2.2480/2.2470
#2 Brg. Journal Dia.	1.8105/1.8095	2.1225/2.1215	2.2430/2.2420	2.3080/2.3070	2.1225/2.1215	2.2480/2.2470
#3 Brg. Journal Dia.	1.8105/1.8095	2.0600/2.0590	2.2430/2.2420	2.1830/2.1820	2.1225/2.1215	2.2480/2.2470
#4 Brg. Journal Dia.	1.2485/1.2475	1.7475/1.7465	2.2430/2.2420	2.0580/2.0570	2.1225/2.1215	2.2480/2.2470
#5 Brg. Journal Dia.	None	None	None	None	2.1225/2.1215	2.2480/2.2470
*Wear Limit—		.001 Wear Under Minimum Bearing Journal Diameter.				
Cam Lift—Intake	.2815	.3309	.3378	.386	.386	.450
Cam Lift—Exhaust	.2815	.3205	.3200	.370	.370	.450
Camshaft Bush. Clear.	.001/.003	.0015/.003	.0015/.003	.0015/.0025	.0015/.0025	.0015/.0025
*Wear Limits—Max. Cl.	.0045	.0045	.0045	.004	.004	.004
Tappet Dia.	.9975/.9970	.9975/.9970	1.1220/1.1215	.6087/.6082	.6087/.6082	.6087/.6082
*Wear Limits	.9960	.9960	1.1205	.6072	.6072	.6072
Clearance Limits	.0015/.0025	.0015/.0025	.0015/.0025	.0019/.0002	.0019/.0002	.0019/.0002
*Wear Limits	.004	.004	.004	.0029	.0029	.0029
End Play	.003/.007	.005/.009	.005/.009	.005/.009	.005/.009	.005/.009
CONNECTING RODS						
Length—Center to Center	7.002/6.998	8.377/8.373	8.377/8.373	10.502/10.498	10.502/10.498	10.502/10.498
Bushing Hole Dia.	.914/.913	1.313/1.312	1.500/1.499	1.750/1.749	1.750/1.749	1.8735/1.8745
Brg. Hole Dia.	2.1870/2.1865	2.3745/2.3740	2.6870/2.6865	2.8745/2.8740	3.2020/3.2012	3.6935/3.6925
Brg. Thickness	.06130/.06155	.06180/.06205	.09300/.09325	.0622/.0617	.100/.0997	.0955/.0950
*Wear Limits—Min. Th.	.0608	.0613	.09250	.0612	.0992	.0945
Dia. Crank Pin	2.0627/2.0619	2.248/2.249	2.498/2.499	2.7485/2.7475	3.000/2.999	3.500/3.499
*Wear Limits—Min. Dia.	2.0609	2.247	2.497	2.7465	2.998	3.498
Clearance Limits	.0007/.0025	.0009/.0029	.001/.003	.0011/.0036	.0012/.0028	.0015/.0045
Desired Clearance	.0015	.0015	.002	.0025	.002	.003
*Wear Limits—Max. Cl.	.0035	.0039	.004	.0046	.0038	.0055
Width @ Brg. End	1.3055/1.3035	1.5555/1.5535	1.6795/1.6775	1.804/1.802	1.929/1.927	2.428/2.426
Side Play	.006/.010	.006/.010	.006/.010	.006/.010	.006/.010	.008/.012
Desired Side Play	.006 Min.	.006 Min.	.006 Min.	.006 Min.	.006 Min.	.008 Min.
MAIN BEARINGS						
Dia. of Brg. Bore in Block	2.5615/2.5622	2.8115/2.8127	3.0615/3.0622	2.9420/2.9410	3.5000/3.4992	4.000/3.999
Brg. Shell Thickness	.09250/.09275	.09275/.09300	.09275/.09300	.0957/.0952	.1235/.1232	.1237/.1232
*Wear Limits—Min. Th.	.0920	.09225	.09225	.0947	.1227	.1227
Dia. of Main Brg. Jnl.	2.3752/2.3744	2.623/2.624	2.873/2.874	2.7485/2.7475	3.250/3.249	3.750/3.749
*Wear Limits—Min. Dia.	2.3734	2.622	2.872	2.7465	3.248	3.748
Clearance Limits	.0008/.0028	.0015/.0036	.0015/.0037	.0011/.0041	.0022/.0046	.0016/.0046
Desired Clearance	.0015	.0025	.0025	.0025	.003	.003
*Wear Limits—Max. Cl.	.0038	.0046	.0047	.0051	.0056	.0056
C/S End Play	.002/.006	.005/.008	.005/.008	.006/.010	.006/.010	.006/.010

LIMITS AND CLEARANCE DATA

	FO-6226	K-330 K-6363	K-363 K-6363	T-427 T-6427
PISTONS				
Actual Inside Dia. of Bore	3.3125/3.3130	4.0000/4.0005	4.0000/4.0005	4.3125/4.3130
Piston Pin Hole Dia.	.8594/.8592	1.1094/1.1092	1.1097/1.1095	1.2504/1.2502
RING GROOVE DIA.				
#1	2.940/2.930	3.557/3.545	3.556/3.546	3.834/3.824
#2	2.940/2.930	3.557/3.545	3.556/3.546	3.834/3.824
#3	2.940/2.930	3.557/3.545	3.556/3.546	3.834/3.824
#4	2.928/2.918	3.576/3.566	3.572/3.562	3.876/3.886
#5	2.928/2.918	3.576/3.566	3.572/3.562	3.876/3.886
RING GROOVE WIDTH	*(Maximum Wear Should Not Exceed .002 Over New Piston Ring Groove Maximum Width)			
#1	.0965/.0955	.0983/.0963	.0975/.0965	.0983/.0963
#2-3	.1265/.1255	.0975/.0965	.0975/.0965	.0975/.0965
#4	.252/.251	.251/.250	.1885/.1875	.1885/.1875
#5	.157/.156	.1880/.1895	.1895/.1880	.1885/.1875
RING LAND DIA.				
#1	3.286/3.281	3.974/3.970	3.972/3.968	4.271/4.267
#2	3.292/3.287	3.981/3.977	3.976/3.972	4.280/4.276
#3	3.292/3.287	3.981/3.977	3.976/3.972	4.284/4.280
#4	3.256/3.251	3.963/3.957	3.980/3.976	4.284/4.280
Piston Fit.—Feeler Ga.	.0015	.005	.002	.004
Lbs. Pull	5-10#	5-10#	5-10#	5-10#
PISTON RINGS				
RING WIDTH	*Maximum Wear—Should Not Exceed .002 Under Minimum New Ring Width.			
#1	.0935/.0930	.0930/.0935	.0935/.0930	.0935/.0930
#2	.1240/.1235	.0930/.0935	.0935/.0930	.0935/.0930
#3	.1240/.1235	.0930/.0935	.0935/.0930	.0935/.0930
#4	.249/.2485	.2490/.2485	.1865/.1860	.1865/.1860
#5	.1550/.1545	.1865/.1860	.1865/.1860	.1865/.1860
RING THICKNESS				
#1	.166/.156	.200/.190	.200/.190	.216/.206
#2	.149/.139	.200/.190	.200/.190	.182/.172
#3	.149/.139	.200/.190	.200/.190	.216/.206
#4	.152/.142	.170 Max.	.172/.162	.150/.140
#5	.149/.139	.170 Max.	.172/.162	.182/.172
RING GAP CLEARANCE				
#1	.010/.020	.013/.023	.013/.025	.013/.023
#2	.010/.020	.013/.023	.013/.023	.013/.023
#3	.010/.020	.013/.023	.013/.023	.013/.025
#4	.007/.017	.013/.025	.013/.023	.013/.023
#5	.010/.020	.013/.023	.013/.023	.013/.023
RING SIDE CLEARANCE	*Maximum Wear Should Not Exceed .0025 Over Maximum New Ring Side Clearance.			
#1	.002/.0035	.0028/.0053	.003/.0045	.0028/.0053
#2	.0015/.003	.003/.0045	.003/.0045	.003/.0045
#3	.0015/.003	.003/.0045	.003/.0045	.003/.0045
#4	.002/.0035	.001/.0025	.001/.0025	.003/.0045
#5	.001/.0025	.0025/.0035	.0015/.0035	.001/.0025
PISTON PIN				
Length	2.815/2.805	3.440/3.425	3.440/3.425	3.630/3.620
Diameter	.8593/.8591	1.1093/1.1091	1.1093/1.1091	1.2500/1.2498
*Wear Limits—Min. Dia.	.8588	1.1088	1.1088	1.2495
Desired Fit	Light Push	Light Push	Light Push	Light Push
Bush. Hole Dia. Fin.	.8597/.8595	1.1097/1.1095	1.1097/1.1095	1.2504/1.2502
*Wear Limits—Max. Dia.	.8607	1.1107	1.1107	1.2514
Pin Clearance in Bush.	.0006/.0002	.0006/.0002	.0006/.0002	.0006/.0002
*Wear Limits—Max. Cl.	.0016	.0016	.0016	.0016
Desired Pin Fit	.0004	.0004	.0004	.0004

U-501—6501 R-513—6513	R-572 R-6572	R-602 R-6602	S-749 S-6749	S-820 S-6820
4.5000/4.5005	4.7500/4.7505	4.8750/4.8755	5.3750/5.3755	5.6250/5.6255
1.5000/1.4998	1.5000/1.4998	1.5000/1.4998	1.7500/1.7498	1.7500/1.7498
3.993/4.003	4.227/4.217	4.338/4.328	4.789/4.779	5.009/4.999
3.993/4.003	4.227/4.217	4.338/4.328	4.813/4.803	5.009/4.999
3.993/4.003	4.227/4.217	4.338/4.328	4.813/4.803	5.009/4.999
4.047/4.037	4.291/4.281	4.405/4.395	4.864/4.854	5.101/5.091
4.047/4.037	4.291/4.281	4.405/4.395	4.864/4.854	5.101/5.091
Maximum Wear Should Not Exceed .002 Over New Piston Ring Groove Max. Width				
.0975/.0965	.0975/.0965	.0975/.0965	.0995/.0985	.0995/.0985
.0965/.0955	.0965/.0955	.0965/.0955	.0955/.0965	.0965/.0955
.2515/.2505	.2515/.2505	.2515/.2505	.2515/.2505	.2515/.2505
.1890/.1880	.1890/.1880	.1890/.1880	.1890/.1880	.1890/.1880
4.455/4.450	4.714/4.710	4.830/4.826	5.322/5.318	5.570/5.566
4.460/4.455	4.719/4.715	4.843/4.839	5.333/5.329	5.581/5.577
4.460/4.455	4.719/4.715	4.843/4.839	5.338/5.334	5.591/5.587
4.460/4.455	4.724/4.720	4.848/4.844	5.338/5.334	5.591/5.587
.005	.005	.006	.008	.008
5-10#	5-10#	5-10#	5-10#	5-10#
Maximum Wear Should Not Exceed .002 Under Minimum New Ring Width				
.0935/.0930	.0935/.0930	.0935/.0930	.0935/.0930	.0935/.0930
.0935/.0930	.0935/.0930	.0935/.0930	.0935/.0930	.0935/.0930
.0935/.0930	.0935/.0930	.0935/.0930	.0935/.0930	.0935/.0930
.2490/.2485	.2490/.2485	.2490/.2485	.2490/.2485	.2490/.2485
.1865/.1860	.1865/.1860	.1865/.1860	.1865/.1860	.1865/.1860
.225/.215	.237/.227	.234/.244	.269/.259	.281/.271
.225/.215	.205/.195	.234/.244	.269/.259	.235/.255
.225/.215	.205/.195	.234/.244	.235/.255	.235/.255
.183/.173	.189/.179	.192 Max.	.192 Max.	.215 Max.
.183 Max.	.189/.179	.192/.182	.205/.195	.215/.205
.013/.025	.013/.025	.013/.025	.017/.027	.017/.027
.013/.023	.013/.018	.013/.023	.017/.027	.022/.032
.013/.023	.013/.108	.013/.023	.022/.032	.022/.032
.013/.025	.013/.025	.013/.025	.013/.023	.013/.023
.010/.020	.013/.025	.013/.023	.022/.032	.017/.027
Maximum Wear Should Not Exceed .0025 Over Maximum New Ring Side Clearance				
.003/.0045	.003/.0045	.003/.0045	.005/.0065	.005/.0065
.002/.0035	.002/.004	.002/.0035	.002/.0035	.002/.0045
.002/.0035	.002/.004	.002/.0035	.002/.004	.002/.0045
.001/.003	.0015/.003	.0015/.003	.0015/.003	.0015/.003
.0015/.003	.0015/.003	.0015/.003	.0015/.003	.0015/.003
3.718/3.703	3.988/3.973	3.988/3.973	4.539/4.524	4.539/4.524
1.5000/1.4998	1.5000/1.4998	1.5000/1.4998	1.7500/1.7498	1.7500/1.7498
1.4995	1.4995	1.4995	1.7495	1.7495
Light Push	Light Push	Light Push	Light Push	Light Push
1.5005/1.5003	1.5005/1.5003	1.5005/1.5003	1.7505/1.7503	1.7505/1.7503
1.5015	1.5015	1.5015	1.7515	1.7515
.0006/.0002	.0006/.0002	.0006/.0002	.0006/.0002	.0006/.0002
.0016	.0016	.0016	.0016	.0016
.0004	.0004	.0004	.0004	.0004