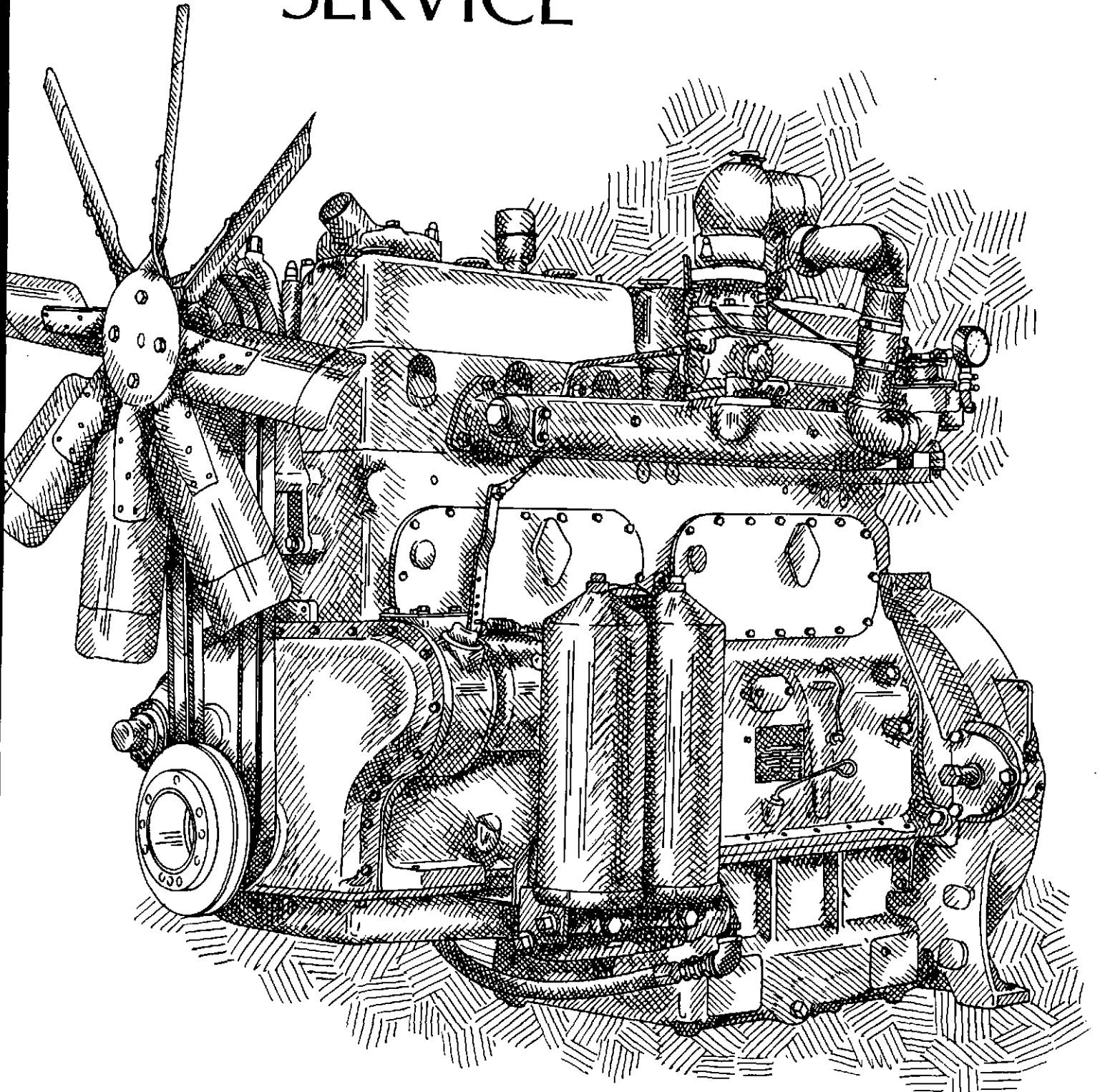


# OPERATION AND SERVICE



6WAK and F1197G Series

**OPERATION  
AND  
SERVICE  
MANUAL**

**WAUKESHA  
6WAK and F1197G SERIES  
GAS AND GASOLINE ENGINES**



Form 1660B, Edition 11  
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Waukesha Engine Division  
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(Revised by A. W.)

## SAFETY PRECAUTIONS

### EXHAUST GASES

The exhaust products of an internal combustion engine are toxic and may cause injury or death if inhaled. All engine installations, especially those within a closed shelter or building, should be equipped and maintained with an exhaust discharge pipe so that exhaust gases are delivered into the outside air. A closed building or shelter must be adequately vented. A means of providing fresh air into a closed building or shelter is necessary.

### ENGINE FUELS

All internal combustion engine fuels are highly combustible and may ignite or explode. Fuels must be conducted to the engine with proper piping, free from leaks, and designed to resist breakage from vibration. When filling fuel tanks, never smoke or use open flame in the immediate area. Fuel tanks should be grounded to prevent buildup of static electricity.

### POSITIVE FUEL SHUT-OFF

All engine installations should be equipped with a means of positive fuel shut-off for emergency use when fuel is conducted to the engine from a remote source. Fuels under pressure such as natural gas or liquified petroleum gas, should be controlled by a positive shut-off valve, preferably automatic, other than those integral with the carburetor or gas pressure regulation equipment. It shall be the final responsibility of the engine owner to ensure that the installation is free from fuel or exhaust leakage, and such installation meets all applicable codes.

### GAS USED TO ENERGIZE STARTERS

Gas used to energize starters must be discharged away from the engine into a harmless area. Ignition connections and electrical equipment on engines exposed to potentially explosive ambient atmospheres should be specially equipped to eliminate spark hazard and it is the responsibility of the engine owner to specify or provide such connections and equipment.

### SAFETY GUARDS

Internal combustion engines must be properly provided with guards against hazards to persons or structures in close proximity to rotating or heated parts and it is the responsibility of the engine owner to specify or provide such protection.

### CRANKCASE ANTI-EXPLOSION VALVES

These valves must be kept in proper working condition to relieve crankcase pressure when regulations require their installation on engine crankcases.

### IGNITION SYSTEMS

Breakerless, magneto and battery ignition systems can cause electrical shocks. Avoid contacting these units or their wiring. The reaction from the shock could cause persons to fall or jerk their hands, thus striking other objects and injuries could occur.

### ENGINE SURGE TANK AND RADIATOR PRESSURE CAPS AND CONNECTIONS

Do not remove the pressure caps while the engine is operating or while coolant is hot. The cooling system is under pressure and severe burns could result from the hot coolant spewing out when cap is removed. Wait until engine and coolant have cooled down before removing radiator or surge tank caps. Always replace weak hoses, lines, and fittings.

### FUEL INJECTORS

Never allow an injector to spray against the skin. The fuel oil will penetrate the skin and may cause serious infection and injury.

### GENERATOR SETS

The voltage produced by generator sets is dangerous to personnel coming in contact with any part of the electrical system during operation. Severe, possibly fatal, shock may result. Make sure the generator set is grounded before operation. Be extremely careful when the unit or surrounding area is damp or wet.

When servicing any part of the electrical system or making any connections, make sure main power switch is OFF. Clean or service generator set only when engine is shut down.

In case of an accident from electrical shock, shut down the generator set at once. If it cannot be shut down, free the victim from the live conductor. Avoid direct contact with the victim. Use a dry board, dry rope, or any nonconducting implement to free the victim. If the victim is unconscious, apply artificial respiration and get medical help.

Do not operate the generator set with the ammeter circuit open. Voltage, dangerous to both equipment and personnel, can be generated in an open secondary circuit of a current transformer.

If the generator set is stopped by operation of safety devices, do not attempt to operate it until the cause has been eliminated.

When the generator set is shut down after operation, disconnect all line switches to all external power load and parallel circuits.

### ENGINE AND EQUIPMENT, REPAIR AND SERVICE

Always stop the engine before cleaning, servicing, or repairing the engine or driven equipment. Place all controls in off position to prevent accidental restarting. Before restarting, make sure that all tools and other material are removed from the engine and equipment.

Proper service and repair is important to the safe reliable operation of engines and related equipment. The procedures recommended by Waukesha in this manual are effective methods for performing service and repair operations. Some of these procedures require the use of specially designed tools. The special tools should be used when and as recommended. Anyone who uses a service, repair, or installation procedure not recommended by Waukesha must first satisfy themselves thoroughly that their safety will not be jeopardized by the service methods they select.

### HOUSEKEEPING

Good housekeeping results in a clean, safe work area. An orderly work area with clean walkways and neatly arranged tools and equipment is conducive to better work performance and morale, and is a major factor in accident prevention. Accidents resulting from poor housekeeping include tripping over loose objects on the floor, stairs, or platforms, slipping on greasy, oily, wet, or dirty floors, falling of poorly piled material, and cuts from sharp edges.

### ENGINE FAN BLADES

If a fan blade or fan drive shaft is bent or damaged in any way, it should be replaced. No attempt should be made to repair the damaged parts. Fan assemblies must remain in proper balance. When damaged, an unbalanced fan can fly apart during use and create an extremely dangerous condition.

### TURBOCHARGERS

Turbochargers are specifically designed for applicable engine horsepower and altitude ratings. Nozzle rings must not be changed without consulting the engine manufacturer since they limit turbocharger rpm. Excessive rpm may result in turbocharger failure with resultant personal safety hazards. Turbochargers operate at high temperatures. Therefore, all flammable material must be kept away from them. Engines must be shut down and at room temperature before working on turbochargers or burns will result.

### ENGINE STORAGE CHEMICALS

Nucle-Oil contains Petroleum Distillate. Harmful or fatal if swallowed. Avoid contact with skin. Vapor is harmful. Causes irritation of eyes, nose, throat and skin. Use only with adequate ventilation. Avoid prolonged or repeated breathing of vapor. Avoid contact with skin, eyes, and clothing. Do not take internally. Keep container closed and away from heat. Always read and observe the "CAUTION" labels on the containers. Do not destroy the labels on the containers.

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Generally speaking, heating of preservative compounds is confined to 200°F. (93°C.) or less. These temperatures are easily reached by placing the preservative container in heated water. If this is done, the container must be vented or opened to reduce the danger of explosion. Direct heating presents a dangerous and unnecessary fire hazard.

### FIRE PROTECTION

Locate fire extinguishers so that they are easily accessible if a fire starts. Carefully maintain records of extinguisher inspection and recharging to ensure the fire extinguishing capabilities when required. Consult your fire extinguisher supplier or insurance engineer for recommendations on the type, size, and quantity of fire extinguishers required for the engine installation. Select alternate routes of escape from any engine installation and post such routes in accordance with local and government requirements.

### CLEANING SOLVENTS

Use approved cleaning solvents in a well ventilated area. Avoid breathing fumes. Keep away from open flames or sparks. Do not use gasoline or paint thinners or other highly volatile fluids for cleaning. Breathing carbon tetrachloride or carbon disulfide fumes can be fatal. Always read and observe the "CAUTION" labels on containers. Do not destroy the labels on the containers. Cleaning solvents can cause various types of skin irritations.

### WELDING EQUIPMENT

If a welding gas cylinder is damaged by falling or being struck, it could burst with destructive force. Cylinders must be stored in accordance with manufacturer's specifications and applicable safety requirements.

When welding, brazing or cutting with acetylene, check valves should be installed between the regulators and hoses to prevent flashback into the regulators and supply tanks. Without these check valves, the flashback could cause the regulators and supply tanks to explode.

Oily and greasy materials must be kept away from oxygen valves, hoses, etc. Oxygen may combine with such materials and an explosive reaction could result.

Always wear protective eye shields when welding, cutting or watching a welding operation. Protective clothing and face shields must be worn. Do not weld or cut near combustible materials.

### ELECTRIC POWER TOOLS

Be certain the electric tool is properly grounded. Wear proper eye protection. Do not work in wet or damp conditions. Be sure the tool is in good condition and safety guards are in position. An electric trouble light must also be grounded. Do not carry electric power tools by the cord. Do not yank the cord when removing from outlet; instead grasp the plug to remove it from outlet.

### LEAD ACID BATTERIES

Always disconnect the battery ground connection from batteries before performing any work on the engine or equipment. This will prevent sparks or burns when accidentally shorting an electrical connection.

Never expose batteries to open flame or electric spark. Battery action generates hydrogen gas which is flammable and explosive. Don't allow battery fluid to contact skin, eyes, fabrics, or painted surfaces. Battery fluid is a sulfuric acid solution which could cause serious personal injury or property damage. Wear eye protection when working with batteries.

### PRECAUTIONS WHEN USING BOOSTER BATTERIES AND CABLES

Do not attempt to jump start an engine having a frozen battery because the battery may rupture or explode. If a frozen battery is suspected, examine all fill vents on the battery. If ice can be seen, or if the electrolyte fluid cannot be seen, do not attempt to start with jumper cables.

Both charged and discharged batteries should be treated carefully when using jumper cables. The following procedures assist in reducing sparks and explosion hazards always present in both batteries when connecting charged batteries to discharged batteries.

Turn off all electrical loads. Remove vent caps and lay a damp cloth over open vent wells of each battery. The charged booster battery or batteries must have the same voltage capacity as the discharged battery or batteries.

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The positive post is identified by a +, pos. and red color and is larger in diameter than the negative post.

The negative post is identified by a -, neg. and gray color.

### Negative Grounded Battery or Batteries

First, connect one jumper cable from the positive post on charged battery or batteries to positive post on discharged battery or batteries. If more than one battery is connected in "series" or "series parallel" connect jumper cable to positive post that has cable leading to starting motor.

Second, connect other jumper cable from negative post on charged battery or batteries to a good ground on engine.

When removing jumper cables, always disconnect the ground jumper cable from the engine before disconnecting the other jumper cable.

### Positive Grounded Battery or Batteries

Same procedure as for negative grounded battery or batteries, except the negative post will have the cable leading to the starting motor and the positive post will be grounded.

## COMPRESSED AIR

Compressed air or gases should never be used to clean clothing or body of foreign materials. A highly compressed stream of air flowing through a very small opening can pierce the skin and cause severe and very painful injury. Never use your hand to check air, gas, or liquid flow rates. Do not engage in "horseplay" with air, gas, or liquid hoses. Observe all applicable regulations as related to compressed gases.

## SODIUM FILLED VALVES

When handling sodium filled valves always wear approved safety goggles, a hat or cap, long sleeves, and gloves. If refacing sodium filled valves is required, do not exert undue force at the grinding wheel as this could crack the hollow valve stem and allow the sodium to escape.

Do not handle broken sodium filled valves with bare hands as the sodium or sodium residue can cause severe burns. Sodium burns on the skin are of the same nature as caustic burns. They must be washed with large volumes of cold water before being neutralized with vinegar. The affected parts should then be treated as a burn and medical attention sought.

If a broken valve should ignite, it may be extinguished by smothering in dry soda ash or dry sand. The smoke and fumes are irritating; adequate ventilation should be provided and inhalation or contact with the smoke and fumes avoided. Water, carbon dioxide in any form, or carbon tetrachloride should never be used on sodium fires since these materials react violently with hot sodium.

Broken sodium filled valves may be stored prior to disposal in moisture free clean oil or kerosene. Unserviceable sodium filled valves must be disposed of in accordance with local, state and/or federal regulations as applicable.

## INTOXICANTS AND NARCOTICS

Workers under the influence of intoxicants and/or narcotics are unsafe workers and are a hazard to themselves and other employees.

## SAFE DRESS

When around machinery, loose clothing, neckties, rings, wrist watches, bracelets, etc., should not be worn. Severe injuries have resulted from this all too common practice.

## HAIR LENGTH

Long hair worn around rotating equipment is dangerous. Hair is charged with static electricity and can be drawn to a piece of rotating machinery like a magnet. Persons with long hair must wear complete head covering when around rotating machinery.

**NOISE PROTECTION**

Wear O.S.H.A. approved hearing protection devices when around excessive noise.

**FOOT PROTECTION**

Wear O.S.H.A. approved steel tip safety shoes.

**HEAD PROTECTION**

Wear O.S.H.A. approved safety helmets.

**EYE PROTECTION**

Wear O.S.H.A. approved eye shields, safety glasses, and sweat bands.

**RESPIRATORY SYSTEM PROTECTION**

Wear O.S.H.A. approved equipment when near dust and toxic fumes to protect the eyes and respiratory system. This type of equipment must be checked and maintained on a regular basis.

**REFERENCES**

For details on safety rules and regulations in the United States, contact your local Occupational Safety and Health Administration (O.S.H.A.).

The publication of these safety precautions is done for your information. The Waukesha Engine Division, Dresser Industries, Inc. does not, by the publication of these precautions, imply or in anyway represent that these published precautions are the sum of all dangers present near industrial engines. If you are operating industrial engines, it is your responsibility to insure that such operation is in full accordance with all applicable safety requirements and codes. All requirements of the United States Federal Occupational Safety and Health Administration Act must be met when Waukesha Engines are operated in areas that are under the jurisdiction of that United States Department. Engines operated in countries other than the United States of America must be installed, operated and serviced in accordance and compliance with any and all safety requirements of that country which may be applicable.

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## INTRODUCTION

The Waukesha Engine Division, Dresser Industries, Inc., supplies this manual as a guide for operating and servicing Waukesha engines. For the convenience of the user certain conventional and well-established maintenance practices have been omitted or included by brief mention only. In such instances, good judgment and common sense should be used as a basis for whatever mechanical operation is involved.

Occasionally, unusual or extreme circumstances may appear to justify some degree of variation from the recommended procedures. When this happens, it is strongly suggested that the problem be submitted to the Service Department of your local Authorized Waukesha Distributor. When requesting information or ordering parts always be sure to include the engine model and serial number from the engine nameplate. In addition, any special features of the installation, or conversions made by the owner, should be mentioned.

Where tabulated data is provided, the user should realize that clearances, part numbers, and so on, are subject to change. Consult your local Authorized Waukesha Distributor if any doubt arises as to the suitability of a given part or clearance.

Throughout this manual we have used symbols to stress important information. These symbols and their meanings are as follows:



..... This symbol precedes information which, if disregarded, may result in injury or death of the user of the engine or to others.



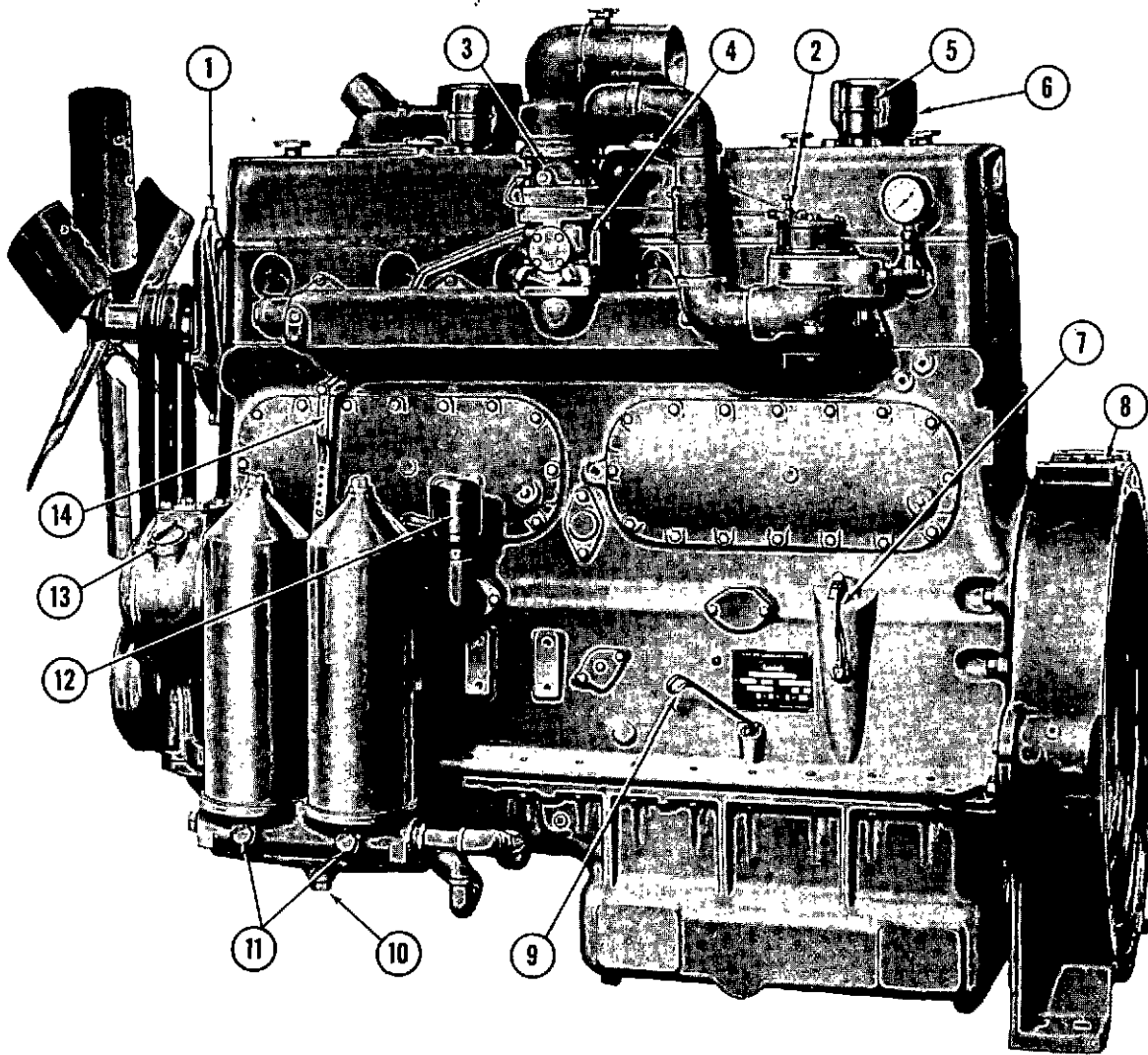
..... This symbol precedes information which, if disregarded, may result in damage to the engine.

NOTE ..... This symbol precedes information which is vital to the operation or maintenance of the engine.

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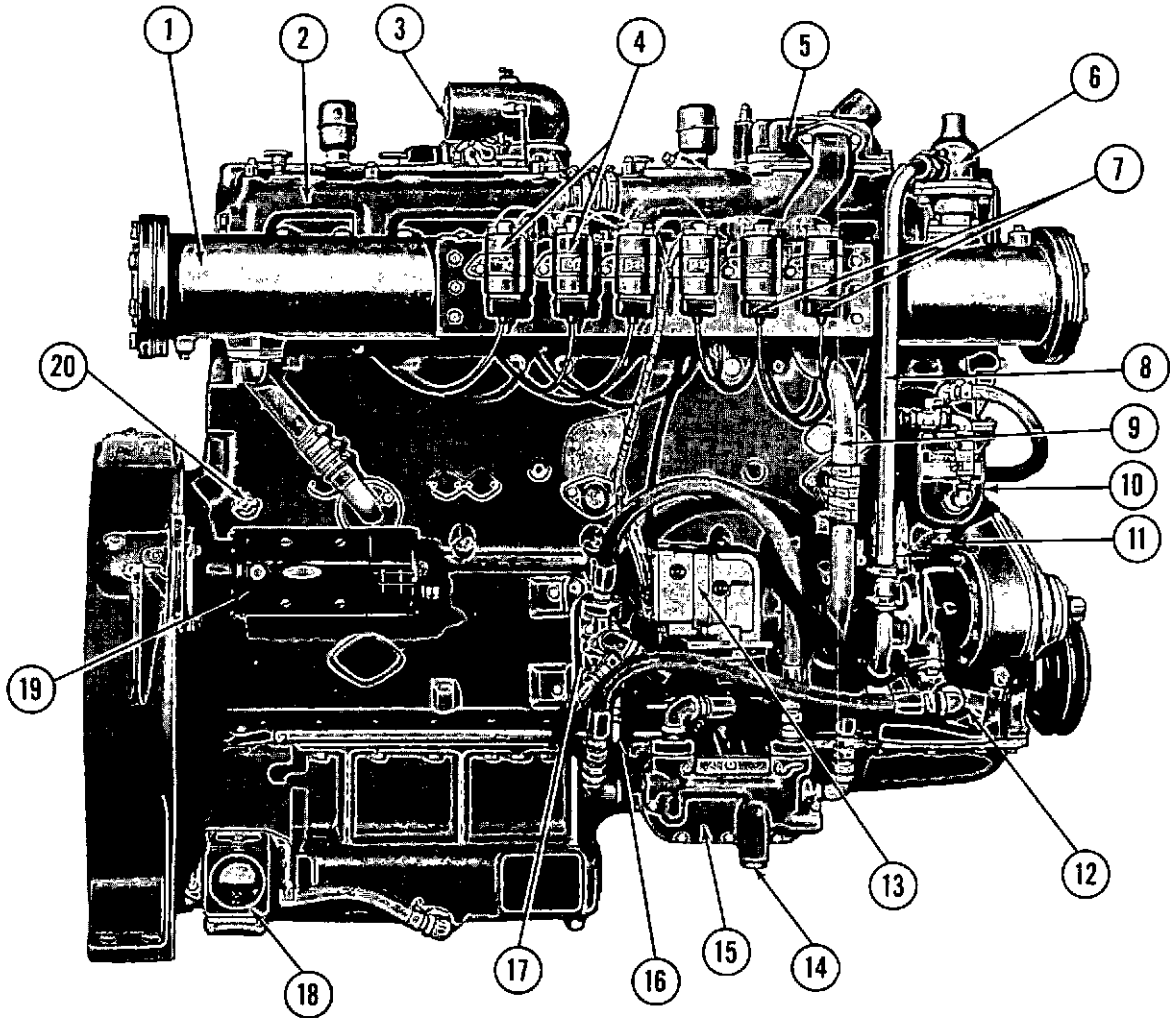
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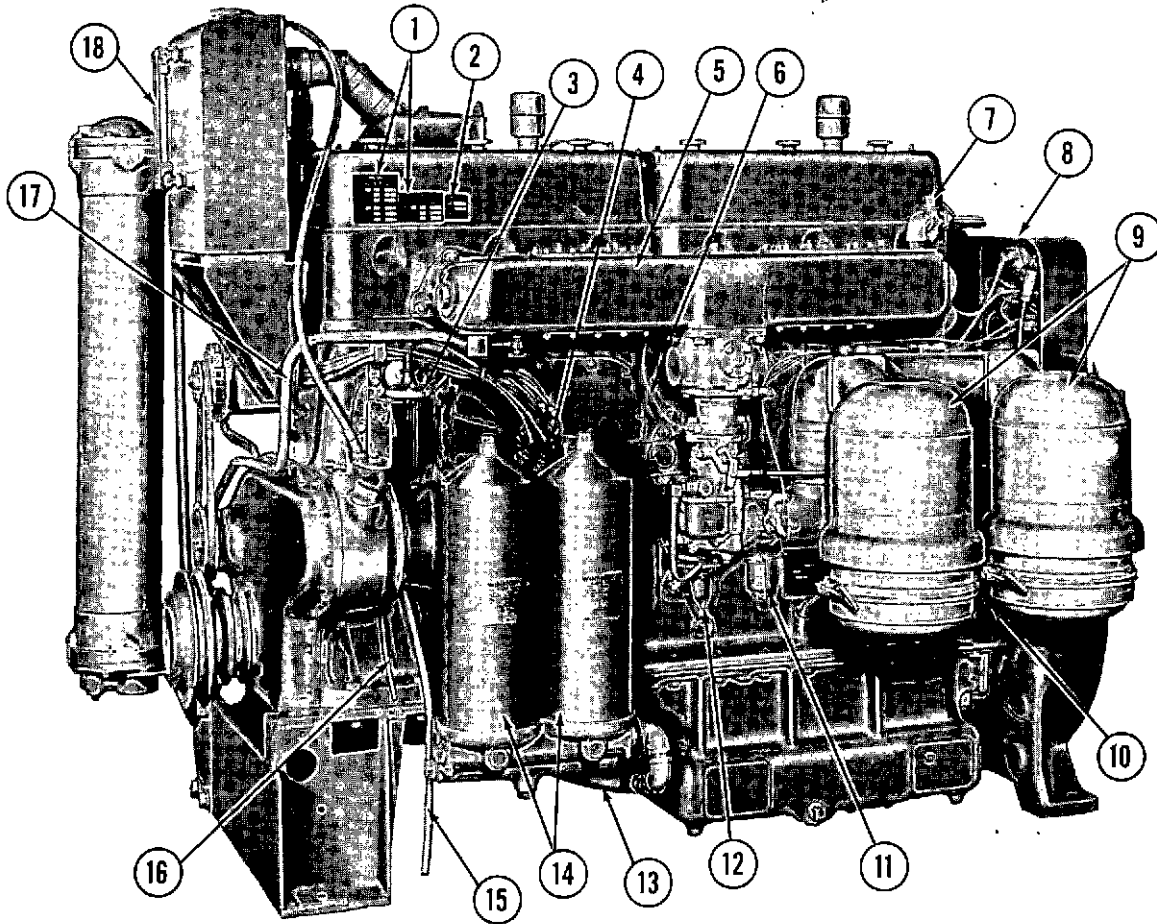
WAUKESHA MODEL WAKC, LEFT SIDE VIEW  
DOWNDRAFT GAS CARBURETION ENGINE

- |   |                                       |
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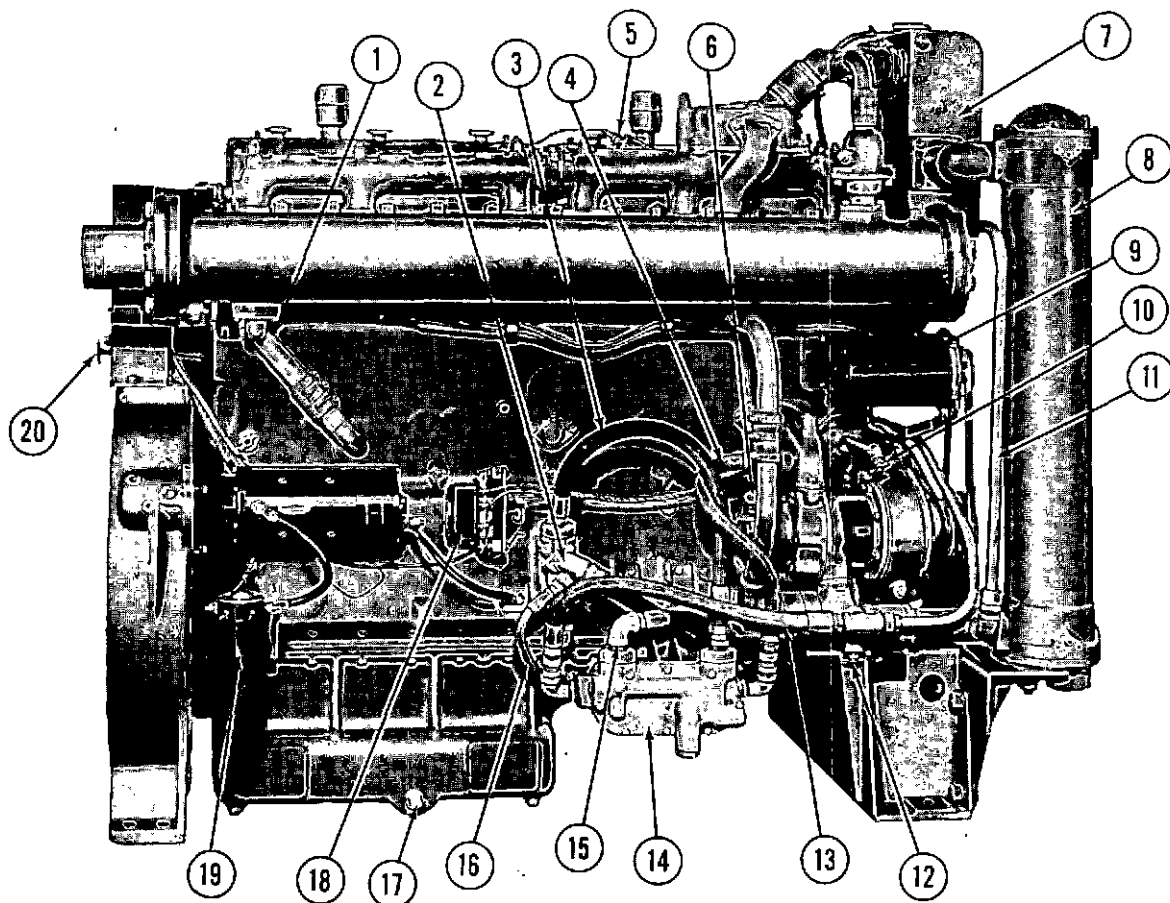
WAUKESHA MODEL WAKC, RIGHT SIDE VIEW  
LOW TENSION IGNITION ENGINE

- |  |                                      |
|--|--------------------------------------|
| 1. Water Cooled Exhaust Manifold         | 11. Cooling System Filter Drain      |
| 2. Top Water Manifold                    | 12. Water Pump Inlet Elbow           |
| 3. Carburetor Air Horn                   | 13. Low Tension Ignition Magneto     |
| 4. Low Tension Ignition Transformers     | 14. Pressure By-Pass Valve           |
| 5. Thermostat Housing                    | 15. Oil Cooler                       |
| 6. Exhaust Manifold Thermostat Housing   | 16. Engine Oil Pressure Relief Valve |
| 7. Spark Ignition Wires                  | 17. Relief Valve Body                |
| 8. Water Cooled Exhaust Manifold By-Pass | 18. Oil Level Regulator              |
| 9. Water By-Pass Line                    | 19. Electric Starting Motor          |
| 10. Cooling System Filter                | 20. Crankcase Water Drain            |



WAUKESHA MODEL WAKC, LEFT SIDE VIEW  
DISTRIBUTOR IGNITION ENGINE

- |   |  |
|---|--|
| 1. Engine Timing Charts                           | 10. Barring Device                             |
| 2. Valve Clearance Chart                          | 11. Fuel Sediment Bowl                         |
| 3. Distributor Ignition Coil                      | 12. Fuel Pump Manual Primer                    |
| 4. Ignition Distributor                           | 13. Oil Line - Filter to Engine                |
| 5. Intake Manifold (Updraft)                      | 14. Full Flow Oil Filters                      |
| 6. Carburetor By-Pass Line                        | 15. Expansion Tank Overflow Line               |
| 7. Water Line - Water Manifold to Intake Manifold | 16. Intake Manifold Drain Line                 |
| 8. Instrument Panel                               | 17. Water Line - Intake Manifold to Water Pump |
| 9. Air Cleaners                                   | 18. Water Level Gauge                          |



WAUKESHA MODEL WAKC, RIGHT SIDE VIEW  
HEAT EXCHANGER COOLING SYSTEM

- |   |   |
|---|---|
| 1. Exhaust Manifold Water Inlet           | 11. Heat Exchanger By-Pass Line           |
| 2. Oil Line - Engine to Filters           | 12. Water Pump Drain                      |
| 3. Oil Line - Oil Cooler to Engine        | 13. Water Line - Pump Inlet to Oil Cooler |
| 4. Water Line - Oil Cooler to Pump Outlet | 14. Oil Cooler                            |
| 5. Water Temperature Bulb                 | 15. Oil Line - Filters to Oil Cooler      |
| 6. Water Pump Grease Cup                  | 16. Oil Line - Pressure By-Pass to Sump   |
| 7. Cooling System Expansion Tank          | 17. Oil Pan Drain                         |
| 8. Cooling System Heat Exchanger          | 18. Voltage Regulator                     |
| 9. Generator                              | 19. Electric Starting Solenoid            |
| 10. Crankcase Water Drain                 | 20. Manual Choke Control                  |

## PRINCIPAL ENGINE DIMENSIONS

BORE AND STROKE . . . . .	6-1/4 x 6-1/2
NUMBER OF CYLINDERS . . . . .	6
DISPLACEMENT, cubic inches . . . . .	1197
NUMBER OF MAIN BEARINGS . . . . .	7
FRONT MAIN BEARING, diameter x length . . . . .	4 x 2-3/16
CENTER MAIN BEARING, diameter x length . . . . .	4 x 3-9/16
REAR MAIN BEARING, diameter x length . . . . .	4 x 3-1/4
INTERMEDIATE BEARINGS (4), diameter x length . . . . .	4 x 2-3/16
THRUST — taken at front main bearing	
CONNECTING ROD LARGE BEARING, . . . . .	3-3/8 x 2-1/16
diameter x length	
CONNECTING ROD SMALL BEARING, . . . . .	1-7/8 x 2-1/4
diameter x length	
CONNECTING ROD LENGTH, c. to c. . . . .	13-1/4
PISTON PIN, floating, diameter x length . . . . .	1-7/8 x 5-1/2
RINGS, straight side, compression (3) . . . . .	1/4
RINGS, straight side, oil control (2) . . . . .	1/4
(1 for 1800 RPM operation)	
VALVE, Intake, clear diameter . . . . .	2-3/8
VALVE, Exhaust, clear diameter . . . . .	2
TIMING GEARS, face width . . . . .	1-1/2
FAN, 8-blade diameter . . . . .	32 and 36
CRANKSHAFT THRUST — taken at front main bearing	
FIRING ORDER . . . . .	1-5-3-6-2-4
FLYWHEEL HOUSING, Size . . . . .	SAE 0
SPARK PLUGS . . . . .	18 mm.
CARBURETOR FLANGE, SAE size (downdraft) gaseous fuels . . . . .	2-1/2
CARBURETOR FLANGE, SAE size, gasoline . . . . .	2
OILING SYSTEM, capacity, gal. (not including lines and filters) . . . . .	8
WEIGHT, Engine (bare) approximate lb. . . . .	3050
WEIGHT, unit (with starting engine and PTO) lb. . . . .	5680

All dimensions stated in inches unless otherwise indicated.  
Do not use for service adjustments.

## DESCRIPTION

### GENERAL

The Waukesha Model WAK and F-1197-G are six cylinder overhead valve, spark ignition, gasoline and gaseous fuel engines designed and constructed for heavy duty applications. The 1197 cubic inch displacement engines are, because of their sturdiness and smooth performance, ideally suited for many industrial power services. Since the many different applications these engines are suited for will result in many engine and equipment variations, this text will cover only the standard engine and the most commonly used optional equipment and accessories. Although reference is made to the WAK throughout the manual, this information also applies to the naturally aspirated F-1197-G engine series.

The following operational and service data have been prepared from a practical viewpoint. There are no special techniques or "tricky" adjustments necessary to keep the WAK in good operating condition. Consistently careful maintenance of the engine and its fuel, oil and coolant, will more than pay for itself in prolonged good performance and reliability. Never overlook the great contribution that properly serviced air cleaners can make to engine life. In addition, reasonable storage care, especially of the precision parts, is extremely important.

For the purpose of discussion, or correspondence, the following references are used:

**CYLINDER NUMBERING** - Cylinders are numbered consecutively from one to six, starting from crankshaft pulley end of engine.

**FRONT and REAR** - Reference to such locations on the engine shall be interpreted as meaning from the crankshaft pulley (front) and flywheel (rear) ends.

**RIGHT and LEFT** - Shall be interpreted as meaning from the right and left of a viewer standing at and facing the rear (flywheel) end of the engine.

**ROTATION** - Standard rotation is counter-clockwise standing at and facing the rear (flywheel) end of the engine.

Since many of the parts described contain complex oil or water passages, no mention has been made of these passages except as is nec-

essary to avoid uncertainty. Lubrication and cooling are discussed under separate headings at the end of this section.

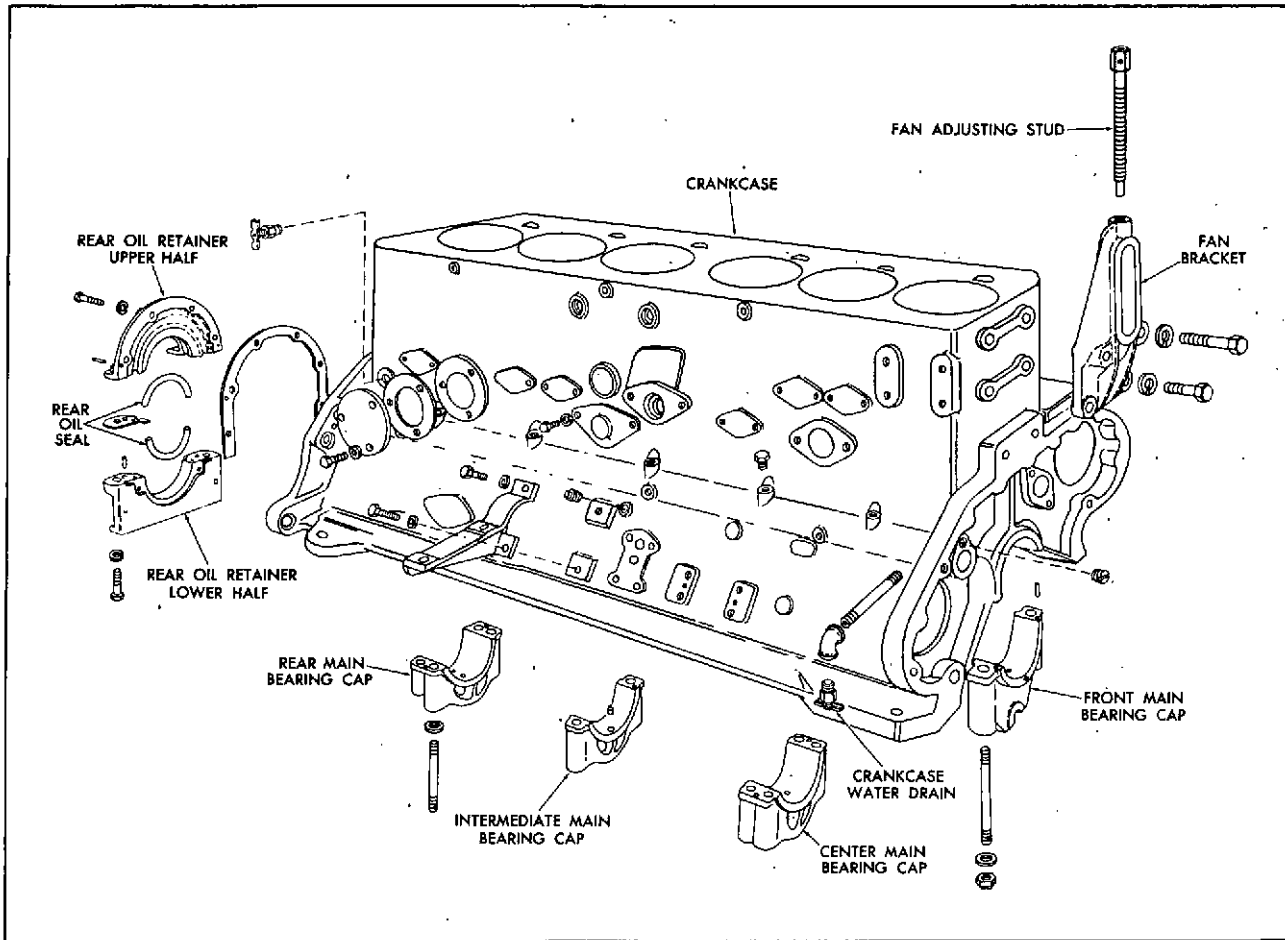
### CRANKCASE

The main crankcase of the WAK engine is a single high-grade iron casting incorporating seven heavily ribbed main-bearing supports and locations for the six wet-type cylinder sleeves. The cooling water passages are formed between the side-wall structure of the crankcase casting and the cylinder sleeves. Thus, the sleeves are always in direct contact with the coolant. Since the cylinder sleeves are of the removable type, it is necessary to maintain a seal at the upper and lower sleeve-to-crankcase contact surfaces. This is done by the head gasket which seals the accurately finished mating surfaces at the joint between the sleeve flange and the crankcase deck recess at the upper end, and by two seal rings at the lower end of the sleeve.

The crankcase has four accurately aligned locations for the camshaft bearing bushings. These bushings, located on the left side of the engine, support the camshaft at the front and rear and at two intermediate points, all of which are supplied with oil under pressure. Immediately above the camshaft are 12 locations for the sleeve type cam follower guides.

At the rear end of the crankcase is a mounting surface for a flywheel housing of the specified size and two (upper and lower) packed-type crankshaft oil retainers. To ensure accurate mounting of the clutch or other drive unit in the flywheel housing, the rear surface of the engine is held to very close tolerances and the housing itself is machined true after the engine has been assembled. Whenever the power take-off, the fly-wheel, or fly-wheel housing are removed, the run-out and eccentricity of the related parts should be checked and adjusted to the following limits: fly-wheel housing should not be eccentric more than 0.010-in. total indicator reading; nor should there be more than 0.010-in. indicator reading for the housing face run-out. The maximum indicator reading for the clutch pilot bearing eccentricity is 0.005 inch. Flywheel face run-out should not exceed 0.013".

Inspection panels, located on the left side of the crankcase, allow access for removal and inspection of the cam followers and permit removal of any sludge that may collect in this area.



CRANKCASE, EXPLODED VIEW

A longitudinal rib extending along the right side and about midway up on the crankcase is drilled to form the main pressure-oil header. Six threaded plugs spaced along this rib indicate the intersection points of oil leads to the main bearings. Removal of these plugs permits cleaning of the oil passages after crankshaft and main bearings have been removed for major inspection or repair.

Faced mounting bosses and connections are provided at various points on the crankcase exterior for mounting accessories; lines, and other equipment selected by the engine operator.

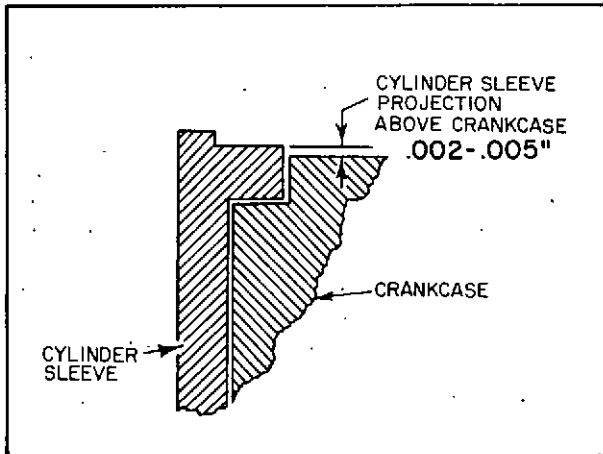
**CYLINDER HEADS**

Two cast-iron cylinder heads are designed and fabricated especially for the temperatures and pressures of industrial and commercial use. Three intake-valve guides and three exhaust-valve guides are pressed into each head. To assure maximum valve performance and life, inserts are used in intake and exhaust valve

seats. Mounting pads for the intake and exhaust manifolds are provided on the left and right side of each head. Two mounting pads on each head, support a water manifold that collects the coolant leaving the engine or in some applications, "hot" exhaust manifolds. The cylinder heads may be interchanged between front and rear positions, but if this is done it is necessary to move the rocker-arm oil line connection from one end of the head to the other and install a plug in the hole formerly used.

**CYLINDER SLEEVES**

The wet-type cylinder sleeves are cast from high-grade iron especially selected and hardened for long wearing qualities and resistance to distortion. Each sleeve has a shoulder and flange at the upper end to locate it in the crankcase upper deck and prevent shifting and leakage when the cylinder head and gasket are secured above it. This flange, and the crankcase deck recess into which it fits, both have precision-finished mating surfaces to form a water seal



CYLINDER SLEEVE PROJECTION

in this area. The cylinder sleeve projects 0.002-0.005-in. above the deck to ensure a tight crush gasket joint. Whenever sleeves are installed, this should be checked. The following procedure should be used to measure cylinder sleeve projection:

1. After removal of head, clean carbon and other deposits from face of block and sleeve projections.
2. Place metal bar across center of sleeve and bolt both ends into place using 100 ft. lbs. torque. This step will force the sleeve into the position it normally occupies when head is in place.
3. Use dial indicator to measure height of sleeve projection above face of block.

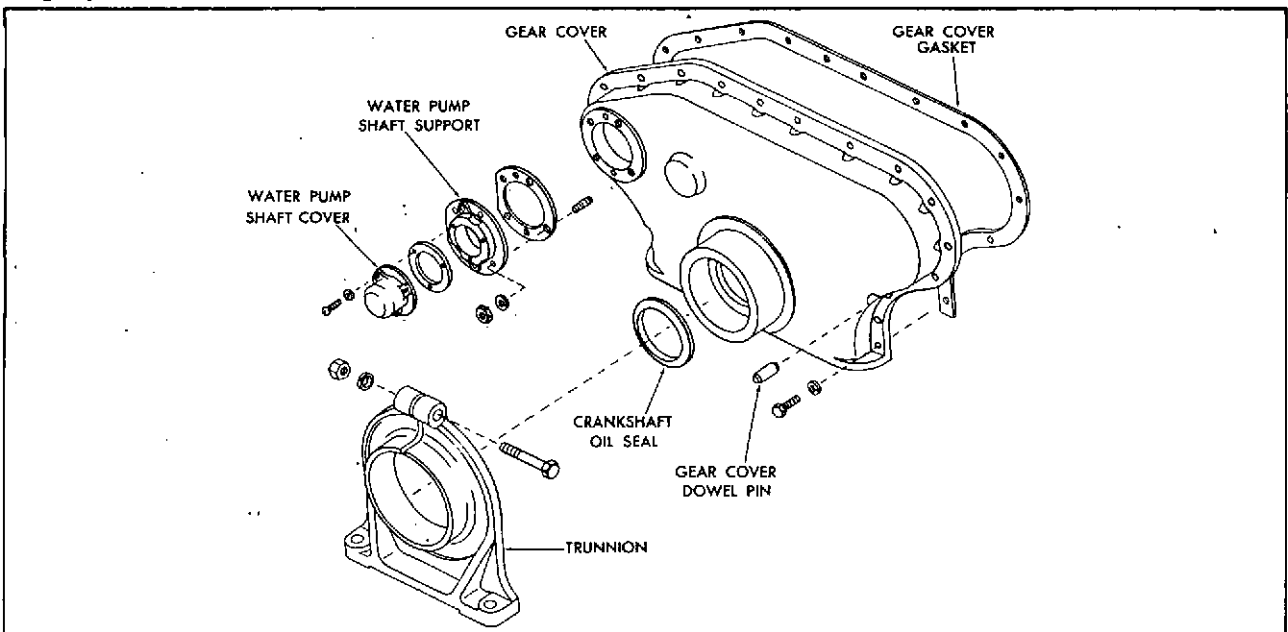
The lower end of the sleeve is tapered, and immediately above the taper are two grooves for the rubber seal rings. Engines with special cooling use a Teflon seal ring in the bottom groove.

#### VALVES AND MECHANISM

Intake and exhaust valves are both of the poppet type with hardened tips and annular recesses for split-taper locks. Stellite seat facings are employed on the exhaust valves. The seat angle of the intake valve is 30 degrees, while the exhaust valve has a 45-degree seat. To aid in maintaining free travel in the valve guide, the exhaust valve stem has a sharp shoulder for a light scraping action.

The intake and the exhaust valves seat on inserts in the cylinder heads. These seat inserts are shrunk in place and have a small recess to permit insertion of a puller, for removal. Intake and exhaust guides are pressed into place in the cylinder heads but may be pulled and replaced. Each guide has a separate collar that rests on the top of the cylinder head to support the springs. Intake and exhaust guides may be distinguished by a 45-degree taper on the upper end of the intake guide. The upper end of the exhaust guide has a 3/32-inch radius.

Valves and springs are retained by hardened washers stepped to center the springs and seating on split-taper locks. The springs incorporate damper coils and are interchangeable between intake and exhaust valves, but should always be installed with the close-wound coils towards the



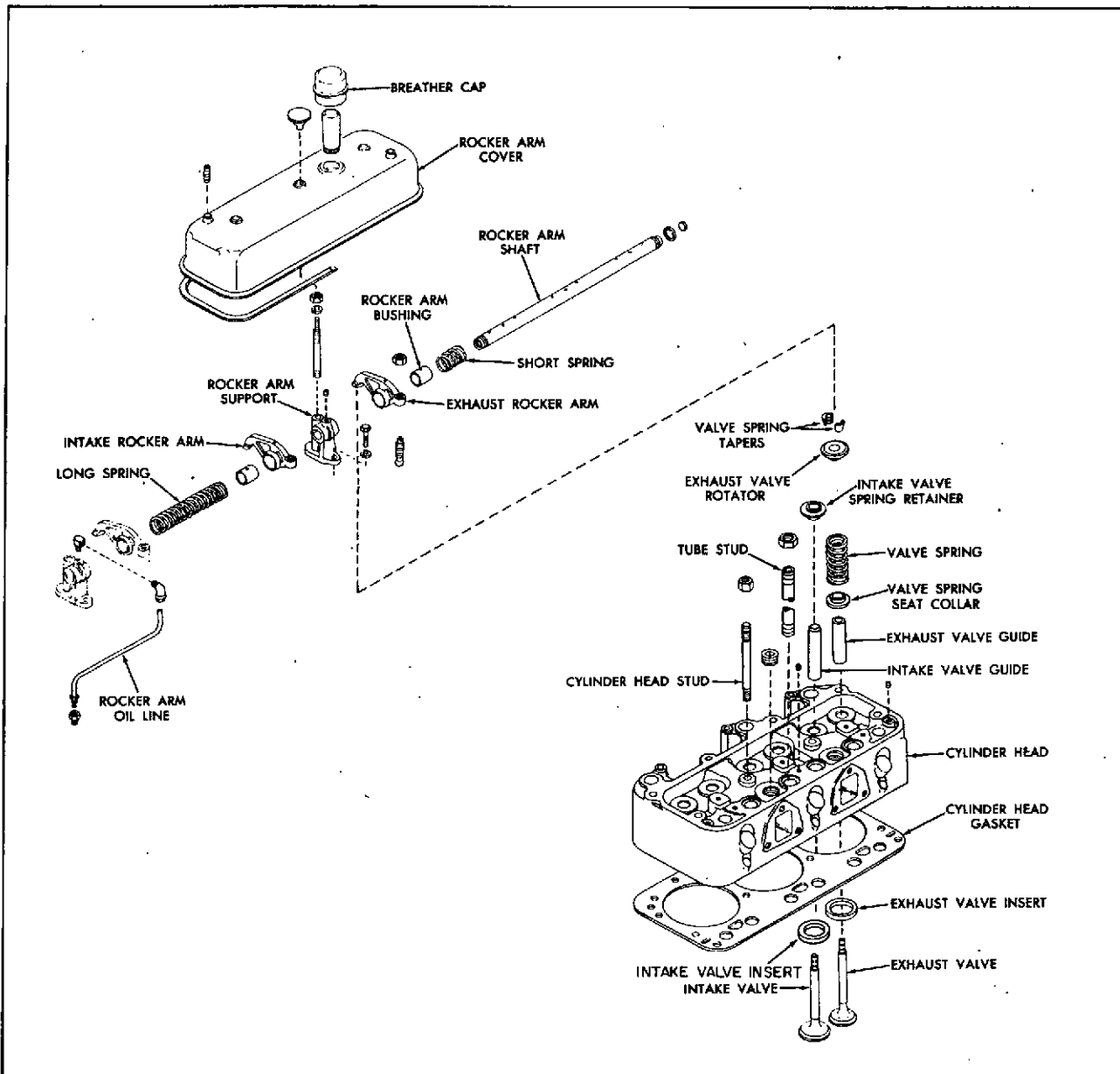
GEAR COVER, EXPLODED VIEW

head (downward). Low speed industrial engines employ only one spring, others usually have two.

Valve actuation is obtained through chilled and polished molybdenum-iron alloy roller type cam followers, riding directly on the camshaft. This motion is transmitted to rocker arms through tubular steel push rods equipped with hardened sockets at each end. Another socket seats in the cam follower and receives the lower end push-rod tip.

The forged steel rocker arms pivot on split-

type graphite-bronze bushings riding on a hardened hollow steel shaft. The bronze bushings are pressed in place, then reamed. The rocker arms are curved to align with their respective intake or exhaust valve tips. To ensure long wear and accurate adjustment the arms are hardened in the valve-tip contact area. The rocker-arm shafts are plugged at each end by spot-welded expansion plugs. Drilled openings along the shaft mate with passages in the rocker-arm bushings and rocker arms to permit lubrication of the entire overhead mechanism. Three grooves across one side of each shaft prevent shaft rotation.



CYLINDER HEAD, EXPLODED VIEW

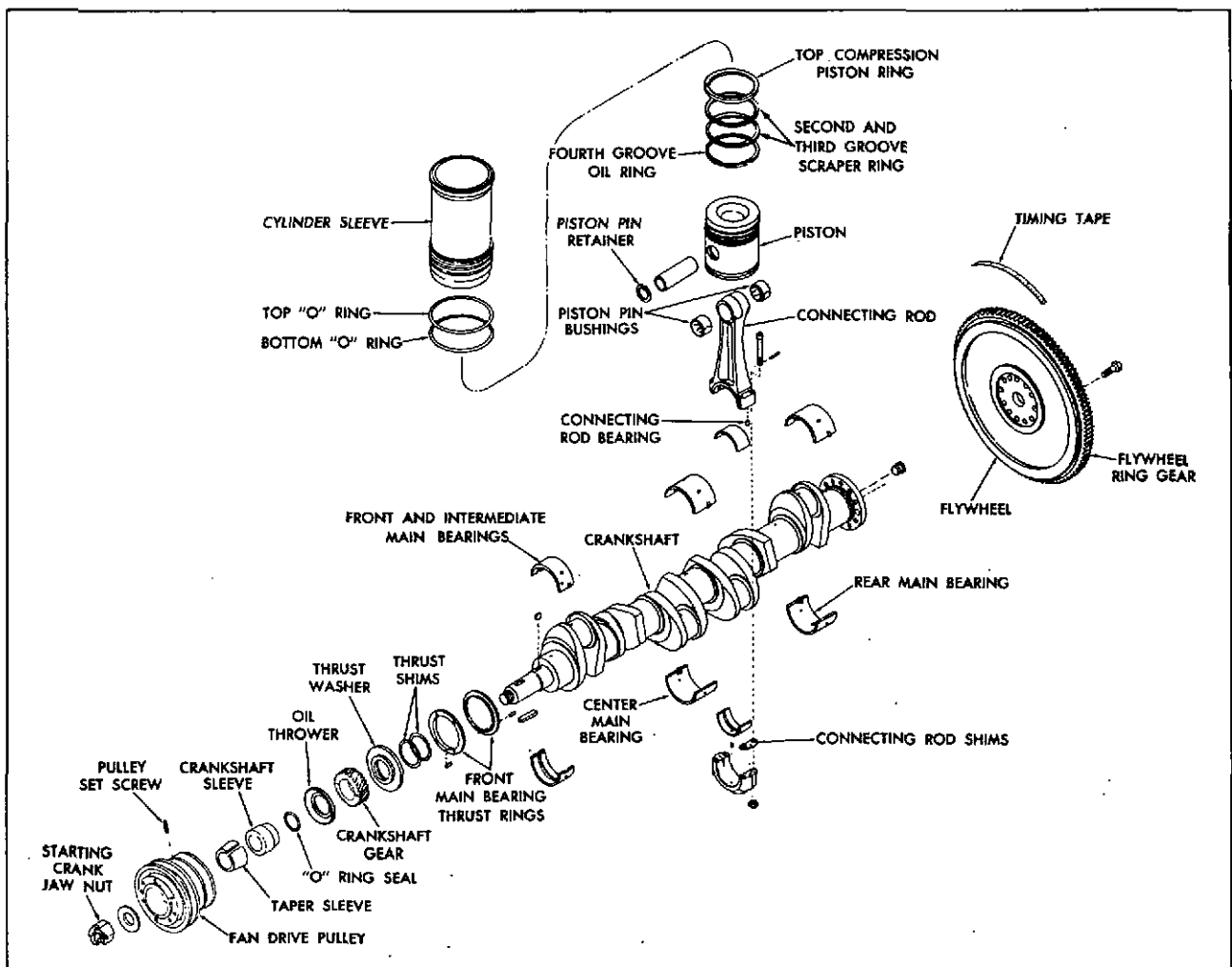
**PISTONS**

The aluminum alloy pistons are heavy-duty castings and of the cam-ground, tapered, full-skirt type. The piston pins are of the full floating type and are retained in the piston by spring type clips. These pistons were furnished in "A", "B", "C", and "D" sizes, differing by about 0.0005 (one-half thousandth) on the skirt diameter. In addition, they are matched for weight within one ounce. Weight marking should be noted and service pistons selected to match others in the engine.

**CONNECTING RODS**

Six I-section connecting rods of the split-big-end type are used in the WAK Series. The rods and caps are forged, heat-treated, and machined in one piece, then separated at the crank pin end to accommodate steel backed,

precision-type bearings. Hard bronze bushings are a press fit in the piston-pin end and are burnished in place, then diamond bored for precise alignment. These bushings are used as a master reference for boring the large end bearing seat. For this reason, the connecting rods in the WAK Series are never bent for alignment purposes, at the factory nor in the field. A rifle-drilled passage running slightly to the right of the rod center permits oil transfer from the large-end bearing to the piston-pin area. A locating dowel for the bearing is fitted in the cap at a point 7/16 inch towards the front face of the rod. Observation of this point will prevent improper installation of the rod cap. Current engines utilize bearing lugs instead of bearing locating dowels. Four heat-treated bolts with slotted nuts retain the bearing caps in place. Bearing clearance is controlled by 0.002-inch shims laminated to a total of 0.008 inch thick, one pack on each side. These shims may be



**CRANKSHAFT, PISTONS AND SLEEVES, EXPLODED VIEW**

peeled apart for adjustment purposes, but if such a procedure is undertaken, it will also be necessary to remove equal amounts from the bearing shell crush ends by filing, or lapping on a surface plate. The upper and lower halves of these bearings must not be interchanged; to do so will stop oil circulation to the piston and pin. Current engines have the same upper and lower rod bearing halves and do not use shims.

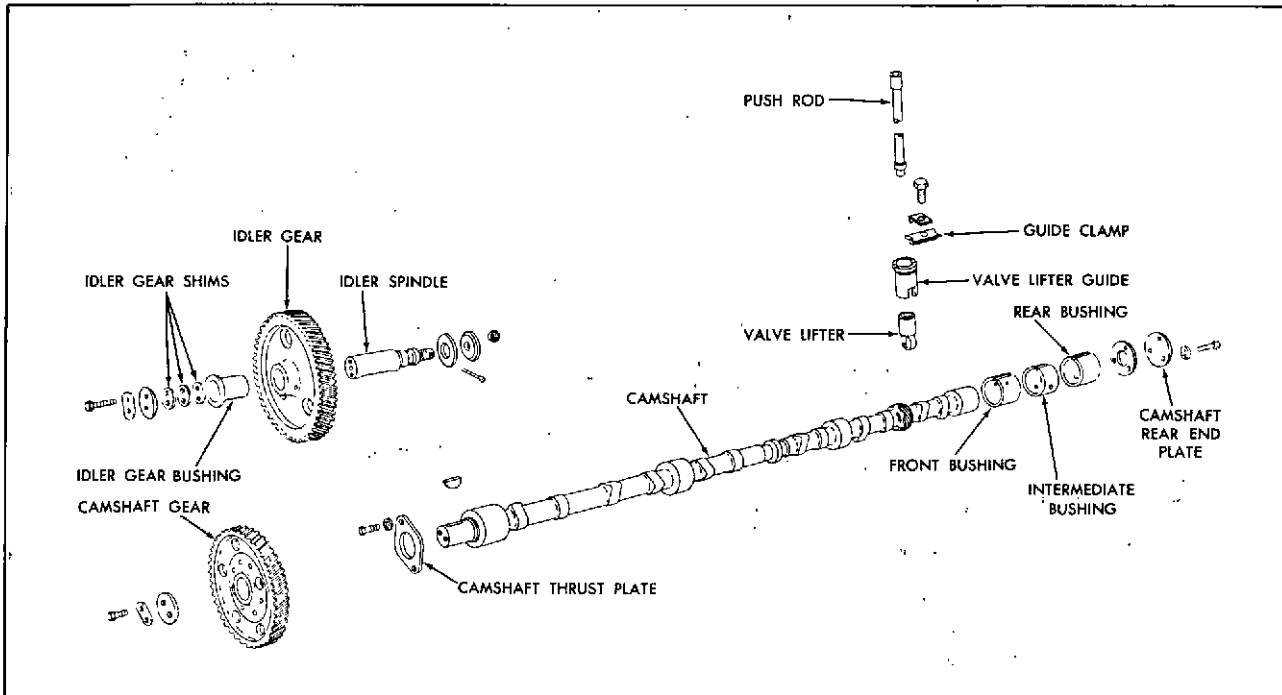
**CRANKSHAFT**

The Model 6-WAK crankshaft is precision ground from a heat-treated steel forging. In all WAK models, crankcheeks are of massive design to provide ruggedness for hard, continuous service. The crankshaft has seven locally-hardened main-bearing journals which run in precision-type steel-backed, aluminum alloy bearing shells. The upper and lower halves of these bearings must not be interchanged. Upper halves have a transverse slot on the outside; lower halves do not. Drilled passages, running diagonally from the main-bearing journals through the crankcheeks, carry pressure oil to the connecting-rod bearing areas. The rear extremity of the shaft has an integral mounting flange for the flywheel. This flange is drilled and tapped for ten 1/2-20 flywheel mounting bolts. The bolt hole opposite number-six crankpin is offset 1/16 inch in order

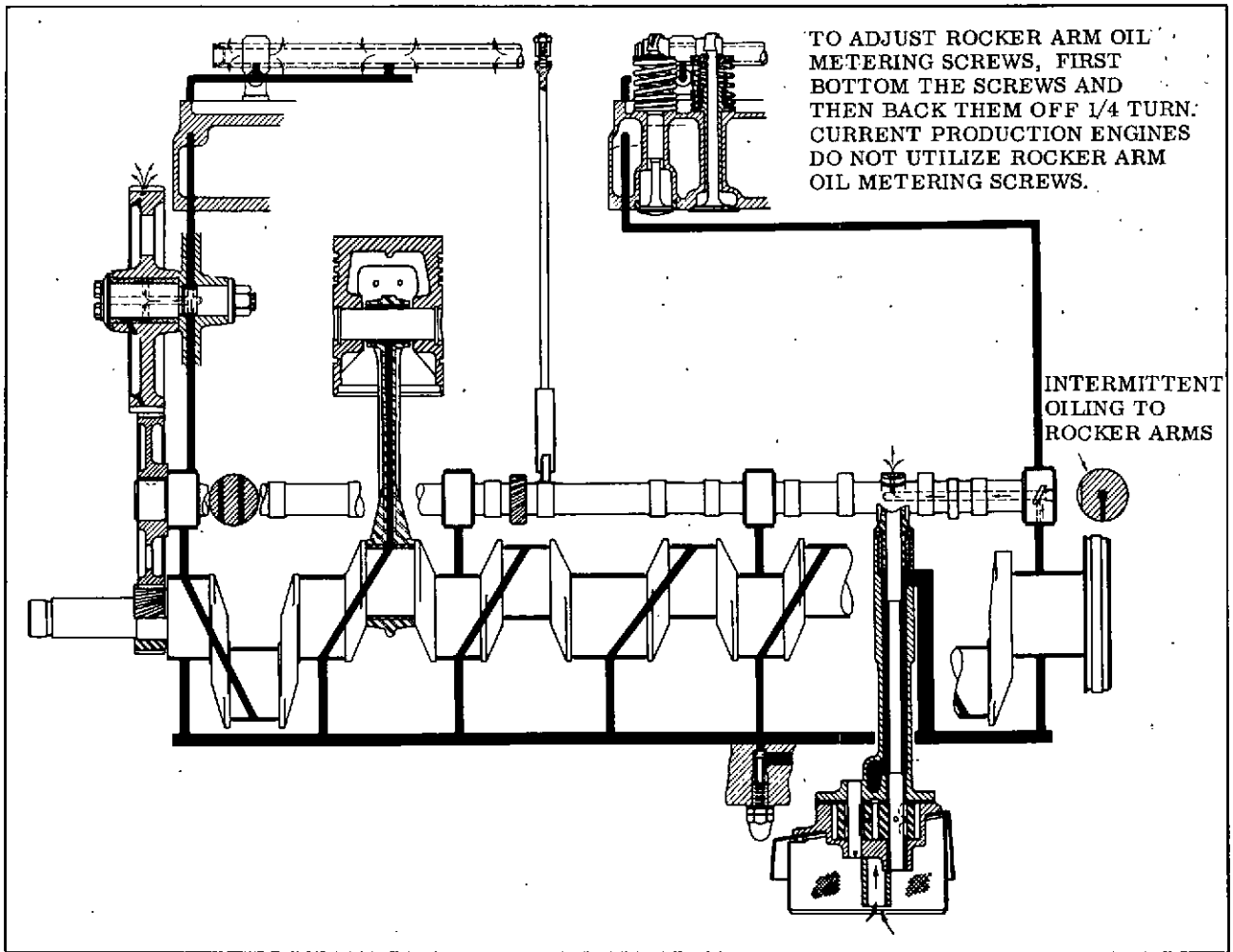
to ensure the installation of the flywheel in the proper relationship to the crankshaft. The front crankshaft journal blends into a finished shoulder surface designed to absorb thrust loads. This shoulder bears against the inner of the two bronze flanges doweled in place on each side of the front main bearing. The front extension of the crankshaft provides two keyed mounting surfaces to support the crankshaft drive gear and the fan pulley. The foregoing parts are a press fit, retained by a crank-jaw nut. The crankshaft must be locked forward whenever a new pulley is installed. Failure to do this could result in improper end play.

**CAMSHAFT**

The camshaft is a single forging, with ground cams and journals held within very close tolerances of dimension and alignment. Individual, hardened cams actuate each of the twelve cam followers. An integral worm gear drive, located between the rearward intermediate journal and the rear journal drives the internal oil pump. The forward end of the camshaft is drilled and tapped and keyed for the retention of the cam-drive gear and the governor drive gear. Thrust and end play are absorbed by a thrust plate assembled directly behind the cam drive-gear. A diagonal slot on the camshaft rear bearing journal, and a drilled hole in the front journal control intermittent pressure oiling to the over-



CAMSHAFT AND IDLER, EXPLODED VIEW



LUBRICATION SYSTEM

head valve members. Four steel-backed babbitt bushings, doweled in the main crankcase, support the camshaft at each end and at two intermediate points. Replacement of the gears in the cam drive or governor drive set-up is not recommended as a field procedure.

Formerly these gears were a selective fit, with size markings stamped on them. A standard size is now used without size marks. Only in extreme cases should a selective fit be necessary.

**LUBRICATION SYSTEM**

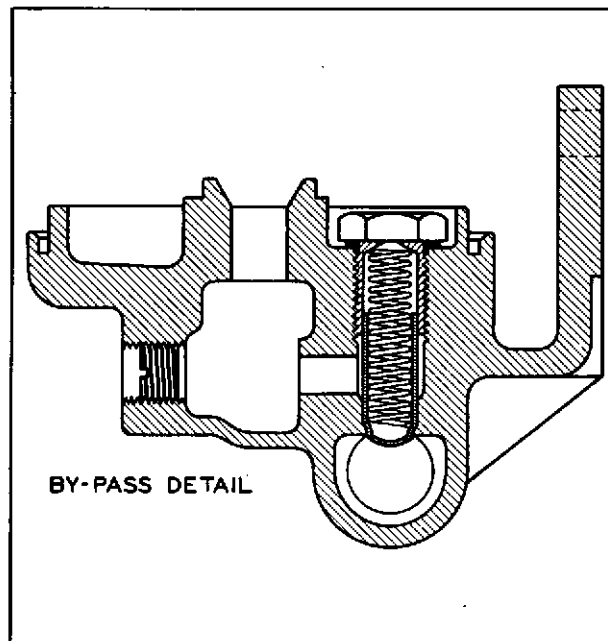
The WAK Series uses a wet-sump, pressure lubrication system. With the exception of the incidental oil that normally remains in the lines, filters, and passages, the entire oil supply of the engine collects in the engine sump. The rear sump oil pan has been designed to receive the oil in such a manner as to minimize turbulence

and to spread it out in a smooth flowing sheet for contact with the aluminum wall surfaces. An overhang above the deepest portion of the sump impedes any surging action to the forward end of the sump under rough operating conditions.

The suction produced on the inlet side of the oil pressure pump, or the scavenger pump if used, draws the oil into the oil-level equalizer cup and screen in the sump and conducts it to the oil pressure pump inlet. Having entered the oil pump, the oil is carried around the space between the gear teeth and the pump walls by the mechanical action of the oil pump gears and is discharged under pressure at the top of the pump.

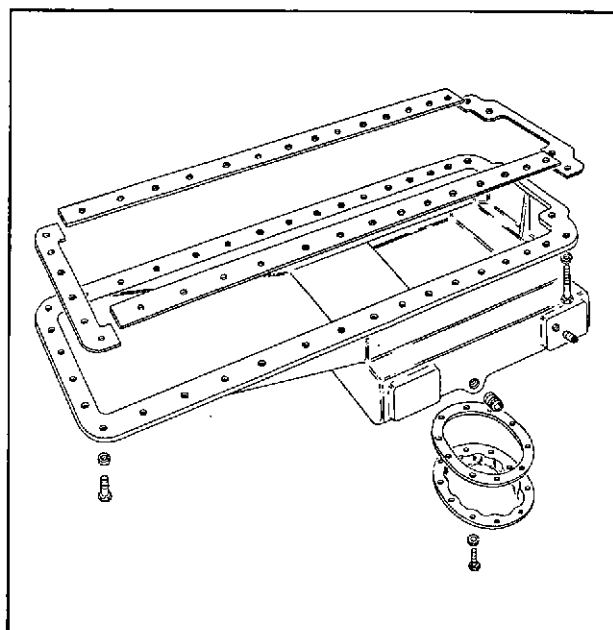
The pressure-control valve, or pressure-relief valve as it is sometimes termed, is located in the main oil header and prevents excessive variations in oil pressure in the face of many conditions—heat and cold, new parts and worn parts, speed variations, and so on—

under which an engine must operate. This valve is a very effective, and simple, device, and its proper adjustment is important to engine life. For this reason, the setting is properly made at the factory and it ordinarily will be unnecessary to make any adjustment for a long period of operation. In operation, the oil enters the pressure-relief valve body as a first step into the main engine pressure passages. If excess pressure, beyond that for which the spring has been adjusted, builds up for any reason, the valve or piston moves away from its seat and permits the pressure to relieve by spilling oil directly into the crankcase. The remaining quantity of oil that is held at the desired and established pressure now enters the main oil header which passes through a horizontal rib extending the length of the right side of the engine. From this main header, drilled passages extend through the crankcase webs to each of the seven main bearings. One of these passages, at the front of the crankcase, intersects a groove around the idler-gear stub shaft on its way to the front main bearing. A small portion of the oil enters this hollow stub shaft and feeds through to another groove in the bronze bushing supporting the idler gear. In addition to lubricating the idler gear bushing, this oil is bled through three small holes to the outside of the gear hub and then is thrown by centrifugal action to the inner rim of the idler gear. A collector groove in the rim retains a small amount of the oil and again bleeds it outward through two holes, this time to the gear teeth contact surfaces.



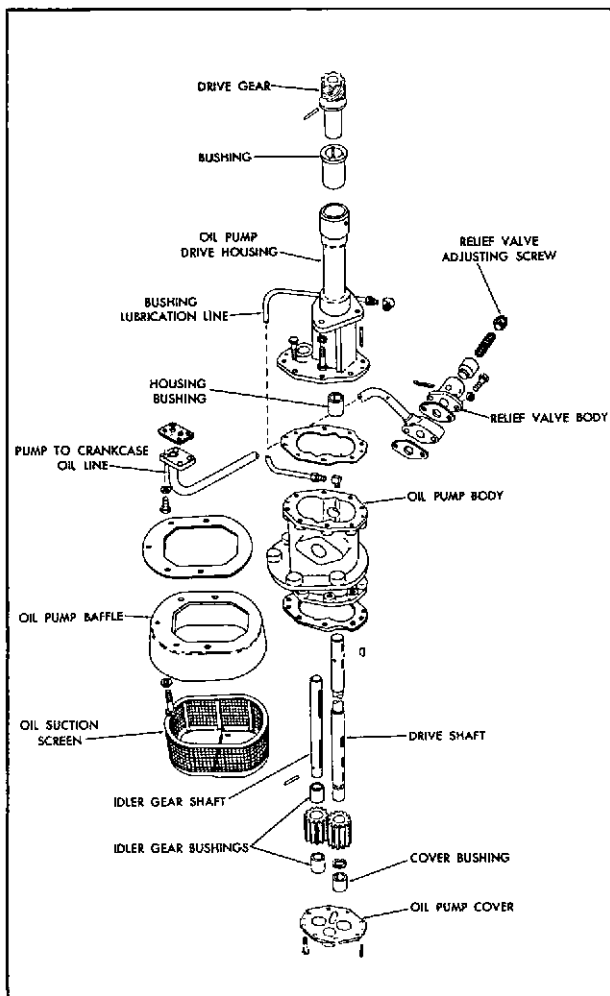
WAUKESHA OIL FILTER

After lubricating the front main bearing, another portion of this oil is again diverted and passes upwards to the front camshaft bushing. Here, a hole drilled through the cam-shaft bearing journal indexes with a hole in the bushing twice each revolution in the manner of a simple rotating valve. Pressure oil passing through this hole, and thus metered in accordance with engine speed, passes through a drilled passage upwards through the crankcase, through a mating passage in the cylinder head, and emerges through a fitting and tube on the top surface of the cylinder head. The tube conducts this oil to the rocker arm shaft where it is allowed to bleed to individual rocker arms bushings by drilled outlets in the shaft. Further lubrication of the overhead mechanism is accomplished by bleed holes through the rocker arms and bushings which allow oil to escape to a flattened ridge on top of the rocker arms and flow down onto the valve stems and push rod sockets before draining back to the sump. A similar intermittent lubrication pattern lubricates the rear cylinder head with the exception that the controlling passage in the camshaft journal is a diagonal slot rather than a drilled hole.



OIL PAN, EXPLODED VIEW

A small portion of the oil fed to the front camshaft bearing journal passes to a drilled opening



OIL PUMP, EXPLODED VIEW

behind the camshaft bushing and through the mounting flange for the governor drive into a mating hole in the governor housing.

A major portion of the oil originally conducted to the front main bearing enters a drilled passage leading from the front main bearing journal diagonally to the crankpin of number one connecting rod. Part of this oil lubricates the connecting rod bearing and escapes to the cylinder walls and adjacent areas by spray. Another portion of it, however, passes into a groove behind the connecting rod bearing shell and into a rifle-drilled passage leading up the connecting rod to the piston pin bushing.

The oil filtering system is full-flow. With this system all oil in the pressure system must go through the filter element or its by-pass valve before entering the engine.

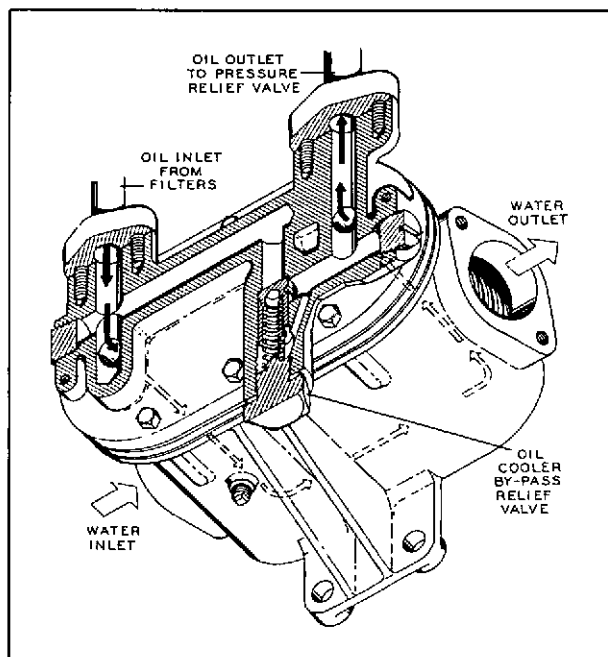
OIL PUMP

An internally mounted, gear-type, pressure oil pump with a large reserve capacity is used. The pump consists of a cast body unit and removable cover, which together act as a housing for the two oil pump gears. The oil-pump drive gear is keyed and pinned to the heat-treated drive shaft which runs in replaceable bushings in the housing and cover. The oil-pump idler gear, like the drive shaft, has replaceable bushings for long wear and continued accuracy of displacement.

The oil-pump cover to oil-pump body seal is effected by a paper gasket of 0.010-inch thickness. Substitution of thinner or thicker gasket materials will disturb the end-clearance relationship of the pump gears. An internal scavenger pump, employed on some models, is located just above the main pumping gears and is driven by the same spiral drive gear on the cam shaft. This pump is of the conventional spur-gear type.

OIL COOLER

To help maintain the oil at the proper temperature and viscosity under all operating conditions, the Model 6-WAK is equipped with an oil cooler. Mounted externally, this radiator-like cooler provides a large number of passages through which the oil flows under pressure. Cooling water surrounding the passages provides a



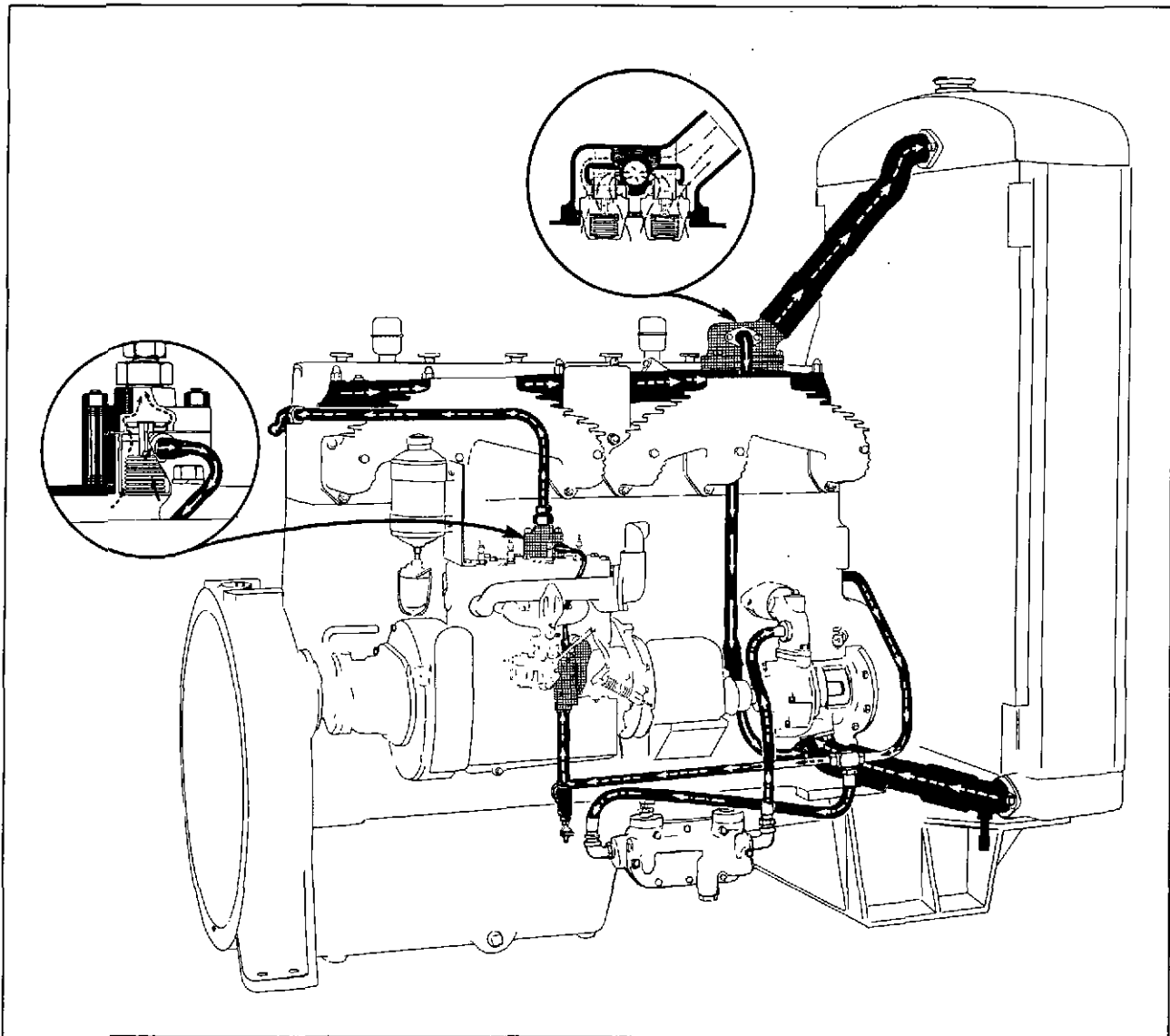
OIL COOLER, SCHEMATIC

heat-exchange medium and stabilizes the temperature of the engine oil. Under conditions of unusually high oil viscosity, such as occur on starting, a by-pass valve allows the thick oil to flow around the cooler core and directly into the engine. An air vent from the oil cooler jacket to the engine water jacket prevents air locking and excessive oil temperature.

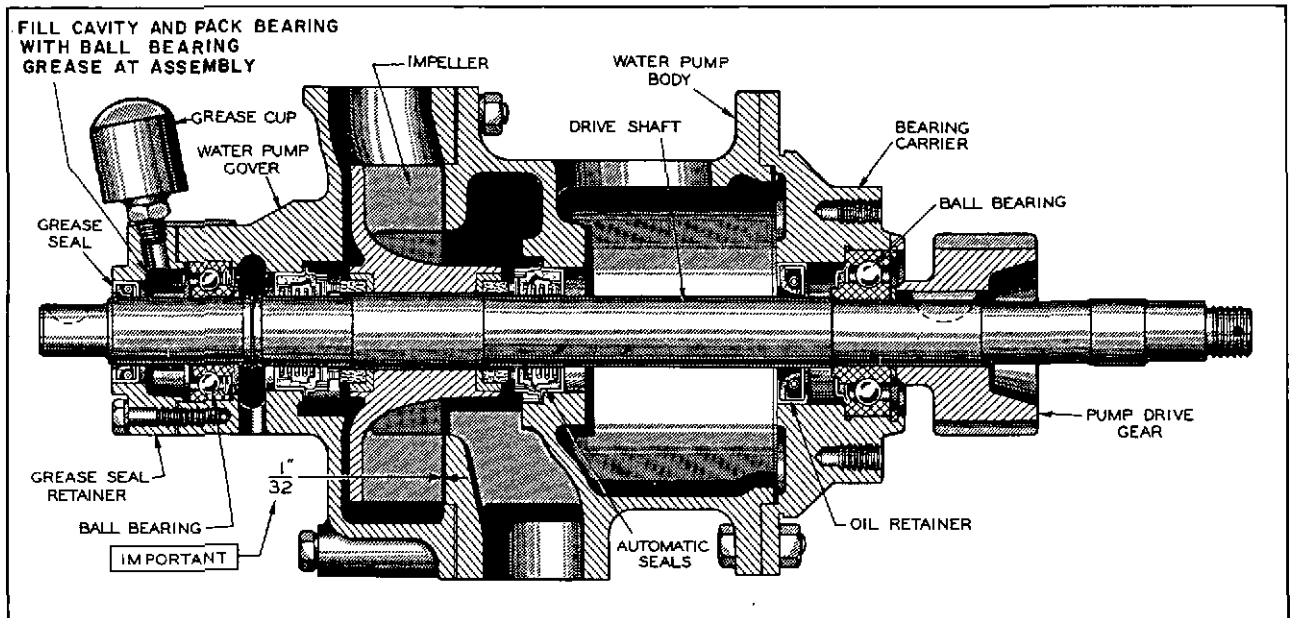
**COOLING SYSTEM**

The cooling system used on the WAK Series is of the pressure circulating type and may employ a variety of external cooling devices such as radiators, cooling towers, heat exchangers, and so on. In all cases, the water

enters the water pump inlet on the lower right side of the engine. The centrifugal pump causes this supply of cool water to pass into and through the oil cooler and then through a fitting that leads directly into the engine cylinder jacket. The water enters the engine in the area of the cylinder sleeve lower ends. From here the water flow is directed about the cylinder sleeves in an even manner until it passes upward from the crankcase and into the cored passages in the cylinder heads. These passages are carefully designed to allow cooling water access to all areas around the valves. A manifold collects the water from the cylinder heads on the right side of the engine and directs it to the radiator or other cooling device. Thermostats at the forward end of the water manifold control the exit temperature of



SCHMATIC OF COOLING SYSTEM



AUTOMATIC SEAL TYPE WATER PUMP

the water. Back pressure at the water outlet must not exceed 2 pounds per square inch regardless of the type of cooling system employed. A bypass line from the thermostats leads vertically down the right side of the engine and returns the water to the pump inlet for recirculation under cold water conditions. When the engine is warmed up and operating normally, the entire flow passes out of the engine for cooling unless temperatures are marginal, in which case occasional bypassing will occur. When the Model ICK gasoline starting engine is used, external lines couple the starting engine cooling system with the main engine passages.

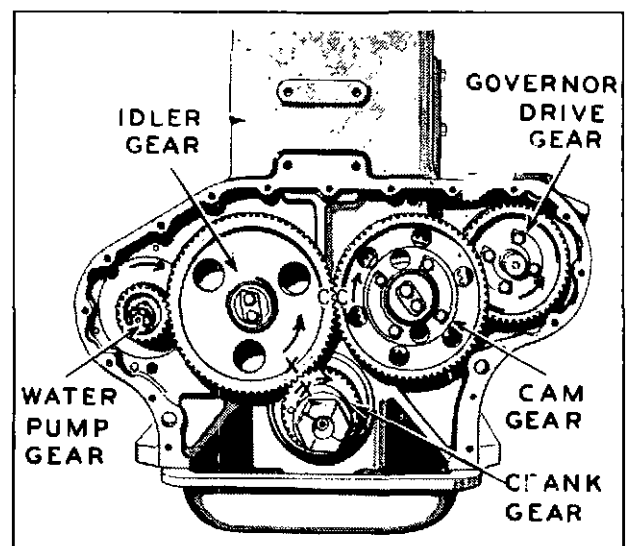
**WATER PUMP**

The water pump used on the WAK Series is an externally mounted centrifugal unit driven by a positive gear train from the crankshaft. The pump itself is a vaned impeller, press fitted on a hardened shaft, and operating in the chamber formed between the cast water-pump body and the water-pump cover. A third member of the unit is an iron casting that acts as a carrier for the water-pump ball bearing and serves as a mounting surface when the pump is installed on the engine. The water-pump shaft runs in a grease-lubricated bearing located just behind the impeller, and is supported at the drive end by the ball bearing pressed into the carrier. This bearing is located just behind the drive gear. An oil retainer, also pressed into the bearing carrier, prevents engine oil from the gear housing from passing along the shaft.

Self-adjusting automatic type seals at two points on the pump shaft prevent water seepage. A grease cup supplies grease to the water-pump bearing.

**INTAKE MANIFOLDS**

The intake manifolds used on the WAK series are selected according to the engine application. They may be of the water-heated type for gasoline or the conventional cold type for gaseous fuels; in either case updraft or down-draft types are available.



DRIVE GEAR ARRANGEMENT

## EXHAUST MANIFOLDS

As with the intake manifolds, exhaust manifolds are suited to the engine installation. Provisions are made for various combinations to permit exhaust gas to exit at center or rear of the manifold; and in some cases in an upward or downward direction. Installations where high exhaust manifold temperatures might create a fire hazard or make for operator discomfort may be equipped with water-cooled manifolds.

When designing systems to conduct exhaust gases from the engine, restrictions to flow should be minimized and back pressure held to one-half pound per square inch maximum. For high speed operation with a muffler, one pound per square inch is permissible.

## IGNITION SYSTEMS

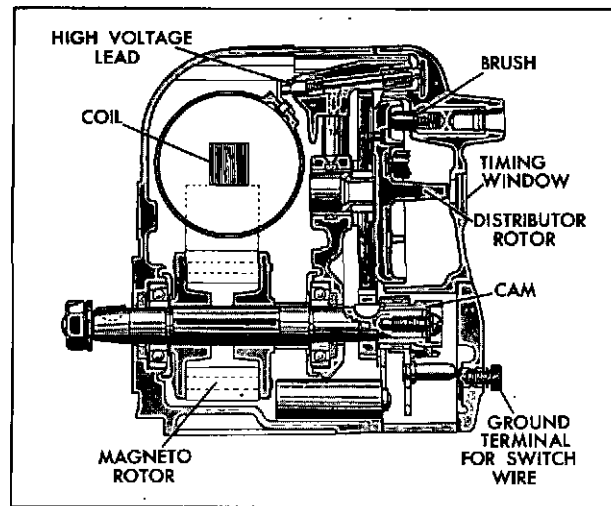
Smooth combustion requires positive ignition in the cylinders at finely defined intervals. This function is performed on the WAK engine by a magneto or distributor. Magneto equipped engines employ either a high-tension or low-tension magneto system depending upon the engine service involved. Magnetos are mounted to the rear of and driven by the water pump through shaft. The distributor is usually mounted on the left front side of the crankcase and is driven by a spiral gear mating with a similar distributor drive gear on the camshaft.

In both theory and service practice there is little difference between a magneto and a distributor. Whereas a distributor depends upon a generator and storage battery for its primary current, the magneto uses a primary current generated within itself by rotation of permanent magnets between the pole shoes.

A new breakerless distributor ignition system is receiving some usage in certain engine applications requiring long periods of unattended service. The distributor used in this system does not have contact breaker points or automatic advance device. Since the only moving part in this system is the distributor rotor trigger wheel shaft assembly, longer periods of operation are possible. The system currently in use employs an external electrical power source of 100 to 125 volts AC at 50-60 cycles.

### High-Tension Magneto Ignition

Magneto equipped engines in this series employ a high-tension magneto in the variant required for the service involved. Here, the variable factors include the speed at which the



TYPICAL HIGH TENSION MAGNETO

engine is expected to operate continuously, the possibility of fire hazard from combustible vapors, installation factors requiring wire exit positions on vertical or horizontal lines, spark advance and impulse coupling angles, radio shielding and so on. These points should be considered when ordering replacement units or parts.

An impulse coupling is built into the magneto to produce a spark at cranking speed to assure easy starting. When the magneto attains a speed of approximately 180 RPM, the coupling will automatically disengage and act as a positive drive timing the ignition to the normal spark advance.

### Low-Tension Magneto Ignition

The low tension magnetos available as optional equipment generate and distribute low voltage current through low tension cables to individual coils, one located adjacent to each spark plug. The current is stepped up to high voltage by the individual coils and is then conducted to the spark plug by a short length of high tension cable at the proper firing interval of the cylinder.

This low tension ignition system differs from the high tension ignition system in several ways. Primarily, the low tension system confines the high voltage electricity necessary to fire the spark plugs to a relatively small part of the entire system. Thus, possible deterioration of longer wires and loss of current is minimized.

The low tension system is less affected by moisture, since only the short high tension lead

is directly vulnerable. The stationary coil used in this magneto has only a single primary winding. The pivotless contact breaker is connected in series with the coil in the primary circuit. The condenser is connected across the breaker points.

The small distributor gear, located on the rotating magnet shaft, drives the large distributor gear and distributor cam. The ratio between these gears is such that the low tension current is distributed by a group of contacts, one pair for each cylinder, arranged about the distributor cam shaft. The individual high tension coils, one for each spark plug, are enclosed in housings protecting them from moisture and vibration. The cartridge type condenser is located inside the magneto housing.

#### Distributor Ignition

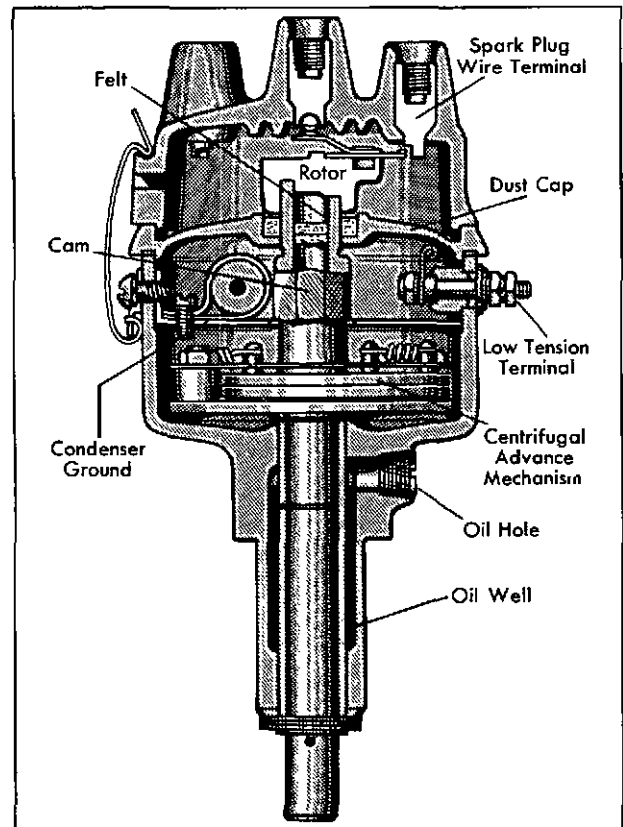
Utilizing battery current and an ignition coil, the distributor functions in much the same way as the magneto. The retarded spark for starting is obtained by the centrifugal spark advance mechanism that automatically advances the spark as engine speed increases.

#### Breakerless Distributor Ignition

The Bendix breakerless ignition system currently used consists of three parts: (1) a distributor with a magnetic triggering device, a distributor rotor and a standard distributor cap; (2) a control unit which provides an energy storing circuit, a control circuit, and a transformer coil; (3) a lead assembly to connect the distributor and control unit. Metal vanes mounted on the distributor shaft move past the end of a magnet in the triggering coil in the distributor, and, in passing, upset the magnetic flux through the coil. This change in flux produces an electrical pulse in the coil which is transmitted through the lead to the control unit, releasing the energy previously stored there. The output of the control unit discharges through the primary of the ignition coil, which is a part of the control unit assembly. This discharge of current through the coil primary induces a high voltage current in the secondary and produces a spark across the spark plug gap. The trigger circuits immediately become nonconductive and the whole cycle repeats at as fast a rate as required for engine operation.

#### GASOLINE CARBURETION

In the gasoline carburetor the functions of metering and vaporization of fuel are accomplished through a float valve and an intricate

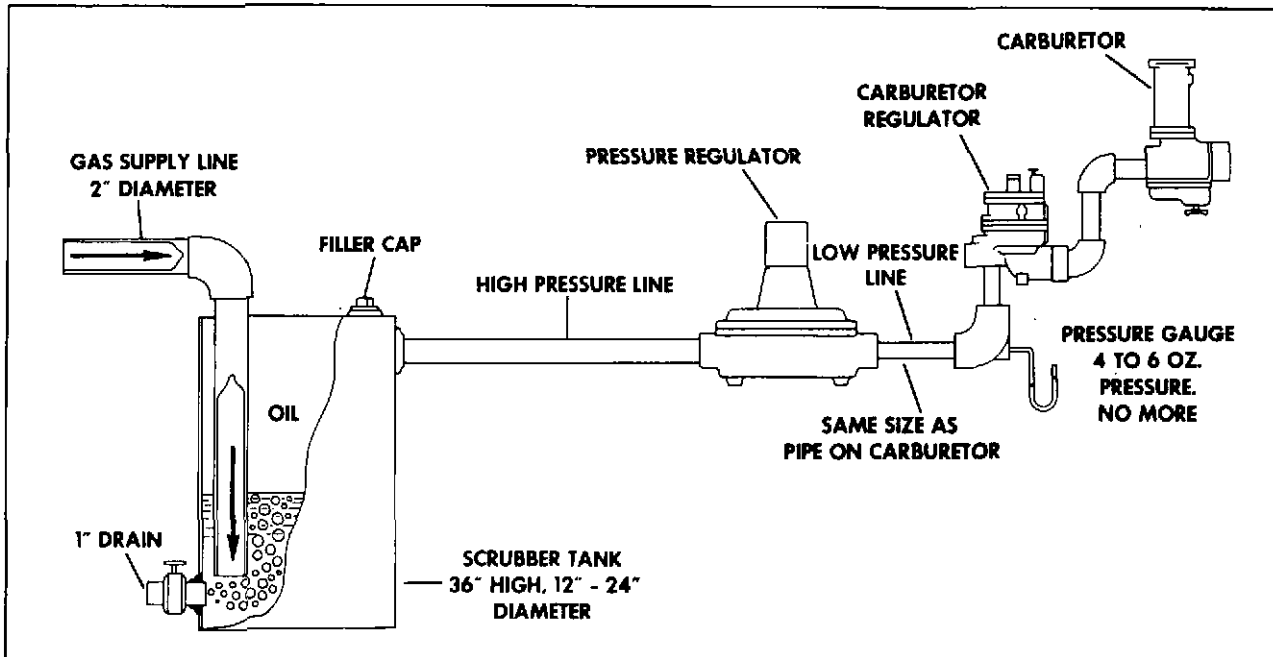


TYPICAL IGNITION DISTRIBUTOR

series of jets and venturis according to the speed and load of the engine. This process is carried out in three phases; idling, part load, and full load, with each phase involving a particular combination of the carburetor system.

Idling performance is obtained through a special fuel jet and air bleed past the throttle valve supplying fuel independently of the normally loaded system of the carburetor. When the engine is working under part load, economical use of fuel is desirable and is obtained by a mixture leaning out provision that supplies only enough fuel to carry the load at the most economical fuel and air mixture. With the throttle wide open, maximum power is the major concern, and the leaning out system becomes ineffective so the fuel and air mixture becomes rich enough for maximum power.

The extra amount of fuel needed for quick acceleration necessary when load is suddenly applied to the engine is provided by an accelerating pump and special accelerating jet system. Without this provision the engine would operate momentarily after the throttles opened with too lean a mixture to "pick up" the load rapidly.



FUEL PIPING DIAGRAM FOR GAS OPERATION

### GAS CARBURETION

Operation of the engine on gaseous fuels requires the use of a gas carburetor, fuel line regulators, and fuel filter.

The gas mixer, or carburetor, consists of a simple jet, a throttle valve and special idling system passages and venturi to operate in conjunction with the carburetor regulator. Some models of gas carburetors with air shutter type choke are provided with an economizer action that permit part load operation with economical mixtures and enrich the mixture for maximum power when necessary.

When liquified petroleum gases (LPG) such as butane or propane are used, the fuel system will include a butane filter, butane regulating unit, either a gas or gas-gasoline carburetor and a heat exchanger to vaporize the fuel.

The butane regulating unit reduces the higher incoming fuel pressure to that required by the carburetor and converts LPG fuel from a liquid state under tank pressure into a dry gaseous fuel slightly below atmospheric pressure. This is achieved by heating the fuel with hot water drawn from the engine cooling system.

### GOVERNORS

The standard Waukesha WAK engine is furnished with a centrifugal type mechanical gover-

nor which provides speed regulation and also prevents engine damage from overspeeding. A vacuum compensator, which works off intake manifold vacuum and thereby reflects load conditions, is used in combination with the mechanical governor in applications requiring closer engine speed and load regulation. An optional hydraulic type governor, the Woodward Model PSG, is used in place of the mechanical governor in certain close regulation applications.

### Mechanical Governor

The mechanical governors used on the WAK series engines are of the familiar centrifugal type. Two weights, driven directly from the engine gear train, respond to variations in engine speed by moving inward or outward from the governor shaft. This movement is transmitted to the governor weight shifter lever through a pilot bearing sliding on the governor shaft. From the shifter lever the movement is carried to the butterfly valve between the intake manifold and the carburetor by a series of linkages. For example, as the engine tends to slow down under an applied load, the weights move inward due to the reduced centrifugal force. Through the linkage system, this weight movement causes the butterfly valve to open and admit more fuel and air to the engine, thus restoring normal loaded speed.

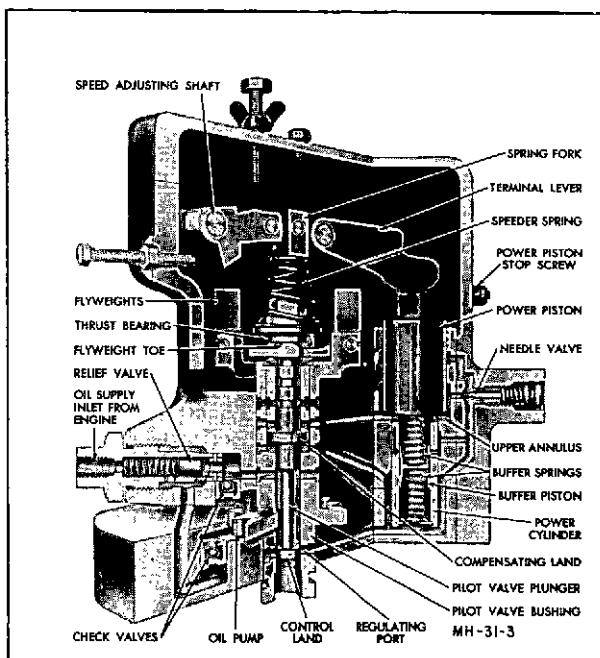
The governor also acts as a protective device to prevent engine damage from overspeeding. Here, as the speed increases towards that speed

established as the maximum, the weights move outward under the increased centrifugal force. This movement is opposed by the governor spring. When the force acting on the weights is balanced by the spring tension the butterfly linkage stabilizes. At this point the amounts of fuel and air entering the engine are held to those needed for the selected maximum speed and no more.

From the above paragraph, it can be seen that the maximum speed of the engine is regulated by the tension of the spring. An increase in spring tension increases the maximum governed speed; a decrease in spring tension decreases the maximum governed speed.

Because overspeeding is apt to have such serious effects upon engine life, it is strongly recommended that the rated speed for any particular engine not be exceeded. In cases where some advantage seems possible through increased speed, the Engineering Department of WAUKESHA ENGINE DIVISION should be consulted before changes are made.

Also, since the speed of response to load, the desired speed drop under load, and so on, will differ depending on the engine application and circumstances, it is recommended that unusual governing requirements be worked out with the assistance of the Engineering Department of WAUKESHA ENGINE DIVISION. Ordinarily, certain minor changes are all that is required to adapt this type of governor to its job.



WOODWARD PSG GOVERNOR

### Woodward PSG Governor

The PSG governor is a hydraulic speed governor with buffer type compensation. It is normally isochronous, that is if the engine is not overloaded it maintains the same speed regardless of load, except momentarily at the time load change occurs.

The governor uses engine lubricating oil or an oil supply from a separate sump furnished by the engine manufacturer. If the latter is used, lift should not exceed 12 inches and a foot valve should be furnished.

It is desirable that the engine be equipped with a separate overspeed device to prevent runaway in the event of any failure which may render the governor inoperative.

Oil is supplied to the governor oil pump where its pressure is boosted to 175 psi above inlet pressure. Four check valves (two of which are shown) are used to permit rotation of the governor in either direction. Relief valve discharge is back to supply, so unused oil is recirculated within the governor.

The governor oil under pressure is carried through ducts to the pilot valve, which is a three-way spool valve arranged to connect the area below the governor power piston to the pressure oil supply upon an underspeed signal or to discharge upon overspeed. The governor flyweights are carried on pivot pins in the rotating bushing which forms both the outer member of the valve and the drive shaft. The flyweights act upon a thrust bearing attached to the pilot valve plunger and their centrifugal force is translated to axial force at the flyweight toes and opposed by the speeder spring. Speeder spring compression, and therefore the speed at which the governor must run in order that the flyweight force will balance that of the spring, is adjusted by the position of the speed adjusting lever.

The isochronous feature of this governor is provided through the use of a compensating system which establishes temporary speed droop stability and then dissipates this droop so that engine speed is constant under steady state conditions regardless of load. This compensating system consists of a buffer piston floating between two springs to establish a pressure differential as oil flows to or from a section of the power cylinder together with a compensating land on the pilot valve plunger across which this differential pressure is applied, and a needle valve through which the pressure difference is dissipated.

Upon a reduction in engine speed from its set value, the speeder spring force overcomes the reduced centrifugal force of the flyweights and the pilot valve plunger moves downward in its bore. This movement uncovers the port at the lower end of the plunger, permitting oil under pressure to enter the passage leading to the power cylinder. The power piston has two concentric areas, both of which are exposed to the control oil metered by the pilot valve, the lower smaller diameter being acted upon directly, and the upper annulus being connected through the bore in the power piston in which the buffer piston is carried. Flow of the oil into the power cylinder forces the power piston up against the return spring (not shown in diagram) and some of the oil displaces the buffer piston to force oil into the upper annulus. This flow into the upper annulus establishes a pressure differential across the buffer piston, which is transmitted to the spaces above and below the compensating land on the pilot valve plunger. Higher pressure on the lower side of this land acts in the direction to supplement the flyweight force, causing closure of the pilot valve before original speed has been regained. As oil leaks across the needle valve this false speed signal is dissipated and the buffer piston recenters in its bore with engine speed returning to normal.

Action under the influence of an overspeed is similar but in the reverse direction. Increased centrifugal force of the flyweights, due to increased speed, overcomes the speeder spring force and lifts the pilot valve plunger. Upward movement of the pilot valve plunger opens the regulating port to drain and permits the power piston to be forced in the reduced fuel direction by the return spring. At the same time, flow of oil out of the annular space between the two diameters of the power piston, uncenters the buffer piston in the downward direction. Pressure difference thus created across the buffer piston, acting on the compensating land, recenters the pilot valve plunger. As oil leaks across the needle valve this pressure difference is dissipated and return of speed to normal brings the flyweight force back to normal.

#### STARTING SYSTEM

The starter mechanism used for these engines is either electric starting, a starter engine, or an air motor starter.

##### Electric Starting

The electric starting system consists of a heavy-duty starter and generator and regulating

devices, switches, and circuits similar to automotive installations. Starting is accomplished by closing a circuit from battery to starter with the instrument panel switch that actuates the magnetic switch. Positive engagement of the pinion before cranking commences is accomplished by the starting motor solenoid. After cranking is completed and the engine starts, the generator replenishes energy expended by the battery. Cut-outs and regulators control the generator's output and protect the system from reverse currents and excessive charging rates.

##### Starting Engine

A Model ICK gasoline starting engine is provided for units requiring heavy-duty starting equipment that operates through a starter drive mechanism. The starter engine is easily started by a rope starter on the gear end. By furnishing adequate power for full cranking speeds even when the oil is heavy, dependable starts for the main engine are insured.

The starting engine is built up of a four-cylinder block containing valves and tappets; a cast head; a crankcase which supports the crankshaft and camshaft; and miscellaneous oil pan and cover parts. The crankshaft is supported by two single-row, annular, ball-bearings, one at each end. Remaining elements of design are entirely conventional with the exception that the cooling-water system is a branch of the main engine cooling supply. Those points involving the starting engine that are of importance to the operator are treated in their respective locations.

##### Air Starting Motor

Engines located near a convenient source of compressed air or near a gas supply of sufficient pressure may utilize Ingersoll-Rand Air Driven Starting Motors. Velocity of gas or air entering the motor strikes the vanes causing a rotor shaft to revolve. The rotor shaft rides in two ball bearings and is geared to a Bendix starter device which is manually engaged when rotation is sufficient to crank the engine.

When natural gas is used for engine starting through the air motor, the exhaust and breather openings should be connected and piped to a safe distance from the engine. The motor should also be checked periodically for gas leakage at all points where gaskets and seals are used. Refer to the SAFETY PRECAUTIONS in the front of this manual for further recommendations.

## SERVICE

### LUBRICATING OILS

The performance of a lubricant, like that of any manufactured product, is the responsibility of the refiner and producer. Also, the engine operator, to a large degree, controls the oil's performance, for he is the one who must make decisions on oil changes, filter changes, loads, general maintenance, and operating conditions.

The Waukesha Engine Division does not recommend lubricating oils by brand name. A table of lubricating oils, and the performance grades for which their suppliers indicate these products are qualified, is available from the Engine Manufacturers Association, One Illinois Center, 111 East Wacker Drive, Chicago, Illinois - 60601. This publication is titled, "EMA Lubricating Oils Data Book for Heavy-Duty Automotive and Industrial Engines". All Waukesha WAK engines are considered Class B, that is over 1000 cu. in. (16.4 litre) displacement.

We recommend lubricating oil compounded for natural gas engine operation. The additive level of the lubricating oil shall have 5,000 PPM of barium, calcium, or combination of both with a maximum of .03 percent zinc. The sulfate ash level should be 1 to 1.5 % by weight. The EMA Lubrication Oils Data Book specification columns headed "Nat. Gas/LPG-High Ash" and "Ash Content % by WT." will assist in selection of oils to this specification.

This recommendation is based on many years of actual operating experience that conclusively verifies that high ash lubricating oils substantially reduce valve face and seat erosion because the ash oxidizes and provides a dry lubricant on the valve face and seat. However, we also recognize that due to extensive research and testing, several oil companies have now successfully formulated low ash lubricating oils that also reduce valve face and seat recession and/or erosion.

Synthetic lubricating oils are not recommended by Waukesha Engine due to insufficient experience with them.

Waukesha's warranty is limited to the repair or replacement of parts that fail due to defective material or workmanship during the warranty period and as such, the compliance or non-compliance of lubricating oil recommendations in no way alters the Standard Warranty.

Waukesha's warranty does not include responsibility for satisfactory performance of the lubricating oil whether it be high ash or low ash, this being the responsibility of the oil supplier.

Simply stated this means the owner may use the lubricating oil of his choosing without concern for the engine warranty status since the warranty is not affected by the type or brand of lubricating oil used in the engine.

### LUBRICANTS

Lubrication points and recommended lubricants are as listed. The intervals are recommendations for normal service only. These intervals should be changed if dirt, excessive heat, or unusual wear of parts is apparent.

1. Store all lubricants in closed containers in a clean dry place away from heat.
2. Keep lubrication equipment clean and ready for use.
3. Clean areas around lubrication points with a lint free cloth, moistened with solvent to remove hardened lubricants.
4. Do not over lubricate. Wherever possible, recommended quantities of lubricant are stated.

### OIL CAPACITY

The oil capacity of the main engine without filters or other equipment is 8 gallons. When the Waukesha full-flow filter is used 3-1/2 gallons more are required. If additional filters or other engine lubricated equipment is used, the capacity should be determined and the correct amount added. Engines operating with a full-flow type oil filter must have the filter prefilled. Prefilling the filter is necessary because the engine will be starved for oil until the filter and lines are filled.

After prefilling the filter, operate the engine 10 or 15 minutes without load. Shut the engine down to determine how much, if any, additional oil is needed to bring the level to "full" on the dipstick. This will establish the total amount required for future oil changes.

**OIL CHANGES**

The crankcase level should be checked prior to each day's engine operation and at the same time the condition of the oil as revealed on the bayonet gauge should be observed carefully. Replace oil at any time it is plainly diluted, broken down, thickened by sludge, or otherwise deteriorated. Remember that some modern oils cannot be judged on the basis of color alone because the additives are intended to hold carbon particles in suspension. The standard filter supplied will not remove these particles. The dark appearance of the oil is not necessarily an indication that the oil should be changed. Whenever oil is changed, the filter must be serviced. Oil performance will reflect engine load, temperature, fuel quality, atmospheric dirt, moisture and maintenance. Where oil performance problems arise or are anticipated, the oil supplier should be consulted. For F1197G series engines, recommended oil change intervals for engines receiving normal maintenance are as follows:

- Every 720 hours for continuous duty operation at continuous duty rating. Clean environment with oil header temperature of 190°F. or below.
- Every 500 hours for engines operated in excess of continuous duty rating, for engines operated with coolant temperature above 200°F., for engines with ebullient cooling system, and for engines in stand-by service.\*
- Every 360 hours for engines operated consistently at 25% or less of continuous duty rating.

**CAUTION**

The use of some types of oil, as well as dusty environment, marginal installation, internal engine condition and/or operating the engine with malfunctioning carburetion equipment may require more frequent oil changes. We suggest the lubricating oil be monitored with a good oil analysis program. Contact your local Waukesha Distributor for periodic engine maintenance.

Extended oil change intervals should be utilized with caution on any engine using highly dispersant oils. The dispersants function by absorption of particles of contaminants; however, when dispersant saturation is reached, these oils tend to "dump out" all of the suspended

\*If stand-by service is less than 500 hours annually, change oil annually.

contaminants in a relatively short period of time. Laboratory analysis will not predict the "dump out" point precisely, consequently close attention to engine conditions by the operator is required when establishing an extended oil change interval.

When using an engine oil with which you have no previous operating experience, a well monitored maintenance program should be conducted to observe the engine's performance and internal condition for the first year's usage. This procedure will help in determining if the new oil is compatible to your type of operation.

**OIL SCREENS**

If any indications of low or fluctuating oil pressure appear, we recommend the removal and cleaning of the screen mesh strainer below the oil-level equalizer in the oil sump. To remove any accumulation of sludge and carbon gum from the screen mesh, it is recommended that the screen be soaked in a suitable solvent. Soaking should continue until softening of the deposit permits easy removal without damage to the screen.

**SELECTING OIL VISCOSITY**

The correct lubricating oil viscosity (often referred to as "weight") must be determined with the engine operating under its normal loaded speed and temperature, using either SAE 30 or SAE 40 oil.

1. Start and load engine.
2. After oil and coolant temperatures are no longer increasing, note the temperature of the oil in the oil header or oil pan. Use a temperature gauge of known accuracy. Compare this temperature with the chart below. The correct oil viscosity will be found in the right hand column.

CLASS "B" ENGINES OIL TEMPERATURE METHOD		
Oil Header Operating Temperatures	Oil Pan Operating Temperatures	SAE Viscosity Numbers
175° - 210° F.	210° - 230° F.	40
140° - 175° F.	180° - 210° F.	30

**CAUTION**

Class B engines should not be operated with temperatures below 140°F. (oil header).

## GREASING

Every effort has been made to make the WAK Series "clean" engines requiring little lubrication beyond the automatic functions of the oiling system. Consequently, grease applications have been reduced to a single grease cup on the water pump for which ball bearing grease must be used as indicated on the tab. On those installations with a fan, it will be necessary to remove the screw plug from the fan hub about once a month, install a grease fitting temporarily, and apply a good quality grease selected for ball-bearing applications.

## BREAK-IN

New or overhauled engines should receive a break-in run. NOTE: All new Class B engines receive a break-in run before shipment from Waukesha. This operation can be performed with the lube oil specified above. After warm-up of approximately 30 minutes, proceed with a load and unload cycle. Repeated loading (minimum of half load, maximum full load), with equal idle periods in 5-minute intervals for a period of two hours, results in rapid break-in and quick seating of piston rings. Never idle for more than 15 minutes during the break-in or for the first 100 hours of operation. NOTE: Stand-by generator engines should follow this procedure using a load bank.

## OIL CONSUMPTION

Acceptable oil consumption should range from 0.0005 to 0.004 pounds per horsepower-hour. To figure use —

$$\text{LBS/HP-HR} = \frac{1.82 \times \text{quarts of oil used}}{\text{Operating HP} \times \text{total hours of operation}}$$

## LOW TEMPERATURE OPERATION

At low temperatures an oil must be used which will provide proper lubrication when the engine is hot and working. If special heaters are needed to warm oil or coolant for starting, they should be used. Waukesha Engine Division

will supply information on these devices upon request. Such heating systems permit the use of the recommended oil grades for the operating loads and temperatures involved.

Multi-viscosity oil should be used only where cold starting conditions make it absolutely necessary. Oil change periods for Class B engines using multi-viscosity oil should be reduced to 25 hours. At the present state of development, multi-viscosity oils are normally not recommended for use in heavy duty industrial engines. The viscosity improvers presently used may tend to deteriorate in continuous service, allowing the oil to revert to its original low viscosity base. In this state, the oil may not supply sufficient film strength and/or oil pressure.

## OIL FILTER

Model F-1197-G engines are factory equipped with large capacity full-flow oil filters. When a condition arises where neglect of the filters or an unusually rapid accumulation of sludge tends to bring about filter element clogging, the engine will not be starved of oil because of this condition, but it is very important to remember that the dirty oil that brought about the filter element clogging is now passing through the engine itself, and may reduce engine life materially.

Because of the above possibility, the recommendations made for filter change periods coincide with the recommendations for oil change.

If the oil shows evidence of sludge formation or improper filter operation, it should be changed and the filter elements as well. Also a check should be made to see that the oil and water temperatures are within the desired range.

**CAUTION**

When changing full flow filter elements, be sure to refill the filter. Be sure that all oil lines and pipes installed between the oil filter outlet and the oil header are clear and free from scale, rust and dirt.

### Use Genuine Filter Elements

The genuine dual density filter elements are of a patented type and are designed to continuously self-adjust the pressure within the filter and allow for a full stream of filtered oil to the bearings without opening by-passes.

The two different filtering materials are in series rather than in parallel. Effective filtering is accomplished at all times, yet the flow characteristics of the filter remain constant over a long period of service. This reduces the possibility of operating with a partially open by-pass valve because of pressure drop across the filter resulting from inadequate filter maintenance. The by-pass valve, now provided, however, is especially positioned to avoid plugging under such conditions and will, of course, open if necessary.

We are not aware that any "replacement" element, other than the genuine element will provide the "controlled pressure" in this full flow system. It is urged that no chance of damage to these engines be risked through an attempt to use any except genuine filter elements.

### Technical Data

Selection of the correct filter element is important and the following description is provided to avoid confusion.

Element No. 167602. Dual density standard element. Used in dual element filters 167601.

Element No. 167602-A. Dual density treated element. Used when high sulphur fuels are involved. Same application as indicated for part number 167602.

For filter No. 172384-C (single element filter) use element No. 172607.

### OIL PRESSURE CONTROL

Under all normal operating conditions, the high-capacity pumps used on the WAK Series will maintain the oil pressure within the specified limits of  $45 \pm 5$  lbs. A cold engine, or the addition of cold oil to the crankcase of a warm engine, will cause high oil pressure until the oil temperature stabilizes in the proper range. A warm engine will normally carry a low oil pressure at idle speeds and no alarm should be felt under these circumstances if it does not fall below 15 pounds. Moreover, the

oil pressure gauge of an engine started under cold conditions may fail to register pressure immediately because of congealed oil in the gauge line. If pressure still fails to register after the engine has run for 25 to 30 seconds, the engine should be shut down and the cause of the lack of pressure determined and corrected.

Adjustment of the oil-pressure relief valve is seldom necessary. However, when necessary, this operation should only be done AFTER the engine and oil temperatures have stabilized at normal levels. It is equally important that all other factors - no leakage, and soon - be satisfactory before attempting to adjust the oil pressure. Tightening the pressure relief valve is not proper compensation for diluted or broken-down lubricating oil.

Oil pressure fluctuations may sometimes be caused by erratic operation of the pressure relief valve. If this occurs, it is recommended that the pressure relief valve adjusting screw and the spring be removed. It is then possible to check the pressure relief valve itself for freedom of movement. Small particles of carbon or other material may have jammed the valve or clogged the vent passage behind the valve. In both cases, the valve and the control valve body passages should be cleaned thoroughly. If burring or nicking of the valve seat is found, it may be beneficial to polish the damaged surface carefully with a hone and crocus cloth dipped in fuel oil.

### OIL COOLER MAINTENANCE

Maintenance of the oil cooler unit consists largely of periodic cleaning and inspection for clogging, corrosion, or an inoperative by-pass valve. Improper or fluctuating oil pressure, or an undesirable increase in oil temperature, may indicate the need for servicing the cooler more frequently. Generally, the cooler should be removed from the engine, disassembled, and cleaned whenever the engine oil is changed. After long service, expediency may make it more practical to replace the inner cooling core with a new unit. This may be done by removing the cap screws retaining the cover on the cooler body and lifting out the core. All rust and lime deposits should be removed from the water passage area of the cooler at this time. The sludge deposits within the cooler core may be cleaned out by several methods.

It is recommended that cleaning take place as quickly as possible after removing the cleaner from the engine. Exposure of the tube interiors to the air, or blowing air through the tubes, contributes to a hardening action that makes for difficult cleaning. Cleaning fluids suitable for sludge removal range from benzol, or coal-tar-naphtha, to more complex industrial washers and degreasers utilizing carbon tetrachloride or some of the excellent industrial detergents available. Personnel doing such cleaning should remember that most cleaning substances capable of removing oil varnish are also, to a greater or lesser degree, toxic and may be injurious to skin, eyes, and respiratory passages. Moreover, adequate ventilation and fire-protection measures are essential in most cases. Techniques for sludge removal will vary somewhat according to the equipment at hand. Generally, it is best to allow a soaking period during which the cooler core unit is submerged in the cleaner. When the cleaner has loosened the deposits, usually within about 15 minutes, a pressure pump should be used to force the cleaner back and forth through the core passages. This pumping should continue for several minutes. When all foreign material appears to be removed, drain and dry the core, then test it in a clean solvent solution for traces of deposits still remaining. Reassembly of the oil cooler unit is the reverse of disassembly. Observe normal precautions with the gaskets to prevent leaks and to ensure that no oil passage holes are blocked.

#### EXERCISE OF STAND-BY UNIT

It is recommended that standby units be exercised once each week with normal load. When these units must be exercised without load, or in very light load conditions, we recommend extending this exercise period to once every 2 weeks. At least once in every 3-month period the entire standby unit (engines and the attached compressors, generators, etc.) should be exercised to ensure proper performance of the system.

#### LIGHT-LOAD OPERATION

The following maintenance schedule should be followed when engine is consistently run at 25% or less of continuous duty rating:

1. Maintain engine jacket coolant temperature at a level between 180° to 190°F.

2. Check air cleaner elements daily. Clean and replace as required.
3. At 50 operating-hour intervals, run engine at 50% load or better to clean carbon off of engine components.
4. Spark plug fouling can be reduced by the use of single electrode plugs.
5. Inspection and overhaul of cylinder heads should be updated to allow for a 25% reduction in hours between servicings.
6. Change lube oil every 360 hours for natural gas and LPG engines.

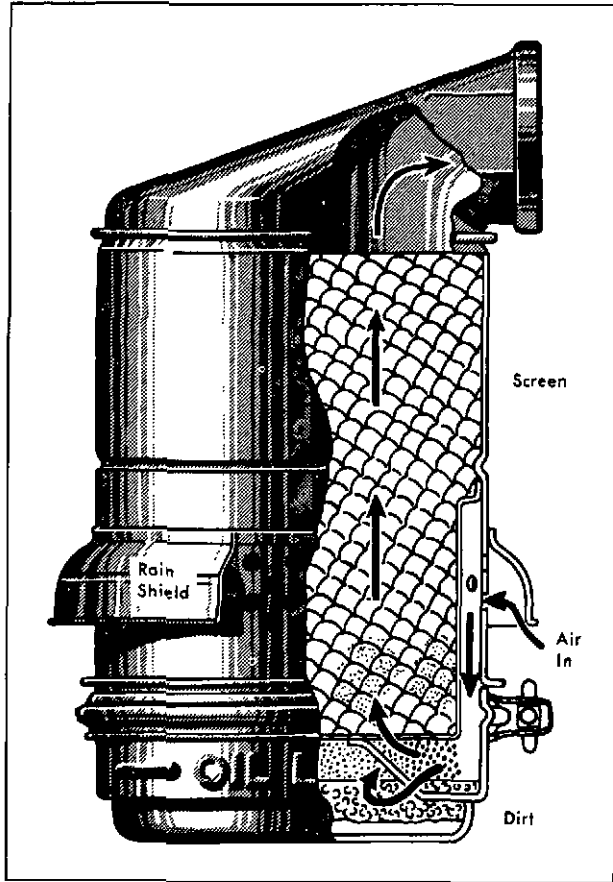
#### NOTE

When applicable, we recommend running fewer engines per site to increase the load on each engine.

#### AIR CLEANERS

Although various types of engine installations will have differences in air-cleaner types and arrangements it is important for the operator to appreciate that the common purpose of all air-cleaners is to collect dirt and grit and so keep it out of the engine working parts. As a result, the cleaner units must themselves be cleaned, sometimes several times each day if operating conditions are particularly bad. Glass jars, on those cleaners employing glass-jar pre-filters, should be emptied whenever they approach half-full. Do not oil the jar interiors. Most modern cleaners are of the so-called oil-bath type. In principle, the intake air passes over a pool of oil located at the bottom of the filter shell. Some of the dust particles are simply caught by the oil and settle at the bottom of the pool; other particles adhere to the oil vapor and droplets that leave the surface of the oil pool. The latter are prevented from entering the engine by a wire-screen element.

To clean filters of the type described above, flush out the oil in the lower part whenever an obvious accumulation of sediment, or thickening of the oil, makes itself apparent. Scrape away any accumulation, then refill the unit with fresh, clean engine oil. A bead pressed in the metal indicates the proper oil level. The screen filter is easily washed out in a non-volatile cleaning solvent.



OIL BATH AIR CLEANER

Because the dust particles are so small, yet possess the ability to cause great damage, it is absolutely imperative that air-inlet connections be kept in tight condition to avoid taking in unfiltered air.

**COOLING AND ANTI-FREEZE**

The cooling system of the bare WAK Series engines holds 10-3/4 gallons of water without provision for radiators or other equipment. When adding anti-freeze compounds on a percentage basis therefore, remember to include the coolant volume of the radiator system or other external parts of the cooling system. The following table may be used as a guide.

Ethylene Glycol "Prestone"	Radiator Glycerine (G. P. A.)	Freezing Points	
		°F.	°C.
16%	37%	20	-7
25%	55%	10	-12
33%	70%	0	-18
39%	81%	-10	-23
44%	92%	-20	-29
48%	100%	-30	-35

To prevent rust when using water alone, add one ounce of soluble oil for every gallon of coolant in the cooling system.

Never fill an engine with straight water after it has been exposed to sub-freezing temperatures for any length of time. This applies even when warm water is used because the water in the radiator and jacket passages cools rapidly and is likely to freeze before the engine can be started. If it is planned to leave the coolant in the engine at the next shutdown, then mix the proper proportion of soluble oil, anti-freeze and water before filling the engine. If water alone is to be used, then be sure that enough water to fill the entire system is immediately available; start the engine; and add water quickly before overheating can occur. This last method requires, of course, that the water be drained immediately when the engine is shut down.

Periodic additions of anti-freeze will be required to compensate for evaporation. Use a hydrometer type test gauge to ensure that the anti-freeze solution is maintained at its proper strength.

Under normal conditions, the two heat-sensitive thermostats in the outlet of the water manifold will maintain temperatures within the desired limits of 160° to 180° F.

By way of caution, it must be remembered that if the engine is to be operated with the thermostats removed - and this is not recommended except in case of emergency - provision must be made to block off the by-pass passage or else water will continue to recirculate without passing through the radiator or other external cooling system. Also shutters or other means will be required to maintain the temperature at the desired level.

**Thermostat Removal**

Ordinarily thermostats will seldom need replacement in the field. They should be checked from time to time, however, and are quickly accessible by removing the thermostat housing at the forward end of the water manifold. The steps necessary to accomplish this are simply the removal of the by-pass line elbow, the water outlet connection hose, and the cap screws securing the housing to the manifold. Thermostats damaged by corrosion or other causes are not repairable and must be replaced.

### Thermostat Testing

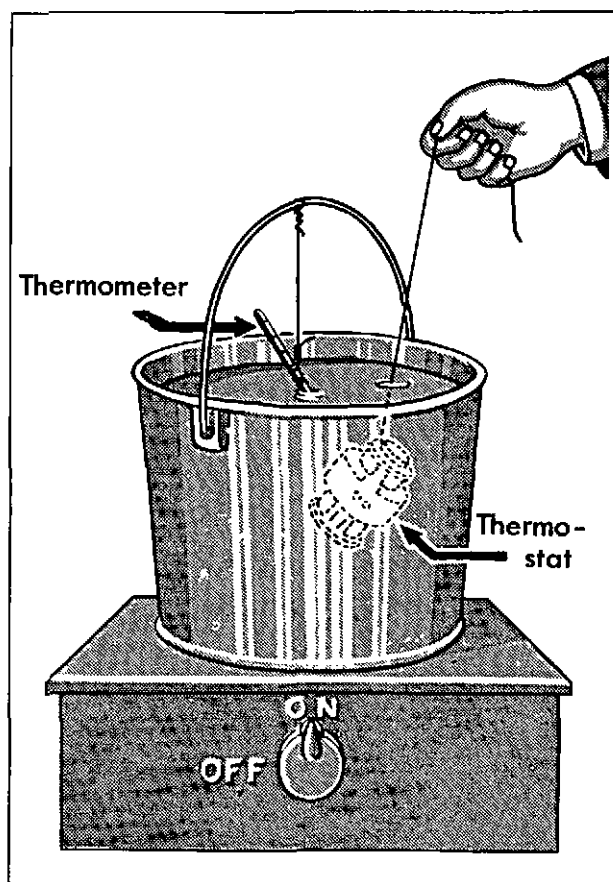
Thermostats should be tested in hot water for proper opening. A bucket or other container should be filled with sufficient water to cover the thermostats and fitted with a good quality thermometer suspended in the water so that the sensitive bulb portion does not rest directly on the bucket bottom or side. A stove or torch is used to bring the water to a heat range of 160°F. while the thermostat is submerged in the water. Stir the water for even heating. As the temperature passes the 160°-165°F. range, the thermostat should start to open and should be completely open when the temperature has risen to 185°-190°F. Lifting the thermostat into the colder temperature of the surrounding air should cause a pronounced closing action and the unit should close entirely within a short time. Both thermostats must be tested in this way. Two thermostats are used in order to ensure adequate reserve circulation for heavy operation and to pass large volumes of cooling water. Use care to seat the thermostat squarely and concen-

trically to avoid interference with the thermostatic action.

### Cleaning the Cooling System

When clean, soft water is used as a coolant, and when the proper inhibitors and anti-freeze solutions are used, radiator and cooling passage accumulations will not be excessive. About once each year, however, the engine will benefit if the cooling system is cleaned of sludge and sediment.

It is recognized that a number of excellent commercial cooling system cleaners are available. WAUKESHA ENGINE DIVISION suggests, however, that an operator considering the use of such a cleaner first investigate its possible reaction with the copper and bronze parts in the engine. If such a cleaner is used, follow the manufacturer's recommendations carefully.



THERMOSTAT TESTING

### Cooling Fans

About the only maintenance work encountered in connection with cooling fans will be the occasional replacement of a blade damaged in some manner and the replacement of fan belts. In the case of slightly bent blades, it is important to remember that inaccurate blade alignment can cause considerable roughness and vibration as well as inefficient cooling and bearing wear. Hence, fan blades should be examined for security of the hub attachment and possible cracks in the spider area. Refer to the SAFETY PRECAUTIONS in the front of the manual for further recommendations.

### Fan Belts

Periodic replacement of fan belts is good insurance against damaged radiators and inopportune shut downs. Provision has been made to reduce the stretch between the fan pulley and the drive pulley on the engine and this adjustment should be used to install the belt. Attempting to force the belt over the pulley while it is under tension is almost certain to damage the belt.

To install new fan belts, (both should be replaced at the same time), follow the procedure below:

1. Loosen the fan-hub nut located behind the fan-support bracket.
2. Loosen the fan adjustment nut on top of the fan-support bracket and lower the fan hub and pulley until the belt tension is completely relieved and the old belts can be slipped free.
3. Slip the new belts over the pulley and take up on the adjusting nut until the belts show some tension but are not so tight as to prevent movement with the thumb and forefinger for about one-half an inch to either side.
4. Retighten the fan-hub retaining nut.

#### Compressor Drives

Many installations will use a three-point belt drive to drive an air compressor. This arrangement is detailed on the installation drawings obtainable from the WAUKESHA ENGINE DIVISION.

#### Greasing Fan Hub

On those installations with a fan, it will be necessary to remove the screw plug from the fan hub about once a month, install a grease fitting temporarily, and apply a good quality grease selected for ball-bearing applications.

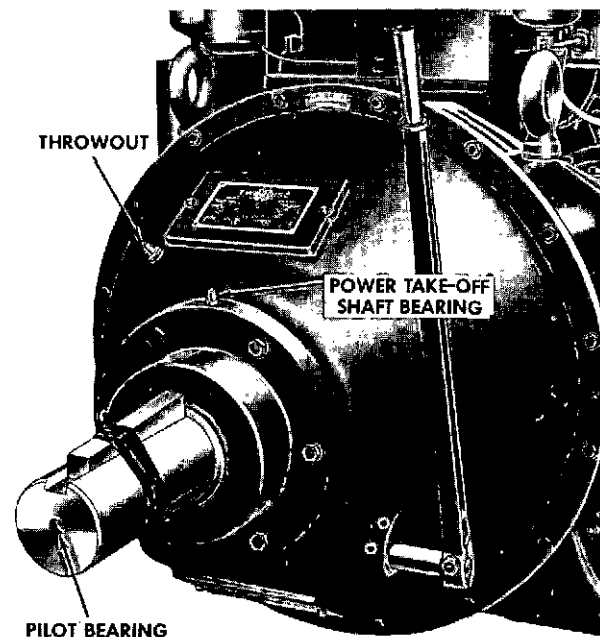
#### CLUTCH AND POWER TAKE-OFF

The clutch and power take-off, on engines so equipped, is a heavy duty dry friction disc type unit capable of withstanding continuous service with little attention from the operator. Spring loaded friction discs compensate for normal wear and when adjustments are necessary, they can be made with tools normally available.

If the clutch slips, overheats, or if the operating lever jumps out of the engaged position, the friction disc springs have extended to a length where they are no longer effective, clutch adjustment is usually necessary.

#### Clutch Adjustment

1. Remove the clutch housing inspection cover.
2. Rotate the engine until the adjusting lock pin can be reached.
3. Pull adjusting lock pin out and turn adjusting yoke clockwise until the operating lever requires a distinct effort to engage.
4. After the adjusting yoke is turned to this point, engage the lockpin in the nearest notch.



TYPICAL POWER TAKE-OFF SHOWING LUBRICATION FITTINGS

A new clutch generally requires several adjustments until the friction surfaces are worn in. After considerable service, wear may occur to the extent that further adjustments with the adjusting yoke cannot be made, and the friction discs must be replaced.

#### AIR STARTER LUBRICATION

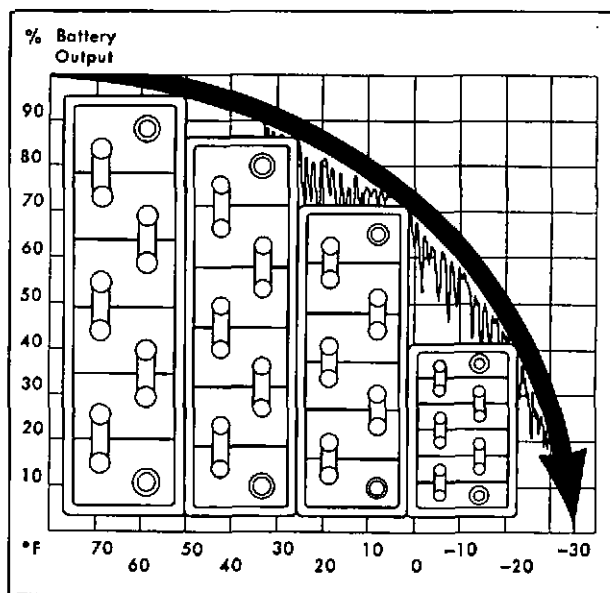
Check the oil level before starting the air motor by opening the oil level plug in the motor housing cover. The oil level should be checked weekly and oil added as required to fill the oil reservoir. On systems equipped with line lubricators, maintain the proper oil level as marked on the "Lubricator" bowl. Use SAE 10W oil above 32°F. and No. 2 diesel oil below 32°F.

The drain plug below the oil level plug should be removed occasionally to allow any water or condensate in the bottom of the housing cover to drain off. This should be done before adding new oil and after the motor has been idle long enough to permit the oil and water to separate.

Once every three months, or as experience dictates, remove the pipe plug from the gear case and insert a grease fitting to apply a good quality No. 2 cup grease. Two or three strokes from a grease gun are sufficient for the gear case. Do not pack the gear case full.

Whenever the air starting motor is removed from the engine, unscrew the bushing oiler plug at the end of the drive housing and saturate the felt bushing oiler with SAE 20 motor oil.

Do not adjust the built-in lubricator unless the starter exhaust is either oil-free or contains an excessive amount of oil. Turn either or both of the oiler adjusting screws in to decrease the oil flow; back them out to increase the oil flow. Both of the oiler adjusting screws are located in the housing cover. They are either both accessible through the air inlet or one oiler adjusting screw is accessible behind the air inlet (this has a locking screw on top of the adjusting screw) and the other oiler adjusting screw is accessible only after removing the housing cover.



COLD REDUCES BATTERY POWER

## IGNITION SYSTEM MAINTENANCE

The WAK series engines may be equipped with either distributor or magneto ignition. For top engine performance, each unit of the ignition system must be in good condition and properly adjusted. Normal maintenance consists of replacing defective units at periods determined by experience with the type of service involved. Adjustment several times during the service life will extend the usefulness and help benefit engine life.

The battery is often subjected to abuse and insufficient maintenance in a distributor ignition system. Occasionally the starting motor and generator brushes and commutator require reconditioning. For other repairs and adjustments, these units should be referred to a qualified service man with the necessary tools and instruments.

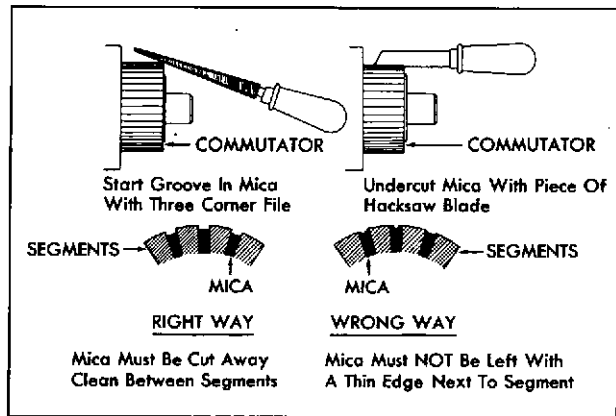
## Battery

Check the electrolyte level weekly and maintain it  $3/8$ " above to even with the lead plates. If possible check the specific gravity at this time since that information is valuable in detecting trouble before damage occurs. A specific gravity of between 1.250 and 1.285, all cells reading within 0.010 and 0.015 of each other, indicates a well charged battery. Readings below 1.250 indicate the necessity for commercial charging while repeated specific gravities below 1.250 call for thorough inspection of the electrical system. Deposits that appear on the battery cables may be removed by washing with a weak baking soda and water solution or household ammonia. A vasoline coating on the exposed parts will prevent the formation of more deposits.

## Starter and Generator

The starter and generator bearings must be lubricated with about five drops of light engine oil every 300 hours, oftener for the starter if it is used frequently. Do not over lubricate because excess oil may reach the commutator, brushes, or insulation and seriously impair the unit's operation.

Also after 300 hours of operation inspect the commutator and brushes for indications of excessive wear. A slightly tan commutator that is smooth and shiny is in good condition and will not require attention. If it is rough and dirty, place a strip of 00 or 000 sandpaper, not emery cloth or paper, over a block of wood and hold it against the commutator while the motor



UNDERCUTTING MICA

is turning over. Continue this operation until the commutator is free from dirt and rough spots but do not remove any more stock than is necessary. Then blow any sandpaper dust out of the motor.

The mica insulating strips between copper segments should be about 1/32" below the commutator surface. If through wear or several dressings of the commutator the mica is flush with the copper, remove the unit and refer it to a service shop for undercutting. Any visible out of round must be corrected by turning the commutator then undercutting the mica.

During each 300 hour inspection check to see that the brushes are loose in the holder, remove them, clean in gasoline or solvent until they fit freely. Replace the brushes when worn down to one half their original length. New brushes should be fitted to the commutator by placing a strip of 00 or 000 sandpaper, abrasive side facing upward, under the brush and sanding until about 3/4 of the brush end makes contact with the commutator.

**Regulator and Solenoid Switch**

Do not attempt repairs or adjustments of the regulator or solenoid switch without the aid of a competent service man and special instruments. Generator manufacturers report that almost every case of early failure of the generator is due to tampering with the charging rate or voltage adjustment by inexperienced personnel.

**Spark Plugs**

Misfiring or ragged operation may be due to faulty spark plugs caused by carbon accumulations and burning of the electrodes. They

should be cleaned, inspected, and the gaps checked approximately every 200 hours of operation, or oftener if the engine idles for prolonged periods. After 300-400 hours, it is advisable to replace the entire set when any spark plug is defective.

Deposits on the electrodes and insulator may be removed by commercial abrasive cleaners. Scraping the insulator is not recommended since the resulting scratches increase the tendency of carbon deposits to form.

After the spark plug has been cleaned, adjust the gap with a round wire gauging tool to 0.025" by bending the outer electrode. As the spark plugs will have a tendency to burn the electrodes and widen the gap, it is important that gap be checked whenever the plugs are removed from the engine. Missing at low speeds is very often due to a wide spark plug gap.

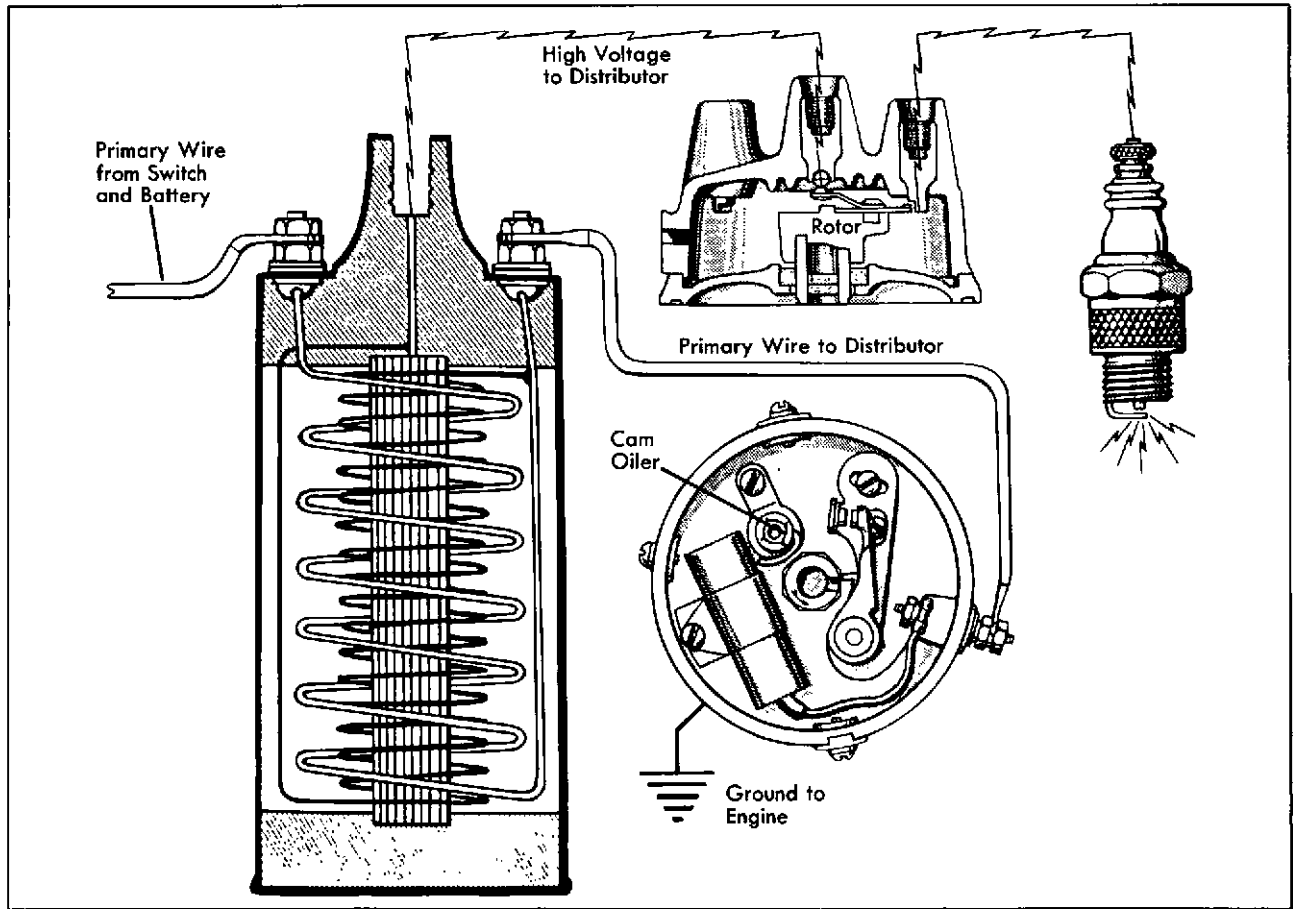
Also inspect the plug for cracked or porous insulator and check condition of the ignition cable.

When replacing spark plugs, use new gaskets. Proper seating of the gasket is necessary for sealing the combustion chamber and transferring heat from the plug.

The following tabulation will be found useful when checking through the ignition system. **DO NOT SLIGHT MINOR POINTS, THEY ARE ALL IMPORTANT.**

**IGNITION SYSTEM MAINTENANCE CHECKLIST**

- Spark Plugs      Check for correct heat range. Examine for cracked porcelain, leakage, burned electrodes, deposits on center insulator, correct gap, good washers, and clean threads and seating surface. Remember, a plug may APPEAR satisfactory and still miss.
- Lead Wires      Check for sound, unburned, insulation without cracks, breaks, or oil contamination. Terminals at each end should seat firmly on clean, uncorroded contacts.
- Distributor Cap      Check for secure seating, clean exterior, and interior free from oil, grime, powdered metal, paint, or hairline cracks. Clean corrosion from terminal sockets.



TYPICAL BATTERY IGNITION SYSTEM, SCHEMATIC

- |   |  |
|---|--|
| <p><b>Distributor Rotor</b> Check for cleanliness, firm seating, shiny center contact, arm contact not eroded short, nor striking cap contact lugs.</p>   | <p><b>Breaker Housing</b> Check for interior cleanliness, freedom from oil and grease, free movement of centrifugal advance system without looseness or slack in parts. Observe operation of vacuum load retard.</p>   |
| <p><b>Distributor Shaft</b> Refill at oil plug with SAE 20 engine oil every 200 hours; test manually at breaker cam for wobble from excessive bushing clearance.</p>  | <p><b>Coil</b> If a coil is suspected to be defective, test by replacing with one known to be good.</p>  |
| <p><b>Breaker Points</b> Check for wear on fiber cam follower; secure mounting; tight, clean, well-insulated low-tension wire; correct spring breaker tension (19-23 ounces); point contacts meeting squarely and not excessively pitted; point movement (gap) 0.018"-0.020" for distributors, 0.016" to 0.018" for magnetos.</p> | <p><b>Breaker Cam Wick</b> For magneto, lubricate with SAE 50 or 60 oil approximately every 500 hours of operation. For distributor, 3 to 4 drops of light engine oil every 200 hours. Do not over lubricate as excess oil is apt to cause contact points to burn.</p> |
| <p><b>Condenser</b> Check for secure ground to breaker case, freedom from oil and grease, wire connection solid. Try new condenser if in doubt.</p>   | <p><b>Timing</b> Use simple light circuit across points to establish correct point opening with flywheel marks. Centrifugal advance compensates for higher speed timing.</p>   |

### TIMING TAPES

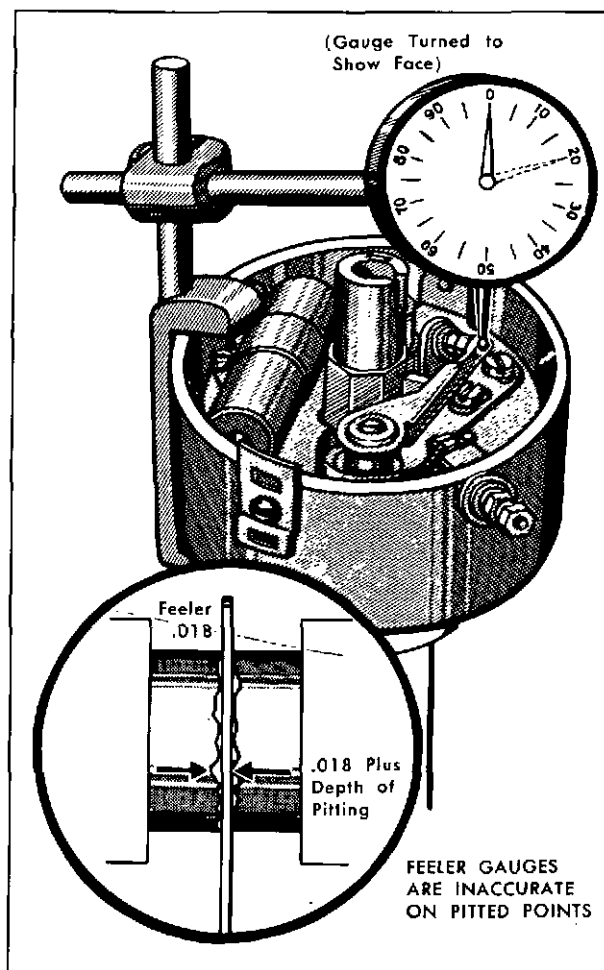
On current production engines the flywheel stamped timing marks, except for the TDC marking, have been eliminated. In place of the stamped markings, industrial type adhesive backed timing tapes with degree markings are used. Each engine having the timing tape will also have an adhesive backed Ignition timing chart and another chart giving the valve cold clearance setting.

### DISTRIBUTOR

The primary or low-tension circuit of an ignition distributor passes directly from the primary wire connection, through the breaker points, to the grounded body of the distributor. The condenser is connected across the breaker points. One side of the condenser is connected to the insulated primary wire connection; the other side is grounded to the distributor body. Each time the rotating cam in the center of the distributor permits the breaker points to close the primary circuit is complete. Hence, the cam and breaker assembly is nothing more than a switch timed to pass primary current through the ignition coil six times for every two revolutions of the engine crankshaft.

When the cam forces the breaker points apart, the primary current flow through the coil is interrupted. It is this abrupt interruption in primary current that induces the secondary current in the separate secondary winding of the coil. An explanation of the induction principle will be found in the publications of electrical equipment manufacturers. From the standpoint of engine maintenance, it is only necessary to be able to recognize when ignition units are in good condition, working properly, and accurately adjusted.

The high-voltage secondary current induced in the coil passes through another circuit of the distributor. Entering the distributor cap at the center lead, the current passes through the carbon button at the center of the cap interior and into the rotating distributor rotor. The distributor rotor moving contact is held against the carbon button by spring pressure. The distributor rotor passes in turn each of the six electrodes leading to the spark plugs. The positioning of the rotor tip opposite an electrode occurs at the same time the breaker points separate to cause a high voltage discharge through the secondary system. Consequently, this high-voltage current jumps from the rotor tip to the opposite electrode and into the lead going to the spark plug.



### SETTING DISTRIBUTOR POINTS

Since the mechanical arrangement of the engine requires a certain firing order, the wires leading to the spark plugs must be crossed to lead the successive sparks to the proper cylinder. Thus, the proper method is to start with number one spark plug wire in the terminal of the distributor cap to which the rotor points when number one cylinder is TDC on compression stroke. The next wire would go to number five cylinder, the next to number three cylinder, and so on in firing order 1-5-3-6-2-4.

### Timing Distributor Ignition

The steps in timing the ignition system are shown in the accompanying illustration. This cannot be accomplished until the breaker points are accurately adjusted for clearance. Point clearances may be adjusted with the distributor installed in the engine. In some cases, however, it will be found much more convenient to remove the capscrew holding the adjustment collar and carefully lift the entire distributor from the

engine for inspection and adjustment. This avoids working in cramped quarters and difficulties in trying to crank the engine over to bring the cam peak under the fibre bumper block.

Distributor points do not have to be absolutely free of pits and grey oxide for satisfactory performance. Excessive cratering and build-ups of sharp peaks, however, require new breaker points. Slight point roughness may be cleaned

up as much as is practical with a fine hone. Never use abrasive cloth or paper regardless of what the abrasive material is. A file is equally unsatisfactory with regard to continued point life, although improved performance may be obtained for a short while.

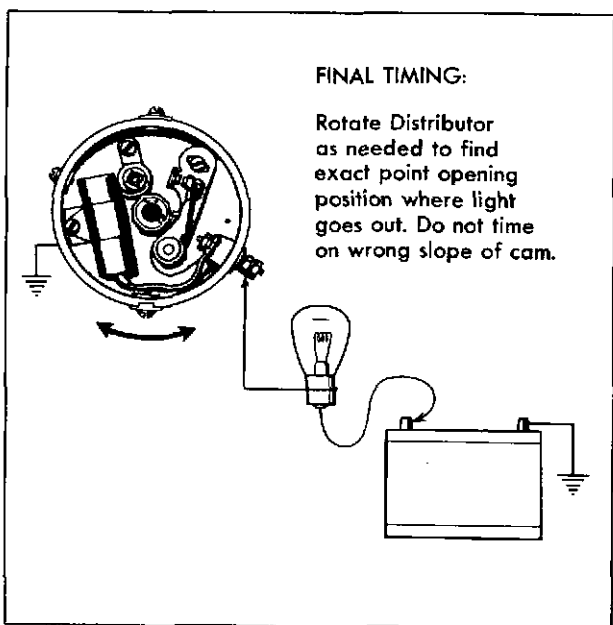
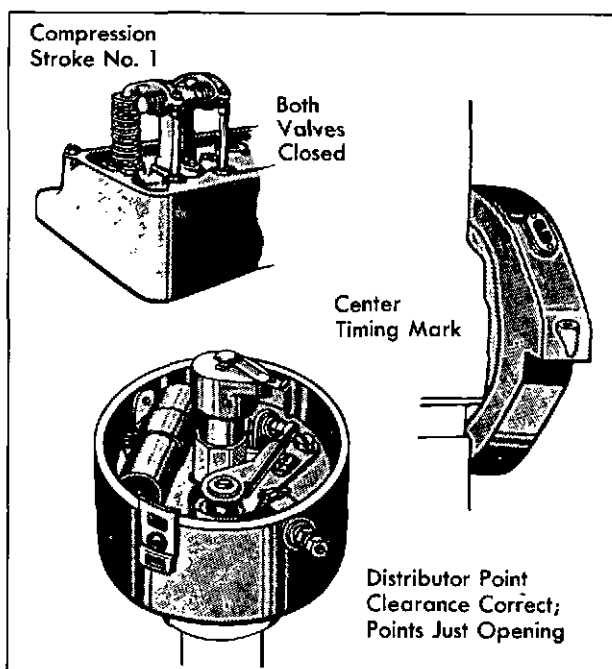
A feeler gauge is not an accurate method of setting points, particularly when there are some inequalities in the contact surfaces.

The simplest method, and the most accurate, is the use of a dial indicator. Here, the gauge is solidly clamped to the distributor body in whatever manner is convenient. The gauge tip is brought to bear against the movable breaker point just behind the contact surface and the gauge is set to read zero with the fibre bumper on the flat of the cam and the points closed. Thus, by rotating the distributor cam, with the starter if the distributor is installed, or with the fingers if being bench adjusted, the exact point opening in thousandths is read on the dial indicator. This method will also reveal worn cams and distributor shafts that are loose in the bushings because the opening readings will be erratic. Clearances are adjusted in the conventional manner by turning the eccentric screw holding the fixed point. Do not forget to re-tighten the fixed point clamp screw after adjustment.

When the breaker point clearance is accurately adjusted, the engine should be turned to firing distributor position on the compression stroke for #1 cylinder. This may be determined by bringing the correct degree marking on the flywheel to the center of the timing hole in the flywheel housing or aligning the timing pointer on the gear cover with the notch on the crankshaft pulley. At the same time make sure that both valves on number one cylinder are closed, or remove number one spark plug and feel the compression with the thumb.

If the distributor assembly was removed from the engine, turn the rotor to the same position it was in when removed. Insert the drive shaft carefully in the opening with the distributor body held approximately the same as it was when removed. For example, if the primary wire terminal and the grease plug were to the right originally, reinstall them that way if possible.

When the distributor drive strikes its mating member, it may be necessary to rotate the shaft slightly by turning the rotor back and forth until the proper alignment is felt and the distributor drops into position. Install and tighten the cap screw holding the slotted adjustment arm to the



STEPS IN IGNITION TIMING

boss with the cap screw in the approximate center of the slot. The screw and nut holding the split clamp collar on the distributor body may now be loosened just enough to permit slight rotation of the distributor body for final adjustment.

The exact timing of the spark depends on the actual breaking of electrical contact across the points. Hence, checking for the apparent mechanical separation with feeler stock, cellophane, and so on is apt to be misleading depending on the condition of the points and the skill of the operator. To assure accurate timing, make up a simple light circuit consisting of an automotive light bulb with soldered-on leads or a socket with lead wires attached. Clip or wedge one lead to the ungrounded side of the starting battery, and attach the other lead to the primary wire connection at the side of the distributor.

Note: If using a 6-volt bulb and a 12-volt starting battery, use only half of the battery voltage by clipping the wire to one of the inter-cell straps midway on the battery.

With the above installation, if the bulb is lit the points are closed and the distributor should be shifted slightly to determine the point of opening where the light just goes out. The distributor clamp may now be tightened and the flywheel turned backwards about a quarter of a revolution and then brought forward towards the timing mark on the flywheel as before. The light should just go out as the correct degree marking on the flywheel timing tape centers in the flywheel housing opening.

Since the engine is set for number one cylinder firing, install the distributor cap and start installing the spark plug wires with number one in the hole to which the rotor points and working clockwise around the cap.

It is best to install a wire at the distributor, and then without installing any more follow up that wire and secure it to the proper spark plug in firing order. Take each in turn to avoid confusion.

Once the timing is properly set for the idle (no-speed) position, the centrifugal weight system of the distributor will automatically advance the spark as required by changes in engine speed. The mechanism involved is matched to each engine application by laboratory tests determining the best spark advance point over the entire speed range. Therefore, substitution of unmatched parts from other equipment will impair timing and engine performance.

The distributor requires lubrication of the shaft, advance mechanism, breaker cam, and breaker lever pivot. For shaft lubrication, a supply of oil is placed in the oil reservoir at the time of assembly sufficient to last 1000 hours under normal operating conditions. Thus, the oil plug need not be removed oftener than this period (or at overhaul) except when unusual heat or other operating conditions are experienced. Add grade 20W oil when the plug is removed. Avoid overfilling; there should be a small air space above the plug hole when the plug is replaced. Seal the plug with a sealing compound that will retain oil.

For cam lubrication, add a drop or two of light engine oil to the center hole of the lubricator if the cam wick appears to be dried out. Inadequate lubrication here is shown by excessive wear of the breaker bumper fibre and traces of the fibre material on the cam surface. Excess oil is indicated by fouling of the points, carbon streaks under the points, and a generally dirty appearance of these parts. Every 100 hours put one drop of light engine oil on the breaker lever pivot, and a few drops on the felt wick under the rotor.

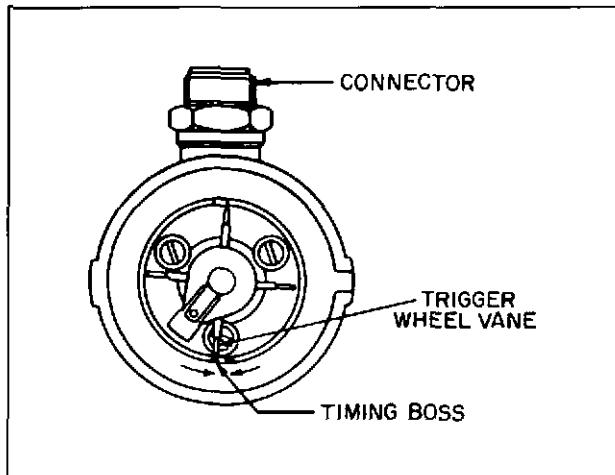
The centrifugal advance mechanism can be checked for freeness by turning the breaker cam in the direction of rotation and then releasing it. The advance springs should return the cam to its original position without sticking.

#### BREAKERLESS DISTRIBUTOR IGNITION

The Bendix system consists of the following three parts: (1) a control unit which provides an energy storage circuit, a control circuit, and a transformer coil; (2) a distributor which includes a magnetic triggering device, a distributor rotor, and a standard distributor cap; and (3) a lead assembly which electrically connects the control unit and the distributor.

The engines for which this system is designed usually operate on Natural or LP gas and are used to run commercial and residential air conditioners, refrigeration units and heat pumps. The Breakerless Ignition System operates from an external electrical power supply of 100-125 volts A. C. at 50-60 cps.

The input is fed into the control unit by means of a three-wire lead. The green wire is grounded inside the control unit. The black wire goes to a 1/4 amp, 3 AG type 250 volt fuse and then to the filter unit. The white wire connects directly to the filter unit. The filtered input current goes to an electronic module which



**TIMING BREAKERLESS DISTRIBUTOR  
IGNITION**

converts it to D.C. The direct current is then used to charge a capacitor in the energy storage circuit. This capacitor is connected to the high voltage transformer coil through a trigger circuit containing a switching device which is normally nonconductive or "open."

The distributor includes a trigger wheel with four vanes and a magnetic pickup unit. When one of the vanes approaches the tip of the pickup with sufficient speed, an electrical pulse is generated in the pickup. This pulse goes thru the lead from the distributor to the control unit and is used to turn on the switching device in the trigger circuit. This permits the electrical energy in the storage capacitor to discharge thru the primary winding of the high voltage transformer coil. The resulting high voltage from the secondary winding of this coil is conducted to the distributor and then to the spark plugs. The trigger circuit quickly recovers its nonconductive state and the whole cycle of events is repeated at the rate required by the engine rpm.

#### Installation - Timing

Before installing the distributor on engine, rotate engine to its No. 1 firing position as specified. Hold the distributor so the connector points in the direction most convenient for installation of the lead between the distributor and control unit. Lower the distributor into position so the drive member mates with the engine drive. Remove distributor cap and note the two timing bosses on the inside wall of the distributor housing. Each boss is identified by an arrow above it. Rotate the distributor until one of the trigger wheel vanes is in line with the proper timing boss as indicated

in the timing illustration. Arrow adjacent to each timing boss indicates direction of distributor shaft rotation.

Install the distributor cap after noting with which electrode and cable well the rotor electrode is aligned. Install high tension cable between this cable well and the spark plug in the No. 1 cylinder. Install the other five cables relative to distributor rotation and engine firing order. With engine turning, adjust final timing in accordance with engine instructions. Secure distributor to the engine. Make sure that the mounting surface of the control unit is grounded to the engine to complete the high voltage circuit to the spark plugs.

**CAUTION:** It is recommended that the control unit be mounted so its coil outlet is at the top and the mounting flange in full contact with a horizontal metal surface to provide a good heat sink for the unit.

Install the end of the power input cable in an electrical junction box which provides 100-125 volt A.C. 50-60 cps power. Connect the green wire to a good earth ground. Make sure that the correct fuse (1/4 amp, 3 AG type 250 volt) is in the fuse post on the side of control unit.

Connect the control unit to the distributor using the Bendix lead assembly and tighten retaining nuts.

Install one end of a high tension cable in the coil outlet at top of control unit and the other end in the center cable well of the distributor cap. No terminal is required on the end which is installed in the coil. To assist in weatherproofing the system, it is recommended that a light film of Scintilla #47 Compound or a non-hardening sealing compound be applied to the first 1/4 inch of the cable outside diameter before insertion into the coil. Insert the lead into coil a minimum of 5/8 inch.

#### Maintenance

The Bendix Breakerless Ignition System is designed to give thousands of hours of maintenance-free service. However, the following preventive maintenance procedures, if followed at each engine inspection period, will greatly prolong its trouble-free service life.

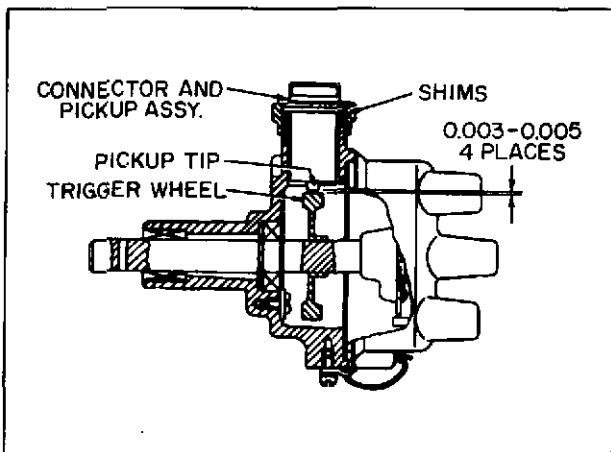
Remove the distributor cap by unhooking the two clips which secure it. In confined areas, be sure the cap is lifted enough to clear the spring terminal on distributor rotor before moving it to the side.

Wipe cap with a clean, dry cloth if cleaning is necessary. Check all cable wells and electrodes to insure that they are clean and free of corrosion. If necessary, carefully clean the inside of distributor housing with a dry cloth.

**CAUTION:** The vanes of the trigger wheel are of necessity made of a relatively soft metal. Use extreme care that they do not get bent at any time. Their location controls the timing accuracy and proper functioning of the ignition system. Therefore, any change in their position relative to the shaft will adversely affect engine operation.

Inspect all wiring insulation for fraying, scuffing, cracking, or other conditions that could cause malfunction. Replace any defective wiring and locate it so the above conditions will be avoided.

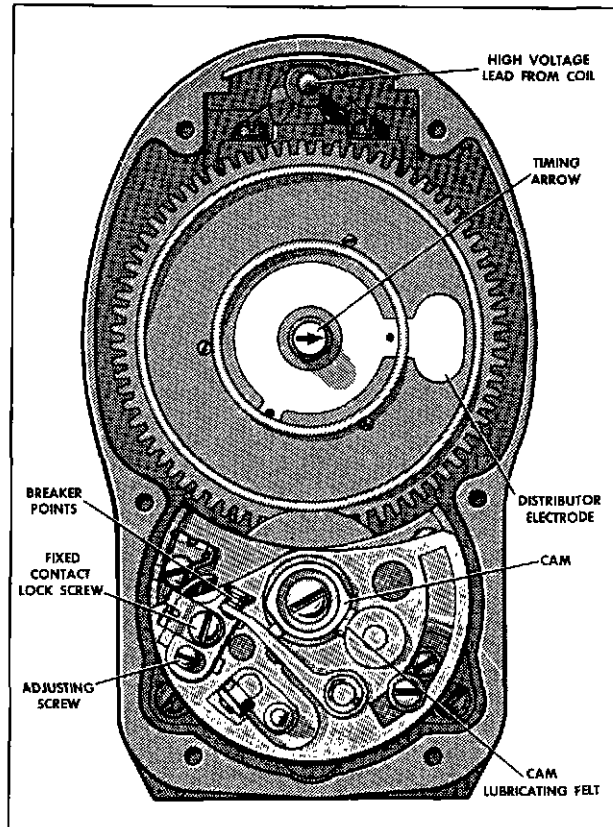
**CAUTION:** The clearance dimension between trigger wheel and pickup tip is critical. If the connector and pickup assembly on side of distributor is removed for any reason, this dimension shall be checked during reassembly. Adjust the clearance to 0.003 to 0.005 inch between each vane and the pickup tip by adding or removing Bendix shims where indicated in the accompanying illustration. Nonconformance with this requirement will cause malfunction of the system.



BREAKERLESS IGNITION - TRIGGER WHEEL TO PICKUP CLEARANCE

**MAGNETO**

The basic magneto used on the WAK engines is the same in most applications, however, special conditions require different lag angles of the impulse coupling. Therefore, replace-



MAGNETO, COVER REMOVED

ments should be made with magnetos bearing the same lag angle designations.

Minor servicing of the magneto is confined to cleaning, replacement, and adjustment of the breaker points. More extensive repair and overhaul operations require specialized training and equipment and should be made only at authorized service agencies.

The magneto uses a primary current generated within itself by rotation of permanent magnets between the pole shoes. Because of the movement of the permanent magnets and the periodic reversals of magnetic flux a magneto must be timed internally as well as with relation to the engine. To accomplish this internal timing requires an edge distance gage of a size specified for the magneto involved and for this reason a magneto that is properly adjusted at the factory or a service agency should not be upset by tampering with the breaker plate adjustment.

**Magneto Maintenance**

From the maintenance standpoint, most of the principles applying to distributors can be applied to magnetos as well. Cleanliness, freedom

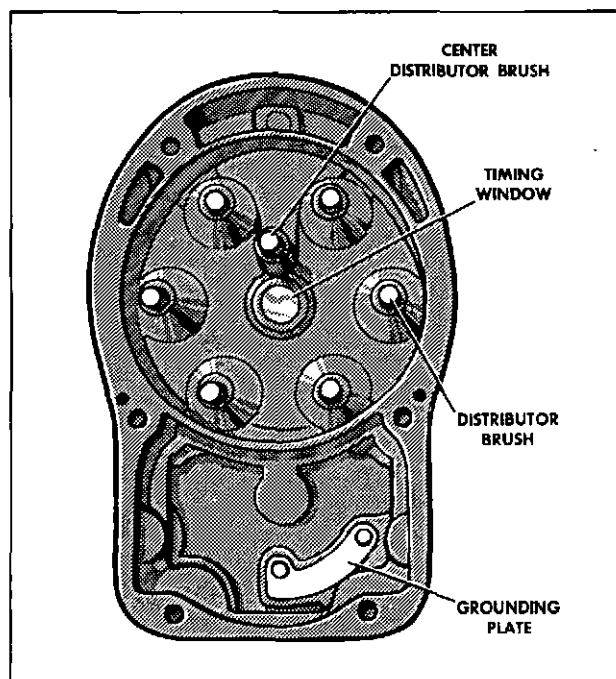
from dirt, grease, and burning, and so on, are equally important. Point clearance adjustment to 0.016"-0.018" is accomplished in the same manner as with the distributor.

The cam lubricating felt wick should be re-lubricated at intervals with a small quantity of SAE 50 or 60 oil. Avoid overlubrication. The magnet rotor ball bearings and the distributor gear oil-less bearings require no lubrication between overhauls.

#### Timing Magneto

The magneto timing procedure follows very closely the steps given for timing the distributor. The engine must be turned over until number one piston is on the correct degree mark, compression stroke. This is the point at which firing occurs when the engine is running and the impulse coupling has disengaged. Hence, this is also the point at which the breaker contacts must just begin to separate when the magneto is rotated in the direction indicated by the arrow on the name plate.

When the impulse coupling is engaged, as it is when starting to time the magneto, it must be released or "snapped" in order not to incorporate its lag angle in the timing procedure. The easiest way to do this is to turn the magneto impulse coupling backwards (against the arrow on the name plate) as many turns as needed to align the arrow in the inspection window with



MAGNETO COVER

the terminal connecting to number one spark plug. Reverse rotation automatically disengages the impulse unit. With the breaker point cover open, it will be seen that the points just close as the arrow lines up with the terminal. Rotate the impulse coupling very slightly in the opposite (normal) direction enough to just open the points, hold the rotor from further turning, and connect the magneto drive to the engine.

Final timing is done with the magneto in place. Here, either a timing light or cellophane may be used to determine the exact location where the points open. If cellophane is used, be extremely careful that a tiny fragment does not tear away and remain between the points. If a timing light is used, ample current will be available from a few flashlight cells. Clip one side of the circuit to the breaker points and the other side to the magneto housing for a ground. If excessive current is used for such a timing light, two things may happen. First, by grounding back through the primary coil, which has too much resistance to permit passage of a small current, erroneous results will be obtained. Secondly, passage of current through the primary wires may cause weakening of the magnets.

Whichever method is used to determine point opening, the remaining steps are the same. With the engine in firing position, rotate the coupling slightly one direction or the other as needed, the exact point opening position is readily determined and the coupling screws may be installed. Replace the breaker cover.

#### FM-LTR6A MAGNETOS

##### Timing Type FM-LTR Base Mounting Magnetos to the Engine

When installing all base mounting type FM-LTR magnetos, it will be necessary to use the C2862B Float Disc unless otherwise designated in the application sheet. This disc serves as a flexible coupling to properly align the mounting holes in the magneto housing with the holes in the engine mounting pad.

1. Rotate the engine flywheel until the No. 1 cylinder is in running or advanced spark position on the compression stroke.
2. Remove the timing bolt from the top of the magneto end cap. Turn the magnetic rotor shaft until the yellow timing mark, on the edge of the distributor disc, is centered in the timing window. This mark denotes that the end cap cover terminal stamped No. 1 is approximately ready to fire the No. 1 cylinder. The point opening can

easily be determined by inserting a thin piece of cellophane between the contact points, by using a timing light or by the use of a sounding device.

- Align the painted groove on the impulse coupling shell with the painted groove on top of the coupling outer shell. When these two marks are properly aligned and the yellow mark on the edge of the distributor disc is centered in the timing window, the magneto is timed to fire the No. 1 cylinder.

Since all base mounting magnetos are connected to the engine drive shaft by a drive member, the alignment of the timed magneto to the engine drive unit must be made by adjusting the drive member.

- After the magneto is installed on the engine, connect the transformer lead wires on the end cap terminals. Starting with the No. 1 terminals, connect the wires to agree with the engine firing order. When facing the end cap cover, the No. 1 terminal is at the upper left for both rotations. Connect the wires in counterclockwise rotation for left hand rotation engines and clockwise for right hand rotation engines.

- After the engine is running, the timing should be checked with a timing light.

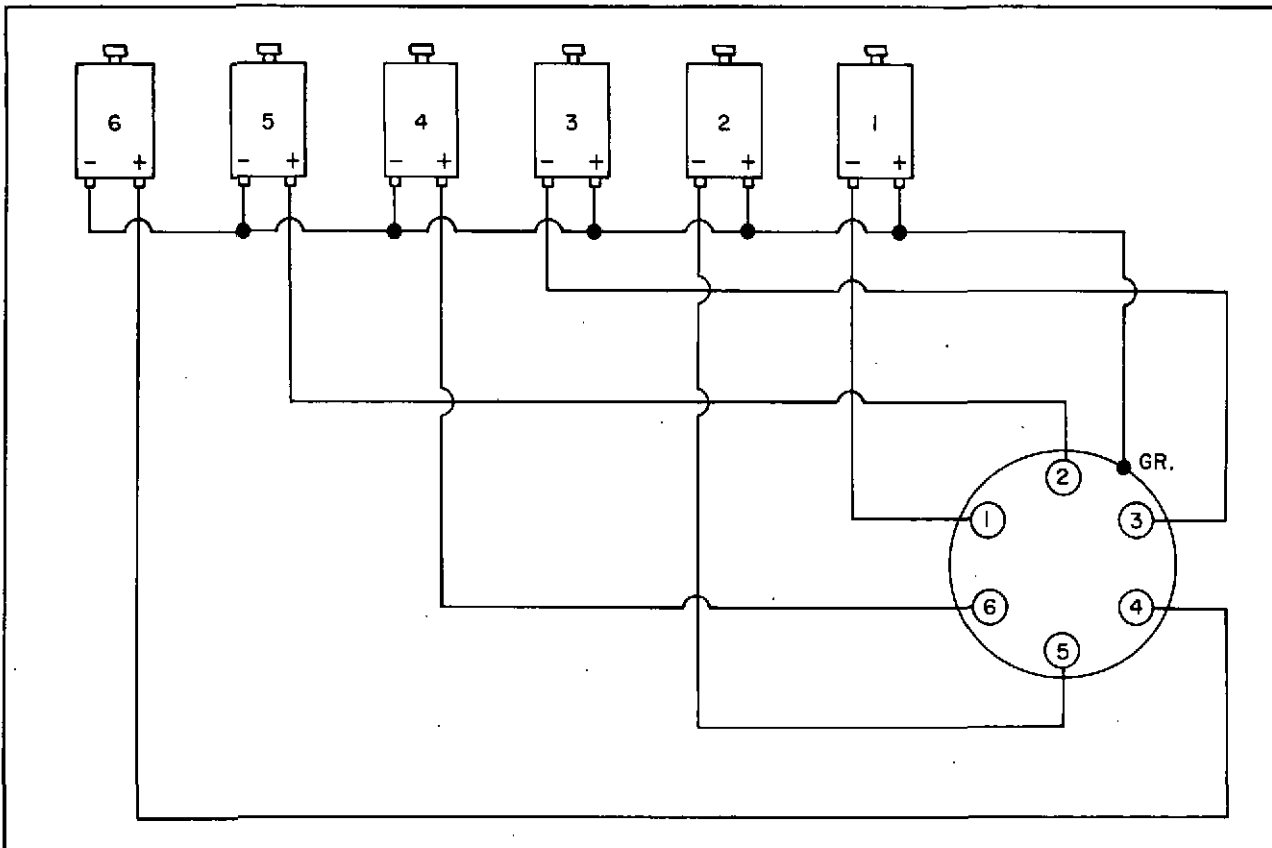
**Adjustable Drive Members**

Ordinarily, the position of the drive member is not altered when removing the magneto but, when necessary, the drive collar nut can be loosened to permit relative movement of the engine drive shaft. The drive member slots J can then be turned for alignment with the impulse coupling lugs, after which the nut L should be tightened. Turn locking washer lugs M up around the nut to prevent it from loosening.

**Installation Instructions**

Use the following procedure to obtain peak performance of Fairbanks-Morse heavy duty Type FM-LTR low tension magnetos.

Install the magneto on the engine as described. When this is completed, the engine No. 1 cylinder will be on the compression stroke ready to fire. The magneto timing mark on the edge of the distributor disc will be visible through the timing window and the No. 1 magneto terminal will be ready to fire. The No. 1



FM-LTR LOW TENSION MAGNETO — INSTALLATION WIRING DIAGRAM

magneto terminal is in the upper left hand corner of the magneto end cap cover when facing the cam end of the magneto.

Using No. 14 stranded automotive lighting wire, connect the No. 1 magneto terminal to the negative (-) terminal of the transformer at the No. 1 engine cylinder.

After noting the engine firing order, connect the No. 2 magneto terminal to the positive (+) terminal of the transformer at the cylinder which is second in the engine firing sequence.

Connect the No. 3 magneto terminal to the negative (-) terminal of the transformer which is third in the engine firing sequence.

Complete the wiring of the magneto terminals to the transformers in accordance with the engine firing order with transformers being connected in alternate negative (-), positive (+) sequence.

By means of a jumper wire, interconnect the remaining primary transformer terminals. From the transformer nearest the magneto, connect the jumper wire or the common ground wire of the transformers to the magneto end cap screw.

Connect a ground wire from the primary terminal, on the magneto housing, to the engine panel switch or relay.

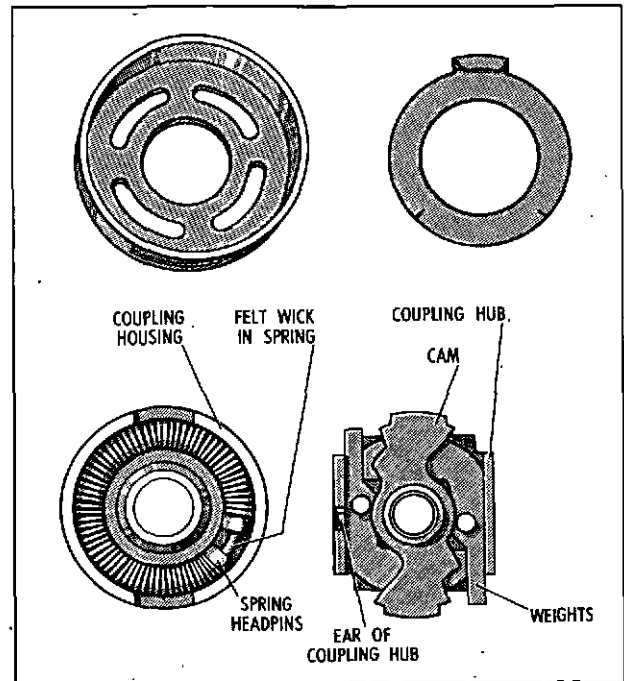
Using 7 mm ignition wire and clips, connect the transformer high voltage power to the corresponding number engine cylinder spark plug.

Recheck the hookup to be sure all screws are tight and that the magneto and transformers are connected in the correct engine firing order.

Start the engine and check the magneto-to-engine timing with a timing light.

#### MAGNETO IMPULSE COUPLING

The impulse coupling is engaged only when starting. Its purpose is to snap the magneto rotor over faster than the relatively slow engine cranking speed. In addition, the impulse coupling automatically retards the spark for as many degrees as it has been adjusted to do so. Thus, the spark occurs after the piston has passed top center and kickback is eliminated. The gain in spark intensity resulting from snapping the rotor over makes boosters and auxiliary starting devices unnecessary.

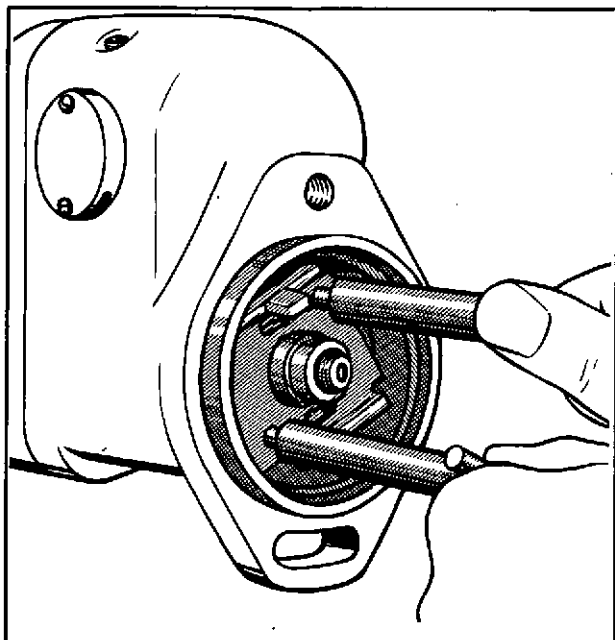


IMPULSE COUPLING ASSEMBLY.

Once the engine starts and attains a speed of about 180 RPM the impulse automatically disengages and the magneto is driven directly from the engine in normal timing.

The coupling employs sliding "L" shaped weights and a curved coil spring which absorbs the impulse shock. The vertical movement of the sliding weights is guided by ears of the impulse member hub which engages the housing into which are assembled the spiral spring and cam. The coupling is released by the arrester plate mounted at the shaft end of the magneto frame. The majority of the parts are designed so that they can be assembled for either clockwise or anti-clockwise rotation.

When disassembling the coupling to check parts for wear or damage, use a puller to remove the coupling hub from the magneto shaft. Damaged or worn parts must be replaced. Reassemble pins and spiral spring with felt wick to the coupling housing. Pins must rest against groove in housing channel. With ear of coupling hub facing you, locate weights in elongated hub slots. **IMPORTANT:** If the coupling is being assembled for clockwise rotation, letter "C" stamped on weights must be face up; for anti-clockwise rotation letter "A" must be face up. Place cam on coupling hub with letter "A" or "C" facing upward as required. Engage ear of coupling hub between pins in housing and mesh the two assemblies.



REMOVING IMPULSE COUPLING

**Installing Coupling on Magneto**

To provide accurate setting of the coupling retard, marks spaced  $5^{\circ}$  apart have been placed adjacent to the upper left-hand slot of the arrester plate. When the heavy center mark lines up with the fastening hole in the magneto housing, the automatic retard or lag angle of coupling is approximately  $30^{\circ}$  for either clockwise or anti-clockwise rotation.

Turning the arrester plate in a clockwise direction increases the automatic retard or lag angle and turning it in an anti-clockwise direction decreases the automatic retard or lag angle for clockwise magnetos. The opposite is true if the magneto operates in an anti-clockwise rotation. The coupling arrester plate has only two marks indicating coupling rotation when the plate is assembled to a magneto. Graduation marks spaced  $5^{\circ}$  apart are on the face of the magneto flange. Retards of from  $10^{\circ}$  to  $50^{\circ}$  are obtained by moving the arrester plate as outlined above. Fasten the arrester plate to the magneto frame. Adjust plate to required retard and securely fasten in place. Locate impulse member assembly on magneto drive shaft and fasten in place with rotor shaft nut and lock washer.

**NOTE:** Hub of the impulse member assembly is provided with two keyways - one for clockwise rotation marked "C", the other for anti-clockwise rotation marked "A". Be sure to select the proper keyway. The correct retard angle for the WAK is  $50^{\circ}$ .

**BREAKERLESS IGNITION SYSTEM****General**

Some WAK Series engines are equipped with Magtronic, Altronic III or Bendix S1800 breakerless ignition systems.

Breakerless (capacitor discharge) ignition systems consist basically of an ignition generator, transformer coils, and an interconnecting wire harness with a plug attached to the ignition generator.

The absence of breaker points and high tension distributor contacts makes the ignition generator completely free of internal arcing. Also, mechanical reliability is greatly enhanced.

The ignition generator includes extensive use of pulse activated solid state electronic components. Alternating current is rectified and stored in the storage capacitors. Silicon controlled rectifiers (SCR) function as switches to release the stored energy to the transformer coils. The switching or turning on of the SCR's is accomplished by a trigger coil arrangement which produces the small SCR turn-on voltage.

**PERIODIC INSPECTION**

Breakerless ignition systems are designed to operate from one engine overhaul period to the next without requiring any intermediate inspection or maintenance procedures. This has been accomplished through the solid state design of its circuitry and by the elimination of many of the normal magneto parts which make rubbing or intermediate contact.

If the engine should develop trouble which appears to be definitely associated with its ignition system, inspect wiring, spark plugs, and transformer coils for the difficulty. If the trouble appears definitely related to the ignition generator, remove it from the engine and replace it with a unit known to be good. It is suggested that a spare ignition generator be kept on hand at the facility for these emergency situations. A defective ignition generator should be sent to a qualified service station for overhaul.

The ignition generator and transformer coils will benefit from periodic cleaning with a cloth dampened with solvent. Inspect the primary terminals and harness plug for security and make certain that the ignition cable is inserted all the way into the high tension terminals. They may be cleaned with a fine brass wire brush. Periodic inspection of the mounting bolts is also recommended.

It is not necessary to open the ignition generator for periodic inspection. Opening of the unit will only permit dirt to enter.

### TIMING

When leading edge of longest (red) finger of distributor rotor is approximately in center of timing window in cover of Magtronic, it's ready to fire No. 1 cylinder.

When red mark on distributor shaft aligns with CW mark on Altronic III housing, it's ready to fire No. 1 cylinder. Opposite rotation engines must have the CCW mark aligned.

When timing pointer on large distributor gear is centered in timing window on Bendix housing, it's ready to fire No. 1 cylinder.

Timing must be checked with stroboscopic type timing light at governed rpm. If timing is not correct, shutdown engine and adjust by removing coupling screws and rotating ignition generator drive hub in the applicable direction. Replace coupling screws and recheck timing. Repeat procedure as necessary. Be sure to lockwire coupling screws when timing is correct.

### GASOLINE CARBURETORS

The WAK Series engines have been built with a considerable variation in carburetor details to provide for specialized operating conditions. Therefore, carburetors should not be interchanged or replaced indiscriminately. Remember, a few thousandths of an inch in jet size can make the difference between normal engine operation and burned valves, ring sticking, poor economy, and so on. The carburetors are identified by stamped tags riveted to the top of the float bowl cover. When ordering replacement carburetors, always give all information on the tag plus the engine serial number and specification number.

The carburetors generally used on these engines are of Zenith manufacture, 63AW-16, although a number of variations of them, with respect to venturi and jet sizes, installation details, and so on, will be found.

Carburetor service consists largely of maintaining the fuel supply in a clean condition, making proper adjustments at rare intervals, and leaving the carburetor alone when no specific

attention is needed. More carburetors are ruined by tampering than by hard service.

When it becomes necessary to perform major cleaning and service operations, the carburetor manufacturer's special bulletin for the unit at hand should be followed without deviation.

### Gasoline Carburetor Adjustments

The throttle stop screw should be screwed in (clockwise) against the stop pin to hold the throttle just slightly open. Adjust the throttle stop screw to obtain the desired idling speed of the engine.

Adjust the idling adjusting screw to obtain smooth idling when engine has become thoroughly warmed up. Turning the screw in (clockwise) cuts off air, making the idling mixture richer; while turning it out (anti-clockwise) admits more air, making the mixture leaner.

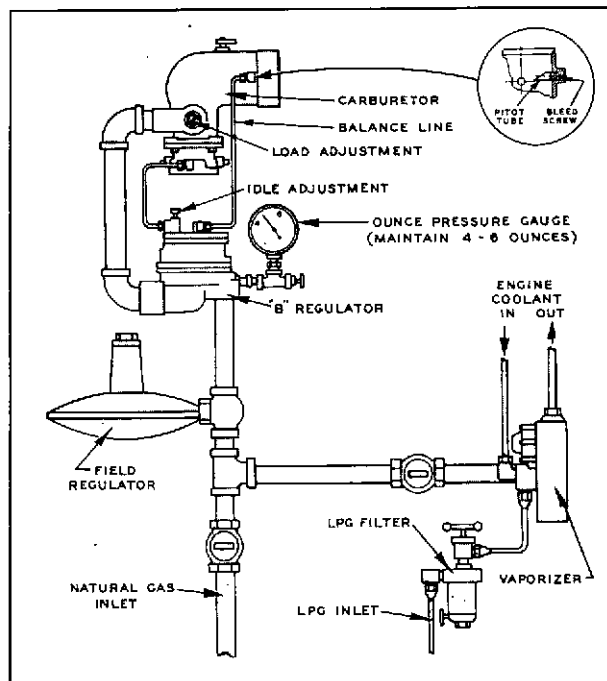
If it becomes necessary to turn the screw in to less than 1/2 turn off the seat to obtain good idling of the engine, it would indicate either an air leak or a restriction in the flow of fuel for idling. Look for air leaks at the manifold flange; at carburetor throttle body to intake gasket, and at carburetor bowl to cover gasket, due to loosened assembly screws or damaged gaskets. A badly worn throttle shaft will produce sufficient air leakage to affect the idling mixture.

Dirt or other foreign matter in the idling jet calibration will restrict the flow of fuel for idling and affect the mixture. If the idling jet becomes completely clogged, it will be impossible to run the engine at idling speed regardless of adjustment of the idling adjustment screw.

Some models of these series are supplied with a main jet adjustment. Turning the needle clockwise cuts off fuel making the medium and high speed mixtures leaner. The needle should be adjusted to give highest manifold vacuum (or highest R.P.M. on a tachometer) for a set-throttle position. If engine is equipped with speed governor, set the throttle to hold the engine speed just below the governed speed while adjusting the main jet adjustment. If adjustment is set too lean, the engine will lack power and the fuel economy also will be poor. If set too rich, the engine will be sluggish and the fuel economy poor.

**GAS CARBURETION - ENSIGN CARBURETORS**

Operation of Waukesha spark ignition engines on gas type fuels requires that the fuel be delivered to the engine in adequate volume and pressure throughout the entire speed and load range of the engine. Reference to the illustration will show that a gas fuel system consists of a primary or "field" regulator, a secondary or "B" regulator, and a gas carburetor. A typical LPG system consists of a carburetor and a combination regulator and vaporizer unit. If the vaporizer does not contain any pressure regulating device, a field and secondary regulator must also be included in the system. The components of either system appear similar in most cases but it must be remembered that the internal parts such as orifices and diaphragm springs determine gas flow capacity. Only strict adherence to the recommendations given in this manual will result in optimum engine performance. In addition, it is extremely important to use a fuel with an adequate anti-knock characteristic for the engine involved.



**COMBINATION NATURAL GAS  
LPG SYSTEM - ENSIGN CARBURETORS**

**NATURAL GAS FUEL SYSTEMS - ENSIGN CARBURETORS**

**Field Regulators**

Field regulators noted in this discussion are manufactured by the Fisher Governor Company, Marshalltown, Iowa. The purpose of the field regulator is to reduce the gas supply line pressure to a value low enough to be easily controlled by the sensitive "B" regulator. The tabulation shows the Fisher Series 730 regulators which will control pressures up to 150 psi. It is recommended however, that the maximum and minimum inlet pressures listed in the tabulation be definitely maintained. Failure to supply gas within the recommended pressure range will result in insufficient gas volume for optimum performance and field experience has proven that damage to the regulator is a possibility. If the line pressure is greater than that recommended for the inlet to the Fisher 730 Series, a Fisher Model 630 regulator can be used. This Model will handle pressures up to 1500 psi and if the situation warrants the control of higher pressure, the regulator can be converted further.

The Fisher 730 series field regulators have been gradually superseded by the Fisher Model S-201 in many production Waukesha gas engines. Both faster response and more convenient mounting make this desirable in most applications.

The S-201 regulator body may be rotated 360 degrees around the Tee connection without disturbing its operating characteristics. An aircraft type flange union is used and only two bolts need be loosened to rotate the regulator body. In addition, the aluminum regulator body, valve stem, and orifice reduce weight and add ease of handling.

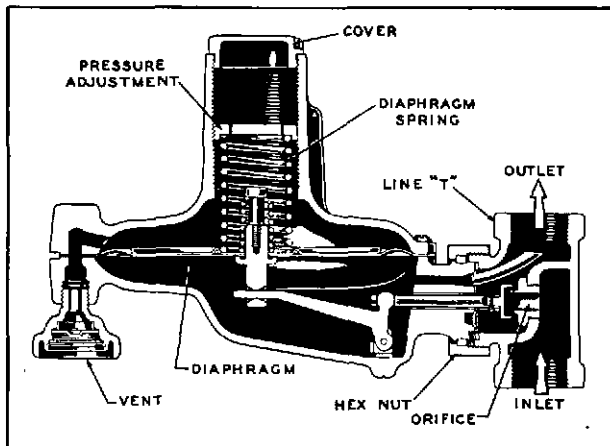
**Fisher S-201 Regulator**

Waukesha Engine Number	Pipe Size	Spring Color	Orifice Size	Inlet Press. Range PSI	Req'd Outlet Press. Ounces
162895-B	2"	Gray	3/4"	10-25	4-6

Outlet pressures from the field regulator regardless of engine size, speed, or load must be 4 to 6 ounces pressure measured at the inlet to the "B" regulator. The outlet pressure is determined by the diaphragm spring in the regulator and its adjustment. The correct springs are listed in the tabulation and the pressure is adjusted by removing the large hex-head cover screw at the top of the regulator and turning the screw within to the right or left to establish the recommended pressure at the inlet to the "B" regulator. Re-

**Field Regulator Recommendations**

Fisher Regulator Model	Regulator Pipe Size	Diaphragm Spring Number	Orifice Size	Inlet Pressure Range PSI	Req'd. Outlet Pressure Ounces
WAK 730-B-32	2"	B-194	3/4"	10-25	4-6



FISHER REGULATOR

member, an ounce pressure gauge is to be used at the "B" regulator.

Sufficient volume of gas for maximum performance is determined by the orifice size in the "T" connection to the regulator. Orifice sizes increase as engine size increases and failure to provide adequate gas volume will not only impair performance but will cause damage because of lean mixtures. Orifices are easily changed by loosening the large nut between the "T" connection and the regulator body which permits the body to be removed to provide access to the orifice. The orifice is removed with a socket wrench and the correct size is easily reinstalled.

In the illustration of the field regulator note that the vent assembly is mounted in the downward position. The vent permits atmospheric pressure to affect movement of the regulator diaphragm and must be installed in the position shown to provide a weather proof opening. This unit may be installed outside of the building or wherever atmospheric pressure is most stable. This vent is used only on the 733C-1 series regulators in that the 730-B-32 series and the S-200 incorporate a combination stabilizer and vent within the regulator body.

**Low Pressure Regulators and Carburetors**

Carburetors and low pressure regulators presently used on production engines are manufactured by the Ensign Carburetor Company. The regulator and carburetor must be considered as a unit in that the regulator serves a function similar to the float valve in the fuel bowl of a gasoline carburetor. The regulator must accurately control low pressure gas fuel according to the needs of the engine. The name "B" which is generally used in reference to the

low pressure regulator is a model designation given by the manufacturer.

Engine Model	Ensign Model	Ensign Number	Waukesha Engine Number	Pipe Size	Inlet Press. Ounces
WAK	B	5121	50582	2"	4-6

These low pressure regulators are specified for engines according to size and the corresponding fuel requirements. The listing points out the particular regulator model required and the inlet and outlet pipe size to be used. Note also that the inlet pressure to the regulator must be 4-6 ounces.

Low pressure regulators are equipped with an idle adjustment consisting of a gas line between the regulator and the carburetor and a screw type adjustment at the regulator. Idle adjustment under operating conditions is covered in the carburetor adjustment section of the manual. Another similar line called a balance line is also used to equalize the atmospheric pressure between the regulator and the carburetor air horn and compensate for air cleaner restriction. It is important that both these lines be a minimum 3/16 O.D. copper tubing. Failure to follow this recommendation will not permit sufficient movement of the regulator diaphragm and will result in erratic engine operation.

**Line Sizes**

It is important that the line sizes of a natural gas fuel system be large enough to supply adequate gas volume. The line between the high and low pressure regulators must not be reduced in size from that provided for at the regulator inlet and outlet.

**Carburetor Adjustments - Natural Gas**

1. Install vacuum gauge in manifold between carburetor and the engine.
2. With the engine stopped, adjust the gas pressure to the inlet of the "B" regulator to read 4 to 6 ounces.
3. On initial start-up back out the carburetor load adjustment approximately 5 turns and the regulator idle adjustment out approximately 3 1/2 turns.
4. Start engine and allow it to warm up 10 to 15 minutes.
5. Open throttle 1/3 and apply a partial load to the engine. Loosen the load adjustment lock nut and turn the screw in or out for highest vacuum reading. Check the adjustment by turning the screw out (rich position) until the reading drops and then in for

- highest vacuum reading. A slightly rich setting is preferred. Tighten the lock nut.
6. Operate the engine without load at low idle speed (approximately 500 rpm) and adjust the idle screw of the "B" regulator the same as the load adjustment above.
  7. Operate the engine throughout its speed and load range and note the gas pressure at the inlet to the "B" regulator. The pressure must be 4 to 6 ounces at all times. If it is low on acceleration or load the engine is operating on a dangerously lean mixture and the following should be checked.
    - (a) Make sure the "B" regulator is of ample capacity. Refer to chart.
    - (b) Check the gas supply line sizes. They must all be the same size from the inlet to the field regulator to the carburetor.
    - (c) The field regulator must be the correct model, have the correct spring and orifice, be adjusted properly, and be installed as close to the "B" regulator as possible.
    - (d) In applications where a volume tank is used the pressure at the inlet to the tank must be the same throughout the speed and load range as the pressure at the "B" regulator.

**LPG FUEL SYSTEMS - ENSIGN CARBURETORS**

Operation of Waukesha engines on LPG (liquefied petroleum gas) follows the same general recommendations as for Natural Gas engines. In both cases factory specifications in regard to regulator sizes, line sizes, and pressures must be followed. The basic difference between the two fuels is that LPG is initially a gas that has been compressed under extreme pressure to a liquid state. The liquid is then transported in a pressure vessel meeting rigid government construction specifications. The liquid must then be transformed into a gas at the engine for efficient mixing of fuel and air on the carburetor. LPG usually consists of a mixture of propane and butane. In some areas one or the other may be sold separately but for Waukesha engines 100% propane is recommended and a mixture of 60% propane and 40% butane is the minimum for safe operation.

A complete LPG fuel system consists of a high pressure liquid regulator, a vaporizer, and a low pressure gas regulator. All of these components are usually contained in one unit with the addition of idle and balance lines to the carburetor. In some applications the vaporizer is a separate component and the complete system must then

include a field regulator and a "B" regulator as in the natural gas system.

**Vaporizer and Regulator Combinations**

The vaporizer-regulator combinations used on Waukesha engines are manufactured by the Ensign Carburetor Company and are given the model designation "S". These units make up a complete LPG fuel system in that they provide high pressure regulation, vaporization of the liquid, and final low pressure regulation of the gas fuel for efficient mixing with air in the carburetor. The vaporizer utilizes the heat of engine coolant to provide sufficient temperature differential between the liquid fuel and the vaporizer body to aid in vaporization of the liquid and prevent icing of the regulator parts. Icing occurs when the expanding liquid absorbs heat with a resulting refrigeration effect.

**LPG Vaporizer or Regulator**

Engine Model	Ensign Vaporizer Regulator Model	Waukesha Engine Number
WAK	S	161542-A

The balance and idle lines used with the combination vaporizer-regulator units must be large enough in diameter to provide adequate movement of the regulator diaphragms. Correct balance and idle line sizes are listed in the chart. Larger balance lines, than those listed, may be required where vaporizer-regulators are placed some distance from carburetor. A line too small in this instance results in erratic operation and poor acceleration.

**Balance and Idle Line Sizes**

	Balance Line	Idle Line
S vaporizer-regulator	5/16" I. D.	3/16" O. D.
B regulator	3/16" O. D.	3/16" O. D.

**Carburetor**

All Ensign carburetors are equipped with a pitot tube in the air horn at the carburetor end of the balance line. Reference to the inset in the natural gas fuel system illustration will show that the pitot tube is fitted with a small bleed orifice. When the carburetor is used with the Ensign "B" regulator the orifice should remain in the tube. When the carburetor is used with a combination vaporizer-regulator however, the orifice must be removed to permit adequate movement of the LPG regulator diaphragm. Failure to remove the screw will result in back-firing and missing on acceleration.

### LPG Carburetor Adjustments

Carburetor adjustments for LPG systems follow the same recommendations as for natural gas systems. Both carburetors are equipped with load adjustments and the combination vaporizer-regulator has an idle adjustment identical to that of the "B" regulator. Low pressure fuel requirement to the "B" regulator is 4 to 6 ounces throughout the entire speed and load range of the engine.

### MODEL 'S' VAPORIZER-REGULATOR COMBINATION USED FOR NATURAL GAS OPERATION - ENSIGN CARBURETORS

Although the Ensign Model "S" vaporizer-regulator is usually considered initially for use with LPG fuel it can be adapted to permit operation on Natural Gas also. In this case, the Natural Gas is introduced through piping into the regulator body at 10 pounds pressure and reduced to almost zero pressure at the regulator outlet for efficient mixing with air in the carburetor. The gas line pressure drop to ten pounds can be accomplished by the use of the Fisher Model 630 regulator. The tabulation below shows the correct Model 630 regulator to use. Note the maximum and minimum inlet pressure to the Model 630 regulator that must be maintained for optimum performance.

Engine Model	Reg. Model	Regulator Size	Orifice Size	Diaphragm Size	Spring No.	Initial Pressure
WAK	630	1"	1/2"	5"	W192	20# to 100#

### ENSIGN COMBINATION CARBURETOR

The accompanying drawing illustrates the Ensign model Dg gas carburetor in section. Air entering through the air horn mixes with gas entering at nozzle (A) within the venturi: The mixture then passes through throttle tube into the engine. Gas enters carburetor at (B), passes through orifice (C) where the main load adjusting screw (D) controls the amount of flow to venturi nozzles.

#### Starting

To start engine close the choke in the usual manner. Air choke disc (E) and gas choke disc (F) are mounted on the same shaft, therefore, both air and gas are choked together. Orifice (G) in the air choke disc permits passage of enough air for starting and idling. The correct amount of gas for starting passes first through orifice (C) and then by-passes around gas choke disc (F) through opening (H) in which passage-way starting gas adjustment (I) is located. Starting gas adjusting screw is locked in place

once the correct mixture for starting is found. This mixture usually is richer than for normal operation.

Enough air and gas are allowed to enter the engine on "starting position" to run well past idling speed. When the choke is returned to its open position this "Easy Starting Device" is rendered inoperative and the main air-fuel orifices are put into operation. Gas idle line from regulation is connected at (S).

#### Economizer

The purpose of the economizer is to reduce flow of fuel during part throttle operation when mixtures can safely run a little leaner. Yet the economizer must automatically become inoperative for full load when maximum fuel is required.

Manifold vacuum applied at (J) through line (K) pulls diaphragm (L) back, also closing off secondary gas passage at (M). When engine reaches 75 to 80 percent of its maximum power, the manifold vacuum is reduced permitting diaphragm (L) with aid of spring (N) to move inward opening valve (O) to position shown by dotted lines. This allows additional gas to flow as indicated by curved arrows. A fixed calibrated orifice (U) controls the flow of fuel through economizer.

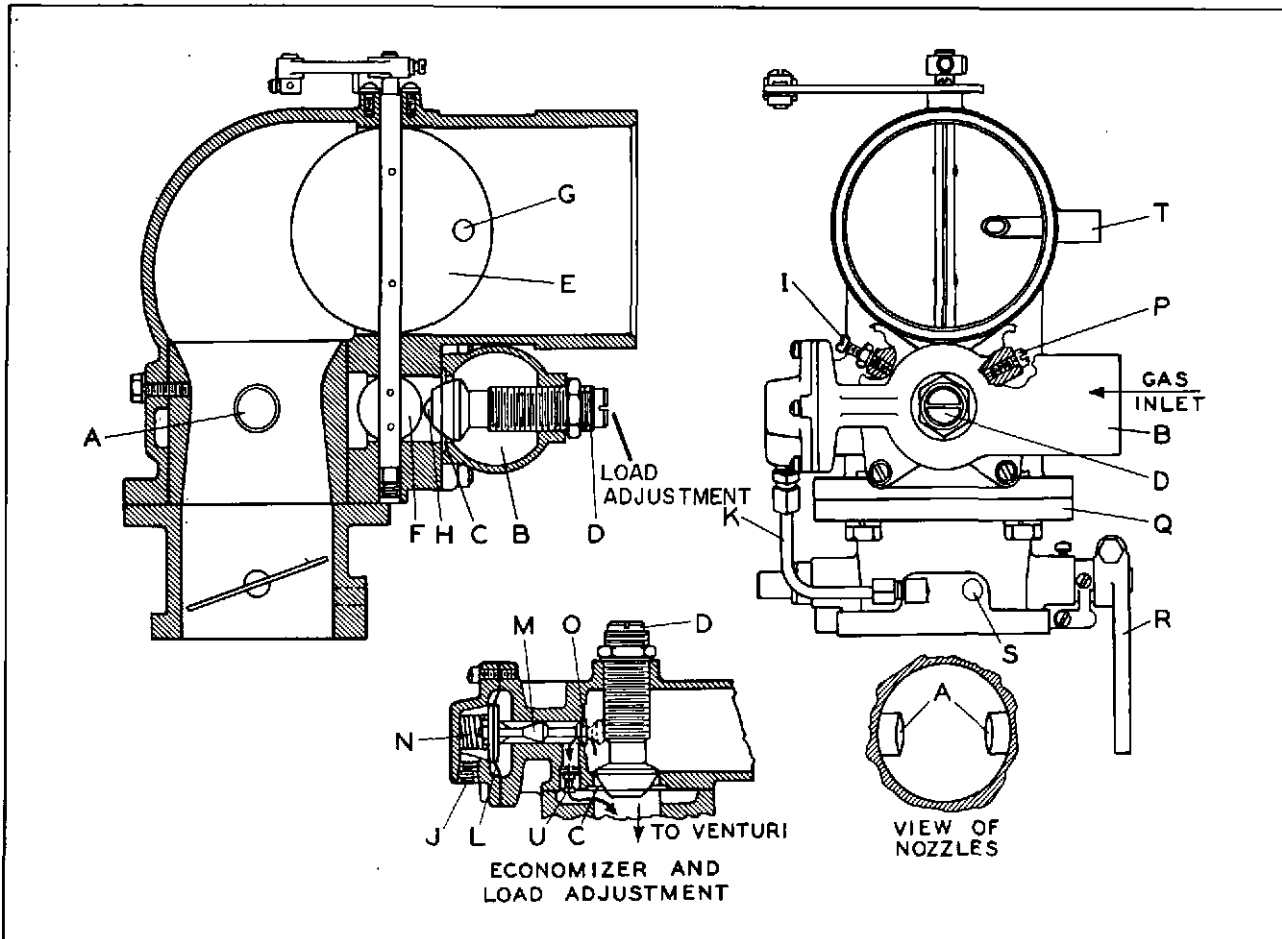
NOTE: When the Dg carburetor is used on engines equipped with governor the economizer connection (K) should be made at a point on the inlet manifold between the governor and engine.

Balance line connection (T) communicates air horn depression to the Ensign fuel regulator automatically reducing the flow of gas in proportion to the reduction in the flow of air as caused by excessive air cleaner restriction and other air entrance losses. The Ensign regulator for use with this carburetor may be either the Ensign Model B differential pressure type or Ensign Butane Regulating Unit Model S.

#### Balance Line

The bleed screw, installed at the factory, in the air horn of all Model 2-1/2" and 3" Dg carburetors is intended for use with Ensign Model B Fuel Regulators. The Model 3-1/2" Dg carburetor is not equipped with bleed screw.

When carburetor is used with Ensign Model S Butane Regulating Unit the bleed screw should be removed.



ENSIGN COMBINATION CARBURETOR

**Installation**

Installation of the Ensign Dg carburetor is universal in its application. It may be mounted in either updraft or downdraft position directly to engine inlet manifold. To facilitate easy installation, the main gas inlet (B) may be turned 180° on the four screws holding the gas inlet connection to the air horn. Gas starting adjustment (I) may be used on either side of the carburetor in position shown, or at position (P). Throttle lever (R) may also be used on either side of the carburetor. The entire air horn may be rotated 360° on round four bolt flange (Q). When making balance line connection from carburetor to regulator, or butane-propane vaporizing unit, care should be taken to provide fittings and hose having a minimum opening of 1/4" diameter.

**Service**

The Ensign Dg carburetor serves for both butane and natural gas. Due to its simplicity and few moving parts, it rarely needs attention. When

it is necessary to look to the carburetor for trouble, a thorough cleaning and replacement of worn parts is recommended.

In reassembling the carburetor, make sure the passages are open. The throttle bearing bushings and shaft should be replaced when worn excessively. The air horn assembly will attach to the throttle tube in any one of four positions. A new air horn gasket should be installed.

The economizer is disassembled by removing the five cover screws. It should be thoroughly cleaned. The only part that may need replacing is the diaphragm. Carefully check vacuum control connections to economizer for air leaks.

**ENSIGN TYPE "B" FUEL REGULATOR**

The Type "B" fuel regulator has the same general function with gas as the float bowl of a gasoline carburetor has with gasoline; it accurately regulates the supply of gas to the carburetor and it shuts off the supply of gas when engine demand has ceased.

The Type "B" fuel regulator is supplied in 1" and 2" sizes. The 1" size can be used with all sizes of carburetors from 1" to 2" inclusive and is available in several models each differing slightly in internal specifications, according to the B.T.U. value and pressure of the gas to be used. When the 1" fuel regulator is used with natural gas of 1100 B.T.U. at an inlet pressure of from 4 to 6 oz. (7 to 10" water column) it has sufficient capacity for 125 HP.

The 2" fuel regulator can be used with S.A.E. size carburetors from 2" to 3-1/2". When used with natural gas of 1100 B.T.U. and at an inlet pressure of 4 to 6 oz. (7 to 10" water column) it has sufficient capacity for 325 H.P.

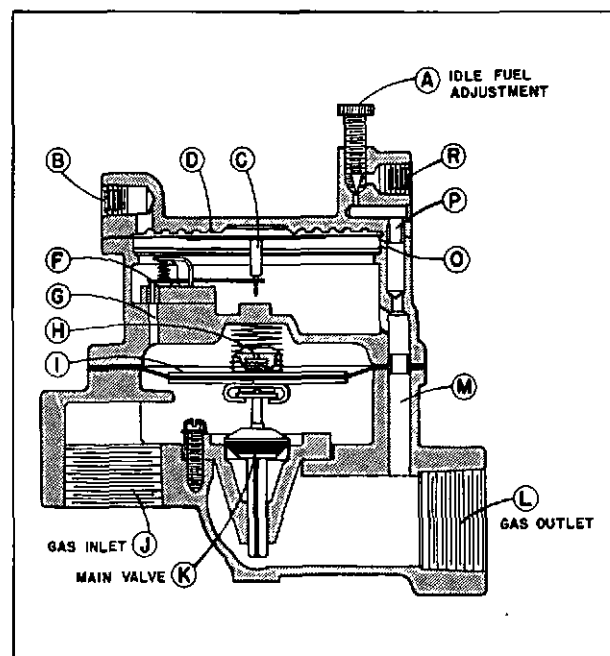
#### Operation

The fuel regulator operates as follows: (Refer to illustration.)

With the engine at rest - the main valve "K" is closed and gas supply through the inlet "J" exerts a pressure below the lower diaphragm "I" and equally above "I" through orifice "H". Atmospheric pressure through the carburetor air intake is exerted on the upper side of the upper diaphragm "D" through opening "B" and on the under side of "D" through orifice "O", passage "M" and opening "L". "B" is connected to the carburetor air intake by a small tube known as the "balance tube connection." This connection compensates for increased air cleaner resistance, thereby maintaining a constant mixture in the carburetor.

When the engine is started, suction from the carburetor is applied to the regulator at "L" and communicated by way of passage "M" and orifice "O" to the under side of diaphragm "D" which is pulled down. As diaphragm "D" moves down, push-rod "C" opens pilot valve "F". The reduction in pressure of gas over "I" bled through passage "G" by the opening at "F" permits "I" to lift and to open main valve "K" which in turn passes gas through to the carburetor.

Passage of gas through "K" into "L" relieves some suction on "D" by way of "M" and "O" thus partly closing "F" - allowing pressure to increase over "I" which in turn partly closes "K" to accurately maintain pressure at "L" of 3/16" water column below atmosphere. When the engine stops - suction ceases entirely, permitting "F" and "K" to close and completely shut off the supply of gas to the engine.



ENSIGN REGULATOR, TYPE B

At idle engine speed the carburetor throttle is nearly closed and therefore little suction is applied at "L". The differential type regulator functions accurately at slow idle speed by means of a patented "idle fuel connection system". This system applies suction from the engine side of the carburetor throttle through the idle connection tube directly to the under side of upper diaphragm "D" by way of "R", "P" and "O" to operate the valve "K" as described above. Fuel for the engine at idle, is controlled therefore, by the idle fuel adjustment "A". Part of the idle fuel is supplied directly through the idle tube.

The fuel regulator should be protected from all foreign matter which might injure the regulator's valve seat.

#### SUGGESTIONS FOR LOCATING TROUBLE ON GASEOUS FUEL ENGINES - ENSIGN CARBURETORS

##### When Engine Fails To Start

##### No Fuel to Carburetor

Lines plugged.

Tank empty.

Fuel regulator main diaphragm broken thereby preventing valve opening. (Model "B" fuel regulator only).

Check pressure at tank, on "B" regulator.

**Too Much Fuel**

Fuel regulator leaking.  
 Valve stuck open.  
 Starting adjustment set too rich.  
 Choke at fault causing wrong mixture.

**When Engine Fails To Idle Properly**

If the range of the idle adjustment screw will vary the mixture from too lean to too rich without an improvement in the idling of the engine the trouble is outside the carburetion equipment.

**Model "B" Fuel Regulator**

If in adjusting the idle, the mixture is found to be too rich with idle screw closed tight it may be the regulator is leaking more gas than is required to idle the motor.

If in adjusting idle, the mixture is found to be too lean with the idle screw out several turns you will find one of the following:

1. Idle connections between regulator and carburetor leaking.
2. Idle connection plugged, such as: small hole in carburetor bore above throttle disc, small hole above brass plate in regulator bowl and adjusting screw seat.
3. Upper diaphragm too stiff.
4. Upper diaphragm ruptured.
5. Pilot valve pin low.

Balance tube (or vent, if used) plugged or badly restricted.

**When Engine Fails To Operate Properly Under Load**

Improper fuel adjustment.

Intake manifold too hot.

Fuel supply restricted or valve closed.

Fuel lines too hot.

Varying pressure in vaporizer due to high pressure regulator valve sticking, caused by using dirty fuel.

Regulator discharging in surges.

Balance tube plugged or badly restricted.

Diaphragm by-pass bleed, partially plugged.  
 (On Model "B" fuel regulator.)

**Fuel Regulator Leaks**

Main valve or seat scored.  
 Pilot valve leaks.  
 Diaphragm by-pass bleed, plugged.  
 Lower diaphragm too stiff or too tight.

**Main Valve Sticks Open**

Guides and stem gummy.  
 Springs on top of main diaphragm broken.  
 Particles lodged between valve and seat.  
 Diaphragm by-pass bleed, plugged.  
 Diaphragm too stiff.

**IMPCO CARBURETORS**

The Impco carburetor may be arranged to operate on natural gas or a combination of natural gas and LPG with automatic changeover. These carburetors are of the air valve type, designed to operate directly from an "ounce" regulator. Normal pressure to the carburetor is 5 inches water column for 1000 BTU LHV natural gas. For natural gases of different heat values, slightly higher or lower pressures are required and readjustment is normally made in the field. LPG contains more heat units for a given volume than natural gas and for this reason the pressure at the carburetor inlet must be regulated at 1-1/2 inches water column negative. This pressure is non-adjustable and is controlled by the regulator.

**CAUTION**

Waukesha Engine recommends only HD-5 propane for LP-gas fueled engine operation.

The Impco carburetor consists of a main body with a conventional butterfly valve and two diaphragm operated gas metering valves. The amount of air going to the engine is measured by two air-flow measuring valves which rise in direct proportion to the air volume passing through. The gas metering valves are mechanically fixed to the air measuring valves and rise with them, thus opening the gas passages an amount proportionate to the air entering the engine. This establishes and holds a definite fuel/air ratio throughout the operating range. The actual movement of the parts results from the negative pressure at the air measuring valves which is communicated to the back side of each diaphragm through four small holes.

On natural gas, the Impco carburetor is somewhat less sensitive than other types to the effects of moderate air cleaner restriction and a balance line may not be needed. When operating on LPG, however, the results of air cleaner restriction may be quite significant and a balance line is important.

**IMPCO INSTALLATION**

Natural gas installation of an Impco carburetor requires a line pressure regulator large enough and of suitable pressure reducing capability to handle the fuel source involved and provide an adequate volume of natural gas. No mechanical choke is provided for starting and none is necessary with this type of carburetor.

**IMPCO SERVICE INSTRUCTIONS**

**General**

The normal arrangement for natural gas uses a field regulator to reduce pounds pressure to the final value of 5 inches water column (3 oz.) maximum. Excessive pressure will increase gas fuel consumption. This pressure will have its main effect on fuel economy.

For reasons of safety . . . ALL GAS INSTALLATIONS IN CLOSED AREAS OR BUILDINGS SHOULD HAVE A POSITIVE SHUT OFF VALVE TO PREVENT GAS LEAKAGE WHEN THE ENGINE IS AT REST.

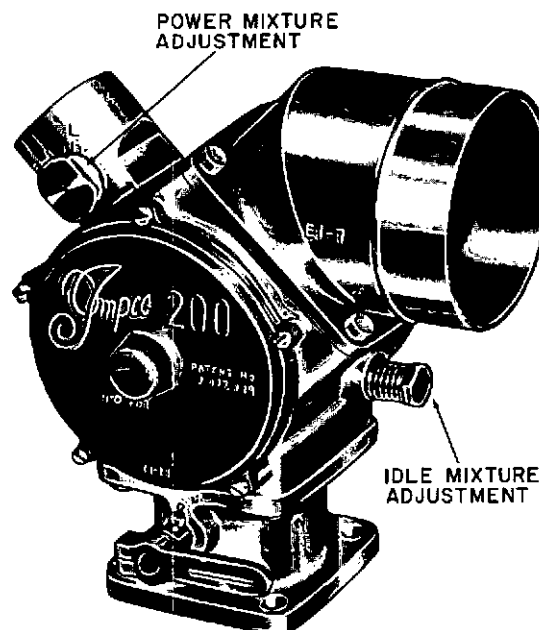
LPG installations should have the liquid fuel filtered before entering the vaporizer or "EB" converter. The liquid fuel is converted to gas by addition of heat from the hot water from the engine jacket which is circulated through the water chambers of the vaporizer. The regulator section reduces the high pressure gas to the desired level for use. Because of the high BTU content of LPG, the gas volume required is smaller than needed for natural gas and the pressure at the carburetor is maintained at a negative value. A balance connection from the carburetor inlet to the regulator should be used in this installation.

With the 2" line pressure regulator, the following orifice size and type of spring must be used to obtain required pressure to the carburetor.

Inlet Line Pressure	Orifice Size	Spring Color	Outlet Pressure to Carburetor
10-25 lbs.	3/4	Red	5" H <sub>2</sub> O column

**Load Adjustment**

1. Set natural gas pressure with engine idling, by adjusting line pressure regulator, to 5" water column plus or minus 1/4 inch, for 1000 BTU LHV gas with idle mixture screw backed out 3 turns, and power fuel mixture turned to rich (R) position.
2. Full load gas pressure may drop as low as 3" water column at the carburetor gas inlet. Exact pressure at full load is immaterial as long as power mixture adjustment is still effective (carburetor can be set over-rich).
3. With the engine warm and running full load at governed speed, adjust the power fuel mixture from rich (R) towards lean (L) slowly to obtain maximum vacuum. After maximum vacuum is obtained, adjust for slightly leaner mixture to decrease vacuum 1/2" of mercury. This setting will improve fuel economy. If application is such that transient load changes occur, such as a generator set, omit this adjustment to decrease vacuum. The power adjustment is not effective at a fast idle or light load.



IMPCO CARBURETOR ADJUSTMENTS

**Low Idle Adjustment.**

1. Reduce throttle speed setting to bring carburetor butterfly lever against low idle stop.
2. Adjust carburetor idle stop screw to obtain desired engine RPM.
3. Adjust carburetor idle fuel adjustment screw to obtain highest engine RPM.
4. Re-adjust idle stop screw to obtain desired engine RPM.

**LP Gas**

The adjustment sequence for Impco carburetors when operated on liquid or vaporized LPG, either as the only fuel source or as a dual fuel source along with natural gas, is very similar to the adjustment sequence for natural gas, with the following exceptions:

1. L.P. gas inlet pressure to the carburetor must be 1-1/2" (negative) water column as set by the IMPCO "EB" vaporizer regulator (blue spring).
2. If vaporized LPG is used, the Impco pressure reducing valves (with regulator spring removed and valve mounted upside down) provide 1-1/2" water column negative pressure to the carburetor fuel inlet. Line pressure regulators utilized with vaporized LPG are adjusted the same as for natural gas to supply 5" water column gas pressure to the pressure reducing valve.
3. The idle fuel adjustment for dual fuel engines need not be repeated for LPG after it has been set for natural gas.
4. Dual fuel installations require load adjustment for both fuels, since they utilize separate load adjustment controls. The load adjustment valve at the carburetor is used for the natural gas adjustment.

**Balance Lines**

1. Due to the insensitivity of the air valve carburetor to minor inlet air restrictions, most installations do not require a balance line.
2. Balance lines may be used on all IMPCO carburetors. Series 200D carburetors use a 7/16" I.D. balance line.

**Digester Gas**

1. For low BTU fuels (500 to 800 BTU) a special DG model carburetor must be used.
2. Digester gas is used at 6" water column pressure into the carburetor.
3. For combination digester gas and natural gas, the Impco pressure reduction valve (with spring removed and mounted upside down) provides 1" water column negative pressure to carburetor fuel inlet.
4. The idle fuel adjustment for dual fuel engines need not be repeated for digester gas after it has been set for natural gas.
5. Dual fuel installations require load adjustment for both fuels since they utilize separate load adjustment controls.

**SYNCHRONIZATION PROCEDURE (Engines on Compound Load) - ENSIGN AND IMPCO CARBURETORS**

The following procedure is listed for applications where more than one engine is used in compound to overcome a load. In particular, this would be a drilling rig application where two or three engines are used to power the drawworks, rotary, and mud pump.

1. First adjust carburetors as outlined under Carburetor Adjustment.
2. Put engines in compound and adjust low idle stop on carburetor until all engines have the same vacuum. (Since all engines are in compound all will be running the same speed.)
3. Disengage one engine clutch from compound and set throttle in wide open position to allow engine to run against governor. The desired governor speeds loaded are not to exceed the loaded speeds for continuous service, listed below. High idle speed will exceed loaded speed approximately 7 per cent. Adjust governor spring tension to permit this speed on this engine.
4. Now put this engine in compound with the other engine (or engines) and place throttles of all engines in wide open position. Adjust the governor adjusting screw so that the vacuum reading on the other engine or engines is the same as the one adjusted in Step #3, above.

5. The engine now should be in compound so that the vacuum readings on each will follow one another from idle to full governor speed and on load.

NOTE: If after the above adjustment, you cannot get the engines to run together, check the relative position of the governor butterfly valve of each engine (stopped). If you find a slight difference in the position of the governor butterfly this can be adjusted by changing the length of the governor rod at the rod ends.

6. Do not attempt to make adjustments on the carburetor to obtain equal vacuum on the engines in compound as this will offset the fuel mixture making the engines run too rich or too lean. Always adjust the carburetor for load before you try to synchronize engines in compound.

#### VALVE CLEARANCES

Accurate valve clearance settings materially prolong engine life and aid performance. In addition to impairing performance, excessive clearances are detrimental to cams and tappets as well as the rest of the valve mechanism. On the other hand, when clearances are too low, timing is again disturbed and the possibility of burned valves becomes much greater.

Valve clearances specified in the tables of clearances and on the engine nameplates are for normal room temperatures . . . NOT FOR HOT ENGINES. When checking clearances or timing, the rocker arms must be contacting the valve tips evenly and not be hollow. When the rocker arm to valve tip surfaces are worn hollow, it is impossible to make an accurate check with a feeler gauge. Never attempt to adjust valve clearances without loosening the adjusting screw lock nut and re-tightening it when completed.

#### VALVE TIMING CHECK

It is very seldom necessary to check valve timing. The timing of the camshaft is established at the time of assembly by the proper matching of the timing marks as shown elsewhere in this manual. Since there are no couplings or other adjustment mechanisms to slip, there is no way in which the timing can be changed. Moreover, it is often difficult for a person inexperienced in this operation to check for proper timing with absolute accuracy even though the engine is correctly timed. This is because of the many factors such as gear backlash, manufacturing tolerances, cam wear, rocker arm wear, and personal judgment that vary.

If the valve timing should be disturbed during the replacement of worn parts, or, if for any reason it may be suspected of being incorrect, be sure to use the valve timing clearances rather than the valve running clearances. These clearances are different. The valve running clearances specified on the engine nameplate and in the table of clearances are not correct for setting valve timing. After the valve timing operation is completed, be sure to reset the valves at the proper running clearances as indicated on the engine nameplate.

#### VALVE TIMING SEQUENCE

The actual steps in making a timing check are not complicated.

1. Bring number one piston to top center on the compression stroke so intake and exhaust valves are both closed.
2. Adjust the clearance of number one intake valve to .016.
3. Rotate the engine in the direction of normal operation (to remove backlash from the gear train) through the power and exhaust stroke until the number one piston is again approaching top center, this time for the beginning of the intake stroke.
4. Very carefully feel for the instant that the rocker arm starts to bear against the valve stem. This is easiest to determine by rotating the upper end of the push rod between the fingers.
5. When the push rod just becomes snug, the intake valve is starting to open. Check the flywheel position through the inspection opening. It should be on or about TDC. If the flywheel markings are inaccessible, TDC may be determined visually by watching the piston through the spark plug hole with the aid of a flashlight.
6. After timing check, reset valves to cold clearance settings.

Whenever the rocker covers are removed, the valve and spring mechanism should be examined for evidence of inadequate lubrication due to sludging or plugged oil lines. Excessive sludge in the rocker arm area is an indication of too low oil operating temperatures, poor filtering action, or an oil that breaks down and is unsuited for the operation involved.

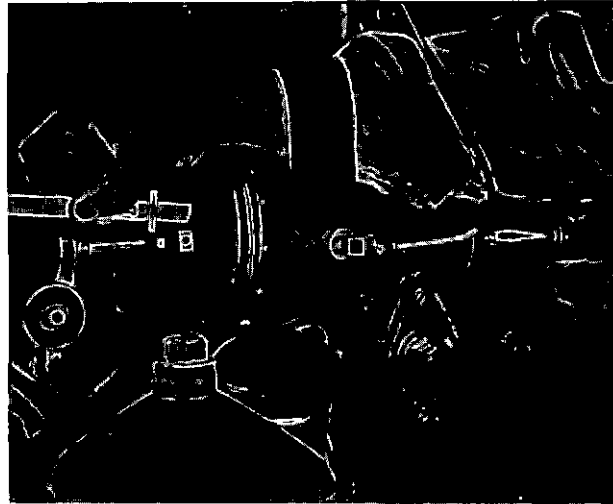
#### MECHANICAL GOVERNOR

There are several types of governors used on the WAK series engines. The particular method

of governing depends directly on the engine application. In the case of a generator set application, extremely close speed control is necessary. This is often controlled by means of a vacuum compensator.

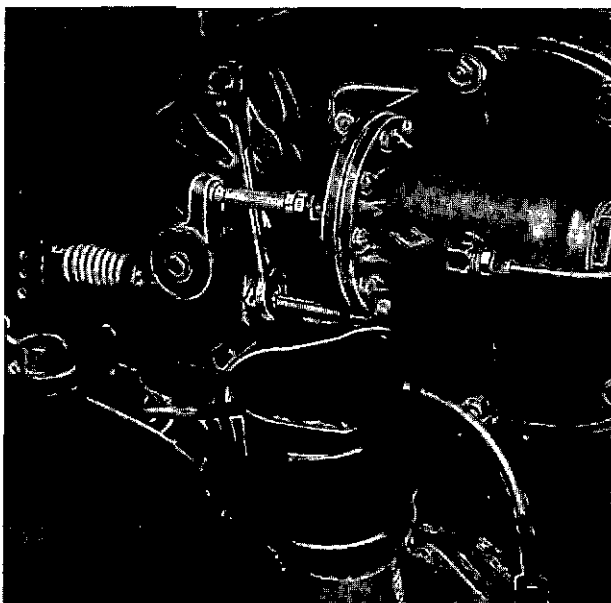
**Resetting the Mechanical Governor**

If it should be necessary to dismantle the governor at any time for other adjustments - and it is only for that purpose that it should ever be necessary to disturb this mechanism - there are some basic requirements which should be observed. These requirements can all be met if the governor parts are carefully marked before they are removed so that they will be reassembled with the same adjustment and in the same places from which they were removed. Most important, make sure that the operating linkage and the adjusting nuts are accurately assembled exactly as before to prevent improper positioning of the butterfly valve. Also, be sure the lock nuts are in place and securely tightened to prevent change in the length of any of the linkage. Notice carefully, and mark, the position of the butterfly valve so that it goes back exactly as before. Close it, and with a pencil, mark the top side and the adjacent wall of the intake so that it is not reassembled upside down, or backwards. If these precautions are followed, the governor should operate exactly as before when it is again put into service provided the tension of the governor spring and the length of the operating rods have not been changed. To secure the best operation, make sure that the length of the operating rod is adjusted so



VACUUM COMPENSATOR STOP COLLAR ADJUSTMENT

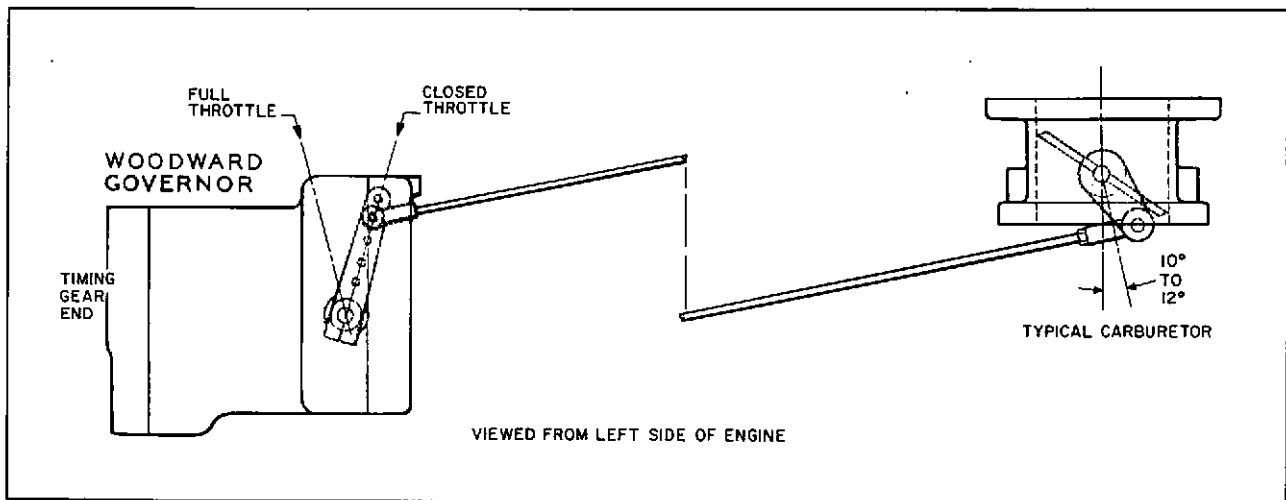
that the butterfly stands a trifle towards the closing position when the engine is stopped. Variation from the proper speed can be corrected by tension of the regulating spring. Increasing the tension increases the maximum speed, and decreasing the tension decreases the maximum speed.



GOVERNOR SPRING TENSION ADJUSTMENT



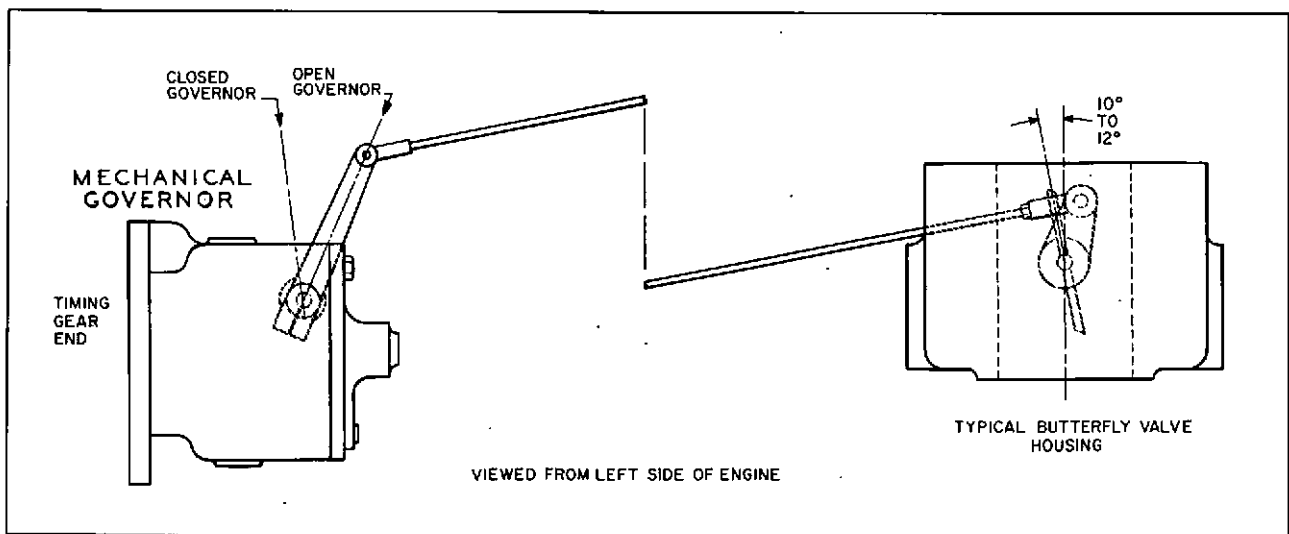
GOVERNOR TO BUTTERFLY VALVE LINKAGE ADJUSTMENT



**WOODWARD GOVERNOR**

Adjust the linkage so that full governor travel provides somewhat less than full throttle travel. When the engine is shut off the external return spring moves the governor lever to the off or minimum position. With the governor lever in that position the linkage should be adjusted so

the butterfly is very near completely closed. With the governor lever in the maximum or full throttle position, the throttle butterfly should be somewhat less than wide open. 10° to 12° short of wide open is sufficient for full power.



**MECHANICAL GOVERNOR**

With the engine shut off, the governor lever will be in the wide open governor position. Adjust the linkage so that the butterfly leans toward the closed position, approximately 10°

to 12°. Lever length ratios are designed so that full butterfly valve travel is obtained with slightly less than full available governor arm travel.

**GOVERNOR BUTTERFLY LINKAGE ADJUSTMENTS**

**VACUUM COMPENSATOR (For Close Governor Regulation)**

The vacuum compensator, located on the engine side plate is a tempering device which works in combination with the engine governor to provide closer speed regulation than is possible with the governor alone. Its operation is a function of the intake manifold vacuum which reflects the load on the engine. (At full load, vacuum is low; at no load, vacuum is high.) Thus the governor's action is controlled not only by speed, as in ordinary operation, but by load as well. This close regulation is necessary in generator operation to permit proper control of generator frequency and voltage.

The governor is a flyball type in which, as the speed increases, the lever, S, is moved to the left, toward a closed throttle position. The movement of S is restricted by the spring, R, maximum tension of which is controlled by the screw, Q, and should not be disturbed. It will be noticed that spring tension can also be decreased or increased as the transfer lever, P, moves right or left respectively. This movement is controlled by the intake manifold vacuum and the compression of the compensator spring, D, as follows:

When the vacuum in the manifold increases, due to reduced load, the diaphragm, F, moves right against the compensator spring, D. This movement is transmitted by the rod, L, to the lever, P; and as a result, the tension of the governor spring, R, is decreased to permit the lever, S, to move to the left toward closed throttle position. Knob, A, sometimes located on the instrument panel, controls the compression of spring, D, and the degree to which it affects

governor spring tension and engine speed. Clockwise rotation of the knob increases speed; counterclockwise rotation decreases speed. The compensator reduces the speed drop from no load to full load operation to 3% to 5% of maximum speed.

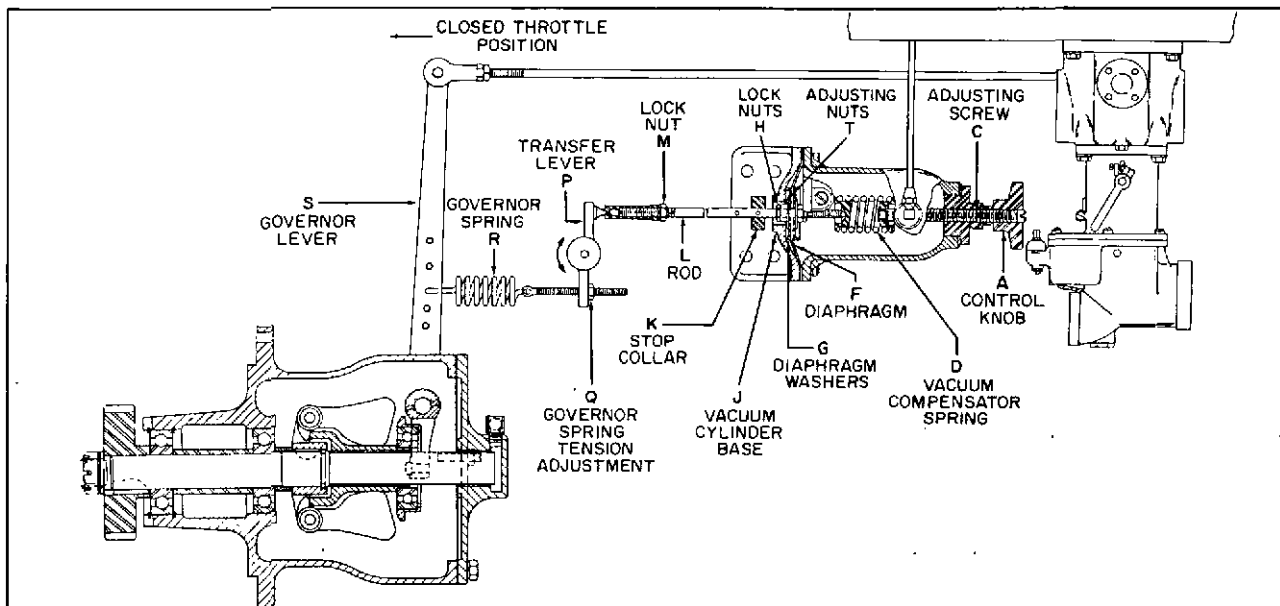
In cases where two engine driven generators must be synchronized, the compensator permits close manual regulator of speed by means of the knob, A.

**Assembly**

Relieve the tension on the vacuum compensator spring, D, by backing off the adjusting screw, C. Remove the vacuum cylinder cover assembly. Position the diaphragm, F, and washers, G, on the push rod, L, by adjusting the nuts, T, and lock nuts, H, located on either side of the diaphragm, so when the diaphragm is held against the vacuum cylinder base the distance between the cylinder base and the stop collar, K, is 1/2 inch. With the diaphragm in place, slip the spring, D, on the adjusting screw, C, and position the cover assembly on the vacuum cylinder base. Install the cap screws and tighten evenly. The above procedure must be followed so that the diaphragm has the proper amount of wrinkle for 1/2 inch travel.

**Adjustment**

Be sure the vacuum line does not leak. With the engine running at governed idle speed, adjust the screw, C, until the stop collar, K, clears J by 3/32 inch. Check speed and correct by adjustment at M. Make sure the stop collar, K, clears J by 3/32 inch.



VACUUM COMPENSATOR — GOVERNOR REGULATION

**PSG GOVERNOR INSTALLATION AND ADJUSTMENTS**

When the governor is installed on the engine, particular care should be exercised to see that it is mounted squarely and that the drive connection to the engine is properly aligned. A gasket should be used between the base of the governor and the engine mounting pad. Be certain the gasket does not block off any holes in the governor base. Install fuel control linkage, making sure that the governor in its closed position can cut fuel flow off completely and that it is capable of opening fuel control mechanism to its full load position. Be sure linkage is free from friction or lost motion.

The governor is single acting, that is, it utilizes oil pressure in one direction only and depends upon spring force to move the fuel control linkage in the fuel off direction. This spring is incorporated in the governor cover in some models, particularly those used with completely enclosed linkage, but most governors require an external spring exerting a torque of 50 lb. in. on the terminal shaft.

Unless the engine pad is drilled for oil supply to the governor through the mounting flange a

3/8" oil line must be connected from the engine lubricating oil pump pressure line or separate oil sump. An automotive type oil filter must be installed in the line to eliminate the possibility of dirty oil reaching the governor. It should be a 40 micron filter with a minimum capacity of 2 G.P.M.

Free discharge of oil from the governor pilot valve must be assured by provision of adequate (1/4" diameter or equivalent in multiple holes) drain holes from the drive coupling. No back pressure can be tolerated. Also, the drain passages from the governor ballhead cavity must be free in the engine adapter housing.

The governor may be mounted with the drive shaft horizontal if desired but the control and terminal shafts must also be horizontal and the servo side down in this case. If the horizontal mounting is used a 1/4" pipe tapped hole must be provided in the low end of the governor cover and connected to the engine sump or to the separate governor sump.

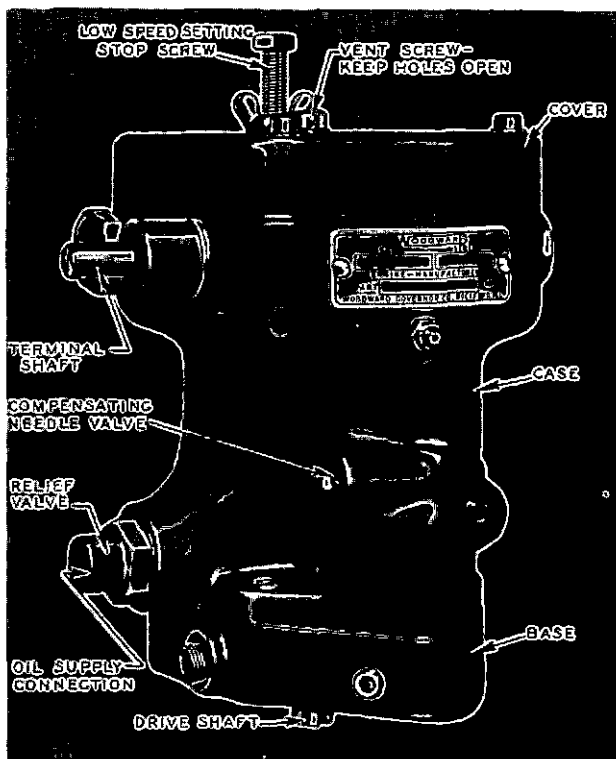
Regular engine lubricating oil is usually satisfactory for the governor. Special conditions such as low temperature starting in an installation using a separate sump may require use of a lower viscosity than engine lubricating oil.

**Speed Droop**

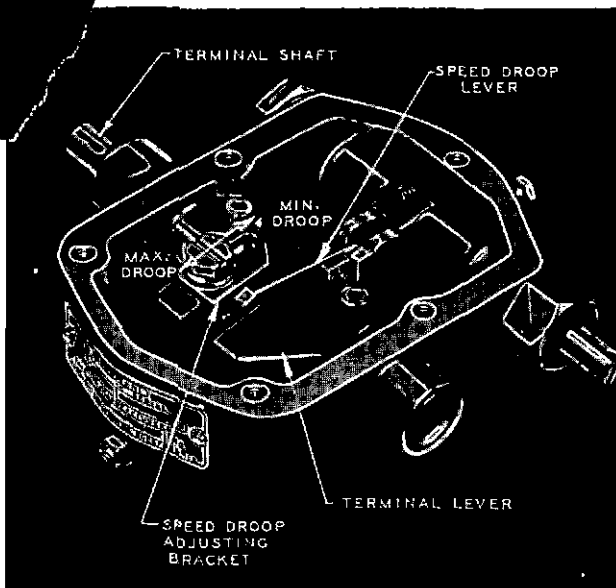
Speed droop adjustable (internally) between zero and seven percent is provided. Speed droop may be used to permit load division between two or more engines operating in parallel on an alternating current system or connected to a single shaft. If the engine is operated alone or on a DC system with proper generator compounding, the governor may be set for zero droop (isochronous operation).

A.C. generating units tied in with other units should have droop set sufficiently high to prevent interchange of load between units. If one unit in the plant or system, has enough capacity, its governor may be set on zero droop and it will regulate the frequency of the entire system. This unit will take all load changes within the limits of its capacity and will control frequency if its capacity is not exceeded.

The system frequency is adjusted by changing the speed setting of the governor having zero droop. The distribution of load between units is accomplished by changing the speed setting of the governors having speed droop.



**WOODWARD PSG GOVERNOR  
EXTERNAL VIEW**



PSG GOVERNOR, COVER REMOVED

#### Installation Adjustment

Start the engine as instructed by the engine manufacturer. Position the speed adjusting shaft for desired running speed and allow the engine to warm up. Open the compensating needle valve two or three turns and allow the engine to hunt or surge for about one-half minute to bleed trapped air from the governor oil passages. Gradually close the needle valve until hunting just stops. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change. Test action by manually disturbing engine speed. Engine should return promptly to original steady speed with only a small overshoot.

#### Speed Adjustment

Several different means for speed adjustment may be supplied with this governor. A speed control shaft is attached to the speed adjusting lever through a serrated connection. The outer end of this lever forms a pivot point for the speed droop lever, the purpose of which will be explained later. Rotation of the control shaft and speed adjusting lever will raise or lower the end of the speed droop lever and change the compression of the speeder spring. Extreme limits of travel, and therefore maximum and minimum speed settings, are established by adjustment of the stop screws in the governor body and cover. The high speed stop is the horizontal screw in the body and the low speed stop is the vertical screw in the cover. Rotation of the control shaft in the low speed direction beyond minimum rpm will shut the engine down by positively raising the pilot valve plunger through the

speeder spring, which is attached rigidly to the upper and lower seats.

For local manual speed adjustment, the governor is sometimes furnished with a stub speed control shaft and adjustment is made through the low speed stop screw.

Synchronizing motor speed adjustment is supplied as a special auxiliary. This motor is a split field universal motor which drives the speed adjusting shaft through a worm and gear with a friction clutch to protect the motor if the adjustment is run against the stops.

#### Speed Droop Adjustment

The governor with the top cover removed to expose the speed droop mechanism and adjustments. The speed droop bracket is clamped to the terminal lever by the slotted hexagonal head screw. When loosened, it can be moved radially to the terminal shaft. The bracket carries a pivot pin for the speed droop lever and this pin can be adjusted from a position on the terminal shaft centerline to a location and a radius of about one-half inch. When the pin is at the shaft center rotation produces no vertical movement of the pin and therefore no movement of the speed droop lever. As the pin is moved out away from the shaft center, rotation produces movement of the end of the speed droop lever which is pivoted on the speed droop pin. This speed droop lever movement thus produces a speed setting which is a function of terminal shaft position with speed decreasing as fuel flow increases. This is speed droop.

Speed droop is increased by moving the bracket outward and is reduced to zero when the pivot pin is at the shaft center. Since there is no calibration for the droop adjustment the zero droop position may be set only by trial and error on the engine or by use of a dial indicator on the speed droop lever during manual rotation of the terminal shaft. If speed droop is required, it must be set by operation on the engine, readjusting the slides to obtain the desired speed droop between full load and no load.

#### MURPHY SAFETY SWITCH

Many engines in this series will be equipped either in the field or at the factory with Murphy safety shut-down switches. The adjustment and operation of the Murphy type switch is easily understood since an emergency shut-down will occur if either the oil pressure or water temperature gage needle moves into the dangerous range far enough to make electrical contact with an adjustable ground connection pin.

Therefore, the indicator needles on both oil and water gages serve as movable elements in a switch. The operation of the shut-down feature thus becomes perfectly visible to the operator.

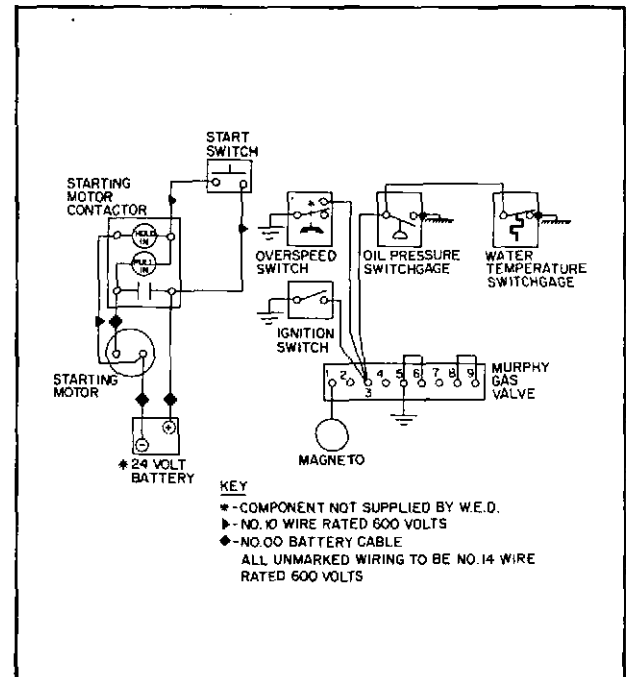
To adjust the precise value of temperature or pressure where grounding of the magneto primary circuit will stop the engine, loosen the small check nuts on the fixed contact and turn the contact screw in or out to shift the cut-off point to a higher or lower range.

The function of the Re-set buttons should be recognized before attempting to start the engine. Clearly, since the oil-pressure shut-down contact cuts the ignition whenever the oil pressure is too low, it will also cut it when no pressure at all exists, as while starting the engine. Hence, this shut-down feature must be made temporarily inoperative. This is done by the Re-set button which pushes the indicator needle back away from the contact. Unless some provision were made to hold the needle here, the operator would be required to maintain pressure on the button until the engine started, but in most switches a small automatic latch retains the needle. After starting, the normal running oil pressure moves the needle farther across the dial and disengages the automatic latch. The instrument will then stop the engine if the oil pressure drops too low (usually 10 to 20 Lbs.) or if the water temperature goes too high (usually about 205° F.).

#### ELECTRICAL SYSTEM POLARITY

The Waukesha Engine Division has for some time now, supplied new engines with negatively-grounded electrical equipment only. This standardization of electrical system polarity is standard practice for most equipment manufacturers and thus increases compatibility between Waukesha supplied electrical equipment and that supplied by the equipment builder. There are instances, however, when it will be necessary to supply positive-ground electrical equipment to adapt to other equipment related to the engine.

Therefore, servicemen engaged in the installation and trouble shooting of electrical equipment must be aware of the importance of correct polarity to avoid damage to the system. In most cases damage to the voltage regulator and rapid battery discharge will result from incorrect polarity. Voltage regulators are marked to indicate their installation with a negative or positive ground battery. A typical Delco-Remy polarity marking is 24VP which indicates 24 volts and a positive ground, while 6VN would indicate 6 volts and a negative ground. The regulator



ENGINE WIRING DIAGRAM (TYPICAL)

polarity is indicated either on the regulator base along with the Delco-Remy part number, or on a tape which has been affixed at the Waukesha Motor Company.

Since it is the voltage regulator, for the most part, that dictates the polarity of an electrical system it is possible to change the polarity of a system by replacing the regulator and rewiring to the other components. In most cases the engine electrical equipment will include only a starter, generator, voltage regulator, ignition coil, distributor, and possibly an electric overspeed shutdown, fuel shutoff, and a choke. If a replacement regulator of the correct polarity is not available it is possible to change the polarity of the system by reversing the leads at the battery and coil, substituting a regulator with one of the opposite polarity and repolarizing the generator. Remember that the ignition coil lead wire to the distributor must correspond to the ground polarity of the battery. For a negative ground battery connect the distributor wire to the negative terminal of the coil.

When engines are equipped with the Waukesha Engomatic Control System, however, it is imperative to follow the polarity of the unit as marked on the panel. When a polarity change is required on an Engomatic Control System consult the Waukesha Engine Division.

### CHECKING DELCO-REMY GENERATOR POLARITY ON WAUKESHA ENGINES

The Waukesha Engine Division has received frequent inquiries about how to polarize a generator properly after it has been repaired or tested. If the generator is not properly polarized serious damage will result.

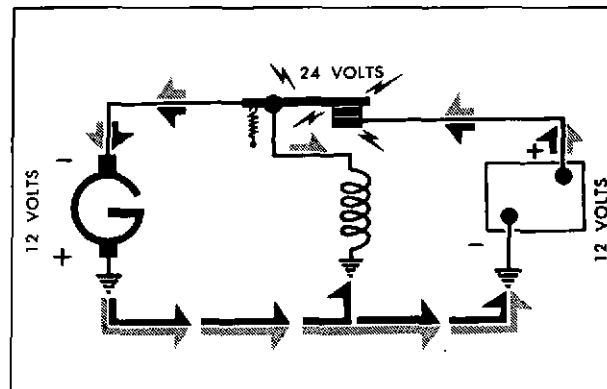
The Delco-Remy Company covers this matter in their Training Chart Manual DR-5133E. The following information is taken from that manual. An "A" circuit may be considered a heavy duty circuit and a "B" circuit as a standard circuit.

#### Generator Polarity

The magnetism of the pole pieces is determined by the field coil's current and its direction of flow. The residual magnetism and the polarity of each pole will remain the same as induced from the magnetism of its field coil the last time current was passed through it. Generators, therefore, will build up voltage that will cause current to flow in either direction depending upon residual magnetism in the poles. When working on electrical units, and when "ringing out" circuits with a small battery and bell, it is possible for current to accidentally flow through the field coils in the wrong direction and the generator will become improperly polarized with respect to the battery in the vehicle. An instantaneous flash is all that is required to create a reverse polarity of the generator.

After a generator has been repaired and installed on a vehicle, or at any time after a generator has been tested, it must be polarized. This is to make sure that it has correct polarity to develop voltage that will cause current to flow in the proper direction to the battery it is to charge. Failure to polarize the generator in agreement with the battery on the vehicle may result in burned cut-out relay points, a run-down battery, and possible serious damage to the generator itself. If the direction of current flow from the generator to the battery is correct, the battery will be charged. However, if the direction of current flow from the generator to the battery is wrong, voltages of the battery and generator will be added together to give approximately double voltage across the contact points of the cut-out relay.

What can happen when the generator is of the opposite polarity from that of the battery is shown in the illustration. Plus and minus symbols are used to indicate the direction of current flow. It is assumed that current will flow from plus to minus.



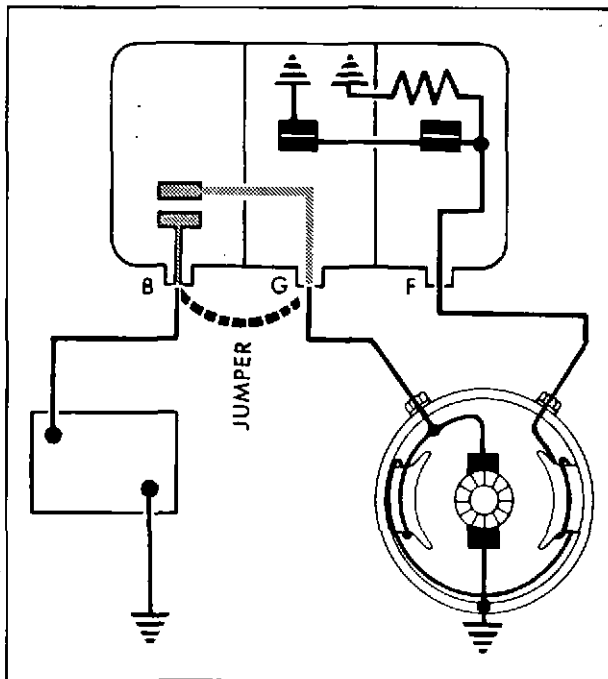
OPPOSITE POLARITY DIAGRAM

As the generator builds up in voltage, current will flow in the operating coil of the cut-out relay causing the contact points of the relay to close, completing the circuit between the battery and generator. The battery and generator are now connected together in series and their respective voltages are added together. Approximately double system voltage is now obtained across the contact points and extremely high currents will result from the high voltage short circuited in the battery and generator circuit. This high current produces heat that can weld the contact points together instantly.

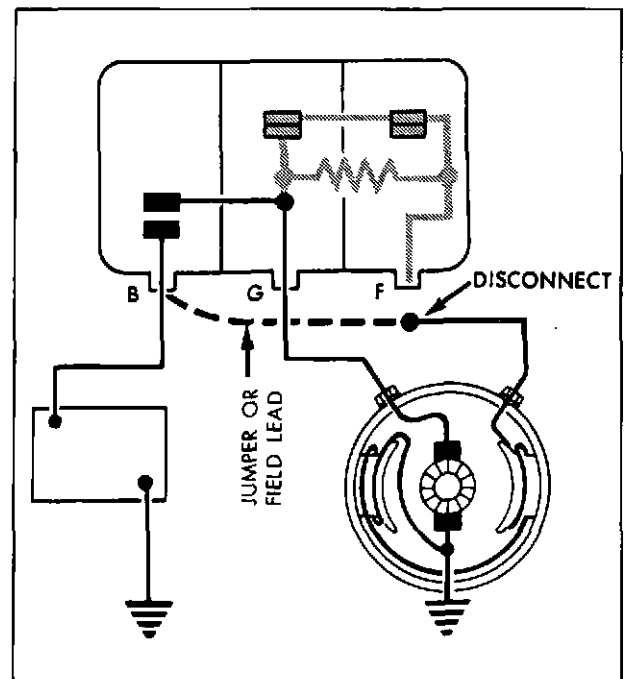
However, as the illustration shows, at the instant the points of the relay close, there is battery voltage on the insulated side of the operating coil of the cut-out relay and generator voltage (which will be approximately the same as battery voltage) on the ground side of the operating coil. Since there is little or no difference in voltage between the ends of the coil, the current flow in the coil is insufficient to hold the points of the relay closed and spring pressure may open them.

Generator voltage will again close the points and the action is repeated. The points of the relay thus open and close very rapidly with voltage and current present. Eventually heat and arcing from the high current and voltage will cause the points to actually weld together.

Relay points welded together allow the battery and generator to be connected together at all times. Since resistance of the generator is low, the battery has a very low resistance path back to the battery and large discharge current will flow from the battery through the generator and back to the battery. This, in a short time, completely discharges the battery and the large current may develop enough heat to burn the armature of the generator and render it inoperative for future use.



POLARIZATION OF "A" CIRCUIT GENERATORS



POLARIZATION OF "B" CIRCUIT GENERATORS

The importance, therefore, of polarity cannot be stressed too highly. Lack of understanding generator polarity and its relationship to the vehicle battery has been responsible for many unnecessary electrical failures in the cut-out relay, battery and generator.

The procedure to follow in correcting generator polarity depends upon the generator regulator wiring circuits - that is, whether the generator field is internally grounded or is grounded through the regulator. Procedures for polarizing "A" and "B" type circuit generators differ.

**Polarization of "A" Circuit Generators**

Generators using an "A" circuit are polarized by connecting a jumper lead from the insulated or "hot" side of the battery to the armature or "A" terminal of the generator. The battery, generator and regulator grounds must be connected. On the vehicle this is done through the frame. This causes current to flow in the normal direction through the field coils which will correctly polarize the generator's pole shoes. A touch of the jumper lead is all that is required and a flash or arc will be noted when the lead is removed.

Insulating the brushes is recommended with all 24 or 32 volt generators of circuit "A" construction during polarizing. If the brushes are

not insulated, low resistance of the generator armature will cause an extremely high discharge current through the armature when the jumper lead is connected between the battery and generator terminal. This can result in a badly burned armature. With the brushes insulated, only field current will flow.

An easily accessible place to polarize the generator when it is located on a vehicle is at the regulator. A short jumper lead between the battery and armature terminals of the regulator is all that is required.

**Polarization of "B" Circuit Generators**

Generators designed for a "B" circuit are polarized by disconnecting the field lead from the regulator and momentarily flashing this lead to the battery terminal of the regulator. Battery and generator ground circuits must be connected together. Current will flow through the field coils in the proper direction to correctly polarize the generator's pole pieces. A touch of the field lead is all that is required and a flash or arc will be noted when the lead is removed.

It is important to remove the field lead from the regulator. Failure to do so will result in burned regulator points if a jumper lead is used between the battery and field terminals of the regulator. A very low resistance circuit from the

battery through the points to the generator armature to ground and back to the battery would carry high current if the connection were not broken.

The importance of generator polarity cannot be stressed too greatly. For proper polarization, the rule should be to pass current through the field coils in a direction that will have the ground side of the coils connected to the ground side of the vehicle battery.

#### ENGINE STORAGE

Preservation of engines in storage involves several basic requirements. For a completely new engine, these are as follows:

1. Protection of machined metal surfaces from the effects of both dampness and salt or other corrosive substances in the atmosphere.
2. Protection of openings into the engine against foreign matter of all types.
3. Protection of accessory equipment and fan belts against corrosion, dirt, moisture saturation and deterioration.
4. Protection of cooling system against freezing, rusting or seizure of water pump seals.
5. Protection of a general nature against the elements, rain, snow, extremes of temperature, improper stacking and piling and objects that might scratch or batter the exterior, especially the radiator cores.

In the case of engines previously operated, several additional items must be considered.

6. Protection of interior engine parts from corrosion by the products of combustion combined with atmospheric moisture and corrosion by lubricating oil contaminants.
7. Protection of fuel system units against gumming and the effects of stale gasoline, oil and gas residues.

The extent of the attention given to each of the foregoing points of possible damage, depends on the judgment of the person in charge of the engine. Generally speaking, the following factors should be taken into account before deciding how much preservation is required.

1. The period of time the engine is likely to be inoperative.
2. The severity of the weather and atmospheric conditions at the point of storage. The problems of storing an engine in a tidewater warehouse, for example, differ greatly from storage problems in a location where the air is dry and dusty.

3. The accessibility of the engine for periodic inspection and attention. An engine on a show-room floor that may be turned over occasionally and given periodic oiling requires less extensive treatment than engines crated and stocked in a warehouse.

#### NUCLE-OIL STORAGE (Recommended Procedure)

Nucle-Oil storage procedures based on volatile-corrosion-inhibiting chemicals are factory recommended for reasons of lower cost, convenience, and greater reliability. The primary advantages are avoidance of large and expensive quantities of special oil, freedom from the need to change the oil again when going back into service, and a simplified application technique without any requirement to actually coat the engine internal surfaces with oil. Nucle-Oil is offered in one gallon cans under Part No. 166709A.

Applied in the required amounts and in the proper way, Nucle-Oil will offer above average protection of engines stored for over one year.

#### WARNING

Nucle-Oil contains Petroleum Distillate. Harmful or fatal if swallowed. Avoid contact with skin. Vapor is harmful. Causes irritation of eyes, nose, throat and skin. Use only with adequate ventilation. Avoid prolonged or repeated breathing of vapor. Avoid contact with skin, eyes, and clothing. Do not take internally. Keep container closed and away from heat. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes; for eyes, get medical attention. Remove and wash clothing before reuse. If affected by exposure, move to fresh air. If swallowed, do not induce vomiting. Remove ingested material by gastric lavage with 2 to 4 quarts or liters of tap water or milk. Follow with fruit juice or vinegar to neutralize the alkali.

The following procedure for preservation with Nucle-Oil is suggested:

1. Start with a cold engine (below 100°F) containing clean oil and filter elements.
2. Add 21 oz. of Nucle-Oil to the crankcase and 2 oz. to the oil bath air filter.
3. Crank engine for 20 seconds, if possible.
4. Add 1-1/2 oz. of Nucle-Oil to each cylinder through the plug openings and replace plugs. Apply to rocker arm area by light brushing or pouring. Replace the rocker covers.

5. Store engine up to one year. If storing for more than one year, inspect and re-serve annually, as necessary.

For more complete information on the use of Nucle-Oil, refer to Service Bulletin #16-1855B.

### CONVENTIONAL STORAGE

Engines recently received from the factory and not intended to be used for an indefinite period may be stored successfully in the following manner. As mentioned above, circumstances may compel omitting some steps and, on the other hand, special conditions may point to greater emphasis on other steps.

### CAUTION

All F1197G engines shipped by Waukesha Engine Division receive storage measures internally which prepare the engine for a storage period of up to 6 months, unless they are test run, operated for any reason, or have the external openings unsealed. Engines stored outdoors or in a humid environment may require more frequent representation.

1. When engine is operable.

- A. Mix an inhibitive type preservative oil with the engine lubricating oil in the proportions recommended by the manufacturer of the preservative oil, or, no mixing may be necessary. Operate engine until oil is thoroughly hot. Cooling water used in this run should have two to three per cent soluble oil added.
- B. Remove air cleaner. With manually operated sprayer, squirt can, or other means, inject preservative oil of a type suited for this purpose into the air intake while the engine is running. Approximately one minute is ordinarily adequate. If possible, stop engine by "slugging" enough oil through intake to stall. Continue injecting oil until engine stops turning.
- C. Drain oil and water while hot. If extra protection is desired the rocker arm covers may be removed and a quantity of preservative oil poured over the rocker arm and valve mechanism.
- D. Remove spark plugs and squirt or spray several teaspoons of preservative oil into each combustion chamber. Coat plug threads with oil and reinstall plugs.
- E. Drain carburetor and fuel pump of gasoline if practicable. Be sure to re-

move water from butane vaporizer if freezing is likely.

- F. Remove distributor cap or magneto covers and apply small amount of petroleum jelly to polished surface of breaker cam. Where dampness in storage is expected, removal of magnetos may be worthwhile.
- G. Wipe engine clean and dry. Apply wax type masking tape or like material to all openings such as intake openings in air cleaner, exhaust outlets, breathers, magneto vents and open line fittings.
- H. Relieve tension on fan belts and generator drive belts. This is important because continual tension on these parts without the working action that occurs in normal operation causes deterioration of the rubber.
- I. Apply a coating of heavy preservative compound with brush to all exposed machined surfaces such as flywheels, clutch shafts and like areas.

Engines treated in accordance with these instructions will normally be protected for six months or longer. Continual inspection, however, is the only way to determine if protection is adequate. If possible, crank the engine by hand for one or two turns about once a month. This helps prevent seizure of water pump seals. If this is done, however, it is usually best to add more preservative oil to each cylinder. Some types of preservative oil are not well suited to periodic engine rotation because they are scraped from the cylinder walls which are then unprotected. Other oils are not scraped away. Therefore, the operator should carefully investigate the characteristics of the oil used.

2. When engine is not operable.

- A. Open drains in oil pan, radiator, carburetor, butane vaporizer and fuel pump to remove oil, water and fuel.
- B. Remove spark plugs and pour or squirt about a teaspoon of preservative oil into each cylinder.
- C. With hand or mechanically operated atomizing spray (do not use ordinary compressed air) inject preservative oil into each cylinder. Crank engine in normal direction about one-quarter turn and spray each cylinder again. Do this about eight times, or until engine has been turned through two complete revolutions. The purpose of this procedure is to bring each valve into an exposed position so the preservative oil will coat it.

- D. Depending on the judgment of the operator as to the severity of storage conditions, open as many points as possible. . . . oil panplug, valve rocker covers, tappet chamber cover, front gear cover and so on, where oil may be sprayed, poured or squirted over the interior parts. Replace all plugs and covers.
- E. Remaining steps may be the same as listed in "F" through "I" for an operable engine.

**Storing Engines That Have Been in Use**

In the course of normal engine operation residues of various combustion products such as lead and sulfur accumulate in the combustion area and in the lubricating oil. Portions of these residues combine with atmospheric moisture to form corrosive compounds of a destructive nature. Butane engines are probably less subject to this than others. The following treatment will help reduce damage from this source.

1. Engine in operable condition.
  - A. Run engine until original oil is thoroughly hot. Drain.
  - B. If practical, run engine with a good flushing oil in crankcase and drain while hot.
  - C. Refill crankcase with preservative oil, or with the proper grade of lube oil to which an inhibitive type preservative oil has been added in the proportion recommended.
  - D. Carry out previous instructions "B" through "I" as the circumstances indicate.
2. When engine is not operable.
  - A. Carry out instructions as for an inoperable new engine.
  - B. If in the judgment of the operator, storage conditions and the time period likely warrant it, the engine should be disassembled, thoroughly cleaned and reassembled for treatment as a new engine. Ordinarily, this last procedure is unnecessary except in cases where fuels contain considerable sulfur, or where extremely bad climatic conditions prevail.

**PRESERVATION EQUIPMENT AND MATERIALS**

**Sprays and Atomizers**

In the foregoing instructions it is recognized that many times it is necessary to apply protective compound under difficult field conditions. Several simple tools may be used to atomize

preservative oil and force it into the manifolds and combustion chambers. One of these is a manually operated gun used ordinarily to lubricate inaccessible points on car and truck chassis. Another is a hand operated pump type sprayer with a pointed discharge nozzle commonly used with insecticides. If desired, small oil pumps may be rigged with a motor drive to make a convenient spray unit of the mechanical pressure type. In almost all cases, the air available from shop compressor line carries too much moisture to be safe for this purpose. Do not use high-pressure air from this source.

**Heating Compounds**

Many preservative compounds are most effective when heated before application. Heating reduces their viscosity so as to gain penetration into inaccessible areas. In addition, the hot compound reduces the moisture film at the metal surface and thus avoids trapping moisture under the preservative layer.

Generally speaking, such heating is confined to 200° F., or less. These temperatures are easily reached by placing the preservative container in heated water. Direct heating presents a dangerous and unnecessary fire hazard.

Specifications for Protective Materials	
Internal Surfaces, Cyls., Etc.	External Surfaces
U. S. Army Spec. 2-126 (Available as SAE 10 or SAE 30)	U.S. Army Spec. 2-121 (Waxy Coating) Army Ordinance Spec. AXS 673 (Harder black coating)
Nucle-Oil #120 Mil. Spec. MIL-L-4600Z Grade 1	

**PREPARING ENGINE FOR OPERATION**

These steps needed to bring an engine into active service after storage in accordance with those instructions are about the same as those normally carried out on any new engine. These are inspection, checking for free rotation, adequate cooling water or anti-freeze, ample oil of the correct grade and proper adjustments. In addition, accumulated dust and dirt should be wiped or washed from the exterior before removing the covers over the engine openings. Engines that have not been rotated for some time should be oiled through the spark plug openings and cranked by hand or with the starter before actually running. Any resistance to free cranking should be investigated; rust and corrosion can cause severe seizure that cannot be forced clear without engine damage.

## OVERHAUL AND MECHANICAL ADJUSTMENT

### GENERAL

The overhaul and adjustment of the WAK Series engines, like any other mechanical operation on precision machinery is best accomplished by experienced personnel using equipment built for accurate work. On the other hand, assembly and disassembly present no unusual features requiring special tools or techniques. For this reason, no effort has been made to detail in this manual the steps that are self evident or well established mechanical practices. In those instances where a considerable number of these engines are being overhauled, the Waukesha Engine Division will be glad to make suggestions on permanent type tooling such as pullers, jigs, and other fixtures.

All major parts in the Waukesha Model 6-WAK engine are replaceable as units in the field without special tools or equipment. Main and connecting rod bearings are of the precision type and require no special fitting procedures beyond routine inspection of the crank journal and pins for roundness and condition. Cylinder sleeves are easily removed with conventional pullers. For best results install new pistons of a letter size mating with the letter size of the new sleeve. Order "A" size pistons for "A" size sleeves, "B" size pistons for "B" size sleeves, and so on. Each progressive letter size of piston and sleeve is approximately 0.0005" (one-half thousandth) larger. Current engine pistons and sleeves are of only one size range.

Piston pins should also be ordered in matched sets. Otherwise, when possible match the color marks on the underside of the new pistons. White pins in White painted pistons, Red pins in Red pistons, and Blue pins in Blue pistons. The differences here are in 0.0001" (one tenth of a thousandth) graduations, although the deciding factor should always be a piston fit that permits an easy hand push to insert the pin.

Water pumps should either be replaced as a unit or re-built using the Waukesha Motor Company Repair Kits which include the parts necessary to replace those parts which are subject to wear and to the corrosive action of engine coolants.

There are a number of good practices that should be followed in overhauling any engine, some of these are listed below.

### Do Not Mix or Confuse Engine Parts

Mark for position on disassembly; tag assemblies from different engines; stamp or otherwise identify parts reground to special sizes.

### Do Not Mix Bolts, Capscrews and Washers

Capscrews and like parts are of a length, material, and heat-treatment suited to the place they are used. Numerous instances have been reported where too long or too short a capscrew has resulted in leakage or interference with internal parts. Washers of various materials and types are selected according to application. Standard soft steel washers, for example, when used to retain a bearing cap are known to have caused complete engine failures. Hardened washers are used at that particular point.

### Inspect as Engine is Disassembled

Once engine parts have been disassembled and cleaned, many valuable indications of engine condition are lost. Materials found in the oil or on burned or carboned surfaces at disassembly often point to operating, service, or maintenance improvements of genuine value to the operator.

### Protect Delicate Parts and Surfaces

Do not pile engine parts, ignition equipment, carburetors, and bearings, indiscriminately. Oil surfaces likely to rust. Tape surfaces subject to scratching or nicking during repair operations. Plug off passages likely to accumulate dust, abrasives, and machining chips. Some heavy-duty detergents and cleaning compounds will etch or corrode bearing materials and bushings. Test any cleaner before using it on good parts.

### Clean Thoroughly

No engine is completely overhauled if it is not cleaned internally and externally to "new part" condition. Dirty parts can not be inspected nor fitted; neither do they conduct heat properly nor allow top engine performance. Modern chemical cleaners easily remove all engine grime; but don't forget to remove the cleaners from oil passages and casting pockets when the job is completed.

**Work Accurately**

Use precision gages where needed; follow tables of limits and tightening torque values for best performance.

**INSPECT COMPLETELY**

Magnetic inspection of crankshaft, connecting rods, valves, and other critical parts is highly recommended. Inspect each part, piece by piece, for wear, evidence of damage, and indications that might point to improvement of operating technique or service procedures.

**DISASSEMBLY****Vibration Dampner and Fan Pulley**

The vibration dampner is easily removed by taking out the cap-screws holding it to the fan pulley. To remove the fan pulley from the crankshaft it is necessary to remove the fan pulley nut and employ a three-jaw puller of suitable size since the pulley is pressed on the shaft. The pulley nut may be replaced on the crankshaft if desired for turning the crankshaft during later operations.

**CAUTION:** Lock the crankshaft forward to prevent end thrust shims from dropping causing improper end play when installing pulley.

When replacing the fan pulley, it will be found practical to make up an installing tool capable of sliding over the shaft and driving squarely against the pulley hub. The installation will be much easier, particularly on the high-output models if the pulley is heated to approximately 400-500° F.

**Gear Cover**

Remove the capscrews securing the gear cover to the crankcase and oil pan. The crankshaft fan pulley key must be removed and any incidental burrs honed from the shaft before sliding the cover oil seal over it. Ordinarily the oil seal may be left in place and used again.

**Flywheel**

Before loosening the flywheel retaining screws, make up a "dogleg" hoist eye to support the weight and permit swinging the wheel out without canting. Take up some of the weight on the hoist, remove the capscrews, and using suitable threaded pullers if necessary, pull the wheel free and swing it out of the housing. It is recommended that new bolts be used whenever a flywheel is re-installed.

**Water Pump**

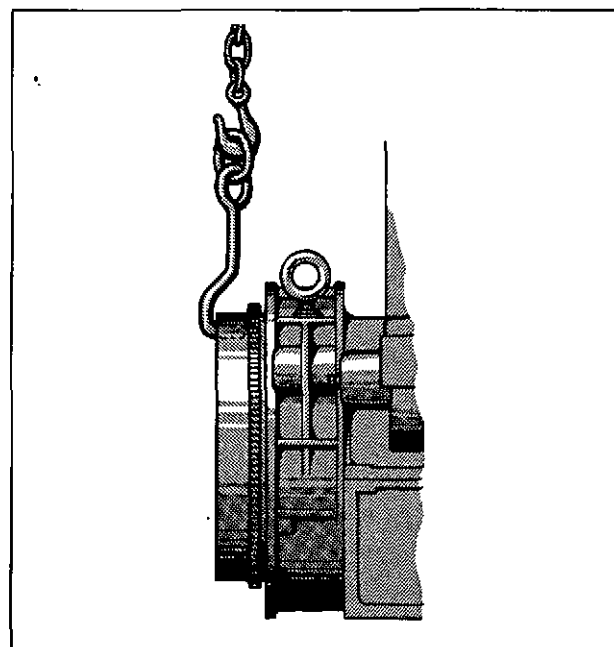
The water pump is removed as a unit after removal of the six through bolts extending through the gear housing. It is not necessary to disturb the bolts holding the two halves of the pump together. Neither, is it necessary to remove the inspection plate in the gear housing cover.

**Pistons**

Before attempting to lift the pistons from the sleeves, prepare a suitable arrangement to permit the use of an overhead hoist. After the pistons and connecting rods have been lifted free, be careful to avoid swinging the rod too far from side to side. If this precaution is not observed, the small oil jet tube projecting from the top end of the rod may be bent, broken, or cracked against the sides of the piston slot.

**Cylinder Sleeves**

When the cylinder heads have been removed, the only thing that prevents the sleeves from being lifted out freely is the sticking action of the rubber seal rings. Often, considerable force is required to break loose the seal rings and a screw-jack or hydraulic puller is recommended. Attempts to drive the sleeves out from the lower ends, forcing them with blocks against the crankshaft, and other unworkmanlike methods will usually damage the engine in some respect.



FLYWHEEL LIFT HOOK

### Cylinder Heads

Both front and rear cylinder heads, including the intake and exhaust manifolds may be removed as a unit if desired. First, loosen the hose connection at the upper end of the water by-pass line. Remove the crown nuts retaining the water manifold and lift off the manifold. Loosen the rocker arm oil lines and remove the rocker arm support bracket retaining nuts so the rocker arm assemblies and push rods may be lifted free.

The cylinder head hold-down nuts will now be accessible.

When the cylinder heads are replaced after the intake manifold has been removed for any reason, it is important to carry out the steps below in the order given.

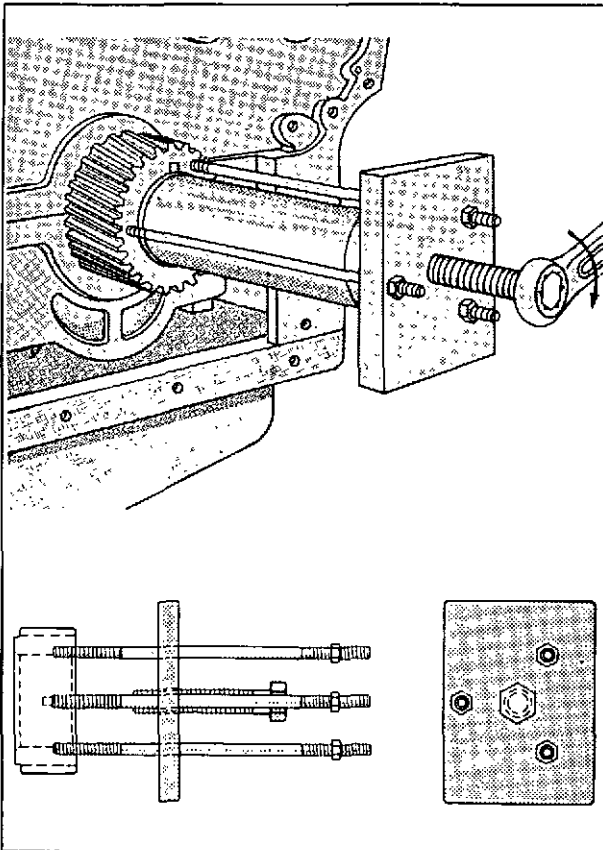
1. Place the heads in position and run down three or four retaining nuts just enough to pull the heads squarely in place against their gaskets. Do not overtighten.
2. Install the intake manifold and tighten all nuts evenly.

3. Torque down the head nuts to the values specified in the table at the back of this manual. Always tighten evenly, starting at the center of the head and working outward.
4. Install the exhaust manifold, rocker arms and push rods, oil lines, and water manifold.

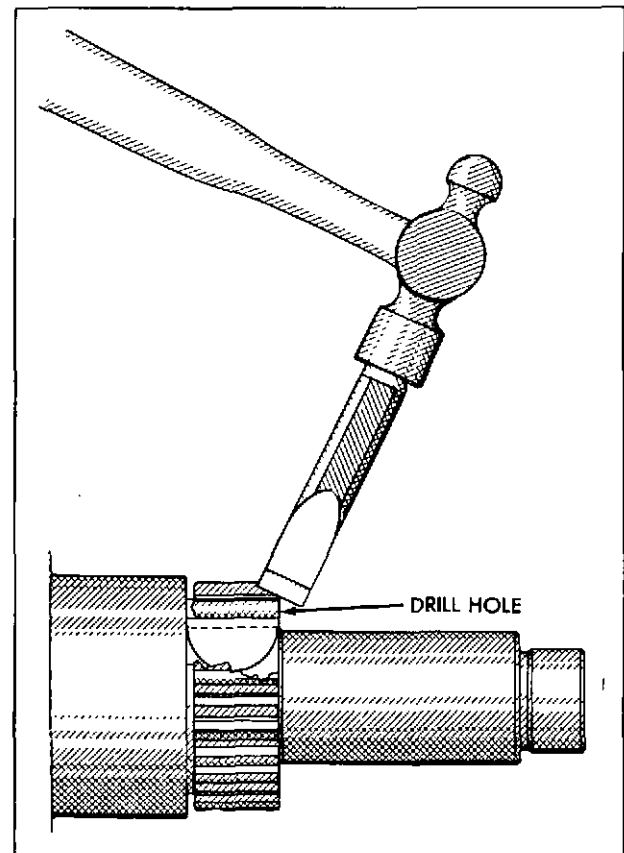
The point to note about the above procedure is that the heads are left partly loose when installing the intake manifold. Thus, they are free to move slightly and square up with the manifold mounting flanges. If the heads are pulled down first, tightening the intake manifold nuts may put a strain on the manifold that will cause cracking or leaking in service.

### Crankshaft Gear

In those instances where replacement of the crankshaft gear is necessary, it is easiest to remove the gear with a puller as shown in the accompanying illustration. If such a puller is not available, or if the gear has no puller holes it is necessary to split the gear as shown. First



CRANKGEAR PULLER



REMOVING CRANKGEAR BY SPLITTING

drill a hole of approximately 1/4-inch diameter lengthwise of the gear and between the keyway and the teeth. Thus, a variation in drill direction will result in nothing more than damage to the replaceable key. After drilling, a light blow with a cold chisel will spread the gear a few thousandths and permit removal.

### CLEANING

Cleaning disassembled engine parts is a necessary part of overhaul practice for a number of reasons. First, of course, clean parts are much easier to work on accurately. Equally, important, is the exclusion of dirt from re-finished bearings and running surfaces on re-assembly.

Inspection is sometimes almost impossible until oil varnish, rust, or carbon have been removed, and, not often considered, the cooling of operating parts by the oil circulation depends on the oil coming in intimate contact with the hot metal. If dirt on the engine interior, or rust in the water cooling area, prevent intimate heat pick-up and impair oil or water circulation the engine will not perform properly regardless of its mechanical fitness.

Shop cleaning methods may be considered under three headings -- washing with steam, water or mild solvent; chemical loosening of insoluble deposits; and mechanical removal of material softened by the chemicals. Pre-disassembly washing is an example of the first class, as is de-greasing in unleaded gasoline, or mineral spirit solvent prior to chemical cleaning. Chemical cleaning includes stripping heavy grease, varnish, gum, paint, and so on from surfaces as well as softening carbon and rust.

Mechanical cleaning is usually resorted to when removing previously softened carbon from ring grooves, brushing out oil passages, and scraping gasket surfaces.

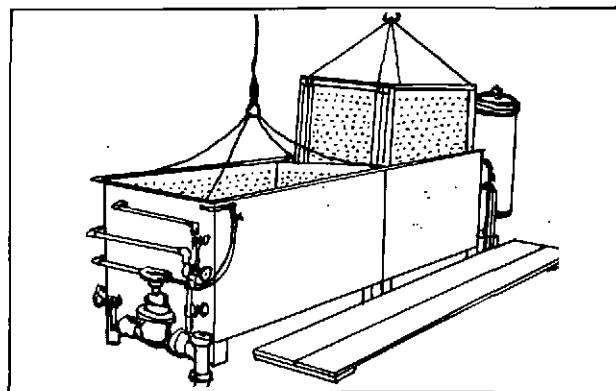
External washing should be a pre-disassembly step. Internal washing and external washing differ to a considerable degree. Thorough internal washing is very often an economy in that it prevents the contamination of expensive carbon softeners with ordinary oil and dirt. A number of wash baths of the tank type are available. Here, a water solution of commercial cleaner, often of the "tri-sodium-phosphate-sodium-metasilicate" type is heated and agitated in a large tank. A liftable basket is used for holding the parts. This type of tank may be heated by gas, steam, or electricity; usually it is held at a temperature of about 140°F. for alkaline base solution.

Agitation is accomplished by air, a circulating pump, or live steam. Immersion in the bath for normally dirty parts will usually run about an hour or more. Final rinsing is sometimes confined to simple drainage, but a better practice is to pressure rinse away all traces of cleaning solution with a hot water jet and follow up with an air jet for drying and removal of water from pockets and passages.

The importance of complete removal of cleaning solutions from parts is seldom realized. The commonly used alkaline or soap compound cleaners will sometimes remain in drilled passages or casting pockets in sufficient quantity to form a soap when combined with oil in the presence of combustion gas acids. The resultant oil foaming and impairment of lubrication will cause excessive wear and failure from this totally unsuspected source.

Engine parts cleaned to a chemically clean surface by efficient washing are immediately subject to rust. Polished surfaces such as crankshaft journals and piston pins should not be touched with the bare hands because of the corrosive characteristics of perspiration. To prevent damage of this nature, a light, non-gumming oil may be sprayed over parts to be used within a short time. Parts intended for long-term storage should be protected with one of the compounds especially made to form a relatively heavy and tough coating on the surface.

A final consideration to parts washing, where done on a continuous basis, is maintenance of the wash bath in an efficient condition. Infrequent removal of sludge, erratic addition of fresh chemicals to solutions, and promiscuous intermixing of different brands of chemicals will sooner or later cause trouble in the form of corrosion, lost time, and heat losses in the tank.



WASH TANK

### Chemical Cleaning

When the top coating of oil and sludge has been removed from many engine parts, considerable deposits of hard carbon, varnish, lead compounds, and so on will normally remain. In field service work, such materials may have to be removed by manual scraping or like methods, but these techniques in the overhaul shop are costly and certain to result in a percentage of damaged parts.

Depending on the job in hand, chemical cleaning equipment may range from the convenient bucket tank furnished with the solution by some manufacturers to steam-heated pressure tanks for production cleaning in a large overhaul shop.

Usually, the solutions used in heated tanks--open tanks run about 100°F.; pressure tanks about 270°F.--are faster than the so-called cold solutions. A pressure tank will soften hard piston carbon that is not touched by open tanks or cold solutions. Before using any solution on expensive parts, the operator should try its effect on various metals, separately and together. Numerous instances can be cited of effective cleaners that are unsuited for a particular job because they react with special metals used in bearing bushings, seals, and so on. Sometimes this effect appears to be chemical, at other times it can be traced to electrolytic action. For cleaning injectors, pistons, and like parts, a carbon solvent such as Cities Service Solvent #62 is suggested.

### Mechanical Cleaning

Immediately after removing the parts from the chemical bath, remove deposits as much as possible with a stiff bristle brush. In those instances where parts contain drilled oil passages remove plugs leading to these openings before cleaning and follow chemical cleaning with a thorough internal brushing.

Use brushes with long extension handles of the type used for cleaning guns. Be sure that all loosened material is completely rinsed and blown out of these passages.

Some parts, such as pistons and valves may still show some deposits after chemical cleaning and brushing.

Some specialized tools may be considered under the head of cleaning. Examples are reamers used to cut carbon from valve guides, and refinishing tools for cylinder sleeve bores.

### Selecting Cleaning Methods

Engine deposits should be considered as to source and nature before expending costly cleaning agents on them. An example is the familiar low-temperature engine sludge commonly found at overhaul. This sludge could, of course, be removed by a chemical cleaner. Such treatment, however, would soon render the chemical useless and would do no better job than a quick washing with a petroleum solvent under pressure, or a water solution. Remaining gum or varnish deposits could very likely be polished away without excessive effort. On the other hand, inspection might reveal very stubborn deposits in the oil passages within these parts which would make a follow-up with chemical cleaning necessary.

At other times the cylinder sleeves and crankcase are badly deposited with sludge. This sludge is the result of some engine or water pump lubricant entering the coolant, forming a gummy substance in combination with heat and possible anti-freeze, and finally a binding together of silt and rust particles with the gum. Silt particles came from impure water, plus rust from not using a small amount of inhibitor in the coolant. Here, the problem is one of forming a flushable solution of the sludge in the water passages. This can probably be done successfully with a hot tank solution. Very thorough agitation and copious flushing under pressure will remove most of this material.

Some other cooling system deposits are less readily removed. Cylinder blocks and water heated intake manifolds with lime deposits are sometimes found. Since these deposits are alkaline in nature, most washing solutions have little effect upon them. Some opening of such passages can be gained before disassembling the engine, by muriatic acid treatment. Attempts to remove deposits with acid while the engine is disassembled are very difficult because of the necessity for protecting running and mating surfaces against acid action.

Ball or roller bearings should never be thrown into a cleaning solution with other parts. Wash them in a small container of fresh, clean solution, examine for condition--grease or oil, and wrap in wax paper until ready for assembly. Small particles of grit are extremely damaging to these bearings. Ball bearings of the sealed or self-lubricated variety should receive no more than an external wiping with a clean cloth. Immersion in cleaning solutions is not recommended. When such bearings show need for internal cleaning because of roughness or sticking, they should be replaced.

## VALVES AND MECHANISM - REPAIR

Valves require grinding at various intervals during the engine service life. These intervals cannot be specified exactly because a host of variable factors enter the picture, often without the engine operator's knowledge. Of these factors, the following have been found to a greater or lesser degree to make for reduced valve life.

1. Fuels that break down to form deposits that impair seat contact and prevent heat conduction and valve cooling.
2. Deposits from either fuels or oils that accumulate on the valve stems and cause sticking and burning.
3. Oil not reaching rocker arms due to clogged lines or improper fittings.
4. Shutting down a hot engine without idling for a few minutes. Exhaust valves that happen to be off their seats when engine stops may warp so that burning occurs on restarting.
5. Tappet clearances not properly maintained so that at least 0.008 to 0.010 is available when running.
6. Lean mixtures due to improper carburetor or adjustment.
7. Pre-ignition due to wrong plugs, carbon deposits, excessive operating temperatures.

## Compression Checks

A compression check is the best method of determining whether valves need grinding. Since different pistons will develop different cranking compression pressures due to compression ratio variations, no specific figures are given for this test. The most significant thing is for the pressures on the individual cylinders to match with a fair degree of evenness. If it is felt that compression may be leaking past the piston rings, inject some heavy engine oil through the spark plug hole before making the test. This will seal the rings temporarily. In addition, a quick knowledge of valve condition may be gained by listening at the carburetor entrance (disconnect air cleaner) and the exhaust outlet while the engine is cranked over. Piston ring blow-by may be heard at the oil-filler opening as the pistons are slowly brought onto compression and the air allowed to seep past. If valves are leaking badly, the piston ring leakage may not be noticeable. Another indication of leaking valves is an unsteady vacuum reading, particularly at idle.

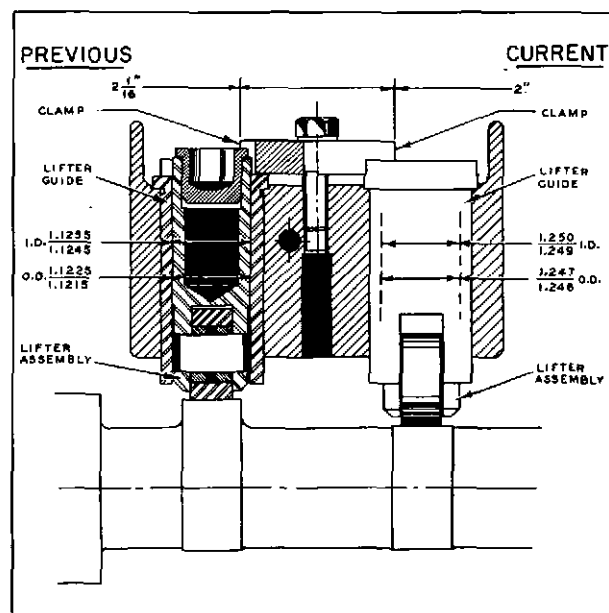
## Valve Mechanism

When the push rods have been withdrawn they should be tagged or otherwise marked so that each rod may be replaced in its own tappet. Examine each rod to make sure it is straight, and that both upper and lower ends are in good condition. Replace--do not straighten--any that are bent, and if there are any of the ball and socket fittings, pressed into the ends of the rods, that show signs of wear beyond the case hardening, replace these fittings also. Sockets at the rocker arm end must not be used if they are worn so deep that the upper edge rides the adjusting lock nut or the rocker arm at any point.

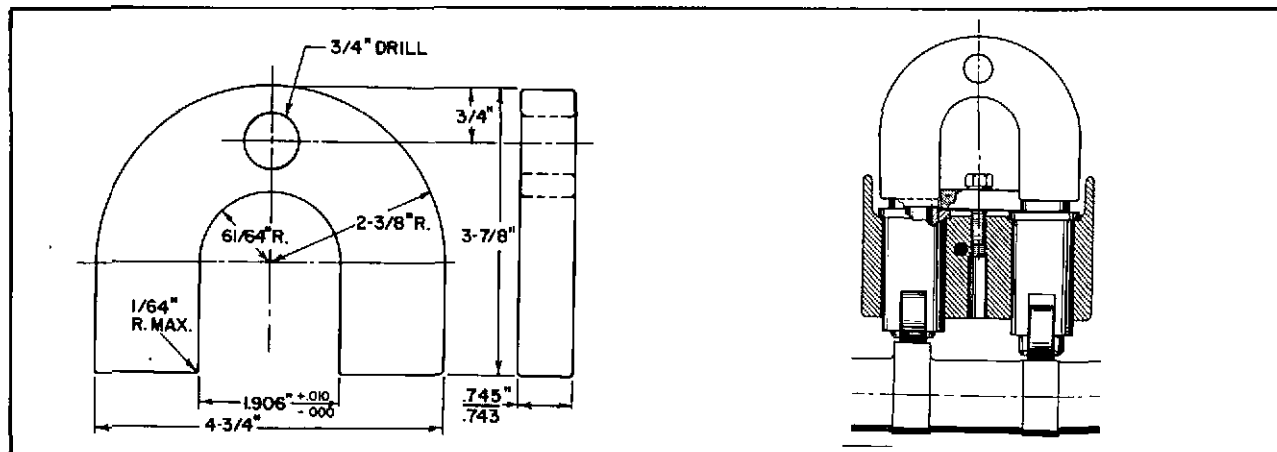
The end of each valve stem is fitted with a shallow steel retainer that accommodates the end of the valve spring, and is held to the stem by a pair of split tapers. The locking tapers must be removed before the valve can be withdrawn. To release the lock from the recess in the spring retainer, it is only necessary to push the retainer down against the spring until the tapers fall away from the valve stem. Weak or cocked springs should be discarded and new ones installed when reassembling. Free-type rotators are available for exhaust valves on commercial engines when required.

## VALVE LIFTERS

At overhaul periods Waukesha recommends a check of the roller type valve lifters for signs of wear. Wear could lead to improper lifter action.



LIFTER REPLACEMENT



VALVE LIFTER GUIDE ALIGNMENT TOOL (Part No. 494203)

The currently used valve lifters are interchangeable with the previously used valve lifters only in pairs along with new lifter guides and clamp. These improved valve lifters are larger in diameter (see illustration) and include a longer roller pin which is arc welded to the lifter body in four places.

A change has been made to improve cap screw tightening of the valve lifter guide clamp. The previously used cap screw, part no. 21360, and cap screw lock, part no. 167113, have been replaced with a Nyloc cap screw, part no. 28521. The new cap screw eliminates the need for the cap screw lock and the possibility of misalignment when crimping the lock tab.

#### CAUTION

Valve lifter misalignment will result in premature camshaft wear. To assure proper alignment of valve lifters Waukesha recommends the use of tool number 494203. This tool can be ordered from Waukesha or fabricated according to the above illustration. The tool can be made of cold rolled steel, and hardened if facilities are available.

To properly install the valve lifters and guides, proceed as follows:

1. Before installing the valve lifters, guides and clamps, carefully inspect the bore area and grind off any crankcase material that could interfere with valve lifter guide alignment. Excess metal can force the valve lifter guide out of alignment when tightening the valve lifter guide clamp screw.
2. Valve lifter guides must fit freely in the crankcase bores to obtain proper align-

ment. Rotate guides to check for proper fit. Discard any snug fitting guides.

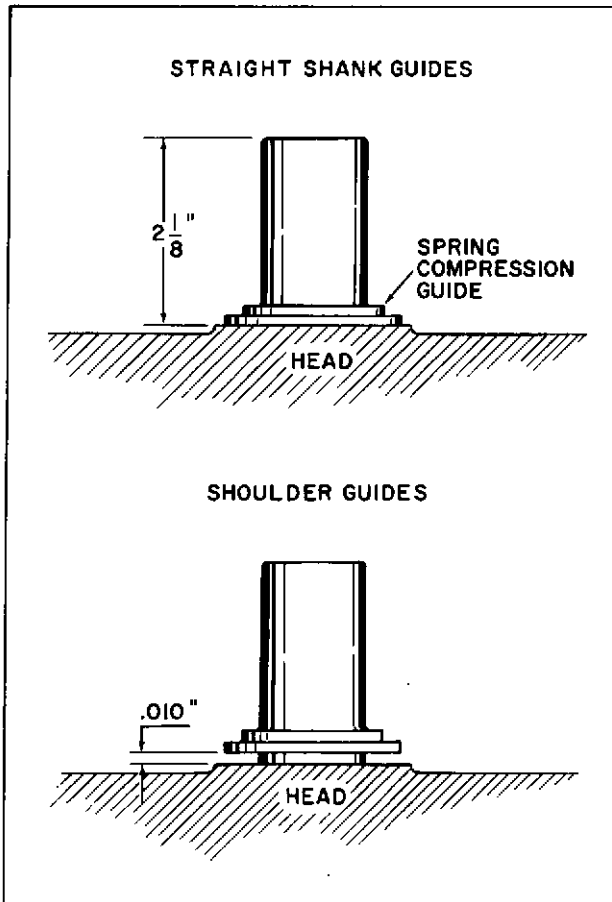
3. When tightening the valve lifter guide clamp screw be careful not to twist the valve guide clamp, misaligning the valve lifter guides (the alignment tool should prevent this).
4. When crimping the cap screw lock tab be careful not to jar the clamp and misalign the valve lifter guide. If possible, use the new Nyloc cap screw which does not require cap screw locks.

The torque is 26.5 ft.lbs. oiled for the Nyloc and previously used cap screws.

#### GUIDES AND SEATS

Upon removing each valve examine it carefully. Remove all carbon and burned oil and check the valve stem and its fit in the guide. Excessive wear in either the stem or guide will make it impossible to secure a tight seat by grinding unless the valve or guide, and possibly both, are replaced. Special notice of the exhaust valve guide and valve stem shoulder should be taken to make sure the guide does not project into the valve gas passage, and that the shoulder on the valve stem is sharp. This shoulder should be slightly inside the end of the valve guide when the valve is seated. Thus, any accumulation of carbon around the guide and stem will be sheared off each time the valve is lifted, and in this way prevent valve sticking.

Worn valve guides and valve seat inserts should be replaced with new ones. The guides are a pressed fit in the head casting, and service guides are especially machined to press in place, and give proper stem clearance without further machining. On the other hand, the valve seat



PRESSING IN VALVE GUIDE

in the head **MUST** be re-cut concentric with the new guide whenever new guides are installed. The valve seat inserts are furnished in 1/64, 1/32, and 1/16 oversize for a press fit, but require a shrinking process to anchor them in place.

The accuracy of the machine method of valve grinding depends entirely upon the condition of the valve guide and the pilot mandrel's fit, both in the guide itself, and the hub of the grinder stone. It is vitally important, therefore, to make sure that the mandrel is a snug push fit in the valve guide, and will not wobble at the upper end. If it does have any upper-end movement the seat will not be ground true. Guides that are worn too much to give the mandrel solid support should be replaced before grinding is attempted. The maker's instructions for dressing the grinding wheel must be followed to secure smooth, accurate seats.

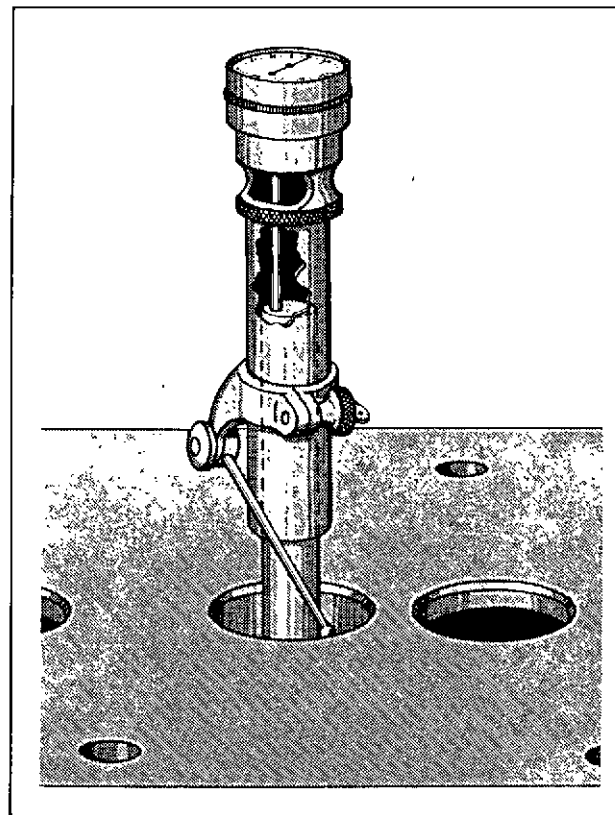
**Valve Grinding**

Modern valves are much harder than formerly

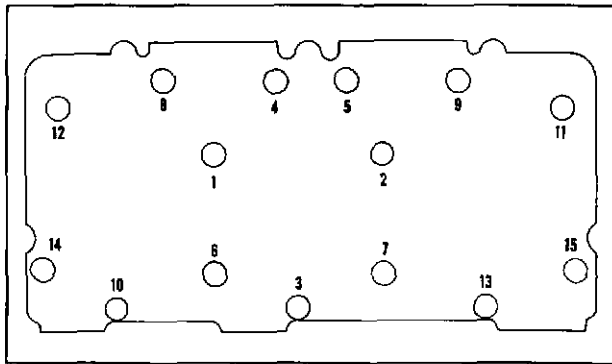
so that a valve grinding machine is much quicker and more accurate than hand grinding. If machine grinding equipment for both valves and seats is not immediately at hand, it will often save time and money, as well as getting a better job if the head and valve assembly are sent to a local specialist. Even if hand grinding is employed, the valve stems and guides must be a good fit without wobble to insure a concentric seat and a properly fitted valve.

**Hand Grinding**

Apply a good, medium grinding compound sparingly around the entire valve seat, slip a light lifting spring over the stem, lubricate the stem, and drop the valve into its original place in the cylinder head. The spring should just barely hold the valve off its seat. Place the grinding tool in the two holes or slot in the head of the valve to be ground. Press down until the valve is seated. Turn the valve a quarter turn, first in one direction then in the other. Do this three or four times. Release the pressure on the valve, and the little spring will lift it off its seat. Now turn the valve about 10 or 15 degrees to another position, and repeat the grinding. Do this until all the compound is rubbed



CHECKING SEAT FOR CONCENTRICITY



HEAD TIGHTENING SEQUENCE

off the valve seat. Withdraw the valve, and put on some fresh compound. Repeat the grinding operation.

Clean the valve and its seat occasionally to see how the grinding is progressing. When all pits and grooves have disappeared, clean the valve and valve seat, and place eight or ten equally spaced marks with a soft lead pencil on the seat. Then drop the valve in place, give it a quarter turn, and remove it. A perfect seat will be indicated if every pencil mark shows where the valve has rubbed it. If any pencil marks are left untouched, continue the grinding. When the grinding is completed, check the valve seat for concentricity with a dial indicator, then oil the valve stem, clean all traces of the grinding compound from the valve chamber and ports, and REASSEMBLE EACH VALVE IN ITS OWN OPENING.

#### REPLACING CYLINDER HEADS

First, make sure that any oil leads which may be drilled in the head to feed the rocker arms, as well as the drilled oil leads in the cylinder block, are clean to insure full oiling of the valve mechanism.

A torque wrench when used according to the table at the rear of this book will prevent overstraining studs, while insuring a tight joint. The order of tightening is also important. As shown in the typical case, the hold-down studs should be tightened in two or three successive stages starting with the center and working toward each end alternately. This will insure even pressure over the entire surface of the cylinder head and gasket. If the outside nuts are pulled up first instead of the center ones, the head will be cocked, and the gasket will not fit tight enough to prevent blowing out between cylinders. A torque wrench, where used according to the maker's directions, is the best way of setting up cylinder head nuts to insure full tension without excessive strain that might stretch the studs.

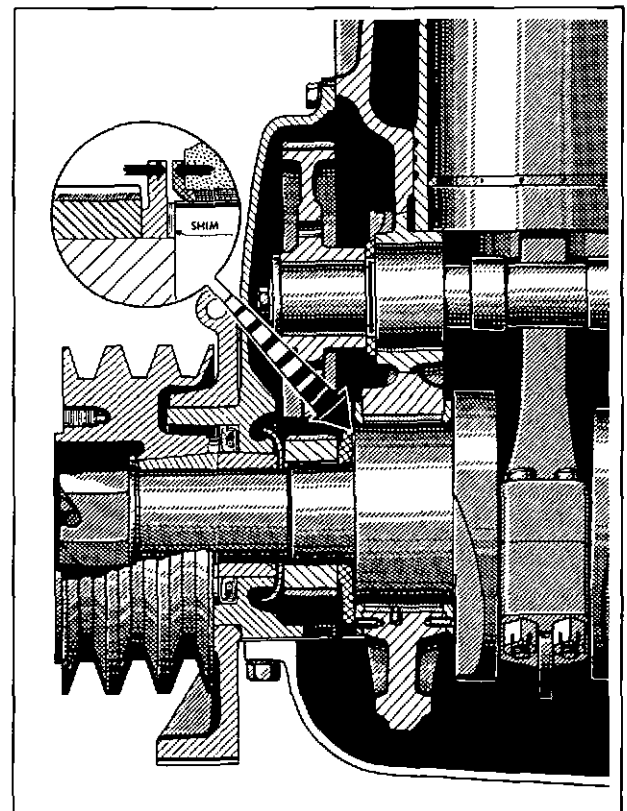
Retorque replaced cylinder heads after running the engine either idle or after load testing.

Do not neglect to connect the oil lead to the rocker arm shaft. Test it to be sure it is not clogged.

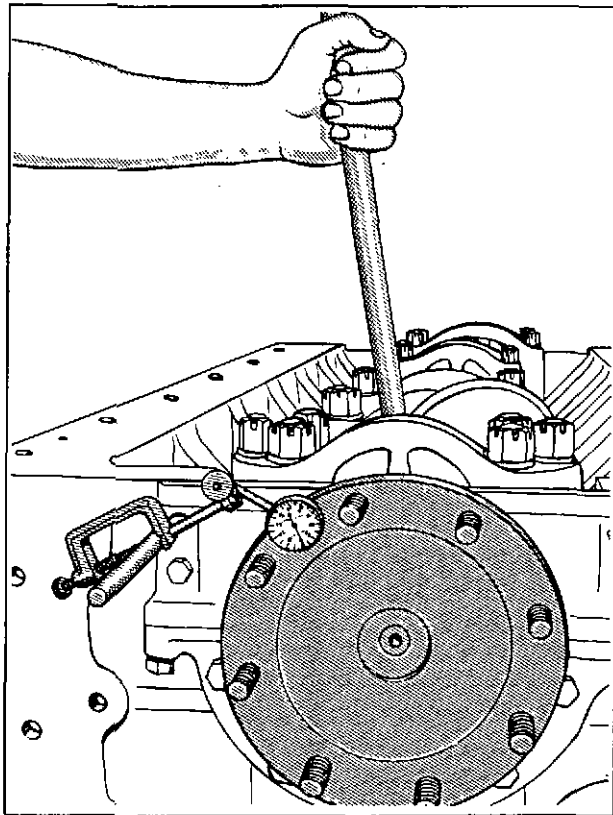
#### CRANKSHAFT END THRUST ADJUSTMENT

As shown in the accompanying illustration, increasing the number of shims between the thrust washer and the shoulder on the front of the front main journal will increase the shaft end play. Reducing the number of shims reduces end play. Current production engines have a slightly increased front main bearing length on the crankshaft and crankcase to give the correct end play without using shims.

Measure end play with a dial indicator clamped to the case and seating against the end of the shaft as shown. A small pinch bar is used to move the crankshaft forward until it is snug against the thrust surface of the rear thrust ring. The dial indicator is then set at zero when positioned against the rear flange. Now, use the bar to move the shaft as far rearward as it can go. The dial indicator should then read directly in thousandths of an inch of end play.



CRANKSHAFT THRUST ADJUSTMENT



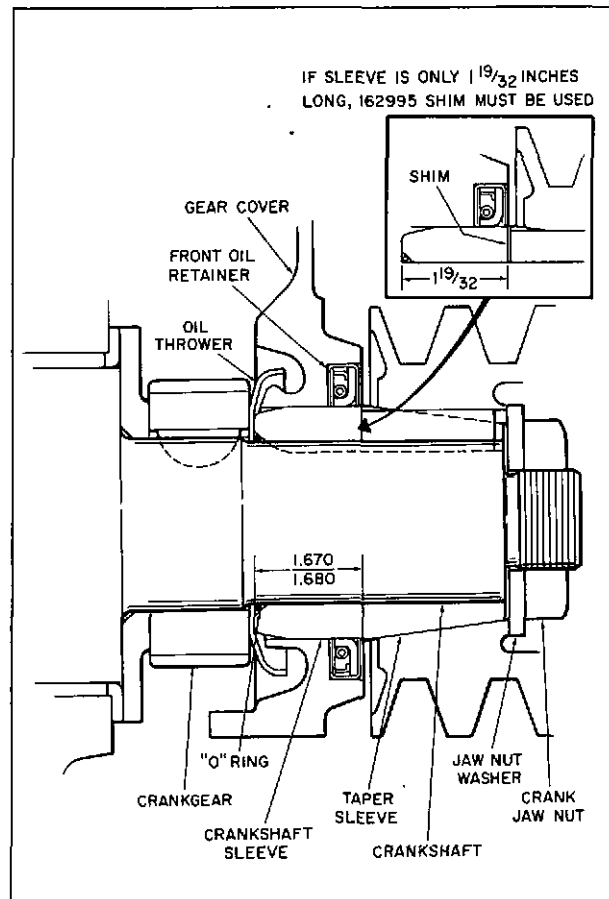
CHECKING CRANKSHAFT THRUST

Obviously, the above reading will not be accurate unless the shims are tightly compressed between the shoulder on the shaft and the thrust washer. In operation, the crankshaft nut serves to force the crank gear solidly against the thrust washer and thus compresses the shims. Since the crank gear is a very tight fit, however, it would involve some inconvenience to draw it into place only to measure the end play and find that additional shims were needed, or that some had to be removed. To eliminate this problem, make a short sleeve about the same length as the gear. This sleeve should slide easily over the shaft and the cut off ends should be square. Tubing, pipe, or an old gear which has been split will serve equally well. By substituting the sleeve for the gear, the crankshaft nut may be drawn up, the end play measured, and the nut and sleeve quickly removed to add or subtract shims as needed.

Normal end play for the WAK Series is 0.005 to 0.015, and the shims are 0.002" thick.

**CAUTION:** In those instances where it becomes necessary to remove the fan pulley from the crankshaft in the field, certain precautions will help to avoid dropping the crankshaft end thrust shims from their correct location. First,

it is suggested that the end play be measured with a dial indicator before and after removal and replacement of the pulley. Thus, an accurate check will be available to show up any shim displacement. Secondly, while the pulley is missing from or loose on the shaft, do not permit the crankshaft to be turned or moved lengthwise. Before installing the pulley, back up the flywheel or shaft to prevent driving the shaft backward while seating the pulley. Failure to observe these precautions may result in the thin steel thrust shims being dislodged from their proper position in relationship to the bearing thrust flanges and later torn and dropped into the oil pan. If at some time after pulley replacement, a deposit of thin steel shim material is found in the oil pan, this is the probable source and further investigation must be made. To remove the fan pulley from the crankshaft, however, it is necessary to remove the fan pulley nut and employ a three-jaw puller since the pulley is pressed on the shaft. Never attempt to pull the pulley by applying the puller to the rim of the vibration dampner.



USE OF SHIMS WITH CRANKSHAFT SLEEVE

After removing the pulley, examine the crankshaft front extension for any nicks, burrs, or rough spots that might damage the front oil seal. Use a fine file or stone to clean up such places.

The starter crank jaw may be threaded back on the shaft for use in turning the crankshaft if desired.

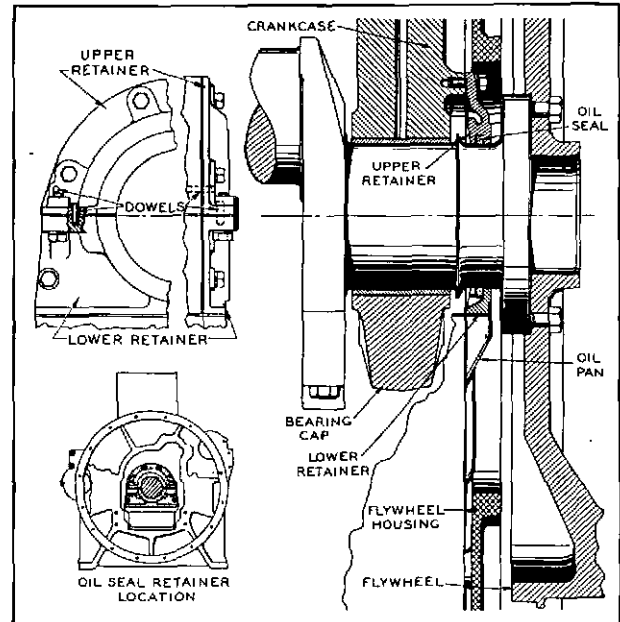
Check for proper end thrust before assembling a power take-off to an engine. Check again after the power take-off is assembled to the engine. If the crankshaft has lost end clearance it can probably be restored by "bumping" the end of the crankshaft. Place a block of wood against the end of the crankshaft and strike the wood.

#### Rear Oil Seal Replacement

Rear oil seal replacement is seldom necessary except at overhaul. When investigating rear seal leakage in the field, crankcase breathing should always be checked first. With the desired slight negative pressure, very little oil will escape at the seal.

In production, the rear seal retainers are assembled and doweled in place and the bore is then sized to its final dimension by means of a cutting tool piloted in the crankshaft rear main bearing bore. Two factors are critical in fitting and locating the retainer halves. First, the lower retainer must be flush with the face of the crankcase so it will seal against the oil pan; secondly, with the lower half so located, the clearance between the retainer bore and the crankshaft should be even within a few thousandths of an inch all around. These checks are made without the seal packing in the retainer groove but with the gasket between the upper and lower halves of the retainer.

Once the retainer assembly has been fitted as described above, there should be no reason to re-locate it. If, however, breakage or other damage makes field replacement of the retainer necessary, the following procedure should be followed. Remove the flywheel to gain access to the retainer. Remove the external oil pan to crankcase bolts. Remove flywheel housing to oil pan external bolts, and disconnect any oil, water, or exhaust connections which would interfere with dropping oil pan or with raising the engine. Drop the oil pan or in the case of the base type oil pan raise the engine with a suitable hoist, or jacks, until the lower retainer half may be dropped down to clear the crankshaft flange.



REAR OIL SEAL INSTALLATION

The dowels in the retainer upper half may be driven deeper to permit sliding out the upper retainer. Later these dowels may be drilled out or new ones installed in a new location.

Service retainers currently have a smaller bore than the production retainers since the extra metal left for the centering cut at assembly has not been removed. The following steps will permit the proper fitting of the bore without special tooling.

1. Temporarily install the new lower half so the lower edge is flush with the crankcase when checked with a straight edge.
2. With the retainer lower half thus located, slide a long piece of feeler stock around and between the crankshaft and the unfinished bore of the retainer. Try several sizes until the clearance at this point is determined. It may prove to be very little, possibly none at all.
3. Install the top retainer half, using the lower half as a locating means. Secure the top half and remove the lower half so feeler measurements of the upper half clearance to the crankshaft can be made.
4. After making the above measurements of the retainer bore to crankshaft clearance, it should be possible to calculate the metal which must be removed to give approximately 0,015" running clearance all around.
5. Remove the retainer assembly and with the two halves (with gasket) bolted together, mount and center it on a lathe face plate so

the correct bore size may be machined. Remember, the amount of metal to be removed may not be the same on both halves. The important thing is to remove the correct amount from the lower half so it will have both the correct running clearance and the desired flush location with the bottom of the crankcase.

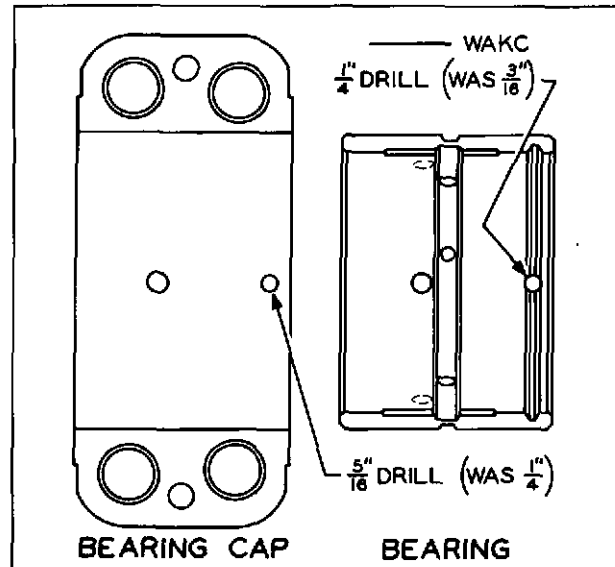
6. Install the upper and lower halves and space them from the shaft with shim stock or feelers. Secure, drill, and ream for dowels in the upper half.
7. With the retainer disassembled, roll in the seal packing. Trim the ends so they are slightly above flush on each half. Install the retainer and drive in the dowels which locate the upper half.

**REAR OIL SEAL PERFORMANCE IMPROVEMENT**

Improved oil control in the WAKC and F-1197-G series engines has reduced the quantity of oil present in the rear seal area, thereby lessening the chance of seal saturation and leakage. Current engines also use a redesigned oil pump pressure relief valve. The oil relief holes on this new valve are located on the sides instead of on the top and bottom as was the case on the earlier relief valves. This avoids discharge from the upper relief hole directly into the rear seal area which may cause excessive saturation of the seal.

Since modification of earlier engines is relatively easy and economical it is recommended that these changes be incorporated in all engines where this condition is critical at the next oil change period. Replacement of the earlier style oil pressure relief valve is not necessary as an inexpensive oil deflector can be used to direct oil from the upper relief hole away from the rear seal area.

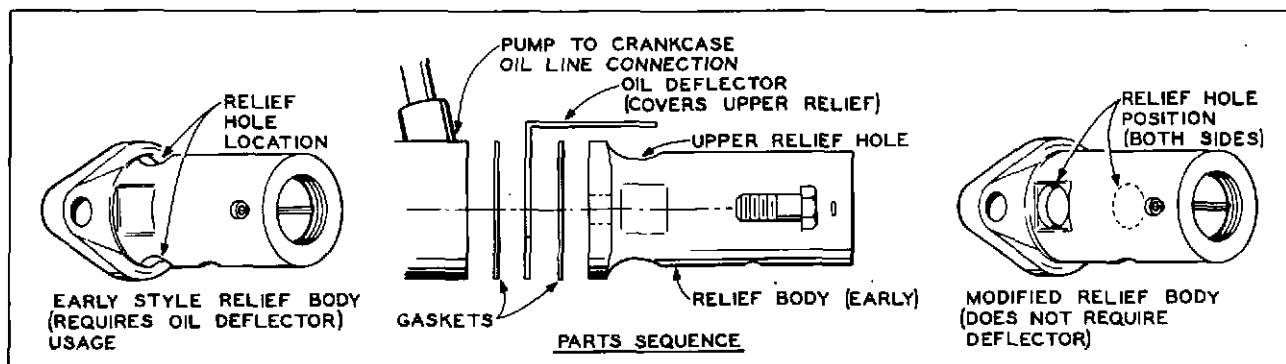
To modify bearing oil drains in the engine proceed as follows after draining and removing the engine oil pan.



**BEARING AND BEARING CAP**

1. Carefully remove the rear main bearing cap and lower bearing half from the engine.
2. Place the cap with the bearing in position and align on the base of a drill press. Block the bearing and cap securely to prevent distortion when drilling.
3. Using the accompanying illustration as a reference, enlarge the bearing drain with a 1/4" size drill. Drill completely through the bearing shell before removing the bearing from the cap. It is neither necessary nor recommended to attempt widening of the bearing oil drain groove.
4. With the bearing removed from the cap, enlarge the cap drain using a 5/16" drill.
5. After drilling both the bearing and cap, carefully remove any burrs, then thoroughly clean the parts in a cleaning solution.

Further protection against rear oil leakage involves removing the relief valve at the oil



**REAR OIL CONTROL**

line connection and installing an oil deflector. The relief valve is secured to this connection by two cap screws. Remove the cap screws and the relief valve. Remove and discard the old gasket. Clean the gasket surface on both the relief valve flange and the oil connection. The oil deflector must be reassembled with a gasket between it and the oil line connection, and another between the relief valve flange as shown in the relief valve illustration. The only new parts required for this modification are two gaskets and the oil deflector, that can be obtained from Waukesha. The oil deflector must be installed so that it deflects oil spurting from the upper relief. After this is completed, the oil pan can be reinstalled and the engine oil supply replenished prior to starting.

### TIMING GEAR OVERHAUL

All gears in the front end of the engine should be inspected carefully as the engine is being disassembled. It is suggested that they be washed off reasonably clean with solvent and backlash reading be taken with a dial indicator. Narrow strips of feeler stock may be used instead, if a dial indicator is not available. Gears on which the backlash (running clearance) appears to be excessive or too tight, should be checked further. Sometimes unusual running clearances may not be the fault of the gear but may result instead from badly worn bushings or bearings. Before deciding that a gear must be replaced, inspect its shaft or bearings to be sure the gear is not dropping out of position. Readings taken at this time will indicate those bearings and bushings which must be ordered for replacement. Also, the gear sizes should be noted, and those gears for which replacements are ordered should be specified according to the size desired. All gears are currently made in standard sizes. The letter "S" on the gear rim means "Standard".

Because wear, previous overhauls or servicing, and slight accumulations of variations in center differences may have altered the relationships of the gears to each other to a small extent, gear fits must be given a final check with a dial indicator or feeler stock. Do not hesitate to select a gear that will give the correct backlash rather than run the gears too loose or too tight. Slightly loose gears, although noisy, are better than gears which run too tight.

### Timing Marks

To time the Model 6-WAKC engine, it is necessary to mate "X" mark on the crank gear with "X" mark on the idler gear; and "C" mark on the idler with "C" mark on the cam drive gear.

Always check the crank gear, idler, and cam gear to be sure the timing marks are clearly visible before disassembly. If, for some reason, the mark on any one of them is obscured, remark it before disturbing the mating position.

If the timing gears are removed during overhaul or for replacement, it is advisable to check the valve timing when reassembling the gear train to ensure proper meshing of the gears.

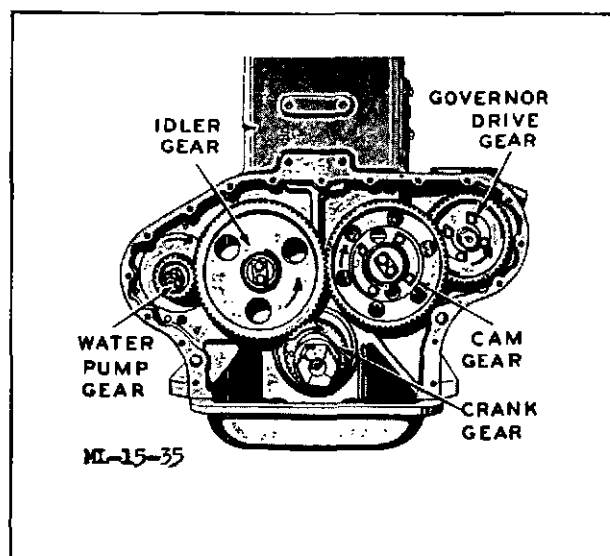
In addition to excessive wear, gears may require replacement for other damage such as might occur from foreign material passing through them, plugged oil feeds or other causes. Examine each gear tooth carefully for chips, nicks, breaks, severe pitting, or indications of cracks.

As a general recommendation for engines in heavy duty service, it is a good idea to replace all main gears at the same time if it becomes necessary to replace one or two of them.

### Removing and Installing Gears

The cam gear and crankshaft gear carry the relatively heavy load between crankshaft and camshaft. They must, therefore, be securely held in place. Both of these gears require pullers of the heavy duty type to remove them. To pull the cam gear, first remove the two capscrews and gear retaining washer on the front of the shaft. Screw the puller studs into the threaded holes in the gear. A similar puller is needed to remove the crankshaft drive gear. As mentioned elsewhere under disassembly, it may be necessary to heat the crankgear before it will loosen.

To ease the installation of these gears, it is recommended that they be heated in an oil bath or other even source of heat at temperatures not



DRIVE GEAR ARRANGEMENT

to exceed 400°F. After heating long enough for the gear to be thoroughly saturated, quickly put the gear on the shaft and hold it securely in position until cooling takes place. A soft face hammer or driving tool should be immediately available to tap the gear home if slight cocking or binding should cause it to stick. A lubricant such as Lubri-Plate is often helpful when installing shrink-fit gears on a shaft.

When removing the idler gear, bend down the lock tab washer and remove the retaining cap screws. Note that the end play of the idler gear is controlled by the selected shims. Save shims.

### CAMSHAFT AND CAM-FOLLOWER OVERHAUL

Good engine performance demands accurate valve timing, and accurate valve timing starts at the camshaft. The entire camshaft mechanism should be carefully inspected at overhaul. In circumstances where internal engine damage such as a broken connecting rod has occurred, an exceptionally careful check should be made. In some instances, broken parts have caused severe camshaft damage in a localized area.

Under field conditions, the camshaft may be removed by opening up the front of the engine via the gear cover, loosening the rocker arm supports to permit blocking or wiring up the cam followers, and withdrawing the shaft after removing the two capscrews holding the camshaft thrust plate in the case.

#### Inspecting Camshaft

The following points should be carefully checked.

1. Shaft journals for out-of-round at several points. Record measurements and subtract from inside micrometer readings of journal bushings to determine running clearance.
2. Micrometer check each cam lobe for wear at tip. Visually examine for signs of battering, scuffing, spalling, pitting, or similar trouble.
3. If the cam gear has been removed, examine key way and seating surface of gear for signs of looseness.

Any condition found by the above checks must be correctable by relatively light honing or polishing, or else the camshaft must be replaced. Ordinarily, excessive running clearances in the camshaft bushings will indicate the need for bushing replacement rather than shaft wear. When a new camshaft is installed to replace a failed or excessively worn camshaft, an entire set of new valve lifters must also be installed. Wear patterns on the old lifters and/or damaged old lifters can result in early failure of the new camshaft when new lifters are not installed.

### Replacing Camshaft Bushings

Excessively worn bushings must be removed and new ones pressed in place. Either precision type or undersize for align boring camshaft bushings are available for service replacement. Precision type cam bushings are manufactured with dimensions to allow for proper running clearance and alignment without align reaming. The bushings are a press fit in the crankcase. A removing tool will permit driving the old bushings out. The flange of the removing tool must be sufficiently smaller than the outer diameter of the bushing to allow it to pass freely through the bushing bore in the case. Use a driving bar long enough to permit working from the front of the case. A portable hydraulic power unit or other means of driving may be used. When all bushings have been removed, clean up the bore surfaces and remove any sheared metal. It is best to replace all bushings at once.

To ensure accurate placement of the new bushings, use a driving tool with an accurate pilot in the bushing bore. Work slowly and carefully when driving to prevent cocking and scraping or distortion of the bushing. If a good installing tool is not available, or, if space is limited, a threaded puller type tool may be made up to pull the bushing into place. Be sure the puller plate bears squarely against the bushing. When starting the installation, very carefully align the oil hole in the bushing with the oil hole in the case. Be sure the holes are open and clean.

#### Align Boring Cam Bushings

Align boring of new undersize camshaft bushings is not a difficult job when the proper equipment is used. Be sure the boring bar pilot is exactly centered in the crankcase cam bushings at front and rear. To prevent chips from entering the oil passages during the align boring, it is suggested that bee's wax or like material be used to fill the oil hole in the cam bushings. When finished, carefully clean away all chips and remove the wax plugs.

#### Camshaft End Thrust

End thrust on the WAK series is taken by a thrust plate which is secured to the crankcase just forward of the front camshaft shoulder. Forward end travel of the camshaft is limited by the front shoulder riding against the near face of the thrust plate while rearward travel is likewise limited by the rear thrust face of the cam gear which rides against the front face of the thrust plate. Camshaft end play, if excessive, is adjusted only by thrust plate replacement and by re-establishment of the proper 0.004" to 0.006" cam gear to thrust

plate clearance. Correct end thrust is obtained with the camshaft removed from the engine and the cam gear assembly removed from the camshaft. Install a thrust plate of the correct 0.1825" to 0.1835" thickness on the camshaft. After heating, press the gear assembly on the shaft until the 0.004" to 0.006" clearance is measured by inserting feeler stock between the cam gear thrust face and the thrust plate. After this clearance is obtained, lock the gear assembly with the retainer and lock nut. With the camshaft assembly properly re-installed in the crankcase, secure the thrust plate to the crankcase with the two lock washers and capscrews which are inserted and tightened through the holes provided in the cam and fuel pump drive gear assembly.

#### Cam Followers: Removal and Replacement

If a cam follower is suspected of sticking due to oil gumming or some other cause, it should be removed and cleaned in benzol, or renewed. To accomplish this, remove the rocker arm assembly and lift out the push rods. Next take out the cap screws retaining the side cover plates on the left side of the engine and slide the plates clear. Usually it will be found possible to do this without disturbing the safety shutdown mechanism mounted on the rear plate. It will, of course, be necessary to disconnect and cover the lines to this unit. The cam followers will now be visible and may be lifted out for examination. Sometimes oil deposits will make it difficult to lift a cam follower entirely out of its bore. In such cases the polished surface of the part should be protected with a piece of brass or copper wrapped about it; it will then be possible to grip the cam follower carefully with a pair of pliers and rotate it from side to side to work it free. In no case should the cam followers be allowed to become mixed when out of the engine. Always re-install them in their original position. See page 65 for use of the lifter alignment tool.

Any nicks or burrs on the edge of the cam-follower opening, or in the bore of the opening, should be carefully removed with a light hone or file to avoid scratching or scuffing the cam follower. Always examine the cam-follower face for pitting, dishing, or other unusual conditions.

#### Cleaning and Prelubrication of Cam Followers Used for Service Replacement

Cam followers used for service replacement are shipped from the factory coated with Cosmoline. We have received reports of followers being dipped or immersed in cleaning solvent to remove the Cosmoline. This practice not only removes the Cosmoline, but also re-

moves the Molycote from the follower roller bushing and pin which can result in follower failure.

The Cosmoline should be removed from the followers by wiping them with either a dry cloth or a cloth dampened with cleaning solvent. After the Cosmoline has been removed, we recommend immersing the followers in clean engine lubricating oil for 4 to 5 minutes to ensure adequate roller bushing and pin lubrication. Don't wipe the oil from the followers before installing them in the engine.

These prelubrication procedures also apply to reinstallation of removed cam followers which are being reused.

#### BEARING ADJUSTMENT

All main and connecting rod bearings in the WAK engines are of the steel-backed precision type. Because of the extremely close machining of this type bearing, no fitting, filing, scraping, boring, or other adjustment is required or permissible. Special treatment of shimmed bearings is discussed later in this section. Replacement must be in complete bearing units. Never replace only one half of a bearing. Service bearings are available in 0.020 and 0.040 under size for use on reground crankshafts. Never attempt to adjust a bearing by filing, grinding, or lapping, the bearing cap. The bearing seats are precision bored with the caps in place. Hence, any metal removed from either side forever prevents proper fitting of a connecting rod bearing in the rod, and in the case of a crankcase makes the entire case unsuited for further use.

Be sure that the bearings seat on absolutely clean surfaces and that the back of the bearing is wiped perfectly clean. The slightest bit of dirt or carbon squeezed between the back of a bearing and its seat can cause rapid bearing failure due to a localized high spot.

Equally important in obtaining maximum bearing life is the correct tension on the bearing cap nuts. Pull down on all nuts evenly, going from one side of the bearing to the other. Apply final tension with a torque wrench using a slow steady pull and holding the wrench "on torque" for a few seconds when the proper value is reached. Desired torque values will be found in the table of limits at the end of this manual. Never back off on a bearing nut to install a cotter pin. It is preferable to go to a slightly higher tension if necessary. If it is apparent that the cotter pin cannot be installed without bringing the tension dangerously near the limit of the bolt, remove the nut and try again with another

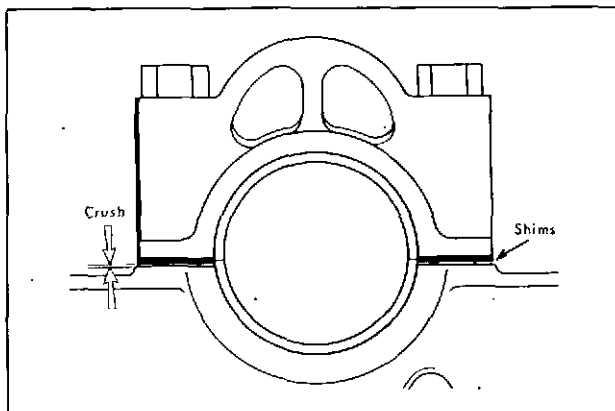
nut at the location. Previous over-torquing, or some other damage to the bolt or nut is sometimes encountered and will be felt by the torque "softening up" so that the nut can be turned without appreciable increase in wrench tension. Never allow a bolt and nut in this condition to remain in an engine.

Current production engines are equipped with Marsden, self-locking nuts on the connecting rod assembly. The torque values for them is the same as the castellated type nut.

#### Shimmed Rod Bearings

Although the connecting rod bearings in these engines are of the precision type, they are provided with laminated shims to permit a slight amount of adjustment. These shims do not extend into the bearing itself and are clamped between the cap and the rod but not between the crushed edges of the bearing shells. When assembling bearings use caution to properly align these shims this way. When the rods are machined, the shims are clamped in place and the bolts tightened to the proper torque so that the final bearing seat is the exact diameter required to accommodate the two bearing shells plus the desired crush with all shims in place.

For this reason, whenever a shim is removed, and such adjustment should only be considered in an emergency, it is also necessary to remove the same amount from the crush edge of one of the bearing shells. For example, the shims are laminated in four thicknesses of 0.002 each. If it were decided to take up 0.002 on the bearing, one layer on each shim would be peeled away. Never remove shim stock on one side only. After removing the shim stock, the bearing shell must be reduced 0.002 on the crush edges of one shell, or 0.001 on all four crush edges of both shells if desired. This may be done on a lapping plate, or by carefully dragging the shell edges across a flat mill-cut file clamped



BEARING CRUSH

to a flat surface. Obviously, this is a job requiring both skill and experience. It is considered best practice to replace the bearings completely rather than attempt to adjust them. Current engines do not use shims.

#### Bearing Replacement in the Field

Under normal circumstances it is seldom necessary to replace individual bearings in the field between regular overhauls. When such a requirement arises, however, the precision type bearings used in the WAK Series may be installed without special fitting or adjustments providing the following factors are given proper consideration.

1. What caused the individual bearing failure? Was it dirt; plugging of an oil passage; improper installation; some condition peculiar to a given journal or crankpin, such as out-of-round; and is it possible under field conditions to correct the trouble source before installing the new bearing?
2. Has the shaft been damaged in any way which would prevent future satisfactory running? If the damaged bearing is believed to have run in that condition for any prolonged period of time, some thought should be given to the possibility of a fatigue crack starting as a result of that portion of the shaft being unsupported. If a situation such as this is known to exist, it may be safest to take the engine in for overhaul so the shaft can be magnetically inspected.
3. Is the nature of the bearing failure such that particles of bearing metal may have been conducted to other bearings or forced back into oil passages?
4. Did the damaged bearing shells turn in their rod or main bearing seat and produce a surface unfit for seating a new bearing? Was the rod or cap overheated enough to discolor? Parts in this condition usually require replacement.

If good judgment indicates the practicality of installing a new bearing, the conventional method of "rolling" in the top insert of a main bearing may be used. Connecting rod inserts are replaced directly after cleaning the bearing seat in cap and rod. Never attempt to adjust a precision type bearing by shimming or filing. Removal of metal from the bearing cap mating surfaces will forever prevent proper fitting of a new bearing.

A recent connecting rod change eliminates the dowel from the rod cap and the associated hole from the rod bearing insert. When the current bearings are to be used in rods which incorporate dowels, the dowels must be removed. After removal, light stoning or polishing is

recommended to blend out any raised metal around the dowel hole.

Ordinarily, a loose connecting rod will be most noticeable on deceleration after quick speed up of the engine without load. Sometimes listening at an oil filler opening or breather will help to identify the noise by general location. Main bearing noises, on the other hand, usually are most noticeable as thumping, heavy sounds when the engine is pulling a load.

If it is indicated that a localized knock is definitely present in a given cylinder, a further check may be made by removing the oil pan to gain access to the suspected bearing. Use a pinch bar to move the lower end of the rod and at the same time feel for relative motion between the rod and crankcheek. A loose bearing will usually be detectable by an unusually large movement.

Further inspection of a bearing, of course, requires removal of the cap. It is definitely not a good practice to disturb precision type bearings which do not require service. When this is done, the parting edges of the bearing have a tendency to roll inward and impair the crush when the cap is again tightened down. For this reason, be as careful as possible to locate the bearing causing the noise before disassembly. Do not work with oily bearings on a dirty bench or work surface. This permits small particles to be picked up accidentally and introduced behind the inserts or in other critical places. Examine each insert for proper position of oil passages and to prevent possible mis-location. With regard to this, it will be noted that the dowels in the bearing cap mating surface are off-set, and the locating tabs on the inserts must enter the recesses provided for them. If the cap or insert is not in the proper position, it should be very apparent. Whenever any difficulty or extra force seems involved in assembling a bearing, do not go further until everything has been checked over. If burrs or damaged threads on the bearing cap studs are present, they should be cleaned up. Any damage to the studs of more than very minor nature is cause for replacement with new studs.

#### Side Clearances

Although less critical than the bearing running clearances, no bearing should be assembled without checking side clearance. This may be done by forcing the rod fully to one side or the other and inserting a feeler between the crankcheek and the bearing end.

#### Running Clearances

Even in the case of precision bearings, it is good mechanical practice to check running clearances when installing bearings. There are sev-

eral methods of doing this, some of which are merely checks of whether any clearance exists and others that give an indication of how much clearance is present. The familiar test of connecting rod bearing clearance consists of manually gripping the rod cap after the bearing bolts are tightened and attempting to move the bearing from side to side in the direction of end clearance. A well-fitted bearing is usually just loose enough to be "snapped" from side to side without actually feeling so loose as to push easily. Sometimes a slightly snug bearing will not move under finger pressure but will move readily under light blows from a soft-face hammer. This is usually considered as satisfactory providing the engine is given adequate break-in time. In the final analysis, this test is a matter of judgment and is not altogether suitable for general use.

A similar test on main bearings consists of tightening each bearing cap in turn and turning the shaft to detect binding. Again, the difference between tight and "about right" is a matter of judgment.

More accurate tests may be carried out with fuse wire or with a special crushing gauge material that squeezes between the shaft and the bearing to flatten into a measurable gauge.

It is emphasized that any unusual bending or run-out in a crankshaft makes it impossible to fit bearings accurately. For this reason, the time spent in making a run-out check at overhaul is well worth while. Also, magnetic inspection of the crankshaft and other stressed parts is recommended if the proper equipment is available.

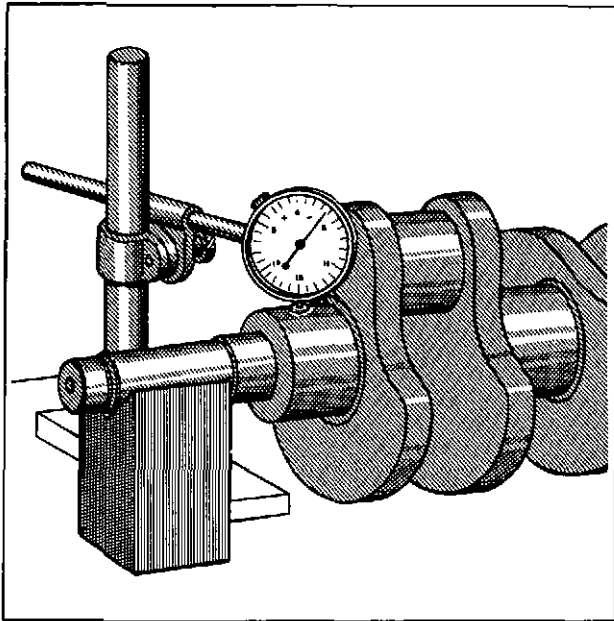
**DO NOT FORGET TO COAT ALL RUNNING SURFACES WITH CLEAN, FRESH ENGINE OIL WHEN INSTALLING NEW BEARINGS!**

#### CYLINDERS AND PISTONS

##### Matching Replacement Pistons, Sleeves and Pins

The precision and skill with which pistons are re-fitted during overhaul is sure to have a very great effect on later engine performance.

Unusually loose pistons will soon show up as noisy, with excessive blow-by, high oil consumption and sluggish power characteristics. Overly tight pistons may be even more dangerous because of the possible severe damage to sleeves or cylinder walls and other running parts. Less well understood, but very definitely important, is the necessity for using pistons that match each



CHECKING CRANKSHAFT RUN-OUT

other within specified weight limits. Off-balance conditions established by relatively slight variations in piston weight can bring about effects ranging from merely annoying vibrations to fatigue failure within a short time.

The vital point about the above details is that an overhaul job where they are ignored or improperly handled is often worse than no overhaul at all. It is not enough to use new pistons and sleeves assembled from open service parts stock. The pistons should all come within the specified weight range and the piston-to-sleeve clearances must fall within a selective fit tolerance as actually measured by a person skilled in this operation.

All of the above facts are borne out by the long experience of Waukesha Engine both in production and in providing service parts. We therefore believe that the very best way to obtain properly matched and fitted pistons, sleeves and pins, is to order factory selected sets as complete units for a given job.

When ordering parts of the above type, the following points should be remembered:

1. Pistons, sleeves, and pins, ordered as separate items for stock cannot, of course, be fitted at the factory and will be selected at random. To ensure a sufficiently wide assortment of parts to select the correct fit on the above basis requires a large inventory. To use assemblies that have not been so fitted is an injustice to the engine.

2. Complete assemblies ordered as such, that is . . . all pistons and sleeves; pistons, sleeves, pins and retainers; or other combinations for a given engine, will be selected for both weight and clearances at the factory and will be equivalent to new factory-production assemblies when properly installed. An extra charge is made for labor involved to make this service possible. We are sure your experience will prove this extra cost is more than justified.

3. Instances where a portion of a factory assembly, for example, one sleeve and piston; several pistons in an engine; and so on is replaced and is to run in conjunction with some of the original parts, it is good practice to order replacement pistons that will match the original weights. To do this, clean the original piston until the weight figure stamping becomes legible, or, if these markings are obscured, weigh the piston to the nearest quarter ounce without the pin or retainers. This may be done on a postal scale.

If the weight is not reported with the order, open stock parts must be supplied and consequently there is no assurance of a good match between old and new parts.

**Identification Marking**

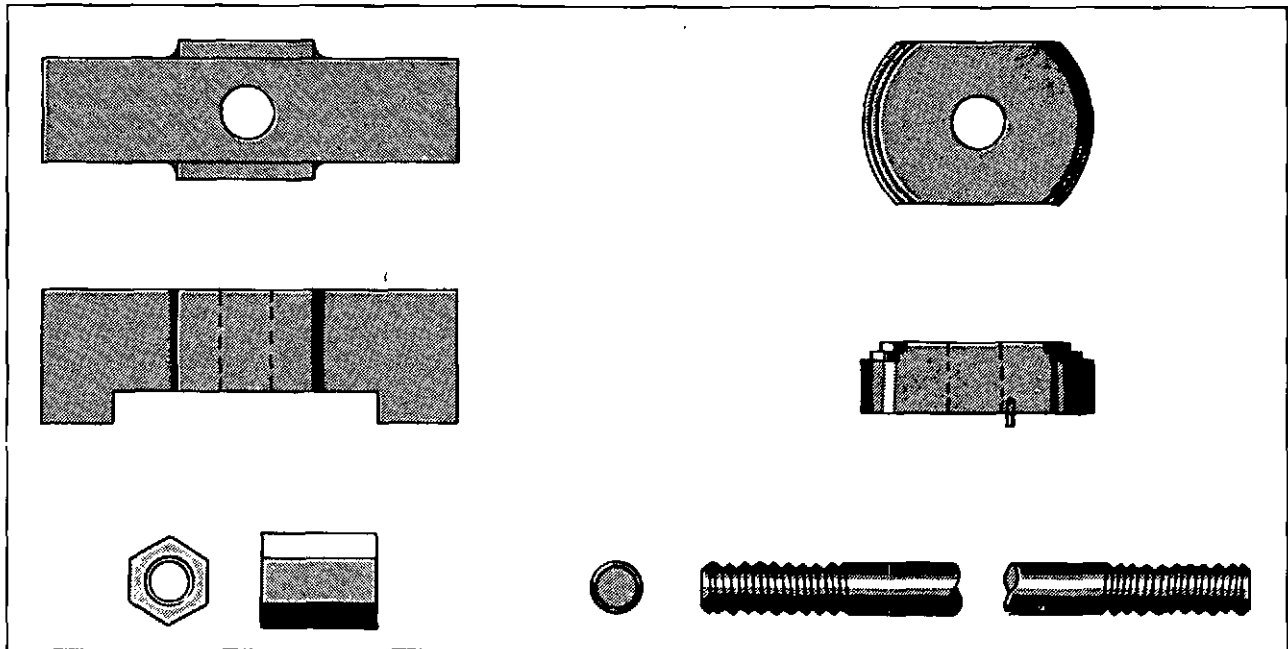
To aid accurate fitting of pins to pistons, and pistons to sleeves, each piston, pin, and sleeve, is checked with precision equipment and marked for size classification within the following limits.

Sleeves, Pistons		Pins and Piston Bosses	
Am't Oversize	Letter Mark	Example of Size	Color Mark
0.0000" to 0.0003"	A	1.8743" - 1.8744"	Red
0.0003"+ to 0.0007"	B	1.8744" - 1.8745"	White
0.0007"+ to 0.0010"	C	1.8745" - 1.8746"	Blue
0.0010"+ to 0.0015"	D		

(Matching colors of pin and piston should give a hand push pin fit at room temperature.)

Ordinarily, sleeves and pistons with the same letter, and pistons and pins with the same color are fitted together, although merely matching letters or colors is not considered a sufficient check for correct fit. Instead, the letters and colors should be used as a guide to save time in eliminating unnecessary trial fits of parts dimensionally impossible to fit properly because they are in the wrong range. Current engine piston and sleeves are of only one size range, and current piston pins are only coded red and blue.

In addition to the letter classification mark on a piston another numerical marking will also be found. This is the piston weight and may be



HEAVY DUTY SLEEVE PULLER

stamped as total ounces of weight, for example, "97", 97-3/4, 96-1/2, or it may be stamped as pounds and ounces, for example, 5-10, 5-11-1/2, or whatever the weight may be. Ordinarily this mark will be found on the top of the piston, as will be the letter size marking. In some cases, however, weight markings are located in such places as the lower edge of the skirt, the lower side of the pin boss, or elsewhere.

Other markings will be found on some pistons. Some of these will appear as letters other than A, B, C or D and others will be merely devices or designs. These are inspector's marks and may be disregarded. In the case of pistons installed in an engine at the factory, the numerical order of the cylinders, 1 through 6, will also be found. Pistons with such designations should always be re-installed in proper order and facing the original direction.

Many pistons will be found with a small arrow, the word "front", or both, stamped on top. In such cases the word "front" or the arrow must always point towards the gear-cover end of the engine when installing the piston. This is important.

Piston part number marks are usually stamped on the top of aluminum pistons and cast on the inside of the skirt of iron pistons.

#### Selecting a Piston, Sleeve and Pin Set

Presuming it is desired to fit a set of pistons and pins to new sleeves or a new block already in stock, the general procedure is as follows:

1. Select enough sets of pistons within the specified weight range to permit a careful fitting to the best obtainable clearances. A tabulation of the factory recommended weight range is included at the end of the manual.
2. Note the letter sizes A, B, C or D on each of the new sleeves or opposite the bore in the block and select several pistons in each letter size required. All extra pistons and weight ranges can now be returned to stock. Current engine pistons and sleeves are of only one size range.
3. Use a dial bore gauge, or inside micrometer to check the sleeve bore for distortion due to handling. Here, a maximum permissible out-of-round of 0.001" has been established as a practical limit. Eccentricities slightly in excess of this may be corrected by careful application of a wooden or plastic face mallet as needed to round up the sleeve.
4. Using several strips of one-half inch wide feeler stock to make up a gauge as specified in the clearance limits for the engine being overhauled, attach a spring scale to this gauge and take the measurement of piston clearance as shown in the accompanying illustration.

#### Removing and Installing Sleeves

Removal of the wet-type cylinder sleeve is a comparatively easy operation since the only substantial force required is that needed to loosen

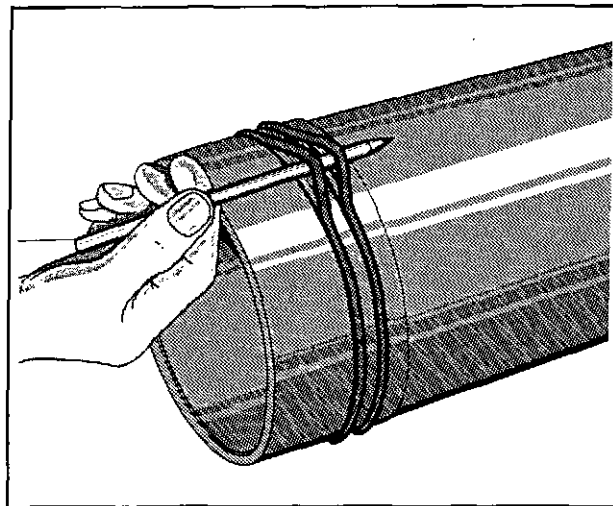
the lower rubber seal rings. A screwjack type puller may be made up with a plate seating against the lower end of the sleeve and connected by a through bolt to a bridge-like structure at the top of crankcase. Once the rubber rings have been freed, the sleeve is readily lifted out. Rubber rings cannot be re-used.

There are several important points to note on installing the sleeves. First in importance is the use of seal rings that are fresh and elastic. Do not use aged and hardened rings since these will not compress evenly and sleeve distortion will result. Also, the ring seating surfaces must be clean and well lubricated with liquid soap. Do not use engine oil on rubber rings. After slipping the rings over the sleeve and into the grooves, run a pencil or like instrument around under the ring to distribute the rubber material around the sleeve more evenly.

Inspect all seating surfaces at the upper end of the sleeve and in the crankcase counterbore to ensure that no dirt will interfere with accurate seating.

After the rubber rings and surrounding area are well soaped, align the sleeve in the crankcase and force it home with a smart, firm thrust of the hands. No hammering or driving is necessary or desirable.

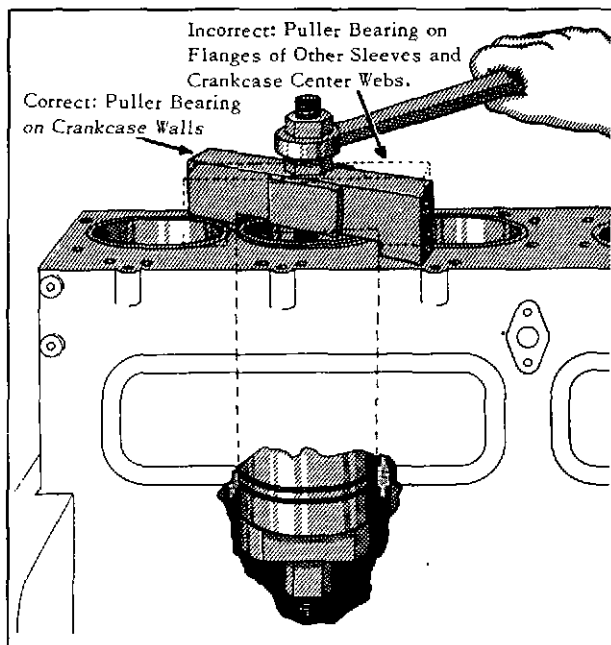
When all sleeves are in place, check the sleeve bores for distortion that might have occurred due to inaccurate placement of the seal ring material. This must be done with a clamping



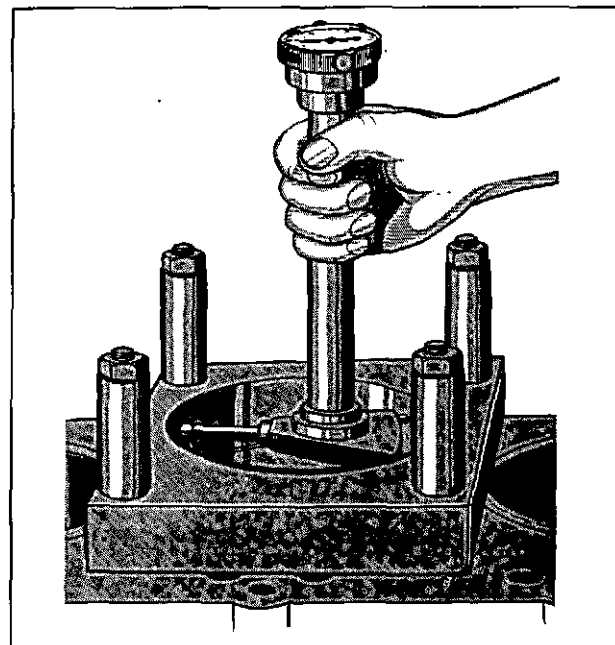
EVENING UP RUBBER RINGS

load on the top of the sleeve and a dial indicator of the extension arm, three contact type. Practical limits for maximum out-of-round permissible are 0.001" -0.0015." The clamping action may be obtained from any accurately built ring that simulates the cylinder head pressure and is retained by the head studs. If a considerable number of sleeves are to be replaced over a period of time, it may prove convenient to make up a clamping tool from a discarded cylinder head with openings cut out to allow the gauge to drop through into the cylinder.

It is not unusual when fitting this type of sleeve to find it necessary to withdraw the sleeve, re-soap and even up the rings, and re-install it



SLEEVE PULLER IN USE



CHECKING SLEEVE FOR DISTORTION

several times before obtaining an out-of-round reading within the limits in the back of this manual. Uneven distribution of the rubber rings causes this trouble. Always make this check in the seal ring area.

In connection with the above check for out-of-round, it may be more convenient to make a gauging piston by re-grinding an oversize piston to just slide through the sleeve within the proper tolerances. Such a gauge requires some skill and judgment in use since forcing it through a distorted sleeve will not correct the distortion and may cause score marks or scratches.

**Installation of Spring-Loaded Teflon Sleeve Seal Rings**

A significant advance in sleeve sealing technique is now being incorporated in Waukesha Model F1197G engines and is also available for service use. The new seal consists of a machined Teflon ring with a flat-wound stainless steel inner spring. The materials used make this seal extremely resistant to temperature variables and attack by crankcase or cooling water chemicals. The Teflon seal is employed in the lower groove only and a large-diameter, natural rubber ring is used in the upper (water side) groove.

**CAUTION**

Installation tools for the Waukesha teflon packing rings consist of a pusher and resizer. The use of these tools is recommended. Using the tools makes installing the packing rings easier and faster. Proper use of the pusher will help prevent damage to the packing rings during installation. Less time will be spent in resizing the packing rings when the resizing tool is used. Efficient use of the pusher will eliminate the need for using the resizer.

For installation of the new Teflon rings the following installation tools should be used:

- Pusher Tool - STS43686-7
- Resizer Tool - STS43687-7

Certain installation procedures must be followed to ensure success with the Teflon seal. . .

**NOTE**

The cylinder sleeves have a large chamfer at the bottom of the sleeve to facilitate the installation of the packing rings.

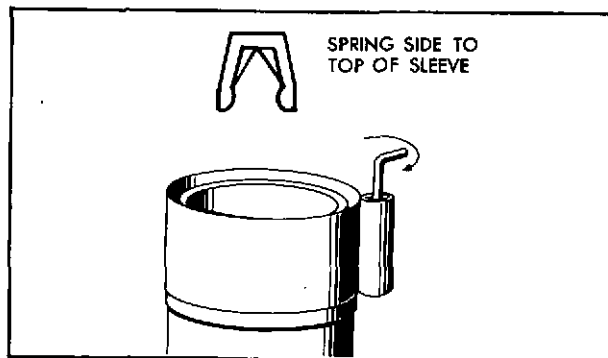
1. Place the sleeve on a flat surface, lubricate the cylinder sleeve taper as described in the following caution, and slide the packing ring

onto the sleeve taper by exerting uniform finger pressure around the perimeter of the ring (see illustration). Press the packing ring onto the sleeve taper far enough so that the pusher tool can fit squarely on the sleeve.

**CAUTION**

Lubricate the surface of the sleeve taper with Parker O-Lube or an SAE 10W non-detergent oil equivalent. Exercise care during installation to prevent damage to packing ring sealing surfaces.

2. Next, place the pusher tool squarely onto the sleeve taper and push the packing ring into the groove in the cylinder sleeve.



TEFLON SLEEVE SEAL INSTALLATION

3. The packing ring may stretch during the installation process, therefore, a resizing tool should be used. Place the resizing tool over the packing ring. The resizing tool should be left on momentarily or until the packing ring has returned to its original shape. The packing ring should be a snug fit in the cylinder sleeve groove to prevent damage during installation.



INSTALLING TEFLON PACKING RING

## NOTE

When installing the packing ring, the longer the period of time it is stretched the longer it will require to resize.

4. Remove the resizing tool and install the cylinder sleeve in the engine block (see Cylinder Sleeve Installation Instructions).

## NOTE

A#105 rubber band can be used to resize packing rings under field emergency situations only. Compression with the rubber band may require a few hours or overnight to be adequate.

Certain installation procedures must be followed to ensure success with the Waukesha teflon packing ring.

1. All seating surfaces and all surfaces over which the packing ring must pass on both the sleeve and within the crankcase must be absolutely free of burrs and nicks. The upper edge of the crankcase lower bore must not be sharp.
2. Lubricate the packing ring with liquid soap in the conventional manner and slide the sleeve in as perpendicular to the crankcase bore as possible.
3. Inspect cylinder sleeve for cylinder bore roundness.
4. It is a good practice after the engine is assembled, to check for leakage by performing a pressure test before installing the pan or closing the crankcase.

## Cylinder Head Gasket Crush

In order to prevent sleeve movement and seal the water at the joint between the upper sleeve flange and the crankcase, the sleeve must project a few thousandths above the crankcase deck. This distance is important and a definite and measurable amount must exist. In effect, this projection provides a localized crush in a concentrated area around the top of each sleeve. Improper tightening of the cylinder head or detonation may cause this crush to be lost. If this occurs, the thrust action of the piston may cause enough rocking action of the sleeve to wear the sleeve seating counterbore in the case unevenly. Thus, even though the sleeve indicated

a projection as specified above the deck, it would actually be riding on a high spot and the clamping action would not be satisfactory. Check for such wear with a depth micrometer or dial indicator. The counterbore depth of a WAK engine should be 0.437-0.435. If measurement shows these dimensions to be incorrect, remachine the counterbore so that the addition of a 0.004 to 0.005 shim will bring the counterbore back to proper depth.

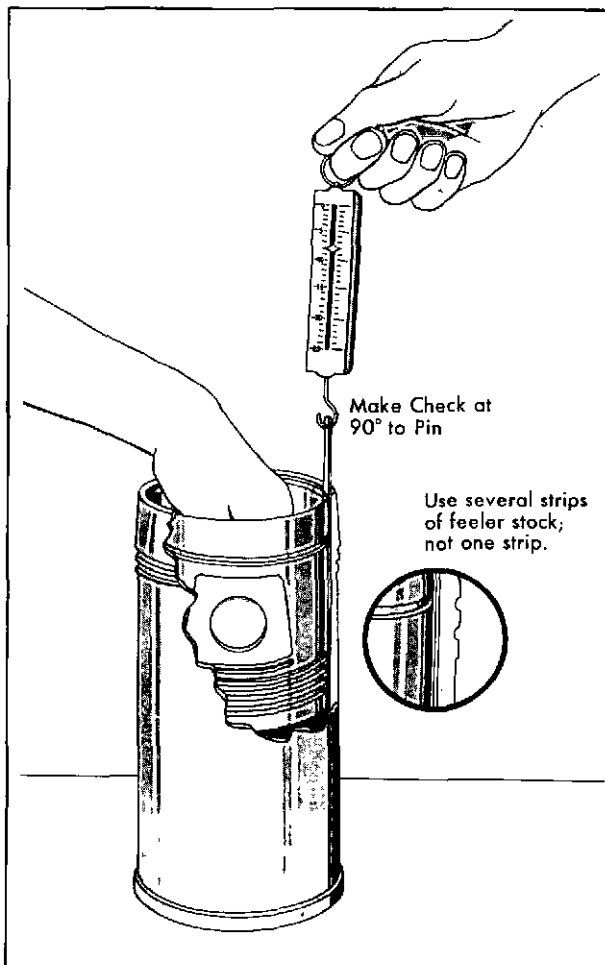
## Piston Fitting

Proper fitting of pistons requires at least four different precision checks. These are: Ring gap, ring side clearance, pin clearance in boss, and piston skirt to sleeve clearance.

Ring gaps are easily checked with a feeler gauge. Slip a piston ring into the sleeve. Slide a piston into the sleeve above it. Push the piston up against the ring to square the ring with the bore. Move the piston out of the way and measure the gap in the ring with a feeler gauge. Those rings with gaps less than specified in the table of limits in the back of this manual should be carefully dressed off with a flat cut file until the correct clearance is obtained. Contrary to popular impression, fairly wide ring gaps, near the top limit, are far less detrimental to engine performance than gaps which are too tight.

Piston ring side clearance must always be checked when fitting rings to pistons which have been in service. In this case, the object of the check is to spot any pistons in which the ring grooves may have worn excessively wide. A piston in this condition must be replaced. To check side clearance, select a piece of feeler stock of the maximum clearance specified in the table of limits. With the ring in place, insert the feeler if possible between the ring land and the ring held well back in the groove. If the feeler slides in at any point, it indicates the clearance is at or over allowable maximum. A snug fit of the feeler points to further consideration by the operator as to whether the piston warrants re-installation since the groove wear is at the top limit. On all pistons passing the above check, make an inspection for minimum clearance with a feeler of the minimum thickness specified in the table of limits. This feeler should slide freely all around the groove as the piston and ring are rotated.

Piston pin fitting is a job requiring great precision and pin and piston assemblies are usually sold in matched sets. Oversizes of 0.003" and 0.005" are available, however, if desired. The specified pin clearance will permit a hand "push"



FITTING PISTON TO SLEEVE

fit at ordinary room temperatures. Some engines with aluminum pistons, however, have been fitted with pins that cannot be pushed in by hand until the piston has been heated to about 100°F.

A pin that is loose enough to drop through the piston by its own weight, is ordinarily considered too loose. From the service standpoint, a fit of this variety, if not due to severely worn parts, will cause an engine to be somewhat noisy but will not necessarily impair performance or reduce engine life.

If oversize pins are installed, do not forget to check the fit of the pin in the connecting rod bushing since the new pin will be too snug in a standard rod.

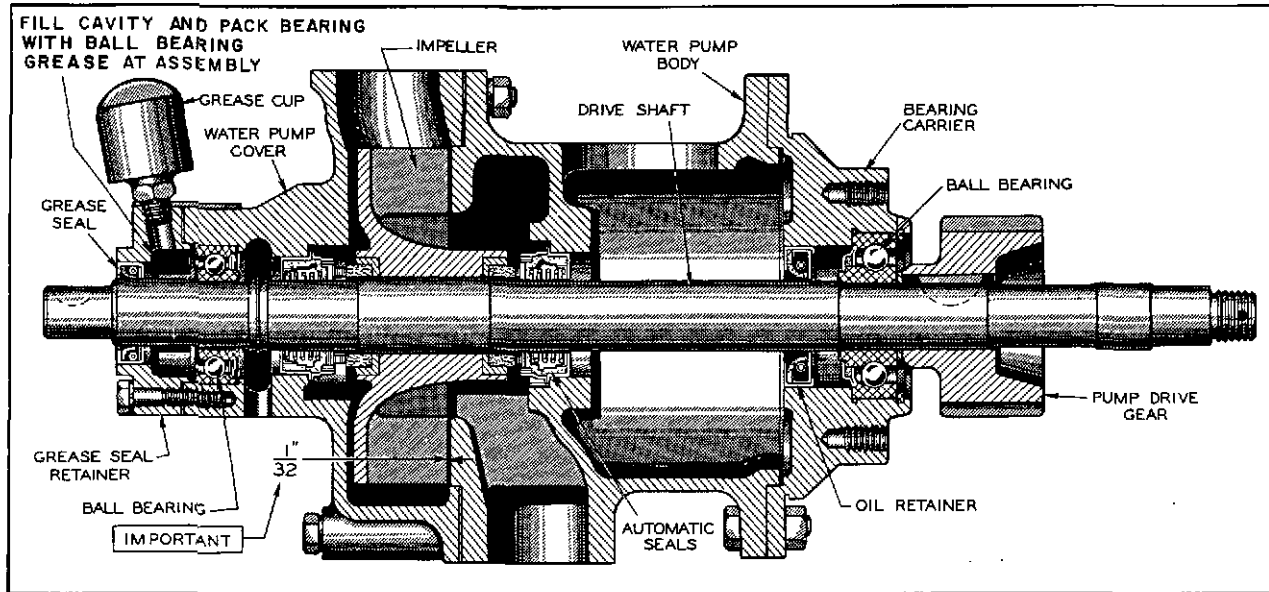
Piston to sleeve clearance is probably the most critical dimension in the entire piston fitting sequence. For this reason, pistons and sleeves are sold in matched sets. Also, pistons are sold for re-dimensioned sleeves in 0.010", 0.020",

and 0.040" oversizes. They are not sold in semi-finished condition for these engines, and it is not recommended that a piston of given oversize be re-ground to a smaller oversize.

There are several reasons for this, including such factors as the nature of the equipment required, the necessity for specialized knowledge and skill, and the characteristics of cam-ground pistons. By cam-grinding, it is meant that the piston area below the rings is not round but slightly cam shaped or "oval". The long axis of the oval is located at 90° to the piston pin. Consequently, a micrometer measurement of the piston skirt diameter along the axis of the pin will be slightly less than a measurement taken across the thrust faces. The amount of "cam" for any piston is carefully worked out to compensate for the metal mass, the engine temperature, and so on, that control piston expansion. Hence, the addition material at the piston pin bosses brings about an expansion that rounds out the piston under operating conditions.

Because of the foregoing facts, it is clear that piston skirt to sleeve clearance can only be taken on an axis 90° to the piston pin. That is, across the thrust faces. To take the clearance, select two pieces of 1/2"-wide feeler stock 8 to 10" long and totaling the desired skirt clearance. A single strip is not satisfactory because it is too stiff to conform to the curve of the sleeve bore and thus gives an erroneous reading. Attach the feeler stock to an accurate spring scale as shown in the accompanying illustration. Invert the piston and support it with one hand while holding the feeler and spring scale in the other hand. Place the feeler stock in the sleeve and lower the piston into position in such a manner that the feeler stock is spaced 90° from the piston pin. Hold the piston and withdraw the feeler stock. If the correct clearance is present, the tension required to withdraw the feeler should read 4-8 pounds on the scale. Too low or too high a scale reading indicates too much or too little clearance.

When fitting a piston to a new or accurately re-sized sleeve, the sleeve inner diameter should be the same at top and bottom. Therefore the clearance may be taken at either end. In sleeves that have been worn, but not re-sized, some taper giving extra clearance at the top of the sleeve is likely. In such cases, the clearance must be checked at the bottom of the sleeve where the wear is least and the fit is closest. Remember, the skirt of the piston fits closer than the ring lands. Check skirt, not land, clearance.



AUTOMATIC SEAL TYPE WATER PUMP, SECTIONAL VIEW

**WATER PUMP REBUILDING****Automatic Seal Type Pump**

Since the current type water pumps feature longer life ball type bearings and seals which automatically adjust and compensate for normal wear, field service, with the possible exception of grease seal replacement or grease retainer repacking, is unnecessary during the normal service life of the pumps. Also since an arbor press is required for further pump dis-assembly and repair, field repair and service is not usually attempted unless such a press is available.

For the most satisfactory pump service life after re-building, it is suggested that the Waukesha Engine Division water pump repair kits be used. These kits contain the necessary replacements for those parts which are most subject to wear and to the corrosive effects of the engine coolant.

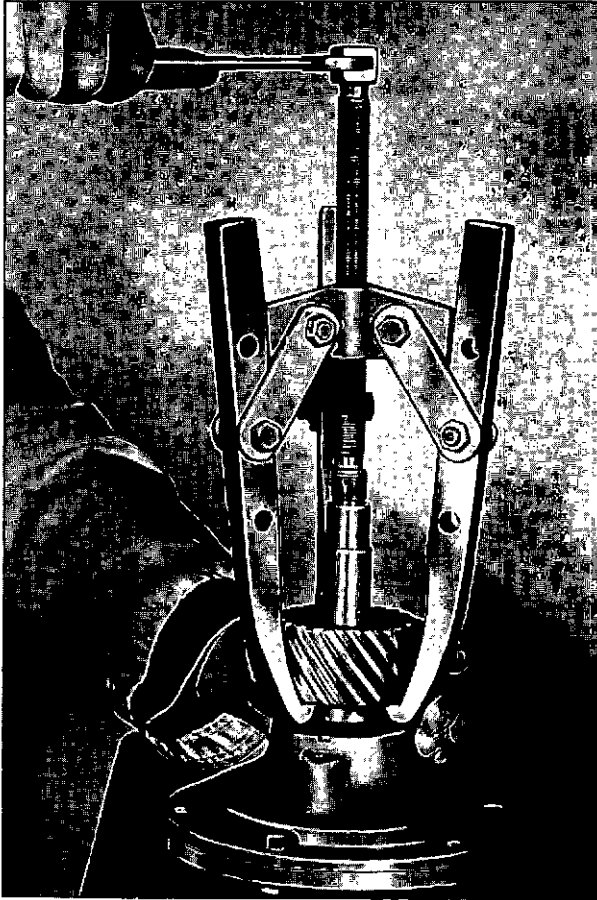
Before starting disassembly, study the sectional view of the pump carefully to become thoroughly familiar with the locations of the various snap rings, oil and grease seals, and relationships of the parts. Note particularly, that the grease shields on the ball bearings point towards each other. The shield on the forward bearing permits engine oil to lubricate the bearing but prevents it from going back farther into the pump. The shield on the rear bearing permits grease to enter the ball bearing, but prevents it from moving forward into the pump. Note also, that the lips of the two grease seals point towards the front of the pump.

The impeller is a 0.002" to 0.003" press fit on the shaft and must be properly positioned to allow for 1/32" clearance with the water pump body.

The following general outline of disassembly and rebuilding is offered as a suggestion and may be altered to suit the equipment available providing the final result is a pump assembly with the correct impeller clearance, and no damage to any of the seals. Carefully wipe the carbon or teepelite sealing surface and the mating ceramic surface with a soft cloth or absorbent paper to remove all traces of wax, grease or oil. Use a small amount of solvent if necessary. To provide for initial lubrication of the seal, apply either a 1% soluble oil and water solution or ethylene glycol type antifreeze to both of the sealing faces. Lubrication of the seal after installation is provided by the engine coolant. When using only water as the engine coolant, about 1% soluble oil should be added as a seal lubricant and cooling system corrosion inhibitor.

**Pump Disassembly**

Pump disassembly starts with removal of the pump drive gear. The gear, which is keyed to and a 0.002"-0.003" press fit on the shaft, may be removed using a jaw type puller as illustrated. If, however, a suitable puller of this type is not available the arbor press and a notched out plate may be utilized to remove the gear. If the arbor is used, position the pump in such a manner that the pump gear rests on the notched out plate on the arbor base and suspends the weight of the pump. Before attempting to press the gear off, devise some method or request additional help to hold and prevent damage to the shaft and pump assembly as they will drop as the shaft is pressed free of the gear. Examine the gear for excessive wear, pitting or chipping.



PULLING DRIVE GEAR

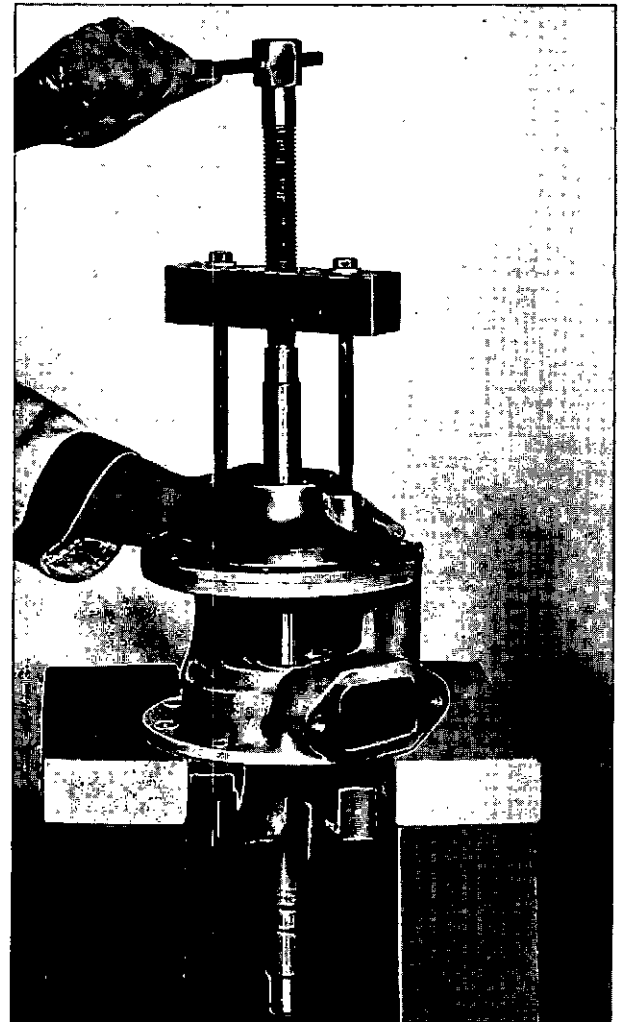
The bearing carrier is normally secured to the pump body by six capscrews which bolt these parts and the pump to the engine gear cover. Since these capscrews are removed when the pump is removed from the engine, the carrier is now secured to the pump body by the slight press fit of the ball bearing which is, in turn, locked in position by a snap ring. A simple puller, as illustrated, is utilized to break this press fit of the bearing and to pull the carrier after the snap ring is removed with a suitable snap ring pliers. Before pressing the ball bearing out of the carrier, use a dowel and hammer to knock the oil retainer out of the opposite end of the carrier. Disregard damage done to the oil retainer when removing as this part should not be re-used in the rebuilding of the pump. Place the carrier, bearing end down, on the arbor and using a dowel which will fit inside of the carrier, press the bearing out.

The grease seal retainer may be removed next. After removing the three capscrews, lightly tap the retainer to break the seal created by the grease seal and remove by hand. Remove and discard the grease seal.

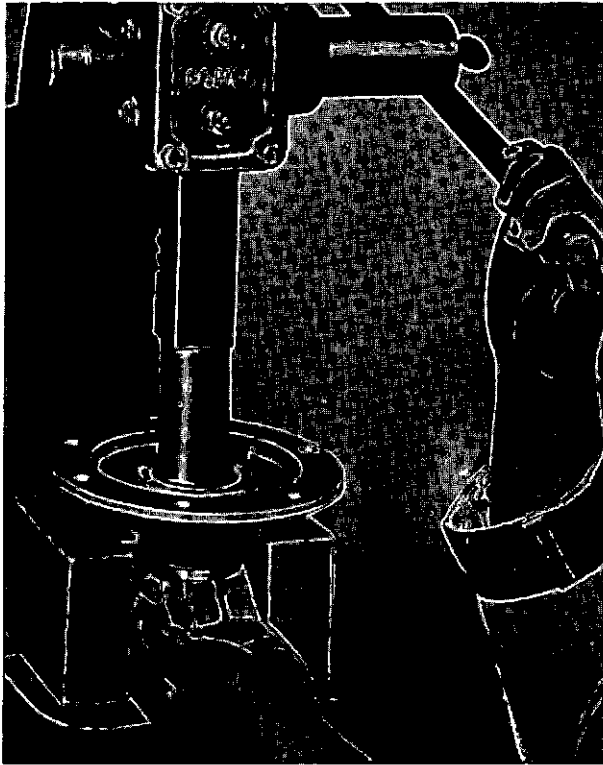
Remove the body to cover bolts and lightly press or carefully tap the gear end of the shaft until the cover separates from the body. With the body thus removed place the remaining assembly, gear end of the shaft down, on the arbor and press the shaft through the cover bearing.

Place the pump cover, grease retainer end down, and press the bearing out in the same manner used in removing the carrier bearing.

If the shaft is to be re-used, press the impeller off, again using the arbor press. The impeller ceramic insert faces were previously bonded in a special process to the impeller metal and were not therefore purchased as separate items and installed. If these impeller ceramics were worn, impeller replacement was required. Current engines utilize replaceable ceramic inserts. The grease and oil retainers, the ceramic inserts, and the automatic seals should not be re-used and should be discarded at this time to prevent re-use when rebuilding the water pump.



PULLING BEARING CARRIER



REMOVING BEARING

With the pump thus completely disassembled, inspect all parts to be re-used for unusual wear, grooves and for evidences of corrosion. Clean all parts in a suitable solvent and in the case of the bearings and drive shaft, dip them in a light oil immediately after cleaning and drying to prevent an immediate rust formation. Clean preservative materials off of new parts at this same time.

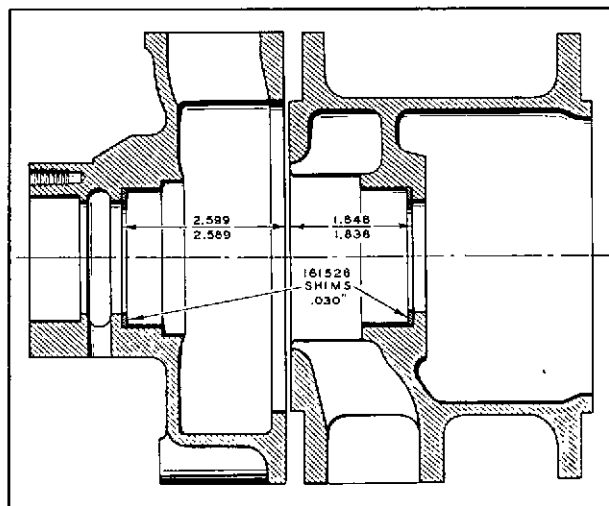
**Pump Reassembly**

Although water pump reassembly is essentially the reverse procedure of disassembly, several points important in respect to satisfactory pump rebuilding and to prolonged service life, should be noted before reassembly is started.

Adequate pressure, although not excessive pressure, is very important in obtaining a good seal between the contact surfaces of an internal seal water pump. Moreover, if the seal has only very light pressure at assembly, it is obvious that wear of the contact surfaces may cause

ultimate loss of all seal pressure before the normal service life of the parts expires. It is possible for this condition to exist on earlier WAK series pumps using the automatic seals. A modification to this seal changed the available free travel of the sealing member. Later production pumps incorporated a counterbore 0.030 shallower and thus build up a somewhat greater pressure on the seal surfaces in the impeller as well as extending the surface life substantially. To provide the same reduction in counterbore depth when rebuilding earlier pumps, use one 0.030" shim, #161526 in each counterbore before inserting the seal. The counterbore must be clean and smooth before installing these parts. The accompanying illustration shows the shims in place and the counterbore dimensions involved. It will be necessary to use a depth micrometer or machinist's scale to determine whether the pump is counterbored to the old dimensions or new. The later production dimensions are shown on the drawing. If deeper than this use the shims as shown. Current production water pumps are equipped with a different seal (see sectional view) and have reduced counterbore depth.

Installation of the impeller on the drive shaft may be the first step in water pump reassembly. Do not press on the impeller ceramic face (if applicable) as damage to the ceramic would certainly result and necessitate replacement of the impeller. Block the gear end of the shaft and, using a tube or pipe with an inside diameter slightly larger than the 1-21/32" diameter of the ceramic face, press impeller on to a distance of approximately 4-1/4" from the grease



PUMP COVER AND BODY  
COUNTERBORE DEPTH (Early Models)



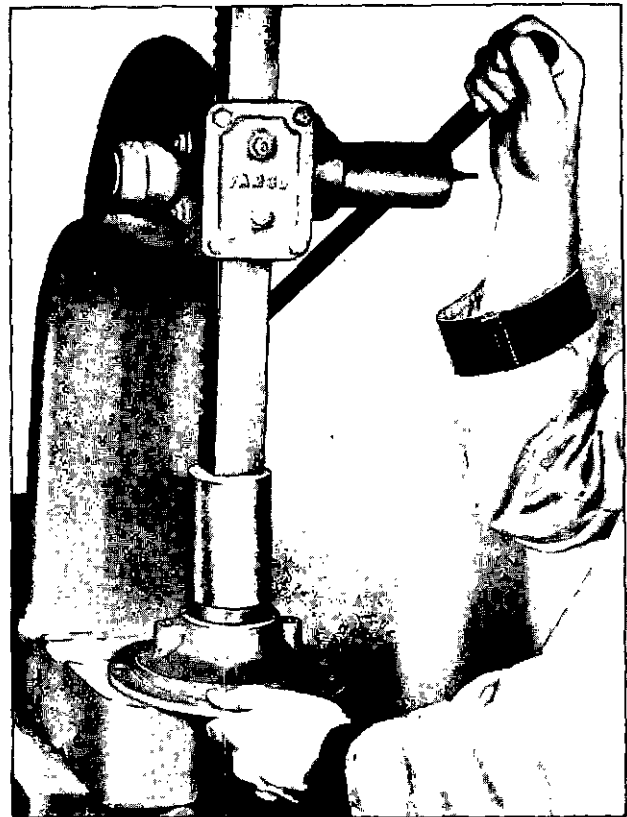
INSTALLING IMPELLER

retainer end of the shaft. This is not the final position of the impeller on the shaft but will allow further pressing which will be necessary to obtain the proper impeller blade to pump body clearance later in reassembly.

Before installing the oil seal and ball bearing in the bearing carrier, check the water pump sectional view for the proper installation of these parts. Only slight pressure is required to press these parts into the carrier. Press the bearing into the carrier recess and lock with the outer race snap ring.

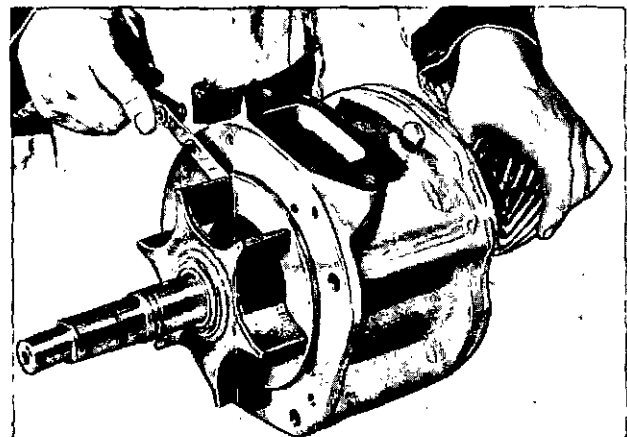
Measure the depth of the pump body automatic seal recess to determine if a shim is required. Install a shim if needed and press the automatic seal into the pump body. Place a piece of wood or other soft material between the press and the seal when installing to prevent bending the metal shield, also avoid too much pressure as this will distort the shield and may, make the seal inoperative.

Obtain several small capscrews and assemble the pump body to the bearing carrier. These capscrews will be replaced by the pump to engine gear cover capscrews when the pump



INSTALLING CARRIER BEARING

is reinstalled on the engine. Place the pump body and bearing carrier assembly, carrier end down, on the arbor base and carefully guide the assembled impeller and shaft in through the body and carrier seals and bearing. Press the shaft into the assembly until the shaft flange firmly contacts the inner race of the carrier bearing. Caution should be used at this point as excessive pressure on the arbor could cause the bearing races to mis-align.

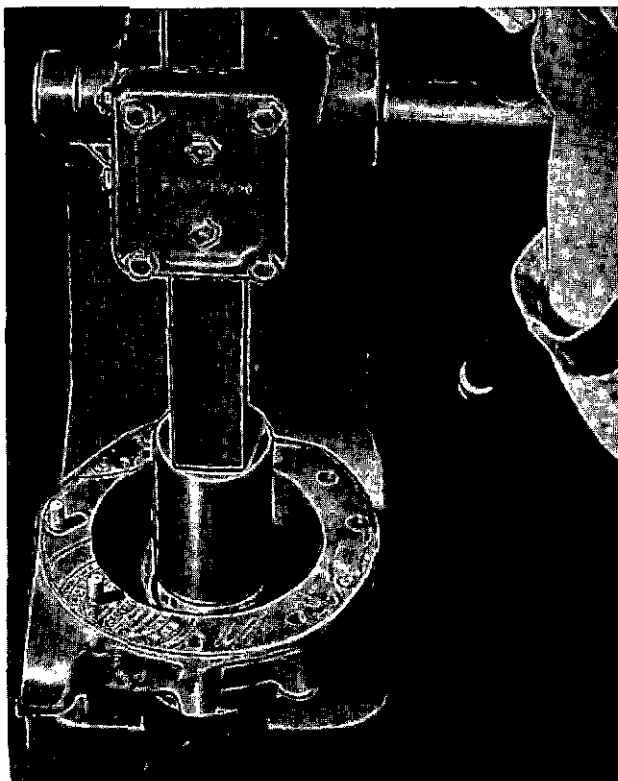


IMPELLER TO BODY CLEARANCE

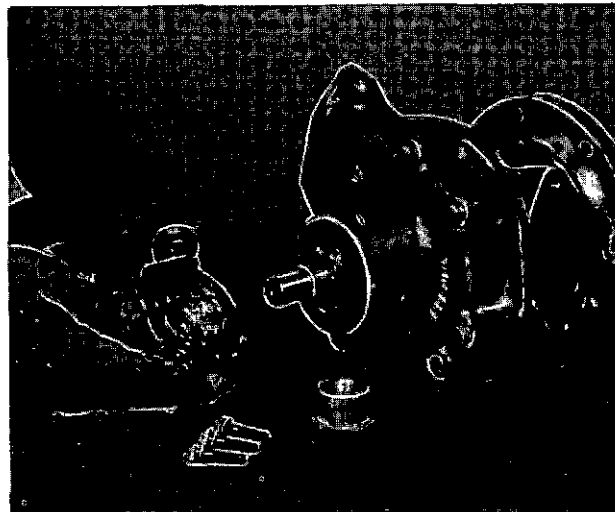
Although several methods could be employed to re-install the gear on the drive shaft, the most common method will be described. Place the gear on the arbor base and after installing the gear spacer and the woodruff key on the shaft, press the shaft and pump assembly into the gear until the gear fits securely against the spacer. Although the gear is a 0.001" press fit on the shaft, considerable force may be required to overcome this fit plus the action of the woodruff key.

The pump shaft is now properly positioned and held by the snap ring and the press fit of the gear against the carrier ball bearing races. With the shaft thus positioned the impeller to body clearance can now be properly established. Using the same method as previously employed, press the impeller further on the shaft to the point where 1/32" clearance is obtained between all the impeller blades and the pump body.

Press the cover bearing, which is a light press fit, into the pump cover recess. Again using the same method employed when installing the automatic seal in the pump body, press the cover automatic seal into position in the cover recess.



PRESSING SEAL INTO PUMP COVER



PACKING GREASE RETAINER AND BEARING

After installing the cover gasket on the body flange, position the cover on the pump assembly and draw the cover down by tightening the stud nuts and capscrews.

Pack the grease retainer and the ball bearing with a good grade of ball and roller bearing grease. After pressing the grease retainer seal in position and repacking the grease retainer, re-install the retainer and tighten the three retainers to pump cover capscrews to complete the reassembly of the pump.

Check the pump for freedom of movement and, if possible, pressure check for leakage before reinstalling the pump on the engine.

#### Installing Water Pump

The procedure for installing a water pump is essentially the reverse of the removal sequence. As the drive gear is brought into mesh with its mating gear in the front housing, it may be found helpful to rotate the pump impeller slightly to align the teeth. This is easily done through the water outlet opening on the upper side of the pump. The pump bearing carrier will seat down squarely against the mounting face on the crankcase when the gears are meshed and the forward end of the shaft is piloted into the shaft support on the gear cover.

On engines that have an accessory drive pulley mounted on the water pump shaft, an out-rigger bearing is used to provide additional support on the shaft end. When this bearing is replaced or the water pump is removed, care

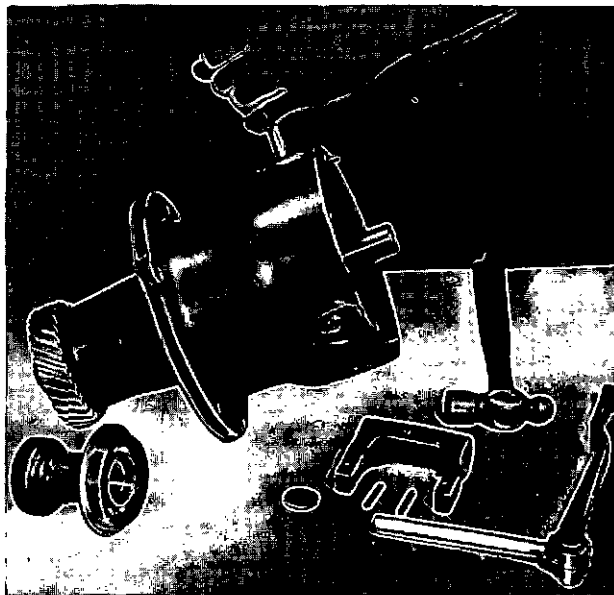
must be taken to properly align the water pump and the outrigger bearing. The bearing is held in place by a retainer that is doweled to the gear case. For re-alignment purposes these dowels can be removed, the holes drilled to a larger size, and new dowels put in place. Use a dial indicator on the end of the shaft to check the alignment.

Any lack of squareness in the seating should be investigated and corrected since it may cause serious trouble later in attempting to align the magneto. A new gasket should be used and the gasket surface must be clean and even. Realign the magneto after installing the water pump.

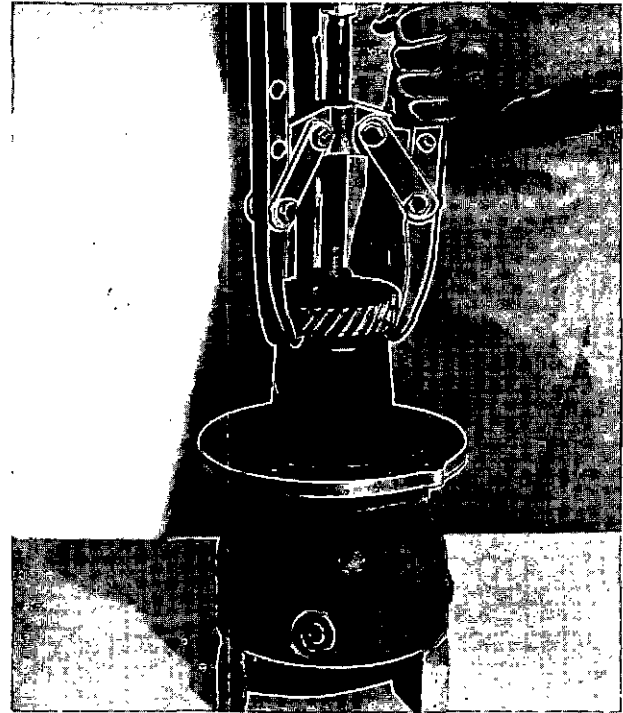
#### DISASSEMBLY OF THE MECHANICAL GOVERNOR

A gear puller and arbor press are needed for disassembly. Careful workmanship should be used to minimize damage to the various parts. With the governor off the engine, the oil line on the side of the governor should be removed and any oil left in the housing allowed to drain out.

Remove the five capscrews on the cover of the governor and separate the cover from the housing. Using a punch of a slightly smaller diameter than the roll pin, drive the shifter arm roll pins out. Slip the lever shaft, shifter arm and thrust bearing assembly out. Note that one of the lever shaft bearings has an expansion type seal covering it. Using a hammer and a



KNOCKING OUT BEARING



REMOVING DRIVE GEAR

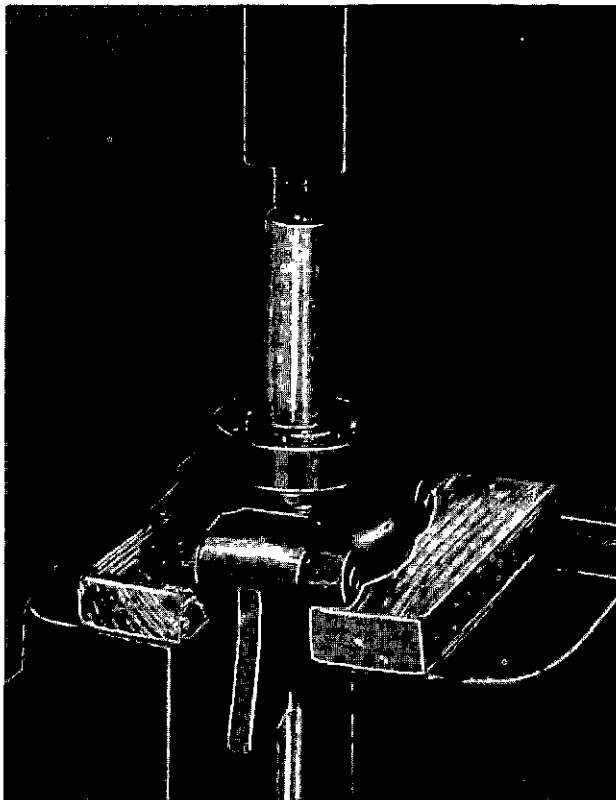
dowel (7/16" dia.) knock this seal out. The bearing can now be removed. These bearings are a press fit in the housing so care must be taken when installing new bearings to insure a proper fit.

Break the nut loose on the gear end of the governor shaft and with a gear puller, pull the gear off as shown. If a gear puller is not available, the arbor press and a notched out plate may be utilized to remove the gear. If the arbor press is used, position the governor in such a manner that the governor drive gear rests on the notched out plate on the arbor base and suspends the weight of the governor.

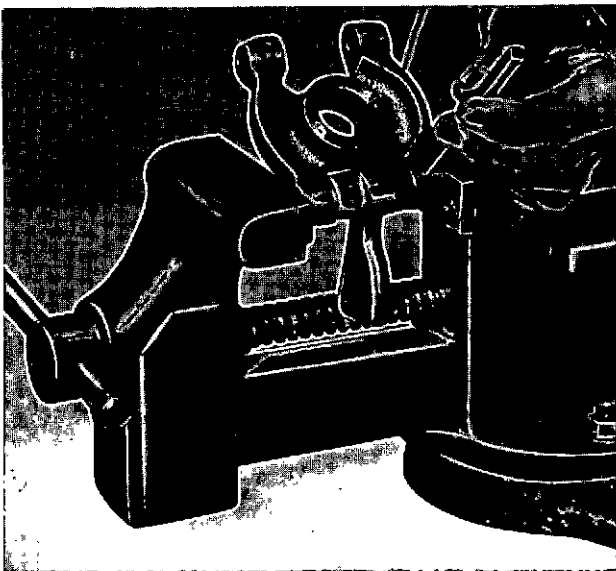
**CAUTION:** Before attempting to press the gear off, devise some method, or request additional help, to hold and prevent damage to the governor as it will drop as the gear is pressed free of the shaft. Examine the gear after removal for excessive wear, pitting or chipping.

Support the governor as shown and press the shaft from the housing. There is a second snap ring in the area of the oil return holes in the casting. It is not necessary to remove this snap ring as it will support the bearing while pressing the shaft out.

After the shaft has been removed, use a wooden dowel and tap the outer bearing from the housing.



REMOVING FLYWEIGHT ASSEMBLY



REMOVING ROLL PINS

Support the shaft as shown and press the flyweight carrier assembly, spacer, and bearing off the shaft. Hold the flyweight assembly in a vice. Use a punch of a smaller diameter than the roll pins and drive them out so the flyweight shaft can be removed.

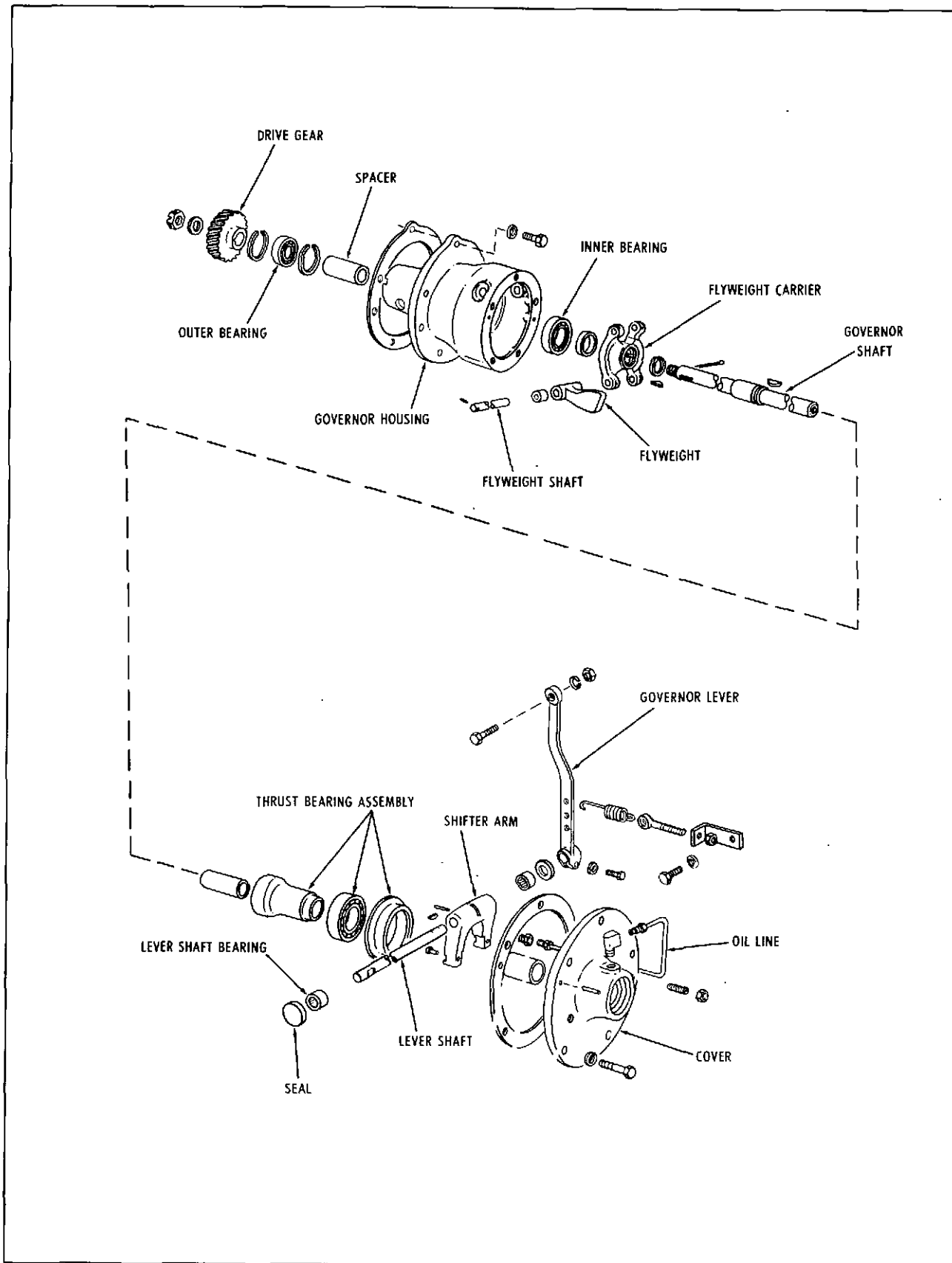
When replacing the governor flyweight shaft in the flyweight carrier assembly, replacement governor flyweight shafts are not drilled for roll pins. These holes should be drilled through the shaft on the end marked "S", indicating soft.

It is advisable to inspect carefully all the working parts for any signs of excessive wear and replace them as necessary to insure proper functioning of the governor. Also, careful cleaning and oiling of all the parts during reassembly will insure proper lubrication upon engine startup.

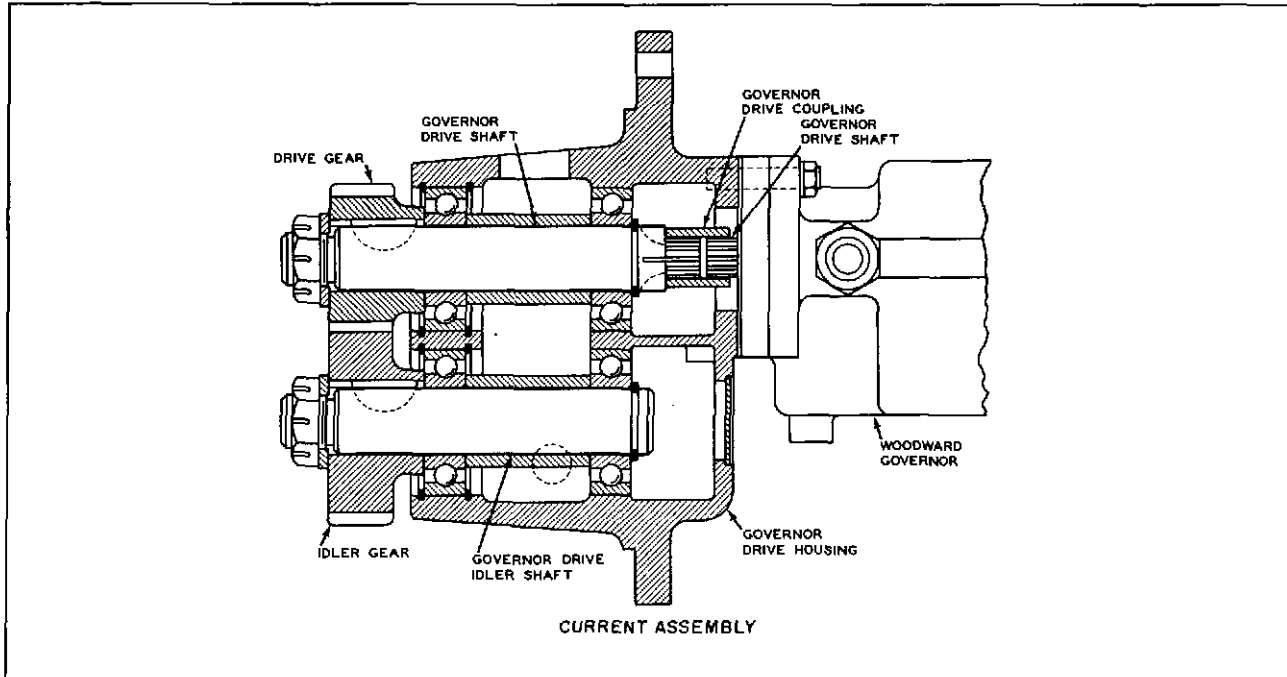
Reassembly is basically the reverse of the foregoing. It is assumed that for reassembly all worn parts have been replaced. Before pressing the flyweight carrier assembly on the shaft, align the assembly with the woodruff key. Press the assembly on the shaft up to the snap ring. Slip the small spacer on next to the flyweight carrier and press the bearing up to the spacer. Install the inner snap ring in the housing. Put the second bearing in the end of the governor housing and press it flush with the snap ring. The outer snap ring should now be installed to hold the bearing in place. Place the long spacer on the governor shaft and insert it into the governor housing cavity. Take care to align the shaft with the outer bearing before pressing it in place. The governor should be placed on the notched out plate in the arbor press.

**CAUTION:** While pressing the shaft, position it as near to vertical as possible so as not to cock the shaft on the bearing.

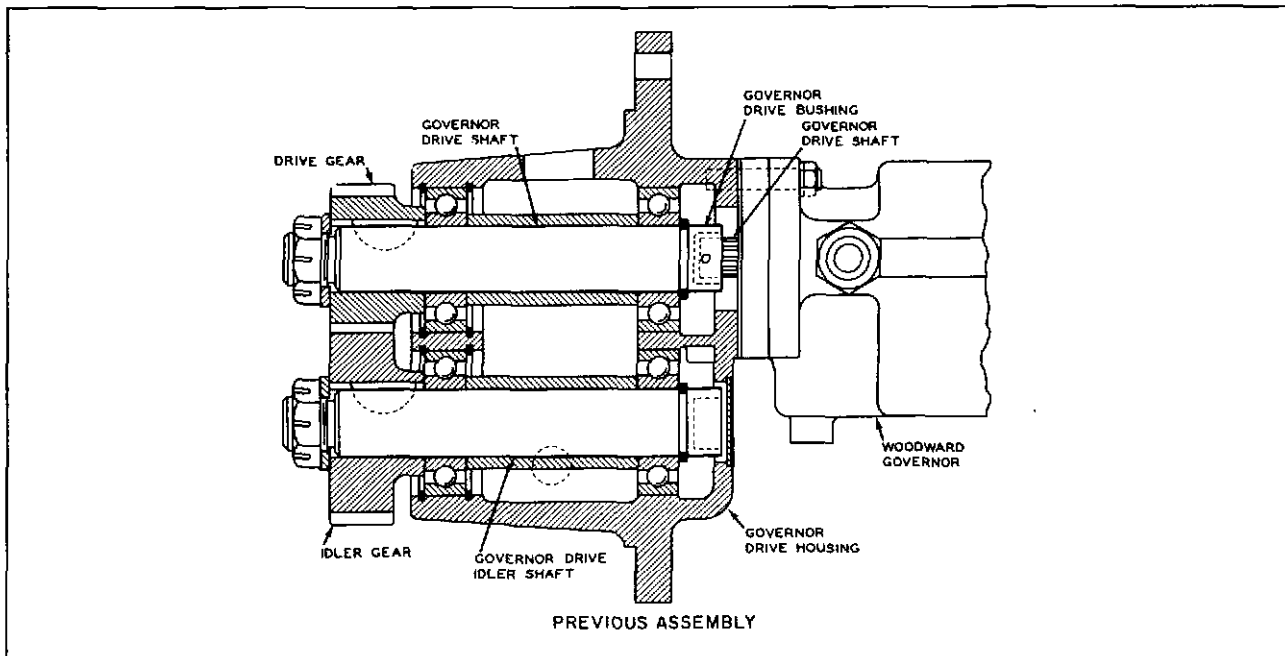
Press the assembly tightly together as there are no clearances to be held. Press the gear on the shaft, shoulder toward the housing. To tighten the nut on the shaft, clamp the gear in a vice between two wooden blocks and snug up the nut. Place the thrust bearing assembly on the shaft and position the flyweight lifting arms under the shifter body. Slip the governor lever shaft into the housing and at the same time, through the shifter arm. Pin the shifter arm to the lever shaft with roll pins. Install a new gasket on the end of the housing. Notch the gasket so the dowel pins can line up the cover and bolt the cover snugly in place. Check the cover while tightening it down for any distortion that would result in the gasket leaking. Remount the governor on the engine and connect the linkage. Consult the service section of this manual for resetting the mechanical governor.



GOVERNOR (MECHANICAL TYPE)



CURRENT GOVERNOR DRIVE ASSEMBLY

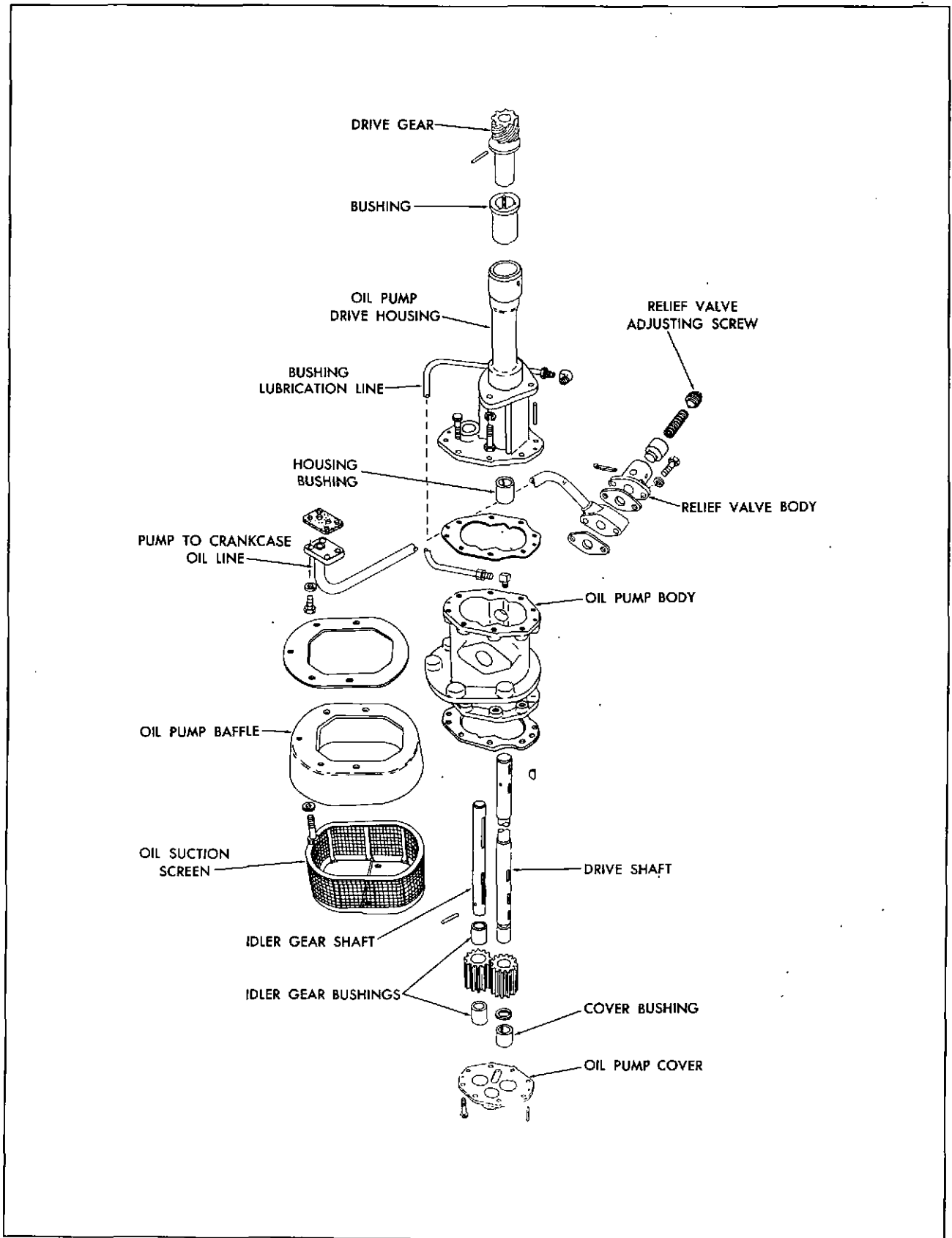


PREVIOUS GOVERNOR DRIVE ASSEMBLY

GOVERNOR DRIVE ASSEMBLY

The current governor drive assemblies now being used on the WAK and F-1197-G series engines are designed to eliminate wear on the governor drive shaft spline. These new assem-

blies incorporate a splined drive coupling as shown in the illustration. Parts of either the current or previous assemblies are not interchangeable because of the obvious difference in internal components; however, these assemblies are interchangeable as a complete unit.



PRESSURE OIL PUMP, EXPLODED VIEW

**OIL PUMPS**

The lubricating oil pumps used on the WAK Series engines are all of the spur gear type. The exact size, drive method, and design of a given pump depends upon the engine application and the oil pan design. Ordinarily, only a pressure pump is used, but where the engine may be subjected to angular operation a scavenger pump is available.

In all cases, the pumping action is obtained from a pair of precision gears running together within a closely fitted housing. Since the oil is carried from the inlet side to the pressure side of the pump in the pockets formed between the pump walls and the gear teeth, it is plain that clearances must be correct in this area. Hence, the use of gaskets of incorrect thickness when inspecting or repairing the pump may lead to trouble. Also, foreign material such as hard carbon, bits of broken cotter pins, lock wire, and so on will ruin the pump if allowed to run through the gears.

For the above reasons, as well as for the sake of the engine in general, the pumps are all provided with a so-called "diving bell" oil level equalizer and a screen. The level equalizer helps maintain an air-free supply of oil at the pump inlet regardless of engine movement. Together with the screen, this unit protects the engine against poor lubrication. Removal of the screen followed by a thorough cleaning and replacement is recommended at intervals determined by experience with the service and oil involved.

Oil pump drives of the spiral gear type, actuate the pumps from the camshaft through a shaft running in bronze bushings at each end of the pump casting. The pump drive gear in turn rotates the mating driven gear which runs on an idler shaft supported at each end by bronze bushings. Oil pressure control is maintained by a conventional piston-type, spring-loaded, pressure relief valve located in the main oil header and adjustable from the outside of the engine. A second pressure relief valve integral with the oil pump is set at a pressure higher than the external valve and is not intended for service adjustment.

**OIL PUMP REPAIR**

Since the oil pump is internally mounted the oil pan must be removed before any repairs can be made to the oil pump. The drive gear keyed to the drive shaft while the idler gear rotates freely on the idler shaft which is pinned to the pump cover.

The following information is for inspection or rebuilding of the oil pump.

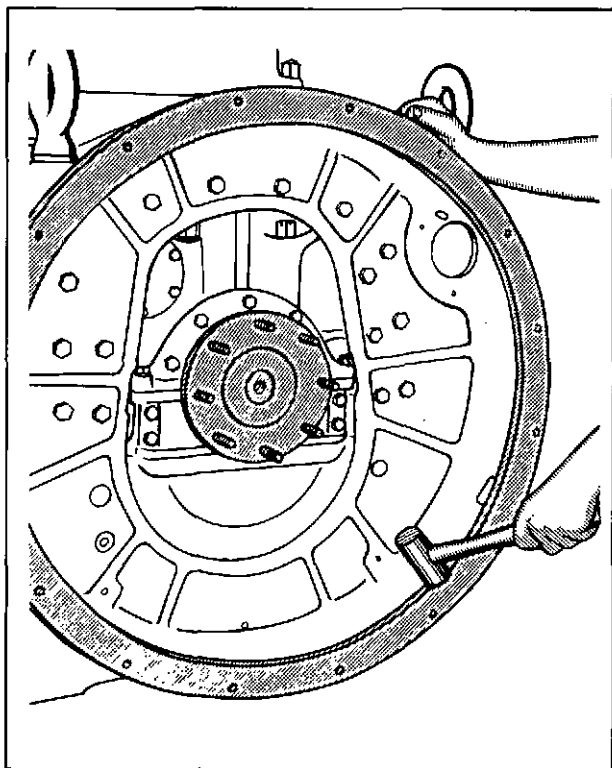
1. The drive shaft at running surfaces is 0.7495" to 0.750" and the drive shaft bushings should be line reamed to 0.751" to 0.752" (cover) and 0.753" to 0.754" (housing).
2. The idler shaft diameter at running surfaces is 0.622" to 0.6225" and the idler gears should be line reamed to an inside diameter of 0.6235" to 0.6245".
3. The drive housing upper end bushing should be line reamed to an inside diameter of 1.126" to 1.127".
4. Maximum drive shaft end play is from 0.005" to 0.010".
5. Correct radial clearance between the pumping gears and the pump chamber walls is 0.003" to 0.004".
6. Spiral drive gear backlash is 0.002" to 0.0105" and backlash for the idler gears is 0.012" to 0.015".
7. Correct gasket thickness is 0.008" to 0.010".

**FLYWHEEL AND FLYWHEEL HOUSING ALIGNMENT**

A major factor in obtaining long service life from any engine and clutch or power take-off assembly is the proper alignment of the flywheel housing, flywheel, and pilot bearing bore. Distortion or lack of a common center on either of these parts will set up forces sure to be destructive to bearings, crankshaft, clutch, and the driven equipment. In addition, because of normal manufacturing tolerances, when an engine is installed in a mounting formerly occupied by another engine, it is not safe to assume that the drive shaft of the power take-off will automatically line up with a coupling located for the previous engine. In such circumstances, either the engine mounts must be shimmed or adjusted or the driven mechanism must be re-located and adjusted a few thousandths to bring the entire drive line from crankshaft bearings to driven shaft coupling into good alignment.

Distortion or misalignment of the flywheel, housing, or both may occur because of a number of reasons, even though the alignment is carefully checked before the engine leaves the factory. Some of these reasons are listed below.

1. Rough handling in shipping or storage. Jolting and roughness in railway shipment will definitely cause this trouble.



ALIGNING FLYWHEEL HOUSING

2. Improper loading or unloading techniques. The use of fork trucks, lift trucks, bulldozers and similar equipment to bump or skid an engine from a freight car or truck, or for pushing in a warehouse or on a loading dock is a common source of misalignment trouble.
3. Dropping, sliding violently down skids, tipping the engine on end for repair work, prying against wheel or housing with bars, or uneven mounting surfaces during operation will also produce misalignment.
4. Removal of the flywheel, the housing, the crankcase, the oil pan, or the crankshaft for service and maintenance operations always introduces the possibility of misalignment.

#### Flywheel Housing Mounting

The machined contact surface of the flywheel housing mounts on the machined rear surface of the oil pan and crankcase. In order to provide a perfectly flat surface for the housing it is very important that the rear surface of both pan and case be in perfect alignment and flush with each other. To check this, lay a steel straight edge across both surfaces and sight towards a light.

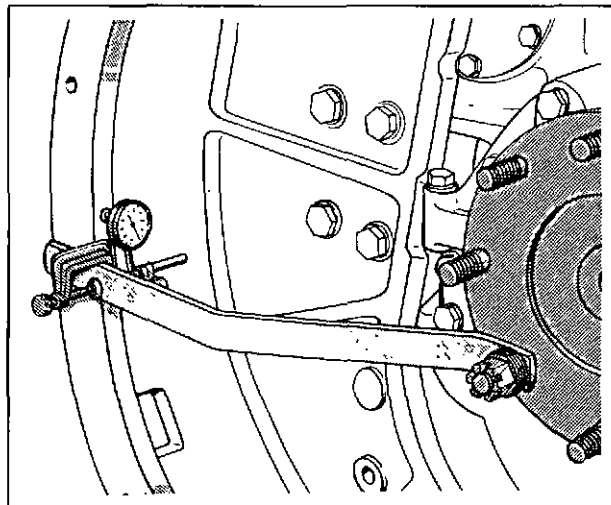
The straight edge should show even bearing and good contact on both surfaces over the entire surface.

Before installing the flywheel housing, use a straight edge to check the housing rear surface for high spots around the bolt holes and burrs or pick ups that might prevent accurate seating. Dress these off if found. When the housing has been installed and the bolts snugged up just enough to hold it in place make the following check for concentricity before installing the dowels.

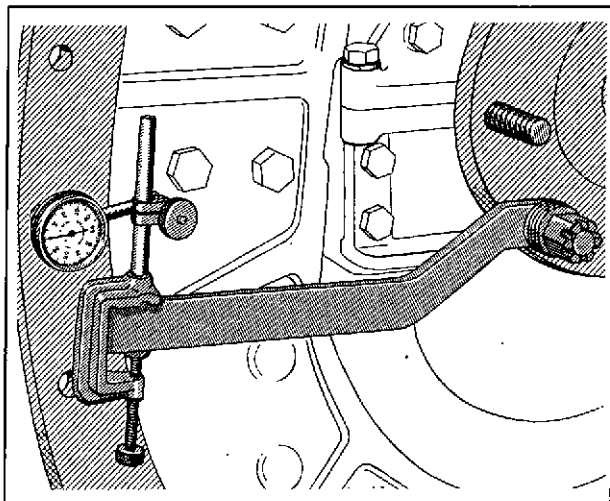
1. Support a dial indicator in the same general manner as shown and check the run-out of the housing bore all the way around.
2. Use a soft-face hammer as shown to correct mis-alignment until the run-out does not exceed 0.010 total indicator reading.
3. Tighten bolts partially, working back and forth across the housing. Re-check with dial indicator.

After tightening bolts to final tension, re-locate the dial indicator as shown to indicate the flywheel housing face

1. Housing face run-out should be confined to 0.010 or less. Although under emergency conditions it may be possible to correct minor distortions by means of a block of hard wood and a hammer, this procedure is definitely not recommended as good operating practice. If correction is required, it should be done with a cutting tool mounted on a radius arm and firmly attached to the



CHECKING HOUSING BORE RUN-OUT



CHECKING HOUSING FACE RUN-OUT

flywheel or flywheel flange. Thus, by rotating the crankshaft by means of a suitable drive the cutting tool will dress the housing face into a plane in alignment with the crankshaft flange.

2. When making the above inspection it is very important not to be misled by end

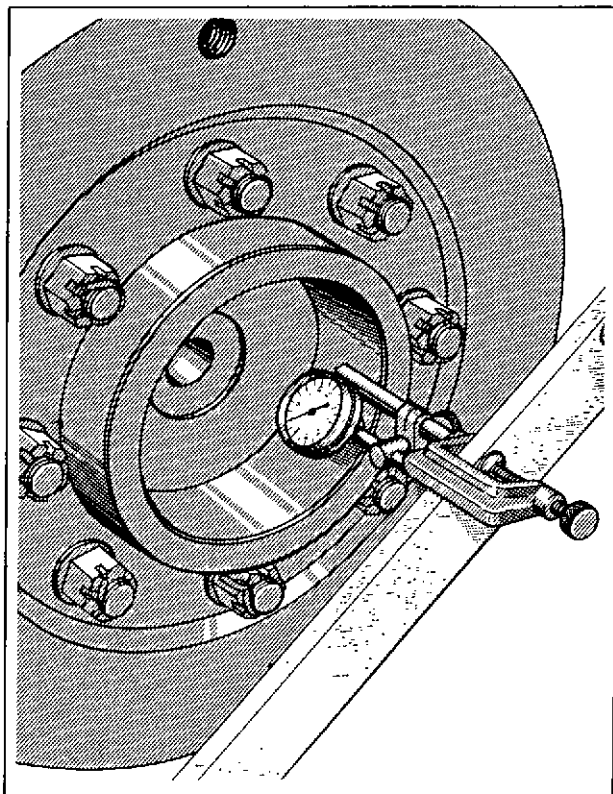
movement of the crankshaft. To prevent this, use a pry bar to bring the shaft into full forward position at each point where the indicator reading is taken. Do not pry against the housing or crankshaft flange.

3. Before starting the dressing operation, check to make certain the housing bolts are snug and the dowel holes are aligned.

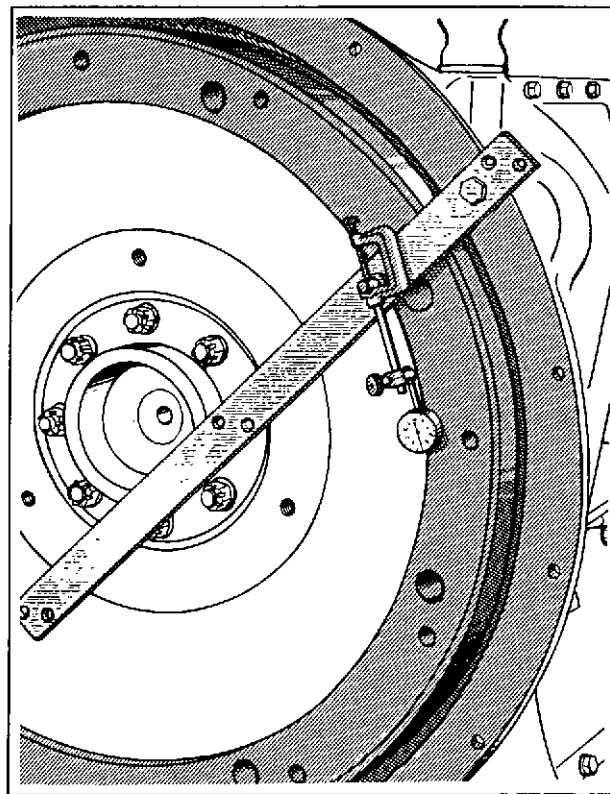
Unless the dowel holes are in perfect alignment, it will be necessary to ream them for an oversize dowel or re-drill and ream in a new location. Do not force the dowels into a misaligned hole since this will definitely spoil the alignment job. If the bolts and dowels are not snug, the tool may cause the housing to shift during the cutting operation and this, of course, will produce a very unsatisfactory job.

As with the flywheel housing, the mounting surface of the flywheel and the crankshaft flange must be free of burrs and conditions which would prevent accurate seating.

1. The drilling of the flywheel holes prevents the wheel from being located improperly.



CHECKING PILOT BEARING BORE



CHECKING FLYWHEEL FACE RUN-OUT

With the aid of adequate hoisting equipment, lift the wheel and align the offset hole so the wheel mounts on the flange.

2. Use a torque wrench to apply the correct tightening value to all bolts evenly, working across the wheel from one to another in several stages. Refer to the table of tightening torque values in the back of this manual.

Mount a dial indicator on a bar extending across the flywheel housing and check the run-out of the pilot bearing bore as shown. Run-out should not exceed 0.005".

Re-mount the dial indicator as shown to measure the run-out of the flywheel face. Again, it is emphasized that each reading must be taken with the crankshaft moved all the way forward to contact the thrust ring. Maximum run-out should not exceed 0.013".

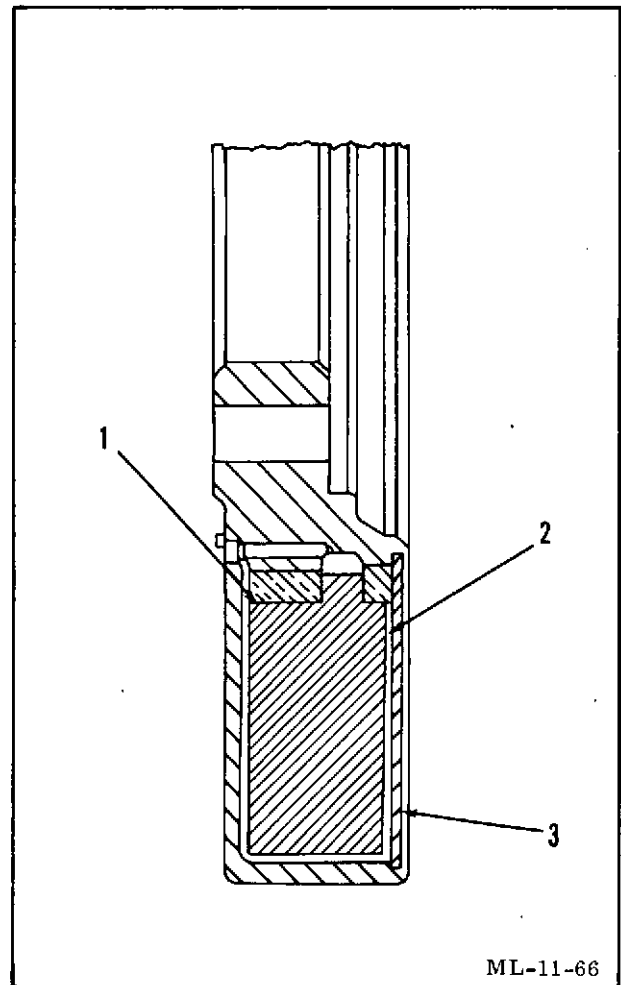
If inspection does not reveal any other reason for excessive run-out, it will be necessary to mount a cutting tool on the wheel and face off the housing slightly to bring the two surfaces into the correct relationship. Machining of the housing bore may also be accomplished at this time if needed.

#### CHECKING VISCOUS VIBRATION DAMPER RUNOUT

A viscous damper is constructed of a solid cast iron weight (1) (see illustration) enclosed in a metal case (3). The small space (2) between the case and weight is filled with a viscous fluid which permits the iron weight to move within the case to counteract the vibrations of the crankshaft.

The accompanying graph provides data covering the permissible radial and face runout of various sizes of viscous vibration dampers. By keeping runout within limits, considerable engine vibration can be eliminated, thus limiting the possibility of serious vibration damage to the engine. Vibration damper runout is checked at the factory during assembly, but when replacing a damper, the runout should be checked after mounting.

Position the damper with the mounting bolts and tighten bolts evenly to the specified torque. Now check the face runout of the replacement damper.

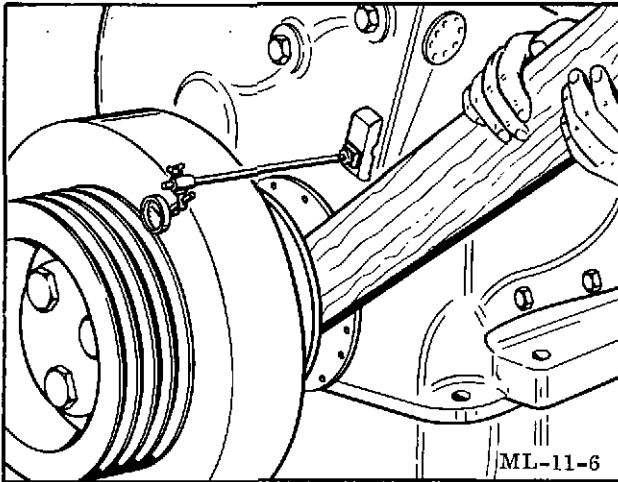


TYPICAL VISCOUS VIBRATION DAMPER CROSS SECTION

Mount the base of a dial indicator on the front of the crankcase and place the indicator button on the face of the damper at the outside edge. Then, by barring the engine over, it is possible to observe the indicator reading. NOTE that the chart gives the permissible runout as the TOTAL indicator reading. To avoid introducing crankshaft end play into this reading, the crankshaft must be forced either rearward or forward (but always in the same direction) against the thrust bearing at each point of reading.

Should the damper face runout be excessive shift the damper 90 degrees on the crankshaft and try again. If this does not reduce the runout sufficiently, remove the damper and check the crankshaft mounting surface. It may be necessary to mount the damper in a lathe and check the damper itself.

The graph may be used when the diameter of the damper is known. Locate the diameter of the damper along the horizontal axis and then



CHECKING VIBRATION DAMPER  
FACE RUN-OUT

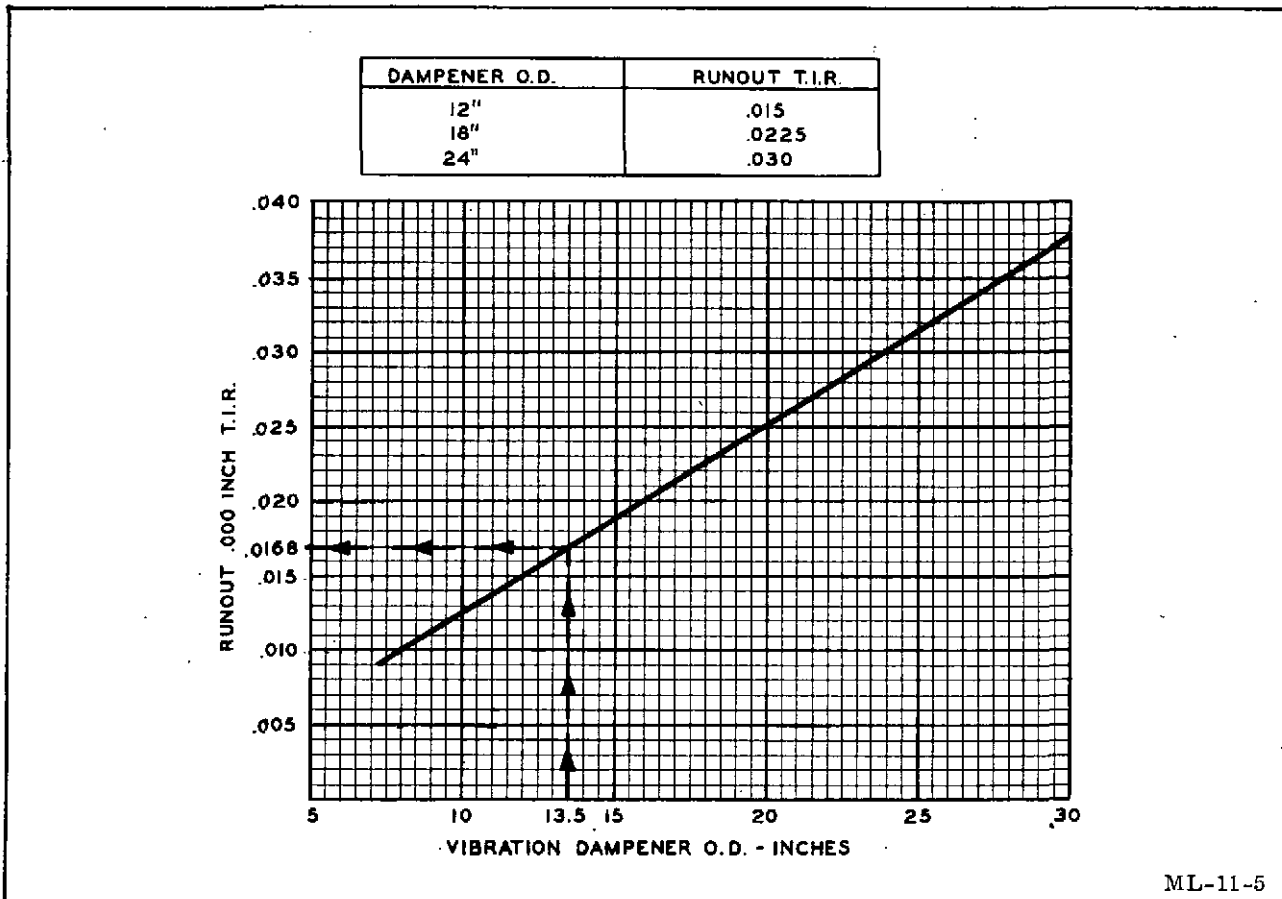
follow up the graph to the diagonal line. Now move across the graph to the vertical axis to read the permissible runout. For example, for a 13.5 inch diameter damper the runout should be less than .0168 inch.

**CAUTION**

A true running damper does not indicate the quality of the damper. The quality can only be determined by test. A damper manufactured by Houdaille Industries, Inc. can be returned to their factory for testing. However, they can only determine that the damper is good at the time of test and cannot assure possible service life. There is a service charge for the test. The Waukesha Engine Division recommends that a viscous damper be replaced at major overhaul periods.

**STARTING ENGINE REPAIR AND OVERHAUL**

In those instances where information is required regarding overhaul of the ICK starting engine sometimes used on the WAK Series, refer to the manual "Operators Manual, Waukesha Model ICK, F-1585".



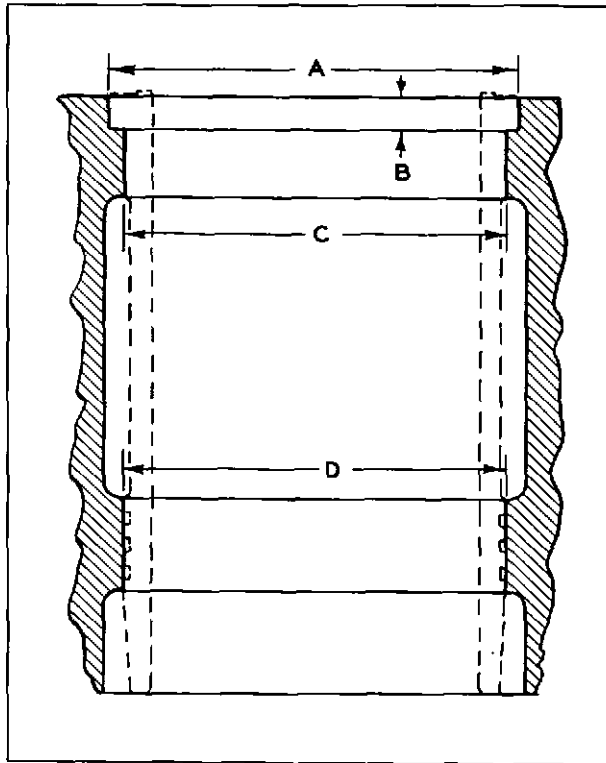
GRAPH FOR OUTSIDE DIAMETER OTHER THAN SPECIFIED

GENERAL TORQUE VALUE RECOMMENDATIONS

The values specified below are to be used only in the absence of specified torquing instructions and are not to be construed as authority to change existing torque values. A tolerance of  $\pm 5\%$  is permissible on these values.

HEAT TREATED MATERIAL SAE GRADE 5 & GRADE 8				
THREAD SIZE	SAFE TORQUE (LB-FT.) (Multiply by 12 for inch pounds)			
	GRADE 5 (3 radial dashes on bolt or cap screw head)		GRADE 8 (6 radial dashes on bolt or cap screw head)	
	DRY THREADS	OILED THREADS	DRY THREADS	OILED THREADS
1/4-20	8	6	12	9
1/4-28	10	7	14	11
5/16-18	17	13	24	18
5/16-24	19	15	27	21
3/8-16	31	24	44	34
3/8-24	35	27	49	38
7/16-14	49	38	70	54
7/16-20	55	42	78	60
1/2-13	75	58	105	82
1/2-20	85	65	120	90
9/16-12	110	84	155	120
9/16-18	120	93	170	132
5/8-11	150	115	210	165
5/8-18	170	130	240	185
3/4-10	270	205	375	290
3/4-16	295	230	420	320
7/8-9	395	305	605	455
7/8-14	435	335	670	515
1-8	590	455	905	695
1-14	660	510	1030	785
1-1/8-7	795	610	1285	990
1-1/8-12	890	685	1440	1110
1-1/4-7	1120	860	1820	1400
1-1/4-12	1240	955	2010	1550
1-3/8-6	1470	1130	2380	1830
1-3/8-12	1670	1290	2710	2085
1-1/2-6	1950	1500	3160	2430
1-1/2-12	2190	1690	3555	2730
1-3/4-5	3075	2370	4980	3810
2-4-1/2	4620	3550	7480	5760





TYPICAL SECTION THROUGH CRANKCASE

**CRANKCASE**

Crankcase main bearing journal  
bore . . . . . 4.5000" - 4.5007"

**PISTON PIN**

Piston pin diameter  
Red . . . . . 1.8743" - 1.8744"+  
Blue . . . . . 1.8745" - 1.8746"  
Piston pin length . . . . . 5.475" - 5.485"

Piston pin fit: Pin selected (color) to provide a loose fit at normal room temperature. . 0.0003" - 0.0005"

**PISTON**

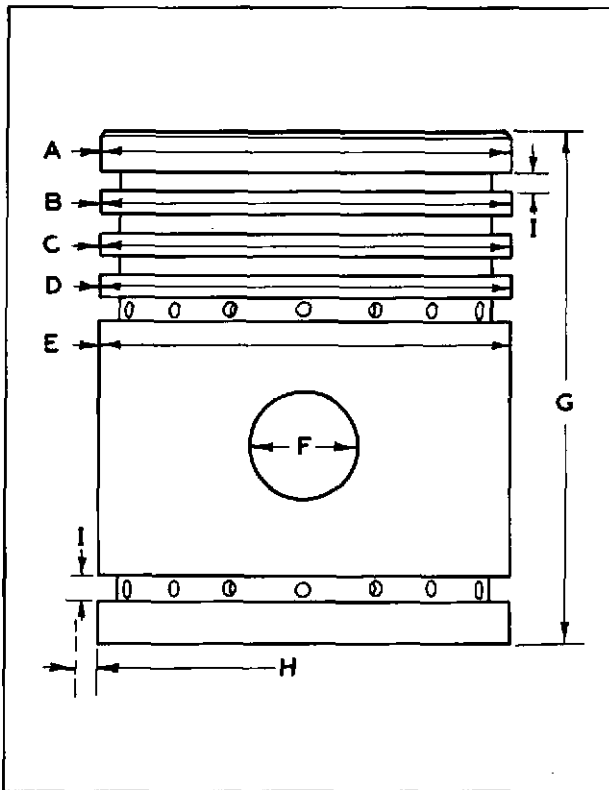
Piston material . Tin plated aluminum alloy  
Piston type . . . . . Cam ground  
Piston fit: Use three strips of 0.003" feeler 1/2" wide. Feeler must pull out with four to eight pounds pull.  
Pistons are removed from . Top of crankcase  
Permissible weight variation . . . One ounce

(PISTON LAND TO CYLINDER SLEEVE BORE CLEARANCE)

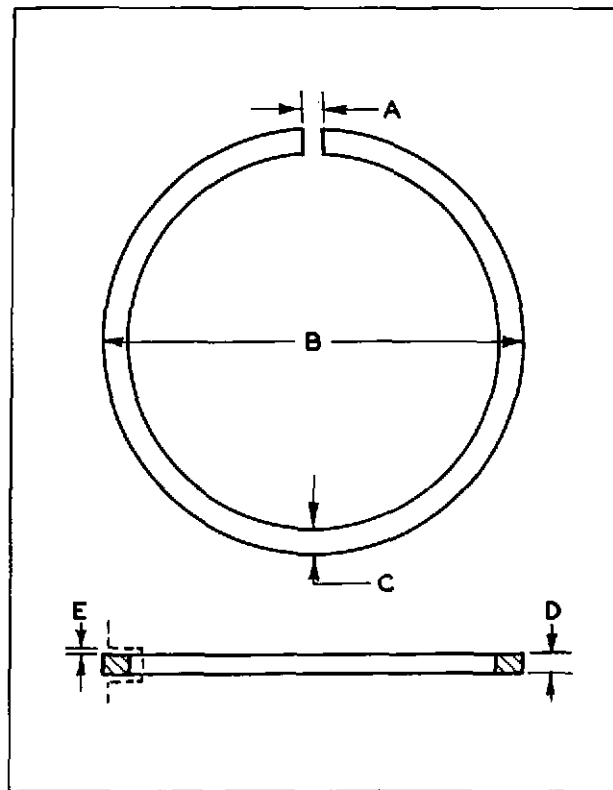
	Land dia.	Sleeve bore dia.	Clearance		
(A) Top land . . . . .	6.204" - 6.208"	6.2503"-6.2508"	0.0423" - 0.0468"		
(B) 2nd land . . . . .	6.217" - 6.221"	6.2503"-6.2508"	0.0293" - 0.0338"		
(C) 3rd land . . . . .	6.217" - 6.221"	6.2503"-6.2508"	0.0293" - 0.0338"		
(D) 4th land . . . . .	6.217" - 6.221"	6.2503"-6.2508"	0.0293" - 0.0338"		
(E) Piston skirt diameter (Bottom thrust) . . . . .			6.2412" - 6.2417"		
(F) Piston pin hole bore . . . . .	Red . . . . .		1.8747" - 1.8748"+		
	Blue . . . . .		1.8749" - 1.8750"		
(G) Piston length . . . . .			7-11/16"		
(H) Piston skirt to sleeve clearance (Thrust) . . . . .			.0086" - .0096"		
(I) Groove width					
	Top	2nd	3rd	4th	5th (if used)
	0.189" - 0.190"	0.189" - 0.190"	0.189" - 0.190"	0.251" - 0.252"	0.251" - 0.252"

**PISTON RINGS**

- Top ring . . . . . Chrome plated, compression
- Second ring . . . . . Grooved edge compression
- Third ring . . . . . Grooved edge compression
- Fourth ring . . . . . Grooved oil cutter
- Fifth ring . . . . . Grooved oil cutter



TYPICAL PISTON



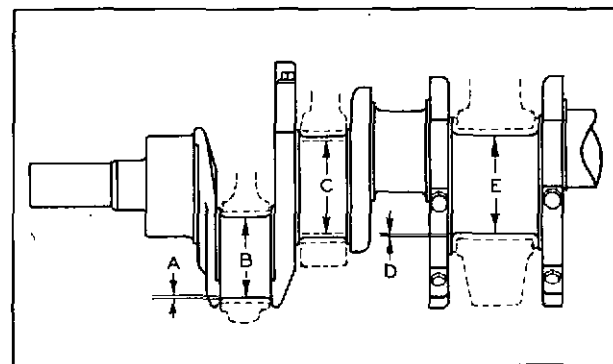
TYPICAL PISTON RING

PISTON RINGS

	Top	2nd	3rd	4th	5th (if used)
(A) Ring gap	0.017"-0.032"	0.017"-0.032"	0.017"-0.032"	0.017"-0.032"	0.017"-0.032"
(B) Ring dia.	6.250"	6.250"	6.250"	6.250"	6.250"
(C) Ring wall	0.247"	0.247"	0.247"	0.247"	0.247"
(D) Ring width	0.1855"-0.1865"	0.1855"-0.1865"	0.1855"-0.1865"	0.248"-0.249"	0.248"-0.249"
(E) Side clearance	0.0025"-0.0045"	0.0025"-0.0045"	0.0025"-0.0045"	0.002"-0.004"	0.002"-0.004"

CRANKSHAFT

- Crankshaft end play . . . . . 0.005" - 0.015"
- End play adjustment 0.002" shim at front main  
(current engines do not use shims)
- (A) Connecting rod bearing running  
clearance. . . . . 0.0015" - 0.004"
- (B) Connecting rod bearing journal  
diameter . . . . . 3.374" - 3.375"
- (C) Main bearing journal maximum  
undersize. . . . . 0.040"
- (D) Main bearing running  
clearance. . . . . 0.002" - 0.0047"
- (E) Main bearing journal  
diameter . . . . . 3.999" - 4.000"



TYPICAL CRANKSHAFT

**MAIN BEARINGS\***

Number . . . . . Seven  
 Type . . . . . Precision  
 Material . . . . . Steel backed, aluminum  
 Undersize bearings  
 available . . . . . 0.020" and 0.040"  
 Adjustment . . . . . Replacement (precision type)  
 Running clearance . . . . . 0.002" - 0.0047"  
 Crush in crankcase bore. . 0.0015" - 0.0025"

\* Upper and lower bearing shells are not interchangeable. Upper shells have an exterior transverse slot - lower do not.

**IDLER GEAR**

Running clearance in bushing 0.002" - 0.003"  
 Idler spindle O.D. . . . . 1.4985" - 1.498"  
 Idler gear bushing I.D. . . 1.5005" - 1.501"  
 Idler gear end play. . . . . 0.002" - 0.004"  
 (Adjust with 0.003" shims)

**CAMSHAFT**

Camshaft bushing I.D.\* . . . 2.058" - 2.059"  
 (Rear) 2.745" - 2.7455"  
 Camshaft journal dia. . . . . 2.742" - 2.743"  
 (Rear) 2.055" - 2.056"  
 Camshaft running clearance  
 in bushings . . . . . 0.002" - 0.004"  
 (Rear) 0.002" - 0.0035"  
 Camshaft end play . . . . . 0.004" - 0.006"  
 Camshaft end play adjustment . Thrust Plate  
 Replacement  
 Thrust Plate Thickness . . 0.1825" - 0.1835"  
 Cam lift . . . . . measured at pushrod .384"

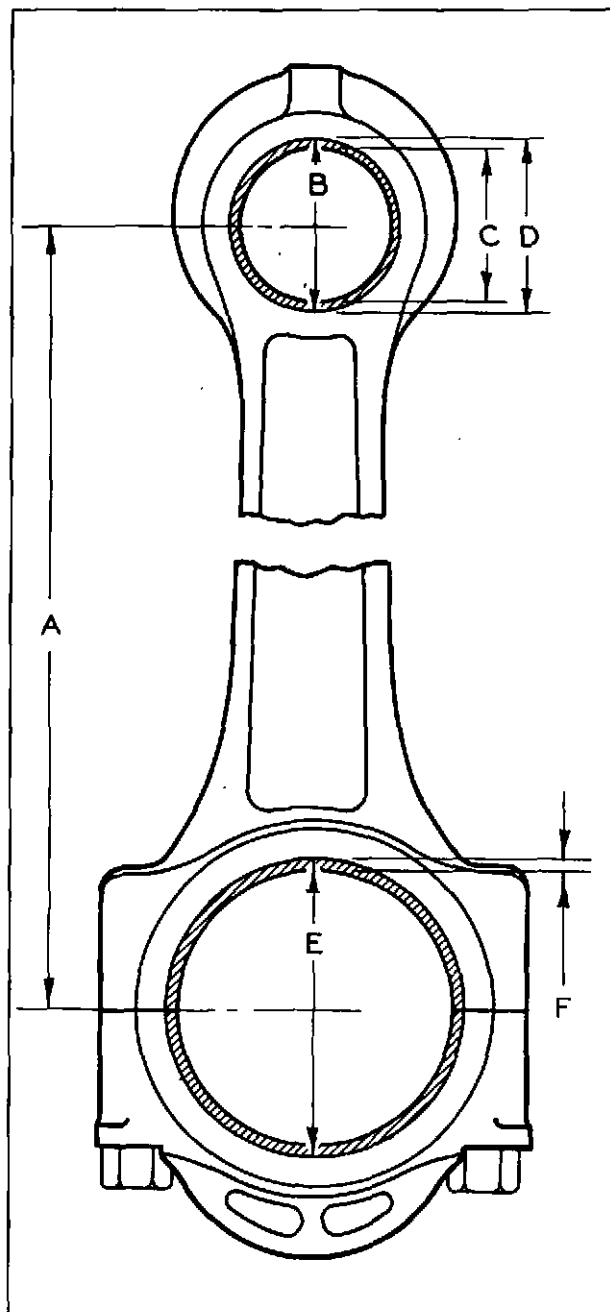
\*Replacement bushings available as either pre-sized precision type or undersized for line boring.

**CONNECTING ROD, BUSHING AND BEARING**

Rod material. . . Heat Treated-Steel forging  
 Rods, permissible weight variation. Two ounce  
 Side play limit . . . . . 0.008" - 0.014"  
 (A) Rod length, center to  
 center . . . . . 13.251" - 13.252"  
 (B) Rod small end finish  
 size. . . . . 2.0620" - 2.0625"  
 (C) Bushing bore diameter. . 1.8760" - 1.8764"  
 (D) Bushing Press in Rod  
 (Burnish in place) . . . . . 0.002" - 0.004"  
 (E) Rod large end finish  
 size . . . . . 3.6255" - 3.6260"  
 (F) Bearing wall thickness. . 0.1240" - 0.1245"  
 Bearing running  
 clearance. . . . . 0.0015" - 0.004"  
 Rod bearing undersize  
 available. . . . . 0.020" & 0.040"

**FLYWHEEL AND HOUSING**

Pilot Bearing Run-out . . . . . 0.005"  
 Total Indicator Reading  
 Face Run-out on Wheel. . . . . 0.013"  
 Total Indicator Reading  
 Housing Bore Run-out . . . . . 0.010"  
 Total Indicator Reading  
 Housing Face Run-out . . . . . 0.010"  
 Total Indicator Reading



TYPICAL CONNECTING ROD, BUSHING AND BEARING

VALVE CLEARANCES

CLEARANCE (Adjust valves with engine cooled to room temperature)

**VALVE CLEARANCE COLD SETTING**

INTAKE

EXHAUST

WAUKESHA MOTOR CO.  
WAUKESHA, WISCONSIN  
U.S.A.

**VALVE CLEARANCE COLD SETTING**

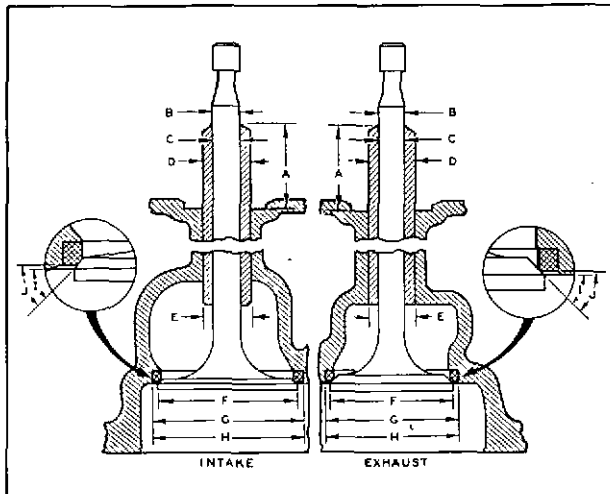
INTAKE

EXHAUST

WAUKESHA MOTOR CO.  
WAUKESHA, WISCONSIN  
U.S.A.

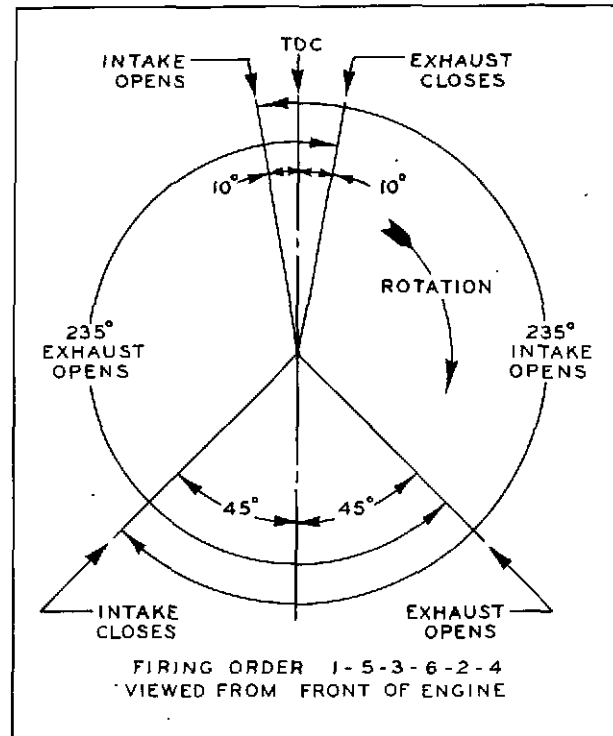
INDUSTRIAL TYPE

COMMERCIAL TYPE



TYPICAL SECTION THROUGH CYLINDER HEAD

VALVE TIMING

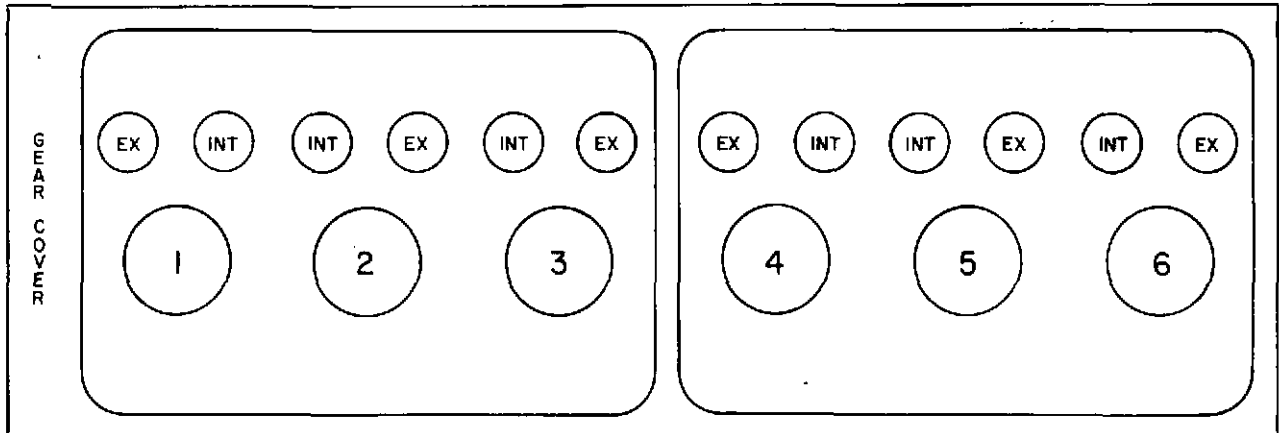


VALVE TIMING DIAGRAM

VALVE PORT CLEARANCES

	Intake	Exhaust
(A) Guide extends above block . . . . .	2-1/8"	2-1/8"
(B) Valve stem diameter . . . . .	0.4965" - 0.4975"	0.6205" - 0.6215"
(C) Guide I. D. . . . .	0.500" - 0.501"	0.625" - 0.626"
(D) Guide O. D. . . . .	0.876" - 0.877"	0.876" - 0.877"
(E) Guide hole diameter . . . . .	0.874" - 0.875"	0.874" - 0.875"
(F) Valve head diameter . . . . .	2.640" - 2.650"	2-7/32"
(G) Insert O. D. . . . .	2.8155" - 2.8165"	2.4405" - 2.4415"
(H) Insert counterbore diameter . . . . .	2.8115" - 2.8125"	2.4365" - 2.4375"
(I) Insert seat angle . . . . .	30°	45°
(J) Valve seat angle . . . . .	30°	45°
Valve stem clearance in guide . . . . .	0.0025" - 0.0045"	0.0035" - 0.0055"
Insert press fit in head . . . . .	0.003" - 0.005"	0.003" - 0.005"

VALVE SEQUENCE FOR WAKC SERIES ENGINES



TIMING GEAR BACKLASH

Between All Timing Gears . . . .005"-.007"

SPARK ADVANCE RECOMMENDATIONS

6-WAKC Model	Compression Ratio	Fuel	Distributor Timing	Magneto Timing at Engine RPM
Commercial type	7.0 to 1	Gasoline	4° BTDC	32° BTDC at all speeds
Industrial type	7.0 to 1	Gasoline	4° BTDC	24° BTDC at all speeds
Industrial type	7.0 to 1	LPG	14° BTDC	32° BTDC at all speeds
Industrial type	7.0 to 1	Natural gas	14° BTDC	35° BTDC at all speeds
Industrial type	9.0 to 1	Natural gas	14° BTDC	32° BTDC at all speeds
Industrial type	9.0 to 1	Gasoline	4° BTDC	22° BTDC at all speeds
Industrial type	9.0 to 1	LPG	8° BTDC	27° BTDC at all speeds

SPARK PLUG RECOMMENDATIONS

Plug Size . . . . . 18mm - 7/8" Hex.  
 Plug Gap . . . . . 0.025" New  
 except 0.011" for 60999B plug

IGNITION DATA

Distributor Breaker Point Gap . .018"-.020"  
 Magneto Breaker Point Gap . . .016"-.018"

	← Hotter (Plug Heat Range) Colder →		
	Light Duty	Normal Duty	Heavy Duty
Plug Recommended For Gasoline Fuel	50432-B	69532-A	69532-A
Plug Recommended For Gaseous Fuels	69532-A	69532-A	69532-A

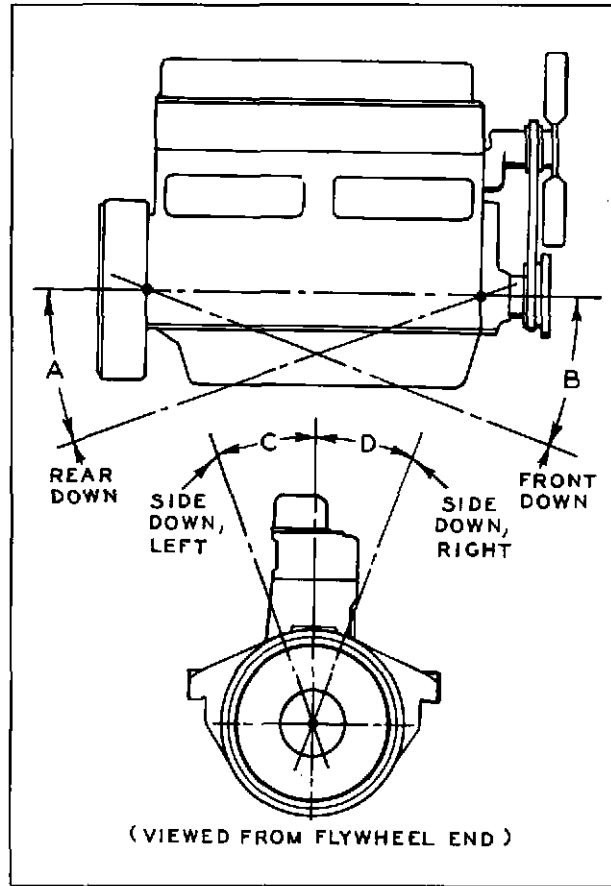
69532-A recommended for all generator set applications for all fuels for light, normal, and heavy duty.

60999B is recommended platinum tip plug for gaseous fuels.

167037 is recommended shielded plug for gasoline and gaseous fuels.

Hotter Plug: Recommended for "Cold Engine", to remedy plug oil fouling and sooting conditions.

Colder Plug: Recommended for "Hot Engine", to remedy pre-ignition, burned plug electrodes and porcelain cracking.



MAXIMUM ANGLE OF OPERATION

Pan Type	Pump Type	A Rear Down		B Front Down		C Side Down, Left		D Side Down, Right	
		C	I	C	I	C	I	C	I
STD. Rear Sump	STD. Pressure	30°	30°	10°	10°	30°	30°	25°	25°

C — Continuous      I — Intermittent      (One minute duration in five minutes)

## DISTRIBUTORS AND SERVICE

The Waukesha Engine Division, Dresser Industries, Inc., has established a system of reputable distributors with trained mechanics and full facilities for maintenance and rebuilding, and to carry an adequate parts stock in all areas of major engine population all over the world. Their sales engineers are available for installation consultation. If you cannot locate a Waukesha distributor in your area, contact the Waukesha Service Department, 1000 West St. Paul Avenue, Waukesha, Wisconsin 53186, or call (414) 547-3311.

Authorized distributors can respond to your service needs more quickly if the following procedures are observed:

1. Give engine model, serial number and specification number which are stamped on the nameplate attached to the crankcase. The serial number is also stamped on the crankcase at either the gear cover or flywheel housing end.
2. When ordering parts, always furnish the complete description and part number, where known, of the parts wanted. Do not use the words "complete" or "sets" - state the quantity of each item required.
3. Tell the distributor how and where to ship parts--state whether to ship by freight, express or parcel post--furnish shipping point and post office address. Without specific shipping instructions the distributor will use his own discretion and will not be responsible for any charges by doing so. Be sure to mark your name, address, and where you can be reached on any order for parts as well as on any correspondence.
4. Terms on repair--to avoid delay, all repairs will be C.O.D. unless prior arrangements are made with the distributor.

In situations which may fall within the parameter of the Waukesha standard warranty obligations, proceed as follows:

1. When placing a request for service, specifically state that the repair is believed to be

within the terms of warranty (this may be indicated on the purchase order if desired). Produce documentation showing the date of start up or installation of the engine and the engine model, serial number and specification number.

2. Once the service or repair is completed, pay for the service and/or parts in accordance with whatever terms were previously arranged, but indicate with the payment that a claim is pending under the provisions of warranty.
3. Confirmation of the submission of a warranty claim can be requested from the Waukesha distributor handling the repair. This is usually done by a notation on the distributor's invoice to the end user.
4. The Waukesha Distributor will notify you via letter or credit on an invoice of the decision of Waukesha as to the request for warranty on a particular repair.
5. Any parts replaced in the repair which may be subject to warranty should be left with the distributor for proper handling.
6. Any part replaced under warranty assumes the identity of the part which it replaces in regard to warranty. That is to say, if the engine is six months old the new part placed in that engine for a failed part is six months old in regard to any future warranty determination.

Remember - you own the best. If repairs are needed use only Genuine Waukesha Parts purchased from Authorized Waukesha Distributors.



## Waukesha Engine Division Dresser Industries, Inc.

### WARRANTY AND LIMITATION OF REMEDY AND LIABILITY

Effective September 1, 1976

A. Seller warrants only that its products and parts, when shipped, and its work (including start-up), when performed, will meet all applicable specifications and other specific product and work requirements, including those of performance, if any, of this agreement, and will be free from defects in material and workmanship. With respect to products, parts and work not manufactured or performed by Seller, Seller's only obligation shall be to assign to Buyer, to the extent possible, whatever warranty Seller receives from the Manufacturer. All claims for defective products or parts under this warranty must be made in writing immediately upon discovery and, in any event, within eighteen (18) months after shipment, but not to exceed twelve (12) months of service or 4000 operating hours after initial startup, whichever occurs first, and all claims for defective work must be made in writing immediately upon discovery and in any event within one (1) year of completion thereof by Seller. Defective items must be held for Seller's inspection and if requested by Seller returned to the original f.o.b. point, transportation prepaid. THE FOREGOING IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES WHATSOEVER, EXPRESS, IMPLIED AND STATUTORY INCLUDING WITHOUT LIMITATION THE IMPLIED WARRANTIES TO MERCHANTABILITY AND FITNESS. It is understood that Seller's warranty shall not apply to products or parts, which in Seller's opinion, have been damaged as a result of overloading, overspeeding, overheating, inadequate maintenance, accident or improper installation or storage.

B. Upon Buyer's submission of a claim as provided above and its substantiation Seller shall at its option either (i) repair or replace its product, part or work at the business establishment of a Waukesha Distributor or other location authorized by Waukesha, during said Distributor normal business hours. This Warranty does not include reimbursement of any costs for transporting the product or part to such establishment, or for removal or reinstallation of a product when necessary in connection with a Warranty repair, or (ii) refund an equitable portion of the purchase price. In no event shall Seller be liable for the cost of labor in connection with replacement or repair of defective parts when the engine or power unit has been in the possession of the using owner or rental operator for a period of six (6) months or longer.

C. THE FOREGOING IS SELLER'S ONLY OBLIGATION AND BUYER'S EXCLUSIVE REMEDY FOR BREACH OF WARRANTY AND, EXCEPT FOR GROSS NEGLIGENCE WILLFUL MISCONDUCT AND REMEDIES PERMITTED UNDER THE PERFORMANCE, INSPECTION AND ACCEPTANCE AND THE PATENTS CLAUSES HEREOF, THE FOREGOING IS BUYER'S EXCLUSIVE REMEDY AGAINST SELLER FOR ALL CLAIMS ARISING HEREUNDER OR RELATING HERETO WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY) OR OTHER THEORIES; BUYER'S FAILURE TO SUBMIT A CLAIM AS PROVIDED ABOVE SHALL SPECIFICALLY WAIVE ALL CLAIMS FOR DAMAGES OR OTHER RELIEF, INCLUDING BUT NOT LIMITED TO CLAIMS BASED ON LATENT DEFECTS. IN NO EVENT SHALL BUYER BE ENTITLED TO INCIDENTAL OR CONSEQUENTIAL DAMAGES. ANY ACTION ARISING HEREUNDER OR RELATING HERETO WHETHER BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY) OF OTHER THEORIES, MUST BE COMMENCED WITHIN ONE (1) YEAR AFTER THE CAUSE OF ACTION ACCRUES OR IT SHALL BE BARRED.

# Distributor Directory

## UNITED STATES

### ALABAMA

**BIRMINGHAM, 35233**  
 Carlross Well Supply Company  
 Branch Office  
 2901 - 3rd Avenue, South  
 Phone: (205) 324-0689  
 Main Office - See Tennessee

### ALASKA

**ANCHORAGE, 99502**  
 Waukesha-Alaska Corporation  
 239 E. International Airport Road  
 Phone: (907) 278-9651

### ARIZONA

**PHOENIX, 85005**  
 Arizona Engine & Pump Co.  
 407 South 17th Avenue  
 P. O. Box 6139, Capital Station  
 Phone: (602) 252-1731

**CASA GRANDE, 85222 - Branch Office**  
 896 West Gila Bend Highway  
 Phone: (602) 836-8731

**TUCSON, 85705 - Branch Office**  
 4260 N. Sullinger  
 Phone: (602) 868-1690

### ARKANSAS

**FT. SMITH, 72901 - Branch Office**  
 Waukesha-Pearce Industries, Inc.  
 6006 Hwy. 11 South  
 P. O. Box 6312  
 Phone: (501) 646-4396

### CALIFORNIA

**EMERYVILLE, 94608**  
 King-Knight Company  
 6202 Christie Avenue  
 Phone: (415) 658-9400

**COMPTON, 90221**  
 Waukesha Engine Servicer, Inc.  
 17803 S. Santa Fe Avenue  
 Phone: (213) 774-5700

**BAKERSFIELD, 93301 - Branch Office**  
 1221 - 33rd Street  
 Phone: (805) 327-7571

**VENTURA, 93001 - Branch Office**  
 1636 N. Ventura Avenue  
 Phone: (805) 648-1865

**EMERYVILLE, 94608**  
 Waukesha Engine Division  
 (Western Regional Office)  
 1900 Powell St., Suite 455  
 Phone: (415) 653-1824

### COLORADO

**DENVER, 80239**  
 PAMCO  
 P. O. Box 39068  
 10777 East 45th Avenue  
 Phone: (303) 371-0330

### FLORIDA

**JACKSONVILLE, 32205**  
 Gator Service & Supply, Inc.  
 2535 St. Clair St.  
 P. O. Box 37446  
 Phone: (904) 783-1280

**POMPANO BEACH, 33061**  
 Melley Energy Systems, Inc.  
 P. O. Box 999  
 941 S. W. 12th Avenue  
 Phone: (305) 941-0200

### GEORGIA

**ATLANTA, 30325**  
 Demco Division  
 Division of Auto Electric & Diesels  
 810 Lambert Dr. N.E.  
 Phone: (404) 876-3622

**DECATUR, 30036**  
 Waukesha Engine Division  
 (Southeastern Regional Office)  
 4336 Covington Highway  
 Suite 204C  
 Phone: (404) 289-0960

## HAWAII

**HONOLULU, 96820**  
 Waukesha Engine Servicer Co. - Hawaii  
 P. O. Box 30525  
 Phone: (808) 833-3664

## ILLINOIS

**VILLA PARK, 60181**  
 Charles Equipment Company  
 P. O. Box 368  
 187 East North Avenue  
 Phone: (312) 834-6000

**GRAYVILLE, 62844**  
 Oil Field Motor Service, Inc.  
 P. O. Box 98  
 Phone: (618) 375-2151

**DEERFIELD, 60015**  
 Waukesha Engine Division  
 (Central Regional Office)  
 106 Wilmot Rd., Suite 203  
 Phone: (312) 948-5210

## INDIANA

**INDIANAPOLIS, 46202**  
 Eagle Machine Company, Inc.  
 P. O. Box 88  
 635 East Market Street  
 Phone: (317) 637-2521

## IOWA

**WATERLOO, 50704**  
 Lewis Motor Supply Inc.  
 1801 Washington Street  
 P. O. Box 325  
 Phone: (319) 235-1481

## KANSAS

**KANSAS CITY, 66103**  
 Sam Brown Company  
 275 Southwest Blvd.  
 P. O. Box 3248  
 Phone: (913) 831-9770

**GREAT BEND, 67530**  
 PAMCO - Branch Office  
 714 Patton Road  
 Phone: (316) 793-3553  
 Main Office - See Colorado

**LIBERAL, 67901**  
 PAMCO - Branch Office  
 210 Country Estates Road  
 Phone: (316) 624-5674  
 Main Office - See Colorado

## KENTUCKY

**LOUISVILLE, 40203**  
 Atlas Machine & Supply Inc.  
 1328 West Jefferson  
 Phone: (502) 584-7282

## LOUISIANA

**HARVEY, 70058**  
 Reagan Equipment Company  
 P. O. Drawer 628 (Zip 70059)  
 2230 Peters Road  
 Phone: (504) 367-1870

**MORGAN CITY, 70380 - Branch Office**  
 P. O. Drawer 2487  
 Highway 90 East  
 Phone: (504) 631-0321

**VIDALIA, 71373 - Branch Office**  
 P. O. Box 914  
 Highway 84 West  
 Phone: (318) 336-7161

**NEW IBERIA, 70560**  
 Waukesha-Pearce Industries, Inc.  
 Branch Office  
 P. O. Box 938  
 929 Jane Street  
 Phone: (318) 369-3741  
 Main Office - See Texas

**SHREVEPORT, 71107**  
 Waukesha-Pearce Industries, Inc.  
 Branch Office  
 P. O. Box 7066  
 1815 Barton Drive  
 Phone: (318) 221-4075  
 Main Office - See Texas

## MARYLAND

**BALTIMORE, 21230**  
 Tate Engineering, Inc.  
 601 W. West Street  
 Phone: (301) 639-0787

## MASSACHUSETTS

**ALLSTON, BOSTON, 02134**  
 W. A. Kraft Corporation  
 308 North Harvard Street  
 Phone: (617) 782-0076

## MICHIGAN

**NOVI, 48050**  
 Engine Supply of Novi, Inc.  
 P. O. Box 437  
 44455 Grand River  
 Phone: (313) 349-9330

## MINNESOTA

**SOUTH ST. LOUIS PARK, 55426**  
 Jeffco Power Systems  
 2236 Florida Avenue S.  
 Phone: (612) 546-5566

## MISSISSIPPI

**HEIDELBERG, 39439**  
 Reagan Equipment Co. - Branch Office  
 P. O. Box 285  
 Highway 28 West  
 Phone: (601) 787-2221  
 Main Office - See Louisiana

**JACKSON, 39208**  
 Reagan Equipment Co. - Branch Office  
 P. O. Drawer 5700  
 Highway 80 East  
 Phone: (601) 939-4512  
 Main Office - See Louisiana

## MISSOURI

**ST. LOUIS, 63118**  
 Charles Equipment Company  
 3100 Gravois Avenue  
 Phone: (314) 771-4700

## NEW JERSEY

**CARLSTADT, 07072**  
 W. A. Kraft Corporation - Branch Office  
 485 Washington Avenue  
 Phone: (201) 973-5151  
 (212) 608-0135  
 Main Office - See Massachusetts

**RIDGEWOOD, 07451**  
 Waukesha Engine Division  
 (Northeastern Regional Office)  
 1156 East Ridgewood Avenue  
 Phone: (201) 652-4805

## NEW MEXICO

**FARMINGTON, 87401**  
 PAMCO - Branch Office  
 P. O. Box 1558  
 218 Airport Drive  
 Phone: (505) 325-7529  
 Main Office - See Colorado

**HOBBS, 88240**  
 Waukesha-Pearce Industries, Inc.  
 Branch Office  
 P. O. Box 488  
 2601 West Marland  
 Phone: (505) 393-9135  
 Main Office - See Texas

## NEW YORK

**SYRACUSE, 13202**  
 Power Plant Equipment Corp.  
 929 S. Salina Street  
 Phone: (315) 475-7251

**LATHAM, 12110**  
 Power Plant Equip. Corp. - Branch Office  
 8 Northway Lane  
 Phone: (518) 783-1891

**TONAWANDA, 14150**  
 Ronco Power Systems  
 585 Sheridan Drive  
 Phone: (716) 873-0760

# WAUKESHA WAK AND F-1197-G SERIES

## NORTH DAKOTA

**WILLISTON, 58801**  
PAMCO - Branch Office  
P. O. Box 1147  
Highway 2 North  
Phone: (701) 572-6343  
  
Main Office - See Colorado

## OHIO

**YOUNGSTOWN, 44508**  
Power Equipment, Inc.  
168 South Meridian Road  
Phone: (216) 792-1475

**COLUMBUS, 43219 - Branch Office**  
P. O. Box 18085  
889 N. 22nd Street  
Phone: (614) 253-2711

**NORTH ROYALTON, 44133 - Branch Office**  
10156 Royalton Road  
Phone: (216) 237-1818

## OKLAHOMA

**WOODWARD, 73801**  
Waukesha-Pearce Industries, Inc.  
Branch Office  
P. O. Box 1086  
Martina Road  
Phone: (405) 266-7421  
  
Main Office - See Texas

**OKLAHOMA CITY, 73124**  
Waukesha-Pearce Industries, Inc.  
Branch Office  
1128 S. E. 25th  
P. O. Box 24003  
Phone: (405) 670-1381  
  
Main Office - See Texas

## OREGON

**PORTLAND, 97210**  
L-D, Inc.  
P. O. Box 10124  
2355 N. W. Quimby Avenue  
Phone: (503) 226-7986

## PENNSYLVANIA

**PITTSBURGH, 15234**  
P. C. McKenzie Company  
3561 Valley Drive  
Phone: (412) 833-2100

## SOUTH CAROLINA

**CHARLESTON, 29405**  
Diesel Engineers, Inc.  
2025 Austin Avenue  
P. O. Box 4388  
Phone: (803) 554-5151

## TENNESSEE

**MEMPHIS, 38105**  
Carlross Well Supply Company  
111 North Parkway Avenue  
Phone: (901) 526-1141

**NASHVILLE, 37213 - Branch Office**  
101 South First Street  
Phone: (615) 254-1669

## TEXAS

**HOUSTON, 77035**  
Waukesha-Pearce Industries, Inc.  
P. O. Box 38068  
12320 South Main Street  
Phone: (713) 723-1050

**ARLENE, 79804 - Branch Office**  
P. O. Box 1962  
3542 S. Treadaway  
Phone: (915) 692-4045

**CORPUS CHRISTI, 78408 - Branch Office**  
P. O. Box 9267  
5226 Frontage Road I-37  
Phone: (512) 884-8275

**IRVING, 75060 - Branch Office**  
P. O. Box 365  
525 North Loop 12  
Phone: (214) 259-1581

**KILGORE, 75662 - Branch Office**  
P. O. Box 1185  
Industrial Blvd.  
Phone: (214) 984-2011

**ODESSA, 79760 - Branch Office**  
P. O. Box 3543  
1000 West 2nd Street  
Phone: (915) 332-9106

**PAMPA, 79066 - Branch Office**  
P. O. Box 1976  
201 N. Price Road  
Phone: (806) 662-3251

**SAN ANTONIO, 78223 - Branch Office**  
P. O. Box 20163  
J. Frank Doble Station  
3740 S. E. Loop 410  
Phone: (512) 824-7256

**SAN JUAN, 78869 - Branch Office**  
P. O. Box 248  
Phone: (512) 787-4231

**WICHITA FALLS, 76307 - Branch Office**  
P. O. Box 2185  
4725 Jacksboro Highway  
Phone: (817) 767-9234

**HOUSTON, 77027**  
Waukesha Engine Division  
(Mid-Continent Regional Office)  
1535 West Loop South  
410 Honeywell Building  
Phone: (713) 626-0255

## UTAH

**SALT LAKE CITY, 84115**  
Diesel Electric Service & Supply  
P. O. Box 15858  
652 W. 17th Street, South  
Phone: (801) 972-1836

**VERNAL, 84078**  
PAMCO - Branch Office  
P. O. Box 400  
Highway 40 East  
Phone: (801) 789-3383

Main Office - See Colorado

## WASHINGTON

**SEATTLE, 98107**  
Kem Equipment, Inc.  
4301 Leary Way, N. W.  
Phone: (206) 784-2372

## WISCONSIN

**APPLETON, 54911**  
Arthur G. Dietrich Co., Inc. - Branch Office  
641 Hickory Farm Lane  
Phone: (414) 731-6688

**MILWAUKEE, 53217**  
Arthur G. Dietrich Co., Inc.  
8035 N. Port Washington Road  
Phone: (414) 352-7452

**WAUKESHA, 53187**  
Waukesha Engine Division  
Main Office  
P. O. Box 379  
1000 West St. Paul Avenue  
Phone: (414) 547-3311

## WYOMING

**CASPER, 82601**  
PAMCO - Branch Office  
P. O. Drawer 2795  
3400 West Yellowstone Road  
Phone: (307) 234-1548  
  
Main Office - See Colorado

## CANADA

### ALBERTA

**CALGARY - T2C 1H9**  
PAMCO, Ltd.  
8241 - 31st St., S. E.  
Phone: (403) 279-5561

**CALGARY X-T2P 0M2**  
Waukesha Engine Division  
(Western Canada Regional Office)  
Aquitaine Tower, Suite 540  
540 - 5th Avenue, S. W.  
Phone: (403) 266-8566

**EDMONTON 82 - T6E 4N6 - Branch Office**  
P. O. Box 5798 Postal Station L  
5235 Wagner Road  
Phone: (403) 485-5371

**REDCLIFFE - T1A 7N4 - Branch Office**  
P. O. Box 870  
No. 2 1901 Highway Avenue, N.  
Phone: (403) 548-3935

### BRITISH COLUMBIA

**RICHMOND V7C 4R9**  
PAMCO, Ltd. - Branch Office  
5920-F No. 2 Road  
Phone: (604) 378-7958

### MANITOBA

**WINNIPEG R34 0X3**  
Keewatin Electric & Diesels, Ltd.  
1040 Coulter Avenue  
Phone: (204) 772-0443

### NEW BRUNSWICK

**MONCTON - E1C 8N6**  
Consolidated Engines & Machinery  
Co., Ltd. - Branch Office  
146 Albert Street  
P. O. Box 848  
Phone: (506) 854-0982

Main Office - See Quebec

### ONTARIO

**TORONTO 16 - M4A 2N3**  
Atlas Polar Company, Ltd.  
60 Northline Road  
Station "O", P. O. Box 160  
Phone: (416) 751-7740

### QUEBEC

**MONTREAL H4T 1L7**  
Consolidated Engines & Machinery  
Co., Ltd.  
8550 Delmeade Road  
Phone: (514) 342-9233

**LORETTEVILLE G2A AT2**  
Consolidated Engines & Machinery  
Co., Ltd.  
38, Louis Hebert  
Phone: (418) 842-8581

**INTERNATIONAL**

**ARGENTINA**

TIPSA - Tecnica Industrial y  
Commerical Petrolera, S. C. A.  
Territory: Argentina  
Cordoba 1367, 3rd Floor  
Buenos Aires 1055, Argentina  
Phone: 42 1367 Cable: TIPSA

Branch: San Martin 1002,  
Comodoro Rivadavia

**AUSTRALIA**

A. N. I. Perkins Division  
A. N. I. Australia Pty. Limited  
Territory: Australia  
16 Farramatta Road, P. O. Box 117  
Lidcombe, N. S. W., 2141, Australia  
Phone: 648-4088 Cable: PERKAUST  
SIDNEY

**AUSTRIA**

FILTOR  
Gross-und Kleinhandels-Gres. M. b. h.  
Territory: Austria  
2482 Münchendorf Niederosterreich  
1110-Vienna, Austria  
Phone: (02259) 204

**BANGLADESH**

Dana Engineers, International  
Territory: Bangladesh  
56, Dikusha Commercial Area  
P. O. Box No. 914, Dacca-2  
Bangladesh  
Phone: 255020 Cable: DANARS-DACCA

**BELGIUM**

Waukesha Engine Division  
Dresser Europe S. A.  
(Europe & Middle East Regional Office)  
Boulevard Du Souverain 191-197 (B. 3)  
B-1160 Brussels, Belgium  
Phone: 860.20.60 Cable: WAUKESHA

Werkhuizen Frans Stevens N. V.  
Territory: Belgium  
Slachthuislaan-21  
2000 Antwerp  
B-Belgium  
Phone: 031-36.92.02 Telex: 33342  
(STEVEN B)

**BOLIVIA**

Oil Industry Supply & Service Company  
Territory: Bolivia  
Calle Buena No. 144 - Casilla 1268  
La Paz, Bolivia  
Phone: 53917 Cable: OISSCO

Branch: Casilla 3157  
KM 31/2 Carr Cochabamba  
Santa Cruz, Bolivia  
Phone: 2-2988/2-1442 Telex: BX 7668

**BRUNEI/BURMA**

Avery-Laurence (S) Pte. Ltd.  
Territory: Brunet & Burma-Petroleum  
Products Only  
8th Floor, Cathay Building  
P. O. Box 190  
Singapore 9  
Phone: 324121 Cable: AVLAU

**CHILE**

SERPEMIN S. A. C.  
Servicios del Petroleo, Minería e Industria  
Territory: Chile  
Avenida Pucuro 2135  
Casilla 14926, Correo 21  
Santiago, Chile  
Phone: 743671 Telex: SGO-347

**COLOMBIA**

General Sales Corporation Ltda.  
Territory: Colombia - Marine Engines Only  
Air Mail Box 395  
Barranquilla, Colombia, S. A.  
Phone: 12-501 Cable: MAECO

Milchem Western Hemisphere, Inc.  
Territory: Colombia - Excluding Marine Engines  
Apartado Aereo 9313  
Bogota, D. E., Colombia  
Phone: 813704 Cable: MILCHEM

**DENMARK**

OMK Maskinfabrik Koge A/S  
Territory: Denmark  
Mercandia Teknisk Industri Islandsves 1  
DK-4681 Herfølge  
Denmark  
Phone: (03) 674410 Telex: 43588

**DOMINICAN REPUBLIC**

La Antillana Commercial, S. A.  
Territory: Dominican Republic  
P. O. Box 1227  
Av. Maximo Gomez No. 67  
Santo Domingo, Republica Dominicana  
Phone: 5653151 Cable: COMIMPORT

**ECUADOR**

Maquinarias y Equipos Gamma, S. A.  
Territory: Ecuador  
P. O. Box 3588  
Panamericana Norte, Km 1.3  
Quito, Ecuador  
Phone: 249-090 Telex: 22486 GAMMAED

**EGYPT**

HCH Supply Co., Ltd.  
Territory: Arab Republic of Egypt  
110, 26 July Street  
Zamalek, Cairo, Egypt  
Phone: 818721 Cable: PLESSCO

**FRANCE**

Ateliers et Chantiers d'Elie  
Territory: France  
7, Rue de la Frenale  
76800, St. Etienne du Rouvray  
France  
Phone: (035) 653473 Telex: 770572

**GERMANY**

Industrie & Schiffstechnik  
Territory: West Germany  
2000 Hamburg-Schenefeld  
Osterbrooksweg, 21  
P. O. Box 1365  
West Germany  
Phone: 40 830 5041 Telex: 0212635

**GREECE**

Gemco  
Stavropoulos-Leptourgos S. A.  
Territory: Greece  
24 Capodistriou St.  
Athens 208, Greece  
Phone: 21 364772 Cable: STAVROMOTORS

**GUYANA (British Guiana)**

Psaila Bros.  
Territory: Guyana  
P. O. Box 140  
Water & Holmes Streets  
Georgetown, Guyana  
Phone: 4170 Cable: PSAILA

**HONG KONG**

Gilman & Co. Ltd. Marine Department  
Territory: Hong Kong  
P. O. Box 55  
41st Floor, Connaught Centre  
Wanchai, Hong Kong  
Phone: 5-227011 Cable: GILMAN

**ICELAND**

Velasan, H. F.  
Territory: Iceland  
P. O. Box 1006  
Reykjavik, Iceland  
Cable: VELASAN

**INDIA**

AEICORP Private Limited  
Territory: India  
Mercantile Bldgs., 10,  
Lall Bazar Street  
Calcutta 700001, India  
Phone: 23-5120 and 23-0879  
Cable: EAGERNESS

Branches: Arun Chambers, Rm. 438 (4th Floor)  
Tardeo Rd., Bombay - 400034  
Central St., Hindipuri, Ranchi, 834001, Behar  
Nilum Enterprises  
B52, Dayanand Colony  
Lajput Nagar, New Delhi - 110024

**INDONESIA/MALAYSIA/SINGAPORE**

Waukesha Engine Far East Servicecenter  
Division of Burneo Motors Singapore Pte. Ltd.  
Territory: Indonesia, Malaysia, Singapore,  
including Sabah and Sarawak  
995 Bukit Timah Road  
Singapore 21  
Phone: 4694433 Telex: RS 25405 IRO SING

**IRAN**

SERVOIL Engineering Co., Ltd.  
Territory: Iran  
Shaya Building, Argentine Square  
38, Alvand Street  
P. O. Box 155  
Tehran, Iran  
Phone: 687096-9, 687100  
Cable: 628 TEHRAN IRAN

**ITALY**

Eurodiesel-Milano S. R. L.  
Territory: Italy  
Via E. Cosenz 44  
Milano, Italy  
Phone: 3763450 Cable: EURODIESEL

**JAPAN**

Mikuni Kikai Kogyo Co., Ltd.  
Territory: Japan  
2-2-2 Kajicho, Chiyoda-Ku  
Tokyo, Japan  
Phone: (03) 252-5151  
Telex: 0222-5508 MIKUNI J

**KUWAIT**

The Trading & Industrial Equipment Co. (W. L. L.)  
Territory: Kuwait, Iraq  
P. O. Box Safat 2159  
Kuwait Town, State of Kuwait  
Phone: 819179/819188 Cable: SUCCESS-  
KUWAIT

Waukesha Engine Division  
Dresser Europe S. A.  
(Middle East Regional Office)  
P. O. Box Safat 4544  
Kuwait Town, State of Kuwait  
Phone: 412120/412124 Cable: DRESSERIND-  
KUWAIT

# WAUKESHA WAK AND F-1197-G SERIES

## LEBANON

S. Sadaka & Sons  
Territory: Lebanon, Syria, Jordan  
P. O. Box 4  
Zahle, Lebanon  
Phone: 82-00-31 Telex: 21211 LE SADAKA

## LIBYA

Sahara Oilfield Services Co. of Libya, Ltd.  
Territory: Libya  
Sc. Sidi Issa; P. O. Box 800  
Tripoli, Libya  
Phone: 34874/37773 Cable: SOS

## MAURITIUS & REUNION ISLANDS

Robert Le Maire, Ltd.  
Territory: Mauritius & Reunion Islands  
28 St. William Newton Street  
Port Louis, Mauritius  
Cable: ROBMER

## MEXICO

Moto Equipos, S. A.  
Territory: Republic of Mexico (Excluding state of Sonora, state of Sinaloa up to and including Cabo Corrientes in the State of Jalisco for Marine Products Only)

Alemania 14  
Mexico 21, D. F., Mexico  
Phone: 549-32-65/66/67 Cable: MEOSA

Propulsión Industrial y Marítima, S. A.  
Territory: State of Sonora, state of Sinaloa up to and including Cabo Corrientes in the State of Jalisco (Marine Engines Only)

A. Serdan y Calle 27-AP 74  
Guaymas, Sonora, Mexico  
Phone: 2-05-20

Waukesha Engine Division  
Dresser International, S. A.  
(Mexico/Central America/Caribbean Regional Offices)

Dinamarca 85-4 Piso  
Mexico 6, D. F., Mexico  
Phone: (805) 533-6809 Telex: 00177-2588

## MOROCCO

Stanislas Jullien  
Territory: Morocco  
256 Boulevard Ba Hamad  
Casablanca, Morocco  
Cable: ORBI

## NETHERLANDS

Landre & Glunderman, N. V.  
Division Landre Ruhaak Motoren  
Territory: Netherlands (Industrial Gas and Diesel Products Only)  
P. O. Box 63  
Industrieweg, 30  
Vianen (Z.H.) 2620, The Netherlands  
Phone: 3473-3044 Cable: LANDREMAN

Laan & Kooy Technische Handelmaatschappij BV  
Territory: The Netherlands (Marine Products Only)  
Zwijnstraat 47  
Den Oever, Holland  
Phone: 02271-841

## NEW ZEALAND

MSI Corporation, Ltd.  
Territory: New Zealand  
90 Anzac Avenue, P. O. Box 1670  
Auckland 1, New Zealand  
Phone: 362-010 Cable: EMSICO

## NICARAGUA

Casa Commercial McGregor, S. A.  
Territory: Nicaragua  
3a. Calle S. E. No. 104; Aptdo. 448  
Managua, Nicaragua  
Phone: 2-1311 Cable: MCGREGOR

## NIGERIA

Allied Oilfield Services, Ltd.  
Territory: Nigeria  
39, Norman Williams Street  
S. W. Hoyt  
P. O. Box 5628  
Lagos, Nigeria  
Phone: 22863/27469/56068  
Cable: OILTOOLS

## PAKISTAN

Brentford, Yusuf & Company Limited  
Territory: Pakistan  
Ebrahim Bldg.  
20 W. Wharf Road  
P. O. Box No. 4327  
Karachi, Pakistan  
Phone: 201797, 201412  
Cable: BRENTICO-PAKISTAN

Branch: P. O. Box 85, The Mall, Lahore

## PHILIPPINES

Engineering & Construction Corp. of Asia  
Territory: Philippines  
J & L Building, 251-268 E. Delos Santos Ave.  
P. O. Box 451  
Mandaluyong, Metro Manila  
Philippines  
Phone: 71-10-21, 77-10-79, 77-24-12  
Telex: 2220 ECCO-PM

## PUERTO RICO & VIRGIN ISLANDS

West India Machinery & Supply Company  
Territory: Puerto Rico and Virgin Islands  
Roosevelt Avenue at 26th Street  
C. P. O. Box 4308  
San Juan, Puerto Rico 00936  
Phone: 782 2850 Cable: WIMSCO

## SAUDI ARABIA

Abdullah Ibrahim Alkhorayef  
Territory: Saudi Arabia  
P. O. Box 305  
Riyadh, Saudi Arabia  
Phone: 54174 Cable: AL-KHORAYEF

## SINGAPORE

Waukesha Engine Division  
Dresser Industries, Inc.  
(Singapore Regional Office)  
355 Orchard Rd.  
1st Floor, Lido Theatre Building  
Singapore 9  
Phone: 370-888  
Cable: WAUKASIA SINGAPORE

## SPAIN

Iberdiesel/Navalux S. A.  
Territory: Spain, including Majorca, Ibiza, & Canary Islands  
Honduras, 4 1°  
Madrid (16), Spain  
Phone: 457 56 62 Telex: 42237 NALB

## SUDAN

The New Plant Equipment Company  
Territory: Sudan  
P. O. Box 2221, 865  
Khartoum, Sudan  
Phone: 77275 - 72565 Cable: PLFCOY

## TAIWAN (Republic of China)

William Hunt & Co. (Int'l.) Inc.  
Territory: Taiwan, Republic of China  
8th Floor, Lung-Meu Building  
128 Chung Hsiao East Road, Sec. 4  
Taipei, Taiwan, Republic of China  
Phone: 721-9711/9713/9716 Cable: WILHUNT

## THAILAND

East Asia International Co., Ltd.  
Territory: Thailand  
142 N. Sathon Road  
Bangkok, Thailand  
Phone: 2336202/2336203 Cable: EASIAINCO

## TRINIDAD & TOBAGO, B.W.I.

Engineering Services & Supply Co., Ltd.  
Territory: Trinidad and Tobago  
Coconut Drive Cross Crossing  
P. O. Box 104  
San Fernando, Trinidad  
Phone: 65-79012-77355-77498 Cable: ESSCOL

## TURKEY

OBA Automotive & Mining Co., Ltd.  
Territory: Turkey  
Vali Dr. Resit Cad. 40/2  
Cankaya, Ankara, Turkey  
Phone: 27-10-28,  
27-79-52 Telex: 42885

## UNITED ARAB EMIRATES

The Trading & Industrial Equipment Co.  
P. O. Box 5291 Deira  
Dubai, United Arab Emirates  
Phone: 26255 Cable: TTECO-DUBAI

## UNITED KINGDOM

Daegam Ltd.  
Applied Energy Systems  
Territory: United Kingdom, Northern and Republic of Ireland  
1 Whippendell Road  
Watford Herts WD1 7LZ, England  
Phone: Watford (0923) 42222 Telex: 935926

## VENEZUELA

Bompert de Venezuela C. A.  
Territory: Venezuela  
Apartado 749  
Maracaibo, Venezuela  
Phone: 71183 Cable: USIVEN

Branch: Apartado 135  
Amaco, Venezuela  
Phone: 22576

Dresser International S. A.  
Waukesha Engine Division  
(South American Regional Office)  
Bompert de Venezuela, C. A.  
Apartado 80700  
Caracas 108, Venezuela  
Phone: 978-08-68,  
978-21-46 Telex: 395-232-67

## YUGOSLAVIA

Stojan International  
Territory: Yugoslavia  
Trattnerhof 2, Postfach 12  
1014 Vienna, Austria  
Phone: 52 75 58 Telex: 01-1675

**Waukesha**

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