

MM 105

6-84



280 **Operation & Maintenance Section**

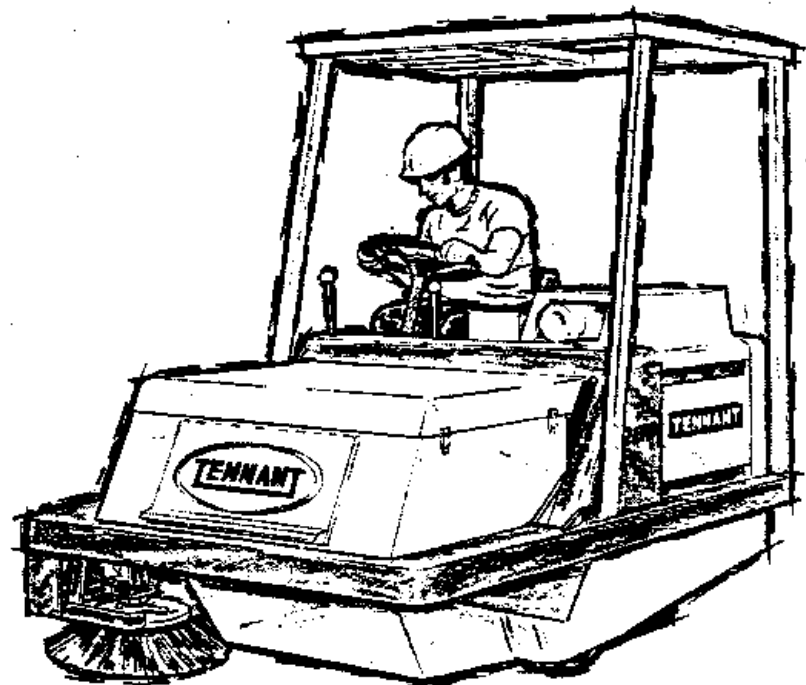
POWER SWEEPER

Operation, Maintenance, and Parts Manual

Gasoline, LPG, and Diesel Engine

Includes High Dump Model

First Serial Number 2206



SPECIALIZED MAINTENANCE EQUIPMENT
SWEEPERS • SCRUBBERS • SCARIFIERS • FLOOR COATINGS



280

POWER SWEEPER

This manual is furnished with each new TENNANT® Model 280. The machine operators will easily learn how to operate the machine and understand its mechanical functions by following the directions and absorbing the information in the Operation section.

This machine will give excellent service and sweeping results, and save maintenance expenses. However, as with all specially engineered mechanical equipment, best results are obtained at minimum costs if:

- The machine is operated with reasonable care and
- The machine is maintained regularly — per the maintenance instructions provided.
- Components used in this machine have been carefully selected for performance and safety. Use only Tennant Company supplied or equivalent parts.

Parts and supplies may be ordered by phone or mail from any Tennant Company parts and service center, distributor, or from any of the Tennant Company subsidiaries.

The telephone, telex, mailing addresses, and locations are listed on the last page of the manual.

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Published: 6-84

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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.

Battery and tires will be replaced if failure occurs due to defective material or workmanship within 90 days from date of purchase. Thereafter, a pro rata adjustment from date of purchase to 12 months will be made. The pro rata adjustment price of the new battery and/or the new tire will be the Tennant Company current price as of the adjustment request less 1/12th of that price for each month remaining in the 12-month period. All warranty applies only to batteries and tires purchased from Tennant Company and installed in vehicles used in normal service.

Brushes that fail due to defective material or workmanship will be replaced on a pro rata basis within the first 12 months of purchase. The replacement price will be calculated by multiplying the current Tennant Company price by the percentage of usable bristle remaining at the time of adjustment.

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 and 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
P. O. Box 1452
Minneapolis, MN 55440
(612) 540-1200

TENNANT COMPANY REPRESENTATIVE

ENGINE DEALER



SAFETY PRECAUTIONS

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 could result in equipment damage.

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.

RECOMMENDED SWEEPING BRUSHES

TENNANT

Part No.	Descriptions	Size
53063	HIGH DENSITY COMBINATION, natural fiber & crinkle wire—adds stiffness, increases brush life.	42 in (1,066 mm) 24 row
53064	NATURAL FIBER, ideal for sweeping average soilage	42 in (1,066 mm) 8 row
53065	CRINKLE WIRE, provides maximum cleaning action for heavy semi-impacted soilage & hard-to-sweep dirt:	42 in (1,066 mm) 8 row
53067	COMBINATION, crinkle wire & natural fiber	42 in (1,066 mm) 8 row
53068	NYLON, combines long life with excellent sweeping qualities (lasts about 2 1/2 times longer than natural fiber)	42 in (1,066 mm) 8 row
53069	PATROL, nylon for outside, med/light bulky debris	42 in (1,066 mm) 5 row
53070	HIGH DENSITY NYLON	42 in (1,066 mm) 24 row
53221	PROEX & WIRE, resilient bristles for sweeping medium heavy soilage	42 in (1,066 mm) 8 row
09600P	POLYPROPYLENE—Side sweeper	21 in (533 mm) dia
09600N	NYLON—Side sweeper	21 in (533 mm) dia
10712K	FLAT WIRE—Side sweeper	
43708 P	POLYPROPYLENE—Side sweeper (with adaptor)	
43708N	NYLON—Side sweeper (with adaptor)	
43708K	WIRE—Side sweeper (with adaptor)	
43708J	WIRE & FIBER—Side sweeper (with adaptor)	

SCRUBBING BRUSHES

TENNANT

Part No.	Description	Size
43424	POLYPROPYLENE, stiff - front	38 in (965 mm) 24 row
43592	POLYPROPYLENE, medium stiff - front	38 in (965 mm) 24 row
43428	STAINLESS STEEL - front	38 in (965 mm) 20 row
43393	ABRASIVE ROLL, stripping - front	38 in (965 mm) strip
53155	NYLON, Rear	42 in (1,066 mm) 8 row
43148	FIBER, stiff - side scrubber	14 in (356 mm) dia
43593	FIBER, medium stiff - side scrubber	14 in (356 mm) dia
43417	STAINLESS STEEL - side scrubber	14 in (356 mm) dia
46857	POLYPROPYLENE - side scrubber (with U-Joint) stiff	
46858	POLYPROPYLENE - side scrubber (with U-Joint) medium stiff	
46859	STAINLESS STEEL - side scrubber (with U-Joint)	
43680	ABRASIVE, bristle, heavy, .050 ga	38 in (965 mm) 24 row

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TENNANT COMPANY, TENNANT COMPANY SUBSIDIARIES,
AND MAJOR PARTS AND SERVICE LOCATIONS DIRECTORY

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	4	8	16	32	64	1.000000	25.400000

STANDARD BOLT TORQUE CHART

STANDARD TIGHTENING REQUIREMENTS FOR NORMAL ASSEMBLY APPLICATIONS

Bolt Thread Size (in)	SAE Gr. 5 Minimum		SAE Gr. 8 Minimum		Carr Bolts & B RH SSQ Bolts Minimum Torque Ft Lbs (Nm)
	Torque Ft Lbs (Nm)		Torque Ft Lbs (Nm)		
	Plain	Plated	Plain	Plated	
0.25	8(11)	7(10)	12(16)	10(14)	4(5)
0.31	18(24)	15(20)	26(35)	21(29)	8(11)
0.38	31(42)	25(34)	48(65)	39(53)	15(20)
0.44	53(72)	43(58)	75(102)	60(81)	26(35)
0.50	82(111)	66(90)	115(156)	92(125)	38(52)
0.56	170(231)	140(190)	235(319)	190(258)	70(95)
0.75	290(393)	230(312)	415(563)	330(448)	130(176)
0.88	430(583)	340(461)	600(814)	480(651)	140(190)
1.0	640(868)	510(692)	900(1220)	720(976)	210(285)



NOTE: Increase the torque by 20% when using engine oil or chassis grease as a thread lubricant.

EXCEPTIONS TO THE ABOVE STANDARD:

Motor axle nuts: 200-250 ft lbs (271-339 Nm)

Scrub brush motor porting block socket head bolts: 18-20 ft lbs (24-27 Nm)

BOLT IDENTIFICATION

Identification Grade Marking	Specification and Grade
	SAE-Grade 5 ASTM-A 449
	SAE-Grade 8 ASTM-A 354
	Grade BD

All hardware is of grade 5 unless specifically stated otherwise.

HYDRAULIC TAPERED SEAT FITTING (JIC) TORQUE CHART

Tube O.D. (in)	Thread Size	Maximum Torque
0.25	0.44"-20	9 ft lbs (12 Nm)
0.38	0.56"-18	20 ft lbs (27 Nm)
0.50	0.75"-16	30 ft lbs (41 Nm)
0.62	0.88"-14	40 ft lbs (54 Nm)
0.75	1.12"-12	70 ft lbs (95 Nm)
1.0	1.31"-12	90 ft lbs (122 Nm)

HYDRAULIC O-RING FITTING TORQUE CHART

Tube O.D. (in)	Thread Size	Minimum Torque	Maximum Torque
0.25	0.44"-20	6 ft lbs (8 Nm)	9 ft lbs (12 Nm)
0.38	0.56"-18	13 ft lbs (18 Nm)	20 ft lbs (27 Nm)
0.50	0.75"-16	20 ft lbs (27 Nm)	30 ft lbs (41 Nm)
0.62	0.88"-14	25 ft lbs (34 Nm)	40 ft lbs (54 Nm)
0.75	1.12"-12	45 ft lbs (61 Nm)	70 ft lbs (95 Nm)
1.0	1.31"-12	60 ft lbs (81 Nm)	90 ft lbs (122 Nm)

NOTE: Do not use sealant on o-ring threads.

HYDRAULIC TAPERED PIPE FITTING (NPT) TORQUE CHART

NOTE: Ratings listed are when using teflon thread seal.

Size	Minimum Torque	Maximum Torque
1/4 NPT	10 ft lbs (14 Nm)	30 ft lbs (41 Nm)
1/2 NPT	25 ft lbs (34 Nm)	50 ft lbs (68 Nm)
3/4 NPT	50 ft lbs (68 Nm)	100 ft lbs (136 Nm)

RECOMMENDED GENERAL MAINTENANCE ITEMS

01973

KEY	TENNANT® PART NO.	MACHINE SERIAL NUMBER	DESCRIPTION	QTY.
	59474	(-)	REPLACEMENT PARTS PACKAGE, Gasoline engine	1
	45770-7	(-)	PLUG, Spark	4
	45631	(-)	CONDENSER	1
	37420	(-)	POINT SET	1
	37421	(-)	ROTOR	1
	45662	(-)	BELT	1
	53055-2	(-)	ELEMENT, Oil filter	2
	53165A	(-)	V-BELT	1
	51561	(-)	ELEMENT, Air cleaner	2
	59473	(-)	REPLACEMENT PARTS PACKAGE, High dump	1
	SK1511	(-)	REPLACEMENT KIT, Fusible link	1
	53298	(-)	SKIRT	1
	23275	(-)	SKIRT, Shroud	2
	53137	(-)	SKIRT	1
	53431	(-)	ELEMENT, Pressure relief filter	1
	23386	(-)	SEAL, Top pan	1
	35607	(-)	LIP ASSEMBLY	5
	37021	(-)	LIP, Side	2
	23382	(-)	SEAL, Side pan	2
	53348-1	(-)	ELEMENT, Oil filter	1
	59471	(-)	REPLACEMENT PARTS PACKAGE, Low dump	1
	SK1511	(-)	REPLACEMENT KIT, Fusible link	1
	53298	(-)	SKIRT	1
	23275	(-)	SKIRT, Shroud	2
	53137	(-)	SKIRT	1
	53431	(-)	ELEMENT, Pressure relief filter	1
	48060	(-)	LIP, Rubber	5
	53348-1	(-)	ELEMENT, Oil filter	1
	23386	(-)	SEAL, Top pan	1
	23382	(-)	SEAL, Side pan	2
	59475	(-)	REPLACEMENT PARTS PACKAGE, Diesel engine	1
	32904	(-)	V-BELT	1
	52770-5	(-)	ELEMENT, Oil filter	2
	52770-9	(-)	ELEMENT, Fuel filter	2
	27179	(-)	V-BELT	1
	51561	(-)	ELEMENT, Air cleaner	2
	59472	(-)	REPLACEMENT PARTS PACKAGE, Scrubber	1
	43323	(-)	BLADE, Squeegee, gum	2
	43324	(-)	BLADE, Back up, neoprene	1
	43292	(-)	BLADE, Squeegee, gum	2
	43322	(-)	BLADE, Front, rubber	2



SPECIFICATIONS

FOR

TENNANT MODEL 280 POWER SWEEPER

General Information

SWEEPING PATH WIDTH	53 inches (1346mm)
SWEEPING SPEED	0 to 6 mph (recommended) (0 to 9.6 km/hr)
TRAVEL SPEED	0 to 10 mph (0 to 16.1 km/hr)
TURNING RADIUS	Left (vehicle clearance)- 62 in. (1575mm) Right (vehicle clearance)-82 in. (2083mm)
ISLE WIDTH TURN	Left-105 in. (2667mm) Right-156 in. (3962mm)
DIMENSIONS	See "Dimension" Drawings
WEIGHT	Net (with battery and standard brushes)
Standard Diesel machine 2830 lbs (1284kg)	Standard gas machine: 2670 lbs (1211kg)
Hi-Dump Diesel machine 3435 lbs (1558kg)	Hi-Dump gas machine: 3275 lbs (1485kg)

MECHANICAL DATA

FRAME	.187 in. (4.75mm) electrically-welded steel plate, reinforced at stress points. Channel shaped bumper around entire frame.
ENGINE	(See "Engine Specifications")
HYDRAULIC TANK	Tank capacity: 4 gallons (15.1 liters) System Capacity: 5 gallons (18.9 liters)
COOLING SYSTEM	8.3 quarts (7.85 liters)
REAR TIRE PRESSURE	Sweeper: 80 to 85 psi (552 to 586 kPa) Scrubber: 70 to 75 psi (483 to 517 kPa)
RECOMMENDED MAXIMUM RAMP CLIMBING AND DESCENDING ANGLES	See Chart under "General Operating Suggestions" In Operation Chapter.

MECHANICAL DATA

GAS TANK	8 gallon (30.3 liters) capacity (located under seat)
BATTERY	12 volt, automotive - type lead - acid, 84 amp (located under floor panel)
PROPELLING DRIVE	Direct - coupled, engine - driven, variable - volume, piston pump. Pump provides infinitely variable flow to direct rear - wheel - mounted hydraulic motor. Engine runs at constant speed.
BRUSH AND VACUUM FAN DRIVE	Hydraulic - motor - driven vacuum fan, main sweeping brush, and side brush. All motors are on single "on-off" control. Separate shut-off for side brush. Hydraulic motors driven by direct mounted pump on the engine.
MAIN BRUSH	42"(1070mm) tubular, one - piece disposable unit. 14" (355mm) diameter with 3.50" bristle length. Brush can be operated in either "Free Float" or "Restricted Down" position. Brushes available in various bristle combinations to suit the sweeping conditions.
BRUSH COMPARTMENT	Brush completely enclosed by heavy .187" sheet steel, rigidly braced, sealed against dust leakage. Replaceable oil resistant rubber skirts with plastic fiber ply reinforcement provide dust seal to floor. Dust sealed access doors are provided on both sides. A rear rubber strip deflector prevents loss of swept material carried over the brush. Rear brush suspension provides automatic clearance adjustment to this deflector as brush wears.
SIDE BRUSH	Rotary, disposable type, 21 inch (530mm) diameter (across outer bristle ends). Brush can be raised when not in use. The brush is protected by a rigid bumper. Other side brushes are available. Shut-off control for side brush provided.
FILTER AREA	Enclosed type filter system includes multiple dust filters to provide a total filtering area of 130 sq. ft. (12.1m ²) Filter system is in separate compartment above debris hopper, and has a shut-off door controlled by a fusible link to close off air flow in case of a fire in the debris area. Filters are cleaned through vibration of an eccentric weight on two motors fixed to steel rods on the bottom of each filter envelope.

(continued on next page)

MECHANICAL DATA (Continued)

VACUUM CONTROL

High volume 9 inch (230mm) diameter fan driven by hydraulic motor. Fan shuts off with main brush.

HOPPER

14 cu. ft. (0.40 cu. m) hopper holds over one-half ton of soilage. Hopper is constructed of heavy sheet steel with spill-resistant opening. An 8" x 24" front access opening provided for hand loading of bulky objects and to check loading of hopper.

Hopper dumps hydraulically in 10 seconds. Hopper can be held in up position with hydraulic control in "Hold" position. A mechanical safety lock arm is provided if work is being done under the hopper or lift arms.

Standard Hopper is designed to allow "floating" action which allows hopper vertical movement for passing over objects up to 2" (51 mm) above the floor level.

STEERING

Automotive, recirculating - ball type with single rear wheel steering. A 100 degree steering angle provides narrow isle turns. A horn button is provided on the steering wheel.

PROPELLING CONTROL

One foot pedal controls rate of travel and directs instant forward or reverse motion.

BRAKES

Hydraulic service brakes and mechanically actuated parking brakes on the front wheels. A separate foot pedal is provided for the hydraulic service brakes.

BRUSH AND FAN CONTROL

A 4-position hydraulic valve provides:

1. Hopper raise
2. Hopper hold
3. Hopper down and brush & fan motors off
4. Brush and fan motors on

Separate control valve for side brush shut-off
Separate control valve for Hi-Dump hopper roll-out.

LUBRICATION

All ball bearings on rotating shafts are lubricated for life and sealed.

TIRES

REAR: pneumatic 5.00-8, 8 ply, 18.46 in. (468.9 mm) diameter, steel guard insert.

FRONT: 2 zero pressure, heavy service rubber, 16 in. (406 mm) diameter.

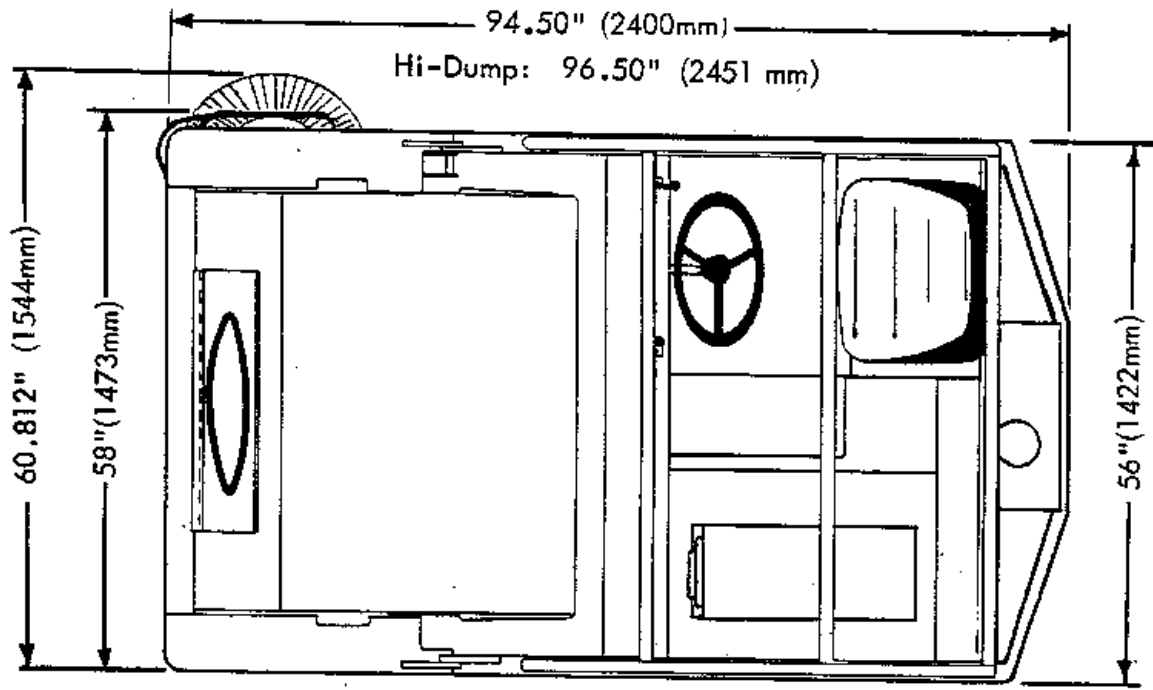
GASOLINE OR LPG ENGINE SPECIFICATIONS

ENGINE MANUFACTURER.....	TELEDYNE CONTINENTAL MOTORS
MODEL.....	Y112 L-HEAD
WEIGHT (Bare Engine).....	290 lbs. (131.5kg)
NUMBER OF CYLINDERS.....	4
FIRING ORDER.....	1-3-4-2
DISPLACEMENT.....	112 cubic inches (1835cc)
CYLINDER BORE.....	3.187 inches (80.95mm)
PISTON STROKE.....	3.50 inches (88.9mm)
HORSEPOWER.....	33 H.P.
COMPRESSION RATIO.....	8.00 to 1
OIL CAPACITY, Crankcase.....	3.50 qts (3.3 liters)
OIL CAPACITY, with Filter.....	4 qts. (3.8 liters)
INTAKE VALVE CLEARANCE.....	.012 inches (0.30 mm)
EXHAUST VALVE CLEARANCE.....	.020 inches (0.51 mm)
BREAKER POINT GAP.....	.022 inches (0.55 mm)
SPARK PLUG GAP.....	.025 inches (0.6 mm)
SPARK PLUG TORQUE.....	35 ft lb (47.5 Nm)
IGNITION TIMING.....	T. D. C.
BATTERY.....	12 Volt, 60 amp.
ALTERNATOR.....	12 VOLT, 35 amp.
REGULATOR-RECTIFIER.....	SOLID-STATE TYPE
ENGINE SPEED.....	Sweeper: 1750 to 1850 rpm (min.) Sweeper-Scrubber: 1900 to 2000 rpm (min.)
STARTER.....	12 VOLT, SOLENOID SHIFT
CHOKE.....	REMOTE MANUAL TYPE

DIESEL ENGINE SPECIFICATIONS

ENGINE MANUFACTURER	PERKINS ENGINES, LTD
MODEL	4.108 DIESEL
WEIGHT (Bare Engine)	450 lbs. (204kg)
NUMBER OF CYLINDERS	4
FIRING ORDER	1 - 3 - 4 - 2
DISPLACEMENT	107.4 cubic inches (1760 cc)
CYLINDER BORE	3.125 inches (79.4 mm)
PISTON STROKE	3.50 inches (88.9mm)
HORSEPOWER	46 H.P.
COMPRESSION RATIO	22 to 1
OIL CAPACITY, Crankcase	5 Qts. (4.7 L)
OIL CAPACITY, with Filter	5 1/2 Qts. (5.2 L)
VALVE CLEARANCE . . . . .	.012 inches (cold) (0.30mm)
BATTERY	12 VOLT, 84 amp.
ALTERNATOR	12 VOLT, 32 amp.
ENGINE SPEED	1800 to 1900 rpm, full throttle, no load
STARTER	12 VOLT, SOLENOID SHIFT

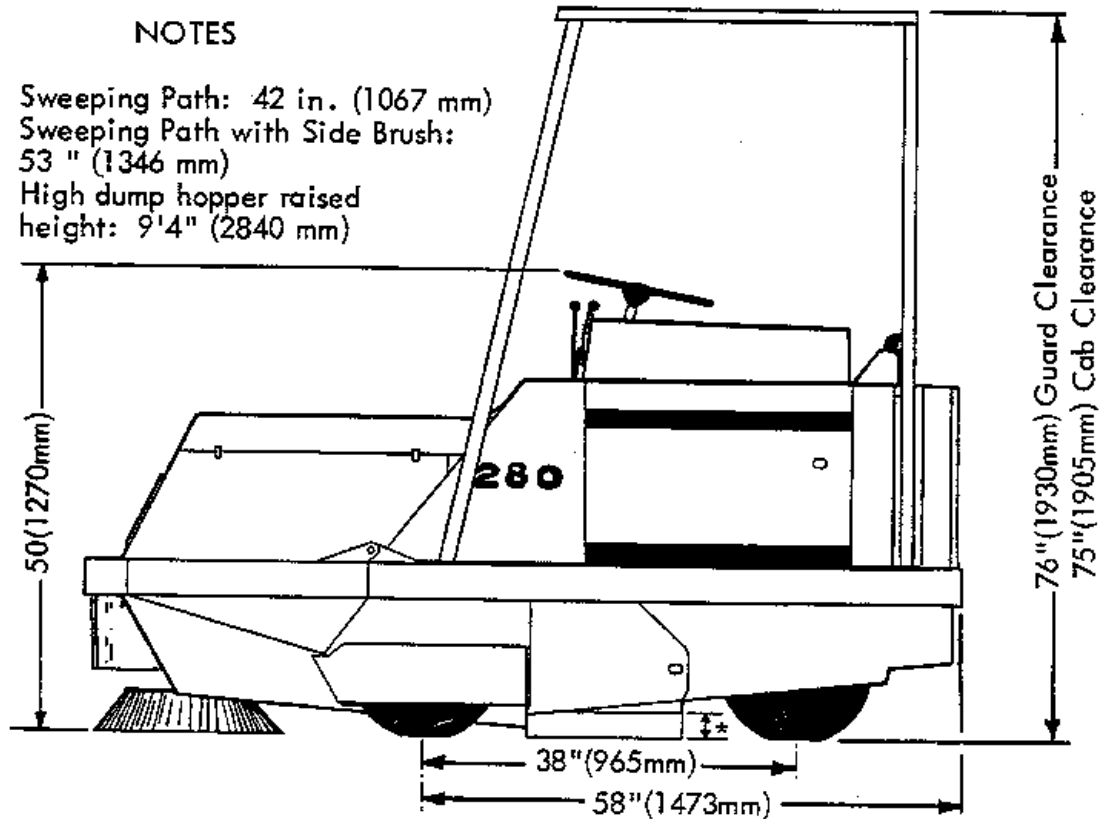
DIMENSIONS



TOP VIEW

NOTES

- Sweeping Path: 42 in. (1067 mm)
- Sweeping Path with Side Brush: 53 " (1346 mm)
- High dump hopper raised height: 9'4" (2840 mm)



SIDE VIEW

*2.375" (60.4mm) Clearance, frame to floor

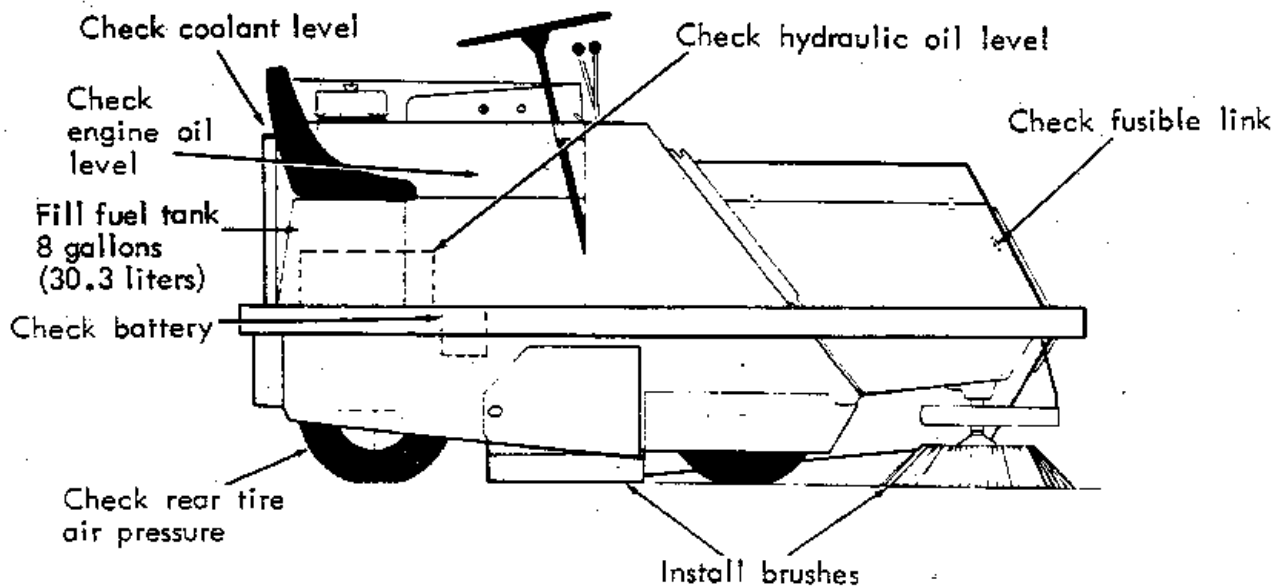
PREPARATION FOR OPERATION

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

AFTER UNCRATING:

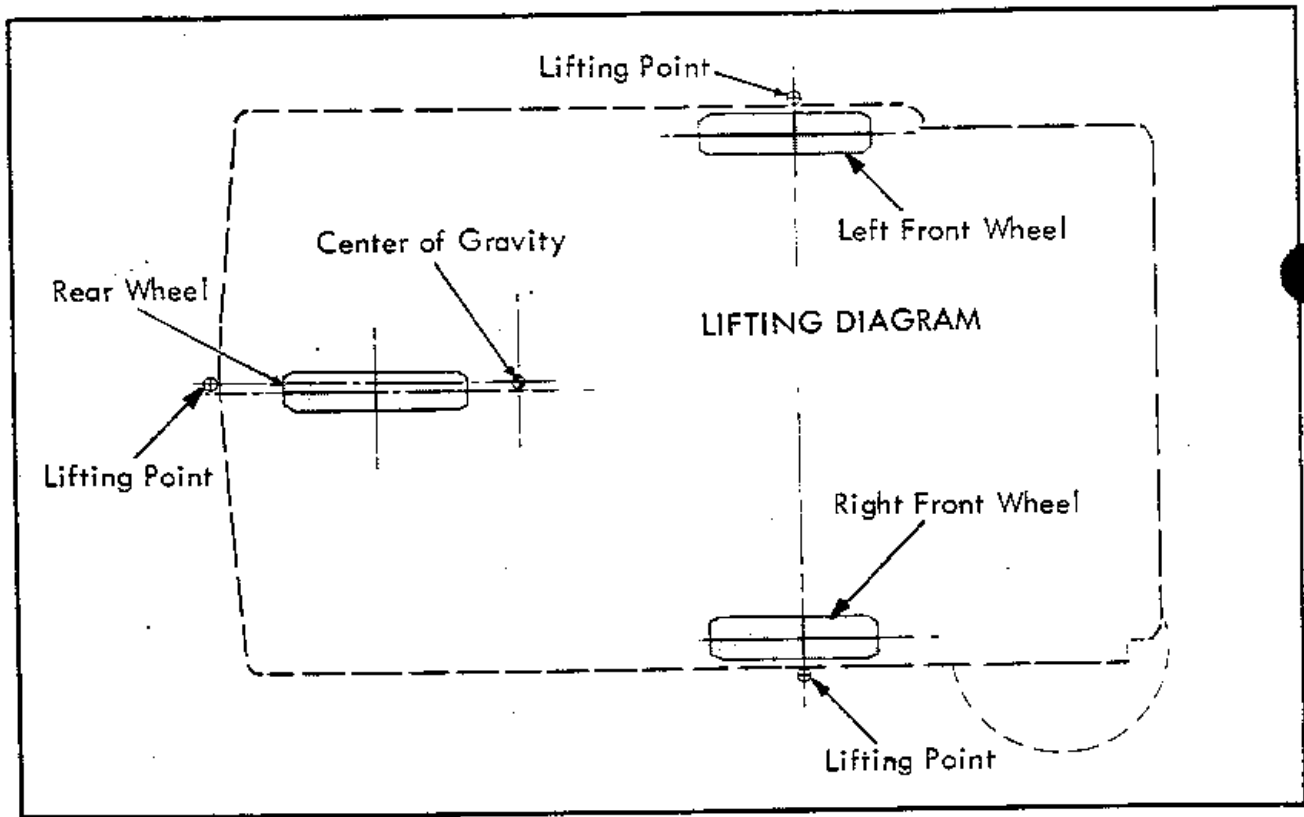
1. Check to see if battery is installed and connected to cables. Battery is located under floor cover below operator's seat.
2. Check oil level in hydraulic oil tank. An oil level sight gauge is provided on tank. TENNANT Hydraulic Oil is recommended. See Maintenance Section for a complete description of TENNANT Hydraulic Oil. Capacity of the hydraulic oil tank is four gallons. Capacity of the complete system is five gallons (19 liters.)
3. Check to be sure that the fusible link on the filter box fire door has not been broken in shipment. See section titled "Fusible Link Replacement" in Maintenance Section for replacement procedure.
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. Please read this manual carefully before attempting to operate your machine.

PREPARATION FOR OPERATION (Standard machine shown)



LIFTING INSTRUCTIONS:

1. The approximate location of the three recommended lifting points are shown in the diagram below.
2. Use lifting hooks or install eye-bolts at the locations shown in the diagram.
3. Lift the machine from only the bottom of the bumper and side frame, not from the upper frame or overhead guard.
4. Use a spreader bar to prevent the lifting chains from pressing inward on the machine and damaging it.
5. The center of the lifting chain must be directly above the machine center of gravity.
6. The location of the center of gravity is based on a machine with hopper empty, no operator and hydraulic tank full.



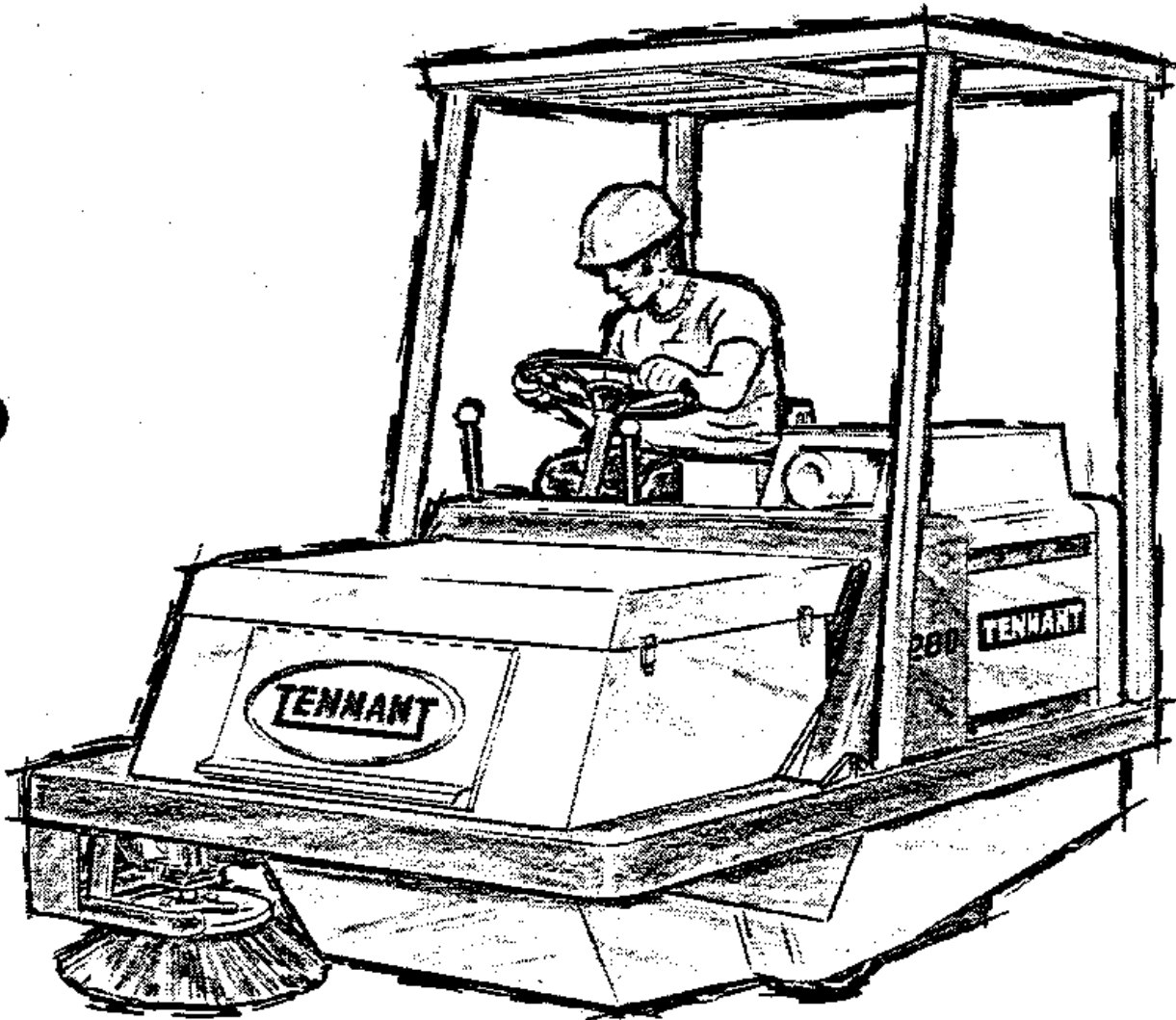
WHEEL LOADING WEIGHTS

	Gas or Lp Standard machine	Gas or LP Hi-Dump machine	Diesel Standard machine
Left front wheel	725 lbs (329kg)	1245 lbs (565kg)	840 lbs (381kg)
Right front wheel	540 lbs (245kg)	950 lbs (431kg)	590 lbs (268kg)
Rear wheel	1265 lbs (574kg)	985 lbs (447kg)	1400 lbs (635kg)

MM105

280

POWER SWEEPER



operation & maintenance



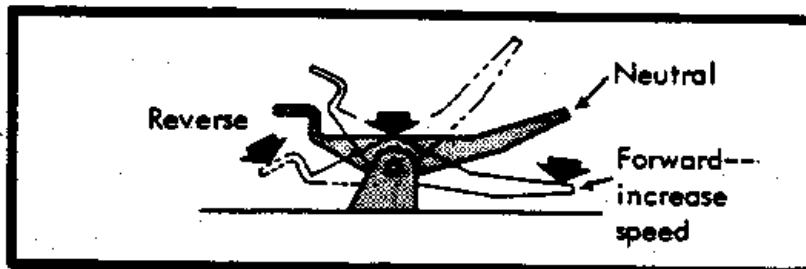
OPERATION OF CONTROLS

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.

DIRECTION CONTROL

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 sketch.



Positions Of The Directional Control 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 pressure on the pedal.

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

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

ENGINE THROTTLE

The engine throttle has only two positions: "closed" and "open". In the "open" position the governor controls engine speed.

ATTENTION! The machine must always be operated with the engine at full "open" throttle. If not, there is danger of over-loading the engine and causing damage.

KEY-OPERATED IGNITION SWITCH

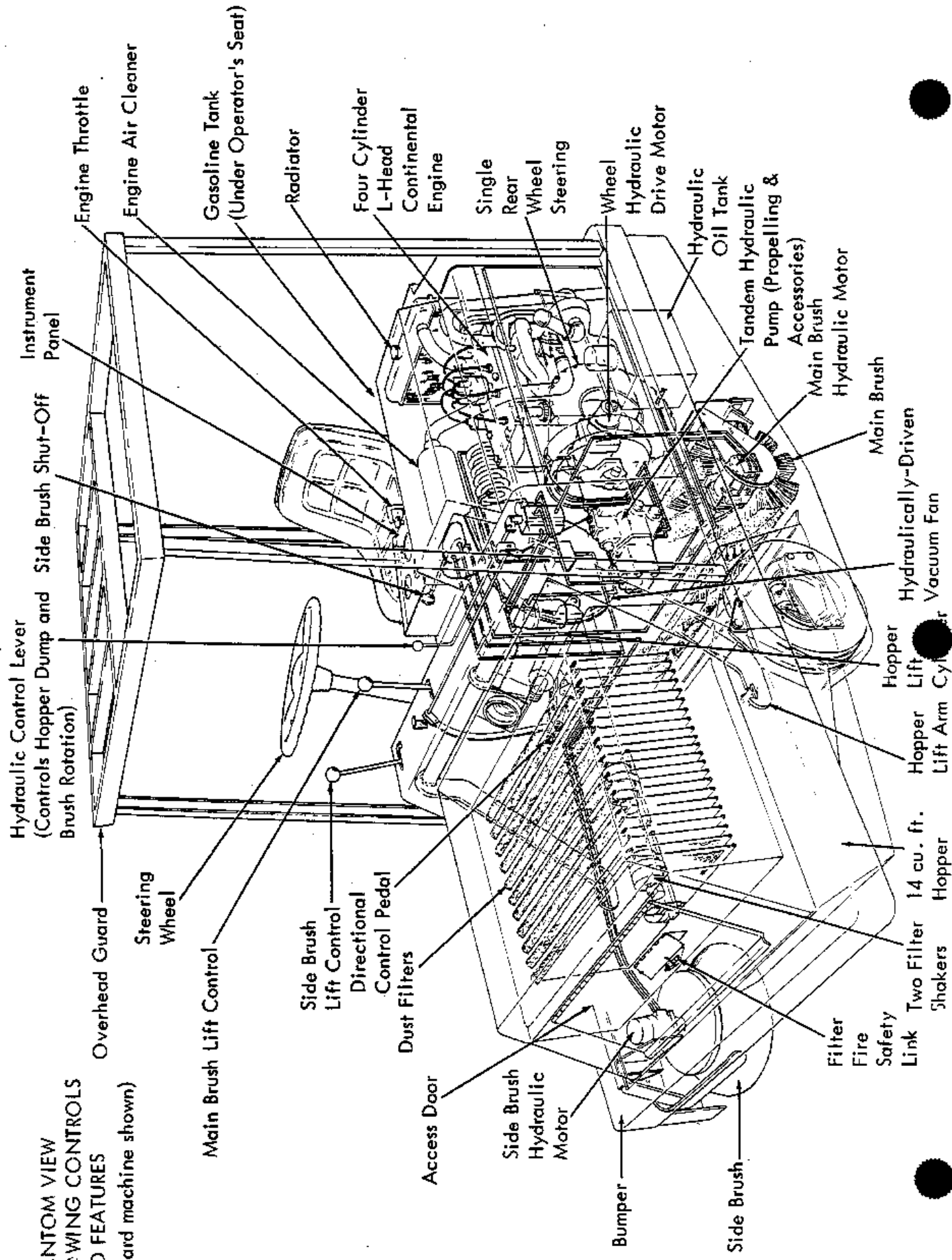
The ignition switch is located on the side of the instrument panel. Turn the key momentarily in order to start the engine. Do not operate the starter for more than 10 seconds at one time.

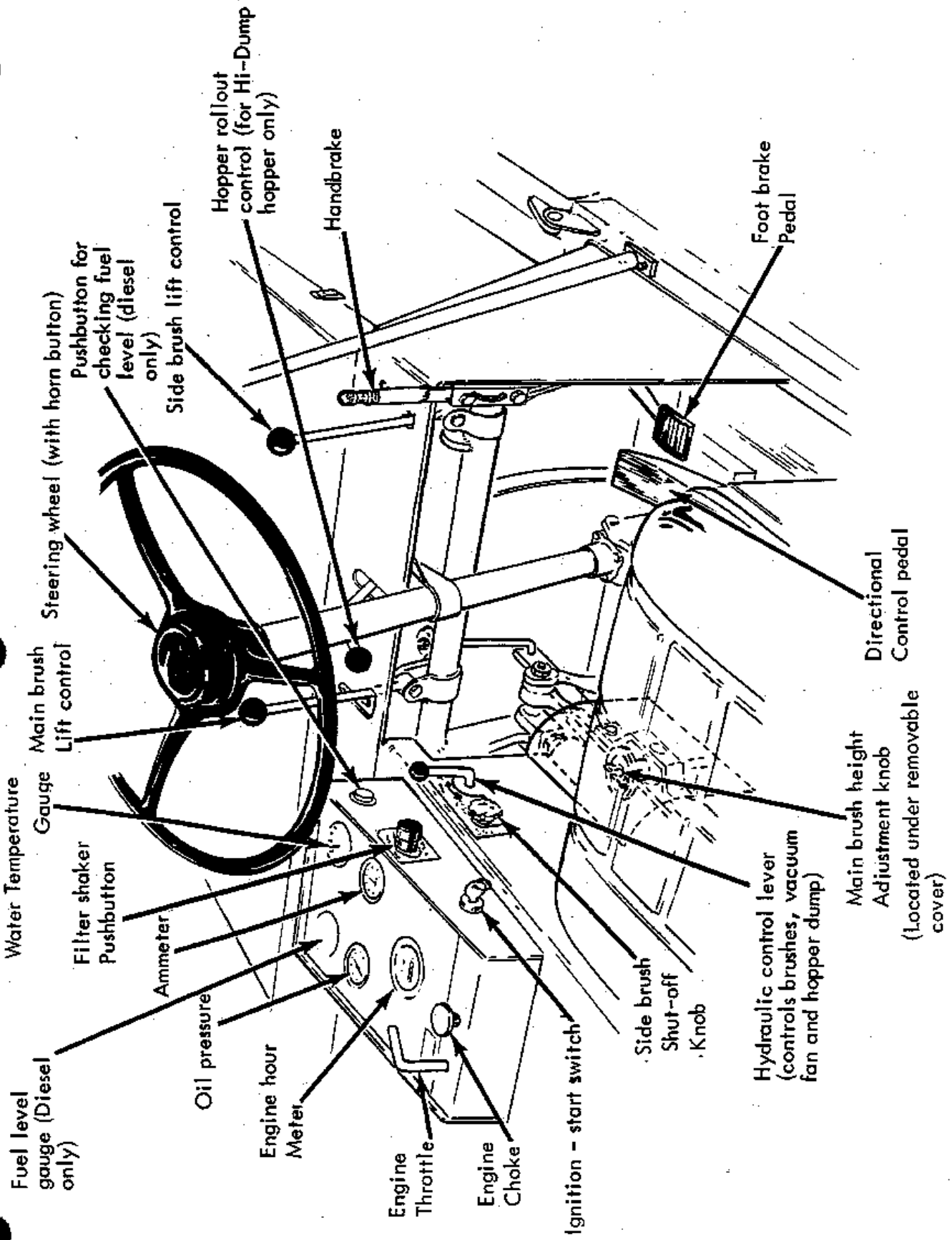
FUEL LEVEL CHECK BUTTON AND GAUGE (DIESEL ONLY)

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.

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PHANTOM VIEW SHOWING CONTROLS AND FEATURES (Standard machine shown)



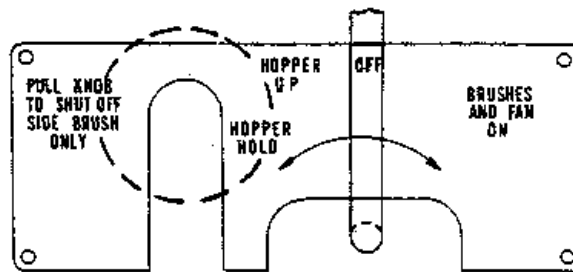


CONTROLS AND INSTRUMENTS

HYDRAULIC CONTROL LEVER

The Hydraulic Control Lever operates a manual directional control valve. The lever has four positions: "Brushes and Vacuum Fan On", Off", "Hopper Up" and "Hopper Hold".

CONTROL POSITIONS OF THE HYDRAULIC CONTROL LEVER



The hopper will remain up when the control lever is placed in "Hopper Hold" position. (If it is necessary to reach under hopper, be sure to engage safety lock.)

The "Brushes and Vacuum Fan On" position of the lever will start both main and side brush, as well as the vacuum fan.

If the machine is equipped with the Scrubbing Attachment, the "Brushes and Vacuum Fan On" position of the control will also start the scrubber main brush and side brush rotation.

SIDE BRUSH SHUT-OFF

A separate control knob is provided for stopping side brush rotation.

HI-DUMP HOPPER ROLLOUT CONTROL

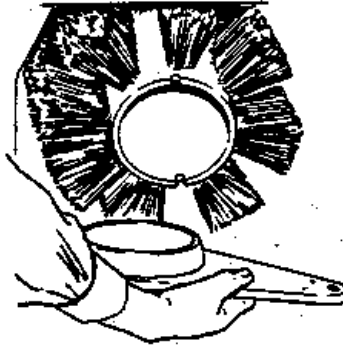
Use the Hopper Rollout Control to dump the hopper after it has been raised to the desired height. The control has two positions (forward rollout and reverse) with a spring - loaded return to neutral. The hopper can be rolled out at any height; but to avoid damage, the hopper must be at least 12 inches (304.1 mm) off the floor before being fully dumped.

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.

MAIN SWEEPING BRUSH

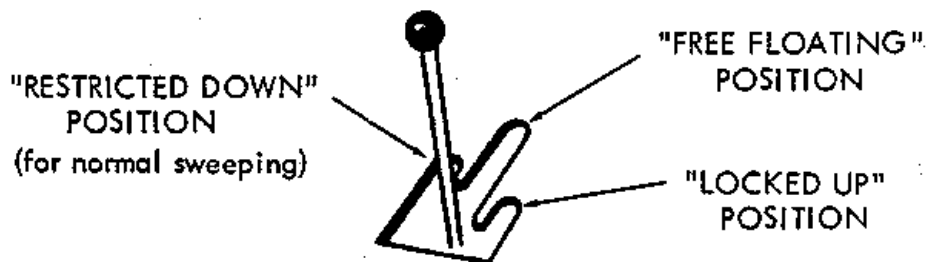
The main sweeping brush is 42 inches (1066.8 mm) long and 14 inches (355.6 mm) in diameter. The brush is driven by a hydraulic motor. Brush rotation is stopped and started by means of the hydraulic control lever; and is raised or lowered into sweeping position with the Brush Lift Lever. An adjustment knob is provided for setting the brush height from the floor. When not sweeping, the operator should keep the brush in the raised position. Brush replacement is described in the "Operation Section". Part numbers of the standard and accessory brushes are given in the Parts Catalog. The main brush can be turned "end for end" in order to prolong brush life. Replace the brush when the bristles are worn to one inch length or less.



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, then move the lever to the left and into either one of the two slots. To raise the brush, pull the lever back, then to the right and into the small slot where it will be locked in place (see sketch).

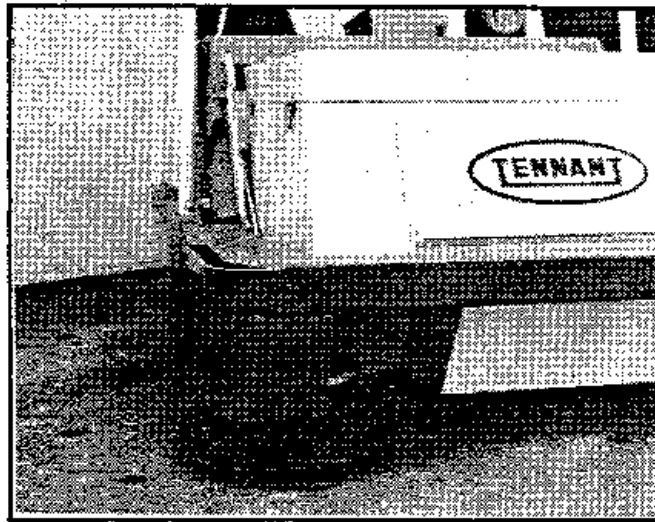


You may operate the main brush in either the "RESTRICTED DOWN" or "FREE FLOATING" positions, HOWEVER, the "RESTRICTED DOWN" position should be used for normal sweeping and will result in much longer brush life. The "FREE FLOATING" position should be used only when sweeping extremely uneven areas where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

SIDE SWEEPING BRUSH

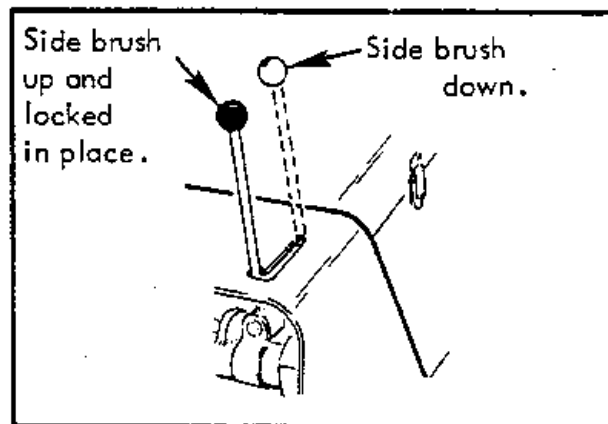
The 21-inch (530 mm) diameter side sweeping brush is driven by a hydraulic motor whenever the main brush is operating. To start side brush rotation, turn the hydraulic control lever to "Brushes and Vacuum Fan On" position. To stop side brush rotation, pull shut-off knob. A lift lever is provided for raising or lowering the side brush. Side brush replacement and adjustment are covered in the Operation Section.

The side brush arm can be lifted out of the way, if desired, when working on the machine.



SIDE BRUSH LIFT LEVER

To raise and lock up the side brush, pull the lever back, then move the lever to the left so that it is locked in place in the small slot, see sketch.



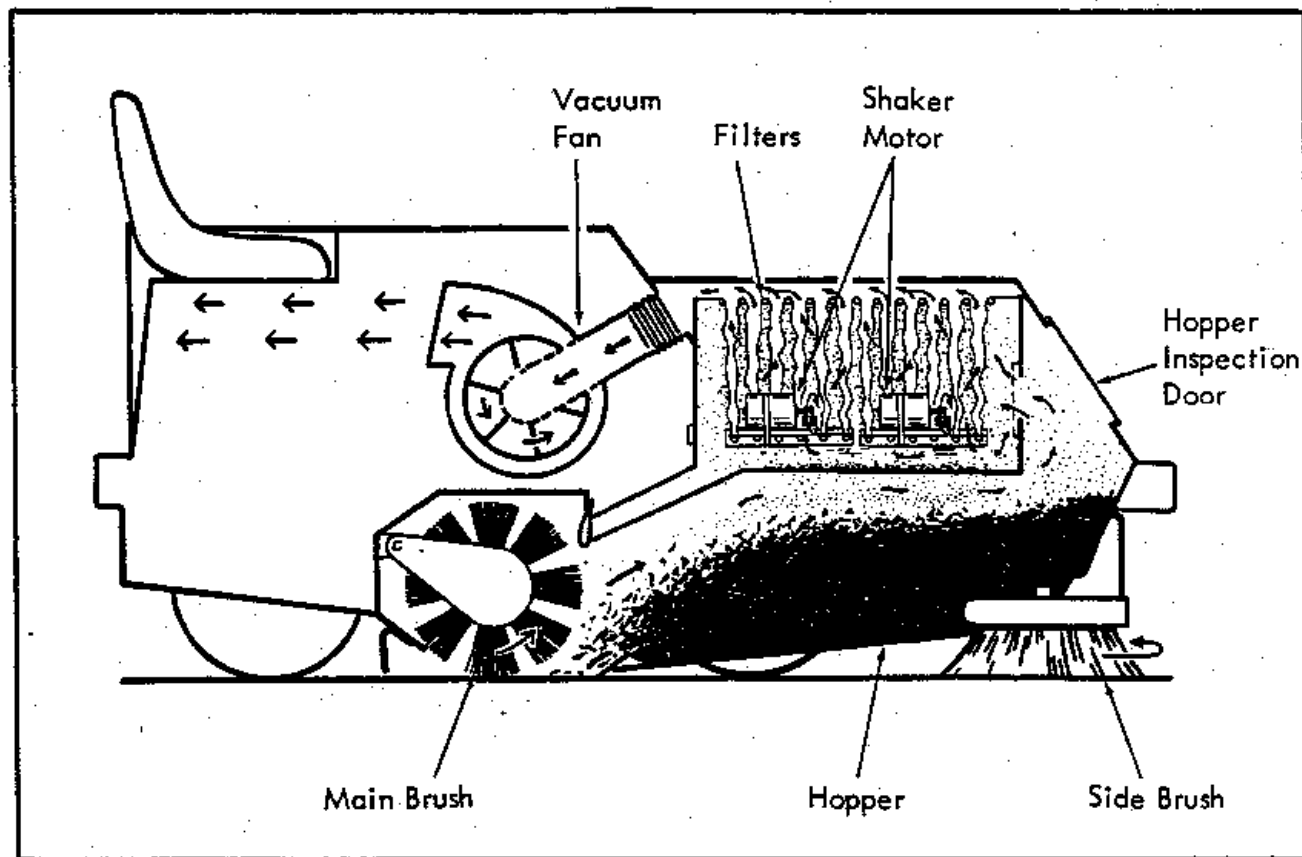
SIDE BRUSH LIFT LEVER

To lower the side brush, pull the lever back, then move it to the right and allow it to move through the long slot until the brush is down. Whenever the side brush is not needed, or when transporting the machine, be sure to raise and lock up the side brush.

FILTER SHAKER SWITCH

Press button to actuate shaker motor. Keep button depressed for 10 to 15 seconds -- or longer as needed to shake filter clean.

NOTE Activate shaker switch only with brushes and vacuum shut off and hopper in "Down" position. Vacuum must always be shut off when shaking filters (if not, dust will be drawn back into filter envelopes).



VACUUM FAN, FILTER SHAKER, AND HOPPER DESIGN

VACUUM FAN

The high volume, 9 inch (228.6) diameter 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.

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.

OPERATION

▲WARNING Always provide adequate ventilation when operating this machine. Carbon monoxide is a poisonous gas, present in the exhaust of all internal combustion engines. If you are operating the machine in a confined area, be sure the area is well ventilated.

TO START ENGINE

1. **▲WARNING** Do not attempt to start machine unless you are in the drivers seat, with foot on brake pedal or hand brake engaged and with the directional pedal in neutral.
2. For diesel engine only: Press "Fuel Level Check" button to check fuel level. Fill fuel tank if necessary. Never allow 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. For gasoline or LP engine: If engine is cold, pull up choke button (about 3/4 choke).
4. Set throttle at "Open" position. Turn starter key switch to "start" momentarily until motor starts. Release key as soon as motor starts. Never operate starter for more than a few seconds.

PUSHING OR TOWING MACHINE

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

TO DRIVE SWEEPER

1. Start engine (engine should be set at full throttle).
2. Release parking brake.
3. Start brush rotation and vacuum fan.
4. Lower main and side brushes to floor. (Brush position should be set correctly).
5. Gently depress directional control pedal - with toe for forward direction, or with heel for reverse.
6. Vary your foot pressure on pedal to obtain desired travel speed.
7. Be sure to follow "General Operating Instructions" information in next section.

TO STOP SWEEPER

1. Return directional pedal to neutral (centered) position.
2. Apply foot brake.
3. Raise brushes and stop brush rotation.
4. Apply parking brake.

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.
2. Do an entire floor, or section at one time.
3. Pick up oversize debris before sweeping. Flatten or remove bulky cartons, etc., from aisles before sweeping. Avoid sweeping up wire which could become entangled in brushes.
4. Allow a few inches overlap of brush paths. This will eliminate leaving dirty patches.
5. **▲ CAUTION** Do not turn steering wheel too sharply when machine is in motion. Your sweeper is very responsive to movement of the steering wheel--avoid sudden turns, except in emergencies.

▲ CAUTION Avoid driving sweeper with hopper removed. Removing the hopper changes the machine center of gravity and affects the balance. Do not back machine down ramps.

6. Try to sweep as straight a path as possible. Avoid bumping into posts or scraping sides of sweeper.
7. Hi-Dump machines: Observe cautions described under "The Hi-Dump Hopper." Reduce machine travel speed when driving up or down inclines.
8. Scrubber: Reduce machine speed when driving on wet and soapy floors.

RECOMMENDED MAXIMUM RAMP CLIMB AND DESCENT ANGLES

	Max Recommended Ramp Climb		Max Recommended Ramp Descent	
	Accy. On or Off Empty	Accy. On Carrying Advertised Load	Empty	Carrying Advertised Load
280 Sweeper	15°	12°-1000 lbs. (453.6 kg)	15°	15°-1000 lbs. (453.6 kg)
280 Scrubber	15°	13°-400 lbs. (181.4 kg)	15°	15°-400 lbs. (181.4 kg)
280 High Dump	15°	10°-1000 lbs. (453.6 kg)	15°	10°-1000 lbs. (453.6 kg)
280 D Sweeper	15°	12°-1000 lbs. (453.6 kg)	15°	15°-1000 lbs. (453.6 kg)
280 D Scrubber	15°	13°-400 lbs. (181.4 kg)	15°	15°-400 lbs. (181.4 kg)
280 D High Dump	15°	10°-1000 lbs. (453.6 kg)	15°	10°-1000 lbs. (453.6 kg)

* Also, note that in some cases, a loaded machine cannot descend as steep a ramp as an empty machine. This is because of limitations imposed by machine stability and braking ability.

HOPPER - STANDARD HOPPER ONLY, NOT HI-DUMP

Hopper capacity is 14 cubic feet (0.40m³). The hopper has a "floating" action which allows it to pivot slightly so that objects up to two inches in height can pass under the hopper and then be swept into the pan by the brush.

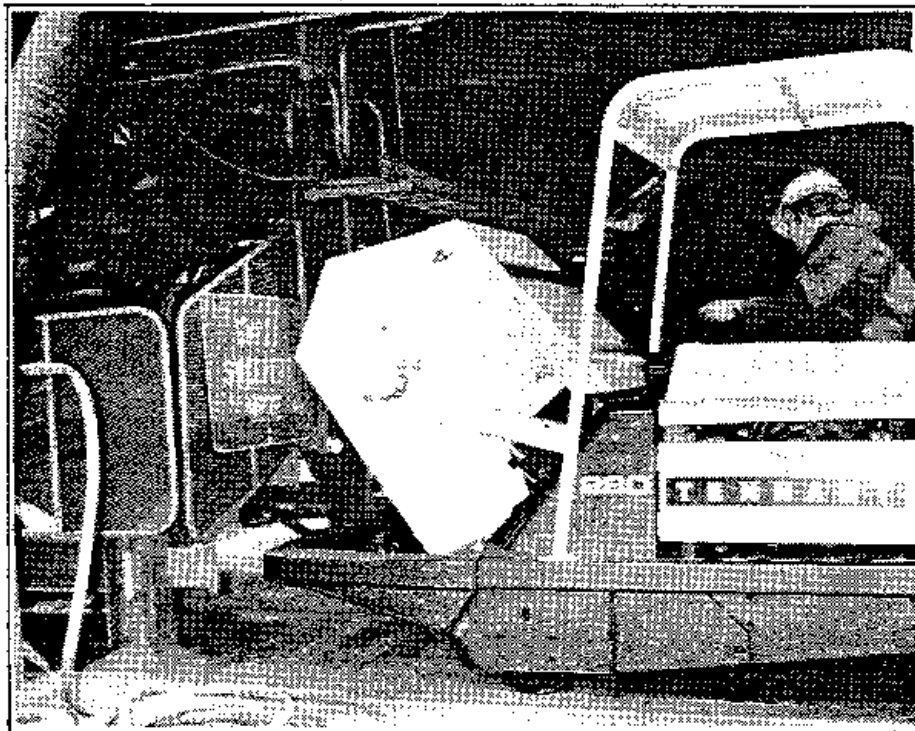
An access door is provided at the front of the hopper so that the operator can inspect hopper contents. The door can also be used for inserting items which are too large for sweeping, or for flushing out the hopper.

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.

Hopper floor clearance adjustments and fusible link replacement are covered in the Maintenance Section.

TO DUMP HOPPER

1. Turn off brushes and vacuum fan. Raise both main and side brushes.
2. Push filter shaker button to clean filter.
3. Turn hydraulic control lever to "Hopper Up" position (engine full throttle).
4. After hopper is emptied, back sweeper away and turn to left so that side brush will clear dirt pile.
⚠WARNING Never reach under upraised hopper without first engaging safety lock.
5. Lower hopper to sweeping position by moving hydraulic control lever to "Off".
NOTE The hopper will lower much faster if the engine speed is dropped down to idle. Return engine speed to full after dumping.



THE HI-DUMP HOPPER

The Hi-Dump Model hopper has the same capacity as the standard machine (1/2 ton, 455 kg). Ceiling clearance height of the fully raised hopper is 9ft. 4 in. (2845 mm).

A separate hand control lever is used to roll the hopper forward for dumping. The hopper door unlatches and opens automatically during rollout, and closes when the hopper is returned to its normal position.

When the hopper has been raised approximately 11 inches (279 mm), a stabilizer leg is automatically lowered at the left front of the machine to provide machine stability.

In addition, when the hopper is raised to a height of 36 inches (914 mm), an automatic speed limiter is engaged which limits machine forward speed to no more than 2 mph (3.22 km/hr).

The Hi-Dump Hopper is provided with a fire safety fusible link, which will open if the hopper debris should catch fire.

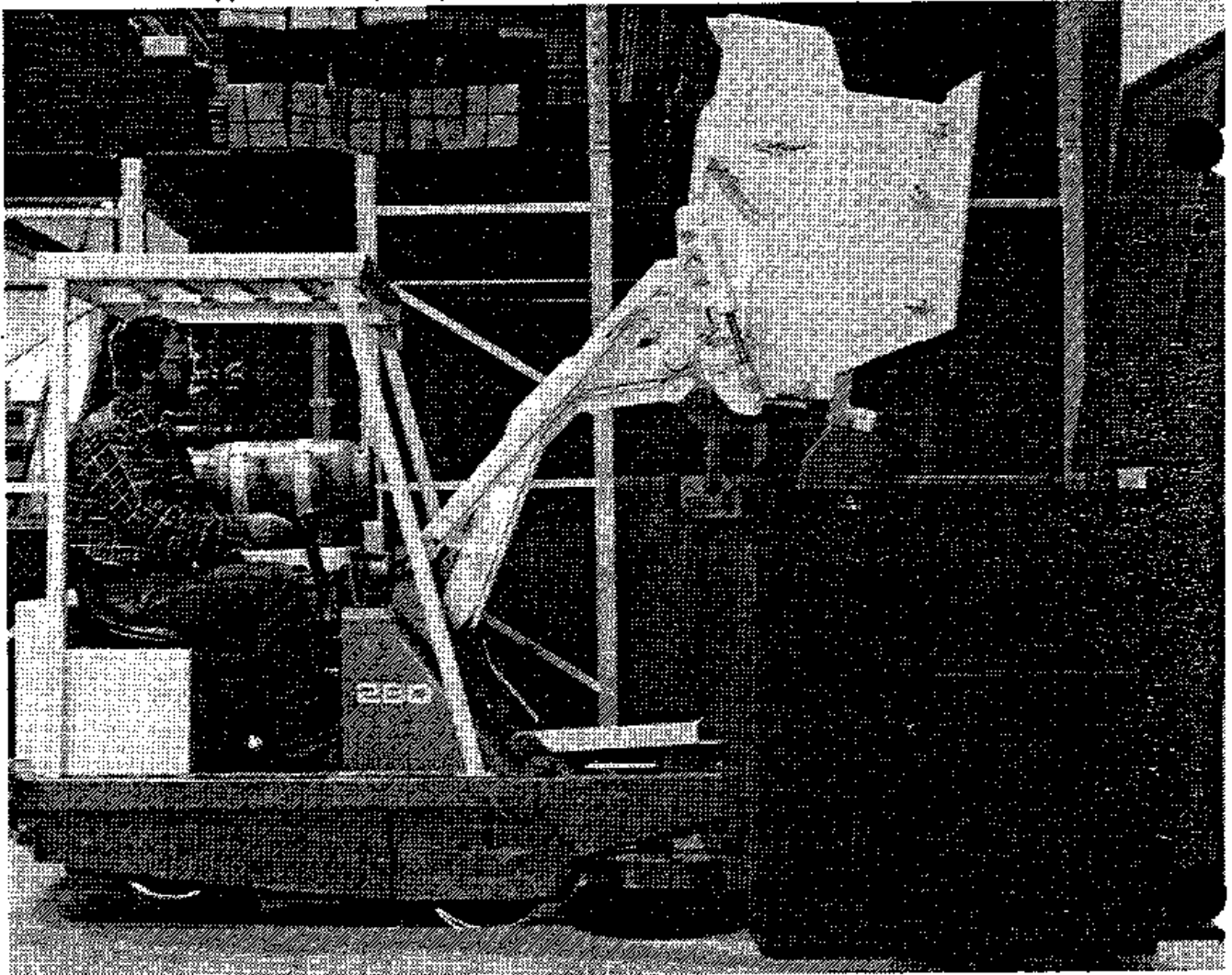
Hopper replacement and adjustments are described in the Maintenance Chapter.

ATTENTION! There are certain cautions to be observed when dumping the Hi-Dump hopper:

1. Before raising the hopper, make sure that there is sufficient clearance to lift the hopper and roll it forward.
2. Remember that to avoid damage, the hopper must be at least 12 inches (305 mm) off the floor before rollout (hopper door or shear pin may be damaged).
3. Don't attempt to drive the machine any distance with the hopper raised (because of reduced visibility, danger of striking overhead objects, possibility of catching lowered stabilizer leg on rough floor).
4. When dumping off the edge of a loading dock, make sure that the stabilizer leg is contacting floor (with front wheels at edge of dock, stabilizer leg could be beyond edge of dock).

TO DUMP HI-DUMP HOPPER

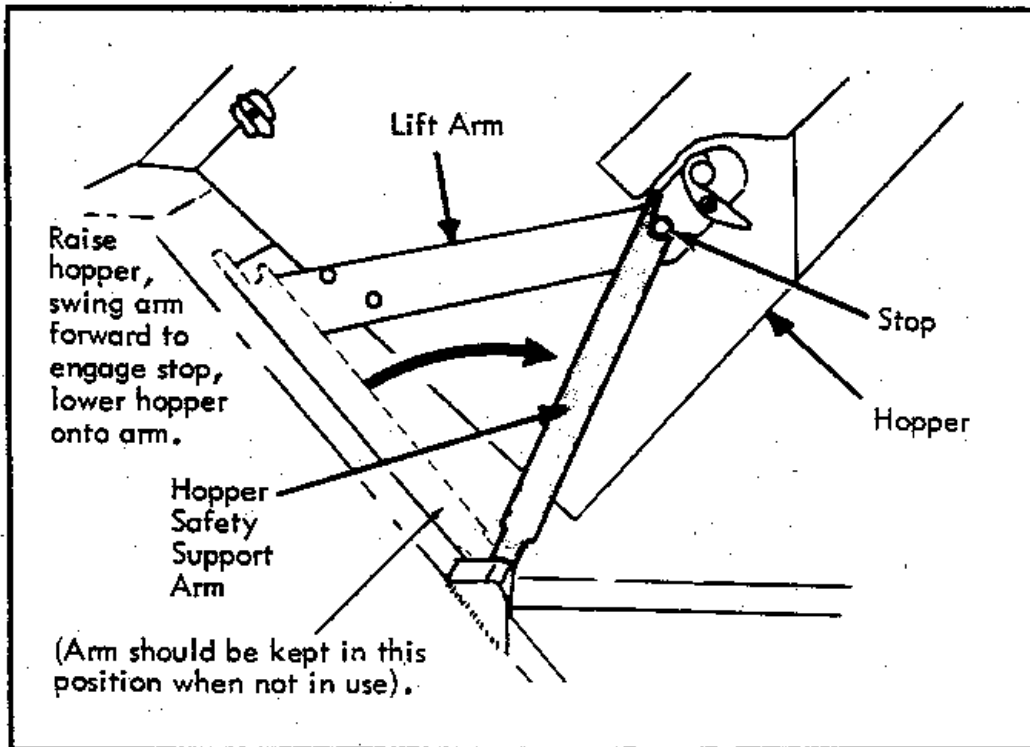
1. Turn off brushes and vacuum fan. Raise both main and side brushes.
2. Push filter shaker button to clean filter.
3. Turn hydraulic control lever to "Hopper Up" position (engine full throttle).
4. Raise hopper enough to clear waste receptacle during forward rollout.
⚠WARNING When hopper is raised or lowered, lift arms cross, creating a shear point. STAY CLEAR OF ARMS.
5. Drive machine carefully forward so that hopper is in position to dump properly into waste receptacle.
6. Move hopper rollout control to "Roll Out", hopper will move forward and dump.
7. Move hopper rollout control to "Roll In". After hopper returns to normal position, release control.
8. Back machine away from receptacle.
9. Lower hopper to sweeping position.



HOPPER SAFETY SUPPORT ARM (STANDARD HOPPER)

To engage safety lock, first swing safety lock forward all the way, then raise hopper to extreme "Up" position. The safety arm should then position itself under the hopper lift arm so that the notch in the safety lock engages the lift arm. Lower hopper slightly so that it is engaging the safety lock. To release the safety lock, it is necessary to raise the hopper slightly first in order to release the lock from the arm.

▲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.



STANDARD MACHINE HOPPER SAFETY SUPPORT ARM

HOPPER SAFETY SUPPORT ARM (Hi-Dump Machines)

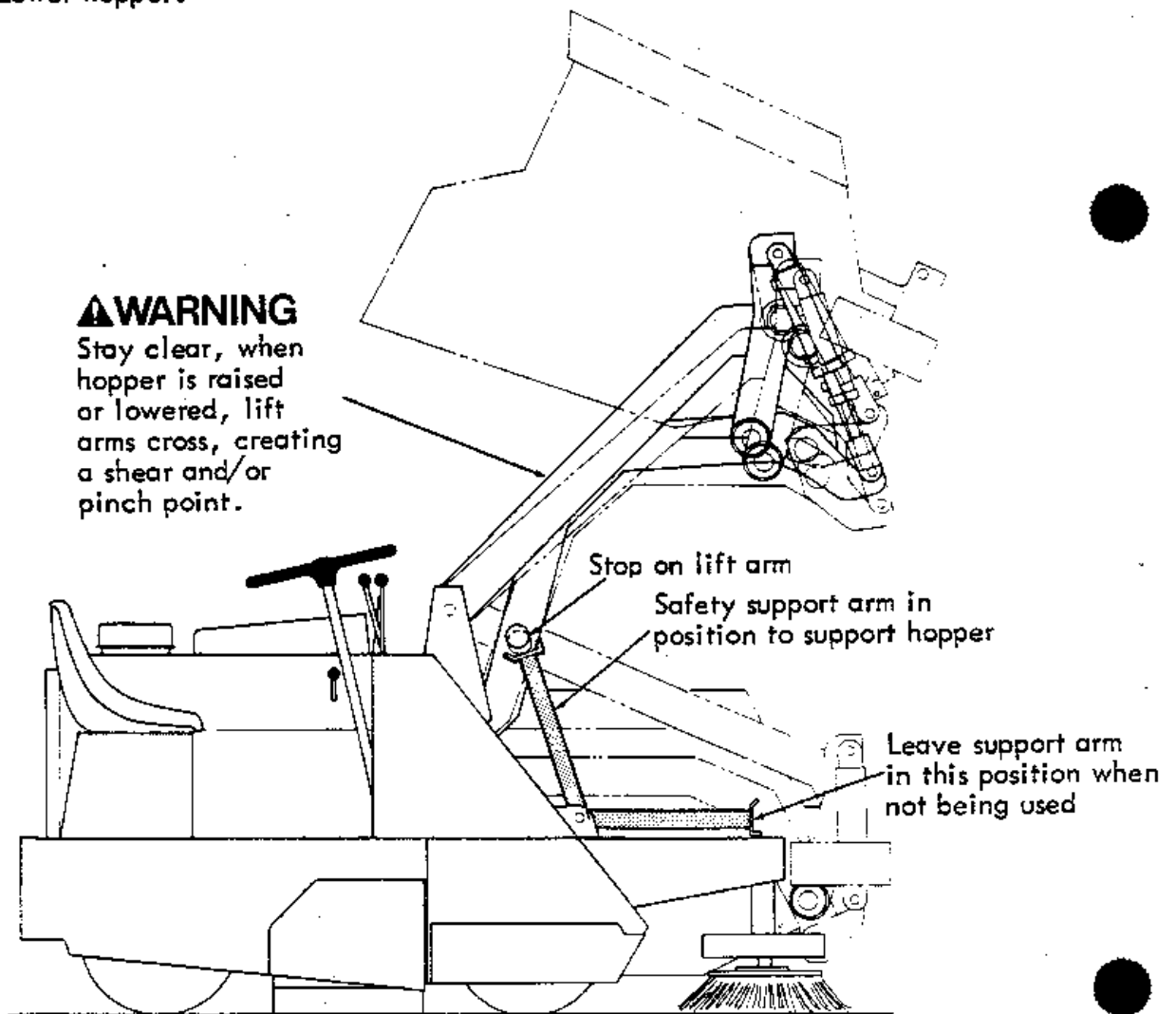
▲WARNING Never reach under upraised hopper without first engaging the safety arm. When the hopper is raised or lowered, lift arms cross, creating a pinch point. Stay clear.

To Engage Hopper Safety Support Arm:

1. Lift hopper to extreme "up" position.
2. Raise and swing back safety arm until it engages stop on hopper (see sketch).
3. Lower hopper until it is supported by arm.
4. Shut engine off.

To Disengage Hopper Safety Support Arm:

1. Lift hopper to extreme "up" position.
2. Swing safety arm forward and down (see sketch).
3. Lower hopper.



TO REPLACE MAIN BRUSH

A. To Remove Brush

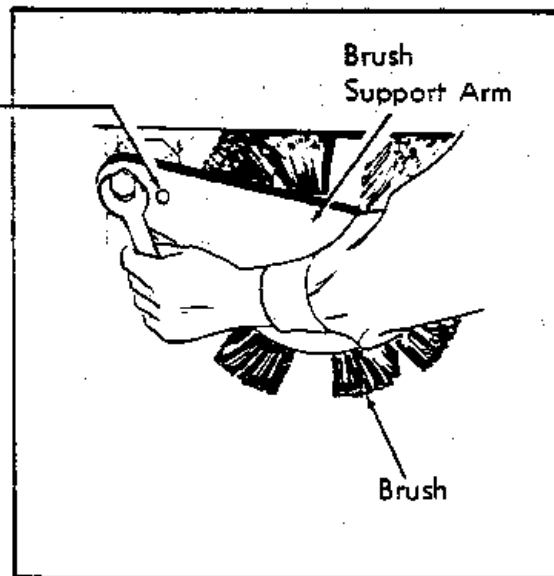
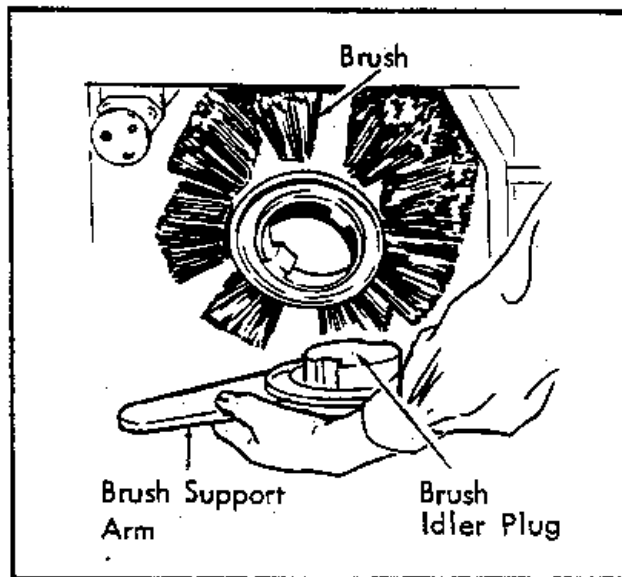
CAUTION To protect your hands, be sure to wear gloves. This is especially important when changing brushes which contain wire bristles.

1. Lower main brush to floor with lift handle.
2. Open brush access door.
3. Using the wrench provided, remove the hex head screw which attaches the brush support arm.
4. Pull out and remove the support arm and brush idler plug from the end of the brush.

If the support arm does not come off easily, insert the arm screw into the tapped hole in the arm. Remove plastic plug in hole. Turn the screw in with a wrench to force the arm off - at the same time, pull and wiggle the arm to help it come loose. Do this very carefully to avoid injuring your hands if the arm should suddenly come off.

5. Grasp the brush and pull it off the opposite (drive) plug, then out the brush access door. (If the brush support arm idler plug is stuck in the brush, it may be easier to pull out both arm and brush at same time.)

NOTE If arm does not come off easily, remove plastic plug from this hole and screw in arm attaching screw to force arm off.



(continued on next page)

TO REPLACE MAIN BRUSH (continued)

B. To Install Brush

1. With brush lever in "down position, insert one end of brush through access opening and push in brush until it touches opposite brush plug.
2. Sight through brush tube (or align brush keys by "feel") to align brush keys with, and onto keyways on left side brush plug.
3. Replace right side brush support arm, with plug into open brush end. (To prevent the arm from sticking in place, apply a little grease to the arm pins.)
4. Insert hex screw with washer to hold support arm. Tighten screw securely.

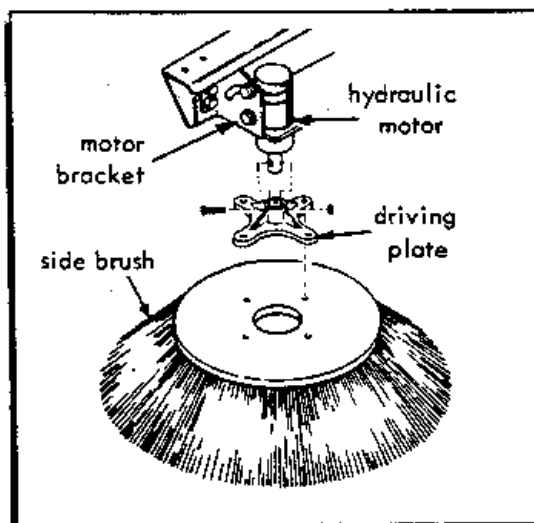
TO REPLACE SIDE BRUSH

A. To Remove Brush

1. Be sure hydraulic control lever is in "OFF" position.
2. Raise side brush with side brush lift lever.
3. Remove bolt from brush drive shaft. (Brush can then be lowered and removed.)

B. To Install Brush

1. With side brush still raised slide brush onto drive shaft. Insert and tighten screw.
2. Using lift lever, lower side brush to sweeping position.
3. Loosen adjusting lug holding motor bracket to side brush arm. Slide motor and brush up or down until about one-half of the bristles touch the floor.
4. Readjust if dust streak is left by side brush, or if bristles are severely bent when sweeper is operated. (See "Side Brush Adjustments".)



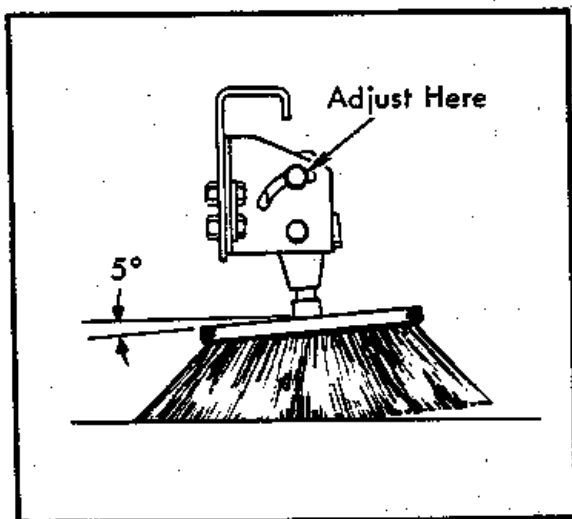
SIDE SWEEPING BRUSH ASSEMBLY

SIDE BRUSH ADJUSTMENTS

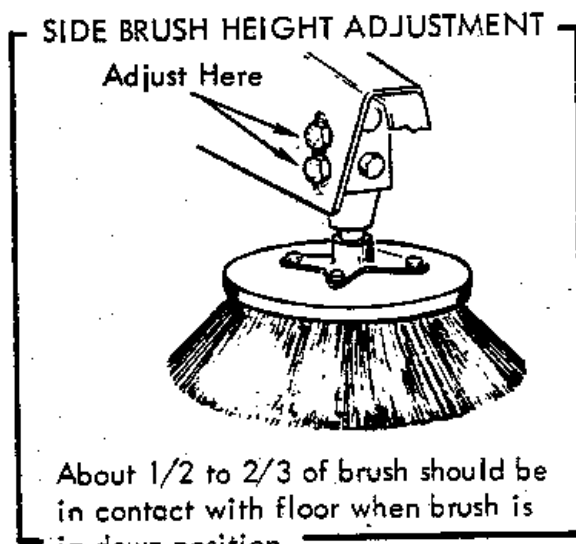
Brush Height Adjustment

Height adjustment has been made at the factory. However, if you replace the lift cable, be sure to adjust the cable length properly. Proper cable adjustment should allow the full weight of the brush unit on the floor when brush lift lever is in "Down", or sweeping position -- but sufficient cable tension to allow clearance off the floor when the brush unit is lifted and not used for sweeping. (See sketch.)

Brush Contact Angle -- should be adjusted as indicated in sketch. Approximately five degrees is the angle normally used. Special conditions may require changing the brush angle.



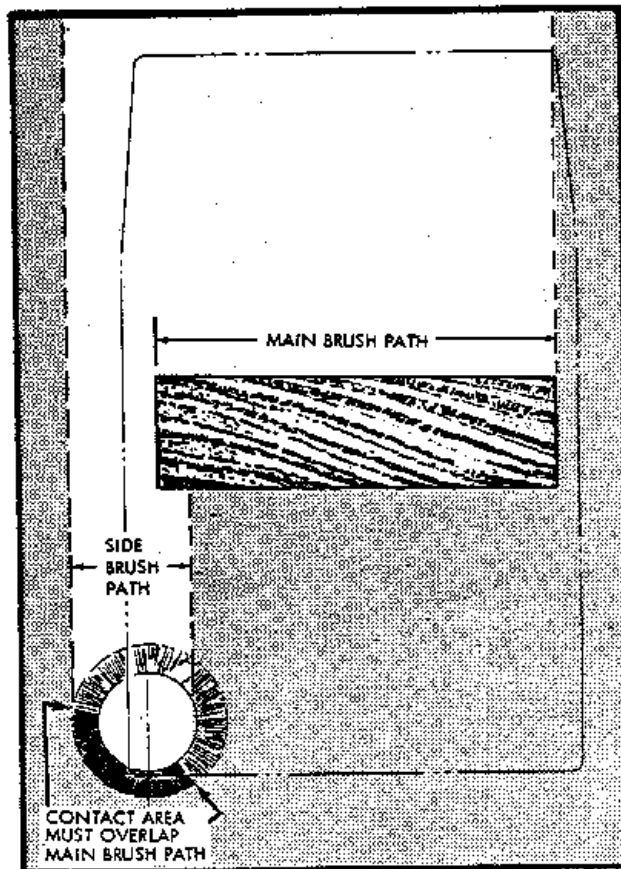
SIDE BRUSH ANGLE ADJUSTMENT



NOTE

Side brush mounting shown here is for Standard machine. Hi-Dump machine side brush is mounted differently, but slots are provided for height and other adjustments. The angle adjustment is fixed on Hi-Dump machines.

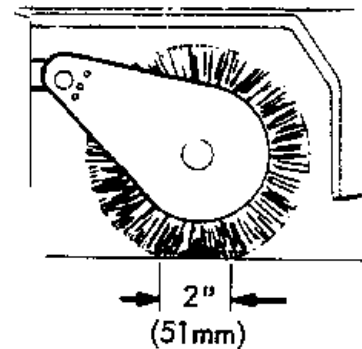
This sketch shows the relationship between the main brush and side brush sweeping paths.



BRUSH HEIGHT ADJUSTMENT

The "Restricted Down" position of the brush can be adjusted to compensate for wear, changing conditions, etc. This is done by turning the adjustment knob shown in the "Location of Controls" illustration.

NOTE Correct brush height will make a "polished" mark on the floor about two inches wide.



The brush height adjustment knob is set to restrict the brush down position, as follows: The best method for checking the brush adjustment is to park the machine on a level surface, (with the brush up), then lower the brush to "Restricted Down" position and allow it to rotate against the floor for about one minute. Raise the brush and drive the machine off of the test area. The brush should leave a "polished mark" (see sketch) on the floor about two inches wide for the full length of the brush. If not, adjust the "Brush Height Knob". (Clockwise rotation of the knob raises brush).

Various sweeping conditions and special brushes with stiffer bristles may require a different adjustment.

FUEL TANK

The eight-gallon (30.3 liters) capacity fuel tank is located under the operator's seat. Tilt the seat forward to gain access to the tank.

▲WARNING Fuel container and machine must be electrically connected before pouring. Connect insulated wire between machine and container. Never fill tank while engine is running.

FUEL LEVEL CHECK BUTTON AND GAUGE (DIESEL ENGINE ONLY)

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.

TROUBLE SHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
No vacuum-- poor dust pick-up.	1. Dust skirts worn or not adjusted correctly.	1. Check dust skirts, adjust to clear floor by 0.13" (3 mm)
	2. Fusible link on filter box fire door may have failed	2. Replace fusible link.
	3. Dust filters clogged.	3. Clean filters.
	4. Failure in fan drive such as key broken, or hydraulic motor worn.	4. Check and repair.
Poor sweeping.	1. Sweeping brush not adjusted correctly.	1. See "Side & Main Brush Adjustment"
	2. Sweeping brushes worn.	2. Replace brushes
	3. Dust skirts not adjusted or worn.	3. Replace or adjust dust skirts.
	4. Filters clogged.	4. Clean filters.
	5. Main brush drive hydraulic motor worn or damaged.	5. Check motor.
	6. Side brush hydraulic motor worn.	6. Check motor -- "Hydraulic Motor Trouble Shooting"
	7. Brush driving plugs worn or damaged.	7. Check Plugs.
Machine moves slowly.	1. Low hydraulic oil level.	1. Add oil.
	2. Front wheels: Brakes dragging, wheels jamming, tires softened from contact with oil or solvent.	2. Check wheels, repair or replace. See Maintenance Instructions.
	3. Hydraulic oil temperature too high -- oil is too thin. May be caused by: operating with excessive load or drag, prolonged ramp climbing, high temperature operation, or worn pump.	3. Use TENNANT® 32397 - 10W40 hydraulic oil. Check pump
	4. Worn hydraulic pump or rear drive wheel motor.	4. See "Hydraulic Components" Section

TROUBLE SHOOTING (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
Hopper dumps slowly or will not dump.	<ol style="list-style-type: none"> 1. Load in hopper too heavy. 2. Lift arms or hopper binding. 3. Wear or failure in manually-operated control valve. 4. Defective dump cylinder, seals leaking. 5. Accessory portion of tandem hydraulic pump worn or damaged. 	<ol style="list-style-type: none"> 1. Empty more often. 2. Check for binding or obstructions. 3. Check valve. 4. Repair cylinder. 5. Check pump.
Motor runs, but machine will not move.	<ol style="list-style-type: none"> 1. Foot pedal and/or linkage jammed or not adjusted. 2. Front wheels jammed or brakes locked. 3. Hydraulic pump trouble, such as relief valve failure, leakage, etc. 4. Rear wheel hydraulic motor trouble such as broken shaft key, broken shaft, etc. 	<ol style="list-style-type: none"> 1. Check pedal linkage. 2. Check wheels. 3. Check & repair. 4. See "Hydraulic Components" Section.
Hydraulic pump making excessive noise.	<ol style="list-style-type: none"> 1. Partially clogged pump inlet line. 2. Air leak at pump intake line connections. 3. Air bubbles in hydraulic fluid. 4. Hydraulic pump is worn or damaged. 	<ol style="list-style-type: none"> 1. Check the inlet line to pump and tank inlet. If oil is dirty, drain system and flush thoroughly. Refill with clean TENNANT® Hydraulic fluid 32397 2. Pour fluid on connections to check for leaks--listen for change in pump sound level. Tighten connections which are loose. 3. Check for low hydraulic fluid or loose connections in hydraulic lines. 4. See "Hydraulics Components".

MAINTENANCE

ENGINE OIL SELECTION (FOR GASOLINE OR LPG ENGINES)

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:

TEMPERATURE

Below 0° (-17.78°C)	SAE 5W-20	} or SAE - 10W-30
0° to 32° (-17.78°C to 0°C) . . .	SAE 10W	
32° to 75° (0 to 23.89°C)	SAE 20W	
Above 75° (23.89°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.

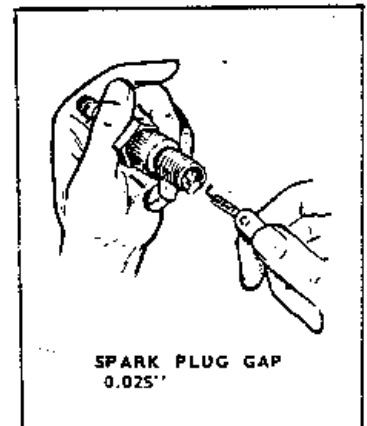
Engine oil should always be drained when the engine is warm. Remove the crankcase pipe plug to drain engine oil.

IMPORTANT

RECOMMENDED INITIAL 50-HOUR INSPECTION (FOR GASOLINE OR LP MACHINES)

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

1. Change engine oil and filter.
2. Check valve tappet clearance Intake: .012" (0.30mm) for both gasoline and LPG engines. Exhaust: .020" (0.51mm)
3. Check spark plug gap .025" (0.64mm).
4. Check point gap .022" (0.56mm) Dwell angle is 31° to 34°.
5. Check engine timing (see engine manual).
6. Torque down cylinder head (see engine manual for correct torque and sequence).
7. Retorque wheel drive hydraulic motor shaft nut 300 to 400 ft lb (407 to 542 Nm).



MODEL 280
LUBRICATION AND MAINTENANCE CHART

Index No. on Chart	Description	Procedure	Interval (hours)					
			8	50	150	250	500	
1	Hopper lift bearings(2)	Apply grease to fittings		X				
2	Engine Air Cleaner	Clean element*	X	X				
3	Steering gear box	Check level, add grease						X
4	Hydraulic tank oil level	Check oil level gauge	X					
	Hyd. tank breather filter	Replace filter element						X
	Hydraulic tank	Change hydraulic oil, clean tank (Tank capacity:4 gals.(15.1 liters) (Use TENNANT Hydraulic Oil)						X
5	Hydraulic oil filter	Change filter element						X
6	Battery	Check electrolyte level		X				
7	Engine oil filter	Change filter element			X			
8	Engine crankcase	Check oil level with dipstick Change oil	X	X				
9	Radiator	Check coolant level	X					
10	Brake Pedal pivot	Grease fitting		X				
11	Brake cylinder	Check fluid level		X				
12	Gasoline Fuel Filter	Clean filter						X
	+Diesel Fuel Filters	Check for water		X				
13	Rear tire	** Check Pressure		X				
14	+Engine Miscellaneous: (See Engine Manual)	Clean spark plugs, set gap Check points, set gap Lubricate distributor cam Lubricate distributor shaft (grease fitting) Check belt tension Adjust valve tappets					X	
				X				
15	Rear Wheel Pivot Bearing	Hand pack with Lithium EP						X
16	Front Wheel Bearings (2)	multi-grease						X

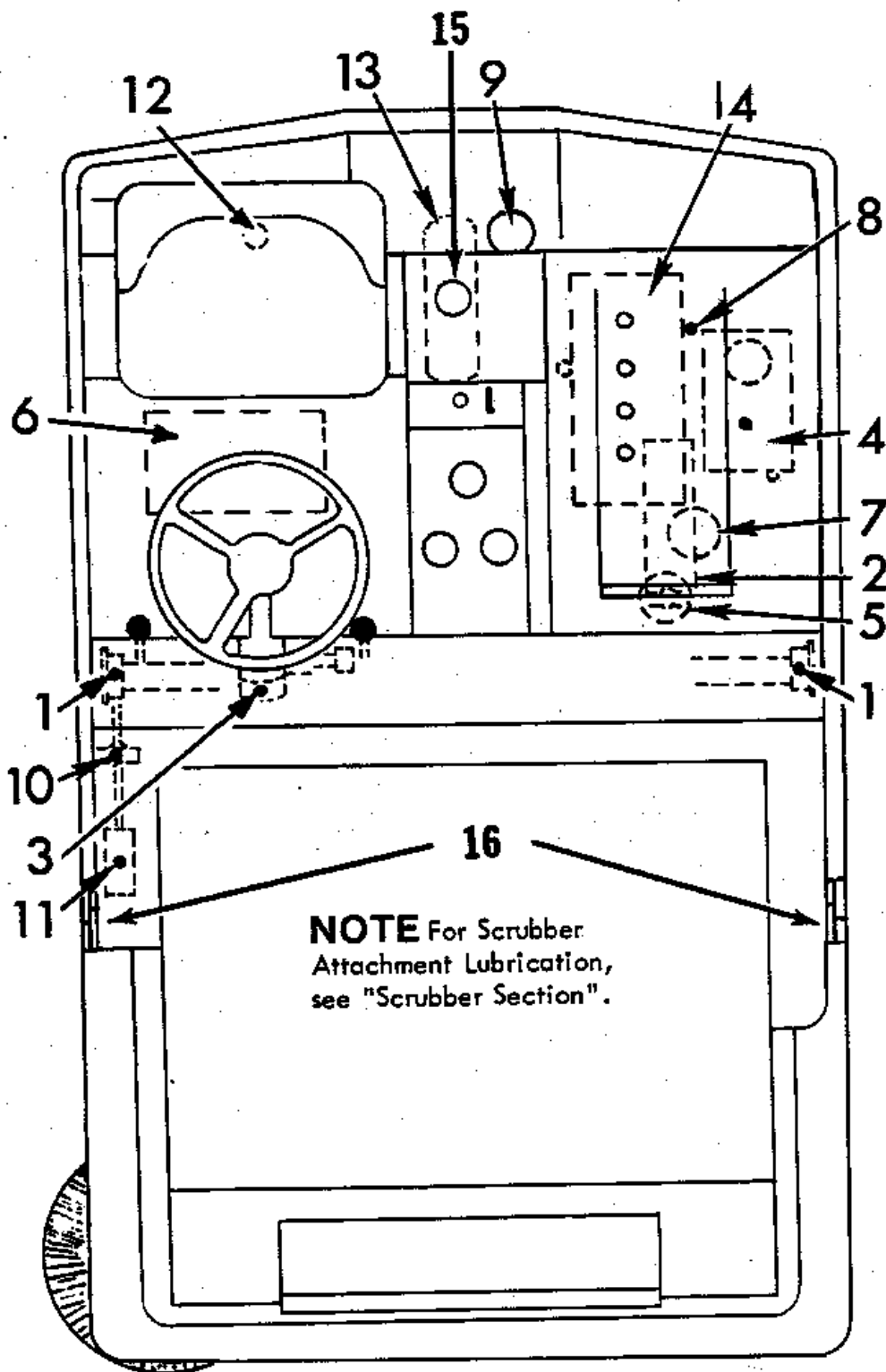
+See "Diesel Engine Section" for diesel engine preventive maintenance.

*Under normal conditions, clean element every 50 hours, in extremely dusty applications every 8 hours.

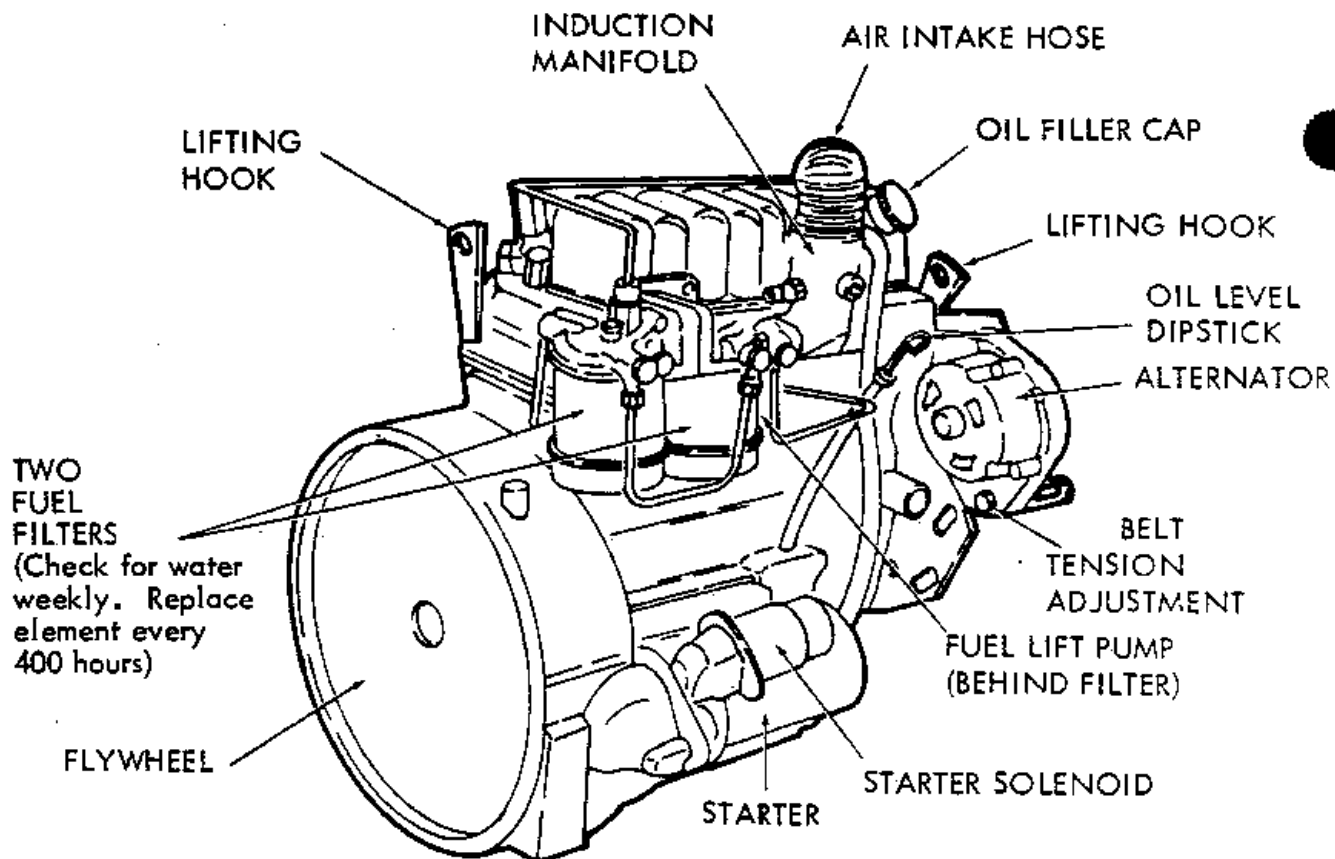
** 80 to 85 psi (552 to 586 kPa) for sweeping; 70 to 75 psi (483 to 517 kPa) for scrubbing.

RECOMMENDED LUBRICANTS

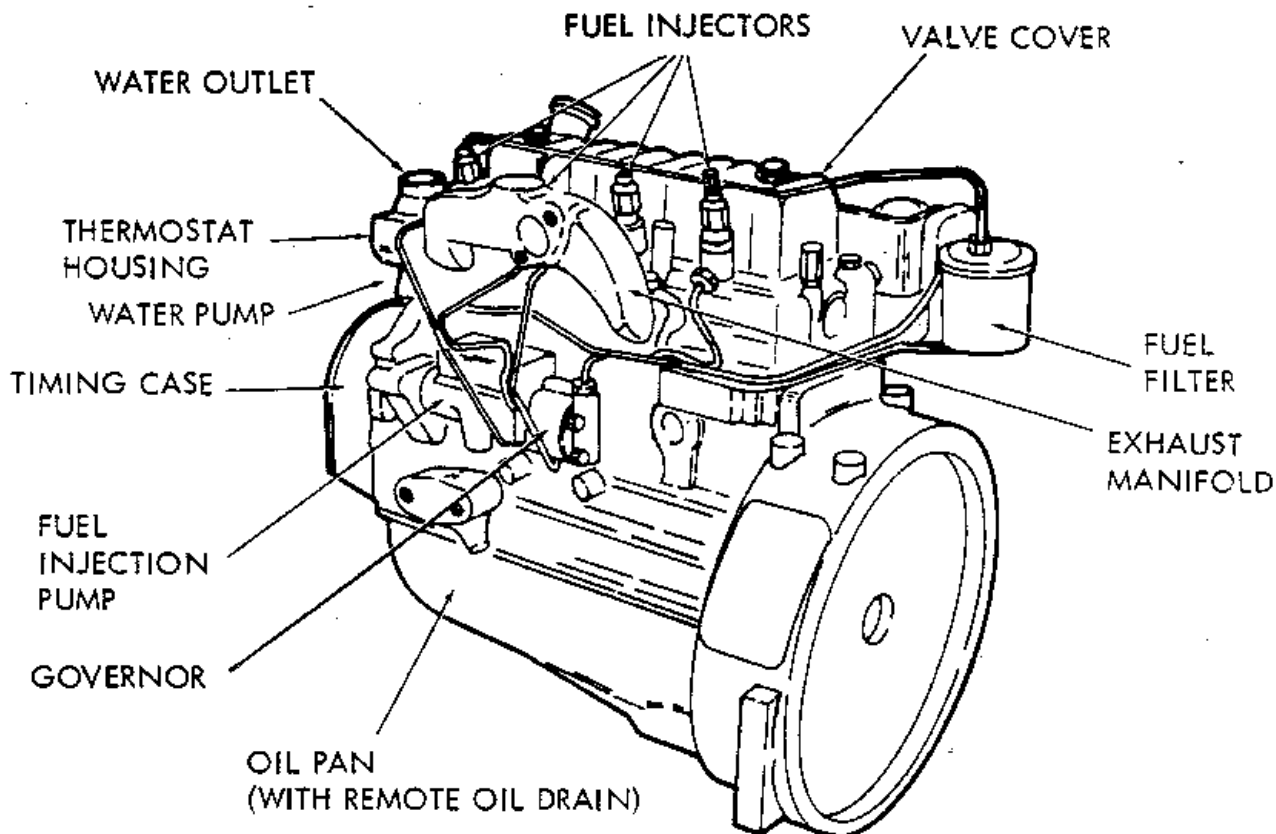
1. All grease fittings: Lithium-Moly E.P. grease.
2. Steering gear: GM4673M or equal steering gear grease.
3. Brake Fluid: SAE J1703 brake fluid.
4. Gas or LP Engine oil: 10W - 30 API type "SE" engine oil.
5. Diesel Engine Oil: 20W - 20API type "CC" engine oil.
6. Hydraulic oil: TENNANT Part No. 32397 - 10W40
7. Wheel bearings: Lithium EP multi-purpose grease.



LUBRICATION CHART



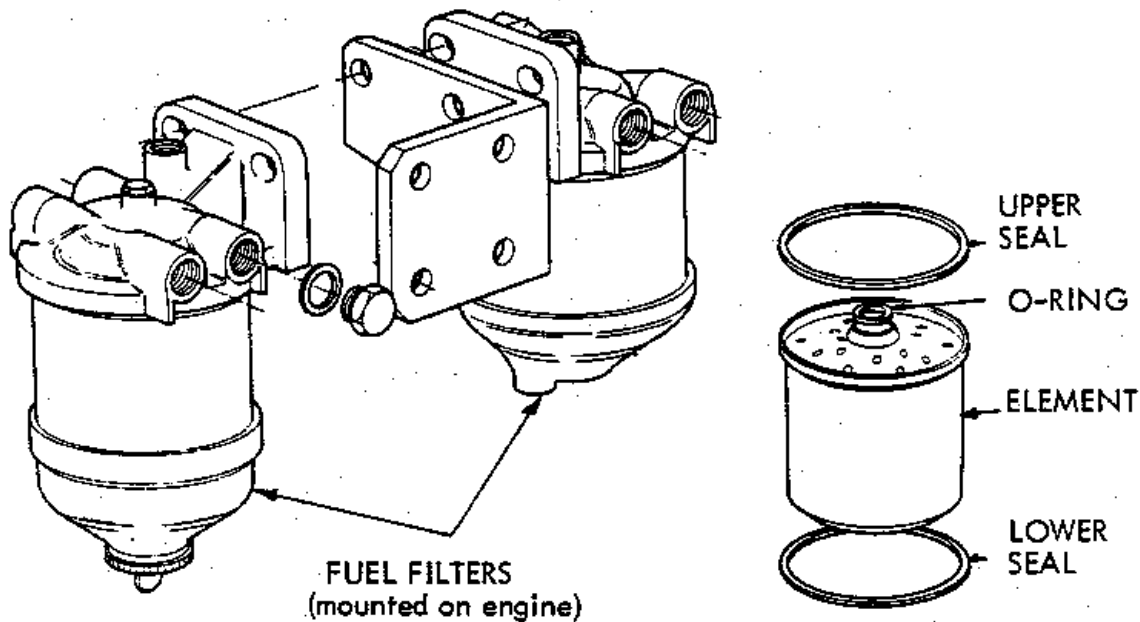
(ENGINE OIL FILTER REMOTELY MOUNTED ON BRACKET)



FEATURES OF THE 4.108 PERKINS DIESEL ENGINE

IMPORTANT NOTES ON THE PERKINS DIESEL ENGINE

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.
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.

(Continued on next page)

DIESEL ENGINE NOTES (Continued)

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 (22.68 kg) between each cylinder. Normal compression should be between 500 to 525 lbs (226.8 to 238.1 kg).
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. Don't leave the ignition switch "on" for very long--this will cause the solenoid to overheat.
12. 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.
13. After first 50 hours of service, be sure to check valve tip clearance, .010" hot or .012" cold (.254 or .304 mm).
14. After first 50 hours of service, be sure to tighten the cylinder head nuts, 60 ft lbs (81.36 Nm) torque in the correct sequence described in the Engine Manual.
15. 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.
16. **ATTENTION!** Do not attempt to use a "starting spray". This could cause serious engine damage.

RECOMMENDED DIESEL ENGINE SERVICE AFTER FIRST 50 TO 75 HOURS OF OPERATION

1. Change engine oil and replace oil filter element.
2. Check engine air cleaner indicator.
3. Tighten all engine air intake connections (hose, air cleaner, etc.).
4. Tighten cylinder head nuts to 55/60 ft. lbs (74.58/81.36 Nm) (See Engine Manual for correct sequence and procedure).
5. Check valve clearance and adjust if necessary (see Engine Manual-- .012" (.30 mm) cold).
6. Check engine alternator belt tension (see Engine Manual - .375" deflection at midpoint of belt longest span).
7. Check for correct engine idle speed (550 to 600 rpm), and operating speed (governor - controlled at 1800 to 1900 rpm).
8. Check tightness of all external nuts, bolts, etc. (such as manifolds, exhaust pipe, engine accessories, etc.).
9. Start engine and check for any fuel, coolant and engine oil leaks.
10. Bleed air from the fuel injection system.

DIESEL ENGINE OIL SELECTION

For normal temperatures of 45° to 80° (7.22 C to 26.67° C), use good quality heavy-duty oil with 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° (-17.78°C to 7.22°C)	SAE 10W
45° to 80° (7.22°C to 26.67°C)	SAE 20W-20
Above 80° (Above 26.67°C)	SAE 30W

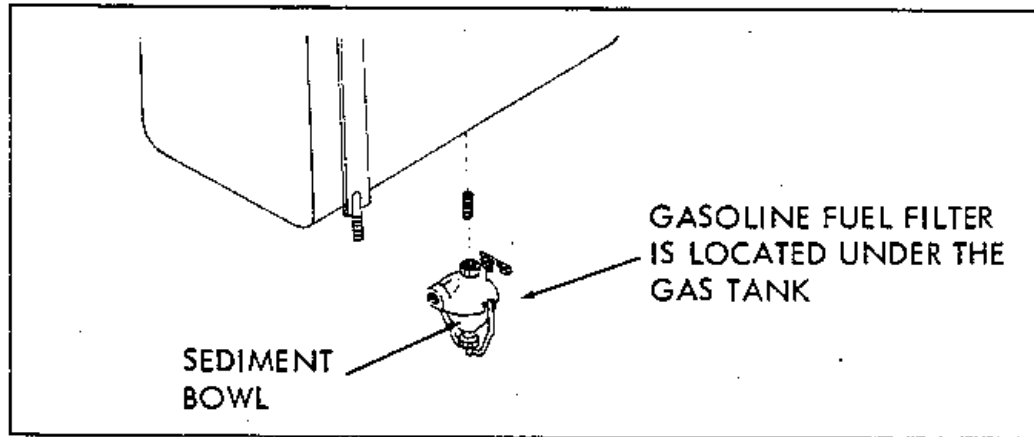
RECOMMENDED DIESEL ENGINE FUEL

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)

FUEL SYSTEM MAINTENANCE

Empty the carburetor and gasoline fuel filter sediment bowls of any accumulated sediment. Reassemble and check for leaks. 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.



ENGINE SPEED

The engine operates at a constant, factory-set governor-controlled engine speed.

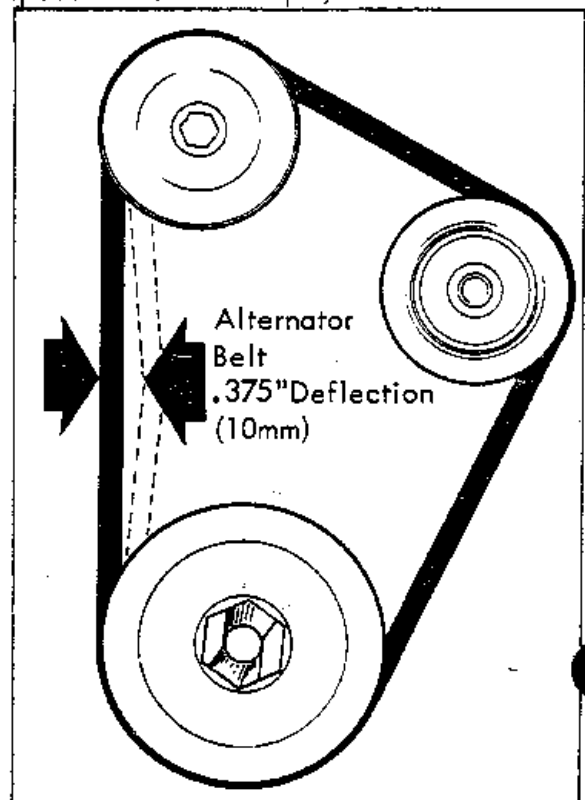
ATTENTION! Engine speed should never be set higher. If engine speed exceeds factory-set speed, the hydraulic pump may be damaged.

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

Recommended engine speed with accessories on and brush down: 1750 to 1850 rpm (sweeper), 1900 to 2000 rpm (scrubber). Idle speed should be 600 to 800 rpm. (For diesel engine: 1800 to 1900 rpm. Idle speed: 550 to 600 rpm)

ALTERNATOR BELT TENSION

Loosen adjusting screw on alternator and pull out on alternator to tighten belt. When adjusted correctly, the belt should have about .375" (10mm) deflection from moderate force applied at midpoint on longest span of belt.



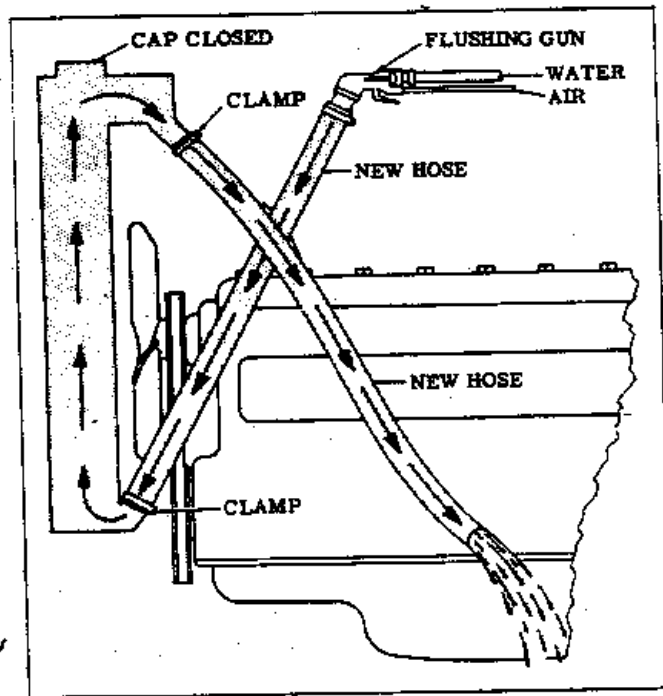
RADIATOR MAINTENANCE

Use soft, clean water mixed with a permanent-type, ethylene glycol antifreeze in a 1 to 1 ratio.

Deposits of sludge, scale and rust will prevent normal heat transfer. Flush out the radiator after every 500 hours of operation. If radiator is clogged, use "reverse flushing" procedure to clean it. Use a good cleaning compound and follow standard automotive practice.

A thermostat is located in the water outlet elbow on top of the engine cylinder head.

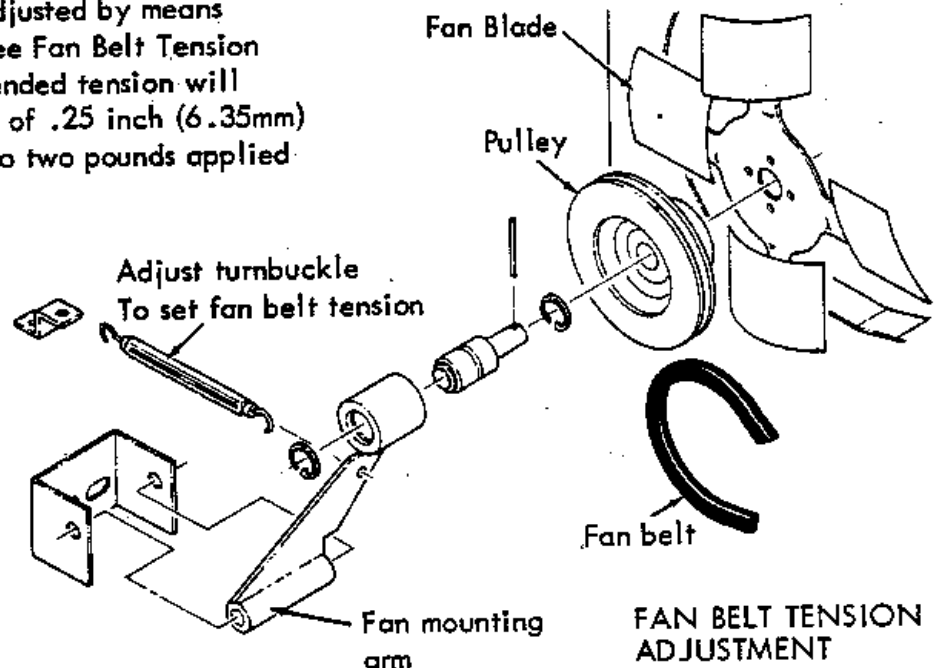
Engine overheating may also be caused by dirty radiator fins. The exterior fins of the radiator can be cleaned with an air hose. Blow out all dust, dirt, etc. between the fins. This should be done only after the radiator has cooled off, to avoid cracking caused by uneven cooling. Blow air "inward", toward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



— Reverse Flushing Radiator

RADIATOR FAN BELT TENSION

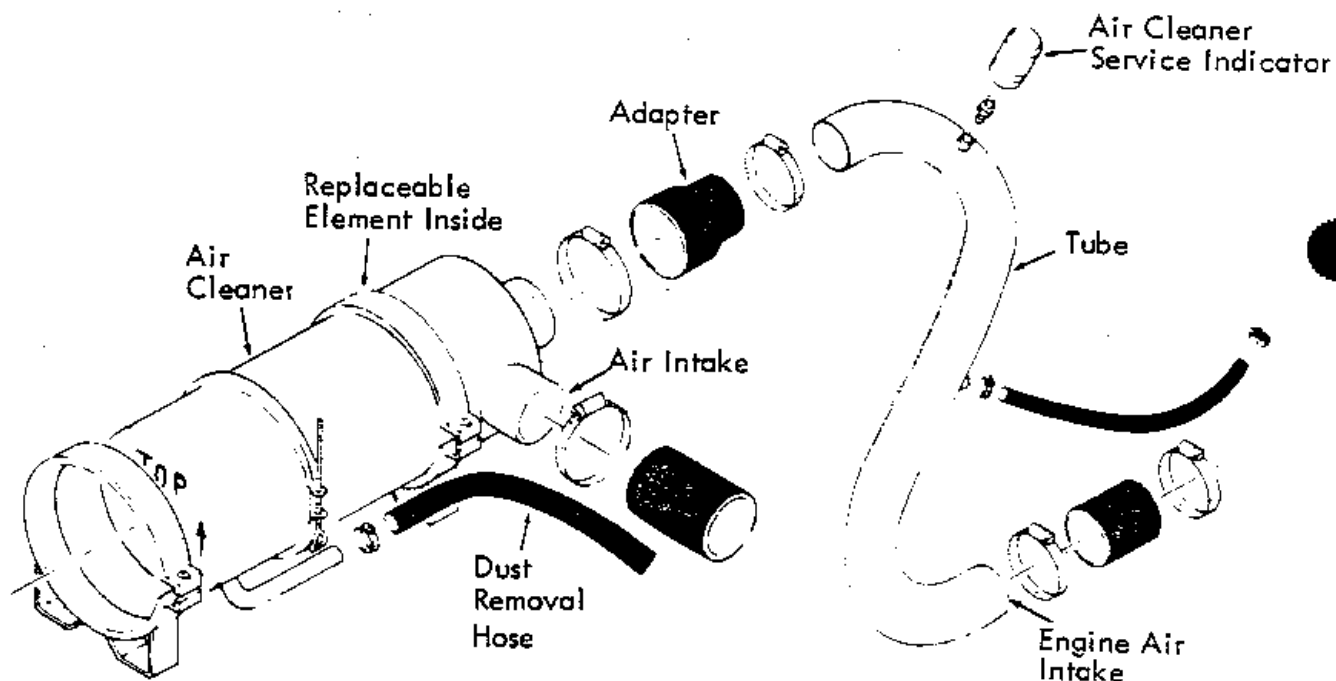
Fan belt tension is adjusted by means of a turnbuckle. (See Fan Belt Tension drawing). Recommended tension will produce a deflection of .25 inch (6.35mm) from a force of one to two pounds applied at belt midpoint.



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 at recommended intervals 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.

Under normal operating conditions, disassemble and service air cleaner components every 50 hours of operation. Do this more frequently (even daily) if extremely dusty or dirty conditions prevail.



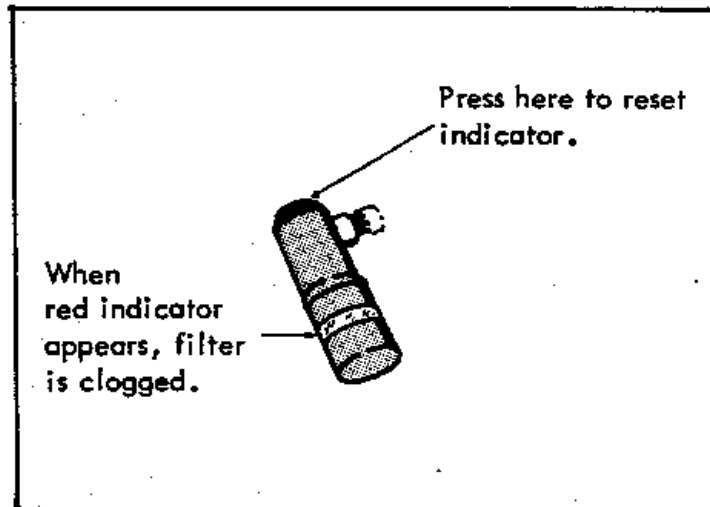
ENGINE AIR CLEANER SYSTEM

The filter element is equipped with a number of angled fins which impart a high-speed rotation to the incoming air. This rotation removes a large part of the dust by centrifugal action. The dust falls into the dust cup at the front end of the unit where it is automatically removed through a hose attached to the vacuum system.

The finer particles remaining in the incoming air are then removed by the filter element.

AIR CLEANER (continued)

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).



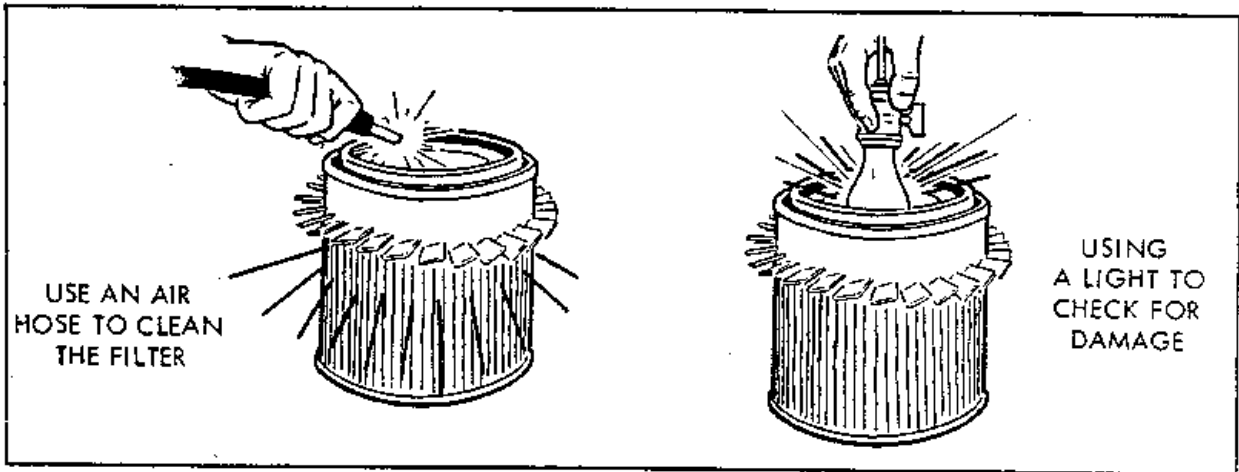
AIR CLEANER SERVICE INDICATOR

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.

To replace Filter Element:

1. Unscrew clamp ring on filter.
2. Remove dust cup.
3. Remove thumbscrew.
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 are rear of air cleaner. Use care so that fins are not damaged. Tighten thumbscrew attaching element.
7. Install dust cup and tighten clamp ring to hold it in place. Check all intake hose connections for leaks.

AIR CLEANER (continued)

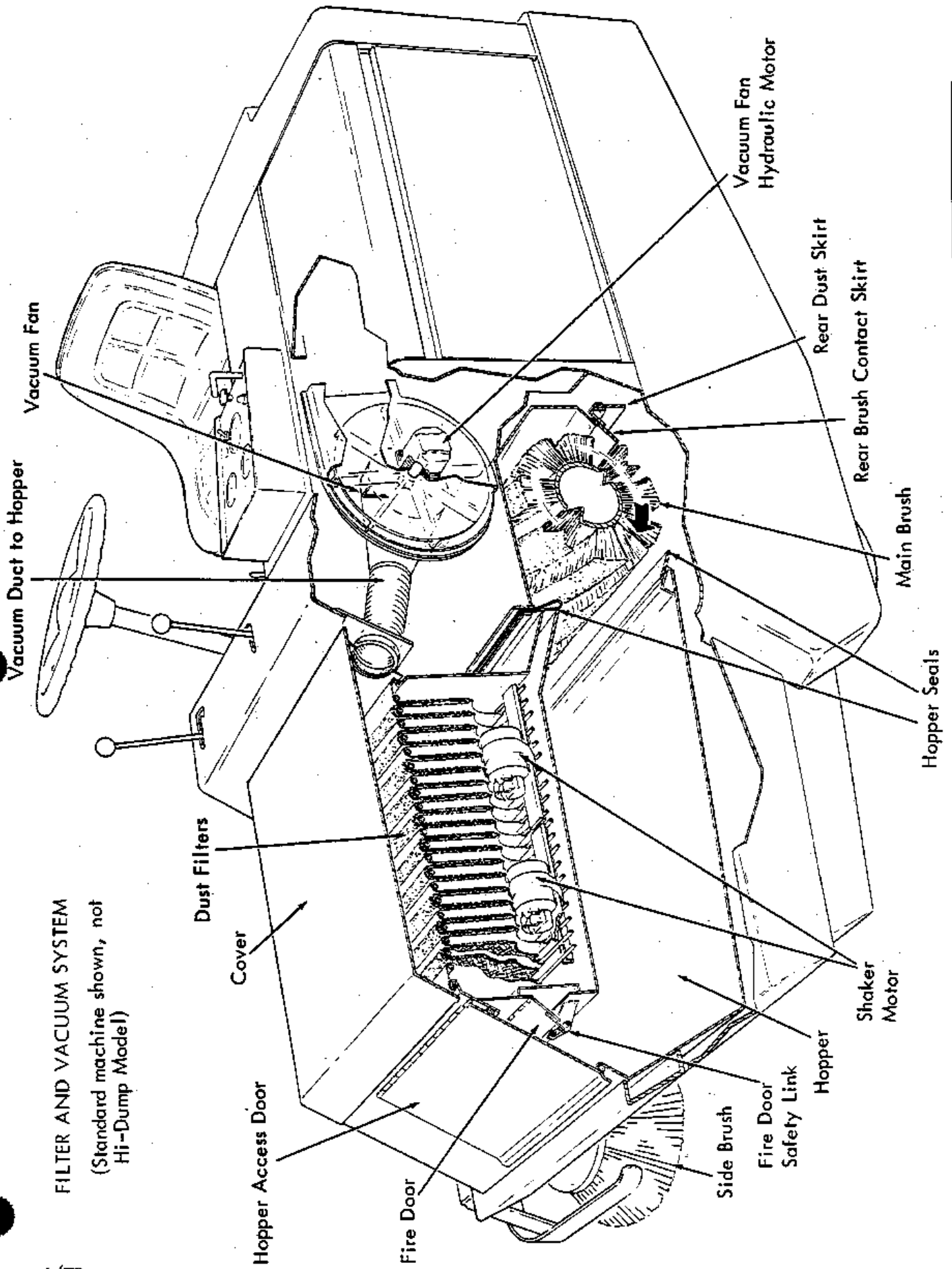


To Clean and Inspect Filter Element:

1. Using an air hose, direct dry, clean air up and down pleats on the inside of filter.
ATTENTION! Air pressure at nozzle must not exceed 100 psi (690 kPa).
Maintain reasonable distance between nozzle and 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 hours, replace the element with a new one (Part #51561).

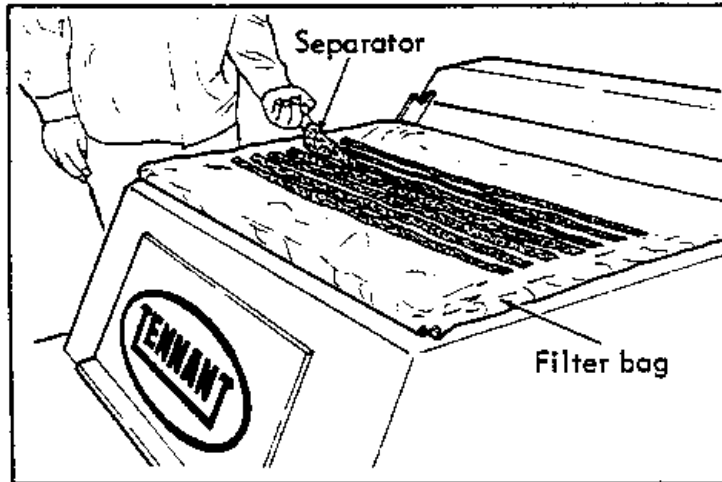
FILTER AND VACUUM SYSTEM

(Standard machine shown, not Hi-Dump Model)



TO REMOVE AND REPLACE FILTERS

1. Push shaker button to clean filters.
2. Remove filter box cover.
3. Lift out filter complete with filter rack. Clean or replace filter bag.
4. Replace filter and all other parts in same position as they were originally installed. Be sure all parts are assembled compactly and neatly in place to prevent leakage around cover.

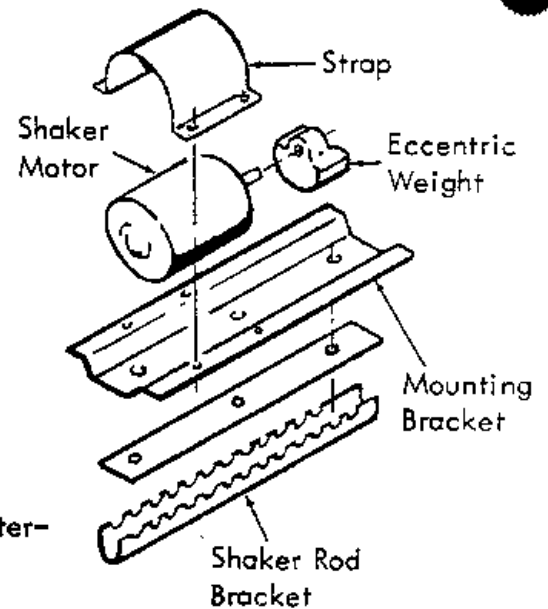


When replacing filter bag, make sure separators are in place between filter bag envelopes.

FILTER SHAKER MOTOR REPLACEMENT

As shown in the drawing, the shaker motor is mounted at the bottom center of the filter bags. The motor is attached to its bracket by a strap which fits over the motor. The motor and bracket are attached to the rods which pass through the bottom edges of the filter bags. An eccentric weight, attached to the motor shaft, provides the vibration for shaking the filter bags.

NOTE The shaker motor is sealed with a dust and water-proofing compound and cannot be repaired.



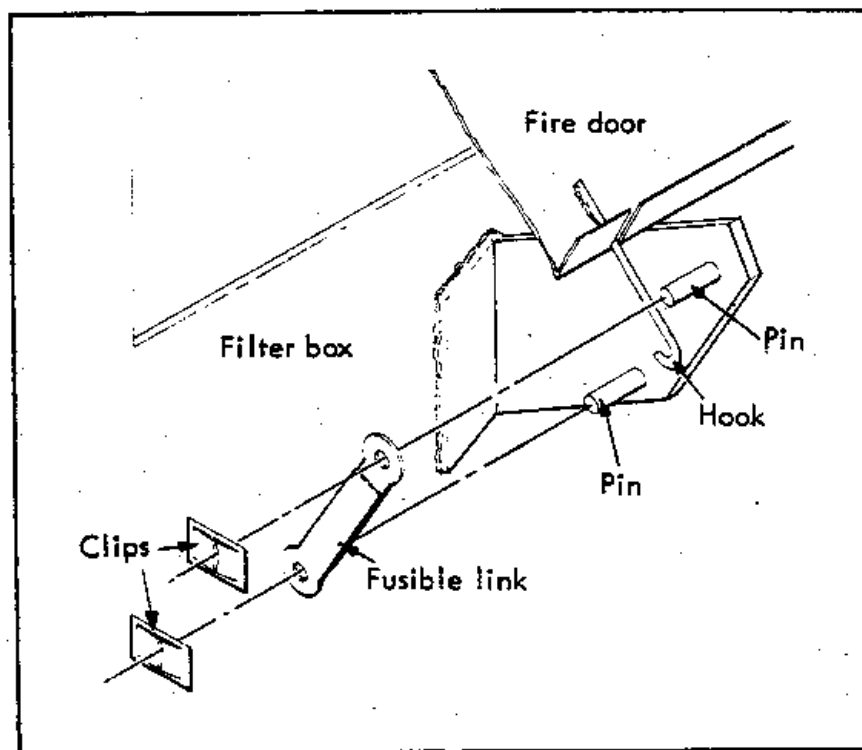
FUSIBLE LINK REPLACEMENT

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 for breakage or failure due to heat. On the standard machine, the fusible link is accessible through the hopper front access door.

On Hi-Dump machines, the fusible link is accessible through the hopper dump door opening.

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



FUSIBLE LINK REPLACEMENT
(Standard Machine Shown)

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

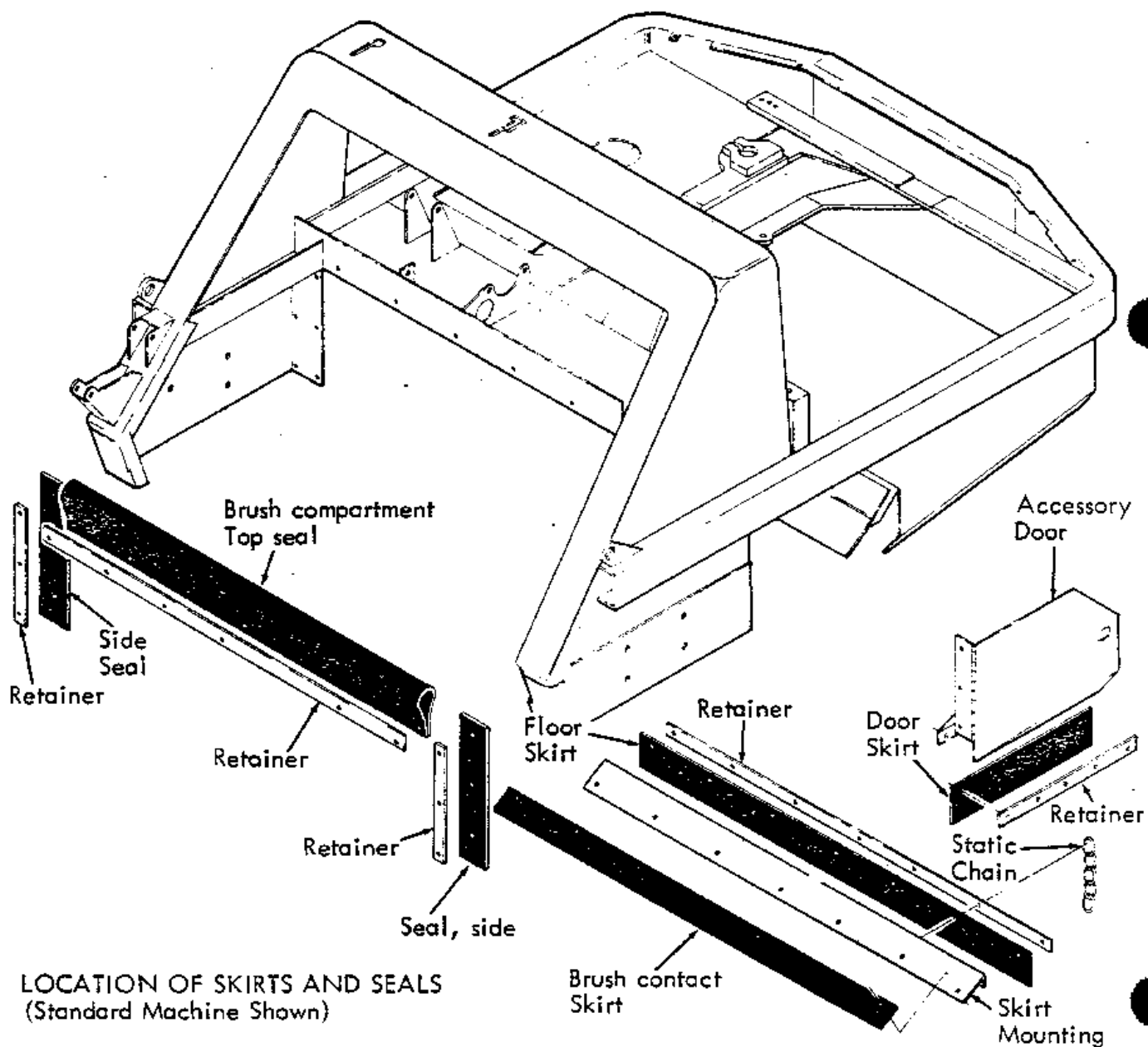
STATIC DRAG CHAIN

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.

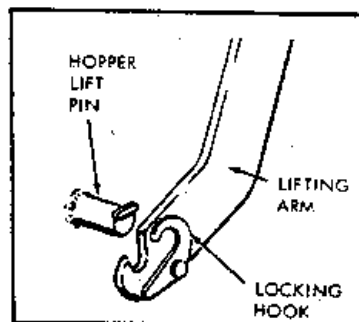
DUST SKIRTS AND SEALS

All dust skirts have slotted screw openings to provide adjustment for skirt clearance from the floor. This clearance should be adjusted to allow 0.125 in (6.35 mm) between the skirt edge and the floor (operator is not on the machine). Be sure when making this or other floor clearance adjustments that you have the machine on a level surface. Inspect seals occasionally and replace the seals if worn or damaged.



TO REMOVE SWEEPING HOPPER

1. Raise bumper and latch in place with chains.
2. Start engine. Raise hopper and engage safety lock.
3. Place dolly (accessory) under hopper. (If dolly is not available, block up hopper.)
4. Swing open locking hooks which hold hopper lifting pins to the lift arms (see sketch).

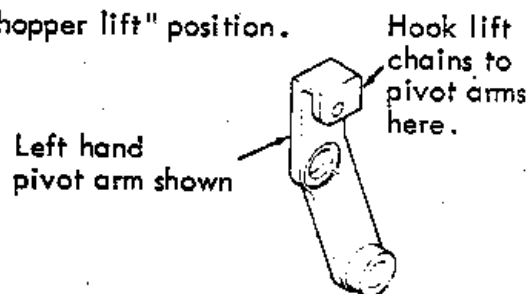


5. Raise the hopper, disconnect the lift arm safety lock, and lower hopper onto dolly. Stop the engine. Place hydraulic control in "OFF" position. Push down hopper lift arms until they clear the hopper lift pins.

MANUAL METHOD OF RAISING HI-DUMP HOPPER

If it is necessary to raise the hopper and the hydraulic pump is not operating, use an overhead chain hoist to lift the hopper, as follows:

1. Hook the chain to the left and right front pivot arms on the hopper lift arms.
2. Place the hydraulic control valve handle in "hopper lift" position.
3. Use the chain hoist to raise the hopper.
4. Use the safety arm to support the hopper.



TO REMOVE HI-DUMP HOPPER

1. The hopper should be supported off the floor.
2. Disconnect the filter shaker motor lead at the point where it enters the hopper (bottom of hopper near side brush).
3. Pull pin at rod end of rollout cylinder (both sides).
4. Remove two bolts which attach right and left torque shaft to hopper.
5. Disconnect the door latch chains (at clevis pin).
6. Pull torque arms out of hopper.
7. Remove hopper.

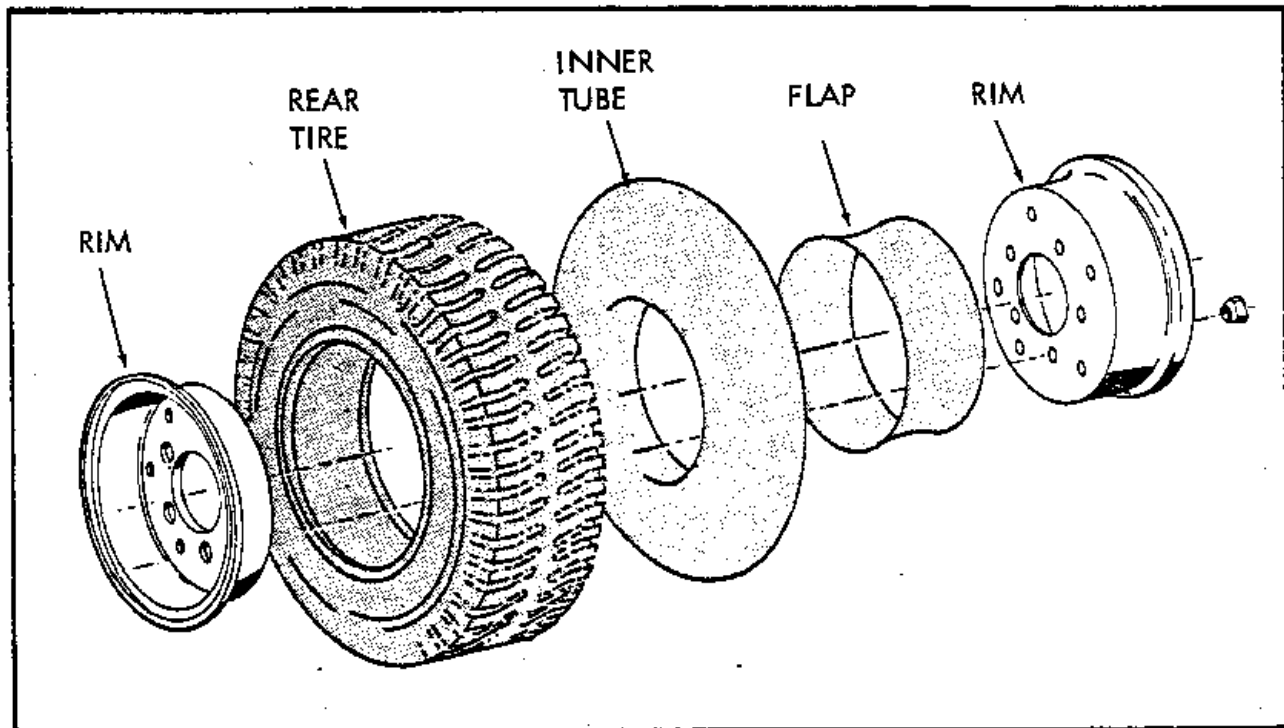
REPLACING REAR WHEEL OR TIRE

Refer to drawing for arrangement of parts.

▲WARNING Deflate tire before separating rims.

1. Raise and block up rear of machine.
2. Remove wheel from hub.
3. Remove bolts holding wheel rims together. Separate rims.
4. Replace tire and/or tube.
5. Bolt rims together.
6. Bolt wheel to hub. (Inflate tire to 80 to 85 psi (5.44 to 5.78 bar) for sweeping, 70 to 75 psi (4.76 to 5.10 bar) for scrubbing.)

▲WARNING When mounting tire, place tire inside cage before inflating.



RECOMMENDED ASSEMBLY TORQUES

Rear Wheel Hub Nut

Nut holds rear wheel hub on rear axle - 300 to 400 ft lb (407 to 542 Nm).

Rear Wheels

Rear wheel mounting nuts - 85 to 95 ft. lbs (115.26 to 128.8 Nm).

Rear Wheel King Pin

Tighten rear king pin nut 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.

Vacuum Fan to Hydraulic Motor

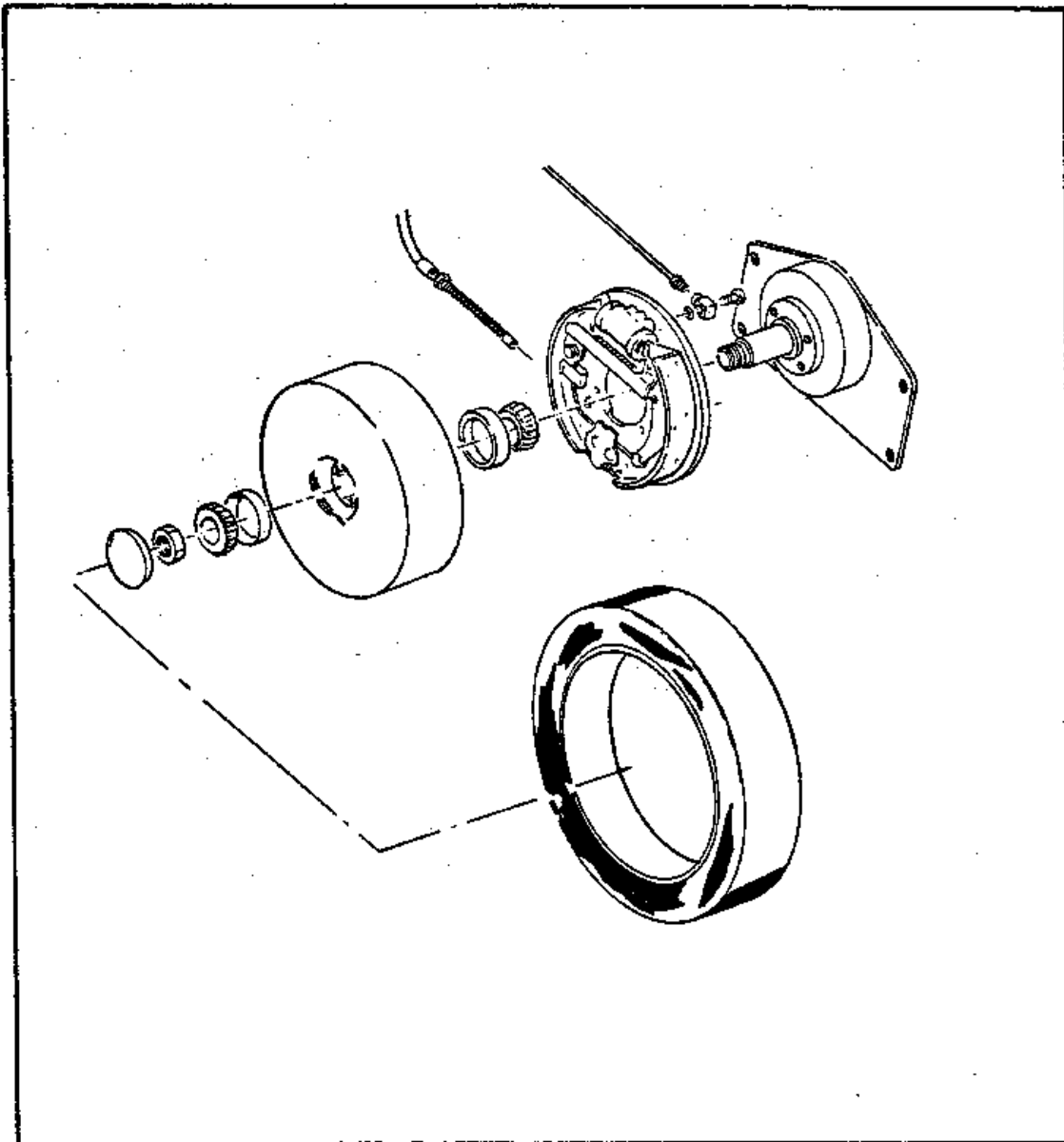
Tighten nut to no more than 20 ft. lbs (27.12 Nm).

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 bearings clean.

4. Disconnect and remove brake shoe retracting spring.
5. Remove brake shoes.
6. Clean brake assembly and brake drum.
7. Position new brake shoes on anchor pin and install shoe retracting spring.
8. Position wheel on axle and install nut.



EXPLODED VIEW OF FRONT WHEEL AND BRAKE ASSEMBLY

RECOMMENDED HYDRAULIC FLUID

TENNANT Hydraulic Fluid is recommended for use in your machine.

TENNANT Hydraulic Fluid is 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 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.

TENNANT Hydraulic Fluid Viscosity Specifications		
	Tennant Hyd. Fluid No. 32397(10W40)	Tennant Hyd. Fluid No. 32398(20W60)
SUS @ 100°F(37.78°C)	404-445	940-1010
SUS @ 210°F(98.89°C)	78-84	122-130

ATTENTION! Do not attempt to substitute automatic transmission fluid (ATF) for hydraulic fluid

The hydraulic fluid level should be between the "high" and "low" marks on the fluid level sight gauge when the fluid is at room temperature. As the hydraulic fluid heats up to its normal operating temperature, it expands. Always allow for this expansion when filling the hydraulic fluid reservoir. Do not overfill the reservoir.

HYDRAULIC TANK (See Drawing)

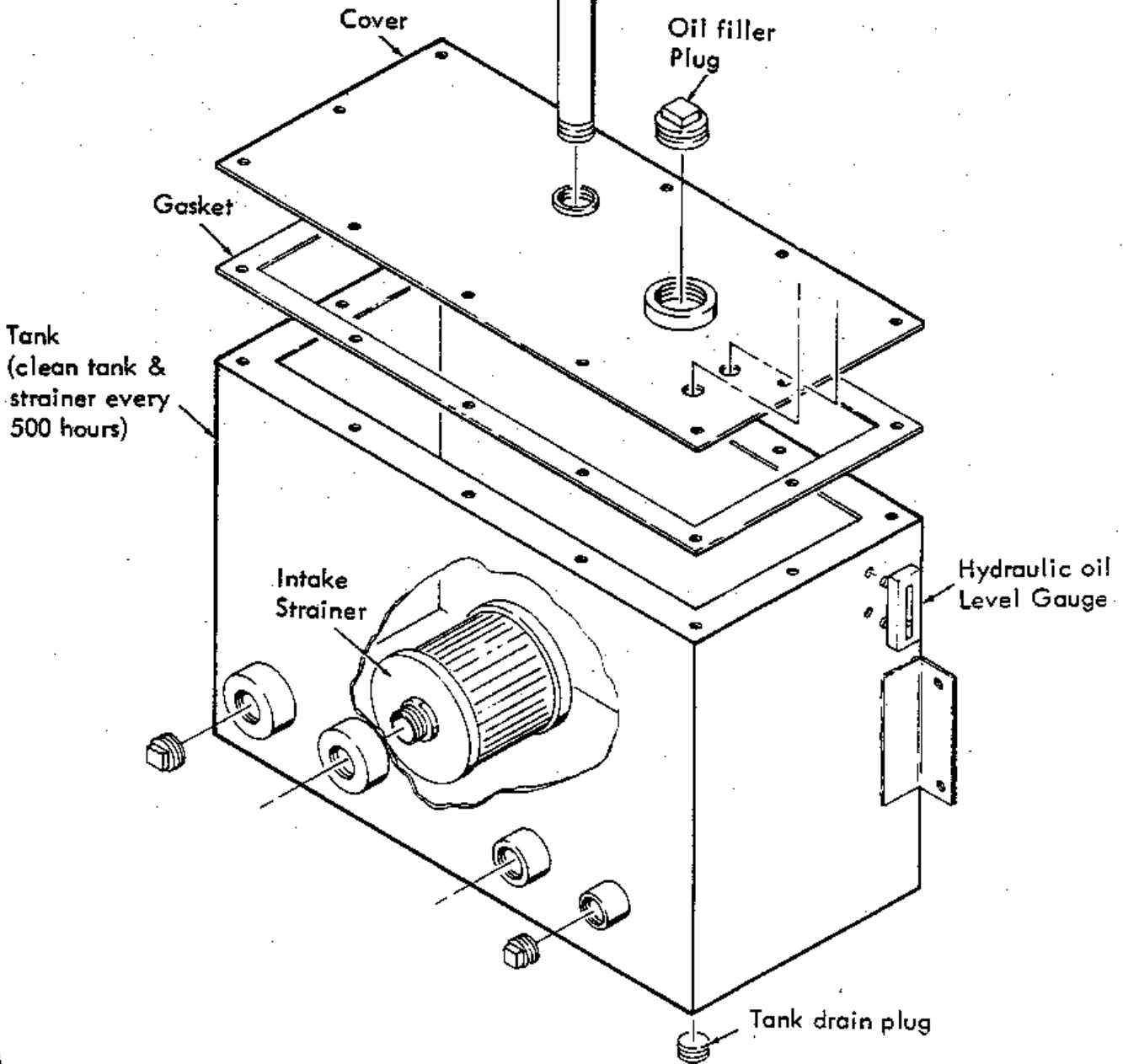
The hydraulic tank has a capacity of four gallons (15 L). System capacity is five gallons (19 L). For average operating temperature up to 90°F(32.2°C) use Tennant Company hydraulic fluid 32397-10W40. For ambient temperature above 90°F (32.2°C) use Tennant Company hydraulic fluid 32398 - 20W60. An oil level gauge is provided on the tank. To fill the tank, remove the pipe plug in the top of the tank.

Breather
(with filter inside)

Replace Filter Every
500 hours.

NOTE

Use TENNANT HYDRAULIC OIL
(See Specifications of TENNANT
Hydraulic oil)



HYDRAULIC OIL TANK

CHANGING HYDRAULIC OIL FILTER

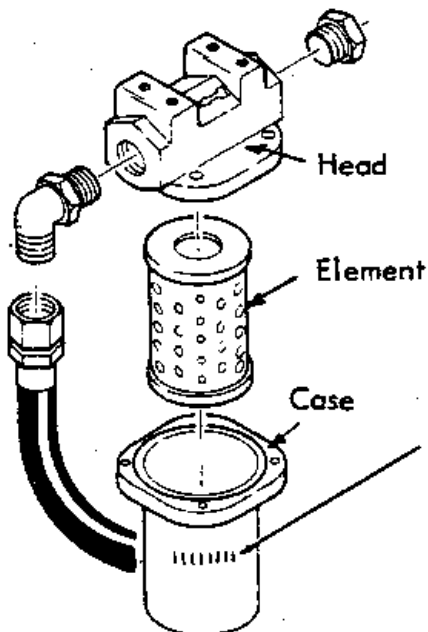
Change hydraulic oil and replace oil filter element at every 500 hours of operation.

The hydraulic oil filter is located below the lintel and just behind the hopper. In order to change the filter element, it will be necessary to remove either the hopper cover or the entire hopper.

WARNING Do not attempt to change filter by reaching under upraised hopper.

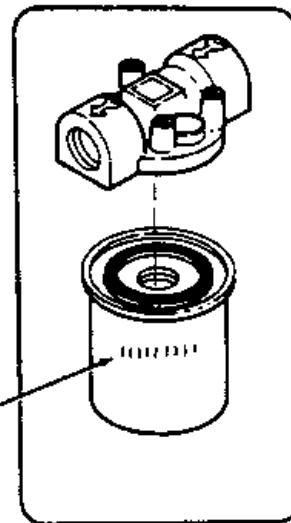
NOTE Either one of two different filters may be used on your machine:

1. The standard filter (Ripley), has a replaceable cartridge located inside a case. Check your machine to determine which filter is used so that correct replacement elements can be ordered. Element part number is located on filter.
2. The alternate filter element is an automotive-type "spin-on" element. When installing the new element, apply a film of oil to the gasket. Turn element in until contact, then tighten an additional one and one-half turns. See instructions on element. Start the machine and check for leaks.



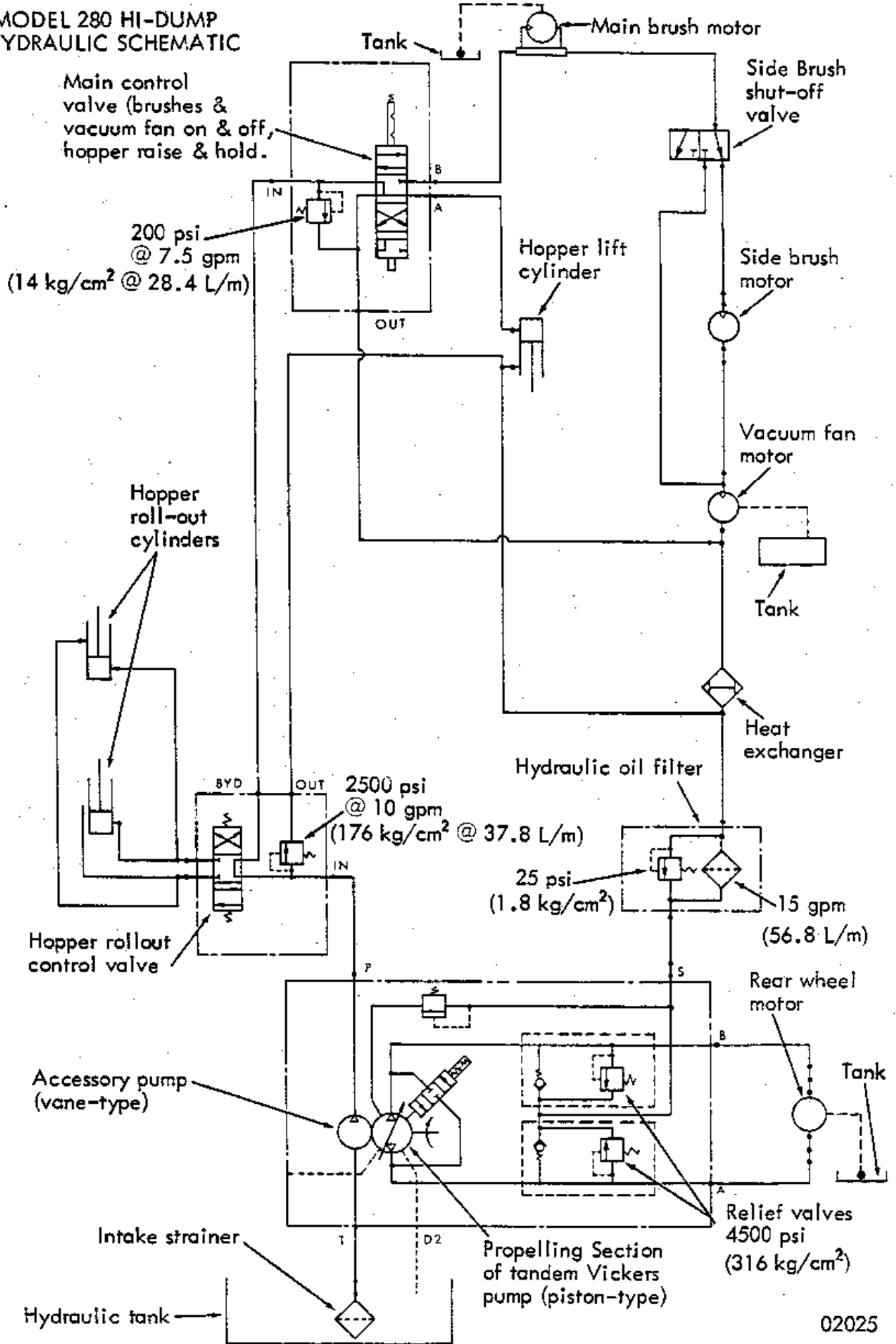
Standard filter made by Ripley (Element #53348-1)

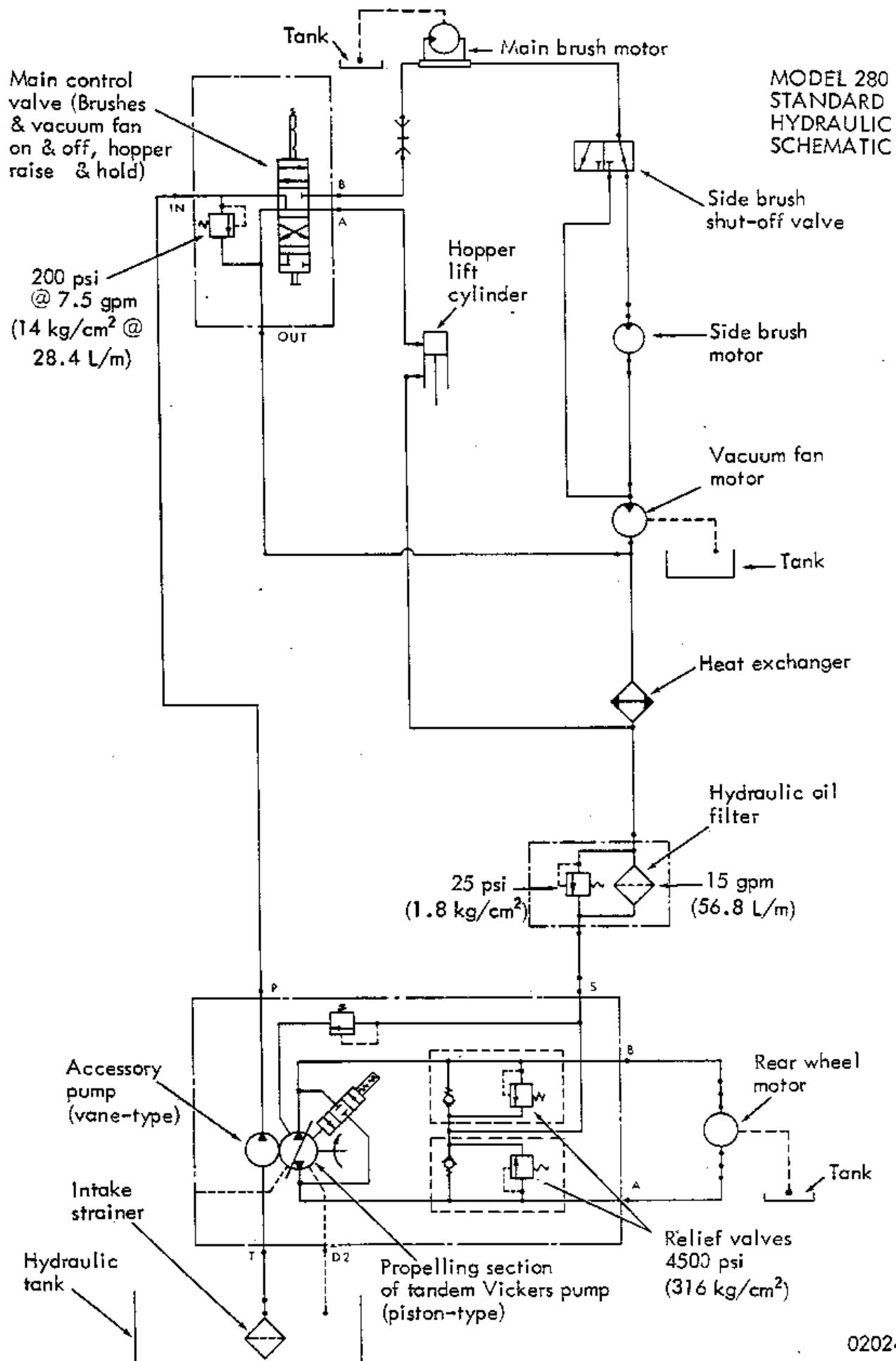
NOTE
Element part number located here.

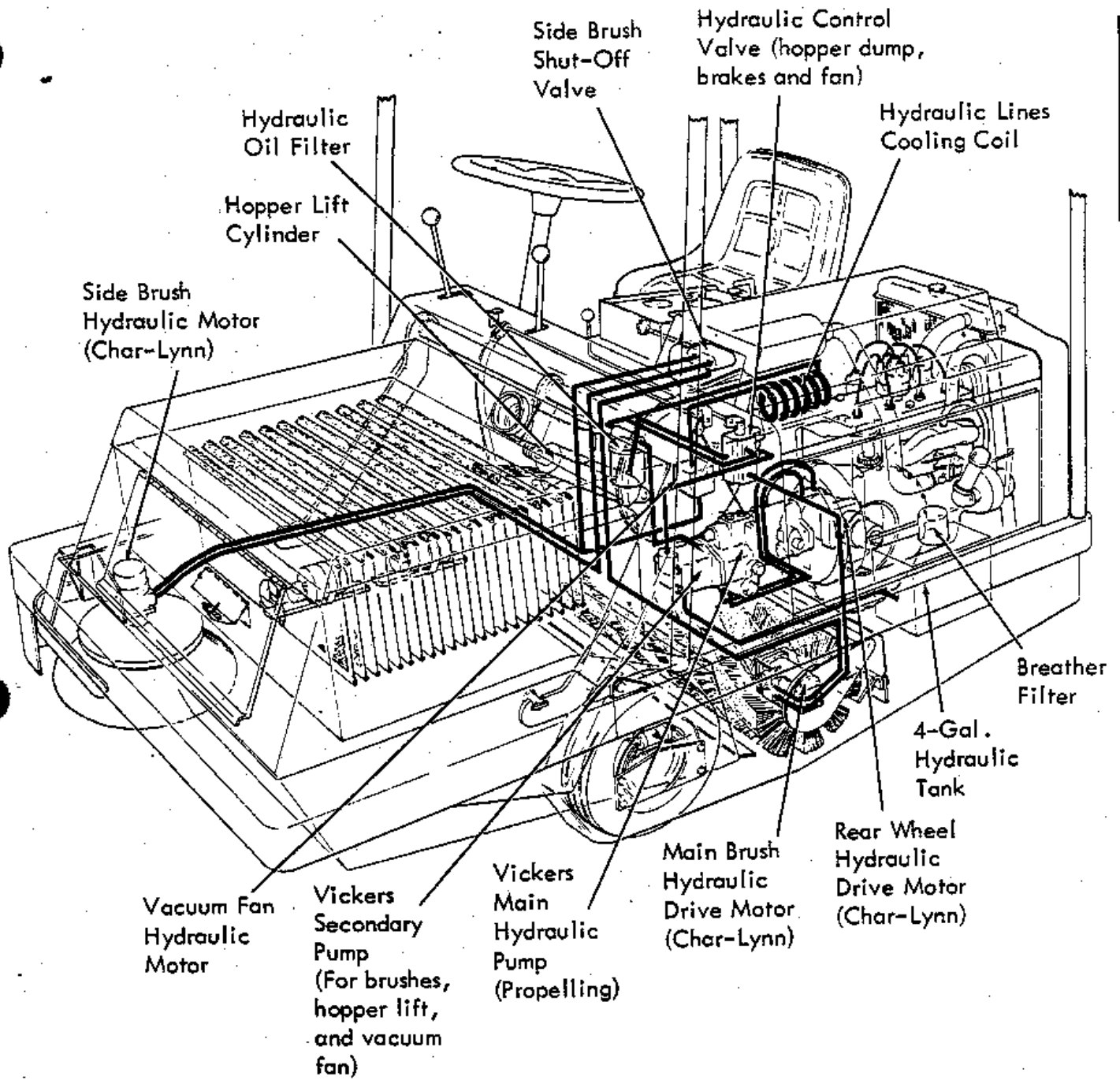


Alternate Spin-on Type Filter made by Deluxe (Element #67718-2)

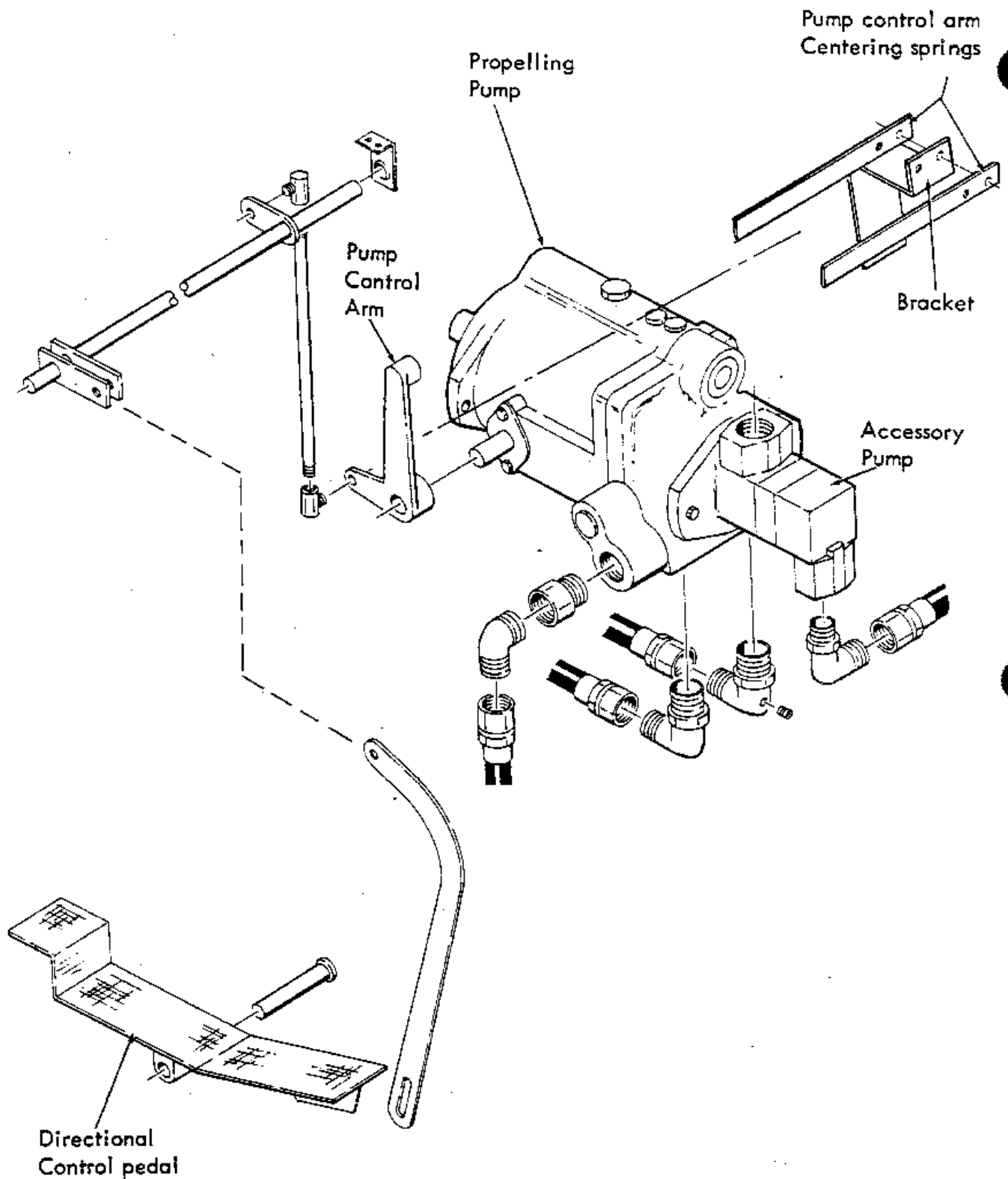
**MODEL 280 HI-DUMP
HYDRAULIC SCHEMATIC**







PICTORIAL VIEW OF MODEL 280 - HYDRAULIC SYSTEM
 STANDARD MACHINE SHOWN, NOT HIGH DUMP



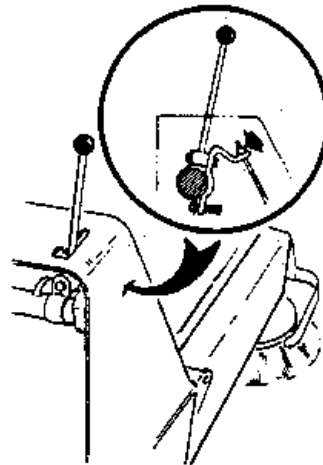
Adjust Neutral Position of Control Pedal by Shifting Position of Pump Arm Centering Springs.

HYDRAULIC PUMP REPLACEMENT

1. Disconnect and cap hydraulic lines to pump. Mark lines for correct reassembly.
 2. Disconnect foot pedal linkage from pump control arm.
 3. Remove two screws attaching pump to drive housing which is attached to engine bellhousing.
 4. Remove pump by pulling straight out from housing. The pump splined drive shaft should slip out of the coupling. It should not be necessary to disassemble the pump coupling.
 5. Hydraulic pump parts lists are in the "Hydraulic Components" Section of this manual. Repair instructions are provided with the pump seal kit.
 6. Mount new or repaired pump on drive housing. Install centering bracket. The pump splined drive shaft should slip into coupling on engine. The drive housing will align the pump correctly with the engine.
 7. Connect hydraulic lines to pump, following markings made during disassembly to insure correct connections.
- ATTENTION!** Hydraulic connections must be clean.
8. Fill pump case through plugged opening in top of pump with hydraulic oil.
 9. Connect foot pedal linkage to pump control lever.
 10. Set hand brake. Start engine and check for correct operation. Check for leaks at all hydraulic connections to pump.

TO REPLACE SIDE BRUSH LIFT CABLE

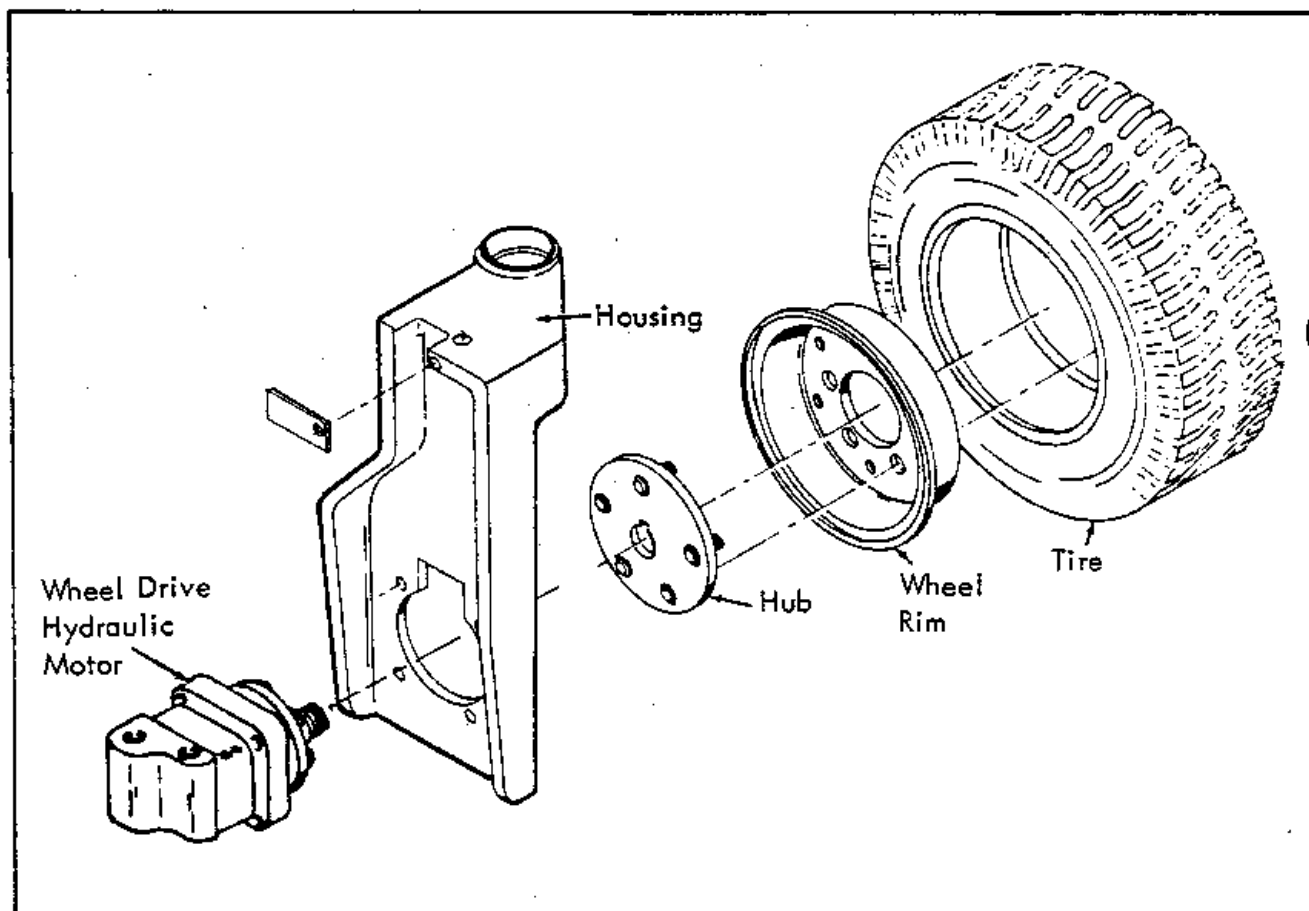
1. Remove old cable by disconnecting lower and upper cable ends. Lower cable end has clevis and pin located just in front of front wheels. Remove lower cable end first.



2. Upper cable end is threaded through adjusting nuts. Remove adjusting nuts from upper cable end to free cable.
- NOTE** Adjust cable, loosening adjusting nut at upper cable end (see drawing).

REPLACING REAR WHEEL HYDRAULIC DRIVE MOTOR

1. Raise and block up rear of machine.
2. Disconnect and cap hydraulic lines to rear wheel drive motor. Mark lines for correct assembly. Plug ports in motor.
3. Remove wheel from motor shaft. Do not pound on motor shaft. Use wheel puller if removal of wheel from motor tapered shaft is difficult. (See "Hydraulic Components" Section for hydraulic motor parts illustration).
4. Remove screws attaching drive hydraulic motor to housing (see exploded view drawing for arrangement of parts).
5. Remove hydraulic motor.
6. Install new motor.
7. Connect lines to motor.
8. When installing wheel on new or repaired motor, tighten wheel hub nut on axle to 300 to 400 ft lb (407 to 542 Nm).



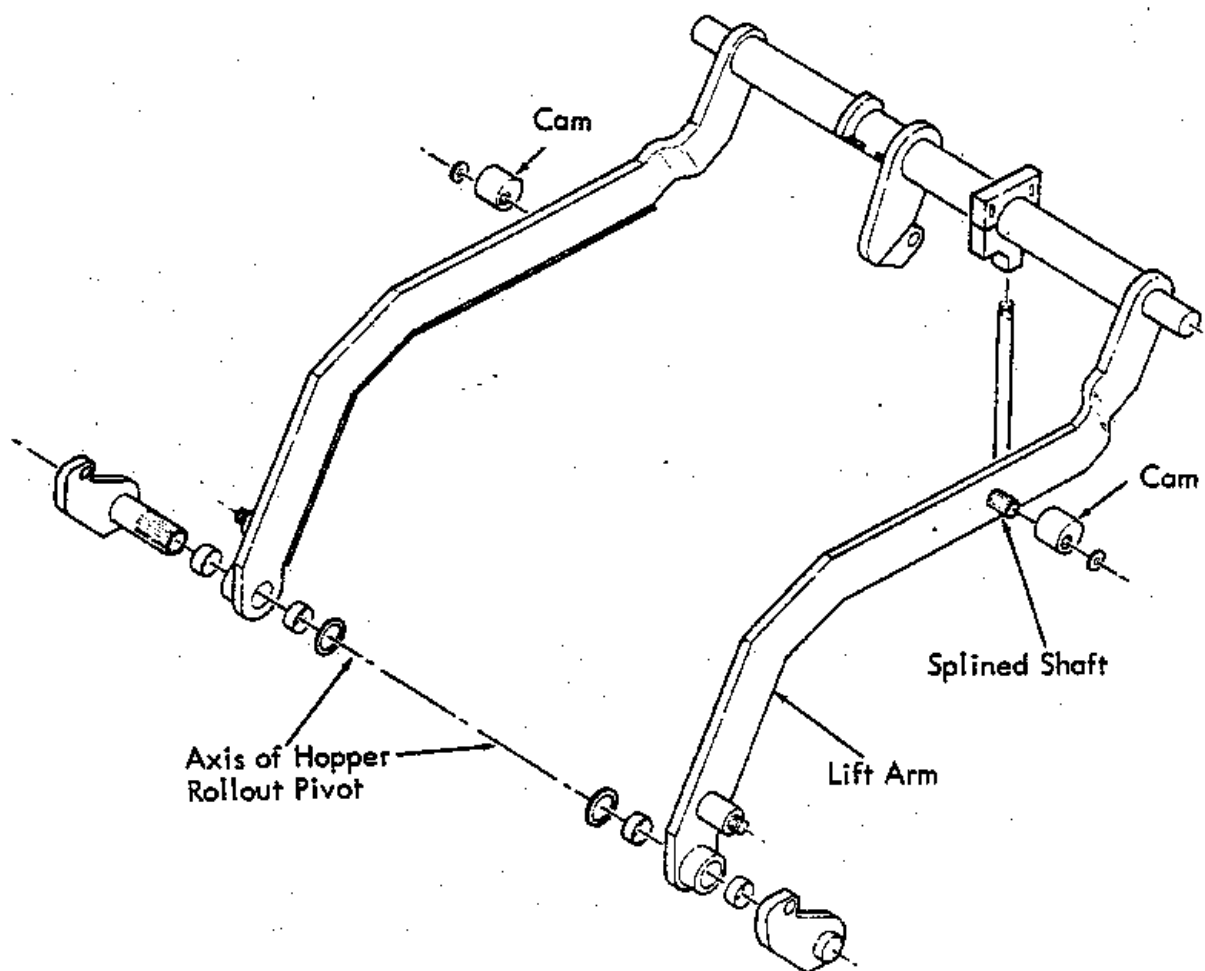
EXPLODED VIEW OF REAR WHEEL AND DRIVE MOTOR

HI-DUMP MACHINE ADJUSTMENTS

The following are factory adjustments which should be necessary only if the hopper, lift arms, or other parts have been replaced or repaired. The adjustments should be performed in the following order:

HOPPER LIFT ARM ADJUSTMENT

1. The axis of the hopper rollout pivot should be $6.625" \pm .125"$ (168.3mm ± 3.2 mm) from the floor (both sides).
2. When the hopper is at the required dimension, adjust the two cams on the main lift arms so that they contact the front, sloping edge of the main frame. The cams are mounted on splined shafts and, once they are adjusted, should not require readjustment.



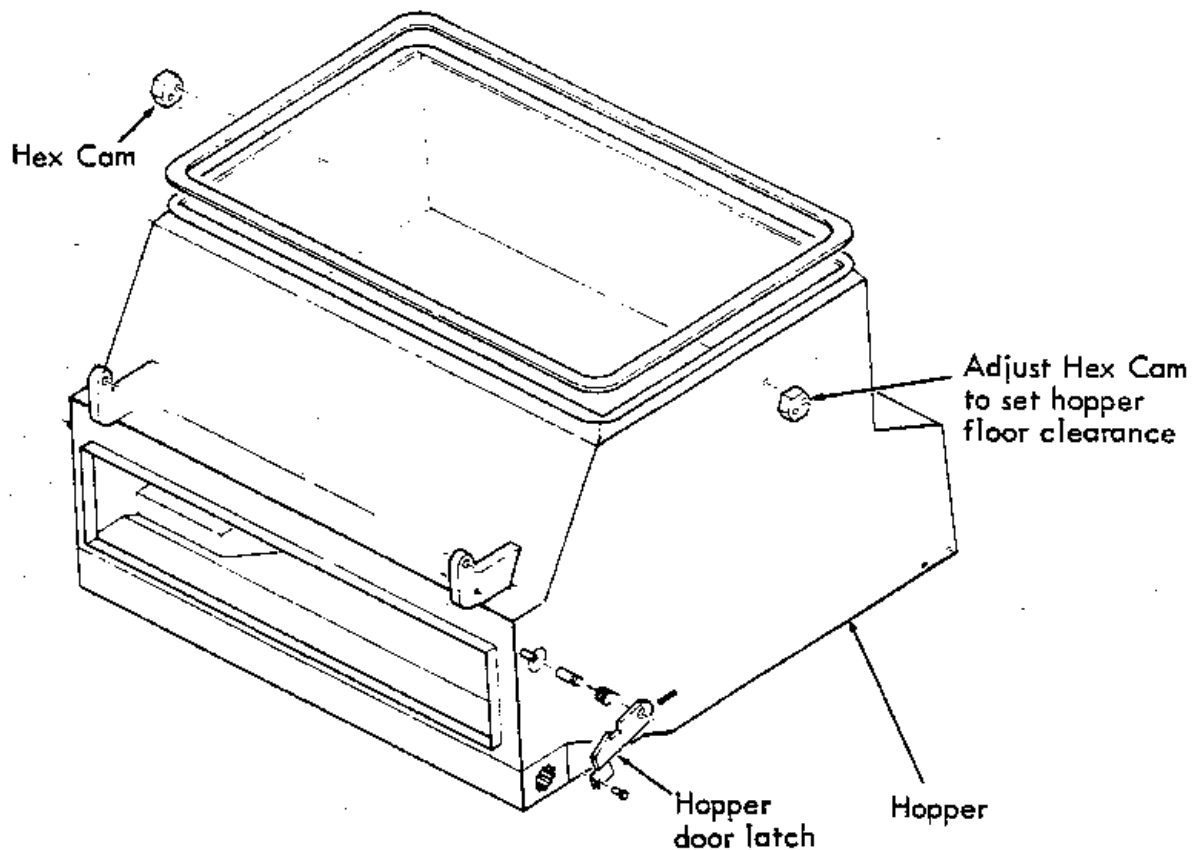
MAIN LIFT CYLINDER

1. After the lift arm has been adjusted as described above, adjust the clevis on the main lift cylinder so that the cylinder is fully retracted. To do this, loosen the jam nut on the cylinder piston rod, then turn the rod by means of a pin inserted through the hole in the rod.

HI-DUMP MACHINE ADJUSTMENTS (continued)

HOPPER ADJUSTMENT FOR FLOOR CLEARANCE

1. After performing the adjustments described above, disconnect the rollout cylinders at their lower pivot point.
2. Level the hopper and position it so that the rear hopper bottom is 3 in. \pm .125 in. (76.2 mm \pm 3.2 mm) from the floor.
3. At this point, adjust the hex cam (one on each side of the hopper) so that they make contact with the top surface of the main lift arms.



ROLLOUT CYLINDER ADJUSTMENT

After above adjustments are completed, adjust the rollout cylinders as follows: Retract the cylinders completely. Then adjust each cylinder clevis until the .75 in. dia. pin can be inserted through the clevis and torque arm. Lock the clevis in place with the jam nut.

SPEED LIMITER ADJUSTMENT

Adjust the speed limiter cam position so that it restricts forward speed to 1.5 - 2 mph (2.41 - 3.22 km/hr) when the hopper is raised to any point over 36 in. (914.4 mm) from the floor.

HI-DUMP HOPPER DOOR LATCHES ADJUSTMENT

- A. The latching bracket should be shimmed so that when the door is slammed shut, the latches will fully engage and hold the door closed tightly.
- B. When the hopper is fully raised and rolled in, the latches should be fully engaged. Adjustment is made by means of eye-bolts at end of each chain. The latches should release at the same time.

HI-DUMP MACHINE STABILIZER LEG ADJUSTMENT

When the Hi-dump hopper is down, the stabilizer leg should be tucked up inside of the bumper and not exposed. Adjustment is made by turning the threaded rod in the adjustable clevis. On old-style stabilizer leg, adjustment was made by turning the stud between the ball joints.

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. Engage mechanical safety lock on 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.

BATTERY REPLACEMENT

The battery is located below an access panel in the floor. The standard battery is a wet-cell, 12-volt, 60-ampere hour type (TENNANT Part No. 37183).

When installing new battery, be sure to connect ground cable to negative terminal of battery.

BATTERY INSPECTION AND MAINTENANCE

Inspect the battery as follows:

1. Check the battery cables for loose connections to battery terminals. Inspect cables for corrosion or damage.
2. 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.

Checking Battery Electrolyte

1. Check electrolyte level in each cell daily. Electrolyte level must always be above the plates. Add distilled water to maintain solution at correct level above the plates, but do not overfill.
2. Use a hydrometer to check the electrolyte specific gravity.

NOTE Do not take readings immediately after adding water. The reason for this is, if the water and acid are not thoroughly mixed, readings may not be accurate. Check hydrometer readings against this chart:

SPECIFIC GRAVITY 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	(Recharge at this point) . 25% charged
1.140 - 1.160	Very little useful capacity remaining
1.110 - 1.130	Discharged

If one or more cells tests lower than the other cells (.025 or more), the cell is damaged, shorted or is about to fail.

CHARGING BATTERIES

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

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

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

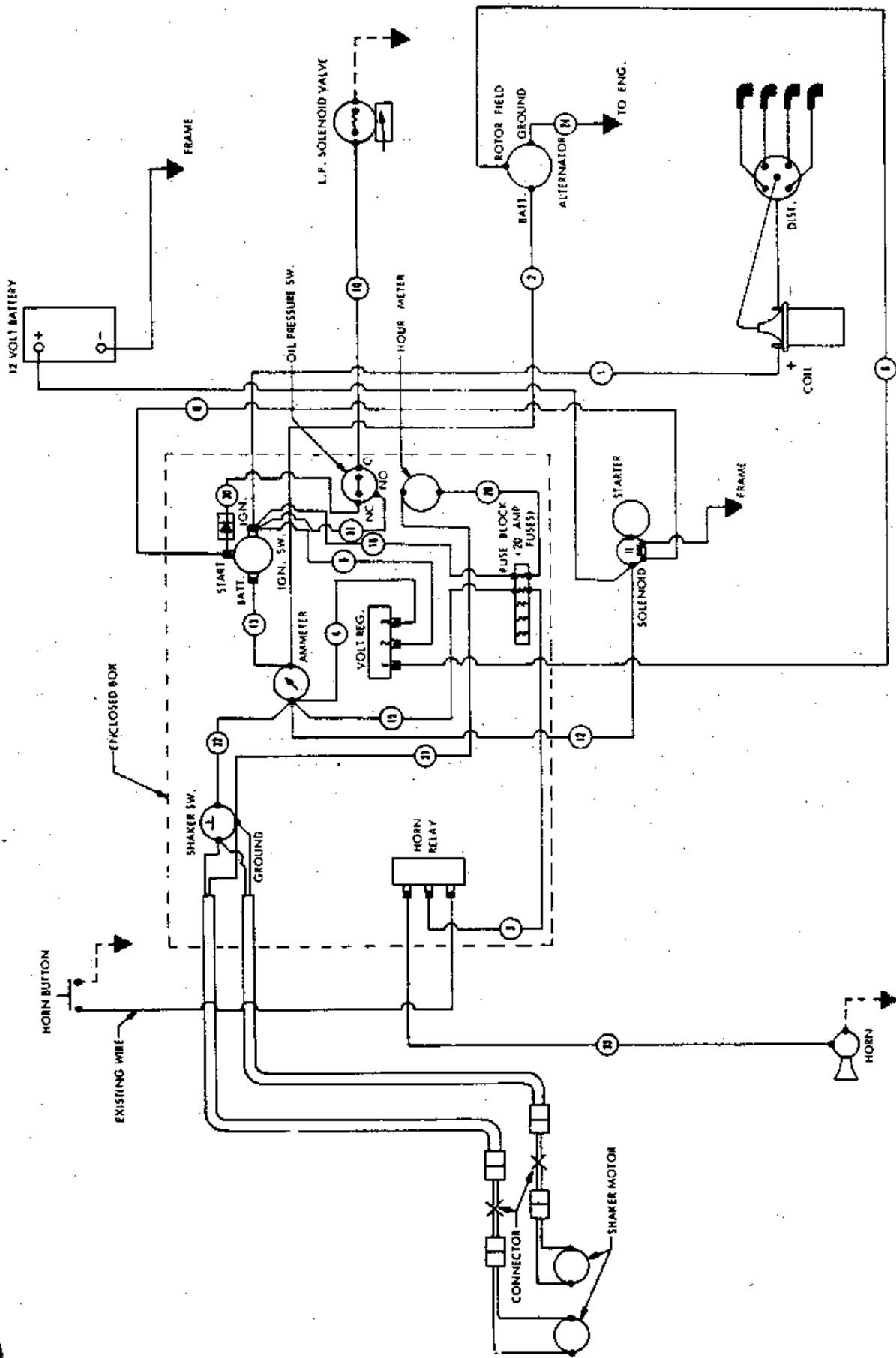
IMPORTANT NOTES ON BATTERY CARE

- + Raise cover of battery during charge, for maximum ventilation.
- + 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.
- + Do not discharge battery below specific gravity of 1.140.
- + Do not allow battery to remain in discharged condition for any length of time.

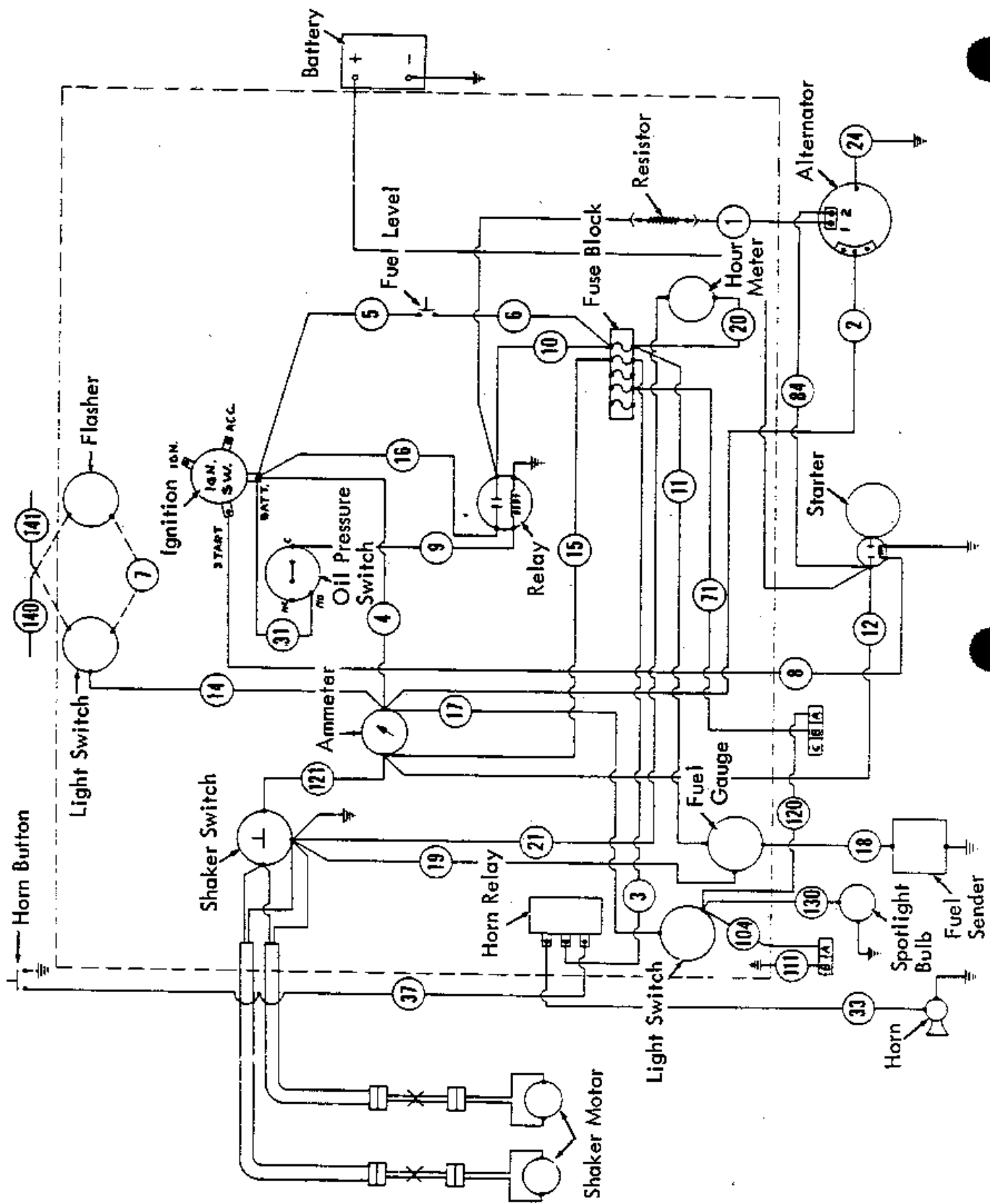
LOCATION OF FUSES AND CIRCUIT BREAKERS

A fuse panel is located inside the instrument panel enclosure. Other fuses are located on the back side of the light switches. To replace fuses, remove the screw attaching the instrument panel, move the panel forward, then lift it up.

A fuse is used in the shaker motor circuit. Fuses are used to protect the accessory circuits such as the headlights, flashing lights, hour meter, etc. Before replacing a blown fuse, try to determine the cause.



MODEL 280 WIRING DIAGRAM (FOR GASOLINE & LP ENGINE ONLY)



MODEL 280 WIRING DIAGRAM FOR DIESEL ENGINES

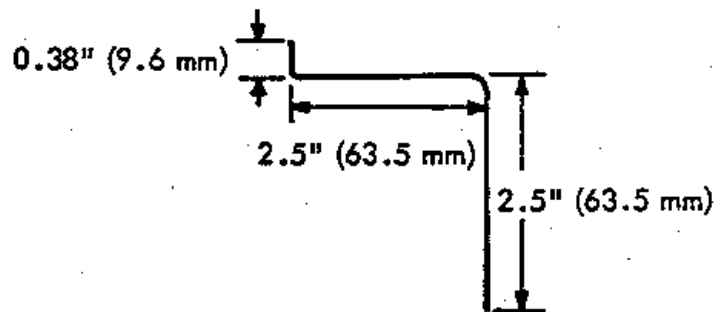
IGNITION SWITCH

Occasionally the ignition switch may jam because of having objects other than the key inserted into the key slot. Jamming may also be caused by not fully inserting the key before turning it. Either of the above may cause the tumblers to rotate preventing the machine from being operated.

To unjam the ignition switch, first disconnect the battery cables from the battery.

⚠ CAUTION Always disconnect the battery cables from the battery before working on machine electrical components.

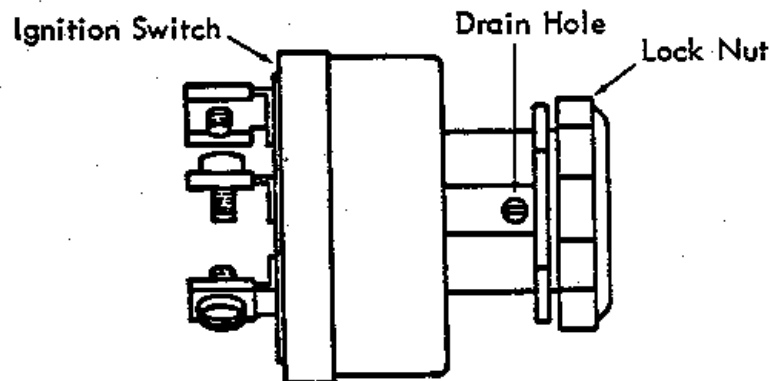
Make an unjamming tool as shown with a piece of wire or a paper clip.



UNJAMMING TOOL

Insert the 0.38 in (9.6 mm) end of the unjamming tool into the ignition switch. Turn the tool to the right or left until a click is heard. Remove the unjamming tool from the ignition switch. Try the ignition key in the ignition switch. Repeat the procedure if necessary.

NOTE When the switch tumblers are properly aligned, a slot will be visible in the switch drain hole.



IGNITION SWITCH DRAIN HOLE

NOTE Never insert foreign material into the ignition switch. Only use the ignition key provided.



280

POWER SWEEPER

CONTENTS:

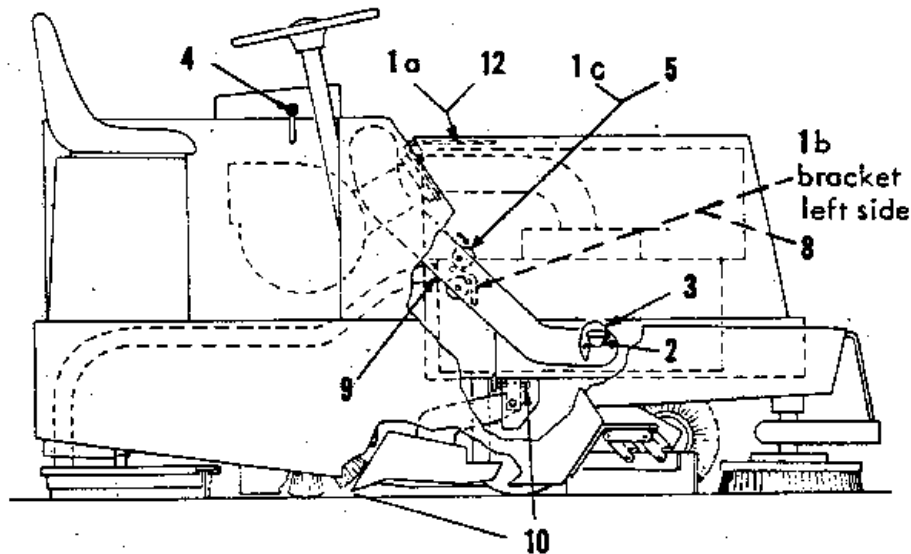
Initial Alignment	3
Removing Sweeping Hopper	5
Installing Scrubbing Unit	6
Removing Scrubbing Unit	9
Re-installing Sweeping Hopper	10
Scrubber Operation	11
Scrubber Trouble Shooting	15
Scrubber Maintenance	16

scrubber section



INITIAL ALIGNMENT OF NEW SCRUBBING UNIT TO MACHINE

ATTENTION! New Scrubbing Units may require alignment to the machine. Follow these instructions carefully.



ALIGNING SCRUBBING UNIT TO MACHINE:

- 1 a Loosen vacuum connection bracket in top center of scrubber and move all the way to front of scrubber in slots.
- b Loosen bracket on left rear side of scrubber.
- c Loosen top cam on the right hand lift arm and rotate back. **DO NOT LOOSEN LOWER CAM.**
- 2 Move scrubber into place and connect hydraulic hoses to unit. Line up lift pins over slots in lifting arms.
- 3 Start engine and let idle. Engage lift pins on lift arms and swing locking hooks over pins.
- 4 Operate hydraulic control to lift scrubber all the way up. **ENGAGE SAFETY LOCK.**
- 5 Rotate top cam on right hand lift arm to contact ear of scrubber and tighten bolt.
- 6 Fold up the four support legs by pulling out the locking knob and swinging each leg up. **WARNING:** Do not work under scrubber unless safety lock
- ▲WARNING** Do not work under scrubber unless safety lock is engaged.
- 7 Release safety lock and lower scrubber to down position.
- 8 Lower bracket on left hand rear side of scrubber to contact cam on arm and tighten bolts.
- 9 Connect vacuum hose to scrubber from squeegee.

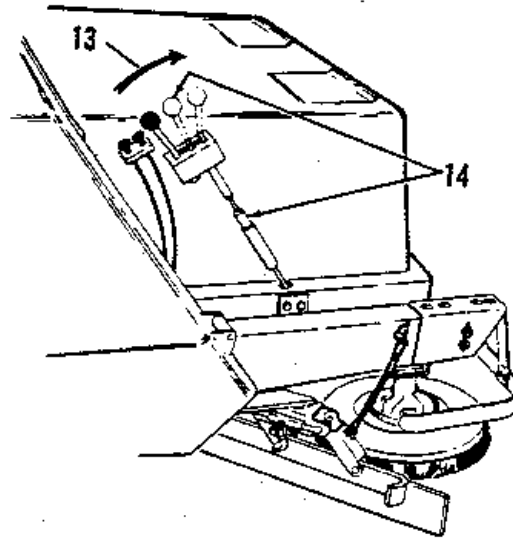
(Continued)

TROUGH ADJUSTMENT:

- 10 The correct clearance of the trough lip is from .375" to .50" (9.53 to 12.7 mm) from the floor. Adjust by turning .50" (12.7 mm) square head set screws.
- 11 The correct clearance of the trough in the up position is from 1" (25.4 mm) to 1.125" (28.58 mm).

VACUUM CONNECTION:

- 12 Move bracket at top center of scrubber rearward to contact seal on lintel and tighten bolts sufficiently to hold bracket in place. Rap bolts sharply to move bracket from 1/16" to 1/8", compressing sponge rubber seal on lintel, and tighten bolts.



BRUSH ADJUSTMENT:

- 13 Release brush lift handle and allow brush to rest on floor.
- 14 Turn cylinder and cylinder end until handle is opposite center notch of bracket. Tighten jam nut on cylinder end.

INSTRUCTIONS FOR FACTORY-INSTALLED SCRUBBING ATTACHMENT
(Assuming that machine is modified to accept scrubbing attachment)

A. TO REMOVE SWEEPING HOPPER (BEFORE INSTALLING SCRUBBER)

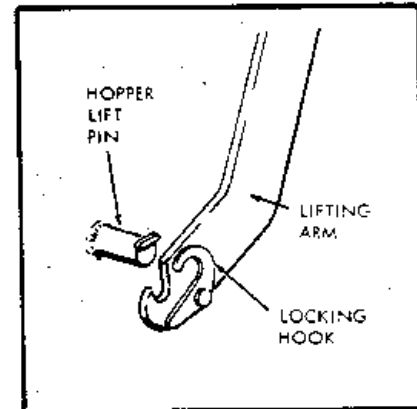
1. Start motor.

2. Raise hopper all the way.

▲WARNING Engage mechanical safety lock on hopper lift arm.

3. Place dolly under hopper.

Disconnect hopper from lifting arms by moving locking hooks away from hopper lift pins.



4. Swing aside locking hooks which attach hopper lifting pins to the lift arms.
5. Raise the lift arms, disconnect the lift arm safety lock, and lower hopper onto dolly. Stop the motor. Place hydraulic control in "OFF" position. Push down hopper lift arms until they clear the hopper lift pins.
6. Move hopper out from machine slightly and disconnect the wire to the shaker motor mounted on the hopper. Complete the removal of the hopper.
7. Remove the side sweeping brush by removing the bolt attaching it to the motor shaft. The brush will drop down to the floor.
8. Remove main sweeping brush.

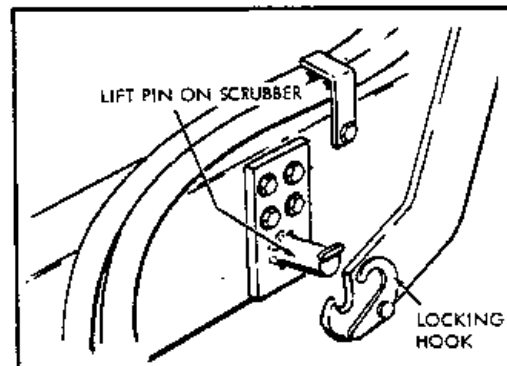
B. TO INSTALL SCRUBBING UNIT (AFTER REMOVING SWEEPING HOPPER)

1. **NOTE** Do not fill scrubber tank before installing scrubber on machine. The scrubbing unit is mounted on folding support legs equipped with wheels. Raise bumper. Carefully roll the scrubber into position between the lift arms, but allow enough room between the machine and the scrubber so that the hydraulic hoses can be connected in the next step.
2. Disconnect the coupling on the hydraulic hose located in one of the lines to the hydraulic control valve.

ATTENTION! Clean both coupling halves.

Connect the separated halves of the coupler to the two hoses located on the side of the scrubber.

Use locking hooks to lock scrubber to lift arms.



With the folding support legs down, the scrubber can be rolled into position.

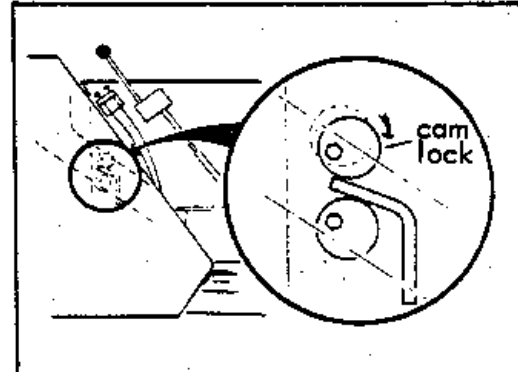
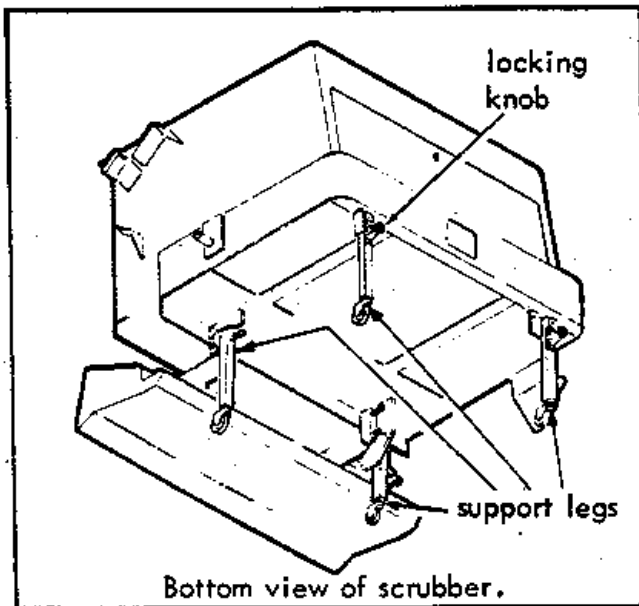


3. With lift arms lowered, carefully move scrubber into position so that lifting pins on scrubber will engage their sockets on the lift arms. Swing locking hook on each arm over scrubber lifting pins, locking them onto lift arms.
4. Start motor and operate hydraulic control to lift scrubber.

INSTALLING SCRUBBER (Continued)

5. Fold up the four support legs by pulling out the locking knob and swinging each leg up.

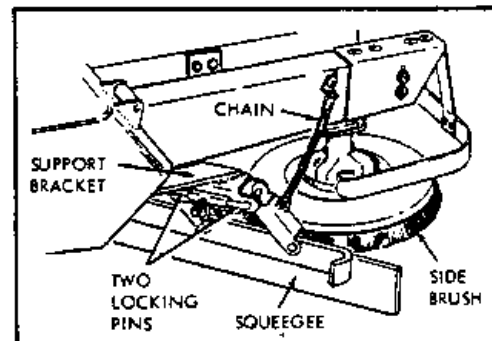
▲WARNING Engage safety lock on lift arm before reaching under scrubber.



Rotate the cam lock to the down position as shown here. This is the correct position of the lock when the scrubber is installed.

6. Loosen bolt attaching cam lock to right-hand lift arm and rotate cam into position against lip on scrubber. Use wrench provided for removing main brush. This cam lock will prevent scrubber from tilting forward.
7. Make sure that end of suction hose is in pick-up trough located at bottom of scrubber.
8. Start engine and lift scrubber enough so that safety lock on lift arm can be released. Lower the scrubbing unit. Lower bumper.
9. Install side brush squeegee assembly on support bracket and lock in place by inserting two locking pins. Turn ends of pins under the clamp which is held in place by a spring.

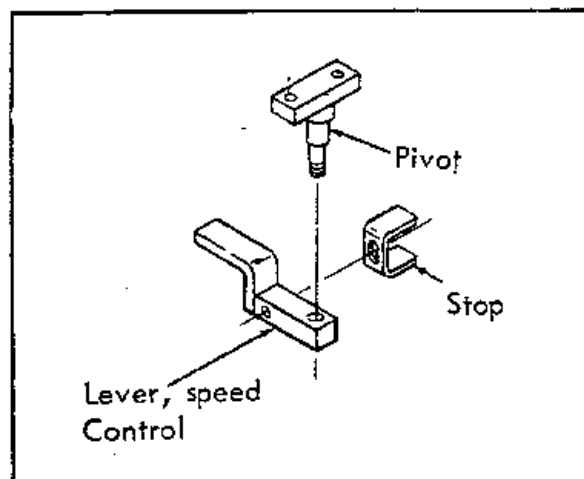
NOTE Install the side brush squeegee on the support bracket as shown here.



10. Attach chain from squeegee to side brush arm. Adjust chain so that squeegee is lifted when side brush is lifted.

INSTALLING SCRUBBING UNIT (Continued)

11. Position side scrubbing brush on motor shaft and lock in place with bolt and nut.
12. If necessary, adjust motor height until full weight of the arm is on the brush when the side brush lift is fully released.
13. If side squeegee is not level with floor, adjust as described in Maintenance Instructions.
14. Attach hose from squeegee to recovery tank inlet as shown in drawing.
15. Check condition of rear squeegee rubber blade and replace it if necessary. See Maintenance Instructions. If rear squeegee blade assembly is not on machine, install it as shown in drawing. The squeegee is attached to the two outboard pivot brackets and the center lift mechanism by means of pins and cotter pins.
16. Install the main scrubbing brush (also called rear pick-up brush) in the same manner as a sweeping brush is installed.
17. **▲WARNING** Engage speed control stop lever to reduce machine speed during scrubbing. This is necessary to prevent skidding on wet, slippery floors.



18. The Scrubber is now completely installed. Please refer to "Scrubber Operating Instructions" next.

C. TO REMOVE SCRUBBING UNIT FROM MACHINE

1. Drain recovery tank as explained in "Operating Instructions".
2. Remove rear main scrubbing brush in same manner as sweeping brush is removed.
3. Remove side scrubbing brush by removing bolt attaching it to the motor shaft.
4. Remove side brush squeegee by pulling out the two lock pins and unhooking chain. Leave squeegee mounting bracket attached to machine.
5. Start motor and raise scrubbing unit.

▲WARNING Engage lift arm safety lock before reaching under unit.

6. Swing down the four scrubber support legs -- make sure they are locked in place.
7. Loosen bolt attaching the cam lock to the right-hand lift arm, and swing lock away from lip on scrubber. Tighten lock attaching bolt.
8. Operate hydraulic control to lift scrubber. Release safety lock, then lower scrubber to floor. Stop motor. Place hydraulic control in "OFF" position.
9. Swing aside locking hooks which hold scrubber lifting pins to lift arms.
10. Push lift arms down and carefully roll scrubber away from machine for a short distance so that hydraulic hoses can be disconnected.
11. Disconnect the two hydraulic hoses between scrubber and machine. Disconnect rear squeegee suction hose from scrubber (end of hose can be placed in clip under seat).
12. Connect the two machine hydraulic hoses together (check to be sure that couplers are clean).

NOTE Machine will not operate properly if these lines are not connected.

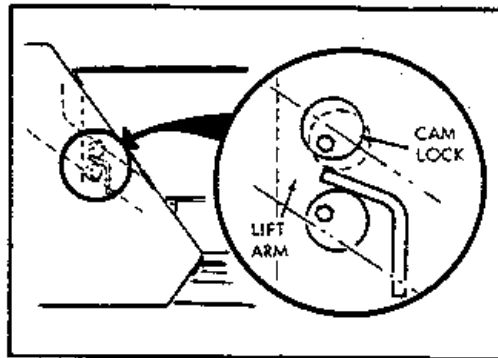
13. The rear squeegee can remain attached to machine in "UP" position during sweeping -- provided that machine is not used over rough surfaces which could damage the squeegee rubber blade. To remove squeegee, pull out the attaching pins.

D. TO INSTALL SWEEPING HOPPER AFTER REMOVING SCRUBBER

1. Raise bumper. Position hopper on dolly between lift arms near machine, but allow enough room to connect the wire to the shaker motor. Connect the shaker wire. Move hopper up to the machine.
2. Start motor and raise lift arms so that lift pins on hopper will contact their sockets on the lift arms.
3. Close the locking hooks over the lifting pins.

NOTE The cam lock on right-hand arm must be positioned away from the hopper so that it does not restrict hopper movement.

When the sweeping hopper is used, the cam lock must be set at the "UP" position.



4. Raise hopper.

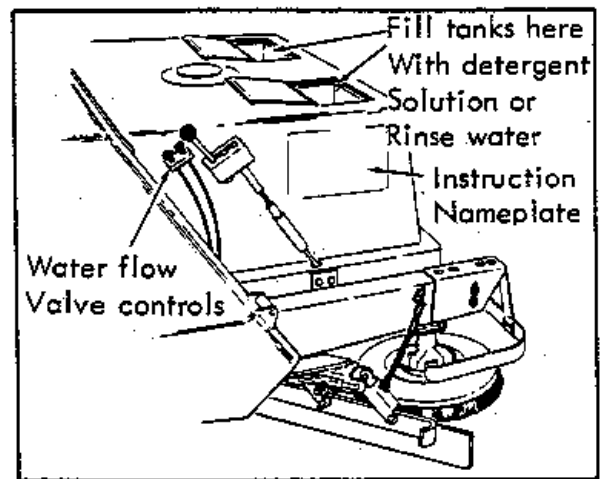
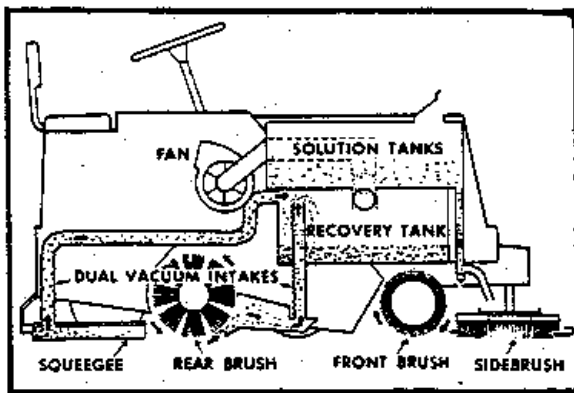
⚠WARNING Engage safety lock.

5. Remove dolly from under the hopper.
6. Raise hopper slightly in order to release safety lock, then lower hopper to floor.
7. Lower bumper. Install main sweeping brush.

SCRUBBER OPERATING INSTRUCTIONS

Filling the Tanks:

1. The solution mixture required will depend upon the condition of the floor. Recommendations for detergent dilution are given on the TENNANT detergent container and on the nameplate mounted on the scrubber. TENNANT #622 (powder) or #670 (liquid) are recommended.
2. Shut off the water flow with the valve controls located on the right side of tank.
3. There are two separate upper tanks. One or both tanks may be used for detergent solution or rinse water. Fill both tanks with hot water when using both tanks for detergent solution; or fill one tank with solution and one with cold rinse water. The water flow can be approximately doubled by using both tanks at the same time, but this, of course, will require more frequent refilling.

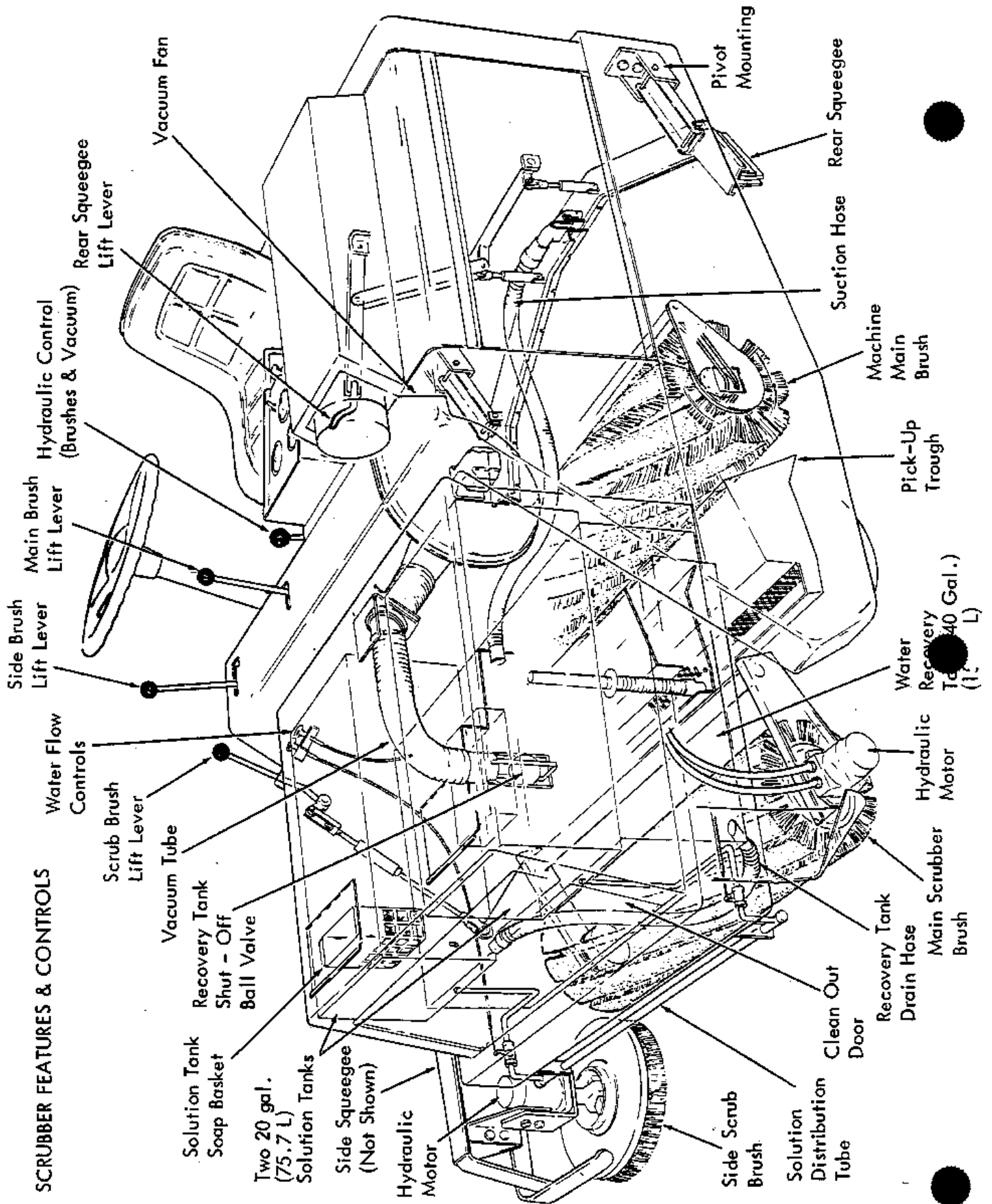


4. To avoid foaming, fill the tanks with hot water first, then add detergent and stir the solution.
5. The two water flow control valves may be used to combine the flow or to open either tank.
6. The rate of flow and the consumption of either detergent or rinse water is dependent upon scrubbing conditions and rate of travel.

TIRE CARE

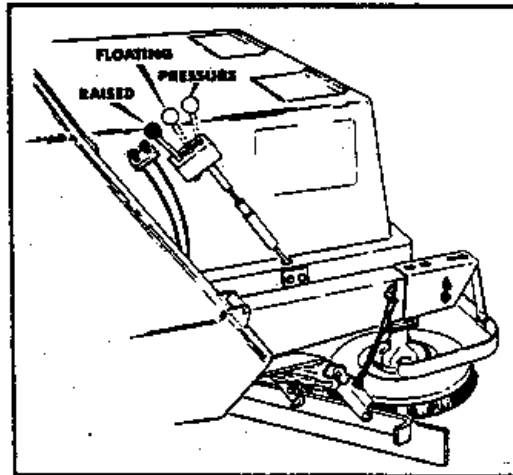
If the machine is operated in areas where solvents, oils and other petroleum-base fluids may contact the tires, it is strongly recommended that the tires be cleaned after use. This will greatly prolong the life of the tires.

SCRUBBER FEATURES & CONTROLS



TYPICAL SCRUBBING CONTROL OPERATION SEQUENCE

1. Start the motor. Set throttle at full engine speed.
2. Move hydraulic control lever to "Brushes and Vacuum Fan On" position. This starts rotation of all brushes and vacuum fan.
3. Lower the machine main brush to the "Restricted Down" position.
4. Lower the scrubber brush to the down position, using the brush lift lever on the scrubber.



POSITIONS OF SCRUB BRUSH LEVER

5. Lower the side brush -- the side squeegee will also lower with the brush. Lower side squeegee if it is locked in up position.
6. Open the water flow control valves. The two control valves may be used to combine the flow or to open either tank.
7. Lower the rear squeegee and place the lever in the "Pressure" down position.

ATTENTION! Always raise squeegee before reversing machine.

8. Depress the accelerator pedal and begin scrubbing.

⚠ WARNING When scrubbing, always reduce machine speed by engaging speed control lever. This will prevent skidding on wet, slippery floors.

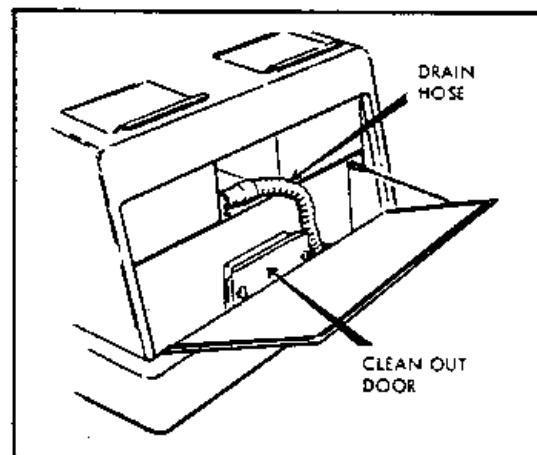
9. Shut off the solution about five feet before making a turn.
10. After the scrubbing operation is completed, raise all the brushes. Allow brushes to revolve for 30 seconds or more to throw off excess water.

SOME NOTES ON SCRUBBING OPERATIONS

1. **NOTE** Never use main sweeping brush for scrubbing. Always replace main sweeping brush with the brush designed especially for scrubbing.
2. The front cylindrical brush performs the bulk of the scrubbing. The side brush is provided in order to scrub close to walls. The main (rear) brush provides secondary scrubbing and also sweeps light debris and water into the shallow trough located under the scrubber. A hose vacuums the water from this trough into the recovery tank in the scrubber. The rear squeegee provides a "vacuum cleaner" pick-up on smooth floors and erases tire tracks.
3. Extremely dirty floors may require soaking with the detergent for a period of time. Apply the solution with the front and side scrub brushes down (the main brush, side squeegee and rear squeegee should be up). After soaking, pass over the same area with the main brush and squeegees down.
4. If rinsing is desired after scrubbing the floor, apply plain cold rinse water, scrub and pick-up.
5. When scrubbing very rough floors, it may be desirable to raise the rear squeegee in order to prevent damage to the rubber blade. The main brush will provide adequate water pick-up in this case.

DRAINING AND CLEANING RECOVERY TANK

1. Position front of scrubber adjacent to large floor drain or 40 gallon (151.4 L) tank below the floor level.
2. Pull upper end of drain hose, (see sketch) off the plug and lower in the direction of the floor drain.
3. Open the clean out door to which the drain hose is attached and flush out any sludge accumulation.
4. Raise scrubber on dump arms and engage safety lock so that the lower trough may be cleaned and inspected



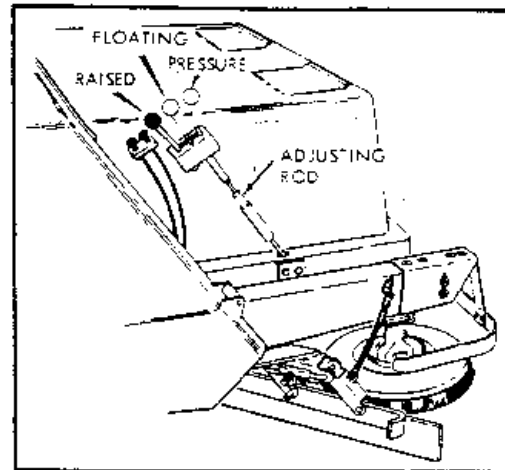
SCRUBBER TROUBLE SHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
Poor water pick-up at squeegees.	<ol style="list-style-type: none"> 1. Side or rear squeegees are worn or damaged. 2. Clogging in water pick-up trough of rear squeegee or in suction hose to recovery tank. 3. Air leaks in suction hose and connections. 4. Poor vacuum. 	<ol style="list-style-type: none"> 1. Examine squeegee rubber blades and back-up strips for cuts or worn areas. Replace blades if necessary. 2. Clean out rear squeegee and hose. 3. Repair or replace hose and connections. 4. Check vacuum fan.
Water spills from side of scrubber.	<ol style="list-style-type: none"> 1. Side squeegee blades worn or damaged. 2. Too much solution being applied. 	<ol style="list-style-type: none"> 1. Replace squeegee blades. 2. Cut down solution flow 5 to 10 feet before making turns.
Little or no vacuum suction at rear squeegee.	<ol style="list-style-type: none"> 1. Clogged suction hose or pick-up trough in rear squeegee. 2. Loose connections between squeegee and suction hose or between suction hose and tank. 3. Scrubber vacuum fan not operating. 	<ol style="list-style-type: none"> 1. Disconnect suction hose from squeegee, wash squeegee and hose thoroughly. 2. Check all hose connections for looseness or damage. Check suction hose for damage. 3. Check for suction at suction hose to recovery tank. Next, check for air discharge from vacuum fan. If no air discharge, impeller, hydraulic motor, or pump are at fault.
Poor scrubbing action.	<ol style="list-style-type: none"> 1. Worn scrubbing brushes. 2. Incorrect method of operation. 3. Wrong detergent or mixture. 	<ol style="list-style-type: none"> 1. Inspect brushes. If bristles are badly worn, replace brush. 2. Check scrubbing procedures, brush pressure adjustment, solution flow, etc. If floor is extremely dirty, two passes may be needed. 3. Use TENNANT Detergents. See "TENNANT Detergent Selection and Dilution Guide".
Poor solution distribution.	<ol style="list-style-type: none"> 1. Clogged outlet holes in distribution tube. 2. Clogged or pinched hose from solution tank to valve. 3. Jammed solution valve or cable to valve. 	<ol style="list-style-type: none"> 1. Clean out tube and outlet holes. 2. Check hose. 3. Check cable and valve for free operation.

SCRUBBER MAINTENANCE INSTRUCTIONS

FRONT SCRUB BRUSH ADJUSTMENT

- Back - To raise Front Brush.
- Center - "Float" scrubbing position (also used for adjustment).
- Forward - "Pressure-down" scrubbing position.



An adjustment for brush wear is provided on the lift rod beneath the brush control handle. Loosen the jam nut on the clevis and turn the adjusting rod just below it until the control handle is in the "Center" position when the brush is resting on floor.

NOTE Be sure jam nut against lower clevis is tight to prevent drift of adjustment.

FRONT SCRUB BRUSH REPLACEMENT

The front brush is removed and replaced in the same manner as the main sweeping brush. See "To Replace Main Brush" in "Maintenance Instructions" Section of this manual.

WATER SPREADER TUBE

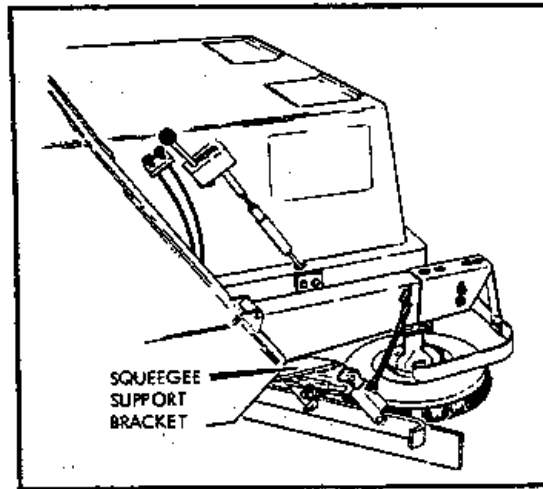
The small holes in the water spreader tube may become clogged. Loosen set screw of tube hanger and remove hoses. Slide tube out of hangers and clean with hot water and brush.

SIDE SCRUB BRUSH REPLACEMENT

The side brush is adjusted for wear in the same manner as the side sweeping brush. See "To Replace Side Brush" in "Maintenance Instructions".

SIDE SQUEEGEE LEVELING ADJUSTMENT:

Check to be sure that the squeegee blade is level with the floor. If adjustment is required, loosen the two support bracket mounting screws and twist the bracket slightly until the blade is level. Then tighten mounting screws.

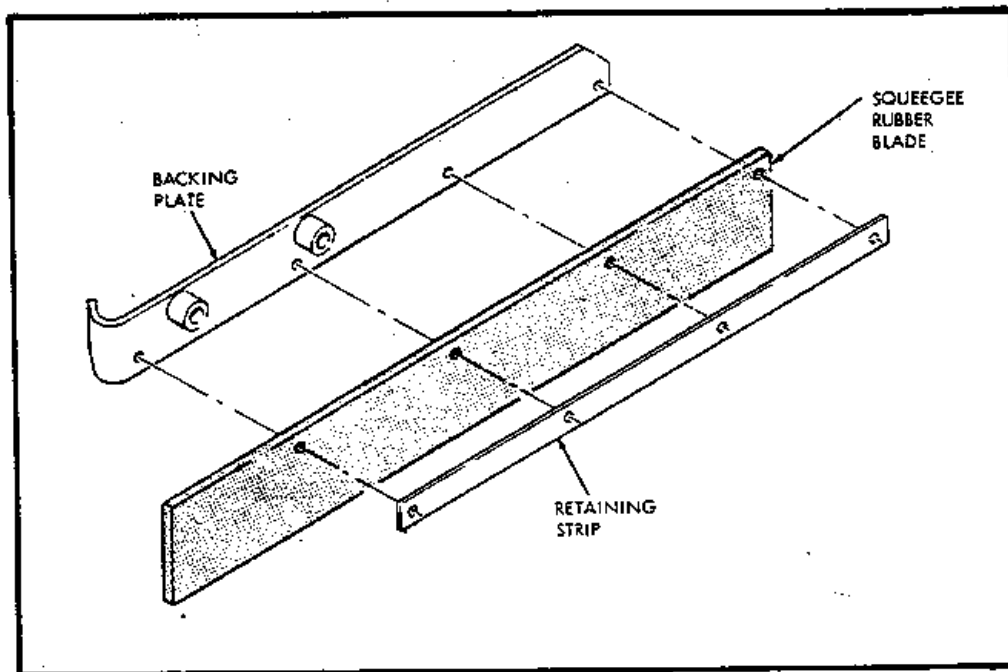


NOTE

Level the side squeegee by loosening the support bracket screws and moving the bracket.

SIDE SQUEEGEE RUBBER REPLACEMENT:

Remove five retaining clamp bolts, install new rubber strip, and replace retaining clamp. Replace the rubber when the leading edge is worn and is no longer wiping floor correctly.

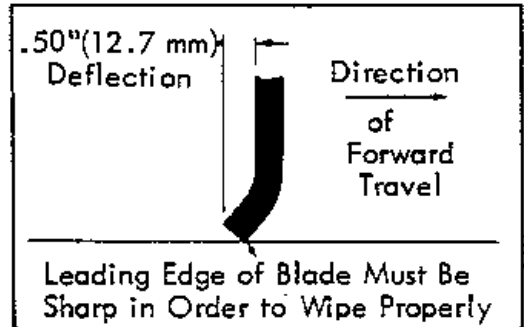


SIDE SQUEEGEE BLADE REPLACEMENT

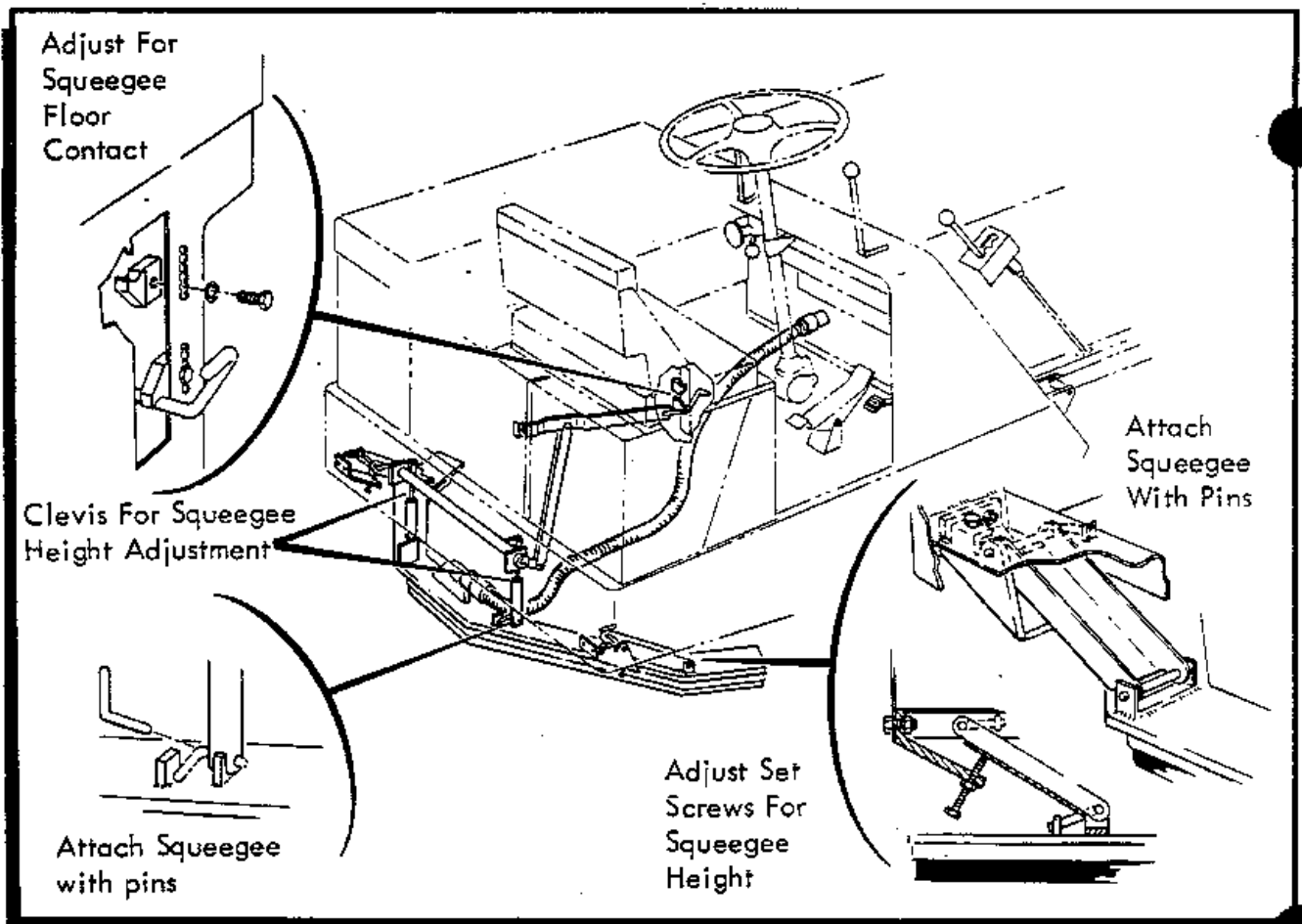
REAR SQUEEGEE MAINTENANCE

In order to work properly, the rubber squeegee blade must be deflected about .50" (12.7 mm) as it moves across the floor -- this is shown in sketch. This deflection should be uniform across the full length of the squeegee. The deflection of the blade is set by adjusting the stops and linkage as shown below. This adjustment is correctly made at the factory and should not normally be required again. In the "up" position the squeegee should just touch the frame at three places: the rear and two ends.

The squeegee rubber blade must be adjusted as shown here.



As shown in sketch, the leading edge of the squeegee rubber does the entire wiping job. If this edge is worn, the rubber must either be replaced, or turned around if the opposite edge is not worn. Adjusting a worn blade to a lower position will not improve wiping action.



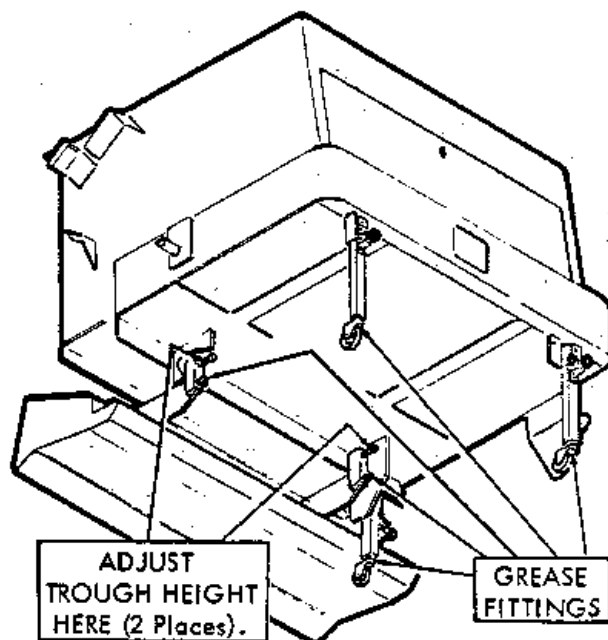
REAR SQUEEGEE ADJUSTMENTS

LUBRICATION OF SCRUBBER

Grease Fittings	Location	Lube Period
2	Lower trough pivot	8 hours
4	Caster wheels	200 hours

Apply light grease to threads on front brush lift rod every 200 hours.

⚠ WARNING Never reach under up-raised scrubber attachment without engaging safety lock.



TO ADJUST PICK-UP TROUGH HEIGHT:

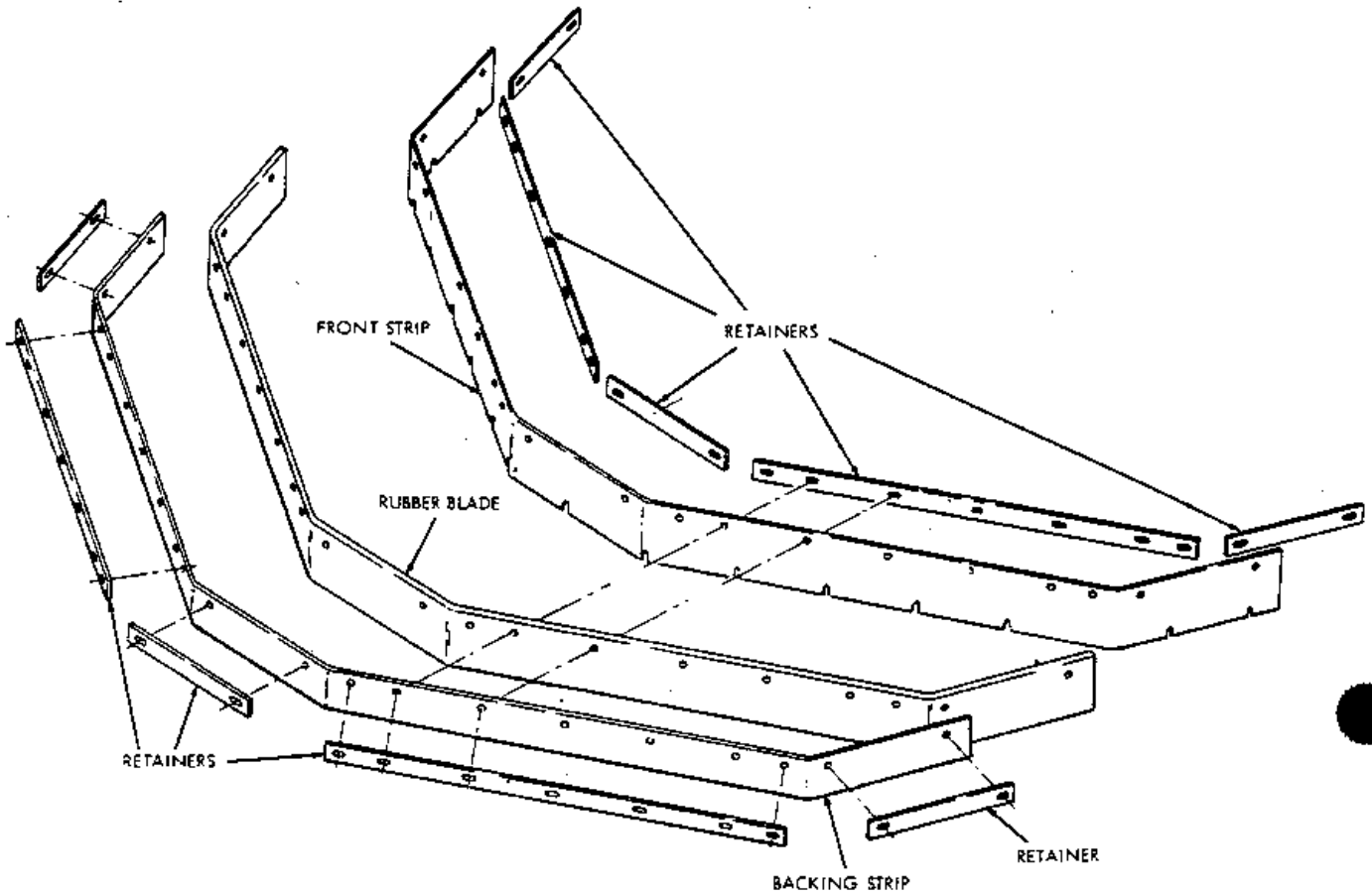
1. Park machine on smooth level surface.
2. Check clearance between lip of pick-up trough and floor. Correct clearance .375" (9.53 mm)
3. If adjustment is required:
 - (a) Raise scrubber attachment to extreme "up" position and engage lift cylinder safety lock.
 - (b) Referring to drawing, loosen lock nut and adjust bolts until correct clearance is obtained. Then tighten lock nuts.

NOTE After each adjustment is made, it will be necessary to lower scrubber attachment to check clearance.

ATTENTION! Be sure that lip of trough is never allowed to touch floor, or needless wear to trough will result.

REPLACING REAR SQUEEGEE BLADE

To replace or reverse the rubber blade, refer to exploded view for the arrangement of parts. Note that a special front strip and a backing strip are used on each side of the rubber blade. Replace the front strip if it is worn.



EXPLODED VIEW OF REAR SQUEEGEE RUBBER BLADE AND MOUNTING PARTS

280**POWER SWEEPER**

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lpg section 6d1



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 fuellock. See machine manual for instructions and replacement parts.
- 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 consumed. Then, turn off the ignition switch.
- Perform regular maintenance as recommended in the machine manual.

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 maintenance list and those in the manual.

- 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 fuellock 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 malfunctioning 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 fuellock 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 fuellock should click when the switch is shorted out if the switch is working properly.

- Check the filter-fuellock for proper operation:

Start the engine.

Remove the wire going to the solenoid section of the fuellock. This should cause the solenoid to close, shutting off the fuel supply, stopping the engine. If the engine continues to operate, replace the filter fuellock.

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 fuellock. After 10 minutes, operate the starter motor. If the engine starts or fires, L.P. fuel has leaked by the fuellock and the fuellock should be replaced. If it just turned over, the fuellock 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.

OPERATING INSTRUCTIONS
FOR
MODEL 280 SWEEPER
EQUIPPED FOR LPG OPERATION

PREPARING MACHINE FOR OPERATION

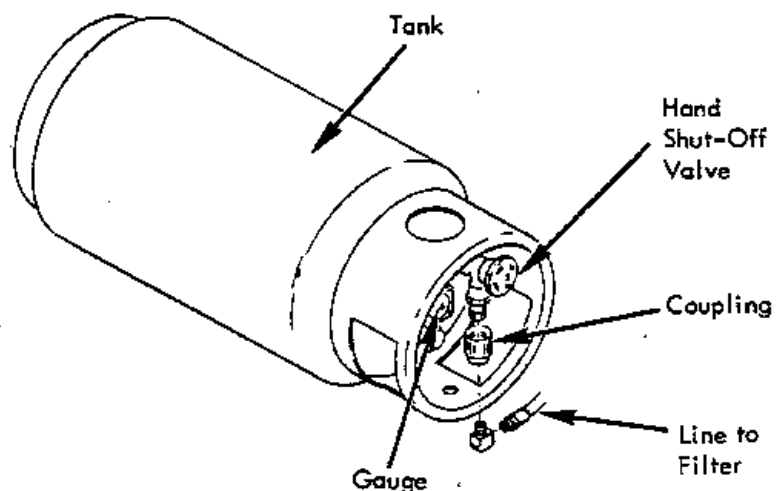
Follow the instructions given in "Preparing Machine for Operation" at the beginning of this manual. Instead of step #4, fill or replace the LP tank. The tank is a LIQUID WITHDRAWAL, 33-lb. CAPACITY type. The tank is equipped with a visible gauge and an automatic shut-off valve. Always close the hand valve when the machine is not in use.

TO START LPG EQUIPPED ENGINE

1. **▲WARNING** Do not attempt to start engine unless you are in driver's seat, with foot on brake pedal or handbrake engaged, and with directional pedal in neutral position.
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 Gas Trouble Shooting" in a following section. See the Engine Manual for more information.

LPG FUEL TANK

The 33-lb. capacity tank is mounted on top of the machine. The tank is a liquid-withdrawal type equipped with a visible gauge which measures the per cent of fuel left in the tank. Always fill the tank by weight capacity (33-lb.) plus the "tare" weight (TW) which is marked on the tank.



LPG FUEL TANK (Continued)

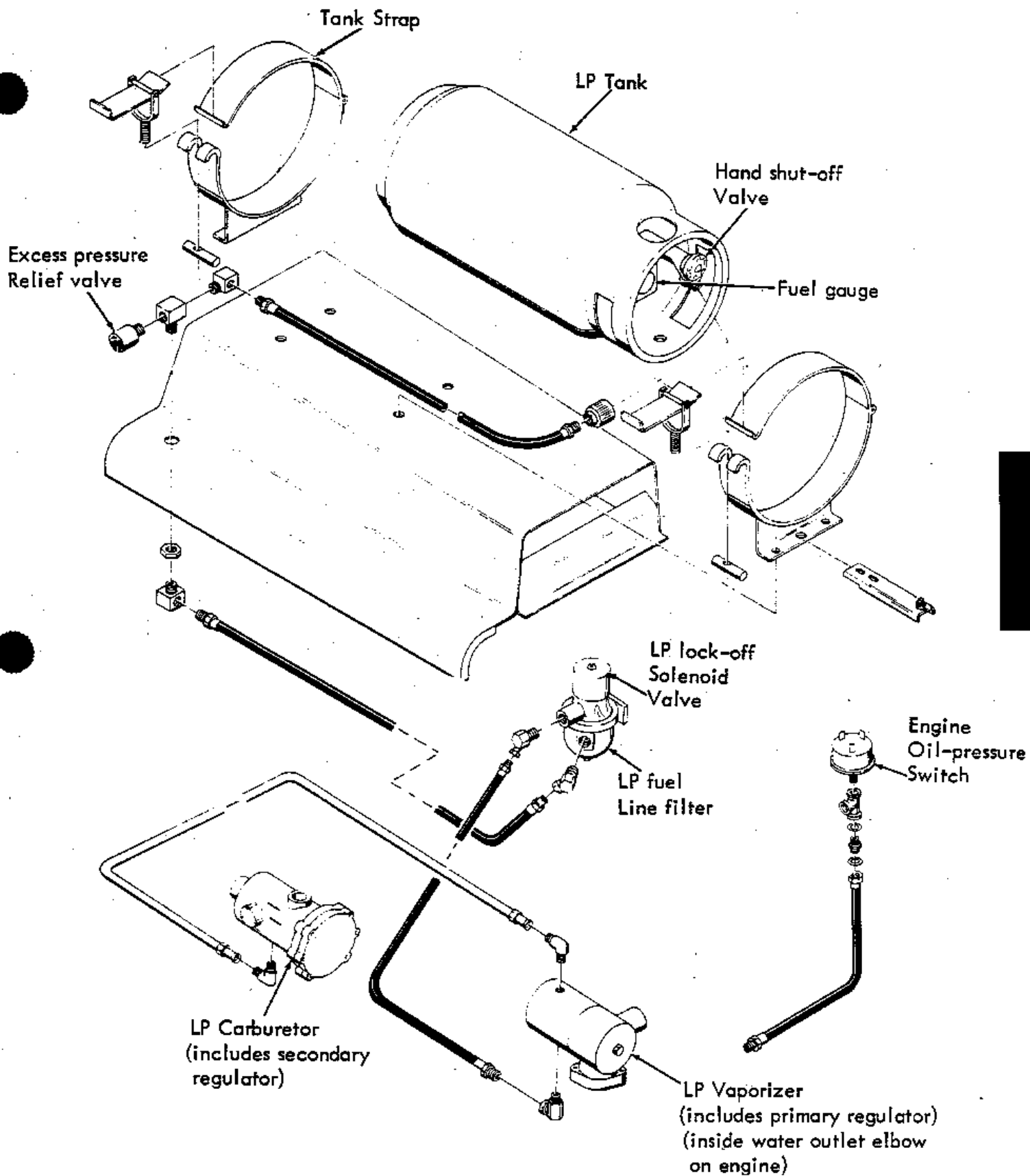
The tank must be mounted in one position only. Do not turn the tank in its mounting--this will affect the liquid withdrawal process, because of the shape of the discharge tube inside the tank.

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.

HOW THE LP SYSTEM OPERATES (See LPG Parts Drawing for location of LP Components)

1. Opening LP tank valve slowly permits the liquid fuel to pass through the fuel line to the combination fuel line filter and electric lock-off valve (called "Filter-Fuelock").
2. Excessive fuel line pressure will escape through the pressure relief valve.
3. The fuel line filter is required on liquid withdrawal systems because the fuel is drawn from the bottom of the tank where impurities could accumulate.
4. The solenoid (electric lock-off valve) is activated by the ignition switch during starting, allowing fuel flow through the valve. Engine oil pressure operated switch holds solenoid valve open after the engine has been started.
5. After passing through the combination filter and solenoid valve, the liquid fuel enters the vaporizer and primary regulator combination unit (located in water elbow on engine). At this point, the liquid fuel is changed to vapor as hot water from the engine is directed past the vaporizer part of this combination unit.
6. The vapor fuel passes through the primary regulator part of this combination unit and is reduced in pressure at the regulator outlet.
7. The fuel is then metered into the carburetor in small amounts as required and controlled by the carburetor.



LPG FUEL SYSTEM

USE & CARE OF L.P. FUEL TANKS

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, 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.
- . 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 in the machine manual.
- . 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.

- 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 fuellock 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 fuellock should click when the switch is shorted out if the switch is working properly.

- Every 400 hours, replace the filter in the filter fuellock. 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).

The following service instructions can be performed by most equipment maintenance personnel. Noted are the repair kit part numbers. If individual repair part numbers are needed, refer to the machine parts manual.

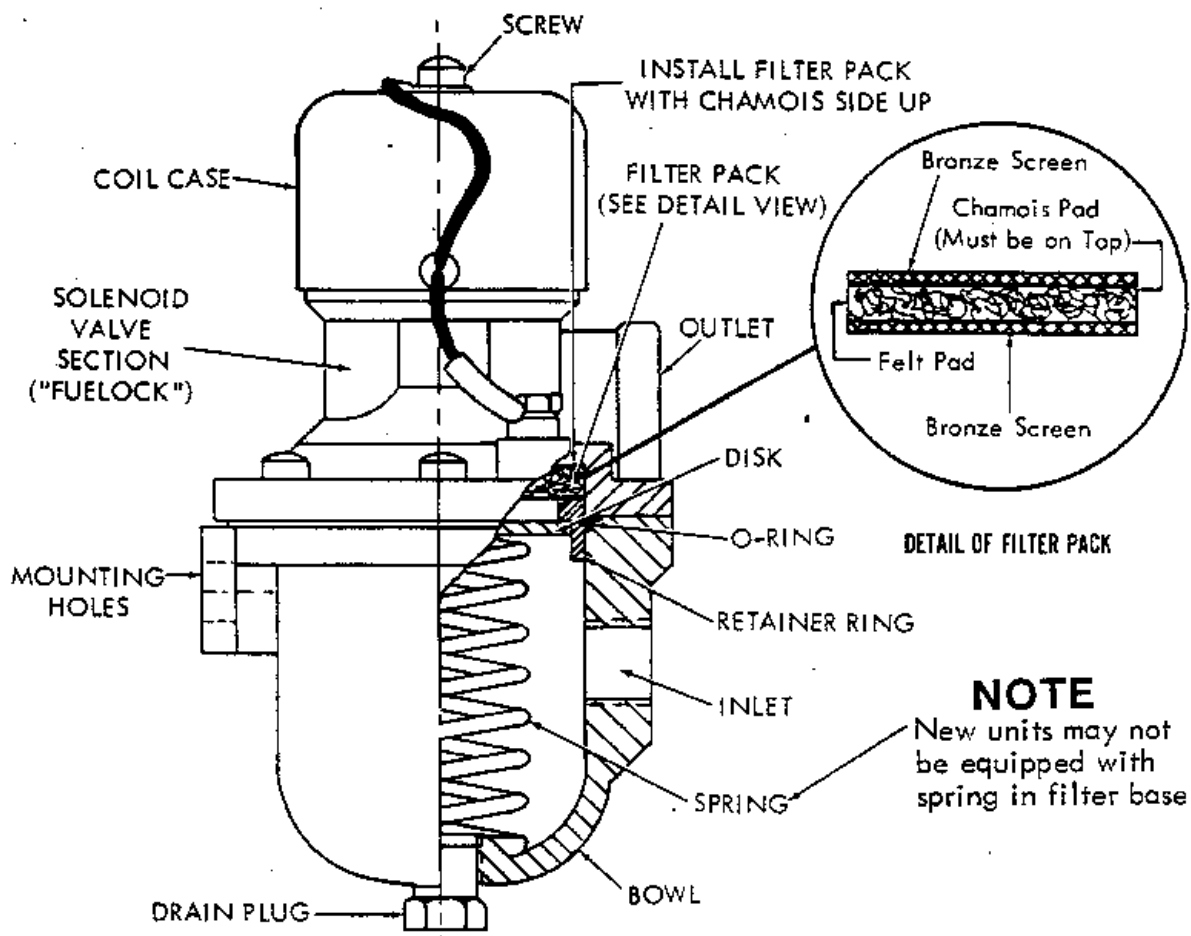
THE FUEL FILTER LOCK (COMBINATION FUEL FILTER AND SOLENOID LOCK-OFF VALVE)

The fuel filter lock 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 FUEL FILTER LOCK 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 fuellock valve section.
3. Remove six screws attaching filter bowl to top section.

▲ CAUTION SPRING INSIDE FILTER BOWL MAY SUDDENLY PUSH UP THE TOP SECTION WHEN THE SCREWS ARE REMOVED.

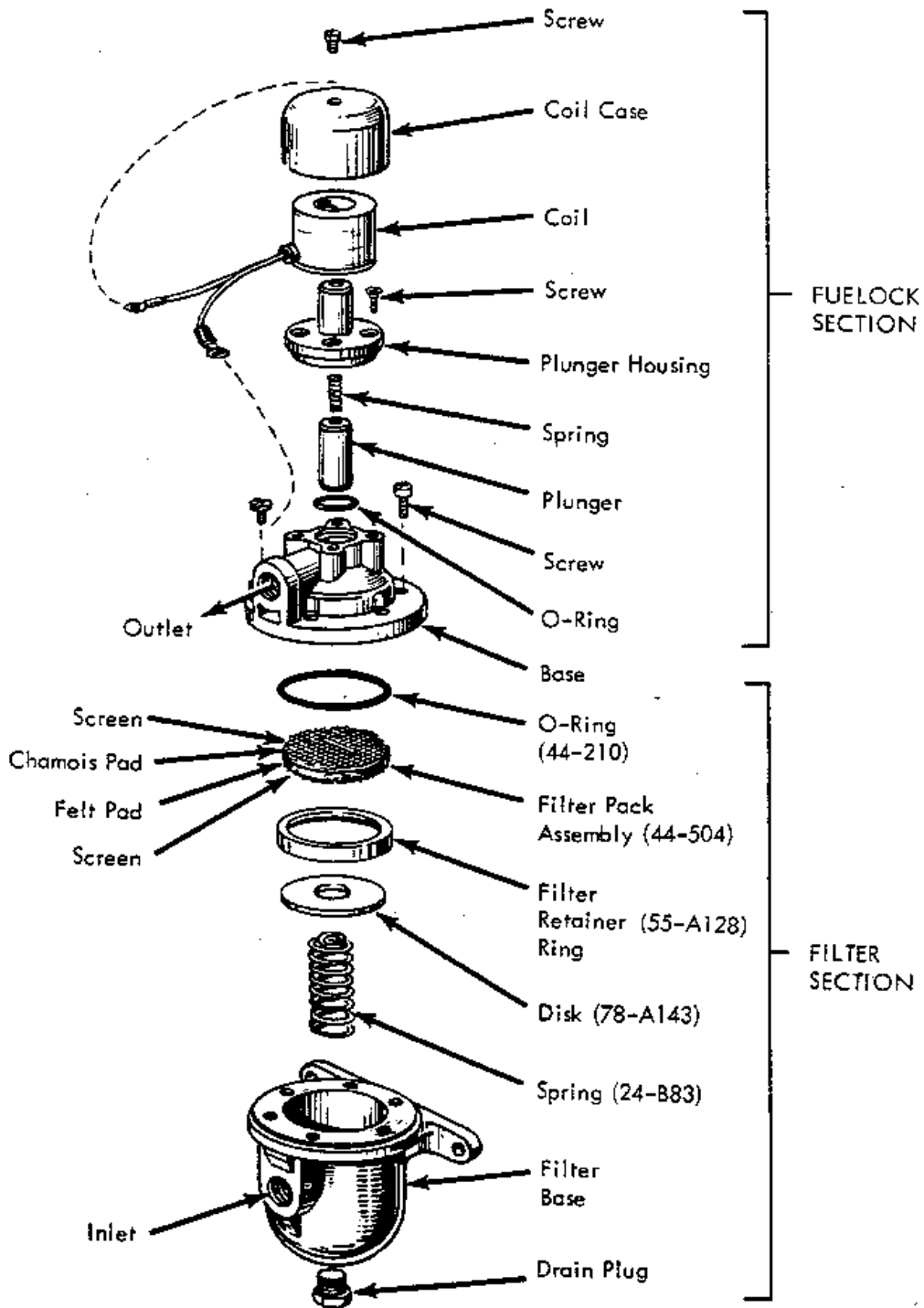
4. Lift off the top valve section (fuel filter lock). Remove the flat disk and spring in the bowl section.
5. Carefully pull out the filter retainer ring, O-Ring, and filter pack (see section drawing and exploded view to identify parts).
6. Discard O-Ring and filter pack.
7. Clean out filter bowl and all parts in solvent. Dry parts with compressed air. Check parts for damage.

ASSEMBLY:

1. Install new filter pack in recess in top section. **NOTE: INSTALL FILTER PACK WITH 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 FUEL FILTER LOCK

TROUBLESHOOTING

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.

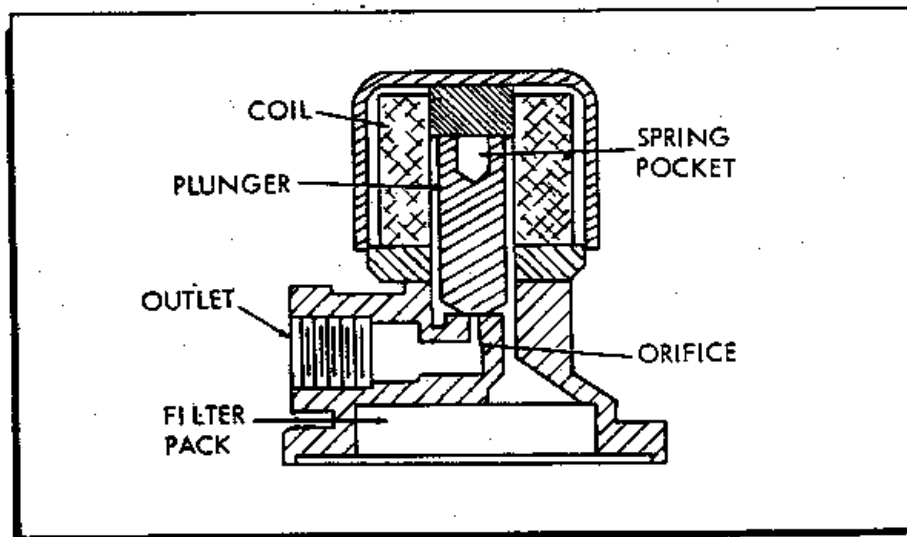
Any apparent shortage of fuel should result in an immediate inspection of the filter to assure that it is not responsible. This is best done by temporarily bypassing the filter and running the engine to see if the problem is eliminated. **DO NOT CONTINUE THE OPERATION WITHOUT CORRECTING THE CAUSE AND CONNECTING THE FILTER BACK INTO THE FUEL SYSTEM.**

B. THE FUELOCK SECTION (SOLENOID-OPERATED LOCK-OFF VALVE)

OPERATION:

The fuel filter lock plunger is held against the 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 the fuel filter lock).

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 FUEL FILTER LOCK (SOLENOID-OPERATED VALVE)

REPAIR OF THE FUEL FILTER LOCK SECTION

A. To Replace Coil

1. Remove single screw 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 the fuel filter lock 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: COIL MAY HAVE INSULATED TERMINAL ON ONE LEAD ONLY. THIS LEAD IS ATTACHED TO TERMINAL POST. BE SURE OTHER COIL LEAD IS GROUNDED TO FUELOCK ASSEMBLY WITH 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: Spring is small and can be easily dropped and lost. BE SURE THERE IS NO FUEL PRESSURE IN FILTER BOWL BEFORE LOOSENING 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 fuellock 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 fuel filter lock assembly, make certain that it is preceded by a good, clean filter. Foreign material which can reach fuel filter lock area will result in leakage and possibly sticking problems. A complete repair kit is available to service STF fuel filter lock assemblies. All normally serviceable parts are included (no coil) as well as a filter pack, pack retainer and filter bowl gasket.

L.P. FUEL VAPORIZER-REGULATOR

TENNANT No. 54238

Used in Tennant Models: 92, 92AA, 92SE, 550, 525, and 280

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 L.P. 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 L.P. liquid fuel is vaporized in the heat exchanger coil.

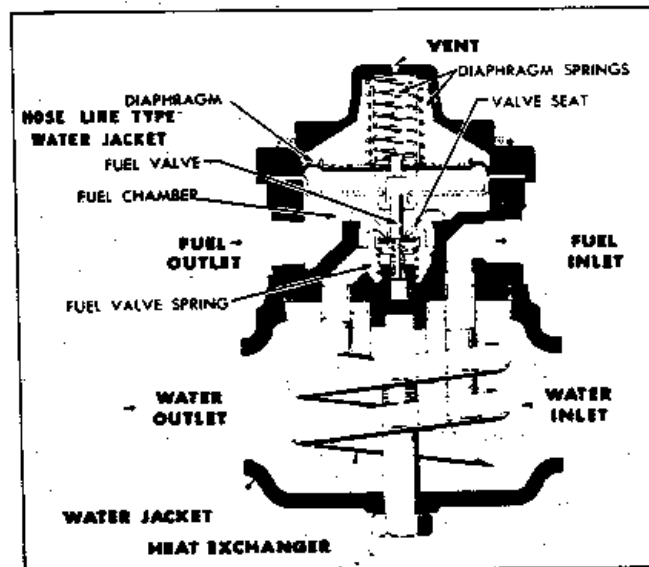


FIG. 16 - Cutaway View of Vaporizer-Regulator

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:

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 the diaphragm baffle plate, baffle plate gasket and fuel valve cap.
5. Remove valve seat with a 1" socket wrench and discard valve seat O-ring. Also remove fuel valve assembly together with fuel valve spring.

(continued on next page)

DISASSEMBLY OF VAPORIZER (continued)

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 the 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.

NOTE 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.
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.

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 the 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 gauge to one of the three vaporizer outlets. Close the remaining outlets with .25" 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 and remain steady. If the gauge reading creeps up, it indicates that vaporizer valve or valve seat is leaking. If leak is indicated, eliminate leak by cleaning or replacing the valve parts as necessary.

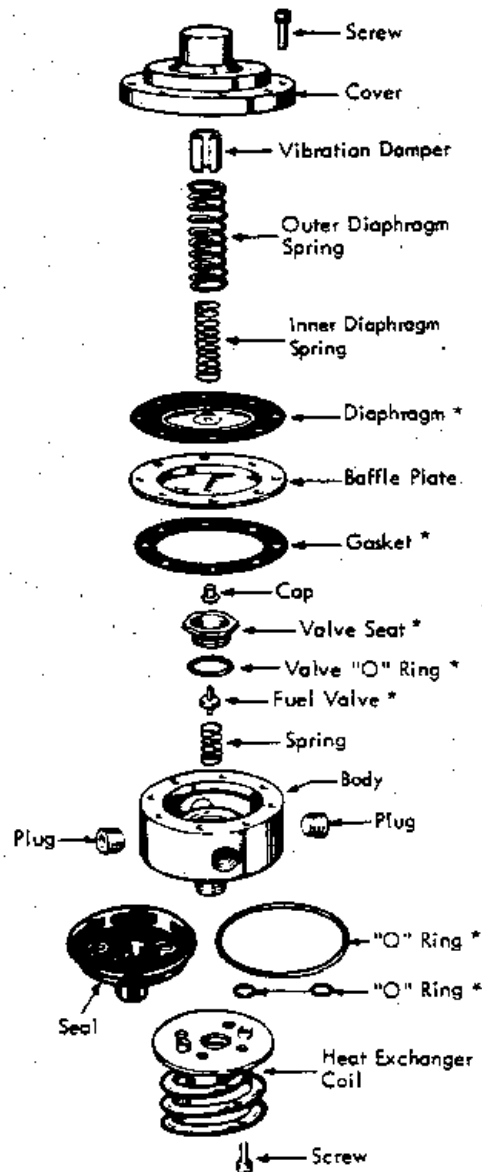
LEAK TESTS

1. Cover vent hole in diaphragm cover with bubble solution. If bubbles form
(continued on next page)

LEAK TESTS (continued)

at this point, diaphragm is leaking. Replace the 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 the O-rings.



* Parts included in diaphragm/seal repair Kit No. SK1839 (Tennant Part No.)

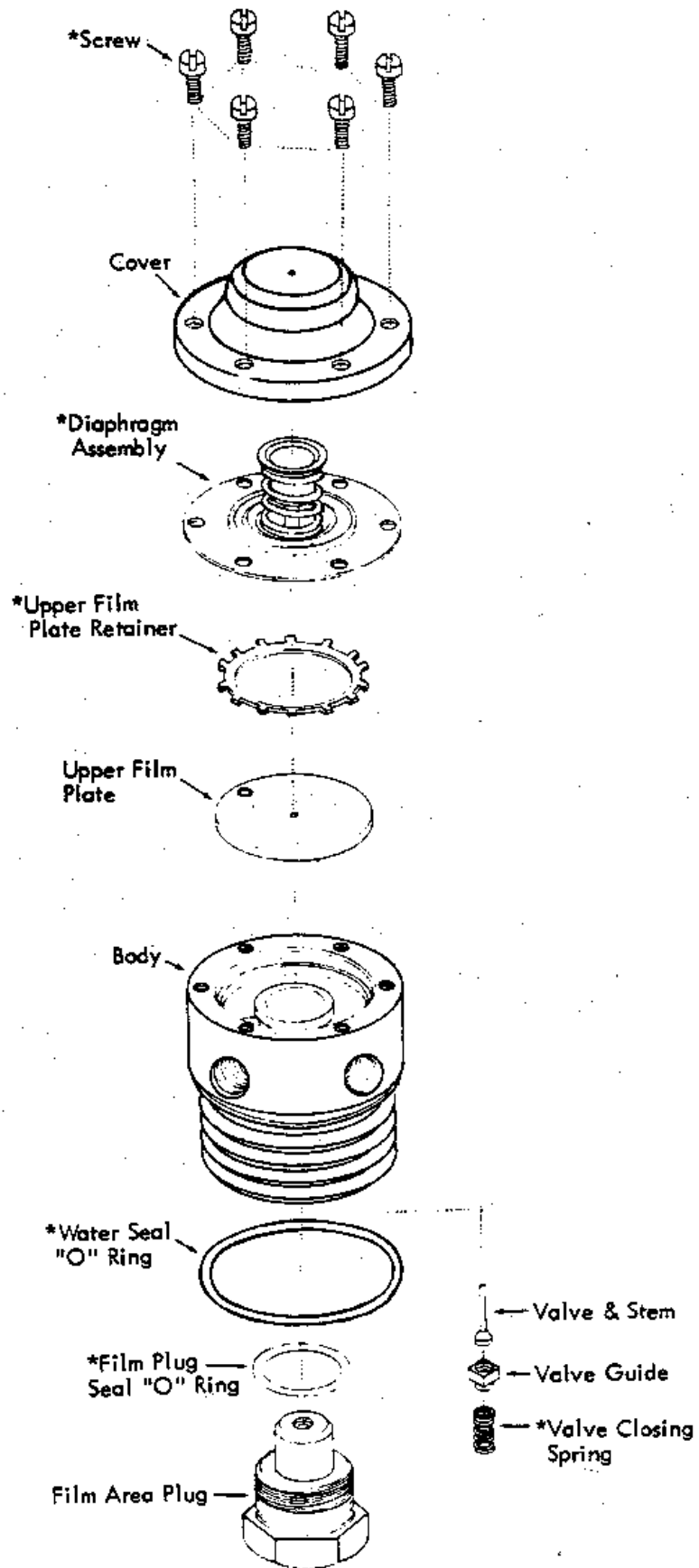
L.P. FUEL VAPORIZER-REGULATOR

TENNANT No. 33600
Used on Tennant Models: 280

J & S Carburetor Manufacturer

SERVICING THE RT1-27 VAPORIZER

1. Remove film area plug with O-ring.
2. Remove spring valve and guide assembly.
3. Remove the six screws.
4. Remove cover and diaphragm assembly.
5. Remove retainer.
6. Remove burrs from body that were caused by the retainer.
7. Remove upper film plate
8. Clean and inspect all major parts. (Particular attention to orifice in body).
9. Assemble upper film plate with vent hole. Locate vent hole over center of the outlet port.
10. Press film plate retainer into body firmly so the film plate has no movement.
Use only enough pressure to make contact on outer diameter.
11. Assemble valve and guide assembly with spring into body.
Align valve stem into center hole of upper film plate.
12. Assemble O-ring with a film of oil onto plug (film area) and torque 40 ft. pounds into body.
13. Check valve stem clearance at center of upper film plate. It should be .062" below body surface.
14. Assemble diaphragm assembly into cover. Align holes and insert screws through cover and diaphragm.
15. Assemble on body. Start all screws. Diagonally tighten firmly.
16. Assemble O-ring on body.



*Parts included in Diaphragm/Seal Repair Kit No. 33602

LP GAS TROUBLE SHOOTING

To assure quick starting and to trouble shoot an engine that won't start, use the following procedure. Be sure to trouble shoot in order of sequence shown below.

A. General Check (for failure to start-- or hard starting)

1. Flooded carburetor--shut off tank valve with ignition switch "ON", crank engine through a few times. If 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.
2. Fuel supply--use only liquid withdrawal type tank. Check fuel supply gauge
3. Tank shut off valve--if hand valve is opened too fast, shut-off valve will automatically close. If this happens, close hand valve at tank. Then open slowly and use standard starting procedure.
4. Check quick-disconnect fitting at tank--if tank valve is not properly seated, no fuel will flow through the line.
5. Check fuel tank and lines for frosting up. To relieve frosting, open shut off valve slowly (approximately .50" open). Start engine and idle until warm. Then open tank valve completely before loading engine. If frost forms on connections fittings, check for fuel leakage, kinked lines or restriction at frost points.

B. Ignition System

NOTE Always check ignition system first before changing LP system adjustments. This is because an LP Gas system does not usually go out of adjustment. Therefore, do not change any LP adjustments until you are sure that the ignition system is not at fault.

1. Check spark at plugs and plugs in general. Replace if defective.
2. Check for broken wires or loose connections.
3. Check ignition points and condenser.
4. Check coil.
5. Check ignition switch. Replace if defective.

C. LP System Components

1. Check fuel filter. Remove and clean if dirty filter is restricting fuel line. See "Filter-Fuelock" Instructions.
2. Check vaporizer regulator. Be sure it is functioning properly.
3. Check carburetor for correct operation.

D. Engine Assembly

Check for mechanical malfunction of engine. See Trouble Shooting Chart and Engine Manual.

L.P. FUEL TROUBLESHOOTING

(1)
Fuel Tank

Won't Start	Stops During Operation	Runs Unevenly-Lacks Power
<p>Check fuel tank type and fuel supply (vapor tank for vapor with-drawal system)</p> <p>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.</p>	<p>Out of fuel</p> <p>Check fuel tank type and fuel supply (liquid tank for liquid with-drawal system)</p>	<p>Tank valve not opened sufficiently.</p> <p>Tank could be overfilled, allowing liquid withdrawal and "freeze-up" of system (vapor system only).</p> <p>Check fuel tank type and fuel supply (liquid tank for liquid withdrawal system).</p>
<p>Check lines, connections, leaks, etc., using soap bubble test method.</p> <p>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.</p> <p>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.</p> <p>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.</p>	<p>Broken fuel line or loose fuel line connection could cause tank internal shut-off valve to close automatically and shut off the fuel supply.</p>	

(2)
Fuel Lines

(continued on next page)

L.P. FUEL TROUBLESHOOTING (Continued)

	Won't Start	Stops During Operation	Runs Unevenly-Lacks Power
(3) Ignition System	<p>Remove and check spark plug to be sure it is the correct type with proper gap.</p> <p>Check ignition points and condenser.</p> <p>Check coil.</p> <p>Check ignition switch .</p> <p>Check wiring for loose connections or wire breakage. Check battery terminals for corrosion or loose ground cable. Check possible shorts in wiring</p> <p>Battery dead.</p> <p>No current to "Filter-Fuel-ock"solenoid valve or possible defective solenoid.</p>	<p>Check electrical system for loose connections or intermittent shorts.</p> <p>Check spark and electrical system for malfunction of condenser, points etc.</p> <p>Check for broken wires or defective relay. Relay can be checked by by-passing relay and directly energizing the solenoid valve in "Filter-Fuelock"</p>	<p>Check ignition for poor connections or weak or worn ignition parts.</p>
(4) Carburetor	<p>Always check carburetor for proper settings before tampering with regulator adjustment.</p> <p>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.</p>	<p>Restricted air cleaner</p> <p>Clean or replace filter element.</p>	<p>Check carburetor setting.</p> <p>Check ignition system.</p>
(5) Regulator	<p>Be sure carburetor is properly adjusted before attempting to adjust regulator setting.</p> <p>Check vaporizer regulator. Be sure it is functioning properly. (Liquid system only). In trouble shooting, be sure all of the previous five check points have been checked thoroughly before making any adjustment to regulator.</p>	<p>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.</p>	<p>Could be improper setting. Allow too rich or too lean mixture to carburetor. Check and adjust only after checking carburetor Adjustment.</p>

L.P. FUEL TROUBLESHOOTING (continued)

(6)
Engine

Won't Start	Stops During Operation	Runs Unevenly-Lacks Power
<p>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.</p>	<p>Check Engine Trouble-Shooting Chart in Machine Manual.</p>	<p>See Engine Trouble-Shooting Chart in Machine Manual</p>

NOTE Always check through L.P. Fuel system in order of numerical sequence.



280 POWER SWEEPER

NOTE

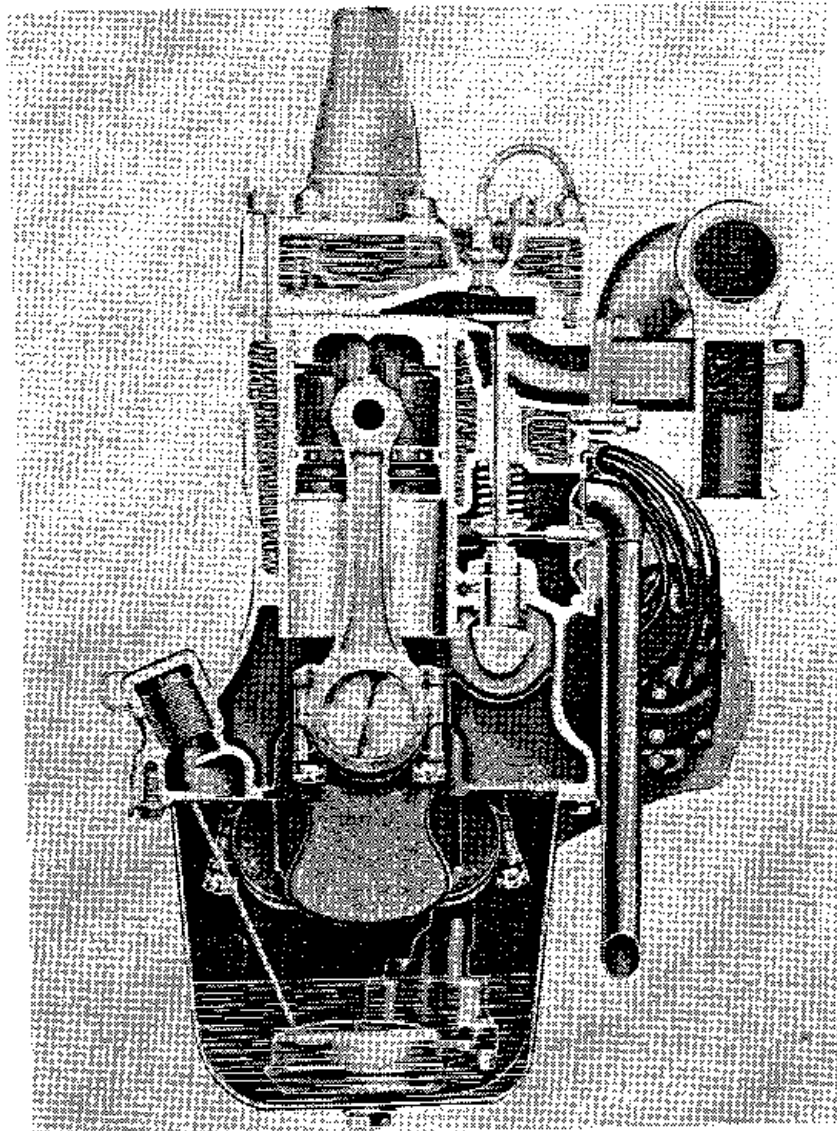
This Section contains Operation and Maintenance
Instructions for the Continental Model Y-112
Gasoline or LPG Engines.

(For Engine Repair Parts, please refer to the
Parts Catalog provided in the separate Parts Manual).

gas & lpg engine section



Operation and Maintenance *Instructions*



L-HEAD ENGINES

MODEL Y-112

 **TELEDYNE CONTINENTAL MOTORS**

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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.

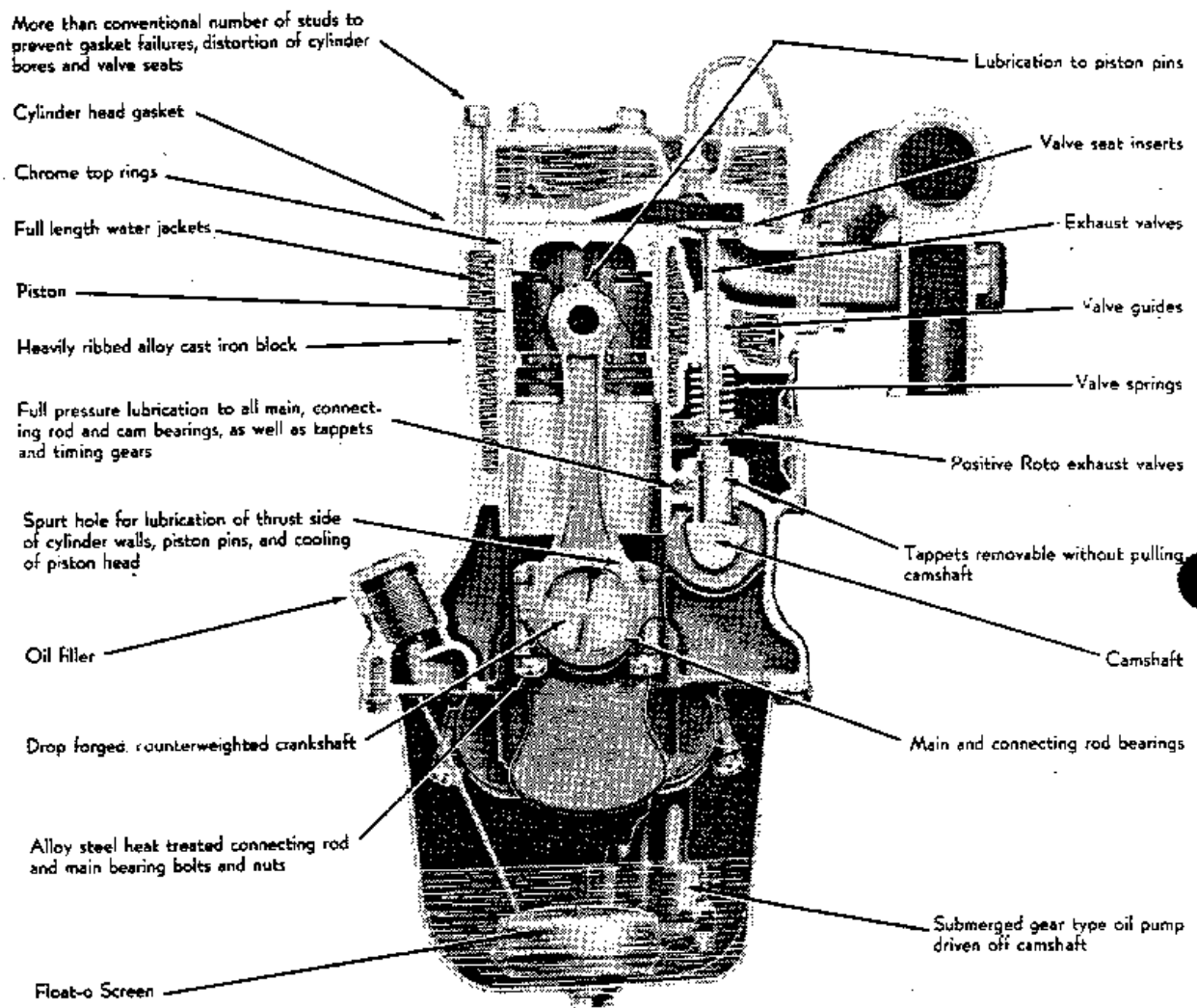
The operator is cautioned against the use of any parts, other than Genuine Teledyne Continental Parts for replacement or repair. These parts have been engineered and tested for their particular job, and the use of any other parts may result in unsatisfactory performance and short engine life. Likewise, 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.

MADE IN U.S.A.					
CONTINENTAL MOTORS CORP'N.					
DETROIT & MUSKEGON, MICH.					
MODEL		SPEC.		ENGINE NO.	
[REDACTED]					
TAP. CL.	OIL	PATENTS	2,241,461	2,347,097	
IN. 012 W. 20W		2,344,863	2,350,226	2,353,231	
		2,361,191	2,369,105	2,472,117	
EX. 020 S. 30		2,368,080	2,545,458	2,806,450	
		2,488,769	2,633,348		

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

SECTION 1 GENERAL INFORMATION



Cross Section of a

Typical Continental "L" Head Engine

MODEL Y-112 ENGINE SPECIFICATIONS

No. of Cylinders	4	Valve Clearance	
Bore and Stroke	3.19" x 3.50" (81mm x 89mm)	Intake	.012" (0.3mm)
Displacement	112 cu. in. (1835cc)	Exhaust	.020" (0.5mm)
Compression Ratio	8.00 to 1	Water Capacity	
		Engine	3.75 qts. (3.54 liters)
		Weight (Bare Engine)	290 lbs. (131.5kg)
Firing Order	1-3-4-2	Engine Speed (accessories on and brushes down)	1800 ± 50 rpm.
Main Brg. Frt.(dia.& length)	1.75" x 1.22"	Engine Idle Speed	700 ± 100 rpm.
Main Brg. Center	1.75" x 1.44"	Timing	T.D.C.
Main Brg. Rear	1.75" x 1.44"	Spark Plug Gap	.025" (0.6mm)
Conn. Rod Brg.	1.50" x 1"	Point Gap	.022" (0.55mm)
Oil Capacity Crankcase	3.50 qts. (3.31 liters)	Dwell angle	31° to 34°
Filter	.50 qt. (0.47 liter)		
Total	4 qts. (3.78 liters)		

LUBRICATION RECOMMENDATIONS

S.A.E. OIL BODY GRADES*

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

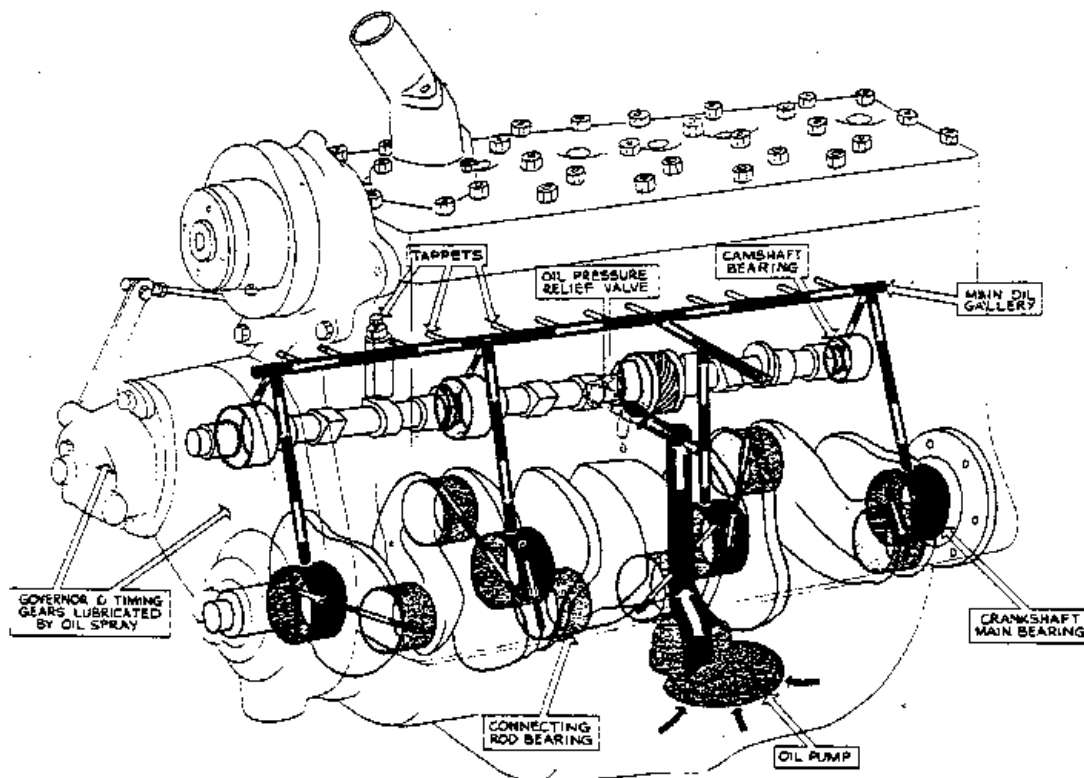
MULTI-GRADE OILS

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

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

SEVERE WINTER BELOW 0°F (-17.8°C)	NORMAL WINTER 0° - 32°F (-17.8 - 0°C)	SPRING-FALL 32°F - 75°F (0°C - 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.



Engine Lubrication System

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 -
Check for adequate oil pressure indicated on gauge.
7. Check Coolant Temperature

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

ATTENTION! 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 cylinder head studs to specifications.
2. Adjust valve tappets to specified clearances.
3. Adjust idle mixture and 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 choke when stopping engine. Raw gasoline will wash lubricant from cylinder walls.

COLD WEATHER OPERATION

Sludge formation at low temperatures is a close second to dirt in causing engine damage and wear. This is formed by the piston combustion gases mixing with the fine oil mist in the crankcase and condensing on a cold surface. This condensation forms both a sulphuric and sulphurous acid which combines with the oil to become a highly injurious sludge. This dew point is about 135° F (57.22°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 (57.22°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 3.5% for every 1000 feet of altitude above sea level.

High Temperature Operation

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

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.

5. CHECK AIR CLEANER

Dry Type Air Cleaner

Under normal conditions, dry-type filters should be serviced every 50 hours of operation. Extremely dirty conditions will require daily cleaning. Follow air cleaner instructions in Maintenance Section.

6. CHECK OIL PRESSURE

Check for adequate oil pressure as indicated on gauge.

◀ 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.

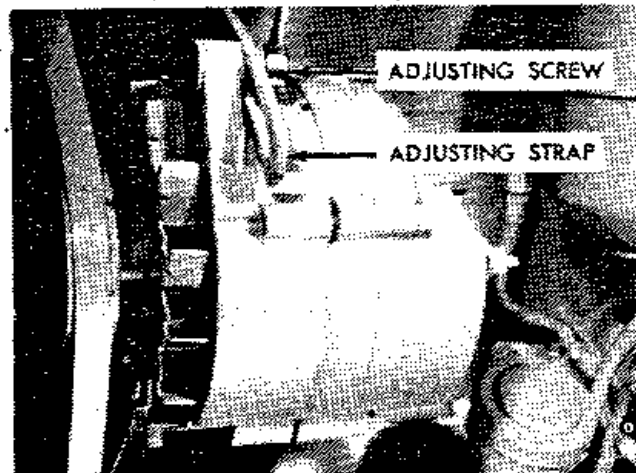
4. CHECK BELT TENSION

Radiator Fan Belt Tension

Fan belt tension is adjusted by means of a tumbuckle. Recommended tension will produce a deflection of .25 inch (6.3 mm) from a force of one to two pounds (.45 to .91 kg) applied at belt midpoint.

Alternator Belt Tension

Loosen adjusting screw on alternator and pull out on alternator to tighten belt. When adjusted correctly, the belt should have about .50 inch (12.7 mm) deflection from moderate force applied at midpoint on longest span.



FAN and ALTERNATOR BELT TENSION ADJUSTMENT

5. CHECK BATTERY

Check specific gravity of each cell - which should be at least 1.250.
Add distilled water, if required, to raise level .38" (9.7 mm) above the separators.

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

6/79 7. TORQUE DOWN CYLINDER HEAD TO SPECIFICATIONS IN MANUAL

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. Install spark plugs (18mm). Torque to 35 ft lbs (47.46 Nm).

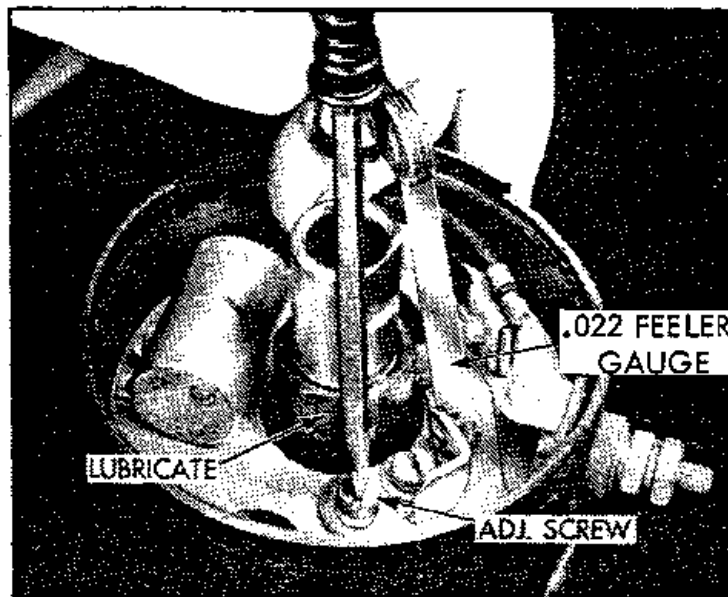
5. CHECK DISTRIBUTOR

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 gap to .022 in. (0.55 mm).

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

7. Replace air cleaner element.



Check Distributor Points, Set Gap

EVERY 500 HOURS

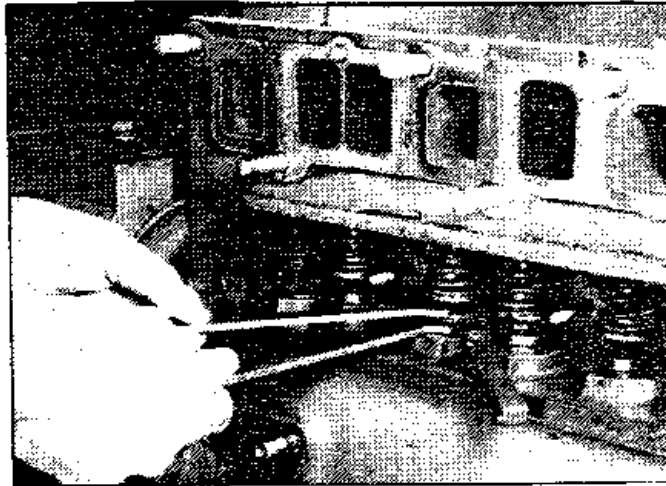
1. REPEAT DAILY, 50 HOUR, AND 250 HOUR SCHEDULES
2. COOLING SYSTEM

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 - .012" (.30 mm) Exhaust - .020" (.508 mm)



Adjusting Valve Tappet Clearance

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

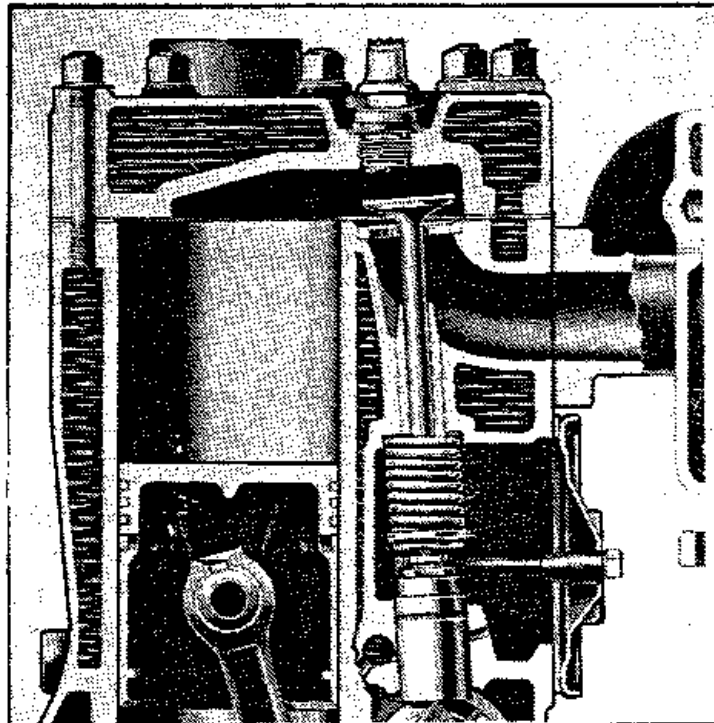
Clean Filter bowl and screen. Inspect mounting and gasket. Check all connections for leaks.

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 (82.22°C - 93.33°C) and a thermostat and by-pass system is used to control these temperatures.

The thermostat valve remains closed and only allows the water to recirculate within the engine 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*

ATTENTION!

The thermostat begins to open at 180°F (82.22°C). However, temperature gauges are not always exactly accurate and may sometimes indicate higher than actual temperature. This can lead operators to believe engines are overheating when they are actually operating normally.

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

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 other words, 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 cleaned 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.

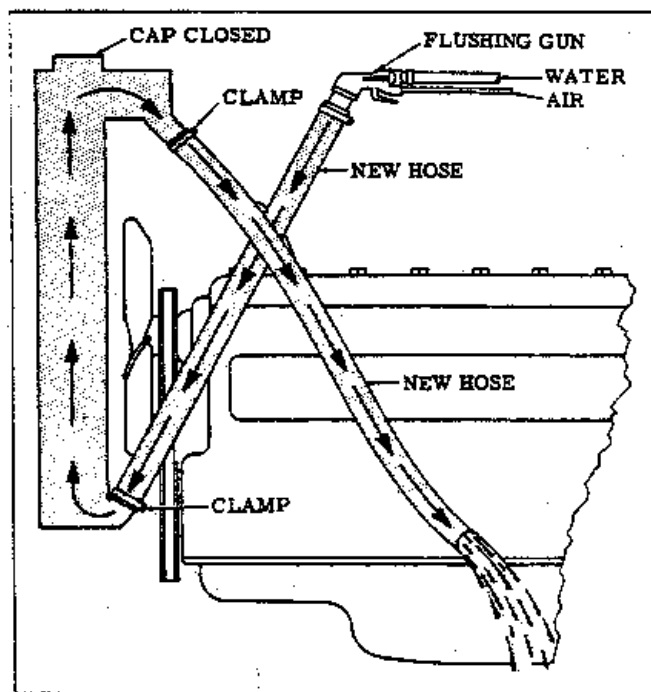
REVERSE FLOW FLUSHING

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 FLOW FLUSHING (Continued)

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 outlined above for the radiator by alternately filling the water jacket with water and blowing it out with air pressure, 80 lbs (552 kPa.) 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 block. Keep 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.

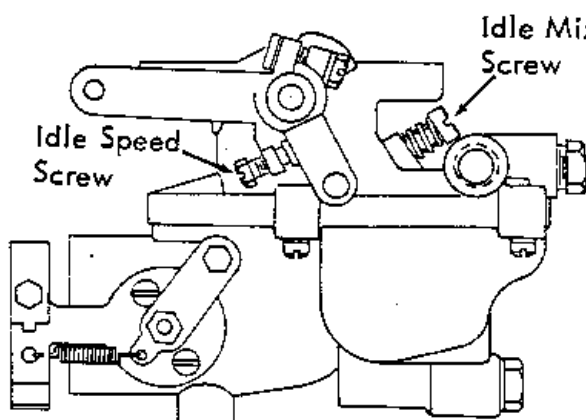
If none of these items corrects flooding, remove the fuel pump for replacement or overhaul.

CARBURETOR

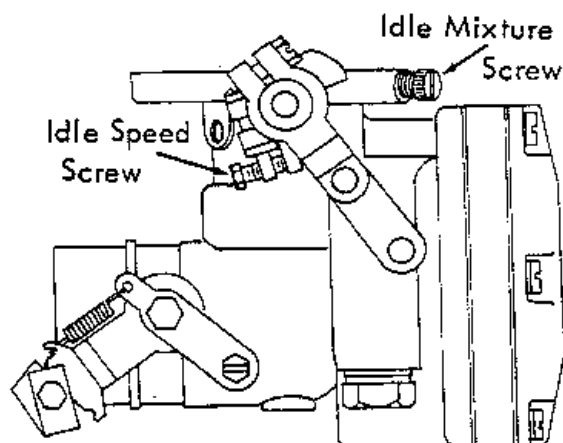
Idle Mixture Adjustment Needle

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.



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 disturbing the carburetor.

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

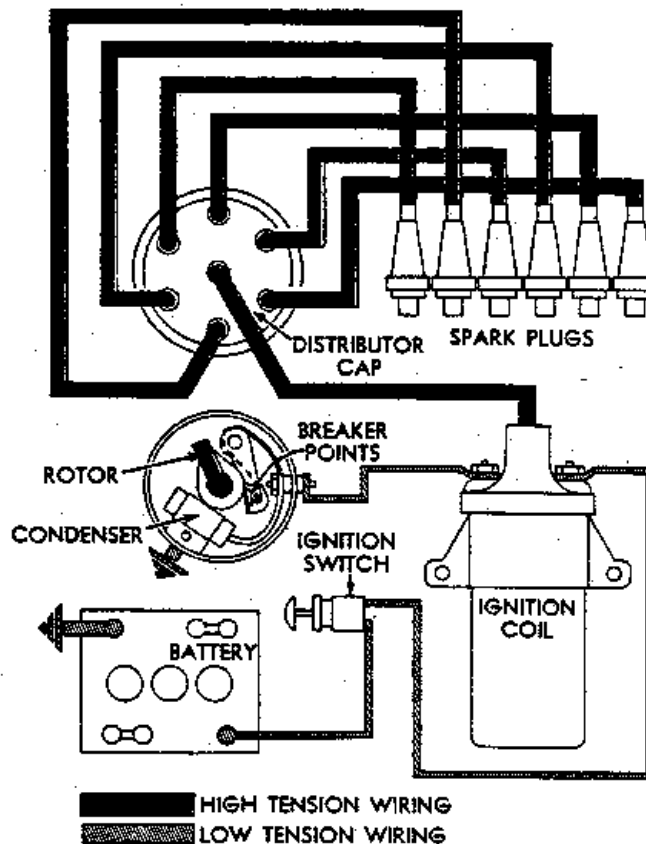
Never use a wire to clean out restrictions in jets as this will destroy the accurate calibrations of these parts. Always use compressed air. The jets are made of brass to prevent rust and corrosion and a wire would cut or ream the hole in the jet and ruin it.

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

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

SECTION VII IGNITION

The ignition system has the job of producing and delivering high voltage surges of about 20,000 volts to the correct spark plug, at the correct intervals and with the correct timing to the engine. Each high voltage surge produces a spark at the spark plug gap to which it is delivered, so that the mixture of air and fuel in the cylinder is ignited.



Schematic drawing of battery ignition system

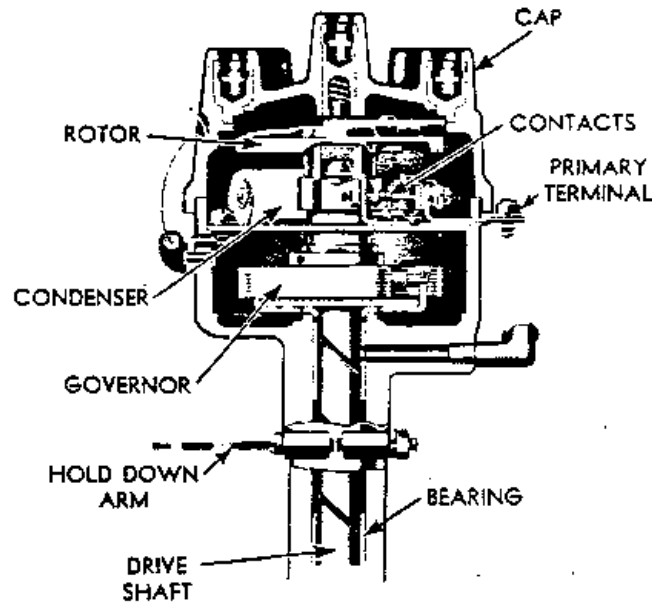
Ignition Coil - The function of the ignition coil is to transform the low voltage supplied by the battery into the high voltage to jump the spark plug gap.

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

Ignition coils can be tested for grounded windings by placing one test point on a clean part of the metal container and touching the other point to the primary and high voltage terminals. If tiny sparks appear at the points of contact, the windings are grounded. If the coil is further suspected of being faulty, remove and check its operation on a coil tester and replace it if inoperative.

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 condenser 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:

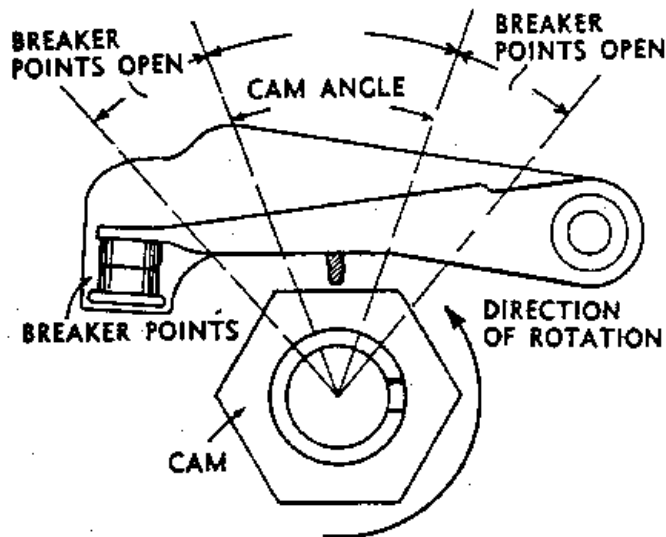


Diagram illustrating cam angle

The cam is further designed to open the breaker points at a given speed in relation to cam travel to obtain proper point and condenser action. It is therefore important that the breaker points be adjusted to .022" (.558 mm) gap so that proper cam angle is obtained.

DISTRIBUTOR MAINTENANCE—

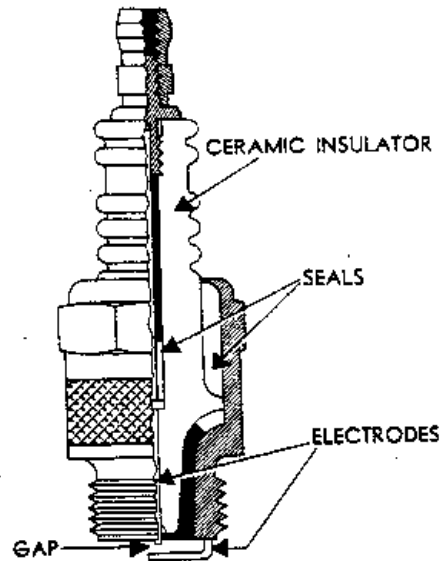
The distributor operation is vital to the operation of the engine and the following items should be carefully inspected every 250 hours of normal operation; however, dirt, dust, water and high speed operation may cause more rapid wear and necessitate more frequent inspections:

1. Remove Distributor Cap (without removing wires)
Clean cap and examine for cracks, carbon runners, corroded terminals or if the 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. The centrifugal advance mechanism should also move freely. To insure this, place a drop of light oil in the end of the shaft when servicing the distributor.

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

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" (0.6 mm).

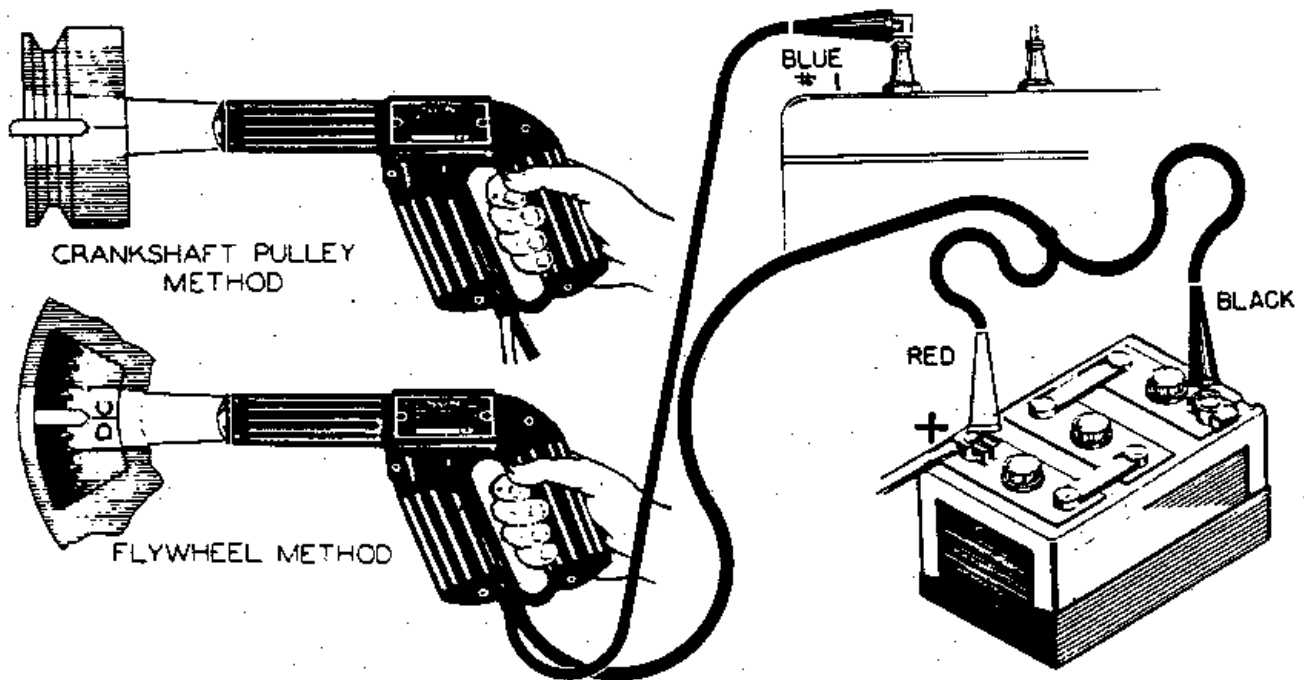


Spark plug gaps are best checked with a wire gauge unless the points are dressed to obtain a correct reading with a flat gauge. The adjustment should always be made on the side electrode and never on the center electrode which may cause a broken porcelain. "Gapping" the electrode tip is more easily done 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 ft. lbs (475 Nm) torque with socket wrench of correct size.

DISTRIBUTOR — IGNITION TIMING With Timing Light



*Schematic diagram showing
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 positive 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 at 0° T.D.C. at 400 rpm., 14° at 1800 rpm. and 16° at above 2000 rpm.

(continued on next page)

Adjusting Timing (continued)



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.

ATTENTION! After adjusting timing, be sure to increase idle speed up to speed recommended in "Specifications".

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 (-12.22°C) electrolyte temperature below 80°F (26.67°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.

III. Alternator

ATTENTION! Precautions to be observed when testing or servicing the alternator:

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 rectifier 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.)

IV. Regulator

Installation of Regulator for Alternator

To insure proper operation and to protect the alternator and regulator, the following steps should be observed during installation.

1. Make sure regulator is of the same voltage and polarity as the alternator and battery.

III. ALTERNATOR (continued)

2. Disconnect battery cable at battery terminal.
3. Make sure the mounting area of the alternator and regulator base are clean and make a good tight connection.
4. Connect alternator in accordance with the manufacturer's instructions.
5. Do not flash field or ground terminals of the regulator.
6. Reconnect battery cable.
7. Start engine and observe ammeter. A "High" charge rate is normal for the first few minutes, but will decrease as the regulator warms up.

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.

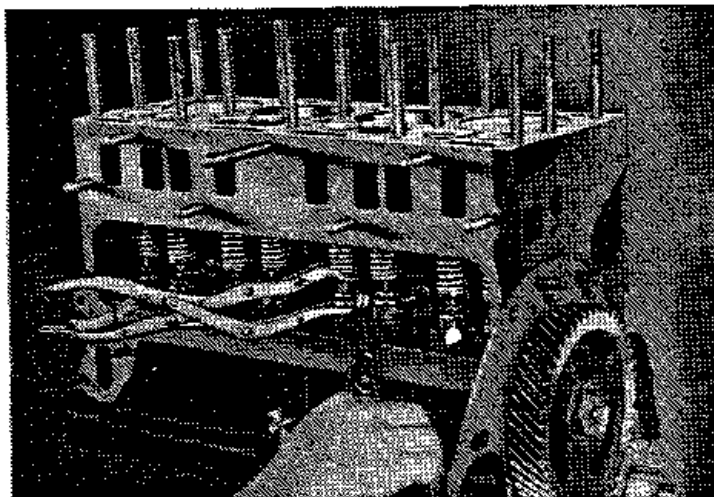
SECTION VIII ENGINE REPAIR AND OVERHAUL

CYLINDER HEAD REMOVAL

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 straight edge and feeler gauge; maximum permissible is .00075 inches per inch of width or length. Thus for a cylinder head 16" (406.4 mm) long, maximum permissible lengthwise out-of-flatness is .012" (.30 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" (.076 mm).

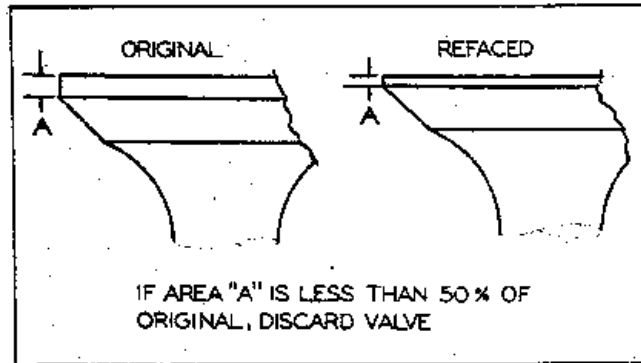
Valve Removal

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 in-take and exhaust valves so they will not be mixed in handling.



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 .002 over the 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

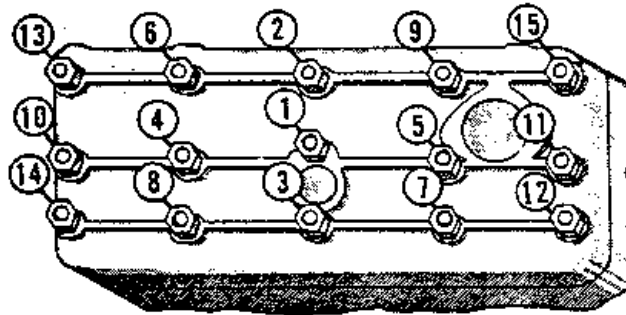
1. Check all valve springs on a spring tester to make sure they meet specifications regarding weight and length. Springs, when compressed to the "valve open" or "valve closed" length, must fall within the specifications shown on the chart when new, and must not show more than 10% loss to re-use.
2. Reassemble 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 .25" 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 35 to 40 ft. lbs (47.6 to 54.24 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.

NOTE New engines use RTV silicone sealant instead of oil pan gaskets.

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.

Operators handling the same engine every day, soon develop a sense of impending trouble when abnormal operation occurs. Immediate attention to these danger signals can prevent major failures, insure dependable operation and increase the life of the engine.

Operators should depend on their well-developed senses of feeling, hearing, seeing and smelling and replace their sense of taste in this type of work -- with a generous amount of "Common-Sense".

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

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

A. STARTING MOTOR WILL NOT CRANK ENGINE:

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

B. ENGINE CRANKS - BUT DOES NOT START:

Disconnect one spark plug wire, turn ignition on with starter cranking engine and free end of wire .125" (3.175 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" (508 mm) water.
6. Exhaust line obstructed - should have back pressure of not more than 20" (254 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

K. HIGH OIL CONSUMPTION (continued)

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

Manifold may be removed for visual inspection

L. ENGINE KNOCKS AND OTHER NOISES

1. Operating Knocks - which may be due to:
 - a. Pre-ignition - most common cause is due to wrong type plugs which are too hot
 - b. Carbon - noticeable when engine is accelerated while hot - clean head and pistons
 - c. Timing - early timing causes knocks similar to carbon - but may tend to kick back when starting
 - d. Fuel - detonation knock caused by poor gas
 - e. Overloads - particularly at lower operating speeds
2. Mechanical Knocks - result from wear, abuse or improper adjustments - which may be due to:
 - a. Crankshaft and main bearings:
 - (1) Worn or burned-out main bearings - A heavy, dull knock when accelerating under load. Locate by shorting out plugs on both sides of the bad bearing.
 - (2) Crankshaft end-play - excessive end-play is indicated by an intermittent knock which will come and go when the load is released and engaged.
 - b. Connecting rod bearings
 - (1) Worn or burned-out bearings - The worst condition, a light pound or metallic knock, is noted at idling and to about 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.

L. ENGINE KNOCKS AND OTHER NOISES (CONTINUED)

- f. Camshaft - Noise due to loose bearings or end play, usually occurs at half engine speed
 - g. Timing gear noise - loose or worn gears rattle or knock - tight gears hum
3. Vibration Originating at Engine - The most common sources of vibration originating in or on the engine, as distinguished from causes created outside the engine are as follows:
- a. Misfiring
 - b. Misalignment of engine
 - c. Bent or off-center coupling
 - d. Engine loose on bed and type of mountings
 - e. Out of balance condition of flywheel and clutch assembly

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.

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

Size-Diameter	.313"	.375"	.438"	.50"	.563"	.625"
Cylinder Heads	.....	35-40	70-75			
Main Bearing Caps	.....	35-40	70-75	85-95	110-120	140-150
Connecting Rods	20-25	40-45	55-60	90-100	110-120	.....
Flywheels	20-25	35-40	70-75	85-95	100-110	145-155
Manifolds	15-20	25-30	40-50	50-60	50-60	60-70
Gear Covers, Water Pumps, Front and Rear End Plates	15-20	25-30	50-55	80-90	.....	.....
Oil Pans	12-16	12-16	.....	.....	.....	.....
Flywheel Housings	15-20	25-30	50-55	80-90	115-125	.....

Camshaft Nut

Thread Size	.75"	.875"	1"	1.125"	1.25"	
C.I. Shafts	65-70#	70-80#	95-100#	125-130#	145-150#	
Forged Steel Shafts		*120-125#	*175-180#			
Elastic Stop Nut w. C.I. or Forged Steel Shaft		65-70#				

*When Cam Gear Governor is used with a steel camshaft, torque cam nut to 85-90#

SECTION XI

LIMITS AND CLEARANCE DATA

NOTE: DIMENSIONS SHOWN ARE FOR
STANDARD ENGINES
MODEL Y112 ENGINE

VALVE GUIDE	INTAKE AND EXHAUST	PISTONS	
Length	2.28"	Cylinder Dia.	3.1875/3.1895
Outside Dia.	.5645/.5635	*Wear Limits-Cyl. Bore	.008
Stem Hole Dia.	.3167/.3157	Piston Pin Hole Dia.	.7086/.7084
*Wear Limits-Max. Dia.	.3182	Ring Groove Width-#1	.0955/.0945
Distance, Cyl. Block Contact face to Guide	.875"	*Max. Wear Limit Width	.0975
		Ring Groove Width #2	.0955/.094
		#3	.251 / .250
		*Max. Wear Limit Width #2	.0975
		#3	.253
VALVES, INTAKE		Ring Groove Width #4	None
Stem Dia.	.3149/.3141	*Max Wear Limit Width	-
*Wear Limits, Min. Dia.	.3121	Piston Fit-feeler Gauge	.002
Seat Angle	30°	Lbs. Pull	5-10#
Stem Clearance Limits	.001/.0006		
*Wear Limits-Max. Cl.	.003		
Desired Stem Clear.	.0008		
VALVES, EXHAUST		PISTON RINGS	
Stem Dia.	.3132/.3124	Ring Width-#1	.0935/.0925
*Wear Limits-Min. Dia.	.3104	*Wear Limits-Min Width	.0905
Seat Angle	45°	Ring Width-#2	.0935/.0925
Stem Clearance-Limits	.0047/.0043	#3	.249 / .2485
*Wear Limits, Max. Cl.	.0063	*Wear Limits-Min Width #2	.0905
Desired Stem Cl.	.0035	#3	.2465
VALVE SPRINGS		Ring Width-#4	None
Outside Dia	.969"	Wear Limits-Min. Width	-
Length-Valve closed	1.70"	Ring Width-#5	None
Load-Valve closed	47-53 #	Wear Limits-Min. Width	-
*Wear Limits-Min. Wgt.	42#	Ring Gap Clear.-#1	.013/.008
Length-Valve open	1.42"	#2-.013/.008	#3-.016/.008
Load-Valve open	96-104#	Ring Gap Clear-#2&3	None
*Wear Limits-Min. Wgt.	86#	Ring Gap Clear - #4	None
		Ring Gap Clear- #5	None
		Ring Side Clear - #1	.003 / .001
		Ring Side Clear - #2	.003/.001
		#3	.0025/.001
		Ring Side Clear-#4	None

LIMITS AND CLEARANCE DATA

CAMSHAFT

Brg. Journal Dia. #1	1.8095/1.8085
#2	1.7465/1.7457
#3	1.2475/1.2465
#4	None
*Wear Limits-Min. Dia	
Bushing-Inside Dia. #1	1.8125/1.8115
#2	1.7502/1.7495
#3	1.2505/1.2495
#4	None
Bushing-Clearance Limits	.004/.002
End Play	.007/.003
CONNECTING RODS	
Bush. Hole Dia	.7632/.7622
Brg. Hole Dia	1.6245/1.6240
Brg. Thickness	.0617/.0614
*Wear Limits-Min. Thk.	.0609
Dia-Crank Pin	1.500-1.499
*Wear Limits-Min. Dia.	1.498
Clearance Limits	.0006/.0027
Desired Clearance	.0015
*Wear Limits-Max Cl.	.0037
Side Play	.0105/.006
Desired Side Play	.0065

MAIN BEARINGS

Dia of Brg. Bore in Block	1.8747/1.8740
Brg. Thickness	.0625/.0622
*Wear Limits-Min Thk.	.0617
Dia. of Main Brg. Jr.	1.7485/1.7475
*Wear Limits-Min. Dia.	1.7465
Clearance Limits	.0005/.0028
Desired Clearance	.0015
C/S End Play	.003/.008
PISTON PIN	
Length	2.066/2.056
Diameter	.7085/.7083
*Wear Limits-Min. Dia.	.7080
Desired Fit	Light Push
Bush. Hole Dia.-Fin.	.7089/.7087
*Wear Limits-Max. Dia.	.7099
Pin Cl. in Bushing	.0006/.0002
Desired Pin Fit	.004

CAMSHAFT BORE IN BLOCK - FINISH REAMED

Model	Front	Front Interm.	Center	Rear Interm.	Rear
Y400	1.9375	None	1.8750	None	1.3750
	1.9370		1.8745		1.3745

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 manufacturers.

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

11-1-72



280 POWER SWEEPER

NOTE

This Section contains Operation and Maintenance Instructions for the Perkins Model 4.108 Diesel Engines.

(For Engine Repair Parts, please refer to the Parts Catalog provided in the separate Parts Manual).

diesel engine section



4.108

**manual for
4.108
diesel engines**

 **Perkins
engines**

Perkins Engines Limited

Peterborough England

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 Perkins'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 Perkins'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

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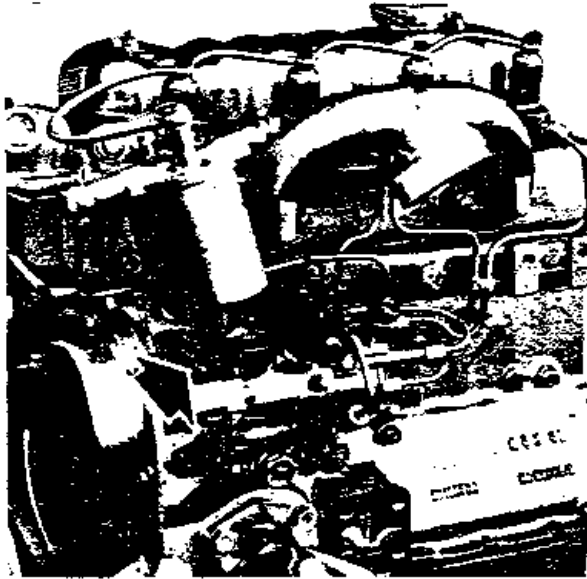
Perkins reserves the right to make changes or add improvements to its products at any time without incurring any obligation to make such changes to products manufactured previously. Perkins or its distributors accept no responsibility for variations which may be evident in the actual specifications of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

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ENGINE IDENTIFICATION

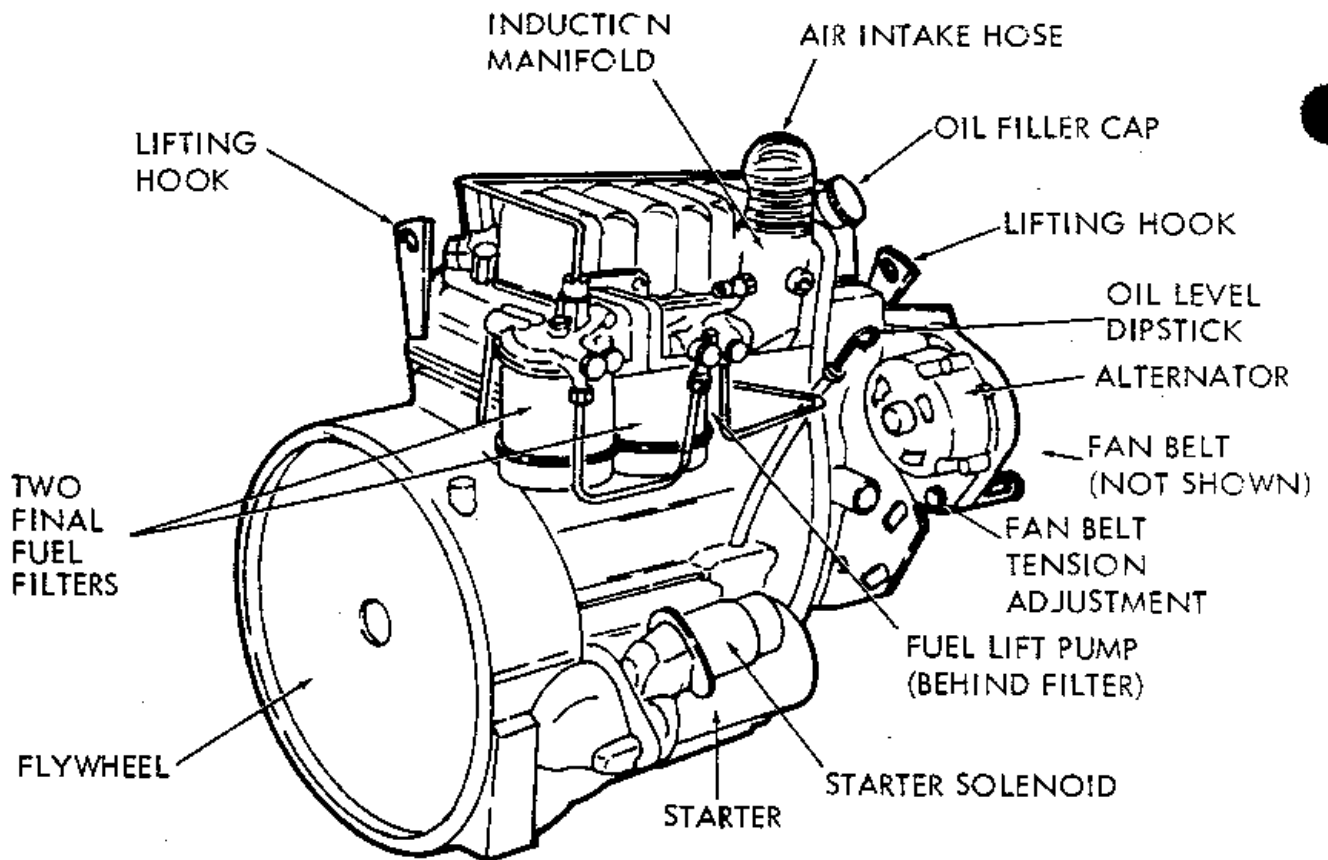


The engine number is stamped on the fuel pump mounting flange as shown in the above illustration. With current engines, the number consists of figures and letters, e.g.,

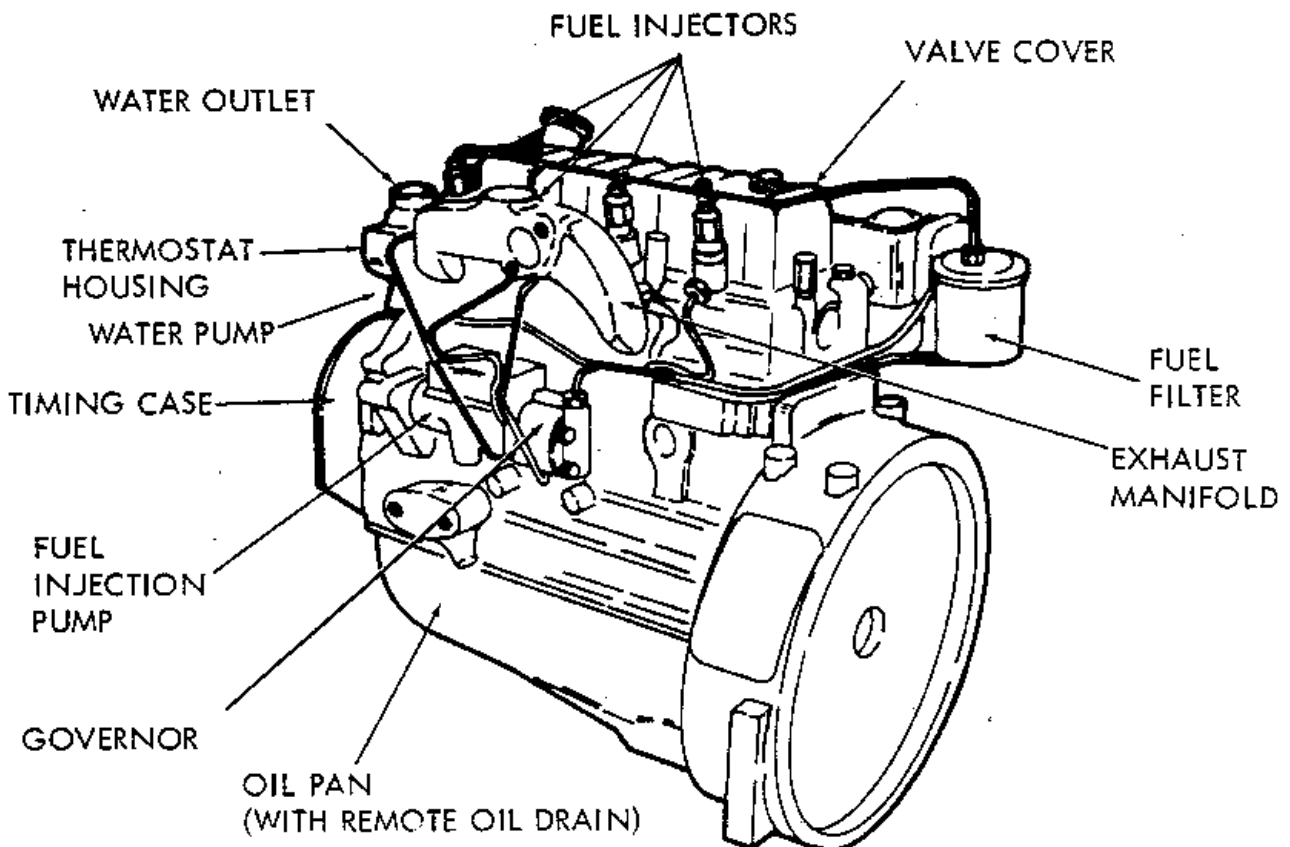
ENGINE TYPE
4.108

TYPICAL ENGINE NUMBER
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 "Tuffride" 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)

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.
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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-Syphon 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 by 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.						
<table> <tr> <td>EH39</td> <td rowspan="5">} For 4.108 Engine</td> </tr> <tr> <td>MH26</td> </tr> <tr> <td>MH27</td> </tr> <tr> <td>PH28</td> </tr> <tr> <td>PH30</td> </tr> </table>	EH39	} For 4.108 Engine	MH26	MH27	PH28	PH30	18°	0.108 in. (2.75mm)
EH39	} For 4.108 Engine							
MH26								
MH27								
PH28								
PH30								

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.

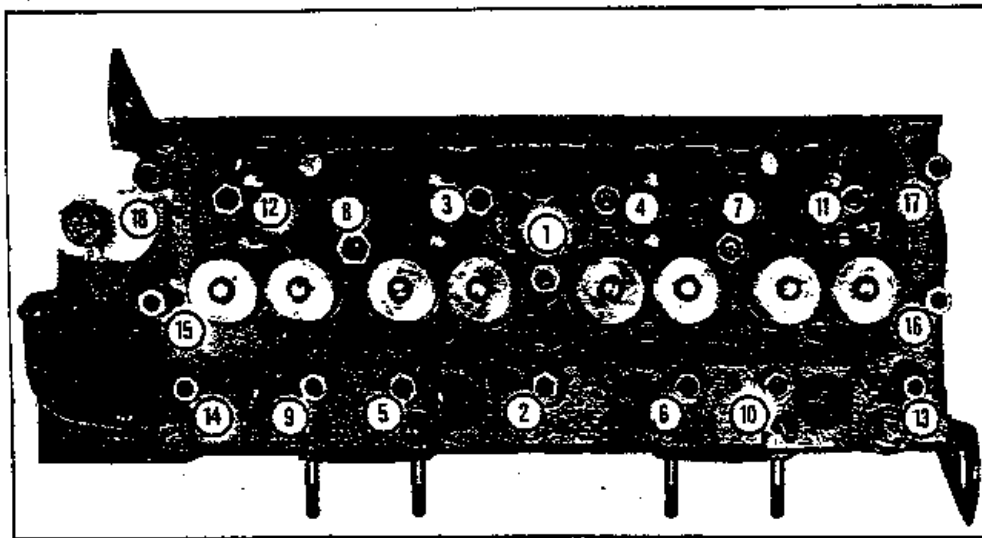


Fig. C-1 - Torque Tightening Sequence for Cylinder Head Nuts

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	<i>Moderate Duty Diesel & Gasoline Engine Service</i> 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.				Min.	Max.	Min.	Max.			
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 minimum viscosity shall be 1.8 cs and the minimum 90% point shall be waived.

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 disturbance 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),

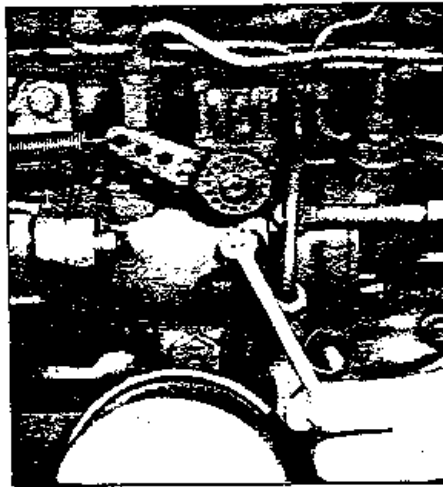


Fig. C-4

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.

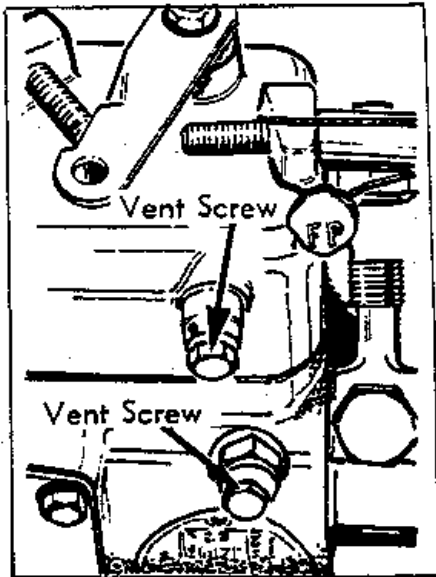


Fig. C-5
Vent Screw on Governor Housing



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

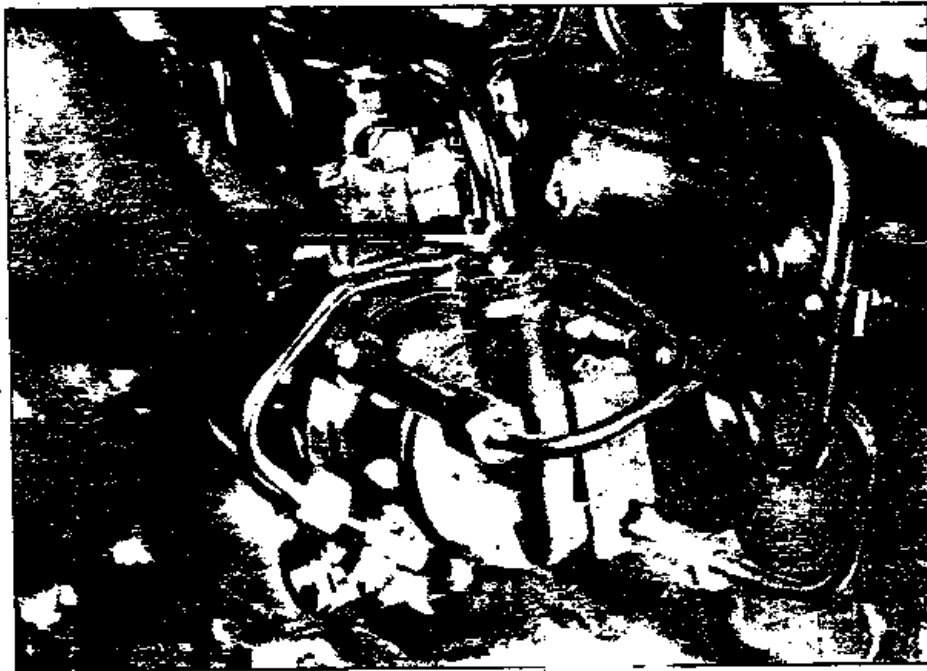


Fig. C-8
Slackening Pipe Union Nut at Fuel Injection Pump Inlet

BLEEDING FUEL SYSTEM (continued)

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.

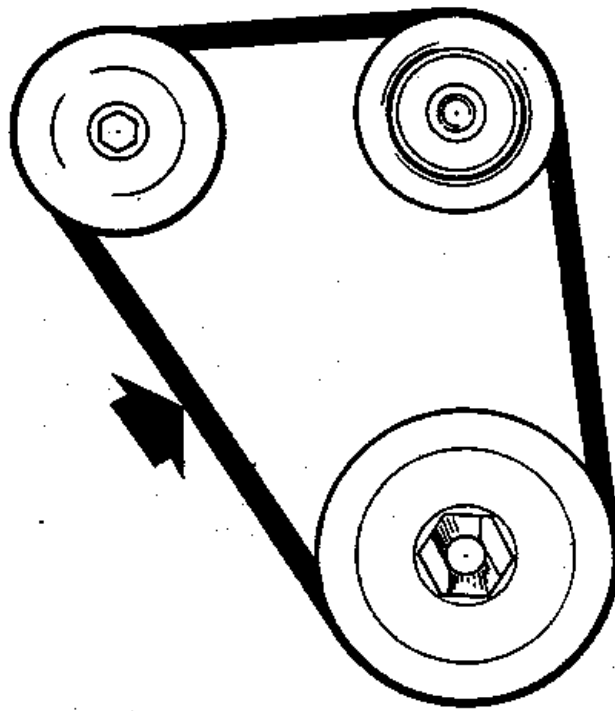
If, after bleeding the fuel system, the engine starts and runs satisfactorily, but after a few minutes stops, then it can be assumed that air is trapped in the fuel injection pump and the bleeding procedure should be repeated, at the same time checking for air leaks on the suction side, such as loose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

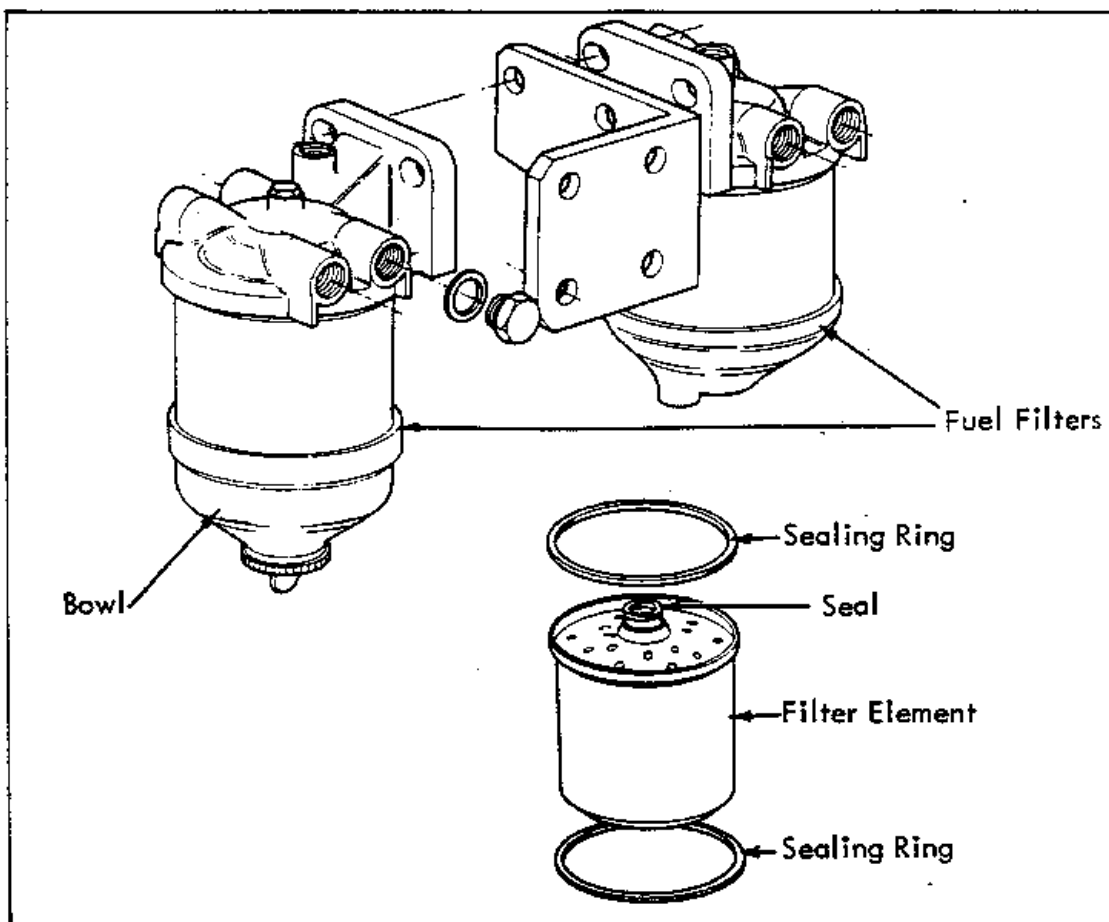
run of belt between any two pulleys and apply pressure in the center of the run and adjust the tension until the belt deflects about $\frac{3}{8}$ " (10mm) as shown above.

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.

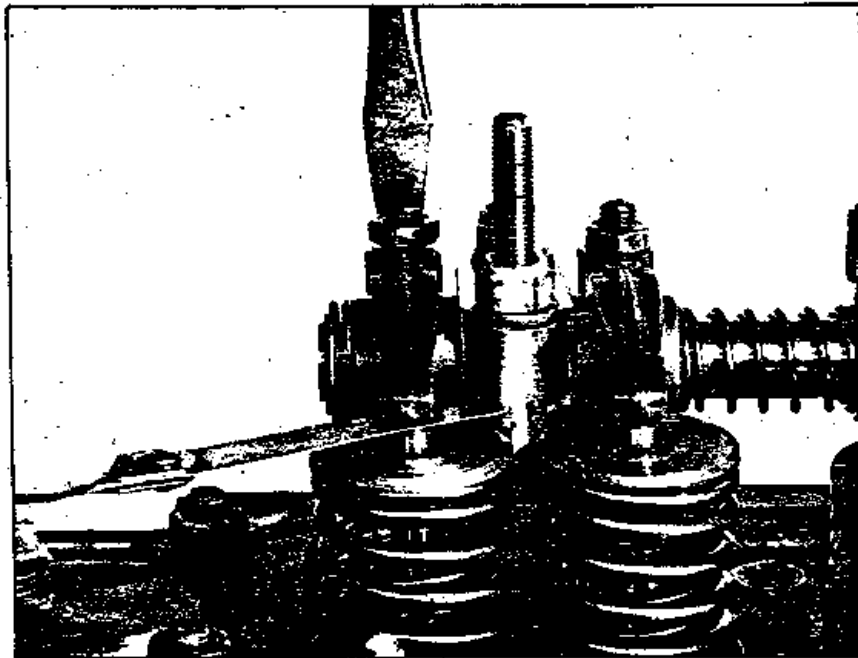


Fig. C-12
Setting Valve Clearance

FAULTY INJECTOR

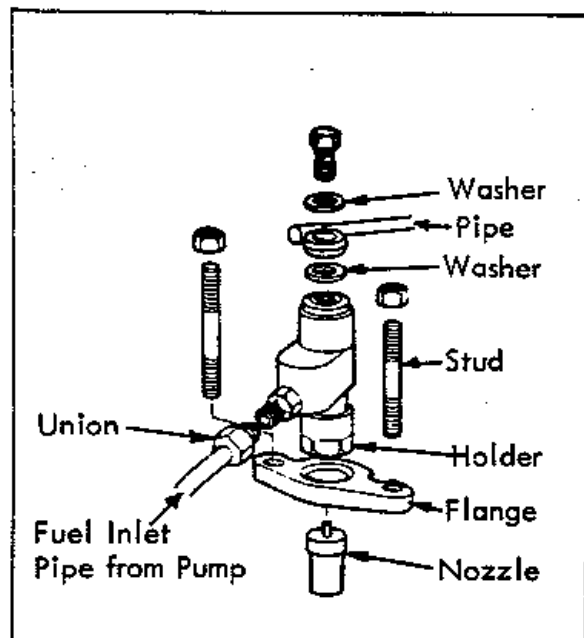
A faulty injector may show itself as an intermittent or consistent misfire and can be detected by running the engine at a fast idling speed and loosen each injector pipe union in turn, taking particular notice of the running condition of the engine. The faulty injector will have little or no effect upon 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

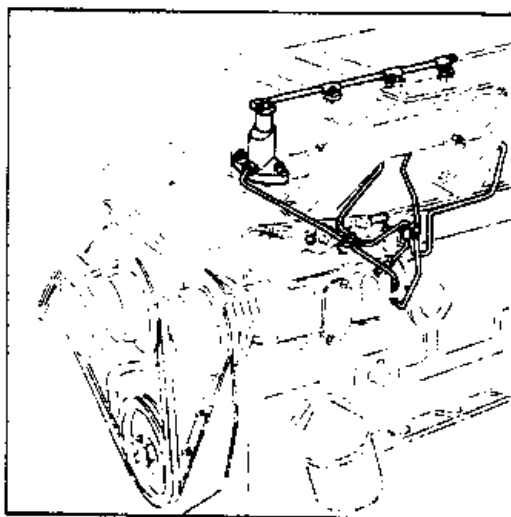
Never bend the high pressure pipe between the injector and the fuel injection pump. Remove the pipe completely. Fit the replacement injector as square as possible into the head by pulling down with the securing nuts a little at a time, each side in turn. Having fitted the injector and pipe, run the engine 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

- | | |
|--|---|
| <ol style="list-style-type: none"> 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. | <ol style="list-style-type: none"> 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. |
|--|---|

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.
Smoke at full load particularly at high and medium speeds, engine quieter than normal.	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 low and medium speeds, engine noisier 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 verify advance device if fitted).
Smoke at full load particularly at high and medium speeds, probably with loss of power.	Pump timing too advanced.	Correct timing according to engine maker's instructions, taking up pump drive backlash (or verify advance device if fitted).
Smoke at full load at higher speeds only.	Injector nozzle holes (or some of them) wholly or partially blocked.	Replace injectors by reconditioned set or clean and recondition with proper equipment.
Intermittent or puffy exhaust smoke, sometimes with white or blue tinge, usually coupled with knocking.	Air cleaner restricted due to blockage with dirt, or damage.	Clean or replace air cleaner element according to type.
Smoke at full loads at high speed, engine running faster than normal when on governor.	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 higher loads and speeds, not necessarily at maximum.	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 all speeds at high loads, mostly low and medium speeds and probably coupled with poor starting.	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 full load, either at lower or higher speeds only, but in some cases at all speeds.	Loss of cylinder compression due to stuck rings, bore wear, valve wear or burning, sticking valves, incorrect valve setting.	Pigtail requires top overhaul at least; re-ringing, or sleeving, piston renewal if wear indicates.
Smoke at full load, mostly at medium and high speeds, probably coupled with low power.	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 lurre at ends, or due to sharp bends.	Fit only the engine makers' listed pipe. Check ends for closing in.

**BLUE OR BLuish GREY
OR GREYISH WHITE**

COLOR :

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 persisiting 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.

Engine Overhaul

Cylinder Head

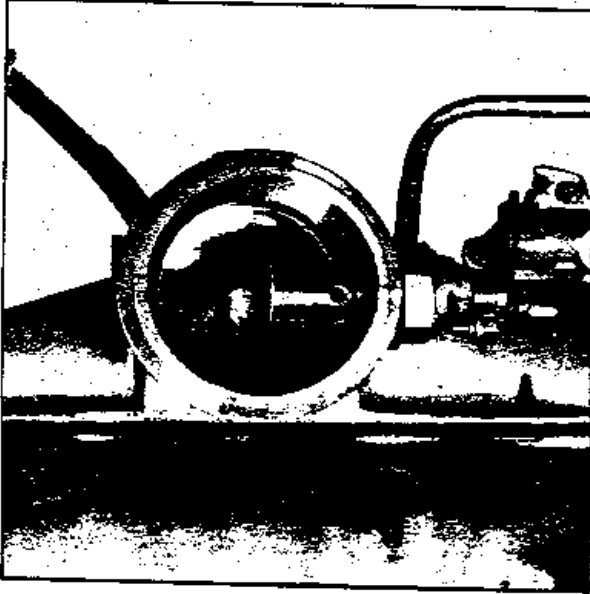


Fig. E1-Disconnect starting aid (if used).

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.

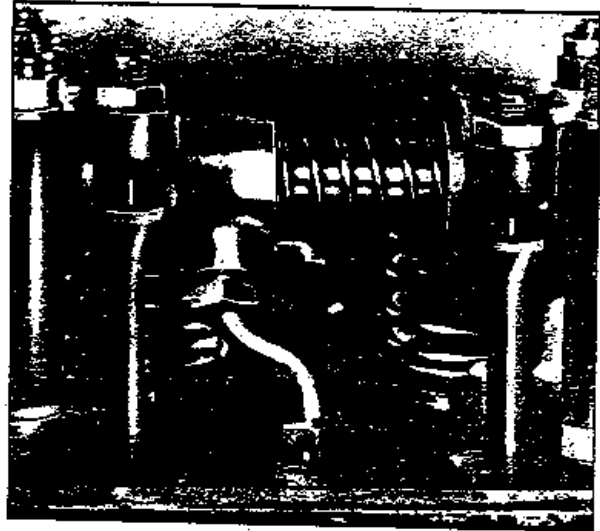


Fig. E2-Disconnect oil feed pipe

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.

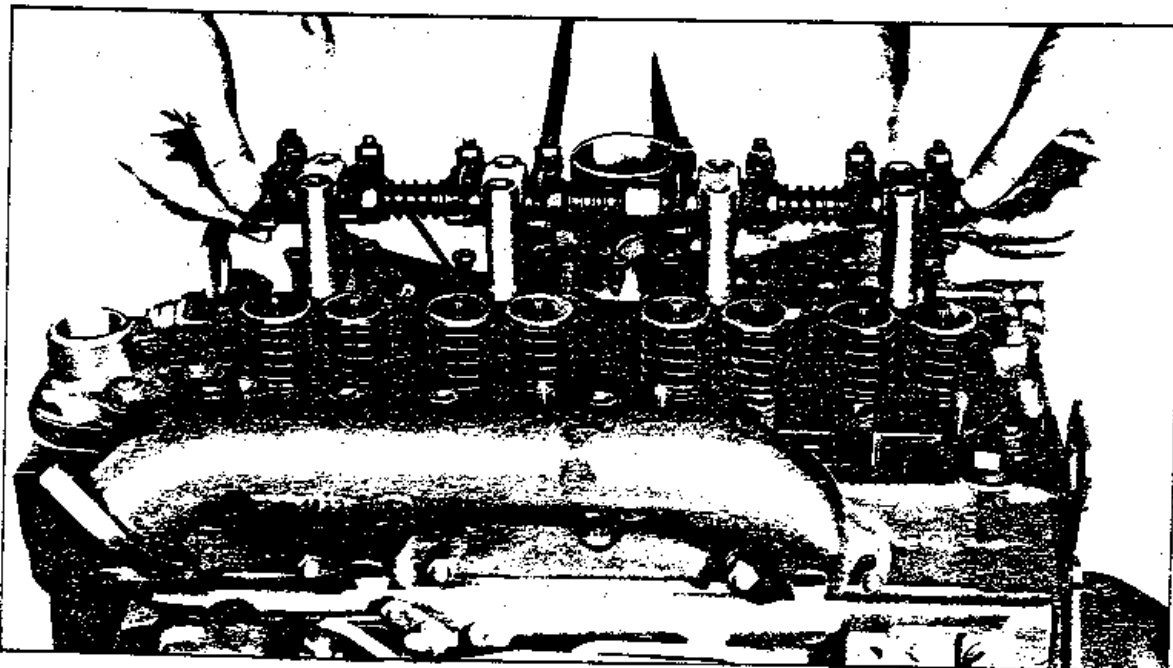
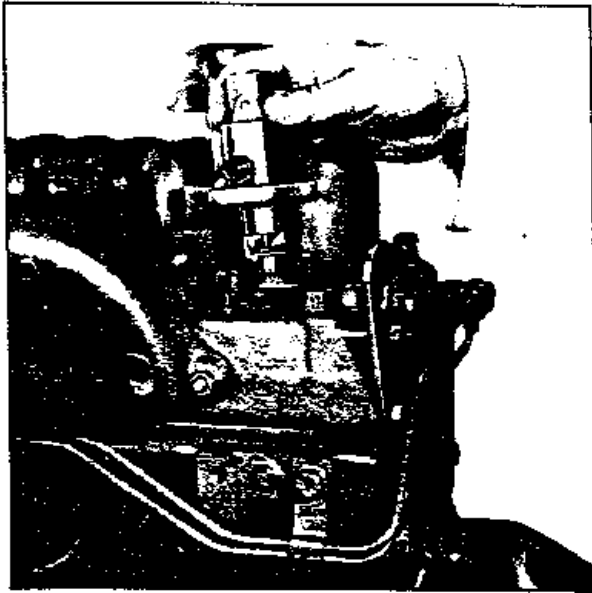
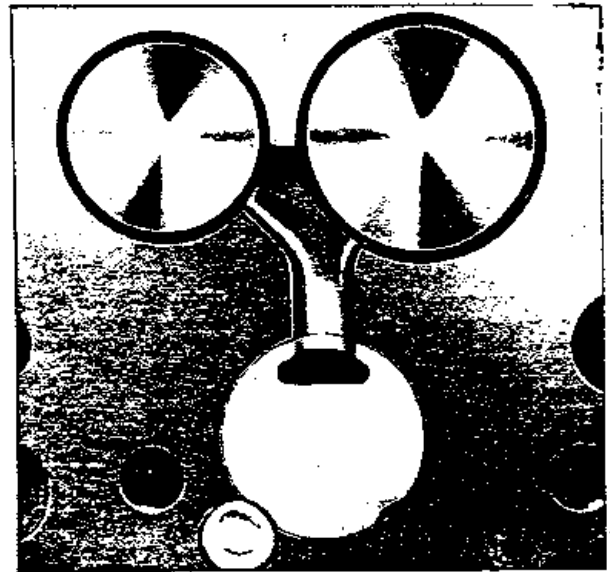


Fig. E3 - Removing rocker shaft.



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).

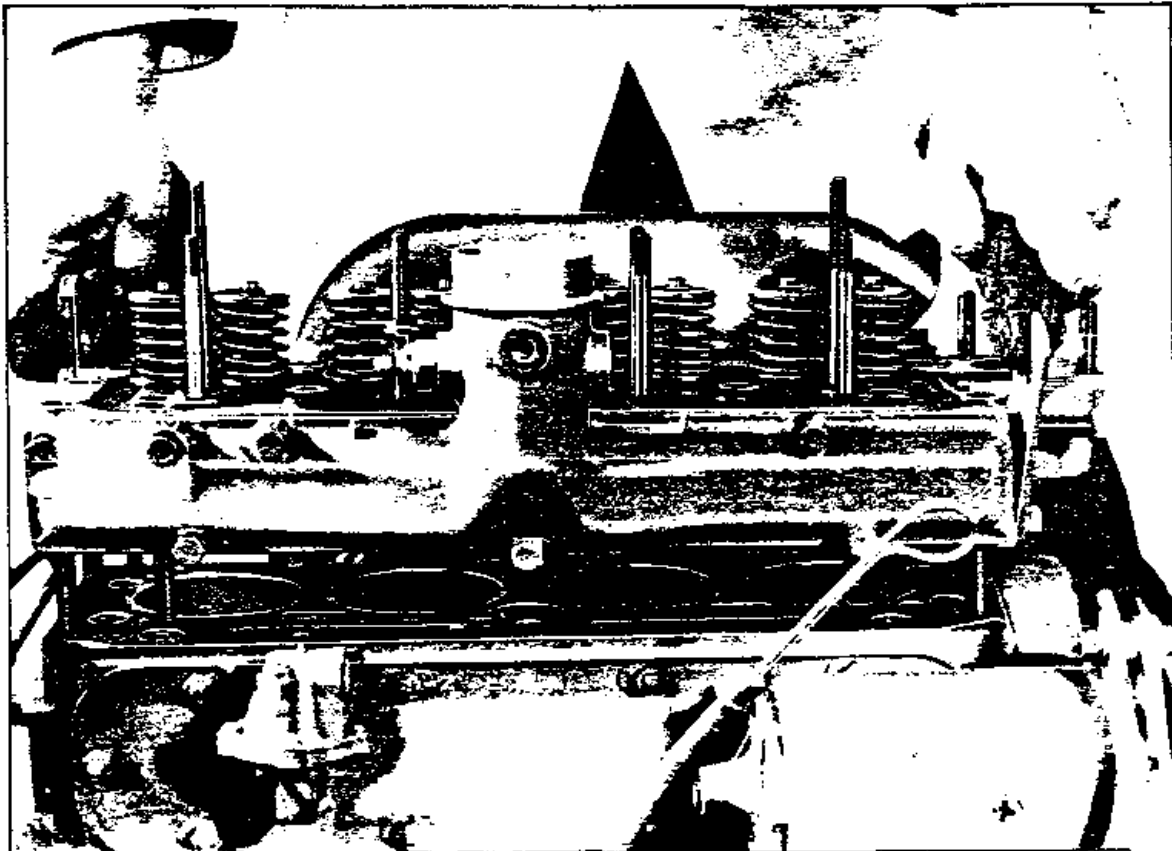


Fig. E5 - Removing cylinder head

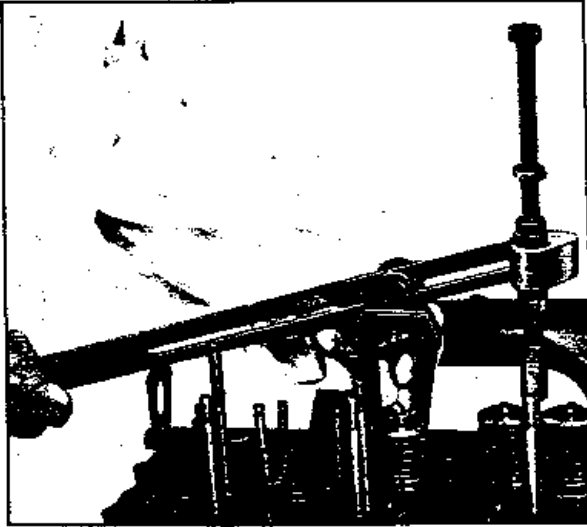


Fig. E7-Compress valve springs and remove keepers (also called "collets")

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.

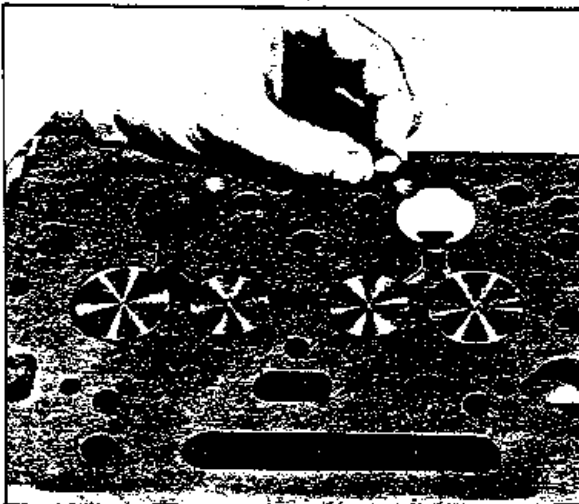


Fig. E8 - Combustion chamber inserts.

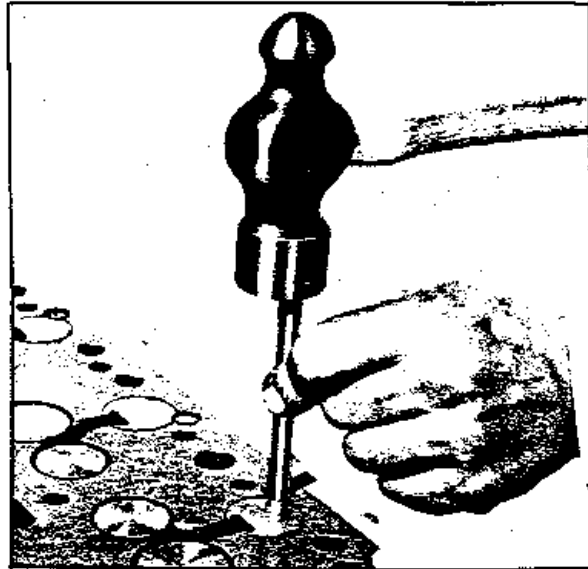


Fig. E9 - Installing combustion chamber inserts and washers.

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.

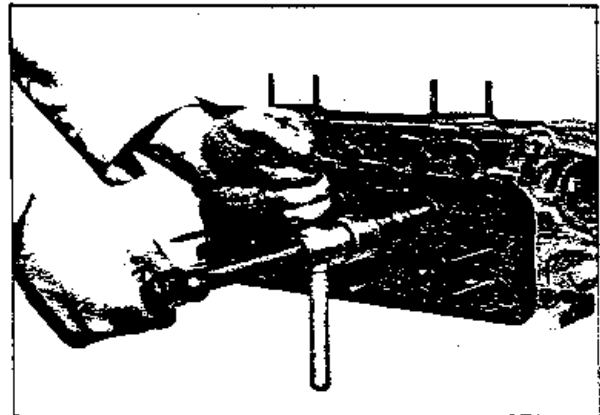


Fig. E10 - Using valve guide removal tool.

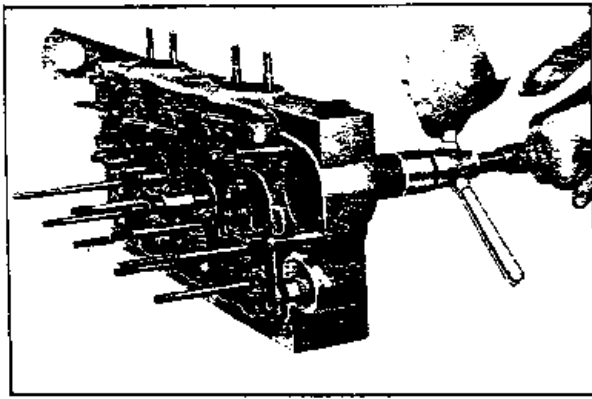


Fig. E11 - Installing valve guides

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.

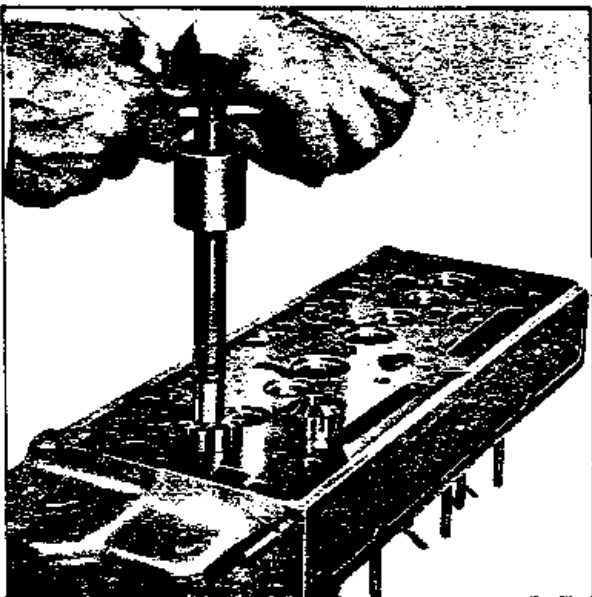


Fig. E12 - Using valve seat cutting tool.

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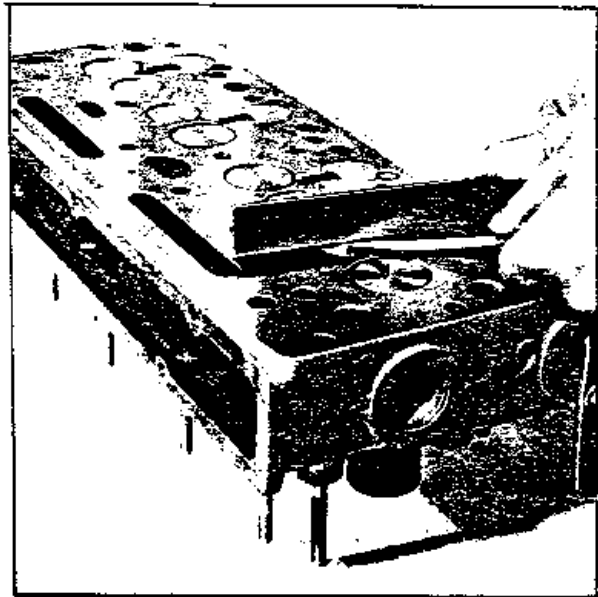


Fig. E13 - Checking valve head depth.

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.

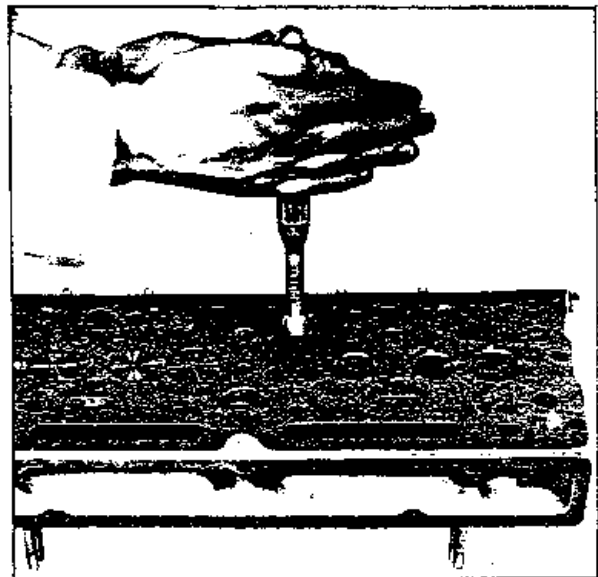
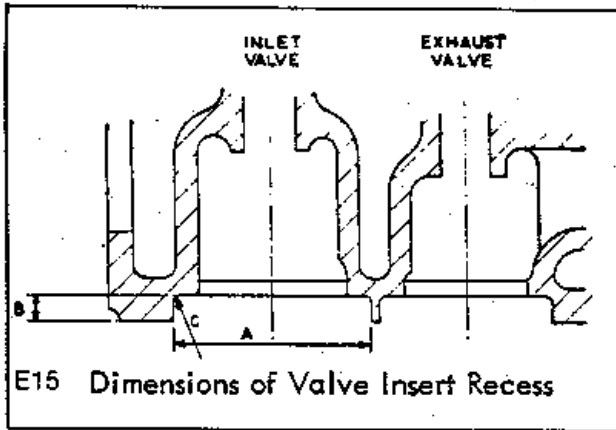


Fig. E14 - Hand lapping valves.



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.

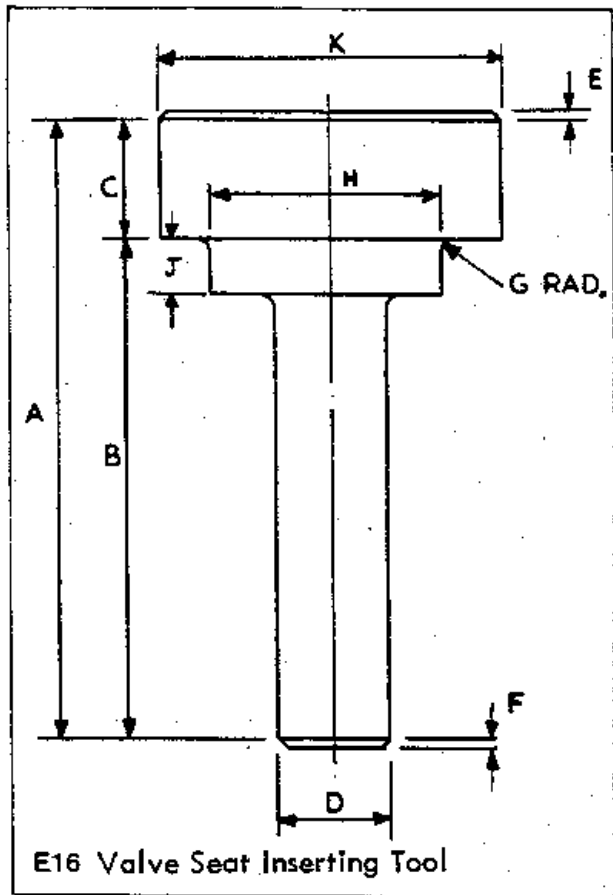
This depth can be checked, as shown in Fig. E.13, by placing a straight edge across the face of the cylinder head, then by careful selection of feeler gauges measuring the distance between the straight edge and the head of the valve.

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.

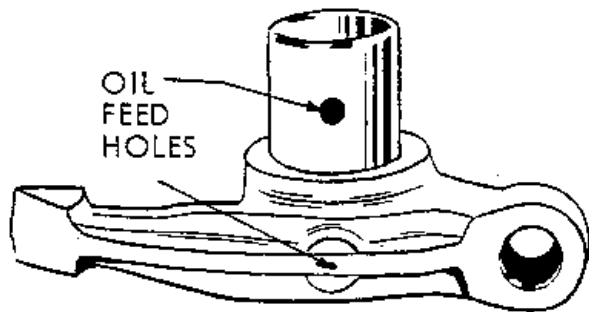


Fig. E17 - Oil feed holes must align.

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 re-assembly 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).

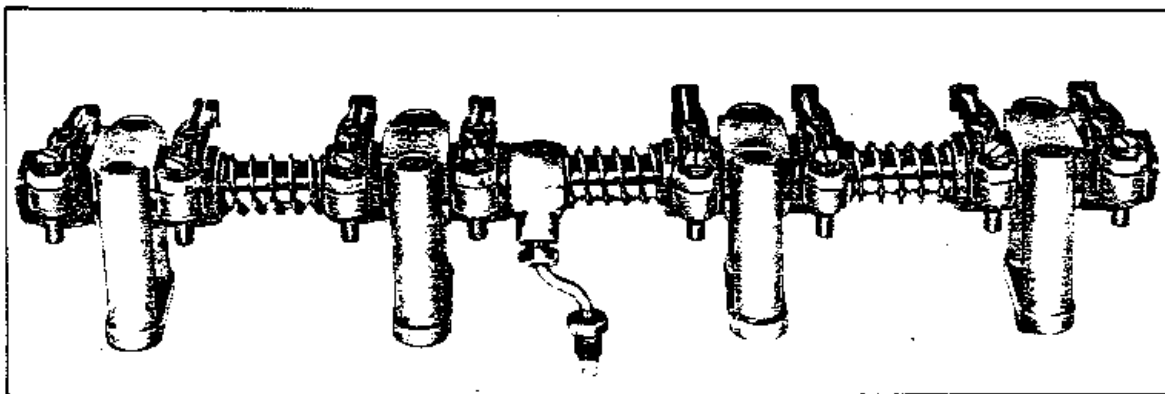


Fig. E18 - Reassembled rocker shaft assembly.

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

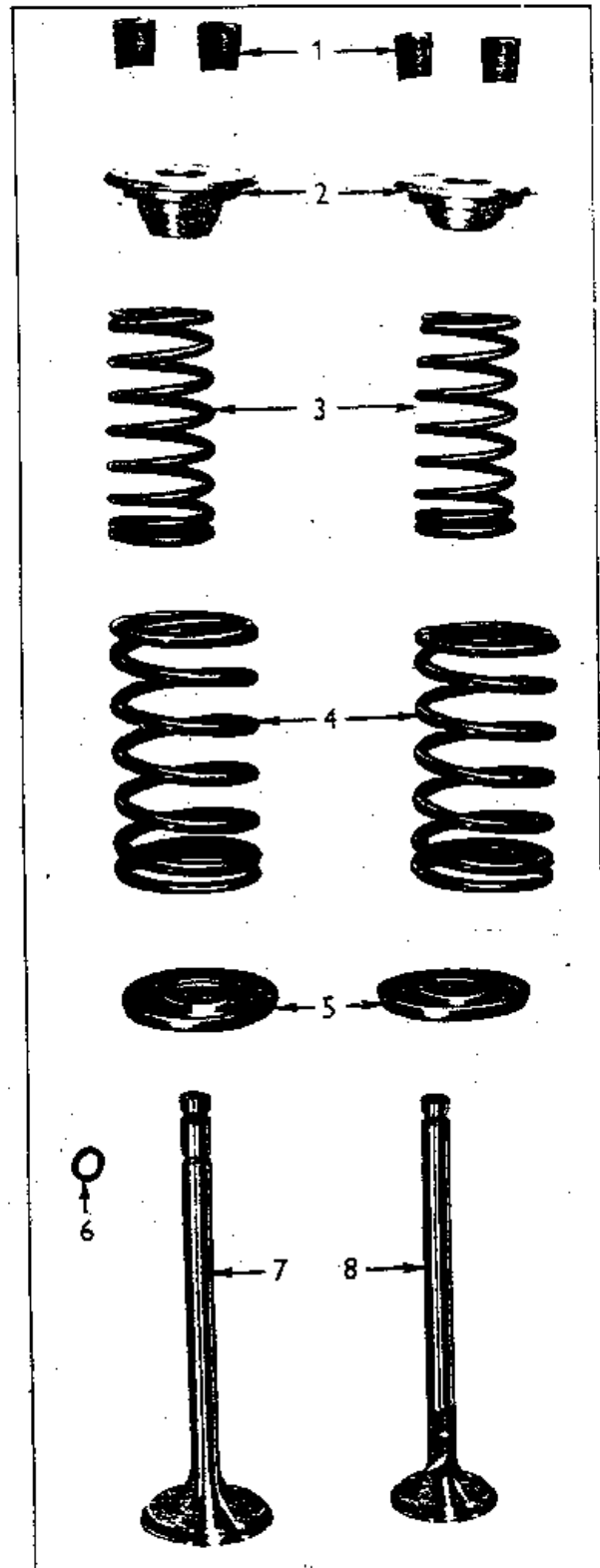
Always use a new cylinder head gasket. Ensure that the correct type is used.

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 jointing compound be used.

It is very important that the gasket is placed correctly, otherwise the steel beading may be ripped 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.



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

E19

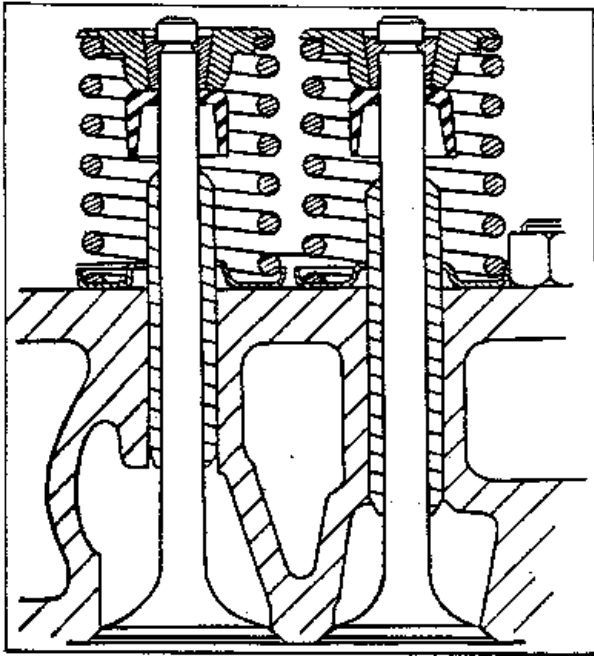


Fig. E20 - Cross section view of valves.

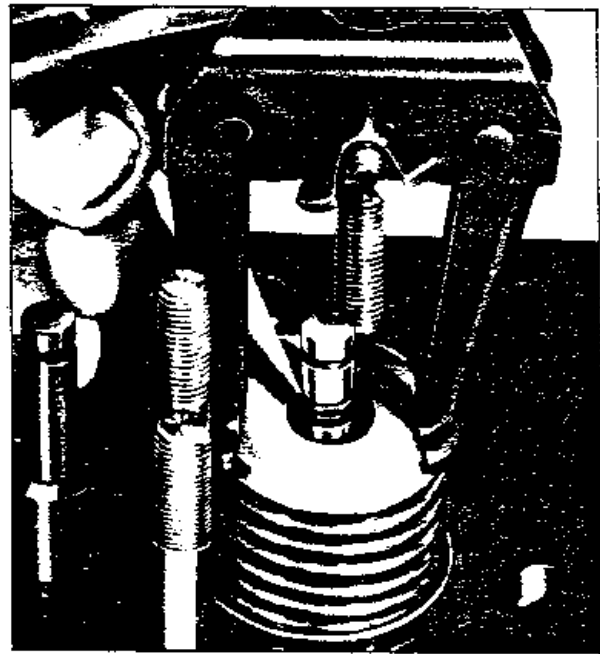


Fig. 21 - Seal ring on intake valve only.

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

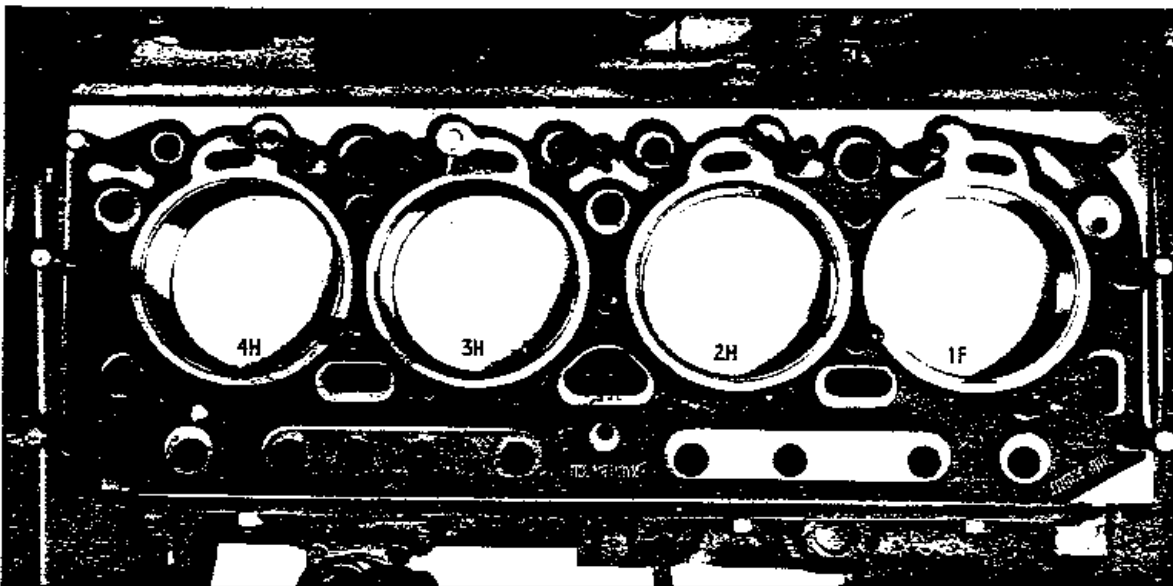
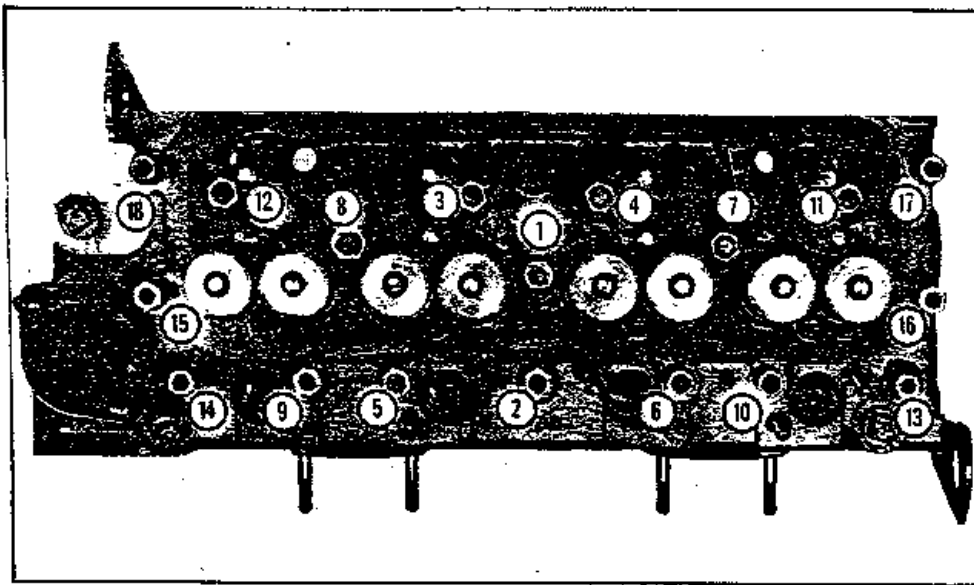


Fig. E22 - Cylinder head gasket is marked "top front" for correct installation.



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.

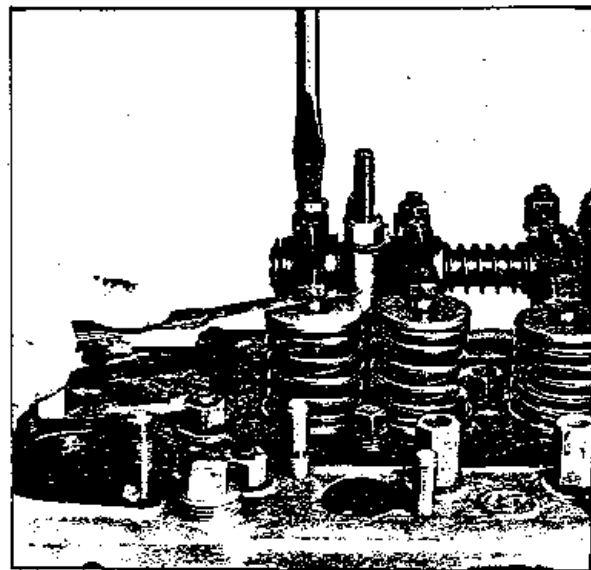


Fig. E24 - Adjusting valve clearance.

Fuel System

FUEL OIL FILTERS

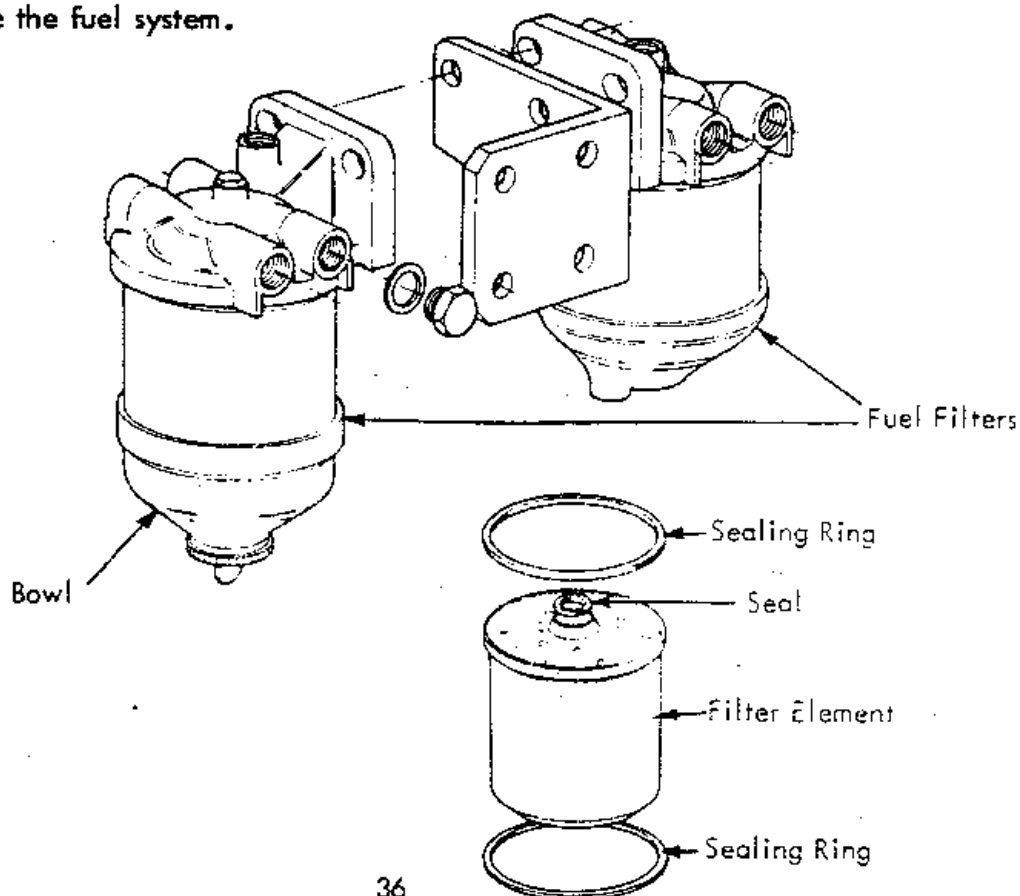
The twin element series flow filter is mounted on the rear, top right-hand side of the engine. The elements are held between the filter heads and bottom bowls by bolts that extend through the elements. Both elements should be renewed at the same time in accordance with the recommended periodical attentions 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.

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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 7/8 in (19.05 mm) outside diameter.

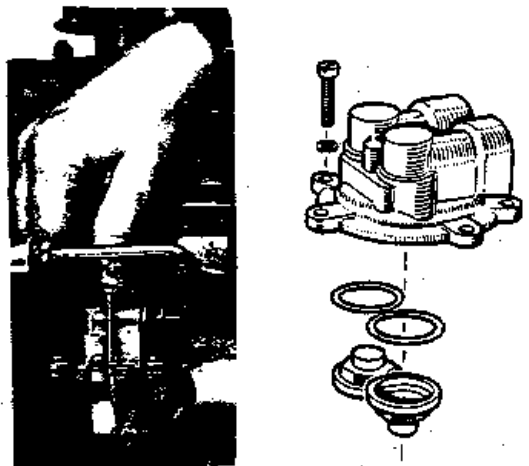


Fig. P7 - Hand primer

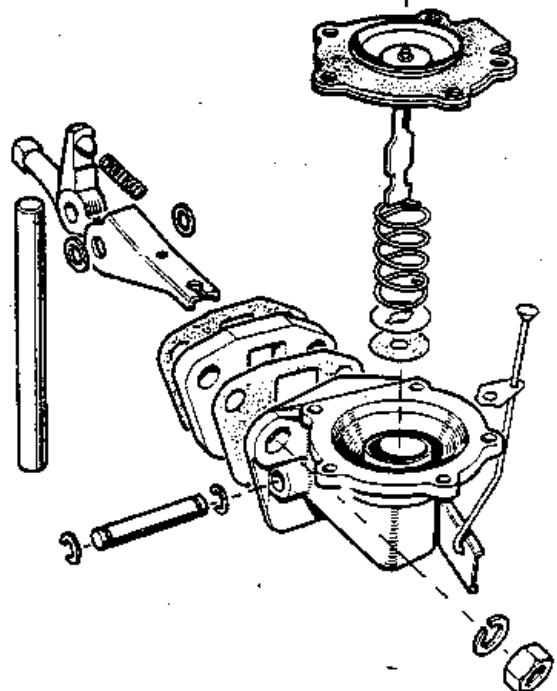


Fig. P8 - Fuel Lift Pump

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.

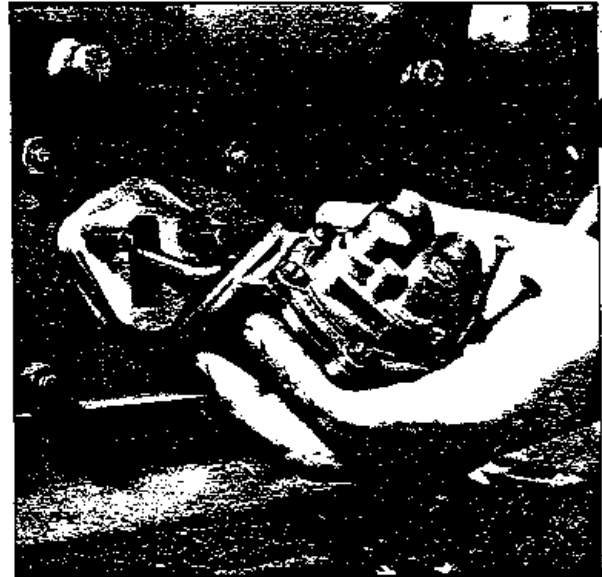


Fig. P9 - Installing Fuel Pump

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.

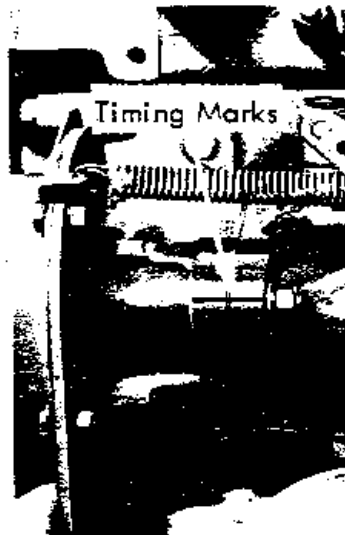


Fig. P11 - Timing Marks on Pump Flanges

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.

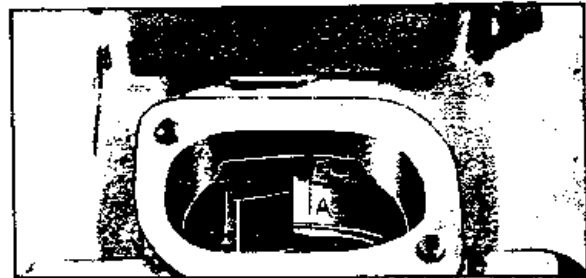


Fig. P12 - Timing Marks on Rotor

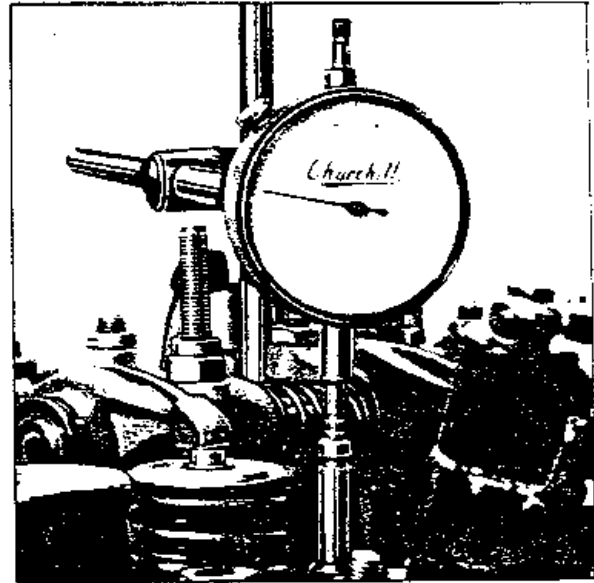
CHECKING FUEL PUMP TIMING

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 0.108 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 eighth 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.



P13

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. Mistfiring.
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".

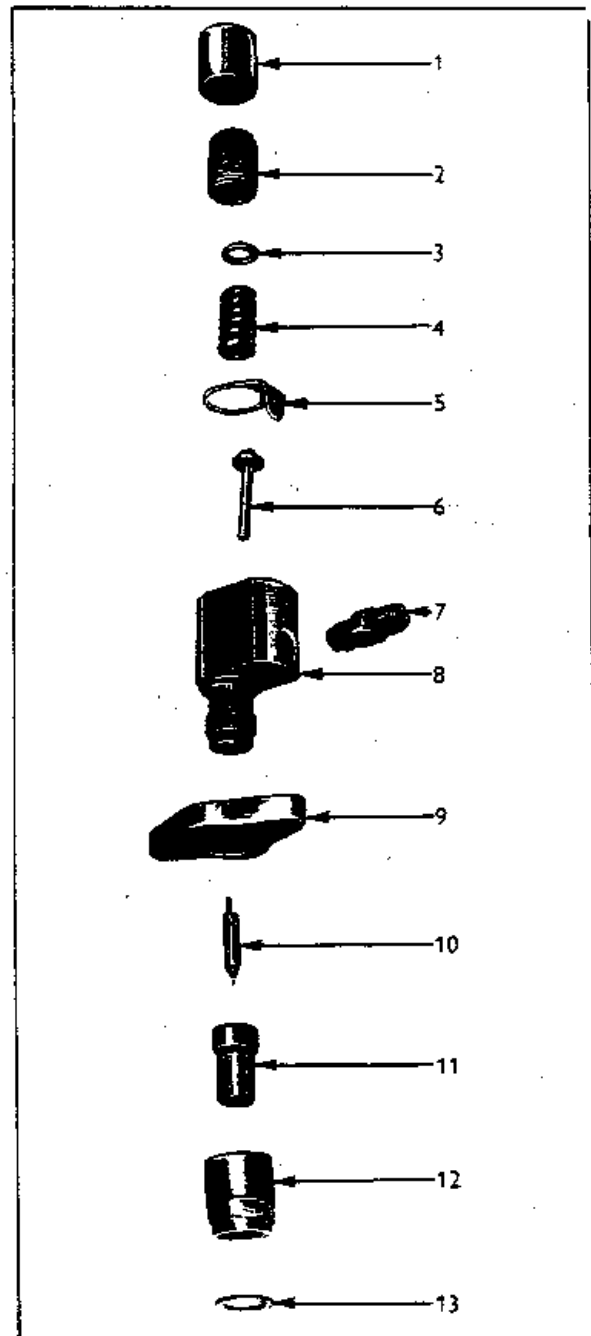


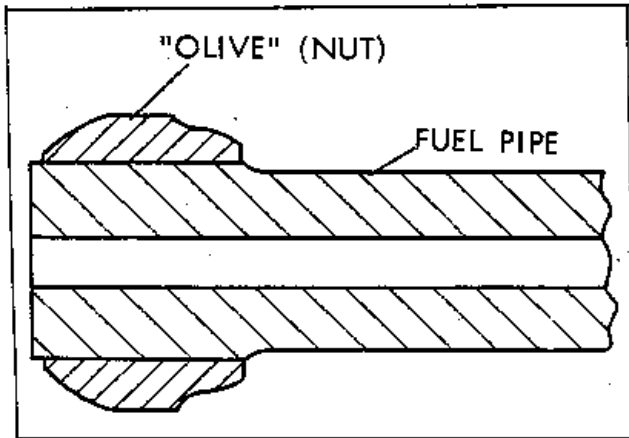
Fig. P16 - Atomiser (fuel injector)

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.



P.17

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

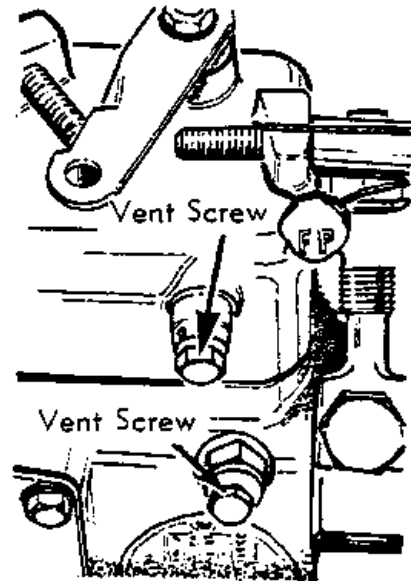
The air must be vented from the fuel system whenever any part of the system between the fuel tank and injection pump has been disconnected for any reason, or when the system has been emptied of fuel.

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.