Crusader

ENGINES

SERVICE MANUAL

GASOLINE INBOARD ENGINES PRIOR TO 1980

TECHNICAL MANUAL

THERMO ELECTRON
MARINE ENGINES

INLINE 6 AND V-8 ENGINES
292 CID 6, 307, 350, 427 AND 454 CID V-8

MANUFACTURED BY:

THERMO ELECTRON ENGINE CORP.
7100 EAST 15 MILE ROAD
STERLING HEIGHTS, MICHIGAN 48077
(313) 264-1200

PRINTED IN U.S.A.

TEEC 100

TABLE OF CONTENTS

INSTRUCTION MANUAL

THERMOPOWER
MARINE ENGINES
292 CID INLINE 6, 307, 350, 427 AND 454 CID V-8

INTRODUCTION

Thermo Electron Marine Engines embody the latest basic engineering developments by Chevrolet Division of General Motors, in V-8 design, oversquare, short stroke, with inherent smoothness and high power to weight ratio.

These engines are modified for marine application by Thermo Electron Engine Corp., built to exact specifications, with predelivery inspection, by expert craftsmen with many years of experience in the marine field.

This manual includes specifications, engine descriptions, operating instructions, and essential information for maintenance and service.

For good service, safety and long engine life it is recommended that major repairs be done by service stations experienced in marine engines with a reputation for competent workmanship and a proper acceptance of responsibility.

THERMO ELECTRON ENGINE CORP.
STERLING HEIGHTS, MICHIGAN

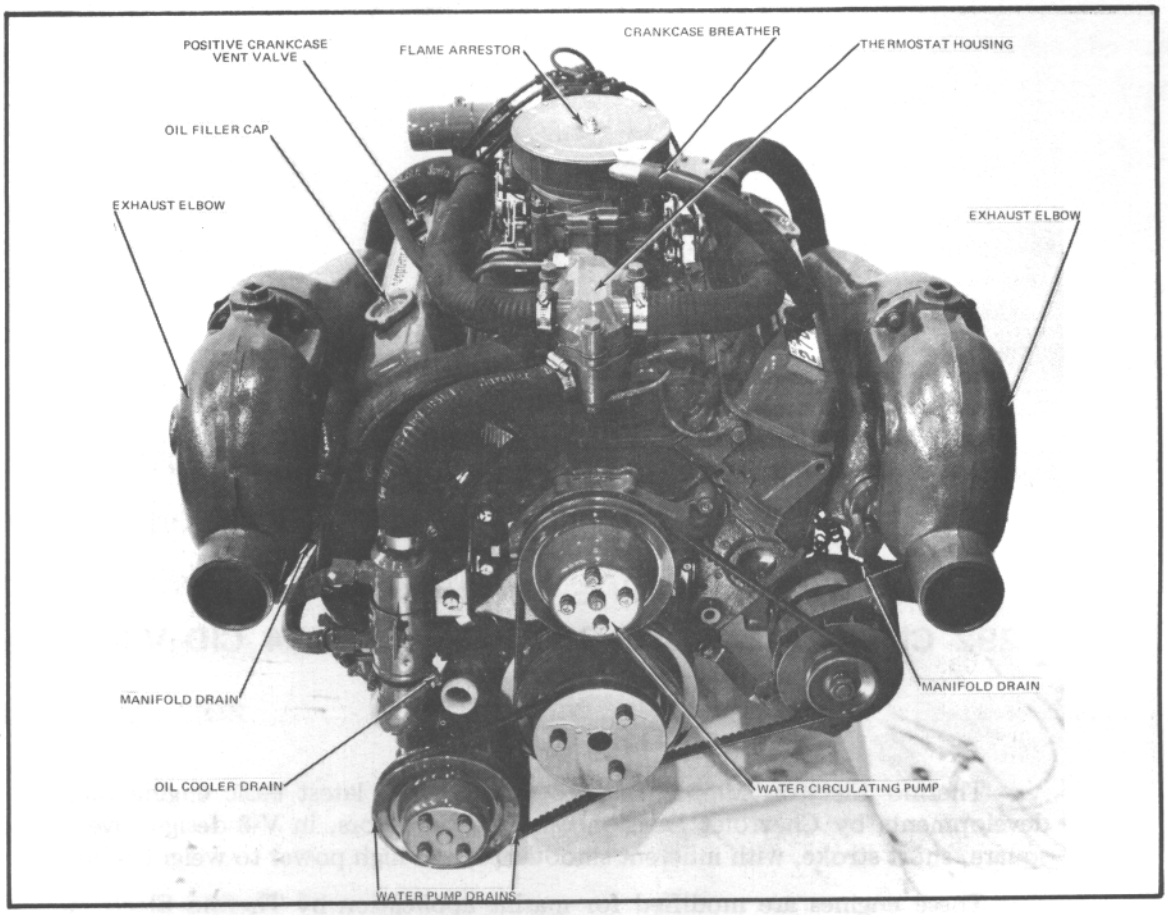


Fig. 1. 307-350 – CID with Warner 15° V Drive

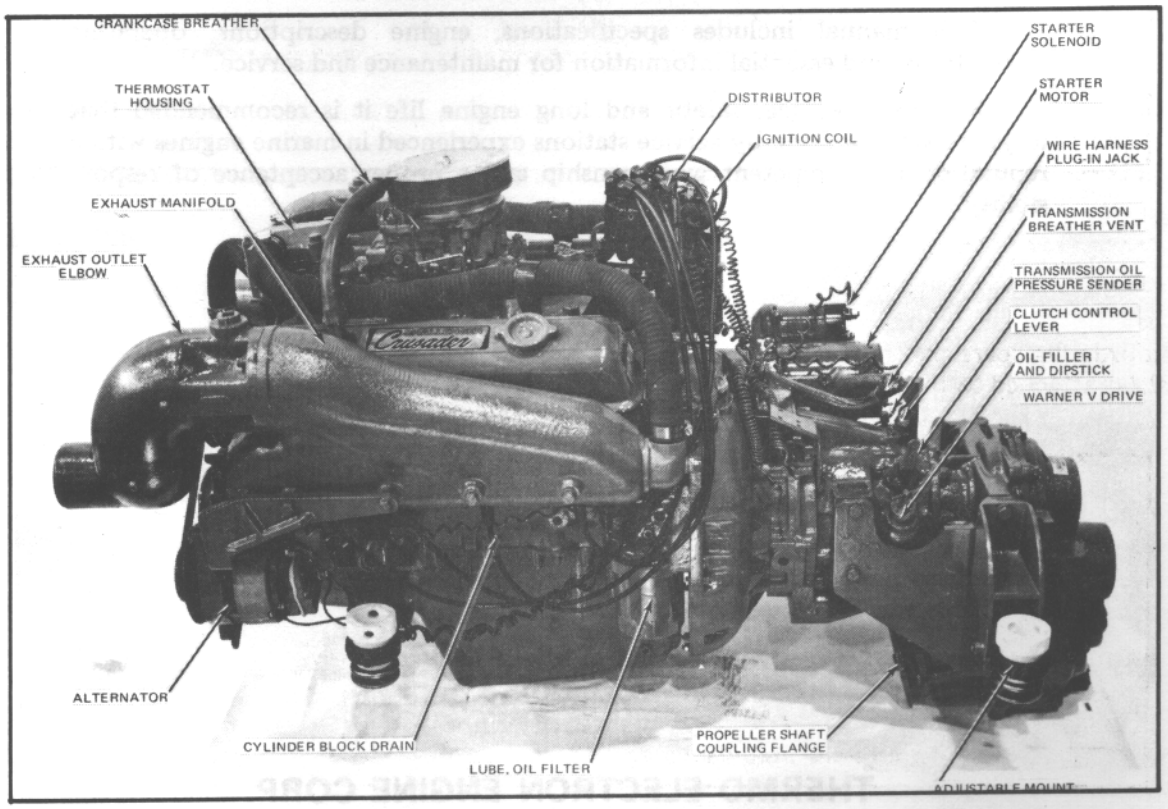


Fig. 2. 307-350 – CID with Warner 15° V Drive

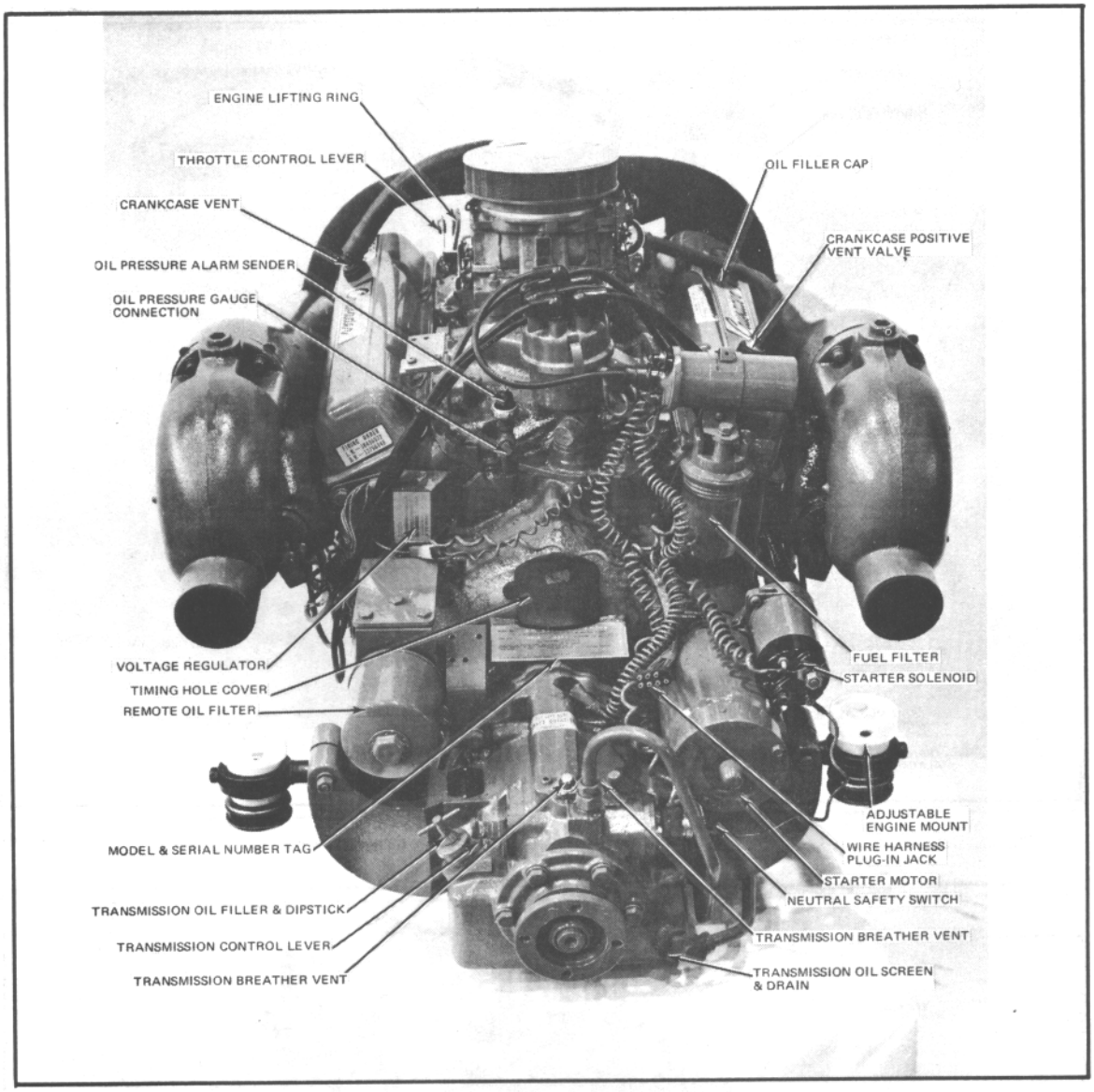


Fig. 3. 307-350 CID

ENGINE IDENTIFICATION

When ordering spare parts or obtaining information, always give Engine Model, and Serial No. This is found on a metal tag attached to the flywheel housing, below timing hole cover (Fig. 4).

MODEL NO. _____ SERIAL NO. _____

THIS ENGINE CONTAINS HYDRAULIC VALVE LIFTERS — NO ADJUSTMENT REQUIRED

SPARK PLUG _____ GAP DISTRIBUTOR 30° DWELL .015" GAP

FUEL REQUIREMENT REGULAR

ENGINE OIL: USE PREMIUM GRADE SAE 10W30 TYPE MS SERVICE.
REVERSE GEAR OIL: AUTOMATIC TRANSMISSION FLUID TYPE "A"

FIRING ORDER: MODEL	RIGHT HAND ROTATION	LEFT HAND ROTATION
4 CYL.	1243	1342
6 CYL.	142635	153624
8 CYL.	12756348	18436572

50 HOUR SERVICE CONSULT OWNERS MANUAL.

CMC 500

Fig. 4.

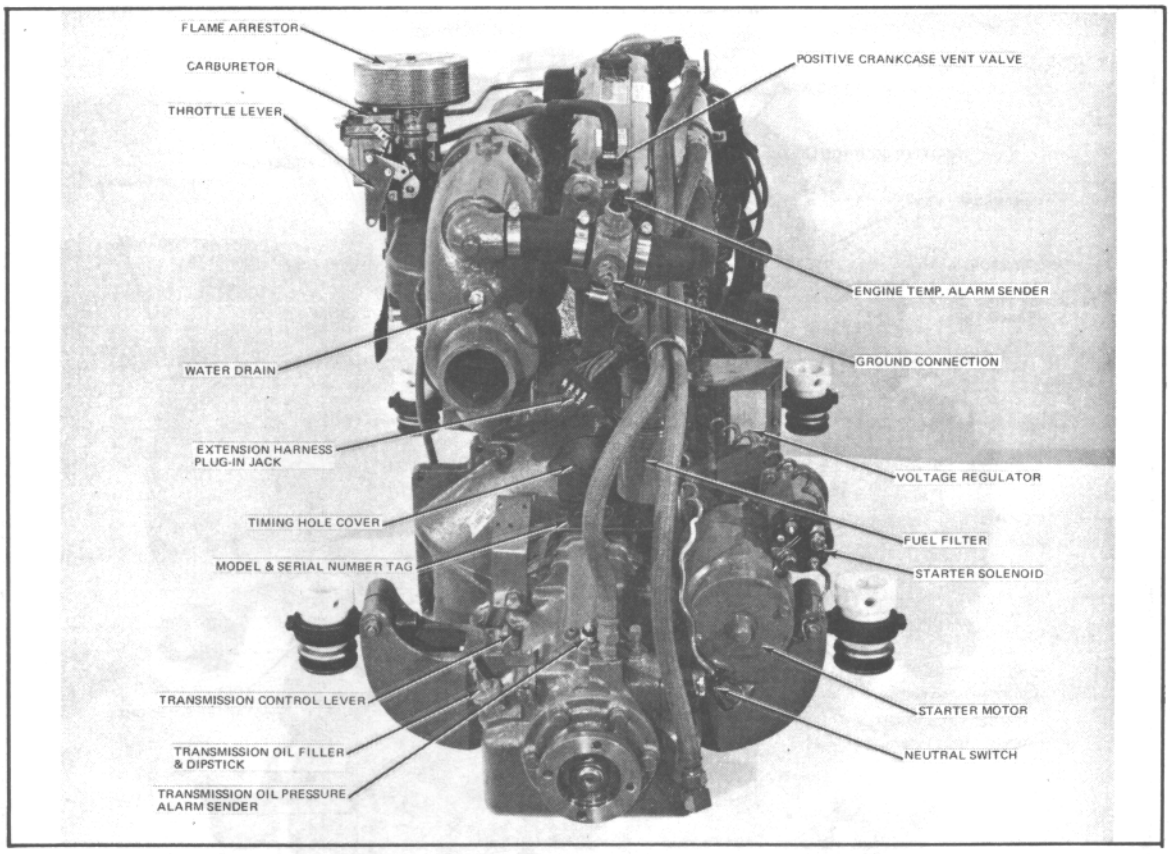


Fig. 5. 292 CID

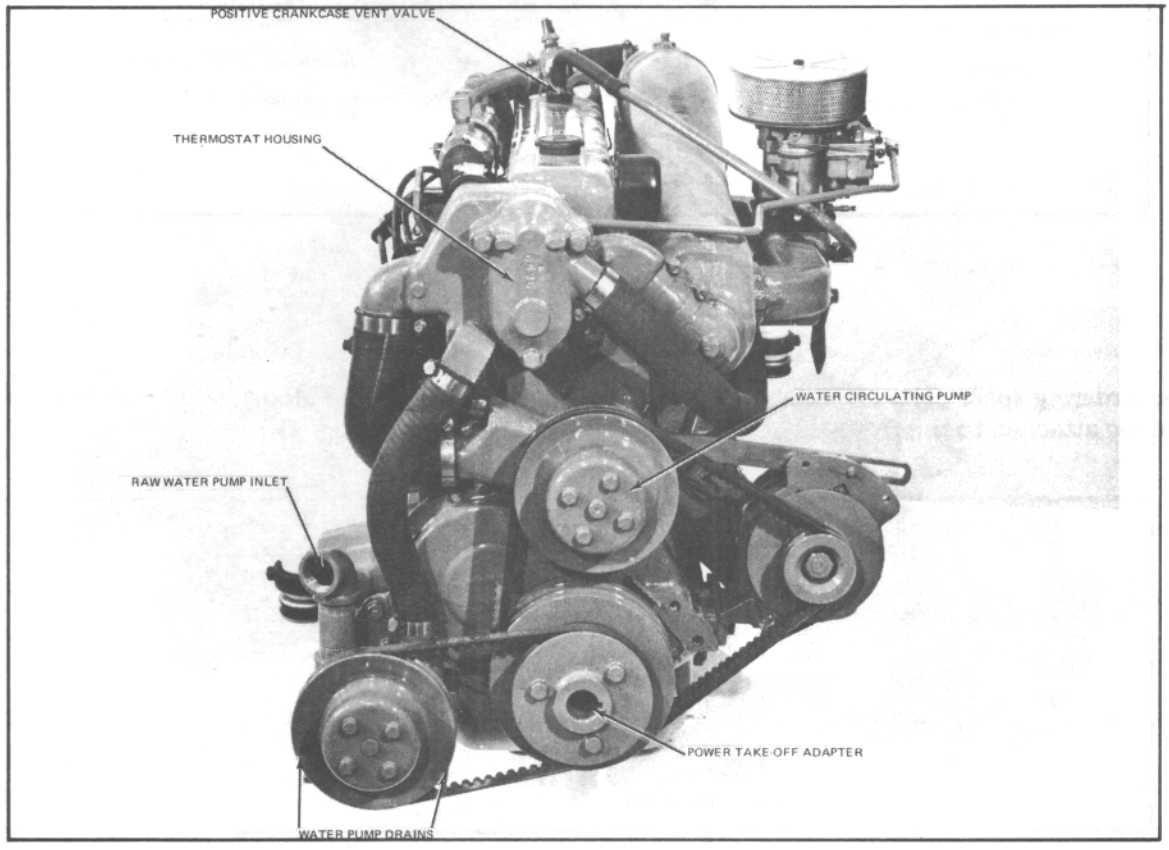


Fig. 6. 292 CID

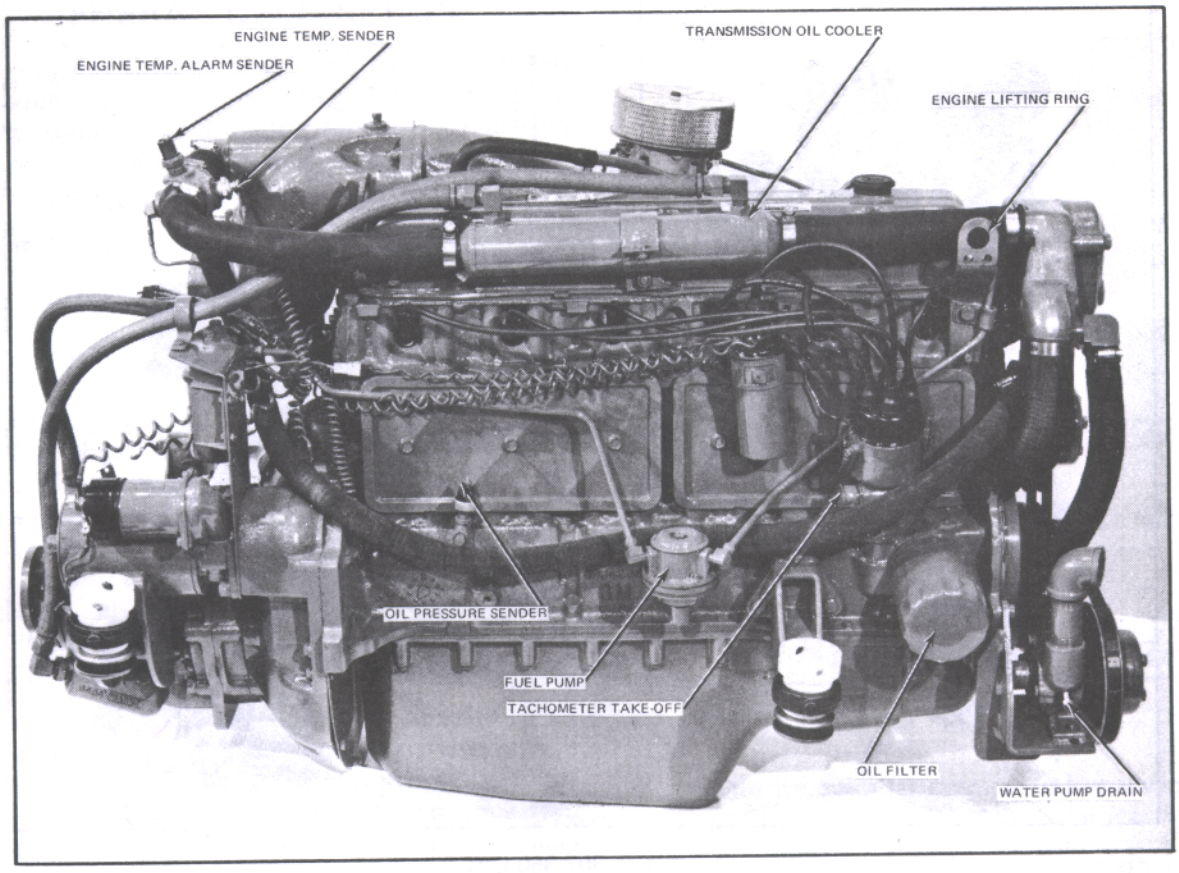


Fig. 7. 292 CID

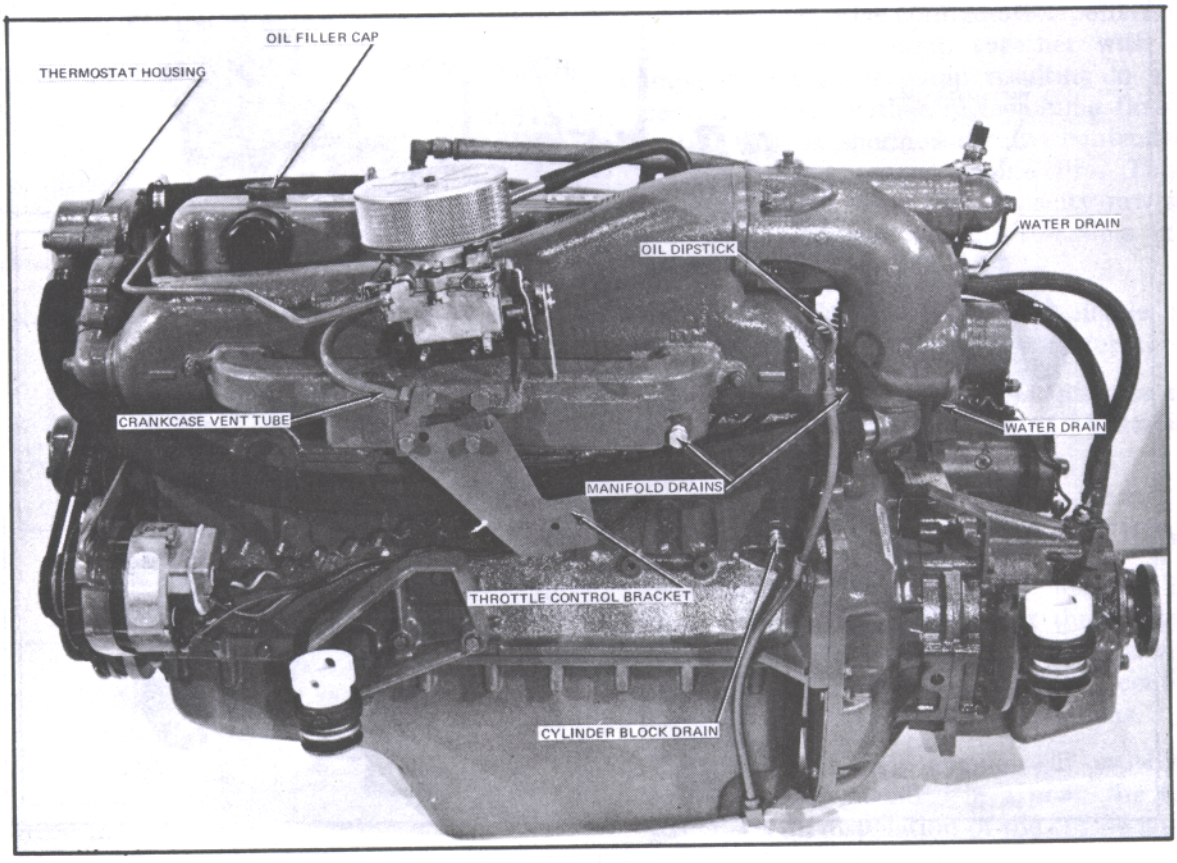


Fig. 8. 292 CID

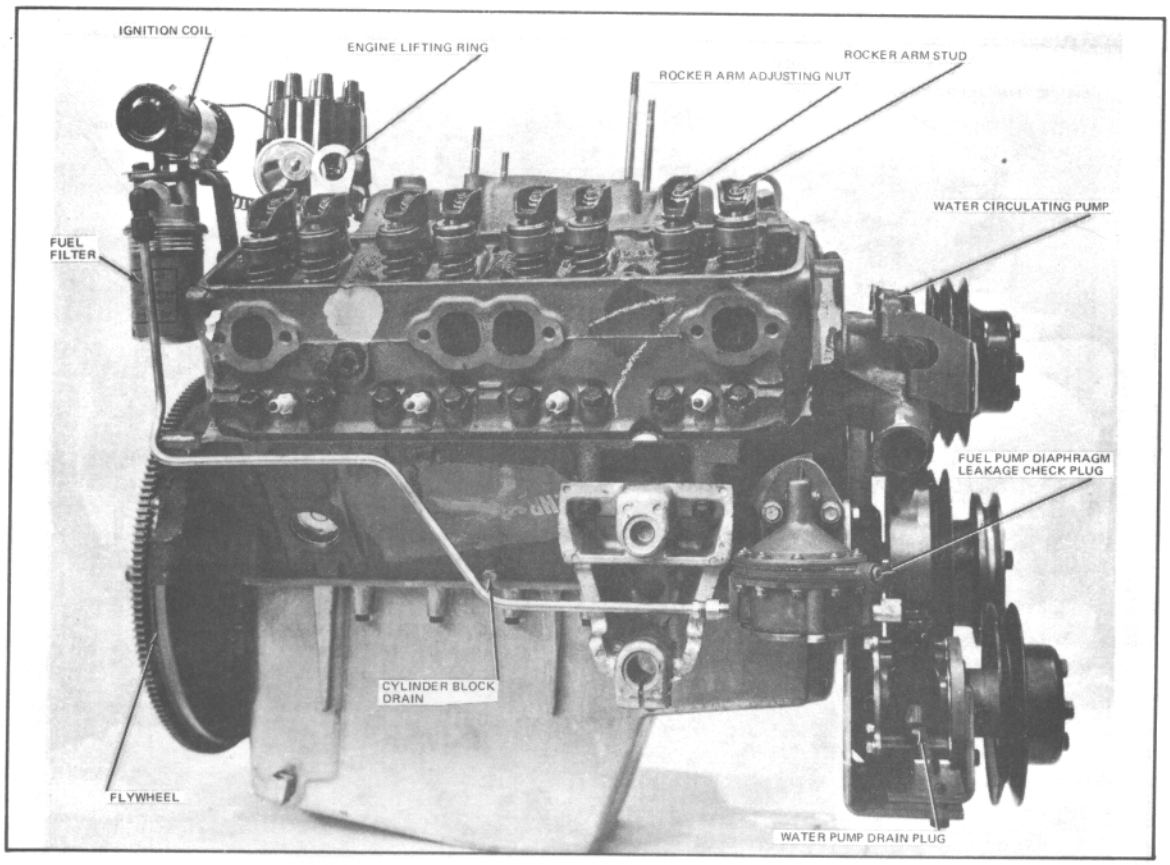


Fig. 9. 307-350 CID

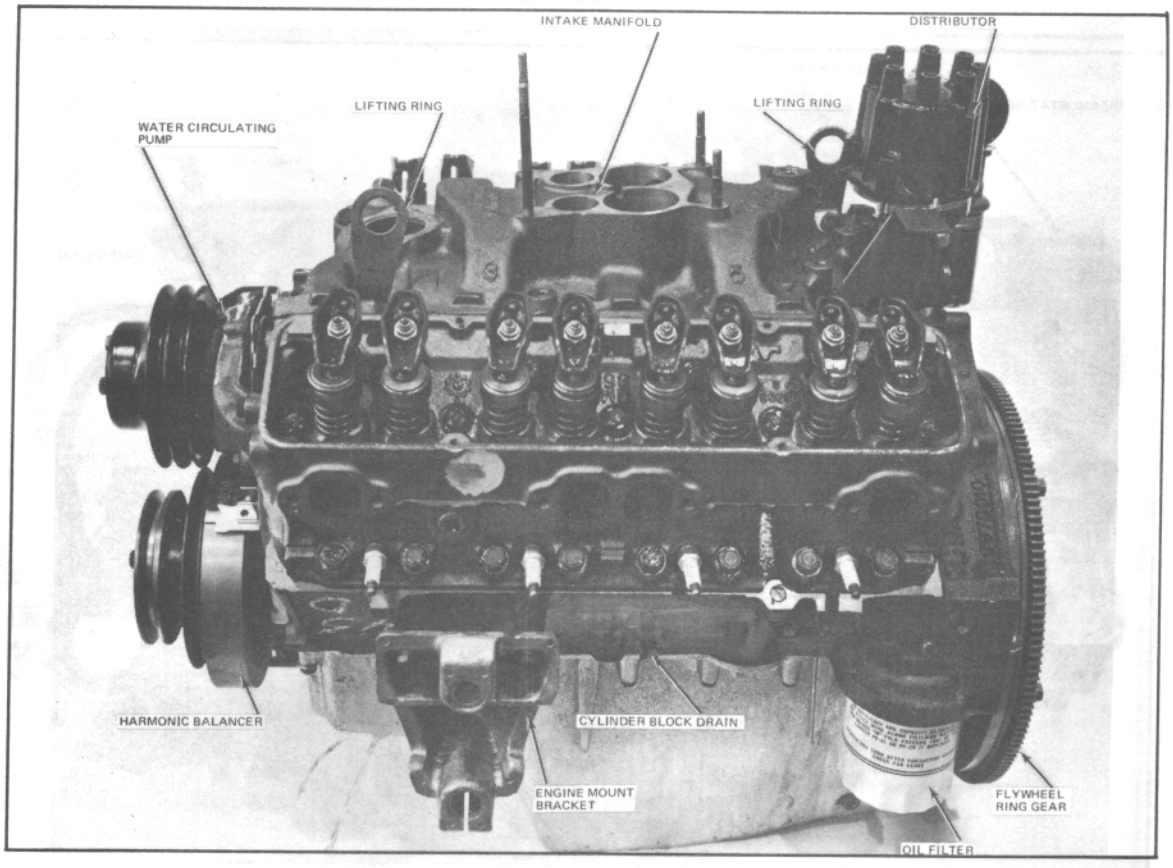


Fig. 10. 307-350 CID

GENERAL DESCRIPTION

The engines covered in this manual are overhead valve, gasoline engines in-line 6 cylinder and V-8 configuration, designed and built primarily for marine application by Thermo Electron Marine Engine Corporation. These include the following models.

6 Cylinder, In-Line	CH-185	292 CID
V-8	CH-220	307 CID
V-8	CH-270	350 CID
V-8	CH-320	427 CID
V-8	CH-350	454 CID

Full pressure lubrication through a full-flow oil filter is furnished by a gear-type oil pump. The distributor is driven by a helical gear on the camshaft which also drives the oil pump. The main oil gallery feeds oil through drilled passages to lubricate the camshaft, main and connecting rod bearings. The main gallery also feeds the valve lifters, which through hollow push rods, feed the individually mounted rocker arms (Fig. 11 & Fig. 12).

The cylinders are numbered from forward to aft and crankshaft rotation is determined by viewing the engine from the flywheel end. Right-hand rotation is clockwise and left hand rotation, counter clockwise. The right hand and left hand side of the engine is also determined from this point of view.

FIRING ORDER

ROTATION	6-CYLINDER	8-CYLINDER
R.H.	142635	12756348
L.H.	153624	18436572

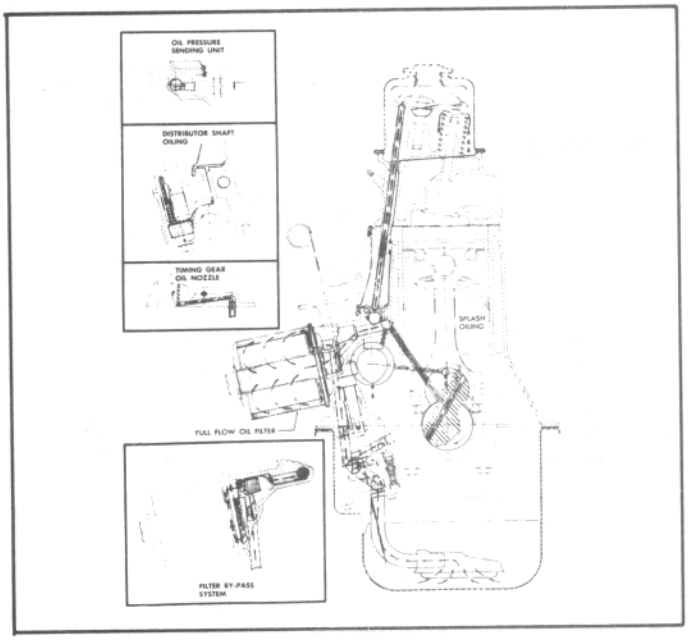


Fig. 11.

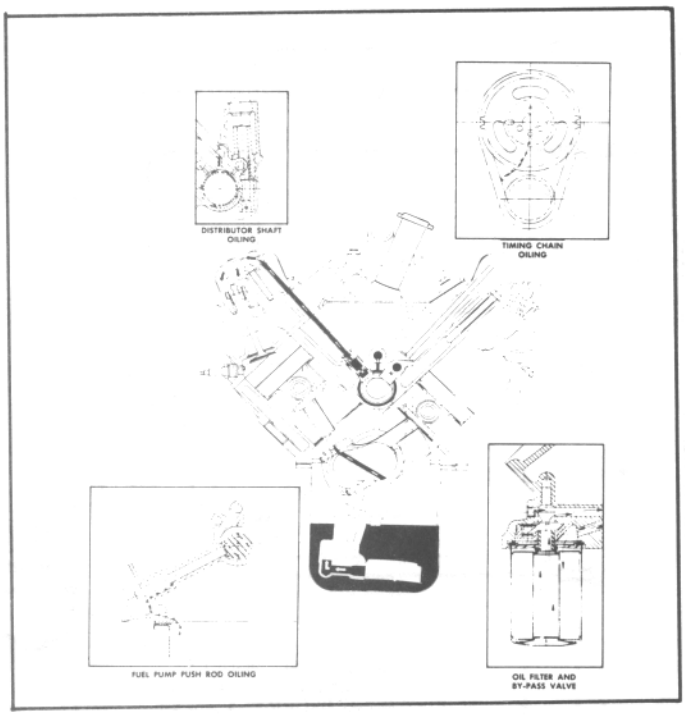


Fig. 12.

The six cylinder crankshaft has seven main bearings and the camshaft has four bearings.

The V-8 crankshaft has five main bearings and the camshaft has five bearings.

Flywheel drive configuration permits the use of a centrifugal water pump together with a neoprene impeller raw-water pump resulting in a two pump cooling system with a high volume flow of cooling water that is thermostatically controlled for best efficiency and longer engine life. This advanced cooling system with high capacity raw-water pump maintains cool and virtually steamless exhaust at all engine speeds.

Fresh water cooling is available as optional equipment, factory installed or kit form.

Warner Velvet Drive Transmissions are standard on all models. Integral mounted "V" drives 15° and 18° are available on all models.

ENGINE INSTALLATION

Foreword: Thermo Electron Marine Engines are designed with the intent that these engines can be installed in pleasure craft or commercial vessels with a minimum of effort on 22-1/2" center stringers normally found in current boat designs.

While the new engine will usually reach the owner already installed in a boat, the following instructions on installation of the engine are included as useful information for mechanics.

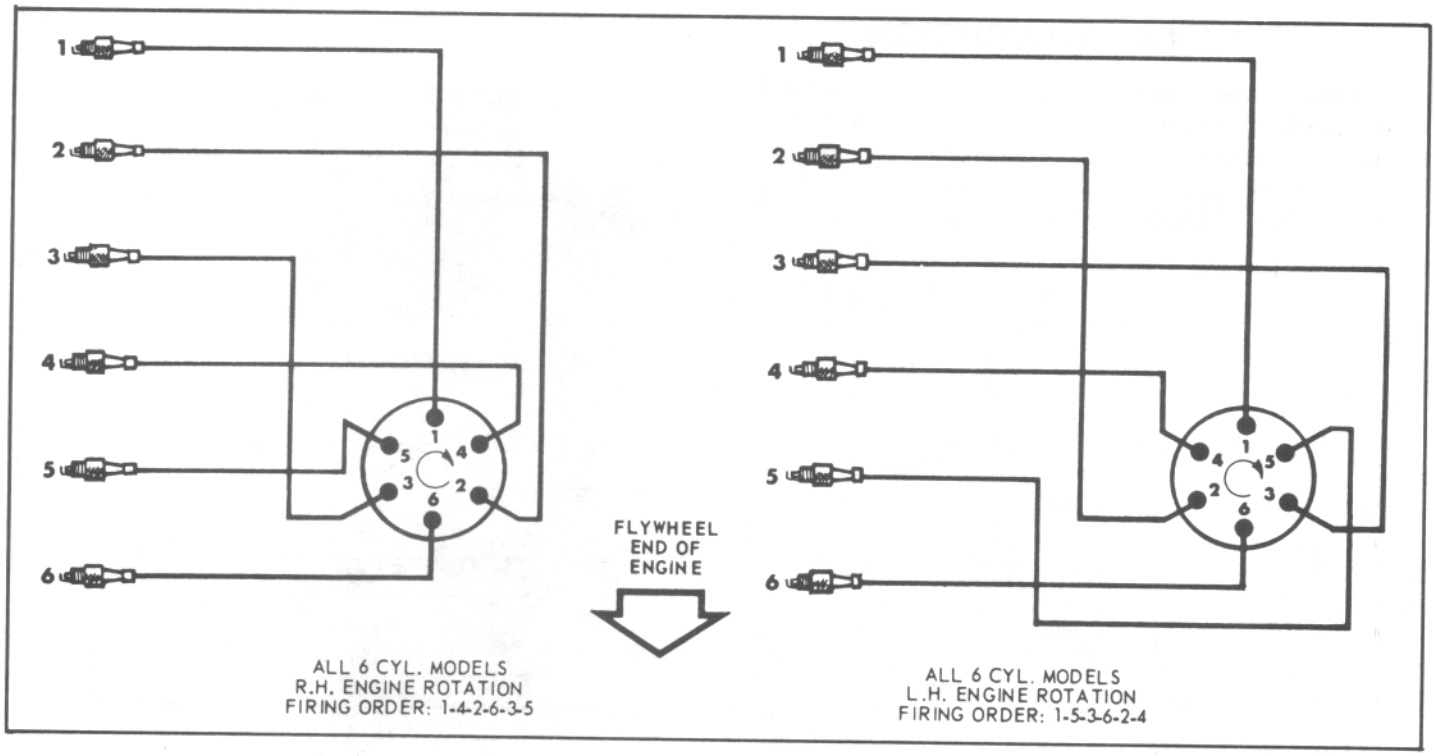


Fig. 13.

Many engine troubles and inconveniences can develop from minor items of incorrect installation, or malfunction of accessories, rather than from some cause originating in the basic engine assembly. It is important to thoroughly understand the details and procedure of the engine installation.

Each Thermo Electron Marine Engine is carefully assembled, tested and inspected before shipment. The engines are ready for use when properly installed and serviced with the proper amount and type lubricating oil as recommended for the crankcase, transmission and "V" Drive, if equipped with enclosed fresh water cooling system, the proper coolant has been installed and system purged of air.

For Safety Precaution: All controls and wiring, and fuel line connections, should be carefully checked before attempting to start engine for the first time.

Break-in Schedule:

The first 15 minutes **Do Not** operate over 1000 RPM.

The next 15 minutes **Do Not** operate over 1500 RPM.

*The next 2 hours **Do Not** operate over 2000 RPM.

*The next 3 hours **Do Not** operate over 2500 RPM.

*The next 10 hours **Do Not** operate over 3000 RPM.

*The next 5 hours **Do Not** operate over 4000 RPM.

*Operate infrequently for short periods of two to three minutes at higher RPM. Do Not Operate steadily at the prescribed RPM for running during the break-in period. Reduce throttle occasionally and then come back gradually to that portion of the break-in schedule you are following.

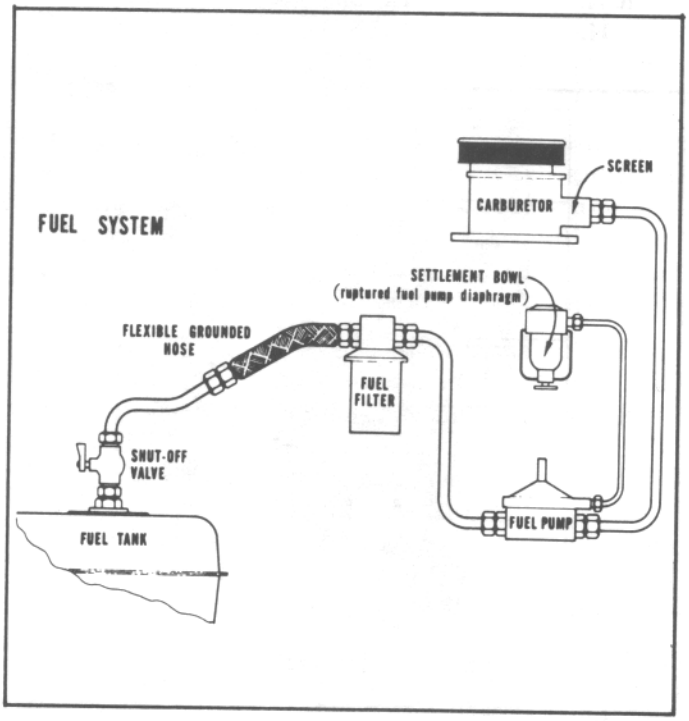


Fig. 14. Fuel System

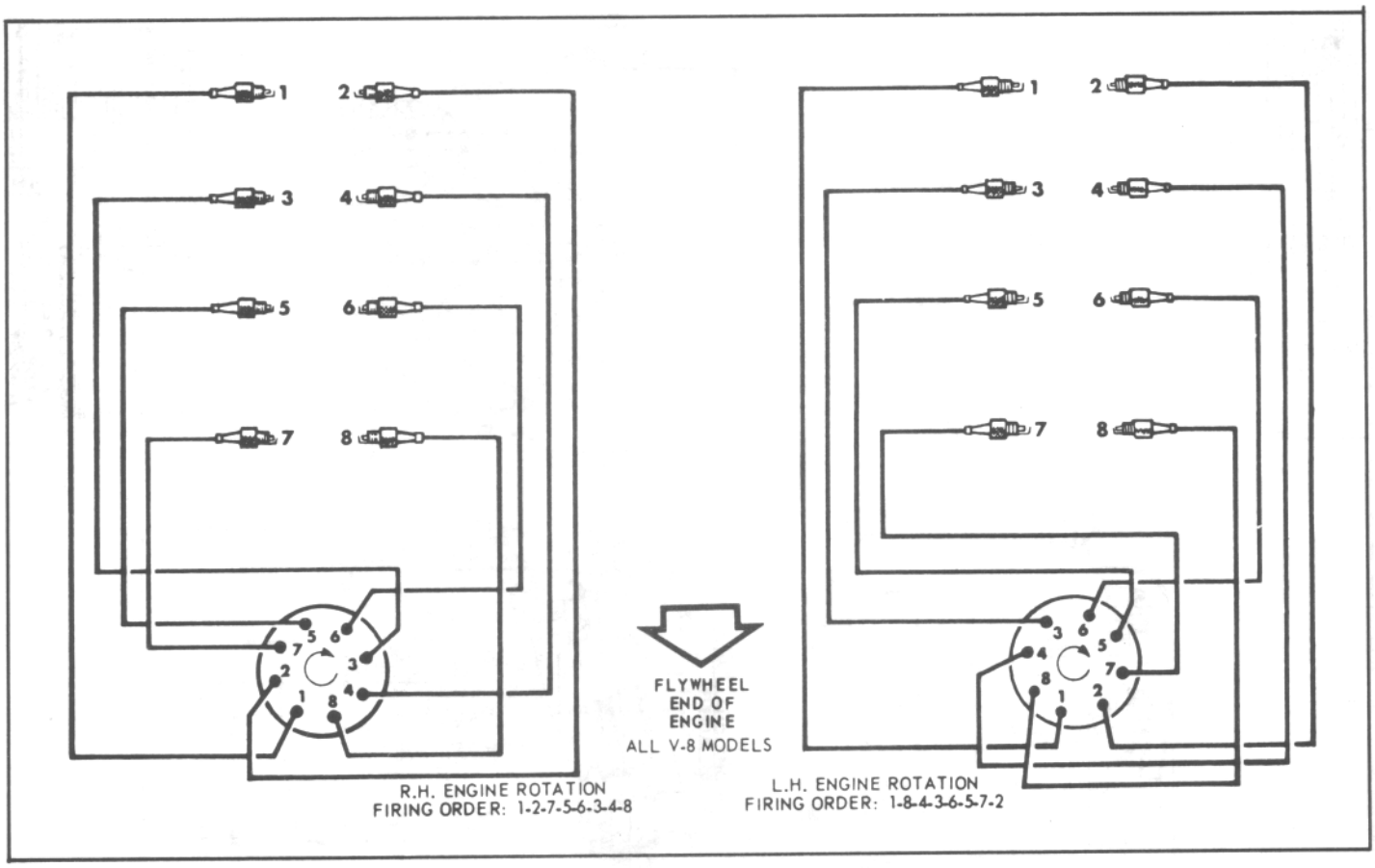


Fig. 15. R.H. & L.H. Engine Rotation

General: The engine is properly skidded or crated for shipment. When received, an immediate inspection for shortage or breakage should be made. Any claim for breakage or shortage in shipment should be filed with the carrier.

Moving the Engine: The engine is equipped with lifting rings designed to carry the full weight of the engine. For safe and easy handling and to prevent any damage to the accessories on the engine, it is recommended that the lifting rings be used. Never use jury rigged slings, these are unsafe and dangerous.

Engine Compartment: The engine compartment should be well planned, with adequate space for proper maintenance, thus assuring longer engine life and trouble free boating. The engine compartment must be well ventilated, a sufficient supply of fresh air is very essential for good performance. If an increase in engine RPM is observed with hatches open as opposed to hatches closed, this is an indication of inadequate ventilation.

Engine Bed: The engine bed should be of the horizontal type of sufficiently heavy construction to insure adequate rigidity, and spaced for 22-1/2" lag bolt centers.

Engine Support Mountings: The engine is equipped as standard with four "angle type" adjustable rubber mounts. The mounts are adjustable up, down, and side ways for quick alignment of the engine to the propeller shaft. Use only 1/2" diameter stainless steel or bronze lag screws of sufficient length or stainless steel or bronze bolts to secure the engine to stringers.

Installation Angle: The angle of engine installation should not exceed a maximum of 18° of the water level.

Sea Water Piping: The thru-hull fitting should be one size larger than the water pump inlet fitting and provided with a scoop facing forward. The connection between the hull and the water pump inlet can be made to suit the convenience of the boat builder. Any hose used in this connection must be of non-collapsing type.

The engine is provided with a thermostat which maintains engine operating temperature. No recirculating piping is required. Cooling water is discharged through the exhaust line no extra piping is required.

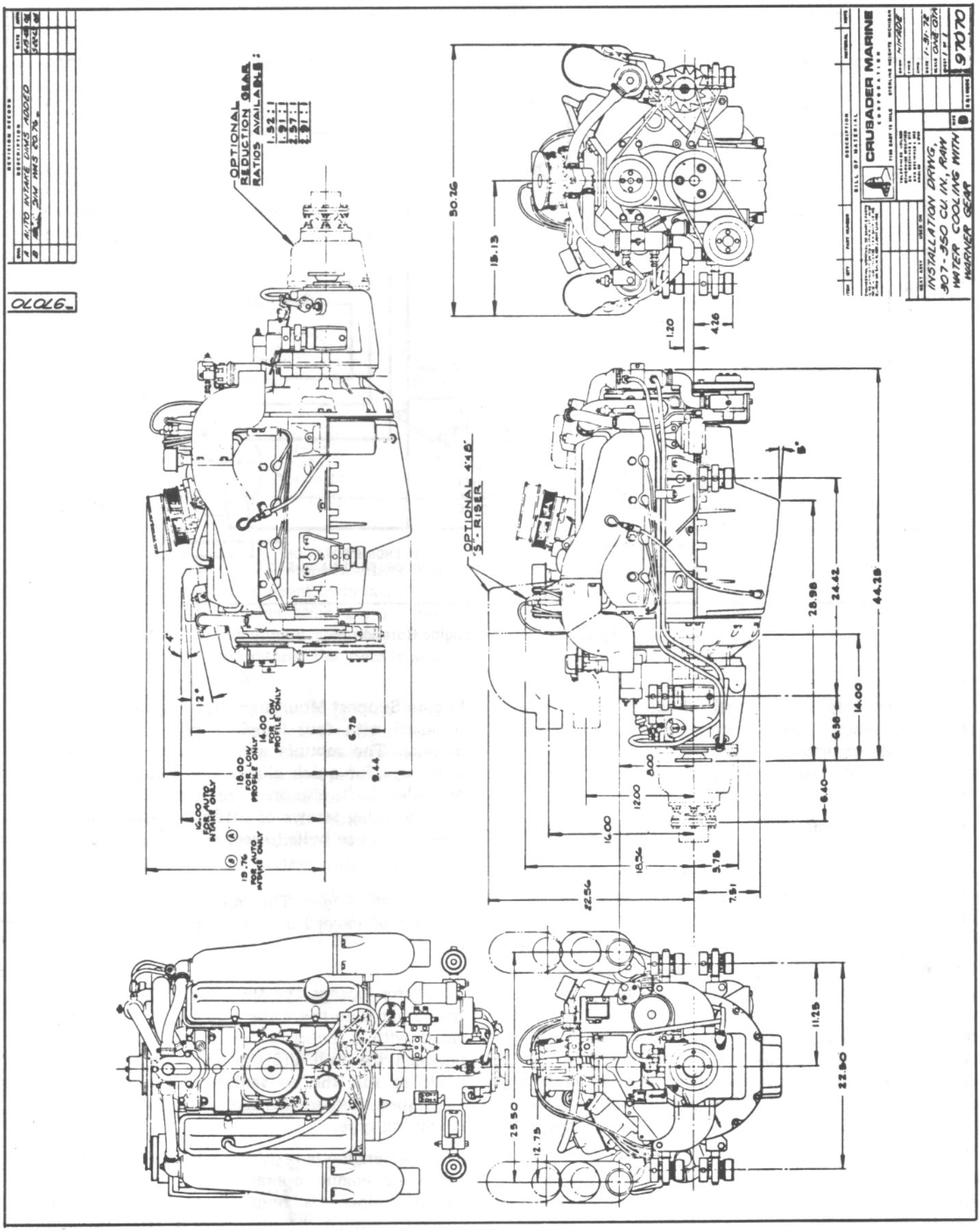


Fig. 16. CH 220 & CH 270 INB

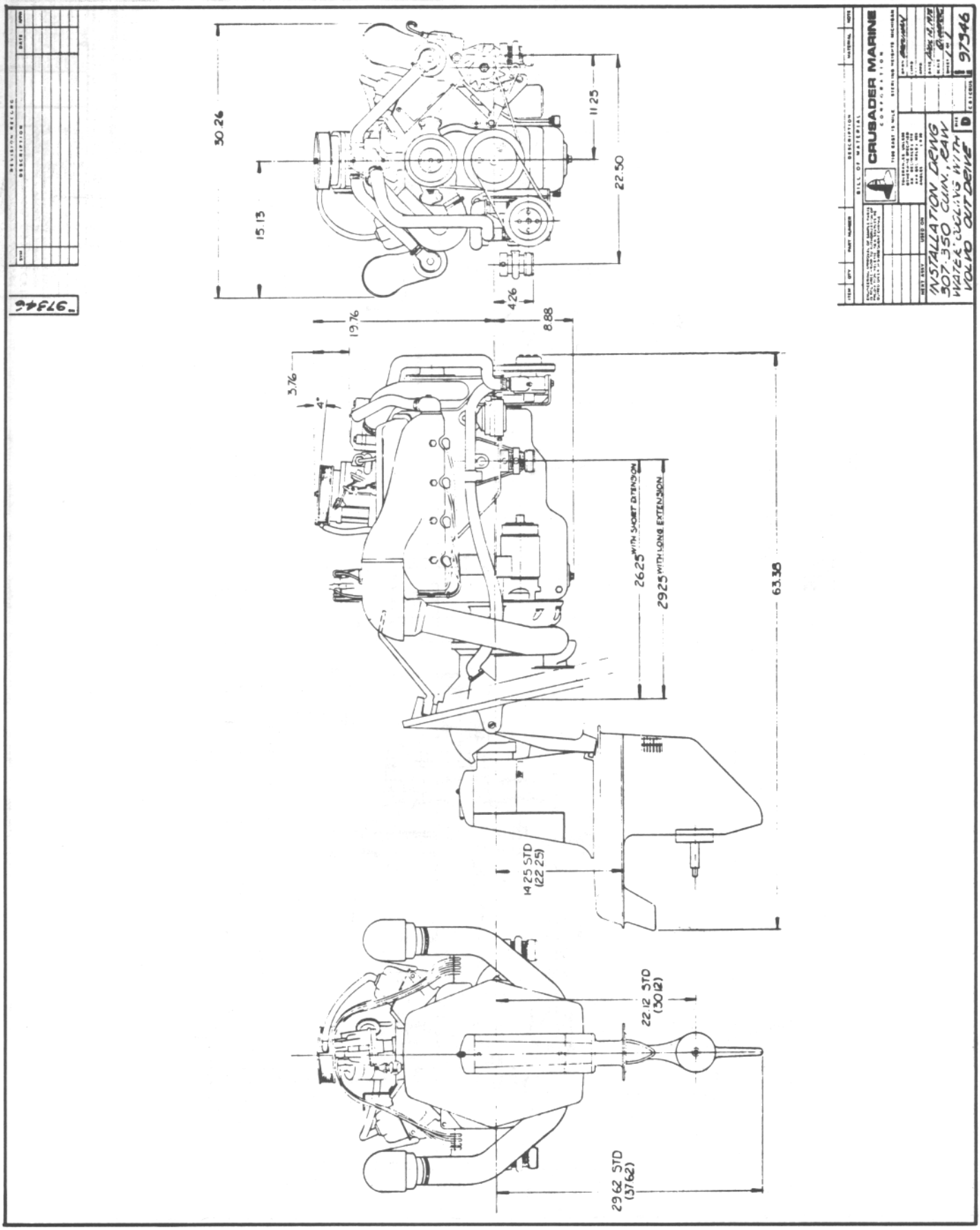


Fig. 17. CS 300 I/O CS 220 & CS 270 I/O

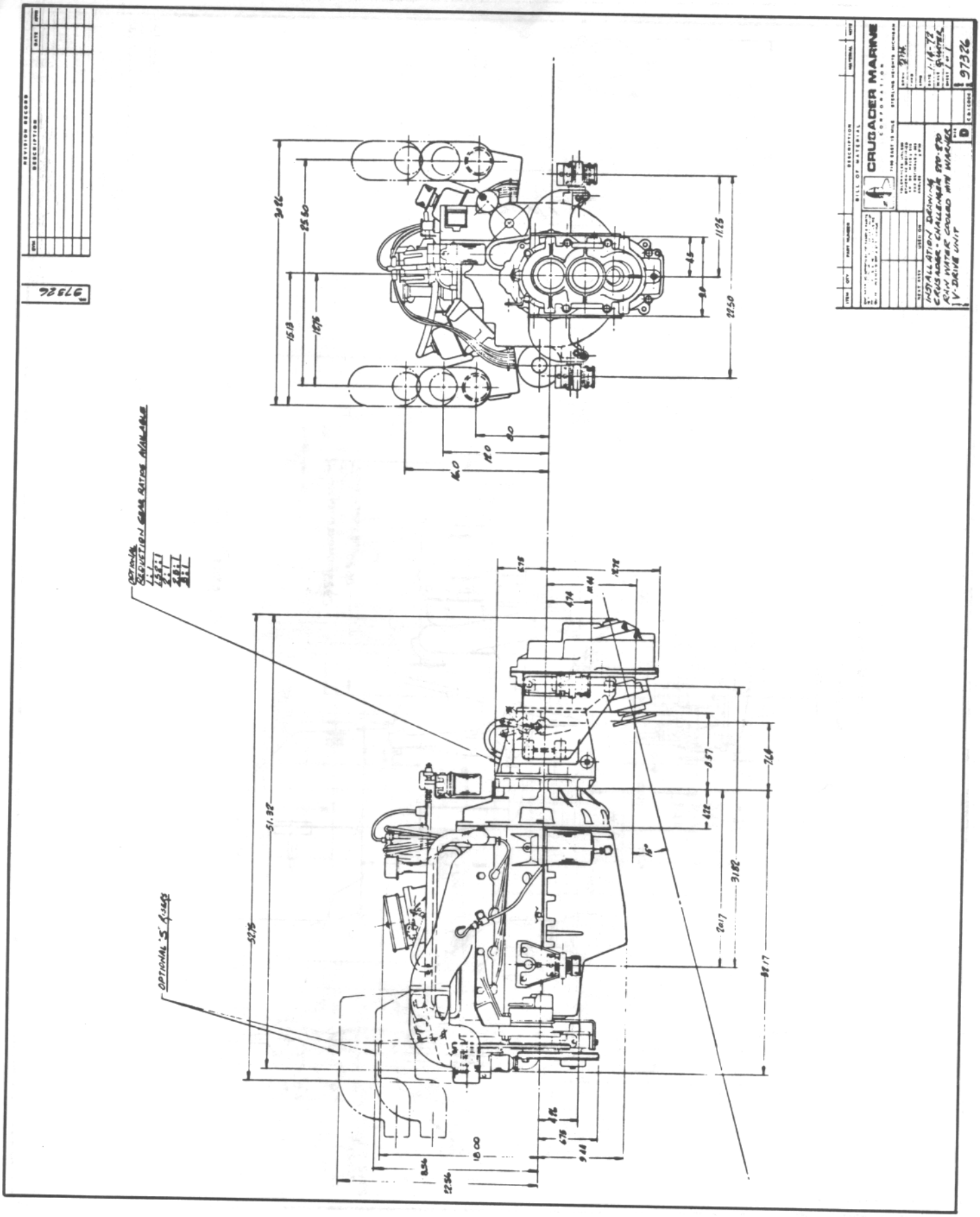


Fig. 18. CH 220 & CH 270 V-DR 15°

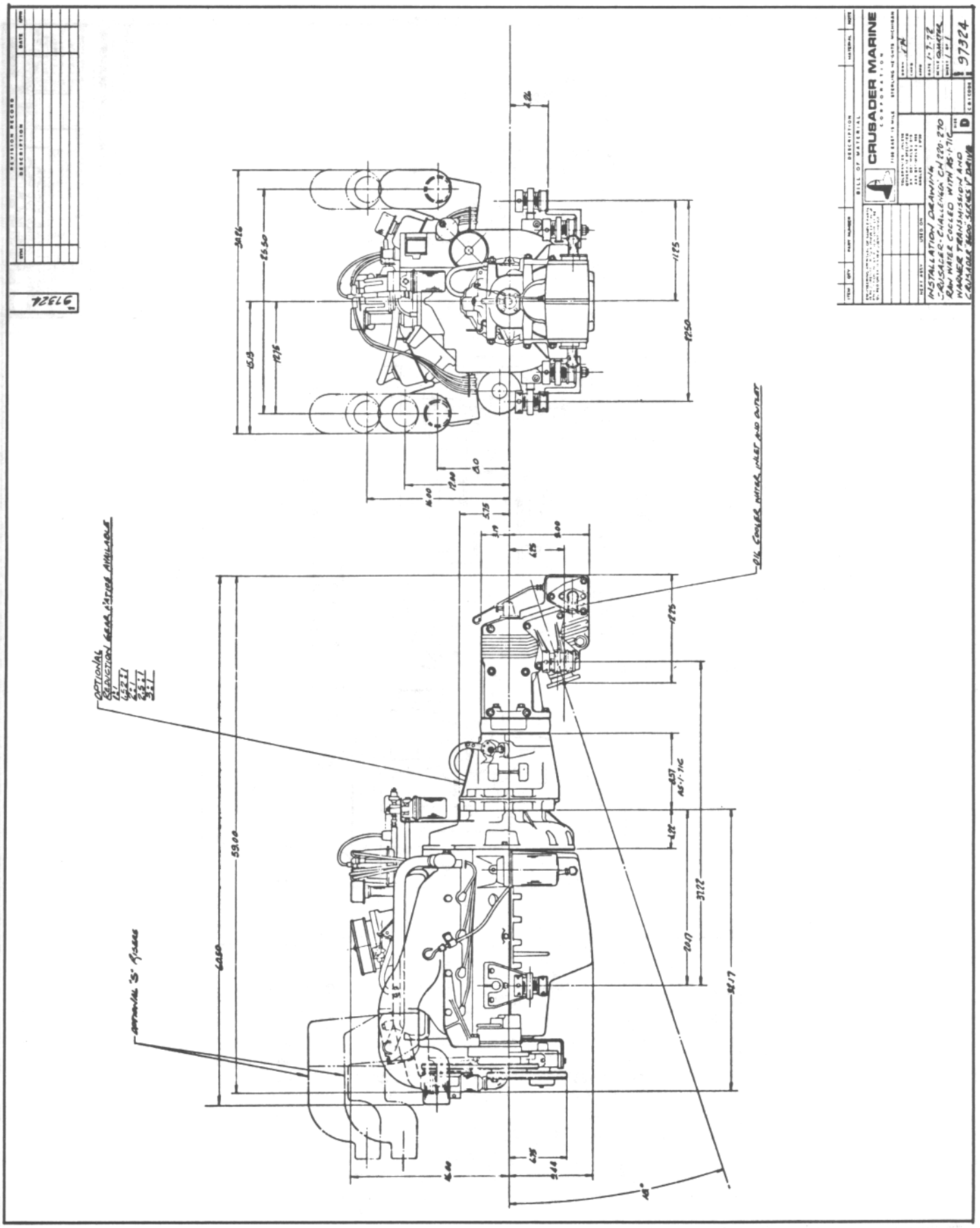


Fig. 19. CH 220 & CH 270 V-DR 18°

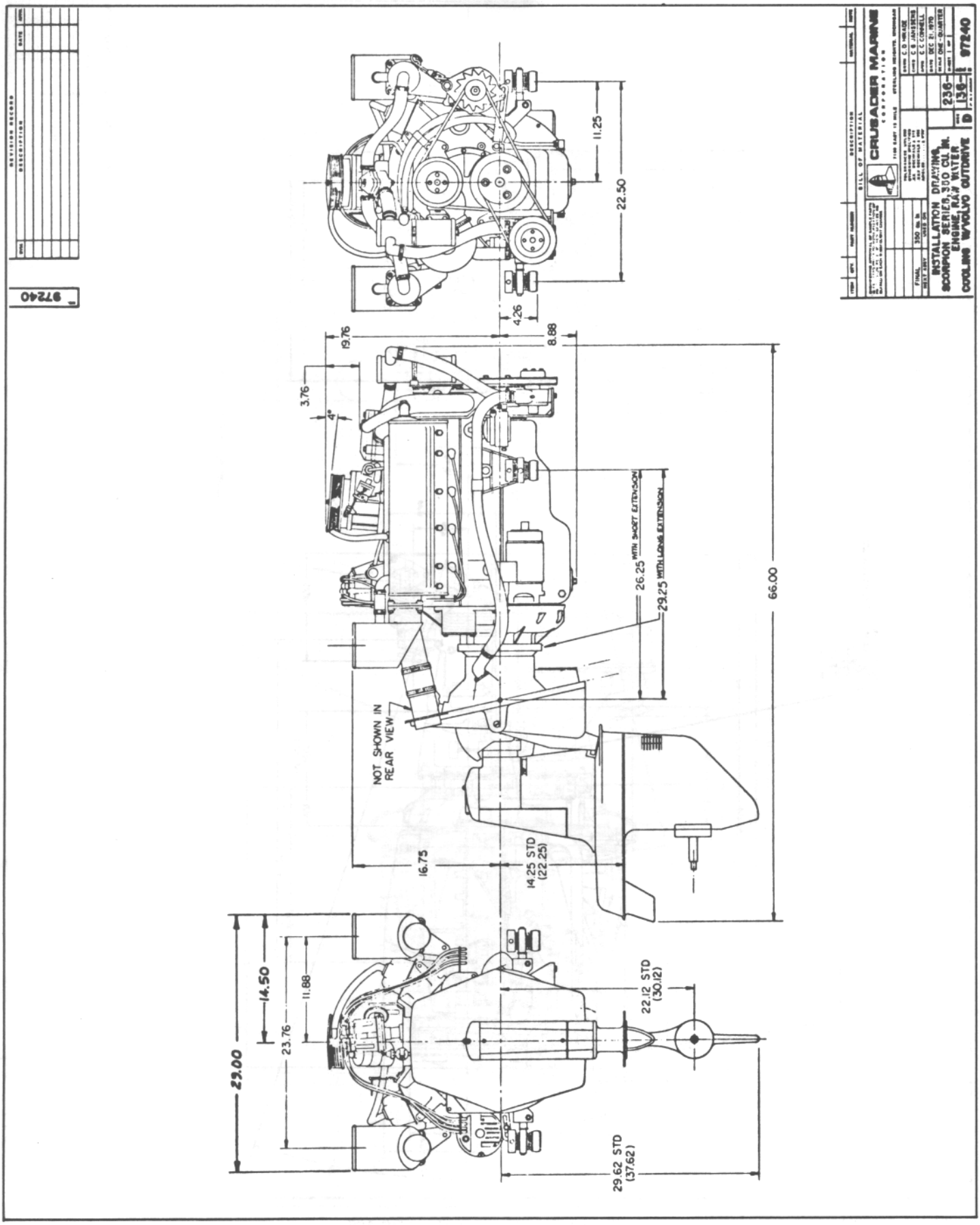


Fig. 20. SS 300 I/O

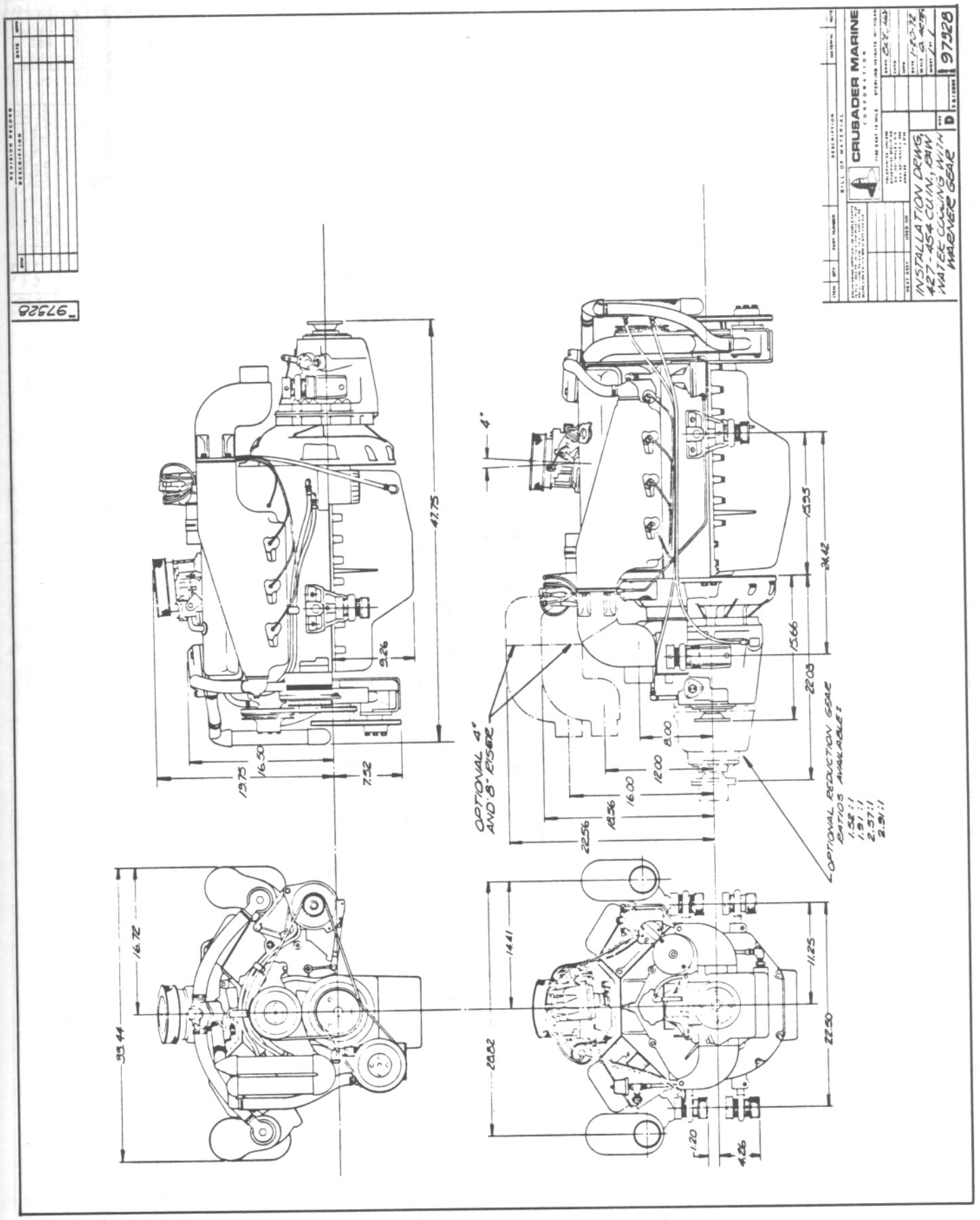


Fig. 21. CH 320 & CH 350 INB

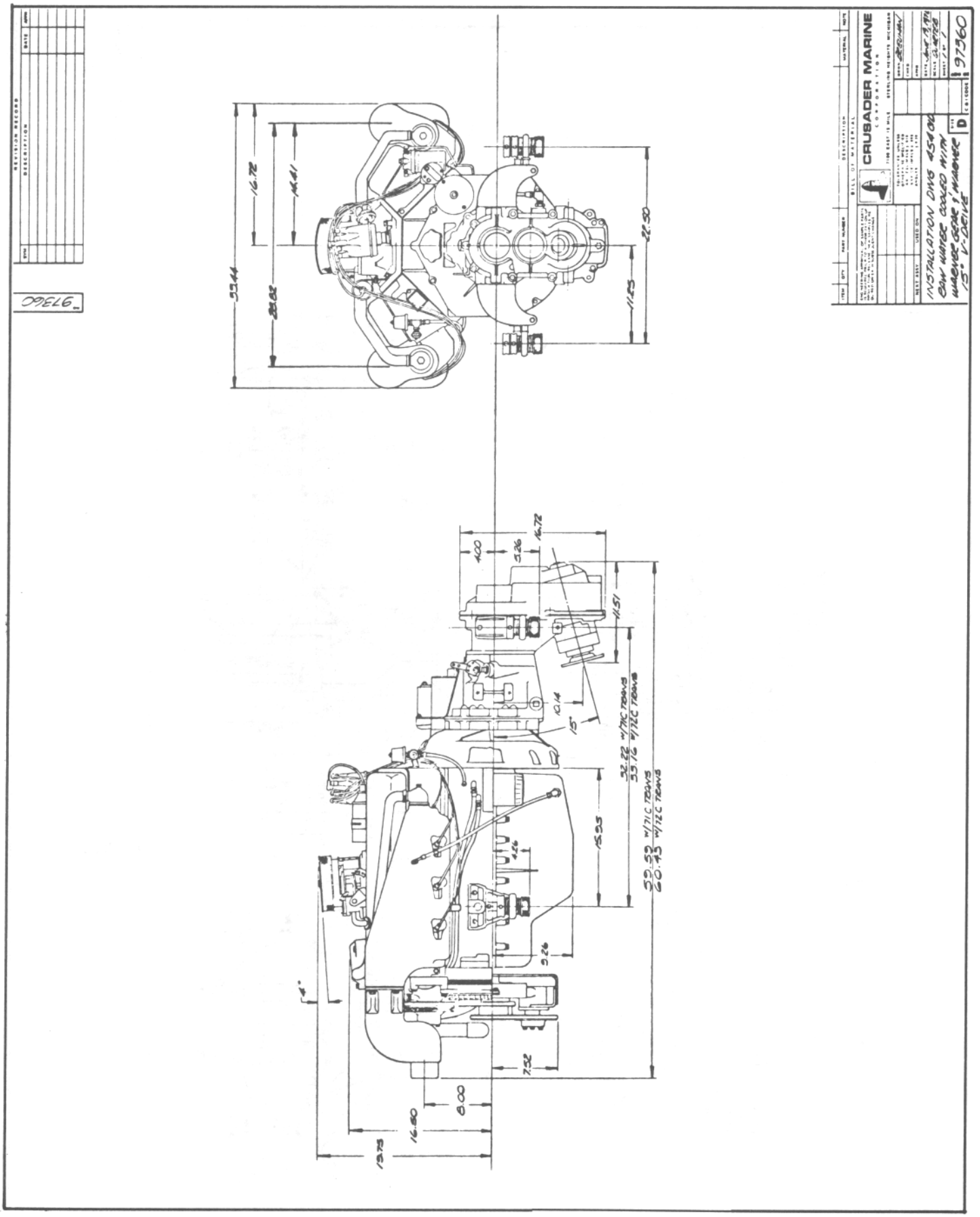


Fig. 22. CH 350 V-DR 15°

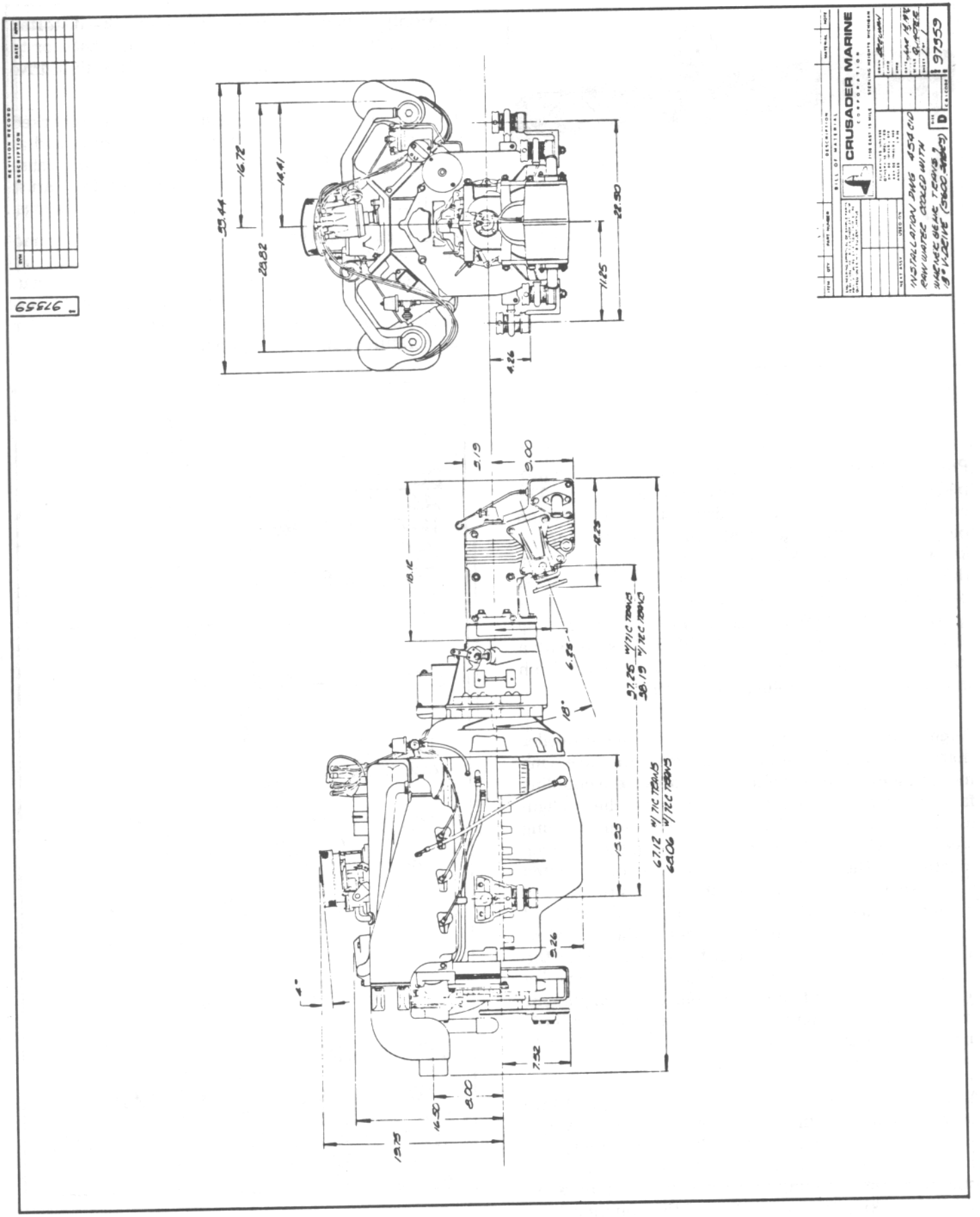


Fig. 23. CH 350 V-DR 18°

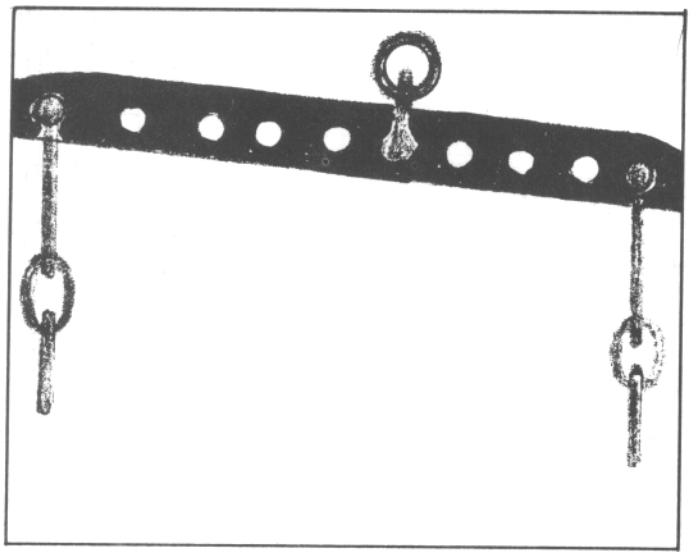


Fig. 24. Lifting bar with center of gravity holes

Propeller Shaft Coupling: The engine end of the propeller shaft must be provided with a keyway. The coupling should have a light drive fit on the shaft and be provided with a key that will fit the sides of the keyway, but with clearance at the top of keyway in the coupling hub. The propeller shaft coupling must be secured to the propeller shaft with set screws spotted in the shaft and safety wired, or by drilling through the coupling hub and shaft and secure with a stainless steel pin, this is to prevent the shaft from pulling out of the coupling when reversing.

Alignment: Preliminary alignment of the propeller shaft coupling faces should be made before the engine mounting hold-down bolts are installed, the coupling faces must be parallel, within .002". To check alignment, insert a .002" feeler gauge between coupling faces at twelve "o'clock" position, bring the coupling together so the .002" feeler gauge can be retracted with a slight pull. Holding the shaft in position, insert the feeler gauge at the three, six, and nine "o'clock" position between the coupling faces. If the alignment is correct, the feeler gauge can be retracted with the same (pull or drag). Secure engine hold down lag screws or bolts and repeat coupling face alignment check. Any misalignment can be corrected by adjustment of the engine mounts.

NOTE: The propeller shaft half of the coupling face must be true within .002 runout. Occasionally distortion of the propeller shaft half of the coupling can occur when using under size shafting, that can cause runout of the coupling face when the set screws are secured, making true alignment of the coupling faces impossible. The only remedy for this is to reface the distorted coupling in a lathe while secured to the shaft, or to bore a "blank" coupling to fit the shaft with a drive fit.

The propeller shaft alignment should be rechecked after the boat is in the water for several days and at the beginning of each season. Misalignment will cause vibration and rapid wear or damage to the thrust bearing, in the reverse gear, and stuffing box bearings.

Electrical Systems and Connections: Thermo Electron Marine Engines are equipped with 12 volt prewired electrical system with plug-in jack to instrument panel. A alarm system for low engine and transmission oil pressure and high engine water temperature is standard equipment.

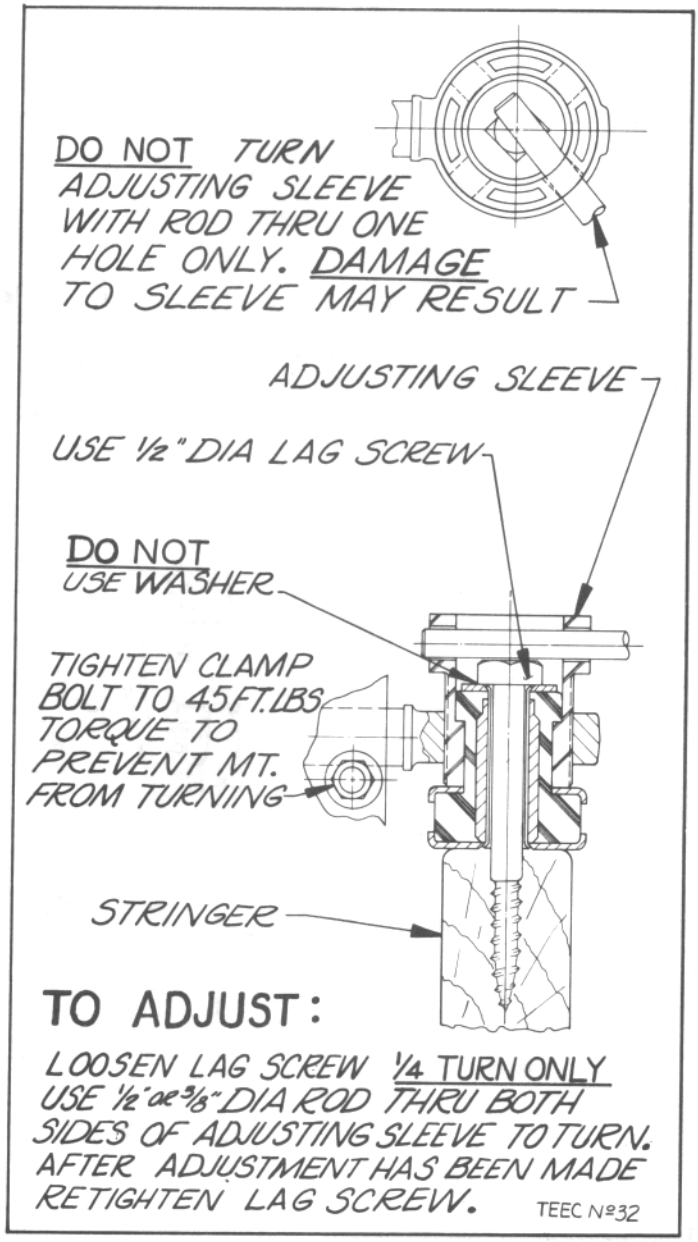


Fig. 25. TEEC No. 32

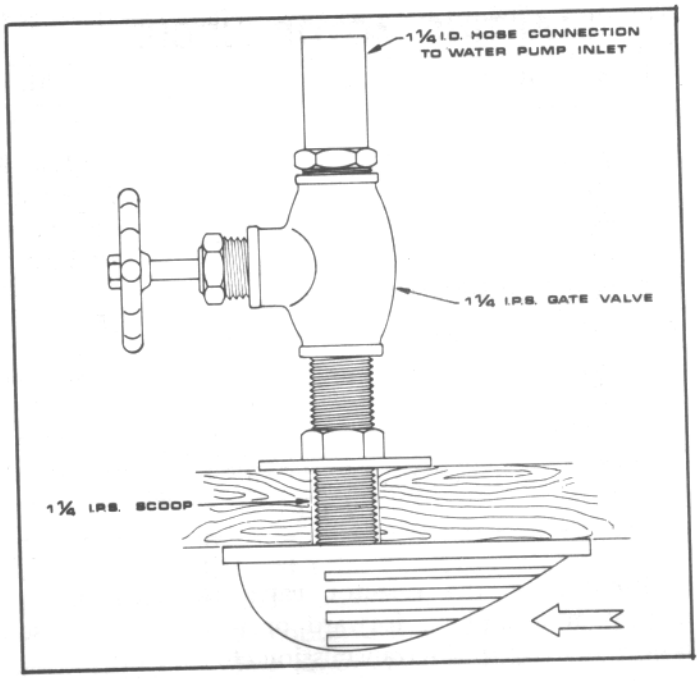


Fig. 26. Through-Hull & Shut Off Valve

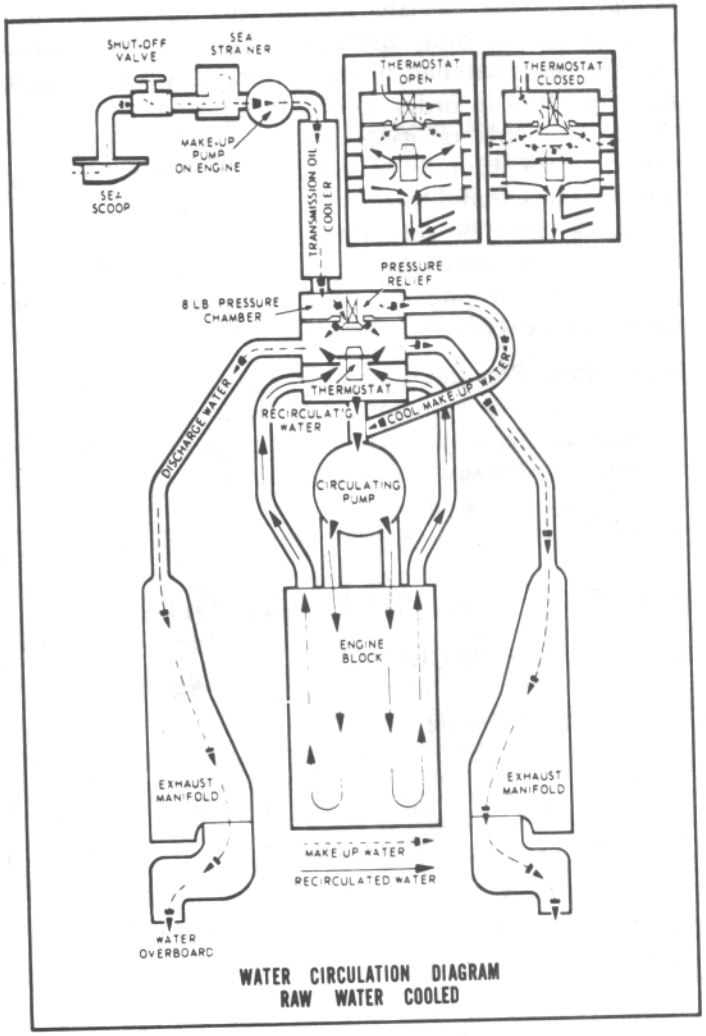


Fig. 27. Raw Water Cooling System Water Circulation

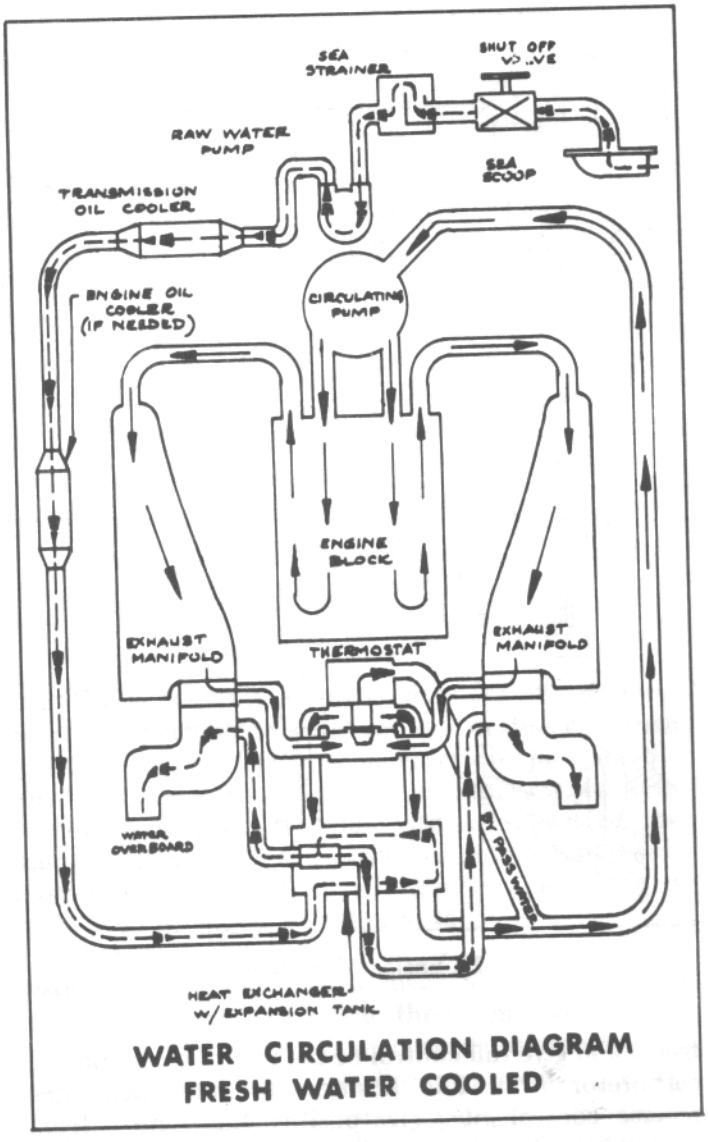


Fig. 28. Closed Cooling System Water Circulation

The voltage regulator is mounted on the engine at the factory. To insure satisfactory operation, the electrical system must be properly installed. (See wiring diagram) In order to prevent excessive voltage drop, and insure good starting, the battery must be installed as close to the engine as possible. Battery cables must be of adequate size. (See Table of Recommended Wire Size) If the starting switch is over 12 Ft. from the engine, a relay in the starter circuit is recommended.

Terminals on wiring must be soldered or tightly crimped. It is recommended that a heavy duty marine type battery be used, capacity 70 ampere hours minimum. **Do Not** connect negative ground terminal to any aluminum part on the engine.

Controls: To insure safety and good boat handling it is very important therefore, that a good set of controls be installed. The throttle control must operate

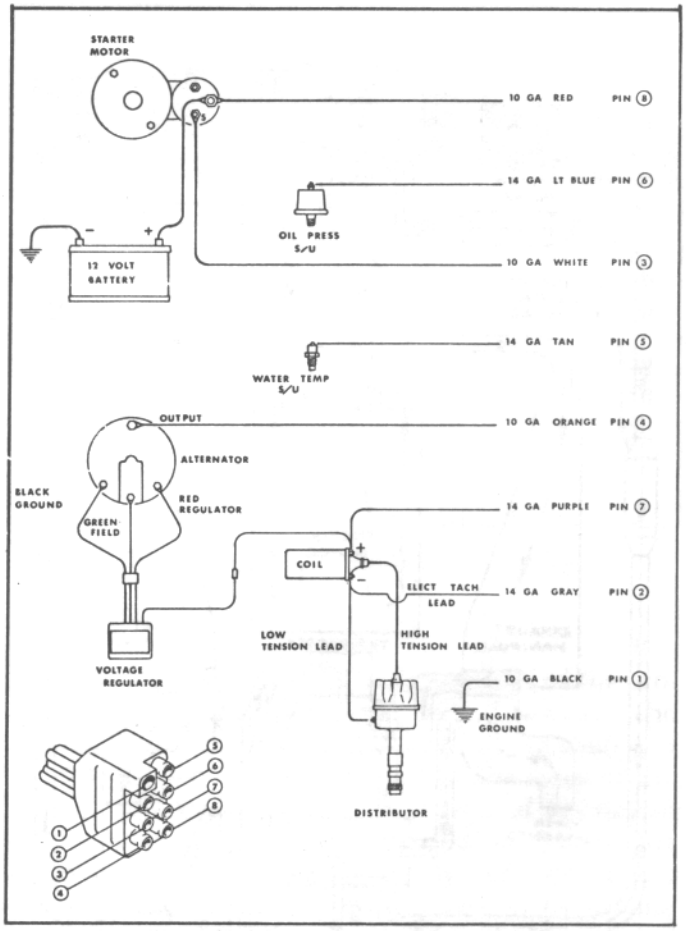


Fig. 29. Engine Wiring Diagram

freely and give full control of the throttle lever on the carburetor from idle position to full open. The reverse control must give positive full control from forward to neutral to reverse.

WARNING: The selector valve control on the Warner transmission has a built-in detent for neutral, forward and reverse position. **Do Not** use a reverse gear control with its own detent as this might prevent proper positioning of the selector valve resulting in no neutral or a slipping forward or reverse and cause serious damage to the transmission clutch pack.

STARTING MOTOR CIRCUIT

CABLE SIZE B&S GAGE	TOTAL LENGTH
0	5 FT.
00	7.5 FT.
000	10 FT.
0000	12.5 FT.
CIRCULAR MILS	
250,000	15 FT.
350,000	20 FT.
450,000	25 FT.
550,000	30 FT.
MAX. PERMISSIBLE LOSS IN CABLE = 5% AT 1000A = 0.6V	

Instruments: Instruments or gauges should be installed in a position for easy observance by the operator. With electric instruments or gauges, use only those sending units supplied by the manufacturer and matched to the gauges, **this is important** and **necessary** in order to obtain a proper reading on the instruments or gauges. All wiring should be of water proof type installed in a manner for easy tracing and secured to prevent fouling. All connecting terminals must be soldered or properly crimped and securely connected. Minimum instruments required per engine, oil pressure gauge, ammeter or voltage meter, water temperature gauge, and tachometer.

Fuel Line: For the fuel line from the tank to the engine, we recommend 3/8" min. O.D. tubing adequately secured and provided with a flexible section near the engine to reduce vibration to the fuel line fittings. The tubing should conform to Coast Guard Yacht Safety Bureau standards. The use of a

RECOMMENDED WIRE SIZES FOR ALT. & CONTROL CIRCUITS

CURRENT IN CIRCUIT AMPS	TOTAL FEET OF SINGLE WIRE IN CIRCUIT									
	10	20	30	40	50	75	100	125	150	200
	USE WIRE NOT SMALLER THAN									
5	No. 12	No. 12	No. 12	No. 10	No. 10	No. 8	No. 8	No. 6	No. 6	No. 4
10	No. 12	No. 12	No. 10	No. 8	No. 8	No. 6	No. 4	No. 4	No. 3	No. 2
15	No. 12	No. 10	No. 8	No. 6	No. 6	No. 4	No. 3	No. 2	No. 1	No. 0
20	No. 10	No. 8	No. 6	No. 6	No. 4	No. 3	No. 2	No. 1	No. 0	
30	No. 10	No. 6	No. 4	No. 4	No. 3	No. 1	No. 0			
40	No. 8	No. 6	No. 4	No. 4	No. 2	No. 0				
50	No. 6	No. 4	No. 3	No. 3	No. 1					
	WIRE SIZE RECOMMENDATION BASED ON MAXIMUM VOLTAGE DROP OF 2.5% OR 3 VOLT									

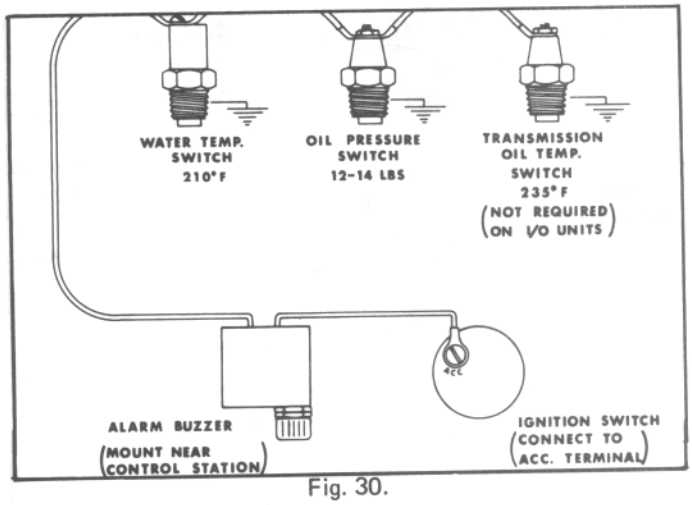


Fig. 30.

large capacity fuel filter in this line is recommended. Fuel tanks should be of a size commensurate with the hull requirements and should be anchored and vented in such a manner to conform to Coast Guard regulations. The fuel filling arrangements should conform to all safety regulations, and must be outboard. The installation of an approved fuel shut-off at the tank is mandatory.

Note: The fuel tank should be installed below the height of the carburetor.

Exhaust System: Thermo Electron Marine Engines are equipped with a two pump cooling system affording a full flow of 20-30 gallons of water thru the exhaust system. Emission of steam from the exhaust is almost completely eliminated at all engine speeds except under certain atmosphere conditions. The exhaust manifolds are high rise type designed for efficient flow of exhaust gas away from the exhaust ports with long sweeping curves, eliminating internal pressure for optimum power out-put and economy. The manifolds are fully water jacketed with no external hot spots. Factory installed water cooled exhaust outlet elbows are standard equipment. For large boats and deep "V" designed hulls, 4" and 8" water cooled exhaust risers are available as optional extra equipment. Exhaust line size requirement is 3" I.D. hose or tubing for twin exhaust or 4" I.D. hose or tubing for single exhaust with ,'Y" connector.

CAUTION: The exhaust lines must be installed with a gradual slope aft with a minimum of 1/2" drop per foot of length. The exhaust outlet at the transom must be at least 2" above the water level. The exhaust lines must be self draining, with no sags in exhaust lines. See diagram ("Exhaust System Installation").

Exhaust mufflers, must be of adequate size with inlet and outlet connections not smaller in diameter than the recommended exhaust pipe size. The mufflers must be designed to create a back pressure of not more than 3 P.S.I. @ 4000 RPM.

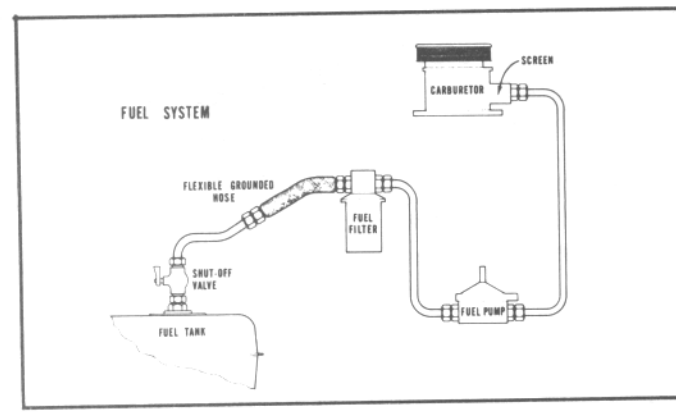


Fig. 31.

CAUTION: Do Not use 90° bends with less than a 6" radius in the exhaust lines. All exhaust system pipes and mufflers must be supported in a manner to eliminate any strain on the exhaust manifolds.

Dry Stack Exhaust System: Dry exhaust systems must be of adequate size, not less in diameter than the threaded dry stack connectors provided on the engine. The exhaust system must be equipped with flexible connections to eliminate any strain on the exhaust manifolds and independently supported. Back pressure caused by any muffling device must not exceed three P.S.I. @4000 RPM.

WARNING: An improperly installed exhaust system without adequate slope from the engine exhaust outlet to transom outlet and with outlet at transom less than 2" above the water line can result in water entering the engine cylinders, causing serious damage to the engine, even while the boat is at its mooring or in a following sea.

Any attempt to start the engine with a (hydrostatic lock) caused from water entering the cylinders through the exhaust system, WILL RESULT IN BROKEN PISTONS AND/OR BENT CONNECTING RODS.

Back Pressure: Excessive back pressure in the exhaust system will affect fuel economy and durability of the engine and is often over looked by servicing and operating personnel as being a contributing factor of engine malfunction.

High exhaust back pressure is usually attributed to one or more of the following:

1. Exhaust pipe too long
2. Exhaust pipe too small
3. Muffler too small
4. Too many sharp bends in exhaust system

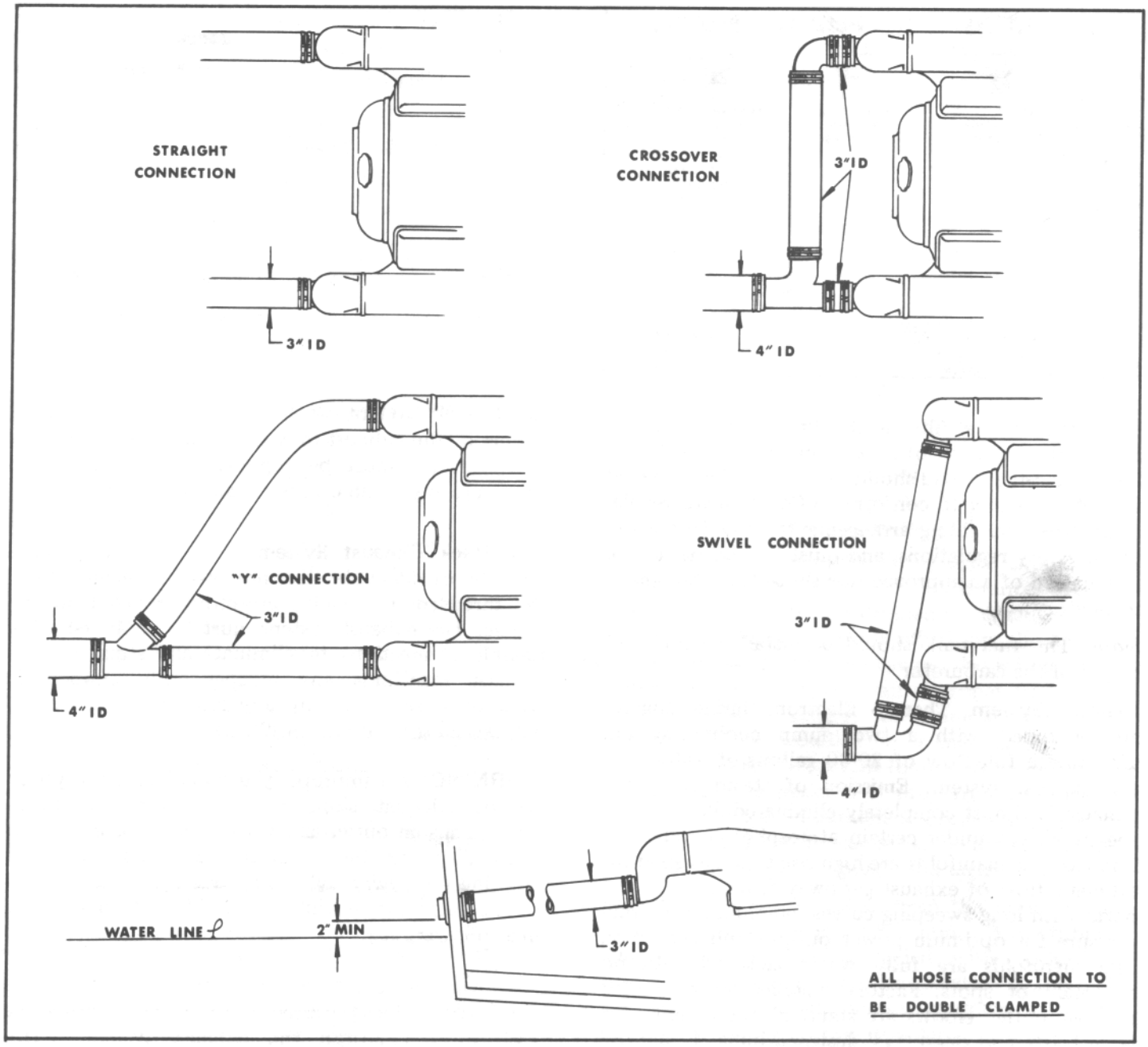


Fig. 32. Exhaust System

PRIOR TO ACTUAL INSTALLATION

Check the rotation of the engine or engines. This is important on twin installations. The normal practice is to turn the propeller outboard. The propeller rotation on engines equipped with direct drive, 1.52:1, 2.57:1 and 2.91:1 transmission is the same as the engine rotation. The propeller rotation on engines with 1:91:1 transmission is opposite engine rotation.

PRECAUTION: Before placing the engine in the boat, it is good practice to check for and tighten any bolts or cap screws on the under side of the engine.

SUMMARY: A few extra moments given to plan a good installation and the use of good quality materials, plus allowing ample access space for normal maintenance of the engines, will result in maximum operating and ultimate safety for your crew and passengers.

Regular maintenance of the engines and accessories as outlined in the owners manual is the responsibility of the owner or operator. Regular maintenance by a competent mechanic will add hours of life to the engine with pleasurable and trouble free performance.

PREPARATIONS FOR STARTING ENGINE FIRST TIME

When a new boat is put into service, an interval of time has usually elasped in storage or transit since the engine was installed. For this reason as a matter of precaution it is wise to carefully check the following items before attempting to start the engine.

1. **Fill Crankcase with Lubricating Oil** to high level mark on oil dipstick-Use 10W-30 "SE" for break in and cold weather operation and 30W "SE" for warm weather operation. The oil filler is located on top of valve rocker arm cover.
2. **Fill Transmission with Lubricating Oil,** use automatic transmission oil type "A" to high level mark on oil dipstick.
3. **Check Engine Cooling System:** Close all drains. Open gate valve (if used) at the seawater intake. If engine is equipped with a fresh water cooling system, fill with permanent type ethylene glycol antifreeze for all year round operation. (See instruction Fresh Water Cooling). To prevent any damage to the neoprene impeller in the sea water pump, it is desirable to prime the pump on first start. This may be done by disconnecting either the pump inlet or outlet and fill with water. The pump will retain its prime after the first start.
4. **Check Engine Lag Bolts:** Securing engine to bed, also the mounting clamping bolts. All must be secured. **Note:** If the boat was transported by a carrier, or if it has been out of the water for a considerable time, the propeller shaft alignment should be checked.
5. **Check Storage Batteries:** Make sure the storage batteries are filled to recommended level, with water, and fully charged. Proper fluid gravity is 1.250-1.275. Low battery will result in slow cranking speed and weak spark.
6. **Check All Electrical Connections:** Make sure the battery cable connections are tight. (Ground Negative) Reversed battery connections will damage the rectifiers or other components of the alternator.
7. **Check All Controls:** Be sure all work freely with full travel.
8. **Fill Fuel Tanks** with recommended 93 Octane (Research Method) gasoline. Observe all safety precautions.
9. **Open Valves in Fuel Line:** The shut off valve is properly located near the fuel tank. **IMPORTANT** check for leaks.

IMPORTANT: On the first start when the boat is put into service, and always after an oil and lube oil filter change, stop the engine after several minutes of running in forward gear and recheck both the crankcase and transmission oil level. Add oil as necessary to full level mark on oil dipsticks, to compensate for oil required to fill oil passages, oil filter, and oil coolers.

FIRST TIME STARTING ROUTINE

1. Open hatches, always check for gasoline fumes in bilge. Turn on blower fan. Set reverse gear control in neutral position.
2. Fill carburetor with fuel by cranking the engine with starter motor.
3. Pump the throttle several times to prime intake manifold.
4. Set throttle 1/4 open.
5. Turn ignition switch to start position. The engine should start within a few seconds. **DO NOT ATTEMPT STARTING WITH FLAME ARRESTOR REMOVED.**

CAUTION: Do Not operate starting motor longer than 30 seconds without allowing an equal time for cooling. Prolonged operation of the starting motor may damage the solenoid switch and starting motor. If engine fails to start, refer to "Trouble Shooting" section of this manual.

WHEN ENGINE STARTS

1. Run engine at 700 RPM, immediately check oil pressure and alternator charging rate.

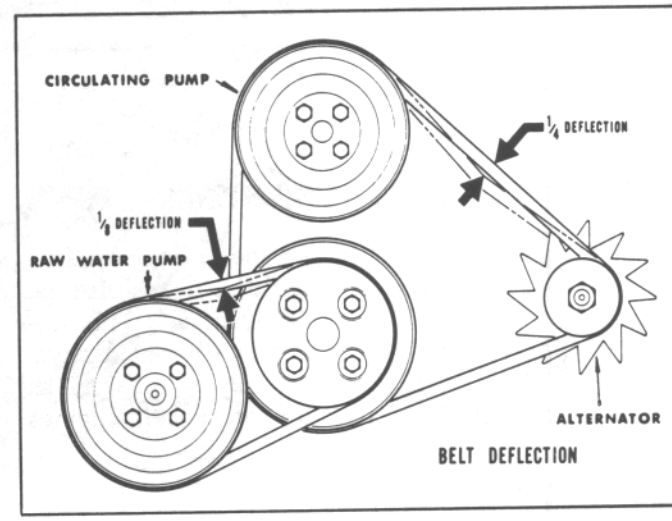


Fig. 33. Belt Deflection

2. Check water flow at exhaust outlets.
3. If oil pressure, water, flow and alternator charging rate is normal, and engine is warmed up, adjust idle speed to 650 RPM in forward gear. Adjust I/O idle speed to 550 RPM in neutral.
4. Before leaving dock or mooring, check forward and reverse controls and steering gear.
5. **Do Not** race engine with clutch disengaged.
6. Reduce engine speed when shifting transmission to forward or reverse. **Do Not** shift forward to reverse or engage the transmission at over 800 RPM.

BREAK-IN SCHEDULE

The first 15 minutes **Do Not** operate in excess of 1000 RPM.

The next 15 minutes **Do Not** operate in excess of 1500 RPM.

*The next 2 hours **Do Not** operate in excess of 2000 RPM.

*The next 3 hours **Do Not** operate continuously in excess of 2500 RPM.

The next 10 hours **Do Not operate continuously in excess of 3000 RPM.

The next 5 hours **Do Not** operate continuously in excess of 4000 RPM.

*Operate infrequently for short periods of two to three minutes duration at higher RPM. **Do Not** operate steadily at the prescribed RPM for running during break-in periods. Reduce the throttle occasionally and then come back gradually to that portion of the program you are following. At the end of 25 hours operation make the 25 hour check. (See Below) Observe engine temperature indicator frequently.

RECOMMENDED PROCEDURE FOR FIRST 25 HOUR INSPECTION CHECK

1. Check distributor breaker point gap .020 MALLORY .016 DELCO
2. Set ignition timing .010 B.T.C. use timing light **(Do Not Power Time)**
3. Set spark plug point gap .035 AC-R43T .035 Champion RBL-8
4. Check accessory drive belts, tighten if necessary (See Page)
5. Change engine oil - - Use 30-W SE.
6. Change oil filter (See Specifications)
7. Change fuel filter (See Specifications)

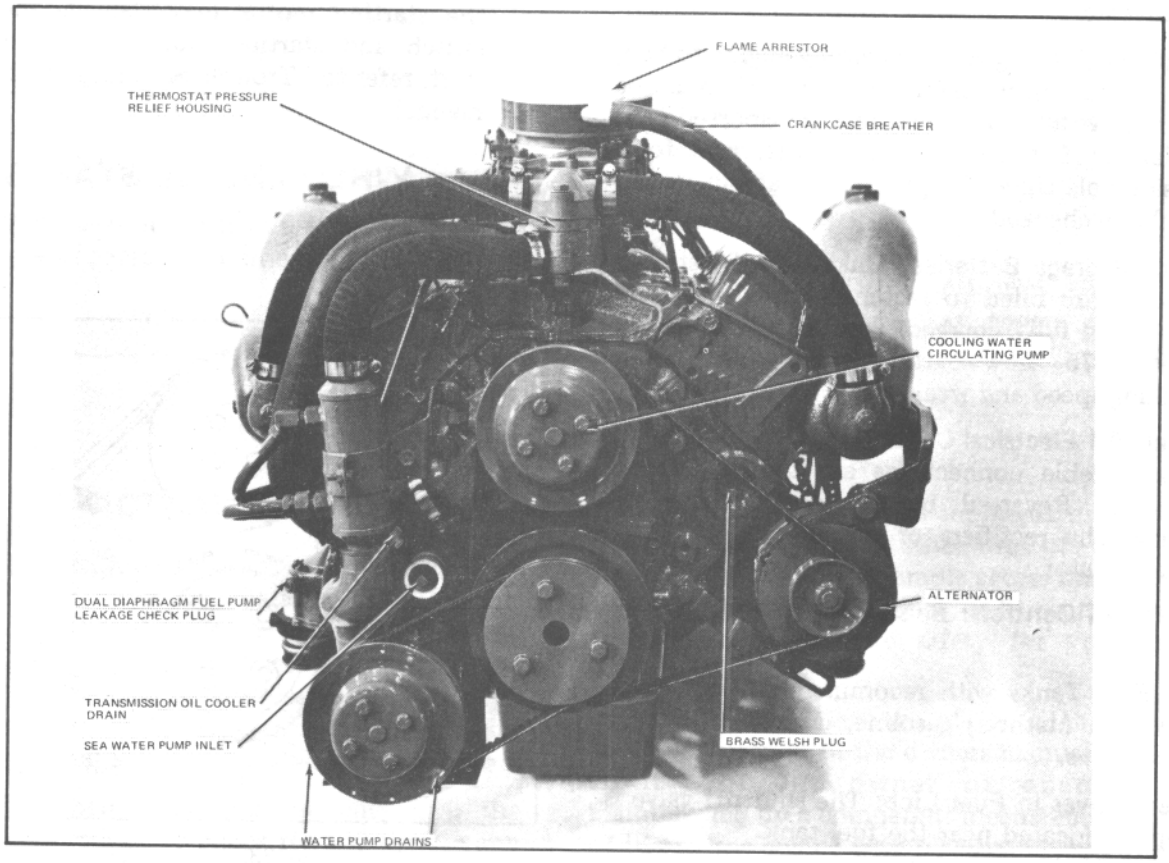


Fig. 34. 307-350 CID

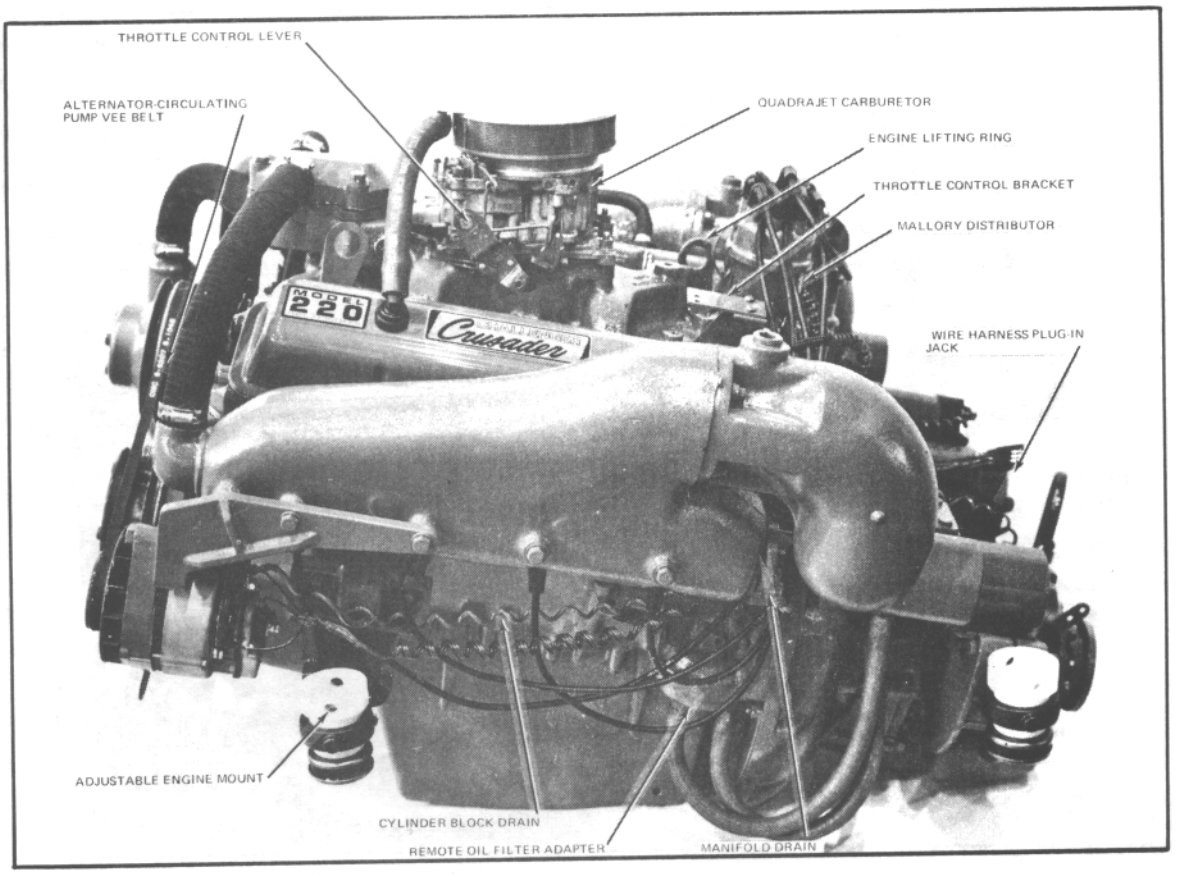


Fig. 35. 307-350 CID

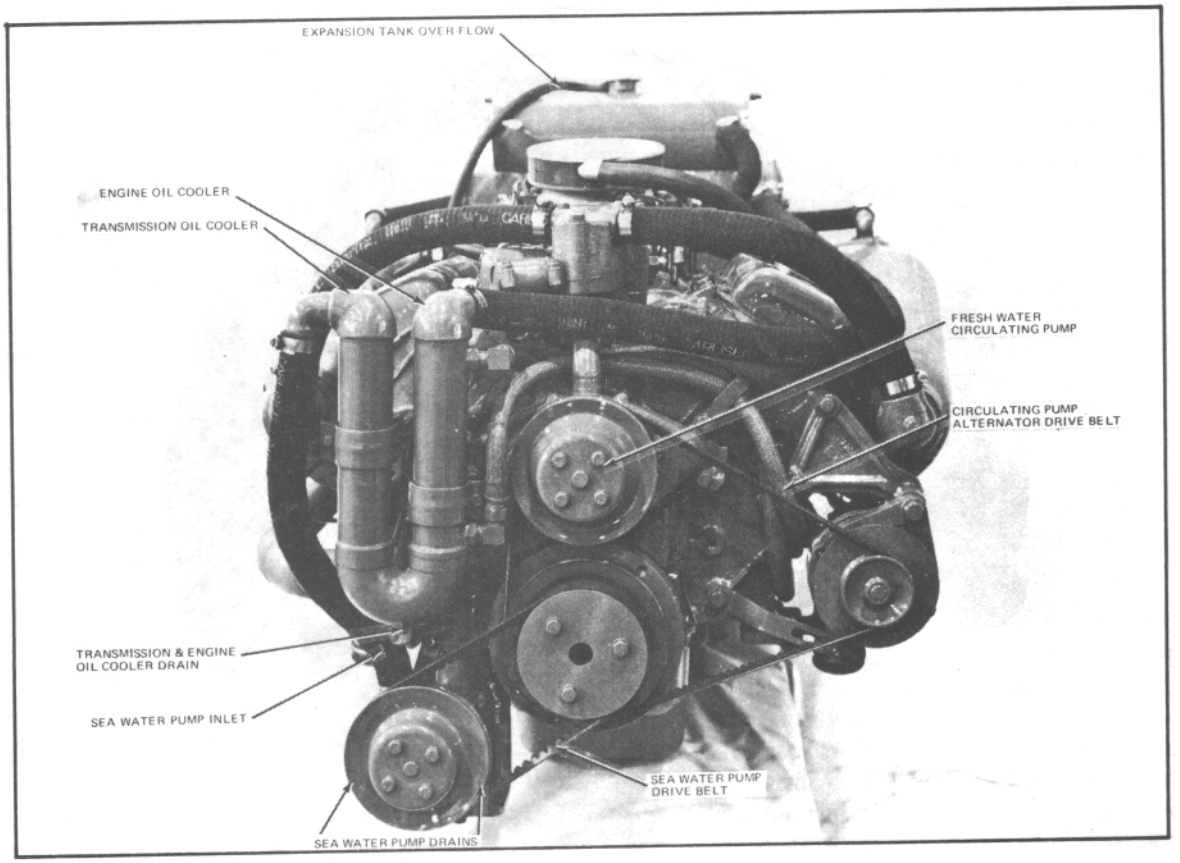


Fig. 36. 454 CID Fresh Water Cooled

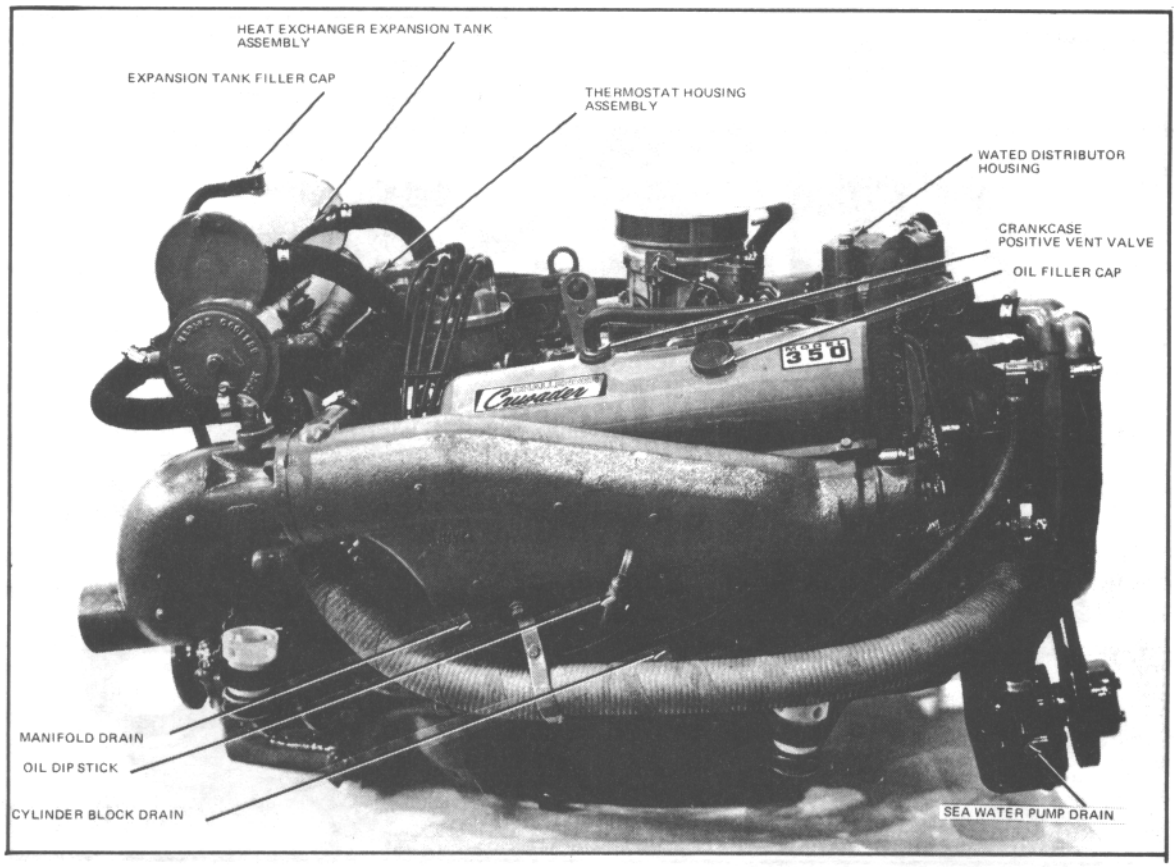


Fig. 37. 454 CID Fresh Water Cooled

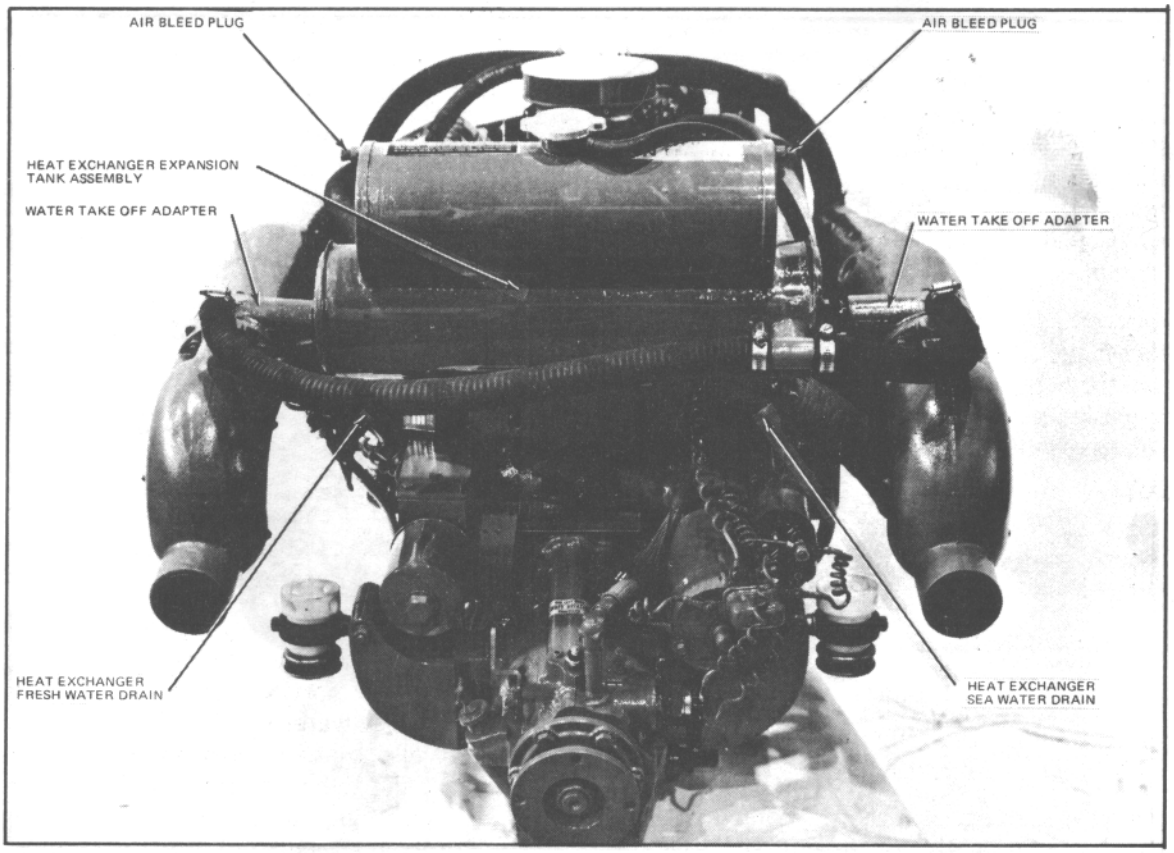


Fig. 38. 454 CID Fresh Water Cooled

8. Clean flame arrestor
9. Clean PCV Valve (See Instructions)
10. Check all controls (Adjust if necessary)
11. Check propeller shaft alignment
12. Tighten engine mounts.

    NOTE: If the engine or engines do not rev up to recommended RPM after break-in period and general tune up, the propeller or propellers may be too large.

MEMO ON FLOODING

Should the fuel induction system or intake manifold become flooded, the correct way to dry out the intake manifold is to fully open the throttle and continue cranking with ignition on. This will draw only air through the carburetor, as the idling jets and main jets are out of action at cranking speed with full open throttle.

CAUTION: Be ready to close the throttle as soon as the engine starts.

OPERATING INSTRUCTIONS

1. Before starting engine always check the bilge for gasoline leaks and fumes and observe all boating safety rules.
2. Clean fuel is extremely important, a clogged filter will cause the engine to lose RPM and backfire. Severe engine damage, such as burned valves and melted pistons can result from operating on a lean fuel mixture. The fuel filter element should be changed at least once a season. If water or dirt is detected in the fuel more frequent changes will be required.
3. Using recommended grade fuel is important. Use regular grade 93 Octane (Research Method). Ignition timing set at 10° B.T.D.C. The use of lower grade fuel with advanced ignition timing will damage the pistons and valves.
4. **Do Not** cast off until the engine is running smoothly and instruments read normal. **Do Not** race a cold engine, let it warm up gradually at low RPM.
5. Always reduce engine speed when shifting into forward or reverse. **Do Not** run engine at high speed in reverse except in an emergency.
6. Inspect carburetor and flame arrestor air intake often, clean when necessary.
7. Observe the readings of the instruments frequently, particularly the oil pressure and water temperature gauges.
8. A buzzer alarm system warning the operator of low engine and transmission oil pressure and high engine temperature, is supplied with each engine as standard equipment. When the alarm buzzer sounds, stop the engine immediately and correct any malfunction.
9. An empty fuel tank at the end of a days run will collect condensation due to cooling of the air in the tank, water in the fuel can cause trouble. It is best to keep the fuel tanks full while boat is not in use.
10. Before stopping the engine after continuous running at high speed, it is desirable to let the engine run at idling speed for several minutes, to permit circulating cooling water to dissapate residual heat in the engine.
11. If the engine is stopped suddenly after a hard run, the temperature gauge will indicate a high reading several minutes after stopping. This is normal and is caused by residual heat released by hot metal around the combustion chambers, exhaust manifolds, etc.

LOCATION OF WATER DRAINS

To prevent serious damage to the engine components that are water cooled, all drain points listed below must be opened and completely drained during freezing temperature. Remove drain plugs and prod the drain holes with a wire to make sure they are open. For location of water drains see Fig. No.

1. There is one drain plug in each bank of cylinders, at the center of cylinder block just above the oil pan.
2. There is one drain plug at lower aft end. (Six Cylinder 292 CID rear left side of block.)
3. There is one drain plug lower oil cooler model 454 CID.
4. There are two drain plugs in body of water pump
5. Fresh water cooled engines have two drain plugs in bottom of heat exchanger, one fresh water and one seawater (See Fig. No.).
6. **NOTE**: Engines equipped with fresh water cooling system, using permanent type antifreeze, only those portions of the cooling system containing sea-water need to be drained. Note carefully also that any portion of the cooling system that cannot be properly drained by removal of the drain plugs and due to angle of installation it may be necessary to remove connecting hoses for thoroughly draining the cooling system.

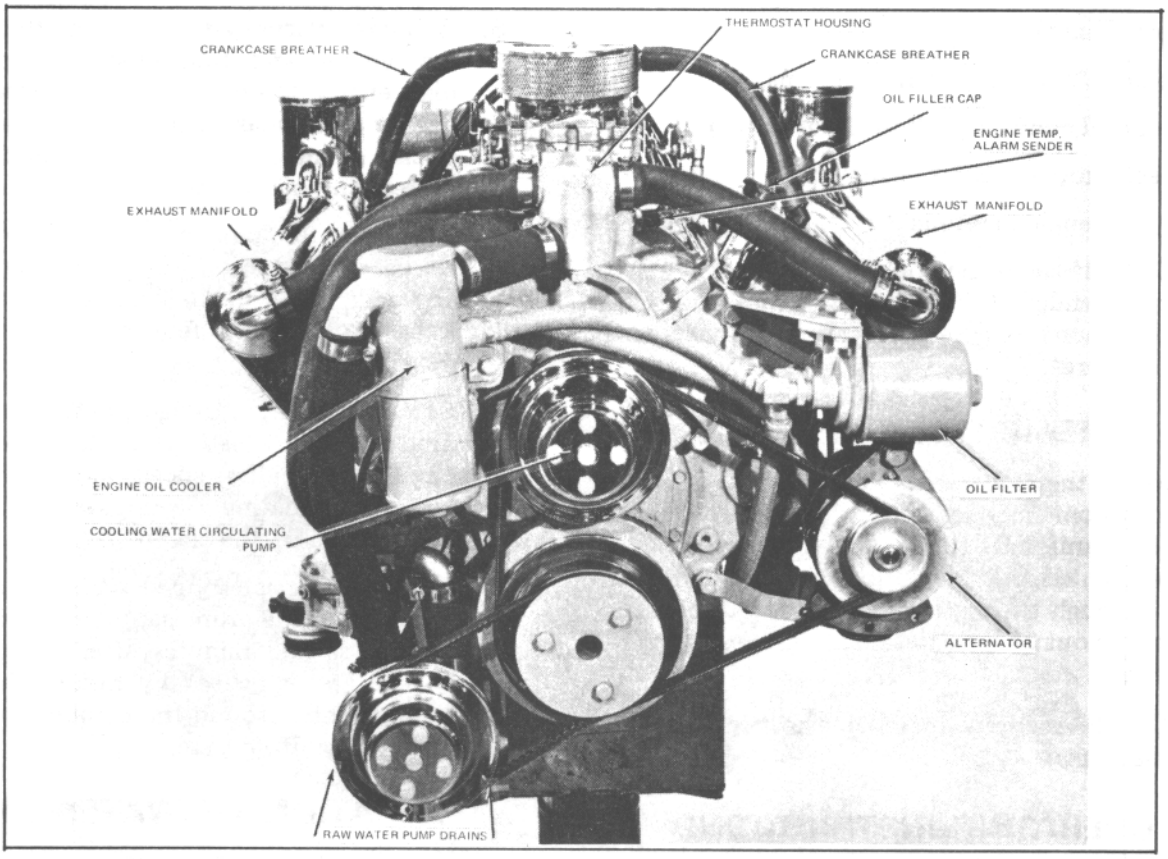


Fig. 39. Model SS-300

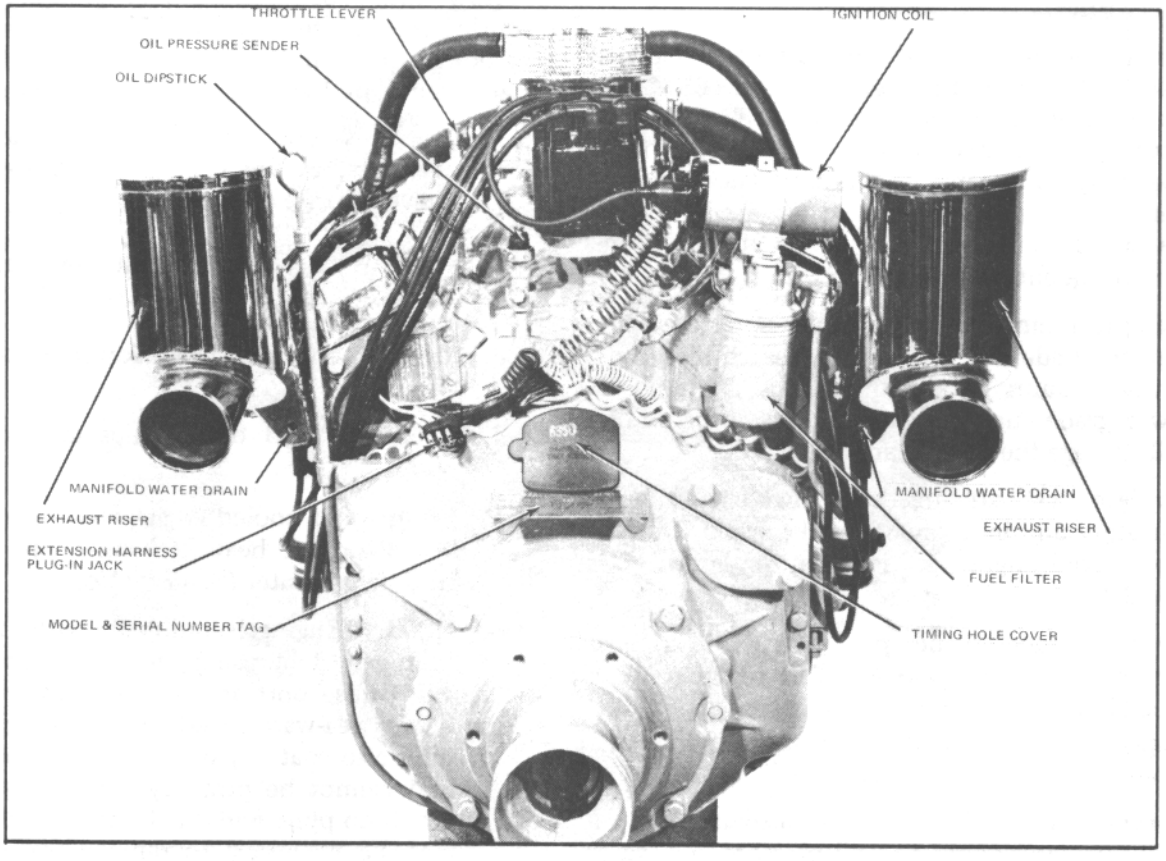


Fig. 40. Model SS-300

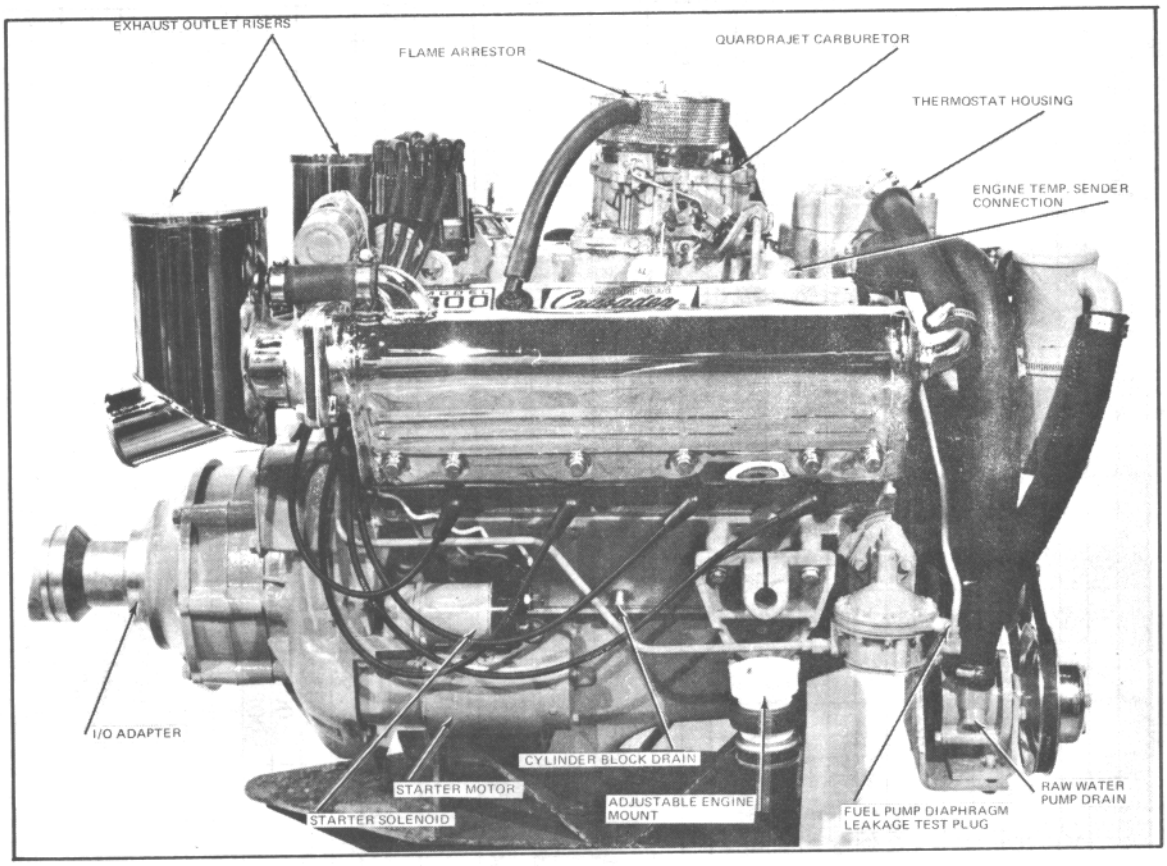


Fig. 41. Model SS-300

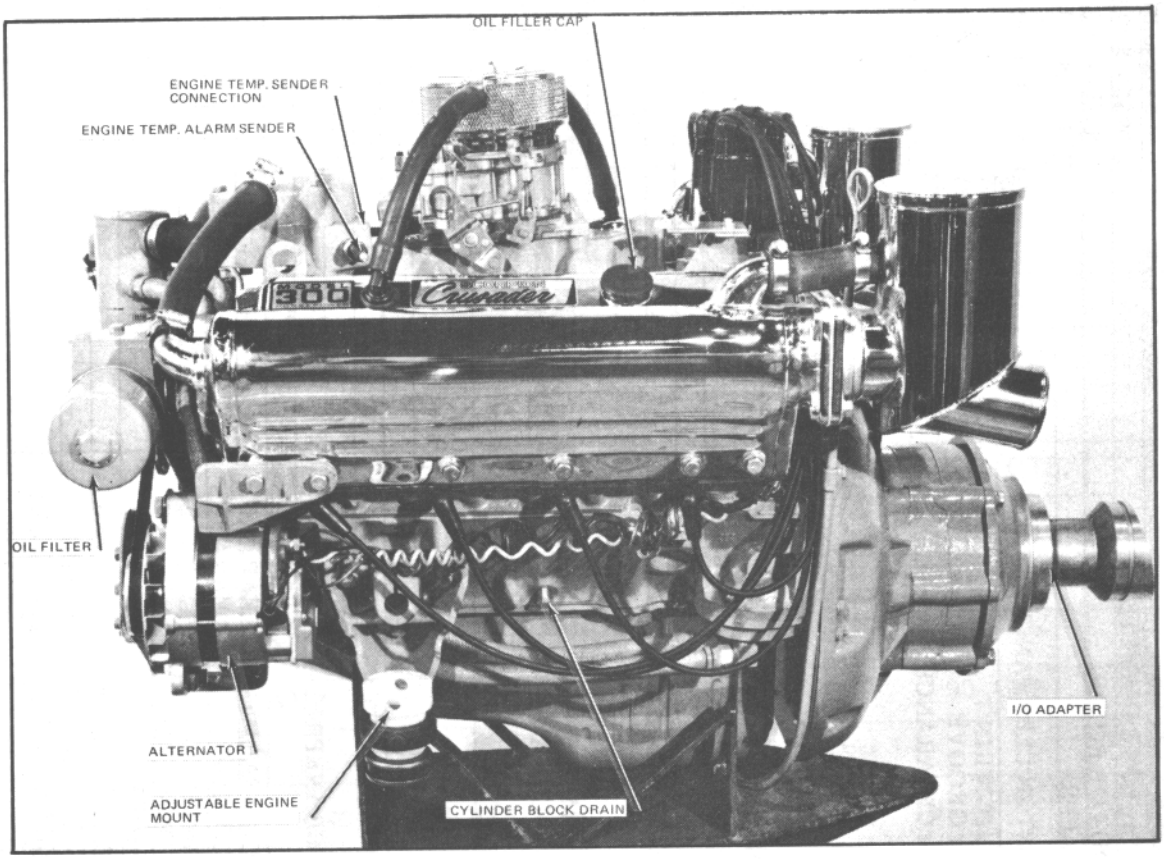


Fig. 42. Model SS-300

OVERHAUL SPECIFICATIONS

MODEL		CH-185	CH-220	CH-270 – CS-300 – SS-300	CH-320	CH-350
DISPLACEMENT		292	307	350	427	454
BORE & STROKE		3.87 x 4.12	3.87 x 3.27	4.00 x 3.48	4.25 x 3.76	4.25 x 4.00
CYL. BORE DIAMETER			3.9995 - 4.0025		4.2495 - 4.2525	4.2495 - 4.2525
OUT OF ROUND			.0005 - 4.0025			
TAPER			.0005 - .001 MAX.			
PISTON CLEARANCE			.0036 -.0042 MAX.	.0034 - .0049 MAX.		
PISTON RING						
GROOVE CLEARANCE	TOP	.0012 - .0032		.0012 - .0032	.0017 - .0032	
	2ND	.0012 - .0027		.0012 - .0027		
GAP	TOP	.010 - .020			.010 - .020	
	2ND	.010 - .020			.010 - .020	
GROOVE CLEARANCE		.005 MAX.			.0012 - .0060	
GAP		.015 - .055			.010 - .020	
PISTON PIN						
DIAMETER		.9270 - .9273			.9895 - .9898	
CLEARANCE	PISTON	.001 MAX.				
	ROD	.0008 - .0016 (INTERFERENCE)				
CRANKSHAFT						
MAIN JOURNAL	DIAMETER	ALL 2.2983 - 2.2993	NO. 1 2.4484 - 2.4493		NO. 1 2.7485 - 2.7494	
			NO. 2-3-4 2.4481 - 2.4491		NO. 2-3-4 2.7481 - 2.7490	
			2.4479 - 2.4488		2.7478 - 2.7488	
MAIN JOURNAL	TAPER OUT-OF-ROUND	.001				
	CLEARANCE	.0035				
CRANKSHAFT	END PLAY	.002 - .006			.006 - .0010	
CRANKPIN	DIAMETER	1.999 - 2.000		2.099 - 2.100	2.199 - 2.200	
	TAPER	.001 MAX.				
	OUT-OF-ROUND	.001 MAX.				
ROD BEARING	CLEARANCE	.0035 MAX.				
ROD SIDE	CLEARANCE	.008 - .0014			.013 - .021	
CAMSHAFT JOURNAL DIAMETER		1.8682 - 1.8692			1.9482 - 1.9492	
CAMSHAFT RUNOUT		.0015 MAX.				
VALVE SYSTEM		HYDRAULIC				
SEAT ANGLE (INT. & EXH.)		46°				
FACE ANGLE (INT. & EXH.)		45°				
SEAT WIDTH	INTAKE	1/32" - 1/16"				
	EXHAUST	1/16" - 3/32"				
STEM CLEARANCE	INTAKE	.0010 - .0027				
	EXHAUST	.0015 - .0032				
VALVE SPRINGS INSTALLED HEIGHT $\pm$ 1/52"		REPLACE AT OVERHAUL				
		1 - 21/32	1 - 23/32		1 - 7/8	

GENERAL SPECIFICATIONS

MODEL	CH-185	CH-220	CH-270	CH-350	SS-300 SC-300
C.I.D.	292	307	350	454	350
NO. OF CYL.	6	8	8	8	8
BORE	3.87	3.87	4.00	4.25	4.00
STROKE	4.12	3.27	3.48	4.00	3.48
COMPRESSION RATIO	7.8:1	8.1:1	8.8:1	8.6:1	8.8:1
COMPRESSION PRESSURE	140 PSI	150 PSI	150 PSI	150 PSI	150 PSI
POINT GAP DELCO	.018	.016	.016	.016	.016
POINT GAP MALLORY	.024	.020	.020	.020	.020
POINT MAL. DWELL DELCO	31°-34°	28°-31°	28°-31°	28°-31°	28°-31°
POINT SPRING TENSION	17-21 OZ	17-21 OZ	17-21 OZ	17-21 OZ	17-21 OZ
SPARK PLUG AC	R-43T	R-43T	R-43T	R-43T	R-43T
SPARK PLUG CHAMPION	RBL-8	RBL-8	RBL-8	RBL-8	RBL-8
SPARK PLUG GAP	.035	.035	.035	.035	.035
TIMING AT 500 RPM	10° BTDC	10° BTDC	10° BTDC	10° BTDC	10° BTDC
MAX RPM @ W.O.T.	3800	4000	4000	4400	4600
IDLE RPM	550-650	550-650	550-650	550-650	550-650
FIRING ODR. R.H. ROT.	142635	12756348	12756348	12756348	N.A.
FIRING ODR. L.H. ROT.	153624	18436572	18436572	18436572	18436572
CARBURETOR	2-BBL	4-BBL	4-BBL	4-BBL	4-BBL
FUEL REQ'D	93 OCTANE RESEARCH MIN.*				
FUEL PUMP PRESSURE	4-7 PSI	4-7 PSI	4-7 PSI	4-7 PSI	4-7 PSI
ELECTRICAL SYSTEM	12 VOLT NEGATIVE GROUND				
OIL PRESS. @2000 RPM	30-45 PSI	30-45 PSI	30-45 PSI	30-45 PSI	30-45 PSI
CRANKCASE CAPACITY	6 - QTS.	6- QTS.	6 - QTS.	6 - 7 QTS.	5 - QTS.
OIL FLTR. REMOTE	N.A.	AC-PF- 2	AC-PF-2	AC-PF-2	AC-PF-2
OIL FLTR. STANDARD	PF-11	AC-PF-25	AC-PF-25	AC-PF-25	
ALTERNATOR RATING	50 AMP	50 AMP	50 AMP	50 AMP	50 AMP
BATTERY RATING	70 AMP	70 AMP	70 AMP	90 AMP	90 AMP
VALVE LASH	3/4 TURN DOWN FROM "O" LASH				

*DO NOT USE — LEAD FREE OR NO-LEAD FUELS

ENGINE TORQUES

ITEM	ENGINE				
	292	307	350	427	454
CYLINDER HEAD	95 LB. FT.	65 LB. FT.	65 LB. FT.	80 LB. FT.	80 LB. FT.
OIL PAN TO BLOCK	80 LB. IN.	80 LB. IN.	80 LB. IN.	135 LB. IN.	135 LB. IN.
MANIFOLD INLET	25 LB. FT.	30 LB. FT.	30 LB. FT.	30 LB. FT.	30 LB. FT.
MANIFOLD EXHAUST	20 LB. FT.	20 LB. FT.	20 LB. FT.	20 LB. FT.	20 LB. FT.
THERMOSTAT HOUSING	15 LB. FT.	15 LB. FT.	15 LB. FT.	15 LB. FT.	15 LB. FT.
FLYWHEEL TO CRANKSHAFT	60 LB. FT.	60 LB. FT.	60 LB. FT.	65 LB. FT.	65 LB. FT.
MAIN BEARING CAP BOLTS	65 LB. FT.	75 LB. FT.	75 LB. FT.	105 LB. FT.	105 LB. FT.
OIL PAN DRAIN PLUG	20 LB. FT.	20 LB. FT.	20 LB. FT.	20 LB. FT.	20 LB. FT.
OIL PUMP TO BLOCK	115 LB. IN.	65 LB. FT.	65 LB. FT.	65 LB. FT.	65 LB. FT.
OIL PUMP COVER	70 LB. IN.	80 LB. IN.	80 LB. IN.	80 LB. IN.	80 LB. IN.
ROCKER ARM COVER	45 LB. IN.	45 LB. IN.	45 LB. IN.	50 LB. IN.	50 LB. IN.
OIL PAN TO FRONT COVER	50 LB. IN.	50 LB. IN.	50 LB. IN.	80 LB. IN.	80 LB. IN.
CRANKCASE FRONT COVER	80 LB. IN.	80 LB. IN.	80 LB. IN.	80 LB. IN.	80 LB. IN.
CAMSHAFT THRUST PLATE	80 LB. IN.				
CONNECTING ROD CAP	35 LB. FT.	45 LB. FT.	45 LB. FT.	50 LB. FT.	50 LB. FT.
WATER CIRCULATING PUMP	15 LB. IN.	30 LB. FT.	30 LB. FT.	30 LB. FT.	30 LB. FT.
CAMSHAFT SPROCKET		20 LB. FT.	20 LB. FT.	20 LB. FT.	20 LB. FT.
TORSIONAL DAMPER	60 LB. FT.	60 LB. FT.	60 LB. FT.	85 LB. FT.	85 LB. FT.
ROCKER ARM STUD				50 LB. FT.	50 LB. FT.
PUSH ROD COVER	50 LB. IN.				
TEMPERATURE SENDING UNIT	20 LB. FT.	20 LB. FT.	20 LB. FT.	20 LB. FT.	20 LB. FT.
OIL FILTER	HAND TIGHT	25 LB. FT.	25 LB. FT.	25 LB. FT.	25 LB. FT.
SPARK PLUG	15 LB. FT.	15 LB. FT.	15 LB. FT.	15 LB. FT.	15 LB. FT.
OIL FILTER BYPASS VALVE		80 LB. IN.	80 LB. IN.	80 LB. IN.	80 LB. IN.
FLYWHEEL HOUSING COVER	80 LB. IN.	80 LB. IN.	80 LB. IN.	80 LB. IN.	80 LB. IN.

TORQUE LIMITS FOR VARIOUS SIZE BOLTS

SIZE - DIAMETER	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"
CYLINDER HEADS		35-40	70-75	100-110	130-140	145-155
MAIN BEAR. CAPS CON-RODS	20-25	35-40	70-75	85-95	100-110	145-155
FLYWHEELS	20-25	35-40	70-75	85-95	100-110	145-155
MANIFOLDS	15-20	25-30	50-55	80-90	110-110	130-140
GEAR COVERS, WATER PUMPS, OIL PANS	15-20	25-30	50-55	80-90		
FLYWHEEL HOUSINGS	15-20	25-30	50-55	80-90	115-125	

SCORPION MODEL SS-300

The Scorpion Model SS-300 has the same basic cylinder block assembly as the model CH-270, all basic parts are interchangeable except the camshaft and the intake manifold.

MARINE DRESS:

For the purpose of weight reduction, the exhaust manifolds and exhaust risers are of fabricated copper, chrome plated.

The oil pan is of stamped steel. The engine is equipped with a full flow oil filter, and an oil cooler. The engine has a two pump cooling system with automatic thermostatic temperature control. The engine has a special high lift camshaft and is available in left hand rotation only, with Volvo Model 270 B and/or Volvo 270 T outboard drive.

Maintenance and repair procedure is the same as outlined in the Owner Manual and Service Manual covering the Model CH-270. Refer to General Specifications for adjustment data.

SCORPION MODEL CS-300

The Scorpion Model CS-300 has the same basic cylinder block assembly as the model SS-300, all parts are interchangeable with the Model SS-300 except the exhaust manifolds.

MARINE DRESS:

The engine is equipped with cast iron exhaust manifolds, full flow oil filter, and an oil cooler. The engine has a two pump cooling system with automatic thermostatic temperature control. The engine has a special high lift camshaft and is available in left hand rotation only, with Volvo Model 270 B and/or Volvo 270 T outboard drive.

Maintenance and repair procedure is the same as outlined in the Owner and Service Manual Covering the Model CH-270. Refer to General Specifications for adjustment data.

TUNE UP DATA

COMPRESSION PRESSURE:

(Ignition off with wide open throttle) cranking speed 150 RPM with fully charged battery, all spark plugs removed. 140 P.S.I. minimum all cylinders uniform within + or — 10%.

IDLE SPEED & MIXTURE ADJUSTMENT

1. Connect vacuum gauge to intake manifold.
2. Start and warm engine to normal operating temperature. Be sure choke is fully off, and that carburetor is on slow idle.
3. Set idle speed 650 RPM in forward gear. Adjust I/O idle speed 550 RPM maximum in neutral.
4. Turn idle mixture screws in (finger tight) and back out 1-1/2 turns.
5. Turn one idle mixture screw in or out in order to obtain highest reading on both vacuum gauge and tachometer.
6. Repeat step 5 with other idle mixture adjusting screw.
7. Reset idle RPM as required.

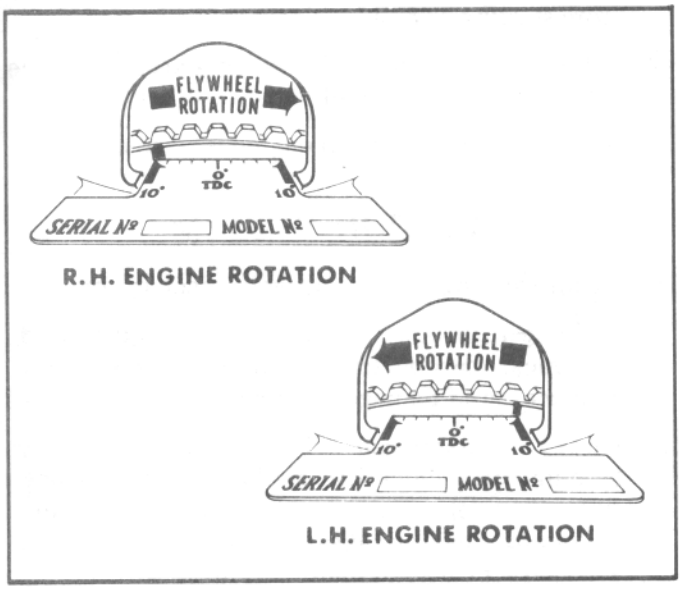


Fig. 43. Flywheel Rotation

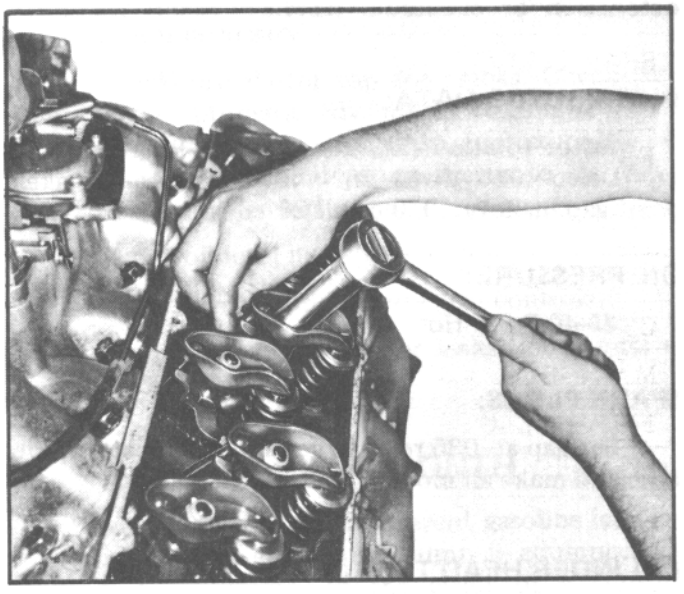


Fig. 44. Adjusting Valve Clearance V-8

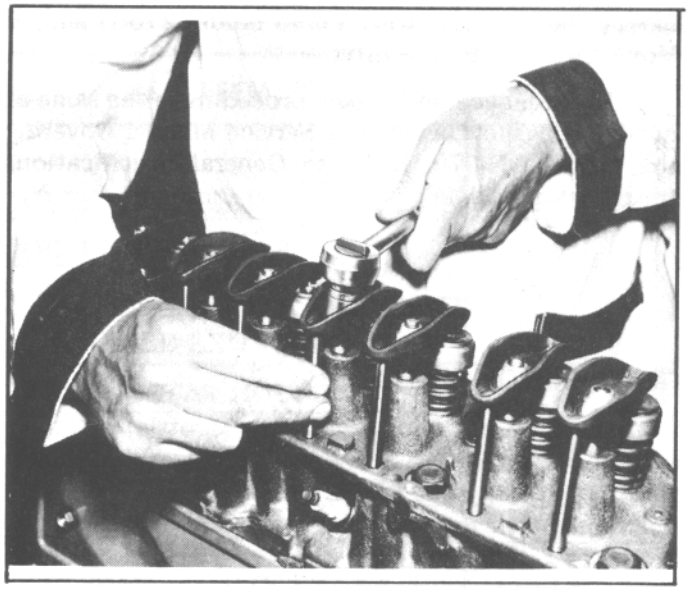


Fig. 45. Adjusting Valve Clearance 292 In-Line Six

8. Repeat step 5 and 6 until turning idle mixture screws will not cause an increase in engine idle RPM, and the smoothest engine idle is obtained.

   NOTE: The main jets on the carburetor are not adjustable.

IGNITION TIMING:

Refer to general specifications for degree timing B.T.D.C. with engine idling not higher than 500 RPM, set timing to correspond with specifications. Use stroboscope timing light connected to No. 1 spark plug. Disconnect vacuum line (on Dist. so equipped) when timing.

CAUTION: Do Not power time the engine on basis of detonation or maximum RPM.

DISTRIBUTOR DATA:

Rotor rotation (all models) C.W. Breaker point gap Delco .016 dwell 28° - 31° degrees. Breaker point gap mallory, .020 dwell 26° degrees.

OIL PRESSURE:

35-40 P.S.I. Hot

SPARK PLUGS:

Set gap at .035 refer to general specifications for type and make all models. Torque 15 ft. lbs.

CYLINDER HEAD TORQUE:

65 - 80 ft. lbs. (See Engine Torques)

VALVE CLEARANCE

Hydraulic all models. Adjustment - (Only when readjustment is required) engine warm, (run at idle speed).

1. Back off valve rocker arm nut until the rocker arm starts to clatter.
2. Turn rocker arm nut down until clatter just stops. This indicates zero lash (Fig. 45 - 292 In-Line Six, Fig. 44 - V8).
3. Turn rocker arm nut down 1/4 additional turn and pause until engine runs smoothly. Repeat additional 1/4 turns, pausing each time until rocker arm nut has been turned down 3/4 turn from zero lash.

   NOTE: It is important that the 3/4 turn preload adjustment be done at intervals as prescribed to allow the hydraulic lifter to adjust itself, and prevent possible interference between the valve head and piston, that could result in internal damage, bent valve or push rod.

These instructions apply for adjusting both intake and exhaust valves. Install new valve rocker cover gaskets if necessary.

FIRING ORDER: (See general specifications)

NOTE: After careful tune up the engine does not rev up to designed speed, check propeller for any damage and proper size.

MAINTENANCE SCHEDULE

DAILY

1. Ventilate engine compartment thoroughly before starting engine.
2. Check lube oil level in crankcase (engine stopped). **Do Not** overfill.
3. Check water flow when engine is started.

IGNITION SYSTEM

Distributor cap, rotor, wires advance mechanism:

1. Remove distributor cap, wipe clean and inspect for cracks, carbon tracks and eroded electrodes. Replace cap if damage is found.
2. Check centrifugal advance mechanism by turning rotor clockwise by hand as far as possible, then release rotor. If rotor does not return to retard position, disassemble the distributor and correct cause of malfunction.
3. Inspect rotor for cracks and eroded electrode.

4. Examine breaker contact points. Replace points if badly burned or pitted. Contact points which are only slightly pitted, can be dressed with a breaker point file. **Do Not** use sandpaper or emery cloth for cleaning or dressing contact points, since this may leave imbedded particles, that will cause arcing and rapid burning of points.
5. Adjust breaker point gap after cleaning or replacement.
6. The condenser seldom fails, but in a thorough engine tune-up it is usually replaced at the same time that new breaker points are installed.
7. Check distributor point tension with spring gauge hooked to breaker lever at contact and pull at 90° to breaker lever. Points should be closed and reading taken just as points separate. Spring tension should be 17-21 oz. Spring tension can be decreased by pinching the spring carefully with pliers. To increase tension, the breaker lever must be removed from the distributor so that the spring can be bent away from the lever.

   NOTE: Excessive point pressure will cause excessive wear on cam and rubbing block, and improper action of the automatic advance mechanism.
8. Check alignment of points with points closed. Align points by bending fixed contact point support. **Do Not** bend breaker arm.
9. Lubricate cam with a light coating of non melting cam grease. **Do Not** over lubricate.
10. Check all spark plug leads and coil leads for cracks and abrasion of insulation.

    NOTE: The transmission does not normally consume oil. Unless there is noticeable oil leak it will only be necessary to check the oil level occasionally, and always at 50 hour periods of running time.

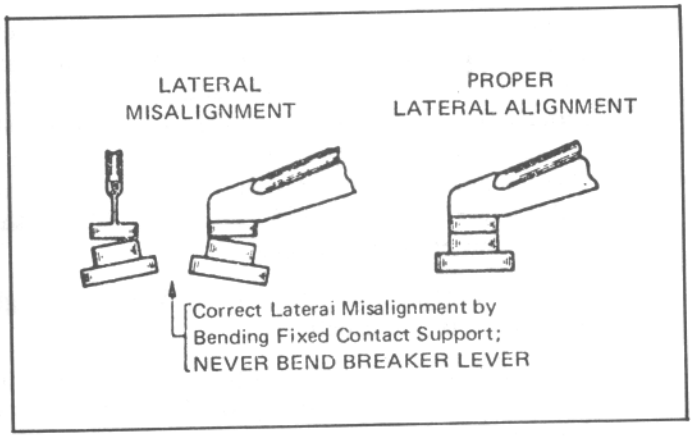


Fig. 46. Alignment of Points

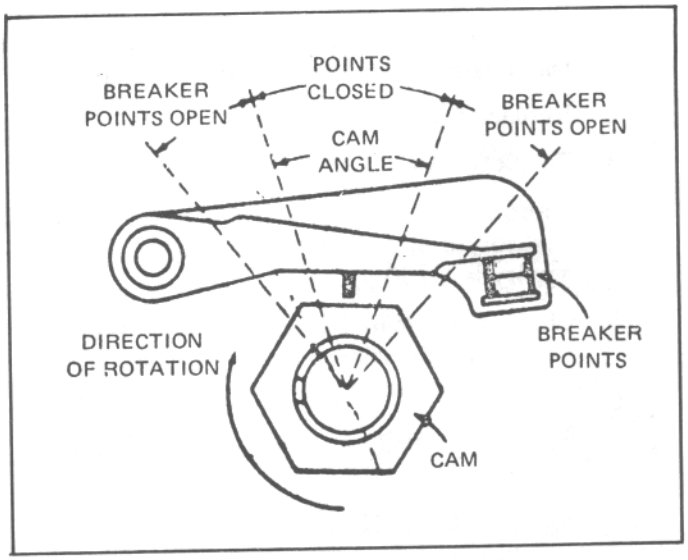


Fig. 47. Cam Angle

EVERY 50 HOURS OF OPERATION

1. Change oil in crankcase, connect sump pump, to oil dipstick tube for removal of oil. Refill with 10/30W (SE) for cold weather, or 30/W (SE) for warm weather operation.

   NOTE: Before attempting to remove the old oil, run the engine until thoroughly warm. **Do Not** overfill. Replace oil filter. Start engine, let run several minutes and recheck oil level.
2. Inspect flame arrestor for dirt or lint between the quenching plates. Remove and wash in solvent if necessary.
3. Check distributor cap for cracks. Check distributor automatic advance by turning rotor with fingers, advance clockwise approximately 80° degrees, it should return freely to its original position when letting go.
4. Check oil level in transmission.
5. Check throttle and reverse gear controls.
6. Check for oil and water leaks, loose nuts and bolts.

ONCE A MONTH

1. For safety reasons, to prevent gasoline leak into the crankcase, the fuel pump is equipped with dual diaphrams. In the event of a ruptured diaphram, there will be fuel leak, remove plug

from side of fuel pump (See Fig. 34), replace if leak is discovered. **Do Not** attempt repair.

2. Replace fuel filter if necessary.
3. Check for water and oil leaks.
4. Check water level in battery. Maintain electrolyte at 3/8" above the plates. Proper fluid gravity is 1.250 to 1.275.
5. Check and clean flame arrestor if lint or dirt is present in air passage between quenching plates.
6. Check condition and tension of accessory drive belts. See instructions page no. 23 Fig. 33.

TWICE A SEASON

1. Clean the engine thoroughly.
2. Adjust breaker points on the distributor. For gap and cam angle, refer to general specifications page 31. Replace points if burned or badly pitted.
3. Remove distributor rotor and apply 3 or 4 drops of light oil to wick in the camshaft. Apply one drop of oil on the breaker arm pivot. Apply a trace of vaseline on the cam. **Do Not** Over Lubricate.
4. Check spark plugs, inspect for broken or cracked porcelain and badly worn electrodes. Set gap .035 using a round feeler. Replace any plugs that are not serviceable.
5. Be sure that all plugs are the same make and number (See General Specifications).
6. Before replacing plugs be sure threads are clean, use new gaskets. Tapered seat plugs **Do Not** require gaskets. Torque to 20-25 ft. lbs.
7. Check engine propeller shaft coupling for misalignment, and tighten engine mounting bolts.
8. Check accessory drive belts, adjust tension if necessary (See Instructions Page 23).
9. Clean battery terminals and after tightening, coat with vaseline.

ONCE A SEASON

1. Change oil in transmission. Refill with automatic transmission oil type "A". Recheck oil level after several minutes of running in forward and reverse.
2. Change fuel filter element.
3. Remove all spark plugs, check and record compression each cylinder. Pressure should read 140 P.S.I. + or - 10% at cranking 150 RPM speed with fully charged battery. If compression pressure reading is low, look for poorly seating or sticking valves, worn piston rings or blown cylinder head gasket.
4. Install complete set **New** spark plugs. Set gap .035 before installation (use round feeler).
5. Replace breaker points in distributor. Set point gap .016 (DELCO), .020 (MALLORY).
6. Check ignition timing. 10° B.T.D.C. at 500-550 RPM. Use timing strobe light.

   CAUTION: Do Not Power Time on basis of detonation or RPM.

LUBRICATION

Full pressure lubrication of the main and connecting rod bearings, camshaft bearings and valve gear is maintained by a gear driven oil pump, with oil pick up form the crankcase sump. A pressure regulating valve in the oil pump maintaining a constant oil pressure of 35-40 P.S.I.

CRANKCASE OIL CHANGE:

The engine lubricating oil should be changed after the first 20 hours of operation, and thereafter every 50 hours of operation. Before attempting removal of oil from the crankcase, the engine should be thoroughly warmed. Warm oil flows better, and when the engine has just been run any particles of dirt in the oil will be held in suspension and will be removed with the oil.

1. Remove oil dipstick from the steel tube into which it is inserted, which extends to the bottom of the oil sump.
2. Attach the sump pump hose over the dipstick tube and pump old oil from the crankcase sump.
3. Remove and discard the oil filter cartridge, replace with new. For engines with remote filter, for replacement use Thermo Electron part #9002514 for engines with standard filter, for replacement use Thermo Electron part #20104. Be sure that a new gasket is in place on the new filter element, screw on and tighten by hand only. Over tightening with tools can distort the gasket and cause an oil leak.
4. Refill crankcase with fresh oil 30/W (SE) to high level mark on oil dipstick.
5. Recheck oil level, after running three or four minutes, (with engine stopped). Check filter area for possible leaks, add oil as necessary, to high level mark on dipstick.

CAUTION: Always observe the oil pressure gauge on first start after an oil change.

TRANSMISSION OIL CHANGE:

The transmission oil should be changed after the first 50 hours of running, and thereafter once a season. The engine should be thoroughly warmed up before the oil change.

1. Remove the oil filler cap and dipstick assembly located below the shift lever or the rear left side of the transmission case.
2. Insert the sump pump hose into the transmission case and pump out as much oil as possible.
3. If space permits, place a shallow container having approximately three (3) quarts capacity under the drain plug assembly, located on the lower port side aft on transmission case direct drive. (a) Remove oil cooler return line. (b) Remove oil drain plug and screen assembly. (c) Let oil drain completely. Reverse step (a), (b) and (c) for reassembly of drain plug, screen and oil line.

   NOTE: Wash screen in mineral spirits before reassembly.

4. Refill transmission with automatic transmission fluid (ATF), type "A" to high level mark on oil dipstick.

   CAUTION: It is extremely important that the recommended oil be used, and all rules of cleanliness be observed when draining and refilling the transmission.

5. Start and run engine three to four minutes in forward gear, with one or two shifts forward to reverse. Check oil level on dipstick in transmission. Add oil as necessary, to high mark on dipstick to compensate for oil retained in the oil cooler and hydraulic system. Check for oil leaks.

TROUBLE SHOOTING

TROUBLE	CAUSE
1. Starter will not turn engine.	A. Loose or corroded battery connections. B. Weak battery. C. Defective starter switch. D. Faulty starter solenoid. E. Open circuit in wiring. F. Broken or worn brushes in starter. G. Faulty starter armature or fields. H. Hydraulic Lock
2. Starter turns but pinion does not engage.	A. Starter clutch slipping. B. Broken teeth on flywheel gear. C. Armature shaft rusted, dirty or lacking lubrication. D. Broken bendix spring.
3. Solenoid plunger virbates when starter switch engage.	A. Weak battery. B. Loose connections. C. Faulty solenoid.
4. Starter pinion jams or binds.	A. Starter mounting loose or misaligned. B. Broken or chipped teeth on flywheel gear or pinion.
5. Starter turns engine but hard to start or won't start.	A. Empty gas tank B. Tank vent clogged C. Shut-off valve closed. D. Clogged fuel filter. E. Dirt or water in fuel line or carburetor. F. Choke not operating. G. Faulty fuel pump. H. Carburetor flooded or out-of-adjustment. I. Vapor lock. J. Faulty coil or condenser. K. Moisture on ignition wires or distributor cap. L. Fouled spark plugs or improper plug gap. M. Improper ignition timing. N. Ignition points improperly gapped, burned or dirty. O. Cracked distributor cap or rotor. P. Poor connections or damaged ignition wiring.
6. Poor idling.	A. Incorrect air-idle adjustment. B. Idle discharge holes plugged or gummed. C. Worn throttle shaft. D. Air leak at mounting between carburetor and manifold.

TROUBLE	CAUSE
	E. Damaged or worn idle needle. F. Incorrect fuel or float level. G. Choke does not completely open. H. Loose main body to throttle body screws. I. Carburetor icing. J. Loose distributor base plate bearing. K. Corroded wire ends or distributor towers. L. Incorrect distributor point gap. M. Fouled spark plugs or improper plug gap. N. Incorrect ignition timing. O. Overheated spark plugs. P. Incorrect valve timing. Q. Compression not within limits. R. Intake manifold leak. S. Internal coolant leak. T. Low boiling point fuel (winter fuel in summer). U. Low grade fuel.
7. Engine misses while idling.	A. Dirty or incorrectly gapped spark plugs; cracked porcelain. B. Broken or loose ignition wires. C. Burned or pitted contact points. D. Faulty coil or condenser. E. Weak battery. F. Distributor cap or rotor cracked or burned. G. Incorrect distributor advance or point dwell. H. Moisture on ignition wires, distributor cap or spark plugs. I. Excessive play in distributor shaft. J. Burned, warped or pitted valves. K. Incorrect carburetor idle adjustment. L. Incorrect carburetor float level. M. Low compression. N. Worn or damaged camshaft. O. Improper valve lash adjustment.
8. Engine has loss of power	A. Incorrect ignition timing. B. Defective coil or condenser. C. Distributor rotor burned or cracked. D. Excessive play in distributor shaft. E. Worn distributor cam. F. Dirty or incorrectly gapped spark plugs. G. Dirt or water in fuel line or carburetor. H. Improper carburetor float level. I. Defective fuel pump. J. Incorrect valve timing.

TROUBLE	CAUSE
	K. Blown cylinder head gasket. L. Low compression. M. Burned, warped or pitted valves. N. Faulty ignition cables. O. Worn or damaged camshaft. P. Improper valve lash adjustment.
9. Engine misses on acceleration.	*A. Distributor contact points dirty or improperly gapped. B. Coil or condenser defective. C. Spark plugs dirty or gap too great. D. Incorrect ignition timing. E. Dirt in carburetor. F. Burned, warped or pitted valves. G. Accelerator pump in carburetor faulty.
10. Engine misses at high speed.	A. Dirt or water in fuel line or carburetor. B. Dirty jets in carburetor. C. Defective coil or condenser. D. Incorrect ignition timing. E. Distributor contact points dirty or incorrectly gapped. F. Distributor rotor burned or cracked. G. Excessive play in distributor shaft. H. Spark plugs dirty or gap set too wide. I. Distributor shaft cam worn. J. Faulty ignition wiring.
11. Noisy valves.	A. Worn tappets. B. Worn valve guides. C. Excessive run-out of valve seats or valve face. D. Broken/damaged spring. E. Clogged hydraulic valve lifters or oil galley. F. Improper valve lash adjustment.
12. Connecting rod noise.	A. Low oil pressure. B. Insufficient oil supply. C. Thin or diluted oil. D. Misaligned connecting rods. E. Excessive bearing clearance. F. Crankpin journals out-of-round.
13. Main bearing noise.	A. Low oil pressure. B. Insufficient oil supply. C. Thin or diluted oil. D. Loose flywheel. E. Excessive bearing clearance. F. Excessive end play. G. Crankshaft journals out-of-round. H. Loose vibration damper or pulley.

TROUBLE	CAUSE
14. Oil pressure drop.	A. Low oil level. B. Clogged oil filter. C. Worn parts in oil pump D. Excessive bearing clearance. E. Thin or diluted oil. F. Oil pump relief valve stuck. G. Oil pump suction tube not aligned or bent. H. Intake screen clogged. I. Defective or kinked oil lines.
15. Engine backfires.	A. Spark plug cables improperly installed. B. Intermittent fuel supply, dirt or water in system. C. Stuck intake valve. D. Improper distributor timing.
16. Engine knocks or pings (most noticeable on quick acceleration or at full throttle).	A. Low octane fuel. B. Excess deposits in combustion chambers. C. Overheated engine. D. Incorrect spark plugs. E. Ignition timing advanced too far.
17. Poor performance - mixture too lean.	A. Damaged main metering jet. B. Damaged tip or bad top shoulder seat of main discharge jet. C. Vacuum piston worn or stuck. D. Incorrect fuel or float level. E. Automatic choke not operating properly. F. Incorrect fuel pump pressure. G. Clogged fuel filters or lines. H. Clogged fuel tank vent.
18. Poor performance - mixture too rich.	A. Restricted flame arrestor. B. Excessive fuel pump pressure. C. High float or fuel level. D. Damaged needle and seat. E. Leaking float. F. Worn main metering jet. G. Sticking choke.
19. Excessive fuel consumption.	A. Overloading engine (wrong propeller). B. Cruising in high winds. C. Sticky choke. D. Incorrect ignition timing. E. Faulty distributor advance. F. Incorrect valve timing. G. High fuel level in carburetor. H. Detonation or pre-ignition. I. Fouled spark plugs. J. Low engine compression.

TROUBLE	CAUSE
	K. Worn camshaft lobes. L. Sticking valves. M. Elevation and atomospheric conditions. N. Restricted exhaust system. O. Operating at excessive speeds.
20. Poor acceleration.	A. Step-up piston stuck in down position (lean mixture at wide open throttle). B. Accelerator pump piston (or plunger) leather too hard, worn or loose on stem. C. Faulty accelerator pump discharge ball. D. Accelerator pump inlet check ball faulty. E. Incorrect fuel or float level.

TROUBLE	CAUSE
	F. Worn accelerator pump and throttle linkage. G. Automatic choke not operating properly. H. Carburetor gummed up. I. Faulty coil. J. Loose distributor base plate bearing. K. Distributor not advancing properly. L. Incorrect ignition timing. M. Incorrect spark plug gap. N. Fouled spark plugs. O. Overheated spark plugs P. Low fuel pump pressure or vacuum. Q. Compression not up to specifications. R. Incorrect valve timing. S. Low grade of fuel. T. Detonation or pre-ignition.

ENGINE LAY-UP INSTRUCTIONS

1. **Change-Oil:** Start the engine and run until thoroughly warm, stop the engine and change oil in both the engine and transmission. The reason for removing the oil is that it may have an acid content a by product of combustion, that can be harmful to the engine bearings if left in the engine during a lengthy lay-up period. Remove the old oil using a suction pump connected with a hose to the dipstick tube. Change oil filter, and fill crankcase with a good grade 30/W SE motor oil. For removal of the oil from the transmission, remove the oil dipstick and insert the suction pump hose into the transmission case. Refill with type "A" automatic transmission oil.

   After the oil change start the engine and run a few minutes at 800-1000 RPM to circulate the new oil through the engine. Stop engine and add oil as necessary to high level on dipstick. This is to compensate for the oil required to fill the oil filter and oil circuits.

2. **Fogging Engine:** For prevention of rust formation in the cylinders, valve guides etc. disconnect fuel line at fuel pump, making sure fuel supply is shut off at tank. Hook up a temporary fuel line from the fuel pump to a one-quart container with a fifty-fifty mixture of fuel and fuel conditioner and valve lubricant. Start engine and remove flame arrestor, set idle speed 900 to 1000 RPM and slowly pour Rust Preventative Oil through primary side of carburetor until heavy smoke is emitted at the exhaust outlets, watching fuel supply in container.

   Just before engine starts to die, pour balance of rust preventative oil in carburetor to stall out engine. Shut off ignition switch and do not restart until ready to recommission. Replace flame arrestor and seal off with masking tape. Reconnect fuel line at fuel pump.

3. **Closed Cooling:** The cooling system should be filled with antifreeze (Ethylene Glycol) tested to insure sufficient protection against winter freezing. This preparation and test should be made prior to step No. 2, while engine is hot.

   Fresh water models without antifreeze in the system, must be thoroughly drained by use of drain plugs or pet cocks on both sides of cylinder block and manifolds, and removal of connecting hoses if necessary. The sea water side of the system must also be drained by removing the drain plugs from the heat exchanger, water pump, and exhaust elbows, and removal of connecting hoses if necessary. After thoroughly draining both fresh water and sea water side of the cooling system, replace all drain plugs and hoses. Remove the temperature sending unit and pour two quarts of antifreeze into cylinder block, a quart of antifreeze should also be poured into the sea water side of the heat exchanger. This can be accomplished by disconnecting the water overboard hose at the exhaust elbows.

4. **Open Cooling System:** On raw water cooled engines there are two drains, one on each side of the cylinder block, one aft end each exhaust manifold and one below each the inlet and outlet side of the raw water pump. To insure complete drainage of the block remove the temperature sending unit to break the vacuum while draining the system. On all models the transmission and engine oil coolers must also be drained. After thorough draining replace all drain plugs, and pour two quarts or more antifreeze into temperature sending unit hole, this is to insure against freezing of any remaining water in the cooling system.

   NOTE: If the water pump intake is equipped with a shut off valve this must be closed prior to insertion of the antifreeze. If without shut off valve the water intake hose must be first removed and plugged.

5. In order to prevent condensation from entering the engine cylinders, the exhaust hoses should be removed at the exhaust elbows and the opening sealed with suitable plugs and or masking tape.

6. **Electrical System:** Remove the battery and properly store during lay-up period.

7. **Propeller Shaft:** Disconnect propeller shaft coupling.

8. Remove from the engine compartment any items which might hold moisture, such as, ropes, life preservers, mops, rags, cushions, and pillows.

9. **Paint:** Clean engine and touch up paint.

   NOTE: Engines with cooling systems, that are operated in salt water, should be thoroughly flushed with fresh water prior to lay-up.

   IMPORTANT: Exhaust lines and mufflers often are not self draining. It is therefore important to keep the bow of the boat high when hoisting to prevent the water retained in the exhaust lines from entering the engine cylinders, thus preventing hydraulic lock and internal damage.

10. **Draining Fuel Tanks:** Always observe all safety precautions.

FITTING OUT AFTER STORAGE

1. **Launching:** Before the boat is put in the water, make sure that bilge drains are closed and all inside through hull fittings, including the water inlet to the raw water pump are properly connected.

   NOTE: If the boat is launched on a sloping marine railway it is **Very Important** to guard against water entering the exhaust outlets and possibly entering the engine cylinders causing a hydraulic lock, and bent connecting rods, or broken pistons on starting the engine.

2. Close all drains, check all hose connections.

3. Remove all spark plugs and leave them out of engine until the next step is completed.

4. Remove the valve rocker covers and individually check each valve by depressing it with a screwdriver, prying against the nearest rocker arm to make sure the valve is free in the guide. In the modern marine engine there is very small clearance between the valve guide bore and the valve stem so that even a slight film of rust can cause a valve to stick, resulting in a bent push rod or bent valve when the engine is cranked. If a valve is found to be stuck, it can usually be freed by applying penetrating oil directly on the valve stem above the valve guide. It is good practice to spray all valve stems with a light oil. Intermittently engage the starter to make at least two complete revolutions. Observe the valve action to be sure that all valves are free. If the valves function properly, the valve covers can be replaced. To avoid any possible oil leak, new gaskets should be used. Replace all spark plugs with new. Check spark plug gap before installation.

5. Remove distributor cap and rotor. Check breaker points and gap (See Specifications) for gap setting. If the breaker point spring shows any signs of rust, replace with new points and reset gap. Check inside of distributor cap for dirt or moisture that may have accumulated and wipe clean. Reinstall distributor rotor and cap.

6. Check all ignition wires for cracks and loose connections. Replace if necessary.

7. **Fuel Filters and Screens:** Clean flame arrestor quench plates. Check and clean carburetor fuel inlet screen. Replace fuel filter.

8. **Battery and Cables:** Install a fully charged battery. Check and clean cable terminals and battery before installation. Install battery (Ground Negative). **Do Not Reverse or Arc the Battery Cables** when installing, as this will damage the alternator and/or regulator diodes.

9. **Oil Level:** Check oil level in the engine and fluid level in the transmission. The quantity of oil in the crankcase will vary with angle of installation. Keep operating oil level between the high and low mark on oil dipstick.

10. **Propeller Shaft Alignment:** Check propeller shaft alignment, adjust engine alignment if necessary and secure coupling.

11. **Fuel Tank Lines and Connections:** Check the fuel tanks and fill if necessary. Open all valves in the fuel lines and check all connections for leaks.

12. Make a final check of the engine for loose nuts or screws. If the boat is provided with a valve at the sea water inlet for the engine cooling system, be sure the valve is open. If the exhaust lines were disconnected from the engine, remove plugs from exhaust elbows and connect. Before starting the engine make sure that the bilge is dry and engine compartment is properly vented and free from gasoline fumes. **Always Observe All Safety Precautions.**

ENGINE OPERATIONAL CHECKS

After starting the engine, immediately check the water flow at the exhaust outlets. Check oil pressure, ammeter, and temperature readings.

If the boat was stored with the propeller shaft connected, disconnect the coupling and check the engine shaft alignment after it has soaked up and with normal gear aboard. Check all controls.

QUADRAJET-MODEL 4 MV CARBURETOR

GENERAL DESCRIPTION

The Quadrajet is a 4-barrel two stage carburetor of down-draft design. Its simplicity in construction makes it easy to service, yet its versatility and principles of operation make it adaptable to small and large engines, without major casting changes.

The Model 4 MV Rochester Carburetor is used on the following Thermo Electron Marine Engines: 307 - 350 - 427 AND 454 C.I.D. ENGINES

The 4 MV is an automatic choke model designed for use with a manifold mounted thermostatic choke coil.

The Quadrajet carburetor has two stages in operation. The primary (fuel inlet) side has small

1-3/8" bores with a triple venturi set-up equipped with plain tube nozzles. Operation is similar to most carburetors using the venturi principle. The triple venturi stack up, plus the small primary bores, result in more stable and finer fuel control during idle and part throttle operation. During off-idle and part throttle operation, fuel metering is accomplished with tapered metering rods operating in specially designed jets, positioned by a manifold vacuum responsive piston.

The secondary side of the Quadrajet has two large 2-1/4" bores. These, added to the primary, give enough air capacity to meet most engine requirements. The air valve is used in the secondary side for metering control and supplements the primary bores to meet air and fuel requirements of the engine.

The secondary air valve mechanically operates tapered metering rods which move in orifice plates, thereby, controling fuel flow from the secondary nozzles in direct proportion to air flowing through the secondary bores.

The float bowl is centrally located to avoid problems of fuel spillage causing engine turn cut out and delayed fuel flow to the carburetor bores. The float bowl reservoir is smaller in design than most 4-barrel carburetors to reduce fuel evaporation loss during engine "shut down" hot.

The carburetor float chamber is internally vented on all models through two vent tubes located in the air horn. The internal vent tubes lead from beneath the flame arrestor to the float bowl chamber. Their purpose is to balance air pressure acting on the fuel in the bowl with air flow through the carburetor bores. In this way, balanced air/fuel mixture ratios can be maintained throughout all carburetor ranges of operation.

IDLE SYSTEM

The idle system is only in the two primary bores of the carburetor. Each bore has a separate and independent idle system. During idle the throttle valve is held slightly open by the idle speed adjusting screw. The small amount of air which passes between the primary throttle valve and the bore is regulated by this screw to give the engine the desired idle speed. Since the engine requires very little air for idle and low speeds, fuel is added to the air to produce a combustible mixture by the direct application of vacuum (low pressure) from the engine manifold to the idle discharge hole below the throttle valve. With the idle discharge holes in a very low pressure area and the fuel in the float bowl vented to atmosphere (high pressure), the idle system operates as follows:

Fuel flows from the fuel float bowl down through the main metering jets into the main fuel wells. It is picked up in the main wells by the two idle tubes (one for each primary bore) which extend into wells. The fuel is metered at the lower tip of the idle tube and passes up through the tubes. The fuel mixture crosses over to the idle down channels where it is mixed with air at the side idle bleed located just above the idle channel restriction. The mixture continues down through the calibrated idle channel restrictions past the lower idle air bleeds and off-idle air discharge ports where it is further mixed with air. The air/fuel mixture moves down to the adjustable idle mixture needle discharge holes where it enters the carburetor bores and blends with the air passing slightly open throttle valves. The combustible mixture then passes through the intake manifold to the engine cylinders.

The float system has a single pontoon float and fuel valve for simplification and ease in servicing. An integral fuel filter located in the float bowl ahead of the float needle valve is easily removed for cleaning or replacement.

The throttle body is aluminum to reduce overall weight and improve heat conduction to prevent icing. A heat insulator gasket is used between the throttle body and bowl to prevent fuel percolation in the float bowl.

SERVICE FEATURES

The primary side of the carburetor has six operating systems. They are float, idle, main metering, power, pump, and choke. The secondary side has one main metering system plus accelerating wells on some models. All metering systems receive fuel from the one float chamber.

The Quadrajet carburetor is unique in that it has a centrally located fuel reservoir (fuel bowl). The fuel bowl is centered between the primary bores and is adjacent to the secondary bores. This type design assures an adequate fuel supply to all carburetor bores, which results in excellent performance with respect to boat inclination or severity of turns.

The float pontoon is solid and is made of a light closed cell plastic material. This feature gives added buoyancy which allows the use of a single float to maintain constant fuel levels.

The float valve is a needle type with brass seat. The needle seat is a brass insert and is threaded in to the bowl fuel inlet channel below the needle tip. The seat is removable, the needle valve tip is of a material which makes the seat wear negligible. Care should be used during servicing so that the seat is not nicked, scored or grooved.

The fuel filter is an integral part of the float bowl and is located behind the fuel inlet nut. Should the filter become plugged due to excessive dirt or improper service, a pressure relief spring located behind the filter element allows fuel pump pressure to force the element off its seat. This allows fuel to by-pass the filter and enter the carburetor so the engine will run until the filter can be serviced.

IT IS VERY IMPORTANT THAT THE FILTER BE SERVICED PERIODICALLY TO PREVENT DIRT FROM ENTERING THE CARBURETOR METERING ORIFICES.

OFF IDLE OPERATION

As the primary throttle valves open from idle to increase engine speed, additional fuel is needed to combine with extra air entering the engine. This is accomplished by the slotted off-idle discharge ports. As the primary throttle valves open, they pass by the off-idle ports, gradually exposing them to high engine vacuum below the throttle valves. The additional fuel added from the off-idle ports mixes with the increased air flow past the open throttle valves to meet increased engine air fuel demands.

Further opening of the throttle valves increases the air velocity through the carburetor venturi sufficiently to cause low pressure at the lower idle air bleeds. As a result, fuel begins to discharge from the lower idle air bleed holes and continues to do so throughout operation of the part throttle to wide open throttle ranges, supplementing the main discharge nozzle delivery.

The idle needle holes and off-idle discharge ports continue to supply sufficient fuel for engine requirement until air velocity is high enough in the venturi area to obtain efficient fuel flow from the main metering system.

MAIN METERING SYSTEM

The main metering system supplies fuel to the engine from off-idle to wide open throttle. The primary bores (two smaller bores) supply fuel and air during this range through plain tube nozzles and the venturi principle.

POWER SYSTEM

The power system in the Quadrajet carburetor provides extra mixture enrichment to meet power requirements under heavy engine loads and high speed operation. The richer mixtures are supplied through the main metering systems in the primary and secondary sides of the carburetor.

The primary side of the carburetor provides adequate air and fuel for low speed operation. However, at higher speed more air and fuel are needed to meet engine demands. The secondary side of the carburetor is used to provide extra air and fuel through the secondary throttle bores.

When the engine reaches a point where the primary bores cannot meet engine air and fuel demands, a lever on the primary throttle shaft through a connecting link to the secondary throttle shaft, begins to open the secondary throttle valves. As the secondary valves are opened, engine manifold vacuum (low pressure) is applied directly beneath the air valves. Atmosphere pressure on top of the air valves force the air valves open against spring tension and allows metered air to pass through the secondary bores of the carburetor.

The air/fuel mixture is fed to the secondary bores immediately after the secondary throttle valves begin to open to supplement the air/fuel mixture from the primary bores and goes directly into the engine as a combustible mixture.

AIR VALVE DASH POT

The air valve dash pot operates off of the choke vacuum break diaphram unit. The secondary air valve is connected to the vacuum break unit by a rod, to control the opening rate of the air valve. During acceleration or heavy engine loads when the secondary throttle valves are opened, the manifold vacuum drops. The spring located in the vacuum break diaphram overcomes the vacuum pull and forces the plunger and link outward which in turn, allows the air valves to open. The opening rate of the air valves is controlled by the calibrated restriction in the vacuum inlet in the diaphram cover. This gives the dash pot action required to delay air valve opening enough for efficient fuel flow from the secondary discharge nozzles.

ACCELERATING PUMP SYSTEM

The accelerating pump system is located in the primary side of the carburetor. It consists of a spring loaded pump plunger and pump return spring, operating in a fuel well. The pump plunger is operated by a pump lever on the air horn which is connected directly to the throttle lever by a pump rod. When the primary throttle valves are opened the connecting linkage forces the pump plunger downward. The pump cup seats instantly and fuel is forced through the pump discharge passage, where it unseats the pump discharge check ball and passes on through

the passage to the pump jets located in the air horn where it sprays into the venturi area of each primary bore.

CHOKE SYSTEM

The Quadrajet choke valve is located in the primary side of the carburetor. It provides the correct air/fuel mixture enrichment to the engine for quick cold engine starting and during the warm-up period. The air valve is locked closed until the engine is thoroughly warm and choke valve is wide open. The choke system consists of a choke valve located in the primary air horn bore, a vacuum diaphram unit, fast idle cam, connecting linkage, air valve or secondary throttle valve lockout lever and a thermostatic coil. The thermostatic coil is located in the engine manifold and is connected by a rod to the intermediate choke shaft and lever assembly. Choke operation is controlled by the combination of intake manifold vacuum, the off-set choke valve, temperature, and throttle position. The thermostatic coil located in the engine manifold is calibrated to hold the choke valve closed when the engine is cold.

NOTE: To close the choke valve, the primary throttle valves have to be opened to allow the fast idle cam follower to by-pass the step on the fast idle cam and come to rest on the highest step of the fast idle cam.

When the choke valve is closed, the air valve lockout lever is weighted so that a tang on the lever catches the upper edge of the air valve and keeps the air valve closed. During engine cranking, the choke valve is held closed by the tension of the thermostatic coil. This restricts air flow through the carburetor to provide a richer starting mixture.

When the engine starts and is running, manifold vacuum applied to the vacuum diaphram unit mounted on the float bowl opens the choke valve to a point where the engine will run without loading or stalling. Also at this point, the cold enrichment feed holes are no longer in a low pressure area so they cease to feed fuel. From this point on they will be used as secondary main well air bleeds. At the same time, the fast idle cam follower lever on the end of the primary throttle shaft will drop from the highest step on the fast idle cam to a lower step when the throttle is opened. This gives the engine sufficient fast idle and correct fuel mixture for running until the engine begins to warm up and heat the thermostatic coil. As the thermostatic coil on the engine manifold becomes heated, it relaxes its tension and allows the choke valve to open further because of intake air pushing on the off-set choke valve. Choke valve opening continues until thermostatic coil is completely relaxed at which point the choke valve is wide open. When the engine is throughly warm, the choke coil pulls the intermediate choke lever completely down and allows the fast idle cam to rotate so that the cam follower drops off the last step of the fast idle cam allowing the engine to run at normal speeds.

When the choke rod moves upward in the choke shaft lever, the end of the rod strikes a tang on the air valve lockout lever. As the rod moves to the end of its travel it pushes the lockout tang upward and unlocks the air valve. The choke system is equipped with an unloader mechanism which is designed to partially open the choke valve, should the engine become loaded or flooded. To unload the engine, the throttle lever must be in wide open position so that the throttle valves are held wide open. A tang on a lever on the choke side of the primary throttle shaft contacts the fast idle cam aid through the intermediate choke shaft forces the choke valve slightly open. This allows extra air to enter the carburetor bores and pass on into the engine manifold and cylinders to lean out the fuel mixture so that the engine will start.

CARBURETOR MAINTENANCE AND SERVICE PROCEDURE

CHOKE

The choke mechanism should be checked for free operation. A binding condition may develop from pertroleum gum formation on the choke shaft or from damage. Choke shafts can usually be cleaned without disassembly by using Delco X-66 Carburetor and Combustion Chamber Conditioner or equivalent.

Bolts, carburetor to manifold-Carburetor attaching bolts and/or nuts should be carefully adjusted to correct torque to compensate for compression of gasket at first 50 hours of operation.

Filter-Carburetor and/or primary-A clogged carburetor or main filter may restrict fuel flow or bypass foreign material into carburetor. Replace primary fuel filter at 50 hours of operation, and thereafter twice each season.

PRELIMINARY CHECKS

1. Thoroughly warm-up engine. If the engine is cold, allow to run for at least 10 minutes.
2. Inspect torque of carburetor to intake manifold bolts and intake manifold to cylinder heads bolts to exclude the possibility of air leaks.
3. Inspect manifold heat control choke coil for freedom of action.
4. Check and adjust choke as required, follow procedure specified in this section.

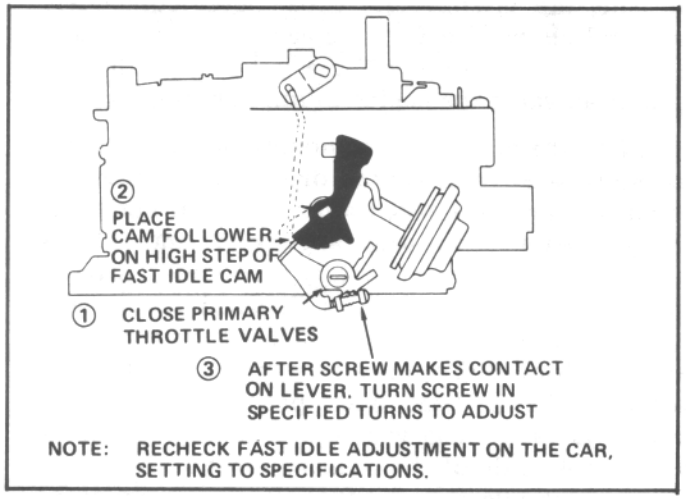


Fig. 48. Fash Idle Adjustment (Rochester 4MV)

5. Adjust ignition timing, idle speed and idle mixture as outlined in section "Engine Tune Up" and carburetor adjustments this section.

EXTERNAL ADJUSTMENTS

FAST IDLE ADJUSTMENT (Fig. 48):

1. Position fast idle lever on second step of fast idle cam.
2. Be sure choke is properly adjusted in wide open position (engine warm).
3. Adjust fast idle speed screw to desired fast idle RPM.

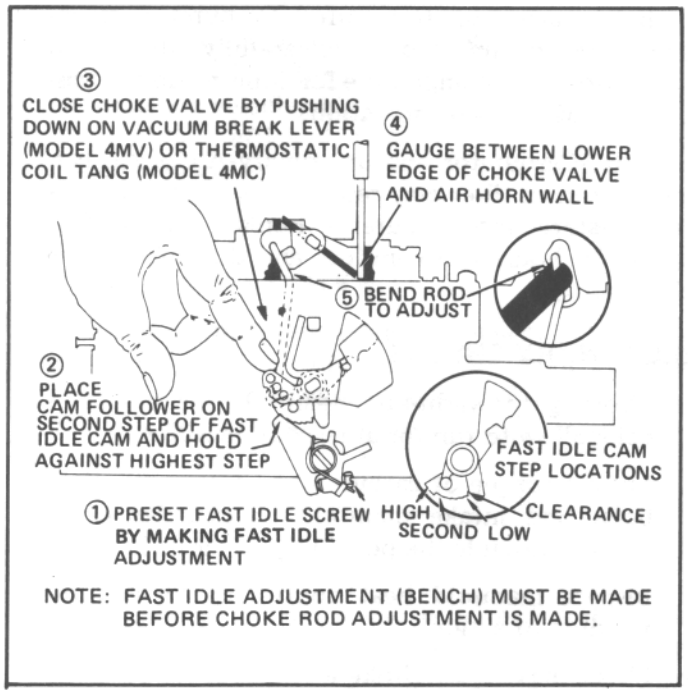


Fig. 49. Chock Rod (Fast Idle Cam) Adjustment

CHOKE ROD (FAST IDLE CAM) ADJUSTMENT

With the cam follower on second step of fast idle cam and against the high step, rotate choke valve toward the closed position by turning the external choke lever Counter-clockwise. Dimension between the lower edge of choke valve, at choke lever end, should be .100 (See Fig. 49).

AIR VALVE DASHPOT ADJUSTMENT

1. Completely seat choke vacuum break diaphram using an outside vacuum source.
2. With choke diaphram seated and air valve fully closed, measure the distance between the end of slot in vacuum break plunger lever and air valve. Measurement should be .030 (See Fig. 50).

CHOKE COIL ROD ADJUSTMENTS

1. Remove thermostatic coil cover, and remove thermostatic coil rod from lever.
2. Rotate coil lever counter-clockwise until choke valve is completely closed.
3. Push down on coil rod so that the coil rod contacts bracket surface.
4. Rod should fit into hole of choke lever.
5. Bend rod as shown to adjust (See Fig. 51).

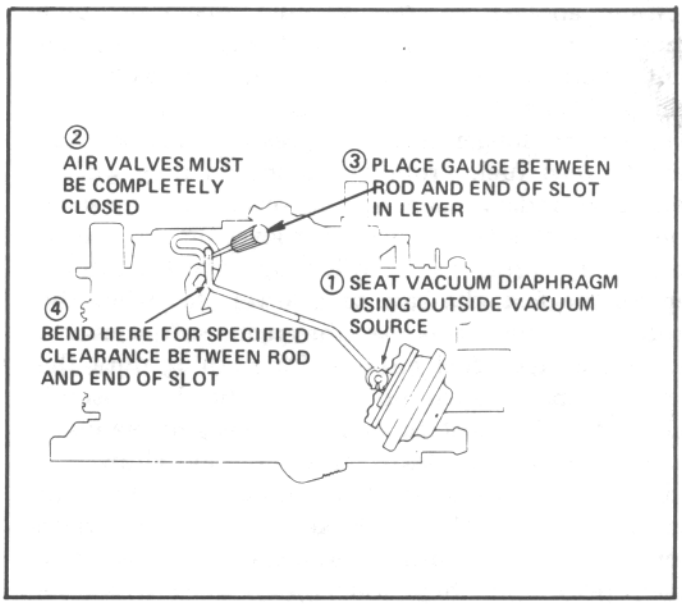


Fig. 50. Air Valve Dashpot Adjustment

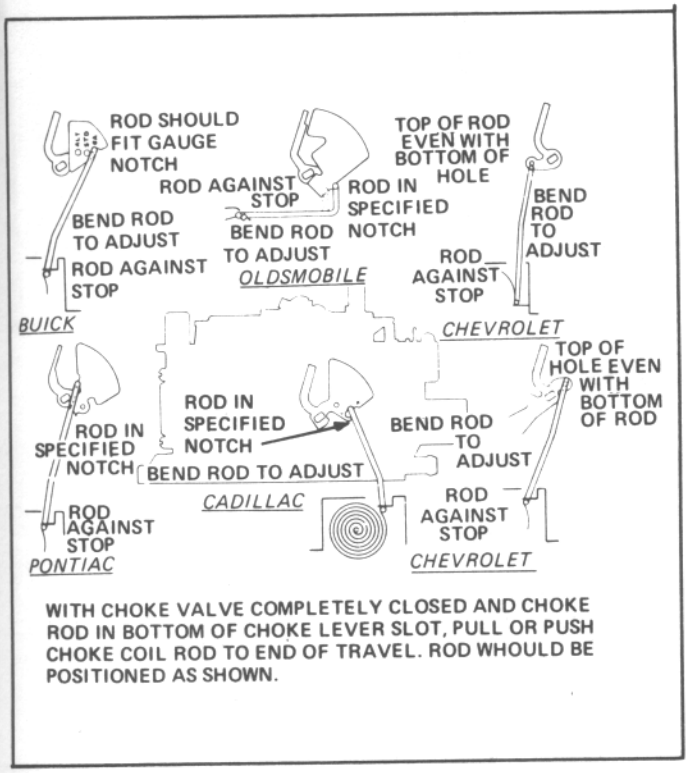


Fig. 51. Choke Coil Rod Adjustment

IDLE SPEED AND MIXTURE ADJUSTMENT

1. Connect vacuum gauge to intake manifold.
2. Start and warm engine to normal operating temperature. Be sure that choke is fully off, and that carburetor is on slow idle.
3. Set idle speed 650 RPM in forward gear. Adjust I/O idle speed 550 RPM maximum in neutral.
4. Turn idle mixture screws in (finger tight) and backout 1-1/2 turns.
5. Turn one idle mixture screw in or out in order to obtain highest leading on both vacuum gauge and tachometer.
6. Repeat step 5 with other idle mixture adjusting screw.
7. Reset idle RPM as required.
8. Repeat step 5 and 6 until turning idle mixture screws will not cause an increase in engine idle RPM, and the smoothest engine idle is obtained.

NOTE: No other adjustments on the carburetor are required.

SERVICE AND REPAIR MANUAL

THERMO ELECTRON MARINE ENGINES

292 CID IN-LINE SIX CYLINDER
307 CID, 350 CID AND 454 CID V-8

THERMO ELECTRON ENGINE CORPORATION
7100 EAST 15 MILE ROAD
STERLING HEIGHTS, MICHIGAN 48077
(313) 264-1200

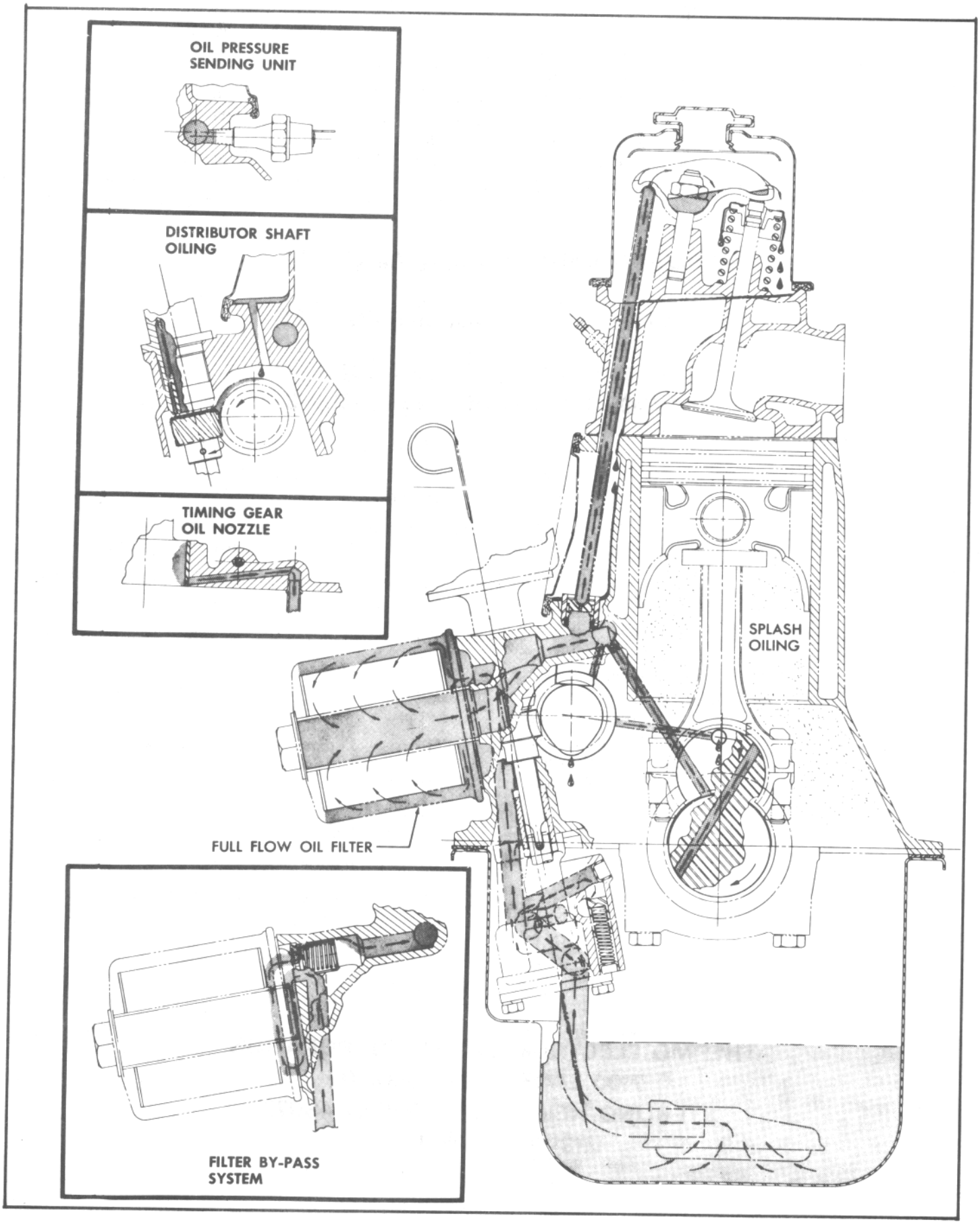


Fig. 52. In-Line Engine Lubrication

INTRODUCTION

This manual covers all models gasoline engines identified as basic 292 CID in-line six, 307, 350 and 454 V-8 engines. Typical illustrations and procedures used will help to clarify operations. The similarity of engines, engine parts and engine sub assemblies and the resulting similarity of procedure required to service these units should aid the technician in servicing the engines.

Many operations outlined in this manual, when done as single operations and not part of a general overhaul, should be performed with the engine(s) in the boat.

GENERAL DESCRIPTION IN-LINE ENGINES

Cylinders are numbered front to rear. Firing order is 1-5-3-6-2-4 L.H. rotation, 1-4-2-6-3-5 R.H. rotation. Crankshaft rotation is viewed from the rear or flywheel end of the engine. The six cylinder engine has seven main bearings and the camshaft has four bearings.

Full pressure lubrication, through a full flow filter is furnished by a gear-type oil pump. The distributor, driven by a helical gear on the camshaft, drives the oil pump. The main oil gallery feeds oil, through drilled passages, to the camshaft and crankshaft to lubricate the bearings. The main oil gallery also feeds the valve lifters which, through hollow push rods, feed the individually mounted rocker arms (Fig. 52).

V-8 ENGINES

Cylinders are numbered front to rear, 1-3-5-7 on left bank and 2-4-6-8 on right bank. Firing order is 1-8-4-3-6-5-7-2 L.H. rotation and 1-2-7-5-6-3-4-8 R.H. rotation. Crankshaft rotation is viewed from the rear or flywheel end of the engine.

The crankshaft has five main bearings and the camshaft has five bearings. Full pressure lubrication through a full flow oil filter, is furnished by a gear type oil pump. The distributor driven by a helical gear on the camshaft, drives the oil pump. The main gallery feeds oil, through drilled passages, to the camshaft and crackshaft to lubricate the bearings. The valve lifter oil gallery feeds the valve lifters which, through hollow push rods, feed the individually mounted rocker arms (Fig. 53 & 54).

MAJOR OVERHAUL REPAIR PROCEDURES

Disconnect and remove engine(s) from boat.

CAUTION: To prevent any damage to accessories and engine components, make certain that the engine hold down lag screws are removed, propeller shaft coupling, exhaust lines, oil and fuel lines controls, and all wiring are disconnected. To prevent damage and for safety when lifting the engine **Use Lifting Rings** provided.

DISASSEMBLY:

With engine removed from boat, and safely suspended on hoist:

1. Drain water from block, manifolds and (fresh water cooling system if so equipped).
2. Drain oil from crankcase and transmission.
3. Place engine on a suitable stand or bench.
4. If so equipped, remove fresh water cooling system.
5. Remove the transmission oil cooler and connecting oil lines and remove the transmission.
6. Remove distributor cap, spark plug wire assembly, distributor and coil.
7. Disconnect water hoses, remove exhaust manifolds.
8. Remove sea water pump, circulating pump and crankshaft pulley.
9. Remove alternator and current regulator.
10. Remove starter motor.
11. Remove fuel filter, fuel lines, crankcase vent tubes and carburetor.
12. Remove rocker arm covers.
13. Remove rocker arm nuts, fulcrum seats, rocker arms, and push rods.
14. Remove intake manifold.
15. Remove valve lifters.

    NOTE: Rocker arm nuts, rocker arm fulcrum seats, rocker arms, push rods, and valve lifters should be placed in a rack in sequence as removed so they can be reinstalled in their original position.
16. Remove cylinder heads.
17. Remove oil pan.
18. Remove torsional damper (Fig. 55), using tool J23523.

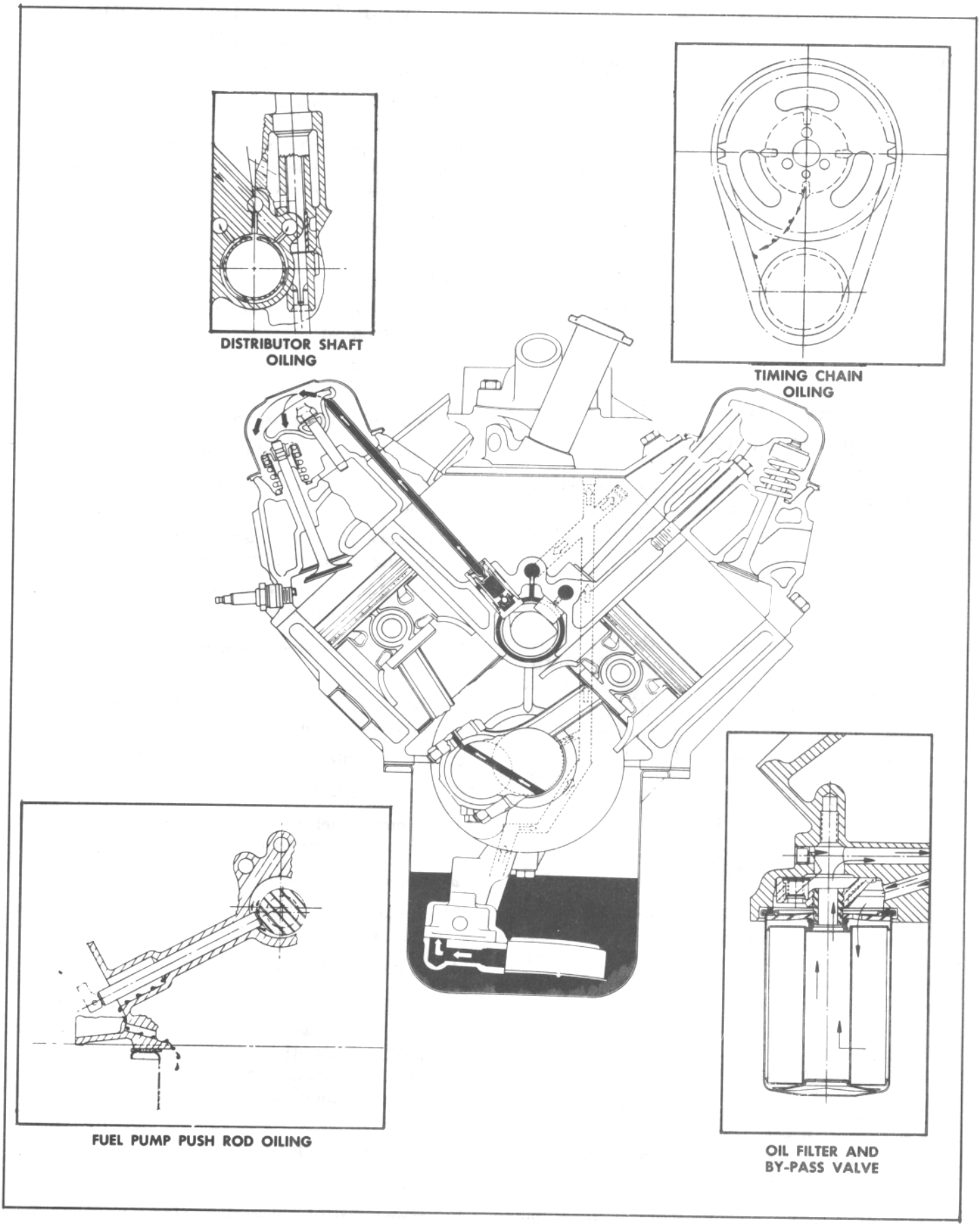
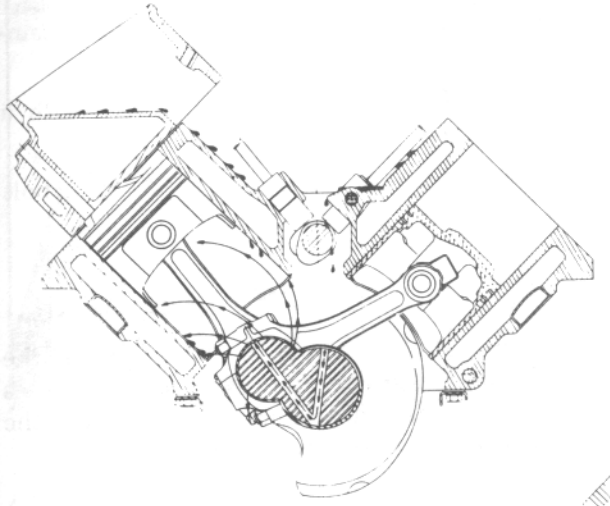
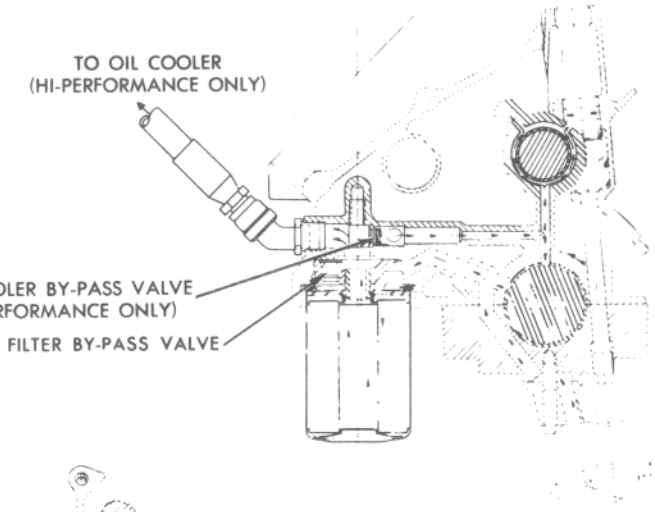


Fig. 53. "Small V8" Engine Lubrication

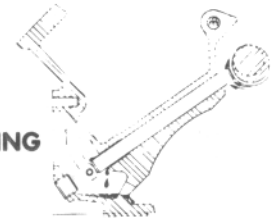


CYLINDER WALLS ARE OILED BY OIL THROWN OFF PRESSURE FED CONNECTING ROD BEARINGS

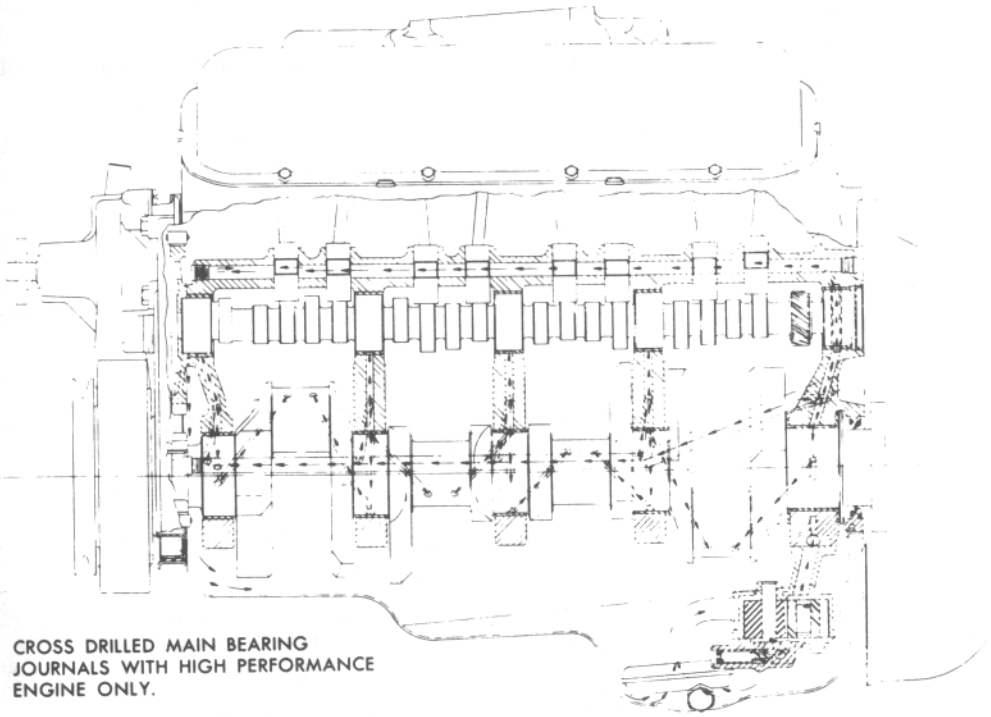
CYLINDER WALL AND CAMSHAFT LOBE OILING



OIL FILTER AND DISTRIBUTOR OILING

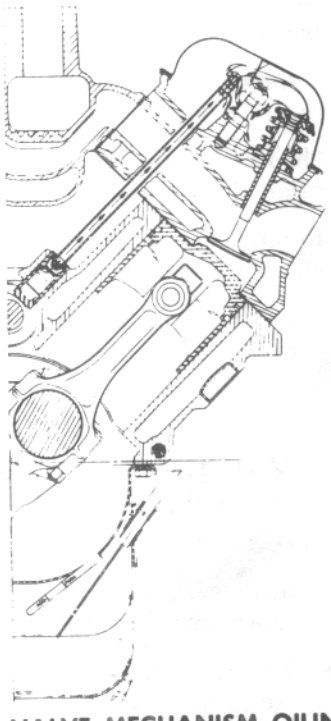


FUEL PUMP PUSH ROD OILING



CROSS DRILLED MAIN BEARING JOURNALS WITH HIGH PERFORMANCE ENGINE ONLY.

CRANKCASE AND CRANKSHAFT OILING



VALVE MECHANISM OILING

Fig. 54. "Mark IV" Engine Lubrication

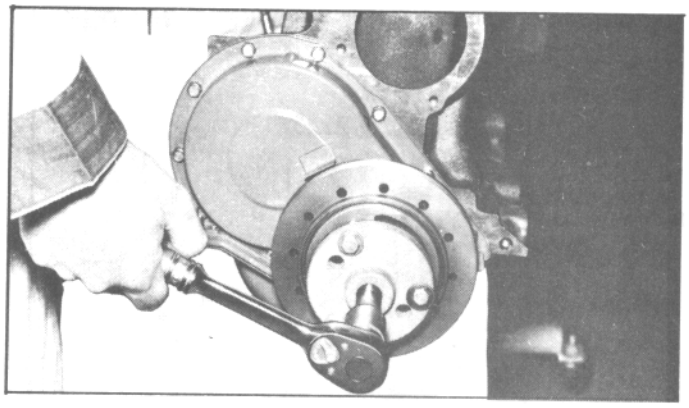


Fig. 55. Removing Torsional Damper

19. Remove cylinder front cover.
20. Remove the oil pump and screen assembly.
21. Remove the transmission damper drive assembly, flywheel and flywheel housing.
22. Check connecting rods and caps for cylinder number identification and if necessary, mark them so they can be reinstalled in their original position.
23. Remove connecting rod cap and using connecting rod guide set, tool J-5239 (3/8") or J-6305 (11/32"), push connecting rod and piston assemblies out of block and replace connecting rod bearing caps to original position.
24. Remove main bearing caps and lift crankshaft out of cylinder block.

    NOTE: Mark caps for reassembly to their original position.
25. Remove rear main bearing oil seal from cylinder block and rear main bearing cap.
26. Discard all gaskets and seals removed during engine disassembly.

CAMSHAFT
V-8-307-350, AND 454 CID WITH TIMING CHAIN

REMOVAL:

1. Remove camshaft sprocket bolts, then remove camshaft sprocket and timing chain.

   NOTE: Sprocket is a light press fit on camshaft. To dislodge, tap lightly on lower edge of sprocket with a plastic hammer.
2. Install two 5/16-18 bolts in camshaft sprocket bolt holes and carefully remove camshaft.

   CAUTION: Use care in removing camshaft to avoid damaging bearings.

V-8-307-350 CID WITH TIMING GEAR

REMOVAL:

1. Remove camshaft gear bolts, then remove camshaft gear.

   To loosen the timing gear tap lightly with a plastic hammer.
2. Install two 5/16-18 bolts in camshaft gear bolt holes and carefully remove camshaft.

V-8-454 CID WITH TIMING GEAR

The camshaft timing gear is pressed on to the camshaft. Remove the camshaft with timing gear as an assembly. Exercise care so as not to damage the camshaft bearings when removing the camshaft.

IN-LINE 292 CID SIX CYLINDER

Remove camshaft thrust plate screws (through holes in camshaft gear), then remove camshaft and gear as an assembly.

CLEANING AND INSPECTION:

1. Wash cylinder block throughly with cleaning solvent. Remove old gasket material from all machined surfaces. Remove all plugs that seal the oil passages; then clean out all passages, bolt holes etc. with compressed air.
2. Make sure that the threads in the cylinder bolt holes are clean. Dirt in the threads may cause binding and result in a false torque reading. Use a tap to true-up the threads and to remove any deposits.
3. Clean and inspect water passages in the cylinder block.
4. Inspect the cylinder block for cracks in the cylinder bores, water jacket, valve seats, valve lifter bores and main bearing webs.

   NOTE: To remove a core plug, drill a 1/4-inch hole in the center and pry it out with a drift punch.
5. All other cleaning and inspection is outlined under part or sub assembly being serviced.

ASSEMBLY

Before installation carefully inspect the bores of all core plugs that have been removed for any damage that would interfere with the proper sealing of the plug. If the bore is damaged it will be necessary to true the surface by boring for the next specified oversize plug. Coat the plug and/or bore lightly with an

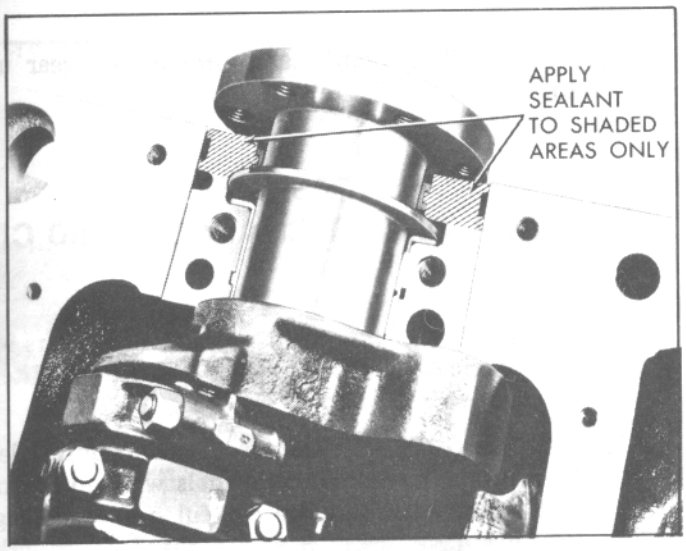


Fig. 56. Sealing Bearing Cap & Block

oil resistant (oil gallery) or water resistant (cooling jacket) sealer and install the plugs.

Install the crankshaft as follows:

INSTALLATION:

1. Install rear main bearing oil seal in cylinder block and rear main bearing cap grooves. Install with lip of seal toward front end of engine. Where seal has two lips, install lip with helix toward front end of engine.
2. Lubricate lips of seal with engine oil. Keep oil off parting line surface.

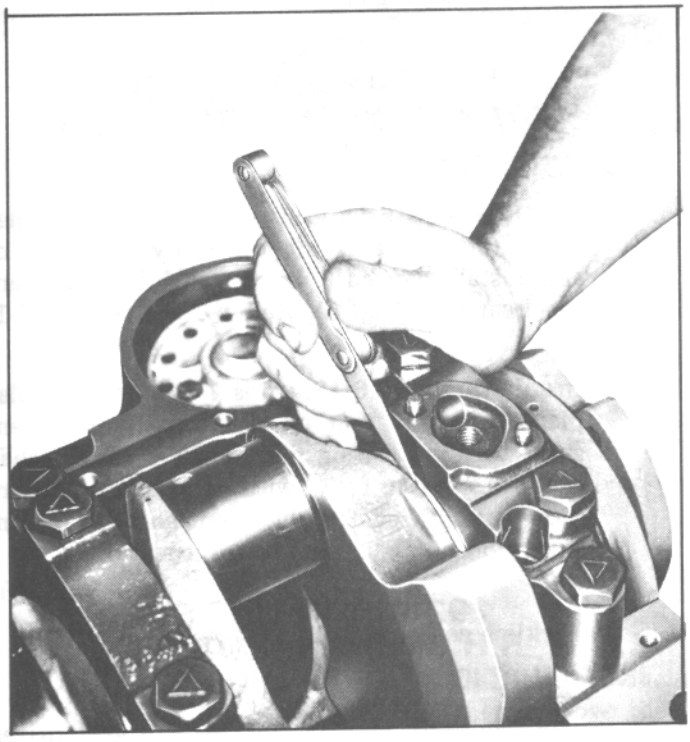


Fig. 57. Measuring Crankshaft End Play

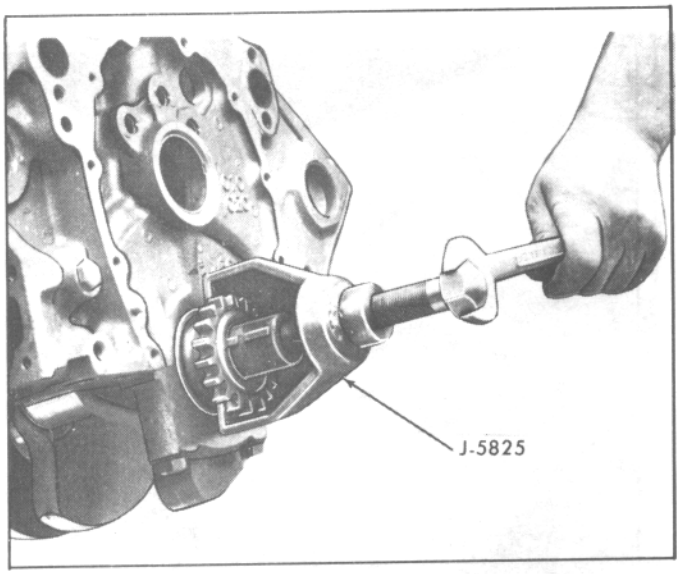


Fig. 58. Removing Crankshaft Sprocket "Small V8"

3. Install main bearings in cylinder block and main bearing caps, then lubricate bearing surface with engine oil.
4. Install crankshaft, being careful not to damage bearing surfaces.
5. Apply a thin coat of brush-on type oil sealing compound to block mating surface and corresponding surface of cap only (Fig. 56). **Do Not** allow sealer on crankshaft seal lip.
6. Install main bearing caps with arrows pointing toward front of engine.

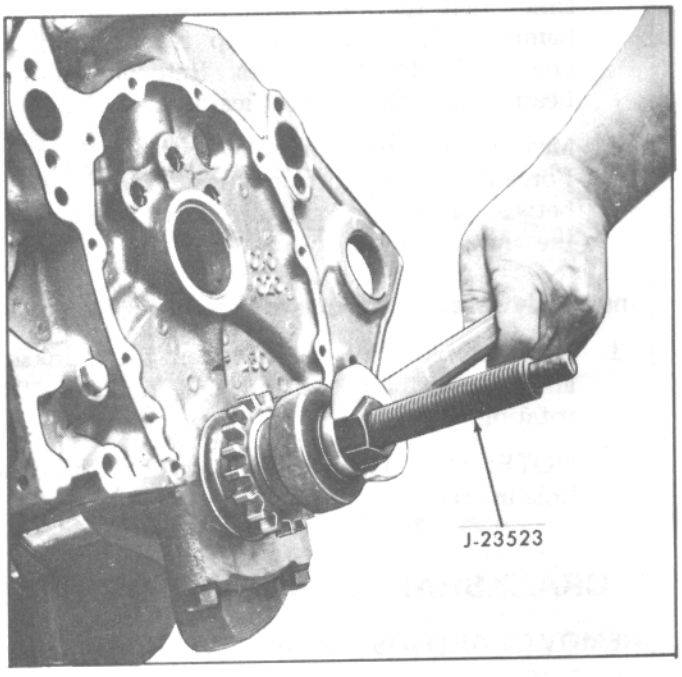


Fig. 59. Installing Crankshaft Sprocket

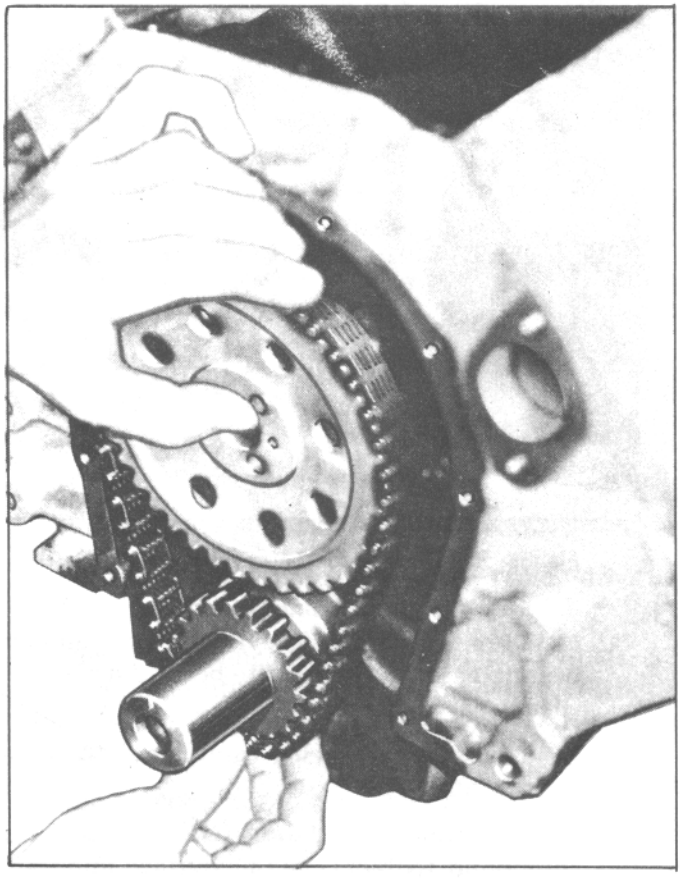


Fig. 60. Installing Timing Chain

7. Torque all except rear main bearing cap bolts to specifications. Torque rear main bearing cap bolts to 10-12 ft.-lbs. then tap end of crankshaft, first rearward then forward with a lead hammer. This will line up rear bearing and crankshaft thrust surfaces. Retorque all main bearing cap bolts to specifications.
8. Measure crankshaft end play with a feeler gauge. Force crankshaft forward and measure clearance between the front of the rear main bearing and the crankshaft thrust surface (Refer to Fig. 57).

Install Flywheel and torque to specifications.

1. A wood block placed between the crankshaft and cylinder block will prevent crankshaft from rotating.

   NOTE: Align dowel hole in flywheel with dowel hole in crankshaft.

CRANKSHAFT SPROCKET OR GEAR

REMOVAL AND INSTALLATION:

1. For removal of crankshaft sprocket or gear use tool J-5825 (Fig. 58).
2. For installing crankshaft sprocket or gear use tool J-23523 (Fig. 59).

CAMSHAFT
V-8 WITH TIMING CHAIN 307-350 CID

INSTALLATION:

NOTE: Whenever a new camshaft or new lifters are installed, lubricate camshaft lobes and foot of lifters with "Molykote" or its equivalent.

1. Install two 5/16-18 bolts in camshaft bolt holes, then lubricate camshaft journals with engine oil and install camshaft, be careful not to damage bearings (Fig. 62). Remove the two 5/16-18 bolts.
2. Install timing chain on camshaft sprocket then align marks on camshaft and crankshaft sprockets and connect chain to crankshaft sprocket. Align dowel on camshaft with dowel hole in camshaft sprocket and install sprocket on camshaft (Fig. 63).

   CAUTION: **Do Not** Hammer camshaft sprocket onto camshaft. This may loosen camshaft rear welsh plug.
3. Draw camshaft sprocket onto camshaft, using the mounting bolts. Torque bolts to specifications.
4. Lubricate timing chain with engine oil.

V-8 WITH TIMING GEAR
307-350 CID R.H. ROTATION

INSTALLATION:

1. Install two 5/16-18 bolts in camshaft bolt holes, then lubricate camshaft journals with engine oil and install camshaft, being careful not to damage bearings. (Fig. 5). Remove the two 5/16-18 bolts.
2. Install three 5/16-18 studs in camshaft holes, place camshaft gear on stud's and rotate camshaft to align timing marks and push camshaft gear into mesh fully with crankshaft gear, remove studs used for alignment and install camshaft gear bolts. Torque to specifications.

292 CID IN-LINE SIX
R.H. AND L.H. ROTATION

INSTALLATION:

The camshaft in these models are gear driven. The camshaft gear position is located with a woodruff key and is a press fit on the camshaft.

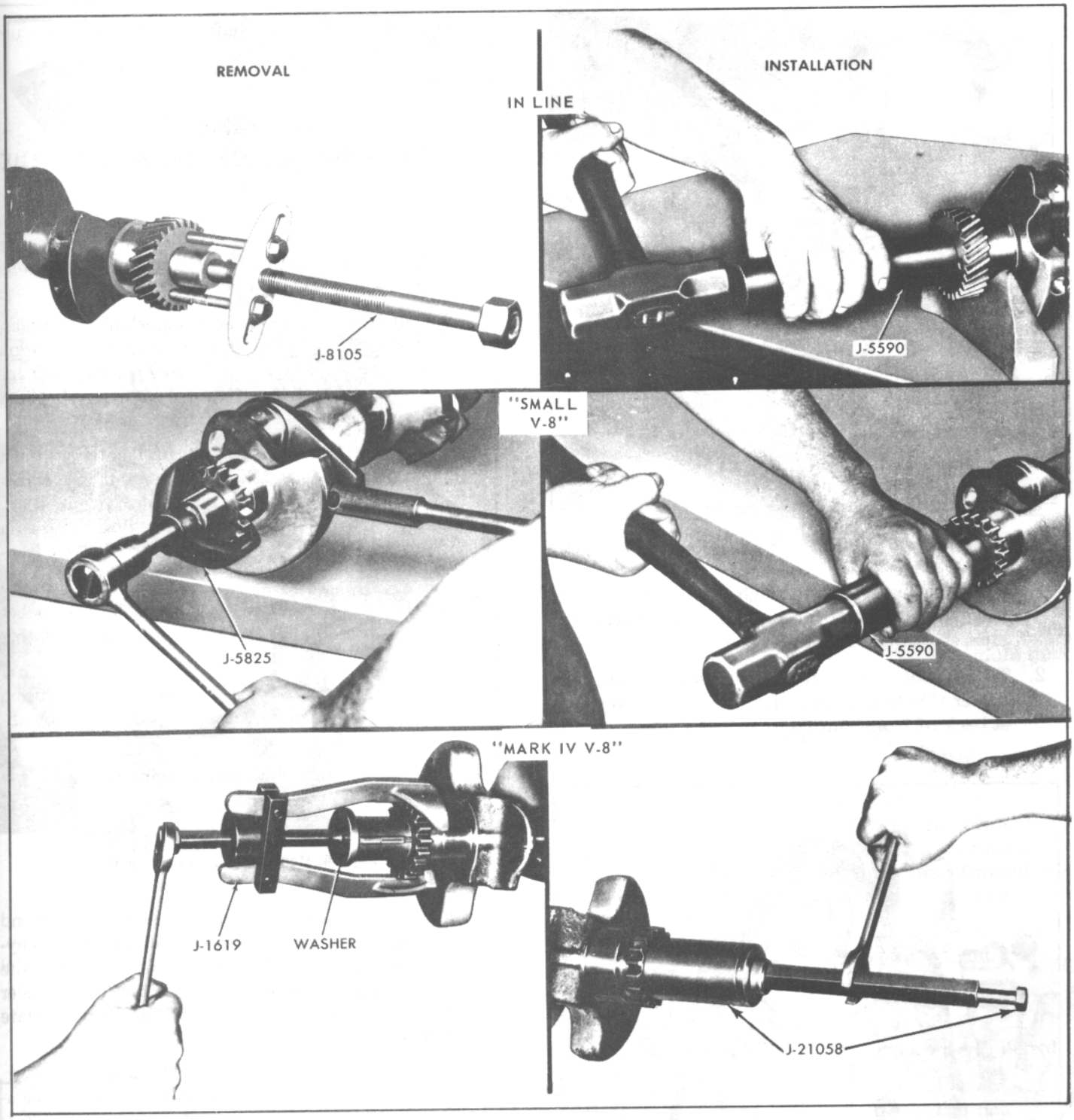


Fig. 61. Sprocket or Gear Replacement

REMOVAL:

1. The camshaft is removed as an assembly.
2. Through holes in the timing gear, remove the thrust plate screws (Fig. 66), then remove the camshaft assembly, being careful not to damage the camshaft bearings.

CAMSHAFT GEAR

REMOVAL:

CAUTION: The thrust plate must be positioned so that woodruff key in shaft does not damage it when the shaft is pressed out of gear. Also support the hub of the gear or the gear will be seriously damaged.

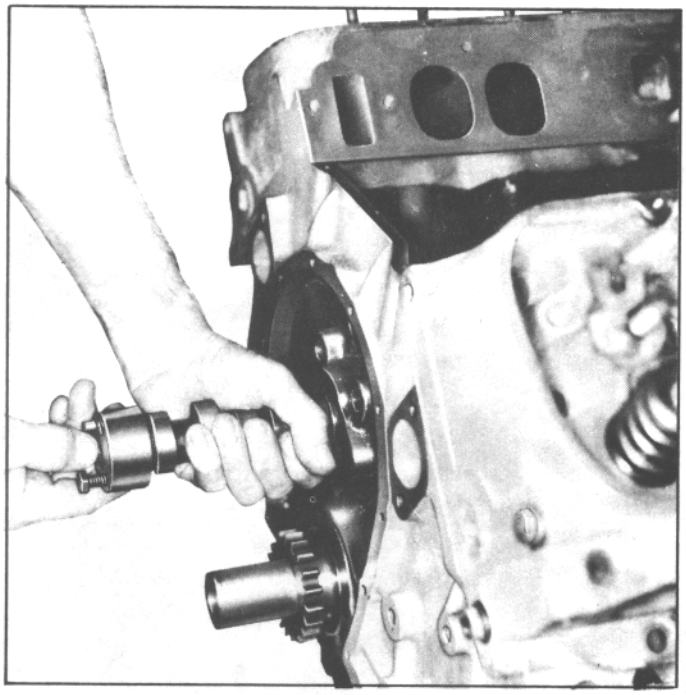


Fig. 62. Installing Camshaft

1. Place the camshaft through the gear remover, place end of remover on table of a press and press shaft out of gear (Fig. 64).
2. To assemble camshaft gear thrust plate and gear spacer ring to camshaft, firmly support camshaft at back of front journal in an arbor press.

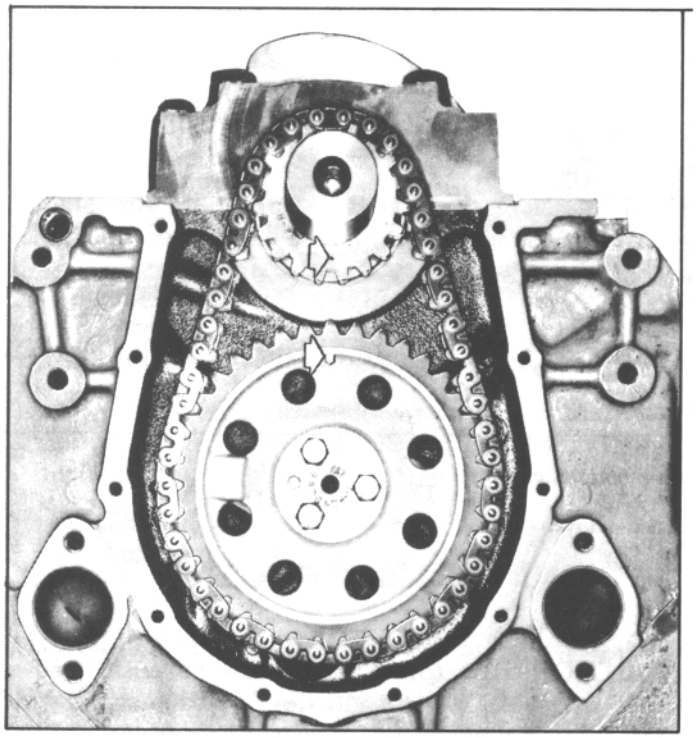


Fig. 63. Timing Sprocket Alignment Marks

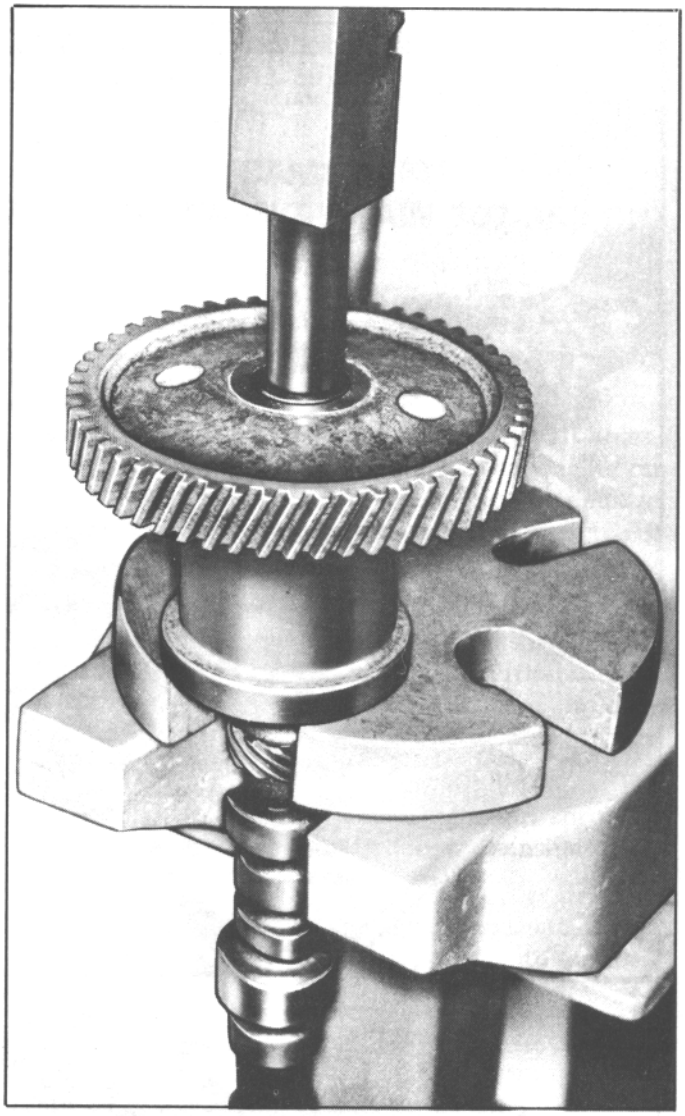


Fig. 64. Removing Camshaft Gear

3. Place gear spacer ring and thrust plate over end of shaft, and install woodruff key in shaft keyway. Install camshaft gear and press it onto the shaft until it bottoms against the gear spacer ring. The end clearance of the thrust plate should be .001 to .005 (Fig. 67).

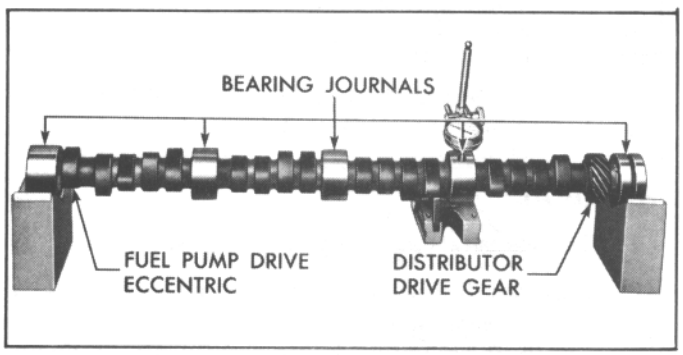


Fig. 65. Checking Camshaft Alignment

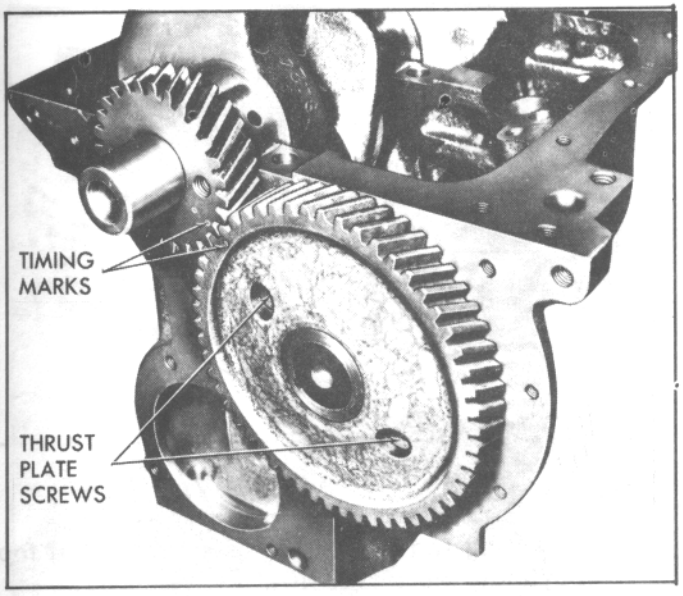


Fig. 66. Timing Gear Alignment Marks

4. Lubricate camshaft journals with engine oil, then rotating crankshaft so that timing marks on gears will line up, install camshaft and gear assembly being careful not to damage bearings (Fig. 66).

5. Check camshaft gear run out with a dial indicator (Fig. 68). The camshaft gear run out should not exceed .004", and the crankshaft gear run out should not exceed .003".

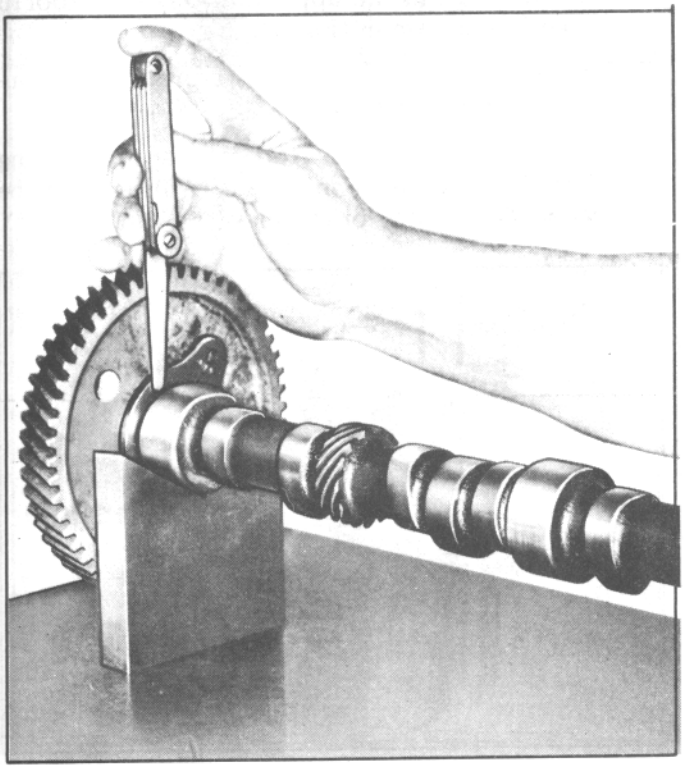


Fig. 67. Measuring Camshaft End Play

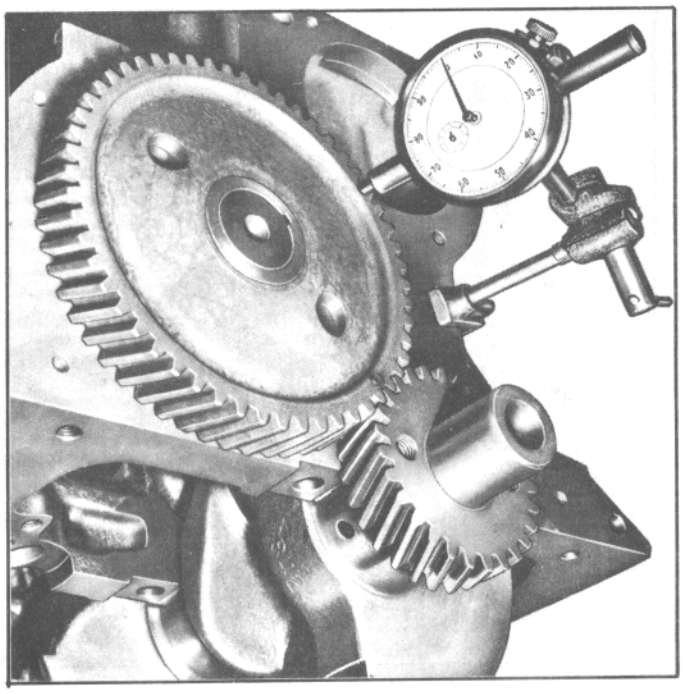


Fig. 68. Checking Timing Gear Runout

6. Check the back lash between the timing gear teeth with a dial indicator (Fig. 9). The back lash should be not less than .004" nor more than .006".

CAMSHAFT

INSPECTION:

The camshaft bearing journals should be measured with a micrometer for an out-of-round condition. If the journals exceed .001" out-of-round, the cmashaft should be replaced.

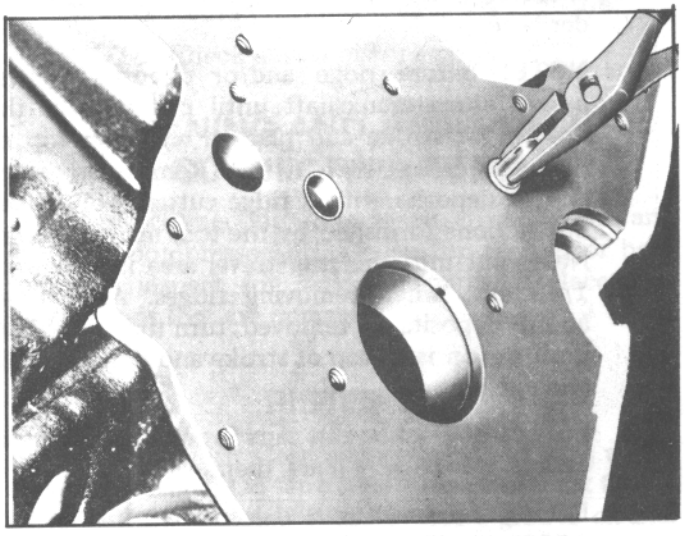


Fig. 69. Oil Nozzle Replacement (In-Line)

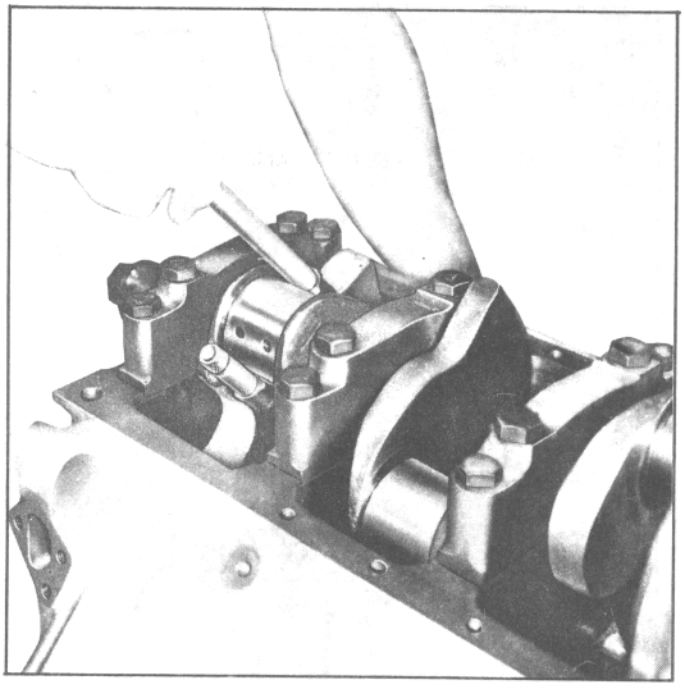


Fig. 70. Removing Connecting Rod & Piston Assemblies

The camshaft should also be checked for alignment. The best method is by use of "V" blocks and a dial indicator (Fig. 65). The dial indicator will indicate the exact amount the camshaft is out of true. If it is out more than .0015" dial indicator reading, the camshaft should be replaced.

CONNECTING ROD AND PISTON ASSEMBLY

REMOVAL:

1. With oil pan, oil pump, and cylinder head(s) removed, use a ridge reamer to remove any ridge and/or deposits from the upper end of the cylinder bore.

   NOTE: Before ridge and/or deposits are removed, turn crankshaft until piston is at the bottom of stroke and place a cloth on top of piston to collect the cuttings. Remove any ridge and/or deposits with a ridge cutter. Follow the instructions furnished by the tool manufacturer. Never cut into the ring travel area in excess of 1/32 inch when removing ridges. After ridge and/or deposits are removed, turn the crankshaft until piston is at top of stroke and remove cloth and cuttings.

2. Inspect connecting rod caps for cylinder identification. If necessary mark them.

3. Remove connecting rod cap and install tool J-5239 (3/8") or J-6305 (11/32") on studs. Push connecting rod and piston assembly out of top of cylinder block (Fig. 70).

   NOTE: It will be necessary to turn the crankshaft slightly to disconnect some of the connecting rod and piston assemblies and push them out of the cylinder.

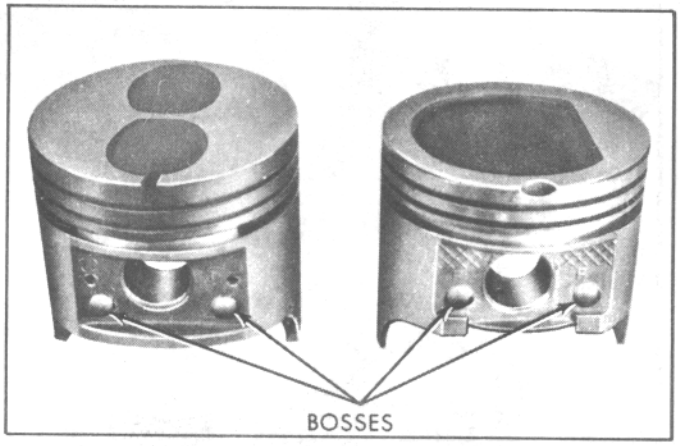


Fig. 71. Piston Bosses

PISTON SUPPORT TOOL

DISASSEMBLY:

If bores on pistons (Fig. 71) **Do Not** allow piston support tool J-9510-1 to seat squarely on the piston for press operations, modifications to the tool are necessary. To allow adequate clearance for these bosses, turn or grind the upper portion of the tool to the dimensions shown in (Fig. 72).

1. Remove connecting rod bearings from connecting rods and caps.

   NOTE: If connecting rod bearings are being reused, place them in a rack so they may be reinstalled in their original rod and cap.

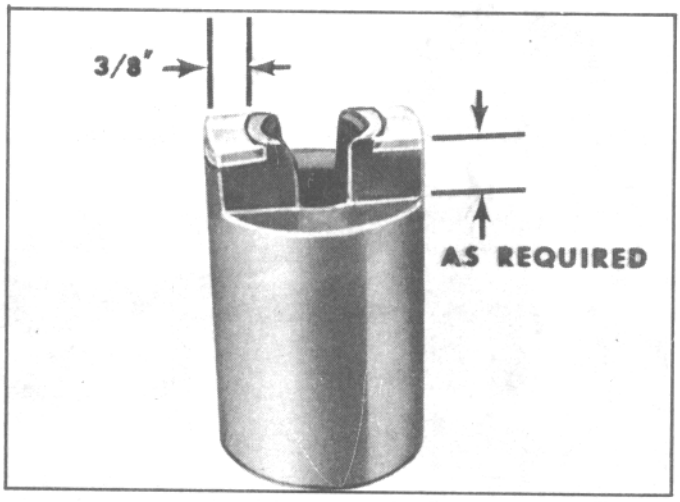


Fig. 72. Piston Support Tool Rework

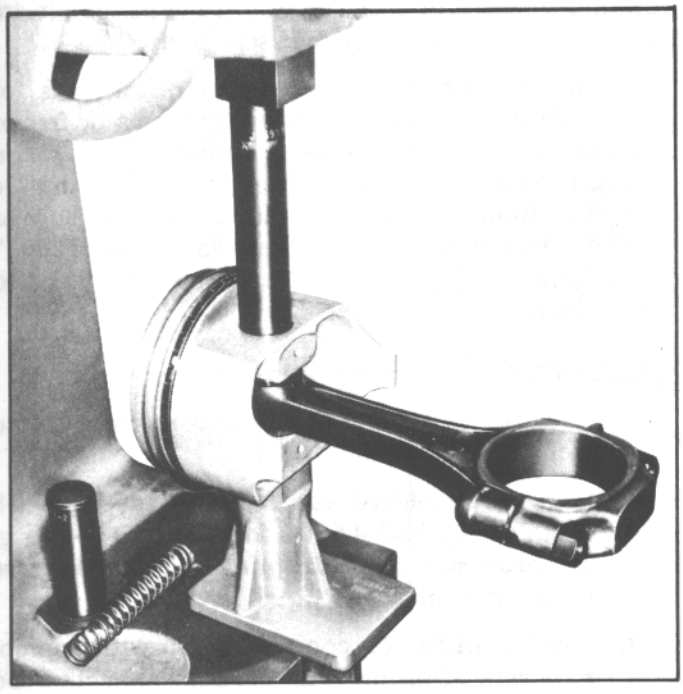


Fig. 73. Remvong Piston Pin ("Mark IV V8")

2. Remove piston rings by expanding and sliding them off the pistons, tools
3. Using tool J-9510 for In-Line and "small V-8" (Fig. 74), or tool J-6994 for 454 CID (Fig. 73), place connecting rod and piston assembly in arbor press with piston on support then using

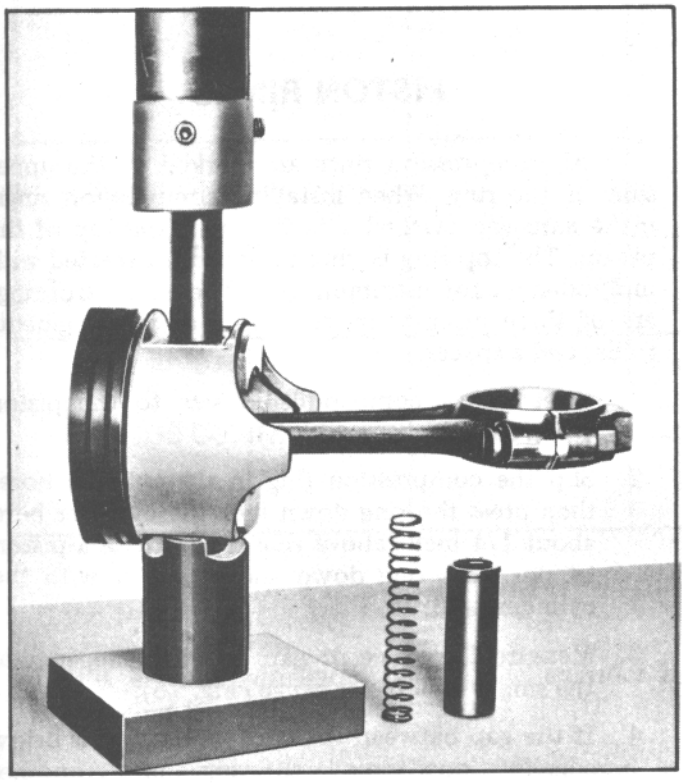


Fig. 74. Removing Piston Pin (In-Line & "Small V8")

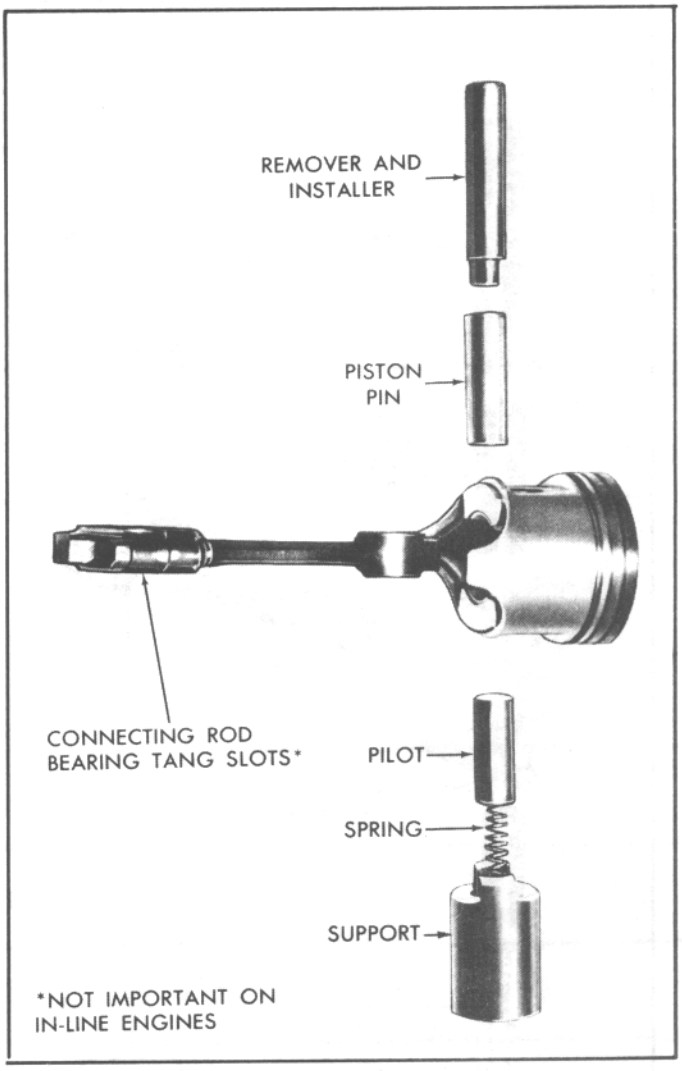


Fig. 75. Piston Pin & Tool Layout (In-Line & "Small V8")

remover, press piston pin out of connecting rod and piston.

4. Remove assembly from arbor press and remove tools, piston pin, connecting rod and piston.

NOTE: Check actual pistons used.

CLEANING AND INSPECTION CONNECTING RODS

Wash connecting rods in cleaning solvent and dry with compressed air. Check for twisted or bent rods and inspect for nicks or cracks. Replace connecting rods that are damaged.

PISTONS

Clean varnish from piston skirts and pins with a cleaning solvent. **Do Not Wire Brush Any Part Of the Piston.** Clean the ring grooves with a groove cleaner and make sure oil rings holes and slots are clean.

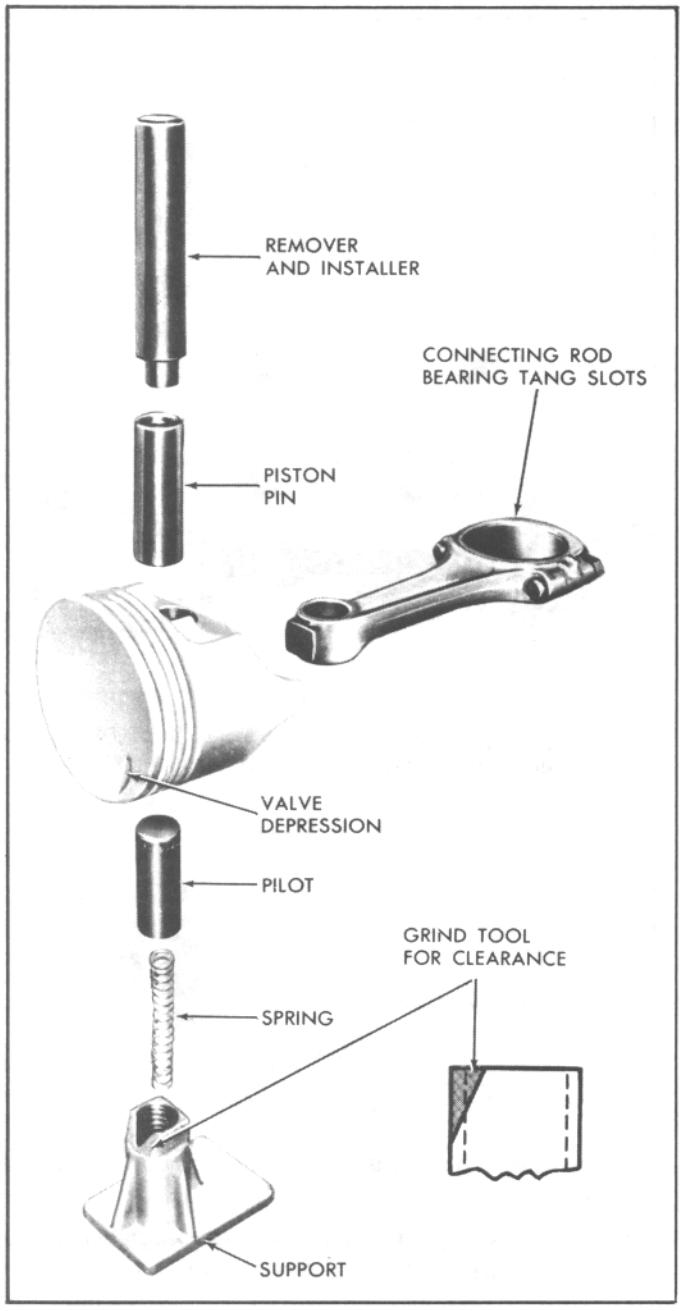


Fig. 76. Piston Pin & Tool Layout ("Mark IV V8")

Inspect the piston for cracked ring lands, scuffed or damaged skirts, eroded areas at top of the piston. Replace pistons that are damaged or show signs of excessive wear. Inspect the grooves for nicks or burrs that might cause the rings to hang up.

Measure piston skirt (across center line of piston pin) and check clearance as outlined under piston selection.

PISTON PINS

The piston pin clearance is designed to maintain adequate clearance under all engine operating conditions. Because of this, the piston and piston pin are a matched set and not serviced separately.

Inspect piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured. The piston pin should be measured with a micrometer and the pin bore should be measured with a dial bore gauge or inside micrometer. If clearance is in excess of .001" wear limit, the piston and piston pin assembly should be replaced.

ASSEMBLY:

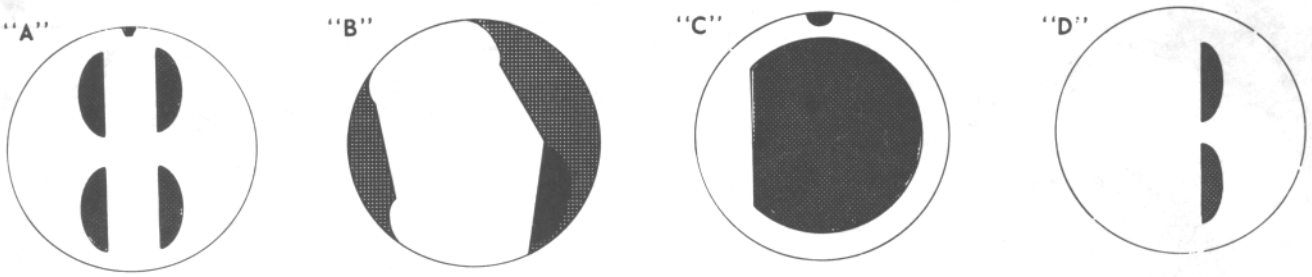
1. Lubricate piston pin holes and connecting rod to facilitate installation of pin.
2. Using tool J-9510 for In-Line and small V-8 (Fig. 75) or tool J-6994 for 454 CID V-8 (Fig. 76) place support with spring and pilot in place on an arbor press.
3. Position piston on connecting rod with appropriate side of piston (Fig. 77) and connecting rod bearing tangs aligned (Fig. 75 or 76).
4. Place piston on support, indexing pilot through piston and rod.
5. Place installer on piston pin into piston and press on installer until pilot bottoms in support.
6. Remove installer from connecting rod and piston assembly and check piston for freedom of movement on piston pin.

PISTON RINGS

All compression rings are marked on the upper side of the ring. When installing compression rings, make sure the marked side is toward the top of the piston. The top ring is chrome faced, or treated with molybdenum for maximum life. The oil control rings are of three piece type, consisting of two segments (rails) and a spacer.

1. Select rings comparable in size to the piston being used.
2. Slip the compression ring in the cylinder bore; then press the ring down into the cylinder bore about 1/4 inch (above ring travel). Use a piston to push the ring down and square it with the cylinder wall.
3. Measure the space or gap between the ends of the ring with a feeler gauge (Fig. 78).
4. If the gap between the ends of the ring is below specifications, remove the ring and try another for fit.

PISTON—VIEWED FROM TOP



ENGINE	PISTON	CYLINDER	SIDE OF PISTON ALIGNED WITH CONNECTING ROD BEARING TANGS
250 CU. IN. 292 CU. IN.	"C"	ALL	ALIGNMENT NOT NECESSARY NOTCH ON PISTON TOWARD FRONT OF ENGINE
307 CU. IN.	"A"	1-3-5-7	LEFT
		2-4-6-8	RIGHT
427 CU. IN.	"B"	1-3-5-7	LEFT
		2-4-6-8	RIGHT
454 CU. IN.	"B"	1-3-5-7	LEFT
		2-4-6-8	RIGHT
350 CU. IN.	"D"	1-3-5-7	LEFT
		2-4-6-8	RIGHT

Fig. 77. Connecting Rod & Piston Relationship

5. Fit each compression ring to the cylinder in which it is going to be used.

6. If the pistons have not been cleaned and inspected as previously outlined, do so.

7. Slip the outer surface of the top and second compression ring into the respective piston ring groove and roll the ring entirely around the groove (Fig. 79) to make sure that the ring is free. If binding occurs at any point, the cause

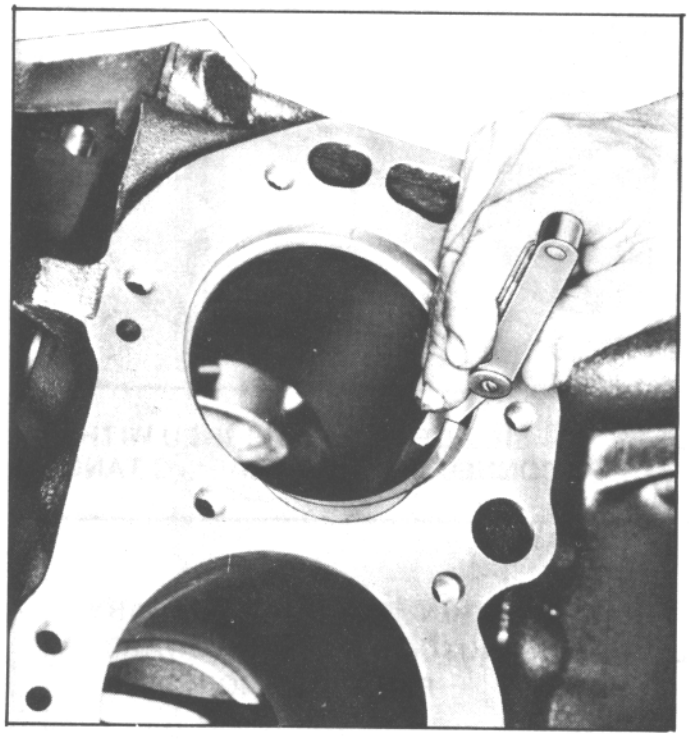


Fig. 78. Measuring Ring Gap

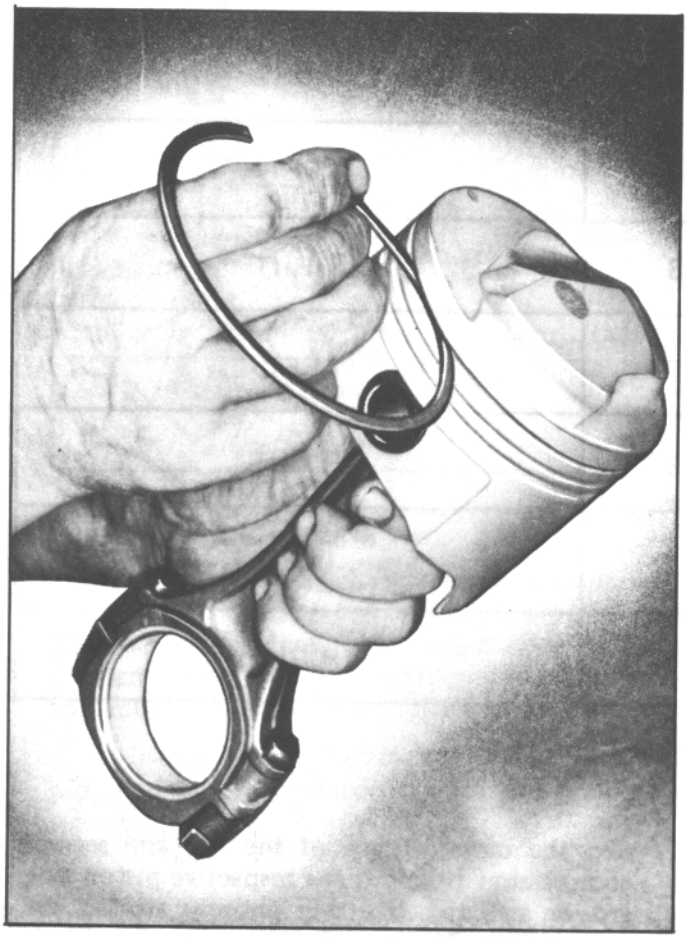


Fig. 79. Checking Ring In Groove

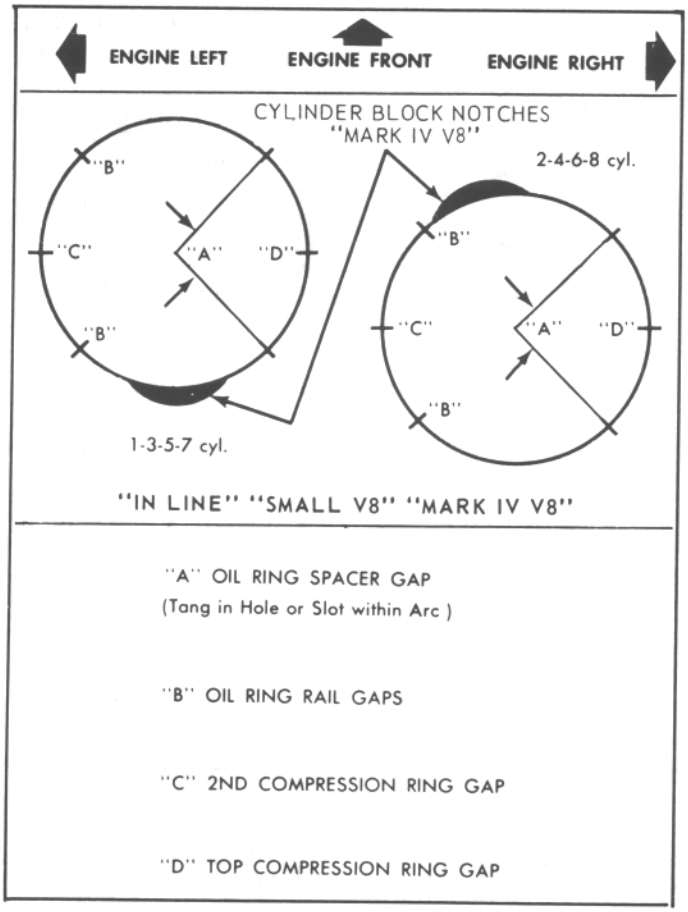


Fig. 80. Ring Gap Location

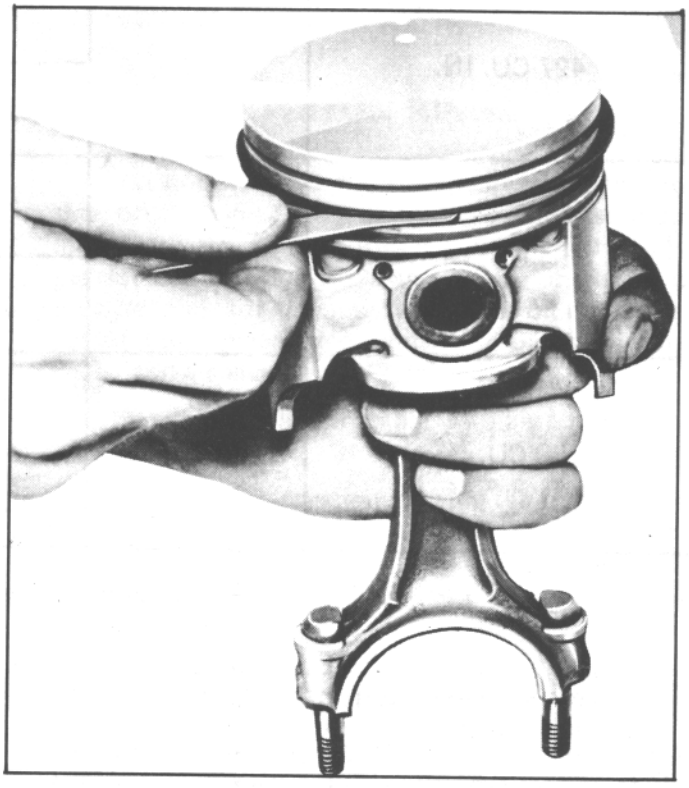


Fig. 81. Measuring Ring Groove Clearance

should be determined, and if caused by ring groove, remove by dressing with a fine cut file. If the binding is caused by a distorted ring, check a new ring.

8. Install piston rings as follows (Fig. 80):
   (a) Install oil ring spacer in groove, insert anti-rotation tang in oil hole.
   (b) Hold spacer ends butted and install lower steel oil ring rail with gap properly located.
   (c) Install upper steel oil ring rail with gap properly located.
   (d) Flex the oil ring assembly to make sure ring is free. If binding occurs at any point the cause should be determined and if caused by ring groove, remove by dressing groove with a fine file. If binding is caused by a distorted ring, check a new ring.
   (e) Install second compression ring expander then ring with gap properly located.
   (f) Install top compression ring with gap properly located.
9. Proper clearance of the piston ring in its piston ring groove is very important to provide proper ring action and reduce wear. Therefore, when fitting new rings, the clearance between the surfaces of the ring and groove should be measured (Fig. 81, See Specifications).

PISTON AND CONNECTING ROD

INSTALLATION:

NOTE: Cylinder bores must be clean before piston installation. This may be accomplished with a light honing as necessary and washed with a hot water detergent solution. After cleaning, the bores should be swabbed several times with light engine oil and a clean dry cloth.

1. Install connecting rod bearings in rods and caps. Lubricate with engine oil.
2. Lightly coat pistons, rings and cylinder walls with light engine oil.
3. With bearing caps removed, install tool J-5239 (3/8") or J-6305 (11/32") on connecting rod bolts.

   CAUTION: Be sure ring gaps are properly positioned as previously outlined.
4. Install each connecting rod and piston assembly in its respective bore. Install with connecting rod bearing tang slots on side opposite camshaft on V-8 engines (Fig. 82). In-Line engine pistons must have piston notch facing front of engine (Fig. 83).

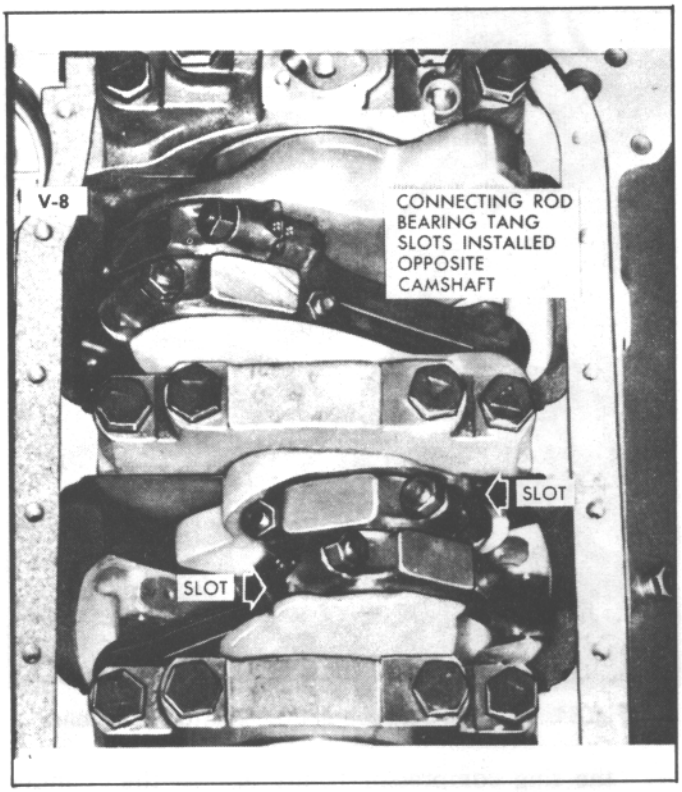


Fig. 82. Connecting Rods - Installed Position V8

Use tool J-8037 to compress the rings (Fig. 84).

Guide the connecting rod into place on the crankshaft journal with tool J-5239 (3/8") or J-6305 (11/32"). Use hammer handle and light blows to install the piston into the bore. Hold

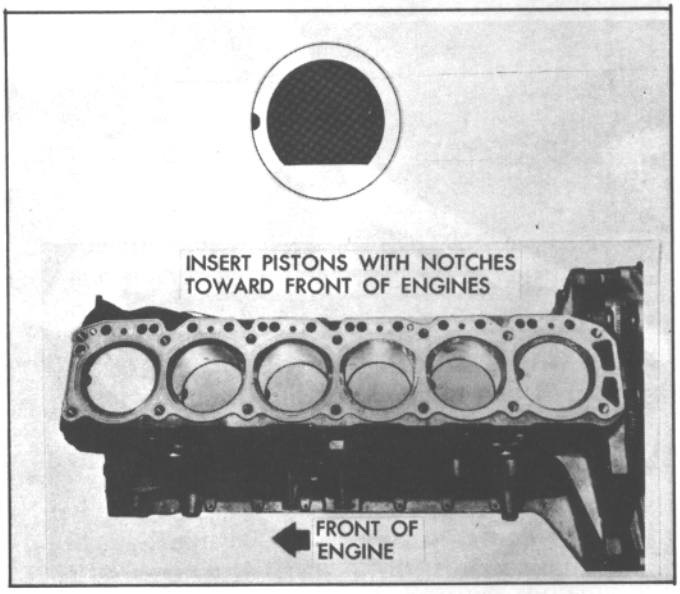


Fig. 83. Piston - Installed Position (In-Line)

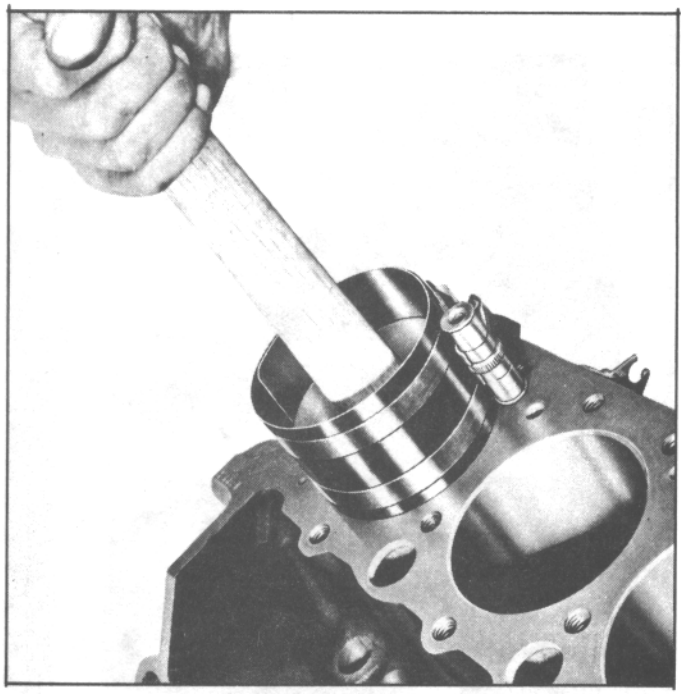


Fig. 84. Installing Connecting Rod & Piston Assemblies

the ring compressor firmly against the cylinder block until all piston rings have entered the cylinder bore.

5. Remove tool J-5239 or J-6305.
6. Install the bearing caps and torque nuts to specifications.

NOTE: If bearing replacement is required refer to connecting rod bearings.

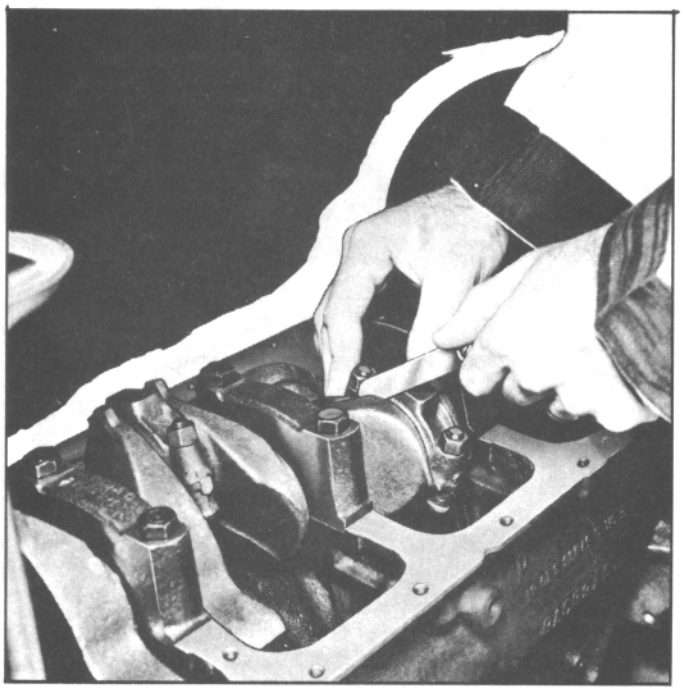


Fig. 85. Measuring Connecting Rod Side Clearance (In-Line)

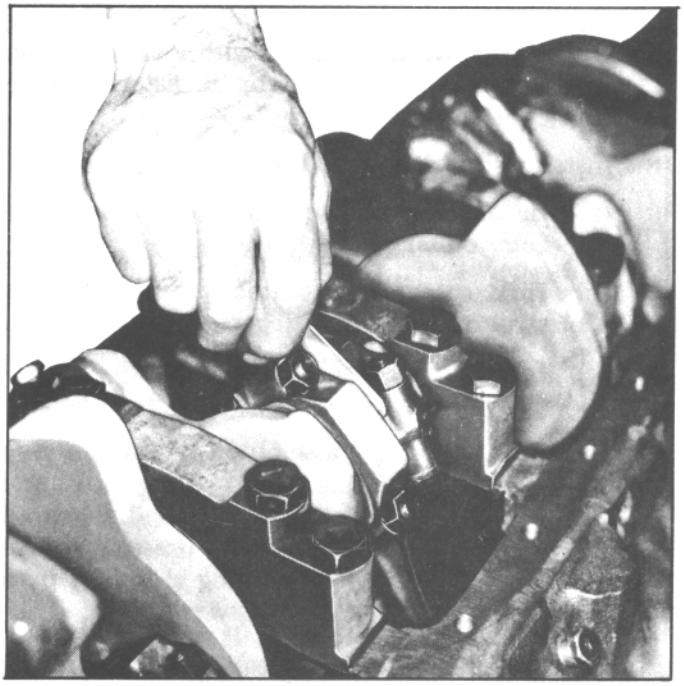


Fig. 86. Measuring Connecting Rod Side Clearance (V8)

NOTE: Be sure to install new pistons in the same cylinders for which they were fitted, and used pistons in the same cylinder from which they were removed. Each connecting rod bearing cap should be marked, beginning at the front of the engine. On V-8 engines, 1, 3, 5 and 7 in left bank and 2, 4, 6 and 8 in the right bank. The numbers on the connecting rod and bearing cap must be the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one block to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

CONNECTING ROD SIDE CLEARANCE

After connecting rods are installed and bearing cap bolts are torqued to specifications, check connecting rod side clearance (Fig. 85 & 86). See specifications for tolerance.

CONNECTING ROD BEARINGS

Connecting rod bearings are of the precision insert type and do not utilize shims for adjustment. **Do Not File Rods or Caps.** If clearances are found to be excessive, new bearings will be required. Bearings are available in standard size .001" and .002" undersized for use with new and used standard size crankshafts, and in .010 and .020 undersize for use with reconditioned crankshafts.

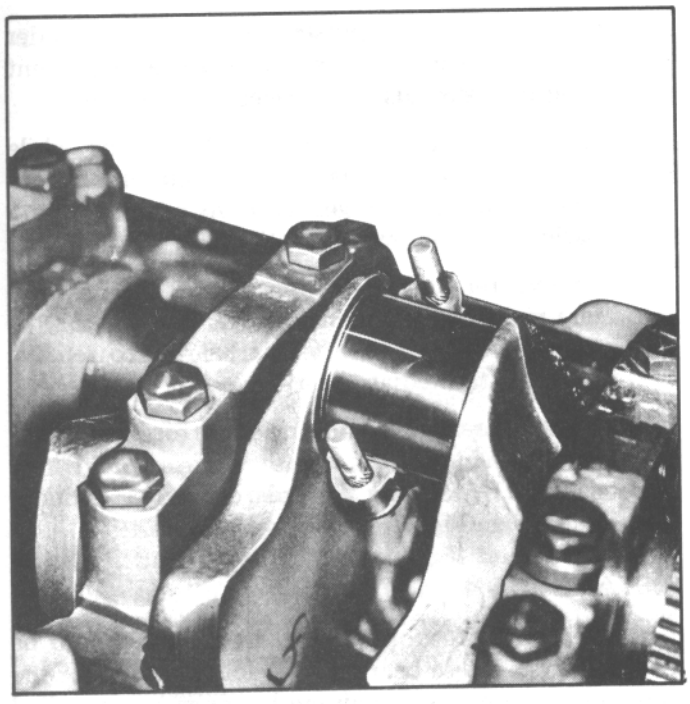


Fig. 87. Gauging Plastic on Crankpin

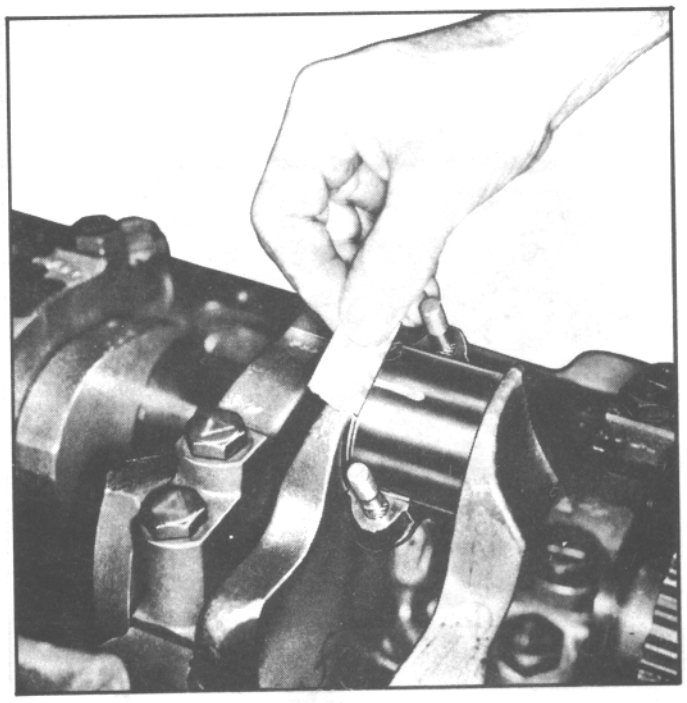


Fig. 88. Measuring Gauging Plastic

INSPECTION AND REPLACEMENT

1. Inspect the bearings for evidence of wear or damage (Bearings showing wear or damage should be replaced).

2. Wipe the bearings and crankpins clean of oil.

3. Measure the crankpin for out-of-round or taper with a micrometer. If not within specifications replace or recondition the crankshaft. If within specifications and a new bearing is to be installed, measure the maximum diameter of the crankpin to determine new bearing size required.

4. If within specifications measure new or used bearing clearances with plastigage or its equivalent.

   NOTE: If a bearing is being fitted to an out-of-round crankpin, be sure to fit the maximum diameter of the crankpin. If the bearing is fitted to the minimum diameter and the crankpin is out-of-round .001", interference between the bearing and crankpin will result in rapid wear.

   (a) Place a piece of gauging plastic the full width of the crankpin parallel to the crankpin (Fig. 87).

   (b) Install the bearing in the connecting rod and cap.

   (c) Install the bearing cap and evenly torque nuts to specifications.

   CAUTION: Do Not turn crankshaft with the gauging plastic installed.

   (d) Remove the bearing cap and using the scale on the gauging plastic envelope, measure the gauging plastic width at the widest point (Fig. 88).

5. If the clearance exceeds specifications, select a new, correct size bearing, and remeasure the clearance.

6. Coat the bearing surface with oil, install the rod cap and torque nuts to specifications.

7. When all connecting rod caps have been installed tap each rod lightly (parallel to crankpin) to make sure they have clearance.

8. Measure all connecting rod side clearances (see specifications) between the connecting rod cap and side of crankpin on In-Line engines (Fig. 85) or between connecting rod caps on V-8 engines (Fig. 86).

CAMSHAFT BEARINGS

INSPECTION:

With camshaft removed, inspect the bearings for evidence of wear or damage. Bearings showing wear or damage should be replaced.

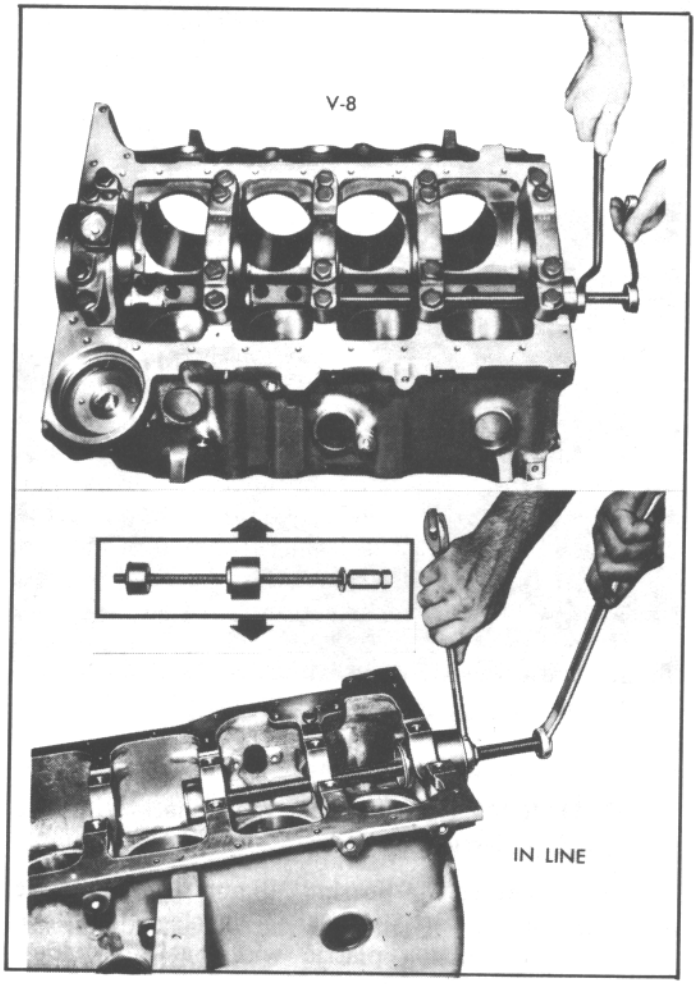


Fig. 89. Replacing Camshaft Center Bearing

REMOVAL:

Camshaft bearings can be replaced while the engine is disassembled for overhaul, or without complete disassembly of the engine. To replace bearings without complete disassembly, remove the camshaft and crankshaft leaving cylinder heads attached and pistons in place. Before removing crankshaft tape threads of connecting rods to sides of engine so they will not be in the way while replacing camshaft bearings.

1. With camshaft and crankshaft removed, drive camshaft rear plug from cylinder block.

   NOTE: This procedure is based on removal of the bearings nearest center of the engine first. With this method a minimum amount of turns are necessary to remove all bearings.

2. Using tool set J-6098, with nut and thrust washer installed to end of threads, index pilot in camshaft front bearing and install puller screw through pilot.

3. Install remover and installer tool with shoulder toward bearings, making sure a sufficient amount of threads are engaged.

4. Using two wrenches, hold puller screw while turning nut. When bearing has been pulled from bore, remove, remover and installer tool and bearing from puller screw (Fig. 89).

5. Remove remaining bearings (except front and rear) in the same manner. It will be necessary to index pilot in camshaft rear bearing to remove the rear intermediate bearing.

6. Assemble remover and installer tool on driver handle and remove camshaft front and rear bearings by driving towards center of cylinder block (Fig. 64).

INSTALLATION:

The camshaft front and rear bearings should be installed first. These bearings will act as guides for the pilot and center the remaining bearings being pulled into place.

1. Assemble remover and installer tool on driver handle and install camshaft front and rear bearings by driving toward center of cylinder block (Fig. 90).

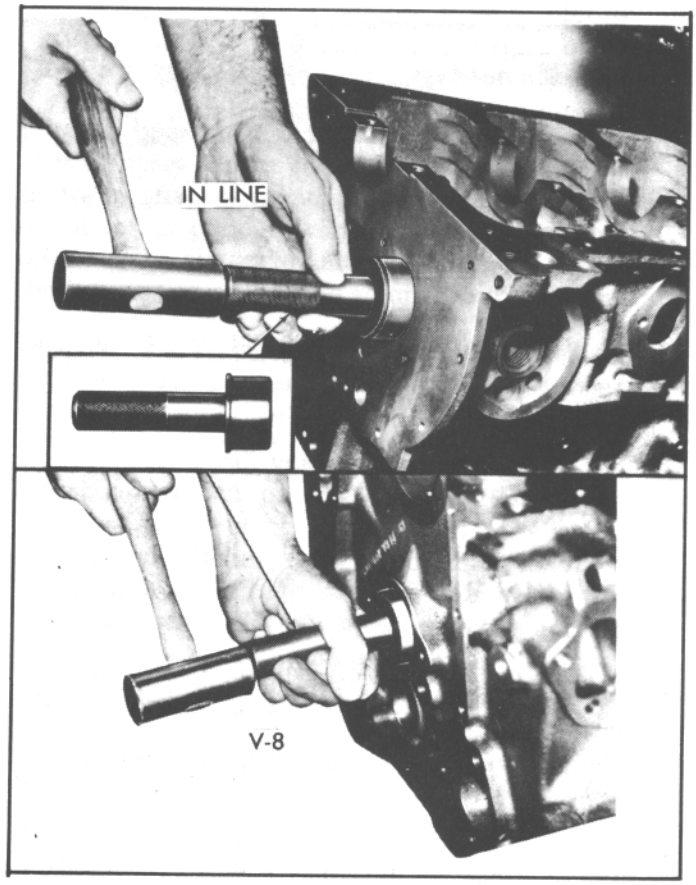


Fig. 90. Replacing Camshaft Front Bearing

2. Using tool set J-6098, with nut then thrust washer installed to end of threads, index pilot in camshaft front bearing and install puller screw through pilot.

3. Index camshaft bearing in bore (with oil hole aligned as outlined below), then install remover and installer tool on puller screw with shoulder toward bearing.

   (a) In-Line engines — All cam bearing oil holes must be aligned with oil hole in cam bore.

   (b) 307 and 350 CID engines — Number one cam bearing oil holes must be positioned so that oil holes are equidistant from 6 o'clock position. Number two through number four bearing holes must be positioned at 5 o'clock position (toward left side of engine and at a position even with bottom of cylinder bore). Number five bearing oil hole must be in 12 o'clock position.

   (c) 454 CID engines — Number one through number four cam bearing oil hole must align with oil holes in cam bearing bore. The number five bearing bore is annulus and cam bearing must be positioned at or near the 6 o'clock position.

4. Using two wrenches, hold puller screw while turning nut. After bearing has been pulled into bore, remove the remover and installer tool from the puller screw and check alignment of oil hole in camshaft bearing (Fig. 89).

5. Install remaining bearings in the same manner. It will be necessary to index pilot in the camshaft rear bearing to install the rear intermediate bearing.

6. Install a new camshaft rear plug.

   NOTE: Plug should be installed flush to 1/32" deep and be parallel with rear surface of cylinder block.

CYLINDER BLOCK

CLEANING AND INSPECTION:

1. Wash cylinder block throughly in cleaning solvent and clean all gasket surfaces.

2. Remove oil gallery plugs and clean all oil passages.

   NOTE: These plugs may be removed with a sharp punch or they may be drilled and pried out.

   CAUTION: When removing core plugs, exercise care so as not to mar or damage the plug bores or seats.

3. Clean and inspect the water passages in the cylinder block.

4. Inspect the cylinder block for cracks in the cylinder walls water jacket, valve lifter bores, and main bearing webs.

   NOTE: Minute cracks not visible to the naked eye may be detected by coating the suspected area with a mixture of 25% kerosene and 75% light engine oil. Wipe the part dry and apply a coating of zinc oxide dissolved in wood alcohol. If cracks are present, the coating will become discolored at the defective area. Replace the block if cracked. Check all machined gasket surfaces for burrs, nicks, scratches, and scores. Remove minor imperfections with an oil stone.

5. Measure the cylinder walls for taper, out-of-round or excessive ridge at top of ring travel. This should be done with a dial indicator. Set the gauge so that the thrust pin must be forced in about 1/4" to enter gauge in cylinder bore. Center gauge in cylinder and turn dial to "O". Carefully work gauge up and down cylinder wall to determine the out-of-round condition. If cylinders are found to exceed specifications, honing or boring will be necessary. (Fig. 91).

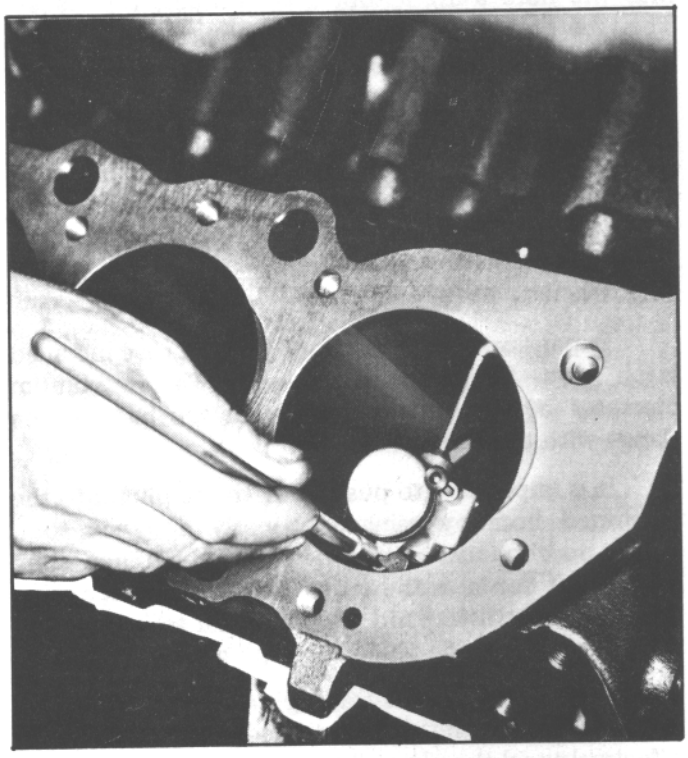


Fig. 91. Measuring Cylinder Bore

CORE PLUGS

REMOVAL:

To remove a large core plug, drill a 1/2" hole in the center of the plug and remove by prying it out with a large drift punch.

On a small core plug drill a 1/4" hole in the center of the plug and pry it out with a small pin punch.

Prior to installation the plug bore should be inspected for any damage that would interfere with the proper sealing of the plug.

If the bore is damaged it will be necessary to true the surface, by boring for the next specified oversize plug.

INSTALLATION CUP TYPE:

Coat the plug and/or bore lightly with an oil-resistant sealer. Cup-type core plugs (Fig. 92) are installed with the flanged edge outward. The maximum diameter of this plug is located at the outer edge of the flange.

The flange on cup-type plugs flare outward with the largest diameter at the outer (sealing) edge. It is imperative to pull the plug into the machined bore using a properly designed tool.

Under no circumstances is the plug to be driven into the bore using a tool that contacts the flange. This method will damage the sealing edge and will result in leakage and/or plug blow out.

The flanged (trailing) edge must be below the chamfered edge of the bore to effectively seal the plugged bore.

EXPANSION TYPE:

Expansion-type core plugs (Fig. 92) are installed with the flanged edge inward. The maximum diameter of this plug is located at the base of the flange with the flaring inward.

It is imperative to push or drive the plug into the machined bore by using a properly designed tool. Under no circumstances is the plug to be driven using a tool that contacts the crowned portion of the plug. This method will expand the plug prior to installation and may damage the plug and/or plug bore.

When installed, the trailing (maximum) diameter must be below the chamfered edge of the bore to effectively seal the plugged bore.

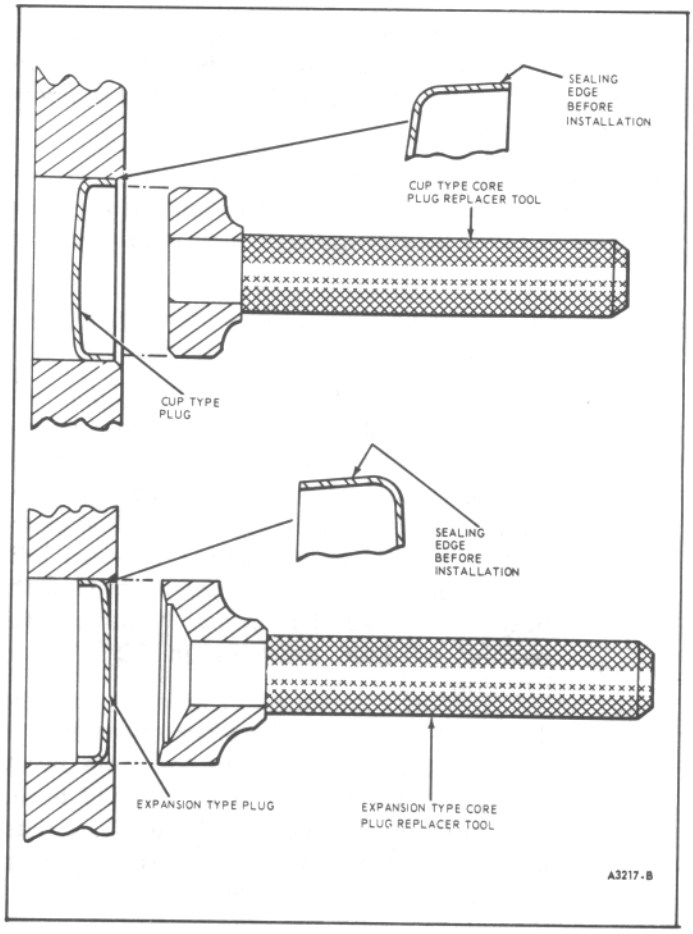


Fig. 92. Typical Core Plugs & Installation Tools

CYLINDER

CONDITIONING:

The performance of the following operation is contingent upon engine condition at time of repair.

If the cylinder block inspection indicated that the block was suitable for continued use except for out-of-round or tapered cylinders, they can be conditioned by honing or boring.

If the cylinders were found to have less than .005" taper or wear they can be conditioned with a

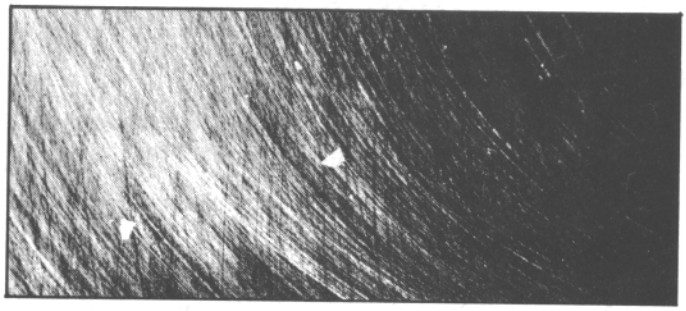


Fig. 93. Cylinder Finish Marks

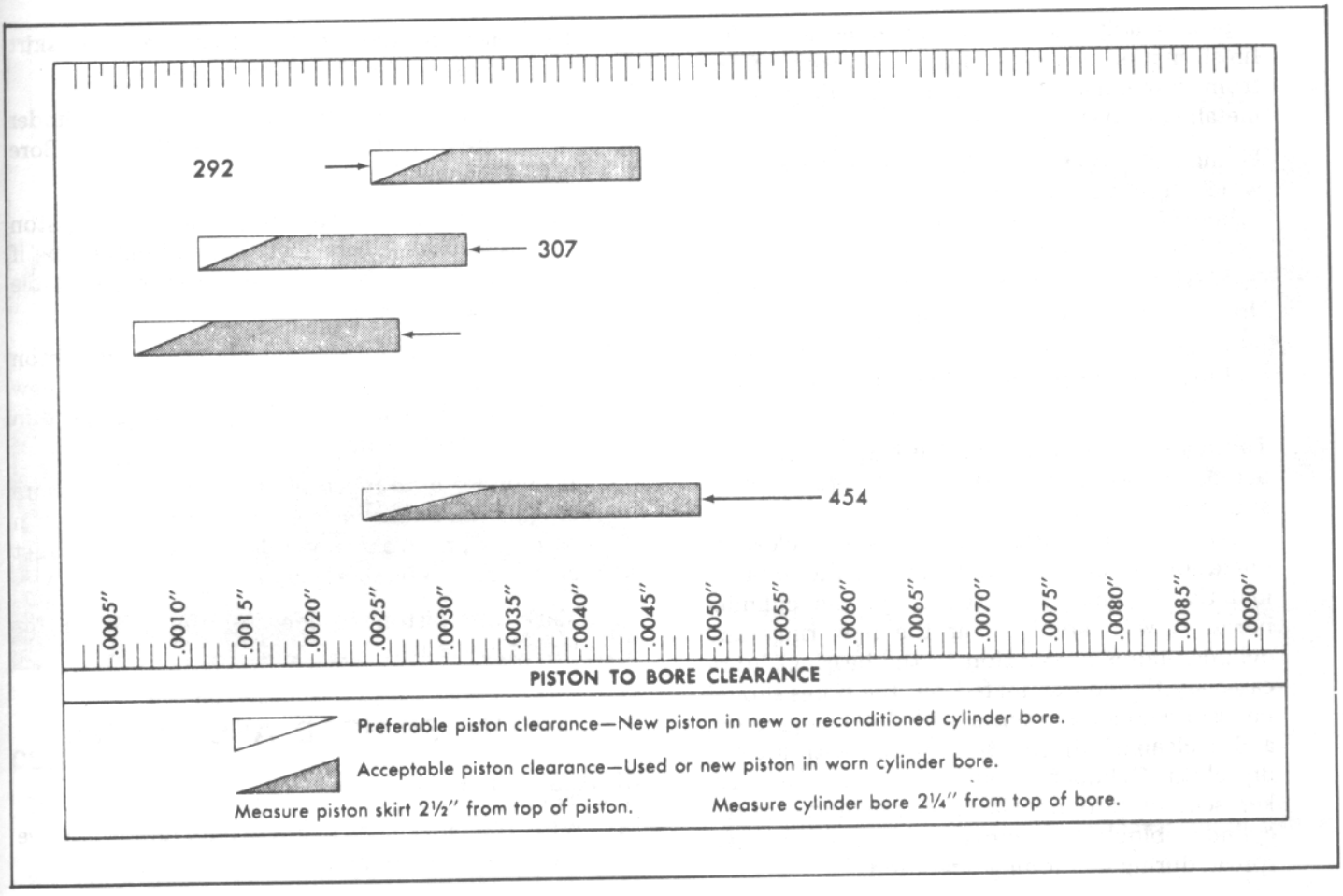


Fig. 94. Piston Selection Chart

hone and fitted with the high limit standard size piston. A cylinder bore of less than .005" wear or taper may not entirely clean up when fitted to a high limit piston. If it is desired to entirely clean up the bore in these cases, it will be necessary to rebore for an oversize piston. If more than .005" taper or wear, they should be bored and honed to the smallest oversize that will permit complete resurfacing of all cylinders.

When pistons are being fitted and honing is not necessary, cylinder bores may be cleaned with a hot water detergent wash. After cleaning, the cylinder bores should be swabbed several times with light engine oil and a clean cloth and then wiped dry with a clean dry cloth.

BORING:

1. Before using any type boring bar, the top of the cylinder block should be filed off to remove any dirt or burrs. This is very important. Otherwise, the boring bar may be tilted which would result in the rebored cylinder wall not being at right angle to the crankshaft.
2. The piston to be fitted should be measured with micrometer, measuring at the center of the piston skirt and at right angles to the piston pin. The cylinder should be bored to the same diameter as the piston and honed to give the specified clearance.

   NOTE: Hone cylinders as outlined under "cylinder honing and piston fitting".
3. The instructions furnished by the manufacturer of the equipment being used should be carefully followed.

HONING:

1. When cylinders are to be honed follow the hone manufacturer's recommendations for the use of the hone and cleaning and lubrication during honing.
2. Ocasionally during the honing operation, the cylinder bore should be throughly cleaned and the piston selected for the individual cylinder checked for correct fit.
3. When finish honing a cylinder bore to fit a piston, the hone should be moved up and down at a sufficient speed to obtain very fine uniform surface finish marks in a cross-hatch pattern of

approximately 45° to 65° included angle. The finish marks should be clean but not sharp, free from imbedded particles and torn or folded metal. (Fig. 93).

4. Permanently mark the piston for the cylinder to which it has been fitted and proceed to hone cylinders and fit the remaining pistons.

CAUTION: Handle the pistons with care and **Do Not** attempt to force them through the cylinder until the cylinder has been honed to correct size as this type piston can be distorted through careless handling.

5. Throughly clean the bores with hot water and detergent. Scrub well with a stiff bristle brush and rinse throughly with hot water. It is extremely essential that a good cleaning operation be performed. If any of the abrasive material is allowed to remain in the cylinder bores, it will rapidly wear the new rings and cylinder bores in addition to the bearings lubricated by the contaminated oil, the bores should be swabbed several times with light engine oil, and a clean cloth and then wiped with a clean dry cloth. Cylinders should not be cleaned with kerosene or gasoline. Clean the remainder of the cylinder block to remove the excess material spread during the honing operation.

PISTON SELECTION

1. Check **Used** piston to cylinder bore clearance as follows:
   (a) Measure the "Cylinder Bore Diameter" with a telescope gauge (2-1/2" from top of cylinder bore).
   (b) Measure the "Piston Diameter" (at skirt across center line of piston pin).
   (c) Subtract piston diameter from cylinder bore diameter to determine "Piston to Bore Clearance".
   (d) Locate piston to bore clearance on piston selection (Chart-Fig. 94) and determine if piston to bore clearance is in the acceptable range.
2. If used piston is not acceptable, check Piston Size Chart (Fig. 95) and determine if a new piston can be selected to fit cylinder bore within the acceptable range.
3. If cylinder bore must be reconditioned, measure new piston diameter (across center line of piston pin) then hone cylinder bore to correct clearance (preferable range).
4. Mark the piston to identify the cylinder for which it was fitted.

CYLINDER HEAD ASSEMBLIES

DISASSEMBLY:

1. With cylinder head removed, remove valve rocker nuts, balls, and rocker arms.
2. Using tool J-8062, compress the valve springs (Fig. 96), and remove valve keys. Release the compressor tool and remove spring caps, spring shields (if so equipped) springs and spring damper, then remove oil seals and valve spring shims.
3. Remove valves from cylinder head and place them in a rack in their proper sequence so that they can be assembled in their original position.

ENGINE (DISPLACEMENT)	PISTONS AVAILABLE		
	STD.	OVERSIZE	
		.001"	.030"
250 & 307	3.8750 3.8760	3.8760 3.8770	3.9035 3.9055
292	3.8730 3.8740	3.8740 3.8750	3.9038 3.9062
350 (Exc. 255 H.P.)	3.9998 4.0008	4.0008 4.0018	4.0283 4.0303
350 (255 HP)	3.9953 3.9963	3.9963 3.9973	4.0252 4.0272
400	4.1241 4.1251	4.1251 4.1261	4.1526 4.1546
402	4.1237 4.1247	4.1247 4.1257	4.1550 4.1570
454	4.2481 4.2491	4.2491 4.2501	4.2775 4.2795

Fig. 95. Piston Size Chart

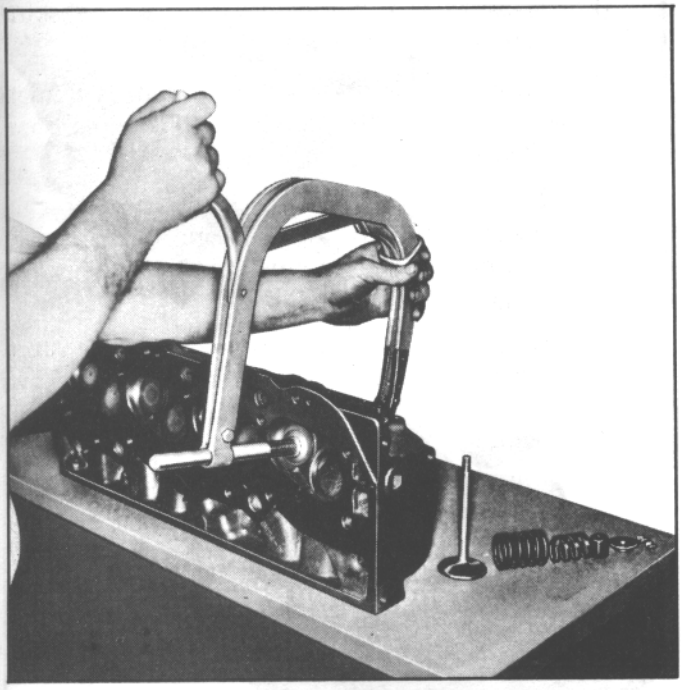


Fig. 96. Compressing Valve Spring

CLEANING:

1. Clean all carbon from combustion chambers and valve ports using tool J-8089 (Fig. 97).
2. Throughly clean the valve guides using tool J-8101 (Fig. 98).
3. Clean all carbon and sludge from push rods, rocker arms and push rod guides.
4. Clean valve stems and heads on a buffing wheel.
5. Clean carbon deposits from head gasket mating surface.

INSPECTION:

1. Inspect the cylinder head for cracks in the exhaust ports, combustion chambers, or external cracks to the water chamber.
2. Inspect the valves for burned heads, cracked faces or damaged stems.

   NOTE: Excessive valve stem to bore clearance will cause excessive oil consumption and may cause valve breakage. Insufficient clearance will result in noisy and sticky functioning of the valve and disturb engine smoothness.

3. Measure valve stem clearance (Fig. 99) as follows: Clamp a dial indicator on one side of the cylinder head rocker arm cover gasket rail, locating the indicator so that movement of the valve stem from side to side (crosswise to the head) will cause a direct movement of the indicator stem. The indicator stem must contact the side of the valve stem just above the valve guide. With the valve head dropped about 1/16" off the valve seat; move the stem of the valve from side to side using light pressure to obtain a clearance reading. If clearance exceeds specifications, it will be necessary to ream valve guides for oversize valves as outlined.

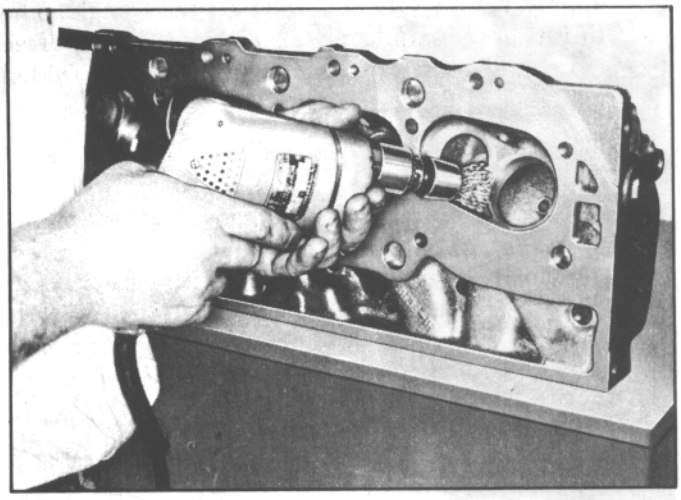


Fig. 97. Cleaning Combustion Chambers

4. Check valve spring tension with tool J-8056 spring tester (Fig. 100).

   NOTE: Springs should be compressed to the specified height and checked against the specifications chart, springs should be replaced if not within 10 lbs. of specified load (without dampers).

5. Inspect rocker arm studs for wear or damage. Inspect push rod guides 454 CID engines.

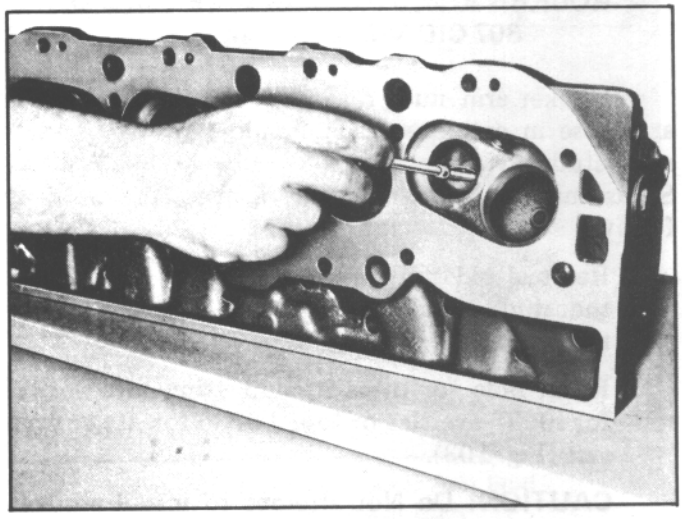


Fig. 98. Cleaning Valve Guides

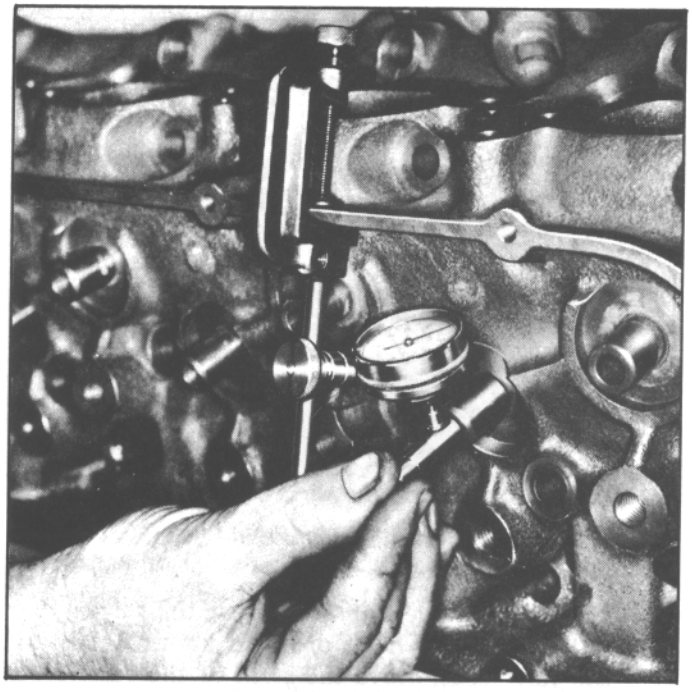


Fig. 99. Measuring Valve Stem Clearance

ROCKER ARM STUDS AND PUSH ROD GUIDES (454 CID ENGINES)

REPAIRS:

The push rod guides are retained to the cylinder head by the rocker arm studs (Fig. 101). Replace where necessary and torque rocker arm studs to specifications.

NOTE: Coat threads on cylinder head end of rocker arm studs with sealer before assembling to cylinder head.

ROCKER ARM STUDS (IN-LINE 292 CID, 307 CID V-8 & 350 CID V-8)

Rocker arm studs that have damaged threads or are loose in cylinder heads should be replaced with new studs available in .003" and .013" oversize. Studs may be installed after reaming the holes as follows:

1. Remove old stud by placing tool J-5802-1 over the stud, installing nut and flatwasher and removing stud by turning nut (Fig. 102).
2. Ream hole for oversize stud using tool J-5715 for .003" oversize or tool J-6036 for .013" oversize (Fig. 103).

   CAUTION: Do Not attempt to install an oversize stud without reaming stud hole.

Fig. 100. Checking Valve Spring Tension

3. Coat press-fit area of stud with hypoid axle lubricant. Install new stud, using tool J-6880 as a guide. Gauge should bottom on head (Fig. 104).

VALVE GUIDE BORES

Valves with oversize stems are available (see specifications). To ream the valve guide bores for oversize valves use tool set J-5830 (In-Line and 307-350 CID V-8) or J-7049 (454 CID V-8)

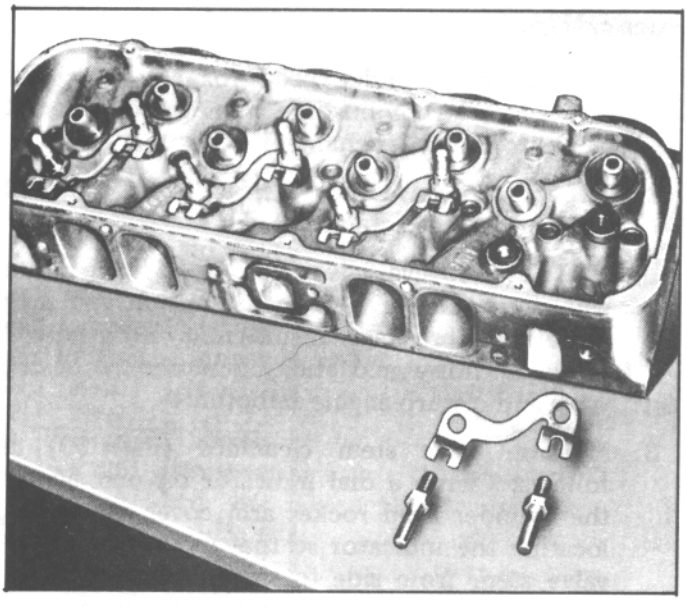


Fig. 101. Rocker Arm Stud & Push Rod Guide

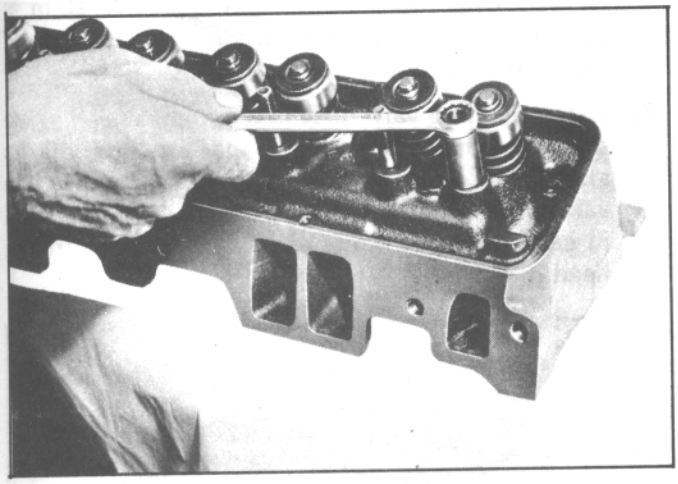


Fig. 102. Removing Rocker Arm Stud (In-Line & "Small V8")

VALVE SEATS

Reconditioning the valve seats is very important, because the seating of the valves must be perfect for the engine to deliver the power and performance built into it.

Another important factor is the cooling of the valve heads. Good contact between each valve and its seat in the head is imperative to insure that the heat in the valve will be properly carried away.

Several different types of equipment are available for reseating valve seats. The recommendations of the manufacturer of the equipment being used should be carefully followed to attain proper results.

Regardless of what type of equipment is used, however, it is essential that valve guide bores be free from carbon or dirt to insure proper centering in the guide.

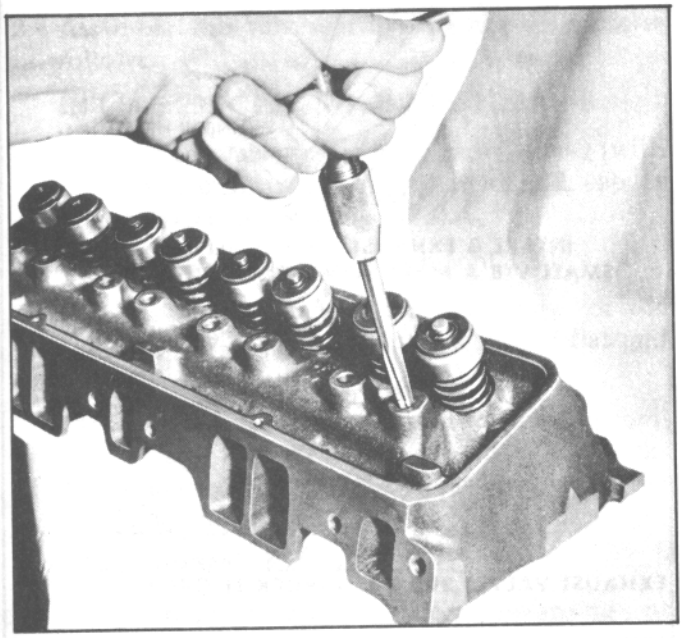


Fig. 103. Reaming Rocker Arm Stud Bore (In-Line & 'Small V8")

1. Install expanding pilot in the valve guide bore and expand pilot.
2. Place roughing stone or forming stone over pilot and just clean up the valve seat. Use a stone cut to specifications.
3. Remove roughing stone or forming stone from pilot, place finishing stone, cut to specifications, over pilot and cut just enough metal from the seat to provide a smooth finish (Refer to specifications & Fig. 106).
4. Narrow down the valve seat to the specified width.

   NOTE: This operation is done by grinding the port side with a 30° stone to lower seat and a 60° stone to raise seat.
5. Remove expanding pilot and clean cylinder head carefully to remove all chips and grindings from above operations.
6. Measure valve seat concentricity (Fig. 107).

   NOTE: Valve seats should be concentric to within .002" total indicator reading.

VALVES

Valves that are pitted can be refaced to the proper angle, insuring correct relation between the head and stem on a valve refacing mechanism. Valve stems which show excessive wear, or valves that are warped excessively should be replaced. When a valve head which is warped excessively is refaced, a knife edge

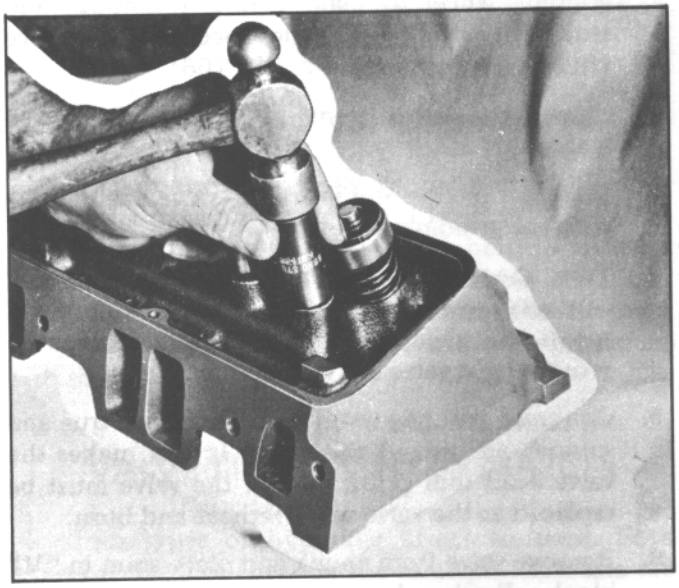


Fig. 104. Installing Rocker Arm Stud (In-Line & "Small V8")

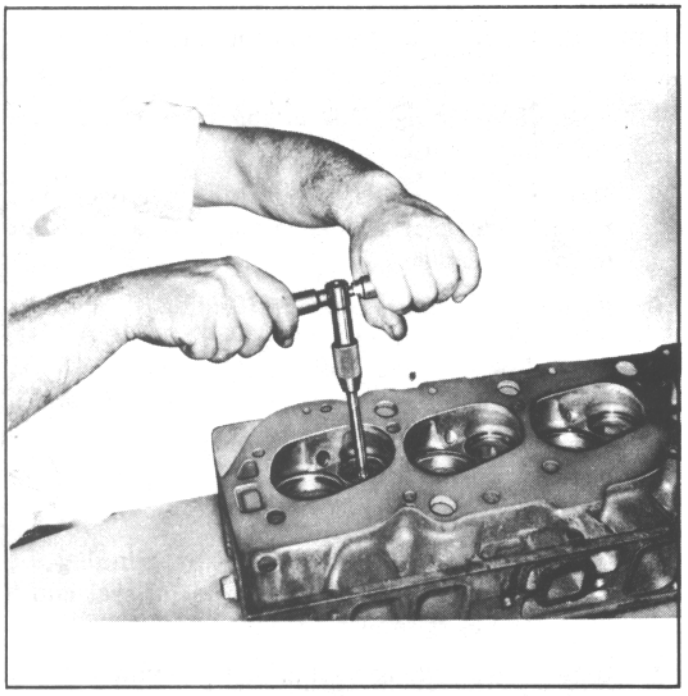


Fig. 105. Reaming Valve Guide

will be ground on part or all of the valve head due to the amount of metal that must be removed to completely reface. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve is less than 1/32" thick after grinding, replace the valve.

Several different types of equipment are available for refacing valves. The recommendations of the manufacturer of the equipment being used should be carefully followed to attain proper results.

1. If necessary, dress the valve refacing machine grinding wheel to make sure it is smooth and true. Set chuck at angle specified for valve (Refer to specifications & Fig. 106).
2. Clamp the valve stem in the chuck of the machine.
3. Start the grinder and move the valve head in-line with the grinding wheel.
4. Turn the feed screw until the valve head just contacts wheel. Move valve back and forth across the wheel and regulate the feed screw to provide light valve contact.
5. Continue grinding until the valve face is true and smooth all around the valve. If this makes the valve head thin (1/32" min.), the valve must be replaced as the valve will overheat and burn.
6. Remove valve from chuck and place stem in "V" block. Feed valve squarely against grinding wheel to grind any pit from rocker arm of stem.

NOTE: Only the extreme end of valve stem is harnened to resist wear. **Do Not** grind end of stem excessively.

7. After cleaning valve face and cylinder head valve seat of grinding particles, make pencil marks about 1/4" apart across the valve face, place the valve in cylinder head and give the valve 1/2 turn in each direction while exerting firm pressure on head of valve.

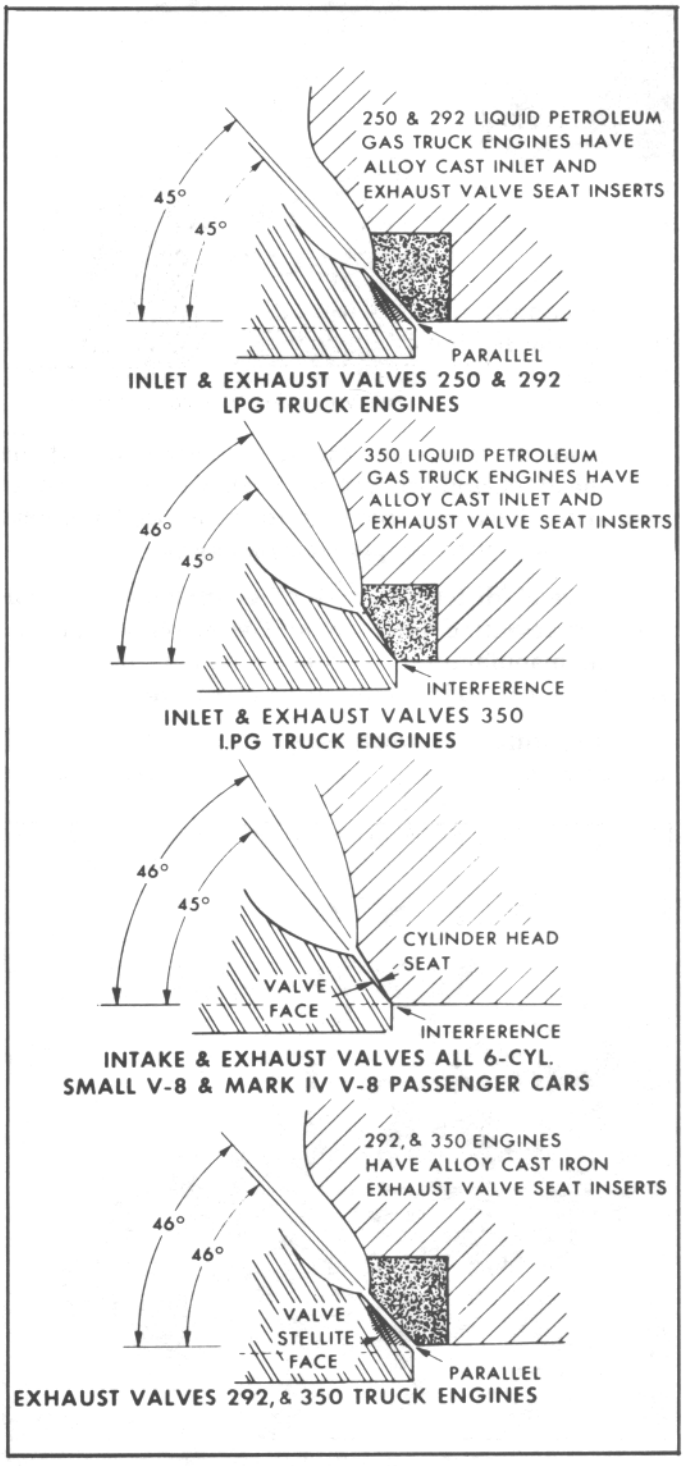


Fig. 106. Relation of Valve & Seat Angles

Fig. 107. Measuring Valve Seat Concentricity

8. Remove valve and check face carefully, if all pencil marks have not been removed at the point of contact with the valve seat, it will be necessary to repeat the refacing operation and again recheck for proper seating.
9. Grind and check the remaining valves in the same manner.

ASSEMBLY

1. Insert a valve in the proper port.
2. Assemble the valve spring and related parts as follows:

IN-LINE 292 CID, 307, AND 350 CID V-8

(a) Set the valve spring shim, valve spring (with damper if used), valve shield and cap or rotator in place (Fig. 108).

(b) Compress the spring with tool J-8062.

(c) Install oil seal in the lower groove of the stem, making sure that the seal is flat and not twisted.

(d) Install the valve locks and release the compressor tool, making sure that the locks seat properly in the upper groove of the valve stem.

454 CID V-8

(a) Install valve spring shim on valve spring seat then install a new valve stem oil seal over valve and valve guide.

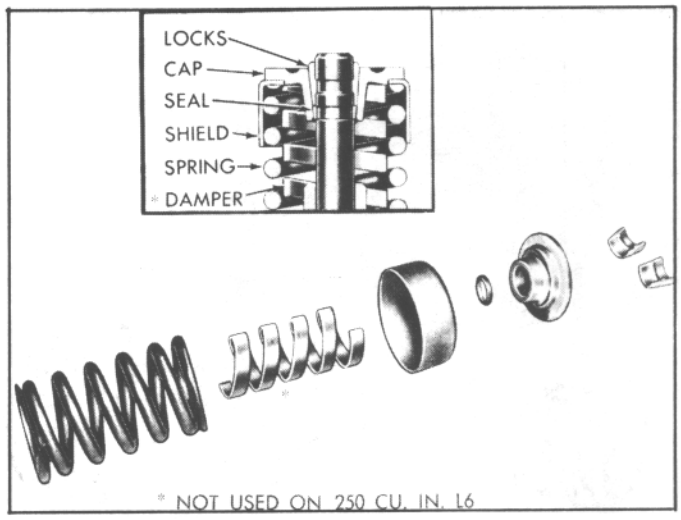


Fig. 108. Valve Spring Installation
(In-Line & 307-350-CID V8)

(b) Set the valve spring (with damper), and valve cap in place (Fig. 109).

(c) Compress the spring with tool J-8062.

(d) Install the valve locks and release the compressor tool, making sure the locks seat properly in the groove of the valve stem.

NOTE: Grease may be used to hold the locks in place, while releasing the compressor tool.

3. Install the remaining valves.
4. On In-Line 292 CID, 307 and 350 CID V-8 engines check each valve stem oil seal by placing Valve Seal Leak Detector (tool J-23994) over the end of the valve stem and against the cap. Operate the vacuum pump and make sure no air leaks past the seal (Fig. 110).
5. Check the installed height of the valve springs, using a narrow thin scale. A cutaway scale will help (Fig. 111). Measure from the top of the shim or the spring seat to the top of the valve spring or valve spring shield (Fig. 112). If this is found to exceed the specific height, install a valve spring seat shim approximately 1/16" thick. At no time should the spring be shimmed to give an installed height under the minimum specified.

VALVE LIFTERS (HYDRAULIC)

Two types of hydraulic lifters are used. Both types of lifters operate on the same principle and are serviced basically in the same manner. The complete lifter assemblies are interchangeable with another.

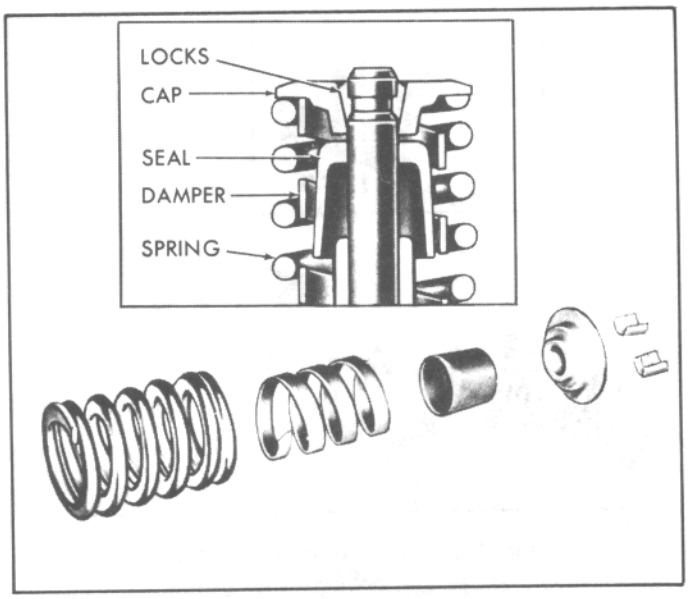


Fig. 109. Exhaust Valve Spring Installation (454 CID V8)

Both lifters are easily identified by the outside configuration of the lifter body. For purposes of identification we refer to them as Lifter "A" and Lifter "B" (Fig. 113).

DISASSEMBLY:

1. Hold the plunger down with a push rod, and using the blade of a small screw driver, remove the push rod seat retainer.
2. Remove the push rod seat and metering valve (Lifter "A"), or the push rod seat and inertia valve assembly (Lifter "B").

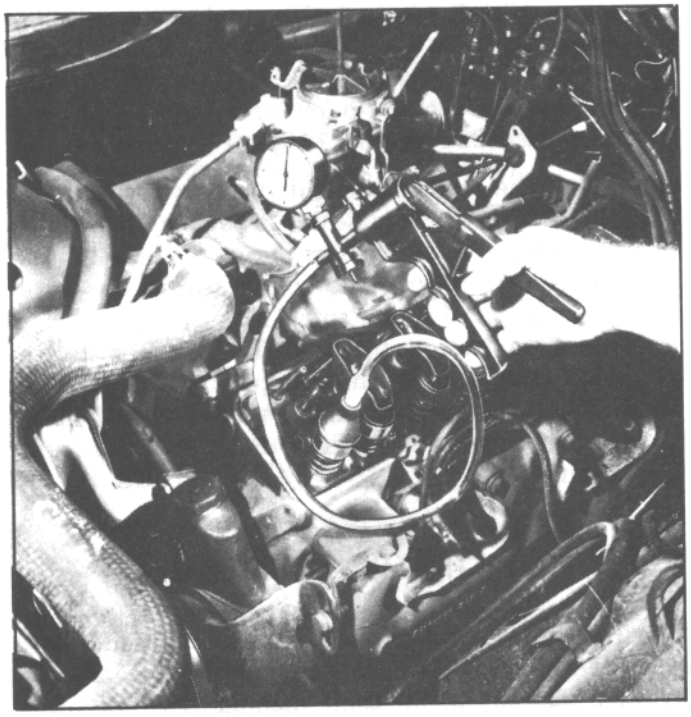


Fig. 110. Checking Valve Stem Oil Seals

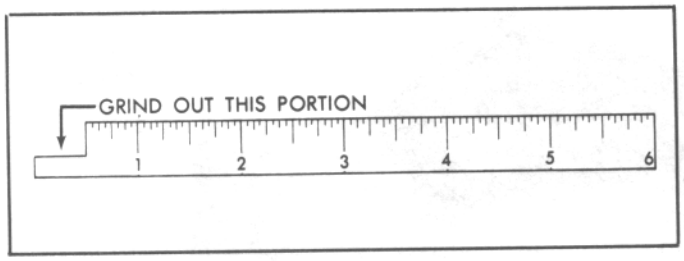


Fig. 111. Cutaway Scale

3. Remove the plunger, ball check valve assembly and the plunger spring.
4. Remove the ball check valve and spring by prying the ball retainer loose from the plunger with the blade of a small screw driver (Fig. 114).

CLEANING AND INSPECTION:

Throughly clean all parts in cleaning solvent, and inspect them carefully. If any parts are damaged or worn the entire lifter assembly should be replaced. If the lifter body wall is scuffed or worn, inspect the cylinder block lifter bore, if the bottom of the lifter is scuffed or worn inspect the camshaft lobe, — if the push rod seat is scuffed or worn inspect the push rod. An additive containing EP lube, such as EOS, should always be added to crankcase oil for run-in when any new camshaft or lifters are installed. All damaged or worn lifters should be replaced.

NOTE: Inertia valve and retainer (Lifter "B"), (Fig. 113) should not be removed from the push rod seat. To check the valve, shake the push rod seat and inertia valve assembly and the valve should move.

ASSEMBLY:

1. Place the check ball on samll hole in bottom of the plunger.

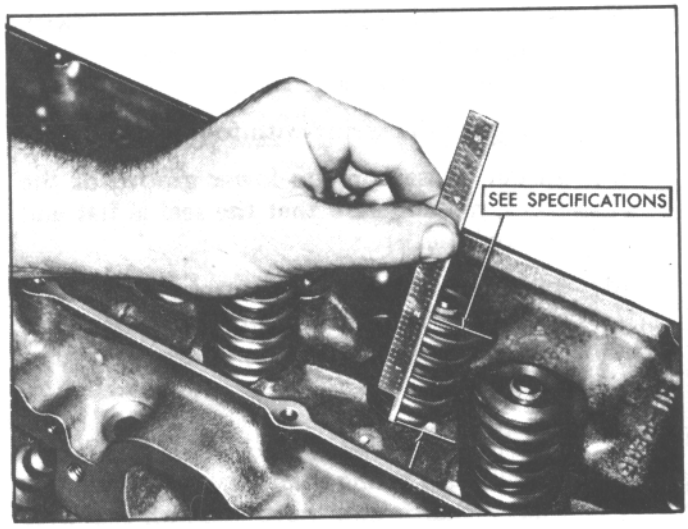


Fig. 112. Measuring Valve Spring Installed Height

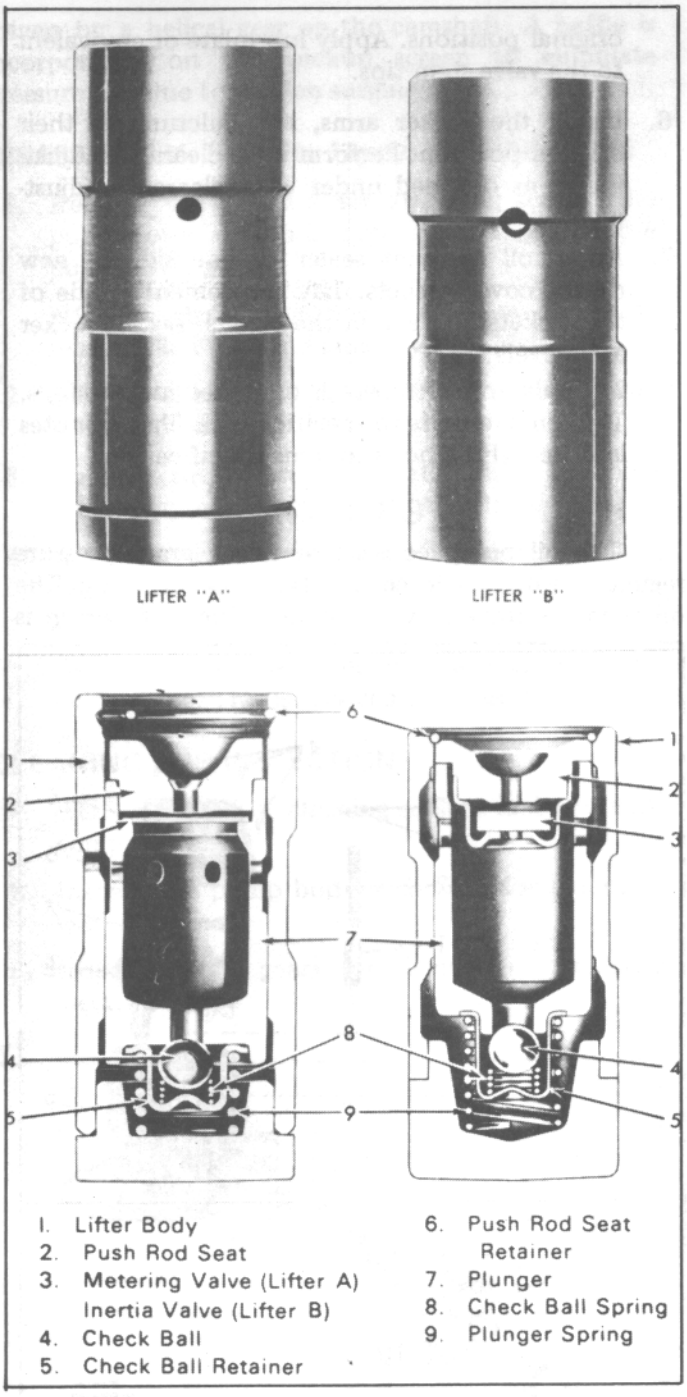


Fig. 113. Hydraulic Valve Lifters

2. Insert check ball spring on seat in ball retainer and place retainer over ball so that spring rests on the ball. Carefully press the retainer into position in plunger with the blade of a small screw driver (Fig. 115).

3. Place plunger spring over the ball retainer and slide the lifter body over the spring and plunger, being careful to line up the oil feed holes in the lifter body and plunger.

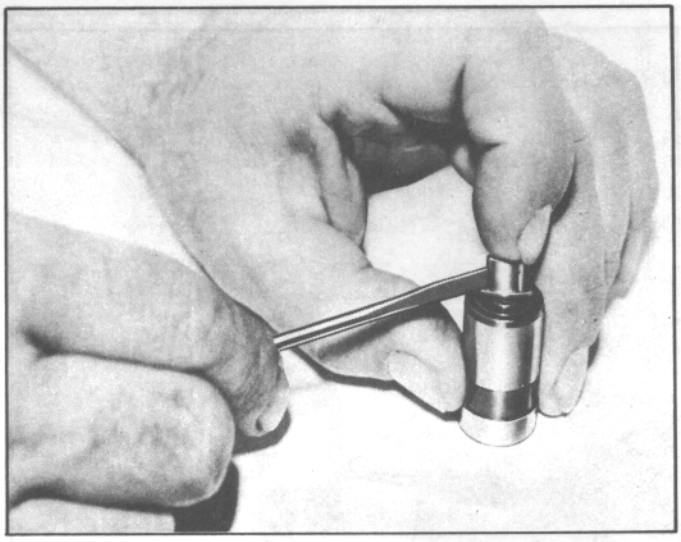


Fig. 114. Removing Ball Check Valve

4. Fill the assembly with SAE-10 oil, then insert the end of a 1/8" drift pin into the plunger and press down solid. At this point oil holes in the lifter body and the plunger assembly will be aligned (Fig. 116).

   CAUTION: Do Not attempt to force or pump the plunger.

5. Insert a 1/16" drift pin through both oil holes to hold the plunger down against the lifter spring tension. (Fig. 116).

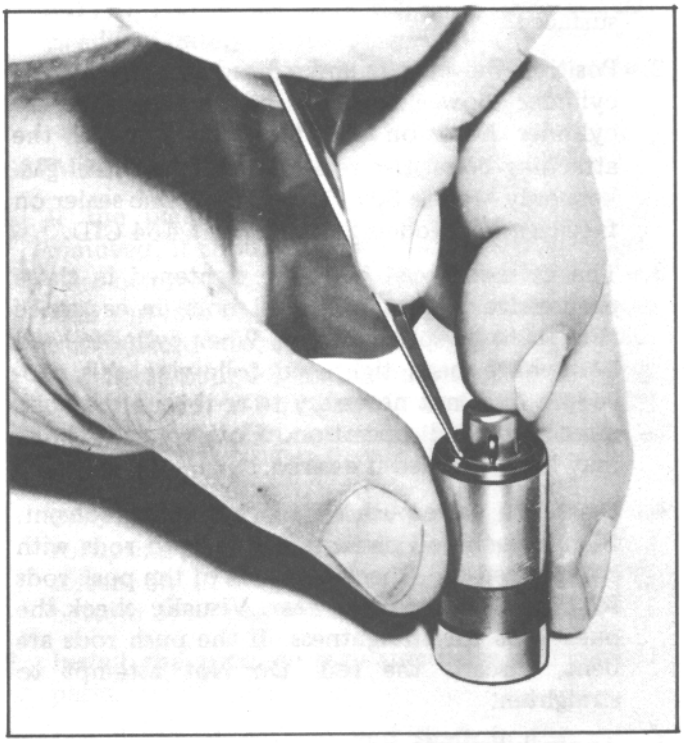


Fig. 115. Installing Ball Check Valve

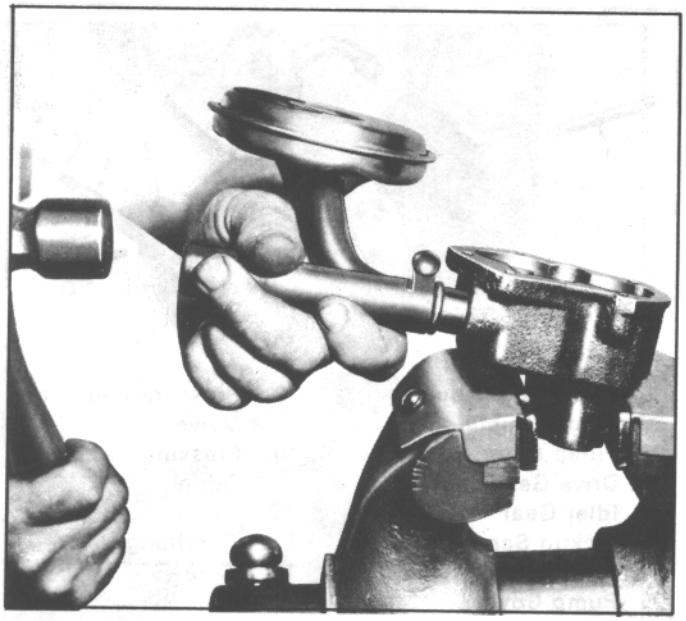


Fig. 120. Installing Screen ("Mark IV V8")

4. Install the idler gear in the pump body with the smooth side of gear towards pump cover opening.
5. Install the pump cover (with new gasket on In-Line engines) and torque attaching screws to specifications.
6. Turn drive shaft by hand to check for smooth operation.
7. Install oil pump and screen in engine, torque bolts to specifications.

CRANKCASE FRONT COVER

INSTALLATION:

1. Clean crankcase front cover and drive out the old oil seal.
2. Coat a new seal with grease, drive the seal in until fully seated (with lip toward rear of engine). Check the seal after installation to be sure the spring is properly positioned in the seal.
3. Coat the gasket surface of the block and cover with sealer and position a new gasket on the block.

IN-LINE 292 CID ENGINES

(a) Lubricate seal lip with lubriplate then install crankcase front cover aligning tool J-23042 in seal (Fig. 122).

(b) Place crankcase front cover gasket in position on cover, then install crankcase front cover on cylinder block and torque bolts to specifications, remove tool.

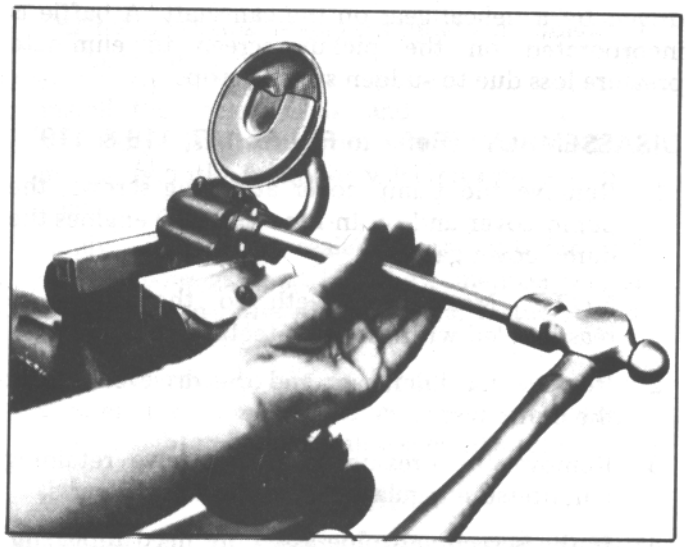


Fig. 121. Installing Screen (307-350 CID V8)

307-350, & 454 CID V-8 ENGINES

(a) Place crankcase front cover gasket in position over dowel pins on cylinder block.

(b) Lubricate seal lip with lubriplate then place crankcase front cover in position over dowel pins and torque bolts to specifications.

OIL PAN

INSTALLATION:

1. Install side gaskets on cylinder block. **Do Not** use sealer.
2. Install rear oil pan seal, in groove in rear main bearing cap, with ends butting side gaskets.

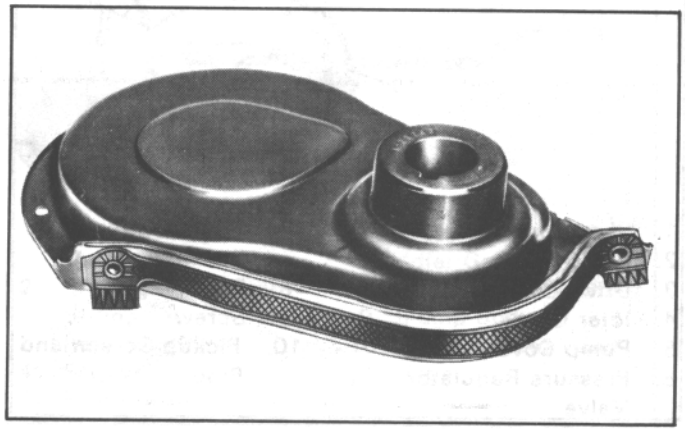


Fig. 122. Centering Tool in Cover (In-Line)

3. Install oil pan front seal, in crankcase front cover, with ends butting side gaskets.
4. Install oil pan and torque bolts to specifications.

TORSIONAL DAMPER

INSTALLATION:

CAUTION: The inertia weight section of the torsional damper is assembled to the hub with a rubber type material. The installation procedures (with proper tool) must be followed or movement of the inertia weight section on the hub will destroy the tuning of the torsional damper.

DRIVE ON TYPE (Without Retaining Bolt)

(a) Coat front cover seal area (on damper) with engine oil.

(b) Attach damper installer tool J-22197 to damper. Tighten fingers of tool to prevent weight from moving (Fig. 123).

(c) Position damper on crankshaft and drive into position using J-5590 until it bottoms against crankshaft sprocket or gear (Fig. 123).

PULL ON TYPE (With Retaining Bolt)

(a) Coat front cover seal contact area (on damper) with engine oil.

(b) Place damper in position over key on crankshaft.

(c) Using tool J-23523, pull damper onto crankshaft (Fig. 124).

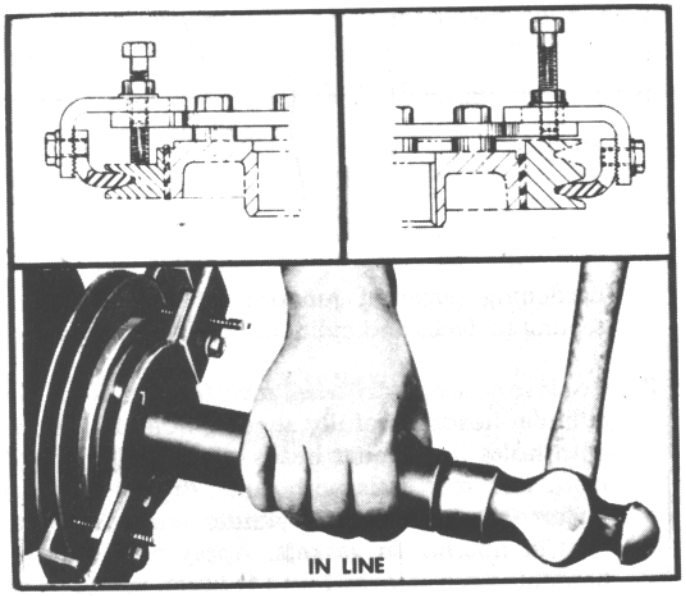


Fig. 123. Installing Torsional Damper (Drive on Type)

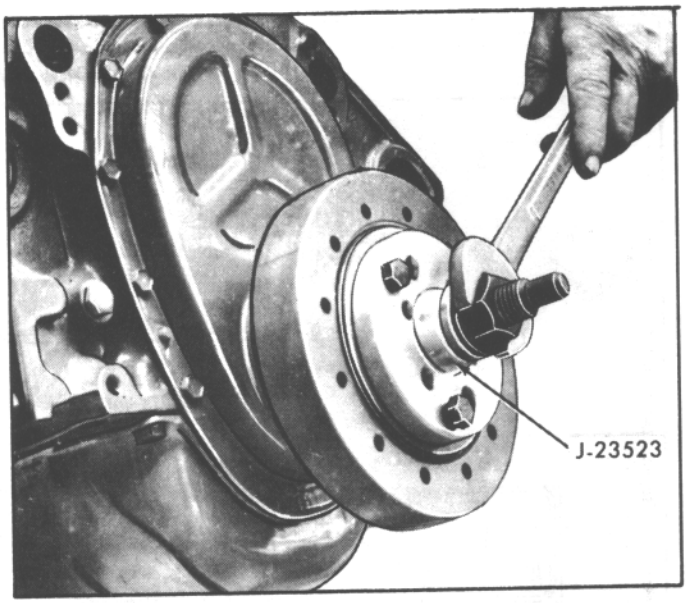


Fig. 124. Installing Torsional Damper (Pull on Type)

CAUTION: Install bolt in crankshaft with sufficient thread engagement (min. 1/2").

(d) Remove tool from crankshaft.

(e) Install damper retaining bolt and torque to specifications.

INTAKE MANIFOLD

REMOVAL:

1. Drain cooling system.
2. Disconnect and remove water circulating hoses and thermostat housing.
3. Disconnect positive crankcase ventilation valve and hoses.
4. Remove ignition coil and wiring harness.
5. Disconnect throttle control.
6. Remove fuel line.
7. Remove distributor and vacuum line.
8. Remove attaching bolts and nuts and remove intake manifold and carburetor as an assembly. If necessary to pry manifold away from cylinder heads, take care so as not to mar or damage gasket sealing surfaces.
9. Remove and discard intake gaskets and seals. Remove all gasket material from the machined surfaces of the manifold. Clean the manifold in a suitable solvent and dry with compressed air.

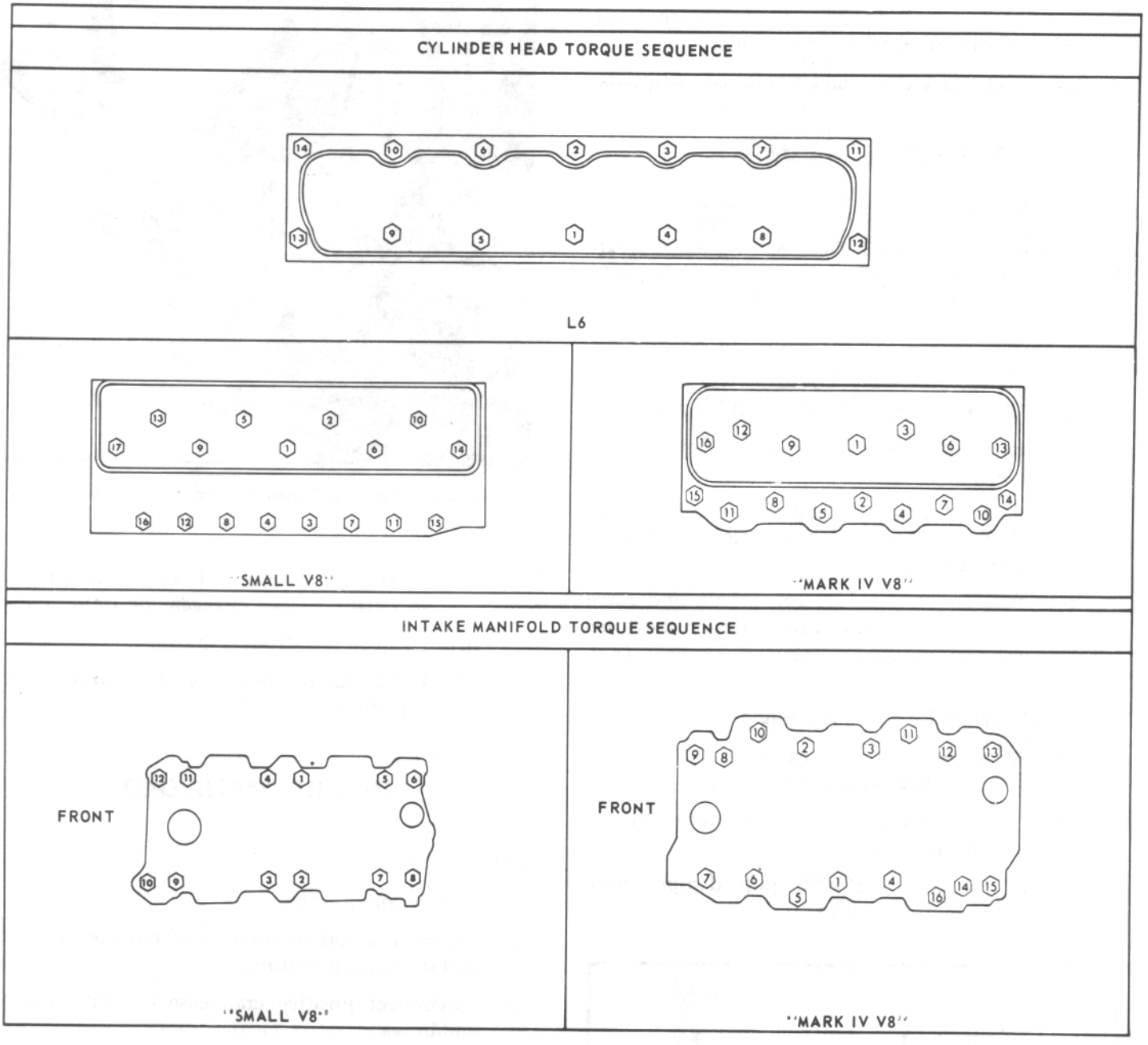


Fig. 126. Torque Specifications

Inspect the manifold for cracks, damaged gasket surfaces, or other defects that would make it unfit for further use.

INSTALLATION:

1. Clean mating gasket surfaces of intake manifolds, cylinder heads, and cylinder block. Use suitable solvent to remove all traces of oil.
2. Coat cylinder block seal surfaces with quick drying adhesive sealer. Apply thin bead of non-hardening sealer at junction of cylinder block sealing surfaces and cylinder heads (4 places).
3. Position new intake manifold gaskets on cylinder heads, carefully aligning holes in gaskets with holes in cylinder heads. Coat under side of front and rear seals with quick drying adhesive sealer and fit seals to cylinder block, aligning tabs in notches in gaskets. Apply bead of non-hardening sealer over four (4) junction points of seals and gaskets.

4. Carefully lower intake manifold into position over cylinder heads. When intake manifold is in place, run finger around seal area to be sure seals are in place. If seals have shifted, remove manifold and reposition seals.
5. Be sure intake manifold gaskets are properly aligned. Then install attaching bolts and nuts snugly to manifold. Torque bolts in sequence (Fig. 126) to specifications to compress gasket and seals. Then repeat sequence, torquing bolts and nuts to same specifications.

WATER CIRCULATING PUMP

REMOVAL:

1. Drain water from cooling system.
2. Remove water pump pulley and alternator adjusting bracket.
3. Remove water hose pump to thermostat housing.
4. Remove bolts that attach the water pump to the cylinder block front cover.
5. Remove water pump and gasket. Discard gasket.

INSTALLATION:

Before a water pump is reinstalled, check it for damage. If it is damaged, replace it.

1. Remove all gasket material from the mounting surfaces of the cylinder front cover and water pump.
2. Position a new gasket, coated on both sides with sealer, on the cylinder front cover; then install pump torque attaching bolts to specifications.
3. Connect the pump to thermostat housing hose and (bypass hose on 454 CID) engine.
4. Install pulley, alternator belt and adjusting bracket.
5. Adjust the drive belt to specifications.

FLYWHEEL

REMOVAL:

1. With engine out of boat, remove transmission oil lines.
2. Remove starting motor.
3. Remove transmission.

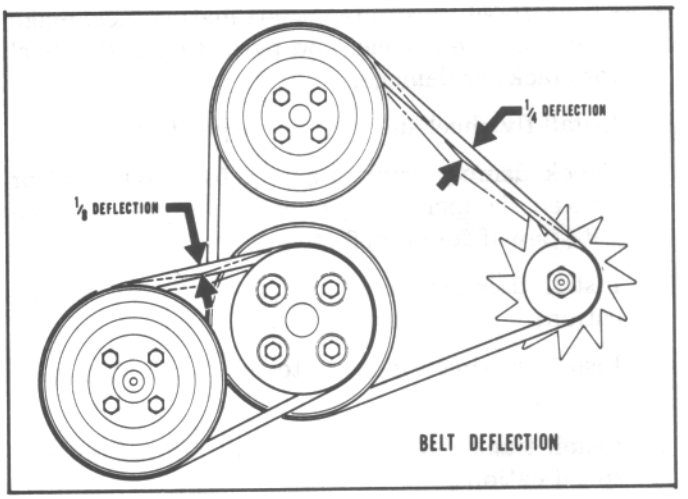


Fig. 127. Belt Adjustment

4. Remove flywheel housing.
5. Remove damper driver assembly.
6. Remove flywheel.

INSTALLATION

1. Before installation make sure the crankshaft flange is clean and free of nicks or burrs. Use oil stone to remove nicks or burrs if necessary.

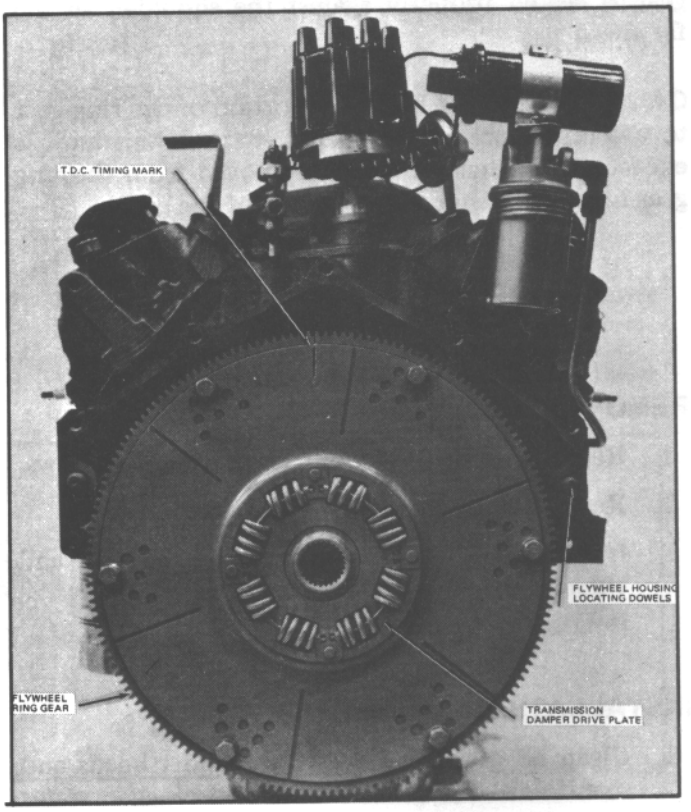


Fig. 128.

2. Check flywheel to crankshaft mating face, make sure the face is clean and even. Check flywheel for cracks or damage.
3. Install flywheel and torque to specifications.
4. Check damper drive assembly for cracks and/or broken damper springs, worn springs. Replace with new if found defective.
5. Install damper drive, torque bolts to specifications.
6. Install flywheel housing, torque bolts to specifications.
7. Install transmission and oil lines, torque bolts to specifications.

FLYWHEEL RING GEAR

REMOVAL:

To replace a damaged or worn ring gear, heat the ring gear with a blow torch, and knock it off the flywheel. **Do Not** strike the flywheel when removing the ring gear.

INSTALLATION:

Heat the new ring gear evenly until it expands enough to slip unto the flywheel. Make sure the ring gear is seated properly against the shoulder on the flywheel.

CAUTION: Do Not heat any portion of the ring gear to a temperature higher than 500°F. If this limit is exceeded, the temper will be removed from the ring gear teeth; thus shortening the life of the gear.

EXHAUST MANIFOLDS

REMOVAL:

1. Remove water connections and exhaust elbows.
2. Remove bolts and remove manifolds.

   NOTE: On In-Line engines, the intake and exhaust manifolds are held together and may be removed as one assembly.

INSTALLATION:

1. Clean all gasket surfaces on cylinder heads and manifolds. Check for cracks and clogged water passages.

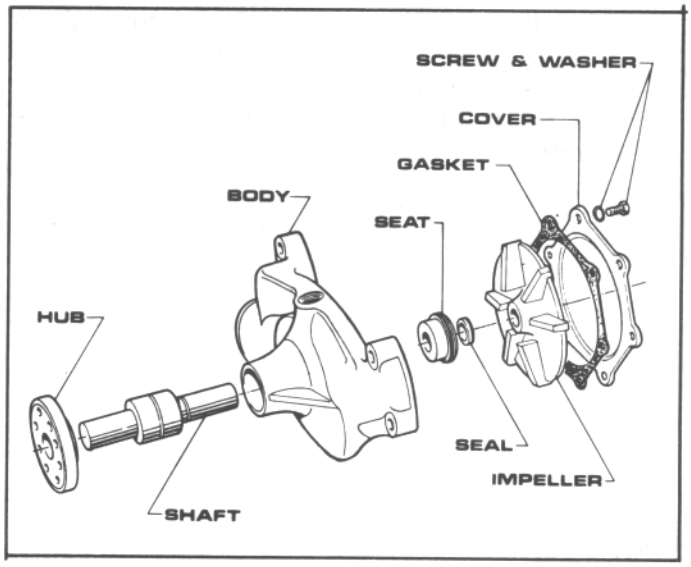


Fig. 129. Circulation Water Pump

2. Install new gaskets, install manifolds, torque all bolts to specifications.
3. Install water hose connections. Check hoses for defects, replace with new if necessary.

JABSCO WATER PUMP

DISASSEMBLY:

1. Remove drain plugs in pump body.
2. Remove end cover bolts, end cover and gasket.
3. Pull body away from bearing housing. Push impeller out of body.
4. Remove wear plate and wear plate gasket.
5. Remove "O" Ring.
6. Remove pulley hub from shaft end with gear puller.
7. Remove retaining ring from bearing housing.
8. Pressing on impeller drive end of shaft, remove shaft and bearing subassembly from bearing housing.
9. Press seal out of bearing housing.

ASSEMBLY:

1. Install shaft subassembly in bearing housing and secure with retaining ring.

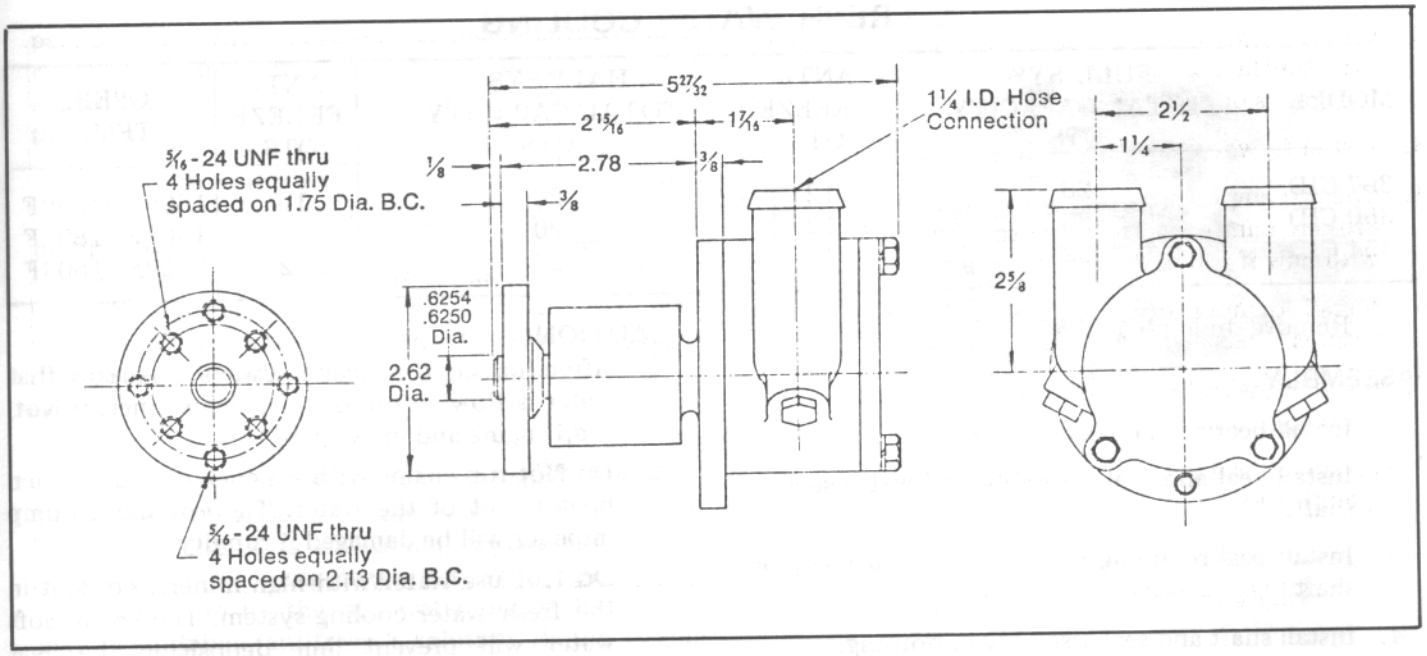


Fig. 130.

2. Install seal seat on shaft with grommet facing bearing. Install seal face in bearing housing seal bore with carbon ring facing seat, and press flush with face of flange.
3. Press pulley hub on shaft so outboard side is 2.78 inches from rear face of bearing housing with approximately 1/8" shaft extending from pulley hub.
4. Install "O" ring in bearing housing flange.
5. Install wearplate, gasket, body, gasket and end cover and secure with bolt and lock washer located above cam. (**Do Not** tighten.) Lubricate impeller bore.
6. Swing end cover and gasket away from impeller bore (taking care not to damage the gasket) and install impeller in body.
7. Install spline seal in impeller.
8. Locate end cover and gasket in correct position and secure with bolts and lock washers.
9. Install drain plugs in body.

SHERWOOD WATER PUMP INSTRUCTIONS

DISASSEMBLY:

1. Remove drive pulley.
2. Remove end cover bolts, end cover and gasket.
3. Remove impeller, (can be pulled from shaft with pliers).
4. Remove cover dowel pins.
5. Press shaft and seal assembly out through pulley hub.
6. Remove woodruff key, retaining rings and remove seal and seal seat assembly.
7. Remove bearing retainer ring and remove bearing.
8. Remove screw from top of housing to remove camplate.

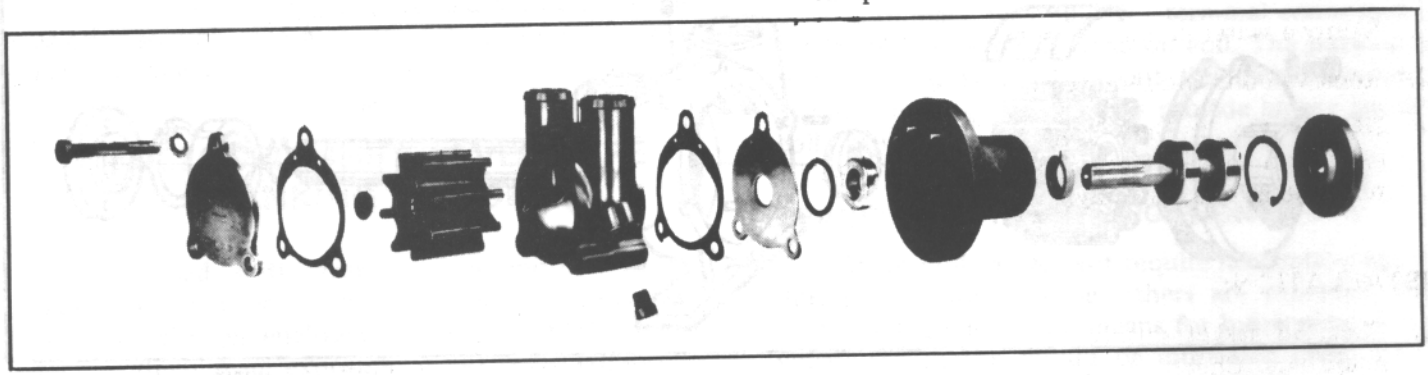


Fig. 131.

FRESH WATER COOLING

MODEL	FULL SYS. TOTAL CAPACITY QTS.	ANTI-FREEZE QTS.	HALF SYS. TOTAL CAPACITY QTS.	ANTI-FREEZE QTS.	OPER. TEMP.
307 CID	26	12	20	10	160°F—180°F
350 CID	26	12	20	10	160°F—180°F
454 CID	32	14	26	12	160°F—180°F

9. Remove drain plugs.

ASSEMBLY:

1. Install bearing and retaining ring.
2. Install seal and seat assembly and water seal on shaft.
3. Install seal retaining rings and woodruff key on shaft.
4. Install shaft and seal assembly in housing.
5. Press drive pulley hub onto shaft.
6. Install cam plate.
7. Install impeller.
8. Install drain plugs and drive pulley.

FRESH WATER COOLING FILLING INSTRUCTIONS

1. Close water drain cocks and/or install water drain plugs.
2. Install permanent type antifreeze (type Ethylene Glycol).
3. Add water to fill system, (use soft fresh water only).
4. Start engine and run at 800 RPM, expell air from system (fill cap removed).
5. While engine is running at idle speed, fill system to within one inch below filler neck on expansion tank.

CAUTION:

1. After starting the engine, always make sure that water is flowing out of the exhaust lines. **If Not, Stop** engine and investigate.
2. **Do Not** run engine with sea cock closed or when boat is out of the water. The raw water pump impeller will be damaged if run dry.
3. **Do Not** use water with high mineral content in the fresh water cooling system. The use of soft water will prevent lime deposit in the heat exchanger and engine, and will assure efficient cooling of the engine.
4. Always remove the filler cap slowly, and only when the engine is stopped or idling (temperature normal).

FRESH WATER COOLING SYSTEM HEAT EXCHANGER

DESCRIPTION:

The heat exchanger used is known as a liquid-to-liquid cooling type. The heat exchanger consists of a core, which forms the element and a housing for the core combined with an expansion tank. The core is permanently soldered at both ends in the housing. The housing is fitted with connections for both the fresh water and raw-water coolant.

OPERATION:

The fresh water or (antifreeze solution used) is circulated through the engine by a belt driven centrifugal pump. When the cooling solution leaves the cooling system through the thermostat housing, it

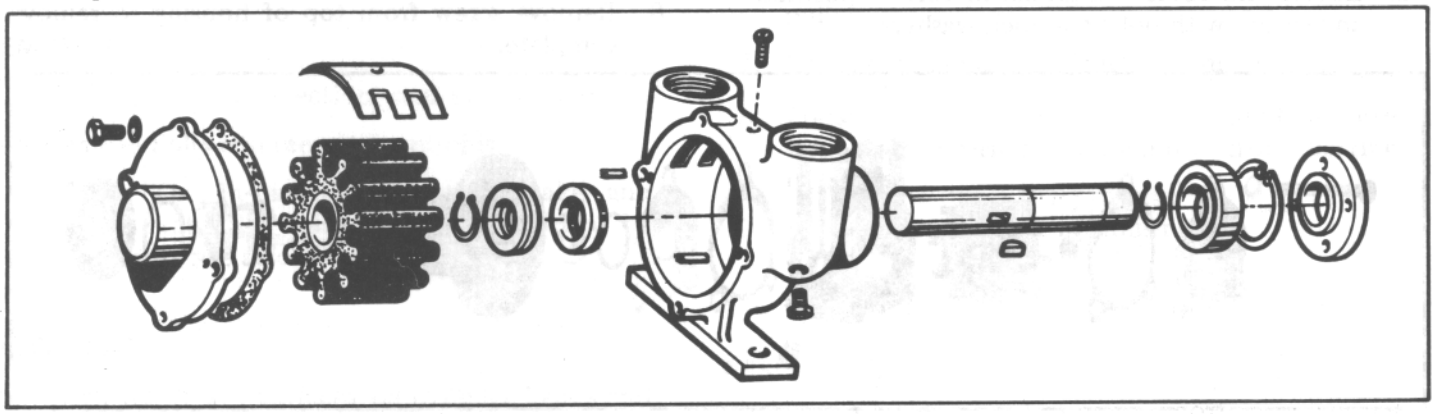


Fig. 131A

passes around the outside of the heat exchanger core tubes, and into the expansion tank. From the expansion tank the coolant is recirculated through the engine.

Water from the raw-water pump, which does not circulate through the engine cooling system, is pumped through the inside of the core tubes to cool the hot cooling solution on the outside of the tubes. The raw-water after passing through the heat exchanger core enters the exhaust elbows and is discharged overboard through the exhaust lines.

SERVICE:

The length of time a heat exchanger will function satisfactorily as a cooling unit will be governed largely by the kind of cooling liquid used in the engine and the cooling water passed through the heat exchanger core by the raw water pump. Soft water with a suitable (antifreeze) solution as the engine cooling liquid to prevent lime deposits in the heat exchanger core as well as in the engine water jacket.

When the heat exchanger fails to cool the engine properly and the raw water is circulating a normal amount of cooling water through the exchanger core, the exchanger should be inspected for foreign deposits. The thermostat should also be checked to make sure it is opening properly.

CLEAN HEAT EXCHANGER:

Deposits of dirt or like material may be removed from the heat exchanger core with live steam. If the deposits consist of lime or similar scale, this material may be removed by immersing the core in a scale solvent composed of one-third (1/3) muriatic acid and two-thirds (2/3) water, to which has been added one-half (1/2) pound of oxalic acid to each two and one-half (2-1/2) gallons of solution.

To prevent hardening and drying of accumulated foreign substances, the heat exchanger core should be cleaned as soon as possible after removing from service.

The heat exchanger body and core are serviced as one assembly, **Do Not** attempt to remove the core from the body.

ENCLOSED SHIFT LEVER TYPE CRANKING MOTORS

Enclosed shift lever cranking motors, as the name implies, have the shift lever mechanism and the solenoid plunger enclosed in the drive housing protecting them from exposure to dirt, icing conditions and splash.

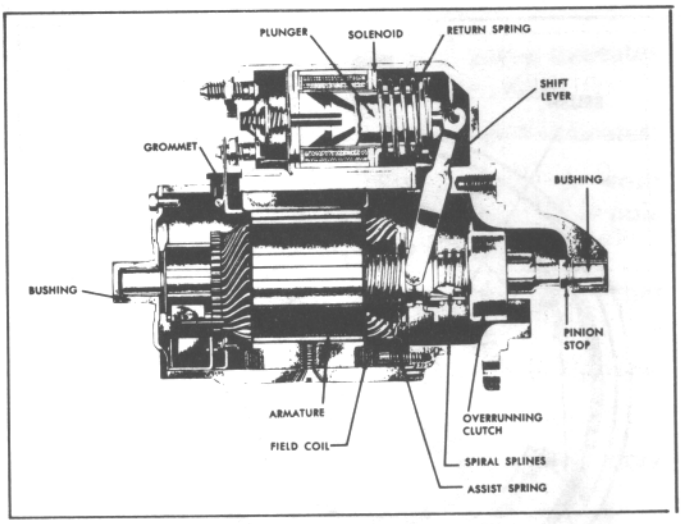


Fig. 132. Sectional View of Enclosed Shift Lever Type Cranking Motor

A solenoid switch mounted to the flange on the cranking motor drive housing operates the overrunning clutch drive by means of a linkage and shift lever. When the control switch closes the cranking circuit the solenoid is energized, shifting the cranking motor pinion into mesh with the engine flywheel ring gear and closing the main contacts located inside the solenoid. Battery current is then directed to the motor causing the armature to rotate. Cranking torque is transmitted by the clutch from the cranking motor armature to the engine flywheel ring gear. To protect the armature from excessive speed as the engine starts, the clutch is designed to "overrun" or turn faster than the armature which permits the pinion to disengage itself.

FEATURES

Two different field circuits are used in this type motor, compound and series. (Fig. 133) illustrates a compound field consisting of one shunt coil and three series coils. (Fig. 134) illustrates a series type field coil connection.

Some solenoids, in addition to the standard three terminals, have an "R" terminal connected to the battery side of the ignition coil. The purpose of this terminal is to short out the ignition resistor, during cranking, and thereby provide higher ignition coil output.

CRANKING MOTOR LUBRICATION

Some motors **Do Not** require lubrication except during overhaul, whereas others are provided with lubrication fittings. If a means for lubricating is provided, the motor should be lubricated every 5,000 miles or 300 hours of operation as follows:

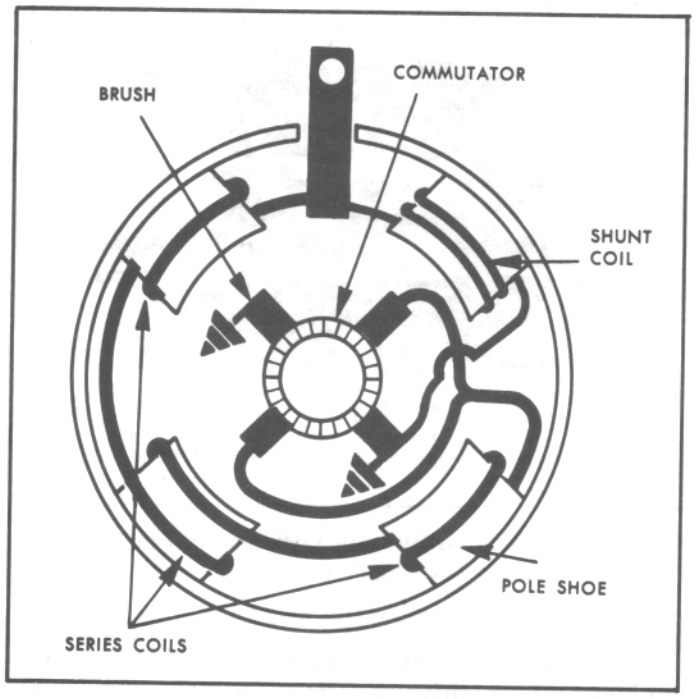


Fig. 133. Compound Motor Circuit.

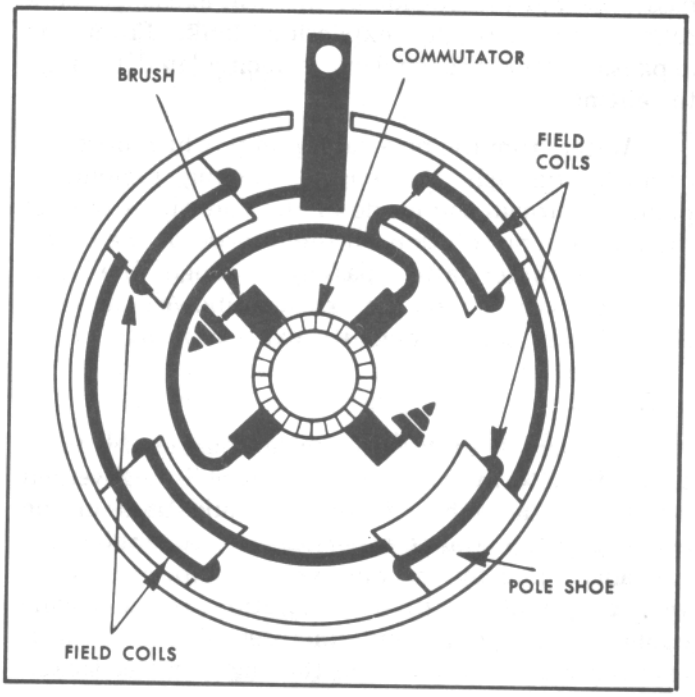


Fig. 134. Series Motor Circuit.

1. Hinge cap oilers or oil tubes sealed with a pipe plug should have 8 to 10 drops of medium grade engine oil.
2. Grease cups should be turned down one turn. Refill if necessary.

When the motor is disassembled for any reason, lubricate as follows:

1. Oil wicks, if present, should be resaturated.
2. The armature shaft and brushings should be coated with Delco-Remy Lubricant No. 1960954.
3. The roll type overrunning clutch requires no lubrication. However, the drive assembly should be wiped clean.

   CAUTION: Do Not clean in any degreasing tank or with grease dissolving solvents; this will dissolve the lubricant in the clutch mechanism.
4. Avoid excessive lubrication.

TROUBLESHOOTING THE CRANKING CIRCUIT

Several checks, both visual and electrical, should be made in a defective cranking circuit to isolate trouble before removing any unit. Many times a component is removed from the vehicle only to find it is not defective after making reliable tests. Therefore, before removing a unit in a defective cranking system, the following checks should be made:

Battery: To determine the condition of the battery, follow the testing procedure outlined in Service Bulletin 7D-100.

Wiring: Inspect the wiring for frayed insulation or other damage. Replace any wiring that is damaged. Inspect all connections to the cranking motor, solenoid or magnetic switch, ignition switch or any other control switch, and battery, including all ground connections. Clean and tighten all connections and wiring as required. Many engine and vehicle manufacturers specify allowable voltage drops in the cranking circuit. For this information, refer to the engine or vehicle manufacturer's shop manual.

Magnetic Switch or Solenoid and Control Switches: Inspect all control switches and the ignition switch, to determine their condition. Connect a jumper lead around any switch suspected of being defective. If the system functions properly using this method, repair or replace the bypassed switch.

Motor: If specified battery voltage can be measured at the motor terminal of the cranking motor, allowing for some voltage drop in the circuit (refer to engine or vehicle manufacturer's shop manual for circuit voltage drops) and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

CRANKING MOTOR TESTS

With the cranking motor removed from the engine, the pinion should be checked for freedom of operation by turning it on the screw shaft. The armature should be checked for freedom of operation by turning the pinion. Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoe screw will cause the armature to drag and it will not turn freely. If the armature does not turn freely the motor should be disassembled immediately. However, if the armature does operate freely, the motor should be given a no-load test before disassembly.

Regardless of the construction, never operate the cranking motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessive cranking will seriously damage the cranking motor.

NO-LOAD TEST (Fig. 135)

Connect the cranking motor in series with a fully charged battery of the specified voltage, an ammeter capable of reading several hundred amperes and a variable resistance. Also connect a voltmeter, as illustrated, from the motor terminal to the motor frame. An RPM indicator is necessary to measure armature speed. Obtain the specified voltage by varying the resistance unit. Then read the current draw and the armature speed and compare these readings with the values listed in the published specifications.

Interpret the test results as follows:

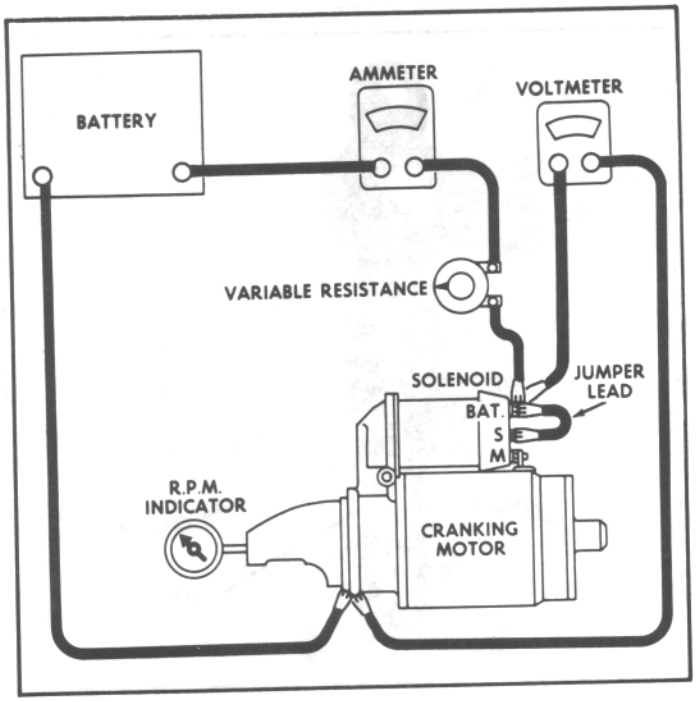


Fig. 135. No-load Test Hookup.

INTERPRETING RESULTS OF TESTS

1. Rated current draw and no-load speed indicates normal condition of the cranking motor.
2. Low free speed and high current draw indicates:
   (a) Too much friction—tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.
   (b) Shorted armature. This can be further checked on a growler after disassembly.
   (c) Grounded armature or fields. Check further after disassembly.
3. Failure to operate with high current draw indicates:
   (a) A direct ground in the terminal or fields.
   (b) "Frozen" bearings (this should have been determined by turning the armature by hand).
4. Failure to operate with no current draw indicates:
   (a) Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.
   (b) Open armature coils. Inspect the commutator for badly burned bars after disassembly.

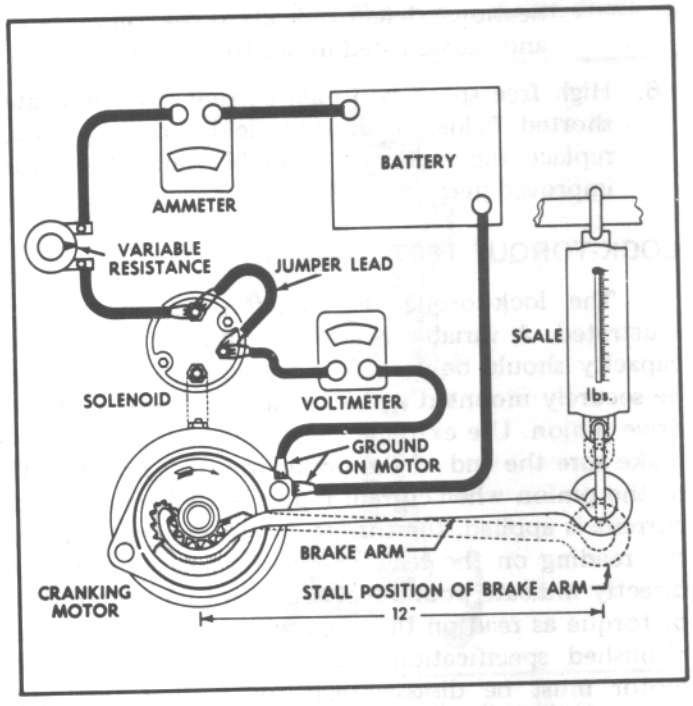


Fig. 136. Lock-torque Test Hookup.

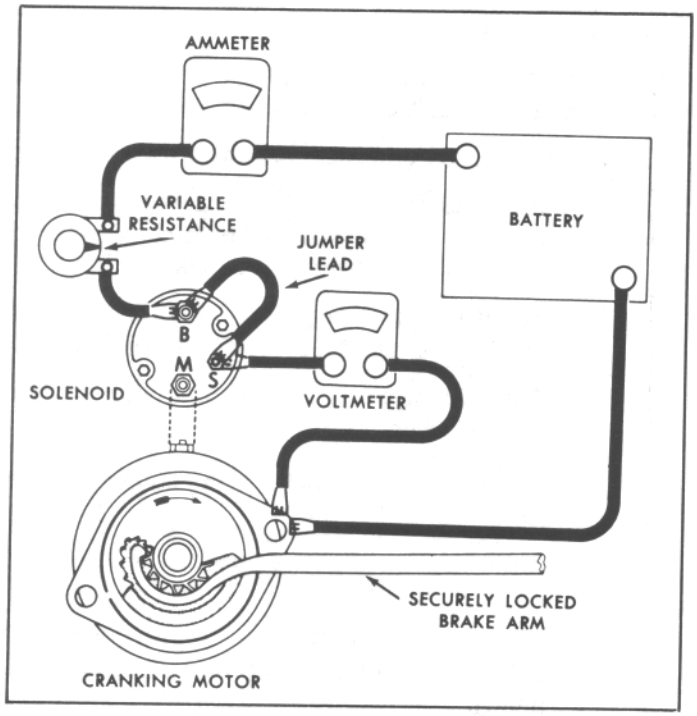


Fig. 137. Resistance Test Hookup.

(c) Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

5. Low no-load speed and low current draw indicates:

   (a) High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Number 4.

6. High free speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

LOCK-TORQUE TEST (Fig. 136)

The lock-torque test requires the equipment illustrated. A variable resistance with a high current capacity should be used. The cranking motor should be securely mounted and a brake arm hooked to the drive pinion. Use extreme caution during this test to make sure the end of the brake arm does not slip off of the pinion when current is applied. When specified current is applied, the torque can be computed from the reading on the scale. A one foot brake arm will directly indicate pound-feet. Compare the pound-feet of torque as read on the scale with that listed in the published specifications. If the torque is low, the motor must be disassembled for further test and repair.

RESISTANCE TEST (Fig. 137)

This test requires equipment similar to the lock-torque test, with the exception that the pinion is locked securely so it cannot rotate. When the specified voltage is applied, the current should fall in a range as indicated in published specifications. A high current indicates shorted or grounded conductors, and a low current indicates excessive resistance.

DISASSEMBLY

If the motor does not perform in accordance with published specifications, it may need to be disassembled for further testing of the components. Normally the cranking motor should be disassembled only so far as is necessary to make repair or replacement of the defective parts. As a precuation, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor. Following are general instructions for disassembling a typical overrunning clutch drive cranking motor:

1. Disconnect the field coil connections from the solenoid motor terminal.
2. Remove the thru-bolts.
3. Remove the commutator end frame and field frame assembly.
4. Remove the armature assembly from the drive housing. On some models it will be necessary to remove the solenoid and shift lever assembly from the drive housing before removing the armature assembly.

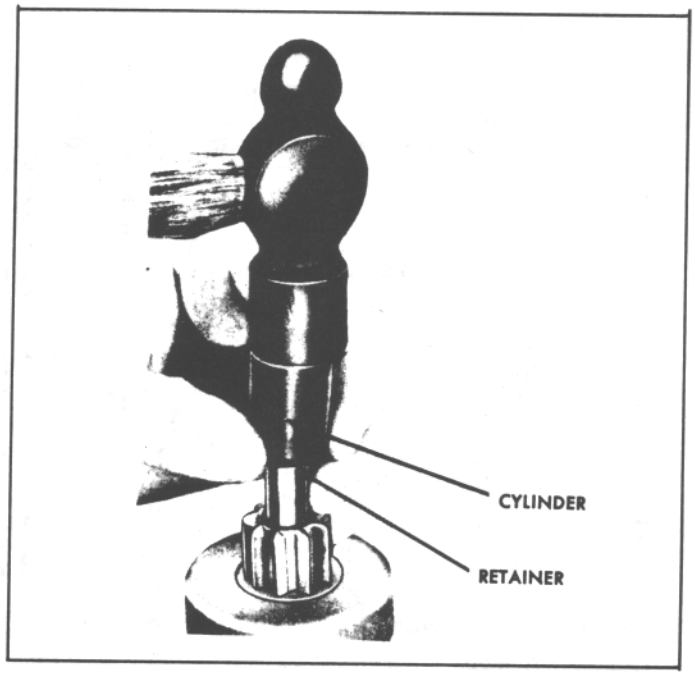


Fig. 138. Removing Retainer From Snap Ring.

5. Remove the thrust collar from the armature shaft.

6. Remove the pinion from the armature by sliding a metal cylinder onto the shaft; with a hammer striking the metal cylinder against the retainer, drive the retainer toward the armature core and off the snap ring (Fig. 138).

7. Remove the snap ring from the groove in the armature shaft.

8. Roller type clutches are designed to be serviced as a complete unit, therefore **Do Not** disassemble. Replace if necessary.

COMPONENT INSPECTION AND REPAIR

1. **Brushes and Brush Holders**—Inspect the brushes for wear. If they are worn down to one-half their original length, when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator with proper spring tension (refer to test specification booklets) to give good, firm contact. Brush leads and screws should be tight and clean.

2. **Armature**—The armature should be checked for short circuits, opens, and grounds:

   (a) Short circuits are located by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature (Fig. 139). The steel strip will vibrate on the area of the short circuit. Shorts between bars are sometimes produced by brush dust or copper between the bars. Undercutting the insulation will eliminate these shorts.

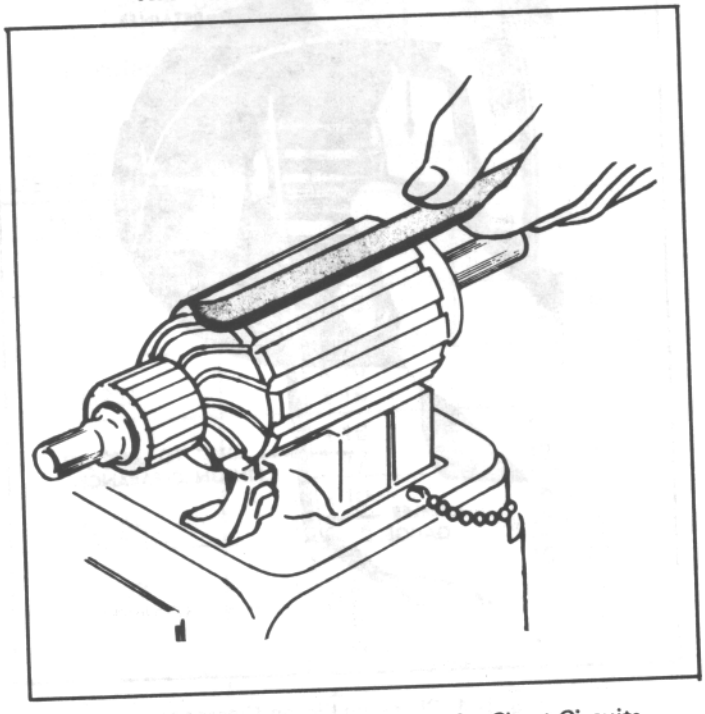


Fig. 139. Checking the Armature for Short Circuits.

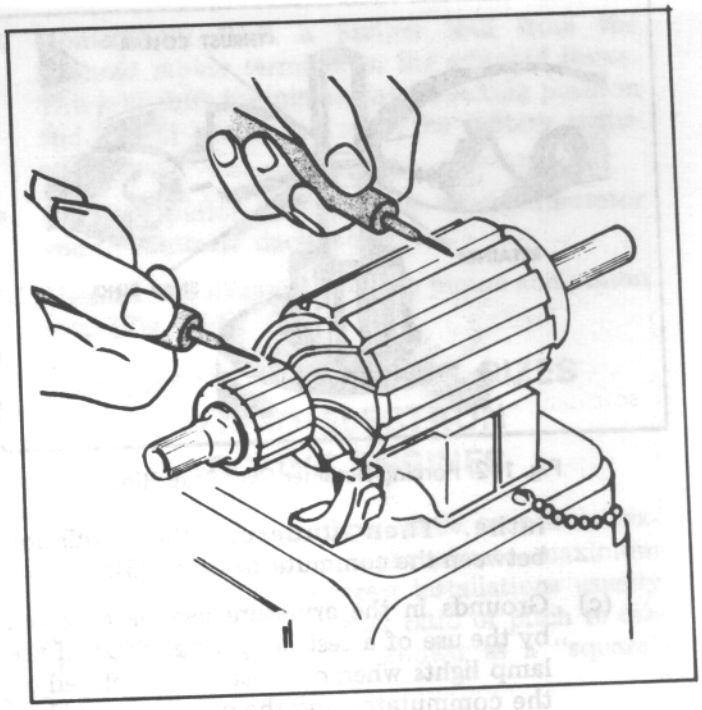


Fig. 140. Checking the Armature for Grounds.

   (b) Opens may be located by inspecting the points where the conductors are jointed to the commutator for loose connections. Poor connections cause arcing and burning of the commutator. If the bars are not badly burned, resolder the leads in the riser bars and turn the commutator down in a

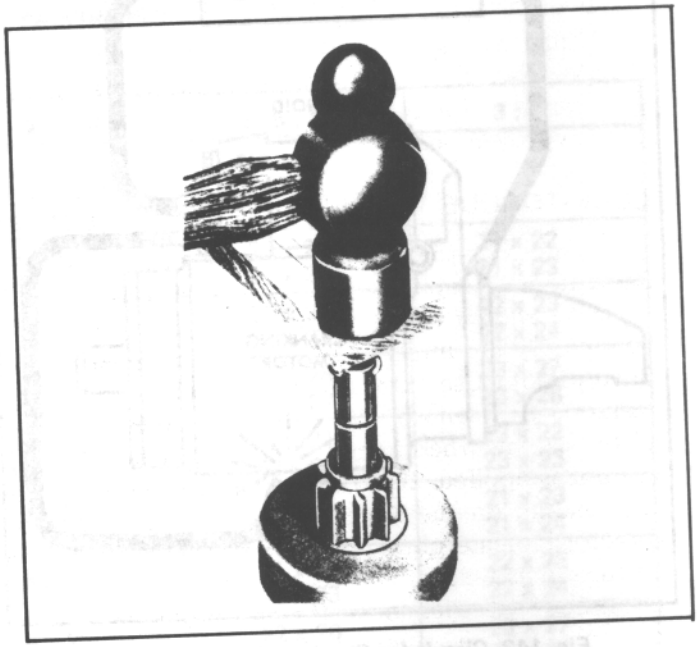


Fig. 141. Forcing Snap Ring Over Shaft.

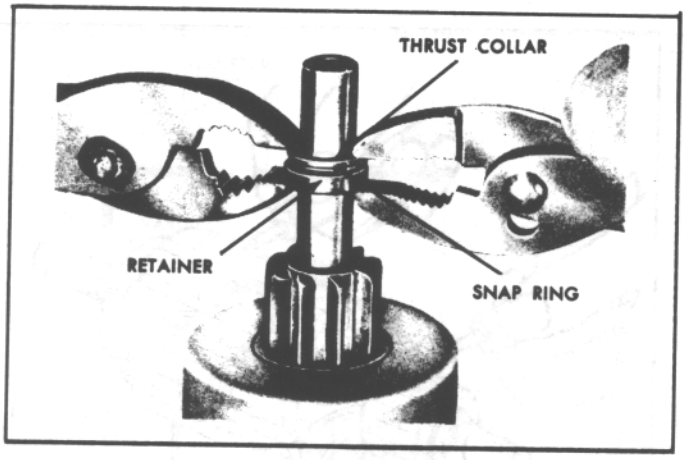


Fig. 142. Forcing Retainer Over Snap Ring.

lathe. Then undercut the insulation between the commutator bars 1/32".

(c) Grounds in the armature can be detected by the use of a test lamp (Fig. 140). If the lamp lights when one test prod is placed on the commutator and the other test prod on the armature core or shaft, the armature is grounded. If the commutator is worn, dirty, out of round, or has high insulation, the commutator should be turned down and undercut as previously described.

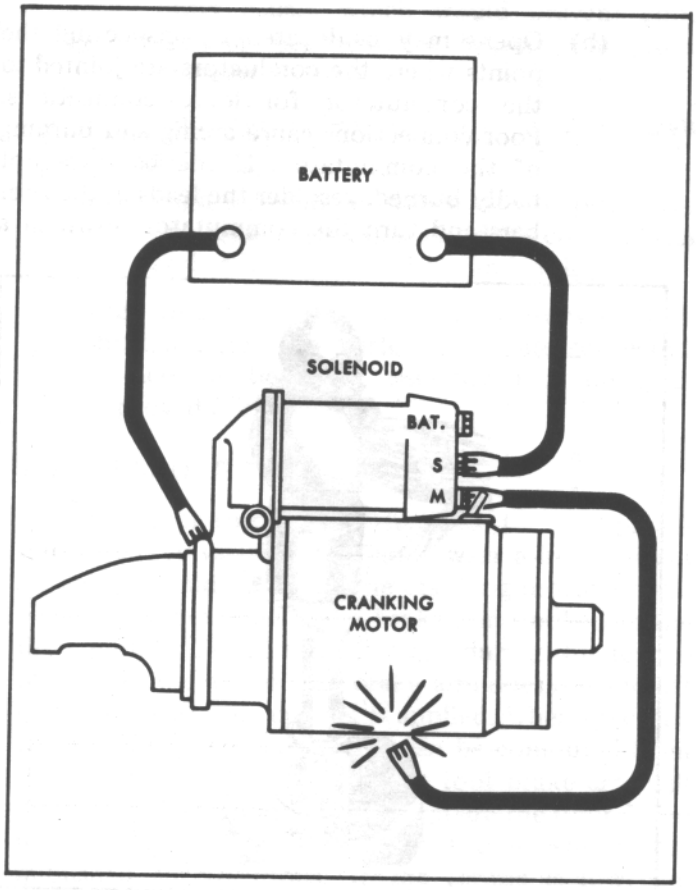


Fig. 143. Circuit for Checking Pinion Clearance.

3. **Field Coils**—The field coils should be checked for grounds and opens using a test lamp.

(a) Grounds—Disconnect field coil ground connections. Connect one test prod to the field frame and the other to the field connector. If the lamp lights, the field coils are grounded and must be repaired or replaced.

(b) Opens—Connect test lamp prods to ends of field coils. If lamp does not light, the field coils are open.

If the field coils need to be removed for repair or replacement, a pole shoe spreader and pole shoe screwdriver should be used. Care should be exercised in replacing the field coils to prevent grounding or shorting them as they are tightened into place. Where the pole shoe has a long lip on the side, it should be assembled in the direction of armature rotation.

REASSEMBLY

1. Place the clutch assembly on the armature shaft. To facilitate replacing the snap ring and retainer onto the armature:

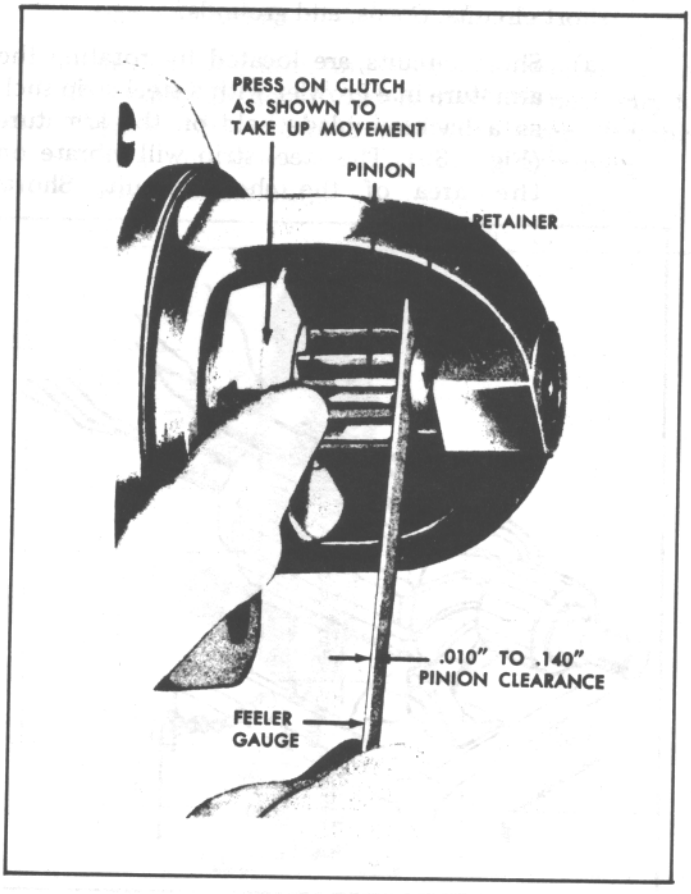


Fig. 144. Checking Pinion Clearance.

(a) Place the retainer on the armature shaft with the cupped surface facing the snap ring groove.

(b) Place the snap ring on the end of the shaft. With a peice of wood on top of it, force the ring over the shaft with a light hammer blow (Fig. 141), then slide the ring down into the groove.

(c) To force the retainer over the snap ring, place a suitable washer over the shaft and squeeze retainer and washer together with pliers (Fig. 142).

(d) Remove the washer.

2. Refer to the disassembly procedure and follow in reverse to complete the reassembly.

3. When the solenoid is reinstalled, apply sealing compound between field frame, flange, and solenoid junction.

PINION CLEARANCE

The pinion clearance cannot be adjusted but should be checked after reassembly of the motor to insure proper clearance. Improper clearance is an indication of worn parts.

To check pinion clearance, follow the steps listed below:

1. Disconnect the motor field coil connector from the solenoid motor terminal and **Insulate It Carefully.**

2. Connect a battery, of the same voltage as the solenoid, from the solenoid switch terminal to the solenoid frame (Fig. 143).

3. **Momentarily** flash a jumper lead from the solenoid motor terminal to the solenoid frame. This will shift the pinion into cranking position and it will remain so until the battery is disconnected.

4. Push the pinion back towards the commutator end to eliminate slack movement.

5. Measure the distance between pinion and pinion stop (Fig. 144).

AVERAGE PROPELLER SIZES THERMO ELECTRON GASOLINE ENGINES

These sizes are for three blade propellers (except where indicated), to approximate maximum rated engine RPM. Twin screw installations usually require propellers with a higher ratio of pitch to diameter, approaching what is known as a "square" wheel or even over square.

There is a most desirable shaft speed for every boat, which has a relationship to boat speed. Fast runabouts do best with a direct drive engine. Cruisers require reduction gear drive, and the heavier the boat, the higher the drive ratio.

The following table of average size propeller sizes may be useful as a starting point in selecting the propeller(s), it is best however, to consult the boatbuilder or your Thermo Electron Engine dealer who will have records of performance with similar boats. This is especially important for drive ratios 2:1, 2.5:1, and 3:1 because propellers in this range are expensive.

GEAR RATIO	1 : 1	1 . 5 : 1	2 : 1	2 . 5 : 1	3 : 1
MODEL					
P-60	12 x 8-2B 10 x 7-3B		16 x 10-2B 15 x 10-3B		
PA-220	12 x 13 12 x 14	15 x 16 15 x 17	18 x 16 18 x 17	20 x 21 21 x 20	21 x 22 21 x 23
PA-225	12 x 16 13 x 15	16 x 16 16 x 17	18 x 19 18 x 20	21 x 21 21 x 22	22 x 23 22 x 24
PA-350	14 x 16 14 x 17	17 x 18 17 x 19	20 x 22 20 x 23	22 x 26 22 x 27	23 x 27 23 x 28
CH-185	14 x 10 14 x 12	18 x 13 18 x 16	19 x 20 21 x 16	22 x 21 22 x 22	23 x 22 23 x 23
CH-220	12 x 14 13 x 14	16 x 17 16 x 18	17 x 20 18 x 20	20 x 21 21 x 21	21 x 23 21 x 24
CH-270	13 x 15 13 x 16	16 x 19 16 x 20	19 x 19 19 x 20	21 x 22 21 x 23	22 x 23 22 x 24
CH-350	14 x 16 14 x 17	18 x 18 18 x 19	19 x 23 20 x 22	22 x 26 22 x 27	23 x 27 23 x 28

Crusader

ENGINES

7100 E. 15 Mile Rd.
Sterling Heights, MI 48077
(313) 264-1200
Fax (313) 264-2344