



CMC

*Continental Red Seal  
4-Cylinder Over-Head Valve Engines*

**OPERATION AND  
MAINTENANCE  
INSTRUCTIONS**

***Continental Motors Corporation***

*AUTOMOTIVE-INDUSTRIAL ENGINE DIVISION*

205 MARKET STREET • MUSKEGON, MICHIGAN 49443

FORM NO. X-27054

# **Operation and Maintenance Instructions**

## **4 CYLINDER OVER-HEAD VALVE GASOLINE ENGINES**

### **INDUSTRIAL**

Z-129  
G157-G193  
E201-E208-E223-E242  
H260-H277  
J382-J403

### **TRANSPORTATION**

G4193

**Continental Motors Corporation  
Muskegon, Michigan**












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Form No. X27054

## QUICK REFERENCE SECTION INDEX

### *Index*

First page of each group has black tab in same position as below.

SECTION I — General Information.....	Page 7	
SECTION II — Lubrication .....	Page 9	
SECTION III — Operation .....	Page 15	
SECTION IV — Preventive Maintenance.....	Page 21	
SECTION V — Cooling System.....	Page 26	
SECTION VI — Fuel System.....	Page 34	
SECTION VII — Ignition .....	Page 41	
SECTION VIII — Engine Repair & Overhaul.....	Page 50	
SECTION IX — Trouble Shooting .....	Page 76	
SECTION X — Torque Specifications .....	Page 79	
SECTION XI — Limits & Clearance Data.....	Page 80	

(See following pages for details of each section)

# INDEX

## SECTION I — GENERAL INFORMATION

Four Cylinder Overhead Valve Engine Specifications .....	5
How to Order Parts .....	6
Continental Overhead Valve Engine Features.....	7

## SECTION II — LUBRICATION

Engine Lubricating System .....	9
Oil Filters .....	10
Oil Pump .....	10
Air Cleaner .....	11
Lubrication Recommendations .....	13
Transmission and Converter Lubrication Recommendations.....	14

## SECTION III — OPERATION

Preparation of New Engine for Operation.....	15
Starting the Engine .....	16
Stopping the Engine .....	18
10 Operating Precautions .....	18
Cold Weather Operation .....	19
Seasonal Storage of Engine .....	20

## SECTION IV — PREVENTIVE MAINTENANCE

Daily Preventive Maintenance Schedule.....	21
50-Hour Preventive Maintenance Schedule.....	23
250-Hour Preventive Maintenance Schedule.....	24
500-Hour Preventive Maintenance Schedule.....	25

## SECTION V — COOLING SYSTEM

Continental Overhead Valve Cooling System.....	26
Effect of Altitude on Cooling.....	27
Anti-Freezes .....	27
Cleaning Cooling System .....	28
Testing Thermostat .....	29
Radiator Pressure Cap .....	30
Fan Belt Tension .....	31
Water Pump .....	32

## SECTION VI — FUEL SYSTEM

Gravity Fuel System .....	34
Mechanical Fuel Pump .....	34
Electrical Fuel Pump .....	35
Marvel-Schebler Carburetors .....	35
Zenith Carburetors .....	36
Carburetor Chokes .....	38
Cam Gear Governor .....	39
Velocity Governors .....	40
Zenith Gov-U-Retor .....	40

## INDEX

## SECTION VII — IGNITION

Battery — Ignition System .....	41
Ignition Coil — Distributor & Condenser.....	41
Distributor Maintenance .....	43
Spark Plugs .....	44
Distributor — Ignition Timing, with Timing Light.....	45
Ignition Timing, without Timing Light .....	46
Magneto — Ignition .....	47
Magneto Impulse Coupling .....	48
Timing Magneto to Engine.....	49

## SECTION VIII — ENGINE REPAIR AND OVERHAUL

Cylinder Head .....	50
Valve Guides .....	51
Valve Seat Inserts .....	52
Valves .....	53
Valve Springs .....	54
Cylinder Block .....	57
Re-Ringing .....	58
Preparing the Bores .....	59
Pistons .....	61
Piston Rings .....	61
Connecting Rods .....	62
Bearings .....	64
Crankshaft .....	64
Camshaft .....	67
Valve Tappets .....	67
Timing Gears .....	68
Crankshaft End Play .....	69
Rear Oil Seals .....	70
Oil Pumps .....	73
Flywheels and Housings .....	74
Reassembling Engine .....	75

## SECTION IX — TROUBLE-SHOOTING

Starting Motor Will Not Crank Engine.....	76
Engine Will Not Start.....	76
Engine Runs Unevenly .....	77
Poor Compression .....	77
High Oil Consumption .....	78
Engine Knocks .....	78
Engine Vibration .....	78

## SECTION X — TORQUE SPECIFICATIONS .....

## SECTION XI — LIMITS &amp; CLEARANCE DATA .....

## FOREWORD

Gasoline engines have, over the years, maintained a position of importance in the field of power development. Because of their inherent characteristics of dependable and economical service, they have been the answer to a long standing demand for power. CONTINENTAL MOTORS CORPORATION, with its extensive research, maintains a reputation earned in over 64 years of leadership in the internal combustion engine industry.

Continental gasoline engines are designed for rugged service and are simple to service and maintain; they are capable of producing smooth dependable power, with excellent fuel economy.

Good operation and a **planned** maintenance program as outlined in this manual are of vital importance in obtaining maximum engine performance, and long engine life. The instructions on the following pages have been written with this in mind, to give the operator a better understanding of the various problems which may arise, and the manner in which these problems can best be solved or avoided.

The operator is cautioned against the use of any parts, other than **Genuine Continental Parts** for replacement or repair. Genuine Continental parts have been engineered and tested for their particular job, and the use of any other parts may result in unsatisfactory performance and short engine life. Likewise, Continental distributors and dealers, because of their close factory relations, can render the best and most efficient service.

INDUSTRIAL ENGINES

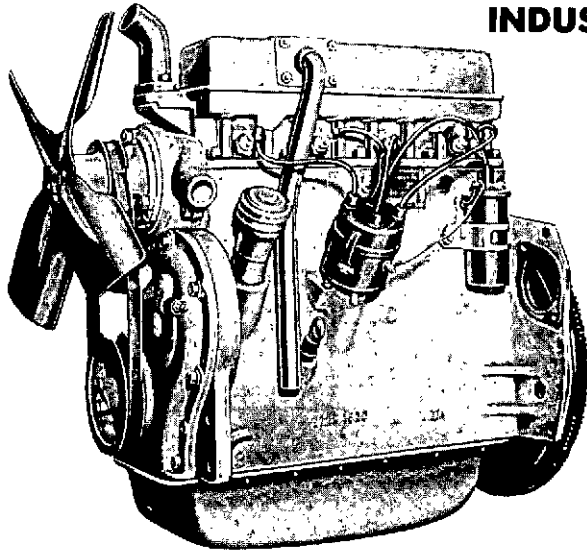


Figure 1 — Z-129

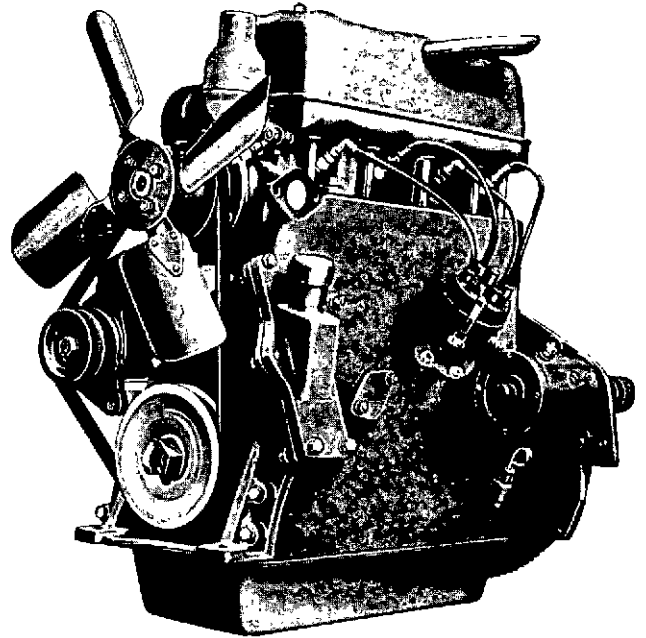


Figure 2 — G-157

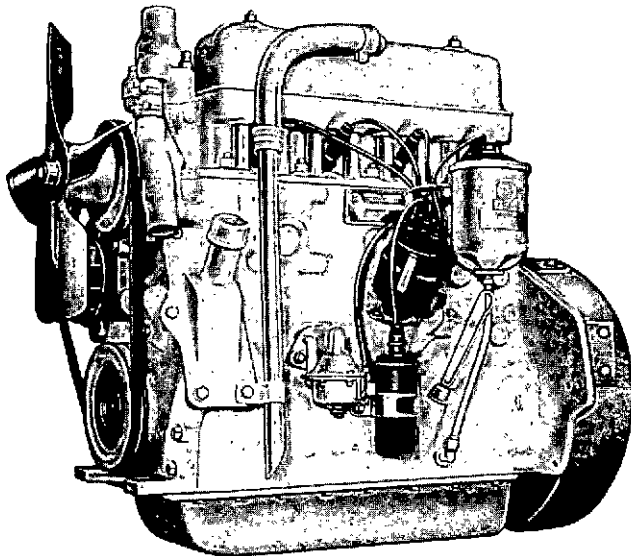


Figure 3 — G-193

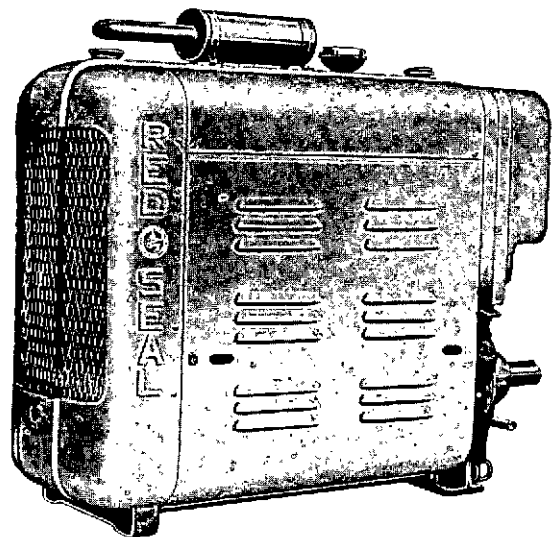


Figure 4 — Closed Power Unit  
E-Series

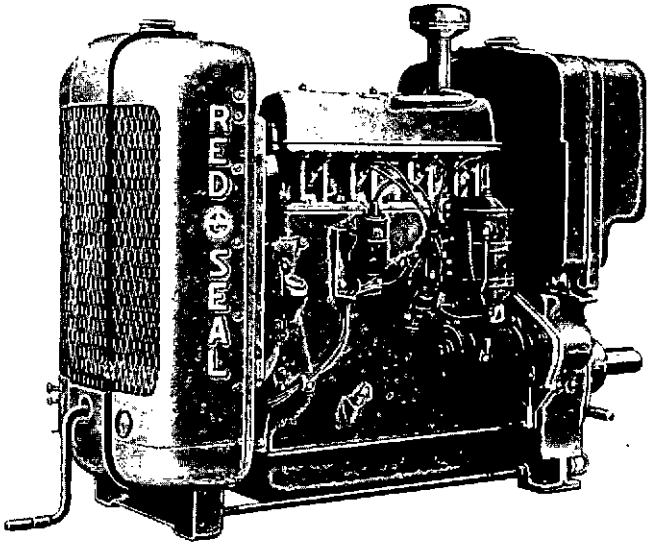


Figure 5 — H-277

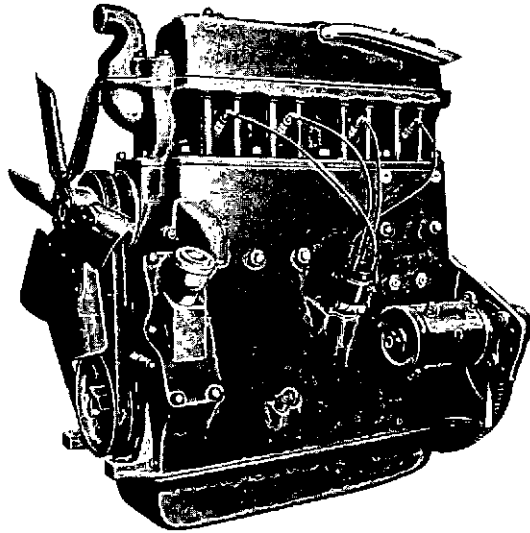


Figure 6 — J-382

### TRANSPORTATION ENGINES

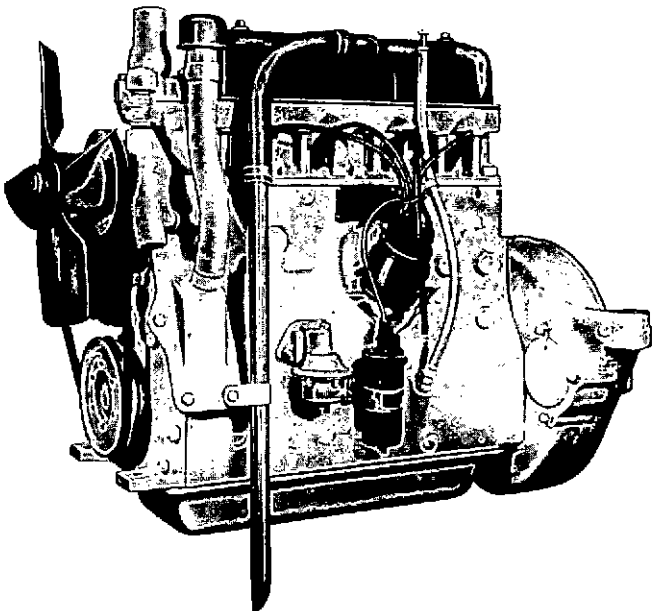


Figure 7 — G-4193 LH Side

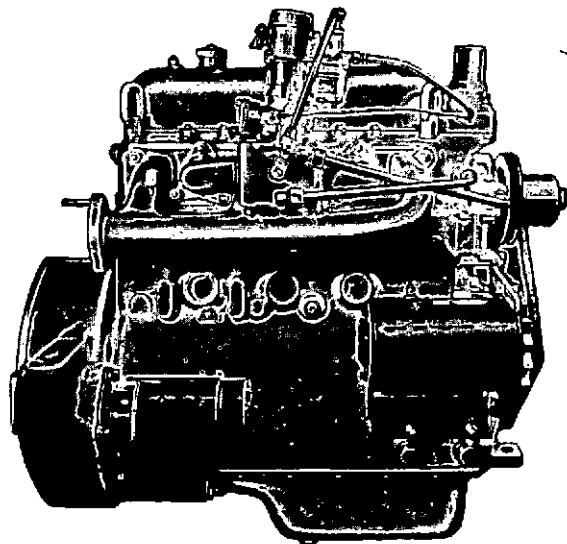


Figure 8 — G-4193 RH Side

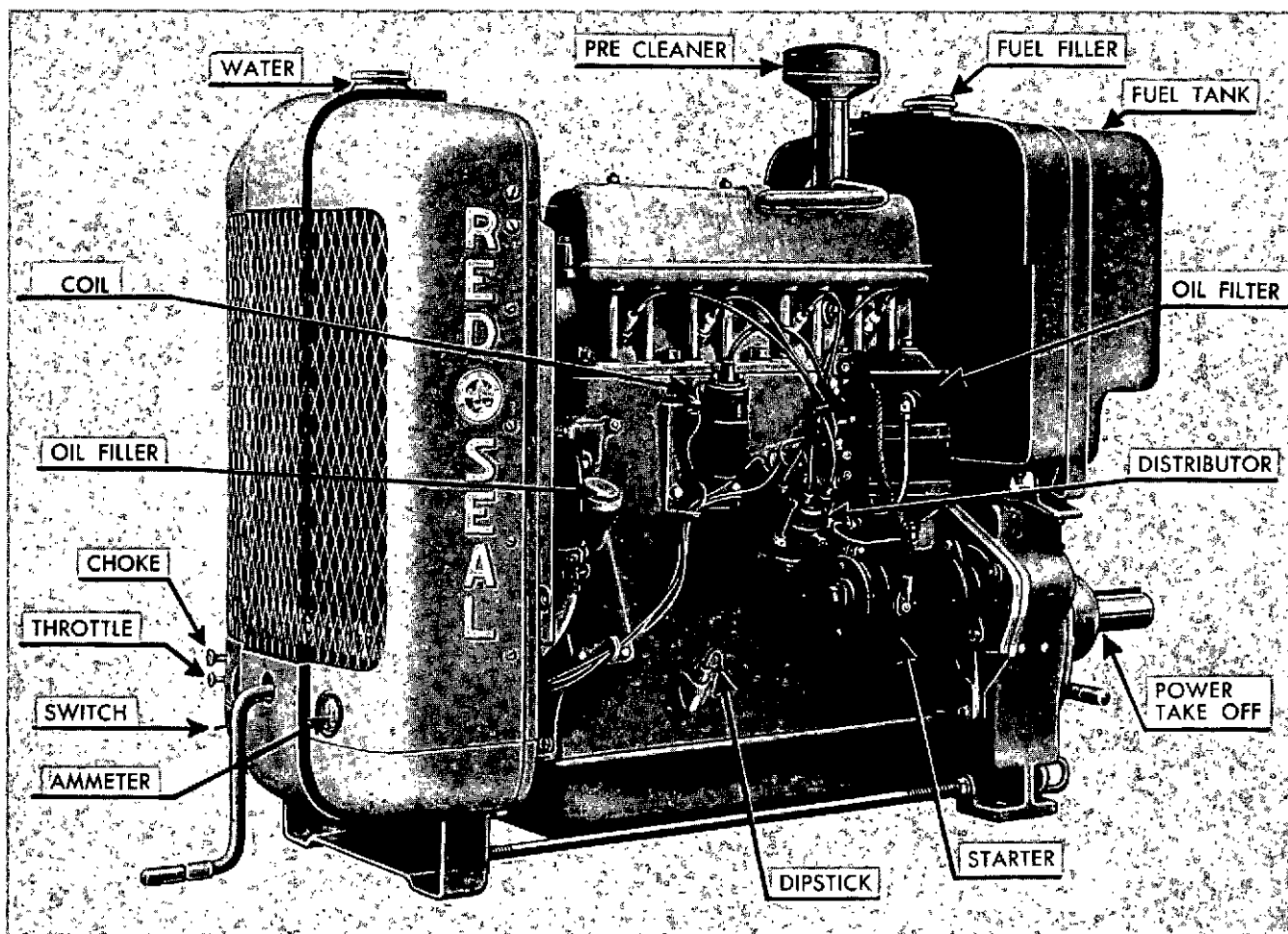


Figure 9 — H-260 Open Power Unit

## FOUR CYLINDER OVER-HEAD VALVE INDUSTRIAL AND TRANSPORTATION GASOLINE ENGINES

MODEL	Z-129 <sup>①</sup>	G-157 <sup>②</sup>	G-193	G-4193	E-208 <sup>③</sup>	H-277 <sup>④</sup>	J-382 <sup>⑤</sup>
No. of Cylinders	4	4	4	4	4	4	4
Bore and Stroke	3¼ x 3⅞	3⅜ x 4⅜	3¾ x 4¾	3¾ x 4¾	3⅞ x 4⅞	4 x 5½	4½ x 6
Displacement Cu. In.	129	157	193	193	208	277	382
Compression Ratio	6.50	6.16	7.00	7.00	6.50	6.25	5.82
Oil Pressure at 1800 RPM	20-30	10-20	20-30	30-40	10-20	10-20	10-20
Min. at Idling	7	7	7	7	7	7	7
Firing Order				1-3-4-2			
Main Brg.—Front	2¼ x 1⅞	2⅜ x 1⅞	2⅜ x 1⅞	2⅜ x 1⅞	2⅝ x 1⅝	2⅞ x 1¾	3¼ x 2⅞
Main Brg.—Center	2¼ x 1½	2⅜ x 1¾	2⅜ x 1¾	2⅜ x 1¾	2⅝ x 2	2⅞ x 2⅝	3¼ x 2⅝
Main Brg.—Rear	2¼ x 1⅞	2⅜ x 1⅞	2⅜ x 1⅞	2⅜ x 1⅞	2⅝ x 1⅞	2⅞ x 2⅞	3¼ x 2⅞
Conn. Rod Brg. Dia. and Length	1⅞ x 1¼	2⅞ x 1⅞	2¼ x 1⅞	2¼ x 1⅞	2¼ x 1⅞	2½ x 1⅞	2¾ x 1⅞
Oil Capacity (Qts.)							
Crankcase Only	5	5	5	5	6	7	9
Oil Filter	1	1	1	1	1	2	2
Total	6	6	6	6	7	9	11
Water Capacity (Gal.)	4¾	5	5	5	5	6	9
Valve Clearances (Hot and Idling)							
Intake	.010	.014	.014	.014	.014	.014	.014
Exhaust	.012	.014	.014	.014	.014	.014	.014
Weight—Bare Engine	340	500	525	535	585	690	880

Note 1 Data for Z134 same except 3⅞ Bore—134 Cu. In. Displ.

Note 2 Data for G174 same except 3⅞ Bore—174 Cu. In. Displ.

Note 3 Data for E201 same except 3⅞ Bore—201 Cu. In. Displ.

Data for E223 same except 3⅞ Bore—223 Cu. In. Displ.—Valve Clearance, .016 Intake, .018 Exhaust.

Data for E242 same except 3⅞ Bore and 5⅞ Stroke—242 Cu. In. Displ.—Valve Clearance, .016 Intake, .018 Exhaust.

Note 4 Data for H260 same except 3⅞ Bore—260 Cu. In. Displ.

Note 5 Data for J403 same except 4⅞ Bore—403 Cu. In. Displ.

**INFORMATION FOR ORDERING PARTS**

When ordering parts, refer to the engine name plate attached to side of the cylinder block, which lists the model and serial number. In most cases a specification number is listed. This data is of vital importance in obtaining the correct parts: always include this information on your parts order.

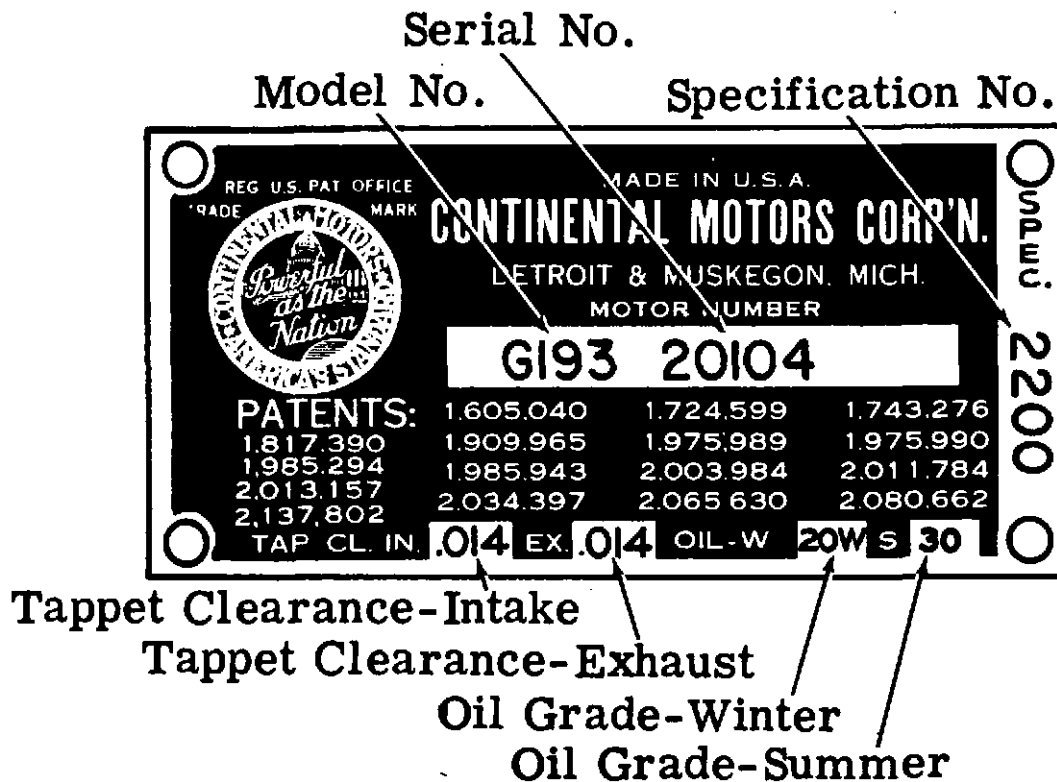


Figure 10 Nameplate

## SECTION 1 GENERAL INFORMATION

Overhead valve engine design provides the highest power output and operating efficiency.

The valves are located in the cylinder head, which permits larger valves to assure improved combustion and engine output. The ease of servicing the valves coupled with the improved cooling of the exhaust valves and ports are important features of engine maintenance. Overhead valve design minimizes the tendency to impose thermal deformation on the cylinder structure.

Engines of this type being narrower in frontal elevation, lend themselves to a more favorable arrangement of the engine accessories, such as carburetor, magneto, starter, generator and filters for transportation and industrial applications.

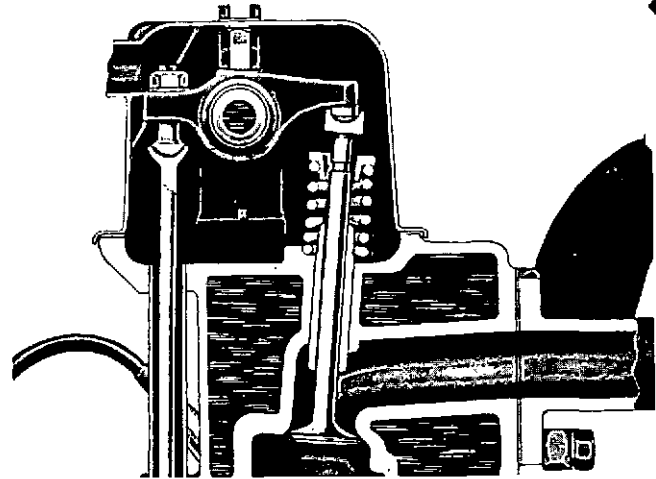


Figure 11

### CONTINENTAL OVER-HEAD VALVE ENGINES

Continental has thirteen four cylinder overhead valve industrial engines and one transportation engine — which range in size from 129 to 403 cubic inches displacement.

The combustion chamber design is a result of much research and includes the very latest developments to ensure dependable and economical heavy duty service.

Some of the principal design features are:

1. **Individual Porting** — of the intake manifold whereby each cylinder is fed with the fuel-air mixture individually and not influenced by other cylinders of the engine.

This is accomplished by casting the cylinder block with individual intake valve passages for each cylinder and connecting these passages to an intake manifold which also has individualized passages for each cylinder.

This equal distribution results in maximum power, smooth operation, easy starting and longer engine life.

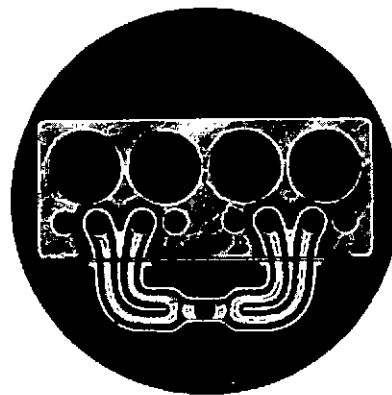
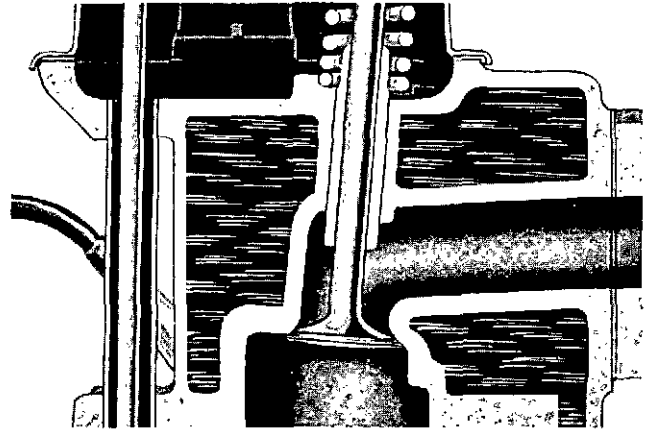


Figure 12

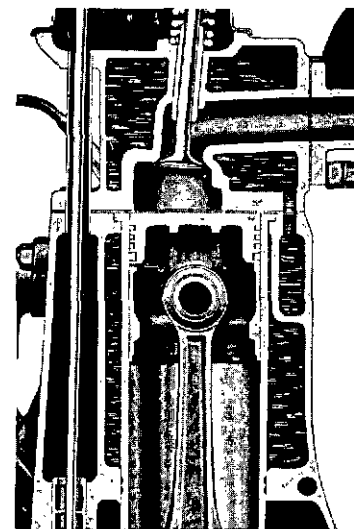
**2. Directional Cooling**—The large capacity water pump directs the coolant flow through integral distribution passages cast in the cylinder head, to the areas in and around the valve seats — which provides the coldest water reaching the parts in the engine, subjected to the highest temperatures.



**Figure 13**

**3. Full Length Water Jackets** — Completely surround all cylinder bores the full length of the piston travel.

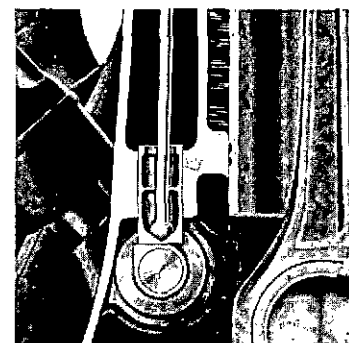
This insures uniform cooling with minimum bore distortion — resulting in lower oil consumption; less blow-by and minimum tendency to sludge — which is so detrimental to engine life.



**Figure 14**

**4. Removable Tappets** — The simple tappet design allows tappets on the H and J series engines to be removed from the top of the block for examination or replacement.

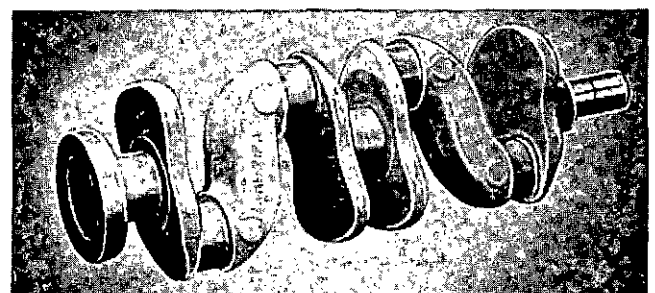
The Z-G-E series engines have mushroom tappets and can only be removed from the bottom of the block after the camshaft is removed.



**Figure 15**

**5. Counterweighted and Dynamically Balanced Crankshaft** — Drop-forged, scientifically heat-treated crankshafts, with Tocco-hardened journals on the larger engines, are fully counterweighted and dynamically balanced to within one-half ounce.

This reduces the main bearing loads materially, eliminates objectionable vibration and is largely responsible for the smooth operation and longer life of Continental engines.



**Figure 16**

# SECTION II LUBRICATION

## ENGINE LUBRICATION SYSTEM

CONTINENTAL FOUR CYLINDER OVER-HEAD VALVE ENGINES have full pressure lubrication through drilled passages in the cylinder block and crank shaft to all main and connecting rod bearings as well as to the timing

gears and overhead valve rocker arms, the overflow from which lubricates the tappets. The oil pressure is automatically regulated by a spring loaded Relief Valve.

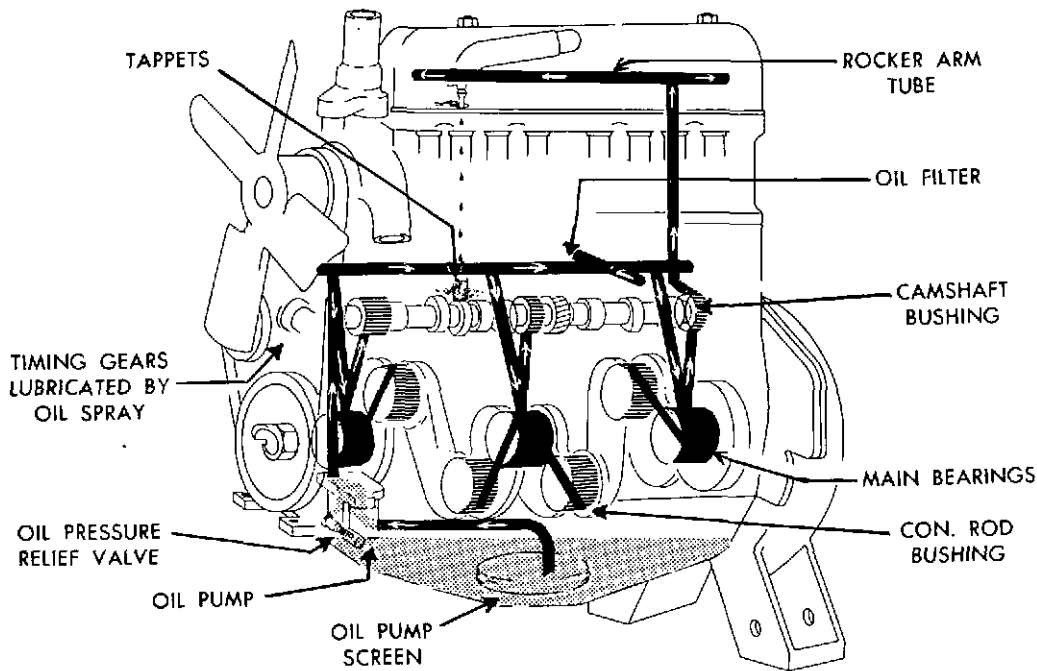


Figure 17 — Lubrication Diagram (G-193)

The gear type oil pump is driven off the crankshaft gear and has several times the capacity required by the engine — the excess being bypassed. Oil is supplied the pump by a suction tube with a screened inlet which picks up clean oil without any residue which may have settled in the bottom of the pan.

To insure piston pin lubrication and prevent piston scuffing during the warm-up period in cold weather — the large end of the connecting rods have drilled spurt holes pointing toward the thrust side of the pistons. These line up with the

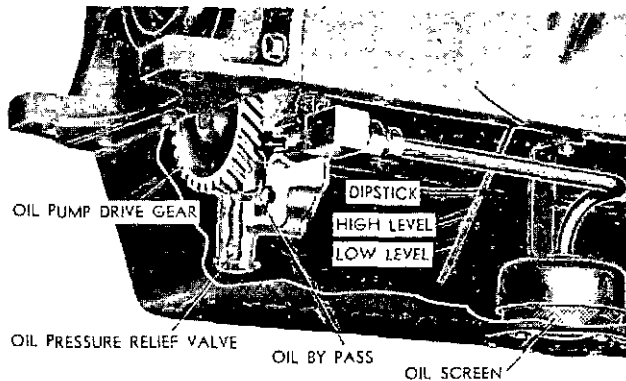


Figure 18 — Sectional View of By-Pass Oil Pump

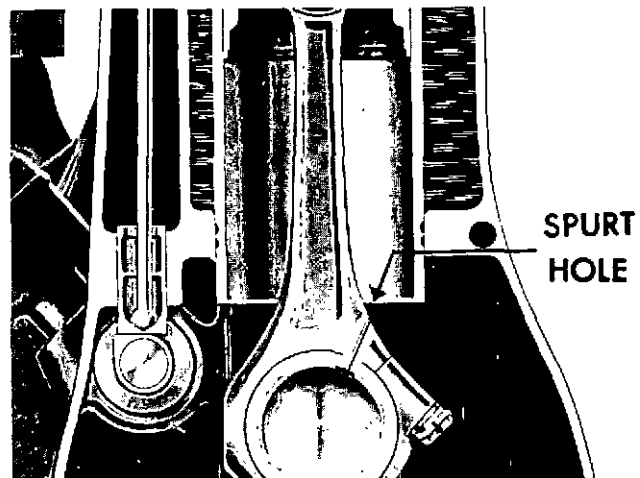


Figure 19 — Connecting Rod Spurt Hole (Looking at engine from rear)

oil hole in the crank pin so that once each revolution oil is sprayed on the cylinder wall for lubrication. Rocker arm lubrication is pressure fed from the crankshaft intermittently.

A by-pass type oil filter is provided to remove dirt and foreign elements from the oil, a per-

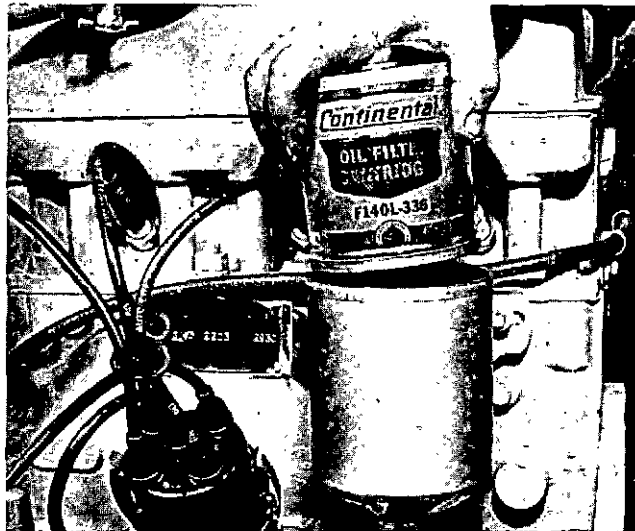


Figure 20 — Oil Filter

centage of which is passed through the filter during operating period. The removal of grit, sludge and foreign particles causes filter elements to clog and become ineffective unless they are replaced at regular intervals.

### OIL FILTER

A lubricating oil filter is provided to separate and remove the grit, sludge and foreign particles from the oil to prevent these injurious materials from being circulated in the engine. This will prevent operating failures, prolong bearing life and reduce maintenance expense.

This by-pass type filter allows only a part of the oil to circulate through the filter at one time; however, all the engine oil eventually passes through and is cleaned. It also includes a replaceable element which collects and retains all the foreign matter.

Eventually the minute passages in the element become clogged and unless replaced at regular intervals, ceases to pass oil through and will by-pass the oil around it. This results in abrasive particles remaining in the oil and circulating to the bearings. To prevent this, replace the filter element every 100 hours or 4000 miles.

### OIL PUMP

The oil pump on the four cylinder over-head valve engine is mounted on the front bearing cap. It is a gear type pump driven by the timing gear on the crankshaft.

This pump rarely gives any trouble; if it does it can be readily removed and either repaired or replaced with a new one.

Normal oil pressures under operating conditions are:

G157 E-H-J Series	10-20 pounds
Z Series G193	20-30 pounds
G4193	30-40 pounds

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

**CAUTION:** If the oil pressure is erratic or falls below these limits, stop the engine IMMEDIATELY and find the cause of the trouble. Refer to trouble shooting section for this information.

### OIL CHANGE FREQUENCY

Engine oil does not "wear out". However, the lubricating oil in internal-combustion engines becomes contaminated from the by-products of combustion: dirt, water, unburned fuel entering the crankcase, and the detergents holding the carbon particles in suspension in the crankcase.

The frequency with which engine oil should be changed depends upon (1) The quality of the oil, (2) Type of operation, (3) Mechanical condition of the engine and (4) The type of contaminants from the engine operation and the surrounding atmosphere.

In normal operation, the Continental over-head valve engines should have the oil changed after every 50 hours, or 2000 miles of operation. The oil filter should be changed every 100 hours or 4000 miles. The oil should be drained when the engine is at normal operating temperature.

## BREAKING-IN NEW OR RECONDITIONED ENGINES

New or reconditioned engines have very small clearances. To assure adequate oil distribution to these closely fitted surfaces during the first week of engine operation, the use of a lighter bodied oil is desirable.

1. Fill crankcase with SAE 10W-30 oil to high level mark — regardless of outdoor temperature.
2. Start engine and run-in at following schedule:

### INDUSTRIAL

½ hour warm-up period at 800 RPM (no load). Check for leaks, oil pressure and water temperature.

- ½ hour at 1000 RPM — no load.
- ½ hour at 1200 RPM — ¼ load.
- ½ hour at 1500 RPM — ¼ load.
- ½ hour at 1800 RPM — ½ load.

During the first 10 hours, do not operate at more than ¾ load and then for only short periods. And for the next 10 hours it may be operated under full load intermittently only, for periods of not more than 10 minutes at a time.

### TRANSPORTATION

#### First 500 miles operation

1. When pulling — use a gear lower than normal — Don't lug.
2. Keep under governed speed in all gears.
3. Accelerate gradually.
3. At end of first day's operation — while warm:
  - (1) Torque down cylinder head studs to specifications.
  - (2) Adjust intake and exhaust valve to specified clearances.
  - (3) Check cooling system hoses and fan belt tension and make needed adjustments from initial settings.
4. After 25 hours or 1000 miles operation
  - (1) Change crankcase oil in accordance with recommendations.

### DO NOT FLUSH CRANKCASE WITH KEROSENE

Some operators unwisely put kerosene in the crankcase after draining the engine oil, then turn the engine over with the starter — in the belief they are doing a better job of crankcase cleaning.

In doing this, kerosene is circulated through the oil pump, the main oil header and the branches leading into the engine bearings — thereby washing away the protective oil film. In addition, some

of the kerosene will be trapped and remain to thin out the new oil, reducing its lubricating qualities.

Do not put kerosene into the crankcase. The best method is to drain the oil when the engine is thoroughly heated — which will carry off most of the sediment.

## AIR CLEANERS

All engines, when operating, consume several thousand cubic feet of air per hour. Since dusty air is full of abrasive matter, the engine will soon wear excessively if the air cleaner does not remove the dust before entering the cylinders.

Two basic types of air cleaners are normally used — the oil bath type and the dry replaceable element type.

**OIL-BATH TYPE** — Regular service habits are an absolute must to help the oil-bath cleaner do its vital job.

Servicing the oil cup regularly is very important — however, the prefilter, main filter element, inlet pipe and outlet connections must be regularly serviced to keep the air cleaner efficient.

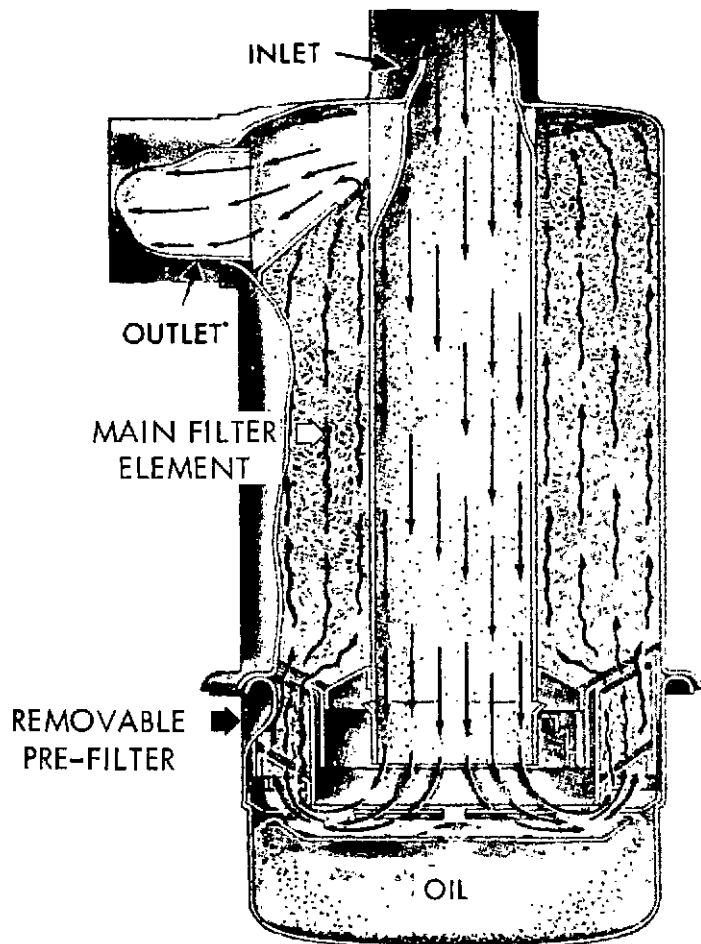


Figure 21 — Sectional View of Oil Bath Cleaner

*A planned air cleaner servicing program will increase the effective life of your engine.*

Operating conditions determine the air cleaner service periods. In extremely dusty operations, this may be once or twice daily. In dust protected areas, the air cleaner should be serviced when changing oil.

As the dirt is strained from the air flowing through the cleaner, it thickens the oil in the cup and raises the level. If the level is too high, agitation of the oil on the screen is affected and gritty oil is carried over into the air stream, through the carburetor and into the engine cylinders. This would actually introduce a grinding compound with resulting very rapid wear.

Servicing oil-bath air cleaners includes:

1. **Remove oil cup** — Pour out old oil and wipe out cup clean. Refill with fresh oil up to oil level bead — but no higher. Use oil no heavier than used in engine.
2. **Remove prefilter every service period** — wash out all chaff or dust in a solvent.
3. **Remove the entire air cleaner** — every 4-6 months — and immerse and back-flush the main filter element with a cleaning solvent.

**CAUTION:** Do not steam clean or use high pressure air to clean the filter elements as it opens a direct channel through the filter — which permits oil, as well as dirt, to pass directly through the oil-bath cleaner.

4. **Clean Center Tube** — When cleaning the main filter element, by ramming cloth through the tube.
5. **Reassemble Cleaner** — Check hose and hose clamp connections to carburetor inlet — so there are no leaks of unfiltered air.

**DRY-TYPE AIR FILTERS** — Are optional equipment on many engines and it is very important that the dirt build up in the cartridge does not reduce the air flow sufficient to cause a noticeable loss in power.

Dry-type filters normally are serviced as follows at every oil change (100 hours)—Extreme conditions will require daily cleaning.

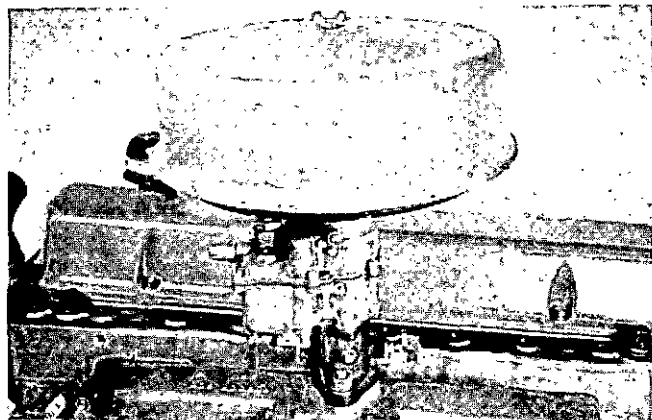


Figure 22 — Dry Replaceable Element Type Air Cleaner

1. **Remove Wing Bolt** — And remove cover and cartridge — don't let dirt fall into the exposed carburetor.
2. **Clean Cartridge** — By gently tapping flat on a smooth horizontal surface to shake out the dust — or flow compressed air from inside out — not closer than 2 inches and do not exceed 90# pressure.
3. **Wipe Inside Screen and cartridge gasket surface;** inside cover and mounting seat **Before installing element.**
4. **Place Cartridge on Mounting Seat** — Make sure outer edge of cartridge fits inside edge of bottom plate.
5. **Replace Cover** — And assemble wing bolt finger tight to insure air filter seal.

**CAUTION: DO NOT WASH OR OIL CARTRIDGE**

**Replace with New Cartridge:**

- (a) If bent, crushed or damaged.
- (b) Every 400 hours (10,000 miles).
- (c) When servicing does not result in full power recovery.
- (d) When intake manifold vacuum exceeds 10" water restriction.

**REMEMBER** — A 1/4 teaspoonful of dust admitted in the engine every hour — will completely ruin an engine in an 8-hour day.

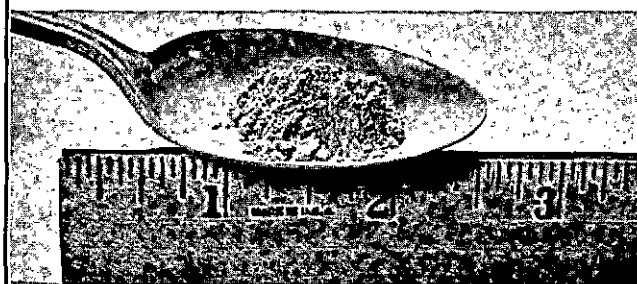


Figure 23

**THE AIR CLEANER ARRANGEMENT SHOULD NOT HAVE RESTRICTIONS GREATER THAN 10" WATER.**

If the engine speed increases noticeably when removing the air-cleaner — it needs cleaning or replacement of dry element badly.

## LUBRICATION RECOMMENDATIONS

Motor oils used for internal-combustion engine lubrication perform many useful functions including: dissipating heat; sealing piston rings; preventing metal to metal contact wear and reducing power loss through friction.

The lubricating oil recommendation is based upon engine design; type of service and the atmospheric temperature prevailing. High quality oils are required to assure maximum performance, long engine life and minimum cost of operation.

Overhead-valve gasoline engines operate in a wide range of service conditions and seasonal temperatures, so our recommendations are given for various types of service and ambient temperatures.

The American Petroleum Institute (API) has established new service classifications so that the engine operator can properly select the best type of oil.

They have the following three classifications of engine oils relating to the different operating conditions for gasoline or other spark-ignition engines:

**SERVICE ML** — (Former API Designation: Regular)

**Light or Easy Service Conditions** — Such as moderate operating speed at normal engine temperatures — especially where the engine is relatively insensitive to promote deposit formation and bearing corrosion.

**SERVICE MM** — (Former API Designation: Premium)

**Moderate Severe Service Conditions** — Involving higher speeds and operating temperatures; particularly when the higher temperatures tend to promote deposit formation and bearing corrosion.

**SERVICE MS** — (Former API Designation: Heavy-Duty Type)

**Severest Service Conditions** — include:

**Start-Stop Operation** — which leads to emulsion sludge and corrosive wear; involves essentially a low-temperature condition, and one which gets worse in colder weather.

**Severe High Temperature Operation** — Resulting from high loads or overloads or high operating speed which tends to result in carbon, lacquer and sludge deposits.

### S.A.E. OIL BODY GRADES

The oil body grades recommended from the lightest (SAE 5W) to the heaviest (SAE 40) are:

5W	10W	20W	20	30	40
← 5W - 20 →					
	← 10W - 30 →				

**MULTI-GRADE OILS** — Such as SAE 5W-20 and SAE 10W-30 have the starting grade characteristics of the lighter oil and after it warms up it has the running characteristic of the heavier grade.

The following SAE grades are general recommendations for Continental Overhead-valve engines during changing seasonal atmospheric temperatures:

ENGINE SERIES	SEVERE WINTER Below 0°F	NORMAL WINTER 0°F to 32°F	SPRING-FALL 32°F to 75°F	SUMMER Above 75°F
Z	SAE 5W-20	20W	SAE 30	SAE 30
G	SAE 5W-20	20W	SAE 30	SAE 30
E	SAE 5W-20	20W	SAE 30	SAE 30
H	SAE 5W-20	20W	SAE 30	SAE 40
J	SAE 5W-20	20W	SAE 30	SAE 40

The Multi-Grade oil used should cover the single grade recommendation for the atmospheric temperature involved, e.g. SAE 10W-30 covers SAE-10W, SAE 20W, SAE 20 and SAE 30.

Use High Grade MS Oils such as Socony Mobile Oil Company Mobiloil or Delvac 1100-series. Favorable conditions may warrant oils listed under ML and MM service; however our above general recommendations are listed under SERVICE MS Oils such as:

Mobiloil AF (SAE 40)	Delvac 1140 (SAE 40)
Mobiloil A (SAE 30)	Delvac 1130 (SAE 30)
Mobiloil Arctic (SAE 20-20W)	Delvac 1120 (SAE 20W)
Mobiloil 10W (SAE 10W)	Delvac 1110 (SAE 10W)
Mobiloil 5W (SAE 5W-20)	Delvac Special (SAE 10W-30)
Mobiloil Special (SAE 10W-30)	

**Generators - Starters - Distributors** — Add 3-5 drops of engine oil to the generator and starter oil cups every 50 hours and to the distributor every 250 hours.

**AIR COMPRESSORS (ENGINE MOUNTED)** normally are engine lubricated — however, if lubricated separately from the engine, use the same type and grade as used in the engine.

**Clutches** — Use a high temperature bearing grease such as Mobilgrease No. 5 or Mobilgrease MP. Do not over-lubricate.

**Conventional Transmissions** — For the greatest efficiency over the life of the transmission, use a high quality straight mineral oil such as the "Mobilube C" line. The oil should be changed seasonally.

Use the following proper grades:

	SUMMER	WINTER
Clark	SAE 90	SAE 90
Fuller	SAE 140	SAE 90
Twin Disc	SAE 40	SAE 40
Warner	SAE 140	SAE 90

**Torque Converters and Hydraulic or Automatic Transmissions** — These units employ a fluid medium to transmit power which must be very stable

to resist formation of harmful deposits or change in body in use. The correct fluid must be selected to obtain maximum efficiency of the transmission. All fluids should be changed seasonally.

Type "A" Automatic Transmission fluid is most widely used. There are many widely distributed brands of this type, such as Socony Mobil Oil Company's Mobilfluid 200.

For some models of Twin Disc Clutch Company's torque converters, a Special Fluid having a viscosity of 35 Saybolt seconds @ 100° F. is required — other models use SAE 10W engine oil. The Special low viscosity fluid may be obtained from Twin Disc Clutch Company Dealers. To satisfy the SAE 10W requirement, we recommend the use of MS type oils, such as, Socony Mobil Oil Company's Delvac 1110 or Mobiloil 10W.

Allison Division torque converters and Torqmatic transmissions require a type C-1 fluid, which is on their approved list, such as, Delvac 1110.

### TRANSMISSION AND CONVERTER LUBRICATION RECOMMENDATIONS

The following grades are generally recommended for hydraulic torque converters and transmissions for Summer and Winter operation:

MANUFACTURER	SUMMER	WINTER
<b>Continental Motors Corp.</b> Co-Matic Drive Fluid Coupling HC15	Type A Type A	Type A Type A
<b>Clark Equipment Co.</b> Torcon (converter only) Torcon Converter and Transmission	SAE 10W Type A	Type A (below 10° F.) Type A
<b>Fuller Mfg. Co.</b> Torque Converter	SAE 10W	Type A (below 0° F.)
<b>Borg-Warner</b> Borg & Beck & Long Mfg. Co. All converters and hydraulic transmissions	Type A	Type A
<b>Allison Division</b> Torque Converters and Torqmatic Transmissions	Type C-1	Type C-1
<b>Twin Disc Clutch Co.</b> Hydraulic Reverse Gears Coupling or Power Take-off	SAE 10W	SAE 10W
Hydraulic Converter Transmissions Input Shaft & impeller bearings (C, FC)	Same as Engine	
Fluid Medium except Two speed transmission and converter transmission combinations (Models T-DRR-FT-IT)	Special Twin-Disc Fluid	
Reverse Transmissions Models RR-CRR-ICRR	Type A SAE 40	Type A SAE 20

**NOTE:** For all Grease applications on the above units a good high temperature grease, such as, Socony Mobil Oil Company's Mobilgrease No. 5 or MP should be used.

## SECTION III OPERATION

### OPERATING INSTRUCTIONS

The person operating the engine naturally assumes responsibility for its care while it is being operated. This is a very important responsibility since the care and attention given the engine goes a long way in determining how long a period it will operate satisfactorily before having to be shut down for repairs.

The operating and preventive maintenance instructions for the Overhead Valve type engines are simple and should be followed without deviation.

The entire aim in setting forth these instructions is to give you the benefit of the knowledge and experience gained over a long period of collaboration between Engineering Research and Field Service.

#### PREPARATION OF NEW ENGINE FOR OPERATION

Before placing a new engine in operation, it must be thoroughly inspected for external damage and particular attention paid to the following items:

1. **Inspect Engine Hold Down Bolts** — To make certain that they are firmly set.

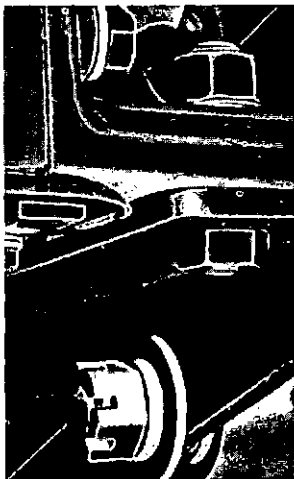


Figure 24 — Engine Mounting Bolts

2. **Open Fuel Tank Shut Off Valve** — By turning handle counter-clockwise as far as it will go.

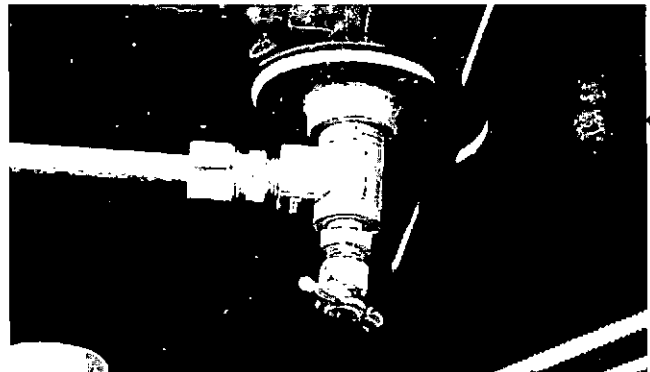


Figure 25 — Fuel Shut-off Valve

3. **Close water drain cock** — in lower radiator connection, also on the side of the block. (In some cases, this may be a pipe plug.)

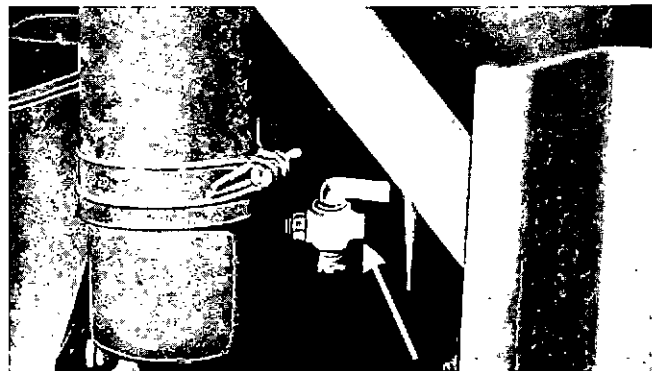


Figure 26 — Water Drain Cock

4. **Examine Oil Drain Plug** — to make certain that it is tightly closed.

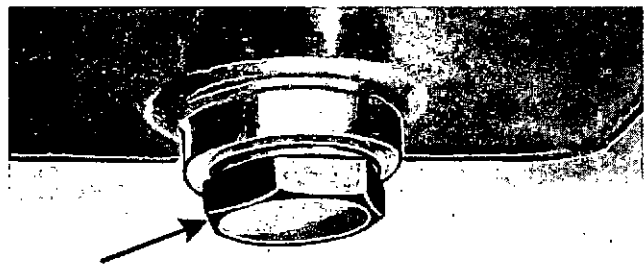


Figure 27 — Oil Drain Plug

5. Fill Crankcase with SAE 10W-30 Oil — for the first week or 50 hours operation — then follow lubrication recommendations in Section II.

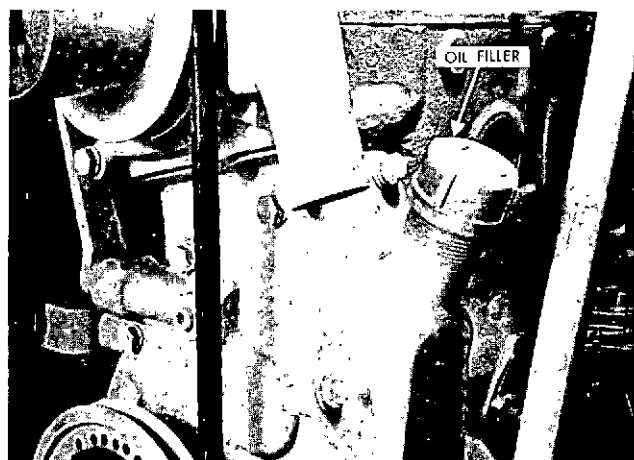


Figure 28

6. Fill Radiator with Clean Water — during freezing weather, use a sufficient amount of anti-freeze to protect the system for the lowest anticipated temperature — refer to Section V.

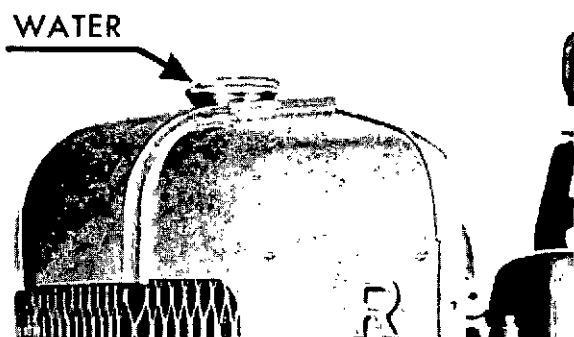


Figure 29

7. FILL GASOLINE TANK FULL — All new engines are shipped with a treated tank which should be completely diluted with a full tank of gasoline to eliminate any tendency to clog.

Be sure that the container used for filling is clean and free from dirt. Replace cap securely.

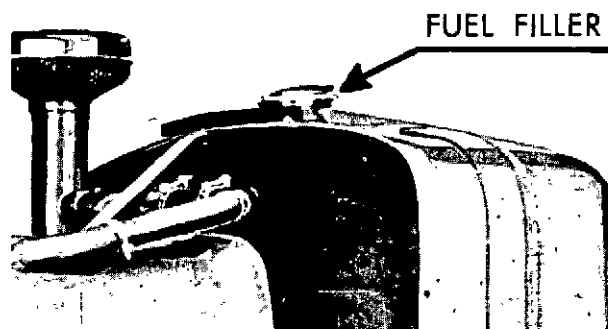


Figure 30

8. Engine Accessories — see that all points requiring lubrication are properly supplied.

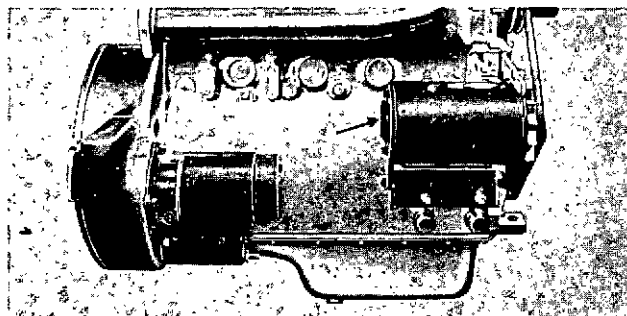


Figure 31

9. Electrical Connections — check storage battery terminals and all electrical connections. Check each spark plug wire for tightness.

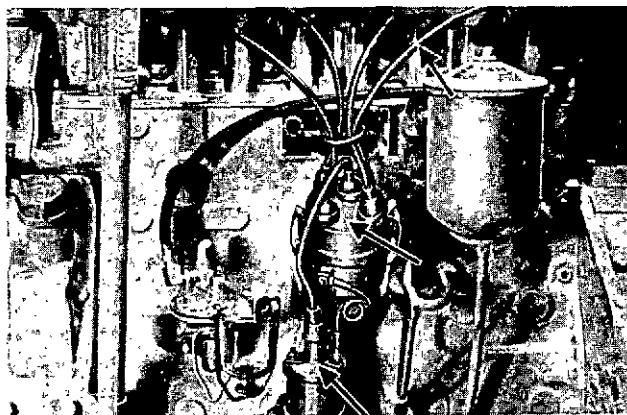


Figure 32

10. RADIATOR COOLANT CAPSULE — The radiator coolant capsule, which comes with the engine, should not be removed: this is a water conditioner and anti rust inhibitor to protect the cooling system.

### STARTING THE ENGINE

Normally check daily preventive maintenance schedule before starting. — (See Section IV).

1. Safety Control Switch — (If supplied) Turn Manual control knob with arrow pointing toward "on" position. When oil pressure builds up to normal, control knob will automatically release and arrow will point to "run" position.

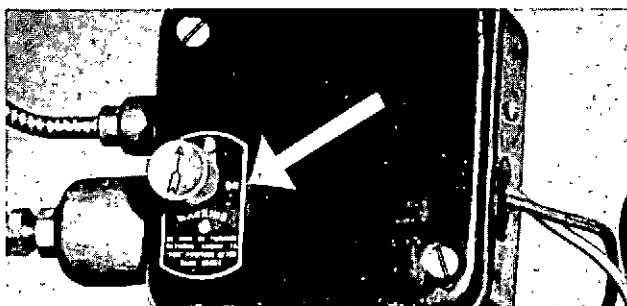


Figure 33 — Safety Switch

2. Disengage Power Take-Off — (if equipped)  
Starting engine under load throws overload on starter and battery.

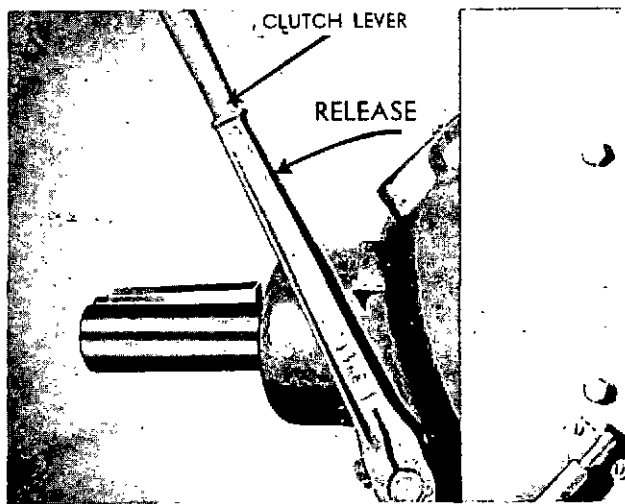


Figure 34 — Power Take-off

3. Open throttle Control about 1/3 open
4. Turn on Ignition Switch
5. Pull Out Choke (if manually operated)  
But avoid flooding the engine. Operate the engine without choking as soon after starting as possible.
6. Push Starter Button In  
Keep on until engine starts; but not longer than 15 seconds at a time.

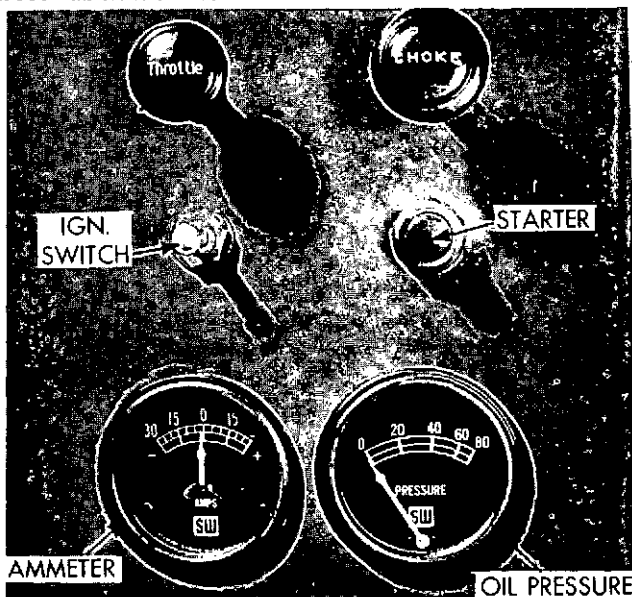


Figure 35 — Instrument Panel

7. Warm-up Before Applying Load  
Idle the engine about 700 R.P.M. for a few minutes to circulate and warm oil — then increase the speed to approximately half throttle until the engine water reaches 100° F. This procedure will prolong the engine life.

8. Check Oil Pressure

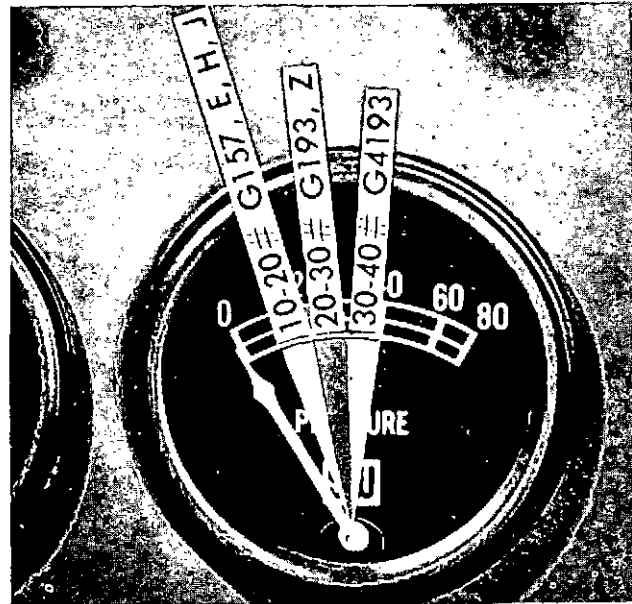


Figure 36 — Oil Pressure Gauge

(Other pressures available for special Applications)

9. Check Water Temperature

Water temperatures should be maintained at 180°-200°F.

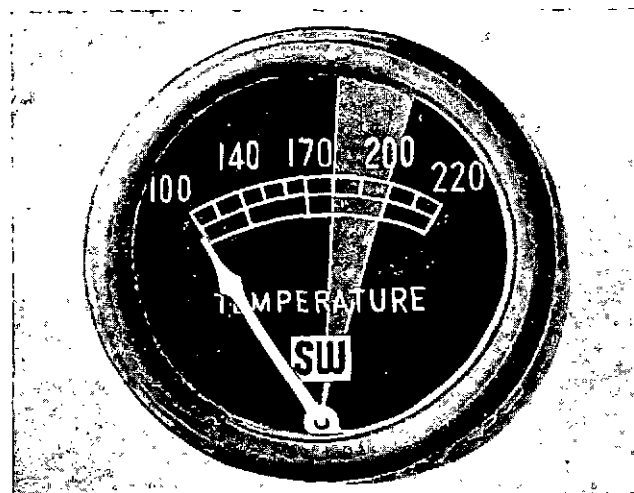


Figure 37 — Water Temperature Gauge

**CAUTION:**

After starting new engine — run it at idle for 5 minutes, then stop engine and recheck oil level in crankcase — then bring oil level to high mark on dipstick.

## STOPPING THE ENGINE

### IF INDUSTRIAL UNITS — FIRST DISENGAGE POWER TAKE-OFF

1. **Reduce engine Speed to Idle** — If hot, run engine at idle (400-600) for several minutes to cool.

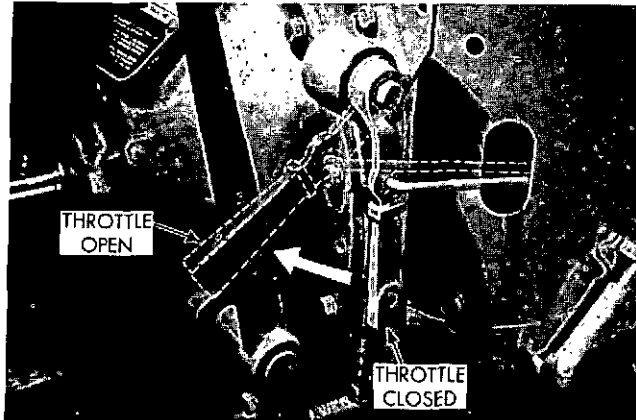


Figure 38 — Hand Throttle Control

2. **Turn Off Ignition Switch** — if engine continues to run due to high combustion chamber temperatures, either continue idling to further cool or shut off fuel supply.

#### CAUTION:

**NEVER PULL OUT CHOKE WHEN STOPPING ENGINE — BECAUSE RAW GASOLINE WILL WASH LUBRICANT FROM CYLINDER WALLS.**

## 10 OPERATING PRECAUTIONS

1. **Oil Pressure** — should be up to recommended pressure at operating speed and over 7 pounds at idle (400-600 R.P.M.)

2. **Ammeter** — should register "Charging" at all times engine is running. (A voltage regulator, if used, may limit it to a very low reading).

3. **Water temperature** — should be maintained 180°-200° F. — continued overheating may cause internal damage. "Frequent Readings of Gauge should become a Habit".

4. **Muffler Restriction** — should not exceed 20" water or 1½" Mercury. Inspect mufflers periodically for restrictions to prevent burned valves.

5. **Clean and Service Air Cleaner** — as recommended to maintain its efficiency. The rapidity that dirt collects in the oil cup indicates how often the air cleaner should be serviced.

6. **When engine is Over-Heated** — do not add water — allow engine to cool so as to prevent cracking the cylinder head.

7. **Engine Load Indication** — a manifold vacuum of 6 inches of Mercury indicates

the recommended maximum continuous full load operation and a vacuum of 18-20 inches of Mercury indicates normal idling vacuum. Between full load and idling, vacuum gauge readings may be used to approximate the percent of load. Any reading below 6" HG indicates engine is overloaded for continuous duty.

8. **Avoid Cold-Sludge Condensation** — by protecting unit to maintain crank case temperature over 135° F.

9. **Breaking in a new or rebuilt engine** — for peak performance and economical operation, the following adjustments should be made at end of first day's operation:

- 1) Torque down cylinder head studs to specifications.
- 2) Adjust valve tappets to specified clearances.
- 3) Adjust idle mixture and idle speed to 400-600 R.P.M.

10. **Follow Preventive Maintenance Schedules Recommended** — This will avoid troubles which might cause expensive breakdowns and maintain your engine for dependable and economical operation.

### COLD WEATHER OPERATION

The oil used during cold weather should have a cold test below the lowest anticipated temperatures that will be encountered during its use. The new multigrade lubricating oils 5W-20 and 10W-30 are ideal for cold starting with its reduced initial drag until warmed up, when it assumes the characteristics of the heavier oil.

Sludge formation at low temperatures is a close second to dirt in causing engine damage and wear. This is formed by the piston combustion gases mixing with the fine oil mist in the crankcase and condensing on a cold surface. This condensation forms both a sulphuric and sulphurous acid which combines with the oil to become a highly injurious sludge. This dew point is about 135° F. — when crankcase temperatures are higher, the contaminated gases remain in gaseous form and the engine operates clean as long as breather system is kept clean — however temperatures below this will result in injurious sludge formation. It is vitally important therefore to maintain oil and crankcase temperatures above 135° F., as shown on the following chart:

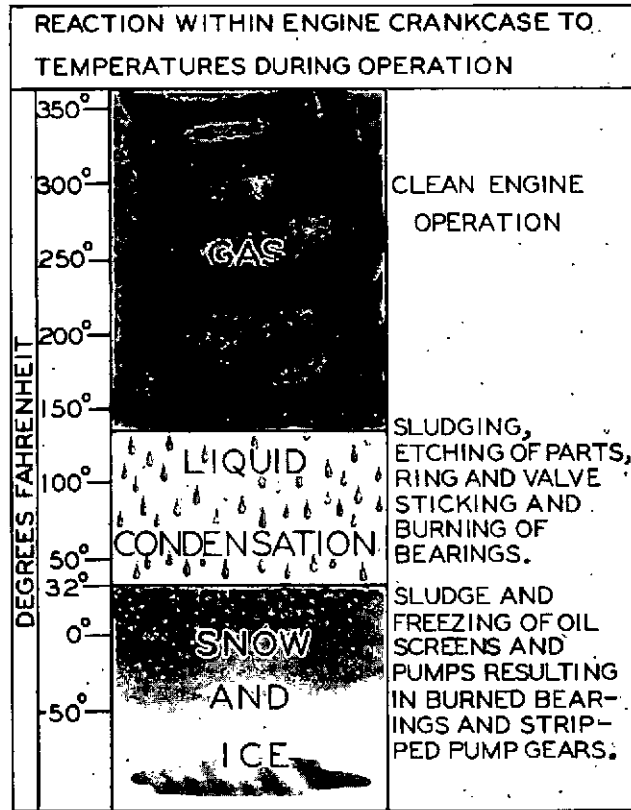


Figure 39

When sludging conditions prevail, the oil should be examined daily and changed as it may freeze, or clog the inlet strainer and cause bearing failures.

**High Altitude Operation** — High Altitude operation reduces the power output approximately 3 1/2% for every 1000 feet of altitude above sea level.

**High Temperature Operation**—for every 10° above 60° F. carburetor air temperature — a power loss of 1% results.

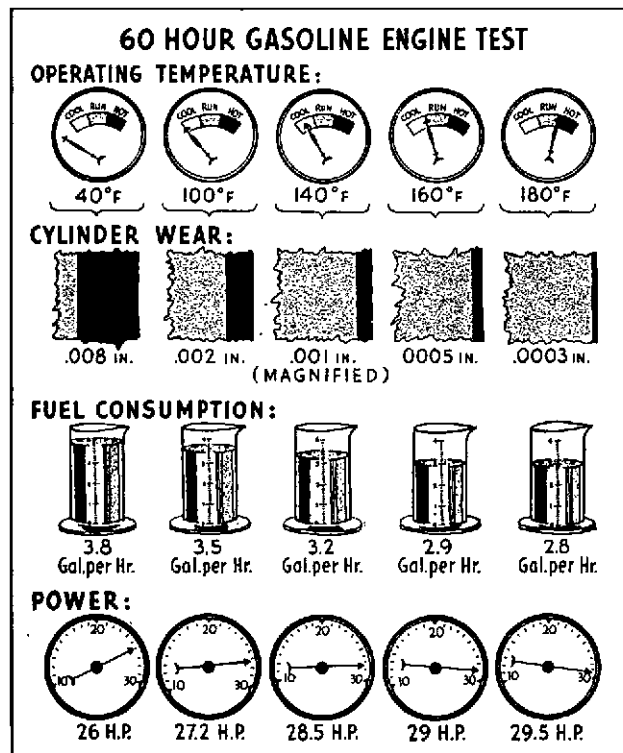


Fig. 40 — The Effects of Operating Temperature on Engine Wear, Fuel Consumption and Power

## **PREPARATION OF ENGINE FOR SEASONAL STORAGE**

### **CAUTION**

Before starting the processing, engine must be cooled down to the surrounding temperature, since oil will adhere much better to cold metal surfaces.

1. **Drain Oil from Oil Pan** — and replace drain plug.
2. **Refill Oil Pan** — with high grade SAE 50 engine oil to  $\frac{1}{2}$  its normal capacity.
3. **Start up Engine** — and run at above 600 R.P.M. for 2 minutes to complete oil distribution on all surfaces — **Do Not Run Longer Than 2 Minutes.**
4. **Stop Engine**—Remove all Spark Plugs.
5. **Pour 3 Ounces of SAE 50 Engine Oil** — into each Spark Plug Hole.
6. **With Ignition Cut Off** — Crank engine with Starter — for at least a dozen revolutions to distribute this oil over the cylinder walls and valve mechanism.
7. **Drain Oil from Pan and Reassemble Plug.**
8. **Drain Cooling System and Close Drain Cocks.**
9. **Drain All Gasoline** — from tank, lines and carburetor bowl.
10. **Replace All Spark Plugs.**
11. **Seal Air Cleaner Inlet** — exhaust outlet — **Crankcase Breather Tube** — with weather proof masking tape.
12. **Check Oil Filler Cap** — **Gas Tank Cap** and **Radiator Cap** to make certain they are securely in place.

### **SHORT TERM STORAGE**

(Instructions below should be adhered to every 90 days on outside storage and every 6 months on inside storage.)

If the shut down period is to be over 30 days duration, the following instructions should be adhered to:

1. Stop engine, remove spark plugs.
2. Pour 3 ounces clean engine oil in each spark plug hole.
3. With ignition cut off, crank engine with starter at least a dozen revolutions to dis-

tribute this oil over the cylinder walls and valve mechanism.

4. Replace all spark plugs.
5. Remove drain plug from carburetor bowl, and drain gasoline.
6. Replace drain plugs.

**CAUTION:** Gasoline evaporates if left in carburetor for long periods. This evaporation of gasoline will leave a gum and varnish coating over jets and moving parts; when engine is started up again, you may have flooding or poor operation from carburetor.

## SECTION IV PREVENTIVE MAINTENANCE

In order to obtain maximum efficiency from your gasoline engine, a definite maintenance program should be set-up and followed. Haphazard maintenance will only lead to faulty engine performance and shorten engine life.

All moving parts in the engine are subject to wear; however, wear can be retarded by careful operation and a planned maintenance program.

In general, gasoline engine operation demands careful attention to the cleanliness of air, fuel and oil and maintaining operating temperatures of 180°-200° F.

The following pages, covering daily, 50-250 and 500 hour maintenance, have been worked out with our field service division as "Minimum Requirements" to keep your engine in dependable operating condition.

### DAILY

#### PREVENTIVE MAINTENANCE SCHEDULE

##### 1. OVERALL VISUAL INSPECTION OF ENGINE

Look for evidence of fluid leaks on floor, cylinder head and block, indicating loose fuel, oil or water connections — **tighten if found.**

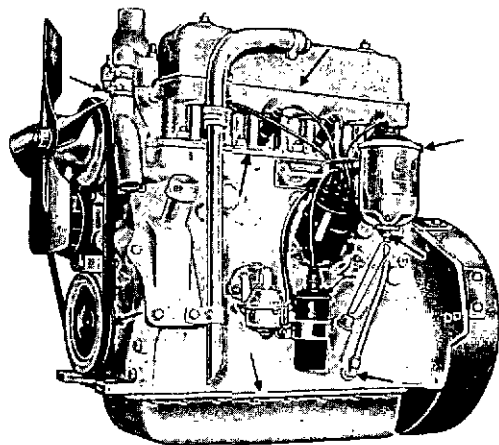


Figure 41 — Check for Possible Leakage

##### 2. CHECK OIL LEVEL OF ENGINE

The dipstick indicates the high and low oil level in the crankcase—make allowance for additional oil drainage back into oil pan if engine has not been stopped 15 minutes. The most efficient oil level is between the two dipstick levels.

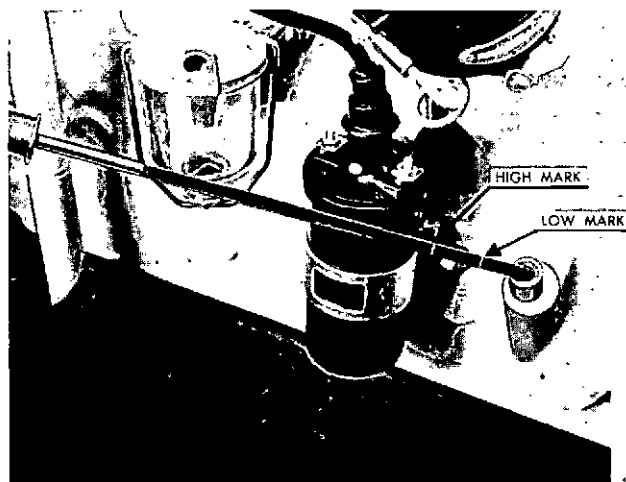


Figure 42 — Check Oil Level of Engine

*Do not add oil until oil level approaches the low mark — then add only enough to bring it to high level — NEVER above.*

*Do not operate the engine with oil below low level mark.*

**3. CHECK RADIATOR**

Fill radiator with clean water or anti-freeze to normal level maintained due to expansion when heated. Visually inspect fan and belt for condition and adjustment.

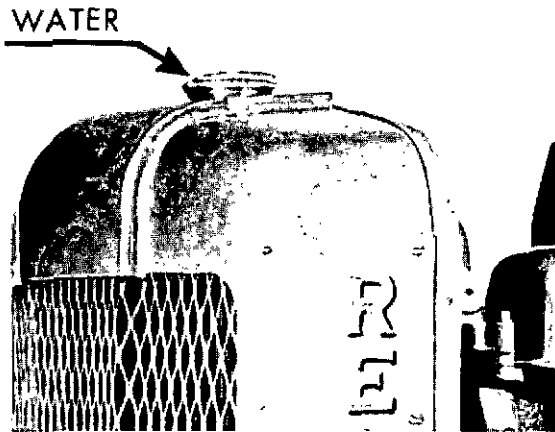


Figure 43

**4. FILL FUEL TANK**

Should be done at end of day's operation to prevent condensation forming in tank. Clean filler cap and area around spout before filling to prevent entrance of dust into fuel system.

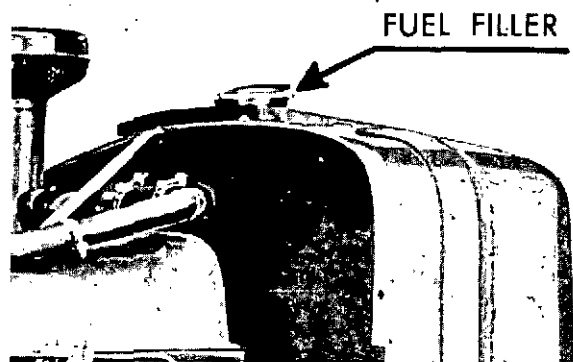


Figure 44

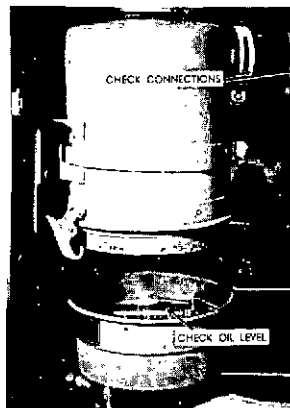
**5. CHECK AIR CLEANER**

Remove air cleaner oil cup and note amount of sediment—if required, clean and refill with engine oil to level. Visually inspect air cleaner connections to manifold.

Extremely dusty conditions may require servicing the air cleaner daily or even twice daily.

Some oil bath cleaners have a removable screen unit above the oil cup which can be removed for cleaning—others with built-in screens require removal of entire cleaner, after the oil cup is removed, to wash in a good cleaning solvent.

(See detailed instructions in lubrication section II)



Oil Bath Air Cleaner



Dry Type

Figure 45 — Air Cleaner

**Dry replaceable element type service**

Remove filter element and apply a reverse flow of low pressure air on the inside to blow off the accumulated dirt on the outside. This can only be repeated a few times as the element will finally clog and restrict the air flow causing a loss of power.

*Caution:* Never wash a dry element in a liquid tank

**6. CHECK OIL PRESSURE\***

Note oil pressure gauge which should indicate the following pressure range at full throttle and a minimum of 7 pounds pressure at idling speed (400-600 R.P.M.):

- 10-20 lbs. pressure — G157-E-H-J Series
- 20-30 lbs. pressure — G193-Z Series
- 30-40 lbs. pressure — G4193

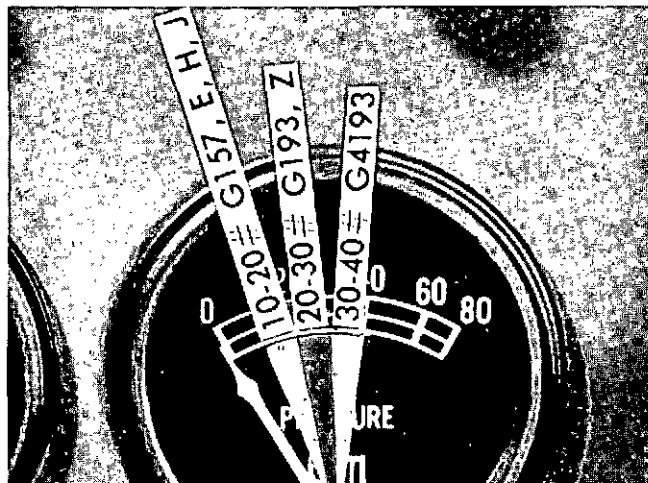


Figure 46 — Operating Oil Pressures

\*Standard Engines: on some special customer specifications, this may change.

**7. NOTE ANY UNUSUAL NOISE**

Operators familiar with daily engine operation soon become alert to any noise not normally present. This is very valuable in correcting defects in the early stages and preventing expensive repairs or delays.

**EVERY 50 HOURS**

**1. REPEAT DAILY OPERATIONS OUTLINED**

Follow previous instructions.

**2. CHANGE CRANKCASE OIL**

Engine life is dependent upon clean oil being circulated to all moving parts; therefore, the frequency of oil changes and oil filter replacement is very important and should be made at regular, scheduled periods.



Figure 47

The crankcase oil should be changed after 50 hours or 2000 miles service and when the oil is at operating temperatures so that complete drainage will result.

Replace the oil filter element every 100 hours or 4000 miles unless extremely unfavorable operating conditions indicate that filter replacements should be made at every oil change period.

Thoroughly clean the filter, cover and sealing surfaces before replacing new element and gasket.

**3. SERVICE AIR CLEANER**

If oil-bath air cleaner is used, remove bottom half of air cleaner — clean thoroughly and fill with engine oil to oil level mark on cup, avoid overfilling. Replace cup and check all connections to manifold. Be sure that no unfiltered air can enter the engine intake manifold.

If a dry type air cleaner is used, clean element with compressed air — *Never wash in a liquid.*

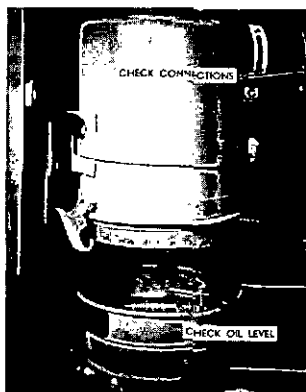


Figure 48 — Air Cleaner

**4. CHECK FAN BELT TENSION**

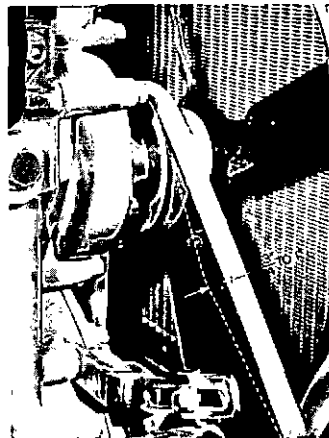


Figure 49 — Fan Belt Tension

Inspect wear condition of fan belt; note alignment and check belt tension which should allow  $\frac{3}{4}$ " to 1" deflection on long span.

**5. CHECK BATTERY**

Check specific gravity of each cell — which should be at least 1.250. Add distilled water, if required, to raise level  $\frac{3}{8}$ " above the separators.

Particular attention should be given battery during cold weather. The cranking power of a fully charged battery @ 80° F. is reduced 60% @ 0° F. — yet the power required to crank the engine is  $2\frac{1}{2}$  times greater @ 0° F. than @ 80° F.

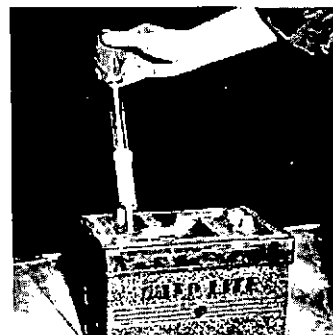


Figure 50 — Checking Battery

**6. LUBRICATE GENERATOR AND STARTER**

Apply 3-5 drops of engine oil to each cup on the generator and if required on the starter (Many starters have sealed bearings).



Figure 51 — Generator Lubrication

**8 TO 10 DROPS OF ENGINE OIL**

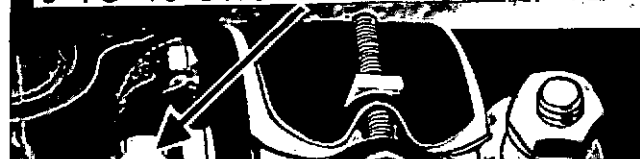


Figure 52 — Starter Lubrication Point

**7. LUBRICATE POWER TAKE OFF**

Using grease gun, lubricate the clutch throw-out bearing and output shaft bearing with approved ball bearing grease.

Operations requiring frequent de-clutching should be lubricated daily.

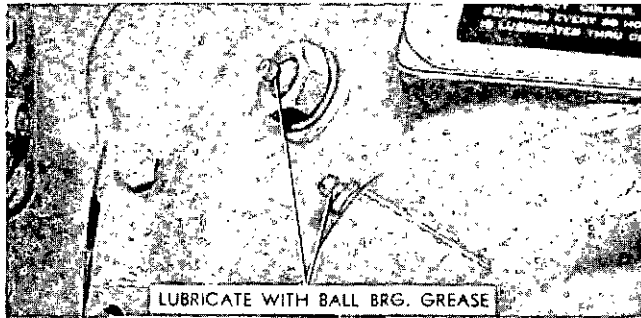


Figure 53

**EVERY 250 HOURS**

**1. REPEAT DAILY AND 50-HOUR SCHEDULES**

Follow previous instructions.

**2. CLEAN EXTERIOR OF ENGINE**

Use steam if available, otherwise any good commercial engine cleaner to wash down the engine.

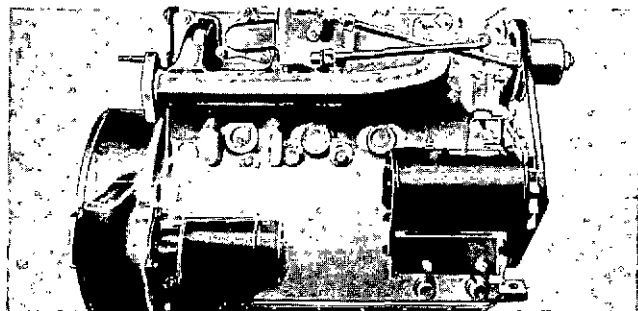


Figure 54

**3. CHECK GOVERNOR CONTROL**

Clean and lubricate all governor linkage to insure free operation of governor. Free-up any joints that may be binding or rods or levers that may be twisted. Check for full throttle opening.

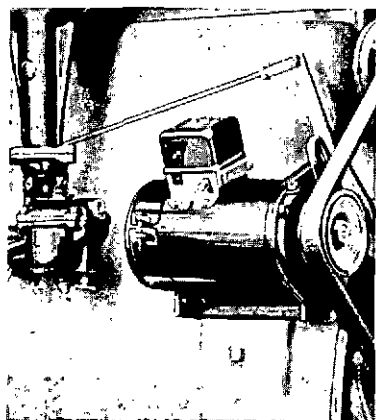


Figure 55

**4. CLEAN SPARK PLUGS**

Clean depression around plugs before removing them — then clean and re-set point to .025 on standard plugs and .035 on resistor plugs.

Install spark plugs and tighten to 34 pounds torque.



Figure 56

**5. CHECK DISTRIBUTOR**

Clean distributor cap inside and outside with solvent without removing wires and blow off with compressed air — inspect cap and rotor for cracks.

Examine contact surfaces of points — replace if burned or pitted and adjust to .020 gap.

Lubricate distributor cam sparingly with a lubricant such as Mobilgrease Special (with Moly).

Check distributor clamp bolts and if found loose — retiming the engine is necessary.

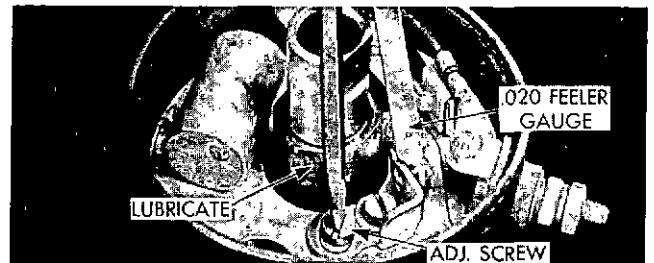


Figure 57

**6. INSPECT IGNITION WIRES AND CONNECTIONS**

Examine ignition wires for breaks in insulation, chafing and loose connections. Replace if defective.

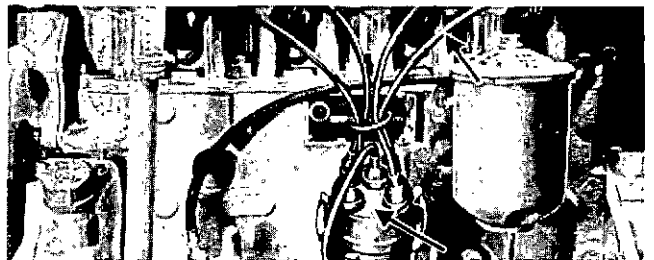


Figure 58

**7. IF DRY REPLACEABLE ELEMENT AIR CLEANER IS USED, REPLACE ELEMENT.**

**EVERY 500 HOURS**

**1. REPEAT DAILY — 50 HOUR AND 250 HOUR SCHEDULES**

**2. COOLING SYSTEM**

Clean radiator core by blowing out with compressed air.

Inspect radiator mounting.

Inspect water pump and connections for leaks.

Check fan and accessory drive belts.

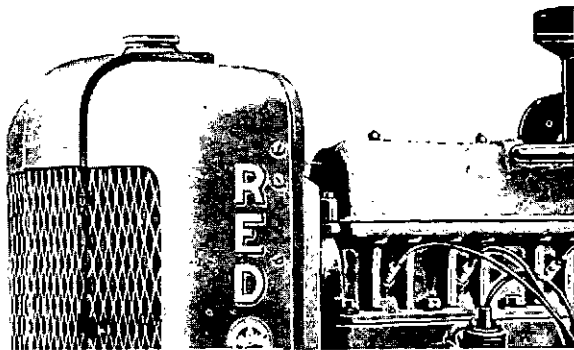


Figure 59

**3. ADJUST VALVE TAPPET CLEARANCE**

Check and adjust intake and exhaust valve tappets to following clearances at idling speed and running temperature:

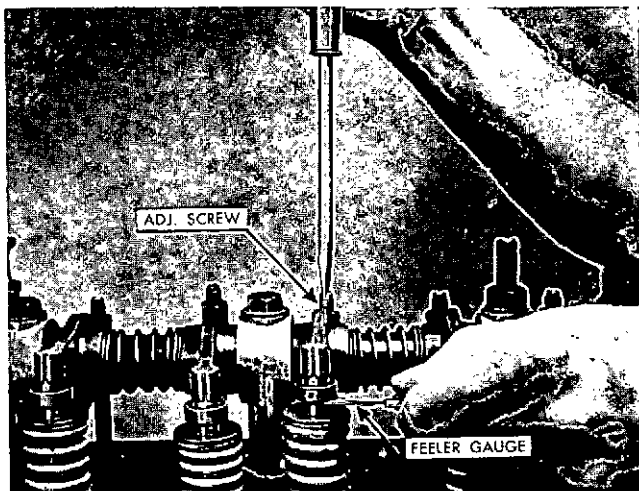


Figure 60 — Adjusting Valve Tappet Clearance

ENGINE	INTAKE	EXHAUST
Z Series	.010	.012
G Series	.014	.014
E Series (201-208)	.014	.014
E Series (223-242)	.016	.018
H Series	.014	.014
J Series	.014	.014

**4. CARBURETOR**

Clean exterior and check mounting to manifold.

Adjust carburetor air adjustment for even running and adjust idle speed to 400-600 R.P.M. minimum.

Inspect throttle and choke linkage for free operation.

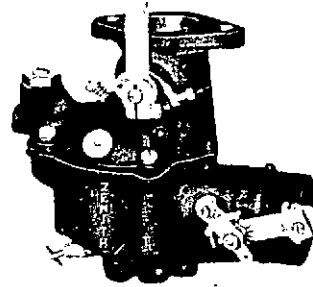


Figure 61 — Carburetor

**5. FUEL PUMP**

Clean Filter bowl and screen.

Inspect mounting and gasket.

Check all connections for leaks.

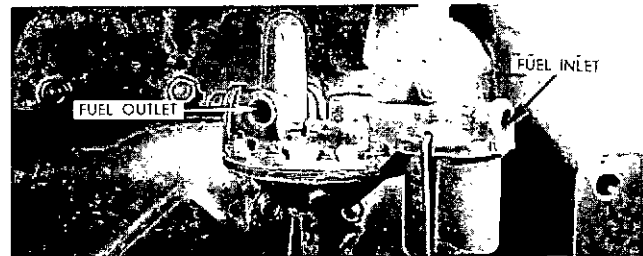


Figure 62 — Fuel Pump Mounting

**6. MAGNETO (when equipped)**

Spark test with engine operating by checking firing with each high tension cable held about 1/16" away from spark plug terminal.

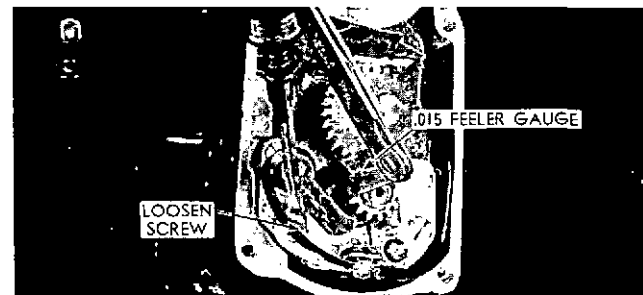


Figure 63

Remove end cap and examine carbon brushes for free-movement and inspect breaker points for wear and gap. Gap should be .015-.018.

**7. SAFETY AND THERMAL CONTROLS**

Inspect control wires and connections.

Examine armored capillary tubing on water temperature element for visual damage that may cause faulty operation.

## SECTION V COOLING SYSTEM

The function of the cooling system is to prevent the temperatures in the combustion chamber, which may reach as high as 3500°F, from damaging the engine and at the same time keep the operating temperatures within safe limits.

Maintaining the cooling system efficiency is important, as engine temperatures must be brought up to and maintained within satisfactory range for efficient operation, in order to prevent damage to valves, pistons and bearings.

Continental Four Cylinder Overhead Valve Gasoline Engines operate most efficiently with water temperatures of 180°-200° F. and a thermostat and by-pass system is used to control these temperatures.

The thermostat valve remains closed and only allows the water to recirculate within the engine itself until normal operating temperatures are reached. This provides for both rapid and even temperature increase of all engine parts during the warm up period. When desired temperature is reached, the thermostat valve opens and allows the water to circulate through both the engine and radiator or heat exchanger.

The cooling water is circulated by a water pump located at the front of the engine block. The coolest water enters the pump from the lower or suction opening, then is directed through integral distribution passages cast in the cylinder head, to the areas in and around the valve seats

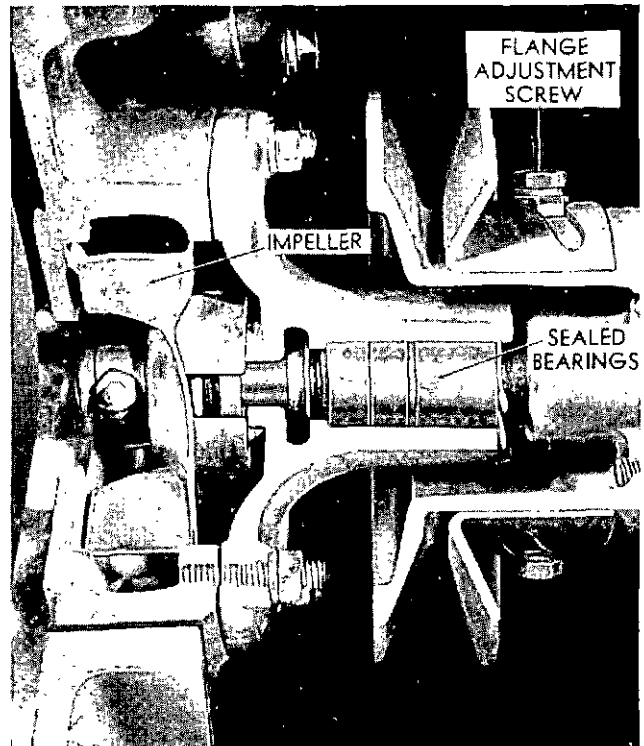


Figure 65 — Water Pump

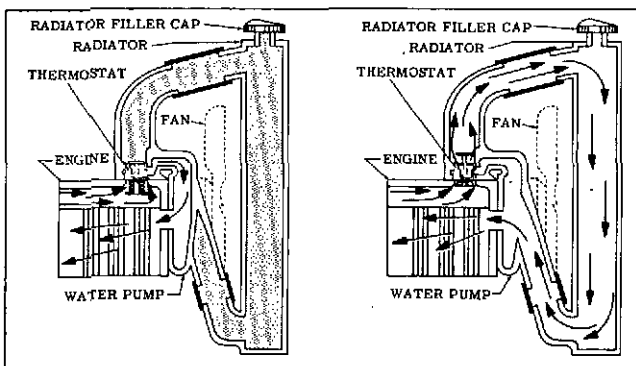


Figure 64 — Thermostat Flow Control  
Thermostat Closed, Water Re-Circulating through Engine ONLY  
Thermostat Open, Water Circulating through BOTH Engine and Radiator

and combustion chamber. This method provides that the coldest water reaches the parts in the engine subjected to the highest temperatures.

The cylinder walls, in turn, are cooled their full length by convection currents only, which keeps the cylinder barrels at a uniform temperature and thereby reduces oil dilution and sludge formation.

Upon leaving the cylinder head, the water enters the thermostat housing in which is mounted the by-pass type thermostat which controls the opening to the radiator or heat exchanger. Upon being discharged from the thermostat housing, the water enters the radiator or heat exchanger,

### I M P O R T A N T

Present thermostats begin to open at 180° F. and are fully open at 202° F. Operation of engines in this temperature range is not harmful. However, temperature gauges are not always exactly accurate and may sometimes indicate higher than actual temperature. This can lead operators to believe engines are overheating when they are actually operating normally.

**Overheating is always accompanied by loss of coolant water. In case of doubt, this should be checked.**

depending upon the application, where it is cooled before re-entry into the engine.

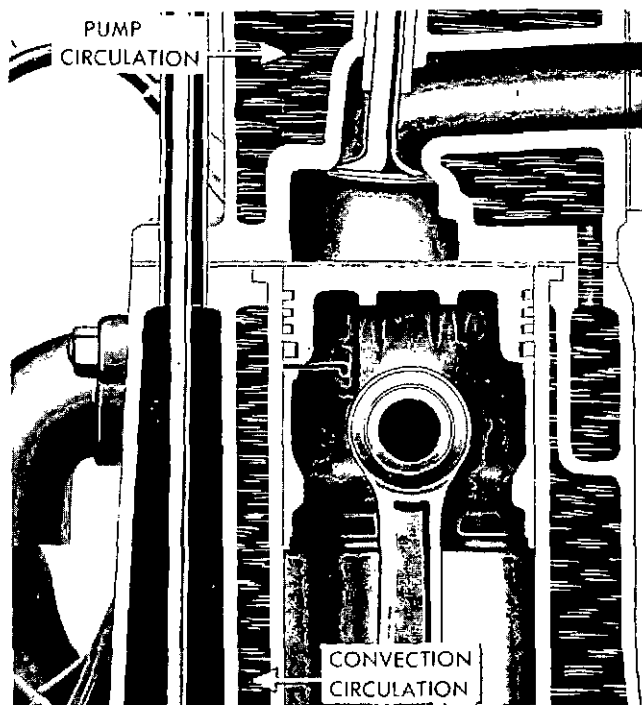


Figure 66 — Cooling by Convection and Pump Circulation

### EXPANSION OF WATER

Water has always been the most commonly used coolant for internal combustion engines because it has excellent heat transfer ability and is readily obtained everywhere. Like all liquids it expands when heated, the rate of expansion being  $\frac{1}{4}$  pint per gallon when the temperature is raised from 40° to 180° F.

For example: If a 4 gallon cooling system is filled completely full of water at 40° F, 1 pint will be lost through the radiator overflow pipe by the time the water temperature reaches 180° F.

### WATER FILTERS

In some areas, the chemical content of the water is such, that even the best of rust inhibitors will not protect the cooling system from the formation of rust and scale.

There are instances where this corrosive element has eaten holes through cast iron parts such as water pump impellers and bodies. This condition is caused by electrolysis taking place in the parts involved.

Where these conditions exist, water filters, such as those made by the Perry Co. and the Fram Corp., should be incorporated in the assembly to remove these troublesome elements and offset the electrolytic action.

### EFFECT OF ALTITUDE ON COOLING

Water boils at 212° F under atmospheric pressure at sea level. This pressure becomes less at higher altitudes and the reduced pressure causes water and other liquids to boil at a lower temperature. The following chart shows the effect on boiling point of water and anti-freeze solution:

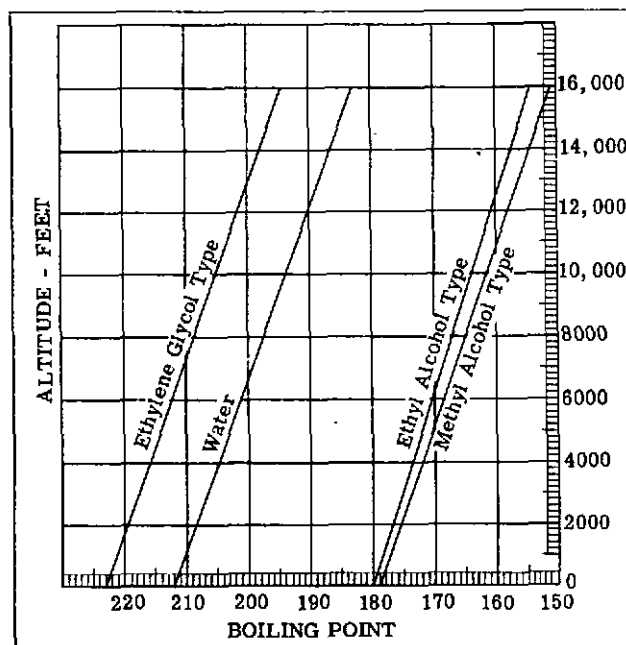


Figure 67 — Effect of Altitude on Boiling Point of Coolant

### ANTI-FREEZES

Water freezes at 32° F., forms solid ice and expands about 9% in volume — which causes tremendous pressure and serious damage when allowed to freeze inside the cooling system.

When operating temperatures are below 32° F. an anti-freeze liquid must be added which will lower the freezing point a safe margin below the anticipated temperature of outside air.

Anti-freeze solutions come in 3 general types and may be used in the following proportions by volume to withstand the temperatures indicated for example, 1 quart of alcohol to 3 quarts of water for 10° F.

TYPES OF ANTI-FREEZE	OPERATING TEMPERATURE RANGE		
	32° to 10° F	+10° to -10° F	-10° to -30° F
PLAIN ALCOHOL — (evaporates easily) .....	Not Recommended w/180° Thermostat.		
METHYL ALCOHOL COMPOUNDS .....	Not Recommended w/180° Thermostat		
ETHYLENE GLYCOL — such as Mobil Permazone, (permanent type) — When there are no leaks add water only to make up for evaporation.....	1 to 4	2 to 5	1 to 1

**NOTE:** While the above list includes three types of generally used Anti-Freeze, the Ethylene Glycol or Permanent Type will be found to be the most desirable and likewise the most economical because of the temperatures desirable to maintain for efficient operation.

Every 500 hours of operation the radiator and cooling system should be well cleaned and flushed with clean water.

**CORROSION INHIBITORS**

Water forms rust due to its natural tendency to combine chemically with iron and air in the system. Rust inhibitors for water are inexpensive, simple to use and make cleaning and flushing necessary only after long periods of operation.

The most commonly used are either a 3% addition of soluble oil or commercial corrosion inhibitors such as Mobil Hydrotone that are readily available at low cost. The addition of corrosion inhibitors are not necessary if an anti-freeze containing a rust inhibitor is used.

**RADIATOR**

The radiator or heat exchanger consists of a series of copper tubes through which the cooling water is circulated. In standard radiator design, fins are connected to the copper tubes to give an extended surface through which heat can be dissipated. It is important that these tubes be kept clean on the inside and the fins free of dirt on the outside so that maximum heat transfer can take place in the radiator.

Blowing out between the fins of the radiator, using compressed air, in a direction opposite to that of the fan circulated air, will serve to keep the cooling surfaces of the core free of dirt and other particles.

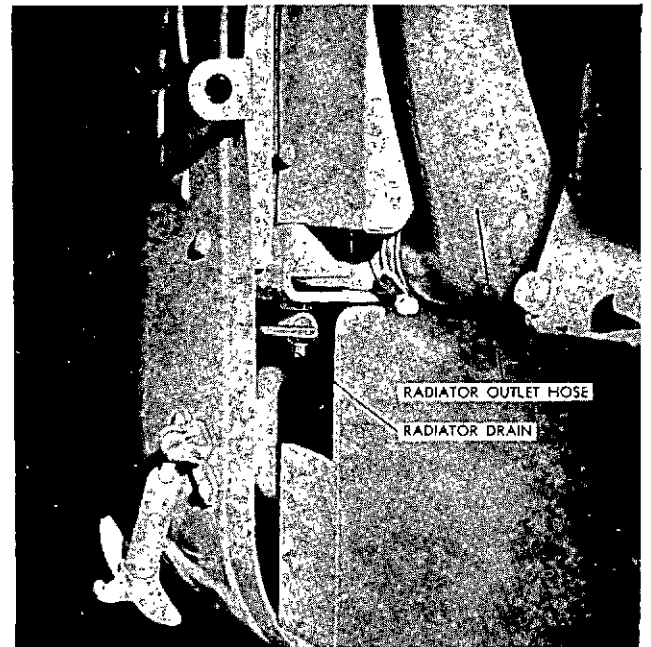


Figure 68 — Radiator Drain

Wherever possible, only soft clean water should be used in the cooling system. Hard water will cause scale to form in the radiator and the engine water jackets and cause poor heat transfer. Where the use of hard water cannot be avoided, an approved water softener can be used.

**CLEANING COOLING SYSTEM**

Deposits of sludge, scale and rust on the cooling surfaces prevent normal heat transfer from the metal surfaces to the water and in time

render the cooling system unable to properly maintain normal operating temperatures. The appearance of rust in the radiator or coolant is a warning that the corrosion inhibitor has lost its effectiveness and indicates that the cooling system should be thoroughly flushed and cleaned before adding fresh coolant.

Dependable cleaning compounds should be used. Follow the procedure recommended by the supplier. This is of prime importance because different cleaners vary in concentration and chemical compositions. After cleaning and flushing, the system should be filled with an approved anti-freeze compound containing a rust and corrosion inhibitor or water with a corrosion inhibitor.

### REVERSE FLOW FLUSHING

Whenever a cooling system is badly rust-clogged as indicated by overflow loss or abnormally high operating temperatures, corrective cleaning by reverse flow flushing will most effectively remove the heavy deposits of sludge, rust and scale. The reverse flow flushing should be performed immediately after draining the cleaning solution and it is advisable to flush the radiator first, allowing the engine to cool as much as possible.

Reverse flush the radiator, as follows:

1. Disconnect the hoses at the engine.
2. Tighten radiator cap.

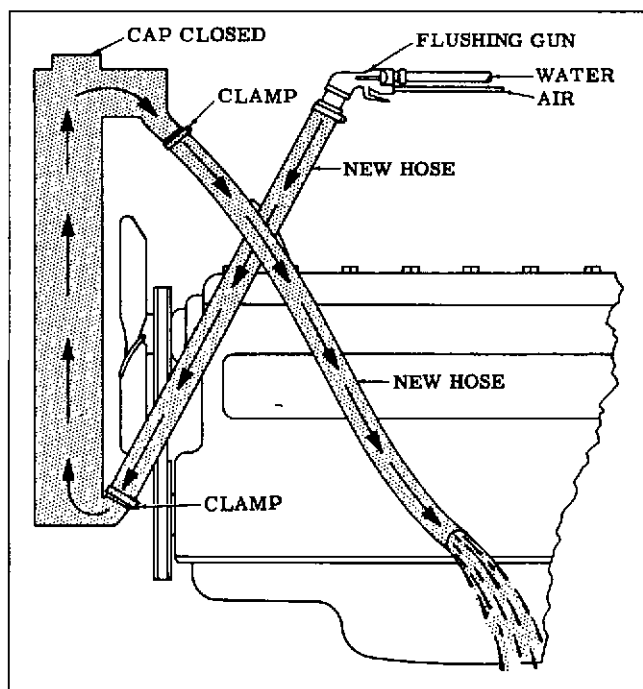


Figure 69 — Reverse Flushing Radiator

3. Clamp the flushing gun in the *lower* hose with a hose clamp.

4. Turn on the water and let it fill the radiator.

5. Apply air pressure gradually, to avoid radiator damage.

6. Shut off the air, again fill the radiator with water and apply air pressure — repeat until the flushing stream runs clear.

7. Clean and inspect radiator cap.

To Reverse flush the engine water jacket

1. Remove the thermostat.

2. Clamp the flushing gun in the *upper* hose.

3. Partly close the water pump opening to fill the engine water jacket before applying the air.

4. Follow the same procedure outlined above for the radiator by alternately filling the water jacket with water and blowing it out with air (80# pressure) until the flushing stream is clear.

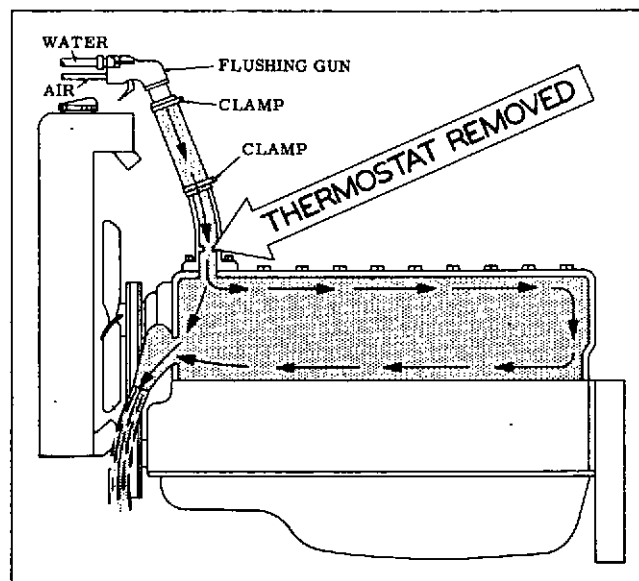


Figure 70 — Reverse Flushing Engine

### TESTING THERMOSTAT

Remove Water Pump Header as shown in illustration. Before testing, clean and examine the bellows for rupture or distortion. If the valve can be pulled or pushed off its seat with only a slight effort when cold or it does not seat properly, the unit is defective and should be replaced.

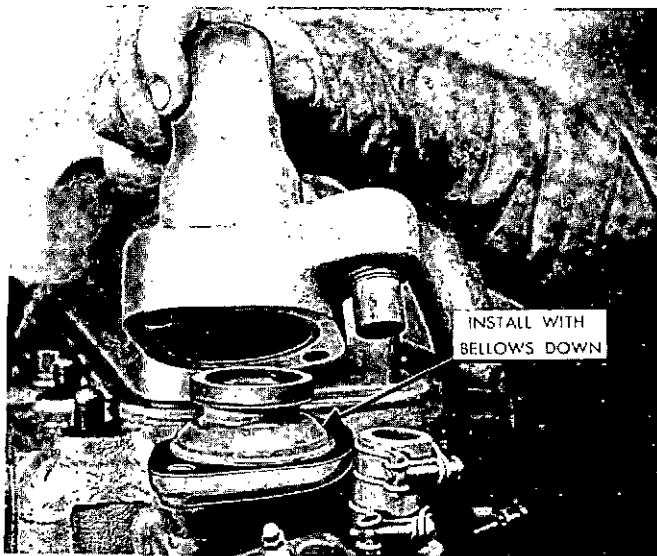


Figure 71 — Installing Thermostat

The thermostatic operation can be checked in the following method:

1. Hang thermostat by its frame in a container of water so that it does not touch the bottom.
2. Heat the water and check temperature with a thermometer.
3. If the valve does not start to open at temperatures of 180°-200° F or if it opens well before the 180° point is reached the thermostat should be replaced.

When replacing the thermostat in the water outlet elbow, be sure seal is in place, and seal seat as well as the counterbore is clean.

Assemble new gasket to pump body or spacer. Thermostat flange must seat in counterbore with gasket sealing contact between it and the pump body.

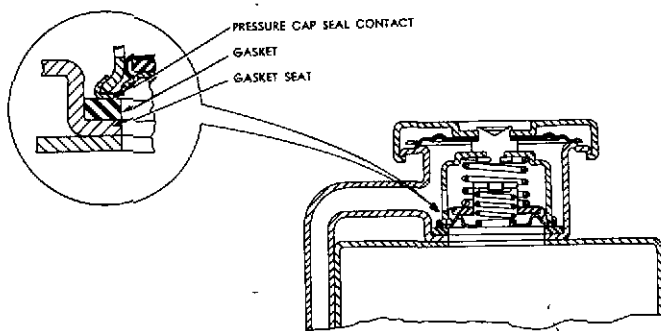
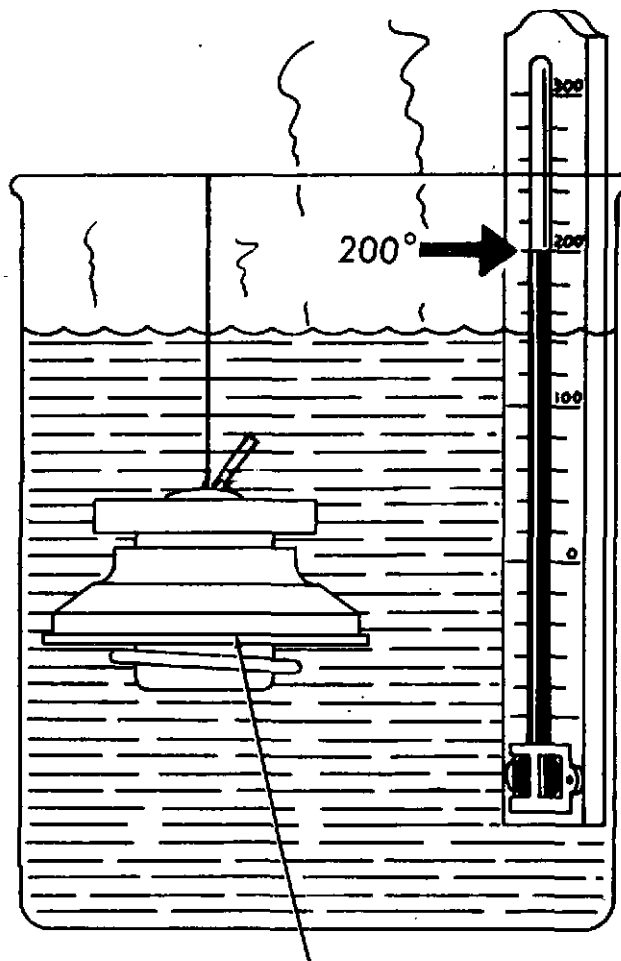


Figure 72



## THERMOSTAT

Figure 73 — Checking Thermostat

## RADIATOR PRESSURE CAP

Many operations use a pressure cap on the radiator to prevent overflow loss of water during normal operation. This spring loaded valve in the cap closes the outlet to the overflow pipe of the radiator and thus seals the system, so that pressure developing within the system raises the boiling point of the coolant and allows higher temperatures without overflow loss from boiling. Most pressure valves open at 4½ or 7 pounds, allowing steam and water to pass out the overflow pipe, however, the boiling point of the coolant at this pressure is 224°F or 230°F at sea level. When a pressure cap is used an air tight cooling system is necessary with particular attention to tight connections and a radiator designed to withstand the extra pressure.

Pressure caps must be regularly inspected and replaced when springs corrode and weaken or the gasket shows poor sealing on the radiator fitting.

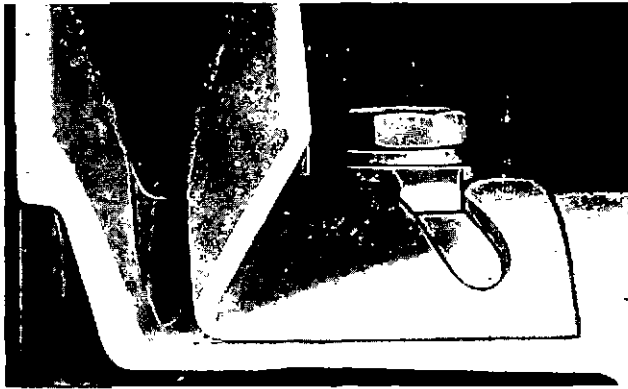


Figure 74 — Fan Belt Adjusting Flange

### FAN BELT TENSION

Puller Fans pull air through the radiator and should have  $\frac{2}{3}$  of the fan blade width inside the shroud and  $\frac{1}{3}$  outside the shroud.

Pusher fans push air through the radiator and should have  $\frac{1}{3}$  of the fan blade width inside the shroud and  $\frac{2}{3}$  outside the shroud.

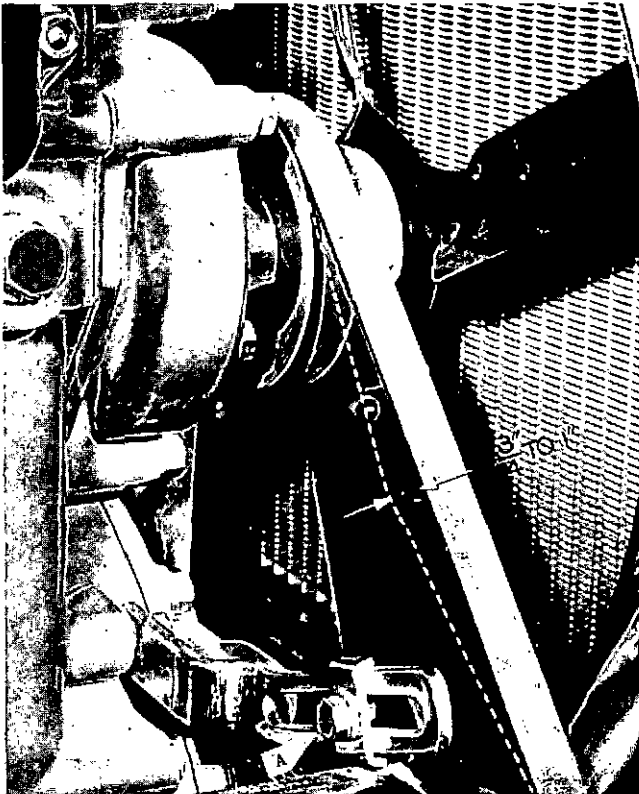


Figure 75 — Fan Belt Tension

When tightening fan belts, loosen the generator mounting and adjusting bolts and pull out on the generator by hand until the belt is just snug. Under no consideration should a pry bar be used on the generator to obtain fan belt tension or damage to the bearings will result.

When adjusted correctly the fan belt should have between  $\frac{3}{4}$ " to 1" deflection on the long side.

### CYLINDER BLOCK WATER DRAINS

When the cooling system is to be completely drained, there are one or two drain plugs on the right hand side of the cylinder block depending upon engine models, which drain all cooling water which might be trapped in the base of the block.

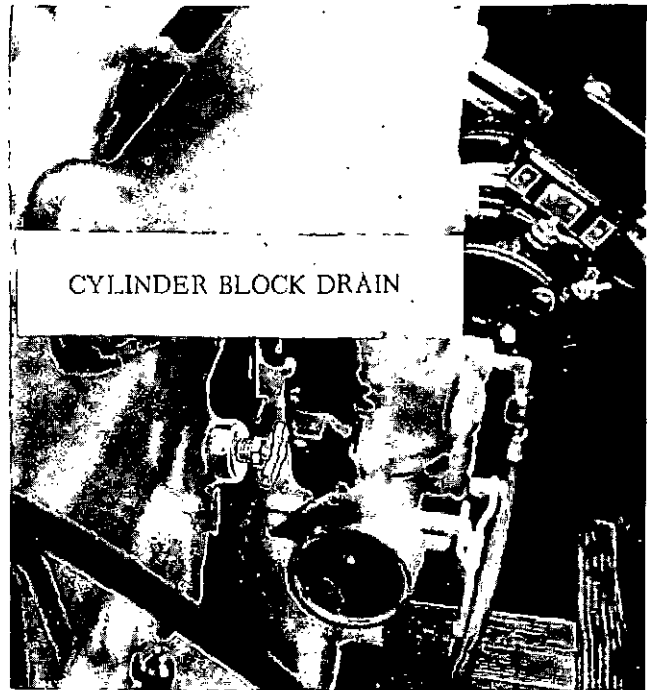


Figure 76 — Cylinder Drain Plug

### CAUTION: OVERHEATED ENGINE

Never pour cold water or cold anti-freeze into the radiator of an over-heated engine. Allow the engine to cool and avoid the danger of cracking the cylinder head or block. Keep engine running while adding water.

### OVERCOOLING

Continuously low operating temperature wastes fuel, increases engine wear and causes oil sludge and corrosion of engine parts.

Overcooling may be caused by operating conditions such as excessive idling, low speeds and light loads during cold weather. Partly covering the

radiator or use of a thermostatic or manually controlled shutter will improve this condition. Improper thermostat or shutter operation can also result in over-cooling. Temperatures should be regulated to maintain 180°-200° operating temperature.

### WATER PUMP

The water pump is located in the front of the cylinder block and is driven by the fan belt from the crankshaft pulley. The inlet of the water pump is connected to the lower radiator connection and the outlet flow from the pump is through integral passages cast in the cylinder head.

No lubrication of the pump is required as the bearings are of the permanently sealed type and are packed with special lubricant for the life of the bearing.

The water pump requires no attention other than bearing replacement when they show excessive looseness or if a water leak develops which shows a damaged or badly worn seal that needs replacement.

### REMOVING WATER PUMP

The water pump assembly can be removed from the engine as a unit for service or repair in the following manner:

1. Remove fan by taking out four cap screws.

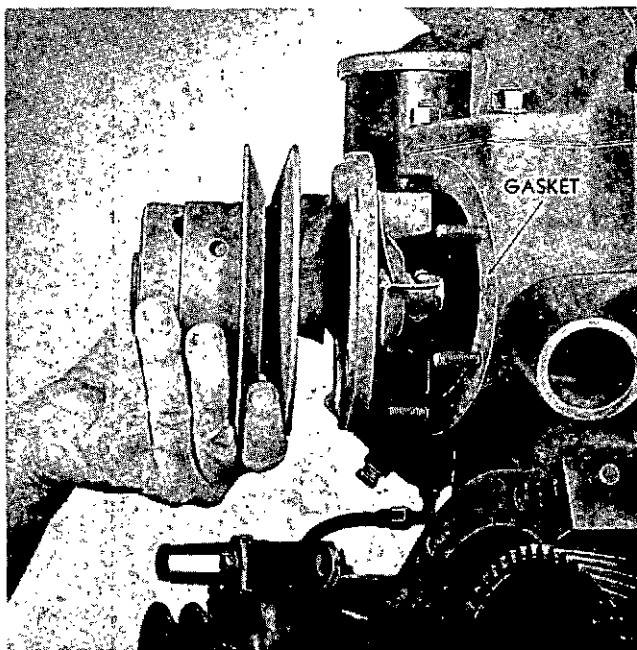


Figure 77 — Water Pump Removal

2. Loosen generator so that fan belt can be slacked off enough to slide over pulley.

3. Remove nuts and lockwashers holding the pump support to the front of the block and remove the pump assembly.

### DISASSEMBLY OF WATER PUMP

1. Remove the bolt from the impeller hub and using a puller, remove the impeller from the shaft. Do not pound or drive on the pump shaft or the carbon seal on shaft will be damaged.

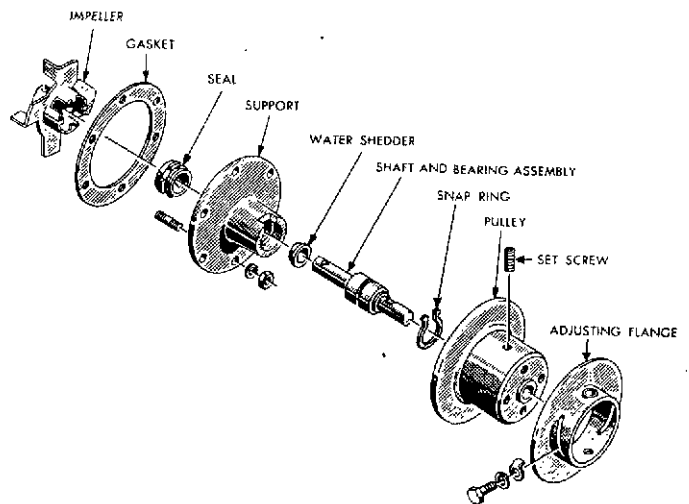


Figure 78 — Water Pump Disassembly (H & J Series)

2. Remove the impeller snap ring and the seal assembly can be lifted from the impeller hub.

3. Where removal of the shaft is required for inspection, loosen the Allen set screw and pull the fan hub from the shaft using a puller.

4. Remove the snap ring, then the shaft and bearing assembly can be pressed out of the pump toward the front end.

**REASSEMBLY AND INSTALLATION**

1. Reassemble pump, replacing worn or failed parts and reverse above instructions.

Seal contact surface must be smooth and flat, regardless of whether it is on a replaceable bushing or machined directly in the iron of the support. The bushing may be replaced, if scored or cut, but either of them may be refaced and polished for further use.

A light film of lubricant applied to the face of the seal will facilitate seating and sealing.

2. Use thick soapsuds on both the seal and shaft when assembling in order to prevent damage to the seal.

3. Mount pump assembly on block using a new housing gasket.

4. Install fan belt and adjust belt tension to have  $\frac{3}{4}$ " to 1" deflection on long side. Pull out the generator by hand, as bearing damage will result with a pry bar.

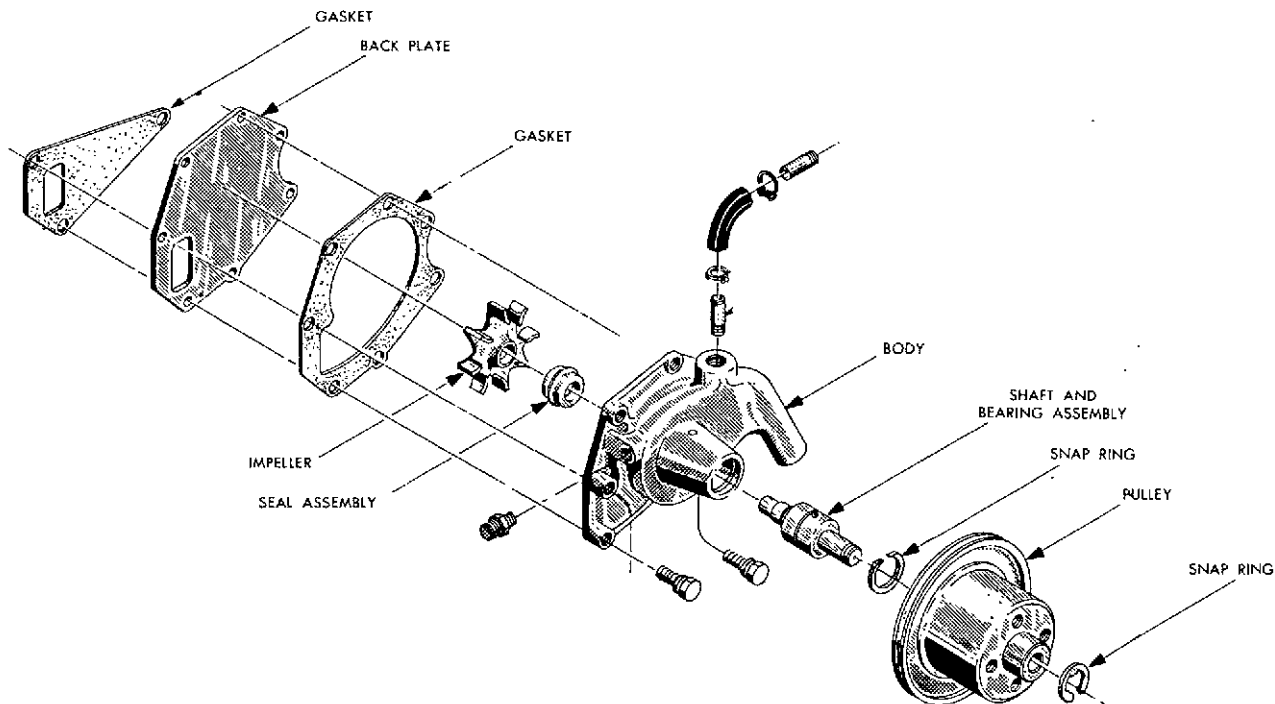


Figure 79 — Water Pump Disassembly (G)

**COOLING SYSTEM PROTECTOR PELLET**

All Continental Engines are shipped with a cooling system protector pellet in the water outlet header. *Remove the pellet from its plastic covering and replace the pellet in the cooling system.*

This pellet is a water-conditioner and rust inhibitor, and can be used with all types of anti-freeze during cold operation.

**ENGINE HOUSE VENTILATION**

Engines operating inside buildings must be adequately ventilated to supply sufficient air to cool the engine — provide air to mix with the fuel and in addition, to carry the heated air from the building.

## SECTION VI FUEL SYSTEM

The basic purpose of the fuel system is to store, convey, mix fuel with air, then vaporize and introduce the mixture into the engine.

Fuel is stored in the gasoline tank; it is filtered and flows through the fuel supply line to the carburetor — either by gravity or under pressure of a fuel pump. The carburetor mixes the fuel with proper proportions of air and at the same time breaks it into very fine spray particles. This atomized spray changes to vapor, by absorbing heat as it travels through the intake manifold to the combustion chamber. Fuel must be vaporized since it will not burn well as a liquid.

### GRAVITY FUEL SYSTEM

This is the most simple fuel system and is generally used on power units as it eliminates the need of a fuel pump — it only requires the fuel tank located higher than the carburetor.

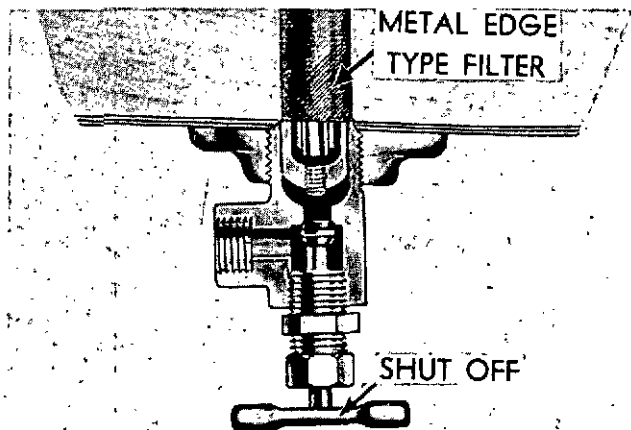


Figure 80 — Edge Type Filter

All power units with fuel tank have a combination shut-off valve and an efficient metal edge type filter. This filter prevents all foreign particles and water from entering the carburetor.

With reasonable care in filling the tank with clean fuel, this filter will require only seasonal cleaning of both the filter and tank.

### MECHANICAL FUEL PUMP

The Mechanical Fuel Pump is generally used when the fuel supply is below the level of the carburetor. They are of several models dependent upon the diaphragm diameter and assembly arrangement with fuel strainer bowl, air dome and manual primer.

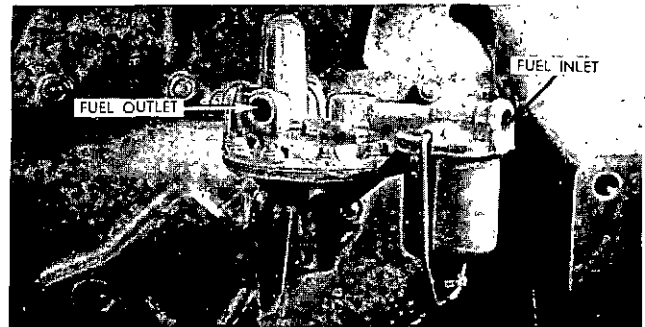


Figure 81 — Fuel Pump

This mechanical fuel pump mounts on the cylinder block pad and is driven by an eccentric on the engine camshaft contacting the fuel pump rocker arm.

Constant fuel pressure is maintained by an air dome and a pulsating diaphragm operated and controlled by linkage which adjusts itself to pressure demands.

**Fuel Pump Tests** — The fuel pressure may be measured by installing the pressure gauge between the fuel pump and carburetor.

The AC fuel pump size and static pressures @ 1800 R.P.M. for the four cylinder overhead valve engines that have been supplied with fuel pumps are:

ENGINE MODEL	DIAPHRAGM DIAMETER	FUEL PRESSURE
G157	3 <sup>3</sup> / <sub>16</sub>	1½ - 2¼#
G193	3 <sup>3</sup> / <sub>16</sub>	1½ - 2¼#
G4193	3 <sup>7</sup> / <sub>16</sub>	4 - 5#
E Series	3 <sup>1</sup> / <sub>4</sub>	3 - 4½#

When pressures are below the range, pump should be disassembled and reconditioned with the special overhaul kits available.

**Maintenance** — Fuel pump trouble is of only two kinds — either the pump is supplying too little gas or, in rare cases, too much.

If the pump is supplying too little gas, the engine either will not run or it will cough and falter. If too much gas — it will not idle smoothly or you will see gasoline dripping from the carburetor.

If the engine is getting too little gas — the trouble may be in the pump, fuel line or the gas tank. First, be sure there is gas in the tank, then disconnect the pump to carburetor line at the pump or carburetor, and turn the engine over a few times with the ignition off. If gas spurts from the pump or open end of the line — the pump, gasoline and tank are OK.

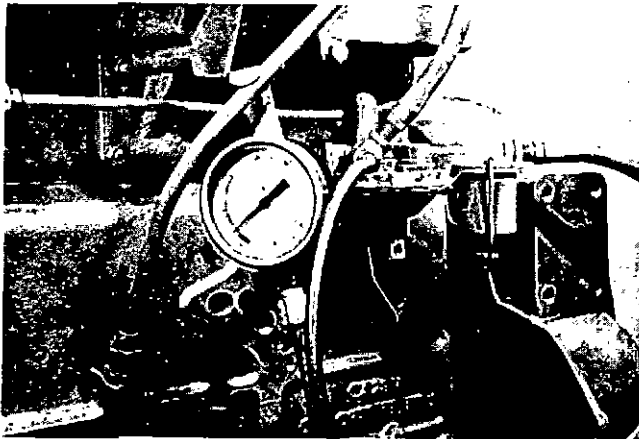


Figure 82 — Checking Fuel Pressure

If there is little or no Flow—check the following:

1. Look for leaky bowl gasket or line connections — tighten them.
2. Remove and clean with solvent the gas strainer or screen inside the pump bowl.
3. Look for clogged fuel line — Blow out with compressed air.
4. Make sure that all pump cover screws and external plugs are tight.
5. Inspect flexible fuel line for deterioration, leaks, chafing, kinks or cracks. If none of the items restore proper flow — remove the pump for replacement or overhaul.

If getting too much gas — an oversupply of gasoline is generally caused by trouble other than the fuel pump — so first check the following:

1. Defective Automatic Choke.
2. Excessive use of hand choke.
3. Loosely connected fuel line, or loose carburetor assembly screws.
4. Punctured carburetor float.
5. Defective carburetor needle valve.
6. Improper carburetor adjustment.

If none of the items corrects flooding, remove the fuel pump for replacement or overhaul.

### ELECTRIC FUEL PUMP

Many Over-head Valve engines use electric fuel pumps operated from the storage battery supply. The pumps should be mounted close to the fuel tank so as to provide fuel pressure at all points along the fuel line to eliminate vapor lock.

The electric fuel pump is energized in the ignition circuit — which assures quick filling of the carburetor and fuel lines to effect easy starting.

When fuel pump trouble is suspected, disconnect the fuel line at the carburetor and turn on the ignition switch. Pump fuel into a small container, then place your finger on the outlet side of the fuel line. If the pump stops or ticks very infrequently, the pump and fuel line connections are satisfactory. Remove your finger from the outlet side of the fuel

line and if ample fuel flows — the pump is satisfactory.

If fuel does not flow and all connections are tight, the pump should be replaced or repaired. Always be sure of a good ground and check for faulty flexible fuel lines and poor electrical connections.

## CARBURETOR

Continental Over-head Valve gasoline engines normally use Marvel-Schebler and Zenith carburetors — of both the updraft and downdraft types.

The carburetor mixes fuel with air and meters the mixture into the engine as the power is demanded. Most carburetors incorporate the following systems to provide the flexibility and sensitive requirements of varying loads and conditions:

- 1 — **Float System** — Controls the level and supply of fuel.
- 2 — **Idle or Low Speed** — Furnishes the proper mixture for the engine idle, light load and slow speeds, until the main metering system functions.
- 3 — **Main Metering System** — Controls the fuel mixture from part throttle operation to wide open throttle.
- 4 — **Power or Economizer System** — Provides a richer mixture for maximum power and high speed operation. This system ceases to function when the manifold vacuum is above 6" Hg.
- 5 — **Compensating System** — Provides a mixture which decreases in richness as the air speed increases.
- 6 — **Choke System** — Delivers additional fuel to the manifold for cold engine starting.

### MARVEL-SCHEBLER CARBURETOR

(Model TSX)

The Model TSX carburetor without power adjustment has the following two adjustments.

#### Preliminary Adjustments

- 1 — Set throttle stop screw "A" so that throttle disc is open slightly.
- 2 — Make certain that gasoline supply to carburetor is open.
- 3 — Set throttle control lever to  $\frac{1}{3}$  open position.

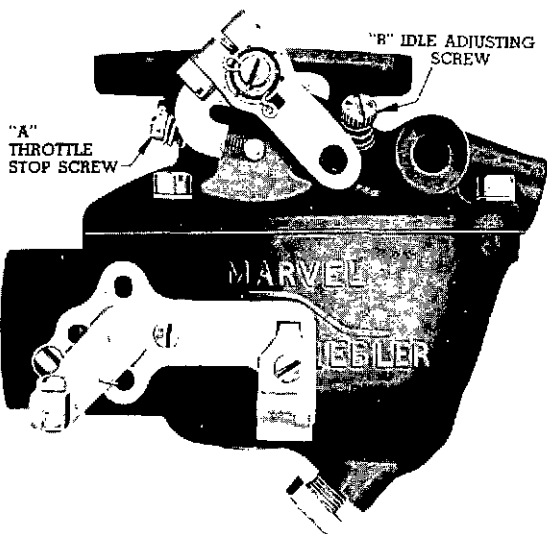


Figure 83 — Marvel-Schebler TSX Carburetor

- 4 — Close choke valve by means of choke control button.
- 5 — Start engine and partially release choke.
- 6 — After engine is up to operating temperature throughout, see that choke is returned to wide open position.

**Low Speed or Idle Adjustment**

- 1 — Set throttle or governor control lever in slow idle position.

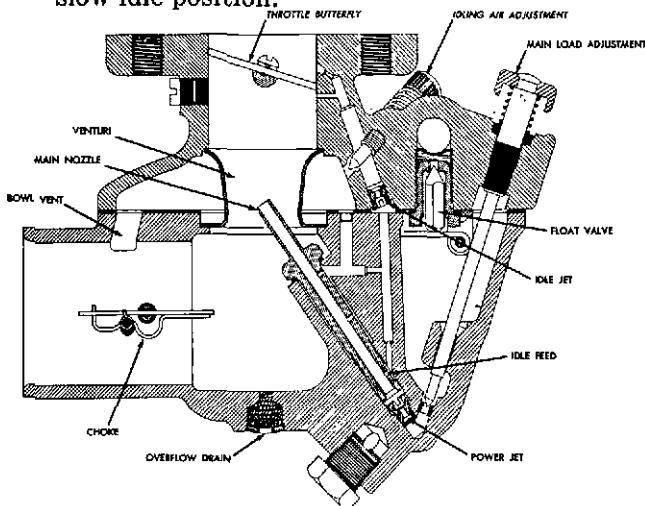


Figure 84 — Sectional View of the Marvel-Schebler Carburetor

- 2 — Adjust throttle stop screw "A" for correct engine idle speed (normally 400-600 RPM).
- 3 — Turn idle adjusting screw "B" in, or clockwise, until engine begins to falter or roll from richness, then turn screw "B" out, or counter-clockwise, until the engine runs smoothly.

**"TSX" Float Level**

Set Floats 1/4" from gasket face to nearest edge of float, keeping edge of float parallel with gasket.

**ZENITH CARBURETOR**

The Zenith 62 Series carburetor shown below is used on the G-H-J series engines and has the following three adjustments.

- 1 — Main Adjustment Screw — Determines the amount of fuel which may be obtained for high speed operations.

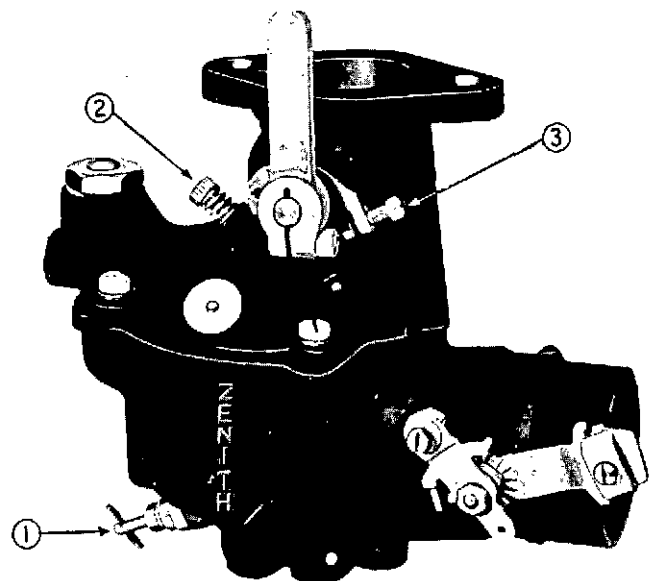


Figure 85 — Zenith 62 Series Carburetor

To set this adjustment, open the throttle to about 1/4 open. Turn the adjustment clockwise, shutting off the fuel until the engine speed decreases or begins to miss due to lean mixture. Now open the adjustment until the engine reaches its maximum speed and runs smoothly without missing.

- 2 — Idle Mixture Adjustment Needle—Controls the amount of air admitted to the idling system, which functions only at low speeds.

Turning the screw clockwise cuts off the air, making the mixture richer — while unscrewing it admits more air making the mixture leaner. The idling adjustment needle should be set for the smoothest running of the engine; or, if a vacuum gauge can be attached to the manifold, set the adjustment for highest manifold vacuum.

- 3 — Idle Speed Adjustment Screw — controls the idling speed — which should be 400-600 R.P.M. for most industrial applications.

THE NORMAL FLOAT LEVEL IS

$$1\frac{3}{64} \pm \frac{1}{32}$$

(See Zenith method of checking float levels on next page)

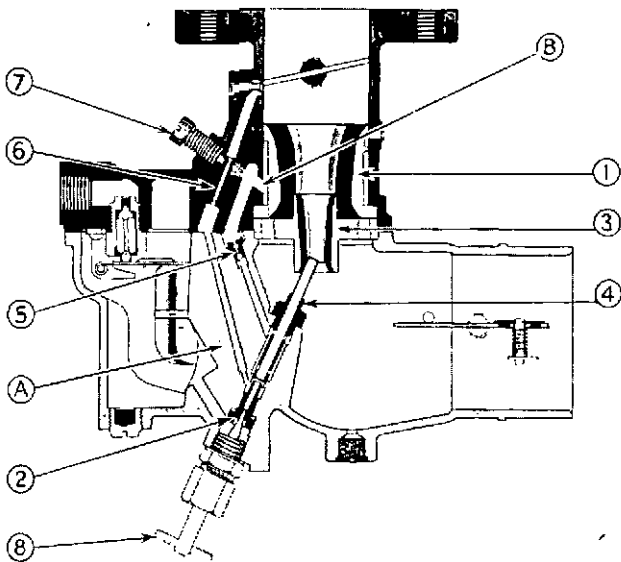


Figure 86 — Sectional View of a Zenith Carburetor

- No. 1. Venturi
- No. 2. Main Jet (High Speed)
- No. 3. Secondary Venturi
- No. 4. Main Discharge Jet
- No. 5. Well Vent
- No. 6. Idling Jet
- No. 7. Idle Adjusting Needle
- No. 8. Main Jet Adjustment
- A — Main Jet Channel
- B — Idle Channel

### ZENITH 28 SERIES FOR G4193 ENGINES

The G4193 engines use a Zenith series 28 carburetor with single throat, of the downdraft type.

This carburetor is of the plain-tube balanced type and fully sealed against dirt. It also has all fixed jets except the idle adjustment.

The series 28 carburetor has the idle adjustment on the air supply.

The following adjustments are required in normal service.

1 — Idle Speed Adjustment — Controls the idling speed — which should normally be 350-500 RPM.

2 — Idle Mixture Adjustment

Series 28 — Turn idle air adjusting screw clockwise or "IN" to provide a richer mixture and counterclockwise or "OUT" for a leaner mixture.

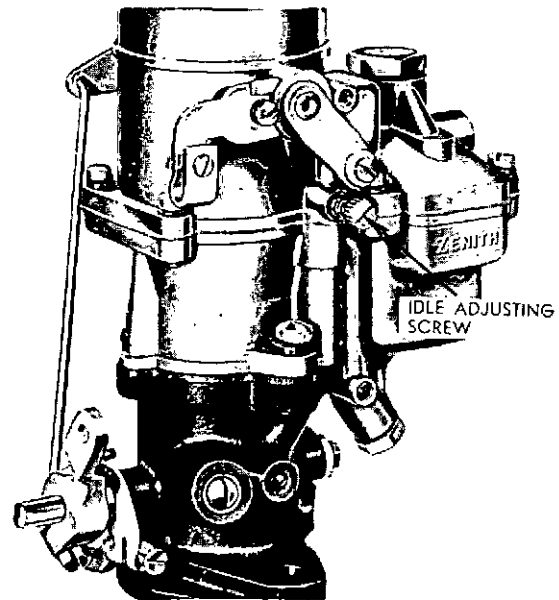


Figure 87  
Zenith Series 28 Carburetor

THE NORMAL FLOAT LEVEL IS 1 1/2".

#### CHECK THE FLOAT LEVEL OF ZENITH CARBURETORS IN THE FOLLOWING STEPS:

1. Remove the top casting of the carburetor.
2. Remove gasket.
3. Holding the carburetor top — in an inverted position as shown in the following sketch — measure dimension "A" from the machined surface to the top of the float. (If there is a seam on top of the float — measure to the top of the float rather than to the top of the seam.)

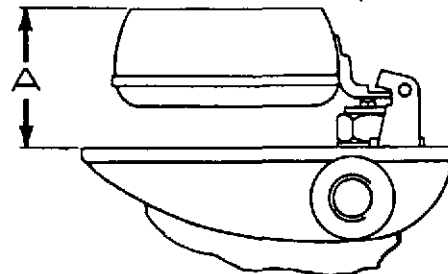


Figure 88 — Measuring Float Level

4. Bend float lever close to body — with long-nosed pliers to increase or decrease float level — be accurate. The float body must be centered and at right angles to the machined surface.

**CAUTION:** Do not bend, twist or apply pressure on the float body. Be sure that the float moves freely on its axle.

## CARBURETOR CHOKES

**Manually Operated Choke** — is operated by a flexible cable control from the instrument panel or rear house panel. While this is the most simple type, it is most important that the operator have the choke valve in wide open position when engine operating temperature is reached.

## ZENITH ELECTRIC CHOKE CONTROL

Is made as part of the carburetor assembly. It is directly connected to the choke shaft and automatically controls the opening during the entire engine operation.

Manifold vacuum is used to open the choke shaft partially after the initial firing of the engine, and heat is used on the thermostat spring to control the amount of opening during the warming up period. This heat is provided by an electric element in the thermostat chamber. Fast idling during the warm-up period is also provided by a throttle advance mechanism which is actuated from the choke shaft.

The heating element which is energized when the ignition is "on" gradually warms the thermostat, decreasing its resistance to the pull of the

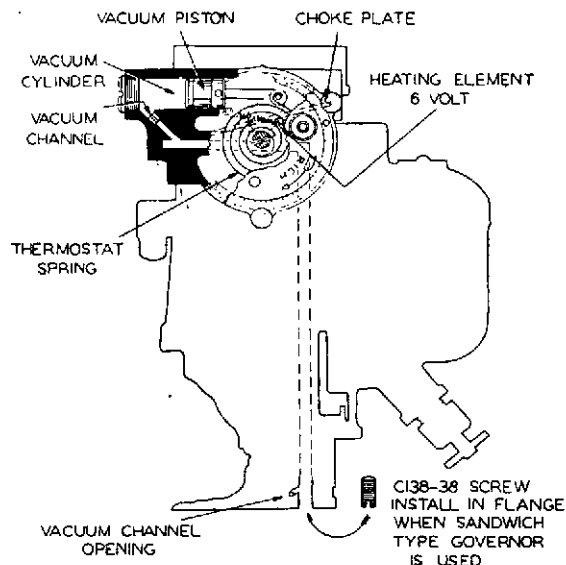


Figure 89 — Zenith Electric Choke

vacuum piston, which gradually causes the choke to open and moves the throttle advance to the warm idle position.

All units are initially set with the thermostat 15 notches rich for 70° F. ambient temperature. Temperature corrections can be made by allowing one notch on the cover for each 5 degrees variation — making certain that the choke valve is fully open when operating temperatures are reached.

## SISSON AUTOMATIC CHOKE

Uses an electro-magnet and a thermostat to automatically close the carburetor choke valve for cold starting and regulates its degree of opening as the engine warms.

The unit is mounted on the exhaust manifold and a small rod connects it to the carburetor choke lever. The electro-magnet is energized by the starter circuit which pulls an armature lever down, closing the choke valve.

As soon as the engine starts, the electro-magnet circuit is broken and then the thermostat provides automatic adjusting of the choke valve during the warming-up period.

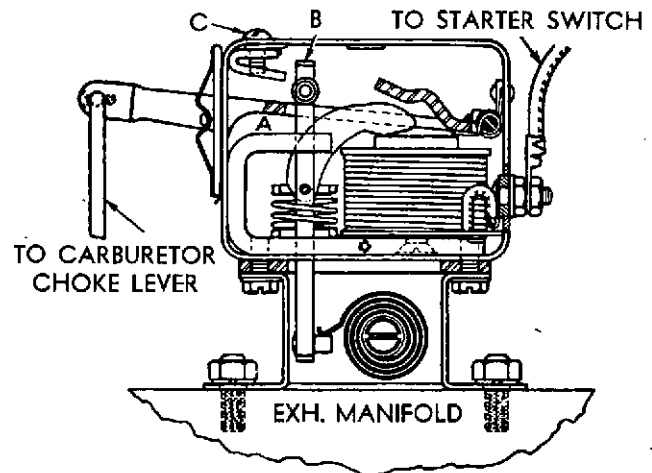


Figure 90 — Sisson Automatic Choke

The carburetor choke lever should be adjusted so that when the carburetor choke valve is closed tight, there will be .015" to .020" clearance between the automatic choke lever and the field pole that serves as a stop. This measurement is taken at "A" and must be made with thermostatic control "B" pushed down as far as it will go.

**CAUTION:** Do not oil the Sisson automatic choke under any circumstance.

**Carburetor Service** — In general any change in carburetor action will usually come gradually, therefore, if the carburetor operated satisfactorily when last used, it can reasonably be assumed that some other part of the engine is at fault — which should be corrected before disturbing the carburetor.

Dirt is the main enemy of good carburetion as it fills up the minute air and gasoline passages and accelerates the wear of delicate parts.

Never use a wire to clean out restrictions in jets as this will destroy the accurate calibrations of these parts — always use compressed air. The jets are made of brass to prevent rust and corrosion and a wire would cut or ream the hole in the jet and ruin it.

Maintaining correct fuel level in the carburetor bowl is important — as the fuel flow through the jets is naturally affected by the amount of fuel in the bowl.

After a carburetor has been in service for some time, the holes in the jets and the float valve and seat become worn from the constant flow of fuel

through them and should be overhauled by a competent carburetor service station.

Do not experiment with other size jets or any so-called fuel-saving gadgets as your arrangement has been thoroughly tested on a dynamometer program.

## GOVERNORS

The governor is a device which controls engine speed — either keeping it operating at a constant speed or preventing it from exceeding a predetermined speed. It promotes engine operating economy and eliminates needless engine failures.

Continental Four Cylinder Overhead-Valve Engines in general use the Continental Mechanical "Built-in" Cam Gear Governor and a few types of velocity governors.

### CONTINENTAL CAM GEAR GOVERNOR

This built-in cam-gear governor is sealed, dust proof, engine lubricated, is compact and easily adjusted. The control shaft floats on two needle bearings to remove friction for closer and more accurate control through the whole power range. This governor is normally used on all industrial applications.

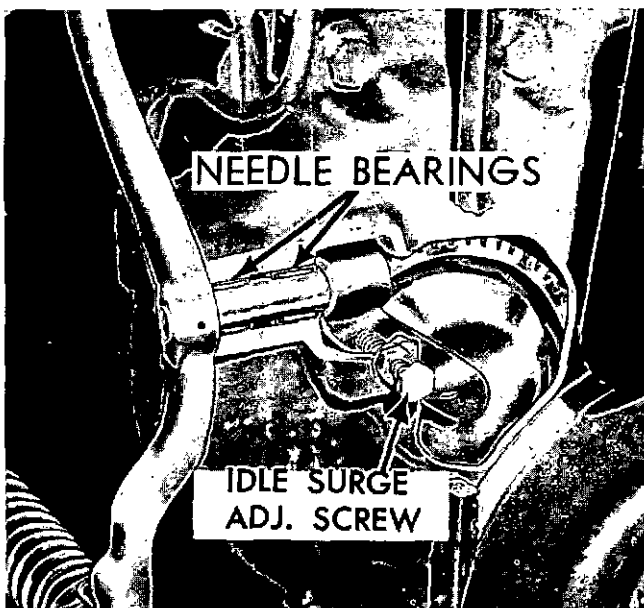


Figure 91 — Cam Gear Governor

### CAM GEAR GOVERNOR

The cam-gear governor is a variable speed type and has no speed adjustment other than the amount of travel the control rod is moved.

Control rod movement is determined by accelerator pedal or hand control linkages.

The idle surge adjusting screw should be adjusted "in" just far enough to eliminate any tendency of the engine to surge.

### ADJUSTMENTS:

#### 1 — Linkage Adjustment

With the engine stopped and spring tension about normal, the governor should hold the throttle, (butterfly) in the wide open position.

The governor to carburetor control rod should be adjusted in length so that the throttle stop lever is  $\frac{1}{64}$  -  $\frac{1}{32}$  off the stop pin. Be sure that the bumper screw is backed out so as not to interfere.

Make certain that all linkage at governor and carburetor operate free — without any binding.

2 — Speed Adjustment — Turn governor adjusting screw to the right to increase speed — to the left to reduce speed.

3 — Idle Surge Adjustment — Turn governor idle surge adjusting screw "IN", or to the right until corrected.

**CAUTION:** Do not turn bumper screw in far enough to reduce the maximum governed speed for full throttle.

Continued surging — may indicate an excessive looseness or binding of governor linkage and sometimes too lean a fuel mixture.

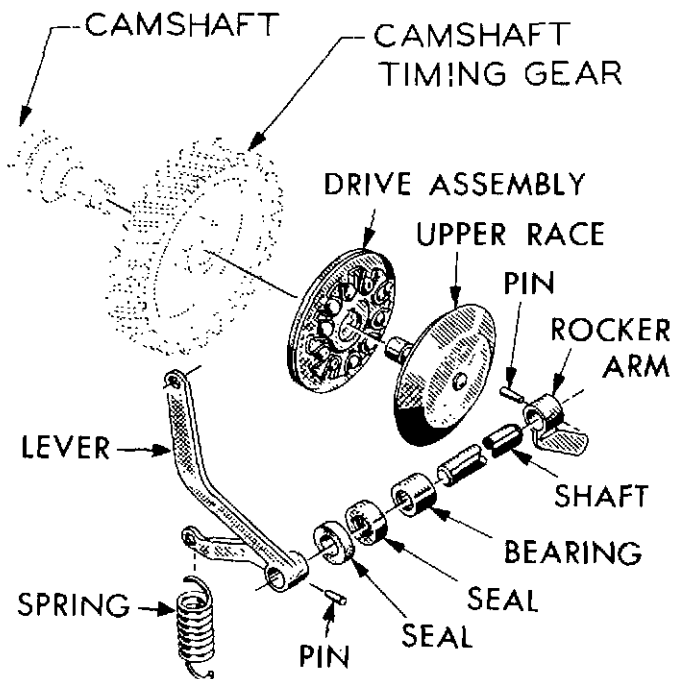


Figure 92

Exploded View of Cam Gear Governor

## VELOCITY GOVERNORS

**Velocity Governors** — are generally used to prevent engine speed from exceeding a predetermined maximum. The governor is mounted between the carburetor and manifold flanges. In its most simple form, it consists of a main body, which contains a throttle shaft, a throttle valve and a main governor spring. The main governor spring is attached by linkage to the governor shaft and the spring force holds the throttle valve open.

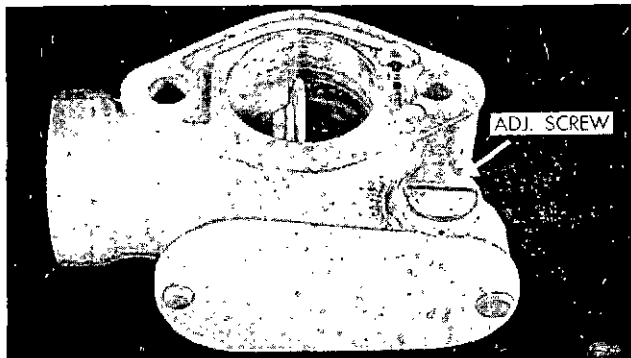


Figure 93 — Hoof Velocity Governor

When the engine is started, air flows through the carburetor throat and the governor throat. The velocity of the air creates a pressure above the throttle valve. When this pressure exceeds the force exerted by the spring, the throttle will move toward a closed position. The adjusting screw varies the spring tension.

When this closing action of the valve exactly balances the spring, governing action takes place and maximum speed is fixed at this point.

When load is applied — the engine speed tends to drop — the velocity of the gas through the manifold and the pressure against the governing valve is reduced and the spring opens the valve to feed more gasoline to the engine to handle the increased load demand. Thus an almost constant speed is maintained whether the engine is running with or without load.

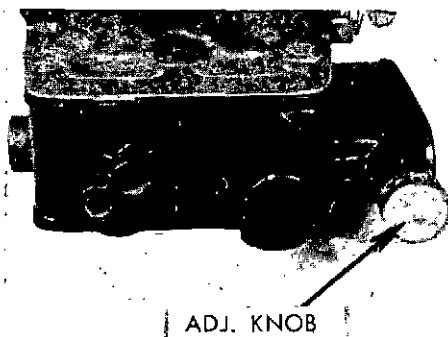


Figure 94 — Handy-Vari-Speed Governor

**Adjustment** — Both the Handy-Vari-Speed and Hoof Velocity Governors have only one adjustment — which is for adjusting the governor speed.

The Handy Vari-Speed governor is adjusted by removing the seal from the adjusting knob

— turning clockwise reduces speed and counter-clockwise increases speed. (See arrow on adjusting knob.)

The Hoof Velocity Governor is adjusted by removing the seal wire and with screwdriver turn clockwise to increase speed and counter-clockwise to reduce speed.

**IMPORTANT** — *Dirt and water entering the governor cover is the main cause of failures.*

## ZENITH GOV-U-RETOR

Continental G-4193 series engines, on small applications, use the Zenith 28 or 288 series carburetors and the Zenith "Gov-U-Retor" combined in an integral unit that is sealed fully against entrance of dust.

This is a velocity type governor which gives the operator full manual control of throttle opening at engine speeds below the governor speed — at which time the governor "takes-over".

If smooth accurate governor action is to be obtained, friction of the throttle shaft and its bearings must be avoided. Most governor failures are due to carbon accumulating on the throttle shaft bearings. — Especially if engines are in poor mechanical condition. Many governor failures can be temporarily corrected by application of a good penetrating oil to the throttle shaft bearings.

Lack of sufficient end play in throttle shaft and bearings will cause friction and governor failure when the engine is hot.

## GOV-U-RETOR ADJUSTMENTS

**1 — To Change Governor Speed** — Remove the seal wire and large seal plug, and with small screwdriver turn the main spring adjusting screw clockwise to increase the speed and counter-clockwise to decrease the speed.

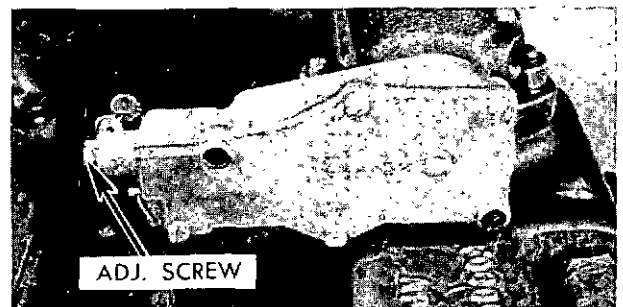


Figure 95 — Gov-u-retor Adjustment

**2 — Performance Adjustment** — If the governor surges or hunts to a higher or lower engine speed — remove the compensating spring adjusting screw seal passage plug and with a narrow screwdriver turn the compensating spring block adjusting screw  $\frac{1}{4}$  turn counter-clockwise until the surge is overcome.

**3 — Recheck Governed Speed** — After making compensating spring adjustment.

**4 — Install Threaded Seal Passage Plugs and seal wire and seal adjustment.**



This collapsing field induces a very high voltage in the secondary winding which is carried by the high tension wire to the center terminal of the distributor cap. The rotor connects this center terminal to one of the cap terminals which in turn is connected to the proper spark plug.

The spark produced by this high tension current ignites the fuel in that cylinder. This process is repeated for every power stroke of the engine and at high speeds, an impulse may be required as often as 300 times per second.

**Ignition Coil** — The function of the ignition coil is to transform the low voltage supplied by the battery into the high voltage to jump the spark plug gap.

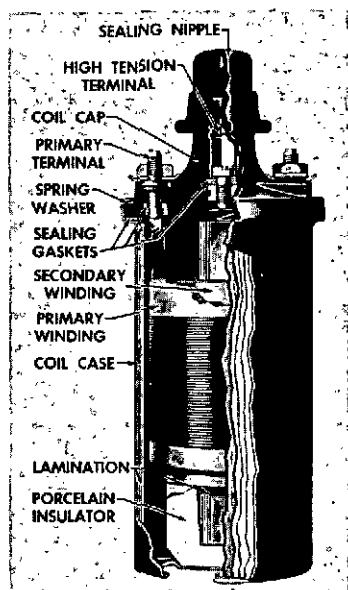


Figure 97 — Cutaway View of an ignition coil

An ignition coil has two windings wound on a soft iron core; the primary winding which consists of a comparatively few turns of heavy wire, and the secondary winding of many thousand turns of very fine wire. The primary winding is wound around the outside of the secondary winding. A soft iron shell encloses the outside of both windings and serves to complete the magnetic circuit.

Ignition coils do not normally require any service except keeping all terminals and connections clean and tight. The coil should be kept reasonably clean; however, it must not be subjected to steam cleaning or similar cleaning methods that may cause moisture to enter the coil.

Ignition coils can be tested for grounded windings by placing one test point on a clean part of the metal container and touching the other point to the primary and high voltage terminals. If tiny sparks appear at the points of contact, the windings are grounded.

If the coil is further suspected of being faulty, remove and check its operation on a coil tester and replace it if inoperative. Most coil testers compare the operation of the coil being tested with one known to be in good condition. This test should be made with the coils at room temperature and then

warming the coils five minutes by connecting the primary to a battery of the same voltage rating as the coils. Recheck the comparison test to see if the expansion due to heating has caused some defect to appear.

**Distributor** — The distributor conducts and interrupts the current through the primary winding of the ignition coil at the correct time and distributes the high tension voltage to the correct spark plug.

There are two separate electrical circuits in a distributor. The breaker contacts and condenser are in the primary circuit and carry low voltage current — while the cap and rotor are in the secondary circuit and carry the high voltage spark current.

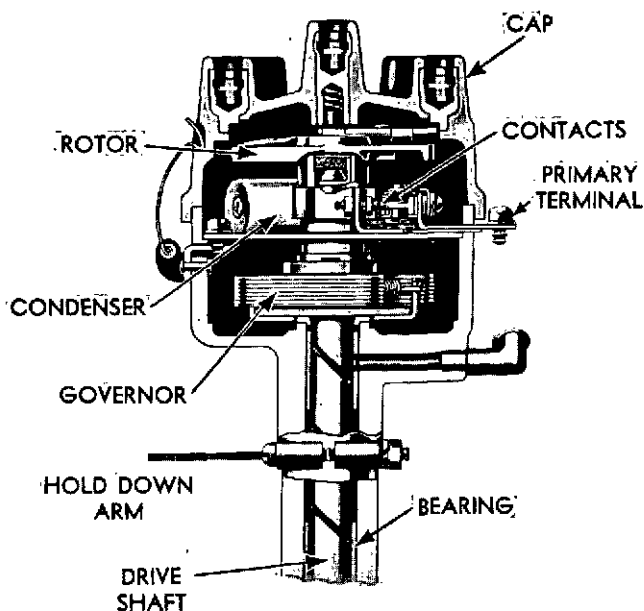


Figure 98 — Cutaway View of a distributor

The breaker contacts are mounted on a plate in the top part of the distributor housing. The grounded contact is stationary and the insulated contact is mounted on a breaker arm which is actuated by a cam near the top of the distributor shaft.

The rotor is mounted above the cam and turns with it to make a connection between the cap center contact and the various side contacts.

Continental Over-head Valve engines have distributors equipped with a centrifugal governor which varies the timing by advancing the breaker cam as the engine speed increases. This mechanism consists of weighted levers which revolve with the distributor rotor and act against a set of springs. As the speed of rotation increases, the weights are moved out and the timing is advanced. With this arrangement it is possible to have a retarded spark for idling and obtain a gradual advance in spark timing as the engine speed is increased.

The condenser in the distributor prevents excessive arcing at the contacts. When the contacts first open, the current tends to continue flowing across the gap. The condenser absorbs this current until it becomes fully charged; but by this time, the contacts have opened far enough to prevent the current flow. If there were no condenser in the circuit, the current would continue to flow and cause an arc that would soon burn the contacts. The capacity of the condenser is designed to be large enough to prevent arcing and burning of the contacts and small enough to reduce the transfer of material from one contact to the other.

The cam is designed so that the breaker points remain closed for a certain number of degrees so as to give the coil a given length of time to build up or become energized. This is called the cam angle, as shown below:

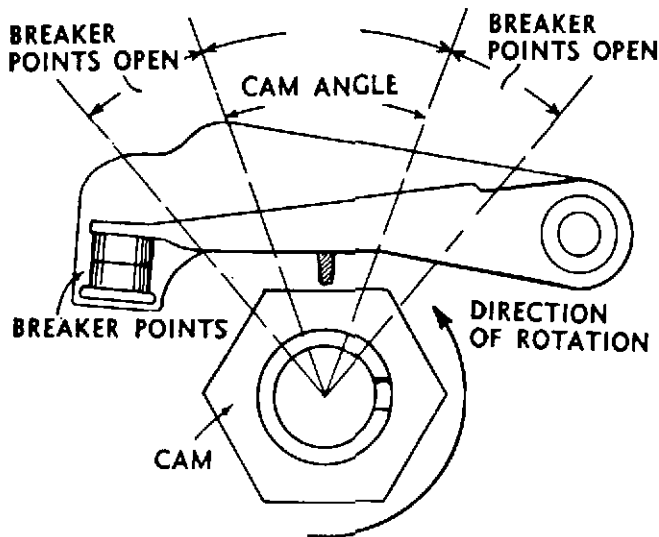


Figure 99 — Diagram illustrating cam angle

The cam is further designed to open the breaker points at a given speed in relation to cam travel to obtain proper point and condensor action. It is therefore important that the breaker points be adjusted to .020 gap so that proper cam angle is obtained.

**DISTRIBUTOR MAINTENANCE** — The distributor operation is vital to the operation of the engine and the following items should be carefully inspected every 250 hours of normal operation; however, dirt, dust, water and high speed operation may cause more rapid wear and necessitate more frequent inspections:

1 — **Remove Distributor Cap** — (without removing wires) — Clean cap and examine for cracks, carbon runners, corroded terminals or if the vertical faces of the inserts are burned — install a new cap.

If the horizontal faces of the inserts are burned — replace the cap and rotor as this is due to the rotor being too short.

2 — **Check Centrifugal Advance Mechanism** — for “freeness” by turning the breaker cam in the direction of rotation and then releasing it. The advance springs should return the cam to its original position.

3 — **Inspect Breaker Points and Gap** — if points are pitted, burned or worn to an unserviceable condition, install a new set of points. Badly pitted points may be caused by a defective or improper condenser capacity.

If the condenser capacity is too high, the crater (depression) will form in the positive contact; and, if condenser is too low, the crater will form in the negative contact as shown on the following sketch.

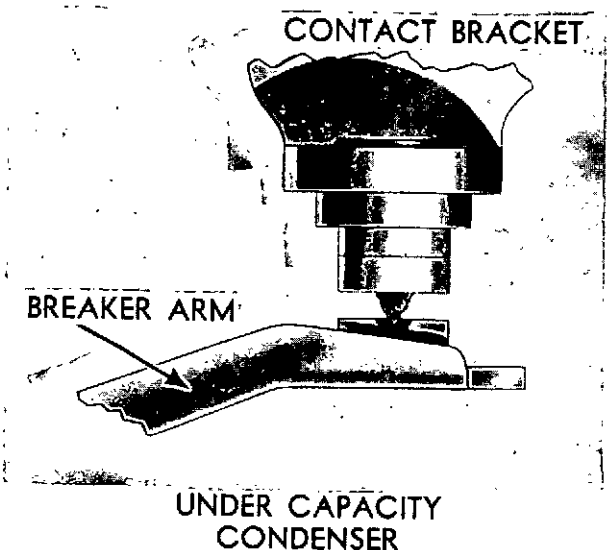
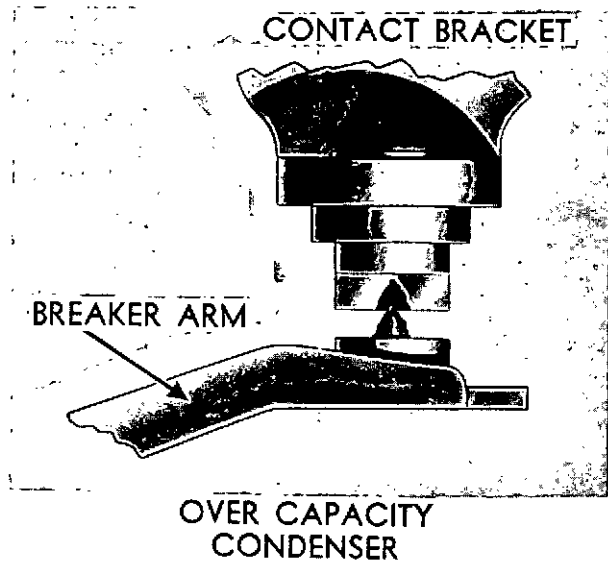


Figure 100 — Badly pitted breaker points caused by arcing due to incorrect condenser capacity

If the points are servicable, they should be dressed down with a fine-cut stone or point file. The file must be clean and sharp — *never use emery cloth to clean contact points.*

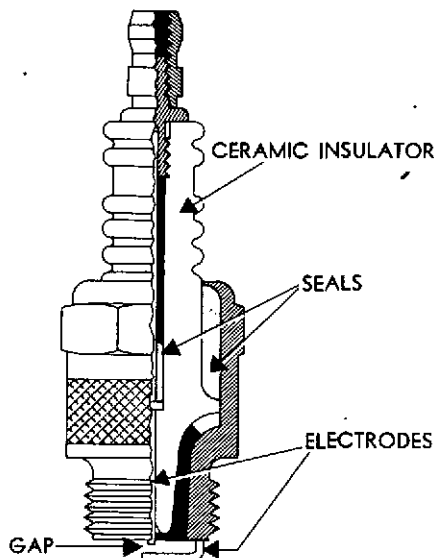
After filing, check the point gap and reset to .020 — the breaker arm must be resting on the high point of the cam during this operation.

When replacing points, make sure they are aligned and that they make full contact. Bend the stationary arm to obtain proper alignment — *do not bend the breaker arm.*

4 — **Lubrication** — is required at the shaft, advance mechanism, breaker cam and pivot. The shaft may be either oil or grease cup lubricated and should be given attention every oil change. Make sure the breaker arm moves freely on its hinge and apply a drop of light oil. A trace of ball bearing lubricant such as Mobilgrease Special (with Moly) should be used sparingly on the breaker cam unless lubricated by a felt wick with a few drops of oil.

**CAUTION:**  
**AVOID EXCESSIVE LUBRICATION — AS THE EXCESS MAY GET ON THE CONTACT POINTS AND CAUSE BURNING.**

**SPARK PLUGS** — A spark plug consists of two electrodes; one grounded to the outer shell of the plug and the other well insulated with a core of porcelain or other heat resistant material. The space between these two electrodes is called the gap which should be set at .025 on standard plugs, and .035 on resistor type plugs for Continental Over-Head Valve Engines. Correct and uniformity of the gaps of all spark plugs in the engine is important for smooth running.



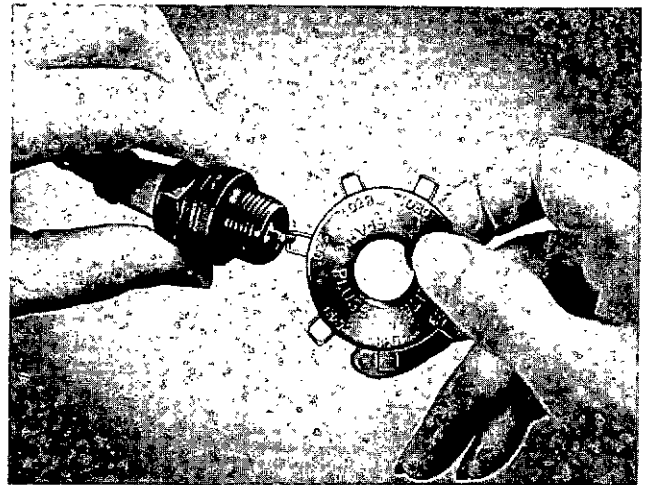
**Figure 101 — Sectional view of spark plug**

Spark plug gaps are best checked with a wire gauge unless the points are dressed to obtain a correct reading with a flat gauge. The adjustment should always be made on the side electrode and

never on the center electrode which may cause a broken porcelain.

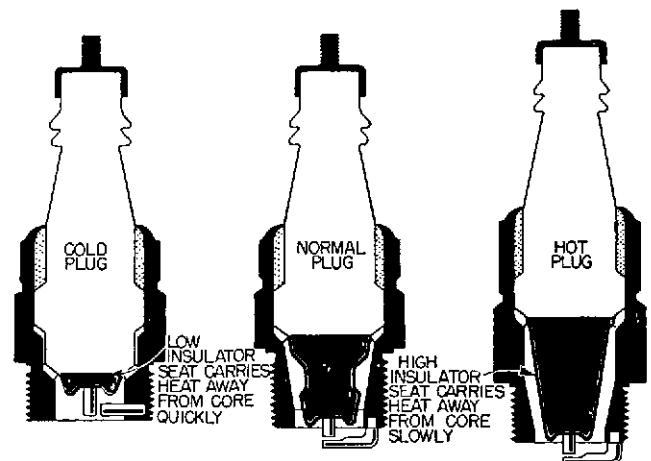
“Gapping” the electrode tip is more easily done with proper tools.

**GAPPING THE SPARK PLUG.** This illustration shows the use of the gapping tool which both measures and adjusts the electrode gap.



**Figure 102 — Checking spark gap**

Spark Plugs must operate within a certain temperature range to give good performance — not too hot and not too cold. The ability of a spark plug to conduct heat away from the center electrode and porcelain is controlled by the design of the shell and insulator — so varying the length of the insulator below the gasket shoulder controls the temperature.



**Figure 103 — Cold — Normal — Hot Spark Plugs**

**Cold-Normal-Hot Spark Plugs**

Examination of a used spark plug will show if it is in the correct heat range for the operating conditions. If the plug runs too hot, the insulator will blister or crack and the electrodes burn away rapidly. If the plug remains too cool — soot and carbon will deposit on the insulator causing fouling and missing.

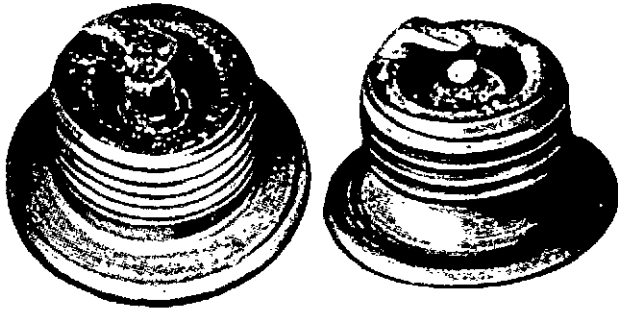


Figure 104 — Faulty spark plugs. Left: cold plug used in an engine that should have a hot plug. Right: hot plug used in an engine that should have a cold plug.

Spark plug electrodes will wear in the course of time and present day fuels have a tendency to form rusty-brown oxide deposits on the insulator tip. Therefore it is necessary to periodically clean the plugs with a plug cleaner and to reset the gaps to specifications.

Spark plugs must be correctly installed in order to obtain good performance from them. It is a simple but important matter to follow the following procedure when installing plugs:

1. Clean the spark plug seat in the cylinder head.
2. Use new seat gasket and screw plug in by hand.
3. Tighten all 14mm plugs to 30# and 18mm to 34# torque with socket wrench of correct size.

### DISTRIBUTOR — IGNITION TIMING With Timing Light

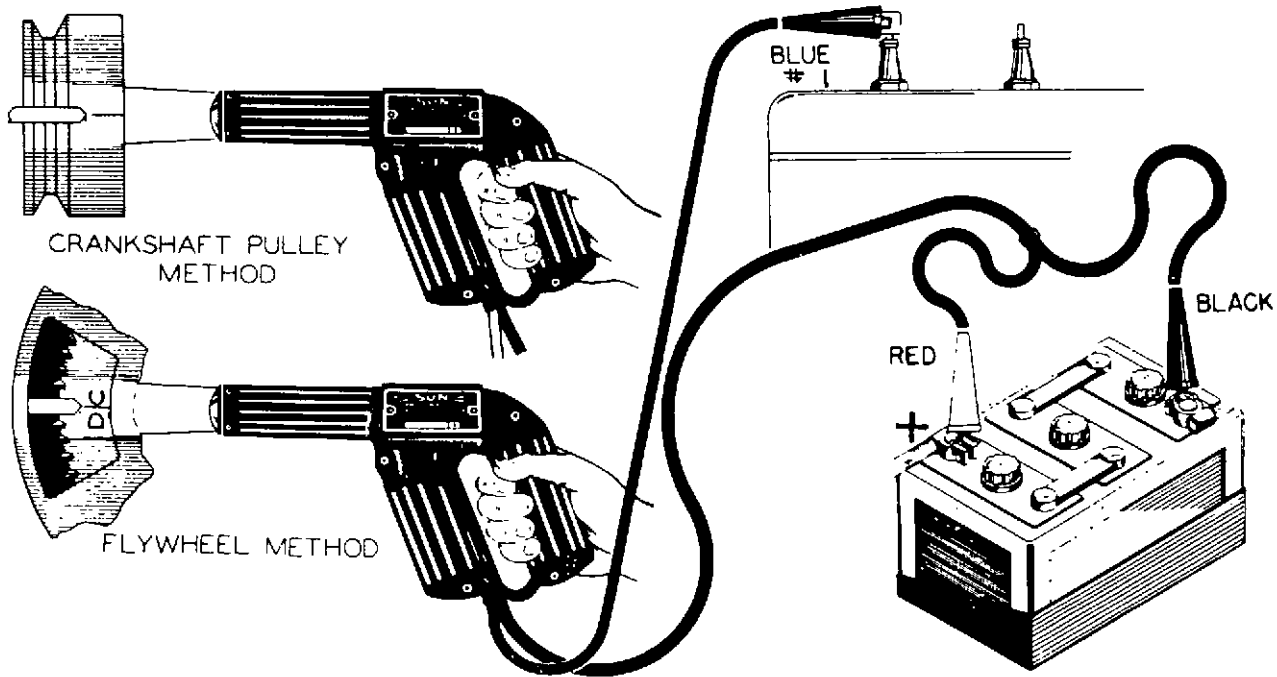


Figure 105 — Schematic diagram showing timing light hookup

Normally Continental Overhead-Valve engines with distributor-ignition are timed to have the distributor points start to open when #1 cylinder is on compression stroke and the flywheel mark "DC" or "IGN" mark lines up with the pointer in the bell housing.

There are two methods of checking ignition timing — *with or without a timing light.*

The *preferred method* is to use a timing light in following sequence:

Paint a line on the flywheel (or in some cases, on the front pulley) so the timing mark will be more legible under the timing light.

1. Clip blue secondary lead of light to the #1 spark plug — leave spark plug wire on plug.
2. Connect primary positive lead (red) to positive terminal of battery.
3. Connect primary negative lead (black) to negative battery terminal.

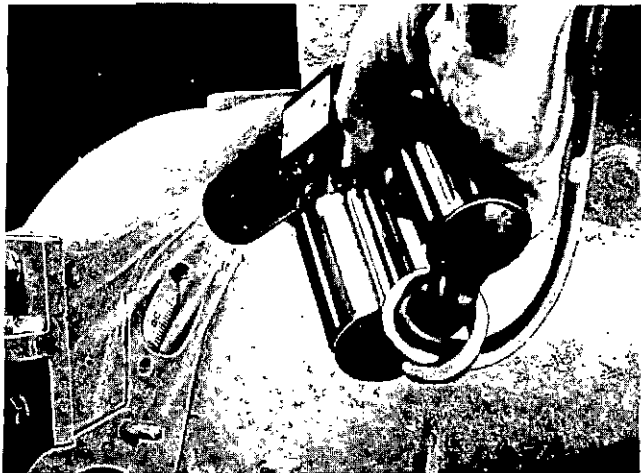


Figure 106 — Checking flywheel timing with timing light

4. Start engine and run at idle speed, 400 RPM or lower, so the automatic advance of the distributor is completely retarded. **THIS IS VERY IMPORTANT TO OBTAIN CORRECT TIMING.**

5. Direct timing light on the flywheel through opening in bell housing and note timing marks as light flashes.

6. Timing is normally at "D.C." or "IGN" unless specified otherwise on your engine specification sheet.

7. To advance timing, turn distributor body clockwise. To retard timing, turn distributor body counter-clockwise.

8. When timing is correct, tighten distributor clamp screw securely. Then recheck timing again with light.

9. This operation is best performed in shaded area, so timing light is visible.

## DISTRIBUTOR IGNITION TIMING

### Without Timing Light

(Emergency Method)

An alternative method without timing light, is as follows:

1. Remove #1 Spark Plug — put your thumb over the spark plug hole and crank engine by hand until air is exhausting.

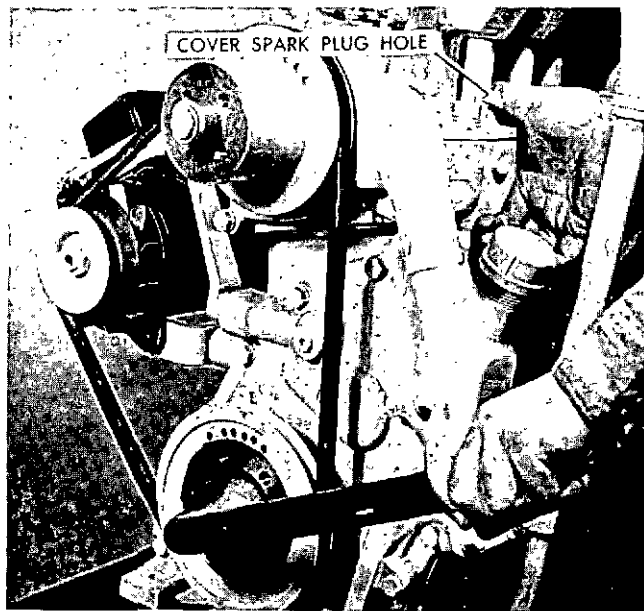


Figure 107 — Checking No. 1 Cylinder on Compression Stroke

2. Set piston on top-dead-center by slowly cranking until "DC" or "IGN" mark on flywheel will line up with the pointer in bell housing.

Note: Some special applications may have timing several degrees before top dead center (BTDC).



Figure 108 — Flywheel timing marks

3. Loosen the distributor clamp bolt and rotate the distributor body until the contact points just *Start to Open*.

This may be more accurately checked by means of a test lamp connected between the distributor primary lead and the negative terminal of the battery — when the points are closed the light will be ON and as soon as the points break the light will go OFF.

4. Tighten distributor mounting bolts.

In high altitudes there is less tendency for sparking as well as low altitudes with premium gasolines. In such cases, improved performance may be obtained by advancing the spark not to exceed 4 degrees ahead of specified setting.

**CAUTION: WHEN ENGINE SPECIFICATIONS HAVE SPECIAL TIMING OTHER THAN TOP-DEAD-CENTER — THEY MUST BE FOLLOWED IN ORDER TO OBTAIN SATISFACTORY SERVICE IN SPECIAL APPLICATIONS OR HIGHER ALTITUDES.**

### MAGNETO - IGNITION

Magneto-Ignition is furnished on Continental Over-Head Valve engines on special applications to provide a complete ignition system without requiring a battery.

The magneto comprises all the parts of the battery-ignition system with the exception of the battery, and in addition, means for generating current impulses directly in the primary winding — which is in effect a spark coil.

The advantage of the magneto is this self-contained character. All the elements of the ignition system are in one compact unit, from which it only requires a low-tension cable to the ignition switch and high-tension cables to the spark plugs.

#### Operation

Magnetos are of the rotating magnet type with jump-spark distributor and are flange mounted to an accessory timing gear drive.

The rotation of the magnetic rotor sets up an alternating magnetic flux which cuts the primary winding each time it rises and falls. This induces electric currents, alternating in direction, to flow in the primary circuit during the intervals the breaker points are closed.

The current in the primary winding of the coil establishes a magnetic field which interlocks the turns of the coil secondary winding, this field reaching its maximum simultaneously with the primary current. Breaker point action at the instant of maximum primary current and field, opens the primary circuit so the primary current can't flow — causing the immediate and complete collapse of the magnetic field existing in the coil.



Figure 109 — Magneto installation

### SCHEMATIC DRAWING OF MAGNETO IGNITION

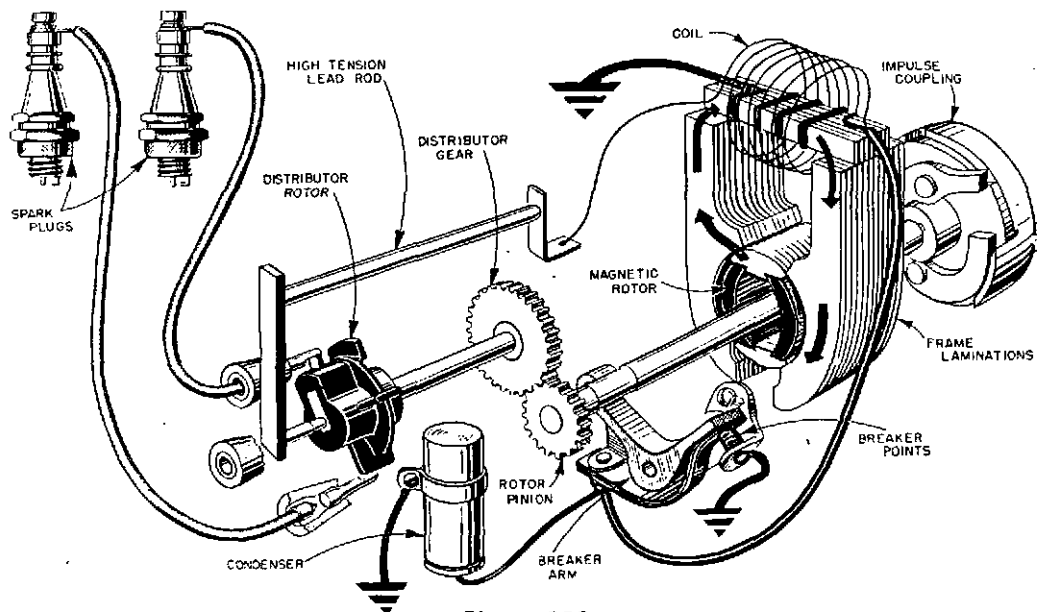


Figure 110

The ratio of turns in the coil secondary winding to those of the primary is very high so the induced voltage in the secondary winding is also very high.

The self-induced voltage occurring in the primary winding, as a result of the quick break of the

primary circuit, is absorbed by the condenser which is shunted across the breaker points. This action promotes a more rapid collapse of the primary field and at the same time reduces contact point burning caused by arcing.

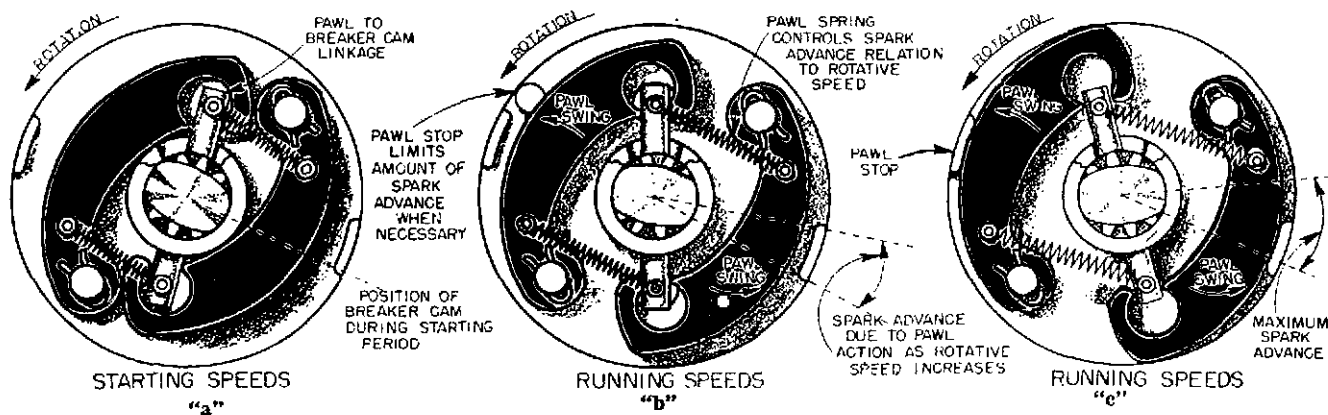
### IMPULSE COUPLING

All magnetos have an impulse coupling which assists starting by automatically retarding the ignition spark during the starting operation and at the same time producing an intense, hot spark — which would otherwise be impossible at very low engine speeds.

This device prevents the rotor of the magneto from turning during the starting operation until the engine piston is about at top-dead-center, at which instant the rotor is snapped forward at very high speed, producing an intense spark which is

automatically retarded to prevent back-firing. Since the point at which the release occurs can be controlled in the coupling construction — it is possible to provide an automatic retard of the ignition spark during the starting period.

Basically the impulse coupling consists of a shell and a hub, connected together by a strong spring. One half of the coupling (shell) is fitted to a drive member on the engine drive shaft — while the other half (hub) is keyed to the magneto rotor shaft.



**Figure 111 — Operation of Automatic Spark Advance Rotor**

### AUTOMATIC SPARK ADVANCE

In slow speed operation, a pawl on the magneto half of the coupling engages a stop pin mounted on the magneto frame — which prevents further movement of the rotor. The engine half of the coupling continues to rotate and the relative change in position winds up the connecting spring.

When the desired point of ignition spark is

reached, the pawl is released and the drive spring snaps the magneto rotor forward at high speed through its firing position.

As the engine speed increases, the centrifugal force acting on the pawls — withdraws them to a position not engaging the coupling stop pin — the impulse coupling then acts as a solid drive member.

## TIMING MAGNETO TO ENGINE

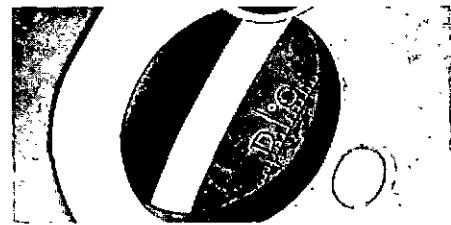
1. Remove rear (#4 spark plug. Put your thumb over the spark plug hole and crank engine by hand until air is exhausting.

Figure 112



2. Set piston on top-dead-center by slowly cranking until "DC" mark on flywheel will line up with the pointer in the flywheel housing.

Figure 113



3. With magneto removed from the engine — put it firmly in a vise lined with soft cloths and turn drive lugs of impulse coupling until lead to rear plug (#4) fires. Bosch and Wico magneto indicate #1 lead so rear plug is directly opposite — F. M. magnetos are not marked, but rear plug lead is at 5 o'clock position when facing distributor end.

Figure 114



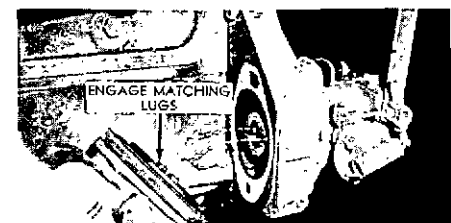
4. Check front end governor drive and make certain that punch-marked tooth of timing gear is meshing between the two punch-marked teeth of the governor drive gear.

Figure 115



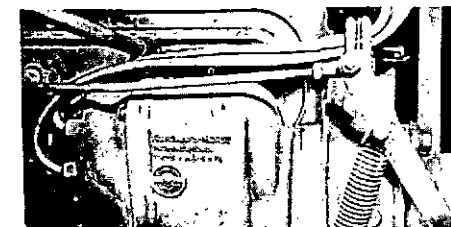
5. Turn back magneto drive lugs of impulse coupling counter-clockwise about  $\frac{1}{4}$  turn so as to mesh with the driving slots of the engine drive member.

Figure 116



6. Position magneto on engine and tighten mounting bolts moderately and connect wires to spark plugs.

Figure 117



7. Start and idle engine 600 R.P.M. and using a timing light connected to rear plug and battery source — check to see if timing is directly at "IGN-M" indicated by pointer.

Figure 118



If not, rotate magneto assembly until timing is correct, then tighten magneto mounting bolts.

**IMPORTANT:** Engine specifications require magnetos with the correct amount of "Built-in Lag" — which permits timing the magneto to the engine correctly as outlined.

*Do not substitute other magnetos.*

## SECTION VIII ENGINE REPAIR AND OVERHAUL

This section includes instructions for repairs and overhaul of the component units of Continental Red Seal four 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

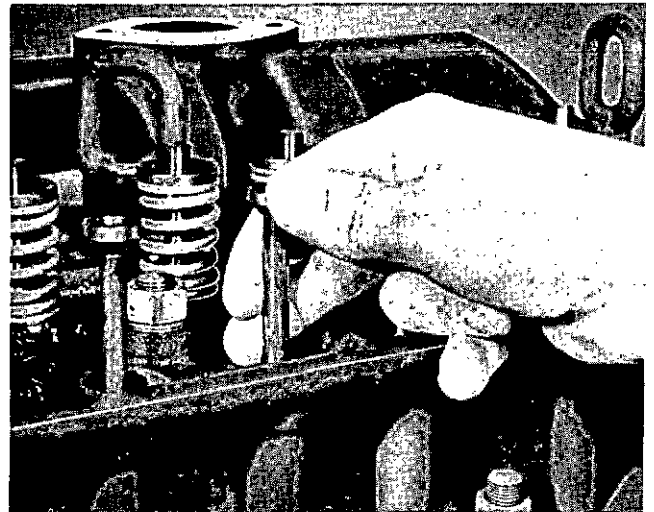


Figure 119  
Snapping Push Rod out of Ball Socket of Tappet

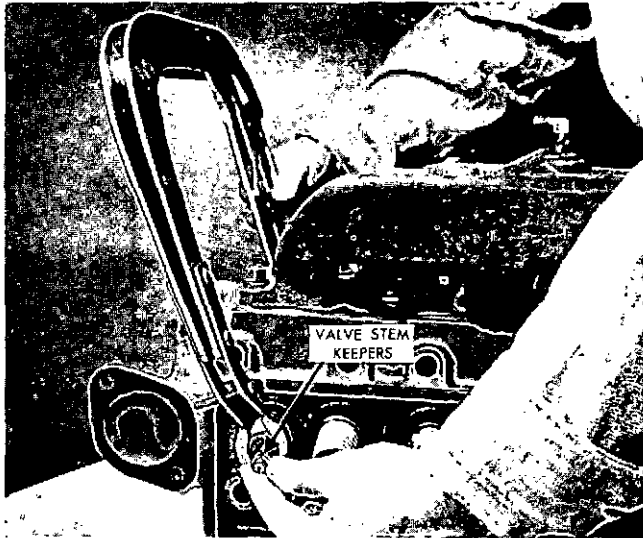
rods out and leaving the tappets in place. (If tappets are lifted out of the guides they will have to be reassembled through the opening in the block if only the cylinder head is removed for servicing.)

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.

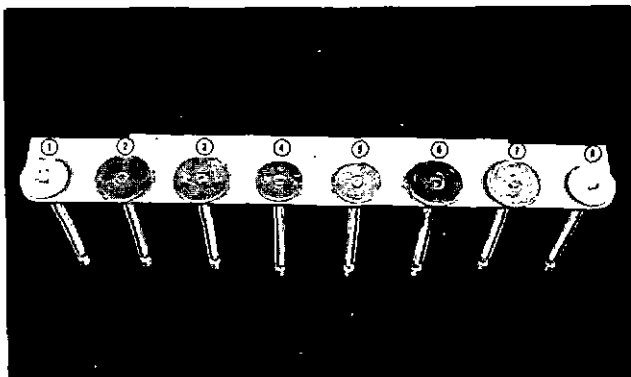
2. Using a C type valve spring compressor, remove the valve spring retainer locks, retainers,



**Figure 120**  
**Removing Valve Springs**

springs and oil seals on intake valve stems — placing all parts in a container of solvent.

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.



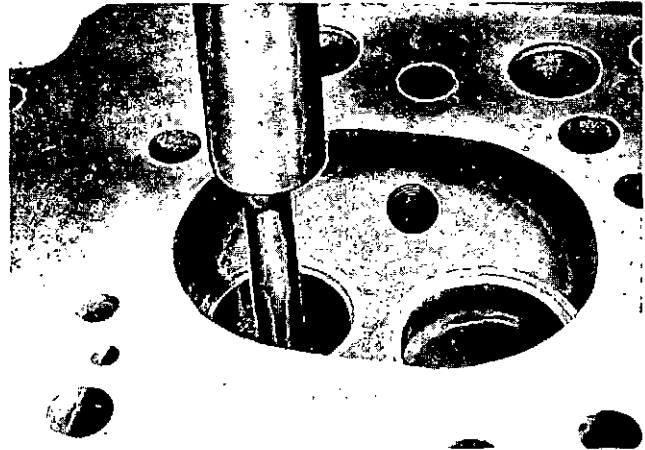
**Figure 121**  
**Valves in Rack**

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

### 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 ac-



**Figure 122**  
**Removing Valve Guides from**  
**Combustion Chamber Side**

tual amount it has increased. Remove all valve guides when necessary by pressing them out from the combustion chamber side.

3. Replace worn guides as required by pressing in new guides to the correct depth as given in the Section XI limits and clearance data.

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.

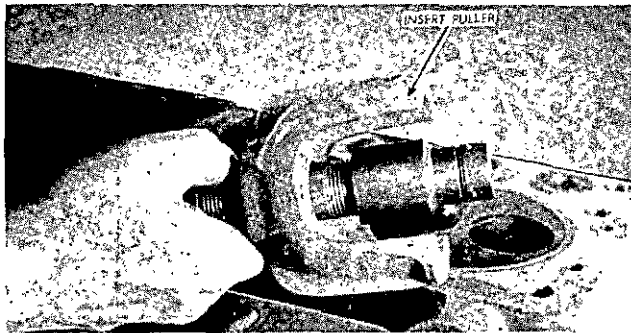
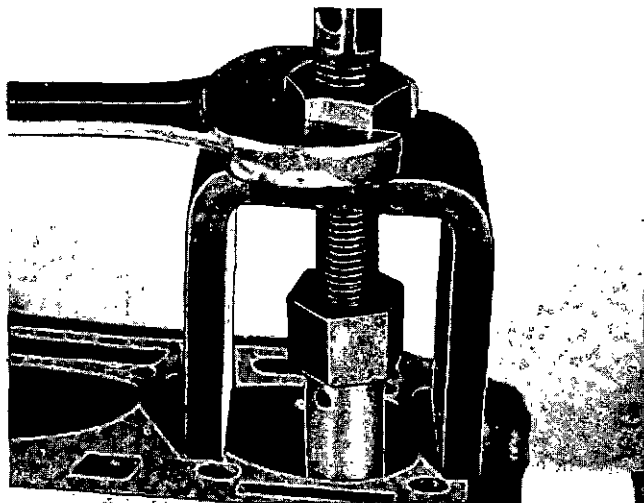


Figure 123  
Exhaust Valve Seat Insert Removal Tool



Removing Exhaust Valve Seat Insert  
Figure 124

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.

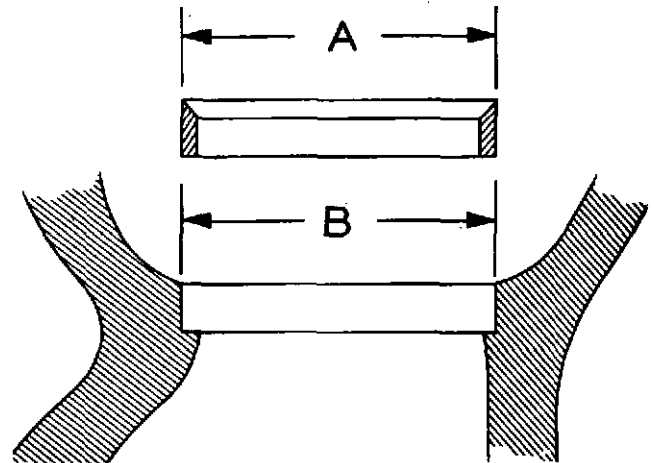


Figure 125  
Insert and Counterbore

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
Z	1.2545/-1.2535	1.2505/1.2495	.005/.003
G157	1.3485/1.3475	1.3445/1.3435	.005/.003
G 193 G4193	1.5205/1.5195	1.5165/1.5155	.005/.003
E	1.442/1.441	1.438/1.437	.005/.003
H	1.5785/1.5775	1.5745/1.5735	.005/.003
J	1.817/1.816	1.8130/1.8120	.005/.003

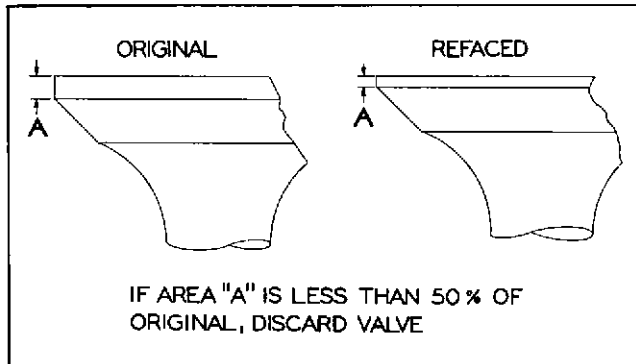
When **OVERSIZE** inserts are used, dimensions of the insert and counterbore increase proportionately (.010, .020, .030 — depending on the oversize).

New insert installation should have .003-.005 press fit. Chill insert in container between dry ice for 30 minutes before assembling.

Insert may then be installed in the counterbore using a pilot and pressing in place. This assures it being seated firmly on the bottom of the counterbore.

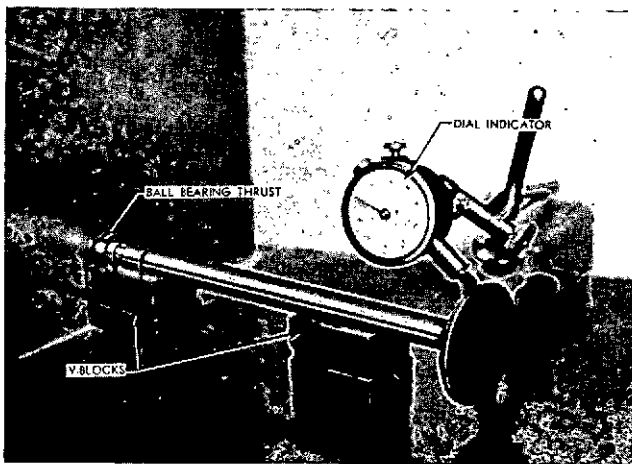
## VALVES

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 126**  
**Allowable Head Thickness of Refaced Valves**

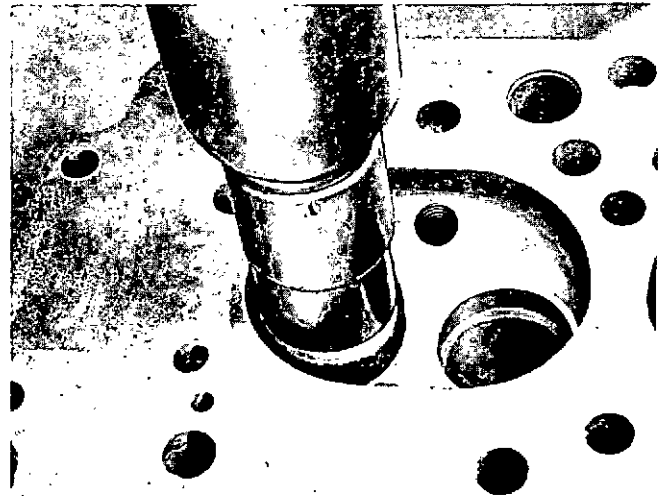
2. All valves having less than 50% margin thickness (outer edge of valve head) after re-facing has been completed must be replaced. To check this dimension, compare the refaced valve with a new valve.



**Figure 127**  
**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.

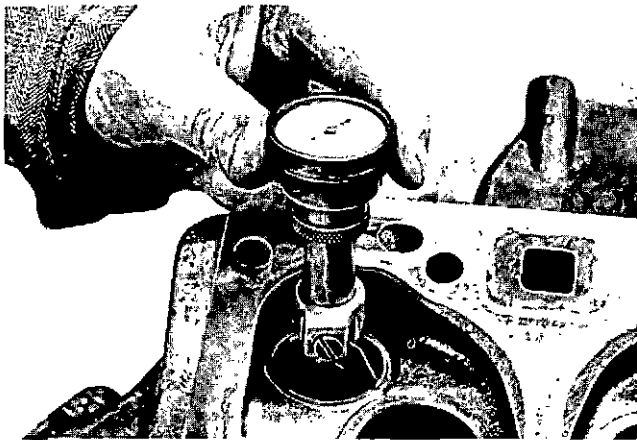


**Figure 128**  
**Grinding Valve Seat**

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.

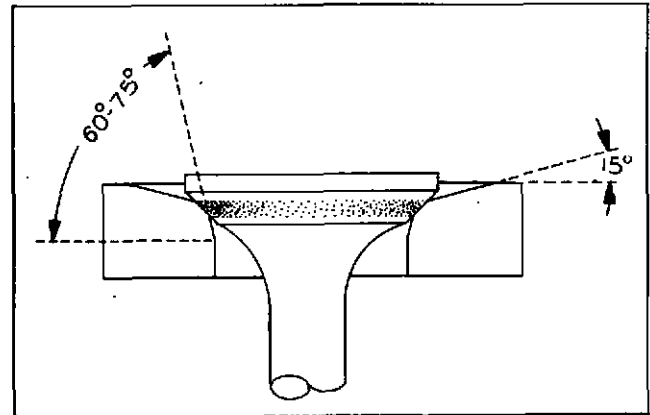
5. After the valves and seats have been re-faced and reground, coat the seat lightly with Prussian blue and drop the valve into position, oscillating it slightly to transfer the blue pattern to the valve face. This should show a contact width of 1/16" to 3/32" and should fall well within



**Figure 129**  
Checking Valve Seat Run-out

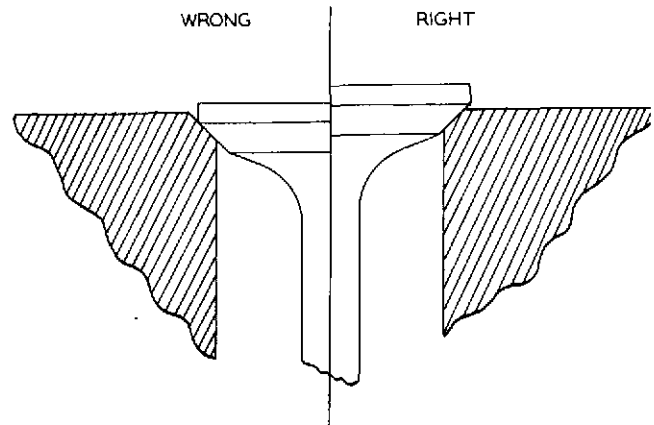
the width of the valve face, leaving at least 1/64" on either side where the blue does not show.

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 130**  
Method of Narrowing Valve Seats

Never allow valves to set down inside the seat.



**Figure 131**  
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.

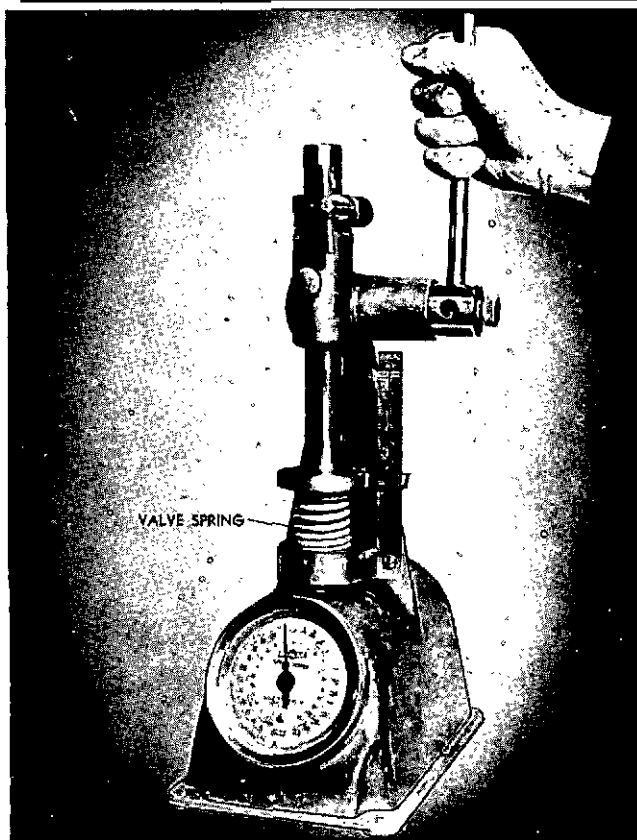


Figure 132  
Valve Spring Tester

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.

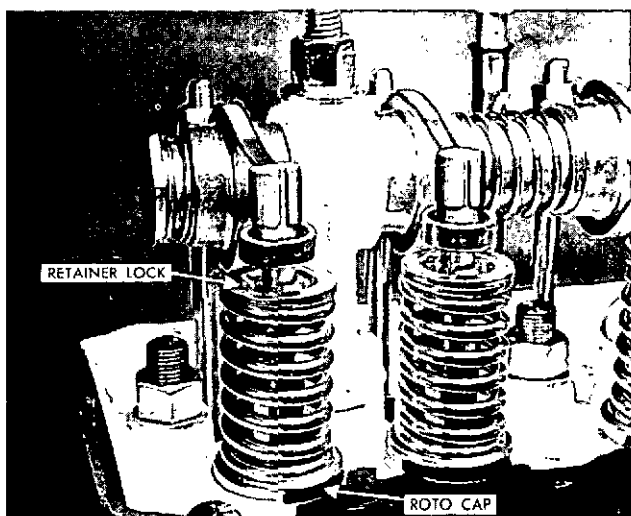


Figure 133  
Valve Assembly

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.

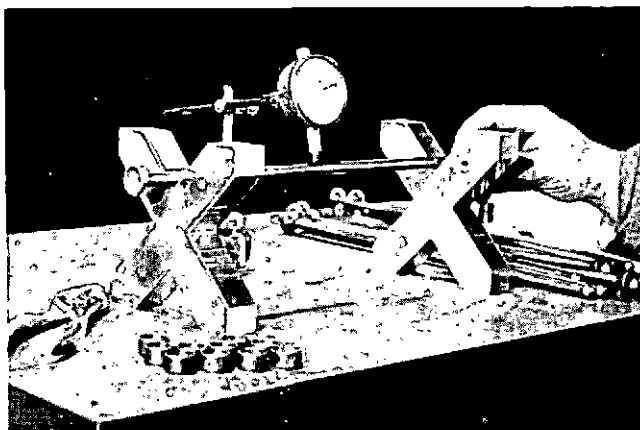


Figure 134  
Push Rod Inspection for Runout

### 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 crosswise. The maximum permissible is .004 low in the center lengthwise, gradually decreasing towards the ends, or .003 crosswise or in localized low spots. Cylinder head or block must be resurfaced if these limits are exceeded.



Figure 135  
Checking Cylinder Head Flatness



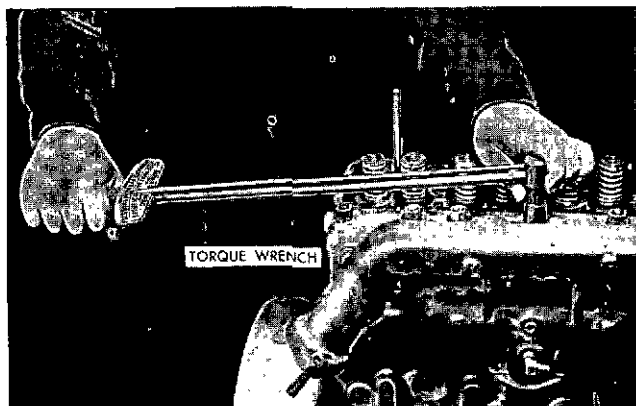
**Figure 136**  
**Checking Cylinder Head Flatness Crosswise**

2. Use new cylinder head gasket, which is pre-coated, thus no cement is required.

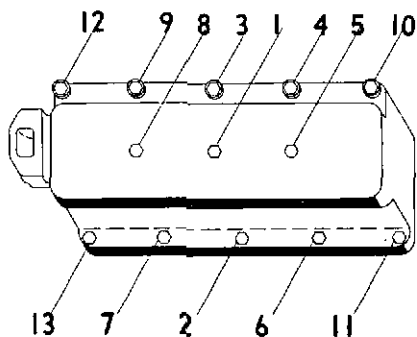
(When difficulties are encountered with gasket sealing, coat both sides of gasket with heat resisting aluminum paint and assemble immediately.)

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.

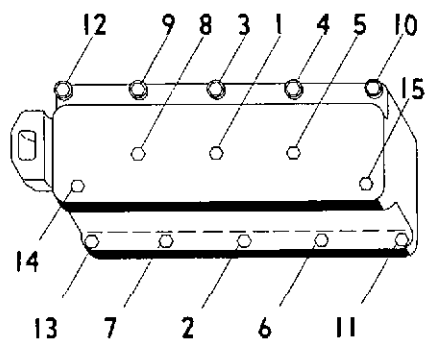
4. Tighten with torque wrench in recommended sequence to the correct torque shown in Chart by going over them two times before pulling them down to the final torque specification on the third round.



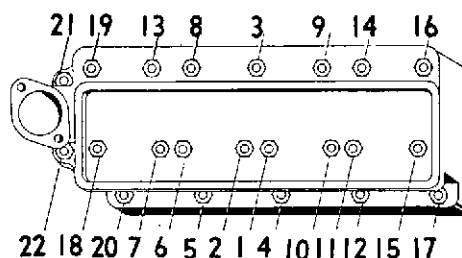
**Figure 137**  
**Torquing Cylinder Head Nuts**



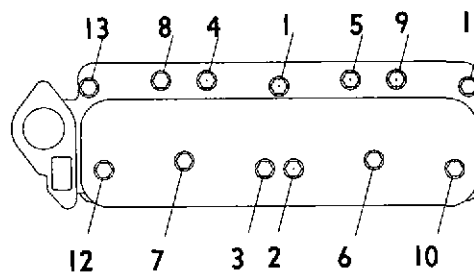
**Figure 138**  
**Z-129**  
**Cylinder Head Tightening Sequence**



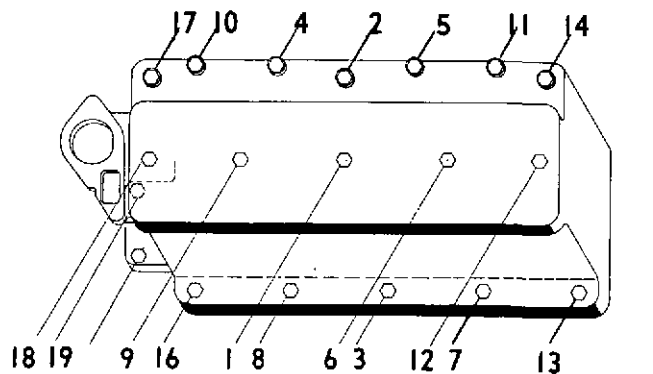
**Figure 138A**      **Z-134**



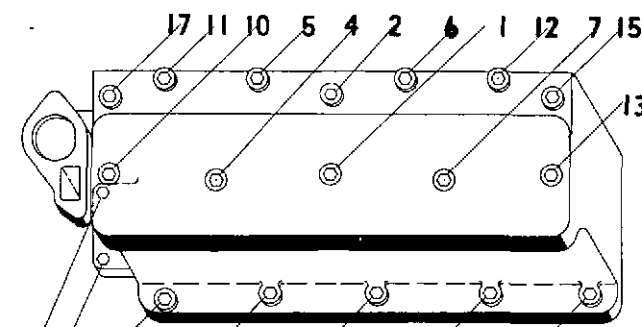
**Figure 139**      **G Series**



**Figure 140**      **E Series**



**Figure 141**      **H Series**



**Figure 142**      **J Series**

### CYLINDER BLOCK

All of the 4 cylinder overhead-valve engines except the G-193 models, have cylinder barrels with replaceable sleeves, commonly termed the "wet-type", meaning that they complete the water jacket of the cylinder block when they are assembled in place. The G193 and G4193 engines have no sleeves.

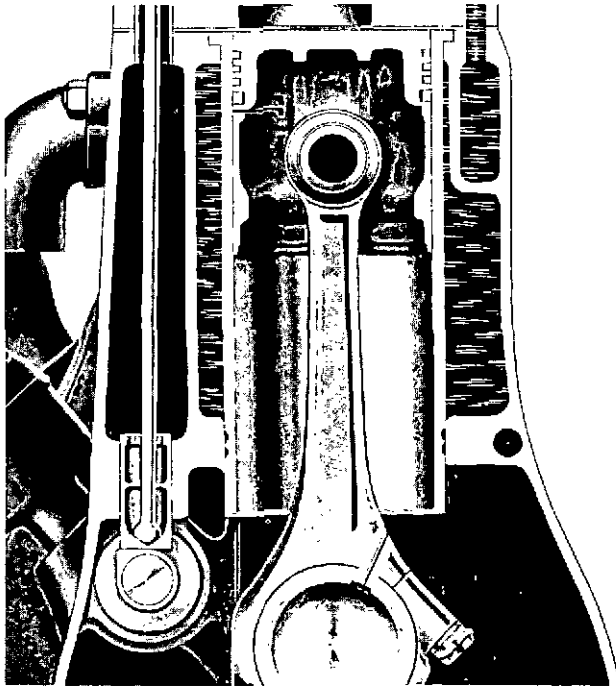


Figure 143 — Sectional View of Cylinder

When cylinder bores of wet-sleeve engines are worn more than .008 it is more economical to replace the sleeve and use a standard piston and ring assembly instead of reboring the cylinder and assembling an oversize piston. When worn less than .008, a set of service rings may be used to restore the engine to satisfactory operating condition.

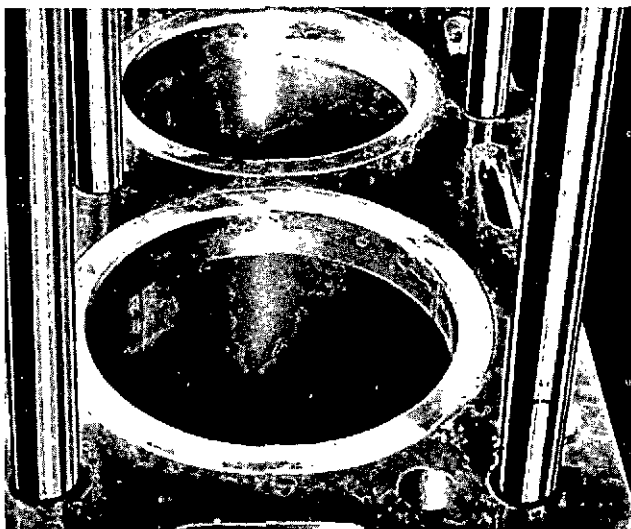


Figure 144  
Deposits on Cylinder Sleeve Before Cleaning

### 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.

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



Figure 145 — Measuring Original Diameter of Sleeve

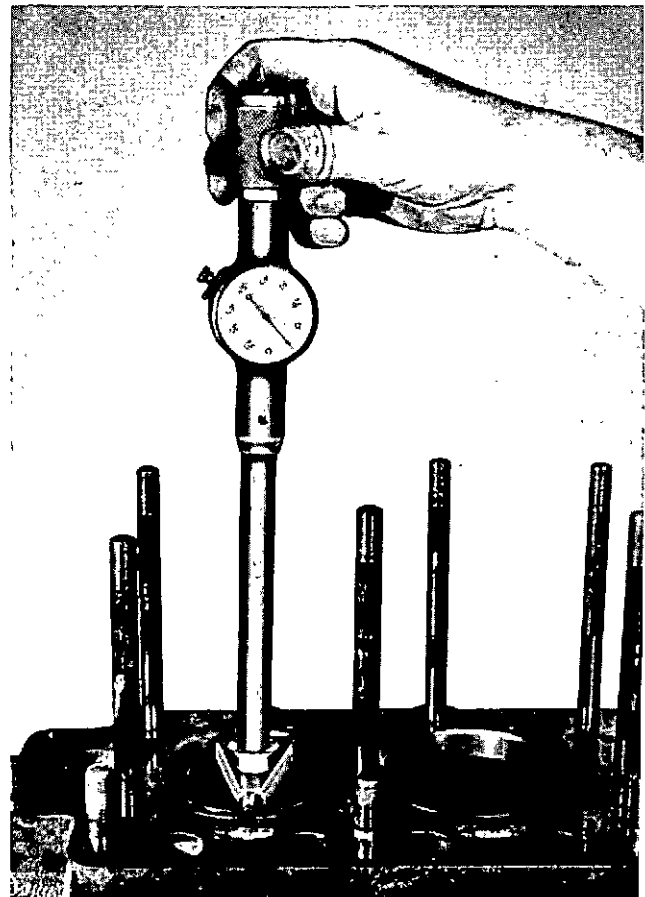


Figure 146 — Measuring Original Diameter of Sleeve with Bore Gauge

3. Check in same manner the top of the ring travel area approximately 1/4" below the 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.

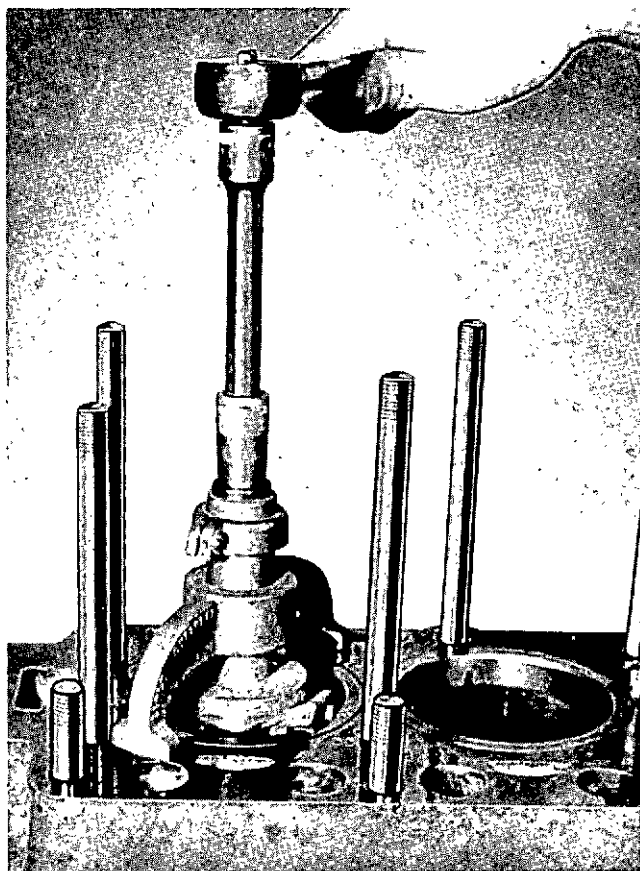
**RE-RINGING** (For bore wear less than .008)

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.

With the head removed, there is no compression on the sleeves to hold them in place and it may be necessary to make some form of clamp to hold them while ridge reaming.

A flat piece of steel with a slot can be slipped over one of the cylinder head studs and

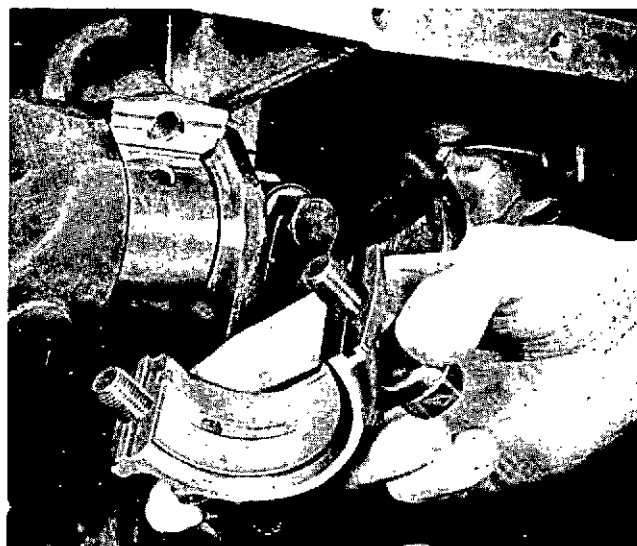


**Figure 147 — Ridge Reaming Top of Cylinders**

with the outer end resting on the milled surface of the block, it can be drawn down on the flange of the sleeve to hold it firmly in position.

2. Drain the crankcase and remove the oil pan.

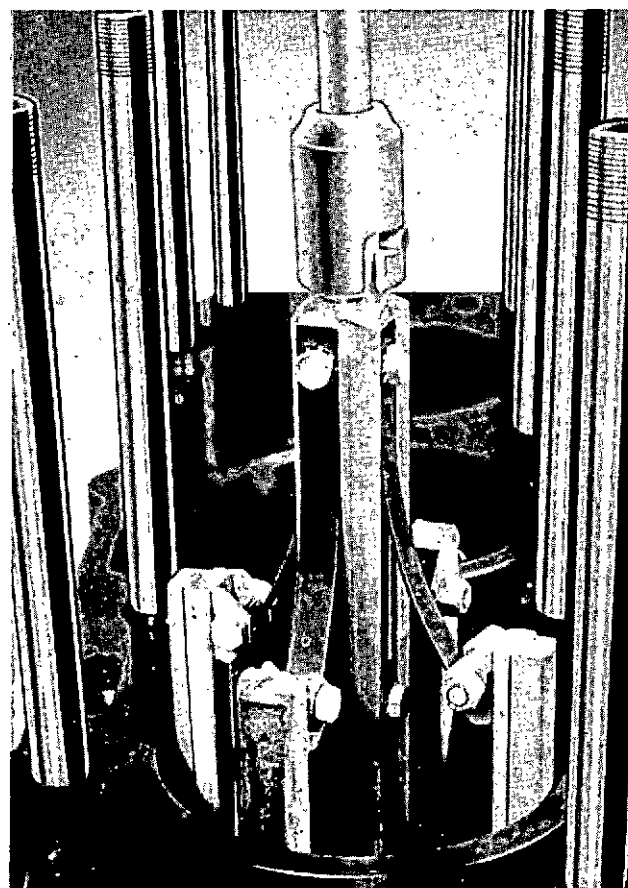
3. Remove cotter pins and nuts from the connecting rod bolts, permitting removal of caps. Keep the caps and bolts in numerical order so that when the pistons and rods are removed from the engine, the cap can be reassembled and kept



**Figure 148 — Removing Connecting Rod Cap**

with its mating part. If not already numbered, do so at this time.

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.



**Figure 149 — Breaking the Cylinder Wall Glaze**

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.

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. Check the pistons for excessive ring groove wear usually found in the top groove, which can be salvaged by installing a 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.

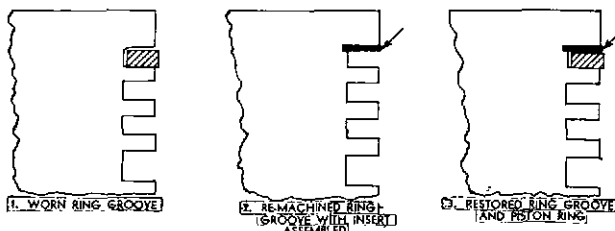


Figure 150  
Ring Groove Insert

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.

#### RE-SLEEVE BLOCK (Wet-Sleeve Type)

When the bore wear measures over .008 or bores are badly scored or damaged, re-sleeving is recommended, using standard piston and ring assemblies, which are available in complete kits including sleeves, pistons, piston pins, rings and piston pin retaining rings.

1. Pull the sleeves, using a puller of the type shown in the illustration which makes this a simple, easy operation.

2. Clean out the counterbore thoroughly, removing all rust and scale to permit metal to metal contact of the new sleeve with the block.

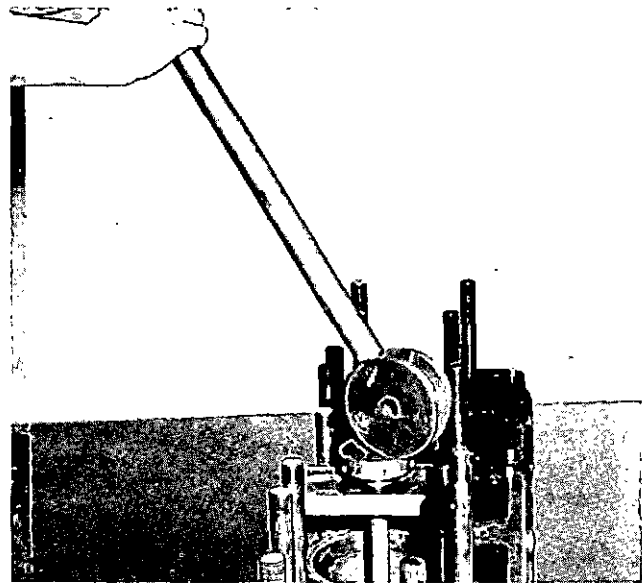


Figure 151 — Cam-Action Sleeve Puller

3. Clean the lower seal contact so that the new seals when assembled will not be torn or damaged by particles of rust or corrosion protruding from the machined surfaces.

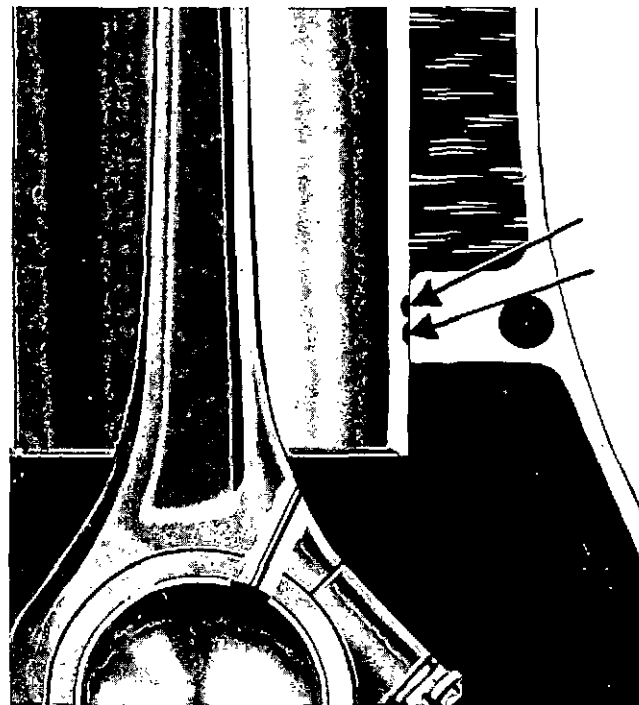


Figure 152 — Cylinder Section Showing Seals

4. A new sleeve should first be dropped in place in the cylinder block, without the seals, to determine the amount it protrudes above the top of the block.

Lay a straight edge across the top of the sleeve and use a feeler gauge to measure the height. This amount should be from .001 - .004, thus permitting a slight pressure build-up where the gasket contacts the sleeve, assuring a good seal at this point.

It may be necessary to shift the sleeve from one bore to another until the desired projection is obtained or shims of .0015 and .003" thickness are

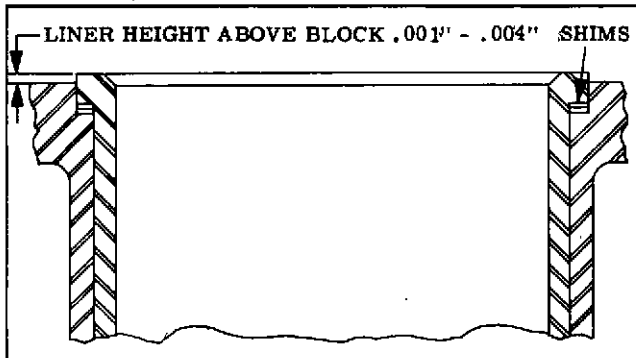


Figure 153 — Height of Sleeve Above Block

available which, when assembled around the sleeve, will raise it the desired amount.

5. Remove the sleeve, selected for each bore, and assemble new seals in the grooves provided for them.



Figure 154 — Assembling Seals on Sleeve

The seals must not be twisted during assembly; otherwise they are very likely to leak. To prevent any possibility of twist slip the fingers under the seals, sliding them out of the grooves in the cast iron sleeves and running the finger

around inside two or three times, allowing the seal to slide back in place without a twist.



Figure 155 — Installing Sleeve in Block

6. Thoroughly lubricate the seal with either petroleum jelly or hydraulic brake fluid, after which the sleeve may be dropped back into the bore to a point where it is resting on the seal.

7. Press the sleeve in place with the palm of the hand, a simple operation, when the seal con-

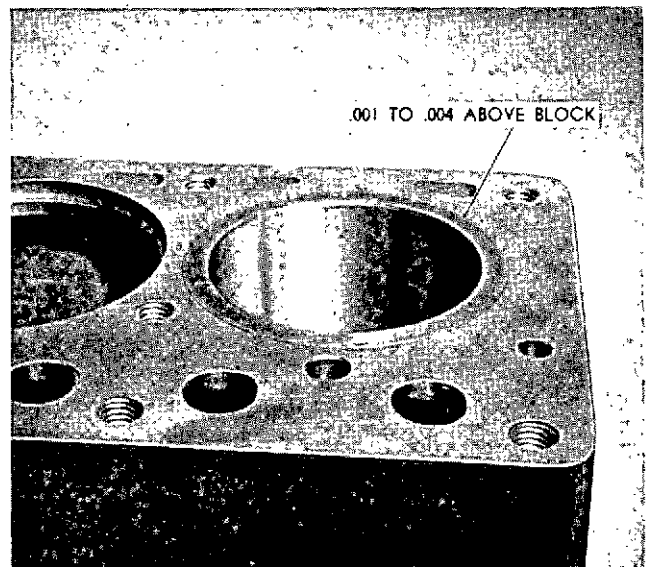


Figure 156 — Sleeve Pressed in Place

tact bore in the block and the chamfer on the upper corner of the bore is thoroughly cleaned.

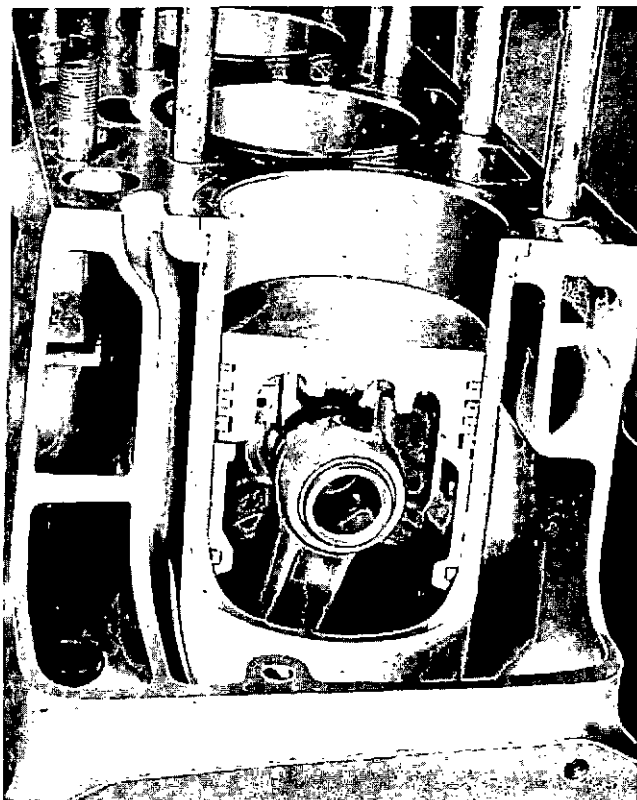


Figure 157 — Section Showing Sleeve Installed

**PISTONS**

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.

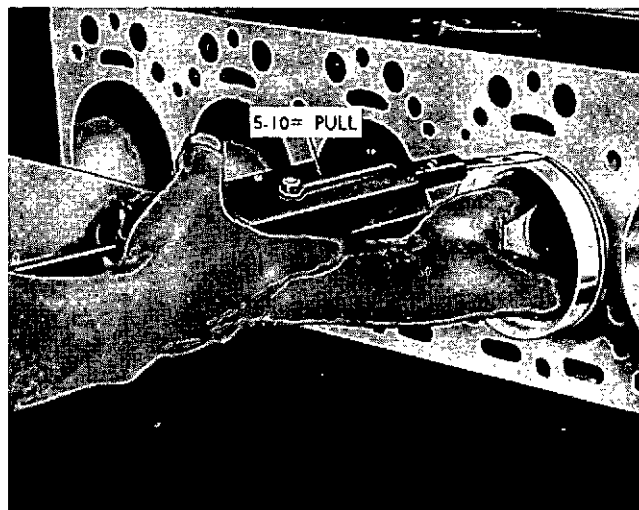


Figure 158 — Checking Piston Fit in Bore

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-LB. PULL**

Z SERIES . . . . .	.003
G157 . . . . .	.002
G193-G4193 . . . . .	.0035
E SERIES . . . . .	.004
H SERIES . . . . .	.004
J SERIES . . . . .	.004

Figure 159 — Piston Fit Chart

**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.

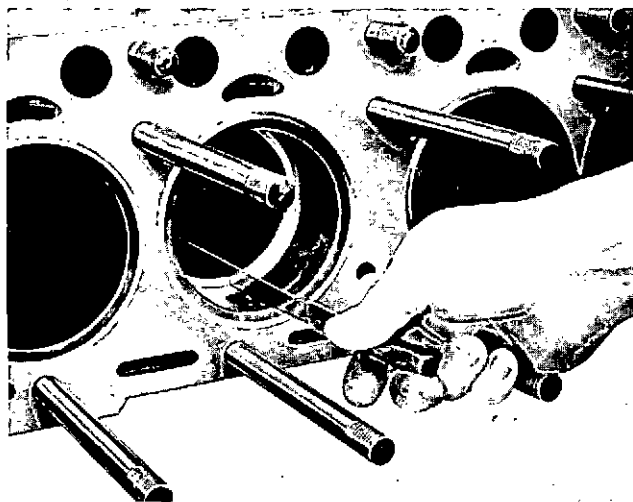


Figure 160 — Checking Ring Gap

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



Figure 161 — Filing Piston Ring to Increase Gap

gap, they may be filed either in a ring filing fixture 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 increase 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.*

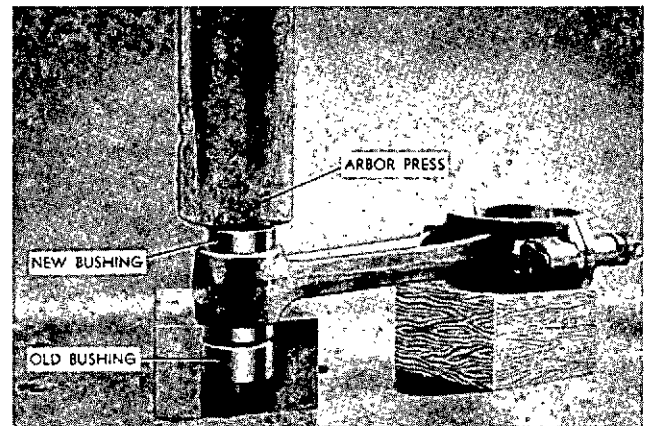


Figure 162 — Pressing in Piston Pin Bushing

### 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 piston 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.

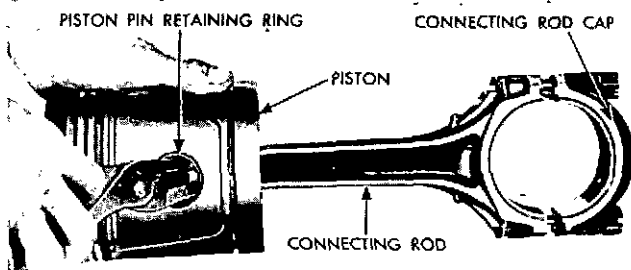


Figure 163

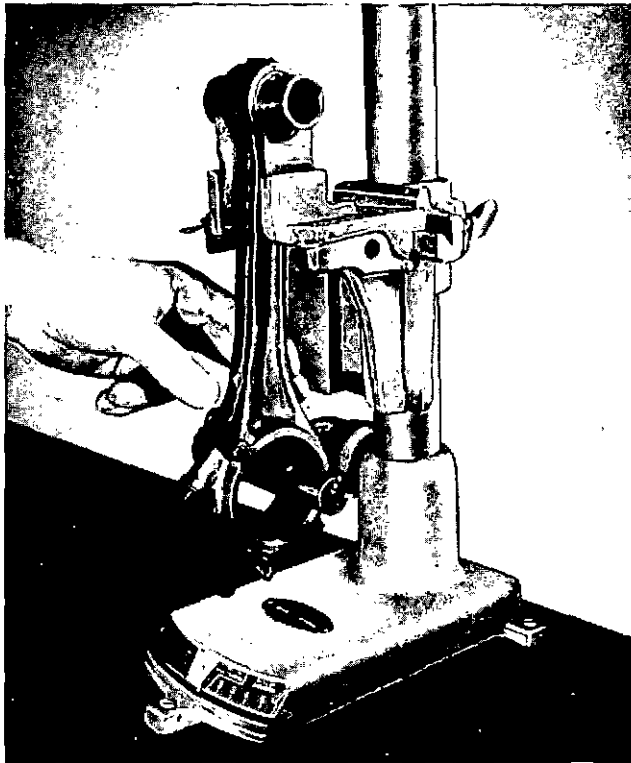


Figure 164 — Checking Connecting Rod for Twist

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.

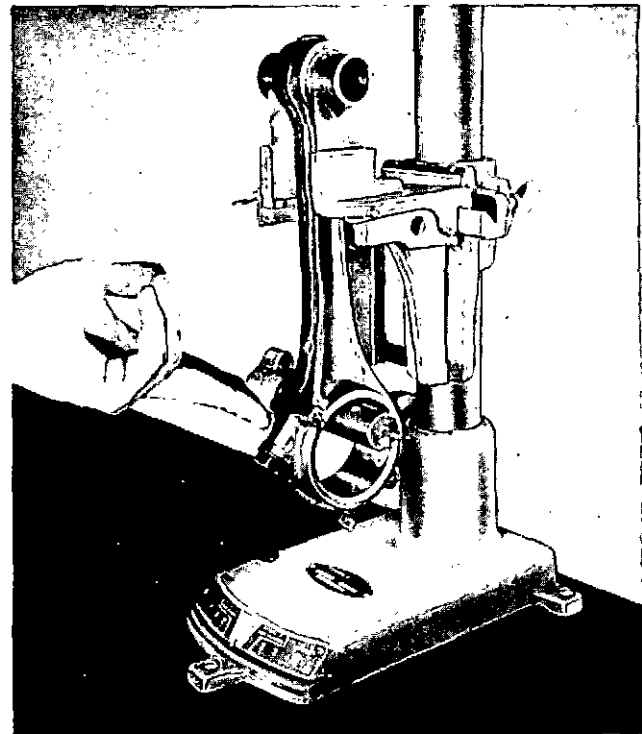


Figure 165 — Checking Connecting Rod for Alignment

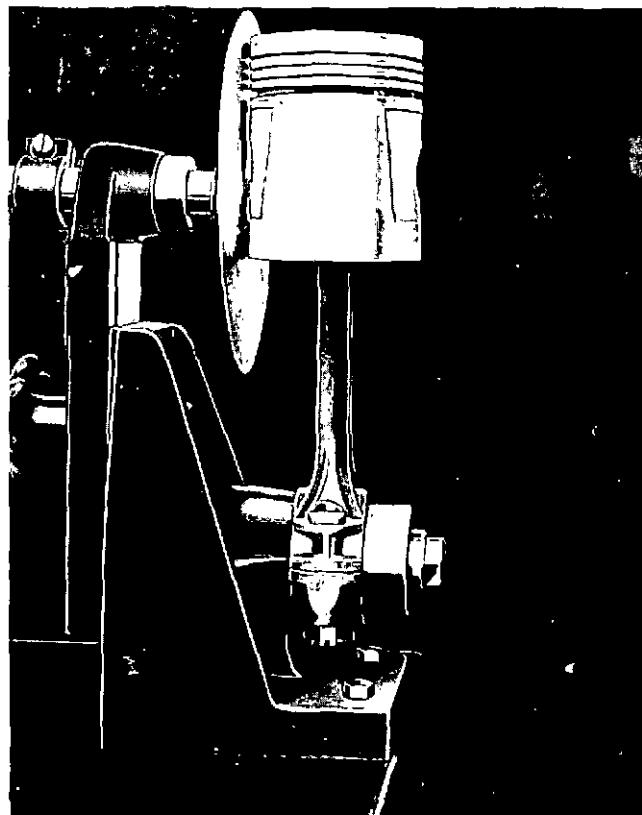


Figure 166 — Checking Connecting Rod Assembly for Squareness and Twist

### 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 167  
Checking Ring Clearance in Groove

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.

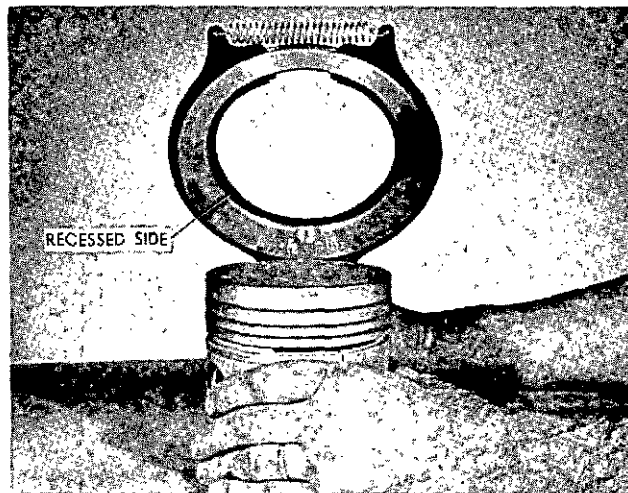


Figure 168  
Installing Rings with Ring Expander Tool

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. 169.

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

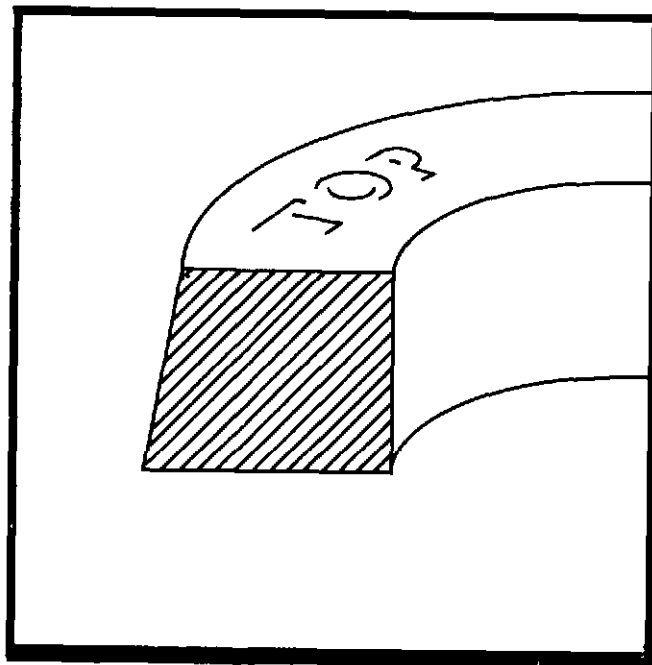


Figure 169  
Install Tapered Rings with "Top" Side Up

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.

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 starting jaw and washer and remove the crankshaft pulley with a puller.

2. Remove the screws holding gear cover to the front of the block.

3. Remove the oil pump suction tube preparatory to checking the crankshaft journal and main bearing clearances.

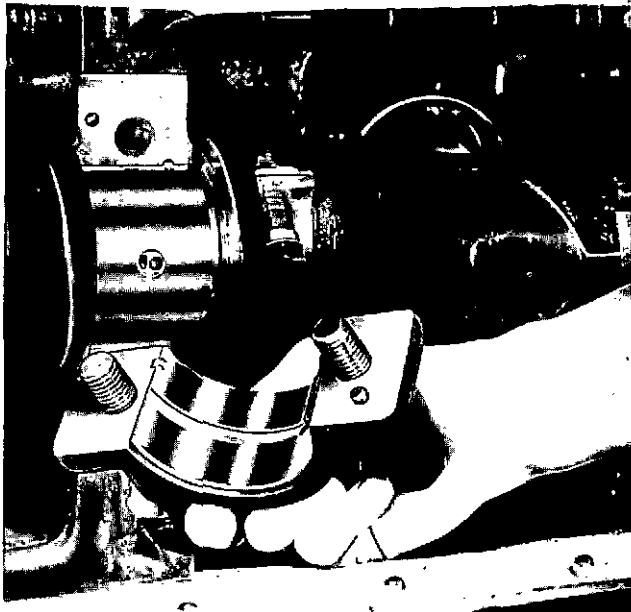


Figure 170—Inspecting Main Bearing and Crankshaft

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

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.

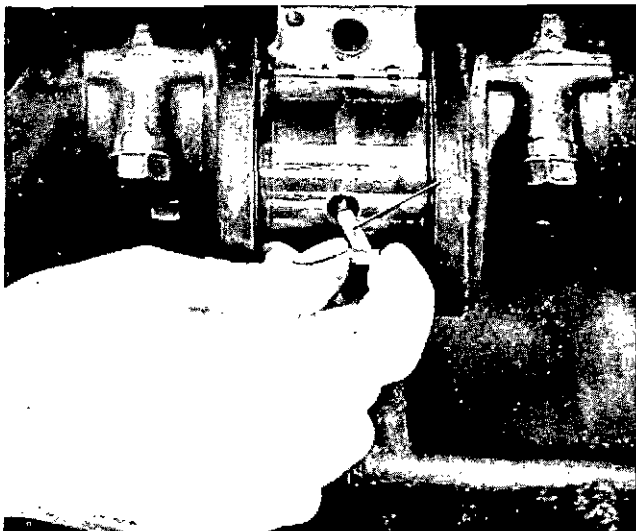


Figure 171 — Inserting Bearing Removal Pin

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 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 172 — 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.

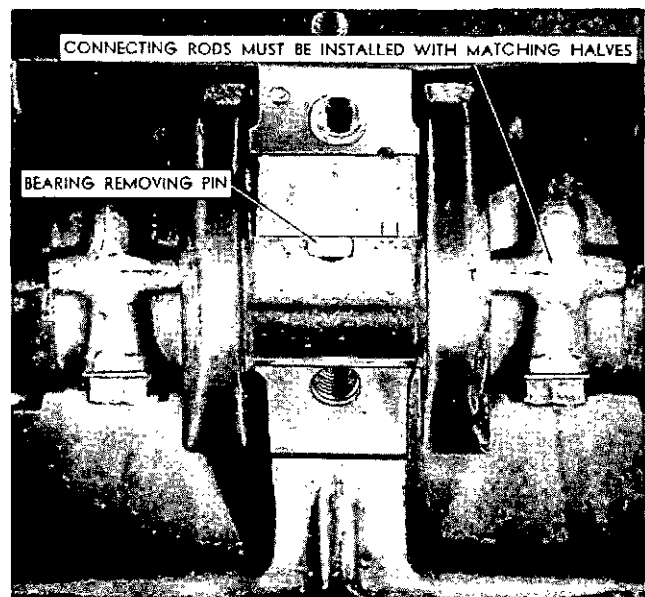


Figure 173 — Removing Upper Half of Main Bearing

6. The crankshaft is scientifically heat-treated or Tocco-hardened, so that the journals are subject to very little wear and it is normally safe to use unless 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  $\frac{1}{2}$ " wide and approx-

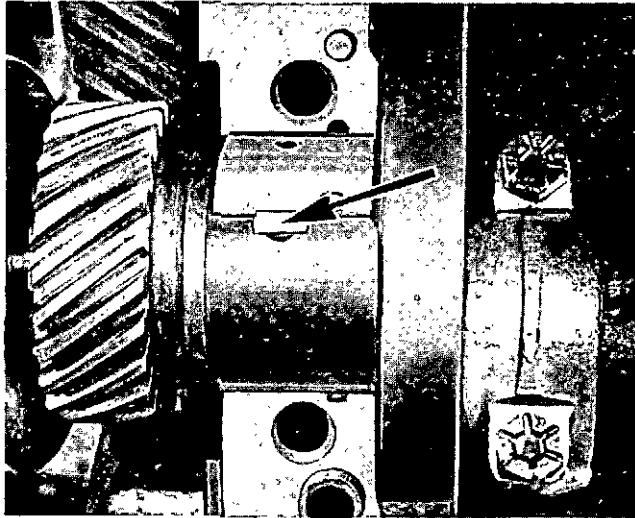


Figure 174  
Replacing Bearing

imately  $\frac{1}{8}$ " shorter than the length of the bearing, dressing all edges carefully to be sure there are no burrs to mark the bearing.

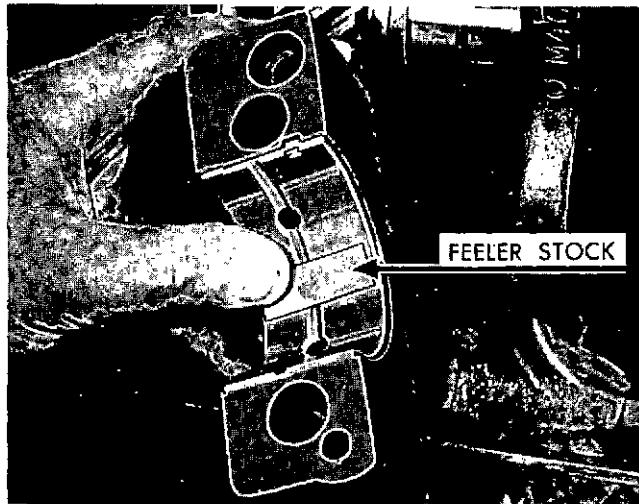


Figure 175  
Checking Bearing Clearance

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.

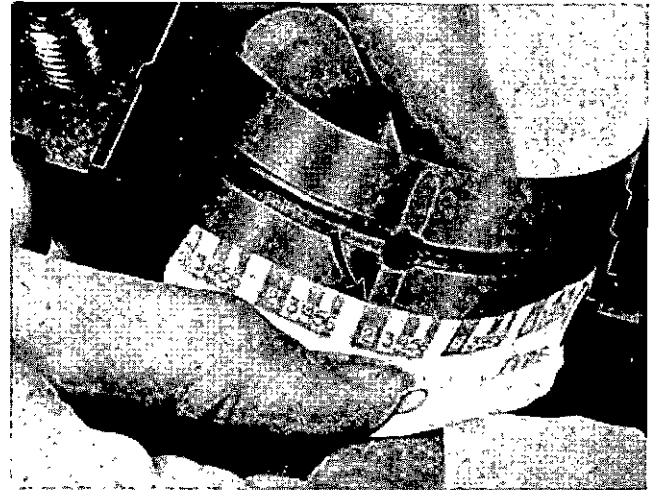


Figure 176  
Checking Bearing Clearance with Plastigage

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 and heat-treated 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 given dimensional limits and must be perfectly blended into thrust and bearing surfaces.*

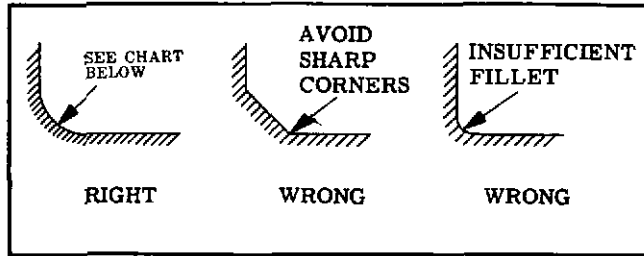


Figure 177

Z	$\frac{3}{32}$ "R on All Crankpins and Mains except $\frac{1}{8}$ "R on Rear Main
G157	$\frac{3}{32}$ "R on All Crankpins and Mains
G193 G4193	$\frac{1}{8}$ "R on All Crankpins $\frac{3}{32}$ "R on All Mains
E	$\frac{1}{8} \pm \frac{1}{32}$ R on All Crankpins $\frac{3}{16} \pm \frac{1}{32}$ R on All Mains
H	$\frac{5}{32}$ R on All Crankpins and Mains
J	$\frac{5}{32} \pm .010$ on All Crankpins and Mains

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.

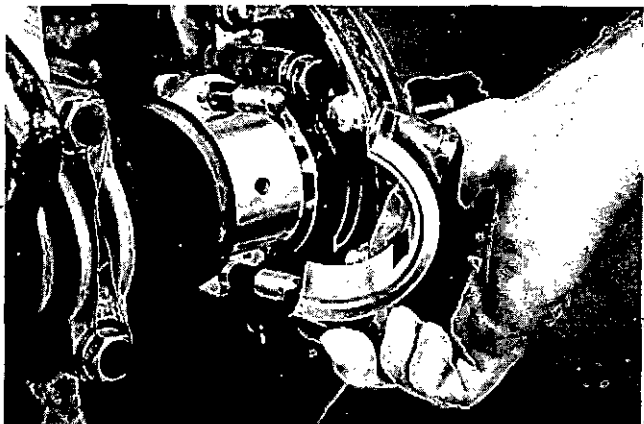


Figure 178  
Checking Rod Bearings with Feeler Stock

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.

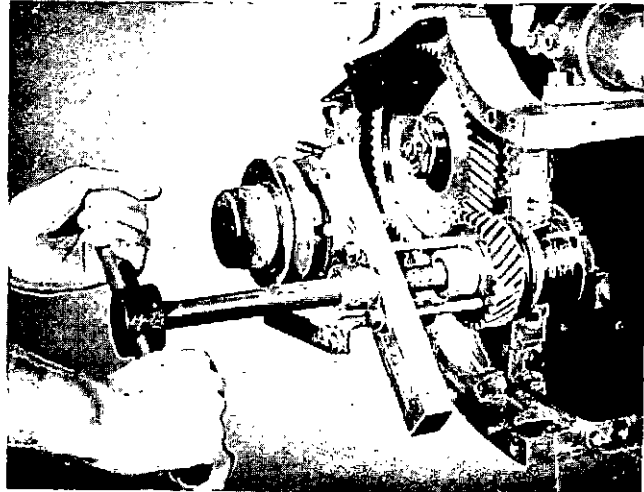


Figure 179 — Removing Crank Gear

### CAMSHAFT

1. Using a puller, remove the cam and crank gears.
2. Remove the screws holding the camshaft thrust plate to the block which permits pulling the camshaft forward out of the bearings.
3. If engine is bench-worked — Lay it on its side, remove push rods and push tappets up with finger about  $\frac{1}{2}$ " (not out of hole) so that camshaft can be pulled.

If engine must remain in vertical position — raise the tappets about  $\frac{1}{2}$ " by using magnetized rods long enough to reach down through the push rod holes and lift the tappets free of the camshaft.

When magnetized rods are not available — clean the push rod ends, then coat with a tacky, fibrous grease to raise the tappets.

Either the magnetized rods or the push rods must be held up about  $\frac{1}{2}$ " by clothes pins or gripping them in pairs with rubber bands or winding them tightly with soft wire to hold them against the push rod hole.

4. H and J barrel type tappets can be removed from the top of the block for examination or replacement without pulling the camshaft by using a magnetized rod.

Z-G and E mushroom tappets can only be removed from the bottom of the block after the camshaft is removed as the push rod holes are too small.

5. Before pulling the camshaft completely — check the clearance of the camshaft journal in the bearing hole or bushing with a  $\frac{1}{4}$ " wide piece of feeler stock with edges dressed to remove any burrs. The G and H series engines have replaceable camshaft bearings.
6. If the clearance is equal to or greater than the amount indicated under wear-limits — check the diameter of the camshaft journals—excess wear requires shaft replacement.

If wear is found to be in the G or H series engine bushings instead, replace the set with precision service bushings, which require no reaming — *only use care in assembly to line up the oil holes and not to damage the bushings as they are being pressed in.*

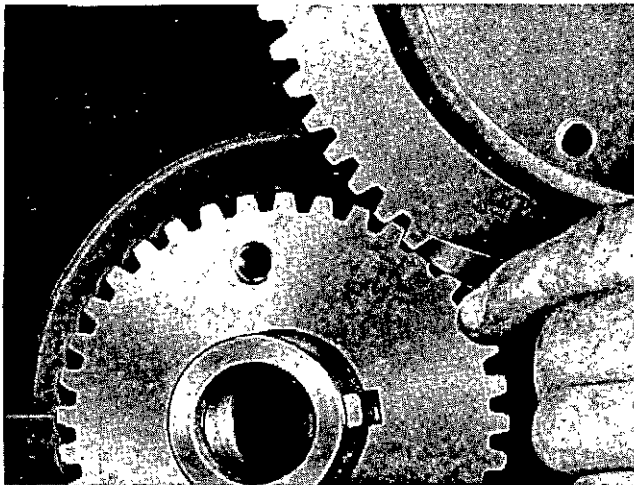


Figure 180 — Checking Backlash of Timing Gear

### 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.

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

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.

**CAUTION: NEVER USE THE CAMSHAFT NUT TO PULL THE GEAR ONTO THE SHAFT.** This will break the threaded end off cast iron camshafts and damage threads on steel camshafts.

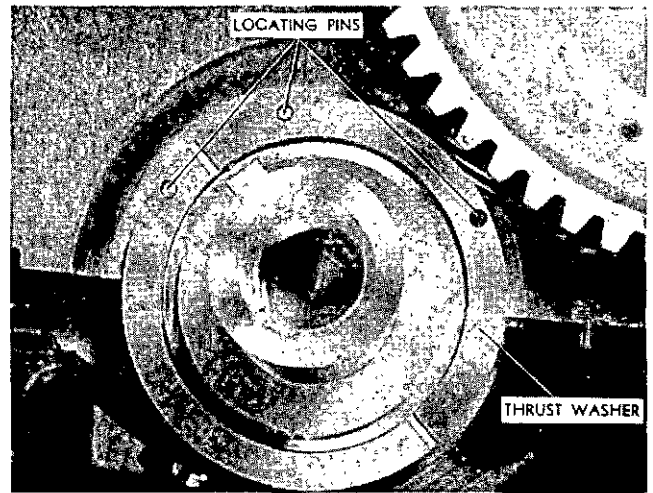


Figure 181 — Crankshaft Thrust Washer (Front Bearing Thrust)

4. Inspect crankshaft thrust washers for wear and scoring. Replace if necessary before re-assembling gear.

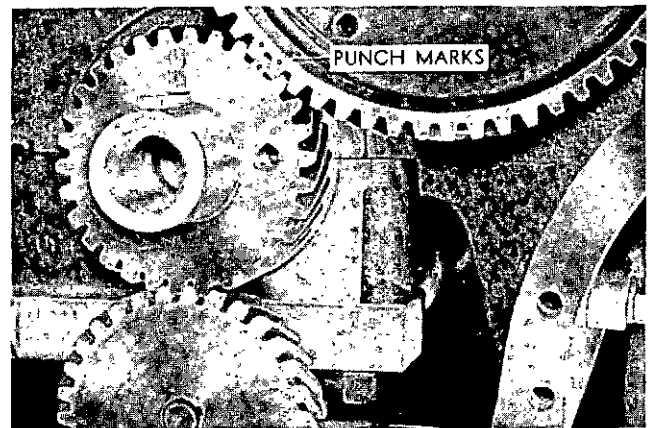


Figure 182 — Timing Gears Assembled According to Timing Marks

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

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.

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.

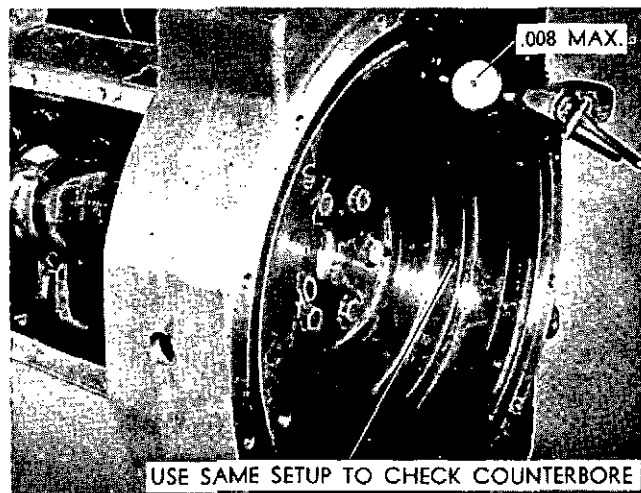


Figure 183 — Checking End Play

### CRANKSHAFT END PLAY

All standard four cylinder overhead-valve gasoline engines except the Z series have center main thrust bearing flanges, which control the crankshaft end play to .004-.006 on the G and E series and .005-.008 on the H and J series engines.

Z series engines have the end play controlled at the front main bearing by shims in the assembly between the front end of the main bearing journal and the crankgear.

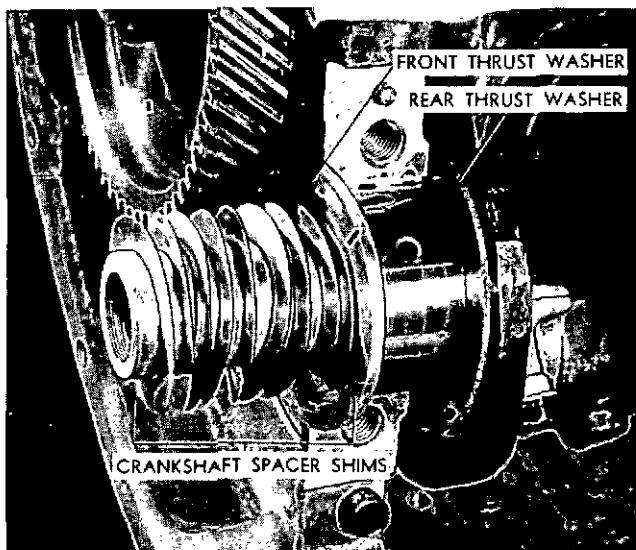


Figure 184 — Thrust Washers & Shims Controlling Crankshaft End Play\* (Z Series)

1. Check the crankshaft end play before replacing the gear cover. A shim pack containing shims of .002" and .008" thickness is 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.

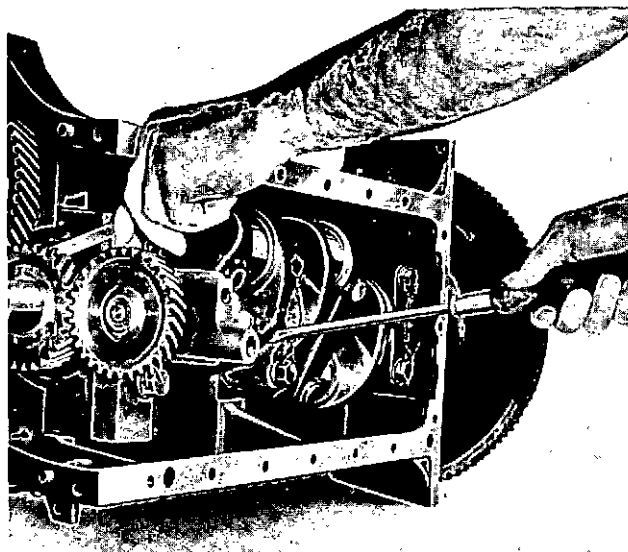


Figure 185 — Alternative Method of Checking Crankshaft End Play with Feeler Gauge\*

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.

Replacement of the center main bearing will restore the correct end play limits on all the engines that have end play controlled at this point.

### FRONT OIL SEAL

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

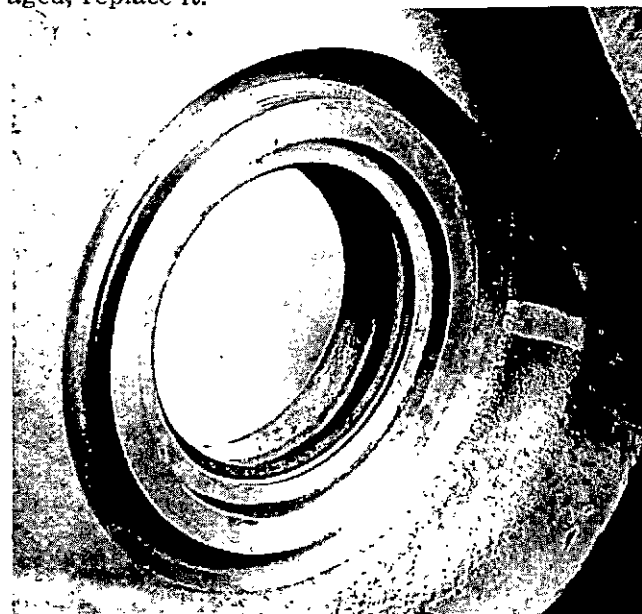


Figure 186 — Crankshaft Front Oil Seal

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

### REAR CRANKSHAFT OIL SEALS

All of the four-cylinder over-head valve engines except the H and the J use the "spring" type oil seals to keep the dust out and the oil in. The seal contacts the polished surface of the crankshaft flange and is pressed into a seal retainer which bolts to the rear of the cylinder block.

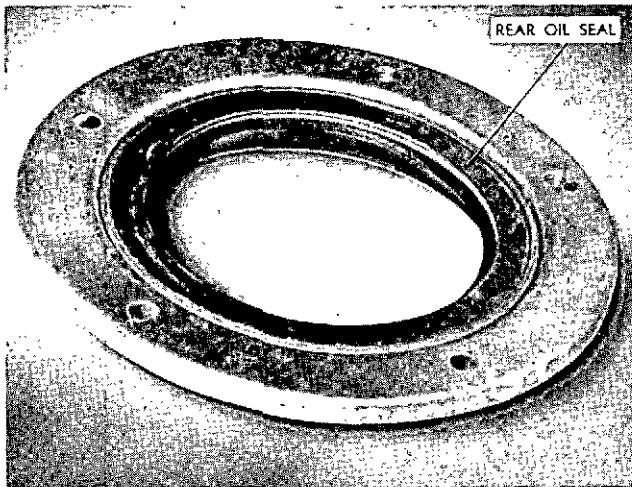


Figure 187 — Rear Oil Seal (Spring type)

Replacement of worn rear oil seals of this spring type, should be done as follows:

1. Remove cap screws mounting the seal retainer to the block.
2. Remove old oil seal with a driver which fits the seal.

3. Press in new oil seal using driver so as not to damage seal assembly — with the scraping edge of seal contact next to the engine.

4. Examine carefully the surface on which the seal makes contact. Any scratches or other damage to this surface must be polished out before reassembly of seal, otherwise it will be damaged and become ineffective.

5. Mount retainer and oil seal assembly on block.

### FILLER BLOCK ASSEMBLY

The sides of the filler block, where it fits into the milled gap in the cylinder block, are sealed, oil-tight, by candlewick packing soaked in cement, — and 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.

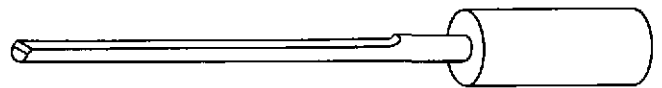


Figure 188  
Packing Tool

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 "pig-tail" 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 grooves A and D are completely filled — without voids — then wipe off excess cement on filler block.

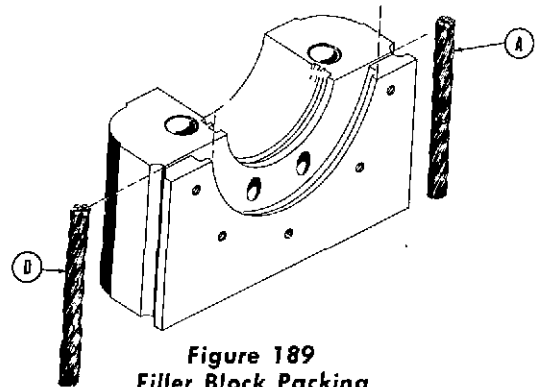


Figure 189  
Filler Block Packing

### CAUTION

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

H and J Model Engines have the rear crankshaft oil seals incorporated in the combination rear main bearing cap and filler block.

Both the H and J filler blocks use the same moulded rubber side seals and crankshaft oil seal.

The newer type crankshaft oil seal has a metal stiffener ring imbedded in the rubber and no sheet metal retainer is required.

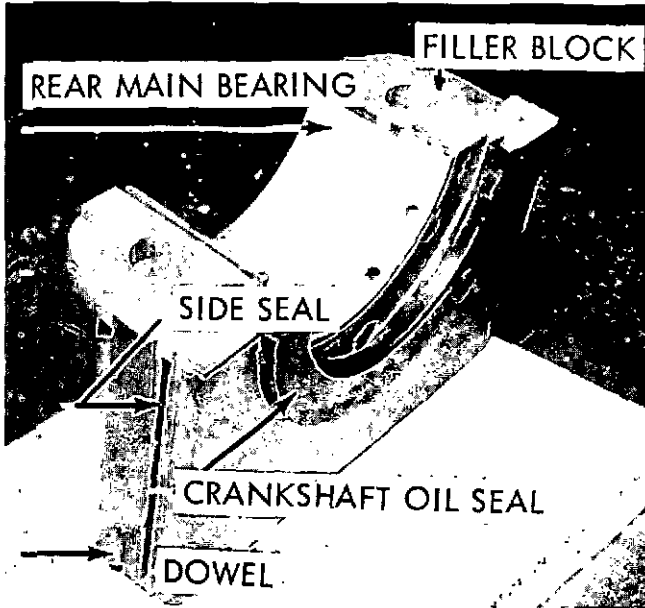


Figure 190 — H & J Rear Oil Seal Assembly

The H and J series engine have a good, trouble-free rear crankshaft oil seal — if carefully installed.

Worn oil seals should be replaced in the following manner:

1. Remove rear bearing cap and filler block assembly by using a puller as shown.

As the cap is pulled, tilt forward to clear the flywheel housing.

Remove old seals and thoroughly clean all contact surfaces.

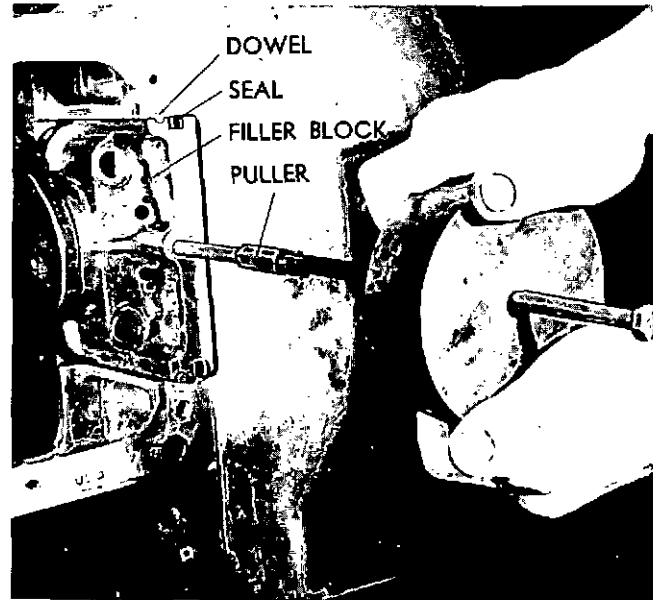


Figure 191 — Removing Rear Oil Seal

2. Install crankshaft oil seals B—on engine block and main bearing cap.

Before installing — break edge E slightly on both cap and block to avoid cutting the seals during installation and coat seal edge F, contacting the groove with shellac.

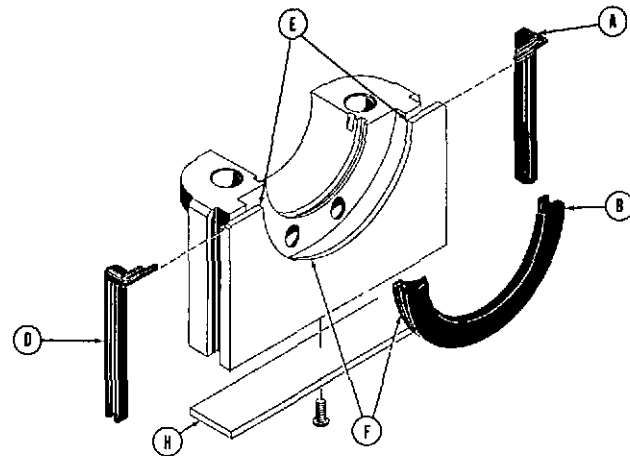


Figure 192 — Filler Block and Seals

NOTE: This oil seal can be installed without removing the crankshaft — in this case, use only light grease in the seal groove to assist sliding the seal in place. Apply pressure to the seal so that it will hug the crankshaft which will also help moving it in place.



Figure 193 — Crankshaft Oil Seal in Block

3. Slide the LH (D) and RH (A) side seals — in the filler block grooves dry.

Then coat the outside edge slightly with an oily finger to help slide in the block gap without stretching.

4. Apply a light coat of cement — National Oil Seal or M.M&M EC-847 to the tab end side seal surfaces that contact the block and filler block and also to the butting ends of the crankshaft oil seal halves — allow to become tacky before assembly.

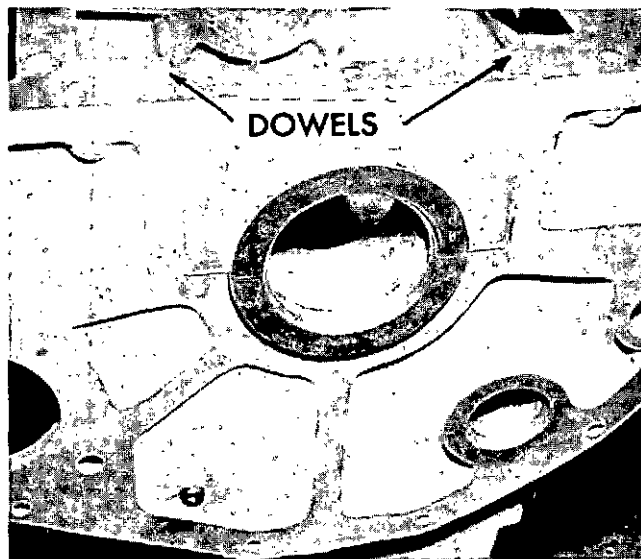


Figure 194 — Completed Oil Seal Assembly

5. Assemble the filler block with seals carefully to the block — by starting it straight and square with the gap, so that when in place, the dowel holes register.

When in place, the side seals should not project more than  $\frac{1}{32}$ " above the oil pan contact surface.

Pound in the two dowels flush and then torque the two main bearing cap screws to 140-150 foot-pounds torque — Then wire cap screws.

Lightly coat the crankshaft contact edge of the seal with a graphite grease to prevent damage prior to use.

**IMPORTANT:** Installing rear oil seals correctly demands careful workmanship.

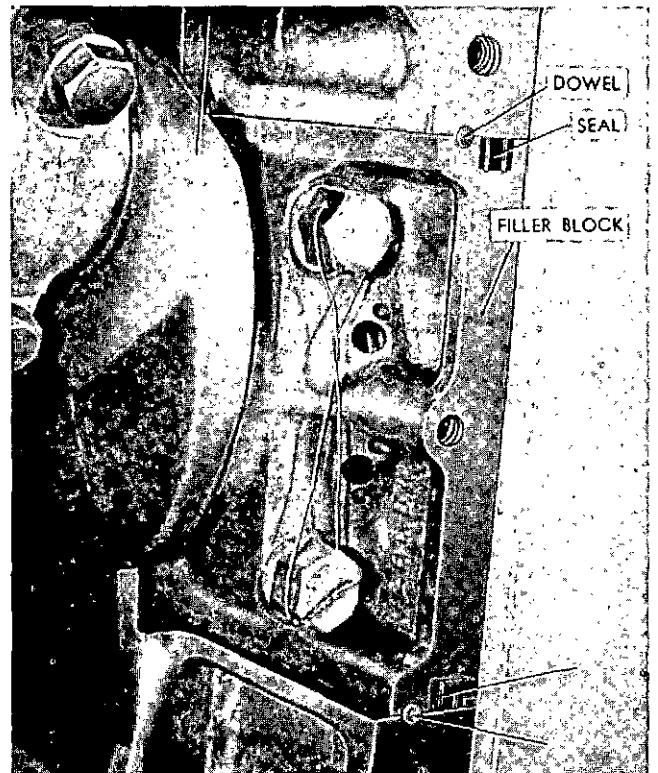


Figure 195 — Rear Bearing Filler Block Showing Lock Wires in Place

## OIL PUMP

The oil pump assembles to the front main bearing and is held in place by the main bearing cap screws. The oil pump drive gear meshes with

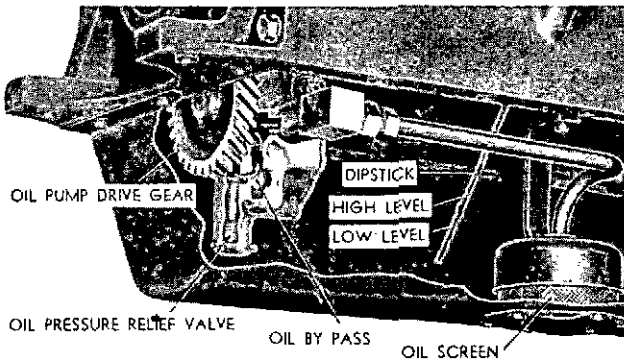


Figure 196

and is driven by the crankshaft gear. These gears have a specified .004-.008 drive or clearance fit, which must be checked when reassembling the engine to be sure that it falls within the specifications.

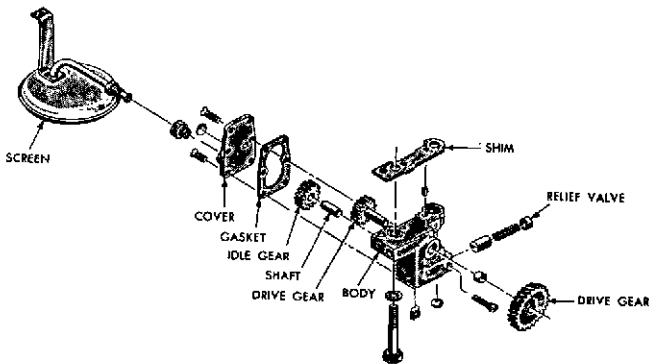


Figure 197  
Oil Pump Exploded View



Figure 198—Checking Backlash Between Crank Gear and Oil Pump Drive Gear

Shims are available for adjusting the center distances of the oil pump and crankshaft gears so that .004-.008 backlash can be maintained.

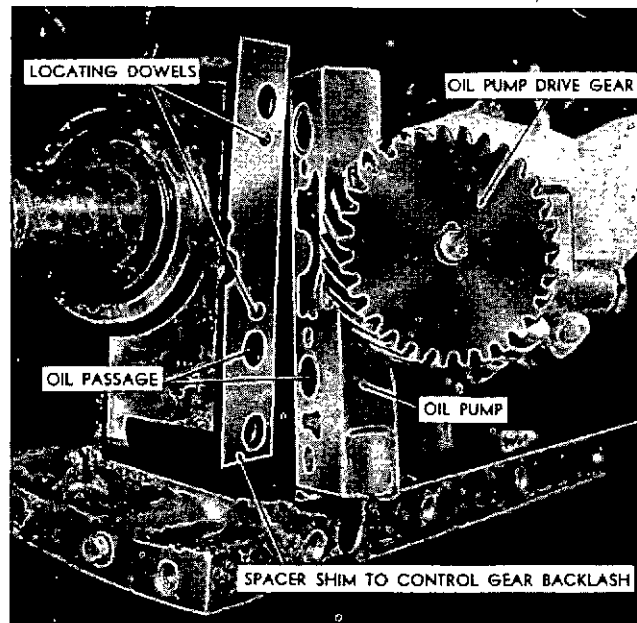


Figure 199 — Removing Oil Pump

The oil pump is of the gear type and while it is removed, the oil pump gears should be inspected for excessive wear of the gear teeth as well as any possibility of the gears rubbing the

oil pump body or cover — either of which would require overhauling the pump.

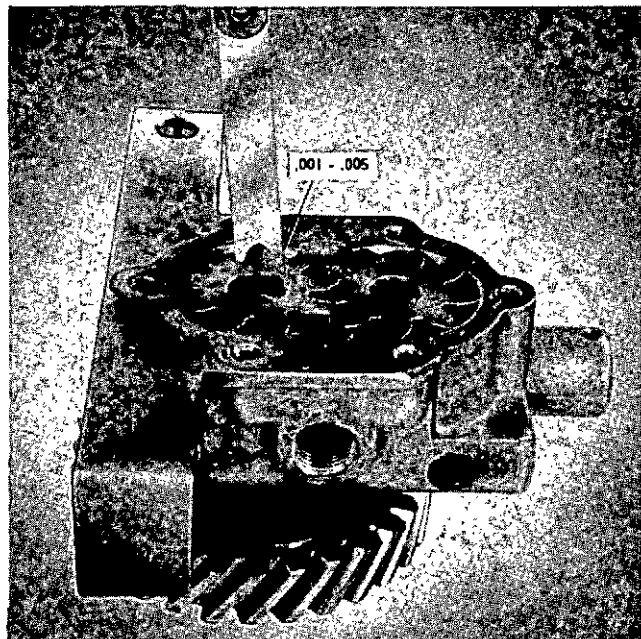


Figure 200 — Checking Oil Pump Gear Clearance in Body

New gears, a new shaft, or if severely damaged, even a complete new pump may be necessary to restore dependable lubrication of the engine — which must be determined by careful inspection of the parts.

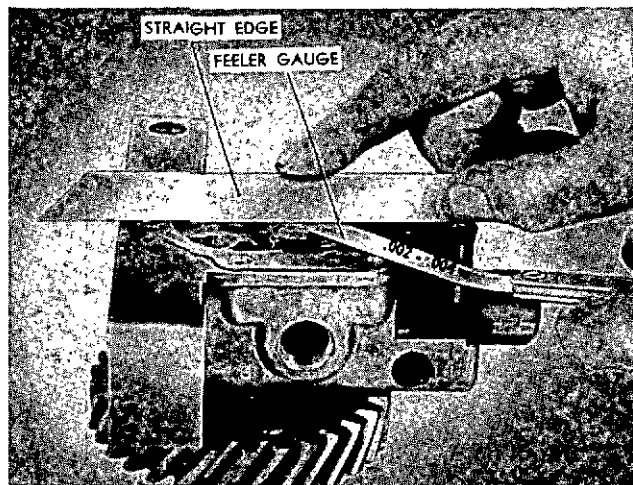


Figure 201 — Checking End Clearance

The oil pressure is regulated by a pressure regulating spring. The normal pressure at operating speed is:

- 10-20 Pounds — G157 — E-H-J Series
- 20-30 Pounds — G193 — Z Series
- 30-40 Pounds — G4193

And approximately 7 pounds at idle. When-

ever the pressure is below these limits or fluctuates, *stop the engine* — find the cause and correct it before severe engine damage results. Usually the trouble will be no oil in crankcase, broken or loose lines or a clogged strainer screen.

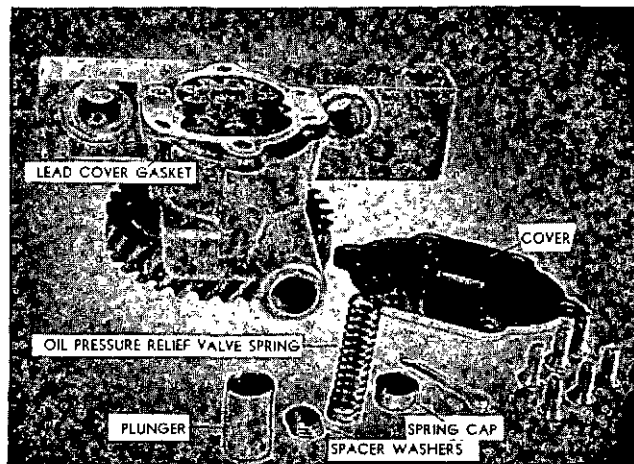


Figure 202 — Oil Pump Disassembled

## 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.

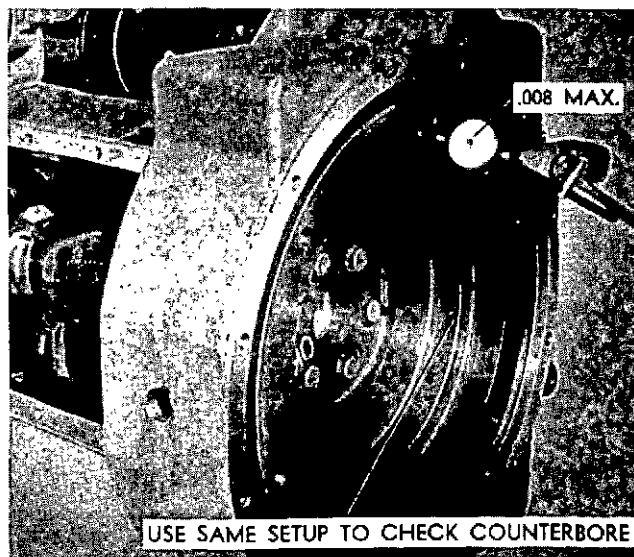


Figure 203 — Checking Flywheel Runout

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.

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.

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.

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.

Dirt or nicks in the flywheel counterbore is the most prevalent cause of run-out of this part.

## 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.

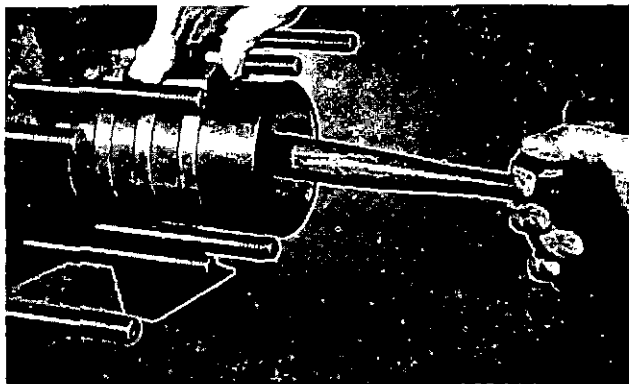
When reassembling pistons and connecting rods, use a good ring compressor and oil the bores thoroughly. A hammer handle may be used to bump the pistons out of the ring compressor into the cylinder bore.

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.

Assemble the oil pan with new gaskets cemented in place. Tighten screws in accordance with limits prescribed in torque chart — to avoid looseness or overstressing.



**Figure 204 — Assembling Piston in Cylinder**

## 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  $\frac{1}{8}$ " 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 filler neck.

(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 line.

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  $\frac{2}{3}$  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.

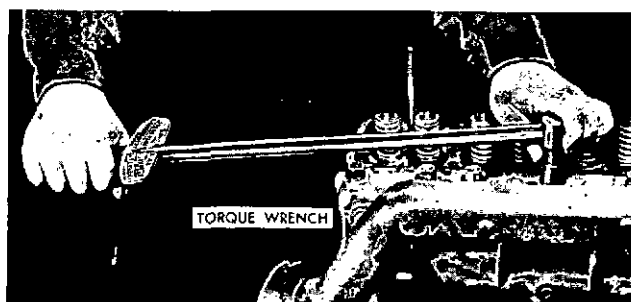
The torque specifications, foot pounds, listed below, **MUST** be followed in order to have the assembled engine conform to the original specifications:

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
Main Brg. Caps	.....	.....	35-40	70-75	85-95	110-120	140-150
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	3/4"	7/8"	1"	1 1/8"	1 1/4"	
C.I. Shafts	65-70#	70-80#	95-100#	125-130#	145-150#	
Forged Steel Shafts		120-125#	175-180#			
Elastic Stop Nut w/C.I. or Forged Steel Shaft		65-70#				

\* 1/16" to 5/8" Manifold End Nuts — 35# Torque



**Figure 205**  
**Torquing Cylinder Head Nuts**

## SECTION XI LIMITS AND CLEARANCE DATA

**NOTE: DIMENSIONS SHOWN ARE FOR  
STANDARD ENGINES**

ENGINE SERIES	Z-129	G-157	G-193	G-4193	E-201 E-208 E-223 E-242	HD-260 HD-277	I-382 I-403
<b>INTAKE VALVE GUIDE</b>							
Length	1 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$	2 $\frac{3}{4}$	2 $\frac{1}{4}$	2 $\frac{1}{8}$	2 $\frac{1}{2}$
Outside Dia.	.5645/.5640	.6575/.6565	.6575/.6565	.6575/.6565	.6575/.6565	.752/.751	.752/.751
Stem Hole Dia. in Head	.3172/.3157	.3432/.3422	.3432/.3422	.3432/.3422	.3432/.3422	.4365/.4360	.4365/.4360
*Wear Limits—Max. Dia.	.3182	.3442	.3442	.3442	.3442	.4375	.4375
Distance—Location of Guide in Head	$\frac{1}{2}$ Below Top of Head	2 $\frac{1}{2}$ Cyl. Head Contact Face to Guide	1 $\frac{1}{4}$ Bottom Face Valve Seat to Guide	1 $\frac{1}{4}$ Bottom Face Valve Seat to Guide	$\frac{1}{8}$ to Spot Face for Valve Spring Seat	1 $\frac{1}{2}$ to Valve Seat Surface	1 $\frac{1}{8}$ to Valve Seat Surface
<b>EXHAUST VALVE GUIDE</b>							
Length	1 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$	2 $\frac{3}{4}$	2 $\frac{1}{4}$	2 $\frac{1}{8}$	2 $\frac{1}{2}$
Outside Dia.	.5645/.5640	.6575/.6565	.6575/.6565	.6575/.6565	.6575/.6565	.752/.751	.752/.751
Stem Hole Dia. in Head	.3172/.3157	.3432/.3422	.3432/.3422	.3432/.3422	.3432/.3422	.4365/.4360	.4365/.4360
*Wear Limits—Max. Dia.	.3182	.3442	.3442	.3442	.3442	.4375	.4375
Distance—Location of Guide in Head	$\frac{1}{2}$ Below Top of Head	2 $\frac{1}{2}$ Cyl. Head Contact Face to Guide	1 $\frac{1}{4}$ Bottom Face Valve Seat to Guide	1 $\frac{1}{4}$ Bottom Face Valve Seat to Guide	$\frac{1}{8}$ to Spot Face for Valve Spring Seat	1 $\frac{1}{2}$ to Valve Seat Surface	1 $\frac{1}{8}$ to Valve Seat Surface
<b>VALVES—INTAKE</b>							
Overall Length	4.0	5 $\frac{3}{4}$	5 $\frac{1}{2}$	5 $\frac{1}{2}$	5 $\frac{1}{4}$	5 $\frac{3}{4}$	5 $\frac{3}{4}$
Stem Dia.	.3149/.3141	.3414/.3406	.3410/.3402	.3410/.3402	.3414/.3406	.4352/.4344	.4352/.4344
*Wear Limits—Min. Dia.	.3121	.3386	.3382	.3382	.3386	.4324	.4324
Head Dia.	1.283/1.273	1.333/1.323	1.646/1.636	1.646/1.636	1 $\frac{3}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{4}$
Angle of Valve Face	30°	30°	30°	30°	30°	30°	30°
Stem Clearance Limits	.0008/.0031	.0008/.0026	.0012/.003	.0012/.003	.0008/.0026	.0008/.0021	.0008/.0021
*Wear Limits—Max. Cl.	.0051	.0046	.005	.005	.0046	.0041	.0041
Desired Stem Cl.	.002	.0015	.002	.002	.0015	.0015	.0015
<b>VALVES—EXHAUST</b>							
Overall Length	4 $\frac{1}{4}$	5 $\frac{3}{4}$	5 $\frac{1}{2}$	5 $\frac{1}{2}$	5 $\frac{1}{2}$	6 $\frac{1}{4}$	5 $\frac{3}{4}$
Stem Dia.	.3132/.3124	.3390/.3382	.3390/.3382	.3390/.3382	.3390/.3382	.4325/.4315	.4325/.4315
*Wear Limits—Max. Dia.	.3104	.3362	.3362	.3362	.3362	.4295	.4295
Head Dia.	1.145/1.135	1.208/1.198	1.380/1.370	1.380/1.370	1 $\frac{3}{4}$	1 $\frac{3}{4}$	1 $\frac{1}{4}$
Angle of Valve Face	44°	44°	44°	44°	45°	44°	44°
Stem Clearance Limit	.0025/.0048	.0032/.005	.0032/.005	.0032/.005	.0032/.005	.0035/.005	.0035/.005
*Wear Limits—Max. Cl.	.0068	.007	.007	.007	.007	.007	.007
Desired Stem Cl.	.0035	.004	.004	.004	.004	.004	.004
<b>OUTER VALVE SPRING</b>							
Free Length	2 $\frac{1}{4}$	2 $\frac{3}{8}$	2 $\frac{1}{8}$	2 $\frac{1}{8}$	1 $\frac{3}{4}$	2 $\frac{3}{8}$	2 $\frac{3}{8}$
Outside Dia.	.968/.988	1.302/1.282	1.151/1.161	1.151/1.161	1.150/1.130	1.302/1.282	1.302/1.282
Wire Gauge	.142	.162	.172	.172	.156	.162	.162
Length—Valve Closed	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1.817	1.817	1 $\frac{3}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{4}$
Load—Valve Closed	47 - 53#	58 - 64#	76 - 79#	76 - 79#	47 - 53#	58 - 64#	58 - 64#
*Wear Limits—Min.	45#	55#	69#	69#	45#	55#	55#
Length—Valve Open	1 $\frac{3}{4}$	1.521	1.436	1.436	1 $\frac{1}{8}$	1.521	1.521
Load—Valve Open	96 - 104#	115 - 123#	167 - 169#	167 - 169#	103 - 110#	115 - 123#	115 - 123#
*Wear Limits—Min.	90#	107#	152#	152#	90#	107#	107#

**LIMITS AND CLEARANCE DATA**

ENGINE SERIES	Z-129	G-157	G-193	G-4193	E-201 E-208 E-223 E-242	H-260 H-277	J-382 J-403
<b>CAMSHAFT</b>							
#1 Brg. Journal Dia.	1.8090/1.8080	1.8090/1.8080	1.8090/1.8080	1.8090/1.8080	1.9965/1.9955	1.9965/1.9955	2.1225/2.1215
#2 Brg. Journal Dia.	1.7465/1.7455	1.7465/1.7455	1.7465/1.7455	1.7465/1.7455	1.7465/1.7455	1.7465/1.7455	1.7465/1.7455
#3 Brg. Journal Dia.	1.6840/1.6830	1.6840/1.6830	1.6840/1.6830	1.6840/1.6830	1.6840/1.6830	1.6840/1.6830	1.6840/1.6830
*Wear Limit	.001 WEAR UNDER MINIMUM BEARING JOURNAL DIAMETER						
Cam Lift—Intake	.1868	.2731	.2731	.2731	.2296	.2489	.2489
Valve Lift—Intake	.3042	.380	.380	.380	.317	.3500	.3528
Cam Lift—Exhaust	.212	.2731	.2731	.2731	.2296	.2489	.2489
Valve Lift—Exhaust	.344	.380	.380	.380	.317	.3500	.3528
Tappet Dia.	.551/.547	.551/.547	.551/.547	.551/.547	.6245/.6240	.9975/.9985	.9975/.9985
*Wear Limits	.546	.546	.546	.546	.623	.9965	.9965
End Play	.003/.007	.003/.007	.003/.007	.003/.007	.005/.009	.005/.009	.005/.009
<b>CRANKSHAFT</b>							
Crankpin Dia.	1.9375/1.9365	2.0625/2.0615	2.250/2.249	2.250/2.249	2.249/2.248	2.4990/2.4980	2.7485/2.7475
*Wear Limit—Min. Dia.	1.9355	2.0605	2.248	2.248	2.247	2.4970	2.7465
Main Brg. Journal Dia.	2.250/2.249	2.3750/2.3740	2.3750/2.3740	2.3750/2.3740	2.625/2.624	2.874/2.873	3.251/3.250
*Wear Limit—Min. Dia.	2.248	2.3730	2.3730	2.3730	2.623	2.872	3.249
End Play	.004/.006	.004/.006	.004/.006	.004/.006	.004/.006	.005/.008	.005/.008
<b>CONNECTING RODS</b>							
Length—Ctr. to Ctr.	6.377/6.373	7.002/6.998	7.002/6.998	7.002/6.998	8.377/8.373	9.502/9.498	10.502/10.498
Bushing Hole Dia.	.914/.913	1.188/1.187	1.188/1.187	1.188/1.187	1.188/1.187	1.3753/1.3743	1.6249/1.6239
Brg. Hole Dia.	2.062/2.0615	2.1870/2.1865	2.3745/2.3740	2.3745/2.3740	2.3745/2.3740	2.6245/2.6240	2.8745/2.8740
Brg. Thickness	.06185/.06160	.06165/.06140	.06125/.06100	.06125/.06100	.06180/.0621	.06225/.06200	.06235/.06210
*Wear Limits—Min. Th.	.0611	.0609	.0605	.0605	.0613	.0615	.0616
Clearance Limits	.0023/.0003	.0027/.0007	.0015/.0035	.0015/.0035	.0008/.0029	.0005/.0025	.0008/.0028
Desired Clearance	.0015	.0015	.002	.002	.002	.0012	.002
*Wear Limits—Max. Cl.	.0033	.0037	.0045	.0045	.0039	.0035	.0038
Side Play	.006/.010	.006/.010	.006/.010	.006/.010	.006/.010	.006/.010	.006/.010
Desired Side Play	.006 Min.	.006 Min.	.006 Min.	.006 Min.	.006 Min.	.006 Min.	.006 Min.
<b>MAIN BEARINGS</b>							
Dia. of Brg. Bore in Block	2.4372/2.4365	2.5622/2.5615	2.5622/2.5615	2.5622/2.5615	2.8122/2.8115	3.0615/3.0622	3.5000/3.4992
Brg. Shell Thickness	.09300/0.9275	.09300/.09275	.09300/.09275	.09300/.09275	.09300/.09275	.09350/.09325	.12390/.12365
*Wear Limits—Min. Th.	.09225	.09225	.09225	.09225	.09225	.09275	.12315
Clearance Limits	.0027/.0005	.0005/.0027	.0005/.0027	.0005/.0027	.0005/.0027	.0005/.0027	.0004/.0027
Desired Clearance	.0015	.0015	.002	.002	.002	.002	.002
*Wear Limits—Max. Cl.	.0037	.0037	.0037	.0037	.0037	.0037	.0037
<b>PISTON PIN</b>							
Length	2.691/2.676	2.750/2.735	3.065/3.050	3.065/3.050	3.065/3.050	3.314/3.307	3.718/3.703
Diameter	.8593/.8591	1.1252/1.1250	1.1093/1.1091	1.1093/1.1091	1.1093/1.1091	1.2500/1.2498	1.5000/1.4998
*Wear Limits—Min. Dia.	.8588	1.1247	1.1088	1.1088	1.1088	1.2495	1.4995
Desired Fit	Light Push	Light Push	Light Push	Light Push	Light Push	Light Push	Light Push
Bush. Hole Dia.—Fin.	.8597/.8595	1.1255/1.1253	1.1097/1.1095	1.1097/1.1095	1.1097/1.1095	1.2504/1.2502	1.5005/1.5003
*Wear Limits—Max. Dia.	.8607	1.1265	1.1107	1.1107	1.1107	1.2514	1.5015
Pin Clearance in Bush.	.0002/.0006	.0001/.0005	.0002/.0006	.0002/.0006	.0002/.0006	.0002/.0006	.0003/.0007
*Wear Limits—Max. Cl.	.0016	.0015	.0016	.0016	.0016	.0016	.0017
Desired Pin Fit.	.0004	.0003	.0004	.0004	.0004	.0004	.0005

## LIMITS AND CLEARANCE DATA

	Z-129	G-157	G-193	G-4193	E-201
<b>PISTON RINGS</b>					
RING WIDTH	MAXIMUM WEAR SHOULD NOT EXCEED .002 UNDER MINIMUM NEW RING WIDTH				
#1	.1245/.1235	.1235/.1240	.0935/.0930	.0935/.0930	.1240/.1235
#2	.1245/.1240	.1235/.1240	.1240/.1235	.1240/.1235	.1240/.1230
#3	.1245/.1240	.1235/.1240	.1240/.1235	.1240/.1235	.1240/.1230
#4	.1865/.1860	.2490/.2485	.2490/.2485	.2490/.2485	.2490/.2485
RING THICKNESS					
#1	.147/.137	.143/.153	.187/.177	.187/.177	.181/.171
#2	.140/.150	.143/.153	.164/.154	.164/.154	.160/.150
#3	.140/.150	.143/.153	.164/.154	.164/.154	.160/.150
#4	.150 Max.	.141/.151	.164/.154	.164/.154	.160 Max.
RING GAP CLEARANCE					
#1	.007/.017	.010/.015	.010/.020	.010/.020	.013/.023
#2	.009/.014	.010/.015	.010/.020	.010/.020	.008/.015
#3	.009/.014	.010/.015	.010/.020	.010/.020	.008/.015
#4	.007/.017	.010/.020	.010/.018	.010/.018	.013/.023
RING SIDE CLEARANCE	MAXIMUM WEAR SHOULD NOT EXCEED .0025 OVER MAXIMUM NEW RING SIDE CLEARANCE				
#1	.003/.005	.003/.0045	.002/.0035	.002/.0035	.004/.0055
#2	.003/.0045	.002/.0035	.002/.0035	.002/.0035	.004/.006
#3	.003/.0045	.002/.0035	.002/.0035	.002/.0035	.003/.005
#4	.0015/.0035	.002/.0035	.0015/.0035	.0015/.0035	.003/.0045
<b>PISTONS</b>					
Cylinder Bore	3.2505/3.2500	3.3750/3.3755	3.7500/3.7505	3.7500/3.7505	3.6250/3.6255
*Wear Limits—Cyl. Bore	.008	.008	.008	.008	.008
Piston Length	3 $\frac{3}{16}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	4 $\frac{1}{16}$
Piston Pin Hole Dia.	.8595/.8597	1.1255/1.1253	1.1097/1.1095	1.1097/1.1095	1.1096/1.1094
RING GROOVE DIA.					
#1	2.887/2.897	3.028/3.018	3.333/3.323	3.333/3.323	3.221/3.211
#2	2.887/2.897	3.028/3.018	3.388/3.378	3.388/3.378	3.263/3.253
#3	2.887/2.897	3.028/3.018	3.388/3.378	3.388/3.378	3.263/3.253
#4	2.871/2.881	2.988/2.978	3.348/3.338	3.348/3.338	3.223/3.213
RING GROOVE WIDTH	MAXIMUM WEAR SHOULD NOT EXCEED .002 OVER NEW PISTON RING GROOVE MAXIMUM WIDTH				
#1	.1275/.1285	.128/.127	.0965/.0955	.0965/.0955	.129/.128
#2	.1275/.1285	.127/.126	.127/.126	.127/.126	.129/.128
#3	.1275/.1285	.127/.126	.127/.126	.127/.126	.128/.127
#4	.1885/.1895	.252/.251	.2520/.2505	.2520/.2505	.253/.252
RING LAND DIA.					
#1	3.230/3.2250	3.360/3.355	3.7215/3.7220	3.7215/3.7220	3.599/3.594
#2	3.230/3.2250	3.360/3.355	3.7215/3.7220	3.7215/3.7220	3.599/3.594
#3	3.230/3.2250	3.360/3.355	3.7215/3.7220	3.7215/3.7220	3.599/3.594
#4	3.193/3.183	3.320/3.315	3.6955/3.6960	3.6955/3.6960	3.575/3.570
Piston Fit—Feeler Gauge	.003	.002	.0035	.0035	.004
Lbs. Pull	5 - 10#	5 - 10#	5 - 10#	5 - 10#	5 - 10#





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