CLARK EQUIPMENT INDUSTRIAL TRUCK DIVISION CLARK EQUIPMENT

OPERATORS MAINTENANCE PARTS MANUAL

FOR

CLARKLIFT 40 B

CODE GOV'T O-212

CLARK EQUIPMENT COMPANY

PUBLISHED BY

TECHNICAL SERVICE DEPARTMENT,

BATTLE, CREEK, MICHIGAN, U.S.A.

SAFETY INSTRUCTIONS FOR MAINTAINING INDUSTRIAL TRUCKS

Powered industrial trucks may become hazardous if adequate maintenance is neglected. Therefore, adequate maintenance facilities, personnel and procedures should be provided.

Maintenance and inspection of all powered industrial trucks should be performed in conformance with the recommendations in this Manual and the following practices:

1. Only qualified and authorized personnel should be permitted to maintain, repair, adjust, and inspect industrial trucks, and a scheduled preventive maintenance, lubrication, and inspection system should be followed.

2. When truck is to be parked for maintenance: Turn off engine, lower lifting mechanism, place directional controls in neutral, (clutch type trucks may be left in gear) apply parking brake and chock wheels.

3. Before working on truck raise wheels free of floor or disconnect power source. Use chocks or other positive truck positioning devices and block carriage, innermast(s), or chassis before working under them. Before working on engine fuel system of: (a) Gasoline powered trucks with gravity feed fuel systems, be sure fuel shutoff is closed; (b) LP gas powered trucks, close LP-gas cylinder valve and run engine until fuel in system is depleted and engine dies.

4. When starting engine place shift levers in neutral and depress clutch (or brake pedal on automatic transmissions).

5. Avoid fire hazards and have fire protection equipment present. Do not use an open flame to check level, or for leakage, of fuel, electrolyte or coolant. Do not use open pans of fuel or flammable cleaning fluids for cleaning parts.

6. Properly ventilate work area, vent exhaust fumes and keep shop clean and floor dry.

7. Use hoisting equipment for heavy lifts.

8. Handle LP Gas cylinders with care. Do not drop, dent, or damage in any way.

9. Brakes, steering mechanisms, control mechanisms, warning devices, lights governors, lift overload devices, safety guards and safety devices should be inspected regularly and maintained in a safe operating condition.

10. All parts of lift and tilt mechanisms and frame members should be carefully and regularly inspected and maintained in a safe operating condition.

11. Special trucks or devices designed and approved for hazardous area operation should receive special attention to ensure that maintenance preserves the original approved safe operating features.

(Continued)

SAFETY INSTRUCTIONS FOR MAINTAINING INDUSTRIAL TRUCKS

12. Fuel systems should be checked for leaks and condition of parts. Extra special consideration should be given in the case of a leak in the fuel system. Action should be taken to prevent the use of the truck until the leak has been corrected.

13. All hydraulic systems should be regularly inspected and maintained in conformance with good practices. Tilt cylinders, valves, and other similar parts should be checked to assure that "drift" has not developed to the extent that it would create a hazard.

14. Capacity rating, operation and maintenance instruction plates, tags, or decals should be maintained in legible condition.

15. Batteries, motors, controllers, limit switches, protective devices, electrical conductors and connections should be inspected and maintained in conformance with good practices. Special attention should be paid to the condition of electrical insulation.

16. Industrial trucks should be kept in a clean condition to minimize fire hazards and facilitate detection of loose or defective parts.

17. Modifications and additions which affect capacity rating and safe operation should not be performed by the user without manufacturer's approval.

18. Care should be taken to assure that all replacement parts are interchangeable with the original parts and of a quality equal to that provided in the original equipment.

PLEASE NOTE

INSTRUCTIONS ON USE OF MANUAL

This Operator's Manual is published as a service reference guide and includes Specifications, Operating Instructions, Lubrication and Preventive Maintenance Instructions, and Trouble Shooting Guide.

The *TABLE OF CONTENTS for this manual is printed on* green paper and is placed at the front for easy reference. A separate INDEX (also printed on green paper) is placed in front of the Lubrication and Preventive Maintenance Section.

Lubrication and Preventive Maintenance Instructions are listed under the TIME INTERVALS that they should be performed.

The TIME INTERVAL is part of the page number and code number. Example: 8H 002-0; 8H is the TIME INTERVAL (8 operating hours), 002 is the PAGE NUMBER, and -0 is a CODE NUMBER that you as a customer should disregard. The dash number or code number is for the benefit of the publisher only.

The INDEX is set up under the TIME INTERVALS that the Lubrication and Preventive Maintenance should be performed.

Example: (8 Hours)	Time Interval (H=Hours)	&	Page Number (000-)
Hydraulic Sump Tank, level check...	8H		503
Brake Pedal Free Travel, check.....	8H		303

The above states to check the sump tank fluid level every 8 operating hours and refer to page 503 for fluid recommendations etc. Also, to check brake pedal free travel at this interval and turn to page 303 for instructions.

Turn to the eight (8) hour section (8H) and then to the page listed — 503 or 303 etc. The instructions covered therein will pertain only to the checks or adjustments that should be performed at this TIME INTERVAL.

If, for instance, the Brake Pedal Free Travel is incorrect, you would then refer to the INDEX for "Brake Pedal Free Travel, adjust" which would be listed in the TIME INTERVALS following the 8 hour section.

Example: (100 Hours)	Time Interval (H=Hours)	&	Page Number (000-)
Brake Pedal Free Travel, adjust....	100H		302

Turn to the one hundred hour section (100H) and then to

(continued)

INSTRUCTIONS ON USE OF MANUAL

page 302. Complete instructions as to the importance of pedal free travel, the method to check and adjust for correct free travel with illustrations are included therein.

NOTE

YOU WILL NOTE THAT AT THE BEGINNING OF EVERY SECTION A LUBRICATION AND PREVENTIVE MAINTENANCE ILLUSTRATION IS SHOWN GIVING THE LOCATION OF THE COMPONENTS TO BE SERVICED.

It is impossible to cover all types of machine operations in one manual. Operating conditions should determine the lubrication and maintenance intervals. Common sense and a close observance can best determine the frequency with which you should service your machine.

The care you give your machine will greatly determine the satisfaction and service life that you will obtain from it. A difinite maintenance program should be set up and followed. Haphazard maintenance will only lead to faulty performance and short life.

CLARK EQUIPMENT

INDUSTRIAL TRUCK DIVISION

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LUBRICATION AND PREVENTIVE MAINTENANCE

TROUBLE SHOOTING GUIDE

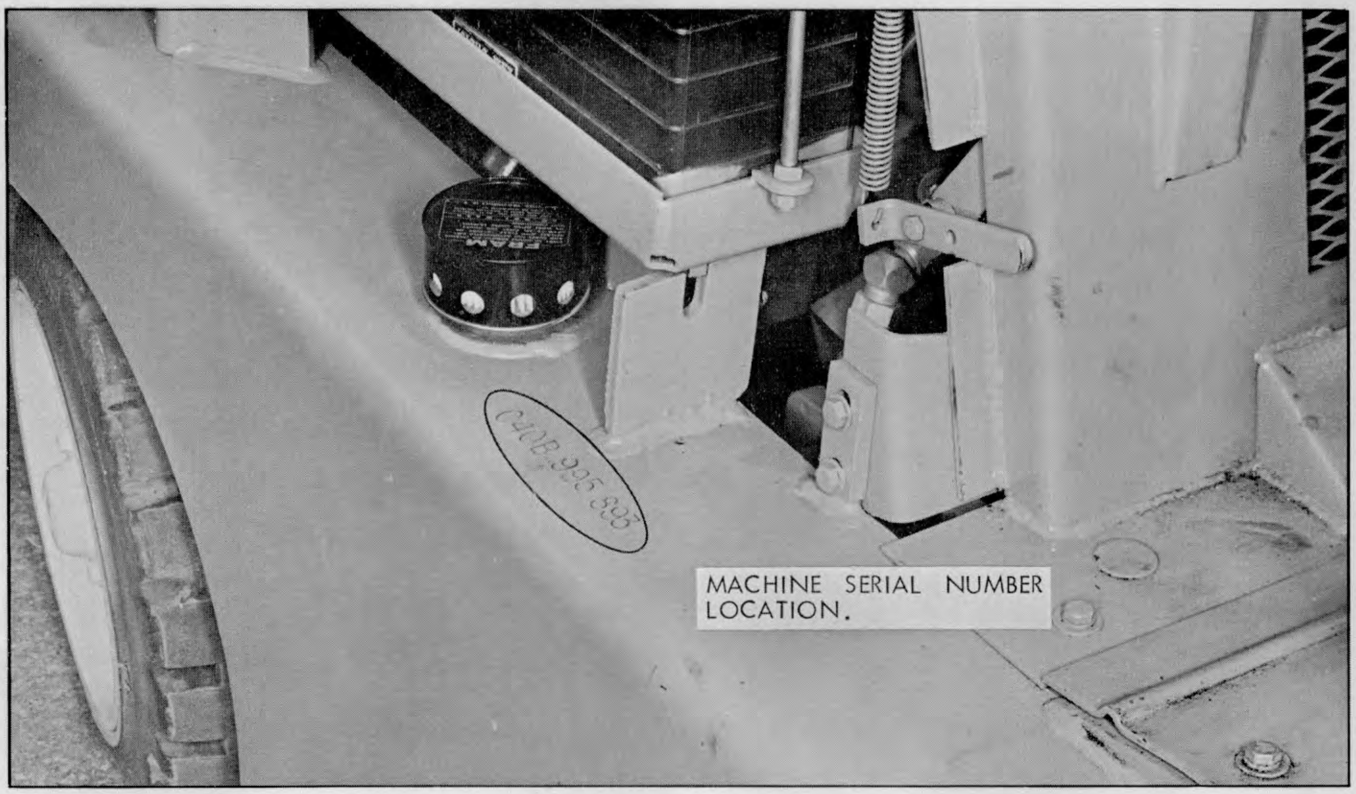


Plate 9474. Machine Serial No. Location

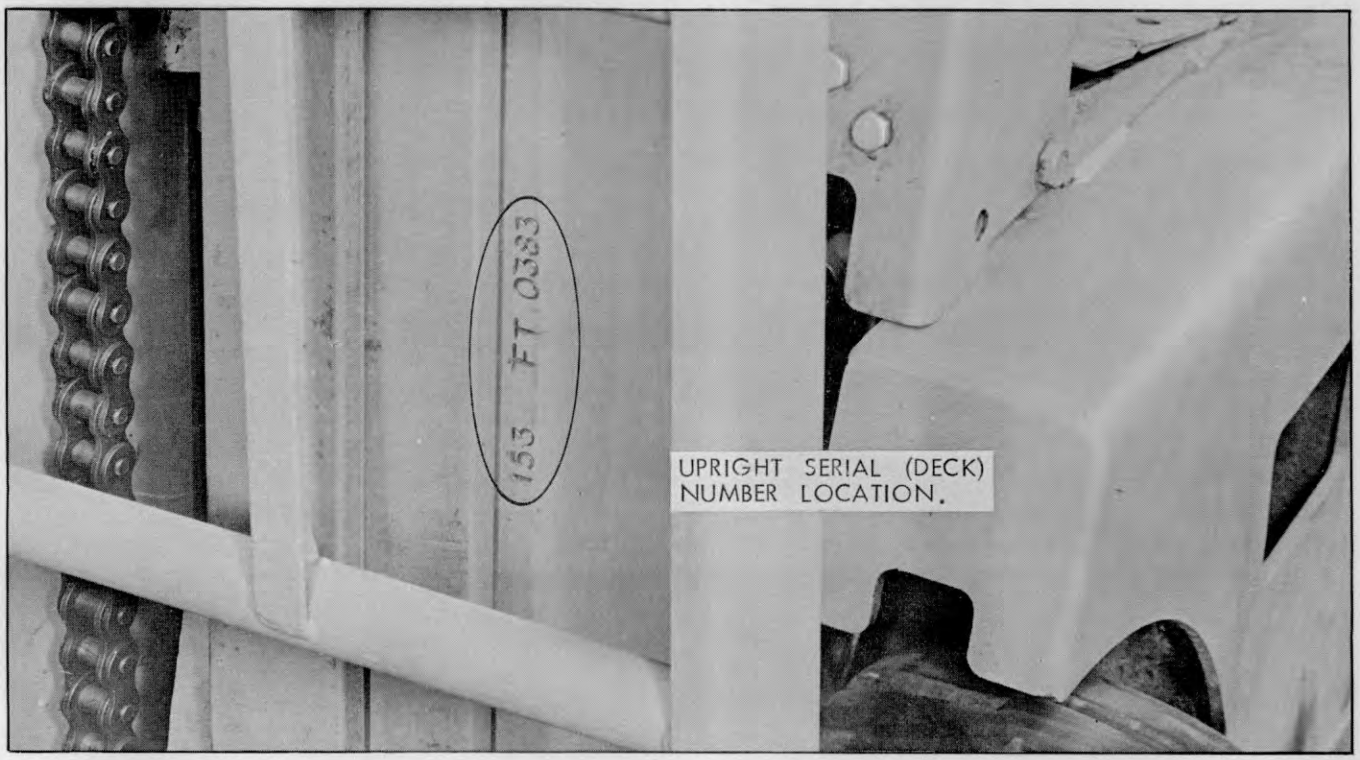
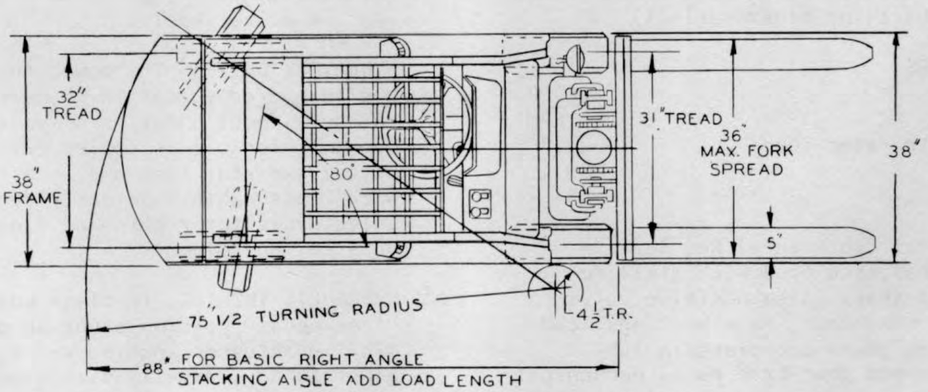


Plate 9475. Upright Serial (Deck) No. Location

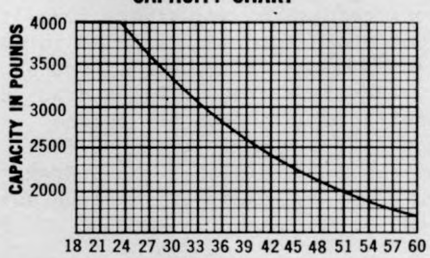
DIMENSIONAL SPECIFICATIONS

CLARKLIFT® C - 40

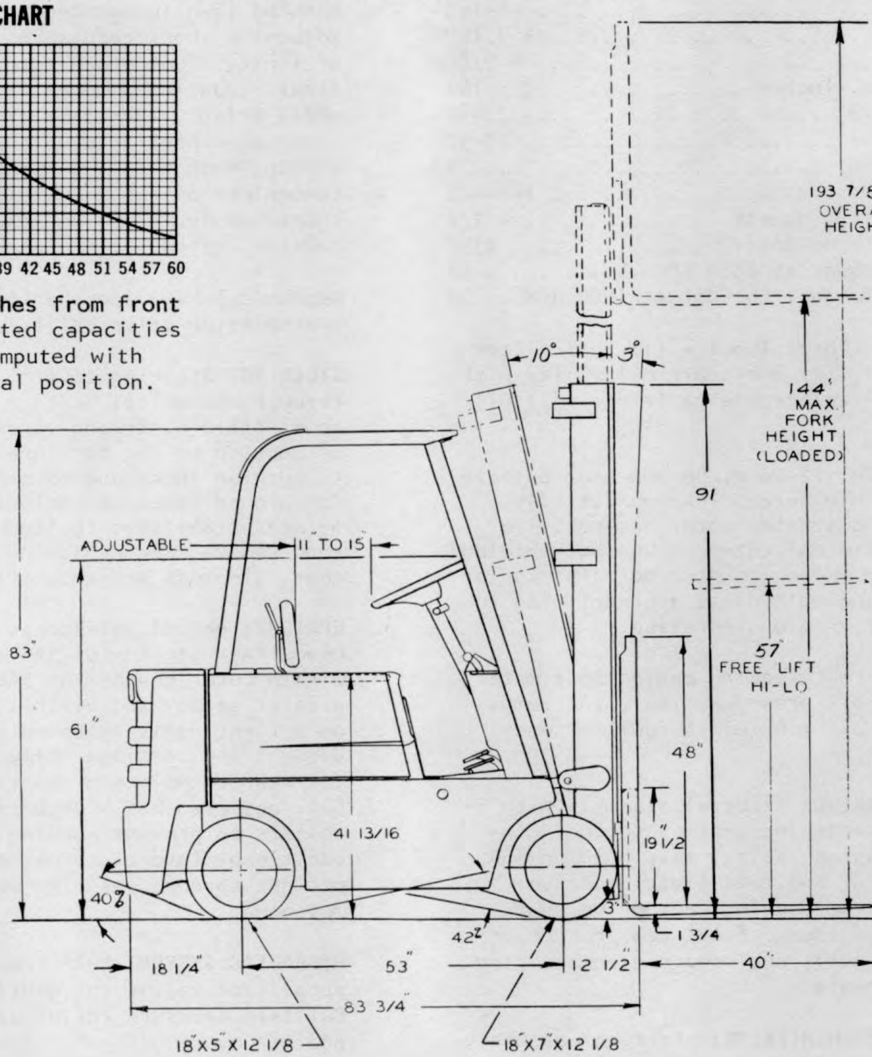


MINIMUM INTERSECTING AISLE 77.5
CAPACITY - 4000# AT 24" LOAD CENTER

CAPACITY CHART



Load center in inches from front face of forks - Rated capacities shown above are computed with uprights in vertical position.



CLARK EQUIPMENT INDUSTRIAL TRUCK DIVISION CLARK EQUIPMENT

D I M E N S I O N A L   S P E C I F I C A T I O N S

MODEL: Clarklift 40 Weight .... 11,075 Lbs.

WEIGHT DISTRIBUTION AND CAPACITY:
Percent on drive wheels, truck empty: 43%
Rated Capacity.....4,000 Lbs. at 24" load center
(See capacity chart for other ratings)

SPEEDS AND GRADES:

	LOADED
Travel Speeds:	8.3 MPH
Gradeability with rated load	27.7
Lift Speed	60
Lowering speeds	60

ENGINE: Industrial Continental Red Seal, 4 Cylinder, "L" head, equipped with stellite-faced valves and seats; also positive valve rotators. Connecting rods, main bearings, cam shaft, and timing gears are pressure lubricated by submerged gear-type pump. Mechanical governor controls engine speed accurately without choking off power. Updraft carburetor.

Model F-163
Bore .... 3 7/16"
Stroke.................................. 4 3/8"
Displacement, Cu. Inches 162
Compression Ratio 7.4:1
Max. Oil Pressure 20-30
Min. Oil Pressure 7
Firing Order......................... 1-3-4-2
Crankcase Capacity, quarts 4 1/2
Governed RPM with no load.................. 2350
SAE rated horsepower at 2350 RPM 52
Max. SAE Rated Torque, Lb Foot at 1600 RPM...123

ENGINE FILTERS: Three Types - (1) Fuel filter in metallic bowl. (2) One-quart oil filter with automotive type replaceable cartridge. (3) Oil bath air cleaner.

ELECTRICAL SYSTEM: 12-volt, 46 amp-hour battery; 25 amp low cut-in generator charges at idle. Enclosed electric starter motor has positive engagement, electrical cut-out. Weather-shielded keyless starting switch; dust-proof distributor electric horn; and multiple disconnect plug to instrument panel. Radio suppressed.

INSTRUMENTS: Direct reading engine hour meter; ammeter, engine oil pressure, fuel, and temperature gauges, all mounted in cowl for easy reading.

AXLE AND FINAL DRIVE: Integral assembly with 3-point mounting including engine, torque, converter, transmission, spiral bevel pinion and ring, differential and full-floating drive axle assembly. Axle housing, not drive shaft, carries weight of truck. Final gear reduction is made through fully enclosed pinion and ring gear at drive wheels.

DRIVE AXLE AND TRANSMISSION: Integral assembly with 3-point mounting including engine, torque converter, transmission, spiral bevel pinion and ring gear, differential and full-floating drive axle assembly. Axle housing carriers weight of truck not drive shaft. Final gear reduction is made through fully enclosed pinion and ring gear at drive wheels.

HYDRATORK DRIVE: The power shifted transmission has torque converter which multiplies engine torque without shock on drive shaft and gears. Transmission oil is cooled thru cooler in bottom radiator tank and is a filtered system with replaceable type cartridge. The direction selector is for right hand finger-tip control on steering column.

HYDRAULIC INCHING. In close quarters, the "free-pedal" portion of brake pedal hydraulically actuates inching valve, permitting power to be gradually disengaged from drive wheels, even when the engine is running at top speed for fast lifting.

BRAKES: (Two independent systems). Self-adjusting shoes require no adjustment for lift of lining. Foot brake torque multiplied through final reduction at each drive wheel, reduces pedal effort, increases brake lift. Hydraulic internal expanding double shoe has bonded lining. Wide pedal, centrally located, for convenient operation with either foot. Brake shoes and drums are enclosed within drive axle housing instead of inside drive wheels.

Mechanical "V" block parking brake operates on transmission drive shift.

STEERING: Steering control is maintained through mechanical linkage in the event of power failure. Strong vanadium steel axle is mounted on two torsional rubber bushings to cushion shock and to provide articulation for ground level variations. Positive stops for lateral stability. Inclined king pins minimize road shocks. Recirculating ball type steering gear. Tie rods are automotive type.

UPRIGHT: Nested telescopic roller types. "I" beam inner section of SAE 1045 steel is nested within outer channel of SAE 1045 steel for greater safety and visibility. Side loading on upright rails is taken on upright rollers. Upright and carriage rollers are adjustable for wear to maintain new truck tolerances. Carriage also has 4 adjustable side thrust rollers to prevent binding. Carriage has additional lateral thrust rollers to prevent upright spread, insuring maximum free-rolling movement.

HYDRAULIC SYSTEM: Full feathering balanced spool type valves for gentle starts and stops. Built-in pressure relief valve protects system against overloads; will open fully within 100 p.s.i. cracking pressure. SAE straight threads

HYDRAULIC SYSTEM: (CONTINUED)
and O-ring seals used throughout pressure system. Vane-type pump is driven by hardened gears. Hydraulic sump, built into frame. Flexible rubber hydraulic hose lines are steel braid reinforced. System is protected from dirt by (1) a 5 micron pleated replacement filler cap breather, (2) a 25-micron full flow filter in sump.

FORK CARRIAGE AND FORKS: All-welded construction, 1045 steel fork carriage to withstand impacts. Lateral fork adjustments from "0" to 60". Convenient snap action latch assures positive fork positioning. Heat treated and upset forged forks to provide full section strength at heel.

SEATING: Rubber mounted extra wide seat and back rest are Polyurethane Foam, covered with vinyl plastic. Curved back rest tilts to provide additional driver comfort. An automotive type latch releases the seat for horizontal adjustment up to 4".

MAINTENANCE: Split swing-out hood offers easy access for servicing. Check-points such as water, hydraulic sump filler caps, oil dipstick, and filler readily accessible. Battery swings out. Quickly detachable counterweight is hook mounted, secured with one large bolt.

GENERAL: Protectoseal gas tank filler cap. 12" height recessed pin-type coupler. Bolts and screws are zinc or cadmium plated. Multi-pass muffler. All exposed surfaces are shot-blasted and prime painted with weather resistant paint.

SPECIFICATIONS

Air Cleaner .... 3/4 pints

Fuel Tank Capacity .... 7.8 gallons

Cooling System Capacity .... 11 1/2 quarts

Fan Belt Deflection .... 3/4" to 1"

Torque Converter .... diameter 11 inches
.... Torque multiplication 2.2 to 1

Transmission & Differential
Speeds: .... 1 Forward & 1 Reverse
Capacity: ....15 quarts

STEERING AXLE

Toe-In.......................... 0 degrees
Camber Angle..................... 1 degree
Caster.......................... 0 degrees

Lift-Hand turning radius angle:
Left wheel..................... 80 degrees
Right wheel .... 55 degrees

Right hand turning radius angle:
Left wheel .... 55 degrees
Right wheel.................... 80 degrees

DRIVE AXLE

Ratio .... 4.4 to 1
Axle End Capacity .... 1 Lb. (each End)

ELECTRICAL SYSTEM ....
........................12 volt negative ground

Battery ....12 volts 46 amp hour

Distributor
Contact point gap .... .022 inch
Rotation (viewed from cap end)..........
.... clockwise
Dwell Angle .... 25° - 34°

Spark Plugs
Gap Setting
Resistor .... .035 inch
Standard .... .025 inch

Starting motor
Brush spring tension ....
.... 35 ounces min.

Ignition Timing .... 2° BTDC

HYDRAULIC SYSTEM

Sump Tank Capacity........ Approx. 5.5 gal
Sump Tank Filter (Replaceable)............
.... 25- micron
Sump Tank Breather (Replaceable) ....
.... 5- micron

Hydraulic Pumps
Main pump:
Type............................ vane
Capacity ....
13 1/2 G.P.M. at 2350 R.P.M.

Hydraulic Valve
Pressure Relief Valve Setting.........
.... 2000 P.S.I.

Power Steering Pump
Controlled flow................. 3.0 GPM
Relief Valve Setting .... 1250 PSI

BRAKE SYSTEM

Type .... Hydraulic

Brake Pedal Free Travel
(as measured from top pedal position -to- where pedal meets resistance from the master cylinder)................ 3/16" to 5/16"

(as measured from bottom of floor board -to- top of brake lever)........ 3/16" to 5/16"

GENERATOR

Armature Rotation (viewed from drive end).
.... Clockwise
Cold Output.............................
.... 25 Amps at 14 volts at 1750 R.P.M.
Field Current...........................
..... 1.69 - 1.79 Amps at 12 Volts (80° F)
Brush Spring Tension (ounces)....... 24-28

STARTERS

Rotation C
Brush Spring Tension 35
No Load Test
Max. Amps 76
Volts............................. 10.6
Approx. RPM 6200-9400

WHEEL NUT TORQUE

Steering Wheel .... 290-300 Lb Ft.
Drive Wheel ....490-500 Lb Ft.

ENGINE LIMITS AND CLEARANCE DATA

Weight - Bare Engine 415

Valve Clearance
- Intake (Hot) .... .014
- Intake (Cold)...................... .012
- Exhaust (Hot)...................... .014
- Exhaust (Cold)..................... .020

Valve Guide:
- Length 2 5/16
- Outside Diameter.............. .6575/.6565
- Stem Hole Diameter .... .3432/.3422
- Wear Limits - Max. Dia .... .3447
- Distance, Cyl. Block Contact .... Face to Guide....... 1 15/32

Dimensions of Standard Inserts and Counterbores:
- Outside Dia. of Inserts (A)....1.442-1.441
- Inside Dia. of Counterbore (B).1.438-1.437
- Press Fit .... .003-.005

Valves, Intake
- Stem Dia .... .3414/.3406
- Wear Limits, Min. Dia .... .3386
- Seat Angle .... 30°
- Stem Clearance Limits .... .0026/.0008
- Wear Limits-Max. Clearance.......... .0046
- Desired Stem Clearance .... .0015

Valves, Exhaust
- Stem Dia. .... .3385/.3377
- Wear Limits - Min, Dia. .... .3357
- Seat Angle .... 45°
- Stem Clearance-Limits .... .0055/.0037
- Wear Limits. Max. Clearance .... .0075
- Desired Stem Clearance 45

Valve Springs
- Outside Dia. 31/32
- Length-Valve Closed 1 45/64
- Load Valve Closed................. 47-53#
- Wear Limits-Min. Wgt................ 42#
- Length-Valve Open 1 27/64
- Load-Valve Open .... 961-104#
- Wear Limits-Min. Wgt. .... 86#

Tappets
- O.D. Tappet .... .9990
- Bore in Block 1.0000
- Total Max. Wear Limits .... .005

Camshaft
- Brg. Journal Dia. #1 .... 1.8725/1.8715
- #2 .... 1.7465/1.2455
- #3 .... 1.2475/1.2465
- #4 .... None

Wear Limits-Min. Dia. (.001 UNDER MIN.......... (NEW SHAFT DIAMETER)..........

Bushing-Inside Dia. #1 .... 1.8755/1.8745
- #2 .... 1.7502/1.7495
- #3 .... 1.2505/1.2495
- #4 .... None

Bushing-Clearance Limits .... .004/.002
End Play .... .009/.005

Connecting Rods
- Bush. Hole Dia. .... .914/.913
- Brg. Hole Dia.............. 2.1870/2.1865
- Brg. Thickness 06130/.06155
- Dia. of Rod Brg. Journal 2 1/16
- Dia. - Crank Pin............2.0619/2/0627
- Clearance Limits .... .0007/.0025
- Desired Clearance .... .0015
- Side Play .... .010/.006
- Desired Side Play .... .006

Main Bearings
- Dia. of Brg. Bore in Block 2.5615-2.5622
- Brg. Shell Thickness ...... .09250/.09275
- Dia. of Main Brg. Journal .. 2.3744/2.3752
- Clearance Limits .... .0028/.0008
- Desired Clearance 0015
- C/S End Play 002/.006

Crankshaft Fillet Radii
- C/S Fillet Radii -3/32" + or - 1/64" R on all crankpins and mains except rear.
- C/S Fillet Radii 1/8" + or - 1/64" R on Rear main.

Piston Pin
- Length 2.878/2.868
- Diameter .... .8593/.8591
- Desired Fit .... Light Push
- Bush. Hole Dia - Fin .... .8597/.8595
- Pin Cl. in Bushing .... .0006/.0002
- Desired Pin Fit .... .0004

Pistons
- Cylinder Dia 3.4395/3.4375
- Wear Limit-Cyl. Bore .... .008
- Piston Pin Hole Dia .... .8597/.8595
- Ring Groove Width #1 .... .097/.096
- Max. Wear Limits .... .099
- Ring Groove Width-#2-3 ..... .1285/.1275
- Max Wear Limit .... .1305
- Ring Groove Width-#4 .... .2530/.2515
- Max. Wear Limit .... .255
- Ring Groove Width-#5 .... None
- Max. Wear Limit .... —
- Piston Fit-Feeler Gauge .... .003
- Lbs. Pull .... 5-10#

Piston Rings
- Ring Width-#1 .... .0935/.0930
- Wear Limits-Min. Width .... .091
- Ring Width-#2 & #3 .... .1240/.1235
- Wear Limits-Min. Width............. .1215
- Ring Width-#4 .... .249/.2485
- Wear Limits-Min. Width .... .2465
- Ring Width-#5 .... None
- Wear Limits-Min Width .... —
- Ring Gap Clearance-#1......... .010/.020

ENGINE LIMITS AND CLEARANCE (CONTINUED)

Ring Gap Clearance-#2 & 3	.010/.020
Ring Gap Clearance-#4	.015/.055
Ring Gap Clearance-#5	None
Ring Side Clearance-#1	.004/.0025
Ring Side Clearance-#2 & 3 ..	.0055/.0025
Ring Side Clearance-#4	.0045/.0025

ENGINE TORQUE SPECIFICATIONS

Engines have many studs, bolts, and cap screws of special material and sizes and it is very important that care be exercised to torque all studs and bolts correctly.

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

Size - Diameter	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"
Cylinder Heads	------	35-40	70-85	100-110	130-140	145-155
Manifolds	15-20	25-30	40-50	50-60	50-50	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	-----	------	-------	-----

INDUSTRIAL TRUCK DIVISION

CLARK EQUIPMENT

NEW MACHINE 50 HOUR SERVICE AND INSPECTION

Air Cleaner, Service	8H 403
Battery Test and Level Check.....................................	100H 603
Brake Master Cylinder Level Check................................	100H 303
Brake Pedal, Adjust..	100H 302
Cooling System, Inspect..	100H 103
Cylinder Head, Tighten...	1000H 002
Engine Crankcase, Drain and Refill...............................	100H 002
Engine Oil Filter, Change..	100H 002
Fan Belt, Adjust...	100H 203
Fuel Pump Strainer, Clean or Replace.............................	500H 002
Hand Brake, Adjust...	1000H 1103
Hydraulic Oil Filter, Change.....................................	500H 103
Intake and Exhaust Manifold, Tighten.............................	500H 403
Lift Chains, Adjust..	100H 403
Lubricate Machine..	100H 703
Nuts, Bolts and Capscrews, Tighten...............................	500H 403
Power Steering Reservoir Level Check.............................	8H 703
Pressure Check Main Hydraulic System.............................	1000H 1503
Steering Gear Level Check..	100H 603
Transmission, Converter and Axle Adapter Level Check.............	100H 002
Transmission, Converter and Axle Adapter Change Filter...........	500H 002

N O T E

PERFORM THIS SERVICE AND INSPECTION AFTER THE FIRST 50 HOURS OF OPERATION ON NEW MACHINES.

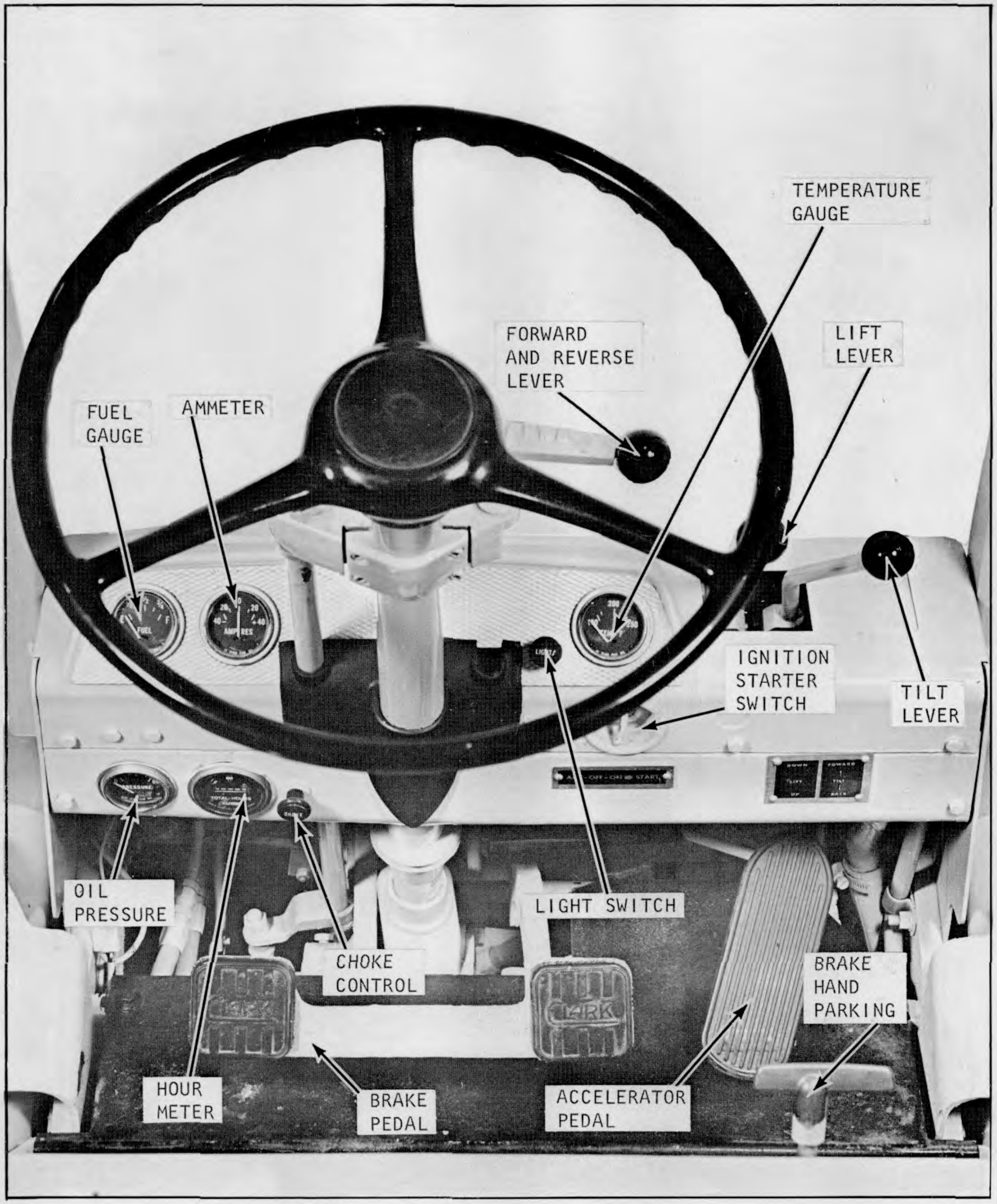


Plate 9957. Overall Controls

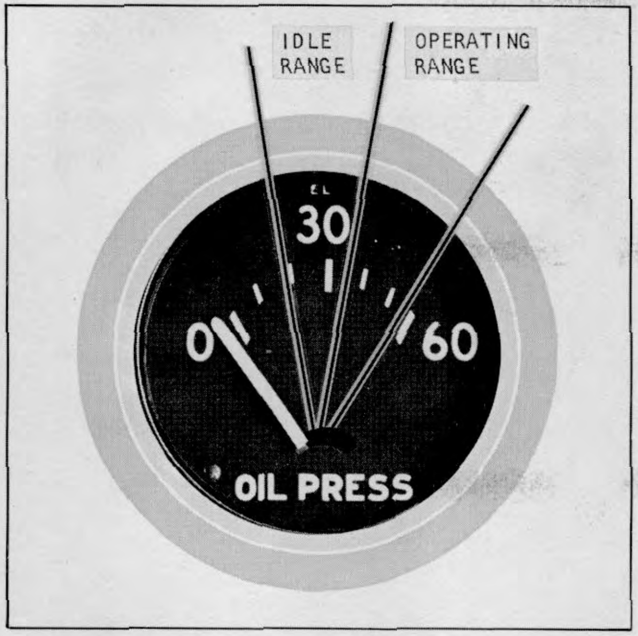


Plate 8606. Oil Pressure Indicator

If the oil pressure is erratic or falls below the above limit, stop the engine immediately and find the cause of the trouble. Refer to trouble shooting section for this information. On new machines, after starting machine, run it at idle for five minutes, then stop engine and recheck oil level in crankcase. Bring oil level to high mark, if necessary.

NOTE

Before placing machine in operation, run engine a few minutes to warm oil especially in cold operating condition.

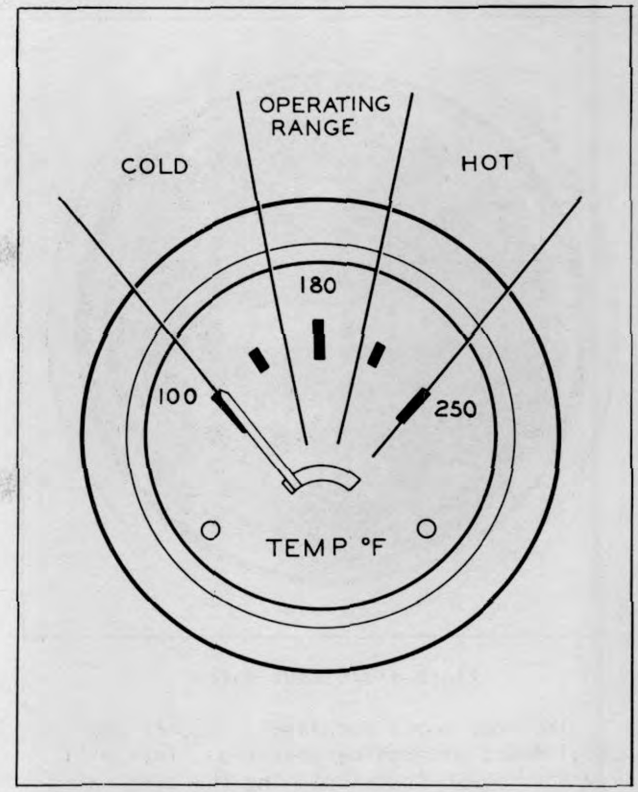


Plate 9955. Engine Coolant Temperature Indicator

NOTE

The coolant temperature should register in the operating range after the first few minutes of operation. Low operating tempera- tures wastes fuel and increases engine wear.

<u>CAUTION</u>

DO NOT IDLE THE ENGINE FOR LONG PERIODS AS IT IS NOT ONLY DETRIMENTAL TO THE ENGINE BUT ALSO INCREASES OPERATING COSTS AS YOU ARE USING FUEL WITHOUT BENEFIT.

Plate 7162. Hour Meter

The hour meter accurately records the actual hours of machine operation. This will serve as an aid in determining the time intervals for lubrication and preventive maintenance services.

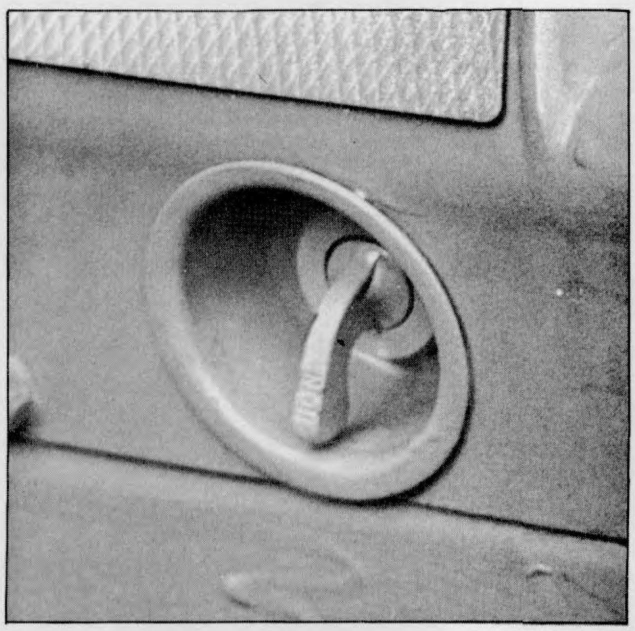


Plate 7018. Ignition Switch

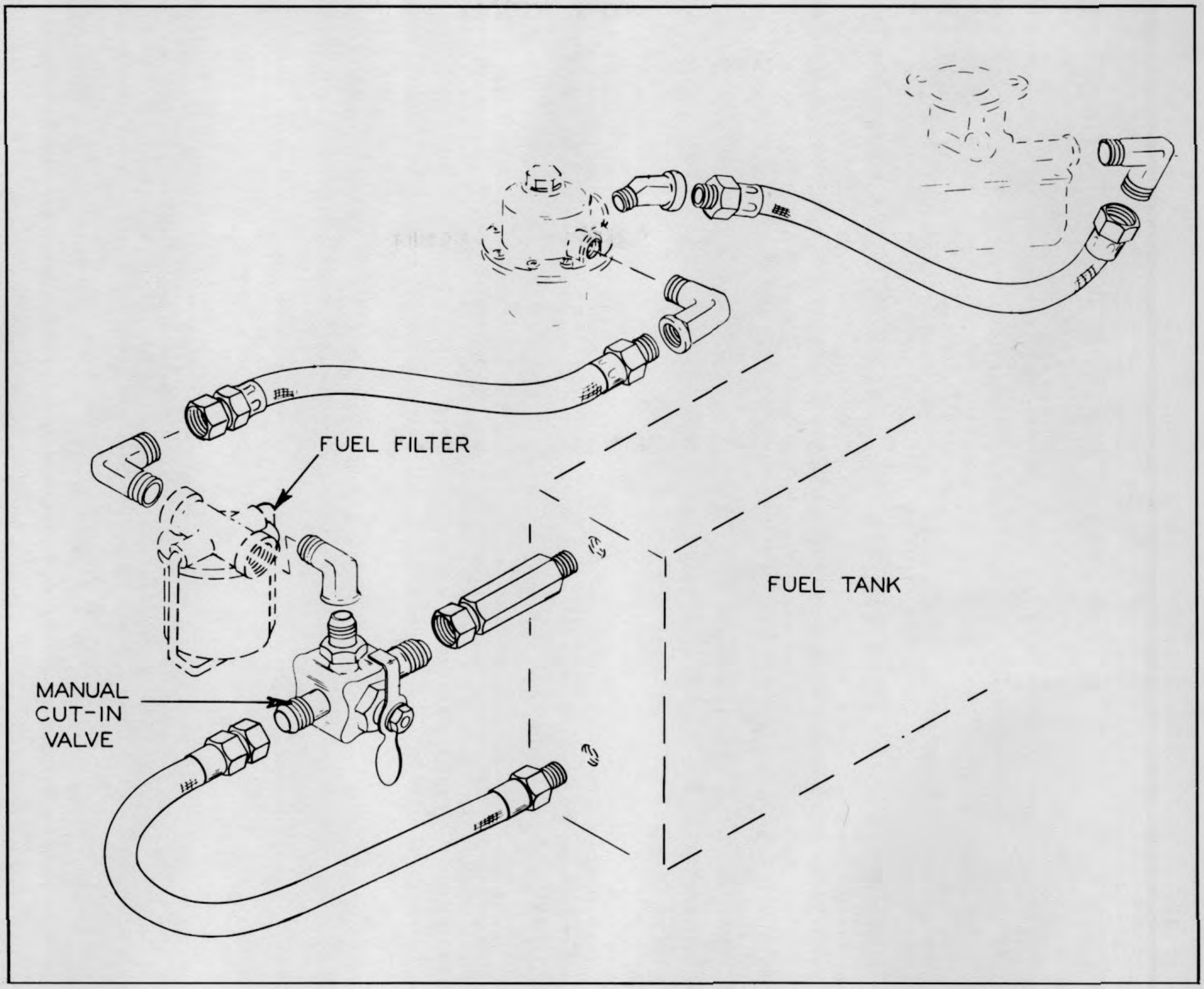


Plate 7019. Manual Cut-In Valve

The auxiliary fuel reserve manual cut-in valve located at the front of the fuel tank may be turned to the auxiliary position in the event that the main fuel tank supply becomes exhausted. The reserve fuel supply of approximately 1/2 gallon will in most cases be adequate to allow the machine to be driven to its refueling location. After the fuel supply has been replenished the manual cut-in lever should be turned to the normal position.

OPERATIONS

STARTING

Place all transmission control levers in neutral position. Pull out on choke and engage the starter by actuating the ignition switch in the start position.

CAUTION

DO NOT ENGAGE THE STARTER LONGER THAN 15 SECONDS WITHOUT A MINUTE OR SO INTERVAL BETWEEN TRIALS.

If the engine becomes overchoked or flooded; push choke button in, depress accelerator pedal fully and engage starter. If all necessary equipment is in correct working order, the engine will start.

After engine has started, check instrument panel making certain the engine oil pressure indicator shows adequate pressure. If no oil pressure is indicated, stop engine and correct the difficulty.

NOTE

RUN ENGINE A FEW MINUTES TO WARM OIL, BEFORE PUTTING MACHINE TO WORK ESPECIALLY IN COLD OPERATING CONDITIONS.

TO OPERATE MACHINE

1. Place transmission control levers in neutral position and start engine.

2. Now move forward and reverse lever out of neutral and into position for desired direction. Accelerate as required.

3. Inching Operation: To inch the machine into a load, the brake pedal should be depressed in its free travel range and the accelerator pedal actuated as required. The initial brake movement is used to regulate the inching control valve which allows a decrease in pressure on the transmission selector pack discs. This permits controlled slippage of the discs allowing the machine to inch----after the brake pedal travel has actuated the inching valve mechanism the brakes become applied and all pressure by-passes the selector discs.

CAUTION

TO PROLONG MACHINE LIFE IT IS BEST TO COME TO COME TO A COMPLETE STOP BEFORE SHIFTING TO THE OPPOSITE DIRECTION.

ALLOW FOOT TO REST ON BRAKE PEDAL ONLY WHEN INCHING IS DESIRED. DO NOT ALLOW FOOT TO REST ON BRAKE PEDAL WHILE DRIVING MACHINE FROM POINT TO POINT. RIDING THE BRAKE PEDAL WILL CAUSE CONTINUED SLIPPAGE OF THE TRANSMISSION SELECTOR PACKS RESULTING IN OVERHEATING AND UNNECESSARY WEAR OR DAMAGE TO TRANSMISSION COMPONENTS.

TO STOP MACHINE

Remove foot from accelerator pedal and depress brake pedal. If machine is to be parked, place transmission control levers in neutral position, apply hand brake and shut engine off.

CAUTION

IF THE ENGINE HAS BEEN OPERATING AT OR NEAR FULL LOAD, IT SHOULD BE ALLOWED TO RUN AT FAST IDLE (600 to 800 R. P. M.) FOR ONE OR TWO MINUTES AFTER LOAD IS REMOVED BEFORE BEING STOPPED. THIS ALLOWS INTERNAL ENGINE TEMPERATURES TO EQUALIZE.

TO MOVE A LOAD

The forks should be adjusted sideways on fork bars to obtain maximum balance in proportion to width of load. Raise or lower forks to proper level and center the load as nearly as possible on the forks. Tilt upright assembly slightly backwar to prevent the load from falling, accelerating engine slightly at the same time. Back away from stack.

Adjust the forks with load so they are close to the floor or ground but high enough to avoid hitting obstructions. The operator should have clear vision ahead when moving in a forward direction. When this is not possible, the operator should drive in reverse and sufficiently turn in his seat to obtain clear vision backward.

When the load is to be deposited, enter the area squarely, especially when placing one load on top of another, in order that all piles will be square and secure. Place load directly over desired area and slowly lower to the floor.

IMPORTANT

EVERY 8 OPERATING HOURS (OR EVERY SHIFT) ELEVATE UPRIGHT TO THE UPPER LIMIT. THIS WILL PROVIDE LUBRICATION TO THE TOP PORTION OF THE LIFT CYLINDER.

SAFETY AND OPERATION SUGGESTIONS

The use of industrial powered trucks is subject to certain hazards that cannot be overcome by purely mechanical means. The exercise of intelligence, care and common sense by the truck operator is necessary to eliminate the hazards of overloading, slipping and falling of the load; obstructions in the parth of travel, or the use of equipment for a purpose for which it is not intended or designed.

The following are a few suggestions that should be followed in the operation of this machine.

1. Operate machine with forks close to floor, loaded or empty, but high enough to avoid hitting obstructions.

2. If vision is obstructed by the load, operate machine in reverse and sufficiently turn in the seat to obtain clear vision.

3. Avoid sudden stops or starts. When backing, be sure to look for fellow workmen before moving machine.

4. Drive carefully at all times. Exercise caution at cross aisles. Sound horn for safety

5. Be sure loads are safe to move. Have loads properly centered on machine. Refer to the Capacity Chart in Specifications for various load center ratings.

6. An operator should be assigned to a specific machine.

7. The operator should be qualified and drive in accordance with established safety rules.

8. If the machine does not respond immediately, report to designated individual in charge. A minor adjustment now may save a major repair later.

9. Do not allow riders or hitchhikers.

10. Operate the machine at a safe distance behind other vehicles.

11. Do not operate machine with wet or greasy hands.

12. Observe highway traffic laws in the operation of the vehicle in the plant.

13. Drive carefully on wet or slippery floors.

14. Keep feet within running line of truck.

15. Avoid overloading the truck -- this is a safety measure against possible injury to the driver and fellow workmen. Overloading shortens the life of the truck and increases maintenance.

16. Do not operate machine for prolonged periods in an unventilated area. All engines produce poisonous carbon monoxide gas as a by-product of combustion and can be dangerous if allowed to accumulate in a closed area.

17. Be sure the brakes are in proper working condition. Be sure all mechanical and electrical components are working correctly.

INDUSTRIAL TRUCK DIVISION

CLARK EQUIPMENT

LUBRICATION AND PREVENTIVE MAINTENANCE INDEX

NOTE

Lubrication and Preventive Maintenance Illustrations at the beginning of each time interval section. When performing the 100, 500, 1000 hour lubrication and preventive maintenance, always include the previous lubrication and preventive maintenance schedules.

8 HOURS

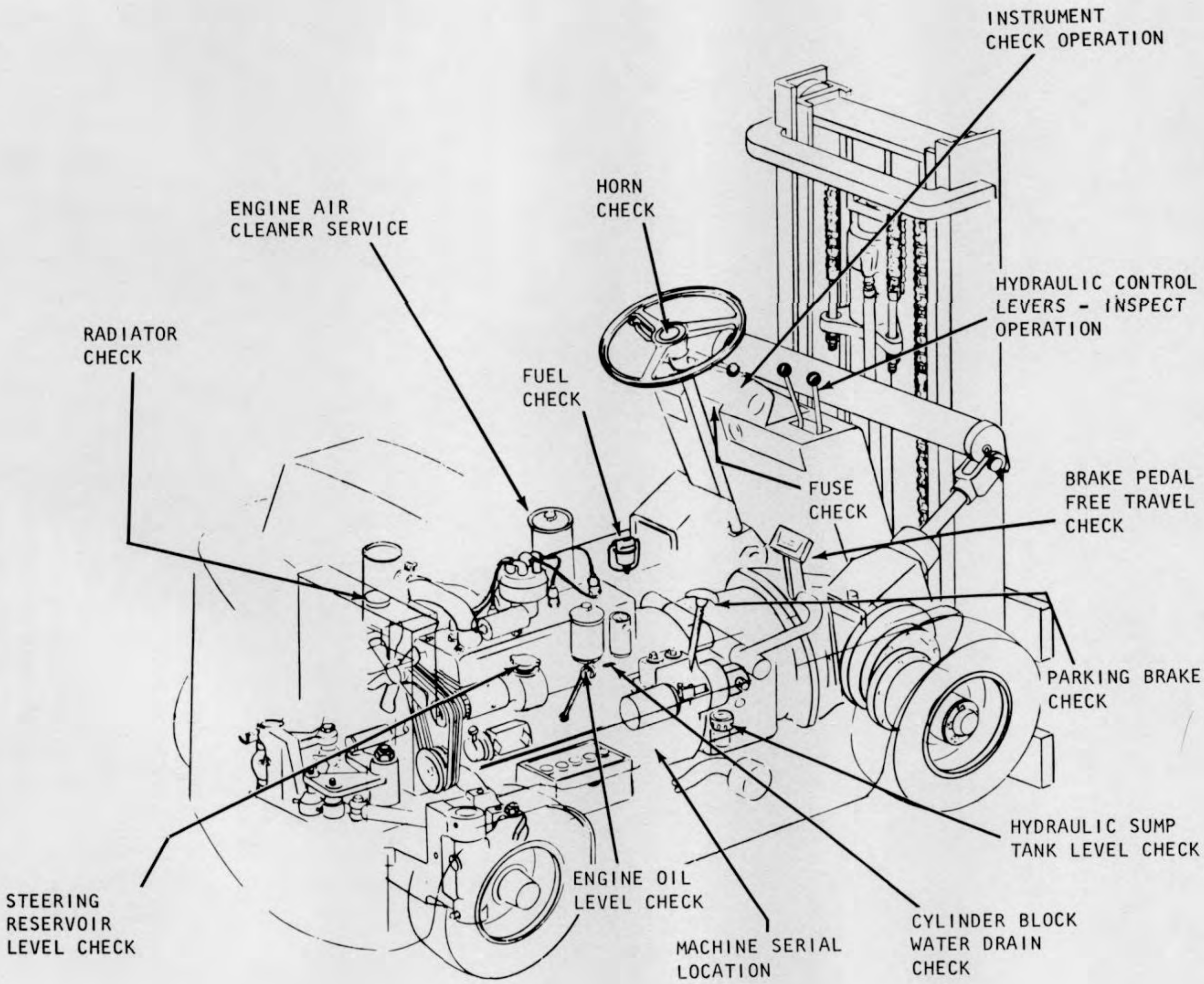


Plate 9956. Lubrication & Preventive Maintenance Illustration

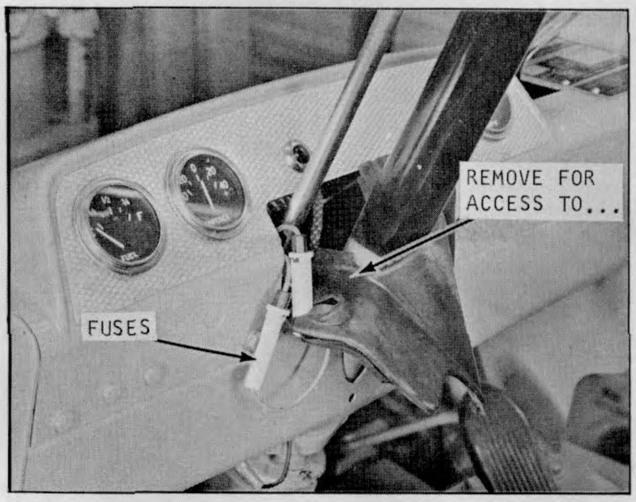


Plate 9473. Electrical System Fuse

HORN

Check to be sure the horn is working properly. The horn and ignition fuse is located beneath the dash near the steering column. Fuses are accessible by removing steering column grommet.

FUEL TANK

Check fuel sypply and fill if necessary. Use a good grade of fuel.

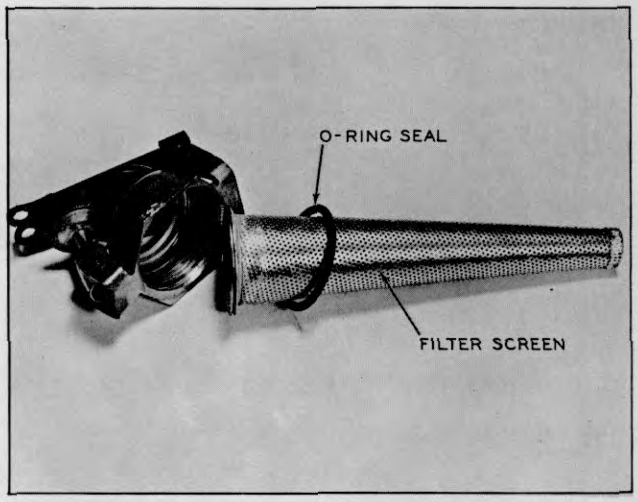


Plate 6627. Fuel Tank Filler Cap & Screen

Before filling fuel tank, make certain the filler cap screen and "O" ring is in place and not damaged.

C A U T I O N

DO NOT REMOVE THE SCREEN WHILE FILLING TANK.

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W A R N I N G

CARE SHALL BE TAKEN NOT TO DAMAGE FILLER CAP SCREEN WITH FILLER HOSE NOZZLE WHILE FILLING FUEL TANK

X X X X X X X X X X X X X X X X X X X X X X X X X

ENGINE CRANKCASE

Before attempting to start the engine, first make sure that it has sufficient oil. The oil filler pipe is located on the right side of the machine. The oil level stick is of the dipstick or bayonet type and is also located on the right side of the machine. Fill the crankcase reservoir through the filler pipe to the proper level as indicated on the dipstick.

CAUTION

NEVER PERMIT THE OIL LEVEL TO FALL BELOW THE "ADD" MARK ON THE DIPSTICK.

DO NOT OVERFILL THE CRANKCASE, AS TOO MUCH OIL WILL BRING THE LEVEL HIGH ENOUCH FOR THE CONNECTING RODS TO DIP, THUS CAUSING EXCESSIVE QUANTITIES OF OIL TO BE THROWN TO THE CYLINDER WALLS RESULTING IN OIL CONSUMPTION, SMOKING, EXCESSIVE CARBON DEPOSITS AND FOULED SPARK PLUGS.

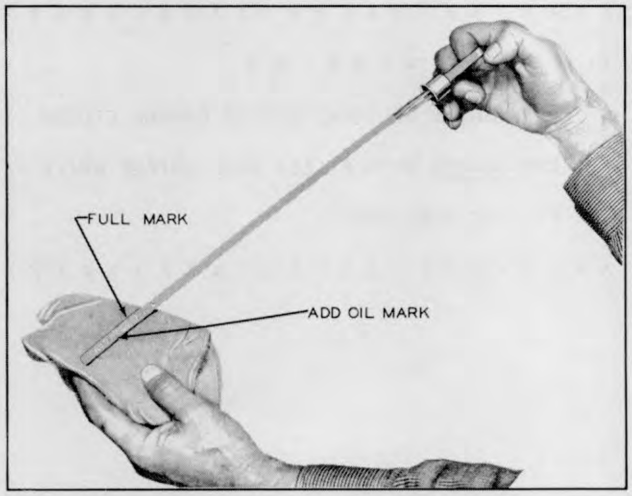

Plate 3145. Crankcase Oil Check

Crankcase Capacity — Refer to Specifications

Service "MS" Oils

S.A.E.	10W	.... 0° to 32° F.
S.A.E.	20W	.... 32° to 75° F.
S.A.E.	30W	.... above 75° F.
or use	10W	.... 30 MULTI-GRADE OIL

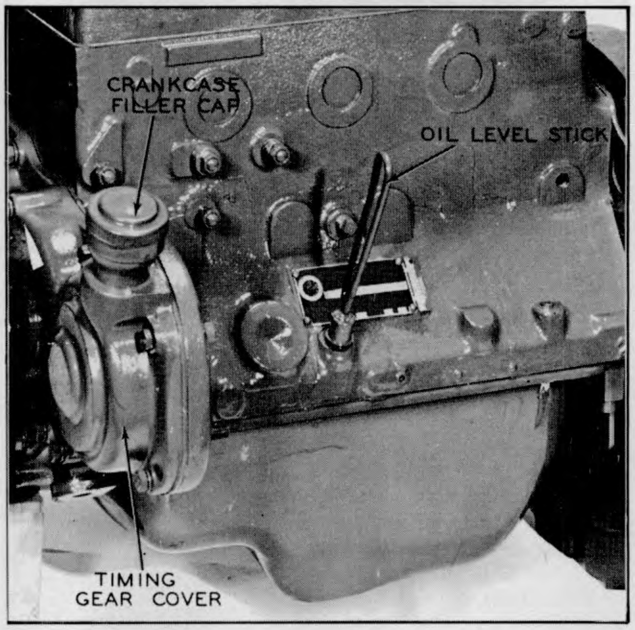

Plate 6629. Engine Crankcase Fill

ENGINE COOLING

Make sure that the radiator drain cock and the water drain in the cylinder block are closed. Check radiator coolant level and fill to within 1 inch of the top with clean water; or if operation is in cold weather, use a suitable anti-freeze solution.

It is recommended that a soluble oil in the proportion of 1 ounce per gallon of water be added to the Cooling System.

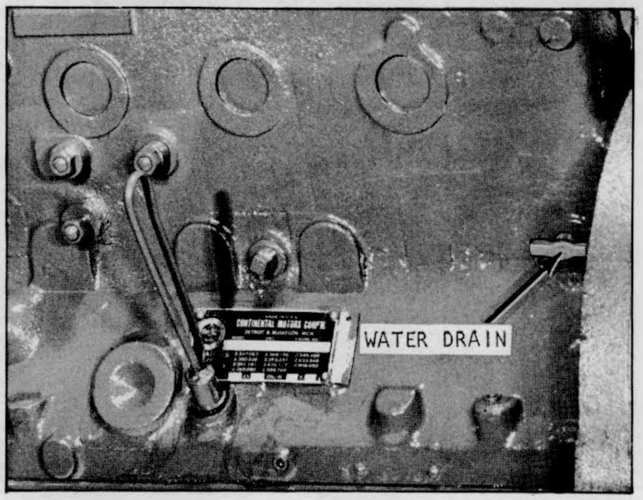

Plate 7008. Typical Cylinder Block Water Drain

CAUTION

NEVER POUR COLD WATER OR COLD ANTI-FREEZE INTO THE RADIATOR OF AN OVERHEATED ENGINE. ALLOW THE ENGINE TO COOL AND AVOID THE DANGER OF CRACKING THE CYLINDER HEAD OR BLOCK. KEEP ENGING RUNNING WHILE ADDING WATER OR ANTI-FREEZE. WHEN PERMANENT ANTI-FREEZE OF THE ETHYLENE GLYCOL TYPE IS USED, THE COOLANT SOLUTION MUST CONTAIN AT LEAST 40% WATER.

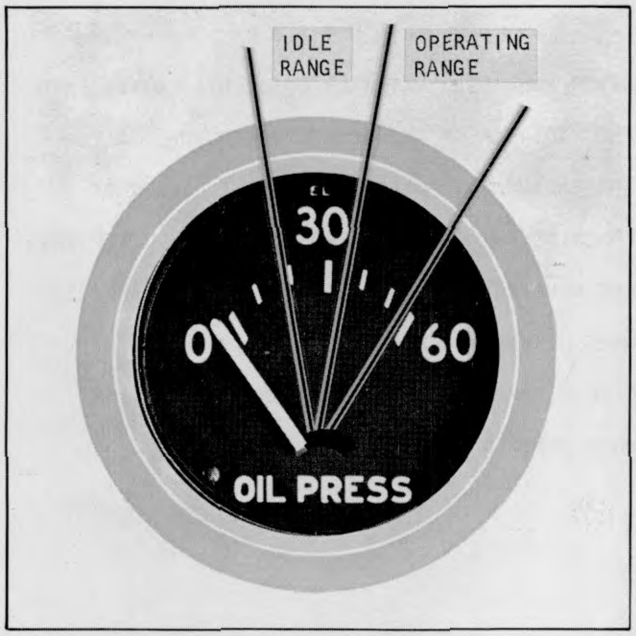

Plate 8606. Oil Pressure Indicator

If the oil pressure is erratic or falls below the above limit, stop the engine immediately and find the cause of the trouble. Refer to trouble shooting section for this information. On new machines, after starting machine, run it at idle for five minutes, then stop engine and recheck oil level in crankcase. Bring oil level to high mark, if necessary.

NOTE

Before placing machine in operation, run engine a few minutes to warm oil especially in cold operating condition.

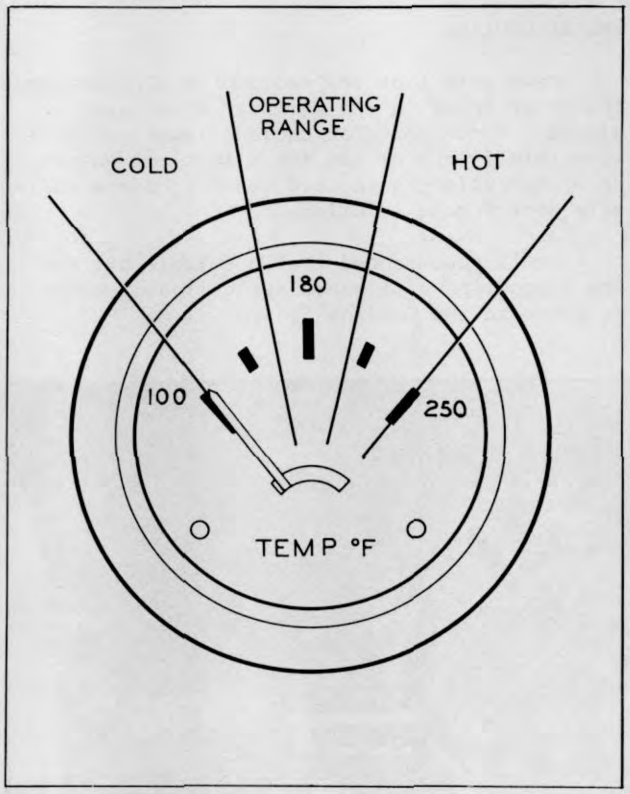

Plate 9955. Engine Coolant Temperature Indicator

NOTE

The coolant temperature should register in the operating range after the first few minutes of operation. Low operating temperatures wastes fuel and increases engine wear.

CAUTION

DO NOT IDLE THE ENGINE FOR LONG PERIODS AS IT IS NOT ONLY DETRIMENTAL TO THE ENGINE BUT ALSO INCREASES OPERATING COSTS AS YOU ARE USING FUEL WITHOUT BENEFIT.

Plate 7162. Hour Meter

The hour meter accurately records the actual hours of machine operation. This will serve as an aid in determining the time intervals for lubrication and preventive maintenance services.

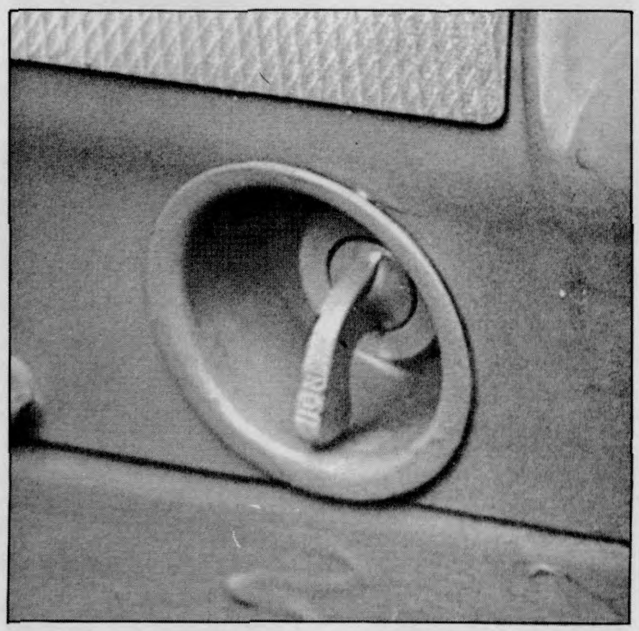

Plate 7018. Ignition Switch

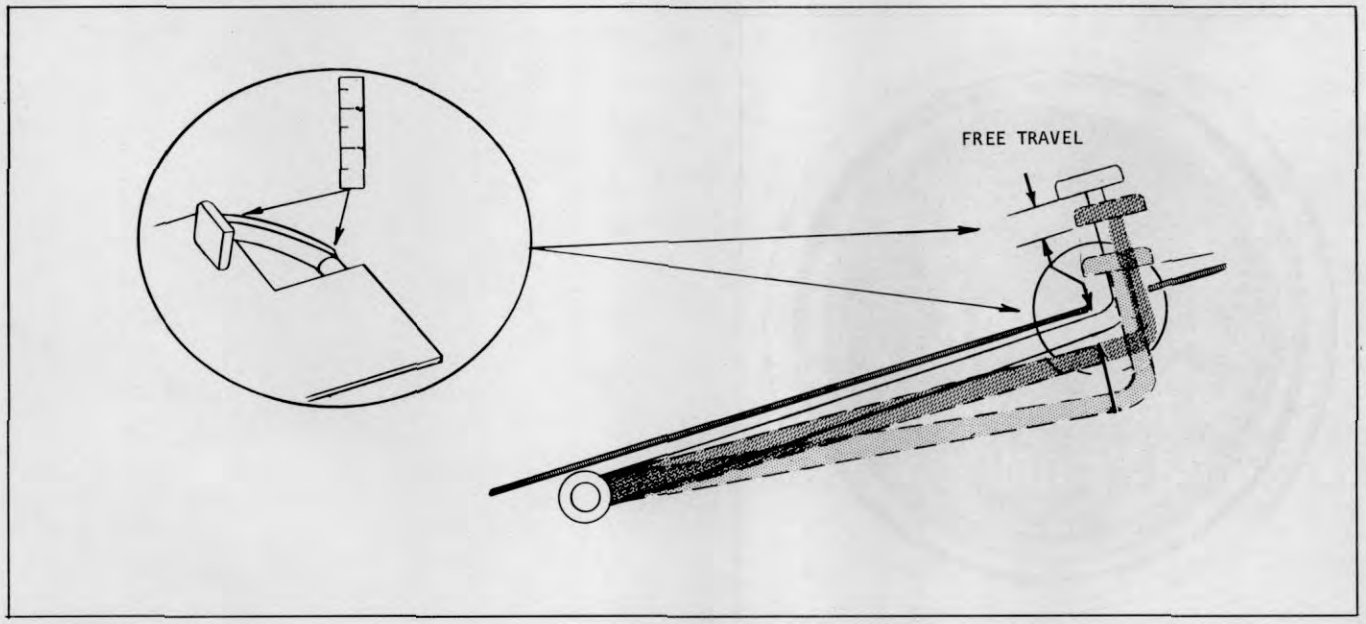

Plate 9592. Brake Pedal Free Travel

BRAKE PEDAL

1. Depress brake pedal by hand. When pedal meets resistance from the master cylinder, the distance traveled should be 3/16" to 5/16". If free travel is incorrect an adjustment should be made at the master cylinder linkage adjuster.

2. Depress foot pedal and hold for at least 10 seconds. Pedal must be solid, must not be spongy or drift under foot pressure

PARKING BRAKE

The parking brake linkage should be adjusted so that the brake handle will have 2 inches of upward free travel, before resistance is noticed and the brake becomes applied.

The parking brake must be capable of holding the truck, with full rated load, on a 15% grade. This should be tested while occupying the driver's seat with the parking brake applied and truck out of gear.

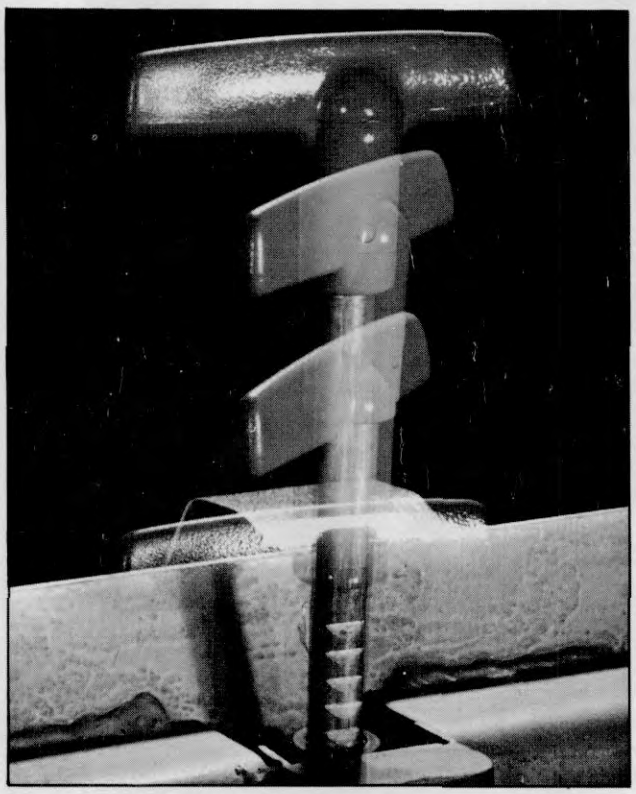

Plate 7482. Parking Brake

Plate 5985. Air Cleaner
Fill to oil level only.

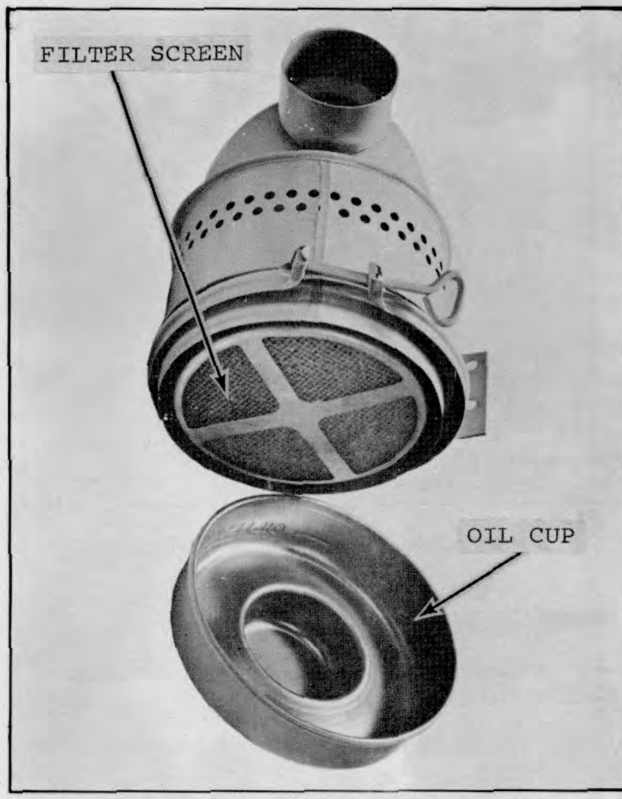

Plate 7663. Air Cleaner Screen and Oil Cup.

AIR CLEANER (OIL BATH TYPE)

The air cleaner is of the oil bath type. The main function of the air cleaner is to prevent dirt and grit from getting into the engine. All engines, when operating, consume several thousand cubic feet of air per hour. Since dusty air is full of abrasive matter, the engine will soon wear excessively if the air cleaner does not remove the dust before entering the cylinders.

Operating conditions determine the air cleaner service periods. As the dirt is strained from the air flowing through the cleaner, it thickens the oil in the cup and raises the level. If the level is to high, agitation of the oil on the screen is affected and gritty oil is carried over into the air stream, through the carburetor and into the engine cylinders. This would actually introduce a grinding compound with resulting very rapid wear.

Air cleaner maintenance may seem trivial, but it can mean longer engine lift, less engine up keep and better economy providing proper maintenance is exercised. Common sense with a close observance can best determine the frequency of air cleaner maintenance.

RECOMMENDED MAINTENANCE

The air cleaner should be checked every 8 operating hours and cleaned if needed. This may be necessary twice daily under extreme dirty conditions.

Remove air cleaner oil cup and wash in a Stoddard type cleaning solvent. Wipe dry and refill with new engine oil. Replace oil cup on air cleaner being sure it is properly positioned.

Check all hose connections to be sure they are tight. Periodically remove hose connections and check interior of hose for dirty or dust. If found, this indicates that additional cleaning intervals are necessary.

C A U T I O N

ALWAYS CHECK AIR CLEANER ASSEMBLY WITH THE ENGINE TURNED OFF. NEVER CHECK OR REFILL THE OIL CUP WITH THE ENGINE IN OPERATION.

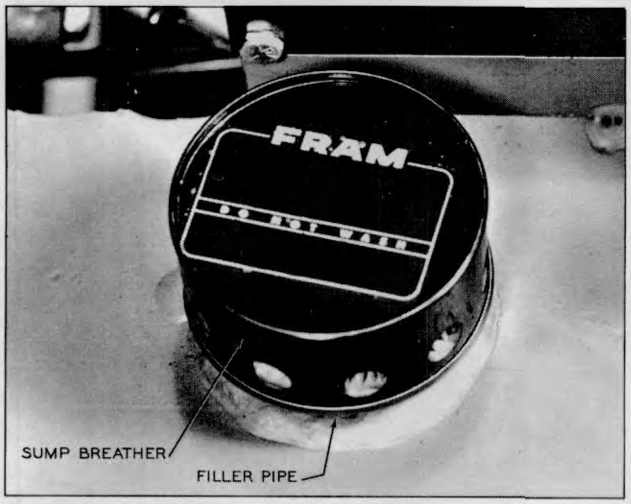

Plate 6626. Hydraulic Sump Tank and Sump Breather

HYDRAULIC SUMP TANK

Check hydraulic sump tank fluid level in the following manner:

1. Lower upright.

2. Turn switch key to off position

3. Remove sump breather. Fluid level should be up to bottom of filler pipe.

If necessary, fill sump tank using MS 68 Hydraulic fluid. Move valve control levers with hydraulic pump operating to allow any air in the lines to escape, then recheck sump tank fluid level and fill as requred before putting machine in operation.

HYDRAULIC CONTROL LEVERS

I M P O R T A N T

EVERY 8 OPERATING HOURS (OR EVERY SHIFT) ELEVATE UPRIGHT TO THE UPPER LIMIT. THIS WILL PROVIDE LUBRICATION TO THE TOP PORTION OF THE LIFT CYLINDER.

Check lift and tilt operation. The lift and tilt cylinders should actuate when lift or tilt levers are moved either way from neutral position.

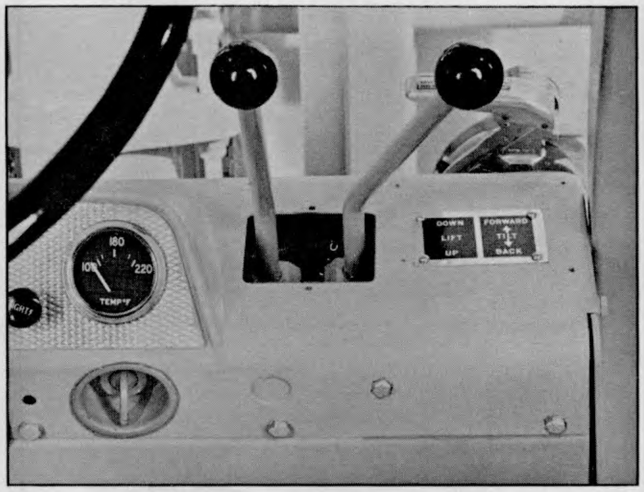

Plate 9535. Lift and Tilt Lever

When load is elevated and control lever returned to neutral position, load should remain in elevated position, with no noticeable downward drift. If load drifts downward excessively, this may indicate lift cylinder U-Cup or seal damage.

With tilt lever in neutral position, upright should remain steady with no noticeable backward or forward drift. If upright drifts excessively either way, this may indicate tilt cylinder seal or U-Cup damage.

C A U T I O N

NEVER ALLOW LOADED OR UNLOADED LIFT CARRIAGE TO REMAIN IN AN ELEVATED POSITION FOR ANY PROLONGED PERIODS. LIFT CARRIAGE SHOULD BE LOWERED WHEN NOT IN USE.

DO NOT HOLD CONTROL LEVERS IN EXTREME POSITIONS AFTER A LOAD HAS REACHED ITS LIMITS. TO DO SO WILL RESULT IN HIGH OIL PRESSURE THAT MAY RESULT IN OVERHEATING OF THE HYDRAULIC OIL.

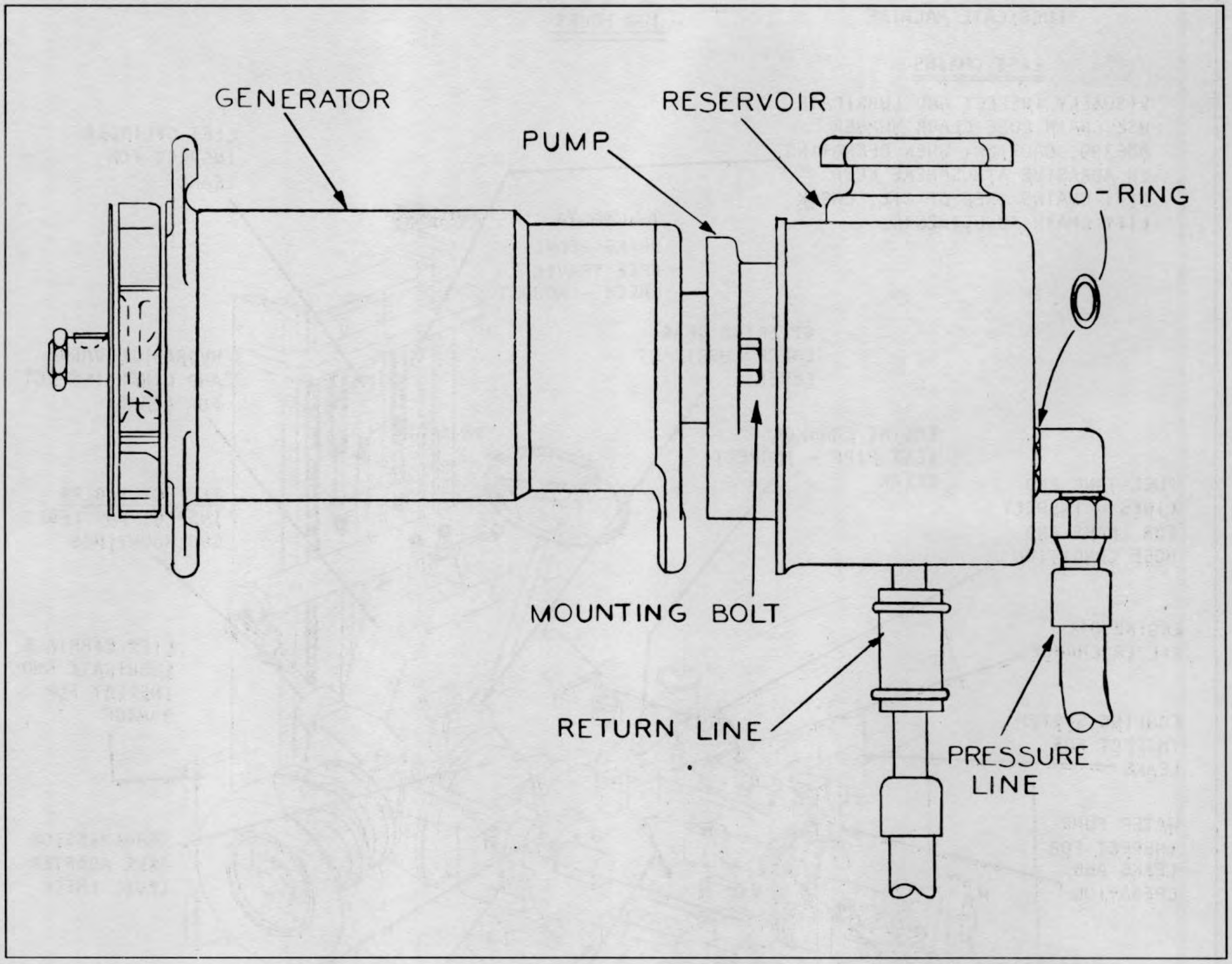

Plate 5940. Power Steering Pump

POWER STEERING PUMP

Check reservoir fluid level each 8 operating hours. Fill (if necessary) with type "A" suffix "A" automatic transmission fluid, CLARK part number 879803. (Fluid containers must display a qualification number prefixed by AQ-ATF.) When fluid in reservoir becomes contaminated it should be drained by removing the return line hose at the bottom of the reservoir. After draining refill to the proper level with the above mentioned fluid. Operate engine for a few minutes and recheck fluid level. Fill to the proper level if necessary.

CAUTION

DO NOT OPERATE ENGINE WHILE RESERVOIR IS EMPTY AS THE STEERING PUMP WILL NOT BE LUBRICATED AND SERIOUS DAMAGE WILL OCCUR.

INDUSTRIAL TRUCK DIVISION

LUBRICATION AND PREVENTIVE MAINTENANCE

LUBRICATE MACHINE

100 HOURS

LIFT CHAINS

VISUALLY INSPECT AND LUBRICATE USE CHAIN LUBE CLARK NUMBER 886399. CAUTION: WHEN OPERATING IN ABRASIVE ATMOSPHERE KEEP LIFT CHAINS FREE OF OIL. CHECK LIFT CHAIN ADJUSTMENTS.

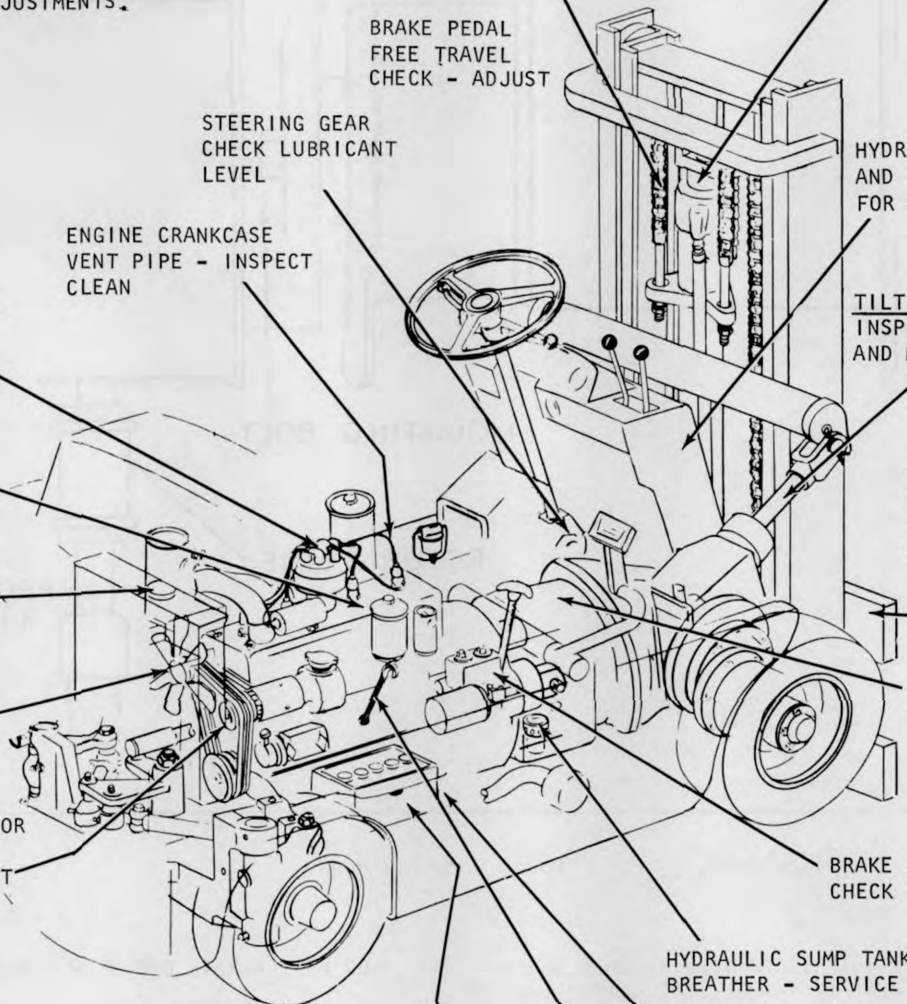

Plate 9481. 100 Hour Lubrication & Preventive Maintenance Illustration Index

CONVERTER, TRANSMISSION AND AXLE ADAPTER

Verify fluid level with engine operating and transmission in neutral.

Fill with Transmission Fluid Type "A" Suffix "A" that are in cans that have AQ-ATF on them, through the combination filler and dipstick opening. Fill to "Hot Full" mark on dipstick if transmission fluid is at normal operating temperatures. Fill to "Cold Full" mark when oil is at a lower temperature.

FUEL LINES. Make certain that fuel line connections are secure. Check fuel lines for obstructions and leaks. Check screen in fuel filler cap to make certain that it is properly installed.

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WARNING

THE FUEL TANK IS AN INTEGRAL PART OF THE MACHINE FRAME AND ANY WELDING IN THIS AREA SHALL NOT BE ATTEMPTED BEFORE FIRST TAKING ADEQUATE SAFETY PRECAUTIONS REPORT TO DESIGINATED PERSON IN AUTHORITY

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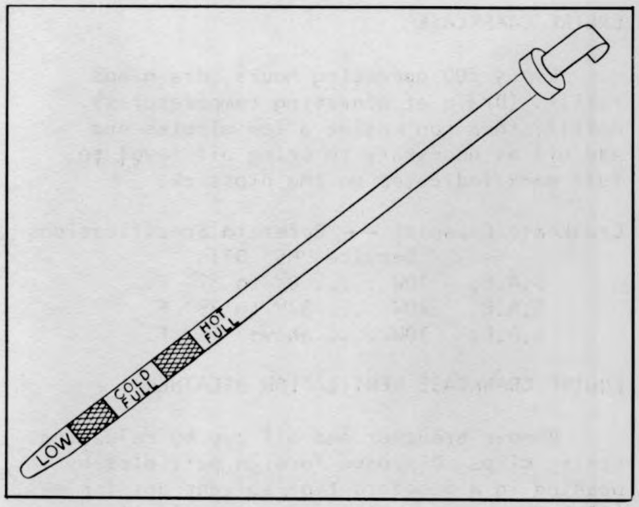

Plate 7303. Transmission Dipstick

ENGINE CRANKCASE

Every 100 operating hours, drain and refill. (Drain at operating temperatures). Refill, then run engine a few minutes and add oil as necessary to bring oil level to full mark indicated on the dipstick.

Crankcase Capacity — Refer to Specifications
Service "MS" Oils

S.A.E.	10W	..... 0° to 32° F.
S.A.E.	20W	.... 32° to 75° F.
S.A.E.	30W	.... above 75° F.

ENGINE CRANKCASE VENTILATION BREATHER

Remove breather and oil cup by releasing spring clips. Dislodge foreign particles by washing in a Stoddard type solvent until clean. Allow to air dry. Fill oil cup to level mark with oil of same viscosity as used in engine. Replace breather after it is completely air dried.

Plate 7033. Engine Breather

ENGINE OIL FILTER

The oil filter element is of the replaceable type. The element should be changed whenever the crankcase is drained. To remove the element, remove oil filter cover screw and gasket, oil filter cover, cover spring and cover gasket. Lift out oil filter element. Install new element after draining and thoroughly cleaning filter case. Install new gaskets and replace cover spring, oil filter cover and secure with oil filter cover screw.

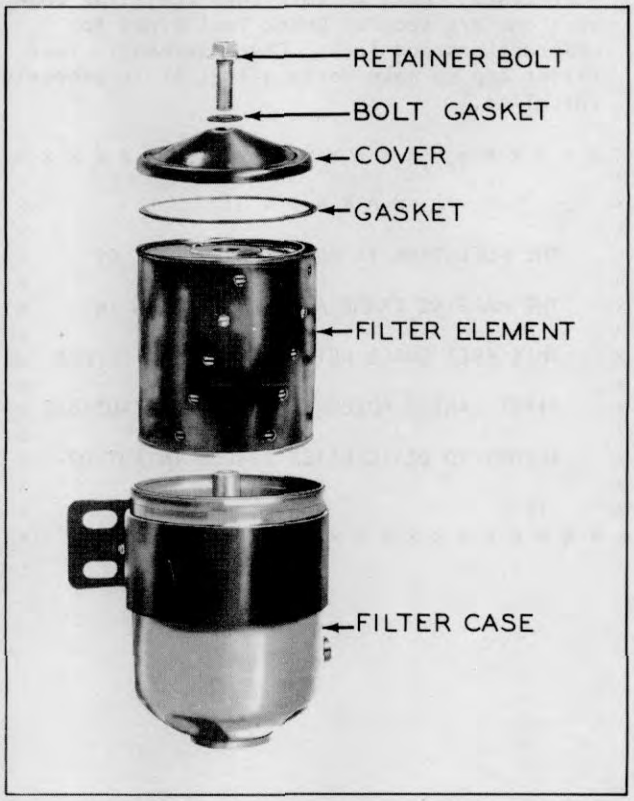

Plate 6332. Engine Oil Filter

C A U T I O N

START ENGINE, RUN AT IDLE FOR A FEW MINUTES,

CHECK COVER AND COVER SCREW FOR LEAKS.

Plste 6458. Radiator Pressure Cap

WARNING

USE EXTREME CARE IN REMOVING THE RADIATOR PRESSURE CAP. IN PRESSURE SYSTEM, THE SUDDEN RELEASE OF PRESSURE CAN CAUSE A STEAM FLASH AND THE FLASH, OR THE LOOSENED CAP CAN CAUSE SERIOUS PERSONAL INJURY. LOOSEN CAP SLOWLY AND ALLOW STEAM TO ESCAPE. THIS MACHINE IS EQUIPPED WITH A 7 LB. PRESSURE CAP.

COOLING SYSTEM

Check radiator, hoses and water pump for leaks.

Add proper amount of water or antifreeze solution to cooling system. If antifreeze is not available and machine is to be at rest for an appreciable length of time; drain system when temperature is likely to be 32^{o} F, or lower, If water is added to radiator containing antifreeze solution, always test solution in radiator with a hydrometer to determine the degree of protection. For proper amount of antifreeze solution required to protect the cooling system, refer to instructions on antifreeze container.

NOTE

COOLING SYSTEM CAPACITY - REFER TO SPECIFICATIONS.

Accumulated foreign material should be blown from radiator fins with compressed air. Direct air stream through radiator fins towards engine to make this process effective.

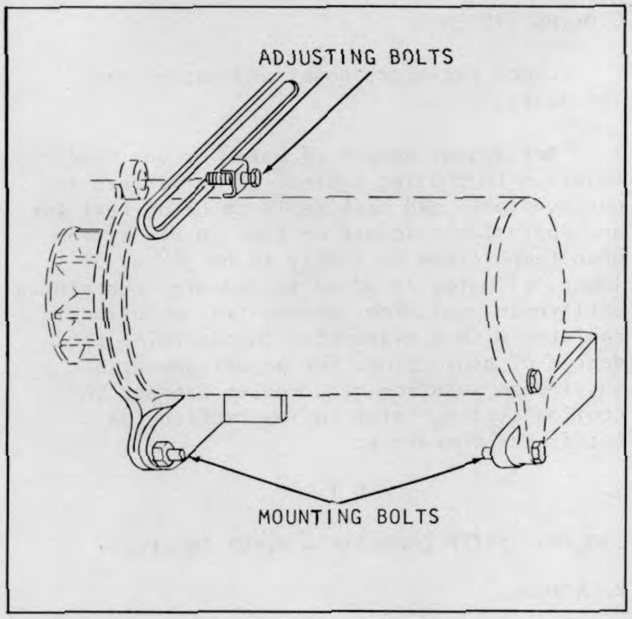

Plate 6631. Generator Drive Belt Adjustment

FAN AND GENERATOR DRIVE BELTS

The drive belts should have finger pressure deflection of 3/4 to 1 inch midway on long span. If belts require adjustment, use following procedure.

1. Loosen generator brace adjusting bolt and two lower mounting bolts, See Plate 6631.

2. Move generator toward cylinder block to loosen Generator Drive Belts and away from cylinder block to tighten belts. Tighten bolts when correct finger deflection is obtained.

C A U T I O N

EXERCISE CAUTION WHEN ADJUSTING BELTS. BELTS ADJUSTED TOO TIGHT WILL VERY LIKELY CAUSE

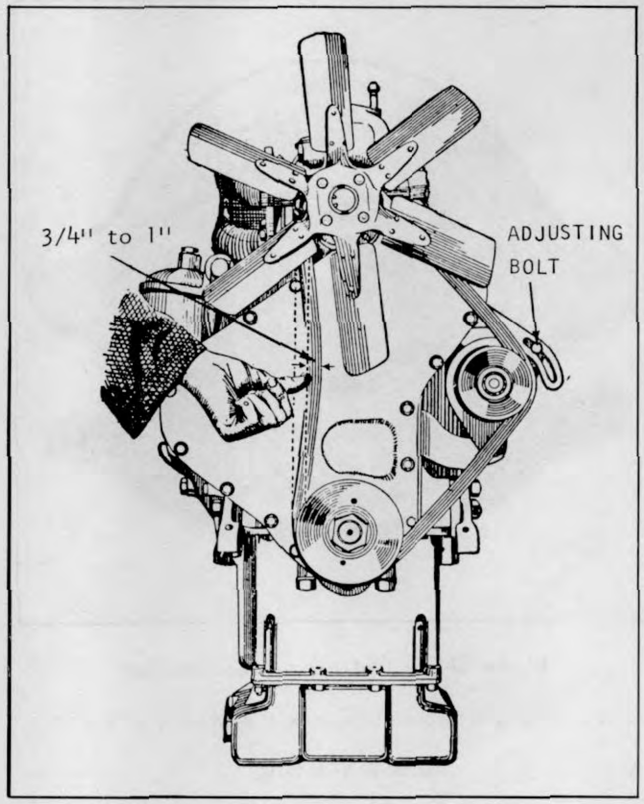

Plate 6632. Belt Deflection Check

BEARING DAMAGE. CONVERSELY, BELTS ADJUSTED TOO LOOSE WILL RESULT IN BELT WEAR AND HIGH ENGINE TEMPERATURE DUE TO BELT SLIPPAGE.

N O T E

UPON REPLACEMENT OF DRIVE BELTS, IT WILL BE NECESSARY TO USE A MATCHED SET OF BELTS.

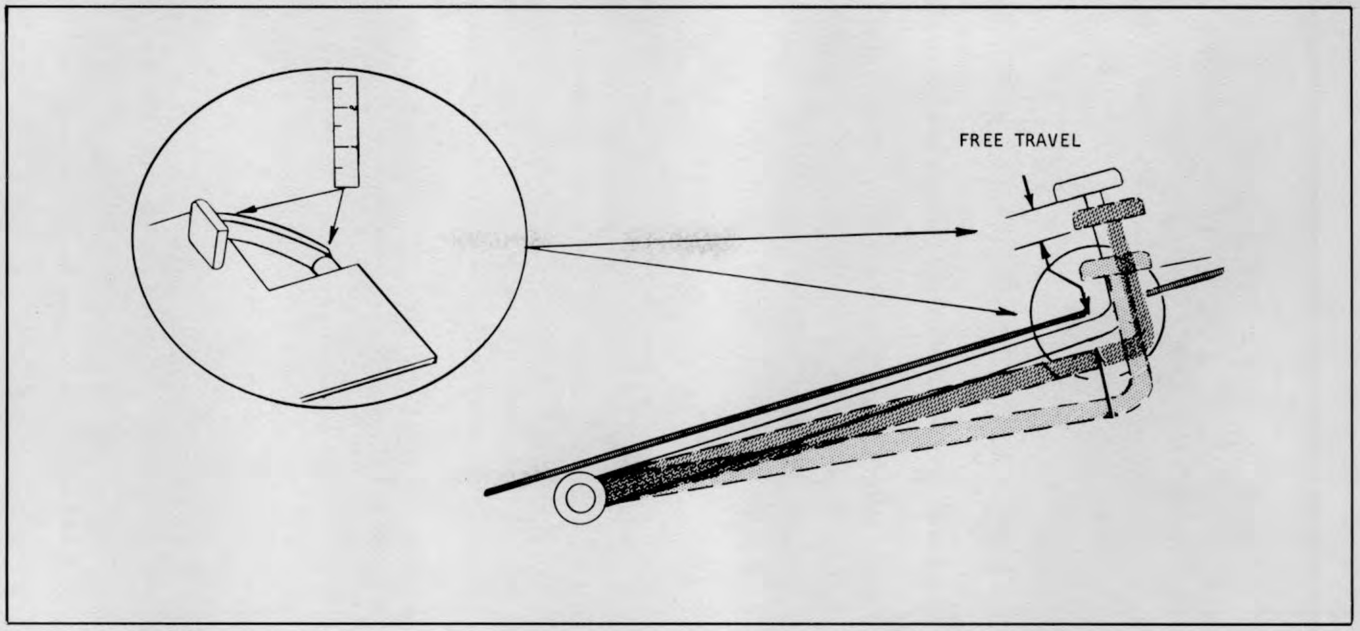

Plate 9592. Brake Pedal Free Travel

BRAKE PEDAL

1. Depress brake pedal by hand. When pedal meets resistance from the master cylinder, the distance traveled should be 3/16" to 5/16". If free travel is incorrect an adjustment should be made at the master cylinder linkage adjuster.

2. Depress foot pedal and hold for at least 10 seconds. Pedal must be solid, must not be spongy or drift under foot pressure.

BRAKE SYSTEM

Check brake fluid level in the master cylinder. Brake fluid should be within 1/4 inch of the top. Fill with SAE 70 R3 Heavy Duty Brake Fluid. Clark Part Number 1800200.

Master Cylinder Filler Cap Vent Hole: Check cap vent hole for obstruction. Vent hole must be open at all times. Clean if necessary, see Plate 6987.

Brake Pedal Adjustment

1. Loosen locknut, See plate 6987.

2. Rotate adjuster in the direction necessary to obtain specified free travel.

3. Tighten locknut to secure adjustment.

ACTUATION STROKE

If nearly full pedal travel is necessary to apply the brakes, there is an indication of either lack of fluid in the master cylinder; air in system, leakage at the cylinders, or the brake linings require adjustment or replacement.

WARNING

CORRECT BRAKE PEDAL FREE TRAVEL IS IMPORTANT FOR SAFE OPERATING BRAKES.

LIFT AND TILT CYLINDERS

Check for drift, leakage at packings, damage and security of mountings. (Anchor pivot pins, flanges and mounting rings).

LIFT CHAINS

The lift chains are mounted to the chain anchors on the lift carriage and at the chain anchor rods near the lift cylinder piston head.

If it becomes necessary to adjust the lift chains, proceed as follows:

WARNING

KEEP CLEAR OF LOAD AND CARRIAGE WHEN MAKING ADJUSTMENTS TO AVOID INJURY IF ANY MALFUNCTION SHOULD OCCUR AND CAUSE LOAD OR CARRIAGE TO FALL.

1. Elevate carriage to about 4 feet.

2. Smear grease on the innerslide channel as shown in Plate 8622.

3. Pick up a capacity load.

NOTE

It is important that the chain adjustment be made with a capacity load. In this manner you will allow for chain stretch.

4. Making sure uprights are either vertical or aft of vertical, lower load to the bottom.

5. Remove capacity load.

6. Raise carriage and measure the distance from where the center of the bottom carriage roller stopped, to the bottom edge of the inner slide. Distance must not be less than ½''.

LUBRICATE MACHINE

Lubricate all miscellaneous linkage with SAE 20 oil and all grease fittings with chassis grease. (Refer to Lubrication Chart).

CAUTION

WHEN LUBRICATING MACHINE, INSPECT FOR LEAKING HYDRAULIC LINES, FITTINGS, AND DAMAGED ELECTRICAL WIRING.

HYDRAULIC CONTROL VALVE AND LINES

Inspection for damage, leakage and security of mounting.

LIFT BRACKET

Inspect for damage, bent forks, etc.

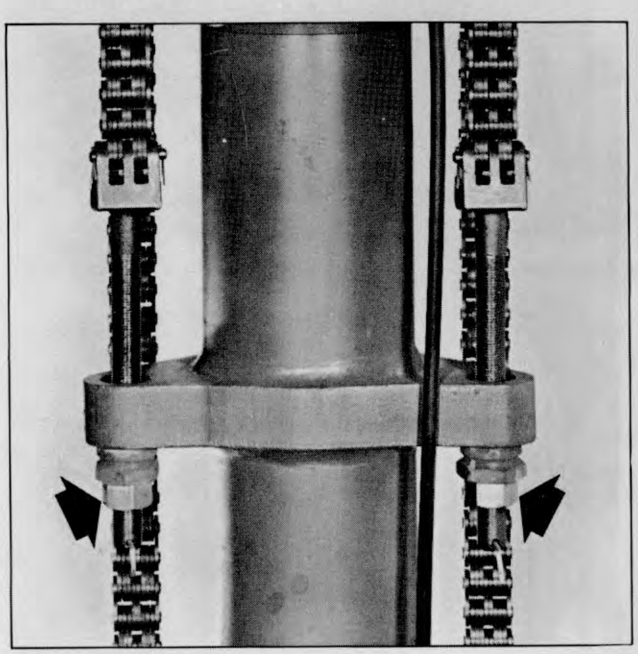

Plate 6634. Lift Chain Adjustment (Chain Anchor Rods)

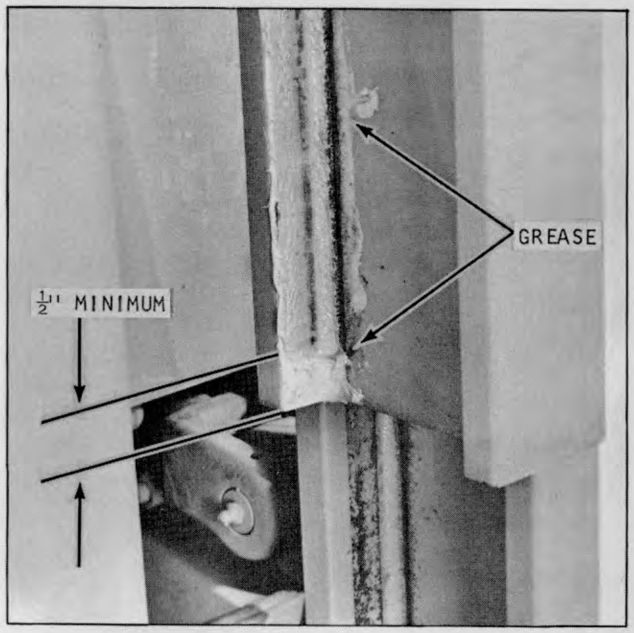

Plate 8622. Lift Chain Adjustment

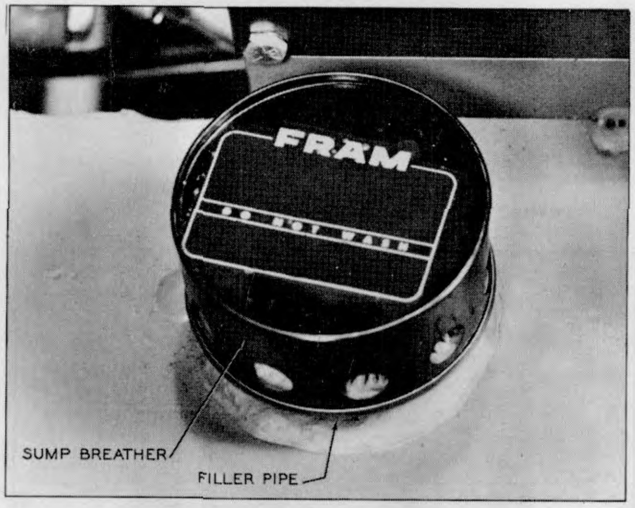

Plate 6626. Hydraulic Sump Tank

HYDRAULIC SUMP TANK BREATHER

Check breather to be sure it is not dirty or clogged with foreign matter. Replace breather if dirty.

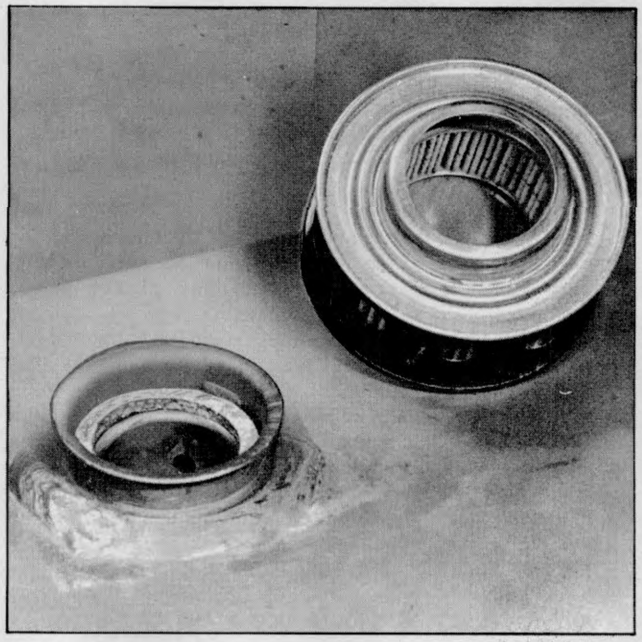

Plate 6682. Hydraulic Sump Tank & Sump Breather

STEERING GEAR

Verify lubricant level, fill if necessary with AMOCO Lithium Multipurpose Grease or its equivalent.

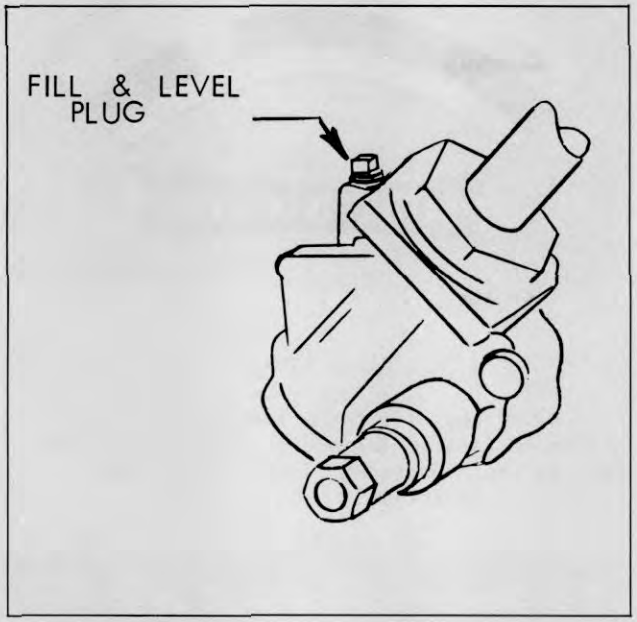

Plate 6429. Steering Gear

BATTERY INSPECTION

Remove all caps and check fluid level. Keep the fluid in each battery cell above the plates or up to the level ring in the bottom of the filler well. Use only pure distilled water. If the machine is exposed to freezing temperatures, operate the engine for a period of time to make sure the added water mixes thoroughly with the battery electrolyte solution. Otherwise, the water may freeze and damage the battery.

x x x x x x x x x x x x x x x x x x x x x x x x x

WARNING

NEVER ALLOW FLAME OR SPARKS NEAR THE BATTERY FILLER HOLES BECAUSE EXPLOSIVE HYDROGEN GAS MAY BE PRESENT

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Take hydrometer reading of electrolyte to determine state of charge. Charge battery if reading is below 1.225 at 24° C (75° F), or below 1.265, if machine is exposed to freezing temperatures. If machine is operating in tropical areas in which freezing weather is not encountered, the full charge specific gravity reading may be lowered from 1.375 to 1.225 by diluting the electrolyte with distilled water.

NOTE

Add distilled water before charging. Do not add distilled water immediately after a charge.

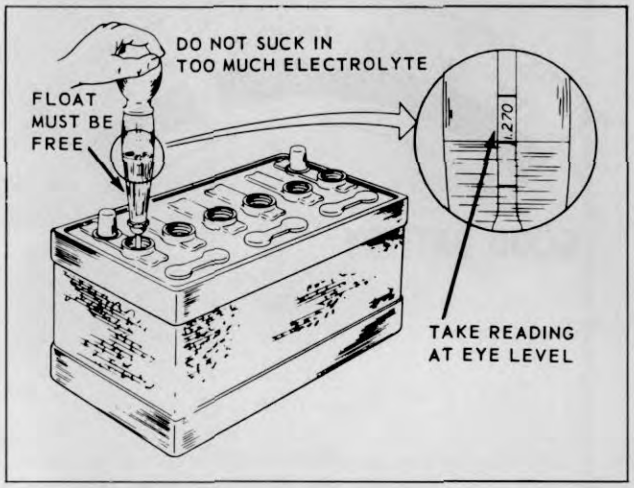


Plate 6271. Checking Specific Gravity of Battery

Make sure that all connections are tight at battery, starter, generator voltage regulator, distributor and spark plugs. Corrosion can be removed from the battery cables and terminals with a solution of baking soda or ammonia and water. After cleaning, flush the top of the battery with clean water, and coat the parts with grease to retard further corrosion.

BATTERY TEST PROCEDURE

A defective battery or a discharged battery may be found by performing the following "Light Load Test"

1. Place an electrical load on the battery by cranking the engine for three seconds. If it starts, turn the ignition off immediately.

2. Place a 10 ampere load across the battery terminals for one minute. This will condition the battery so an accurate voltage comparison test can be made between cells. (Turning two headlights on low beam will equal the 10 ampere load - this method may be used in place of the load placed across the terminals)

3. After one minute, and with the 10 ampere load still on the battery, check the individual cells with an expanded scale voltmeter.

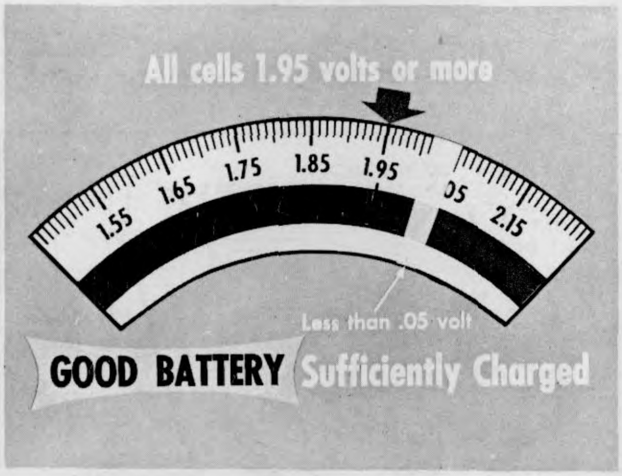


Plate 8306.

4. Place the positive voltmeter prod on the positive side of the cell and the other prod on the negative side. A good battery, sufficiently charged will read 1.95 volts or more on each cell with a difference of less than .05 volt between hightst and lowest cell.

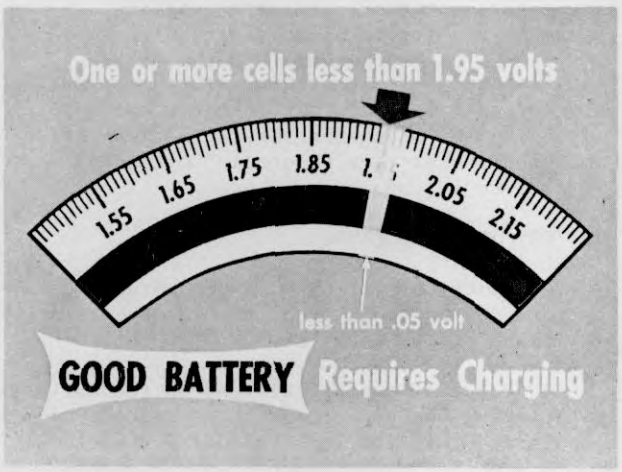


Plate 8307.

5. If cells read both above and below 1.95 volts and the difference between highest and lowest cell is less than .05 volt, battery is good but requires charging.

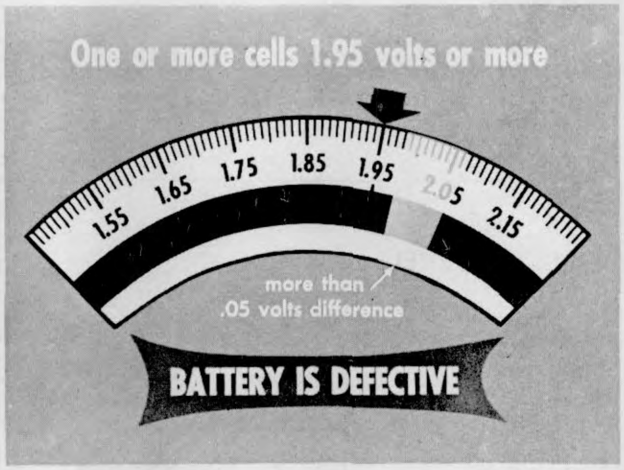


Plate 8308.

6. If any cell reads 1.95 volts or more and there is a difference of .05 volt or more between the highest and lowest cell, the battery is defective.

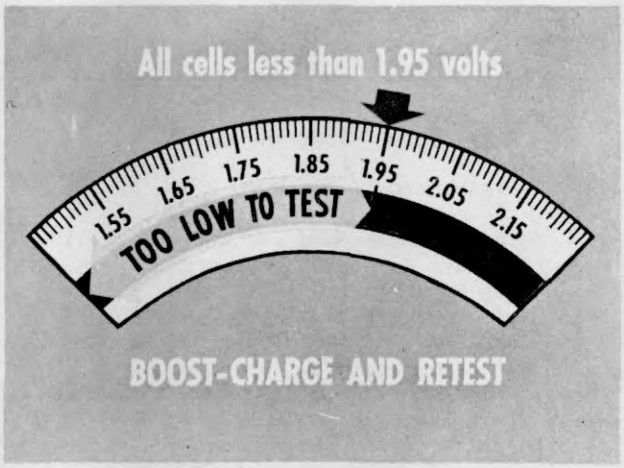


Plate 8309.

7. If all cells read less than 1.95 volts, battery is too low to test accurately. Boost-charge and repeat light load test.

INDUSTRIAL TRUCK DIVISION

CLARK EQUIPMENT

LUBRICATION CHART KEY

ENGINE OIL........................
SAE 10W ---- 0 deg. to 32 deg. F.
SAE 20W ---- 33 deg. to 75 deg. F.
SAE 30 ---- above 75 deg F.
Low Temperature Operation......Multi-Grade Oil

Multi-viscosity oil should be used ONLY where cold starting conditions make it necessary. The oil supplier should assume full responsibility for satisfactory performance of the engine operating temperatures.

Shell X-100 or Rotella T Motor Oil
Sunfleet MIL-B Motor Oil
Sinclair Extra Duty Motor Oil or Tenol Motor Oil
Gulflube Motor Oil X.H.D.
AMOCO 200
Citgo C300 LP Gas Engine Oil & Preminum Motor Oil
Havoline or URSA Extra Duty Motor Oil
Purol HD Motor Oil
or the equivalent to the above.....................

TRANSMISSION FLUID.................
Automatic Transmission Fluid, Type "A", Suffix "A". Fluid Containers must display a qualification number prefixed by AQ-ATF. Clark Part Number 879803.
Automatic Transmissions and Hydracool Clutch ....Standard Transmissions.
Transmission/Axle Adaptor/Power Steering System have a common sump.

Shell Automatic Transmission Fluid Donax T-6
Sunoco Automatic Trans. Fluid Type "A", Suffix "A"
Sinclair Automatic Trans. Fluid Type "A", Suffix "A"
Gulf Automatic Trans. Fluid Type "A", Suffix "A"
AMOCO Automatic Trans. Fluid Type "A", Suffix "A"
Citgo Automatic Trans. Fluid Type "A", Suffix "A"
Texamatic Automatic Trans. Fluid Type "A" 1826-3528
Purelube Automatic Trans. Fluid Type "A", Suffix "A"
or the equivalent to the above.....................

BRAKE MASTER CYLINDERS............
SAE 70R3 (Heavy Duty Brake Fluid), Clark Part Number 1800200.
R.H. Brake Master Cylinder....and, Inching/Brake Master Cylinder.

Shell Super Heavy Duty Hydraulic Brake Fluid
Gulf Heavy Duty Hydraulic Brake Fluid
Atlas Heavy Duty Hydraulic Brake Fluid
Texaco Super Heavy Duty Hydraulic Brake Fluid
Pure Super Heavy Duty Hydraulic Brake Fluid
or the equivalent to the above.....................

HYDRAULIC SUMP TANK..............
Hydraulic Fluid per Clark Specifications MS-68.
Clark Part Number 885385.

Shell LO Hydrax 127
Sunvis Industrial Oil #816 WRP
Gulf Harmony 43 AW
AMOCO Industrial Oil RL #14A
Citgo Pacemaker XD-15 MS-68 Hydraulic Oil
Texaco 729 Rando Oil HD-A
Puropale RX Hydraulic Oil #150
Molub-Alloy Industrial Hydraulic Oil #601
or the equivalent to the above.....................

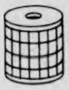
AXLE END/STEER WHEEL BEARINGS...
NLGI #1 or NLGI #2....A smooth multi-purpose grease or refined mineral oil blended with a lithium soap thickner containing anti-wear, anti-rust and anti-oxidants with "EP" additives. To meet or exceed Clark Specifications MS-107 and Timken Test 40# minimum.

Shell Aluania "EP" Grease #1 or #2
Sun Prestige 741 "EP" #1 or 742 "EP" #2
Gulfcrown Grease "EP" #1 or #2
Amolith Grease "EP" #1 or #2
Citgo HEP Grease #1 or #2
Texaco Multifak "EP" #1 or Marfak All Purpose #2
Poco HT Grease "EP" #1 or #2
Molub-Alloy General Purpose Grease #1 or #2
or the equivalent to the above.....................

CHASSIS LUBRICANT..................
NLGI #2 (same as stated above)

NLGI #2 (refer to the above)

CHAIN LUBE........................
Lift Chain Lube, Clark Part Number 886399.



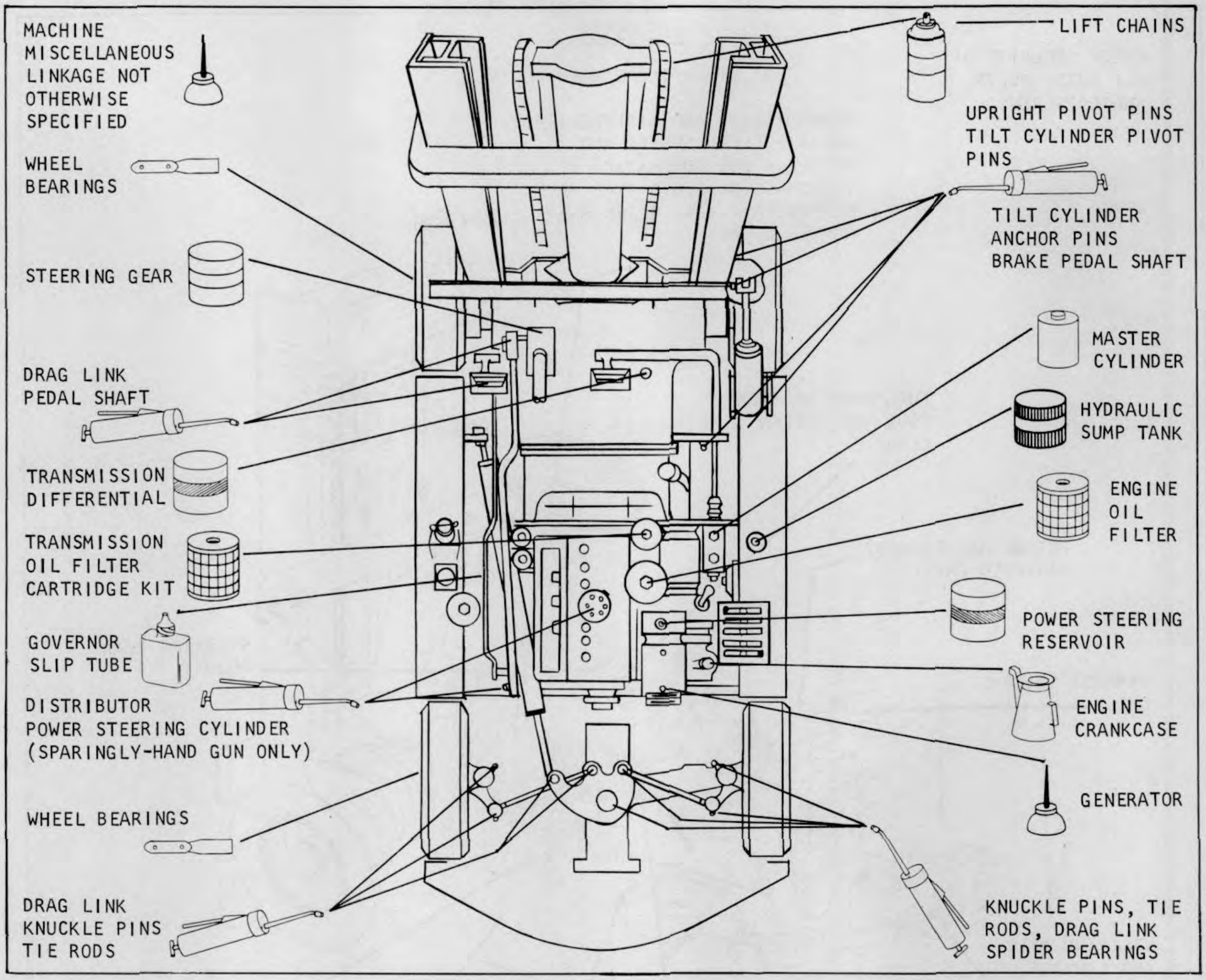
OIL FILTERS.........................
Oil Filter Cartridge Kit.
Engine Oil Filter/Hydraulic Sump Tank Fluid Filter/Transmission Fluid Filter.

Technical Societies in Reference

AGMA..American Gear Manufacturers Association
API.....American Petroleum Institute
ASTM...American Society for Testing Materials
ICEI.... Internal Combustion Engine Institute
MIL.... Military Specification
NGPA.. Natural Gas Processors Association
NLGI...National Lubricating Grease Institute
SAE.....Society of Automotive Engineers

INDUSTRIAL TRUCK DIVISION

LUBRICATION AND PREVENTIVE MAINTENANCE



CHASSIS GREASE

ENGINE OIL: S.A.E. 20

GEAR LUBE: S.A.E. 90

OIL FILTER
CARTRIDGE KIT

1800200 HYDRAULIC BRAKE FLUID
HEAVY DUTY S.A.E. 70R3

879803 AUTOMATIC
TRANSMISSION FLUID
TYPE "A", SUFFIX "A"
(CAN MUST HAVE NUMBER
PREFIXED BY "AQ-ATF".

HYDRAULIC FLUID - CLARK
SPECIFICATION MS-68 885385

ENGINE OIL--S.A.E. 10W 0 deg-32 deg F
S.A.E. 20W 32 deg-75 d F.
"Service MS"S.A.E. 30 above 75 deg F.
Or use 10W-30 MULTI-GRADE OIL.

GRAPHITE GREASE

886399 CHAIN LUBE

WHEEL BEARING GREASE
SPEC. MS 9C GREASE
AXLE ENDS-#1 EP LITHIUM SOAP GREASE

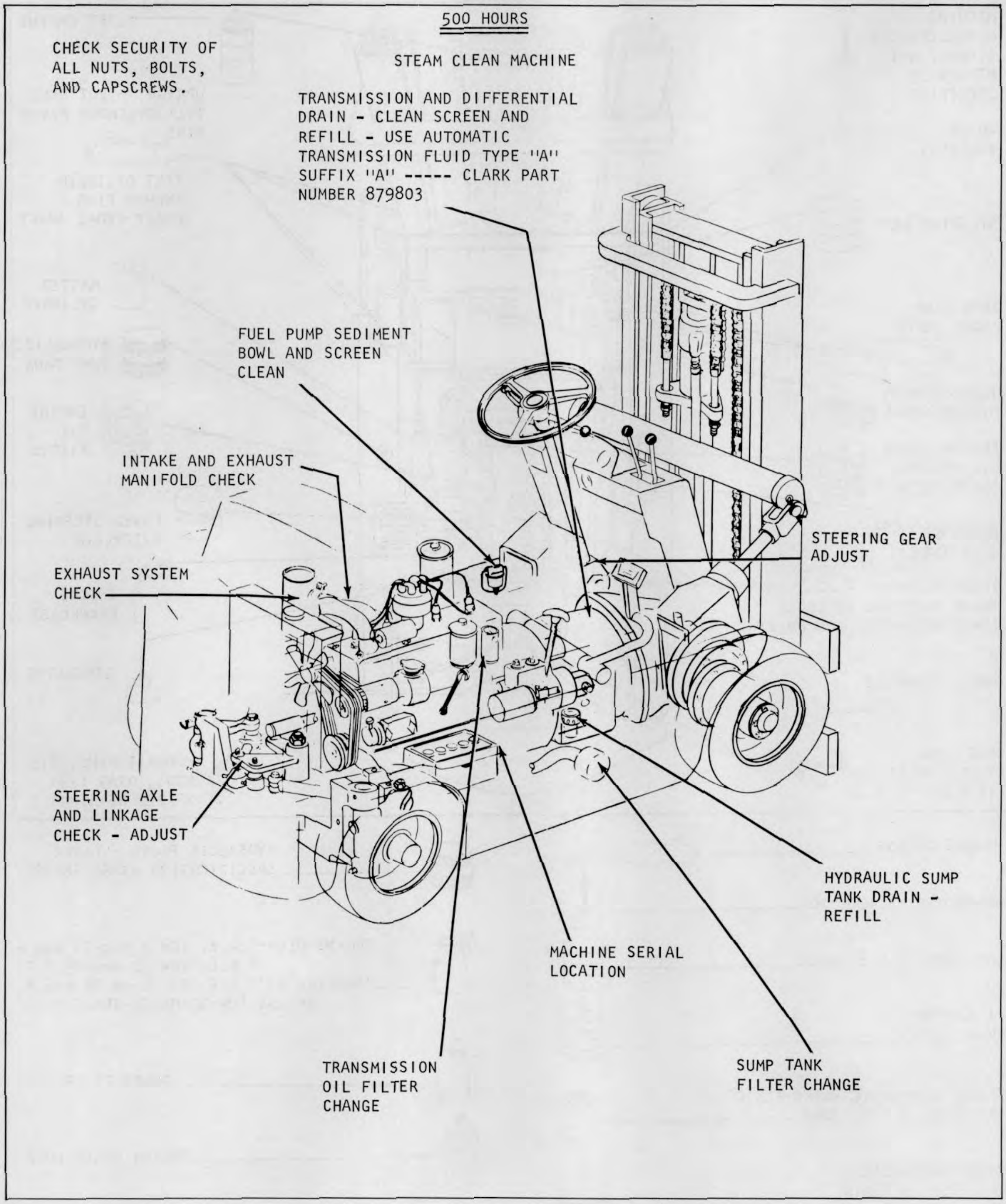


Plate 9482. Lubrication and Preventive Maintenance Illustration

FUEL PUMP STRAINER

The fuel filter and sediment bowl should be cleaned every 500 operating hours. Remove and clean sediment bowl. If fuel strainer is dirty, install a new strainer assembly and gasket. Do not reuse old gasket.

FUEL PUMP

To determine if the fuel pump is defective, remove the fuel tank supply line at the pump and blow out line with compressed air to remove any possible obstructions. Reconnect fuel tank line and disconnect pump to carburetor line. Install a fuel pressure gauge, by placing a "T" in the line, and run engine at 1800 R. P. M. with all lines connected. Fuel pump pressure should be between 1 1/2 and 2 1/4 pounds. If the fuel pump pressure is not within this range the pump should be removed for repair or replacement.

C A U T I O N

TO AVOID CREATING A FIRE HAZARD CARE SHOULD BE TAKEN SO THAT GASOLINE IS NOT SPILLED DURING THESE OPERATIONS.

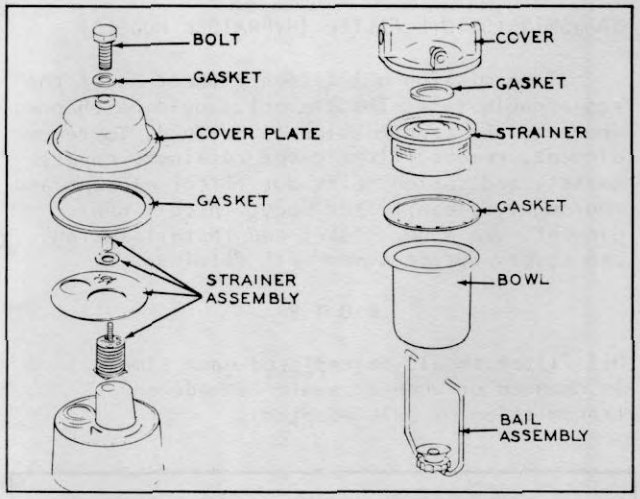


Plate 6638. Fuel Pump & Sediment Bowl

TRANSMISSION OIL FILTER (HYDRATORK MODELS)

Transmission oil filter element is of the replaceable type. The element should be changed whenever the transmission is drained. To remove element, remove filter cover retainer, cover, gasket, and spring. Lift out filter element and thoroughly clean filter body. Install new element. Use a new gasket and install spring and cover. Secure cover with retainer.

NOTE

Oil filter should be replaced each time oil is changed or when a repair is made on transmission or axle adapter.

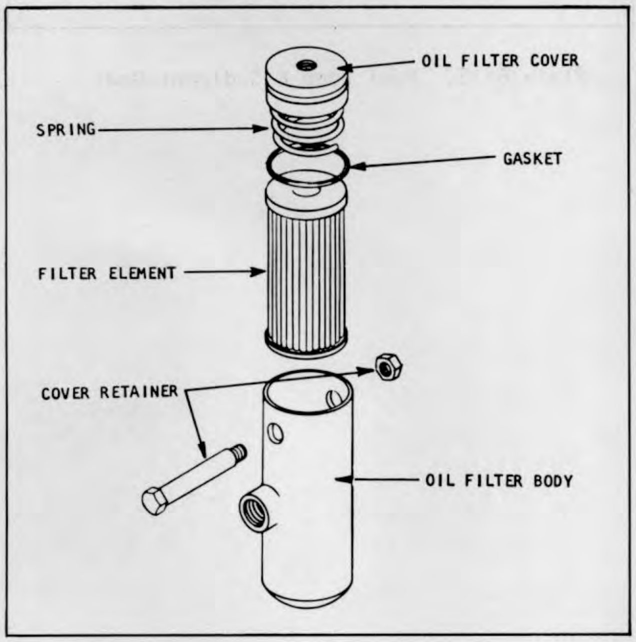


Plate 7234. Transmission Oil Filter

CONVERTER, AXLE ADAPTER AND TRANSMISSION SUMP SCREEN.

1. Drain transmission and axle adapter at operating temperatures. See Plate 7301 on following page for location of drain plugs.

CAUTION

DO NOT USE FLUSHING OIL OR COMPOUND TO FLUSH SYSTEM.

2. Remove and clean transmission sump screen in a Stoddard type solvent. Dry with filtered compressed air - directing air thru neck of screen.

Plate 7235. Transmission Sump Screen

3. It is recommended that a new "O" ring be used when installing the sump screen.

4. Refill transmission and axle adapter to the full mark as indicated on the dipstick. Use Automatic Transmission Fluid Type "A", Suffix "A". Clark part number 879803. Fluid containers must display a qualification number prefixed by "AQ-ATF".

5. Operate engine for a short period of time to completely charge the converter and plumbing with fluid; then recheck fluid level. To accurately check the fluid level the transmission should be at normal operating temperature, engine running at low idle, and transmission in neutral.

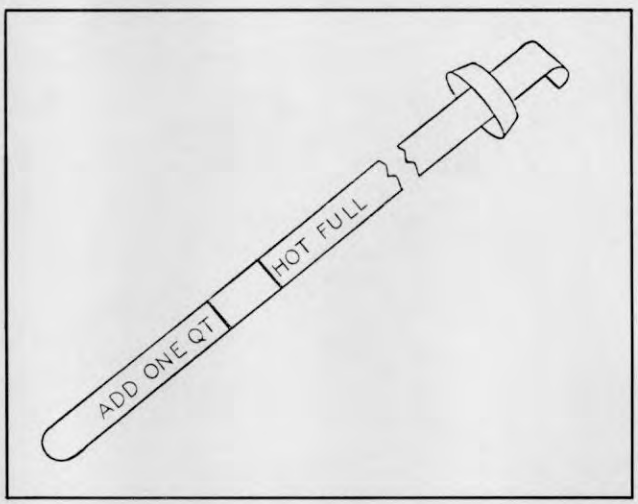


Plate 8281. Transmission Dipstick

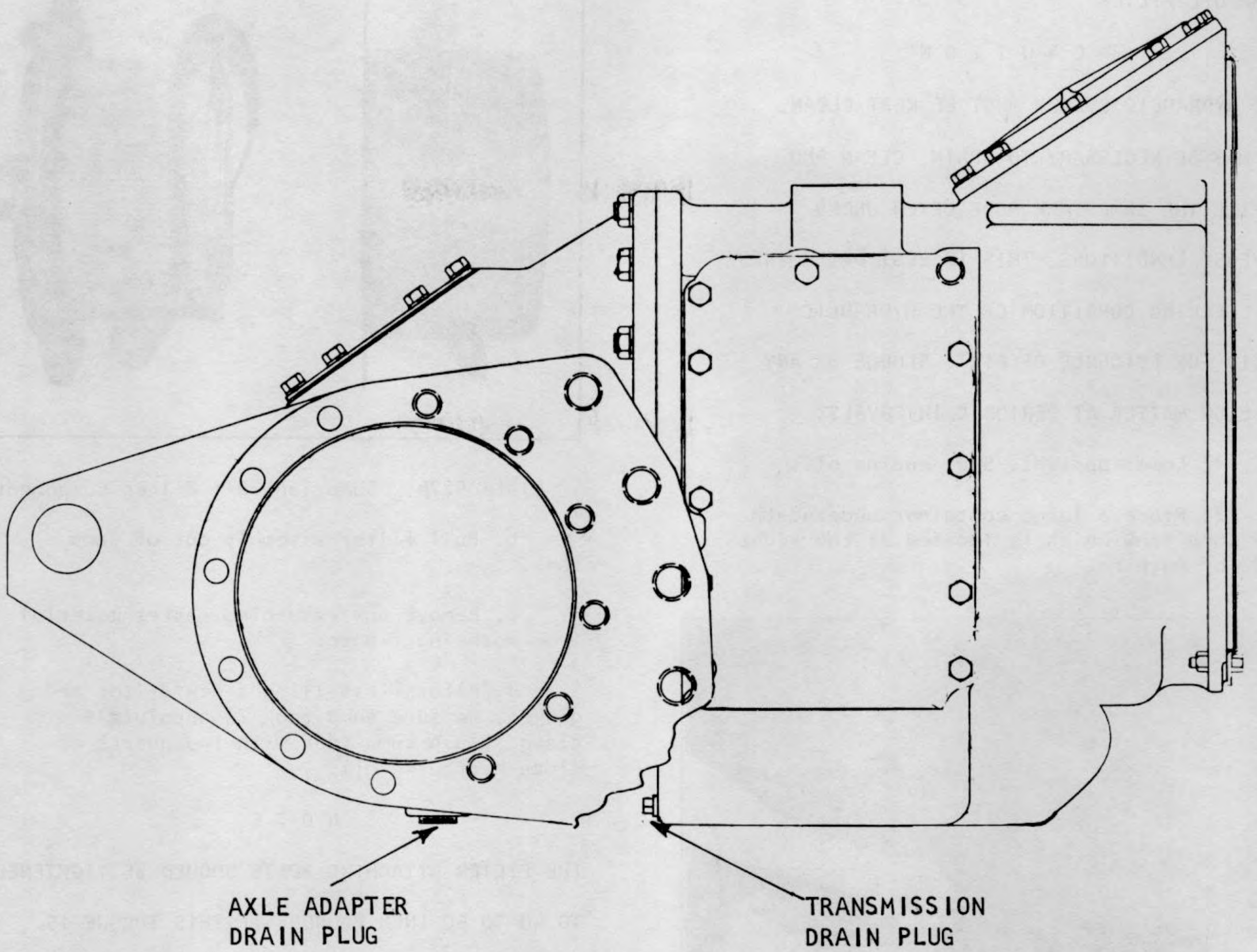


Plate 7301. Axle Adapter and Transmission Drain Plugs

HYDRAULIC SUMP TANK AND
SUMP OIL FILTER

CAUTION

THE HYDRAULIC SYSTEM MUST BE KEPT CLEAN. IT MAY BE NECESSARY TO DRAIN, CLEAN AND REFILL THE SUMP TANK MORE OFTEN UNDER ADVERSE CONDITIONS. THIS IS BEST DETERMINED BY CHECKING CONDITION OF THE HYDRAULIC FLUID FOR EVICENCE OF DIRT, SLUDGE OR ANY FOREIGN MATTER AT PERIODIC INTERVALS.

1. Lower upright. Shut engine off.

2. Place a large container underneath the sump tank which is located at the right side of machine.

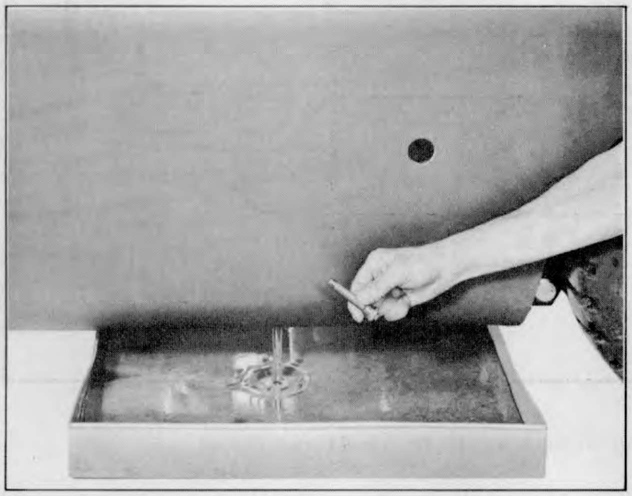


Plate 5359. Draining Sump Tank

3. Remove sump tank drain plug, located at bottom of tank, and allow the fluid to drain. Replace drain plug.

CAUTION

DO NOT START ENGINE WHILE SUMP TANK IS EMPTY AS DAMAGE TO THE HYDRAULIC PUMP WILL RESULT.

4. Remove Filter and Clean Sump Tank:

a. Disconnect hose and remove filter retainer bolts.

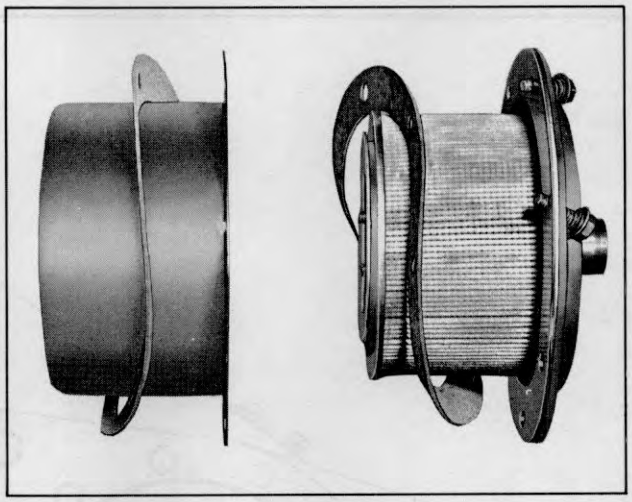


Plate 5274. Sump Tank Oil Filter Components

b. Pull filter assembly out of sump tank.

c. Remove any remaining gasket material from mounting flange.

d. Before installing a new filter and gasket, be sure sump tank is absolutely clean. Flush sump tank with two quarts of clean hydraulic oil.

NOTE

THE FILTER ATTACHING BOLTS SHOULD BE TIGHTENED TO 40 TO 50 INCH POUNDS. IF THIS TORQUE IS EXCEEDED, DISTORTION MAY OCCUR, CAUSING LEAKAGE.

e. Install hose and tighten hose connections.

5. Fill sump tank with MS 68 Hydraulic fluid until level reaches the bottom of the fill pipe.

CAUTION

START ENGINE AND OPERATE HYDRAULIC CONTROL LEVERS SEVERAL TIMES. CHECK OIL FILTER FOR LEAKS, RECHECK OIL LEVEL AND FILL TO BOTTOM OF FILL PIPE IF NECESSARY.

STEERING GEAR

Steering gear adjustments must be made in the following manner (see Plates 6636 and 6637).

Always check worm bearing thrust adjustment, and adjust if necessary, before making sector gear lash adjustment.

Before making above adjustments, the following preliminary operations are necessary.

1. Disconnect steering drag link from pitman arm. Note relative position of drag link parts when disconnecting link so the parts may be re-assembled correctly.

2. Check lubricant level in steering gear housing. If low, add enough lubricant to bring level up to filler plug hole. (Use AMOCO Lithium Multipurpose Grease or its equivalent.)

3. Tighten steering gear housing to frame side member bolts, see Plate 6636.

4. Determine straight-ahead position of steering mechanism by turning steering wheel to extreme right.

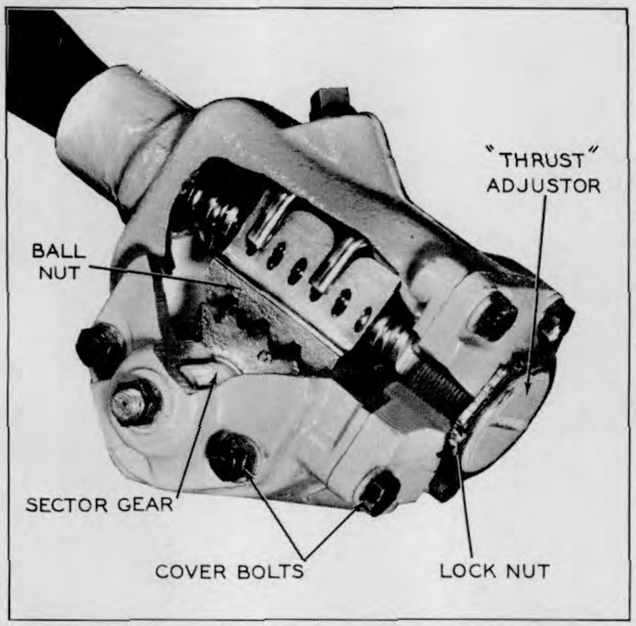


Plate 6636. Steering Gear Thrust Adjustment (Worm Bearings)

CAUTION
APPROACH EXTREME ENDS CAUTIOUSLY; WORM BALL NUT MUST NOT STRIKE ENDS WITH ANY DEGREE OF FORCE.

Then turn to extreme left, counting the exact number of turns from right to left end. Turn wheel back one-half number of wheel turns. Mark wheel with respect to steering column so center position may readily be found during adjustment procedures.

Worm Bearing THRUST Adjustment: Refer to Plate 6636 and proceed as follows:

1. Check tightness of cover bolts, see Plate 6636. Loosen lock nut and turn lash adjuster screw (Plate 6637) counter-clockwise a few turns to provide clearance between sector gear and worm ball nut.

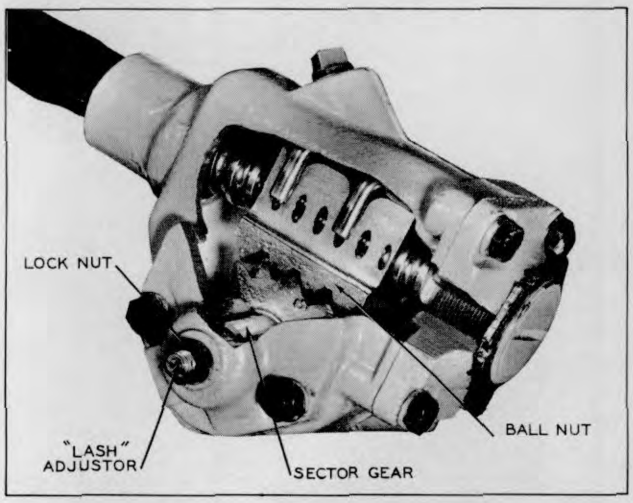


Plate 6637. Steering Gear Lash Adjustment (Sector Gear)

2. Turn steering wheel GENTLY to one extreme end. Turn wheel back one full turn. With spring scale on spoke of wheel, measure pull required to KEEP WHEEL MOVING. Pull on scale should be made at right angles to wheel spoke. If pull is within 1 1/2 to 2 pounds, proceed to lash adjustment in the following paragraphs. If pull is not within 1 1/2 to 2 pounds, adjust worm bearings. The pitman shaft adjustment must be made if worm bearing check is accomplished, or if the worm bearings are adjusted.

3. If it is necessary to adjust the worm bearings, loosen lock nut and then turn worm bearing adjuster nut clockwise until all end play is removed, see Plate 6636. Using spring scale, as directed in Step 2, check pull and readjust as necessary; then tighten lock nut securely.

Sector Gear Lash Adjustment: Refer to Plate 6637 and proceed as follows:

1. Steering Gear Mechanism must be in straight ahead position as previously explained.

2. Turn lash adjuster screw clockwise to remove all lash between gear teeth. Tighten adjuster screw lock nut. Position spring scale on steering wheel so pull may be made at right angles to wheel spoke.

3. Measure pull while wheel is TURNED THROUGH CENTER POSITION. Readjust if reading is not within 2 1/2 to 3 pounds.

4. Tighten adjuster screw lock nut, check pull again.

5. After adjustments are made, install drag link on pitman arm.

NOTE

IF STEERING LINKAGE ADJUSTMENT IS NECESSARY

DO NOT INSTALL DRAG LINK TO PITMAN ARM.

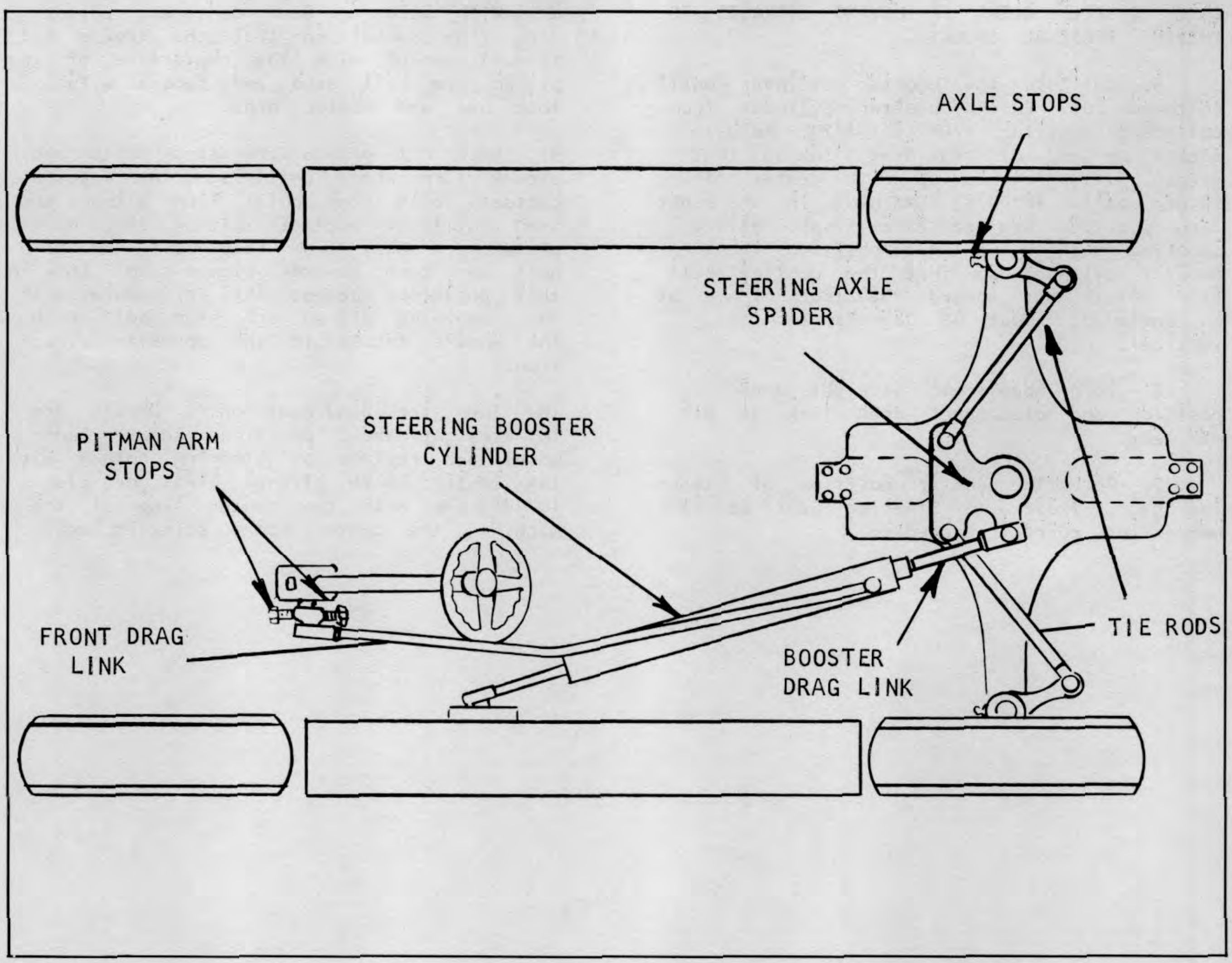


Plate 7340. Steering Linkage

STEERING AXLE AND LINKAGE ADJUSTMENTS

1. Raise the steering wheels far enough to clear the floor and place heavy blocking under the machine frame so it cannot accidentally become lowered during adjustments.

2. The steering wheels should track square with the drive wheels with no toe-in or toe-out. If adjustment is necessary loosen the lock nuts at the tie rod ends and turn each tie rod in a manner so they will be the <u>same length</u> when the correct adjustment is obtained. Tighten tie rod lock nuts to secure this adjustment.

3. Disconnect the steering booster socket from the steering axle spider noting the relative position of the socket parts so they may be re-installed correctly after checking wheels for correct turning geometry.

4. Check wheels for correct turning geometry by turning the wheels all the way for a left turn - this should allow the left wheel to attain an angle of 75 degrees to the frame on pneumatic tire machines and 78 degrees on solid tire machines. If an adjustment is necessary, the axle stop on the left side should be turned in or out whichever is necessary to acheive the correct angle. Repeat this procedure in a right turn with the opposite wheel and adjust the right axle stop as required.

WARNING

IF THE STEERING BOOSTER CYLINDER IS TO BE ACTUATED UNDER POWER DO SO ONLY WITH THE ENGINE RUNNING AT IDLE SPEED, USING EXTREME

CARE TO KEEP CLEAR OF MOVING LINKAGES TO PREVENT PERSONAL INJURY.

5. Collapse the booster cylinder until bottomed out. Extend booster cylinder from collapsed position 1/4" to 1/2". Adjust socket on end of rear drag link so that grease fitting lines up with center of spider ball. (Wheels remaining in the right turn position against axle stop). Before securing socket lock nut position the booster cylinder so that the control ball stud points out toward the truck frame at an angle of about 45 degrees to the vertical.

6. *Turn wheels to straight ahead* position and disconnect drag link at pitman arm.

7. Determine center position of steering gear. (Refer to Steering Gear adjustments for correct procedure).

8. With Steering Gear centered; adjust drag link socket so that the grease fitting lines up with the centerline of the pitman arm ball stud and secure with lock nut and cotter pin.

9. Back off pitman arm stop bolts and slowly turn wheel until steering knuckle contacts axle stop bolt. Turn pitman arm stop until it contacts pitman arm. Move pitman arm away from stop bolt and turn bolt one turn towards pitman arm. Lock in this position. Repeat this procedure with the remaining pitman arm stop bolt with the wheels turned in the opposite direction.

10. Turn the handwheel until wheels are in straight ahead position. Remove handwheel and replace on steering column with the center spoke aligned minus or plus 10 degrees with the center line of the machine, the center spoke pointing back.

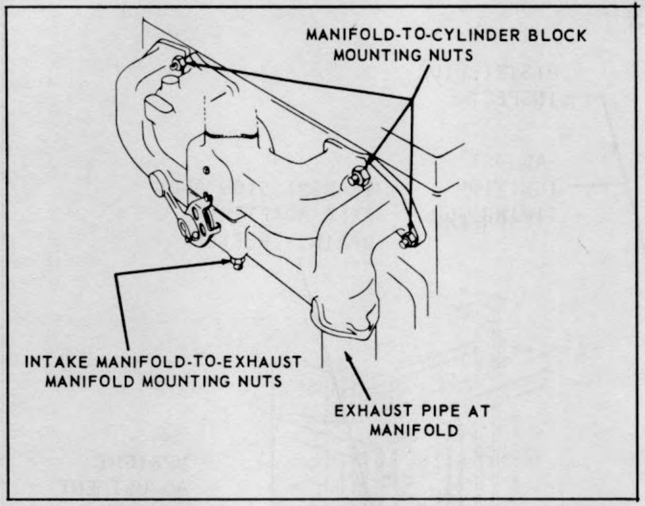


Plate 6269. Intake and Exhaust Manifolds

INTAKE AND EXHAUST MANIFOLDS

1. Inspect gaskets for leaks and inspect security of manifold nuts.

2. Inspect exhaust pipe and muffler for damage, leakage and security of mountings.

NUTS, BOLTS AND CAP SCREWS. Check security of mounting, tighten as required.

LUBRICATION AND PREVENTIVE MAINTENANCE

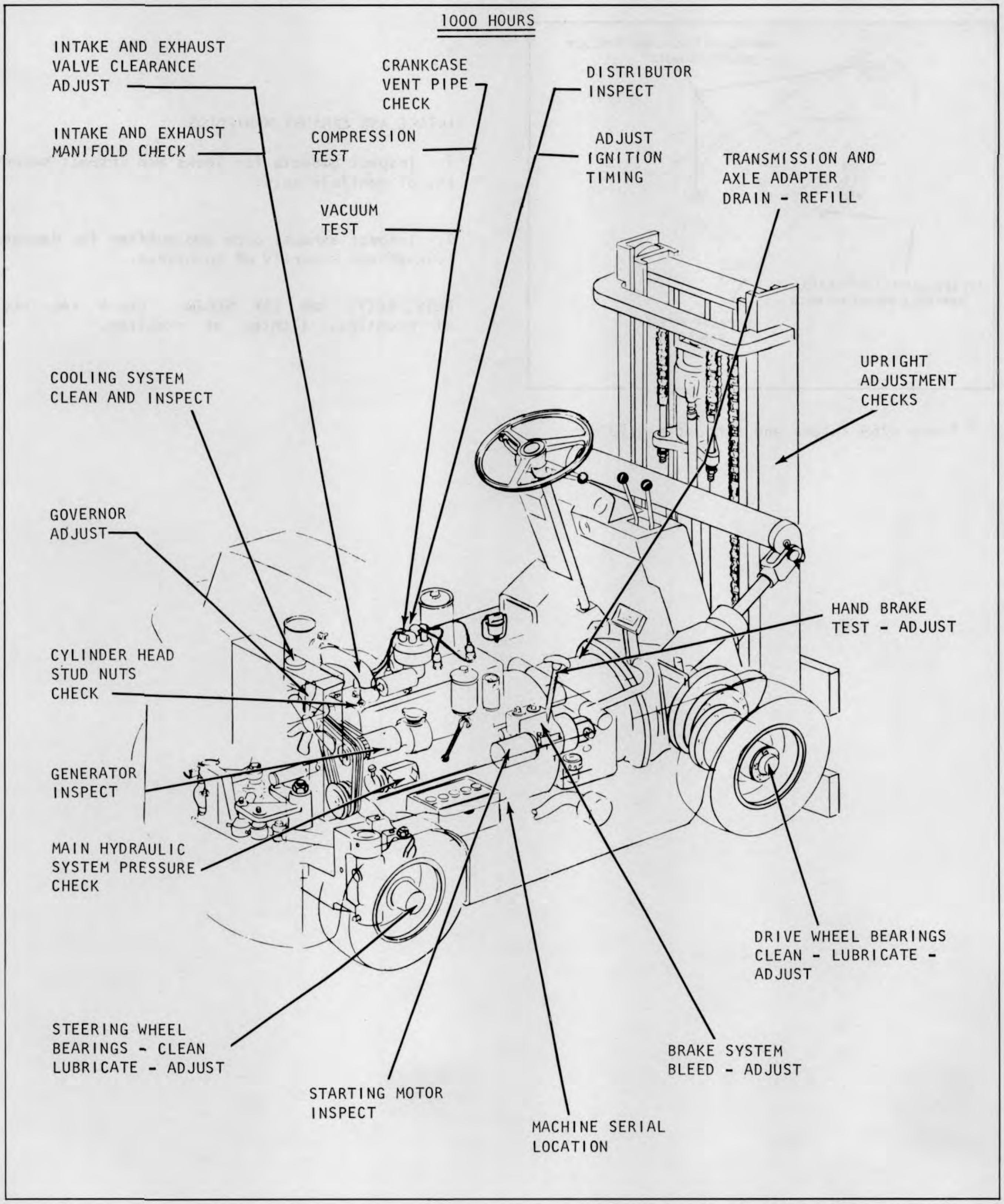


Plate 9484. Lubrication and Preventive Maintenance Illustration

ENGINE TUNE-UP

Engine tune-up is the orderly and systematic process of checking the engine and accessory equipment to maintain or restore satisfactory engine performance. Engine tune-up must be accomplished semi-annually and more frequently if engine performance indicates the need for these services. Perform engine tune-up as follows:

1. AIR CLEANER. Be sure air cleaner has received proper service. Air Cleaner must be installed before making engine tune-up.

2. FUEL PUMP. Be sure the fuel pump bowl and strainer has been properly serviced and the fuel pump is operating satisfactorily.

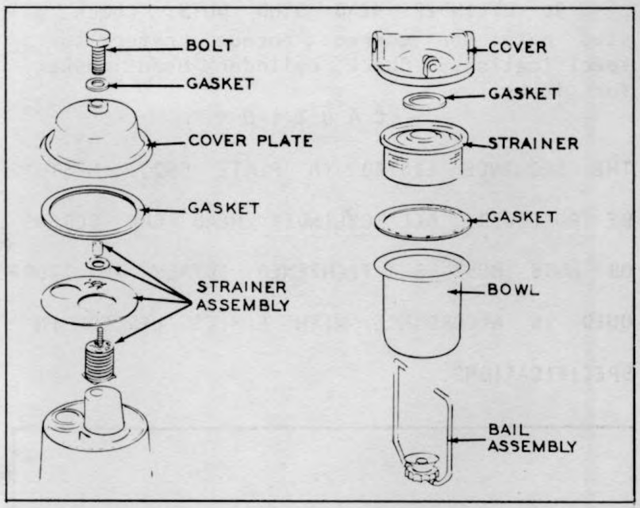


Plate 6638. Fuel Pump Strainer & Sediment Bowl

3. CYLINDER HEAD STUD NUTS. Check all stud nuts for correct torque, refer to specifications. Check cylinder head gasket for leaks.

C A U T I O N

THE SEQUENCE LISTED IN PLATE 5927. MUST BE FOLLOWED. ALL CYLINDER HEAD CAP SCREWS OR NUTS MUST BE TIGHTENED EVENLY AND TORQUED IN ACCORDANCE WITH LIMITS LISTED IN SPECIFICATIONS.

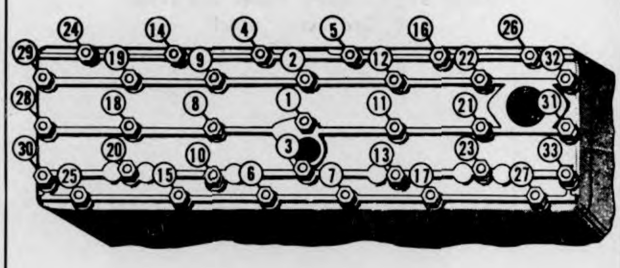


Plate 5927. Cylinder Head Stud Nut Tightening Sequence

4. INTAKE AND EXHAUST MANIFOLDS. Inspect for gasket leaks and security of mounting.

5. CRANKCASE VENTILATION METERING VALVE. The metering valve connected between the intake manifold and valve cover regulates the amount of air which will flow through the crankcase and is controlled by the engine vacuum.

Remove metering valve and disassemble and wash in a Stoddard type cleaning solvent. Before assembling, put a small quanity of very light oil on the metering pin to prevent sticking until its own lubrication is established. The ventilation tube and valve cover should also be cleaned at the same time, particularly if any noticeable amount of sludge accumulation is found.

After installing the metering valve on the engine be sure hose is in good condition and all connections are properly sealed to prevent unfiltered air from entering the engine.

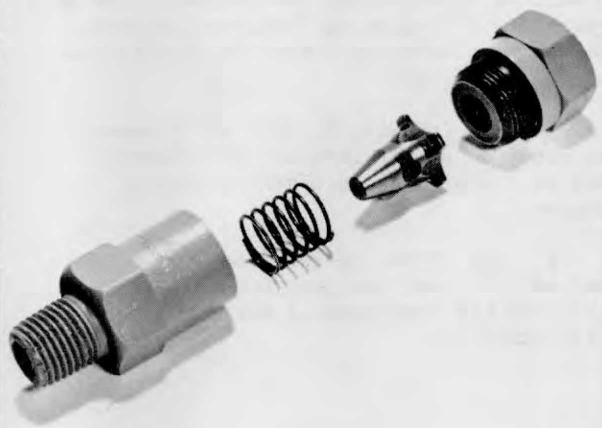


Plate 7034. Crankcase Ventilation Metering Valve

6. INTAKE AND EXHAUST VALVE CLEARANCE ADJUSTMENTS.

a. Remove valve chamber cover mounting screws, and the valve chamber cover gasket.

b. With engine running at idling speed and at normal operating temperature, adjust intake valves as follows:

c. Check for proper 0.014 inch clearance by alternately passing a 0.013 inch and a 0.015 inch flat feeler gauge between head of adjusting screw and valve stem, see Plate 3223 on following page.

d. If a 0.013 inch feeler gauge moves freely back and forth in gap when valve is not being lifted and a 0.015 inch feeler gauge binds, at all times, clearance requires no adjustment.

e. If a 0.013 inch feeler gauge is gripped at all times, the clearance is insufficient.

f. Hold valve lifter with an open end wrench while using a second wrench to turn adjusting screw 1/4 to 1/2 turn clockwise. Repeat clearance check and adjustment, until proper clearance is obtained. The adjustable type valve lifters have self-locking adjusting screws that require no lock nuts.

g. If 0.015 inch feeler moves freely when valve is not being lifted, the clearance is too great. Hold valve lifter with an open end wrench while using a second wrench to turn valve lifter adjusting screw counterclockwise 1/4 to 1/2 turn. Repeat clearance check and adjustment until proper clearance is obtained.

h. Repeat clearance check and adjustment on remaining intake valves.

i. With engine running at idling speed and at normal operating temperature, adjust exhaust valve as follows:

j. Check for proper 0.014 inch clearance by alternately passing a 0.013 inch and a 0.015 inch flat feeler gauge between head of adjusting screw and valve stem cap, See Plate 3223.

k. Follow procedure outlined in paragraphs (d) thru (h).

m. Install valve chamber cover using new valve chamber cover gasket and replace cover mounting screws.

NOTE

DO NOT REUSE OLD GASKETS. THEY DO NOT AFFORD A POSITIVE SEAL.

n. Check valve chamber cover gasket for leaks.

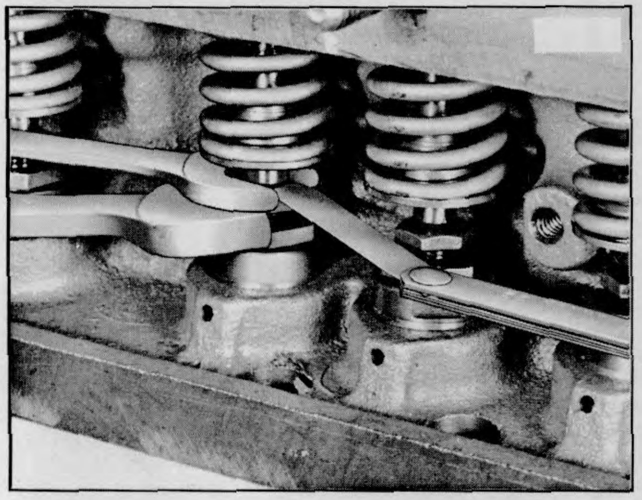


Plate 3223. Adjusting Valve Clearance

6A. COLD SETTING. (ALTERNATE METHOD) To adjust valve clearance when engine is at room temperature and not running, proceed in the following manner:

a. Remove distributor cap.

b. Crank engine until distributor rotor points to No. 1 cylinder position with the breaker points open. In this position the No. 1 piston is at the top of its compression stroke with both lifters on the base circle of the cam and both valves can be adjusted.

c. Adjust the valve clearance to 0.012 inch on the intake and 0.020 inch on the exhaust. The exhaust (e) and intake (I) valve arrangement on the six cylinder engine is: E-I-I-E-E-I-I-E-E-I-I-E.

d. The other valves may be adjusted by setting the engine with the distributor rotor pointing to the rest of the cylinder positions in the sequence of the firing order which is 1-5-3-6-2-4.

7. COMPRESSION TEST

a. Test battery for full charge (specific gravity 1.280 temperature of 24°C (75° F). If battery is not fully charged, replace with fully charged battery.

b. Start engine and allow it to warm up until normal operating temperature is reached.

c. Turn off ignition.

d. Remove spark plug cables from spark plugs and remove spark plugs from cylinder head. Examine spark plugs for carbon deposits, defective insulation and general serviceability. All carbon or lead deposits must be removed from the insulation shell and electrodes. This can be done on a sand blast cleaner. Carbon deposits should be removed from the plug threads with a stiff brush. After cleaning, inspect plugs carefully for cracked or broken insulator, badly pitted electrodes or other signs of failure.

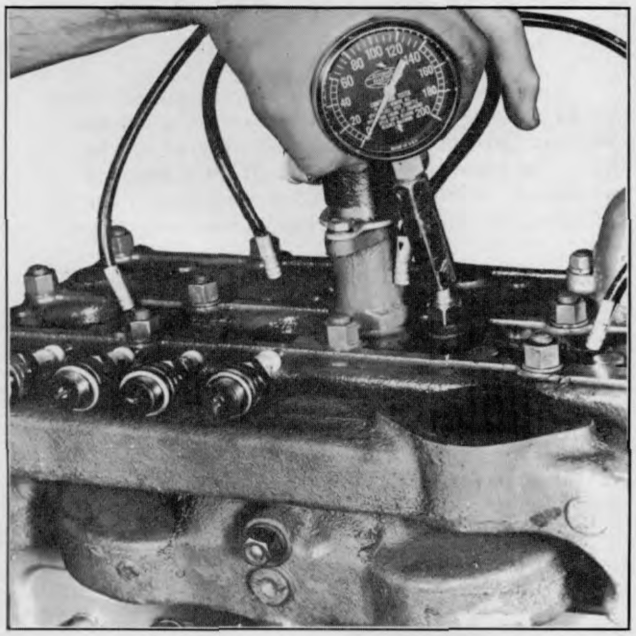


Plate 3486. Compression Test

e. With all plugs removed, install compression gauge in front spark plug port. Operate starting motor until maximum reading on gauge is obtained, see Plate 3486., Record gauge reading. Repeat this operation on each remaining cylinder.

f. If readings are reasonably high (110 to 120) pounds and the readings do not vary more than about 10 pounds between cylinders, compression may be considered normal. Excessively low readings or readings that vary more than 10 pounds between cylinders indicate internal trouble to be corrected after further examination and testing.

g. Set the spark plug gap as specified, by bending side electrode only. The gap should be checked with a wire feeler gauge rather than a flat type gauge as it is better suited for this purpose.

h. Spark Plug Specifications:

Resistor Type - .035" Gap

i. Replace spark plugs using new gaskets. Always replace spark plug gasket whenever a spark plug is removed from the engine. Before installing plugs, be sure that the spark plug seat in the cylinder head is clean and free from obstructions. The spark plug should be screwed into cylinder head (using a socket of proper size) sufficiently tight to fully compress the gasket. This is most important as a large percentage of troubles due to overheated spark plugs are caused by plugs being too loose in the cylinder head. Conversely, excessive tightening may change the gap between the electrodes or crack the insulator.

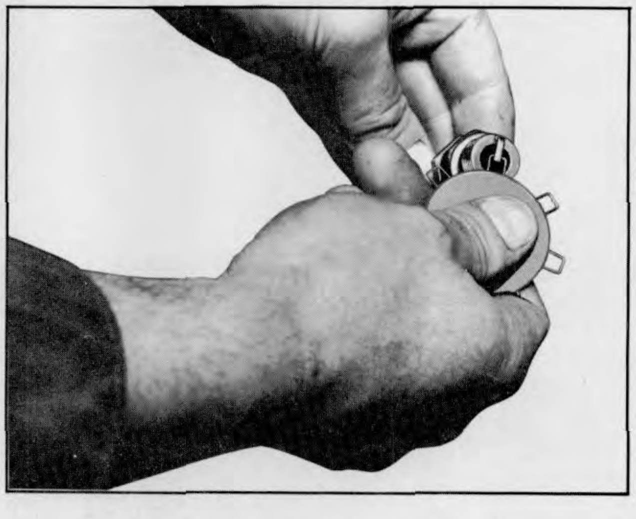


Plate 3278. Check Spark Plug Gap

8. DISTRIBUTOR

Inspection: Remove distributor cap (without removing wires). Wipe cap with a clean cloth. Examine rotor and cap for chips, cracks, corroded terminals, carbon runners (paths which will allow high-tension leakage to ground) or if the vertical faces of the inserts are burned -- install a new cap and rotor, as this is due to the rotor being too short.

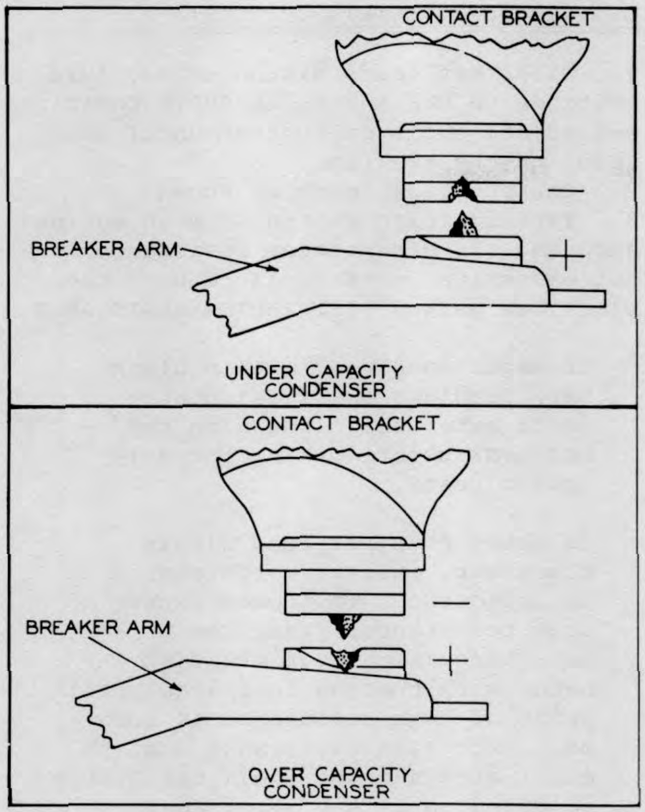


Plate 5933. Breaker Points

Check the 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 without sticking.

Inspect breaker points. If points are pitted, burned or worn to an unserviceable condition, install a new set of points.

The normal color of contact points should be a light gray. If the contact point surfaces are black, it is usually caused by oil vapor, or grease from the cam. If they are blue, the cause is usually excessive heating due to improper alignment, high resistance or open condenser circuit.

Badly pitted points may be caused by a defective or improper condenser capacity.

If the condenser capacity is too high, the crater (depression) will form in the positive contact. If the condenser capacity is too low, the crater will form in the negative contact, see Plate 5933.

For a temporary repair, dress the contact points with a few EVEN strokes using a clean fine-cut contact file. DO NOT ATTEMPT TO REMOVE ALL ROUGHNESS OR DRESS THE POINT SURFACES DOWN SMOOTH. See Plate 7475.

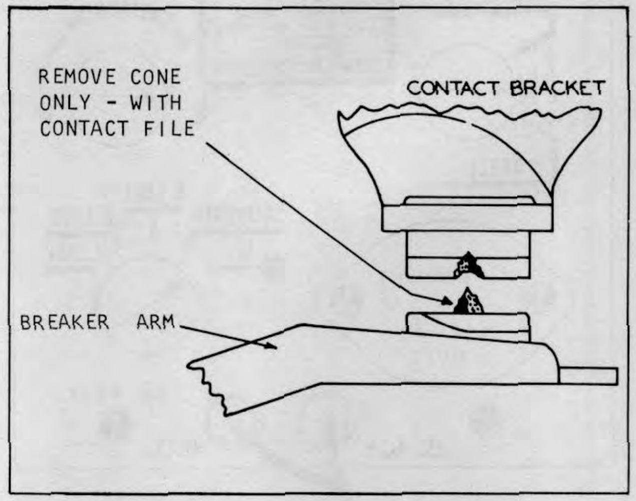


Plate 7475. File Contact Points

CAUTION

NEVER USE EMERY CLOTH OR SANDPAPER TO CLEAN POINTS AS PARTICLES WILL EMBED IN THE POINTS AND CAUSE ARCING AND RAPID BURNING.

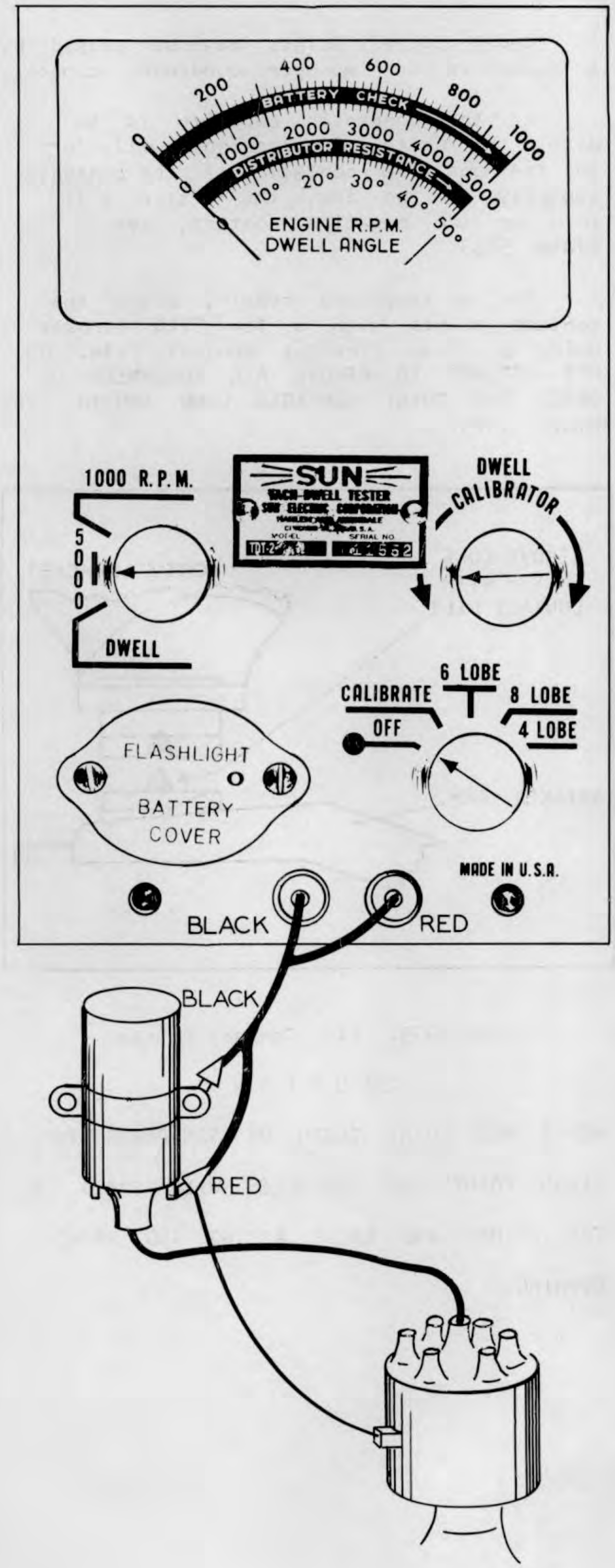


Plate 6887 Tach Dwell Meter

MEASURING ENGINE SPEED

1. Connect the test leads as shown.
2. Turn switch to the LOBE position corresponding to the number of cylinders.
3. Turn the other switch to the 1000 rpm position for all idle and low speed testing. Use the 5000 rpm position for all speeds over 1000 rpm.

DISTRIBUTOR RESISTANCE TEST

1. With test leads disconnected, turn switches to DWELL and CALIBRATE positions and adjust dwell calibrator until meter reads on the SET LINE.
2. Connect test leads as shown.
3. Turn ignition switch ON with engine stopped. If distributor resistance is not excessive, meter will read in the black bar marked DISTRIBUTOR RESISTANCE.

If meter does read within black bar, readjust dwell calibrator until meter again reads on the SET LINE before making the following tests.

If meter does not read within black bar, excessive resistance is indicated. To locate excessive resistance, trace the primary circuit through the distributor with the red test lead until point of high resistance is located. Excessive resistance must be eliminated and the dwell calibrator adjusted until the meter again reads on the SET LINE before proceeding with the following tests.

DWELL AND DWELL VARIATION TESTS

1. Turn switch to the proper LOBE position.
2. Operate engine at idle speed and note reading on dwell scale of meter. Refer to specifications for proper dwell.
3. Turn tachometer switch to the 5000 rpm position and increase speed to 1500 rpm.
4. Turn switch back to the DWELL position and again note dwell reading. Slowly reduce speed to idle while watching meter. Dwell should not change more than 3 degrees in either case.

<u>Contact Point Adjustment</u>: The point opening of new points can be checked with a wire feeler gauge, but the use of a feeler gauge on older, rough points is not recommended, since accurate gauging cannot be done on such points. The gauge measures between high spots on the points instead of the true point opening. Point opening of used points can be checked with a Dwell Angle Meter. A meter of this type indicates the cam or contact angle. This angle is the number of degrees that the breaker cam rotates from the time the points close until they open again. The cam angle increases as the point opening decreases and it is reduced as the point opening is increased. Manufacturers of this type equipment furnish complete instructions as to their use.

NOTE

REFER TO SPECIFICATIONS FOR DWELL ANGLE AND CONTACT POINT OPENING.

To check point opening with a feeler gauge, insert a wire feeler gauge of proper size between the contact points. MAKE CERTAIN THAT THE BUMPER BLOCK ON THE MOVABLE CONTACT IS AT THE HIGH POINT ON THE CAM. If adjustment is necessary, loosen the lock screw, and insert a screwdriver of the proper size in the adjustment slot and move the stationary arm until the correct clearance is obtained. Tighten locking screw and recheck point gap. See Plate 7457.

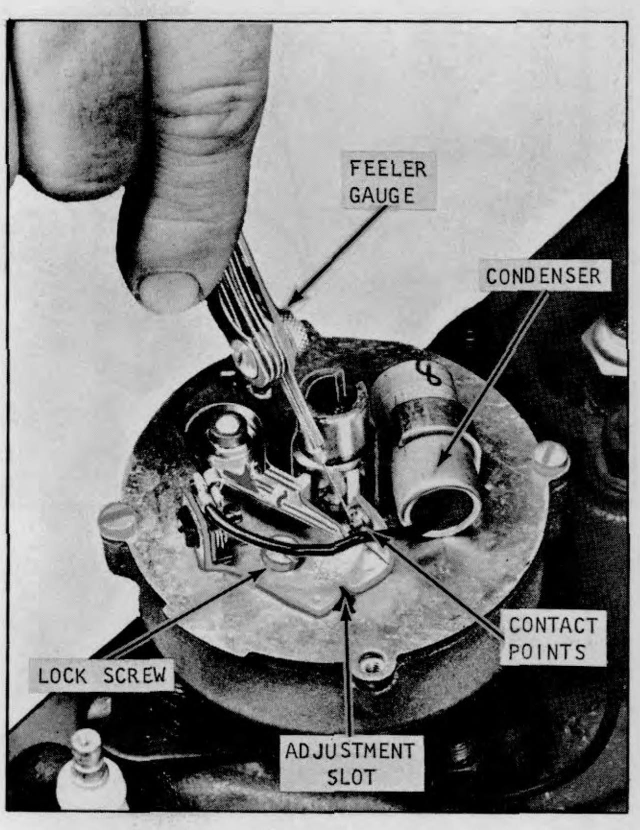


Plate 7457. Contact Point Adjustment

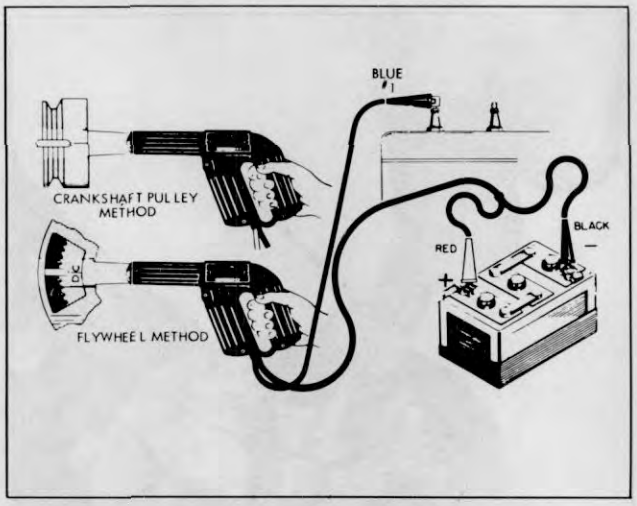
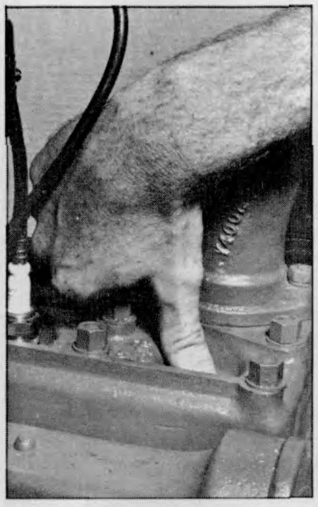


Plate 7818. Timing Light Hookup



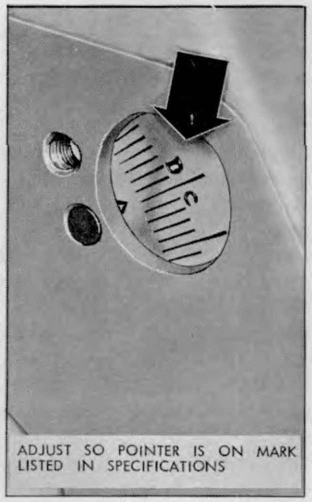


Plate 7861. Ignition Timing

9. IGNITION TIMING

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 correct timing mark will be more legible under the timing light.

a. Clip blue secondary lead of light to the #1 spark plug -- leave spark plug wire on plug.

b. Connect primary positive lead (red) to positive terminal of battery.

c. Connect primary negative lead (black) to negative battery terminal.

d. Start engine and run at 400 RPM or below so the automatic advance of the distributor is completely retarded. THIS IS VERY IMPORTANT TO OBTAIN CORRECT TIMING.

NOTE

The initial advance RPM range is 430-580. Distributor advance at 600 engine RPM should be 1° to 5°.

e. Direct timing light on the pulley (or flywheel through opening in bell housing) and note timing marks as light flashes. The light should flash on the timing mark that is listed in specifications.

f. To advance timing, turn distributor body clockwise. To retard timing, turn distributor body counterclockwise.

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

ALTERNATE TIMING METHOD

a. Remove #1 Spark Plug -- put your thumb over the spark plug hole and crank engine by hand until air is exhausting.

b. Continue to slowly crank engine until the mark listed in specifications lines up with the pointer in bell housing.

c. Loosen the distributor clamp bolt and rotate the distributor body until the contact points just start to open. (This may be more accurately checked by means of a test lamp connected between the distributor primary lead and the negative terminal of the battery -- when the points are closed the light will be ON and as soon as the points break the light will go OFF.)

d. Tighten distributor mounting bolts.

10. VACUUM TEST

Before making vacuum test, make certain cylinder head is securely tightened and that cylinder head gasket is not leaking. Air cleaner must be installed and must be clean to perform vacuum test. Manifold stud nuts must be tight and there must not be any leakage at gasket.

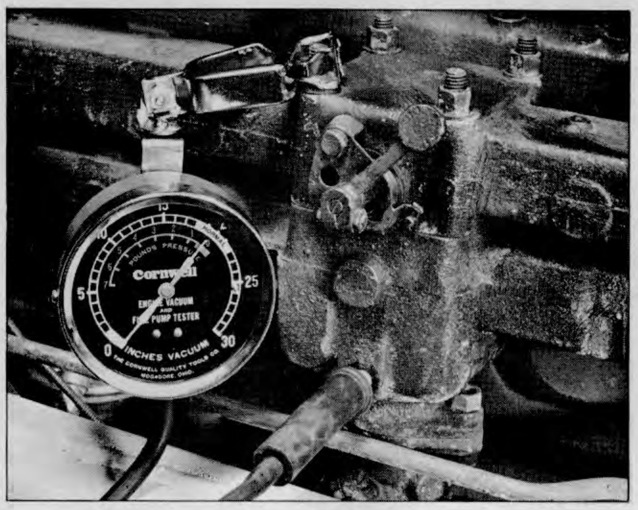


Plate 6643. Vacuum Test

(a) Remove plug at intake manifold and install vacuum gauge, see Plate 6443. Using the tachometer, set the engine idle speed at 450 to 500 RPM.

Idle Speed Adjustment: A stop screw controls action of the throttle valve. Turn screw clockwise for faster idle speed, or counterclockwise for slower idle speed. This adjustment should be made with a tachometer. Idling speed should be set for 450 to 500 revolutions per minute. Reset idle mixture screw if necessary, after throttle adjustment has been made, see Plate 6889.

(b) Check the vacuum gauge. A steady reading from 18" to 22" of mercury is a normal reading, indicating that valve and spark timing, valve seating, and piston ring sealing are all satisfactory.

(c) A steady but below normal reading indicates a condition common to all cylinders such as a leak at the carburetor gasket, late ignition or valve timing, or uniform piston ring and bore wear.

(d) A slowly fluctuating or drifting reading indicates that the fuel idle mixture is incorrect. Look for the cause in the fuel system.

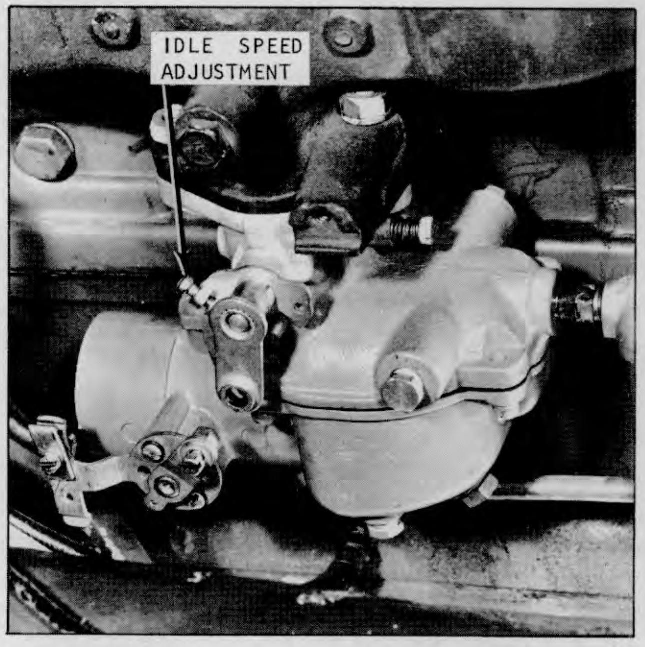


Plate 6889. Idle Speed Adjustment

(e) A rhythmic pulsating reading is caused by a condition affecting one or more cylinders, but not all, and indicates leaky valve, gasket blow-by, restricted intake port, or an electrical miss.

(f) An intermittent pulsating reading is caused by an occasional malfunction, such as a sticking valve (all valves may be erratic in operation if the valve springs are weak), electrical miss caused by insufficient distributor point tension or low coil voltage coupled with inconsistent spark plug gaps or fouled plugs, or dirt in the fuel system finding its way into passages of critical size or valve seats in the carburetor.

(g) A normal reading that quickly falls off (with engine running at approx. 1860 RPM) indicates exhaust back pressure caused by a restriction in the exhaust system.

(h) Make indicated corrections to bring vacuum to 18" to 22" of mercury normal reading.

Idle Fuel Adjustment: The carburetor is controlled by the idle adjustment screw that regulates the fuel-air mixture, see Plate 6889. Turning the screw clockwise, towards the seat, cuts off air increasing the suction on the idle jet and making the mixture richer. Turning the idle adjusting screw counterclockwise, or away from seat, allows more air to be mixed with the fuel making a leaner mixture for idling.

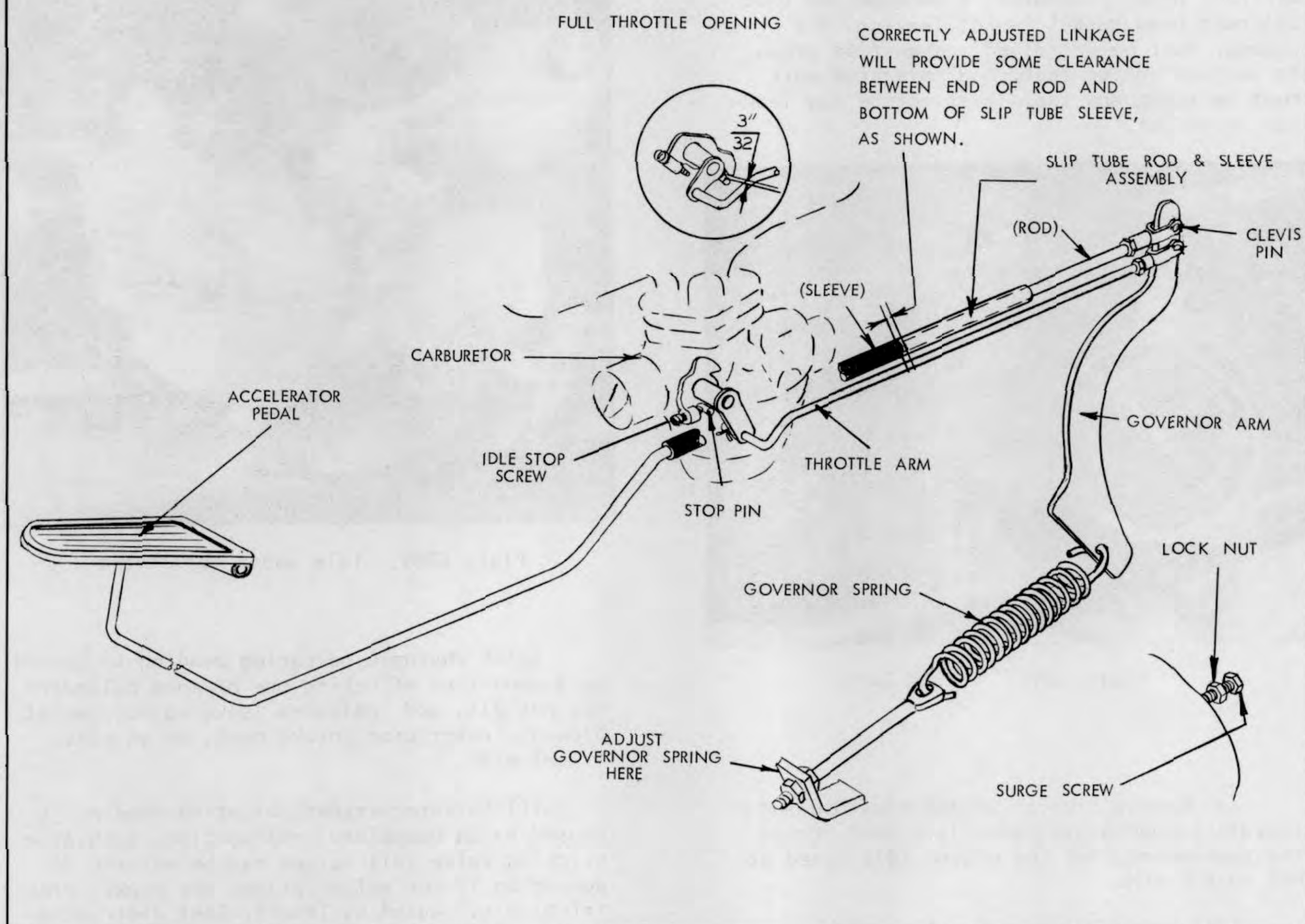


Plate 6660. Governor Adjustment

11. GOVERNOR ADJUSTMENT

With timing set on top dead center, and the carburetor properly adjusted to idle at 500 R.P.M., proceed with the following:

A. Loosen Governor Surge Screw Jam Nut and back Surge Screw out.

B. Disconnect Slip Tube Rod from Governor Arm by removing Clevis Pin.

NOTE

REMOVE CLEVIS PIN --- DO NOT LOOSEN CLEVIS JAM NUT.

C. Pull rod from Slip Tube Sleeve and thoroughly clean rod and sleeve. Lubricate rod with Graphite Grease after cleaning.

NOTE

THE SLIP TUBE ROD AND SLEEVE ASSEMBLY CANNOT FUNCTION PROPERLY IF IT IS BINDING, THEREFORE, THE ASSEMBLY MUST BE CLEAN AND PROPERLY LUBRICATED TO CORRECTLY ADJUST THE GOVERNOR.

D. With the Slip Tube and Sleeve Assembly disconnected, the Governor Arm will move forward. Check the Carburetor Throttle Opening. There should be 3/32 inch clearance between the Full Throttle Opening Stop and Stop Pin on the carburetor.

If adjustment is necessary, adjust the Throttle Rod between carburetor and governor arm until the specified clearance (3/32 inch between STOP and STOP PIN) is obtained.

E. Push the Governor Arm toward rear of machine until the Idle Stop Screw contacts Stop Pin on the carburetor. Rotate the Governor Surge Screw inwards until screw comes in contact with the Governor Shaft Lever (when holding the Governor Arm rearward) ---- Do Not Rotate Screw So Far That The Idle Stop Screw Moves Away From Stop Pin. When correct surge screw adjustment is obtained, tighten jam nut.

F. With the use of an Electric Tachometer, start engine (Warm up to normal temperature) and check for NO -- LOAD 2350 R.P.M.

NOTE

GOVERNED R.P.M. SHOULD BE CHECKED WITH THE SLIP TUBE ROD DISCONNECTED BETWEEN THE ACCELERATOR LINKAGE AND THE GOVERNOR ARM.

If adjustment is necessary, adjust the Governor Spring, see Plate 6660.

G. Install Slip Tube over rod. Attach Rod Clevis to Governor Arm with Clevis Pin.

IMPORTANT

WITH IGNITION OFF, DEPRESS ACCELERATOR PEDAL AND CHECK THROTTLE OPENING. IF THERE IS MORE THAN 3/32 INCH CLEARANCE BETWEEN THE FULL THROTTLE OPENING STOP AND STOP PIN (ON THE CARBURETOR), ADJUST THE SLIP TUBE CLEVIS, OR ACCELERATOR PEDAL LINKAGE TO OBTAIN THIS DIMENSION.

H. Start engine and again check for NO - LOAD 2350 R.P.M.

If specified R.P.M. is not obtained, check for binding linkage, bent Slip Tube, etc., free up, straighten or repair as required.

STARTING MOTOR

1. Remove end plate (or Brush Cover) from starter. Use a wire hook to lift a brush spring and remove brush from holder. Compare brush size with that of a new brush. If brush is worn beyond half the original size, or if brushes are jammed, chipped, or broken they must be replaced.

CAUTION

NEVER ALLOW SPRING TO SNAP DOWN ON BRUSHES.

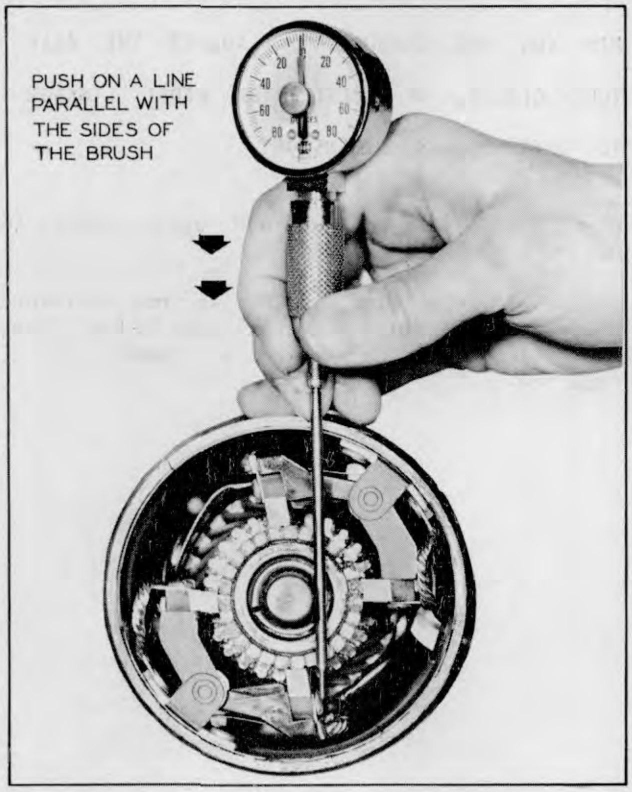


Plate 6449 Checking Brush Spring Tension

2. Check for Brush Spring Tension, refer to Specifications. Refer to the following procedures for checking spring tension.

<u>Measuring Brush Spring Tension - Reaction Type Brushes.</u> Hook the scale under the brush spring near the end and push or pull on a line parallel to the sides of the brush. To assist in telling the exact instant that the pressure is relieved, a small strip of paper can be placed under the brush. Pull slightly on the paper and the paper will slip out at the correct instant for reading the spring scale.

<u>Measuring Spring Tension - Swinging Type Brushes:</u> Hook the spring scale under the brush screw tight against the brush and push or pull on a line parallel to the sides of the brush. Take the reading just as the brush leaves the commutator. Pulling slightly on a strip of paper which has been placed under the brush will indicate when the brush leaves the commutator and the correct instant for reading the spring scale.

3. If commutator is glazed or dirty, clean with a strip of No. 00 sandpaper. Blow out all dirt and grit with compressed air.

CAUTION

DO NOT USE EMERY CLOTH TO CLEAN COMMUTATOR.

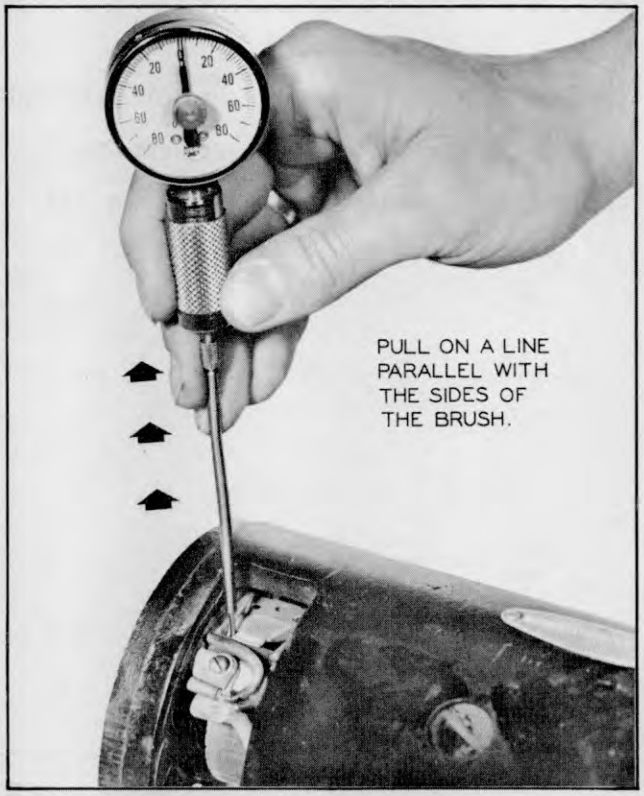


Plate 6450. Checking Brush Spring Tension

<u>Condition Test:</u> Use one of the two following methods to determine whether the starting motor should be removed from the engine for inspection, service or replacement.

1. <u>First Method:</u> Operate the starting motor by disconnecting the battery cable from the solenoid switch and holding the cable terminal firmly against the starting motor terminal, using a battery known to be fully charged and in good condition. To do this it will be necessary to remove the solenoid switch.

2. If the motor reacts correctly, and the drive mechanism engages and disengages each time the starting motor is operated, the starting motor is in good condition.

3. If motor does not react properly, it must be removed for inspection or replacement.

4. Second Method: Using a voltmeter and a battery (fully charged) that is in good condition, connect positive lead of test voltmeter to positive terminal of battery and negative lead of voltmeter to negative (grounded) terminal of battery. Record voltmeter reading. Now pull high-tension wire from ignition coil so engine will not start when starter is engaged. Connect positive lead of test voltmeter to ground and negative lead of test voltmeter to starter switch terminal. Turn ignition switch to start position and note voltmeter reading. Compare this reading with the previously recorded reading. If the voltage drop is more than 4 volts, or if the second reading is below 8 volts, the starting motor should be removed from the engine for further testing and repair, or replacement.

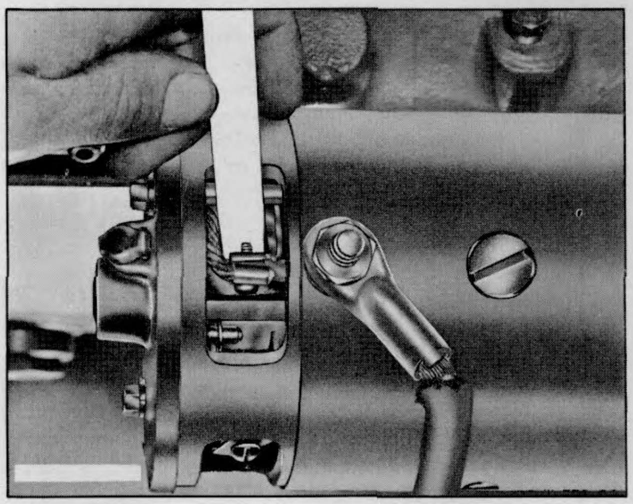


Plate 3436. Seating Brushes

NOTE

BLOW OUT ABRASIVE PARTICLES AFTER SEATING BRUSHES.

GENERATOR

1. Remove end plate (or Brush Cover) from generator. Use a wire hook to lift a brush spring and remove brush from holder. Compare brush size with that of a new brush. If brush is worn beyond half the original size, or if brushes are jammed, chipped, or broken they must be replaced.

CAUTION

NEVER ALLOW SPRING TO SNAP DOWN ON BRUSHES.

New brushes can be seated with a brush seating stone. When held against the revolving commutator, the abrasive material carries under the brushes, seating them in a few seconds. Blow out abrasive particles after seating brushes. See Plate 3436.

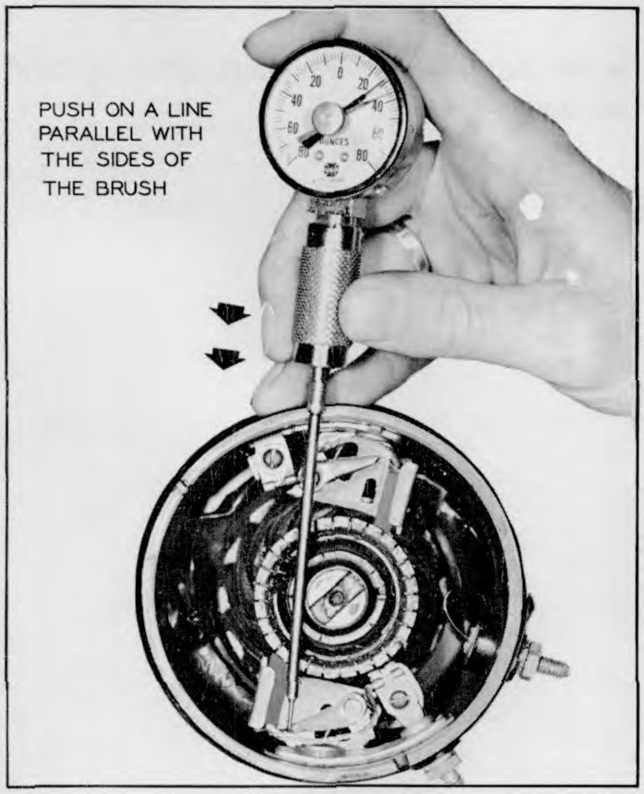


Plate 6451. Checking Brush Spring Tension

Using a spring scale, check for proper brush spring tension. Refer to Specifications. Refer to the following procedures for checking spring tension.

Measuring Brush Spring Tension - Reaction Type Brushes. Hook the scale under the brush spring near the end and push or pull on a line parallel to the sides of the brush. To assist in telling the exact instant that the pressure is relieved, a small strip of paper can be placed under the brush. Pull slightly on the paper and the paper will slip out at the correct instant for reading the spring scale.

Measuring Spring Tension - Swinging Type Brushes: Hook the spring scale under the brush screw tight against the brush and push or pull on a line parallel to the sides of the brush. Take the reading just as the brush leaves the commutator. Pulling slightly on a strip of paper which has been placed under the brush will indicate when the brush leaves the commutator and the correct instant for reading the spring scale.

3. If commutator is glazed or dirty, clean with a strip of No. 00 sandpaper. Blow out all dirt and grit with compressed air.

CAUTION

DO NOT USE EMERY CLOTH TO CLEAN COMMUTATOR.

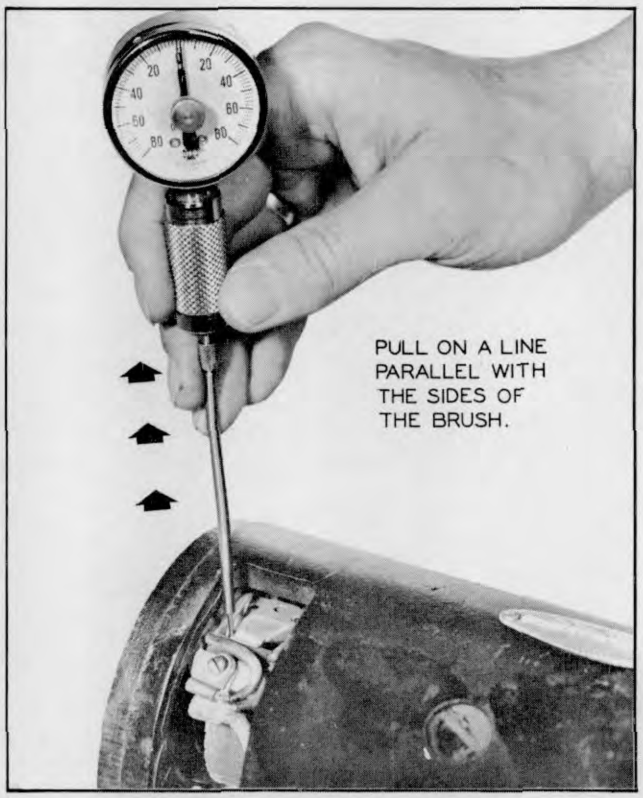


Plate 6450. Checking Brush Spring Tension

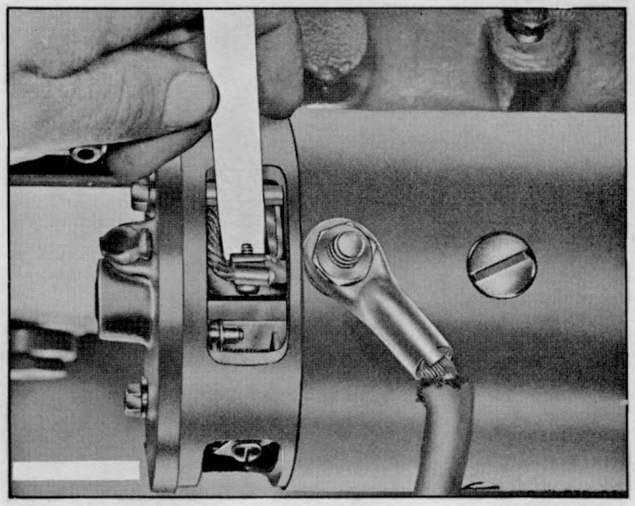


Plate 3436. Seating Brushes

NOTE

BLOW OUT ABRASIVE PARTICLES AFTER SEATING BRUSHES.

REGULATOR

Inspect regulator leads for frayed or worn condition. Check to make certain that leads are tight and securely mounted.

WIRING

Check all wires for loose or corroded connections and for fraying. Replace defective wires.

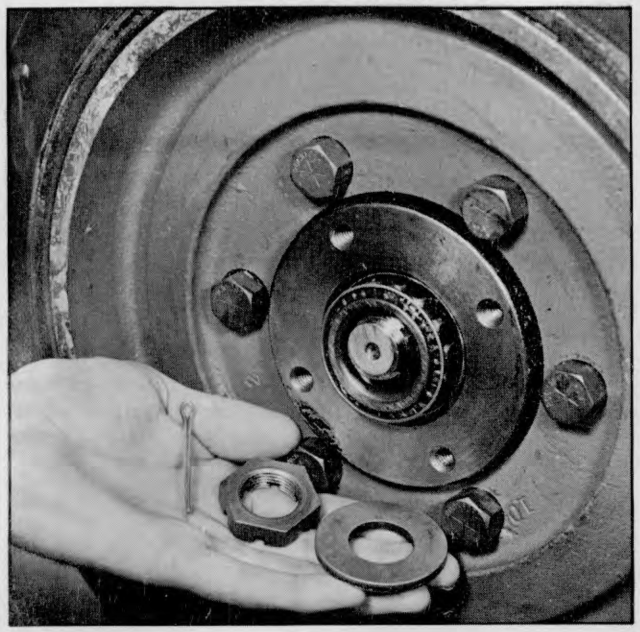


Plate 6640. Typical Wheel Bearings

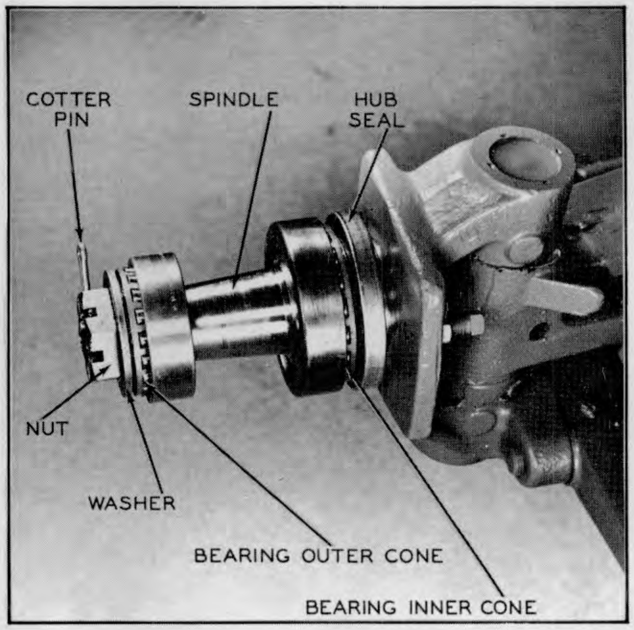


Plate 6703. Typical Wheel Bearings

STEERING WHEEL BEARINGS

<u>Adjustment:</u>

1. Raise rear of machine so that tires clear floor.

W A R N I N G

AFTER RAISING MACHINE AND BEFORE MAKING ANY ADJUSTMENTS OR ADJUSTMENT CHECKS, PLACE ADEQUATE (HEAVY) BLOCKING (SUFFICIENT TO SUPPORT THE WEIGHT OF THE MACHINE) UNDER THE FRAME TO PREVENT ACCIDENTAL LOWERING OR FALLING OF THE VEHICLE, THUS PREVENTING PERSONAL INJURY TO MECHANIC OR BYSTANDERS.

2. Inspect adjustment of bearings by gripping top and bottom of tire, chuck tire 'in' and "out" to determine looseness or wobble.

N O T E
BEFORE MAKING WHEEL BEARING ADJUSTMENTS, BE SURE PLAY (LOOSENESS OR WOBBLE) IS IN THE WHEEL BEARINGS AND NOT IN THE KING PINS.

N O T E
IF WHEEL BEARINGS NEED ADJUSTING, CLEAN AND REPACK BEARINGS BEFORE MAKING ADJUSTMENTS. REFER TO LUBRICATION PARAGRAPH. BEFORE REPACKING WHEEL BEARINGS, CHECK FOR ANY INDICATION OF LEAKAGE AROUND HUB SEALS. IF SUCH A CONDITION EXISTS, REPORT TO DESIGNATED PERSON IN AUTHORITY.

3. If loosenss or wobble is in the wheel bearings, remove hub cap and spindle cotter pin, see (Plate 6640). Tighten nut with a 12" wrench, and at the same time rotate the wheel in one direction and then in the other until there is a slight bind to be sure all bearing surfaces are in contact. Then back off the nut 1/6 to 1/4 turn allowing the wheel to rotate freely. Secure nut at this position with a new cotter pin and replace hub cap.

<u>Lubrication</u>:

1. Remove wheels after 1000 hours or every six months of operation. Clean bearings and repack with medium bodied high temperature wheel bearing grease, Clark Specification MS9C.

2. Install wheels and adjust wheel bearings as previously described.

CLEAN AND REPACK AXLE ENDS

Every 1000 operating hours remove and repack the axle ends.

1. Tilt upright back. Place solid heavy blocks under each upright rail. Tilt upright forward until vertical to the floor. This should allow the drive wheels to clear the floor. Remove drive wheels.

WARNING

ON PNEUMATIC TIRE MACHINES DEFLATE TIRES BEFORE REMOVING WHEELS.

2. Remove hub cap, outer spindle nut, lockwasher, inner spindle nut and washer. Pull hub assembly from spindle.

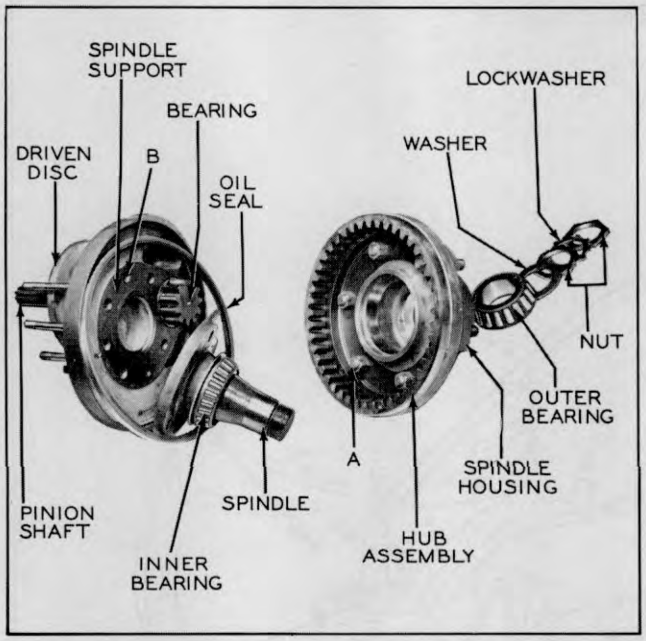


Plate 5694. Axle End Assembly

3. Remove bearings and clean in a Stoddard type cleaning solvent. Slosh bearings up and down in solvent. Remove and tap large side of bearing against a block of wood to dislodge solidified particles of lubricant. Repeat operation until bearings are thoroughly clean. Blow bearings dry with compressed air. Direct air stream across bearing to avoid spinning. Slowly rotate bearing by hand to facilitate drying. Dip bearings in gear oil and wrap in paper until they are to be reinstalled.

4. Pack all bearings with NLGI #1 (Amolith grease EP #1 or its equivalent) before final assembly. Also pack the hub cavity between the bearings 1/2 full. (As an alternate grease No. 1 E.P. lithium soap grease may be used).

5. Clean ring gear, pinion drive shaft, hub assembly, spindle and spindle support.

6. Inspect seals for cuts, scratches and nicks. It is necessary to replace seal if such a condition is found. Check the axle end vent for obstruction, vent must be open. See Plate 6893.

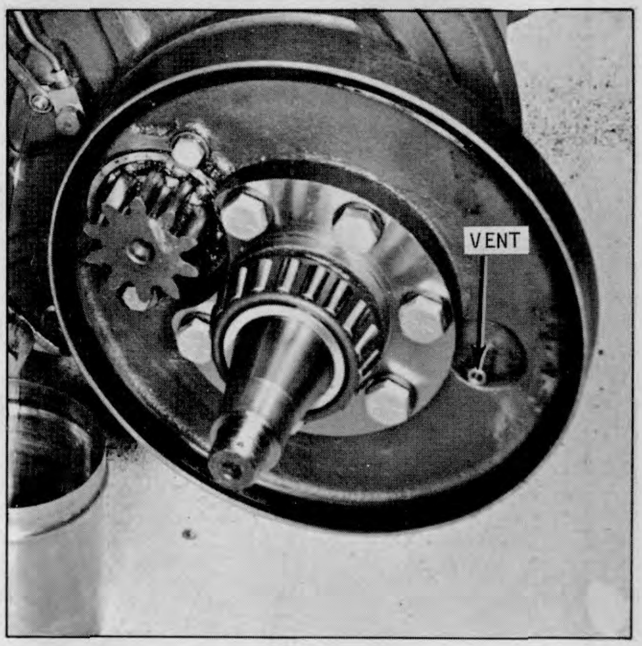


Plate 6893. Typical Axle End Vent

7. Pack the spaces between the teeth of the ring gear and pinion, level full for the entire circumference with NLGI #1 (Amolith grease EP #1 or its equivalent). The approximate amount of grease in this area is to be 1 1/4 pounds.

8. Install bearings, seal and hub assembly on spindle. Tighten inner bearing adjusting nut until bearings bind slightly during rotation. Back off adjusting nut approximately 1/8 turn and lock with outer nut. Secure this adjustment by bending the tangs on the lock washer. Install the hub cap.

9. Replace drive wheels and tires. Inflate tires if they are of the pneumatic type. Tilt upright back and remove blocking.

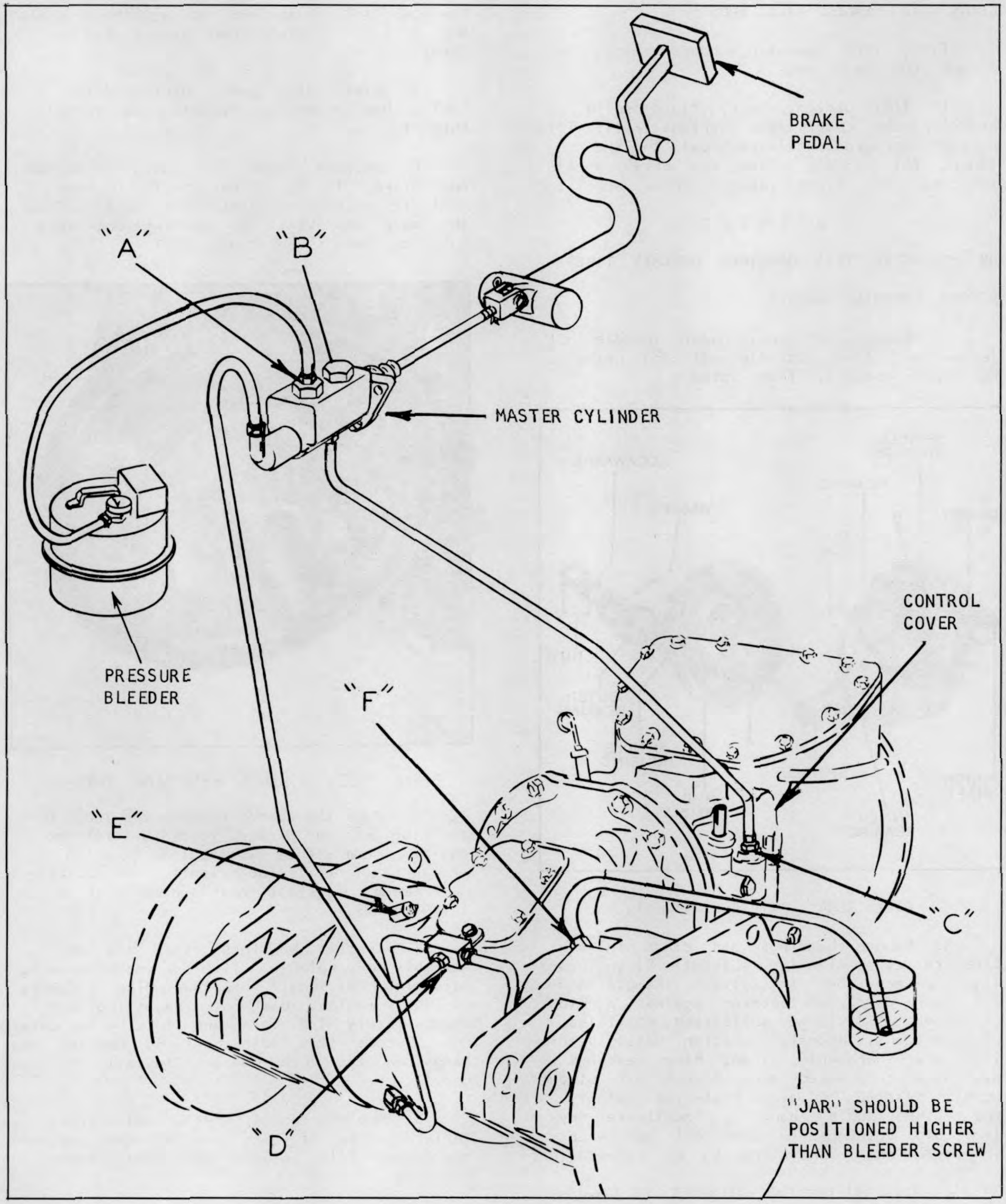


Plate 7302. Bleeding Brakes

BRAKE BLEEDING PROCEDURE

Proper operation of the hydraulic brake system requires a solid column of fluid without air bubbles at all points in the pressure system. Under certain conditions it becomes necessary to bleed fluid from the system in order to expel air bubbles which have become mixed with the fluid. The necessity of bleeding is indicated by a soft spongy pedal, or at any time a brake line is removed (or broken) the system must be bled.

Step 1. Tilt upright back, Place solid heavy blocks under each upright rail. Tilt upright forward until vertical to the floor. This should allow the drive wheels to clear the floor. Remove drive wheels.

Step w. Check the brake pedal free travel (Refer to Specifications). Clean dirt from around the filler cap of the master cylinder reservoir. Brake fluid should be within 1/4 of an inch from the top. With filler cap removed from the master cylinder, depress and release brake pedal. A small displacement of fluid should be noticed in the reservoir each time the pedal is actuated. If this happens, the brake pedal (upon being released) is returning the master cylinder piston to its normal position to open a cylinder port. This port must be open. If a noticeable displacement of fluid is not observed in the reservoir, during depression of the brake pedal, improper pedal free travel is indicated, and an adjustment is required.

Step 3. To properly bleed the system it is recommended that a pressure bleeder filled with about two quarts of S.A.E. 70R-3 heavy duty brake fluid be connected to the master cylinder reservoir. Pressure bleeder should then be pressurized to approximately 30 P.S.I.

Step 4. Loosen the brake line fitting at Point "A" (Plate 6881) enough to allow fluid and air to escape. Tighten fitting when escaping fluid is free of air bubbles.

Step 5. Loosen inching valve-check-ball stop bolt at Point "B" (Plate 6881) and depress brake pedal to the floorboard and hold in this position until connection is retightened. This operation should be repeated until escaping fluid is free of air bubbles.

Step 6. Loosen line connection at highest position on "T" block (See Point "C", Plate 6881) and Bleed in the same manner as described in Step 5.

Step 7. Install a bleeder hose on one of the wheel cylinder bleeder screws and submerge the unattached end of the hose in a clean transparent jar containing several inches of brake fluid.

NOTE

During bleeding of the wheel cylinders, the jar should be elevated to a position higher than the bleeder screw making sure that the end of the hose remains submerged in the fluid at all times.

Loosen bleeder screw and slowly push brake pedal to the floorboard and hold pedal in this position until bleeder screw is retightened. Repeat this operation until all air bubbles disappear and clear fluid is being pumped into the jar.

Step 8. Install bleeder hose on the remaining bleeder screw and proceed as in step seven.

Step 9. After all bleeding has been completed close the pressure bleeder shut-off cock and loosen hose connection at master cylinder to allow pressure to escape. Replace master cylinder cap.

Step 10. Replace drive wheels. Tilt upright back and remove blocking from under each upright rail.

If a pressure bleeder is unavilable, the system may be bled manually by following Steps 2, 4, 5, 6, 7, 8 and 10. It must be remembered that the brake pedal should be depressed slowly and held to the floorboard until the line connections or bleeder screws are securely tighten tightened. This prevents the possibility of air being drawn into the system during the bleeding operation. Check master cylinder reservoir level periodically during manual bleeding and fill to within 1/4 of an inch of the top as required.

BRAKE ADJUSTERS

When the brake system is operating properly, the cam like action of the reaction arm allows self-adjustment for the total thickness of the brake linings, without any noticeable increase in brake pedal free travel. The self-adjustment feature eliminates the need for manual adjustment of the brakes.

When brakes become noisy during brake application, this may indicate the linings are worn enough to allow brake shoes to contact brake drum. If such a condition exists, the axle ends shall be removed and a brake lining inspection shall be made to determine further serviceability.

N O T E

When installing new shoe and lining assemblies, be sure to install new assemblies at each wheel. Refer to following instructions covering mounting bolt torque specifications and procedures.

Before installing new brake linings the adjuster mounting bolt torque should be checked with a torque wrench. This should be torqued to 23 to 26 ft. lbs. The brake adjuster with nut and washer assembly has been preassembled and properly torqued and should never need to be changed.

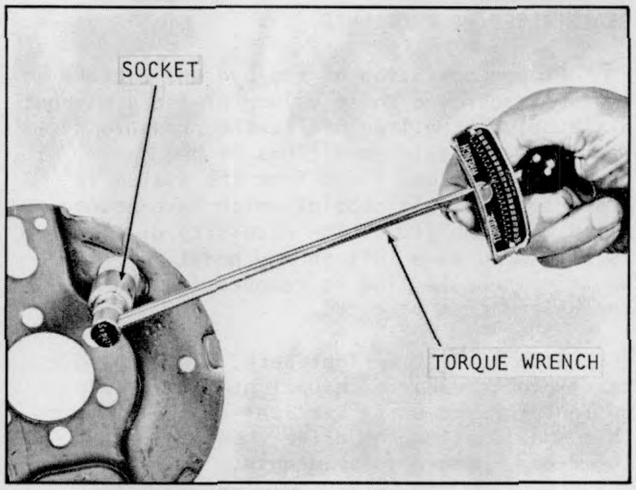


Plate 9958. Checking Adjuster Arm Torque

The backing plate and adjuster arm components must be clean, dry and free from rust when this torque test is made.

HAND BRAKE ADJUSTMENT

The brake on this model is a "V" pulley type drum mounted on the end of the transmission pinion shaft with a "V" shaped brake shoe that fits into the drum groove. When lifting hand brake lever, pressure is applied to the brake shoe which presses the shoe against (into) the drum.

To adjust the hand brake, refer to Plate 5270 and proceed as follows:

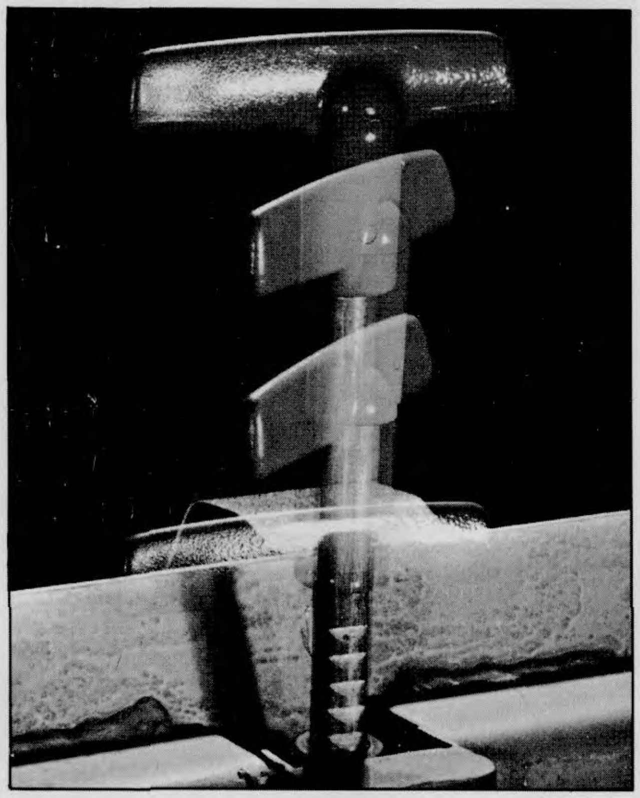


Plate 7482. Hand Brake (Actuating) Lever

Adjustment is made at the Parking Brake Draw Rod LOCK SLEEVE and LOCK NUT, Plate 5270.

These items protrude downward through the bottom-side of the Converter Housing.

1. Loosen the Lock Nut several turns.

2. Rotate the Lock Sleeve counterclockwise to close gap between brake shoe and brake drum.

3. Hold the Lock Sleeve and tighten the Lock Nut until snug against Cam Lever, then back off lock nut one half to three quarters of a turn.

4. Test Adjustment: Test adjustment while occupying the driver's seat.

Fully apply the hand brake. Full application of hand brake should require 1 1/2 to 2 inches of travel. If the lever travel exceeds this amount the linkage should be adjusted.

Test Parking Brake Effectiveness - must be capable of holding the truck, with full rated load, on a 15% grade.

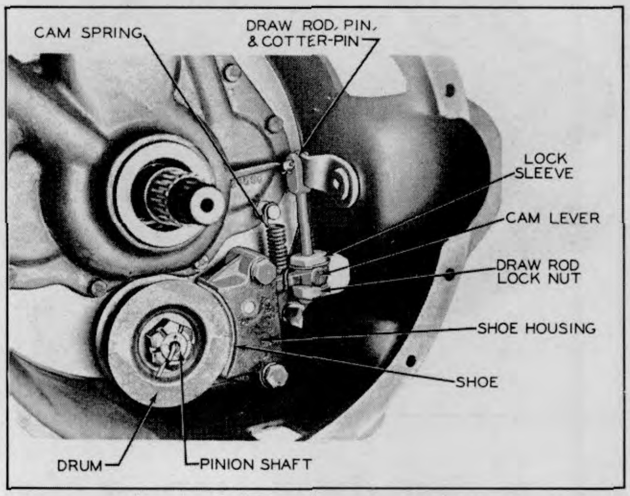


Plate 5270. Adjusting Brake

COOLING SYSTEM

Radiator Pressure Caps:

WARNING

USE EXTREME CARE IN REMOVING THE RADIATOR PRESSURE CAP. IN PRESSURE SYSTEMS, THE SUDDEN RELEASE OF PRESSURE CAN CAUSE A STEAM FLASH AND THE FLASH, OR THE LOOSENED CAP CAN CAUSE SERIOUS PERSONAL INJURY. LOOSEN CAP SLOWLY AND ALLOW STEAM TO ESCAPE.

1. Inspect pressure cap gasket and radiator filler neck to be sure they are providing a proper seal. If the rubber face of the valve is defective, a new cap should be installed.

Plate 6458. Radiator Pressure Cap

2. Inspect pressure cap for freedom of operation.

Pressure caps employ a spring loaded, rubber-faced valve which presses against a seat in the radiator top tank. Pressure caps employ either a vacuum valve held against its seat under spring pressure, or a weighted vacuum valve which hangs open until forced closed by a surge of vapor or coolant. Check to be sure components are free to operate.

NOTE

IF A NEW CAP IS REQUIRED, ALWAYS INSTALL A CAP OF THE SAME TYPE AND PRESSURE RATING. PRESSURE RATING 7 LB.

3. Inspect for dented or clogged overflow pipe. To remove clogged material, run a flexible wire through pipe until obstruction is removed.

When a pressure cap opens the sudden surge of vapor or liquid must pass thru the overflow pipe. If the pipe is dented or clogged, the pressure developed by the obstruction may cause damage to radiator or hoses.

Inspect and Clean Cooling System:

Check hose connections for coolant leaks as well as air leakage. Air leakage around hose connections allows oxygen into the system which is a major factor in corrosion.

Plate 6459. Pressure Cap Gasket, Valve and Valve Gasket

NOTE

EXHAUST GAS LEAKAGE BETWEEN CYLINDER HEAD AND GASKET ALSO RESULTS IN CORROSION. IF EXHAUST GAS DISCHARGES INTO COOLANT, THE COOLANT AND THE GAS COMBINE TO FORM A VARIETY OF ACIDS. IT *IS THEREFORE IMPORTANT THAT CYLINDER HEAD* STUD NUTS BE DRAWN DOWN TO SPECIFICATIONS AS INSTRUCTED IN "ENGINE TUNE-UP".

Using a washing soda solution, flush cooling system in the following manner:

1. Drain system.

2. Replace half of volume with fresh water. Refer to Specifications for capacity.

3. Boil other half of volume and add washing soda until no more will dissolve.

4. Add hot soda solution to cooling system (fill up).

5. Operate engine normally for 24 hours.

6. Drain, flush, refill with clean water to which a soluable oil has been added in a proportion of 1 ounce per gallon of water.

Maintaining the cooling system efficiency is important, as engine temperatures must be brought up to and maintained within satisfactory range for efficient operation; however, must be kept from overheating, in order to prevent damage to valves, pistons and bearings. Continued overheating may cause internal damage, while continuously low operating temperature wastes fuel, increases engine wear and causes oil sludge and corrosion of engine parts.

Overcooling may be caused by operating conditions such as excessive idling, low speeds and light loads during cold weather. Overheating may be caused by faulty thermostat, clogged radiator or an improperly adjusted fan belt.

CAUTION

NEVER POUR COLD WATER OR COLD ANTI-FREEZE INTO THE RADIATOR OF AN OVER-HEATED ENGINE. ALLOW THE ENGINE TO COOL AND AVOID THE DANGER OF CRACKING THE CYLINDER HEAD OR BLOCK. KEEP ENGINE RUNNING WHILE ADDING WATER.

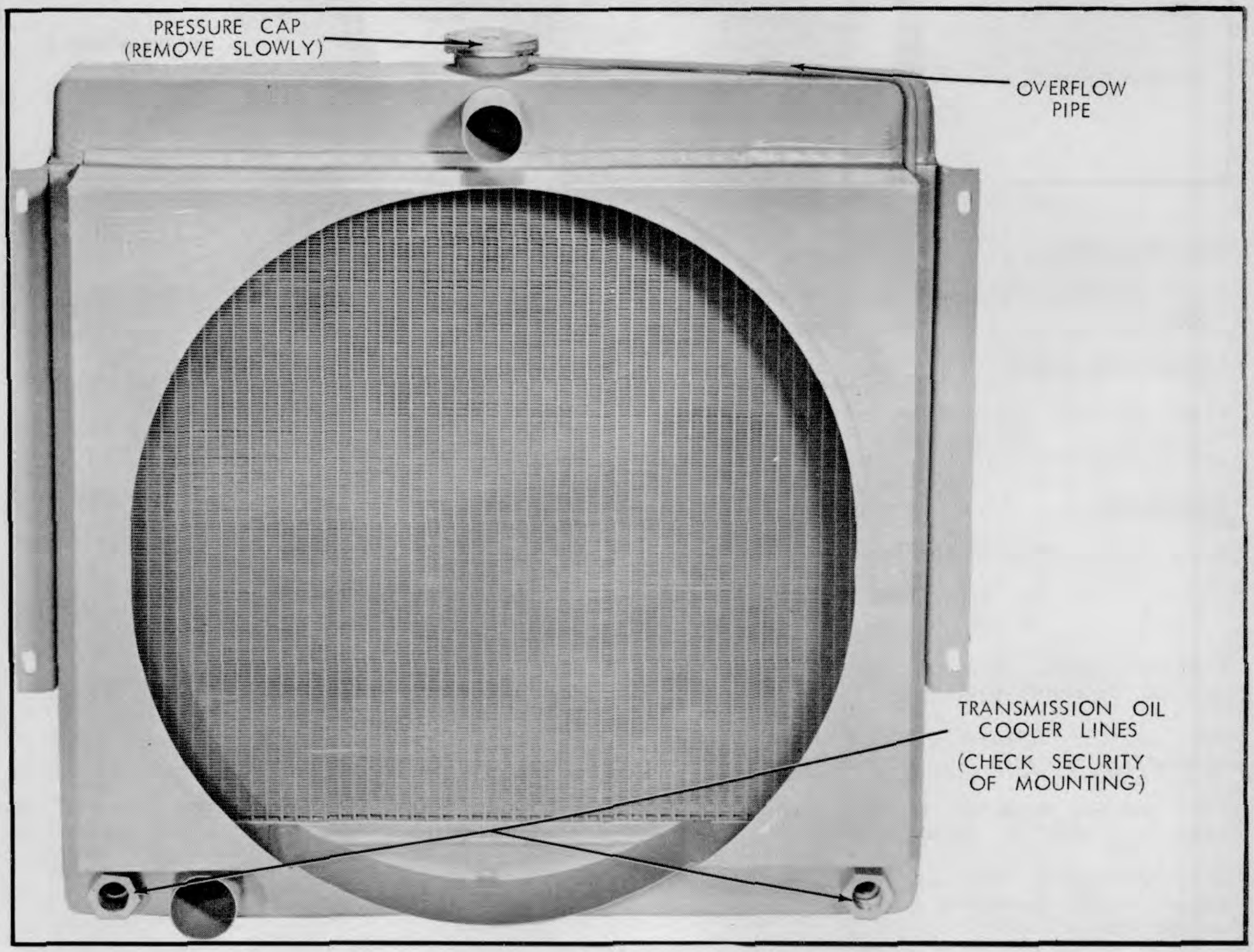


Plate 6460. Typical Radiator

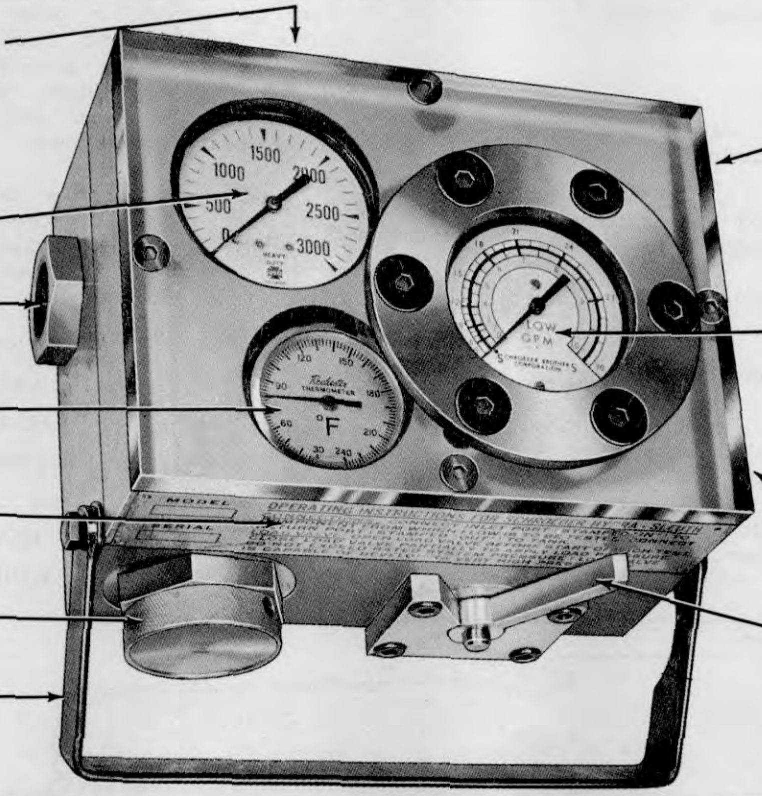


Plate 6747. Schroeder Hydraulic Circuit Tester CLARK PART NUMBER 1800060

PRESSURE GAUGE

Reads directly in pounds per square inch (PSI).

TEMPERATURE GAUGE

Reads directly in degrees Fahrenheit and indicates the temperature of the oil passing through the instrument.

FLOW GAUGE

Reads two scales in gallons per minute.

0 - 30 gallons
9 - 30 gallons

Read the scale that corresponds with the orifice selector position.

Turn orifice selector to the left (counterclockwise) to read 10 gallon scale.

Turn orifice selector to the right (clockwise) to read 30 gallon scale.

You may switch from one scale to the other, while operating machine. Always start on 30 gallon scale.

LOAD VALVE

The load valve is a flow restrictor or *shut off valve. Turning the valve to the* right throttles flow through the Hydra-Sleuth, thus the operator may load a hydraulic pump or circuit to the desired test pressure, simulating work.

SAFETY PLUG

Located opposite the load valve this plug protects the Hydra-Sleuth and the tested system from pressures in excess of 3200 PSI. When pressure becomes higher the plug will rupture and dump oil to atmosphere.

HYDRAULIC FLUID

Unless marked to the contrary, the unit is *for use with petroleum, hydraulic fluids.*

HOW TO CONNECT THE PORTABLE TESTER

Using a 1/2" hose or larger, connect tester INLET PORT to the flow to be tested. Connect the tester outlet port to reservoir fill port, or system return line.

HYDRA-SLEUTH ADJUSTMENTS BEFORE OPERATION

A. Depending on flow (GPM) to be checked choose proper orifice. (It is good practice to start always on 30 gallon scale.)

B. Fully open load valve by turning all the way to the left.

HYDRA-SLEUTH ADJUSTMENTS DURING OPERATION

1. Turn load valve to right to develop test pressures.

CAUTION

LOAD VALVE IS CAPABLE OF VERY HIGH PRESSURES.

A. Always start test with load valve fully open.

B. Do not exceed design pressure of system under test.

C. Keep load pressures within range of the Hydra-Sleuth pressure gauge.

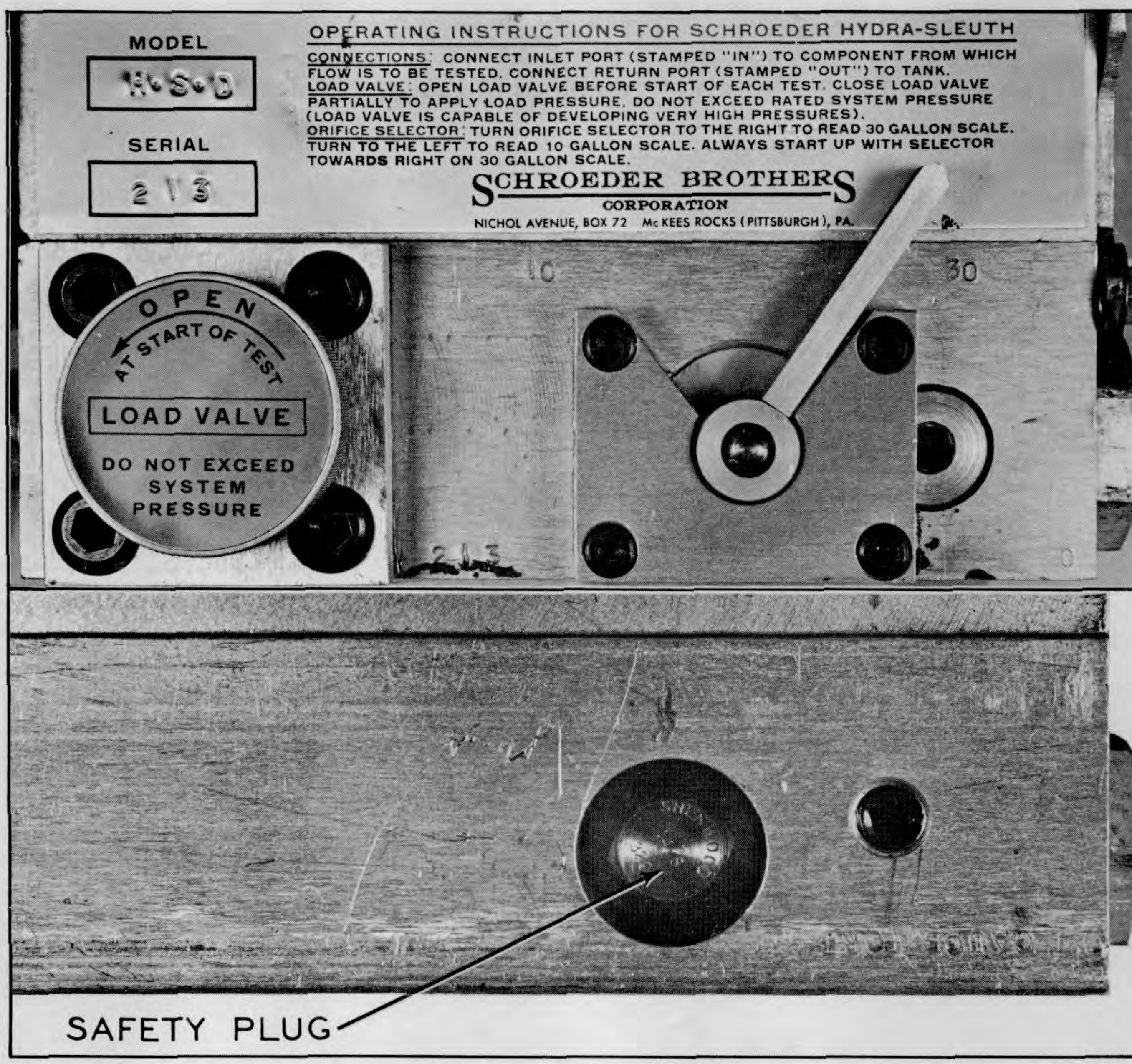


Plate 6748. Schroeder Hydraulic Circuit Tester

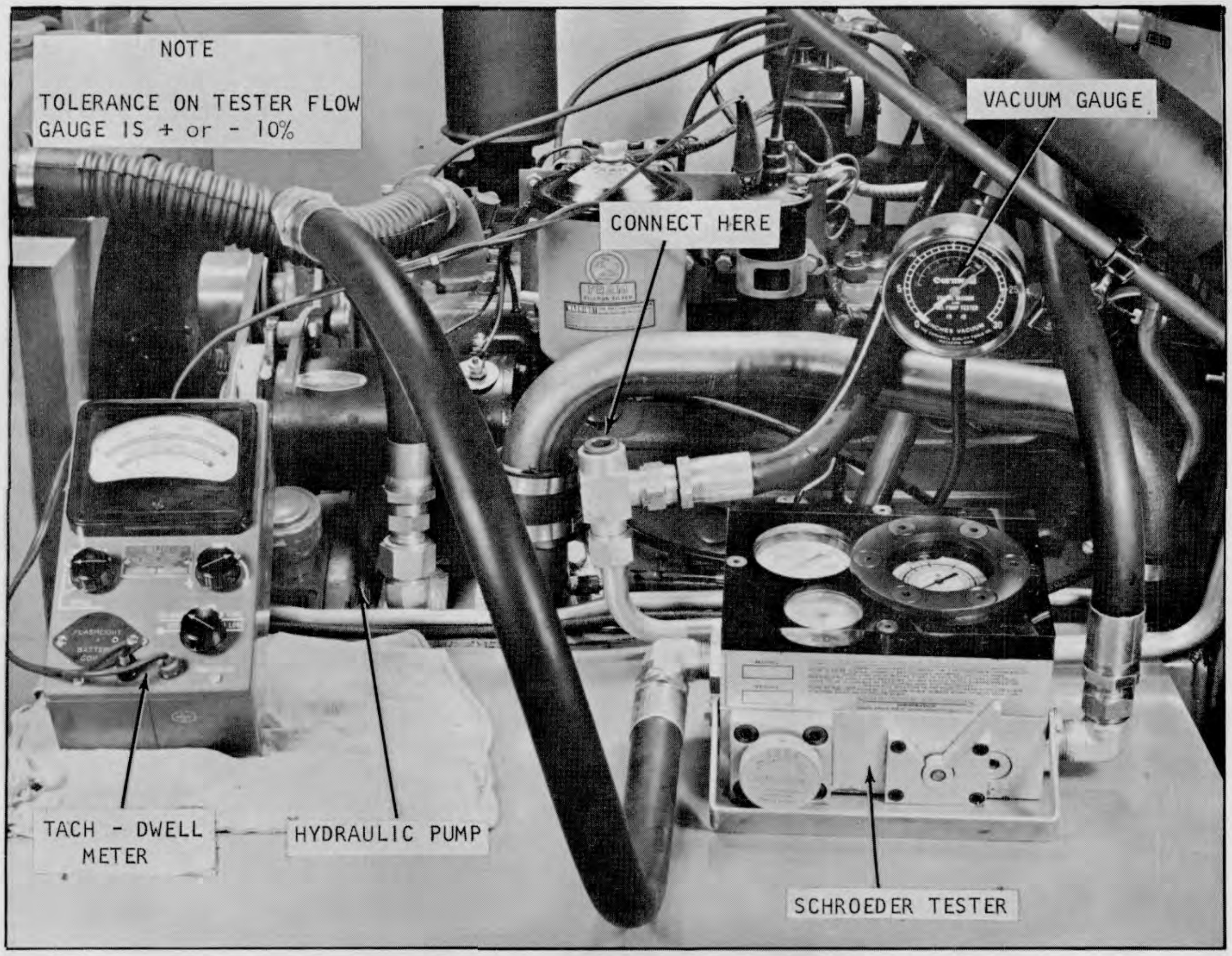


Plate 6749. Flowmeter Hookup

HOOK UP FLOWMETER

Install the high pressure hose onto the pump as shown, see Plate 6749. Attach the return line hose as shown in Plate 6749.

TESTING PUMP OUTPUT

1. Start the Tractor engine, and set speed to the exact R.P.M. stated in the chart below.

2. To heat up oil, apply the load valve until pressure reaches 1000 P.S.I. CAUTION: APPLY PRESSURE GRADUALLY. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN "BLOWING-OUT" THE FLOWMETER RELIEF PLUG.

3. After the oil has come up to test temperature (120°F.) and the flow gauge needle is stabilized, apply the load valve GRADUALLY until desired pressure is achieved. Then stabilize the pressure needle. NOTE: IT WILL BE NECESSARY TO INCREASE TRACTOR SPEED SLIGHTLY AS PUMP MUST BE TESTED UNDER LOAD (AT SPECIFIED R.P.M.)

CAUTION: LIMIT TIME THE LOAD VALVE IS SET FOR A READING OF 2000 P.S.I. TO 30 SECONDS EXTENDED PERIOD OF TIME WITH MAXIMUM READING COULD CAUSE DAMAGE.

4. Read the flow gauge. It should read reasonably close to the specifications for a new pump as listed below.

ENGINE R.P.M.	P.S.I.	G.P.M.
2250	2000	17

PRESSURE CHECKS
HYDRATORK TRANSMISSION

MINIMUM TOOLS REQUIRED
1 - Pressure Gauge 0 -to- 250 P.S.I.
1 - Tachometer

1. Completely clean the truck and hydratork before making pressure checks. This should include cleaning the complete machine with steam. Making sure the radiator and its tubes are clean externally and internally.

2. Check Transmission Fluid Level.

Run machine in Forward and Reverse for about one to three minutes total. Stop engine and check fluid level. Fill if necessary to the "FULL" mark on the Transmission Dip Stick.

3. Check Brake Pedal Free Travel.

The hydraulic inching (brake) pedal should contact the floor board with the pedal in the released (up) position.

Pedal free travel should be measured from bottom of floor board to top of pedal arm, or from top pedal position to where pedal meets resistance from the master cylinder when depressing pedal by hand. Refer to page 100H 302 for Pedal Free Travel and illustrations.

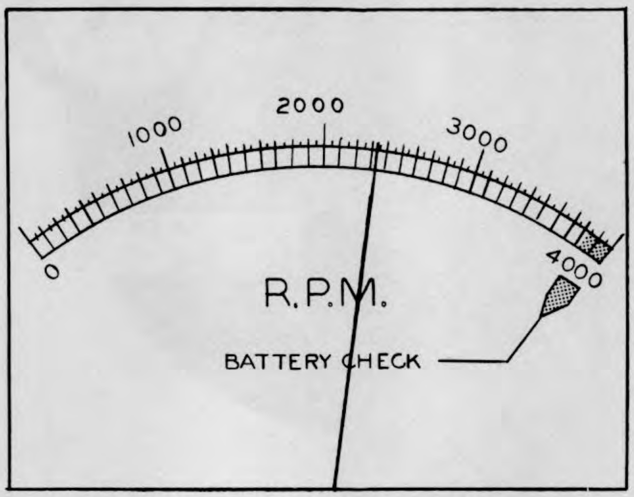


Figure 1703a. Check NO-LOAD R.P.M.

4. Check engine for prescribed NO-LOAD 2350 R.P.M.

5. Check engine for prescribed 2200 R.P.M. with rated load. This may be done by holding the tilt lever in the back position.
Engine must be properly tuned before making transmission pressure checks.

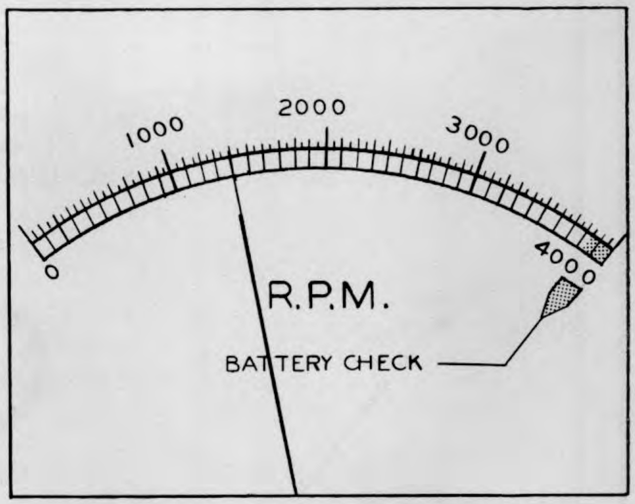


Figure 1703b. Normal Engine Stall

6. Check for normal engine stall by positioning machine against an immovable object. With machine in gear, accelerate to full throttle position. The normal engine stall R.P.M. is 1350 to 1500.

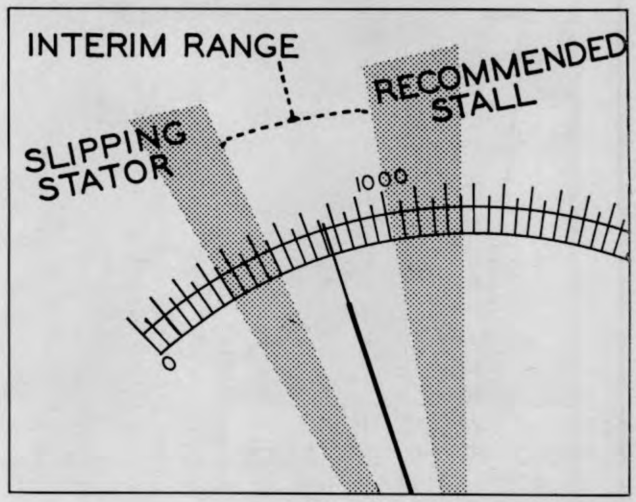
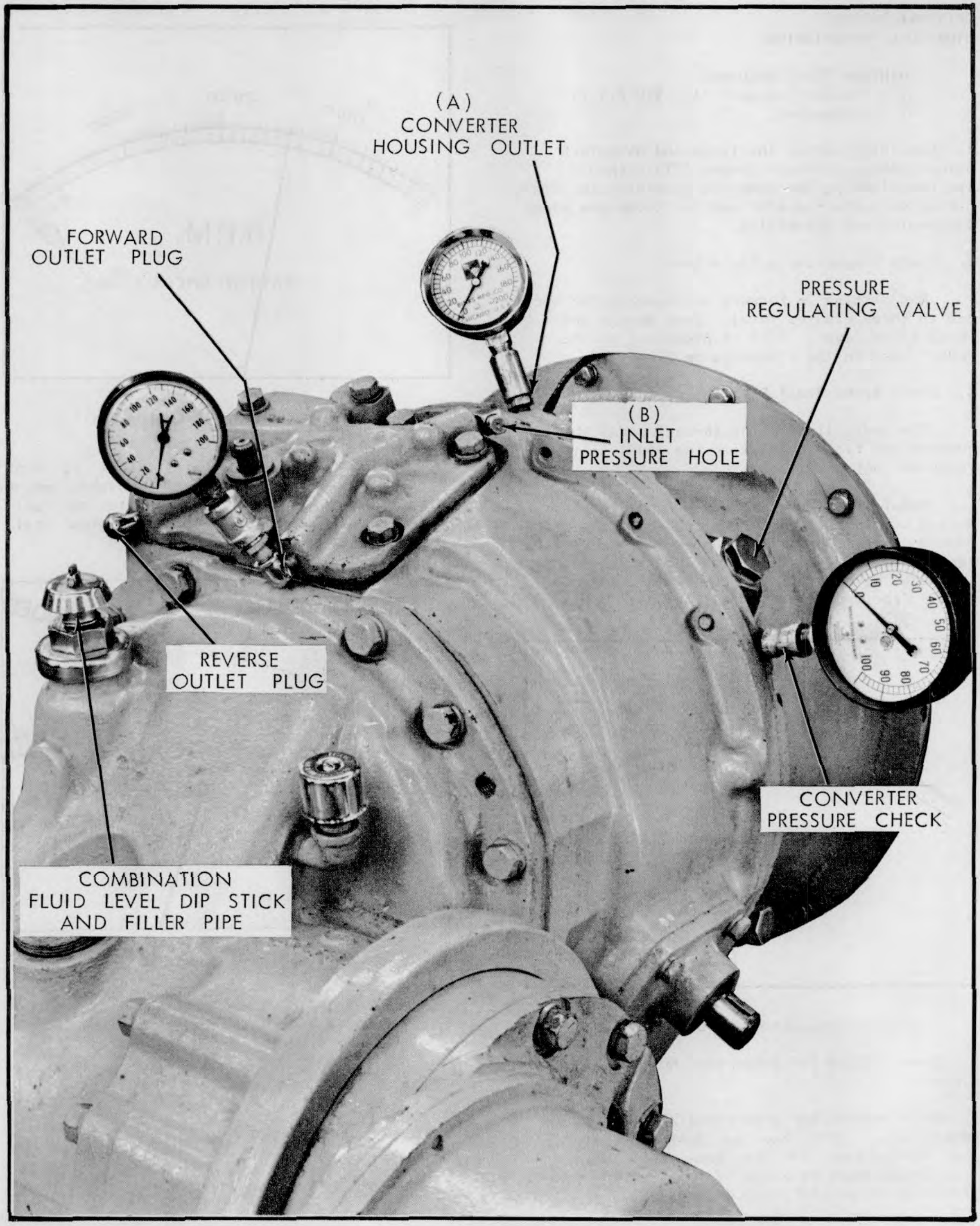


Figure 1703c. Low INTERIM stall

Low Interim Range Engine Stall (1000 -to- 1350 R.P.M.) indicates a loss of engine power. Report to designated person in authority.



(Figure 1704a.) Plate 6658. Transmission Pressure Checks

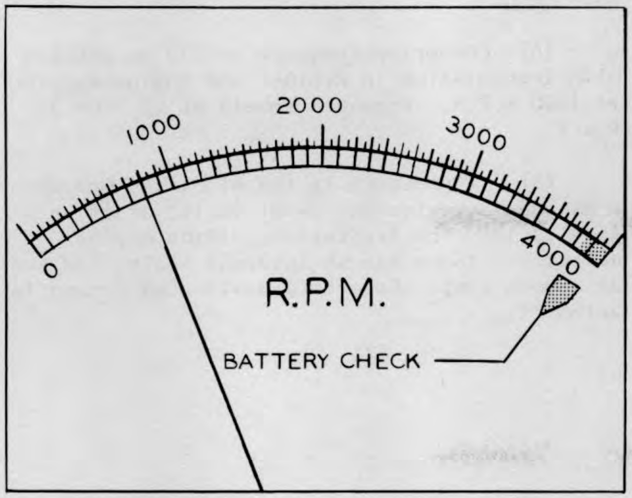


Figure 1705a. Low Engine Stall

Low — Low Engine Stall (650 -to- 900 R.P.M.) indicates Converter Stator slipping. Converter must be replaced. Report to designated person in authority.

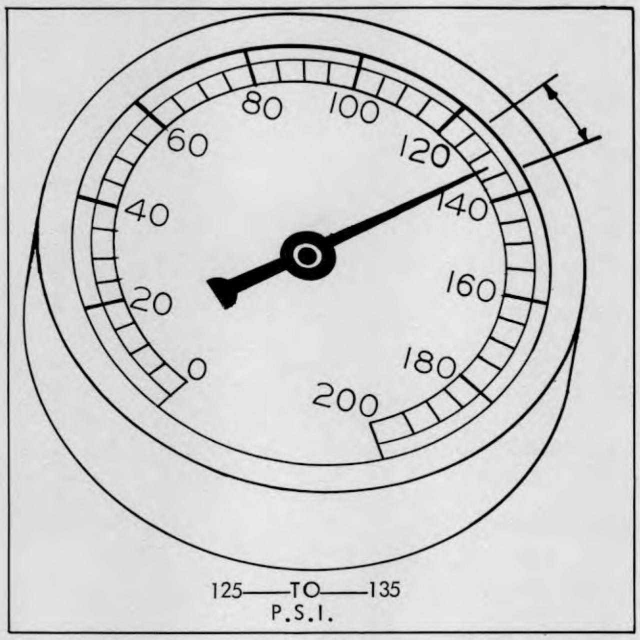


Figure 1705b. Pump Pressure Check

7. Pump Pressure Check, see Figures 1704a and 1705b.

(A) Remove pipe plug and install pressure gauge at the Converter Housing Outlet (A), see Fig. 1704a. Check pressure with transmission in NEUTRAL and engine running at 1400 R.P.M. Pressure should be 125 -to- 135 P.S.I. (Figure 1705b.)

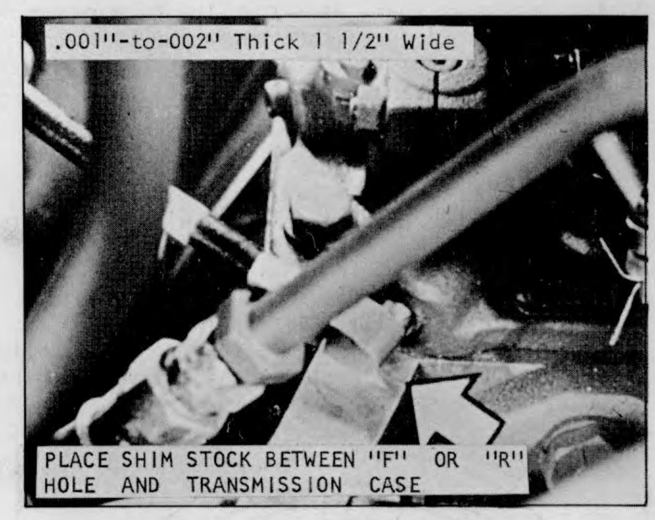


Figure 1705c. Install Shim Stock

(B) If pressure is low, place shim stock (.001" -to- .002" thick -x- 1 1/2" wide) between the Inlet Pressure Hole (B) of the Transmission Control Cover and Transmission Case, see Figure 1705c.

(C) Check pressure again. Pressure should be 125 -to- 135 P.S.I.

(D) If pressure is still low, the Transmission Pump or Pressure Regulating Valve may be defective. Report to designated person in authority.

8. Control Cover - Selector Check.

(A) Check control cover or selectors at either Forward or Reverse Outlet Plugs, see Figure 1704a.

Securely block machine so it cannot move. Install pressure gauge at either the Forward or Reverse Outlet Plugs. Start engine and place Directional Control Lever in either Forward or Reverse (depending upon which selector is being checked). Run engine at 1400 R.P.M. Pressure should be 125 -to- 135 P.S.I. (Figure 1705d.)

(B) If pressure is low, insert shim stock (.001" -to- .002" thick -x- 1 1/2" wide) between either the Forward or Reverse Hole (whichever one was used) and the Transmission Case. Check pressure again. Pressure should be 125 -to- 135 P.S.I. If pressure is low, trouble is in the control cover. If pressure is 125 -to- 135 P.S.I., the trouble is inside of the transmission. Report to designated person in authority.

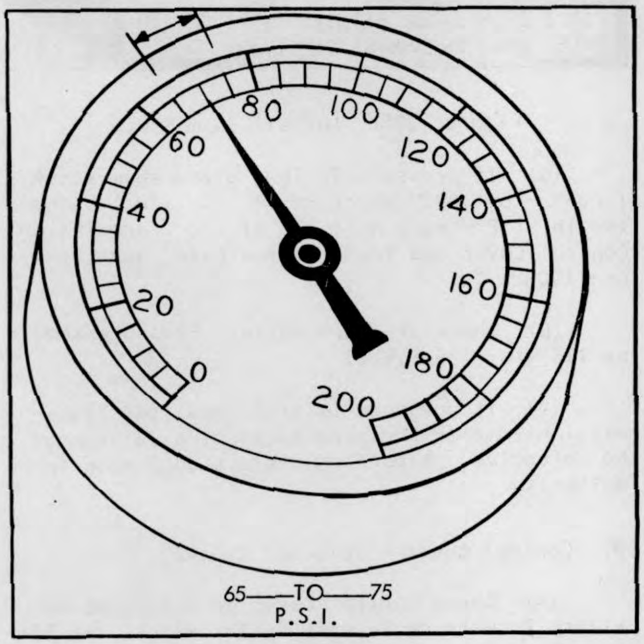


Figure 1707a. Converter Pressure Check

9. Converter Pressure Check, see Figures 1704a and 1707a.

(A) Converter Pressure should be checked with transmission in NEUTRAL and engine running at 1400 R.P.M. Pressure should be 65 -to- 75 P.S.I.

(B) If pressure is too high, the Convertor Pressure Regulator may be at fault; or if pressure is low, the Pressure Regulator may be defective, there may be internal leaks, bad seals, or a worn pump. Report to designated person in authority.

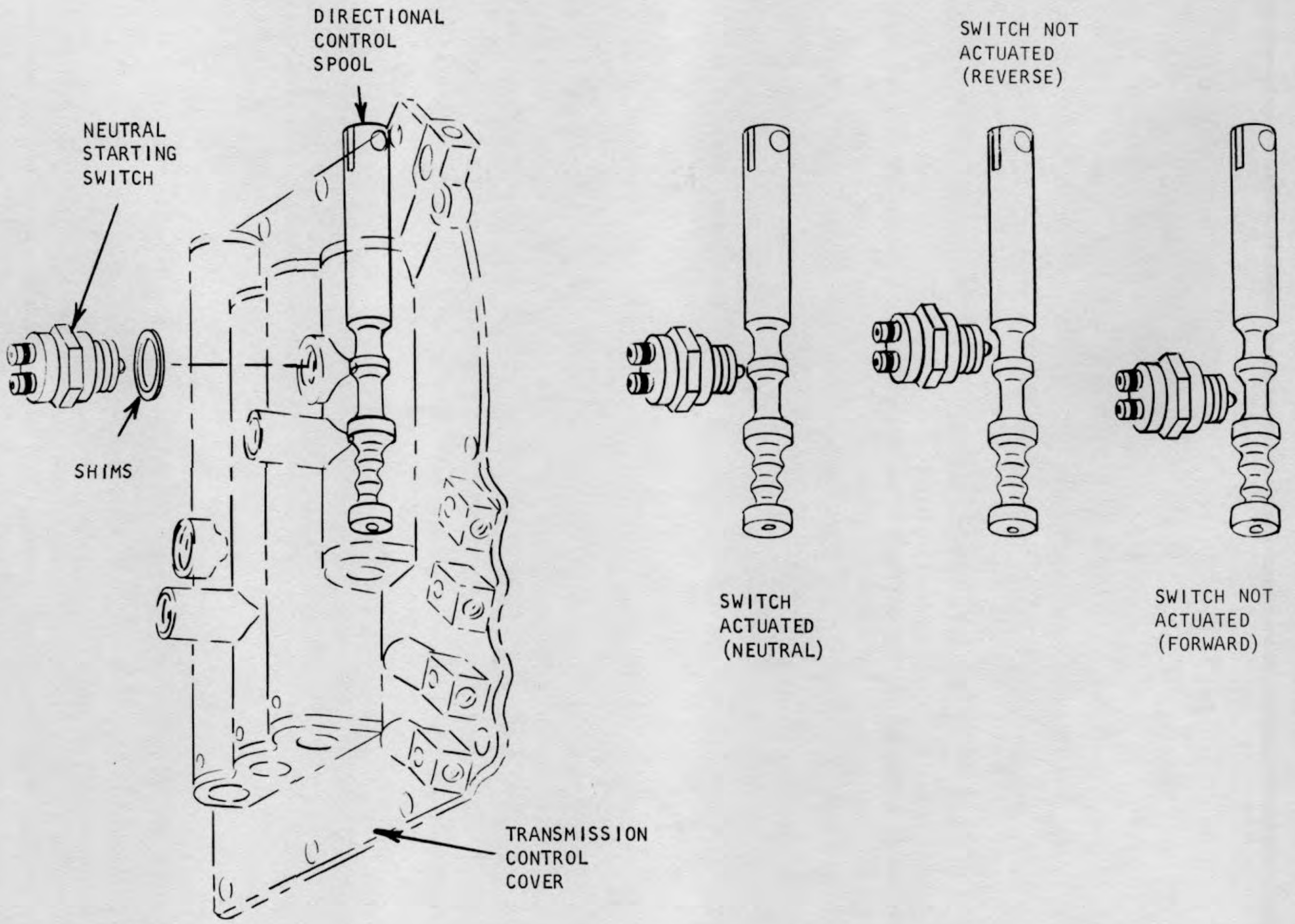


Plate 7300. Neutral Starting Switch

NEUTRAL STARTING SWITCH

The neutral starting switch should be adjusted so that machine will not start except when the transmission control is in the (dead) neutral position.

ADJUSTMENT CHECK

1. With driver's seat occupied and transmission in gear hold starting switch in actuated position and gently move shift lever towards neutral position.

2. If engine does not start, repeat adjustment operation in opposite direction.

3. If engine starts, coming from either direction on the shift lever prior to reaching neutral, switch should be adjusted by means of shims underneath the switch until engine will not start unless it is in (dead) neutral; that is, vehicle will not move regardless of shift lever position during the starting cycle.

TROUBLE SHOOTING GUIDE

ENGINE

TROUBLE	PROBABLE CAUSE	REMEDY
Starting motor will not crank engine.	Battery discharged	Recharge or replace battery.
	Battery cable terminals loose or corroded. Ignition Fuse blown.	Remove and clean, reinstall and tighten cables. Replace fuse.
	Starting motor drive gear jammed in flywheel teeth.	Loosen starting motor and free-up gear.
	Improper oil.	Change oil to proper grade.
	Battery cable terminal broken.	Replace cable.
	Poor starting switch contacts.	Replace switch.
	Faulty Neutral Starting Switch.	Replace Switch
Starting motor operates, but fails to crank engine when switch is engaged.	Starting motor gear does not engage flywheel.	Remove starting motor, and clean drive mechanism.
	Starting motor or drive gear defective.	Replace starting motor.
Engine will not start. No spark. Ammeter shows no discharge (Zero reading) with ignition switch "on".	Ignition switch partly "on".	Turn switch "on" fully.
	Ignition switch defective.	Replace switch.
	Ignition primary wires or starting motor cables broken or connections loose.	Repair, or replace and tighten.
	Ignition coil primary winding open.	Replace coil.
	Distributor points dirty.	Clean and adjust points.
	Distributor points not closing.	Adjust or replace points.
	Loose or corroded ground, or battery cable connections.	Remove and clean, reinstall and tighten cables.
Engine will not start. Ammeter showing abnormal discharge with ignition switch "on".	Defective condenser.	Replace condenser
	Short-circuited or burned distributor cap or rotor.	Replace parts.
	Short-circuited wire between ammeter and ignition switch.	Repair or replace wire.
	Short-circuited primary winding in ignition coil.	Replace coil.
	Distributor points not opening.	Clean or replace, and adjust points.
	Distributor points pitted or burned.	Clean or replace, and adjust points.
	Distributor condenser weak.	Replace condenser.
	Ignition coil weak.	Replace coil.

TROUBLE SHOOTING GUIDE

ENGINE (CONTINUED)

TROUBLE	PROBABLE CAUSE	REMEDY
Engine will not start. Weak spark (continued)	Primary wire connections loose.	Tighten.
	High-tension, spark plug wires, or distributor cap wet.	Dry thoroughly.
	High-tension, spark plug wires, or distributor cap damaged.	Replace defective parts.
	Distributor cap or rotor burned or broken.	Replace defective parts.
	Spark plug gap incorrect.	Reset Gaps.
	Short-circuited secondary circuit in coil.	Replace coil.
Good spark.	Fuel tank empty.	Refill tank.
	Dirt or water in carburetor, or float stuck.	Drain and clean carburetor
	Carburetor and engine flooded by excessive use of choke.	Depress accelerator pedal fully, crank engine with starting motor when engine starts, reset throttle and leave choke control "in".
	Fuel does not reach carburetor.	Inspect for damaged or leaky lines or air leak into line between tank and fuel pump.
	Dirt in fuel lines or tank.	Disconnect lines, drain tank, and blow out lines.
	Fuel line pinched.	Repair or replace line.
	Ignition wires incorrectly installed in distrubutor cap.	Install wires correctly.
	Ignition timing incorrect.	Reset timing.
	Fuel Strainer Clogged.	Remove and clean strainer.
	Fuel pump does not pump.	Clean screen, replace pump if defective.
	Lack of engine compression.	Replace head gasket, Grind valves, replace valve spring, replace bad valve.
Backfiring.	Ignition out of time.	Reset timing.
	Spark plug wires incorrectly installed distributor cap or at spark plugs.	Install wires correctly.
	Distributor cap cracked or shorted	Replace cap.
	Valve holding open.	Reset timing. replace valve springs. Adjust tappets.

TROUBLE SHOOTING GUIDE

ENGINE (CONTINUED)

TROUBLE	PROBABLE CAUSE	REMEDY
Engine operates, but backfires and spits.	Improper ignition timing.	Reset timing.
	Spark plug wires incorrectly installed in distributor cap.	Install wires correctly.
	Dirt or water in carburetor.	Drain and clean carburetor.
	Carburetor improperly adjusted.	Clean and adjust carburetor.
	Carburetor float level low.	Reset Float Level
	Valve sticking or not seating properly, burned or pitted.	Regrind Valves
	Excessive carbon in cylinders.	Remove carbon from cylinders.
	Valve springs weak.	Replace Valve Springs
	Heat control valve not operating.	Free-up, and adjust valve.
	Fuel pump pressure low.	Clean screen; replace pump, if defective.
	Fuel strainer clogged.	Remove and clean strainer.
	Partly clogged or pinched fuel lines.	Clean and repair lines.
	Intake manifold leak.	Inspect gaskets and tighten manifold stud nuts.
	Distributor cap cracked or shorted.	Replace cap.
Engine stalls on idle.	Carburetor throttle valve closes too far, or idle mixture incorrect.	Adjust carburetor.
	Carburetor choke valve remains closed.	Free-up and lubricate valve.
	Dirt or water in idler passages of Carburetor.	Clean or replace carburetor.
	Air leak at intake manifold.	Inspect gaskets and tighten manifold stud nut.
	Heat control valve defective.	Free-up and adjust valve.
	Spark plugs defective, gaps incorrect.	Clean or replace spark plugs, set gap clearance.
	Ignition timing early.	Reset timing.
	Low compression.	Tighten intake manifold. Adjust valve.
	Water leak in cylinder head or head gasket.	Replace gasket.

TROUBLE SHOOTING GUIDE

ENGINE (CONTINUED)

TROUBLE	PROBABLE CAUSE	REMEDY
Engine misfires on one or more cylinders.	Dirty spark plugs.	Clean, adjust, or replace plugs.
	Spark plug gap incorrect.	Reset gap.
	Cracked spark plug porcelain.	Replace spark plug.
	Spark plug wires grounded.	Replace wires.
	Spark plug wires incorrectly installed in cap or at spark plugs.	Install wires incorrectly.
	Distributor cap or rotor burned or broken.	Replace defective parts.
	Valve tappet holding valve open.	Adjust tappets
	Low engine compression.	Adjust tappets, Retime engine, Replace rings.
	Leaky cylinder head gasket.	Replace gasket.
	Cracked cylinder block, broken valve tappet or tappet screw.	Replace defective or broken parts.
Engine does not idle properly.	Ignition timing.	Reset timing.
	Dirty spark plugs, or gaps too close.	Clean and adjust spark plugs.
Engine misses at high speeds.	Ignition coil or condenser weak.	Replace defective parts.
	Distributor points sticking, dirty or improperly adjusted.	Clean, adjust, or replace points.
	Distributor rotor or cap cracked or burned.	Replace defective parts.
	Leaky cylinder head gaskets.	Replace gaskets.
	Uneven cylinder compression.	Adjust tappets or timing.
	High-tension or spark plug wires leaky, cracked insulation.	Replace defective parts.
	Carburetor choke not adjusted.	Adjust choke.
	Carburetor accelerating pump system defective, dirt in metering jets or float level incorrect.	Replace defective parts, Clean carburetor, reset float level.
	Fuel pump defective, causing lack of fuel.	Clean screen, replace defective pump.
	Air cleaner dirty.	Clean complete air cleaner and refill oil cup.
	Heat control valve defective	Free-up and adjust.

TROUBLE SHOOTING GUIDE

ENGINE (CONTINUED)

TROUBLE	PROBABLE CAUSE	REMEDY
Engine misses at high speeds. (Continued)	Valves sticking, weak or broken valve springs.	Free up valves, replace valve springs.
	Fuel strainer clogged.	Remove and clean strainer.
	Weak distributor bracket arm spring.	Replace point set.
	Excessive play in distributor shaft bearing.	Replace distributor.
	Spark plugs defective, dirty or gap incorrectly set.	Clean, adjust or replace spark plugs.
Engine pings (Spark Knock.)	Ignition timing early.	Reset timing.
	Distributor automatic spark advance stuck in advance position, or spring broken.	Replace distributor.
	Excessive carbon deposits in cylinders.	Remove cylinder head and clean.
	Incorrect fuel.	Drain, use correct fuel.
Engine lacks power.	Ignition timing late.	Reset timing.
	Incorrect fuel.	Use correct fuel.
	Leaky cylinder head gasket.	Replace gasket.
	Excessive carbon formation.	Remove cylinder head, and clean cylinder head, piston heads, cylinder block, and valves.
	Engine runs cold.	Test thermostat; in cold weather, cover radiator.
	Insufficient oil, or improper grade oil.	Lubricate in accordance with lubrication section.
	Oil system failure.	Fill crankcase to prescribed level, check oil pressure.
	Air Cleaner dirty.	Clean complete air cleaner, change oil in cup.
	Spark plug gaps to wide.	Reset gaps.
	Choke valve partially closed, or throttle does not open fully.	Adjust valve or throttle.
	Manifold heat control inoperative.	Free-up and adjust control.
	Exhaust pipe, muffler or tail pipe obstructed.	Service or replace obstructed parts.
	Low compression, broken valve spring, sticking valves.	Replace valves or springs, Free up valves.

TROUBLE SHOOTING GUIDE

ENGINE (CONTINUED)

TROUBLE	PROBABLE CAUSE	REMEDY
Engine lacks power. (Continued)	Improper tappet adjustment.	Adjust Tappets.
	Lack of fuel.	Clean filter, inspect fuel pump, inspect carburetor for water or dirt and clean if necessary.
Engine overheats.	Cooling system deficient. Water low, air flow through radiator core restricted.	Clean radiator core from engine side with compressed air or water, or fill radiator to proper level.
	Clogged radiator core (Clogged internally).	Clean by flushing radiator.
	Cylinder head gasket leaking.	Tighten cylinder head stud nuts and/or replace gasket.
	Radiator or water pump leaking.	Repair or replace defective parts.
	Damaged or deteriorated hose or fan belt.	Replace defective parts.
	Loose fan belt.	Adjust fan tension.
	Cylinder block or head leaking.	Replace block or head.
	Ignition timing incorrect.	Reset timing.
	Damaged muffler, bent or clogged exhaust pipe.	Service or replace defective parts.
	Excessive carbon in cylinders.	Remove cylinder head, and clean cylinder head, piston heads cylinder block, and valves.
	Insufficient oil, or improper grade.	Refer to lubrication Instructions.
	Air Cleaner restricted.	Clean complete change oil in cup.
	Inoperative thermostat.	Replace thermostat and gasket
	Water pump impeller broken.	Replace pump.
	Poor compression.	Check ignition timing.
	Valve timing incorrect.	Reset timing.
High fuel consumption.	High engine speeds (Excessive driving in lower gear range).	Correct driving practice.
	Air cleaner clogged.	Clean complete air cleaner and change oil in cup.
	Carburetor float level too high, accelerating pump not properly adjusted.	Reset float level, overhaul carburetor pump.
	Fuel line leaks.	Correct leaks, replace lines.

TROUBLE SHOOTING GUIDE

ENGINE (CONTINUED)

TROUBLE	PROBABLE CAUSE	REMEDY
High fuel consumption. (Continued)	Overheated engine.	See "Engine overheats".
	Carburetor parts worn or broken.	Replace fuel carburetor.
	Fuel pump pressure too high, or leaky diaphragm.	Replace fuel pump.
	Engine running cold.	Inspect thermostat, cover radiator in winter.
	Ignition incorrectly timed.	Reset timing.
	Spark advance stuck.	Replace distributor.
	Leaking fuel pump bowl gasket.	Replace gasket.
	Low compression.	Check timing, Rebuild Engine.
	Carburetor controls sticking.	Free-up and lubricate controls.
	Engine idles too fast.	Adjust carburetor throttle stop screw.
	Spark plugs dirty.	Clean or replace spark plugs.
	Weak coil or condenser.	Replace coil or condenser.
	Clogged muffler, or bent exhaust pipe.	Service or replace defective parts.
	Loose engine mounts, permitting engine to shake and raise fuel level in carburetor.	Tighten; if damaged, replace defective mounts.
High oil consumption	High engine speeds, or excessive driving in low gear range.	Correct driving practice.
	Oil leaks.	Replace leaking gaskets.
	Improper grade oil, or diluted oil.	Use new oil of proper grade.
	Overheating of engine causing thinning of oil.	See "Engine overheats".
	Oil filter clogged.	Clean filter case thoroughly and replace element.
	Defective piston or rings, excessive side clearance of intake valves in guides, cylinder bores worn (scored, out-of-round, tapered); excessive bearing clearance, misaligned connecting rods.	Replace worn parts.

TROUBLE SHOOTING GUIDE

ENGINE (CONTINUED)

TROUBLE	PROBABLE CAUSE	REMEDY
Low oil pressure.	Insufficient oil supply.	Fill crankcase to prescribed level.
	Improper grade of oil, or diluted oil foaming at high speed.	Change oil, inspect crankcase ventilator inspect for water in oil.
	Oil too heavy (Funneling in cold weather).	Change to proper grade oil. (Refer to Lubrication Instructions.
	Oil pump screen clogged.	Remove oil pan and clean pump screen.
	Oil leaks.	Replace gaskets or seals.
	Faulty oil pump, pressure regulator valve stuck or improperly adjusted, or spring broken.	Replace worn parts.
Defective valves.	Incorrect tappet adjustment.	Adjust tappets.
Abnormal engine noises.	Loose fan, fan pulley or belt, heat control valve.	Tighten or correct conditions as required.
	Leaking intake or exhaust manifold or gaskets, cylinder head gasket, or spark plugs.	Tighten loose components or replace defective gaskets.
	Overheated engine, clogged exhaust system	Remove obstruction from exhaust system. Inspect for further serviceability.
Poor compression.	Incorrect tappet adjustment.	Adjust tappets.
	Leaking, sticking, or burned valves; sticking tappets; valve spring weak or broken; valve stems and guides worn; piston ring grooves worn or rings worn, broken, or stuck; cylinder bores scored or worn.	Replace worn, Broken, or Defective parts.

TROUBLE SHOOTING GUIDE

FUEL SYSTEM

TROUBLE	PROBABLE CAUSE	REMEDY
Fuel does not reach carburetor	No fuel in Fuel tank.	Fill fuel tank.
	Fuel pump inoperative.	Replace pump.
	Fuel line air leak between tank and fuel pump.	Repair or replace line.
	Fuel line clogged.	Disconnect and blow out lines.
	Fuel tank cap vent clogged.	Clean vent.
Fuel reaches carburetor, but does not reach cylinders.	Choke does not close.	Free-up and lubricate, inspect for proper operation.
	Fuel passage in carburetor clogged.	Clean or replace carburetor.
	Carburetor float valve stuck closed.	Clean or replace carburetor.
High fuel consumption	Lubricant in power train too heavy.	Use correct lubricant.
	Incorrect adjustment of carburetor.	Adjust carburetor.
	Vehicle overloaded.	Reduce loads to specified maximum capacity.
	Tires improperly inflated.	Inflate tires properly.
	Tight brakes.	Adjust brakes.
Low Fuel Pressure.	Air leak in fuel lines.	Tighten connections, repair lines if damaged.
	Fuel pump defective, diaphragm broken; valve leaking, linkage worn.	Replace fuel pump
	Fuel lines clogged.	Clean or replace lines.
Engine idles too fast.	Improper carburetor throttle stop adjustment.	Adjust throttle stop screw.
	Carburetor control sticking.	Free-up and lubricate control.
	Control return spring weak.	Replace spring.
Fuel gauge does not register.	Loose wire connection at instrmment panel or tank unit.	Tighten connections.
	Instrument panel unit or tank unit inoperative.	Replace unit.

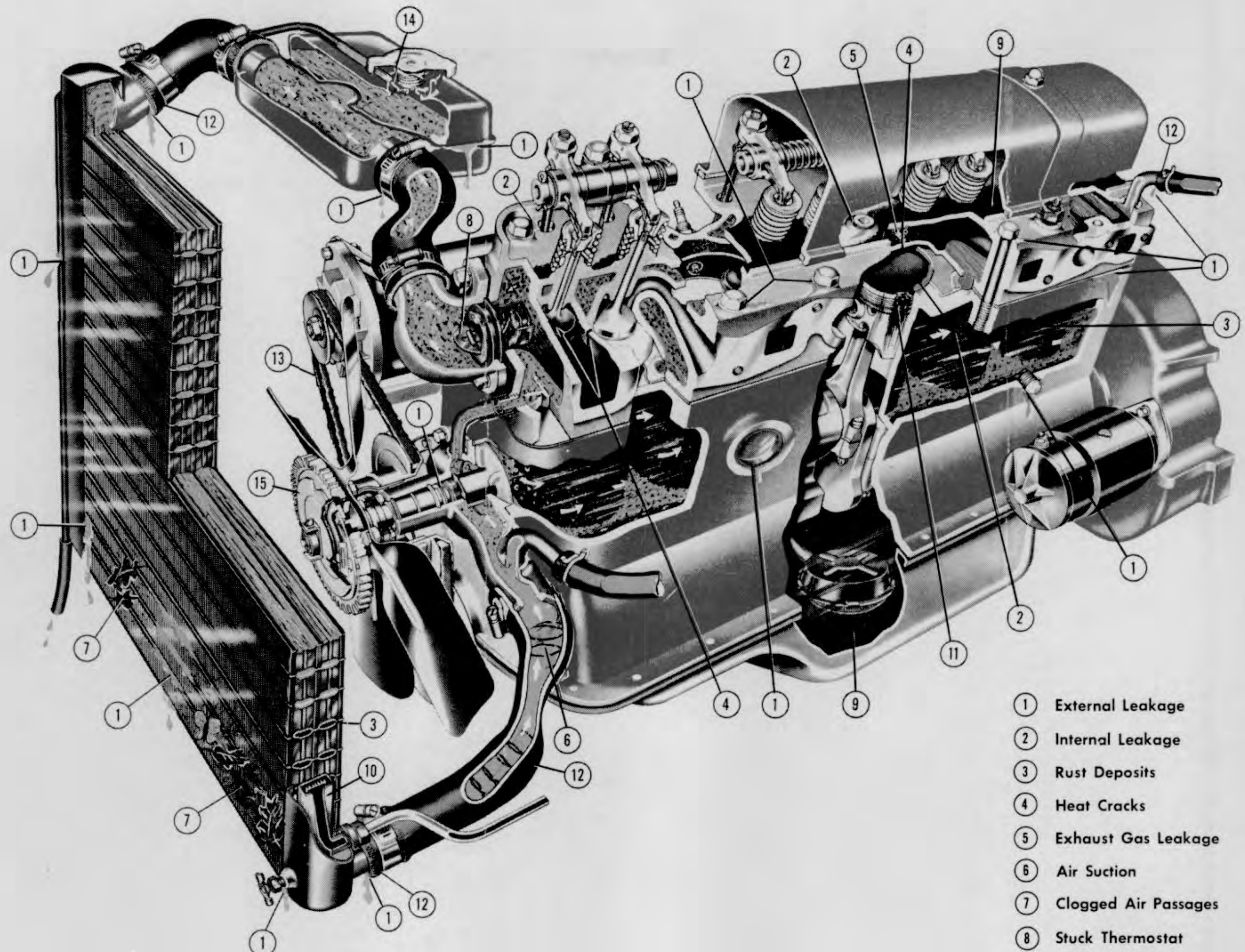
TROUBLE SHOOTING GUIDE

COOLING SYSTEM

TROUBLE	PROBABLE CAUSE	REMEDY
Overheating.	Unusual operating conditions of high temperature.	Inspect. (Refer to "Engine over-heats".)
Loss of cooling solution.	Loose hose connections.	Tighten hose connections.
	Damaged or deteriorated hose.	Replace hoses.
	Leaking radiator.	Repair or replace radiator.
Engine operates too cool.	Thermostat sticking.	Replace thermostat and gasket.
	Low air temperature.	Cover radiator.
Noises.	Frayed or loose fan belt.	Replace or adjust belt.
	Water pump defective.	Replace pump.

THE ENGINE COOLING SYSTEM

Trouble spots resulting from service neglect



1. External Leakage
2. Internal Leakage
3. Rust Deposits
4. Heat Cracks
5. Exhaust Gas Leakage
6. Air Suction
7. Clogged Air Passages
8. Stuck Thermostat
9. Sludge Formation in Oil
10. Transmission Oil Cooler
11. Heat Damage
12. Hose Failure
13. Worn Fan Belt
14. Pressure Cap Leakage
15. Temperature Control Fan Drive

The cooling system depicted here does not represent that of any particular make of car; it incorporates features used by many different manufacturers.

Cooling System Care Pays!

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INDUSTRIAL TRUCK DIVISION

CLARK EQUIPMENT

TROUBLE SHOOTING GUIDE

IGNITION SYSTEM

TROUBLE	PROBABLE CAUSE	REMEDY
Ignition System troubles.	Weak spark.	Refer to "Engine will not Start."
	Timing incorrect.	Retime ignition.
	Moisture on distributor wires, coil, or spark plugs.	Clean and dry thoroughly
	Ignition switch inoperative	Replace switch
	Primary or secondary wiring loose, broken, or grounded.	Service.
	Coil defective	Refer to "Ignition coil troubles," below.
	Distributor defective.	Refer to "Distributor troubles", below.
	Spark plug defective.	Refer to spark plug troubles below.
Ignition coil.	Connections loose; dirty or broken external wire, wet.	Clean and tighten, or repair, dry thoroughly.
	Coil defective.	Replace coil.
Distributor troubles.	Distributor breaker points dirty or pitted, point gaps incorrect.	Clean, adjust or replace breaker points.
	Distributor breaker point arm spring weak.	Replace breaker point arm.
	Distributor breaker points sticking.	Free-up breaker points.
	Distributor automatic advance defective.	Lubricate and free-up. If seized, replace distributor.
	Distributor cap or rotor shorted, cracked or broken.	Replace defective parts.
	Distributor rotor does not turn.	Replace broken shaft, rotor, or gear.
	Condenser defective.	Replace condenser.
Spark plug troubles.	Cracked, broken, leaking, or improper type.	Replace spark plug.
	Spark plug wires incorrectly installed on plugs or in distributor cap.	Install wires correctly.
	Spark plugs dirty; gap incorrect.	Clean, set gaps, or replace plugs.
	Spark plug porcelain cracked or broken.	Replace plug.

STARTING MOTOR

TROUBLE	PROBABLE CAUSE	REMEDY
Starting motor cranks engine slowly.	Engine oil too heavy.	Change to proper grade oil.
	Battery charge low.	Recharge or replace battery.
	Battery cell shorted.	Replace battery.
	Battery connections corroded, broken, or loose.	Clean and tighten, or replace cables.
	Dirty commutator.	Clean commutator.
	Insufficient brush surface contact.	Free-up or replace brush.
	Defective starting motor.	Replace starting motor.
	Starting switch defective.	Replace switch.
Starting motor does not crank engine.	Engine oil too heavy.	Change to proper grade oil.
	Starting motor, Solenoid, or cables defective; loose connections.	Replace or tighten loose connections.
	Starting motor pinion gear jammed in flywheel drive gear.	Remove starting motor and reinstall. Replace defective driving gear.
	Dirty drive mechanism.	Clean and lubricate drive mechanism.
	Faulty Relay Switch.	Replace Relay Switch.
	Ignition Fuse Blown.	Replace Fuse.
	Faulty Ignition Switch.	Replace Switch.
	Faulty Neutral Starting Switch.	Replace Switch. NOTE: The INDEX of this manual will list an ADJUSTABLE Neutral Starting Switch if your machine is so equipped.

TROUBLE SHOOTING GUIDE

GENERATOR TROUBLES

TROUBLE	PROBABLE CAUSE	REMEDY
No output.	Regulator defective.	Replace regulator.
Low or fluctuating output.	Loose fan belt.	Adjust belt.
	Insufficient brush surface contact.	Free-up or replace brush.
	Weak brush springs.	Replace spring.
	Worn commutator.	Turn commutator and undercut.
	Broken or loose connections.	Repair, tighten or replace
	Dirty commutator.	Clean commutator.
	Regulator defective.	Replace regulator.
	Loose or dirty connections in charging circuit.	Clean and tighten connections.
Excessive output.	Short circuit between field coil and armature leads.	Replace generator
	Regulator defective.	Replace regulator.
Noisy.	Loose pulley or generator mounting.	Tighten.
	Defective bearings, or armature rubbing on field poles.	Replace generator.
	Improperly seated brushes.	Seat Brushes.
Generator regulator trouble.	Loose connections or mountings.	Clean and tighten.
	Defective regulator.	Replace regulator.

INDUSTRIAL TRUCK DIVISION

CLARK EQUIPMENT

TROUBLE SHOOTING GUIDE

BATTERY, LIGHTS AND HORN

TROUBLE	PROBABLE CAUSE	REMEDY
Battery discharged.	Battery solution level low.	Add distilled water to bring level above plates; inspect for cracked case.
	Short in battery cell.	Replace battery.
	Generator not charging.	Inspect generator, fan belt, and regulator.
	Loose or dirty connections; broken cables.	Clean and tighten connections; replace cables.
	Excessive use of starting motor.	Tune up engine; charge battery.
	Idle battery, or excessive use of lights with engine at idle.	Recharge or replace battery. Use lights sparingly.
	Short circuits.	Replace defective wiring.
Battery (other troubles)	Overheated battery.	Inspect for short circuit or excessive generator charge.
	Case bulged (or out of shape).	Inspect for overcharging and overtightening of hold-down screws.
Light switch.	Loose or dirty connections; broken wire.	Clean and tighten; replace broken wire.
	Defective switch.	Replace switch.
Wiring.	Loose or dirty connections; broken wire or terminal.	Clean, tighten, repair or replace. Wire or terminal.
Lights do not light.	Switch not fully "on".	Turn switch "on" fully.
	Loose or dirty connections; broken wire.	Clean and tighten; replace or repair wire or terminal.
	Wiring circuit short-circuited, or open.	Correct short circuit or replace defective parts.
	Light burned out.	Replace light.
Lights dim.	Loose or dirty connection.	Clean and tighten connections.
	Wiring short-circuited.	Correct short circuit or replace defective parts.
	Defective switch.	Replace switch.

TROUBLE SHOOTING GUIDE

BATTERY, LIGHTS AND HORN (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
Horn troubles.	Loose or dirty wiring connections.	Clean and tighten connections.
Horn sounds continuously.	Short-circuit in wiring between horn and horn button.	Replace wire.
Improper tone.	Loose or dirty wiring connections.	Clean and tighten connections.
	Cover or bracket screws loose.	Tighten.
	Points adjusted improperly.	Adjust points.
Horn will not operate.	Horn Fuse Blown.	Replace Fuse.
	Open Circuit.	Trace, repair or replace as required.
	Faulty Horn Relay.	Replace relay.

TROUBLE SHOOTING GUIDE

DRIVE AXLE

TROUBLE	PROBABLE CAUSE	REMEDY
Continuous Axle Noise.	Badly worn parts.	Replace worn parts with new.
	Unevenly worn tires.	Replace tires.
	Improperly adjusted wheel bearing.	Adjust correctly.
	Lack of lubricant.	Add sufficient lubricant of correct grade.
Axle Noise on Drive or on Coast Only.	Differential pinion gear and ring gear out of adjustment or worn excessively.	Adjust, repair or replace entire unit if conditions warrants.
Excessive Backlash in Axle Driving.	Loose axle shaft drive flange cap screws.	Tighten cap screws.
	Flange loose on axle shaft.	Reweld flange to shaft.
	Worn splines on axle shaft at differential end.	Replace drive flange and shaft assembly.
	Differential drive pinion gear and ring gear out of adjustment or worn excessively.	Adjust or replace as condition warrants.
Complete Failure to Function.	Broken axle shaft.	Replace axle shaft.
	Broken teeth on ring gear or pinion gear.	Replace ring gear and pinion and other parts of differential necessary. Adjust ring gear and pinion gear correctly.

INDUSTRIAL TRUCK DIVISION

TROUBLE SHOOTING GUIDE

STEERING AXLE

TROUBLE	PROBABLE CAUSE	REMEDY
Trouble.	Damaged axle.	Replace axle.
	Lubrication leaks.	Replace oil seals.
	Incorrect caster or camber.	Adjust and Replace worn parts.
	Uneven tire wear.	Inflate tires properly. Check wheel alignment.

TROUBLE SHOOTING GUIDE

STEERING

TROUBLE	PROBABLE CAUSE	REMEDY
Steering difficult.	Lack of lubrication	Lubricate.
	Tight steering system connections.	Lubricate and adjust linkage.
	Tight steering gear; misaligned wheels.	Adjust steering gear bearings, realign wheels.
	Bent steering connecting linkage or arm.	Straighten or replace linkage.
	Misaligned steering gear mounting.	Adjust mounting.
Wander or weaving	Improper toe in camber or caster (axle twisted).	Replace worn parts. Adjust for proper camber and caster.
	Steering system connections or king pin bearings not properly lubricated.	Lubricate.
	Loose wheel bearings.	Adjust wheel bearings.
	Steering gear worn or maladjusted.	Replace worn parts and adjust bearings.
	Steering gear mountings loose.	Tighten mounting bolts.
Low speed shimmy or wobble.	Loose steering connections.	Adjust and tighten linkage.
	Steering gear worn, or adjustment too loose.	Tighten mounting bolts.
Low speed shimmy or wobble.	Loose steering connections.	Adjust and tighten linkage.
	Steering gear worn, or adjustment too loose.	Replace worn parts; adjust worn thrust bearings and lash adjustment.
	Loose wheel bearings.	Adjust wheel bearings.
Vehicle pulls to one side.	Odd size, or new and old tires on opposite wheels.	Match tires.
	Bent steering arm or connection.	Straighten or replace bent linkage.

TROUBLE SHOOTING GUIDE

BRAKES

TROUBLE	PROBABLE CAUSE	REMEDY
Brakes drag.	Improper pedal adjustment.	Adjust brake pedal free travel.
	Brake pedal return spring broken or weak.	Replace spring.
	Brakes improperly adjusted.	Adjust brakes.
	Brake shoe anchor pin tight in shoe.	Free-up pin and lubricate lightly.
	Brake shoe return spring broken or weak.	Replace spring.
	Loose or damaged wheel bearings.	Adjust or replace wheel bearings.
	Insufficient brake shoe clearance, or improper brake anchor pin adjustment.	Adjust brakes.
	Brake backing plate loose.	Tighten plate.
	Grease on linings.	Correct grease leakage; clean or install new shoes and lining assemblies.
	Dirt imbedded in lining.	Clean lining with wire brush.
	Drums scored or rough.	Replace drum and brake shoe and lining assemblies.
Severe brake action on light pedal pressure.	Brake shoes improperly adjusted.	Adjust brakes.
	Grease on linings.	Correct grease leakage; clean or install new shoes and lining assemblies.
	Loose brake shoe anchor.	Adjust and tighten.
Brake locked.	Brake pedal lacks free travel.	Adjust pedal free travel.
	Brakes frozen to drums (cold weather).	Break loose by driving vehicle.
Brake noisy or chatters.	Brake lining worn.	Replace shoe and lining assemblies.
	Grease on linings.	Correct leakage; clean or replace shoe and lining assemblies.
	Dirt embedded in linings.	Clean lining with wire brush.
	Improper or loose linings.	Replace shoe and lining assemblies.
	Brake shoe or drum distorted.	Straighten or replace.

INDUSTRIAL TRUCK DIVISION

TROUBLE SHOOTING GUIDE

BRAKES (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
Excessive pedal travel.	Lining worn.	Adjust or replace shoe and lining assemblies.
	Brake improperly adjusted.	Adjust brake.
	Scored brake drums.	Repair or replace drums.
Excessive pedal pressure.	Grease on linings; worn or glazed lining.	Correct grease leakage; clean up and replace shoe and lining assemblies.
	Warped brake shoes, or defective brake linings.	Replace shoe and lining assemblies.
	Shoes improperly adjusted.	Adjust brakes.
	Brake drum scored or distorted.	Repair or replace drums.
	Shoes improperly adjusted.	Adjust brakes.
	Insufficient fluid in master cylinder.	Fill master cylinder to within 1/4 inch of the top.
Wheel troubles.	Wheel wobbles; bent.	Inspect mounting on hub, spindles, and drive axle; replace defective wheel or mounting.
	Wheel loose on hub.	Tighten.
	Wheel out of balance.	Balance wheel.
	Wheel bearings run hot.	Adjust, lubricate wheel bearings.

INDUSTRIAL TRUCK DIVISION

CLARK EQUIPMENT

TROUBLE SHOOTING GUIDE

HYDRAULIC SYSTEM

TROUBLE	PROBABLE CAUSE	REMEDY
Pump not delivering oil.	Wrong direction of rotation.	Must be reversed immediately to prevent seizure and breakage of parts due to lack of oil.
	Tank oil level low.	Add recommended oil.
	Oil intake pipe or suction filter plugged.	Replace filter cartridge, clean strainer if so equipped.
	Air leak in suction line.	Will prevent priming, or cause noise and irregular action of control circuit.
	Oil viscosity too heavy to pick up prime.	Thinner oil should be used, per recommendations for given temperature and service.
	Broken pump shaft or gear.	Replace broken, worn or defective parts.
Pump not developing pressure.	Pump not delivering oil for any of the above reasons.	Check oil circulation by watching oil in tank.
	Relief valve spring broken	Replace relief valve
	Relief valve sticking open.	Dirt under pressure adjustment valve. Clean valve
	Leak in hydraulic control system (cylinders or valves).	Find leak and correct.
	Partially clogged intake line, intake filter or restricted intake pipe.	Pump must receive intake oil freely or cavitation will take place.
Pump making noise.	Small air leak at pump intake piping joints.	Test by pouring oil on joints while listening for change in operation. Tighten as required.
	Air leak at pump shaft packing.	Repair or replace.
	Tank air vent plugged.	Must be open thru breather opening or air filter.
	Too high oil viscosity.	Use recommended oils.
	Shaft packing worn.	Replace shaft packing per preceding instructions.
	Oil filter dirty.	Replace filter element.
Forks do not lift to maximum height.	Hydraulic Oil level low.	Fill sump tank.

TROUBLE SHOOTING GUIDE

HYDRAULIC SYSTEM CONTINUED

TROUBLE	PROBABLE CAUSE	REMEDY
Lift or tilt action fails.	Loss of oil pressure.	See "pump not delivering oil
Oil leak at top of lift cylinder assembly.	Worn or damaged lift piston seal.	Replace seal.
	Scored cylinder wall.	Replace Cylinder
	Plugged vent line.	Clean out vent line. Replace if collapsed.
Oil leak around piston rod at tilt cylinder	Worn seal.	Replace seal.
	Scored piston rod.	Replace rod and eliminate cause of scoring which myy be caused by misalignment, worn bearing or foreign matter.
With load centered on lift forks load is lifted unevenly.	Lift chains out of adjustment.	Adjust chains.

TROUBLE SHOOTING GUIDE

TRANSMISSION, CONVERTER AND AXLE ADAPTER

TROUBLE	PROBABLE CAUSE	REMEDY
Machine will not move in either direction	Parking brake not released.	Release brake.
	Control linkage not properly adjusted.	Readjust linkage.
	Oil level low.	Determine cause and correct. Fill to proper level with Type "A" Automatic Transmission Fluid Armour Qualified.
	No oil pressure.	Replace Pump.
Machine will move in one direction only.	Control linkage not adjusted.	Adjust linkage.
	No oil pressure to Directional Selector. Seals and "O" Rings in Directional Selector may be defective.	Replace seals and "O" Rings.
	Directional Selector Discs not releasing. Discs defective. Relief hole in D.S. Drum clogged.	Replace Discs and clean all orifices.
Machine moves slowly in both directions at wide open throttle.	Oil level low.	Fill to correct level and determine cause for loss of oil.
	Low oil pressure. Faulty Inching Valve, Faulty Relief Valve, Faulty Pump.	Replace defective parts.
	Brakes dragging.	Adjust brakes.
	Clogged Sump screen.	Clean Screen.
Transmission overheating.	Low oil.	Check and fill to correct level.
	Low Directional Selector pressure (check with gauge). Inching valve not functioning properly.	Replace worn parts as necessary and clean.
	Seals in selector defective.	Replace seals
	Regulating valve sticking open.	Clean valve; replace worn or defective parts.
	Brakes Dragging.	Adjust brakes.
	Clogged Sump Screen.	Clean Screen.

TRANSMISSION, CONVERTER AND AXLE ADAPTER

TROUBLE	PROBABLE CAUSE	REMEDY
Transmission Overheating (continued)	Insufficient oil to Torque Converter and Cooler.	Add oil to proper level; check for plugged lines; replace defective parts.
	Cooler clogged internally stopping flow of oil.	Clean Cooler.
	Bushing in Torque Converter Impeller Hub worn, allowing oil to leak out.	Replace worn or defective parts.
	Slipping Stator.	Refer to Transmission Pressure Checks.
Machine has full power and overheats.	Overloading machine.	Check Capacity loads. Never overload.
	Radiator core clogged externally.	Clean Core.
	Pressure Regulator Valve sticking, giving low pressure.	Clean Valve; replace worn or defective parts.

INDUSTRIAL TRUCK DIVISION

MAINTENANCE SECTION
ALPHABETICAL INDEX

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 in 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 1/8" 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″ water.

6 — Exhaust line obstructed — should have back pressure of not more than 20″ water.

7 — Poor fuel.

8 — Piston rings sticking or worn.

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

1 — Valves holding open — no tappet clearance.

2 — Leaky cylinder head gasket.

3 — Broken or weak valve springs.

4 — Burned or sticking valves.

5 — Badly worn, broken or stuck piston rings.

6 — Wrong valve timing.

H — OVERHEATING

1 — Lack of water in radiator.

2 — Fan belts slipping.

3 — Thermostat sticking or inoperative.

4 — Radiator clogged or leaky.

5 — Late ignition timing.

6 — Back pressure in exhaust line.

7 — Defective water pump.

8 — Overloading of engine.

I — LOW OIL PRESSURE

1 — Low Oil level.

2 — Oil pressure gauge or line faulty.

3 — Oil too light — diluted.

4 — Suction screen plugged.

5 — Dirt in relief valve or broken spring.

6 — Worn bearings.

7 — Worn or damaged oil pump gears.

8 — Worn Cam Bushings.

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

1 — Engine oil too heavy.

2 — Stuck relief valve.

3 — Obstruction in distributing line.

4 — Faulty oil pressure gauge.

K — HIGH OIL CONSUMPTION

1 — Oil leaks.

2 — Too high oil level.

3 — Incorrect grade of oil used.

4 — Clogged crankcase breather.

5 — Oil pressure too high — stuck relief valve.

6 — Piston rings not run-in, due to too smooth cylinder bore finish or glazed condition.

7 — Worn, broken or stuck piston rings and clogged oil control rings.

8 — Worn pistons and sleeves.

9 — Worn bearings.

10 — Worn valve guides.

(Manifold may be removed for visual inspection.)

L — ENGINE KNOCKS AND OTHER NOISES

1 — Operating Knocks — which may be due to:

(A) **Pre-Ignition** — Most common cause is due to wrong type plugs which are too hot.

(B) **Carbon** — 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 ⅔ 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.

(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.

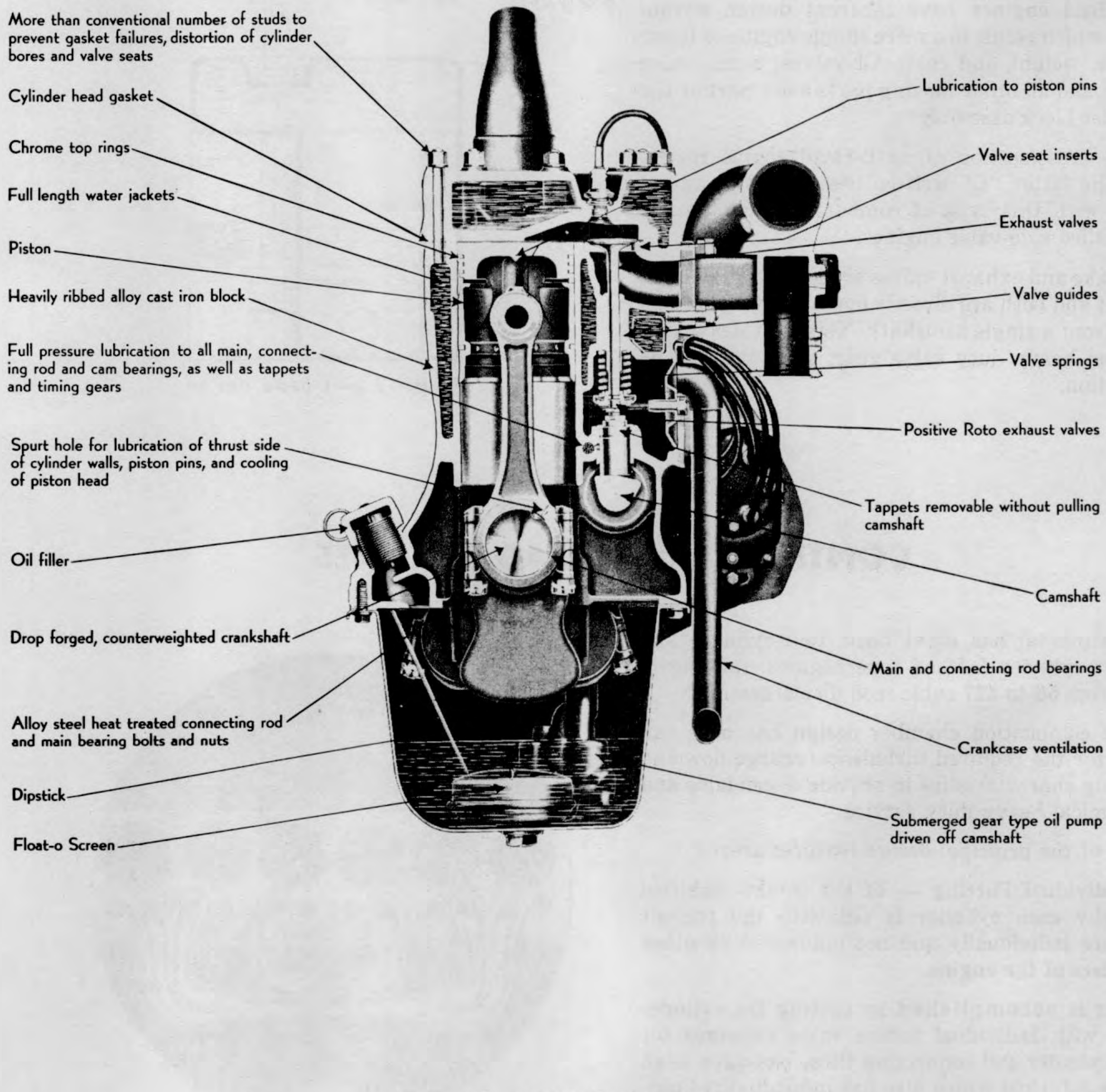


Figure 1 — Cross Section of a Typical Continental "L" Head Engine

GENERAL INFORMATION

L-Head engines have inherent design advantages which result in a more simple engine of lower height, weight and cost. All valves, cams, valve lifters and all other moving parts are a part of the cylinder block assembly.

The cross-section of an L-Head engine resembles the letter "L" written upside down and engines with this type of combustion chamber are also called side-valve engines.

Intake and exhaust valves are located in the side pocket and both are directly operated through tappets from a single camshaft. This provides a simple and heavy duty valve gear, since there is no deflection.

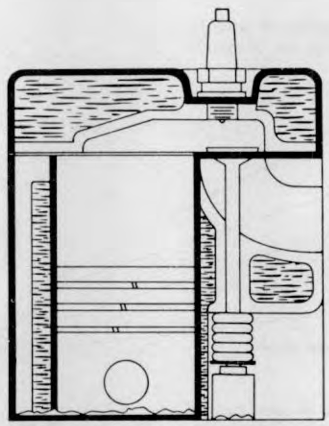


Figure 2 — L-head design

CONTINENTAL L-HEAD ENGINES

Continental has eight basic four-cylinder and ten six-cylinder L-Head type engines, ranging in size from 56 to 427 cubic inch displacement.

The combustion chamber design has been tailored for the required turbulence, charge flow and burning characteristics to provide dependable and economical heavy duty service.

Some of the principal design features are:

1. **Individual Porting** — of the intake manifold whereby each cylinder is fed with the fuel-air mixture individually and not influenced by other cylinders of the engine.

This is accomplished by casting the cylinder block with individual intake valve passages for each cylinder and connecting these passages to an intake manifold which also has individualized passages for each cylinder.

This equal distribution results in maximum power, smooth operation, easy starting and longer engine life.

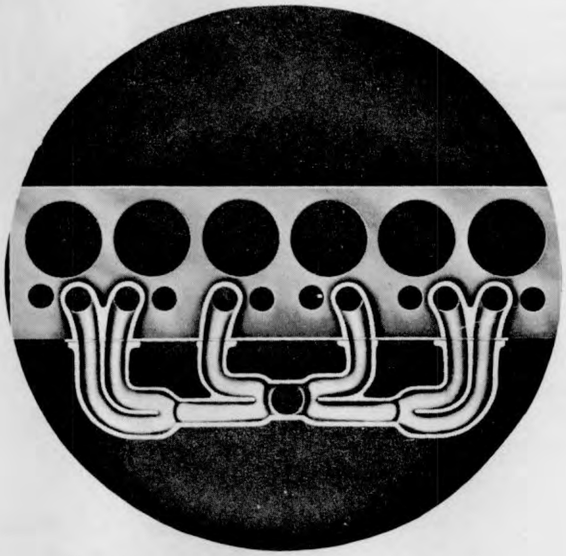


Figure 3 — Individual Porting

2. **Directional Cooling** — is accomplished by regulating the course of the cool water from the water pump so it first comes in contact with exhaust valve seats and then to other points as indicated by their relative temperatures.

This feature promotes uniform cooling throughout the system, prevents hot-spots and prolongs valve life.

This coupled with the by-pass and thermostat included in the engine assembly, insures rapid warm-up and even temperature distribution.

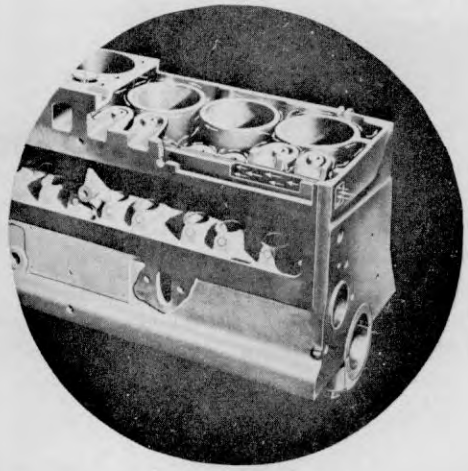


Figure 4 — Directional Cooling in Block

3. **Full Length Water Jackets** — completely surround all cylinder bores the full length of the piston travel.

This insures uniform cooling with minimum bore distortion — which results in lower oil consumption; less blow-by and minimum tendency to sludge.

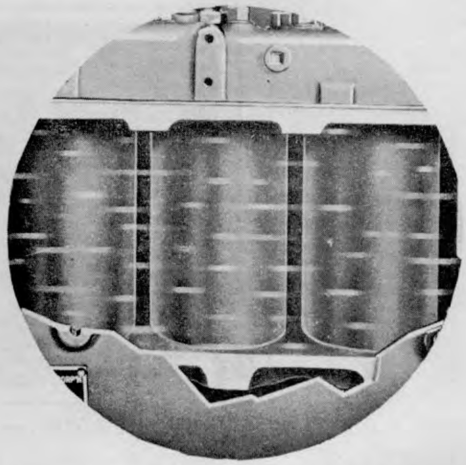


Figure 5 — Full Length Water Jackets

4. **Removable Tappets** — The large, barrel shaped, pressure lubricated tappets are so designed that by removing the adjusting screw — the main body can be lifted out and replaced from above through the valve chamber. This eliminates the costly service operation of dropping the oil pan and pulling the camshaft. Locking of the adjustment is both simple and effective.

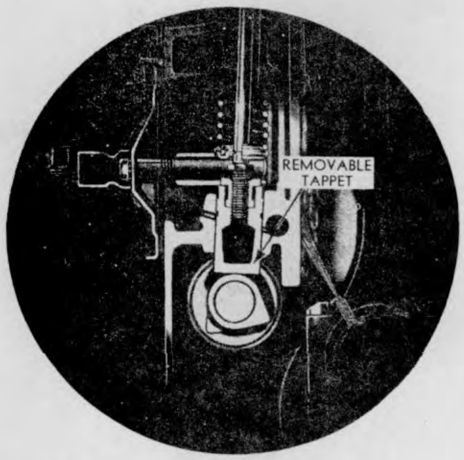


Figure 6 — Removable Tappets

5. **Choice of Fuels** — Gasoline - LPG - Natural Gas - Fuel Oil — Continental L-Head engines have been tailored for heavy-duty operation using gasoline - LPG - natural gas - fuel oil fuels.

INFORMATION FOR ORDERING PARTS

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

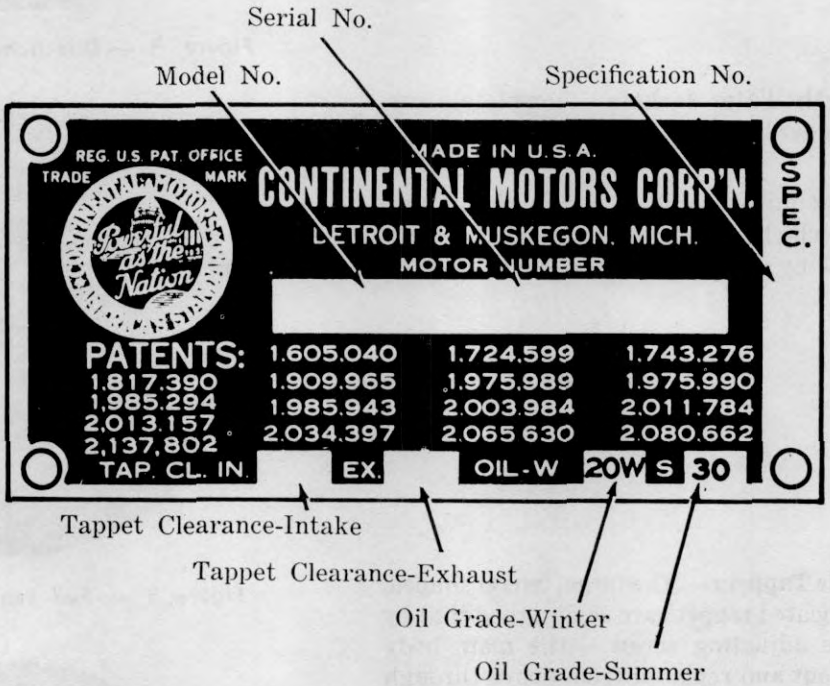


Figure 7 — Nameplate

LUBRICATION

ENGINE LUBRICATION SYSTEM

Continental L-Head engines have full pressure lubrication to all main, connecting rod and camshaft bearings as well as tappets and timing gears.

To insure piston pin lubrication and prevent piston scuffing during the warm-up period in cold weather — the large end of the connecting rods have drilled spurt holes pointing toward the thrust side of the pistons. These line up with the oil hole in the crank pin so that once each revolution, oil is sprayed on the cylinder wall for lubrication.

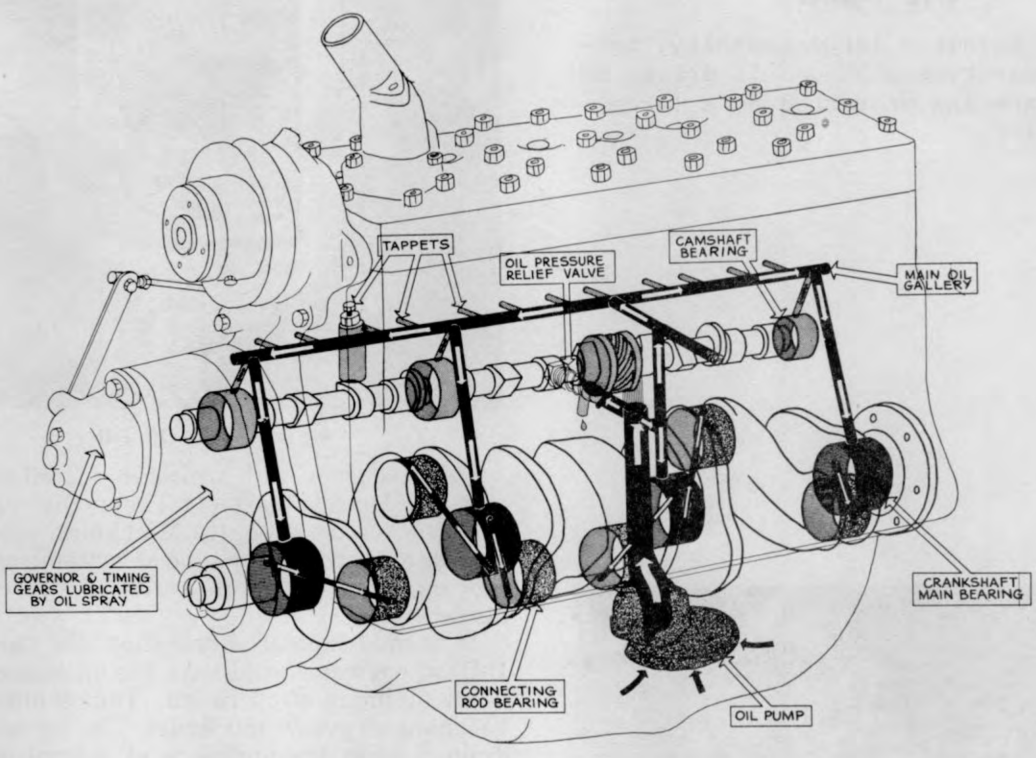


Figure 8 — Oiling Diagram

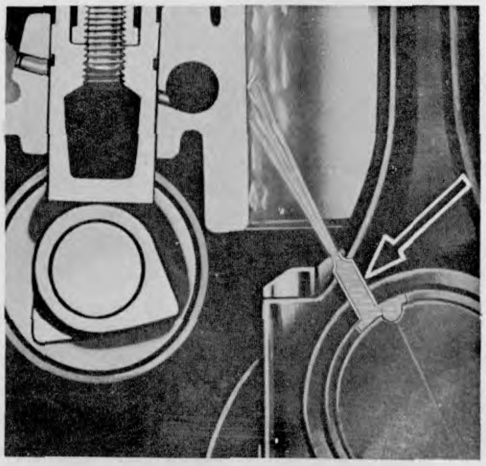


Figure 9 — Connecting Rod Spurt Hole

OIL PUMP

On all engines a large capacity, submerged, gear type oil pump is driven off the camshaft and protected by a large screen inlet.

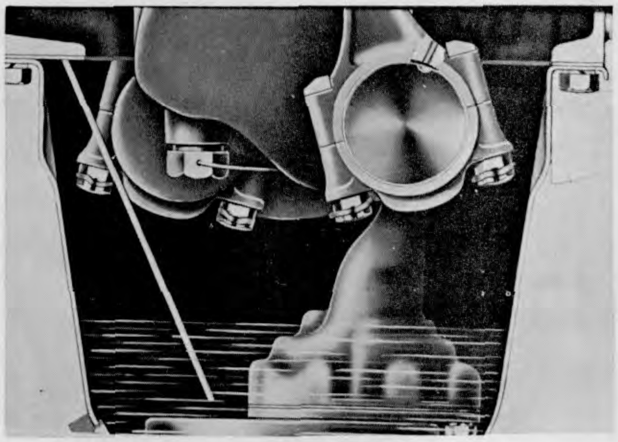


Figure 10 — Oil Pump

*Other pressures are available, based on customer specifications.

A by-pass type oil filter is normally provided to remove dirt and foreign elements from the oil, a percentage of which is passed through the filter during the operating period. The removal of grit, sludge and foreign particles causes filter elements to clog and become ineffective unless they are normally replaced every 150 hours.

OIL CHANGE FREQUENCY

Engine oil does not "wear out". However, the lubricating oil in internal-combustion engines becomes contaminated from the by-products of combustion: dirt, water, unburned fuel entering the crankcase, and the detergents holding the carbon particles in suspension in the crankcase.

Figure 11 — Oil Filter

The frequency with which engine oil should be changed depends upon (1) The quality of the oil, (2) Type of operation, (3) Mechanical condition of the engine and (4) The type of contaminants from the engine operation and the surrounding atmosphere.

In normal Industrial operation, the Continental L-Head engines should have the oil changed after every 50 hours of operation. The oil filter should be changed every 150 hours. The oil should be drained when the engine is at normal operating temperature.

BREAKING-IN NEW OR RECONDITIONED ENGINES

New or reconditioned engines have very small clearances. To assure adequate oil distribution to these closely fitted surfaces during the first week or 50 hours of engine operation, the use of a lighter bodied oil is desirable.

When the engine break-in is performed during the warmer months of the year, an SAE 10-W-30 oil should be used. Be sure to allow a several-minutes warm-up period before applying the load.

DO NOT FLUSH CRANKCASE WITH KEROSENE

Some operators unwisely put kerosene in the crankcase after draining the engine oil, then turn the engine over with the starter — in the belief they are doing a better job of crankcase cleaning.

In doing this, kerosene is circulated through the oil pump, the main oil header and the branches leading into the engine bearings — thereby washing away the protective oil film. In addition, some of the kerosene will be trapped and remain to thin out the new oil, reducing its lubricating qualities.

Do not put kerosene into the crankcase. The best method is to drain the oil when the engine is thoroughly heated — which will carry off most of the sediment.

AIR CLEANER

All engines, when operating, consume several thousand cubic feet of *air per hour.* Since dusty air is full of abrasive matter, the engine will soon **wear excessively** if the air cleaner does not remove the dust before entering the cylinders.

Two basic types of air cleaners are normally used — the oil bath type and the dry replaceable element type.

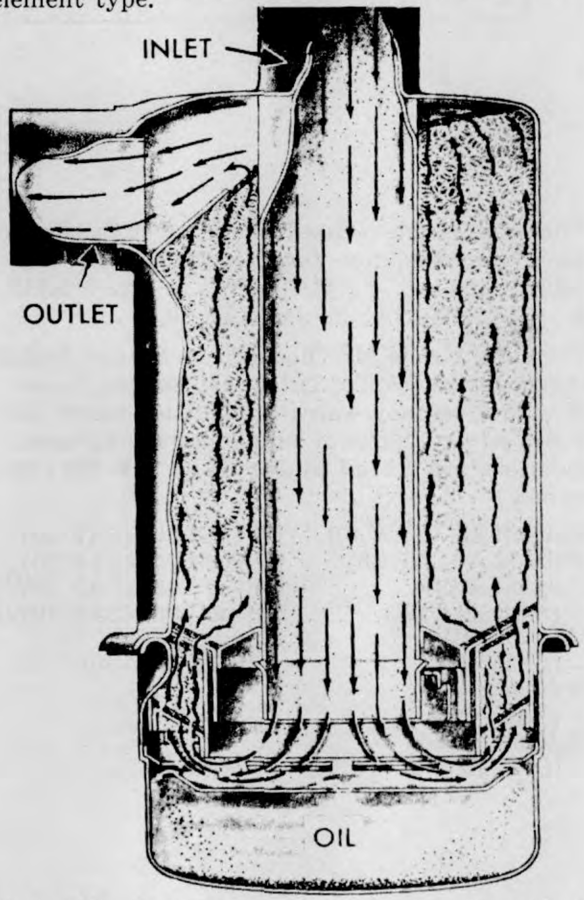


Figure 12 — Sectional View of Oil Bath Air Cleaner

Operating conditions determine the air cleaner service periods. In extremely dusty operations, this may be once or twice daily. In dust protected areas, the air cleaner should be serviced when changing oil.

As the dirt is strained from the air flowing through the cleaner, it thickens the oil in the cup and raises the level. If the level is too high, agitation of the oil on the screen is affected and gritty oil is carried over into the air stream, through the carburetor and into the engine cylinders. This would actually introduce a grinding compound with resulting very rapid wear.

LUBRICATION RECOMMENDATIONS

Motor oils used for internal-combustion engine lubrication perform many useful functions including: dissipating heat; sealing piston rings; preventing metal to metal contact wear and reducing power loss through friction.

The lubricating oil recommendation is based upon engine design; type of service and the atmospheric temperature prevailing. High quality oils are required to assure maximum performance, long engine life and minimum cost of operation.

L-Head gasoline engines operate in a wide range of service conditions and seasonal temperatures, so our recommendations are given for various types of service and ambient temperatures.

The American Petroleum Institute (API) has established new service classifications so that the engine operator can properly select the best type of oil.

They have the following three classifications of engine oils relating to the different operating conditions for gasoline or other spark-ignition engines:

SERVICE ML — (Former API Designation: **Regular)**

Light or Easy Service Conditions — Such as moderate operating speed at normal engine temperatures — especially where the engine is relatively insensitive to promote deposit formation and bearing corrosion.

SERVICE MM — (Former API Designation: **Premium)**

Moderate Severe Service Conditions — Involving higher speeds and operating temperatures; particularly when the higher temperatures tend to promote deposit formation and bearing corrosion.

SERVICE MS — (Former API Designation: **Heavy-Duty Type)**

Severest Service Conditions — include:

Start-Stop Operation — which leads to emulsion sludge and corrosive wear; involves essentially a low-temperature condition, and one which gets worse in colder weather.

Severe High Temperature Operation — Resulting from high loads or overloads or high operating speed which tends to result in carbon, lacquer and sludge deposits.

S.A.E. OIL BODY GRADES

The oil body grades available from the lightest (SAE 5W) to the heaviest (SAE 40) are:

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.	NORMAL WINTER 0° - 32°F.	SPRING-FALL 32° - 75°F.	SUMMER ABOVE 75°F.
10W	10W	SAE20W	SAE30

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.

Use High Grade **MS** Oils such as Socony Mobil Oil Company Mobiloil or Delvac 1100-series. Favorable conditions may warrant oils listed under ML and MM service; however our above general recommendations are listed under **SERVICE MS** Oils such as:

Mobiloil AF (SAE 40)
Mobiloil A (SAE 30)
Mobiloil Arctic
(SAE 20-20W)
Mobiloil 10W
(SAE 10W)
Mobiloil 5W
(SAE 5W-20)
Mobiloil Special
(SAE 10W-30)

Delvac 1140 (SAE 40)
Delvac 1130 (SAE 30)
Delvac 1120 (SAE 20W)
Delvac 1110 (SAE 10W)
Delvac Special
(SAE 10W-30)

ENGINE REPAIR AND OVERHAUL

This section includes instructions for repairs and overhaul of the component units of Continental Red Seal L-Head engines.

Provide a clean place to work and clean the engine exterior before you start disassembling — dirt causes engine failures. Many shop tools have been developed to save time and assure good workmanship; these should be included in your equipment.

Use only genuine Red Seal parts in Continental engines since years of development and testing have gone into these specifications to assure maximum life and performance.

CYLINDER HEAD

The cylinder head is an important part of the engine assembly since it contains the complete combustion chamber and cored passage for water flow. Remove the cylinder head in the following sequence:

1. Drain water from engine and disconnect radiator or heat exchanger 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.

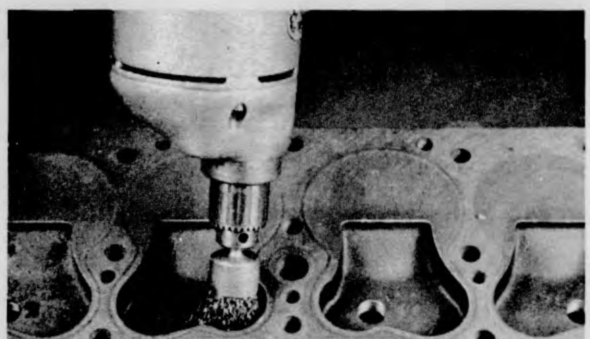


Figure 14 — *Cleaning carbon from combustion chamber*

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.

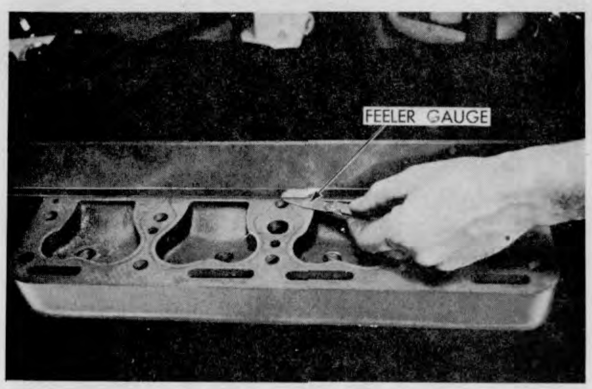


Figure 13 — *Checking cylinder head flatness lengthwise.*

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″ long, maximum permissible lengthwise out-of-flatness is .012″. 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.

Figure 15 — *Checking cylinder head flatness crosswise.*

CYLINDER BLOCK

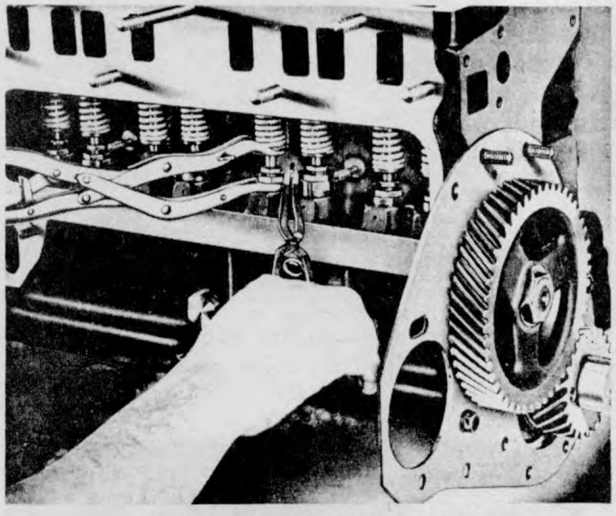


Figure 16 — Valve Removal

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

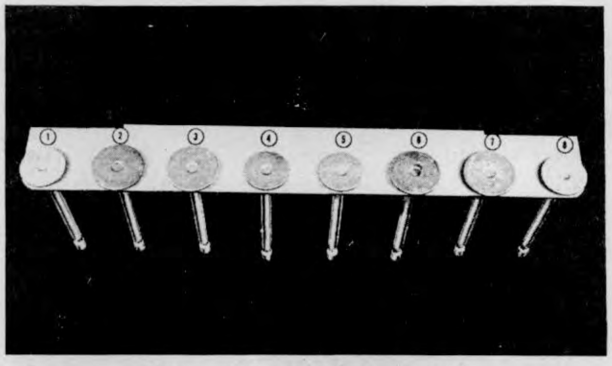


Figure 17 — Valves in rack

VALVE GUIDES

1. Clean the valve stem guides, removing lacquer or other deposits by running a valve guide cleaner or wire brush through the guides.

2. Check guides for wear by using "Go and No-Go" plug gage or a telescope gage and 1" micrometer. Replace all guides that are worn bell-mouthed and have increased .0015 in diameter. See Limits and Clearance Section for maximum diameter permissible to determine actual amount the diameter has increased. Remove all valve guides when necessary by using an arbor press and pressing them out from the combustion chamber side with a driver slightly smaller than the O.D. of the valve guide.

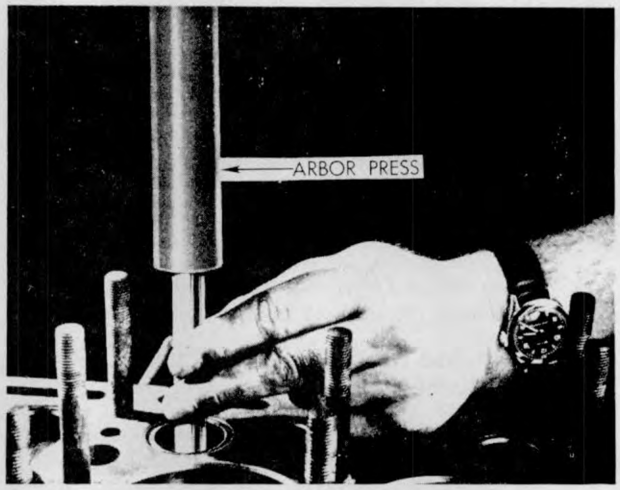
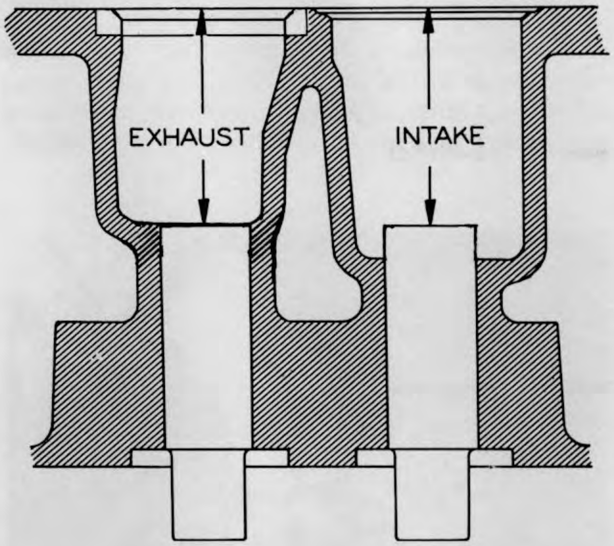


Figure 18 — Removing valve guides

3. Replace worn guides as required by using a suitable driver and an arbor press from the combustion side to the correct depth below the valve seat as given in the Limits and Clearance Chart.



Engine	Distance from Block Face to Top of Guide	
	Intake	Exhaust

Refer to Limits and Clearance in front of manual.

CAUTION: When replacing guides that are ferrox coated do not ream since these are all pre-reamed before being ferrox coated — any further reaming will remove the coating.

VALVE SEAT INSERTS

1. The exhaust valve seat insert is held in place by a shrink fit.

Inspect all exhaust valve inserts in the block and replace any that are loose, cracked or otherwise damaged. Use puller for removing faulty insert as shown in illustration.

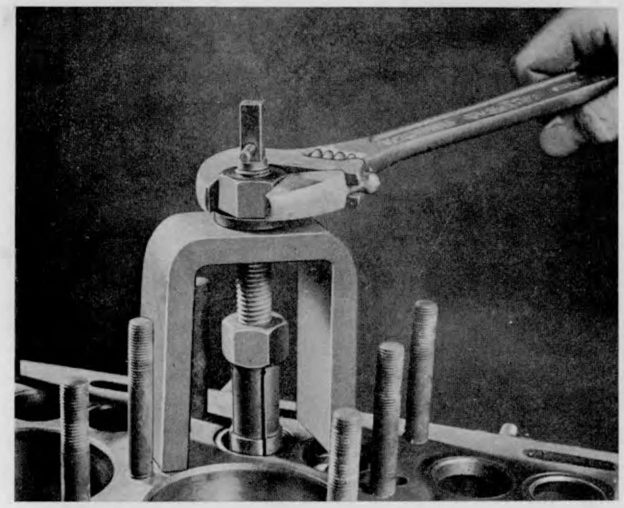


***Figure** 19 — Removing exhaust valve seat insert*

2. When required to replace with new insert, clean and counterbore for .010 larger insert using counterbore tool with correct fitting pilot.

When machining the counterbore, be sure to go deep enough with the tool to clean up the bottom so that the insert will have full contact to carry away the heat.

Continental does not recommend installing new inserts having the same outside diameter as the one removed. The following chart shows the dimensions of Standard Inserts and counterbores:

DIMENSIONS OF STANDARD INSERTS AND COUNTERBORES

Engine Model	Outside Dia. of Insert (A)	Inside Dia. of Counterbore (B)

Refer to Limits and Clearance in front of manual.

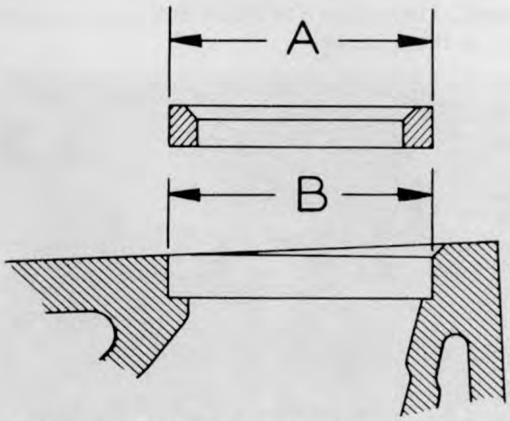


Figure 20-A — Insert and counterbore

When OVERSIZE inserts are used, dimensions of the insert and counterbore increase proportionately (.010, .020 — depending on the oversize).

New insert installation should have a press fit. Chill insert in container with dry ice for 20 minutes before assembling.

Insert may then be installed in the counterbore using a piloted driver, tapping in place with very light hammer blows, without the possibility of shearing the side walls. This assures it being seated firmly on the bottom of the counterbore.

Figure 21 — Installing valve seat insert with an arbor press

3. Grind the intake and exhaust valve seats in the block in accordance with instructions in the limits and clearance chart and before removing the arbor, indicate the seat. Total indicator reading of the run-out must not be more than .002". Use a pilot having a solid stem with a long taper, as all valve seats must be ground concentric and square with either new or worn valve stem guide holes.

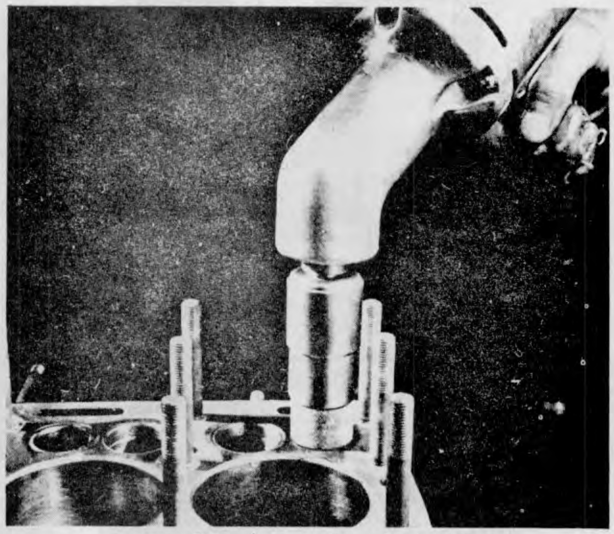


Figure 22 — Grinding Valve Seat

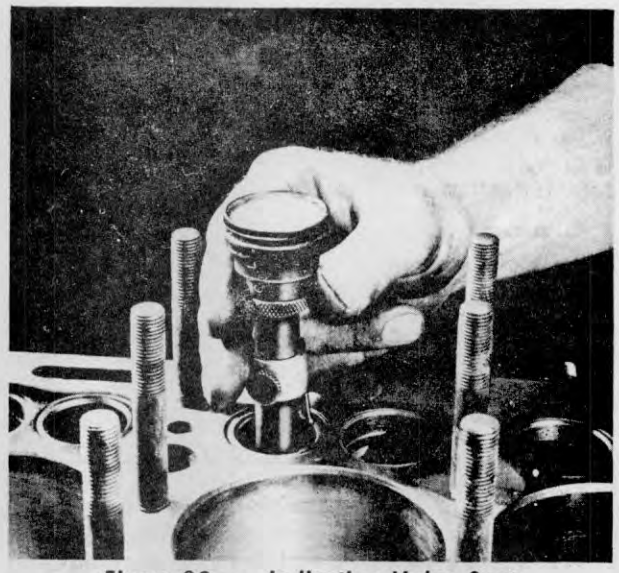


Figure 23 — Indicating Valve Seat

VALVES

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.

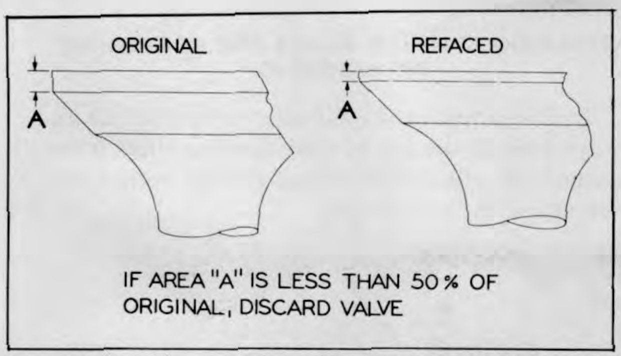


***Figure* 24 — Allowable head thickness of refaced valves**

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.

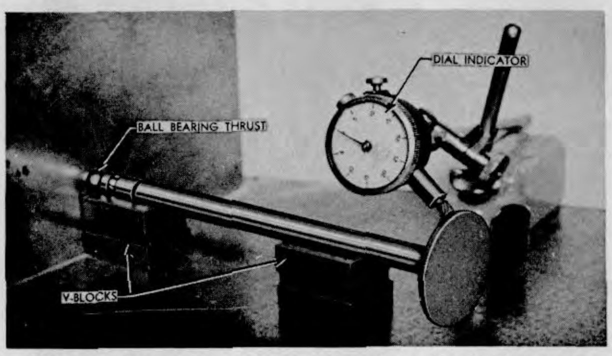


***Figure* 25 — Checking valve face in "V" blocks**

3. Check all refaced or new valves in V-blocks with indicator to determine if the contact face is true with the stem within .002. If not, repeat the refacing operation.

4. After the valves and seats have been refaced and reground, coat the seat lightly with Prussian blue and drop the valve into position, oscillating it slightly to transfer the blue pattern to the valve face. This should show a contact width of 1/16" to 3/32" and should fall well within the width of the valve face, leaving at least 1/64" on either side where

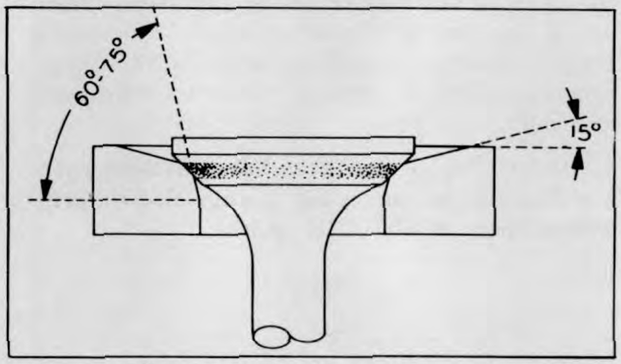


***Figure* 26 — Method of narrowing valve seats**

the blue does not show. If the contact is over 3/32" wide, the seat in the head may be narrowed by using a 15° stone to reduce the outside diameter or using a 60° or 75° stone to increase the inside diameter.

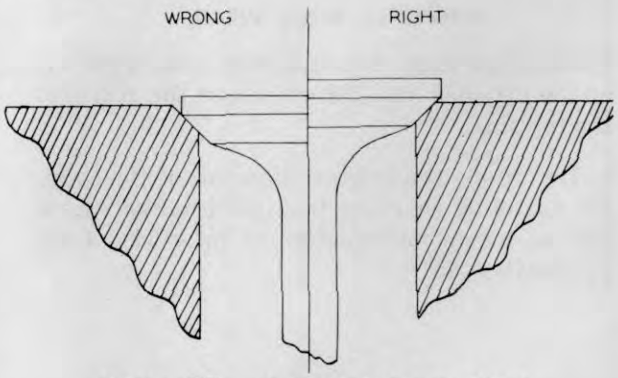


***Figure* 27 — Valve position in block**

Never allow valves to set down inside the seat.

After the narrowed-down seat is brought within specifications, the seat should be retouched lightly with the original stone to remove burrs or feathered edge.

> **"A poor valve grinding job cannot be corrected by valve lapping."**

5. Coat the valve stem with a light film of engine oil.

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.

***Figure* 28 — Valve spring tester**

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

CYLINDER BLOCK

All "L" head engines, except the N56, have cylinder barrels cast in the block.

CHECKING 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°.

***Figure** 29 — Measuring original bore diameter above ring travel*

3. Check in same manner the top of the ring travel area approximately ¼" 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.

PREPARING CYLINDER WALLS FOR RE-RINGING OR REBORING

1. Ridge ream the cylinders to remove the unworn area at the top so that the new rings when assembled will not bump and distort both themselves and the piston lands.

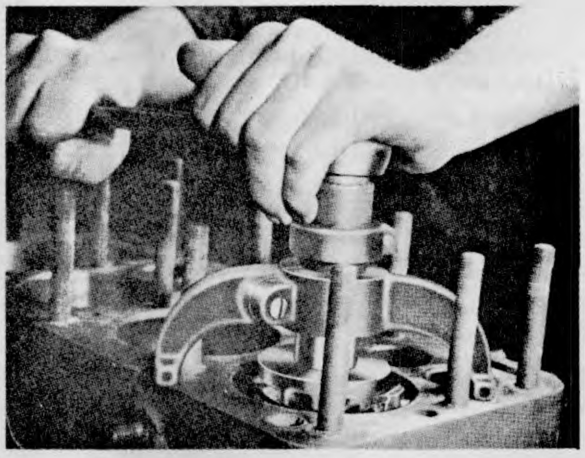


***Figure** 30 — Ridge reaming top of cylinder bore*

Several good makes of ridge reamers are available which will ream the top of the bore in direct relation to the worn area so that should the worn area be off center slightly there will be no partial ridge remaining.

2. Drain the crankcase and remove the oil pan.

3. Remove the cap screws holding the connecting rod caps to the rod. *Keep the cap and bolts in numerical order so that when the pistons and rods are removed from the engine, the cap can be reassembled and kept with its mating part.*

4. Push the pistons and connecting rods up through the top of the cylinder, carrying with them all the carbon and metal chips left from the cleaning and ridge reaming operation. *When doing this, every precaution must be taken to prevent damage to cylinder bores by the sharp corners and rough edges of the connecting rods and bolts.*

5. To get the correct cross hatch pattern with a cylinder hone, use a top quality electric drill with a speed of 500 RPM or less.

5. It is important to remove the glaze on the cylinder bores by using a glaze breaker in order to assure quick seating of the new piston rings. **If the cylinder glaze is not removed, you will have no assurance as to when the rings will begin to function properly and control the oil; this is especially true when chrome rings are used.**

The following step by step procedure is recommended:

a. Cover the entire crankshaft with a clean, slightly oily cloth to prevent abrasives and dirt from getting on the crankshaft.

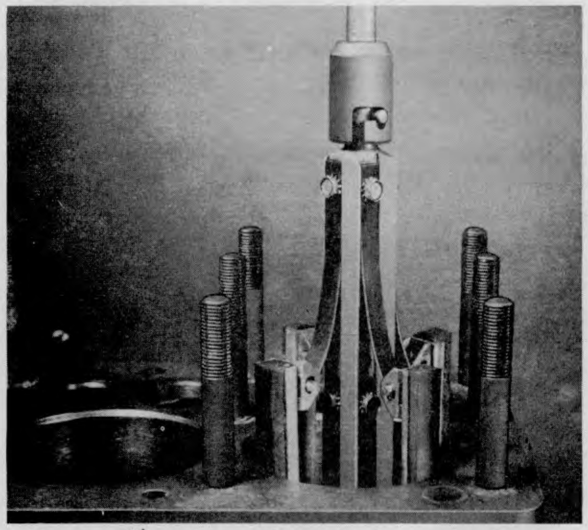


Figure 34— Removing cylinder wall glaze

b. Remove the excess carbon deposits from the top of the cylinder wall before beginning the glaze breaking operation. (This is to prevent loading the stones.)

c. Surface hone each cylinder several times; move the glaze breaker up and down in the cylinder rapidly to produce a 45 degree cross hatch pattern similar to that illustrated.

d. Clean the loose abasives from the stones by using kerosene and a wire brush. (Do not use thinner to clean the stones because of the explosion hazard.) Dry the glaze breaker before moving to the next cylinder.

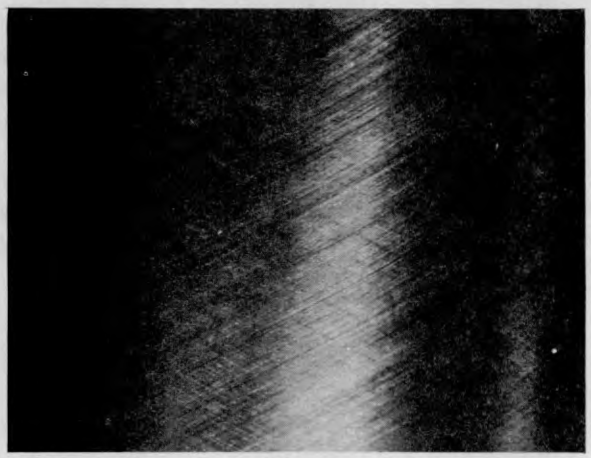


Figure 35— Desirable cross hatch pattern obtained with a glaze breaker

e. The most desirable cylinder finish is 30 — 40 micro inches; with this finish the depressions in the surface tend to keep the supply of lubrication between the mating parts. This finish can be obtained by using 220 grit stones on the glaze breaker.

f. Clean all bores thoroughly with a clean oiled rag to pick up all the small particles of dust that may be embedded in the walls. Follow this with a clean cloth to make certain the walls are **CLEAN.**

PISTONS

Check the pistons for excessive ring groove wear, and replace any that exceed the allowable limits in our limits and clearance data.

The cylinder walls and pistons must be perfectly clean and dry when fitting pistons in the cylinder bores. Pistons should be fitted with the block and piston at room temperature (68° - 70° F).

Refer to Limits and Clearance in front of manual.

Check the piston fit in the bore using a half-inch wide strip of feeler stock, of the thickness specified in the Limits and Clearance Chart, the feeler being attached to a small scale of approximately 15 lbs. capacity.

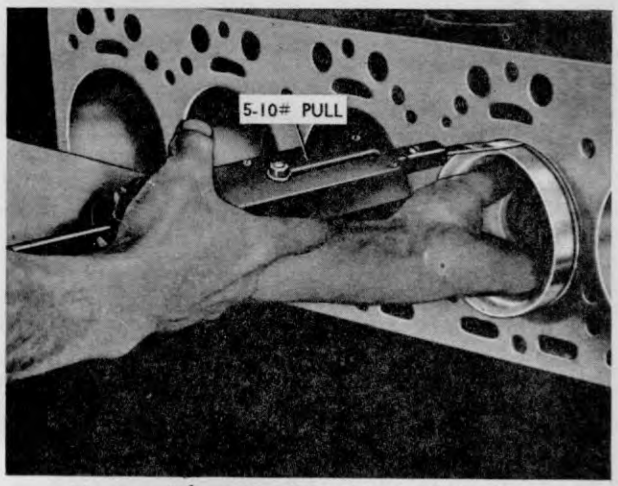


Figure 36— Checking Piston fit in bore

When the correct fit is obtained you must be able to withdraw the feeler with a pull of 5-10 pounds on the scale, with the feeler inserted between the piston and the cylinder midway between the piston pin bosses where the diameter of the piston is the greatest. Check the fit of the piston when it is approximately 2" down in the cylinder bore in an inverted position.

PISTON PINS

Check the bushing in the upper end of the connecting rod for wear. If worn and you are using the original pistons with a service set of rings, an oversize piston pin may be obtained in .003 or .005" oversize.

The piston pin hole in the piston and the bushing in the connecting rod may be honed to increase

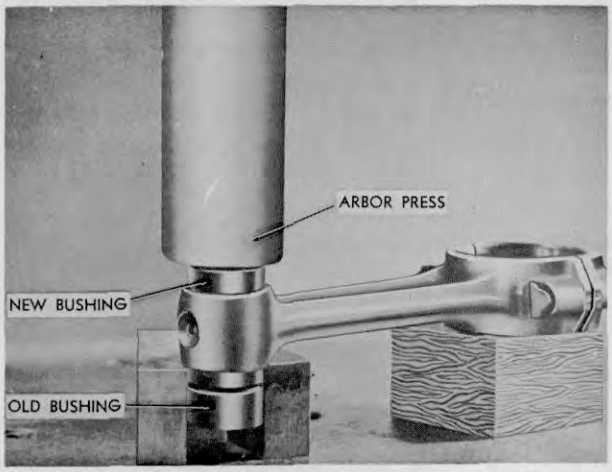


Figure* 34 *— Pressing in Piston Pin Bushing

their diameter to obtain the desired fit as shown in your Limits and Clearance Chart.

> Note that while the chart specifies a light push fit of the pin in the piston, there is a definite clearance of the piston pin in the connecting rod.

CONNECTING ROD

Replace the bushing in the connecting rod if new pistons and sleeves are used. Using an arbor press, press out the old bushing and press in the new one — after which the bushing must be honed to obtain the correct fit of the pin in the bushing as shown on Limits and Clearance Chart.

If there is an excess of stock in the piston pin bushing, it may be reamed first, then honed. In any event, the final operation should be done with a hone to obtain the desired fit with better than 75% bearing area on the pin.

PISTON AND CONNECTING ROD ASSEMBLY

1. Assemble the pistons on the connecting rod by first heating them in some form of oven or in hot water to a minimum temperature of 160°F. When heated, the piston pin will enter the piston very easily and can be tapped through the connecting rod and into place without distorting the piston.

The snap rings must be assembled in the grooves, making sure they are fully seated in place.

2. The piston pin hole in the connecting rod must be parallel to and in plane with, the large bore in the bearing end of the connecting rod.

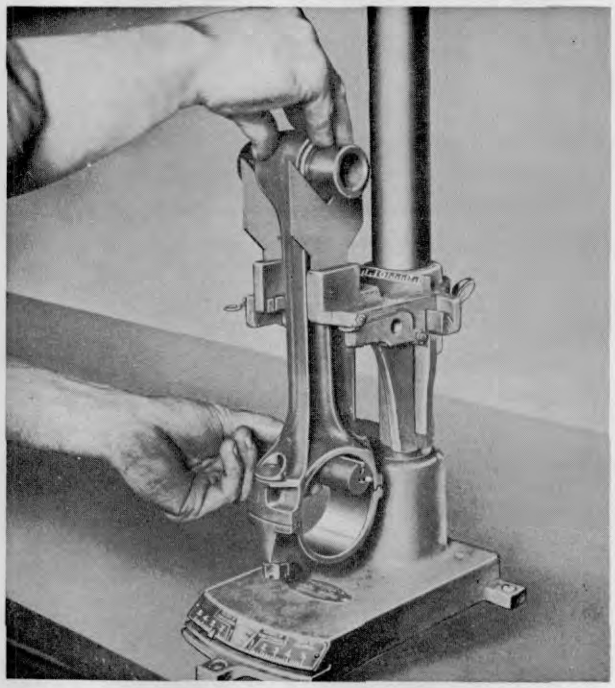


Figure* 35 *— Checking connecting rod for twist

This may be checked on a fixture with the piston pin assembled in the rod before assembling the piston; but regardless of this preliminary check, the completed piston and rod assembly must be rechecked and there must not be more than .002" twist or out of squareness checked over a spread of approximately 4 inches. The connecting rod can be bent or twisted to meet this specification.

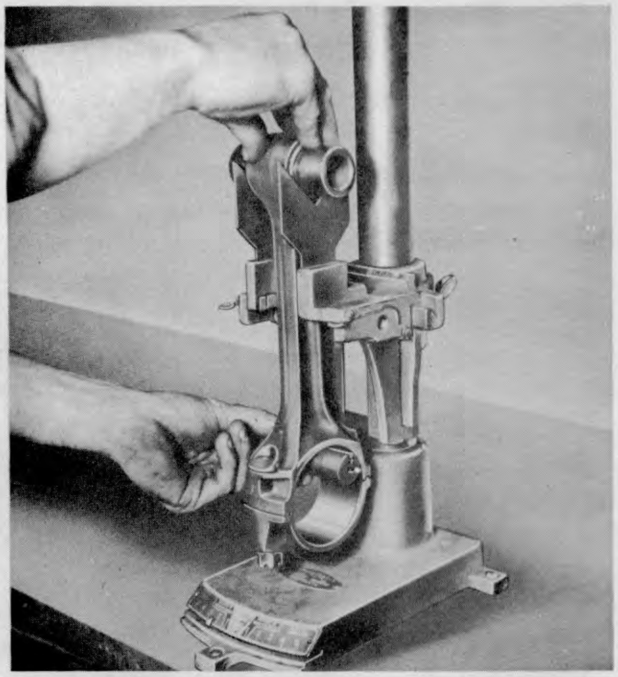


Figure 39. · Checking connecting rod for alignment

Pistons are cam and taper ground, and this must be taken into consideration when checking alignment of the assembly, since the diameter in line with the piston pin would be less at the top of the skirt than at the bottom.

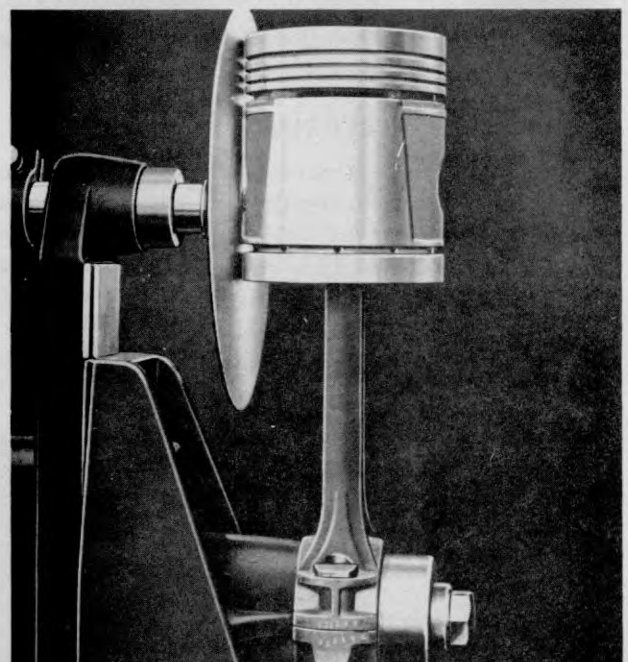


Figure 40 — Checking connecting rod assembly for alignment

PISTON RINGS

Check the piston rings in the cylinders for gap.

To do this, insert a piston in the cylinder bore in an inverted position and then insert each ring one at a time about 2" down in the bore and bring the bottom edge of the piston up against the ring to square it up in the cylinder bore.

Check the gap between the ends of the ring with a feeler gauge in accordance with specifications shown in the Limits and Clearance chart. If any of the rings do not have enough gap, they may be filed either in a ring filing fixture or by clamping the file in a vise and holding the two ends against opposite sides of the file.

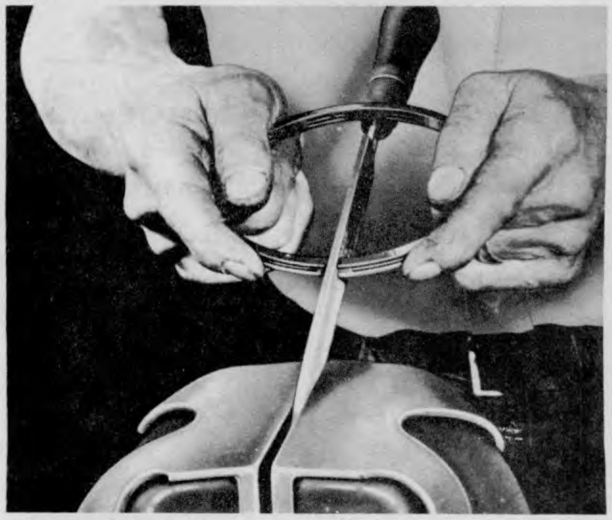


Figure 41 — Filing piston ring to increase gap

RECOMMENDED METHOD OF INSTALLING PISTON RINGS

1. Grip the connecting rod in a vise with lead lined jaws to hold the piston firmly and roll each of the straight side rings in its groove to be sure there are no burrs or other interference with the free action of the ring in the groove.

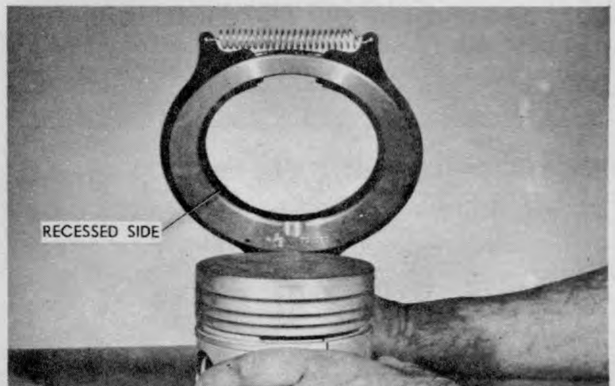


Figure 42 — Installing Rings with Ring Expander Tool

2. The 3 piece oil ring should be installed first on the piston, from the top side so skirt will not be scratched.

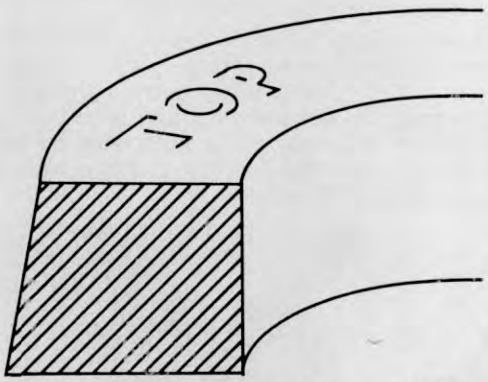


Figure 40 — Install Tapered Rings with "Top" Side Up

3. To install the balance of the rings, use a ring tool with **recess** side up and place the ring in with the bottom side up. **Start with the lowest ring first.**

Some piston rings are taper faced. These are clearly marked "TOP" on the side to be **up** when assembled on piston.

4. Position ring in the tool so the expanding fingers will fully engage both ends.

5. Apply pressure on handles so ring is completely expanded. Pass the expanded ring and tool **recessed side down** over the piston to the proper groove.

CAUTION

If piston is equipped with a steel groove insert, this must be installed on top of the number one ring. (The steel groove insert is not part of the re-ring kit — this can be re-used when replacing rings.)

6. Check the ring side clearance at various positions with a feeler in accordance with the tolerances shown on the Limits and Clearance Chart.

Figure 41 — Checking Ring Clearance in Groove

CRANKSHAFT AND MAIN BEARINGS

1. Using a puller, remove pulley from crankshaft.

2. Take out screws and remove gear cover.

3. Drop the oil pump, by removing nut or cap screws holding pump to center main bearing cap.

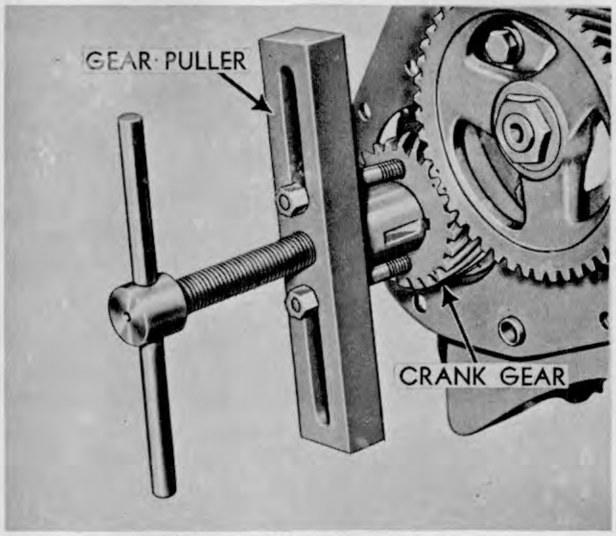


Figure 42 — Removing Crank Gear

4. Remove each main bearing cap, one at a time, and inspect the bearing and crankshaft journals.

If there is any indication of flaking out, scoring or actual wear, — **they must be replaced.**

BEARINGS

Some models use tri-metal bearings which when new are smooth and highly polished. However, a *very few hours of operation will change their appearance completely.* The bearing surface becomes a leaden gray in color and develops minute craters, almost cellular in appearance as indicated in the photograph, which follow the pattern of the matrix. *This appearance is a natural characteristic of this type bearing and in no way indicates failure.*

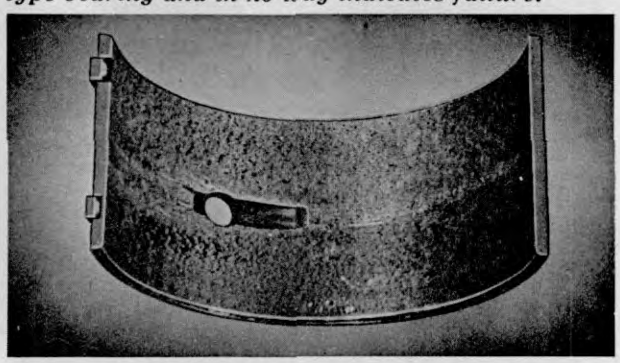


Figure 43 — Appearance of a Good Bearing

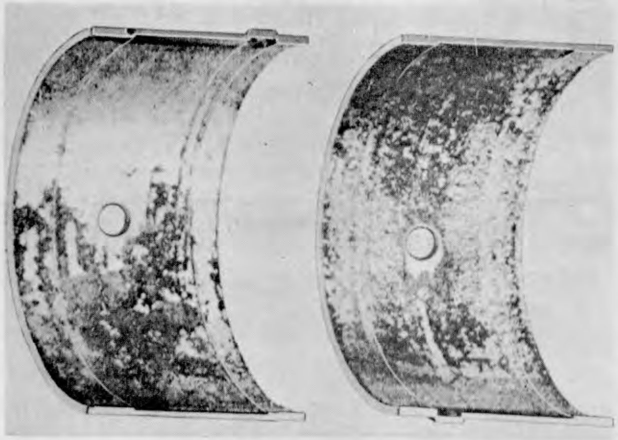


Figure 44 — Bearing Damage Due to Corrosion

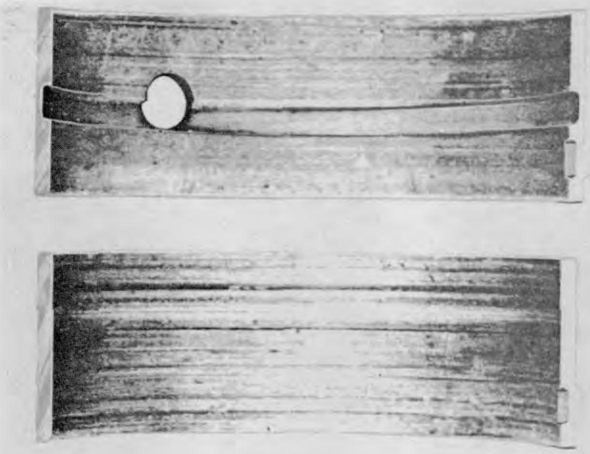


Figure 45 — Scored Bearing Due to Dirt or Lack of Oil

5. If the visual inspection appears satisfactory, they should be removed and checked for thickness using a ball micrometer.

Figure 46 — Removing Main Bearing

To remove the upper half of the bearing shell use a special tool obtainable at most parts houses, which is a pin with an angular head. It may be inserted in the oil hole of the crankshaft and as the crankshaft is turned in a clockwise direction, the head of this pin picks up the bearing shell and forces it out of the bore in the block.

Figure 47 — Measuring Bearing Thickness

The thickness of the bearing shells is given in the Limits and Clearance Chart, and if this thickness has been reduced more than .0005 beyond the maximum allowable tolerance the bearing shell must be replaced.

6. If visual inspection of the crankshaft shows no indication of excessive wear or scoring, the clearance of the feeler should be checked.

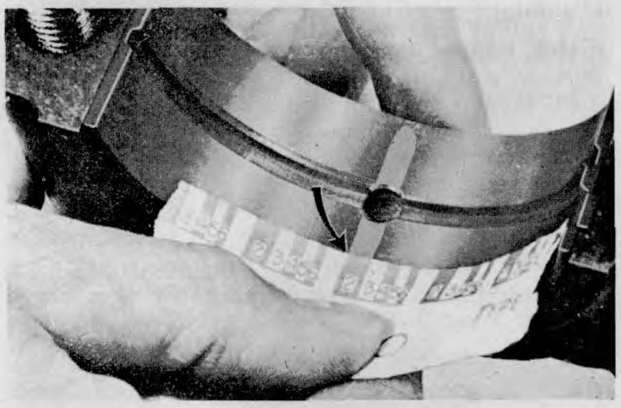


Figure 48 — Checking Bearing Clearance with Plastigauge

7. Check each bearing, one at a time, by using a piece of Plastigage of a diameter specified to check certain clearances.

By placing this Plastigage in the bearing and tightening it in place, the width of the Plastigage after crushing determines the bearing clearance as shown above.

CAUTION

When using this method DO NOT TURN the crankshaft as that would destroy the Plastigage.

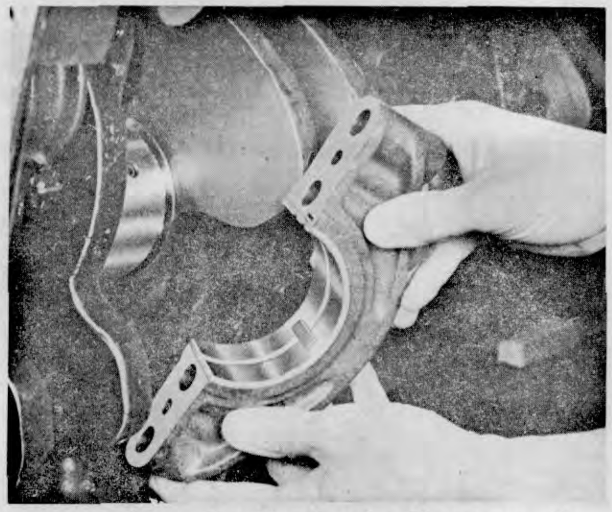


Figure 49 — Checking Bearing Clearance with Feeler Stock

An alternative method is to use a piece of ½″ feeler stock (the thickness of which should be equivalent to the maximum clearance permissible in the bearing) lengthwise, in the bearing shell, on a film of oil. Assemble the bearing cap and tighten the screws, torquing them to the specifications, — then try to turn the crankshaft by hand to determine whether or not you can feel a drag.

If a definite drag is felt and the piece of feeler stock is equivalent to, but no more in thickness than the maximum clearance specified, you may be sure that neither the crankshaft nor bearing are worn excessively as far as clearance is concerned.

When using new bearings and the crankshaft is not worn, checking with a piece of feeler stock as outlined above should lock up the crankshaft, making it possible to turn only by use of a bar or wrench.

If crankshaft is scored, or worn enough so that new bearings will not fit with the required clearance, it should be removed and reground.

Standard crankshafts may be reground to decrease the diameter a maximum of .040.

Before shaft is reground, it must be checked for straightness and straightened if necessary to be within .002 indicator reading. When reground, the fillet radii must be within dimensional limits and must be perfectly blended into thrust and bearing surfaces.

8. Connecting rod bearings and crank pins may be checked in the same manner with one exception; instead of trying to turn the crankshaft when the connecting rod bearing is tightened on it with a piece of feeler gauge assembled, try to move the connecting rod from side to side.

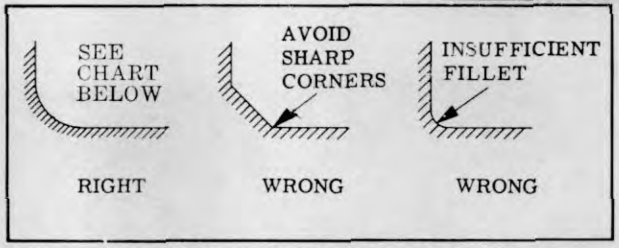


Figure 50 — Crankshaft Fillet Radii

Refer to Limits and Clearance in front of manual.

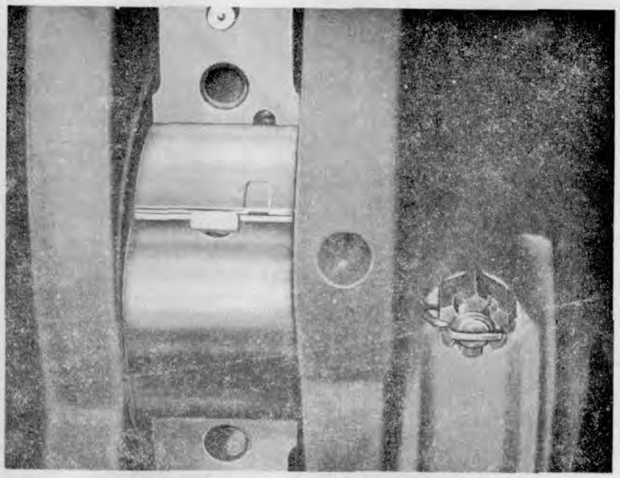


Figure 51 — Replacing Bearing

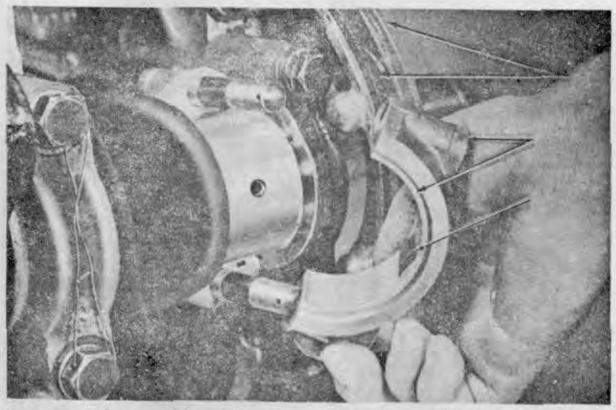


Figure 52 — Checking Rod Bearing with Feeler Stock

With new bearing shells and feeler stock equivalent to the specified clearance in thickness, if the crank pin is not worn you will quite probably have to use a hammer tap to move the rod from side to side, indicating that the clearance is well within the specification range.

CAMSHAFT

1. Using a puller, remove the cam and crank gears.

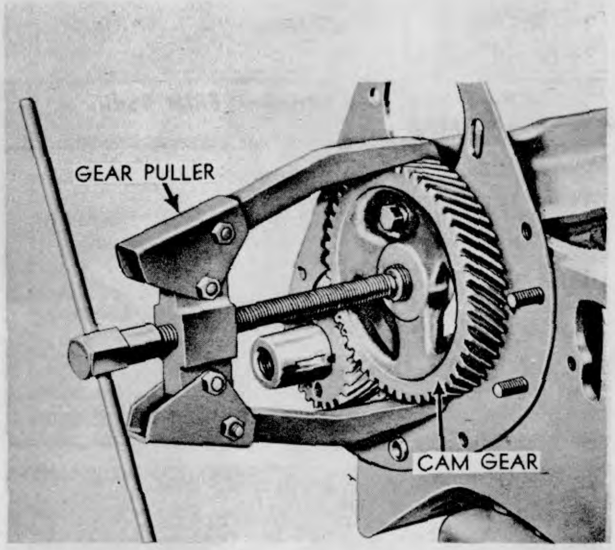


Figure 53 — Removing Cam Gear with Puller

2. Remove the screws holding the camshaft thrust plate to the front of the cylinder block, which makes it possible to pull the camshaft forward out of the bearings.

3. Unless engine is lying on its side, tappets must be removed or lifted before camshaft can be pulled.

4. Remove tappet chamber covers.

5. Tappets can then be lifted out and lined up in sequence, for installation in the same location unless inspection shows that they require replacement.

6. Before pulling the camshaft completely, check the clearance of the bearing journals in the bushing (or block in some models). To do this use strips of feeler stock 1/4" wide with edges dressed with a stone to eliminate any burrs or feathered edges.

7. If clearance is equal to or greater than the amount indicated under wear limits, check the diameter of the camshaft journals to determine the next step. Excess wear at these positions require replacement of the shaft.

If wear is found to be in the bushings instead, these must be replaced using precision service bushings, available for that purpose, which require no reaming, only care in assembly, to line up oil holes, and not to damage the bushings as they are being pressed in.

TAPPETS

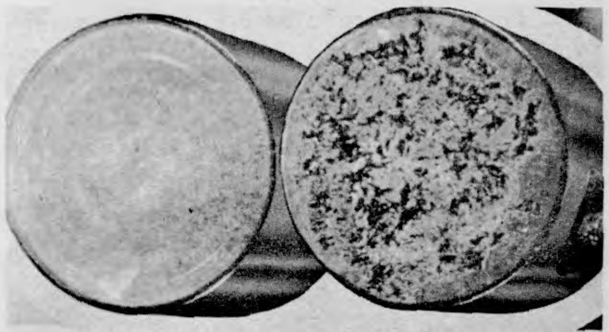


Figure 54 — Valve Tappet Wear Comparison

1. Inspect each tappet carefully. Two or more small pits on the contact face is acceptable; more than that calls for replacement of the tappet on the N, Y, F4, F6 Series.

Oversize tappets are available as required.

2. Check the outside diameter with micrometers to determine if replacement is necessary because of wear.

The tappet bore may be reamed oversize, and oversize tappets installed.

TAPPETS				
ENGINE	O. D. TAPPET	BORE IN BLOCK	TOTAL MAX. WEAR LIMITS	

Refer to Limits and Clearance in front of manual.

CAUTION — WHEN INSTALLING CAMSHAFT USE SPECIAL CARE TO PREVENT CAMSHAFT BUMPING AND LOOSENING EXPANSION PLUG TO CAUSE AN OIL LEAK

TIMING GEARS

1. Timing gears and timing gear fits must be checked carefully while the engine is being overhauled. To check the fit, use a screw driver to force the mating teeth as far apart as possible and check this clearance with a feeler gauge. If this clearance is .002" or greater, or if the gear teeth are badly scuffed and worn, the gear must be replaced. Timing gears must be replaced in pairs.

Figure 55 — Checking Timing Gear Backlash

Gears marked same as the original as far as sizes are concerned should be used as replacements.

2. Examine the camshaft thrust plate carefully for scoring and wear and if any indication of either shows, a new thrust plate should be assembled without question.

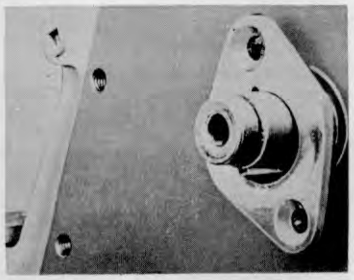


Figure 56 — Camshaft Thrust Plate

3. Assemble the cam gear to the camshaft by driving or pressing it on, at the same time **holding the camshaft forward with a suitable bar through the fuel pump opening in the block so there is no possibility of the camshaft bumping the expansion plug at the rear end and forcing it out of position, thus causing an oil leak.**

Check camshaft end play as shown in illustration. Refer to limits and clearance section for the correct dimension.

> CAUTION: NEVER USE THE CAMSHAFT NUT TO PULL THE GEAR ONTO THE CAMSHAFT. This will break the threaded end off cast iron camshafts and damage threads on steel camshafts.

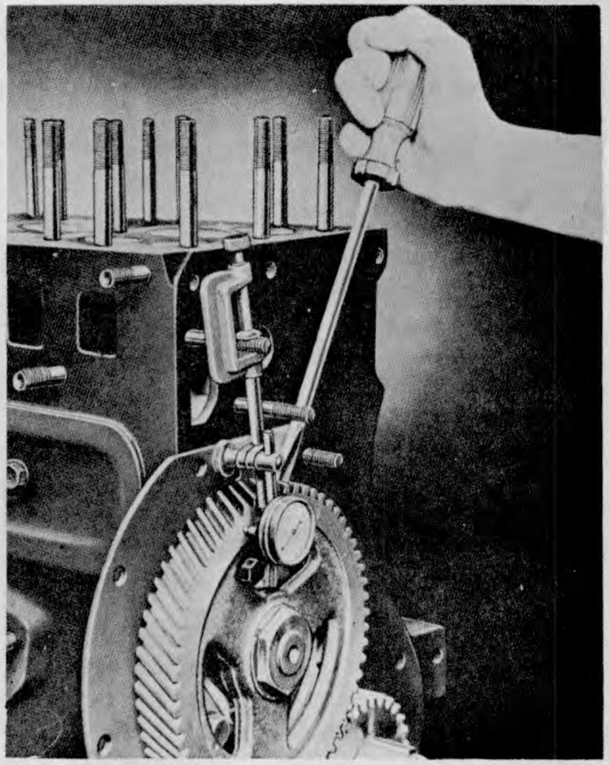


Figure 57 — Checking Camshaft End Play

4. Inspect crankshaft thrust washers for wear and scoring. Replace if necessary before reassembling gear.

5. Drive the crank gear on the shaft making sure that the marked teeth on the cam gear straddle the marked tooth on the crank gear, which assures you of the crankshaft and camshaft being in time.

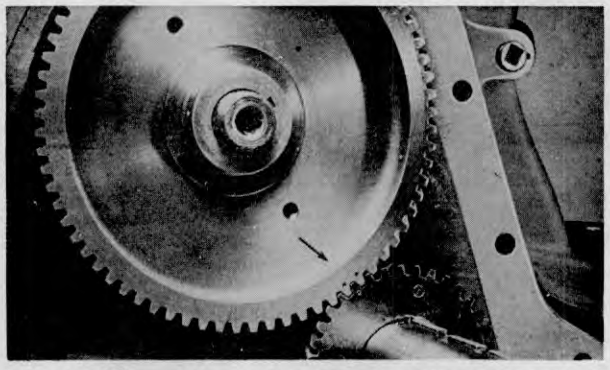


Figure 58 — Timing Gears Assembled According to Timing Marks

6. Check for clearance with the above gears assembled in place, since it may be possible that it is not within specifications. Repeat the operation previously outlined. Using a screwdriver pry the teeth as far apart as possible and check the clearance with a feeler gauge. If a .0015" feeler will not enter the gap the clearance is not excessive.

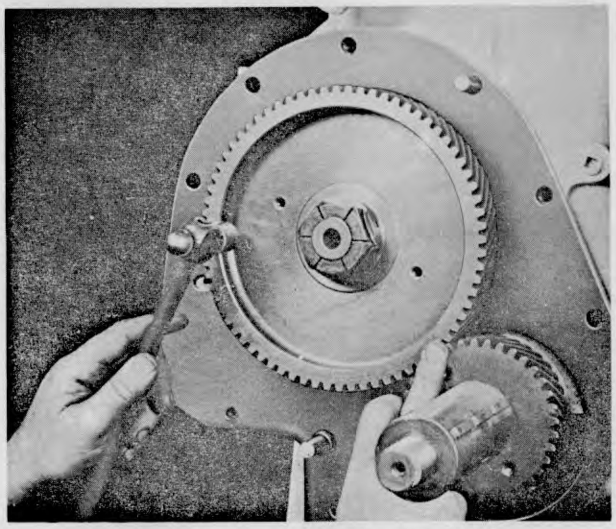


Figure 59 — ***Checking Gear Fit***

To be certain that there is enough clearance, hold your finger at the junction of the two gears and with a light hammer tap the rim of the cam gear and note if there is vibration felt at this point.

If there is vibration and a .0015" feeler gauge will not enter the gap between the two gear teeth, the gear fit is within specifications.

7. Crankshaft gears and camshaft gears are furnished in standard and under and over sizes. Gears marked "S" are standard; if they are marked with figures "1" or "2" in a letter "U" this signifies undersize. If they are marked with figures in the letter "O" this signifies oversize.

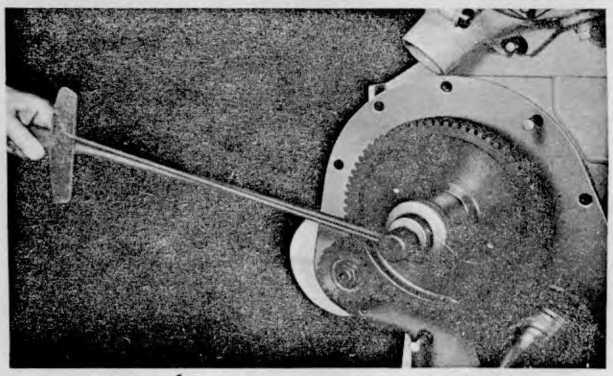


Figure 60 — ***Torquing Cam Gear Nut***

CRANKSHAFT END PLAY

1. Check the crankshaft end play before replacing the gear cover. A shim pack containing shims of .002" and .008" thickness is incorporated in the assembly between the front end of the main bearing journal and the crank gear and by removing or adding shims, this end play can be corrected to fall within the specifications.

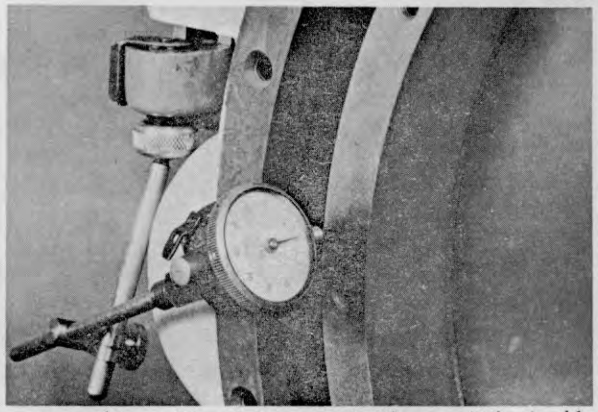


Figure 61 - Checking End Play with Indicator

ASSEMBLING OIL SEALS IN FILLER BLOCK AND OIL GUARD

Continental L-head engines have 2 types of crankshaft and oil pan seals.

The first type is jute packing which is used in sealing the filler block and oil guard in block to crankshaft.

The second type is a neoprene seal which is used in sealing the oil pan to the filler block.

JUTE TYPE OIL SEALS

First, remove the filler block and oil guard, the latter being the semi-circular die casting which fits in the cylinder block just to the rear of the rear bearing bore. Clean out the grooves thoroughly and clean the outer surface of this oil guard so as to remove all dried cement and grease.

Jute packing for crankshaft seal as it is received is approximately one-third larger in diameter than the width of the groove. To fit the grooves in the filler block, this must be crushed in a vise or flattened with a hammer on a flat surface so the jute packing is narrow enough to fit into the grooves.

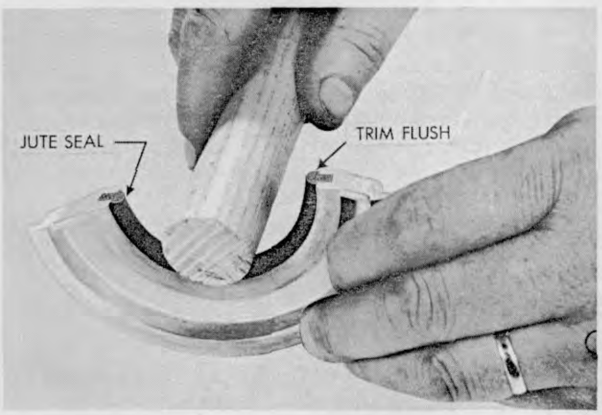


Figure 62 — Top Half of Rear Seal

Next, press it into the grooves of both the filler block and the oil guard. Then, using a piston pin, a smooth hammer handle or some other instrument with a rounded surface, iron this packing into the groove so that it is seated firmly and expanded so that it seizes the sides.

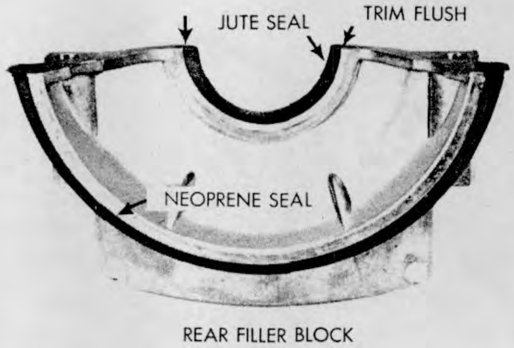


Figure 63 — Lower Half of Rear Seal

In its present condition the packing will protrude from the grooves at either end in varying amounts. With a sharp knife, or razor blade, cut this off flush, making the cut parallel to the surface of the casting. Then slip it into place, either around the crankshaft, if the engine is still assembled, or directly into the groove if the crankshaft is out.

NEOPRENE OIL SEAL

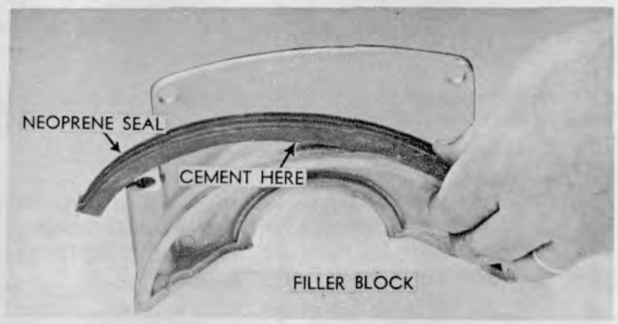


Figure 64 — Installing Neoprene Seal in Rear Filler Block

1. To replace neoprene seal, thoroughly clean all cement, dirt, and oil from the contacting surface of the filler block. To hold seal in place for assembly, use **only a small spot** of non-hardening cement in the center of the contacting surface, before inserting seal in groove. **No other cement is required.**

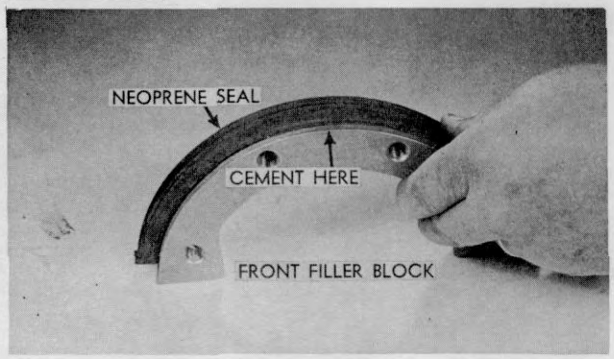


Figure 65 — Installing Neoprene Seal in Front Filler Block

2. Neoprene seal on front filler block is installed in the same manner.

When replacing gear cover, cement gasket to gear cover with a quick drying gasket cement and reassemble to engine block.

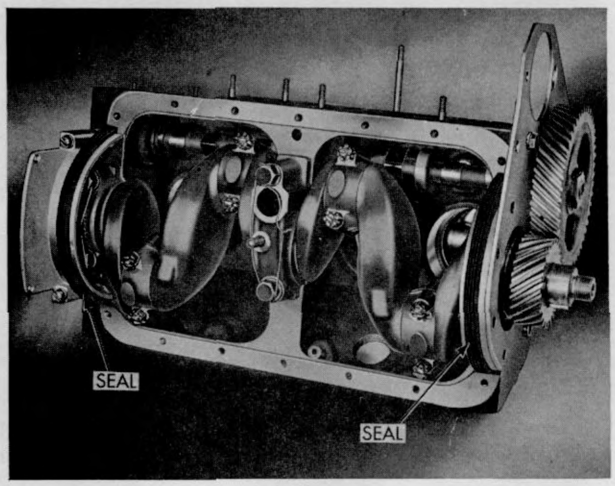


Figure 66 — Neoprene Seals in Place

OIL PUMPS

The oil pump is assembled to the center main bearing, held in position vertically against a machined pad by studs.

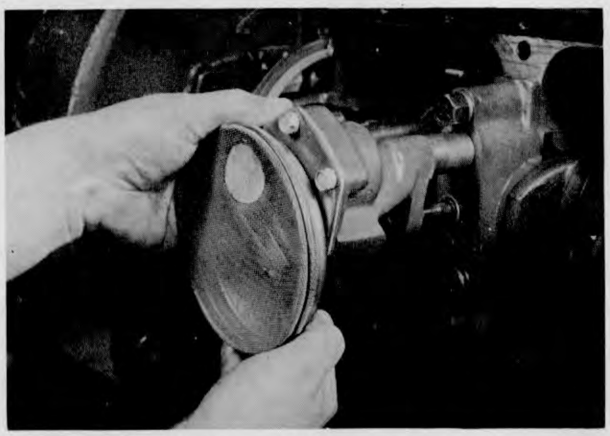


Figure 67 — Oil Pump Removal

The extended portion of the body acts as a pilot, fitting closely in a reamed hole in the main bearing web, maintaining definite relationship between the camshaft and the oil pump drive shaft.

A gear assembled to the upper end of this shaft is driven by a mating gear cut on the camshaft and drives the oil pump gear which is assembled to the lower end of the pump shaft.

The pump shaft is carried in two bronze bushings assembled in the cast iron housing, which is also a part of the oil distributing system, transmitting oil to the drilled passages.

The gear type pump has a capacity well in excess of that required by the engine.

When the pump is removed, examine the drive gear carefully for wear, inspecting the gear on the camshaft at the same time. If scored or worn badly, both the camshaft and the gear on the pump must be replaced.

Examine the pick-up screen for clogging or damage.

Remove the cover, being careful not to damage the lead gasket which acts as a spacer as well as a gasket to seal the joint.

Examine the gears and pump body for any sign of wear indicating lack of clearance. The gears should have from .001 to .003 clearance in the chamber and should make no contact with the walls.

Inspect the cover and face of the gears for excessive wear or scoring. With the gasket assembled to the body there should be .0015 - .006 clearance between the gears and the cover.

Worn or scored gears can be replaced, as can a worn cover. If the body shows wear in the chamber, it can be replaced, but in a case like this a new pump would be the most economical.

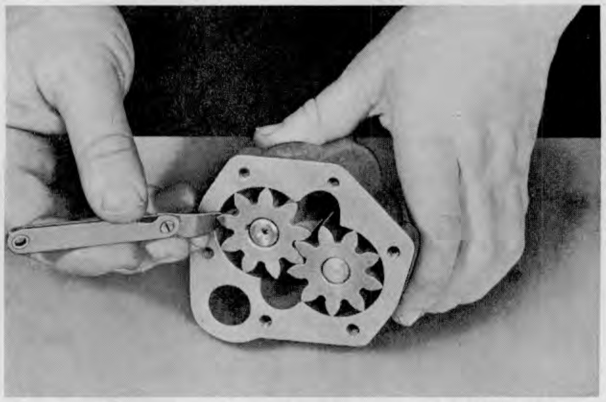


Figure 68 — Checking Oil Pump Gear Clearance in Body

Engine oil pressure must be maintained to specification for satisfactory engine life.

Figure 69 — Checking Oil Pump End Clearance

Pressure relief is located externally on the right-hand side, near the oil pan flange at the center.

Pressure is controlled by a plunger and spring, the latter specifically for a certain range. The only adjustment variation is either to change springs or assemble or remove washers from behind the present spring. Up to four washers are permissible.

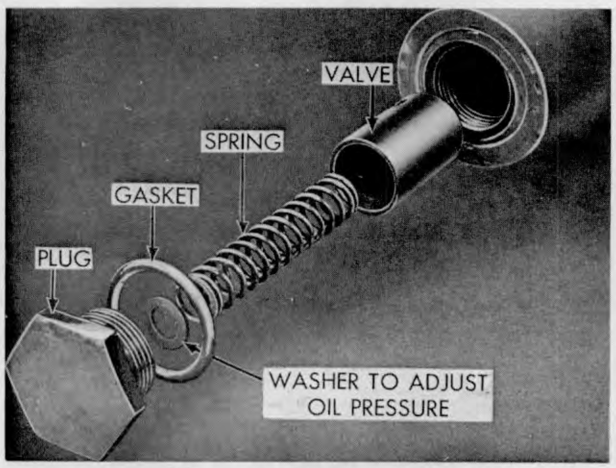


Figure 70 — Oil Pressure Relief Valve

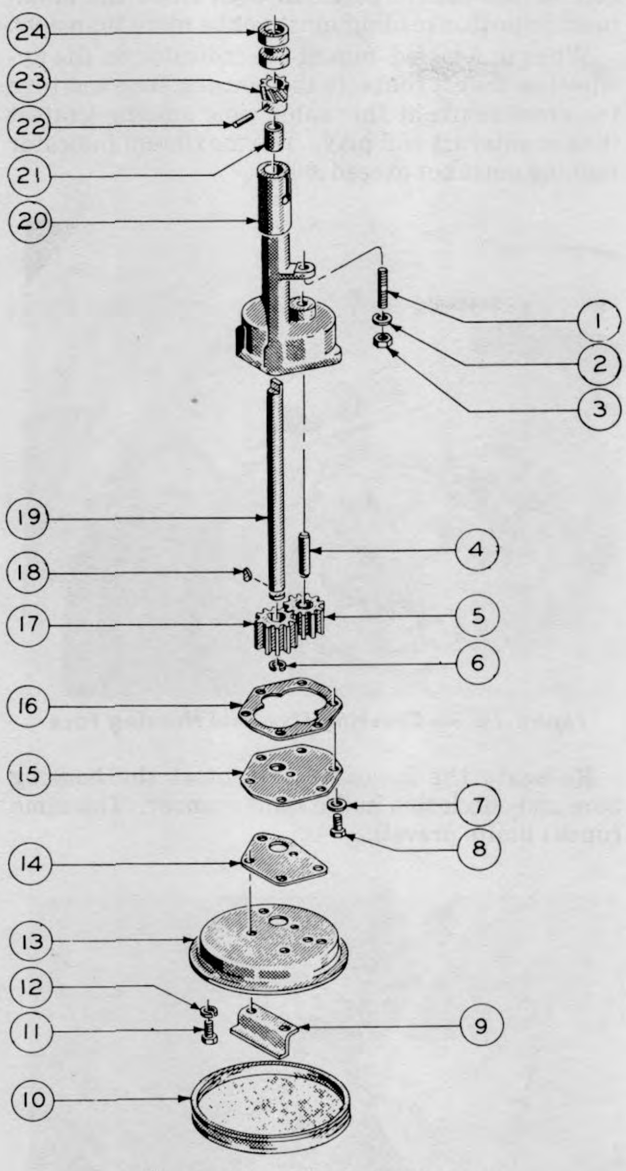


Figure 71 — Typical Oil Pump

1. Stud
2. Washer
3. Nut
4. Stud
5. Gear — idler
6. Snap ring
7. Washer
8. Screw
9. Spacer
10. Screen
11. Screw
12. Washer
13. Frame — oil pump screen
14. Gasket
15. Cover — oil pump
16. Gasket
17. Gear — driver
18. Key
19. Drive shaft
20. Body assembly
21. Bushing
22. Pin
23. Gear
24. Bushing

CAUTION

On several models of our L-Head engines, a 1/8" flat spacer washer is used **between** the oil pump mounting lug and the center main bearing cap. When reassembling, be **SURE** that this washer is placed on the oil pump mounting stud before the oil pump is installed in place. Failure to do this will cause interference between oil pump and camshaft and will not allow the distributor drive to mesh correctly.

NOTE

When replacing oil pump drive gear (Item 23, Fig. 171) it is necessary to line up the hole in the gear with the hole in shaft and drill through the other half of the gear before pinning in place.

FLYWHEEL AND FLYWHEEL HOUSING

The flywheel is machined and balanced so that the clutch face and locating counterbore will run true with its axis.

To be sure that the crankshaft flange has not been sprung or otherwise damaged or that the counterbore in the flywheel, which locates it on the crankshaft, is not damaged, mount an indicator on the flywheel housing and check the flywheel for runout. Caution: When checking runout remove spark plugs to allow engine to be turned over freely.

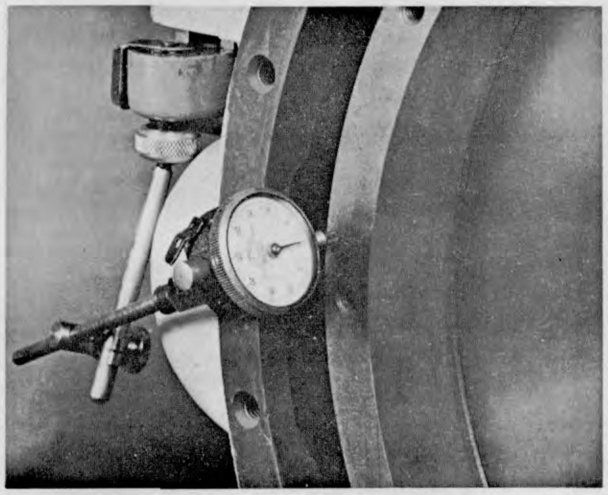


Figure 72 — Checking Flywheel Run-Out

The indicator should be set up so that it contacts the clutch face or the vertical surface of the clutch counterbore, then turn the flywheel at least one full revolution at the same time holding against the crankshaft to offset the possibility of end play.

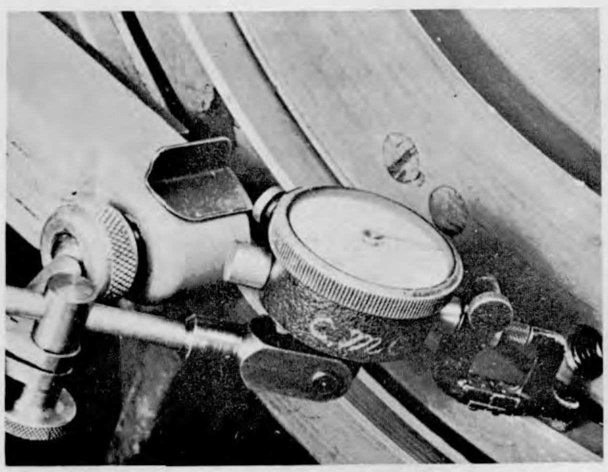


Figure 73 — Checking Flywheel Counterbore

Excessive runout of the flywheel, in either position, is probably caused by dirt in or damage to counterbore locating the flywheel on the crankshaft flange.

Re-locate the indicator to check the inside diameter of the counterbore. In both cases the maximum indicator reading must not be more than .008.

When assembled, mount the indicator on the flywheel so that it contacts the housing face and turn the crankshaft, at the same time holding against it to counteract end play. The maximum indicator reading must not exceed .008.

Figure 74 — Checking Flywheel Housing Face

Re-locate the indicator to contact the housing bore and check this in the same manner. The same runout limits prevail.

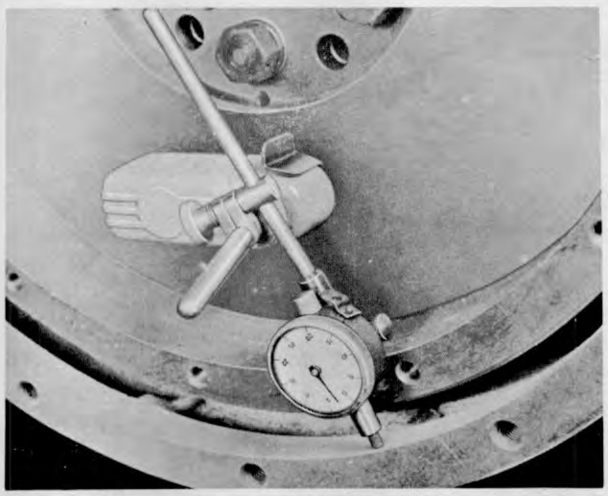


Figure 75 — Checking Housing Bore

If more than one engine is being rebuilt at a time, the housing should be identified with its original cylinder block and should be reassembled to that block in the rebuilding process.

REASSEMBLING ENGINE

In the foregoing, we have outlined procedures for checking, repairing or replacing the many wearing parts in the engine.

In most cases, the instructions have covered the reassembly of parts or subassemblies made up of several parts.

When reassembling pistons and connecting rods, use a good ring compressor and oil the bores thoroughly. A hammer handle may be used to bump the pistons out of the ring compressor into the cylinder bore.

Once more, we call attention to care demanded to prevent connecting rods damaging the cylinder bore finish and at the same time as they are assembled over the crank pin, locate them carefully in order to protect the bearing surfaces.

Always lubricate the bearings with clean engine oil when assembling, and tighten them to the torque specified. Use lockwires, cotter pins or lockwashers as required to prevent nuts and screws from loosening.

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.

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.

Torque Specifications for Cylinder Head Tightening Sequence in Foot Pounds

Size - Diameter 3/8"	7/16"	1/2"	9/16"	5/8"
Cylinder Heads 35-40	70-75	100-110	130-140	145-155

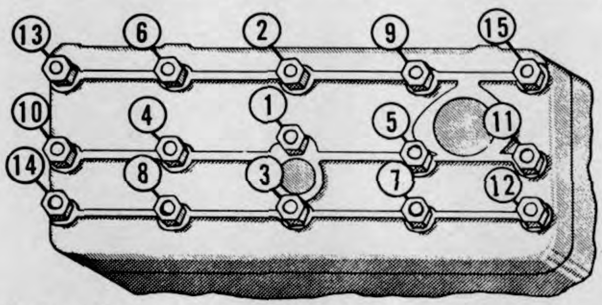


Figure 76 — ***Cylinder Head Tightening Sequence — Four Cylinder***

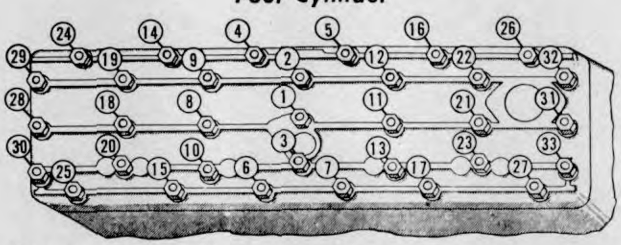


Figure 77 — ***Cylinder Head Tightening Sequence — Six Cylinder***

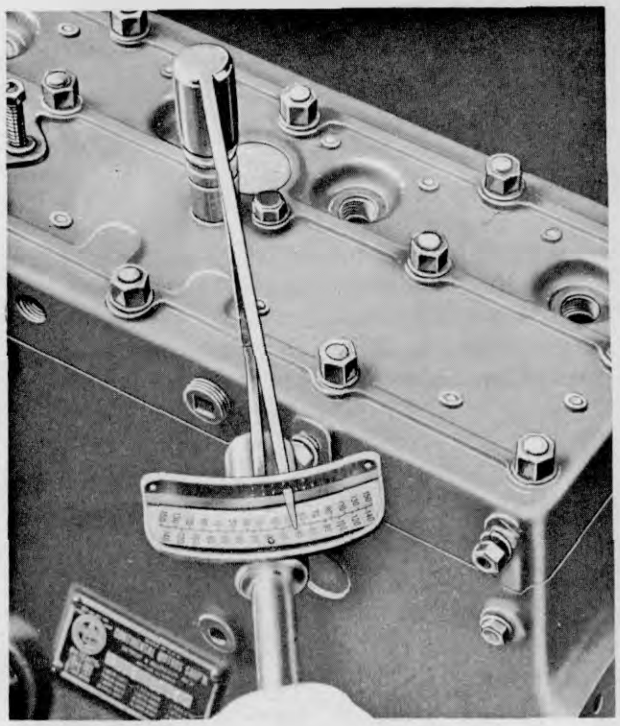


Figure 78

When engine is completely assembled and filled with proper oil, (See Lubrication Sec.) set tappets and refer to Engine Limits and Clearance Data.

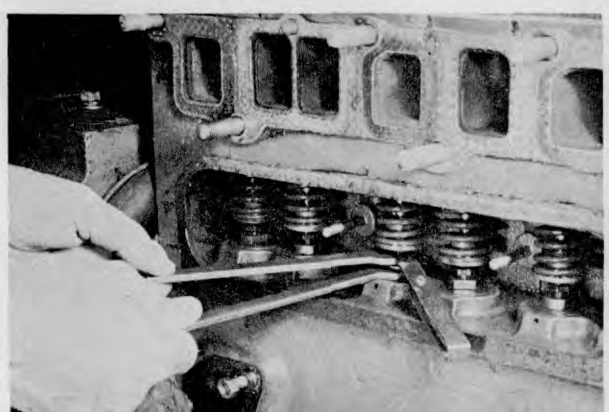


Figure 78 — ***Setting Tappets***

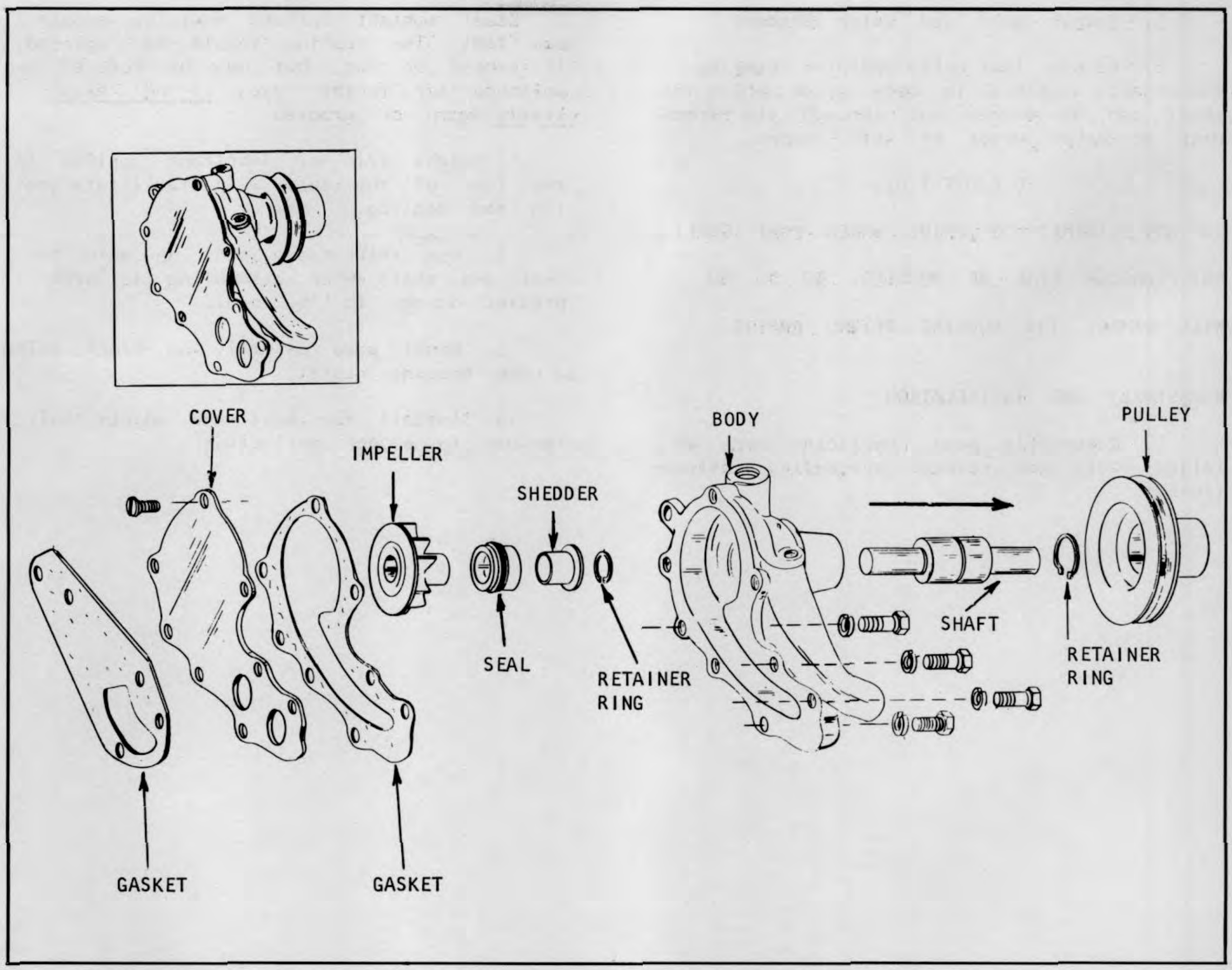


Plate 6992. Water Pump Components

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

Check bearings for excessive looseness. If a water leak develops, a damaged or badly worn seal needs replacement.

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 cap screws.

2. Loosen generator and fan belt adjusting bracket, if so equipped) retainer bolts so that belts 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.

DISASSEMBLY OF WATER PUMP

Disassembly must be in the following sequence in order to prevent damage to the pump.

1. Before removing pump, use puller to remove pulley from shaft.

2. Remove cap screws attaching pump to engine.

3. Remove countersunk screws holding cover. Remove cover and gasket.

4. Use puller to remove impeller taking precautions to prevent damage to the casting.

5. Remove seal and water shedder.

6. Remove lock ring holding bearing and shaft assembly in body after which the shaft can be forced out through the front with an arbor press or lead hammer.

CAUTION

DO NOT ATTEMPT TO DRIVE WATER PUMP SHAFT OUT THROUGH REAR OF HOUSING. TO DO SO WILL DAMAGE THE HOUSING BEYOND REPAIR.

REASSEMBLY AND INSTALLATION

1. Reassemble pump, replacing worn or failed parts and reverse preceeding instructions.

Seal contact surface must be smooth and flat. The bushing should be replaced, if scored or cut, but may be refaced and polished for further use, <u>if not excessively</u> worn or grooved.

A light film of lubricant applied to the face of the seal will facilitate seating and sealing.

2. Use thick soap suds on both the seal and shaft when assembling in order to prevent damage to the seal.

3. Mount pump assembly on block using a new housing gasket.

4. Install fan belt and adjust belt tension to proper deflection.

SECTION VII
FUEL SYSTEM

DESCRIPTION

The fuel system consists of a main fuel tank, fuel filter, air cleaner, fuel lines, carburetor and fuel pump. For fuel tank capacity see machine specifications in the front of this manual.

CARBURETOR

The carburetor is a jet, one venturi updraft type. It is mounted to the intake manifold on the left side of the engine. There are five systems that comprise the carburetor operation: the fuel supply system, the idle system, the high speed system, the economizer system and the choke system.

The fuel supply system is made up of the threaded fuel inlet, the fuel valve seat, fuel valve, float and fuel bowl.

The idle system consists of two idle discharge ports, idle air passage, idle adjusting needle, idle jet, fuel passage, and idle air bleed.

The high speed system controls the fuel mixture and part throttle speeds and at wide open throttle. This system consists of a venturi, controlling the maximum volume of air admitted into the engine; the main jet, which regulates the flow of fuel from the float chamber to the main discharge jet; the well vent which maintains uniform mixture ratio under changing suction and engine speeds; and a discharge jet, which delivers the fuel into the air stream.

The economizer system consists of a "milled" slot in the throttle shaft, which acts as a valve to open or close the system; a vacuum passage from the throttle bore to the slot in the throttle shaft; and a vacuum passage from the slot in the throttle shaft to the fuel bowl vent channel.

The choke system consists of a valve mounted on a shaft located in the air entrance and operated externally by a lever mounted on the shaft. The choke valve is used to restrict the air entering the carburetor. This increases the suction on the jets when starting the engine. The choke valve is of a semi-automatic type, having a poppet valve incorporated in its design, which is controlled by a spring.

CARBURETOR ADJUSTMENT
(See Figure 1)

Warm engine to normal operating temperature and let idle at normal idling speed. To make the fuel mixture richer; turn mixture adjusting needle, figure 1, counterclockwise; and to lean mixture, turn in a clockwise direction. To get correct mixture tighten needle screw until engine runs rough, then let off on adjusting needle until engine starts to "Lope", Note the position of the needle, The correct setting will be half way between these two points.

CARBURETOR REMOVAL

Remove cotter key from accelerator rod at throttle arm and pull rod from throttle arm hole.

Remove the air cleaner to the carburetor hose.

Disconnect choke control.

Disconnect fuel pump to carburetor line.

Remove two nuts and lockwashers at the manifold to carburetor flange and withdraw carburetor from machine.

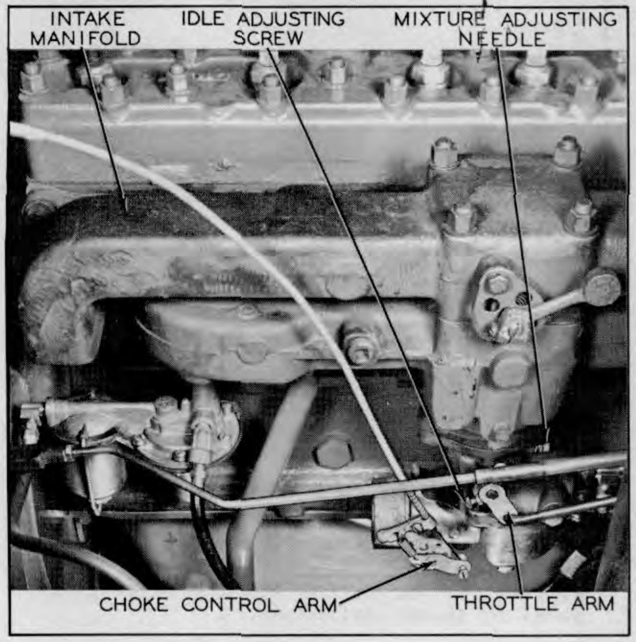


Figure 1. Carburetor

In event of disassembly, refer to an exploded view of the carburetor in the Parts Section of this manual.

CARBURETOR MAINTENANCE AND INSPECTION

Clean all metal parts thoroughly with cleaning solution and rinse in solvent.

Blow out all passages in the air intake and fuel bowl assembly and throttle body.

NOTE

Be sure all carbon deposits have been removed from throttle bore and idle port.

It is advisable to reverse flow of compressed air in all passages to insure that all dirt has been removed. NEVER use a wire or drill to clean out jets.

Replace float assembly if loaded with gasoline, damaged, or if float axle bearing is worn excessively. Inspect top side of float lever for wear where it contacts fuel valve needle.

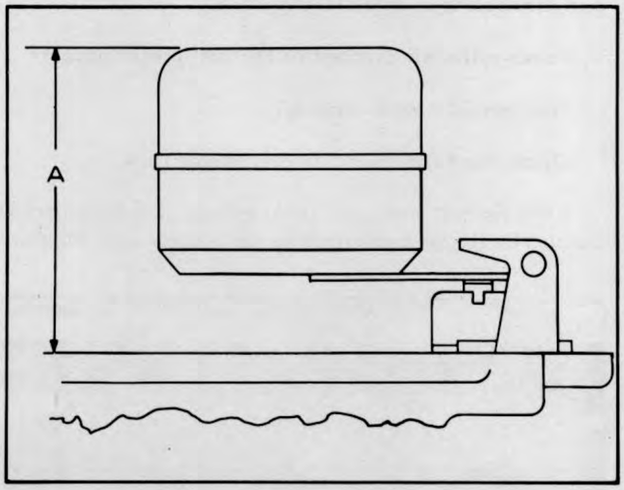


Figure 2. Setting Float Level

Replace the float axle if any wear can be visually detected on the bearing surface.

Always replace fuel valve seat and needle because both parts wear and may cause inproper float level.

Idle adjusting needle point must be smooth and free of ridges.

Inspect throttle plate for burrs or damaged edges. Never clean with a buffing wheel or sharp instrument.

Inspect air shutter for bends, butts or damaged edges.

Check air shutter shaft bearing surface for wear - see that shaft is straight.

Replace all gaskets and fibre washers every time carburetor is disassembled.

NOTE

Replacement parts must be of the same part number and specifications.

Check float level with throttle body in an inverted position, measure level from machined surface of body to top of float at highest point. The measurement, "A" figure 2, should be 1 5/32" + or - 1/32". To increase or decrease measurement, bend float close to float body.

CLEANING PARTS

Clean all metal parts thoroughly with cleaning solution and rinse in solvent. Blow out all passages in the air intake and fuel bowl casting and throttle body.

NOTE

Be sure all carbon deposits have been removed from throttle bore and idle port. It is advisable to reverse flow of compressed air in all passages to insure that all dirt has been removed. Never use a wire or drill to clean out jets.

DISASSEMBLED VIEW

Disassembly of the carburetor is not recommended except by experienced mechanics. The disassembled view will identify the various component parts and show their relation to assembly. Use the disassembled view with the identifying part numbers to identify and locate parts when performing the disassembly and reassembly operations.

CARBURETOR

OPERATION SCHEMATIC

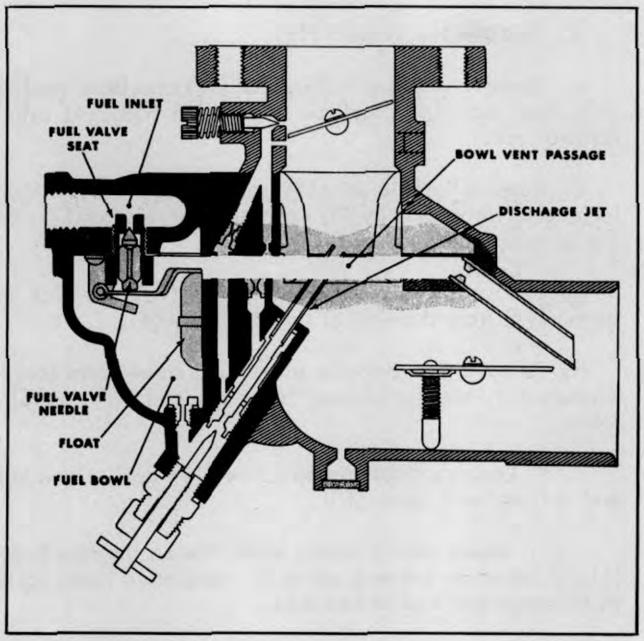


Figure 5. Fuel Supply System

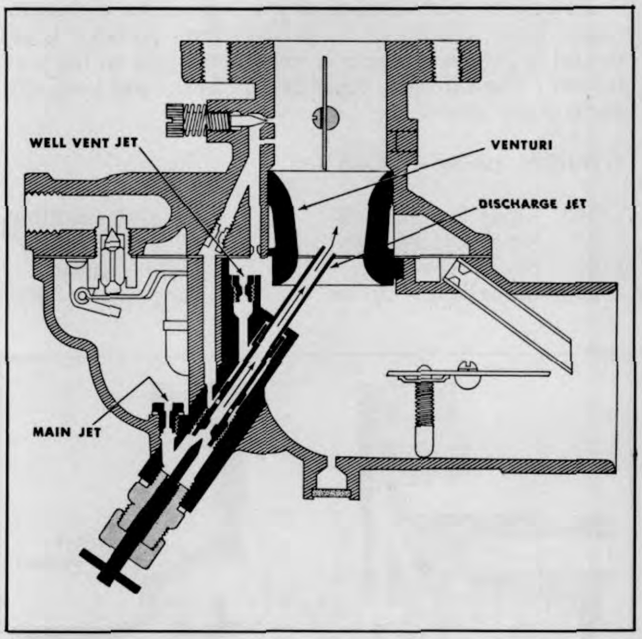


Figure 7. High Speed System

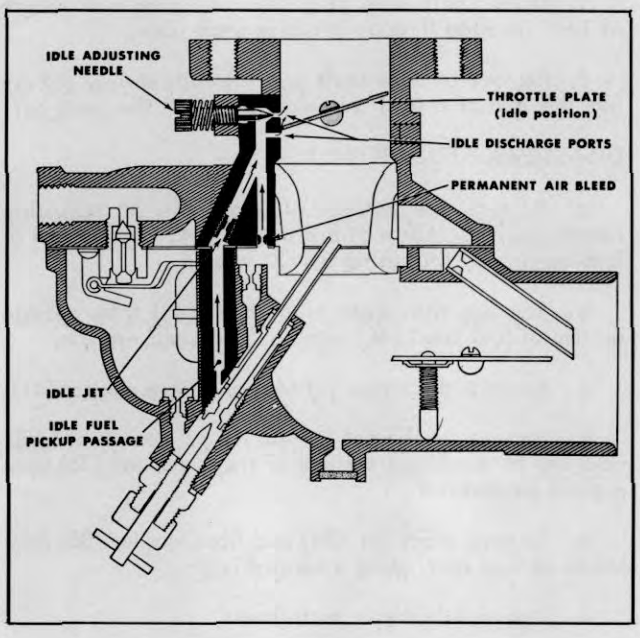


Figure 6. Idle System

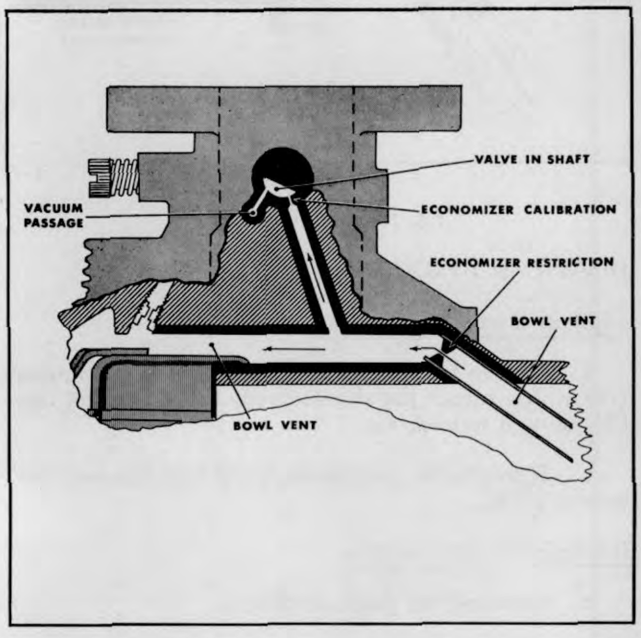


Figure 8. Back Suction Economizer System

cept by experienced mechanics. The disassembled view will identify the various component parts and show their relation to assembly. Use the disassembled view with the identifying part numbers to identify and locate parts when performing the disassembly and reassembly operations.

REPAIR PARTS

Refer to the parts section of this manual for carburetor repair kits. The use of the proper repair parts kit is essential in the event repair is to be performed on the carburetor. The following suggested general hand tools will perform the service job.

GENERAL HAND TOOLS

7/16"	Open End Wrench	Long Nosed Pliers
1/2"	Open End Wrench	6" Depth Gauge
1/4"	Blade Screw Driver	Light Hammer
5/32"	Blade Screw Driver	Long Rod or Punch

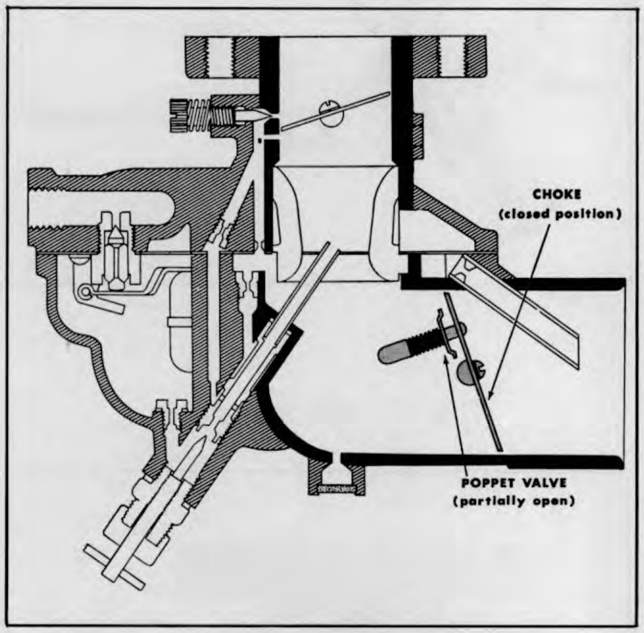


Figure 9. Choke System

DISASSEMBLY PROCEDURE

Separate Carburetor Bodies

a. Remove the four assembly screws and lockwashers (14) which attach the throttle body (4) to the fuel bowl (36) using a screwdriver.

b. Separate the throttle body (4) from the fuel bowl assembly (36).

Disassemble Throttle Body

a. Remove Float Axle as follows:

1. Press screwdriver against float axle (21) at slotted side of float hinge bracket and force through hinge bracket.

2. Remove float axle (21) completely with fingers from opposite side and remove float (20).

b. Remove fuel valve needle (17).

c. Remove the assembly gasket (18) from the machined surface of the throttle body.(14).

d. Remove the venturi (19).

e. Remove the fuel valve seat (17) and fibre washer (16) from machined surface of throttle body (4) using screwdriver.

f. Remove the idle jet (15) from passage in machined surface of throttle body (4) near fuel valve seat (17) using a small screwdriver (5/32" blade).

g. Remove the idle adjusting needle (13) and friction spring (12) from the side of throttle body (4).

h. Remove the throttle plate (2), screws and lockwashers (1), shaft and stop lever assembly (7), as follows:

1. Unscrew throttle stop screw (11) until threaded end is flush with lever (10).

2. Make match marks with file on throttle body (4) and levers to act as a guide to reassemble these parts in the same position as removed.

3. Remove the screws (1) and remove the throttle plate (2).

4. Remove the throttle shaft and stop lever assembly (7) from the throttle body (4).

i. Drive shaft hole plug (3) out, using a 6" length of 1/4" inserted through opposite shaft hole.

j. Remove throttle shaft seal (5) and retainer (6) using the end of a small screwdriver to lift the parts out.

DISASSEMBLE FUEL BOWL BODY

a. Remove the passage plug or main jet adjusting needle assembly (45) and fibre washer (44) from bottom of fuel bowl body (36) using a 1/2" wrench.

b. Remove the drain plug (hex) (43) from outside bottom of fuel bowl (36) using a 7/16" end wrench.

c. Remove discharge jet (42) and fibre washer (41).

d. Remove well vent jet (31) from center of large opening in machined surface of the fuel bowl (36) with a small screwdriver.

e. Remove main jet (34) and fibre washer (35) from inside of fuel bowl using a screwdriver.

f. Disassemble choke as follows:

1. Make match marks with a file or prick punch on choke bracket (28), choke lever (23) and adjacent

shaft boss as an aid to correct reassembly.

2. Remove choke lever spring (22).

3. Remove choke plate screws and lockwashers (37).

4. Remove the choke plate (38) and choke shaft and lever (23).

NOTE

In some cases it may be necessary to bend the bowl vent tube up a very little to give the choke clearance. (Use a screw driver inserted in the tube.)

5. Remove bracket assembly screws (29), packing washer (33) and choke bracket (28).

6. Remove choke shaft hole plug (39), packing washer (33) and retainer (32) using method suggested in throttle body disassembly section "Disassembly Throttle Body", items "i" and "j".

REASSEMBLY

Fuel Bowl Body

a. Install the choke shaft hole plug (39), packing (33) and retainer (32) in fuel bowl body (36) as follows:

1. Assemble packing (33) and retainer (32) and place completed assembly on bushing driver with packing facing small end of tool.

2. Start retainer (32) into counter bore in body (36) and lightly drive retainer into body until it is flush with machine surface.

3. Install shaft hole plug (39) with hammer.

b. Reassemble choke parts as follows:

1. Refet to match marks for correct position and install choke bracket (28), screws (29) and lockwashers (30).

2. Start the choke plate (38), poppet valve first and stem down, into the air intake.

3. Hold the choke plate up and insert the choke shaft (23) into place with cut-out section facing up.

4. Rotate the shaft to the closed position, place the choke plate in the cut-out section and install the screws (37). (Be sure the plate is properly centered before tightening the screws).

5. Install lever spring (22) to return the choke to the wide open position.

c. Install main jet (34) and fibre washer (35) in the fuel bowl, using a screwdriver.

d. Install well vent jet (31) in fuel bowl (36) and tighten with a small screwdriver.

e. Install discharge jet (42) and fibre washer (41) in large threaded passage beneath the fuel bowl.

f. Install the drain plug (43) in threaded passage, bottom of fuel bowl, using a 7/16" end wrench.

g. Install main jet adjustment or passage plug (45) and fibre washer (44) using a 1/2" wrench.

Throttle Body

a. Install throttle shaft hole plug (3) in the side opposite the stop pin using a light hammer to drive it into place flush with the boss.

b. Install throttle shaft seal (5), open side out, followed by retainer (6), using fingers only.

c. Install the throttle shaft and stop lever assembly (7), throttle (2), screws (1) as follows:

1. Insert the throttle shaft and stop lever assembly in throttle body.

NOTE

Be sure stop (11) is backed out far enough to permit complete closing of throttle.

2. Rotate throttle shaft to closed position, insert throttle plate in the cut-out section of the shaft, holding the plate in position with fingers.

3. Start throttle plate screws and tighten with small screwdriver, being sure that the throttle plate is properly centered in the throttle body bore.

NOTE

The screw holes in the throttle plate are off center. Start the side of the throttle plate with the shortest distance between the screw holes and beveled edge into place first. The throttle plates are made with two opposite edges beveled to fit the throttle body bore when the plate is closed. The throttle plate will not close tightly if installed upside down. Pressure on the plate must be maintained with the finger until the screws are tightened. When properly installed, the side of the throttle plate farthest away from the mounting flange will be aligned with the idle port when the plate is closed.

d. Install idle adjusting needle (13) and friction spring (12) in threaded passage on side of throttle body. Seat lightly with screwdriver and back out 1-1/4 full turns as preliminary adjustment.

e. Install idle jet (15) in counter-bored passage in machined surface.

f. Install fuel valve seat (17) and fibre washer (16) using wrench.

g. Place new throttle body to fuel bowl gasket (18) on machined surface of fuel bowl cover.

h. Install fuel valve needle (17) in seat followed by float (20) and float axle (21).

i. Float Level. Check position of float assembly for

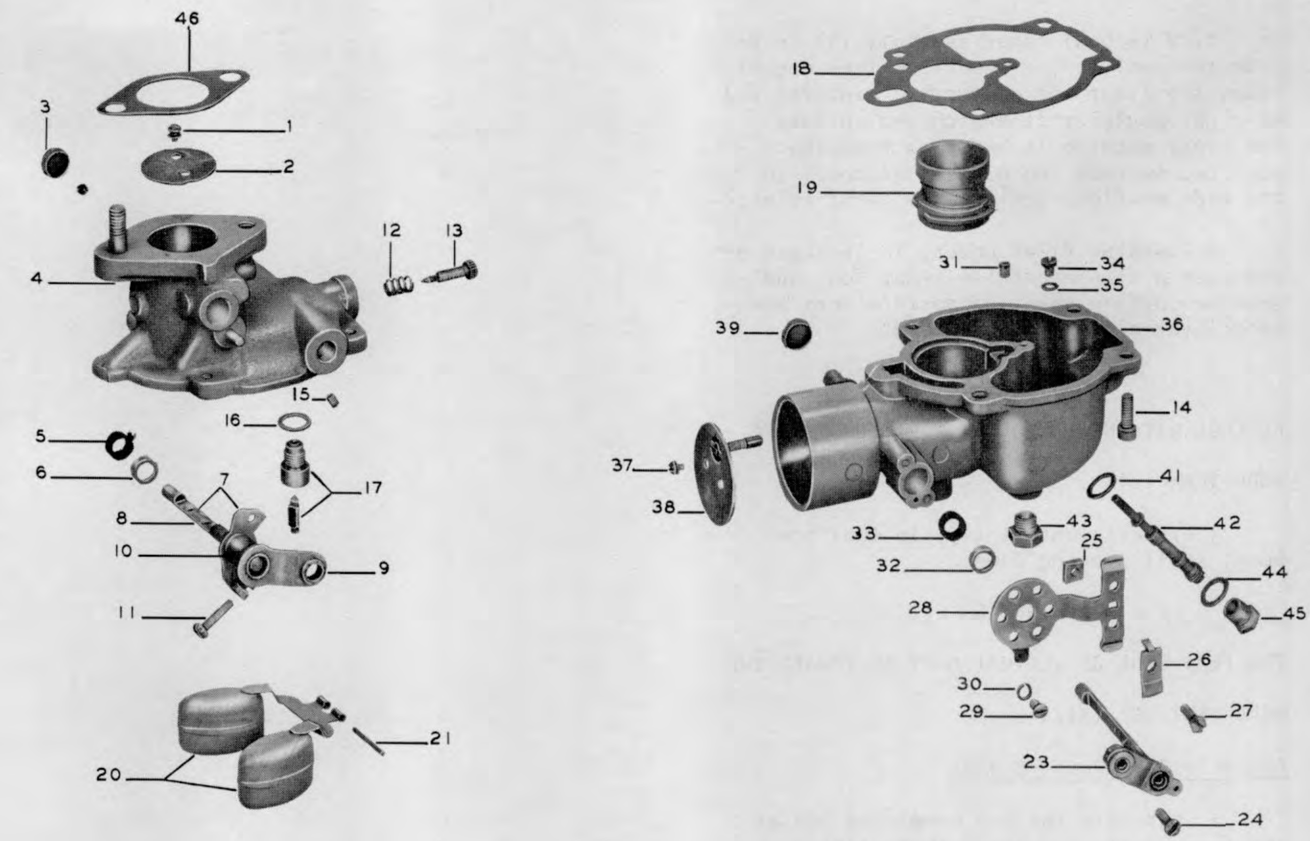


Figure 10. Carburetor

1. Screws and Lockwashers, Throttle Plate
2. Throttle Plate
3. Shaft Hole Plug
4. Throttle Body
5. Throttle Shaft Seal
6. Retainer, Throttle Shaft Seal
7. Shaft and Stop Lever Assembly
8. Throttle Shaft
9. Lever
10. Lever Pin
11. Stop Screw
12. Friction Spring
13. Idle Adjusting Needle
14. Assembly Screws & Lockwashers
15. Idle Jet
16. Fibre Washer
17. Fuel Valve Needle and Seat
18. Assemble Gasket
19. Venturi
20. Float
21. Float Axle
22. Choke Lever Spring (Not Shown)
23. Choke Lever and Shaft
24. Screw, Swivel
25. Clamp Screw Nut
26. Clamp Cable
27. Cable Clamp Screw
28. Choke Bracket
29. Bracket Assembly Screws
30. Lockwashers, Bracket Screw
31. Well Vent Jet
32. Packing Washer Retainer
33. Packing Washer
34. Main Jet
35. Fibre Washer
36. Fuel Bowl
37. Choke Plate Screws & Lockwashers
38. Choke Plate
39. Choke Shaft Hole Plug
40. Plug.
41. Fibre Washer, Discharge Jet
42. Discharge Jet
43. Drain Plug (Hex)
44. Fibre Washer , Pressure Plug
45. Main Jet Adjusting Needle Assembly
46. Gasket

correct measurement to obtain proper float level using a depth gauge. The "A" dimension should be 1-5/32" plus or minus 1/32", see Figure 2.

1. With bowl cover assembly (4) in an inverted position, viewed from free end of float the float bodies must be centered and at right angles to the machined surface. The float setting is measured from the machined surface (no gasket) of cover to top side of float bodies at highest point.

2. Bending Float Lever. To increase or decrease distance between float body and machine surface use long nosed pliers and bend lever close to float body.

NOTE

REPLACE WITH NEW FLOAT IF POSITION IS OFF MORE THAN 1/16".

j. Insert venturi (19) in fuel bowl bore, small opening down.

NOTE

THE FLAT SIDE OF VENTURI MUST BE TOWARD THE WELL VENT JET (31).

Assemble Carburetor Bodies

a. Assemble the two completed bodies and four screws and lockwashers (14) and tighten screws evenly and firmly.

b. Hold the throttle lever in a closed position and turn the throttle stop screw (11) in until it just contacts the stop pin, then turn screw in 1-1/2 additional turns as a preliminary adjustment of the idle speed.

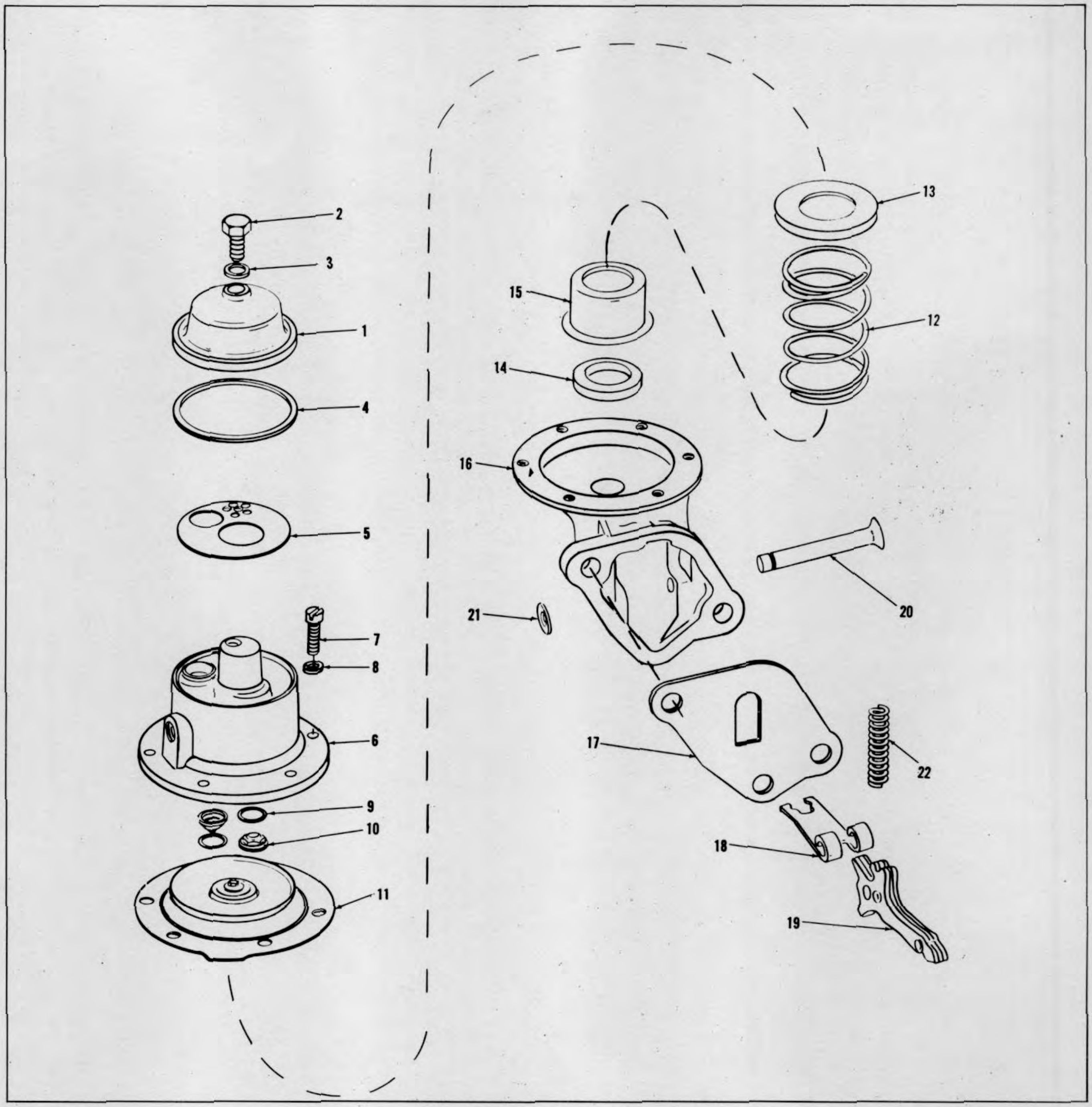


Plate 6978. Fuel Pump

Before disassembling any pump, scribe a mark across the housings in such a manner that they may be reassembled with inlet and outlet fitting holes in correct location.

When disassembled, clean all parts (except diaphragms) in solvent and blow dry with compressed air. Examine the diaphragm for cracks, torn screw holes or ruptures. If deteriorated, install new diaphragm and pull rod assembly. Check the strainer screen and if found to be corroded or clogged, install a new screen. Check rocker arm for wear or scoring or that portion that contacts the camshaft eccentric. If arm is scored or worn install a new one.

When reassembling a pump, do not use shellac or other adhesive on a diaphragm.

HYDRATORK DRIVE TROUBLE-SHOOTING GUIDE

DIFFICULTY	CAUSE	REMEDY
A. Machine will not move in either direction.	1. Parking brake not released.	1. Release brake.
	2. Control linkage not properly adjusted.	2. Readjust linkage.
	3. High and low range linkage not properly adjusted.	3. Readjust linkage.
	4. Oil level low.	4. Determine cause and correct. Fill to proper level with type "A" Transmission Oil
	5. No oil pressure.	5. (a) Defective inching valve operation. (b) Check pump and associated parts.
B. Machine will move in one direction only.	1. Control linkage not adjusted.	1. Adjust linkage.
	2. No oil pressure to directional selector.	2. Check seals and "O" rings for and in directional selectors.
	3. Directional selector discs not releasing.	3. Defective directional discs (replace disc and correct cause). Relief hole in D.S. drum clogged.
C. Machine moves slowly in both directions at wide open throttle.	1. Oil level low.	1. Fill to correct level and determine cause for loss of oil.
	2. Low oil pressure.	2. (a) Check inching valve. (b) Relief valve sticking in open position. - Replace valve or free valve in valve body. Remove all nicks and burrs with fine stone. (c) Check pump and associated parts.
	3. Clogged sump screen	3. Clean screen.

HYDRATORK DRIVE TROUBLE-SHOOTING

DIFFICULTY	CAUSE	REMEDY
D. Transmission overheating.	1. Low oil.	1. Check and fill to correct level.
	2. Low directional selector pressure (check with gauge).	2. Find cause and correct. (a) Inching valve not functioning properly. (b) Seals in selector bad. (c) Regulating valve sticking open.
	3. Clogged sump screen.	3. Clean screen.
	4. Not sufficient oil to torque converter and cooler.	4. Check volume output. If low, check "by-pass spring", if weak or broken - replace.
	5. Cooler clogged internally stopping flow of oil.	5. Clean cooler.
	6. Bushing in torque converter impeller hub worn, allowing oil to leak out.	6. Replace converter. (Clearance between bushings and stator support not to exceed .004").
	7. Slipping stator.	7. Check converter stall.
		N O T E Secure drive wheels either by the emergency brake or a load against a stationary object. Place machine in Forward Direction, using "Electric Tachometer" in distributor, accelerate machine to maximum and take R.P.M. reading. C A U T I O N DO NOT HOLD IN STALL POSITION FOR MORE THAN 30-SECONDS AT A TIME. Converter should stall at 1350 to 1500 R.P.M. If stall is below 900, the stator in the converter is slipping.
E. Machine has full power and overheats.	1. Overloaded machine.	1. Check capacity loads. Never overload.
	2. Radiator core clogged externally.	2. Clean core.
	3. Pressure regulating valve stuck = low pres.	3. Replace regulator valve.

HYDRATORK DRIVE

Description

The hydratork drive unit is composed of an automotive type torque converter and hydraulically actuated direction selectors geared to the transmission and differential.

In order to service the hydratork drive unit, it is important to first understand how it operates. The construction and operation of the torque converter is discussed under the heading "Torque Converter". To understand the basic operation of the hydratork drive unit, two diagrams are shown to illustrate how the hydratork works.

The necessary maintenance and servicing procedures of the transmission including; removal, disassembly, inspection, reassembly and installation of the transmission are discussed in the "Transmission" Section on Pages 06M201G through 06M201V.

Torque Converter

The torque converter is composed of three members; the impeller or driving member, the turbine or driven side and the stator or reaction member. The impeller or driving side forms the outer shell of the converter and the turbine and stator operate within the shell but turn free of the impeller. This impeller or outer shell is bolted directly to the flywheel and turns at engine speed.

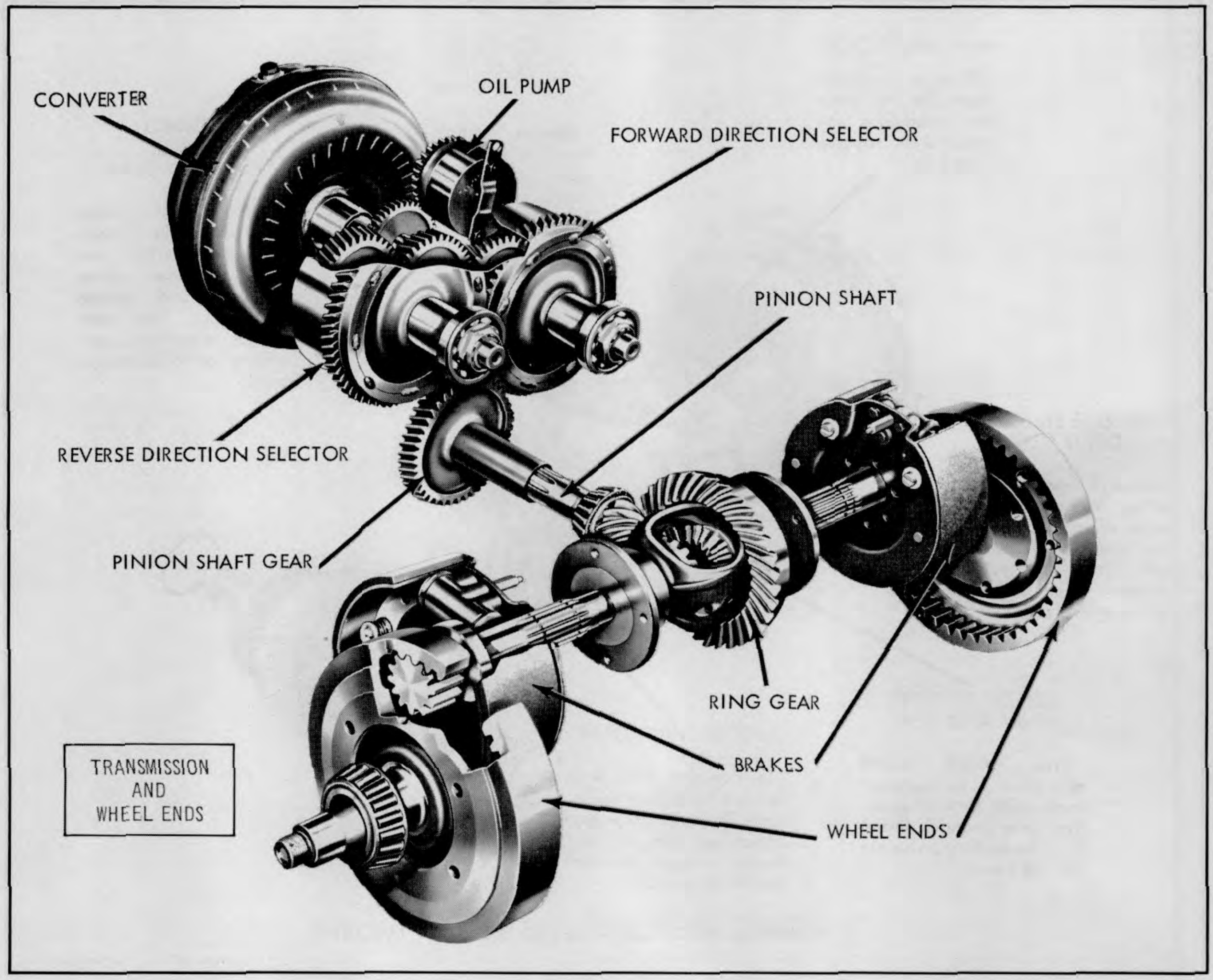


Plate 4443. Transmission and Wheel Ends.

The torque converter is filled with oil and when the engine is started, the impeller turns and forces oil under pressure against the turbine blades. The force of the oil striking the turbine blades causes the turbine member to turn in the same direction as the impeller. Thus, the oil acts as the connecting force between the driving and driven members of the converter.

The oil received in the outer portion of the turbine passes to the inner diameter. The turbine member is so constructed that the flow of oil is directed from the inner diameter against the stator which in turn forces the oil back into the inner diameter or receiving portion of the impeller. Torque multiplication or increased power is developed at lower speeds. This is accomplished by the doubled and sometimes tripled flow of oil created by the stator as previously described in addition to the normal flow of oil furnished by the pump. The hydraulic pump is driven at a speed relative to that of the engine.

As the machine accelerates to higher speeds and the turbine speed approaches that of the impeller, this recirculation decreases with consequent reduction of torque multiplication, the stator tends to free-wheel and the entire unit operates similar to a solid coupling with almost a 1:1 ratio.

As shown in Plate 4456, the main drive gear is in mesh with both direction selector drive gears, and both selector drum gears are in mesh. However, the selectors are set in the housing off center with the forward selector slightly lower than the reverse selector.

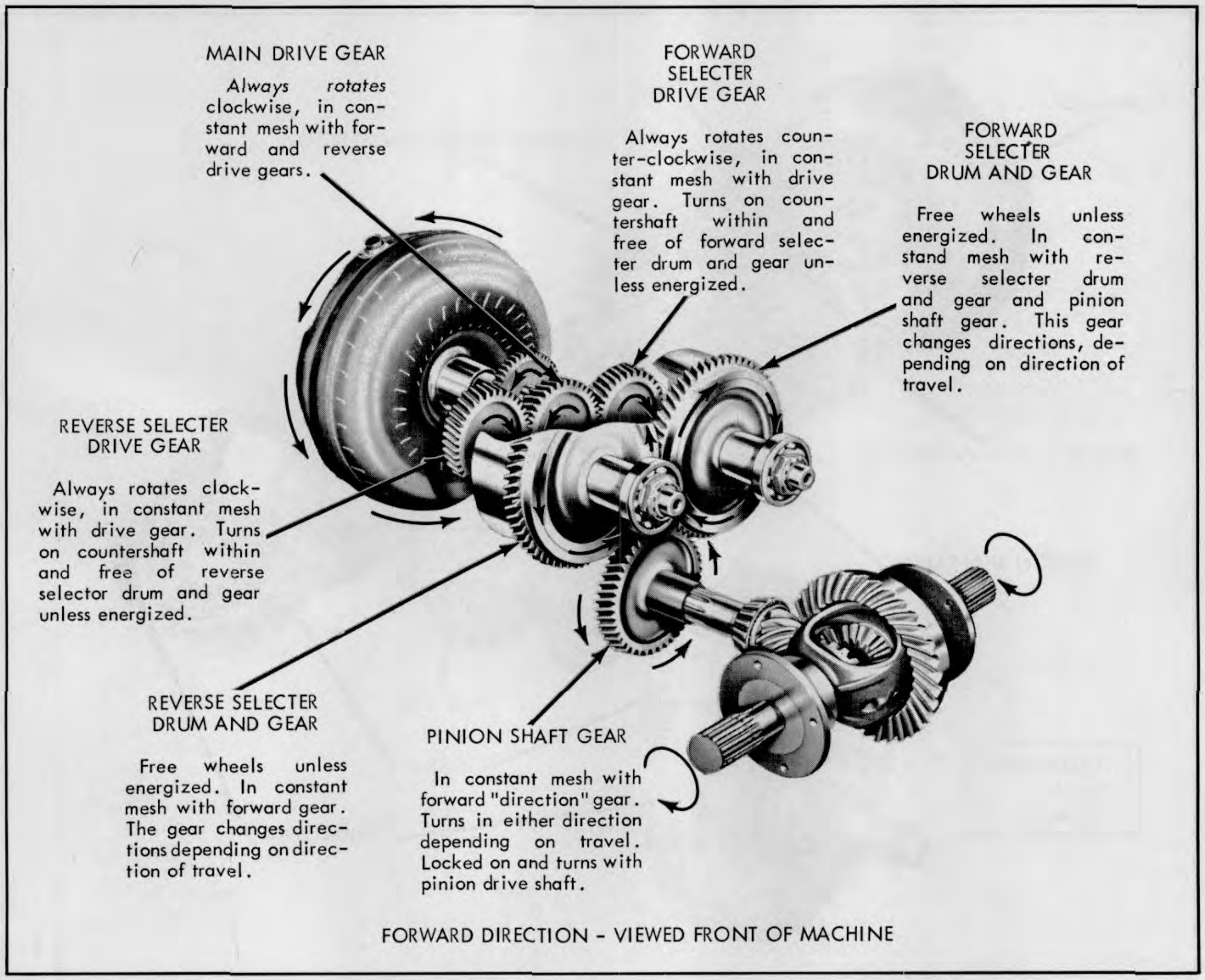


Plate 4456. Forward Direction

This arrangement allows the pinion shaft gear to mesh only with the forward selector.

When the transmission is in "Neutral" the selector drive gears turn or spin free on the selector shafts and there is no power to the pinion shaft gears.

When the direction control lever is moved into forward, the oil is directed to the forward selector which locks the selector discs. There are two sets of discs in a selector. Discs with teeth on the inside diameter are splined to the selector shaft gear. Discs with teeth on the outside diameter are splined to the selector drum. Therefore, when the discs are locked, the selector drum is driven and in turn drives the pinion shaft gear as shown in Plate 4456 on previous page. This ultimately drives the machine in forward direction. The reverse direction selector is in "Neutral" and simply rides free.

In reverse direction the oil flow is directed to the reverse direction (see Plate 4455). As the discs "lock" the reverse direction selector is driven and in turn drives the forward selector drum and gear which is in mesh with the pinion shaft gear driving the machine in reverse direction. The forward selector gear acts as an idler for reverse direction.

Oil System (Refer to Plates 8910 & 8909)

The oil system consists of a control valve, pressure regulating valve, forward and reverse direction selectors, oil pump, torque converter, oil cooler and filter.

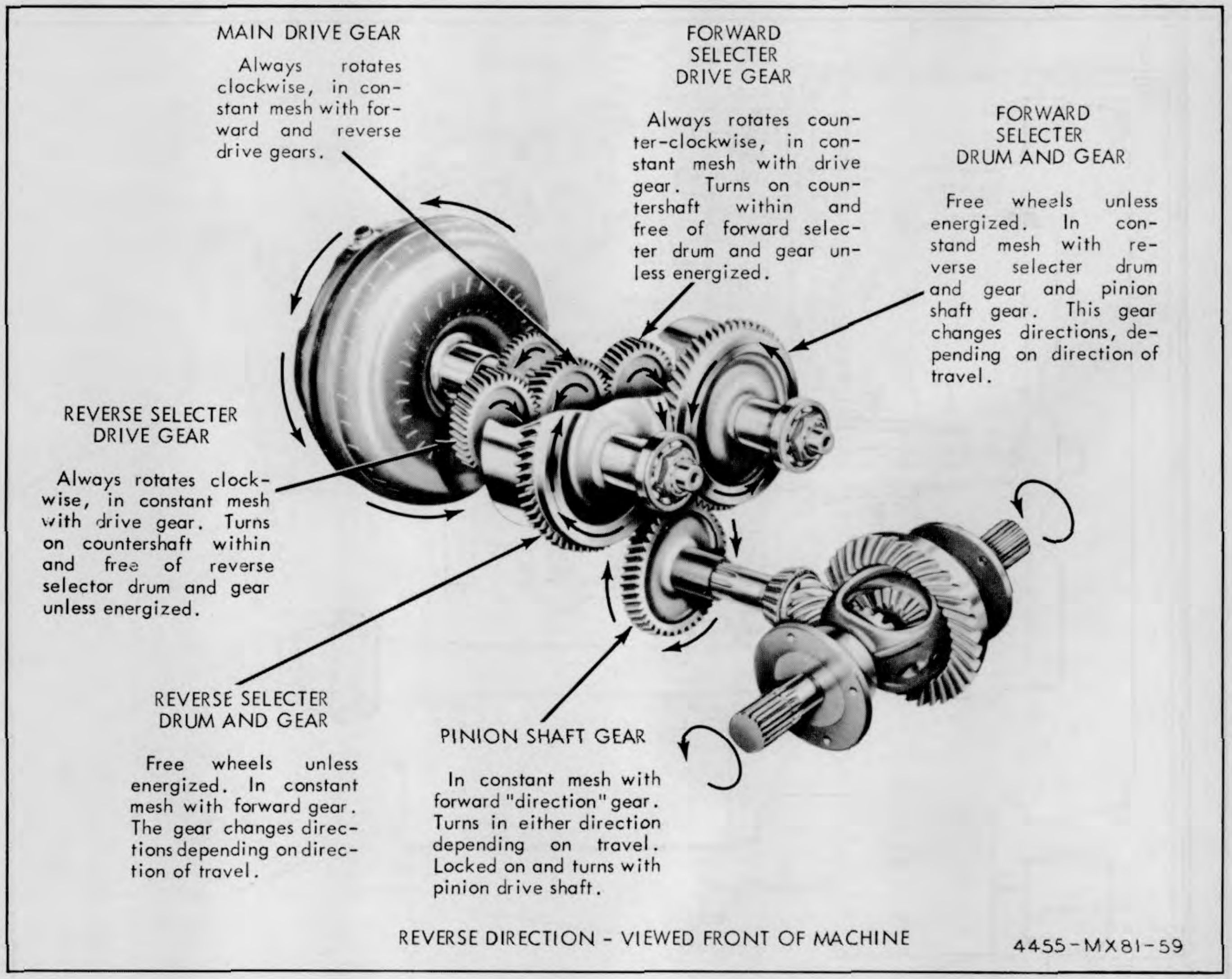


Plate 4455. Reverse Direction

The control valve is mounted in the top of the transmission case and is actuated by linkage from a manually controlled handle of the motor-cycle-grip-type located to the right of the drivers compartment. Oil is picked up from the transmission sump by the pump and delivered under pressure to the valve. When the control handle is pivoted to either forward or reverse position, the oil, under pressure, is directed to the respective direction selector. The oil not consumed by either direction selector is then by-passed by the pressure regulator valve to the converter and then to the cooler. Excess oil not used by the converter is by-passed to the transmission case by the relief valve. Oil flow through converter to cooler is two(2) G.P.M. at 1300 R.P.M. The oil is cooled, sent through the filter and returned to the transmission case.

When the control valve is in "Neutral" there is no pressure at the direction selectors and therefore no power to the drive axle. All excess oil from the pump is then by-passed into the transmission.

Oil Cooler

The oil cooler is located in the side of the tank of the radiator.

Blow out core of radiator regularly. Tighten oil cooler lines at fittings periodically to insure against loss of oil.

Oil Filter

The oil filter cartridge should be changed every 500 operating hours. However, under extremely dirty operating conditions the filter should be checked more frequently. Clean transmission oil will increase the life of the transmission.

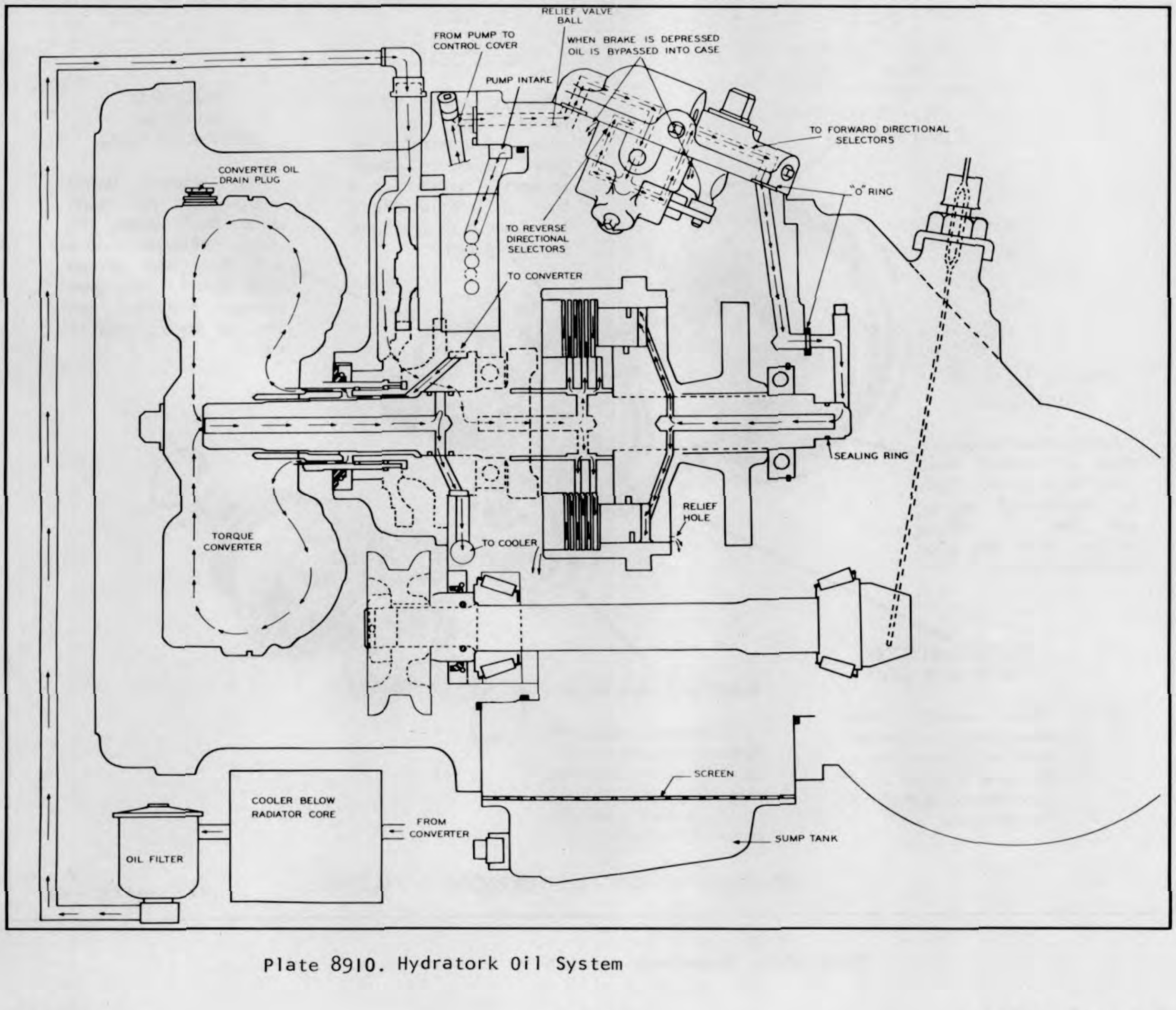


Plate 8910. Hydratork Oil System

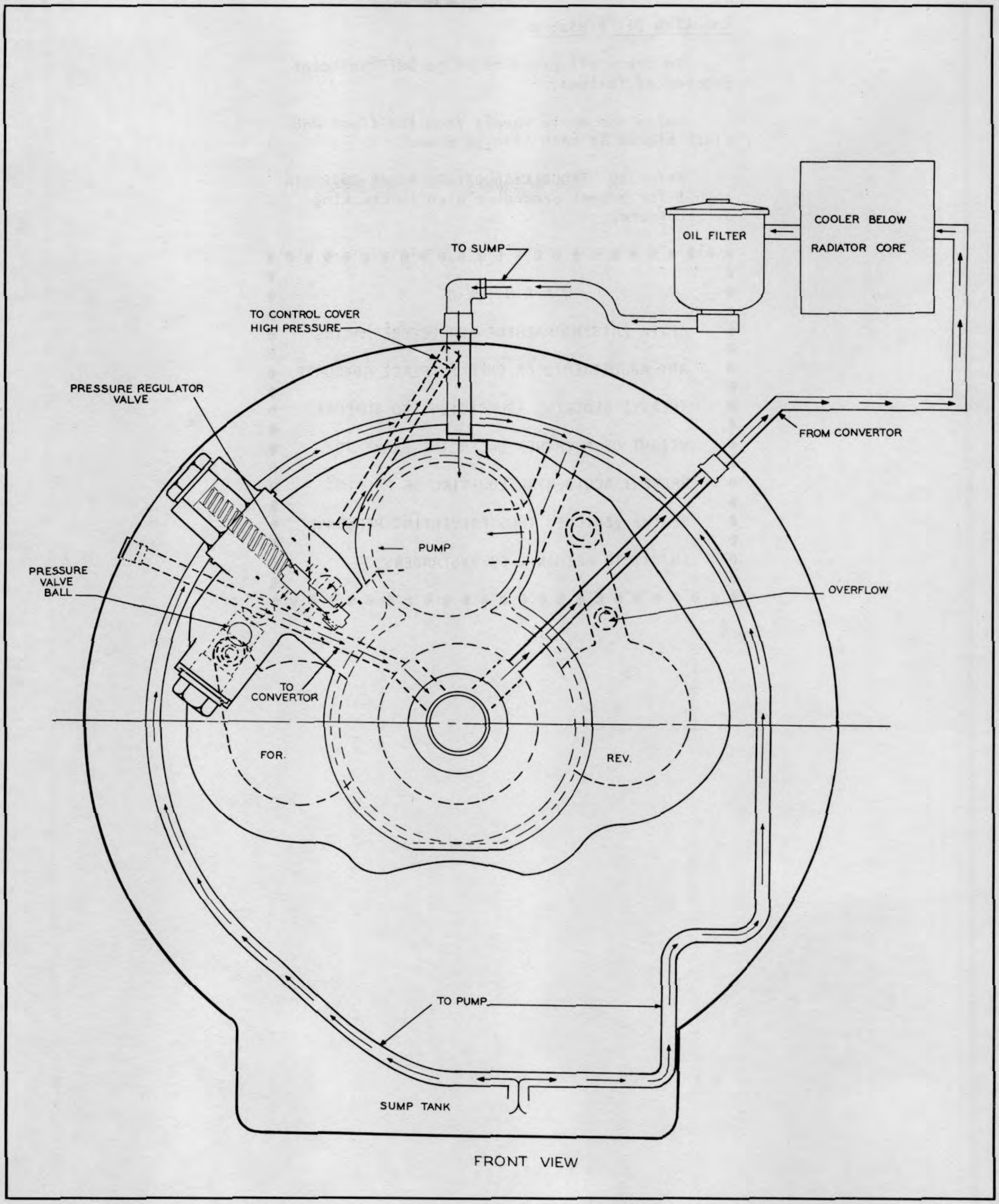


Plate 8909. Hydratork Oil System Viewed From Converter End

Checking Oil Pressure

To check oil pressure of forward selector proceed as follows:

Raise the drive wheels from the floor and place blocks at each side of frame.

Refer to "TROUBLE SHOOTING" Pages 06TS201A thru D for proper procedure used in checking oil pressure.

W A R N I N G

AFTER RAISING MACHINE AND BEFORE MAKING ANY ADJUSTMENTS OR CHECKS, PLACE ADEQUATE (HEAVY) BLOCKING (SUFFICIENT TO SUPPORT WEIGHT OF MACHINE) UNDER THE FRAME TO PREVENT ACCIDENTAL LOWERING OR FALLING OF THE VEHICLE, THUS PREVENTING PERSONAL INJURY TO MECHANIC OR BYSTANDERS.

HYDRATORK TRANSMISSION

MODELS - H127 & H128

Description

A hydraulic torque converter combined with an automatic transmission is incorporated in these model/s transmissions. The construction and operation of the various units are discussed under "Hydratork Drive" on Pages 06M201A through 06M201F. The necessary maintenance and service procedures are outlined in this section.

Lubrication

The transmission is self lubricated by the hydraulic fluid which circulates between the hydraulic pump, torque converter and the direction selectors. A combination filler neck and oil level stick is located on the axle adaptor housing for filling or checking lubricant level.

Check lubricant level following every 40 operating hours. Drain transmission and clean screen following every 500 operating hours or 3 months of operation.

Fill transmission to oil level with Type "A" Automatic Transmission Fluid to "Full" mark on oil level stick. With direction selector lever in "Neutral", start engine and operate approximately three minutes. Stop engine and refill transmission to "Full" mark.

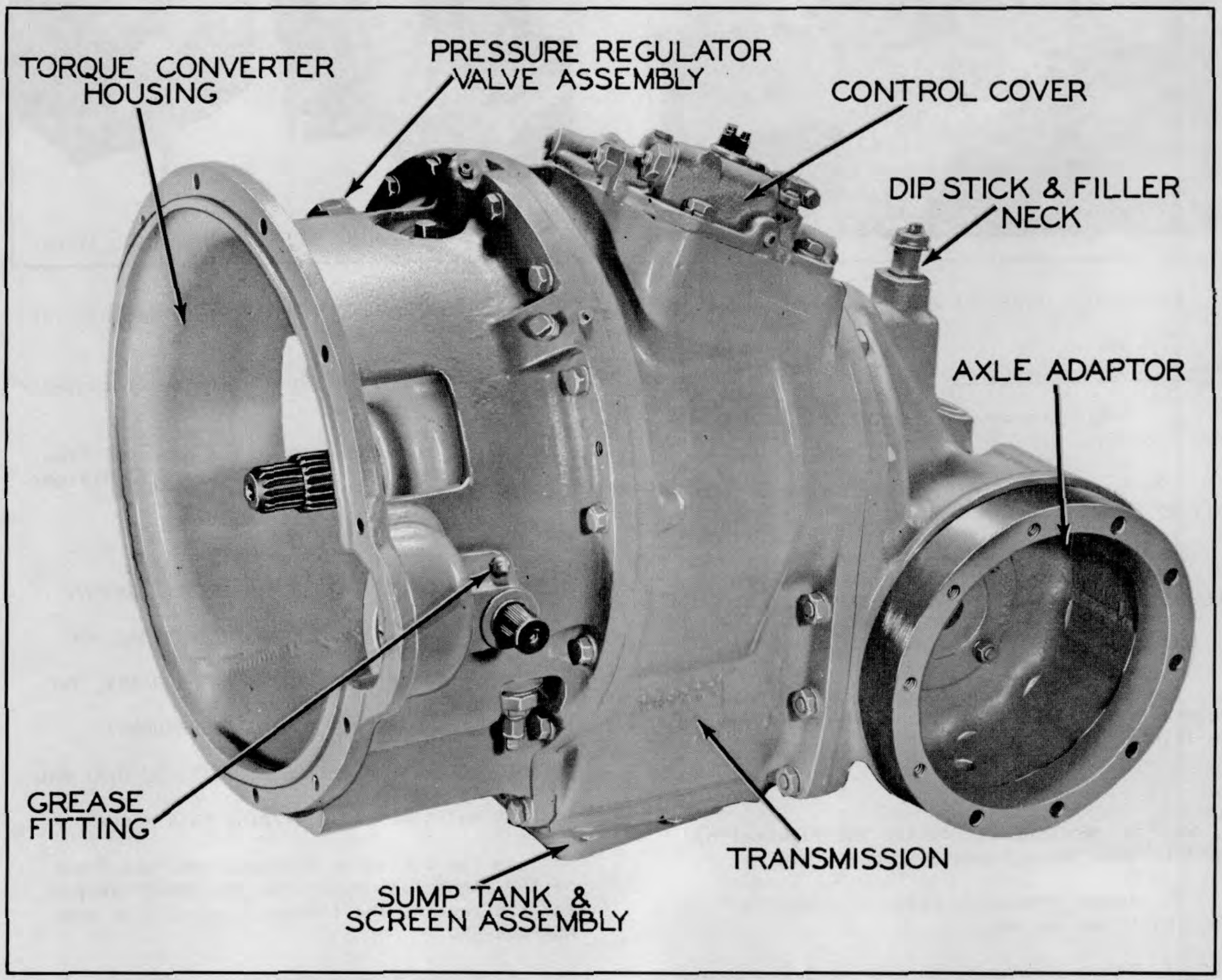


Plate 6180. Hydratork Transmission

Servicing Transmission

The following instructions will aid in servicing the transmission as to removal, disassembly, inspection and maintenance. The text will cover removal and complete disassembly in a sequence that would normally be followed if every assembly is to be completely overhauled. It must be understood, however, that some assemblies may be removed and serviced without the disassembly of the entire unit.

WARNING

MAKE CERTAIN THE ENGINE IS SECURELY BLOCKED BEFORE REMOVING CAPSCREWS.

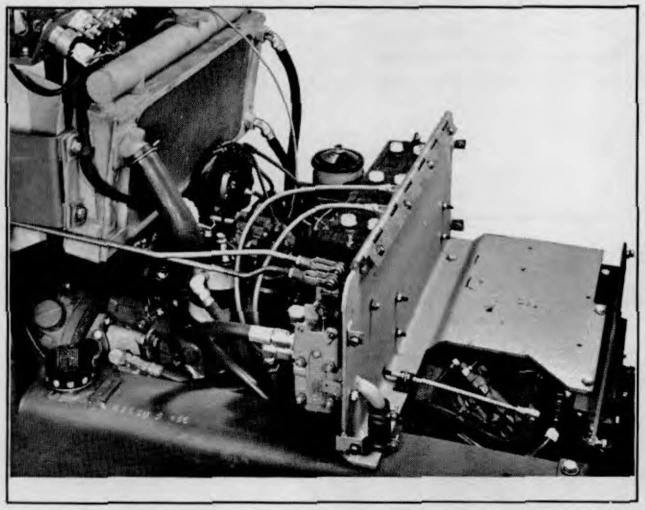


Plate 5848. Firewall and Component Removal

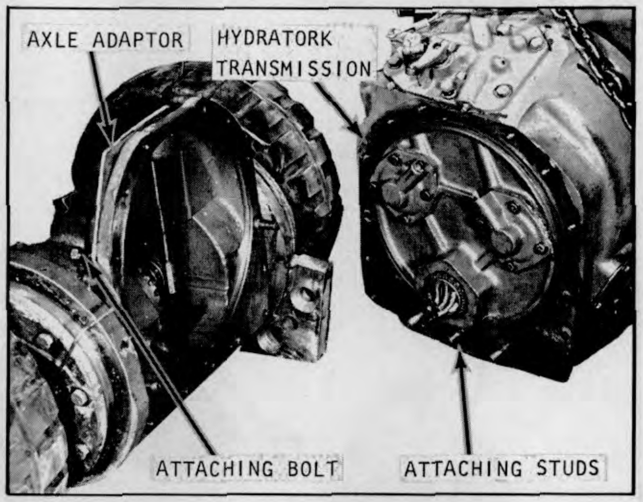


Plate 4428. Remove Transmission from Adaptor

Removal of Transmission

1. Drain transmission & axle adaptor at drain plugs.

2. Remove all parts obstructing accessability to the transmission.

3. Disconnect hydraulic brake fluid line, direction control linkage and two oil cooler lines.

4. Remove upright assembly.

5. Through opening in converter housing, remove 5/16" capscrews securing torque converter to flywheel.

NOTE

It will be necessary to rotate the flywheel by hand to make these capscrews accessible.

6. Remove capscrews securing converter housing to engine block.

7. Remove transmission and wheel end assembly as a unit.

8. Remove drain plug from side of converter and drain oil.

9. Remove torque converter assembly from main drive shaft by pulling converter straight outward from shaft.

CAUTION

CLEANLINESS IS OF EXTREME IMPORTANCE AND AN ABSOLUTE MUST IN THE REPAIR AND OVERHAUL OF THIS UNIT. BEFORE ATTEMPTING ANY REPAIRS, THE EXTERIOR OF THIS UNIT MUST BE THOROUGHLY CLEANED TO PREVENT THE POSSIBILITY OF DIRT AND FOREIGN MATERIAL FROM ENTERING THIS MECHANISM.

In the following instructions, the front of the transmission will be the CONVERTER-END and the rear of the transmission will be the ADAPTOR-END.

1. Remove transmission from axle adaptor, see Plate 4428, by removing the retainer bolts and stud nuts which connect these two units.

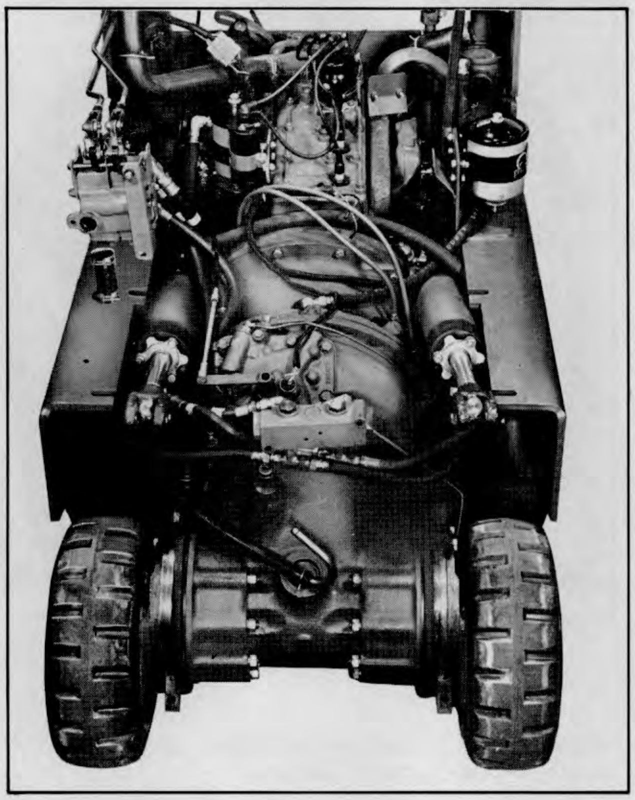


Plate 5849. Transmission Removal

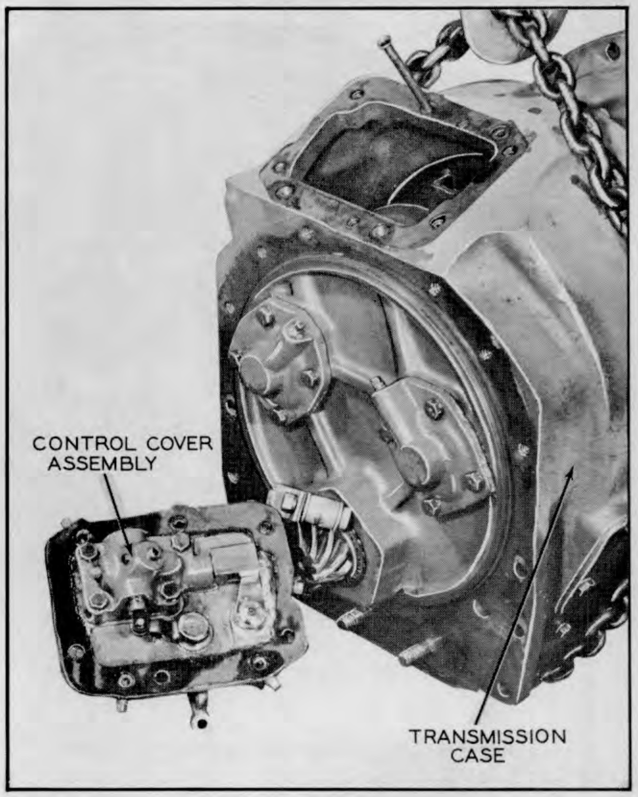


Plate 4426. Control Cover Removal

N O T E

There is one large oil seal and one or more shims located between the axle adaptor and transmission (see Plate 6188). Be careful to not damage components at disassembly and reassembly.

2. Remove control cover retainer screws and remove control cover from transmission (see Plate 4426).

3. Remove pressure regulator assembly from oil pump gear cover. Then remove cover retainer bolts and remove cover from transmission housing (see Plates 6180 & 6179).

N O T E

There are two "O"-rings and one gasket retained in cover, Plate 6179, note their location at disassembly.

4. Remove cotter pin from pinion shaft and remove nut. Using two pry bars (or suitable puller) position pry bars directly opposite one another in back of drum, and pry drum from shaft. Remove drum key (98) from pinion shaft (97).

5. Using a soft mallet, drive pinion shaft from transmission case, tapping only as necessary. Upon removal of the pinion shaft, the following components will drop free and into the bottom of the case: shims, front bearing spacer and one washer (if so equipped), gear and gear spacer. There is one "O"-ring which may remain on the front portion of shaft upon removal (see Plates 6188 & 6182).

The pinion shaft front bearing oil seal is pressed into housing. The oil seal, front bearing and bearing retainer ring should be removed and replaced as necessary. Drive the bearing race from transmission case in the event of replacement for wear. The rear bearing may be pressed off the pinion shaft in the event of replacement for wear. The rear bearing should be driven from case in the event of replacement for wear.

6. Remove capscrews and stud nuts securing converter housing to transmission case and separate the two units.

N O T E

There are two sealing rings (front and rear) located on the back side of the converter housing. NOTE location of EACH component so it may be duplicated at reassembly (see Plate 6187, Items 70 & 71). There is one small "O"-ring located at the top portion of the converter housing, Item 18.

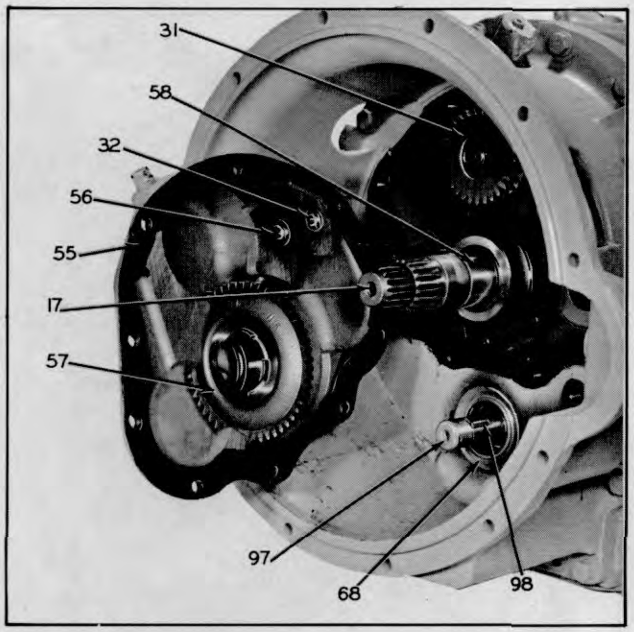


Plate 6179. Oil Pump Gear Cover Removal

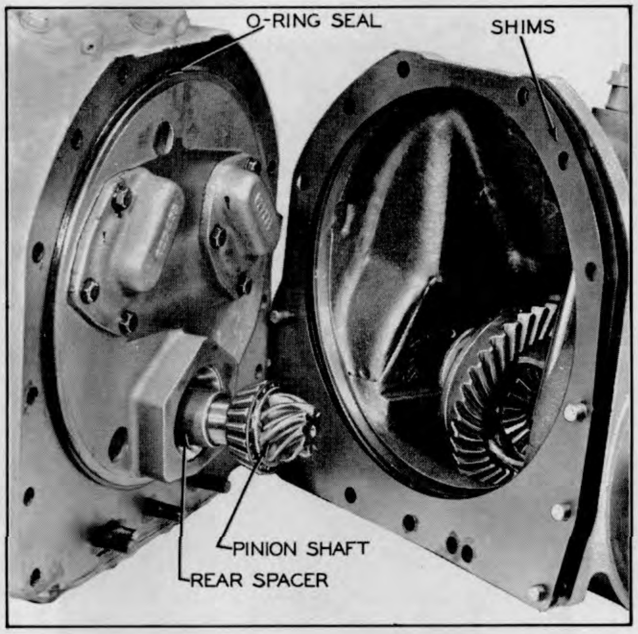


Plate 6188. Axle Adaptor & Transmission

7. Remove the direction selector "Rear" bearing caps.

NOTE

There is one "O"-ring and one gasket located on the back side of each bearing cap (see Plates 4432 & 6190).

8. Unstake and remove direction selector shaft nuts and remove direction selector assemblies.

At this point the transmission assembly is disassembled into major component parts, namely; the control cover, direction selectors, converter housing and transmission housing.

Direction Selector Disassembly

1. From end of D.S. shaft, remove snap ring and spacer (see Plate 4432 on following page).

2. Turn the complete assembly over and pull D.S. shaft with snap ring and bearing. Then remove spacer, D.S. gear and bushing assembly, thrust washer and shaft seal from each D.S. drum (see Plate 5948 on following page).

3. Remove large snap ring from inner diameter of each D.S. drum. Remove selector disc end plate.

4. Remove disc release springs, outer steel discs and inner bronze discs from each D.S. drum. Note that these discs are alternated; one bronze, one steel etc. The bronze discs have teeth on the inner diameter and the steel discs have teeth on the outer diameter.

5. Rotate selector piston back and forth in drum until fully released. Remove piston from drum.

6. The seal ring on the back side of the piston may be removed if damaged or worn. Remove inner seal ring from drum.

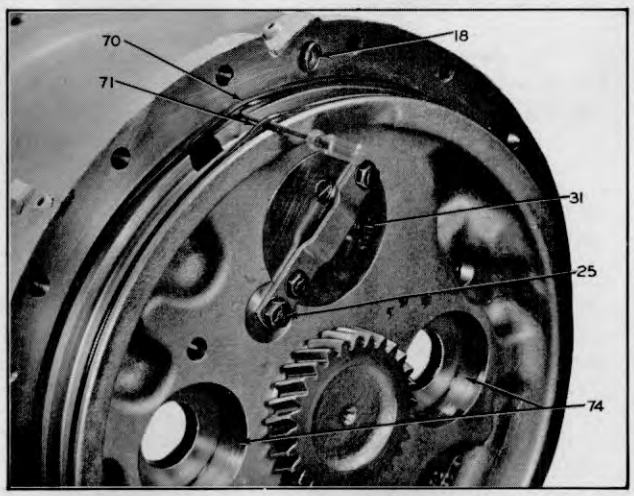


Plate 6187. Transmission and Converter Housing Sealing Rings (Typical Illustration)

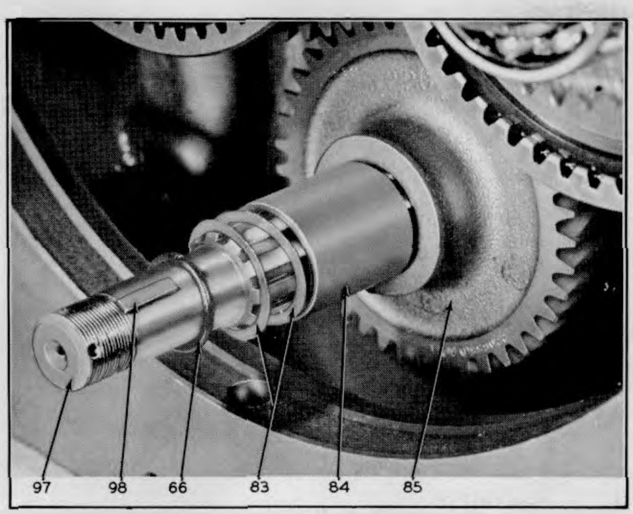


Plate 6182. Pinion Shaft Components

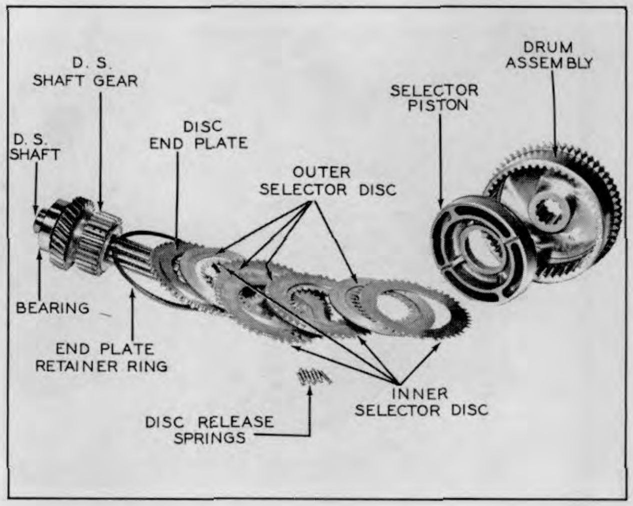


Plate 5948. Selector Drum Components

Converter Housing Disassembly

1. Remove lockwire and remove stator support capscrews. Remove stator and shim from housing. (See Plate 6179 on previous page, and Plate 6185 on following page.)

2. Remove locating ring and oil rings from main drive gear shaft. Exercise CAUTION upon removal of oil rings to not damage them (see Plate 6185).

3. Using a soft mallet, drive main drive gear shaft from bearing and housing. Tap shaft inward towards transmission side (see Plate 6185).

4. Remove main drive gear shaft bearing from bore of housing.

5. Remove bolt (Item 25, Plate 6187 on previous page) from the oil pump retainer plate and then pull pump assembly from the bore of converter housing.

Pump Gear Cover Disassembly

1. Remove oil seal (46) from bore in cover. (See Plate 6186 on following page).

2. Remove oil relief plug (52), plug seal (53), spring (51) and relief ball (50).

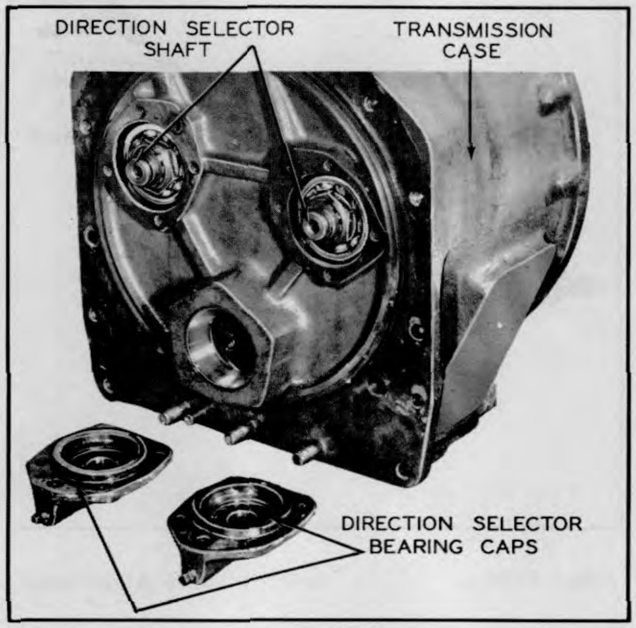


Plate 4432. Selector Shaft Removal

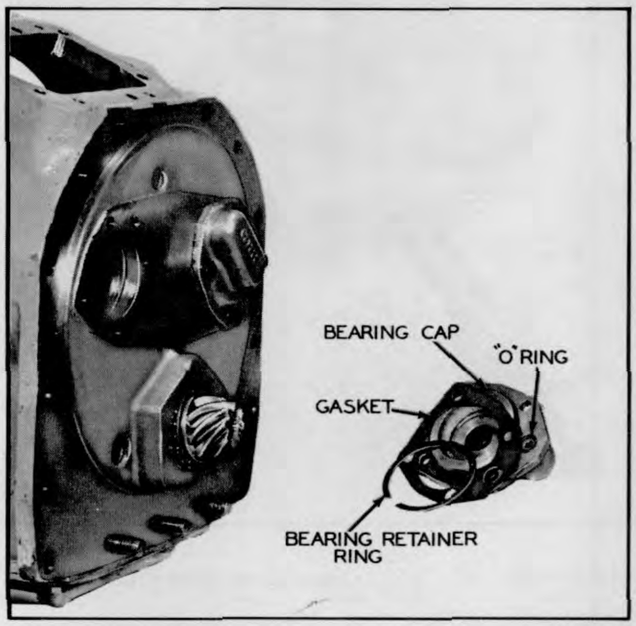


Plate 6190. Bearing Cap Components

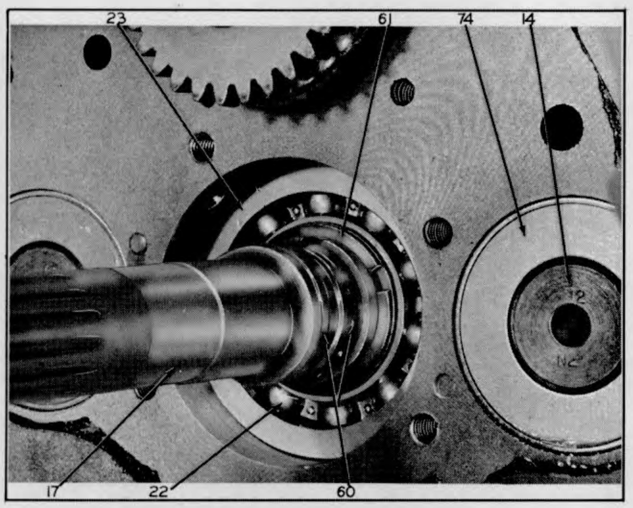


Plate 6185. Main Drive Gear Shaft

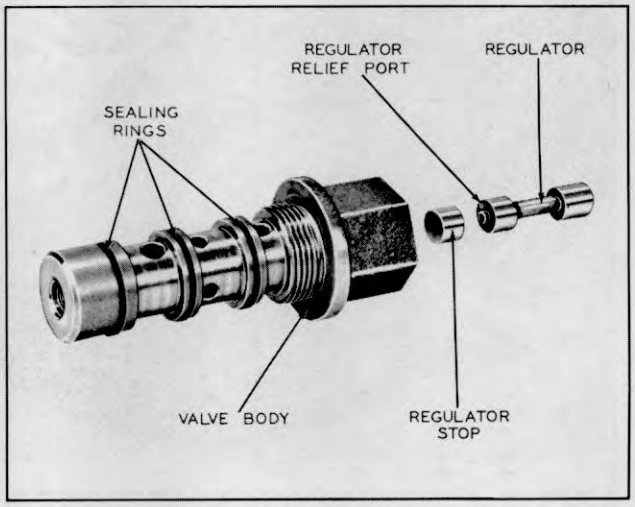


Plate 4434. Pressure Regulator Valve

3. Since the pressure regulator valve (41) was removed to allow removal of the oil pump cover, see the following write-up on valve disassembly.

4. Clean oil pump cover in a Stoddard Type cleaning solvent, and be sure valve bore and relief plug bore is thoroughly clean. Be sure gasket surface of cover is completely free of old gasket material that may have remained on surface at gasket removal.

Pressure Regulator Valve Disassembly

1. Remove body plug (38) and washer (37) from end of valve body (41), (see Plate 6186).

2. Turn end of body (41) downward, allowing the valve spring (37), regulator stop to drop out (see Plates 6186 & 4434).

Remove and replace regulator assembly sealing rings (43) if necessary.

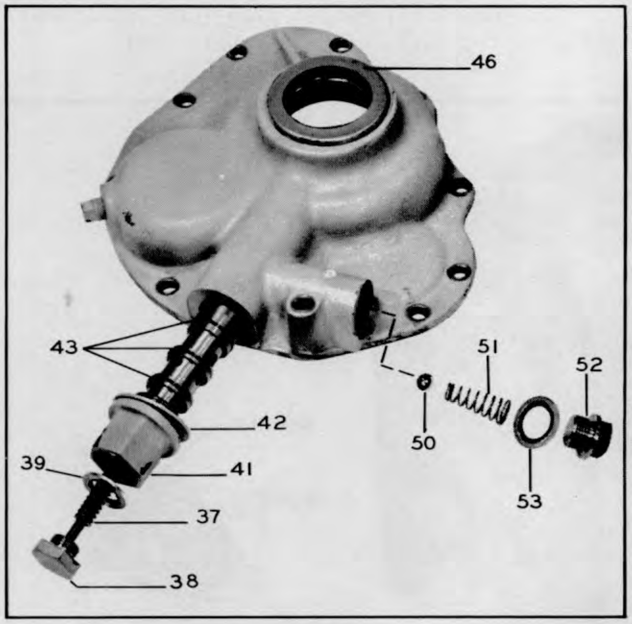


Plate 6186. Pump Gear Cover Components

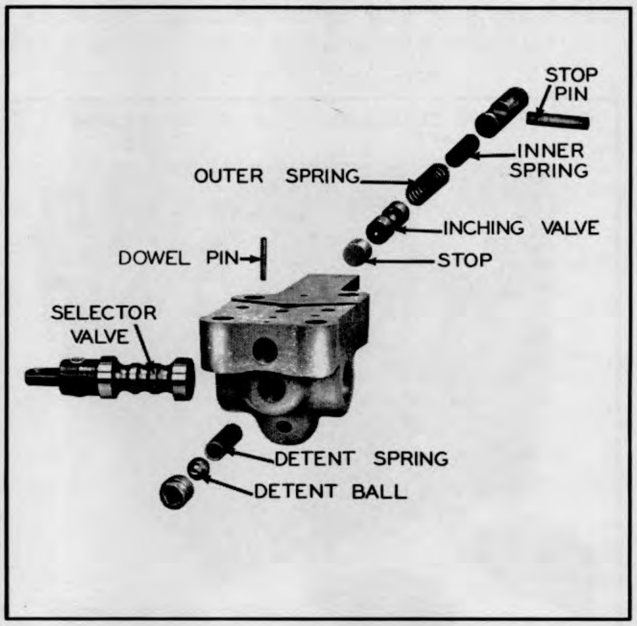


Plate 4386. Control Valve Disassembled

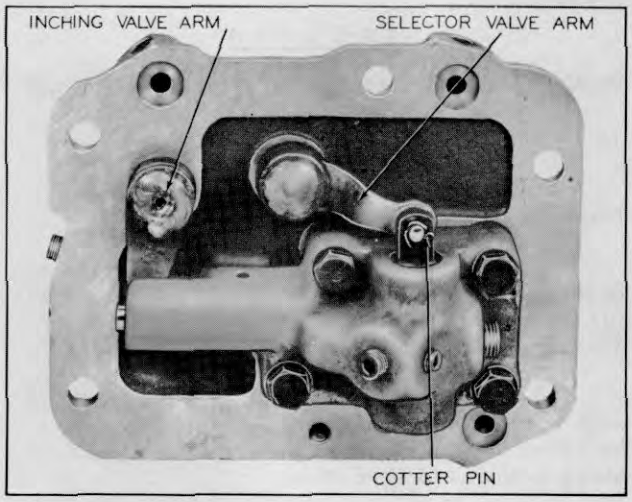


Plate 4388. Bottom View of Control Valve and Cover Illustration)

Control Cover and Valve Disassembly

1. On a clean bench remove cotter pin that locks the shaft to selector valve arm (see Plate 4388).

2. Remove the capscrews and lockwashers that secure valve assembly to cover. This will free valve from cover.

3. With a proper drift, remove the small valve stop dowel pin from opposite protruding boss (see Plate 4386 on previous page).

4. With a proper drift, remove roll stop pin from opposite end.

5. Remove inching valve control rod springs.

6. Inching valve will be free and can now be removed.

7. Remove inching valve stop from bore.

8. Remove plug which secures the detent ball and spring. This will release the detent ball and spring making it possible to remove the selector valve.

9. Remove snap rings and flat washers from valve cover (located at selector arm and inching arm assemblies).

10. Inching valve arm and shaft, and selector arm and shaft can now be removed from cover.

11. Press oil seal from cover and replace with new.

Inspection and Maintenance

Cleanliness of the respective parts is absolutely necessary in reassembly. Dirt in its many forms, can and will cause trouble. Therefore, before reassembling the transmission unit, make sure that all parts have been thoroughly cleaned with a Stoddard Type cleaning solvent. All parts should be wiped dry, or blown dry with moisture free compressed air after cleaning.

A thorough visual inspection of all parts should be made before reassembly. All parts that show excessive wear or damage should be replaced. Small nicks or burrs may be removed with a hone or a crocus cloth. All "O"-rings, sealing rings, gaskets and oil seals must be replaced with new and we recommend that all snap rings be replaced.

Bearings should be dipped in a Stoddard Type cleaning solvent and sloshed up and down slowly until thoroughly clean. Remove bearings from fluid and strike large side of cone flat against a block of wood to dislodge solidified particles of lubricant. Repeat operation until bearings are thoroughly clean.

Carefully inspect cages, balls and cups for wear, chipping or nicks to determine fitness of bearing for further use. After inspection, dip bearings in clean transmission oil and wrap them in clean cloth or paper to protect them against dirt until such time as they are to be installed.

The ring gear and pinion should be checked at this time also. If gear teeth show spots where case hardening is shown through, then it will be necessary to install a new ring gear and pinion set. Pinion and drive (ring) gears are available only in matched sets and must be installed as such to assure satisfactory operation. Small nicks may be carefully removed with a suitable hone. Examine pinion gear teeth for wear and check pinion shaft for evidence of twisting, particularly at splines. If evident, install a new set of gears.

Handle seals carefully, particularly when seals are being installed. Cutting, scratching or curling under of the seal lip seriously impairs efficiency. Use a suitable tool that will contact the O.D. of the seal when installing into position. Do not overpress seals at time of installation. When installing D.S. shaft seals (Items 74), press seals until they are flush with front of converter housing only. When installing the oil pump gear cover oil seal, the seal must not be pressed in all the way. The seal should be installed 3/32 of an inch above cover casting. This will prevent the oil seal from contacting the oil pump drive gear (see Plate 6186 on previous page).

Check, clean and remove old gasket material from the sump cover and sump cover screen. The cover and screen should be thoroughly cleaned. All contact surfaces should be cleaned free of any remaining gasket material before assembling components with new gaskets. Refer to Plate 4390 in Specifications (Page 06S201A) for further assembly instructions.

Control Cover and Valve Reassembly

CAUTION

REMOVE ALL BURRS AND NICKS. THEN CLEAN SURFACES WITH A FINE STONE AND BE SURE THAT ALL MOVING PARTS ARE FREE AND CLEAN IN THE BORES BEFORE REASSEMBLY.

1. Insert inching valve stop, Plate 4386, in bore at opposite end of protruding boss and secure with dowel pin.

2. Insert inching valve in bore with the small hole in the end of valve set against the stop.

CAUTION

IF THE VALVE SHOULD BE INSTALLED BACKWARDS, THE MACHINE WILL NOT FUNCTION PROPERLY.

3. Install both "Inner" and "Outer" springs in housing bore so they are set against the inching valve.

CAUTION

SPRINGS SHOULD BE AGAINST THE INCHING VALVE AT OPPOSITE END OF SMALL HOLE IN INCHING VALVE JUST PREVIOUSLY MENTIONED.

4. Insert inching valve control rod with notch correctly located to allow installation of stop roll pin.

5. Press stop roll pin into position in housing.

6. Remove the large pipe plug and insert poppet spring and ball inward so they are located beyond the selector valve bore.

7. With the detent ball and spring held in their inward position, install the selector valve into housing.

CAUTION

WHEN INSTALLING SELECTOR VALVE, BE CAREFUL NOT TO DAMAGE BORE OF HOUSING.

8. Install and tighten pipe plug in housing.

9. With a light coating of Permatex on the outside diameter of both shaft oil seals. Press oil seals in shaft bores of cover WITH LIP OF SEAL FACED DOWNWARD.

10. Install inching arm assembly equipped with bottom washer and bushing into bore of housing. Secure in position with the upper shaft washer and snap ring.

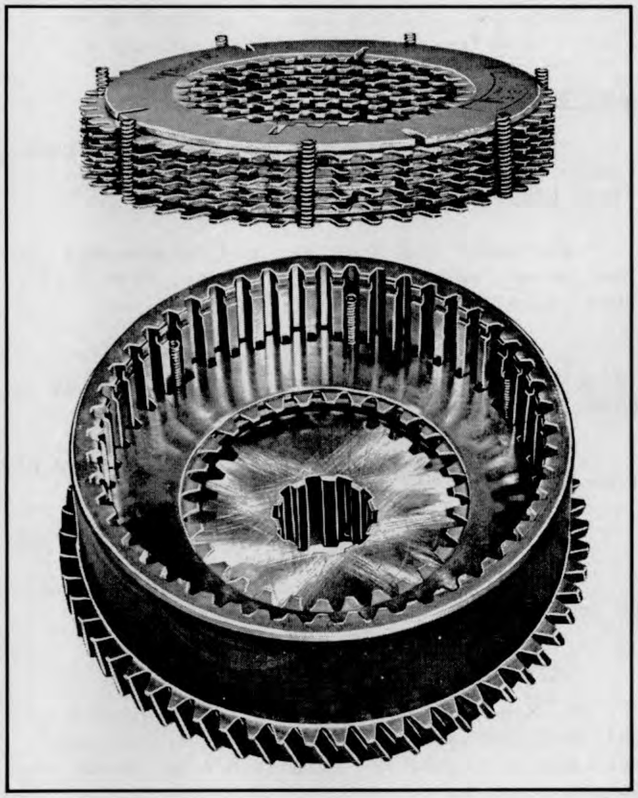


Plate 4479. Install Disc Into D.S. Drum

11. Install selector arm assembly equipped with bushing into bore of housing. Secure in position with the upper shaft washer and snap ring.

12. Position the three oil passage "O"-rings between cover and valve assembly. Secure control valve to cover with retainer capscrews and lockwashers. Tighten capscrews evenly.

13. Secure selector valve linkage to selector valve assembly with clevis pin and cotter pin.

14. Install the inching valve arm to the inching valve shaft and install the outer selector arm to the selector valve shaft. Now install the neutral starting switch equipped with washer and starting switch pin to control cover.

15. Place check ball in bore located at top of cover housing and secure with washer and check ball plug.

16. Place check ball and spring in bore located on side of housing and secure with copper washer and reducer bushing.

17. Install(inching piston) retainer ring, spacer, spring, inching piston, piston cup and reducer bushing equipped with seal into bore located on side of housing.

18. Secure inching piston to inching valve arm with clevis pin and cotter pin.

Pressure Regulator Valve Reassembly

1. Install regulator stop in body.

2. Install regulator and then install new spring (39) into valve body (see Plates 6186 & 4434 on Page 06M201M).

CAUTION

THE SMALL RELIEF HOLE IN THE END OF REGULATOR MUST BE TOWARD THE REGULATOR STOP. SEE PLATE 4434 ON PAGE 06M201M FOR CORRECT POSITION. IF VALVE IS REVERSED, IMPROPER OIL PRESSURE WILL RESULT.

3. Reassemble body plug (38) with seal (39) to valve body (41), (see Plate 6186 on Page 06M201M).

4. Install new sealing rings (43) to valve and install valve body with seal (42) into bore of oil pump gear cover, (see Plate 6186).

CAUTION

WHEN INSTALLING VALVE TO COVER, EXERCISE CAUTION TO NOT DAMAGE THE SEALING RINGS (43) UPON INSTALLATION.

Pump Gear Cover Reassembly

1. Install relief valve ball (50), new spring (51), seal (53) and relief plug (52) into bore of pump cover (see Plate 6186).

2. Apply thin layer of No. 2 Permatex on outside diameter (edge) of oil seal (46) and then press into position. The seal should not be installed all the way. The seal should be installed 3/32 of an inch above cover casting. This will prevent the oil seal from contacting the oil pump drive gear (see Plate 6186). The oil seal "Lip" should be faced downward when correctly installed.

Direction Selector Reassembly

1. Set direction selector drum on a suitable bench with open end upward and install cast iron lock-type-pisron ring to inside of drum. Coat ring with Type "A" Automatic Transmission Fluid after installing.

2. Install piston outer ring to selector piston. Coat ring with Type "A" Automatic Transmission Fluid after installing.

3. Check ring to make sure it is properly locked.

CAUTION

DO NOT DAMAGE SEALING RINGS AT INSTALLATION.

4. Coat inner bore of drum with Type "A" Automatic Transmission Fluid and install piston to drum, rotating and pressing downward until piston is properly seated.

5. Place first disc into bore of drum, this is always the disc with teeth on the outer diameter (steel disc). Install second disc (bronze disc). This disc has teeth on the inner diameter. Position third disc (teeth on outer diameter) to drum and line up the teeth on the third disc with the teeth on the first disc, then rotate third disc one tooth and install to the drum (see Plate 4479 on previous page).

6. Install the remaining discs in the same manner as the second and third. With all discs installed to the drum, insert release springs through openings where teeth are missing.

CAUTION

MAKE CERTAIN THAT RELEASE SPRINGS INSERTED THROUGH OPENINGS WHERE TEETH ARE MISSING ARE SEATED ON A TOOTH OF THE FIRST (STEEL) DISC.

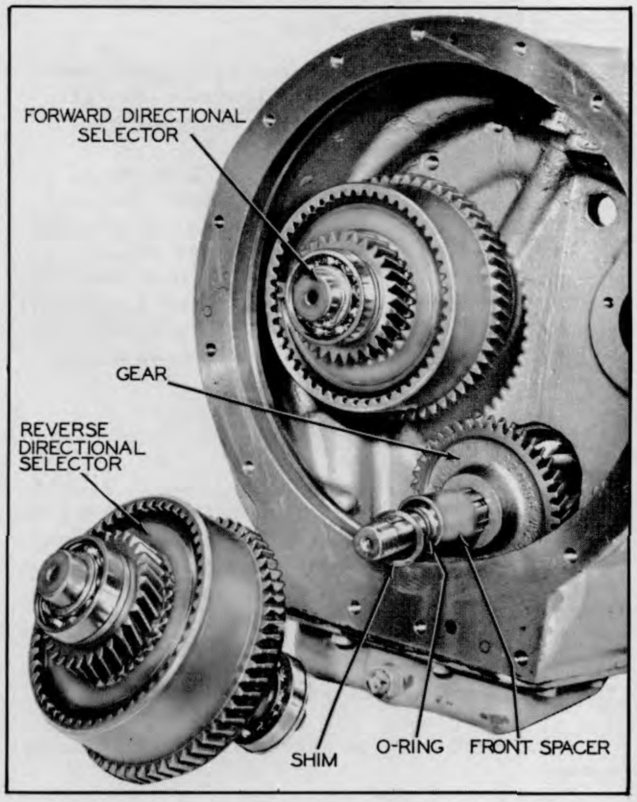


Plate 6189. Transmission Reassembly

7. Install end plate in drum and secure in position with end plate retainer ring. The end plate has a complete set of teeth, therefore the release springs are assured of a contact surface. Plate 6189 illustrates a correctly assembled selector drum.

8. Coat drum thrust washer with Type "A" Automatic Transmission Fluid and insert on inside face of drum with bronze away from drum.

9. Install D.S. gear and bushing assembly to drum. It will be necessary to rotate the gear until it is in mesh with <u>all</u> teeth located on the inner diameter of the discs. The gear must be in mesh with each selector disc.

10. Opposite the threaded end of D.S. shaft, place thrust washer with flat side of washer positioned against shoulder of shaft.

11. Press bearing on shaft against thrust washer and secure with retainer ring.

12. Insert shaft, thrust washer and bearing into drum. Oil holes on shaft and drum MUST be in line with one another.

<u>C A U T I O N</u>

OIL HOLES MUST LINE UP - TO INSURE ADEQUATE FLOW.

13. Install shaft spacer and secure with snap ring.

N O T E

Test selector drum to be sure oil holes of shaft and drum are in correct alignment. Direct a stream of air through the shaft hole on the piston-drum-end of the D.S. selector. The discs should be fluctuating with a reasonable force of air.

14. Both direction selectors are assembled in the same manner. Do not install direction selector in transmission at this time.

<u>Converter Housing Reassembly</u>

1. From rear side of converter housing, install main drive gear shaft through bore.

2. Set converter housing on rear face and press shaft bearing on shaft and secure bearing in place with retainer ring (61), (see Plate 6185 on Page 06M201M).

3. Install new sealing rings (60) on main drive gear shaft. Exercise care to not damage rings when installing, and be sure to properly lock rings after installation (see Plate 6185).

4. Select shim (23), Plate 6185, and install stator support (58) to converter housing. Secure in position with capscrews and lockwire as shown in Plate 6179 on Page 06M201K.

<u>C A U T I O N</u>

SHIMS (23)ARE AVAILABLE IN VARIABLE THICKNESS.

SELECT SHIMS TO INSURE NO END PLAY IN MAIN

DRIVE GEAR SHAFT (17).

5. Assemble oil pump assembly (31) in bore of converter housing and secure pump in place with retainer plate and bolt (Item 25, Plate 6187 on Page 06M201K).

6. Through open face of converter housing, press D.S. shaft oil seals (Item 74, Plate 6185 on Page 06M201M) in housing bores. Lip of seals must face outward when correctly installed.

N O T E

Press oil seals in bores so they are flush with casting only.

Install pump drive gear (57), oil pump gear cover equipped with new gasket and "O"-rings (Items 56 & 32) over stator support and in place on front side of converter housing (see Plate 6179 on Page 06M201K).

C A U T I O N

OUTER DIAMETER OF GASKET MUST BE COATED WITH SHELLAC TO PREVENT LEAKS. BEFORE ASSEMBLING OIL PUMP GEAR COVER TO HOUSING, THE PRESSURE REGULATOR ASSEMBLY (ITEM 41, PLATE 6186) MUST BE REMOVED IN ORDER TO ALLOW INSTALLATION OF COVER. THE REGULATOR ASSEMBLY MAY BE INSTALLED THROUGH HOLE LOCATED IN TOP OF HOUSING (SEE PLATE 6179). BE SURE ALL COMPONENTS ARE ABSOLUTELY CLEAN BEFORE INSTALLATION. BE SURE THAT "O"-RINGS ARE IN PLACE IN COVER. A LIGHT COATING OF SILICON GREASE MAY BE APPLIED TO "O"-RINGS TO RETAIN THEM IN POSITION WHILE INSTALLING COVER. BE CAREFUL TO NOT DAMAGE LIP OF SEAL (46) WHEN INSTALLING COVER IN POSITION.

7. Install "Front" and "Rear" sealing rings (Items 70 & 71, Plate 6187 on Page 06M201K) on back side of converter housing as shown. Install "O"-ring (18) in position to converter housing as shown in Plate 6187. Lubricate sealing rings and "O"-ring with Type "A" Automatic Transmission Fluid before installation.

Transmission Reassembly

Lubricate all bearings, oil seals, "O"-rings and sealing rings with Type "A" Automatic Transmission Fluid when reassembling components.

N O T E

Pinion shaft bearing PRELOAD must be obtained before assembling selector assemblies in transmission, therefore, the following procedure must be followed before completing reassembly.

1. If removed, install bearing on pinion shaft as shown in plate 6188 on Page 06M201K. The large tapered end of bearing must be against pinion gear.

2. Press bearing race in bore of case, if removed, against locating ring assembled in case. Large tapered end of bearing race will face outwards when correctly assembled.

3. Insert pinion shaft through race and transmission case. Set transmission case on rear face with pinion shaft gear-end down and open face upwards. Block in position.

4. Through open face of transmission case, install rear spacer and shaft gear with large offset of gear faced toward front.

5. Place bearing spacer on shaft against gear. Tapered end away from gear.

6. Place converter housing on transmission housing and secure with capscrews.

C A U T I O N

CAUTION SHOULD BE EXERCISED WHEN INSTALLING CONVERTER HOUSING TO TRANSMISSION TO NOT DAMAGE THE SEALING RINGS LOCATED ON THE BACK SIDE OF CONVERTER HOUSING.

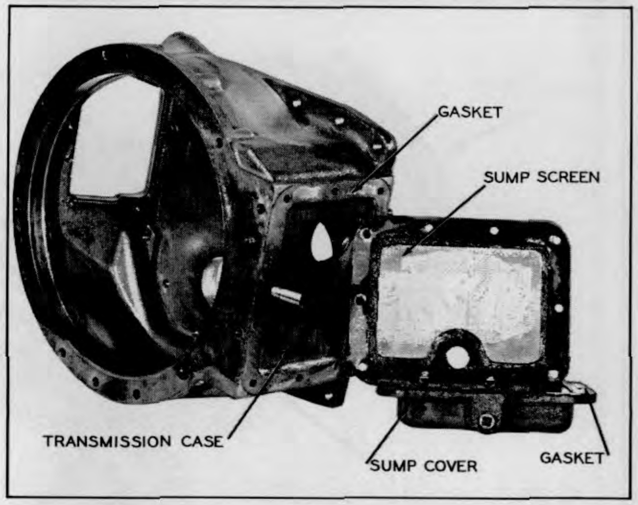


Plate 5959. Sump Cover and Screen

7. Press bearing race in converter housing bore with large tapered end outwards.

8. Press bearing on pinion shaft with large tapered end outwards.

9. Insert "O"-ring and front bearing spacer on shaft.

10. Insert Woodruff Key and brake drum and secure with locknut.

I M P O R T A N T

REMOVE OR ADD PINION SHAFT BEARING SHIMS AS NECESSARY TO OBTAIN 8 TO 12-INCH-POUNDS PRELOAD ON BEARINGS.

NOTE

Pinion shaft oil seal should not be installed at this time. It is important to obtain pinion shaft bearing preload before completing transmission reassembly. The oil seal will be installed at a later time.

11. Remove drum nut, drum and key and bearing spacer, "O"-ring and bearing from pinion shaft. Separate housings.

CAUTION

CAUTION SHOULD BE EXERCISED TO NOT DAMAGE SEALING RINGS LOCATED BETWEEN THE TWO COMPONENTS.

12. Viewed from converter end of housing, install reverse directional selector on the right side of housing (see Plate 6189 on Page 06M201S). Reverse direction selector has 58 teeth.

13. Install bearing from outside of case and secure with nut. Stake nut.

14. Install forward directional selector to left side of housing viewed from converter end. Forward direction selector has 57 teeth. Install bearing, secure with nut and stake nut.

15. Reassemble converter housing to transmission housing and secure with capscrews.

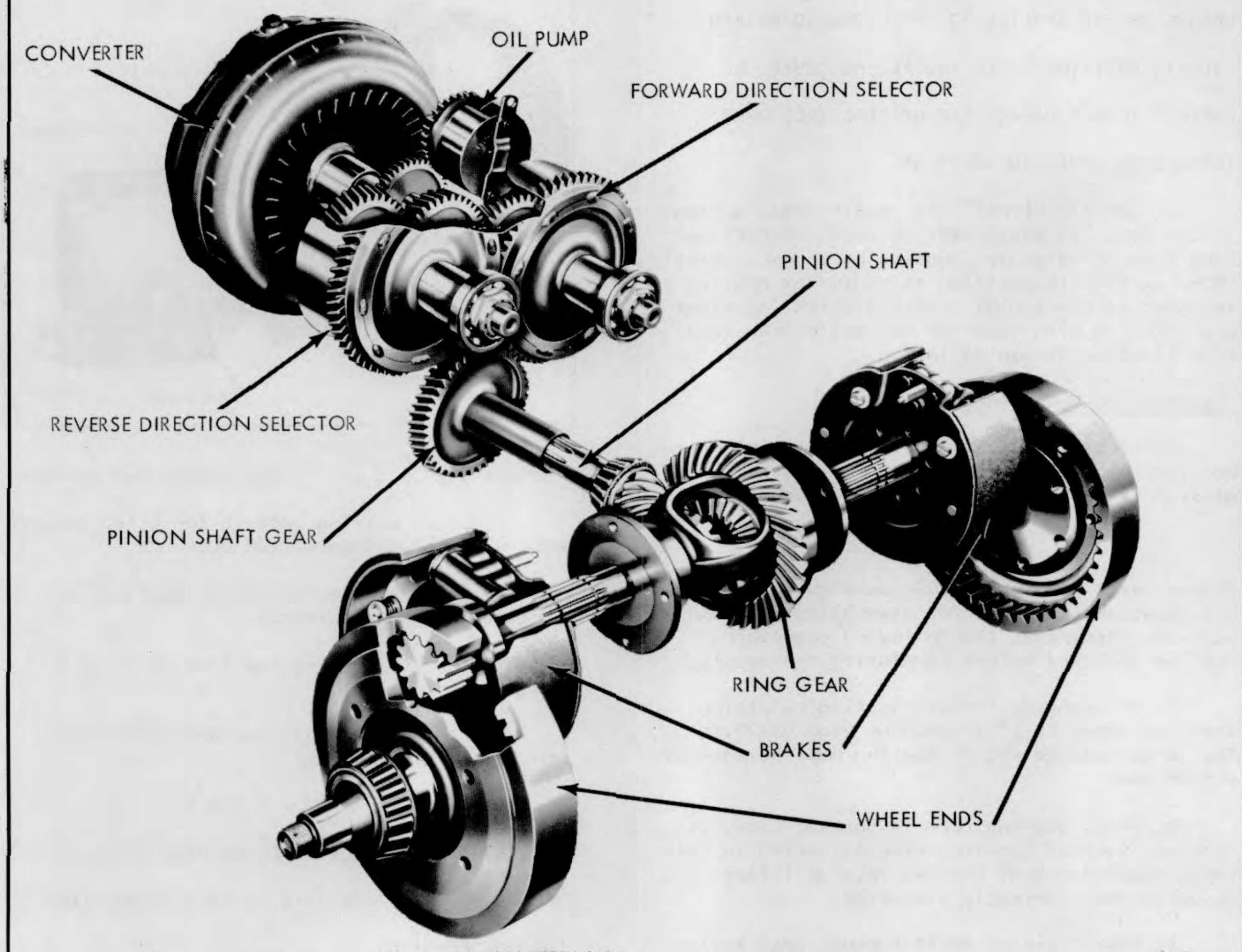


Plate 4443. Transmission and Wheel Ends Illustration)

CAUTION

CAUTION SHOULD BE TAKEN TO NOT DAMAGE LARGE SEALING RINGS AT ASSEMBLY AS AIR INTAKE TO PUMP MAY RESULT, AND OIL LEAKAGE WOULD BE THE END RESULT.

16. Reinstall pinion shaft bearing, "O"-ring and spacer on pinion shaft.

17. Install shims (same number and size shims that were used to obtain pinion shaft preload) on pinion shaft.

18. With light coat of No. 2 Permatex on O.D. od oil seal, press seal into bore of housing with "Lip" of seal faced inward.

CAUTION

THE OIL SEAL SHOULD NOT BE PRESSED IN ALL THE WAY. THE SEAL SHOULD BE INSTALLED 3/32 OF AN INCH ABOVE CASTING. THIS WILL PREVENT THE OIL SEAL FROM CONTACTING THE PINION SHAFT BEARING.

19. Assemble woodruff key and drum. Secure in position with nut and cotter pin.

20. Lubricate "O"-rings and place in position on each bearing cap, (see Plate 6190, on Page 06M201L). Shellac both sides of gaskets and install on bearing caps.

21. Install bearing caps in position on back side of transmission case (see Plate 6188 on Page 06M201K) and secure in place with capscrews.

22. Lubricate and install "O"-ring seal to back portion of transmission (see Plate 6188) Refer to Page 20S801A for instructions on obtaining correct tooth contact between ring gear and pinion gear. Install axle adaptor to transmission.

CAUTION

CAUTION SHOULD BE EXERCISED TO NOT DAMAGE "O"-RING SEAL UPON ASSEMBLING THE TWO COMPONENTS.

23. Install converter drive plate and converter on stator support in converter housing. The drive plate is bolted to the converter and in turn is bolted to the engine flywheel.

NOTE

There is a smaller reinforcement plate located between the converter drive plate and the converter assembly. If the drive plate was removed from the converter, be sure that the reinforcement plate is correctly positioned between these two components before reassembly.

24. Shellac gasket to control cover assembly. Lubricate and position the three "O"-rings in the indentations in control cover. Now install control cover to transmission and secure with capscrews.

25. Place gasket on sump cover, then place screen on gasket. Now install remaining gasket on screen and install cover, gaskets and screen as an assembly to the bottom of the transmission case. Secure in position with capscrews. See Plate 5959 on Page 06M201T for detail.

The transmission will appear as shown in Plate 4443 on previous page. Reinstall transmission to the reverse procedure of removal.

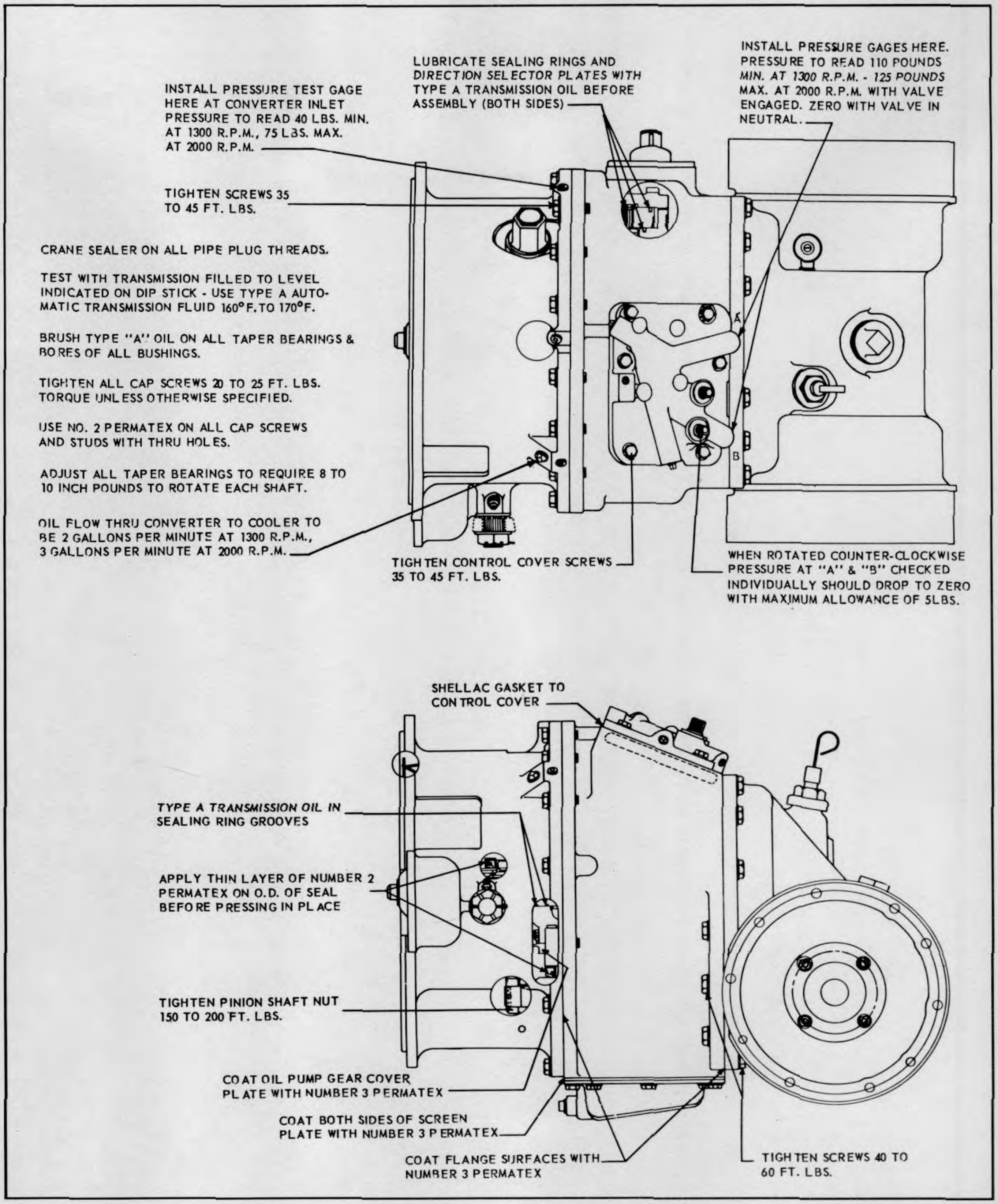


Plate 4390. Assembly Instructions and Specifications

COURTESY OF:
SUN ELECTRIC CORPORATION

HOW TO USE THIS HANDBOOK

To fully utilize all of the facilities of your test equipment, and thereby realize its many values and applications in your service operation, it is suggested that you carefully study the sections of this Handbook that pertain to the pieces of test equipment in your possession.

For your convenience, this handbook is designed to provide application and use data pertinent to a number of testers which can be used individually or in many combinations. As you will note, a complete section, detailed as to application, procedure, results and indications, is provided for each test unit. In addition, a complete sequence of tests, combining the facilities of all the testers, is outlined for the more skilled operator under the heading of "Condensed Test Procedure."

Each step in the Condensed Procedure sequence is labled to indicate what information is to be gained, and is also identified with the particular tester required to perform the test. When the need for more detailed tests of a given area are required, the operator need only refer to the section of the handbook dealing with the specific tester involved.

Whether your shop is equipped with all, or just a few of the testers covered in this publication, it will be to your advantage to review its various sections periodically to make sure you are not overlooking any of the many valuable functions and applications of the test equipment at your disposal.

TESTER MAINTENANCE

SUN test equipment is the finest available and retains its accuracy and long life with a minimum of care. The test leads can be quickly cleaned with waterless soap or solvent. Do not use gasoline as it will deteriorate the rubber. The metal work can be kept glossy with any good automobile polish. To assure accurate test results, meter pointers must read zero when all tester switches are off. To zero a meter, turn the adjustment button on the face of the meter.

INDEX

PAGE NO.

Engine Tune-Up Test Report

ORDER NO.________

CUSTOMER NAME____________________ DATE________

ADDRESS____________________ PHONE________

MAKE________ MODEL________ MILEAGE________ LICENSE NO.________

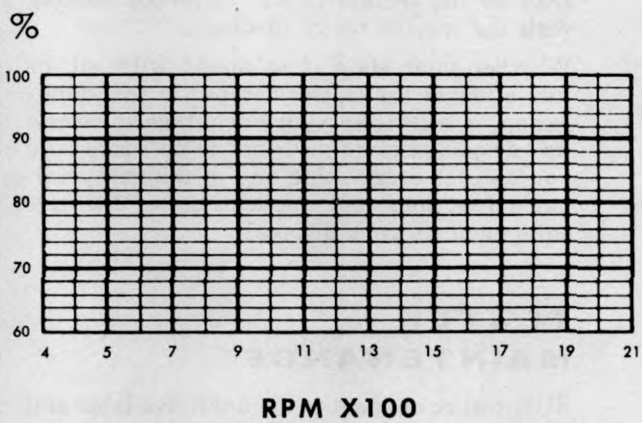
CUSTOMER COMMENTS:____________________

TESTS	SPECS.	RESULTS
Cylinder Leakage	20% or Less	
Spark Plug Inspection		
Cranking Voltage		
Cranking Vacuum		
Distributor Resistance	Black Bar	
Coil-Output-Cranking	+ 20KV	
Dwell		
Dwell Variation		
Initial Timing		
Timing Advance		
Coil Polarity		
Plug Firing Voltage		
Available Voltage		
Secondary Insulation		
Secondary Resistance		
Spark Plugs Under Load		
Point Action		
Coil and Condenser		
Fuel Pump-Pressure		
Volume		
Carburetor Tests		
Idle		
Intake Manifold		
Intermediate		
High		
Accelerating		
Air Cleaner		
Charging Voltage		
Final Idle Adjustment		
STARTING SYSTEM		
Battery Capacity		
Cables & Switches		
Starter Amp. Draw		
CHARGING SYSTEM		
Circuit Resistance		
Generator Output		
Cut-Out Relay		
Voltage Regulator		
Current Regulator		

RECOMMENDATIONS

1.____ 2.____ 3.____ 4.____

5.____ 6.____ 7.____ 8.____



CONDENSED TEST PROCEDURE

The Condensed Test Procedure outlined in this section of the Handbook is designed primarily for the operator who has already acquired some degree of skill in using the individual test instruments at his disposal and interpreting the test results obtained. Note that each step in the Condensed Test Procedure is "keyed", indicating which test instrument is being utilized to perform each test. (If your tester is equipped with the Sun Scope, omit steps 8 and 9. However, if your tester is equipped with a Volts Ignition Tester, omit steps 10 through 17.)

A Condensed Test Procedure is quite valuable for a number of reasons. For the purpose of determining exactly what specific services will be required, prior to writing a work order, it may be used to quickly determine the condition of the five important power plant areas. The Condensed Test Procedure may also be used in conjunction with the actual tune-up operation. In this manner, the test instruments are used to assist in making the various tune-up adjustments and calibrations. In addition, the Condensed Test Procedure, as a whole or in part, may perform a quality control function: the tests being performed prior to vehicle delivery to make sure that all necessary work had been completed, and that the powerplant is now operating at top efficiency.

It is suggested that all the pertinent specifications and data applicable to the vehicle being tested be first recorded on a Test Report Form, such as the one illustrated on the adjoining page. In this manner, the operator is assured of having all the necessary information readily available for reference during the test sequence. In reviewing the Condensed Test Procedure and the arrangement of the Test Report Form, it is readily apparent that both follow a similar, step-by-step arrangement. The Test Report Form serves an important function in the service operation if the results of each test are recorded on it. The completed report can then be used later as a guide in writing the shop work order, or as a factual reference in discussing service requirements with the vehicle owner.

As you will note, the Cylinder Leakage Test and Spark Plug Visual Inspection are listed as preliminary steps to the Condensed Test Procedure. The final results of any tune-up work performed depend to such a great extent on the condition of the engine itself that it is highly recommended that a Cylinder Leakage Test become a step in every major tune-up or engine service operation. Naturally, when service work is being confined to just one or two areas or systems of a vehicle, only the applicable portions of the Condensed Procedure need be used.

1. Cylinder Leakage Test . . . (Cylinder Leakage Tester)

a. Remove Spark Plugs.

b. Remove air cleaner, crank case filler cap and radiator cap. Set throttle valve to wide open position and fill radiator to prescribed level.

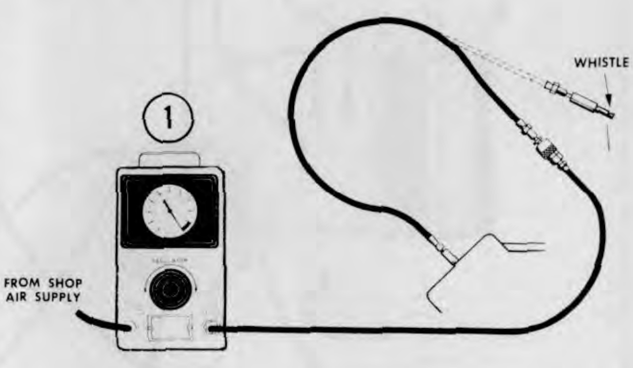
c. Connect shop air line to tester and calibrate tester.

d. Install adapter in No. 1 spark plug hole and attach whistle.

e. Use whistle to locate TDC of No. 1 cylinder.

f. Install TDC indicator and connect indicator light to distributor.

g. Connect tester hose and note percentage of leakage. Listen for sound of leakage at carburetor, oil filler, tail pipe and check for bubbles at the radiator.



h. Disconnect tester hose, rotate engine to next marker on TDC indicator.

i. Install adapter in next cylinder in engine's firing order and repeat test.

j. Repeat test on all cylinders, following sequence of engine's firing order.

2. Spark Plug Visual Inspection

Inspect spark plugs for the following:

a. Physical condition... cracks, chips, blow-by marks indicating leakage, oxidation and erosion of electrodes.

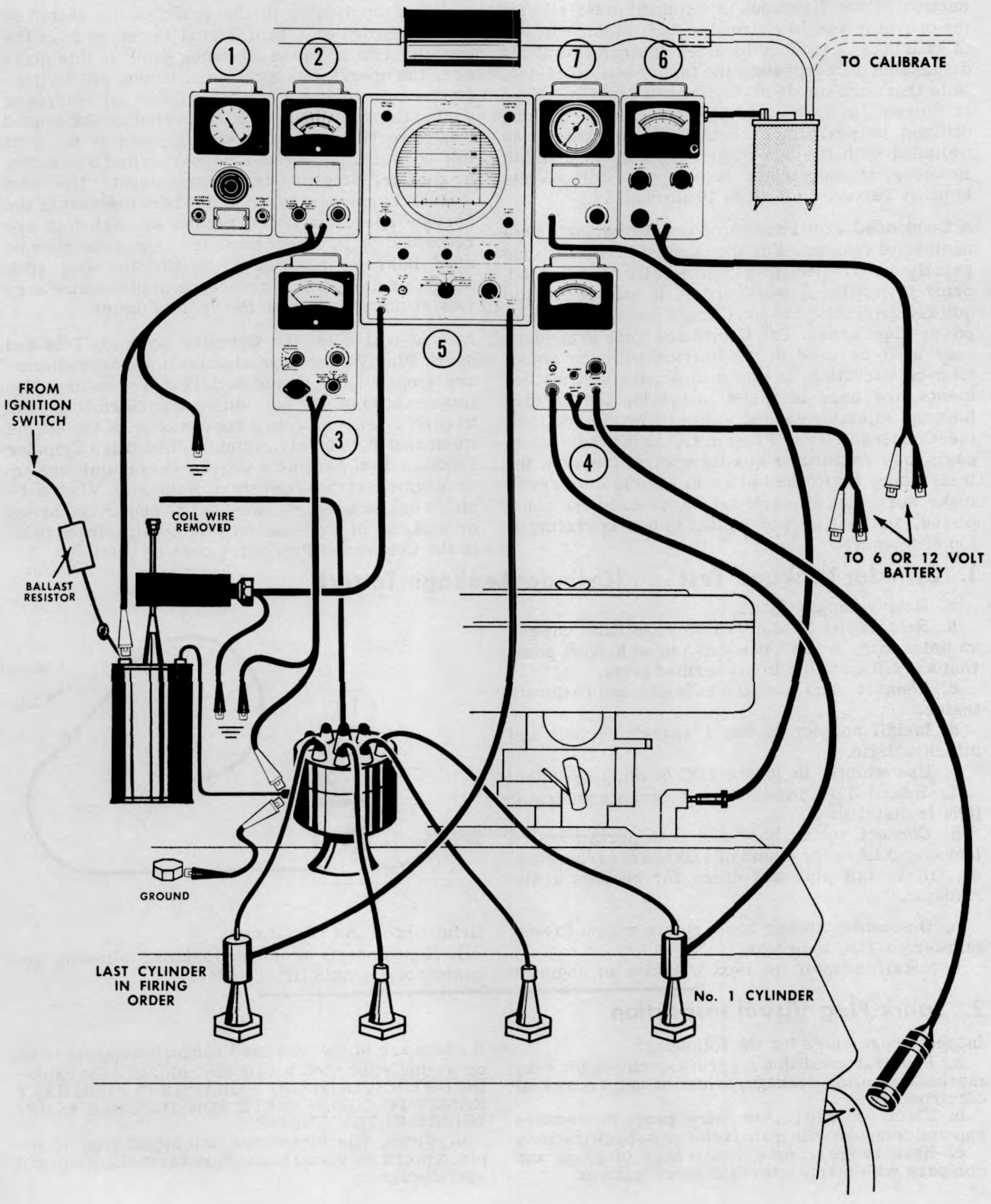
b. Electrode gap... use wire gauge to measure gap and compare with manufacturer's specifications.

c. Heat range... note heat range of plugs and compare with manufacturer's specifications.

If plugs are of the specified range, but appear to be operating either too hot or too cold, find the cause. DO NOT RECOMMEND A CHANGE IN PLUG HEAT RANGE TO COMPENSATE FOR TROUBLE ELSEWHERE IN THE ENGINE!

d. Clean, file electrodes and adjust gap; or replace plugs as visual inspection warrants. Reinstall spark plugs.

Connections to Vehicle



A. Tach-Dwell Tester:...Set switches to CALIBRATE and DWELL positions and adjust the dwell calibrator until the meter reads to SET LINE. Connect leads to primary terminal of distributor and to ground, observing proper polarity.

B. Vacuum Gauge:...Connect hose to intake manifold.

C. Electronic Distributor Tester: . . . Connect battery leads to car battery, observing proper polarity. Connect pickup to No. 1 spark plug.

D. Jumper Lead:...Connect to distributor primary lead and to ground.

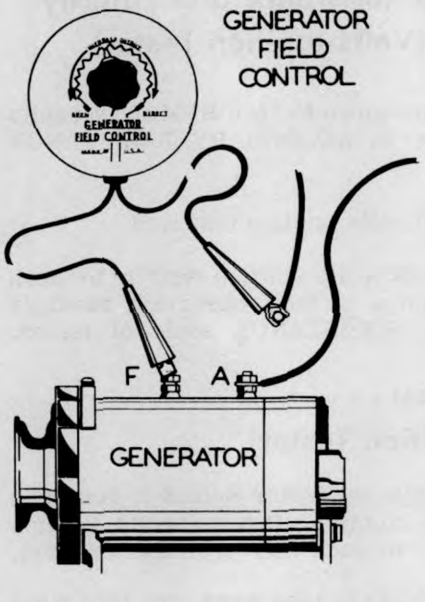
E. Volts-Ignition Tester:...Set switch to voltage position which corresponds to vehicle voltage. Observing proper polarity, connect leads to battery side of coil and to ground.

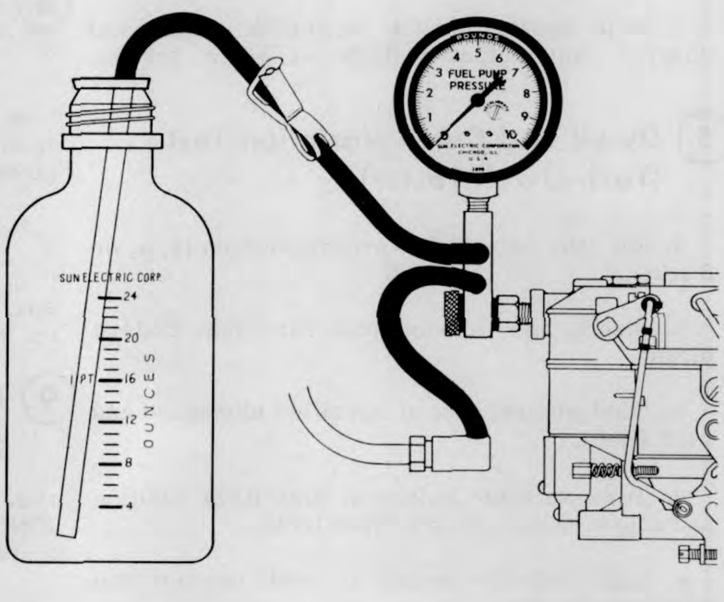
F. Combustion Efficiency Tester:...Observing polarity, connect battery leads to car battery. Connect one end of neoprene hose to exhaust condenser, and the other end to the fitting on the combustion tester.

G. Sun Scope:...Plug power cord into proper outlet. Connect scope's trigger pickup into circuit of last spark plug in engine's firing order. Remove high tension wire from coil and leave disconnected. Insert pattern pickup into coil tower and attach ground clip to ground. Set polarity switch to POSITIVE position, turn display selector to SCOPE CHECK position and adjust scope until trace appears on "Zero" line.

H. Generator Field Control:...Disconnect generator field wire at either end and attach GFC leads; one to end of field wire, the other to terminal. Set GFC to OPEN position.

I. Fuel Pump Tester:...Disconnect main fuel line at carburetor and mount Fuel Pump Tester to carburetor fuel fitting. Connect vehicle's fuel line to fitting on Fuel Pump Tester hose.





(1.) Cranking Voltage . . . (Volts-Ignition Tester)

a. Turn ignition switch ON. (For safety, set parking brake and shift transmission to neutral.)

b. Crank engine, observe cranking speed and note reading on Voltmeter.

(2.) Cranking Vacuum Test . . . (Vacuum Pressure Tester)

a. Back out throttle stop screw and release automatic choke so that throttle valves can seat tightly.

b. Crank engine, noting Vacuum Gauge readings.

(3.) Distributor Resistance Test . . . (Tach-Dwell Tester)

a. Remove jumper lead from distributor.

b. With ignition switch on, Dwellmeter should read in black bar at right end of scale.

(4.) Coil Output Voltage at Cranking Speed . . . (Sun Scope)

a. With ignition switch on, crank engine and observe coil output voltage on Scope screen.

(5.) Dwell and Dwell Variation Test . . . (Tach-Dwell Tester)

a. Set lobe selector to proper position (4, 6, or 8 lobe).

b. Insert high tension coil wire into pattern pickup.

c. Start engine, run at specified idle speed and read Dwell.

d. Turn selector switch to High RPM position and adjust engine speed to 1500 RPM.

e. Turn selector switch to dwell position and read Dwellmeter.

f. Observe dwell reading as engine speed is reduced to idle, noting any difference in dwell readings at 1500 RPM and at idle.

(6.) Initial Ignition Timing . . . (Electronic Distributor Tester)

a. Turn Tach-Dwell selector switch to LOW RPM position.

b. Turn Electronic Distributor Tester ON and set advance control to TIMING position.

c. Operate engine at specified timing speed, and note timing. Adjust if necessary.

(7.) Ignition Timing Advance Test . . . (Electronic Distributor Tester)

a. Turn Tach-Dwell switch to HIGH RPM position.

b. Adjust engine speed to 2500 RPM and adjust advance control until timing mark appears in its original position. Read degrees of advance on tester meter.

c. Turn Electronic Distributor Tester OFF.

NOTE For ignition tests with the Sun Scope, follow steps 10 through 17.

(8.) Secondary Resistance and Polarity Tests . . . (Volts-Ignition Tester)

a. Adjust engine speed to 1500 RPM and set volts ignition selector to SECONDARY RESISTANCE position.

b. Ground RED volts ignition test lead.

c. Touch BLACK volts ignition testclip to each spark plug terminal in turn, observing readings on SECONDARY RESISTANCE scale of tester.

(9.) Ignition Test . . . (Volts-Ignition Tester)

a. Set Volts Ignition Tester selector switch to IGNITION TEST position. Connect volts ignition tests leads, one to each coil primary terminal.

b. Set engine speed to 1500 RPM. (To 1000 RPM for Ford V8, Lincoln and Mercury.)

c. Adjust Ignition Test calibrator to proper SET LINE.

(9.) Ignition Test . . . (Volts-Ignition Tester) (Continued)

d. Using insulated pliers, lift off any one spark plug wire and note reading on IGNITION TEST scale of meter. Reconnect wire.

NOTE To check insulation of all wires and all portions of distributor cap for cracks and carbon tracks, repeat step d at each spark plug.

IF TESTER IS NOT EQUIPPED WITH THE SUN SCOPE, PROCEED WITH STEP 18

(10) Coil Polarity Test . . . (Sun Scope)

a. Adjust engine speed to 1200 RPM.

b. Turn Scope Display Selector to ALL CYLINDERS position, and adjust Pattern Length control until all cylinders appear between the vertical lines on both sides of the screen.

c. Rotate Pattern Shift control counterclockwise until last pattern on screen appears complete.

d. Observe patterns, noting whether they are upright or inverted.

(11) Required (Firing) Voltage Test . . . (Sun Scope)

a. Observe height of each firing line and compare firing lines for uniformity of height.

(12) Available Voltage Test . . . (Sun Scope)

a. Use insulated pliers to disconnect a wire from a spark plug and hold the spark plug wire away from any ground.

b. Observe Scope pattern, noting upward extent of pattern which represents available voltage in kilovolts.

(13) Secondary Insulation Test . . . (Sun Scope)

a. Observe downward extent of pattern of cylinder with spark plug wire removed.

b. Reconnect wire to spark plug.

c. Test secondary circuits to other cylinders in the same manner. (Trigger cylinder may be tested in "SCOPE CHECK" position.)

(14) Secondary Resistance Test . . . (Sun Scope)

a. With Display Selector in ALL CYLINDERS position, observe and compare spark line of patterns for height, length, angle and oscillations. (For closer examination, the pattern for any given cylinder may be expanded, viewed individually, or compared with that of another cylinder.)

(15) Spark Plugs Under Load . . . (Sun Scope)

a. With Display Selector set in ALL CYLINDERS position, rotate Pattern Shift control FULL CLOCKWISE.

b. Momentarily accelerate engine to approximately 2000 RPM, then allow engine speed to return to 1200 RPM.

c. Observe rise of firing lines during momentary engine acceleration.

(16) Point Condition and Action . . . (Sun Scope)

a. Turn Display Selector to the INDIVIDUAL CYLINDER position.

b. Observe point CLOSE and point OPEN signal.

(17) Coil and Condenser . . . (Sun Scope)

a. Observe and note the number of oscillations in the intermediate section of the Scope patterns.

b. Reduce engine speed to idle.

(18) Fuel Pump Pressure and Volume Test . . . (Fuel Pump Tester)

a. Adjust engine speed to approximately 500 RPM unless otherwise specified.

b. Observe pressure gauge and note fuel pump pressure.

c. Insert Volume Test hose into graduated contained and open clamp.

d. Observe time required for pump to deliver one pint of fuel.

(19) Idle Mixture Test . . . (Combustion Efficiency Tester)

a. Set Combustion Tester switch to BATTERY position and adjust BATTERY CALIBRATOR until meter reads on its SET LINE.

b. Set Combustion Tester switch to COMBUSTION position and adjust COMBUSTION CALIBRATOR until meter again reads on SET LINE.

c. Insert metal pickup hose in tail pipe of vehicle.

d. Adjust engine speed to specified idle RPM.

e. Observe idle RPM, combustion efficiency, and vacuum readings.

(20) Manifold Leak Test . . . (Combustion Efficiency Tester)

a. With engine operating at idle speed, use a squirt can to apply a mixture of engine oil and kerosene to the carburetor flange gasket and intake manifold gaskets.

b. Observe Combustion Tester meter for any unusual deflections towards the rich side.

(21) Carburetor Mixture Curve . . . (Combustion Efficiency Tester)

a. Accelerate engine slowly, pausing at intervals of approximately 200 RPM long enough to permit the Combustion Efficiency Meter to stabilize.

b. Observe and note combustion efficiency reading at each step in test sequence.

(22) Accelerator Pump Test . . . (Combustion Efficiency Tester)

a. Set engine speed to 1000 RPM and allow combustion reading to stabilize.

b. Accelerate quickly to approximately half throttle and immediately drop speed back to 1000 RPM.

c. Observe combustion meter for the amount of temporary enrichment.

(23) Air Cleaner Test . . . (Combustion Efficiency Tester)

a. With engine operating at 2000 RPM, observe combustion meter reading with air cleaner in place on carburetor, and observe combustion meter reading with air cleaner removed from carburetor.

b. Compare meter readings observed.

(24) Charging Voltage Test . . . (Volts-Ignition Tester)

a. Set Generator Field Control to DIRECT position.

b. Reconnect Volts Ignition test leads to insulated battery post and to ground, observing polarity.

c. Set Tester selector switch to VOLTAGE position which corresponds to vehicle voltage.

d. Set engine speed to 1500 RPM.

e. Wait until voltmeter pointer stops rising, then read charging voltage.

(25) Final Idle Adjustment

a. Reduce engine speed to idle.

b. Observe idle RPM, combustion efficiency, and vacuum readings.

c. Adjust Vacuum Dampener until gauge responds freely, but does not flutter excessively.

d. Adjust carburetor idle mixture for highest, steadiest vacuum. Idle should be smooth with mixture and speed within specifications.

NOTE Upon completion of the test sequence, disconnect test leads and hoses. Make sure all electrical, fuel and vacuum connections on vehicle are secure.

THE CYLINDER LEAKAGE TESTER

In the modern automotive engine, improved designs and higher compression ratios are providing greater power, performance and economy; but the valves, rings, and cylinder heads are being subjected to greater combustion pressures than ever before. These advances in engine design have increased the need for better and more accurate means of testing cylinder leakage.

The Cylinder Leakage Tester will point out exhaust and intake valve leaks, leaks between cylinders or into the water jacket, or any other causes of compression loss. This tester applies air to the cylinder at controlled volume and pressure and measures the percentage of cylinder leakage. Even the smallest cylinder leak can easily be detected.

Satisfactory Engine performance depends first of all upon a mechanically sound engine. In many cases, unsatisfactory performance and rough idle is caused by combustion chamber leakage. Experience and research have established that a compression test alone may not show up this fault.

It is normal for a small amount of air to escape past the rings into the crankcase. However, any leak through an intake valve, an exhaust valve, head gasket, head, block, or excessive leakage past the rings indicates trouble which must be corrected before satisfactory engine performance can be expected.

PREPARATION OF ENGINE

1. Run engine until normal operating temperature is reached.

2. Stop engine, loosen all spark plugs approximately one turn to break free any accumulated carbon adjacent to the spark plugs.

3. Start engine and accelerate to approximately 1000 RPM, to blow out the loosened carbon.

4. Stop engine and remove any foreign matter from around the spark plugs with compressed air.

5. Remove all spark plugs and gaskets or tubes, if used.

6. Remove air cleaner and set carburetor throttle valve to wide open position.

7. Remove crankcase filler cap.

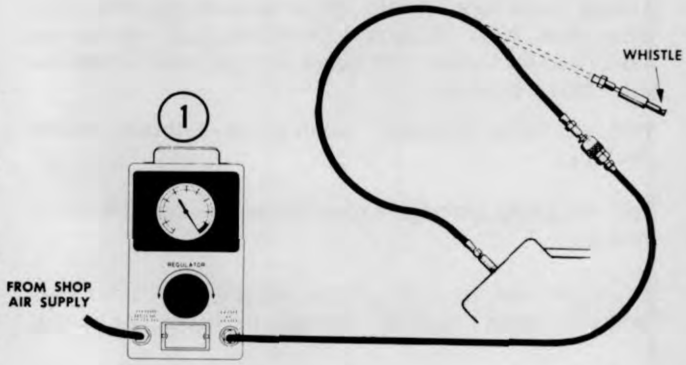
8. Remove radiator filler cap. If coolant level is low, fill to prescribed level.

TESTER CALIBRATION

1. Turn pressure regulator knob counter-clockwise until it turns freely.

2. Connect shop air supply to tester "air inlet" fitting. (minimum 70, maximum 200 PSI.)

3. Turn pressure regulator knob clockwise until guage reads ZERO. Momentarily connect then disconnect test adapter. (The pointer on the gauge should return to ZERO. If not, readjust pressure regulator and recheck adjustment.)



PROCEDURE

1. Select the proper adapter and install in the spark plug hole of number one cylinder. Attach whistle to adapter in the cylinder.

2. Rotate engine until whistle sounds. Continue to rotate engine slowly until engine timing mark (TDC) aligns with engine timing pointer. Remove whistle from the adapter.

3. Remove distributor cap from distributor and connect coil secondary lead to ground.

4. Mount "TDC" indicator on distributor shaft or rotor and chalk mark a suitable reference point on an adjacent surface of the engine which aligns with an applicable mark on the "TDC" indicator.

5. Connect the "Indicator Light"; one lead to the distributor primary terminal, other lead to ground. Turn vehicles ignition switch "ON".

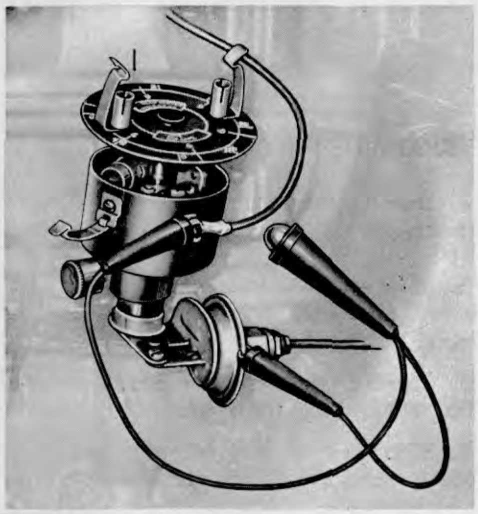
6. Connect tester hose to adapter and note the percentage of leakage on the tester gauge. Listen for escaping air through the carburetor, the exhaust or tail pipe, and the crankcase filler pipe. Check for air bubbles in the radiator.

7. Disconnect tester hose from adapter and rotate engine until the next applicable mark on the "TDC" indicator is aligned with the chalk mark on the engine. NOTE: Indicator light will glow when piston is in firing position.

8. Remove the adapter from the cylinder previously tested and install it in the next cylinder in the engine's firing order. (Piston in this cylinder is now at top dead center.)

9. Repeat steps 6, 7, and 8 until all cylinders have been tested.

Typical applications of the TOP DEAD CENTER INDICATOR



Results and Indications

Gauge readings should be comparatively even and less than 20%. It should be noted that on certain makes and models, readings as high as 20% indicate excessive leakage.

Air escaping through carburetor---intake valve leaking.

Air escaping through exhaust pipe---exhaust valve leaking.

High percent of leakage on adjacent cylinders---leaking head gasket, crack in block or head.

Air escaping through radiator---leaking head gasket, crack in block or head.

High percent of leakage in crank case---worn rings or cylinder walls, stuck or broken rings, cracked piston.

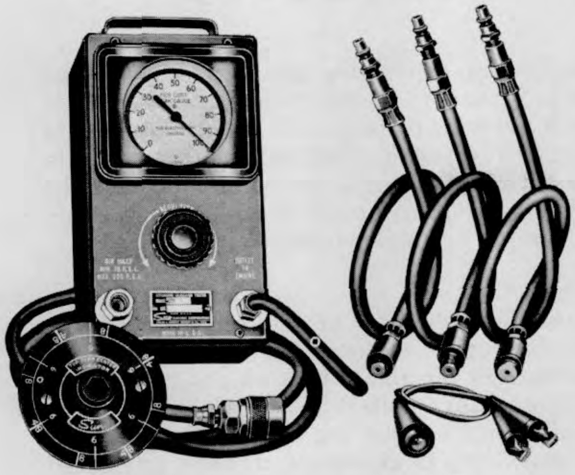
NOTE Analysis of ring and cylinder wall condition should be made with consideration to case history and mileage of the engine.

Occasionally, in cases where high percentage of leakage is noted on engines with comparatively low mileage which could be attributed to stuck piston rings, it is adviseable to treat the engine with a good grade of tune-up or break-in oil for a period of time and then retest, before recommending that the engine be disassembled for major service.

For testing Cylinder Leakage of diesel engines, a kit of Diesel Adapters is available from Sun Electric Corporation.

model CLT-228

A new concept in Engine Testing. This unique tester pin points the location and extent of compression leaks before engine disassembly. Valves tested for leakage. Piston rings checked for wear and blow-by. No Guess-work. Pin points accurately, burnt valves, worn and broken rings, and scored or tapered cylinders. Tests all internal combustion engines —gasoline, propane, and diesel; either 2 or 4 cycle.



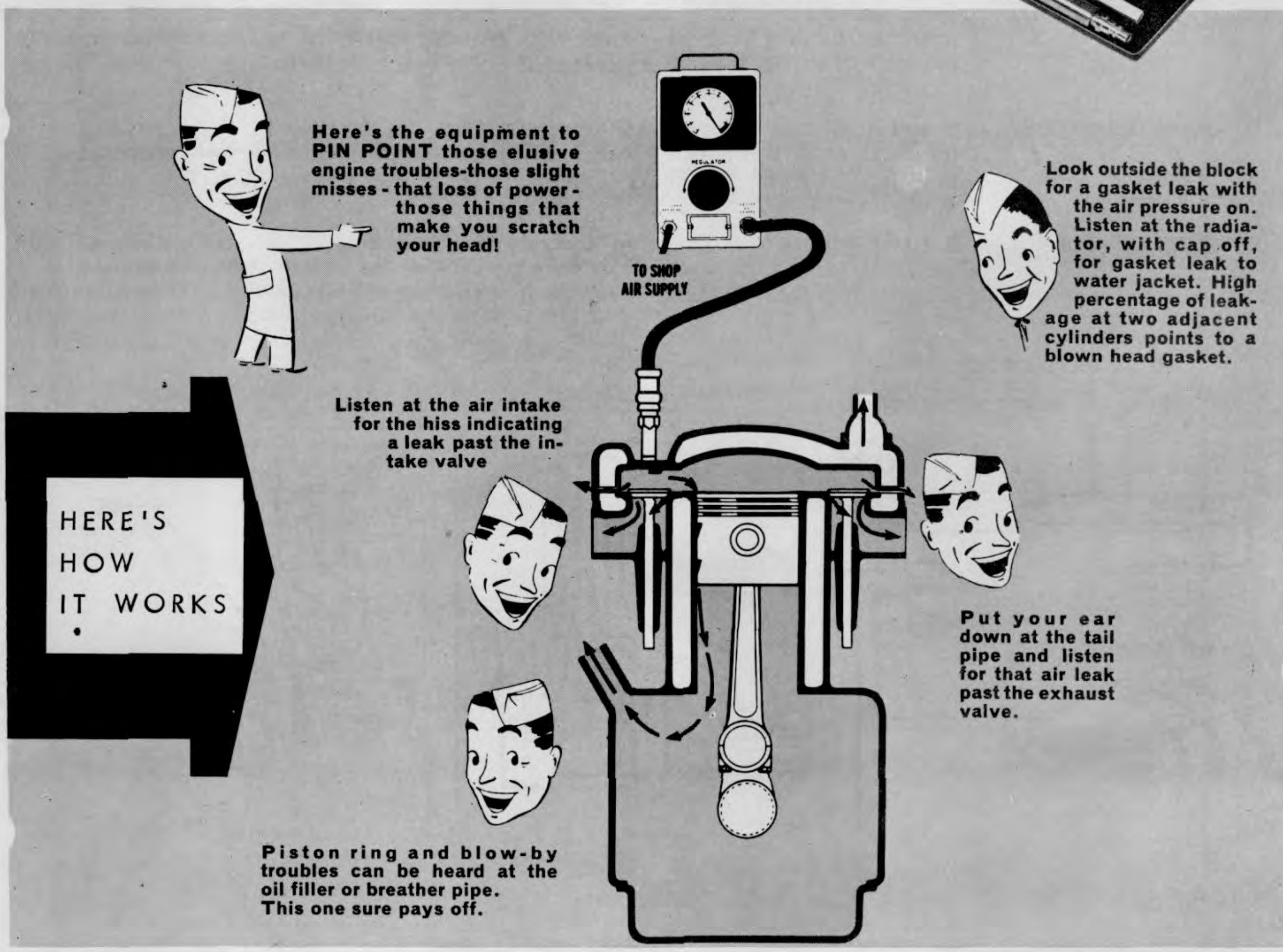
CYLINDER LEAKAGE TESTER

FEATURES:

Four inch gauge, graduated from 0 to 100% leakage • Operates from shop air supply • Built-in pressure regulator for stabilized test conditions • Simple time-saving procedure.

UNIVERSAL DIESEL ADAPTER KIT
Model DAK

For getting the true facts concerning the cylinder, piston ring and valve condition of diesel engines this set of universal adapters may be used with any Sun Cylinder Leakage Tester. Adapters included are compatible to practically all motive type diesel engines. All fittings and adapters are conveniently contained in a sturdy, formed steel case, (Model DAK is not included with CLT-228 above.)



IGNITION PRIMARY CIRCUITS

In the majority of 12 Volt ignition systems, a ballast resistor has been added to the Primary Circuit. On some vehicles the resistor is in the form of a separate component connected in the primary circuit, while on other vehicles a specific ohmic value is built in the lead wire itself. The purpose of a resistance unit is two-fold. First, it limits to a safe maximum the primary current flow through the coil and the distributor contact points, thereby protecting the contact points during slow speed operation when they are closed for a longer period of time. Secondly, the resistor protects against excessive build-up of the primary current when the ignition switch is closed with the engine stopped and the contact points closed.

On certain systems, this resistor is removed from the circuit during cranking and the ignition coil is connected directly to the battery, thus maintaining the ignition voltage as high as possible during cranking. When conducting the Cranking Voltage Test, it is necessary to attach the voltmeter leads to the coil primary terminals to obtain the correct readings. The following diagrams, which illustrate two types of by-pass circuitry in common use, will aid in determining the proper method of voltmeter connections for cranking voltage tests.

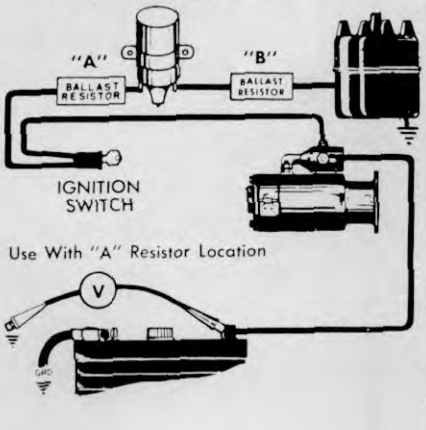
With a ballast resistor in the primary circuit between the switch and the coil, a voltmeter reading from the battery terminal of the coil to ground will be less than battery voltage. The drop in voltage is dependent upon the make and model of vehicle, but if the voltage drop is excessive, it can be attributed to either a defective ignition switch or resistor unit. A faulty ignition switch will give erratic voltmeter readings as the switch is repeatedly turned on and off. The condition of a ballast resistor can be determined by using a SUN ohmmeter.

NO BY-PASS CIRCUIT — With ballast resistor located at "A", the voltmeter is connected from the insulated battery post to ground. With resistor located at "B", the voltmeter is connected from the battery terminal of the coil to ground.

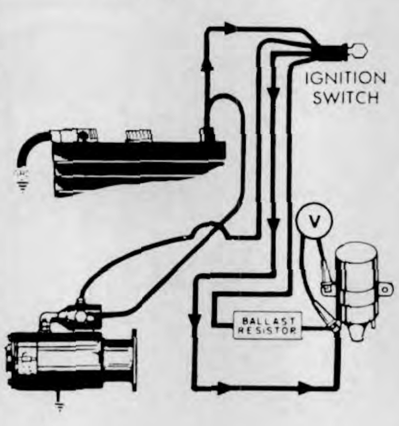
BY-PASS IN SWITCH — Battery voltage is conducted directly from the ignition switch to the coil terminal using a separate lead, thus by-passing the resistor. The voltmeter is connected from the battery terminal of the coil to ground.

BY-PASS IN SOLENOID — Battery voltage is conducted directly from the solenoid switch to the coil terminal using a separate lead, thus by-passing the resistor. The voltmeter is connected from the battery terminal of the coil to ground.

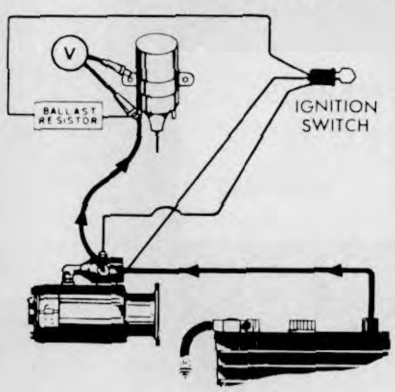
NO BY-PASS CIRCUIT
"A" or "B" RESISTOR LOCATION



BY-PASS IN SWITCH



BY-PASS IN SOLENOID



VOLTS-IGNITION TESTER

The Volts-Ignition Tester combines the versatility of a dual range voltmeter with unique facilities for making two over-all ignition system efficiency tests. The tests listed in the following pages outline but a few of the many applications for this fine test instrument. As indicated, when performing ignition tests, an accurate means of measuring engine speed is required. In addition, the generator is prevented from working, to provide a stable voltage input for the ignition system and assure accurate test results.

Cranking Voltage Test

This test quickly determines whether or not sufficient voltage is being delivered to the ignition system while the engine is cranking. A normal reading confirms that the general condition of battery, cables, starting system and circuit to the ignition system is satisfactory. An unsatisfactory reading indicates that further testing is required in this area.

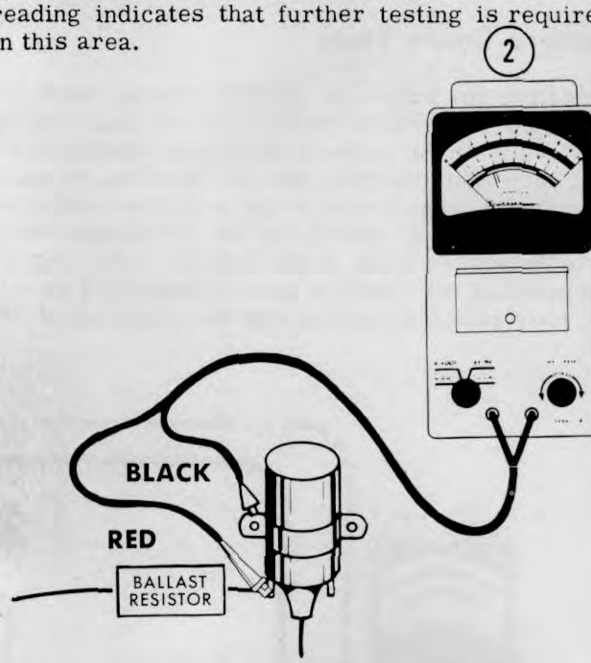
1. Connect tester leads in accordance with type of primary circuit used on vehicle. Observe proper polarity. (Refer to facing page for details on variations in primary circuits.)

2. Turn tester switch to either 8 or the 16 volt position, depending upon vehicle voltage.

3. Connect the jumper lead from the distributor primary terminal to ground.

4. With vehicles ignition switch "ON", crank engine.

5. Observe cranking voltage, cranking speed and evenness of cranking.



CRANKING VOLTAGE TEST

Results and Indications

Meter reads specified voltage or more, cranking speed normal and even---battery, starter, cables, switch and ignition circuit to coil operating satisfactorily.

Meter reads less than specified voltage---weak battery, defective cables, connections, switch or starter; defective bypass circuit or ignition circuit to coil.

Cranking speed below normal---excessive resistance in cables, or starting motor, excessive mechanical drag in engine.

Uneven cranking speed---uneven compression, defective starter or starter drive.

Charging Voltage Test.

The charging voltage test provides a good over-all indication of the voltage available to the vehicle's entire electrical system. The voltage applied to the ignition system is an important factor to be considered in cases of distributor point burning, and when abnormal operating life of other electrical components is encountered.

In cases where abnormal charging voltage readings are encountered, it is suggested that each component in the charging system be tested utilizing the facilities of a Volts-Ampere Tester to determine exactly where the malfunction lies within the charging system.

1. Set tester switch to 8 or 16 volt position depending on vehicle voltage.

2. Observing polarity, connect the tester leads to the insulated post of the battery and to ground, or to the battery post of the regulator unit and to ground, depending on which is more accessible.

3. With a Tachometer connected, operate engine at a speed of 1500 to 2000 RPM.

4. Note Volt Meter reading after meter pointer stops climbing.

Results and Indications

Charging voltage within specified charging voltage range for a vehicle being tested---charging system and voltage regulator operating satisfactorily.

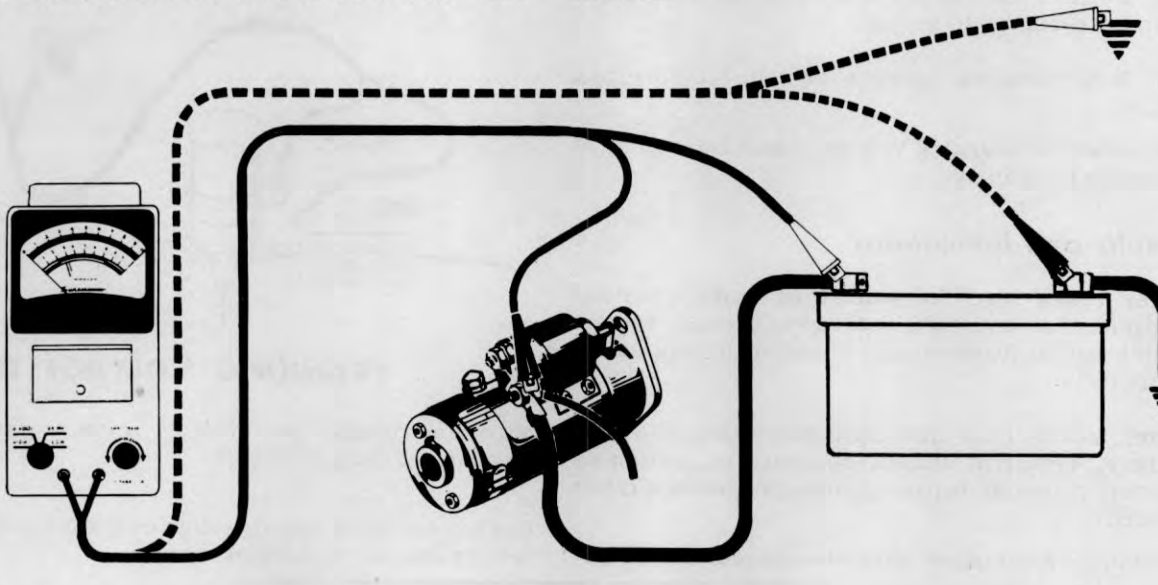
Charging voltage below specified voltage range---defective generator or generator drive, defective or misadjusted voltage regulator, high resistance in circuits.

Charging voltage above specified voltage range---defective or misadjusted voltage regulator, high resistance in regulator ground circuit, defective field circuit.

Battery Cable Tests

Defective or undersize battery cables, loose or corroded connections or excessively long cables can easily be the cause of inefficient starting system operation, charging system operation, or malfunction in many parts of the vehicle's electrical system. Defective cables and/or connections result in excessive voltage loss (voltage drop) during operation of the cranking motor. The battery should be fully charged and the starter amperage draw must be within normal limits when conducting battery cable tests. (If any doubt exists concerning the condition of the battery or the starting motor, these components should be tested with a battery starter tester.)

IMPORTANT— Ground ignition primary at distributor with a jumper lead, to prevent engine from starting.



NOTE:
GROUND IGNITION PRIMARY AT DISTRIBUTOR WITH JUMPER LEAD TO PREVENT ENGINE FROM STARTING

INSULATED CABLE TEST

The entire insulated portion of a cranking circuit may be tested in one operation, or each individual portion of the insulated circuit may be tested separately.

1. Set tester switch to the 8 volt position.

2. Connect one voltmeter clip to the center of the insulated battery post, and the other to the input post of the starting motor, observing proper polarity. (Meter will attempt to read battery voltage until starter switch is closed.)

3. Operate starting motor, and observe voltmeter. Generally, on most vehicles voltmeter reading should not exceed 3/10 of a volt. Refer to specifications.

GROUND CABLE TEST

1. Set tester switch to 8 volt position.

2. Connect one voltmeter clip to a ground on engine block, the other to center of the ground post of battery, observing proper polarity.

3. Crank engine while observing voltmeter. Generally on most vehicles voltmeter readings should not exceed 2/10 of a volt.

Results and Indications

Voltmeter readings within specified limits--cables, connections, etc., in normal operating condition.

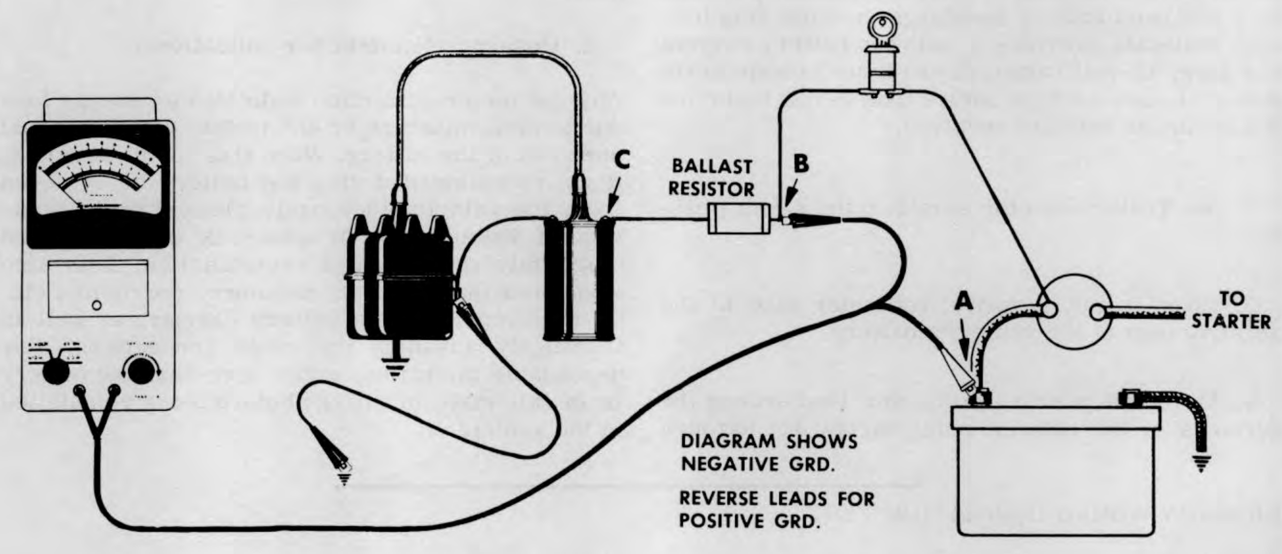
Voltmeter readings exceed specified limits--defective cable, undersized cable, loose or corroded connections, defective switch contacts, possibility of excessive starter draw, etc.

When excessive voltage drop readings are obtained, retest each item and connection within that portion of the circuit to determine exact location of fault. Correct fault by cleaning and tightening connections or replacing cables or components as necessary, then retest.

Ignition Primary Circuit Resistance Test

Excessive voltage loss (voltage drop) in the ignition primary circuit between the vehicles battery and the ignition coil can reduce the secondary output of the ignition coil to the extent that hard starting and poor performance can result.

NOTE On some vehicles, a special type of resistance wire is built into the wiring harness to serve the purpose of a separate ballast resistor unit.



1. Turn voltmeter selector switch to the 8 volt position.

2. Connect voltmeter leads as follows: (observe proper polarity) from "A" to "B" for coils equipped with an external ballast resistor.

From "A" to "C" for coils not equipped with an external ballast resistor.

3. Use jumper lead to ground primary terminal of distributor as shown. (Grounding the distributor primary terminal with the jumper lead makes it unnecessary to spot the engine so that the breaker points are closed and also eliminates the possibility of false test readings due to reduced current caused by defective points, wiring and connections in the distributor.)

4. Be sure all lights and accessories are turned off.

5. Turn ignition switch "ON", and observe voltmeter. Voltmeter should not read more than .5 volts.

6. Test ignition switch by turning it "OFF" and "ON" several times. Voltmeter should read the same each time switch is turned on.

7. Test all wires for tightness. Move them about and note any change in meter reading.

Results and Indications

Voltmeter reading within specified limits---connections, wiring, switch contacts, etc., in satisfactory condition.

Meter readings exceed the specified maximum -- loose or corroded connections, undersized or faulty wiring, damaged or worn ignition switch contacts, etc.

If voltmeter readings exceed the specified maximum, isolate the point of high resistance by placing the test leads across each connection and wire in turn. The reading across a connection should be zero. The reading across any one wire should be proportionate to its length as compared to the length and allowable voltage drop of the entire circuit.

Primary Circuit Insulation Tests

Defective insulation in the primary system, or at the battery, can result in a constant loss of energy from the battery. Trouble of this nature is usually indicated by the battery becoming discharged in damp weather or when the vehicle is not in use for a day or two at a time. Usually leakage of this nature is so gradual that it is impossible to detect on the vehicle's charge indicator.

BATTERY LEAKAGE TEST

Electrolyte, dirt, moisture or foreign material on the surface of the battery cell covers usually results in a continual battery discharge, because this foreign material provides a path for battery current to follow. 12-volt batteries are more susceptible to energy losses of this nature than 6-volt batteries due to higher voltages involved.

1. Set Tester selector switch to the 8-volt position.

2. Connect the negative voltmeter lead to the negative post of the vehicle's battery.

3. Move the positive voltmeter lead around the surfaces of the battery, being careful not to touch the cell connecting straps or the positive battery post.

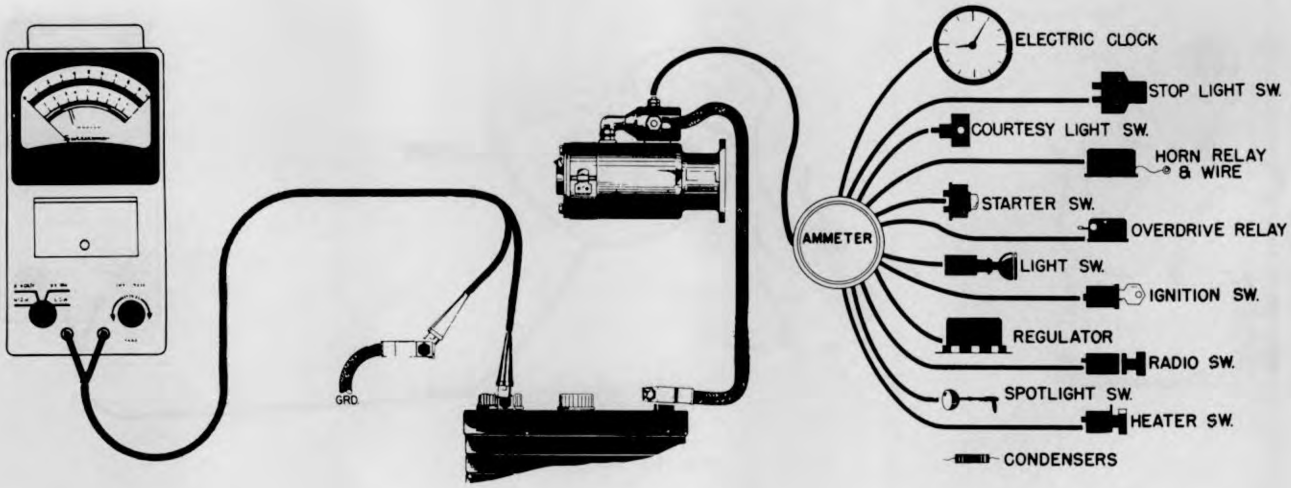
4. Observe voltmeter for indications.

Any voltmeter deflection indicates an energy loss due to dirt, moisture, or electrolyte on the external surfaces of the battery. When this condition exists, it is recommended that the battery be removed from the vehicle, thoroughly cleaned with a solution of baking soda or ammonia and water, and thoroughly dried before reinstallation. It is also suggested that all dirt, moisture, corrosion, etc. be removed from the battery carrier, as well as thoroughly cleaning the cable connections. For dependable operation, make sure that the battery is in full state of charge before being reinstalled in the vehicle.

PRIMARY WIRING INSULATION TEST

This test of primary wiring insulation, using a voltmeter, can detect leakage in the insulation too small to be located with a test ammeter.

PRIMARY WIRING INSULATION TEST



1. Disconnect the ground battery cable from the battery post.

2. Turn off all switches, and close all doors to prevent operation of the courtesy lights from the door switches. Disconnect under-hood light if used.

3. Turn tester selector switch to position corresponding to the system voltage of the vehicle.

4. If vehicle is equipped with an electric clock, touch battery cable to battery post just prior to conducting the test to rewind the clock.

5. Observing polarity, connect voltmeter in the circuit: one lead to battery cable, and one lead to battery post as shown.

6. Note voltmeter. reading.

Results and Indications

Voltmeter reads zero---insulation in vehicle's electrical primary circuits normal, no leakage exists.

Voltmeter reads above zero---insulation leakage exists in one or more of the vehicle's primary electrical circuits.

To locate leakage (a short) in the primary wiring circuits, remove the battery wire from each of the following components in the order in which they are listed. Retest the primary circuit for leaks after disconnecting each item.

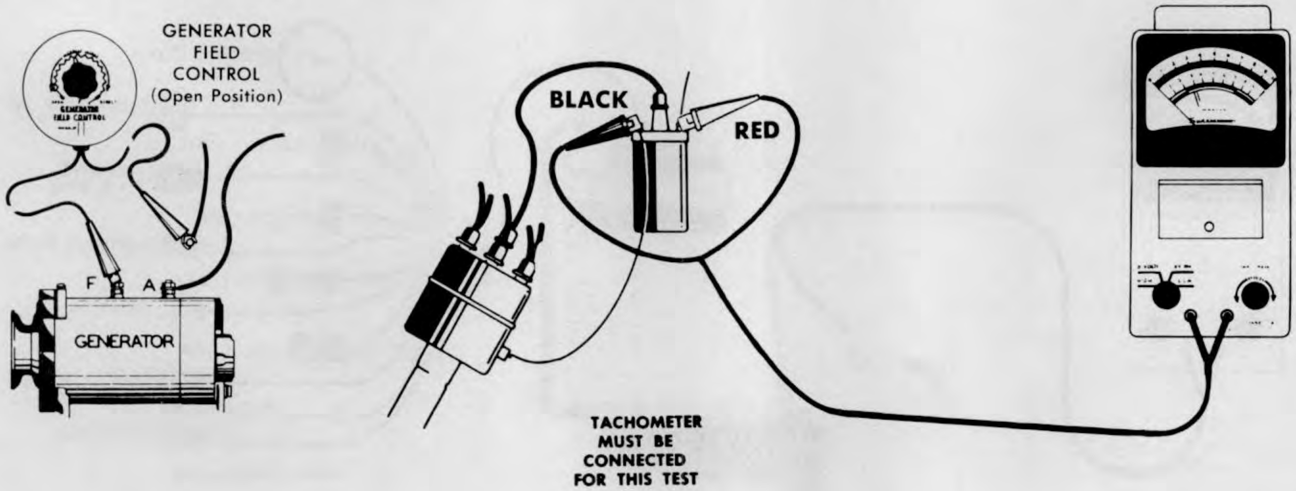
Stop light switch
Courtesy light switches
Horn relay and wire
Starter switch
Overdrive relay
Light switch
Ignition switch
Regulator
Spotlight switch
Heater switch
Condensers

NOTE Condensers may be located on the light switch, the regulator battery terminal, generator armature terminal, etc.

Ignition Test

Efficient, dependable ignition system operation can be expected only when sufficient ignition output is available and the secondary insulation is in satisfactory condition. A defect or malfunction anywhere in the ignition system will result in lower than normal ignition output. Defective, cracked or deteriorated insulation on any component or in any portion of the ignition secondary circuit may permit the high voltage impulses from the coil to leak off to ground and thus result in misfire or an overall reduction in the engine's operating efficiency.

IGNITION OUTPUT & LEAKAGE TEST



1. To prevent vehicle's generator from operating during test, connect Generator Field Control in generator field circuit and set control to "open" position. (Refer to Generator Field Control Section of Handbook.)

2. With tachometer connected, start engine and adjust speed to 1500 RPM.

NOTE For Ford V-8, Lincoln, and Mercury, set engine speed to 1000 RPM. (Refer to Tach-Dwell Section of Handbook.)

3. Set tester switch to Ignition Test position.

4. Connect Tester leads to each primary terminal of the vehicle's ignition coil.

5. Adjust ignition test calibrator until meter reads on proper SET LINE.

6. Using insulated pliers, remove one spark plug wire from its plug, and observe meter reading. For a complete secondary insulation test, note tester reading as each spark plug wire is removed in turn.

Results and Indications

Meter reads in GOOD band when each plug wire is lifted off---both the ignition output and the secondary insulation are satisfactory.

All readings low, or if ignition test calibrator can not be adjusted for set line---high resistance in primary circuit, defective distributor points, defective coil or condenser, coil tower wire, rotor or distributor cap.

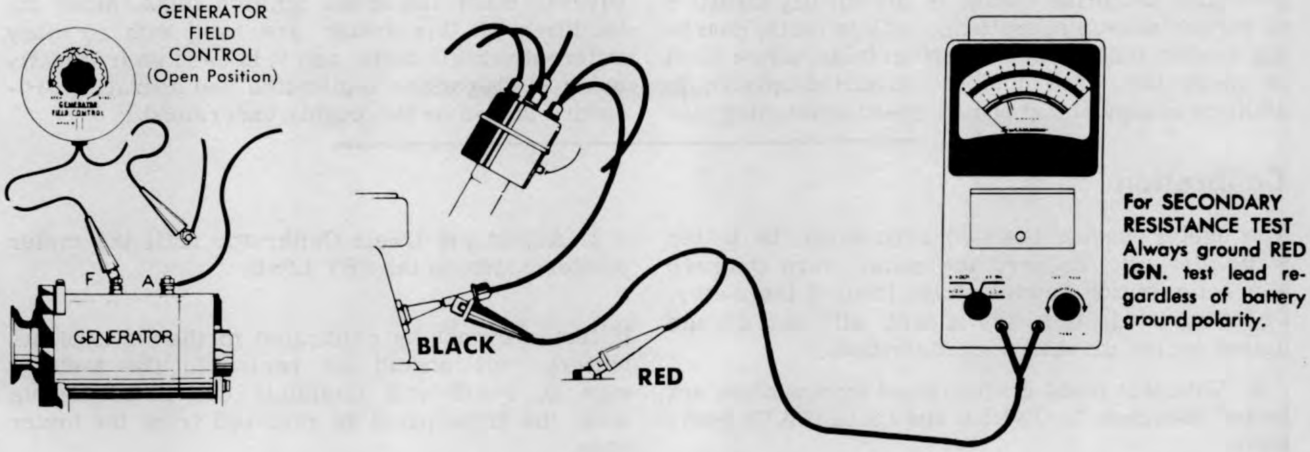
Low readings when only certain plug wires are lifted off---defective insulation on those wires, cracks or carbon tracks in the distributor cap.

NOTE Errors may be introduced if coil is not at operating temperature, improper engine speed or ignition test set line are used, distributor point setting is not within specified limits.

Secondary Resistance and Polarity Test

Excessive secondary circuit resistance uses up energy which is needed to maintain good ignition under all conditions, severely reduces ignition system reserve, and consequently results in poor performance under severe operating conditions. Incorrect secondary system polarity, can result in up to 40% more voltage being required to fire the spark plugs causing misfire and erratic engine operation.

SECONDARY RESISTANCE TEST



1. To prevent generator from operating during test, connect Generator Field Control into field circuit and set knob to open position. (See Generator Field Control Section in Handbook.)

2. With Tachometer connected start engine and adjust speed to 1500 RPM. (See Tach Dwell Tester Section of Handbook.)

3. Set Tester switch to Secondary Resistance position.

4. Connect RED tester lead to engine ground, and contact BLACK test lead to each spark plug terminal in turn. Observe readings on 0-8 secondary resistance scale of meter.

Results and Indications

Readings are average for make and type of circuit being tested---secondary circuit in normal condition.

All readings lower than average for make and type of circuit being tested---corroded coil tower terminal, poorly connected or broken coil wire, center cap electrode burned, burned rotor tip, open secondary in coil.

One or more readings lower than average for make and type of circuit being tested---broken or poorly connected spark plug wires, burned or corroded cap terminals, gouged electrodes inside cap.

Readings higher than average at two or more plugs---crossfire occurring in the distributor cap or between spark plug cables concerned.

Meter reads off scale to left with red test clip grounded---coil secondary polarity reversed; may be due to coil primary wires connected in reverse, wrong coil, or vehicle battery connections reversed.

NOTE On vehicles utilizing suppression type ignition cables, readings can be expected to be somewhat uneven with the lowest readings on the longest cables. Although suppression results in lower test readings, normal suppression does not impair ignition efficiency.

TACH-DWELL TESTER

The Tach-Dwell Tester is a basic test instrument providing facilities useful in practically all types of engine tune-up operations, vehicle tests, charging system tests and fuel system tests, since most of these tests are made at specified speeds. In addition to measuring engine speed, this tester also provides facilities for measuring point-dwell and several other important ignition tests. Since the facilities of this tester are used with so many different vehicle tests, and it is used so frequently in most shops, its application and operating procedure should be thoroughly understood.

Calibration

The meter should read on zero when the tester switch is off. To zero the meter, turn the zero corrector button located on the front of the meter. Once adjusted, this adjustment will not change unless jarred or otherwise disturbed.

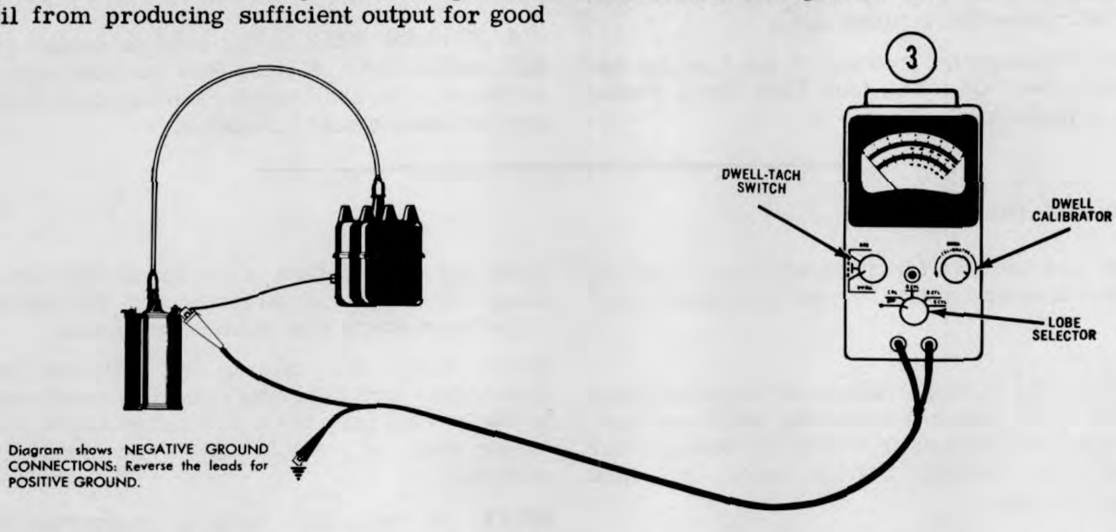
1. With test leads disconnected from vehicle, set tester switches to DWELL and CALIBRATE positions.

2. Adjust the Dwell Calibrator until the meter pointer reads on the SET LINE.

If tester cannot be calibrated to the Set Line, its battery cell should be replaced. The tester's size D, 1-1/2 volt flashlight cell is accessible when the front panel is removed from the tester case.

Distributor Resistance

Excessive resistance in the ignition primary circuit from the distributor side of the coil, through the points, and to the distributor ground, will prevent the coil from producing sufficient output for good over-all ignition. Any resistance in this portion of the ignition system will be indicated on the dwell meter during this test.



1. Observing proper polarity, connect test leads, one to distributor primary lead at coil, and the other lead to ground.

2. Turn vehicle's ignition switch ON.

3. With engine stopped, observe tester meter.

If meter reads zero, crank the engine a fraction of a revolution to close the breaker points.

Results and Indications

Meter pointer reads within range of black bar--- distributor resistance is within normal tolerances.

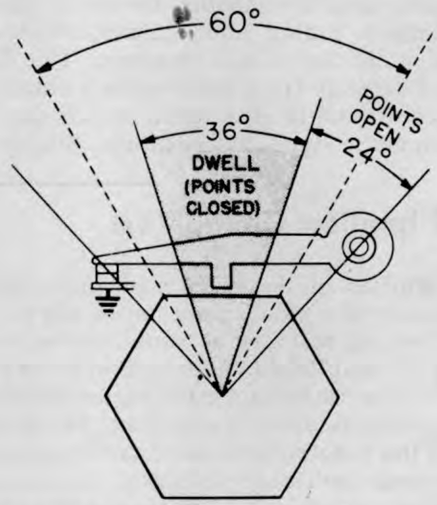
Meter pointer not within black bar . . . high resistance at: internal distributor connections, external distributor connections, contact points, distributor mounting.

To locate excessive resistance, trace the primary circuit by moving tester lead step by step through the distributor toward the ground lead. All excessive resistance must be eliminated before proceeding with Dwell, Dwell Variation and other ignition system tests.

Dwell

Dwell is the period during which the distributor points remain closed for each ignition cycle. The dwell meter electrically measures this period and registers the average for each cylinder in terms of degrees of distributor cam rotation.

The total number of degrees for each ignition cycle is 360 degrees divided by the number of cylinders. The illustration for 6 cylinder engine shows 60 degrees (between dotted lines) for each cylinder, and 36 degrees (the shaded area) as the dwell. A study of this illustration shows that a wider point setting will result in less dwell and a closer point setting will increase the dwell.



1. Calibrate Tach-Dwell Tester and connect to engine as for Distributor Resistance Test.

2. Turn selector switch to the lobe position corresponding to the number of lobes on the vehicle's distributor cam.

3. With engine operating at idle speed, note reading on dwell meter.

Results and Indications

The dwell reading within specified tolerances . . . ignition points are operating normally and are spaced properly.

Dwell reading not within specifications . . . improper point spacing, wrong point assembly, point rubbing block defective, point rubbing block misaligned, distributor cam worn.

Dwell Variation

Dwell variation is determined by noting the dwell change as the engine is operating at different speeds. Excessive variation indicates a change in point opening that can result from shaft or bushing wear, or from the distributor plate shifting because of wear or looseness.

1. Measure distributor dwell at idle speed.
2. Set RPM Switch to 8000 RPM position and increase speed to 1500 RPM.

3. Turn switch to DWELL position and note dwell reading.

4. Slowly reduce speed to idle while observing dwell meter. Dwell reading should not change more than 3 degrees on most vehicles. Refer to vehicle's specifications before condemning distributor.

Results and Indications

Dwell variation within manufacturer's specified tolerances. . . distributor in sound mechanical condition.

Dwell variation exceeds manufacturer's maximum specifications . . . Worn distributor shaft, loose distributor shaft, worn bushings, worn breaker plate.

Measuring Engine Speed

The ignition and combustion efficiency tests, covered elsewhere in this Handbook, call for specific engine speeds in order to obtain correct indications. Therefore, during these tests, the Tach-Dwell Tester must be connected to the vehicle.

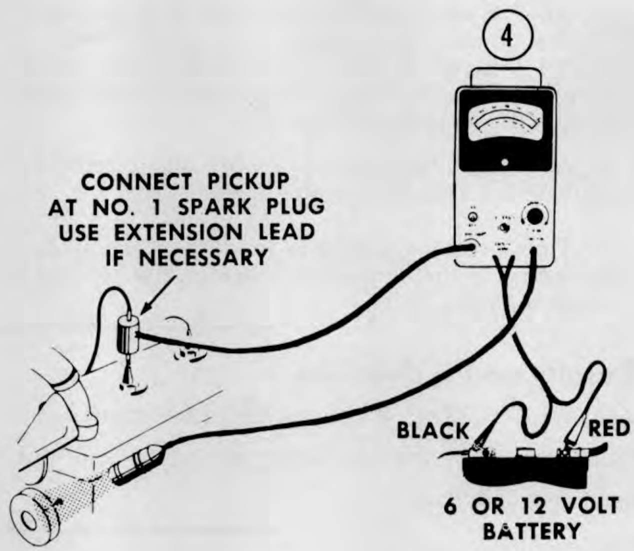
1. Connect Tach-Dwell Tester to vehicle as illustrated.
2. With selector switch in proper lobe position:
   a. Set RPM Switch to 800 RPM position for all idle and low speed testing. Read lower Tach scale.
   b. Set RPM Switch to 8000 RPM position for all testing at speeds above 800 RPM. Read upper Tach scale.
3. Cranking speed may be measured on the 800 RPM scale, providing the ignition switch is "on" and a jumper lead is connected from the coil secondary tower to ground.

ELECTRONIC DISTRIBUTOR TESTER

The Electronic Distributor Tester is designed to test ignition timing and ignition advance on the vehicle with the engine running. The Tester is powered directly from the vehicle's battery, either 6 or 12 volt, and is used to test either conventional or loadomatic type distributors. Should on-the-vehicle tests of the distributor indicate malfunction of either the mechanical or the vacuum advance mechanisms, the distributor should be removed from the vehicle for complete, detailed tests utilizing a Sun Distributor Tester, and then serviced as required before reinstallation.

Initial Ignition Timing Test

Initial ignition timing is the mechanical adjustment establishing the exact point in the engine cycle at which the plug will fire at a specified engine speed. Timing is established and specified by the manufacturer for the exact point in the engine cycle at which the fuel charge should be ignited. The strobe light flash of the Electronic Distributor Tester is simultaneous with the firing of the No. 1 spark plug, and when timing is properly set, the specified mark will appear to be aligned with the pointer when the strobe light flash occurs.



1. Connect Tester's battery leads to the vehicle's battery. (6 or 12 volt)

2. Connect Tester Pickup into circuit of No. 1 spark plug.

3. Connect Tach-Dwell Tester to the engine. (If vehicle is equipped with loadomatic type distributor, connect a manometer into the distributor vacuum line.)

4. Set Toggle Switch to ON position and turn advance control to Timing position.

5. Start engine and adjust speed to RPM specified by manufacturer for initial timing adjustment. (Disconnect distributor vacuum line if specified.)

6. Use light flash to observe the position of the timing mark in relation to the timing pointer. Refer to manufacturer's specifications.

Results and Indications

Timing mark aligns with pointer at specified speed. . . ignition properly timed.

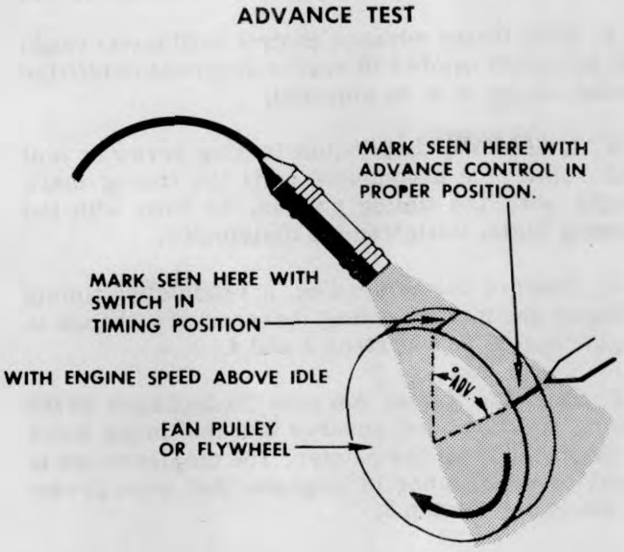
Timing mark not aligned with pointer at idle per manufacturer's specifications. . . ignition not properly timed.

Position of timing mark not steady . . . pitted or misaligned breaker points, incorrect breaker point spring tension, worn or loose breaker plate, or worn distributor shaft or bushings.

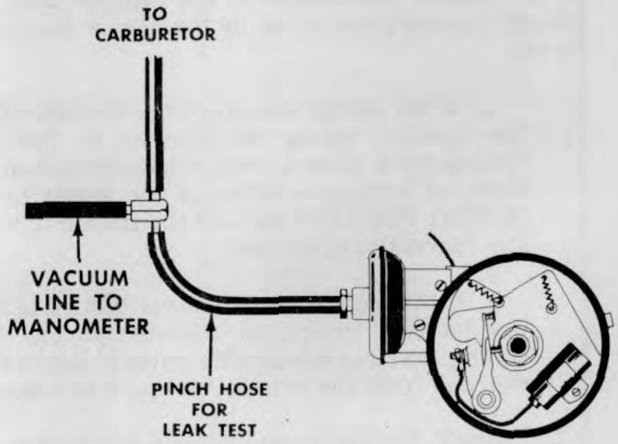
Distributor Advance Test

Correct timing under all speed and load conditions is extremely important to performance and economy. As engine speed is increased, the distributor advance mechanism causes the plug to fire earlier in the engine cycle. As a result, the timing mark moves away from the pointer when viewed with a Timing Light. Through the use of the Electronic Distributor Tester, at a specified test speed, the timing mark can be electronically realigned with the timing pointer. When the timing mark is aligned with the pointer, as shown in the illustration, the meter will indicate the number of degrees the plug is firing ahead of the initial ignition timing.

DISTRIBUTOR ADVANCE TEST



VACUUM LEAK TEST



1. Reconnect distributor vacuum line, if it has been disconnected, for the initial timing test.

2. Adjust engine speed to 2500 RPM, or until manometer indicates first vacuum specification if vehicle is equipped with a loadomatic type distributor.

3. With Strobe Light directed at Timing Pointer, rotate tester advance control clockwise until Timing Mark appears in its original position.

Note degrees advance on tester meter, and compare with manufacturer's specifications.

On conventional type distributors, if total advance is incorrect, disconnect distributor vacuum line and repeat test to determine whether vacuum or centrifugal advance mechanism is at fault.

Results and Indications

Total advance readings within range at specified RPM or specified Vacuum . . . mechanical and vacuum advance mechanisms or loadomatic vacuum advance mechanism operating satisfactorily.

Total advance readings not within range at specified RPM or specified vacuum . . . faulty mechanical or vacuum mechanism, or loadomatic advance mechanism defective.

Distributor Vacuum Leak Test (Applies only to Loadomatic Distributors)

1. With Electronic Distributor Tester, a Tach-Dwell Unit and the Manometer connected as for distributor advance test, adjust engine speed to 1500 RPM.

2. Note exact Manometer reading at 1500 RPM.

3. Pinch the hose closed between the distributor vacuum line and the "T" fitting.

4. Observe Manometer reading and compare with reading obtained in Step 2.

Results and Indications

Manometer readings in step 2 and step 4 above, alike and within normal range for type and make of vehicle being tested . . . carburetor and distributor vacuum system airtight.

Manometer reading increases when hose is pinched . . . defective distributor advance mechanism unit, line or fittings.

Manometer reading does not increase when hose is pinched and distributor vacuum is noticeably lower than that obtained on similarly equipped vehicles at comparable speeds . . . possible air leaks around carburetor gaskets or a faulty carburetor vacuum system.

Adjusting Initial Ignition Timing

When using the Electronic Distributor Tester, there are two methods of adjusting initial ignition timing on an engine. The method to use depends upon the timing requirements given by the engine manufacturer.

a. If the engine manufacturer instructs that the ignition timing be adjusted so that the timing mark lines up with the ignition pointer, turn the advance control of the tester to its TIMING POSITION and use the timing light in the conventional manner.

b. If the engine manufacturer instructs that the ignition timing be adjusted so that the timing mark is advanced a certain number of degrees from the pointer, proceed as follows:

1. Connect the Electronic Distributor Tester as indicated under Initial Ignition Timing.

2. Adjust engine to specified Timing speed.

3. Turn tester advance control until meter reads the specified number of engine degrees to which the initial timing is to be adjusted.

4. Loosen the distributor locking screw or bolt and rotate the distributor until the timing mark aligns with the timing pointer, as seen with the Timing Light. Retighten the distributor.

5. Observe meter reading. If readjusting timing changed the meter reading (because of a change in engine speed) repeat steps 3 and 4.

6. Turn the Tester Advance Control back to the timing position, and observe that the timing mark is displaced from the pointer. The displacement is equal to the number of degrees that were preset on the meter in step 3.

MANOMETER

Sun Model M-640

SUN SCOPE

The Sun Scope provides a convenient means of observing an ignition system's performance by displaying an easily interpreted graph-like picture of all phases of ignition cycle the instant at which these occur on an operating engine. The picture thus displayed permits the observer to actually see in minute detail the results of a multitude of factors effecting the ignition system's operation. The factors which once were assumed in theory only, such as firing voltage requirements, spark duration, coil and condenser action, breaker point action and maximum ignition system voltage output, can now be accurately seen.

Testing with the Sun Scope is comparatively simple. Aside from one or two physical operations involved, actual testing consists of observing the pictures or patterns for irregularity. Since each part of the pattern represents certain events which occur in the various parts of the ignition system, any deviations from the normal appearing patterns will quickly indicate the types of troubles present. The Sun Scope is designed to permit an operator to view the patterns of all cylinders side by side in the engine's firing order, each cylinder's pattern in turn individually, a choice of patterns compared one above the other, or a superimposed display of all cylinders' patterns.

To interpret Sun Scope test results, it is important that the basic Oscilloscope Wave Form Pattern be thoroughly understood. Review and study the following two pages very carefully. Before applying the Sun Scope to an engine, it is suggested that the operator become familiar with each Scope control and its function, and the Scope's connections to the vehicle.

In the interest of speed, ease and over-all ignition testing, a nine-step condensed test procedure is outlined in this section of the Handbook. For a more detailed analysis and to help in pin-pointing ignition troubles, several auxiliary tests are described in the latter portion of this section. To aid in interpreting the variations of the basic wave form pattern, the Scope Test Indication section illustrates and describes the scope patterns representing many of the more commonly encountered ignition troubles.

To quickly associate Scope indications of ignition troubles with a specific cylinder or cylinders of the engine, the operator should be familiar with cylinder numbering arrangements and engine firing orders. The last page of this section illustrates and lists engine cylinder arrangements and firing orders usually encountered on American built passenger cars.

Certain ignition system functions vary with the input voltage available to the ignition coil. Therefore, to be assured of obtaining accurate test results, it is necessary to prevent the generator from operating during the ignition test sequence. A convenient means of preventing the generator from operating, regardless of whether the vehicle is equipped with an AC or a DC system, is to connect a Sun Generator Field Control into the generator's field circuit, and to position the control knob in its "open" position.

5

EXPLANATION OF SCOPE PATTERNS

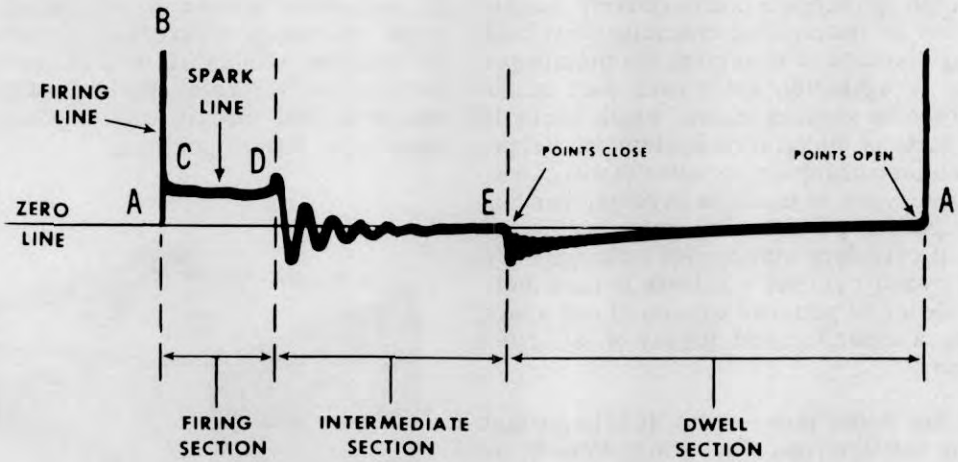
Before applying the Sun Scope to an engine, it is suggested that the operator become familiar with the Scope controls and their function, and the Scope connections to the engine.

To interpret Scope test results, it is important that the basic oscilloscope waveform or pattern be thoroughly understood. Study the following carefully.

The display (or trace) visible on an oscilloscope screen is usually referred to as a pattern or waveform. In studying oscilloscope patterns, consider them to be graphs of voltage with respect to time. The vertical displacement from the ZERO line (either up or down depending on polarity) represents voltage at any instant along the ZERO line.

The Sun Scope is designed to display either a Secondary waveform which is obtained at the coil's high tension tower, or a Primary waveform which is obtained at the distributor primary terminal of the coil. However, because the Secondary waveform is generally the most informative for showing over-all ignition system operation, the screen of the Sun Scope is laid out in kilovolts (KV) to permit accurate voltage measurements of Secondary patterns to be made. Each vertical division of the screen represents 2 kilovolts (2000 volts), providing the Scope's Pattern Height control is positioned at its SET LINE.

Each part of the waveform represents a specific phase of ignition system operation. For the purpose of understanding and analyzing the Scope pattern, it is divided into three sections; The Firing Section, the Intermediate Section and the Dwell Section.



BASIC PATTERN SECTIONS

The Firing Section

So called, because it is during this period that the actual firing of the spark plug takes place. This *section of the pattern is composed of only two lines:*

The Firing Line, a vertical line indicating the voltage required to overcome the plug and rotor gaps.

The Spark Line, a horizontal line indicating the voltage required to maintain the spark.

Point "A" in the pattern illustrated represents the instant at which the breaker points have separated. The resulting high voltage is indicated by the vertical *rise from "A" to "B" in the pattern. The height* at point "B" shows the voltage required to fire the plug and rotor gap; sometimes referred to as the "firing" or "ionization" voltage.

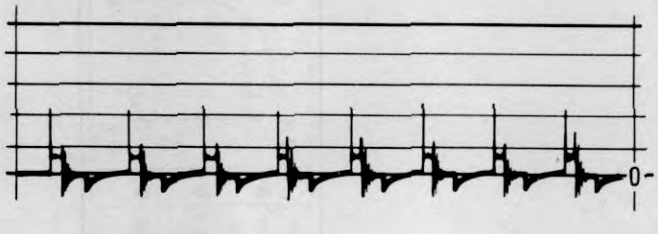
Once the plug fires there is a noticeable drop in secondary voltage to point "C". As the spark continues to bridge the gap, the spark voltage remains at a fairly constant low value until the spark extinguishes at point "D".

The Intermediate Section

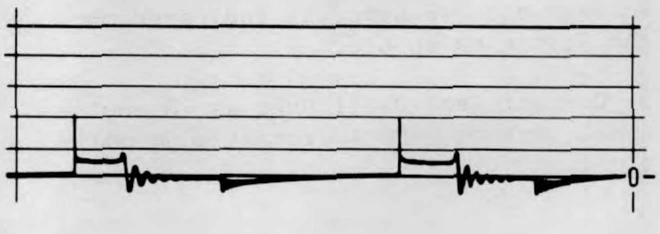
This section, which immediately follows the Firing Section, is seen as a series of gradually diminishing oscillations which disappear or nearly disappear by the time the Dwell Section begins. Beginning at point "D", the remaining coil energy dissipates itself as an oscillating current which gradually dies out as it approaches point "E". The oscillation results from the combined effects of the coil and the condenser in dissipating this energy.

The Dwell Section

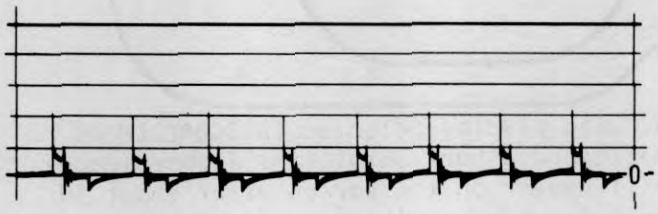
This section represents the period of time during the ignition cycle in which the breaker points are closed. The Dwell Section begins at point "E" when the breaker points close. Closing the points causes a short downward line followed by a series of small rapidly diminishing oscillations. The Dwell Section continues until the points open at the beginning of the next waveform (the next point "A").



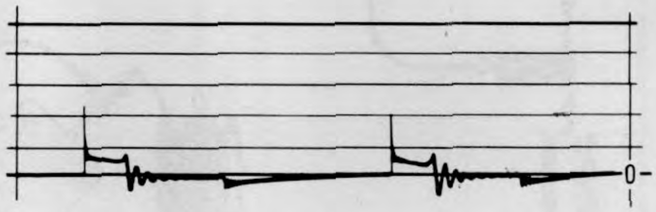
A-1



A-2



A-3



A-4

Figure "A-1" represents an ALL CYLINDER Sun Scope display of an eight cylinder ignition system which contains no suppression and is functioning in a normal manner. Figure "A-2" illustrates the INDIVIDUAL CYLINDER display of the above engine.

The patterns illustrated in Figures "A-3" and "A-4" represent a normally functioning eight cylinder ignition system which incorporates secondary suppression, as they would be observed in the ALL CYLINDER or INDIVIDUAL CYLINDER Sun Scope display.

To be particularly noted is the slight difference in the length and shape of the spark lines when comparing the above illustrated patterns. It will be observed that the spark lines of the suppressor equipped system begin at a slightly higher voltage than that of the other system and that they slant downward slightly as they approach the Intermediate Section and appear to have slightly more oscillations.

SUNSCOPE TEST PROCEDURE

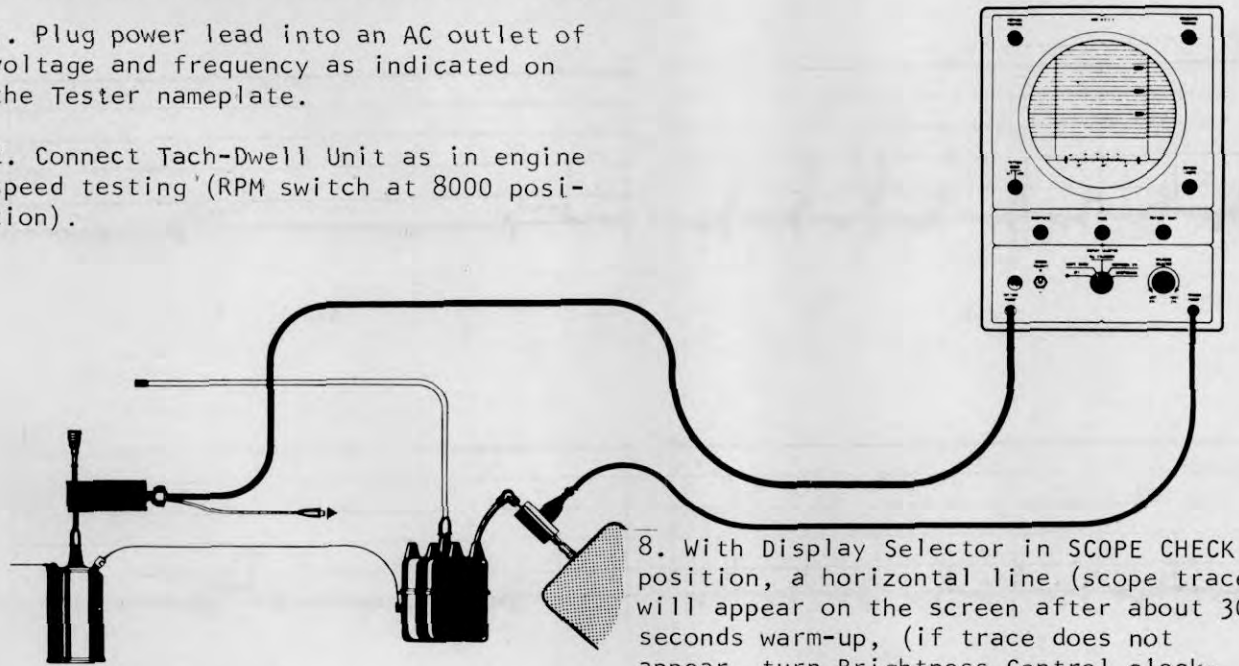
The following test procedures for use of the secondary and primary pattern pick-ups are to serve mainly as a guide, and can be varied in control settings or sequence to best suit the desires of the operator and the particular test problems encountered. An engine speed of 1200 RPM is recommended for performing most tests. However, when an engine does not perform properly at speeds other than 1200 RPM it is recommended that in addition to testing at 1200 RPM, tests should also be performed at the speed or speeds where the performance difficulty is most prominent. To make comparisons of performance, before and after services have been completed, it will of course be necessary that the tests be made under the same speed and operating conditions.

The pattern illustrations associated with each basic step in the test procedure are representative of the average normal system being tested at an engine speed of 1200 RPM. These normal patterns can be expected to vary slightly because of minor variations in engine and ignition system design, number of cylinders, specified dwell settings and the absence or presence of ignition suppression.

CONNECTIONS AND CONTROL SETTINGS

1. Plug power lead into an AC outlet of voltage and frequency as indicated on the Tester nameplate.

2. Connect Tach-Dwell Unit as in engine speed testing (RPM switch at 8000 position).



3. Connect Generator Field Control into generator's field circuit, set control to "OPEN" position.

4. Remove high tension wire from coil and leave wire disconnected.

5. Insert Secondary Pattern Pickup into coil tower and attach Ground Clip to a good ground on the engine.

6. Connect Trigger Pickup into the circuit of the last spark plug in the firing order.

7. Turn Display Selector to SCOPE CHECK position, and Ground Polarity Switch to POSITIVE (+) position.

8. With Display Selector in SCOPE CHECK position, a horizontal line (scope trace) will appear on the screen after about 30 seconds warm-up, (if trace does not appear, turn Brightness Control clockwise and rotate Horizontal and Vertical Position controls until trace appears on the screen.)

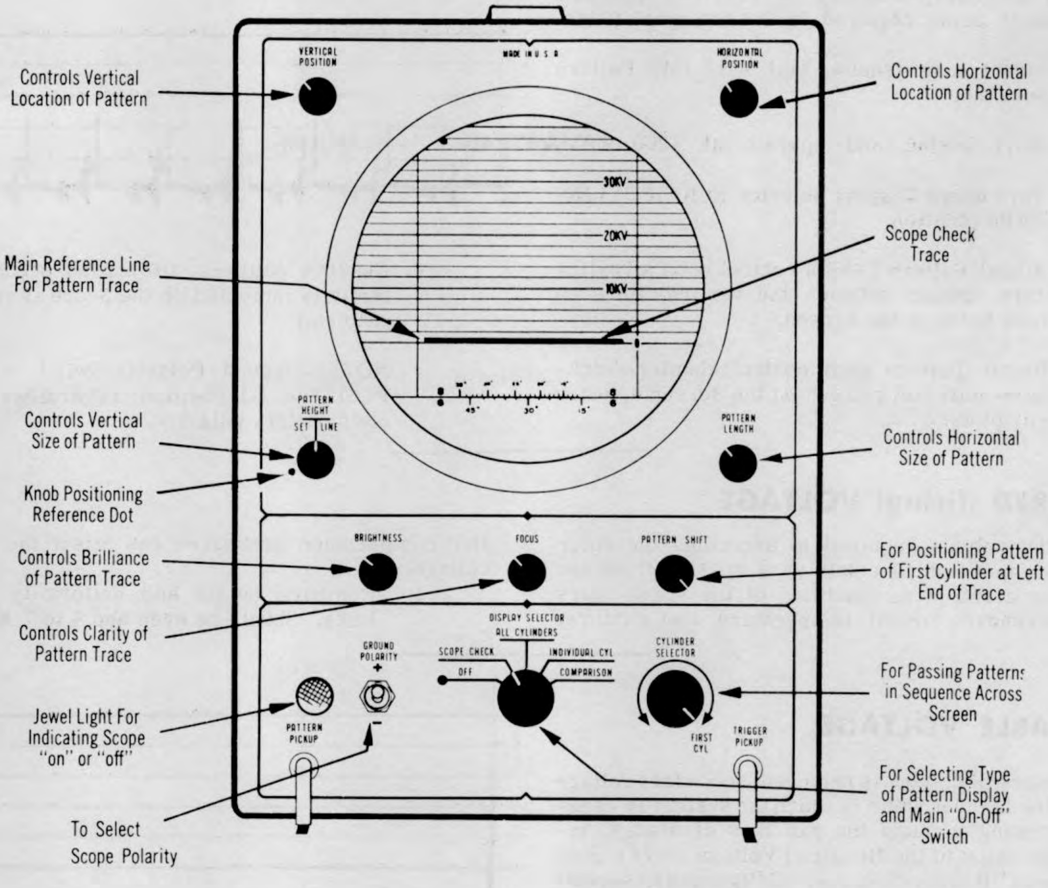
9. Adjust Horizontal and Vertical Position controls to align left end of trace with vertical line on left of screen at ZERO line.

10. Adjust Brightness and Focus controls to obtain desired brilliance and a sharp clear trace.

11. Rotate Pattern Shift and Cylinder Selector controls to FULL CLOCKWISE position.

12. Adjust Pattern Height control to SET LINE.

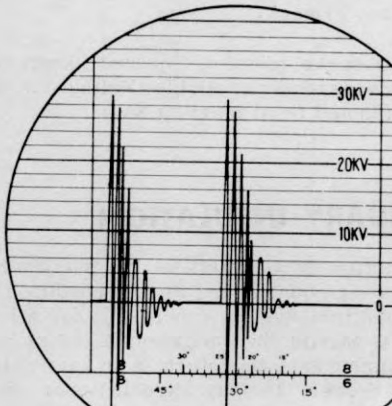
SCOPE CONTROLS



COIL OUTPUT VOLTAGE AT CRANKING SPEED

This is a Scope measurement of the secondary voltage available to fire the spark plug while the engine is being cranked. In instances of hard starting or starting failure, it may quickly confirm or eliminate the primary circuit and coil as the cause.

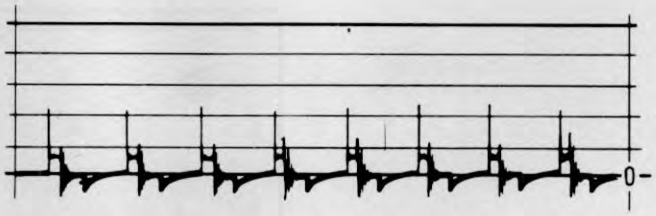
1. With ignition switch ON, crank engine and note coil output voltage. Coil output voltage should extend at least 20 KV above ZERO line.



SECONDARY POLARITY

Incorrect Secondary Polarity can result in up to 40% more voltage being required to fire the spark plugs.

1. Insert high tension coil wire into Pattern Pick-up.
2. Start engine and operate at 1200 RPM.
3. Turn Scope Display Selector to ALL CYLINDERS position.
4. Adjust Pattern Length control until all cylinders appear between the vertical lines on both sides of the screen.
5. Rotate Pattern Shift control counter-clockwise until last pattern on the screen appears complete.



6. Observe patterns. (Reversed secondary polarity is indicated on the Scope as an inverted pattern.)

NOTE: Ground Polarity Switch must be in POSITIVE (+) position, regardless of vehicle's battery polarity.

REQUIRED (firing) VOLTAGE

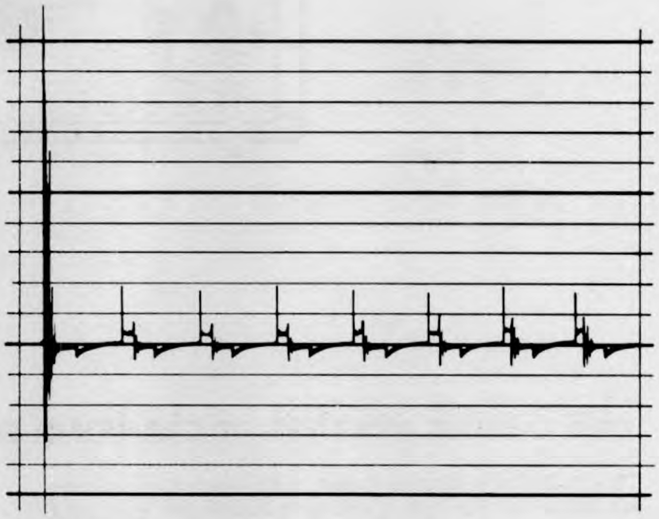
This is the voltage required to overcome the rotor and plug gaps and to establish a spark across the spark plug electrodes. Condition of the spark plugs and/or secondary circuit, temperature, fuel mixture, and compression pressures can affect the required voltage.

1. Compare height and uniformity of firing lines. Should be even and 4 to 7 KV.

AVAILABLE VOLTAGE

When a spark plug wire is removed, secondary voltage rises to the highest value of which the system is capable, attempting to jump the gap thus created. Comparing this value to the Required Voltage gives a good indication of "Ignition Reserve." If "Ignition Reserve" is insufficient at test speed, ignition failure can occur when subjected to the more severe requirements of various driving conditions.

1. Use insulated pliers to disconnect a wire from a spark plug. (Hold spark plug wire away from any ground.)
2. Observe pattern. Upward extent of pattern represents Available Voltage in Kilovolts. (Should be at least 20 KV.)



SECONDARY INSULATION

The insulation of all parts of the secondary circuit must be of high quality and in good condition to insure reliable ignition system function under all operating conditions. Should the insulation of one or more secondary components be defective or have deteriorated to some degree, it may have little or no effect on ignition system operation when the firing voltage requirements of the vehicle are moderate. However, when firing voltage requirements are high, this defective insulation may leak or break down, allowing much of the voltage surge to be lost to ground resulting in misfire of one or more plugs.

1. Observe downward extent of pattern of cylinder with spark plug wire removed. (Note length of downward extent and whether it is consistent or intermittent.) Downward extent should equal at least 1/2 of the upward extent.
2. Reconnect wire to spark plug.
3. Test remaining cylinders in the same manner. (Trigger cylinder must be tested in SCOPE CHECK position.)

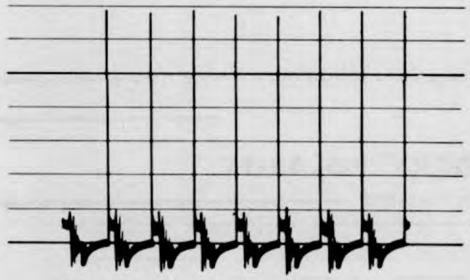
SECONDARY RESISTANCE

"Spark Line" analysis reveals the condition of the secondary circuit conductors. Excessive resistance uses up energy which is needed to maintain good ignition, and consequently results in poor performance under severe operating conditions.

1. With Display Selector in ALL CYLINDERS position, observe and compare spark line of patterns for height, length, angle, and oscillations. For closer examination, the pattern for each cylinder may be expanded, viewed individually, or compared. (Use Pattern Length, Display Selector, and Cylinder Selector controls.)

SPARK PLUGS UNDER LOAD

When a load is applied to an engine the Required Voltage rises. This rise will be slight and uniform if the plugs are in good condition and properly gapped. However, if any unusual firing characteristics are observed while the engine is operating under a load, it generally indicates faulty sparkplug condition. To be particularly noted are the individual firing voltages that are considerably higher or lower than the firing requirements of the other cylinders of the engine.



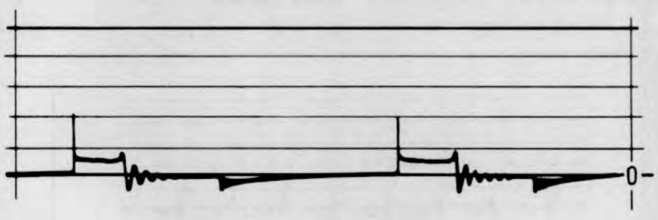
1. With Display Selector set in ALL CYLINDERS position, rotate Pattern Shift control FULL CLOCKWISE.

2. Momentarily accelerate engine (to approximately 2000 RPM) and note rise of the firing lines.

3. Allow engine speed to return to 1200 RPM.

POINT CONDITION AND ACTION

The Scope permits direct observation of point action. Since the points are the main switch in the primary circuit, and are required to make and break this circuit for each spark at the plug, it is essential that every phase of their operation be correct. Arcing, bounce, or poor contact can be quickly detected.

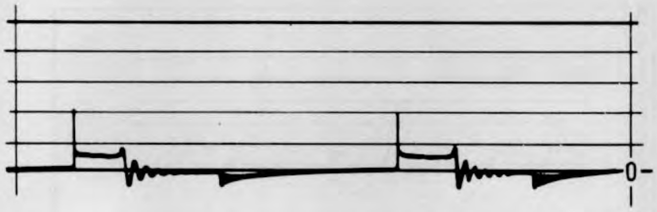


1. Turn Display Selector to the INDIVIDUAL CYLINDER position.

2. Observe POINT CLOSE and POINT OPEN signal for normal operation.

COIL AND CONDENSER

If the coil and condenser are functioning normally, energy remaining in the system, after the firing cycle is completed, dissipates in diminishing oscillations. The absence of these oscillations is a clear indication of trouble.



1. Observe and note the number of oscillations in the intermediate section of patterns.

SCOPE TEST INDICATIONS

The Test Indications section which follows, illustrates only the more frequently encountered patterns which indicate specific types of troubles as displayed at an engine speed of 1200 RPM. It must be realized that many of the troubles and defects which occur, can exist in various degrees of severity which in turn will determine how prominently the trouble will be disclosed in the Scope display. Another important fact which must be considered is that occasionally two or more troubles may be present at the same time, and in some instances these troubles may have opposite effects on an ignition waveform pattern.

UNSATISFACTORY TEST RESULTS — PROBABLE CAUSES

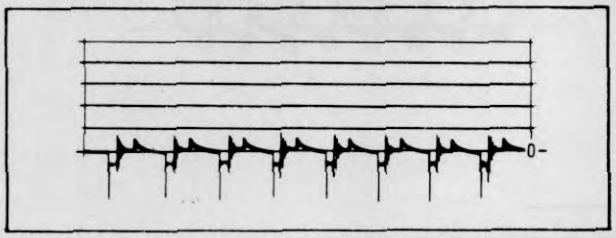
COIL OUTPUT VOLTAGE AT CRANKING SPEED

Low secondary voltage → **Battery Low**
Defective Ignition Circuit
Failure of Resistor By-Pass Circuit
Insufficient Dwell
Excessive Distributor Resistance
Defective Coil or Condenser

No oscillations following voltage rise. → **Defective Coil or Condenser**

SECONDARY POLARITY

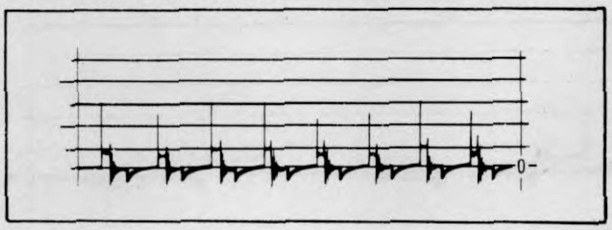
Pattern inverted → **Scope Polarity Switch in Wrong Position**
Battery Polarity Reversed
Coil Improperly Connected
Incorrect Coil for the Vehicle



REQUIRED (FIRING) VOLTAGE

Firing voltages uniform—but high → **Worn Spark Plug Electrodes**
Late Ignition Timing
Lean Fuel Mixture
Too Large Rotor Gap
Break in the Coil Wire

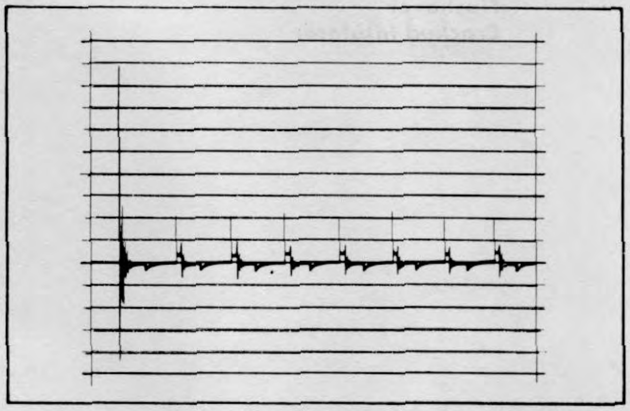
Uneven firing voltages → **Worn Spark Plug Electrodes**
Unbalanced Fuel Mixture
Breaks in Spark Plug Wires
Cocked or Worn Distributor Cap



UNSATISFACTORY TEST RESULTS | **PROBABLE CAUSES**

AVAILABLE VOLTAGE

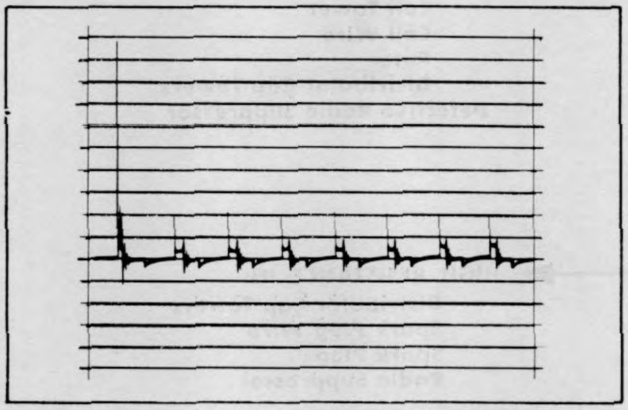
Insufficient available voltage →



Excessive Resistance in the Primary Circuit
Low Primary Input Voltage
Defective Coil
Dwell Less than Specified
Defective Secondary Insulation

SECONDARY INSULATION

Short, intermittent, or absent lower extent →



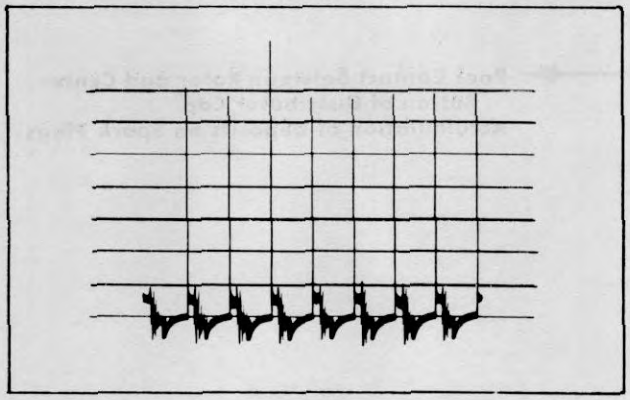
INSULATION LEAKAGE IN:
- **Coil**
- **Coil Tower**
- **Rotor**
- **Coil Wire**
- **Distributor Cap**
- **Spark Plug Wire**
- **(See Below)**

ON ALL CYLINDERS:
Coil Tower, Rotor, Coil Wire, or Distributor Cap

ON ONE OR MORE CYLINDERS:
Distributor Cap or Spark Plug Wires

SPARK PLUGS UNDER LOAD

One or more firing lines higher than others →

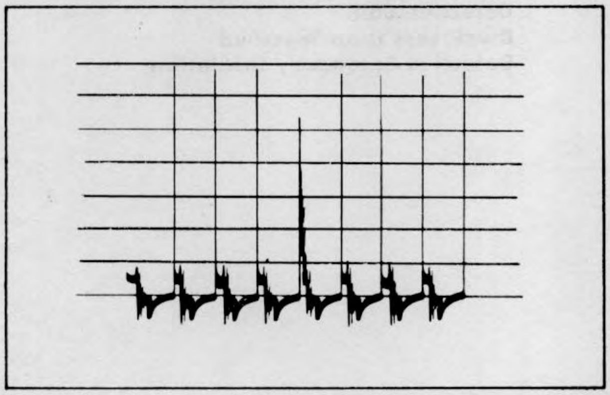


Wide Plug Gap
Open Spark Plug Resistor
Badly Deteriorated Electrodes

UNSATISFACTORY TEST RESULTS — **PROBABLE CAUSES**

SPARK PLUGS UNDER LOAD

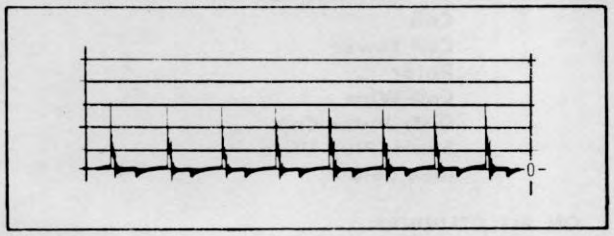
One or more firing lines lower than others → **Spark Plug Fouling**
Flashover
Cracked Insulator



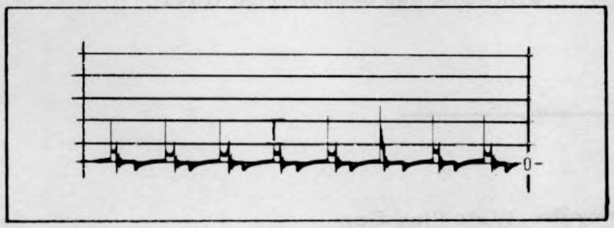
SECONDARY RESISTANCE

Affecting all cylinders → **HIGH RESISTANCE IN:**
- **Coil Tower**
- **Coil Wire**
- **Rotor**
- **Distributor Cap Towers**

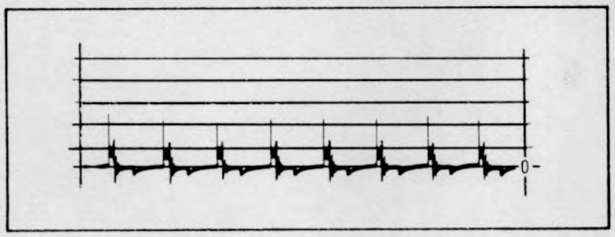
Defective Radio Suppressor



Affecting one or more cylinders → **HIGH RESISTANCE IN:**
- **Distributor Cap Towers**
- **Spark Plug Wire**
- **Spark Plug**
- **Radio Suppressor**



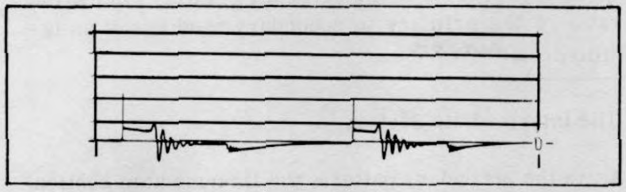
Affecting all cylinders → **Poor Contact Between Rotor and Center Button of Distributor Cap**
Accumulation of Deposits on Spark Plugs



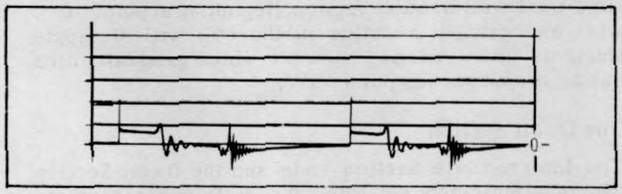
UNSATISFACTORY TEST RESULTS — PROBABLE CAUSES

POINT CONDITION AND ACTION

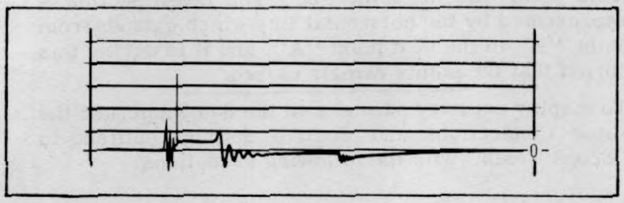
Unusual point close signal → **Poor Point Contact or Point Misalignment**

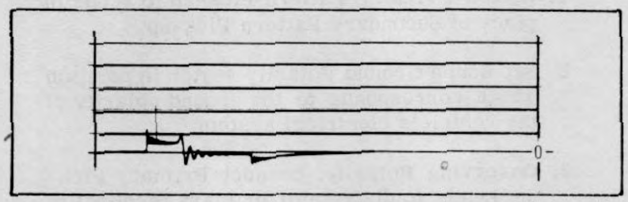


Unusual point close signal → **Point Bounce**
Weak Point Spring Tension



Unusual point open signal → **Dirty Points**
Burned Points
High Condenser Series Resistance





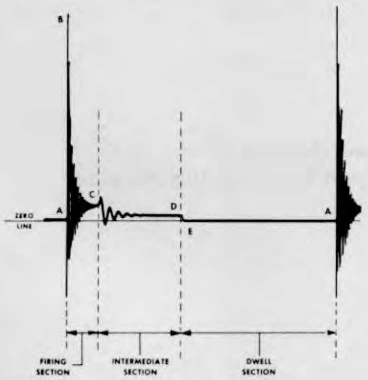
COIL AND CONDENSER

Lack of oscillations in Intermediate Section → **Short in the Coil**
Leaky Condenser

PRIMARY WAVEFORM INTERPRETATION

Since any voltage variation in the ignition primary circuit will be reflected in the secondary, it is seldom necessary to use a primary pattern for general ignition testing. If desired, a primary waveform can be displayed on the Sun Scope by substituting the Primary Pattern Pick-up for the Secondary Pattern Pick-up.

The KV scale on the scope screen applies only to the display of secondary patterns. Although a resemblance exists between primary and secondary patterns, it should be noted that the voltage values represented in the primary patterns are considerably lower than those represented in the secondary patterns due to the ratio of the primary to secondary windings of an ignition coil.



The primary pattern has the same three basic sections as the secondary:

The Firing Section

This section displays the series of rapid oscillations that take place in the ignition primary circuit during the period of time in which the spark plug fires. Point "A" represents the instant at which the breaker points separate.

The vertical rise from "A" to "B" and the diminishing oscillations which follow, represent the initial and repeated charging and discharging of the condenser and the induced voltage surges in the primary circuit while the spark plug is firing. As the spark bridges the gap and energy is being drained from the coil, the amplitude of these oscillations will diminish until the spark is extinguished as indicated at point "C".

The Intermediate Section

As in the secondary pattern, the Intermediate Section is seen as a series of gradually diminishing oscillations which disappear or nearly disappear by the time the Dwell Section begins. Beginning at point "C", what energy still remains in the coil will dissipate itself as an oscillating current which gradually dies out as it approaches point "D".

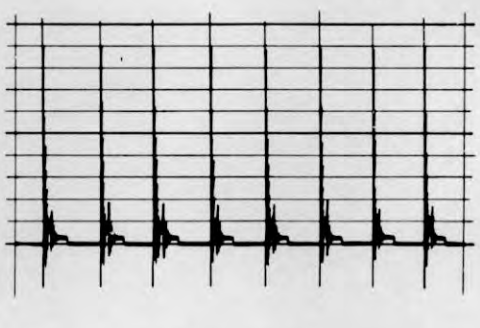
The Dwell Section

The Intermediate Section ends and the Dwell Section begins simultaneously when the distributor contacts close, and can be observed as a faint downward line from point "D" to point "E". The Dwell Section is represented by the horizontal line which extends from point "E" to the next point "A", and it is during this period that the points remain closed.

To display primary patterns on the Sun Scope, use the same Connections and Control Settings outlined in "Scope Tests" with the following exceptions:

1. Attach Primary Pattern Pick-up to Scope in place of Secondary Pattern Pick-up.
2. Set Scope Ground Polarity switch in position which corresponds to the ground polarity of the vehicle's electrical system.
3. Observing Polarity, connect Primary Pick-up Leads to distributor primary terminal of coil and to ground.
4. With engine operating at the desired test speed, adjust Pattern Height control until entire waveform is visible on Scope screen.

TYPICAL PRIMARY PATTERNS



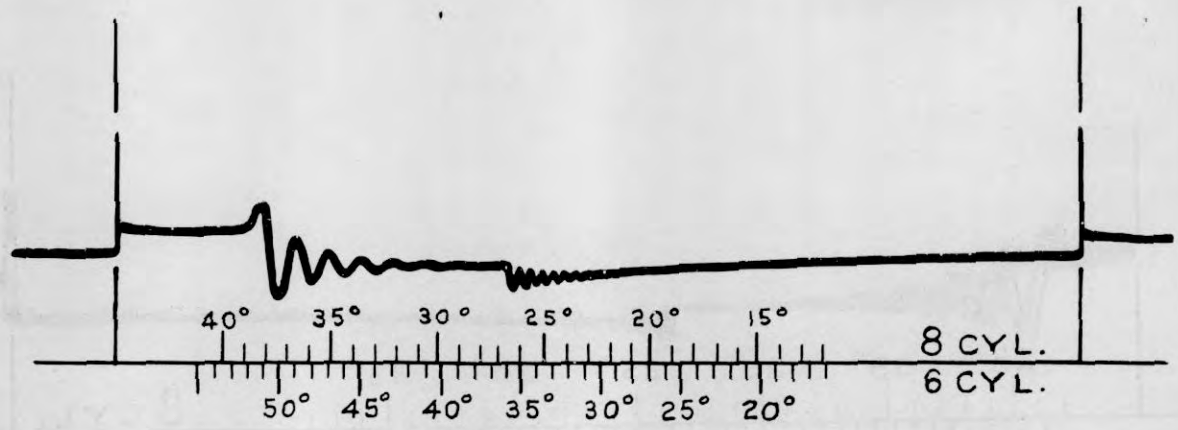
ALL CYLINDERS

INDIVIDUAL CYLINDERS

SUN SCOPE DWELL TEST

Facilities are provided in the Sun Scope for measuring distributor point dwell. These facilities may be utilized when displaying either secondary or primary waveform patterns.

Dwell can accurately be measured by expanding the pattern of any one cylinder until it completely fills the space between the two vertical lines on the screen, then lowering the pattern until it rests on the Dwell Scale. Dwell is measured directly from the scale, which actually consists of two sets of graduations; the upper one for 8 cylinder engines and the lower one for 6 cylinder engines. The dwell of 4 cylinder engines may also be measured by doubling the Dwell reading, obtained from the 8 cylinder scale.



1. With Scope connected and adjusted as outlined in "Scope Tests", set Display Selector to INDIVIDUAL CYLINDER position.

2. Adjust engine speed to 1200 RPM.

3. Set Cylinder Selector to FIRST CYLINDER position.

4. Adjust Horizontal Position control to bring the firing line of the first pattern into alignment with the vertical line at the left of the screen.

5. Adjust Pattern Length control to bring the next firing line into alignment with the vertical line at the right of the screen.

6. Adjust Vertical Position control until the pattern rests on the Dwell Scale near bottom of screen.

7. Measure dwell by noting point on Dwell Scale which is in alignment with the beginning of the pattern's "Dwell Section."

   Refer to specifications for proper dwell.

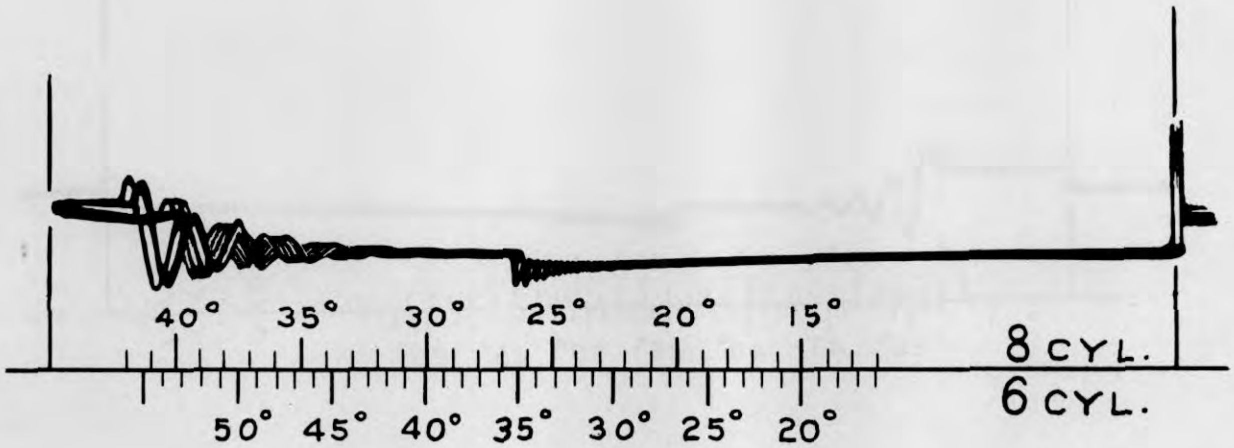
SUPERIMPOSED SCOPE PATTERNS

A superimposed pattern is the display obtained by simultaneously placing the patterns of all cylinders one on top of the other. To obtain a superimposed pattern, it is necessary to trigger the Scope each time the ignition points break. This is accomplished by connecting the Trigger Pick-Up into the secondary circuit between the coil and the distributor cap. Using this method, the operator has a choice of superimposing either a secondary or a primary display by selecting the proper Pattern Pick-Up.

Superimposing Scope patterns of all cylinders is advantageous in many instances, because it provides a convenient method of testing the ignition system for over-all uniformity. By expanding the display horizontally to completely fill the space between the two vertical lines on the screen, any variation in the basic pattern sections can quickly be detected.

Lowering the superimposed display until it rests on the Dwell Scale permits any inaccuracy of the distributor cam to be indicated and measured on the Dwell Scale. The accuracy of the distributor cam determines the ignition timing relationship of all cylinders. Should one or more lobes of the distributor cam become worn, or should the distributor shaft be bent, uneven timing of the cylinders would result.

The display illustrated below shows the superimposed patterns of an eight cylinder engine and indicates a total variation of 1/2 degree at the "Point Close" portion of the pattern.



To display superimposed patterns on the Sun Scope, use the same connections and control settings as outlined in "Scope Tests" with the following exceptions:

1. Using Pick-Up Transformer Adapters, install the Trigger Pick-Up into the secondary circuit between the coil and distributor cap.
2. With Pattern Shift and Cylinder Selector controls in FULL CLOCKWISE position, set Display Selector to ALL CYLINDERS position.
3. Start engine and adjust speed to 1200 RPM.
4. Adjust Horizontal Position control to align beginning of trace with vertical line at left of screen.
5. Adjust Pattern Length control to align end of trace with vertical line at right of screen.

   Observe display for uniformity of patterns.
6. Adjust Vertical Position control to locate display midway between ZERO line and Dwell Scale near bottom of screen. (For easier observation the Pattern Height may be increased by rotating the control CLOCKWISE.)

   Observe number of degrees that "Point Close" signals overlap. This should not exceed three degrees.

COMPARISON TEST

During the process of ignition testing the pattern of one cylinder may appear to look different than the patterns of the other cylinders of that engine. The Sunscope permits displaying one pattern above the others for closer examination of differences in pattern characteristics. Differences in individual cylinder patterns are of great value in evaluating engine problems.

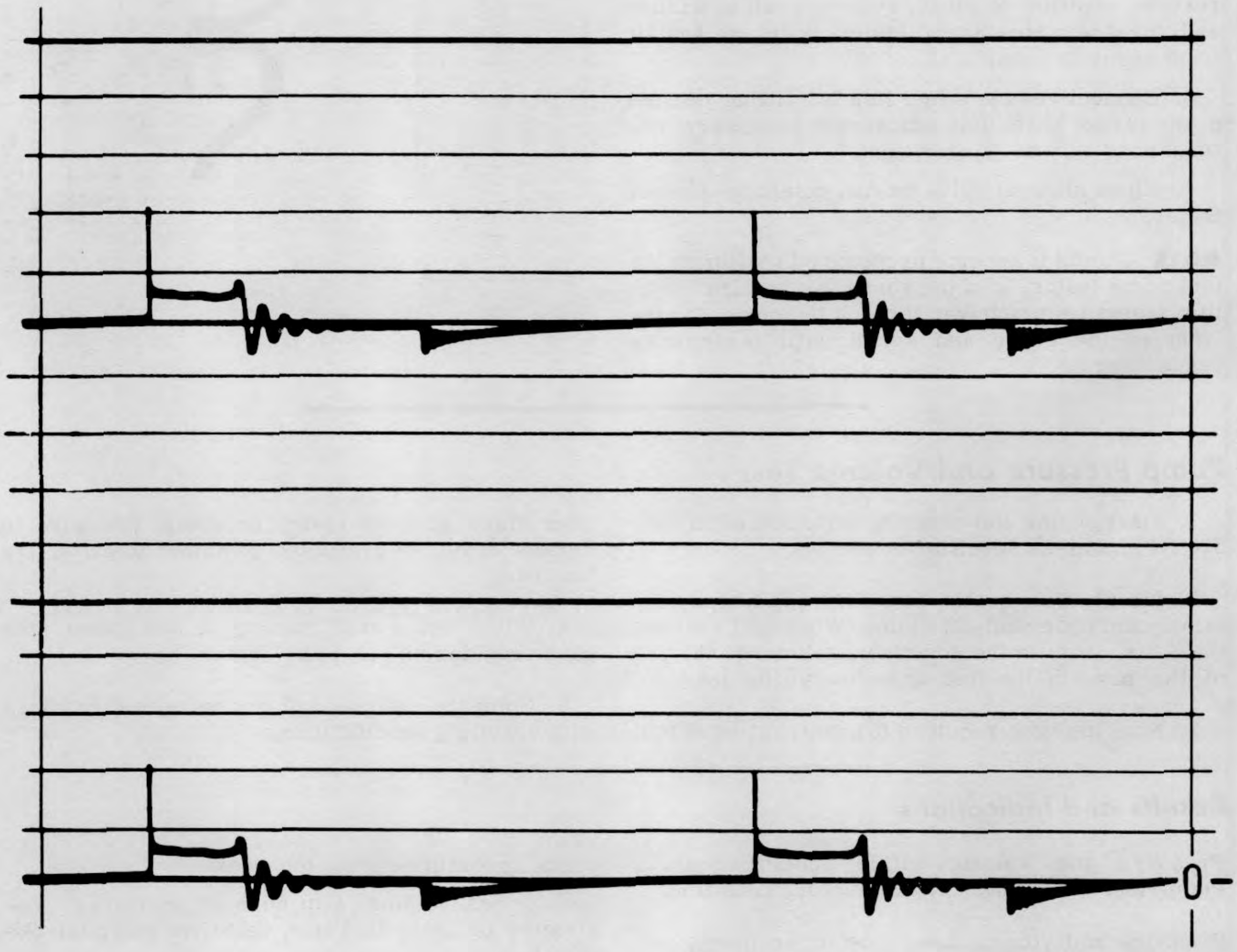
To compare patterns on the Sunscope use the same connections and control settings as outlined in "Scope Tests" with the following additions:

1. After the "Coil and Condenser Test" turn DISPLAY SELECTOR switch to "COMPARISON" position.
2. Turn CYLINDER SELECTOR Control clockwise to first cylinder position.

   Both patterns will be of the cylinder in the firing order following the one with the trigger pickup.

3. Rotate Cylinder Selector Counterclockwise and observe bottom Cylinder and compare patterns as they pass in their respective positions in the firing order.

   Any Cylinder's pattern can be displayed in the upper position by connecting trigger pickups to the Cylinder preceeding it in the firing order.



FUEL PUMP TESTER

In order to assure an adequate quantity of fuel and a constant fuel level for all driving conditions, it is necessary that both Fuel Pump pressure and volume be within specifications. It has been established that the only reliable pressure test is one that is made under actual operating conditions (i.e., with pump supplying fuel to the carburetor and gauge located within six inches of and connected to the fuel line).

Connections to Vehicle

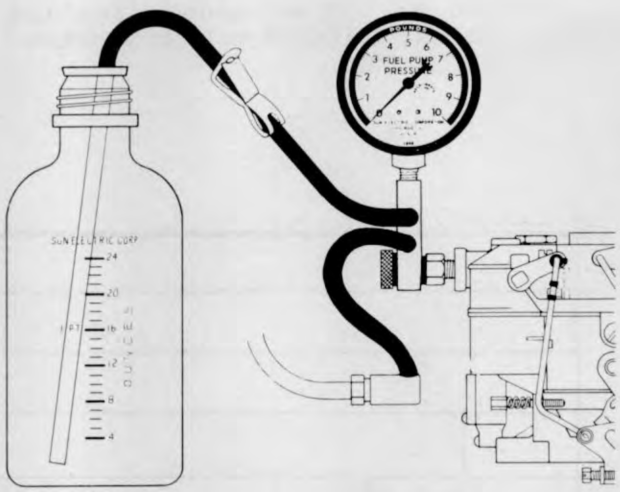
1. Remove vehicle's air cleaner and disconnect main fuel line at carburetor, or at "T" or junction, if vehicle is equipped with more than one carburetor.

2. Mount tester to carburetor inlet with gauge vertical and facing operator. Use adapters if necessary; fittings need only to be "finger tight." (To reverse position of gauge, remove sealing washer and threaded stud from tester body and install from opposite side.)

3. Connect vehicle's fuel line to fitting on fuel pump tester hose. Use adapters if necessary; fittings need only be "finger tight."

4. Close shut-off valve on fuel discharge hose of tester.

NOTE Should it become necessary to calibrate the fuel pump tester, hold the gauge in a vertical position, insert a screwdriver through the opening in the front of the gauge and adjust until the pointer reads "Zero."



Pump Pressure and Volume Test

1. Start engine and adjust speed to approximately 500 RPM, unless specified otherwise.

2. Insert volume test hose into graduated container and open shut-off clamp. When fuel reaches the 4 oz. level in the container, submerge the end of the hose in the fuel and observe for bubbles.

3. Note the time required to pump one pint of fuel then close shut-off clamp securely. (Be sure to dispose of fuel in graduated container to avoid fire hazard.)

4. With engine still running at test speed, note gauge reading on fuel pump tester.

5. Compare volume and pressure test readings with vehicle's specifications.

Results and Indications

Pressure and Volume within specifications... Pump and fuel lines in satisfactory condition.

Pressure and volume low... defective pump, restricted or leaky line.

Pressure low with correct volume... defective pump, (pressure spring too weak).

Insufficient volume with normal pressure... restricted or leaky fuel line, defective pump (stroke too short).

Air bubbles on volume test... leaky fuel line, leaky pump.

COMBUSTION EFFICIENCY TESTER

Combustion efficiency is a very reliable indication of carburetor system operation on a mechanically sound, properly tuned engine with a good ignition system. Combustion efficiency is tested by utilizing exhaust gas samples picked up at the tail pipe to determine the fuel to air ratio, and indicating this information on an electric meter. To obtain accurate test results, the engine must be at operating temperature.

Before testing, determine that both compression and ignition of the engine to be tested are in good condition, and that the exhaust system doesn't leak. While oil smoke from a car does not materially affect the accuracy of a tester during the test, repeated use of a combustion efficiency tester on oil burning engines will eventually decrease its sensitivity because of oil fouling.

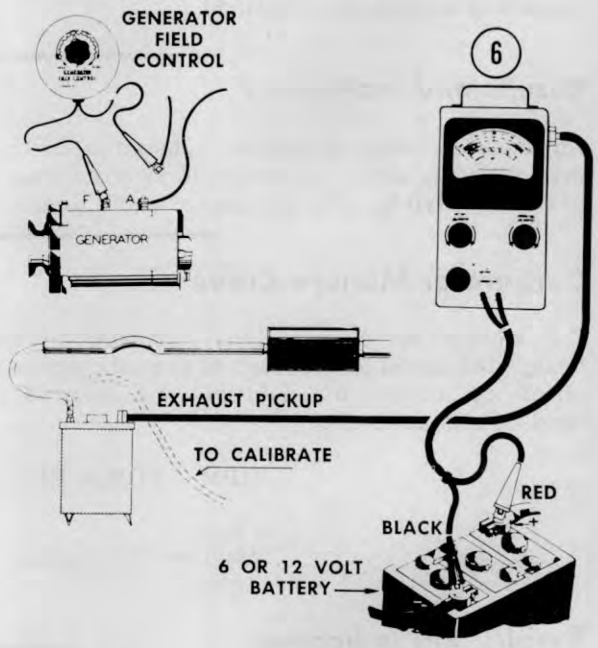
Preparation For Tests

1. Connect a Tachometer to the engine. (Refer to the Tach-Dwell Tester section of this Handbook.)

2. Connect a Vacuum Gauge to the Intake Manifold. (Refer to the Vacuum Pressure Tester section of this Handbook.)

3. Connect the battery leads of the Combustion Tester to either a 6 volt or 12 volt battery as shown. (Red lead to Positive battery post, and Black lead to Negative battery post.) Battery specific gravity must be at least 1.250 to assure accurate test results.

If battery in vehicle is to be used to power tester, it is important that the voltage applied to the tester be maintained at a constant value. Therefore, to prevent the generator varying its input voltage to the tester, it is necessary to connect the generator field control unit into the generator's field circuit. (Refer to the Generator Field Control section of this Handbook.)



4. Connect one end of neoprene hose to Exhaust Condenser and the other end to fitting on Combustion Efficiency Tester.

5. Turn selector switch to BATTERY position and adjust BATTERY CALIBRATOR knob until the meter reads on the SET LINE.

6. Turn the selector switch to COMBUSTION position and adjust the COMBUSTION CALIBRATOR knob until the meter reads on the SET LINE.

7. Start engine and insert metal pick-up hose in tail pipe of vehicle. (With dual exhaust, use side opposite Manifold Heat Control Valve.)

Idle Mixture

1. Adjust engine speed to specified idle RPM.

2. Note reading on Combustion Efficiency Meter. The most desirable idle mixture on most passenger vehicles is 72% to 76%.

3. Make fine adjustments, moving each carburetor idle mixture screw to obtain the desired setting.

4. Note idle speed and reset as necessary to manufacturer's specifications.

Results and Indications

Idle mixture reading ranges from 72% to 76%... Idle speed and idle mixture screw settings satisfactory.

Too lean... Incorrect idle mixture adjustments, low float level, plugged idle jets or air leaks.

Too rich...Incorrect idle mixture adjustment, high float level, or plugged air bleeds.

Little or no change in meter reading when idle mixture adjustment is changed...Plugged idle passages or carbon over idle ports.

Meter reading drifts...Worn needle and seat, fuel pull-over from: high speed nozzle, accelerator pump jet, improper float level, or leaky power valve.

Intake Manifold Leak

1. Using a squirt can, apply a mixture of engine oil and kerosene to the carburetor flange gasket and intake manifold gaskets. (Do not apply this mixture near the choke heat riser tube as it will cause a false meter indication.)

2. Observe Combustion Tester meter for any unusual deflections towards the rich side.

CAUTION Because this mixture is combustible, care should be exercised in its use. Keep the fire extinguisher handy.

Results and Indications

No observed meter deflection...Manifold and gaskets airtight. Meter pointer deflects more than 3% to the right (rich)...Leaky intake manifold gaskets, cracked or warped intake manifold, loose carburetor, or loose manifold mounting bolts.

Carburetor Mixture Curve

1. Accelerate engine slowly, pausing at each designated speed long enough to permit combustion efficiency meter to stabilize and observe for reading recommended:

NOTE These readings have been found the most desirable for economy during no-load carburetor testing as pertaining to most passenger cars and light trucks.

RPM	COMB. EFF.
800, 1000, 1200	78% to 82%
1500, 1800, 2000, 2200	84% to 88%

Results and Indications

Meter reading within specification for listed engine speeds...Carburetor action satisfactory.

Too lean...Low float level, incorrect metering rod adjustment or metering jets, plugged high speed passages or jets, manifold or carburetor air leaks.

Too rich...High float level, leaky power valve, leaky accelerator pump check valve, incorrect metering rod adjustment, incorrect metering jets, plugged air bleeds or restricted air cleaner.

Meter reading drifts...Worn needle and seat. Fuel pull-over from: high speed nozzle, accelerator pump jet, improper float level, or leaky power valve.

Accelerator Pump

1. Set engine speed to 1000 RPM and allow Combustion Reading to stabilize.

2. Accelerate quickly to approximately half throttle and immediately drop speed back to 1000 RPM.

3. Observe Combustion Meter for the amount of temporary enrichment (deflection to the right). Should be a minimum of 8%.

Results and Indications

Meter shows a minimum of 8% temporary enrichment...Accelerator Pump action satisfactory.

Too lean. Little or no change in meter reading...Insufficient pump stroke, leaky check valve, worn linkage, worn plunger.

Air Cleaner Test

1. With engine operating at 2000 RPM;

   a. Observe Combustion Meter Reading with air cleaner in place on carburetor.

   b. Observe Combustion Meter Reading with air cleaner removed from carburetor.

2. Compare meter readings observed in previous step.

Results and Indications

Little or no difference indicated in the two meter readings just observed... Air cleaner not restricting flow of air.

Greater than 5% difference noted in the two meter readings just observed... Air cleaner restriction is indicated.

NOTE Some air cleaners have a built in restriction which will cause considerable leanness of the air-fuel ratio when the air cleaner is removed. Consult manufacturer's data.

Final Idle Adjustment

1. Reduce engine speed to idle.

2. Observe idle RPM, Combustion Efficiency reading and Vacuum readings.

3. Adjust Carburetor Idle Mixture for highest, smoothest vacuum. Idle should be smooth with mixture and speed within specifications. Vacuum reading should be steady.

NOTE Experience is the best guide in determining the normal vacuum for any given engine. Normal manifold vacuum ranges from 15 inches to 22 inches on various engines. On late model engines, lower and less steady vacuum is becoming increasingly common because of greater use of high lift cams and more valve overlap.

Results and Indications

High, steady vacuum. Mixture and speed within specification . . . Proper carburetor adjustment, correct timing.

Vacuum reading lower than normal but steady... Late ignition timing, late valve timing, low compression, and excessive mechanical drag in engine.

Vacuum reading abnormally unsteady... Improper carburetor idle mixture; distributor points faulty; spark plugs improperly gapped; faulty valve adjustment; fouled or dirty spark plugs; manifold air leaks; uneven compression and improper carburetor action.

After completing the test series, stop engine before disconnecting test leads, pickups, hoses or accessories required for performing the tests. Be sure all vehicle electric, fuel, and vacuum connections are secure before restarting the engine.

NOTE Allow combustion tester to operate approximately five minutes after removing hose, to expel any moisture that has accumulated in the unit.

LOAD TESTING

Passenger Cars

The Combustion Efficiency Tester will make accurate tests of combustion efficiency in an engine operating under load, on the road or on a dynamometer, up to an air-fuel ratio of 15 to 1. The proper air-fuel ratio for load tests on passenger cars is best determined by comparison tests and experience with several engines of the same make and model. Consideration must be given to engine conditions, temperatures, grades of fuel, etc.

Trucks

Full load, full throttle readings of 82% to 84% combustion efficiency, or 13.5 to 1, to 13.8 to 1 air fuel ratio, are as high as is practical in truck engines. Leaner mixtures result in valve trouble and detonation. It is suggested that the Combustion Efficiency Tester be used to test the combustion efficiency with the vehicle under load in addition to the no-load tests. This is necessary since the full power system is not in operation at 2000 RPM, no load.

A 14.5 to 1 air-fuel ratio or 87.5% combustion efficiency reading is satisfactory for part throttle operation with the truck under road-load, but it is too lean for sustained open throttle runs. The test equipment operator should be guided by the truck manufacturer's specifications for combustion efficiency under various loadings.

Dynamometer and Road Testing

If the Combustion Efficiency Tester is used for road testing, or in conjunction with the Dynamometer to determine combustion efficiency of the engine at various loads, an auxiliary condenser must be used to prevent moisture from entering the tester element. The tester should be placed at a level considerably above the tail pipe to further guard against water being forced into the tester. When making road or dynamometer tests, it is a good practice to remove the pick-up hose from the tester panel except for periods when actual test data is being recorded. This is a very effective means of keeping moisture out of the tester element.

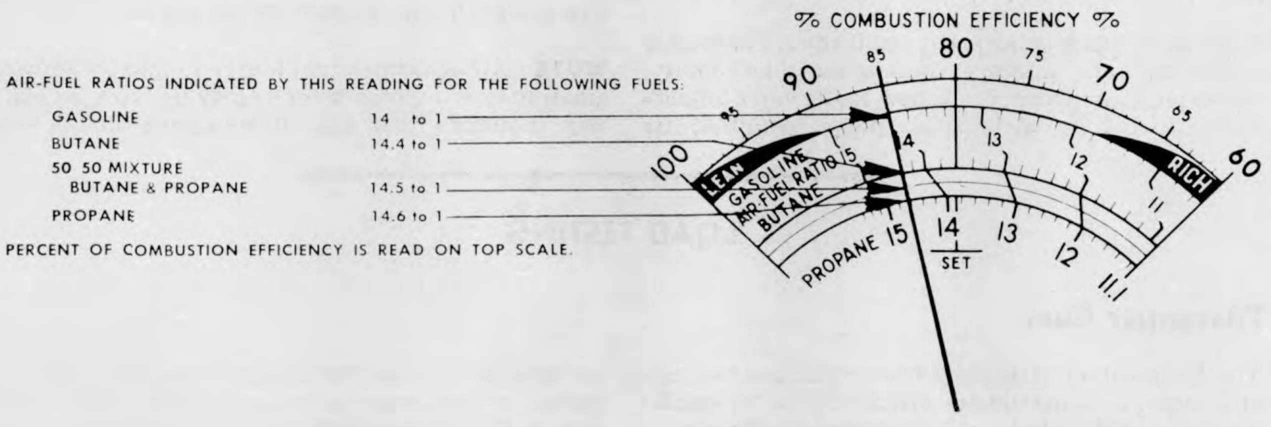
L. P. Engine Testing

When testing engines designed to operate on butane or propane fuels, read the air-fuel ratio on the designated scale of the tester meter. Specifications for the air-fuel ratio of propane and butane on specified engines may be obtained from the various engine manufacturers as well as propane and butane gas suppliers.

Multi-Carburetor Installations

The Combustion Efficiency Tester is ideal for adjusting multi-carburetor installations. With throttle linkage disconnected and the engine operating at a fixed speed on each carburetor in turn, the combustion efficiency readings should be consistent.

HOW TO READ THE COMBUSTION METER



The "Percent of Combustion Efficiency" scale of the tester is provided as a convenient reference and is based theoretically, on the complete burning of fuel and at any given ratio of fuel and air.

Use and Care of The Combustion Tester

The Combustion Tester is a precision instrument and, like any precision instrument, must receive proper care and usage if long life and accuracy are to be obtained.

Never use the Combustion Tester on an engine while gum solvents or oils are being introduced into the Combustion Chamber through the carburetor or by any other means.

Do not use the Combustion Tester on an engine that is burning oil badly. The oil leakage must be stopped before efficient combustion can be obtained. The oil smoke will eventually decrease the sensitivity of the Combustion Tester.

Check the vehicle for exhaust leaks at manifolding, exhaust gasket, exhaust pipe, muffler or tail pipe. Leaks will allow the exhaust gases to be diluted with outside air, causing meter test readings to be inaccurate. Always insert the pick-up tube as far as possible into the tail pipe of the vehicle.

After completing the Combustion Tests, pull the exhaust hose off the meter panel and allow the booster to continue running for about ten minutes to evaporate any trace of moisture in the instrument.

Drain all water from the hose and the pick-up, and remove the water from the auxiliary condenser if used, and then place the hose in a dry place.

Meter Indications

1. Meter will not calibrate to set line with selector switch in battery position. Check for low battery or poor connection.

2. Meter calibration with selector switch in Combustion position very critical or touchy. Rotate the Combustion Calibrator Knob several times, then readjust to SET LINE.

3. Meter constantly floating in Combustion POSITION or showing a fixed reading, indicates moisture in tester. Dry out tester by leaving it in operation with Combustion hose disconnected at tester for ten minutes or more if necessary.

CAUTION Under no condition should compressed air be used in an attempt to remove moisture from tester.

VACUUM PRESSURE TESTER

The Vacuum Pressure Tester is a combination vacuum gauge and 0-7 psi pressure gauge designed for measuring manifold vacuum, fuel pump pressure, the testing of vacuum booster pumps, etc. Adapters are provided for all standard applications.

Manifold Vacuum Test

1. Connect a tachometer to the engine. (Refer to Tach-Dwell section of this Handbook.)

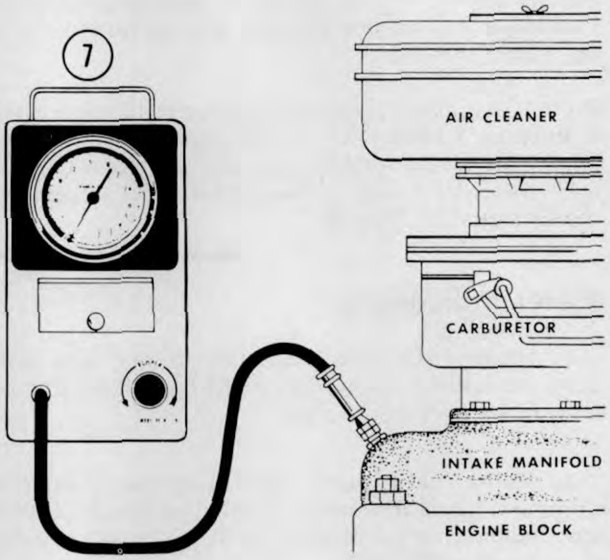
2. Connect Vacuum Pressure Tester hose to the engine's intake manifold, using proper adapter if necessary.

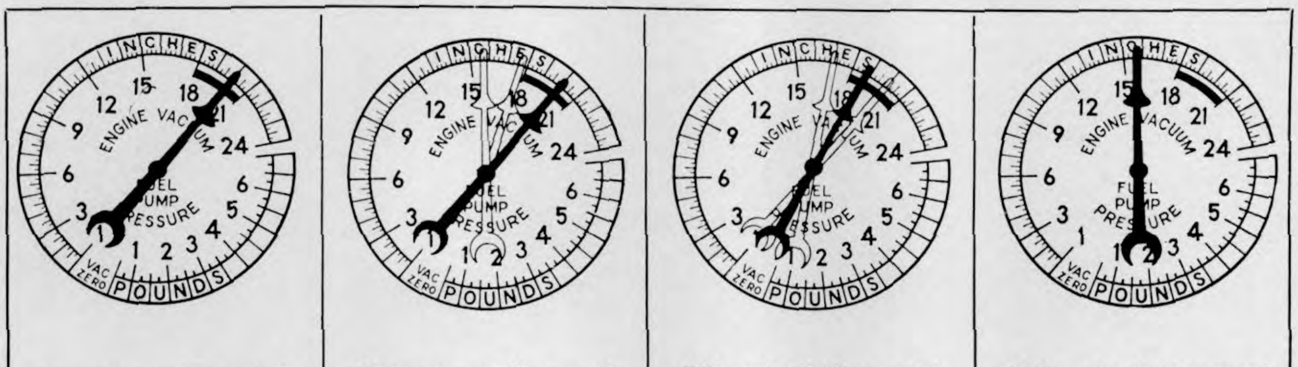
NOTE On vehicles with vacuum booster, be sure the tester hose is connected directly to the intake manifold.

3. Start engine and run until normal operating temperature is reached.

4. With engine operating at specified idle speed, note manifold vacuum. If gauge pointer flutters rapidly, adjust damper control until gauge responds freely, but does not flutter excessively.

NOTE Experience is the best guide in determining the normal vacuum for any given engine. Normal manifold vacuum ranges from 15 to 22 inches on various engines. On late model engines, lower and less steady manifold vacuum is becoming increasingly common because of the greater use of high lift cams and more valve overlap.





With motor at idling speed vacuum pointer should hold steady between 18 and 21.	With motor at idling speed dropping back of vacuum pointer indicates sticky valves.	With motor at idling speed floating motion right and left of vacuum pointer indicates carburetor too rich or too lean.	With motor at idling speed low reading of vacuum pointer indicates late timing or intake manifold air leak.

Results and Indications

Engine running smoothly at specified idle RPM. Vacuum reading average and steady---engine, ignition system and fuel system operating normally.

Vacuum reading lower than normal but steady---late ignition or late valve timing, low compression, valves improperly adjusted, excessive mechanical drag in engine.

Vacuum reading abnormally unsteady---improper carburetor idle mixture, distributor point spacing, spark plug gapping, choke adjustment, or valve adjustment. Poor plug or carburetor condition. Manifold air leaks, defective valves, or uneven compression.

Exhaust Restriction Test

This test is used to determine whether the exhaust system is restricted, or offers excessive back pressure which could result in reduced engine efficiency.

1. Connect Vacuum Tester and Tach-Dwell Tester to engine as for manifold vacuum test.

2. Gradually accelerate engine from idle to 2000 RPM.

3. Note vacuum gauge reading.

4. Maintain engine speed at 2000 RPM for approximately 10 seconds or longer while observing Vacuum Gauge.

If exhaust system is restricted, vacuum reading will gradually decrease.

Cranking Vacuum Test

A high steady vacuum during cranking indicates a mechanically sound engine, properly sealed intake manifold and intake valve guides, and a normal cranking speed. Even though the individual design characteristics of different engines cause the normal cranking vacuum to vary considerably from one type to another, the results of this test have been found to be extremely valuable as a guide in determining compression factor conditions and intake system leakage.

1. Engine should be at normal operating temperature.

2. Connect the jumper lead from the distributor primary terminal to ground to prevent the engine from starting during this cranking operation.

3. Back out throttle stop screw and release automatic choke so that throttle valves can seat tightly.

4. Crank engine, note vacuum gauge readings and observe cranking speed.

Readings should be average for the make and model of engine being tested. Readings will pulsate slightly but should be even. Cranking speed should be normal and steady.

Results and Indications

High, steady vacuum reading---mechanically sound engine, intake manifold gaskets and valve guides in good condition, cranking speed satisfactory.

Uneven pulsating reading---defective valves, rings, pistons, head gasket, uneven cranking speed.

Low even pulsating reading---slow cranking speed, over-all low compression, incorrect valve timing, throttle valves not tightly closed, vacuum leaks at intake valve guides, manifold, or vacuum accessories.

Cranking speed below normal---excessive resistance in battery cables, defective starting motor, excessive mechanical drag in engine.

Uneven cranking speed---uneven compression, defective starter, defective starter drive.

NOTE If Cranking vacuum is low or uneven, make cylinder leakage or compression test. Satisfactory engine performance cannot be obtained until any compression or vacuum leaks that exist have been eliminated.

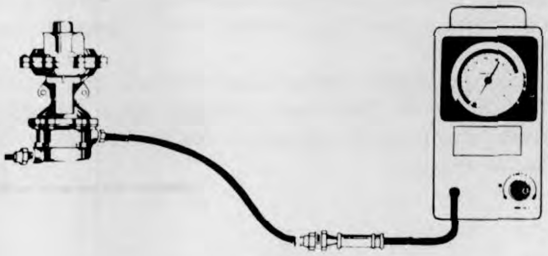
Fuel Pump Pressure Test

1. Disconnect fuel line at carburetor and connect vacuum pressure tester hose to this fuel line.

2. Connect the Tach-Dwell Tester to the engine. (Refer to Tach-Dwell section in this Handbook.)

3. Operate engine at 500 RPM and note pressure reading. Refer to manufacturer's specifications.

NOTE For most accurate readings, hose should be held approximately level.



Fuel Pump Vacuum Test

The fuel pump vacuum test is an auxiliary test and is necessary only when the pump output does not meet the pressure or volume specifications. The fuel pump vacuum test is made to determine whether the defect is in the pump or in the fuel line.

1. Disconnect fuel pump flexible line from tank fuel delivery line.

2. Install proper adapter fitting in flex line and attach Vacuum Gauge hose.

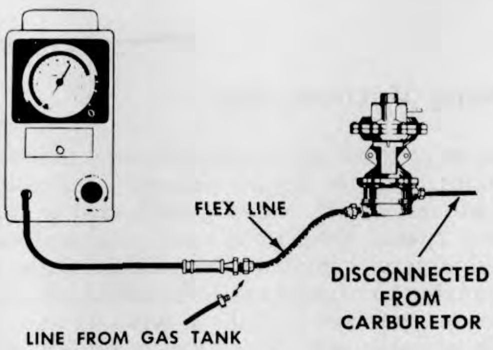
3. Start engine and operate at idle speed.

4. Run Engine for a period of time sufficient to permit Vacuum Gauge to reach its maximum reading.

5. Stop engine and observe Vacuum Gauge for ten or fifteen seconds.

If maximum vacuum is ten inches or more, and does not fall off when the engine is stopped, the flex line, pump valves, and filter bowl gaskets do not leak.

If maximum reading is less than 10 inches, or vacuum falls off rapidly, remove flex line and couple vacuum gauge directly to the inlet opening of the fuel pump and retest pump.



NOTE: The entire line from the fuel tank can be tested for air leaks in a similar manner by connecting the vacuum gauge hose to the fuel line at the tank end of the line, and repeating the test. A rapid fall off of vacuum after the engine is stopped would indicate air leaks into the line somewhere between the tank and the fuel pump.

Vacuum Booster Pump Test

The purpose of the Vacuum Booster section of the fuel pump is to operate the windshield wipers during periods of acceleration and at high speeds when manifold vacuum is too low for proper wiper action. A complaint of improper wiper action may be due to stuck valves or ruptured diaphragm in the booster pump. A ruptured diaphragm can also cause an engine miss (due to a lean air-fuel mixture), fouled plugs, a smoky exhaust, or high oil consumption.

1. Disconnect vacuum line between booster pump and intake manifold.

2. Remove windshield wiper hose from inlet of booster pump and connect vacuum pressure hose to the pump's inlet.

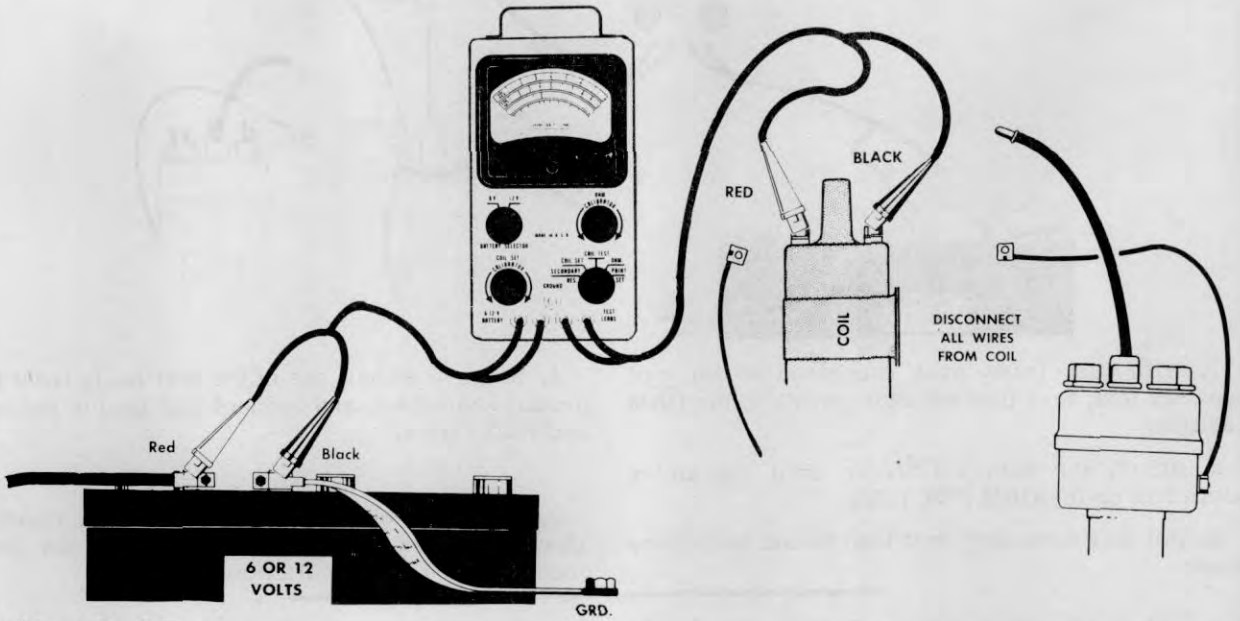
3. Connect the Tach-Dwell Tester to the engine. (Refer to Tach-Dwell section of this Handbook).

4. Operate engine at 1000 RPM. Vacuum reading generally should be 8-1/2 inches or more if the booster pump is operating satisfactorily.

5. Stop engine and observe Vacuum Gauge for a short period of time. A rapid fall-off of the Vacuum Gauge reading would indicate air leaks in the pump, pump valves, tester connection, etc.

COIL CIRCUIT TESTER

The coil circuit tester quickly indicates whether an ignition coil is good or bad. It completely tests six or twelve volt coils for opens, shorts, grounds and insulation breakdown. It also provides facilities for making "on-the-vehicle" tests of secondary circuit resistance, and tests of secondary circuit insulation. Being equipped with a zero to one hundred thousand ohm scale, it provides facilities for testing the condition and continuity of suppressor resistors and other ignition system components.



Ignition Coil Tests

To determine whether a coil is in satisfactory condition, it is necessary to perform both the coil capacity test and the coil secondary continuity test.

1. Observing polarity, connect the battery leads of the coil tester to a battery. (For testing 12 volt coils, a 12 volt battery should be used. For testing 6 volt coils, either a 6 or a 12 volt battery may be used.)

2. Turn battery selector switch of tester to position corresponding with battery voltage.

3. Disconnect all vehicle wires from the coil terminals.

4. Connect tester's test leads one to each coil primary terminal.

NOTE For bench tests, or tests on the vehicle when other than the vehicle battery is used, connect ground lead of tester to the case of the coil.

Coil Capacity Test

5. Turn test selector switch to COIL SET position.

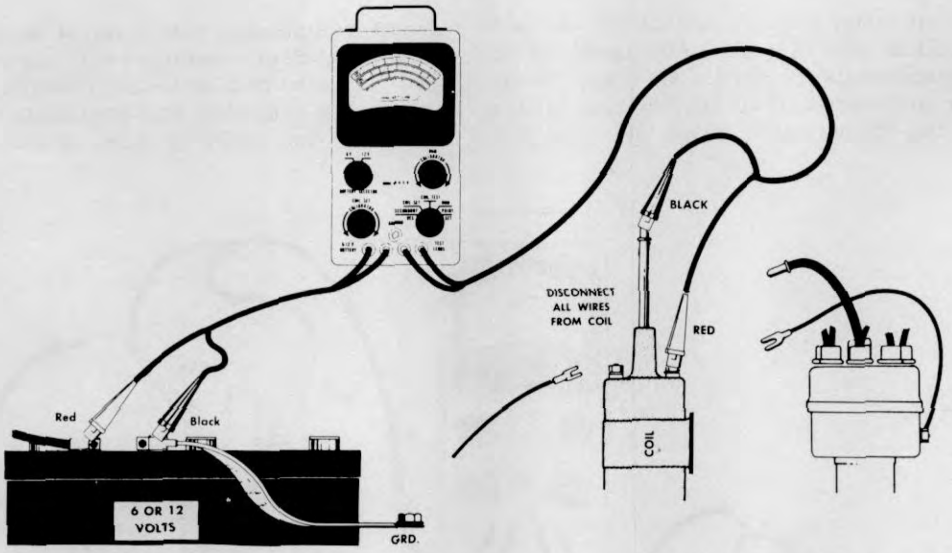
6. Adjust coil set calibrator until meter pointer indicates the specified reading on the COIL SET scale.

Refer to coil test specification chart in this section of the Handbook.

7. Turn test selector switch to COIL TEST position. If coil is good, meter will read steadily in GOOD band. If coil is defective, meter will read in BAD band, or meter reading will read unsteady in the GOOD band.

NOTE If coil capacity shows in the good band, there are no opens, grounds, or shorts in any of the primary or secondary windings. However, it is necessary to test the secondary continuity to be certain that the ends of the secondary windings are securely fastened to their terminals in the coil.

Secondary Continuity Test



1. With test leads still connected as for coil capacity test, turn test selector switch to the OHM position.

2. Adjust the ohm calibrator until the meter pointer is on the OHM SET LINE.

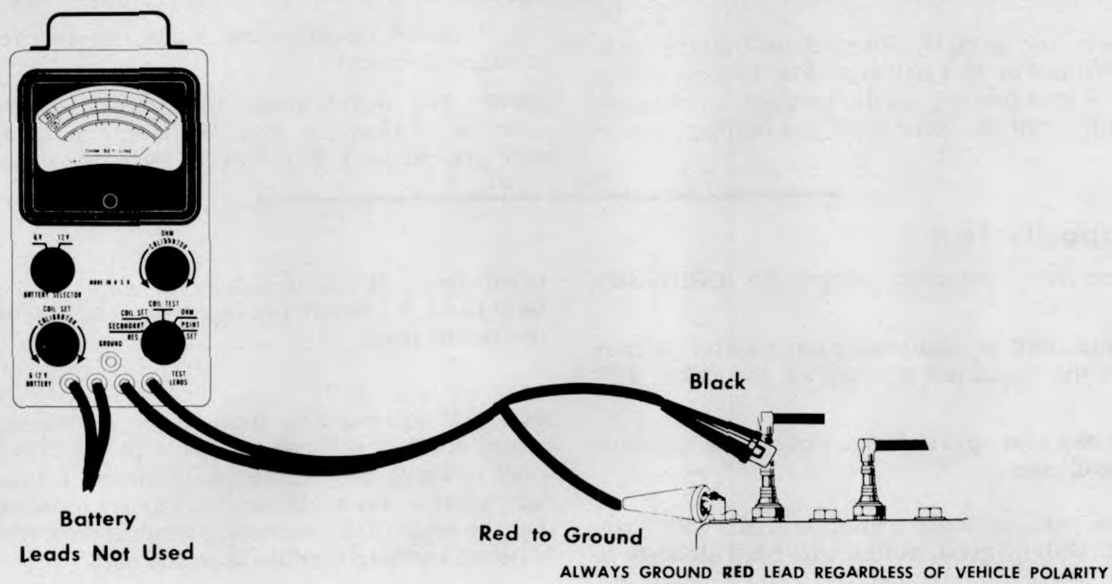
3. Put coil secondary test lead in coil secondary tower.

4. Remove either one of the test leads from the primary terminal, and connect this lead to the coil secondary tower.

5. Read the ohm scale of the meter. Reading should be less than 20K (20,000) ohms for good secondary coil terminal connections.

Secondary Resistance and Polarity Test

Excessive secondary circuit resistance uses up energy which is needed to maintain good ignition under all conditions, severly reduces ignition system reserve, and consequently results in poor performance under severe operating conditions. Incorrect secondary system polarity can result in 40% more voltage being required to fire the spark plugs, causing misfire and erratic engine operation.



1. To prevent generator from operating during this test, connect Generator Field Control into circuit and set knob to OPEN position. (See Generator Field Control section in Handbook.)

2. With tachometer connected, start engine and adjust speed to 1500 RPM. (See Tach Dwell Tester section in Handbook.)

3. Set tester switch to Secondary Resistance position. (Coil Circuit Tester Battery Leads need not be connected to a battery for this test.)

4. Connect Red tester lead to engine ground and connect Black test lead to each spark plug terminal in turn. Observe readings on Secondary Resistance scale (0 to 8) of meter.

Results and Indications

Readings are average for make and type of circuit being tested... secondary circuit in normal condition.

All readings lower than average for make and type of circuit being tested... corroded coil tower terminal, poorly connected or broken coil wire, center cap electrode burned, burned rotor tip, open secondary in coil.

One or more readings lower than average for make and type of circuit being tested... broken or poorly connected spark plug wires, burned or corroded cap terminals, gouged electrodes inside of cap.

Readings higher than average for two or more plugs... Cross fire occuring in the distributor cap or between spark plug cables concerned.

Meter reads off scale to the left with red test clip grounded... Coil secondary polarity reversed: may be due to coil primary wires connected in reverse, wrong coil, or vehicle battery connections reversed.

NOTE On vehicles utilizing suppression type ignition cables, readings can be expected to be somewhat uneven with the lowest readings on the longest cables. Although suppression results in lower test readings, normal suppression does not impare ignition efficiency.

Use of Ohmmeter

The ohmmeter facilities of the coil circuit tester may be used for measuring resistance values which fall within the range of zero to one hundred thousand ohms. Use the scale of the tester with red numerals, and note that the letter "K" represents one thousand ohms.

1. Turn test selector switch to the OHM position.

2. Attach battery leads of the tester to either a 6 or a 12 volt battery.

3. To calibrate, attach test leads together and adjust the ohm calibrator until the meter pointer reads on the OHM SET LINE.

4. Separate test leads and attach one to each end of resistance to be measured, and read the ohm scale.

Calibration of Coil Circuit Tester

To assure accurate tests of ignition coils, the calibration of the Coil Circuit Tester should be checked and/or adjusted periodically. The calibration of the coil circuit tester may vary slightly after long periods of use, due to normal wear of the point rubbing block in the breaker assembly. The calibration should be checked and adjusted as described below.

1. Zero meter pointer to the left end of the scale, using the adjustment on the face of the meter.

2. Connect the tester test lead clips together.

3. Connect the battery leads to a 6 or a 12 volt battery and turn the battery selector to the proper voltage.

4. Turn test selector switch to OHM position, and use the ohm calibrator to adjust the meter pointer to the ohm set line.

5. Turn test selector switch to POINT SET position.

6. Meter now reads the dwell of the coil breaker unit. The pointer should now be on the red 6 of the coil set scale, plus or minus one half division.

If meter does not read within these limits, remove breaker cover located on side of tester. Adjust spacing of tester contacts, with breaker motor running until proper meter reading is obtained. Replace breaker cover, and disconnect test leads. Tester is now properly calibrated for accurate test indications.

TEST "SET NUMBERS" FOR USE WITH SUN COIL TESTERS

FOR COIL CAPACITY TEST, FIRST EXAMINE COIL TO DETERMINE PART NUMBER (DELCO-REMY AND FORD) OR PART NUMBER PREFIX LETTERS DENOTING MODEL (AUTO-LITE), THEN REFER TO CHART FOR SET NUMBER.

COIL TEST SPECIFICATIONS

COIL MAKE	MODEL OR PART NUMBER	TEST VOLTAGE	SET NUMBER
AUTO-LITE	All CE Models	6	10
	All CF Models	12	5
	All *CO Models	12	5
	All *CP Models	12	4.5
	All CR Models	6	8
	All CM Models	12	4.5
	All CZ Models	12	7
	All IG Models	6	7
	All CAB Models	12	4
	All CAC Models	6	9
	All CAD Models	12	7
	All CAE Models	12	6
	All CAF Models	12	4.5
	All CAG Models	12	4.5
	200565, 200572, 200613, 200636, 200637	12	4.5
	All CAH Models	12	8
	200567, 200571	12	8
	All CAL Models	6	8
	All CAM Models	6	8
CHRYSLER	1688212, 2095223	12	8
DELCO-REMY	1115326, 1115327, 1115328, 1115329, 1115330, 1115331, 1115332, 1115333, 1115334, 1115335, 1115336, 1115337, 1115338, 1115351, 1115376, 1115378, 1115380, 1115385, 1115386, 1115387, 1115388, 1115389, 1115390, 1115391, 1115392, 1115393, 1115394, 1115396, 1115397, 1115401, 1115403, 1115404, 1115481	6	9
	1115226, 1115227, 1115379, 1115381, 1115383, 1115384, 1115395, 1115399, 1115400	6	8
	1115081, 1115082, 1115083, 1115084, 1115085, 1115086, 1115087, 1115088, 1115089, 1115090, 1115091, 1115092, 1115094, 1115095, 1115096, 1115097, 1115098, 1115099, 1115100, 1115104, 1115105, 1115106, 1115107, 1115108, 1115109, 1115110, 1115111, 1115485, 1115061, 1115066, 1115112, 1115114, 1115115, 1115118, 1115119, 1115120, 1115121, 1115122, 1115131, 1115132, 1115133, 1115134, 1115135, 1115136, 1115137, 1115154, 1115156, 1115157	12	8
	1115042, 1115043, 1115044, 1115045, 1115046, 1115047, 1115048, 1115049, 1115050, 1115052, 1115053, 1115054, 1115055, 1115056, 1115057, 1115058, 1115251, 1115252, 1115254, 1115255, 1115257, 1115258, 1115259, 1115276	12	5
	1115256, 1115162	12	6.5
ESSEX	62-160-2	12	8
FORD	8BA-12029A	6	8
	FAB-12029B, FAC-12029A, FAY-12029A	12	7

*To test Coil Capacity, connect a Jumper Lead from either Primary Terminal to Coil Case. Do not connect Blue Ground Lead when conducting this test with coil off the vehicle. Meter should read "6" or higher during Coil Capacity Test to be a "Good" Coil. (Read "Coil Set" Scale). To test Coil Secondary Winding Continuity, connect leads to Tower Terminal and Coil Case.

NOTE A non-standard coil should be tested with the same "SET LINE" as the original factory equipment and should also have the same primary draw and secondary resistance.

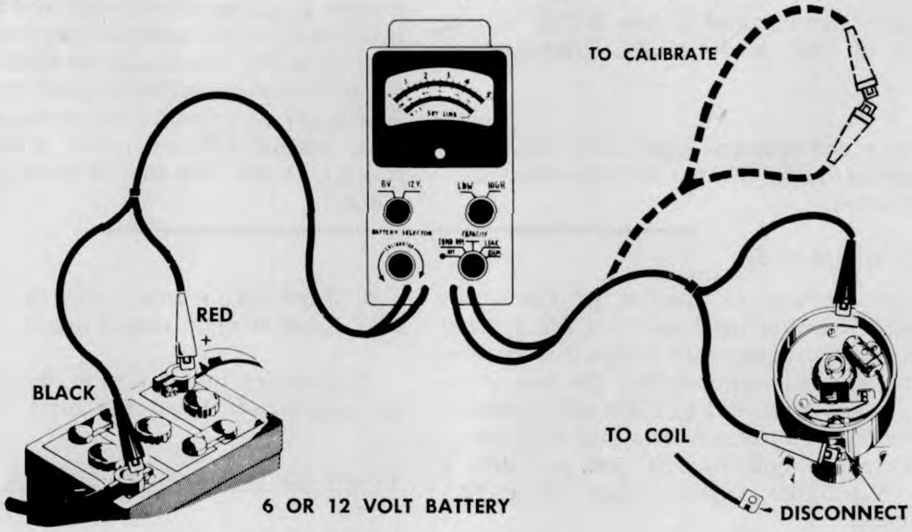
NOTE SET LINE specifications for standard equipment coils not shown above may be established by making Coil Capacity Tests first, on 3 or more new coils of the same model. While in COIL TEST position, turn COIL SET CALIBRATOR until meter pointer reads in the GOOD BAND, then turn TEST SELECTOR switch to COIL SET position. The average reading shown on the meter will be the proper COIL SET specification.

CONDENSER RESISTANCE TESTER

The purpose of the condenser in the ignition system is to prevent arcing and pitting at the breaker points and to aid in collapsing the magnetic field in the ignition coil. In order to function properly, *and to assure good ignition, the condenser must* have three important characteristics.

1. Minimum resistance
2. Correct capacity
3. Minimum insulation leakage

These important factors are conveniently tested on the Condenser Resistance Tester. In addition, the Condenser Resistance Tester is equipped with two Ohmmeter ranges, 0-100 Ohms and 0-100,000 Ohms, providing facilities for testing continuity and condition of many automotive components and circuits.



CALIBRATION

1. Set the Battery Selector Switch to the position which corresponds to the battery voltage, and connect the battery leads of the Condenser Tester to a fully charged 6 or 12 volt battery. If desired, the vehicle's battery may be used.

2. Connect the Condenser TEST leads together.

3. Turn the Tester Selector Switch to Condenser Resistance Position and allow approximately one minute for the tester to warm up.

4. Adjust the calibrator until the meter pointer reads on SET LINE at the right end of the scale.

5. After adjusting the pointer to SET LINE, separate the condenser Tester Leads and proceed with the Tests of the condenser. Do not change the position of the calibrator knob while making condenser tests.

CONDENSER TESTS

Ignition condensers may be tested in or out of the vehicle. If they are to be tested in the vehicle, the condenser must be electrically isolated from the balance of the vehicle's ignition system. Disconnect the wire from the primary terminal of the distributor as shown in the illustration, and block the breaker points open with a piece of fibre between the rubbing block and cam as shown.

CONDENSER RESISTANCE TEST

1. Connect the condenser test leads, one to the primary terminal of the distributor and the other test lead to ground on the distributor body.

2. With the selector switch in the Condenser Resistance position, the meter should read in the BLUE bar at the right end of the scale.

Move condenser pigtail. If a deflection of the meter is noted, the pigtail is making poor contact and the condenser should be replaced.

If reading is in the red bar, marked "Resistance," move the grounded lead of the Condenser Tester to the body of the condenser. If the reading improves, the condenser is not properly grounded to the distributor housing.

CAPACITY TEST (Microfarad)

1. Turn the selector switch to the CAPACITY position.

2. Read top scale of the meter for the microfarad capacity of the condenser being tested.

3. Refer to manufacturer's specifications for condenser capacity in microfarads.

If tester reading in microfarads does not fall within tolerances specified for condenser being tested, the condenser should be replaced.

LEAKAGE TEST

1. Turn selector switch to LEAKAGE position.

2. The meter should read in the BLUE bar at the left end of the scale if the condenser is satisfactory.

If meter pointer reads to the right of the blue bar, condenser insulation is leaking and the condenser should be replaced.

IMPORTANT If the condenser does not test good while mounted in the distributor, remove the condenser from the distributor and retest it. The same procedure is followed whether testing condensers in or out of the vehicle. If the condenser tests bad in the distributor, but tests good when removed, there is a short or ground in the distributor primary circuit. Inspect the insulation of the distributor primary terminal and the internal circuit of the distributor.

USE OF THE OHMMETER

The Condenser Resistance Tester provides two ohmmeter scales which may be used for testing the condition and the continuity of ignition system and electrical system components. The low ohmmeter scale, reads from left to right and provides a test range from 0-100 ohms. The high ohmmeter scale, reads from right to left and provides a range from 0-100,000 Ohms. (The letter "K" represents 1000.)

1. Connect battery leads to a 6 or 12 volt battery.

2. Turn battery selector switch to the position corresponding to the battery voltage.

3. Turn the selector switch to the OHM position.

To use the low scale (0-100)

4. Turn ohmmeter selector switch to LOW position.

5. Do not connect the test leads together.

6. Turn calibrator until the pointer reads on SET LINE at right end of scale.

7. Connect test leads to the resistance unit to be measured. Read the lower 0-100 ohm scale.

To use the high scale (0-100,000 ohms)

8. Turn Ohmmeter Selector Switch to HIGH position.

9. Connect the Test Leads together.

10. Turn Calibrator until the pointer reads on SET LINE on right end of scale.

11. Disconnect Test Leads and connect them to the resistance to be measured. Read 0-100,000 scale.

CAUTION Do not connect the test leads of an Ohmmeter across any source of voltage.

SUGGESTED APPLICATIONS FOR THE OHMMETER

1. Circuit continuity... Low Ohm scale. For locating broken wires or poor connections in such circuits as: horn, overdrive, turn signals, lights, etc. Reference to the wiring diagram for the vehicle being tested aids in making continuity checks.

2. Bench testing of relays, Solenoids, Switches, Etc.,... Low Ohm Scale. This test is primarily for checking continuity of the actuating coils or windings of relays, and components.

3. Generators... On or off the vehicle... Low Ohm Scale. For checking generator circuit continuity and field coil resistance.

4. Regulators... On or off the vehicle... Low Ohm Scale. For locating open resistors or shunt windings.

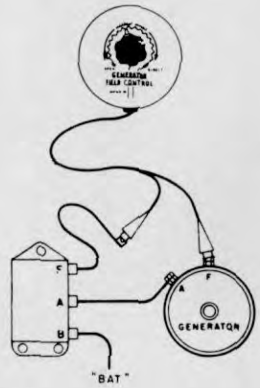
5. Car Radios... Antennas... Check for shorts or grounds. Tubes... Check for open filament. Use low Ohm Scale.

6. Suppressor resistors in rotors, caps, spark plugs, wires,... etc.... High Ohm Scale.

GENERATOR FIELD CONTROL

The Generator Field Control provides a convenient means of varying generator output without changing the vehicle's engine speed. It is equally applicable to either D.C. or A.C. systems.

As indicated in other sections of this Handbook, (i.e., Sun Scope, Combustion Efficiency Tester, Volts Ignition Tester, and Coil Circuit Tester) for the purpose of providing stable test conditions, it is necessary to prevent the generator from producing electrical power while certain tests are being performed. By using the Generator Field Control in the prescribed manner, generator output can be reduced to zero without danger of damage to any charging system component. The operator has full control of generator performance at all times.



NOTE Engine must be stopped when connecting or disconnecting the Generator Field Control.

1. Disconnect Charging System Field Circuit, either at generator (alternator) or at regulator, whichever connection is more accessible.

2. Connect the leads of the field control, one to the end of the vehicle's field wire, the other to the field terminal. (Refer to illustration.)

3. Set Generator Field Control Knob to its OPEN position. (Generator will now be inoperative.)

4. Start engine and proceed with tests in their prescribed manner.

5. Should it be desired that the generator operate at regulated voltage, such as for "Charging Voltage Test", gradually rotate the Field Control Knob to its DIRECT position. (Generator voltage will increase until it reaches maximum value permitted by the setting of voltage regulator.)

Additional Uses

The Generator Field Control, used with a Volts-Ampere Tester, provides a convenient means of controlling generator operation when performing tests of generator output and cutout relay functions.

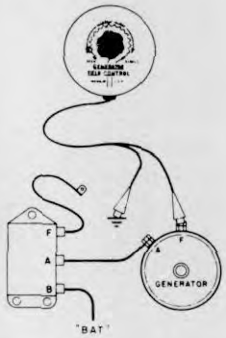


Fig. A

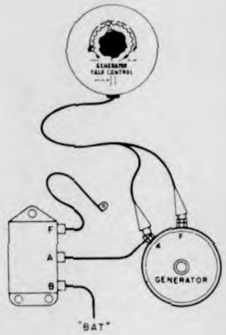


Fig. B

1. Connect Generator Field Control as illustrated:-

Illustration A - for systems having field circuit grounded externally.

Illustration B - for systems having field circuit grounded internally.

2. For Generator Output Test - operate engine at specified RPM, set generator field control to its DIRECT position and observe test ammeter for generator output in amperes.

3. For Cutout Relay Tests - operate engine at approximately 1000 RPM, gradually rotate field control from OPEN towards its DIRECT position, while observing test voltmeter for reading of voltage required to close the cutout relay. After closing voltage has been tested, slowly rotate field control from DIRECT towards its OPEN position, while observing test ammeter for reading of reverse current necessary to open cutout.

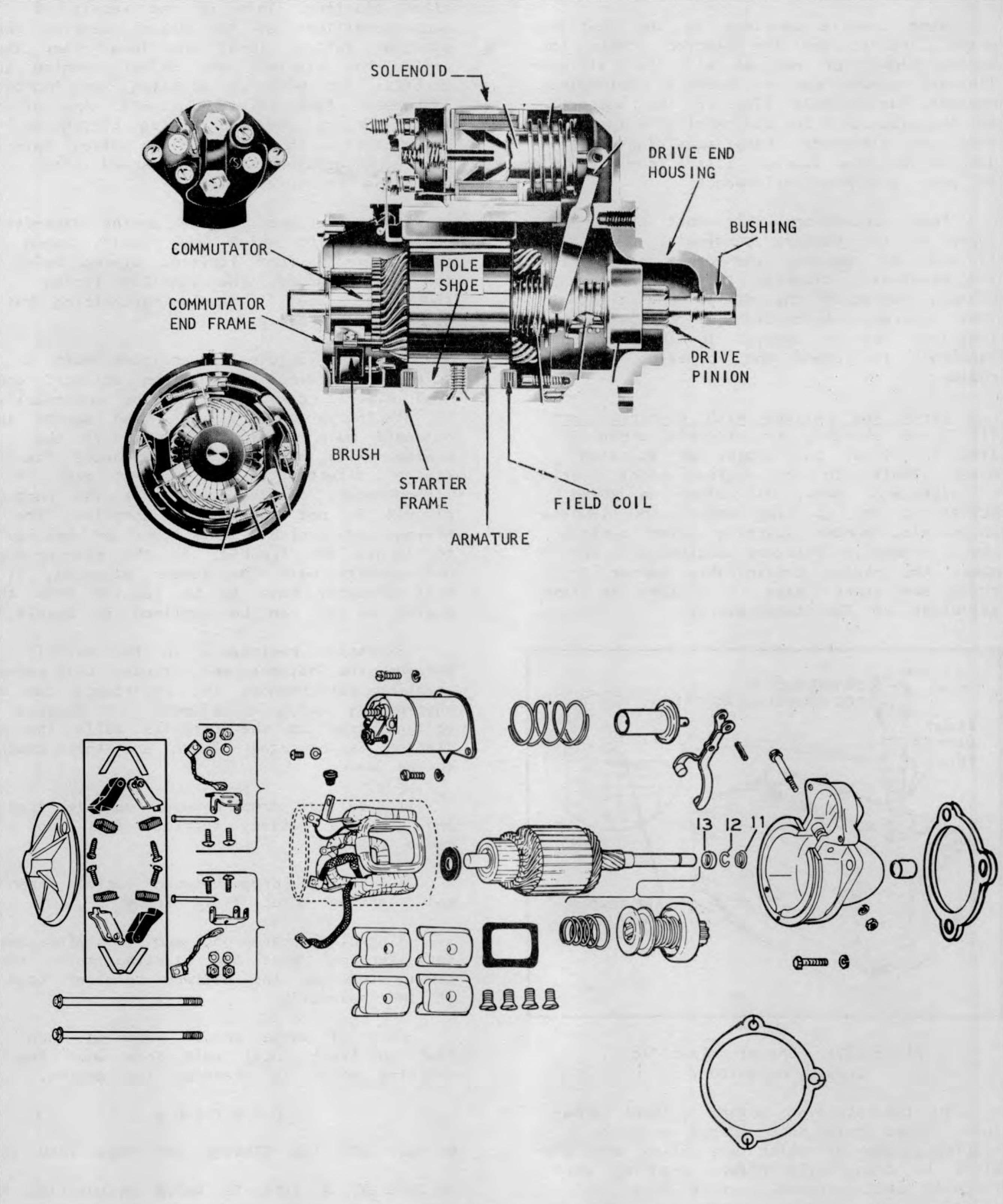


Plate 6997. Starter

STARTING MOTORS

When trouble develops in the starting motor circuit, and the starter cranks the engine slowly or not at all, several preliminary checks can be made to determine whether the trouble lies in the battery, in the starter, in the wiring between them, or elsewhere. Many conditions besides defects in the starter itself can result in poor cranking performance.

Poor connections will most often be found at the battery terminals. Correction is made by removing the cable clamps from the terminals, cleaning the terminals and clamps, replacing the clamps and tightening them securely. A coating of corrosion inhibitor may be applied to the clamps and terminals to retard the formation of corrosion.

Check the battery with a hydrometer: If it is charged, the trouble probably lies in either the engine or starting motor itself. In the engine, tight bearings or pistons or heavy oil place an added burden on the starting motor. Low temperatures also hamper starting motor performance since it thickens engine oil and makes the engine considerably harder to crank and start. Also, a battery is less efficient at low temperatures.

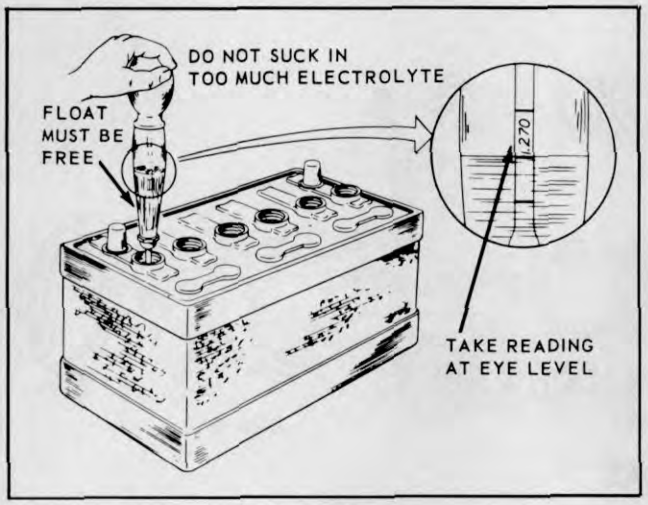


Plate 6271. Checking Specific Gravity of Battery

In the starting motor, a bent armature, loose pole shoe screws or worn bearings, any of which may allow the armature to drag, will reduce cranking performance and increase current draw. In addition, more serious internal damage is sometimes found. Thrown armature windings or commutator bars, which sometimes occur on overrunning clutch drive starting motors, are usually caused by excessive overrunning after starting. This is the result of such conditions as the driver keeping the starting switch closed too long after the engine has started, the driver opening the throttle too wide in starting, or improper carburetor fast idle adjustment. Any of these subject the overrunning clutch to extra strain so it tends to seize, spinning the armature at high speed with resulting armature damage.

Another cause may be engine back-fire during cranking which may result, among other things, from ignition timing being too far advanced. The ignition timing should be reset if engine back-firing has caused the trouble.

If the vehicle is equipped with a solenoid starting switch, the solenoid control circuit can be eliminated momentarily by placing a heavy jumper lead across the solenoid main terminals to see if the starter will operate. This connects the starter directly to the battery and, if it operates, it indicates that the control circuit is not functioning normally. The wiring and control units must be checked to locate the trouble. If the starter does not operate with the jumper attached, it will probably have to be removed from the engine so it can be examined in detail.

Excessive resistance in the circuit between the battery and starter will reduce cranking performance. The resistance can be checked by using a voltmeter to measure voltage drop in the circuits while the starter is operated. There are three checks to be made:

1. Voltage drop between vehicle frame and grounded battery terminal post (not cable clamp).

2. Voltage drop between vehicle frame and starting motor field frame.

3. Voltage drop between insulated battery terminal post and starting motor terminal stud (or the battery terminal stud of the solenoid).

Each of these should show no more than one-tenth (0.1) volt drop when the starting motor is cranking the engine.

CAUTION

DO NOT USE THE STARTER FOR MORE THAN 30 SECONDS AT A TIME TO AVOID OVERHEATING IT.

If excessive voltage drop is found in any of these circuits, make correction by disconnecting the cables, cleaning the connections carefully, and then reconnecting the cables firmly in place.

Starting Motor Service: To obtain full performance data on a starting motor or to determine the cause of abnormal operation, the starting motor should be submitted to a no load and torque test. These tests are best performed on a starter bench tester with the starter mounted on it. From a practical standpoint, however, a simple torque test may be made quickly with the starter in the vehicle. Make sure the battery is fully charged and that the starter circuit wires and terminals are in good condition. Then operate the starter to see if the engine turns over normally. If it does not, the torque developed is below standard and the starter should be removed for further checking.

Removing Starter From Engine: the general procedure for removing a starter from the engine is as follows: Disconnect the leads from the starter. (When the switch is mounted on the motor, the battery lead should be covered with friction tape or a short piece of hose to prevent it from short-circuiting against any metal surface.) Disconnect any linkage directly connected to the starting motor or yoke. Then take out the mounting bolts and lift the starter from the engine.

Disassembly Starting Motor: The disassembly procedure to be followed will vary according to the type and construction of the starting motor. Normally, disassembly should proceed only so far as it is necessary to make repair or replacement of defective parts. For example, the field coils should be checked for opens or grounds and if found to be in normal condition, they should not be removed from the field frame.

1. If the brush holders are of the reaction type, lift the spring with a hook made of stiff wire and take the brushes out of the holders. On swinging type brushes, disconnect the field coil lead from the brush and slightly tighten the screw to keep the brush in place.

2. Before disassembling commutator end heads that are fastened by a number of screws into the end of the field frame, scratch a mark on the frame and head so that they can be reassembled in their original position. This is not necessary on motors using through bolts to hold the heads and having a dowel pin to locate the commutator end head position.

3. Take out the through bolts or commutator end head and drive end housing attaching screws. If necessary, tap the commutator end head slightly with a rubber or plastic hammer and remove the head.

4. Lift off the drive end head (or pinion housing) and the armature. On types having an intermediate bearing, the armature will remain in the pinion housing. On most motors, this bearing assembly is a press fit in the pinion housing and can be forced out with an arbor press bearing on the drive end of the shaft. A few types of motors use a screw or a lock ring to hold the intermediate bearing in place. These must be removed before pressing the armature out of the pinion housing. Gear reduction motors require the removal of the intermediate housing screws to complete their disassembly.

Armature Inspection and Service

1. Visually inspect the armature for mechanical defects such as a worn or bent shaft, worn commutator, scored core laminations, and to see that all windings are properly in place in the core slots.

2. Inspect for evidence of excessively high speeds which would throw the windings outward at the ends and may even cause them to leave the core slots.

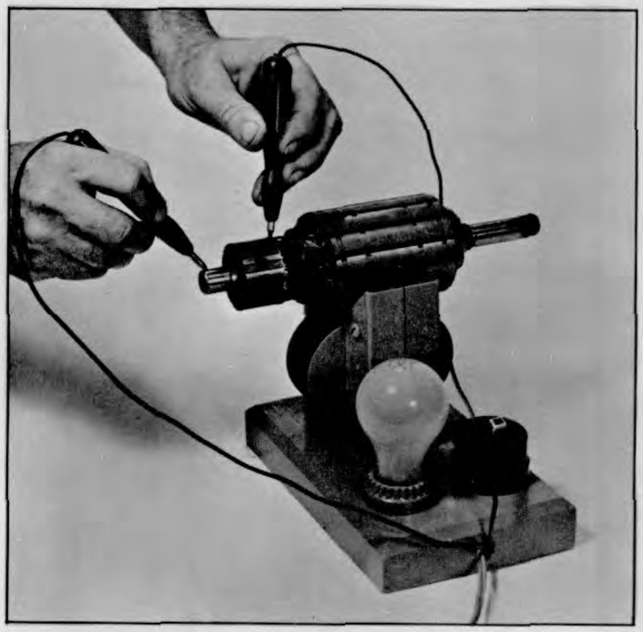


Plate 7222. Testing Armature for Grounds

3. Inspect to see that all windings are properly staked and soldered to the commutator. Resolder if necessary, with rosin core solder, being careful not to short between coils and commutator bars.

4. With test clips or points test the armature for grounds by touching the shaft with one point and the commutator with the other. Do not touch the test points to the bearing or brush surfaces as an arc would burn the smooth finish. If the lamp lights, the armature is grounded and should be replaced.

5. Clean the commutator with 00 sandpaper and remove all dirt from between the bars.

6. Place the armature shaft bearing surfaces on V blocks, and mount a dial indicator against the commutator.

7. Turn the armature slowly and read the total runout as indicated on the dial gauge. If runout exceeds .003", the commutator should be turned down with a lathe to make it concentric.

8. Mount the armature in the lathe by the shaft bearing surfaces (not shaft centers), and take light cuts until the commutator is completely cleaned up. Remove all burrs with 00 sandpaper. This trueing up of the commutator should also be done if it is rough, burned or if the mica extends above the surface of the copper. Recheck runout after turning the commutator.

9. Undercut the mica 1/64" measured depth. This cut should be exactly centered on the mica and the cutting tool used should be .002" wider than the mica. The undercut should be clean and square.

10. If the burrs on the copper after undercutting are not large they can be left on the commutator to help seat the brushes after assembly. However, be sure to remove the burrs with 00 sandpaper before completing the overhaul.

11. Place the armature on an open core transformer, otherwise known as a growler, and hold a hacksaw blade on the core. Rotate the armature slowly and if the armature is shorted the hacksaw blade will become magnetized and vibrate.

12. If a short is present, inspect the commutator risers and bars for copper chips or solder that may be shorting between the bars. If shorts cannot be found, replace the armature.

Frame and Field Coil Service

1. Clean the frame and field with a cloth dampened in cleaning solvent but do not soak insulation or brushes.

2. Inspect for faulty insulation and stripped threads.

Plate 6996. Checking Armature For Short Circuit

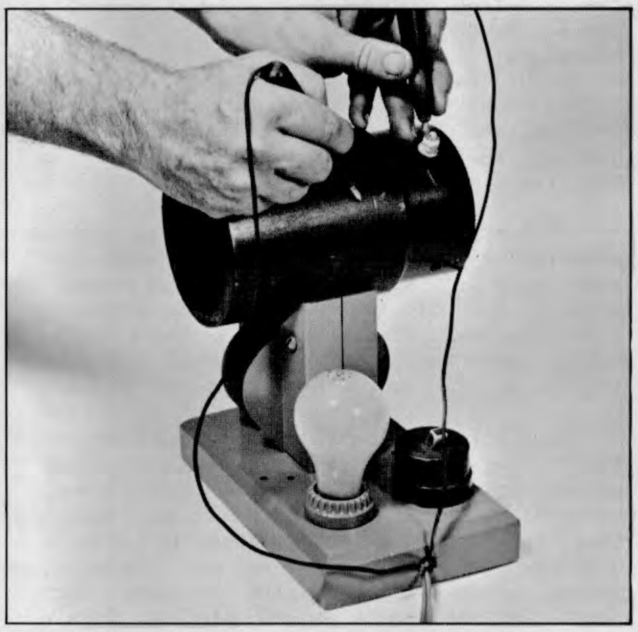


Plate 7223. Testing Field Circuit for Ground

3. With a test lamp, check for grounds by touching the terminal stud with one test point and an unpainted spot on the frame with the other test point. Be sure brushes or leads are not in contact with the frame. If the lamp lights, there is a ground in the field circuit.

4. If a ground is present, remove the terminal stud nuts and if the stud is removable, press it out of the frame. Then recheck the field coils for grounds as before.

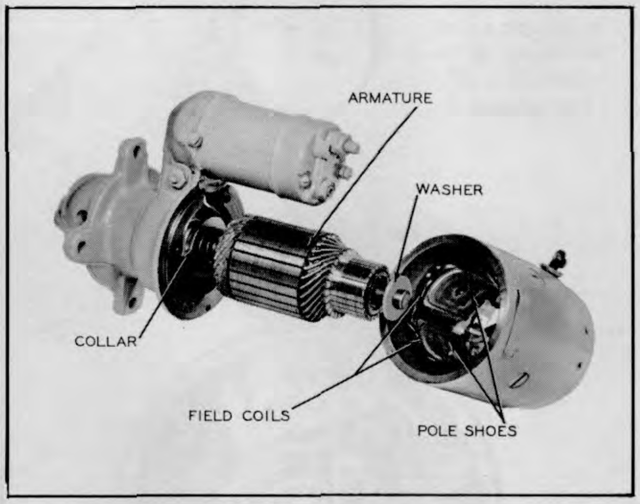


Plate 6237. Armature and Field Coils

5. If the terminal stud is soldered to the field coils or if the field coils are grounded, remove the pole shoe screws and take the coils out of the frame. It is good practice to mark one end of the frame and also the shoes before disassembly so that they can be installed in their original position.

6. Replace any faulty or damaged parts, making sure all connections are tightly clinched and soldered to be sure that no high resistance connections are present.

7. When installing field coils and shoes, a pole shoe spreader and pole shoe screwdriver should be used to insure a tight installation of the coils and shoes.

8. Be sure the pole shoes are installed in the same location and direction as they were originally. On some motors, the shoes are bored after assembly and when they are interchanged they may interfere with the armature. On other motors, the two tips of the shoes are not alike. However, on this type, the long tip is always the trailing edge.

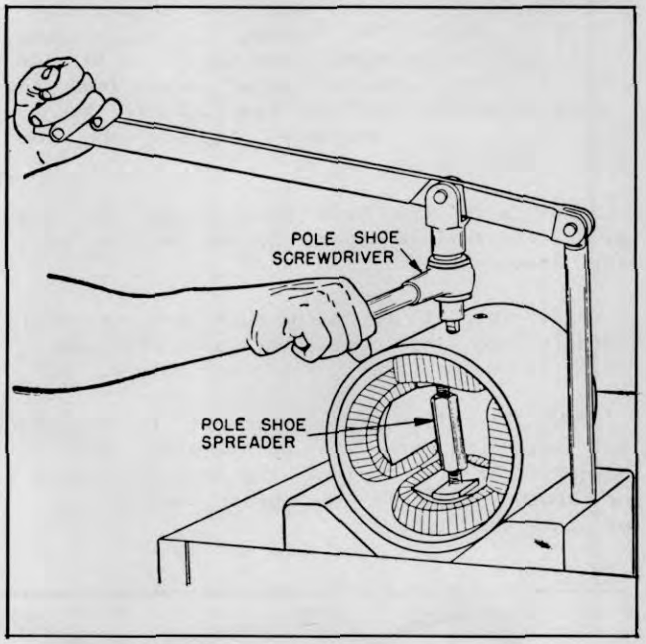


Plate 6994. Field Coil Removal

9. If the brushes are oil soaked or are worn to less than 1/2 their original length they should be replaced.

10. To remove the brushes, unsolder and unclinch the lead from the field coil or connector.

11. Insert the new brush lead to its full dept and insert the equalizer lead (if used).

12. Clinch tightly and solder to make a low resistance connection. Do not use acid for soldering flux as it will damage the insulation. Use a rosin or alcohol solution.

Commutator End Head Service

1. Clean the commutator end head, being careful not to soak the brushes in solvent.

2. Inspect for a cracked, bent or distorted head and replace if these conditions are present.

3. Place the armature in a padded vise and install the commutator end head on the end of the armature shaft.

4. Do not clamp the armature tightly as this distorts the laminated core.

5. Feel the fit of the bearing on the shaft. If side play is excessive, the bearing or shaft is worn and should be replaced. Where the bearing is replaceable, it should be pressed into place with the correct arbor, as the arbor determines the inside diameter of the bearing. If the bearing is not removable, replace the complete head.

6. With the head mounted on the armature, install a spare brush in one of the holders.

7. Inspect to make sure the brush is parallel to the commutator segments and that it moves freely in the holder.

8. To align the brush it is necessary to install a new arm on swinging type holders, or to replace the complete head or brush plate if the brush holders are of the box type.

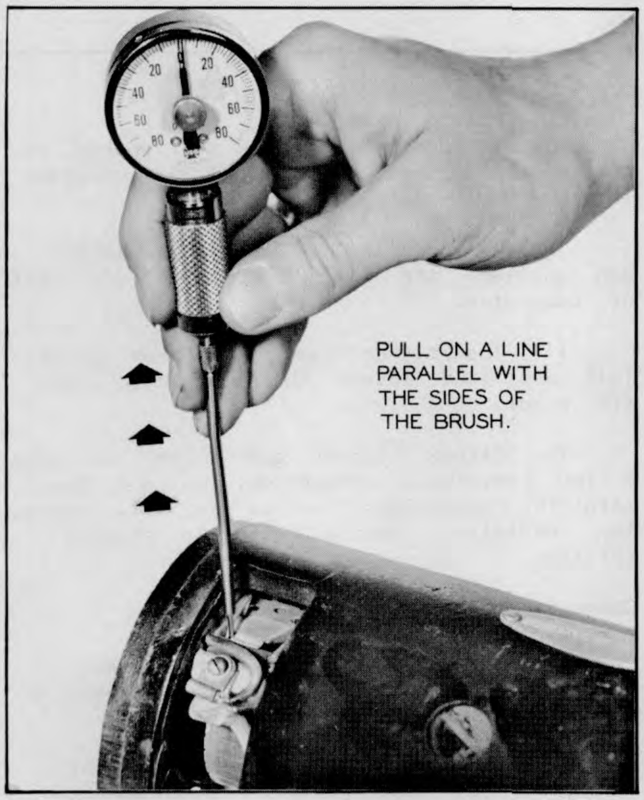


Plate 6450. Checking Brush Spring Tension

9. Measure the brush spring tension with a spring scale hooked under the brush spring, or brush screw, near the end. Pull the scale on a line parallel to the edge of the brush and take the reading just as the spring leaves the brush, or just as the brush leaves the commutator. (Refer to specifications for proper brush spring tension).

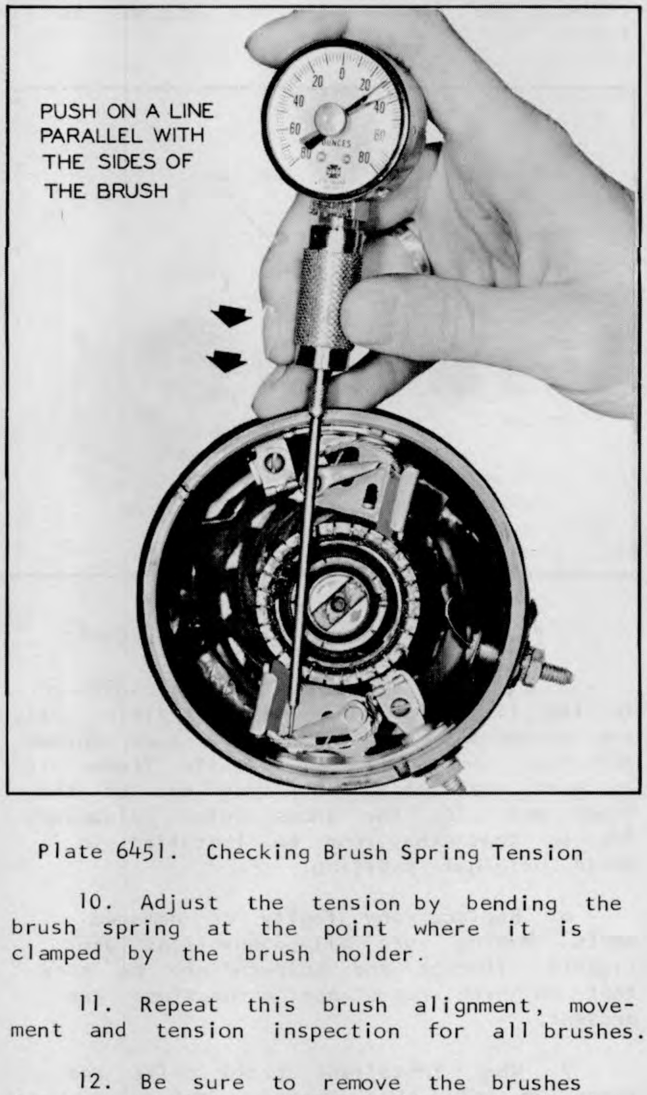


Plate 6451. Checking Brush Spring Tension

10. Adjust the tension by bending the brush spring at the point where it is clamped by the brush holder.

11. Repeat this brush alignment, movement and tension inspection for all brushes.

12. Be sure to remove the brushes from the holders before taking the head off the armature as they may become chipped or cracked if they are allowed to snap off the commutator.

13. If the brush leads are broken or frayed or if the brushes are oil soaked, chipped or cracked, or worn less than 1/2 their original length, the brushes should be replaced.

14. Brushes that are soldered to the field coils or connectors should be replaced as outlined under Frame and Field Coil Service. Brushes that have the ground terminal riveted under the brush holder should have the lead unsoldered and the terminal unclamped.

15. Insert the lead to its full length in the terminal and clamp tightly. Solder it to make a strong and electrically tight connections, using a high temperature solder and a rosin flux. Do not use acid.

Drive End Head Service

1. Thoroughly clean the head or pinion housing and inspect for cracks.

2. Try the fit of the armature shaft in the bearing and replace the bearing if the side play is excessive.

3. When installing a new bearing, be sure to support the housing so that it does not twist or damage the bearing.

4. Install a new bearing, using the correct arbor, as it is designed to give the proper inside diameter of the bearing without the necessity of reaming or scraping.

5. Soak the bearing in S.A.E. 10 engine oil and remove the excess oil from the housing or head.

Starter Drive Service

Starter drives fall into one or the other of two basic groups, the type that uses the principle of the overrunning clutch, and the Bendix, which uses the spinning nut principle.

Starter drive troubles are easy to diagnose and they usually cannot be confused with ordinary starter difficulties. If the starter does not turn over at all or if it drags, look for trouble in the starter or electrical supply system. Concentrate on the starter drive or ring gear if the starter is noisy, if it turns but does not engage the engine, or if the starter won't disengage after the engine is started. After the starter is removed, the trouble can usually be located with a quick inspection.

Worn or chipped ring gear or starter pinion are the usual causes of noisy operation. Before replacing either or both of these parts try to find out what caused the damage. With the Bendix type drive, incomplete engagement of the pinion with the ring gear is common cause of tooth damage. The wrong pinion clearance on starter drives of the overrunning clutch type leads to poor meshing of the pinion and ring gear and to rapid tooth wear.

A less common cause of noise with either type of drive is a bent starter armature shaft. When this shaft is bent, the pinion gear alternately binds and then only partly meshes with the ring gear. Most manufacturers specify a maximum of .003" radial run-out on the armature shaft.

Overrunning Clutch Type Drives: Seldom become so worn that it fails to engage since it is directly activated by a fork and lever. The only thing that is likely to happen is that, once engaged, it will not turn the engine because the clutch itself is worn out. A much more frequent difficulty and one that rapidly wears ring gear and teeth is partial engagement. Proper meshing of the pinion is controlled by the end clearance between the pinion gear and the starter housing or the pinion stop, if one is used.

Cranking motors having a thrust washer require a clearance of 3/16", whereas those cranking motors having a thrust plug require 1/8" clearance. The difference in the pinion clearance is due to a difference in the thickness of the "nose" housing. The absence of the thrust washer and the use of the plug make this type construction easy to identify. No change is required in the procedure of adjusting pinion clearance.

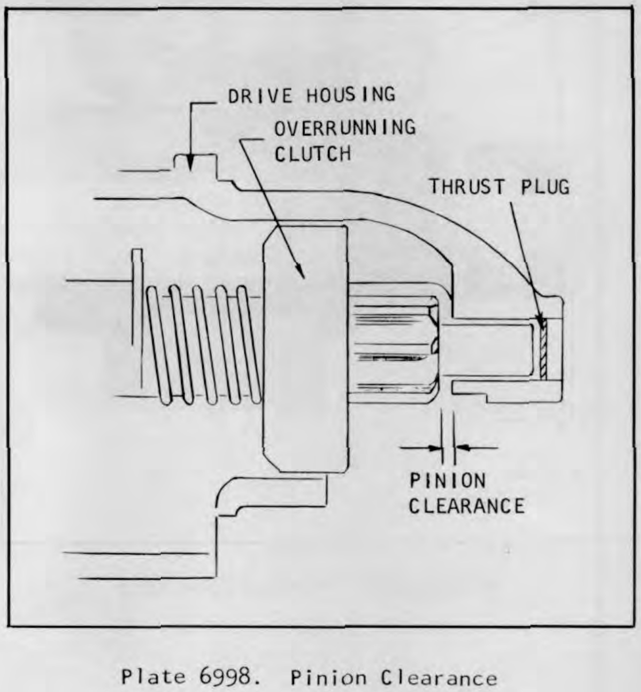


Plate 6998. Pinion Clearance

Clamp the cranking motor in a vise and remove the cable from the "motor" terminal of the solenoid so the cranking motor will not operate. For the type motor having a thrust washer, place a piece of 3/16" bar stock or gauge between the pinion and the housing. If the motor has a thrust plug, place a piece of 1/8" bar stock or gauge between the pinion and the housing. Connect a battery cable of the proper voltage between the "switch" terminal of the solenoid and the solenoid base (ground), and push the solenoid plunger in by hand. Battery current will hold the plunger in the "bottomed" position while the pinion clearance is adjusted. Loosen the solenoid switch mounting screws and pull the solenoid switch away from the shift lever until play is taken out of the lever and clutch mechanism. DO NOT COMPRESS OVERRUNNING CLUTCH SPRING. Moving switch toward lever increases clearance, and moving switch away from lever decreases clearance. When correct adjustment is obtained tighten solenoid switch mounting screws and replace connector at "motor" terminal of solenoid.

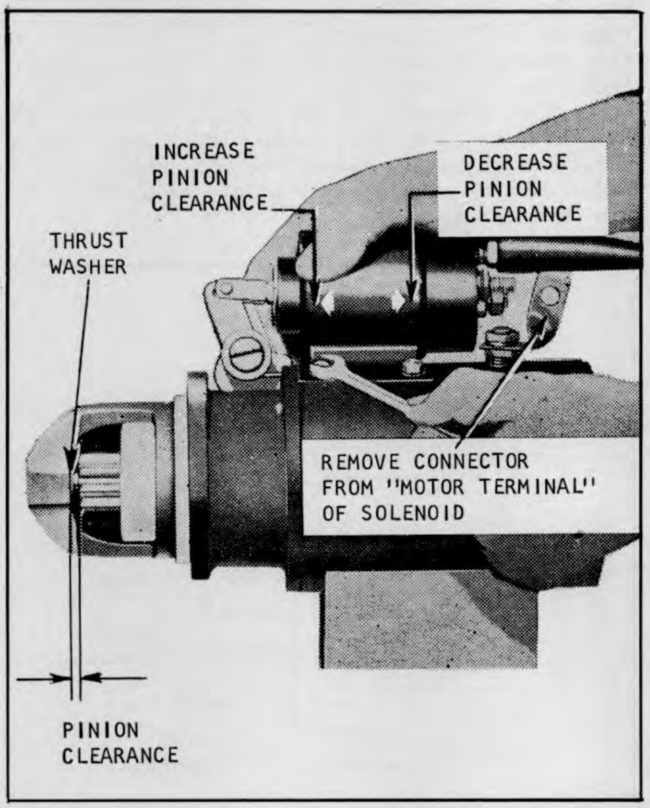


Plate 6999. Pinion Clearance

On some model starters the solenoids are completely enclosed in the starter housing and the pinion clearance is not adjustable. If the clearance is not correct, the starter must be disassembled and checked for excessive wear of solenoid linkage, shift lever mechanism, or improper assembly of parts.

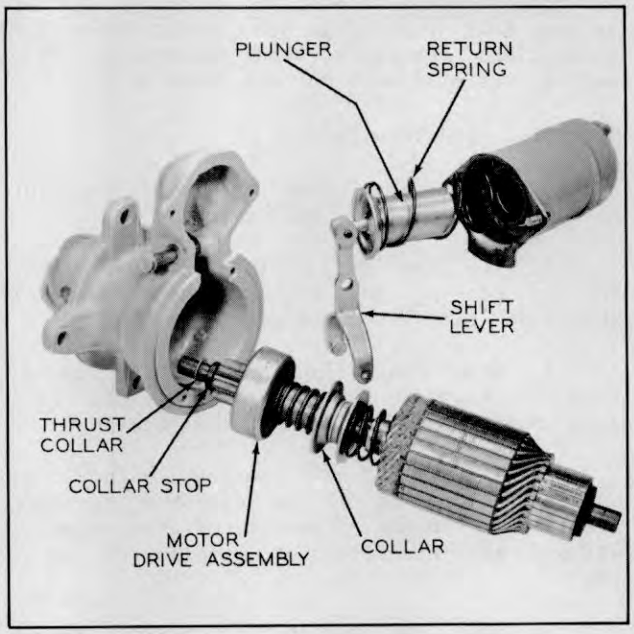


Plate 6238. Starter With Enclosed Solenoid Housing

Failure of the overrunning clutch drive to disengage is usually caused by binding between the armature shaft and the drive. If the drive, particularly the clutch, shows signs of over-heating it indicates that it is not disengaging immediately after the engine starts. If the clutch is forced to overrun too long, it over-heats and turns a bluish color. For the cause of binding, look for rust or gum between the armature shaft and the drive, or for burred splines. Excess oil on the drive will lead to gumming, and inadequate air circulation in the flywheel housing will cause rust.

Overrunning clutch drives cannot be overhauled in the field so they must be replaced. In cleaning, never soak them in a solvent because the solvent may enter the clutch and dissolve the sealed-in lubricant. Wipe them off lightly with solvent and lubricate them sparingly with S.A.E. 10 or 10W oil.

When a Bendix Type Drive doesn't engage the cause usually is one of three things: either the drive spring is broken, one of the drive spring bolts has sheared off, or the screw-shaft threads won't allow the pinion to travel toward the flywheel.

In the first two cases, remove the drive by unscrewing the set screw under the last coil of the drive spring and replace the broken parts. Gummed or rusty screw-shaft threads are fairly common causes of Bendix drive failure and are easily cleaned with a little solvent or steel wool, depending on the trouble. Here again, as in the case of overrunning clutch drives, use light oil sparingly, and be sure the flywheel housing has adequate ventilation. Breather holes in the housing should be kept open.

Bendix Folo-Thru Drives: Incorporates a device that keeps the pinion engaged to the flywheel until the engine reaches a specified R.P.M. When replacing one of these drives, be sure that you have the correct drive for the vehicle. The drives are rated differently and the correct one must be used for the vehicle being serviced. The Folo-Thru, incidentally, is not supposed to be repaired in the field because of the danger of incorrectly assembling the carefully calibrated springs in the pinion head.

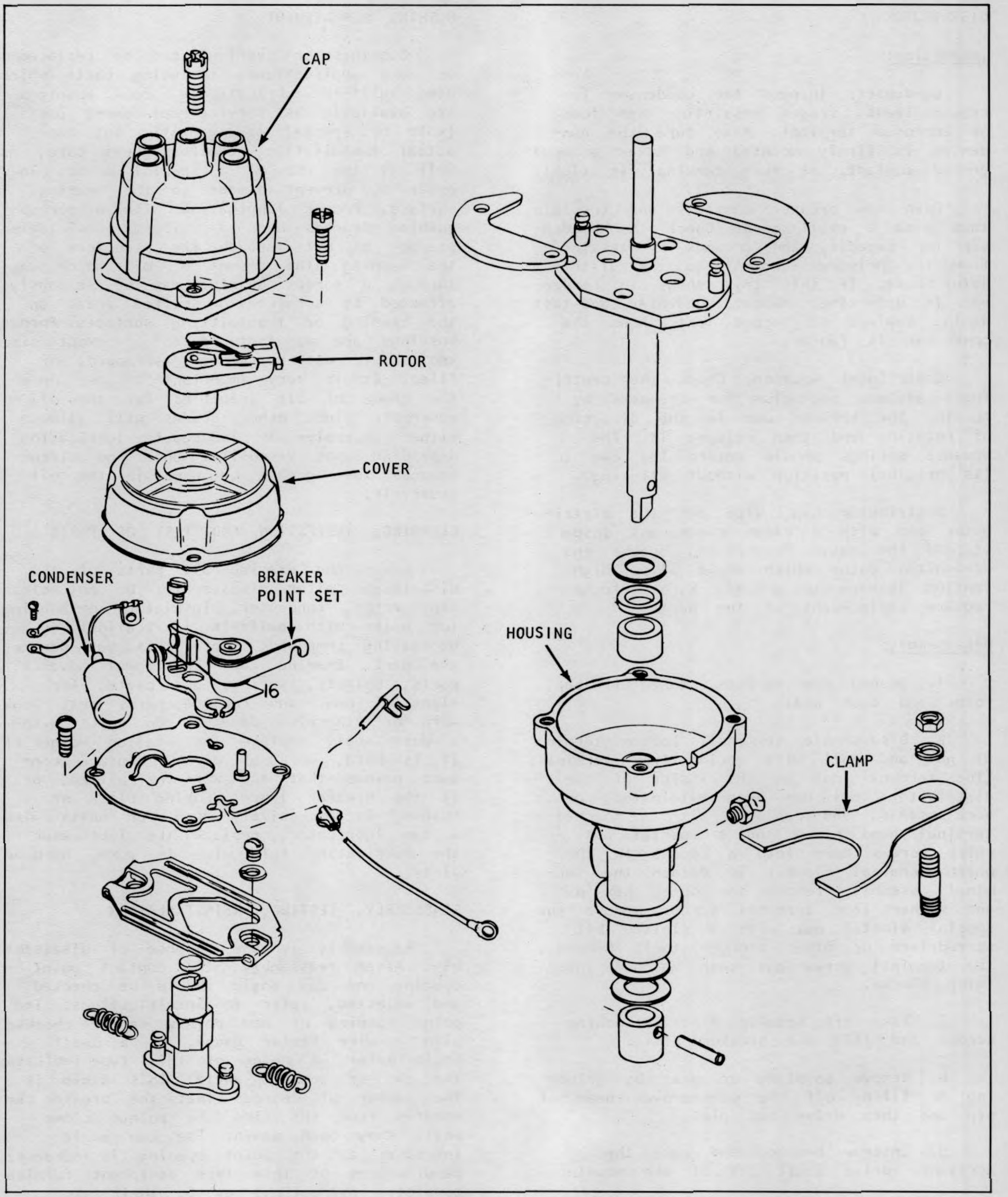


Plate 9633. Distributor

DISTRIBUTOR

Inspection:

Condenser: Inspect the condenser for broken leads, frayed insulation and loose or corroded terminal. Make sure the condenser is firmly mounted and makes a good ground contact. Be sure terminal is tight.

Open the breaker contacts and insulate them with a small card. Check the condenser for capacity and grounds by testing from the primary terminal to the distributor base. If this test shows to condenser is defective, remove condenser and test again. Replace if second test shows the condenser is faulty.

Centrifugal Advance. Check the centrifugal advance mechanism for freeness by turning the breaker cam in the direction of rotation and then release it. The advance springs should return the cam to its original position without sticking.

Distributor Cap. Wipe out the distributor cap with a clean cloth and inspect it and the rotor for chips, cracks and carbonized paths which would allow high-tension leakage to ground. Such defects require replacement of the part.

Disassembly:

1. Unsnap cap springs, take off cap, rotor and dust seal.

2. Disassemble terminal. Loosen terminal nut and pull wire spring from terminal. (The terminal nut on the inside of the distributor bowl has been eliminated, on some models, and replaced with a notched terminal head screw and a special nut which screws down into a recess in the outer terminal block.) To detach the terminal assembly, remove the outer hex nut and washer from terminal screw. Remove the special slotted nut with a slotted bit screwdriver or other pronged tool. Remove the terminal screw and both matched insulator blocks.

3. Take off breaker plate attaching screws and lift out breaker plate.

4. Remove coupling or gear by grinding or filing off the peened-over head of pin and then drive out pin.

5. Unscrew bearing and take the accessory drive shaft out of the housing.

6. Shaft and advance mechanism can now be lifted out. Advance mechanism is disassembled by taking off nuts fastening hold-down plate in place.

BUSHING REPLACEMENT

Bushings or bearings can be replaced on many applications, including units, which have built-in lubrication. Forous bushings are available as service replacement parts (sold by special arrangement), but the actual installation requires great care, as well as the use of a special arbor, in order to prevent damage to the bearing surface. Proper lubrication with a porous bushing depends upon a uniform predictable seepage of oil through the structure of the bushing. The amount of oil which seeps through a porous bushing may be seriously affected by scratches or scuffed areas on the bearing or transmitting surfaces. Porous bushings are manufactured to an exact size and should not be reamed, scrapped, or filed. It is very important to use only the grade of oil specified for the oil reservoir since other grades will allow either excessive or inadequate lubrication depending upon viscosity. Under no circumstances must grease be used in the oil reservoir.

CLEANING, INSPECTION AND TEST OF PARTS

Clean and examine all parts of the distributor after disassembly. Do not clean cap, rotor, condenser, insulators or housing (on units with built-in lubrication) in any degreasing compound, since this may damage the part. Examine the centrifugal advance parts, weights, springs and plate, for signs of wear and replace parts that look worn or otherwise damaged. On units with a dust seal, replace the sealing washer if it is hard, worn or dirty. Replace contact points that are worn or pitted, or if the breaker lever rubbing block or bushing is excessively worn. On units with a cam lubricator, replace the lubricator if the lubricating felt wick is worn, hard or dirty.

REASSEMBLY, TESTING, REINSTALLATION

Reassembly is the reverse of disassembly. After reassembly, the contact point opening and cam angle should be checked and adjusted, refer to Specifications. The point opening of new points can be checked with a wire feeler gauge, or a Dwell Angle Meter. A meter of this type indicates the cam or contact angle. This angle is the number of degrees that the breaker cam rotates from the time the points close until they open again. The cam angle increases as the point opening is increased. Manufactures of this type equipment furnish complete instructions as to their use. Refer to Specifications for dwell angle.

CONTACT POINT PRESSURE

The contact point pressure should be checked with a spring gauge. The scale should be hooked to the breaker lever and the pull exerted at an angle of 90° with the point surface. Reading should be taken just as points separate. The pressure can be adjusted by bending the breaker lever spring. If the pressure is excessive, it can be decreased by pinching the spring carefully. To increase, the lever must be removed from the distributor so the spring can be bent away from the lever. Avoid excessive spring distortion. New breaker lever springs may be stronger than required in service; be sure to check the spring tension of all new levers when installed. Remember that excessive pressure causes rapid rubbing block, cam, and contact point wear while insufficient pressure will permit high-speed point bounce which will, in turn, cause arcing and burning of the points and missing of the engine.

Breaker lever spring tension should be 17-21 ounces when measured at the center of the contact, or 19-23 ounces when measured just behind the contact. The tension may be measured with any suitable spring gauge, provided the pull is exerted at 90° and the reading taken just as the points begin to separate.

The distributor should be tested on a distributor tester that will check the centrifugal advance mechanism.

REINSTALLATION

When installing a distributor, observe the following cautions:

1. Be sure the distributor mounting is clean so there will be a good ground connection for the distributor.

2. Check engine breather pipes, since clogged pipes cause crankcase pressure which will force oil up into the distributor.

3. If the advance mechanism of the old distributor was found to be worn, check the engine for worn oil pump gears, since these cause backlash which produces torsional vibration; such vibration causes rapid advance mechanism wear.

4. Be sure to install the new distributor all the way down in its mounting well. If the distributor is not pushed all the way down, the distributor shaft is apt to freeze in the distributor housing and cause complete urination of the distributor.

5. Be sure that unit is properly timed, refer to proper Operator's Manual.

GENERATOR

Maintenance procedures may be divided into two sections—Lubrication and Inspection.

LUBRICATION

It is very important that proper lubrication procedures be followed in order to obtain maximum life from the generator.

On generators having hinge cap oilers, a few drops of SAE No. 20 oil should be added at vehicle or engine lubrication periods. See Lubrication Chart.

INSPECTION

Inspection procedures are limited mostly to visual checks for loose mounting bolts, a loose drive belt, damaged wiring, and worn commutator brushes.

All mounting bolts should be kept tight, and the belt tension should be adjusted to conform with instructions in operators manual.

Wiring with frayed insulation should be replaced, and all connections should be checked for tightness and cleanliness.

If the commutator is dirty, it may be cleaned with No. 00 sandpaper, or with a brush seating stone, with the generator in operation. Blow away all dust after the cleaning operation. If the commutator is rough, out of round, or has high mica, the armature must be removed so the commutator can be turned down in a lathe and the insulation between bars undercut. Remove only enough material to make the commutator smooth and round, and undercut the insulation 1/32 inch deep and .033 inch wide. Finish with No. 00 sandpaper, and blow away all dust, particularly between bars.

If the brushes are worn down to less than half their original length, they should be replaced. New burshes can be seated to make good contact with the commutator by holding a brush seating stone on the commutator with the generator in operation or by applying brush seating compound to the commutator. Blow away all dust after the seating operation.

A visual inspection will often reveal the condition of the brush springs. If the springs are corroded, or if they are blued and discolored from excessive heat, they should be replaced. If the brush arms move freely, and if the brush moves freely in the holder, with no spring corrosion or discoloration, the springs most likely are satisfactory, If an additional check is desired, use a spring tension scale to measure the brush spring tension, and compare with specifications.

Figure 1. Measuring Brush Spring Tension

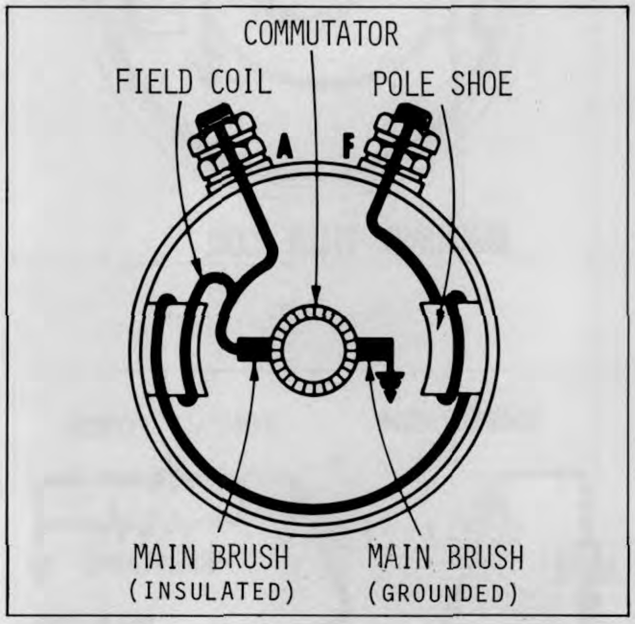


Figure 2.

GENERATOR CIRCUIT

This generator has a bucking field coil which is connected across the generator armature. The magnetism produced by the bucking field coil opposes the magnetism created by the main field coil. On generators of this type, only a small amount of magnetism is needed at high generator speeds for the generator to produce specified voltage. Since the main field magnetism and bucking field magnetism oppose each other, the current through both of these windings remains at a normal level at high speeds, but the opposing effect results in the small magnetic field needed at these speeds. With the normal amount of current in the main field windings at high speeds, the regulator is able to retain voltage control. Without the bucking field, the main field current would have to decrease to an abnormally low value at high speeds. At such a low value, the regulator would not be able to control the voltage.

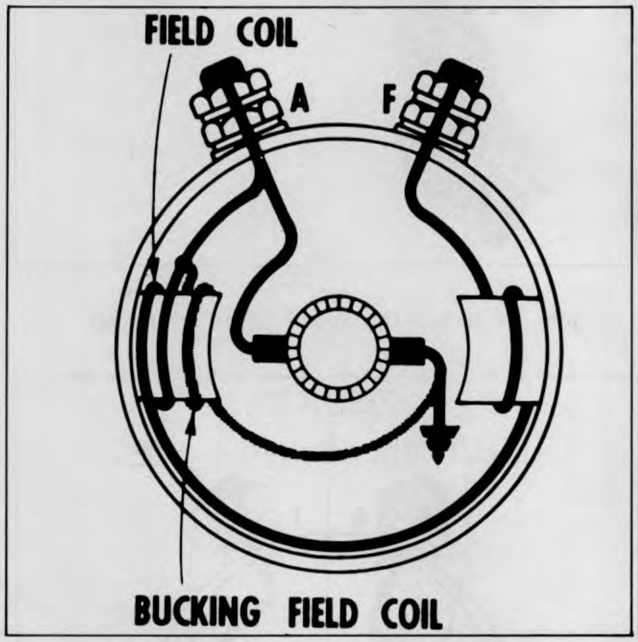


Figure 3.

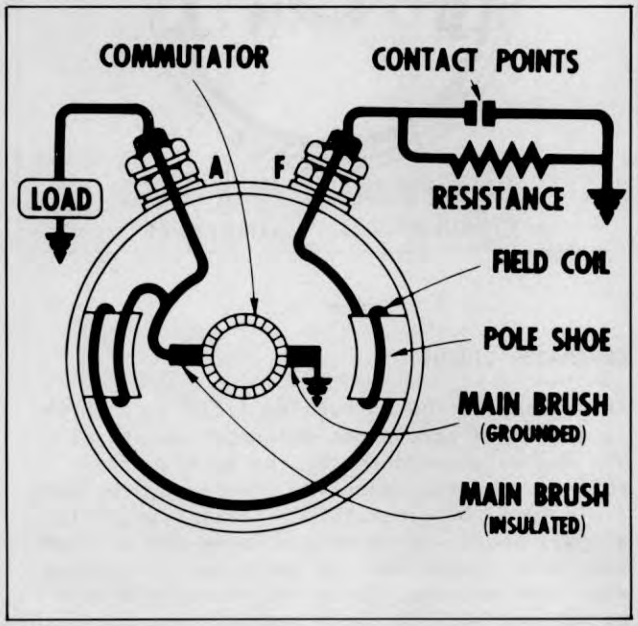


Figure 4.

"A" CIRCUIT

This generator is the "A" circuit type. The "A" circuit generator is shown in figure 4. In this type circuit, the field winding is connected to the insulated brush inside the generator and is connected to ground through the contact points in the regulator.

The check our circuit is shown in Figure 5.

OUTPUT CHECKS

To check the generator for electrical output, connect an ammeter in series with a battery to the generator output terminal. Also connect a voltmeter from the generator output terminal to ground, and a load rheostat across the battery. Then connect a jumper lead to the generator field terminal as shown in Figure 5. Operate the generator at specified speed, and adjust the load rhesotat as required to obtain the specified output.

If the generator does not perform according to specifications, it should be disassembled for further testing.

DISASSEMBLY

Generator disassembly can be accomplished first by removing the thru-bolts, of end frame attaching bolts, and then separating the two end frame assemblies from the field frame.

When removing bearings from the armature shaft or end frame, care should be taken to avoid damage to the balls and raceways. If the bearing is a press fit over the shaft, use bearing pullers against the inner race only. If the inner race is inaccessible, and it is necessary to pull against the outer race, the balls will be loaded and may be damaged. Similarly, when removing a bearing whose outer race is a press fit into the end frame, use an arbor press against the outer race to avoid loading the balls.

After bearing removal, wash in a clean solvent, and carefully inspect for worn surfaces, looseness, broken separators, a cracked ring or race, and a rough or catchy feeling. Always replace any bearing if its condition is doubtful.

IMPORTANT

REFER TO THE SECTION ENTITLED "MAINTENANCE"

FOR PROPER LUBRICATION PROCEDURES.

When remounting bearings, use an arbor press and press firmly and evenly against the proper race to avoid loading the balls. If the mounting surfaces are clean, and the bearing is started properly and is not cocked or mis-aligned, it can be mounted without undue pressure.

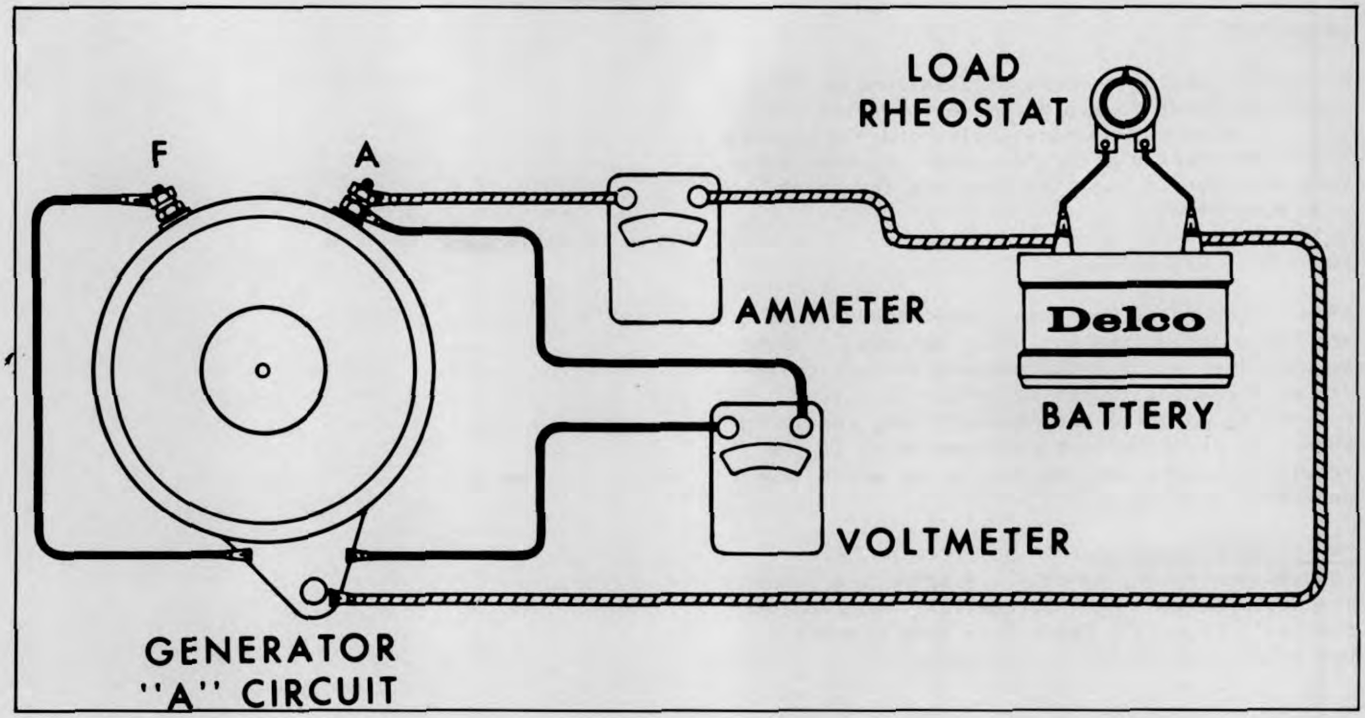


Figure 5. Connections for checking output on "A" circuit generators.

Grease and oil seals should be replaced after appreciable mileage, or if the seal is worn or damaged in any way.

ELECTRICAL TESTS

After the generator has been disassembled, tests can be made of the armature and field coils to determine any electrical defects.

The armature should be checked for shorts, grounds, and opens. To check for shorts, place the armature in a growler, and slowly rotate with a metal blade held on the armature. If the metal blade vibrates, the windings are shorted.

To check the armature for grounds, touch one prod of a 110 volt test lamp to the commutator, and the other test lamp prod to the shaft or laminations. If the lamp lights, the windings are grounded.

To check the armature for opens, visually inspect the wiring connections to the commutator bars, and inspect the commutator for a burned or discolored commutator bar. An open circuit will cause one of the bars to burn and become discolored. Also, the armature may be checked for opens on a growler meter. If the meter reads low, the winding connected to the commutator bars to which the prods are connected is open.

The generator field windings should be checked for shorts, grounds and opens. To check for shorts, connect an ammeter and battery in series with the field windings, and refer to specifications. If the current reading is higher than specified, the windings are shorted.

To check the field windings for grounds, connectone prod of a 110 volt test lamp to the field terminal, and the other prod to the generator frame. If the lamp lights, the windings are grounded.

To check the field windings for opens, connect the 110 bolt test lamp prods across the windings. If the lamp fails to light, the windings are open.

A shorted, grounded, or open field will result in abnormal generator output. A shorted field winding will cause excessive burning of the voltage regulator contact points, resulting in reduced generator output. An open field winding will result in no generator output. A grounded field can cause excessive generator output if the ground is near the "F" terminal. If the ground is near the end of the winding connected to the insulated brush, reduced generator output will be obtained.

On "bucking field" generators a shorted, grounded, or open bucking field winding can cause excessive generator voltage at high speeds.

REASSEMBLY

Reassembly is the reverse of disassembly. Care should be taken to avoid damage to grease seals and oil seals during reassembly, and the brushes should be checked after reassembly to make sure they are free in their holders and the brush arms move freely.

POLARIZING GENERATOR

After a generator has been tested and repaired, and installed on the engine or vehicle, it must be polarized so it will have the correct polarity with respect to the battery polarity. Failure to polarize the generator may result in burned or stuck cuttout relay contacts in the regulator, along with damage to the wiring and generator windings.

"A" Circuit Generator: To polarize an "A" circuit generator, momentarily connect a jumper lead between the regulator BATTERY and ARMATURE terminals after all leads have been connected, but before the engine is started.

AXLE ADAPTOR/DIFFERENTIAL AND AXLE ENDS

TROUBLE	PROBABLE CAUSE	CORRECTION
1. Continuous Axle Noise.	1. Worn parts.	1. Replace with new parts.
	2. Tires wear uneven.	2. Replace tires.
	3. Lack of Lubricant.	3. Fill to level plug with proper oil.
2. Axle Noise On Drive Or Coast Only.	1. Ring gear and pinion gear of differential	1. Replace worn part.
	2. Worn pinion gears or side gear in differential case.	2. Replace worn gears.
3. Excessive Backlash In Axle.	1. Axle Adaptor to transmission loose.	1. Tighten screws.
	2. Worn splines on axle shaft or side gears.	2. Replace axle shaft and/or side gears.
	3. Worn ring gear, drive pinion or differential case pinion.	3. Replace worn parts where necessary.
4. Failure to operate.	1. Broken drive pinion shaft	1. Replace shaft
	2. Broken teeth on ring gear.	2. Replace ring gear.

AXLE ADAPTOR/DIFFERENTIAL AND AXLE ENDS

Description

The drive axle is of the full floating type consisting of the differential, axle adaptor and two axle ends.

The differential is of the bevel gear and pinion type with final reduction at the axle end.

The pinion drive shafts are splined to the differential side gears at one end and to the spur pinion gear at the opposite end. The drive pinion shafts are supported at the spindle support by a bearing and two bearing retaining capscrews.

If the axle ends and/or differential require major repair, they must be removed from the machine.

The axle adaptor and differential are components of the transmission, however, they will be discussed in this section.

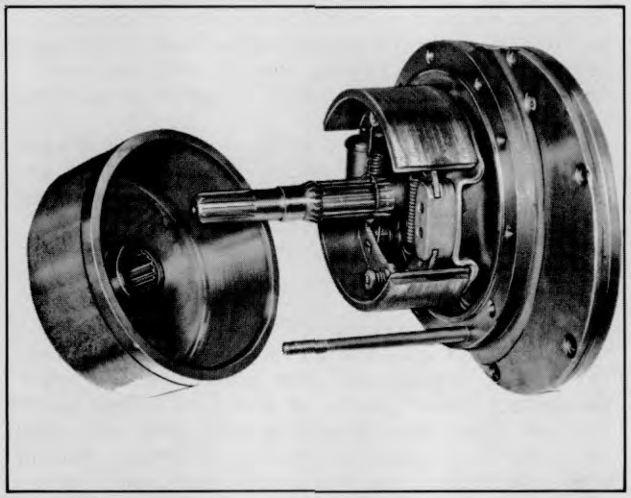


Plate 5272. Remove Wheel End

Axle End Removal

Remove wheel stud nuts and remove wheel from axle end. Remove the ten attaching stud nuts and separate wheel end from adaptor (see Plate 5272).

Axle Adaptor and Wheel End Removal

It is possible to remove the adaptor and wheel ends as a unit. First remove the upright assembly. Disconnect brake line at "T".

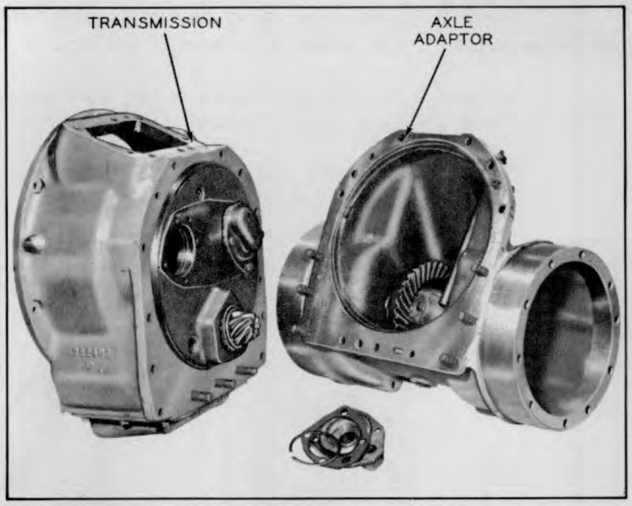


Plate 5308. Remove Adaptor form Transmission

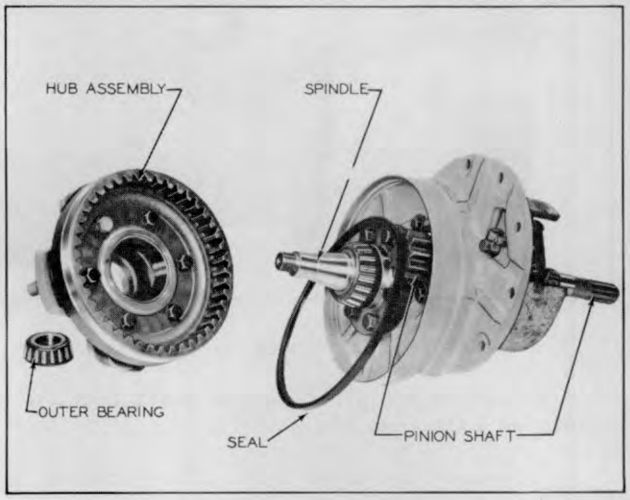


Plate 5080. Axle End Parts

WARNING

SECURELY SUPPORT TRANSMISSION BEFORE SEPARATING FROM AXLE ADAPTOR.

Remove axle to frame bolts. Drain transmission and adaptor at adaptor drain plugs. Remove the attaching capscrews and stud nuts and separate assemblies as shown in Plate 5308.

Axle End Disassembly (See Plate 5080)

1. Remove axle end spindle cotter, nut, *washer and outer spindle bearing cone.*

2. Remove the six spindle housing to spindle support bolts.

3. Remove spindle housing and oil seal from spindle support and press oil seal from housing.

4. Remove hub assembly with outer and inner bearing race from spindle. Remove inner bearing.

5. Take out the six spindle capscrews and remove spindle from spindle support.

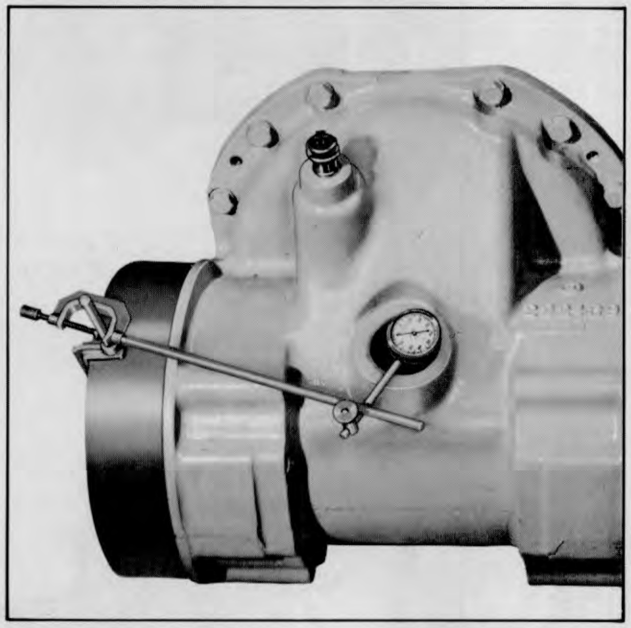


Plate 5307. Check Backlash

6. Remove two pinion drive shaft bearing retaining capscrews and washers.

7. Remove the outer brake drum retainer ring.

8. Remove brake drum.

9. Remove inner brake drum retainer ring.

10. Pull pinion drive shaft and bearing from spindle support and brake drum.

Differential Removal

It will be necessary to remove both wheel end assemblies to remove the differential.

1. Remove the bearing carrier stud nuts.

2. The differential will be free to be removed when bearing carriers are removed.

To aid in disassembly refer to exploded view of differential on following page.

Inspection and Maintenance

Immerse all parts, except bearings, in a Stoddard Type Cleaning Solvent until all parts are thoroughly cleaned.

Dip bearings in a Stoddard Type Cleaning Solvent, and slosh up and down until bearings are clean. Remove bearings from solvent and strike large side of cone flat against a block of wood to dislodge solidified particles of lubricant. Repeat above operation until bearings are cleaned thoroughly. Blow bearings dry with compressed air, directing air stream across bearing to avoid spinning. Bearing may be slowly rotated by hand to facilitate drying procedure. Clean interior of housing thoroughly.

Examine differential case, side gears, pinions and thrust washers for damage or excessive wear. Check clearance between pinions and pinion pin and thickness of all thrust washers. If differential side gears and pinions are worn or damaged, always replace with complete set - consisting of four pinions, two side gears and all thrust washers.

Inspect all parts to detect cracks or fissures to determine serviceability of parts. Surface of spindle support which contacts oil seal lip must be round, smooth finished and free from nicks, scratches, grooves or scores.

Carefully inspect rollers, cages and cups for wear, chipping or nicks to determine fitness of bearings for futher use. After inspection, dip bearings in gear oil and wrap in clean cloth or paper to protect them until installed.

It will be necessary to replace all "O" rings and oil seals when unit is disassembled. It is more economical than premature overhaul to replace these parts at a future time. Further loss of lubricant through a worn seal may result in failure of other differential parts. Handle seals carefully, particularly when seals are being installed. Cutting, scratching or curling under of seal lip seriously impairs efficiency.

Examine teeth of both ring and pinion gears carefully for wear, pitting, chipping, nicks or scores. If gear teeth show spots where case hardening is worn through, install new ring gear and pinion set. Small nicks may be carefully removed with a suitable hone. Examine pinion gear teeth for wear and check pinion shaft for evidence of twisting, particularly at splines. If evident, install new set of gears.

Pinion and drive (ring) gears are available only in matched sets and must be installed as such to assure satisfactory operation.

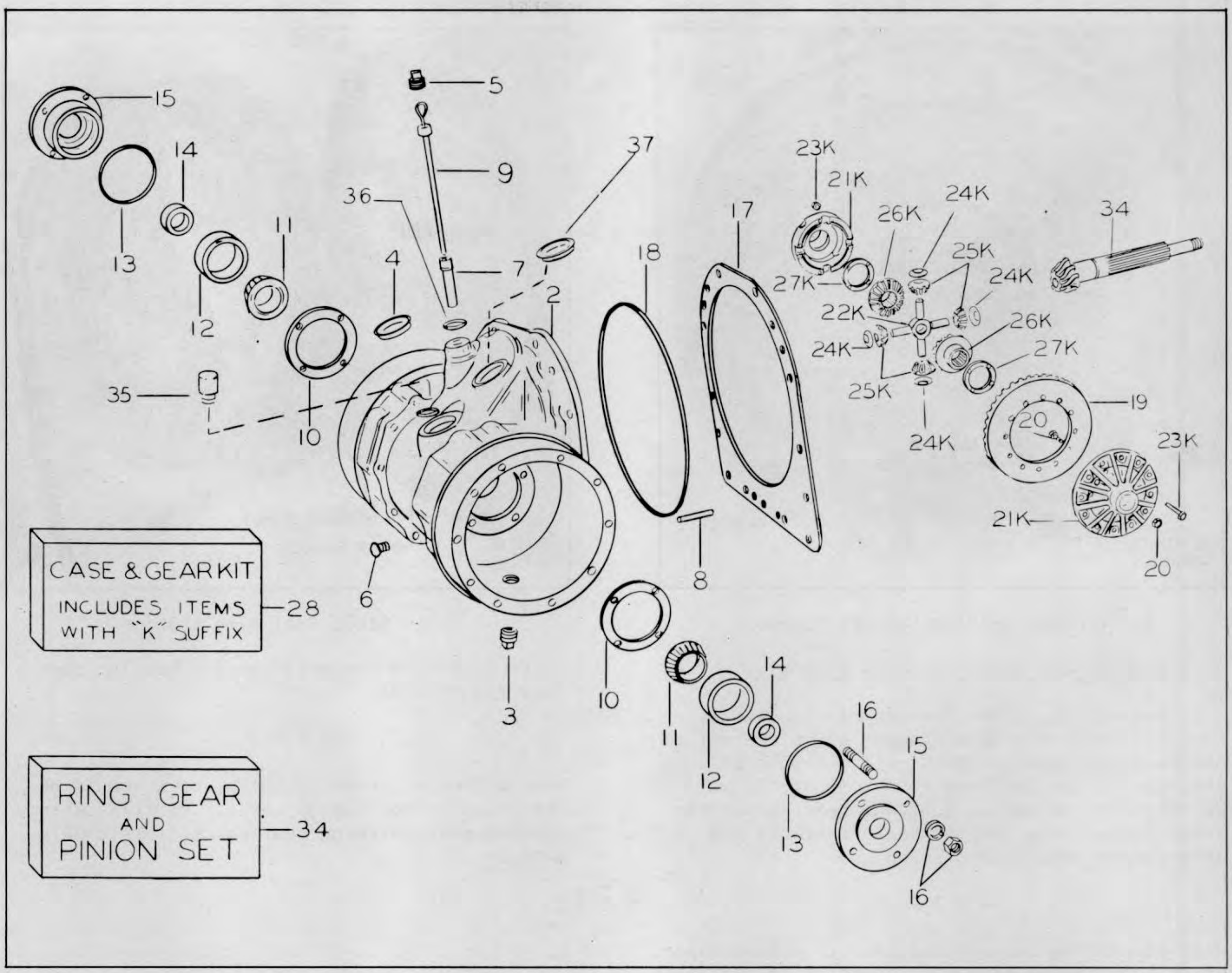


Plate 9968. Axle Adaptor and Differential

2 HOUSING, DIFFERENTIAL
3 PLUG, DIFF HSG DRAIN
4 COVER, DIFF HSG INSPECTION
5 PLUG, TRANS OIL FILTER
6 PLUG, TRANS OIL LEVE
7 TUBE, TRANS OIL LEVEL DIPSTICK SUPPORT
8 DOWEL, DIFF HOUSING
9 DIPSTICK, TRANS OIL LEVEL
10 SHIM KIT, DIFF BEARING CARRIER
11 CONE, DIFFERENTIAL BEARING
12 CUP, DIFFERENTIAL BEARING
13 SEAL, DIFFERENTIAL BEARING CARRIER
14 SEAL, DIFFERENTIAL BEARING CARRIER
15 BEARING C RRIER, DIFFERENTIAL
16 FASTENER, IFF BRG CARRIER TO HOUSING
17 SHIM KIT, DIFFERENTIAL HOUSING
18 SEAL, TRANSMISSION TO HOUSING
19 DIFFERENTIAL RING GEAR
20 FASTENER, DIFF CASE TO RING GEAR
21 BODY, DIFFERENTIAL
22 SPIDER, DIFFERENTIAL SIDE PINION
23 FASTENER, DIFFERENTIAL CASE
24 WASHER, DIFF SIDE PINION GEAR THRUST
25 GEAR, DIFFERENTIAL SIDE PINION
26 GEAR, DIFFERENTIAL SIDE
27 WASHER, DIFFERENTIAL SIDE GEAR THRUST
28 CASE & GEAR ASSEMBLY, DIFFERENTIAL
34 RING GEAR & PINION SET, DIFFERENTIAL
35 VENT ASSEMBLY, DIFF HOUSING AIR
36 SEAL, DIFF OIL LEVEL DIPSTICK SUP
37 COVER, DIFFERENTIAL ACCESS HOLE

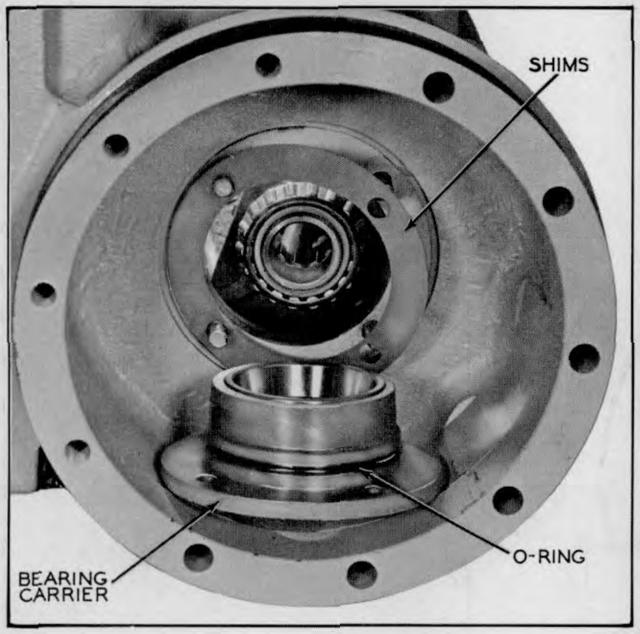


Plate 6184. Bearing Carrier Assembly

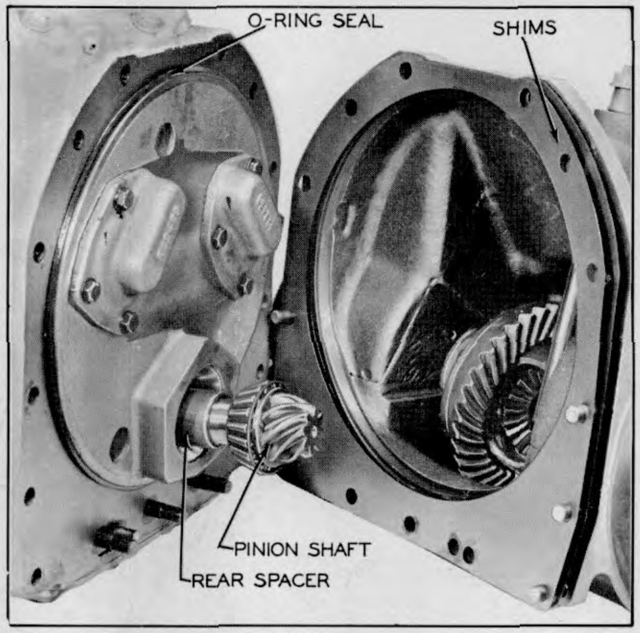


Plate 6188. Seal Ring & Shims

Axle Adaptor and Differential Reassembly

Reassembly is the reverse of disassembly. However, after the axle adaptor and differential has been reassembled the backlash should be checked. If the backlash is not right, it will be necessary to add or subtract bearing carrier shims in the axle adaptor and/or between the axle adaptor and transmission.

N O T E

When assembling the axle adaptor to transmission, exercise care not to damage (scratch, nick, etc.) the "O" ring seal located b tween the two components (see Plate 6188).

Backlash should be measured with a dial indicator ridgidly mounted with the stem perpendicular to the tooth surface at the extreme heel. The correct backlash should be between .006 and .008-inch. The backlash is measured through the filler plug on the axle housing (see Plate 5307 on Page 20M801B).

To check for correct tooth contact between ring gear and pinion - put red lead on three or four teeth of pinion and assemble axle adaptor to transmission housing. Rotate pinion until ring gear makes a complete revolution (see Page 20S801A), to check results of ring gear and pinion contact.

When results show that the pinion must be moved toward or away from ring gear, shims must be added or removed between axle adaptor and transmission housing. If ring gear must be moved in relation to the pinion, shims must be added or removed from the differential bearing caps (see Plate 6184).

N O T E

When adding or removing shims, care should be exercised to not damage carrier "O" ring when removed and replacing bearing carrier to axle adaptor.

TROUBLE SHOOTING GUIDE

	TROUBLE(S)	SYMPTOM(S)	LOCATION(S)	PROBABLE CONDITION(S)
1	**Sudden, Total Failure**	No pedal	Brake fluid	Vapor lock: (1) Lowered fluid boil point; (2) Overheated brakes (refer to "fade").
			Master cylinder	Pressure failure at primary cup. Overhaul required.
			Wheel cylinder(s) ...	Fluid loss, pressure failure at cups. Overhaul required.
			Hydraulic lines	Fluid loss: Ruptured hose or tube.
		Blocked pedal	Master cylinder	Frozen piston: (1) Broken stop lockwire; (2) Effect of rust and corrosion.
			Pedal linkage	Frozen link, bind, or interference.
2	**Low Pedal (Reserve)**	Increased by "pumping"	Shoes/lining	Excess lining/drum clearance. Lining wear. Adjust or reline.
			Hose	Swells ("balloons") under pressure.
			Pedal linkage	Excess free travel (lash).
			System	Air in system, requiring "bleeding" (refer to "spongy pedal").
3	**Pedal Drops or "Fades"**	Depressed pedal "hunts" or travels	Master cylinder	Pressure loss, fluid seepage at primary cup. Overhaul required.
			Wheel cylinder(s) ...	Fluid leak, seepage under pressure. Overhaul required.
			Hydraulic lines	Fluid leak, seepage under pressure.
			Brake drums	Excessive heat expansion or flexing (refer to "fade").
4	**Vibrating Pedal**	"Fight" or "chatter"	Power brake	Pedal assist type: (1) Pedal trigger bent; (2) Faulty pedal linkage adjustment.
			Brake Drums	Distortion, usually out-of-round.
5	**"Spongy" or "Springy" Pedal**	Air in system, fluid level low	Fluid reservoir	Failure to top off fluid at regular service intervals.
			Power brake unit ...	(Some) Fluid sucked past seals into vacuum section.
			Systematic	Fluid leaks in tubes, hose, connections and wheel cylinders.
		Air in system, fluid level correct	Master cylinder or P. B. unit, residual check valve	Leak off of residual pressure may result in air leak at wheel cylinder(s).
			Wheel cylinder(s) ...	Air leak: (1) Cup damage, corrosion, rust; (2) Improper use of parking brake (after pedal is released).
		Temporary effect	Brake fluid	Boiling of overheated fluid (refer to "fade").
		"Springy" effect	Shoes/lining	Excess lining clearance at actuated ends of shoes.
6	**Brake(s) Drags or Locks**	At all wheels	Master cylinder	Blocked by-pass port: (1) Swollen cup; (2) Dirt, corrosion; (3) No pedal free travel (lash); (4) Pedal binds (upon release).
			Power brake unit ...	(1) Release valve port closed so that unit balances; (2) Pressure multiplier type: valve in main hydraulic piston seized (closed).
		At individual wheels	Wheel cylinder	Excessive internal friction: (1) Swollen cup; (2) Seized piston; (3) Rust, corrosion; (4) Action of cup expander.
			Hydraulic lines	Pressure release blocked: (1) Dirt, corrosion; (2) Rip in hose liner.
			Shoes/lining	Insufficient retraction: (1) Adjustment too tight; (2) Shoe alignment binds; (3) Weak retraction springs.
			Wheel bearing	(1) Worn; (2) Loose adjustment.
7	**Poor Stop, Hard Pedal, "FADE", "PULL" (If only the brake on one side is affected, the opposite (normal) brake may "pull".)**	Brakes equalized	Power brake	Less than 16-inch vacuum or 60 psi air pressure: (1) System leaks; (2) Engine condition (vacuum) or compressor condition (air).
			Power brake unit ...	(1) Release port valve leak; (2) air leak at power piston, diaphragm or bellows; (3) pedal assist type: pedal trigger bent, or improper pedal adjustment.
			Brake lining	Friction too low.

(Continued on following page)

	TROUBLE(S)	SYMPTOM(S)	LOCATION(S)	PROBABLE CONDITION(S)
7	(Continued) **Poor Stop, Hard Pedal, "FADE", "PULL" (If only the brake on one side is affected, the opposite (normal) brake may "pull".)**	Pull possible	Wheel cylinder	(1) Frozen piston, rust, corrosion; (2) Step bore type installed facing wrong direction.
			Hydraulic lines	Applied pressure blocked: (1) Rip in hose liner; (2) Dirt, corrosion.
			Shoes/linings	(1) Lubricated lining, grease soaked, fluid soaked, water soaked; (2) Surface heavily grazed or charred by previous overheatings; (3) improper lining fit or adjustment, partial contact, low leverage, uncentered too close to anchor; (4) Shoe alignment binds; (5) non-servo—lining positions reversed; (6) Servo—mis-mated replacement shoes.
			Brake drums	Different diameter or finishes, L.H. and R.H.
			Wheels	(1) Unbalanced bounce, vibration; (2) Worn tire; (3) Low friction road.
		"Fade" conditions (overheating)	— — — — —	Vehicle overloads
			Shoes/linings	(1) Partial lining contact creating "hot spots"; (2) "Drag" conditions (refer to "drag"); (3) Lining used is unsuited to type of vehicle service.
			Brake drums	(1) Too thin, excess thermal expansion or flexing; (2) Grooved or distorted, partial lining contact.
			Wheels	Mud caked, etc., interference with ventilation.
8	**Severe Stops Sensitive Pedal, "GRAB", "DIVE" ("Grab" may be noticed if only one brake is affected.)**	Brakes equalized	Power brake unit ...	(1) Application port valve leak; (2) Pedal assist type: pedal trigger bent or improper pedal adjustment.
			Shoes/linings	(1) Friction too high; (2) "Morning Sickness" due to effect of moisture overnight.
		Grab possible	Wheel cylinder	(1) Fluid leak, spotting the lining; (2) Step bore type installed facing wrong direction.
			Shoes/lining	(1) Grease spotted (not lubricated) lining; (2) New lining arced to oversize diameter; (3) Improper fit or adjustment, high leverage, uncentered too far from anchor; (4) Shoe alignment—loose or distorted backing plate or anchor. Weak retraction springs or hold-downs; (5) Servo—mis-mated replacement shoes or lining positions reversed.
			Brake drums	(1) Distortion, out-of-round or out-of-square; (2) High, hard spots.
			Wheels	Distortion, pulling drums out-of-round.
			Chassis	Steering or suspension faults.
9	**Rapid Lining Wear**		Shoes/lining	Overheating conditions (refer to "fade" and "drag").
			Brake drums	"Heat Checks", which shave off the lining surface.
10	**Squeal, and Other Noise**		Shoes/linings	(1) Overheating conditions (refer to "fade", "drag"). (2) Grease, brake fluid, or dirt on lining; (3) Lining loose on shoe; (4) Improper shoe alignment and binds, including distorted shoe or shoe supports, loose backing plate or anchor, weak springs or hold-downs, rusty shoe support pads, etc.; (5) Lack of lubrication, metal to metal contacts; (6) New lining: pinching against drum at one end; improper seating; improper fit or adjustment. (7) "Rumbling", due to high spots on new lining.
			Brake drums	(1) Turned too thin; (2) Distorted (out-of-square or out-of-round); heat checked; rough; high hard spots; (3) "Clicks" due to shoe run out in tool thread marks of turned drum.
			Chassis	Vibrations transferred to brakes through the suspension system.
			Power brake	"Chatter", on pedal assist types due to improper pedal adjustment; on pressure multiplier types due to weak control valve spring.

Master Cylinder

The combination type master cylinder has the cylinder proper and fluid supply reservoir combined in one casting and joined by "intake" and "compensating" (by-pass) ports located in the cylinder wall between these two cavities. The fluid outlet port is drilled in the casting. The piston, check valve and other internal parts are removed or installed at the push-rod end. The stop plate, for securing internal parts in the cylinder, is retained by a lock wire which fits into a groove milled in the cylinder bore. The cylinder piston is operated through a push rod, connected to the brake pedal.

Brakes Off

When in released position, the master cylinder piston rests against a stop, permitting the cylinder compensating (by-pass) port to be open to the hydraulic system. A residual pressure check valve is located at the cylinder outlet, and is closed when the cystem is at rest in order to hold a residual pressure (up to 18 psi) in the system. Since the ports connecting the cylinder with the fluid supply reservoir are open, fluid can pass through the compensating port to compensate the system for changes in fluid volume caused by expansion or contraction of the fluid due to temperature changes or seepage.

Brakes Applied

After any brake pedal lash is taken up, further travel forces the piston and primary cup toward the outlet end of the cylinder, applying pressure to the fluid. Upon initial movement of piston and cup, fluid is forced through the compensating port, during a very short piston travel. As additional travel takes place, the compensating port is sealed off and the actual pressure stroke begins. Hydraulic pressure acting upon the cup lip assists the cup in sealing against any possible pressure leak past the piston. As soon as this pressure builds up in excess of the residual pressure in the system, the residual check valve is overcome and opens to permit fluid to be displaced from the master cylinder into the remainder of the hydraulic system. After brake linings contact their drums, any additional pressure applied to the brake pedal simply increases the pressure in the brake system. Except for minor spring and frictional loses, the developed hydraulic pressure is equal to the force (in pounds) applied to the piston divided by the piston face area.

PROBABLE SOURCES OF FAILURE

Low Fluid (air in system)

When the fluid level drops below the master cylinder ports, air will be taken into the system. If the master cylinder reservoir is

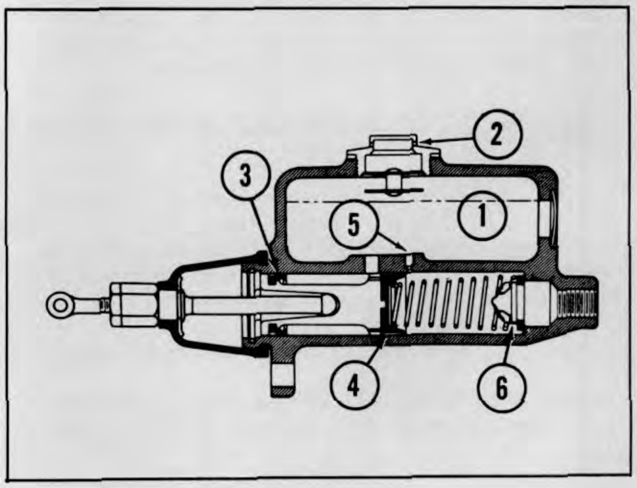


Plate 8694.

refilled before the air is forced into the brake lines, a few strokes of the brake pedal will usually purge the air and restore proper braking. If this fails, the hydraulic system must be "bled" to remove the trapped air.

Blocked reservoir air vent

This produces a vacuum in the master cylinder reservoir which may be sufficient to permit air to enter the system around the secondary piston cup. Clean the filler cap air vent and bleed the hydraulic system.

Fluid and/or air leak at secondary cup

A leak past the primary cup will not leavy any external evidence, but will produce a soft pedal eventually leading to a sudden complete braking loss. The leak may be due to a faulty primary cup or severely pitted cylinder wall.

Blocked compensating (by-pass) port

This prevents compensation within the system until surplus fluid causes hydraulic pressure to build up so that brakes "lock-up" and will not release. A blocked port is usually caused by dirt or corrosion, faulty (swollen) primary cup extending over the port, or improper pedal link adjustment. A swollen cup suggests use of improper or contaminated fluid.

Residual check valve (no residual pr ssure)

A faulty residual check valve will not hold the normal residual pressure in the hydraulic system and may permit air to leak into wheel cylinders, since there is not sufficient residual pressure to hold the cups into firm contact with cylinder walls. It will also make "manual" bleeding difficult, as air will re-enter at a bleeder screw each time the brake pedal is raised during the operation. The fluid also will have a greater tendency to gas when not kept under proper residual pressure.

Master Cylinder Disassembly & Assembly (Plate 9965)

Care should be taken when clamping the master cylinder in a vise so that vise pressure will not distort the cylinder bore or damage other parts. Use a screw driver to pry the lock wire from the groove in cylinder bore.

Remove filler plug (7) and plug gasket (8).

Remove boot strap (1) and separate boot and push rod assembly from master cylinder tank (6).

Remove lockwire (18) piston stop plate (2) piston assembly (17) spring (4), and check valve (5) from tank cylinder.

Remove boot strap (20) and push rod (21) with adjusting stud (22) from Boot (19)

Reassembly is essentially the reverse of disassembly. Make sure all parts are properly oriented and coated with clean brake fluid to prevent damage during assembly and to provide initial lubrication. Attention should be given to the stop wire (lock ring), on master cylinder to make sure it is expanded securely in the groove.

Cleaning and Inspection

Cleaning

Cylinder castings may be degreased, or cleaned with most commercial parts cleaners, provided they are thoroughly rinsed with Stoddard type solvent or brake fluid to remove all traces of solvent. Use compressed air or a lint-free cloth to dry parts after removing them from the cleaning solvent. All hydraulic parts must be thoroughly cleaned and protected (after cleaning), from dust or other air-borne foreign material, until the master cylinder is reassembled. Do not use cotton waste for cleaning or drying parts, as particles of lint or thread fibres may block the compensating port when the cylinder is placed in service. Clean rubber parts by washing them in clean Stoddard type solvent or hydraulic brake flud.

C A U T I O N

DO NOT USE MINERAL-BASE CLEANING SOLVENT SUCH AS GASOLINE, KEROSENE, DISTILLANT, CARBON TETRACHLORIDE, ACETONE, PAINT THINNER, ETC. THESE SOLVENTS DETERIORATE RUBBER PARTS, CAUSING THEM TO BECOME SOFT, TACKY AND SWOLLEN IN AN EXTREMELY SHORT TIME.

Inspection

After cleaning, hold the cylinder casting toward a strong light and sight through the cylinder bore. Blemishes, such as pitting, scratches and visible wear patterns, necessitates unit replacement. Accumulation of dirt or gummy substances, not removed during the cleaning process, may be removed with crocus cloth or jeweler's rouge. A hone may be used to "clean-up" the cylinder, provided its use does not materially increase the diameter of the cylinder bore. The possibility of the cylinder having been honed during a previous overhaul should be overlooked.

The cylinder diameter can be checked with a "No-Go" gage or a micrometer, and must not exceed the standard (nominal) diameter more than 0.007-inch. For example a 1 1/8 inch (1.125) diameter master cylinder must not exceed 1.125 + 0.007 or 1.132 inch. An alternate method of checking a cylinder is to insert a piston and measure its clearance. Maximum clearance checked with a wire gage is 0.007 inch.

Make sure that a honed cylinder has no "burr" at the compensating port, as it would damage the piston cup lip. If a burr or sharp edge is present, remove it with a deburring tool.

For a final inspection, make sure the intake and compensating ports are open. It will be difficult to see the compensating port, but if a soft copper wire not larger than 0.020 inch diameter is used, the port can be probed without danger. Do not use a steel wire to check the port.

Bench Bleeding

Fill the master cylinder reservoir with fluid, then force the piston through one full stroke. Repeat piston stroking until fluid is forced past the check valve and out of the outlet port. This leaves the master cylinder filled with fluid prior to installing it on the vehicle.

PEDAL FREE PLAY ADJUSTMENT

Why Free Play Is Needed

If the piston is not allowed to return to its stop, the primary piston cup lip will block the compensating port and the compensating feature of the master cylinder cannot function to allow surplus fluid to return from the brake lines. After a few applications the brakes will drag and soon lock up completely. Excessive pedal free play should be avoided, however, as it

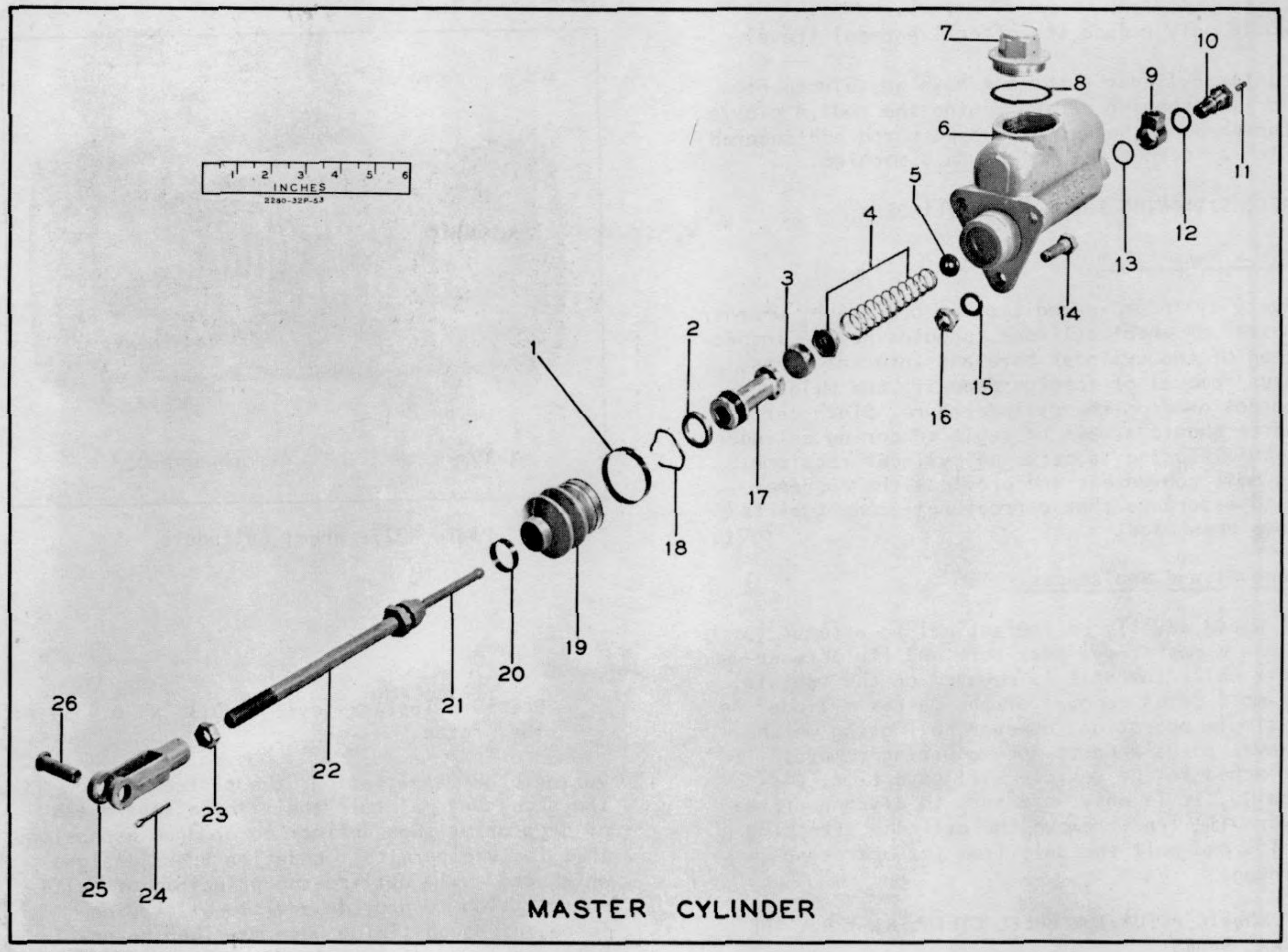


Plate 9965. Master Cylinder

would only reduce the effective pedal travel.

Master cylinder push rods have an adjustment for lengthening or shortening the rod. A clevis threaded on the end of the push rod and secured with a locknut is used on this machine.

RECONDITIONING THE MASTER CYLINDER

Use a Repair Kit

Every cylinder reconditioning operation, whether master or wheel cylinder, should include inspection of the cylinder bore and internal parts, plus removal of foreign deposits and mild corrosion from the cylinder bore. Sinch certain parts should always be replaced during cylinder reconditioning, a packaged cylinder repair kit is most convenient and provides the customer with assurance that correct replacement parts have been used.

Removal and Replacement

It would usually be impractical to attempt to clean a master cylinder bore and fluid reservoir while the unit is mounted on the vehicle. In most cases removal of the master cylinder is a simple operation, however, a routing which leaves certain parts not requiring removal attached to the vehicle will save time. Basically, it is only necessary to disconnect the hydraulic line, remove the cylinder attaching bolts and pull the unit from its operating linkage.

HYDRAULIC ACTUATION WHEEL CYLINDERS APPLY THE BRAKE SHOES

In hydraulic actuation, each wheel cylinder responds to hydraulic pressure in the system and converts this pressure into mechanical force to expand the brake shoes into contact with the drum. A short link is used between each shoe toe and the wheel cylinder piston.

This machine is equipped with a straight-bore, couble-end wheel cylinder normally consists of the cylinder casting, two pistons, two sealing cups, a spring (between the cups), two boots and a bleeder screw.

BRAKES APPLIED

Fluid entering the wheel cylinders forces the pistons to move outward (individually) and bring the lined shoes into contact with the drum. As hydraulic pressure increases the piston cup lips are forced more tightly against the cylinder wall, producing a positive fluid seal. Except for minor friction looses and spring pressure, the control actuating force is proportional to and varies with the hydraulic pressure exerted against each square inch of piston face.

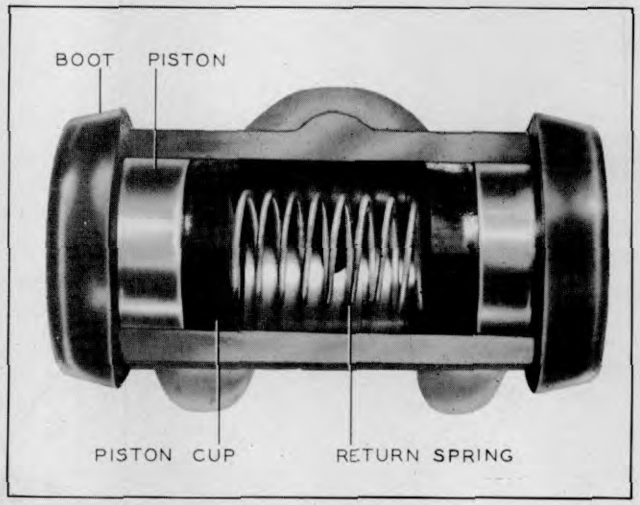


Plate 3727. Wheel Cylinders

Pressure (psi) x (cyl. I. D.) ^{2}x 0.7854 = lbs. force.

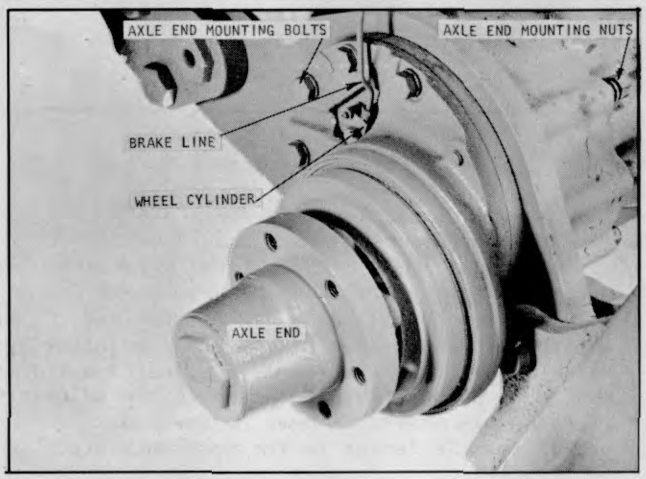
During brake application, the pistons follow the shoes and maintain their force regardless of drum or/or shoe deflection or drum expansion. This feature permits foundation brake designs which can fully utilize the principle of self-energization to provide additional braking force, although lining wear may then be unbalanced.

BRAKES RELEASED

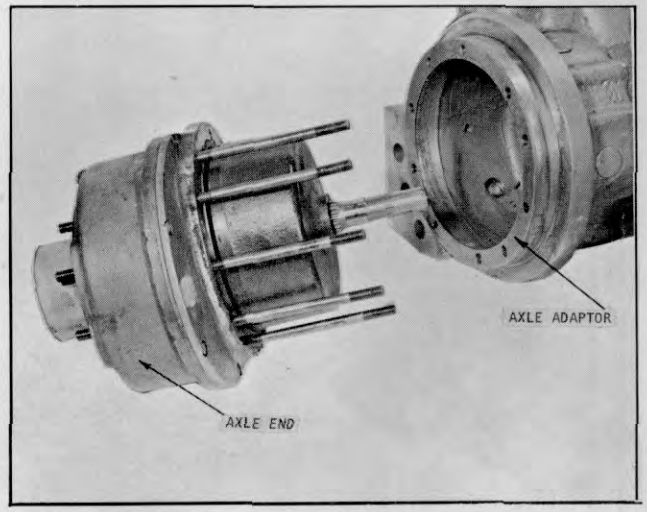
Pistons are returned to off position by the force of brake shoe retracting springs when hydraulic pressure is reduced, thus returning displaced brake fluid to the master cylinder. Piston cup lips retain their seal against the cylinder walls because of the resiliency of the cups plus residual pressure (Maintained by the residual check valve) in order to seal the cylinder against possible air leakage into the system as well as fluid loss.

BRAKE DISASSEMBLY
(Lining Replacement)

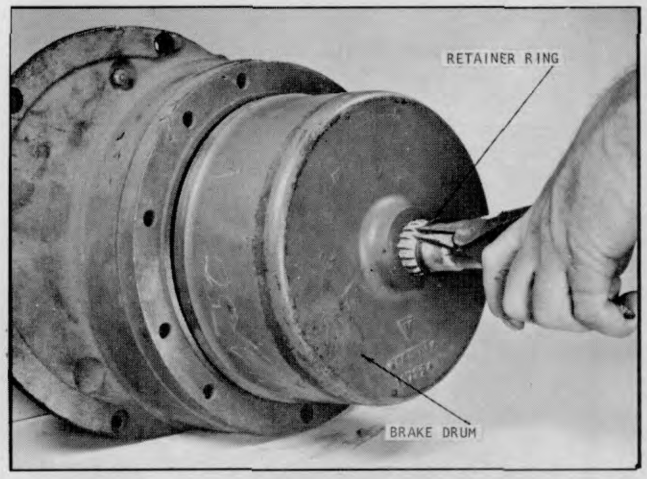
STEP 1. Place blocks under the upright channel and tilt upright forward to raise drive wheels off the floor and remove drive wheels.



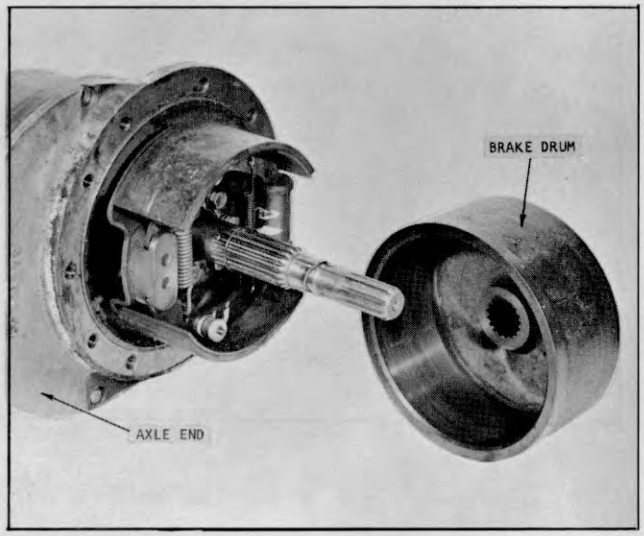
STEP 2. Disconnect the brake lines from the wheel cylinders. Remove the axle end mounting nuts from the axle studs and the axle end bolts.



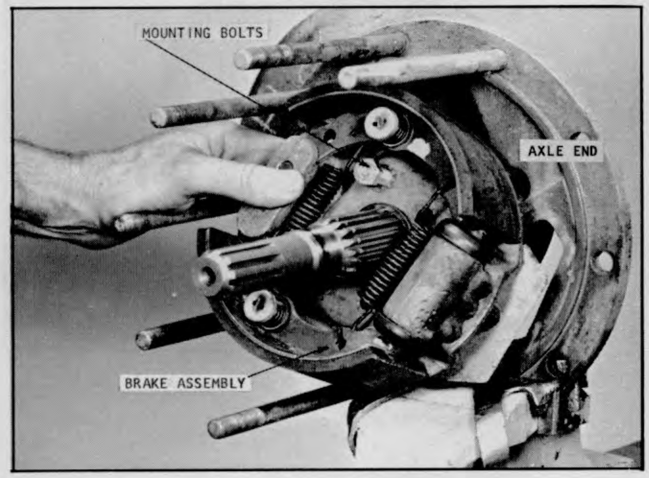
STEP 3. Remove axle end from axle adaptor.



STEP 4. Remove brake drum retainer ring.



STEP 5. Remove brake drum from axle end.



STEP 6. Remove brake assembly mounting bolts and brake assembly from axle end.

DISASSEMBLY

A. Hold the guide pin from the back side and push down on the upper spring retainer cap at the same time turn 90°, then remove guide pin, guide pin spring, and lower spring retainer cap.

B. Disconnect the two brake shoe return springs.

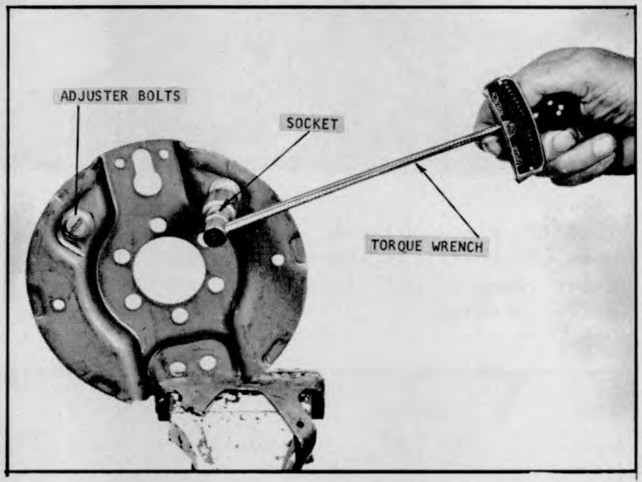
C. Remove the two brake shoes from the backing plate.

CAUTION

(THERE IS A SHOE ANCHOR KEY ON EACH SIDE OF THE ANCHOR BLOCK. THESE ARE LOOSE PIECES AND CARE SHOULD BE TAKEN SO THEY ARE NOT LOST.)

D. Remove the two brake shoe anchor block mounting bolts and the anchor block.

E. Remove the wheel cylinder.



Step 8A. Check for correct torque.

STEP 8. Before reassembling the brake assembly, the backing plate should be checked for correct torque of the adjusters. To do this, an inch pound torque wrench is used with a small drag link socket and inserted in the groove of the brade adjuster bolt. Then rotate the complete adjuster until the index washer that is locked to the adjuster reaction arm starts to move on the index washer that is locked to the backing plate.

Make note at this time of the inch pound reading necessary to move the adjuster arm which should be 38 to 48 inch pounds on models 1689951, 1690313, 1692664, 1697626, and 1701754. On models 1737497 and 1737498 the nut holding adjuster arm to disc should be tightened to 23 to 26 ft. lbs. while holding hex nut.

C A U T I O N

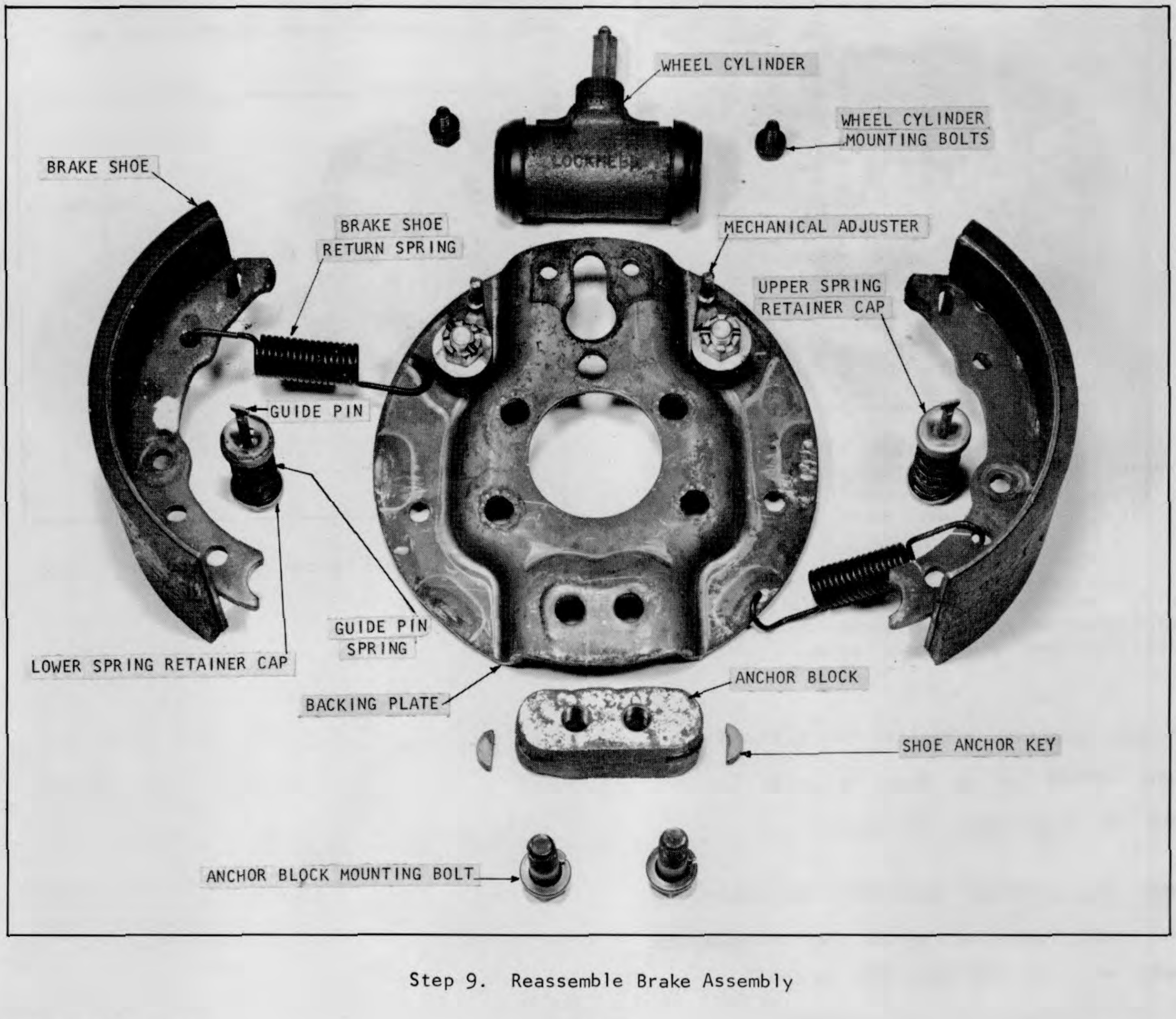
SHOULD BE TAKEN SO THAT THE ADJUSTER IS NOT TURNED FAR ENOUGH TO MAKE THE INDEX WASHERS COME OFF THE HIGH SPOTS.

If you should turn the brake adjuster too far and the index washers come off the high spots, you will have to remove the roll pin and loosen the nut enough so you can relocate the two index washers until the high spots line up.

When you check the torque, should you find it is not correct, remove the roll pin and tighten or loosen adjuster bolt so you can insert the roll pin in the next notch in the adjuster nut. Repeat this until you have the proper torque.

STEP 9. The brake parts are to be reassembled on backing plate by following steps:

A. Install the wheel cylinder on the backing plate.



Step 9. Reassemble Brake Assembly

B. Install the brake shoe anchor block and bolts.

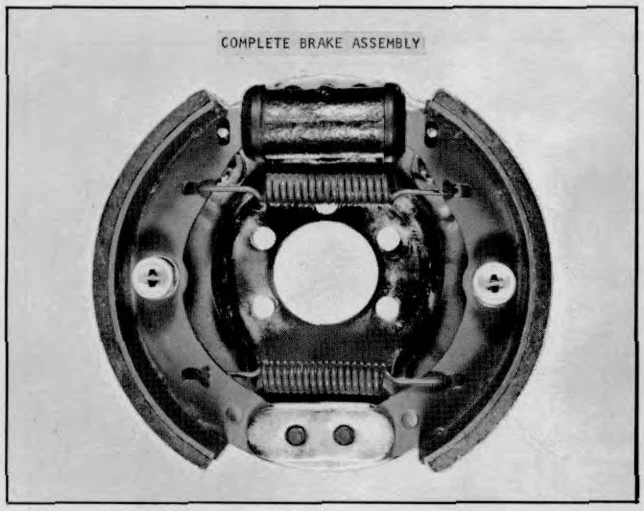
C. Install the brake shoe anchor key and the brake shoe.

NOTE

BEFORE THE BRAKE SHOE ANCHOR KEYS ARE INSTALLED THEY SHOULD BE COATED WITH LUB-RIPLATE.

D. Connect the two brake shoe return springs.

E. Install brake shoe guide pin, spring, and caps.



STEP 10. After the brake has been reassembled as shown in the complete brake assembly, to double check, rotate each adjuster so the brake shoes will move out.

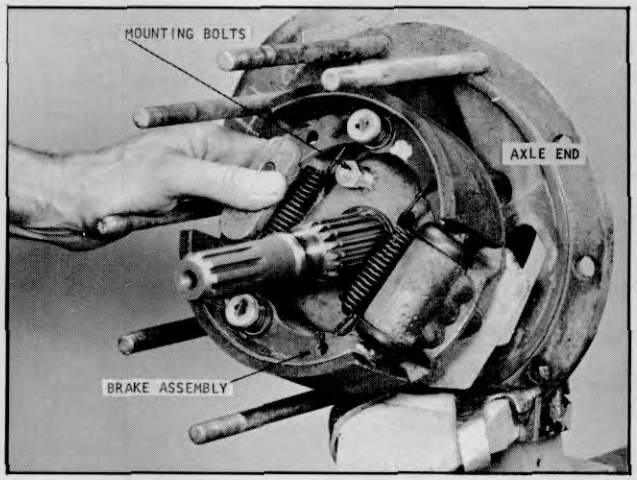
They should stay out and not be pulled back by the springs. Then turn the adjusters back so the brake drum will slide on over the brake shoes.

NOTE

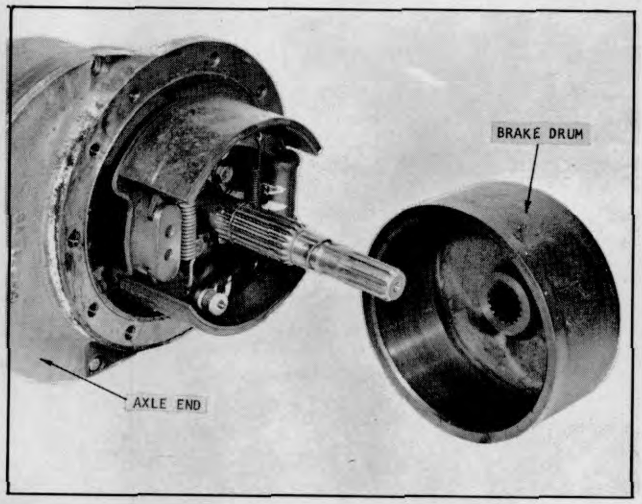
IT MAY ALSO BE NECESSARY TO TAP THE SHOES EITHER UP OR DOWN TO ALLOW THE DRUM TO SLIDE OVER THE SHOES.

THERE IS NO OTHER ADJUSTMENT NECESSARY.

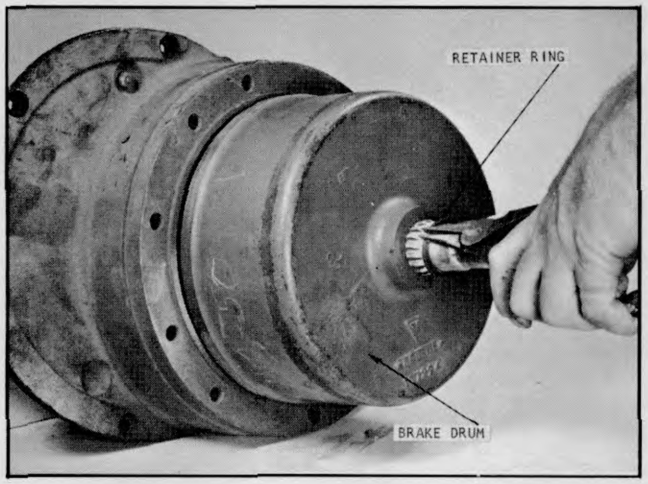
THE FIRST TIME THE BRAKES ARE APPLIED THE SHOES WILL BE CENTERED AND ADJUSTED.



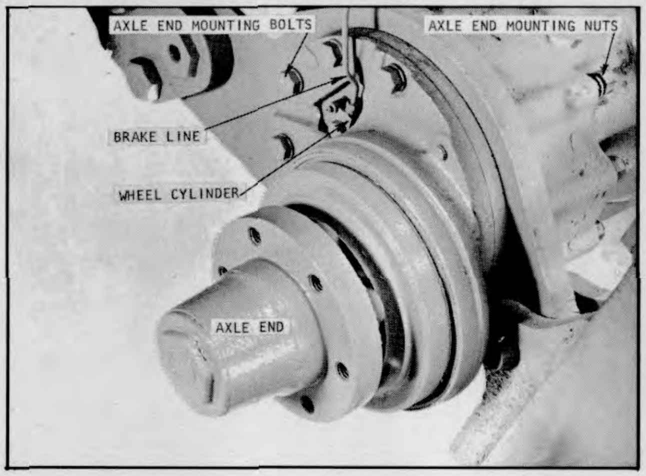
STEP 11. Install brake assembly on axle end.



STEP 12. Install brake drum on axle end.



STEP 13. Install brake drum retainer ring.



STEP 14. Install axle end in axle adaptor. Axle end mounting bolts and nuts should be torqued to 35 to 40 foot pounds.

STEP 15. Install lines.

STEP 16. After lines have been installed, the brakes are ready to bleed.

STEP 17. Replace drive wheels. Tilt upright back and remove blocks from under upright.

WHEEL CYLINDER INSPECTIONS

After dismantling a cylinder, inspect for the following:

(1) If mineral oil is present in the system the RUBBER CUPS will be enlarged and very soft. These cannot be used and should be discarded.

(2) CYLINDER WALLS must be smooth and not pitted or scratched and be free from burrs. Remove light pits, scratches and burrs with a hone. If cylinder does not clean up with light honing, cylinder must be replaced.

(3) Occasionally grease retainers become worn allowing lubricant from wheel bearings to leak through in the brake drum. When grease comes into contact with the END CLOSURES, they become soft and enlarged, preventing them from protecting the cylinder from foreign matter. If this occurs, replace defective parts.

N O T E

AFTER A WHEEL CYLINDER IS REMOVED IT WILL BE NECESSARY TO BLEED BRAKES, AS AIR WILL HAVE ENTERED THE SYSTEM WITH THE WHEEL CYLINDER REMOVED.

STEERING GEAR DISASSEMBLY

1. Rotate steering worm until nut is in center of travel.

2. Remove sector shaft nut.

3. Use puller to remove pitman arm.

4. Remove side cover screws and remove side cover and sector shaft from housing.

5. To remove side cover from sector shaft, turn adjustor screw in end of sector shaft down through cover.

6. Remove screws and take out end cover with worm bearing, adjustor and lock nut.

7. Lift out worm bearing from end cover, loosen worm bearing adjustor lock nut and turn adjustor screw thru cover.

8. Grasp lower end of steering worm and draw steering shaft and nut out of steering housing. Disassembly of worm nut is not recommended.

CAUTION

BE SURE TO KEEP SHAFT IN HORIZONTAL POSITION SO THAT NUT DOES NOT MOVE AGAINST STOPS AT ANY TIME, CAUSING DAMAGE TO BALL RETURN MECHANISM.

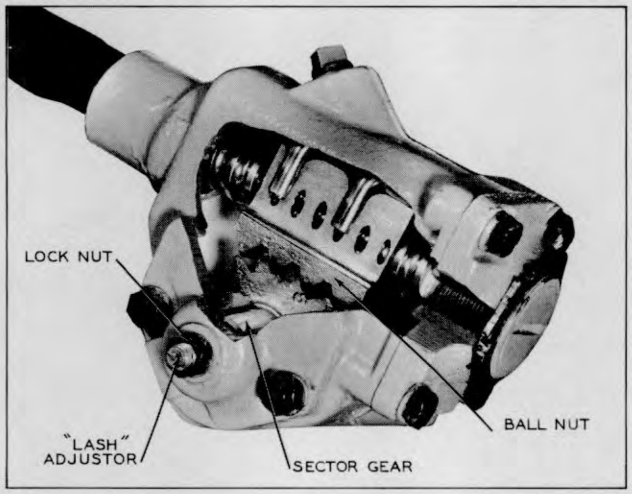


Plate 6637. Steering Gear Lash Adjustment (Sector Gear)

INSPECTION

1. Clean all parts in a Stoddard type cleaning solvent.

2. Inspect all bearings for pitting or wear.

3. Inspect worm, and re-circulating ball nut for nicks or excessive wear. If either of these parts are unfit for use it will be necessary to replace with a new sub-assembly as they are not serviced separately.

4. Inspect sector shaft for nicks or excessive wear.

5. Inspect side cover bushing for excessive wear. If the bushing cannot be reused it will be necessary to replace the side cover new as the bushing is not serviced separately.

STEERING GEAR REASSEMBLY

1. Install worm shaft and nut assembly in gear housing, keeping ball nut away from stops on worm.

2. Install worm bearing adjusting screw with lower worm bearing, and adjustor lock nut in end cover.

3. Install end cover and attaching parts on gear housing, making sure bearings seat properly.

4. Tighten worm bearing adjusting screw until a slight drag is felt on bearings. Do not tighten lock nut.

5. Install a new gasket on side cover.

6. Install sector shaft and adjusting screw inside cover.

7. Rotate steering worm until ball nut is in center of travel so that center tooth on sector shaft will enter center space on nut.

8. Install side cover and sector shaft in gear housing.

9. Tighten sector shaft adjusting screw until a slight drag is felt on bearing but do not tighten lock nut.

10. After steering gear is installed in vehicle and is properly lubricated adjust as follows:

ADJUSTMENTS

1. Disconnect drag link from pitman arm.

2. Loosen sector shaft lash adjustor screw a few turns to relieve load from bearings.

3. Turn steering wheel in one direction until stopped by gear, then back away about one turn.

4. With a spring scale hooked to rim of steering wheel, measure pull required to keep wheel in motion. If not within the limits outlined in specifications, adjust worm bearings as follows:

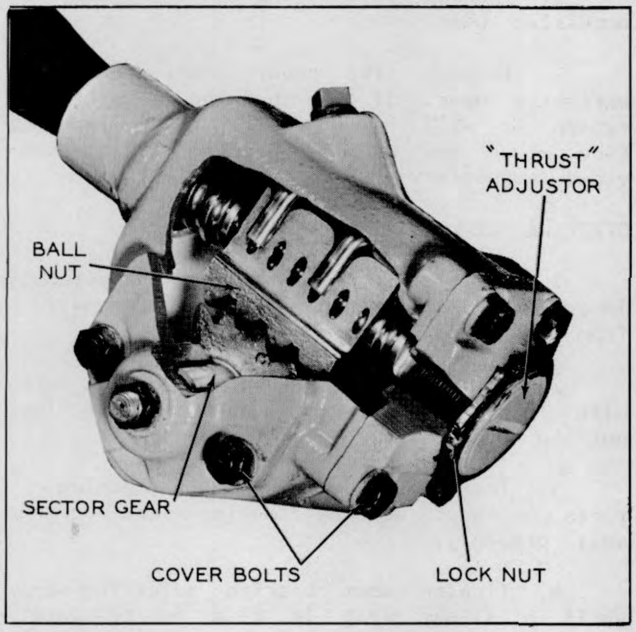


Plate 6636. Steering Gear Thrust Adjustment (Worm Bearings)

a. Loosen worm bearing adjustor lock nut and turn adjustor until there is no perceptible end play in worm. Check pull at wheel rim, readjusting as required to obtain proper pull. Tighten lock nut and recheck pull.

b. After worm bearing adjustment is completed and all mounting bolts tightened, adjust sector shaft end play.

c. With steering wheel in straight-ahead position, turn lash adjustor screw clockwise to remove all lash and tighten lock nut.

d. Check pull at rim of steering wheel, taking highest reading on scale as wheel is turned through the central or straight-ahead position. If this reading exceeds the limits outlined in specifications, turn lash adjustor screw counter-clockwise, then take up on the adjustment in a clockwise motion.

e. Tighten lock nut and recheck pull.

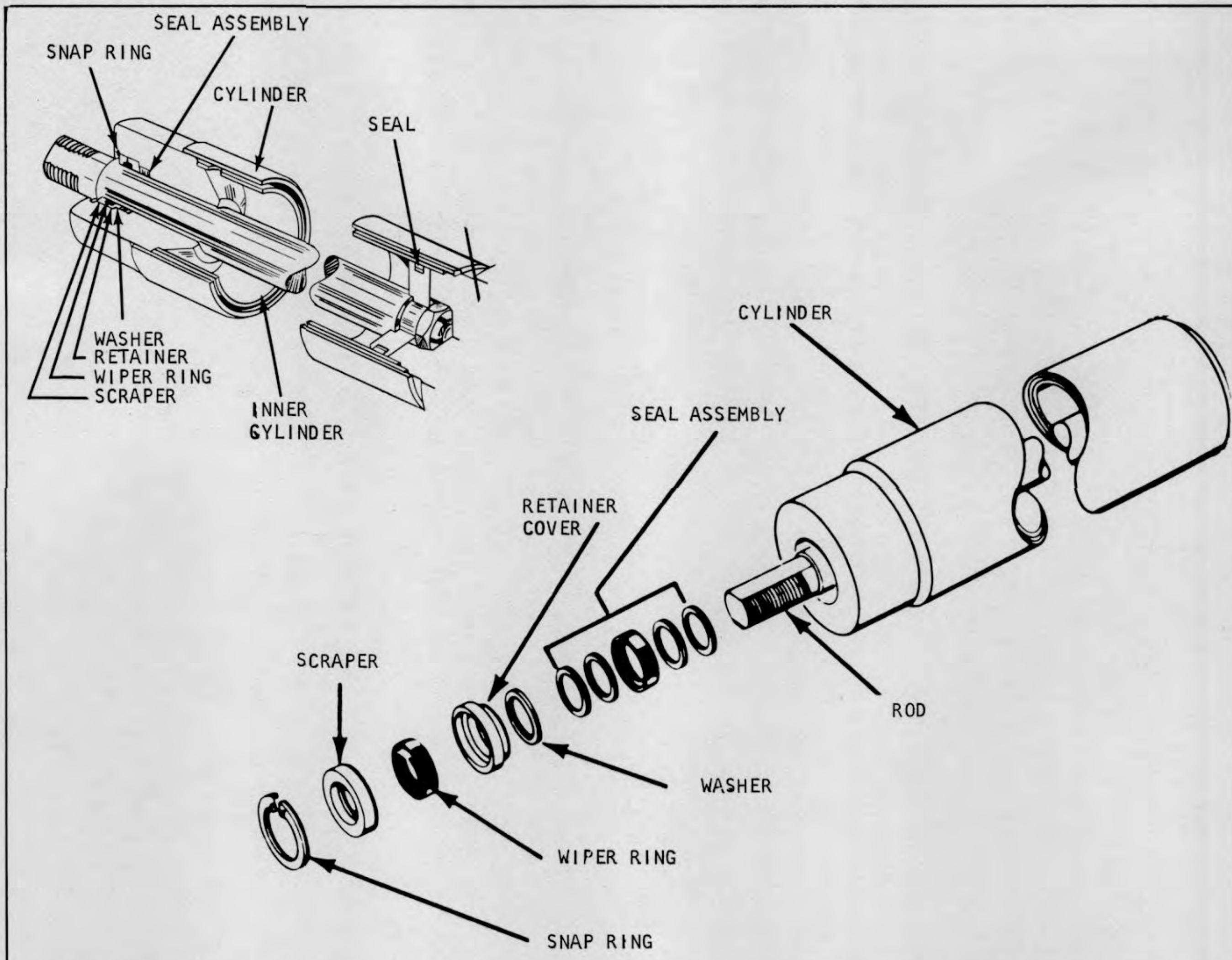


Plate 6905. Cutaway View Steering Cylinder Assembly

STEERING CYLINDER DISASSEMBLY

The cylinder assembly is a sealed unit. Overhaul procedures are restricted to replacing the sealing parts on the rod end of the cylinder.

1. Remove nut, bolt, and lockwasher from the rod end and unscrew from cylinder piston rod.

2. Remove retainer snap ring with snap ring pliers. Rotate the rod and withdraw it far enough from the cylinder to expose scraper, wiper ring, retainer and washer. The shaft seal may be removed with a hooked scriber.

INSPECTION

1. Inspect cylinder shaft for damage and straightness to insure proper sealing.

CYLINDER REASSEMBLY

1. After making sure that the cylinder cap bore is clean, coat the rod seal assembly parts with petroleum jelly. Install two back-up rings over the rod and in the cylinder cap bore. Be sure that the split ends are staggered. Install the seal ring and two outer back-up rings, again with split ends staggered. Install the washer, retainer, wiper and scraper. Install the snap ring.

2. Screw the rod end sub-assembly onto the end of the cylinder rod. Align the split collar with the flat on the rod and install the locking bolt, nut and lockwasher.

TROUBLE	PROBABLE CAUSE	REMEDY
FLUCTUATING PRESSURE	FAULTY OPERATION OF RELIEF VALVE	Fluctuating pressure or loss of pressure in the system is uaually caused by scale, chips, sludge, filings that have lodged between the relief valve and seat or by a damaged spring or worn valve. Flush and refill system. If condition still exists, overhaul valve assembly.
LOSS OF SYSTEM PRESSURE	SLIPPAGE OF PUMP DRIVE, OTHER PUMP MALFUNCTION	Check pump according to manufacturer's recommendations.
CYLINDER PISTON ROD BINDING OR STICKING	CRAMPING OF LINKAGE	With hydraulic flow shut off from the unit and the rod end uncoupled the rod should slide freely in or out by hand with a maximum force of 30 lbs. If binding is apparent, replace the unit and readjust pitman arm stops to prevent recurrence of damage.
CHATTER CONDITIONS	LOOSE MOUNTINGS OR LINKAGE RELIEF VALVE SET TOO LOW INSUFFICIENT PUMP FLOW	Make certain all ball stud mounting and other linkage is tight. Check pitman arm stops to be certain the arm strikes the stops slightly before the steering knuckles contact the stops on the axle. Set relief valve at least 150 PSI higher than normal steering requirements of the vehicle. Bleed air from system. Insufficient pump flow at idle speeds can be corrected by increasing engine idle rpm.
UNSATISFACTORY STEERING IN EITHER DIRECTION	AIR IN SYSTEM, EXCESSIVE WEAR IN STEERING CYLINDER, INCORRECT SYSTEM PRESSURE, WORN PUMP	Check for air in system. Excessive noise or foamy condition of oil indicates aeration. Check to be sure air is not entering system through poor threads, hoses, pump seals, "O" rings, gaskets and loose connections. Excessively worn cylinders result in leakage past the piston. Correct by replacing cylinder. Set relief valve at least 150 PSI higher than normal steering requirements of the vehicle. Repair or replace pump.

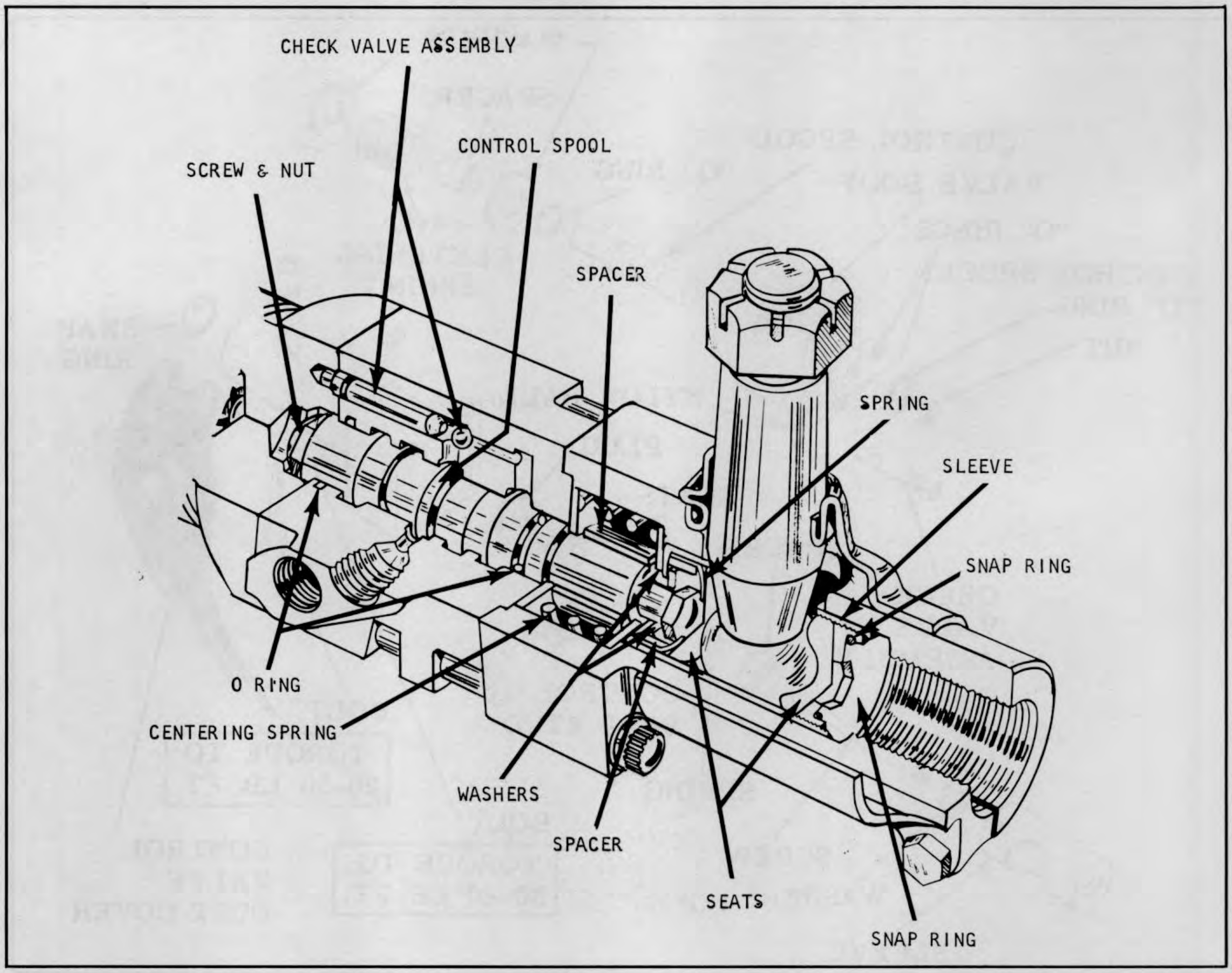


Plate 6904. Cutaway View Steering Valve Assembly

STEERING VALVE DISASSEMBLY

1. Hold control ball stud housing and valve assembly in a vise, by lightly clamping valve body. Use care not be distort spool bore in valve body.

2. Remove control valve dust cover and remove the wire snap ring which locks the control ball stud sleeve plug and remove plug. Remove control ball stud, two ball stud seats, spring washer and spacer.

3. Remove the bolts securing the ball stud housing to the valve and remove self-locking nut from spool capscrew. Remove capscrew, washer and control ball stud sleeve. Then lift the two centering spring retaining washers, centering spring and spacer from the valve body. Remove "O" rings from valve body and from the spool.

4. Remove the check valve, "O" ring, and ball from the valve body to complete the disassembly.

INSPECTION

1. Discard all "O" rings and seals and replace with new upon reassembly.

2. Wash all parts in a Stoddard type cleaning solvent.

3. Inspect all fluid passages in valve body to be certain they are clean and free of obstructions.

4. Check each disassembled part for wear, cracks or pitting that would render them unfit for continued use. Replace all defective parts.

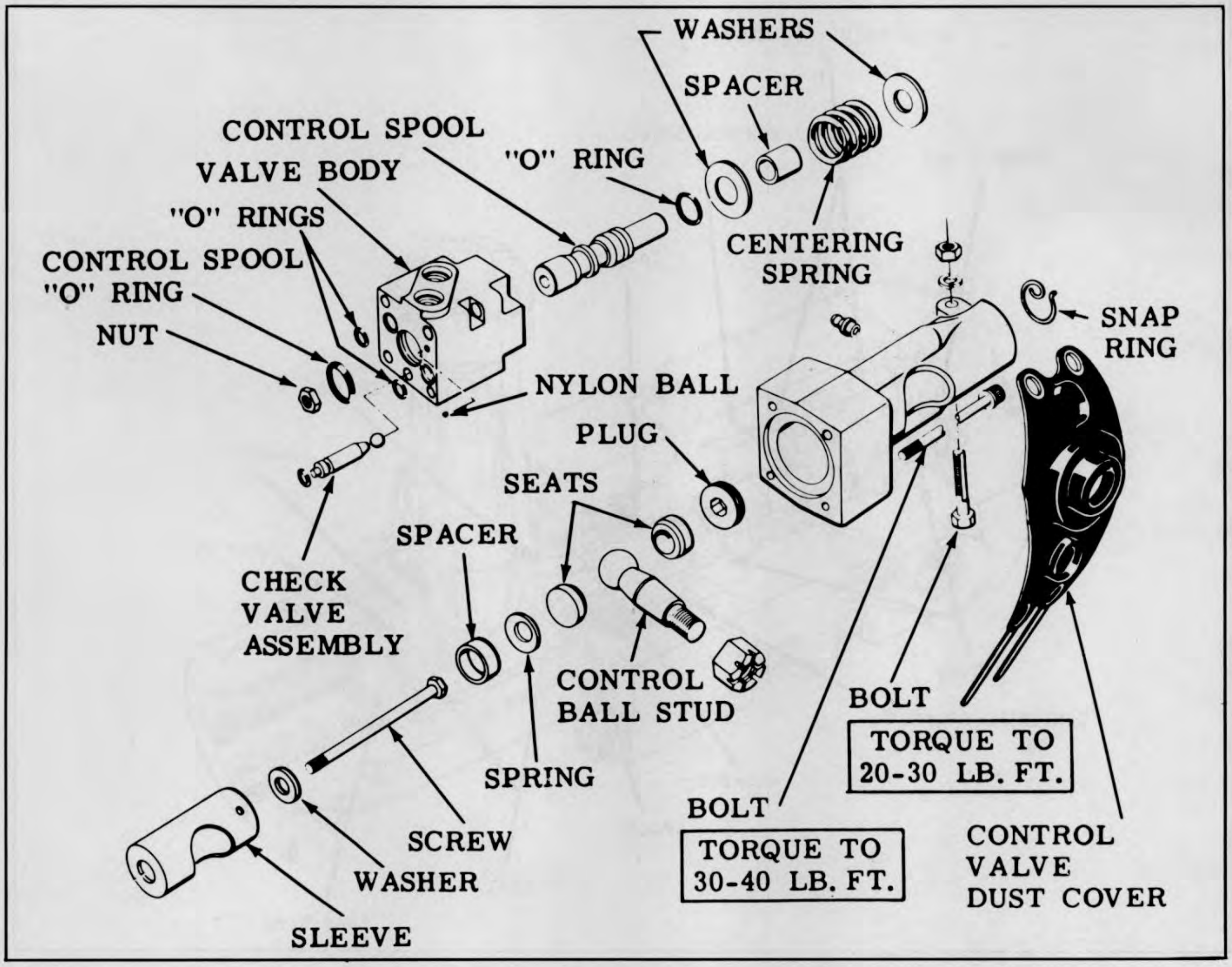


Plate 6977. Exploded View of Steering Valve

5. Inspect valve spool and valve spool bore for deep scoring and excessive wear. As these parts are not ordinarily serviced separately they should be replaced as a unit if badly worn. Do not rework or attempt to touch up the valve spool. This practice will only result in inproper steering unit operation and performance.

REASSEMBLY

1. Immerse all parts in clean hydraulic fluid to facilitate assembly. Coat all "O" rings and seals with petroleum jelly prior to assembly.

2. Install new "O" ring (coated with grease or petroleum jelly) in cylinder end of valve body and on control ball stud end of valve spool. Install spool in bore from the control ball stud end to avoid "O" ring interference during assembly.

3. Install washer, spacer, centering spring, washer, control ball stud sleeve, capscrew washer and capscrew. Install self locking nut and tighten until play between parts is removed. Be sure that nut is in good condition and that the centering spring remains aligned between the two retaining washers. Back nut off one flat (1/6 turn or 60°).

4. Start control ball stud sleeve plug in control ball stud sleeve.

5. Slide the control ball stud housing over the ball stud sleeve.

6. Install new "O" ring on check valve and place ball and check valve in valve body recesses and hold valve against its port end mating surface making sure the locating pin on the check valve engages the recessed hole to insure proper port alignment.

7. Locate control ball stud housing in desired position relative to control ball stud. Install four capscrews while holding valve and control assembly in place to prevent misalignment of "O" rings. Tighten capscrews to proper torque. (Refer to specifications).

8. Install control ball stud spacer. The spring washer must be installed with its convex (raised inside diameter) face toward ball stud to provide spring tension on ball stud. Next install ball stud seats and control ball stud. Position the stud and sleeve so that the stud is centered in the sleeve opening.

9. Tighten control ball stud sleeve plug snugly against seat. Back plug off until slot in plug lines with one of snap ring anchor holes in sleeve which are spaced at 60° intervals in control ball stud sleeve. Install hooked end in anchor hole and engage snap ring in groove in sleeve plug. This can most easily be done by engaging tang in hole in sleeve and then applying pressure with small screwdriver opposite tang on outside edge of snap ring.

VAN TYPE HYDRAULIC PUMPS (POWER STEERING)

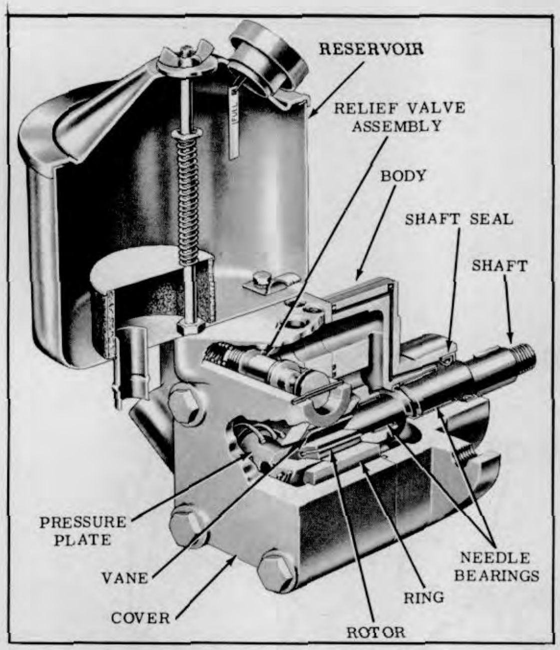


Plate 9471. Integral Reservoir Pump

GENERAL

The VTM series power steering pump is designed for direct mounting with most of the bearing load carried by the external mounting.

Principal components consist of the reservoir, body, cover, ring, rotor, vanes, pressure plate, relief valve and drive shaft assembly. The VTM-40 series is designed for direct mounting with most of the bearing load carried by the external mounting.

OVERHAUL

Disassembly

(1) Remove the pressure line and "O" ring and free the reservoir from pump.

(2) Clamp pump mounting flange in a machinists vise, being certain to use protective jaws. Remove cover mounting cap screws. Separate the cover from the pump body. Remove pressure plate spring and pressure plate. Remove adapter plate and "O" rings. Remove pump ring, locating pins, rotor and vanes, and the two "O" rings.

Mount the cover in a vise. Drive out retaining pin with pin punch. Protect the relief valve plug and subassembly against falling from bore. Work the plug, control valve and spring from the bore.

Remove the shaft and seal from the pump body. The shaft bushing is included in the body subassembly and can not be serviced separately.

Inspection, Repair, Replacement

(1) Wash all parts, except seals, in clear Stoddard type solvent and lay them aside for inspection. Replace all old seals and "O" rings at reassembly.

(2) Inspect the surfaces of all parts which are subject to wear. Light scoring may be removed from the faces of the body or wear plate with crocus cloth (by placing the cloth on a flat surface), medium India stone or by lapping. Check the edges of vanes for wear. Vanes must not have excessive play in slots or burrs on edges. Replace if necessary. Check each rotor slot for sticky vanes or wear. Vanes should drop in rotor slots by their own weight when both slot and vane are dry.

(3) Insert relief valve in its bore in pump cover. There should be no binding. Check valve and bore for excessive wear and scoring. Replace if necessary.

(4) Wash bearing and shaft assembly thoroughly. If the bushing is worn, replacement of the body subassembly is necessary.

(5) Replace the shaft seal at each overhaul to prevent oil leakage. Check the drive shaft oil seal diameter for wear and scoring. Do not install a new seal on a shaft which is worn or damaged at the oil seal diameter. Replace the shaft if worn. Stone and polish sharp edges on the shaft to prevent damage to the seal.

(6) Stone all mating surfaces of the body and cover with a medium India stone to remove all burrs and sharp edges. Rewash all parts after stoning.

Reassembly

NOTE

Immerse all parts in clean hydraulic fluid to facilitate reassembly.

NOTE

Tools for installing bearings can be made from round stock the outside diameter of which is slightly smaller than the outside diameter of the bearing and the inside diameter slightly larger than the shaft diameter. Do not score or otherwise damage the shaft during this operation.

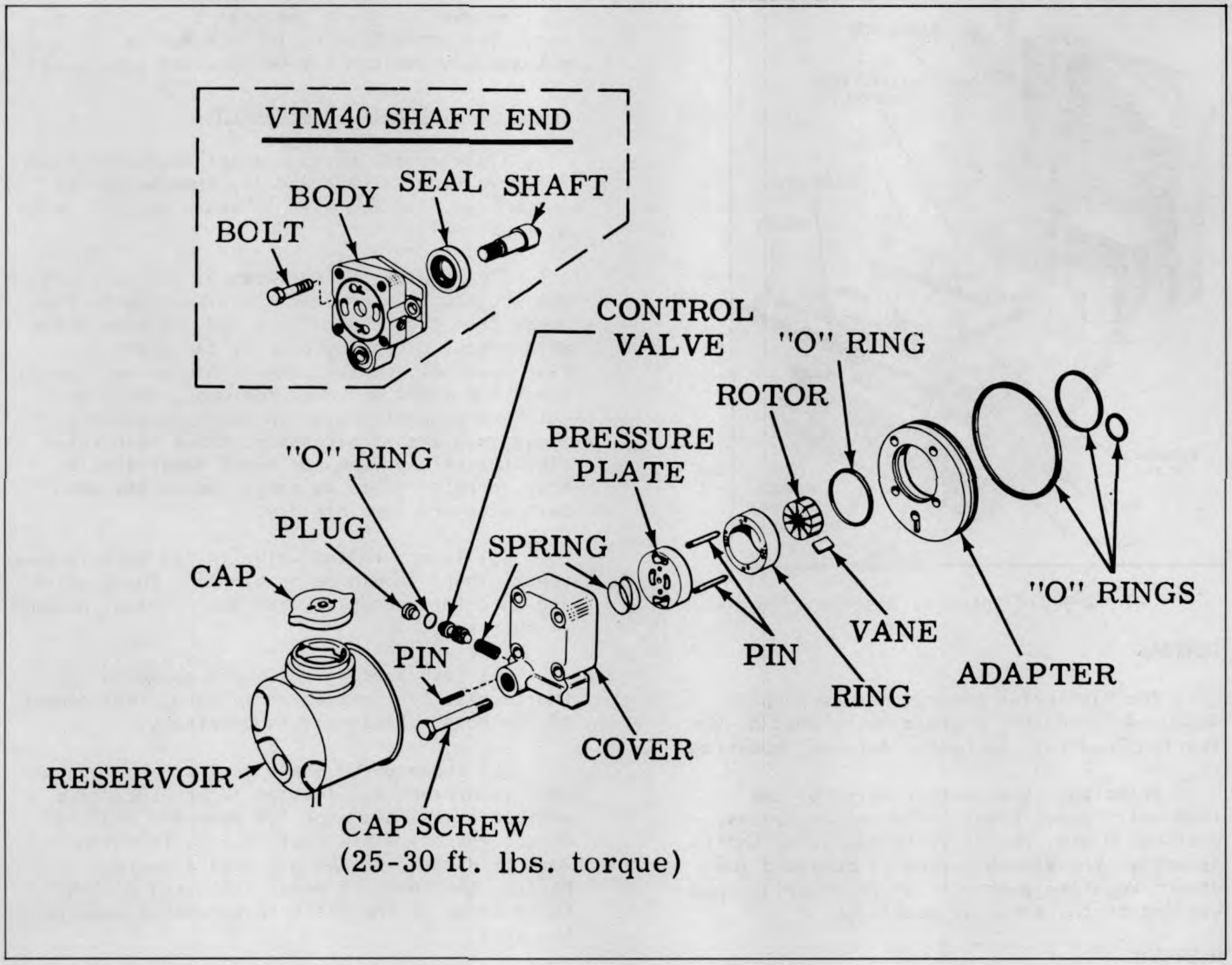


Plate 9472. Hydraulic Pump Exploded View

Position the seal on the shaft end of the body, being careful not to damage seal. Using special tool (see above note) press seal in until it engages the shoulder in the body. This shoulder acts as a positive stop for the seal. Do not overpress as damage to the seal will result.

Carefully install shaft to prevent damage to shaft bushing and seal surfaces.

(2) Install locating pins in body. Install ring over pins in correct direction of rotation. Then install rotor with Chamfered edge of splined hole "in" or toward pump body. The chamfer facilitates assembly.

Install vanes with their radius edge toward the inner ring contour. Then install the adapter plate and "O" rings.

Oil the cartridge with clean hydraulic fluid and install pressure plate.

Install "O" rings, install pressure plate spring and cover. Tighten cover screws to 25 - 30 lb ft. torque.

Install pressure compensating spring in relief valve bore. Insert valve assembly with the hex toward the spring. Install plug with "O" ring in bore and hold it in position while driving a new retaining pin.

Install the two pump mounting bolts in the body flange. Install a new "O" ring on adaptor plate. Install reservoir so the hole is aligned with the cover discharge port. Install a new "O" ring on the discharge fitting and install fitting to secure reservoir. Be careful that the "O" ring is not damaged as it is forced through the hole in the reservoir.

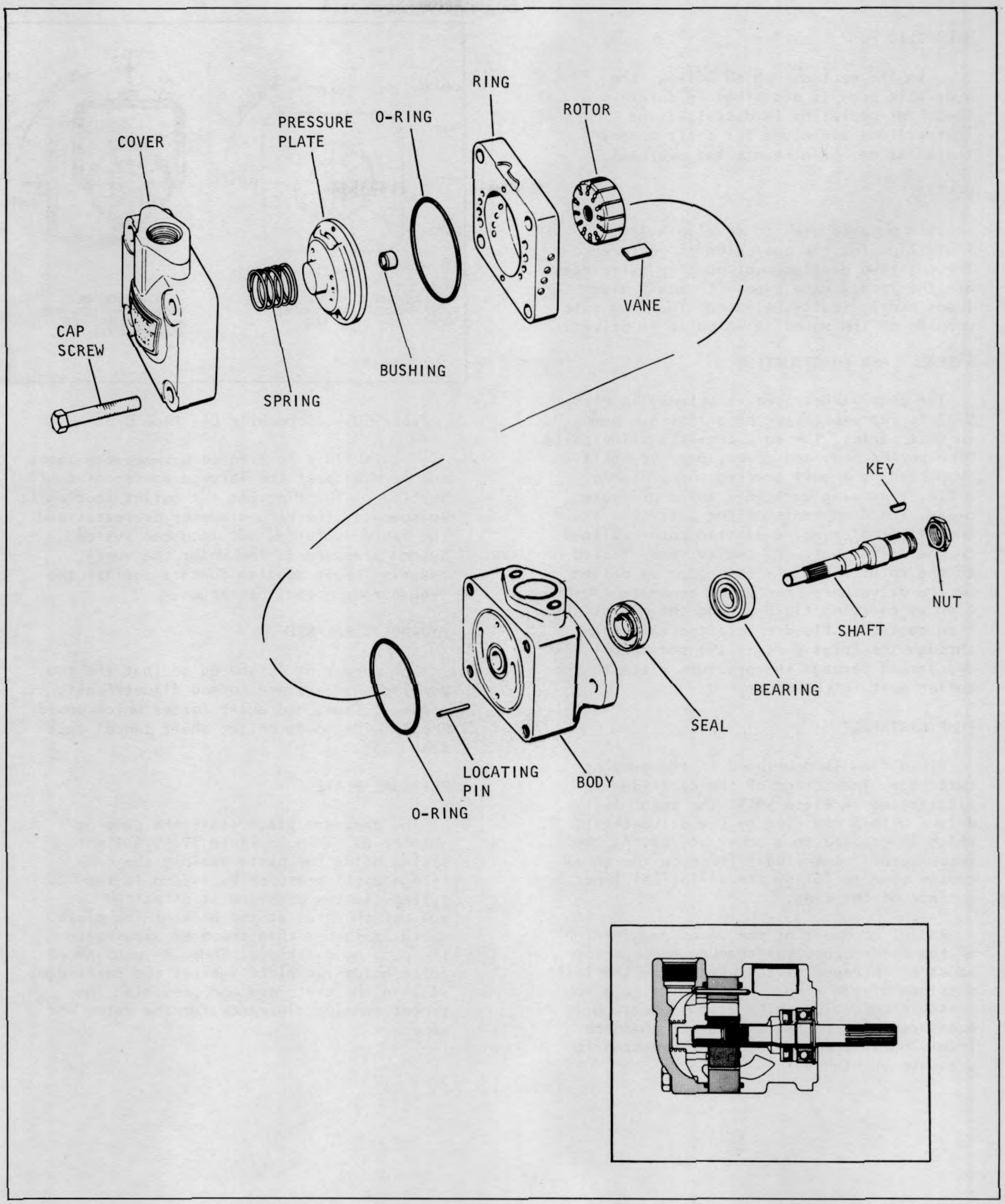


Plate 5777 Cut-a-way View of Pump

HYDRAULIC PUMP

In the sections which follow, the hydraulic pump is described in detail. Theory of operation is discussed and instructions are given for their proper installation, maintenance and overhaul.

GENERAL

This pump is used to develop hydraulid fluid flow for the operation of equipment. The positive displacement pumping cartridges are the rotary vane type with shaft side loads hydraulically balanced. The flow rate depends on the speed at which it is driven.

ASSEMBLY AND CONSTRUCTION

The pump illustrated in cutaway in Plate 5777 is representative of all single pumps in this series. The unit consists principally of a ported body and cover, a drive shaft supported by a ball bearing and pressure plate, a pumping cartridge and a pressure plate. The components of the cartridge are andellipitcal ring, a slotted rotor splined to the drive shaft and twelve vanes fitted to the rotor slots. As the rotor is driven by the driveshaft, the vanes generate fluid flow by carrying fluid around the elliptical ring controur. Fluid enters the cartridge through the inlet port in the body and is discharged through the pressure plate to the outlet port in the cover.

PUMP CARTRIDGE

Fluid flow is developed in the pumping cartridge. The action of the cartridge is illustrated in Plate 5054. The rotor is driven within the ring by the drive-shaft, which is coupled to a power source. As the rotor turns, centrifugal force on the vanes causes them to follow the elliptical inner surface of the ring.

Radial movement of the vanes and turning of the rotor cause the chamber between the vanes to increase as the vanes pass the inlet sections of the ring. This results in a low pressure condition which allows atmospheric pressure to force fluid into the chambers. (Fluid outside the inlet is at atmospheric pressure or higher.)

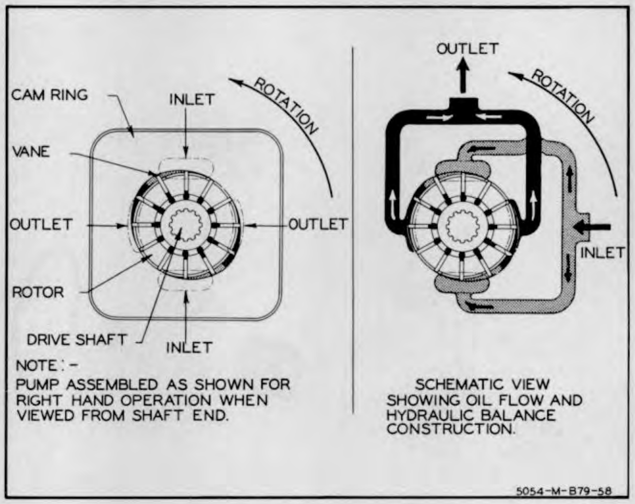


Plate 5054. Schematic Oil Flow Diagram

This fluid is trapped between the vanes and carried past the large diameter or dwell section of the ring. As the outlet section is approached, the ring diameter decreases and the fluid is forced out into the system. System pressure is fed under the vanes, assuring their sealing contact against the ring during normal operation.

HYDRAULIC BALANCE

The pump ring is sha ed so that the two pumping chambers are formed diametrically opposed. Thus, hydraulic forces which would impose side loads on the shaft cancel each other out.

PRESSURE PLATE

The pressure plate seals the pumping chamber as shown in Plate 7725. A light spring holds the plate against the cartridge until pressure builds up in the system. System pressure is effective against the area at the back of the plate, which is larger than the area exposed to the pumping cartridge. Thus, an unbalanced force holds the plate against the cartridge, sealing the cartridge and providing the proper running clearance for the rotor and vanes.

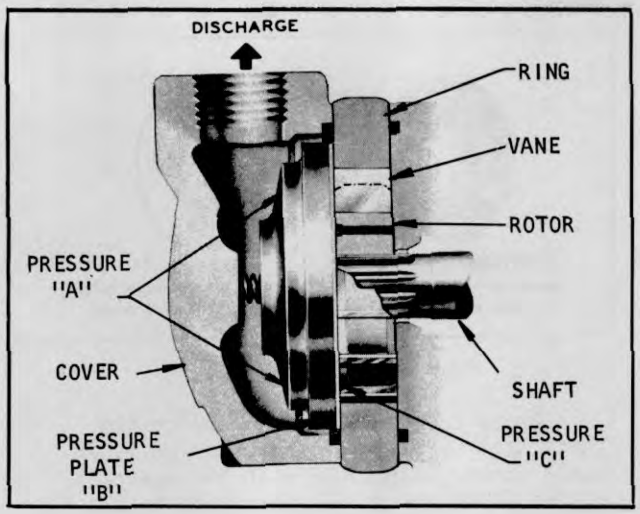


Plate 7725. Schematic View Pump Cartridge and Cover Recess

SHAFT ROTATION

N O T E

THESE PUMPS MUST BE DRIVEN IN THE DIRECTION OF THE ARROWS CAST ON THE PUMP RING.

C A U T I O N

NEVER DRIVE A PUMP IN THE WRONG DIRECTION OF ROTATION. SEIZURE MAY RESULT, NECESSITATING EXPENSIVE REPAIRS.

INSPECTION

Periodic inspection of the fluid condition and tube or piping connections can save time-consuming breakdowns and unnecessary parts replacement. The following should be checked regularly.

1. All hydraulic connections must be kept tight. A loose connection in a pressure line will permit the fluid to leak out and damage to the pump can result. In suction or return lines, loose connections permit air to be drawn into the systems, resulting in noisy and/or erratic operation.

2. Clean fluid is the best insurance for long service lift. Therefore, the reservoir should be checked periodically for dirt or other contaminants.

If the fluid becomes contaminated the system should be thoroughly drained and the reservoir cleaned before new fluid is added.

3. Filter elements also should be checked and replaced. A clogged filter element results in a higher pressure drop. This can force particles through the filter which would ordinarily be trapped, or can cause the by-pass to open, resulting in a partial loss of filtration.

4. A pump which is running excessively hot or noisy is a potential failure. Should a pump become noisy or overheated, the machine should be shut down immediately and the cause of improper operation corrected.

GENERAL

Plug all removed units and cap all lines to prevent the entry of dirt into the system. During disassembly, pay particular attention to identification of the parts, especially the cartridges, for correct reassembly. Plate 5777 is an exploded view which shows the proper relationship of the parts for disassembly and reassembly.

DISASSEMBLY

1. <u>Disassembly of Basic Pump</u> - See Plate 5777. Clamp the pump body in a vise (not too tightly), cover end up, and remove the four cover screws. Note the position of the cover port with respect to the body port before lifting off the cover and "O" Ring.

Remove the pressure plate and spring and note the position of the ring for correct reassembly. Lift off the ring and remove the locating pin. Separate the vanes from the rotor and remove the rotor from the shaft.

Turn the pump body over and remove the shaft key and the snap ring which retains the outer bearing. Tap with a soft hammer so the splined end of the shaft to force the shaft out of the body. Support the bearing inner race and press the shaft out of the bearing. Pull the shaft seal out of the body with a suitable hooked tool and press out the inner bearing.

INSPECTION AND REPAIR

1. Discard the used shaft seal and all "O" rings. Wash the metal parts in mineral oil solvent, blow them dry with filtered compressed air and place them on a clean surface for inspection.

2. Check the wearing surfaces of the body, pressure plate, ring and rotor for scoring and excessive wear, remove light score marks by lapping. Replace any heavily scored or badly worn parts.

3. Inspect the vanes for burrs, wear and excessive play in the rotor slots. Replace the rotor if the slots are worn.

4. Check the bearings for wear and looseness. Rotate the bearings while applying pressure to check for pitted or cracked races.

5. Inspect the oil seal mating surface on the shaft for scoring or wear. If marks on the shaft cannot be removed by light polishing, replace the shaft.

REASSEMBLY

Coat all parts with hydraulic fluid to facilitate reassembly and provide initial lubrication. Use small amounts of petroleum jelly to hold "O" rings in place during assembly.

NOTE

DURING HANDLING AND SHIPPING OF THE PRECISION MACHINED CARTRIDGE PARTS, IT IS POSSIBLE TO RAISE BURRS ON THE SHARP EDGES. ALL SHARP EDGES ON THE PARTS OF A NEW CARTRIDGE KIT SHOULD BE STONED PRIOR TO INSTALLATION.

1. Reassembly of Pump - See Plate 5777. Begin reassembly by pressing the shaft into the front bearing while supporting the bearing inner race. Next, press the inner bearing into the body, using a driver which contacts the outer race only. Be certain both bearings are firmly seated.

NOTE

BEFORE ASSEMBLING THE SHAFT SEAL, DETERMINE THE CORRECT POSITION OF THE SEALING LIP. (SEE PLATE 8293) DOUBLE LIP SEALS ARE ASSEMBLED WITH THE SPRING TOWARD THE PUMPING CARTRIDGE. SINGLE LIP SEALS HAVE TWO PRESSURE HOLES, WHICH ARE ASSEMBLED TOWARD THE SHAFT END OF THE PUMP.

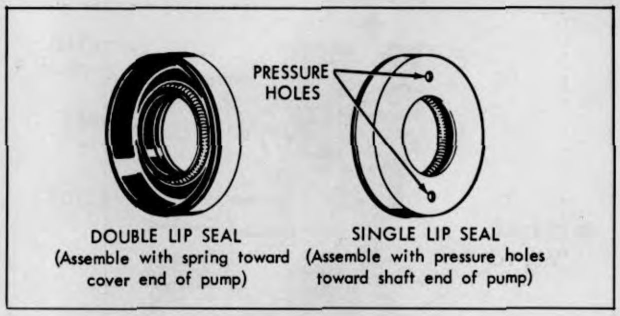


Plate 8293. Shaft Seal

Press the seal firmly in place and lubricate the lip with petroleum jelly or other grease compatible with the system fluid. Slide the drive shaft into the body until the bearing is seated. If necessary tap lightly on the end of the shaft. Install the snap ring.

Install new "O" rings in the body and cover. Insert the ring locating pins in the body and assemble the ring so that the arrow on the perimeter points in the proper direction of rotation. Install the rotor on the shaft and insert the vanes in the rotor slots. Be certain the radius edges of the vanes are toward the cam ring.

Place the pressure plate on the locating pins and flat against the ring. Use a small amount of petroleum jelly or grease to stick the spring on the protrusion of the pressure plate. Carefully install the cover with the outlet port in the correct position. Torque the cover screws 65 to 75 ft. lbs. Turn the shaft through by hand to insure that there is no internal binding. Install the shaft key.

Assemble the pump to its mounting flange using a new gasket. Be certain it is flat to avoid misalignment of the shaft.

T R O U B L E   S H O O T I N G

It should always be remembered that many apparent pump failures are actually the failures of other parts of the systems. The cause of improper operation is best diagnosed with adequate testing equipment and a thorough understanding of the complete hydraulic system.

TROUBLE	PROBABLE CAUSE	REMEDY
PUMP NOT DELIVERING FLUID	DRIVEN IN THE WRONG DIRECTION OF ROTATION	The drive direction must be changed immediately to prevent seizure. Plate 5054 shows the correct ring position (viewed from cover end.)
	KEY OR SHAFT SHEARED OR DISENGAGED	Disassemble the pump and check the shaft and cartridge for damage. Replace the necessary parts.
	FLUID INTAKE PIPE IN RESERVOIR RESTRICTED	Check all filters/strainers for dirt and sludge. Clean if necessary.
	FLUID VISCOSITY TOO HEAVY TO PICK UP PRIME	Completely drain the system. Add new filtered fluid of the proper viscosity. Replace filter/strainers.
	AIR LEAKS AT THE INTAKE. PUMP NOT PRIMING	Check the inlet connections to determine where air is being drawn in. Tighten any loose connections. Check the minimum drive speed which may be too slow to prime the pump.
	VANE(S) STUCK IN THE ROTOR SLOTS(S)	Disassemble the pump. Check for dirt or metal chips. Clean the parts thoroughly and replace any damaged pieces. If necessary flush the system and refill it with clean fluid.
INSUFFICIENT PRESSURE BUILD-UP	WORN PARTS CAUSING INTERNAL LEAKAGE OF PUMP DELIVERY	Replace pump cartridge.
PUMP MAKING NOISE	PUMP INTAKE PARTIALLY BLOCKED	Service the filters/strainers. Check the fluid condition and, if necessary, drain and flush the system. Refill with clean fluid.
	AIR LEAKS AT THE INTAKE OR SHAFT SEAL. (OIL IN RESERVOIR WOULD PROBABLY BE FOAMY)	Check tne inlet connections and seal to determine where air is being drawn in. Tighten any loose connections and replace the seal if necessary.
	PUMP DRIVE SPEED TOO SLOW OR TOO FAST	Operate the pump at the recommended speed.

HYDRAULIC SYSTEM

TROUBLE SHOOTING GUIDE

The following chart lists the difficulties which may possibly be experienced with the pump and hydraulic system and indicates the cause and remedy for each of the troubles listed. It should always be remembered that "Pressure" and "Delivery" are factors which are usually dependent upon each other. Next to having adequate tools, it is probably most important to have adequate pressure gauge equipment when doing repair work.

TROUBLE	PROBABLE CAUSE	CORRECTION
A. Pump not delivering oil.	1. Wrong direction of rotation.	1. Must be reversed immediately to prevent seizure and breakage of parts due to lack of oil.
	2. Tank oil level low.	2. Add recommended oil.
	3. Oil intake pipe or suction filter plugged.	3. Filters must be cleaned of lint soon after new oil is added, due to fact new oil contains considerable amount.
	4. Air leak in suction line.	4. Will prevent priming, or cause noise and irregular action of control circuit.
	5. Oil viscosity too heavy to pick up prime.	5. Thinner oil should be used, per recommendations for given temperature and service.
	6. Broken pump shaft or rotor.	6. Refer to preceding service data for replacement instructions.
B. Pump not developing pressure.	1. Pump not delivering oil for any of the above reasons.	1. Check oil circulation by watching oil in tank.
	2. Relief valve setting not high enough.	2. Block machine travel, or oil circulation, and test with pressure gauge.
	3. Relief valve sticking open.	3. Dirt under pressure adjustment ball. See relief valve instructions.
	4. Leak in hydraulic control system (cylinders or valves).	4. Find leak and correct.
	5. Vane or vanes stuck in rotor slots.	5. Inspect for wedged chips.
	6. Head too loose. (Very frequent).	6. Must not be tightened too tightly.
	7. Broken core passages in pump body.	7. Replace body and check maximum relief valve setting immediately for shock overload condition.
	8. Partially clogged intake line, intake filter or restricted intake pipe.	8. Pump must receive intake oil freely or cavitation will take place.

TROUBLE	PROBABLE CAUSE	CORRECTION
C. Pump making noise.	1. Small air leak at pump intake piping joints.	1. Test by pouring oil on joints while listening for change in operation. Tighten as required.
	2. Air leak at pump shaft packing.	2. Repair or replace.
	3. Stuck pump vane.	3. Inspect for wedged chips or sticky oil and reassemble per preceding instructions.
	4. Pump head too loose.	4. Test by pouring oil over head.
	5. Tank air vent plugged.	5. Must be open thru breather opening or air filter.
	6. Too high oil viscosity.	6. Use recommended oils.
	7. Shaft packing worn.	7. Replace shaft packing per preceding instructions.
	8. Oil filter dirty.	8. Replace filter element.
D. Forks do not lift to maximum height.	1. Hydraulic Oil level low.	1. Fill sump tank.
E. Load on forks drifts down or tilts forward with controls in neutral.	1. Worn or damaged lift or tilt seal.	1. Install new seal.
	2. Leak in hydraulic system between lift cylinder and valve or tilt cylinder and valve.	2. Locate leak and tighten connections or replace parts as indicated.
	3. Oil leaking through valve due to wear or damage to valve parts.	3. Replace worn or damaged valve section complete with new valve plunger or spool.
F. Lift or tilt action fails.	1. Loss of oil pressure.	1. Remove pump to valve line at pump and install a "Tee" into line. Install a pressure gauge capable of registering 2000 PSI into "Tee". If a pressure of 1900 PSI is not indicated at full volumn flow thru the relief valve, check the relief valve for chips or foreign matter which may be holding the plunger off the seat. If the valve is clean adjust the relief valve screw in one turn and check again if pressure fails to respond look for trouble in pump. Do not adjust relief valve too far for unseating of seals can result. If the relief valve pressure is correct, check the pressure in the lift and tilt lines. If relief valve pressure is not being delivered, trouble may be leaks around plungers back to sump instead of to lines selected.
G. Oil leak at top of lift cylinder assembly.	1. Worn or damaged lift piston seal.	1. Replace seal.
	2. Scored cylinder wall.	2. Replace cylinder.
	3. Plugged vent line.	3. Clean out vent line. Replace if collapsed.
	4. Worn or damaged oil seal.	4. Replace seal.
H. Oil leak around piston rod at tilt cylinder.	1. Worn seal.	1. Replace seal.
	2. Scored piston rod.	2. Replace rod and eliminate cause of scoring which may be caused by misalignment, worn bearing or foreign matter.
I. With load centered on lift forks load is lifted unevenly.	1. Lift chains out of adjustment.	1. Adjust chains.

SCHROEDER HYDRA-SLEUTH

Your Schroeder Hydra-Sleuth is an invaluable instrument for:

(1) Determining the condition of a hydraulic pump.
(2) Troubleshooting a hydraulic system.
(3) Testing hydraulic system before and after rebuild.
(4) Preventive maintenance testing of a hydraulic system.

With the Hydra-Sleuth you can tell how much hydraulic horsepower (flow times pressure) your system will deliver to the cylinder (or motor) that does the work.

You can also learn where you are losing this "Hydraulic Horsepower" in a weak system.

The section has been carefully compiled to enable you to put the Hydra-Sleuth to its maximum use. We strongly urge you to read it thoroughly.

PRESSURE GAUGE:

Reads directly in pounds per square inch (PSI)

TEMPERATURE GAUGE:

Reads directly in degrees Fahrenheit and indicates the temperature of the oil passing through the instrument.

FLOW GAUGE:

Reads two scales in gallons per minute

0 - 30 gallons
9 - 30 gallons

Read the scale that corresponds with the orifice selector position.

Turn orifice selector to the left (counter-clockwise) to read 10 Gal. Scale. Turn orifice selector to the right (clockwise) to read 30 gallons scale.

You may switch from one scale to the other, while operating machine. Always start on 30 gallon scale.

LOAD VALVE:

The load valve is a flow restrictor or shut off valve. Turning the valve to the right throttles flow through the Hydra-Sleuth, thus the operator may load a hydraulic pump or circuit to the desired test pressure, simulating work.

SAFETY PLUG:

Located opposite the load valve this plug protects the Hydra-Sleuth and the tested system from pressures in excess of 3200 PSI. When pressure becomes higher the plug will rupture and dump oil to atmosphere.

HYDRAULIC FLUID:

Unless marked to the contrary, the unit is for use with petroleum, hydraulic fluids.

HOW TO CONNECT THE PORTABLE TESTER:

Using a 1/2" hose or larger, connect tester INLET PORT to the flow to be tested. Connect the tester outlet port to reservoir fill port, or system return line.

HYDRA-SLEUTH ADJUSTMENTS BEFORE OPERATION:

A. Depending on flow (GPM) to be checked choose proper orifice. (It is good practice to start always on 30 gallon scale.)

B. Fully open load valve by turning all the way to the left.

HYDRA-SLEUTH ADJUSTMENTS DURING OPERATION:

1. Turn load valve to right to develop test pressure.

C A U T I O N

LOAD VALVE IS CAPABLE OF VERY HIGH PRESSURES.

HYDRA-SLEUTH-PICTORIAL & SCHEMATIC

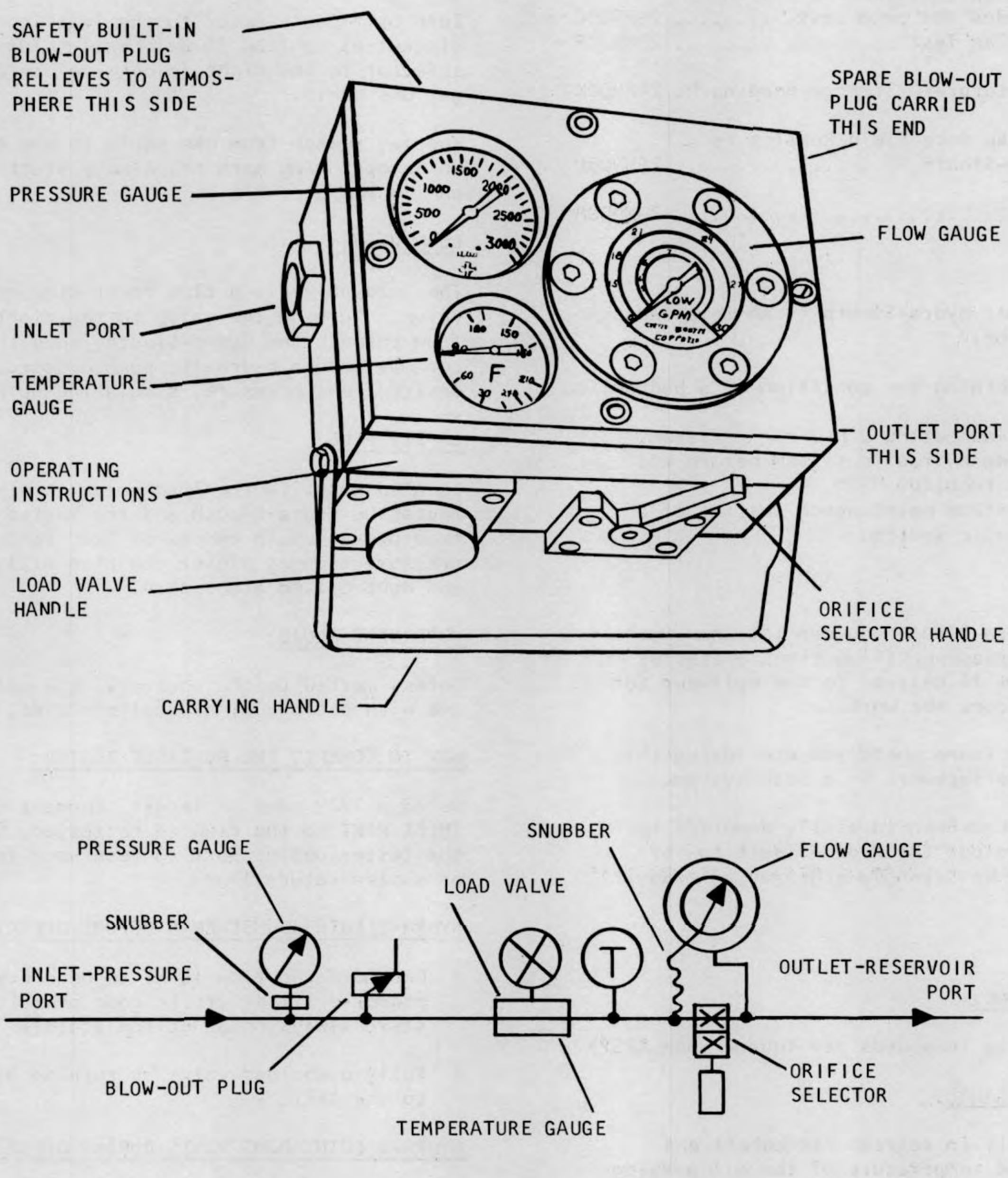


Plate 8625. Hydra-Sleuth Pictorial and Schematic Illustrations

A. Always start test with load valve fully open.

B. Do not exceed design pressure of system under test.

C. Keep load pressures within range of the Hydra-Sleuth pressure gauge.

THE BASIC TEST METHOD

The Hydra-Sleuth is an instrument that will:

(1) Measure the volume of oil passing thru it.
(2) Measure the temperature of the oil passing thru it.
(3) Furnish a manually variable means of restricting the oil passing thru it and a measurement of the resultant pressure.
(4) Determine the amount of power the system is capable of delivering (Horsepower - Flow X Pressure).

The test consist of:

(1) First learning how much fluid in gallons per minute is circulating in the system at no load, and then:

(2) By applying a desired pressure on all the components, find out how much of this fluid is not available for work because it is:

a. Not being delivered by pump due to internal slippage caused by wear.

b. Not being delivered to the working component (cylinder or motor) because it is leaking back to tank by passageways that are supposedly closed; namely valve leakage.

c. Not being used properly by the cylinder or motor because it is leaking past the cylinder packing (or the parts of the motor) and returning to the tank without having produced any useful work.

There are two ways of using your Hydra-Sleuth to learn these things about a hydraulic circuit. The simplest and most readily understood is the "Supply System Test." This test has the disadvantages of (1) being more laborious since it requires reconnecting the tester frequently and (2) not providing a test for the cylinder or motor.

The other method is called the "Tee Test." Once the user has acquired some skill, the tee test is the better test since it requires less work and tests ALL the components of the system from one point.

Both methods will be described but certain things should be done before either is attempted:

(1) Know the output of the pump and the proper relief valve setting of the system you will test.

(2) Bring the oil up to normal operating temperature.

(3) Keep engine RPM constant during test.

SUPPLY SYSTEM TEST (See Sketch A)

Hydraulic trouble has been reported and with the Hydra-Sleuth you want to locate the trouble in a circuit the same or similar to Sketch A, on following page.

TESTING THE PUMP (See Sketch B)

NOTE

The first step or pump test is a good way to familiarize yourself with the Hydra-Sleuth. Purpose, to determine if pump is o.k., completely "shot" or partially worn.

This is done by disconnecting the discharge line of the pump from the system. (Point 1), reconnecting it to the inlet port of the Hydra-Sleuth and connecting the outlet port of the instrument back to the tank, through the fill or any return line.

Then start the machine, drive the pump at full RPM and measure the oil pumped through the tester to the reservoir at no load.

Then by turning the load valve to the right; make the pump deliver oil through the tester at the desired working pressure - and measure the oil at this pressure. This GPM reading is the usable oil delivered by the pump at operating pressures and temperature and tells you what the pump is delivering under actual working conditions.

The GPM difference between the two readings - no load and operating pressures will be the internal slippage in the pump.

If the difference in these readings is small, the pump is O.K. and you must look elsewhere for the trouble. If it is large, you have located at least part of the trouble.

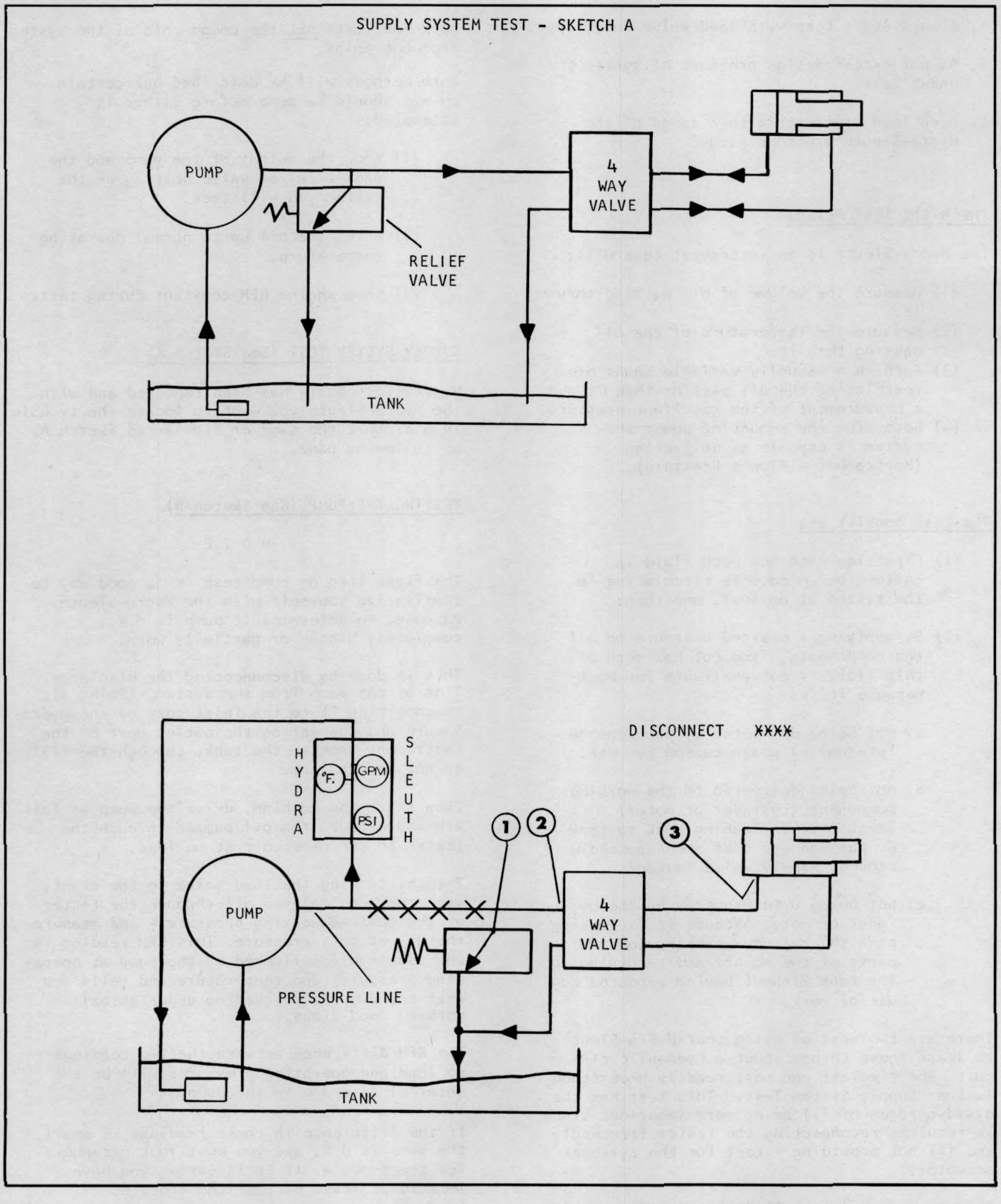


Plate 8626. Supply System Test—Sketch "A" (Upper Illustration), Testing the Pump - Sketch "B" (Lower Illustration)

GPM at NO LOAD	GPM at Operating Pressures	Interpretation of Reading
20	19	Pump is O.K.
20	10	Pump is partillly worn & 50% efficient. Cyl. in Sketch A would take twice the time to complete its movement.
20	0	Pump is completely shot there will be no Cyl. movement under load.

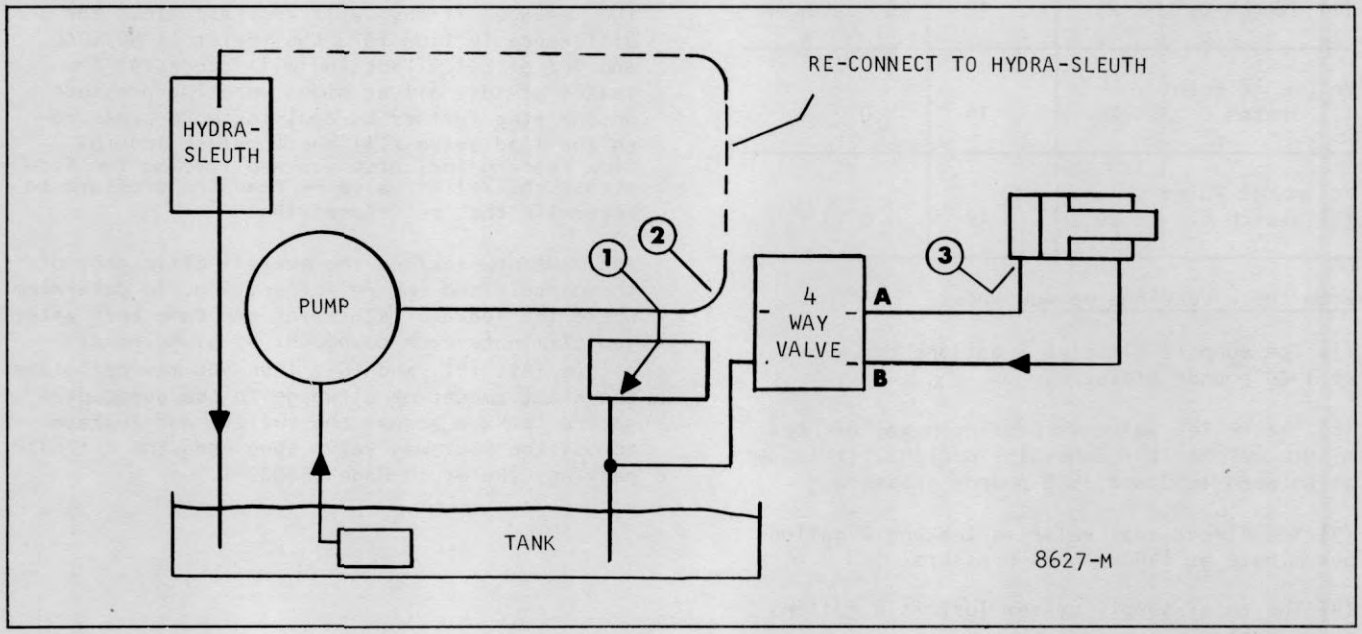


Plate 8627. Testing Other Components of the Supply System—Sketch "C"

Having learned the condition of the pump and relief, disconnect the line at point (3) and connect it to the Hydra-Sleuth and take additional readings — any further reduction will be the leakage in the four way valve.

At point (3) you are also measuring the oil delivered to the working component (cylinder or motor).

Let us say the readings you have taken are as follows:

	No Load 0 PSI	Operating Pressure 1400 PSI	Relief Valve Setting 1500 PSI
Volume at Point (1) Sketch C	20	18	not taken
Volume at Point (2) Sketch C	20	14	0
Volume at Point (3) Sketch C	20	12	0

From these readings we now know:

(1) The pump is slipping 2 gallons per minute at 1400 pounds pressure.

(2) The relief valve is passing 4 gallons per minute before it reaches its setting. It is set at between 1400 and 1500 pounds pressure.

(3) The directional valve is leaking 2 gallons per minute at 1400 pounds pressure.

(4) The total supply system loss is 8 gallons per minute.

Replacement of the relief valve is indicated at once and the wise maintenance man will schedule the four ways valve for a change at the next convenient time. Pump is in Good Shape.

THE "TEE TEST"

This test consists of placing a tee in the discharge line of the pump (Refer to Page 29M900G for hookup and Sketch D Page 29M900H for procedure) connecting the inlet port of the Hydra-Sleuth to the tee and the outlet port of the Hydra-Sleuth to the tank. By doing so you can apply any desired pressure to all parts of the system and determine their condition. Also note that by closing the load valve altogether you leave the Hydra Sleuth pressure gauge in the circuit but cut out the pressure gauge and temperature gauge. This gives you a "teed-in" pressure gauge and enables you to check the setting of the main relief valve.

By positioning the spool of the four way valve to direct oil to cylinder port A and closing the Hydra-Sleuth load valve just enough to run the piston of the cylinder out to the end of its travel, the oil may now flow to the tank either:

(1) Through the Hydra-Sleuth, or

(2) Through supposedly closed passages - i. e. leaks.

By opening the Hydra-Sleuth load valve the pump flow will all pass thru the Hydra-Sleuth — by slowly closing the load valve the pressure on each and evenly component is increased and hence the leakage, if any, will increase. Thus the difference in flow thru the tester at NO LOAD and 90% of relief setting will represent the leaked or lost oil at high operating pressure. Go one step further by applying more pressure on the load valve till the complete loss of flow reading indicates you are forcing the flow across the relief valve — read the pressure to determine the relief setting.

You have now learned the overall efficiency of the circuit and the relief setting. To determine where the leakage is, repeat the same test after you eliminate each component by plugging at points (A), (B), and (C). Thus you may calculate the exact amount of slippage in the pump, premature leakage across the relief, and leakage across the four way valve spool and the cylinder packing, (Refer to Page 29M900H).

BASIC "TEE" TEST FOR SCHROEDER HYDRA-SLEUTH

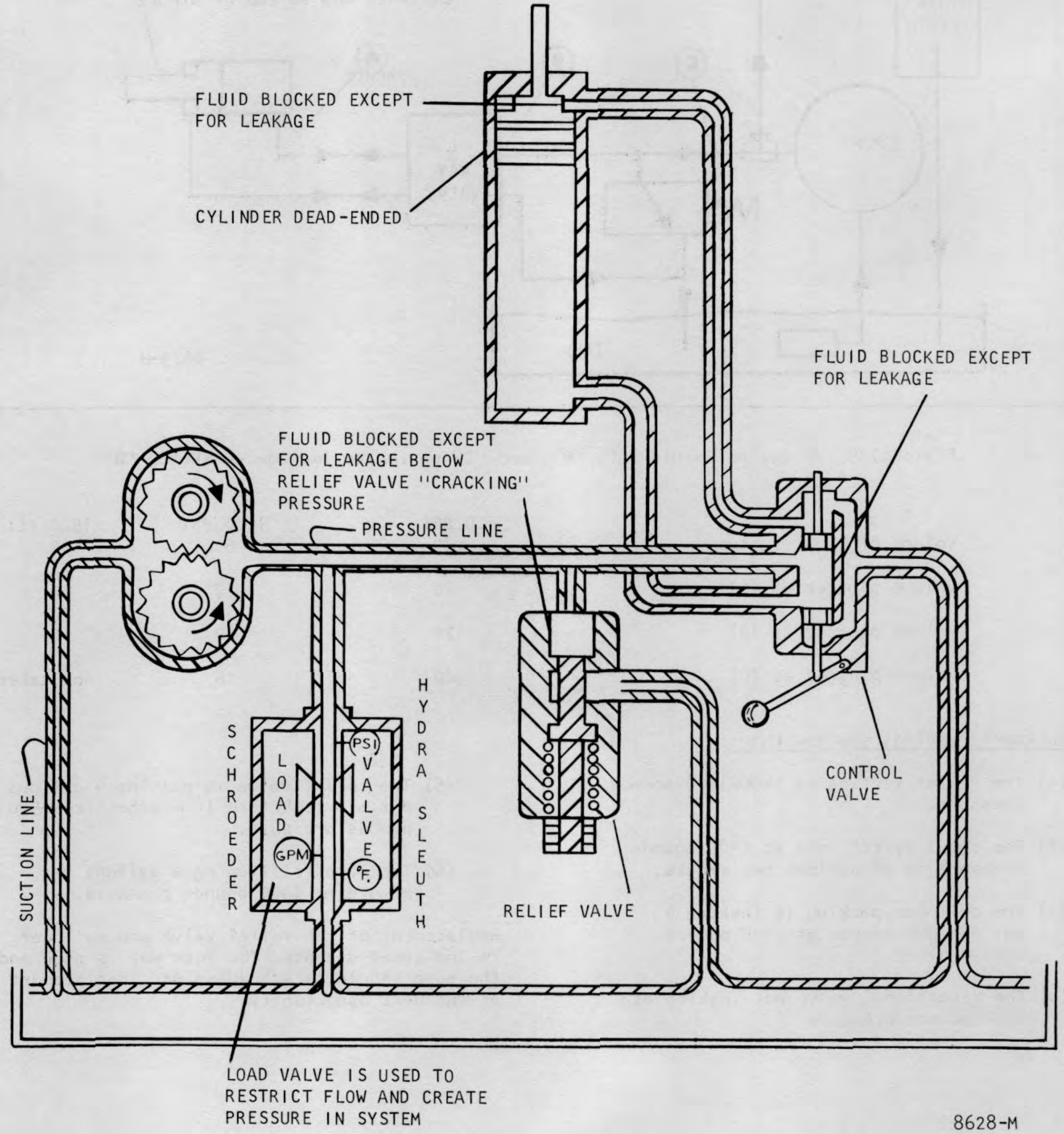


Plate 8628. Basic "Tee" Test For Schroeder Hydra-Sleuth Tester

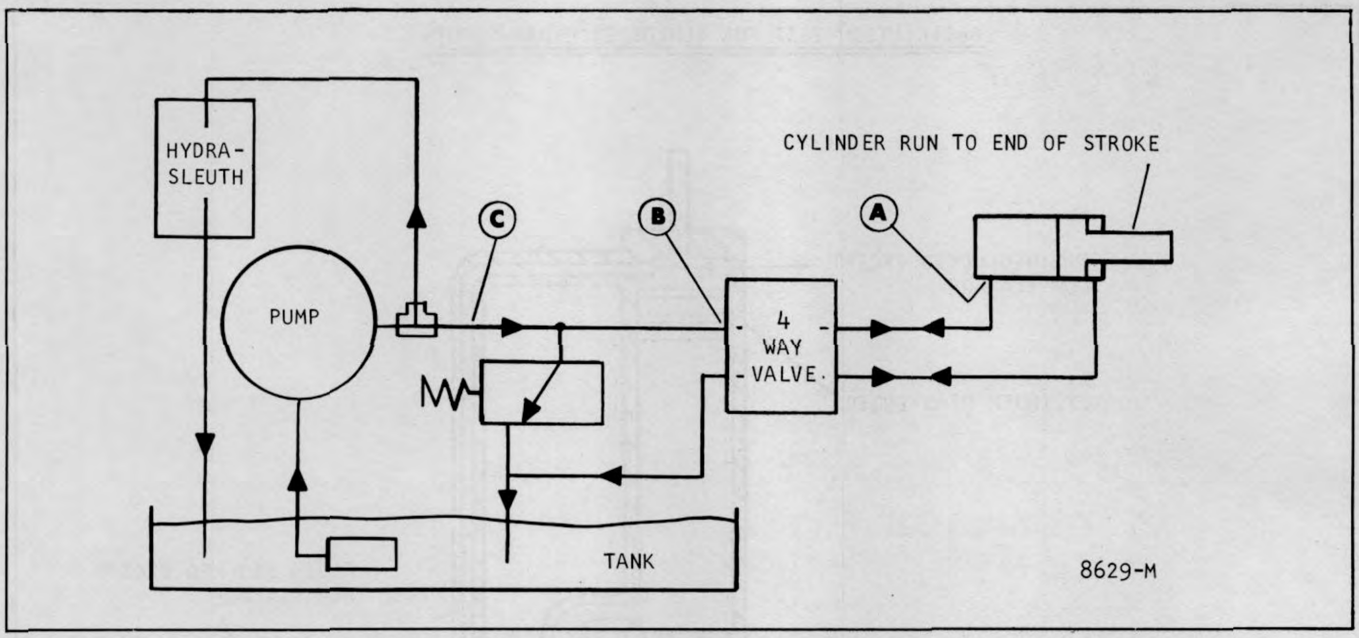


Plate 8729. Plugging Points "A", "B", and "C" to locate leakage — Sketch "D"

	0 PSI	1400 PSI	1500 PSI
Volume of whole system	20	6	0
Volume plugged at (A)	20	12	0
Volume plugged at (B)	20	12	0
Volume plugged at (C)	20	16	not taken

From these readings you now know:

(1) The relief setting is 1400-1500 pounds pressure.

(2) The total system loss at 1400 pounds pressure is 14 gallons per minute.

(3) The cylinder packing is leaking 6 gallons per minute at 1400 pounds pressure.

(4) The directional valve not leaking at 1400 pounds pressure.

(5) The relief valve is passing 4 gallons per minute before it reaches its 1500 pounds pressure.

(6) The pump is slipping 4 gallons per minute at 1400 pounds pressure.

Replacement of the relief valve and cylinder is indicated at once. The four way is good and the pump should be scheduled for replacement at the next opportunity.

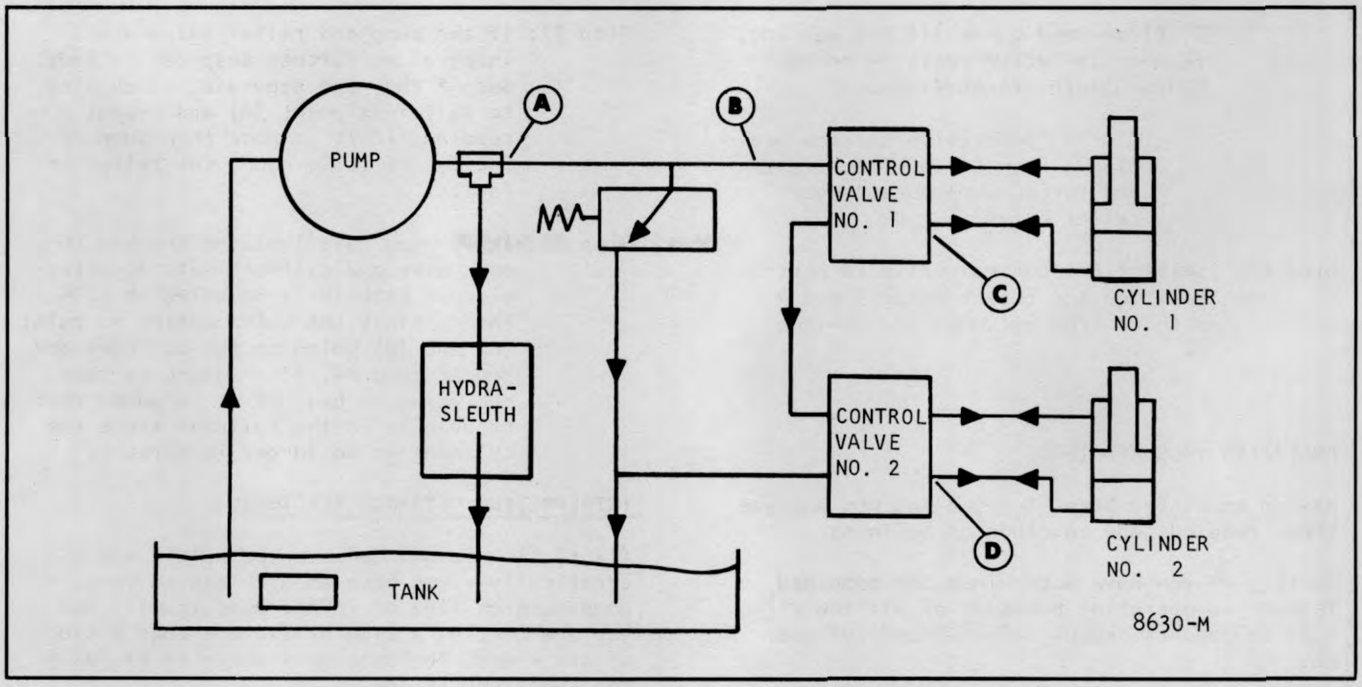


Plate 8630. Hydraulic Schematic Showing Test Points — Sketch E

This tee test may be applied to simple or complicated circuits. A stop-by-stop procedure for a multiple circuit is described below:

Step #1: Connect Hydra-Sleuth inlet port to a Tee at point (A) between pump and first control valve.

Note: An extra pressure port in relief valve or control valve can be used.

Connect Hydra-Sleuth return port to reservoir or low pressure return line.

Step #2: Start machine and if gasoline or diesel engine is involved increase throttle to desired RPM. Bring oil to operating temperature.

Step #3: Shift first control valve in circuit to operating position and partially close load valve to fully extend cylinder. Observe pressure while cylinder is moving. Excessive pressure indicates a mechanical bind.

Step #4: When first cylinder is fully extended FULLY OPEN LOAD VALVE.

A. Read Gallons per Minute at "NO LOAD" Pressure. With cylinder fully extended and control valve open, pump output would normally pump over relief and flow thru tester.

B. Close load valve enough to create operating pressure and again read gallons per minute.

C. Close load valve all the way and read relief valve pressure on the Hydra-Sleuth pressure gauge.

Closing load valve all the way blocks flow through the tester and forces pump output over relief valve.

Step #5: Shift first control valve to neutral position and repeat steps 3 and 4 with control valve #2 and cylinder #2.

ANALYZING YOUR READINGS.

Having completed Steps 1-5 you may not analyze *these readings and conclude as follows:*

In step #4 you have determined the combined leakage at operating pressure of all the circuit components except valve #2 and cylinder #2.

In step #5 you have determined the combined leakage of all components except valve #1 and cylinder #1.

A. If both readings show good circuit gallonage and pressures compated with system specifications the whole system is sound.

B. If both readings show poor gallonage under pressure you have pump or relief valve trouble (PROBABLE - See Step 5) since these are components common to both readings.

C. If one circuit is good and the other poor the circuit showing the poor reading has a faulty valve or cylinder or both (See Step #8).

THIS TEST IS AN EXCELLENT METHOD TO PROVE CONDITION OF A REBUILT HYDRAULIC SYSTEM.

Now proceed with the following steps 6-7-8- if indicated:

Step #6: If readings to both sets of valves and cylinders (See Steps 4 and 5) are poor then block the hose or pipe to the first valve at point (B), repeat reading with the Tester. If reading is same as steps 4 and 5 then you are certain that the trouble is in pump or relief valve.

Step #7: If the pump and relief valve are integral no further test can be made. But if they are separate, block line to relief at point (A) and repeat reading. If it is poor then pump is faulty. If it is good, the relief is faulty.

Step #8: In "C" you have isolated trouble to one valve and cylinder set. To determine if trouble is in valve or cylinder, block the valve outlet at point (C) and (D) going to the cylinder and repeat step #4. If reading is same the valve is bad. If it is good, then trouble is in the cylinder since the cylinder is no longer in circuit.

<u>INTREPRETING "STRANGE READINGS"</u>

(1) If flow gauge needle moves wildly and erratically - you have an air leak in your pump suction line or in the pump itself, and you are getting a slug of fluid - then a slug of air - etc. The same will occur if fluid in the sump tank is low.

(2) If flow gauge needle shows below correct pump flow even at NO LOAD and holds close to this volume at higher loads - you have a restriction in your suction line.

(3) If oil flows out of the safety blow out plug on the side of the Hydra-Sleuth you have ruptured the disc by exceeding the pressure of the Hydra-Sleuth Pressure Gauge - replace disc-see instructions on Field Repairs.

(4) If flow gauge needle persistently reads backwards (dropping below Zero GPM) the flow thru the Hydra-Sleuth is reversed. Correct flow direction by interchanging inlet and outlet or change position of directional control valve. Flow gauge may have been damaged. See Instructions under Field Repairs.

(5) If flow gauge needle swishes quickly back and forth over dial during start up or throwing of a valve, this is a sign of high flow and pressure surges. Only in extreme cases will the flow gauge be damaged. (See Field Repairs.)

(6) The temperature gauge will show a higher reading, while load valve is operated (due to heating of the oil, approximately 7 degrees per 1000 PSI) and will return to inlet oil temperature when load valve is opened.

(7) If flow gauge needle does not return exactly into "Zero" zone, while Hydra-Sleuth *is subjected to extreme temperatures*, flow readings are still correct. If gauge does not return to zero at room temperature check for cause. (See Field Repairs)

HOW TO MAKE SOME FIELD REPAIRS TO THE HYDRA-SLEUTH

The Schroeder Hydra-Sleuth is a rugged instrument which seldom needs repair. It is constructed for easy maintenance and all repairs can be made in the field.

FAULT	CAUSE AND REMEDY
Blow out plug disc ruptured	Caused by excess pressure. Install new cap and disc assembly (a spare is carried in the orifice pocket). Torque should be limited to approximately 150 inch pounds.
Flow gauge does not read correctly and does not Return to zero	Remove flow gauge. If it returns to zero blow air into 1/8" bushing to clear obstruction in capillary snubber tube. If it does not return to zero replace with a new flow gauge. Make sure gauge needle is below the level of the surrounding steel housing so that it is free to move. Broken flow gauges are the result of excess flow, reverse flow, or severe surges. Examine the plastic bag in the flow gauge housing, replace if broken. Reassembly the Hydra-Sleuth. Then pour clean, clear glycerin through 1/8" hole in the bottom of the Hydra-Sleuth until the flow gauge housing is filled. Before installing 1/8" plug direct 10 PSI air pressure (use paint spray reducer) into outlet of tester with inlet plugged. This is partially to inflate the plastic bag while air pressure is applied. Insert and tighten 1/8" socket head pipe plug. (The partially inflated bag absorbs the volume of glycerin that is pushed into the housing by the pipe plug and will absorb the glycerin expansion when Hydra-Sleuth is used with hot oil.
Temperature gauge does not record temperature changes	Install new temperature gauge. Thread deep enough into bushing to clear Plexiglass cover. Caused by excessive back pressure - the sensing tube may be collapsed.
Pressure gauge reads incorrect	Install new pressure gauge. Thread deep enough into block that the gauge clears the Plexiglass cover.
Leakage	Tighten gauges or plugs to eliminate leakage. The inlet and outlet threads are straight threads with "O" rings to seal. Do not over-tighten the fittings but replace with "O" rings to seal again against the aluminum block and the Plexiglass. Replace if "O" rings become damaged during repair work.
Load Valve and Orifice Selector Leakage	Replace Faulty "O" Rings.

USE ONLY GENUINE SCHROEDER PARTS

ADDENDUM

We have run extensive tests on pressure drops through 1/4" gauge ports on flow control valve and relief valves at both 100° F and 150° F.

Pressure required to flow from these ports 50 GPM averages 165 PSI and to flow 35 GPM, 90 PSI.

There is remarkable little difference in these pressures with temperature changes.

Tee Tests with the Hydra-Sleuth can be run by using 1/4" or larger gauge ports (commonly found in relief valves) as Tees if the flow rate does not exceed 50 GPM with 1.4" ports.

With this hook up add the following pressures to the reading of the load gauge:

Flows up to 20 GPM add 50 PSI
Flows up to 30 GPM add 80 PSI

Do not apply these adders to the load gauge readings when testing relief valve settings.

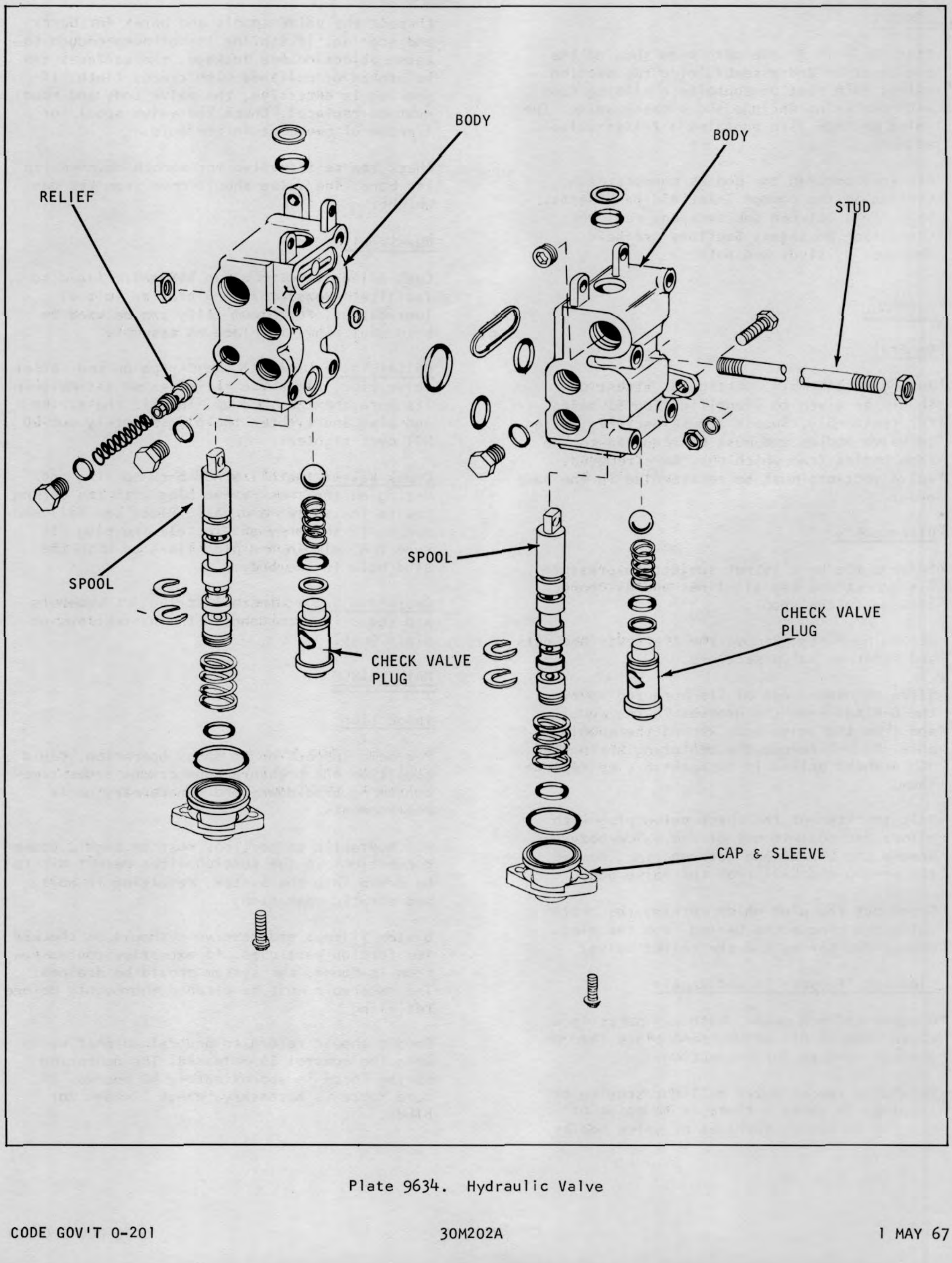


Plate 9634. Hydraulic Valve

GENERAL

Plate 9634 is an exploded view showing the construction and assembly of a two section valve. Each section contains a sliding spool with centering springs and a check valve. The inlet section also contains a relief valve assembly.

Passages between the bodies connect each section to the common inlet and tank ports. Seal rings between the sections seal the connecting passages. Sections are held together by studs and nuts.

OVERHAUL

General

During disassembly, particular attention should be given to identification of parts for reassembly. Spools are selectively fitted to valve bodies and must be returned to the same bodies from which they were removed. Valve sections must be reassembled in the same order.

Disassembly

Be sure the unit is not subject to pressure. Disconnect and cap all lines and disconnect linkage to the spool.

Attaching Parts: Remove the tie studs and nuts and separate valve sections.

Slide the spool out of its bore and remove the O-rings from the grooves in the spool and from the valve body around the spool bore. Do not remove the centering spring and "C" washers unless it is necessary to replace them.

Grip the stem of the check valve plug with pliers and pull it out of the valve body. Remove the O-ring and back-up ring. Remove the spring and ball from the valve body.

Screw out the plug which retains the relief valve and remove the O-ring from the plug. Remove the spring and the relief valve.

Cleaning, Inspection and Repair

Discard all old seals. Wash all parts in a clean mineral oil solvent and place them on a clean surface for inspection.

Carefully remove burrs by light stoning or lapping. Be certain there is no paint or burring on mating surfaces of valve bodies.

Inspect the valve spools and bores for burrs and scoring. If scoring is not deep enough to cause objectionable leakage, the surfaces can be stoned or polished with crocus cloth. If scoring is excessive, the valve body and spool must be replaced. Check the valve spool for freedom of movement in the bore.

Check the relief valve for smooth movement in its bore. The valve should move from its own weight.

Reassembly

Coat all parts with clean hydraulic fluid to facilitate reassembly and provide initial lubrication. Petroleum jelly can be used to hold seal rings in place on assembly.

Relief Valve: Install the O-ring on the relief valve plug. Place the relief valve assembly in its bore, hex nut end up. Install the spring and plug and tighten the plug securely but DO NOT over tighten.

Check Valve: Install a new back up ring and O-ring on the check valve plug with the O-ring toward the spring and ball. Place the ball and spring in the body and install the plug. Be sure the hole in the plug lines up with the stud hole in the body.

Operating Spool: Install spring, "C" washers and seals in accordance with instructions on plate 9635.

MAINTENANCE

Inspection

Periodic inspection of spool operation, fluid condition and pressure connections saves time-consuming breakdowns and unnecessary parts replacements.

All hydraulic connections must be tight. Loose connections in the suction lines permit air to be drawn into the system, resulting in noisy and erratic operation.

System filters and reservoir should be checked for foreign particles. If excessive contamination is found, the system should be drained. The reservoir must be cleaned thoroughly before refilling.

Spools should return to neutral automatically when the control is released. The centering spring force is approximately 40 pounds. If more force is necessary, check linkage for binds.

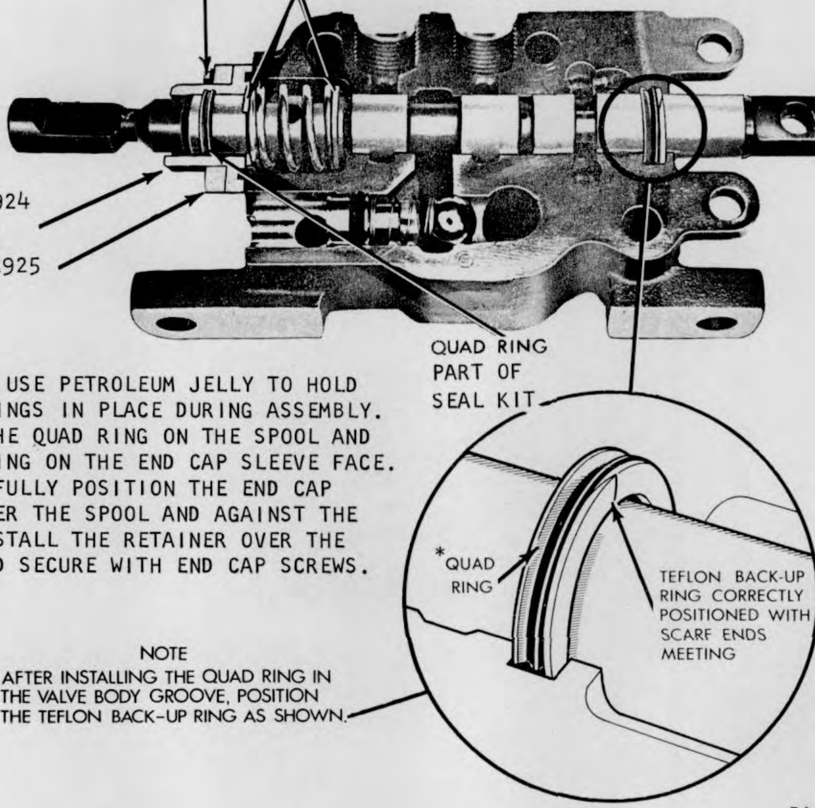
PART #892923 - 2 Each
END CAP SCREWS: WHEN INSTALLING HEX HEAD END CAP SCREWS, BE SURE TO TIGHTEN THEM TO 10 FOOT POUNDS TORQUE.

PART #892669 - 2 Each

"C" WASHER: WHEN ASSEMBLING THE SPOOL SUB-ASSEMBLY, INSTALL ONE "C" WASHER AT EACH END OF THE CENTERING SPRING. ONLY TWO "C" WASHERS WILL BE USED PER SPOOL ASSEMBLY WHERE PREVIOUSLY FOUR WERE USED. THE FLAT SIDE OF THE "C" WASHER FACES AWAY FROM THE SPRING WHEN INSTALLED.

PART #892924
(RETAINER)

PART #892925
(SLEEVE)



END CAP: USE PETROLEUM JELLY TO HOLD SEALING RINGS IN PLACE DURING ASSEMBLY. INSTALL THE QUAD RING ON THE SPOOL AND THE "O" RING ON THE END CAP SLEEVE FACE. THEN CAREFULLY POSITION THE END CAP SLEEVE OVER THE SPOOL AND AGAINST THE BODY. INSTALL THE RETAINER OVER THE SLEEVE AND SECURE WITH END CAP SCREWS.

NOTE
AFTER INSTALLING THE QUAD RING IN THE VALVE BODY GROOVE, POSITION THE TEFLON BACK-UP RING AS SHOWN.

PART #892871
SEAL SET

TEFLON BACK-UP RING AND QUAD RING SEALS: AFTER INSTALLING THE QUAD RING IN THE VALVE BODY GROOVE, POSITION THE BACK-UP RING AS SHOWN IN INSET ABOVE. MAKE CERTAIN THAT THE SCARFED ENDS OF THE BACK-UP RING ARE CORRECTLY MATED.

COURTESY OF:

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

UPRIGHT REMOVAL AND DISASSEMBLY

To remove upright, support upright assembly with a chain fall of sufficient capacity using an "A" frame or other suitable support. Remove bolts from upright (mast) support securing upright to drive axle.

Place suitable drain pan under left cylinder.

Remove tilt cylinder rod end pins.

Disconnect hydraulic hoses.

Place the upright assembly on a clean surface with the fork carriage upward. Disconnect the lift chains at the lift carriage. Slide the lift carriage out the bottom of the upright.

With the carriage removed, disconnect the lift chains at the lift cylinder and remove chains.

To aid in disassembly and reassembly refer to the parts illustration in the parts manual, and refer to the illustration in this section.

LIFT CYLINDERS

There is very little maintenance to perform on the lift cylinder other than a periodic check on security of mounting and leaks at the hydraulic connections.

N O T E

WHEN INSTALLING O-RINGS AND BACK-UP RINGS, PACK O-RING GROOVES WITH CHASSIS GREASE TO FACILITATE ASSEMBLY AND TO PREVENT DAMAGE TO THE SEALS (CUTTING, SCRATCHING ETC.).

When lift cylinder is removed from upright, place the lift cylinder on a clean surface.

C A U T I O N

CLEANLINESS CANNOT BE OVEREMPHASIZED AS EVEN THE SMALLEST OF PARTICLES (LINT, DIRT, DUST, WATER, SEALING COMPOUND ETC.) IS HARMFUL TO THE HYDRAULIC SYSTEM.

DISASSEMBLY

1. Clean external parts of the cylinder thoroughly so that dirt and grime will not enter cylinder during disassembly.
2. Remove pipe elbow (18), elbow tube assembly and packing (17) from piston rod.
3. Remove gland cap (26), lock screw and set screw (48), back-up ring (39) and packing (33) from cylinder assembly.
4. Remove inner piston rod (19) from stationary tube (40).
5. Remove valve retaining ring (16), packing (14), body (4), and packing (15) from piston rod.
6. Remove spring (6), seat (7), piston valve (5), orifice plate (8), spacer (9), ring (10), retainer (12), and ring (13) from piston rod.
7. Remove locking pellet (49) from stationary tube (40).
8. Remove bleeder and set screw (24) from stationary tube end.
9. Remove rod wiper (29) and gland nut (32).
10. Hold the stationary tube (40) while removing cylinder head gland nut (32).
11. Remove packing set (28) packing spring (21) and piston rod bearing (30) from gland cap.
12. Remove intermediate rod (22) and wear ring (50) from c dinder assembly.
13. Remove rod wiper (41) and bushing (46) while holding intermediate rod (22).
14. Remove rod wiper (38), gland nut (37), packing set (34) and bushing (51) from cylinder assembly (2).

Reassembly in reverse order of disassembly.

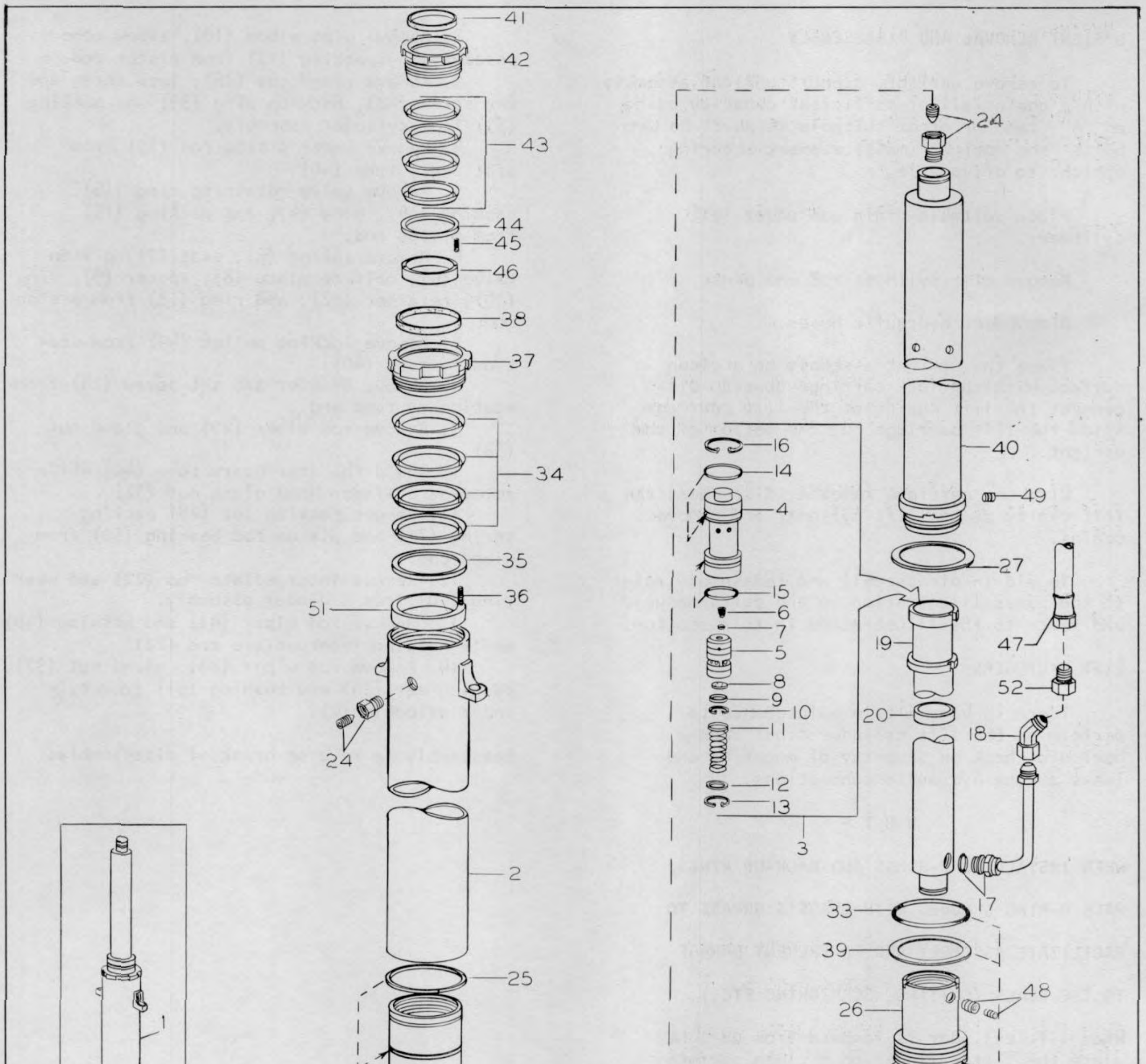


Plate 9971. Telescopic Lift Cylinder

LIFT CYLINDER BLEEDING

Step 1. Raise carriage about 4 feet or until bleeder screw is accessible.

NOTE

Check for proper oil level in sump before and after bleeding.

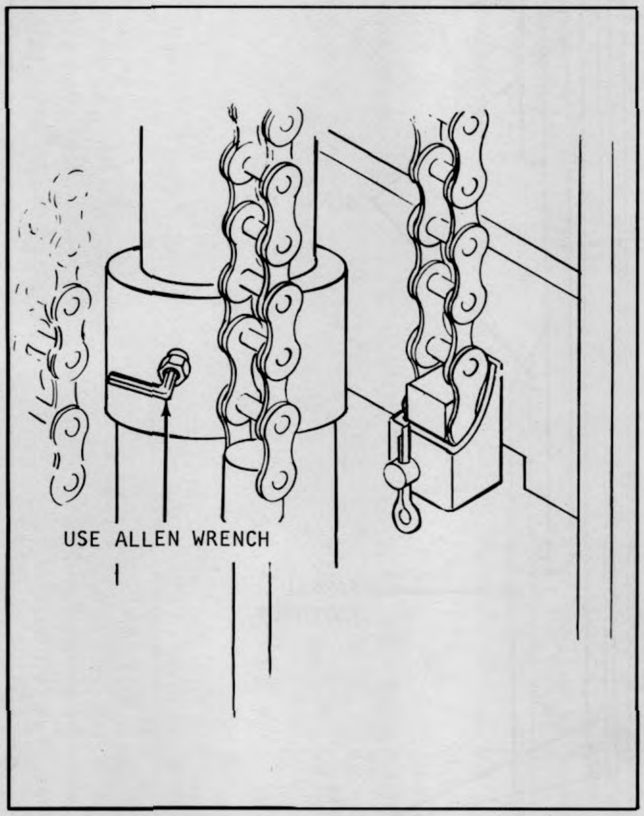


Plate 9661 Side Bleeder Screw

Step 2. Loosen side bleeder screw using allen wrench. The piston will drop a few inches as the air comes out. When air stops and oil starts to flow, tighten bleeder screw.

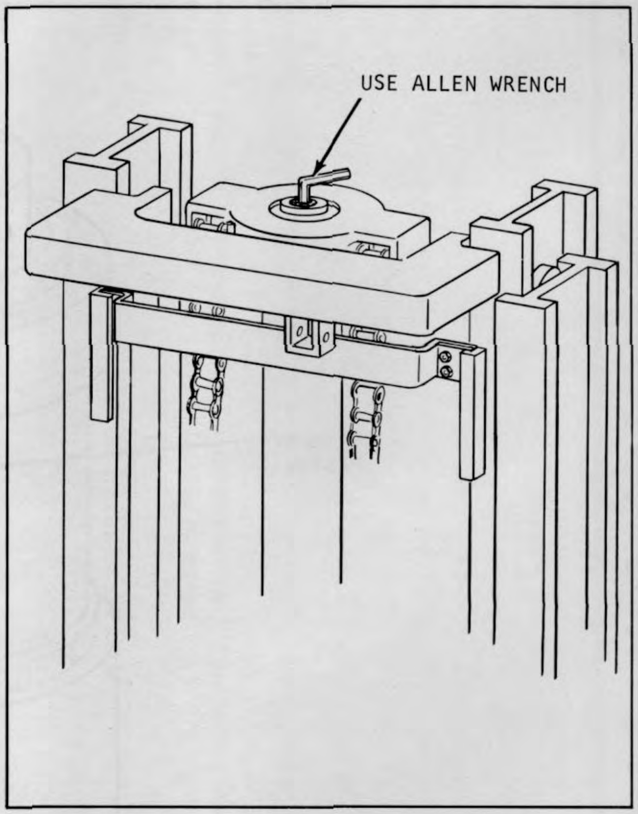


Plate 9662 Top Bleeder Screw

Step 3. Loosen top bleeder screw using allen wrench. The piston will drop a few inches as the air comes out. When air stops and oil starts to flow, tighten bleeder screw.

Step 4. Check oil in sump and add if needed.

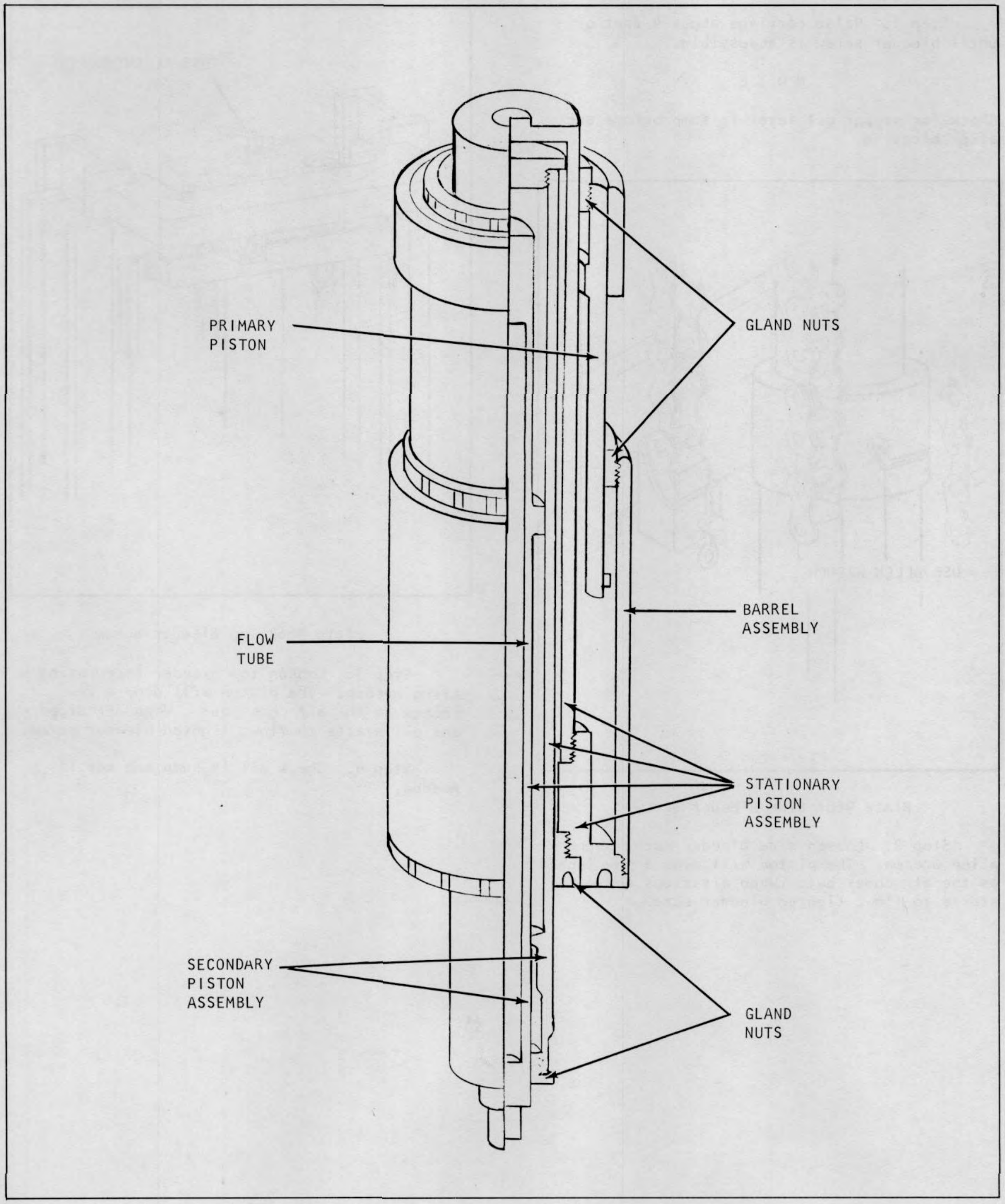

PRIMARY
PISTON
GLAND NUTS
BARREL
ASSEMBLY
FLOW
TUBE
STATIONARY
PISTON
ASSEMBLY
SECONDARY
PISTON
ASSEMBLY
GLAND
NUTS

Plate 9472

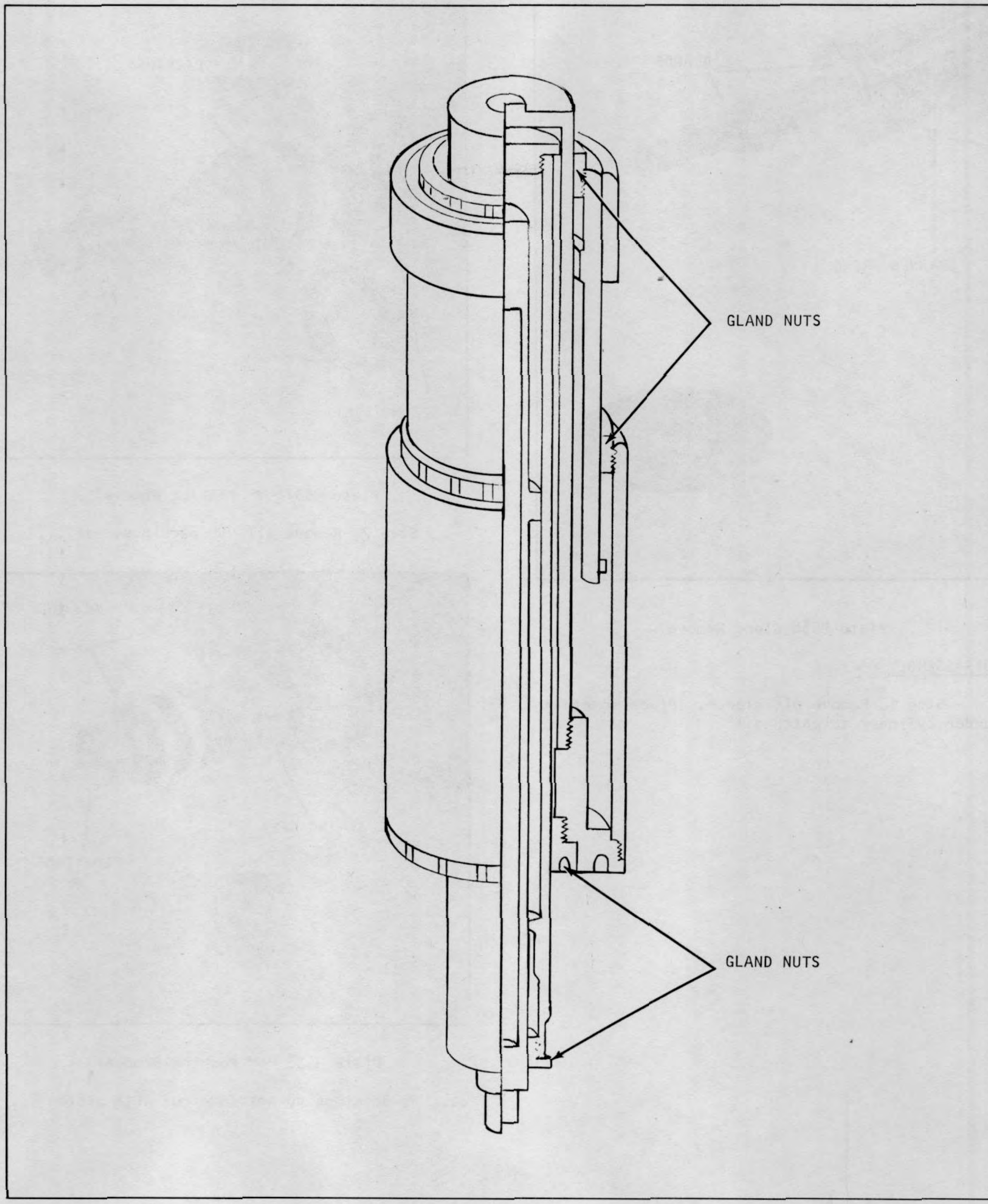


Plate 9473

Plate 9536 Gland Removal

DISASSEMBLY

Step 1. Remove all glands. Place something under cylinder to catch oil.

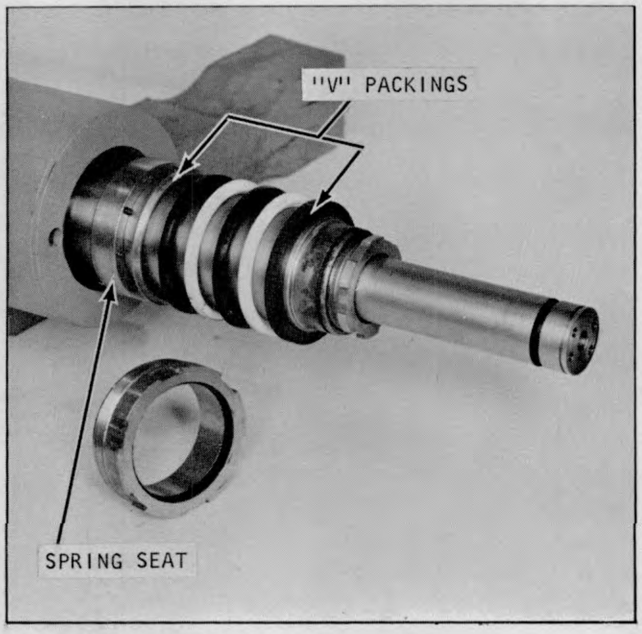


Plate 9537 "V" Packing Removal

Step 2. Remove all "V" packings. If ...

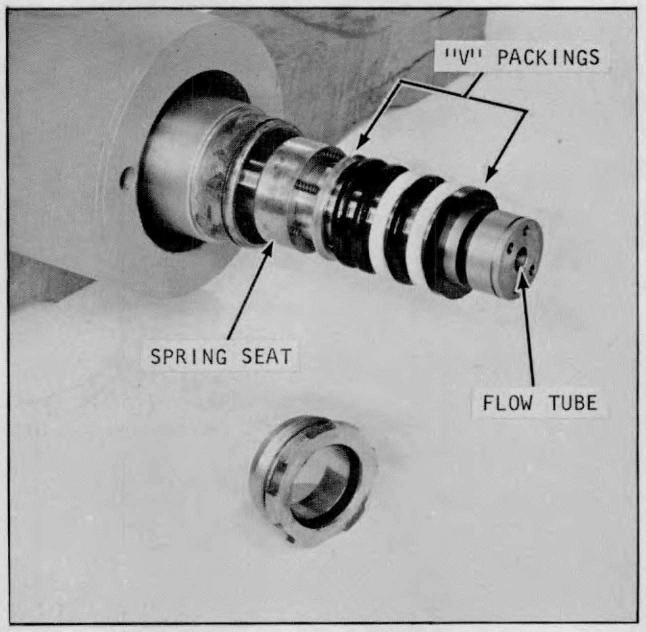


Plate 9538 "V" Packing Removal

... "V" packings do not come out with piston ...

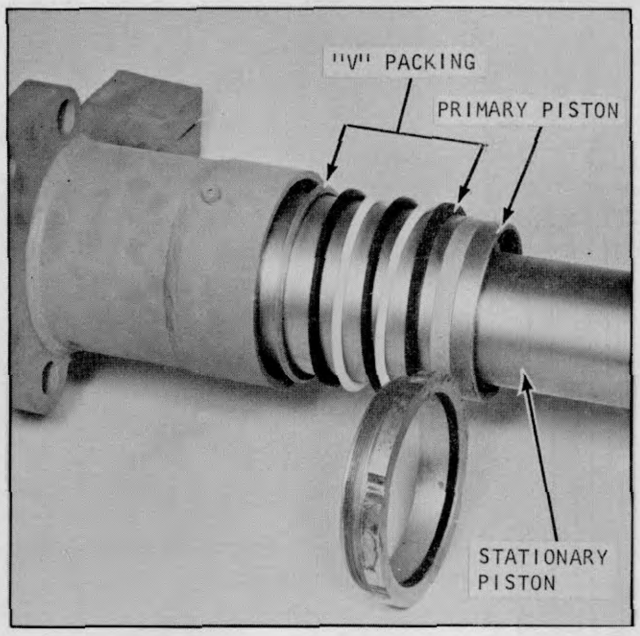


Plate 9539 "V" Packing Removal

Step 2. Continued.

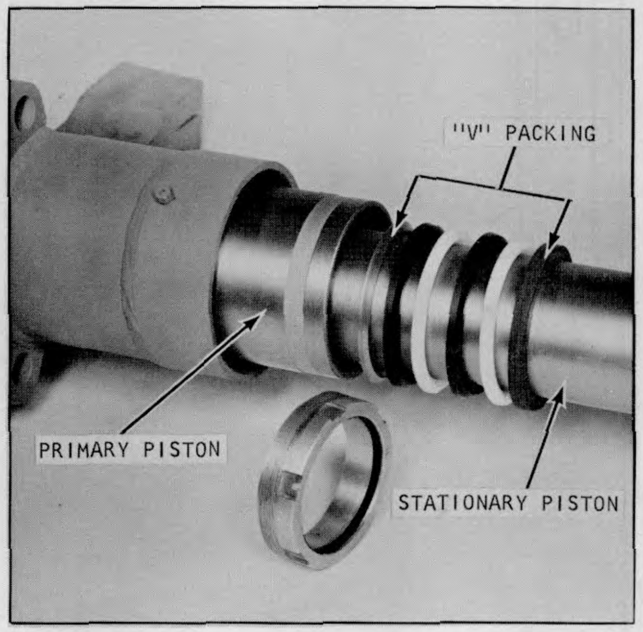


Plate 9540 "V" Packing Removal

Step 2. Continued.

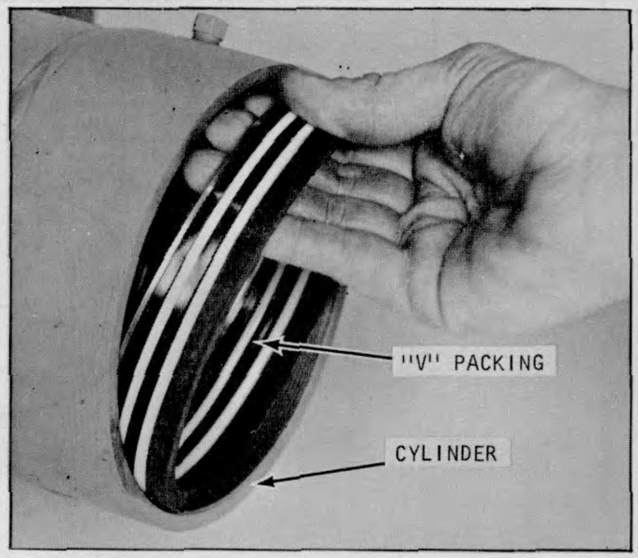


Plate 9541 "V" Packing Removal

Step 2. ... then remove "V" packing by hand.

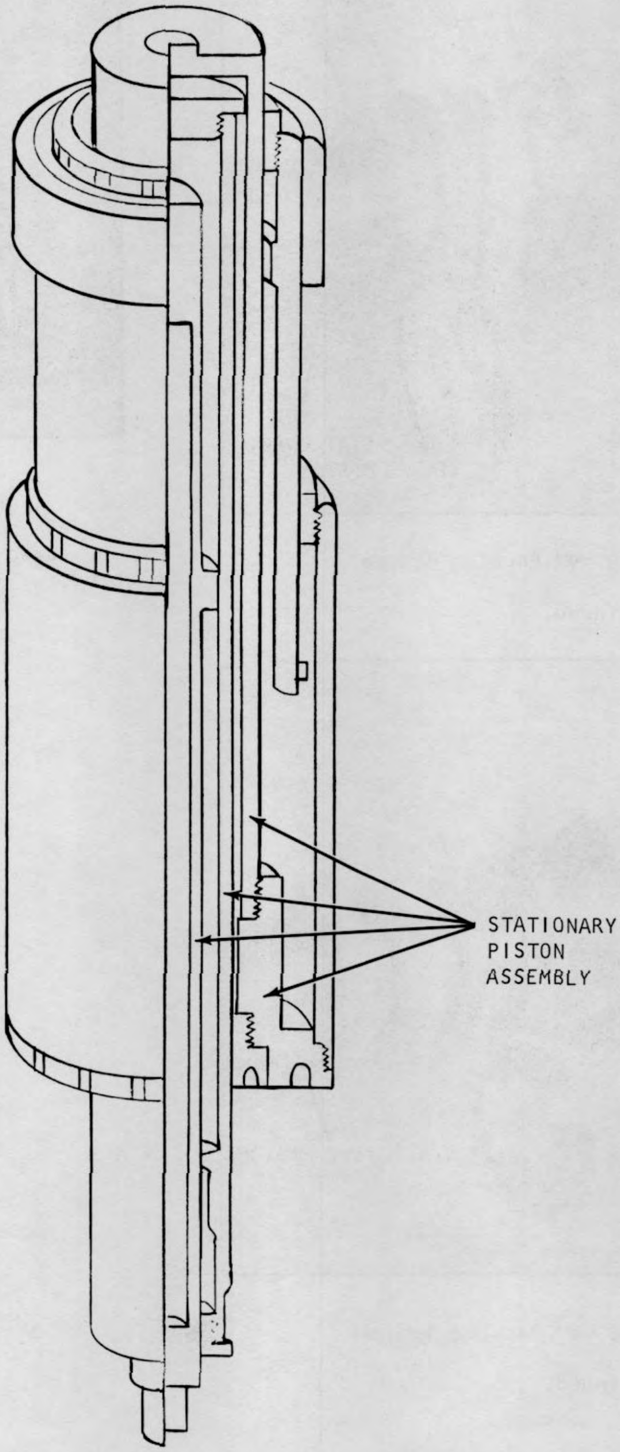


Plate 9474

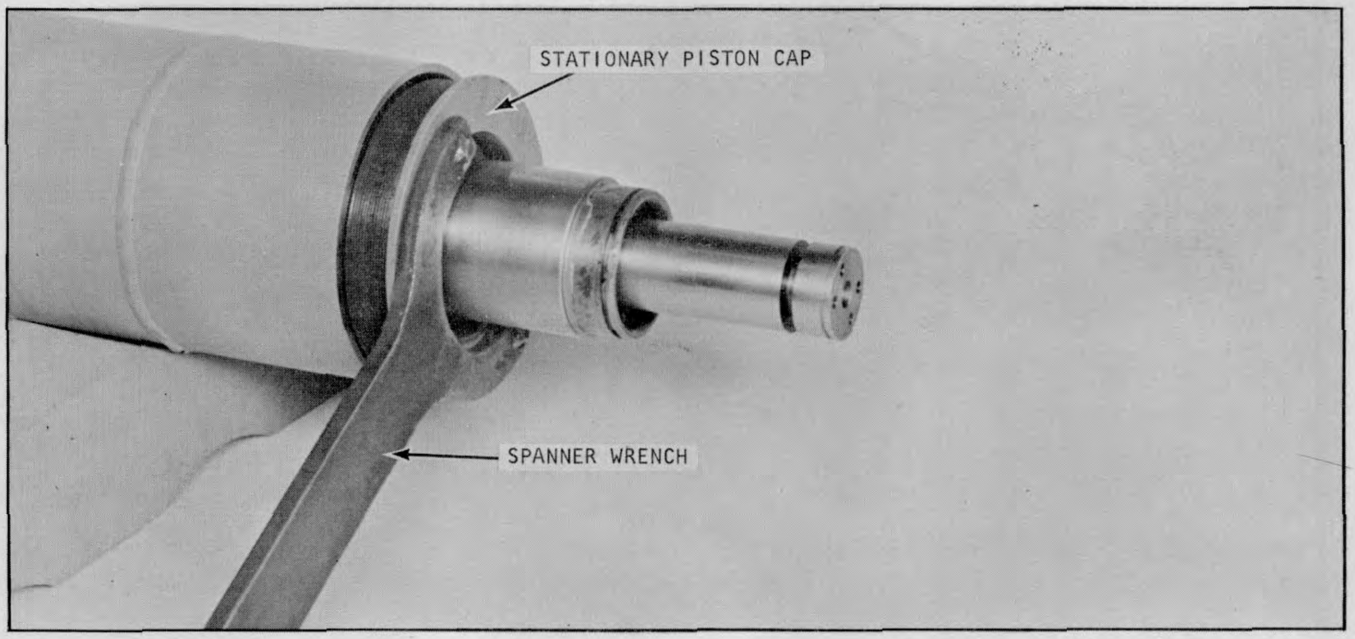


Plate 9545 Stationary Piston

Step 3. Remove stationary piston from barrel assembly, by removing the piston end cap.

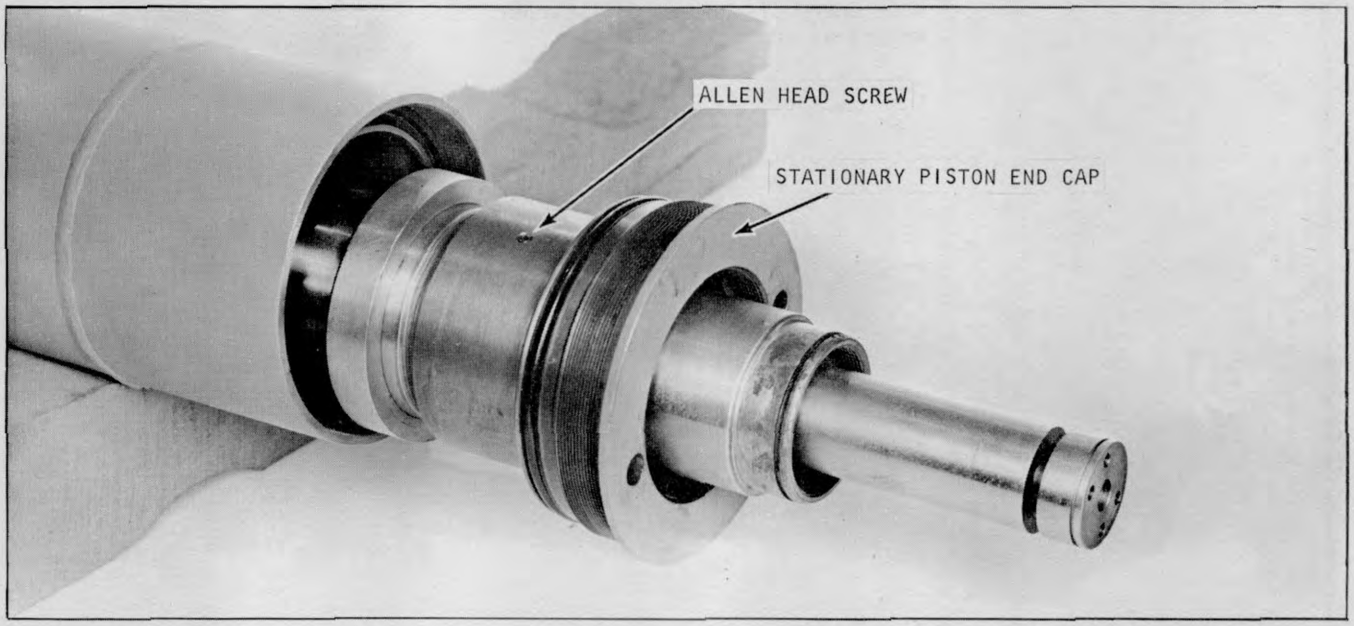


Plate 9546 Stationary Piston End Cap

Step 4. Remove both allen head set screws.

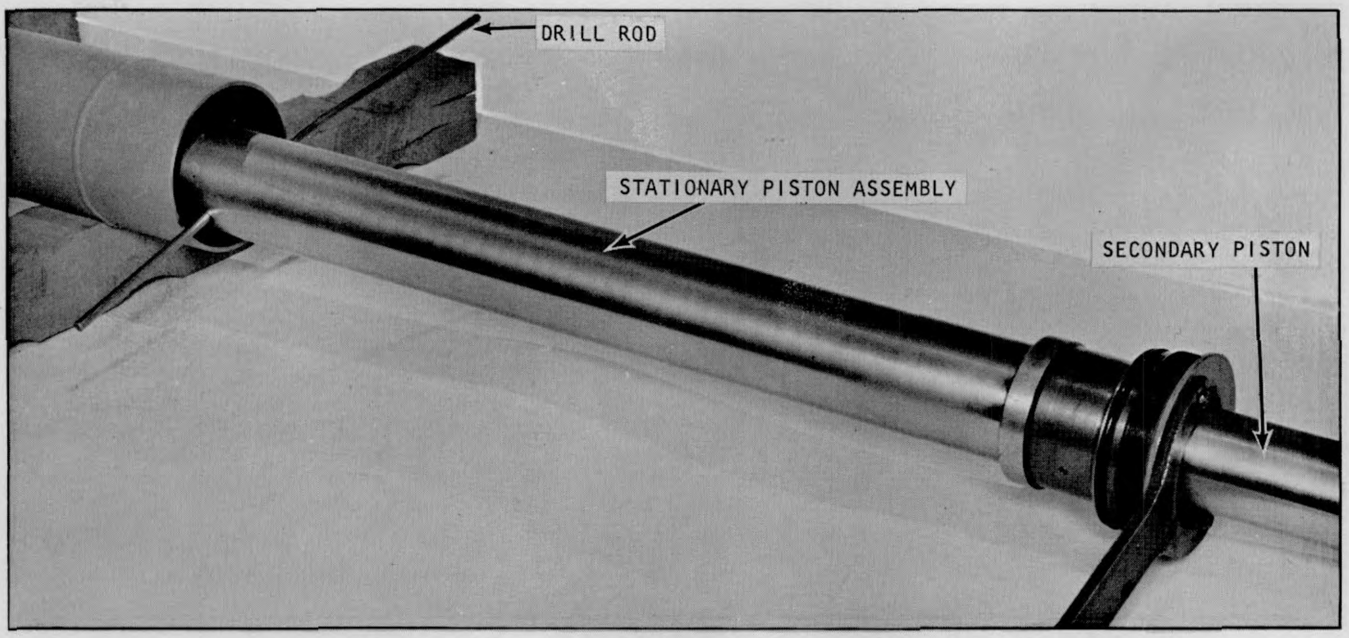


Plate 9547 Stationary Piston End Cap

Step 5. Remove stationary piston cap from stationary piston by pulling secondary piston out until drill rod will go through oil flow hole in stationary piston and use spanner wrench as shown.

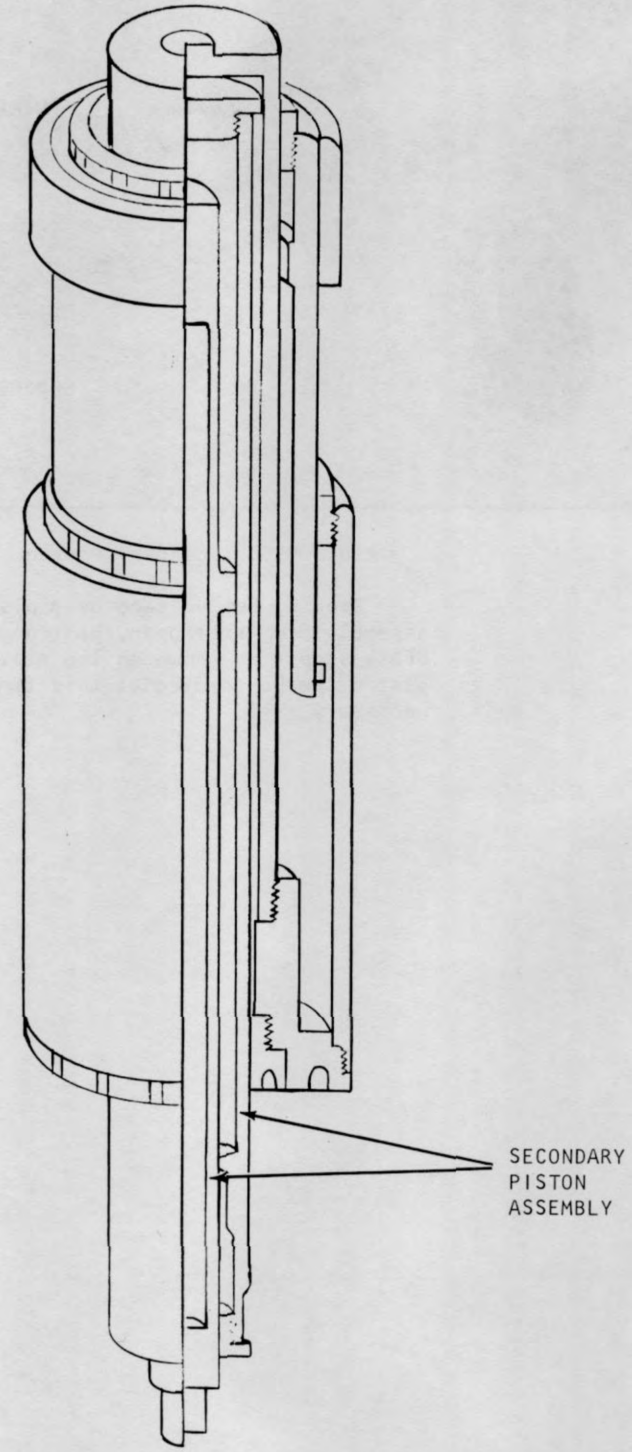


Plate 9478

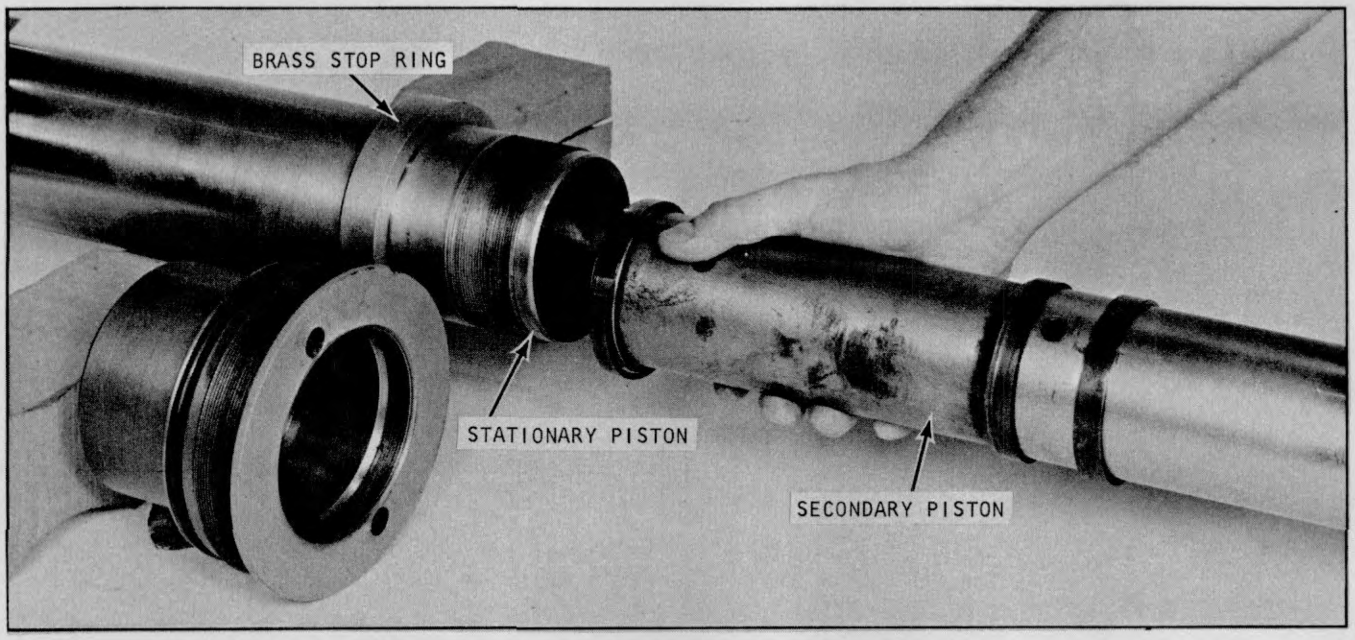


Plate 9550 Secondary Piston

Step 6. Remove secondary piston assembly from stationary piston. The brass stop ring shown on the stationary piston can be removed at this time if necessary.

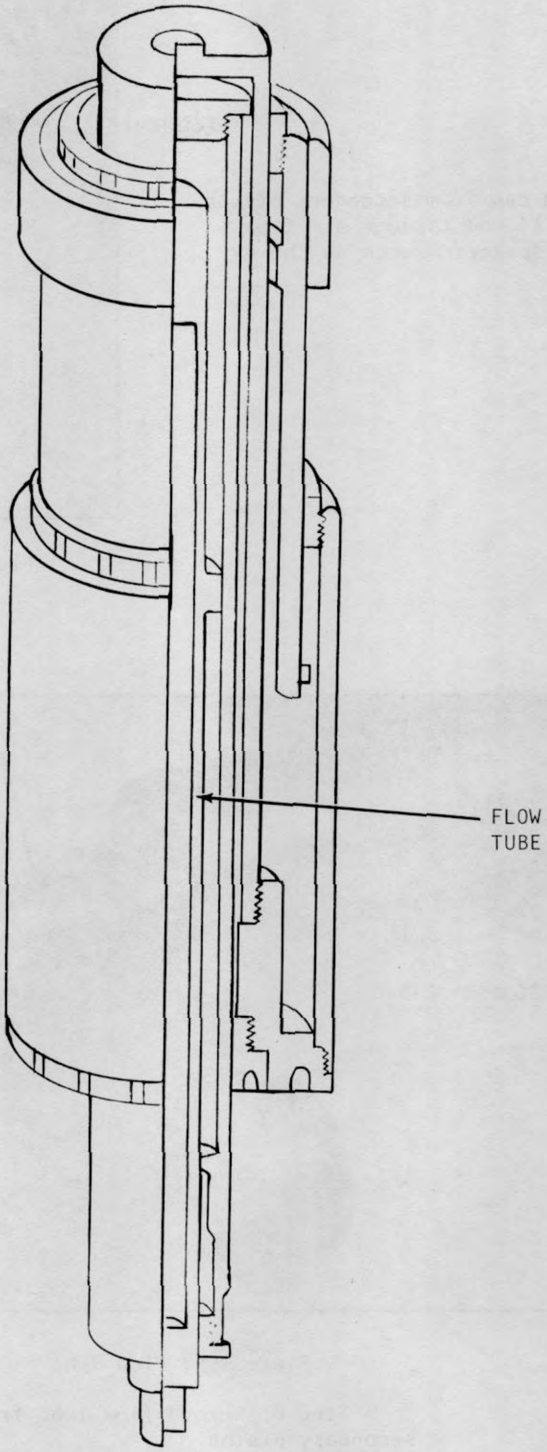


Plate 9479

Step 7. Remove end cap from secondary piston assembly by placing drill rod through oil flow hole in piston and use spanner wrench as shown.

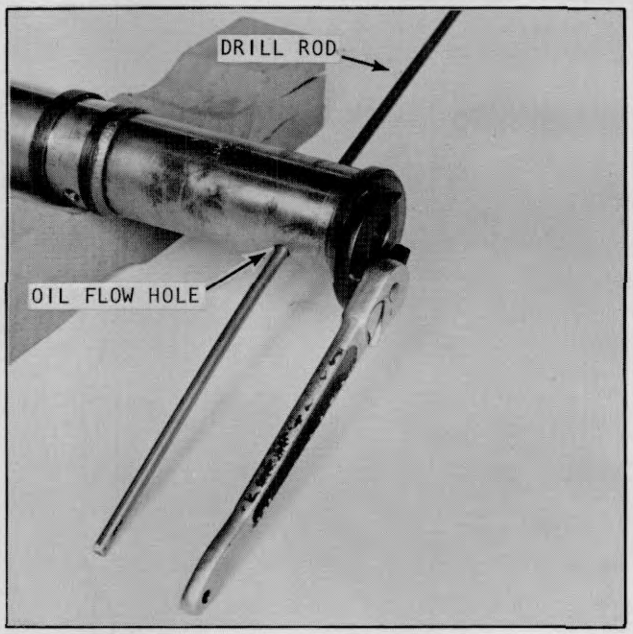


Plate 9551 Secondary Piston End Cap

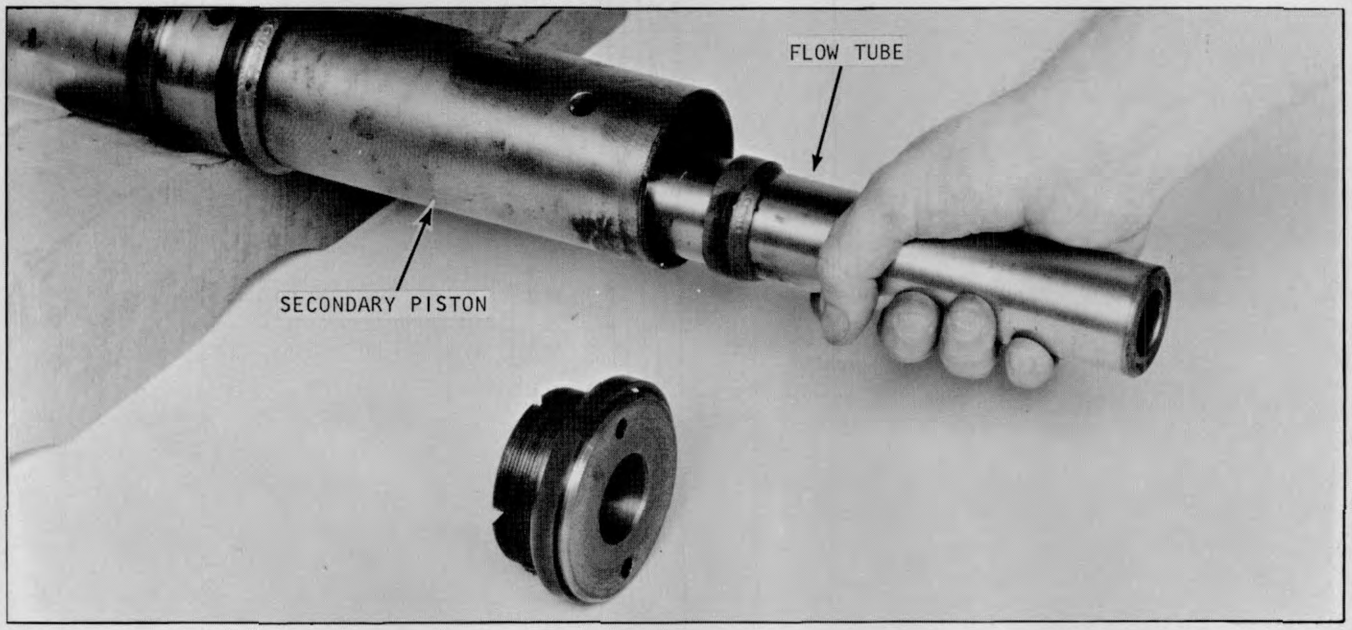


Plate 9552 Flow Tube

Step 8. Remove flow tube from secondary piston.

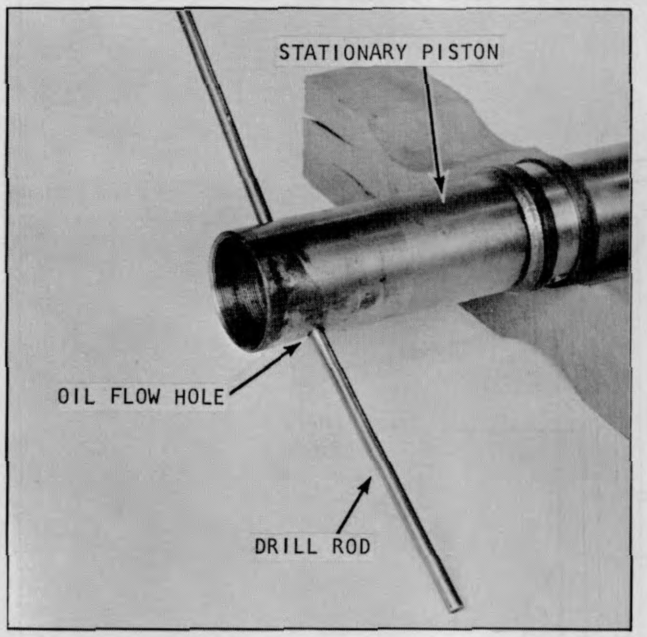


Plate 9553 Drill Rod Placement

Plate 9554 Bushing Removal

Step 9. Remove flow tube guide bushing, if necessary, by placing tool in slots of bushing and turning it out. It will be necessary to place a piece of drill rod through oil flow hole at opposite end of the secondary piston, in the same manner as to remove end cap.

Step 9. Continued.

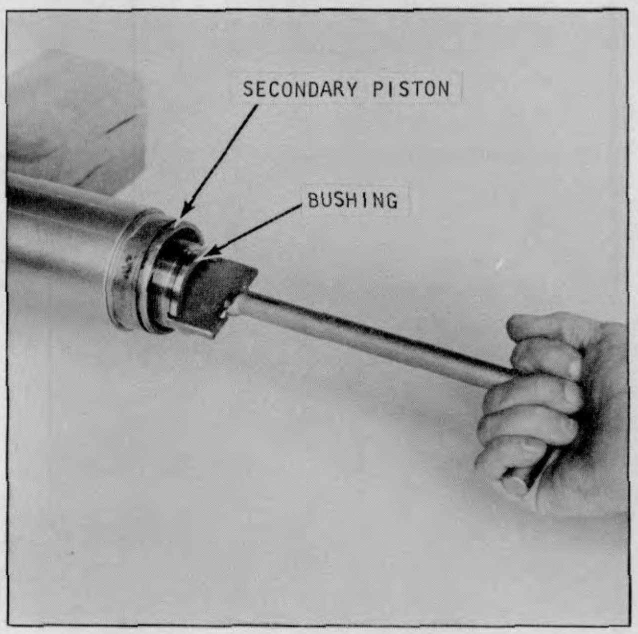


Plate 9485 Bushing

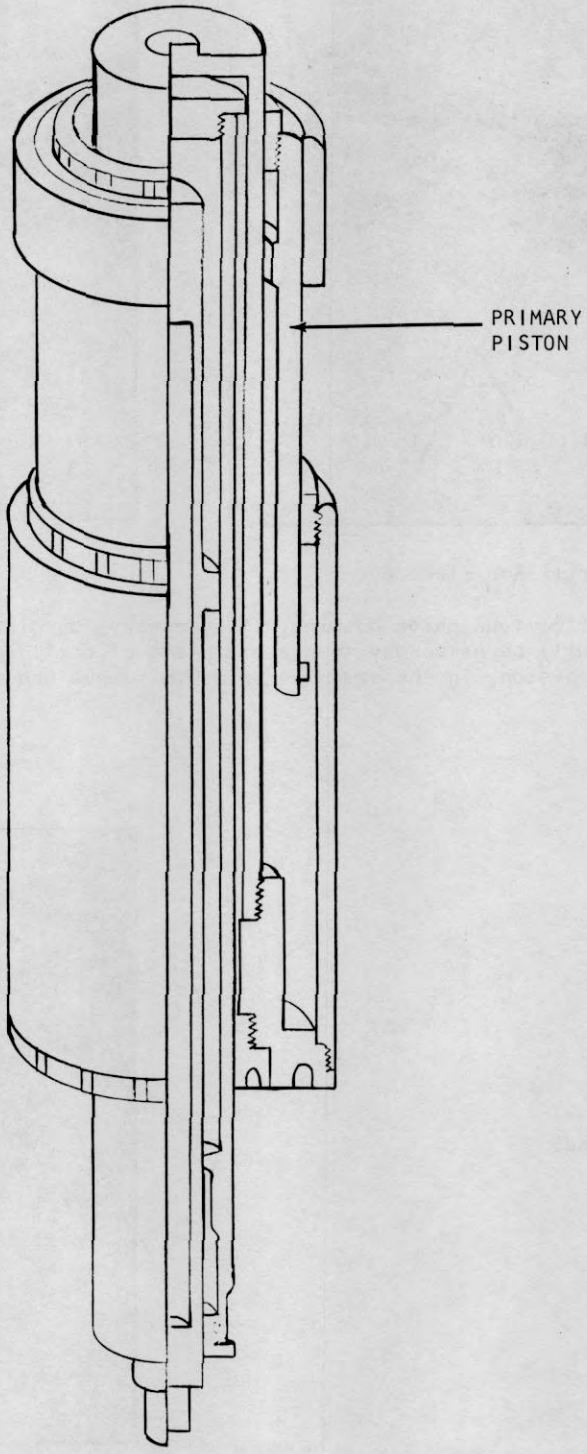


Plate 9486

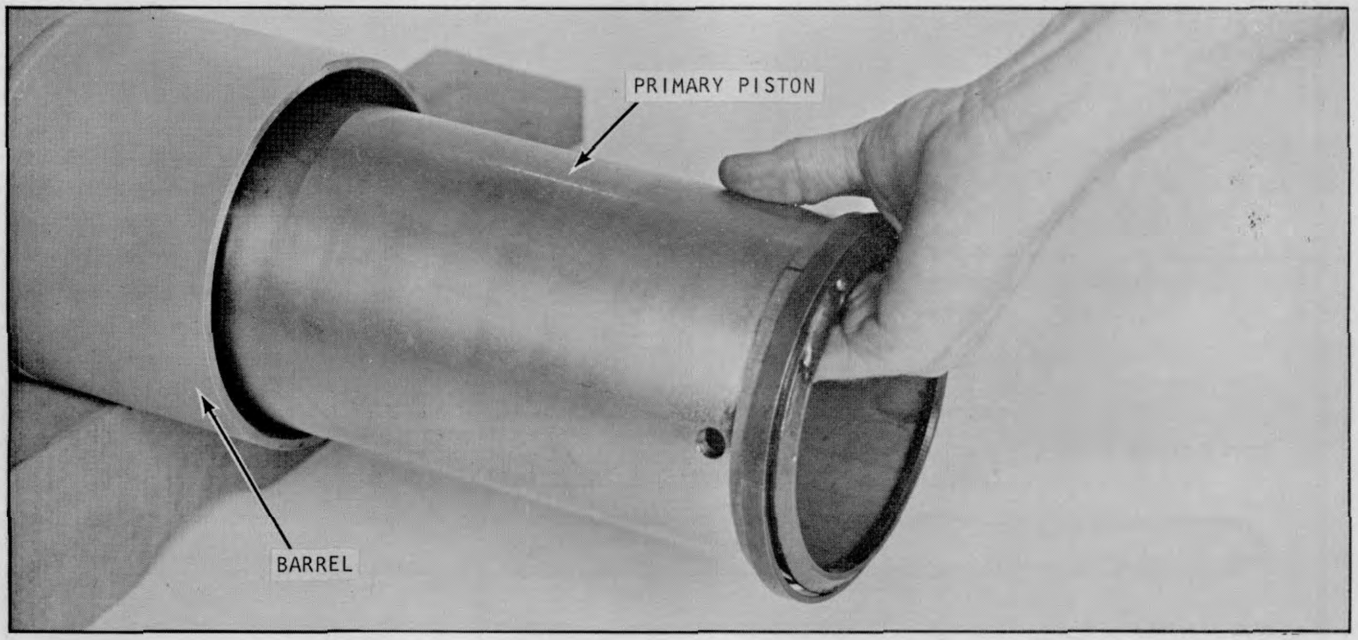


Plate 9487 Primary Piston

Step 10. Remove primary piston from barrel.

Step 11. Remove all "V" packings that did not come out with movement of piston

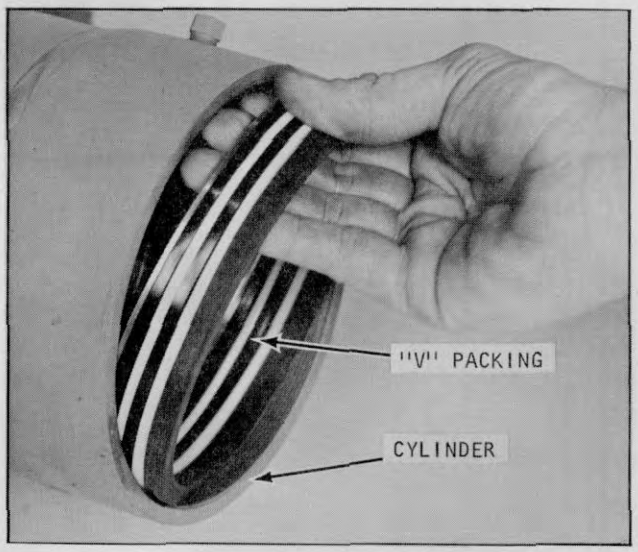


Plate 9541 "V" Packing Removal

REASSEMBLY

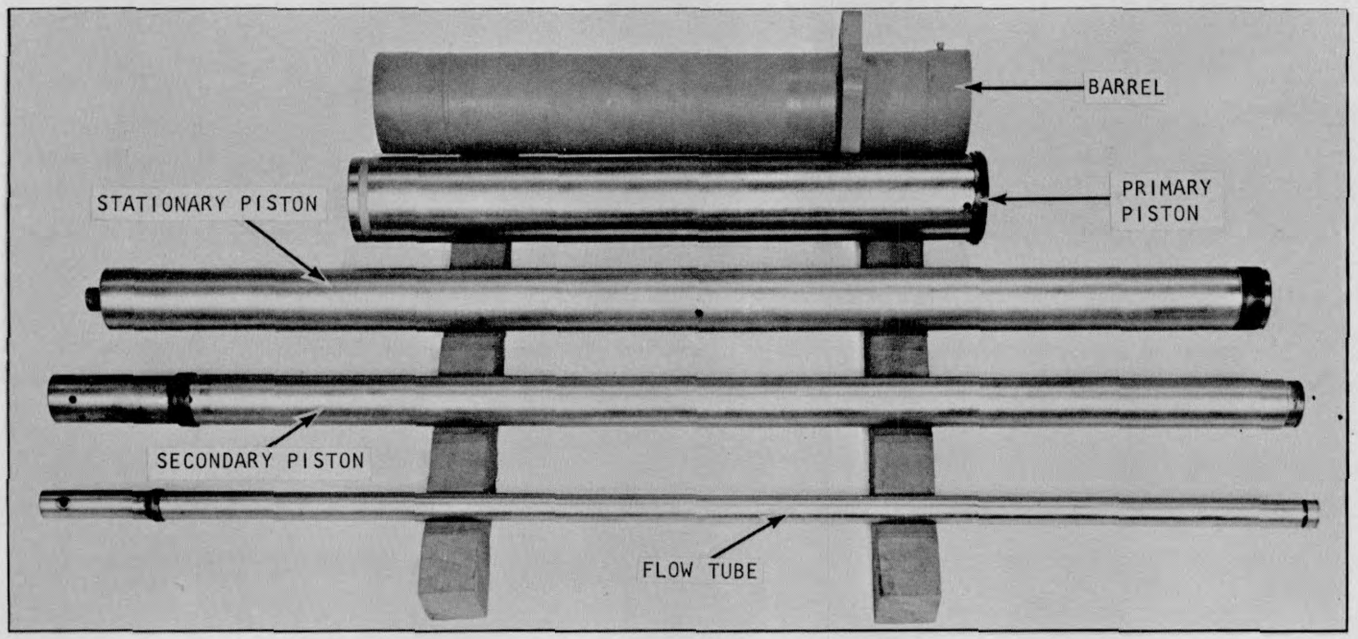


Plate 9488 Cylinder And Barrel Relationship

Step 1. Dip all packings and rings in oil before reassembly.

Place packings on clean surface and put them in order which is as follows: start with brass ring then alternate the rubber and plastic, always starting with rubber and ending with plastic. If there is any rubber left over, place it between the brass ring and the first rubber packing.

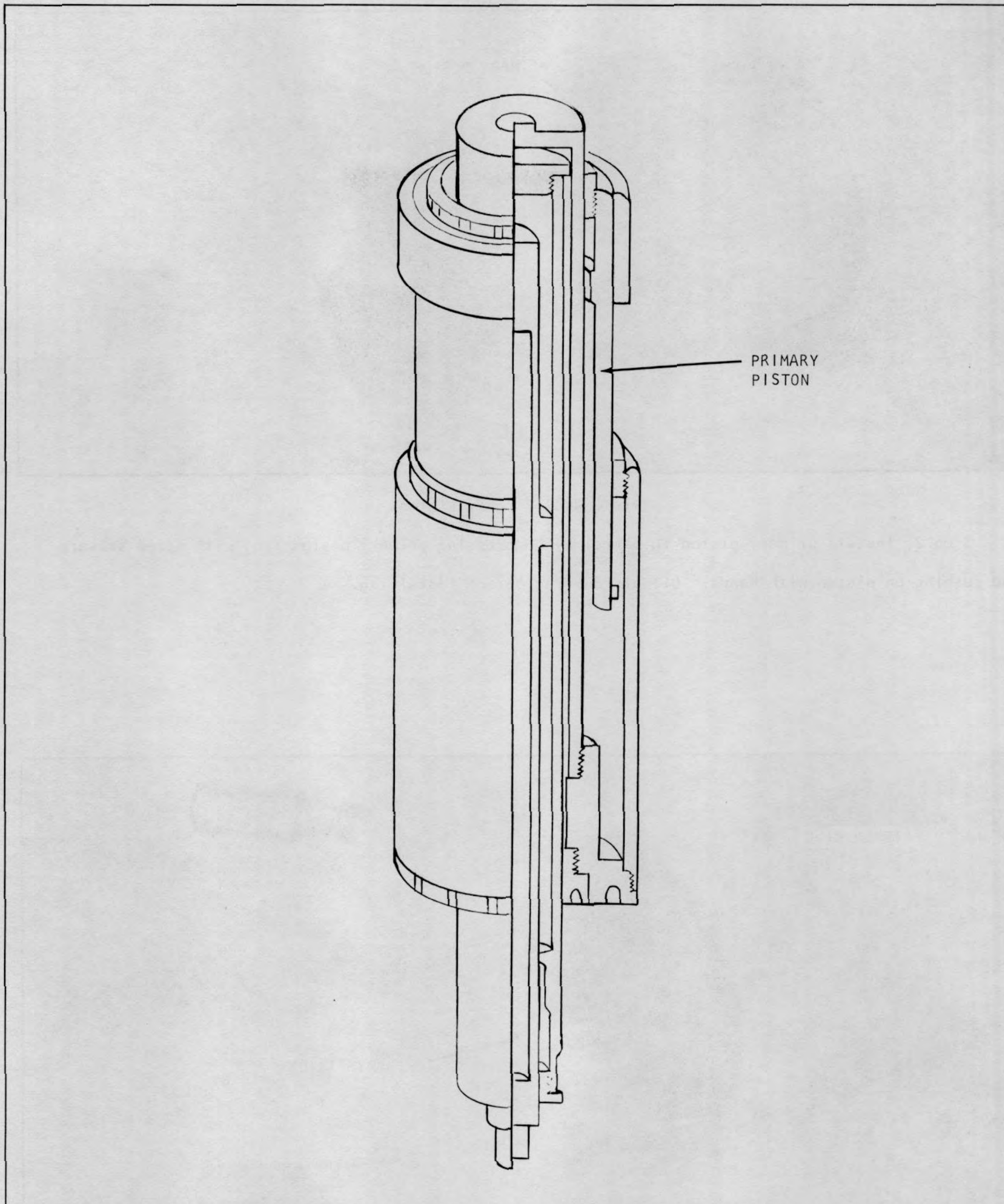


Plate 9516

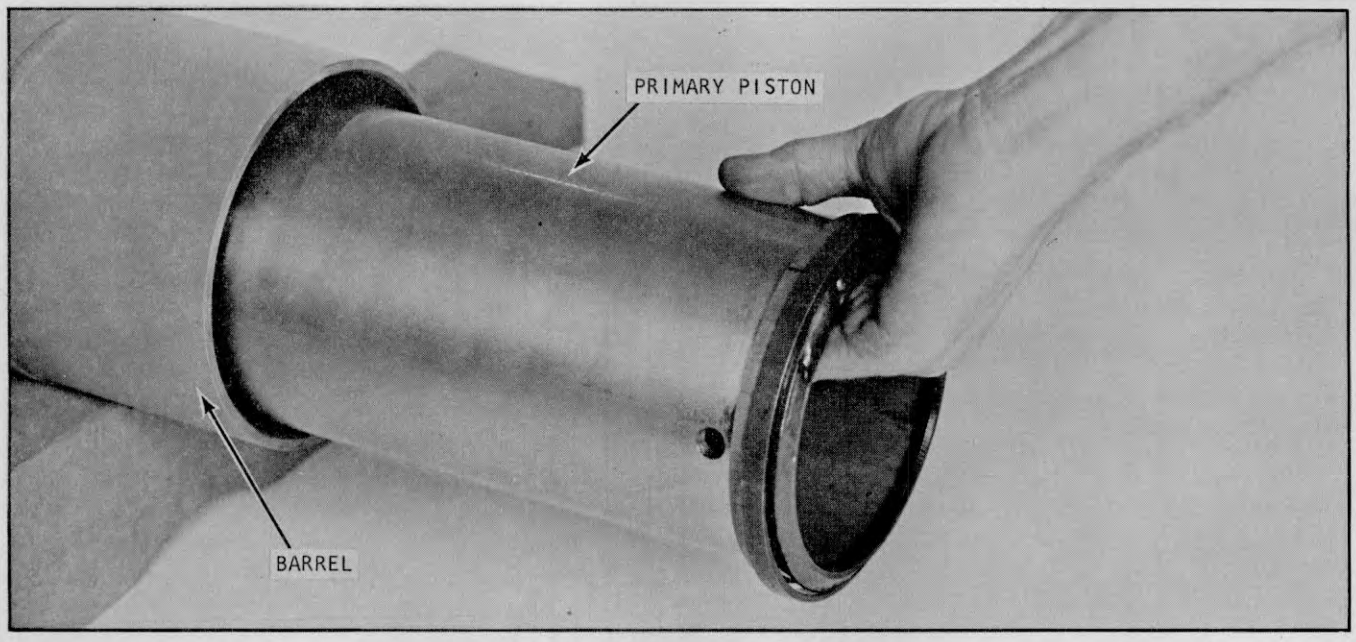


Plate 9487 Primary Piston

Step 2. Install primary piston in barrel by compressing primary piston ring with screw drivers and pushing on piston with hands. Oil piston ring before installing.

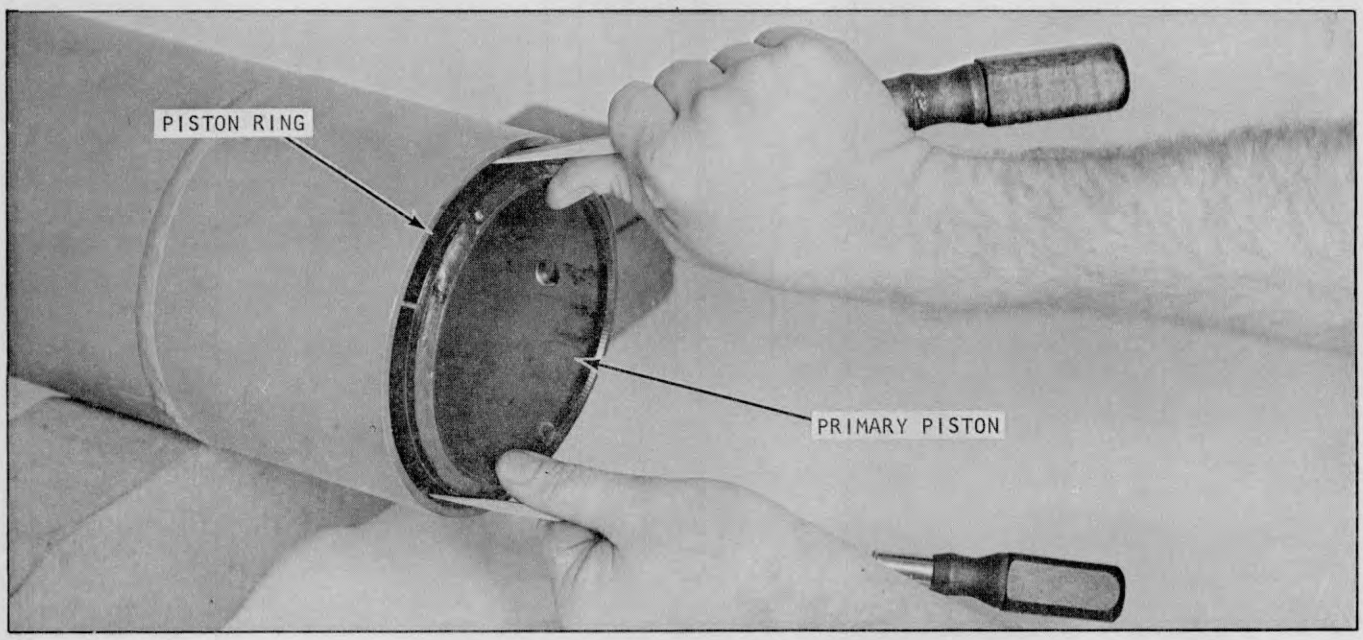


Plate 9532 Primary Piston Installation

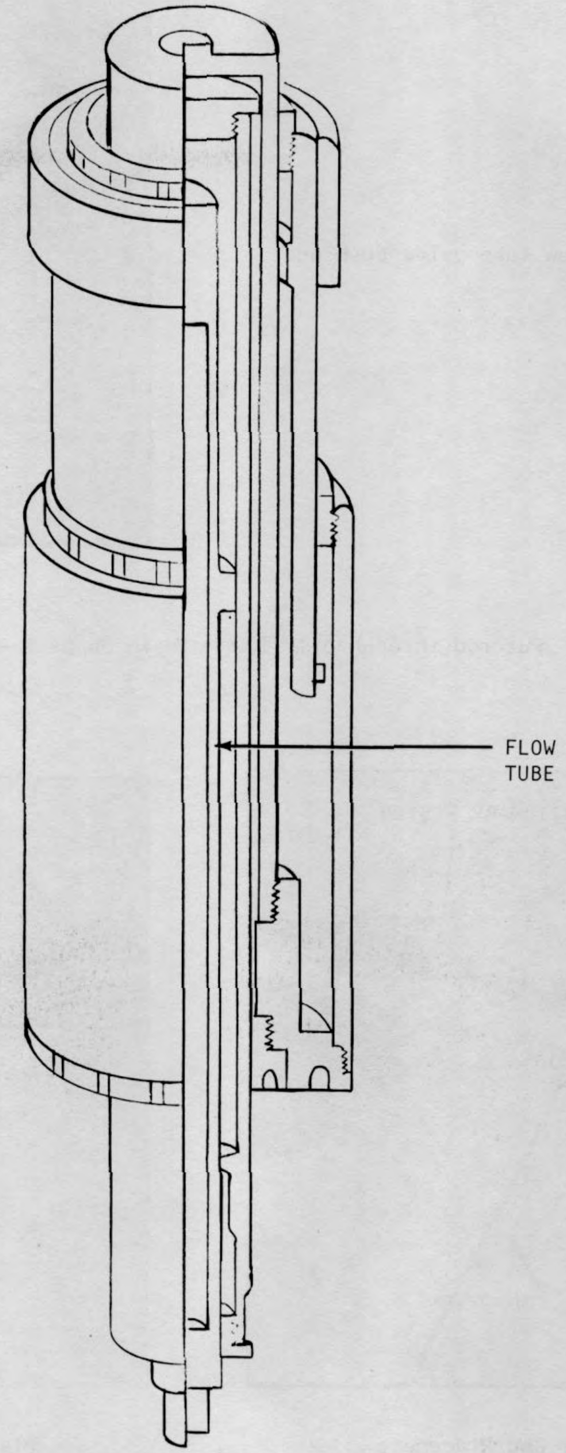


Plate 9517

Step 3. Replace flow tube guide bushing.

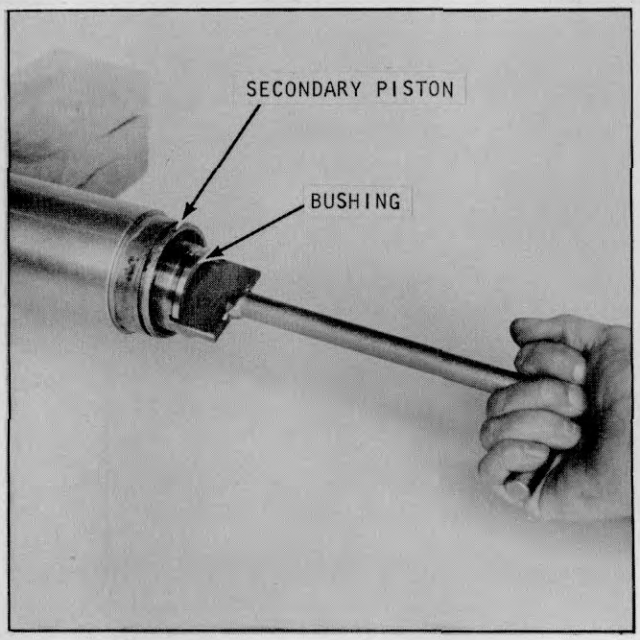


Plate 9485 Bushing

Step 3. Continued. Put rod through oil flow hole in opposit end of secondary piston to support shaft.

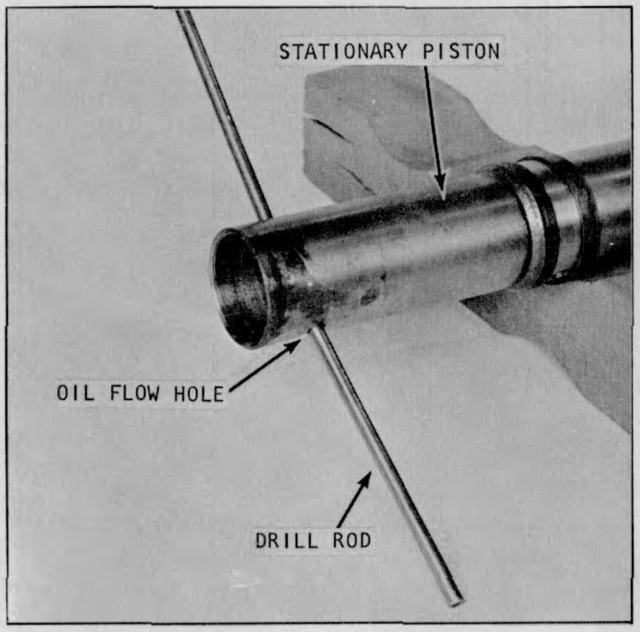


Plate 9553 Drill Rod Placement

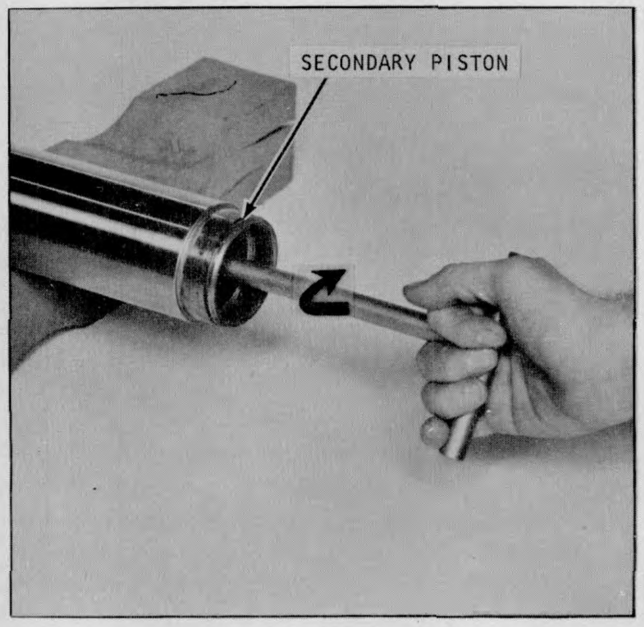


Plate 9555 Bushing Installation

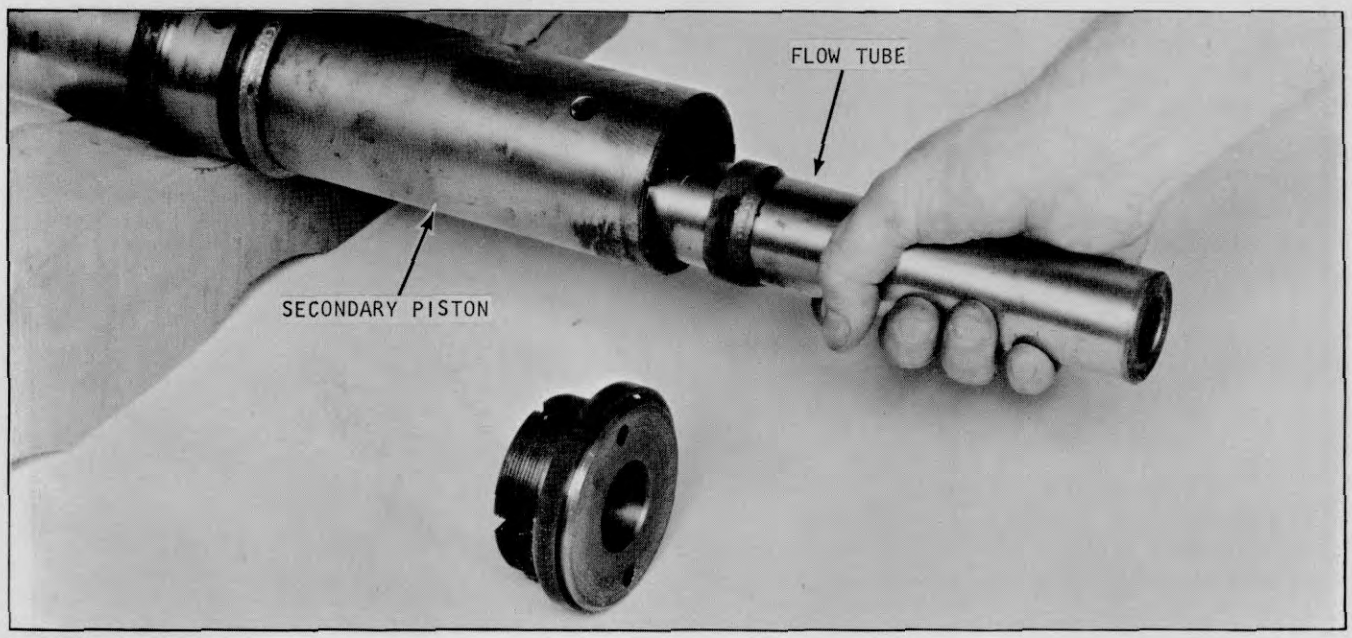


Plate 9552 Flow Tube

Step 4(a). Install flow tube into secondary piston

(b). Line up feed end of flow tube by placing a piece of drill rod (use same rod used to support shaft in Step 4.) in oil flow hole and lifting up (as shown in drawing). This will allow flow tube end to clear stops and bushing.

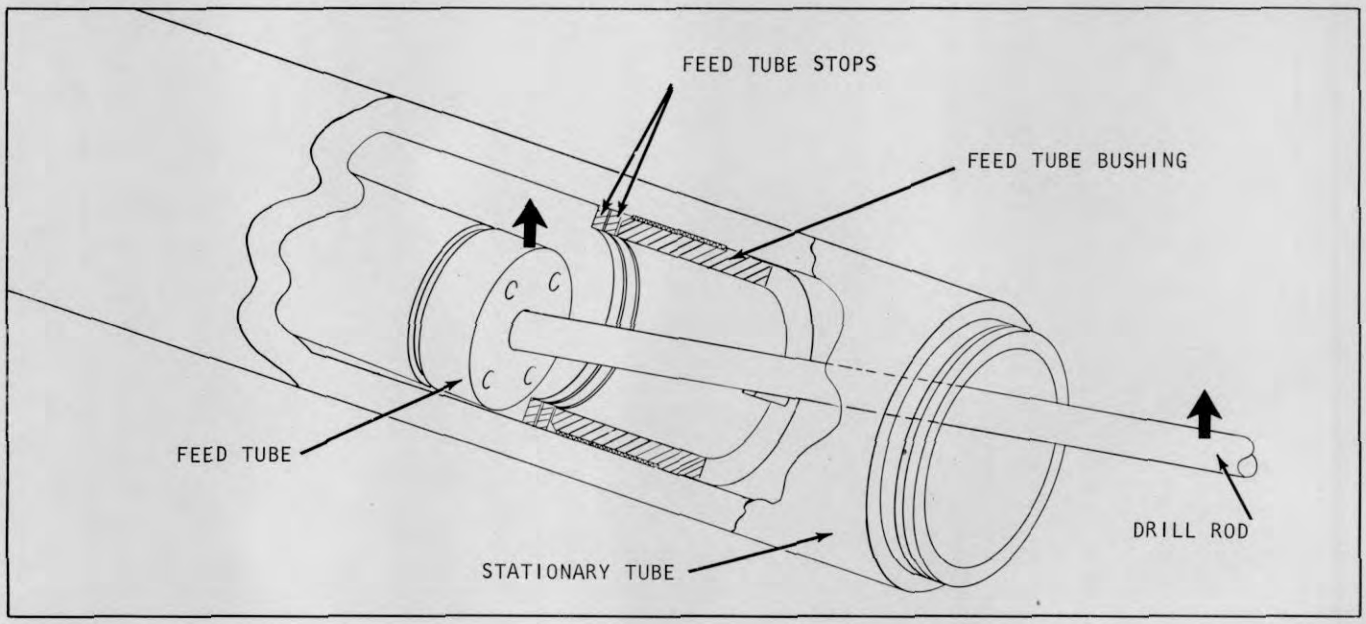


Plate 9521 Guiding Flow Tube

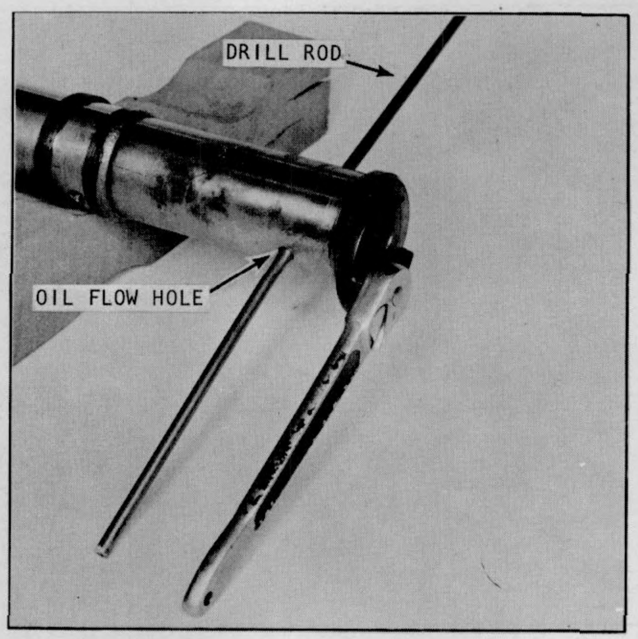


Plate 9551 Secondary Piston End Cap

Step 5. Install primary piston assembly end using spanner wrench and drill rod as shown.

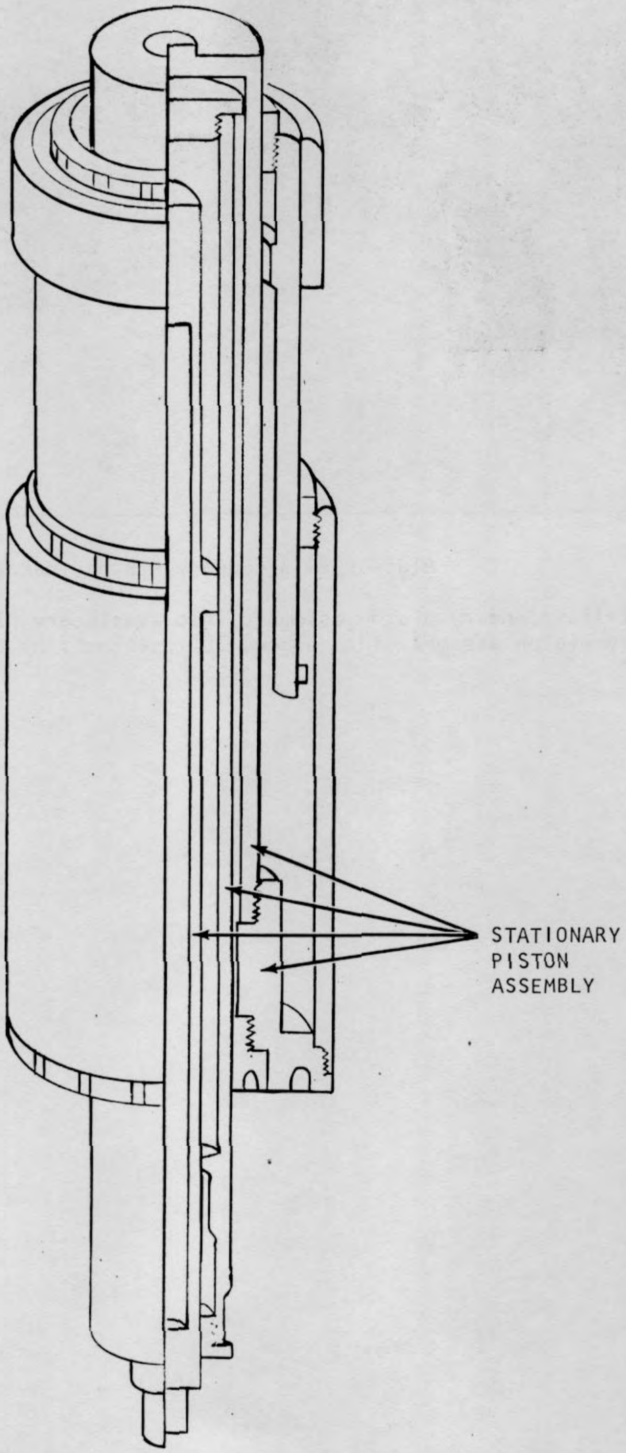


Plate 9519

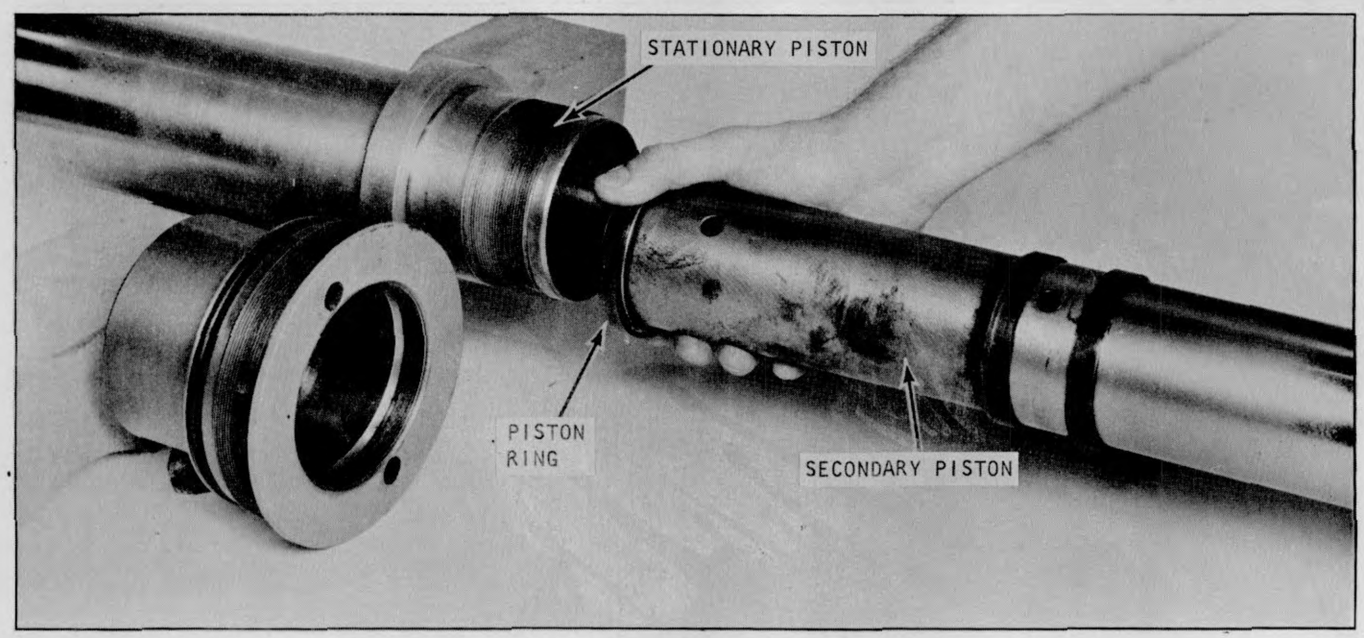


Plate 9522 Secondary Piston Installation

Step 6. Install secondary piston assembly into stationary piston by compressing ring with hand and push secondary piston assembly into place. Oil piston ring before installing.

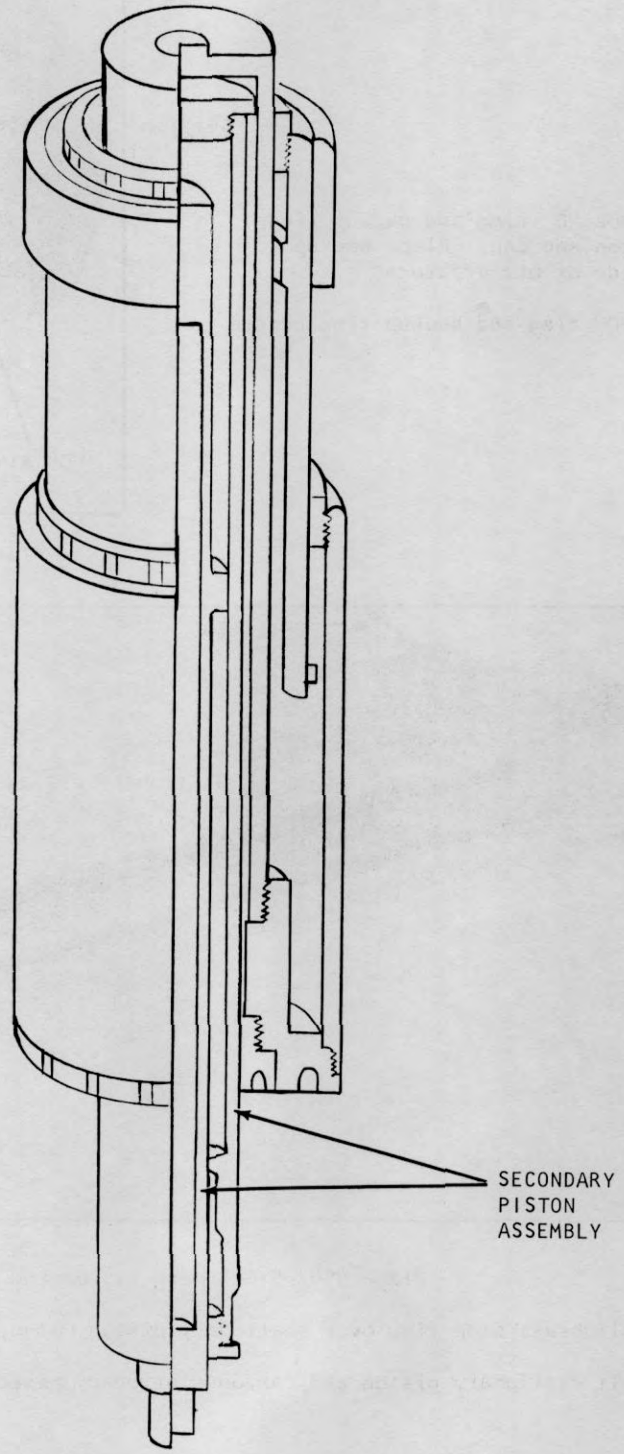


Plate 9518

Step 8. Replace "O" ring and backup ring on stationary piston end cap. Place backup ring on opposit side of oil preasure.

Oil "O" ring and backup ring before installing

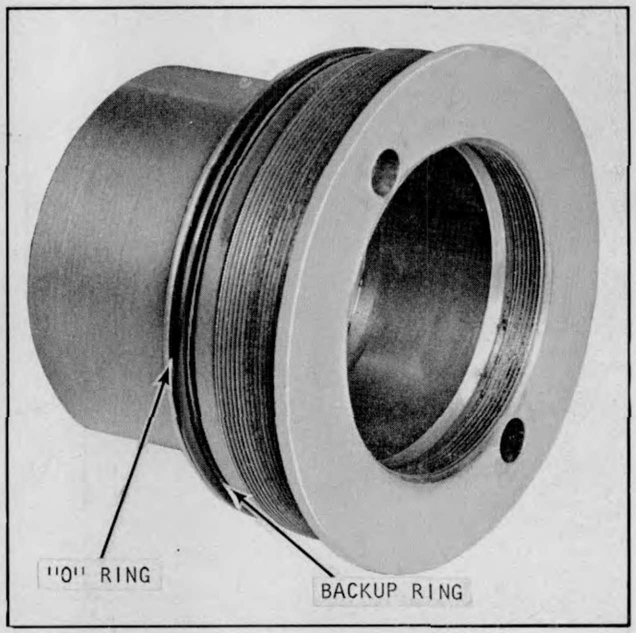


Plate 9534 "O" Ring And Backup Ring

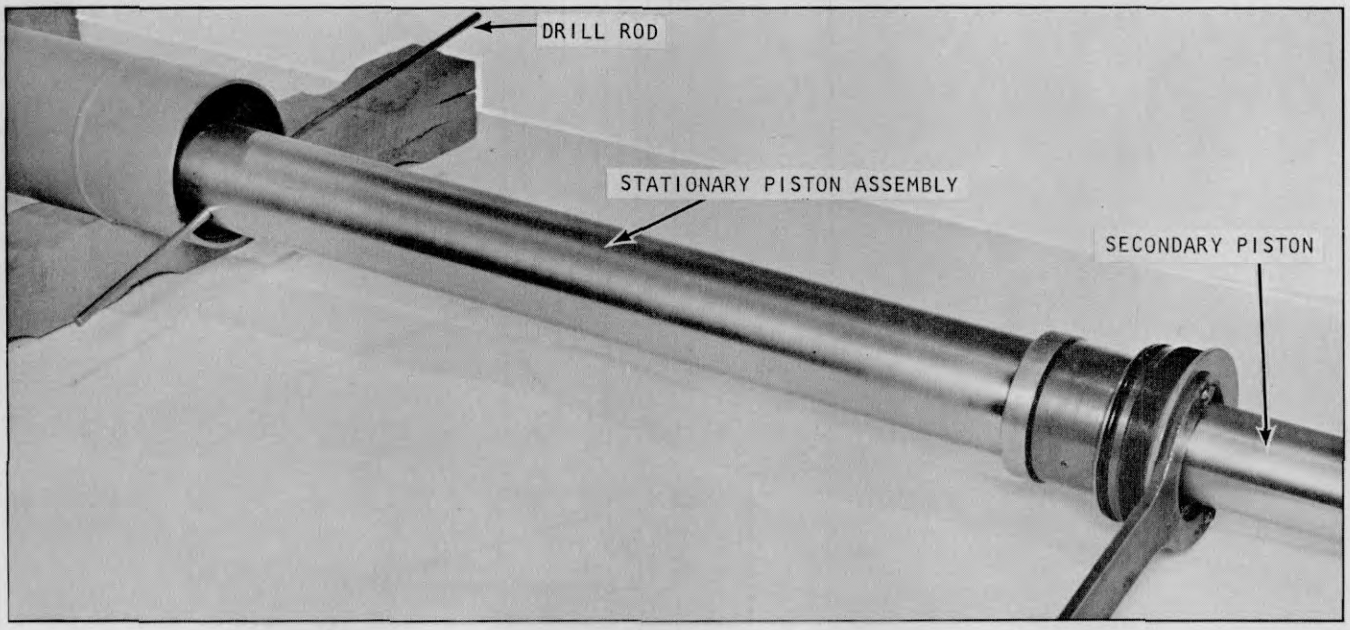


Plate 9547 Stationary Piston End Cap

Step 9. Install brass stop ring over stationary piston, if removed.

Install stationary piston end cap on stationary piston assembly.

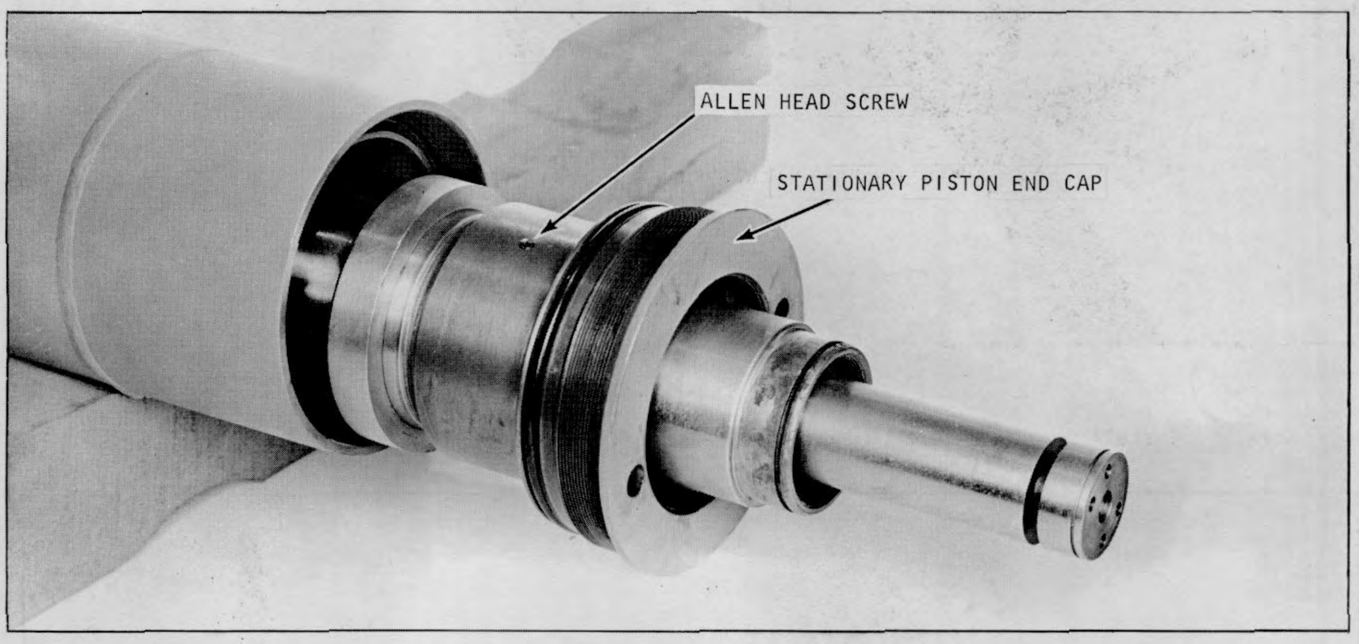


Plate 9546 Stationary Piston End Cap

Step 10. Install BOTH set screw and set screw lock screw back in place.

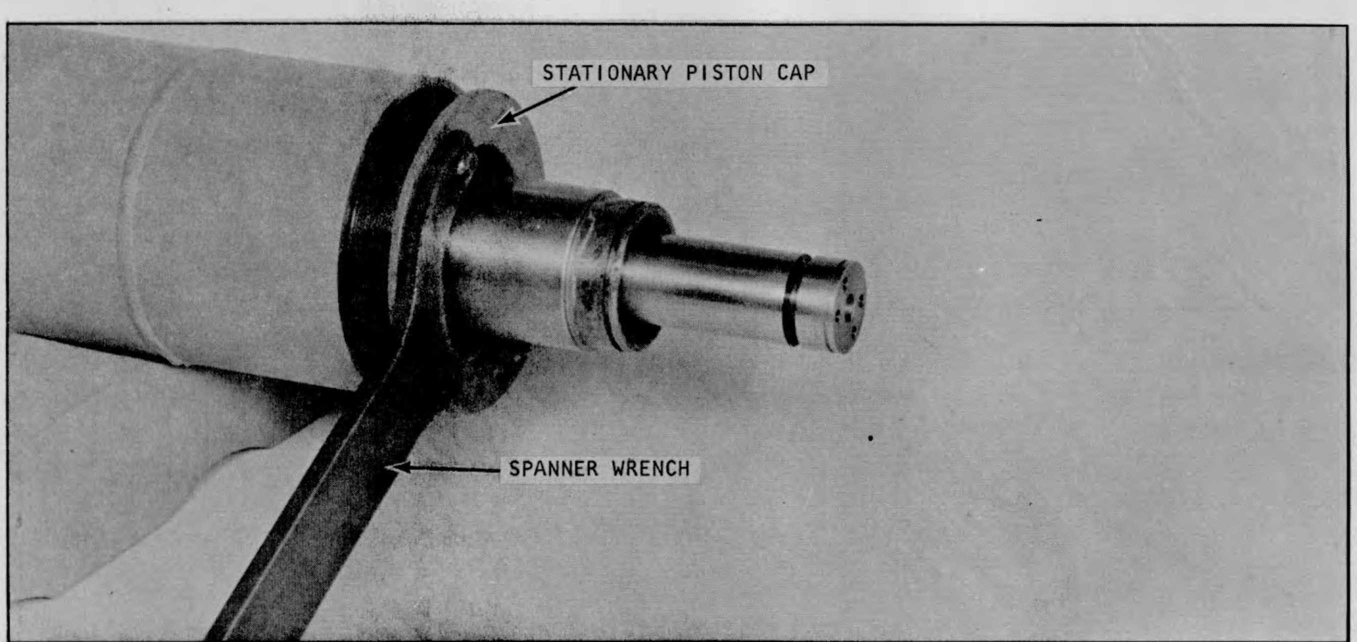


Plate 9545 Stationary Piston

Step 11. Install stationary piston assembly into barrell assembly....

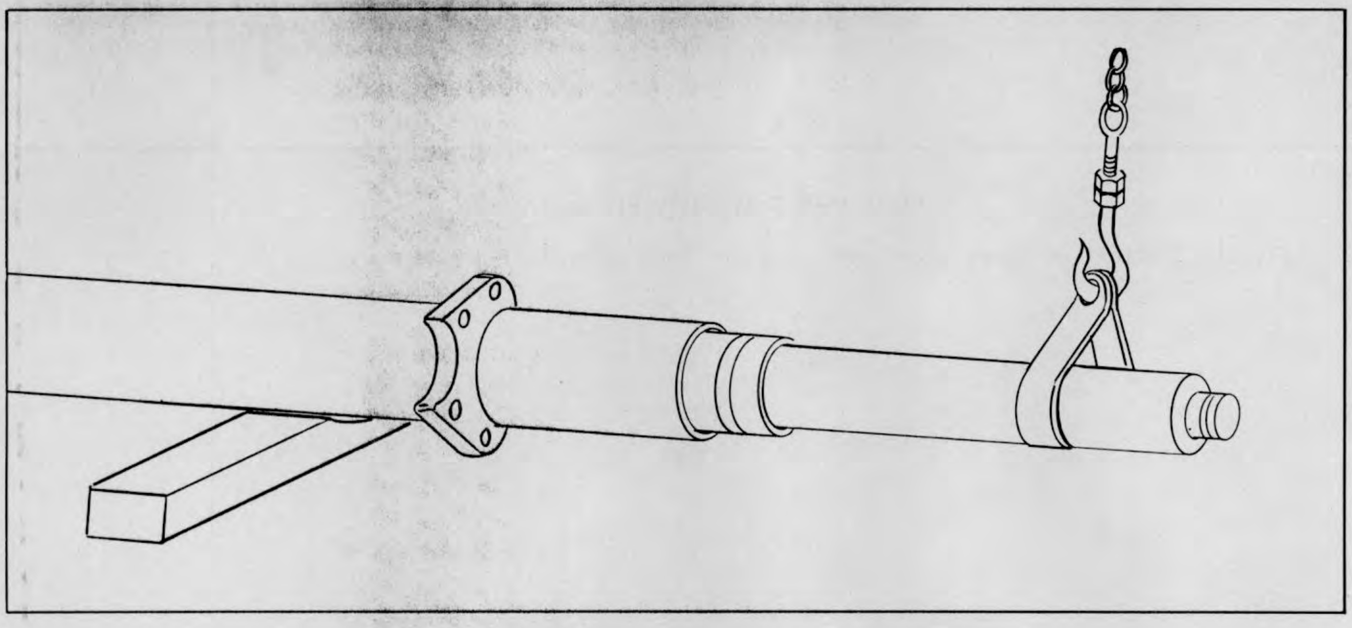


Plate 9524 Supporting Stationary Piston

...Support opposite end and center stationary piston assembly within barrel assembly (as shown) to prevent cross threading.

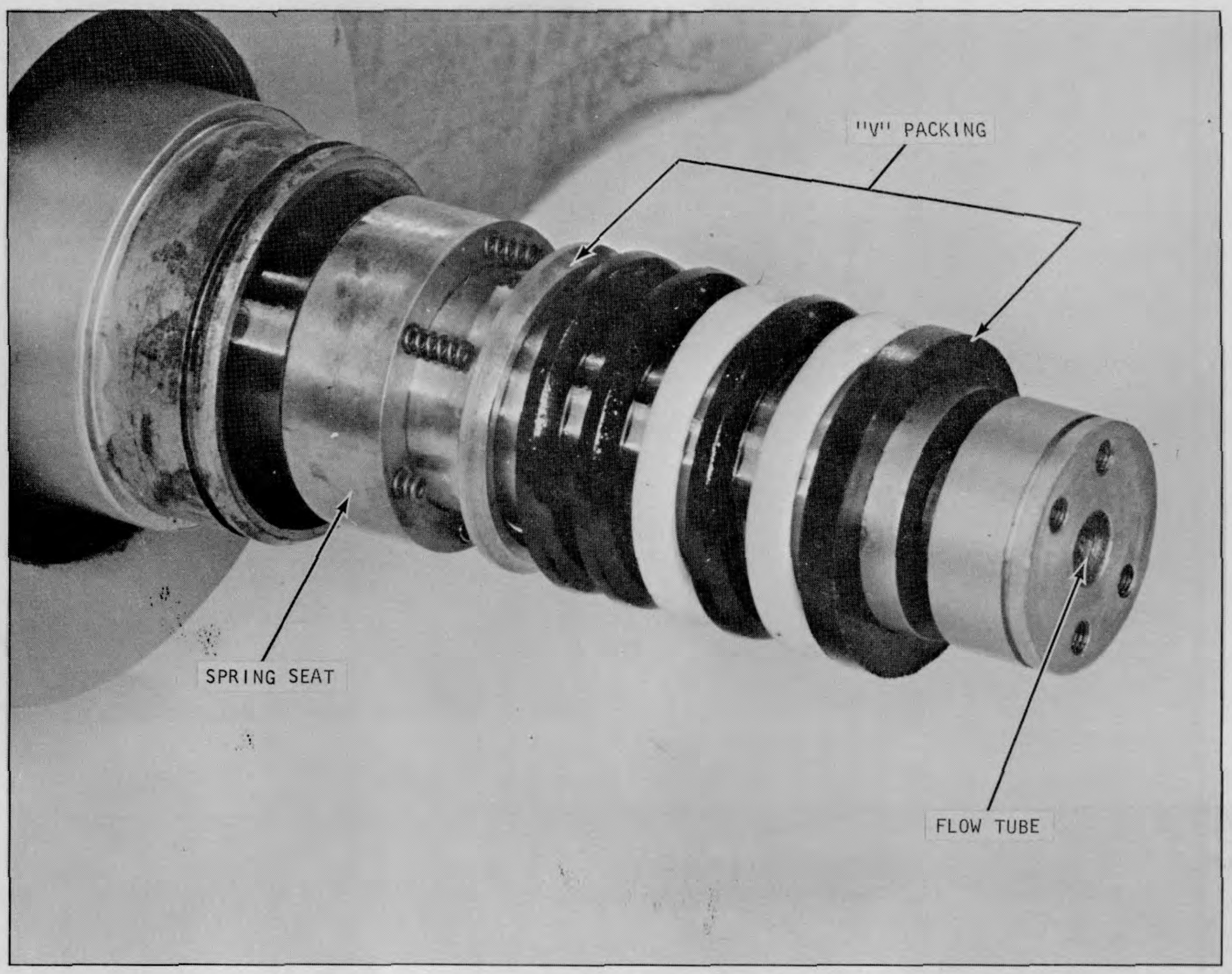


Plate 9525 "V" Packing Installation

Step 12. Replace spring seat, "V" packings and gland nut on flow tube. Oil packings before installing....

...Use tool for "V" packings. DO NOT secure gland nut.

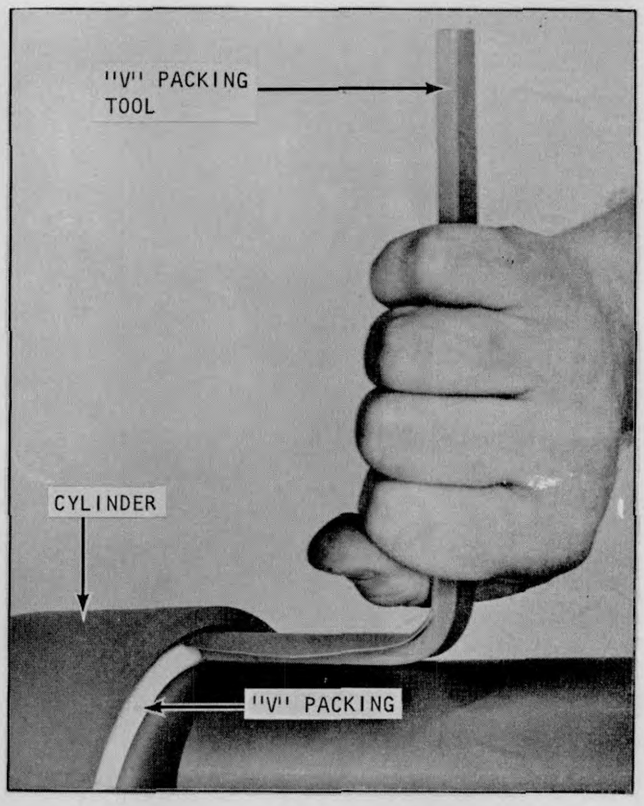


Plate 9529 Using "V" Packing Tool

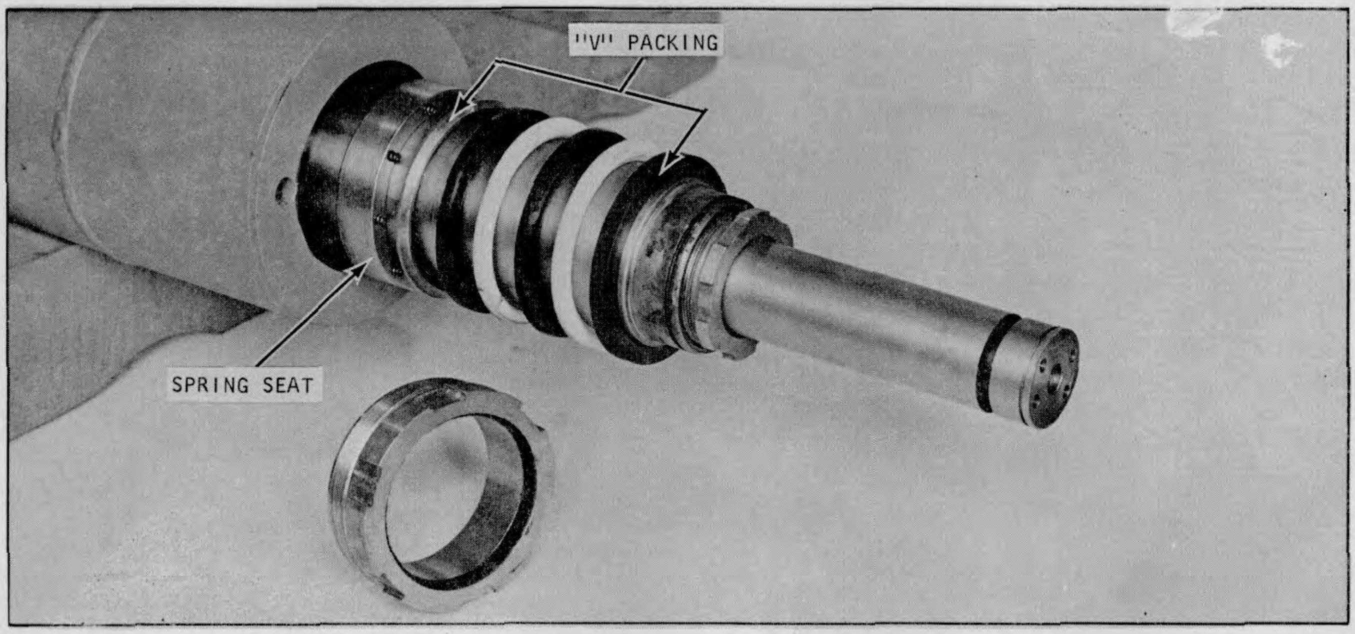


Plate 9526 "V" Packing Installation

Step 13. Replace spring seat, "V" packings and gland nut on secondary piston. DO NOT secure gland nut. Oil packings before installing. Use tool for "V" packings as shown above in Plate 9529.

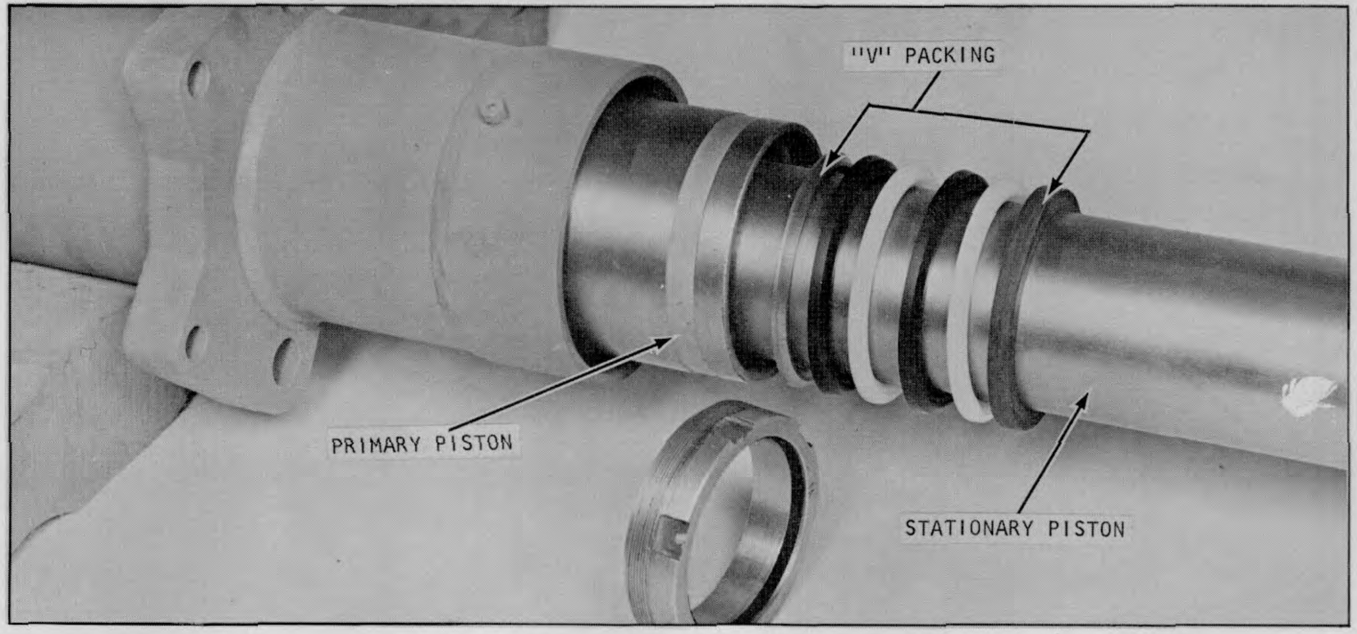
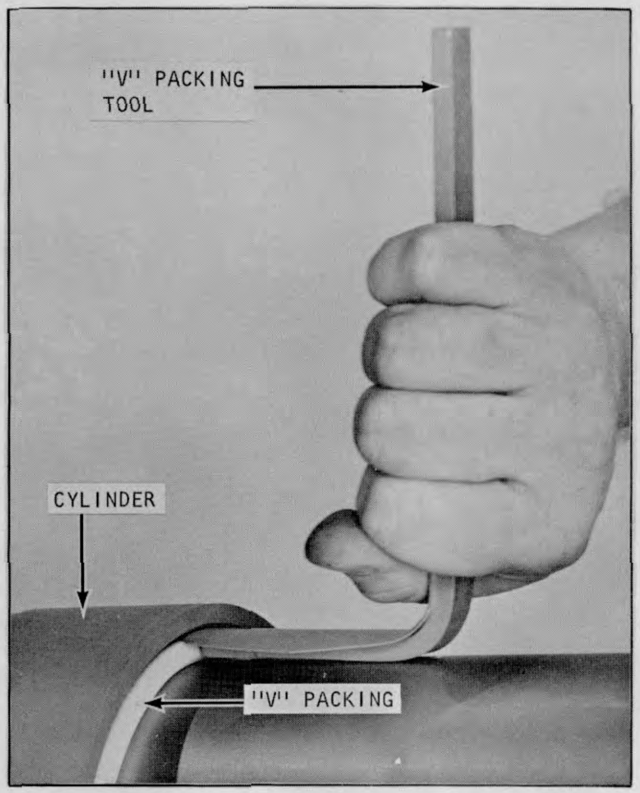


Plate 9527 "V" Packing Installation

Step 14. Replace "V" packings and gland nut on primary piston. Oil packings before installing. DO NOT secure gland nut....



...Use tool for "V" packings.

Plate 9529 Using "V" Packing Tool

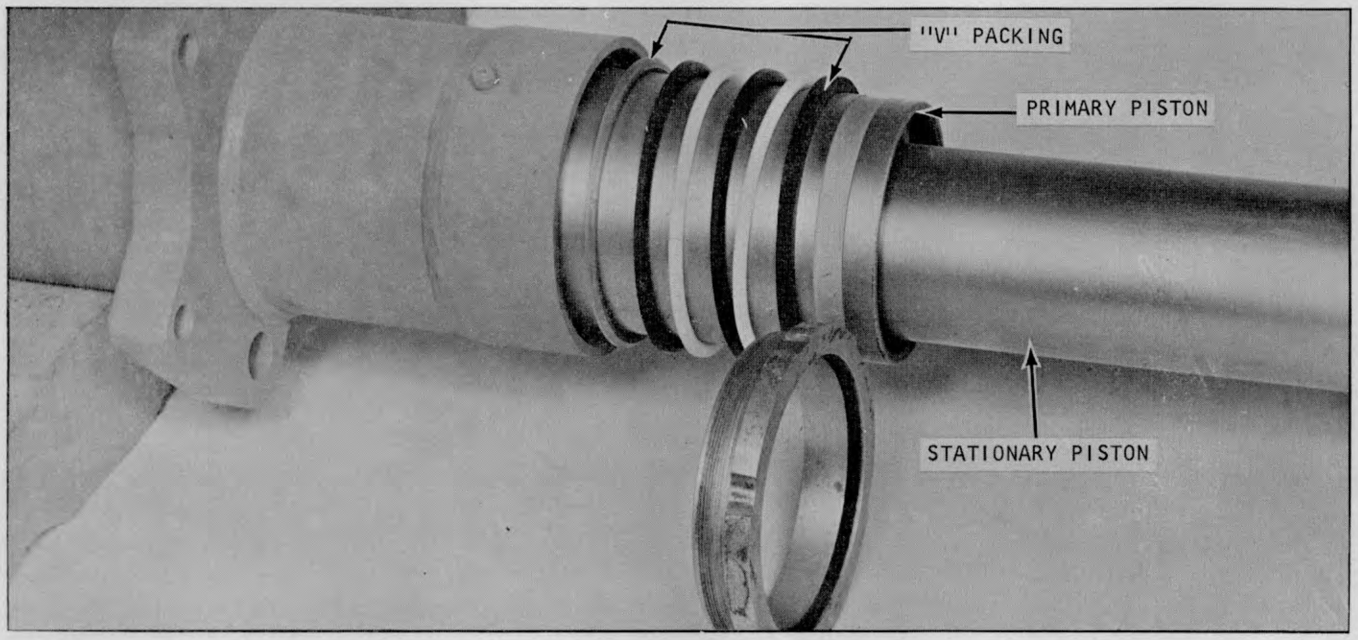
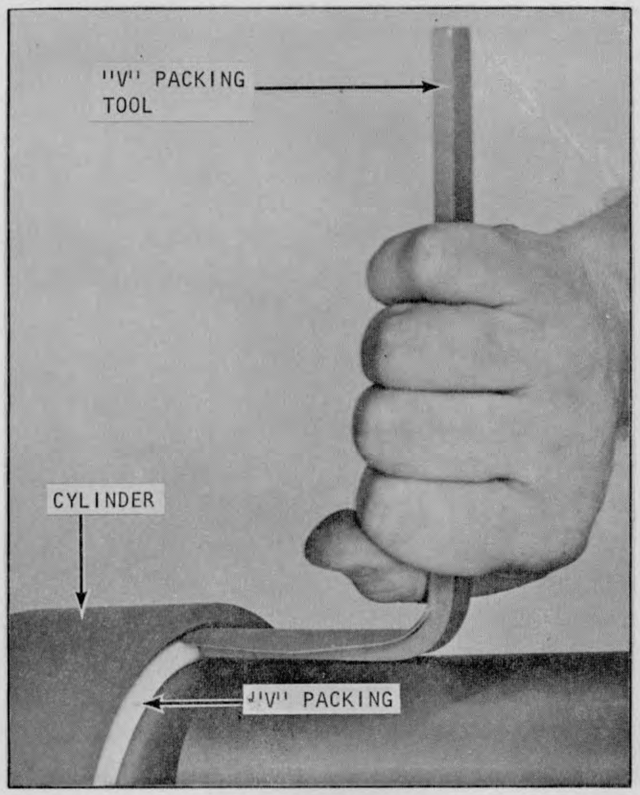


Plate 9528 "V" Packing Installation

Step 15. Replace "V" packings and gland nut on stationary piston. Oil packings before installing.



Use tool for "V" packings.

Plate 9529 Using "V" Packing Tool

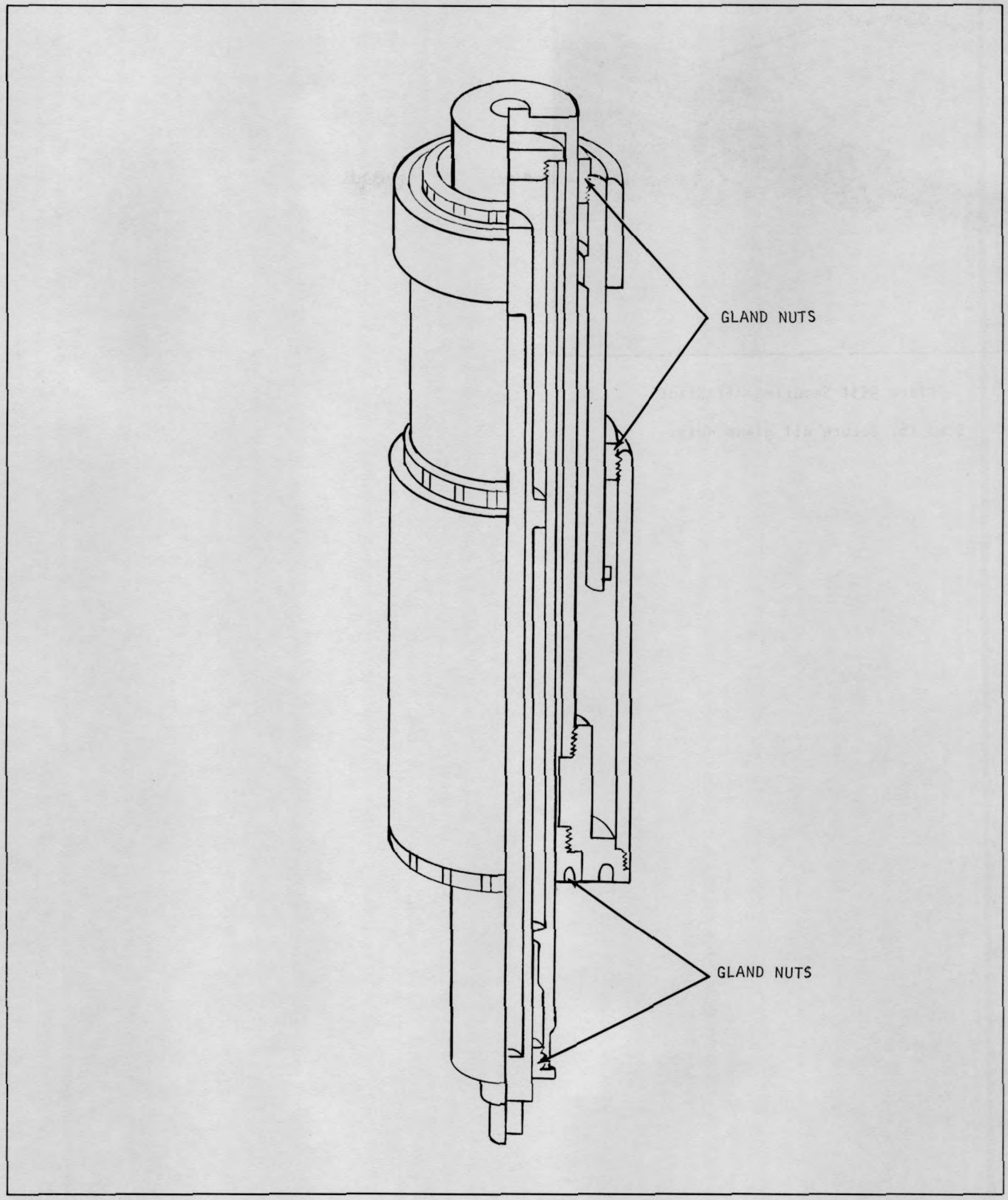


Plate 9530

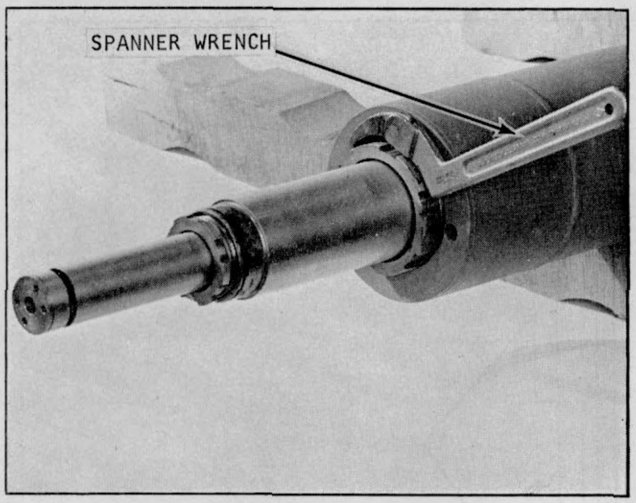


Plate 9531 Securing All Glands

Step 16. Secure all gland nuts.

TILT CYLINDER

Maintenance of the tilt cylinders consists mainly of periodic visual inspections and lubrication at the pivot points. Should it be found that the tilt cylinders will not hold upright at desired angle of tilt, it will be necessary to remove and disassembly cylinder to determine the faulty condition.

Tilt upright to full forward position, disconnect hose lines at front and rear of cylinder.

WARNING

SECURE UPRIGHT WITH A CHAIN TO PREVENT FALLING.

Remove tilt cylinder pivot pins at rear mounting and at upright. Remove tilt cylinder from machine.

An exploded view of the tilt cylinder is shown on the following page to aid in disassembly and reassembly of the unit.

Disassembly

1. Remove three retainer bolts (A) securing the cover (B), seal guard kit (C), retainer (D) and shims (E). (See Plate 5902). Pull these components from end of cylinder and piston rod.

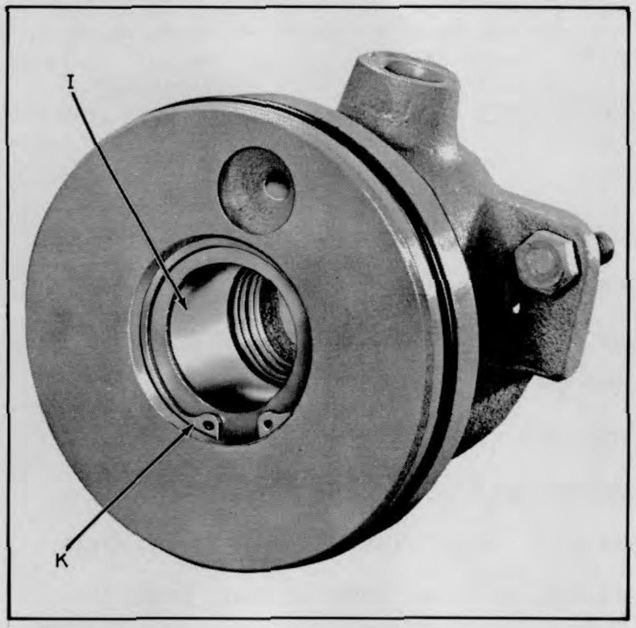


Plate 6193. Gland Bushing and Snap Ring

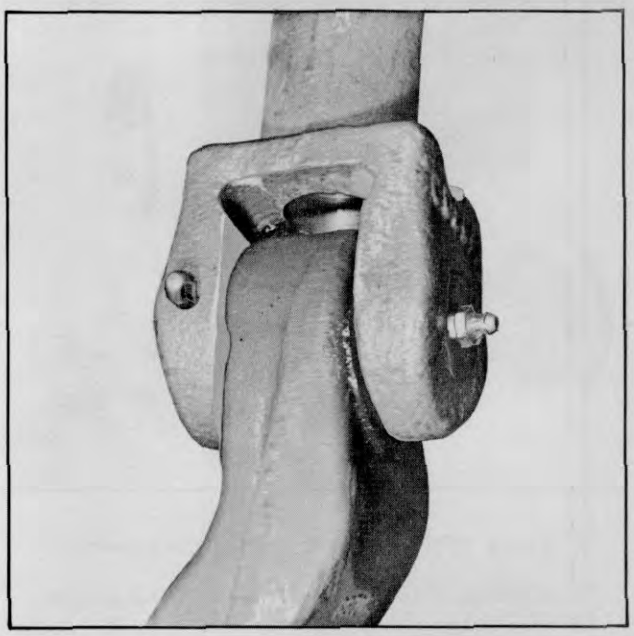


Plate 6049. Tilt Cylinder Pivot Pin Lubrication

2. Loosen gland bolts (F) using suitable wrench. Then, using a screwdriver, rotate each bolt until head is against gland assembly (See Plate 6194).

3. Now tap gland assembly inward into cylinder being careful not to mar, nick, scratch etc, the piston rod. Use a wooden or plastic mallet that does not have a metal frame that might contact piston rod when tapping gland.

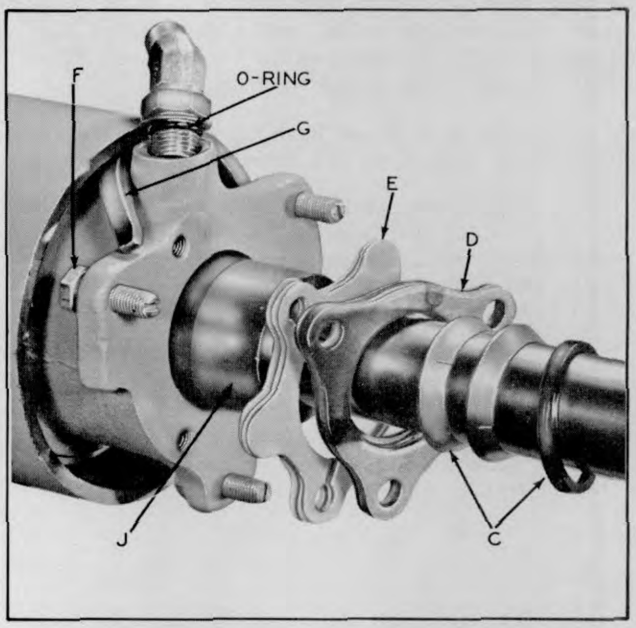


Plate 6194. Seal Guard Kit & Gland Removal

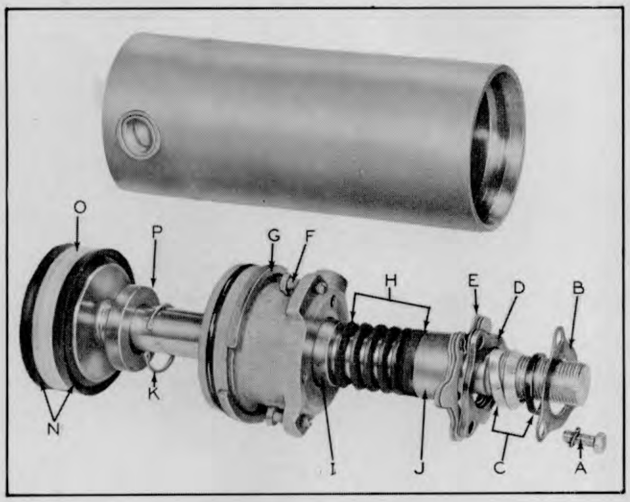


Plate 5902. Tilt Cylinder Components

4. Remove segment rings (G), Plate 6194. This will allow the gland assembly to be pulled from cylinder and piston rod.

5. Refer to Plate 5902 If it is necessary to remove and replace packing set (H) or seal guard kit (C), upon reassembly be sure that all components mate or properly seat in one another. The seal guard kit (C) must be correctly positioned in the seal guard retainer (D), and the flat side of the rubber ring must face outward so the beveled sides of the ring will properly mate with both bronze wiper rings. The packing set has both a bottom and top adaptor. The flat side of the bottom adaptor must set flat against the rear gland bushing (L)with the beveled side of the adaptor facing outward so it will properly mate with packing seals, and flat side of top adaptor must face outward so it will set flush against the front gland bushing (J).

6. The rear gland bushing (L) is held in place with snap ring (K) (See Plate 6193).

7. The gland assembly is equipped with one O-ring (L) and one back-up ring (M). These components must be assembled as shown in Plate 6192. The back-up ring is always on the side opposite the pressure.

8. Now pull the piston rod from the cylinder tube.

9. Check U-cup (N) and wear ring (O) for wear or damage and replace if necessary (See Plate 5902).

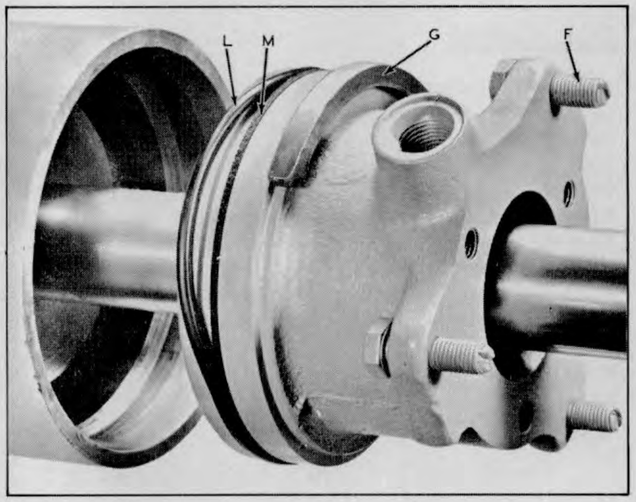


Plate 6192. Gland ORing & Back-Up Ring

Cleaning and Inspection

1. After disassembly, clean all metal parts in a Stoddard Type cleaning solvent and dry thoroughly with compressed air.

CAUTION

CLEAN ALL RUBBER, PLASTIC, FIBER, OR SYSTHETIC PARTS IN CLEAN HYDRAULIC FLUID.

2. Before reassembly, check all parts for further serviceability. Replace all O-rings, and check packings for wear or damage. Be sure that mating parts have smooth surfaces. The piston rod must not have any burrs, nicks or rough spots - rod must be smooth finished. If there are burrs, nicks etc., polish surface with CROCUS CLOTH until rod has an absolutely smooth finish.

CAUTION

DO NOT USE EMERY CLOTH OR SANDPAPER. DO NOT POLISH SO MUCH THAT CHROME PLATING IS WORN OFF ROD. THIS IS IMPORTANT AS PACKINGS AND TUBE WILL BE DAMAGED IF ROD IS BURRED, NICKED, SCRATCHED ETC. TAKE CARE NOT TO DAMAGE O-RINGS AND PACKING SEALS AT REASSEMBLY BY CHECKING CYLINDER, MAKING SURE THAT THE SEALING AREAS ARE FREE OF NICKS, BURRS OR SHARP EDGES THAT MIGHT DAMAGE SEALS. LUBRICATE EACH COMPONENT WITH CLEAN HYDRAULIC FLUID TO FACILITATE ASSEMBLY.

Reassembly

For detail in reassembling the tilt cylinder covered in this section refer to Plate 6194, 6192, 5902, 9858, and 9954 for this reassembly write-up.

1. Install tilt cylinder piston U-cups (5) and wear ring (8) on piston and rod assembly (3). After installing spacer (4), (See Plate 9954), position piston assembly in cylinder assembly.

C A U T I O N

WHEN INSTALLING THE SEALS, PACKINGS, RINGS ETC. THAT MAKE UP THE TILT CYLINDER BE SURE TO LUBRICATE ALL PARTS WITH CLEAN HYDRAULIC FLUID.

2. Install tilt cylinder piston and spacer (14) on piston and rod assembly (3).

3. Install snap ring (6) in tilt cylinder gland (17). Then, position gland on piston rod (3).

4. Install bushing (36) with compression springs (37) on piston rod.) with packing (19) and bushing (18).

5. Replace "O" ring (L) and Back-up ring (M) (Plate 6192) and install gland (17) (Plate 9954) in place by inserting tilt cylinder gland positioning ring (G), and securing gland in place with screws (F) (Plate 6192).

6. Install tilt cylinder gland cover (10) over gland assembly end of tilt cylinder. When installing cover (10), align threaded fitting hole in gland (17) with hole provided in cover. (Plate 9954).

7. After installing shims (E) - install all of the shims supplied in the repair kit - install the gland shim retainer (D). Plate 6194).

N O T E

After the machine has been in service with the tilt cylinder in use, you may want to remove shims (E) (Plate 5902) to increase pressure on packings (H) preventing cylinder leakage.

8. Install Tilt cylinder rod wipers (C). (Plate 6194).

9. Secure wiper with tilt cylinder rod wiper retainer (13). Fasten retainer (B) with cap screw and lockwasher (A).

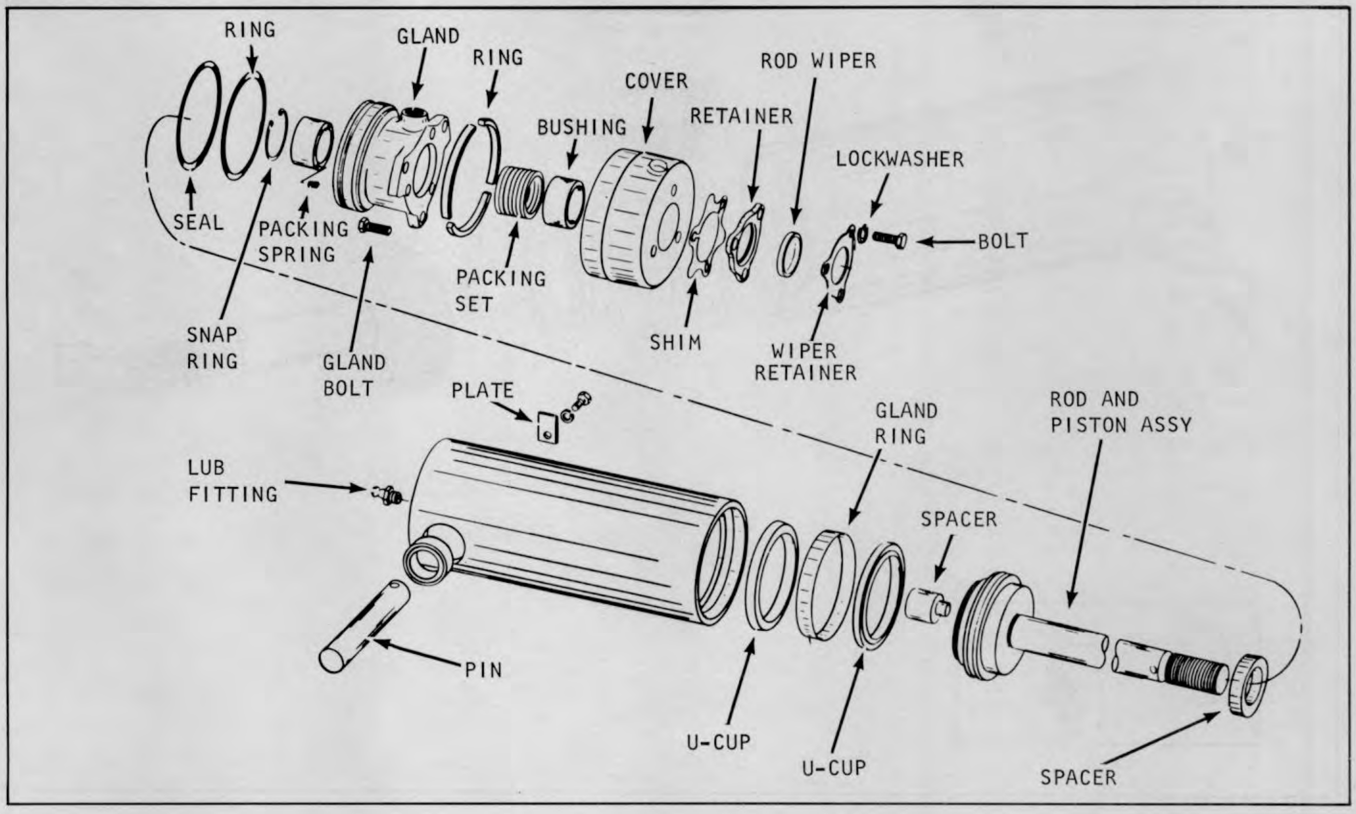


Plate 9858. Tilt Cylinder

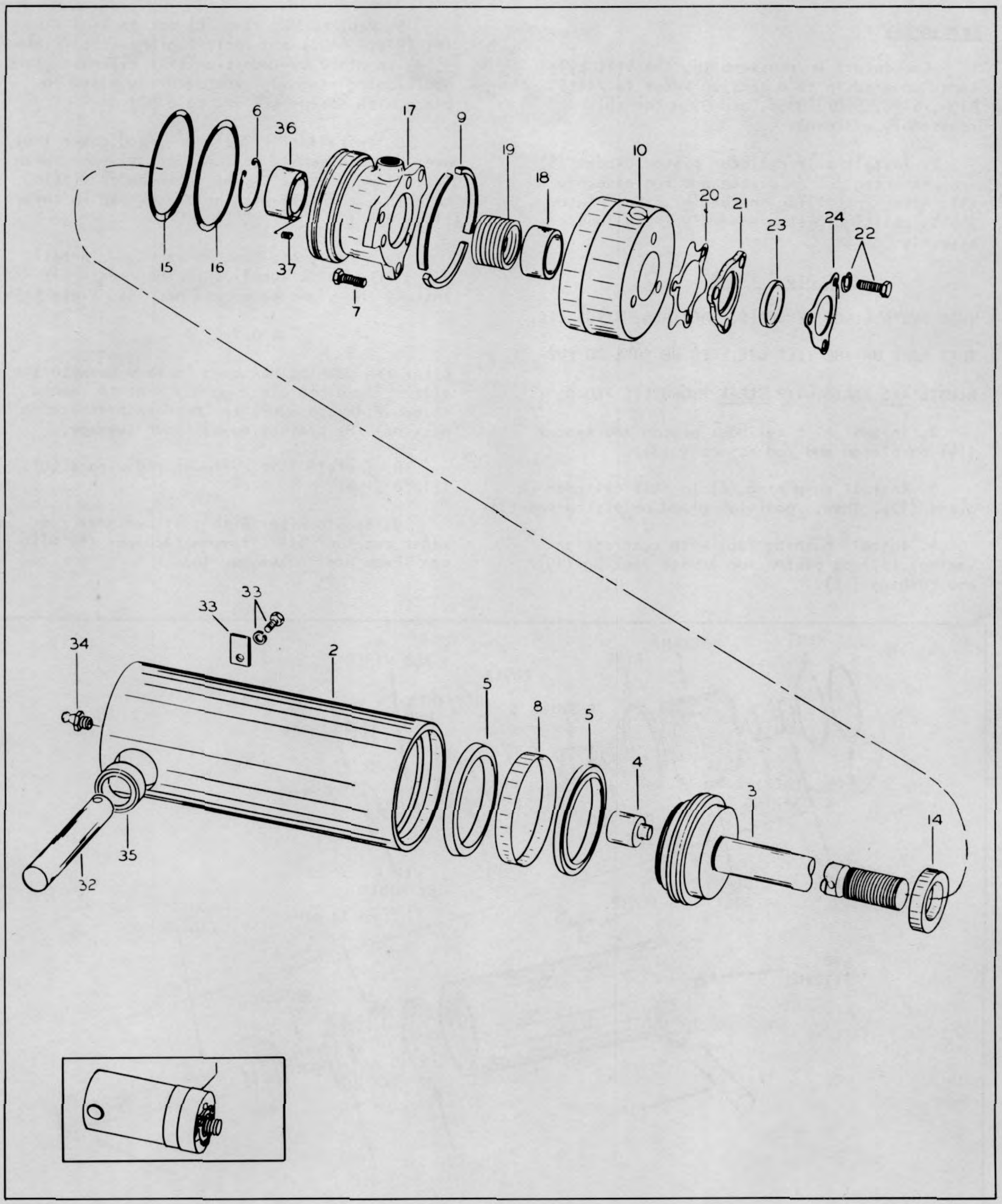


Plate 9954. Tilt Cylinder