RI - 162

HELICOPTER POWERPLANT

operation and maintenance

ROTORWAY INTERNATIONAL 1991

WARNING

The construction and operation of "Home-Built Aircraft" of this type is demanding and could inflict serious injury and possible death. No such operation, construction or undertaking should be initiated unless thorough and complete knowledge, preparation and instruction are available and utilized. The seller (and its agents, servants, employees, contractors, successors, and assigns) makes no warranties express or implied regarding the clarity or correctness of the plans, ease of construction or operation nor the safety of this aircraft or any part thereof. Furthermore, buyer (and his heirs, administrators and assigns) releases and holds said seller (and its agents, servants, employees, contractors, successors, and assigns) harmless from any and all liability, damages, and causes of action which may be incurred by buyer or any third party as a result of the purchase, use, construction and/or operation of said aircraft (or any part thereof) or plans for same. Buyer assumes all risk and responsibility relative to the construction and/or operation of said aircraft. Seller admits no liability by publication of this warning.

INTRODUCTION

The RI-162 powerplant from RotorWay International has been completely assembled and dynamometer tested by factory technicians. Precise parts tolerances, assembly techniques and performance parameters are required of every engine leaving the factory. The dual ignition units you received were each run with the engine and both were adjusted for proper ignition timing. The oil pressure was adjusted to specification and fuel flow verified to be in the proper range at various power levels. The engine has been run long enough for the initial "seating" of the piston rings to occur. While the extended initial run-in period on your engine is very important, this critical period of “break in” was conducted in a tightly controlled and monitored condition in a dynamometer. As a result every engine leaving the factory meets a tight parameter of torque and horsepower requirements.

After the engine has successfully completed it’s dynamometer run, a variety of additional adjustments and checks are performed prior to crating and shipment. This includes a valve lash adjustment and a re-torque of all bolts to specification. All open passages are plugged to help prevent moisture and dirt contamination.

It is very important to store the engine in a clean and dry environment prior to installation in the helicopter.

From this point on, the responsibility for longevity and reliability of the engine is yours. Before you remove the lid from your engine crate, it is important to read and familiarize yourself with this entire manual. We have attempted to address even the most basic procedures involving the proper maintenance and operation of the power plant. It is essential that proper and timely maintenance be performed. If you have any questions or if there is anything you are not sure about, please give our customer service department a call.

We advise you to attend our training program prior to starting the engine. The hands on instruction regarding the proper care and operation of the engine is extremely valuable to even the best mechanic.

A recommended maintenance schedule for the powerplant is included in this manual. You should purchase a log book formatted for powerplant maintenance. An accurate record of the work performed on the engine is a valuable tool in evaluating future maintenance requirements.

The factory provides a complete rebuilding service for the powerplant. In the event you elect to preform the "TBO" procedures on the powerplant yourself, we have provided the necessary specifications in this manual. All of the parts necessary for a rebuild are depicted in this manual and are available from the factory.

Your engine will only perform well if you treat it properly. You must understand its' needs and attend to them by monitoring and maintaining it. By combining the information in this manual with the knowledge gained in our factory training program you will be able to maintain peak performance from your powerplant.

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SECTION I. GENERAL SERVICE INFORMATION

A. RI-162 ENGINE SPECIFICATIONS

Rated Horsepower @ 4250 RPM	150
Torque @ 4250 RPM	185 ft.lb.
Max Torque @ 3950 RPM	191 ft.lb.
Operational RPM (Calibrate with rotor RPM)	4250
Idle RPM	1600-1800
Bore, inches	4.00
Stroke, inches	3.228
Displacement, cubic inches	162
Compression Ratio	9.4:1
Flywheel Rotation (viewed from above)	Clockwise
Firing Order	1-2-3-4
Ignition Systems (Dual-Independent)	Electronic
Ignition Timing	30° BTDC
Spark Plug Gap	.035"
Ignition Sensor/Timing Wheel Gap	.014"±.003"
Valve Lash Clearance	.004"-.006"

NOTE: Measurements and adjustments must be made with engine cold!

Engine Dry Weight (including main drive pulley, flywheel, water manifolds, carburetor, dual ignition systems, and starter ..... 180 lbs.

B. TORQUE REQUIREMENTS

* Main Drive Pulley Bolts	28 ft. lbs.
* Main Drive Flange Attach Nut	200 ft. lbs.
** Cam Gear Bolts	18 ft. lbs.
*** Rod Cap Nuts or Rod Bolts	42 ft. lbs.
Main Stud Nuts	40 ft. lbs.
Cylinder Head Attach Bolts	22 ft. lbs.
Intake Manifold Bolts	12 ft. lbs.
Exhaust Manifold Attach Bolts	120 in. lbs.
Polyloc Set Screws (Rocker Arms)	120 in. lbs.
Valve Cover Attach Bolts	84 in. lbs.
Ignition Sensor Set Screw	15 in. lbs.
Ignition Sensor Jam Nuts	96 in. lbs.
* Oil Pressure Adjustment Plug	40 ft. lbs.
Oil Pressure Adjustment Jam Nut	108 in. lbs.
Carburetor Mount Bolts	12 ft. lbs.
Case Bolts	15 ft. lbs.
Starter Bolts	18 ft. lbs.

* Install with service removable Loctite #242
** Install with Loctite #271
*** All rod bolts should be thoroughly oiled before installing (rods using nuts are not oiled).

B. TORQUE REQUIREMENTS (CONT'D.)

	Starter Mount Bolts	15 ft. lbs.
	Lower Cover Bolts	15 ft. lbs.
	Oil Pump Cover Bolts	15 ft. lbs.
*	Rocker Arm Studs	40 ft. lbs.
**	Spark Plugs	10 ft. lbs.
*	Timing Wheel Bolts	96 in. lbs.
	Cam End Plate	96 in. lbs.
	Oil Hose Nuts	24 ft. lbs.
	Water Pump Bolts	120 in. lbs.
***	Carburetor Temperature Sender	Lightly Snug

C. OIL REQUIREMENTS & SPECIFICATIONS

GRADE OF OIL:

AMBIENT AIR TEMPERATURE	MULTI. VISCOSITY
Above 40 degrees F.	20-50 SF
0 degrees F. To 60 degrees F.	10-40 SF
Below 0 degrees F.	10-40 SF ****

Oil System Capacity, U. S. quarts. (Approx)	5.0
Oil Sump Capacity, U. S. quarts (2-5/8" from bottom)	3.5
Minimum Safe Quantity in sump, U. S. quarts	3.0
Minimum Run-up oil Temp. (Above 2000 rpm)	110° F
Minimum Climb-out Oil Temperature	140° F
Normal Operating oil Temperature	140-210° F
Caution Operating Oil Temperature	210-240° F
Maximum oil Temperature	240° F
Oil Pressure Requirements:	
MINIMUM at IDLE	30 PSI
MINIMUM at 4250 RPM	40 PSI
MAXIMUM	70 PSI
Adjust warm (180-200 F.) @ 4250 RPM	50-55 PSI

* Install with Loctite #271

** Coat threads with a light film Anti-Seize prior to installation and install the end caps using Loctite #271.

*** Over torquing of the sender will distort the O-ring and may cause leakage. Apply a bead of silicone over the sender, O-ring and the body to "secure" the sender.

**** When ambient air temperature is below 0 Degrees F., the powerplant should not be operated above an idle until the oil has warmed to 110 degrees. Pre-warming of the engine and oil may be necessary in extremely cold conditions.

D. GREASE REQUIREMENTS & SPECIFICATIONS FOR MAIN DRIVE PULLEY

GREASE SERVICE INTERVAL:

3 Shots Every 25 Hours

Bearing Replacement @ 500 Hours *

Note: One "shot" of grease equals one full stroke from a standard 14 oz. cartridge, lever action grease gun. The approximate "shot" dimension is .25 inches in diameter by 1.5 inches long.

GREASE TYPE: Determine which type of grease is appropriate for the area you will be operating in.

A. For all flight operating conditions ABOVE 0 degrees F. USE: Mystik JT-6 Multi-Purpose Hi-Temp Grease.

B. If any flight operating conditions are BELOW 0 degrees F. USE: Ronex MP

Note: It is not recommended to use Ronex MP if ambient air temperatures above 90 degrees F. are <u>regularly</u> encountered.

Mystik JT-6 is a Cato oil and Grease Company product. Ronex is an Exxon product.

The correct grease for use in the Main Drive Pulley is also the correct type for use in all other parts of the helicopter. Since use of the correct type of grease is essential to proper performance, it is advisable to dedicate a grease gun specifically for helicopter service!

* Bearing replacement in the Main Drive Pulley is a service offered by the factory. Contact a customer service representative to schedule this service

E. FUEL REQUIREMENTS & CONSUMPTION

Minimum Octane Rating	92
* Fuel Pressure, PSI. (Approx.)	3 - 4
Fuel Consumption at Full Power (Approx.)	68 lbs./hr.

F. DELLORTO DRLA 48 CARBURETOR

Air Bypass Screws	Fully Closed
Idle Mixture Screw	2 Turns Out
Idle Speed Screw (Initial Setting)	4 Turns Out
Main Gas Jet	2.10 mm
Main Air Corrector	1.50 mm
** Idle Jet	.65 mm
Float Height close	13/64" - 7/32"
drop	1.750"±.015"
Accelerator Pump Linkage	Factory Set (DO NOT CHANGE)
Accelerator Pump Jetting	Factory Set (DO NOT CHANGE)

G. COOLING SYSTEM SPECIFICATIONS AND LIMITS

Antifreeze Type	Propylene Glycol
Cooling system Capacity. (Approx.)	8 qts.
Minimum Climb-out Water Temperature ...	140° F
Normal Operating Water Temperature	140-190° F
Caution Operating Water Temperature ...	190-215° F
Maximum Operating Water Temperature ...	215° F

CAUTION

The powerplant can be damaged during the first start-up if adequate oil pressure is not attained within prescribed time limits.

The powerplant may be damaged during the first start up by improper bleeding of cooling system resulting in a rapid increase of engine and water temperature.

* The fuel pressure regulator must be adjusted to conform to a fuel volume/time parameter as outlined in the Fuel System-Flow Calibration section of this manual.

** DRLA 45 mm carburetors use .60 mm idle jets.

H. COMPONENT SPECS AND WEAR LIMITS

CYLINDERS			
	Size	STD	4.0005" ±.0005"
		MAX	4.0035"
	Max Taper		.0015"
	Bore to Bore Distance		4.410" ±.002"
CRANKSHAFT			
	Mains	STD	2.1645" ±.0003"
		MIN	2.1637"
	Rods	STD	2.0860"/2.0865"
		MIN	2.0855"
	End Play	STD	.004"/.006"
		MAX	.012"
CASE			
	Main Bore		2.5590"/2.5600"
	Cam Bore		1.0830" ±.0003"
PISTON			
	Ring Gap	STD	.015" - .020"
		MAX	.030
CAMSHAFT			
	Journal	MIN	.9830"
	Lobe Height	MIN	.326"
	Timing (in crank degrees)		4° Retard ±1°
RODS			
	Small End	STD	.9275"/.9278"
		MAX	.9283"
	Big End		2.2430"±.0005"
VALVE STEM			
	Exhaust	MIN	.3498"
	Intake	MIN	.3128"
VALVE SEAT			
	Exhaust Width		.080"/.090"
	Intake width		.060"/.070"
	Approx. Grind Angles (degrees) ...		15°, 44-1/2°, 60°
VALVE GUIDES			
	Exhaust	STD	.3523"/.3527"
		MAX	.3535"
		MAX TAPER	.0010"
	Intake	STD	.3142"/.3147"
		MAX	.3155"
		MAX TAPER	.0010"

H. COMPONENT SPECS AND WEAR LIMITS (CONT.)

VALVE SPRINGS		
(@ 1.125" Compressed Height)		155/180 lbs.
VALVE LIFT		
@ Valve	STD	.467" ± .005"
	MIN.	.440"

SECTION II. INDIVIDUAL SYSTEM PROCEDURES

A. INTRODUCTION

Every basic system required for powerplant operation is covered individually within this manual. The following topics are addressed only in this section:

1. Correct Installation
2. Preparation For Start-Up
3. Initial Start-Up Procedures
4. Maintenance Procedures
5. Diagnostic Procedures

Read each section entirely, including the diagnostic procedures, as this will help provide an overview and insight leading to successful and long lasting powerplant operation!

B. FUEL SYSTEM

1. FUEL REQUIREMENTS

The RI-162 powerplant is jetted and tuned at the factory to burn premium unleaded or leaded automotive gasoline of minimum 92 octane. The altitude range for the standard jet combination is 0 to 5000 feet MSL. For continuous operations at 5000 to 10,000 feet MSL install 1.90 main fuel jets available from RotorWay International.

100 low lead aviation gas may also be used with the same jet combinations. However, do not attempt to monitor the exhaust pipe for a rich or lean indication as AV gas does not leave enough residue. For this reason it is advisable to periodically burn premium unleaded or leaded automotive fuel (min. 92 octane), to check for proper jetting.

An over-rich mixture will leave a "black soot" deposit in the tail pipe. A lean mixture is indicated by a clean "white" deposit. A proper mixture causes a deposit which is light brown or tan in color. (It is preferable to have a slightly rich mixture than a slightly lean one.) Contact a customer service representative if there is an indication that a jet change may be necessary.

Do not attempt to use old gasoline because it will not deliver the required performance. Gasoline volatility is adjusted by the suppliers seasonally and geographically to reduce the chance of problems such as vapor lock.

2. FUEL FLOW CALIBRATION CHECK

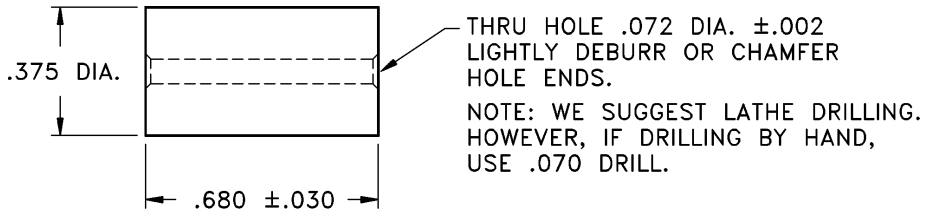
A. This check must be made prior to the first engine start up. The pressure regulator has been calibrated and set at the factory. The specifics of your fuel delivery may require a slight change in this adjustment. Incorrect fuel pressure could result in an over rich or over lean condition which may cause a power reduction and/or engine damage.

B. Use caution during this procedure since gasoline will be used to calibrate the fuel flow. Be careful of flames and sparks. It is advisable to have a fire extinguisher within easy reach.

C. Fill both fuel tanks approximately 1/4 full of fuel.

D. Remove the fuel delivery hose at the carburetor. Make a plug from the following print and install it in the end of the fuel hose.

Fuel Flow Calibration Plug



E. Carefully position the hose over a suitable container. The container should be able to hold at least 1 gallon of fuel. The point at which the hose is held MUST be the same height as the attached position on the carburetor. The pressure regulator was supplied with a mark engraved adjacent to a particular setting on the face of the regulator. This is the position in which the regulator should be set to start the test.

F. Turn on the fuel valve and both fuel pumps and purge all air from fuel lines. Turn off the fuel valve only. Empty container and turn on the valve for exactly 120 seconds. (At 120 seconds turn off the valve first then turn off the pumps.) Measure the fuel quantity. Repeat the test with one pump on at a time.

The parameters which must be met are as follows:

1. Both pumps on for 120 seconds

   Min. Fuel Delivery = 1500 ML or 50.7 oz.
   Max. Fuel Delivery = 1800 ML or 60.8 oz.

2. Single pump on for 120 seconds
   Min. Fuel Delivery = 1450 ML or 49.0 oz.
   Max. Fuel Delivery = 1800 ML or 60.8 oz.

Adjust the fuel pressure regulator, as necessary, to meet the above flow parameters. Reconnect the fuel hose to the carburetor after proper calibration is complete.

If on a subsequent retest, (at the regular maintenance interval), the flow is found to be less than the minimum level, it would be advisable to first replace the fuel filter because it can cause a drop in flow as it becomes plugged.

Do not set the regulator higher than 4 1/2 lbs. or richness and flooding may occur. If this high of a pressure setting is needed to achieve the required fuel flow, either a restriction in the system or a faulty regulator is indicated.

3. PREPARATION

A. Fill the fuel tanks approx. 1/4 full for the initial start up and run-in period. This is for safety reasons since a large quantity of fuel is not needed and would only be a hazard during this period of operation.

B. Review the fuel system plans and verify proper routing. Check the entire set-up for secure mounting, tight and properly placed clamps, and adequate protection from heat and chafing sources.

C. After the fuel flow calibration check, turn on both fuel pumps and the fuel valve. Remove the air cleaner and with the aid of a flashlight look inside the carburetor for leaking fuel. If fuel is leaking, the needle valve is not seated. Tap the carburetor sharply against the air filter base using a plastic screwdriver handle. Verify leak stoppage. Initial "sticking" of the needle is not uncommon after the carburetor has sat dry for extended periods. This problem should not reoccur, but check periodically to make sure that it doesn't. If leaking does continue, see Carburetor Section.

* D. Normal Engine Shutdown

Shut off the fuel valve and wait for the first sign of an engine sputter or miss. Immediately turn off both ignition/fuel pump switches. (This procedure leaves the intake manifolds and cylinders dry and prevents raw fuel from leaking into the cylinders.)

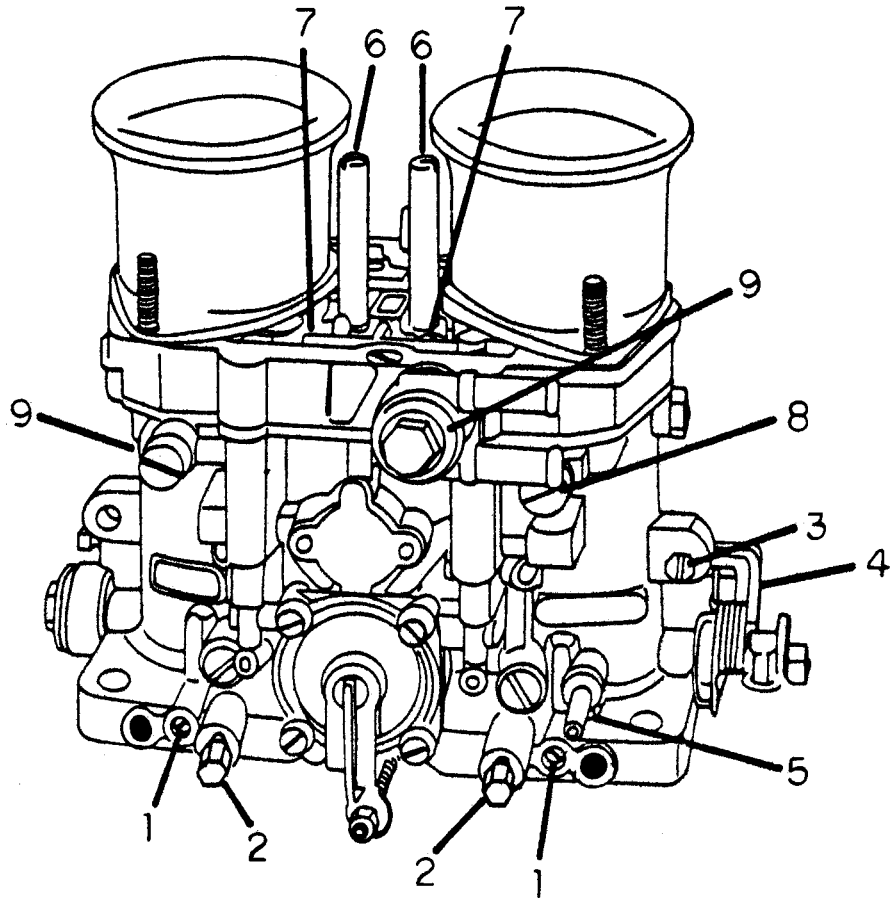
NOTE: TURN OFF THE IGNITION/FUEL PUMP SWITCHES FIRST IN AN EMERGENCY SITUATION. Turn off the fuel valve immediately afterwards.

4. CARBURETOR:

The Dellorto DRLA 48 carburetor was chosen for it's simplicity and reliability. No major service should be required until 500 hours. At this time it is recommended that the carburetor be overhauled. This is a service which is available from the factory.

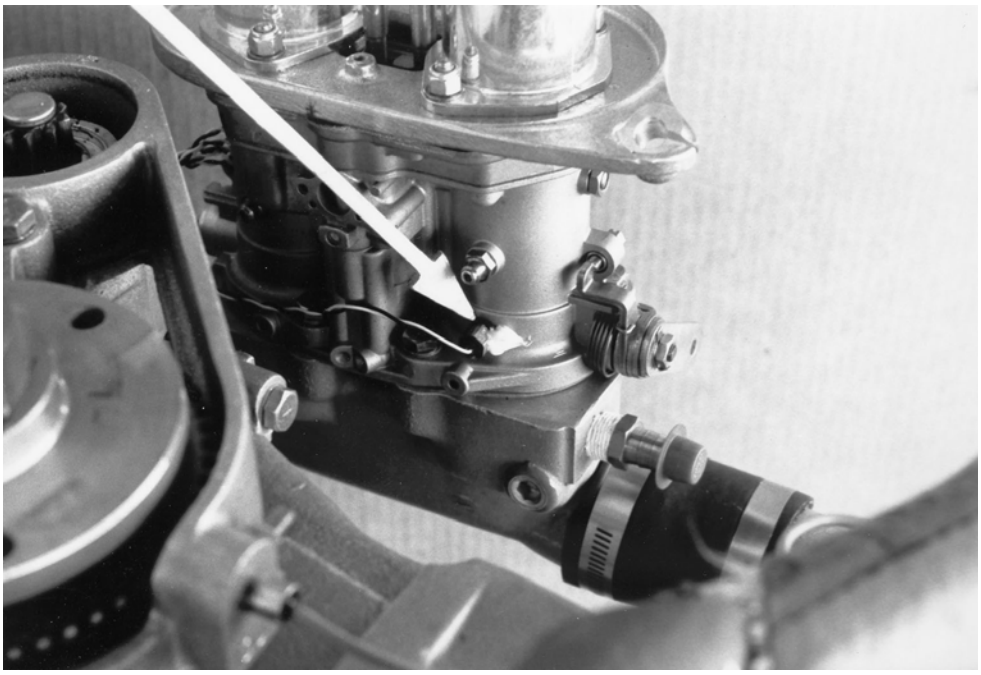
This carburetor does NOT compensate for altitude changes. Operation in an over-rich condition may cause a loss of power and the formation of excess deposits in the engine. Extended flying in an over-rich condition can cause engine damage.

DELLORTO PARTS LOCATOR



1. Air Bypass Screw (fully closed)
2. Idle Mixture Control Screw
3. Idle Speed Screw
4. Throttle Stop Arm (Idle speed arm)
5. Vacuum Inlet (Not used-keep plugged)
6. Main Jet Stack
7. Idle Jet Stack
8. Accelerator Pump Jet
9. Fuel Inlet Fitting

CARBURETOR TEMPERATURE SENSOR LOCATION



The following individual procedures are to be performed, when necessary, on the carburetor. Do not attempt to modify or change the carburetor in any way. The current configuration was finally determined after many hours of calibration testing on the factory dynamometer. Any jet changes necessary should be done on recommendation from a customer service representative.

A. Air Filter Service:

The air filter must remain clean for proper engine performance. A common cause of "power loss" is a clogged or dirty air filter. If upon inspection the air filter appears to have accumulated noticeable dirt or to be contaminated with oil or grease, clean and re-oil it. If any damage is evident, or if cleaning is not effective, replace the air filter. Certain local conditions may warrant inspection on a more regular basis than the 25 hour interval recommended.

WARNING: USE ONLY: K & N AIR FILTER OIL
K & N CLEANING AGENT

Clean Only As Follows: Lightly brush and tap off surface dirt. (Heavy brushing will damage the gauze). Pour K & N cleaning agent into roller paint-tray pan. Keep cleaner shallow so dirt stays away from inside the filter. Wet the filter with cold water and roll it through the cleaner. Rinse filter with cold water from inside towards outside. Shake, dry completely and re-oil.

DO NOT BLOW THROUGH FILTER WITH COMPRESSED AIR!

Oil As Follows: Hold the aerosol can 3" away and make one pass along each pleat. DO NOT go "round & round". Allow twenty minutes for oil to spread. Do not oil twice. The white gauze should appear red, have no "white spots" and be dripless.

B. Carburetor Heat Function:

Turn on the carburetor heat any time the carburetor temperature gauge reads below 20 degrees C. It is also recommended to be used during the first initial start and warm up of the powerplant.

Normally the carburetor heat should not be used if the carburetor temperature gauge is above 30 degrees C. (Use of carburetor heat does not help and may reduce the power output of the engine).

C. Filter Screen:

This is checked and cleaned after ten hours of operation to remove any contaminates which have collected from the section of the fuel system "down stream" of the fuel filter. Check for leakage after reinstalling. Inspect the screen if fuel flow calibration problems occur.

D. Service Adjustments:

1. Jet Change: Ensure that "Jet Stacks" are pressed firmly together during reassembly. Be careful not to over tighten when installing.

2. Float Height Adjustment: Remove the carburetor top cover and hold it inverted. Use 13/64" and 7/32" drill bits as go/nogo gauges to set the float "closed height". The spring must be LIGHTLY compressed for this adjustment. The float "drop" can be measured with calipers and is taken from the base of the carburetor top to the bottom of the float. (Free drop float height = 1.750"±.015").

E. Diagnostic:

1. Idle Speed Increase Occurs (and/or rough idle): Check for "manifold" leaks such as loose clamps, worn hoses, or defective gaskets.

2. Rough Idle: Check air filter and clean or replace as necessary. Remove the idle mixture screws and the air filter. "Backwash" the passage ways using compressed air. Be prepared for fuel to blowout the top of the carburetor during "backwash" procedure. Reset mixture screws to "two turns out".

3. Insufficient Power: This is usually not caused by the carburetor but leanness could occur from loose venturi holding screws (#73 in Parts List). Loosen the lock nuts and check the security of these screws. Then re-tighten lock nuts.

4. Fuel Leaking Inside Carburetor: If fuel is continuously dripping inside the carburetor before start up, tap the air filter base with the plastic handle of a screwdriver. If this does not stop the leak, turn off the fuel valve and the fuel pumps. Remove the carburetor top cover and inspect the needle and seat for dirt contamination or damage. If the needle and seat are in good condition, check the float setting and the fuel pressure regulator setting.

C. COOLING SYSTEM

1. COOLANT REQUIREMENTS

Propylene glycol is the recommended choice for coolant/anti-freeze. Propylene Glycol offers improved cavitation corrosion protection, lower toxicity, and better overall performance than Ethylene Glycol.

It is also recommended to include a compatible supplemental coolant additive (a rust inhibitor/water pump lubricant). WIX #24056 and NALCOOL #3000 are a few of the quality additives available. The best source for locating other brands is diesel parts stores because cylinder corrosion is common in diesel engines. Follow directions for the correct concentration of additive as more is not better.

We have tested a Propylene Glycol anti-freeze solution called COMPLEAT. It is a totally pre-mixed coolant solution containing the proper concentrations of propylene glycol, deionized water and corrosion inhibitor additive. This product is distributed by FLEETGARD Inc., a Cummins (diesel) company.

Testing indicates that this cooling solution performs properly in the helicopter even when ambient air temperature exceeds 105 degrees F. If operation is necessary in extremely hot conditions, it is possible to lower the engine water temperature by 5-10 degrees using a mixture of deionized water and supplemental additive. This type of solution should be used only if necessary. NEVER USE WATER ONLY! Normally the propylene glycol solution should be left in the system until it is removed during an engine overhaul.

2. PREPARATION

Review the plans to ensure that proper routing and attachment of all cooling system components is correct. Verify that the hoses and clamps are aft of the flared ends of all tubes. All hoses must be protected from the exhaust manifolds. Tie down and routing of all hoses must be done in such a way as to prevent chafing damage.

3. PRIMING WATER PUMP

WARNING: Priming of the water pump is an involved process. Careful monitoring of the water temperature is essential during the entire procedure. It is an inherent characteristic of the cooling system to repeatedly lose the prime at the water pump during the initial start up period. All of the air must be bled out of the system.

Water pump priming is one aspect of the initial engine "start-up" which requires two people. One person (the pilot) must start the engine and monitor all instruments. In the case of water temperature, constant monitoring is essential since water temperature increase is extremely rapid if the prime is lost at the water pump.

Another person is needed to "bleed off" air from the water pump and to monitor the cooling system for leaks. (This person will also be in excellent position to monitor several other systems for potential problems.)

Complete the following before Start Up:

A. Prepare the coolant solution according to the specifications given by the manufacturer.

B. Loosen the clamp on the pilot side of the upper radiator hose. Ensure that the hose is loose enough to allow air to bleed from the system.

NOTE: It is advisable to position a catch tray under all "bleed" areas to recover as much coolant mixture as possible.

C. Slowly pour the coolant mixture into the standpipe until full.

D. Remove the most accessible bolt from the water pump. (1 of 7)

E. Continue filling the standpipe until the water pump bolt hole emits coolant without air bubbles. Reinstall the bolt "finger tight" only. (The standpipe must be continually filled during this process).

F. Continue to fill the standpipe until coolant flows continuously from the loose radiator hose. Tighten the hose clamp and top off the standpipe. Leave the cap off at this time.

G. Check for any sign of leakage.

H. Turn on the instruments and verify that the needle on the water temperature gauge (as well as on the oil temperature gauge) moves from a low temperature setting to a "pegged low" position.

I. Position the Carburetor Heat Control Valve parallel to the inlet hose (the ON position). This will assist cold idle smoothness and force trapped air from the system. It can be turned off after the priming procedure is completed.

J. Ensure that enough additional cooling solution is ready to continue filling the standpipe when the engine is first started.

During the initial start up of the engine many systems on the helicopter require attention. We are stressing the importance of monitoring the water temperature because in the excitement of the moment we have seen that this is most easily overlooked.

After engine start-up, the procedures listed below must be followed closely to prevent overheating and engine damage:

A. Keep the standpipe full AT ALL TIMES.

B. At the first sign of water temperature increase, remove the loose water pump bolt and bleed the system until no air exits. Correct bleeding of the system should quickly lower and stabilize water temperature. Rather than replacing the bolt, it is recommended that you hold a finger over the hole so repeated "bleeding" can be prompt and simple.

C. Proper priming of the water pump is evident by a warming of the hoses to the water pump as well as a slow increase in water temperature. At this point, the bolt may be replaced finger tight only and after topping off the standpipe the cap should be installed. Fill the overflow reservoir with 24-36 ounces of coolant solution. If a rapid or continuous increase in water temperature occurs, the engine must be stopped, allowed to cool and the system must be bled at the water pump again. In this case, carefully remove the cap first since the coolant may be HOT.

NOTE: The engine will be stopped after a brief period of running to re-fill the oil sump. At this time, the bolt should be removed and the water pump "bled".

A warm engine restart will display an initial temperature increase followed by a rapid decrease if priming is accomplished.

D. After approximately five minutes of running at stabilized temperatures, stop the engine and let it cool. Remove the standpipe cap. Remove the water pump bolt and allow coolant to bleed for 10-15 seconds while keeping the standpipe full. Stop the flow, dry and clean the bolt, apply silicone to the threads and install the bolt. Torque it to 120 in. lbs. Fill the standpipe and replace the cap.

NOTE: Water temperature should not exceed 185° F. during the initial start up period. Be prepared for loss of prime especially during the first 5 minutes of operation as the remainder of air bubbles are removed from the system. Monitor the cooling system especially close during the first few hours of operation when problems are most likely to occur.

Adjust the amount of water in the overflow reservoir to 24-36 ounces when the engine is cold. You may notice that when the engine is warm, the level in the reservoir decreases as the engine is run-up from an idle to full RPM. The level in the reservoir may increase when a hot engine is stopped. The level should then decrease as the engine cools and coolant is drawn back into the standpipe.

D. OIL SYSTEM

1. PREPARATION / PRIMING

Prior to the first engine start up, the oil pump MUST BE PRIMED. The RI-162 power plant uses a G-Rotor pump rather than a gear type unit. The G-Rotor has several design advantages over the gear type. It does have the disadvantage of needing a prime before first operation. The oil fittings have been angled up at the inlet and outlet side of the oil pump. This is done intentionally in order to keep enough oil at the pump to maintain a prime after shutdown of the engine. The pump should not have to be re-primed again even after a prolonged interval of no engine operation.

CAREFULLY follow the sequence outlined below before the initial starting of the engine.

A. Before installing the sump, oil cooler or any oil hoses, they must all be thoroughly cleaned. You should carefully flush them with solvent, completely drain and blow them dry.

B. Before screwing on the oil filter, remove the rubber gasket and coat it with a light film of oil. Replace the gasket and fill the oil filter with oil. It holds approximately 1/2 qt. Oil must be added slowly, allowing it to soak in. Screw the filter onto the mount by hand. Tighten it firmly by hand only. Approximately 2/3 of a turn after initial contact is correct. Do NOT use a wrench to tighten the filter to the mount as this will make it next to impossible to remove for replacement.

C. Before connecting any oil hoses to the engine, fill the oil pump inlet and outlet fittings with oil. These fittings are numbers 5 and 6 in the oil System Parts List. These fittings will have to be refilled repeatedly until all of the trapped air has bled out and they remain completely full.

D. Install all oil hoses. Torque hose nuts to 24 ft. lbs. Over tightening will result in permanent damage to the fittings and hoses. Secure all hoses away from hot exhaust. Secure hoses in such a way as to avoid any scuffing contact with ANY component of the aircraft.

E. Fill the sump with oil to a level of 2 5/8" up from the bottom. This is the normal level of oil to maintain. Overfilling of the sump will result in oil blowing out of the filler pipe.

F. The oil system is now ready for the first engine start up. All other systems must be prepared before starting the engine. When the engine is started for the first time do NOT operate above an idle until oil pressure is obtained.

CAUTION: If proper oil pressure is NOT obtained after 7 seconds of running, STOP the engine and re-prime the pump as explained in 3 above.

G. When correct oil pressure is observed, continue to run the engine until an oil temperature of 100 degrees F. is obtained and then STOP the engine. Refill the sump to a 2 3/8" level. (Unless you wait for the oil to completely drain back to the sump, filling to the proper pre-start level of 2 5/8" will actually over fill the sump.) Carefully check the entire oil system for any signs of leakage. Adjust the oil pressure if necessary. (See oil Pressure Adjustment Section.)

H. For proper bleeding of air from the oil capillary tube, it will be necessary to loosen the oil pressure line at the gauge. When the engine is restarted, allow air to bleed from the line until oil fills the line and starts to drip out. Tighten the connection and after wiping off any spilled oil, check for leakage.

CAUTION: Always check oil pressure on each start up and throughout each flight. Continually monitor the ENTIRE oil system for any leakage and regularly check all hoses for ANY sign of damage.

2. OIL PRESSURE ADJUSTMENT

A. Oil pressure adjustments must be made when the engine is at operating temperature. (See specification section for exact operating parameters.) The only time that oil pressure would need to be adjusted, when the engine is cold, would be if on an initial start-up the oil pressure did not meet the minimum or maximum specifications. Oil pressure MUST fall within the stated parameters at idle and at full RPM.

Because the oil pressure was set at the factory during the dynamometer testing of the engine, a slight adjustment may have to be made in order to "tune" the pressure regulator to your ship's particular oil system. This adjustment should be minor and should not have to made during the initial warm up of your engine. However, do not take this for granted. Carefully monitor your oil pressure at all times.

B. To adjust the oil pressure, first look at the exploded view of the oil pump cover and the pressure regulator components in the Crankcase Assembly Parts List Section of this manual. Take the time to become familiar with the component parts. It is recommended that you make any adjustment to the oil pressure only when the engine is stopped. As you will notice, the adjustment requires that your hands come in close proximity to the hot exhaust system. This, in conjunction with the generally close quarters, warrants special care from a safety point of view.

C. Proceed as follows to make an adjustment of the oil pressure. Loosen the jam nut on the socket head cap screw. Take care not to move the cap screw. Turning the cap screw clockwise will increase the oil pressure and turning counter clockwise will lower the pressure. It is suggested that you turn the cap screw in increments of 1/4 turns at a time until the desired pressure is achieved. Each time an adjustment is made, re-torque the jam nut to 108 in.lbs. After any adjustment, completely clean off any trace of oil and check for any leaks. If an oil leak is found around the socket head cap screw where it enters the regulator plug, the O-ring must be replaced. To do this, remove the cap screw while carefully counting the exact number of turns as it comes out. Be prepared for a small stream of oil to come out of the regulator plug. When you reinstall the screw, turn it in exactly the same number of turns. By doing this you should be close to the previous setting. During any adjustment, pay close attention to the oil pressure. Make SURE you are not running the engine with incorrect oil pressure.

E. IGNITION SYSTEM

1. INTRODUCTION

The dual ignition system utilized on the RI-162 engine is extremely reliable and easy to maintain. It should provide many hours of trouble free performance. Many types of ignition systems were analyzed and evaluated before deciding to use this custom made configuration.

The system consists of two complete and separate ignition units. Each unit fires one set of spark plugs. Unlike other ignition systems, it does not use a rotor and cap, it fires the spark plugs directly from the coils. The spark control is completely electronic. The advance curve is "programmed" into each unit and occurs automatically in response to RPM. Unlike most systems, a spark occurs every time a piston approaches its top position. A spark occurs on the compression stroke and at the end of the exhaust stroke. This "extra" spark on the exhaust stroke has no effect on the running engine since there is no mixture present to ignite. (An excess of fuel in the intake manifolds or cylinders can cause a pop or backfire on start up.)

Each ignition system contains five components: Ignition pack, sensor, timing wheel, spark plugs, and spark plug wires. The only shared component between the two systems is the timing wheel which is mounted on the drive flange of the crankshaft and has a series of 58 "teeth" with two "missing teeth" spaces. Each sensor transmits a "signal" to its own ignition pack every time the missing tooth segment passes that sensor. The ignition pack then identifies the relative position of the crankshaft and delivers a spark to the plugs based on the timing required for that RPM.

The entire function of spark advance from starting to full RPM operation is controlled by the ignition packs and requires no adjustment. The maintenance is very simple on this system. Spark plugs and spark plug wires are replaced at proper intervals. A sensor or ignition pack is replaced if either is found to be defective in pre or post flight checks. This should be the most trouble free and effective ignition system you could wish for in any aircraft.

NOTE: There are certain operational parameters that must not be violated. These will be covered in detail in this section of the manual. You must carefully read this material prior to installation of the units. Failure to do so could result in permanent damage to the ignition packs.

2. PREPARATION

WARNING: NEVER ELECTRIC WELD with either of the units connected in ANY way to the electrical system of the ship. This means that the positive, negative, ground strap, and sender connections must be disconnected before any welding is preformed!

DO NOT PROVIDE CURRENT to the ignition units until all of the following procedures have been done and double checked.

The following installation and operating procedures MUST be followed before the initial start-up of the engine. Failure to understand and follow these procedures will result in damage to the Dual Direct Fire Ignition System.

A. Install the two ignition packs on the mounting plate as shown on the Ignition System Installation Drawing. It is important to identify which pack is inboard and which is outboard. As indicated on the drawing, the packs are stamped on the outside edge. The stamping identifies whether it is for the outboard or inboard set of spark plugs ("In" or "Out"). Proper mounting of the units on the plate will allow the stamping to be visible on both packs.

B. Also stamped on the side of each pack is the cylinder number of the spark plug wire which will attach to each of the four coil towers. These numbers need to be referenced in order to properly install the spark plug wires. (You will notice that the cylinder numbering is different on the inboard and the outboard units.)

C. A separate grounding strap MUST be installed to the mounting plate. This effectively grounds the body of each unit. This is required in addition to the black ground wire connection of each unit. Install the mounting plate (complete with packs) on the seat back.

D. Use the ignition drawing and the wiring diagram to complete the electrical power connections to the ignition packs. Care must be taken to properly support the positive and negative leads coming out of each unit. Tie these off in such a way as to prevent vibration from causing damage by chafing or excessive flexing.

E. Connect the senders to the ignition packs: Use the ignition drawing to ensure that the correct sender attaches to the proper pack. If the sender for the inboard set of spark plugs is attached to the ignition pack for the outboard set of plugs, the engine will not start and damage could occur from excessive backfire! These wires also need to be carefully tied down to prevent damage. They also MUST be routed so as not to come in close proximity with ANY other wires. The signal transmitted by these wires is very weak and interference from other wires close by could cause false signals to be sent to the ignition packs. Pay close attention to the routing of these wires in relation to the spark plug wires as they are proven the most likely source of interference.

F. Install the spark plugs: Be sure to gap, torque and install end caps according to specifications. (Always inspect the spark plug threads for damage and apply a light film of anti-seize before installation.)

G. Install the spark plug wires: Use the ignition drawing as a guide to the proper connection of these wires. Be sure to double check the connections you have made. (Incorrect spark plug wire hookup is surprisingly easy to do.) Before attaching each wire, look inside the boot and verify that the metal end is in the proper position. When the wire is installed on either a coil tower or a spark plug it should snap into place and feel solidly attached. Wire separators have been provided to properly route the wires. Route the wires in such a way that all of the following conditions are met:

    1. No two wires can come in direct contact with each other.
    2. Wiring must be very well supported and not allowed to chafe or vibrate excessively.
    3. No wire can be pulled tight. Some torque movement of the engine will occur and the wires must have enough slack to move with the engine.

WARNING: NEVER CRANK, START, OR RUN THE ENGINE WITH ANY OF THE SPARK PLUG WIRES DISCONNECTED FROM EITHER THE IGNITION PACKS OR THE PLUGS! (If even one of the wires is left disconnected, damage can be caused to the ignition pack!)

3. DIAGNOSTIC PROCEDURES

NOTE: The ignition packs cannot compute the proper spark timing sequence if the engine is cranking too slowly and because of this, the ENGINE WILL NOT START! The packs can also be damaged by continuous operation at a low or a high voltage. For these reasons, ensure that the battery has a good charge before attempting to start the engine and verify that the alternator is working properly after start-up by monitoring the voltmeter.

The green indicator lights that are connected to the ignition packs monitor the proper operation of the microprocessors and do not indicate that the entire system is operational! The microprocessor is monitored because it is the component most likely to fail. The coils are not monitored. All components are checked for proper operation on pre and post flight ignition checks only! (No power or RPM loss will be evident during flight if one of the ignition systems fails!)

Pre and Post "Flight" ignition checks are done by alternately turning off and on each system individually. The RPM may drop slightly but should not stop the engine or cause it to miss fire dramatically.

WARNING: DO NOT test the ignition systems above a high idle, as a faulty system could stop the engine and leave fuel in the cylinders or possibly cause severe backfiring.

Diagnostic procedures are very simple and straight forward. They must be followed in sequence. Failure to do so can result in much wasted time and the possible purchase of unneeded and expensive parts!

All of these procedures assume that the ignition system is installed properly. If you have a problem on the initial start up, recheck your installation before following the diagnostic procedures.

Below are listed a series of possible problems which may be encountered. If you have a problem with the ignition system, find the heading which fits the problem and follow the accompanying procedure until a problem is found AND CORRECTED. If after correcting a problem the ignition system still does not preform properly, then and only then go on to the next procedure.

A. ENGINE WILL NOT START but signs of combustion are evident, (such as backfire or sputter):

1. Remove the spark plugs and check for signs of fouling. A common cause of backfire or sputter on start up is "flooding" or fuel fouling of the spark plugs. (Insufficient fuel can also cause a sputter, so check for an apparent total lack of fuel.)

2. Check for power at <u>both</u> ignition packs using a voltmeter.

3. Try starting the engine on the inboard system only. Repeat on the outboard system only. If the engine starts and runs on either system and starts to miss or if it quits when the other system is turned on, see Engine Runs On One System Only.

4. If the engine will not start on either system, check the sender gap on both the outboard and the inboard systems.

5. Install a timing light on #1 outboard spark plug wire. With <u>only</u> the outboard system turned on, crank the engine to check for spark. Do the same to outboard wires #2, #3 and #4. If a spark is present on all 4 plugs and none of the plugs were fouled, then there is probably not enough fuel present for start up.

NOTE: Crank the engine <u>only</u> long enough to verify spark. DO NOT crank the engine for a prolonged period as this could damage the starter and the engine!

Pre-check the timing light for proper operation. If its operation is questionable, an alternate method may be used to verify spark at the plug: Remove the spark plug wire from the cylinder in question. Remove the spark plug and reattach the spark plug wire to it. Install an extra spark plug in the vacant hole. Attach a grounded strap to the base of the removed spark plug. Hold this grounded plug against a grounded surface which is not near the carburetor or any other fuel source! Care must be taken to avoid shock AND to prevent the system from being run with a plug wire disconnected. For this reason, do not eliminate the grounding strap from this procedure.

6. If no spark is evident at ANY cylinder and if the voltage AND cranking speed are good, either a sender or an ignition pack is probably bad. In this case, skip 7-9 and proceed to 10. If any of the plugs show signs of spark proceed to 7.

7. If only one, two, or three of the spark plugs do not show signs of spark, then replace the questionable spark plugs and retest. (Defective spark plugs can cause this type of problem.)

8. If only one, two, or three of the spark plugs still show no evidence of a spark, remove the questionable spark plug wires from the defective cylinders. Check for continuity with an ohm meter. If a defective wire is found, retest that cylinder after replacing the wire.

9. If this is also not the problem, then either the sender or the ignition pack is defective.

10. Repeat procedures (1 through 9) on the inboard set of spark plugs.

11. A situation where both systems were defective would be very unlikely since a sender or an ignition pack would have to be defective on each system. Call customer service before proceeding further!

B. ENGINE WILL NOT START and no signs of spark are evident such as backfire or sputter:

1. Check for power at both packs using a voltmeter.

2. Remove the spark plugs and check for signs of fouling. A common problem on start up is "flooding" or fuel fouling of the spark plugs. Insufficient fuel can also keep the engine from firing, so check for an apparent total lack of fuel!

3. Check sender gap on both inboard and outboard units.

4. Install a timing light on #1 outboard wire. With <u>only</u> the outboard system on, crank the engine to check for spark. Repeat as necessary on the remaining wires to determine if a spark is being produced. (Do not crank engine for a prolonged period as this could damage the starter and the engine.)

   If a good spark is present on <u>all</u> plugs and the plugs were not fouled, there is probably not enough fuel present for start up.

5. If no spark is evident at ANY spark plug and if the voltage AND cranking speeds are good, either a sender or an ignition pack is probably bad. In this case, skip 6-8 and proceed to 9. If any of the plugs show signs of spark, proceed to 6.

6. If only one, two, or three of the spark plugs do not show signs of spark, then replace the questionable spark plugs and retest. (Defective spark plugs can cause this type of problem.)

7. If only one, two, or three of the spark plugs still show no evidence of a spark, remove the questionable spark plug wires from the defective cylinders. Check for continuity with an ohm meter. If a defective wire is found, retest that cylinder after replacing the wire.

8. If this is also not the problem, then either the sender or the ignition pack is defective.

9. Repeat this process on the inboard set of spark plugs.

10. A situation where both systems were defective would be very unlikely since a sender or an ignition pack would have to be defective on each system. Call customer service before proceeding further!

C. ENGINE RUNS ON ONE SYSTEM ONLY.

1. Check for power to the defective system using a voltmeter.

2. Install a timing light on a wire of the operable system to verify proper operation of the light. (Run the engine at an idle only.) Check to determine if any of the spark plugs of the defective unit are firing. Do this by checking each of them with the timing light at idle. IF NONE of the spark plugs show any sign of spark, proceed to C. IF ALL of the spark plugs of the defective system show signs of spark, warm the engine to operating temperature, and check for proper spark timing of the defective system. (See Parts Replacement-Ignition Pack section for timing check and adjustment procedures.) In addition to proper ignition timing, check for "stability" of timing. At constant RPM, the timing should remain steady! From idle to full RPM the timing will change with RPM but it should not change if the RPM does not change! If the timing does "jump" around at constant RPM, go to 3. If ONLY one, two or three of the spark plugs shows signs of a spark, check the defective cylinder(s) as described in 6-8 of the preceding section.

3. Check sender gap on the defective system.

4. Warm up the engine and verify good restart ability using the good system only. Disconnect the sender of the good system and connect the sender from the defective system. Remove the spark plug wires from the good system's ignition pack and reinstall them in the cylinder arrangement of the other ignition pack. (#1 wire on #2, #3 wire on #4, #2 wire on #1, and #4 wire on #3.) Try to start the engine using ONLY the "good" system. If the engine starts in this configuration then the ignition pack is bad on the other system.

5. If the engine would not run in the above configuration, the sender of the defective system is bad. In order to verify that the ignition pack of the defective system is not also defective, proceed as follows: Warm up the engine and verify good restart ability using the good system only. Connect the sender from the good system to the defective systems' ignition pack. Switch the spark plug wires of this pack in a similar manner as was done in (a) above. Exchange the spark plugs of the defective system with the spark plugs of the good system. Attempt to start the engine using ONLY the defective system. If the engine starts, the ignition pack of the defective system is good. If it doesn't start, the ignition pack is bad as well as the sender.

4. PARTS REPLACEMENT

A. SENDER

Removal: Disconnect the sender at the plug connector by lifting the lock tab and pulling the connector apart. Pull on the connector body only. Do not pull on the wires themselves! Loosen the jam nut on the set screw which locks the sender in place. Back off the set screw. Cut off the tie down straps for the sender wire and remove the sender. If it does not come out easily, carefully grab it with a pair of pliers and rotate it back and forth while attempting to pull it out. If the sender is to be used again, be careful not to damage it. Do not squeeze it too hard or damage from crushing may occur. Carefully support the wire when removing the sender or wires may break internally.

Installation: Deburr the sender hole in the starter mount if necessary. The sender must be able to slide in and out of the hole easily. Care should be taken to avoid elongating or enlarging the hole. Use compressed air to THOROUGHLY blow clean the area "inside" the starter mount which encloses the ignition timing wheel. (Chips could wedge between the wheel and sender causing damage to the sender.)

Rotate the engine (using a flywheel wrench) until a tooth of the timing wheel is exactly centered on the sender hole. A small mirror and flashlight will be needed to verify the proper positioning of the tooth. Apply a LIGHT film of anti-seize to the outside diameter of the sender. The end of the sender which is toward the timing wheel MUST remain clean and free of lubricant. Excess anti-seize will only contaminate the sender and act as a trap for dirt and chips.

Carefully insert the replacement sender in the hole. Place a .014" feeler gauge between the sender end and the timing wheel tooth. Firmly hold the sender against the feeler gauge and torque the set screw to 15 in-lbs. DO NOT OVER TORQUE THE SET SCREW OR THE SENDER CAN BE DAMAGED! While holding the set screw to keep it from turning, tighten the jam nut to 96 in-lbs. The feeler gauge should be able to be moved back and forth between the sender and the tooth ~ with a light drag. If the feeler gauge does not move easily, DO NOT force it. Loosen the jam nut and back off the set screw. Repeat the procedure until a proper gap is obtained. Verify a gap of .014" ±.003" on two other teeth which are located approximately 120 degrees on either side of the tooth used to set the gap. Do not leave the feeler gauge in place while rotating the flywheel as slight variations in gap could damage the sender. (Be careful if you rotate the flywheel clockwise as this will cause the blades to turn.)

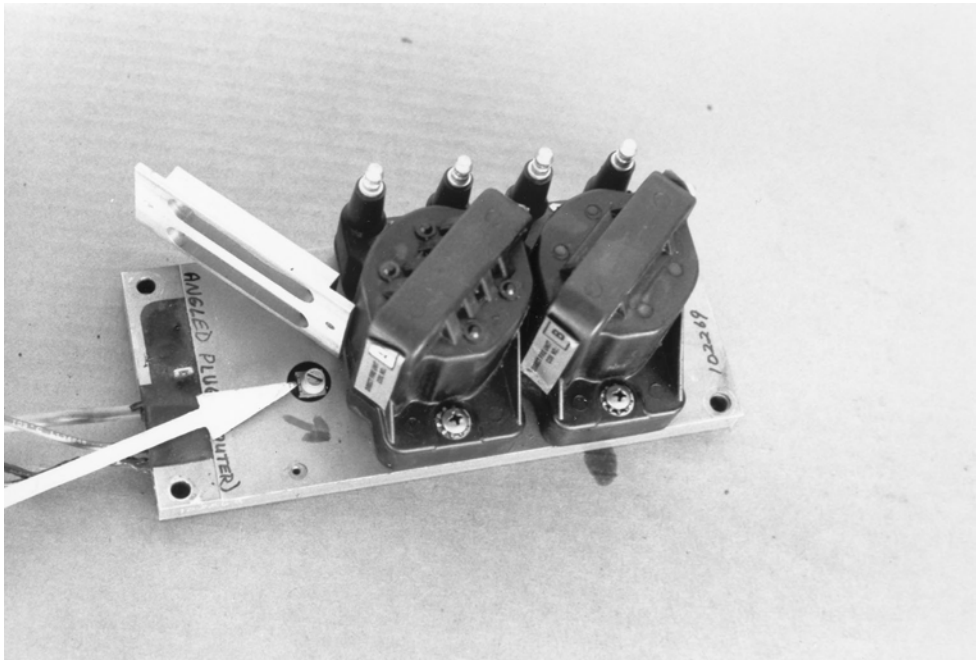
Using tie straps, secure the sender wire in such a way as to keep it from vibrating or being damaged by the heat from the exhaust. Reconnect the sender wire plug and make sure that the locking tab engages. (Route the wire according to the installation instructions.)

B. IGNITION PACK

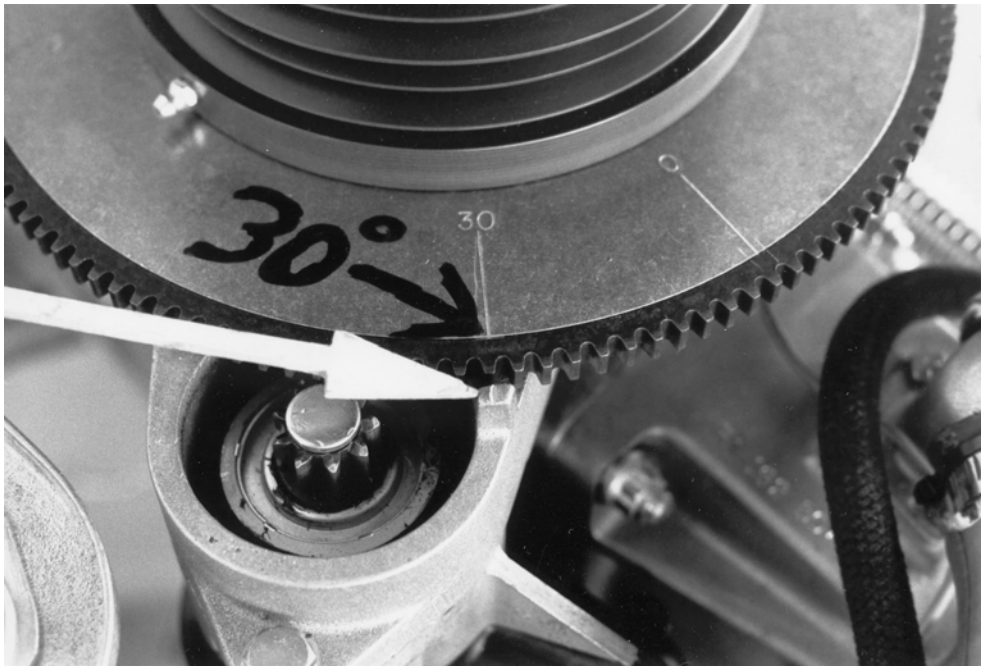
Replacement: The power MUST be off during the removal and installation of an ignition pack. Remove the spark plug wires, power connections, and tach wire. Disconnect the sender at the plug connector by lifting the lock tab and pulling the connector apart. Pull on the connector body only. Do not pull on the wires themselves! Unbolt and remove the ignition pack from the mounting plate.

Reinstall the replacement unit in the reverse order. Be careful to install the spark plug wires onto the correct coil towers. (Refer to the Ignition Installation Drawing.) Make sure that the tab is locked on the sender connector plug.

Remove the two screws from the timing adjustment cover and remove the cover. Note the location and position of the timing adjustment screw. Do NOT change the position of the screw! The unit should be set close enough to the proper timing specification to allow a proper start and warm up of the engine. (The unit was tested in the factory dynamometer and a timing adjustment was made at that time.)



(Install a timing light to the #1 spark plug wire of the unit replaced. There are two marks on the flywheel. One is 0 degrees or Top Dead Center position (TDC). The other is 30 degrees Before Top Dead Center (BTDC). You will notice that the 30 degrees BTDC mark has been "painted" yellow as has the timing mark on the starter mount. This has been done to help identify the marks when using the timing light.



Start the engine and allow it to warm up before making any timing adjustment. The ignition timing adjustment must be made at full operating RPM (4250). The correct timing at full RPM is 30 degrees BTDC. At full RPM, turn the timing adjustment screw to properly align the two marks. You will notice that as you bring the engine back to an idle the ignition timing changes. This is normal! The unit automatically changes the ignition timing as a function of RPM. At constant RPM, timing should remain steady.

Stop the engine and carefully replace the timing adjustment cover. Be careful not to move the timing adjustment screw. Restart the engine and verify proper full RPM timing.

C. SPARK PLUG WIRES

Spark plug wires should be replaced only with ones supplied by the factory. The use of incorrect spark plug wires can cause permanent DAMAGE to the ignition packs! This type of wire has been tested and verified to preform correctly. If a situation demands that you use different wires, they must be 8mm or larger and have not less than 5000 ohms per foot resistance. They must also have two piece steel spring contacts at both ends of the wire.

The spark plug wire supplied by the factory does NOT have 5000 ohms resistance per foot. The resistance is less than 700 ohms per foot unless they become damaged. It is a special grade of wire and has passed the testing required for its use. DO NOT use any wire because you "believe" it to be similar to the factory supplied type!

D. SPARK PLUGS

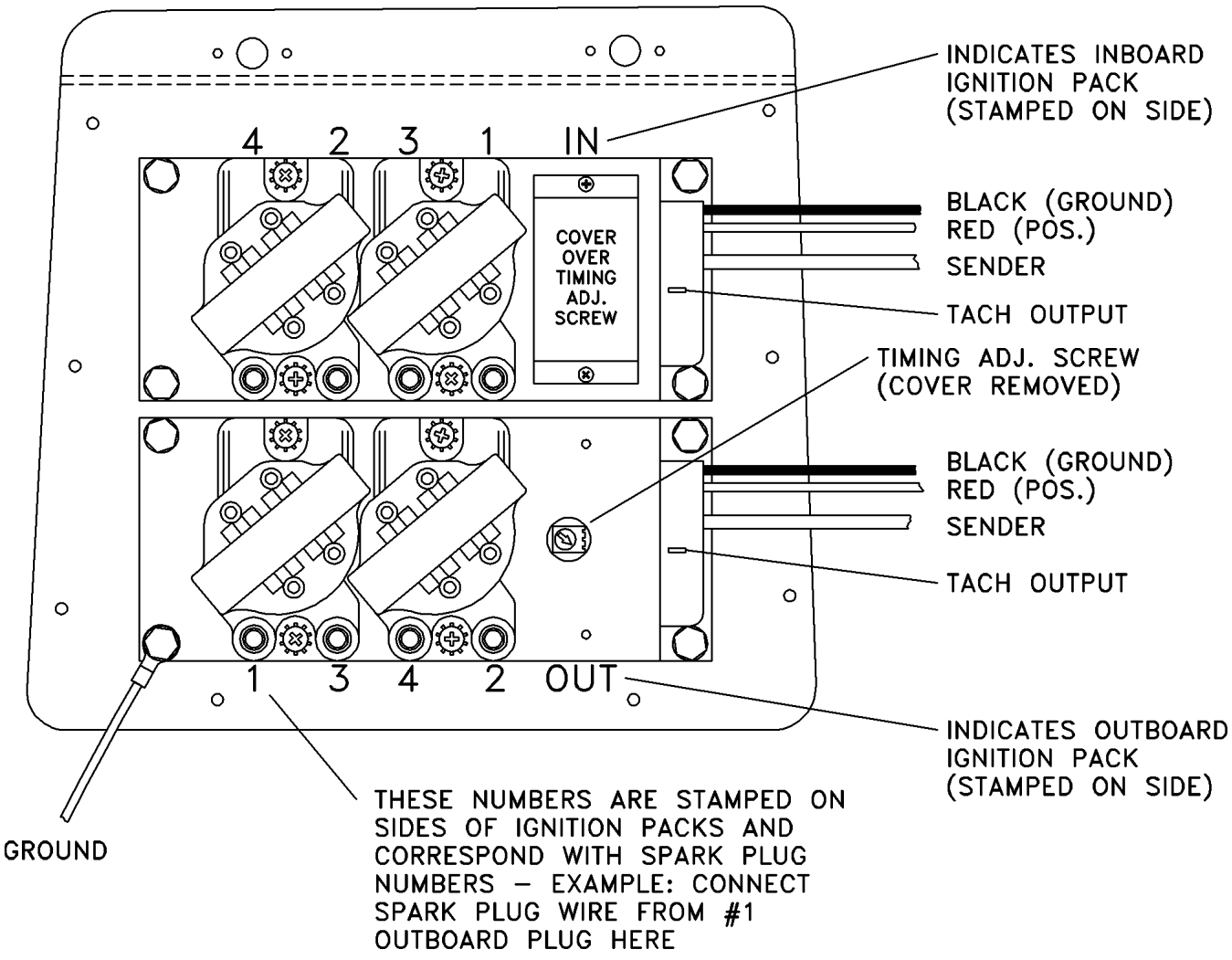
Use only direct replacement plugs. Do not change heat range and do not change to a non-resistor type plug. Damage to the ignition packs and to the engine can result from the use of incorrect spark plugs. Every 50 hours inspect and re-gap all spark plugs. Replace a plug at the first sign of damage or fouling. Mandatory replacement is 100 hours.

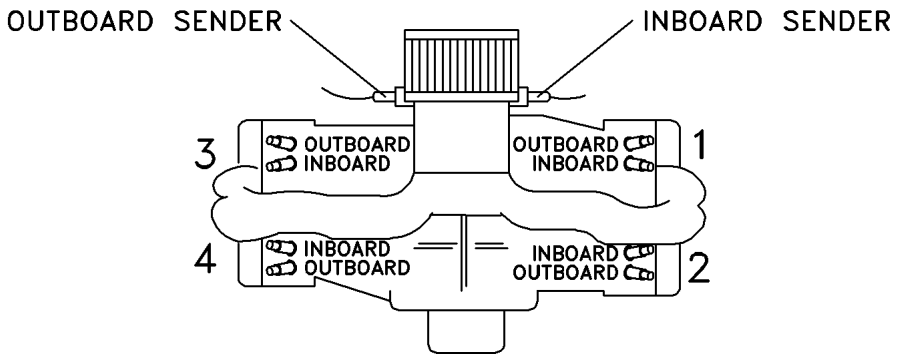
Change spark plugs only when the engine is cold!

Inspect each plug carefully before installation. Pay close attention to any possible damage of the threads. Always screw a spark plug in by hand only and then torque it. If a plug has to be turned in with a socket, damage to the threads in the cylinder head will probably occur.

Always pre-coat the threads of the spark plugs with a LIGHT film of anti-seize before installation. Secure the end cap onto the plug using Loctite # 271.

E. INSTALLATION DRAWING





F. VALVE TRAIN

1. VALVE COVER REMOVAL AND INSTALLATION:

A. Prior to valve cover removal, prepare for a small amount of oil to drain from the rocker box.

B. Remove the two bolts securing each cover and remove the cover.

C. Inspect the rubber O-rings on all four bolts and replace if necessary. Inspect the cover gaskets and replace, as necessary, using silicone adhesive to secure gasket to cover. (No silicone is used to install cover assembly onto engine.)

D. To install: Center the cover both vertically and horizontally over the cylinder head rocker box. When reusing the same gasket you should be able to feel when the cover slips into the previously formed depression. Insert the bolts and tighten finger tight only. Visually check to insure that only the gasket is contacting the cylinder head. Alternately torque bolts to 84 in. lbs. Repeat the process on the other cover.

CAUTION: Do not over tighten the valve cover bolts as this will cause the gasket to extrude and tear. Check for oil leaks after engine start up.

2. VALVE LASH ADJUSTMENT:

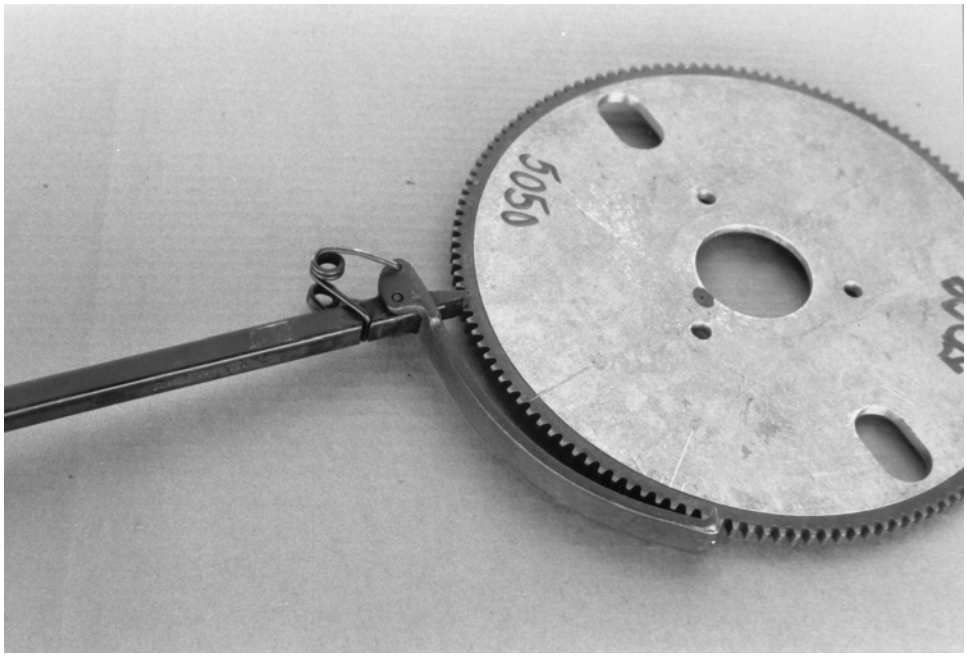
NOTE: VALVE ADJUSTMENTS CAN ONLY BE MADE WHEN THE ENGINE IS COLD. The engine must be COMPLETELY cooled down before you measure and adjust the valve lash!

A. MAKE SURE that the ignition switches are OFF.

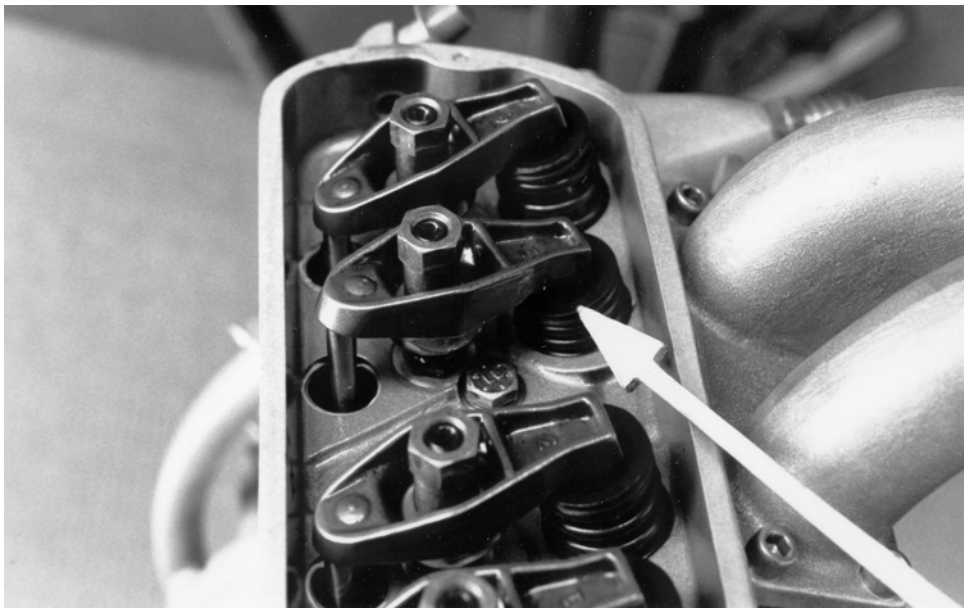
B. Remove both valve covers. (See "Valve Cover Removal")

C. Rotate the engine in a counter clockwise direction (looking down from the top) until one of the valves is FULLY open. (This is when the valve spring is completely compressed). The only way to rotate the engine is with a specially made tool which grips the flywheel ring gear. Two sources to obtain this tool are Snap On Tools and Mac Tools. DO NOT attempt to rotate the engine by engaging the starter or by rotating the main rotor blades by hand. This can cause damage to the rotor system and displace lead/lag adjustments. If making a valve lash adjustment with the main rotor blades attached, be aware that any movement of the engine in a clockwise direction will cause the blades to rotate.

FLYWHEEL ROTATION TOOL



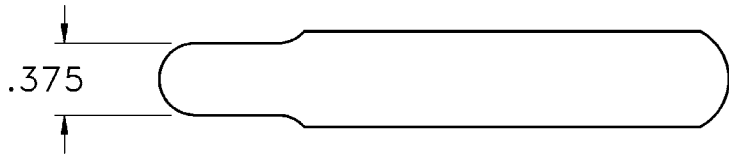
FULLY OPEN VALVE



D. The rocker directly opposite from the valve, which is fully open, is now ready for adjustment. Example: If the #1 exhaust valve is fully open, the #3 exhaust valve is ready for adjustment at the rocker.

E. Use the feeler gauge set which has been modified per the following drawing. Measure the clearance as follows: Insert the blade between the rocker and the lash cap. While moving the rocker up and down, center the rocker on the valve. The proper size is determined when the feeler gauge has a light drag when moved back and forth. (The feeler gauge must be a snug fit and not easily slide in and out between the valve and rocker.)

Narrow the required feeler gauges as shown.
Leave a smooth round edge.

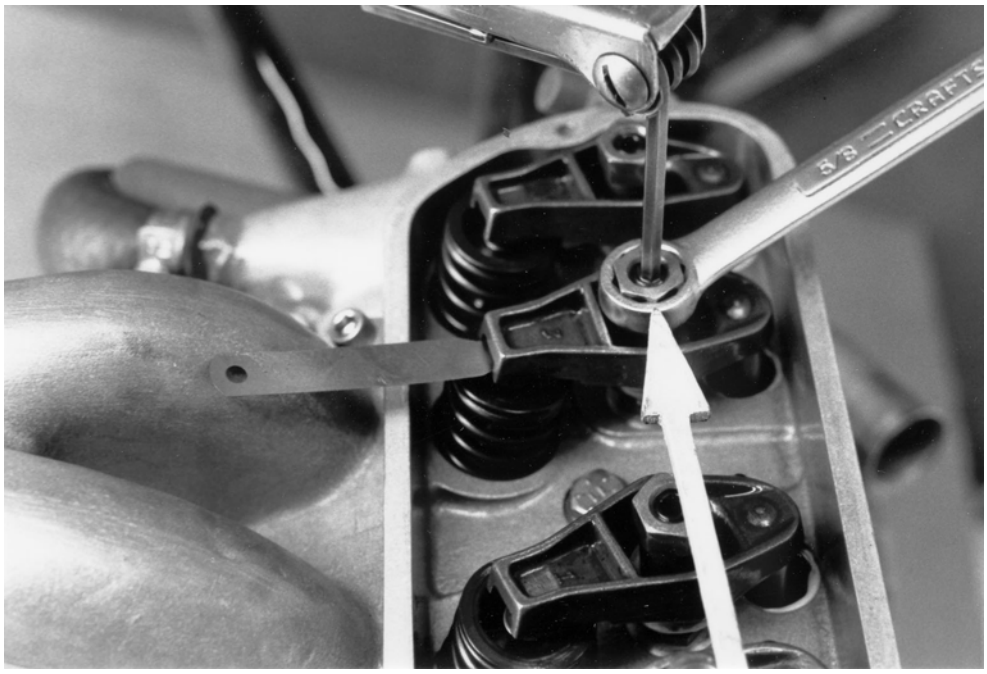


IT IS IMPORTANT to measure the lash before any adjustment is made. In addition to making the correct adjustment you are also monitoring the valve train for excessive wear of parts. A clear and simple indication of wear in the valve train is the development of excessive lash on anyone rocker. For this reason it is recommended that you keep records of all valve lash adjustments.

Any time a lash measurement is made and several of the valves have a lash of more than .008", this is a clear indication that you need to make more regular adjustments. Any lash found in excess of .008" warrants an inspection of the corresponding lash cap.

WARNING: Because of the design of the camshaft in the RI 162 engine, it is essential that proper lash be maintained. Excessive lash will cause damage to the lash caps, pushrods, camshaft, and the timing gear.

F. If adjustment is required: Loosen the set screw and rocker nut. With the .004" feeler gauge in place, tighten the rocker nut by hand until the feeler gauge is snug when you move the rocker up and down. Hold the nut in place and tighten the set screw to 120 in. lbs. Check the adjustment. The .004" feeler gauge should easily slide between the rocker and the lash cap. When moving the rocker up and down, if the .006" feeler gauge can be inserted, it must have a light drag when moved back and forth between the rocker and lash cap. It should not move in and out loosely. (The reason that you should first turn the rocker nut down snug by hand is that the tightening of the set screw causes the nut to back off slightly and loosen up your adjustment. A little practice will give you the right feel for the process.)

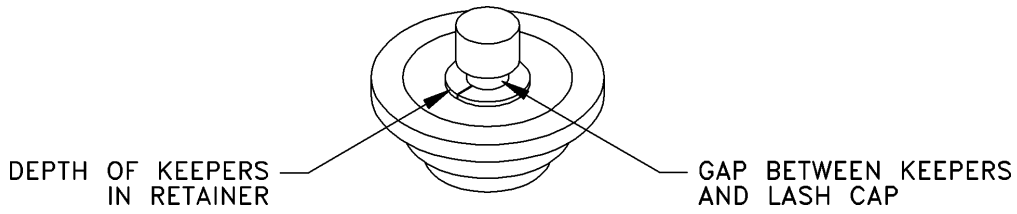


G. Rotate the engine until another valve is fully open. Measure and adjust the lash on the valve opposite it in the same manner. Continue the process until ALL of the valves are measured and adjusted.

3. VALVE TRAIN INSPECTION:

* **A.** **NOTE:** The following 3 inspections should be done every 25 hours. They should be performed prior to each valve lash measurement. While these parts "normally" do not wear and require no maintenance, it is important to monitor their condition in order to prevent a failure.

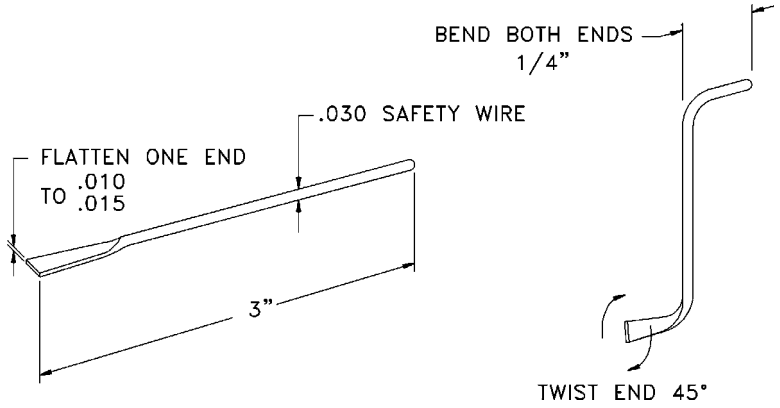
1. Spring Retainer: Note the relative depth of the keeper set in each spring retainer. You may notice a slight variance on different valves, but no keeper set should be sunk deeply into a retainer. The important thing to look for is any change in the relative position of each keeper set. If you determine that a keeper set seems to be sinking deeper into its retainer do not continue to operate the engine. Call customer service for further instructions.



2. Valve Stem - Spring Keeper: If you look closely at the top of each valve assembly you will notice a gap between the lash cap and the spring keepers. If excessive wear occurs between the valve and the keepers, this gap will decrease and eventually the lash cap will contact the keepers. Continued wear beyond this point can cause engine failure. This gap is normally between .020" and .030". While it is not necessary to measure this gap exactly, it is important to note any radical change. Use the following drawing to make a "wire gauge" which will be used to monitor this gap on each valve. The .010"/.015" end should easily fit into the gap. The .030" end should fit snugly if it will go into the gap at all. Do **not** continue to operate the engine if a keeper contacts a lash cap. Call customer service for further instructions if **any** wear of these components is apparent.

WIRE GAUGE

Use a piece of .030" safety wire to fabricate this gauge. A hammer is used to flatten one end of the wire to a thickness of .010"/.015".



* 3. Valve Guide: If excessive wear occurs between a valve and valve guide, the guide will develop an "hour glass" shape on its inside diameter. This can cause excessive oil consumption and if the wear becomes extreme it will cause engine failure by damaging the valve itself. To inspect for wear: Rotate the engine to the proper position for valve adjustment of the individual valve/valve guide to be inspected. Prior to measuring and adjusting the valve lash, grasp the valve spring retainer with your fingers and move it up and down. During this process look between the coils of the valve spring and watch the part of the valve stem which protrudes from the guide. Wear would be evident by excessive movement and by a visible "gap" between the valve stem and guide. You will need to use a fair amount of pressure to get any movement, but under all conditions never use a tool to pry on the assembly. Since this is a difficult area to view it might be helpful to use a small inspection light. Next try to move it from side to side while looking for valve stem movement. Abnormal wear will usually cause more movement in one direction than in the other. This is a subjective measurement since the valve spring is trying to keep the valve from moving and varying degrees of pressure will cause different amounts of deflection. However, you should be able to notice a difference between a "normal assembly" and one which has excessive valve guide wear. If you determine that a valve may have more "play" than normal proceed as follows: Remove the rocker arm, (see Valve Train-Lash Cap, Rocker and pushrod Inspection). Carefully install an external valve spring compressor on the suspect assembly and compress the spring just enough to allow unrestricted movement of the valve. (It is not necessary to remove the lash cap.) Without the interference of valve spring pressure you should be able to verify if the guide has excessive wear. If this is the case OR if you have any questions regarding these procedures DO NOT continue to operate the engine! Call Customer Service for additional instructions.

B. Lash Cap, Rocker and Pushrod: Perform if lash is found to be in excess of .008". Rotate the engine to the proper position for valve adjustment of the individual valve to be inspected. (See Valve Adjustment). Loosen the set screw and rocker nut. Remove the rocker nut with set screw. Set it and all additional parts on a clean surface for inspection and replacement in the engine. Carefully remove the rocker and the ball. Remove the pushrod taking note of which end goes against the rocker and which end goes into the pushrod tube. Inspect the lash cap for wear. The top surface which comes in contact with the rocker should not be "dished out". It should also be relatively snug on the valve and certainly should not rock at all on the valve. Replace as necessary. Visually inspect the rocker and the pushrod for any signs of excessive wear. Roll the pushrod on a flat surface to ensure that it is not bent. Replace any part as necessary. Replace the parts exactly as removed.

CARE MUST BE TAKEN that the pushrod is properly seated in both the rocker and in the lifter, (at the bottom of the pushrod tube). A common error is to have the pushrod improperly located in the rocker arm. Adjust the lash as per instructions in the lash adjustment section. After the adjustment has been made, slowly rotate the engine through two complete revolutions and repeat the valve adjustment as necessary. Continue this process until lash remains unchanged after two complete revolutions. If any parts were replaced, a valve adjustment should be performed hourly until the lash stabilizes.

NOTE: When replacing a lash cap, it is important to seat it on the valve completely. Tapping the lash cap onto the valve with a **plastic** tipped hammer may be necessary. It is important that the piston is not near the top of its stroke when tapping on the lash cap. Removal of a spark plug will allow verification of this. Observing the gap between the lash cap and the keeper will ensure that the lash cap is seated properly.

NOTE: When replacing lash caps it is important to realize that an intake lash cap is different from an exhaust lash cap. The "cavity" on an exhaust lash cap is .120"/.125" deep. This depth on an intake lash cap is .145"/.150". Incorrectly installing an intake lash cap on an exhaust valve would result in the lash cap hitting the valve keepers.

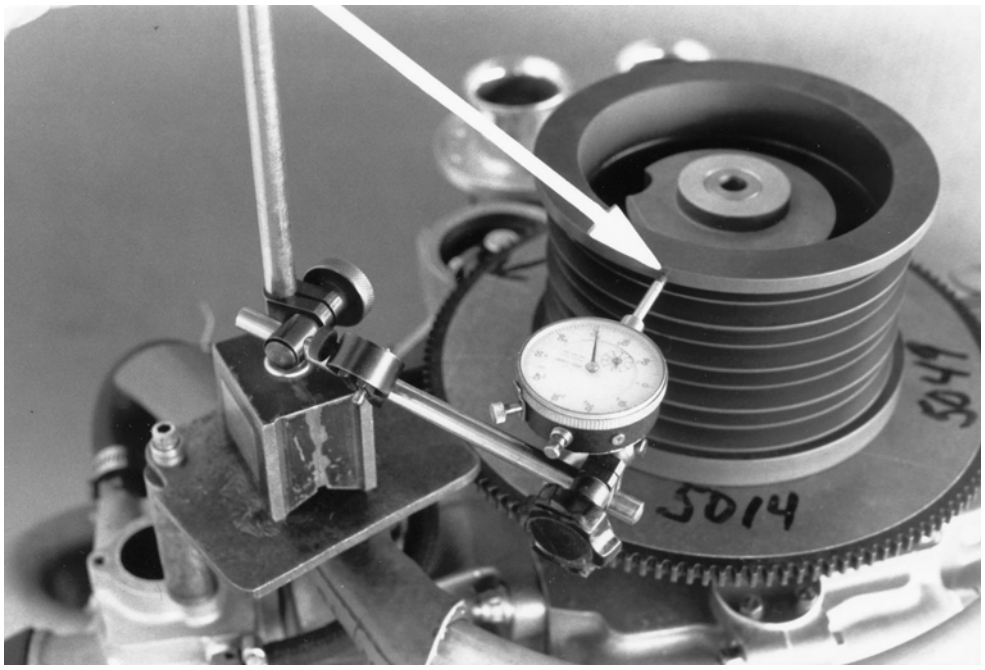
C. Camshaft Lift Inspection: This need only be done if excessive valve adjustment is repeatedly performed on a valve AND on the valve directly opposite it, suggesting wear or breakdown of a cam lobe. Remove the valve cover from one side of the engine and mount a 1" dial travel indicator exactly parallel with the valve and contacting the "flat" of the valve spring retainer. (This is generally done with a magnetic base type indicator mounted on a fabricated steel plate attached locally to the rocker box.)

Camshaft lift inspection (Cont'd.): Zero the indicator when the engine is in the position to adjust that particular valve. Rotate the engine through two complete revolutions and note the maximum lift generated at the valve. Compare your findings with the specifications in the Component Specification And Wear Limit Section of this manual. If you find that a reading appears to be out of tolerance, take a reading on the valve directly opposite the "suspect valve" to verify that the problem is with the cam lobe and not something else. This is not an inspection that is regularly performed. It need only be done at 500 hour intervals unless a problem warrants the inspection.

G. MAIN DRIVE PULLEY

1. REMOVAL: The drive pulley, flywheel and drive flange are indexed with punch marks. Note the mark on the base of the pulley and on the flywheel next to it. These should be lined up upon reassembly. After the pulley is removed, you will see another punch mark on the flywheel next to a mark on the drive flange. These must also be lined up on reassembly. In order to keep the engine from rotating while the bolts retaining the pulley are removed, hold the flywheel with the special flywheel rotating tool. Loosen and remove the three bolts, pulley and the flywheel. There may be a shim between the pulley and the flywheel. If there is, outline its location for reassembly.

2. INSTALLATION: Clean all surfaces of the parts to be reassembled. Place the flywheel on the drive flange aligning the index marks. Insert all three bolts with washers in the pulley prior to positioning it onto the flywheel. Align the index marks and carefully lower the pulley onto the flywheel. Lightly snug, then torque each of the bolts to 28 ft. lbs. Remove one spark plug from each cylinder. Prior to removal, clean the area around each plug to avoid dirt contamination of internal engine parts. Using a dial indicator, check the "run out" of the main drive pulley when rotating the engine. This is usually done by attaching a fabricated steel plate to the engine and mounting the indicator on a magnetic base.



The indicator should contact the pulley on the outside surface approximately .150" from the top of the pulley. The total indicated run out reading must be .004" or less. If it is not, the pulley can be moved to a different position on the flywheel. If it still runs out too much, a shim will have to be added between the pulley and the flywheel in order to correct the problem. Once the pulley meets the run out requirement, remove one bolt and reinstall it using Service Removable Loctite #242. Repeat the process on the other two bolts. Removing, applying Loctite, replacing, and re-torquing the bolts one at a time should not change the run out, but recheck the reading to be sure.

3. BEARING REPLACEMENT: This is a service offered by the factory. Refer to the Parts List of the Main Drive pulley when performing this maintenance. Remove the snap ring from the shaft. Deburr the shaft. Heat the assembly to 275 degrees F. DO NOT exceed 300 degrees F. at any time during this procedure! Carefully support the pulley and press out the shaft-drive cup assembly. Remove the snap ring which retains the bearings in the pulley. Carefully de burr the snap ring groove area of the pulley. Reheat the pulley to 275 degrees. Carefully support the pulley and press out the bearings and spacer. Allow all parts to air cool.

   Remove the grease fitting and thoroughly clean the pulley including the bearing bore and the drilled passageways. All traces of Loctite must be removed and the bearing bore must be carefully deburred. Use acetone to final clean the bearing bore. Replace the grease fitting. Similarly clean the drive cup assembly and the bearing spacer. Place the drive cup assembly in a freezer, place the pulley in an oven and heat to 275 degrees F.

Wipe all surface lubrication from the replacement bearings. Using an air grinder with an abrasive disk, grind a notch in one of the bearings. (Use the old bearing as a guide.) Use acetone to clean the I.D. and O.D. of both bearings. Remove one seal from each bearing by carefully prying them out with a small screwdriver. (On the one bearing, remove the seal from the side with the notch.) Put a light film of #609 Loctite on the O.D. of both bearings.

Remove the pulley from the oven and install the bearings and the bearing spacer. It is important that the notch in both the bearing and in the spacer line up with the drilled passageway upon assembly. The seal remaining in each bearing must face out! If the pulley was properly prepared, the bearings should drop in. However, carefully align the bearings when assembling and be prepared to use an arbor press if necessary. The bearings must be pressed by contact on the outer race and not on just the inner race. Install the snap ring in the pulley. Remove the cup assembly from the freezer. Put a light film of #609 loctite on the portion of the shaft which will contact the top bearing. Similarly place a light film on the I.D. of the bottom bearing. Immediately install the cup assembly. It should drop in. If the press is required, only light pressure is allowed or damage to the bearings could occur. Wipe off any excess Loctite from the bottom of the shaft and install the snap ring. Allow the assembly to cool and slowly pump 10 shots of grease into the pulley while rotating the drive cup.

SECTION III. START UP AND ENGINE RUN IN PROCEDURES

A. INTRODUCTION

It is important that you read this entire manual as vital procedures are contained throughout. Each section contains relevant information essential to properly start and operate the powerplant. Failure to follow all of these procedures may damage the engine. Monitor the RI-162 engine very closely especially during the first 5 hours of operation.

DO NOT idle the engine for extended periods of time. The RPM and LOAD must be varied for most effective "run in". The engine should NEVER be idled for longer than is necessary. On shut down, idle the engine only long enough to cool down and stabilize the engine components. A water temperature drop of 5-10 degrees F. after set down from a hover is adequate for component stabilization.

Follow the maintenance requirements closely. Frequent inspections will expose the need for adjustments before problems and damage occur. This initial experience may also direct you toward additional inspections and adjustments up to and beyond the increments outlined in this manual.

WARNING: DO NOT operate the RI-162 powerplant in a rough running condition under load. (High frequency vibration or roughness in the engine is readily felt through the foot pedals in the ship). This condition may be due to misfiring.

The initial start up procedure on the engine will require at least two people. Each person should have definite responsibilities. A comprehensive review of all procedures and related duties ahead of time will eliminate most of the confusion during the exciting first few minutes of engine operation. Proper preplanning and complete comprehension of all material contained in this manual are essential ingredients to a successful operation of the powerplant.

B. MAINTENANCE REQUIREMENTS

FIRST HOUR SERVICE

* **1.** **ADJUST VALVES & INSPECT VALVE TRAIN:** If any adjustment is necessary at one hour, valve adjustment should be repeated hourly until the lash stabilizes. (Initial "break in" of the valve train may require several hourly adjustments. It is extremely important to make these adjustments.)

2. **INSPECT COOLING SYSTEM:** Check entire system, including engine, for any sign of leakage. Check the security of all clamps, making sure the clamps are past the flared positions of the tube. Check the hoses, making sure there is no interference with vibrating or rotating parts or any sign of heat damage.

3. **INSPECT OIL SYSTEM:** Check entire system for any sign of leakage. Check the security of all oil line connections. Also check the lines for proper clearance from vibrating parts and heat sources.

4. **INSPECT FUEL SYSTEM:** Check the security of all fuel lines and check for any signs of leakage on the entire system.

5. **INSPECT IGNITION SYSTEM:** Check all wiring including spark plug wires for proper mounting and condition. Replace any spark plug wire that shows any sign of damage.

6. **INSPECT THROTTLE CONTROL:** Check return spring and linkage for proper adjustment and freedom of movement.

7. **INSPECT EXHAUST SYSTEM:** Check the entire exhaust system for cracks and leaks. A proper fit of each exhaust manifold to its mating port is important. This can be verified while idling the engine and positioning your finger approximately 1/2" away from the exhaust ports. Test all the way around the circumference of each port for any escaping gases. If no turbulence is felt within the proximity, you can be assured that the system will be sufficiently leak free at full RPM.

Check the security and condition of all exhaust related shielding.

NOTE: All four gaskets should be replaced at the first hint of flange leakage.

WARNING: Any type of exhaust system leak may allow carbon monoxide fumes to enter the cabin area. Exposure to these fumes can be fatal and any indication of leakage must be corrected before operation is continued.

FIRST FIVE HOUR SERVICE

1. **CYLINDER HEAD BOLT TOROUE:** Check all accessible cylinder head bolts for correct final torque. If any of them move at the final torque setting, remove rockers as necessary to access all bolts and torque them all in the proper sequence to the final torque specification. (See Cylinder Head Torque Pattern.)

   NOTE: The engine MUST be cold to torque cylinder head bolts.

2. **REPEAT ALL FIRST HOUR ITEMS**

FIRST TEN HOUR SERVICE

1. **CHANGE OIL AND FILTER**

2. **CLEAN CARBURETOR MOUNTED FUEL SCREEN**

3. **CHECK TO ROUE ON THE INTAKE MANIFOLDS**

4. **CHECK TOROUE ON THE CARBURETOR MOUNTING BOLTS**

5. **REPEAT ALL FIRST HOUR ITEMS**

FIRST 25 HOUR SERVICE

* 1. **TOROUE CYLINDER HEAD BOLTS:** Following the torque sequence diagram on page 73, loosen the first cylinder head bolt approximately 1/2 turn (or until the bolt moves freely). Then re-torque the bolt to proper specifications. Repeat this process on the remaining bolts, in the proper sequence. Remove rockers as necessary to access all head bolts. Note: The engine must be cold when torquing these bolts.

2. **PERFORM ALL "REGULAR" 25 HOUR SERVICE ITEMS**

SECTION IV. INSPECTION AND MAINTENANCE SCHEDULE

A. INTRODUCTION

The following schedule is presented as a guide to the regular maintenance required on the engine. It should be followed exactly, as all of the procedures are essential to achieving a long lasting and reliable powerplant. In no way does this mean this is all of the maintenance YOUR engine may require! By closely monitoring all systems and analyzing any problems you encounter, you may find that you need to increase the amount of the attention you give to an individual system or component. Obviously if any problem is encountered either at a regular maintenance interval or during post or pre flight inspections, immediate action must be taken and you will need to closely monitor the situation until you are certain that the problem is completely resolved.

Each service is to be performed at every increment in the life of the powerplant.

The procedures necessary to complete each maintenance item are covered in the Individual System Procedures section of the manual.

B. 25 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 25 hours.

1. **CHANGE OIL AND FILTER**

2. **AIR FILTER:** Clean as necessary and inspect for damage. (See Carburetor Section for cleaning procedure).

3. **GREASE MAIN DRIVE PULLEY:** Refer to Specification Section for correct type and quantity.

4. **ADJUST VALVES & INSPECT VALVE TRAIN:** Also, if any initial measurement is in excess of .008", inspect the lash cap for wear and repeat valve adjustment at one hour intervals until the lash stabilizes. If repeated excess lash is encountered, all related valve train components should be inspected.

5. **INSPECT COOLING SYSTEM:** Check entire system, including engine, for any sign of leakage. Check the security of all clamps, making sure the clamps are past the flared positions of the tube. Check the hoses, making sure there is no interference with vibrating or rotating parts or any sign of heat damage.

6. **INSPECT OIL SYSTEM:** Check entire system for any sign of leakage. Check the security of all oil line connections. Also, check the lines for proper clearance from vibrating parts and heat sources.

7. **INSPECT FUEL SYSTEM:** Check the security of all fuel lines and check for any signs of leakage on the entire system.

8. **INSPECT THROTTLE CONTROL:** Check return spring and linkage for proper adjustment and freedom of movement. Check cable ends and cable for wear.

9. **INSPECT EXHAUST SYSTEM:** Check entire exhaust system for cracks and leaks. Proper fit of each exhaust manifold to its mating port is important. Proper fit can be verified while idling the engine and positioning your finger approximately 1/2" away from the exhaust ports. Test all the way around the circumference of each port for any escaping gases. If no turbulence is felt within the proximity, you can be assured that the system will be sufficiently leak free at full RPM.

   Check the security and condition of all exhaust related shielding.

C. 50 HOUR SERVICE

NOTE: The following maintenance item is to be performed **EVERY** 50 hours.

1. **SPARK PLUGS:** Re-gap all spark plugs to specification. Check all spark plugs for proper burning. The central ceramic insulator should be a light tan in color, the outside barrel should be light charcoal to dark brown in color. (Prolonged idling of the engine will cause a black soot to form on the spark plugs which will shield visibility of the above determination of colors.) The electrode should have sharp square edges. Replace a spark plug if any sign of wear or damage is evident.

D. 100 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 100 hours.

1. **REPLACE SPARK PLUGS:**

2. **TORQUE CYLINDER HEAD BOLTS:** Following the torque sequence diagram on page 73, loosen the first cylinder head bolt approximately 1/2 turn (or until the bolt moves freely). Then re-torque the bolt to proper specifications. Repeat this process on the remaining bolts in the proper sequence. Remove rockers as necessary to access all head bolts. Note: The engine must be cold when torquing these bolts.

3. **INSPECT IGNITION SYSTEM:** Check all wiring including spark plug wires for proper mounting and condition. Replace any spark plug wire that shows any sign of damage. Using compressed air, blow clean the area of the starter mount enclosing the timing wheel. Check both senders for proper gap and security.

4. **TEST CYLINDER LEAKAGE:** using a cylinder leak down tester, measure the % leakage of each cylinder. If above 15%, determine source of leakage and repair. With tester hooked up, listen for air leakage at:

   Tail pipe (leaking exhaust valve)
   Carburetor intake (leaking intake valve)
   Oil sump breather (leaking by piston rings)

5. **CALIBRATE FUEL FLOW**

E. 250 HOUR SERVICE

NOTE: The following maintenance item is to be performed **EVERY** 250 hours.

1. REPLACE AIR FILTER

F. 500 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 500 hours.

1. REBUILD CARBURETOR: Completely disassemble and inspect for any signs of wear. Reset to proper specifications and replace all gaskets and seals. If damage to any aspect of the carburetor body is evident, replace the entire assembly. This service is offered by the factory.

2. REBUILD CYLINDER HEADS: Specifications have been given to perform this service and all of the necessary parts are available from the factory. This is a critical and complex task and should not be attempted by anyone who is not familiar with all aspects of cylinder head rebuilding. This service is offered by the factory.

3. INSPECT CAMSHAFT LIFT

4. REPLACE CAM GEAR: This is a critical and complex task and should not be attempted unless you are familiar with camshaft timing measurement and adjustment! This service is offered by the factory.

5. REPLACE MAIN DRIVE PULLEY BEARINGS: This service is offered by the factory.

* **6. REPLACE SPARK PLUG WIRES**

* **7. REPLACE ALL WATER HOSES**

* These items are to be replaced every two years even if 250 hours of operation has not occurred.

G. 1000 HOUR SERVICE

NOTE: The following maintenance item is to be performed EVERY 1000 hours.

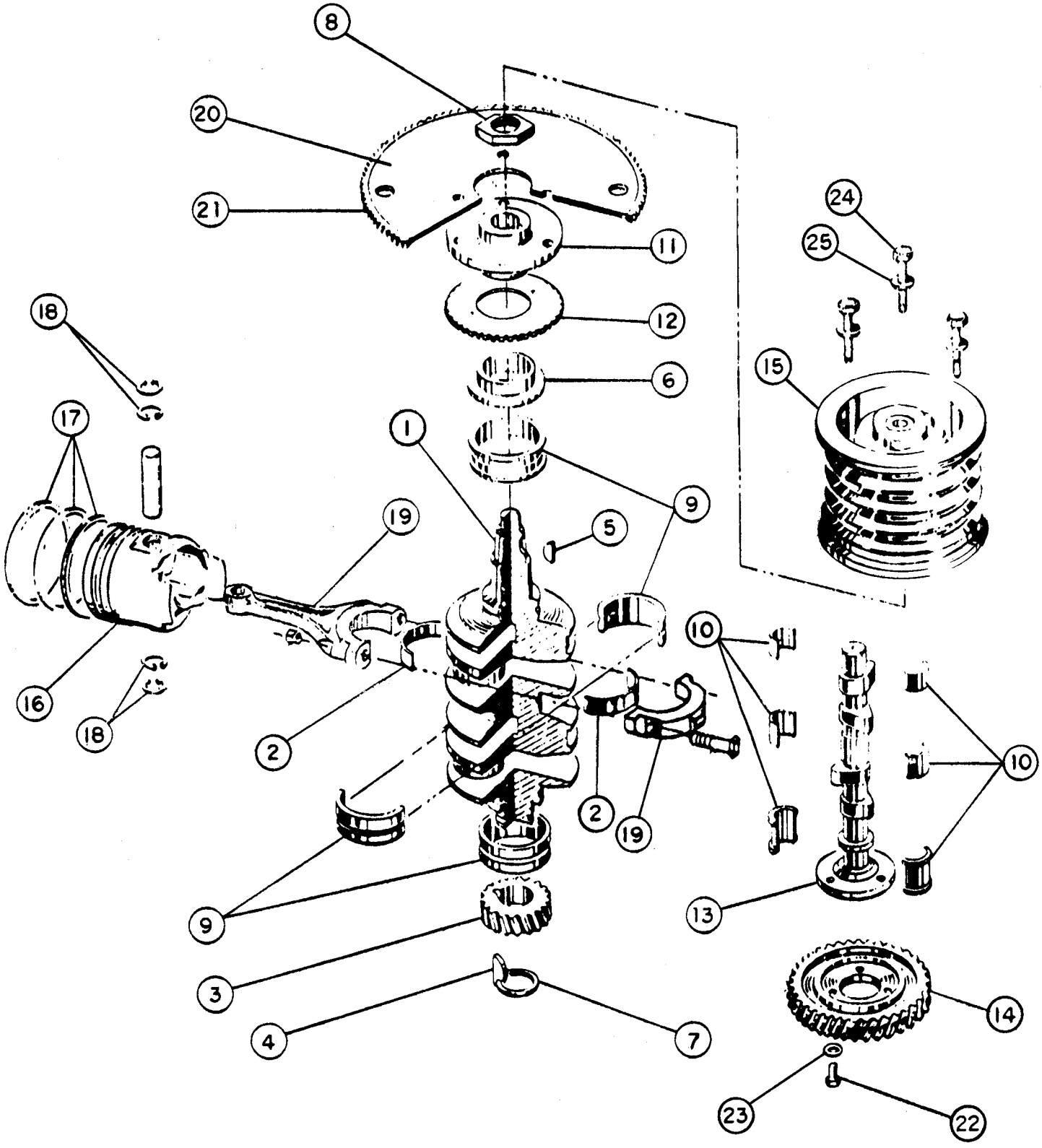
1. **COMPLETE ENGINE OVERHAUL:** This is a critical and complex task. It is recommended that this service be performed only by the factory and not by anyone else even if they are familiar with all aspects of internal engine overhaul. However, specifications have been given to perform this service and all the necessary parts are available from the factory.

SECTION V. DRAWINGS & PARTS LIST

A. ROTATING PARTS ASSEMBLY 24-1000

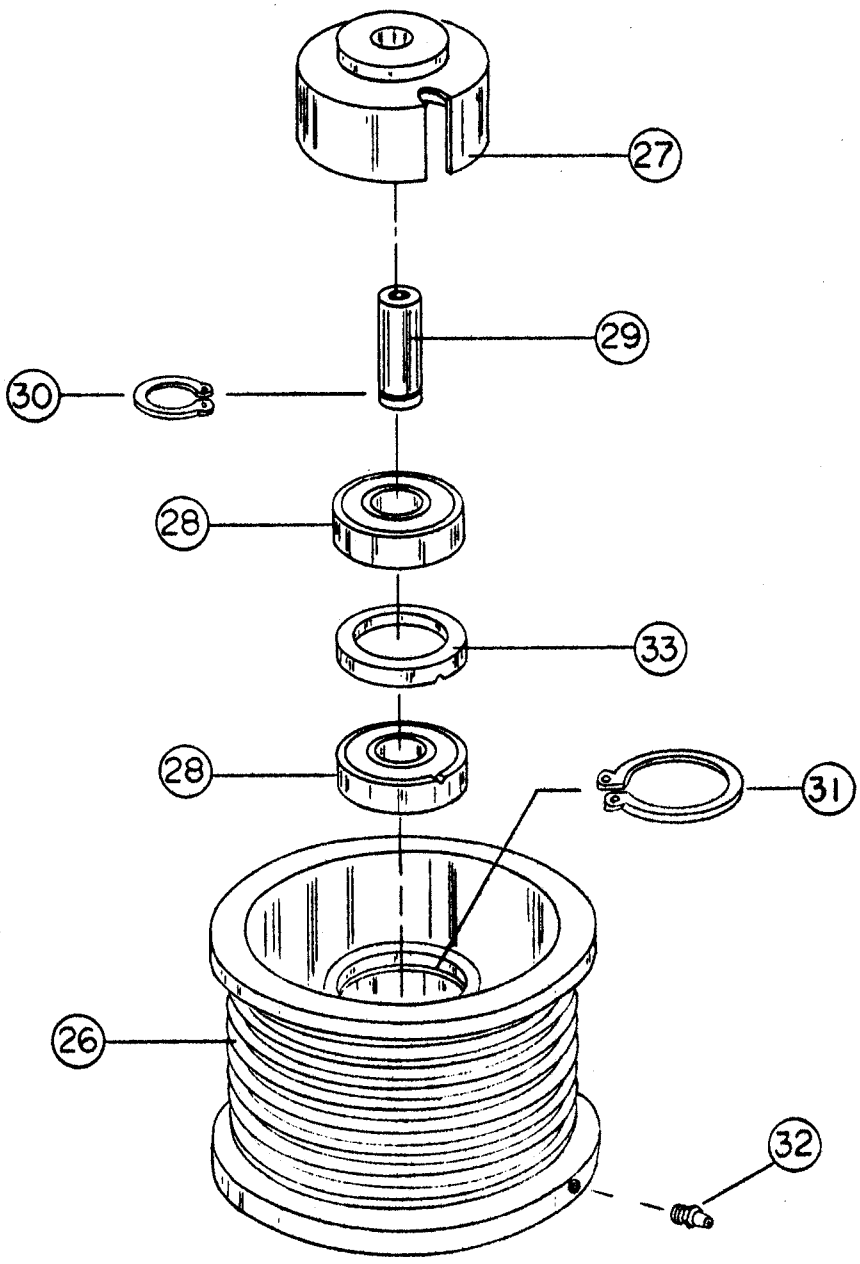
REF. #	PART #	DESCRIPTION	QTY. PER
1	24-1001	Crankshaft	1
2	24-1005	Rod Bearing Set	1
3	24-1006	Crank Gear	1
4	24-1007	Key-Crank Gear	1
5	24-1008	Key-Drive Flange	1
6	24-1009	Flange-thrust	1
7	24-1011	Snap Ring-Gear	1
8	24-1012	Nut-Crank	1
9	24-1013	Main Bearing Set	1
10	24-1014	Cam Bearing Set	1
11	24-1201	Flange-Main Drive	1
12	24-1210	Ignition Sensor Wheel	1
	24-1300	Crankshaft & Flange Assy	1
13	24-1501	Camshaft	1
14	24-1502	Cam Gear	1
15	24-1600	Main Drive Pulley Assy	1
16	24-1702	Piston (W/Pin & Snap Rings)	4
17	24-1704	Piston Ring Set	4
18	24-1710	Snap Ring-Piston	16
19	24-1800	Connecting Rod	4
	24-1900	Flywheel Assy	1
20	24-1901	Flywheel	1
21	24-1902	Ring Gear	1
22	E00-2526	Bolt - 5/16-24 X 1/2 (SHCS)	3
23	E00-4501	Washer - AN960-516	3
24	E00-2611	Bolt - 3/8-24 X 1 1/4 (SHCS)	3
25	E00-4600	Washer - AN960-616	3
	E00-2310	Bolt - 10-32 X 1/2 (SHCS)	2

ROTATING PARTS ASSEMBLY 24-1000



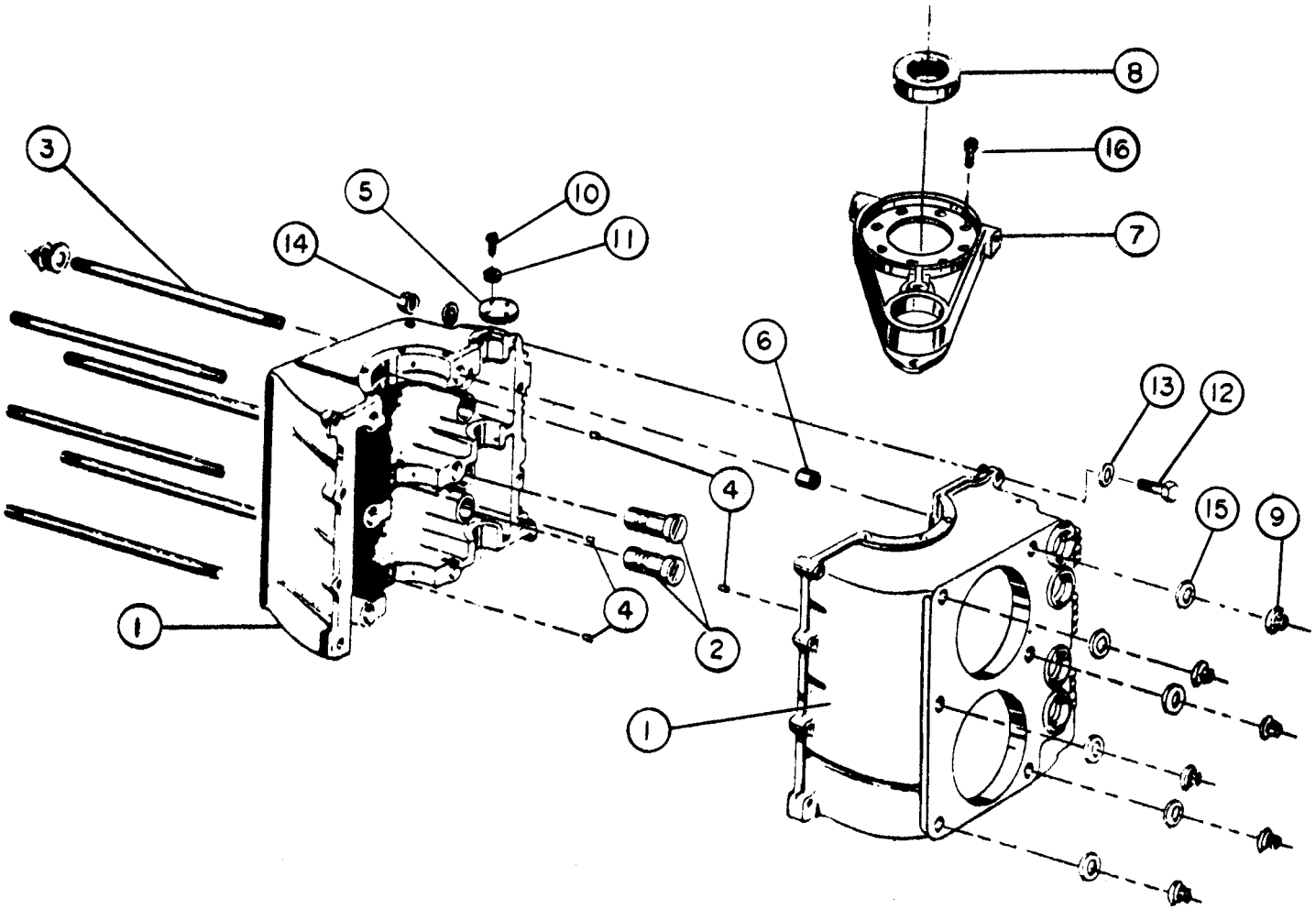
A. ROTATING PARTS ASSEMBLY 24-1000

REF. #	PART #	DESCRIPTION	QTY. PER
26	24-1610	Main Drive Pulley	1
27	24-1601	Upper Drive Cup	1
28	24-1602	Bearing	2
29	24-1603	Shaft	1
30	24-1604	Snap Ring-Small	1
31	24-1605	Snap Ring-Large	1
32	24-1619	Grease Zerk	1
33	24-1620	Bearing Spacer	1



B. CRANKCASE & LOWER COVER ASSEMBLY 24-2000

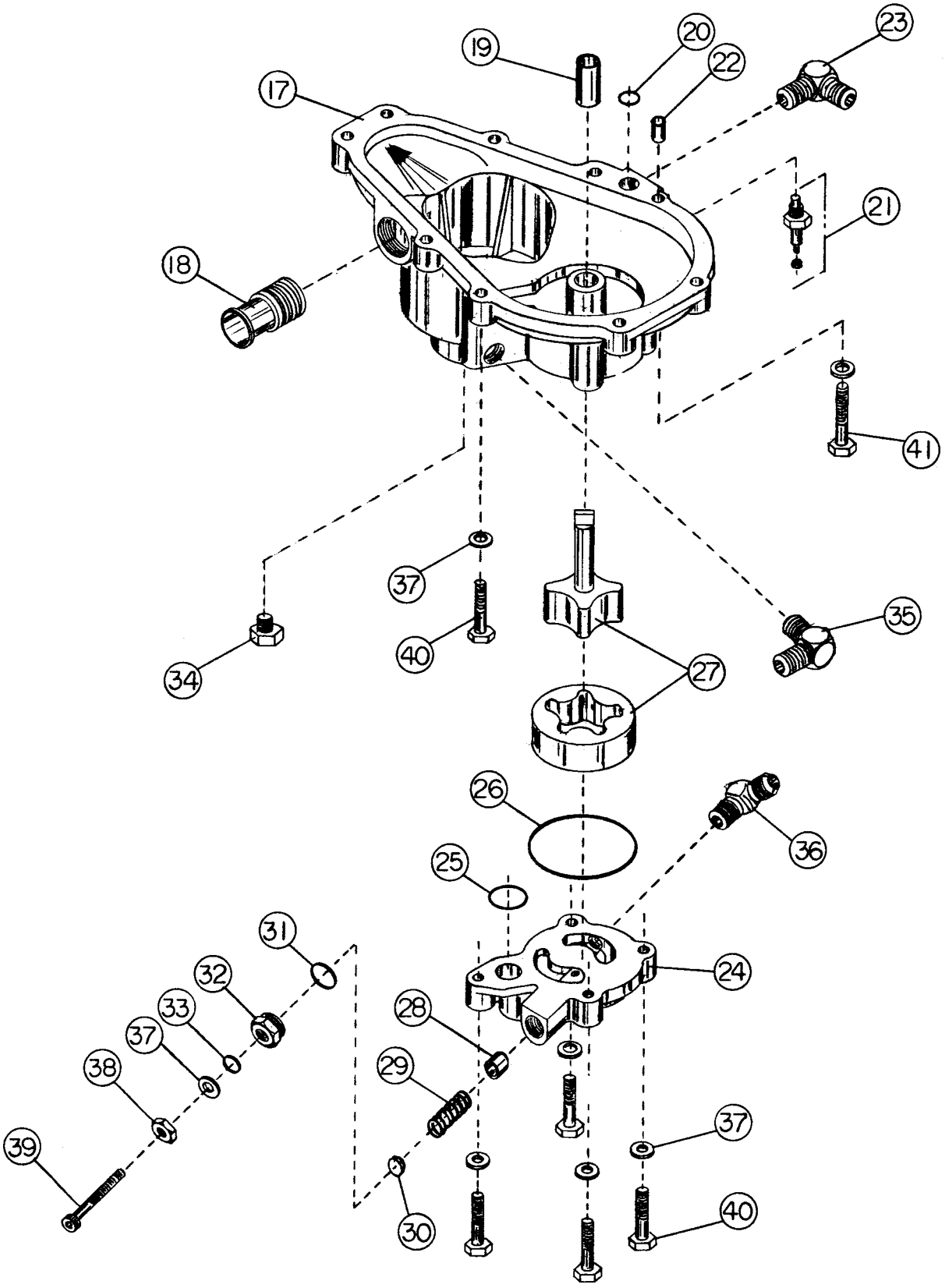
REF. #	PART #	DESCRIPTION	QTY. PER
1	24-2001	Crankcase	1
2	24-2003	Lifters	8
3	24-2004	Main Stud	6
4	24-2006	Bearing Pin	4
5	24-2013	Cam End Plate	1
6	24-2014	Crankcase Dowel	6
7	24-2101	Starter Mount	1
8	24-2103	Seal-Crank	1
9	E00-3901	Nut - SPS 42 FLW-720	12
10	E00-2300	Bolt - AN3-4A	4
11	E00-4301	Washer - AN960-10	4
12	E00-2518	Bolt - AN5-21A	8
13	E00-4501	Washer - AN960-516	16
14	E00-3500	Nut - AN365-524A	8
15	E00-4702	Washer - AN960-716	12
16	E00-2504	Bolt - 5/16-18 X 3/4 (SHCS)	8



B. CRANKCASE & LOWER COVER ASSEMBLY 24-2000

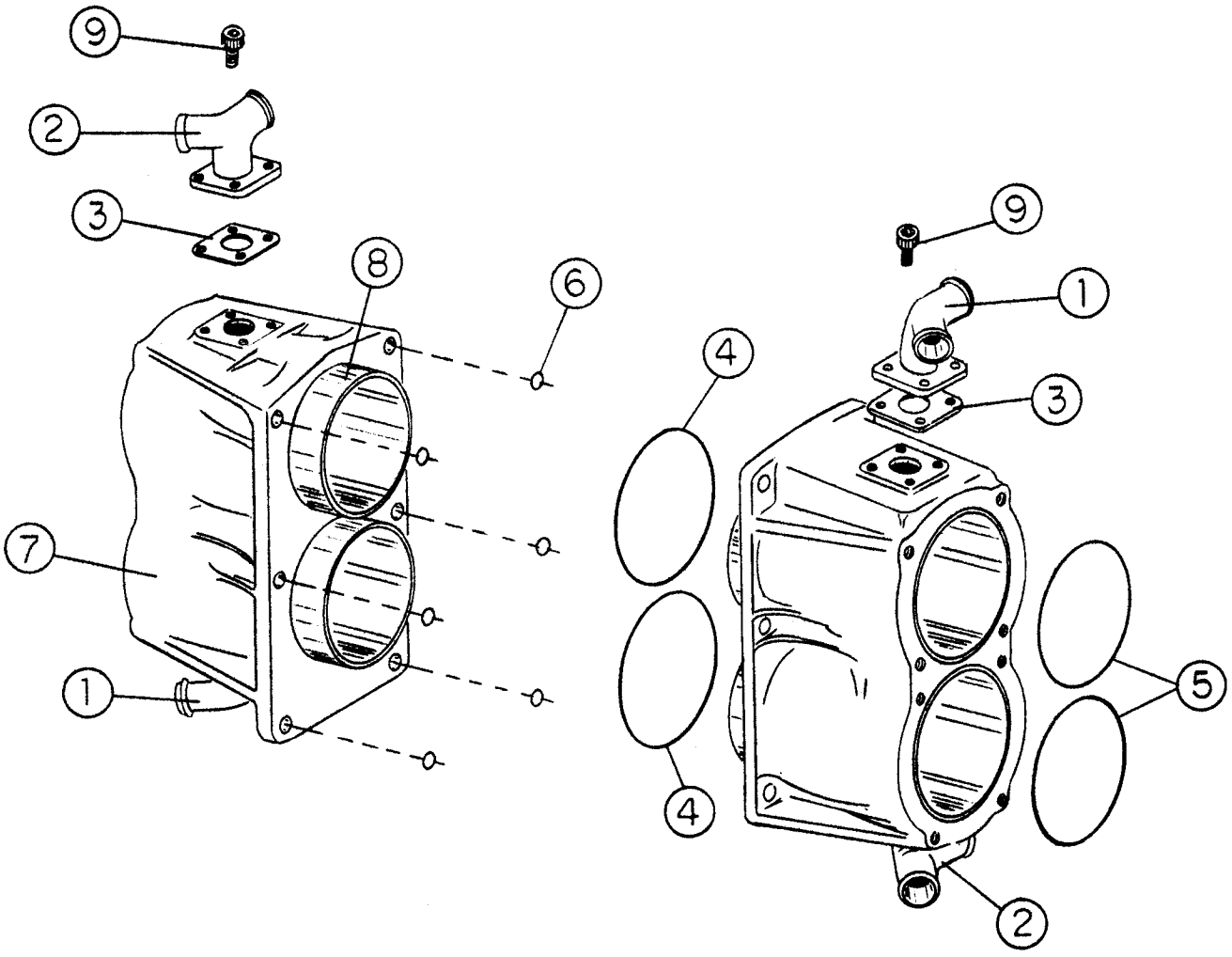
REF. #	PART #	DESCRIPTION	QTY. PER
17	24-2007	Lower Cover	1
18	24-2010	Oil Exit Fitting	1
19	24-2015	Bushing-Lower Cover	1
20	24-2016	"O" Ring (Main Galley)	1
21	24-2201	Oil Temp Sender (Same as Water)	1
22	24-2202	Lower Cover Dowel	2
23	24-2230	90° Oil Hose Fitting	1
24	24-2401	Oil Pump Cover	1
25	24-2402	"O" Ring (Cover-small)	1
26	24-2403	"O" Ring (Cover-large)	1
27	24-2410	Oil Pump Assy	1
28	24-2450	Piston	1
29	24-2451	Spring	1
30	24-2452	Spring Backing Plate	1
31	24-2453	Gasket (Regulator)	1
32	24-2454	Regulator Plug	1
33	24-2455	"O" Ring (Regulator)	1
34	24-2220	Oil Drain Plug (1/4 Pipe)	1
35	24-2230	Oil Hose Fitting - 90 degree	1
36	24-2240	Oil Hose Fitting - 45 degree	1
37	E00-4501	Washer - AN960-516	14
38	E00-3501	Jam Nut - AN316-5R	1
39	E00-2530	Bolt - 5/16-24 X 2 (SHCS)	1
40	E00-2527	Bolt - 5/16-18 X 1-1/2	11
41	E00-2529	Bolt - 5/16-18 X 2	2

CRANKCASE & LOWER COVER ASSEMBLY 24-2000



C. WATERJACKET ASSEMBLY 24-3000

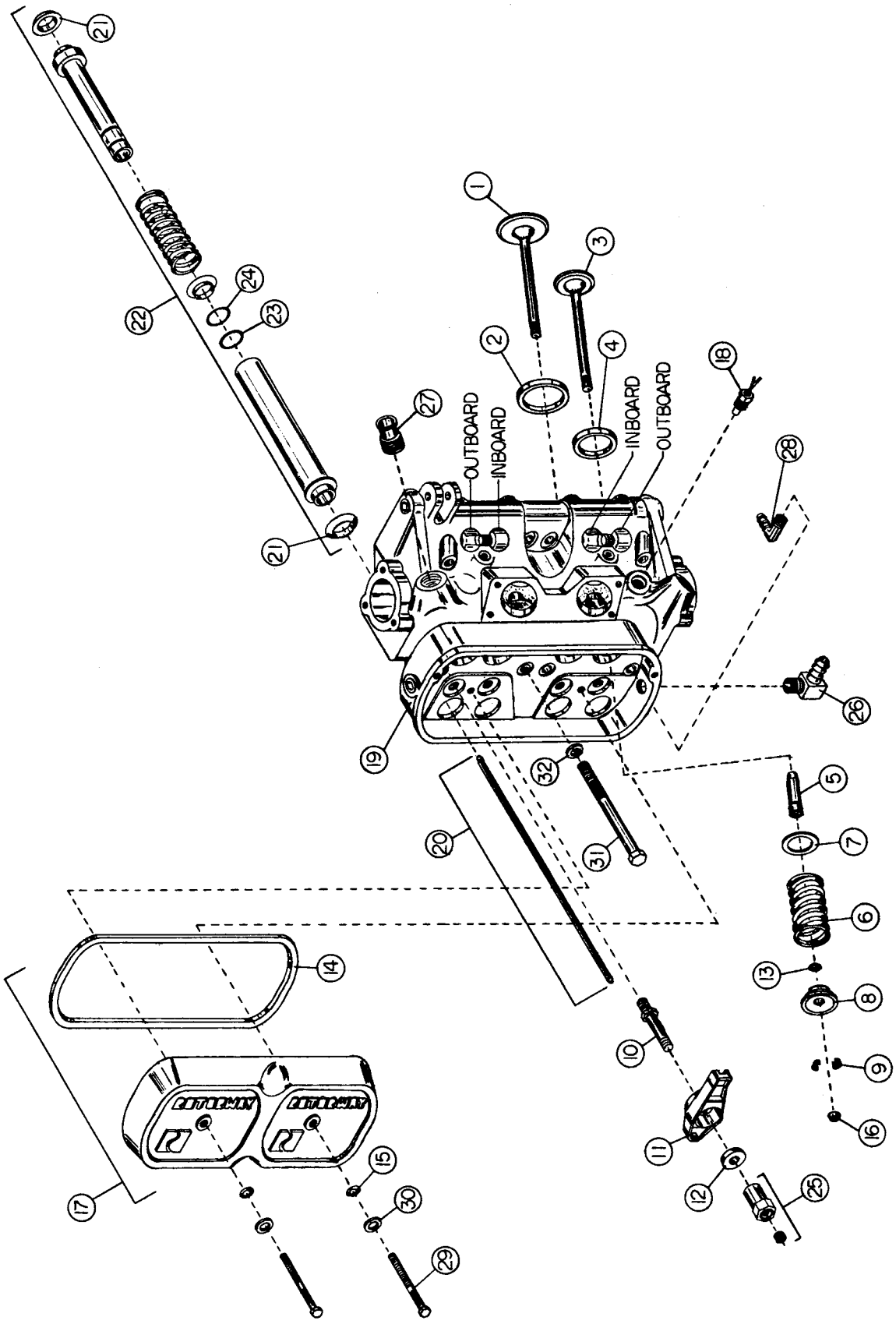
REF. #	PART #	DESCRIPTION	QTY. PER
1	24-3003	"T" Manifold (Cyl. #1 & #4)	2
2	24-3004	"T" Manifold (Cyl. #2 & #3)	2
3	24-3005	Gasket - "T" Manifold	4
4	24-3006	"O"Ring (Cylinder Base)	4
5	24-3007	Compression Seal "O" Ring (S.S.)	4
6	24-3009	"O" Ring (Main Stud)	12
	24-3010	Waterjacket-Sleeve Assy	2
7	24-3011	Waterjacket	2
8	24-3012	Cylinder Sleeve	4
	24-3100	Water Manifold	2
	24-3110	Hose - Manifold to "T"	4
	24-3115	Hose - Cylinderhead to "T"	4
	24-3120	Fire sleeve	8
9	E00-2424	Bolt - 1/4 - 20 X 5/8	16
	E00-9012	Hose Clamp #12	4
	E00-9016	Hose Clamp #16	12



D. CYLINDERHEAD ASSEMBLY 24-4000

REF. #	PART #	DESCRIPTION	QTY. PER
1	24-4002	Intake Valve	4
2	24-4003	Intake Valve Seat	4
	24-4004	Intake Valve Guide	4
3	24-4055	Exhaust Valve	4
4	24-4056	Exhaust Valve Seat	4
5	24-4057	Exhaust Valve Guide	4
6	24-4008	Valve Spring	8
7	24-4009	Spring Shim	8
8	24-4010	Spring Retainer	8
9	24-4011	Spring Keeper (2 per valve)	16
10	24-4012	Rocker Arm Stud	8
11	24-4013	Rocker Arm	8
12	24-4014	Pivot Ball	8
13	24-4015	"O" Ring (Valve Stem)	8
14	24-4017	Gasket (Valve Cover)	2
15	24-4018	"O" Ring (Valve Cover)	4
	24-4040	Lash Cap - Intake	4
16	24-4050	Lash cap - Exhaust	4
17	24-4030	Valve Cover (W/ Gasket)	2
18	24-2201	Water Temp. Sender (Same as Oil)	1
19	24-4090	Cylinderhead (W/ seats & Guides)	2
	24-4095	Cylinderhead (w/ Valves)	2
	24-4100	Cylinder Head Complete Assy	2
20	24-4110	Push Rod	8
21	24-4204	Push Rod Tube Seals	16
22	24-4250	Push Rod Tube Assy	8
23	24-4251	Push Rod Tube "O" Ring (red)	8
24	24-4252	Push Rod Tube "O" Ring (black)	8
25	24-4300	Polyloc Assy	8
26	24-4075	Oil Drain Fitting - 90 degree	2
27	24-4070	Water Hose Fitting - Straight	4
28	24-4080	Carb. Heat Fitting - 90 Degree	1
29	E00-2430	Bolt - 1/4 - 20 X 2 3/4	4
30	E00-4402	Washer - 1/4 Large	4
	E00-2610	Bolt - 3/8 - 24 X 2	4
	E00-2612	Bolt - 3/8 - 24 X 3 (SHCS)	4
31	E00-2613	Bolt - 3/8 - 24 X 4 1/2	8
32	E00-4600	Washer - AN960-616	20

CYLINDER HEAD ASSEMBLY 24-4000



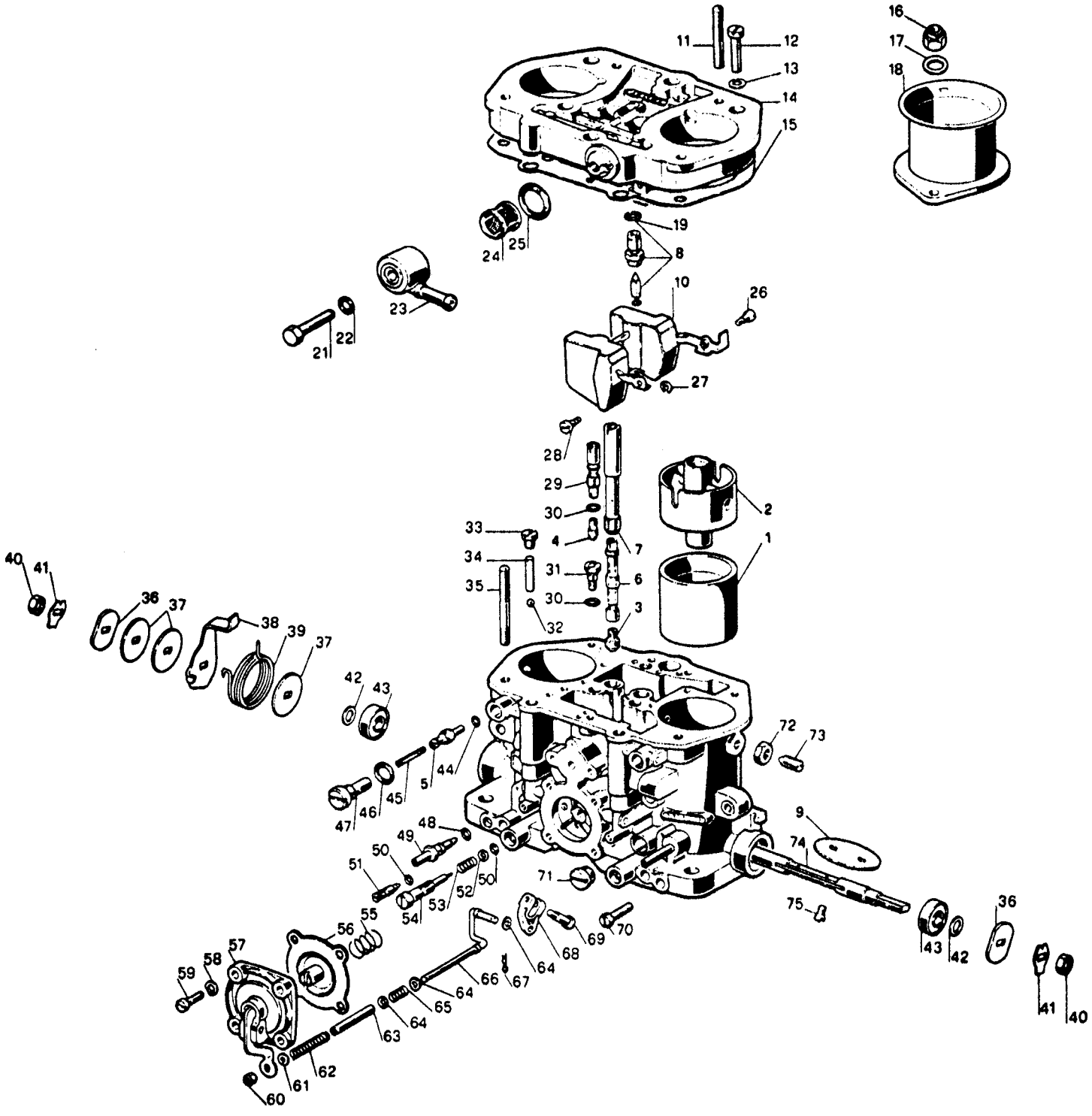
E. CARBURETOR & MANIFOLDS 24-7000

NOTE: Reference numbers 1 to 75 are given as an aid to understanding the internal makeup of the carburetor. Some of these parts are not readily available. Contact a customer service representative if replacement of any of these parts is necessary!

REF. #	PART #	DESCRIPTION	QTY. PER
1	24-7601	Venturi	2
2	24-7602	Auxiliary Venturi	2
3	24-7603	Main Jet	2
4	24-7604	Idle Jet	2
5	24-7605	Pump Jet	2
6	24-7606	Main Emulsion Tube	2
7	24-7607	Main Air Corrector	2
8	24-7608	Needle Valve	1
9	24-7609	Throttle Valve	2
10	24-7610	Float	1
11	24-7611	Velocity Stack Securing Stud	2
12	24-7612	Bowl Cover Securing Screw	5
13	24-7613	Washer	5
14	24-7614	Bowl Cover	1
15	24-7615	Bowl Cover Gasket	1
16	24-7616	Velocity Stack Securing Nut	4
17	24-7617	Washer	4
18	24-7618	Velocity Stack	2
19	24-7619	Needle Valve Gasket	1
20	24-7620	Fuel Inlet Pipe Union	1
21	24-7621	Union Securing Screw	1
22	24-7622	Union Securing Screw Gasket	1
24	24-7624	Fuel Filter	1
25	24-7625	Union Gasket	1
26	24-7626	Float Pin	1
27	24-7627	Float Clip	1
28	24-7628	Float Pin	1
29	24-7629	Idle Jet Holder	2
30	24-7630	Gasket	3
31	24-7631	Intake Valve	1
32	24-7632	Delivery Valve	2
33	24-7633	Delivery Valve Seat Plug	2
34	24-7634	Delivery Valve Weight	2
35	24-7635	Velocity Stack Securing Stud	2
36	24-7636	Washer	2
37	24-7637	Washer	3
38	24-7638	Idle Throttle Lever	1
39	24-7639	Throttle spindle Return Spring	1
40	24-7640	Throttle Spindle Nut	2
41	24-7641	Retaining Plate	2
42	24-7642	Washer	2

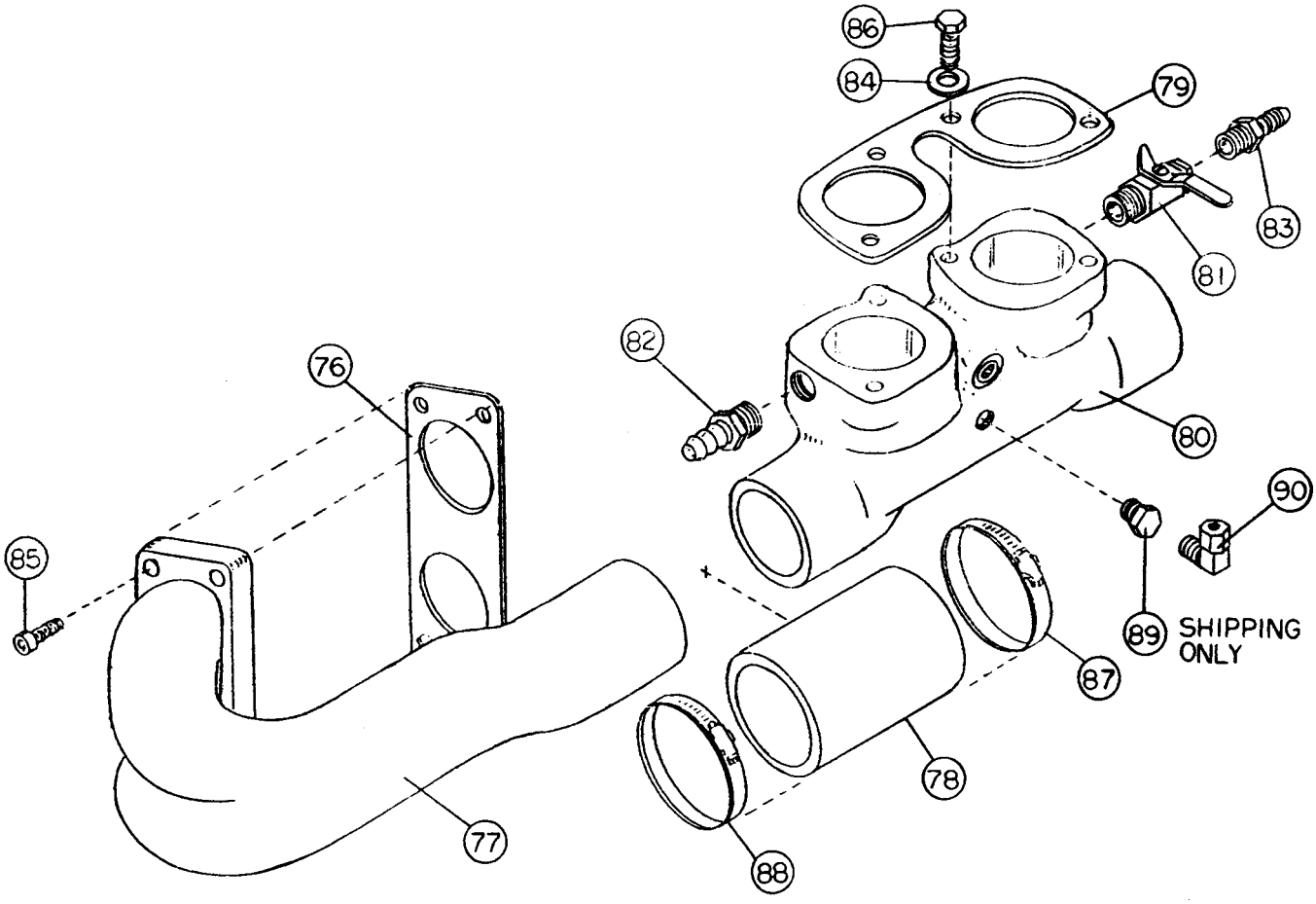
43	24-7643	Ball Bearing	2
44	24-7644	Pump Jet Gasket	2
45	24-7645	Fuel Filter	2
46	24-7646	Pump Jet Plug Gasket	2
47	24-7647	Pump Jet Plug	2
48	24-7648	Pressure Intake Union Gasket	2
49	24-7649	Pressure Intake Union	2
50	24-7650	Gasket	4
51	24-7651	By Pass Screw	2
52	24-7652	Flat Washer	2
53	24-7653	Idle Mixture Adj. Screw Spring	2
54	24-7654	Idle Mixture Adj. Screw	2
55	24-7655	Pump Diaphragm Spring	1
56	24-7656	Pump Diaphragm	1
57	24-7657	Pump Cover	1
58	24-7658	Washer	4
59	24-7659	Pump Cover Securing Screw	4
60	24-7660	Pump Link Nut	1
61	24-7661	Flat Washer	1
62	24-7662	Pump Link Spring	1
63	24-7663	Distance Tube	1
64	24-7664	Flat Washer	3
65	24-7665	Pump Link Spring	1
66	24-7666	Pump Lever Link	1
67	24-7667	Clip	1
68	24-7668	Pump Control Lever	1
69	24-7669	Pump Lever Securing Screw	1
70	24-7670	Idle Throttle Valve Adj. Screw	1
71	24-7671	Progression Holes Well Plug	2
72	24-7672	Aux. Venturi Screw Securing Nut	2
73	24-7673	Aux. venturi Securing Screw	2
74	24-7674	Throttle Valves Spindle	1
75	24-7675	Throttle Valves Securing Screw	4
	24-7678	Gasket Set	1
	24-7690	Throttle Arm	1
	24-7691	Ball Stud	1
	24-7693	O-Ring (Carb. Temp. Sender)	1
	24-7695	Air Filter Base	1
	24-7696	Air Filter Base Gasket	1
	24-7697	Vacuum Port Plug	1
	24-7699	Carburetor Temperature Sender	1
	24-7700	Carburetor Assembly (Complete)	1
	E00-3402	Nut - AN365-428A	1
	E00-4401	Washer - AN960-416	1

CARBURETOR & MANIFOLDS 24-7000



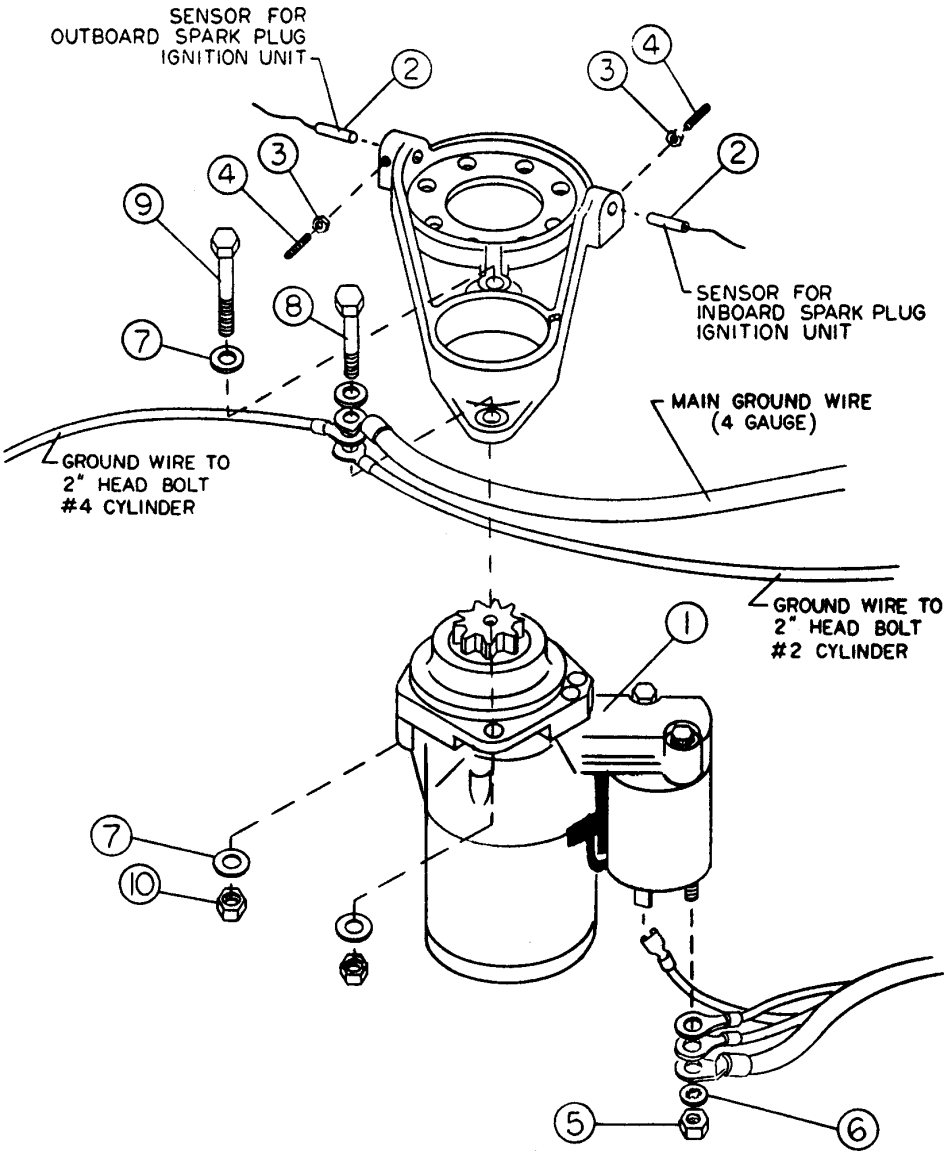
E. CARBURETOR & MANIFOLDS 24-7000

REF. #	PART #	DESCRIPTION	QTY. PER
76	24-7002	Intake Manifold Gasket	2
77	24-7511	Intake Manifold	2
78	24-7511	Manifold Hose	2
79	24-7513	Carburetor Base Gasket	1
80	24-7520	Manifold Midsection	1
81	24-7521	Carburetor Heat Valve	1
82	24-7522	Water Hose Fitting (1/2")	1
83	24-7524	Water Hose Fitting (3/8")	1
84	E00-4501	Washer - AN960-516	4
85	E00-2504	Bolt - 5/16 - 18 X 3/4 (SHCS)	8
86	E00-2506	Bolt - 5/16 - 18 X 1	4
87	E00-9036	Hose Clamp #36	2
88	E00-9032	Hose Clamp #32	2
	E00-9004	Hose Clamp #4	2
	24-7577	Carb Heat Inlet Hose	1
89	***-****	THIS IS THE MANIFOLD PRESSURE PICKUP LOCATION. This hole is plugged for shipping only! Replace with E28-7240	
90	E28-7240	Fitting, 90° x 1/8 Compression	1



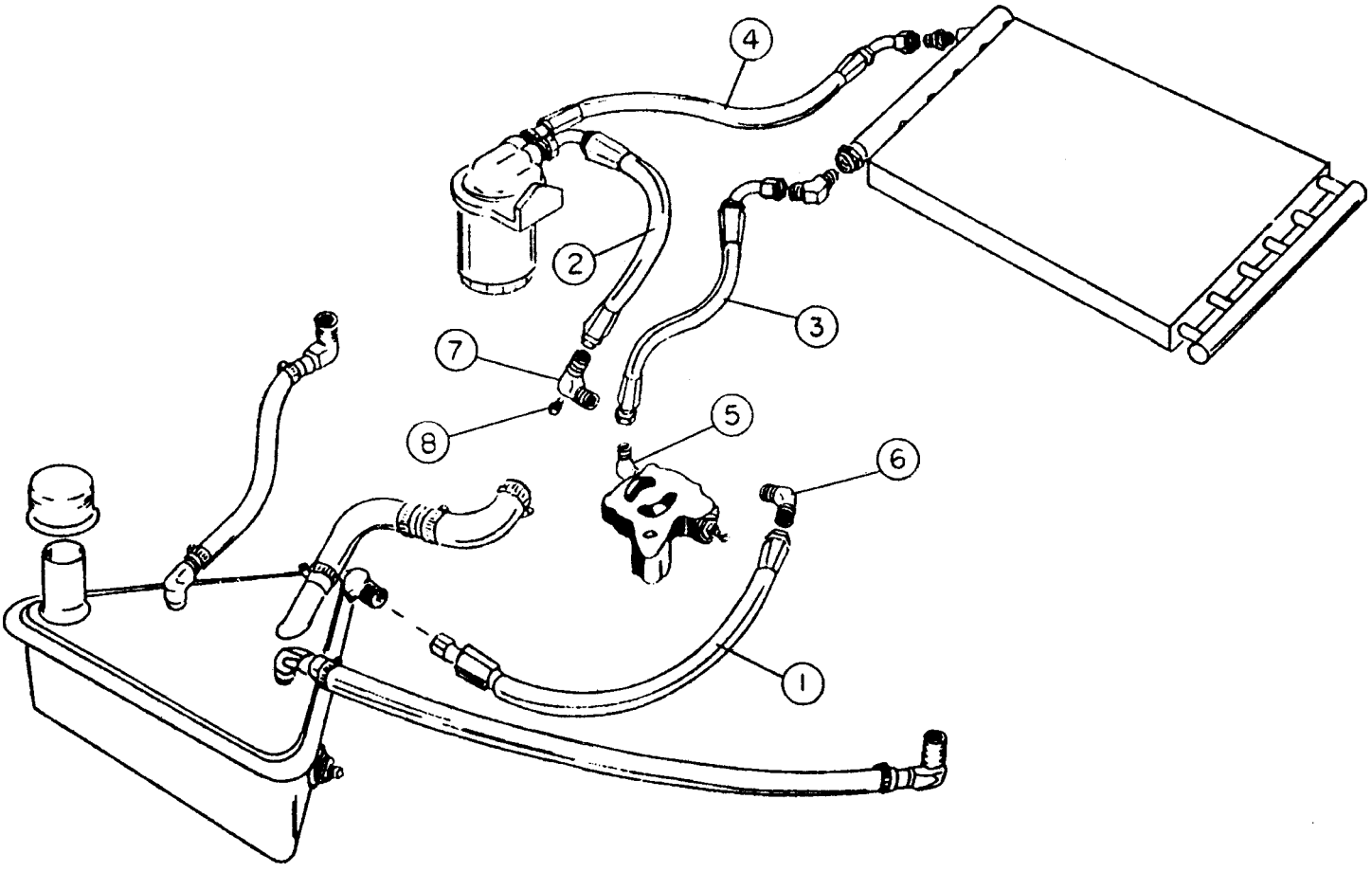
F. IGNITION SYSTEM 24-8000

REF. #	PART #	DESCRIPTION	QTY. PER
1	24-8101	Starter (Lightweight)	1
2	24-8620	Ignition Sender	2
	24-8610	Ignition Pack	2
3	E00-3403	Jam Nut - 1/4-20	2
4	E00-9303	Set Screw - 1/4-20 X 3/4	2
5	E00-3900	Nut-8mm X 1.25 mm	1
6	E00-4503	Lock Washer-5/16 Internal Tooth	1
7	E00-4600	Washer - AN960-616	4
* 8	E00-2603	Bolt - AN 6 -14A	1
* 9	E00-2604	Bolt - AN 6 -20A	1
10	E00-3000	Nut - AN365-624A	2



G. OIL SYSTEM E28-2000

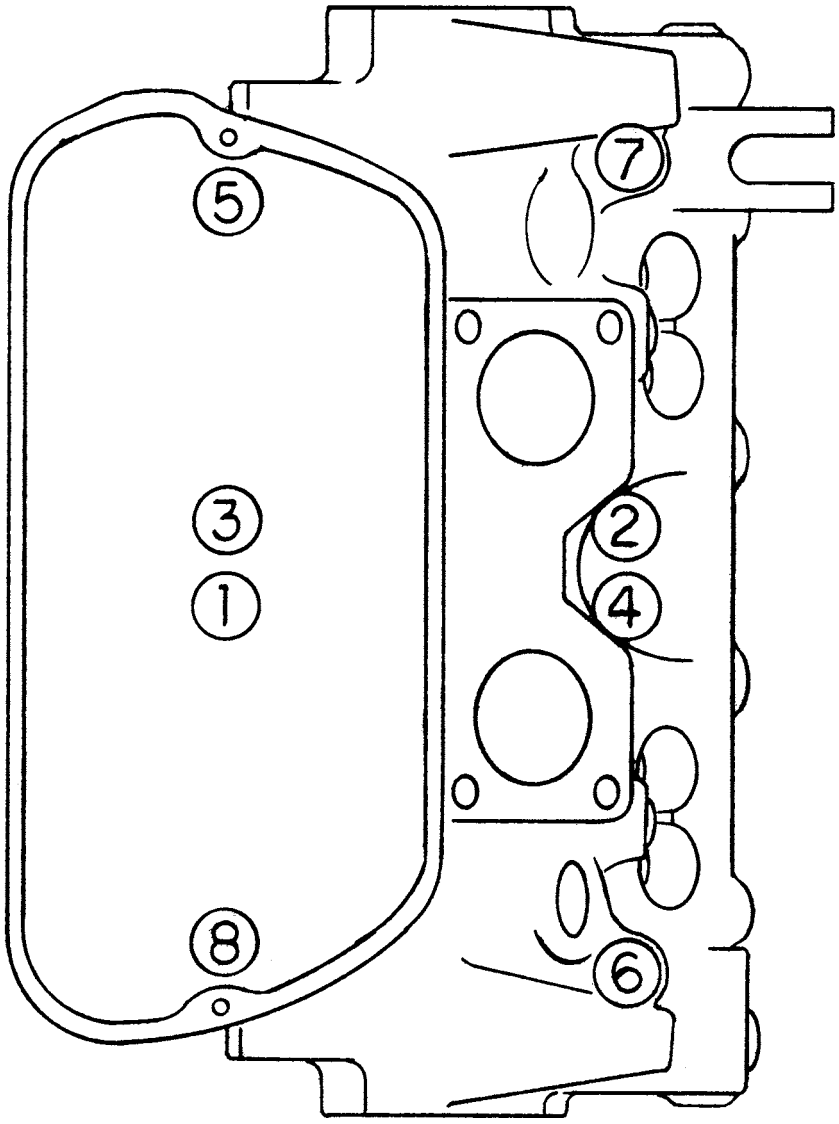
REF. #	PART #	DESCRIPTION	QTY. PER
1	E28-6111	Oil Hose - Sump to Pump	1
2	E28-6121	Oil Hose - Filter to Engine	1
3	E28-6132	Oil Hose - Pump to Cooler	1
4	E28-6141	Oil Hose - Cooler to Filter	1
5	24-2240	45 Degree Fitting - pump outlet	1
6	24-2230	90 Degree Fitting - pump inlet	1
7	24-2205	Modified Fitting - engine inlet	1
8	*******	THIS IS THE OIL PRESSURE PICKUP LOCATION. This hole is plugged for shipping only!	



H. GASKETS & O-RINGS

P/N	DESCRIPTION	QTY PER ENGINE
24-1101	Complete set	1
24-2016	Engine Case/Cover O-Ring	1
24-2103	Oil Seal-Crankshaft	1
24-2402	Oil Pump Cover O-Ring (Small)	1
24-2403	Oil Pump Cover O-Ring (Large)	1
24-2453	Oil Pump Adjuster Gasket	1
24-2455	Oil Pump Adjuster O-Ring	1
24-3005	"T" Manifold Gasket	4
24-3006	Cylinder Base O-Ring	4
24-3007	Compression Seal S.S. O-Ring	4
24-3009	Main Stud O-Ring	12
24-4015	Valve Stem O-Ring	8
24-4017	Valve Cover Gasket	2
24-4018	Valve Cover O-Ring	4
24-4204	Push Rod Tube Seal	16
24-4251	Push Rod Tube O-Ring (red)	8
24-4252	Push Rod Tube O-Ring (black)	8
24-7002	Intake Manifold Gasket	2
24-9710	Exhaust Manifold Gasket	4
24-7513	Carb/Manifold Base Gasket	1

I. CYLINDERHEAD TORQUE PATTERN



SECTION VI. HOURLY SERVICE CHART

	DESCRIPTION	25	50	100	250	500	1000
	1. CHANGE OIL & FILTER	*					
	2. AIR FILTER	*					
	3. GREASE MAIN DRIVE PULLEY	*					
**	4. INSPECT & ADJUST VALVES	*					
	5. INSPECT COOLING SYSTEM	*					
	6. INSPECT OIL SYSTEM	*					
	7. INSPECT FUEL SYSTEM	*					
	8. INSPECT THROTTLE CONTROL	*					
	9. INSPECT EXHAUST SYSTEM	*					
	10. INSPECT SPARK PLUGS		*				
	11. REPLACE SPARK PLUGS			*			
	12. TORQUE CYLINDER HEAD BOLTS			*			
	13. INSPECT IGNITION SYSTEM			*			
	14. TEST CYLINDER LEAKAGE			*			
	15. CALIBRATE FUEL FLOW			*			
	16. REPLACE AIR FILTER				*		
	17. REBUILD CARBURETOR					*	
	18. REBUILD CYLINDER HEADS					*	
	19. INSPECT CAMSHAFT LIFT					*	
	20. REPLACE CAM GEAR					*	
	21. REPLACE MAIN DRIVE PULLEY BEARINGS					*	
	22. REPLACE SPARK PLUG WIRES (or every 2 years)					*	
	23. REPLACE ALL WATER HOSES (or every 2 years)					*	
	24. COMPLETE ENGINE OVERHAUL						*