INSTRUCTION MANUAL

SEE PART 2 FOR PARTS MANUAL

MM108
(PART 1 OF 2)

92 POWER SWEEPER

WITH CONTINENTAL F163 ENGINE & CESSNA PUMP
INCLUDING HI-DUMP MODEL
FIRST SERIAL NUMBER 2399
ALSO COVERS MACHINES WITH DIESEL ENGINES,
FROM FIRST SERIAL NUMBER 2408

TENNANT®
SPECIALIZED
MAINTENANCE SYSTEMS
• SCARIFIERS • FLOOR COATINGS

92

POWER SWEEPER

This manual is furnished with each new TENNANT 92 Power Sweeper. Your machine operators will easily learn how to operate the machine and understand its mechanical functions--by following the directions and absorbing the information under OPERATING INSTRUCTIONS.

Your TENNANT 92 will give you excellent service and cleaning results--and save you maintenance expenses. However, as with all specailly engineered mechanical equipment, you can get best results at minimum costs--if:

1. You operate your machine with reasonable care, and
2. You maintain your machine regularly--per these maintenance instructions provided.

You may order parts and supplies direct from TENNANT COMPANY, P.O. Box 1452, Minneapolis, Minnesota, 55440. A complete, illustrated machine PARTS LISTING is included in this manual. A phone or wire order will receive our prompt attention.

Contact your nearest TENNANT Factory Representative for information or assistance concerning your TENNANT 92.

NOTE: This manual covers only the Model 92 equipped with the Continental engine and Cessna pump, starting with Serial No. 922399. Also, all machines with diesel engines, starting with Serial No. 922408.

TENNANT®

Manual Part No. MM108

Printed in U.S.A.

TENNANT COMPANY WARRANTY POLICY

Tennant Company warrants to the original purchaser, for the period of one (1) year from the date of delivery, that goods manufactured by it will be free from defects of workmanship and material, provided such goods are installed, operated, and maintained in accordance with Tennant Company written manuals or other instructions.

Tennant Company's sole obligation, and Purchaser's sole remedy under this warranty for all claims arising out of the purchase and use of the goods, shall be limited to the repair or replacement, at Tennant Company's option, of parts that do not conform to this Warranty.

For thirty (30) days from date of installation, Tennant Company will, at its option, provide labor for repair, pay for outside repair service, or pay the customer straight time in accordance with Tennant Company's flat rate schedule for particular warranty repairs. Thereafter, Tennant Company's sole obligation shall be limited to the repair or replacement, at Tennant Company's option, of parts that do not conform to this Warranty.

Repair parts supplied by Tennant Company are warranted for the period of thirty (30) days following installation. Tennant Company's obligation is limited to the replacement of the warranted part, and Tennant Company shall not be obligated to provide labor in installing such part.

No Warranty is made with respect to items made by others when such items are warranted by their respective makers or when they are supplied by Tennant Company on special order.

This Warranty shall not cover:

A. Floor materials or application, and models 140 & 140E.

B. Maintenance items, adjustments, or installation of machines.

C. Repairs required as a result of failure due to normal wear, accidents, misuse, abuse, negligence, or improperly installed repair parts.

D. Products altered or modified in a manner not authorized by Tennant Company in writing.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER EXPRESSED OR IMPLIED WARRANTIES INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS AND OF ALL OTHER OBLIGATIONS AND LIABILITIES ON THE PART OF TENNANT COMPANY, INCLUDING LIABILITIES FOR DIRECT, IMMEDIATE, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE FAILURE OF ANY MACHINE OR PART OF IT TO OPERATE PROPERLY, INCLUDING THE COST OR EXPENSE OF PROVIDING SUBSTITUTE EQUIPMENT OR SERVICE DURING PERIODS OF MALFUNCTION OR NON-USE.

This Warranty cannot be extended, changed, or modified by any representative of Tennant Company.

Dear Customer,

Keeping you as a satisfied customer is our primary concern. If for any reason you are not satisfied, please contact anyone of the persons listed below.

One of the addresses is your local engine dealer. We will handle replacements on all parts of our equipment but this dealer probably carries a more complete stock of engine parts than we do and should be able to give you faster service in this area. Try him first for engine parts. Also, your engine dealer should be contacted first for warranty claims pertaining to the engine.

If you find that you need an experienced mechanic, please contact anyone listed below and he will be happy to recommend a mechanic to you.

To get maximum trouble free service from your machine, you must perform maintenance checks as specified in the machine manual and arrange for maintenance on a regular basis. Remember that breakdowns are directly related to maintenance.

TENNANT COMPANY	TENNANT COMPANY REPRESENTATIVE	ENGINE DEALER
Tennant Company		
P. O. Box 1452		
Minneapolis, MN 55440		
(612) 540-1200		

⚠ SAFETY PRECAUTIONS

The following information signals potentially dangerous conditions to the operator or equipment. Read this manual carefully. Know when these conditions can exist. Locate all safety devices on the machine. Then, take necessary steps to train machine operating personnel. Report machine damage or faulty operation immediately.

⚠WARNING Keep cigarettes, sparks and open flame away from fuel tank. Refuel in designated areas only. Do not fill fuel tank with engine running. Make sure fuel container and machine are electrically connected when refueling. Do not overfill LP tank. Check for odor of escaping gas before and during starting LPG engines.

⚠WARNING Provide adequate ventilation system to properly expel discharged gases. Check exhaust system regularly for leaks. Carbon Monoxide is dangerous.

⚠WARNING Keep cigarettes, sparks and open flame away from lead acid batteries. Batteries emit a highly explosive hydrogen gas.

⚠CAUTION Avoid moving parts of the unit. Loose jackets, shirts or sleeves should not be permitted when working on machine because of the danger of becoming caught in moving parts. Keep shields and guards in position. If adjustments must be made while the unit is running, use caution around hot manifolds, moving parts, V-belts, etc.

⚠WARNING Lock hopper in "UP" position, using Safety Lock, before changing brushes or working under hopper. See instructions on lock.

⚠CAUTION Disconnect battery terminal before servicing electrical components.

⚠CAUTION Check brakes and steering control for proper operation. Do not start machine unless you are in driver's seat, with foot on brake pedal, or parking brake engaged, and directional pedal in neutral. Stop engine and set parking brake before leaving machine.

⚠CAUTION This machine is steered by means of the rear wheel, and is very responsive. Become familiar with this type of steering system. Travel slowly and use care on grades and slippery surfaces.

⚠WARNING Never operate in areas of overhead danger unless machine is equipped with overhead guard.

The following symbols are used throughout this manual as indicated in their descriptions:

⚠DANGER To warn of immediate hazards which will result in severe personal injury or death.

⚠WARNING To warn of hazards or unsafe practices which could result in severe personal injury or death.

⚠CAUTION To warn of hazards or unsafe practices which could result in minor personal injury.

ATTENTION! To warn of unsafe practices which could result in extensive equipment damage.

NOTE To give important information or to warn of unsafe practices which

TABLE OF CONTENTS

MAINTENANCE

REPLACEMENT BRUSH LIST

SIDE SWEEPING BRUSHES - 26 in (660 mm) diameter

51870N	SIDE BRUSH & SUPPORT ASSEMBLY, Nylon
51021N	BRUSH, Side, Nylon
51963	SUPPORT (adaptor)
	MOUNTING HARDWARE, Miscellaneous
51939	SIDEBRUSH & SUPPORT ASSEMBLY, Flat wire
51542	BRUSH, Side, flat wire
51963	SUPPORT (adaptor)
	MOUNTING HARDWARE, Miscellaneous

MAIN SWEEPING BRUSHES - 50 in (1,270 mm) long, 16 in (406 mm) diameter

51487	PROEX, 8-Row, (for medium to heavy sand gravel, paper litter, etc.).
52213	NYLON, 24-Row, high density (combines long life with excellent sweeping qualities)
51887	PATROL, 5-Row, nylon (for outside faster, sweeping of medium to light debris).
51567	CRINKLE WIRE, 8 Row, (maximum cleaning action for semi-impacted soilage & hard -to-sweep dirt).
51709	COMBINATION, 8-Row, (Crinkle wire & Proex for slightly-packed soilage & heavier debris).

DECIMAL EQUIVALENTS

INCH-MILLIMETER CONVERSION TABLE

1/2	1/4	1/8	1/16	1/32	1/64	Decimals	Millimeters
					1	.015625	.396875
				1		.031250	.793750
					3	.046875	1.190625
			1			.062500	1.587500
					5	.078125	1.984375
				3		.093750	2.381250
					7	.109375	2.778125
		1				.125000	3.175000
					9	.140625	3.571875
				5		.156250	3.968750
					11	.171875	4.365625
			3			.187500	4.762500
					13	.203125	5.159375
				7		.218750	5.556250
					15	.234375	5.953125
	1					.250000	6.350000
					17	.265625	6.746875
				9		.281250	7.143750
					19	.296875	7.540625
			5			.312500	7.937500
					21	.328125	8.334375
				11		.343750	8.731250
					23	.359375	9.128125
		3				.375000	9.525000
					25	.390625	9.921875
				13		.406250	10.318750
					27	.421875	10.715625
			7			.437500	11.112500
					29	.453125	11.509375
				15		.468750	11.906250
					31	.484375	12.303125
1						.500000	12.700000
					33	.515625	13.096875
				17		.531250	13.493750
					35	.546875	13.890625
			9			.562500	14.287500
					37	.578125	14.684375
				19		.593750	15.081250
					39	.609375	15.478125
		5				.625000	15.875000
					41	.640625	16.271875
				21		.656250	16.668750
					43	.671875	17.065625
			11			.687500	17.462500
					45	.703125	17.859375
				23		.718750	18.256250
					47	.734375	18.653125
	3					.750000	19.050000
					49	.765625	19.446875
				25		.781250	19.843750
					51	.796875	20.240625
			13			.812500	20.637500
					53	.828125	21.034375
				27		.843750	21.431250
					55	.859375	21.828125
		7				.875000	22.225000
					57	.890625	22.621875
				29		.906250	23.018750
					59	.921875	23.415625
			15			.937500	23.812500
					61	.953125	24.209375
				31		.968750	24.606250
					63	.984375	25.003125
2							.000000

SPECIFICATIONS

FOR

TENNANT MODEL 92 POWER SWEEPER

General Information

SWEEPING PATH WIDTH	66 inches (1676mm) (with side brush)
SWEEPING SPEED	3 to 5 mph (4.8 to 8 km/hr)
TRAVEL SPEED	10 mph (16.1 km/hr)
TURNING RADIUS	Left (vehicle clearance) - 71 in (1803mm) Right(vehicle clearance) - 85 in (2159mm)
ISLE WIDTH TURN	Left - 123.5 in (3136 mm) Right - 159 in (4038 mm)
DIMENSIONS	See Dimension Drawings
DRY MACHINE WEIGHT (Standard) (Hi-Dump Model)	4200 lbs (1905 kg) weights are 4500 lbs (2041 kg) approximate
HYDRAULIC TANK CAPACITY	Tank: 4.5 gal (17 liters) System: 5.5 gal (20.8 liters)
COOLING SYSTEM CAPACITY	Radiator: 6.4 qts (6.1 liters) System: 12.4 qts (11.7 liters)
FUEL TANK CAPACITY	18 gal (68 liters)
BATTERY	12 V, 84 A/h
PROPELLING DRIVE	Direct-coupled, engine-driven, piston pump. Pump provides flow to direct rear-wheel mounted Hydraulic motor. Engine runs at constant speed.

(continued on next page)

BRUSHES & VACUUM FAN DRIVE . .	Hydraulic motor driven
MAIN BRUSH	Length: 50 in (1270mm) Diameter: 16 in (406mm)
SIDE BRUSH	Diameter: 26 in (660mm)
FILTER AREA	150 sq. ft. (14 sq. m.)
HOPPER	25.5 cu. ft. (0.72 cu. m.)
BRAKES	Hydraulic front wheel brakes Mechanical parking brake
HOPPER DUMP	Hydraulic
STEERING	Automotive-type, rear wheel
TIRES	Front: Solid Rear: Pneumatic (Rear tire solid on Hi-Dump Model)

MAXIMUM RATED RAMP CLIMB ANGLE

	Accessories on or off, machine empty	Accessories on, with advertised load	
Standard 92	15°	13°	1800 lbs (816.47 kg)
92 Hi-Dump	15°	13°	1500 lbs (680.39 kg)

MAXIMUM RATED RAMP DESCENT ANGLE

	Machine empty	With advertised load	
Standard 92	15°	13°	1800 lbs (816.47 kg)
92 Hi-Dump	15°	13°	1500 lbs (680.39 kg)

Note that loaded machine should not descend as steep a ramp as an empty machine. This is because of limitations imposed by machine stability.

GASOLINE & LPG ENGINE SPECIFICATIONS

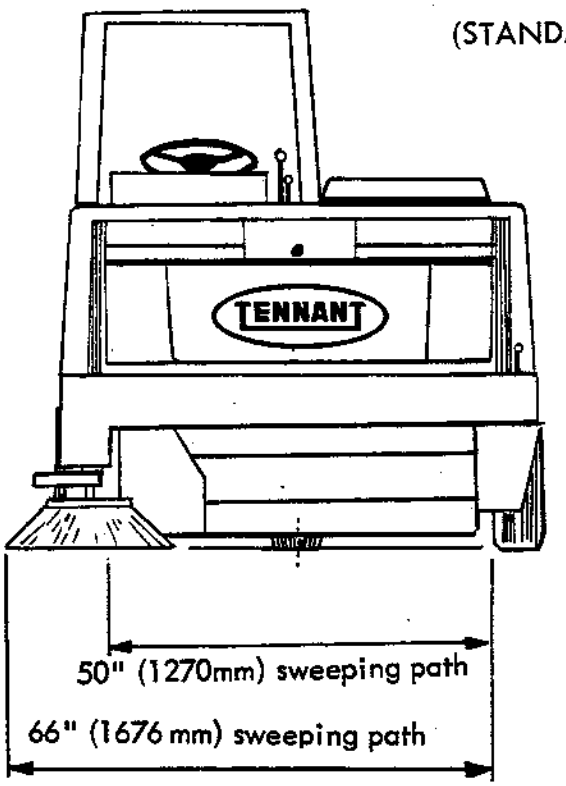
ENGINE MANUFACTURER	TELYDYNE CONTINENTAL MOTORS
MODEL	F163 5100 SERIES
WEIGHT (Bare Engine)	415 lbs (188 kg)
NUMBER OF CYLINDERS	4
FIRING ORDER	1 - 3 - 4 - 2
DISPLACEMENT.	162 cubic inches (2655 cc)
CYLINDER BORE	3.44 inches (87.4 mm)
PISTON STROKE	4.375 inches (111.1 mm)
HORSEPOWER	55 hp at 2200 rpm (governed speed)
COMPRESSION RATIO	7.4 to 1 gasoline, 8 to 1 LPG fuel
OIL CAPACITY, Crankcase	4 qts (3.78 liters)
OIL CAPACITY, with Filter	4.5 qt (4.26 liters)
INTAKE VALVE CLEARANCE . . .	.012 inches (0.3 mm)
EXHAUST VALVE CLEARANCE . .	.020 inches (0.5 mm)
BREAKER POINT GAP	.020 inches (0.5 mm)
SPARK PLUG GAP	.025 inches (0.6 mm)
SPARK PLUG TORQUE	35 ft lbs
IGNITION TIMING	T.D.C.
BATTERY	12 V, 60 A
ALTERNATOR	12 V, 32 A
ENGINE SPEED	2200 rpm (governor controlled)
STARTER	12 V, solenoid shift
CHOKE	Remote manual type

DIESEL ENGINE SPECIFICATIONS

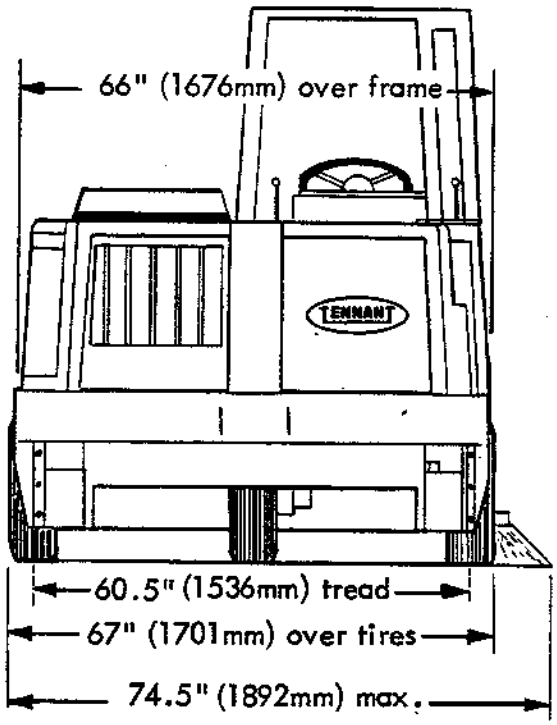
ENGINE MANUFACTURER	PERKINS ENGINES, LTD
MODEL	4.108 DIESEL
WEIGHT (Bare Engine)	450 lbs (204 kg)
NUMBER OF CYLINDERS	4
FIRING ORDER	1 - 3 - 4 - 2
DISPLACEMENT	107.4 cu in (1760 cc)
CYLINDER BORE	3.124 in (79.4 mm)
PISTON STROKE	3.50 in (88.9 mm)
HORSEPOWER	52 H.P. at 4000 rpm.
COMPRESSION RATIO	22 to 1
OIL CAPACITY, Crankcase OIL CAPACITY, with Filter	5 qts (4.73 liters) 5.50 qts (13.4 liters)
VALVE CLEARANCE	0.012 in (0.30 mm) - cold
BATTERY	12 V, 84 A
ALTERNATOR	12 V, 32 A
ENGINE SPEED	2150 to 2200 rpm, full throttle, no load
STARTER	12 V, Solenoid Shift
IDLE SPEED	550 to 600 rpm

DIMENSIONS

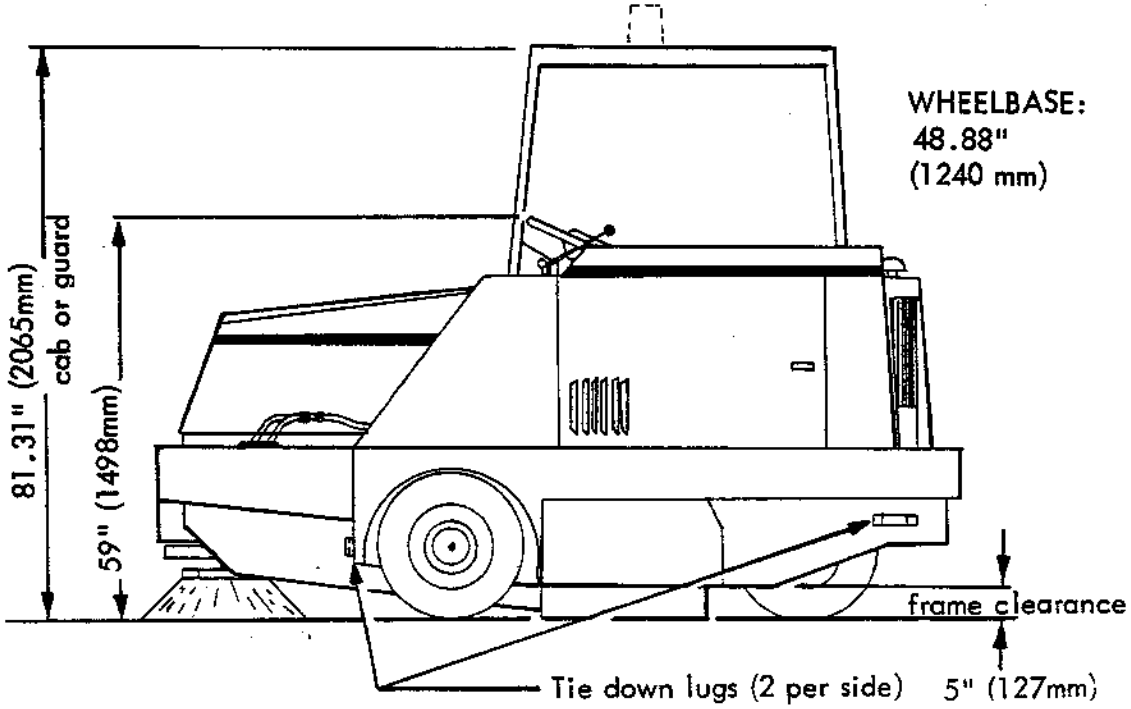
(STANDARD MACHINE)



FRONT VIEW

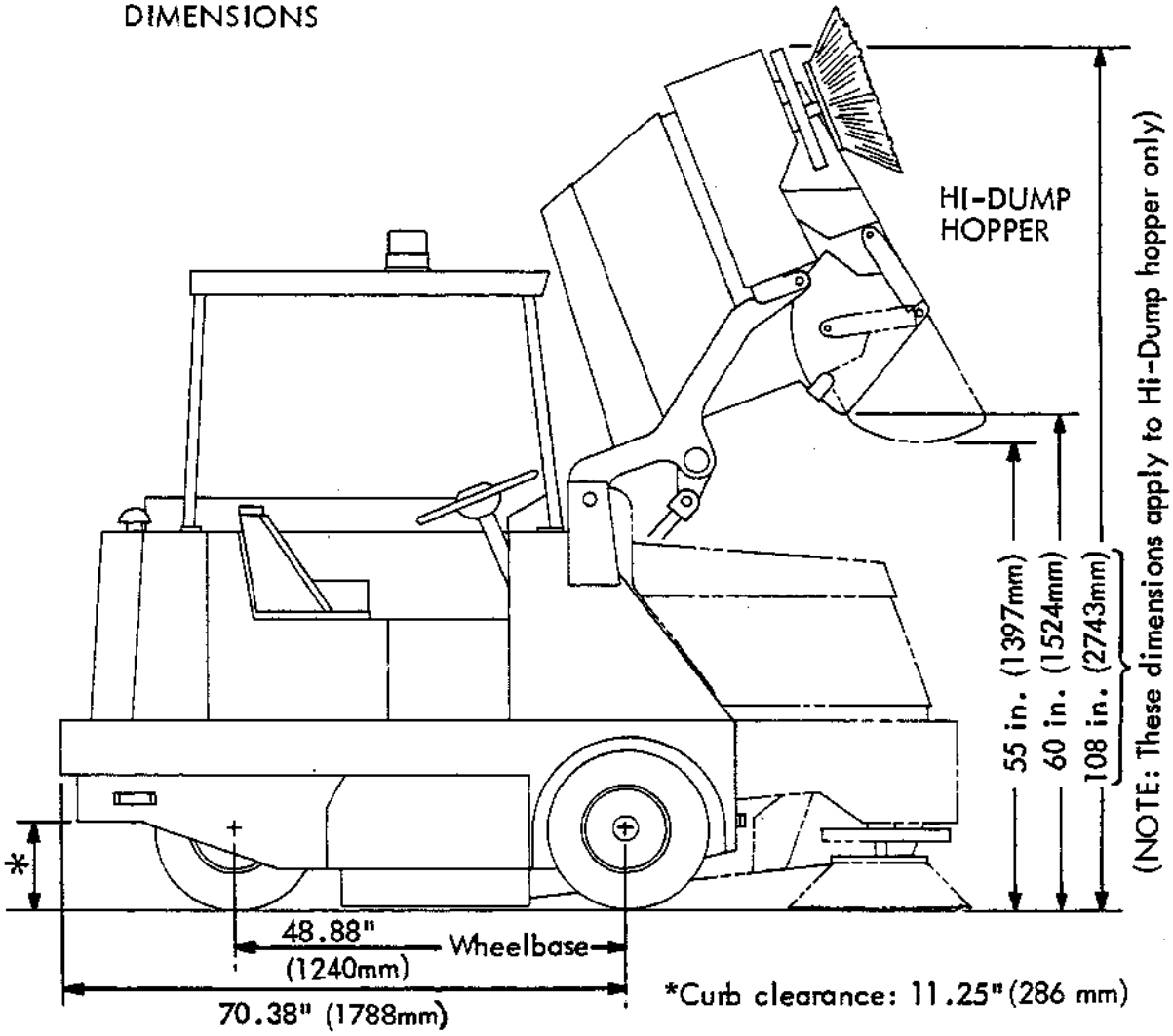


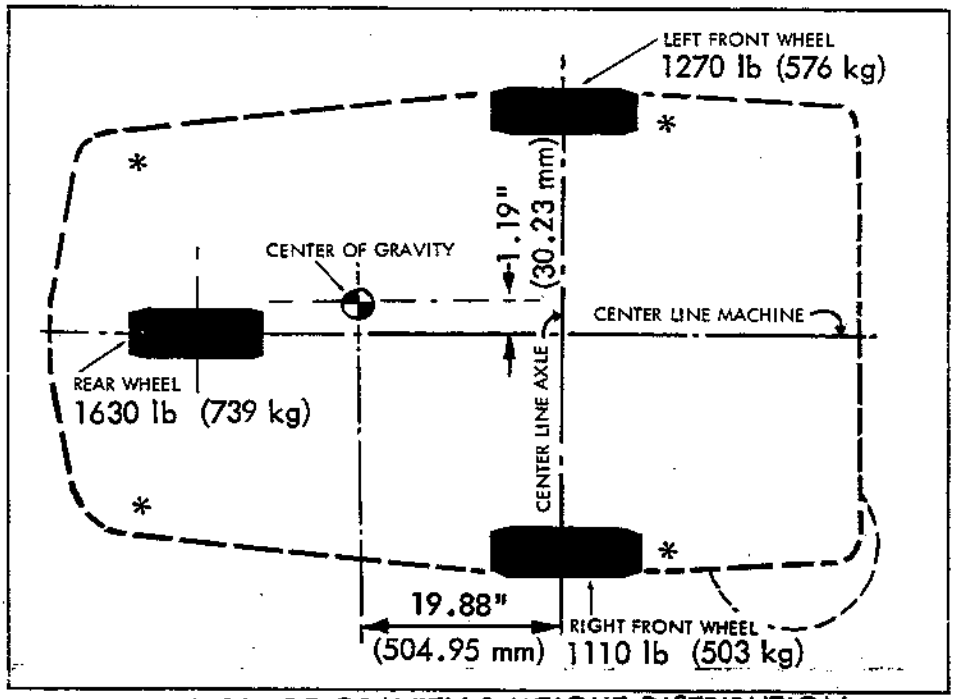
REAR VIEW



LEFT SIDE VIEW

HI-DUMP MODEL DIMENSIONS

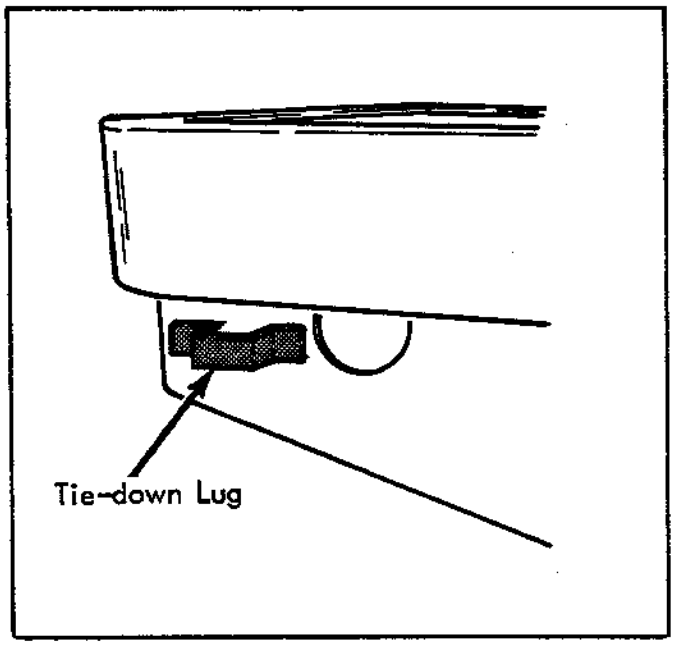




CENTER OF GRAVITY & WEIGHT DISTRIBUTION
(Standard Machine Only)

The location of the center of gravity is based on a machine weight of 4200 lb (1,905 kg), batteries installed, hopper empty, no operator, and hydraulic tank full.

* Indicates tie-down lugs.



FOUR TIE-DOWN LUGS ARE PROVIDED

ATTENTION! Do not tie the machine down at the bumper. This will damage the lift arms. Use the tie-down lugs provided.

PREPARATION FOR OPERATION

Your TENNANT Power Sweeper has been shipped complete. You can operate your machine after following these directions:

AFTER UNCRATING:

1. Check to see if battery is installed and connected to cables. Battery is located below operator's seat. Remove cushion for access.

2. Check oil level in hydraulic oil tank. An oil level sight gauge is provided on tank. TENNANT Hydraulic Oil is recommended. See Maintenance Section for a complete description of TENNANT Hydraulic Oil. Capacity of the hydraulic oil tank is 4.5 gallons (17 liters).

3. Check to be sure that the fusible link located on the filter box fire door has not been broken in shipment (if the link has broken, engine and hydraulic oil will overheat). See section titled "Fusible Link Replacement" in Maintenance Section for replacement.

4. Never fill fuel tank while engine is running. Always be sure fuel container and machine are electrically connected before pouring. This can easily be done by using an insulated wire (permanently attached to container) with a battery clip on the other end.

5. Check engine crankcase oil level. Although properly lubricated at factory, check before starting engine. No special break-in oil is used and recommended number of operating hours before the initial oil change is the same as normal. (See "Engine Section" for daily, 50-hour, 250-hour and 500-hour recommended maintenance schedules.)

6. Check radiator coolant level. Permanent type antifreeze is added at the factory to provide protection to approximately -35° (-37.22°C). To retain this protection level, always add 1/2 part water to 1/2 part antifreeze.

7. Check tire pressures. Recommended tire pressure - Rear tire on standard machine: 95 to 125 psi (655 to 862 kPa). On the Hi-dump model, the rear tire is solid. The front tires on both models are solid.

8. Install main sweeping brush.

9. Adjust seat to comfortable operating position (adjustment lever is located under front edge of seat.)

10. Please read this manual carefully before attempting to operate your machine.

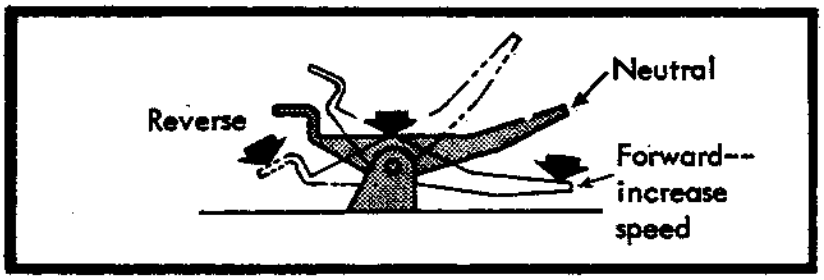
OPERATION OF CONTROLS

BRAKE PEDAL

The brake pedal operates the brakes on the two front wheels.
To stop, return the direction control pedal to neutral, then apply pressure to the brake pedal.

DIRECTIONAL CONTROL PEDAL

A single foot pedal controls the hydraulic propelling drive and is used to select direction of travel and propelling speed of the machine, as shown on the sketch.



POSITIONS OF THE DIRECTIONAL PEDAL

Gradually depress the "toe" portion of the pedal for forward travel or the "heel" portion, for reverse travel. Regulate the machine speed by varying the pressure on the pedal.

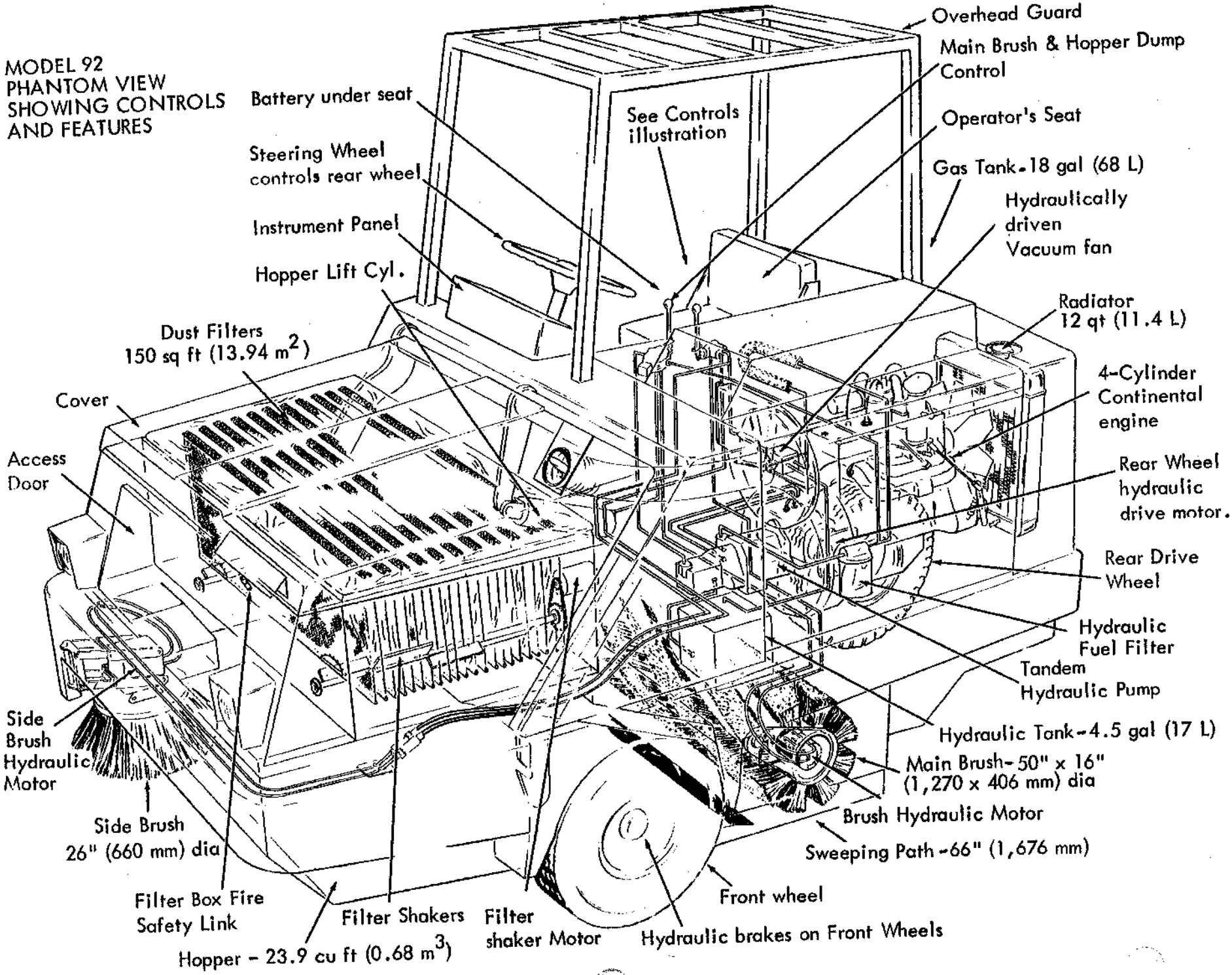
If the machine creeps when the pedal is in neutral position, see "Adjusting Directional Control Pedal Neutral Position" in the Maintenance section.

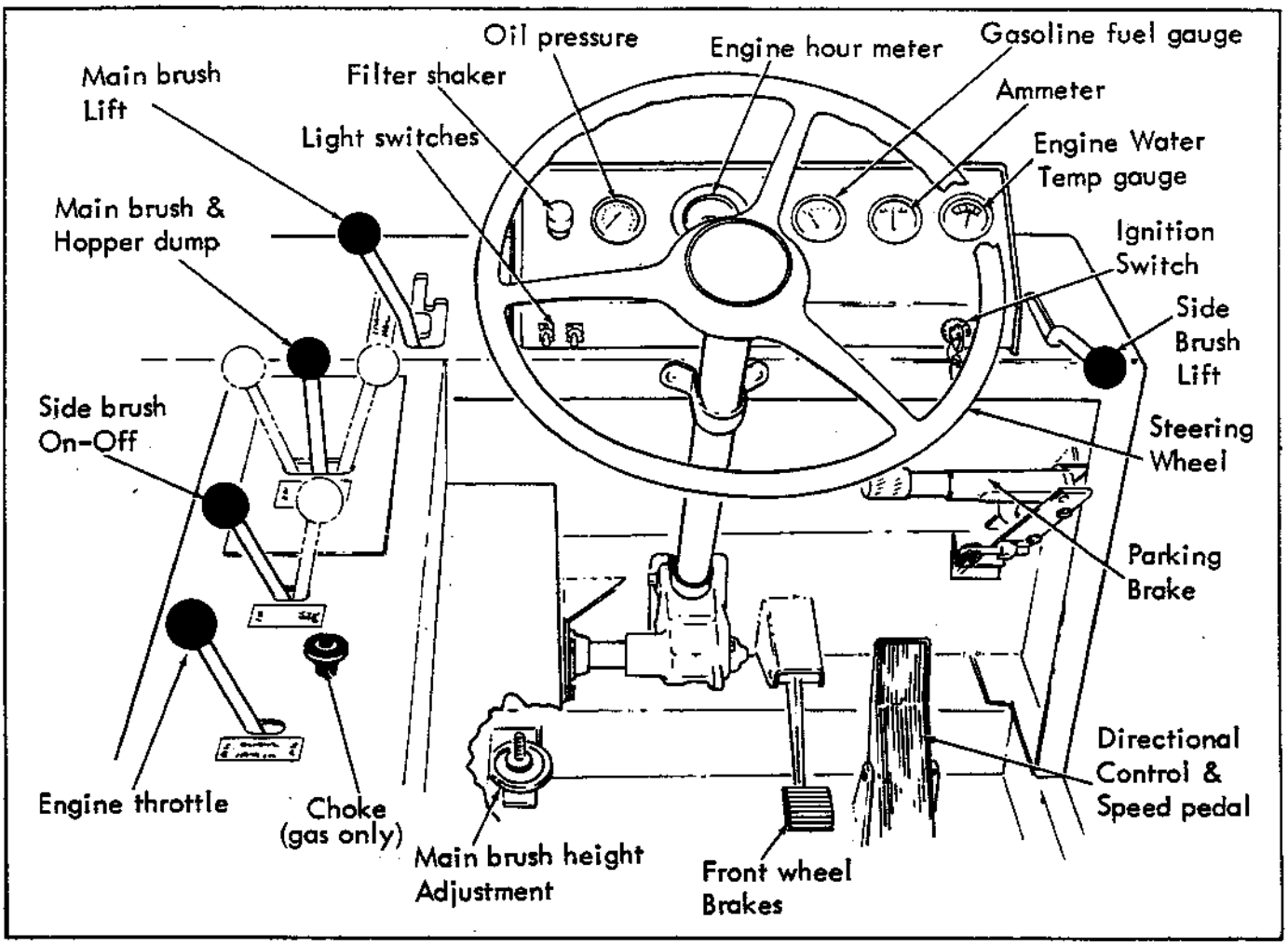
The hydraulic drive may be used to slow the machine travel by moving the direction control pedal thru neutral to the opposite direction. When stopped, return the pedal to neutral.

NOTE Always use the brake pedal for normal stopping and for controlling speed on down grades.

NOTE On the Hi-dump model, a speed limiting device is provided on the control pedal. This device automatically reduces machine speed when the hopper is raised.

MODEL 92 PHANTOM VIEW SHOWING CONTROLS AND FEATURES

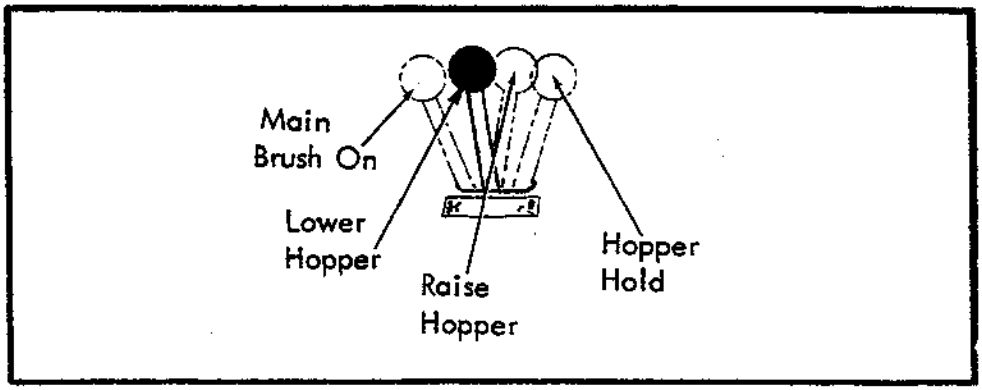




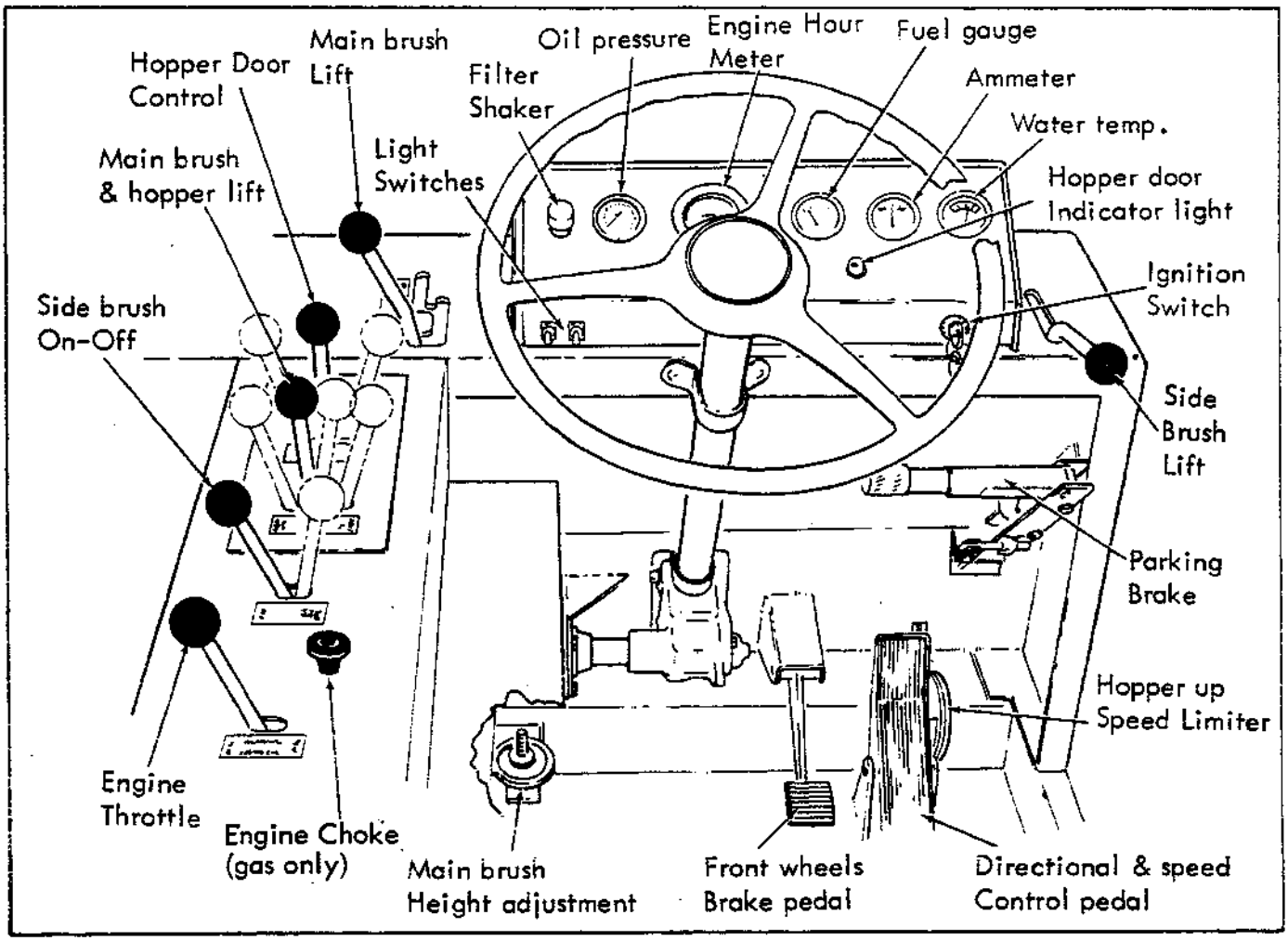
CONTROLS & INSTRUMENTS ON STANDARD MODEL 92

MAIN BRUSH AND HOPPER DUMP CONTROL (Standard Machine)

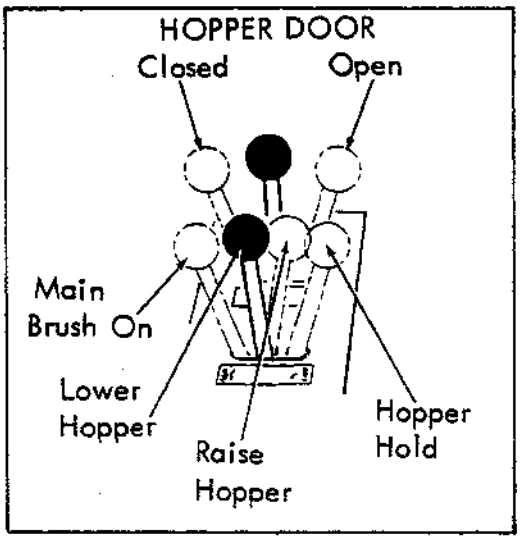
This control lever operates a hydraulic control valve. Two positions of the control start and stop main sweeping brush rotation. The third control position raises and dumps the hopper. This position also stops brush rotation (including side brush and vacuum fan). A fourth position holds the hopper in place.



MAIN BRUSH AND HOPPER DUMP CONTROL LEVER



CONTROLS AND INSTRUMENTS ON THE HI-DUMP MODEL 92



MAIN BRUSH & HOPPER LIFT CONTROL

MAIN BRUSH & HOPPER LIFT CONTROL
(Hi-Dump Model only)

This control is used to start or stop main brush rotation, and to raise or lower the hopper. A separate control lever is provided for opening or closing the hopper door. The hopper door must be closed when raising the hopper, then opened for dumping. An indicator light on the instrument panel informs the operator whether the door is opened or closed. Keep the hopper door open during sweeping.

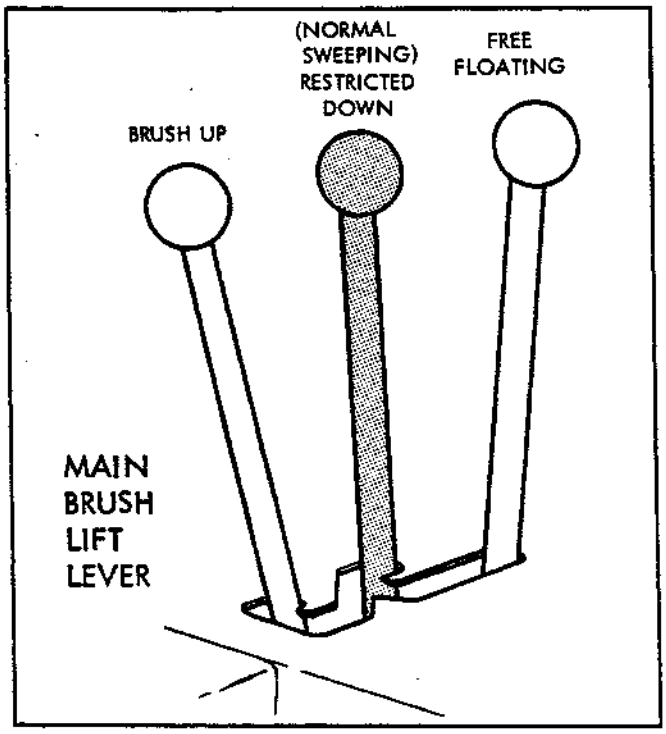
MAIN SWEEPING BRUSH

The main sweeping brush is 50 in (1,270 mm) long & 16 in (406 mm) dia. The brush is driven by a hydraulic motor. Brush rotation is stopped and started by means of a hydraulic control lever; and is raised or lowered into sweeping position with the Brush Lift Lever. An adjustment knob is provided for setting the brush height from the floor. When not sweeping, the operator should keep the brush in the raised position.

MAIN BRUSH LIFT LEVER

The main sweeping brush lever has three positions: "Brush Locked Up", "Restricted Down" (for normal sweeping) and "Free Floating".

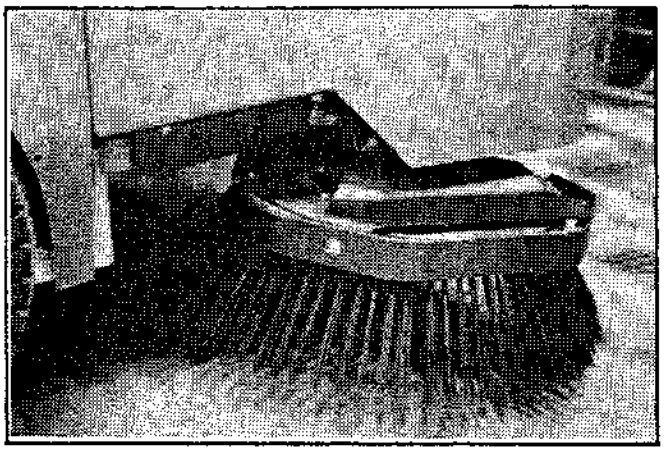
To lower the main sweeping brush, pull the lever back, to clear locking notch, then move the lever forward (see sketch) and into either one of the two positions. To raise the brush, pull the lever back, then to the left and into the small notch where it will be locked in place (see sketch).



You may operate the main brush in either the "RESTRICTED DOWN" or "FREE FLOATING" positions, HOWEVER, the "RESTRICTED DOWN" position should be used for normal sweeping and will result in much longer brush life. The "FREE FLOATING" position should be used only when sweeping extremely uneven areas where unrestricted brush movement allows the brush to follow surface contours.

SIDE SWEEPING BRUSH

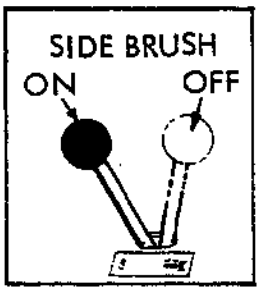
The 26 in (660 mm) dia side sweeping brush is driven by a hydraulic motor whenever the main brush is operating. Side brush replacement and adjustment are covered in this section.



SIDE BRUSH HYDRAULIC CONTROL

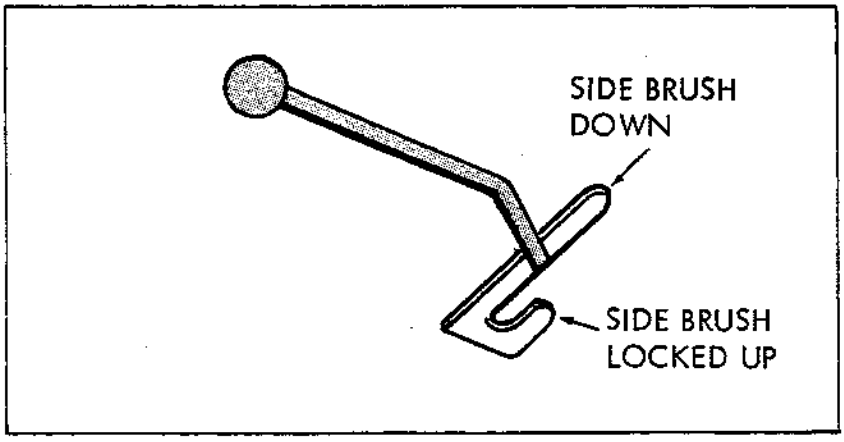
To start side brush rotation, move control lever to "on" position--see sketch of controls.

NOTE Side brush will not rotate unless the main brush is also running.



SIDE BRUSH LIFT LEVER

To raise and lock up the side brush, pull the lever back and move it into locking slot. To lower the brush, move the lever out of the locking slot, then push it forward. Be sure to raise the side brush whenever it is not needed, or when transporting the machine.

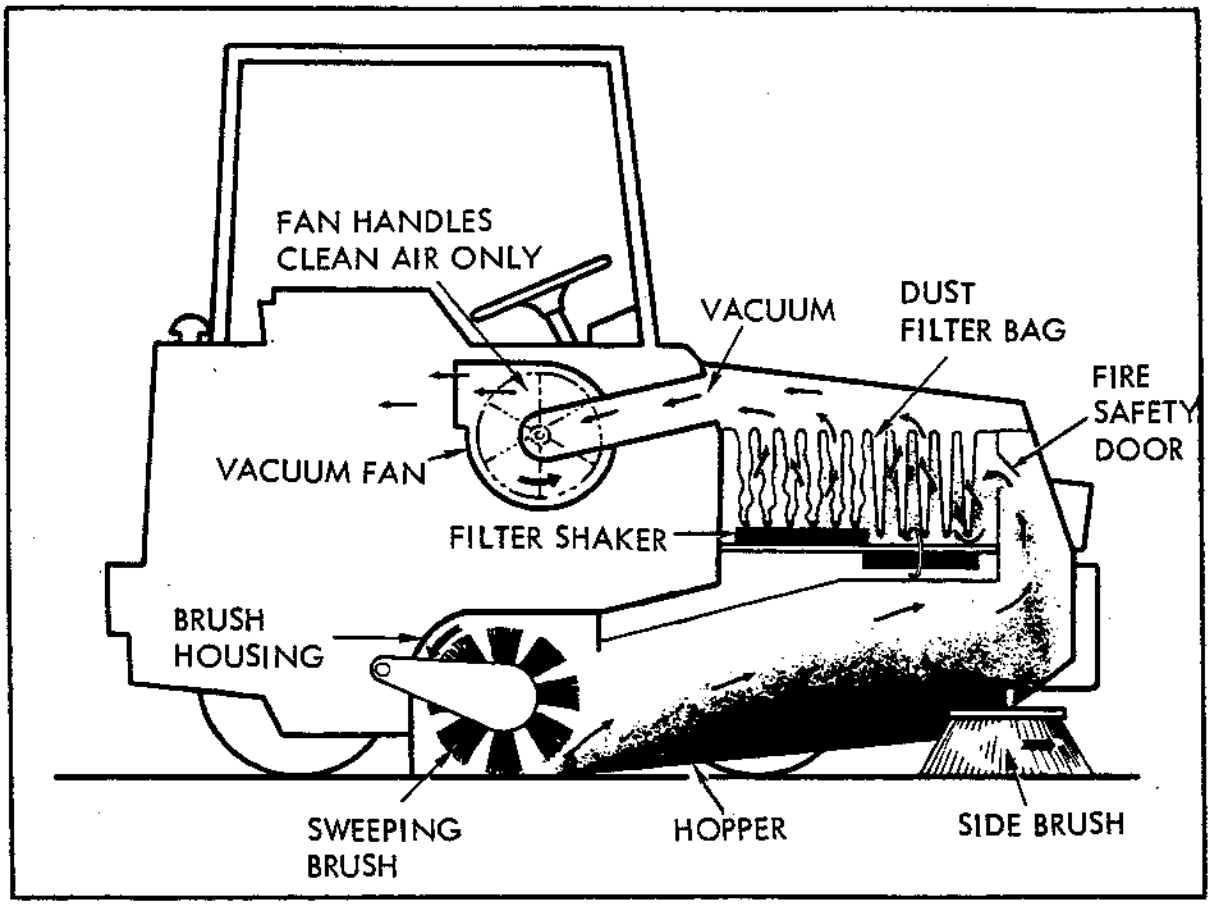


FILTER SHAKER PUSHBUTTON

Press the shaker button to actuate the shaker motors (the brushes must be off and hopper down). Keep button depressed for approximately 30 seconds to shake filter envelopes clean. The two electric shaker motors drive, through chains, two shaker rods which have paddles that strike the bottoms of the filter bags--thus removing dust from the bags.

VACUUM FAN

The high volume 9 in (228 mm) dia vacuum fan is driven by a hydraulic motor. The fan runs whenever the brushes are operating. Exhaust air from the fan is directed over cooling fins located on the hydraulic lines. The vacuum fan and brushes should be stopped whenever operating the filter shaker. Stopping the brushes will automatically stop the vacuum fan.



FILTER AND VACUUM SYSTEM

STEERING WHEEL

The automotive-type steering wheel controls the single rear wheel through an arm and tie rod arrangement. Since the machine is very responsive to movement of the steering wheel, the operator should use care until he becomes more experienced in guiding the machine.

FOOT BRAKE PEDAL

The foot brake pedal operates the hydraulic brakes on the two front wheels.

HANDBRAKE LEVER

Pull the handbrake lever up to vertical position to apply the front wheel brake. Be sure to engage the handbrake whenever parking the machine.

ENGINE CHOKE CONTROL (GAS ENGINE ONLY)

Pull out choke knob when starting engine, but avoid excessive choking which will "flood" the engine. Push choke in all the way as the engine warms up. Never pull out choke when stopping engine--this will cause raw gas to wash oil from the cylinder walls.

ENGINE THROTTLE

The engine throttle has only two positions: "closed" and "open". In the "open" position the governor controls engine speed. The machine must always be operated with the engine at full "open" throttle in order to obtain proper vacuum and dust control. (Diesel engine throttle has stop position).

KEY-OPERATED IGNITION SWITCH

The ignition switch is located on the side of the instrument panel. Turn the key to extreme right momentarily in order to start the engine. Do not operate the starter for more than 10 seconds at one time.

FUEL LEVEL CHECK BUTTON AND GAUGE

To avoid running out of fuel, always check fuel level before starting the engine. To do this press the "fuel level check button". Add fuel if necessary. If the engine is started and allowed to run out of fuel, it will be necessary to perform a very complex bleeding operation to remove all air from the entire fuel system. Once the engine is running, the fuel level gauge will operate without having to press the button.

DIESEL FUEL LEVEL CHECK BUTTON AND GAUGE

To avoid running out of Diesel fuel, always check fuel level before starting the engine. To do this press the "fuel level check button". Add fuel if necessary. If the engine is started and allowed to run out of fuel, it will be necessary to perform a very complex bleeding operation to remove all air from the entire fuel system. Once the engine is running, the fuel level gauge will operate without having to press the button.

HOPPER SAFETY LOCK

A safety lock is provided which props up the hopper mechanically.

⚠WARNING Never reach under the upraised hopper without first engaging the safety lock. Do not depend upon the hydraulic cylinder to support the hopper -- leakage in the cylinder or lines could allow the hopper to lower.

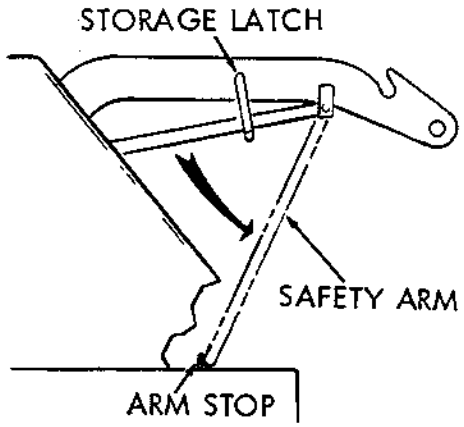
TO ENGAGE SAFETY ARM (Standard Machine)

1. Lift hopper to extreme "UP" position.
2. Release safety arm from storage latch of right lift arm.
3. Lower hopper to apply pressure against stop.

⚠CAUTION Make sure the arm is engaged in arm stop.

TO RELEASE SAFETY ARM (Standard Machine)

1. Lift hopper to extreme "UP" position.
2. Raise safety arm and engage in storage latch.
3. Lower hopper.



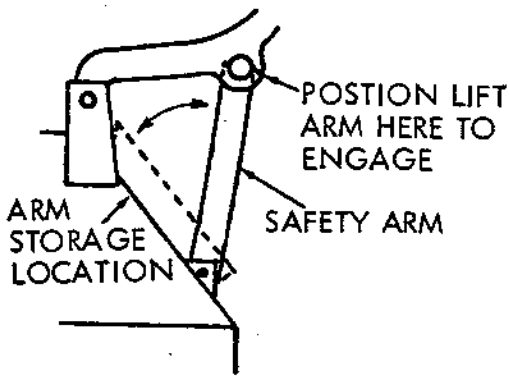
STANDARD MACHINE SAFETY ARM

TO ENGAGE SAFETY ARM (High Dump Machine)

1. Lift hopper to extreme "UP" position.
2. Place safety arm under lift arm.
3. Lower hopper to apply pressure on safety arm.

TO RELEASE SAFETY ARM (High Dump Machine)

1. Lift hopper to extreme "UP" position.
2. Place safety arm against the lintel.
3. Lower hopper.



HI-DUMP MACHINE SAFETY ARM

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POWER SWEEPER

operation

OPERATION

TO START GASOLINE ENGINE

⚠CAUTION Do not attempt to start the machine unless you are in the driver's seat with foot on brake pedal or the hand brake engaged and with the directional pedal in neutral position.

1. If the engine is cold, pull up the choke button (about 3/4 choke). Leave the throttle in closed position (for LP engine, slowly open the hand valve on the LP tank).

2. Turn the starter key switch to "start" momentarily until the motor starts. Release the key as soon as the motor starts. Never operate the starter for more than a few seconds.

3. If the engine fails to start after following the above procedure, refer to the Engine section trouble shooting (for LP engine, see LPG section).

NOTE When the machine has been stored in below freezing temperatures, run the engine at idle speed with the machine standing still for 5-10 minutes to warm the engine and the hydraulic oil.

TO START DIESEL ENGINE

1. Set the throttle at idle position.

2. Press "Fuel Level Check" button to check fuel level. Fill the fuel tank if necessary. Never allow the engine to run out of fuel -- this allows air into the fuel lines and will require complete bleeding of all air in the fuel system.

3. Turn the starter key switch to "start" momentarily until the motor starts. Release the key as soon as the motor starts. Never operate the starter for more than a few seconds.

TO PROPEL MACHINE

1. Start engine (with brakes engaged and directional pedal in neutral).

2. Place main and side brush hydraulic control levers in "ON" position.

NOTE Remember that the main brush must be "On" in order to operate the side brush.

3. Lower the side and main brushes to floor.

4. Place engine throttle in "OPEN" position. (Engine must always be operated at full governed speed while sweeping to obtain recommended brush speed and dust control.)

5. Release brakes and push forward on directional control pedal to place machine in motion.

6. Vary your foot pressure on pedal to obtain desired travel speed.

TO STOP MACHINE

1. Return directional control pedal to neutral (centered) position.

2. Apply foot brake.

3. Raise main and side brushes from floor and place hydraulic controls for both brushes in "OFF" position.

4. Push engine throttle control to "IDLE". (Set at "stop" for diesel).

5. Turn key to "OFF".

6. Apply parking brake.

PUSHING OR TOWING MACHINE

ATTENTION! Never attempt to tow or push the machine for a long distance. To do so may cause damage to the hydraulic drive syste.

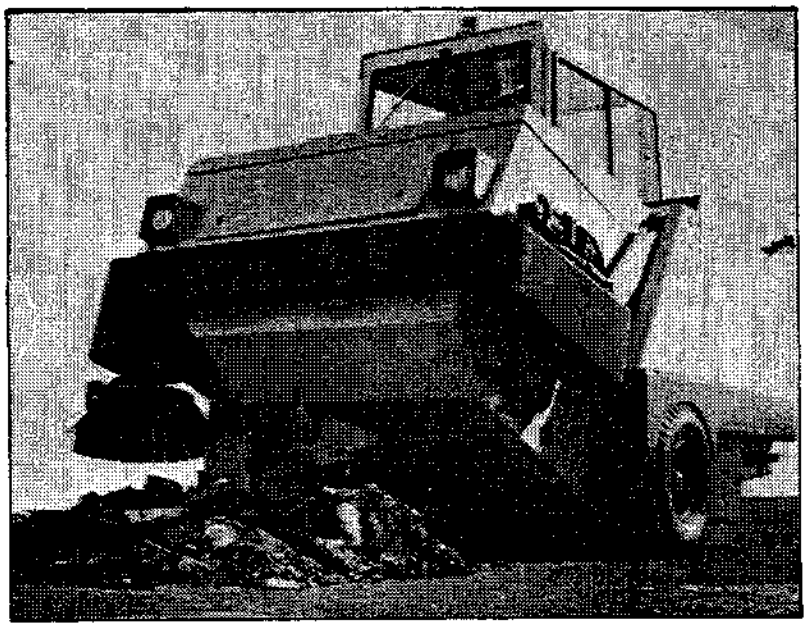
HOPPER - GENERAL DESCRIPTION

The hopper has a "floating" action which allows it to pivot slightly so that objects can pass under the hopper and then be swept into the pan by the brush.

The hopper on the Hi-Dump Model features a hydraulically operated door, controlled by the operator. A safety leg is extended to give extra support when the hopper is raised.

An access door is provided at the front of the hopper so that the operator can inspect hopper contents. The door can also be used for inserting items which are too large for sweeping, or for flushing out the hopper.

The fusible link, accessible through this door, will break if hopper debris should catch fire. The opening of this link allows a spring to close the fire door, which shuts off vacuum air flow through the hopper, thus preventing the ingestion of fire into the filters.



MODEL 92 HOPPER

TO DUMP HOPPER - STANDARD MACHINE, NOT HI-DUMP

1. Turn off brushes and vacuum fan. Raise both main and side brushes.

2. Push filter shaker button for a few seconds to clean filter.

3. Move Hopper Control Lever to "Hopper Dump" position. Engine must be at full throttle.

4. After hopper is emptied, back sweeper away and turn to left so that side brush will clear dirt pile.

5. Lower hopper to sweeping position by moving Hopper Control Lever to "down".

TO DUMP HI-DUMP HOPPER

1. Turn off brushes and vacuum fan. Raise both main and side brushes.

2. Push filter shaker button for a few seconds to clean filter.

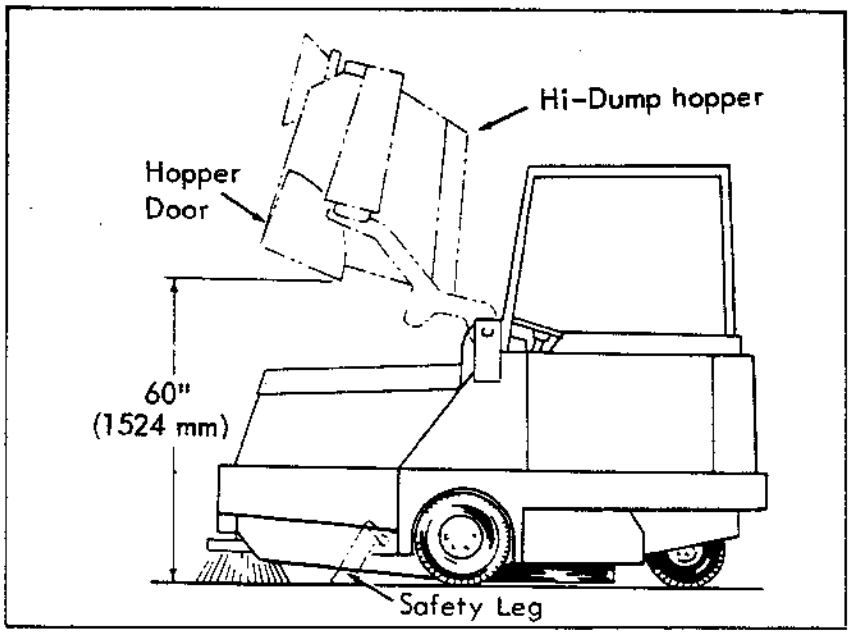
3. Use Hopper Door Control to close hopper door before raising hopper. An indicator light on the panel shows when the hopper door is closed.

4. With the engine at full throttle, raise the hopper. Slowly move the machine into position for dumping. Open the hopper door to dump the hopper.

NOTE When the Hi-dump hopper is raised, a safety leg is lowered which will prevent the machine from tipping. Do not drive the machine with the hopper raised -- the safety leg may catch on rough floor surface.

5. After dumping, close the hopper door, back sweeper away, and lower the hopper. Open the hopper door for sweeping.

NOTE Hopper door must be closed before lowering the hopper after dumping to properly seal the dust compartment. The hopper door must then be opened before sweeping or debris will not be picked up and excessive dusting will occur.



HOPPER SAFETY LOCK

A safety lock is provided which props up the hopper mechanically.

⚠WARNING Never reach under the upraised hopper without first engaging the safety lock. Do not depend upon the hydraulic cylinder to support the hopper -- leakage in the cylinder or lines could allow the hopper to lower.

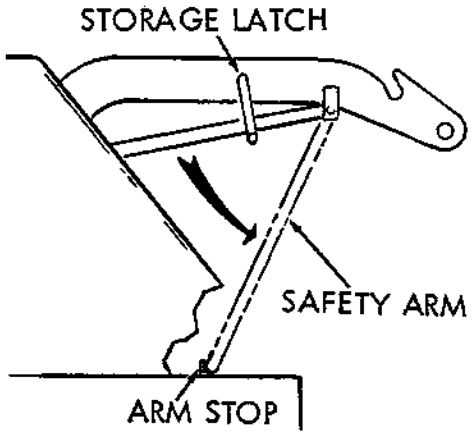
TO ENGAGE SAFETY ARM (Standard Machine)

1. Lift hopper to extreme "UP" position.
2. Release safety arm from storage latch of right lift arm.
3. Lower hopper to apply pressure against stop.

⚠CAUTION Make sure the arm is engaged in arm stop.

TO RELEASE SAFETY ARM (Standard Machine)

1. Lift hopper to extreme "UP" position.
2. Raise safety arm and engage in storage latch.
3. Lower hopper.



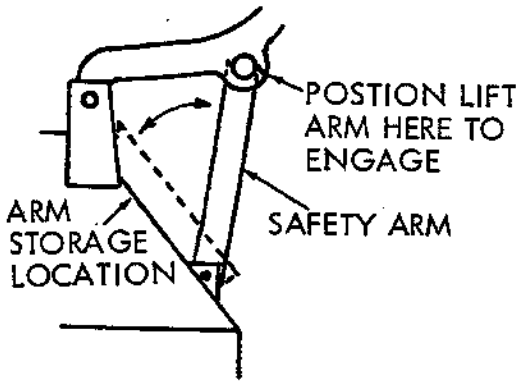
STANDARD MACHINE SAFETY ARM

TO ENGAGE SAFETY ARM (High Dump Machine)

1. Lift hopper to extreme "UP" position.
2. Place safety arm under lift arm.
3. Lower hopper to apply pressure on safety arm.

TO RELEASE SAFETY ARM (High Dump Machine)

1. Lift hopper to extreme "UP" position.
2. Place safety arm against the lintel.
3. Lower hopper.



HI-DUMP MACHINE SAFETY ARM

GENERAL OPERATING SUGGESTIONS

1. Plan your sweeping in advance. Try to arrange long runs with minimum stopping and starting. Sweep debris from narrow aisles out into main aisle ahead of time. Do an entire floor, or section at one time.

2. Pick up oversize debris before sweeping. Flatten or remove bulky cartons, etc., from aisles before sweeping.

3. Allow a few inches overlap of brush paths. This will eliminate leaving dirty patches.

4. Don't turn steering wheel too sharply when machine is in motion. Your sweeper is very responsive to movement of the steering wheel-- so avoid sudden turns, except in emergencies.

5. Try to sweep as straight a path as possible. Avoid bumping into posts or scraping sides of sweeper.

6. When placing sweeper in motion, avoid slamming the directional control pedal all the way forward suddenly. This is equivalent to starting out in "high" gear and puts needless strain on the engine and drive system.

7. Always allow sweeper to warm up before operating in cold temperatures below 30°F (-1°C).

8. Periodically turn the main sweeping brush end for end to prevent the bristles from "setting" in one direction.

9. Be sure to read the precautions concerning maximum recommended ramp climbing or descending angles given in the "Specifications" section.

TO REMOVE MAIN BRUSH

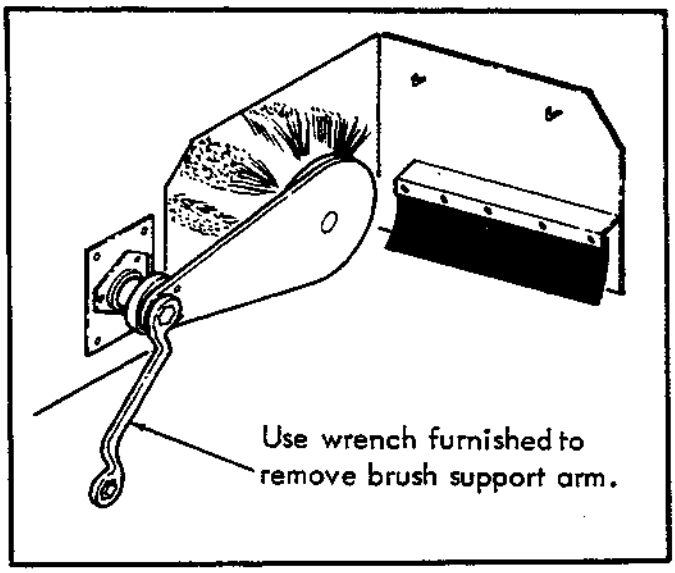
1. Shut off engine.

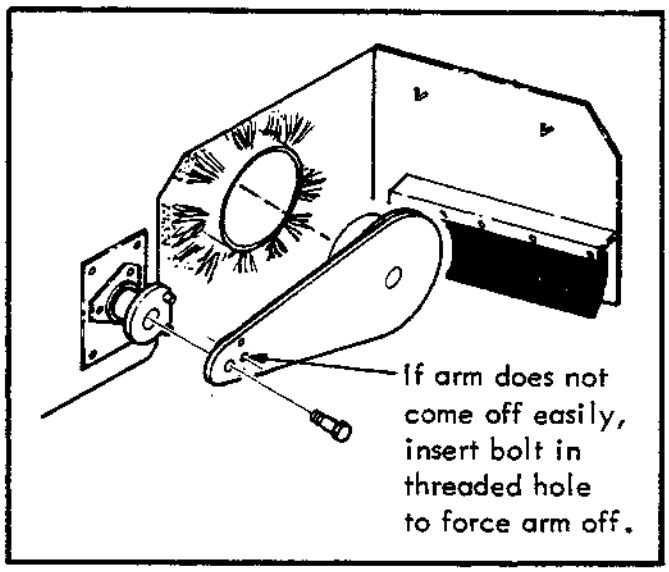
2. Open right side brush access door.

3. Lower brush to floor.

4. Refer to sketch and remove single bolt and plastic plug from upper end of brush support arm. (Use special wrench stored on inside of door.)

5. Pull out on arm to remove.





NOTE If the support arm does not come out easily, insert the bolt in the other threaded hole in the arm to force the arm from the mounting pins.

6. Grasp brush and pull it off left side brush plug; then out through brush access door.

7. Reinstall plastic plug.

TO INSTALL MAIN BRUSH

1. Place brush lift lever in "RESTRICTED DOWN" position.

2. Insert one end of brush through access door opening and push brush in until it touches opposite brush plug.

3. Align brush keys with keyways on left side by slowly turning brush and pushing it into place.

4. Replace right side brush support arm and plug.

NOTE Do not force the brush or the support arm into place. If the keyways are aligned properly, they will easily slide into place.

5. Install hex head bolt with washer and tighten securely.

6. Replace special wrench on access door and close door.

7. Check height adjustment of brush in "RESTRICTED DOWN" position. (See "To Adjust Main Brush Height".)

TO ADJUST MAIN BRUSH HEIGHT

1. Test for correct adjustment as follows:

   a. Park sweeper on smooth, level floor.

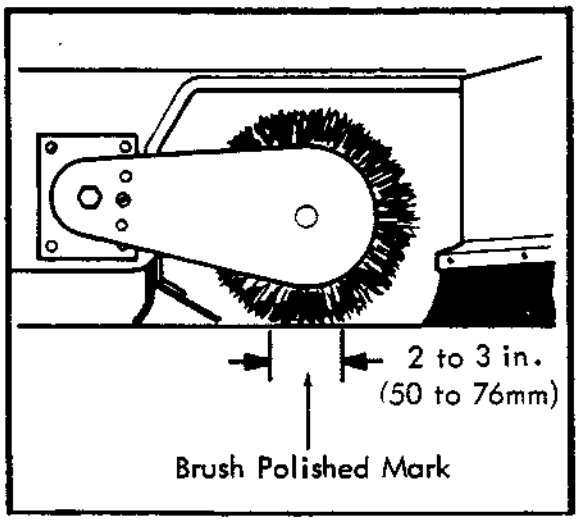
   b. Engage main brush rotation.

   c. Place brush control lever in "RESTRICTED DOWN" position and allow brush to spin in one spot for approximately three minutes.

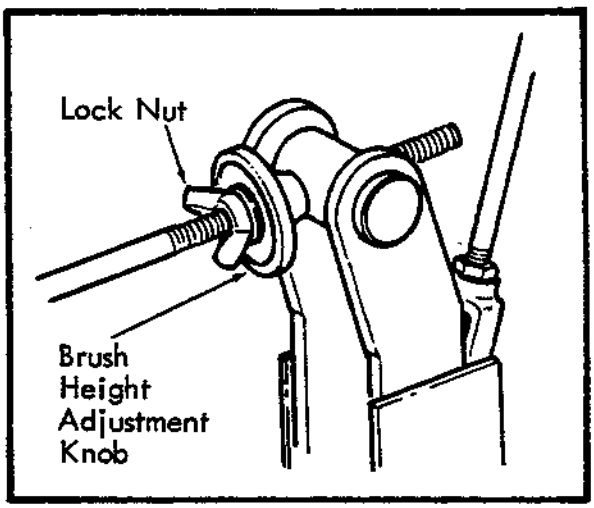
   d. Raise brush and move sweeper off test area.

   e. Refer to sketch. (Polish mark left by brush should be two to three inches wide the full length of brush for normal sweeping.) (Various sweeping conditions and bristle length may require special consideration.)

NOTE Replace the brush if the bristle length is less than one inch (25.4 mm).



BRUSH PATTERN TEST



BRUSH ADJUSTMENT CONTROL

2. If adjustment is required, refer to sketch and loosen lock nut on adjustment knob.

NOTE When making this adjustment, the brush lift lever must be in the "Restricted Down" position.

3. Turn knob as required until 2 to 3 in (50.8 to 76 mm) wide polish mark is achieved (clock-wise rotation of knob raises brushes.)

4. Tighten lock nut.

TO REMOVE SIDE BRUSH

1. Raise hopper to extreme "UP" position and ENGAGE SAFETY LOCK.

2. Shut off engine.

3. Remove bolt from brush drive shaft and remove driving plate and brush.

⚠CAUTION Do not allow the brush assembly to slide off the shaft and drop to the floor as this could cause personal injury or damage to the brush

TO INSTALL SIDE BRUSH

1. If new or different brush is to be installed, remove driving plate from old side brush and mount on replacement brush.

2. With hopper in "DUMP" position and WITH SAFETY LOCK ENGAGED, slide brush on to drive shaft. (If machine is a Hi-Dump Model, do not raise the hopper.)

3. Insert and tighten bolt.

4. If hopper was raised, disengage safety lock and lower hopper to sweeping position.

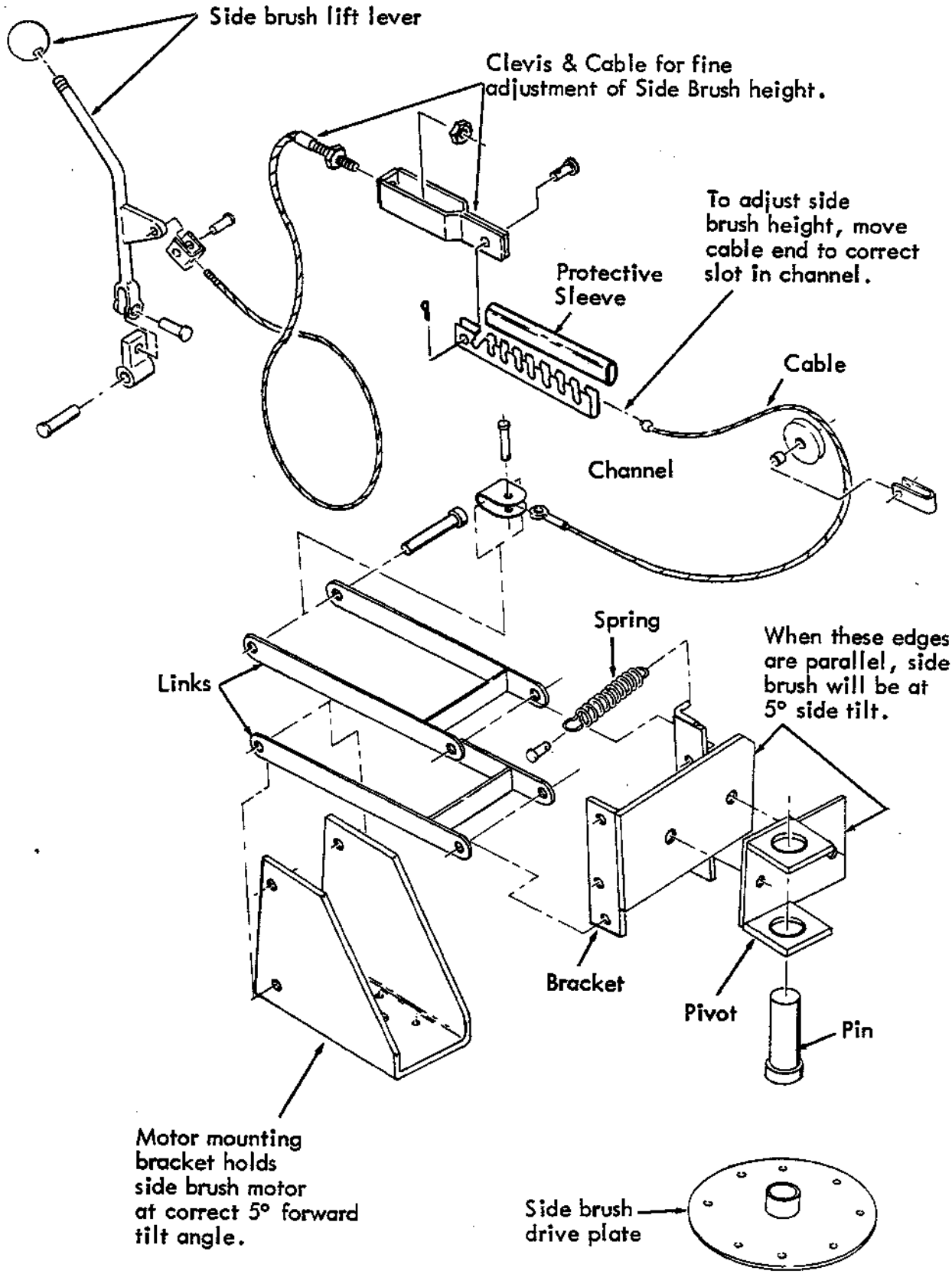
5. Check for proper adjustment of brush. (See "To Adjust Side Brush Height".)

TO ADJUST SIDE BRUSH HEIGHT

1. Adjust as shown in the drawing of the side brush suspension.

NOTE Proper adjustment should allow the full weight of the brush unit on the floor when the brush lift lever is in the "Down" position. However, there must also be sufficient tension to allow clearance off the floor when the brush unit is raised.

2. When proper adjustment is obtained check brush angle.



SIDE BRUSH ADJUSTMENTS

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maintenance

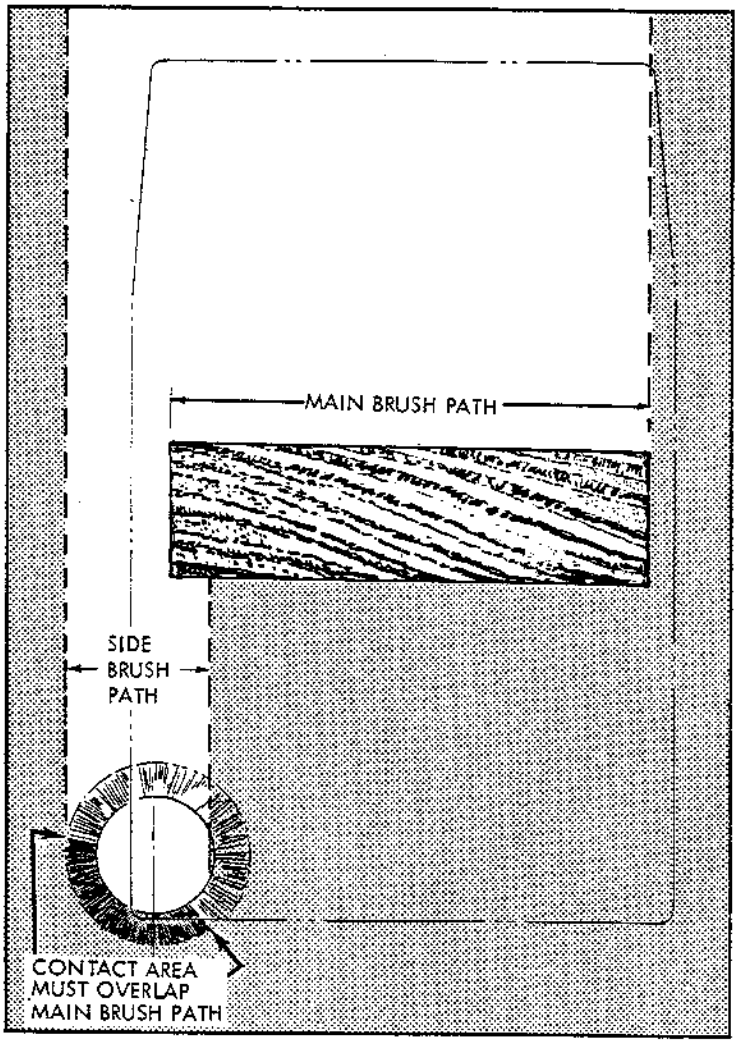
TO ADJUST SIDE BRUSH ANGLE

1. Refer to "Sweeping Path" drawing to check for correct adjustment. (Dark shaded area indicates recommended bristle contact with floor.)

2. If adjustment is required, refer to drawing of "Side Brush Suspension".

TO ADJUST SIDE BRUSH SWEEPING PATH

1. Refer to "Sweeping Path" drawing. (Inside contact point of brush must overlap the path of the main brush.)



2. If adjustment is required, refer to drawing of "Side Brush Suspension".

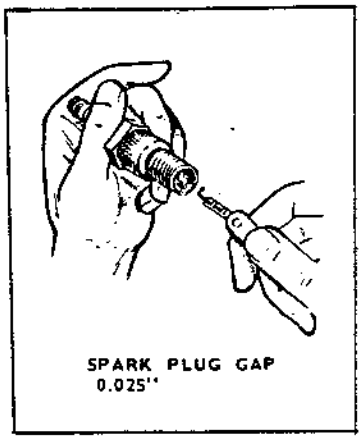
NOTE The above adjustment will normally have to be made only in cases of extreme side brush wear.

IMPORTANT

RECOMMENDED FIRST 50-HOUR MACHINE INSPECTION (applies to all machines)

After the first 50 hours of operation, the following procedures are recommended:

1. Check the air cleaner. Tighten all connections on intake hose, air cleaner, etc.
2. Change the engine oil and the filter.
3. Check the valve tappet clearance. Intake: .012" (.304 mm) for both gasoline and LPG engines. Exhaust: .020" (.508 mm). Diesel engine: .012" (.304 mm) cold.
4. Check spark plug gap: .025" (.64 mm) gas only.
5. Check point gap: .020" (.508 mm) gas only.
6. Check engine timing (see engine manual).
7. Torque down cylinder head (see engine manual for correct torque and sequence).
8. Check idle speed (550 to 600 rpm).
9. Check for belt tension : 0.50" (12.7 mm) deflection at midpoint).
10. Torque manifold nuts.
11. Torque exhaust pipe flange nuts.
12. Tighten all water, oil and fuel line connections.
13. Check tightness of nut attaching rear wheel to shaft: 200 to 250 ft lbs (271 to 339 Nm).
14. For diesel engine only: Bleed air from the fuel injection system.



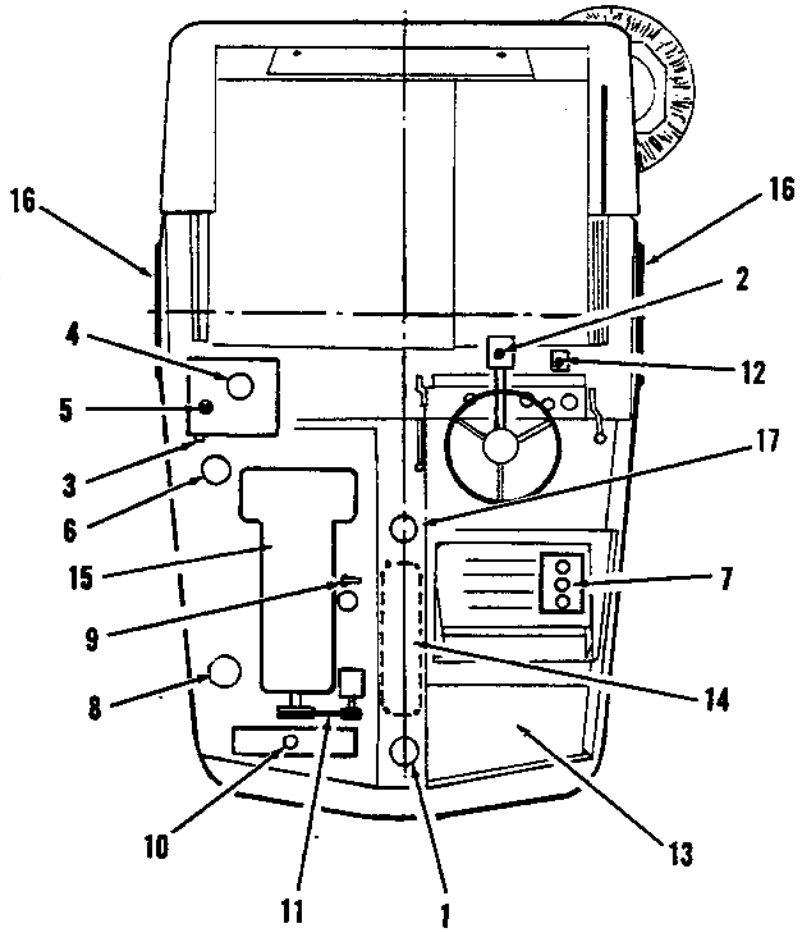
LUBRICATION AND SERVICE CHART
FOR
MODEL 92 EQUIPPED WITH CONTINENTAL ENGINE

Index No. on Chart	Description	Procedure	daily	50	150	250	500
1	Engine Air Cleaner	Check indicator and clean element if necessary	X				
2	Steering gear box	Check level, add grease					X
3	Hydraulic tank oil level	Check oil level gauge	X				
4	Hyd. tank breather filter	Clean or replace filter element					X
5	Hydraulic tank (and intake screen inside tank)	Change hydraulic oil, clean tank (tank capacity:4.5 gal (17 L) (use TENNANT Hydraulic Oil)					X
6	Hydraulic oil filter	Change filter element					X
7	Battery	Check electrolyte level		X			
8	Engine oil filter	Change filter element			X		
9	Engine crankcase	Check oil level with dipstick	X				
		Change oil		X			
10	Radiator	Check coolant level	X				
11	Fan Belt	Check tension and condition		X			
12	Brake cylinder	Check fluid level		X			
13	Gasoline Fuel Filters	Clean filter *					X
	LP Fuel Filter	Change filter				400 hrs.	
14	Rear Tire (on standard machine only)	Check Pressure-95 to 125 psi (655 to 862 kPa		X			
15	Engine Miscellaneous: (See Engine Manual)	Clean spark plugs, set gap				X	
		Check points, set gap				X	
		Lubricate distributor cam				X	
		Lubricate distributor shaft (grease fitting)				X	
		Adjust valve tappets					X
16 17	Front wheel pivot bearings Rear wheel pivot bearing	Hand pack with Lithium EP multi-purpose grease					X X

* A gasoline sediment bowl and in-line filter are located under the gasoline tank. Check the sediment bowl for water weekly. Clean it when necessary. Replace the in-line filter element every 500 hours. See "LPG" Section for LP filter service instructions.

RECOMMENDED LUBRICANTS AND FLUIDS

1. Gasoline: Leaded or unleaded, at least 84 octane.
2. Steering gear: Saginaw Steering Gear Spec. SSG5676630 (SSG CODE 4009) 11 oz (311.8 gr).
3. Brake Fluid: SAE J1703 brake fluid.
4. Engine oil: 10W-30 API type "SE" engine oil.
5. Hydraulic oil: TENNANT Part No. 32397, 10W-40 Hydraulic Oil. (See "Recommended Hydraulic Fluid" page).



LUBRICATION AND MAINTENANCE DIAGRAM (numbers refer to chart)
(For machines with gasoline or LP engines only, not diesel)

ENGINE OIL SELECTION (Gasoline or LP Engine only)

Use a good quality heavy-duty oil with the API designation "SE", SAE #10W-30. When adding oil between changes, always use same brand of oil. Use the proper grade oil for the expected temperature range to be encountered:

Below 0° F (-17° C)	SAE 5W-20	
0° to 32° F (-17° to 0° C)	SAE 10W	or
32° to 75° F (0° to 23.8°C)	SAE 20W	— SAE 10W-30
Above 75° F (23.8° C)	SAE 30	

CHANGING ENGINE OIL

Check Engine Oil Level Daily!

Change engine oil every 50 hours under normal operating conditions. (If environment is extremely dusty--change oil more often.) Change engine oil filter element every 150 hours.

Engine oil should always be drained when the engine is warm. Remove the crankcase pipe plug to drain engine oil.

LUBRICATION & MAINTENANCE CHART

(For machines with Diesel Engines only)

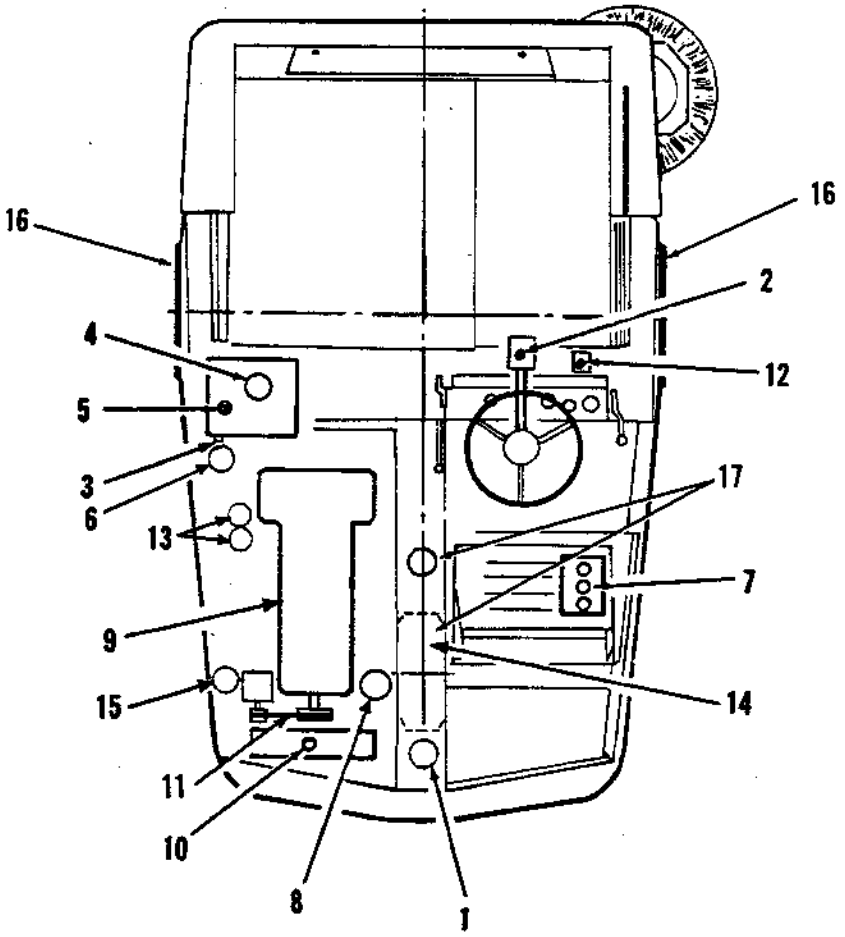
Index No. On Chart	Description	Procedure	Hours Daily	50	150	250	400
1	Engine Air Cleaner	Check indicator & clean element if necessary	X				
2	Steering gear box	Check level, add grease					X
3	Hydraulic tank oil level	Check oil level gauge	X				
4	Hyd. tank breather filter	Clean or replace filter elem.					X
5	Hydraulic tank (& intake screen inside tank)	Change hyd. oil, clean tank ($4\frac{1}{2}$ gal cap.)(use Tennant Oil)					X
6	Hydraulic oil filter	Change filter element					X
7	Battery	Check electrolyte level		X			
8	Engine oil filter	Change filter element			X		
9	Engine crankcase	Check oil level with dipstick	X				
		Change oil **		X	or X		
10	Radiator	Check coolant level	X				
11	Fan Belt	Check tension & condition		X			
12	Brake cylinder	Check fluid level		X			
13	Two Fuel Filters *	Check filters for water weekly		X			
		Replace elements					X
14	Rear tire (St'd. machine) Rear tire solid on Hi-Dump	Check pressure 95 to 125 psi (655 to 862 kPa)		X			
15	Fuel Water Trap	Check daily for water	X				
16	Front Wheel Bearing (2)	Hand pack with Lithium EP					X
17	Rear Wheel Pivot Bearing	multi-purpose grease					X

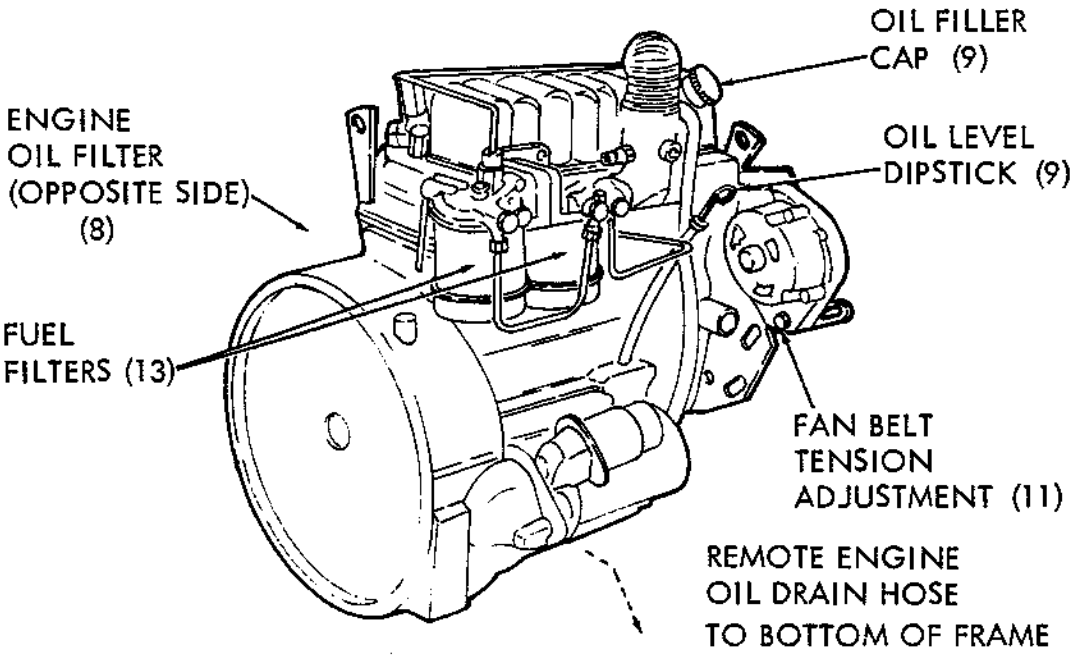
* Two fuel filters are located on side of engine. Check weekly for water

** Change engine oil after first 50 hours, thereafter every 150 hours

RECOMMENDED LUBRICANTS AND FLUIDS

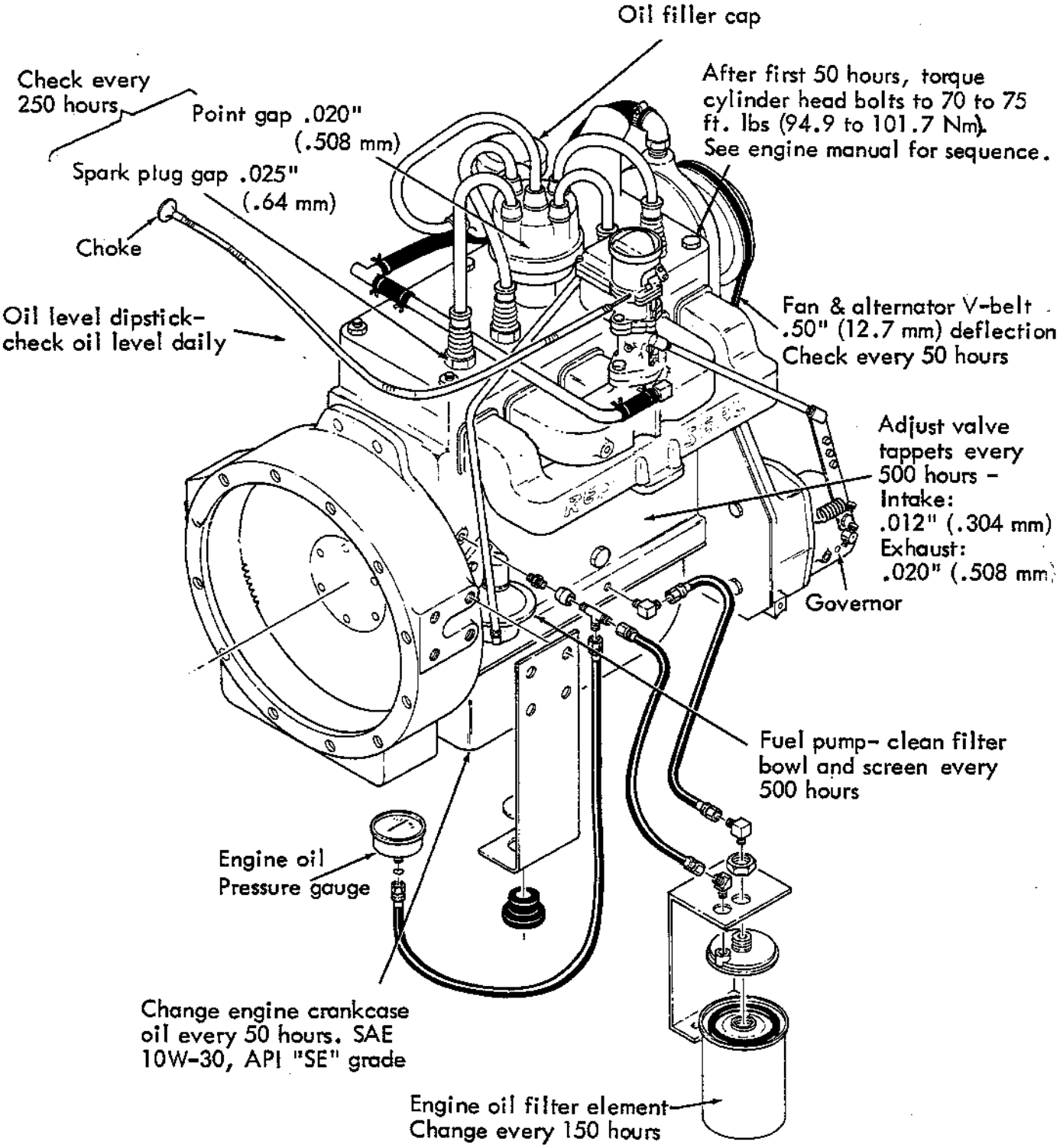
1. Fuel: No. 2 Diesel Fuel - see engine manual for specifications
2. Steering Gear: Saginaw Steering Gear Spec. #SSG5676630 (SSG CODE 4009) 11 oz (311.8 gr)
3. Brake Fluid: SAE J1703 brake fluid.
4. Engine Oil: 20W-20 API Type "CC" engine oil.
5. Hydraulic Oil: TENNANT Part No.32397 , 10W-40 Hydraulic Oil. (See "Recommended Hydraulic Fluid" page.)
6. Wheel Bearings: Lithium EP multi-purpose grease



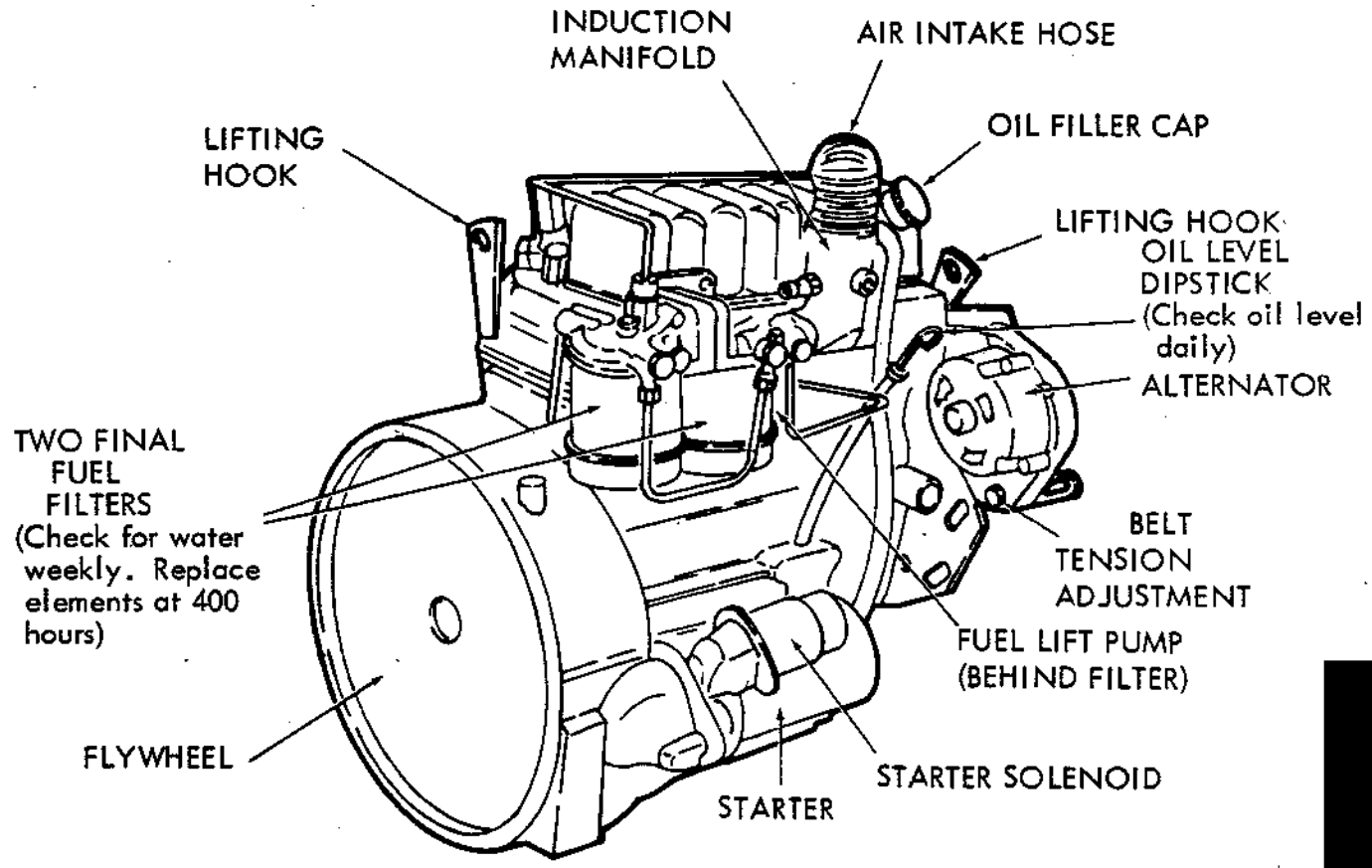


LUBRICATION CHART

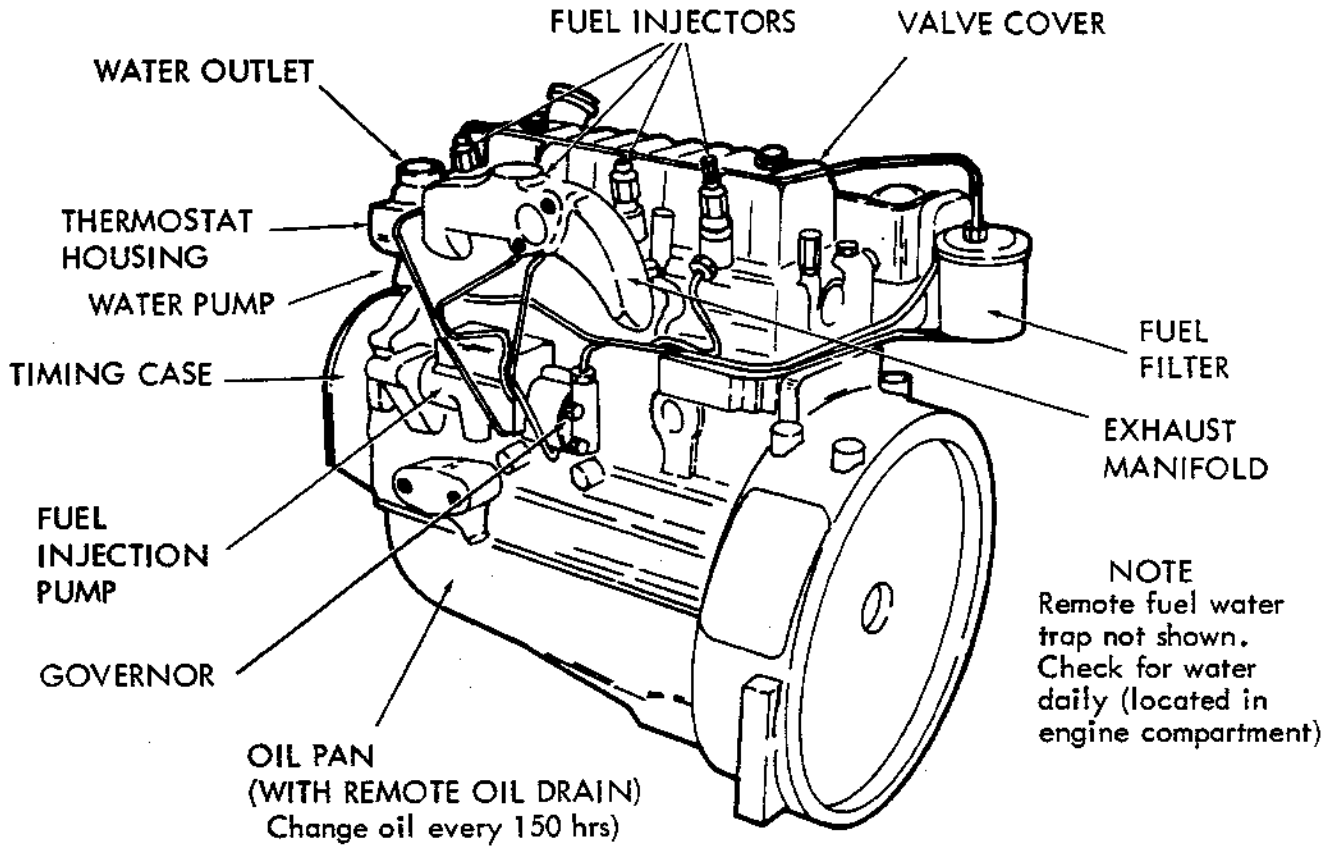
(FOR DIESEL ENGINE ONLY)



CONTINENTAL F163 ENGINE SERVICE LOCATIONS
(See Engine section for detailed instructions)



(ENGINE OIL FILTER REMOTELY MOUNTED ON BRACKET)
(Change filter element at every oil change)



NOTE
Remote fuel water trap not shown. Check for water daily (located in engine compartment)

SERVICE LOCATIONS ON THE 4.108 PERKINS DIESEL ENGINE

ENGINE SPEED (All engines)

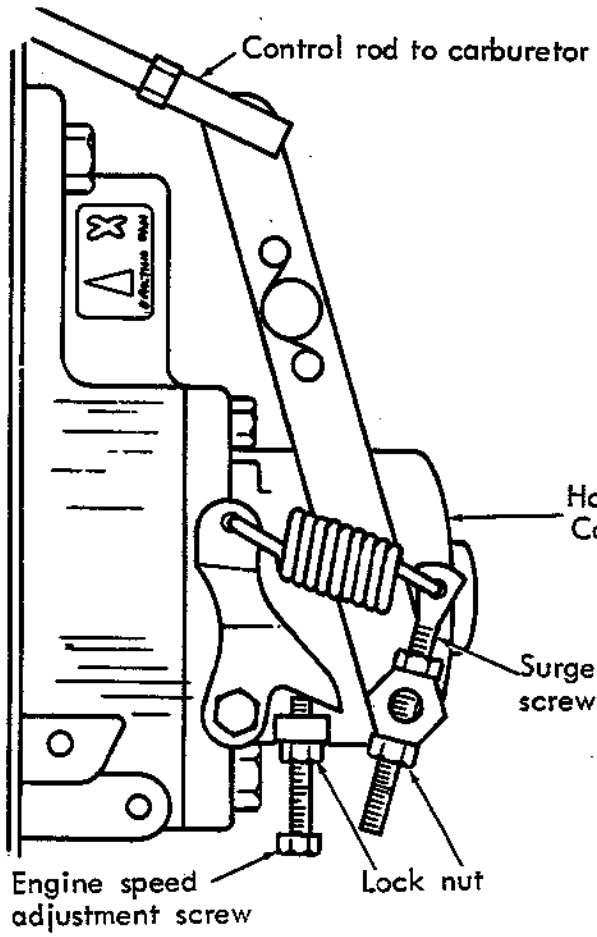
The engine operates at a constant, factory-set, governor-controlled engine speed. The governor is sealed and should not be adjusted. Repairs or adjustments should be done only by Continental Engine or authorized TENNANT service personnel.

FACTORY SET engine speed: (full throttle, no load) 2150 to 2200 rpm.

Idle speed: 550 to 600 rpm.

ATTENTION! Engine speed should never be set higher. If the engine speed exceeds factory-set speed, the hydraulic pump may be damaged. The governor, of course, should be disconnected.

The engine throttle control must be set at full throttle whenever operating the machine.



CONTINENTAL ENGINE GOVERNOR NOTE:

If governor is replaced, it may be necessary to adjust the engine speed. Loosen the lock nut and adjust the speed screw to obtain a no-load speed of 2150 to 2200 rpm. Use a tachometer to check engine speed. If engine speed "surges" adjust surge screw attached to spring.

(Note: Governor shown is Continental No. F401S407, first used on engine serial no. 234340)

RADIATOR MAINTENANCE

Use soft, clean water mixed with a permanent-type, ethylene glycol, antifreeze in a 1 to 1 ratio. Coolant system capacity is approximately 12.4 qts. (11.7 liters). Radiator capacity is 6.4 qts. (6.1 liters).

Deposits of sludge, scale and rust will prevent normal heat transfer. Flush out the radiator after every 500 hours of operation. Instructions for flushing out the radiator are given in the "Cooling System" section of the engine manual.

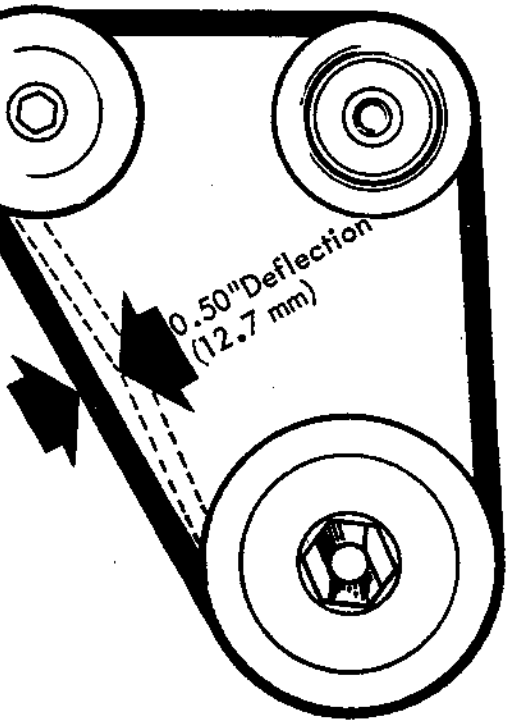
A 180° F (82.2° C) thermostat is located in the water outlet elbow on top of the engine cylinder head.

Engine overheating may also be caused by dirty radiator fins. The exterior fins of the radiator can be cleaned with an air hose. Blow out all dust, dirt, etc. between the fins. This should be done only after the radiator has cooled off, to avoid cracking caused by uneven cooling.

Since a "pusher" fan is used, it is necessary to blow air into the machine to clean out radiator fins.

FAN AND ALTERNATOR BELT TENSION

Loosen adjusting screws on alternator and pull out on alternator to tighten belt. When adjusted correctly, the belt should have about 0.50 inch 12.7 mm) deflection from moderate force applied at midpoint on longest span of belt.



IMPORTANT NOTES ON THE PERKINS DIESEL ENGINE
(See Diesel Engine Manual for more information on these items)

1. Be sure to use only API "CC" engine oil (do not use "CD").

2. No. 2 Diesel Fuel is preferred (No. 1 fuel will not lubricate fuel injection pump as well).

3. Open water trap drain valve on bottom of trap daily and drain off water and sediment. (Water trap is located in engine compartment near engine).

4. There are two fuel filters. Check them for water weekly. Make sure that vent plug on top of filter is not clogged. Both fuel filters use the same paper filter element. Replace elements every 400 hours. Each element has three seals: a large one on top and bottom of element, and a small O-Ring. Replace these with the element (they are included with element in kit).

5. No attempt should be made to repair the fuel injection pump. Return it to C.A.V. for repair. If pump is replaced, line up marks stamped on engine and pump mounting flange.

6. Do not attempt to repair the fuel injectors (except for replacing the matched set of nozzle and needle); replace the entire injector assembly. When cleaning the injectors, disassemble only one at a time, to avoid mixing up the needles and nozzles which are precisely matched to each other. Since extensive testing equipment is required when reassembling the injectors, it is usually more economical to replace either the needle and nozzle assembly, or the entire injector assembly. A bad injector can be recognized by the sharp rapping sound it makes. To locate a bad injector, loosen the fuel line connection to one injector at a time. If the noise stops, you have located the bad injector.

7. If you run out of fuel, or make repairs to fuel system, it will be necessary to bleed all air from the system as described in the Engine Manual.

   ATTENTION! Do not try to prime the fuel system by prolonged engine cranking -- this can ruin the starter.

8. If only the fuel filter elements are replaced, air bleeding can be accomplished by loosening fuel line connections at only two locations: the fuel injection pump inlet and the top of the fuel filter.

9. A special adapter and gauge are required to check cylinder compression. Compression should not vary more than 50 lbs (22.7 kg) between each cylinder. Normal compression should be between 500 to 525 lbs (227 to 238 kg).

(continued)

10. The small, automotive-type fuel lift pump has a hand priming lever. If the lever won't operate, it may be on the high point of the cam. Turn the engine over and try again before replacing pump.

11. If crankshaft pulley is replaced, its attaching screw must be torqued to 150 ft lbs (203.4 Nm). If not, the bolt may loosen, causing extensive damage to the fan and radiator.

12. After first 50 hours of service, be sure to check valve tip clearance (.010" hot or .012" cold).

13. After the first 50 hours of service, be sure to tighten the cylinder head nuts 60 ft lbs (81.4 Nm) torque in the correct sequence described in the engine manual.

14. The 4.108 Engine cylinder head has been specially hardened and cannot be milled or ground flat if it becomes warped. It must be replaced.

ATTENTION! Do not attempt to use starting fluid or spray. This can cause serious engine damage. Consult your local Perkins Diesel Engine distributor for approved starting kits and procedures.

DIESEL ENGINE OIL SELECTION

For normal temperatures of 45° to 80° F (7.2 to 26.7° C), use a good quality heavy-duty oil with the API designation "CC", SAE #20W-20 (Mil. Spec #MIL-L-46152). When adding oil between changes, always use same brand of oil. Use the proper grade oil for the expected temperature range to be encountered:

TEMPERATURE	
0° to 45° F (-17.7 to 7.2° C)	SAE 10W
45° to 80° F (7.2 to 26.7° C)	SAE 20W-20
Above 80° (26.7° C)	SAE 30

RECOMMENDED DIESEL ENGINE FUEL

The following specifications can be regarded as providing acceptable fuel oils for Perkins engines:

ASTM Classification	D-975-66T
Grades	No. 1 or No. 2 (No. 2 is preferred)
Federal Specification	VV-F-800
Grades	DF-A (Arctic), DF-1 or DF-2
Cetane No. (Ignition Quality)	45 (Minimum)

RECOMMENDED GASOLINE

Capacity of the gasoline tank is 18 gal (68 L). Regular gasoline of at least 84 octane is recommended. Unleaded gas may be used. A fuel filter is located under the tank.

⚠WARNING Gasoline container and the machine must be electrically connected before pouring gasoline. Connect the insulated wire between the machine and the container. Never fill the tank while engine is running.

STATIC DRAG CHAIN

A static drag chain is provided to prevent the build-up of static electricity in the machine. This chain is attached below the machine frame.

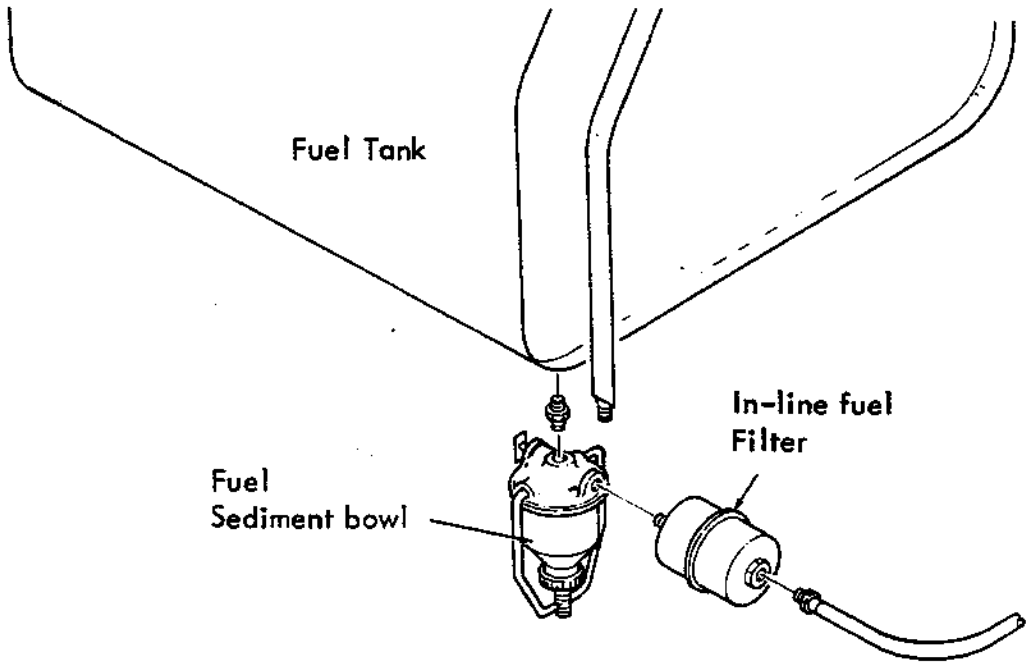
Check the chain periodically for wear. Make sure that it is making contact with the floor at all times.

LP FUEL SYSTEM MAINTENANCE

If your engine is equipped for operation on LP Gas, see the LPG Section of this manual for instructions in cleaning the Filter-Fuelock unit. The Filter-Fuelock is a combination solenoid-operated lockoff valve and filter. The filter element should be replaced every 400 hours, or when gas flow is diminished. The LP tank is a 33 lb (15 kg) capacity, liquid withdrawal type.

GASOLINE FUEL FILTERS

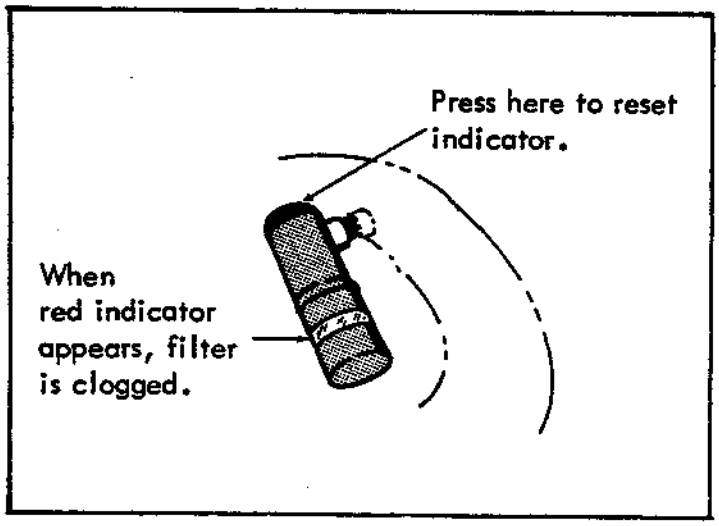
A gasoline filter and sediment bowl are located under the fuel tank. Check the sediment bowl for water or dirt weekly. Replace the gasoline in-line filter element every 500 hours. As described in engine manual, clean the carburetor and fuel pump screens and sediment bowl occasionally.



SERVICING ENGINE AIR INTAKE CLEANER

The importance of maintaining an air cleaner in proper condition cannot be overemphasized! Dirt induced through improperly installed, improperly serviced or inadequate elements, wears out more engines than does long hours of operation. Even a small amount of dirt will wear out a set of piston rings in just a few hours. Furthermore, operating with a clogged element causes the fuel mixture to be richer which can lead to formation of harmful sludge deposits in the engine. Always cover air intake when air cleaner is removed for servicing. Do not neglect servicing air cleaner and use only correct parts for replacement. Keep other air intake components such as hoses, clamps, etc. secure and in good condition to prevent entrance of unfiltered air.

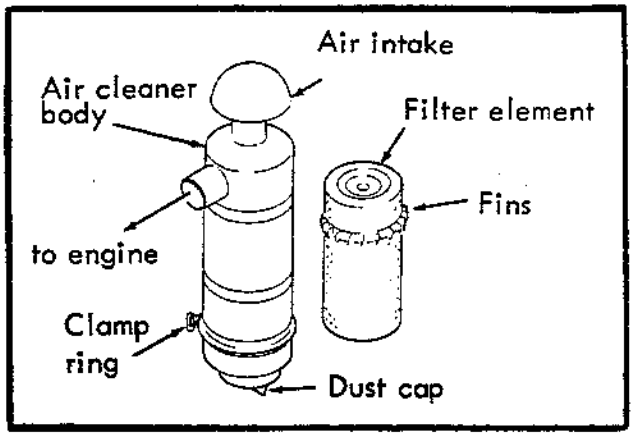
This unit is equipped with a service indicator that signals when to change the cartridge. The red indicator gradually becomes visible as the cartridge loads with dirt. It is not necessary to change the cartridge until the indicator reaches the top and locks in position. (See illustration).



AIR CLEANER SERVICE INDICATOR

When locked, the indicator will remain up after the engine is shut down. Change the cartridge at this time. After changing the cartridge, reset the indicator by pushing the RE-SET end of the indicator.

(Continued on next page)



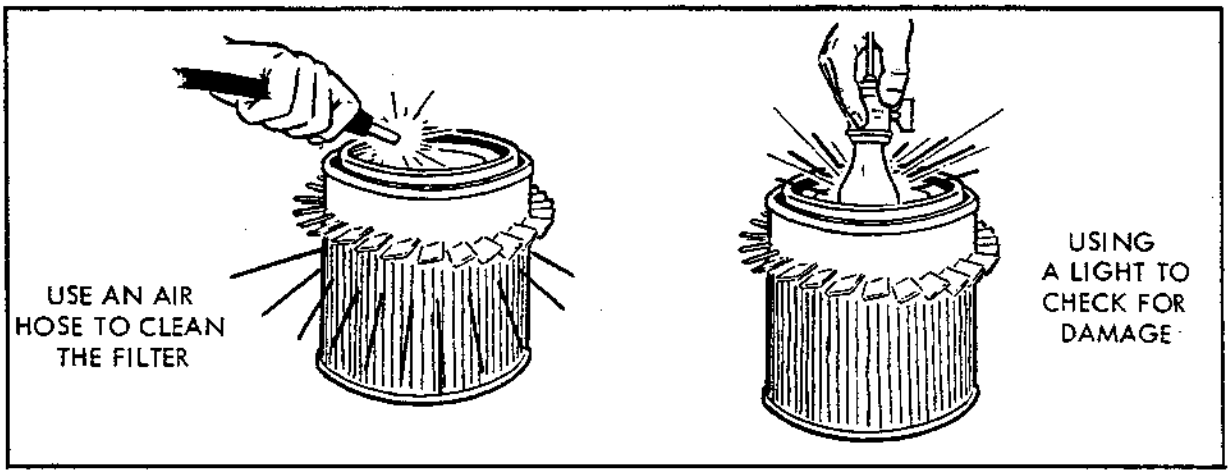
To Replace Filter Element:

1. Unscrew clamp ring on filter.
2. Remove dust cup.
3. Remove wing nut.
4. Pull element out of filter housing.
5. Clean out dust cup and interior of air cleaner housing.
6. Install new or re-cleaned filter element so that fins on the element are at the top of the air cleaner. Use care so that fins are not damaged. Tighten wing nut attaching element.
7. Install dust cup and tighten clamp ring to hold it in place. Check all intake hose connections for leaks.

To Clean and Inspect Filter Element:

1. Using an air hose, direct dry, clean air up and down pleats on the inside of the filter.

⚠CAUTION Air pressure at the nozzle must not exceed 100 psi (689 kPa). Maintain reasonable distance between the nozzle and the filter.



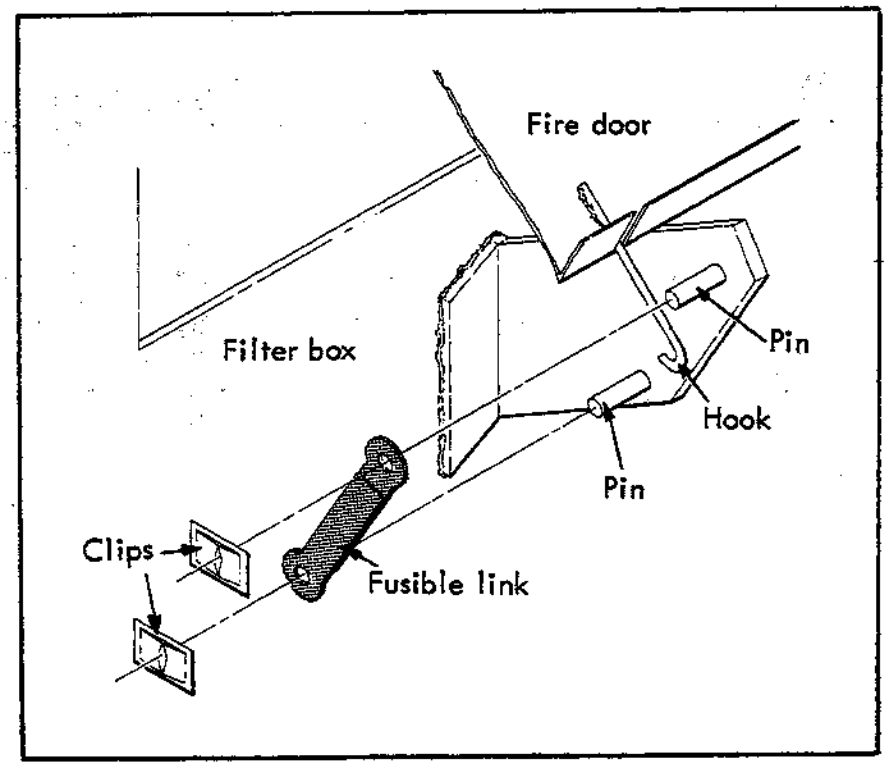
2. After cleaning, inspect for damage by placing a bright light inside the filter. Slightest rupture requires replacement of the filter.
3. After the filter element has been cleaned six times, or at least every 250 ho

FUSIBLE LINK REPLACEMENT

NOTE The filter system in your sweeper is protected, in the event of a fire in the hopper, by a fusible link. This will automatically prevent the passage of air through the filter system if the temperature exceeds the limit of the fuse.

If loss of dust control is noticed, check the fusible link (accessible by opening front access door) for breakage or failure due to heat.

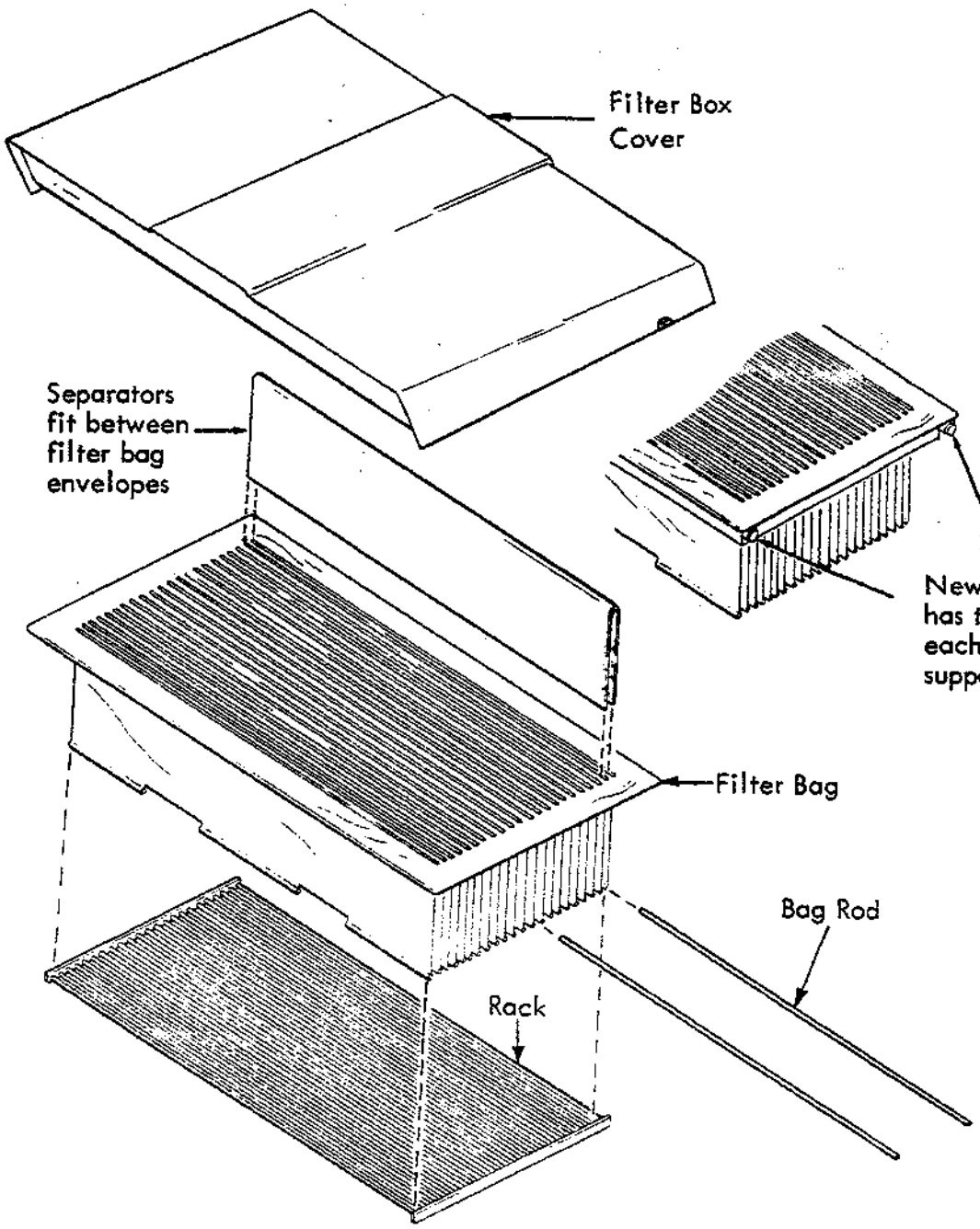
To replace the link, engage hook on fire door with body of link, and slide link onto pins, hold link in place with clips.



ATTENTION! If the fire door is closed because of link breakage, or if the door opening is clogged with debris, engine over heating and hydraulic oil over heating will result.

TO REPLACE OR CLEAN HOPPER DUST FILTERS

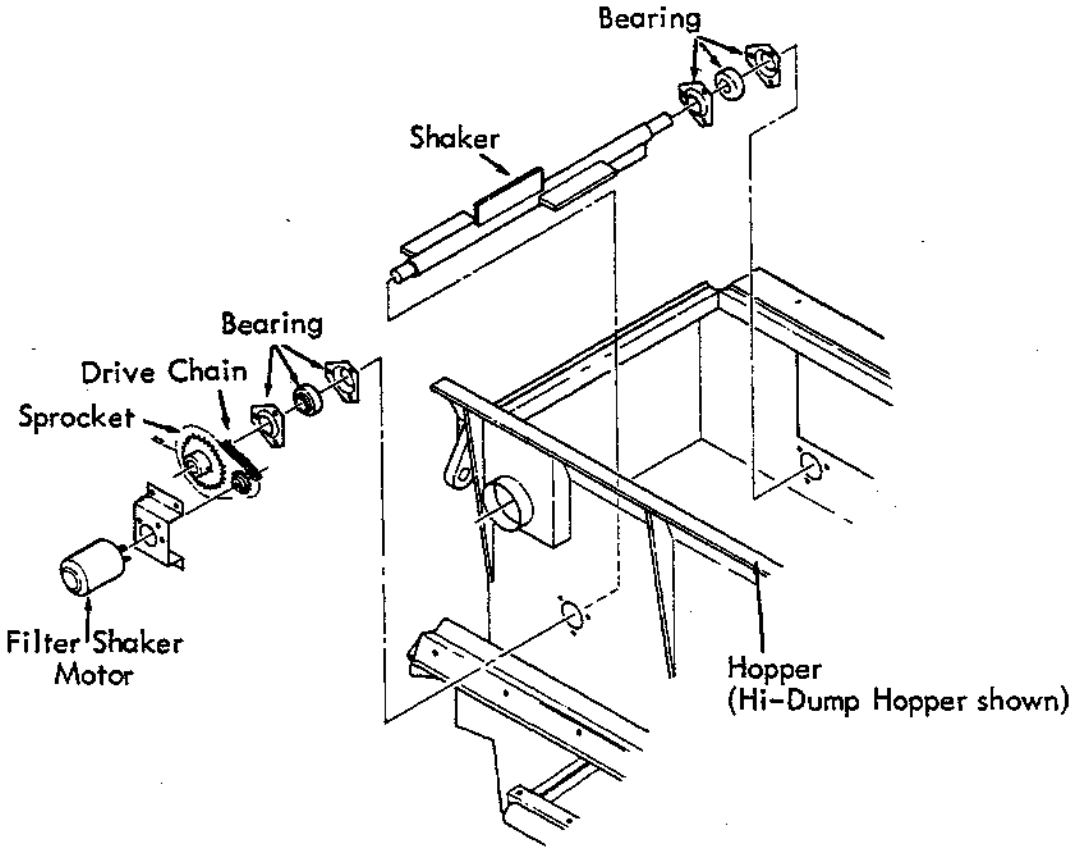
1. Push shaker button to clean filters.
2. Raise filter box cover and prop up.
3. Lift out filter complete with filter rack.
4. Clean or replace filter bag.
5. Replace separators between filter bag envelopes. Be sure all the parts are assembled compactly and neatly in place to prevent leakage around cover.



FILTER SHAKER MOTOR REPLACEMENT

The filter shaker motor is sealed for life with a dust-proofing compound. The motor cannot be repaired, since disassembling the motor would destroy the dust protective coating on the motor.

When replacing the motor, do not over-tighten the shaker drive chain (this would overload the bearings). Tighten the chain only enough to prevent slipping.



HOW TO REMOVE HOPPER (USING DOLLY)

It may be necessary to remove the hopper in order to perform maintenance on the hydraulic system.

TO REMOVE HOPPER:

1. Start engine and raise hopper all the way.

⚠WARNING Always engage mechanical safety lock on the lift arm.

2. The following must be disconnected from the hopper:

    a. Shaker motor wiring plugs (2).
    b. Lights wiring plug (if used).
    c. Vacuum hose connection.
    d. Side brush lift cable (slip ball on cable end out of channel slot after sliding plastic sleeve out of way).
    e. Separate the hydraulic quick-disconnect couplings for side brush motor (located on bumper, L.H. side).
    f. If machine is High-Dump model, separate the hydraulic quick-disconnect couplings for the two hopper door cylinders (located under hopper).

3. Place dolly in position.

4. Raise lift arms, disengage safety lock, then lower hopper onto dolly.

5. Stop engine and place hydraulic control lever in "lower" position.

6. Remove the lift arm release pins which attach the ends of the lift arms to the hopper.

7. Push down on the lift arms so that they will disengage from the lift brackets on the hopper. (Lift arms may be difficult to disengage).

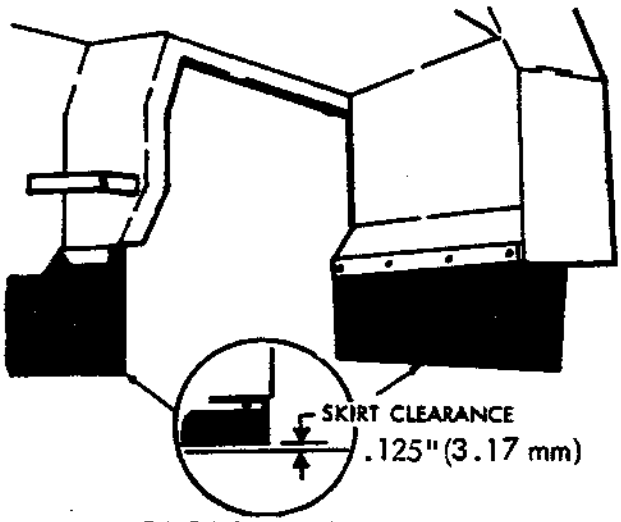
8. Roll the hopper and dolly away from machine.

TO ADJUST DUST SKIRT HEIGHT

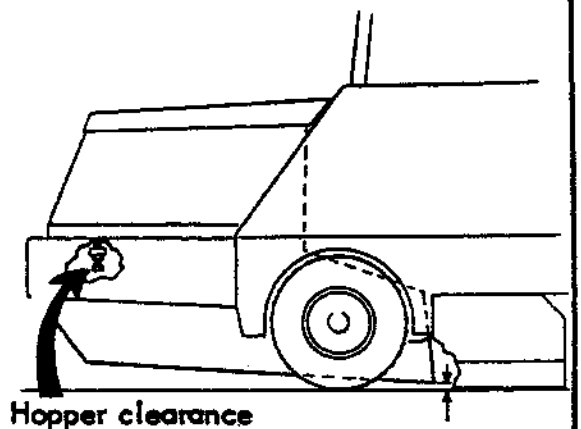
1. Park machine on a smooth level surface (flooring or concrete).

2. Refer to illustration and measure distance between bottom edge of rubber skirts and floor. Correct measurement is 13 in(3.17 mm) without weight of operator.

3. If adjustment is required, loosen the skirt retainer mounting screws and adjust the skirt up or down as needed (the skirts have slotted mounting holes to provide for adjustment).



DUST SKIRT ADJUSTMENT



HOPPER FLOOR CLEARANCE ADJUSTMENT

ADJUSTING HOPPER FLOOR CLEARANCE

1. Park machine on smooth, flat concrete or hard floor surface.

2. Refer to sketch and measure distance between metal lip at rear of hopper and floor. Correct measurement is 1.50 in (38.1 mm). Be sure to check at both corners to determine if hopper is level from side to side.

3. If adjustment is required, refer to sketch to loosen lock nuts on large bolts located under front corners of bumpers.

4. Turn large bolts clockwise to raise and counter-clockwise to lower metal lip.

5. After correct adjustment is obtained, tighten lock nuts.

RECOMMENDED HYDRAULIC FLUID

TENNANT Hydraulic Fluid is a specially compounded oil with the following features not found in many hydraulic oils:

1. FLAT VISCOSITY CURVE
2. Additives to prevent corrosion
3. Additives to prevent oxidation
4. Rust inhibitors
5. Foam suppressors

These features restrict foaming of the hydraulic oil and provide a high standard of lubrication to the components.

TENNANT Hydraulic Fluid Viscosity Specifications		
	Tennant Hydraulic Fluid No. 32397 (10W40)	Tennant Hydraulic Fluid No. 32398 (20W60)
SUS @ 100°F(37.8°C)	404-445	940-1010
SUS @ 210°F (98.9°C)	78-84	122-130

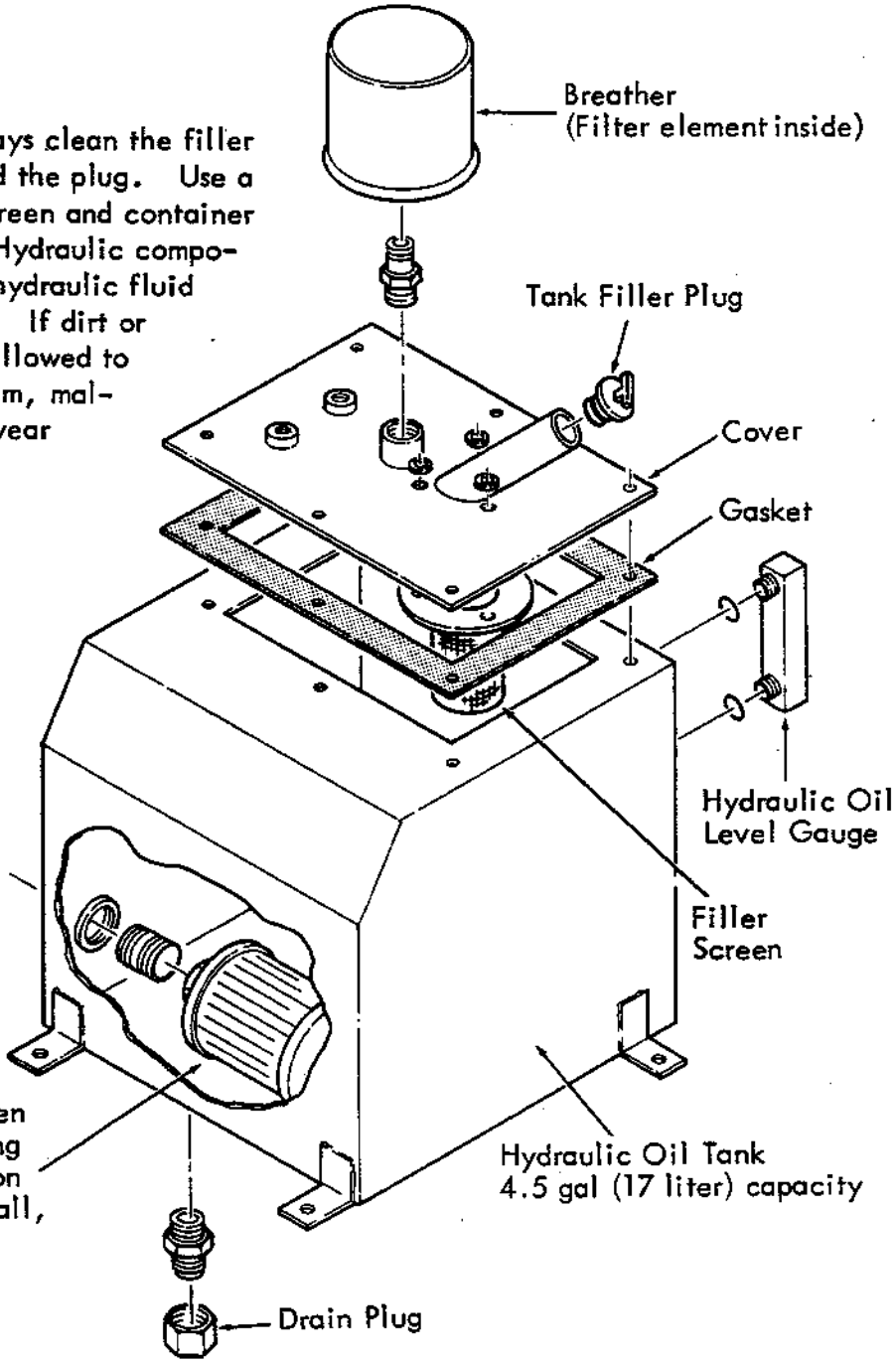
TENNANT Hydraulic Fluids have a very flat viscosity curve (synonymous with "high viscosity index"). The flat viscosity curve means that the thickness of the oil is quite constant over wide temperature ranges.

ATTENTION! If a locally available hydraulic fluid is preferred, or if you have standardized on the products of one oil company, the hydraulic oil used must match closely the viscosity specifications given in the chart for TENNANT hydraulic fluid, as well as the other features described.

CHECKING HYDRAULIC OIL LEVEL AND CLEANING TANK

Check hydraulic oil level daily by looking at oil level sight gauge on side of tank (see drawing). Use TENNANT Hydraulic Oil (See "Specifications"). Every 500 hours, drain and clean out tank. Clean suction strainer located inside tank also. At this time, clean or replace the filter element located inside the breather on top of the tank.

Before filling tank, always clean the filler plug and the area around the plug. Use a funnel with 200-mesh screen and container for the hydraulic oil. Hydraulic components depend on system hydraulic fluid for internal lubrication. If dirt or other contaminants are allowed to enter the hydraulic system, malfunctions, accelerated wear and damage will result.



Clean suction screen when changing oil and cleaning out tank. Use wrench on hex to remove. To install, hand tighten only.

CHANGING HYDRAULIC OIL FILTER ELEMENT

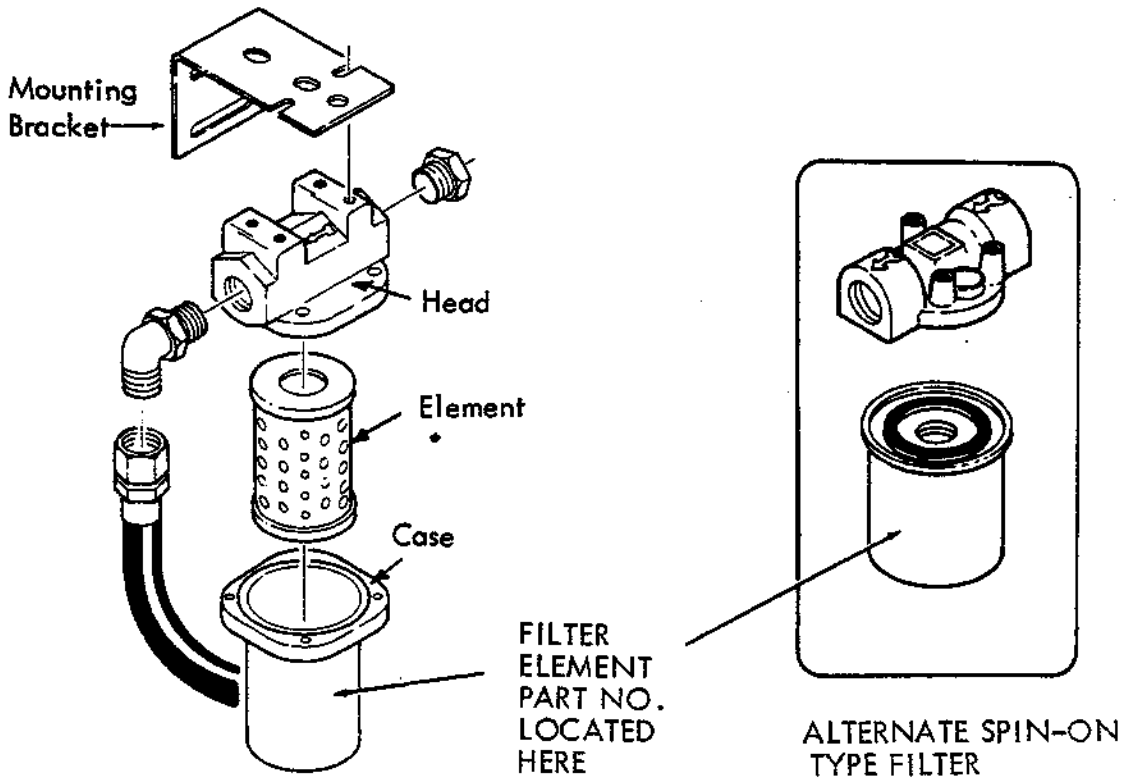
NOTE Several different hydraulic oil filters have been used. Please check your machine for correct element part number before ordering. Element part number is on the filter.

1. Standard Filter:

   "Cartridge-Type" Filter Element: Remove screws, remove filter case and remove old element. Clean out case and install new element.

2. Alternate Filter:

   "Spin-on" Type Filter Element: Turn filter element counter-clockwise to remove. Wipe a thin film of oil on the new element gasket, then screw on the element, using only hand pressure (no wrench).



STANDARD FILTER

ENGINE AND PUMP MOUNTING PLATE REPLACEMENT

Due to the engine to hydraulic pump coupling configuration, care must be taken to insure correct alignment of the pump shaft to the pump drive coupling on the engine. The following outlines the procedure:

DISASSEMBLY

1. Remove the machine hopper.
2. Stop the engine and engage the machine parking brake.

⚠CAUTION Always stop the engine and engage the parking brake before working on the machine.

3. Remove the ball joint on the pump pintle arm.
4. Remove the pump access door.
5. Secure lifting straps, or a similar apparatus, around the pump. This is to enable the pump to be supported and lowered slowly to avoid damaging the pump or surrounding parts.
6. Remove the two bolts holding the pump to the pump mounting plate. Slide the pump out and lower slowly.
7. Inspect the pump shaft spline for wear. If it is worn, it must be replaced.
8. Remove the twelve bolts securing the pump mounting plate to the engine.
9. Remove the pump mounting plate.
10. Remove the two roll pins from the mounting plate or the engine bell housing.
11. Remove and discard the old pump drive coupling if it is a one-piece style.
12. Remove the engine if it is to be replaced.

ASSEMBLY

1. Lower the engine into place.
2. Bolt the engine securely into place on its mounts.
3. Drill two 0.281 in (7.1 mm) diameter holes 180° apart on the pump mounting plate bolt circle.
4. Position the flywheel adaptor on the flywheel.
5. Coat the bottom 0.50 in (12.7 mm) of the threads of the six flywheel mounting bolts in blue locktite.
6. Thread the bolts through the flywheel adaptor, the flywheel, and into the crankshaft. Alternately tighten the bolts to 25-35 ft lbs (172 - 241 Nm).

7. Position the pump mounting plate on the engine bell housing. Secure the plate with the twelve mounting bolts.

8. Dial indicate the inside radius of the pump mounting plate to the center of the crankshaft to 0.004 in (0.102 mm) total indicating reading.

NOTE Make sure that the surfaces are clean.

9. Alternately tighten the twelve mounting bolts.

10. Drill two 0.281 in (7.1 mm) diameter holes through the bell housing using the two holes drilled earlier as a template.

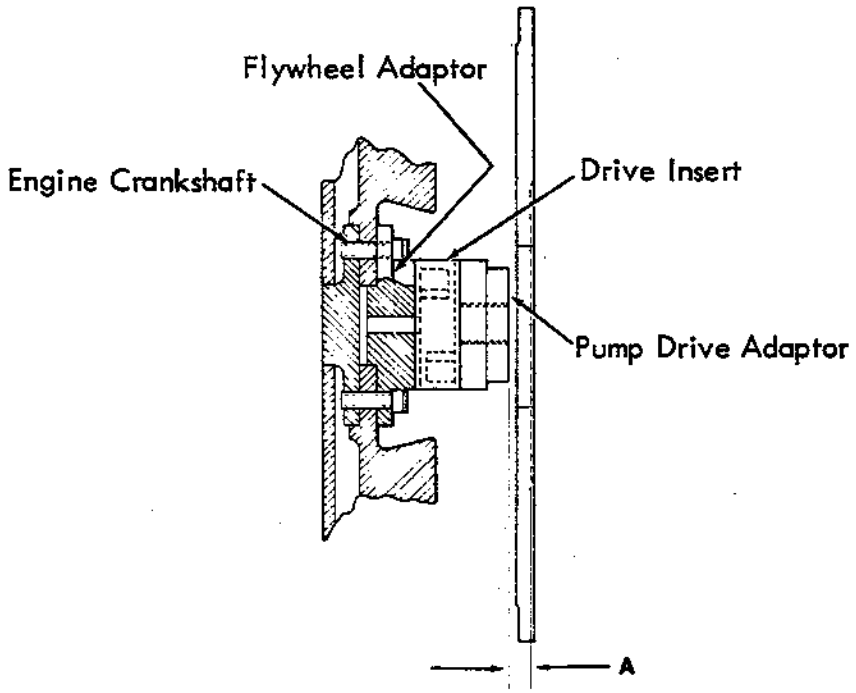
11. Ream the two 0.281 in (7.1 mm) diameter holes to 0.312 in (7.9 mm) diameter.

12. Install the two roll pins in the pump mounting plate.

13. Recheck the total indicating reading to make sure that the pump mounting plate did not move. Repeat the procedure if the measurement exceeds 0.004 in (0.102 mm).

14. Slide the drive insert and the pump drive adaptor into the flywheel adaptor.

15. Apply a force of 20 to 30 lbs (9 to 14 kg) onto the end of the pump drive adaptor. Measure the distance from the end of the pump drive adaptor to the flat counter-sunk surface of the pump mounting plate. This measurement must be accurate to 0.001 in (0.025 mm). This dimension will be referred to as dimension "A."

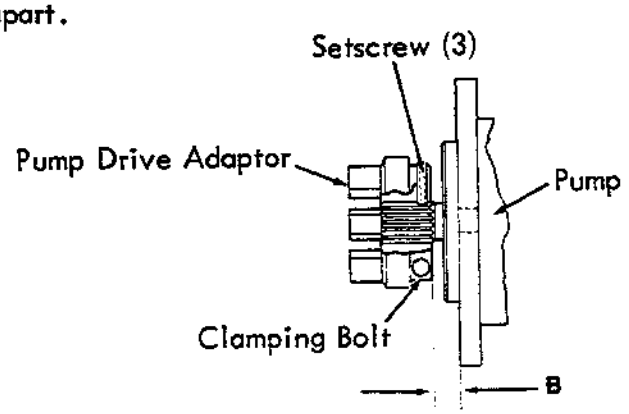


MEASURING DRIVE ADAPTOR TO FLYWHEEL DISTANCE

16. Take the measurement "A" and plug it into the following chart to figure the proper mounting distance between the pump drive adaptor and the pump. This dimension will be referred to as dimension "B."

DIMENSION "A"		DIMENSION "B"	
in	mm	in	mm
0.680 TO 0.670	17.272 TO 17.018	0.660 ± 0.005	16.764 ± 0.127
0.669 TO 0.660	16.993 TO 16.764	0.650 ± 0.005	16.510 ± 0.127
0.659 TO 0.650	16.739 TO 16.510	0.640 ± 0.005	16.256 ± 0.127
0.649 TO 0.640	16.485 TO 16.256	0.630 ± 0.005	16.002 ± 0.127
0.639 TO 0.630	16.231 TO 16.002	0.620 ± 0.005	15.748 ± 0.127
0.629 TO 0.620	15.977 TO 15.748	0.610 ± 0.005	15.494 ± 0.127
0.619 TO 0.610	15.723 TO 15.494	0.600 ± 0.005	15.240 ± 0.127
0.609 TO 0.600	15.469 TO 15.240	0.590 ± 0.005	14.986 ± 0.127
0.599 TO 0.590	15.215 TO 14.986	0.580 ± 0.005	14.732 ± 0.127
0.589 TO 0.580	14.961 TO 14.732	0.570 ± 0.005	14.478 ± 0.127
0.579 TO 0.570	14.707 TO 14.478	0.560 ± 0.005	14.224 ± 0.127
0.569 TO 0.560	14.453 TO 14.224	0.550 ± 0.005	13.970 ± 0.127
0.559 TO 0.550	14.199 TO 13.970	0.540 ± 0.005	13.716 ± 0.127
0.549 TO 0.540	13.945 TO 13.716	0.530 ± 0.005	13.462 ± 0.127
0.539 TO 0.530	13.691 TO 13.462	0.520 ± 0.005	13.208 ± 0.127
0.529 TO 0.520	13.437 TO 13.208	0.510 ± 0.005	12.954 ± 0.127

17. Mount the pump drive adaptor on the pump shaft, the "B" dimension apart.



MEASURING DISTANCE BETWEEN PUMP ADAPTOR AND PUMP

18. Tighten the clamping bolt on the pump drive adaptor to 12-14 ft lbs (16-19 Nm).

19. Tighten the three set screws on the pump drive adaptor to 4-5 ft lbs (5-7 Nm).

20. Recheck the "B" dimension to make sure the pump drive adaptor is still in the proper position.

21. Place the drive insert in the flywheel adaptor.

22. Match up the pump drive adaptor fingers with the holes in the drive insert.

23. Slide and secure the pump in position on the pump mounting plate.

24. Replace the pump access cover.

25. Reconnect the pump pintle arm ball joints.

26. Replace the hopper.

HYDRAULIC PUMP SEAL REPLACEMENT

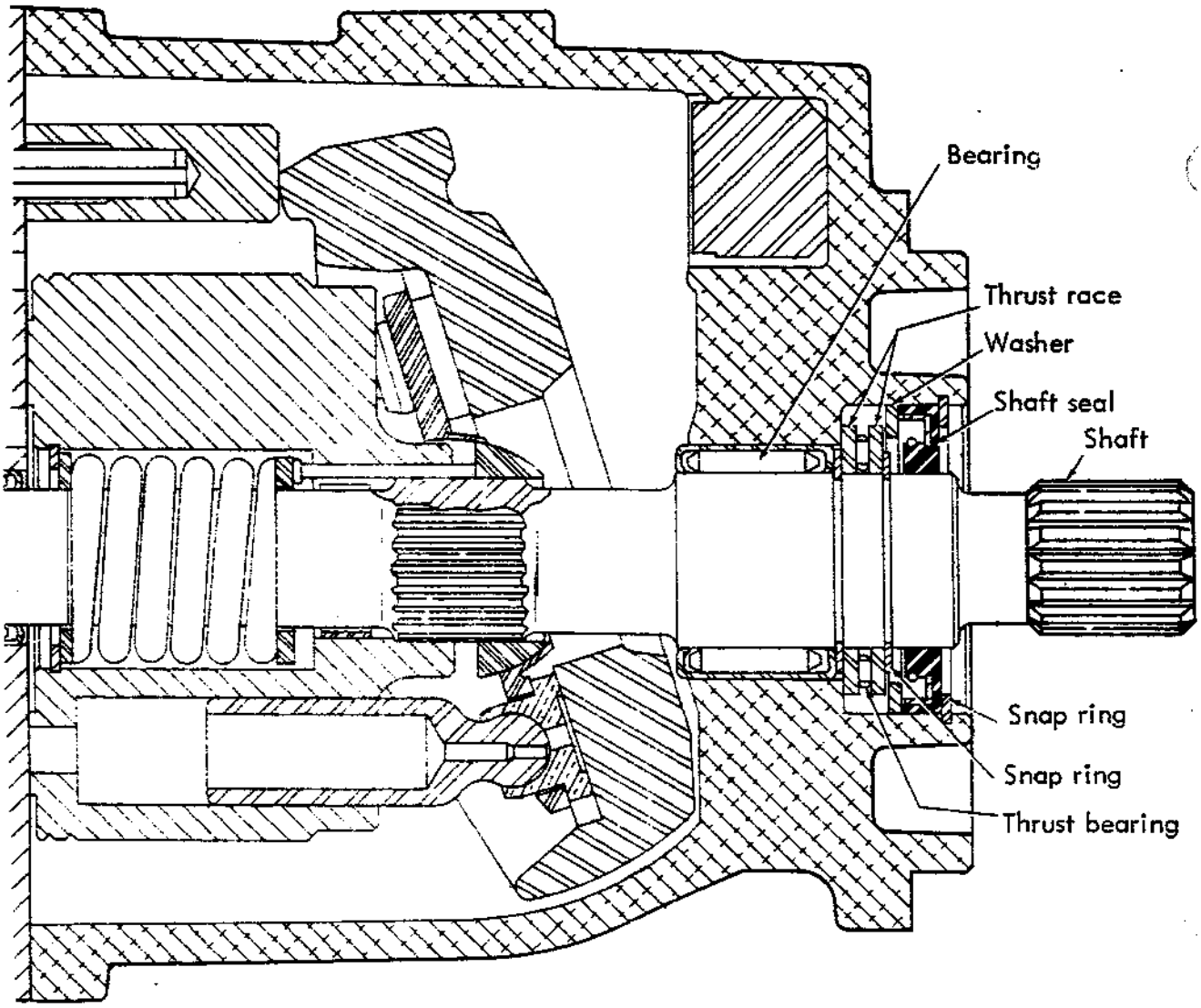
After removing the pump, and before disassembly, cap or plug all ports and disconnected hydraulic lines. Clean the outside of the unit thoroughly to prevent entry of dirt into the system.

ATTENTION! Absolute cleanliness is essential when working on a hydraulic system. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

Seal Kits SK1699 and SK1700 provide all seals for the Cessna Tandem Pump, which consists of a piston-type propelling pump (#62584 or #65144), and a vane-type accessory pump (#65145). The cross-section drawing and parts list show the location of all seals.

Refer to the cross-section drawing and parts lists for the location of seals. When installing the new O-Rings, gaskets and seals, coat them with a thin film of Vaseline or clean hydraulic fluid.

If the shaft seal is being replaced, make sure it is installed facing in the correct direction, as shown in the cross section drawing. If possible, use a shaft seal driver or an arbor press to install the new shaft seal in the housing.



PROPELLING HYDRAULIC MOTOR REPLACEMENT

To Remove Motor From Machine:

1. Raise rear of sweeper so that weight is removed from wheel.

⚠CAUTION Place blocks under sweeper for safety.

2. Remove wheel assembly from hub

3. Remove cotter pin and large nut on end of motor shaft.

4. Slide hub from tapered motor shaft. (It may be necessary to use wheel puller to accomplish this.)

ATTENTION! Do not hammer on end of motor shaft.

5. Disconnect hydraulic line to motor. Then plug all openings to prevent contamination of hydraulic system.

6. Remove four motor mounting bolts to complete removal of motor.

To Re-Install Motor In Machine:

1. Mount motor to rear housing and connect hydraulic oil lines to motor.

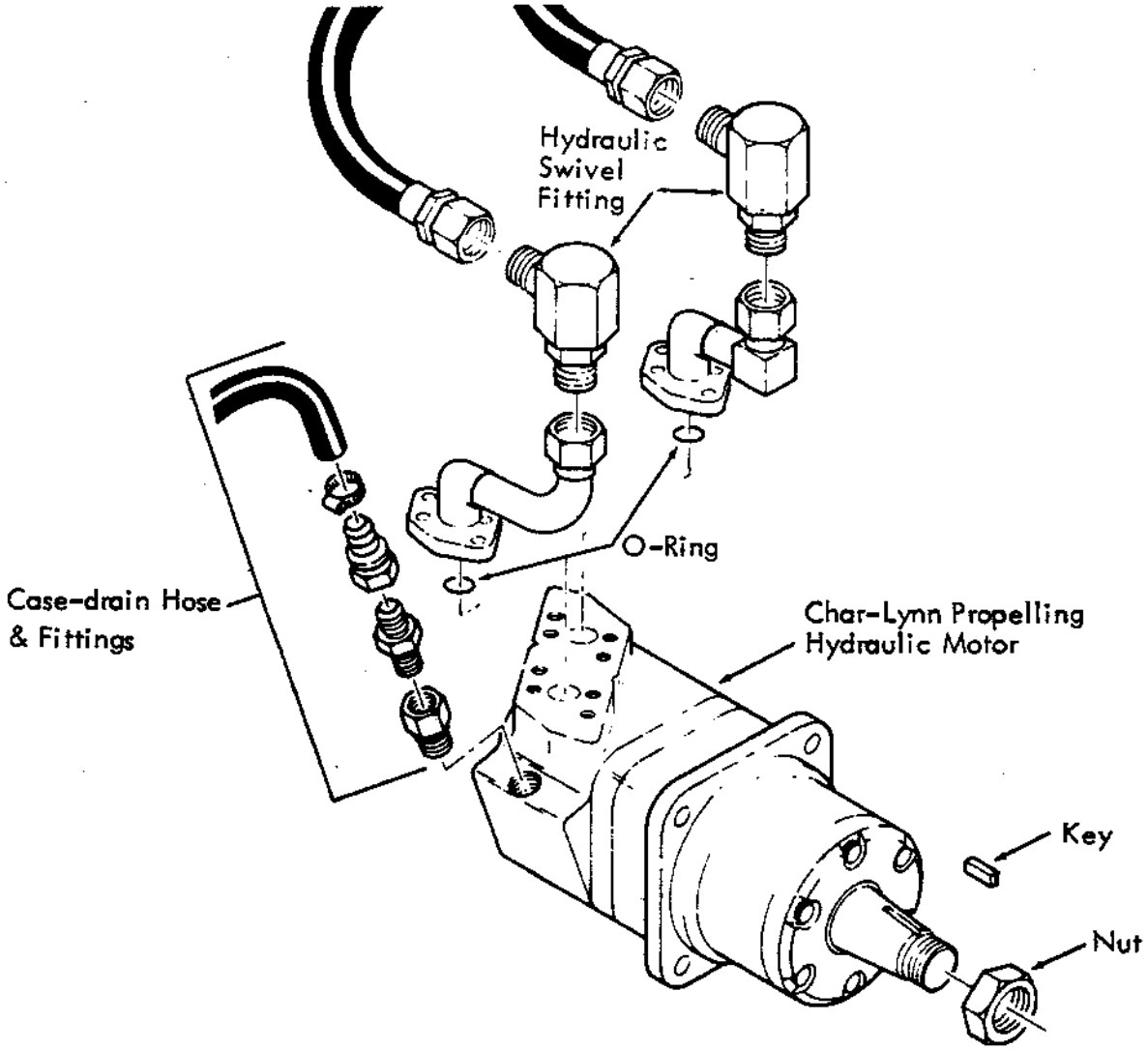
2. Check tapered surfaces of motor shaft and hub for burrs or dirt.

3. Install hub on motor shaft. Tighten wheel nuts to 200 to 250 ft lbs (271 to 339 Nm).

4. Mount wheel assembly to hub. Tighten wheel nuts to 85 to 95 ft lbs (115 to 129 Nm).

5. Remove blocking and lower sweeper to floor.

ATTENTION! Hydraulic connections must be clean.



WHEEL DRIVE MOTOR REPLACEMENT

PROPELLING HYDRAULIC MOTOR SEAL REPLACEMENT

Normally the only seals which would require replacement would be the shaft seals, which can be replaced by merely removing the front retainer plate. If the hydraulic motor is completely disassembled in order to replace worn parts, it will then be necessary to replace all seals and O-Rings. Do not disassemble the motor any more than necessary.

1. Clean exterior of motor thoroughly. Remove key if still in shaft. Remove all nicks, burrs or sharp edges around key slot.

2. Remove the six cap screws which attach the front retainer plate. Refer to drawings for location of parts.

3. Remove the front retainer plate. Use a flange puller to remove the retainer. If a puller is not available, remove the retainer by tapping lightly on it with a soft-headed hammer.

4. The outside dust seal and inside shaft seal with backup washer will come off with the retainer. Remove them with a small screw driver.

5. Clean the retainer.

6. Install the new dust seal in the outside groove of the retainer.

7. Install the new backup washer in the inside recess of the retainer.

8. Install the new shaft seal in the retainer. Make sure it is facing as shown in the cross-section drawing.

9. Make sure that there are no sharp burrs on shaft which could cut the new seals.

10. Slide the retainer over the shaft, using a rotating motion until it is in place.

11. Install the six cap screws which attach retainer to motor. Tighten them to 300± 10 inch lbs (lubricated threads). Be sure to tighten the screws alternately across the diameter--do not tighten adjacent screws at same time.

TO REPLACE ALL SEALS

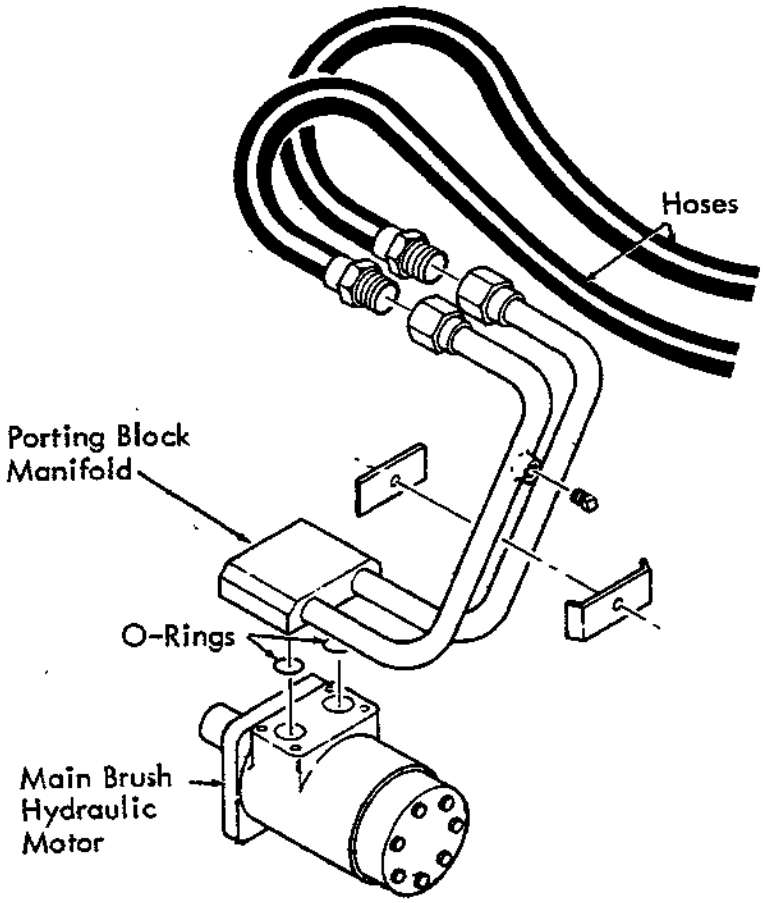
It will be necessary to replace all seals only if the motor is disassembled for repair. The cross-section drawings shown the location of the seals.

ATTENTION! If the motor is disassembled, do not change the relative position of the valve plate and valve. To do so will change the "timing" or direction of rotation of the motor.

MAIN BRUSH HYDRAULIC MOTOR REPLACEMENT

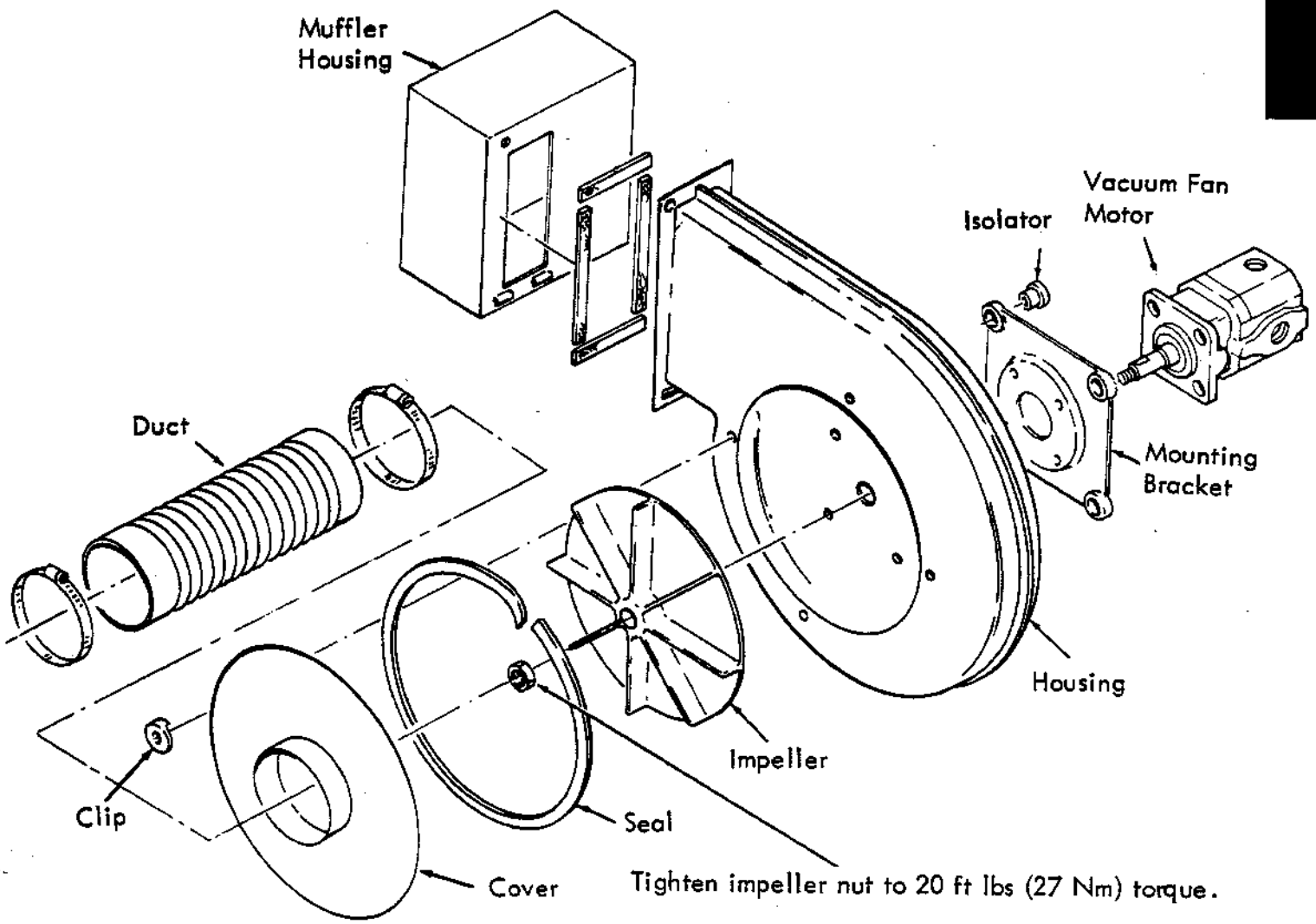
When installing the new motor, make sure that the motor port mounting area is clean and that the O-Rings are in place between the motor ports and the porting block manifold.

Refer to the parts drawing for replacement part numbers.



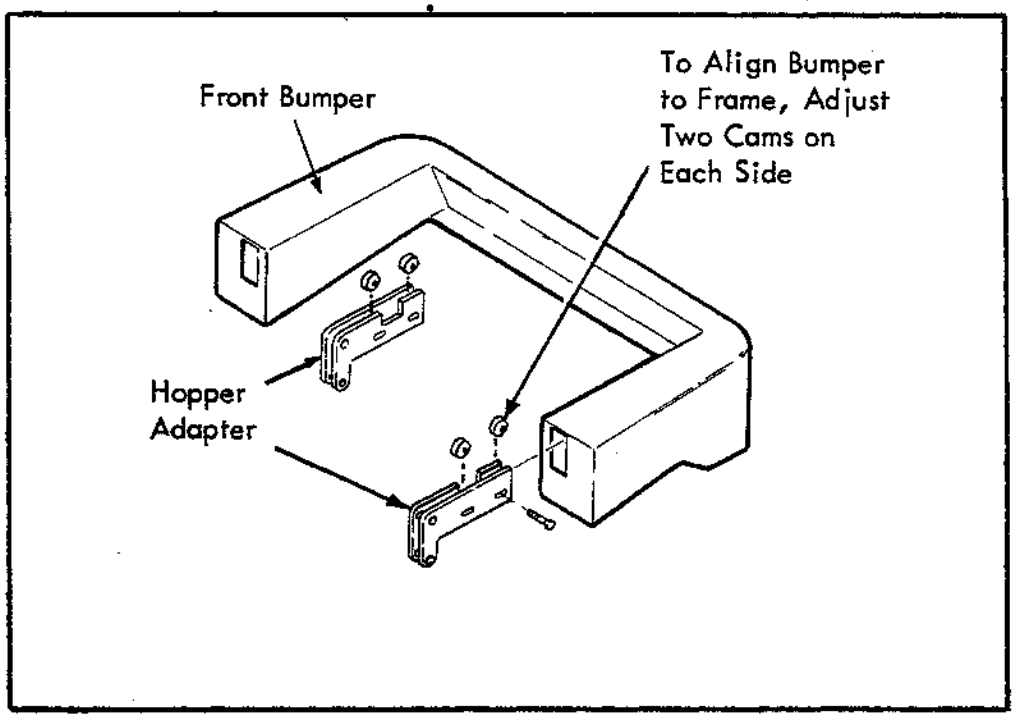
VACUUM FAN HYDRAULIC MOTOR REPLACEMENT

1. Disconnect and cap the hydraulic hoses connected to the motor--be sure to mark the hoses and motor for correct reassembly.
2. Disconnect the duct from the fan housing cover. Remove the cover.
3. Remove the nut attaching the fan impeller to the motor shaft.
4. Remove the screws attaching the motor to the housing.
5. Remove the motor.
6. Install the new or repaired motor on the housing.
7. Attach the impeller (with key) on the motor shaft with nut, 20 ft lbs (27 Nm).
8. Replace the cover.
9. Connect the hydraulic lines, following markings made in step (1).



FRONT BUMPER ALIGNMENT CAMS

The alignment of the front bumper to the machine may change, or if the front bumper is replaced, it may be necessary to align the new bumper to the machine frame. This is done by turning the two cams located on each side of the machine in the hopper adapter assemblies, see sketch.



FRONT BUMPER ALIGNMENT

Turning one cam will raise or lower the bumper on one side. Turning the other cam will adjust the distance between the bumper and the frame. Adjust as required so that the front bumper is aligned with the frame side bumpers.

BRAKE SYSTEM

Brakes are located on the front wheels only and are actuated either hydraulically (foot brake pedal) or mechanically (hand parking brake).

The foot brakes (hydraulic) are self-adjusting.

The hand parking brake is adjusted by turning the hand knob located on brake lever.

To Check Fluid Level in Master Cylinder:

1. Raise hopper to full height and ENGAGE SAFETY LOCK.

2. Unscrew cap on master cylinder (accessible through opening beneath lift arms on right side of machine). Level should be within 0.25 in (6.35 mm) from top of opening.

3. Recommended brake fluid specifications: SAE #J1703.

TO REPLACE FRONT WHEEL BRAKE SHOES

1. Raise machine and block up securely.

2. Remove nut on axle.

3. Remove wheel and hub.

ATTENTION! Keep wheel bearing clean

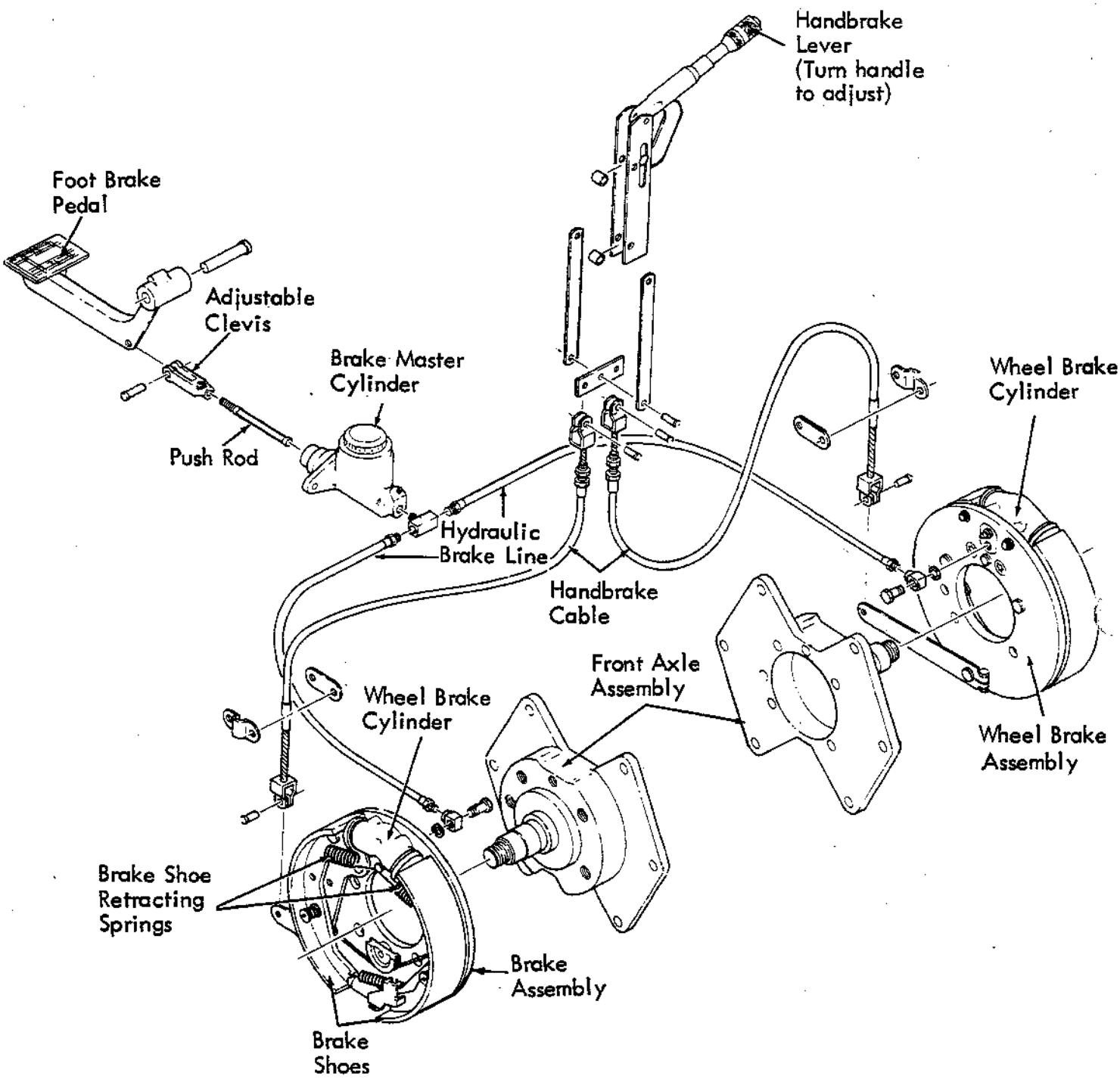
4. Disconnect and remove brake shoe retracting springs.

5. Remove brake shoes.

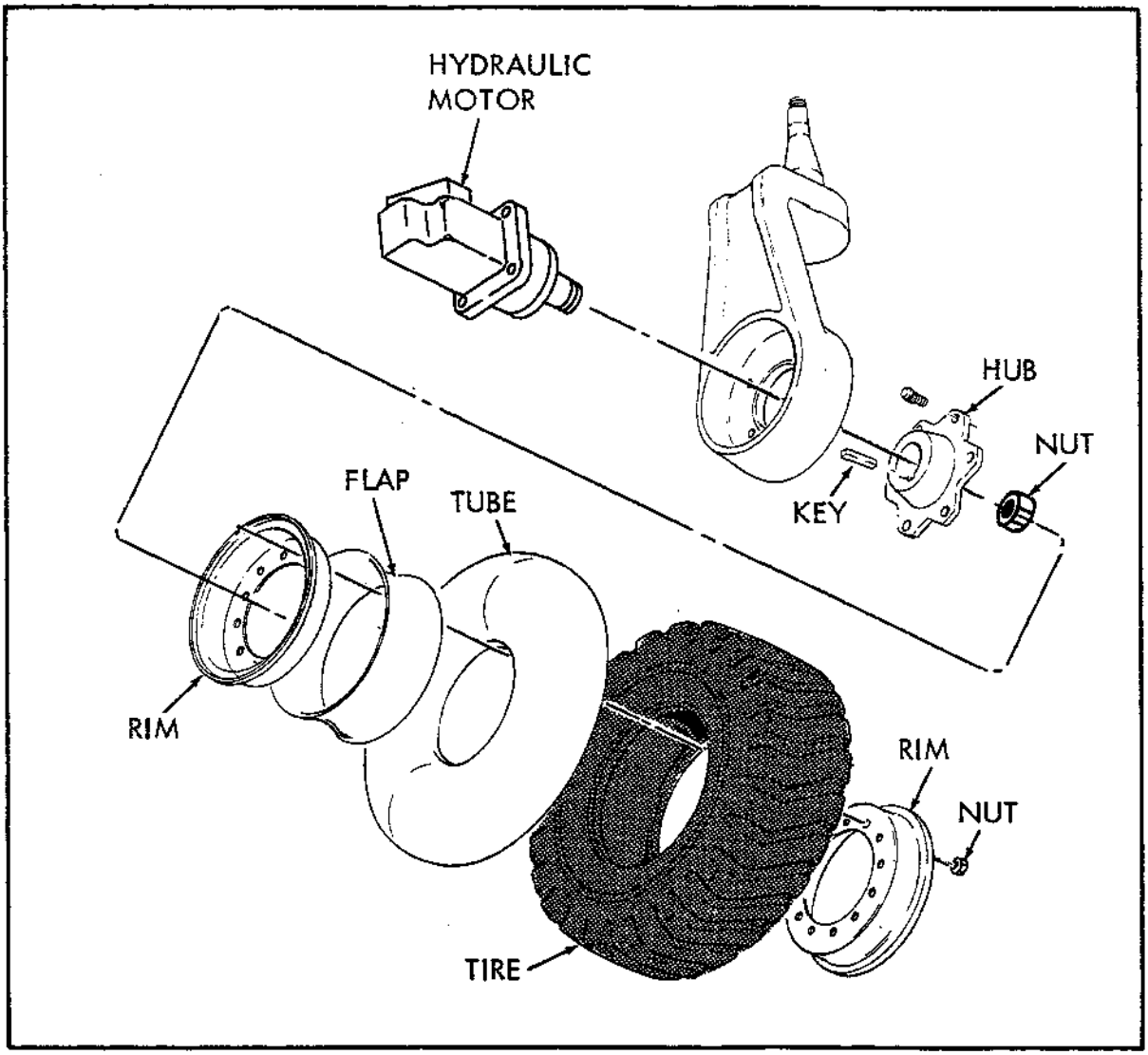
6. Clean brake assembly and brake drum.

7. Position new brake shoes on anchor pin and install shoe retracting springs.

8. Position wheel on axle and install nut. Tighten nut until resistance is felt, then back off nut until cotter pin can be inserted (but no more than 1/12 of a turn).



FRONT WHEEL HYDRAULIC BRAKE SYSTEM AND HANDBRAKE



EXPLODED VIEW OF PROPELLING MOTOR MOUNTING AND WHEEL ASSEMBLY

REPLACING REAR WHEEL OR TIRE

Refer to drawing for arrangement of parts.

1. Raise and block up the machine.
2. Remove the wheel from the hub.

⚠CAUTION Deflate the tire completely before next step. (Hi-dump model rear tire is solid).

3. Remove the bolts holding wheel rims together. Separate the rims.
4. Replace the tire and/or the tube.
5. Bolt the rims together.
6. Inflate the rear tire 50 to 55 psi (344 to 379 kPa). (Hi-Dump rear tire is solid).
7. Bolt the wheel to the hub (tighten to 85 to 95 ft lbs (115 to 129 Nm).

BATTERY INSPECTION AND MAINTENANCE

Every 100 hours inspect the battery as follows:

1. Check the battery cables for loose connections to battery terminals. Inspect cables for corrosion or damage.

2. Check the battery negative cable ground connection.

3. Clean the battery top surface and terminals. Use a strong solution of baking soda and water. Brush the solution sparingly over the battery top, terminals and cable clamps (do not allow any solution to enter the battery). Use a wire brush to clean terminal posts and cable connectors. After cleaning, apply a coating of clear petroleum jelly to the terminals and cable connectors.

4. Check to make sure that battery mounting is holding battery securely.

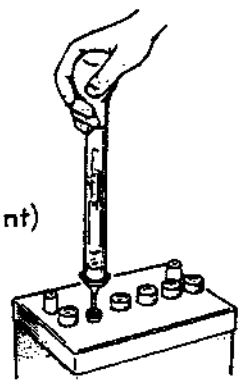
Checking Battery Electrolyte

1. Check electrolyte level in each cell often. Electrolyte level must always be above the plates. Add distilled water to maintain solution about .38 in (9.7 mm) above the plates, but do not overfill.

2. Every 100 hours use a hydrometer to check the electrolyte specific gravity.

NOTE Do not take readings immediately after adding water -- this is because if the water and acid are not thoroughly mixed, readings readings may not be accurate. Check hydrometer readings.

SPECIFIC GRAVITY at 80°F (26.6°C)	BATTERY CONDITION
1.260 - 1.280.....	100% charged
1.230 - 1.250.....	75% charged
1.200 - 1.220.....	50% charged
1.170 - 1.190.....	25% charged (Recharge at this point)
1.140 - 1.160.....	Very little useful capacity remaining
1.110 - 1.130.....	Discharged



If one or more cells tests 0.050 or more lower than the other cells, the cell is damaged, shorted, or is about to fail.

HYDROMETER TEMPERATURE CORRECTION

The hydrometer specific gravity reading must be corrected when the battery electrolyte is any temperature other than 80°F (26.6°C). To determine the corrected specific gravity reading when the temperature of the electrolyte is other than 80°F (26.6°C):

Add to the hydrometer reading 0.004, 4 points, for each 10°F (5.5°C) above 80°F (26.6°C). Subtract from the hydrometer reading 0.004, 4 points, for each 10°F (5.5°C) below 80°F (26.6°C).

CHARGING BATTERIES

The recommended charger should be fully automatic in that the charge rate tapers off by itself as the battery is charged.

ATTENTION! Before charging the battery in the machine, disconnect the battery cables (this will protect the alternator).

⚠CAUTION Do not smoke or light matches, or bring open flame into the area when the battery is being charged. Keep the cover open over the battery. Provide adequate ventilation.

IMPORTANT NOTES ON BATTERY CARE

+ Provide maximum ventilation during battery charging.
+ Keep vent plugs firmly in place at all times, except when adding water or taking hydrometer readings.
+ Keep flames and sparks away from the batteries as they may ignite gas during charging.
+ Keep all metallic objects off the top of the battery, as they may cause a short circuit.
+ Keep the top of the battery clean and dry.
+ Keep the electrolyte level above the plates at all times.
+ Add water only, and avoid over-filling.
+ Keep electrolyte from coming in contact with the eyes, skin, clothing or any other material which it might damage.

RECOMMENDED TORQUES

1. Nut to hold rear wheel on axle - 200 to 250 ft. lbs (271 to 339 Nm).

2. Rear and front wheel nuts - 85 to 95 ft. lbs (115 to 129 Nm).

3. Tighten rear king pin and front axle nuts until resistance is felt. (Turn rear casting when steering is disconnected.) Back off nut to first slot, but no more than 1/12th of a turn.

4. Allen head cap screw on o-ring tube assemblies of drive motor - 15 to 20 ft. lbs (20 to 27 Nm).

   NOTE Tighten the flange evenly before full torque is applied to avoid leakage at the o-ring or possible cracking of the fitting.

5. Allen head cap screws on porting block of main brush motor - 18 to 20 ft. lbs (24 to 27 Nm).

6. Pump drive coupling to flywheel - 35 to 40 ft. lbs (47 to 54 Nm).

7. Vacuum motor impeller nut - 20 ft. lbs (27 Nm).

8. "O-Ring" Type Hydraulic Fittings:
   These fittings have straight threads. Sealing is accomplished by means of an O-Ring which contacts the body of the motor, valve, pump, etc. Turn the fitting into the component until the O-Ring is against the body, then tighten the nut until the O-Ring is compressed enough to seal the connection. Much less torque is required than with pipe thread fittings.

9. Cessna Pump Fittings:
   When screwing fittings into the Cessna pump, do not use excessive torque, this can damage the pump. Recommended torque is:

PORT LOCATION	SIZE	TORQUE
Main pump charge inlet port	0.75"-16	21-24 ft lbs (28-32.5 Nm)
Main pump excess charge port	0.75"-16	21-24 ft lbs (28-32.5 Nm)
Main pump case drain port	0.56"-18	10-12 ft lbs (13.5-16.3 Nm)
Main pump propelling pressure ports	1.06"-12	40-45 ft lbs (54-61 Nm)
Acessory pump suction port	1.06"-12	40-45 ft lbs (54-61 Nm)
Accessory pump pressure port	0.88"-14	27-30 ft lbs (36.6-40.6 Nm)

HOPPER SAFETY LEG ADJUSTMENT (HI-DUMP)

On new machines, a set screw has been added to the safety leg stop so that the safety leg can be adjusted to work properly. Adjust the set screw as shown in the sketches below.

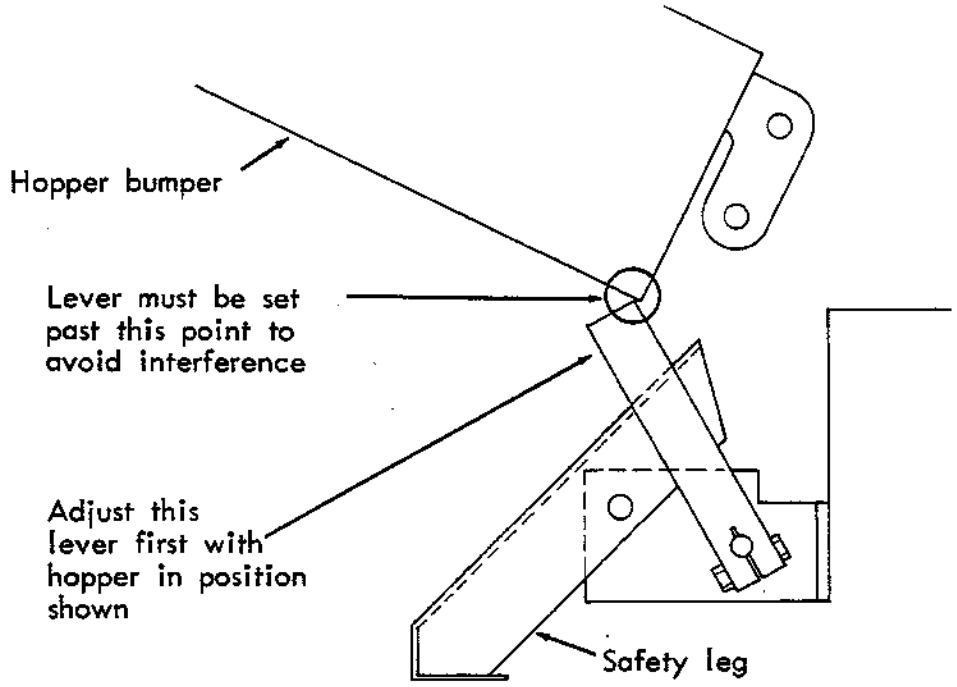


Fig. 1 - Adjust lever first to make sure there isn't any interference between the bumper and lever.

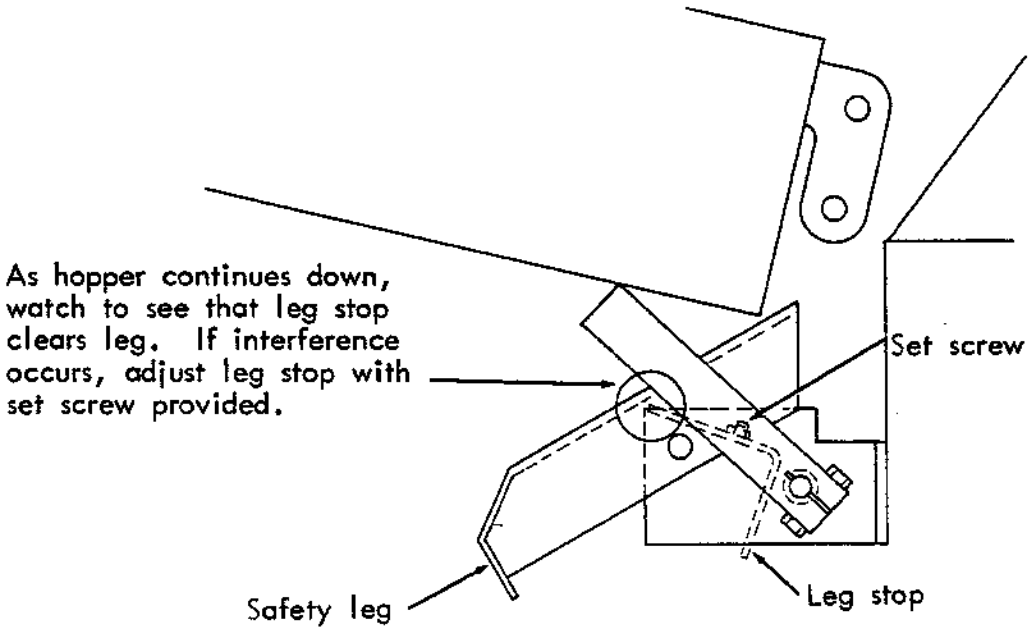


Fig. 2 - Adjust leg stop by means of set screw.

MM108

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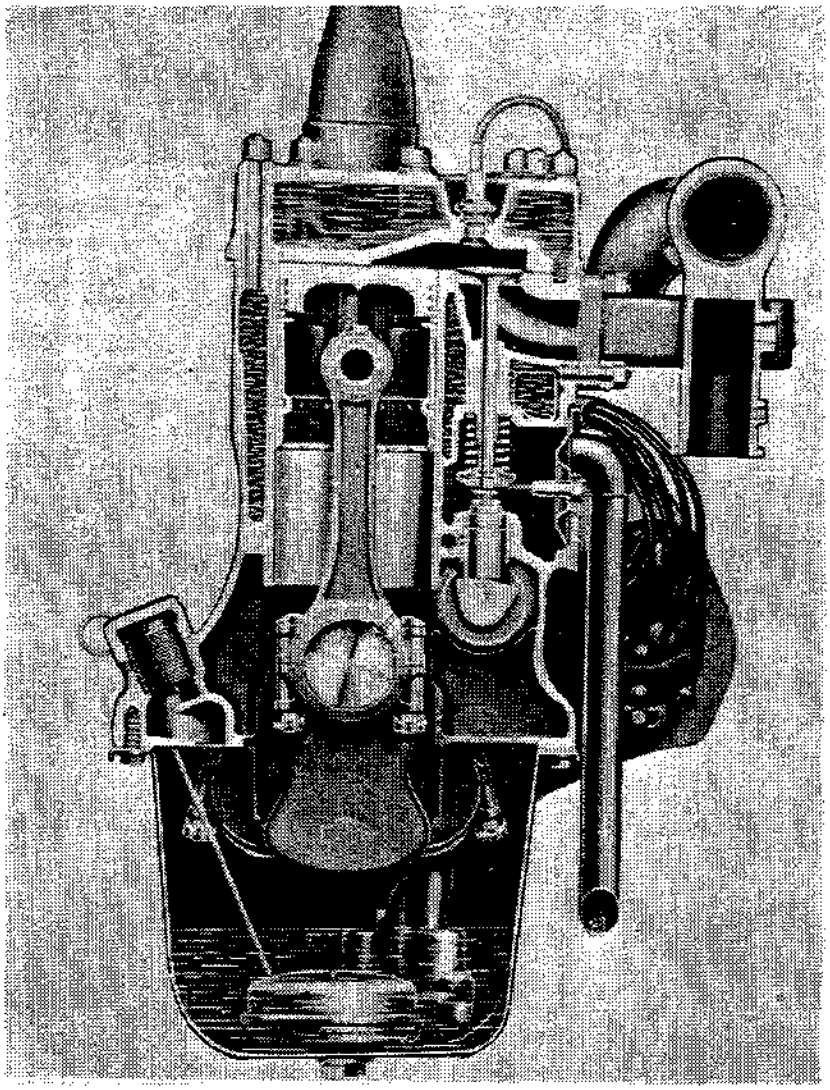
POWER SWEEPER

gas & lpg engine

CONTINENTAL MODEL F-163 SERVICE MANUAL

CONTENTS

Operation and Maintenance *Instructions*



L-HEAD ENGINES

MODEL F-163

TELEDYNE CONTINENTAL MOTORS

WARRANTY
for
TELEDYNE CONTINENTAL MOTORS
INDUSTRIAL PRODUCTS DIVISION
INDUSTRIAL AND MATERIAL HANDLING ENGINES

Teledyne Continental Motors warrants each new engine or power unit manufactured by same to be free from defects in material and workmanship for a period of one (1) year of service or 1500 hours of service, whichever shall first occur.

The obligation of the Company, under this warranty, is limited to repairing or replacing with new or remanufactured parts, as the Company may elect, any part or parts which shall have been returned to a Distributor or licensee of the Company authorized to handle the engine covered by this warranty, and which upon examination is disclosed, to the Company's satisfaction, to have been defective in material or workmanship. Such repair or replacement of any part shall not extend this warranty beyond the original warranty coverage stated above.

This Warranty does not obligate the manufacturer to bear the cost of labor or transportation charges in connection with the replacement or repair of defective parts, nor shall it apply to an engine upon which repairs or alterations have been made unless authorized by the manufacturer.

The manufacturer makes no Warranty in respect to trade accessories, such being subject to the Warranties of their respective manufactures.

THIS WARRANTY, AND THE COMPANY'S OBLIGATION THEREUNDER, IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, and all other obligations or liabilities, including consequential damages or contingent liabilities arising out of the failure of any engine or part to operate properly, and no person is authorized to give any other warranty or to assume any additional obligation on the Company's behalf unless made in writing and signed by an officer of the company.

Before consideration can be given to requests for adjustments covering field service and alleged defective material, the buyer shall furnish Teledyne Continental Motors with the following data:

Owner's name and address
Engine Model, Specification number and Serial number
Date actually placed in service
Accumulated days, hours, or miles of service
Information as to the nature of the trouble

TELEDYNE CONTINENTAL MOTORS
INDUSTRIAL PRODUCTS DIVISION
950 ARTHUR AVENUE, ELK GROVE VILLAGE, ILLINOIS 60007 — PHONE: 312/593-2000

FOREWORD

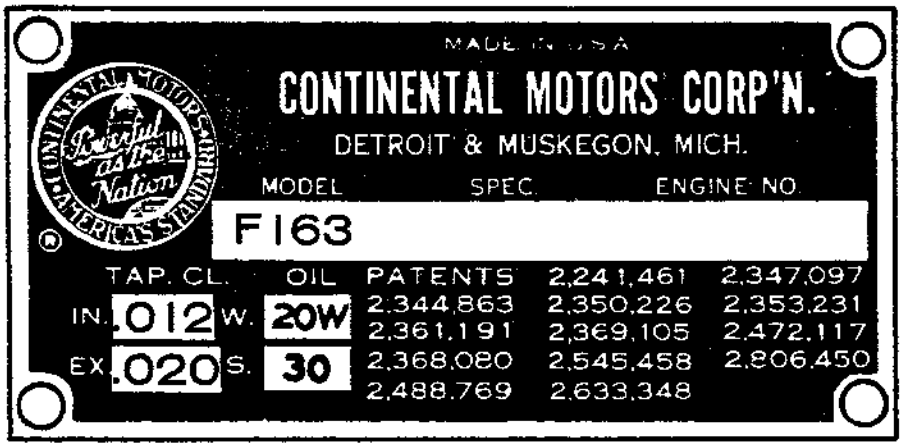
Good operation and a planned maintenance program as outlined in this manual are of vital importance in obtaining maximum engine performance, and long engine life. The instructions on the following pages have been written with this in mind, to give the operator a better understanding of the various problems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

Procedure in the Preventive Maintenance Section must be set up and followed by the owner and operator to obtain dependable service and long life from the engine. Owners and operators are expected to perform these maintenance procedures as outlined under the daily schedule as well as 50-hr., 250-hr., and 500 hr. periods WHILE IN THE WARRANTY PERIOD AS WELL AS DURING THE LIFE OF THE ENGINE.

Warranty service does not include tune-up of the engine such as replacing spark plugs, distributor points, tappet settings, ignition timing, ignition wiring, air cleaner service and lubrication and filter maintenance.

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

THE LIFE OF YOUR ENGINE DEPENDS ON THE CARE IT RECEIVES.



INFORMATION FOR ORDERING PARTS

When ordering parts, refer to the engine name plate attached to side of the cylinder block, which lists the Model and Serial Number. A specification number is listed. This data is of vital importance in obtaining the correct parts: always include this information on your parts order.

MODEL F-163 ENGINE SPECIFICATIONS

No. of Cylinders	4	Valve Clearance:	
Bore and Stroke	3.44" x 4.38" (87mm x 111mm)	Intake	.012"(0.3mm)
Displacement	162 cu. in. (2655cc)	Exhaust	.020"(0.5mm)
Compression Ratio	7.4 to 1	Engine Water Capacity	5 quarts(4.7 liters)
Maximum Oil Pressure	30-40 psi (206-275.9 kPa)	Weight (Bare Engine)	415 lbs. (188kg)
Minimum Oil Pressure (Idling)	7 psi (48.3 kPa)	Engine Speed	2150 to 2200 rpm
Firing Order	1-3-4-2	Engine Idle Speed	550 - 600 rpm.
Oil Capacity		Timing	TDC
Crankcase	4 qts (3.8 liters)		
Filter	0.50 qt (0.47 liters)	Spark Plug Gap	.025" (0.6mm)
Total	4.5 qt (4.26 liters)	Point Gap	.020" (0.51mm)

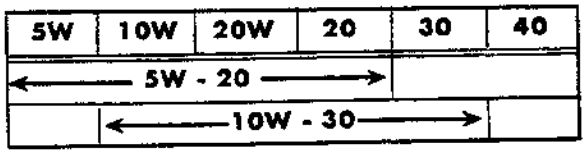
SECTION II
LUBRICATION

ENGINE LUBRICATION SYSTEM

The Continental L-Head engine has full pressure lubrication to all main, connecting rod and camshaft bearings as well as tappets and timing gears. To insure piston pin lubrication and prevent piston scuffing during the warm-up period in cold weather - the large end of the connecting rod has drilled spurt holes pointing toward the thrust side of the pistons. These line up with the oil hole in the crank pin so that once each revolution, oil is sprayed on the cylinder wall for lubrication.

LUBRICATION RECOMMENDATIONS

S.A.E. OIL BODY GRADES*



MULTI-GRADE OILS

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

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

Severe Winter Below 0°F(17.7°C)	Normal Winter 0°-32°F(-17.7° -0°C)	Spring-Fall 32°-75°F(0°-23.9°C)	Summer Above 75°F(23.9°C)
SAE 5W-20	10W	SAE 20W	SAE 30

The Multi-Grade oil used should cover the single grade recommendation for the atmospheric temperature involved, e.g. SAE 10W-30 covers SAE-10W, SAE 20W, SAE 20 and SAE 30. At the TENNANT factory, the following oil is used: API grade "SE", SAE #10W-30.

SECTION III
OPERATING INSTRUCTIONS

STARTING THE ENGINE

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

1. Open throttle Control

2. Turn on Ignition Switch

3. Pull Out Choke –
   But avoid flooding the engine. Operate the engine without choking as soon after starting as possible.

4. Push Starter Button In –
   Keep on until engine starts; but not longer than 15 seconds at a time, to avoid damaging starter.

5. Warm-up Before Applying Load –
   Idle the engine for a few minutes to circulate and warm oil – then increase the speed. This procedure will prolong the engine life.

6. Check Oil Pressure –
   Oil pressure should be 30 to 40 psi (207 to 276 kPa) at full throttle. At idling speed oil pressure should be at least 7 psi (48.3 kPa).

7. Check Coolant Temperature

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

BREAKING IN A NEW OR REBUILT ENGINE

For peak performance and economical operation, the following adjustments should be made at the end of the first 50 hours.

1. Torque down the cylinder head studs to specifications.

2. Adjust valve tappets to specified clearances.

3. Adjust the idle mixture and the idle speed to specifications.

STOPPING THE ENGINE

1. Reduce Engine Speed to Idle
   If hot, run engine at idle for several minutes to cool.

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

ATTENTION! Never pull out the choke when stopping the engine. Raw gasoline will wash lubricant from the cylinder wall.

COLD WEATHER OPERATION

Sludge formation at low temperatutes is a close second to dirt in causing engine damage and wear. This is formed by the piston combustion gases mixing with the fine oil mist in the crankcase and condensing on a cold surface. This condensation forms both a sulphuric and sulphurous acid which combines with the oil to become a highly injurious sludge. This dew point is about 135°F (57.2°C) when crankcase temperatures are higher, the contaminated gases remain in gaseous form and the engine operates clean as long as breather system is kept clean -- however temperatures below this will result in injurious sludge formation. It is vitally important therefore to maintain oil and crankcase temperatures above 135° F (57.2°C).

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

High Altitude Operation

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

High Temperature Operation

For every 10° above 60°F (-12°C above 15.5°C) carburetor air temperature, results. a power loss of 1% results.

SECTION IV
PREVENTIVE MAINTENANCE

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

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

DAILY

PREVENTIVE MAINTENANCE SCHEDULE

1. OVERALL VISUAL INSPECTION OF ENGINE

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

2. CHECK OIL LEVEL OF ENGINE

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

   Do not add oil until oil level approaches the low mark -- then add only enough to bring it to high level -- NEVER above. Do not operate the engine with oil below low level mark.

3. CHECK RADIATOR

   Fill radiator with clean water and anti-freeze mixture (50/50) normal level maintained due to expansion when heated. Visually inspect fan and belt for condition and adjustment.

4. FILL FUEL TANK

   Should be done at end of day's operation to prevent condensation forming in tank. Clean filler cap and area around spout before filling to prevent entrance of dust into fuel system. Observe safety precautions about filling fuel tank given in Preparation for Operation.

(continued on next page)

5. CHECK AIR CLEANER SERVICE INDICATOR

Follow air cleaner instructions in Maintenance Section. Check service indicator daily.

6. CHECK OIL PRESSURE

Note oil pressure gauge which should indicate 30 to 40 psi (207 to 276 kPa) range at full throttle and a minimum of 7 psi (48.3 kPa) at idling speed.

7. NOTE ANY UNUSUAL NOISE

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

EVERY 50 HOURS

1. REPEAT DAILY OPERATIONS OUTLINED

Follow previous instructions.

2. CHANGE CRANKCASE OIL

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

3. SERVICE AIR CLEANER

Clean element with compressed air or replace it if necessary.

4. CHECK FAN AND ALTERNATOR BELT TENSION

Loosen adjusting screw on alternator and pull out on alternator to tighten belt. When adjusted correctly, the belt should have about 0.50 in (12.7 mm) deflection from moderate force applied at midpoint on longes span.

5. CHECK BATTERY

Check specific gravity of each -- it should be at least 1.250. Add distilled water, if required, to raise level 0.38 in (9.7 mm) above the separators.

6. ADJUST IDLE MIXTURE AND IDLE SPEED TO SPECIFICATIONS - REPEAT AGAIN AT THE END OF 500 HOURS.

EVERY 250 HOURS

1. REPEAT DAILY AND 50-HOUR SCHEDULES
   Follow previous instructions.

2. CLEAN EXTERIOR OF ENGINE
   Use steam if available, otherwise any good commercial engine cleaner to wash down the engine.

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

4. CLEAN SPARK PLUGS
   Clean depressions around plugs before removing them. Then clean and re-set point gap to .025 in (0.64 mm). Install spark plugs (18 mm) and tighten to 35 ft lb).

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

   Examine contact surfaces of points - replace if burned or pitted and adjust to .020 gap (0.51 mm).

   Lubricate distributor cam sparingly. Check distributor clamp bolts and, if they are loose, - retiming the engine is necessary. Lubricate end of shaft with a drop of light oil to keep the advance mechanism pivoting freely.

7. Replace air cleaner element.

EVERY 500 HOURS

1. REPEAT DAILY, 50 HOUR, AND 250 HOUR SCHEDULES

2. COOLING SYSTEM

   Clean radiator core by blowing out with compressed air. (Blow air in from outside of machine). Inspect radiator mounting. Inspect water pump and connections for leaks. Check fan and alternator drive belts for damage or incorrect tension.

3. ADJUST VALVE TAPPET CLEARANCE

   Check and adjust intake and exhaust valve tappets to following clearances at idling speed and running temperature: Intake: 0.012" (0.3 mm), Exhaust: 0.020" (0.51 mm).

4. CARBURETOR

   Clean exterior and check mounting to manifold. Adjust carburetor air adjustment for even running and adjust idle speed. Inspect throttle and choke linkage for free operation.

5. FUEL PUMP

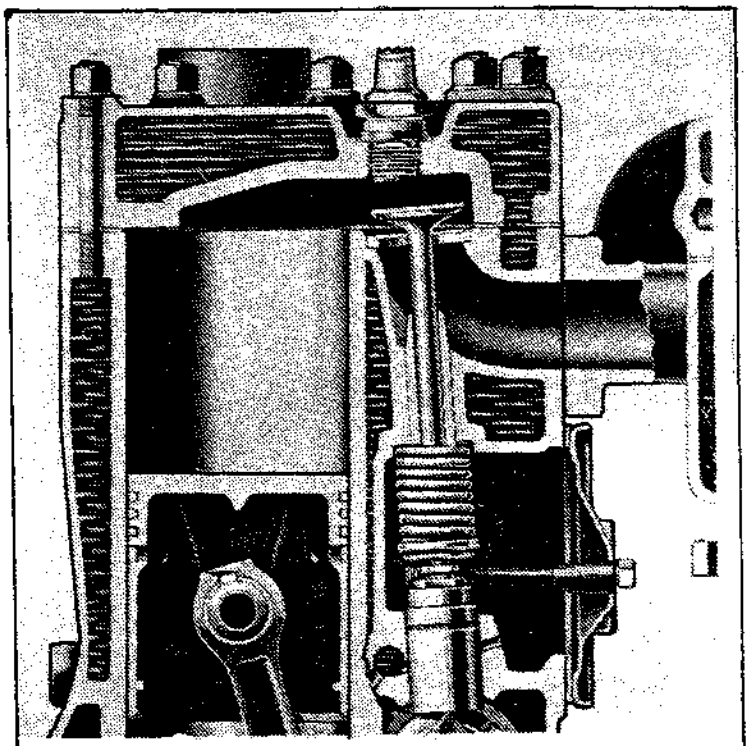
   Clean Filter bowl and screen. Inspect mounting and gasket. Check all connections for leaks.

SECTION V
COOLING SYSTEM

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

Continental L-Head gasoline engines operate most efficiently with water temperatures of 180° - 200°F (82° - 93° C) and a thermostat and by-pass system used to control these temperatures.

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



SECTIONAL VIEW SHOWING WATER PASSAGES IN HEAD AND BLOCK

NOTE The thermostat begins to open at 180°F (82°C). However, temperature gauges are not always exactly accurate and may sometimes indicate higher than the actual temperature. This can lead operators to believe engines are overheating when they are actually operating normally.

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

EFFECT OF ALTITUDE ON COOLING

Water boils at 212°F (100°C) under atmospheric pressure at sea level. This pressure becomes less at higher altitudes and the reduced pressure causes water and other liquids to boil at a lower temperature.

ANTI-FREEZE

Use a permanent-type ethylene glycol anti-freeze. Mix with water at a 50-50 ratio.

RADIATOR

It is important that the radiator tubes be kept clean on the inside and the fins free of dirt on the outside so that maximum heat transfer can take place in the radiator.

Blowing out between the fins of the radiator, using compressed air, in a direction opposite to that of the fan circulated air, (in the case of the Model 92 blow air inwards from outside of machine) will serve to keep the cooling surfaces of the core free of dirt and other particles.

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

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

CLEANING COOLING SYSTEM

Deposits of sludge, scale and rust on the cooling surfaces prevent normal heat transfer from the metal surfaces to the water and in time render the cooling system ineffective to properly maintain normal operating temperatures. The appearance of rust in the radiator or coolant is a warning that the corrosion inhibitor has lost its effectiveness and the radiator should be cleaned before adding fresh coolant.

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

REVERSE FLOW FLUSHING

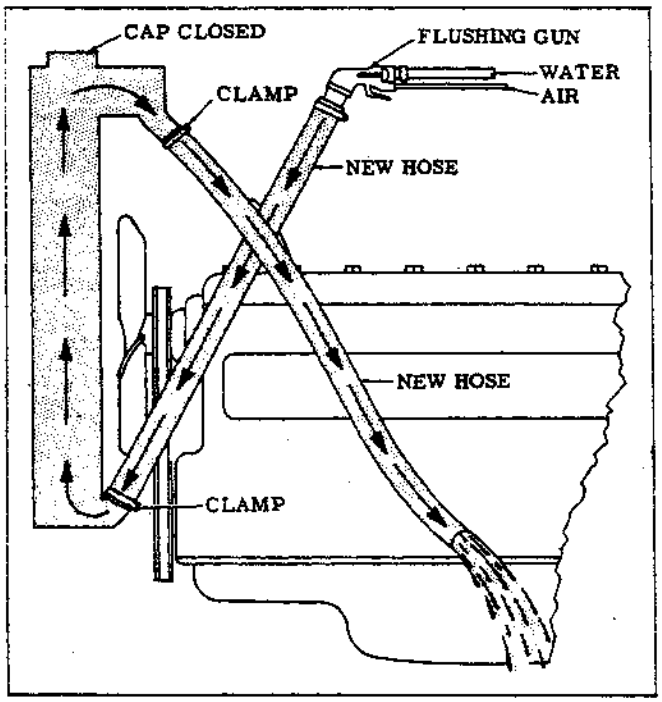
Whenever a cooling system is badly rust-clogged as indicated by overflow loss or abnormally high operating temperatures, corrective cleaning by reverse flow flushing will most effectively remove the heavy deposits of sludge, rust and scale. The reverse flow flushing should be performed immediately after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

Reverse Flush the Radiator, As Follows:

1. Disconnect the hoses at the engine.

2. Put radiator cap on tight.

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



REVERSE FLUSHING RADIATOR

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

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

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

7. Clean and inspect radiator cap.

To Reverse Flush the Engine Water Jacket :

1. Remove the thermostat.

2. Clamp the flushing gun in the upper hose.

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

4. Follow the same procedure outline above for the radiator, by alternately filling the water jacket with water and blowing it out with air at 80 lbs (36 kg) pressure until the flushing stream is clear.

THERMOSTAT

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

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

RADIATOR PRESSURE CAP

A Pressure cap is used on the radiator to prevent overflow loss of water during normal operation. This spring loaded valve in the cap closes the outlet to the overflow pipe of the radiator and thus seals the system, so that pressure developing within the system raises the boiling point of the coolant and allows higher temperatures without overflow loss from boiling. When a pressure cap is used an air tight cooling system is necessary with particular attention to tight connections.

ATTENTION! Never pour cold coolant into the radiator of an overheated engine. Allow the engine to cool to avoid the danger of cracking the cylinder head or the block. Keep the engine running while adding coolant.

WATER PUMP

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

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

REMOVING WATER PUMP

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

1. Remove fan by taking out four cap screws.

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

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

4. When installing a new or rebuilt water pump, use a new gasket between the pump and the engine.

SECTION VI
FUEL SYSTEM

MECHANICAL FUEL PUMP

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

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

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

If there is little or no flow -- Check the following:

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

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

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

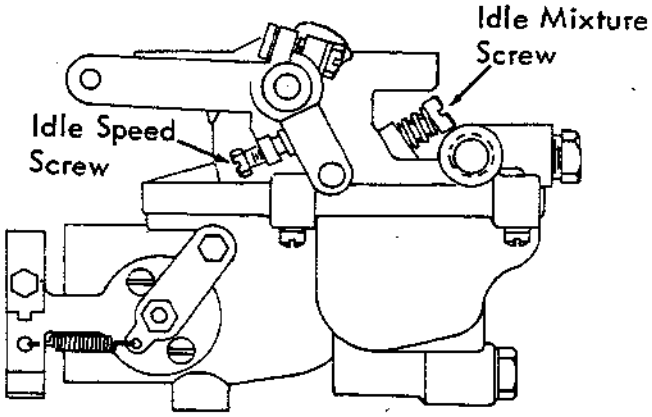
If none of these items corrects flooding, remove the fuel pump for replacement or overhaul.

CARBURETOR

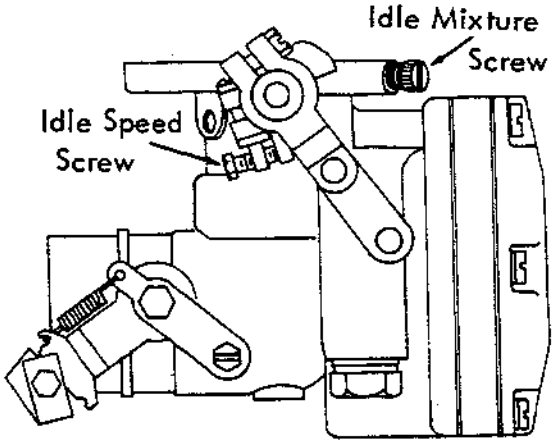
Idle Mixture Adjustment Needle

Controls the amount of air admitted to the idling system, which functions only at low speeds. Turning the screw clockwise cuts off the air, making the mixture richer - while unscrewing it admits more air making the mixture leaner. The idling adjustment needle should be set for the smoothest running of the engine; or, if a vacuum gauge can be attached to the manifold, set the adjustment for highest manifold vacuum.

Idle Speed Adjustment Screw -- Controls the idling speed.
Recommended Idle Speed: 550 to 600 rpm.



GASOLINE CARBURETOR



LP GAS CARBURETOR

Manually Operated Choke -- is operated by a flexible cable control from the instrument panel. It is most important that the operator have the choke valve in wide open position when engine operating temperature is reached.

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

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

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

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

After a carburetor has been in service for some time, the holes in the jets and the float valve and seat become worn from the constant flow of fuel through them and should be overhauled by a competent carburetor service station.

SECTION VII
IGNITION

IGNITION SYSTEM COMPONENTS

The BATTERY supplies the voltage for producing a current flow through the ignition circuit.

The AMMETER indicates the amount and direction of current flow.

The IGNITION SWITCH is an "Off" and "On" switch and the BREAKER CONTACTS function as an intermittent switch. Current flows only when both switches are closed and returns by the ground through the engine or frame. The resistance of the primary winding of the ignition coil restricts the primary current flow.

The IGNITION COIL consists of two windings, a primary winding and a secondary winding and is a transformer to increase the voltage high enough to jump a spark gap at a spark plug.

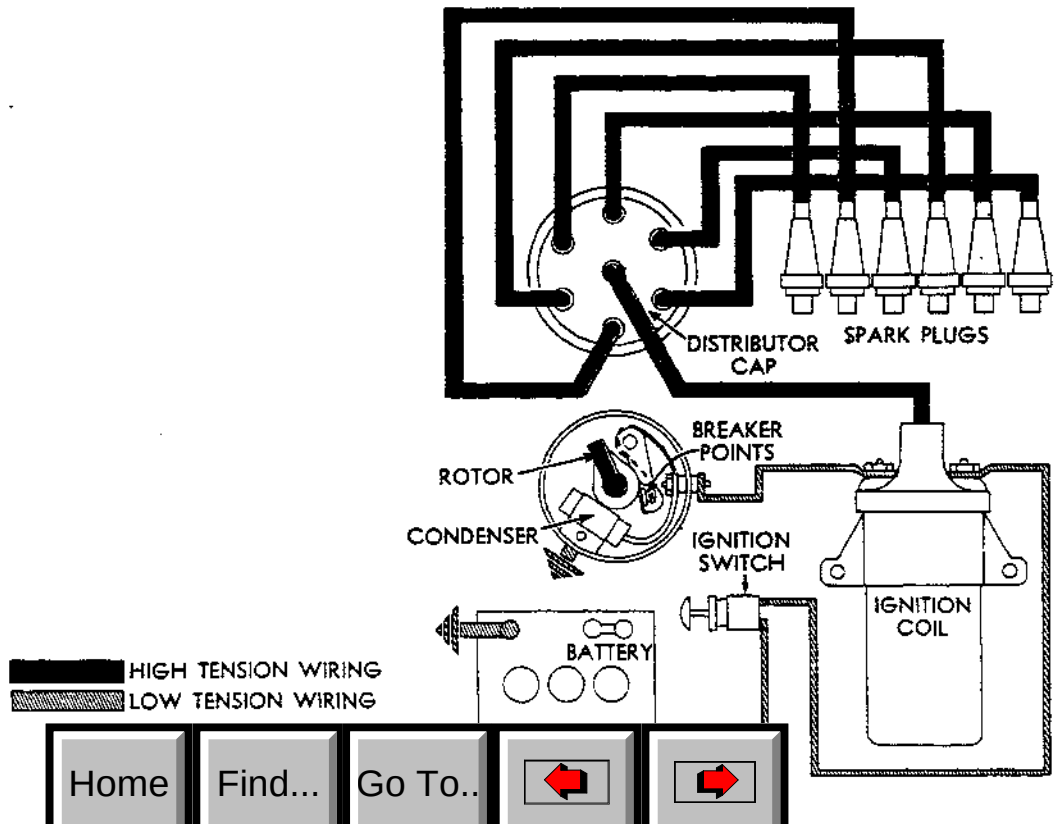
The CONDENSER momentarily provides a place for the current to flow until the distributor contacts are safely separated in order to reduce arcing.

The DISTRIBUTOR interrupts the primary winding current in the ignition coil and distributes the high tension current to the correct spark plug at the correct time.

The SPARK PLUGS provide a spark gap in the combustion chamber. The compressed air and fuel mixture is ignited when the high voltage jumps across this gap.

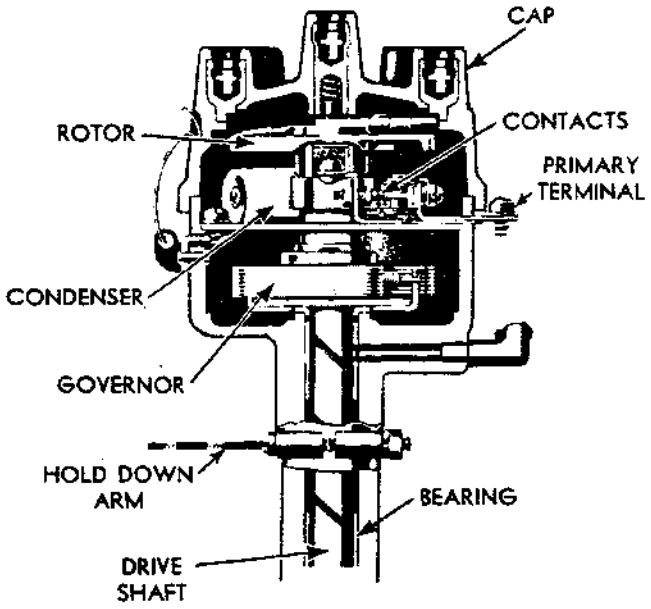
The LOW TENSION PRIMARY WIRING conducts battery current through the ignition coil and contacts.

The HIGH TENSION SECONDARY WIRING conducts the high voltage, produced by the ignition coil, to the distributor and from the distributor to the spark plugs.



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

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



CUTAWAY VIEW OF A DISTRIBUTOR

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

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

Continental L-Head engines have distributors equipped with a centrifugal governor which varies the timing by advancing the breaker cam as the engine speed increases.

The condenser in the distributor prevents excessive arcing at the contacts. When the contacts first open, the current tends to continue flowing across the gap. The condensor absorbs this current until it becomes fully charged; but by this time, the contacts have opened far enough to prevent the current flow.

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

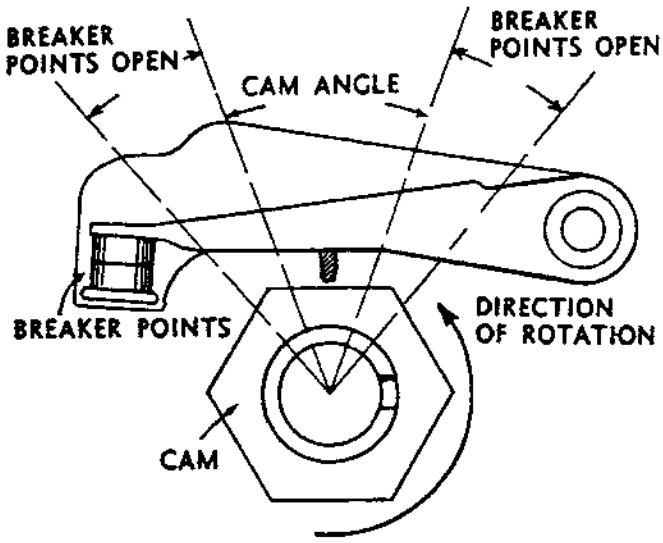


DIAGRAM ILLUSTRATING CAM ANGLE

The cam is further designed to open the breaker points at a given speed in relation to cam travel to obtain proper point and condensor action. It is therefore important that the breaker points be adjusted to 0.20" (0.50 mm) gap so proper cam angle is obtained.

DISTRIBUTOR MAINTENANCE –

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

1. Remove Distributor Cap (without removing wires)
   Clean cap and examine for cracks, carbon runners, corroded terminals or if the inserts are burned – install a new cap. If the horizontal faces of the inserts are burned – replace the cap and rotor as this is due to the rotor being too short.

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

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

4. Lubrication

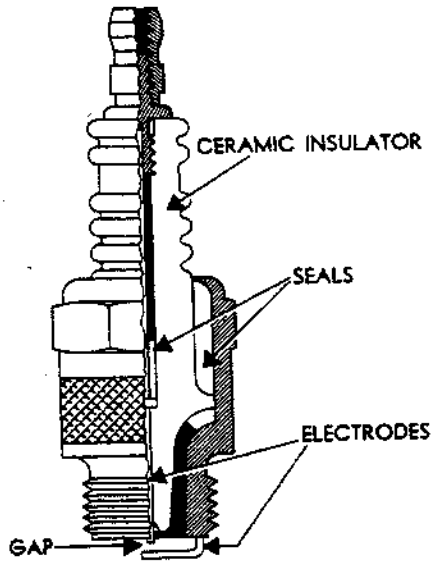
   Lubrication is required at the shaft, advance mechanism, breaker cam and pivot. The shaft may be either oil or grease cup lubricated and should be given attention every oil change. Make sure the breaker arm moves freely on its hinge and apply a drop of light oil. A trace of ball bearing lubricant such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

ATTENTION! Avoid excessive lubrication. The excess may get on the contact points and cause burning.

SPARK PLUGS –

Correct and uniformity of the gaps of all spark plugs in the engine is important for smooth running.

Correct spark plug electrode gap is .025" (0.64 mm).



Spark plug gaps are best checked with a wire gauge unless the points are dressed to obtain a correct reading with a flat gauge. The adjustment should always be made on the side electrode and never on the center electrode which may cause a broken porcelain. "Gapping" the electrode tip is more easily done with proper tools.

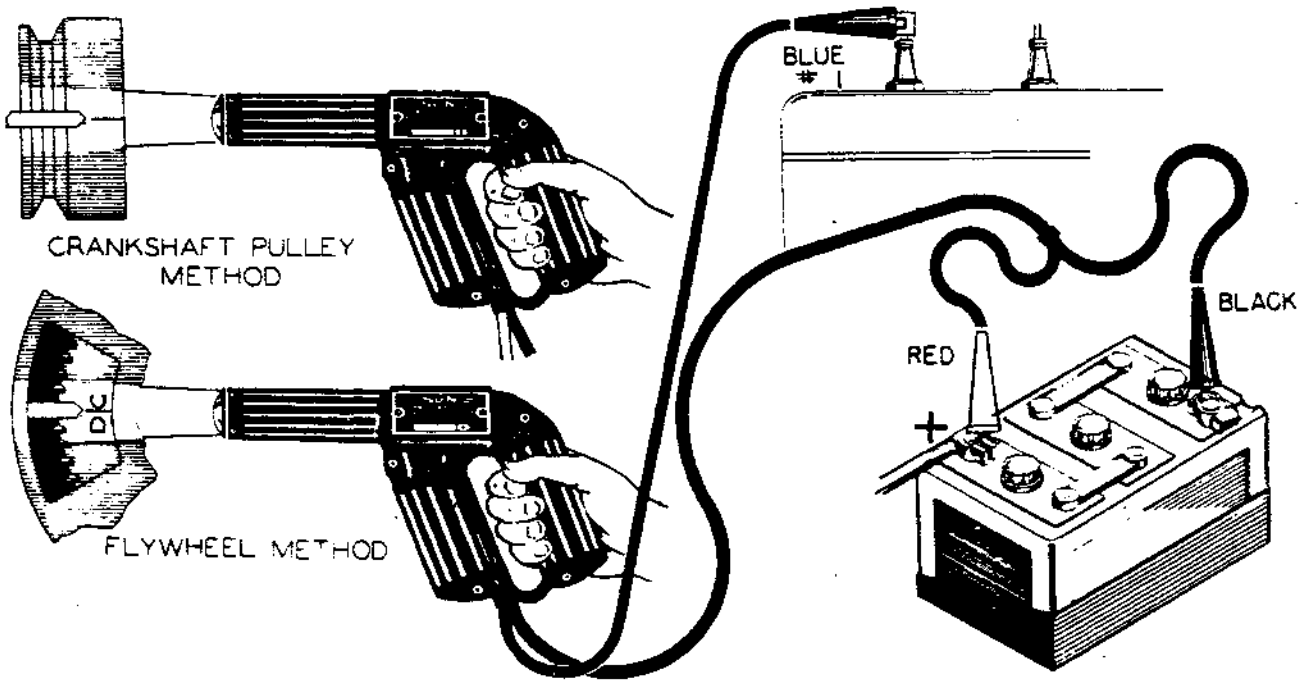
Spark plugs must be correctly installed in order to obtain good performance from them. Follow the following procedure when installing plugs:

1. Clean the spark plug seat in the cylinder head.

2. Use new seat gasket and screw plug in by hand.

3. Tighten all 18 mm plugs to 35 lbs (241 kPa) torque with a socket wrench of correct size.

DISTRIBUTOR — IGNITION TIMING
With Timing Light



TIMING LIGHT HOOKUP

There are two methods of checking ignition timing - with or without a timing light. The preferred method is to use a timing light in following sequence:

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

1. Clip blue secondary lead of light to the #1 spark plug - leave spark plug wire on plug.
2. Connect primary positive lead (red) to posititive terminal of battery.
3. Connect primary negative lead (black) to negative battery terminal.
4. Start engine and run at idle speed, 400 RPM or lower, so the automatic advance of the distributor is completely retarded. This is very important to obtain correct timing.
5. Direct timing light on the crankshaft pulley or on the flywheel through opening in bell housing and note timing marks as light flashes.
6. Timing is normally T.D.C. at 400 rpm., 14° at 1800 rpm., and 16° at above 2000 rpm.

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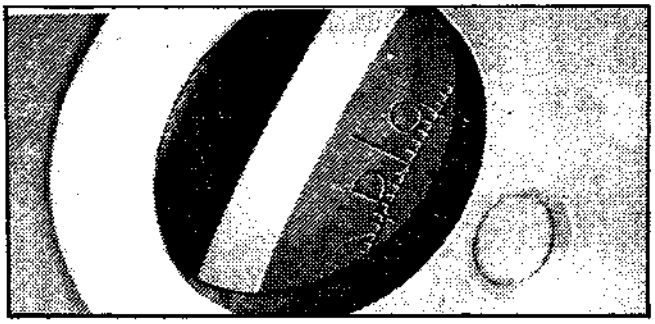


FLYWHEEL TIMING MARKS

CRANK PULLEY TIMING MARK

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

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

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

NOTE Be sure to increase engine idle speed to 550 to 600 RPM after adjusting the timing

CHARGING CIRCUIT

The charging circuit consists primarily of an alternator, regulator, battery and wiring. When analyzing the charging circuit, the components should be checked in the following order:

I. Wiring

Wiring in the charging circuit should be carefully inspected for frayed insulation or other damage, and replace any wiring that is defective. Also inspect all connections to the alternator, regulator and battery (including all ground connections), and clean and tighten as required.

II. Battery

Visual Test - The battery should be inspected visually, checking the level of the electrolyte and the outside of the battery for damage and abuse.

Specific Gravity Cell Comparison Test

Measure the specific gravity of each cell, regardless of state of charge, and interpret results as follows:

If the maximum difference between cell readings is less than .050 (50 points) and the lowest cell reading is 1.200 or above, the battery is good.

Full Charge Hydrometer Test

This test is given to fully charged batteries. If cell readings range between 1.230 and 1.310 specific gravity, the battery is ready for use.

NOTE Add 4 points(.004) to the reading for every 10°F (-12°C) electrolyte temperature below 80°F (26.6°C).

Installing Batteries

The following points are important to properly install a battery:

1. Be sure the battery carrier is clean and that the new battery rests level when installed.
2. Tighten the hold-down evenly until snug. Do not draw down tight enough to distort or crack battery case.
3. Be sure the cables are in good condition and the terminal clamps are clean. Grease battery terminals lightly before attaching cable clamps. Make sure the ground cable is clean and tight at engine block or frame.
4. Check polarity to be sure battery is not reversed with respect to the generating system.
5. Connect "grounded" terminal of the battery last to avoid short circuits which will damage the battery.

ATTENTION! The following precautions are to be observed when testing or servicing the alternator system.

1. Disconnect the battery before connecting or disconnecting test instruments (except voltmeter) or before removing or replacing any unit or wiring. Accidental grounding or shorting at the regulator, alternator, ammeter or accessories, will cause severe damage to the units and/or wiring.

2. To avoid damage to the regulator, do not, at any time, connect battery to the regulator field terminal.

3. The field circuit must never be grounded, on this system, between the alternator and the regulator. Grounding of the field terminal either at the alternator or regulator will damage the regulator.

4. If it is necessary to solder any lead to a rectifer lead, use a pair of pliers as a heat dam between the solder joint and the rectifier.

5. The alternator must not be operated on open circuit with the rotor winding energized.

6. Do not attempt to polarize the alternator. No polarization is required. Any attempt to do so may result in damage to the alternator, regulator, or circuits.

7. Grounding of the alternator output terminal may damage the alternator and/or circuit and components.

8. Reversed battery connections may damage the rectifiers, wiring or other components of the charging system. Battery polarity should be checked with a voltmeter before connecting the battery.

9. If a booster battery or fast charger is used, its polarity must be connected correctly to prevent damage to the electrical system components. (Positive to positive, negative to negative.)

NOTE When servicing the charging system, never remove a unit until tests have shown it to be defective. Reference always should be made to the manufacturer's maintenance manuals for trouble shooting.

SECTION VIII
ENGINE REPAIR AND OVERHAUL

CYLINDER HEAD

Remove the Cylinder Head in the Following Sequence:

1. Drain water from engine and disconnect radiator outlet hose.

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

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

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

5. Clean the cylinder head thoroughly with a solvent or degreasing solution and blow it off with air pressure.

6. Make sure that gasket contact surfaces on the head and block are clean, smooth and flat.

7. Check out-of-flatness with a straight edge and feeler gauge; maximum permissible is .00075 in (.019 mm) per in of width or length. Thus, for a cylinder head 16" (406 mm) long, maximum permissible lengthwise out-of-flatness is .012 in (.304 mm). Out-of-flatness should vary gradually and uniformly from end-to-end and side-to-side. Localized depressions or high spots should not exceed .003 in (.076 mm).

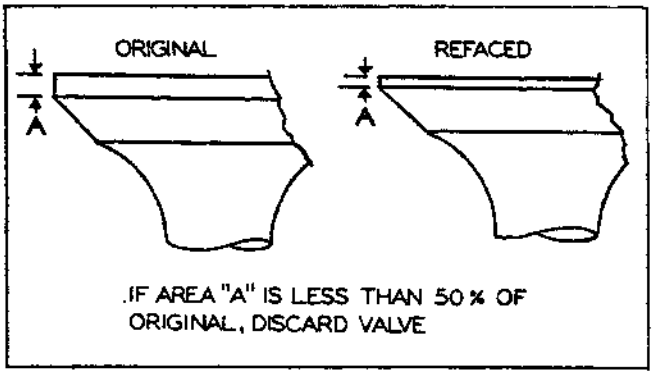
Valve Removal

1. With a valve spring lifter, compress the springs and remove the locks or pins from the valve stems which are in a closed position. Close the other valves by rotating the crankshaft and remove the locks (or pins) from these valves in the same manner. Remove all valves and place in order in a rack, with holes numbered for both intake and exhaust valves so they will not be mixed in handling.

(continued on next page)

Valve Inspection & Repair

1. Inspect valves for condition and replace any that are "necked", cracked or burned, also any on which valve stems are bent or worn more than (0.05 mm) over maximum allowable limits. Reface or replace all valves.



ALLOWABLE HEAD THICKNESS OF REFACED VALVES

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

Valve Springs

1. Check all valve springs on a spring tester to make sure they meet specifications regarding weight and length. Springs, when compressed to the "valve open" or "valve closed" length, must fall within the specifications shown on the chart when new, and must not show more than 10% loss to re-use.

2. Reassemble the valves and springs in the block with the retainer and retainer lock.

Checking Cylinder Block Bore Wear

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

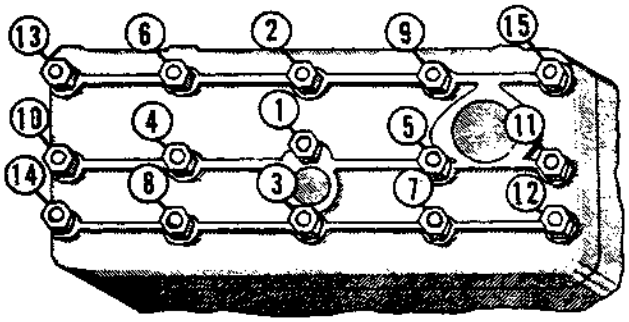
2. Determine the original diameter of the cylinder barrel by checking this unworn area with a pair of inside micrometers at intervals of approximately 45°.

3. Check in same manner the top of the ring travel area approximately 0.25 in (6.35 mm) below the shoulder.

4. The maximum difference in the above checks, indicates the amount of cylinder bore wear. If less than .008, re-ringing will be suitable and if over .008 re-boring is recommended.

INSTALLING CYLINDER HEAD

Clean cylinder head and block surfaces thoroughly before installing gasket. Tighten all cylinder heads or cap screws evenly and torque in following sequence to the recommended torque of 70 to 75 ft. lbs (95 to 102 Nm).



CORRECT SEQUENCE OF CYLINDER HEAD BOLT TIGHTENING

OIL PAN REPLACEMENT

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

SECTION IX
TROUBLE SHOOTING

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

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

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

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

A. STARTING MOTOR - WILL NOT CRANK ENGINE:

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

B. ENGINE CRANKS - BUT DOES NOT START:

Disconnect one spark plug wire, turn ignition on with starter cranking engine and free end of wire .13 in (3.30 mm) from cylinder head. Note spark.

1. No Spark:
   a. If ammeter shows no discharge it indicates an open primary circuit due to:
      (1) Points not closing
      (2) Open primary wires
      (3) Defective ignition switch
      (4) Faulty coil

   b. Normal Ammeter Reading (2-5 amps)
      This indicates that primary circuit is OK - trouble may be in secondary circuit due to:
      (1) Broken or grounded high tension wire from coil to distributor.
      (2) Wet high tension wires.

(3) Faulty distributor cap or rotor
(4) Broken secondary winding of coil

c. Excessive Ammeter Reading (over 5 amps)
Indicates a "short" in the primary winding which may be due to:
(1) Shorted or grounded primary winding
(2) Distributor or magneto points not opening
(3) Grounded breaker point arm
(4) Defective condenser

2. WEAK SPARK - may be caused by:

a. Loose ignition wiring connections
b. Burned or pitted distributor points
c. Wet spark plug wires
d. Defective condenser
e. Cracked distributor cap
f. Weak ignition coil

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

a. No gas in carburetor - which may be due to:
(1) No gas in tank
(2) Clogged filter or lines
(3) Faulty fuel pump
(4) Leaky fuel line from tank
(5) Plugged vent in fuel tank cap.

b. Gas in carburetor - which may be flooded due to:
(1) Too much choking, plugs are wet
(2) Wrong float level
(3) Choke not operating correctly
(4) Water in gas

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

1. Uneven compression
2. Wet or deteriorated high tension wires
3. Cracked distributor cap
4. Faulty spark plugs, if spark plug porcelain is white when removed, use Colder plug - if light brown OK - if Black or oily use Hotter plug

D. ENGINE RUNS UNEVENLY

1. At idling speed - which may be due to:
a. Too wide spark plug gaps
b. Poor carburetor idle adjustment
c. Wrong float level
d. Carburetor or intake manifold air leaks
e. Leaky cylinder head gasket

2. At High Speed – which may be due to:
   a. Wide breaker points
   b. Weak distributor breaker arm spring
   c. Weak valve springs
   d. Spark plug of wrong type or incorrect gap

E. ENGINE RUNS IMPROPERLY

1. Back-firing into manifold – indicates too rich a fuel mixture; into carburetor indicates too lean a mixture – may be due to:
   a. Late Ignition timing
   b. Clogged air cleaner
   c. Fuel line restrictions
   d. Clogged carburetor jets
   e. Sticking valves
   f. Weak or broken valve springs

2. Excessive Ping (Detonation) – results in damaged pistons and bearings and is caused by pre-ignition or using inferior grade of gas.

3. Engine Idles Too Fast – indicates improper throttle adjustment or weak throttle return springs.

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

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

6. Defective Spark Plugs.

F. LACK OF POWER – which may be due to:

1. Poor Compression

2. Wrong Timing

3. Throttle control not opening fully

4. Air leak in fuel system

5. Restriction in air cleaner – should have vacuum less than 10" (254 mm) water.

6. Exhaust line obstructed – back pressure of not more than 20" (508 mm) water.

7. Poor fuel

8. Piston rings sticking or worn

G. POOR COMPRESSION

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

1. Valves holding open – no tappet clearance
2. Leaky cylinder head gasket
3. Broken or weak valve springs
4. Burned or sticking valves
5. Badly worn, broken or stuck piston rings
6. Wrong valve timing

H. OVERHEATING

1. Lack of water in radiator
2. Fan belts slipping
3. Thermostat sticking or inoperative
4. Radiator clogged or leaky
5. Late ignition timing
6. Back pressure in exhaust line
7. Defective water pump
8. Overloading of engine

I. LOW OIL PRESSURE

1. Low oil level
2. Oil pressure gauge or line faulty
3. Oil too light – diluted
4. Suction screen plugged
5. Dirt in relief valve or broken spring
6. Worn bearings
7. Worn or damaged oil pump gears
8. Worn cam bushings

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

1. Engine oil too heavy
2. Stuck relief valve
3. Obstruction in distributing line
4. Faulty oil pressure gauge

K. HIGH OIL CONSUMPTION

1. Oil leaks
2. Too high oil level
3. Incorrect grade of oil used

4. Clogged crankcase breather
5. Oil pressure too high - stuck relief valve
6. Piston rings not run-in, due to too smooth cylinder bore finish or glazed condition.
7. Worn, broken or stuck piston rings and clogged oil control rings.
8. Worn pistons and sleeves
9. Worn bearings
10. Worn valve guides

Manifold may be removed for visual inspection

L. ENGINE KNOCKS AND OTHER NOISES

1. Operating Knocks - which may be due to:
   a. Pre-ignition - most common cause is due to wrong type plugs which are too hot
   b. Carbon - noticable when engine is accelerated while hot - clean head and pistons
   c. Timing - early timing causes knocks similar to carbon - but may tend to kick back when starting
   d. Fuel - detonation knock caused by poor gas
   e. Overloads - particularly at lower operating speeds

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

   a. Crankshaft and main bearings:
      (1) Worn or burned-out main bearings - A heavy, dull knock when accelerating under load. Locate by shorting out plugs on both sides of the bad bearing.
      (2) Crankshaft end-play - excessive end-play is indicated by an intermittent knock which will come and go when the load is released and engaged.
   b. Connecting rod bearings
      (1) Worn or burned-out bearings - The worst condition, a light pound or metallic knock, is noted at idling and to about 2/3 maximum speed. Bad bearings can be determined by shorting out plugs.
   c. Pistons and wrist-pins
      (1) Loose wrist pins - noise doubles when the correct plug is shorted out, most noticeable at idling speed.
      (2) Piston loose in cylinder - "piston-slap" is noted by metallic knocking at low speed under load; but disappears at high speed - also most noticeable when starting cold - test by shorting out plugs.
   d. Broken piston ring or pin - sharp clicking noise that won't short out.
   e. Valves
      (1) Burned valves and seats - engine misses, especially at low speeds, or acceleration under load.
      (2) Weak or broken valve springs - missing at low or high speeds when under load.
      (3) Sticking valves - loss of power and popping sound when bad.
      (4) Tappet noise - excessive clearances cause noise when cold - which diminishes at normal operating temperature.

SECTION X
TORQUE SPECIFICATIONS

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

ATTENTION! The torque specifications listed below, must be followed in order to have the assembled engine conform to the original specifications:

SIZE-DIAMETER	0.313 in	0.38 in	0.44 in	0.50 in	0.56 in	0.63 in
Cylinder heads			70-75 ft lb 95-102 Nm			
Main Bearing Caps		35-40 ft lb 47-54 Nm	70-75 ft lb 95-102 Nm	85-95 ft lb 115-129 Nm	110-120 ft lb 149-163 Nm	140-150 ft lb 190-203 Nm
Connecting Rods	20-25 ft lb 27-34 Nm	40-45 ft lb 54-61 Nm	55-60 ft lb 75-81 Nm	90-100 ft lb 122-135 Nm	110-120 ft lb 149-163 Nm	
Flywheels	20-25 ft lb 27-34 Nm	35-40 ft lb 47-54 Nm	70-75 ft lb 95-102 Nm	85-95 ft lb 115-129 Nm	100-110 ft lb 135-149 Nm	145-155 ft lb 197-210 Nm
Manifolds	15-20 ft lb 20-27 Nm	25-30 ft lb 34-40 Nm	40-50 ft lb 47-68 Nm	50-60 ft lb 68-81 Nm	50-60 ft lb 68-81 Nm	60-70 ft lb 81-95 Nm
Gear Covers, Water Pumps, Front and Rear End Plates	15-20 ft lb 20-27 Nm	25-30 ft lb 34-40 Nm	50-55 ft lb 68-75 Nm	80-90 ft lb 108-122 Nm		
Oil Pans	12-16 ft lb 16-22 Nm	12-16 ft lb 16-22 Nm				
Flywheel Housings	15-20 ft lb 20-27 Nm	25-30 ft lb 34-40 Nm	50-55 ft lb 68-75 Nm	80-90 ft lb 108-122 Nm	115-125 ft lb 156-170 Nm	

CAMSHAFT NUT

Thread Size	0.75 in	0.88 in	1 in	1.13 in	1.25 in	
C.I. Shafts	65-70 ft lb 88-95 Nm	70-80 ft lb 95-108 Nm	95-100 ft lb 129-135 Nm	125-130 ft lb 170-176 Nm	145-150 ft lb 197-203 Nm	
Forged Steel Shafts		*120-125 ft lb 163-170 ft lb	*175-180 ft lb 237-244 Nm			
Elastic Stop Nut w/C.I.		65-70 ft lb 88-95 Nm				

*When Cam Gear Governor is used with a steel camshaft, torque cam nut to 85-90 ft lb (115-122 Nm).

MM108

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POWER SWEEPER

diesel engine

4.108

manual for 4.108 diesel engines

Perkins engines

Perkins Engines Limited

Peterborough England

5/79

Perkins engines inc.

WARRANTY

INDUSTRIAL – AGRICULTURAL

1. DURATION OF WARRANTY

Perkins Engines, Inc. (hereinafter called Perkins) warrants each new engine sold under the trademark "Perkins," and operated in the United States of America or Canada to power industrial or agricultural applications to the first retail purchaser thereof for a period of 12 months or 1,800 hours, whichever event shall first occur, to be free from defects in workmanship and material from the date of delivery to such purchaser.

2. REPLACEMENT OF PARTS UNDER WARRANTY

The responsibility of Perkins is limited to repairing or replacing, at its option, any part or parts of such engines that are returned to Perkins or any authorized Perkins distributor or dealer, with transportation charged prepaid, and which upon examination by Perkins shall disclose to Perkins's satisfaction to have been thus defective.

3. PAYMENT OF REPAIR LABOR COST UNDER WARRANTY

During the first 12 months or 1,800 hours of engine operation, whichever event shall occur first, from the date of delivery to the first purchaser, Perkins or any authorized Perkins distributor or dealer will cover the cost of reasonable labor required to repair any engine or replace any parts found by Perkins to be defective.

4. Perkins's obligation under this Warranty shall not apply to: (a) Starters, Generators, Transmissions, Clutches, Radiators or any other proprietary fittings not manufactured by Perkins. These are warranted by their respective manufacturers, and not by Perkins. (b) Any engine which shall have been subject to negligence, misuse, accident, misapplication or overspeeding. (c) Any engine that has been repaired or altered by anyone in a manner which in Perkin's sole judgment adversely affects its performance or reliability. (d) Any engine which has been fitted with or repaired with parts or components not manufactured or approved by Perkins which in Perkin's sole judgment adversely affects its performance or reliability. (e) Engine tune-ups, normal maintenance services including but not limited to valve adjustment, normal replacement of service items, fuel and lubricating oil filters, lubricating oil, fan belts, antifreeze, etc. (f) Damages caused by prolonged or improper storage of the engine after shipment from a Perkins factory. (g) Loss of operating time to the user while the engine or engine driven equipment is out of operation and damage to equipment powered by the engine.

5. This warranty and the obligation of Perkins Engines, Inc. thereunder is in lieu of all other warranties, express or implied, including without limitations, **the implied warranties of merchantability and fitness for particular purpose**, all other representations to the purchaser and all other obligations or liabilities including liability for incidental and consequential damages on the part of the manufacturer.

SPECIAL NOTE

Perkins engines are marketed throughout the world to many manufacturers of original equipment. In order to meet the special requirements of these, engines may on occasion be covered by specific warranties applicable to the requirements of the driven equipment. In these instances the warranty extended by Perkins to said manufacturer supersedes the above warranty.

HOME OFFICES

U.S.A.
24175 Research Drive
Farmington, Michigan 48024
Phone: 313/477-3900

CANADA
7 Meridian Rd.
Rexdale, Ontario
Phone: 416/677-4960

Perkins reserves the right to make changes or add improvements to its products at any time without incurring any obligation to make such changes to products manufactured previously. Perkins or its distributors accept no responsibility for variations which may be evident in the actual specifications of its products and the statements and descriptions contained in this publication.

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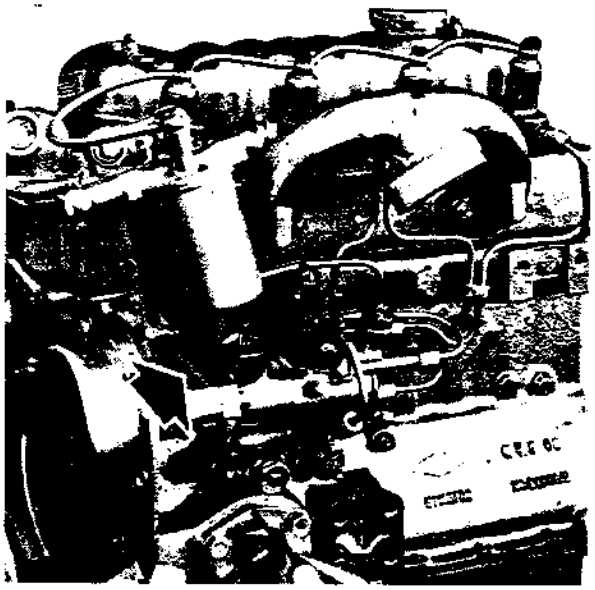
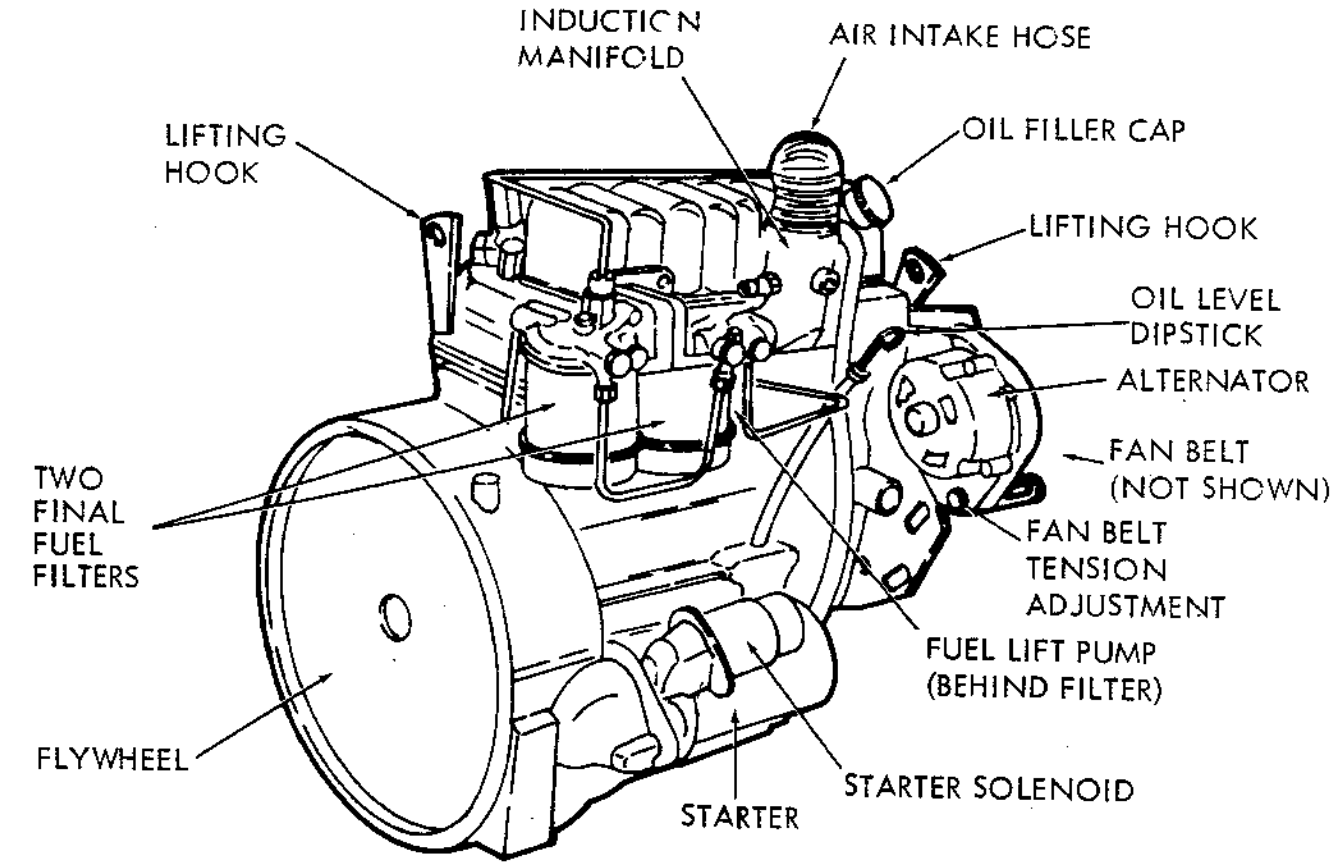
ENGINE IDENTIFICATION



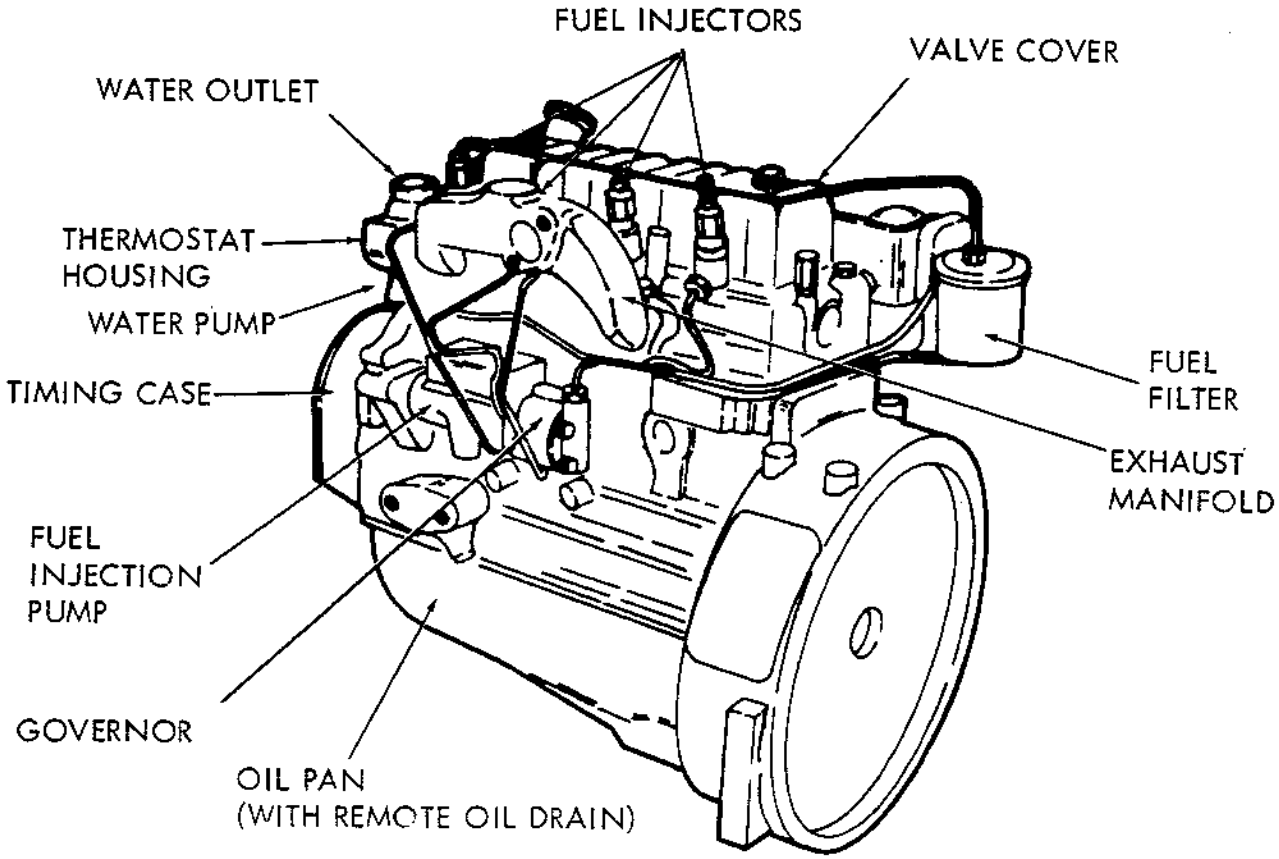
The engine number is stamped on the fuel pump mounting flange as shown in the above illustration. With current engines, the number consists of figures and letters, e.g.,

ENGINE TYPE	TYPICAL ENGINE NUMBER
4.108	108US3317

The first three figures represent the capacity of the engine in cubic inches, the letters "US" signifies that the engine was sold in the United States and the last group of figures comprises the engine serial number.



(ENGINE OIL FILTER REMOTELY MOUNTED ON BRACKET)



FEATURES OF THE 4.108 PERKINS DIESEL ENGINE

Engine Description

The Perkins 4.108 Diesel Engine described in this manual is an indirect injection, four cylinder, four stroke power unit. The 4.108 has a bore of 3.125 in. (79.4 mm) and a stroke of 3.5 in. (88.9 mm).

Throughout this manual, whenever the "left" or "right" hand side of the engine is referred to, it is that side as viewed from the flywheel end of the engine.

CYLINDER BLOCK AND CRANKCASE

The cylinder block is of monoblock construction, cast integrally with the crankcase, it is manufactured from high duty cast iron alloy.

The 4.108 engine is fitted with "dry" type, unshouldered thinwall liners. The liner is centrifugally cast from high duty alloy iron.

CYLINDER HEAD AND VALVES

The cylinder head is specially toughened high duty alloy casting and is secured to the cylinder block by studs and nuts, both are phosphated for increased torque characteristics. The gasket between the cylinder head and block is made from a composite material and is known as a "Klinger" type gasket.

Two overhead valves are fitted to each cylinder push rod operated via the valve mechanism mounted on the head and enclosed by a pressed steel cover. Each intake valve has a synthetic rubber oil deflecting seal, both intake and exhaust valves are retained by two springs located between a hardened steel seat and a hardened spring cap secured by split conical keepers. All valves operate in unshouldered cast iron guides pressed into the head.

COMBUSTION SYSTEM

The Perkins "H" system of combustion is of the precombustion type, being formed completely in the cylinder head, thus giving a flat topped piston with uniform heat distribution.

Intimate mixing of the fuel and air over a wide speed range is ensured, which increases the engine's performance, efficiency and flexibility. The upper part of the combustion chamber is machined in the cylinder head and is hemispherical in shape: the lower part being formed by an insert in the form of an accurately machined plug located in the cylinder head, this contains the throat connecting the combustion chamber to the cylinder. Fuel is introduced into this chamber by means of pintle type injector nozzles.

VALVE MECHANISM

The valves are operated by cast iron, mushroom type tappets, located in guides machined in the cylinder block, through pushrods to forged steel rocker levers with lead bronze lined, steel backed wrapped bushes. Valve clearances are adjusted by means of a hardened ball ended screw and locknut at the pushrod end of the rocker lever.

CRANKSHAFT

The crankshaft is forged from chrome-molybdenum steel with four integral balance weights. The 4.108 crankshaft is treated by "Tufftride" process. The rear of the crankshaft is machined to accommodate the thrust washers which are replaceable, copper lead lined, steel backed, which control the crankshaft end float and are positioned either side of the rear main bearing. An oil thrower and flywheel location flange are also machined at the rear end, while the front end is keyed for a power take off.

MAIN BEARINGS

Three main bearings are provided for the crankshaft and are of the replaceable pre-finished, thin wall, steel backed, aluminium tin lined type. The high duty cast iron bearing caps are dowel located and each is secured by two high tensile steel setscrews locked by tab washers. The injectors are located in an accessible position on the left hand side of the cylinder head. The nozzles are of the pintle type. Provision is made for mounting a fuel filter on either side of the cylinder head. The filter should be of the paper element type and of approved design.

INDUCTION MANIFOLD

The induction manifold is an aluminium die casting. It is fitted on the right hand side of the cylinder head. Provision is made for mounting an air cleaner, the position and type of which can vary according to the particular application.

EXHAUST MANIFOLD

The cast iron exhaust manifold is fitted on the left hand side of the cylinder head. Alternative positions for the outlet flange are available to suit various applications.

ELECTRICAL EQUIPMENT

Twelve volt electrical equipment is fitted to this engine. The generator or alternator is mounted on the right hand side of the engine and is belt driven from the crankshaft pulley. Belt tension is adjusted by means of a slotted link.

The starter motor is flange mounted to the flywheel housing.

CAMSHAFT

The special cast iron alloy camshaft which has chill hardened cams, is mounted in a low position on the right hand side of the cylinder block and supported by three bearings machined directly into the cylinder block. These bearings are pressure lubricated by means of internal drillings and the cams and tappets are splash lubricated.

CONNECTING RODS AND BEARINGS

The connecting rods are molybdenum alloy steel stampings with "H" section shank, the big end parting face is inclined at 45° to the axis of the rod and serrated for cap location. The caps are each secured by two high tensile steel setscrews. The big end bearing bores are fitted with replaceable pre-finished thin wall, aluminium-tin lined, steel backed bearings. The small end bores being fitted with bronze lined steel backed bushings.

TIMING GEAR ARRANGEMENT

The camshaft and fuel injection pump are driven by the crankshaft gear via an idler gear. This helical gear train which makes provision for fuel pump timing adjustments is located on the front face of the cylinder block and enclosed by a pressed steel cover bolted to a steel backplate.

The camshaft and fuel injection pump drive gears are manufactured from spheroidal graphite cast iron, the crankshaft and idler gears being of steel treated by the Sulfinuz or Tuffride process.

PISTONS AND WRIST PINS

The pistons are manufactured from special high silicon aluminium alloy, fitted with three compression rings and one oil control ring above the wrist pin and one oil control ring below. The upper oil control ring comprises four laminated segments. The wrist pins are of the fully floating type, located axially in the piston by circlips. The piston has a steel insert rolled into the top groove.

LUBRICATION SYSTEM

The lubrication of the engine is by full pressure feed from a rotor type oil pump, driven by spiral gears from the camshaft. An oil strainer is fitted on the end of the pump inlet pipe. The pump then delivers the oil via a full flow filter, bolted on the fuel pump side of the cylinder block to the main oil gallery. This gallery is drilled lengthwise through the crankcase, drillings from the main oil gallery to the main bearings and drillings in the main crankshaft journals to the crankpin journals provide the lubrication for the crankshaft. Oil feeds are also taken to the idler gear spigot which maintains an intermittent feed by drillings in the spigot and idler gear to lubricate the timing gear arrangement, and to the center camshaft bearing where due to special machining on the center camshaft journal an adequate reduced pressure feed is maintained at the rocker assembly. The oil pump incorporates a pressure relief valve which limits the maximum oil pressure while the oil filter incorporates a by-pass valve that prevents the engine being starved of oil should the filter element become blocked.

CRANKCASE VENTILATION

A large diameter open type breather pipe is fitted to the cylinder head cover. Air movement assists in drawing fumes from the crankcase, the top end of the pipe is directed downwards to return any oil mist to the sump.

COOLING SYSTEM

A centrifugal type circulating water pump is fitted to the front face of the cylinder block, to assist the water circulation through the cylinder block and head. The water outlet is via a thermostat housing which is cast integral with the cylinder head, the thermostat restricts the flow of water when the engine is cold and brings about a faster warm up. When the water temperature reaches a pre-determined point the thermostat opens and allows normal coolant circulation. The water pump is belt driven from the crankshaft pulley.

FUEL INJECTION EQUIPMENT

A distributor type fuel injection pump is flange mounted on to a drive housing cast on the left hand side of the cylinder block. It is mounted horizontally at the front of the engine and gear driven via a splined drive shaft. The pump incorporates a mechanical governor and an automatic advance and retard mechanism to provide optimum performance at all speeds.

The fuel lift pump is of the diaphragm type mechanically operated by an eccentric on the engine camshaft, via a small pushrod. It is located on the tappet inspection cover on the right hand side of the engine and is equipped for hand priming.

Technical data

Bore	3.125 in (79.375 mm)*
Stroke	3.5 in (88.90 mm)
No. of Cylinders	Four
Cubic Capacity	107.4 in^3 (1.760 liters)
Compression Ratio	22:1
Firing Order	1, 3, 4, 2,
Cycle	Four-Stroke
Combustion System	Indirect Injection

RATING DETAILS

Maximum Rated Output	55 b h p at 4000 RPM
Maximum Torque Output	83 lb ft. (11.5 at 2200 RPM)

ENGINE WEIGHTS

Approx. dry weight, bare engine, i.e. complete with fuel injection equipment, pressed steel oil sump, alternator, water pump, but not including starter motor, air cleaner, fan flywheel or flywheel housing: 330 lb (150 kg)

Typical dry weight, engine with all accessories	450 lb (204 kg)

RECOMMENDED TORQUE TENSIONS

The following torque figures will apply with the components lightly oiled before assembly:

Cylinder Head Nuts	60 lbf ft (8.3 kgf m)
Connecting Rod Setscrews	42 lbf ft (5.81 kgf m)
*Main Bearing Setscrews	85 lbf ft (11.5 kgf m)
Flywheel Setscrews	60 lbf ft (8.3 kgf m)
Idler Gear Hub Setscrews	32 lbf ft (4.4 kgf m)
Crankshaft Pulley Setscrews	150 lbf ft (20.5 kgf m)
Injector Securing Nuts	12 lbf ft (1.7 kgf m)
Alternator Pulley Retaining Nut	20 lbf ft (2.8 kgf m)

*The tab and shim washers may be discarded (used on earlier engines only), but the setscrews must be tightened to the indicated torque.

SERVICE WEAR LIMITS

The following "wear limits" indicate the condition when it is recommended that the items should be serviced or replaced.

Cylinder Head Bow	Longitudinal	0.006 in (0.15mm)
Cylinder Head Bow	Transverse	0.003 in (0.08 mm) concave
		0.005 in (0.13mm) convex
Maximum Bore Wear (when new liners are necessary)		0.006 in (0.15mm)
Crankshaft Main and Big End Journal	Wear	0.001 in (0.03mm)
Crankshaft Main and Big End Journal	Ovality	0.0005 in (0.01mm)
Maximum Crankshaft End Float		0.020 in (0.51mm)
Valve Stem to Guide Clearance	Intake	0.005 in (0.13mm)

on next page)

SERVICE WEAR LIMITS (continued)

Valve Stem to Guide Clearance ...	exhaust	0.006 in. (0.15mm)
Valve Head Thickness at outer edge	...	0.025 in. (0.64mm)
Rocker Clearance on Shaft ...	...	0.005 in. (0.13mm)
Camshaft Journals - Ovality and Wear	...	0.002 in. (0.05mm)
Camshaft End Float ...	...	0.020 in. (0.51mm)
Idler Gear End Float ...	...	0.010 in. (0.25mm)
Valve Head Depth below Head Face	intake and exhaust	0.048 in. (1.220mm)

LUBRICATING SYSTEM

Lubricating Oil Pressure	30/60 lbf/ in^2 (2.1/4.2 kgf/cm^2) at Max. engine speed and normal operating temperature.

SUMP (OIL PAN)

Dipstick Position	Camshaft side of engine opposite No. 2 cylinder
Strainer Location	End of suction pipe to lubricating oil pump.

LUBRICATING OIL FILTER

Type...	Full Flow Spin-on
By-Pass Valve Setting	Opens between 13-17 lbf/in^2 (0.91-1.2 kgf/cm^2) pressure differential
Type of Valve	Spring Loaded

COOLING SYSTEM

Type...	Water Cooled
Cylinder Block and Head...	Thermo-Syhpon Impeller Assisted
Engine Water Capacity (Less Radiator) ...	6 Imp. pt (7.2 U.S. pt or 3.4 Litre)

APPROVED FUEL OIL SPECIFICATION

United Kingdom	BS.2869:1967	Class A.1 or A.2
United States	VV-F-800a	Grades DF-1, DF-2 or DF-A*
	A.S.T.M./D975-66T	Nos. 1-D or 2-D
France	(J.O. 14/9/57)	Gas Oil or Fuel Domestique
India	IS: 1460/1968	Grade Special or Grade A
Germany	DIN-51601 (1967)	---
Italy	CUNA-Gas Oil NC-630-01 (1957)	---
Sweden	SIS.15 54 32 (1969)	---
Switzerland	Federal Military Spec. 9140-335-1404 (1965)	---

Fuel oils available in territories other than those listed above that are refined to an equivalent specification may be used.

*This is a light fuel for use in extremely low ambient temperatures and, preferably should not be used during normal conditions.

FUEL LIFT PUMP

Type	AC Delco Diaphragm 'YJ' Series
Spring Color Code	Green
Method of Drive	From Eccentric on Camshaft via Push Rod
Total Stroke of Operating Lever	0.192 in (4.877mm)
Static Pressure – No Delivery	4-7 lbf/in^2 (0.28-0.49 kgf/cm^2)
Pump to Distance Piece Gasket Thickness ...	0.018/0.022 in. (0.457/0.559mm)
Distance Piece – Lift Pump to Tappet Inspection Cover	0.256 in (6.502 mm)

FINAL FUEL FILTER

Element Type	Paper

FUEL INJECTION PUMP

Make	C.A.V.
Type	D.P.A.
Rotation	Clockwise (viewed from drive end)
Plunger Dia.	6 mm

MECHANICALLY GOVERNED

Timing Letter	C
No. 1 Cylinder Outlet	W

STATIC TIMING POSITION

The static timing position varies according to application, but can be obtained be referring to the first group of letters and digits of the fuel pump setting code (stamped on the fuel pump identification plate), i.e.,

First Group of Fuel Pump Code		Static Timing B.T.D.C.	Piston Displacement B.T.D.C.
EH39 MH26 MH27 PH28 PH30	For 4.108 Engine	18°	0.108 in. (2.75mm)

INJECTORS

Make	C.A.V.
Holder Type	BKB40SD5224
Nozzle Type	BDN12SD6236
Code Letter	BG
Min. Working Pressure	135 atm (2000 psi, 140 kgf/cm^2
Setting Pressure	150 atm (2200 psi, 155 kgf/cm^2

MAINTENANCE

YOU MUST ENSURE THAT THE MAINTENANCE JOBS ARE DONE AFTER THE CORRECT PERIOD HAS ELAPSED OR EVEN EARLIER IF CONSIDERED ADVANTAGEOUS OR NECESSARY.

PREVENTIVE MAINTENANCE

DAILY

Check coolant level.
Check lubricating oil level.
Check oil pressure.
In extreme dust conditions, clean air cleaner or empty dust bowl on dry-type air cleaner.

RUNNING ADJUSTMENT

The driver or user of this engine should not interfere with the idling or maximum speed settings. While the engine unit is under the manufacturer's guarantee, the breaking or interference of the fuel pump seals by an unauthorised person may render the warranty null and void, because interference with the speeds set by the manufacturer can cause considerable damage to the engine.

AFTER FIRST 50 HOURS OF SERVICE:

1. Drain the lubricating oil pan and refill to the correct level with clean new oil. Do not overfill. Use correct temperature grade and specification. Renew Lubricating oil filters.

2. Remove the rocker assembly; tighten the cylinder head nuts in the correct sequence (see fig. C-1) and to the correct torque of 55/60 lbf ft (7.6/8.3 kgf m).

3. Reset the valve tip clearance to 0.012 in (0.3 mm) with the engine cold.

4. Check the tension of the fan belt.

5. Check the tightness of all external nuts, setscrews, mountings, etc.

6. Start the engine and check for any fuel, coolant or lubricating oil leaks. Check oil feed to rockers.

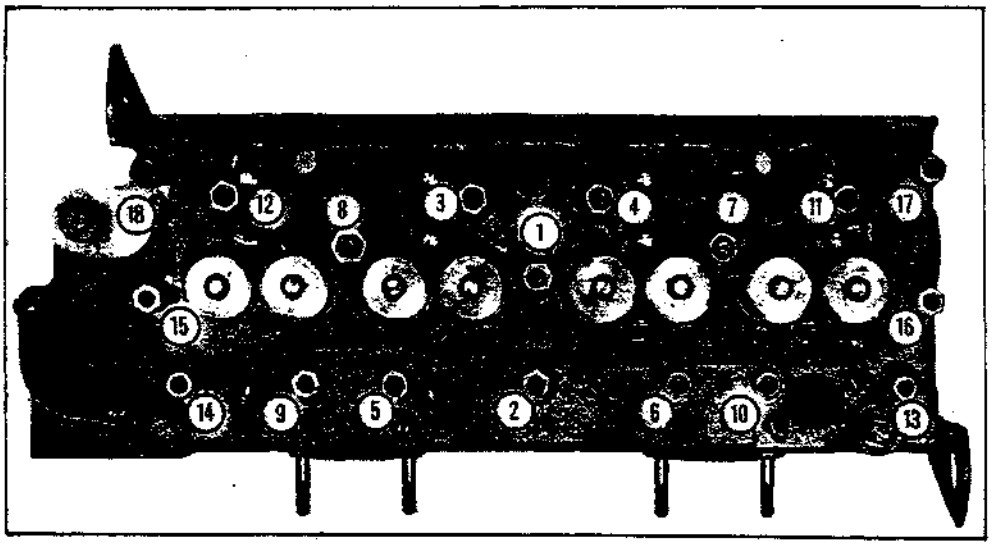


Fig. C-1 – Torque Tightening Sequence for Cylinder Head Nuts

EVERY 150 HOURS

Drain and renew engine lubricating oil.

Renew lubricating oil filters.

Clean air cleaner or empty dust bowl on dry-type cleaner.

Check drive belt tension.

Check for oil, water or fuel leaks.

Clean fuel water trap.

EVERY 400 HOURS

Renew fuel filter element.

Check hoses and clamps.

Clean element of dry type air cleaner or renew.

EVERY 800 HOURS

Renew final fuel filter elements.

EVERY 2,400 HOURS

Arrange for examination and service of accessory equipment, such as starter motor or alternator.

Service injectors.

Check and adjust valve clearance.

general advice to the user

As you may know, a diesel engine does not rely upon an electric spark for ignition, so providing it has an adequate supply of clean air, its proper measure of clean fuel, an adequate supply of approved lubricating oil properly circulated and filtered, that each cylinder has proper compression and the engine cooling water temperature is maintained at its designed level, then the engine should give you a satisfactory service, but only if you maintain it in the proper manner as indicated in this handbook.

Never use petrol (gasoline) for cleaning any parts of the fuel system, such as filter bowls.

FUEL

In order that the fuel oil is always clean and free from any water or foreign matter which can damage the finely built fuel injection pump, the fuel filters must be regularly maintained in accordance with our instructions.

The fuel oil should conform to a particular specification according to the country you are operating in.

Never leave fuel oil stored in a container exposed to atmosphere as water and dust will be absorbed by the fuel.

Never store fuel oil in a galvanised container as a chemical reaction will take place between the fuel and the galvanised coating, considerably contaminating the fuel.

AIR

Air in sufficient quantity must be allowed to reach the compression chambers to mix with the finely atomised fuel in order that ignition can take place.
If there is not sufficient air reaching the cylinders for compression, then the result could be;

(a) black exhaust smoke
(b) erratic running
(c) loss of power
(d) bad starting

Air entering the engine must always be adequately filtered, otherwise dust and dirt can enter the internals of the engine and cause accelerated wear conditions on the piston rings, bores, bearing surfaces and journals, thereby shortening the effective working life of the engine.

Adequate air cleaners are provided, the type will depend upon the application.

The satisfactory running of the engine will depend, among other things, upon the regular maintenance of the air cleaner.

LUBRICATING OILS

Do not have clean engine oil stored in open containers, as condensation and dust will contaminate the oil

LUBRICATING OILS (continued)

The lubricating oil in the engine is filtered by a coarse filter in the sump and then by a replaceable cartridge-type element filter contained in an assembly attached to the engine. Newer engines incorporate a spin-on type filter.

It is important to use only those lubricating oils which come within the requirements of the U.S. Ordnance Specification MIL-L-46152, and API Service Classification "cc" and on page 14 will be found a list of oils which are within this requirement. Because it is not possible to list all suitable oils, care should be taken to ensure that oils not listed meet the above requirement, and have a minimum Viscosity Index of 80.

FUEL, WATER AND OIL LEAKS

It is good practice to regularly wipe the engine over with a non-fluffy rag or have it properly steam cleaned at the time the machine is cleaned. With the engine running hot check all pipe unions, joints, etc. for leaks and remedy where necessary.

The fuel system from the tank to the lift pump is known as the suction side, from the lift pump to the fuel injection pump is the low pressure side, and from the fuel injection pump to the atomisers or injectors is the high pressure side.

Fuel leaks from the low or high pressure pipes or unions can be detected with the engine running, but leaks on the suction side are not so easily detected as they allow air to enter the point of leakage, which can cause misfiring. The suction side leaks can sometimes be seen as a weep when the engine is not running or in bad cases the drain of fuel can be detected from the evidence under the engine after overnight parking.

Watch for pipes chafing and wearing away where the fretting is taking place.

A bad leak on the suction side can cause involuntary stopping of the engine but always beware of a low level of fuel in the tank, which, of course, causes the engine to stop, but will allow air to enter the fuel system until it reaches the injectors, as would happen with a bad leak on the suction side. Such a situation means that the system must be bled as described later.

LUBRICATING OILS

Lubricating oils for normally aspirated engines should meet the requirements of the U.S. Ordnance Specification MIL-L-46152 and below we list some of these oils. Any other oils which also conform to this specification, are of course, also suitable.

Lubricating oils for use in Perkins Diesel Engines should have a minimum viscosity index of 80.

Company	Brand	S.A.E. Designation		
		0°F (-18°C) to 45°F (7°C)	45°F (7°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	B.P. Vanellus	10-W	20W/20	30
	B.P. Vanellus	10W/30	10W/30	10W/30
	B.P. Vanellus S3	10W	20W/20	30
Castrol Ltd.	Castrol/Deusol CRB	10W	20W/20	30
	Castrol/Deusol CRD	10W	20W/20	30
A. Duckham & Co. Ltd.	Fleetol 3	3/10	3/20	3/30
Esso Petroleum Co. Ltd.	Essolube D3. HP	10W	20W	30
Mobil Oil Co. Ltd.	Delvac 1200 Series	1210	1220	1230
Shell	Shell Rotella T	10W	20/20W	30
	Shell Rimula CT	10W	20/20W	30

The above specifications are subject to alteration without notice.

SAE Letter Designation	API Brief Identification and Engine Service Description	ASTM Engine Oil Description
CC	*Moderate Duty Diesel & Gasoline Engine Service* Service typical of lightly supercharged diesel engines operated in moderate to severe duty and has included certain heavy-duty, gasoline engines. Oils designed for this service were introduced in 1961 and used in many trucks and in industrial and construction equipment and farm tractors. These oils provide protection from high temperature deposits in lightly supercharged diesels and also from rust, corrosion and low temperature deposits in gasoline engines.	Oil meeting requirements of MIL-L-46152 Provides low temperature anti-sludge, anti-rust and lightly supercharged diesel engine performance.

approved fuel oil specifications

United Kingdom	B.S2869:1967	Class A.1 or A.2
United States	VV-F-800a A.S.T.M./D975-66T	Grades DF-1, DF-2 or DF-A* Nos. 1-D or 2-D
France	(J.O. 14/9/57)	Gas Oil or Fuel Domestique
India	IS: 1460/1968	Grade Special or Grade A
Germany	DIN-51601 (1967)	--
Italy	CUNA-Gas Oil NC-630-01 (1957)	--
Sweden	SIS. 15 54 32 (1969)	--
Switzerland	Federal Military Spec. 9140-335-1404	--

*This is a light fuel for use in extremely low ambient temperature and, preferably, should not be used during normal conditions.

Grade No. 2-D is the class of distillate gas oils of *lower volatility*. These fuels are for use in high-speed engines in services involving relatively high loads and uniform speeds, or in engines not requiring fuels having the higher volatility or other properties specified for Grade No. 1-D.

The limiting requirements by ASTM for these grades of diesel fuels are shown in the chart.

ASTM LIMITING REQUIREMENTS FOR DIESEL FUELS

Diesel Fuel ***	Flash Point, °F.	Pour Point, °F.	Water and Sediment, % vol.	Carbon Residue on 10% Residuum, %	Ash, % wt.	90% Distillation Temperature, °F.		Kinematic Viscosity at 100°F, Centistokes		Sulfur % wt.	Copper Strip Corrosion	Cetane Number
	Min.	Max.	Max.	Max.	Max.	Min.	Max.	Min.	Max.	Max.	Max.	Min.
No. 1-D	100 or legal	*	Trace	0.15	0.01	—	550	1.4	2.5	0.50	No. 3	40
No. 2-D	125 or legal	*	0.05	0.35	0.01	540**	640	2.0**	4.3	0.50	No. 3	40

*For cold weather operation, the pour point should be specified 10°F. below the ambient temperature at which the engine is to be operated except where fuel oil heating facilities are provided.

**When pour point less than 0°F. is specified, the mininimum viscosity shall be 1.8 cs and the minimum 90% point shall be waived.

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BLEEDING THE FUEL SYSTEM

Air in the fuel system can cause difficult starting, erratic running and loss of power.
Air can enter the fuel system, as the result of running out of fuel, leaks in the system, changing filters or pipes or any distrubance of any fuel connection.

Bleed the system as follows;

1. Unscrew by two or three turns, the fuel pipe on top of the fuel filter cover (not the return pipe to the tank).

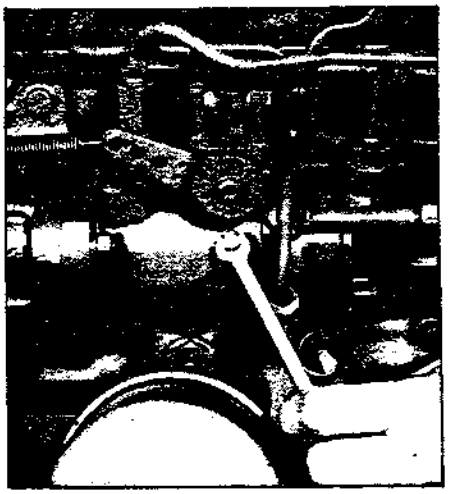


Fig. C-4
Slackening Vent Screw on Hydraulic Head
Locking Screw on Fuel Injection Pump

2. Slacken the vent screw on the hydraulic head locking screw on the side of the fuel injection pump body (see Fig. C-4).

3. Slacken the air vent screw near the side of the governor housing on the fuel injection pump (see Fig. C-5).

4. Operate the priming lever of the fuel lift pump (see Fig. C-7).

It may not be possible to operate the priming lever if the driving cam is in the maximum lift position. To rectify this condition, turn the engine one complete revolution until fuel, free from air bubbles, issues from each vent point.

Tighten the connections in the following order:

1. Filter cover fuel pipe.

2. Head locking screw on fuel injection pump.

3. Governor vent screw on fuel injection pump.

Slacken the pipe union nut at the fuel injection pump inlet (see Fig. C-8), operate the priming lever on the lift pump and re-tighten when the fuel, free from air bubbles, issues from around the threads.

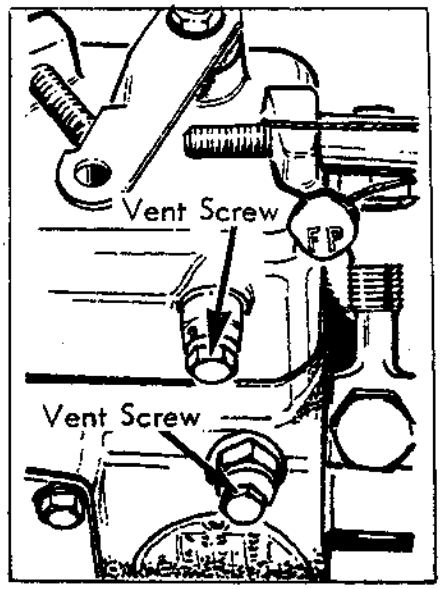


Fig. C-5
Vent Screw on Governor Housing

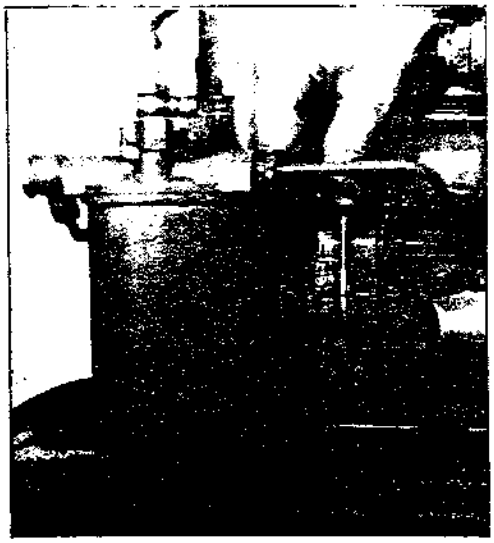


Fig. C-7
Operating the Hand Primer
on the Fuel Lift Pump

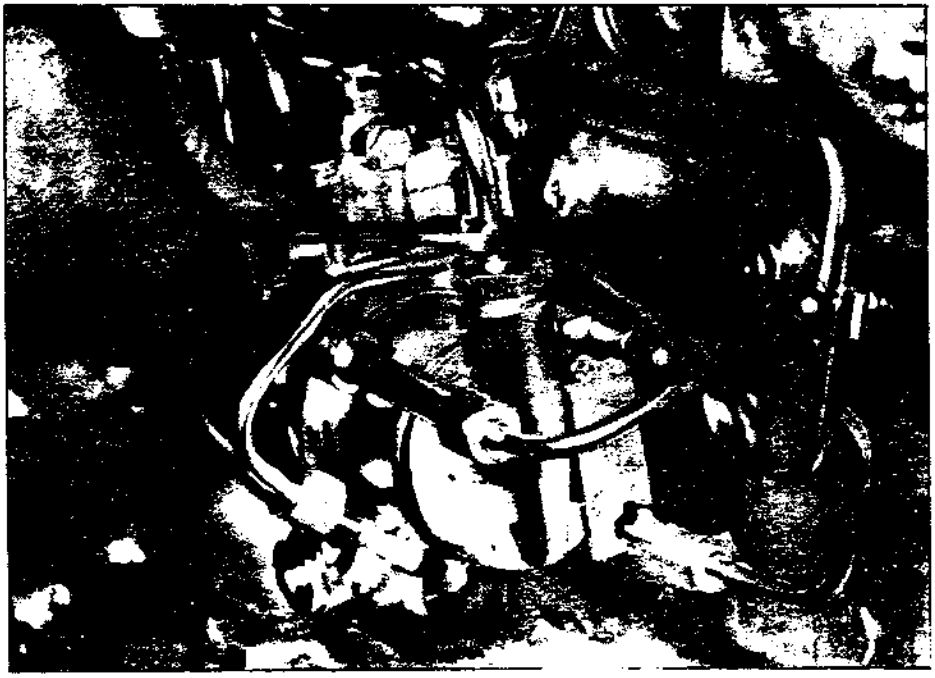


Fig. C-8
Slackening Pipe Union Nut at Fuel Injection Pump Inlet

It must be realized that this whole operation must be carried out completely and no action to tighten connections must be made until all signs of air bubbles have disappeared. Unless care is taken with this operation, and this could take some four or five minutes of hand priming, failure to start will result.

Slacken the unions at the injector ends of the high pressure fuel pipes.

Set the accelerator in the fully open position and ensure that the stop control is in the "run" position.

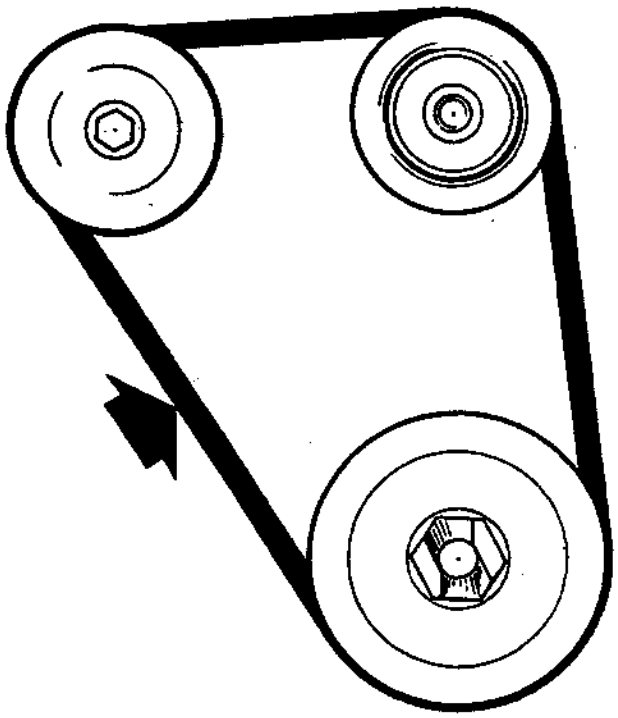
Rotate the engine with the starter motor until fuel oil, free from air bubbles, issues from all fuel pipes. Some 30 to 60 seconds of rotation may be necessary before this condition is reached, and the time will be dependent upon the speed of rotation and the effectiveness of the bleeding operation described above. A fully charged battery in a temperate or warm climate will rotate the engine at upwards of 280 rev/min, and under these conditions, the remaining air should be expelled in under 30 seconds. Cold conditions or partially discharged batteries may take longer.

Tighten the unions on the fuel pipes and the engine is ready for starting.

If, after bleeding the fuel system, the engine starts and runs satisfactorily, but after a few minutes stops, then it can be assumed that air is trapped in the fuel injection pump and the bleeding procedure should be repeated, at the same time checking for air leaks on the suction side, such as loose or faulty connections.

TO ADJUST FAN BELT TENSION

The tension of the belt should be such that it is not loose to a degree that it can slip at the crankshaft pulley, thus preventing the full operation of the water pump and also not turning the generator or alternator at sufficient speeds to charge the battery. If the belt is overtightened this can cause overloading of the bearings fitted in the water pump and alternator or generator. The belt itself can be damaged internally creating an early failure condition.
When fitting a belt never pry it onto a pulley by using a lever, always close in the adjustment on the generator or alternator and "place" the belt in position. At least "wind" the belt over the pulley by turning belt and pulley together by hand.
There is an engineering method of tensioning belts by using spring balances and correct dimensioning but the practical way as installed, is to decide which is the longest



Checking Fan Belt Tension

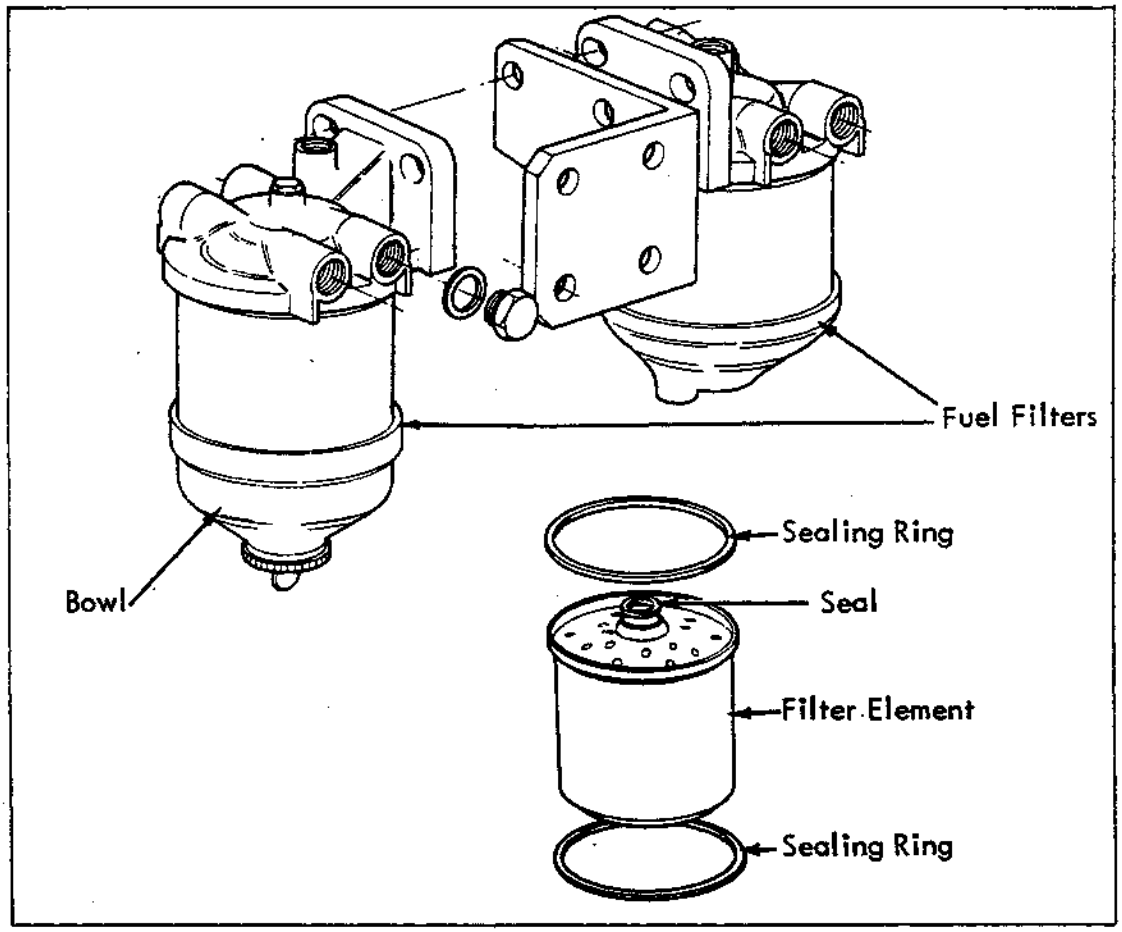
run of belt between any two pulleys and apply pressure in the center of the run and adjust the tension until the belt deflects about 3/8" (10mm) as shown above.
When making adjustments loosen all the setscrews and/or nuts securing the generator or alternator to its brackets as well as both ends of the adjustable linkage. On obtaining the correct tension, retighten all the securing points.
When a new belt is fitted, it is necessary to recheck the adjustment after a short running period when the belt will have settled into the grooves of the pulleys and the initial stretch, if any, will have been completed.

SERVICING FUEL FILTER

(a) Thoroughly clean the exterior of the fuel filter assembly.

(b) Unscrew the filter bolt in the center of the head

(c) Lower the filter bowl and element clear (see drawing) and discard the fuel together with the old element.



(d) Thoroughly clean the filter bowl in cleaning fluid. (Do not use gasoline).

(e) Place the new element and sealing rings in position, fill with fresh clean fuel and offer up the bowl firmly and squarely so that the top rim of the filter element locates centrally against the sealing ring in the filter head.

(f) Hold in this position while the securing bolt is located and screwed home. If the bowl is located correctly, no excessive tightening will be required to obtain a leak proof seal.
After the fuel filter has been reassembled, it is necessary to remove air from the fuel system. Unscrew by two or three turns the vent plug on top of the filter head. Operate the priming lever on the fuel lift pump and when fuel, free from air bubbles, issues from the vent point, tighten the vent plug. Slacken the pipe union at the fuel pump inlet, operate the priming lever. Retighten the nut when fuel, free from air bubbles, issues from around the threads. The engine is then ready for starting.

TO CHECK VALVE TIP CLEARANCES

This is set between the top of the valve stem and rocker arm (see Fig. C-12) and should be 0.012 in (0.3mm) with the engine cold.

When setting valve clearances the following procedure should be adopted:

(a) With the valves rocking on No. 4 cylinder (i.e., the period between the opening of the intake valve and the closing of the exhaust valve), set the valve clearances on No. 1 cylinder.

(b) With the valves rocking on No. 2 cylinder, set the valve clearances on No. 3 cylinder.

(c) With the valves rocking on No. 1 cylinder, set the valve clearances on No.4 cylinder.

(d) With the valves rocking on No. 3 cylinder, set the valve clearances on No. 2 cylinder.

With the engine running at fast idle, check that the oil flow to the rocker assembly is satisfactory.

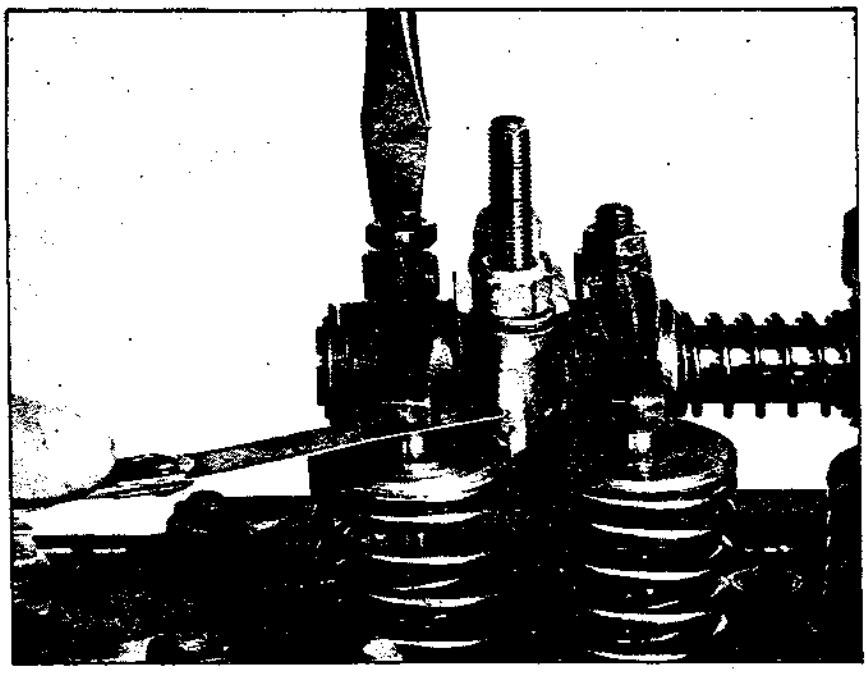


Fig. C-12
Setting Valve Clearance

FAULTY INJECTOR

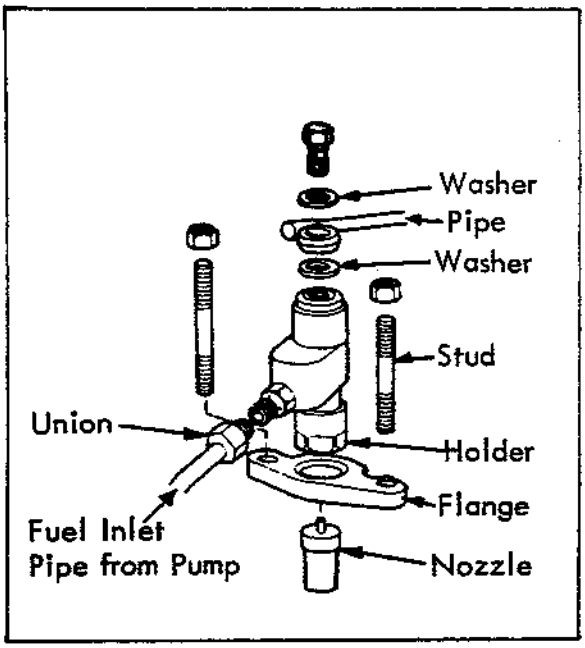
A faulty injector may show itself as an intermittent or consistent misfire and can be detected by running the engine at a fast idling speed and loosen each injector pipe union in turn, taking particular notice of the running condition of the engine. The faulty injector will have little or no effect upon the engine running condition as the union becomes loose. Replace with a known good injector, not forgetting to replace the washer upon which the injector seats in the cylinder head.

REPLACING AN INJECTOR

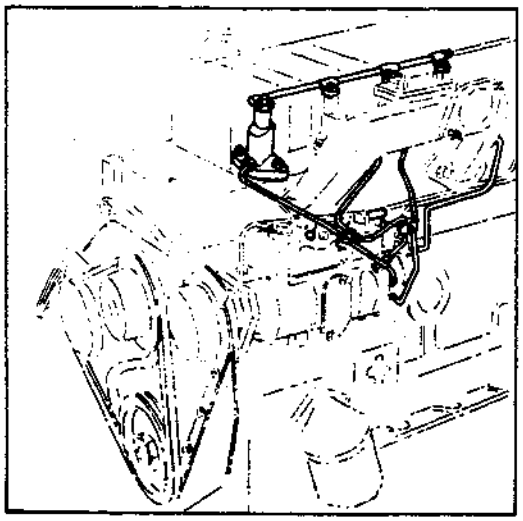
Never bend the high pressure pipe between the injector and the fuel injection pump. Remove the pipe completely. Fit the replacement injector as square as possible into the head by pulling down with the securing nuts a little at a time, each side in turn. Having fitted the injector and pipe, run the engine and listen for any "blowing" from the injector seat, which will indicate that it is not square with the cylinder head. Carefully ease off the injector securing nuts in turn and re-tighten until the blowing stops. Check for fuel leaks at the pipe unions.

WARNING

DO NOT START THE ENGINE WITH LOOSE INJECTOR SECURING NUTS BECAUSE THIS MAY RESULT IN THE INJECTOR FLYING OUT.



FUEL INJECTOR



FUEL INJECTORS (ATOMIZERS) & PIPES

TROUBLE SHOOTING

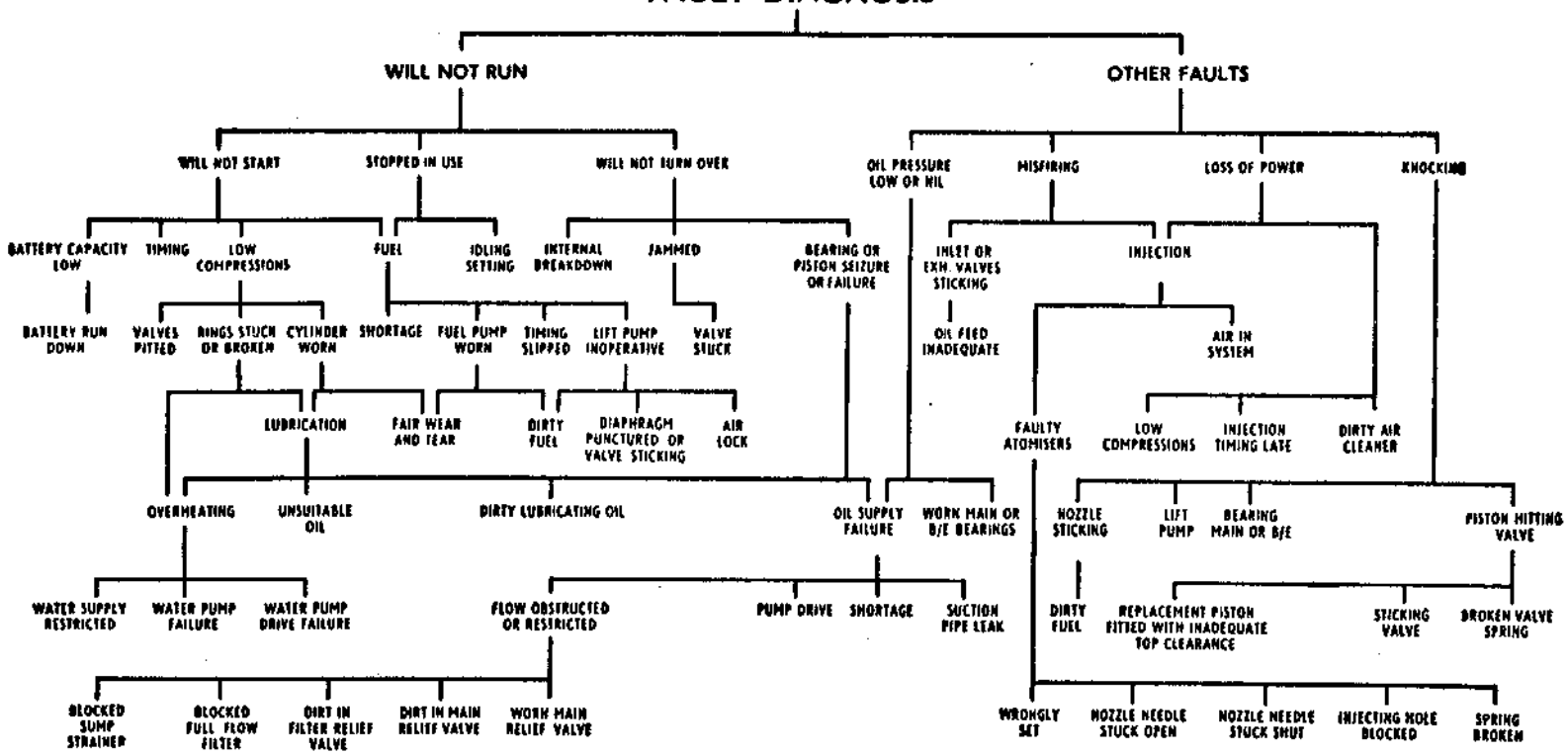
Fault	Possible Cause
Low cranking speed	1, 2, 3, 4.
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33.
Difficult starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33.
Lack of power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56.
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58.
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59.
Erratic running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59.
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49.
High oil pressure	4, 38, 41.
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

Key to Fault Finding Chart

1. Battery capacity low.
2. Bad electrical connections.
3. Faulty starter motor.
4. Incorrect grade of lubricating oil.
5. Low cranking speed.
6. Fuel tank empty.
7. Faulty stop control operation.
8. Blocked fuel feed pipe.
9. Faulty fuel lift pump.
10. Choked fuel filter.
11. Restriction in air cleaner.
12. Air in fuel system.
13. Faulty fuel injection pump.
14. Faulty atomisers or incorrect type.
15. Incorrect use of cold start equipment.
16. Faulty cold starting equipment.
17. Broken fuel injection pump drive.
18. Incorrect fuel pump timing.
19. Incorrect valve timing.
20. Poor compression.
21. Blocked fuel tank vent.
22. Incorrect type or grade of fuel.
23. Sticking throttle or restricted movement.
24. Exhaust pipe restriction.
25. Cylinder head gasket leaking.
26. Overheating.
27. Cold running.
28. Incorrect tappet adjustment.
29. Sticking valves.
30. Incorrect high pressure pipes.
31. Worn cylinder bores.
32. Pitted valves and seats.
33. Broken, worn or sticking piston ring/s.
34. Worn valve stems and guides.
35. Overfull air cleaner or use of incorrect grade of oil.
36. Worn or damaged bearings.
37. Insufficient oil in sump.
38. Inaccurate gauge.
39. Oil pump worn.
40. Pressure relief valve sticking open.
41. Pressure relief valve sticking closed.
42. Broken relief valve spring.
43. Faulty suction pipe.
44. Choked oil filter.
45. Piston seizure/pick up.
46. Incorrect piston height.
47. Damaged fan.
48. Faulty engine mounting (Housing).
49. Incorrect aligned flywheel housing, or flywheel.
50. Faulty thermostat.
51. Restriction in water jacket.
52. Loose fan belt.
53. Choked radiator.
54. Faulty water pump.
55. Choked breather pipe.
56. Damaged valve stem oil deflectors (if fitted).
57. Coolant level too low.
58. Blocked sump strainer.
59. Broken valve spring.

TROUBLE SHOOTING GUIDE AND ANALYSIS OF COMPLAINTS ON PERKINS DIESEL ENGINES

FAULT DIAGNOSIS



Note: – All items listed under loss of power can affect starting of engines.

[redacted]

SMOKE DIAGNOSIS CHART

COLOR: BLACK OR DARK GREY

SYMPTOM	PROBABLE DIAGNOSIS	CURE
Smoke at full load at any engine speed, but particularly at highest and lowest speeds, and power at least normal.	Maximum fuel setting of injection pump too high.	Remove pump, have reset to engine maker's maximum flow figure (or less) by authorized service agent if own equipment not available.
	Excess fuel device not tripping automatically to normal after starting.	Have repaired by authorized agent - removal of pump may be necessary.
Smoke at full load particularly at high and medium speeds, engine quieter than normal.	Pump timing retarded (or advance device not correct if fitted).	Correct timing according to engine maker's instructions, taking up pump drive backlash (or rectify advance device if fitted).
Smoke at full load particularly at low and medium speeds, engine noisier than normal.	Pump timing too advanced.	
Smoke at full load particularly at high and medium speeds, probably with loss of power.	Injector nozzle holes (or some of them) wholly or partially blocked.	Replace injectors by reconditioned set or clean and recondition with proper equipment.
Smoke at full load at higher speeds only.	Air cleaner restricted due to blockage with dirt, or damage.	Clean or replace air cleaner element according to type.
Intermittent or puffy exhaust smoke, sometimes with white or blue tinge, usually coupled with knocking.	Injector nozzle valve stuck open intermittently.	Have injectors examined for sticking valve, broken spring or grossly low opening pressure, or sign of cross-binding in cylinder head. Replace as necessary.
Smoke at full loads at high speed, engine running faster than normal when on governor.	Governor speed setting considerably above engine maker's maximum.	With mechanical or hydraulic governors, reduce governor speed adjustment and seal stops, or better remove pump for attention.
Smoke at most speeds and loads, tending to blue or white when cold and when starting.	Nozzle sprays impinging on cylinder head, due to incorrect fitting of injector into cylinder head.	Examine for number of washers between injector and cylinder head - only one required at most (some engines none required - ref. instruction book).
Smoke at higher loads and speeds, not necessarily at maximum.	Injector nozzle valve lift excessive, due to repeated valve or seat refacing, without lift correction.	Can be rectified by proper equipment during reconditioning.
Smoke at all speeds at high loads, mostly low and medium speeds and probably coupled with poor starting.	Loss of cylinder compression due to stuck rings, bore wear, valve wear or burning, sticking valves, incorrect valve setting.	Engine requires top overhaul at least: re-ringing, or sleeving, piston renewal if wear indicates.
Smoke at full load, either at lower or higher speeds only, but in some cases at all speeds.	Incorrect nozzle type fitted, or mixed types, or out of date type, or type for different duty.	Will be automatically corrected if injectors are reconditioned by an authorized agent, but it is essential to quote exact details of engine type and application.
Smoke at full load, mostly at medium and high speeds, probably coupled with low power.	Injection high pressure pipes of incorrect length or bore, or having badly closed in bore at ends, or due to sharp bends.	Fit only the engine makers' listed pipe. Check ends for closing in.

COLOR : { BLUE OR BLUISH GREY OR GREYISH WHITE

SYMPTOM	PROBABLE DIAGNOSIS	CURE
Blue or whitish smoke particularly when cold, and at high speeds and light load, but reducing or changing to black when hot and at full load, and with loss of power at least at high speeds.	Pump timing retarded (or advance device not correct if fitted).	Reset timing (or rectify advance device if fitted).
Blue or whitish smoke when cold, particularly at light loads, but persisting when hot; probably with knocking.	Injector nozzle valve stuck open, or tip broken off nozzle.	Examine for sticking valve or broken spring, but suspect handling of injectors out of engine if tip is found broken.
Blue smoke at all speeds and loads, hot or cold.	Engine oil being passed by piston rings due to sticking rings or worn bores.	Engine recondition indicated.
Blue smoke particularly when accelerating from period of idling, tending to clear with running.	Engine oil being passed by inlet valve guides due to wear, or valve guide oil shields misplaced.	Recondition cylinder head, and make certain that guide oil shields (if any) are in place.
Light blue smoke at high speed light loads, or running downhill, usually with acrid odor.	Engine running too cold, thermostat stuck or not fitted.	Replace thermostat.

[redacted]

Engine Overhaul

Cylinder Head

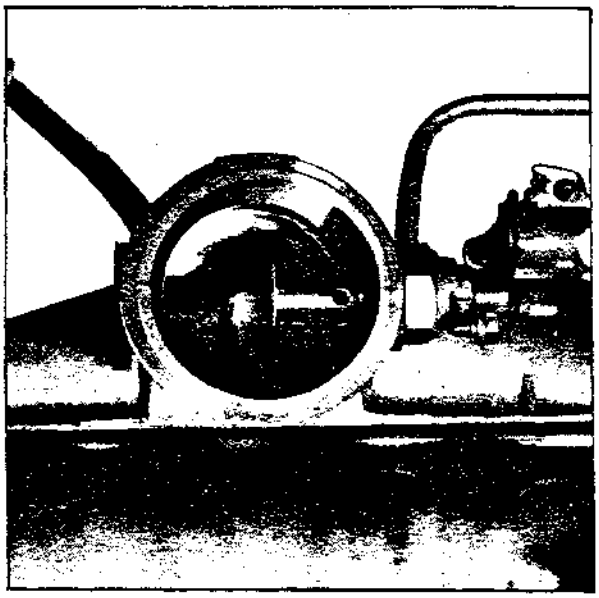


Fig. E1-Disconnect starting aid (if used).

Before commencing to overhaul the cylinder head ensure that all joints, gaskets and any other parts expected to be required are available.
Remove any external components from the vicinity of the cylinder head cover, atomisers and fuel pump.

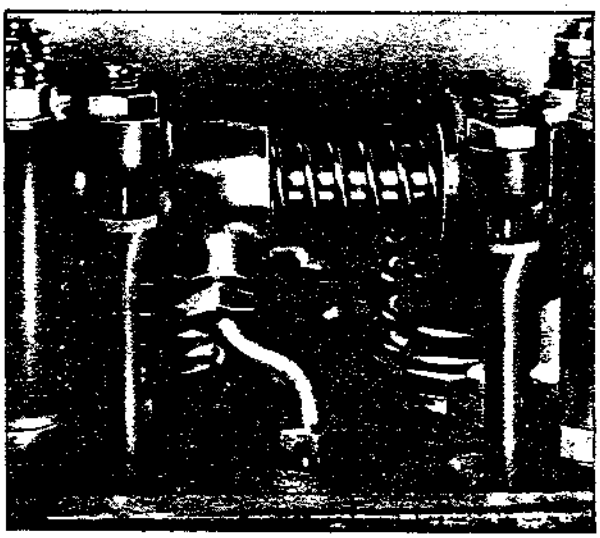


Fig. E2-Disconnect oil feed pipe

To Remove the Cylinder Head

1. Completely drain the cooling system.
2. Disconnect the battery terminals.
3. Remove the securing nuts and detach the exhaust pipe from the exhaust manifold. Blank off the end of the exhaust pipe to prevent entry of any foreign matter.

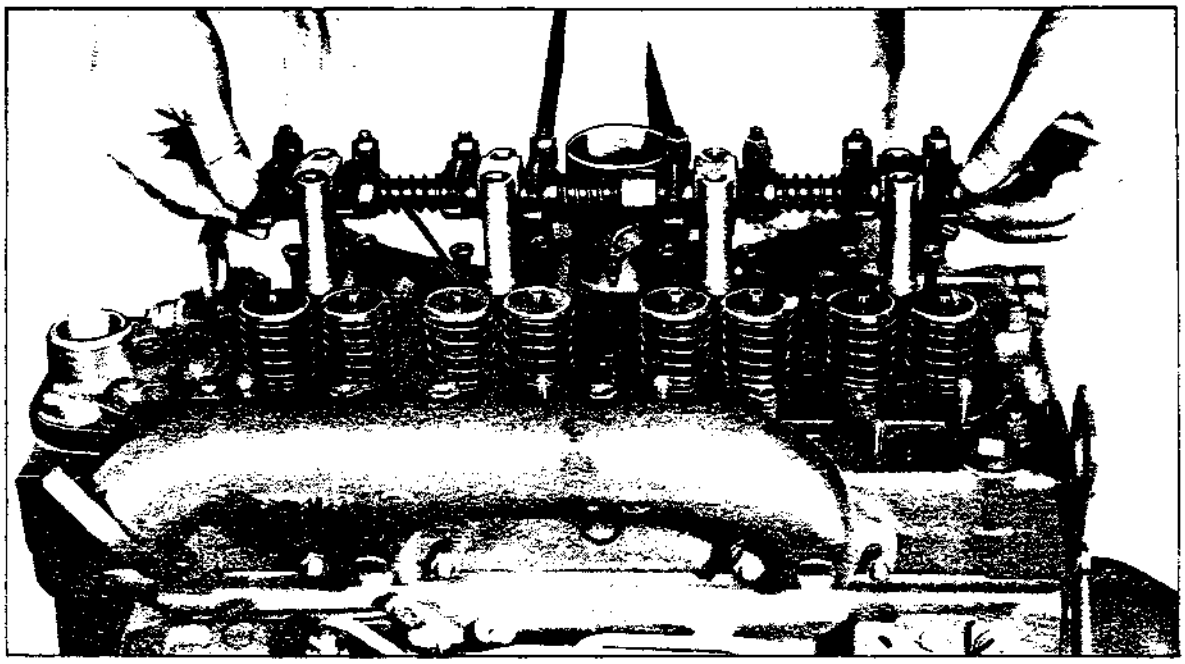
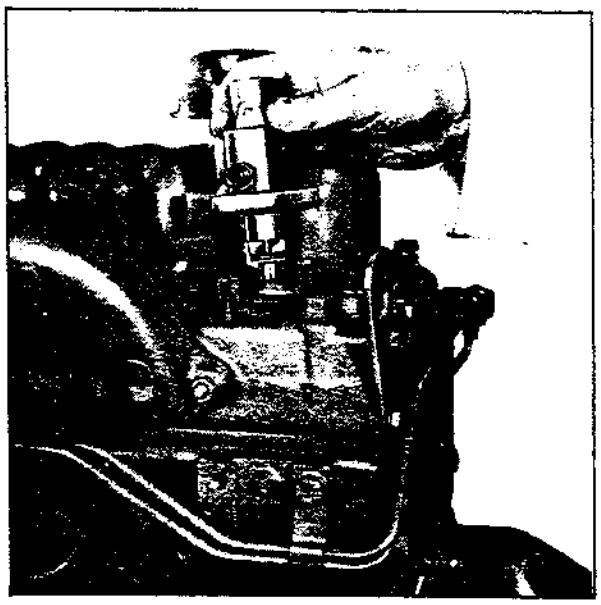
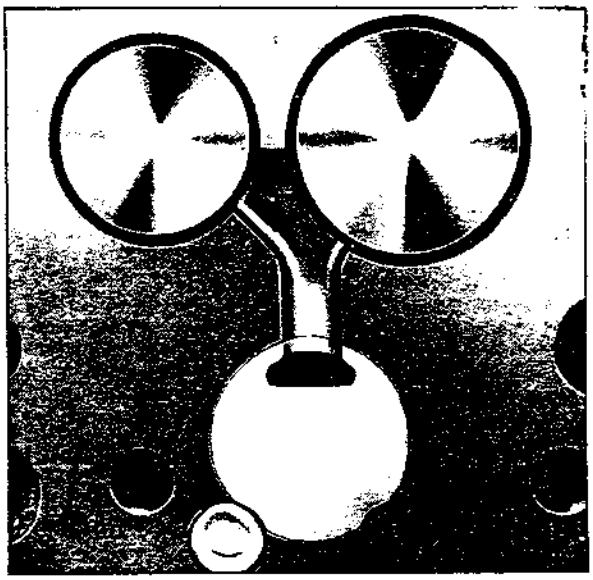


Fig. E3 - Removing rocker shaft.



E4 – Remove atomisers (injectors)

4. Uncouple the water outlet connection on the front of the cylinder head.
5. Remove the air cleaner and place somewhere level ready for servicing.
6. Disconnect the fuel pipe and electrical connection to the starting aid located in the induction manifold. (Refer to Fig. E.1).



E6 – All valves are numbered

7. Remove the cylinder head cover together with the breather pipe.
8. Unscrew the oil feed pipe to the rocker shaft at the cylinder head end. (Refer to Fig. E.2 for its location).
9. Remove the eight rocker shaft bracket securing nuts **evenly** and remove the rocker shaft complete with the oil feed pipe. (Refer to Fig. E.3).

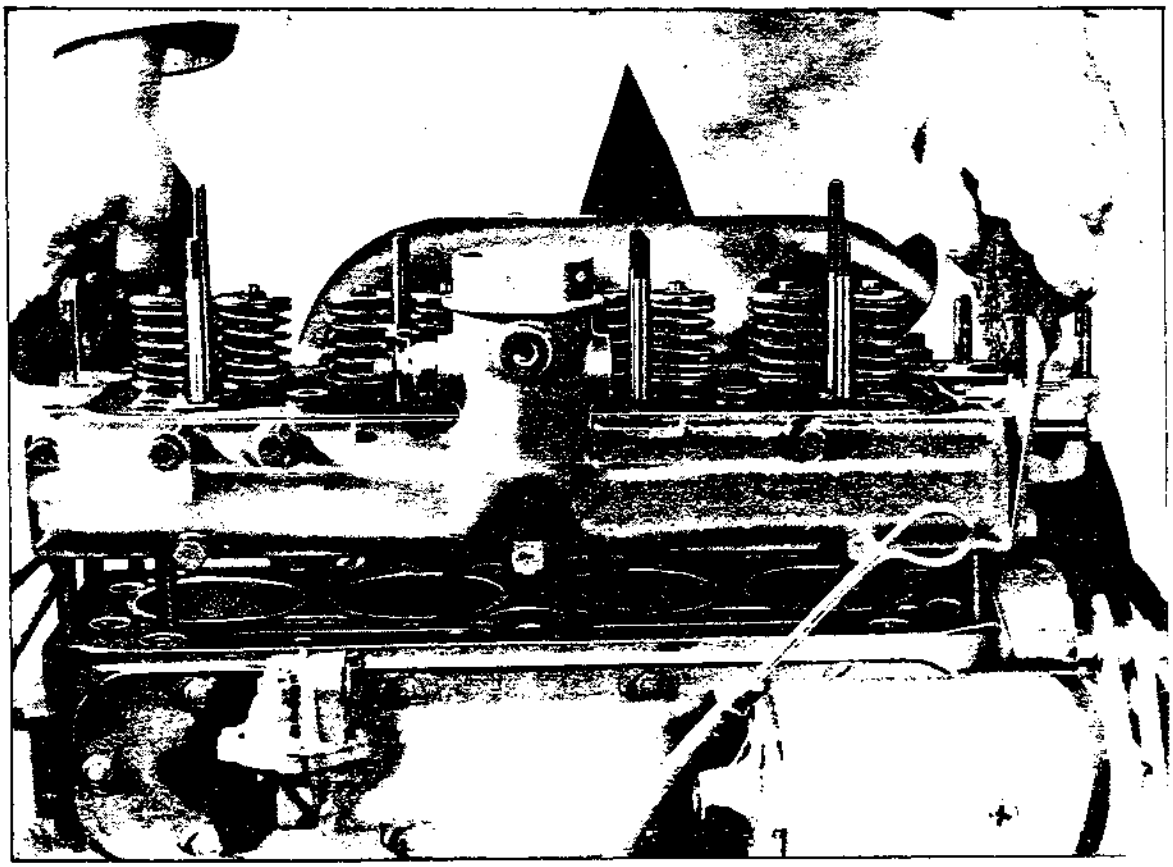


Fig. E5 – Removing cylinder head

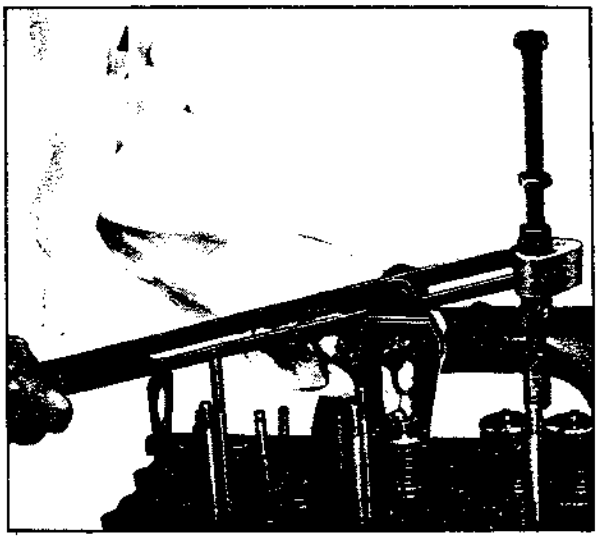


Fig. E7–Compress valve springs and remove keepers (also called "collets")

10. Remove the eight push rods and place somewhere safe (possibly in the cylinder head cover) to avoid the possibility of any being accidentally bent.
11. Unscrew the small banjo bolts on the tops of the atomisers and remove the leak-off pipe by unscrewing the union on top of the fuel filter.
12. Remove the low pressure fuel pipes between the fuel filter and the fuel pump, remove the fuel filter after disconnecting the feed pipe from the lift pump, blank off all pipes and ports to prevent ingress of foreign particles.
13. Remove the four high pressure fuel pipes from the fuel pump to the atomisers. Blank off fuel pump outlet ports.
14. Remove the atomiser securing nuts and carefully remove the atomisers. (Refer to Fig. E.4). Blank off the exposed ports on the atomisers.
15. Uncouple the dynamo or alternator adjusting link.

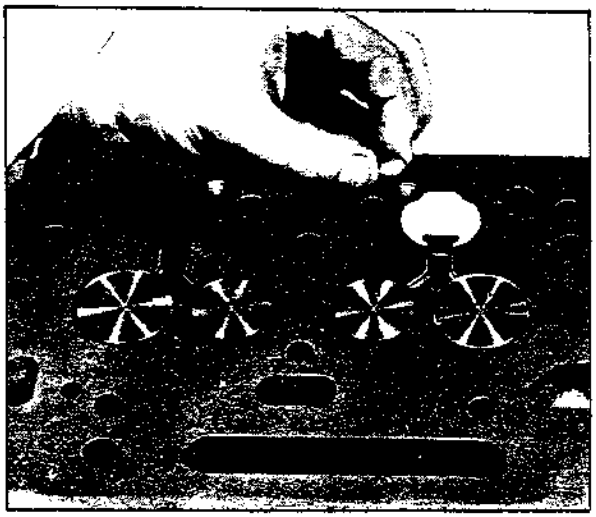


Fig. E8 - Combustion chamber inserts.

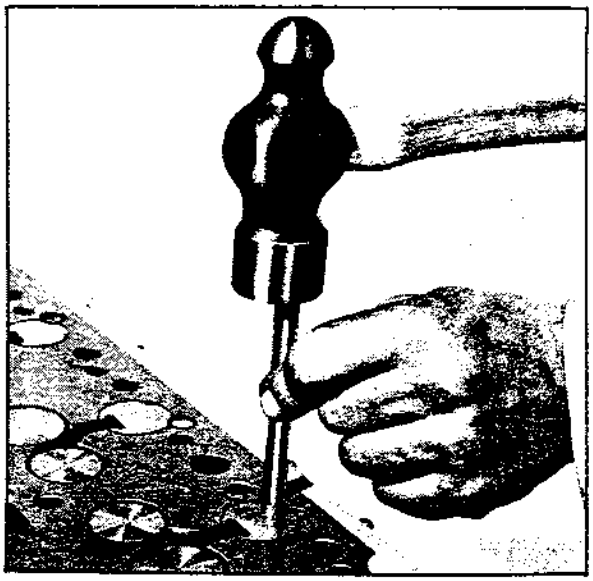


Fig. E9 - Installing combustion chamber inserts and washers.

16. Remove the cylinder head securing nuts and lift off the cylinder head complete with inlet and exhaust manifolds. (Refer to Fig. E.5).

To Remove the Valves

All valves are numbered. The cylinder head is marked with corresponding numbers. (Refer to Fig. E.6).

1. Remove collets by compressing the valve springs as shown in Fig. E.7.
2. Remove the spring caps, springs, seals (where fitted) and spring seats. Remove valves.

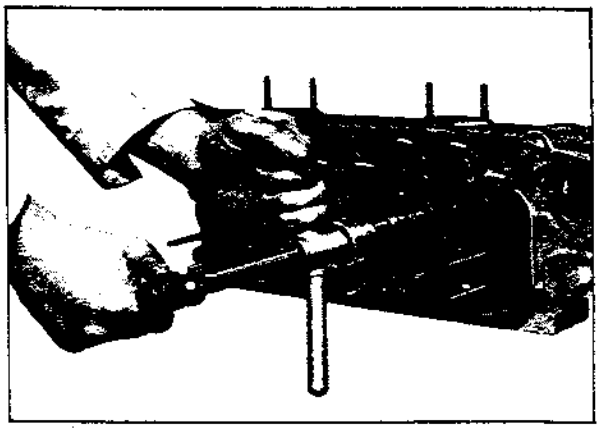


Fig. E10 - Using valve guide removal tool.

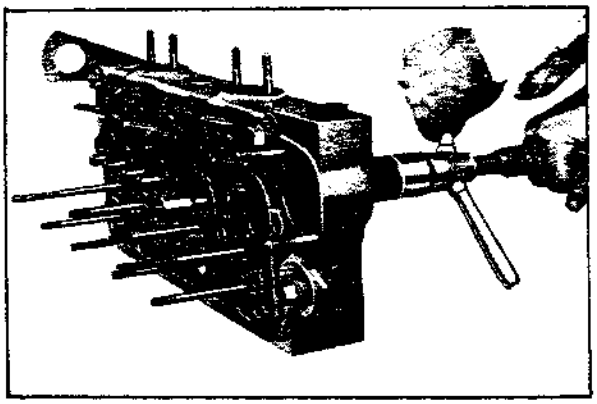


Fig. E11 - Installing valve guides

COMBUSTION CHAMBER INSERTS

These can be gently tapped out of their locations by means of a short length of curved bar through the atomiser bore. When refitting they must be located by means of expansion washers in the recesses provided. as shown in Figs. E.8 and E.9.

Cleaning

Remove any carbon from the cylinder head.
If the water jacket within the cylinder head shows signs of excessive scale, then a proprietary brand of descaling solution may be used, if possible the cylinder head should be tested for water leakage after such treatment

VALVE SPRINGS

It is advisable to fit new valve springs whenever the engine undergoes a major overhaul. Where a top overhaul only is being carried out the springs should be examined, paying particular attention to squareness of ends and pressures developed at specific lengths.

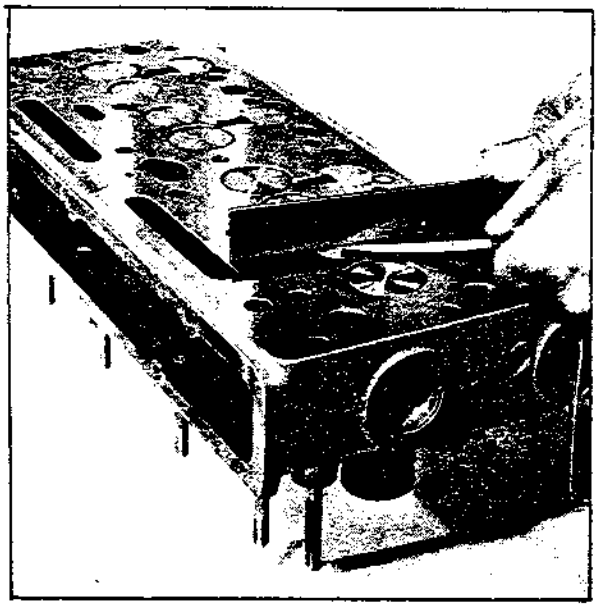


Fig. E13 - Checking valve head depth.

VALVE GUIDES

The worn guides should be removed either by means of a press and a suitable "dolly" or the valve guide removal tool shown in Fig. E.10.
Before fitting the new guides remove any burrs from the cylinder head parent bores, then smear the bores with clean oil and either press in the new guides or pull them in by means of the tool shown in Fig. E.11.

NOTE: Special care should be exercised during this operation as the guides, being made of cast iron, are therefore comparatively brittle.

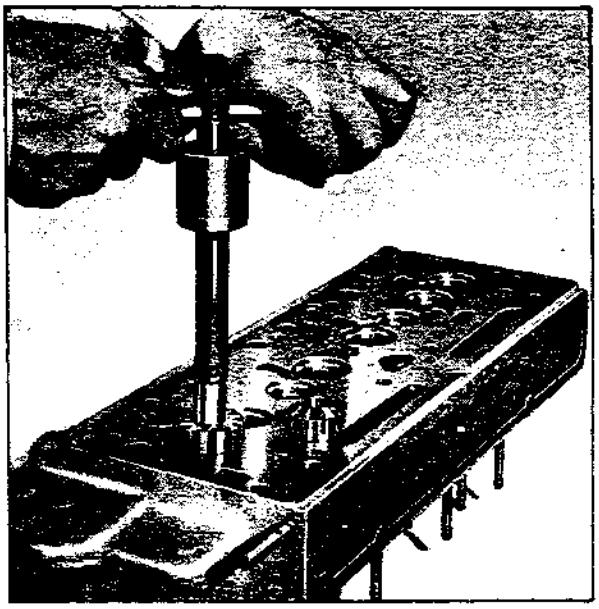


Fig. E12 - Using valve seat cutting tool.

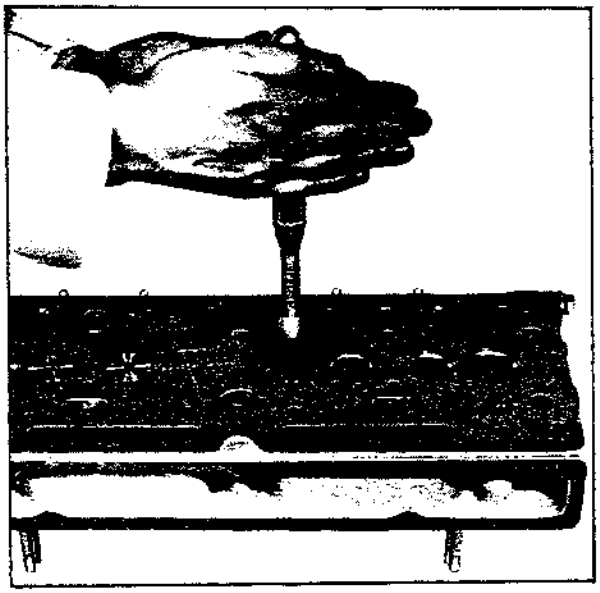
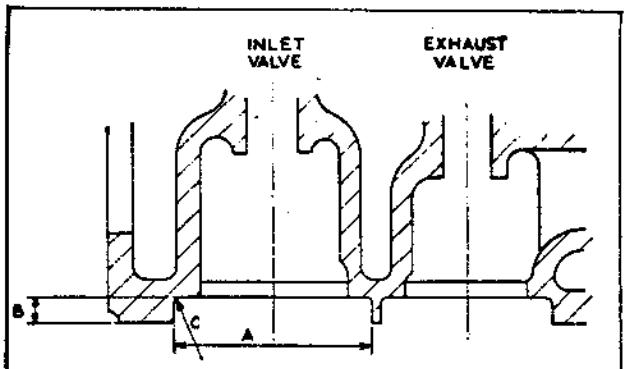


Fig. E14 - Hand lapping valves.



E15 Dimensions of Valve Insert Recess

Inlet
A—1.530 in to 1.531 in
B—0.3125 in to 0.3175 in
C—0.015 in chamfer at 45° (Max.)

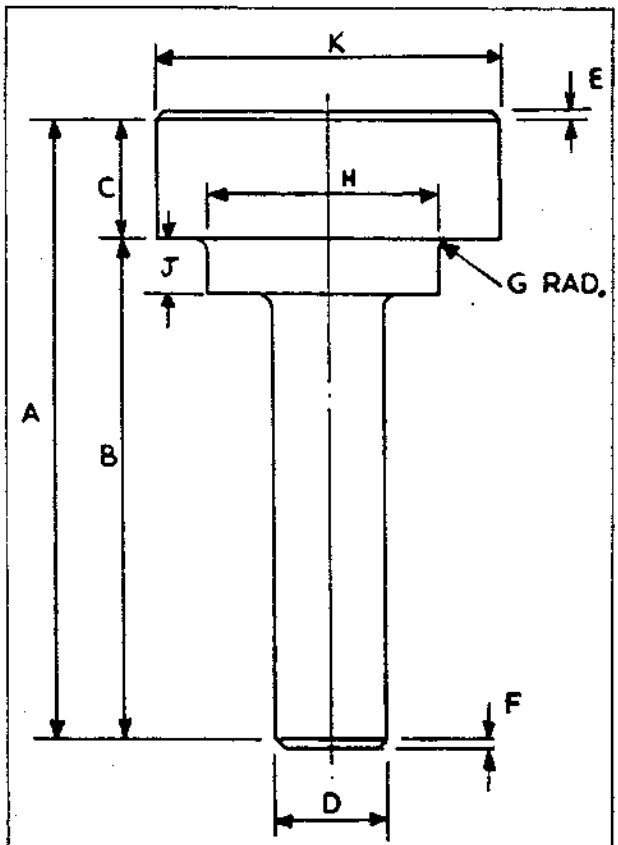
Exhaust
A—1.296 in to 1.297 in
B—0.3125 in to 0.3175 in
C—0.015 in chamfer at 45° (Max.)

VALVES AND VALVE SEATS

The valves should be checked in their respective guides for wear and replaced if wear has taken place. (ensure that the wear is in fact on the valve stem and not in the guide bore before replacing the valve).
The valve and valve seat faces should be reconditioned in the normal way using specialised equipment or with grinding compound, according to their condition. A valve seat (hand operated) cutting tool is shown in Fig. E.12. Valves should always be refitted to their original seats and any new valve fitted should be suitably marked to identify its position if removed at a later date. (Refer to Fig. E.6 for illustration of valve numbering).
Before refitting the valves it should be ascertained whether the valve head depth relative to the cylinder head face is within the limits given . This depth can be checked, as shown in Fig. E.13, by placing a straight edge across the face of the cylinder head, then by careful selection of feeler gauges measuring the distance between the straight edge and the head of the valve.
Where this depth exceeds the maximum limit and even the fitting of a new valve does not reduce this depth below the maximum limit, then the remedy is to fit a valve seat insert, the procedure for this is given in detail commencing on this page.
When refacing valves or valve seats care should be taken to see that only the minimum amount of metal necessary to obtain a satisfactory seat is removed, and that as narrow a valve seat as possible is maintained

Hand Grinding

When grinding or lapping-in valves make certain that all signs of pitting are removed from the seats.



E16 Valve Seat Inserting Tool

Material EN32A Case Hardened and Ground

Inlet Dimensions
A—2.75 in
B—2 in
C—0.75 in
D—0.309 in to 0.310 in
E—1/16 in at 45°
F—1/16 in at 45°
G—1/32 in Radius
H—1.238 in to 1.239 in
J—0.222 in to 0.225 in
K—1.523 in to 1.533 in

Exhaust Dimensions
A—2.75 in
B—2 in
C—0.75 in
D—0.309 in to 0.310 in
E—1/16 in at 45
F—1/16 in at 45
G—1/32 in Radius
H—1.018 in to 1.019 in
J—0.222 in to 0.225 in
K—1.287 in to 1.297 in

After all the valves have been lapped in the valve head depths relative to the cylinder head face should be checked to ensure that they are within the limits given.

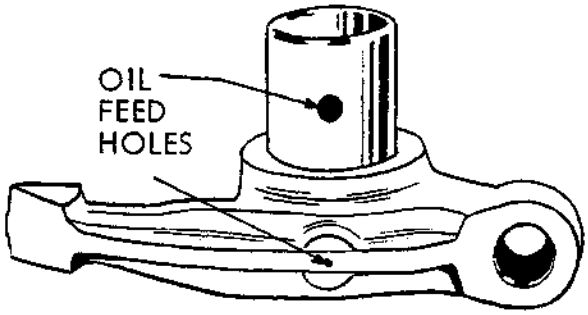


Fig. E17 - Oil feed holes must align.

VALVE SEAT INSERTS

Valve seat inserts are not fitted to production engines, but may be fitted in service.
When fitting inserts ensure that only genuine Perkins parts are used.
In order to fit these inserts proceed as follows:

1. Fit new valve guides
2. Using the new valve guide bore as a pilot, machine the insert recess in the cylinder head face to the dimensions shown in Fig. E.15.
3. Remove all machining swarf and thoroughly clean the insert recess (removing any burrs which may be present).
4. Using the valve guide bore as a pilot once again press the insert home with the inserting tool, this tool is shown fully dimensioned in Fig. E.16.
   NOTE: The insert must not under any circumstances be hammered in, neither should any lubrication be used.
5. Visually inspect to ensure that the insert has been pressed fully home, i.e. is flush with the bottom of the recess.
6. Recut the valve seat at an included angle of 90° (which will give the normal 45° seat) until the valve head depth reaches the minimum limit
   Lightly lap the valve to its new seat.

To Dismantle the Rocker Shaft Assembly

1. Remove the retaining circlips from each end of the rocker shaft.
2. Withdraw the rocker levers, springs and support brackets from the rocker shaft
3. Unscrew the oil feed pipe from the banjo and remove the banjo. (When refitting this feed pipe it should be noted that the end of the pipe locates the banjo position on the shaft).

Examine the rocker bushes and shaft for wear. The rocker levers should be an easy fit on the rocker shaft without excessive side play.
New rocker levers are supplied complete with bush fitted and reamed to size.
NOTE: When fitting new bushes ensure that the oil feed holes are in alignment before pressing home, and when pressed fully home that the holes coincide. (Refer to Fig. E.17).

To Re-Assemble the Rocker Shaft Assembly

1. Refit the oil feed banjo and locate with the feed pipe.
2. Refit the rocker levers, springs and support brackets in the opposite order to which they were removed. Lightly oil the components during reassembly and ensure that each rocker lever does not bind on the shaft. The assembly should now be as shown in Fig. E.18.

PUSH RODS

Check the push rods for straightness, if any are bent then fit new replacements.

To Refit the Valves

Lightly oil the valve stems to provide the initial lubrication.
Replace valves, springs, spring plates, washers, collars and collets, taking care that the numbers on the valves correspond to the numbers stamped adjacent to the valve seat (see Fig. E.6).

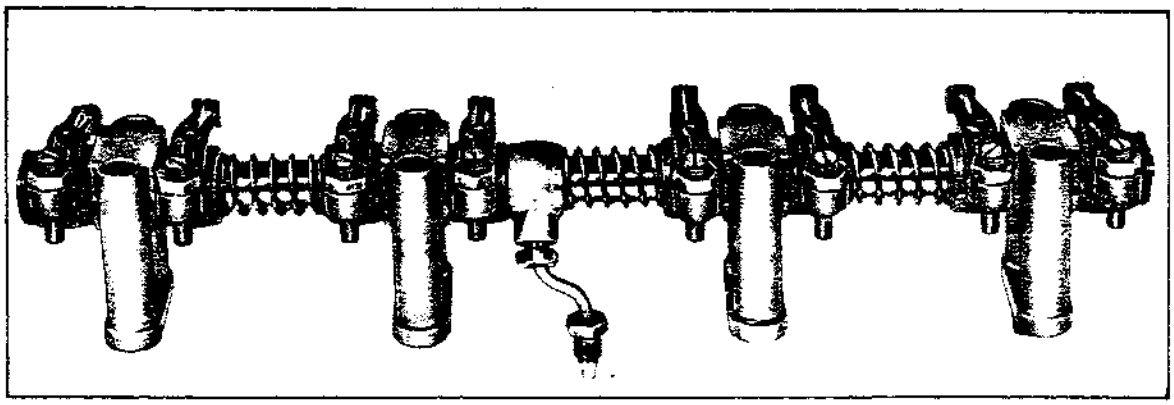


Fig. E18 - Reassembled rocker shaft assembly.

NOTE: Valve springs incorporate a damper coil and care should be taken to ensure that this damper coil is to the bottom of the spring, i.e., nearest the cylinder head when fitted.
Inner valve springs are not required for engines rated at 3,000 rev/min and below.
4.108 engines and 4.99 vehicle engines are fitted with rubber sealing rings on inlet valves only.

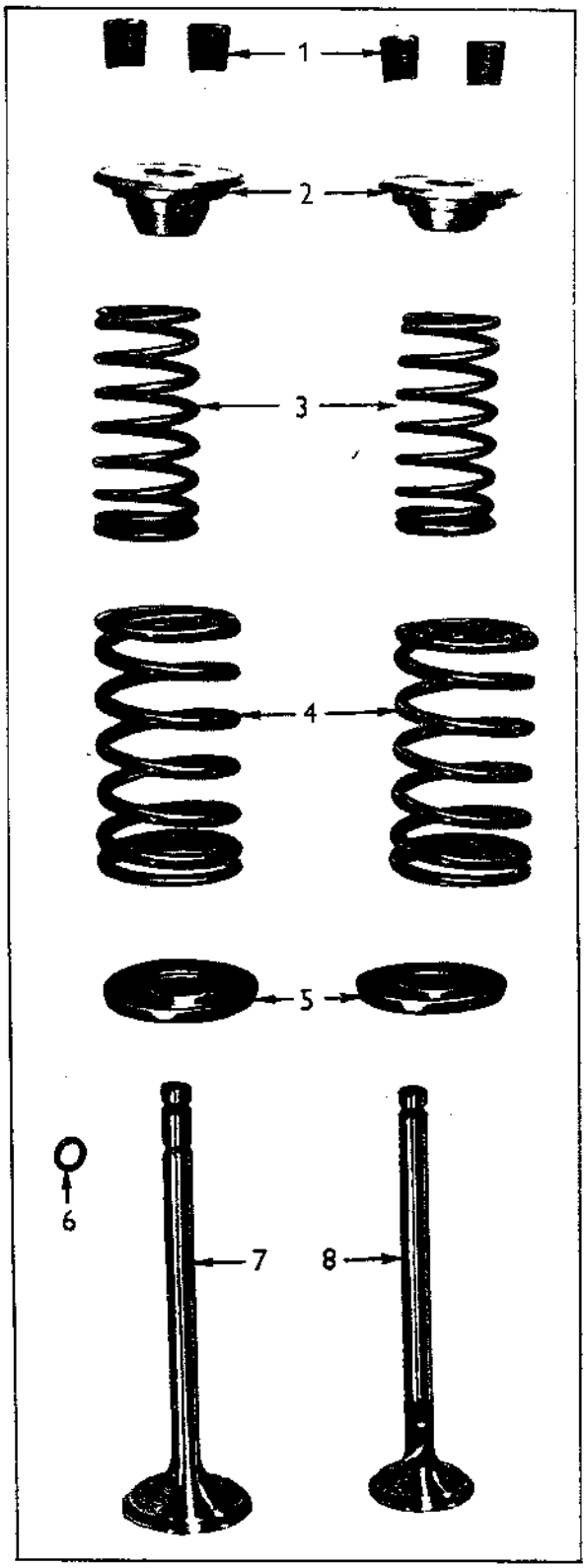
CYLINDER HEAD GASKET

Always use a new cylinder head gasket. Ensure that the correct type is used.

With this engine, the gasket is made of a black composite material and is known as the Klinger type. It MUST be fitted DRY and on no account should joint ing compound be used.
It is very important that the gasket is placed correctly, otherwise the steel beading may be nipped between the cylinder head face and the top of the liner.

To Refit the Cylinder Head

1. Place the cylinder head gasket carefully in position on the cylinder block top face (the gasket is marked "TOP FRONT" to indicate how it should be fitted). (Refer to Fig. E.22).
2. Lower the cylinder head into position on top of the gasket ensuring that it lays perfectly level.
3. Lightly lubricate both cylinder head studs and nuts with engine oil, then tighten the nuts progressively in three stages in the sequence shown in Fig. E.23 to the torque given This final torque tightening stage should be repeated to ensure that no loss of tension has taken place on any studs earlier in the sequence.



E19

1. RETAINING COLLETS (Keepers)
2. SPRING CAPS
3. INNER VALVE SPRINGS
4. OUTER VALVE SPRINGS
5. SPRING SEATING WASHERS
7. INTAKE VALVE
8. EXHAUST VALVE

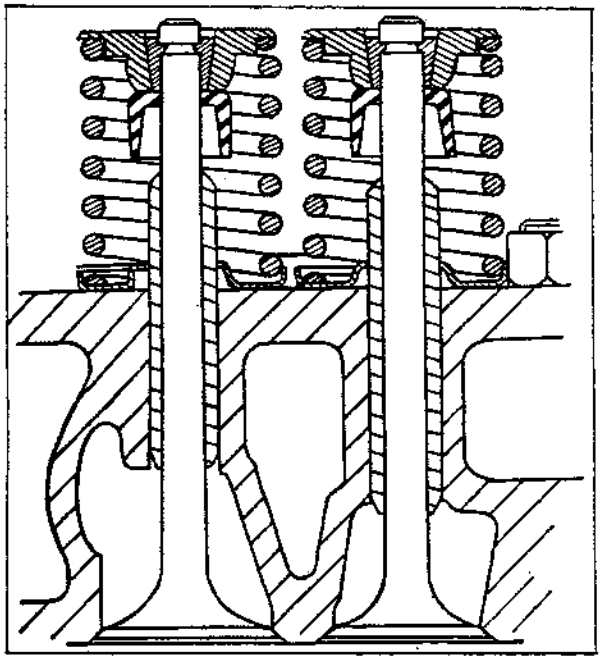


Fig. E20 - Cross section view of valves.

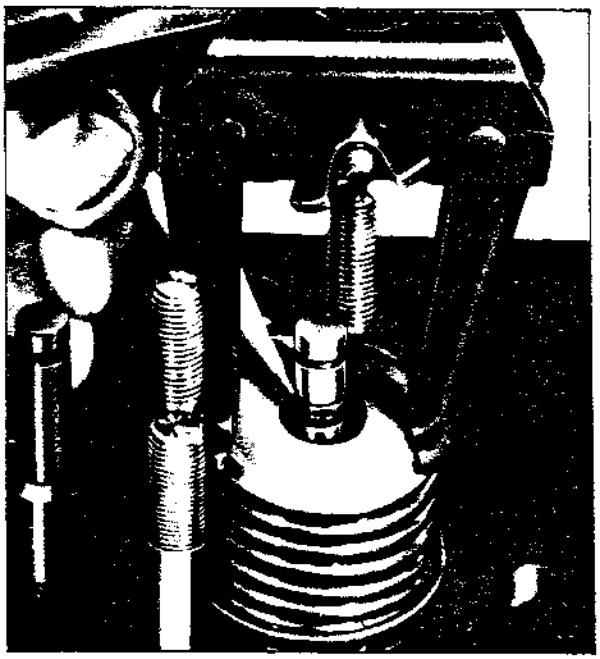


Fig. 21 - Seal ring on intake valve only.

4. Fit the push rods in their locations then carefully fit the rocker shaft assembly, noting that the valve adjusting screw ends locate in their respective push rod cups and the oil feed to the rocker shaft is located correctly.
5. Locate the oil feed pipe nut just finger tight at this stage, then evenly tighten the rocker shaft bracket securing nuts to a torque of 12 - 15 lbf ft (1,7 - 2 kgf m) now tighten the oil feed pipe nut.
   When correctly located the oil feed pipe will be as shown in Fig. E.2.
   NOTE: If the oil feed pipe nut is tightened before the rocker shaft bracket securing nuts, the pipe will either be strained or the olive pulled off the feed pipe.
6. Adjust the valve clearances to 0.012 in (0.3 mm) as follows:—
   Turn the engine so that the valves of No. 1 cylinder are in the position of 'valve overlap', i.e., the period between the opening of the inlet valve and the closing of the exhaust valve. In this position, adjust the clearances of No. 4 cylinder valves: similarly, with the valves of No. 3 cylinder in the overlap position, adjust the valves of No. 2 cylinder. With valves of No. 4 in the overlap position, adjust the valves of No. 1 cylinder and finally with valves of No. 2 cylinder in overlap position, adjust valves on No. 3 cylinder.
7. Replace the dynamo or alternator adjusting link and tension the fan belt

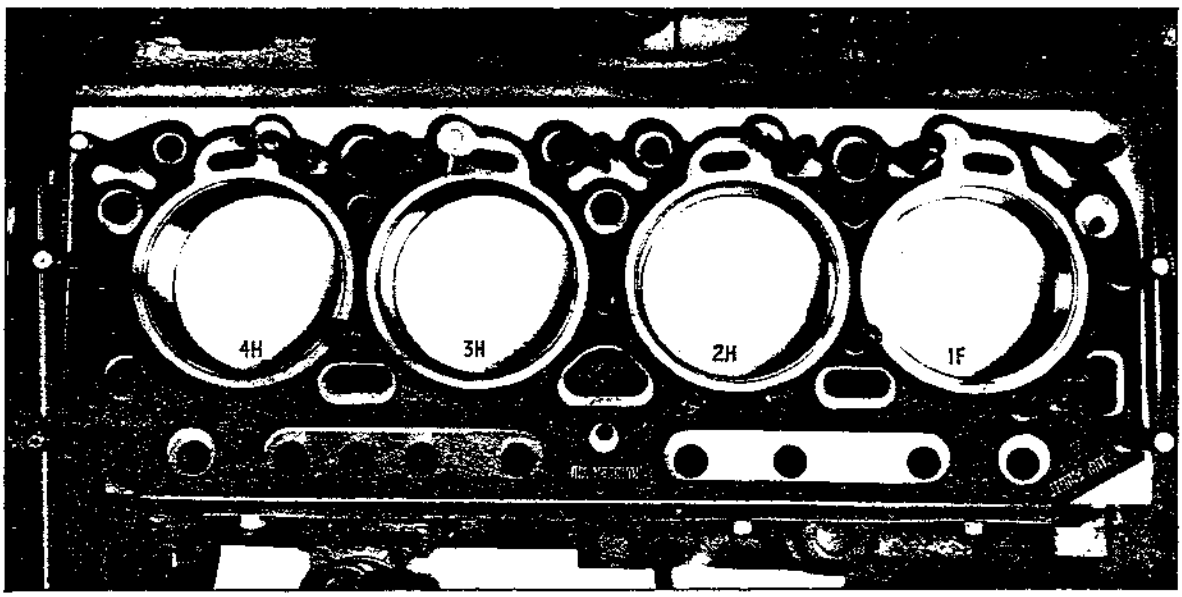
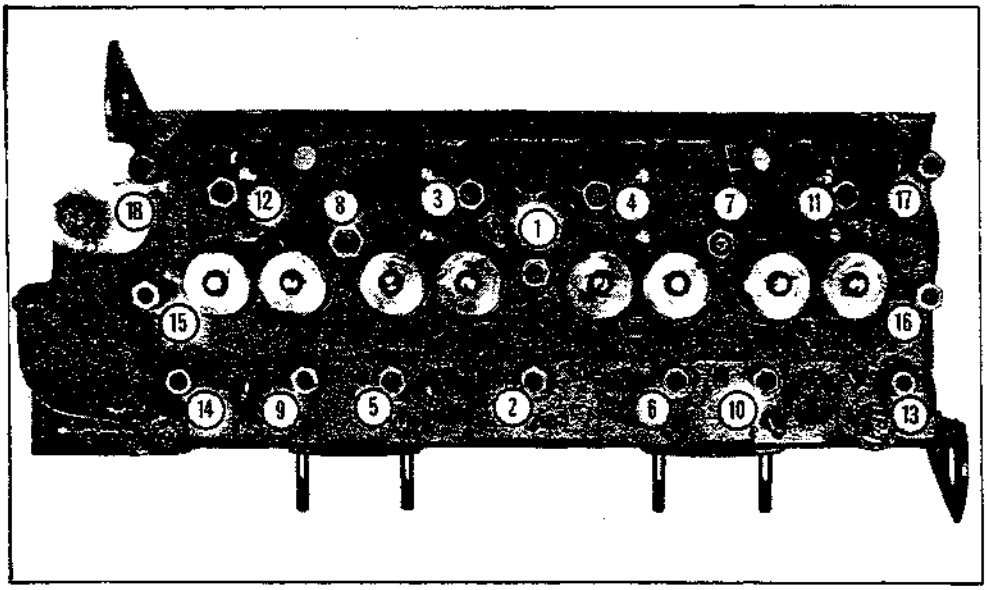


Fig. E22 - Cylinder head gasket is marked "top front" for correct installation.



E23

Cylinder head nuts tightening sequence

8. Replace the atomisers but do not tighten the securing nuts.
9. Replace the leak off pipe assembly and four high pressure fuel pipes to the atomisers. Tighten the the atomiser securing nuts.
10. Replace the fuel oil filter and the low pressure fuel pipes between filter and lift pump and filter and fuel pump.
11. Reconnect the electrical and fuel supplies to the starting aid.
12. Reconnect the exhaust pipe to the manifold.
13. Reconnect the water outlet connection at the front of the cylinder head.
14. Fill the cooling system with clean water ensuring the drain taps are turned off. Check for water leaks.
15. Bleed the air from the fuel system

16. Reconnect the battery.

Starting the Engine

Proceed as instructed with the engine running at a fast idle check that the oil pressure is satisfactory and that the oil reaches the rocker assembly and oozes gently from the rocker levers at this speed.

After the engine has been thoroughly warmed up it should be shut down, the rocker shaft removed and the cylinder head nuts checked, so that any loss of torque tension can be corrected by tightening the nuts to the torque given and in the order shown in Fig. E.23.

Replace the rocker shaft as previously described and set the valve clearances to 0.012 in (0.30 mm) COLD. Start engine and check oil flow to rocker levers, if satisfactory refit cylinder head cover and air cleaner. Finally check for oil leaks and rectify immediately if any are visible.

NOTE

It is essential that the cylinder head nuts are re-torqued to 60 lbf ft (8,3 kgf m) after the first 50 hours with the engine hot and in the sequence shown in Fig. E.23.

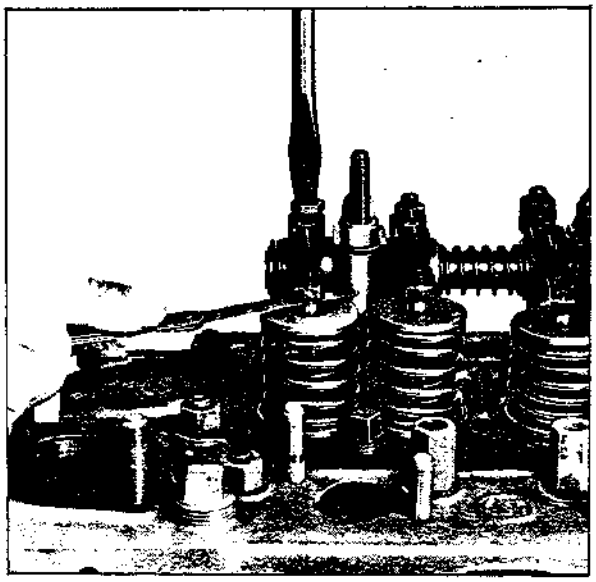


Fig. E24 - Adusting valve clearance.

Fuel System

FUEL OIL FILTERS

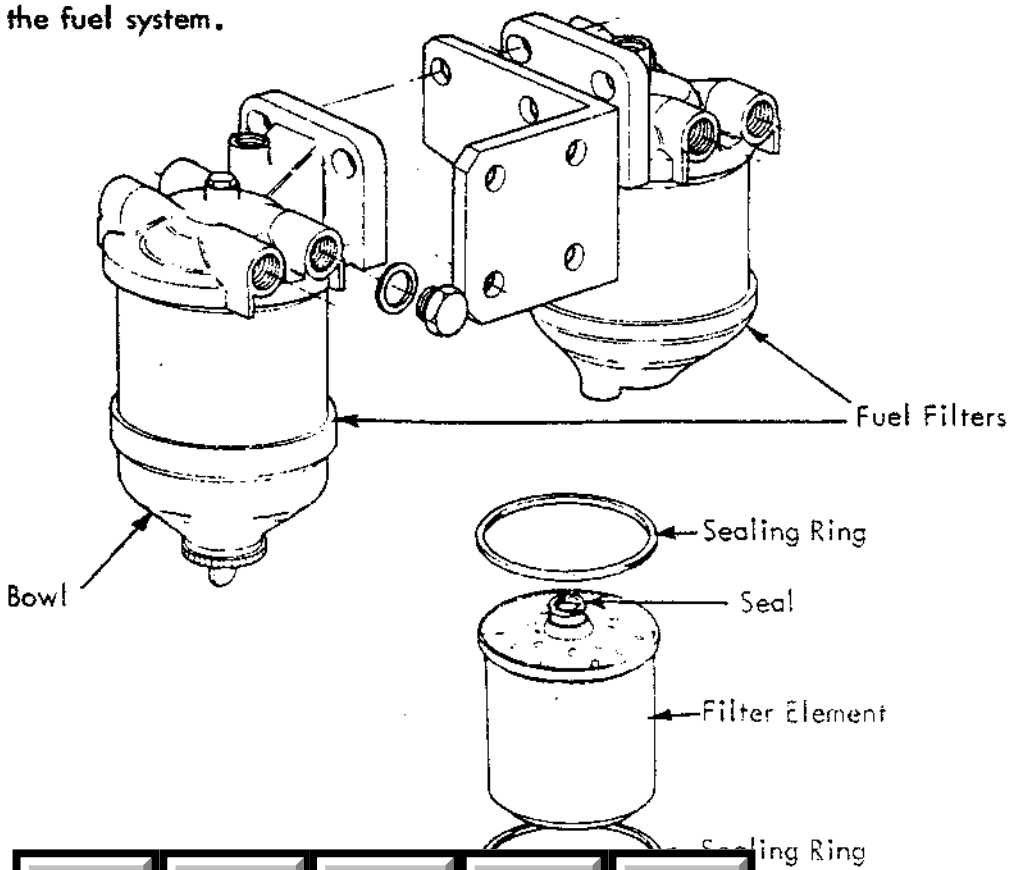
The twin element series flow filter is mounted on the rear, top right-hand side of the engine. The elements are held between the filter heads and bottom bowls by bolts that extend through the elements. Both elements should be renewed at the same time in accordance with the recommended periodical attentions schedule listed in maintenance. This period should be reduced if local conditions are such that a shorter interval becomes an obvious necessity.

TO RENEW THE FILTER ELEMENT

1. Unscrew the filter securing bolt in the center of the headcasting.
2. Lower the filter bowl and element clear, then discard the fuel therein together with the old element and sealing rings.
3. Place new sealing rings in position .
4. Place the new element in position, inside the filter bowl and raise the bowl and element firmly and squarely so that the top rim of the filter element locates centrally against the sealing ring in the filter head casting.
5. Hold in this position while the securing bolt is located and screwed home.

   NOTE: If the bowl and element are located correctly, no excessive tightening will be required to obtain a leak proof seal.

6. Prime the fuel system.



FUEL LIFT PUMP

Testing the Pump in Position

1. Disconnect the outlet pipe (lift pump to filter) leaving a free outlet from the pump.
2. Rotate the engine and note if there is a well defined spurt of fuel from the outlet port once every two engine revolutions.

   NOTE : As an alternative the pump may be operated by means of the hand primer as shown in Fig. P.7, which should give the same result every time the priming lever is operated. However should the engine happen to have stopped in such a position that the eccentric operating the lift pump is in the maximum lift position, then it will not be possible to operate the hand primer properly. If such a condition arises the remedy is to rotate the engine one complete revolution.

To Dismantle the Lift Pump

1. Before dismantling, make a file mark across the two flanges for location purposes when the pump is being re-assembled.
2. Remove the five cover screws and separate the two main castings, then remove the diaphragm assembly from the lower half by turning the diaphragm through 90° in either direction.

   NOTE : The diaphragm and pull rod assembly is a permanent assembly and no attempt should be made to separate the parts.
3. Remove the retaining clip from one side of the pump body and push out the rocker arm retaining pin. Withdraw the rocker arm, etc., from the body.
4. Prise out the valves with a screwdriver or other suitable tool.

Inspection

1. Check the diaphragm assembly and renew if the material is split or checked, or if serious wear is apparent in the link engagement slot.
2. The diaphragm spring should be replaced if faulty or corroded. A new spring should have the same colour identification.
3. Replace the valves unless they appear to be in perfect condition.
4. Examine the rocker arm, operating lever, rocker arm retaining pin and rocker arm return spring for wear. Replace any parts where necessary.
5. Replace all joints, seals and washers as routine procedure.
6. Examine upper and lower castings for wear or distortion. Slight distortion of flanges can be remedied by grinding the flange face to restore flatness.

To Re-Assemble the Lift Pump

Examine the casting and ensure that there is sufficient material to provide a sound staking when new valves are fitted.

Clean the valve recesses to allow the new valves to be correctly fitted.

1. Insert a new valve gasket in each valve recess.
2. Place the new valves in the recesses. The valve in the inlet port should be fitted with the spring outwards (i.e., towards the diaphragm flange) and the valve in the outlet port fitted in the reverse position.
3. Press the valves home with a suitable piece of tubing, approximately 9/16 in (14,29 mm) inside diameter and ¾ in (19,05 mm) outside diameter.

Fig. P7 - Hand primer

Fig. P8 - Fuel Lift Pump

4. Stake the casting in six places (between the original stakings) round each valve, with a suitable punch.

   NOTE: Valves fitted to earlier lift pumps were held in position with a retaining plate and two screws. On no account should attempts be made to stake the valves of this earlier type pump.

5. Place the rocker arm retaining pin in the appropriate hole in the lower casting and push through until it protrudes slightly inside.
6. Fit one packing washer and link into the casting moving the pin in slightly to retain them.
7. Fit the rocker arm and return spring and retain by moving the pin in further, ensuring that the spring seats correctly.
8. Fit the remaining packing washer, then push the rocker arm retaining pin through the link, washer and casting until the ends protrude equally beyond the outside of the casting.
9. Retain by securing with the two clips.
10. Insert the new rubber sealing washer followed by the steel seating washer and diaphragm return spring.
11. Place the diaphragm assembly over the spring with the pull rod downwards, locating the top of the spring in the diaphragm protector washer.
12. Now position the pull rod so that the flat notched blade has one of its thin edges facing the rocker arm. Press downwards on the diaphragm assembly and twist it through 90° in either direction, this action will engage and retain the pull rod in the fork of the link.
13. Operate the rocker arm against the diaphragm spring pressure until the diaphragm is level with the body flange.
14. Place the cover assembly in position and line up the file marks made on the flanges prior to dismantling.
15. Still holding the diaphragm level with the body flanges, fit the five flange securing screws, tighten evenly and securely.

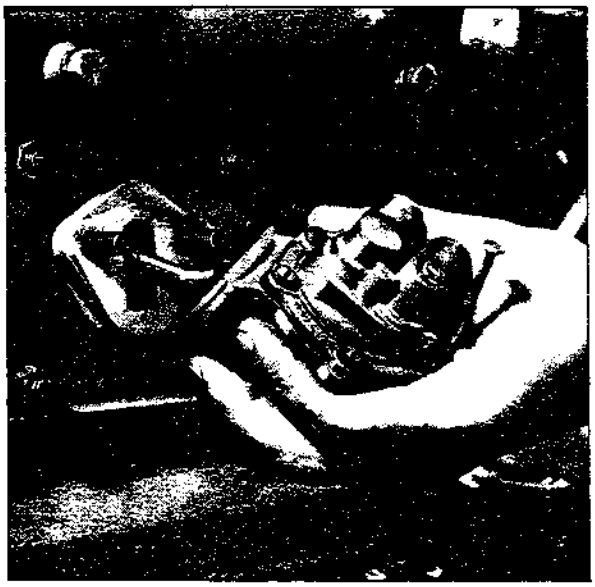


Fig. P9 – Installing Fuel Pump

To Refit the Fuel Pump

1. Fit the distance piece using a joint on either side.
2. Enter the pump operating lever into the recess in the tappet inspection cover as shown on Fig. P.9 and secure with the two nuts and washers.
3. Reconnect the low pressure fuel pipes to the inlet and outlet ports.

FUEL INJECTION PUMP

Description

The fuel injection pump is of the D.P.A. distributor type. It is a precision built unit incorporating a simple hydraulic governor or alternatively one of the mechanical flyweight type depending upon the application to which the engine is fitted.

To Remove the Fuel Injection Pump

1. Remove the four high pressure pipes between the pump and the atomisers and blank off all ports to prevent the ingress of foreign particles.
2. Remove the low pressure fuel pipes from the inlet and outlet connections and blank off all ports.
3. Disconnect the stop and throttle controls and their return springs.
4. Remove the two nuts and the socket headed setscrew which secure the fuel pump to the mounting flange together with their spring and plain washers.
5. Carefully withdraw the fuel pump from its mounting.

To Refit the Fuel Injection Pump

1. Replace the fuel pump mounting flange joint (where necessary).
2. Offer up the pump ensuring that the master spline on its quill shaft is correctly positioned to engage with the female splines within the fuel pump drive hub.

   NOTE: This master spline ensures that the pump will only locate in the drive hub in one position for timing purposes.
3. When the splines are in correct alignment the pump can be pushed in until the mounting flanges meet and the securing nuts and setscrew with their washers can be fitted.
4. Before tightening, align the timing marks scribed on the fuel pump mounting flanges as shown in Fig. P.11. Tighten the setscrew and nuts.
5. Refit the low pressure pipes to the inlet and outlet connections.
6. Refit the high pressure fuel pipes.
7. Reconnect the throttle and stop controls together with their return springs.
8. Prime the fuel system with fuel oil
9. Fuel pump timing can be checked as detailed in the following text.

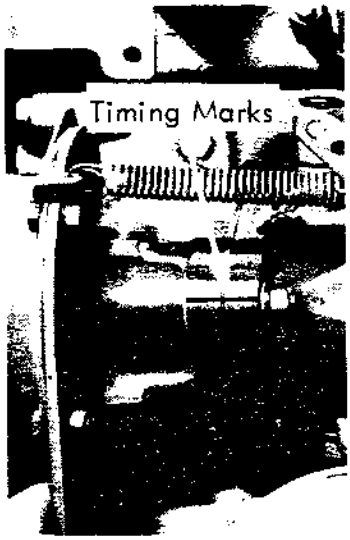


Fig. P11 - Timing Marks on Pump Flanges

FUEL INJECTION PUMP TIMING

Reference should be made to the details given covering engine timing. If this timing sequence has been followed regarding the timing gears and the timing marks on the mounting flanges are correctly aligned as shown in Fig. P.11. then the fuel pump timing should be correct.

A further check is possible and utilises the internal timing marks within the pump body. To be able to see these marks necessitates the removal of the inspection cover.

On the fuel pump rotor inside the fuel pump, are a number of scribed lines, each one bearing an individual letter. A timing circlip, one end of which has a straight edge is positioned inside the pump body and is preset so that when the appropriate scribed line on the fuel pump rotor aligns with the straight end of the circlip, it denotes commencement of injection (static timing) see Fig. P.12.

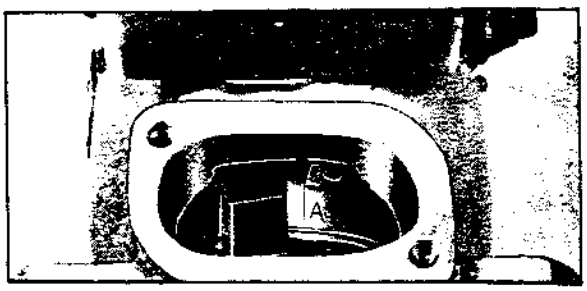


Fig. P12 - Timing Marks on Rotor

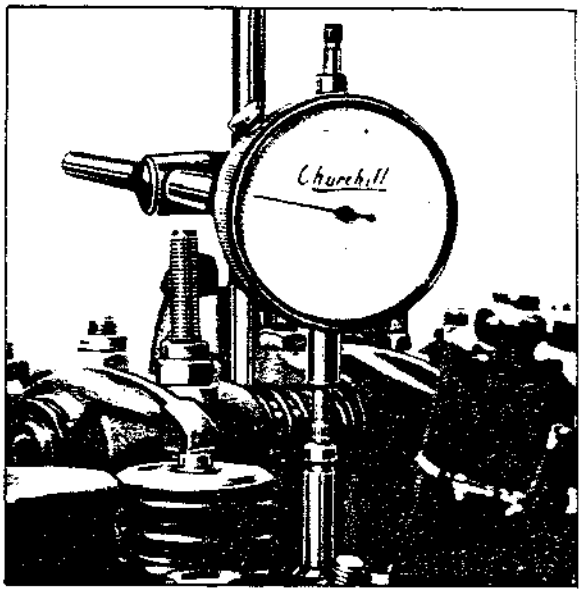
CHECKING FUEL PUMP TIMING

1. Ensure that the fuel pump is correctly fitted with the scribed line on the mounting flange aligning with the adjacent mounting flange on the cylinder block (see Fig. P.11).
2. Position the crankshaft so that No. 1 piston is at T.D.C. on its compression stroke.
3. Remove the cylinder head cover.
4. Slacken the valve adjusting screw on No. 1 exhaust valve sufficiently to allow the rocker lever to be moved to one side and the push rod removed, rotate the rocker lever on the shaft, so that the valve spring cap is accessible for using the valve spring compressor.
5. Remove the collets, spring cap and springs from No. 1 exhaust valve and allow the valve to rest on the top of the piston.
6. With the aid of a clock gauge in contact with the end of the valve now resting on No. 1 piston, it will be necessary to position the crankshaft so that the piston will be 0.106 in B.T.D.C. this being the equivalent of 18° on the engine flywheel. Refer Fig. P.13.

   To do this, turn the crankshaft in the opposite direction to normal rotation, approximately an eight of a turn and then forward until the required position is registered on the clock gauge. This enables the backlash in the timing gears to be taken up.

   NOTE: The above setting is for 4.108 vehicle engines.

7. Remove the inspection plate on the fuel pump enabling the rotor to be seen (Fig. P.12).
8. With No. 1 piston at the static timing point on its compression stroke, the scribed line on the rotor marked 'C' (for mechanically governed engines) should align with the straight edge or scribed line on the timing circlip.
9. If the timing is incorrect proceed by either :—
   (a) making any necessary adjustments by means of the holes in the fuel pump gear, they are slotted enabling the drive shaft to be turned relative to the gear when the securing setscrews are slackened. or
   (b) by slackening the two nuts end socket headed setscrew which secure the fuel pump to the mounting flange and turning the pump body in the direction required.
10. When the fuel pump timing has been set, turn the engine against the normal direction of rotation once again to the appropriate piston displacement to check that the squared end of the circlip is now aligned with the line on the rotor.
11. When the fuel pump timing has been correctly set, slowly turn the engine to T.D.C. in the normal direction of rotation, remove the clock gauge and refit the valve springs.
12. Refit the push rod and reset the valve clearance.



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Maximum Speed Setting

The maximum speed screw is set and sealed by the manufacturers and must not be altered or tampered with in any way, unless factory authority is first obtained and any adjustments necessary are carried out by experienced personnel. As with all seals on the pump unauthorised removal may render the guarantee void.

The maximum no load speed may vary according to the vehicle or application to which it is fitted, reference may be made to the code number stamped on the fuel pump data plate. The last four numbers in the code indicate the maximum no load engine speed, therefore in the case of the following example it would be 4480 rev/min. Code Example EH39/1200/0/4480.

NOTE: If the fuel pump data plate is damaged or defaced so as to make it impossible to read accurately, or if there is no code stamped on the plate you are advised to contact your nearest C.A.V. Distributor, or alternatively, Service Department, Perkins Engines

NOTE: The engine must not be allowed to operate at a speed in excess of that specified or severe damage may occur.

ATOMISERS

General

When replacing atomisers in the cylinder head, it is essential that a new, correct type copper washer is fitted between the nozzle body and cylinder head.
The first symptoms of atomiser trouble usually come under one or more of the following headings :—

1. Misfiring.
2. Knocking in one (or more) cylinders.
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black).
6. Increased fuel consumption.

Testing for Faulty Atomiser

If an atomiser is suspected of being faulty, try this method to isolate it.

Slacken the union nut at the atomiser end of the high pressure fuel pipe. If each atomiser is isolated in turn in this way, (with the engine running at approximately 1,000 rev/min) tightening each union nut firmly before proceeding to the next, then the faulty atomiser, when isolated in this manner, will have little or no effect on the running.

Warning

Great care should be taken to prevent the hands or face from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin with ease.

Atomiser Pressures

Details of holders and nozzle types together with pressure settings are given .

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT AN ATOMISER TESTING PUMP OF THE TYPE ILLUSTRATED. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF ATOMISERS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT.

Atomiser Identification

Atomisers can be identified by code letters stamped on a tab washer fitted under the spring cap nut (see Fig. P.16) or alternatively, the code is stamped on the atomiser body.

NOTE: Correct code for 4.108 engine is "BG".

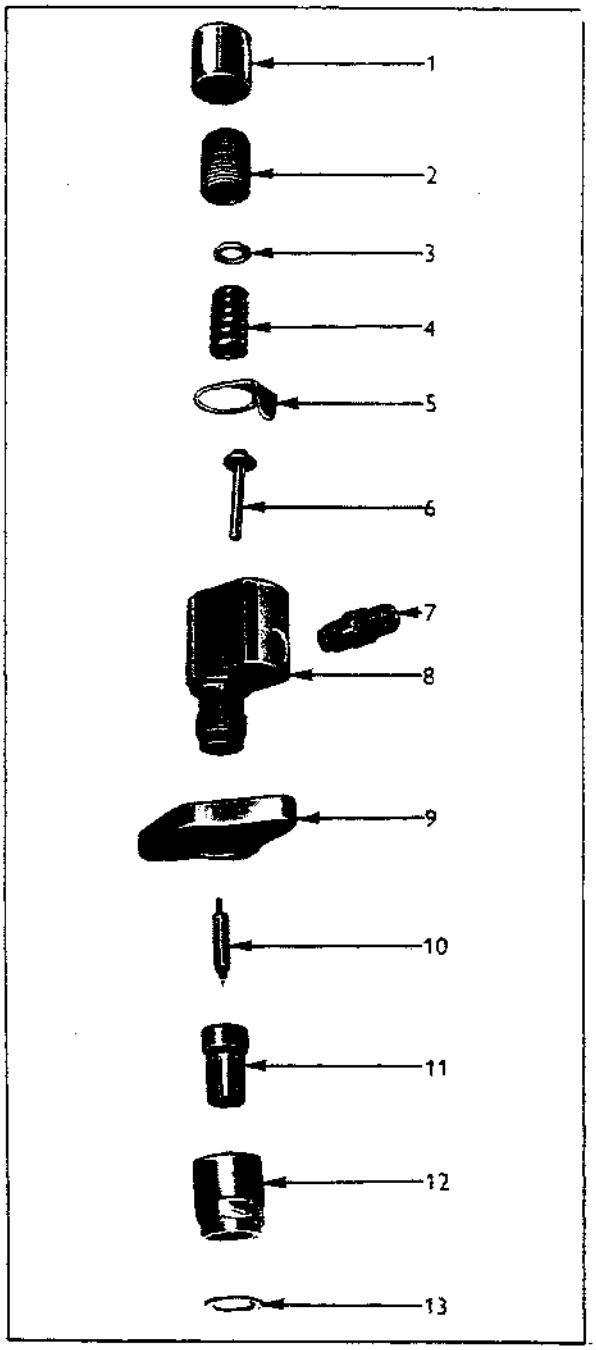


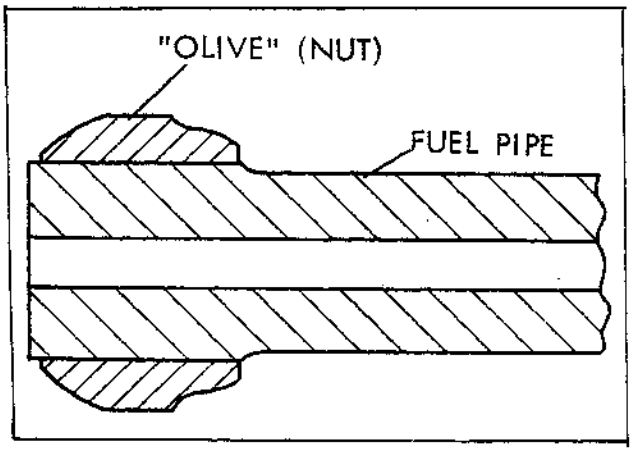
Fig. P16 - Atomiser (fuel injector)

1. Capnut
2. Spring cap
3. Shim washer
4. Nozzle spring
5. Identification tab washer
6. Spindle
7. Fuel inlet union
8. Nozzle holder body
9. Securing flange
10. Nozzle needle
11. Nozzle body
12. Nozzle capnut
13. Copper sealing washer

Fuel Pipes (High Pressure)

When replacing the fuel pipes it should be noted that no two pipes are the same, each is formed to suit an individual atomiser position. This is important when ordering a replacement pipe, as each one has a different part number.

For standardisation purposes, high pressure fuel pipes assemblies are now supplied with olives fitted as shown in Fig. P.17. The earlier type pipe assemblies with olives fitted in the reversed position are still satisfactory.



P17

The pipes should be clean, (wash in clean fuel oil and blow through the fine bore with compressed air if there is any doubt), the olives at each end should not be split or unduly compressed, otherwise leakage will result and a new pipe will be needed.

Ensure when fitting, that the pipe fits squarely at both ends and that the union nuts are tightened firmly but not over-tightened.

When changing an atomiser always remove the pipe completely.

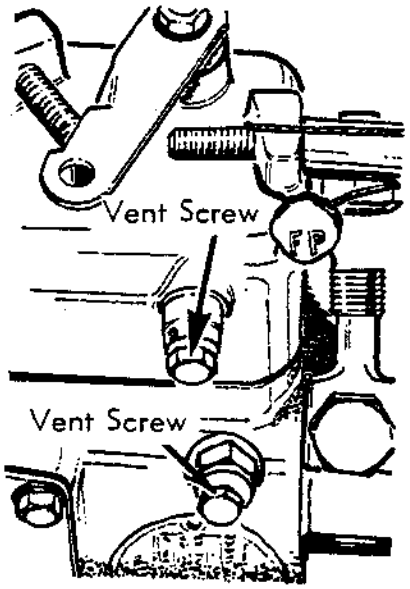
Priming the Fuel System

The air must be vented from the fuel system whenever any part of the system between the fuel tank and injection pump has been disconnected for any reason, or when the system has been emptied of fuel.

No attempt must be made to start the engine until the injection pump has been filled and primed as serious damage can be caused to the pump due to lack of lubrication.

The method of priming detailed below, ensures that only fuel which has passed through the paper filter element can reach the interior of the pump.

1. Slacken the air vent valve on the top of the control gear housing on the front of the governor housing on mechanically governed pumps (refer Fig. P.18).
2. Slacken the vent valve fitted on one of the two hydraulic head locking screws (Refer to Fig. P.18).
3. Disconnect fuel line at top of fuel filter.
4. Operate the priming lever on the fuel feed pump (Refer to Fig. P.7) and when fuel, free from air bubbles, issues from each venting point, tighten the screws in the following order :—
   1. Filter cover
   2. Head locking screw vent valve.
   3. Governor cover vent valve.
5. Slacken the pipe union nut at the pump inlet, operate the priming lever and retighten when fuel oil, free from air bubbles issues from around the threads.
6. Slacken the unions at the atomiser ends of two of the high pressure pipes.
7. Set the accelerator at the fully open position and ensure that the "stop" control is in the "run" position.
8. Turn the engine until fuel oil, free from air bubbles, issues from both fuel pipes.
9. Tighten the unions on both fuel pipes, and the engine is ready for starting.



P.18

Priming Procedure after Changing a Filter Element

1. With the fuel pipe on the filter cover removed, and the union at the filter end of the return pipe (filter to tank) slackened, operate the feed pump priming lever until oil, free from air bubbles, issues from the filter cover.
2. Replace the fuel pipe, and continue to operate the priming lever until oil, free from air bubbles, issues from around the threads of the return pipe union.
3. Tighten the return pipe union.
4. Slacken the union at the filter end of the filter to injection pump feed pipe, and operate the priming lever until oil, free from air bubbles, issues from around the union threads.
5. Tighten the feed pipe union. The pump and filter are now filled and primed and ready for further service.

MM108

92 POWER SWEEPER

CONTENTS:

LPG

SAFETY AND MAINTENANCE TIPS

Safety of fuel systems on machines cannot be taken for granted. There have been reports of increased amounts of oil being present in L.P. fuel in certain areas. Added precautions must be taken , to ensure safer operation of your L.P.G. equipment. Regular maintenance and frequent inspection is important.

Listed below are some suggested maintenance tips as well as general tips to promote added safety in the operation of your Tennant machine.

- Keep cigarettes, sparks, and open flame away when working on L.P. equipment, when inspecting for gas leaks, or when L.P. tanks are present.
- Check all components for proper operation. Replace L.P. components when needed. Never by-pass defective safety components.
- Check routings of all L.P. hoses. Keep them away from sharp edges, exhaust manifolds, or other hot surfaces. Check for signs of abrasion or deterioration.
- Every 400 hours or 3 months (whichever comes first) or if any malfunction is noted:
  a. Completely disassemble the vaporizer-regulator (liquid withdrawal system). See machine manual for instructions and replacement parts.
  b. Clean all parts in alcohol.
  c. Inspect parts and replace where needed.
  d. Carefully reassemble and reinstall in machine.
  e. Check for proper operation.
- Check for gas odor before and during starting operations. If gas odor is noticed, stop and check for leaks or component malfunction.
- Replace electrical wiring if insulation shows signs of abrasion or deterioration.
- Make sure L.P. tank is free of dents or gouges.
- Make sure service coupling is clean and free of damage. Make sure service coupling of tank matches machine service coupling.
- Keep the engine properly tuned.
- Make sure the L.P. tank matches the fuel system (vapor tank with vapor system, liquid tank with liquid system).
- Make sure L.P. tank is securely mounted on the machine and with the locating pin in position.
- Park the machine in a shaded, cool area when not in use.
- Keep the L.P. tank service valve closed when the machine is not in use.
- Never overfill L.P. tank. Fill the L.P. tank to the recommended weight stamped on the tank.

. Use care in handling L.P. tanks. Never drop or drag them.

. Always store and transport L.P. fuel tanks with the safety relief valve in the "Up" position.

. Every 400 hours replace the filter in the filter fuelock.

. Avoid personal contact with L.P. fuel to avoid frostbite.

. When the machine is to stand unused for a period of time, overnight for example, park the machine in a designated area, shut off the service valve at the tank and operate the engine until the remaining fuel is comsumed. Then, turn off the ignition switch.

. Perform regular maintenance as recommended.

QUICK CHECK LIST

This is a small list of checks that can be made quickly and often. Be sure to make all of the checks listed in the service and maintence list.

• To check regulator

Place ignition switch in the on position. Remove the wire from the "C" terminal of the oil pressure switch and touch it to the "NO" terminal. This shorts out the oil pressure switch and opens the fuelock allowing L.P. fuel to flow to the primary regulator. Check the carburetor for L.P. fuel. If L.P. fuel is flowing, the regulator is malfuctioning and must be repaired or replaced. If no L.P. fuel is present, turn the ignition switch off and replace the wire from the "C" terminal to the "C" terminal.

• Check the oil pressure switch

Turn the ignition switch to "On". If a click in the filter fuelock is heard, the oil pressure switch is not operating properly. If no click is heard, remove the wire from the "C" terminal and touch it to the "NO" terminal. This shorts the switch out. The filter fuelock should click when the switch is shorted out if the switch is working properly.

Check the filter-fuelock for proper operation:

Start the engine.

Remove the wire going to the solenoid section of the fuelock. This should cause the solenoid to close, shutting off the fuel supply, stopping the engine. If the engine continues to operate, replace the filter fuelock.

If the engine stopped as it should have, allow the machine to stand with the L.P. tank valve open and the wire removed from the fuelock. After 10 minutes, operate the starter motor. If the engine starts or fires, L.P. fuel has leaked by the fuelock and the fuelock should be replaced. If it just turned over, the fuelock is operating correctly.

Check the vaporizer for proper operation (liquid withdrawal systems only-water heated)

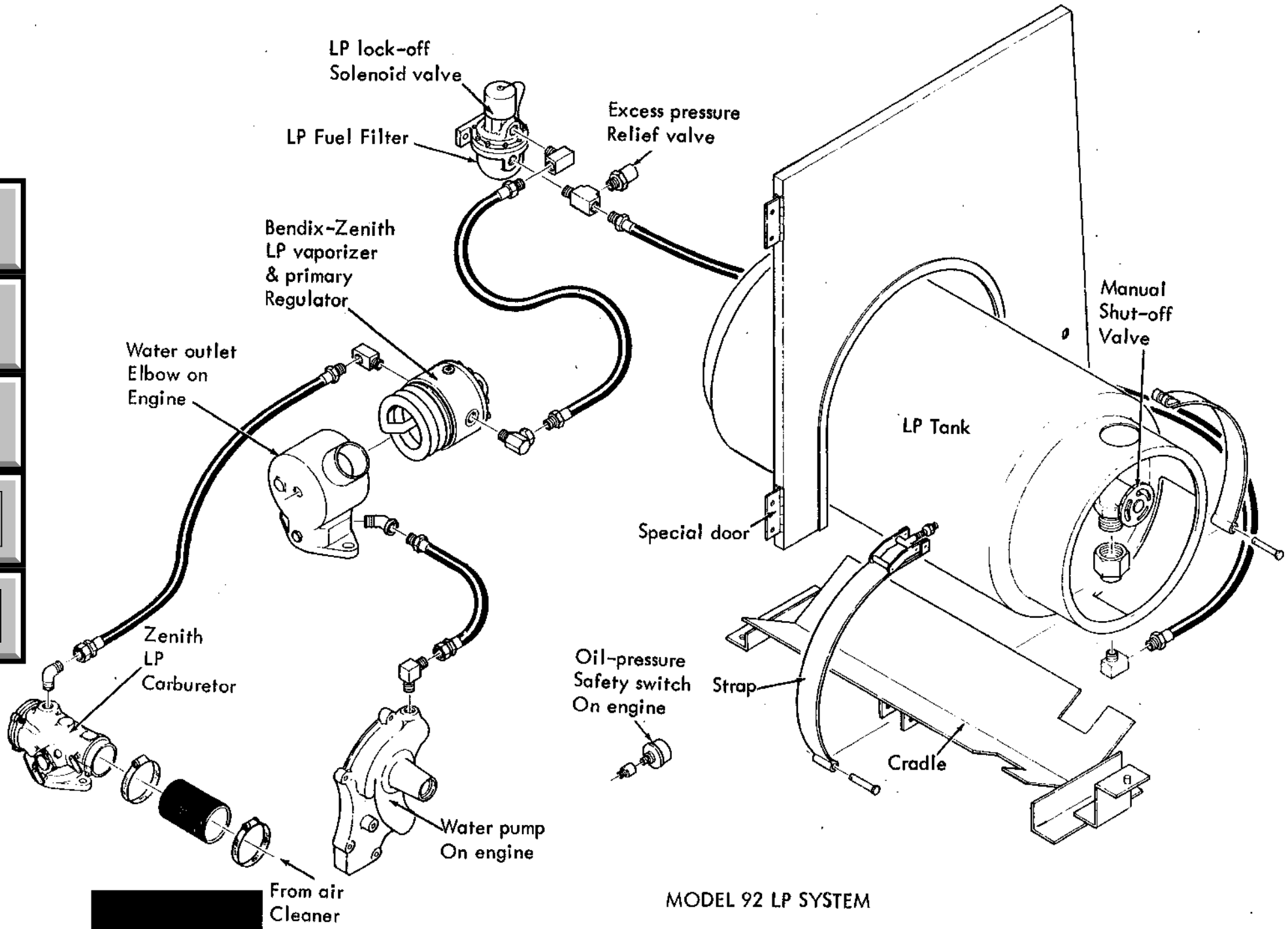
Turn on the ignition switch, short out the oil pressure switch leads and open the radiator cap and check the coolant for bubbles. If bubbles are present, the vaporizer may have a leaking gasket or may have developed a pin hole leak, allowing L.P. fuel to enter the cooling system.

L.P. LIQUID WITHDRAWAL SYSTEM

Liquid withdrawal L.P. fuel systems are made up of six components which are: the L.P. fuel tank, pressure relief valve, filter fuelock, vaporizer, regulator and the carburetor.

Liquid L.P. fuel flows from the L.P. tanks, under its own pressure, to the pressure relief valve. This valve is normally closed, preventing L.P. fuel from escaping into the atmosphere. From the pressure relief valve, the liquid L.P. fuel is piped to the filter fuelock. The filter fuelock filters unwanted tank scale and deposits out of the L.P. fuel. The filter fuelock also stops the flow of L.P. fuel when the engine is not operating or being started. The oil pressure switch controls the fuelock. When the engine oil pressure is 4 psi or greater, the oil pressure switch permits an electrical current to open the fuelock which allows L.P. fuel to flow on to the vaporizer. The oil pressure switch is bypassed when the engine is started, allowing L.P. fuel to flow.

The vaporizer converts the liquid L.P. fuel into a gaseous L.P. fuel. From the vaporizer, the gaseous L.P. fuel is sent to the primary regulator. The primary regulator reduces the pressure of the L.P. fuel and makes the flow more constant. The secondary regulator reduces the L.P. gas pressure to the level required by the carburetor. From the secondary regulator, the L.P. gas is sent to the carburetor where the L.P. gas is finally metered into the air flow which is sent to the combustion chamber.



MODEL 92 LP SYSTEM

L.P. FUEL TANKS

Standard D.O.T. L.P. fuel tank sizes have 14, 20, 33.5, and 43.5 lb capacities. The liquid volume permitted in these containers is less than the total volume of the cylinder, to provide for expansion of the L.P. fuel should the temperature increase a normal amount. Excessive heat may cause the fuel to expand too much, causing the safety relief valve to vent some L.P. fuel, relieving internal tank pressure.

Each tank is marked showing the type of construction (liquid or vapor), the manufacturer, the date of manufacture, the capacity, the tare weight, and the date of re-qualification. D.O.T. L.P. fuel tanks must be re-qualified (checked) periodically. This re-qualification must be recorded and maintained for the life of the container.

L.P. fuel tanks are equipped with the following approved valves and fittings:

A. Safety Relief Valve - This is a spring-loaded valve that relieves excessive pressures which might develop in the tank due to unusual conditions.

B. Service Valve - The L.P. fuel tank may have a vapor service valve or a liquid service valve. The type of equipment burning the fuel would determine the type of service valve to be used.

C. Filler Valve - This valve is optional. If this valve is not present, the tank is filled through the service valve. The filler valve may be either a double back pressure valve, or a positive shutoff valve with an internal back pressure check valve. The filling tube ends in the vapor space of the tank to reduce pressure build-up during filling.

1. Vapor Service Valve - Vapor is withdrawn from the tank through this valve. The L.P. tank may be filled through this valve if the tank is not equipped with a filler valve.

2. Liquid Service Valve - Liquid is withdrawn from the tank through this valve. The tank outlet is fitted with a special coupling. The coupling utilizes spring-loaded check valves to provide a means of quickly connecting or disconnecting the fuel line with a minimum loss of L.P. fuel. The L.P. tank may be filled through this valve if the tank is not equipped with a filler valve.

3. Excess Flow Valve - This valve is part of the vapor service and liquid service valves previously mentioned. It is mounted inside of the tank and prevents L.P. fuel from leaving the L.P. tank in the event of accidental breakage of external fittings or hoses. It permits flow in either direction, but stops outward flow if that flow becomes excessive. The valve is made up of a check that is held in position by a spring. The spring pressure is overcome when there is excess L.P. fuel flow out through the service valve. It will not return to the open position until the pressures are equalized on both sides of the valve. After the flow has been stopped, a small weep hole allows a small amount of L.P. fuel to bleed across the valve, equalizing the pressures.

D. Liquid Level Gauge - This gauge is optional. It is usually a magnetic float gauge with an indicating dial. These gauges will function properly only when the tank is in its normal operating position, unless other wise indicated.

FILLING L.P. TANKS

L.P. fuel tanks are to be filled at regular cylinder filling plants or at designated areas meeting all applicable regulations. Proper L.P. tank filling is of the utmost importance. The person filling the containers must be trained in the safe handling of L.P. fuel

L.P. fuel tanks are to be filled by weight. Magnetic float gauges must not be used as a means of determining the amount of liquid in the container during filling operations. Do not overfill L.P. tanks. An air space must be present inside the tank to allow for expansion of the fuel. Fill tanks to their designated weight.

Whenever an L.P. tank is filled, the tank should be inspected for sharp dents, gouges, leaks, or broken protecting rings. All of the valves must be inspected for leaks, using a soap solution. They also must be checked for dirt, paint, or other debris in the valve openings. The following specific checks must also be made:

Filler Valve – Check for proper functioning and the presence of the handwheel. Valve must be closed except during filling.

Vapor and liquid Service Valves – Check for proper functioning and presence of the handwheel. The valve must be closed except when in service.

Cylinder Service Valve Coupling – Check for proper functioning, thread condition, and damaged, or missing washers or 'O' rings.

Safety Relief Valve – Check for damage. Check for the presence of the relief valve elbow and the proper direction of the elbow. If the rain cap is missing, check for foreign matter and replace cap. Do not tamper with the relief valve setting.

Magnetic Liquid Level Gauge – Check operation against the maximum filling point as determined by weight.

Any tank with any of the above defects must be removed from service and be repaired or destroyed accordingly.

If an L.P. tank is damaged or leaking, it should be removed to a designated safe area and the proper personnel should be notified. Do not attempt to make repairs to the cylinder, regardless of conditions. Repairs must be made by qualified personnel.

The care an L.P. tank receives has a direct bearing on how long that tank can be used safely. L.P. tanks must not be dropped, dragged, or slid across any surface. To move L.P. tanks, use a hand truck, or roll the L.P. tank on its foot ring while it is being held in a position slightly off verticle.

CHANGING MACHINE L.P. TANKS

Refueling machines with L.P. tanks is an important function. Refueling is accomplished by replacing the empty L.P. tank with a full one.

The tank changing operation presents an opportunity for the machine operator to observe, carefully, the tank, tank fittings, and the fuel lines and fittings for his own satisfaction. If abnormal wear is detected, the operator should report his findings to his supervisor for appropriate action.

To begin the tank changing operation, park the machine in a designated safe area and stop the engine. Next, close the tank valve, then remove the quick-disconnect coupling from the tank valve. Observe the machine fuel lines and the quick-disconnect couplings for damage or abnormal wear.

Then, remove the empty tank from the cradle holding device and observe the tank and tank fittings for damage or abnormal wear. Handle the tank carefully; it must not be dropped or mishandled.

Store the L.P. tank in a designated safe area. Select a filled L.P. tank and observe it for damage or leaks. Carefully install the filled tank in the machine so that the tank centering pin enters the aligning hole in the tank collar. This assures that the tank is positioned properly so the safety relief valve, liquid level gauge, and service valves will operate properly. Fasten the tank hold-down clamp (s) so that the tank is locked into position. Reconnect the fuel line to the tank service coupling. Open the service valve slowly and check for leaks. If a leak is found, close the valve immediately and notify the appropriate personnel. If no leaks are found, the engine is ready to start. Do not start the engine unless the operator is in the operator's position with a foot on the brake pedal or parking brake engaged, with the directional control pedal in neutral position.

STORAGE OF L.P. FUEL TANK

Whether the storage is inside or outside, it should not be in the vicinity of combustible materials or high temperature sources such as ovens and furnaces, since the heat may raise the pressure of the fuel to a point where the safety relief valves would function. Care should be taken to insure that the cylinders are stored in such a manner that if the safety relief valves do function, they will relieve vapor, rather than liquid.

Valves on empty tanks must be closed during storage and transportation.

Similar precautions should be taken in storing machines fitted with L.P. fuel tanks. They may be stored or serviced inside buildings, provided there are no leaks in the fuel system, and the tanks are not overfilled. While machines are being repaired inside a building, the shut-off valve on the tanks must be closed, except when the engine must be operated.

While a large amount of safety has been designed into the equipment to make it as "foolproof" as possible, it is necessary for the operator and maintenance personnel to apply a few basic safe practices to assure a good safety record.

This is not unique to L.P. fuel alone. It applies equally well to any mechanical equipment and any fuel.

SERVICE/MAINTENANCE OF L.P. FUEL COMPONENTS

To ensure safe operation of your L.P. equipment, regular maintenance and frequent inspections are important. Listed below are some suggested maintenance tips as well as general tips to promote added safety and efficiency in the operation of your Tennant machine.

- Check for frosting. If frosting occurs on any L.P. component or object near an L.P. component, there is a possibility of an L.P. fuel leak. To locate the leak, apply a soapy water solution to the suspected area. Watch for bubbles forming in a confined area. This area will contain a pin hole. Replace the part which contains the pin hole.

- Check the filter-fuelock for proper operation:

  Start the engine

  Remove the wire going to the solenoid section of the fuelock. This should cause the solenoid to close, shuting off the fuel supply, stopping the engine. If the engine continues to operate, replace the filter fuelock.

  If the engine stopped as it should have, allow the machine to stand with the L.P. tank valve open and the wire removed from the fuelock. After 10 minutes, operate the starter motor. If the engine starts or fires, L.P. fuel has leaked by the fuelock and the fuelock should be replaced. If it just turned over, the fuelock is operating correctly.

  Check the vaporizer for proper operation (liquid withdrawal systems only-water heated)

  Turn on the ignition switch, short out the oil pressure switch leads and open the radiator cap and check the coolant for bubbles. If bubbles are present, the vaporizer may have a leaking gasket or may have developed a pin hole leak, allowing L.P. fuel to enter the cooling system.

- Check all components for proper operation. Replace L.P. components when needed. Never by-pass defective safety components.

- Check routings of all L.P. hoses. Keep them away from sharp edges, exhaust manifolds, or other hot surfaces. Check for signs of abrasion or deterioration.

- Check for gas odor before and during starting operations. If gas odor is noticed, stop and check for leaks or component malfunction.

- Replace electrical wiring if insulation shows signs of abrasion or deterioration.

- Make sure L.P. tank is free of dents or gouges.

- Make sure service coupling is clean and free of damage. Make sure service coupling of tank matches machine service coupling.

- Perform regular maintenance as recommended.

- Never use a match or open flame when searching for an L.P. fuel leak. Always use the soap bubble method.

- There are L.P. fuel sensors available for under $30 which can sense fuel leaks. These sensors are equipped with meters or alarms to indicate the presence of L.P. fuel.

(Continued)

- Every 400 hours or 3 months (whichever comes first) or if any malfunction is noted:

  Completely disassemble the vaporizer-regulator (liquid withdrawal system). See machine manual for instructions and replacement parts.

  Clean all parts in alcohol.

  Inspect parts and replace where needed.

  Carefully reassemble and reinstall in machine.

  Check for proper operation as follows:

  Remove the L.P. hose in which L.P. exits from the regulator. Using a monometer or pressure gauge, check the output of the regulator making sure that it is working according to its proper output specifications. Then, after checking and adjusting or replacing a defective regulator or regulator component, carefully replace the removed L.P. hose.

- Check the oil pressure switch

  Turn the ignition switch to "On". If a click in the filter fuelock is heard, the oil pressure switch is not operating properly. If no click is heard, remove the wire from the "C" terminal and touch it to the "NO" terminal. This shorts the switch out. The filter fuelock should click when the switch is shorted out if the switch is working properly.

- Every 400 hours, replace the filter in the filter fuelock. See machine manual for instructions and replacement parts.

- Keep the engine properly tuned.

- Make sure the L.P. tank matches the fuel system (vapor tank with vapor system, liquid tank with liquid system).

TO START LPG EQUIPPED ENGINE

1. **⚠WARNING** Do not attempt to start the engine unless you are in the driver's seat, with foot on brake pedal or handbrake engaged, and with the directional pedal in neutral.

2. Check gauge on LP tank to make sure there is sufficient fuel.

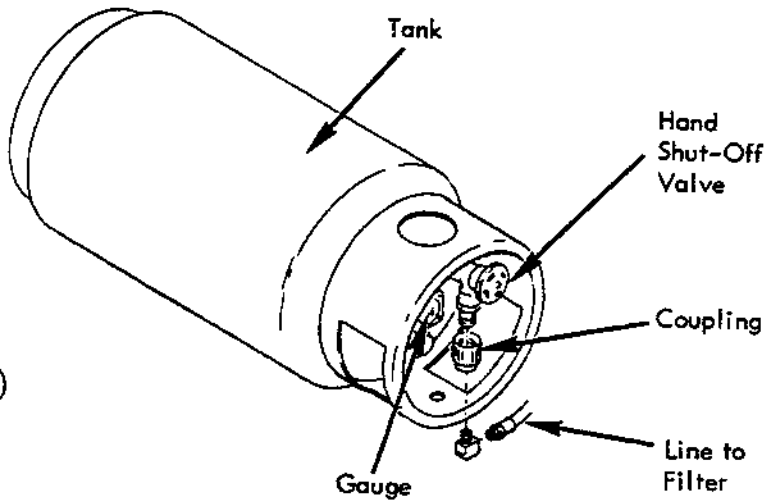
3. SLOWLY open the tank hand valve. (If valve is opened suddenly, automatic shut-off may stop fuel flow.)

4. Insert ignition key and turn to "Start" position momentarily until engine starts. Release key as soon as engine starts. Do not operate starting motor continuously for more than 10 seconds at a time.

5. If engine does not start after several attempts, refer to "LP Fuel Trouble Shooting."

LPG FUEL TANK

The 33 lb (15 kg) capacity tank is mounted in the compartment behind the driver's seat. The tank is a liquid-withdrawal type equipped with a visible gauge which measures the percent of fuel left in the tank. Always fill the tank by weight capacity 33 lb (15 kg) plus the "tare" weight(TW) which is marked on the tank.



The tank must be mounted in one position only. Do not turn the tank in its mounting--this will affect the liquid withdrawal process, because of the shape of the discharge tube inside the tank.

If the tank shut-off valve is opened too quickly, the automatic shut-off valve will close. Open the hand valve slowly to just crack the valve, then close the valve and open slowly.

Always double check to be sure that you have the correct type of tank: This machine requires a liquid withdrawal type of tank.

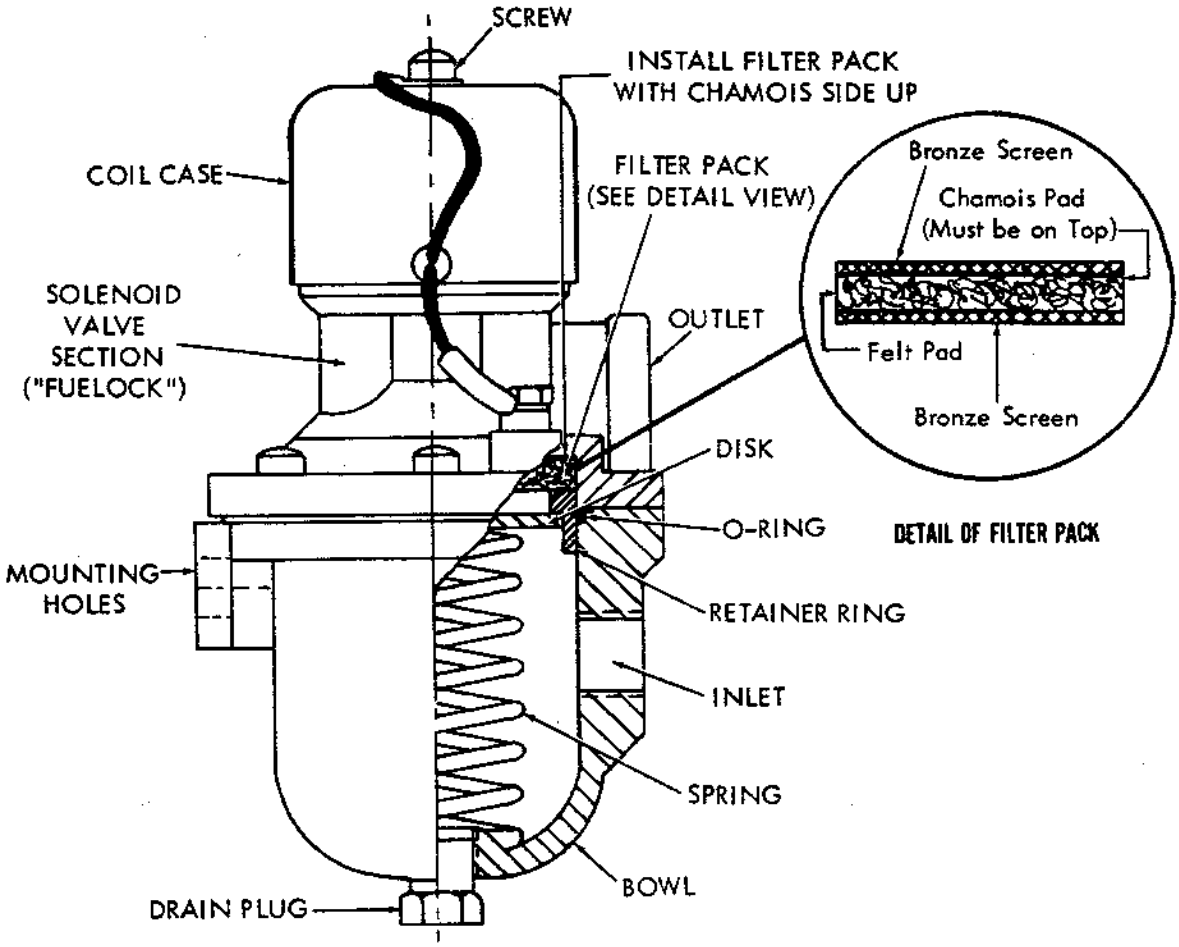
THE FILTER-FUELOCK
(COMBINATION FUEL FILTER AND SOLENOID LOCK-OFF VALVE)

The "Fuelock" is a safety valve which shuts off the fuel flow whenever the engine is turned off.

This unit also filters impurities from the liquid fuel. The filter is necessary because in a liquid withdrawal system the liquid is drawn from the bottom of the tank.

A. THE FILTER SECTION

In this assembly, fuel enters the bowl casting through inlet port in the side of the bowl. Large solid particles, such as tank scale, fall out of the fuel stream and remain in the bowl while the fuel continues to travel upward through the filter pack, where remaining solids are stopped. A drain plug is provided for purging the filter bowl. Clean out the bowl when necessary. Replace the filter pack every 400 hours or when diminished gas flow indicates filter is clogged.



CROSS SECTION DRAWING OF THE FILTER-FUELOCK UNIT, SHOWING CORRECT ARRANGEMENT OF PARTS

REPLACING FILTER PACK

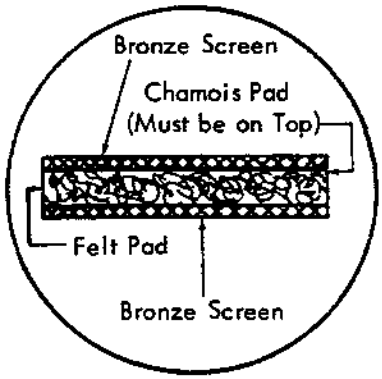
DISASSEMBLY:

1. Shut off fuel supply and run engine to empty fuel lines and filter.
2. Disconnect outlet fuel line from upper fuelock valve section.
3. Remove six screws attaching filter bowl to top section.

⚠CAUTION The spring inside the filter bowl may suddenly push up the top section when the screws are removed.

4. Lift off the top valve section (called "Fuelock" section). Remove the flat disk and spring in the bowl section.
5. Carefully pull out the filter retainer ring, O-Ring, and filter pack (see section drawing and exploded view to identify parts).
6. Discard O-Ring and filter pack.
7. Clean out filter bowl and all parts in solvent. Dry parts with compressed air. Check parts for damage.

INSTALL FILTER PACK
WITH CHAMOIS SIDE UP

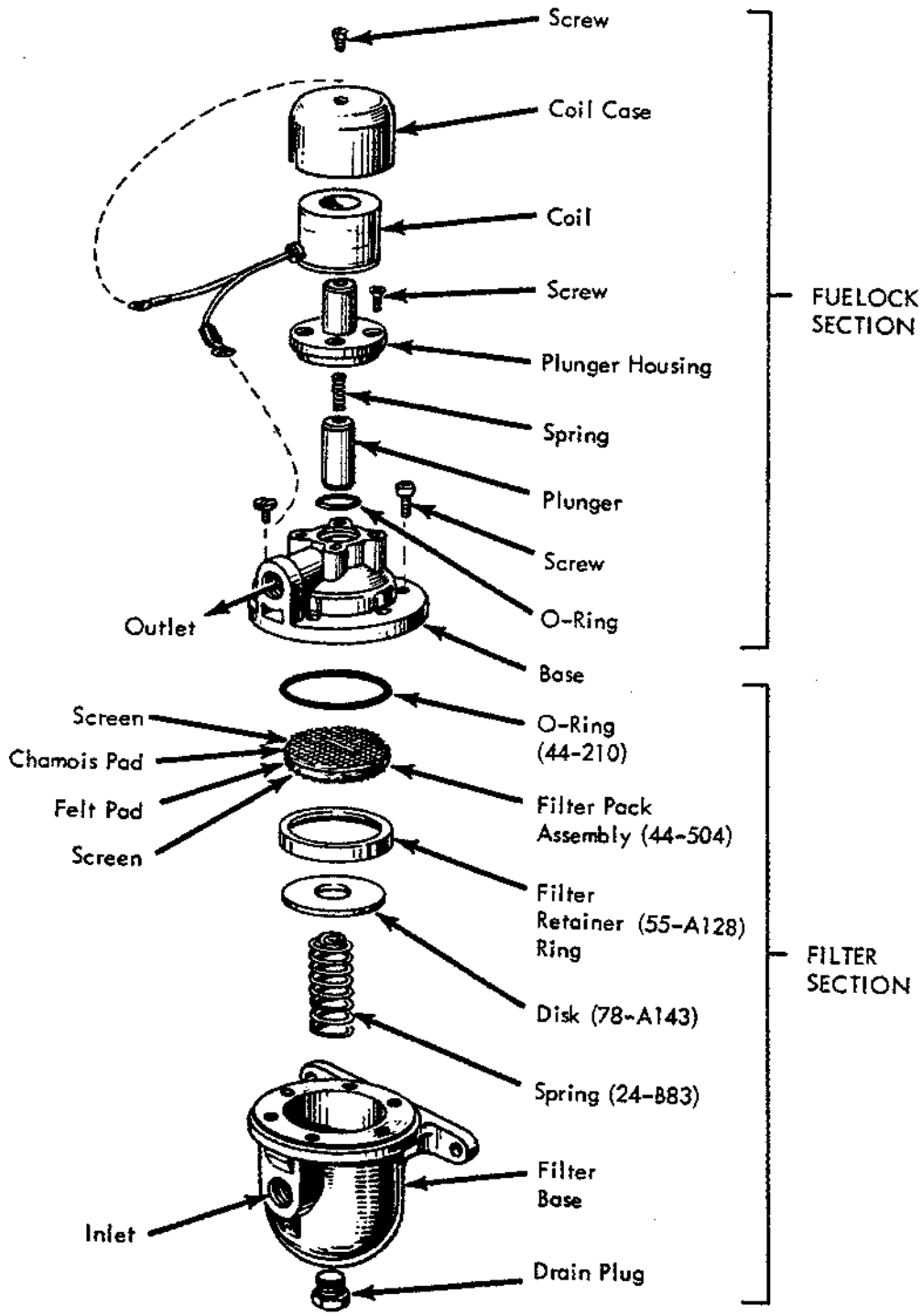


ASSEMBLY:

1. Install new filter pack in recess in top section.
   NOTE Install filter pack with the chamois side up as shown in drawings.
2. Place retainer ring in place and gently tap into position with soft-faced hammer Position retainer as shown in section drawing.
3. Install new O-Ring gasket around retainer ring as shown in section drawing.
4. Place spring in bowl with large open end of spring down. The small end of the spring fits into the retainer ring, as shown in the section drawing.
5. With all parts in their correct relative position, press the top valve section down to compress the spring in the bowl. Then insert the six screws attaching the top section to the bowl and tighten.

NOTE When installing the top section, make sure that the inlet and outlet ports are in the same relative position as they were in before disassembly.

6. Connect outlet line to top valve section outlet port.
7. Open gas valve and check all disturbed connections for leaks.



EXPLODED VIEW OF THE FILTER-FUELOCK

Frost or condensation on any part of the filter assembly indicates a clogged condition or a fuel requirement greater than the capacity of the filter pack. This condition will most frequently be encountered early in the fall of the year on the first cold morning. Under low temperatures, tank pressure is reduced and fuel flow through the filter will decrease considerably. If it is restricted, the frost or condensation will form due to expansion of the fuel as it passes by the restriction.

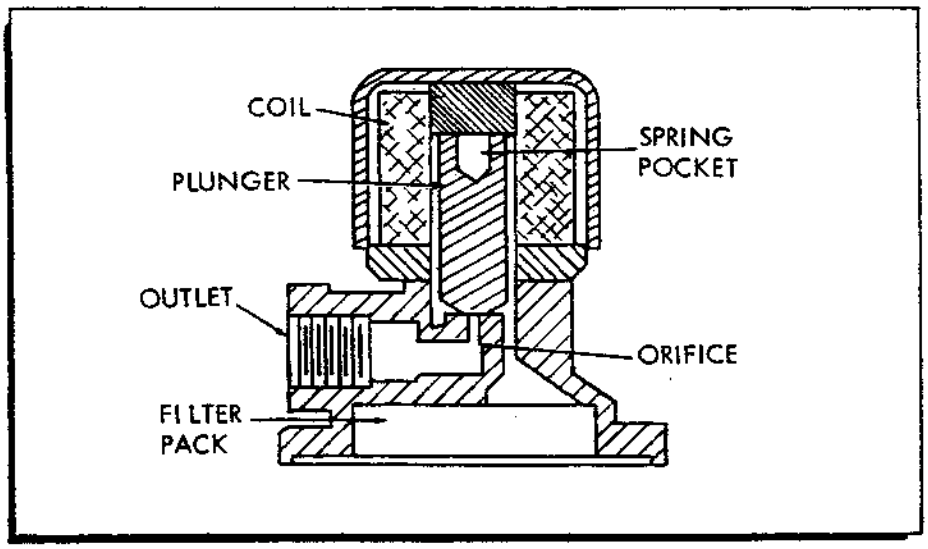
Any apparent shortage of fuel should result in an immediate inspection of the filter to assure that it is not responsible. This is best done by temporarily bypassing the filter and running the engine to see if the problem is eliminated. DO NOT CONTINUE THE OPERATION WITHOUT CORRECTING THE CAUSE AND CONNECTING THE FILTER BACK INTO THE FUEL SYSTEM.

B. THE FUELOCK SECTION (SOLENOID-OPERATED LOCK-OFF VALVE)

OPERATION:

Fuelock plunger is held against orifice by a combination of weak spring pressure and fuel tank pressure which surrounds the plunger by appearing in the entire plunger housing. (See cross section drawing of Fuelock section.)

When battery voltage is applied to the coil a strong magnetic field is formed and draws the plunger away from the orifice, thus allowing fuel to flow out through outlet port.



CROSS SECTION OF THE FUELOCK (SOLENOID-OPERATED VALVE)

REPAIR OF THE FUELOCK SECTION

A. To Replace Coil

1. Remove singlescrew retaining coil case and single screw holding coil lead to terminal post (see exploded view and cross section drawing).
2. Lift case and coil off fuelock plunger housing.
3. Pull old coil from case and insert new coil. MAKE SURE PROPER VOLTAGE COIL IS USED (12-volt).
4. Replace case and coil and screws.

NOTE The coil may have insulated terminal on one lead only. This lead is attached to the terminal post. Be sure other coil lead is grounded to the fuelock assembly with the case retaining screw.

B. To Replace Plunger

1. Remove case and coil (see exploded view).
2. Remove four flat Phillips head screws retaining plunger housing on casting. Lift off plunger housing and remove plunger and spring.

NOTE The spring is small and can easily be dropped and lost. Be sure there is no fuel pressure in the filter bowl before loosening the plunger housing screws.

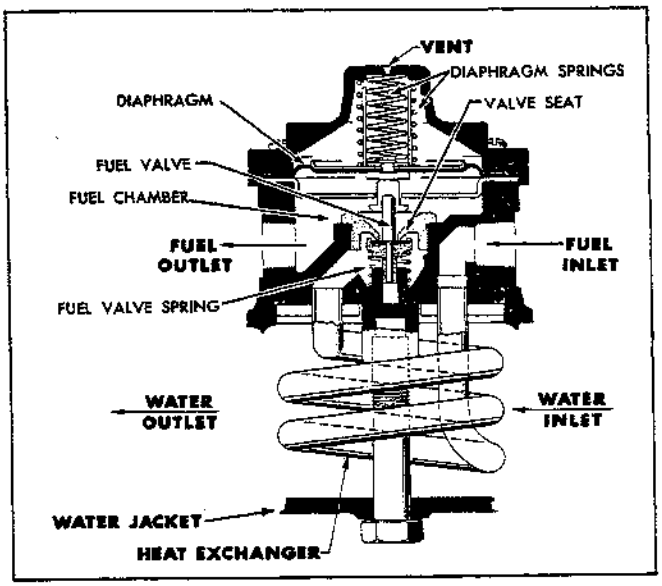
3. Clean housing and spring. Discard oil "O" ring seal around base of housing. Inspect orifice for dirt, nicks or other damage.
4. Locate new "O" ring on housing. Install spring in new plunger and slide UPWARD into housing. Place housing and plunger assembly into position on fuelock casting and insert and tighten four screws.
5. Test assembly for leaks by applying air pressure at filter bowl inlet and using soap solution over all disturbed points.
6. Replace coil and case assembly.

When servicing any fuelock assembly, make certain that it is preceded by a good, clean filter. Foreign material which can reach the fuelock valve area will result in leakage and possibly sticking problems. A complete repair kit, is available to service STF filter fuelock assemblies. All normally serviceable parts are included (no coil) as well as a filter pack, pack retainer and filter bowl gasket.

TENNANT NO. 54238 LP VAPORIZER (ZENITH MODEL A962A-1)

DESCRIPTION

The Type A962A-1 Vaporizer consists of a high pressure regulator and a vaporizer combined into a single unit. The regulator section is at the top, with the vaporizer or heat exchanger section at the bottom. The high pressure regulator reduces the LP fuel tank pressure to a uniform outlet pressure. The vaporizer section located inside of a cast iron jacket receives heat from the engine cooling system to offset the cooling effect produced as the LP liquid fuel is vaporized in the heat exchanger coil.



OPERATION

The liquid fuel is admitted at the fuel inlet port and passes through the heat exchanger coil where the fuel absorbs heat from the engine cooling system before it reaches the regulator pressure valve. As long as the engine is running and pressure at the outlet side of regulator is slightly less than 10 psi (69 kPa), the valve remains partially open to admit fuel through the vaporizer-regulator to the final stage regulator and carburetor. With the engine shut off, the pressure below the regulator diaphragm increases to 10 psi in the fuel chamber. The increase in pressure against the lower side of the diaphragm compresses the diaphragm spring and lifts the diaphragm to permit the valve spring to close the valve and cut off the supply of LP fuel at the valve.

DISASSEMBLY

The first step in servicing the Vaporizer is to remove the vaporizer assembly from its water casting. To avoid damaging threads in the aluminum vaporizer body, it is important to proceed as follows:

(Continued on next page)

DISASSEMBLY OF VAPORIZER (continued)

1. Take out assembly bolt and gasket. Loosen Vaporizer assembly and remove from water casting.

2. Remove the four screws that secure the vaporizer coil and mounting plate to the vaporizer body. Discard the vaporizer coil O-Rings and the water casting O-Ring.

3. Remove diaphragm cover screws as follows:

   Select any four opposite cover screws and remove them, then insert C161-195 studs in their place. Maintain pressure on the diaphragm cover while taking out the remaining four screws.

4. Release pressure on diaphragm cover, and remove cover, diaphragm springs and vibration damper, then remove the C161-195 studs. Next, remove diaphragm, baffle plate, baffle plate gasket and fuel valve cap.

5. Remove valve seat with a 1 in (25.4 mm) socket wrench and discard valve seat O-ring. Also, remove the fuel valve assembly together with fuel valve spring.

This completes the disassembly of the Vaporizer. Clean all parts in alcohol (isopropyl). Do not use any of the carburetor cleaning solvents to clean any part of the Vaporizer. This type of cleaner will destroy the impregnation used in the casting and the coating on the coil. Check for wear or damage and discard all imperfect parts.

REASSEMBLY

1. Place fuel valve spring over boss in center of vaporizer body and place fuel valve on spring with shortest stem toward casting. Make sure top of spring is resting on machined shoulder of fuel valve.

2. Place a new valve seat O-Ring on valve seat, and install valve seat in vaporizer body. Tighten valve seat with a 1" socket wrench.

3. Place fuel valve cap on fuel valve stem.

4. Install four C161-195 studs in alternate holes in top of vaporizer body and then install a new baffle plate gasket, baffle plate, recessed side down, and diaphragm, flanged disc up. Use C161-195 studs to align parts.

   Make sure fuel valve cap enters hole in center of baffle plate.

5. Place vibration dampener inside of outer diaphragm spring, place inner spring over center of diaphragm plate and position outer spring over inner diaphragm spring. Install and depress diaphragm cover far enough to start and seat lightly, the four opposite diaphragm cover screws.

(continued on next page)

6. Remove C161-195 studs and install remaining four diaphragm cover screws. Tighten screws evenly and moderately tight.

7. Place a new water casting O-Ring on the vaporizer body and two new O-Rings over ends of the vaporizer coil on top of the mounting plate.

8. **NOTE** If the four holes in the coil mounting plate fail to line up with the threaded holes in the vaporizer body, turn vaporizer coil assembly 1/2 turn (180°). Attaching screw holes will not line up until vaporizer coil assembly is properly positioned. Install and tighten the four mounting plate attaching screws.

This completes the assembly of the vaporizer.

PRESSURE TESTS

1. Connect a 0 to 30 psi (0 to 206.9 kPa) gauge to one of the three vaporizer outlets. Close the remaining outlets with 0.25 in (6.35 mm) pipe plugs.

2. Connect vaporizer inlet to a source of compressed air, or tank vapor. Loosen gauge connection until it leaks, then retighten and read pressure. Gauge should register a pressure of between 9 and 11 psi (62 and 75.8 kPa) and remain steady. If it creeps up, it indicates that vaporizer valve or valve seat is leaking. If leak is indicated, eliminate leak by cleaning or replacing valve parts as necessary.

LEAK TESTS

1. Cover vent hole in diaphragm cover with bubble solution. If bubbles form at this this point, diaphragm is leaking. Replace diaphragm and recheck for leak.

2. Check with bubble solution for leaks around diaphragm cover. If bubbles form, replace baffle plate gasket.

3. Check for leaks at pipe plugs. If bubbles form, apply pipe plug compound and tighten plugs.

4. Check for leaks of vaporizer coil mounting plate. If bubbles form, replace O-Rings.

L.P. FUEL TROUBLESHOOTING

	Won't Start	Stops During Operation	Runs Unevenly–Lacks Power
(1) Fuel Tank	Check fuel tank type and fuel supply (vapor tank for vapor with–drawal system) Be sure tank hand valve is open (always open valve slowly). If hand valve is opened too fast, shut–off valve in tank will automatically shut off fuel supply. If this happens, shut hand valve and then re–open it slowly.	Out of fuel Check fuel tank type and fuel supply (liquid tank for liquid with–drawal system)	Tank valve not opened sufficiently. Tank could be overfilled. Check fuel tank type and fuel supply (liquid tank for liquid withdrawal system.
(2) Fuel Lines	Check lines, connections, leaks, etc., using soap bubble test method. When changing fuel tanks, always be sure fuel is getting into carburetor. Crank engine briefly and push primer button until vapor fumes are smelled or are visible at carburetor, or around air filter. Check fuel tank and lines for frosting up. To relieve frosting, open shut–off valve slowly (approximately one–fourth open). Start engine and idle until warm. Then open tank valve completely before loading the engine. If frost forms on connection fittings, check for fuel leakage, kinked lines or restriction at frost points. Check fuel filter. Remove and clean if dirty filter is restricting fuel line. Check quick–disconnect fitting at tank: if tank valve is not properly seated, no fuel will flow through the line. Broken fuel line or loose connection could cause the tank shut–off valve to close.	Broken fuel line or loose fuel line connection could cause tank internal shut–off valve to close automatically and shut off the fuel supply.	

(continued on next page)

L.P. FUEL TROUBLESHOOTING (Continued)

	Won't Start	Stops During Operation	Runs Unevenly–Lacks Power
(3) Ignition System	Remove and check spark plug to be sure it is the correct type with proper gap. Check ignition points and condenser. Check coil. Check ignition switch . Check wiring for loose connections or wire breakage. Check battery terminals for corrosion or loose ground cable. Check possible shorts in wiring Battery dead. No current to "Filter–Fuelock"solenoid valve or possible defective solenoid.	Check electrical system for loose connections or intermittent shorts. Check spark and electrical system for malfunction of condenser, points etc. Check for broken wires or defective relay. Relay can be checked by by–passing relay and directly energizing the solenoid valve in "Filter–Fuelock"	Check ignition for poor connections or weak or worn ignition parts.
(4) Carburetor	Always check carburetor for proper settings before tampering with regulator adjustment. Flooded carburetor – shut off tank valve with ignition switch "On", crank engine through a few times. If the engine starts, then slowly open tank valve to provide fuel flow through line. If engine does not start before opening fuel tank valve, then choke engine and use standard starting procedure.	Restricted air cleaner Clean or replace filter element.	Check carburetor setting. Check ignition system.
(5) Regulator	Be sure carburetor is properly adjusted before attempting to adjust regulator setting. Check vaporizer regulator. Be sure it is functioning properly. In trouble shooting, be sure all of the previous five check points have been checked thoroughly before making any adjustment to regulator.	Only after checking the carburetor setting, should the regulator be checked (too rich or too lean). Could very definitely affect operation if carburetor adjustment is correct.	Could be improper setting. Allow too rich or too lean mixture to carburetor. Check and adjust only after checking carburetor Adjustment.

(continued on next page)

L.P. FUEL TROUBLESHOOTING (continued)

	Won't Start	Stops During Operation	Runs Unevenly-Lacks Power
(6) Engine	Under ordinary circumstances a new engine should start easily if the components previously mentioned have been checked through and properly adjusted. On an older engine, if proper adjustment on other components are correct it is possible that major repairs may be required to the basic engine.	Check Engine Trouble-Shooting Chart in Machine Manual.	See Engine Trouble-Shooting Chart in Machine Manual

NOTE Always check through L.P. Fuel system in order of numerical sequence.