

SERVICE MANUAL



Jeep[®]

TRUCK, DIESEL ENGINE,
7000-pound GVW, 4x4

M676 TRUCK, CARGO PICKUP
M677 TRUCK, CARGO PICKUP
w/4 DR. CAB
M678 TRUCK, CARRY ALL
M679 TRUCK, AMBULANCE

KAISER Jeep CORPORATION

TOLEDO 1, OHIO

May 1964

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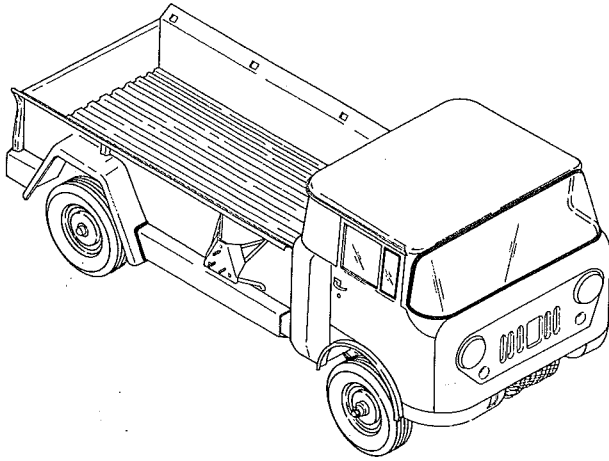
TOLEDO 1, OHIO

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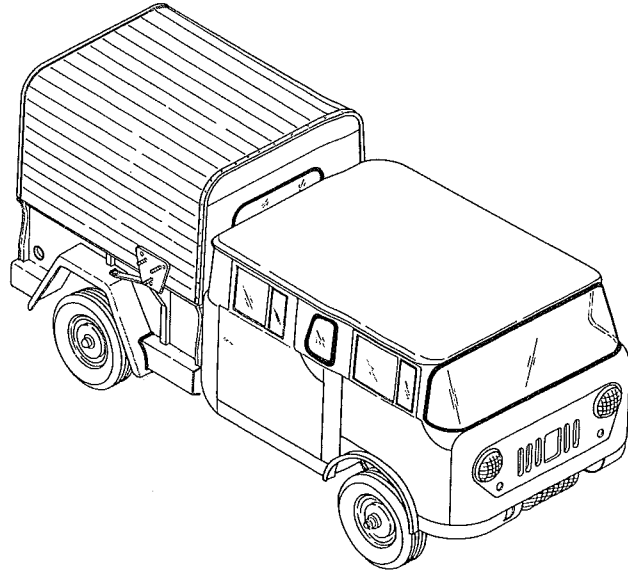
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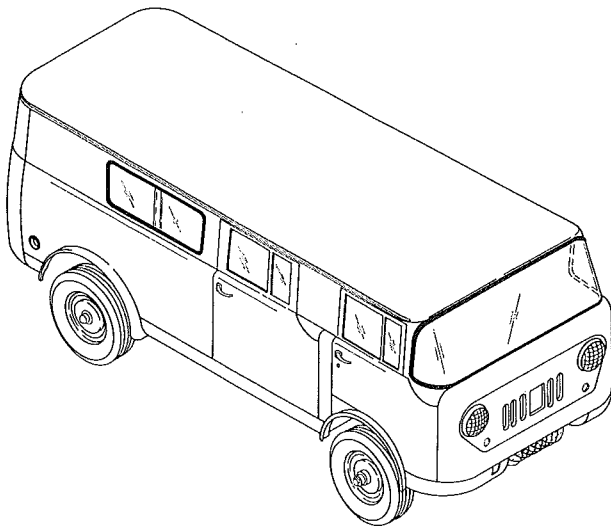
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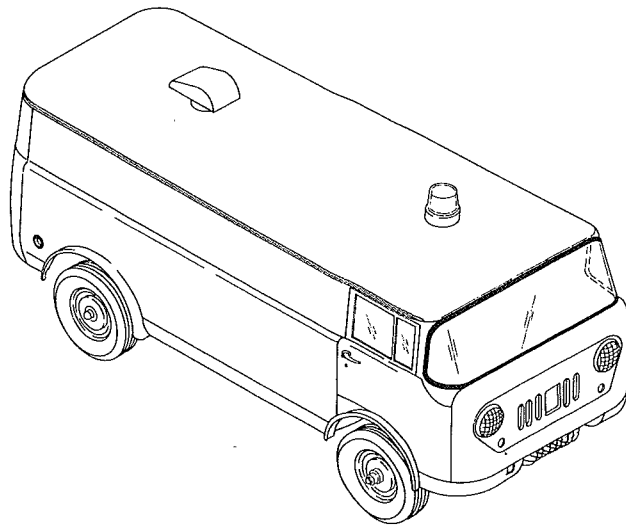
TYPE I. TRUCK, CARGO PICKUP



TYPE II. TRUCK, CARGO PICKUP W/4 DR. CAB



TYPE III. TRUCK, CARRY ALL



TYPE IV. TRUCK, AMBULANCE

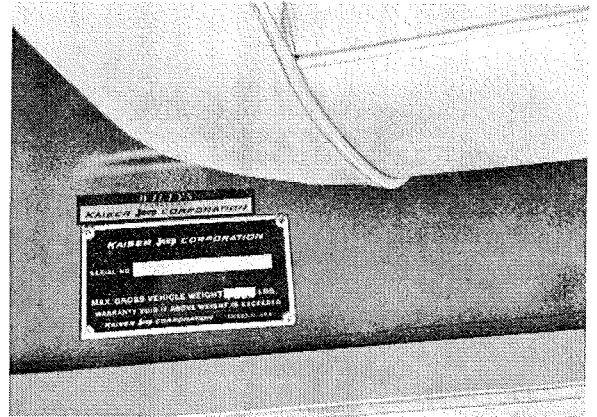
VEHICLE DESCRIPTION

This manual covers four body styles on a single chassis. The four body styles make a pickup truck, three-door panel truck, four-door personnel car-

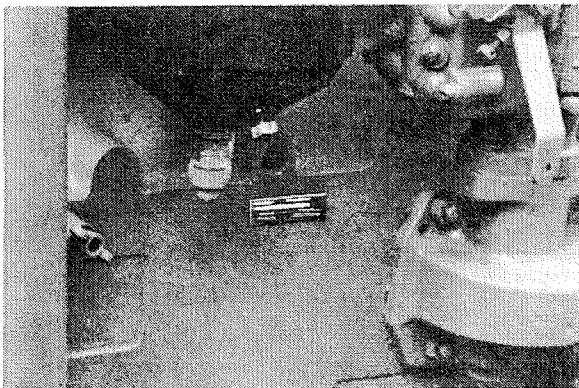
rier, and an ambulance. The unit has a four-wheel drive and three-speed transmission; it is powered by a three-cylinder diesel engine.

VEHICLE SERIAL NUMBER

The vehicle serial number is stamped on a metal plate attached to the cab floor above the wheel housing and to the right of the passenger's seat. A coded prefix precedes a five-digit serial number.



VEHICLE SERIAL PLATE LOCATION



ENGINE SERIAL NUMBER

ENGINE SERIAL NUMBER

The serial number of the diesel engine is stamped on a metal plate that is attached to the left side of the engine block, just to the front of the fuel pump.

GENERAL DATA

Engine:		
Make	.....	Cerlist diesel
Model	.....	3
Cylinder Arrangement	.....	In-line
Wheelbase	.....	103-5/8" [2632 mm.]
Tread:		
Front	.....	63-7/16" [161 cm.]
Rear	.....	63-13/16" [162 cm.]
Height — Over All (Pickup)	.....	91" [231 cm.]
(Panel)	.....	91" [231 cm.]
(Carrier)	.....	87" [221 cm.]
(Ambulance)	.....	94" [239 cm.]
Length	.....	184.28" [467 cm.]
Width	.....	78" [198 cm.]
Ground Clearance	.....	8-7/8" [225 mm.]
Gross Vehicle Weight (GVW)	.....	7000 lb.
Weights (approximate):		
Shipping (less fuel, oil, water):		
Pickup	.....	4075 lb.
Panel	.....	4585 lb.
Carrier	.....	4495 lb.
Ambulance	.....	4585 lb.
Curb (including fuel, oil, water):		
Pickup	4240 lb.
Panel	4750 lb.
Carrier	4660 lb.
Ambulance	4750 lb.

LUBRICATION

Contents

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B-1. GENERAL

It is highly important that the correct amounts of the proper lubricants be used at regular intervals. The specifications given in the charts and detailed description of this section should be closely followed.

B-2. Engine Lubrication

The engine lubrication system is illustrated in Fig. 1 and 2. A description of the lubrication of the engine is given in the engine section. Originally the engine is filled with MIL-L-45199, SAE 30, Series 3, oil. The engine should be run-in with this lubricant for the first 1000 miles. During the run-in period of operation, restrict the engine speed to 2400 rpm (approximately 40 mph in first gear). Use engine oil, Military Specification MIL-L-2104B, SAE 30, Series 3, for operation in temperatures above 10° F. [-12.22°C.], and SAE 10, Series 3, for operation in temperatures below 10° F. [-12.22°C.].

NOTE: When operating with SAE 10, Series 3, oil, the engine speed must be restricted to 2000 rpm (approximately 40 mph in high gear).

B-3. Gear Lubricant

Transmission, transfer case, and steering gear housing are filled with oil, Specification MIL-L-2105. All gears use this lubricant except for the hypoid gears in the Powr-Lok differential, Par. B-18.

B-4. Wheel Bearing Lubricant

Wheel bearings are packed with Grease, General Purpose, Specification MIL-G-10924, Amend. 2. Wheels are packed with a bearing packer or hand packed by kneading grease into all spaces in the bearing. Outer surfaces of bearing cone assembly,

inside surfaces of wheel hub and outside of spindle are lightly coated with grease before assembly.

B-5. Oil Pressure Gauge

The engine oil pressure gauge indicates the pressure of the lubricant in the engine lubricating system. The gauge will not indicate until the engine starts. The gauge should register between 5 psi. [0,35 kg./cm²] and 15 psi. [1,05 kg./cm²] when idling and 35 psi. [2,46 kg./cm²] when the engine is operating at normal speeds. Failure of the gauge to indicate normal oil pressure may indicate insufficient supply of oil in the engine crankcase, low or no oil pump pressure, or a fault in the gauge electrical circuit. The engine must be stopped immediately to prevent possible damage to engine bearings and the fault must be corrected before restarting the engine.

B-6. Engine Lubricating System

The diesel engine is full pressure lubricated at all major bearing surfaces including the blower. Oil picked up by the stationary screen in the oil sump is pumped through the gear-type pump to the oil cooler and filter at the lower right side of the engine. A 125-psi. [8,78 kg./cm²] relief valve built into this unit protects against damage from serious oil blockage. A second relief valve in the full flow filter by-passes oil around the filter element if the filter is clogged or the oil is too thick. Under normal operating conditions, both of these valves are closed since the oil pressure in the main gallery is about 40 psi. [2,81 kg./cm²] and therefore too low to open the valve in the pump. After returning from the cooler and filter, the oil enters the main oil header on the right side of the engine and passes lengthwise through this header from front to rear. Another relief valve located just past the entrance to the oil header determines the

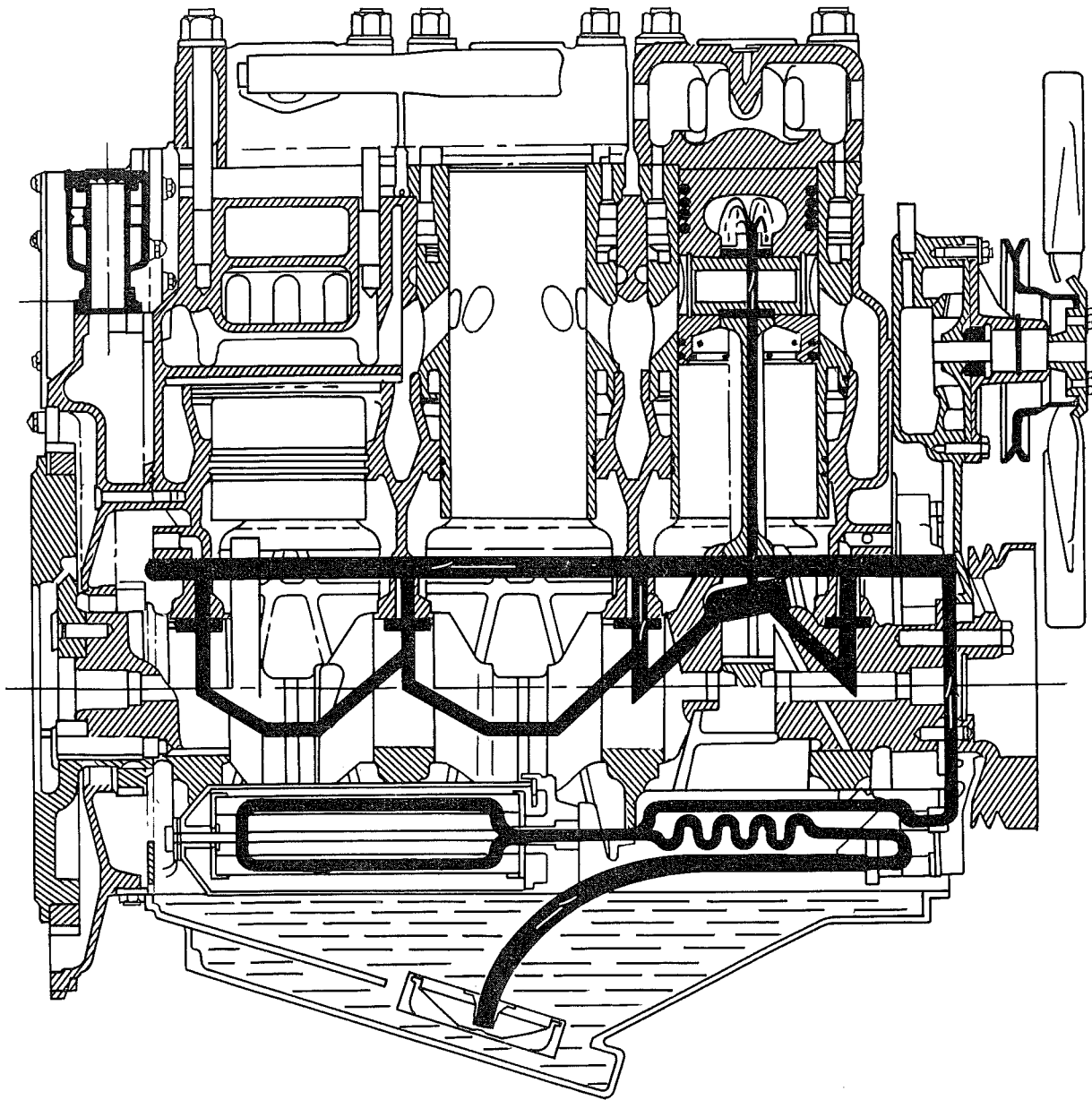


FIG. 1—SCHEMATIC OF LUBRICATION SYSTEM—LONGITUDINAL SECTION

l pressure in the engine system provided bearing clearances, oil viscosity, oil screen and pump condition, and oil cooler condition are normal. Although this valve is not adjustable, the pressure may be increased somewhat by adding small shims behind the oil ring to increase spring pressure. Oil leaves the main header at each main bearing web and feeds the crankshaft main bearing journals, crankpins, connecting rod bearings, piston pins, and undersides of the pistons through the rifle-drilled connecting rods. Separate oil branches from the main header also conduct oil to the blower bearings and

gears and to the balancer shaft front and rear bearings and drive gear areas.

Engine lubrication is shown in Fig. 1.

B-7. DETAIL LUBRICATION REQUIREMENTS

B-8. Initial Lubrication

When a new vehicle is placed in service or an engine overhauled, the engine oil should be changed after the first 500 miles [800 km.] and again after an additional 1500 miles [2,400 km.]. The oil filter

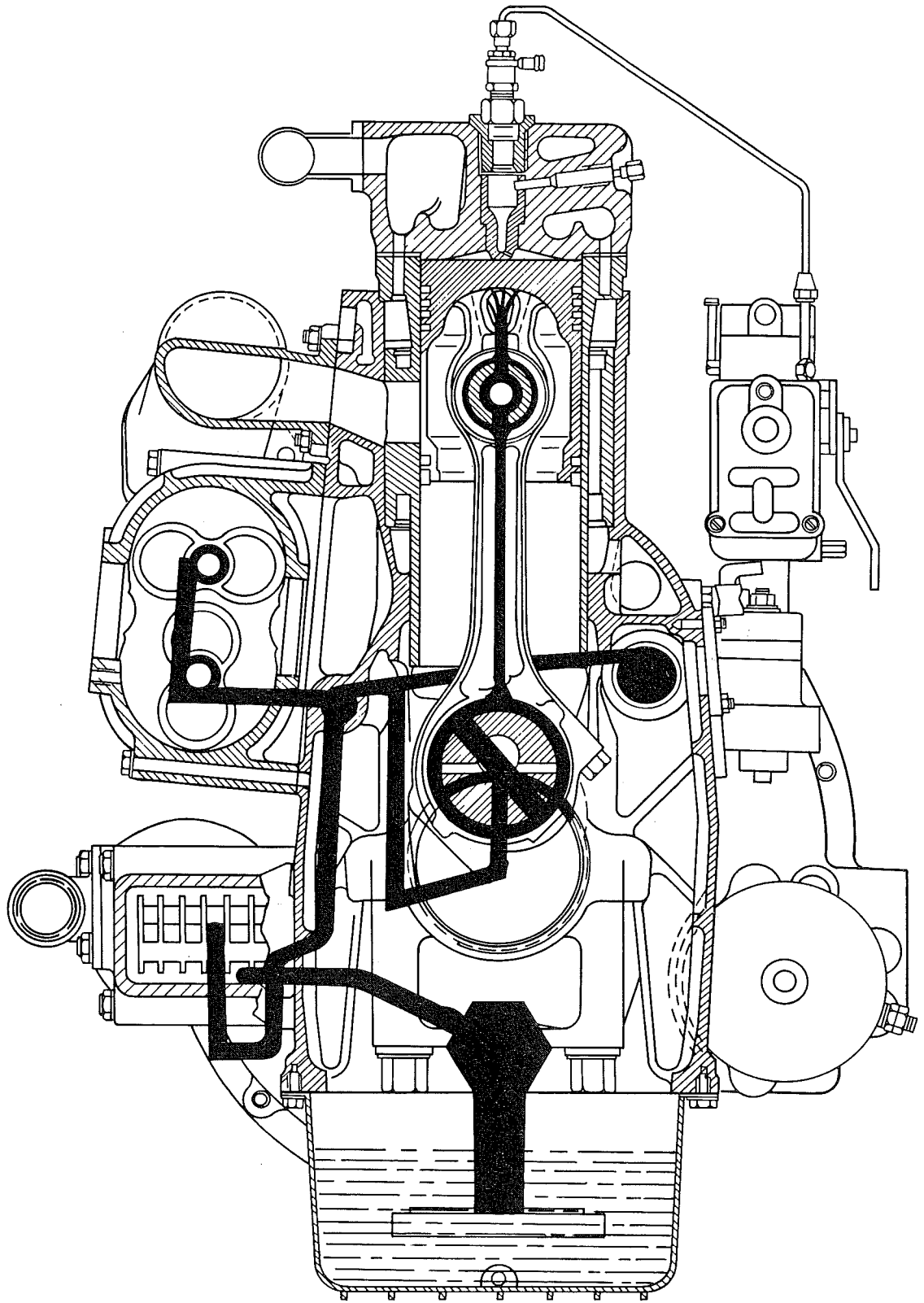


FIG. 2—SCHEMATIC OF LUBRICATION SYSTEM—LATERAL SECTION

ould be cleaned and the element replaced after the first 2000 miles [3.200 km.] of operation. For other vehicle lubrication, follow the instructions given in the remainder of this section of this manual.

during the run-in period, until the piston rings have become seated, oil consumption in the engine is usually greater than that considered normal for proper lubrication. As much as 4000 miles [6.400 km.] of operation may be required to properly seat the rings and decrease oil consumption to normal.

Do not overfill the crankcase as excess oil will be rapidly dissipated. Use engine oil, Military Specification MIL-L-2104B, SAE 30, Series 3, for operation in temperatures above 10° F. [-12.22° C.], and SAE 10, Series 3, for operation in temperatures below 10° F. [-12.22° C.].

NOTE: When operating with SAE 10, Series 3, oil, engine speed must be restricted to 2000 rpm (approximately 40 mph in high gear).

9. Engine Crankcase

The oil in the crankcase should be changed after the first 2000 miles [3.200 km.] or 100 hours of operation. Always drain while crankcase oil is hot. Suspended dirt and contaminants will more likely be held in suspension and, therefore, drain out more completely.

Position drain receptacle under plug.

Remove drain plug using correct size wrench. Be careful of hot oil.

Clean drain plug. Inspect and replace gasket if deteriorated.

When oil has drained, replace and tighten drain plug.

Check for presence of excess water in the oil. It might indicate an internal leak from the cooling system.

10. Lubrication Fittings

At each 1000 miles [1.600 km.] clean each lubrication fitting as indicated by No. 1 on Lubrication Charts. Use a pressure gun to lubricate. Be sure that grease channels are open to provide complete lubrication of bearing surfaces. In some cases it may be necessary to replace the lubrication fitting. In extreme cases it may be necessary to disassemble and clear clogged channels. The following points have lubrication fittings.

Tie rod: 3 fittings

Drag link (steering connecting rod): 2 fittings

Clutch linkage: 4 fittings

Steering bellcrank

Spring shackles and pivot bolts: See Par. B-11

Propeller shaft universal joints: See Par. B-12

Rear wheel bearings: See Par. B-16

11. Spring Shackles and Pivot Bolts

Lubricate the spring shackles and pivot bolts with Grease, Automotive and Artillery; lubricate at each

fitting with a pressure gun each 1000 miles [1.600 km.].

B-12. Propeller Shaft Universal Joints

The propeller shaft universal joint trunnions and slip joints are equipped with lubrication fittings. These should be lubricated with Grease, Automotive and Artillery, each 1000 miles [1.600 km.] using a hand compressor.

B-13. Front Axle Shaft Universal Joints and King Pin Bearings

Both the front axle shaft universal joints and the front axle king pin bearings are enclosed in the steering knuckle housings. Check the lubricant level in the housings each 1000 miles [1.600 km.] to maintain it at filler plug level. Once each year or at each 12,000 miles [19.200 km.], remove the shafts. Thoroughly clean the universal joints and housings and refill the housings with Grease, Automotive and Artillery, using a hand compressor.

B-14. Steering Gear

Check the lubricant level in the steering gear housing at each 1000 miles [1.600 km.] to be sure that the lubricant is at filler plug opening level. Should lubricant be required, fill the housing slowly with a hand compressor. Do not overlook replacing the filler plug.

B-15. Front Wheel Bearings

Seasonally or at each 6000 miles [9.600 km.], remove the front wheels and repack the bearings with Grease, Automotive and Artillery. Work the grease into the cage holding the rollers.

B-16. Rear Wheel Bearings

The rear wheel bearings are equipped with lubrication fittings with a grease relief fitting through the housings above each fitting as shown in Fig. 173. Lubricate sparingly each 1000 miles [1.600 km.]. Use a hand compressor and Grease, Automotive and Artillery, forcing the grease through each lubrication fitting until it flows from the vent. Vent should be kept clear of obstruction or grease will back up into the brakes. Do not add grease after it flows from the vent for it may be forced through the wheel keyway onto the outside of the wheel and possibly onto the brake linings.

B-17. Three-Speed Transmission and Transfer Case

Maintain lubricant at fill plug level in both transmission and transfer case. Check level each 1000 miles [1.600 km.] and add lubricant when necessary.

NOTE: The lubricant level in the transmission and transfer case should be checked immediately after operation in order to obtain a correct reading.

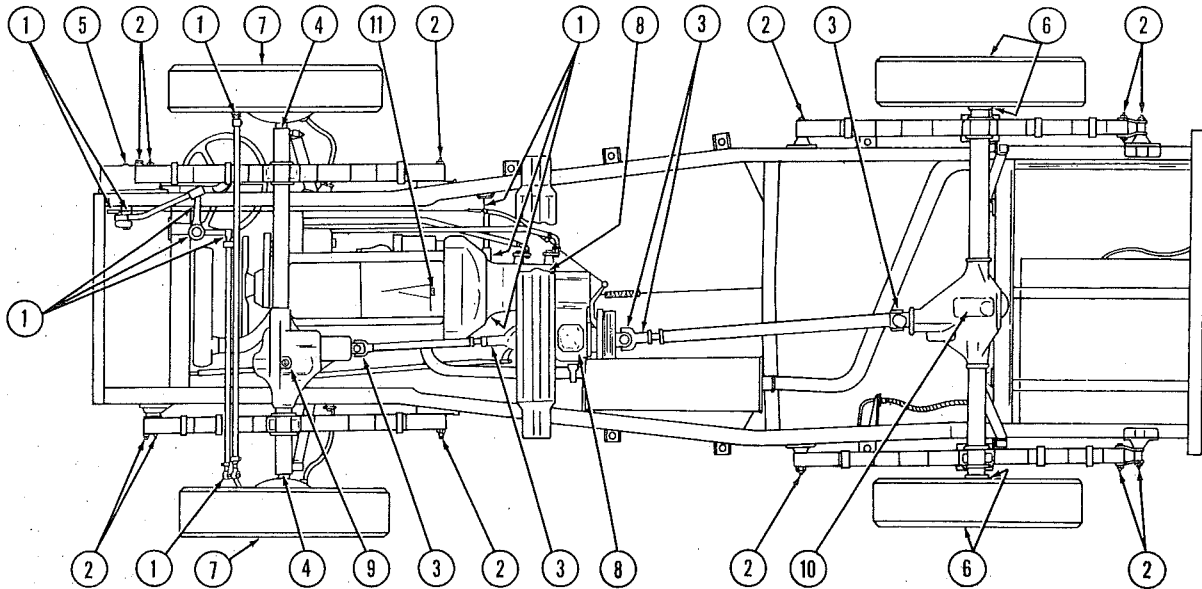


FIG. 3—LUBRICATION CHART

CHART No.	ITEM TO BE LUBRICATED	FREQUENCY 1000 miles= 1.600 km.	QUANTITY			LUBRICANT		
			U.S.	Imperial	Metric	TYPE	GRADE	
							Summer	Winter
1.	Chassis Bearings .	Each 1000 miles		As required		GAA		
2.	Spring Shackle Bushings	With lube fittings Each 1000 miles		As required		GAA	MIL-G-10924	MIL-G-10924
	Spring Pivot Bolt Bushings	Without lube fittings: No lubrication						
	Universal Joints							
3.	Propeller Shaft ..	Each 1000 miles		As required		GAA	MIL-G-10924	MIL-G-10924
4.	Front Axle Shaft .	Check each 1000 miles		As required		GAA		
		Change each 12,000 miles [19,200 km.]		As required				
5.	Steering Gear	Check each 1000 miles		As required		GO	SAE 90	SAE 90- MIL-L-2105B
6.	Rear Wheels	Sparingly each 1000 miles		As required		GAA	MIL-G-10924	MIL-G-10924
7.	Front Wheels	Disassemble to lubricate each 6000 miles [9,600 km.]		As required		GAA	MIL-G-10924	MIL-G-10924
8.	3-Speed Transmission and Transfer Case....	Check each 1000 miles	3-1/2 pts.	3 pts.	1,6 ltrs.		SAE 90- MIL-L-2105B	SAE 90- MIL-L-2105B
		Change each 10,000 miles [16,000 km.]	3-1/2 pts.	3 pts.	1,6 ltrs.		SAE 90- MIL-L-2105B	SAE 90- MIL-L-2105B
	Differentials							
9.	Front Powr-Lok	Check each 1000 miles	2-1/2 pts.	1-7/8 pts.	1,083 ltrs.		WILLYS 94557	WILLYS 94557
10.	Rear Powr-Lok ..	Change each 10,000 miles [16,000 km.]	2-1/2 pts.	1-7/8 pts.	1,083 ltrs.		WILLYS 94557	WILLYS 94557
11.	Engine	Change each 100 hrs or 2000 miles [3,200 km.]	*11 qts. +9 qts.	8-4/5 qts. 7-1/5 qts.	10,340 ltrs. 8,46 ltrs.		MIL-L-2104B SAE 30 SERIES 3	MIL-L-2104B SAE 10 SERIES 3

*Includes filter and cooler
+Without draining filter or cooler

rain and refill both housings each 10,000 miles [16,000 km.].

Service each assembly individually even though drilled passages are provided in both housings for oil circulation between units. Hard shifting of the gears in cold weather is a positive indication that the lubricant is too heavy a grade or the quality allows it to congeal at the prevailing temperature. If the oil is too heavy for each shifting, it will not properly lubricate the closely fitted parts. Change the lubricant to a lighter grade.

B-18. Powr-Lok Differential

Both front and rear axles contain a Powr-Lok differential. This differential requires a special lubricant and ordinary multipurpose gear lubricants must not be used. Use only "Jeep" Powr-Lok Differential Oil, Part No. 94557, furnished in pint cans.

Powr-Lok differential may be cleaned only by disassembling the unit and wiping with clean rags. Do not flush the Powr-Lok unit.

B-19. Oil Filter

After the initial change specified in Par. B-8, clean the filter and replace the element with each engine oil change at each 2000 miles [3,200 km.] or 100 hours of normal vehicle use. Be sure to add 2 quarts [2 ltr.] to the engine change requirement. Change the filter oil at more frequent intervals under conditions of extreme dirt and dust.

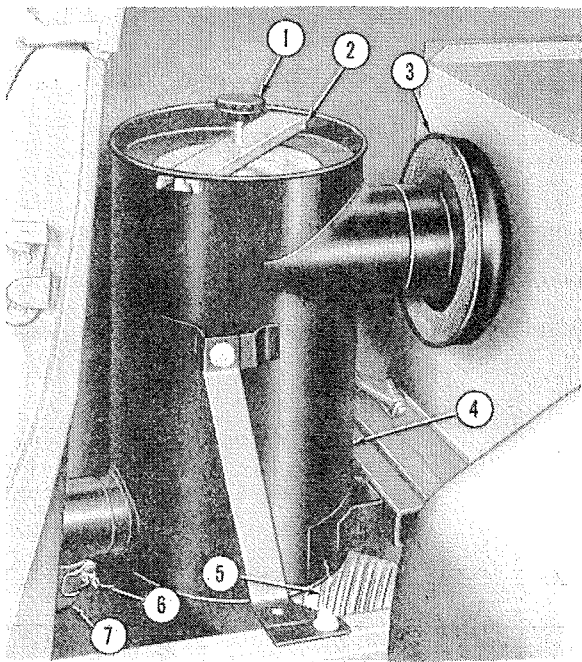


FIG. 4—AIR CLEANER

- | | |
|-------------------------|------------------|
| 1—Screw | 4—Air Cleaner |
| 2—Retainer Bar Assembly | 5—Hose |
| 3—Precleaner | 6—Clamp Assembly |
| | 7—Dust Unloader |

B-20. Air Cleaner

The air cleaner removes the dust and impurities from the air before the air enters the blower on the engine. A clean air cleaner is vitally important for maximum engine life. Cleaning and replacing elements will depend on local dust conditions. Check the dust unloader at the bottom of the air cleaner daily. Service the precleaner weekly. Clean the air filter cartridge every 6000 miles [9,600 km.]; replace the cartridge each year or after 10 washings, whichever occurs first.

To service the dust unloader, loosen the screw in the clamp assembly. Remove the rubber dust unloader and shake and tap it in the inverted position to remove the dust accumulation. Wipe the part clean and position it on the elbow of the air cleaner. Position the clamp assembly over the dust unloader and elbow; tighten the screw in the clamp assembly. To service the precleaner, remove it from the air cleaner intake. Wipe the precleaner clean and replace on the air cleaner intake. To service the air cleaner, turn the screw at the top of the retainer bar assembly until it is loose. Slide the bar to the side and disengage it from the air cleaner; remove the bar assembly. Carefully lift out the paper filter cartridge; take care not to shake loose dust particles into the clean area around the cartridge. Shake off accumulated dirt. Wash the cartridge with water and a non-sudsing detergent. Shake off excess water and dry with a stream of low pressure compressed air. Wipe out the inside of the body with dry-cleaning solvent. Install the cartridge in the body. Position the retainer bar over the cartridge, with the bar extending through the body on both sides. Seat the cartridge firmly by tightening the screw at the top of the retainer bar assembly.

NOTE: Do not use oil on cartridge or precleaner.

Check the connection between the air cleaner and the blower opening. Check that the hose clamps are tight and the hose is in good condition.

B-21. Speedometer Cable

Remove the speedometer cable from the tube every 12,000 miles [19,200 km.]. Clean it thoroughly and coat it with a good quality light graphite grease.

B-22. Flexible Controls—Fuel Pump Shutoff, Hand Brake

Each 12,000 miles [19,200 km.] or once a year, oil the exterior surfaces of the flexible control conduits with penetrating oil. This will usually maintain smooth operation with minimum wear. Should the hand brake control cable require additional lubrication, remove it from the conduit and coat it with light graphite grease.

B-23. ADDITIONAL PERIODIC SERVICES

B-24. Brake Master Cylinder

Check the fluid level in the brake master cylinder every 1000 miles [1,600 km.]. Fill the master

cylinder through the dash plug. Replenish the brake fluid to a level 1/2" [1,3 cm.] below the top of the fill hole. Use only non-petroleum heavy duty hydraulic fluid. (SAE 70-R3).

Be sure to handle the brake fluid in clean dispensers and containers that will not introduce even the slightest amount of other liquids. Replace and tighten the filler cap.

B-25. Radiator

The exterior of the radiator core should be cleaned and the radiator inspected for leaks each 1000 miles [1.600 km.] of normal service of the vehicle. If the vehicle is subjected to considerable off-the-road operation, this interval should be each 1000 miles or 30 days, whichever interval occurs first. Refer to Par. G-6.

B-26. Cooling System

The cooling system should be flushed twice a year and checked for leaks, preferably in the spring and fall at the time of changing the antifreeze. Refer to Par. G-7.

B-27. Clutch Linkage

Lubricate all friction points of the clutch linkage every 1000 miles [1.600 km.]. Use the same grade of engine oil as used for the engine. Failure to lubricate these points will result in premature wear; the links will wear and the holes in the mating parts will become elongated.

B-28. Windshield Wiper

The windshield wiper blades are operated by rigid arms; lubrication is not required.

B-29. Body

A few drops of oil should be placed on the tail gate hinges of the pickup truck and three-door panel

truck. The hand brake ratchet and door hinges should be oiled for easy operation.

B-30. PARTS REQUIRING NO LUBRICATION

B-31. Water Pump Bearing, Clutch Release Bearing

The water pump and clutch release bearings are prelubricated for life when manufactured and cannot be relubricated.

B-32. Starting Motor Bearings

The starting motor bearings are lubricated as a assembly to last between normal rebuild periods. Information covering relubrication is given in Par. H-44.

B-33. Alternator Bearings

The alternator bearings are prelubricated for life when manufactured and cannot be relubricated.

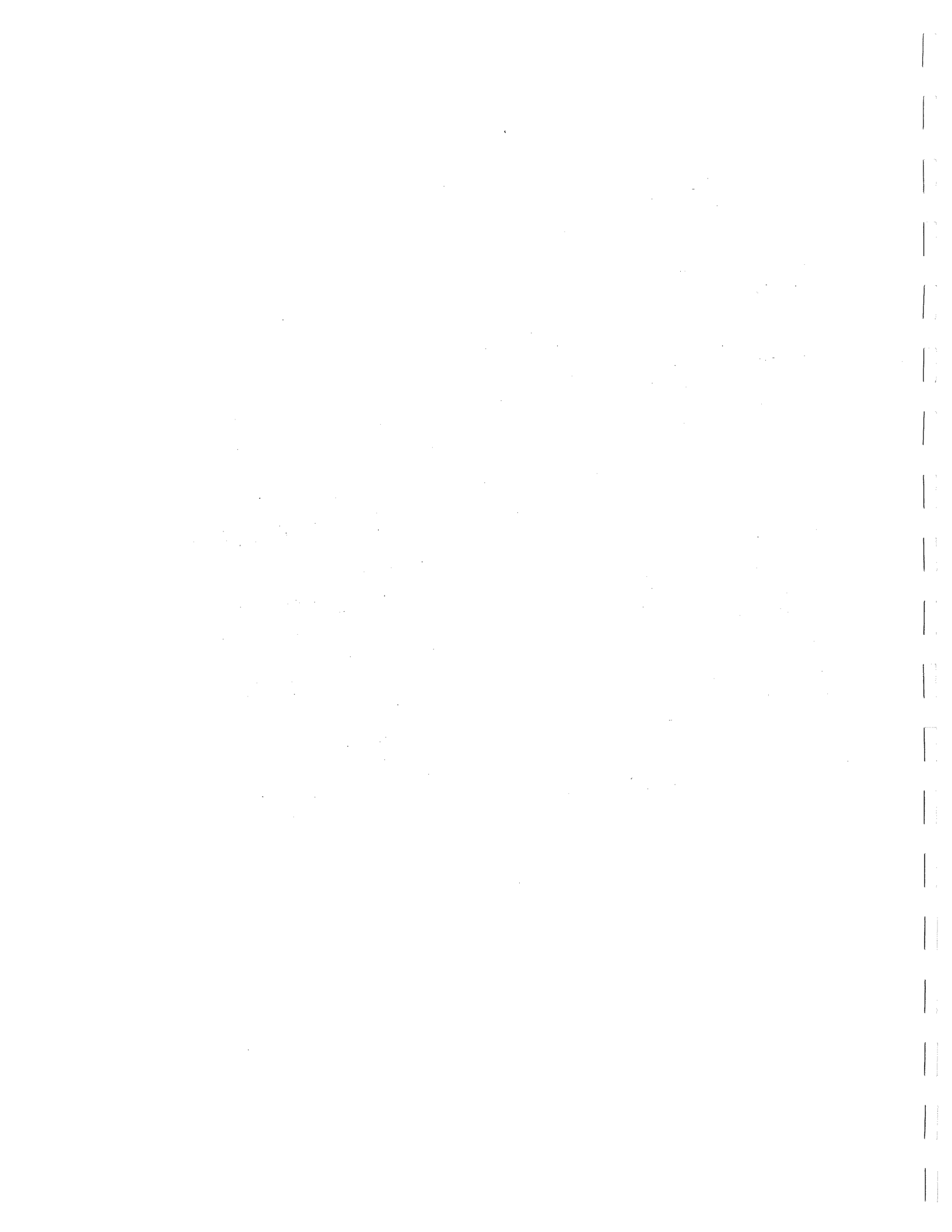
B-34. Springs

The vehicle springs should not be lubricated. As a assembly the leaves are coated with a long lasting special lubricant which is designed to last the life of the springs.

Spraying with the usual mixture of oil and kerosene has a tendency to wash this lubricant from between the leaves, making it necessary to relubricate often to eliminate squeaking.

B-35. Shock Absorbers

Hydraulic direct-action shock absorbers are permanently sealed and require no periodic lubrication service. Also the shock absorber mounting bushings are not to be lubricated.



ENGINE TUNE-UP

Contents

SUBJECT	PAR.	SUBJECT	PAR.
AIR CLEANER	C-9	FUEL STRAINER	C-7
ALTERNATOR BELT	C-12	FUEL SYSTEM	C-11
BATTERIES	C-2	GLOW PLUGS	C-4
BLOWER AND FAN BELTS	C-10	INJECTION NOZZLES	C-8
CYLINDER HEAD	C-3	INLET PORT	C-6
EXHAUST PORT	C-6	STARTER	C-5

C-1. GENERAL

An engine tune-up should be performed each 6,000 miles [9,600 km.], or at the end of each 250 hours of off-the-road use, to restore performance and power lost through wear and deterioration resulting from vehicle use. The tune-up should follow the sequence given below. Correction of items affecting the fuel system should not be attempted until all items affecting compression and ignition have been satisfactorily checked and any problems corrected.

C-2. Clean and Check Batteries

Inspect batteries and cables. If either battery is not satisfactory, install a fully-charged battery to allow completion of the tune-up.

a. Check the specific gravity of the electrolyte in each cell of the batteries. A hydrometer reading of 1.260 indicates that the battery is fully charged. If the reading is 1.225 or below, the battery needs recharging. If one or more cells is 25 "points" (0.025) or more lower than the other cells, this indicates that the cell is shorted, the cell is about to fail, or there is a crack in the battery partition in the case. Unless the battery is repaired or replaced, battery trouble will soon be experienced.

b. Check the electrolyte level in each cell, add distilled water to maintain the solution 3/8" [9,5

mm.] above the plates. Avoid overfilling. Replace the filler caps and tighten securely. It is important to keep the electrolyte level above the plates at all times because plates that are exposed for any length of time will be seriously damaged.

c. Check the wing nuts on the hold-down frame for tightness. Tighten them only with finger pressure, never with pliers or a wrench. Excessive pressure could damage the battery case.

d. Clean the battery terminals and cable connectors. Prepare a strong solution of baking soda and water and brush it around the terminals to remove any corrosion that is present. The cell caps must be tight and their vents sealed to prevent cleaning solution entering the cells. After cleaning, coat the terminals with heavy grease and open vents.

e. Inspect the battery cables and replace if badly corroded or frayed. Check tightness of terminal screws to ensure good electrical connections. Check the tightness of the negative ground cable connection at the clutch housing to ensure a good ground connection.

f. Load test the battery. Connect a voltmeter across each battery. Run the starting motor for 15 seconds. If the voltage does not drop below 10 volts on the 12-volt battery, the battery is satisfactory. If the voltage falls below the figures given, yet the specific gravity is above 1.225, the condition of the battery is questionable.

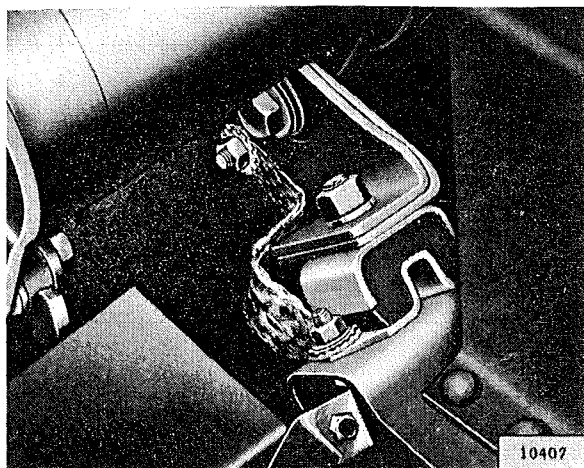


FIG. 5—ENGINE GROUND STRAP

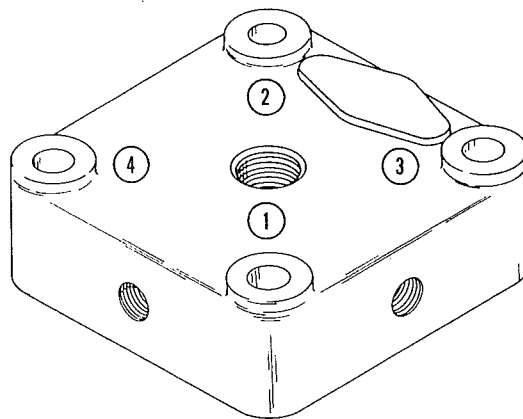


FIG. 6—CYLINDER HEAD TIGHTENING SEQUENCE

Be sure the engine ground strap connection (Fig. 6) is tight at both connections. It is located at the front engine support. If these connections are loose or dirty, hard starting or failure to start may result.

3. Torque Cylinder Head

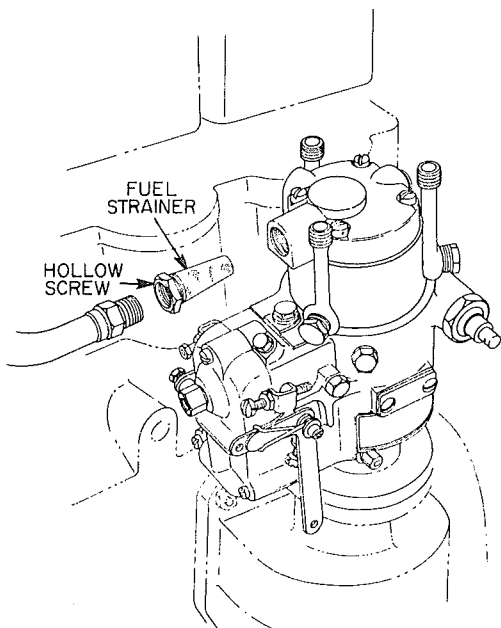
Torque the cylinder head nuts with a torque wrench to 125 foot-pounds [17,29 kg./m.]. Follow the sequence shown in Fig. 6 for each cylinder head.

4. Check Glow Plugs

Check glow plugs quickly by feeling the outer ends after a brief heating period. Replace any which are unusually cold. Sometimes, all will heat, but only partially because of high resistance in the wiring from the battery. The most common location for a resistance is the switch. Try by-passing the switch with heavy wire. Check the current draw; an ammeter should register 15 to 17 amperes discharge when the glow plugs are operating.

5. Check Starter

In any electrical motor, current must reach the starter windings before rotation can be expected. If battery condition is normal, take an electrical reading at the starter terminal to be certain full power is available. In case of any significant drop between the battery and the starter, replace or clean and repair the starter switch relay, starter solenoid relay, or other parts involved. Remove dirt and grease from the starter commutator and correct defective brushes or replace the starter. Check for loose starter bearings, broken drive pinions,



G. 7—REMOVING TRANSFER PUMP STRAINER

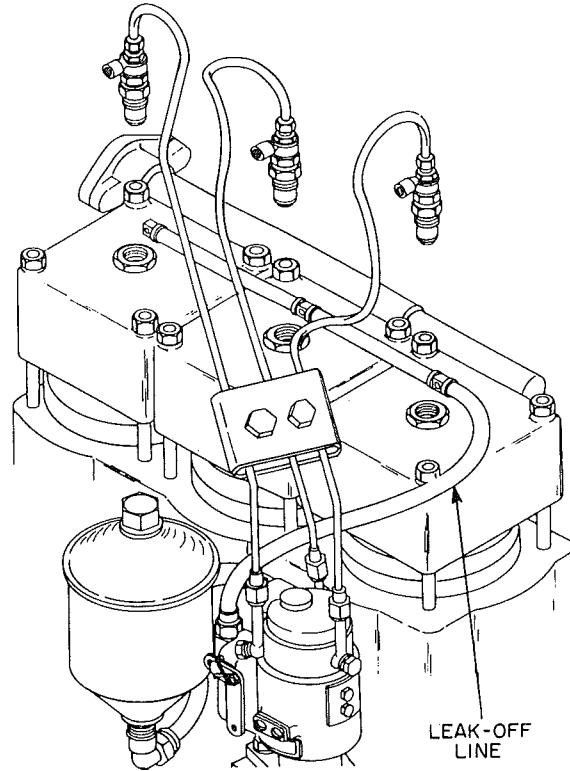


FIG. 8—OPEN-SPRAY NOZZLE TEST

faulty engagement solenoids, or ring gear damage will usually be self-evident.

C-6. Remove Inlet or Exhaust Port Restriction

Remove the exhaust manifold, position the piston so that the top of the piston is level with the bottom of the exhaust ports, and scrape the exhaust ports with a dull blade. Remove as much as possible of any carbon that falls inside the cylinder on top of the piston. Any small particles not removed will burn when the engine is started.

To check the intake ports, use a flashlight. If the ports are more than 20 percent plugged, clean them.

C-7. Clean Fuel Strainer

Unsatisfactory fuel flow may be caused by a clogged transfer pump strainer. Remove the hollow screw shown in Fig. 7. Remove the fuel strainer from the hollow screw and clean the strainer in diesel fuel. Use a fiber brush.

C-8. Check Injection Nozzle

To check for operation of the injection pump and injectors, proceed as follows:

a. Loosen all three injection nozzle nut connections and crank engine. If fuel does not flow from all three loose connections, replace the injection pump.

b. If fuel does flow from all three nut connections, completely disconnect all three nut connections and loosen all three nut connections on the injection pump.

c. Reconnect the injection nozzles and tighten all connections. Remove the injection nozzles and holders from the cylinder heads.

d. Crank engine and watch fuel spray from each nozzle as shown in Fig. 8.

e. If any of the nozzles drip, they are defective. Replace as necessary.

f. If any nozzle fails to emit a spray, remove and connect a good nozzle in its place. If this nozzle emits a spray, the first nozzle is defective. Replace. If the second nozzle, one known to be in working order, fails to emit a spray, the injection pump is defective. Replace.

C-9. Clean Air Cleaner

Clean the air cleaner. See Par. B-20.

C-10. Adjust Blower and Fan Belts

a. Loosen the two nuts holding the idler pulley bracket to the blower until the bracket can be rotated by using the tightening hole on the idler bracket as shown in Fig. 9.

b. With the engine turned off, tighten the idler bracket until when the engine is run at top speed the belt flutters slightly. If the belt flutters too

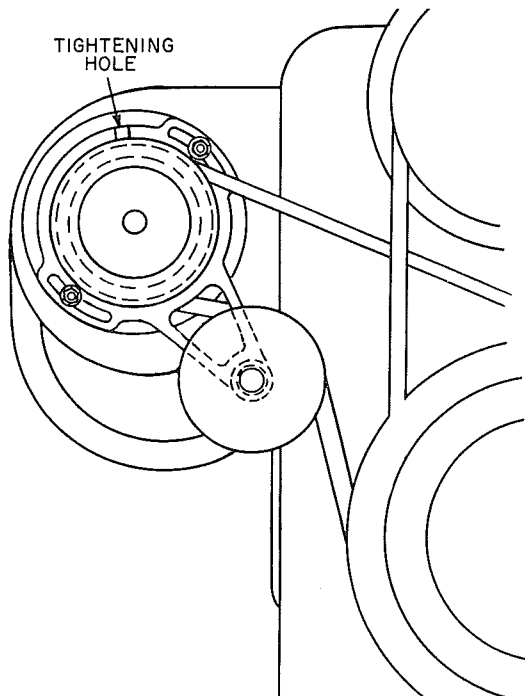


FIG. 9—BELT TENSION ADJUSTMENT

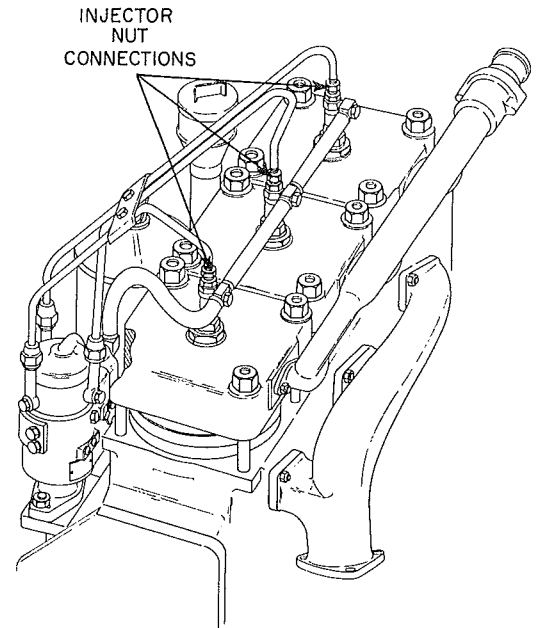


FIG. 10—BLEEDING FUEL LINES

much, increase the belt tension; if the belt does not flutter, loosen the tension.

CAUTION: Do not tighten any more than directed.

c. Tighten idler bracket nuts.

C-11. Bleed Fuel System

Loosen the return line connections and crank the engine with the starting motor. Watch for clear fuel flow from the connection. Loosen all three injector nut connections (Fig. 10) and crank engine with starting motor until clear fuel flows from each connection. Tighten all connections.

C-12. Adjust Alternator Belt

Loosen the bolt securing the alternator adjusting strap to the gear cover. Move the alternator until the belt can be deflected by finger pressure, 3/4' [1,9 cm.] at a point midway between the pulleys. Tighten the bolt and recheck the tension.

C-13. Road Test Vehicle

After completing the tune-up, road test the vehicle for power and over all performance. Make necessary adjustments.



CERLIST DIESEL ENGINE MODEL FC-170

Contents

SUBJECT	PAR.	SUBJECT	PAR.
ALTERNATOR	D-12,D-81	GASKET LEAK	D-90
ASSEMBLY, ENGINE	D-64	GEAR COVER	D-20,D-73
BALANCER SHAFT	D-26,D-36,D-67	IDLER BRACKET	D-53,D-54
BELTS	D-85	INJECTION PUMP	D-25,D-68
BLOCK ASSEMBLY	D-30	INSPECTION, ENGINE	D-28
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CORE HOLE EXPANSION	D-63	OIL PAN	D-17,D-57,D-76
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FUEL SYSTEM	D-92	WRIST PIN	D-38

D-1. GENERAL

This section of the manual covers the subject in the following manner: a general description of the engine; removal of the engine from the vehicle; engine disassembly which includes complete disassembly out of the vehicle as well as special instructions to cover different operations required when disassembly is done with the engine installed; inspection and repair of the parts of the engine with the parts removed; engine assembly with the engine removed from the vehicle.

D-2. Description

The Cerlist diesel is a two-stroke cycle, loop-scavenged, full-diesel, three-cylinder, in-line engine. This engine has no unusual or special features requiring specialized maintenance techniques or more than a very few special tools. Since the engine has no valves or camshafts, adjustments during the normal service life of the engine are minimal. Moreover, the nature of the design allows total interchangeability of cylinders, pistons, and cylinder heads.

The Cerlist diesel is constructed of a light-weight aluminum alloy, and the parts are relatively easy to handle and repair. Use an alkali-type cleaning compound, Federal Specification P-C-436A, to

clean the water jacket or to clean parts during repair.

The terms "front" and "rear" mean the anti-flywheel and flywheel ends of the engine, respectively. The terms "right" and "left" are the right and left hand of a viewer standing at the rear of the engine facing the flywheel.

Cylinders of in-line engines are numbered 1, 2, 3, starting with the cylinder closest to the anti-flywheel end as number 1.

In Cerlist diesel engines, air is introduced into the cylinders by a positive displacement-type blower attached to the cylinder block. This blower forces air into the combustion chambers via air passages within the engine block, through a row of ports on the front and rear of the cylinder liners and out through another series of ports on the side of the liners. The intake ports are cast into the cylinder liner wall so that the lower edges of the ports are approximately level with the upper edge of the piston when the piston is in its lowest position as shown in Fig. 11. These intake ports have a pronounced upward slope, which, together with the upward slope of the intake air passages through the cylinder block, direct the air upward and across the top of the cylinder and down and out the exhaust ports, thus sweeping out the burnt gases and filling the cylinder with fresh air at the beginning

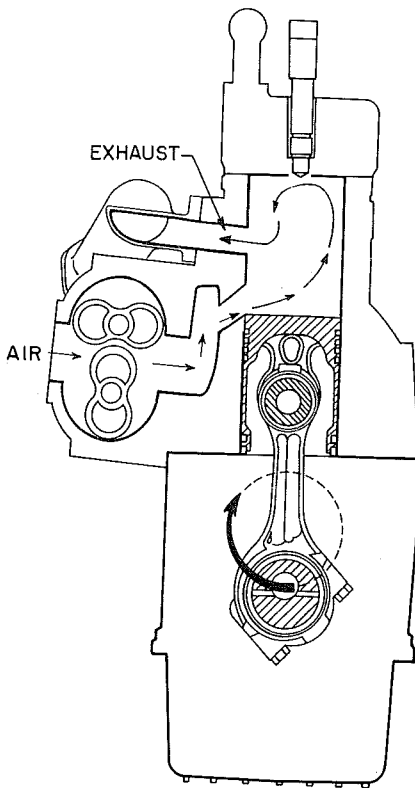


FIG. 11—LOOP SCAVENGING PRINCIPLE

each upward stroke. The piston in its upward movement closes off the intake ports and then the exhaust ports. As soon as the exhaust ports are closed, the fresh air trapped within the cylinder is compressed by the piston. When the piston reaches top dead center, the air is compressed approximately one twenty-second of its original volume. These events occur on every upward stroke of each piston.

Shortly before the piston reaches top dead center, a small amount of highly atomized fuel is sprayed into the combustion chamber at a pressure of approximately 1450 psi. [103,54 kg./cm²]. Here, it is ignited by the heat generated by the compressed air. Pressure from the resulting combustion and expansion forces the piston downward, producing the power which drives the engine. During the downward stroke, the exhaust ports are covered shortly before the intake ports, permitting the compressed burnt gases to escape and the cylinder pressure to be lowered before the intake ports are opened. As soon as the intake ports are uncovered, fresh air is forced into the cylinder to scavenge the remaining exhaust gases. The cycle is then repeated.

The cylinder block and crankcase are combined in a single aluminum casting. The three sleeve locations are directly in line. Each sleeve location has a counterbore in the cylinder block upper deck which receives the flange of the cylinder sleeve and establishes the proper height of the sleeve and

the cylinder head. A water seal is also effected at this point although no gasket is used. Four studs, one at each corner, secure the sleeve and head at each cylinder location. Three seating locations at the bottom and two intermediate points are machined in the block to receive the seal rings. The seal rings, made of a synthetic material that is oil and water-resistant, are fitted in grooves around the sleeves. These rings permit transfer of the water from the water header passage, which runs the length of the block to the cylinder wall area, to the water cooled sleeves; at the same time, the rings seal off the air and exhaust passages provided for charging and scavenging the cylinder.

A front, rear, and two intermediate main bearing bores receive four split-type precision bearings of the tri-metal type. The bearing caps have a slight interference fit between the walls of the bearing saddle; a small spreader is needed to install or remove them.

The balancer shaft is located just below the water header, which extends the length of the left side of the engine. This shaft is supported in a bushing at each end of the crankcase. The shaft is suitably weighted at each end and is gear-driven from the flywheel end of the crankshaft to provide forces to counteract rocking couples arising from piston mass movement.

Each main bearing journal is drilled to receive oil under pressure from mating oil holes in the crankcase. Diagonal drillings through the crankcheeks to the crankpins supply pressure oil to the rod bearings and the piston pins. Cleanout plugs permit cleaning the crankshaft oil cavities and passages at overhaul. A gear at the front end of the crankshaft drives the lubricating oil pump. This gear is retained by the bolts which secure the front belt drive pulley and thread into the end of the crankshaft. At the rear, the balancer shaft drive gear is shrunk and keyed to the crankshaft rear extension. A pilot on the end of the rear extension centers and locates the flywheel which is retained by six special 5/8" [1,587 cm.] bolts. Lip-type seals are provided at both front and rear.

The cast iron cylinder sleeves, or liners, are held to very close tolerances to ensure correct air flow and timing in the port areas. At the upper end, a seating surface for the cylinder head and gasket is machined at the height that provides the correct piston clearance for the design compression ratio. For this reason, neither the top of the sleeve nor the sleeve flange seating surface should be machined in the field. Two locating dowels in the upper surface of the cylinder gasket surface align the head at installation. The cylinder bore is honed to the proper running surface for good ring seating and oil control. The bore area near the ports is honed to a diameter slightly larger than the upper and lower ends of the sleeve so that the small difference in metal expansion in the port area will not cause distortion as the engine warms up.

Each sleeve has four synthetic seal rings, two in the lower grooves and one each in the intermediate and upper grooves. These seals separate the cooling water area from the air charging and exhaust ports in the middle area of the sleeve, and seal the water jacket and crankcase juncture at the base of the sleeve. Since the upper and intermediate seal rings are larger than the lower rings, two ring sizes are required on each liner. Cerlist pistons are formed of a special light-weight alloy. The top ring is chromed and of "keystone" or wedge-shaped cross-section. In addition to the top ring, three notched compression rings are used above the piston pin. Two slotted oil control rings are used below the pin. The hardened and ground pins have a floating fit in the piston, retained by snap rings. The hollow center of the pin is closed off at each end by disk-shaped plates which fit snugly in the pin bore before the retainer rings are installed.

The forged steel connecting rods are rifle-drilled for oil passage to the piston pin area. This oil effectively cools the underside of the piston crown. Two bronze bushings with special bearing surfaces are pressed into the connecting rod upper end so as to leave an oil annulus between them. The lower end of the connecting rod is split to permit assembly, and the split is oriented diagonally for removal and installation of the rod through the cylinder bore. The rod caps and rods have matching serrations for alignment and rigidity. Also, small locating notches are cut in the rod and cap at the parting line to assist in locating the bearing shells at installation. The full-precision rod bearings are of heavy duty tri-metal and must never be resized by machining in the field.

Each cylinder has an individual head, retained by four studs equally positioned at the corners. Cooling passages in the head mate with passages in the sleeve to conduct coolant to the head area. An outlet, with a flange pad for the top water manifold, is located on the right side of the top of each head. The head material is aluminum alloy with suitable inserts for the combustion chambers and glow plugs.

The pre-combustion chamber-type head has a lower insert or chamber-like shield which fits in the head cavity and opens through small openings into the main combustion chamber above the piston. This chamber is retained by a threaded upper insert which in turn receives the injector. Glow plugs employed as a starting aid enter through a threaded insert at the right side of the cylinder head and extend slightly into the combustion chamber through an opening in the side of the chamber.

The oil pump is a conventional gear-type unit driven by a positive gear train off the front gear on the crankshaft. The inlet side is protected by a fixed screen. Discharge pressure under maximum back pressure conditions, such as encountered with cold oil, is controlled by a spring-loaded pressure relief valve on the discharge side of the pump. Ordinarily there is no need to attempt adjustment of this valve. The pump is very rugged and simple

in construction; full replacement is recommended when needed since rebuilding is not practical.

The Cerlist diesel uses a Roots positive displacement, two-lobe blower to introduce or charge the combustion chambers with fresh air and to scavenge combustion gases. The blower is lubricated under pressure from the engine system; however, the oil is confined to the bearing areas and does not enter the rotor lobe area. These lobes are precisely machined and spaced to run without physical contact with each other, the wall of the blower housing, or the end plates of the blower housing. Antifriction bearings at each end of the rotor shafts maintain very accurate axial alignment and center spacings. Closely fitted gears, one on each rotor shaft, keep the lobes in proper phase and at the correct clearance.

The blower is driven by a multiple groove belt from the crankshaft front pulley. Belt tension is maintained by an adjustable idler pulley as shown in Fig. 12.

D-3. Engine Mountings

The engine is supported at its front end by two rubber insulators attached to the frame side rail brackets. It is supported at the rear at the transmission by two rubber insulators attached to the rear engine support cross member. This cross member is bolted to the frame side rails so that it can be dropped when removing the transmission. The rubber insulators should be checked for separation and wear by jacking the power plant away from the frame, near the supports, while watching the action of the insulators. Vibration cannot be effectively controlled by separated or worn insulators and they should be replaced if faulty.

D-4. Engine Ground Strap

To assure an effective ground to the chassis electrical circuits, a ground strap bridges the left front engine support to the chassis. The connections of

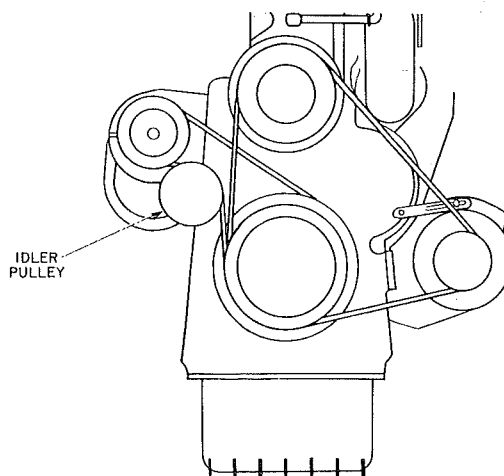


FIG. 12—BLOWER AND PUMP DRIVE BELTS

is strap must be kept clean and tight for proper operation of lights, generator regulator, etc.

5. ENGINE REMOVAL

The engine assembly with transmission and transfer case attached is removed from underneath the vehicle. Easier removal results by loosening the wing clips on the front axle and sliding the axle assembly forward the length of the hydraulic take hose. When the engine is out and resting on the floor, the front of the vehicle is hoisted up so the engine can be removed from under the chassis. Removal procedure:

Drain the radiator and cylinder block by opening the drain cocks at the bottom of the radiator on the left side of the block.

Remove passenger seat by tilting forward and pulling out of support brackets. Remove driver's seat by loosening wing nut at rear support and pulling out of front support brackets.

Disconnect the battery at the positive terminal to avoid the possibility of a short circuit.

Loosen the hose clamp that secures the air cleaner hose to the blower.

Disconnect the engine emergency shutoff control cable from the lever at the side of the fuel pump governor. Loosen the set screw to remove the cable from the lever.

Disconnect the fuel line from the elbow at the end of the fuel filter. Disconnect the fuel return line at the tie connection in the fuel pump governor.

Remove the cable clamps that secure both fuel lines to the clutch housing and to the frame cross brace. Move the fuel lines out from underneath the transfer case and fasten to the side frames so they will not interfere with engine removal. Plug all fuel line openings to avoid contamination.

g. Disconnect the throttle linkage from the outside lever on the fuel pump governor.

h. Remove the radiator hoses by loosening the hose clamps and slipping the clamps back on the hose. Remove the heater hoses (one to the water pump, one to the water manifold) in the same manner.

i. Disconnect the wires from the alternator, voltage regulator, resistor, fuel pump, glow plugs, heat indicator sender, starting motor, and oil pressure sensing unit.

j. Disconnect the exhaust pipe at the exhaust manifold by removing the stud nuts. Remove the clamp that secures the exhaust pipe to the muffler; remove the exhaust pipe.

k. Raise the front of the vehicle and place on stand jacks.

l. Disconnect the clutch control cables at the cross shaft by removing the clevis pins. Remove the bolts and nuts attaching the clutch control cross shaft to the frame and remove the cross shaft.

m. Disconnect the transfer case shift rod at the adjusting link by removing the nut on the end of the rod.

n. Remove the front and rear propeller shafts by disassembling their universal joints.

o. Disconnect the transmission end of the transmission shift rods by removing the cotter keys and washers from the ends of the rods. Secure the rods to the left side rail with a piece of wire.

p. Disconnect the speedometer cable at the transfer case by unscrewing the coupling.

q. Remove bolts from front engine mounts.

r. Attach a lifting bracket to the engine using head studs. Use stud pairs at each end of the engine. Using a single arm crane or the A-frame and chain fall combination as shown in Fig. 13 and 14, attach the crane hook or chain fall to the bracket.

s. Place a dolly jack under the rear engine support cross member. Remove bolts attaching cross member to side rail.

t. Lift engine slightly to free it from front engine mounts. Remove the dolly jack.

u. Lower the engine slowly. The engine will lower with the least difficulty if it is guided to the left and rear during the descent. As the engine approaches the floor, rest it on wood blocks to prevent damage.

v. Disconnect and remove the crane or chain fall.

w. Lift the front of the vehicle as necessary to allow for removal of the engine from under the vehicle.

D-6. ENGINE DISASSEMBLY

Engine disassembly is presented in the sequence to be followed when the engine is to be completely

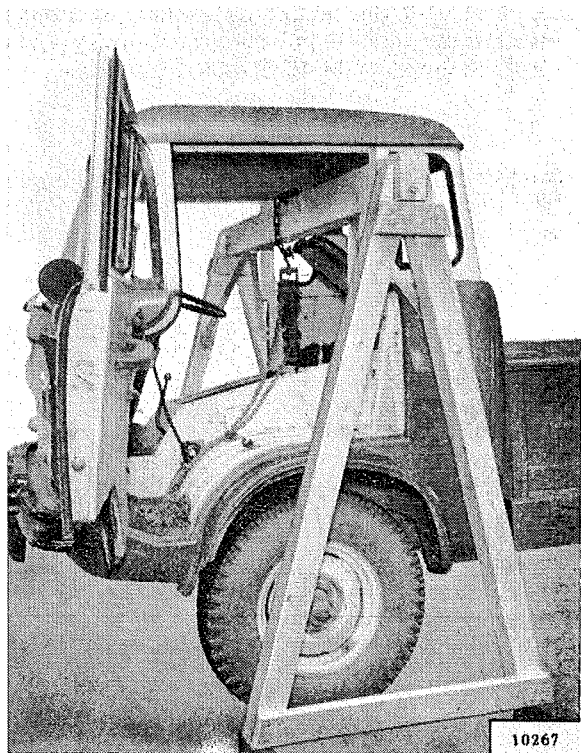


FIG. 13—A-FRAME USED TO REMOVE ENGINE

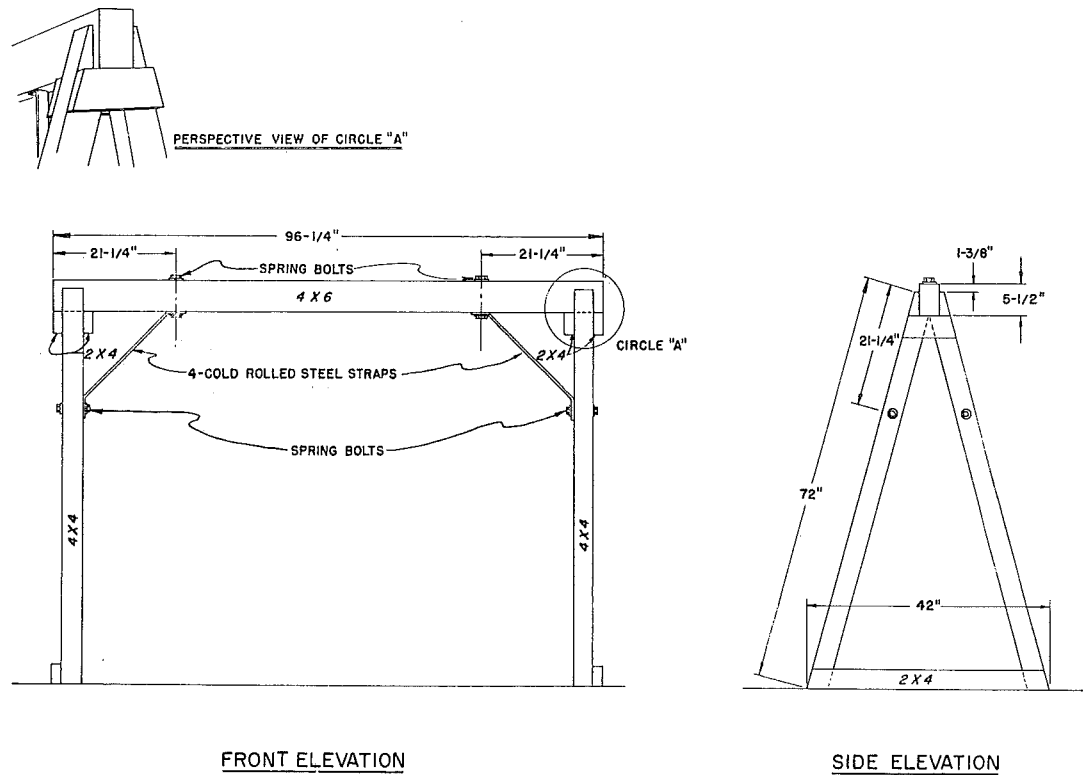


FIG. 14—A-FRAME CONSTRUCTION DETAILS

overhauled on an engine stand after removal from the vehicle. Most of the operations of the procedure are also applicable separately with the engine in the vehicle, provided that wherever necessary the part of the engine to be worked on is first made accessible by removal of engine accessories or other engine parts.

a. Do not mix or confuse engine parts. Mark position during disassembly; tag assemblies from different engines; identify parts reground to special sizes.

b. Do not mix bolts, capscrews, and washers. Capscrews and similar parts are of length, material, and heat-treatment suited to the places where they are used.

c. Inspect as engine is disassembled. Once engine parts have been disassembled and cleaned, many valuable indications of engine condition are lost.

d. Protect delicate parts and surfaces. Do not pile engine parts, injection equipment, wiring, and so on. Oil items that are likely to rust. During repair, tape surfaces subject to scratching or nicking.

e. Clean thoroughly. Wash or steam-clean the engine exterior. Use particular care around the various connections and fittings of the fuel supply and fuel injection system. Do not introduce dirt into the system through failure to remove grit and dust from these areas. Before reassembly,

remove chemical cleaners from oil passages and casting pockets.

f. Work accurately. Use precision gauges where needed; follow tables of clearances and tightening torque values.

D-7. Remove Oil Cooler and Filter

To prevent hardening and drying of accumulated foreign substances, clean the core of the oil cooler as soon as possible after removing from service. Refer to Par. D-45.

a. Remove the clamp that secures the hose to the oil cooler (Fig. 15); remove the hose.

b. Remove the nuts and lock washers that attach the assembled oil cooler and filter to the block. Remove the assembled oil cooler and filter and the gaskets.

c. Remove the nuts and lock washers that secure the assembled oil filter and bracket to the oil cooler mounting bracket. Remove the assembled oil filter.

D-8. Remove Blower

a. Remove the nuts and lock washers that attach the blower air intake to the blower housing. Remove the air intake, gaskets, and screen.

b. Remove the screws and lock washers that secure the blower drive pulley to the hub of the blower. Remove the blower drive pulley.

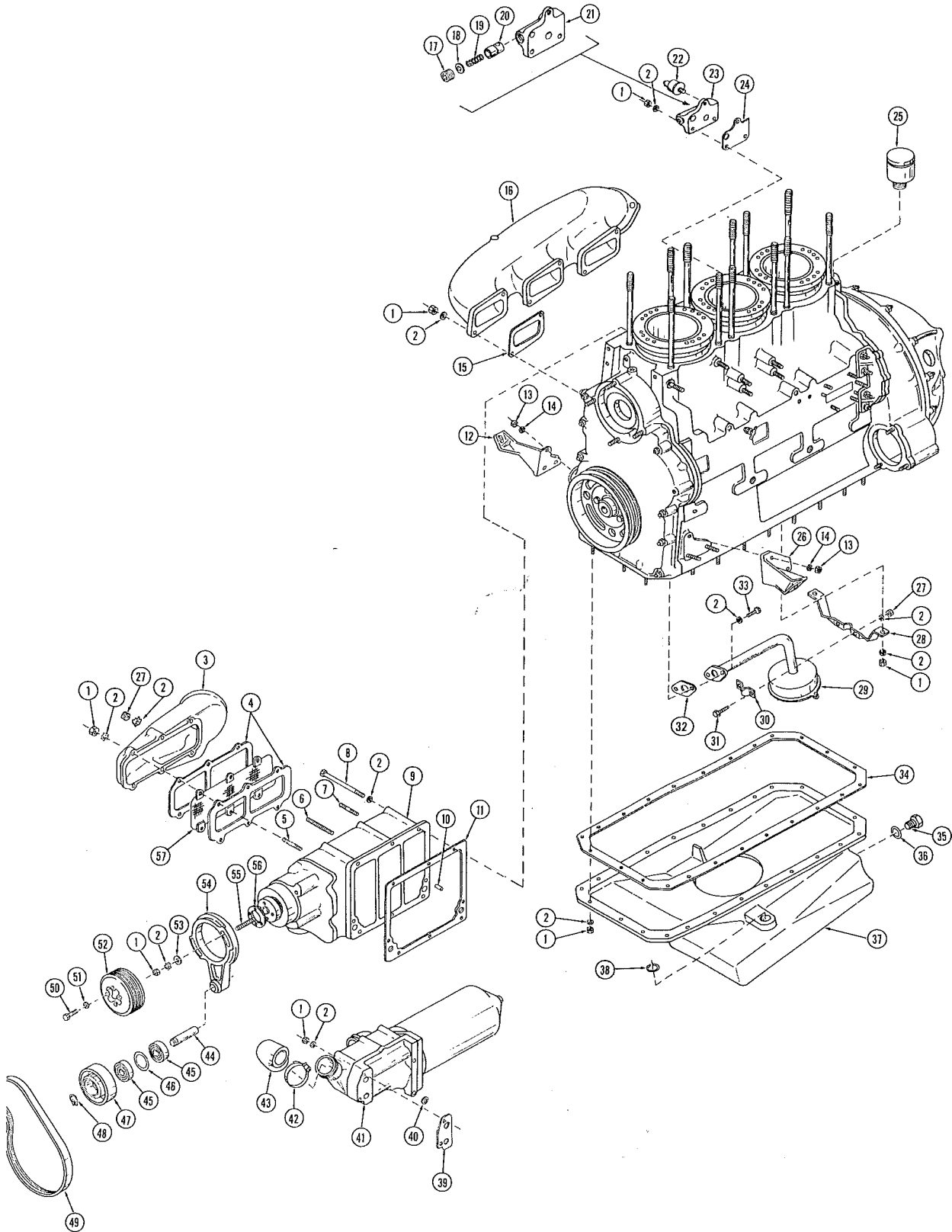


FIG. 15—ENGINE, EXTERNAL PARTS, EXPLODED VIEW, PART I

FIG. 15—ENGINE, EXTERNAL PARTS, EXPLODED VIEW, PART I

1—Nut	20—Valve	39—Gasket
2—Lock Washer	21—Valve Body	40—Gasket
3—Air Intake	22—Pressure Sensing Element	41—Oil Cooler and Filter
4—Gasket	23—Pressure Control Valve	42—Clamp
5—Stud	24—Gasket	43—Hose
6—Stud	25—Breather	44—Pin
7—Stud	26—Mounting Bracket	45—Idler Hub Bearing
8—Bolt	27—Nut	46—Shim
9—Blower	28—Support Clamp	47—Idler Pulley
10—Roll Pin	29—Suction Screen and Tube	48—Retaining Ring
11—Gasket	30—Suction Clamp	49—Drive Belt
12—Mounting Bracket	31—Bolt	50—Bolt
13—Nut	32—Gasket	51—Lock Washer
14—Lock Washer	33—Bolt	52—Pulley
15—Gasket	34—Gasket	53—Plain Washer
16—Exhaust Manifold	35—Drain Plug	54—Idler Hub
17—Plug	36—Gasket	55—Stud
18—Spring Washer	37—Oil Pan	56—Pulley Shim
19—Valve Spring	38—Ring	57—Blower Screen

c. Remove the belt from the idler pulley. Remove the bolts and lock washers that attach the assembled blower and idler pulley to the block. Remove the assembled blower and idler pulley.

d. Remove the nuts, lock washers, and plain washers that attach the idler hub to the blower housing. Remove the assembled idler hub and shaft.

D-9. Remove Starting Motor

Remove the nuts and lock washers that attach the starting motor to the studs in the flywheel housing. Remove the starting motor.

D-10. Remove Fuel Filter and Line

a. Disconnect the filter-to-pump fuel line at the elbow in the bottom of the fuel filter and at the fuel inlet connection of the fuel injection pump. Remove the line.

b. Remove the nuts and lock washers that attach the fuel filter to the studs in the block. Remove the fuel filter.

D-11. Mount Engine

Mount the engine on a stand, if available. Stand mounting holes are on the injection pump side of the block.

D-12. Remove Alternator

a. Remove the bolt, lock washer, and plain washer that attach the alternator to the strap. Remove the bolts, lock washers, plain washers, and nuts that attach the alternator to the bracket. Remove the belt and alternator.

b. Remove the nut and lock washer that attach the strap to the stud in the block. Remove the strap.

c. Remove the nuts, lock washers, and spacers that attach the alternator bracket to the studs in the block. Remove the alternator bracket.

D-13. Remove Fuel Injection and Leak-off Lines

a. Disconnect the nuts that attach the fuel injection lines to the fuel nozzles and nozzle holders and to the fuel line connectors on the fuel injection pump. Remove the fuel inlet lines. Cap the fuel nozzles.

b. Remove the hollow screws and gaskets that attach the leak-off fittings to the fuel nozzles; disconnect the swivel attaching the leak-off return line to the fuel injection pump. Remove the leak-off assembly. Plug the fuel line openings. Cap the fuel openings in the fuel injection pump.

D-14. Remove Water Manifold

Disconnect the hose from the elbow at the water manifold and from the gear cover. Remove the hose. Remove the nuts and lock washers that attach the water manifold to the studs in the block. Remove the water manifold and gaskets.

D-15. Remove Exhaust Manifold

Remove the nuts and lock washers that attach the exhaust manifold to the studs in the block. Remove the exhaust manifold and gaskets.

D-16. Remove Cylinder Heads

Remove the nuts and plain washers that attach the cylinder heads to the studs in the block. Remove the cylinder heads and gaskets.

D-17. Remove Oil Pan and Suction Tube

a. Remove the bolt, nut, and lock washer that hold the clamp to the dipstick tube assembly. Remove the dipstick tube assembly. Remove the nuts and lock washers that attach the dipstick tube clamp support to the studs in the block. Remove the dipstick tube clamp support.

b. Remove the drain plug and drain plug gasket from the oil pan. Drain the oil.

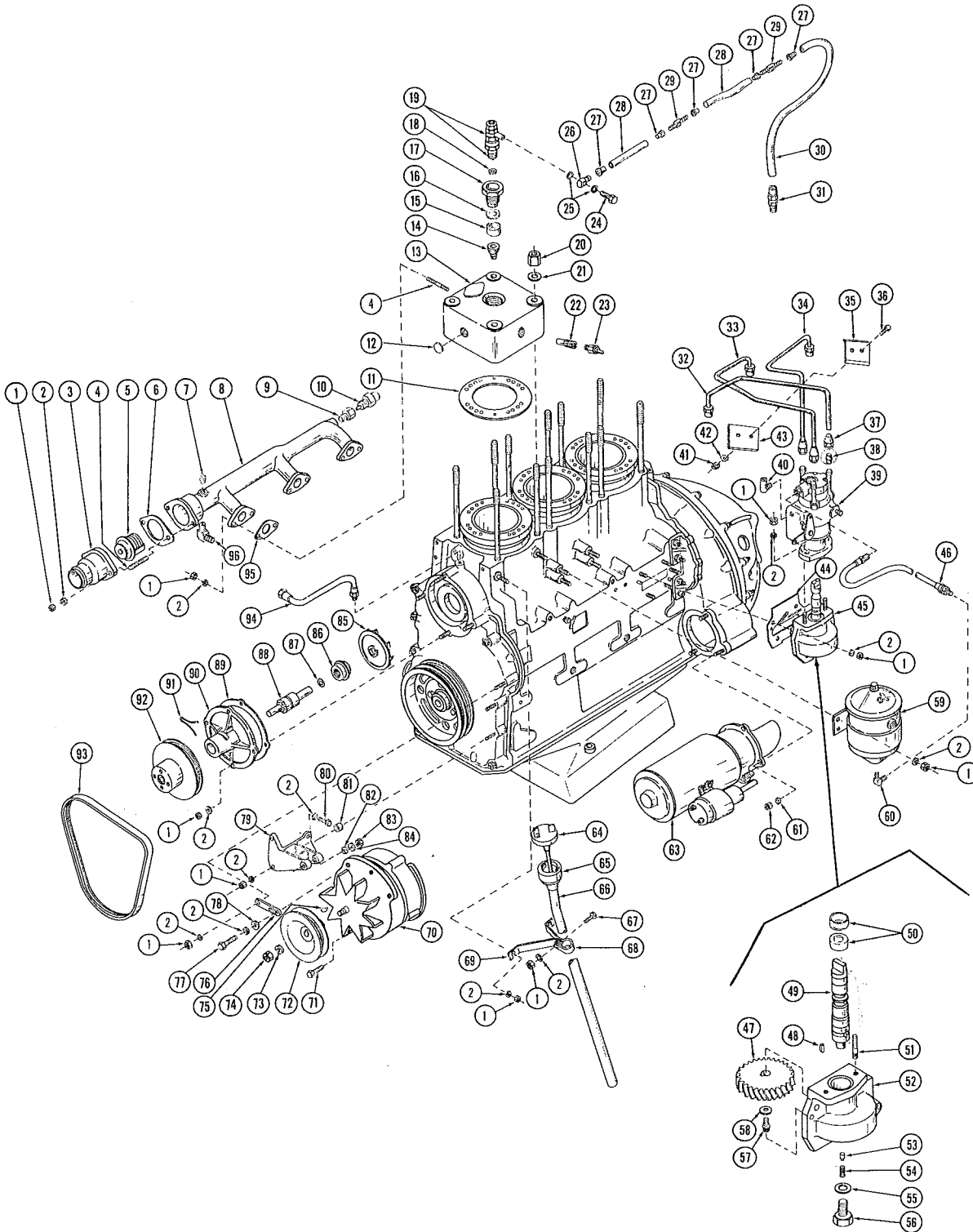


FIG. 16—ENGINE, EXTERNAL PARTS, EXPLODED VIEW, PART II

FIG. 16—ENGINE, EXTERNAL PARTS, EXPLODED VIEW, PART II

1—Nut	31—Swivel	64—Dipstick
2—Lock Washer	32—Injection Line, #1	65—Flange
3—Thermostat Housing	33—Injection Line, #2	66—Tube Assembly
4—Stud	34—Injection Line, #3	67—Bolt
5—Thermostat	35—Upper Plate	68—Clamp
6—Gasket	36—Bolt	69—Clamp Support
7—Pipe Plug	37—Injection Line Nut	70—Alternator
8—Water Manifold	38—Ferrule	71—Bolt
9—Adapter	39—Fuel Injection Pump	72—Alternator Pulley
10—Temperature Sensing Element	40—Leak-off Tee	73—Lock Washer
11—Gasket	41—Nut	74—Nut
12—Core Plug	42—Lock Washer	75—Key
13—Cylinder Head	43—Bottom Plate	76—Alternator Strap
14—Lower Combustion Chamber	44—Gasket	77—Bolt
15—Upper Combustion Chamber	45—Pump Drive Assembly	78—Washer
16—Ring	46—Fuel Line	79—Bracket
17—Threaded Insert	47—Drive Gear	80—Bolt
18—Nozzle Shield	48—Flat Key	81—Bracket Spacer
19—Nozzle and Nozzle Holder	49—Drive Shaft	82—Plain Washer
20—Nut	50—Seal	83—Nut
21—Plain Washer	51—Stud	84—Lock Washer
22—Threaded Insert	52—Gear Housing	85—Water Pump Impeller
23—Glow Plug	53—Thrust Button	86—Pump Seal
24—Hollow Screw	54—Spring	87—Slinger
25—Gasket	55—Washer	88—Shaft and Bearing
26—Leak-off Fitting	56—Screw	89—Gasket
27—Hose Ferrule	57—Screw	90—Housing
28—Leak-off Hose	58—Washer	91—Lock Wire
29—Leak-off Fitting	59—Fuel Filter	92—Pulley
30—Return Line	60—Elbow	93—Belt
	61—Lock Washer	94—Water Hose
	62—Nut	95—Gasket
	63—Starting Motor	96—Elbow

c. Remove the nuts and lock washers that attach the oil pan to the studs in the bottom of the block. Remove the oil pan and gasket.

d. Remove the bolts, nuts, and lock washers that attach the suction clamp around the suction screen and tube to the suction line support clamp. Remove the clamp. Remove the screw and lock washer that attach the suction screen and tube to the oil pump. Remove the suction screen and tube and gasket. Remove the nuts and lock washers that attach the suction line support clamp to the studs in the block. Remove the support clamp.

D-18. Remove Oil Pressure Control Valve

a. Remove the oil pressure sensing unit from the oil pressure control valve.

b. Remove the nuts and lock washers that attach the oil pressure control valve to the studs in the block. Remove the oil pressure control valve and gasket.

D-19. Remove Pistons and Connecting Rods

a. Remove all carbon and ridges at the top of the cylinder liners. Failure to do so may damage piston ring lands when the piston is removed.

b. Remove the connecting rod bolts that attach the caps to the connecting rods. Note all positions and markings. Remove the caps.

c. With a clean piece of wood of suitable size as shown in Fig. 18, push the piston out. Take care

when pushing not to damage the piston. Reassemble the cap to its connecting rod in the original position.

NOTE: The connecting rod caps are not interchangeable. Make sure to assemble the caps to their matched rods.

D-20. Remove Gear Cover

a. Remove the bolts and lock washers that attach the fan to the water pump pulley. Remove the fan. Remove the nuts and lock washers that attach the assembled water pump and pulley to the studs in the gear cover. Remove the assembled water pump and pulley. Refer to Section G for instructions for disassembly, repair, and assembly of the water pump.

b. Remove the screws and lock washers that attach the crankshaft pulley to the crankshaft. Remove the crankshaft pulley.

c. Remove the nuts and lock washers that attach the gear cover to the studs in the block, and the capscrews and lock washers that attach the front angle cover to the gear cover. Remove the gear cover and the gasket. Remove the front oil seal.

d. Remove the nuts and lock washers that attach the front angle cover to the studs in the block. Tap the cover lightly to loosen it. Remove the front angle cover and gasket.

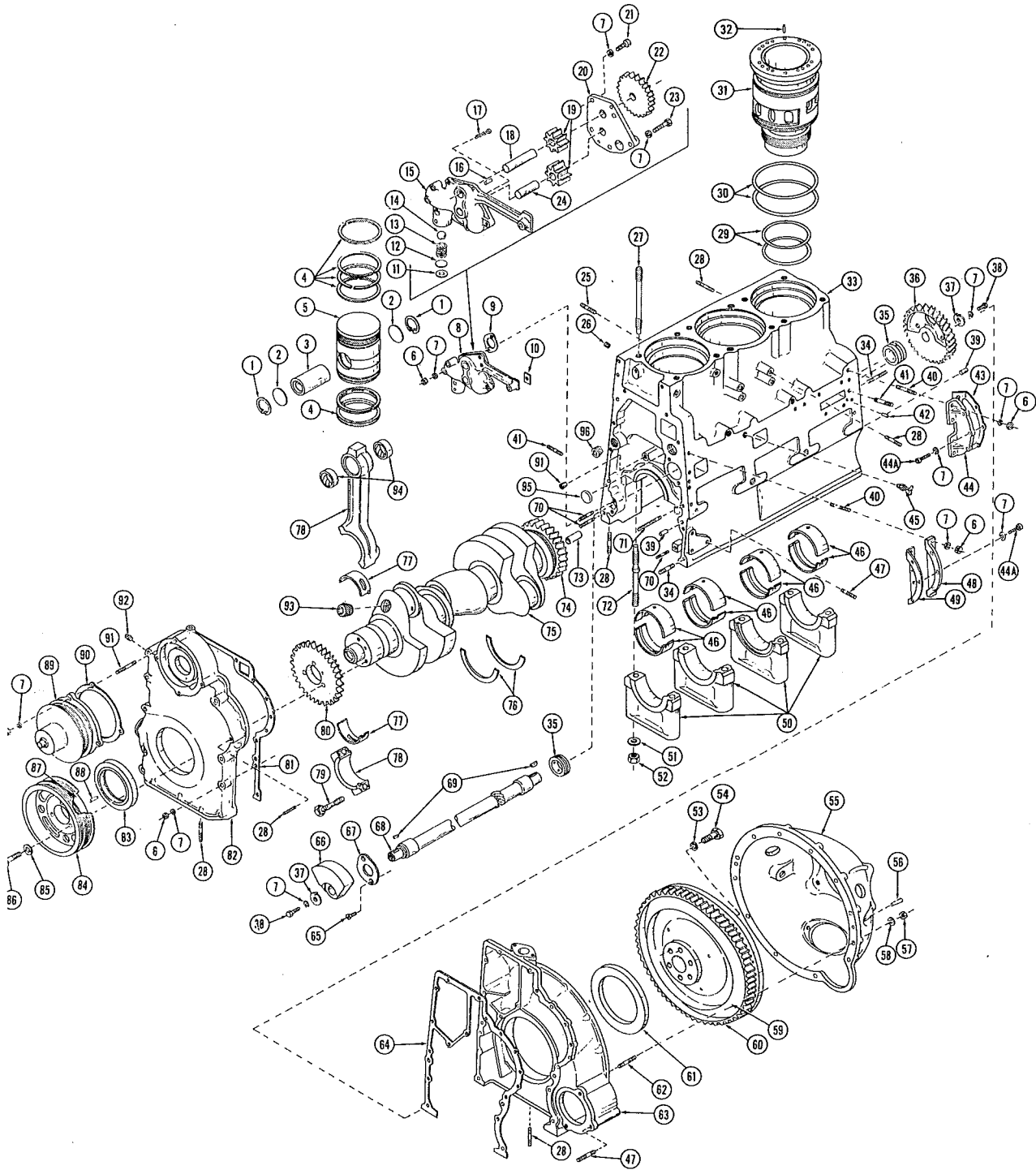


FIG. 17—ENGINE, INTERNAL PARTS, EXPLODED VIEW

FIG. 17—ENGINE, INTERNAL PARTS, EXPLODED VIEW

- | | | |
|----------------------|-----------------------------|------------------------------|
| 1—Snap Ring | 34—Flywheel Housing Stud | 65—Screw |
| 2—Piston Plug | 35—Balancer Shaft Bushing | 66—Balancer Shaft Weight |
| 3—Piston Pin | 36—Balancer Gear | 67—Thrust Plate |
| 4—Ring Set | 37—Balancer Gear Washer | 68—Balancer Shaft |
| 5—Piston | 38—Bolt | 69—Key |
| 6—Nut | 39—Dowel Pin | 70—Stud |
| 7—Lock Washer | 40—Cover Stud | 71—Bracket Stud |
| 8—Oil Pump | 41—Pump Drive Stud | 72—Main Bearing Cap Stud |
| 9—Gasket | 42—Roll Pin | 73—Pilot Bushing |
| 10—Gasket | 43—Cover Gasket | 74—Drive Gear |
| 11—Spring Washer | 44—Rear Angle Cover | 75—Crankshaft |
| 12—Relief Valve Shim | 44A—Bolt | 76—Thrust Washer |
| 13—Valve Spring | 45—Drain Cock | 77—Bearing Set |
| 14—Ball | 46—Bearing Set | 78—Connecting Rod |
| 15—Housing | 47—Support Stud | 79—Bolt |
| 16—Dowel Pin | 48—Front Angle Cover | 80—Drive Gear |
| 17—Cotter Pin | 49—Cover Gasket | 81—Gasket |
| 18—Drive Shaft | 50—Main Bearing Cap | 82—Gear Cover |
| 19—Gear | 51—Plain Washer | 83—Crankshaft Front Oil Seal |
| 20—Cover | 52—Nut | 84—Crankshaft Pulley |
| 21—Bolt | 53—Lock Washer | 85—Lock Washer |
| 22—Drive Gear | 54—Bolt | 86—Screw |
| 23—Bolt | 55—Clutch Housing | 87—Seal Ring |
| 24—Driven Shaft | 56—Lubrication Fitting | 88—Roll Pin |
| 25—Manifold Stud | 57—Nut | 89—Water Pump |
| 26—Threaded Insert | 58—Lock Washer | 90—Gasket |
| 27—Head Stud | 59—Flywheel and Ring Gear | 91—Water Pump Stud |
| 28—Valve Stud | 60—Flywheel Ring Gear | 92—Pipe Plug |
| 29—Sealing Ring | 61—Crankshaft Rear Oil Seal | 93—Pipe Plug |
| 30—Sealing Ring | 62—Clutch Housing Stud | 94—Bushing |
| 31—Cylinder Liner | 63—Flywheel Housing | 95—Expansion Plug |
| 32—Roll Pin | 64—Gasket | 96—Pipe Plug |

D-21. Remove Oil Pump

Remove the nuts and lock washers that attach the oil pump to the studs in the block. Remove the oil pump and gaskets.

D-22. Remove Cylinder Liners

Remove cylinder liners with a puller similar to the puller illustrated in Fig. 19. Pull the liner upward out of the block until it is loose enough to be removed by hand. Release the puller and lift

the liner out of the block. Do not lay the liner on its side.

CAUTION: Always store the liners in a vertical position to avoid distortion.

D-23. Remove Clutch, Clutch Housing, and Flywheel

a. Remove four of the bolts and lock washers that attach the clutch assembly to the flywheel, leaving two opposed bolts to be backed out alternately

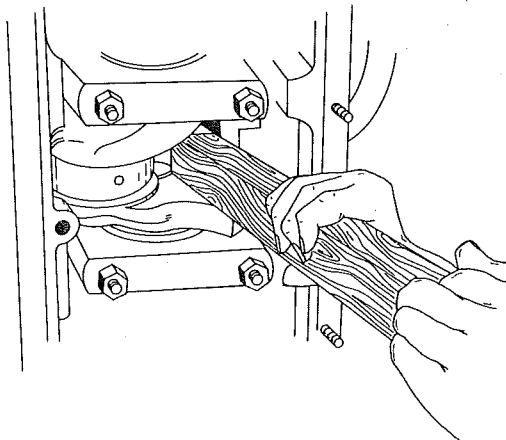


FIG. 18—REMOVING PISTON

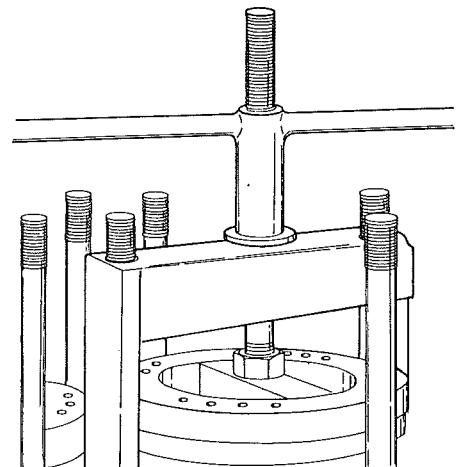


FIG. 19—USING SLEEVE PULLER

il the clutch spring pressure is relieved. Support the clutch assembly with one hand while moving the two remaining bolts. Remove the clutch assembly. For information on disassembly, resection, repair, and assembly of the clutch, refer to Section I. Instructions for removing the clutch when the engine is in the vehicle are also given in Section I.

Remove the nuts and lock washers that attach the clutch housing to the studs in the flywheel housing. Remove the clutch housing.

Remove the bolts and lock washers that attach the flywheel and ring gear to the crankshaft. Remove the assembled flywheel and ring gear.

24. Remove Flywheel Housing

Remove the nuts and lock washers that attach the rear angle cover to the studs in the block, and the capscrews and lock washers that attach the cover to the flywheel housing. Remove the rear angle cover and gasket.

Remove the flywheel housing breather from the flywheel housing.

Remove the nuts and lock washers that attach the flywheel housing to the studs in the block. Remove the flywheel housing and gasket. Loosen the flywheel housing by tapping with a rubber-headed hammer. Remove the rear crankshaft oil seal from the housing.

25. Remove Injection Pump and Pump Drive

Mark the flange of the injection pump housing and the flange of the drive housing for easier reinstallation. Remove the nuts and lock washers that attach the injection pump to the studs in the drive housing. Lift the injection pump up to

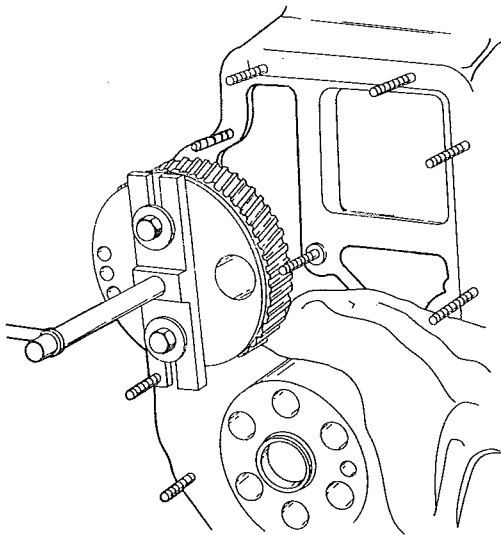


FIG. 20—REMOVING GEAR WITH PULLER

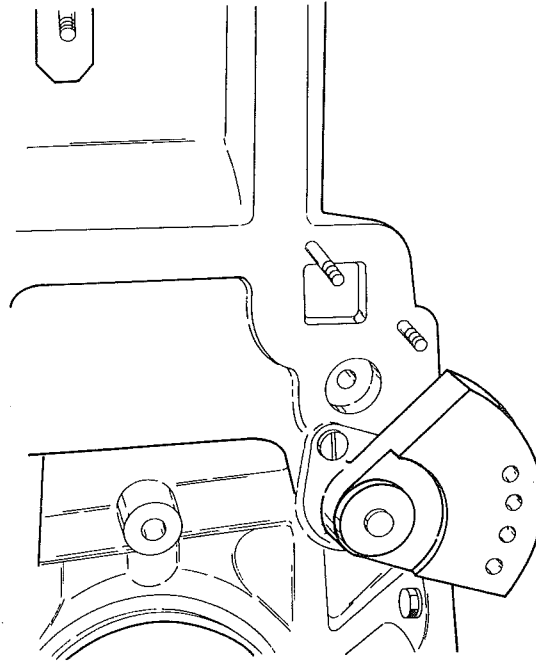


FIG. 21—BALANCER WEIGHT
READY FOR REMOVAL

clear the drive shaft. Remove the assembled injection pump. Seal all pump openings to avoid the entry of dirt into the pump. Lay the pump carefully on its side.

b. Remove the nuts and lock washers that attach the injection pump drive to the studs in the block. Remove the drive and gasket.

D-26. Remove Balancer Shaft

a. Remove the bolt and washer that attach the balancer shaft gear to the shaft. Use a puller as shown in Fig. 20 to pull the gear from the shaft. Remove the gear Woodruff key.

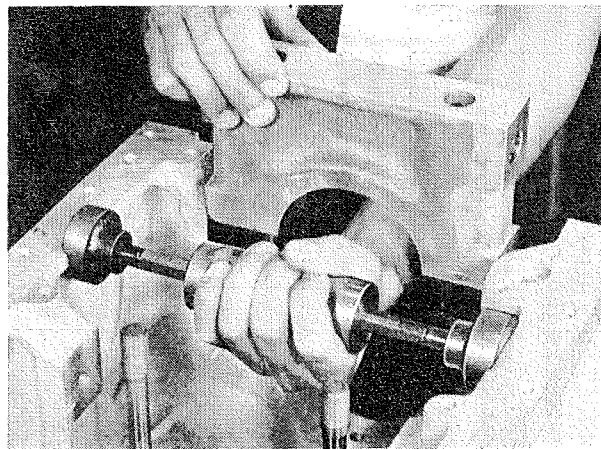


FIG. 22—SPREADING CRANKCASE
TO FREE BEARING CAP

b. Remove the screws that attach the thrust plate to the block. Pull out the assembled balancer shaft. Remove the screws, lock washers, and washers that attach the balancer shaft weight to the balancer shaft as shown in Fig. 21. Use a puller or press to remove the balancer shaft weight from the shaft. If the balancer shaft weight is to be removed without removal of the shaft, do not remove the thrust plate. Remove the screws, lock washers, and washers that attach the balancer shaft weight to the balancer shaft and remove the weight with a bearing puller.

D-27. Remove Crankshaft

a. Use a special hydraulic block spreading tool or a screw jack type tool to spread the block at each main bearing as shown in Fig. 22. Spread the block until the bearing cap can be rocked slightly by hand.

CAUTION: Do not spread the block more than just enough to perform the above operation. Over-spreading will result in a cracked block.

b. Remove the nuts and washers that attach the bearing caps to the main bearing cap studs in the block. Remove the main bearing caps.

c. Set the crankshaft balance weights in a vertical position. Insert a long bolt in each end of the shaft. Lift the crankshaft carefully out of the block. Do not allow the crankshaft to scrape the main bearing studs. To do so might cause serious damage to the shaft. Rubber protective sleeves are recommended.

D-28. Remove Engine Mounting Brackets

Remove the nuts and lock washers that attach the left and right engine mounting brackets to the studs in the block. Remove the left and right engine mounting brackets.

D-29. ENGINE INSPECTION AND REPAIR

The inspection and repair procedures detailed herein are recommended to be followed when a complete engine overhaul is to be made with the engine out of the vehicle. These instructions can generally be applied individually with the engine in the vehicle. Inspection and repair instructions are included to cover the block, cylinder head, crankshaft and bearings, connecting rods and bearings, oil pump, pistons and rings, flywheel, and balancer shaft. In addition, fitting operations for these engine components are included.

D-30. Check Block Assembly

Check the cylinder block for cracks and corrosion. Any suspected crack may be detected by brushing a light film of oil over the surface, wiping clean, and brushing on a solution of chalk and alcohol. Any oil caught in a crack will discolor the chalk

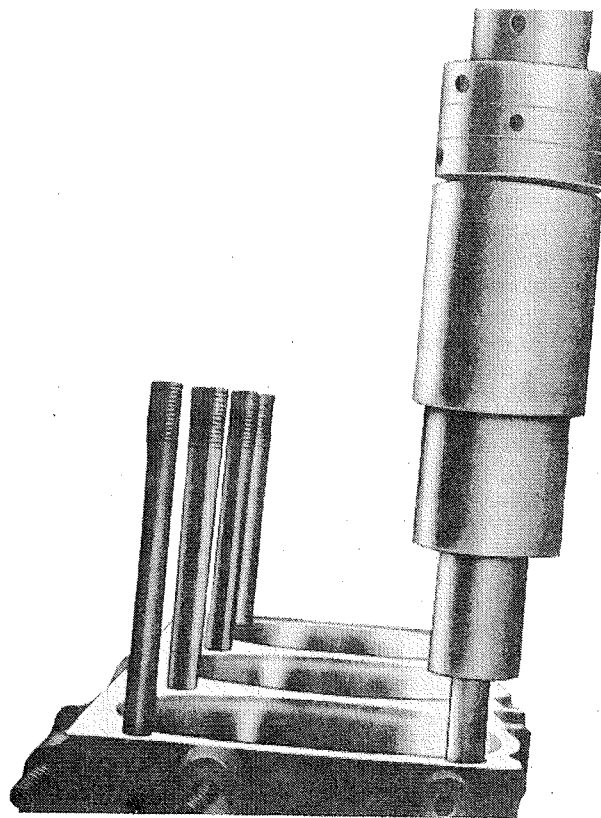


FIG. 23—INSTALLING CRANKCASE STUDS

solution. Remove the expansion plug from both ends of the block. Clean the block.

D-31. Inspect Head and Main Bearing Studs

a. These are tension studs. A scratch or nick will cause breakage. Never remove studs unless they are to be replaced, but replace as often as needed. A bad stud can ruin a good engine overhaul.

b. Remove stud carefully with stud extractor, being careful not to damage threads in block.

c. Coat new stud threads with a light film of anti-seize compound (Fel-Pro C5A, Skokie, Illinois, or equivalent).

d. Use a stud setter similar to the one shown in Fig. 23, install, and torque to 90 foot-pounds [12,4 kg./m.].

CAUTION: If it is desirable to chase threads in the block, a 5/8-11 UNC-2B tap must be used.

D-32. Check Main Bearing Alignment

a. Reinstall main bearing caps in the same manner as removed. Check the block; each bearing position is numbered on the side of the block from 1 to 4. Pick up the corresponding bearing cap and be sure that the number on the cap is next to the number on the block. Insert the cap into place until firmly

ated. Place one flat washer and nut on each of eight studs and torque to 125 foot-pounds [17,2 /m.].

Check the bearing bore with a line boring bar. This bore should not be more than 0.0005" [0,0127 m.] out-of-line.

The inside diameter of the main bearing bore with the caps properly in line and correctly torqued must measure 3.812" to 3.813" [9,6825 a 9,6850 m.] and should not be more than 0.001" [0,0254 m.] out-of-round.

-33. Inspect Main Bearings

To inspect the shells or inserts, wipe clean of any oil or grime. Look for pitting, cracking, or overheating. New bearing shell dimensions are 1.552" to 1.557" [3,9420 a 3,9547 mm.]. Main bearing clearance should be no greater than 0.0035" [0,08890 mm.]. A properly fitted bearing, after a reasonable length of service, will show a dull gray or brown appearance indicating the crankshaft has been moving on an oil film. Any bright spots indicate lack of oil.

Before installing shells or inserts, thoroughly clean bearing saddles and caps and remove any burrs. Clean the shells of any foreign material and install in their respective places. Lubricate each main bearing with clean oil before crankshaft installation.

-34. Inspect Crankshaft

Place crankshaft in suitable stand.

Inspect the crankshaft thoroughly before it is installed in the block and if necessary, recondition.

Remove all Allen plugs from the crankshaft and flush out all oil galleries thoroughly. Be sure all dirt and grit is removed.

Place the crankshaft in a lathe and check alignment. If run-out is greater than permissible limits, replace the crankshaft. Check all crankshaft journals to determine the smallest diameter as shown in Fig. 24.

If journals are worn out-of-round more than 0.002" [0,0508 mm.], replace the crankshaft. Main bearing journals on a new shaft should measure from 3.5000" to 3.4993" [8,890 a 8,888 cm.] and

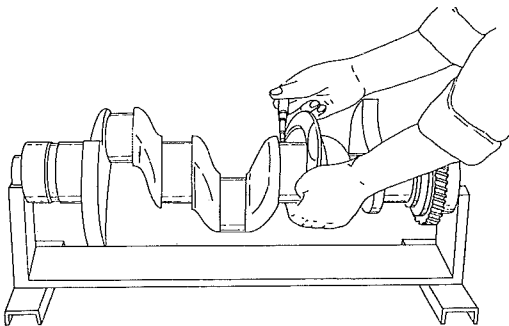


FIG. 24—INSPECTING TYPICAL CRANKSHAFT

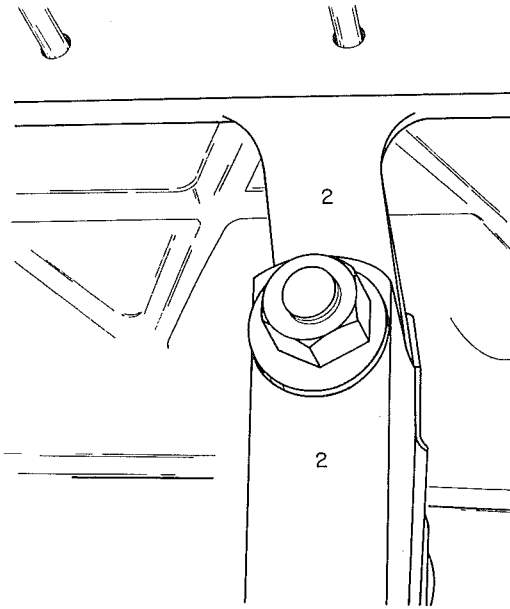


FIG. 25—BEARING CAP AND BLOCK MARKINGS

connecting rod journals from 2.8712" to 2.8705" [7,2928 a 7,2910 cm.].

f. Polish crankshaft journals with very minor grooves.

CAUTION: Polish the crankshaft with the normal direction of engine rotation, clockwise looking at front end.

g. Any extreme wear on the thrust flange of the crankshaft is generally due to improper assembly of the driven unit.

h. If the rear oil seal wear surface is not too badly grooved or roughed, polishing with crocus cloth will repair the damage.

Place a bolt in each end of the crankshaft. Pick the shaft up with the counterweights hanging in a

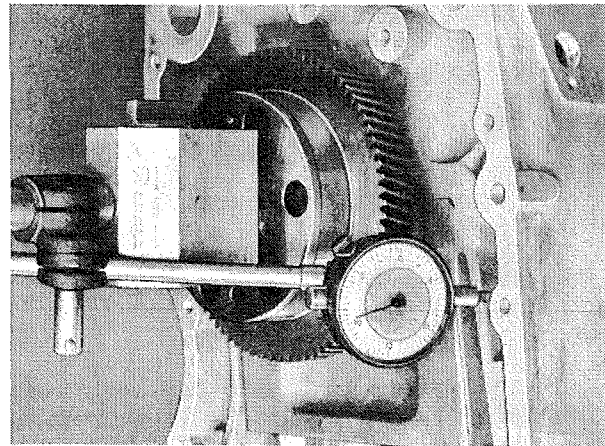


FIG. 26—INDICATING CRANKSHAFT END PLAY

vertical position and lower the crankshaft as squarely as possible into the saddles in the cylinder block.

Using the spreading tool, again spread the block just enough to install the bearing caps. Remember to check the numbers of the caps with the corresponding numbers on the block as shown in Fig. 25. After making sure each cap is down firmly and squarely, remove the spreading tool. Place one flat washer over each stud. Oil the threads; then run the nuts down by hand.

Tighten the bearings in the following sequence: No. 3, which is the thrust bearing; then No. 1, No. 4, and No. 2, torquing 25 foot-pounds [3,4 kg./m.] at a time until 125 foot-pounds [17,2 kg./m.] is reached. Loosen the nuts and tighten again, in the same order, to 100 foot-pounds [13,6 kg./m.]. Check the end play of the crankshaft with the aid of a dial indicator as shown in Fig. 26. The clearance should be no less than 0.004" [0,1016 mm.], nor more than 0.012" [0,3048 mm.]. Check the shaft for free turning. If assembled properly, it should turn freely by hand.

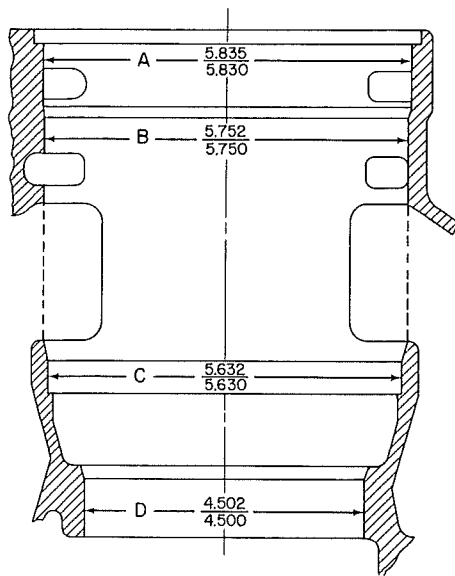


FIG. 27—CRANKCASE SLEEVE SEAT CHECKING VALUES

D-35. Inspect Cylinder Liner Cavity

a. Remove all dirt, oil, and scale from the cavity, being careful not to burr or scratch the machined surface. Measure the cavity at points A, B, C, and D in Fig. 27. These points should not be more than 0.00015" [0,0038 mm.] out-of-round, and within the tolerance shown below.

- A 5.835" to 5.830" [14,820 a 14,808 cm.]
- B 5.752" to 5.750" [14,610 a 14,605 cm.]
- C 5.632" to 5.630" [14,305 a 14,300 cm.]
- D 4.502" to 4.500" [11,435 a 11,430 cm.]

b. Clean the block cavity thoroughly, using 250 grit sandpaper. Clean particularly well in areas where

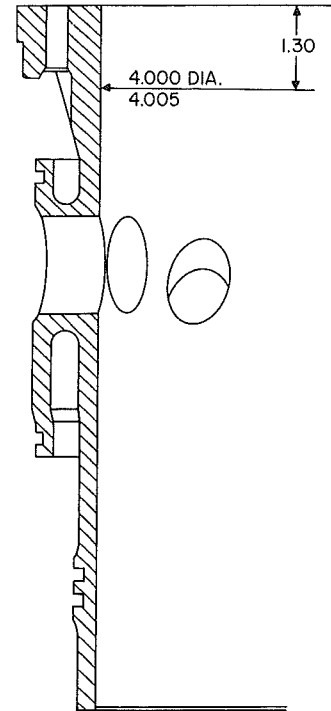


FIG. 28—CYLINDER SLEEVE BORE CHECK POINT

old rings are seated. Polish with crocus cloth. Be careful not to damage any surfaces during cleaning. Avoid introduction of abrasive or dirt into crankshaft or bearing passages.

Check for any burrs or cracks in the cavity. If burrs are not smoothed down, they may cut the liner "O" rings or cause damage to the liner. When cylinder liners are removed, they must be thoroughly cleaned and dimensions checked.

c. To be usable, the inside diameter must be between 4.000" [10,160 cm.] and 4.005" [10,172

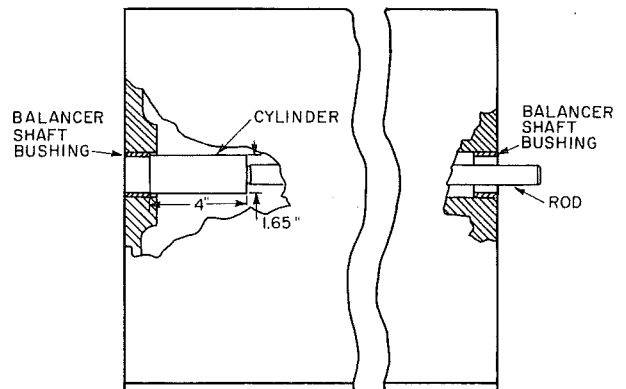


FIG. 29—PULLER FOR BALANCER SHAFT BUSHINGS

m.] at a point 1.3" [3,3 cm.] below the top as shown in Fig. 28.

When a liner is to be reused, it must be honed to remove the glaze or polished surface. This should never be done in the block. Use a spring coated hone. Honing should be done so as to form a criss-cross pattern with hone marks on a 90-degree axis. The hone should run the full length of the liner several times. Use 150 grit stones.

CAUTION: Avoid excessive honing, as this may result in short engine life.

Clean the liner carefully after honing to be sure all the abrasive is removed; then blow dry with air.

-36. Inspect Balancer Shaft Bushings

The balancer shaft bushings are located at each end of the block. These have an interference fit to the block of 0.001" to 0.003" [0,0254 to 0,0762 mm.], and are line-reamed to insure proper size and alignment.

If the balancer shaft bushings are worn, remove them with a bushing puller or use the method shown in Fig. 29. Place the cylinder inside the block and tap the rod to drive out the bushing.

To install new bushings, place them in dry ice for 15 minutes. Rapidly press the bushing into the block. Take care to align oil groove in the bushings with oil passages in the block.

Line ream the bushings on centers as shown in Fig. 30.

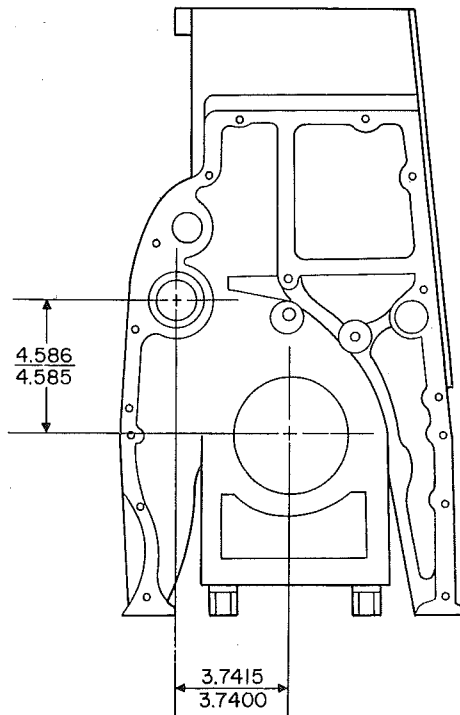


FIG. 30—CRANKCASE CENTER DIMENSIONS

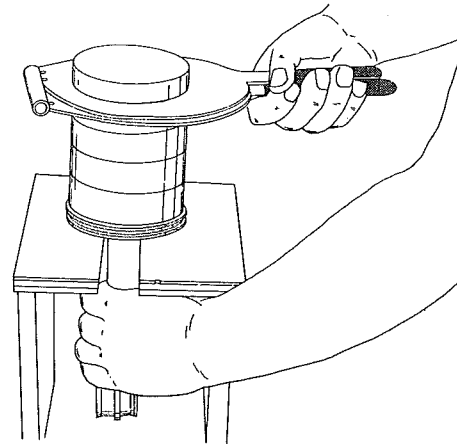


FIG. 31—REMOVING PISTON RINGS

D-37. Disassemble Piston and Connecting Rod

a. Place connecting rod in a suitable holder. If no holder is available and a vise is used, apply only enough pressure to hold the assembly securely. Excessive pressure will distort the connecting rod.

b. Remove the rings from the piston with a suitable ring expander as shown in Fig. 31.

c. Remove the two wrist pin snap rings as shown in Fig. 32.

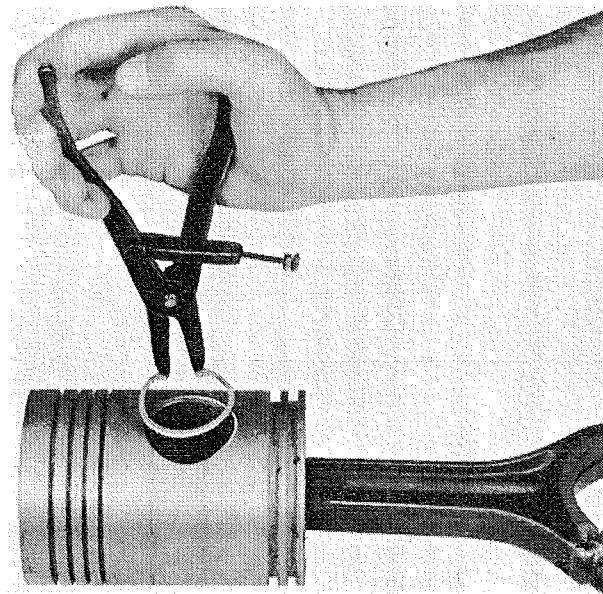


FIG. 32—REMOVING PISTON PIN SNAP RING

d. Remove wrist pin end plugs. Puncture the plug with a sharp instrument, such as a screwdriver. Pry the plug out as shown in Fig. 33.

e. Remove the wrist pins and connecting rods. Clean the connecting rod of all foreign materials.

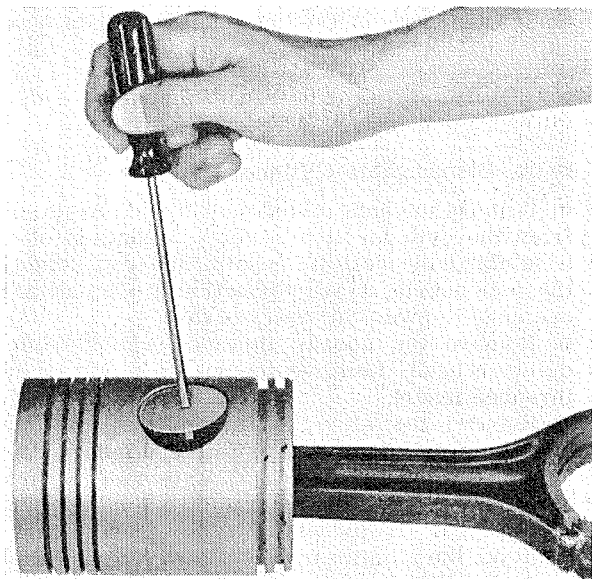


FIG. 33—REMOVING WRIST PIN END PLUG

D-38. Inspect Wrist Pin Bushings and Wrist Pin

- a. Inspect and measure the inside diameter of the wrist pin bushing.
- b. Replace the bushing if wear is more than 0.0015" [0,038 mm.]. Line ream bushings to 1.6274" to 1.6280" [4,1336 a 4,1351 cm.] inside diameter on center as shown in Fig. 34.
- c. Measure the wrist pin. If the pin shows wear, replace it.

D-39. Inspect Connecting Rod

- a. Assemble the bearing cap to the connecting rod and torque to 50 foot-pounds [6,9 kg./m.]. Hold the rod as shown in Fig. 35. Check the crankshaft bore of the rod. The bore cannot be more than 0.002" [0,0508 mm.] out-of-round or oversize. If it is greater, replace the rod.
- b. The small and large bore must be parallel within a total indicator reading of 0.003" [0,0762 mm.] on a 10" [25,4 cm.] length.
- c. Use a small rifling brush to clean the oil gallery in the connecting rod.

D-40. Inspect Piston

- a. Visually inspect to determine if the piston is scored or damaged beyond use.
- b. Measure the top of the piston between the second and third compression ring land. This area cannot be greater than 0.002" [0,0508 mm.] out-of-round or less than the specified diameter.
- c. The Cerlist piston is cam-ground. Measure the piston skirt 1" [2,54 cm.] from the bottom at a right angle (A) and parallel (B) from the piston pin as shown in Fig. 36. Dimension at (A) should be 3.9920" [10,1396 cm.] and at (B) should be 3.9905" [10,1358 cm.].

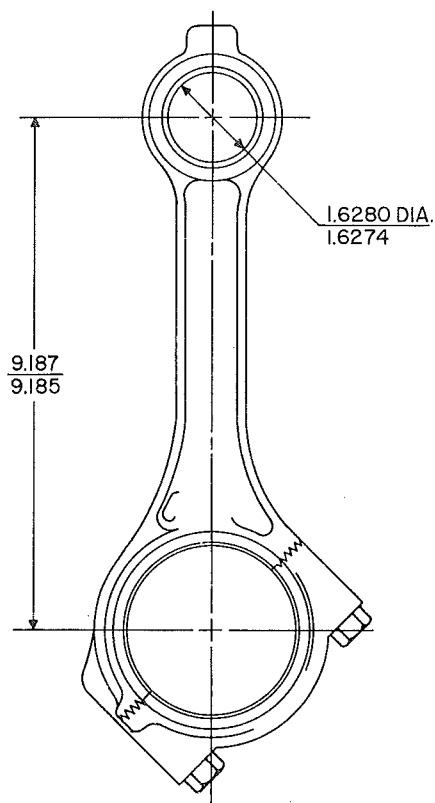


FIG. 34—CONNECTING ROD CENTER DIMENSIONS

- d. Check the ring side clearance in the ring grooves with a feeler gauge. Check the rings with the piston in a sleeve and the gauge inserted through the sleeve ports as shown in Fig. 37. Side clearance

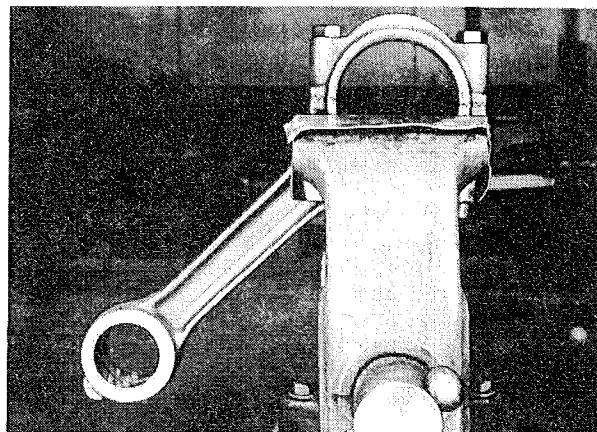


FIG. 35—ROD TORQUED FOR BORE CHECKING

for the compression rings is 0.006" [0,1524 mm.] maximum; for oil rings is 0.0025" [0,0635 mm.] maximum.

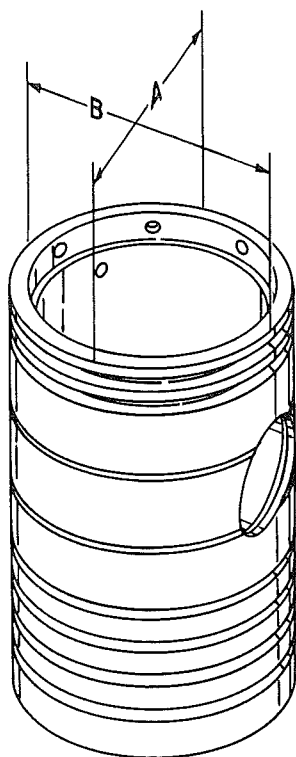


FIG. 36—MEASURING CAM GROUND
PISTON DIAMETER

D-41. Assemble Piston and Connecting Rod

Heat the piston in an oven for 20 minutes at 150° F. [232° C].

CAUTION: Do not use a torch.

Remove and very rapidly install one piston pin and piston pin bushing.

Position the connecting rod so the wrist pin end aligns with the bore in the piston. Install the wrist pin.

Install the wrist pin end plug and snap ring. Never drive the plug into the piston. It has a snug fit, but not a drive fit when the piston is hot. If force is required, reheat the piston.

If a used piston is being installed, be sure to match the rod and piston by number and replace the same as removed.

Install rings on the piston with the proper ring expander. The word "top" on the ring fits toward the top of the piston.

Apply clean oil to the piston pin and connecting rod piston pin bushing. Turn the piston so it sits on its top. Wipe the shell saddle in the rod.

Insert the upper shell so that the locking lip on the shell is in the groove provided for it, and the oil hole in the shell registers with the oil gallery opening in the rod. Press in firmly after checking to see that the shell is properly positioned. Repeat

these instructions on the connecting rod bearing cap.

NOTE: The lower shell does not have a drilled oil passage hole.

D-42. Disassemble Cylinder Head

a. Remove the assembled nozzle and nozzle holder from the cylinder head. For information on disassembly, inspection, repair, and reassembly of the fuel nozzle, refer to Section E. Cap all nozzle openings to avoid the entry of dirt.

b. Remove the nozzle threaded insert from the cylinder head. Remove the nozzle shield from the threaded insert.

c. Remove the glow plug from the side of the cylinder head. Remove the threaded insert.

d. Insert a 5/8" [1,587 cm.] aluminum bar through the opening from the bottom of the cylinder head. Tap the bar lightly with a hammer. Take care not to strike the aluminum head. Push the ring gasket, upper combustion chamber, and lower combustion chamber out of the opening in the head.

e. Remove the cylinder head core plug.

D-43. Inspect Cylinder Head

a. Clean all cavities in the head with an alkali cleaner that is not harmful to aluminum.

b. Inspect all cavities for cracks or damage. Inspect threads.

D-44. Assemble Cylinder Head

a. Install the lower combustion chamber in the center opening in the cylinder head. Insert a 1" [2,54 cm.] diameter aluminum bar and tap the end of the bar lightly to seat the lower combustion chamber. Insert the upper combustion chamber over the lower chamber; make sure the glow plug opening is aligned with the opening in the cylinder head. Seat the upper combustion chamber, using an aluminum bar and hammer as directed above. Install the ring gasket over the upper combustion chamber with the beveled side down. Check that the glow plug opening is clear.

b. Install the threaded insert in the cylinder head. Install the nozzle shield in the threaded insert with the beveled surface down.

c. Install the threaded insert in the glow plug opening in the side of the cylinder head. Install the glow plug in the threaded insert.

d. Install the cylinder head core plug in the side opening of the cylinder head.

e. Install the assembled fuel nozzle and nozzle holder in the threaded insert.

D-45. Disassemble Oil Cooler

a. Remove the nuts and lock washers that attach the elbow flange (Fig. 37) to the oil cooler cover. Remove the elbow flange and gasket.

b. Remove the nuts and lock washers that attach the oil cooler cover to the oil cooler bracket. Remove the oil cooler cover, gasket, oil cooler, and gasket.

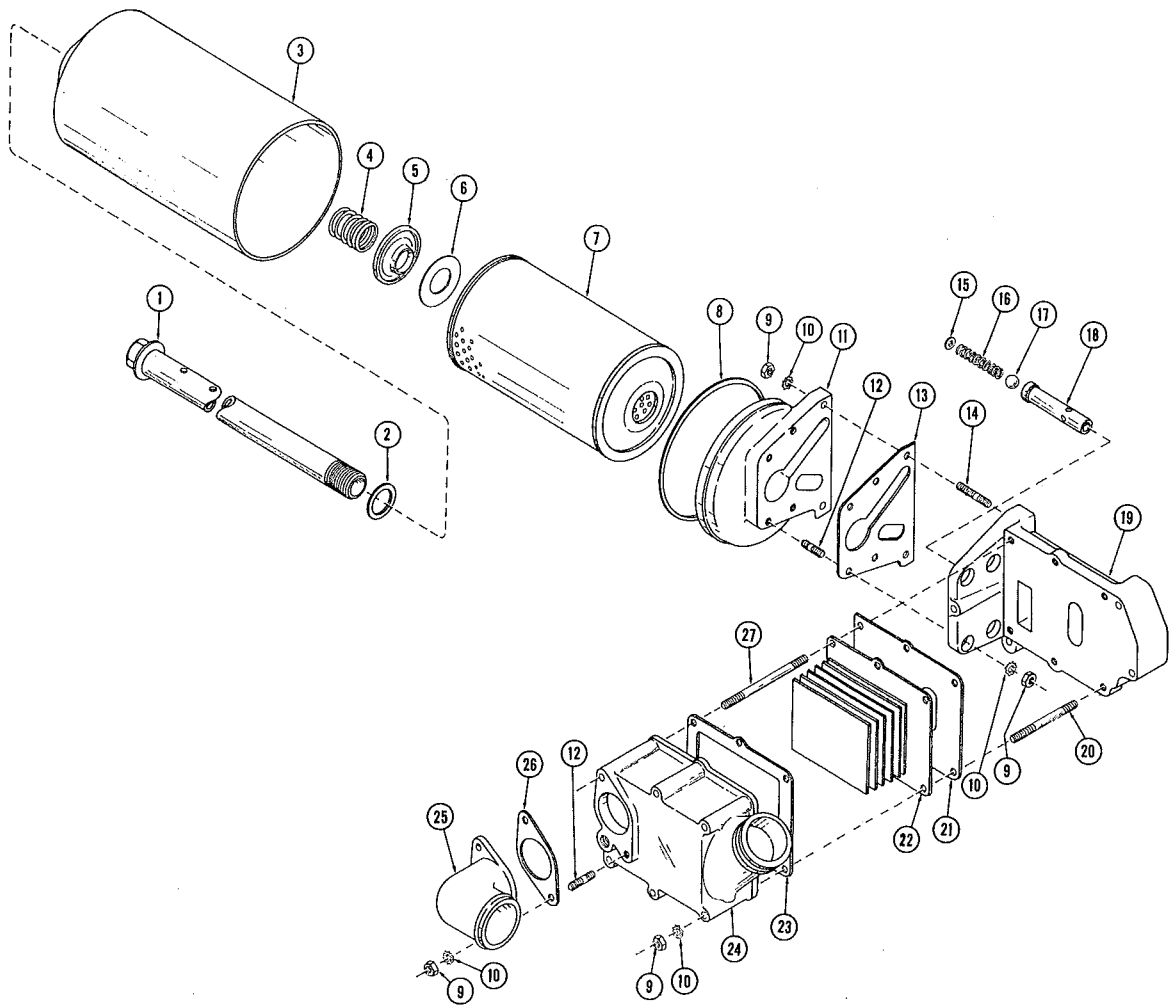


FIG. 37—OIL COOLER AND FILTER, EXPLODED VIEW

- | | | |
|------------------|-------------------|----------------------------|
| 1—Bar Assembly | 10—Lock Washer | 19—Cooler Mounting Bracket |
| 2—Gasket | 11—Filter Bracket | 20—Stud |
| 3—Cover | 12—Stud | 21—Gasket |
| 4—Spring | 13—Gasket | 22—Oil Cooler |
| 5—Sealing Cup | 14—Stud | 23—Gasket |
| 6—Gasket | 15—Washer | 24—Cover |
| 7—Filter Element | 16—Valve Spring | 25—Flange |
| 8—Gasket | 17—Ball | 26—Gasket |
| 9—Nut | 18—Valve Seat | 27—Stud |

c. Remove the bar assembly and gasket that attach the oil filter parts to the oil filter bracket. Remove the oil filter cover gasket, oil filter element, gasket, sealing cup, and spring from the bracket.

d. Remove the assembled oil pressure relief valve, spring seat washer, spring, and ball from the oil cooler valve seat in the mounting bracket. Mark the end of the spring so it will be inserted in the same direction as it was originally.

NOTE: The valve is set for 25 psi. [1,75 kg./cm²].

D-46. Inspect Oil Cooler and Filter

a. Force air through each plate to clear it of foreign material. Boil out cooler and flush with diesel fuel at high pressure. Clean both water and oil sides. If a circulating pump is not available to pump fuel through the plates under pressure, force it through with a hand pump. Coat the cooler with light oil after cleaning.

b. Clean the ball seat in the valve seat, if necessary.

If oil was observed in the cooling system, locate the leak and repair by soldering.

Pressure test the cooler at 125 psi. [8,78 kg./cm²].

Discard the oil filter element.

47. Assemble Oil Cooler and Filter

Install the gasket on the bar assembly. Insert the bar assembly in the oil filter cover. Place the ring, sealing cup, gasket, and a new oil filter element around the bar assembly in the cover. Install the gasket in the filter bracket and position the assembled filter on the bracket. Attach by running the bar assembly into the bracket.

Position the gasket, oil cooler, cover gasket, and cover on the studs in the oil cooler bracket. Attach with lock washers and nuts.

Position the gasket and elbow flange on the studs in the oil cooler cover. Attach with lock washers and nuts.

Assemble the ball, spring, and spring seat washer in the valve. Make sure the same end of the spring is inserted first as in the original installation. Test the valve for release at 25 psi. [2,265 kg./cm²]. Peen the ends of the valve to hold the setting. Retest to check the setting. Insert the assembled valve in the bore in the oil cooler mounting bracket.

48. Disassemble Oil Pressure Control Valve

Remove the plug, spring washer, spring, and drive from the valve body. Mark the end of the spring so that the installed position will be the same as in the original.

Clean the valve seat if necessary. Clean all parts in the valve body with an aluminum alkali cleaner.

Pressure test the valve body for 120 psi. [8,43 kg./cm²].

Assemble the valve spring, spring washer, and plug. Seat the plug. Test the valve to see if it passes the oil at 75 psi. [5,265 kg./cm²]. If the valve opens to bypass below 75 psi. [5,265 kg./cm²], remove the plug and a small shim under the plug. Retest. Continue to shim until the correct pressure of 75 psi. [5,265 kg./cm²] is obtained.

49. Disassemble Lubricating Oil Pump

NOTE: Oil pump disassembly and repair is not recommended by the manufacturer. If the oil pump is repaired, the end clearance of the gears must be maintained at 0.004" [0,1015 mm.]. This dimension is critical. Scored bearing surfaces should be worked. The external drive gear should always be replaced. As an expedient field repair, the external drive gear can be used temporarily if it is tack welded to the shaft at one or two points.

Check the opening pressure of the ball valve in the oil pump housing (Fig. 17); it should be 125 psi. [8,78 kg./cm²]. If the valve is not opening at the correct pressure, remove the cotter pin,

valve spring washer, relief valve shim, spring, and ball from the housing.

b. Pull the drive gear from the drive shaft, using a gear puller.

c. Remove the bolts and lock washers that attach the oil pump cover to the oil pump housing. Remove the oil pump cover and assembled drive gear and shaft and assembled driven gear and shaft.

NOTE: Inspect the gear shaft assemblies. Do not disassemble if they are not damaged.

d. Measure the distance from a marked end of each shaft to the face of the gears. Press the gears off their shafts. Note the dimension with each shaft so that it is available at assembly.

D-50. Inspect Oil Pump

a. Clean the surface of the relief valve seat. Check the bushing surfaces in the housing and cover for wear or out-of-round.

b. Check the gears for worn teeth or other defects. Inspect the shafts for damage.

c. Check bearing surfaces for scores.

D-51. Assemble Oil Pump

a. If the gears were pressed off the shafts, press on new gears to the dimension measured on disassembly. The end clearance of the gears must be 0.004" [0,1015 mm.]. This dimension is critical.

b. Position the assembled gear shafts in the pump housing bores as shown in Fig. 17.

c. Position the cover on the oil pump housing, seating the shafts in the bores in the cover. Attach with bolts and lock washers.

d. Press a new drive gear on the driven shaft extension through the cover. Do not press so far that the gear will bind on the cover.

e. Install the ball, spring, shim, and washer in the bore in the housing. Position so that the valve opens at 125 psi. [8,78 kg./cm²] and install cotter pin. Recheck the pressure and readjust if necessary. If the opening pressure can not be obtained, add shims under the washer until it is correct.

D-52. Inspect Crankshaft Pulley

The crankshaft pulley is equipped with a seal wear surface ring on the hub outside diameter to mate with the crankshaft seal. If the ring is badly grooved, remove it and install a new ring.

D-53. Disassemble Idler Bracket

a. Press the assembled idler shaft, bearings, and pulley from the bracket; press from the inside of the bracket.

b. Remove the retaining ring from the shaft. Press the assembled bearings and pulley from the shaft, pressing from the side where the retaining ring was installed.

c. File off any peened metal. Press the bearings and shim from the pulley. Press from the flanged side and only on the outside race of the bearing.

D-54. Assemble Idler Bracket

a. Press the bearings (with spacer in between) into the pulley by pressing on the bearing outside race only. To secure the pulley to the bearings, crimp the edge with a punch.

NOTE: The idler shaft bearings must be prepacked or hand packed with a lithium base, high-temperature grease.

b. Shrink the shaft into the bearing to the dimensions shown in figure 38. Install the assembled pulley and bearings on the shaft; attach by installing the snap ring.

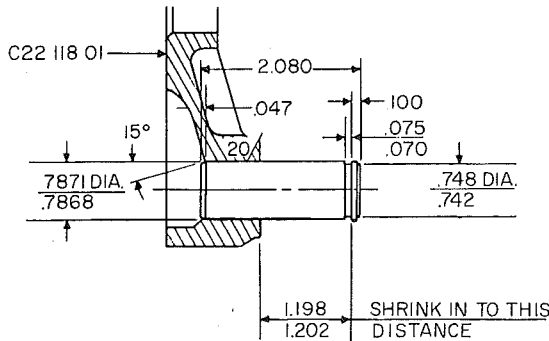


FIG. 38—BELT IDLER DIMENSIONS

D-55. Disassemble Blower

NOTE: Blower must be repaired with metric wrenches.

- a. Mark housing parts of the blower to aid in assembly.
- b. Insert a piece of soft wood or a clean shopwiping cloth between the rotors to prevent them from turning. Remove the bolt that attaches the drive hub. Pull the drive hub from the drive shaft.
- c. Loosen and remove the hex nuts and tapered pins that attach the front and rear covers. Carefully pull off the front and rear covers.
- d. Remove the Allen head bolts that attach the drive shaft. Remove the drive shaft.
- e. Check the backlash of the gears in each end plate. The backlash requirements are marked on the gears as well as on the end plates. The shaft centers and backlash of gears are marked in 100ths of millimeters. Conversion of dimensions to inches is shown in the table below.

CENTER DISTANCE OF SHAFTS
DIFFERENCE FROM NOMINAL

100ths of a Millimeter	Inch
-2	-0.00080
-1	-0.00040
0	0
+1	+0.00040

CENTER DISTANCE OF SHAFTS
DIFFERENCE FROM NOMINAL (Continued)

100ths of a Millimeter	Inch
+2	+0.00080
+3	+0.00120

CORRESPONDING BACKLASH OF GEARS

100ths of a Millimeter	Inch
7 to 9 and 8 to 10	0.0027 - 0.0035
7 to 9	0.0031 - 0.0039
6 to 8	0.0027 - 0.0035
5 to 7 and 5 to 8	0.0023 - 0.0031
5 to 7 and 5 to 8	0.0019 - 0.0027
4 to 6 and 5 to 7	0.0010 - 0.0031
3 to 5 and 4 to 6	0.0015 - 0.0023
4 to 6 and 5 to 7	0.0015 - 0.0023
3 to 5 and 4 to 6	0.0011 - 0.0019
3 to 5 and 4 to 6	0.0015 - 0.0023

NOTE: If the assembly is in good condition and the gear backlash is correct at all points, do not disassemble the gears.

NOTE: Absolute cleanliness and extreme care must be used when working on blower parts.

- f. Remove the nuts at each end of the rotor shafts. Remove the gears from each rotor shaft and loosen the bushings.
- g. Use the bolts in the bushings as draw bolts; remove the bushings and shims. The shims are used to establish the distance between the end plate and the rotors. Do not interchange shims. Tie them in sets and mark the sets for location.
- h. Remove the end plates. Check to see if oil has accumulated in the housing; if there is oil in the housing, replace the seal rings in the end plates. If the seal ring holders are damaged, replace the seal rings and holders.

D-56. Assemble Blower

- a. Make sure all surfaces are cleaned of gasket or sealing compound before assembly.
- b. Coat the sealing surface of the adjustable bushing in the ball bearing end plate with a light coat of No. 300 Permatex or equivalent. Position the end plate on the housing and attach with taper pins.
- c. Assemble the seal rings in the seal ring housings and assemble the housings in the end plates.
- d. Insert the rotors in the end plate and housing.
- e. Coat the sealing surface of the gear side end plate with sealing compound and position it over the housing and rotors. Press in the roller bearing and attach with the washer, lock washer, and screw.
- f. Position the shim packs around the rotor shafts in the adjustable bushing end plate. Install two ball

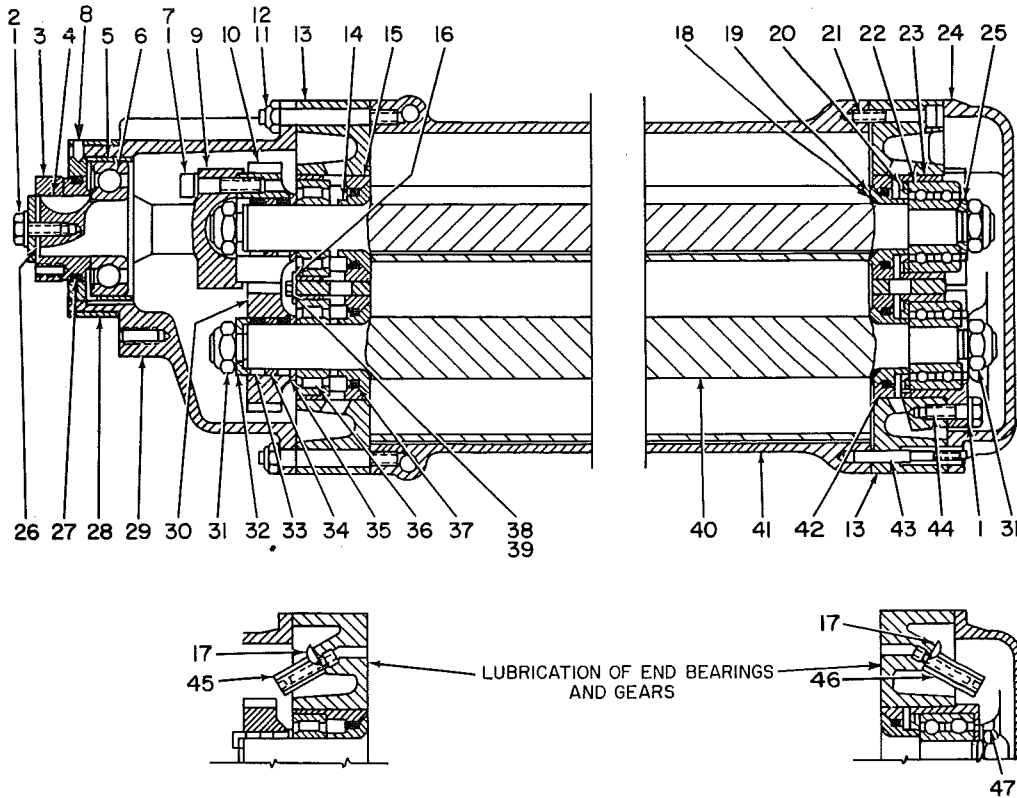


FIG. 39—BLOWER, SECTIONAL VIEW

- | | | |
|----------------------|---------------------|----------------------|
| 1—Lock Washer | 17—Locking Plate | 33—Spring |
| 2—Screw | 18—Seal Ring | 34—Spacer |
| 3—Drive Hub | 19—Seal Ring Holder | 35—Spacer |
| 4—Key | 20—Adjustment Ring | 36—Roller Bearing |
| 5—Seal Ring Housing | 21—Screw | 37—Seal Ring |
| 6—Ball Bearing | 22—Ball Bearing | 38—Screw |
| 7—Screw | 23—Bushing | 39—Lock Washer |
| 8—Set Screw | 24—Rear Cover | 40—Rotor and Shaft |
| 9—Drive Shaft | 25—Washer | 41—Housing |
| 10—Drive Gear | 26—Washer | 42—Seal Ring Housing |
| 11—Stud | 27—Seal Ring | 43—Taper Pin |
| 12—Nut | 28—Bushing | 44—Screw |
| 13—End Plate | 29—Front Cover | 45—Nozzle |
| 14—Seal Ring Holder | 30—Gear | 46—Nozzle |
| 15—Seal Ring Housing | 31—Nut | 47—Oil Slinger |
| 16—Washer | 32—Adjustment Ring | |

arings on each rotor shaft and install the adjustable bushings over the ball bearings and shims. Secure each bushing with screws and lock washers.

The rotor gears are marked on the ends as shown in Fig. 40. They must be installed with the marks in the position shown in the illustration. Position the washers and gears on the rotor shafts with the thicker gear on the drive rotor. A spring, spacer, and spring are installed around the rotor shafts inside each gear bore. Position an adjusting ring on each gear, with the lip of the ring bearing against the spring in the gear bore. Install a nut at the end of each rotor shaft and tighten the nut to 105 to 110 foot-pounds [14,5 a 15,2 kg./m.].

Rotate the rotors. If the rotors do not turn easily by hand, pull out the taper pins in the end

plate so that the end plate is held with only two Allen head screws. Loosen the screws that attach the adjustable bushings until the rotors turn freely. Check the rotor clearance with a feeler gauge as shown in Fig. 41. The clearance should be as shown in Fig. 40. Measure the rotor-to-housing

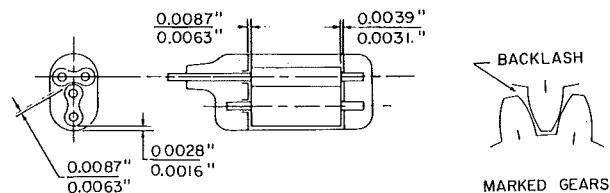


FIG. 40—BLOWER ROTOR CLEARANCES

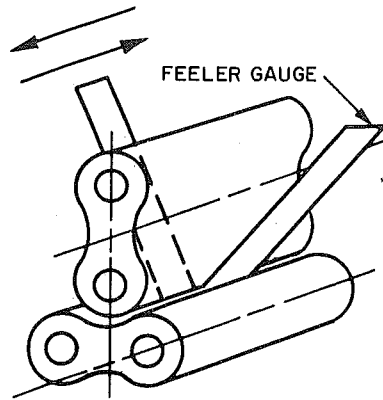


FIG. 41—CHECKING ROTOR CLEARANCE

end clearance. It must be as shown in Fig. 40. If the housing clearance is not correct, adjust the end plates. It may be necessary to ream out the dowel pin holes and insert oversize dowels in order to obtain the correct clearance. Check that the face of the drive gear is parallel with the face of the end plate within 0.0008" [0,0203 mm.].

i. Position the stub drive shaft over the drive gear. Attach with bolts and lock washers. Position the gear cover over the stub drive shaft and attach a dial indicator to the stub gear shaft to indicate the correct position of the bore in the gear cover. When the bore is true with the shaft, attach with nuts.

j. Install the ball bearing, adjustable bushing, seal ring, and drive hub on the stub drive shaft. Attach with the washer and bolt.

k. After reassembly is complete, check that the rotors turn freely by hand. Recheck the rotor clearances.

D-57. Oil Pan

Examine the oil pan carefully for evidence of corrosion, dents, or other damage. Replace with a new pan if necessary. Special attention must be given to the bolting flange to assure proper alignment and a tight seal at the cylinder block. Whenever the oil pan is removed, replace all gaskets regardless of condition.

D-58. Flywheel

The flywheel is mounted to the rear flange of the crankshaft. The crankshaft, flywheel, and clutch are statically and dynamically balanced; therefore, the components should be assembled in their original relative positions to maintain this balance, if possible.

D-59. Inspect Flywheel

Inspection should be done only when assembling the flywheel to the crankshaft during engine assembly. Clean the flywheel thoroughly with a suitable cleaning solvent and wipe dry. Inspect the clutch

face of the flywheel for burned condition, rivet grooves, or scuffed condition. Check the flywheel for run-out, warping, and wear. Mount the flywheel on the crankshaft, with the crankshaft in the cylinder block. Mount a dial indicator with the contact button of the indicator resting against the clutch face of the flywheel (Fig. 42). Set the indicator at zero and rotate the flywheel. Maximum allowable run-out is 0.0015" [0,0381 mm.]. Relocate the dial indicator and check the run-out on the surface where the clutch pressure plate cover bolts to the flywheel. Maximum allowable run-out is 0.0015" [0,0381 mm.]. Excessive run-out at the bolt circle or the clutch face will seriously affect clutch action; therefore, it is recommended that the flywheel be replaced if the run-out exceeds the specified limits. Inspect for worn, broken, or chipped ring gear teeth and replace the ring gear if necessary. Stripped threads in the tapped holes for pressure plate cover will require replacement of the flywheel. Check squareness with crankshaft; it should be within 0.0075" [0,1905 mm.].

D-60. Replace Ring Gear

To remove the ring gear from the flywheel, drill a 3/8" [9,52 mm.] hole through the ring gear and cut through any remaining metal with a cold chisel. Remove the ring gear from the flywheel. Thoroughly clean the ring gear surface of the flywheel. Heat the new ring gear evenly to 650° to 700° F. [343° a 371° C.], and place it on the cold flywheel, making certain that the chamfer on the teeth is opposite the clutch side of the flywheel. Be sure that the ring gear is firmly seated on the flywheel. Allow the ring gear to cool slowly to shrink it onto the flywheel.

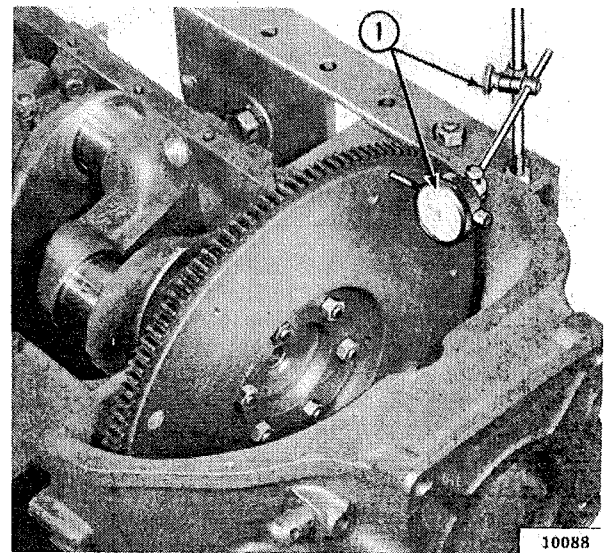


FIG. 42—CHECKING FLYWHEEL RUN-OUT (TYPICAL)

1—Dial Indicator

.61. Inspect Flywheel Housing and Rear Crankshaft Oil Seal

The flywheel housing, which encloses the flywheel, is bolted to the cylinder block. The rear of the housing provides the front support for the clutch housing. Examine the housing for cracks and distortion of the machined surfaces. The front face must seat evenly against the cylinder block without evidence of warpage.

The rear face must be parallel to the front face. Improper alignment will seriously affect the alignment of the power train. Install a dial indicator on the rear face of the flywheel housing. Let the indicator button rest near the rim of the flywheel as shown in Fig. 42.

Rotate the flywheel, noting the run-out on the dial indicator. Maximum allowable run-out is 0.0060" [0,152 mm.]. Relocate the dial indicator so that the indicator button will indicate the run-out near the seal in the flywheel as shown in Fig. 43.

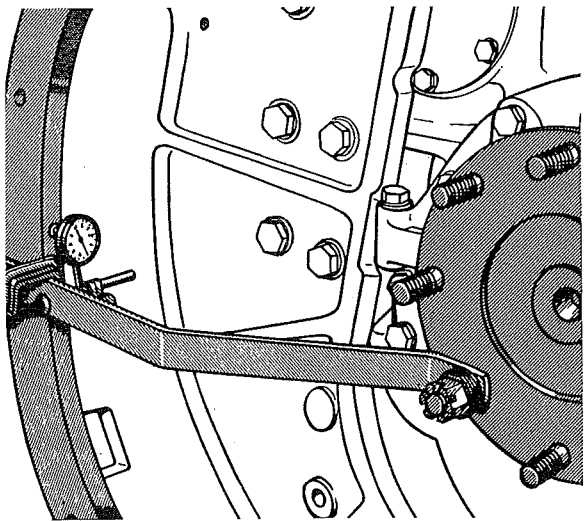


FIG. 43—CHECKING HOUSING BORE RUN-OUT

Rotate the flywheel and note the run-out which would not exceed 0.0030" [0,076 mm.]. If desired, suitable fixture can be made to attach the flywheel with one of the flywheel bolts, provided the clutch is not installed on the flywheel, so that the dial indicator can be mounted on it to check the flywheel run-out. Check for squareness with crankshaft; it should be within 0.0080" [0,203 mm.].

NOTE: Flywheel housing run-out should be checked after the housing is installed when assembling the engine.

If the rear crankshaft oil seal is damaged, press it out of the flywheel housing.

NOTE: Before pressing out the seal, measure depth from face of housing to face of seal. Install new seal to same depth. If it is desirable to seat seal in new position on crankshaft, install seal with a few thousandths of an inch less depth.

c. Coat the inside of the seal with a lubricant. Coat the outside with a sealing agent. Press a new seal in the flywheel housing.

NOTE: If housing is installed on engine, follow instructions in step d.

d. If the seal is to be replaced when the housing is on the engine, drill two 1/8" [3,175 mm.] holes at opposite sides of the seal flange. Thread two No. 10 self-tapping screws in the holes. Pry the seal out with two pry bars inserted under the heads of the screws. Inspect wear and mounting surfaces for nicks and burrs. If present, remove with an emery cloth and polish with crocus cloth. Use a seal guard to install seal. If not available, wrap a piece of 0.005" [0,127 mm.] shim stock around the crankshaft. Start seal into housing with a hammer. After seal has been installed to a point where the sealing lip is beyond the outer edge of the crankshaft, remove shim stock. Be sure sharp edges of shim stock do not cut seal when removing. Finish driving in seal with improvised tool as shown in Fig. 44. In an emergency, the seal may be driven in with a blunt end driver. Make sure seal or seal case is not damaged.

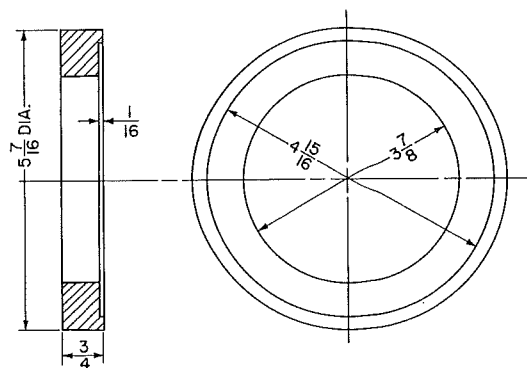


FIG. 44—SEAL SEATING TOOL

D-62. Inspect Clutch Housing

The clutch housing, which encloses the clutch, is bolted to the flywheel housing. The rear of the housing provides the front support for the transmission. Examine the housing for cracks and distortion of the machined surfaces. The front face must seat evenly against the flywheel housing without evidence of warpage. The rear face must be parallel to the front face. Improper alignment of the clutch housing will also seriously affect the

alignment of the power train. Check the concentricity of the bore at the rear face with the crankshaft at engine assembly. It must be concentric within 0.006" [0,152 mm.].

D-63. Replace Core Hole Expansion Plugs

Any evidence of coolant leakage around the core hole plugs will require plug replacement. There are five plugs in the right side of the cylinder block, one in each end, and two in each cylinder head, Fig. 45. The plugs can be replaced with the engine installed in the vehicle. The expansion plugs may be removed by drilling a 1/2" [12,7 mm.] hole through the expansion plug. Pry the plug out of the block. Before attempting to install the new plug, clean the hole in the block thoroughly. Apply a thin coat of gasket paste on the plug. Install the plug.

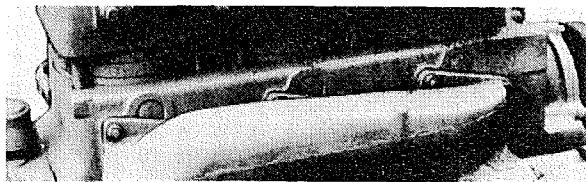


FIG. 45—CORE PLUGS

D-64. ENGINE ASSEMBLY

The engine assembly procedure in the following paragraphs is given in the sequence to be followed when the engine is being completely overhauled. Individual inspection, repair, and fitting operations previously detailed are made throughout the assembly procedure. The assembly procedure does not cover accessories. If a new cylinder block fitted with pistons is used, many of the operations will be unnecessary. Most of the operations as given are also applicable with the engine installed in the vehicle.

D-65. Install Engine Mounting Brackets

Position the right and left engine mounting brackets on the studs in the block. Attach with nuts and lock washers.

D-66. Install Crankshaft and Bearings

Inspect the bearing cap studs in the block. If new studs are installed, torque to 90 to 95 foot-pounds [12,4 a 13,1 kg./m.]. Fit the four upper main bearings into their respective locations in the cylinder block. Fit the four lower main bearings into their respective bearing caps. Lubricate all bearing surfaces generously with clean light engine oil. Place the crankshaft in position in the cylinder block and install the main bearing caps. Be sure to tighten the nuts in each cap evenly to pull the cap into place without distorting the bearing cap. Torque

the nuts as directed in paragraph D-34. Rotate the crankshaft after the installation of each bearing cap is completed. Refer to Par. D-32 and D-33 for main bearing inspection.

D-67. Install Balancer Shaft

- a. Inspect the balancer shaft bushings in the block. Repair the bushings (Par. D-36) if necessary.
- b. Slide the balancer shaft through the bushings in the block. Seat the shaft on the journals.
- c. Position the thrust plate on the balancer shaft and against the block. Attach with screws. Install the Woodruff key in the keyway of the shaft; install the balancer weight on the shaft and key. Attach with a washer, lock washer, and screw. Make sure the lug on the side of the washer is installed in the keyway of the weight. Install a Woodruff key in the keyway on the opposite end of the shaft.
- d. Install the balancer shaft gear on the key and shaft. Attach with a screw, lock washer, and washer.

D-68. Install Injection Pump Drive and Injection Pump

- a. Position the gasket and rear angle cover on the studs in the block. Attach with nuts and lock washers.
- b. Position the gasket and injection pump drive on the studs in the block. Attach with nuts and lock washers. Check that the injection pump drive gear mates correctly with the gear on the balancer shaft. Use additional gaskets for proper gear clearance, if necessary.
- c. If the pump throttle is wired in open position, leave it that way until the pump is installed. This prevents the weights in the governor from falling into a position that might make shaft entry difficult.

Be sure No. 1 piston is on compression, and F.P. or proper degree mark on the flywheel is accurately centered in the timing opening in the flywheel housing. Check the shaft and the shaft opening in the pump for any trace of dirt or grit; grease these parts liberally with light grease. Be very careful not to damage the lips of the seals when slipping the pump in place.

With the small timing cover removed, turn the pump until the mark on the cam and the mark on the governor weight retainer are aligned; install the injection pump on the studs in the drive. Match the housing marks made at disassembly. Make sure the male coupling of the drive shaft engages properly with the female coupling in the injection pump. Attach with nuts and lock washers. Before seating the retaining nuts completely, turn the pump slightly as needed to realign the pump markings perfectly. The bolt holes in the mounting flange should permit this turning. Use a screwdriver in the backlash notch to move the weight retainer in the direction opposite pump rotation to remove any backlash before final timing. The direction of rotation is clockwise as viewed from the drive end of the pump.

member, the timing marks on this pump and on front pulley are for the END of injection, not at closing (beginning of injection) as usually entered on other pumps. There are three timing marks on the front pulley, as shown in Fig. 46. The center one represents top dead center of the engine. Proper timing is 4 degrees after top dead center, use the 5 degree mark following the TDC mark. When the 4 degree mark on the front pulley is aligned with the mark on the front cover, the timing marks in the injection pump should match. When timing is set, install the timing cover.

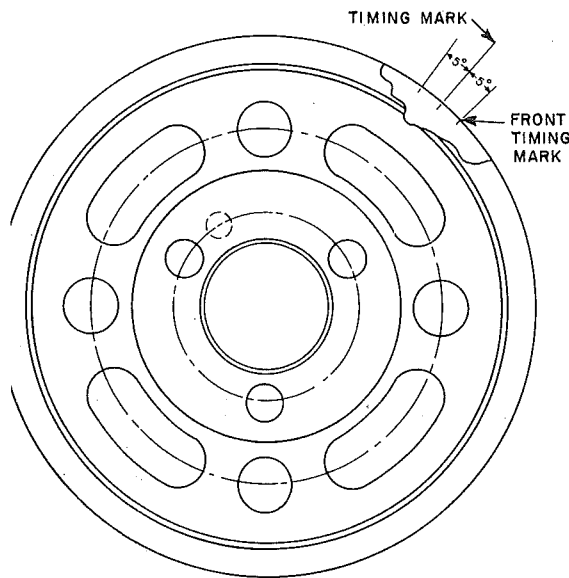


FIG. 46—FRONT COVER AND FRONT PULLEY TIMING MARKS

69. Install Flywheel Housing

Brush clean oil on the crankshaft at the flywheel end and also on the oil seal lip before assembling the housing casting to the rear angle flange. Use a crankshaft rear seal guard tool. Be very careful in mounting the housing not to damage the oil seal. Install lock washers and nuts on the mounting studs; attach to the rear angle flange with nuts and lock washers. Tighten, using a criss-cross pattern to avoid any bowing of the housing casting.

Install the flywheel housing breather in the housing.

Check the rear crankshaft oil seal. Refer to Par. D-61 for oil seal repair.

70. Install Flywheel, Clutch, and Clutch Housing

Be sure that the crankshaft flange-to-flywheel mating surfaces are clean to permit proper flywheel alignment. Place the flywheel on the crankshaft. Attach with bolts and lock washers. Tighten the

bolts alternately and evenly to 85 to 90 foot-pounds [11,7 a 12,4 kg./m.]. Refer to Par. D-59 for checking flywheel alignment and to Par. D-61 for flywheel housing-to-flywheel alignment.

b. To install the clutch assembly with the engine out of the vehicle, use a clutch plate aligning arbor. Placing the clutch disc in position against the flywheel, insert the arbor into the crankshaft pilot bushing and against the clutch disc expanding the arbor in the bushing to hold it in place.

Hold the clutch pressure plate assembly in position against the clutch disc and install the six attaching bolts and washers, tightening the bolts alternately and evenly. Remove the arbor.

c. Be sure that the clutch housing flange-to-flywheel housing mating surfaces are clean to permit proper clutch housing-to-crankshaft alignment. Place the clutch housing over the studs in the flywheel housing. Attach with nuts and lock washers. Refer to Par. D-62 for clutch housing concentricity check.

D-71. Install Cylinder Liners

a. Wipe the liner and liner cavity clean.

b. Install the "O" rings, being careful not to overstretch.

c. Lubricate the liner cavity and outside of the liner, particularly the "O" ring sections, with green soap.

d. Rotate the liner until the exhaust ports are in line with the exhaust openings in the block.

e. Lower the liner into the cavity until the "O" rings begin to seat. Center the two dowel pins at the top of the liner with the two head studs.

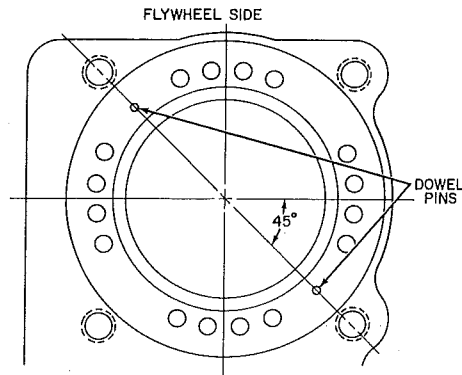
f. Press the liner all the way down into the cavity by hand pressure only. This should be done with a quick thrust downward. If the liner fails to seat properly, pull it out and check for an obstruction in the cavity, check the "O" rings to see if they are seated properly. After satisfied that everything is correct, repeat the installation. After installation, check the dowel pins to see if they are correctly centered with the studs. If not, use a special wrench as shown to align liner position as shown in Fig. 47.

g. Check the liner bore for out-of-round. If it is more than 0.0008" [0,0203 mm.], pull the liner and check for interference.

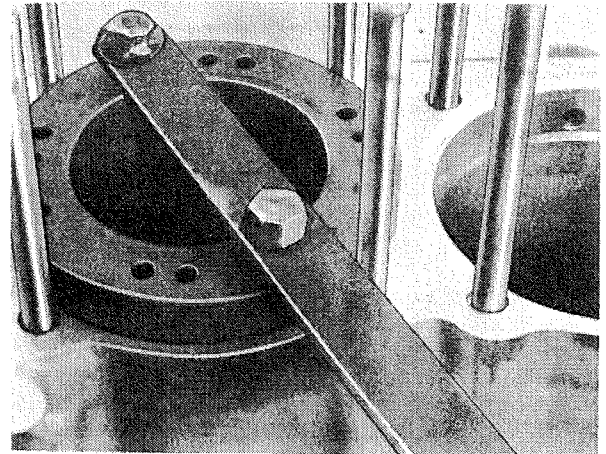
D-72. Install Oil Pump

Coat the gaskets for the oil pump with grease and position them on the studs in the block. Position the oil pump on the gaskets; attach with nuts and lock washers.

Do not tighten the nuts. Check that the pump drive gear mates with the gear on the crankshaft. Measure the gear backlash. It should be 0.003" to 0.005" [0,076 a 0,127 mm.]. If the backlash is too great, tap the pump toward the crankshaft. If the gear does not have enough clearance, tap it away from the crankshaft. When proper backlash is obtained, tighten the nuts.



A. ALIGNMENT OF CYLINDER LINER WITH STUD



B. ALIGNING TOOL IN USE

FIG. 47—LINER INSTALLATION

D-73. Install Gear Cover

a. There are two water gallery openings on the front of the block. Facing the front of the engine, the square opening is on the right and the small round opening on the left. The surface around these openings must be coated with a non-hardening seal before the cover-to-block gasket is installed. Wet the cover-to-block gasket with water and install over studs to the face of the block. Install gear cover and attach with lock washers and nuts; tighten securely, using a criss-cross method of tightening the nuts to avoid any bowing of the cover.

b. Install the angle cover and gasket on the four studs in the block; attach with lock washers and nuts. Do not tighten until the nuts and lock washers are installed in the other face of the cover fastening it to the gear cover.

c. Install the pulley to the crankshaft, coat the surface with a light coat of grease. Align the dowel pin hole with the dowel pin. Tap lightly with a rubber hammer. Install cap screw and lock washers and torque to 45 to 50 foot-pounds [6,2 a 6,9 kg./m.]. Refer to Par. D-52 for pulley repair.

d. Position that gasket and assembled water pump and pulley on the studs in the gear cover. Attach with nuts and lock washers.

D-74. Install Pistons and Connecting Rods

a. Lubricate the piston rings with clean oil.

b. Turn compression rings so the opening on No. 1 is 90 degrees from No. 2, which in turn is 90 degrees from No. 3, which would be turned 90 degrees from No. 4. The openings on the oil rings should be turned 180 degrees from each other.

c. Compress rings with a ring compressor. Install the assembly with the open end of the connecting rod toward the injection pump side, and the wrist pin parallel to the crankshaft. Push down carefully so that rings will not be damaged.

d. Turn the crankshaft until the upper rod bearing can be seated squarely in the journal. Check the number on the bearing cap to see that it corresponds to the number of the connecting rod. Assemble the cap to the rod with connecting rod bolt and torque to 50 foot-pounds [6,9 kg./m.].

e. After installing the three piston assemblies, turn the crankshaft several times. This should center the connecting rod on the crankshaft and wrist pin. For piston and connecting rod disassembly, repair, and assembly, refer to Par. D-37 through D-41.

D-75. Oil Pressure Control Valve

a. Position the oil pressure control valve on the studs in the block. Attach with nuts and lock washers.

b. Install the oil pressure sensing unit in the oil pressure control valve.

c. Refer to Par. D-48 for valve repair.

D-76. Install Suction Tube and Oil Pan

a. Position the suction tube support clamp on the studs in the bottom of the block. Attach with nuts and lock washers. Position the gasket and assembled suction screen and tube on the oil pump cover. Attach with screws and lock washers. Position the clamp around the suction screen and tube assembly, holding it to the support clamp. Attach with bolts, nuts, and lock washers.

b. Coat the oil pan gasket with sealing compound. Position the gasket and oil pan on the studs in the block. Attach with nuts and lock washers.

c. Position a ring in the dipstick tube opening in the oil pan. Insert the dipstick tube assembly into the opening. Position the clamp support on the studs in the side of the block. Attach with nuts and lock washers. Secure the clamp around the dipstick tube assembly and on the clamp support. Attach with a bolt, nut, and lock washer.

d. Install the gasket and drain plug in the oil pan.

-77. Install Cylinder Heads

- . To install, place the head gasket over the dowel in on the cylinder liner. Be sure all water passages are in line with liner passages.
- . Install the head in the same position as when removed.
- . Lower the head to the liner. If dowel pins do not line up with dowel pin holes in the head, use a tool to rotate liner until dowel and dowel hole are in line.
- . Torque heads to 125 foot-pounds [17,2 kg./m.] by torquing each nut 25 foot-pounds [3,4 kg./m.] at a time in a criss-cross manner. Torque in sequence shown in Fig. 6.
- . Refer to Par. D-42 through D-44 for head disassembly, repair, and assembly.

-78. Install Exhaust Manifold

Position the gaskets and exhaust manifold on the studs in the block. Attach with nuts and lock washers.

-79. Install Water Manifold

Position the gaskets and water manifold on the studs in the heads. Attach with nuts and lock washers. Connect the water hose to the elbow in the assembled water manifold.

-80. Install Fuel Injection and Leak-off Lines

- . Position the assembled leak-off line along the injection nozzles and nozzle holders. Attach to the holders with hollow screws and gaskets. Connect the swivel on the other end of the leak-off return line to the opening in the fuel injection pump.
- . Connect each injection line to an injection nozzle and holder. Make sure the cylinders are connected to the proper opening on the injection pump. Facing the injection side of the engine, the front left injection pump fitting is connected to the left or first cylinder, the center rear fitting on the pump is connected to the middle cylinder, and the right front fitting on the pump is connected to the right or third cylinder. Torque the injection line nuts to 10 to 25 foot-pounds [2,8 to 3,4 kg./m.].

-81. Install Alternator

- . Position the spacers and the alternator bracket on the studs in the block. Attach with nuts and lock washers.
- . Position the adjusting strap on the stud in the block. Attach with a nut and lock washer.
- . Position the alternator on the alternator bracket. Attach with bolts, lock washers, plain washers, and nuts. Position the adjusting strap on the alternator. Attach with a bolt, lock washer, and plain washer.

-82. Install Fuel Filter and Line

- l. Position the fuel filter on the studs in the block. Attach with nuts and lock washers.

- b. Connect the filter-to-pump fuel line to the inlet of the injection pump and to the elbow at the outlet of the filter.

D-83. Install Starting Motor

Position the starting motor on the studs in the flywheel housing with the pinion gear of the starting motor engaging the ring gear on the flywheel. Attach the starting motor with nuts and lock washers.

D-84. Install Blower

- a. Rotate the drive shaft by hand before installing blower. It must turn easily.
- b. Position the gasket and assembled blower and pulley on the block. Attach with bolts and lock washers. Torque the bolts evenly.
- c. Position the assembled idler hub and shaft on the studs in the blower housing. Attach with nuts, lock washers, and plain washers. Do not tighten the nuts.
- d. Position the gasket and the air intake manifold on the studs in the blower housing. Attach with nuts and lock washers.

D-85. Install and Adjust Belts

- a. Position the idler pulley toward the engine. Install the belt around the inner portion of the crankshaft pulley and over the idler and blower drive pulleys.
- b. Install the blower pulley on the hub of the blower stud drive shaft. Attach with bolts and lock washers.
- c. Install the alternator drive belt over the alternator, water pump, and outer portion of the crankshaft pulleys.
- d. Position the fan on the water pump pulley. Attach with bolts and lock washers.
- e. Adjust the idler bracket pulley until the blower drive pulley has a 14 foot-pound [1,9 kg./m.] slip. Do not overtighten these belts. Properly adjusted, they will not have any flutter at 2600 rpm. If flutter is observed, retighten belts. Tighten nuts when belt is adjusted.
- f. Adjust the alternator drive belt (Par. C-12).

D-86. Install Oil Cooler and Filter

- a. Position the oil filter and bracket on the oil cooler mounting bracket. Attach with nuts and lock washers.
- b. Position the gaskets and assembled oil cooler and filter on the studs in the block. Attach with nuts and lock washers.
- c. Position the hose on the oil cooler outlet. Attach with the clamp.
- d. For disassembly, repair, and reassembly of oil cooler and filter, refer to Par. D-45 through D-47.

D-87. OIL SYSTEM**D-88. Check Oil Pumping System**

- a. Check for normal oil level in crankcase. Remove oil filter and ball valve in cooler.

b. Crank engine. If oil flows out of hole, the oil cooler, oil pick-up line, and oil strainer are all in operating order.

c. If oil does not flow, engine must be overhauled.

D-89. Check Flywheel Housing Breather

Check crankcase breathing system by removing oil breather cap and cleaning any oil from outside of engine. If oil continues to leak 1/2 hour after removing breather cap, the oil seal or crankshaft bearing surface is defective. If leak stops, clean breather cap with solvent and air.

D-90. Gasket or Oil Seal Leak

a. Tighten the nuts around the oil leak.

b. If leak continues, remove part, clean mating surfaces carefully, and install a new gasket.

D-91. CHECK COMPRESSION

a. Low compression may be caused by crankshaft and connecting rod bearing wear. To check, remove the exhaust manifold, crank the engine by hand until the piston bottoms, and place a 3-3/4" [9,52 cm.] long piece of resin core soldering lead on the top of the piston. Place along the center line of the piston pin.

b. Crank the engine by hand one-quarter revolution or just enough to compress lead. Check the thickness of the compressed lead with a micrometer.

c. A reading above 0,041" [1,041 mm.] indicates bearing wear. A reading of 0,050" [1,270 mm.] indicates that the engine must be overhauled.

d. Remove the exhaust manifold. Examine four of the six rings on any given piston through the port opening, using a suitable light. Each ring is slightly chamfered and if ring wear has progressed to the point where the ring face is flat and the area of contact is not visible, replace the rings. Broken rings may be detected by carefully pressing with a screwdriver to determine if the ring will spring back after being pushed back into the groove. Failure to spring back indicates a broken ring.

e. Check the manifold for exhaust blockage. Excessive blockage will cause undue back pressure on the engine and seriously reduce performance. Back pressure should be no greater than 1-1/2" [3,81 cm.] of Mercury.

f. Remove the exhaust manifold and check with a light to see if the cylinder liner is deeply scored. If necessary, refer to Par. D-22 and D-71 for directions on removal and installation of new cylinder liners.

D-92. FUEL SYSTEM

D-93. Check Blower

Remove the blower belt and turn the blower by hand. Contact spots can be felt and defective bearings or seals are also noticeable during rotation.

If check is inconclusive, remove the intake manifold and screen and check the blower rotors for shiny spots. If wear is visible, remove the blower and install a new one. Check seals on the ends of the rotors. If oil leakage is visible, remove the blower and replace with a new one.

D-94. Check Fuel Pump

Crank the engine with the starting motor. Loosen the connection of the return line at the fuel pump and watch for the flow of clear fuel from the connection. Loosen the nut connections on the injector nozzles and crank the engine until the fuel flow from the nozzle is clear. Tighten all connections and torque nuts in injection lines to 20 to 25 foot-pounds [2,8 a 3,4 kg./m.].

D-95. Replace Cylinder Head Gasket

Water leakage between the cylinder head and the cylinder liner or the presence of exhaust gases in the radiator indicates a blown head gasket. The head gasket can be replaced without a major overhaul.

a. Disconnect the fuel line at the injection nozzle and holder. Disconnect the glow plug wire from the glow plug.

b. Drain the radiator until the coolant level is below the cylinder heads.

c. Remove the cylinder head nuts and carefully jar the cylinder head with a rubber hammer to break it loose from the cylinder liner.

d. Use extreme care not to dent or scratch the bearing surface on the cylinder head. Use a piece of hard wood or copper to scrape the gasket from the head. Surface must be absolutely clean before installing a new gasket.

e. Install a new gasket on the top of the cylinder liner with the side containing graphite facing down toward the liner. Be sure all water passages are lined up correctly with the gasket.

f. Position the head on the cylinder liner so that the dowel pin holes line up with the dowel pins in the cylinder liner. Carefully rotate until the cylinder head seats on the dowel pins.

g. Torque the head nuts to 120 to 125 foot-pounds [16,5 a 17,2 kg./m.] in the sequence shown in Fig. 6. Torque each nut in 25 foot-pounds [3,4 kg./m.] stages.

h. Connect the glow plug wire and the injection line. Refill the radiator to the correct level. Crank the engine with the starting motor and bleed the fuel lines (Par. D-94).

D-96. Retorque Nuts

After the engine has run 30 minutes, retorque. Retorque again after 6 hours running. Failing to retorque heads as prescribed will result in gasket failure.

D-97. SERVICE DIAGNOSIS

Engine Fails to Turn

Starting Switch Inoperative
 Battery Too Low to Turn Engine
 Starting Motor Inoperative
 Water in Cylinder
 Internal Seizure

Engine Turns But Will Not Start or Starts Hard

Lack of Fuel
 Safety Switch Not Working
 Defective Glow Plugs
 Defective Supply Pump
 Defective Fuel Pump or Governor
 Blower Belts Broken or Slipping
 Engine Oil Too Heavy
 Intake or Exhaust System Clogged
 Low Compression
 Incorrect Compression Ratio

Engine Does Not Develop Full Power

Water in Fuel
 Fuel Oil Filter and Strainer Clogged
 Air Cleaner Clogged
 Poor Fuel
 Injection Pump Not Properly Timed
 Injection Pump Not Operating Properly
 Injectors Not Functioning Properly
 Blower Not Functioning Properly
 Cylinder Head Gasket Leaking
 Defective Coupling in Drive Train
 Exhaust Back Pressure Too High
 Rings Worn or Broken

Engine Running

Air in Fuel System
 Faulty Injector
 Incorrect Timing of Injection Pump
 Supply Pump Defective
 Governor Defective
 Low Compression
 Gummy or Sticky Injection Pump
 Coolant Temperature Below Normal

Engine Knocks

Air in Fuel System
 Poor Grade of Fuel or Water in Fuel
 Injection Pump Timing Incorrect
 Incorrect Engine Temperature
 One or More Cylinders Misfiring
 Carbon Deposits in Combustion Chamber
 Loose Connecting Rod

Engine Misses

Air in Fuel Pump
 Poor Fuel
 Injection Nozzle Valve Dirty
 Insufficient Air to Engine
 Blower Not Operating Correctly

Low Compression

Cylinder Head Gasket Leaking
 Rings Worn, Broken, or Cracked
 Cylinder Sleeves Worn

Excessive Oil Consumption

Oil Level in Crankcase Too High
 Oil Seals or Gaskets Leaking
 Piston Rings Not Seating
 Piston Rings Worn or Broken
 Cylinder Sleeves Worn

Low Oil Pressure

Defective Gauge
 Oil Level Low
 Oil Diluted
 Oil Cooler Bypass Valve Defective
 Main Oil Gallery Bypass Defective
 Oil Cooler Clogged
 Oil Pump System Defective
 Worn Crankshaft
 Worn Bearings

Engine Overheats

Faulty Gauge
 Insufficient Water in Cooling System
 Water Hose Collapsed
 Fan and Water Pump Belt Slipping
 Cooling System Clogged
 Defective Thermostat
 Water Pump Defective
 Engine Overloaded

Engine Smokes Black

Not Enough Air
 Fuel Pump Out of Time
 Injector Nozzle Dirty

Engine Smokes White

Low Engine Temperature
 Incorrect Injection Pump Timing
 Low Compression

Engine Smokes Blue

Too Much Oil in Crankcase
 Engine Oil Diluted
 Worn or Badly Scarred Cylinder Liner

Engine Too Cold

Faulty Gauge
 Thermostat Defective
 Low Air Temperature

Engine Speed Runs Away

Oil Seal in Blower Leaking

D-98. ENGINE SPECIFICATIONS

	SPECIFICATIONS	METRIC
ENGINE:		
Type	Diesel	
Number of Cylinders	3	
Bore	4"	10,16 cm.
Stroke	4-1/2"	11,43 cm.
Piston Displacement	170 cu. in.	2786,30 cm ³
Firing Order	1-2-3	
Compression Ratio	22 to 1	
Compression Pressure	650 psi.	45,695 kg./cm.
Horsepower (SAE)	19.2	
Horsepower (max. brake @ rpm)	85 @ 3000	
Maximum Torque (16 ft lb @ rpm)	170 @ 1900	
Idle Speed	500 rpm	
PISTONS:		
Material	Aluminum Alloy	
Description	Cam Ground, Keystone Wedge Slot, Surface Treated	
Length	5-1/2"	13,97 cm.
Diameter (near bottom of skirt; right angle to pin)	3.9905" to 3.9920"	10,1358 a 10,1396 cm.
Crown-to-Cylinder Head Clearance	0.0310" to 0.0420"	0,787 a 1,066 mm.
Piston Parallelism	0.000" to 0.0030"	0,000 a 0,0762 mm.
Weight (piston only)	50 oz.	1,42 kg.
Skirt Clearance	0.0043" to 0.0053"	0,109 a 0,134 mm.
Side Clearance in Groove:		
Compression Rings	0.006" max.	0,152 mm. max.
Oil Ring	0.0025" max.	0,0635 mm. max.
Groove Depth/Dia:		
Compression Ring	3.3550" to 3.5630"	8,521 a 9,050 cm.
Compression Rings (#2, 3, 4)	3.587" to 3.595"	9,110 a 9,131 cm.
Oil Rings (#5, 6)	3.562" to 3.572"	9,047 a 9,072 cm.
Piston Pin Bore	1.6262" to 1.6268"	4,1305 a 4,1320 cm.
Cylinder Liner Bore	4.000" to 4.005"	10,160 a 10,172 cm.
Liner Bore Out-of-Round	0.0008" max.	0,0203 mm. max.
Ring Groove Width:		
Compression Ring (#1)	0.0882" to 0.0866"	2,240 a 2,199 mm.
Compression Ring (#2)	0.1014" to 0.1024"	2,575 a 2,600 mm.
Compression Ring (#3, 4)	0.0965" to 0.0975"	2,451 a 2,476 mm.
Oil Ring (#5, 6)	0.1880" to 0.1890"	4,775 a 4,800 mm.
PISTON RINGS:		
Function:		
Rings #1, 2, 3, 4	Compression	
Rings #5, 6	Oil	
Material:		
Compression #1	Cast Iron, Chrome Plated Face	
Compression #2, 3, 4	Cast Iron	
Oil #5, 6	Cast Iron	
Gap:		
Compression #1	0.020" to 0.040" at 6 to 9 lb. load	0,508 a 1,016 mm. at 2,72 a 4,08 kg. load
Compression #2, 3, 4	0.013" to 0.023" at 6 to 9 lb. load	0,330 a 0,584 mm. at 2,72 a 4,08 kg. load
Oil #5, 6	0.013" to 0.023" at 12.6 to 19 lb. load	0,330 a 0,584 mm. at 5,71 a 8,61 kg. load
Thickness:		
Compression #1	0.142" to 0.152"	3,606 a 3,860 mm.
Compression #2, 3, 4	0.145" to 0.155"	3,683 a 3,937 mm.
Oil #5, 6	0.177" to 0.187"	4,495 a 4,749 mm.
Side Clearance in Groove:		
Compression Rings #1, 2, 3, 4	0.006" max.	0,152 mm. max.
Oil Rings, #5, 6	0.0025" max.	0,0635 mm. max.

D-98. ENGINE SPECIFICATIONS (Continued)

	SPECIFICATIONS	METRIC
CRANK PINS:		
Material	Alloy Steel SAE 8620	. . . . .
Length	3.240" to 3.250"	8,229 a 8,255 cm.
Diameter	1.6247" to 1.6250"	4,1267 a 4,1275 cm.
Type	Piston shrunk on: retaining ring positioned	. . . . .
CONNECTING RODS:		
Material	Steel	. . . . .
Weight	71.42 oz.	3,57 kg.
Length (center to center)	9.185" to 9.187"	23,329 a 23,334 cm.
Bearing:		
Type	Removable, tab located	. . . . .
Material	Tri-metal	. . . . .
Over-all Length	1.340" to 1.350"	3,403 a 3,429 cm.
Clearance Limits	0.0015" to 0.0035"	0,0381 a 0,0889 mm.
Bore Inner Diameter Torqued	3.067" to 3.068"	7,7901 a 7,7927 cm.
Out-of-Round	0.002" max.	0,0508 mm. max.
rod Bushing, ID	1.6280" to 1.6274"	4,1351 a 4,1335 cm.
CRANKSHAFT:		
Main Bearing, Insert Thickness	0.1552" to 0.1557"	3,942 a 3,954 mm.
Running Clearance	0.0015" to 0.0035" (0.0035" max.)	0,0381 a 0,0889 mm. (0,0889 mm. max.)
End Thrust Clearance	0.004" to 0.012"	0,1016 a 0,3048 mm.
Run-out Between Centers	0.0003" max.	0,0076 mm. max.
Main Journal Diameter	3.500" to 3.4993"	8,890 a 8,888 cm.
rod Journal Diameter	2.8712" to 2.8705"	7,2928 a 7,2910 cm.
Out-of-Round	0.002" max.	0,0508 mm. max.
CYLINDER SLEEVE LINER:		
Bore, 1.3 Inches Below Top	4.000" to 4.005"	10,160 a 10,172 cm.
Out-of-Round, Installed	0.0008" max.	0,0203 mm. max.
ROCK:		
Main Bearing Bore	3.812" to 3.813"	9,6825 a 9,6850 cm.
Out-of-Round	0.001" max.	0,0254 mm. max.
Alignment	0.0005" max.	0,0127 mm. max.
Cylinder Liner Cavity Out-of-Round	0.00015" max.	0,0038 mm. max.
Counterbalance Bushing Interference	0.001" to 0.003" in Case	0,0254 a 0,0762 mm. in Case
CRANK HOUSING BORE:		
Concentricity with Crankshaft	0.006" max.	0,152 mm. max.
ROTOR:		
Clearance between Rotor Lobes in Tee Position	0.0087" to 0.0063"	0,2209 a 0,1600 mm.
rod End Clearance, Drive End Rear	0.0087" to 0.0063" 0.0039" to 0.0031" 0.0028" to 0.0016"	0,2209 a 0,1600 mm. 0,0990 a 0,0787 mm. 0,0711 a 0,0406 mm.
rod to Housing		
VALVE GEAR:		
Timing Gears, Backlash	0.0020" to 0.0050"	0,0508 a 0,1270 mm.
Oil Pump Drive Gear, Backlash	0.0030" to 0.0050"	0,0762 a 0,1270 mm.
VALVE HOUSING:		
Run-out at Rim	0.0000" to 0.0060"	0,0000 a 0,1524 mm.
Run-out at Seal	0.0000" to 0.0030"	0,0000 a 0,0762 mm.
Squareness with Crankshaft	0.0000" to 0.0080"	0,0000 a 0,2032 mm.
VALVE:		
Squareness	0.0000" to 0.0075"	0,0000 a 0,1905 mm.
Run-out	0.0000" to 0.0015"	0,0000 a 0,0381 mm.
VALVE:		
Port Closing, Injection Starts	31° BTC	

FUEL SYSTEM

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E-1. GENERAL

The fuel system consists of the fuel tank, fuel lines, fuel injection pump, nozzles, filter, and air cleaner. It is most important to keep the fuel system clean and free from water. It should be periodically inspected for leaks.

CAUTION: Whenever a vehicle is to be stored for an extended period, the fuel system should be completely drained; add a suitable preservative.

E-2. INJECTION PUMP

The Cerlist engine is equipped with a vertically mounted Roosa fuel injection pump timed for the end of injection. The Roosa Master pump is a single-cylinder, opposed plunger, inlet metering, distributor-type pump combined with a rotary vane-type transfer pump and an integral governor. The pump and governor are both lubricated by fuel oil and require no other lubrication.

The injection pump drive is mounted on the left side of the engine toward the rear. It consists of a housing which encloses and supports a spiral gear which, in turn, engages a driving gear on the engine balancer shaft.

The injection pump drive shaft is keyed to the spiral gear. It extends vertically through the housing, and the male coupling end engages the internal rotor of the Roosa pump.

E-3. Primary Fuel Pressure

Since the Roosa Master injection pump is a primary metering pump, control of the primary fuel pressure is extremely important. For this reason, the transfer pump and its associated regulating sleeve,

piston, and spring in the end plate are carefully matched to the engine, its characteristics, and the type of engine application. Fuel delivery or primary pressure is not constant through the engine speed range, but follows a pre-established curve ranging from a few psi at cranking speeds to over 100 psi [7,03 kg./cm²] at full speed. This factor also emphasizes the importance of maintaining the fuel supply system in good condition. A partially plugged filter or tank outlet valve, fuel containing wax or thickened material, or a heavily loaded fuel filter element will definitely interfere with primary fuel pressure control.

E-4. End Plate Operation

The end plate, pressure regulating valve, priming by-pass spring, and strainer are shown in Fig. 48. In the "at rest" position, the piston covers the hand priming port (A) and rests against the priming by-pass spring.

During priming, the pressure differential across the transfer pump forces the piston down, compressing the spring until the priming port (A) is uncovered. Fuel then bypasses the stationary transfer pump to fill the system.

When the engine is in operation, fuel forces the piston up the sleeve until the regulating port or ports (B) are uncovered. Since the pressure on the piston is opposed by the regulating spring, the delivery pressure of the transfer pump is controlled by the spring rate and size and number of regulating ports.

E-5. Pump Operation

Fuel under transfer pump pressure is forced through the drilled passage in the hydraulic head

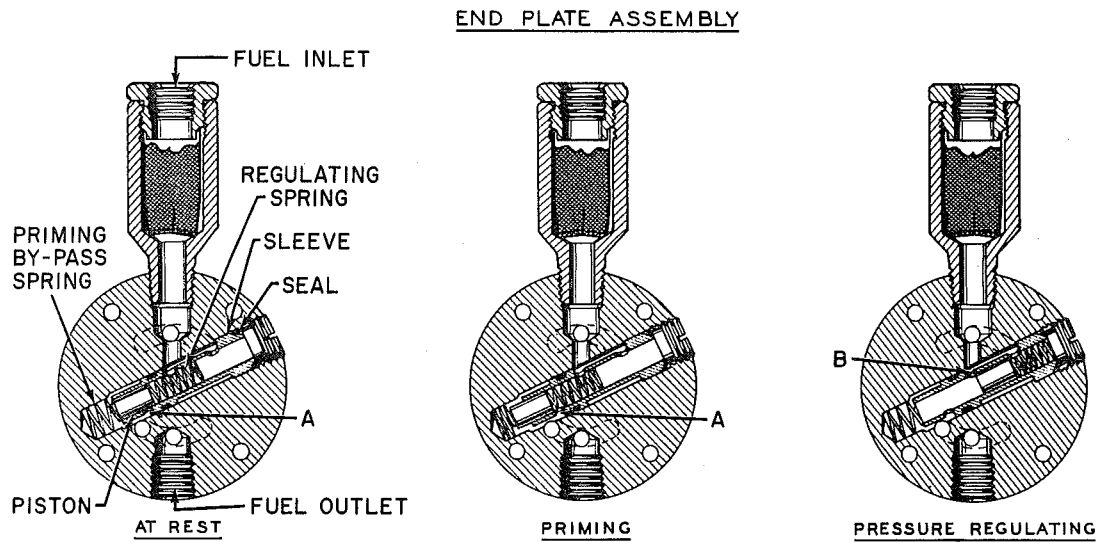


FIG. 48—END PLATE OPERATION DIAGRAM

to the annulus as shown in Fig. 49. It then flows around the annulus to the top of the sleeve and through a connecting passage to the metering valve. The rotary position of the metering valve, controlled by the governor, regulates the flow of fuel into the charging ring, which incorporates charging ports.

As the rotor revolves, its single charging hole registers with one of the charging ports in the hydraulic head. Fuel at transfer pump pressure flows through the angled passage to the pumping cylinder. The in-flowing fuel forces the plungers outward a distance proportionate to the amount of fuel injected on the following stroke.

At idling, only a small amount of fuel is admitted into the pumping cylinder, as at idling, the plungers move very little. As additional fuel is admitted, the plunger stroke increases to the maximum, limited by the leaf spring adjustment.

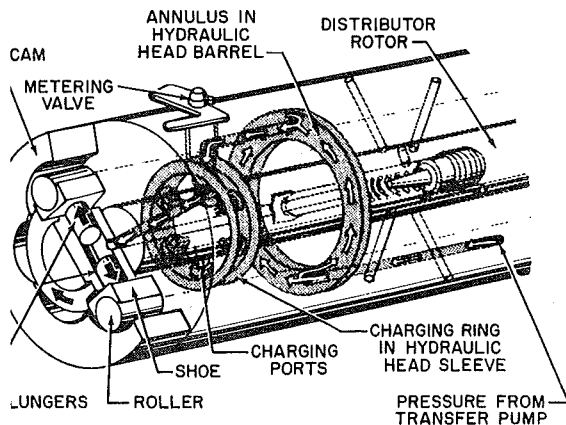


FIG. 49—CHARGE CYCLE SCHEMATIC

At this point (charging) of the cycle, the rollers are in the "valley" or relieved part of the cam between the lobes. The fuel is briefly trapped in the cylinder after charging is complete because the rotor charging port has passed out of registry with the head port and the rotor discharge port has not yet come into registry with an outlet port in the hydraulic head.

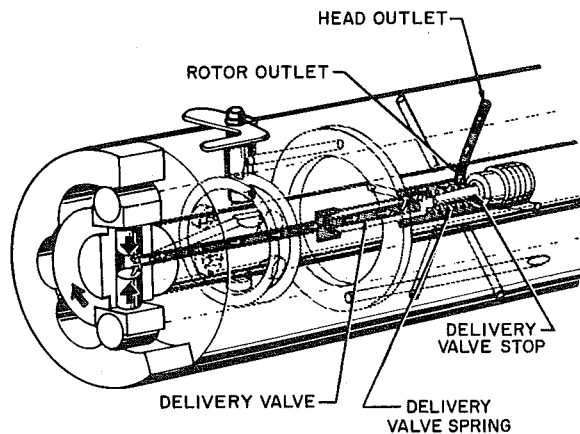


FIG. 50—DISCHARGE CYCLE SCHEMATIC

Further rotation of the rotor brings its discharge port into registry with an outlet port of the head as shown in Fig. 50. At this point, the rollers simultaneously contact the opposing cam lobes and the plungers are forced toward each other. The fuel trapped between the plungers is forced from the pump through one of the outlet ports to an injection line.

The pump for this engine employs a special and unique design for the hydraulic head and distributor rotor assembly. Because of its high speed (3000 rpm full load, 3150 rpm high idle), the head and rotor design allows the pump to be driven at one-half engine speed, even though used with a two-cycle engine. It can be seen from Fig. 51 that the distributor rotor discharges twice during each complete pump revolution. A pumping stroke occurs every 60 degrees of rotor rotation, even though all three discharge outlets are 120 degrees apart

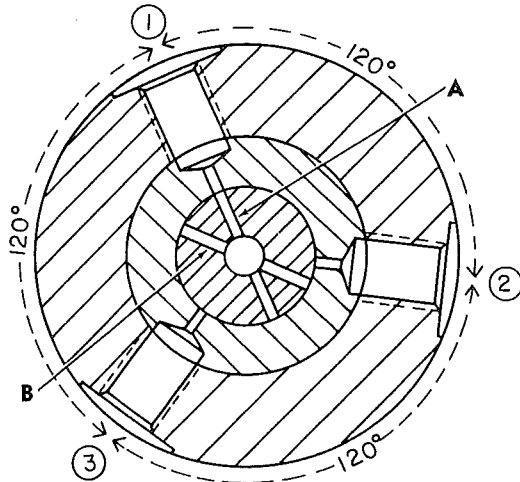


FIG. 51—HYDRAULIC HEAD AND ROTOR ASSEMBLY END VIEW

on the hydraulic head. This is accomplished because the distributor rotor incorporates two discharge ports (A and B, Fig. 51) although only one pump at a time. Referring to Fig. 51, discharge port A has pumped to outlet port Number 1 as the rotor turns in a clockwise direction. Port B in the rotor will next discharge to outlet port Number 3, 60 degrees after port A completes delivery to the Number 1 outlet port.

NOTE: The cam ring used on this hydraulic head and rotor assembly has six lobes.

Pump lubrication is an inherent characteristic of the Roosa Master design. As fuel at transfer pump pressure reaches the charging ring, slots on the rotor shank allow fuel and any trapped air to bleed to a reduced diameter on the shank. This fuel fills the pump housing cavity and acts as a coolant and lubricant, since it is allowed to return to the supply tank through the oil return connection in the pump housing cover. This return line also carries out any air trapped in the fuel or originally contained in the pump.

In addition, an air bleed arrangement incorporated in the hydraulic head connects the outlet side of the transfer pump with the pump housing cavity. This allows air carried into the endplate to be bled back to the fuel tank through the return line.

E-6. Delivery Valve Operation

The delivery valve rapidly decreases the injection line pressure after injection to a predetermined point, which is lower than that of the nozzle opening pressure. This pressure reduction causes the nozzle valve to return rapidly to its seat, achieving sharp delivery cutoff and preventing any dribble of fuel into the combustion chamber.

The simply constructed delivery valve is located and operates in a bore in the center of the distributor rotor as shown in Fig. 52. It requires no seat, only a shoulder to limit travel. Sealing is accomplished by the long, closely-fitted bore into which it fits.

Since the same delivery valve performs the retraction for each line, the retracted amount will not vary from cylinder to cylinder. This results in an extremely smooth-running engine at all loads and speeds.

When injection starts, fuel pressure moves the delivery valve slightly out of its bore and adds the volume of its displacement section (A) to the enlarged cavity of the rotor occupied by the delivery valve spring. This displaces a similar volume of fuel in the spring cavity before delivery through the valve ports.

At the end of injection, the pressure on the plunger side of the delivery valve is quickly reduced by dropping the cam rollers into the retraction step on the cam lobes. Cam retraction value is always equal to, or slightly more than, delivery valve retraction value.

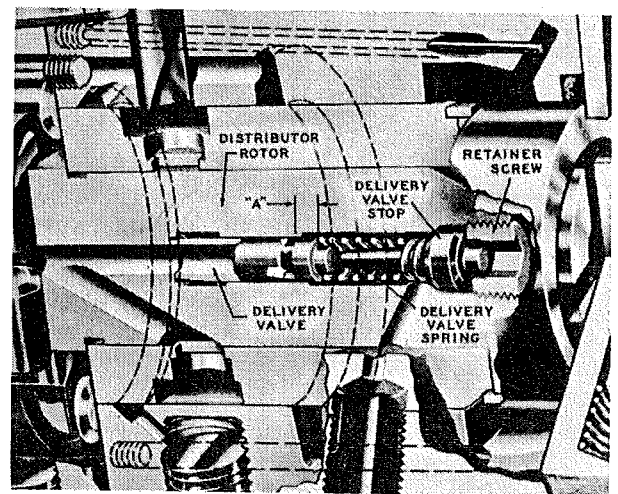
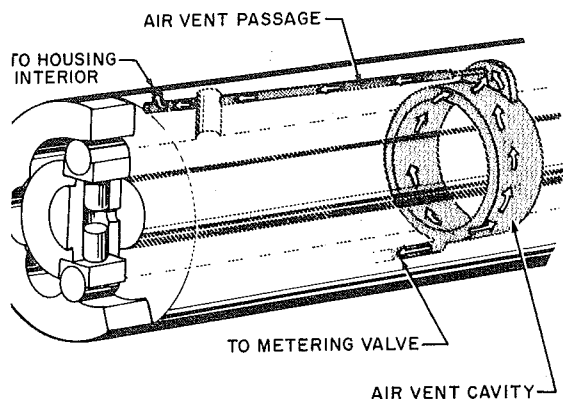


FIG. 52—DELIVERY VALVE SCHEMATIC

As the valve returns to its closed position, it removes its displacement section (A) from the spring cavity. Since the rotor discharge port is still partly in register, fuel rushes back out of the injection line to fill the volume left by the retreating delivery valve. The rotor ports close completely and the remaining injection line pressure is blocked off.



G. 53—RETURN FUEL CIRCUIT SCHEMATIC

g. Return Fuel Circuit

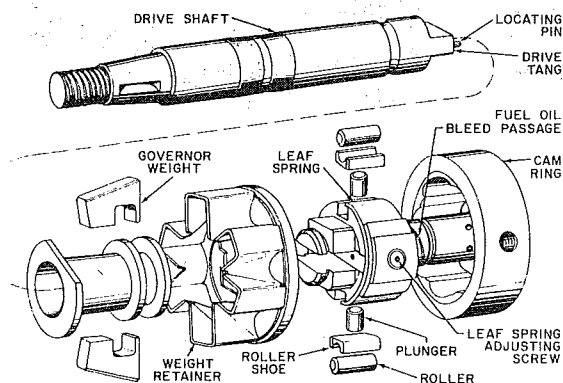
Oil under transfer pump pressure is discharged through the slot in the discharge area of the transfer pump liner into a cavity in the hydraulic head as shown in Fig. 53. The upper half of this cavity connects with a longitudinal passage, the volume of which is restricted by a vent wire to prevent undue pressure loss.

The vent passage passes around the metering valve and connects with a short vertical passage entering the governor linkage compartment.

Oil entering the transfer pump because of suction-side leaks immediately passes to the air vent cavity and then to the vent passage as shown in Fig. 53. Air and a small quantity of fuel then pass from the housing to the fuel tank through the return passage.

h. Governing

In the centrifugal governor, the movement of the flyweights against the governor thrust sleeve rotates the metering valve. This rotation varies the registry of the metering valve slot with the passage to the rotor, thus controlling the flow of fuel to the engine. The governor parts are shown in Fig. 54.



G. 54—INJECTION PUMP GOVERNOR PARTS

This type of governor derives its energy from the centrifugal action of the flyweights pivoting on this outer edge in the retainer. Centrifugal force tips them outward. The governor thrust sleeve moves against the governor arm, which pivots on the knife edge of the pivot shaft, and is connected through a simple positive linkage to the metering valve. The centrifugal force on the governor arm is balanced by the compression-type governor spring, which is manually controlled by the throttle shaft linkage in regulating engine speed. A light idle spring provides more sensitive regulation at the low-speed range. Throttle travel limits are set by adjusting screws for proper idling and high-speed positions.

A light-tension spring allows the stopping mechanism to close the metering valve without overcoming the governor spring force. Only a very light force is required to rotate the metering valve to the closed position.

E-9. Automatic Advance Circuit

The design of the injection pump incorporates a hydraulic servo-mechanism, powered by oil pressure from the transfer pump, to rotate the normally stationary cam ring to advance the injection timing. Transfer pump pressure operates the advance piston against spring pressure as required along a predetermined timing curve. The automatic advance also aids in cold starting as it retards timing during cranking.

Controlled movement of the cam in the pump housing is induced and limited by the action of the power and spring pistons of the automatic advance against the cam advance screw. During cranking, the cam is in the retard position, since the force exerted by the advance springs is greater than that of the transfer pump pressure. As the engine speed and transfer pump pressure increase, oil entering the advance housing behind the power piston moves the cam. Any amount of advance may be predetermined, but total limit of travel is 14 pump degrees.

E-10. Electrical Shutoff

The electrical shutoff supplied in the injection pump is designed for energized-to-run operation. When the solenoid frame is deenergized, the coil releases the armature, allowing the armature spring to move the armature away from the coil. The lower end of the armature moves the governor linkage hook, rotating the metering valve to the closed position and cutting off the flow of fuel.

E-11. Torque Control

Torque is commonly defined as the turning moment or "lugging ability" of an engine. Maximum torque varies at each speed in the operating range for two reasons:

- a. As engine speed increases, friction losses progressively increase.
- b. Combustion chamber efficiency drops due to loss of volumetric efficiency (breathing ability of an

engine) and due to reduction of time necessary to burn the fuel in the cylinder completely and cleanly. Since torque increases with overload conditions, a predetermined point at which maximum torque is desired may be selected for any engine. Thus, as engine rpm decreases, the torque increases toward this preselected point. This desirable feature is called "torque backup."

In the Roosa injection pump, three basic factors affect torque backup. These are the metering valve opening area, time allowed for charging, and transfer pump pressure curve.

E-12. Disassemble Injection Pump

Numbers in parentheses refer to Fig. 55. Install the pump on a holding fixture (Roosa #13363). Hold the fixture in a vise.

a. Remove the cover screws (1), lock washers (3), and washers (2) that attach the governor control cover (9) to the pump housing (124). Remove the governor control cover and gasket (10). Remove the cover contact nuts (6), grounding eyelet (5), and insulating washers (8) that attach the solenoid frame (12) to the governor control cover. Remove the solenoid frame and insulating tube (11). Remove the arm spring (13) and coil arm (14). Remove the connector (7) from the governor control housing.

b. Rotate the shutoff cam (15) to the fully shutoff position (cam horizontal). Place a tool (Roosa #13339) between the pump housing and the governor link hook (16) and pry gently, sliding the cam out of its groove and off the throttle shaft (116).

c. Withdraw the assembled shutoff shaft (32). Remove the screw (33), screw (34), and washers (35) and (36).

d. Slide the throttle shaft lever (134) off the throttle shaft (116) and withdraw the throttle shaft from the housing. Remove the screw (120) and retainer (119) that attach the adjustable throttle lever (117) to the throttle shaft. Remove the adjustable throttle lever and spring (118). Remove the throttle shaft seal washers (29) and (115), seals (28) and (114), and spacers (27) and (111).

NOTE: Identify the side on which the throttle shaft is assembled to aid in assembly.

e. Hold the assembled governor control spring (132), idling spring guide (18), spring retainer (131), and idling spring (130) firmly between the thumb and forefinger. Loosen and remove the guide stud (86) and washer (87). Lift out the assembled governor control spring, idling spring guide, spring retainer, and idling spring.

f. Depress the metering valve (128) and raise the governor link hook (16) at the metering valve end to clear the pin of the metering valve arm (19). Pull the link hook back slightly to disengage it from the governor arm (133) and place it over the side.

g. Remove one retaining nut (21) and seal (20) and withdraw the pivot shaft (110) from the housing. Remove the remaining nut (113) and seal (112).

Remove the governor arm, link hook, and governor linkage spring (17) from the housing.

h. Remove the metering valve arm (19), shim (129), metering valve (128), and spring (127). Remove the two head locking screws (22) and (109) from the housing.

i. Invert the pump and mounting fixture in the vise. Make sure the end plate faces the mechanic. Remove the plug (38) and seals (39) from the power piston side of the housing. Remove the cap (103), nut (102), seal (101), and adjusting screw (100) from the plug (99). Remove the plug (99), spring guide (98), seals (97), outer advance spring (95), and inner advance spring (96) from the spring piston side of the housing. Remove the spring piston (94) and slide washer (93). Note the flat on the side of the spring piston. This prevents hydraulic lock of the spring piston and differentiates the spring piston from the power piston. Push against the cam advance screw (90) through the opening in the housing from which the spring piston was removed. Remove the power piston (41) and slide washer (42). Remove the plug (92), seal (91), and cam advance screw (90). Remove the head locating screw (88) and seals (89). Return the unit to an upright position. Grasp the assembled hydraulic head assembly (43 through 85) firmly in both hands and withdraw with a slight rotary motion.

NOTE: Take care not to drop the governor weights (44) and (85).

j. Disassemble the governor by inverting the hydraulic head assembly and letting the weights, governor thrust sleeve (43), and slide washer (42) fall into the other hand.

k. Place the hydraulic head assembly on the pump holding fixture so that the governor weight retainer (46) engages the bar on the fixture. Remove the end plate screws that attach the end plate (70) to the hydraulic head and rotor assembly (52). Remove the end plate.

l. Remove the end plate plug (63) and use a dull scribe to remove the seal (64) on the end plate sleeve (67). Insert the end plate sleeve retractor (Roosa #13301) in the 1/8" [3,175 mm.] hole in the top of the sleeve and withdraw the sleeve carefully with a rotary motion. Remove the regulating piston (66) and regulating spring (65) from the bore of the sleeve. Hook the spring (69) with the end plate retractor and withdraw the spring and sleeve seal (68) from the end plate. Place the end plate in a soft-jawed vise and remove the cap and filter (62), filter cap seal (61), pipe plug (72), and seal (73).

m. To disassemble the transfer pump, remove the transfer pump seal (60); lift out the transfer pump liner (58) and blades (74).

n. Loosen and remove the delivery valve retaining screw (56). Lift the head and rotor assembly and shake the valve stop (55), spring (54), and delivery valve (53) into the hand. If the delivery valve sticks in the bore, use delivery valve retractor tool (Roosa #13383) to remove the valve.

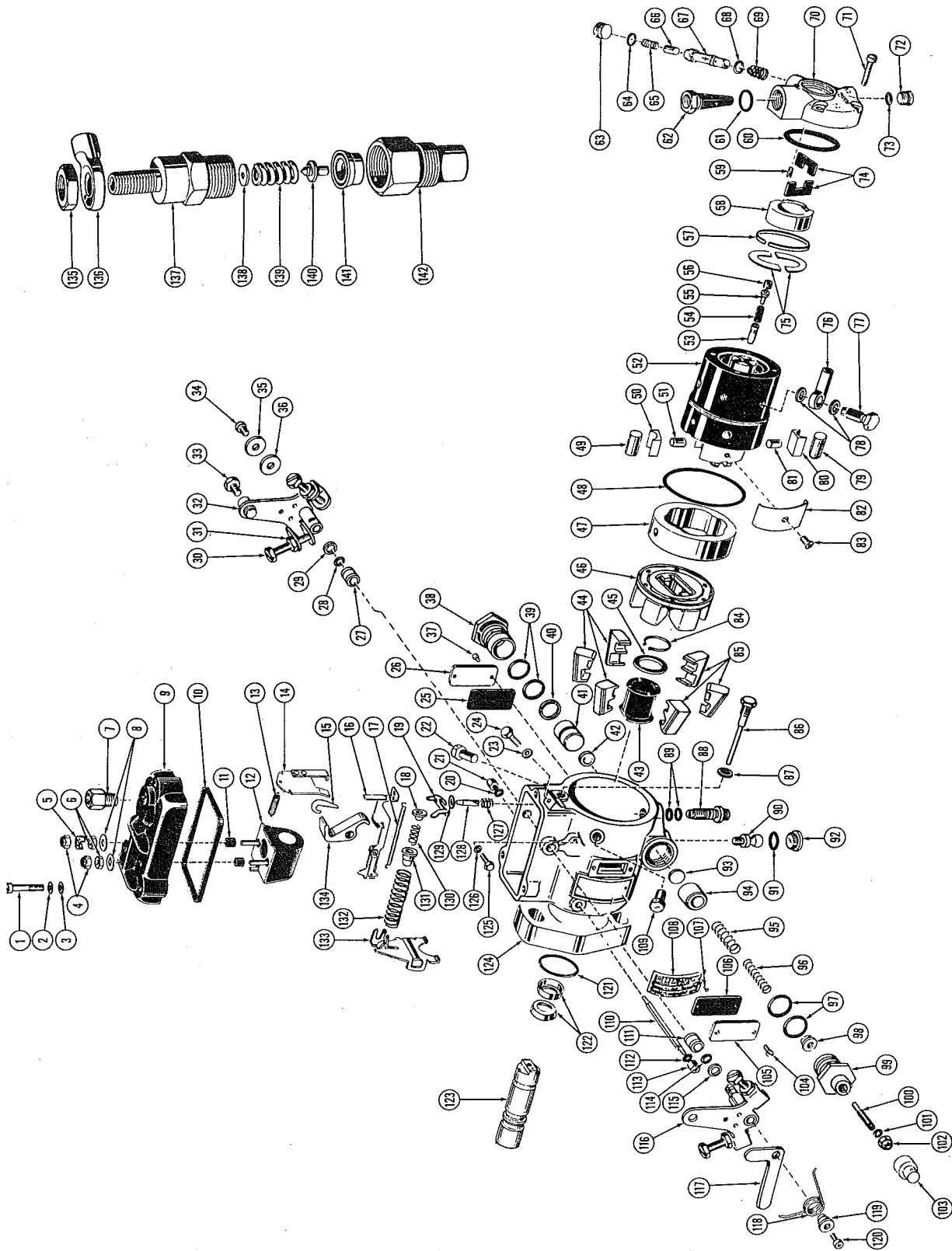


FIG. 55—INJECTION PUMP, EXPLODED VIEW

LEGEND FOR FIG. 55—INJECTION PUMP, EXPLODED VIEW

1—Cover Screw	33—Screw	70—End Plate	107—Screw
2—Cover Screw Washer	34—Screw	71—Screw	108—Name Plate
3—Lock Washer	35—Washer	72—Pipe Plug	109—Screw
4—Lock Nut	36—Washer	73—Seal	110—Pivot Shaft
5—Grounding Eyelet	37—Screw	74—Transfer Pump Blade	111—Spacer
6—Nut	38—Plug	75—Rotor Retainer	112—Seal
7—Connector	39—Seal	76—Connector	113—Nut
8—Insulating Washer	40—Piston Ring	77—Screw	114—Seal
9—Governor Control Cover	41—Power Piston	78—Washer	115—Washer
10—Gasket	42—Slide Washer	79—Cam Roller	116—Throttle Shaft
11—Insulating Tube	43—Thrust Sleeve	80—Cam Roller Shoe	117—Adjustable Throttle Lever
12—Solenoid Frame	44—Governor Weight	81—Rotor Plunger	118—Spring
13—Shut-Down Arm Spring	45—Washer	82—Leaf Spring	119—Retainer
14—Coil Arm	46—Weight Retainer	83—Adjusting Screw	120—Screw
15—Shutoff Cam	47—Cam Ring	84—Retaining Ring	121—Seal
16—Governor Link Hook	48—Head Seal	85—Governor Weight	122—Seal
17—Governor Linkage Spring	49—Cam Roller	86—Guide Stud	123—Drive Shaft
18—Idling Spring Guide	50—Roller Shoe	87—Washer	124—Pump Housing
19—Metering Valve Arm	51—Rotor Plunger	88—Screw	125—Screw
20—Pivot Shaft Seal	52—Hydraulic Head and Rotor Assembly	89—Seal	126—Washer
21—Retaining Nut	53—Delivery Valve	90—Cam Advance Screw	127—Spring
22—Screw	54—Valve Spring	91—Seal	128—Metering Valve
23—Washer	55—Valve Stop	92—Plug	129—Shim
24—Screw	56—Retaining Screw	93—Washer	130—Idling Spring
25—Gasket	57—Retaining Ring	94—Spring Piston	131—Spring Retainer
26—Timing Line Cover	58—Transfer Pump Liner	95—Outer Advance Spring	132—Governor Control Spring
27—Throttle Shaft Lever Spacer	59—Roll Pin	96—Inner Advance Spring	133—Governor Arm
28—Throttle Shaft Seal	60—Transfer Pump Seal	97—Seal	134—Throttle Shaft Lever
29—Seal Washer	61—Filter Cap Seal	98—Spring Guide	135—Nut
30—Adjusting Screw	62—Cap and Filter	99—Plug	136—Banjo Fitting
31—Nut	63—Plug	100—Adjusting Screw	137—Nozzle Holder Body
32—Shutoff Shaft	64—Sleeve Seal	101—Seal	138—Spacer
	65—Regulating Spring	102—Nut	139—Pressure Spring
	66—Regulating Piston	103—Cap	140—Spindle and Seat
	67—Sleeve	104—Screw	141—Intermediate Spacer
	68—Sleeve Seal	105—Cover	142—Nozzle Nut
	69—Spring	106—Gasket	

o. Use a small blade screwdriver or a dull scribe to disengage and remove the retaining ring (57). Move the rotor retainers as far outward as possible to clear the rotor. Gently lift the hydraulic head so that the transfer pump rotor is flush with the inner face of the hydraulic head. Remove the rotor retainers. Lower the head to its former position.

NOTE: The rotor is now not retained in the head. Do not let the rotor or head slip apart during the following steps.

p. Place the hydraulic head assembly in the pump holding fixture and remove the retaining ring (84) that attaches the weight retainer (46) to the head assembly. Remove the weight retainer and cam ring (47).

q. Move the rollers to their extreme outward position and record the dimension from the outside

of one roller to the outside of the other. Record this dimension for use during reassembly.

r. Remove the adjusting screw (83) that attaches the leaf spring (82) to the head and rotor assembly. Remove the leaf spring from the rotor, and the cam rollers (49) and shoes (50) from their slots. Remove the plungers.

NOTE: Take care not to drop or damage the plungers.

s. Withdraw the distributor rotor from the head assembly.

CAUTION: Do not handle the rotor shank. Use a tool to withdraw the rotor.

t. Remove the screws (37) and (104) that attach the timing line covers (26) and (105). Remove the timing line covers and gaskets (25) and (106).

Remove the screws (24) and (125) and washers (126) and (126).

13. Inspect and Repair Injection Pump

TE: Dirt is the greatest enemy of the fuel injection pump. Keep the work area and pump parts clean.

Clean injection pump parts in a suitable solvent and then place them in a clean pan containing fresh oil or calibrating oil.

Discard all seals and gaskets.

Examine all springs for fretting, wear, distortion, or breakage.

Clean and carefully check all bores, grooves, and seal seats for damage or wear of any kind.

Inspect the transfer pump blades carefully, looking for chipping on any edges, scoring or scratching, pitting, imbedded foreign particles, or wear on rounded ends. Determine wear by measuring length with a micrometer. The length must exceed 1.0930" [2,776 cm.] or the blade should be replaced. Inspect the flat surfaces visually for scoring. Blades must be replaced in pairs.

While holding the rotor under clean oil, insert plungers into their bores. Hold the guide slots closed with the thumb and forefinger and tilt the rotor from side to side several times to check for free movement. If free movement is not obtained, reverse the plungers in the slots. The rotor plungers are matched with the rotor and a reversal position (end-to-end or slot-to-slot) may give free movement. If the plungers stick but are not visibly damaged, clean both plungers and rotor bore with a soft brush and lacquer-removing solvent. Do not force the plungers into the bore. Inspect plungers for wear, imbedded foreign particles or dirt, nicks, chipping, scratching, or scoring.

TE: Do not handle the rotor shank.

Inspect the radii of the rotor that is contacted by the leaf spring; check the tang slot and the weight retainer drive on the large end for excessive wear. Check all rotor and head assembly slots and charging and discharging ports for chipping of edges or dirt; check the rotor shank for scratches. Check heads for damage. If damage or excessive wear is apparent, replace the head and rotor as a mated unit.

Check each roller in its shoe for freedom of rotation, and the top edge of each shoe, where retained by the leaf spring, for chipping, scratching, or excessive wear. Improved roller surfaces will result from long, normal operation in clean fuel oil.

Check the leaf spring for wear at points where the spring contacts the radii on the rotor, and along the steps that retain the roller shoes. Check for foreign matter, rust, scratching, scoring, cracks, or distortion.

Examine the drive shaft pilot tabs in the weight retainer hub, the retainer sockets where the weights

pivot, and the pivot points of all weights for wear, rust, nicks or chipping, scratching, scoring, cracks, or distortion. If damage is noted, replace the complete retainer as a unit. Similarly inspect weights.

k. Inspect the pivot points of the governor control arm and pivot shaft. Examine the control arm fork where it contacts the thrust sleeve. If wear is in excess of 0.003" [0,0762 mm.], discard and replace. Examine the metering valve pin hole in the link hook, the spring retainer, throttle shaft lever, and shutoff cam. Check the function of the throttle and shutoff shaft assemblies for looseness. Examine parts for rust, nicks or chipping, cracks, and distortion. Check for damaged threads on the pivot shaft.

l. Check the metering valve body for wear. Be sure the metering valve arm is well seated and there is no radial movement of the arm on the valve. Check the metering valve for imbedded foreign material or rust, nicks or chipping, scratching, scoring, and freedom of movement. Check the metering valve spring for breakage or distortion, and the metering valve arm pin for wear at its point of contact with the link hook.

m. Since only the working portions of the lobes on the inside diameter of the cam ring are ground, the tool marks between lobes should not be considered as damage. The cam ring finish is mottled from heat treatment rather than operation. Carefully inspect the inside diameter and edges of all flat surfaces. If there is evidence of spalling or flaking out, replace with a new cam ring. Improved cam ring lobe finish will result from long, normal operation in clean fuel oil. Inspect for rust, nicks or chipping, scratching, scoring, or cracks.

n. Check the regulating piston of the end plate for freedom of movement in the sleeve. Check all threads in the end plate for damage and check the face of the end plate for excessive wear due to end thrust of the transfer pump rotor. Inspect the inlet screen of the cap and filter for damage; all dirt or rust must be removed from the assembly. Do not attempt to remove the liner locating roll pin (59, Fig. 55) unless obviously damaged. Inspect the sleeve for imbedded foreign material or rust. Inspect the regulating piston for wear, imbedded foreign material or rust, nicks, chipping, scratching, or scoring. Inspect the end plate plug and cap and filter for damaged threads.

o. Inspect the transfer pump liner for excessive wear in the inside diameter. Inspect for imbedded foreign material or rust, nicks, chipping, scratching, or scoring.

p. Inspect the thrust sleeve and washer for excessive wear, imbedded foreign material or rust, nicks, chipping, scratching, scoring, cracks, or distortion.

q. Inspect the pump housing for excessive wear, imbedded foreign material or rust, nicks, chipping, scratching, scoring, thread damage, cracks, or distortion.

r. Check the housing for fretting or scores in the automatic advance piston bore, foreign material or rust in the fuel passages, and damage to the seal

seats. Inspect both spring and power pistons for wear, especially on the ends. Inspect the slide washers for roughness. Remove any high spots on the piston ends and slide washers by carefully rubbing with a flat India stone. Check the cam advance screw for wear and replace if necessary.

s. Examine visually for cracks and swelling in the encapsulating material and looseness of the contact screws. Check the solenoid for a complete circuit with an ohmmeter.

E-14. Assemble Injection Pump

Thoroughly flush all parts in clean oil as they are being reassembled. Cleanliness will contribute to long life and trouble-free operation. Replace all seals and gaskets, whether visibly damaged or not. Numbers in parentheses refer to Fig. 55.

a. Insert the priming bypass spring (69) in its bore in the end plate (70) with the closed coil end upward. Be sure this spring is seated correctly in the bottom of the bore. Improper seating will make hand priming of the pump impossible.

b. Place the regulating piston (66) in the end plate sleeve (67) and hold between the thumb and forefinger. Shake slowly to ascertain complete freedom of the piston. The piston should slide freely by its own weight.

c. Install the sleeve seal (68) on the sleeve. Hold the end plate in a horizontal position and sight down the inlet bore to make certain the lower sleeve seal does not catch and tear on any sharp edges. Carefully insert the sleeve, with regulating piston, into its bore with a slight rotary motion. Apply clean mineral grease to the seal to aid in assembly. Wring into seat using the sleeve retractor tool (Roosa #13301). If the sleeve has been removed for any reason, while the pump is mounted on the engine, insert the regulating piston after the sleeve is installed to prevent it from falling out of the lower end.

d. Install the regulating spring (65) and the top sleeve seal (64); seat the seal carefully on top of the end plate sleeve. Assemble and tighten the end plate plug (63) to 50 to 60 inch-pounds [0,575 a 0,690 kg./m.].

e. Install the filter cap seal (61) and cap and filter (62). Tighten the cap and filter to 240 inch-pounds [2,76 kg./m.]. Install the seal (73) and pipe plug (72). Tighten the pipe plug to 360 inch-pounds [4,14 kg./m.].

f. Refer to Par. E-13 for instructions on inserting the rotor plungers (51) and (81) in the bores of the rotor.

g. Flush the hydraulic head and distributor rotor thoroughly in clean oil and assemble, under oil, with a slight rotary motion. Under no circumstances should any force be used. Do not handle the rotor shank with the fingers, but do hold fingers over the plungers so they will not drop out. This procedure will prevent possible damage and ease assembly.

h. Place the hydraulic head and rotor assembly (52) in the holding fixture (Roosa #13363) and assemble the leaf spring (82). Attach with the adjusting screw

(83). Apply a little clean grease on the edges of the leaf spring hole before assembly to make adjustment easier. Insert the cam rollers (49) and (79) and shoes (50) and (80) and check for freedom of movement. Set the roller-to-roller dimension (maximum fuel adjustment) at $1.9710'' \pm 0.0005''$ [50,063 mm. $\pm 0,0127$ mm.] as directed in step i.

i. Apply clean, dry air (30 to 100 psi [2,10 a 7,03 kg./cm²]) to any one of the head outlets by means of a suitable fitting. Rotate the rotor until the rollers are pushed to the extreme outward position by the air pressure. Using a 1" to 2" [2,54 a 5,08 cm.] micrometer, measure the roller-to-roller dimension (outside of one roller to outside of other roller). To set the roller-to-roller dimension to that required in the pump specification, turn the leaf spring adjusting screw inward (clockwise) to increase travel, and outward (counterclockwise) to reduce travel using the socket screwdriver (Roosa #13336).

NOTE: This setting provides a completely accurate maximum fuel setting and it should not be altered from the specification.

j. Place the cam ring (47) on the hydraulic head with the directional arrow indicating the direction of pump rotation facing upward. Remember that pump rotation is always expressed as viewed from the drive end. The pump will not deliver fuel with incorrect assembly of the cam ring. The injection pump rotor turns clockwise.

k. Place the governor weight retainer (46) in position over the drive on the distributor rotor. Make sure the assembly marks on the weight retainer and the distributor rotor line up with each other. Assemble the retaining ring (84) to its groove with the assembly pliers (Roosa #13337).

l. While holding the assembled head and rotor assembly and weight retainer carefully together so the rotor will not fall out, invert the entire unit so that the governor weight retainer engages the bar on the holding fixture.

m. Install the delivery valve (53), making sure that it operates freely in its bore. Install the delivery valve spring (54) and delivery valve stop (55). The retaining screw (56) internal hex has one end which is slightly relieved to clear the delivery valve stop. Be sure it faces down. Start the screw using the hex end of the delivery valve retractor tool (Roosa #13383). Finish tightening with a torque wrench; torque to 85 to 90 inch-pounds [0,997 a 1,035 kg./m.].

n. Insert the two rotor retainers (75) by lifting the head up slightly so that the inside face of the head is flush with the rotor end. Position the retainers with the outer sleeve of the retainer ring installation tool (Roosa #13375) and install the retaining ring (57).

o. Insert the transfer pump liner (58) so that the large slot is in line with the head locating screw hole, and the letter signifying correct pump rotation faces up. This will correctly position the liner locating slot to accept the locating pin (59) in the

l plate (70). Carefully place the transfer pump ides (74) in their slots in the transfer pump rotor. With one finger, rotate the liner several times to it for binding. Return liner to correct position. Insert the transfer pump seal (60) and mount the l plate so that the inlet fitting is in line with the metering valve bore. The locating pin (59) will w line up with the locating slot in the liner. If use are 180 degrees out of alignment, check the d plate for correct location of the pin as to pump ation (C and CC are marked on the outside of end plate). Attach the end plate with the screws); torque to 25 to 30 inch-pounds [0,287 a 0,345 /m.].

Slip the head and rotor assembly, drive end up, o the open end of the holding fixture. Place the : governor weights (44) and (85) in their sockets h the slots facing the bore of the assembly. Place : governor sleeve thrust washer (45) against the vernor thrust sleeve so that the chamfered edge es the sleeve. Insert the forefinger into the bore the sleeve and washer, holding them together, d insert them into the slots of the governor ights by tilting the weights slightly back. The tab the thrust sleeve flange should face upward. ht across the tops of the assembled weights to certain correct positioning. One weight higher n the others indicates incorrect assembly of the ust washer.

Place the governor arm (133) in position with : fork for the governor link hook (16) facing the d plate. Insert the pivot shaft (110) with the knife ge facing the end plate and assemble the two seals) and (112) and cap nuts (21) and (113). Torque : cap nuts simultaneously to 20 to 25 inch-pounds .230 a 0,287 kg./m.].

Install a new seal (48) on the hydraulic head. tate the cam ring so that the unthreaded hole is line with the metering valve bore. This will ure proper positioning of the cam. Apply a light n of clean grease around the inside edge of the ising to aid in assembly. Assemble the hydraulic ad and rotor assembly, including the transfer np, cam ring, governor weight retainer, weights, vernor thrust sleeve, and washer into the housing. asp the hydraulic head firmly in both hands and ert it into the housing bore with a slight rotary tion. Do not force.

UTION: If the assembly should cock during in- tion, withdraw and start over. This is important cocking can cause particles of metal to be shaved the housing and left in the pump, causing serious age in operation.

UTION: When inserting, make sure the assembly turned into position past the hydraulic head seal. ilure to do this might cause damage to the seal, ulting in leakage. When the head and rotor are ally assembled in their approximate location, ate them until the head locking screw holes line with their corresponding holes in the housing. ach with the head locking screws (22) and (109) d tighten finger tight.

t. Invert the pump and fixture in the vise so the bottom faces upward. Before assembling the cam advance screw (90) and head locating screw (88), make certain the holes in the hydraulic head and cam ring match their corresponding holes in the housing. If necessary, adjust the cam position with the fingers. Assemble and tighten the cam advance screw to 400 inch-pounds [4,6 kg./m.].

NOTE: Place a small quantity of grease in each end of the seal groove and stretch the seal slightly to facilitate assembly.

u. Assemble the cam hole seal (91) and head locating screw seal (89). After rinsing the housing thoroughly in clean oil, place seals in position. If cam advance screw does not move freely, tap the pump housing sharply with a soft-faced hammer at several points to seat any small burs in the housing. Install the plug (92).

NOTE: For clockwise pumps, assemble the power piston and ball check from the C side of the housing.

v. Install the piston ring (40) on the power piston (41). Rinse the slide washers (42) and (93) and pistons (94) and (41) in clean oil and stick the washers to the pistons with clean grease. Slide both pistons into the advance bore, seating the slide washers squarely on the cam advance screw. Move the pistons back and forth to insure freedom of movement.

NOTE: Again check carefully to make sure the power piston is assembled on the C side of the housing. The spring piston has a flat on one side.

w. Insert the advance springs (95) and (96) into the spring piston bore. Assemble the seals (97) and spring guide (98) and plug (99) in the housing. Make sure the advance spring locates in the counter-bore of the plug. Install the adjusting screw (100), seal (101), and nut (102). Install the cap (103). Install the seal (91) on the cam advance screw. Install the plug (92). Install the seals (39) and plug (38) in the power piston bore.

x. Turn the pump on the mounting fixture upright in the vise. Tighten the head locating screws (22) and (109) to 360 inch-pounds [4,14 kg./m.] and the head locking screw (88) to 275 inch-pounds [3,16 kg./m.].

y. Place the metering valve spring (127) on the metering valve (128) and install the assembly into its bore. Depress and rotate the valve several times to insure freedom of movement. If the valve sticks, tap it in carefully with clean oil. Never sand or polish off the special surface treatment provided. Install the shim (129) and metering valve arm (19).

z. Pull back on the governor link hook (16), stretching the spring (17) just enough to assemble the hook correctly to the fork on the governor arm (133). Position the opposite end of the hook over the pin on the metering valve arm. Check all the governor parts again for freedom of movement.

aa. Assemble the governor control spring (132), spring retainer (131), idling spring (130), and idling spring guide (18) on the bench. Pick up between thumb and forefinger and engage the governor spring over the formed tabs on the governor arm. Insert the guide stud (86) and washer (87) through the tapped hole in the rear of the housing and into the idling spring guide, idling spring, spring retainer, and governor spring. Tighten the guide stud to 110 to 115 inch-pounds [1,26 a 1,32 kg./m.].

NOTE: The apparent looseness in the governor parts is normal. Lost motion is immediately taken up as soon as the pump rotates.

ab. Position the adjustable throttle lever (117), spring (118), and retainer (119) on the throttle shaft (116). Attach with the screw (120). Torque the screw to 35 to 40 inch-pounds [0,40 a 0,46 kg./m.]. Install the washer (115), lightly greased seal (114), and spacer (111) on the throttle shaft.

ac. Assemble the throttle shaft partially through its bore in the housing. Slide the throttle shaft lever (134) over the throttle shaft so that the projection on the throttle shaft lever bore engages the keyway on the shaft. Position the forked end of the throttle shaft lever so that it straddles the guide stud. Apply a light coat of grease to the throttle shaft seal (28). Install the seal washer (29), seal, and spacer (27) on the throttle shaft. Assemble the shutoff shaft (32) from the opposite side with a slight rotary motion, so as not to damage the seal; firmly seat the two shafts. Locate and seat the shutoff cam (15).

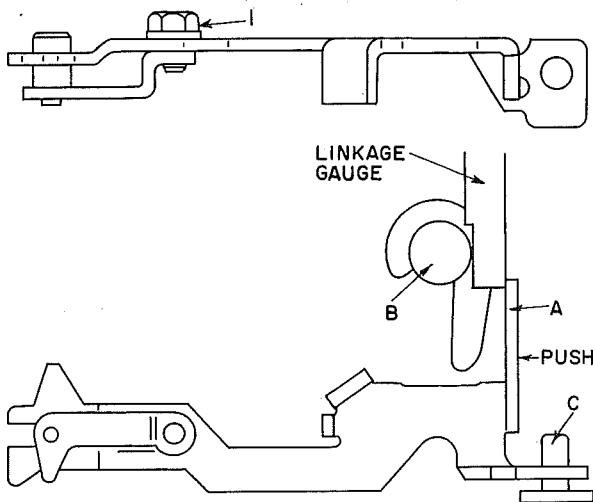
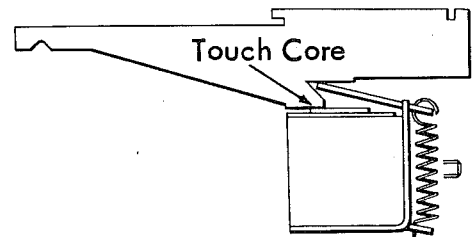


FIG. 56—GOVERNOR LINK HOOK ADJUSTMENT

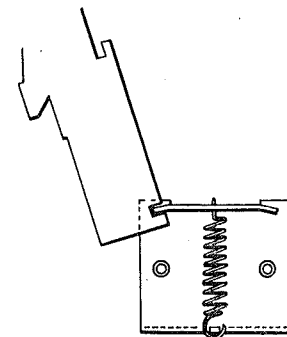
ad. With the throttle lever in wide open position and the screw (125) backed out, check the clearance between the rear of the shutoff shaft (B, Fig. 56) and the vertical tab (A) on the link hook. It should be 0.135" to 0.155" [3,429 a 3,937 mm.]. Adjust the clearance using linkage wrench (Roosa

#13379) by changing the effective length of the link hook. With adjusting screw (1) tight, apply a slight pressure to tab (A). At the same time, rotate the pump one or two complete revolutions to assure that linkage is in full forward position. Loosen adjusting screw (1) and slide link to maximum open length. Insert linkage gauge (Roosa #13389) between vertical tab (A) and shutoff shaft (B) and slide link hook together from rear until face of tab is flush against gauge. Tighten adjusting screw (1). Check adjustment and reset if required.

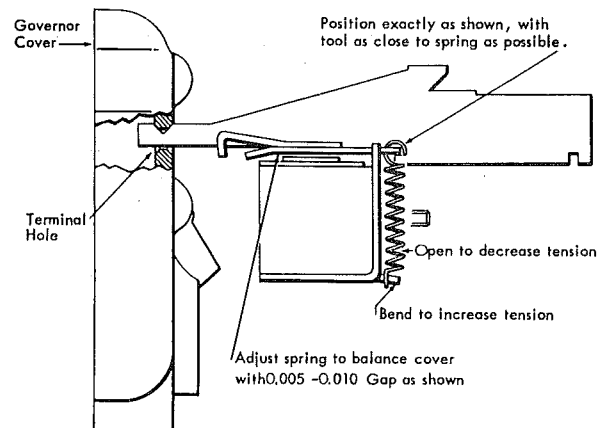
ae. Assemble the coil arm (14) and shut-down arm spring (13) to the solenoid frame (12). Before installing the solenoid assembly to the cover, adjust the arm travel and spring tension as shown in Fig.



A. CHECK ARM TRAVEL



B. ADJUSTING ARM TRAVEL



C. ADJUSTING ARM SPRING TENSION

FIG. 57—SOLENOID ARM ADJUSTMENT

Install new insulating tubes (11) on both contact screws. Apply a light coat of clean mineral grease to the tubes and insert the assembly into the governor control cover (9) as a unit. Replace the insulating washer (8) and assemble the contact nuts. Torque to 20 to 25 inch-pounds [0,230 a 0,287 /m.]. Install the grounding eyelet (5) and lock nuts. Mount the cover assembly, with a new cover bracket (10), to the pump. Attach with lock washers, washers (2), and screws (1). Torque the screws 40 inch-pounds [0,46 kg./m.].

Position the gaskets (25) and (106) and timing covers (26) and (105) on the housing. Attach the screws (37) and (104).

Install the screws (24) and (125) and washers (1) and (126).

15. Test Injection Pump

Conduct all tests using calibrating oil heated to 90° to 115°F [43,33° a 46,11°C.], and 12SD12 nozzles set to open at 2500 psi [175,75 kg./cm²]. Fresh, clean oil is all important for accurate testing and should be changed as often as excessive foam is noted.

A complete set of adapters for all models of the Master pump is available for commercial test benches.

Mount the pump securely on a test stand with an appropriate adapter.

Install high pressure injection lines using new copper gaskets. Leave fuel line connector screws on the pump and injection line nuts and nozzles loose.

Determine proper direction of rotation from pump name plate (C - clockwise, CC - counter-clockwise). Rotation is determined as viewed from drive end of the pump.

Start stand at lowest speed. Move the throttle to full load position. When the transfer pump picks up suction, allow fuel to bleed for several seconds from the loosened connector screws. Likewise, allow fuel to bleed from the loosened injection line screws. Tighten securely.

Operate the pump at full load rated speed for several minutes. Dry off completely with solvent and compressed air. Observe for leaks and correct as necessary.

Close the valve in the supply line. Transfer pump test pull at least 15" [38,1 cm.] of mercury [15 in. Hg]. If it does not, check for air leaks on the suction side or malfunction of the end plate and transfer pump parts.

Fill graduated cylinder to bleed air from the test stand and to wet the glass.

Observe the return oil. Return should be at the rate of 100 to 450 cc./min. at 35 psi [2,46 kg./cm²] transfer pump pressure.

Operate the test stand at full load speed (3000 rpm). Set counter for 1000 rpm. Divert fuel to the graduated cylinder. Record the reading. Difference between readings should not exceed 2 percent. Record transfer pump pressure.

j. Check and record full load fuel delivery and transfer pump pressure. Delivery should be 38 to 40 mm³ per stroke with transfer pump pressure at 70 to 73 psi [4,92 a 5,13 kg./cm²].

k. Check the electrical shutoff device with 24 volts connected at 400 rpm, 3000 rpm, and 3150 rpm. Obtain the 24 volts from a battery or series of batteries or from a battery charger that can be held with minimum droop during voltage application.

NOTE: Do not use a trickle charger. Do not attempt to check the solenoid with the cover removed from the pump.

NOTE: The pump must shut off when deenergized.

l. Adjust test stand speed to high idle speed (3150 rpm) and adjust the high idle screw (Fig. 58).

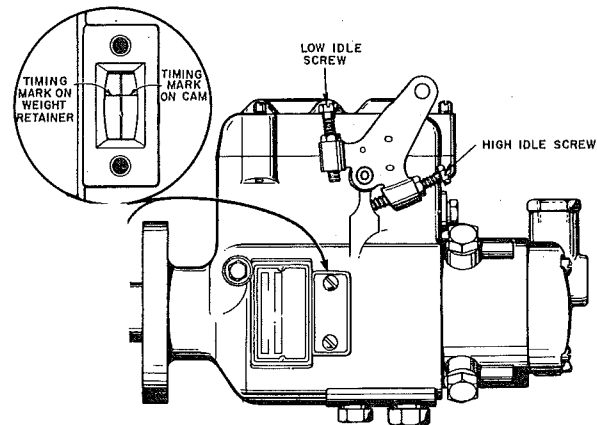


FIG. 58—TIMING MARK AND THROTTLE SCREW LOCATION

m. Set to low idle (500 rpm) (Fig. 58).

n. Check cam ring movement and reset, if necessary. Advance should be 6 degrees. Advance should start at 700 to 900 rpm and finish between 2200 and 2400 rpm.

o. Assemble all sealing wires. Wire the throttle lever in full fuel position for shipment or until installed on the engine.

E-16. INJECTION PUMP DRIVE

Two molded, cup-shaped oil seals are retained in intermediate grooves in the drive shaft. The shaft tang has a small off-center hole which coincides with a similar hole in the distributor rotor to indicate correct assembly. The shaft is installed in a housing that is cut out to allow the drive gear on the drive shaft to mesh with the gear on the balancer shaft in the engine. A thrust button in the housing is adjusted to position the drive gear to mate with the balancer gear with the correct backlash.

E-17. Disassemble Injection Pump Drive

- a. Remove the thrust button screw (Fig. 59), thrust washer, spring, and thrust button from the housing.
- b. Remove the screw and washer that attach the gear to the drive shaft. Remove the drive shaft from

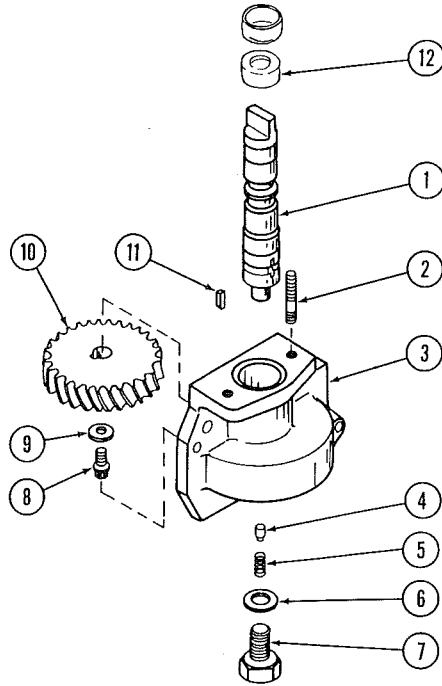


FIG. 59—INJECTION PUMP DRIVE, EXPLODED VIEW

- | | |
|-----------------|-----------------------|
| 1—Drive Shaft | 7—Thrust Button Screw |
| 2—Stud | 8—Screw |
| 3—Housing | 9—Washer |
| 4—Thrust Button | 10—Gear |
| 5—Spring | 11—Key |
| 6—Thrust Washer | 12—Seal |

the housing and gear. Remove the gear from the housing; remove the key from the drive shaft.

- c. Remove the seals from the drive shaft.

E-18. Inspect and Repair Injection Pump Drive

- a. Inspect the drive shaft for excessive wear and damage, particularly in the seal grooves, the tang end of the shaft, and the gear journal and keyway. Inspect the threads on the gear end for damage. Inspect the shaft for nicks, cracking, chipping, scratching, scoring, or distortion.
- b. Inspect the drive gear for excessive wear, nicks, chipping, scoring, or signs of wear in the keyway or bore.
- c. Replace the seals.
- d. Inspect the housing for wear in the bore, damaged threads, rust, scoring, or scratching in the bore, or distortion.

E-19. Assemble Injection Pump Drive

- a. Lubricate the shaft seals with light mineral grease and slide into grooves using the seal installation tool (Roosa #13371). The seals must face in opposite directions to separate external lubricant from fuel oil in the pump. Apply mineral grease liberally around the shaft between the two seals.
- b. Start the drive shaft into the housing, installing the key and gear on the shaft through the cutout in the housing. Attach the gear with a washer and screw.
- c. Position the thrust button on the bore of the housing. Install the spring. Install the washer and thrust button screw in the housing against the thrust button.

E-20. NOZZLE AND NOZZLE HOLDER

The nozzle holder serves to fix the nozzle in the cylinder head and connect it to the fuel injection line and the leak-off line. The nozzle is the pintle type

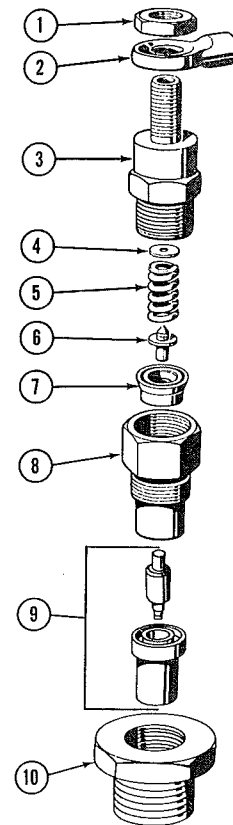


FIG. 60—NOZZLE AND NOZZLE HOLDER

- | | |
|----------------------|-----------------------|
| 1—Nut | 6—Spindle and Seat |
| 2—Banjo Fitting | 7—Intermediate Spacer |
| 3—Nozzle Holder Body | 8—Nozzle Nut |
| 4—Spacer | 9—Nozzle |
| 5—Pressure Spring | 10—Cap Nut |

The pressure at which the nozzle opens is determined by the pressure spring (Fig. 60) whose preloading can be varied by spacers. The pintle needle has a tapered lower end with a pintle extending through the opening in the nozzle body. The pressure of the fuel acts on the tapered end to lift the pintle out of the hole in the body, allowing the fuel under pressure to spray from the body opening. Fuel leaking around the nozzle needle is ported to the leak-off line. The nozzle body opening is designed to produce a spray pattern suited to the engine combustion requirement.

21. Servicing Injection Nozzles

If a nozzle is suspected of improper operation, a general test by allowing it to spray into the atmosphere while cranking the engine can be made. Experience is the best indication of what may be considered a satisfactory spray pattern. Ideally, the spray will leave the nozzle in the form of a cone, its termination will be clean, and the solid-appearing center core of the cone will be surrounded by a fog-like shroud in which the fuel is evenly atomized. Also, an apparent chattering of the spray is normal and is easily recognized. Actually, few nozzles will hold perfectly this pattern after a period of service. In many cases the fog area will be streaked with more or less solid portions of fuel and the cone shape will not be so symmetrical. These conditions, if confined within reasonable limits, are normal and cause little variation in actual engine performance. Under certain other conditions, such as dribbling, sprays that are badly distorted patterns, sprays projected sideways, or up, or down, from the nozzle, and other such self-evident troubles will cause trouble. The best remedy is replacement with another nozzle. However, a thorough cleaning and flushing with a solvent such as "Gunk" forced through with a manually operated nozzle tester may help. When handling injector nozzles, remember their precision construction and avoid striking the pintle, dipping in a vise, or similar abuses. When storing or shipping nozzles, always make a provision for moisture protection to prevent corrosion.

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

22. Disassemble Nozzle and Nozzle Holder

Remove the nut (Fig. 60) that attaches the banjo fitting for the leak-off line to the nozzle holder body. Remove the banjo fitting.

Remove the nozzle nut from the nozzle holder body. Remove the intermediate spacer, spindle and seat, pressure spring, and spacer from the nozzle holder body.

Remove the cap nut from the nozzle nut. Carefully withdraw the nozzle from the nozzle nut.

NOTE: Do not touch the lapped and ground surfaces of the nozzle needle. Hold the needle only by the

pressure spring end. It is of utmost importance to keep the parts of the nozzle and nozzle holder clean. Do not handle the parts. Keep the work area clean. Cover parts when not installed.

E-23. Inspect and Repair Nozzle and Nozzle Holder

a. Wash the nozzle body and needle in clean fuel oil. If the parts show carbon accumulations, clean them with a wood stick dipped in oil. Visually inspect the nozzle needle for a damaged or rough seat or for a worn or damaged injection pin. Visually inspect the nozzle body seat for damage or carbon. Use a magnifying glass and inspect the spray hole for out-of-round or damage. If damage is visible, replace both parts.

NOTE: The needle and body are a matched set and must be replaced as a pair.

b. Dip the needle in clean fuel oil and insert into the nozzle body. Holding the body almost vertically, pull the needle up about one-third of the engaged length. Hold the needle only by the pressure pin. Release the needle. It must slide down to the seat by its own weight.

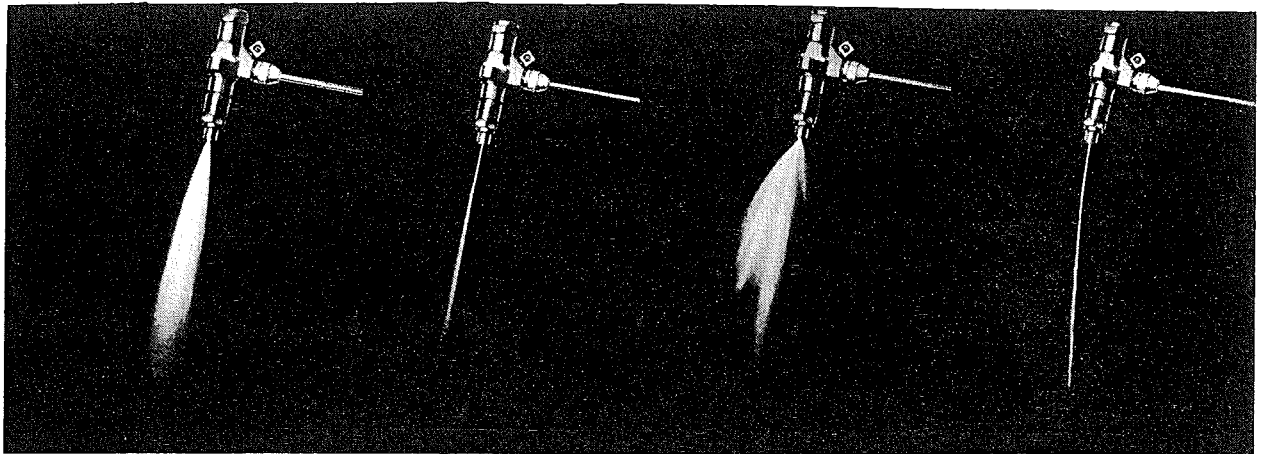
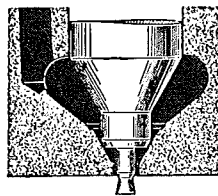
c. If a nozzle tester is available (Bosch #EP 8511/9), install the nozzle in the nozzle holder and test it for opening pressure, leakage, and chattering characteristics and spray pattern. When installing the nozzle in the nozzle holder, make sure the sealing surfaces are perfectly clean. Tighten the cap nut to 44 to 58 foot-pounds [6 to 8 kg./m.]. Press the lever of the tester down vigorously a few times to test for nozzle jamming. Bypass the pressure gauge when testing for jamming. If the nozzle needle is moving properly, the nozzle should chatter with a shrill whistling buzz.

d. With the pressure gauge open to pressure, slowly depress the hand lever until the nozzle ejects fuel with slight chattering. Take a reading on the pressure gauge of the opening pressure. If this is not 1750 psi [123,025 kg./cm²], change the shim thickness in the nozzle holder. Make sure the pressure is changed slowly or the gauge may be damaged.

NOTE: The spacers (4, Fig. 60) are supplied in 20 thicknesses with an increment variation of 0.05 mm. Check the parts manual for the correct spacer number.

e. Operate the hand lever of the nozzle tester until the pointer on the pressure gauge indicates 2215 psi [155,71 kg./cm²]. The nozzle is considered not leaking if a drop of oil does not emerge from the end of the nozzle in 10 seconds.

f. Bypass the pressure gauge of the tester in order to make this test. Operate the lever of the tester between one and two downward movements per second. Chatter ceases when test velocity is increased. The test oil then emerges with a hissing noise. If the lever movement is accelerated to between four and six downward movements per second, the nozzle chatters with a shrill whistle. Until

FULL-LOAD SPRAY
PATTERNIDLE SPRAY
PATTERNSPRAY RAGGED,
UNSATISFACTORYLEAKING NOZZLE VALVE,
UNSATISFACTORY

Closed

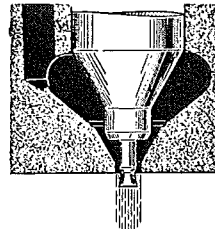
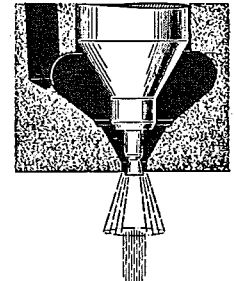
Slightly open
(preliminary spray)Fully open
(main spray)

FIG. 61—DELAY NOZZLE SPRAY PATTERN

the shrill whistling note is reached, the spray should emerge in streams. A divided or flag-like spray is without significance within this range. Accelerate the lever movement to four to six downward movements per second. The spray must then be compact and well atomized. The spray pattern desired is shown in Fig. 61.

WARNING: Fuel nozzle spray can penetrate deeply into the flesh of a hand or finger and will destroy tissue. Fuel entering the blood stream can cause blood poisoning. Keep hands and body out of range of fuel spray.

g. Inspect the parts of the nozzle holder for cracks, nicks, damaged threads, distorted spring, breaks, or rust. Clean all parts in clean fuel oil. Maintain cleanliness.

E-24. Assemble Injection Nozzle and Nozzle Holder

a. Test the nozzle and install in the cap nut. Make sure the sealing surfaces of the nut and nozzle are perfectly clean. Install the cap nut in the nozzle nut. Torque the nozzle nut to 44 to 58 foot-pounds [6 to 8 kg./m.].

b. Assemble the intermediate spacer, spindle and seat, spring, and spacer in the nozzle nut. Attach the assembly to the nozzle holder body. Position the banjo fitting on the stem of the nozzle holder body and attach with the nut.

E-25. INJECTION LINES AND LEAK-OFF LINES

Fuel line connections must be tight to prevent leakage. Any kinks in the fuel lines that might restrict the flow of fuel should be removed. If an excessive amount of dirt is found in the filter element, the fuel tank should be drained and the fuel lines blown out with compressed air.

E-26. AIR CLEANER

These vehicles are equipped with a dry type air cleaner. This cleaner thoroughly removes all dust from the air before it enters the air intake and blower. For efficient operation, the cleaner must be serviced at regular intervals. Service the unit according to conditions of vehicle operation. When using the vehicle regularly in extremely dusty conditions, the cleaner should be serviced daily. For regular highway travel, service the cleaner at each

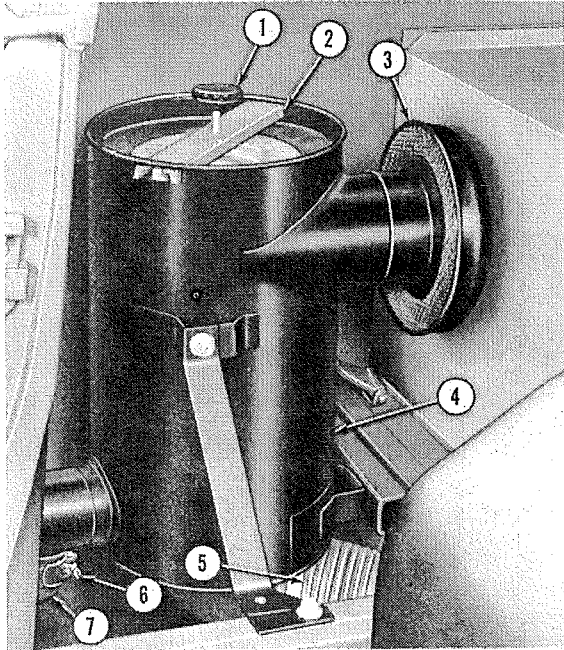


FIG. 62—AIR CLEANER

- | | |
|------------------------|------------------|
| -Screw | 5—Hose |
| -Retainer Bar Assembly | 6—Clamp Assembly |
| -Precleaner | 7—Dust Unloader |
| -Air Cleaner | |

engine oil change. To service the dust unloader, loosen the screw in the clamp assembly. Remove the upper dust unloader and shake and tap it in the inverted position to remove the dust accumulation. Clean the part clean and position it on the elbow of the air cleaner. Position the clamp assembly over the dust unloader and elbow; tighten the screw in the clamp assembly. To service the precleaner, remove the precleaner from the air cleaner intake. Wipe the precleaner clean and replace on the air cleaner intake. To service the air cleaner, turn the screw at the top of the retainer bar assembly until it is loose. Slide the retainer bar to the side and disengage it from the air cleaner; remove the bar assembly. Carefully lift the paper filter cartridge; take care not to shake loose dust particles into the clean area around the cartridge. Shake off accumulated dirt. Wash the cartridge with water and a non-sudsing detergent. Wipe off excess water and dry with a stream of low pressure compressed air. Wipe out the inside of the body with dry-cleaning solvent. Install the cartridge in the body. Position the retainer bar over the cartridge, with the bar extending through the body on both sides. Seat the cartridge firmly by tightening the screw at the top of the retainer bar assembly.

NOTE: Do not use oil on cartridge or precleaner.

Check the connection between the air cleaner and the blower opening. Check that the hose clamps are tight and the hose is in good condition.

E-27. FUEL FILTER

A fuel filter is mounted on the left side of the engine. It filters the fuel before it flows to the injection pump. The filter element is not cleanable and should be replaced every 1000 hours of operation. A drain is provided in the bottom of the filter.

E-28. Disassemble Fuel Filter

- Remove the elbow from the outlet of the fuel filter.
- Turn the screw at the top of the cap assembly that attaches the cap assembly to the center tube of the body. Remove the cap assembly, gasket, and element.
- Remove the bracket from the body. Remove the plug from the body and the drain cock from the cap assembly.

E-29. Inspect Fuel Filter

- Inspect the spring in the cap assembly for distortion, and threads in the cap assembly and in the center tube of the body for damage.
- Replace the element.

E-30. Assemble Fuel Filter

- Position the bracket around the body. Install the drain plug in the body and the drain cock in the cap assembly.

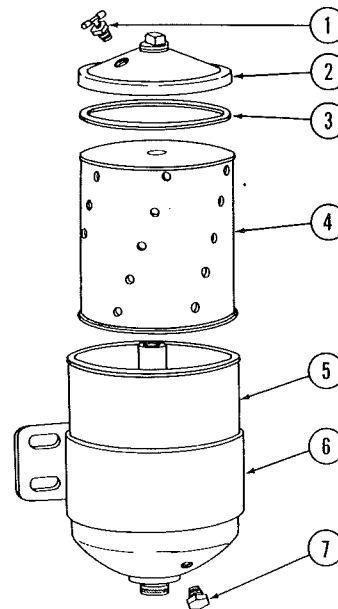


FIG. 63—FUEL FILTER, EXPLODED VIEW

- | | |
|----------------|--------------|
| 1—Drain Cock | 5—Body |
| 2—Cap Assembly | 6—Bracket |
| 3—Gasket | 7—Drain Plug |
| 4—Element | |

- b. Install a new element in the body. Position the gasket in the recess in the cap assembly. Position the assembled cap assembly and gasket on the body. Attach by turning the captive screw of the cap assembly into the center tube of the body.
- c. Install the elbow in the outlet opening of the fuel filter.

is used. This is necessary to prevent fuel leakage from the cap vent opening when the vehicle is on a side slope. Two spring loaded relief valves which open when venting is required are built into the cap. The pressure valve opens at 1-1/2 to 2-1/2 psi [0,105 a 0,176 kg./cm²] and the vacuum valve at 3/4 psi [0,053 kg./cm²]. Should the pressure valve fail to open, pressure in the tank may force fuel by the injection pump inlet causing flooding. Failure of the vacuum valve may prevent flow of fuel to the injection pump. Should the valves fail to vent, install a new cap.

E-31. FUEL TANK CAP

The fuel tank filler cap is located on the right side of the vehicle. A pressure-type fuel tank filler cap

E-32. SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Fuel Not Reaching Pump:	
Tank valve closed	Open valve.
Seizure of distributor rotor	Check for cause of seizure. Replace hydraulic head and distributor rotor assembly.
Engine rotation wrong	Check engine rotation.
Filters or inlet strainer clogged	Remove and replace clogged elements. Clean strainer.
Fuel too heavy at low temperature	Correct fuel grade.
Transfer pump liner pin in wrong hole for correct rotation	Re-install properly.
Transfer pump blades worn or broken	Replace.
Fuel supply lines clogged, restricted, wrong size, or poorly located	Blow out all fuel lines with filtered air. Replace if damaged. Remove and inspect all flexible lines.
End plate regulating piston sticking in "prime" position	Remove piston and sleeve and inspect for burs, corrosion, or varnishes. Replace if necessary.
Air leaks on suction side of system	Bleed line; tighten connections.
Fuel Delivered From Injection Pump But Not To Nozzles:	
One or more connector screws obstructed	Replace.
Metering valve sticking or closed	Check for governor linkage binding, foreign matter, burs, etc. Remove and replace.
Governor spring worn or broken	Remove, replace, and readjust per specifications.
Governor linkage broken	Disassemble, inspect parts, replace if necessary, and reassemble.
Governor not operating; parts or linkage worn, sticking or binding, or incorrectly assembled	Reassemble correctly.
Metering valve incorrectly assembled to metering valve arm	
Fuel supply lines clogged, restricted, wrong size, or poorly located	Blow out all fuel lines with filtered air. Replace if damaged.

E-32. SERVICE DIAGNOSIS (Continued)

SYMPTOMS	PROBABLE REMEDY
Fuel Delivered From Injection Pump But Not To Nozzles: — Continued	
Cam backwards in housing	Reassemble correctly.
Cam roller shoes sticking	Remove, check for size and burs, and reassemble.
Plunger missing	Assemble new plunger.
Plunger sticking	Disassemble and inspect for burs, corrosion, or varnishes.
Passage from transfer pump to metering valve clogged with foreign matter	Disassemble and flush out hydraulic head.
Rotor badly scored	Replace hydraulic head and rotor assembly.
Head plug screws loose or missing	Install as indicated in assembly instructions.
Hydraulic head vent wires missing	Install as indicated in assembly instructions.
Metering valve spring shim missing	Install as indicated in assembly instructions.
Fuel Reaching Nozzles But Engine Does Not Start:	
Cranking speed too low	Charge or replace batteries, starting motor, or solenoid.
Pump timed incorrectly to engine	Correct timing.
Throttle arm travel not sufficient	Check installation and adjust throttle linkage.
Water in fuel	Drain fuel system and pump housing; provide new fuel; prime system.
Fuel lines leaking or connected to wrong cylinders	Relocate lines for correct engine firing sequence.
Fuel supply lines clogged, restricted, or wrong size	Blow out all fuel lines with filtered air. Replace if damaged.
Shutoff device interfering with governor linkage	Check and adjust governor linkage dimension.
Nozzles faulty or sticking	Replace or correct nozzles.
Automatic advance faulty or not operating	Remove, inspect, correct, and reassemble.
Maximum fuel setting at low limit or too low	Reset.
Low cetane fuel	Provide fuel per specifications.
Cam, shoes, or rollers worn	Remove and replace.
Excessive fuel leakage past plungers (worn or badly scored)	Replace rotor and hydraulic head assembly.
Head plug screws loose or missing	Install.
Rotor badly scored	Replace hydraulic head and rotor assembly.
Engine compression poor	Correct compression.
Lube oil too heavy at low temperature	Correct.
Engine Starts Hard:	
Cranking speed too low	Charge or replace batteries, starting motor, or solenoid.
Pump timed incorrectly to engine	Correct timing.
One or more connector screws obstructed	Replace.
Fuel supply lines clogged, restricted, or wrong size	Blow out all fuel lines with filtered air. Replace if damaged.
Air leaks on suction side of system	Bleed fuel system. Tighten all connections.
Filters or inlet strainer clogged	Remove and replace clogged elements. Clean strainer.

E-32. SERVICE DIAGNOSIS (Continued)

SYMPTOMS	PROBABLE REMEDY
Engine Starts Hard: — Continued	
Fuel too heavy at low temperature	Correct.
Lube oil too heavy at low temperature	Correct.
Water in fuel	Drain fuel system and pump housing; provide new fuel; prime system.
Engine compression poor	Correct compression.
Transfer pump blades worn or broken	Replace.
Transfer pump faulty; pressure too low	Remove and inspect parts.
End plate regulating piston sticking in "prime" position	Remove piston and sleeve and inspect for burs, corrosion, or varnishes. Replace if necessary.
Metering valve sticking or closed	Check for governor linkage binding, foreign matter, burs, etc.
Shutoff device interfering with governor linkage	Check and adjust governor linkage dimension.
Governor linkage out of adjustment	Adjust governor.
Governor not operating; parts or linkage worn, sticking or binding, or incorrectly assembled	Disassemble, inspect parts, replace if necessary, and reassemble.
Maximum fuel setting at low limit or too low	Reset.
Delivery valve sticking, missing, or assembled backwards	Remove, clean, or replace as needed.
Cam, shoes, or rollers worn	Remove and replace.
Plungers sticking	Disassemble and inspect for burs, corrosion, and varnishes.
Excessive fuel leakage past plungers (worn or badly scored)	Replace rotor and hydraulic head assembly.
Automatic advance faulty or not operating	Remove, inspect, correct, and reassemble.
Delivery valve retainer screw loose and leaking or incorrectly installed	Inspect delivery valve stop seat for erosion, tighten retainer screw, or replace head and rotor assembly as needed.
Nozzles faulty or sticking	Replace or correct nozzles.
Rotor badly scored	Replace hydraulic head and rotor assembly.
Leak-off line or fittings restricted	Remove line, blow clean with filtered air, and reassemble. Replace if damaged.
Engine Starts and Stops:	
Fuel supply lines clogged, restricted, wrong size, or poorly located	Blow out all fuel lines with filtered air. Replace if damaged, Remove and inspect all flexible lines.
Water in fuel	Drain fuel system and pump housing; provide new fuel; prime system.
Air intake restricted	Check.
Leak-off line or fittings restricted	Remove line, blow clean with filtered air, and reassemble. Replace if damaged.
Engine overheating	Correct.
Filters or inlet strainer clogged	Remove and replace clogged elements. Clean strainer.
Air leaks on suction side of system	Bleed system. Tighten all connections.
Failure of electrical shutoff	Remove, inspect, and adjust parts. Replace parts as necessary.
Metering valve sticking or closed	Check for governor linkage binding, foreign matter, or burs.
Transfer pump blades worn or broken	Replace.

E-32. SERVICE DIAGNOSIS (Continued)

SYMPTOMS	PROBABLE REMEDY
Engine Starts and Stops: — Continued	
Cam roller shoes sticking	Remove, check for size and burs, and reassemble.
Plungers sticking	Disassemble and inspect for burs, corrosion, or varnishes.
Irregular Engine Operation - Surging, Misfiring, Governor Regulation:	
Fuel lines incorrect, leaking, or connected to wrong cylinders	Relocate lines for correct engine firing sequence.
Fuel supply lines clogged, restricted, wrong size, or poorly located	Blow out all fuel lines with filtered air. Replace if damaged.
Filters or inlet strainer clogged	Remove and replace clogged elements. Clean strainer.
Pump timed incorrectly to engine	Correct timing.
Water in fuel	Drain fuel system and pump housing; provide new fuel; prime system.
Pump housing not full of fuel	Operate engine for approximately 5 minutes until pump fills with fuel.
Air leaks on suction side of system	Bleed system. Tighten all connections.
Nozzles faulty or sticking	Replace or correct nozzles.
Nozzle leak-off lines clogged	Remove lines, blow out, inspect, and reassemble.
Automatic advance faulty or not operating	Remove, inspect, correct, and reassemble.
Metering valve sticking or closed	Check for governor linkage binding, foreign matter, or burs.
Metering valve spring shim missing	Install as indicated in assembly instructions.
Governor not operating; parts or linkage worn, sticking or binding, or incorrectly assembled	Disassemble, inspect parts, replace if necessary, and reassemble.
Governor spring worn or broken	Remove and replace.
Governor linkage out of adjustment	Adjust governor.
Idling spring missing or incorrect	Assemble as indicated in assembly instructions.
Governor sleeve binding on drive shaft	Remove, inspect for burs, dirt, etc. Correct and reassemble.
Wrong governor spring	Remove and replace with proper spring.
Transfer pump blades worn or broken	Replace.
Transfer pump faulty; pressure too low	Remove and inspect parts.
End plate regulating piston sticking	Remove piston and sleeve and inspect for burs, corrosion, or varnishes. Replace if necessary.
Delivery valve retainer screw loose and leaking or incorrectly installed	Inspect delivery valve stop seat for erosion, tighten retainer screw, or replace head and rotor assembly as needed.
Delivery valve sticking, missing, or assembled backwards	Remove, clean, or replace as needed.
Cam roller shoes sticking	Remove, check for size and burs, and reassemble.
Head plug screws loose or missing	Install as indicated in assembly instructions.
Tang of drive shaft worn excessively	Remove and install new head and rotor assembly and drive shaft as necessary.
Plungers sticking	Disassemble and inspect for burs, corrosion, or varnishes.
Leak-off line or fitting restricted	Remove line, blow clean with filtered air, and reassemble. Replace if damaged.

E-32. SERVICE DIAGNOSIS (Continued)

SYMPTOMS	PROBABLE REMEDY
Engine Idles Imperfectly:	
Water in fuel	Drain fuel system and pump housing; provide new fuel; prime system.
Pump housing not full of fuel	Operate engine for approximately 5 minutes until pump fills with fuel.
Air leaks on suction side of system	Bleed system. Tighten all connections.
Pump timed incorrectly to engine	Correct timing.
Transfer pump blades worn or broken	Replace.
Governor not operating; parts or linkage worn, sticking or binding, or incorrectly assembled	Disassemble, inspect parts, replace if necessary, and reassemble.
Metering valve sticking or closed	Check for governor linkage binding, foreign matter, or burs.
Metering valve spring shim missing	Install as indicated in assembly instructions.
Idling spring missing or incorrect	Assemble as indicated in assembly instructions.
Governor linkage out of adjustment	Adjust governor.
Nozzles faulty or sticking	Replace or correct nozzles.
Automatic advance faulty or not operating	Remove, inspect, correct, and reassemble.
End plate regulating piston sticking	Remove piston and sleeve and inspect for burs, corrosion, or varnishes. Replace if necessary.
Fuel supply lines clogged, restricted, wrong size, or poorly located	Blow out all fuel lines with filtered air. Replace if damaged. Remove and inspect all flexible lines.
Governor spring worn or broken	Remove and replace.
Governor linkage broken	Remove, replace, and readjust.
Head plug screws loose or missing	Install as indicated in assembly instructions.
Excessive fuel leakage past plungers (worn or badly scored)	Replace rotor and hydraulic head assembly.
Delivery valve sticking, missing, or assembled backwards	Remove, clean, or replace as needed.
Plungers sticking	Disassemble and inspect for burs, corrosion, or varnishes.
Leak-off line or fitting restricted	Remove line, blow clean with filtered air, and reassemble. Replace if damaged.
Engine Does Not Develop Full Power or Speed:	
Throttle arm travel not sufficient	Check installation and adjust throttle linkage.
Shutoff device interfering with governor linkage	Check and adjust governor linkage dimension.
Governor high idle adjustment incorrect	Adjust.
Fuel supply lines clogged, restricted, or wrong size	Blow out all fuel lines with filtered air. Replace if damaged. Remove and inspect all flexible lines.
Air leaks on suction side of system	Bleed system. Tighten all connections.
Filters or inlet strainer clogged	Remove and replace clogged elements. Clean strainer.
Pump timed incorrectly to engine	Correct timing.
Leak-off line or fittings restricted	Remove line, blow clean with filtered air, and reassemble. Replace if damaged.
One or more connector screws obstructed	Replace.
Governor not operating; parts or linkage worn, sticking or binding, or incorrectly assembled	Disassemble, inspect parts, replace if necessary, and reassemble.

E-32. SERVICE DIAGNOSIS (Continued)

SYMPTOMS	PROBABLE REMEDY
Engine Does Not Develop Full Power or Speed: — Continued	
Metering valve sticking or closed	Check for governor linkage binding, foreign matter, or burs.
Governor linkage out of adjustment	Adjust governor.
Automatic advance faulty or not operating	Remove, inspect, correct, and reassemble.
Transfer pump blades worn or broken	Replace.
Transfer pump faulty; pressure too low	Remove and inspect parts.
Maximum fuel setting at low limit or too low	Reset.
Delivery valve sticking, missing, or assembled backwards	Remove, clean, or replace as needed.
Cam, shoes, or rollers worn	Remove and replace.
Plungers sticking	Disassemble and inspect for burs, corrosion, or varnishes.
Excessive fuel leakage past plungers (worn or badly scored)	Replace rotor and hydraulic head assembly.
Tang of drive shaft worn excessively	Remove and install new head and rotor assembly and drive shaft as necessary.
Head plug screws loose or missing	Install as indicated in assembly instructions.
Rotor badly scored	Replace hydraulic head and rotor assembly.
Delivery valve retainer screw loose and leaking or incorrectly installed	Inspect delivery valve stop seat for erosion, tighten retainer screw, or replace head and rotor assembly as needed.
Water in fuel	Drain fuel system and pump housing; provide new fuel; prime system.
Hydraulic head vent wires missing	Install as indicated in assembly instructions.
Engine compression poor	Correct compression.
Air intake restricted	Check.
Wrong governor spring	Remove and replace with proper spring.
Fuel lines incorrect, leaking, or connected to wrong cylinders	Relocate lines for correct engine firing sequence.
Engine Smokes Black:	
Air intake restricted	Check.
Engine overheating	Correct.
Pump timed incorrectly to engine	Correct timing.
Nozzles faulty or sticking	Replace or correct nozzles.
Automatic advance faulty or not operating	Remove, inspect, correct, and reassemble.
Engine compression poor	Correct.
Cam, shoes, or rollers worn	Remove and replace.
Maximum fuel setting too high	Reset.
Engine Smokes Blue or White:	
Pump timed incorrectly to engine	Correct timing.
Automatic advance faulty or not operating	Remove, inspect, correct, and reassemble.
Tang of drive shaft worn excessively	Remove and install new head and rotor assembly and drive shaft as necessary.
Lube oil pumping past piston rings in engine	Correct.
Cranking speed too low	Charge or replace batteries, starting motor, or solenoid.
Engine compression poor	Correct compression.

E-33. FUEL SYSTEM SPECIFICATIONS

	SPECIFICATIONS	METRIC
FUEL TANK:		
Capacity	22 gal.	83,27 lt.
Location	Rear of Vehicle	. . . . .
INJECTION PUMP:		
Governor Regulation	5%	. . . . .
Roller-to-Roller Dimension	1.9745" ±0.0005"	50,152 mm. ±0,0127 mm.
Governor Linkage Gap	0.125" to 0.165"	3,175 a 4,191 mm.
Advance Movement	7 degrees	. . . . .
High Idle Speed	3150 rpm	. . . . .
Full Load Speed	3000 rpm	. . . . .
Electrical Shutoff	24 v	. . . . .
Advance:		
Finish	2800 rpm	. . . . .
INJECTION NOZZLE:		
Opening Pressure	1750 psi	123,025 kg./cm ²



EXHAUST SYSTEM

Contents

SUBJECT	PAR.
EXHAUST PIPE, MUFFLER, TAIL PIPE	F-2
MANIFOLD	F-1
SPECIFICATIONS	F-3

F-1. MANIFOLD

The exhaust manifold is on the right-hand side of the engine. The exhaust pipe is secured to the exhaust manifold by two studs and self-locking nuts.

When assembling manifolds to the cylinder block, a new gasket should be used and the nuts drawn up evenly until they are tight, to avoid leakage. Torque wrench reading should be 30 to 35 foot-pounds [4,1 a 4,8 kg./m.] for the exhaust manifold.

When mounting exhaust pipe on the manifold, use a

new gasket and torque lock nuts 40 to 50 foot-pounds [5,5 a 6,9 kg./m.].

F-2. Exhaust Pipe, Muffler, Tail Pipe

Fig. 64 shows the exhaust system from the exhaust manifold to the tail pipe, including all attaching parts. This system should be checked periodically and all loose or broken hangers and supports should be tightened or replaced. Also check for any dents or restrictions in the pipe or muffler which can cause faulty engine performance.

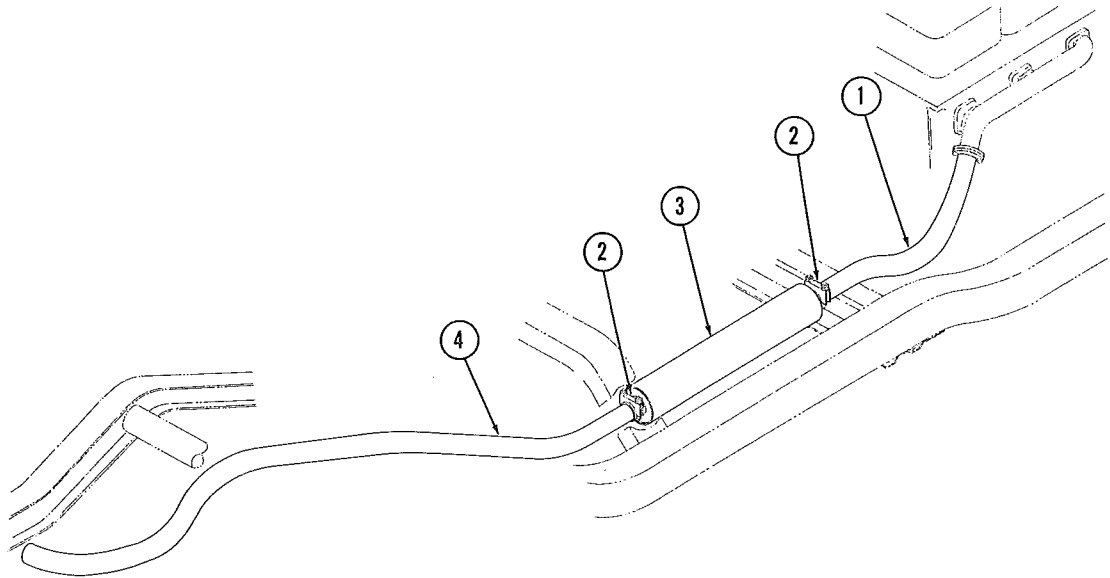


FIG. 64—EXHAUST PIPE AND MUFFLER

1—Exhaust Pipe
2—Clamp

3—Muffler
4—Tail Pipe

F-3. EXHAUST SYSTEM SPECIFICATIONS

	SPECIFICATIONS	METRIC
MUFFLER TYPE	Reverse Flow	. . . . .
EXHAUST PIPE: Diameter Wall Thickness	3" 0.065"	7,62 cm. 1,65 mm.
TAIL PIPE: Diameter Wall Thickness	3" 0.065"	7,62 cm. 1,65 mm.

COOLING SYSTEM

Contents

SUBJECT	PAR.	SUBJECT	PAR.
ANTIFREEZE SOLUTIONS	G-7	RADIATOR HOSES AND	G-9
ANTIFREEZE CHART	G-19	HEATER HOSES	
BELT ADJUSTMENT	G-16	RADIATOR PRESSURE CAP	G-4
DIAGNOSIS	G-18	SPECIFICATIONS	G-20
DRAINING COOLING SYSTEM	G-3	THERMOSTAT	G-8
ENGINE BLOCK	G-5	WATER MANIFOLD	G-15
ENGINE OVERHEATING	G-17	WATER PUMP	G-11
FILLING COOLING SYSTEM	G-2	Assembly	G-14
HEAT INDICATOR	G-10	Disassembly	G-12
RADIATOR	G-6	Inspection and Repair	G-13

G-1. GENERAL

The satisfactory performance of an engine is controlled to a great extent by the proper operation of the cooling system.

The Cerlist diesel is water-cooled by fresh water or a coolant treated with antifreeze or corrosion inhibiting properties. Coolant is constantly circulated by a belt-driven water pump mounted at the forward end of the engine. The front of the engine is constructed so as to form a water pump housing or cavity with both inlet and discharge passages. Before entering the pump, the water passes through a heat exchanger at the lower right side of the engine for oil cooling.

Internal water cooling passages are arranged so that the discharge from the pump passes down the left side of the engine through a water header, is diverted at each cylinder location, and passes around and upward in the sealed area to cool each cylinder. Drilled passages in the cylinder sleeves mate with passages in the lower surfaces of the cylinder heads, and water passes into the heads and toward the outlet in each head to the top water manifold. Flanged connections pick up this discharge water at each head and permit it to collect in the manifold behind the thermostat.

As the engine warms up, the thermostat opens and water is discharged from the top water manifold. The water passes to the top tank of the radiator, moves downward through the radiator tubes, and is reduced in temperature for pickup at the radiator bottom tank for re-use. Fluid in the radiator is cooled by the air stream, created by the fan, passing through the radiator core.

To permit higher operating temperatures of the engine, the cooling system is pressurized by the use of a pressure type filler cap. The pressure permits the coolant to rise to a higher temperature before boiling.

The need for frequent and thorough checking of the cooling system cannot be over emphasized. A thorough check of the cooling system each time the

vehicle is lubricated is recommended. If satisfactory cooling is to be maintained, the system must be properly filled and must be clean, tight, inhibited against corrosion, and all parts must be in good condition and proper working order. Servicing of the individual units is described below. It is recommended that the cooling system be flushed twice a year, preferably in the fall before antifreeze is added and in the spring when the antifreeze is drained.

Reverse flushing will aid greatly in removing rust and scale, especially when used with a flushing solution. A cleaning solution should be used to loosen the rust and scale before reverse flushing the cooling system.

Flushing is accomplished through the system in a direction opposite to the normal coolant flow. This action causes the water to get behind the corrosion deposits and force them out. To do this, remove the radiator hoses. Then attach a drain hose at the inlet. Attach a new piece of hose to the radiator outlet and insert the flushing gun. Connect the water hose to the flushing gun to a water outlet and the air hose to an air line. Turn on the water and when the radiator is full, apply the air in short blasts, allowing the radiator to fill between blasts. Continue this flushing operation until the water runs clear through the inlet hose.

With the thermostat removed, attach a leadaway hose to the water hose inlet. Also attach a length of new hose to the water outlet connection at the top of the engine. Turn the water on and fill the water jacket and then apply air in short blasts. Continue this flushing until the water runs clear. Also do the hot water heater. Remove heater water outlet hose from heater core. Remove inlet from engine connections. Insert flushing gun and flush heater core. Care must be taken when applying air pressure to prevent damage to the core.

G-2. Filling Cooling System

To fill the cooling system, remove the filler cap and fill the radiator. Replace the cap and run the engine at medium speed for approximately 1

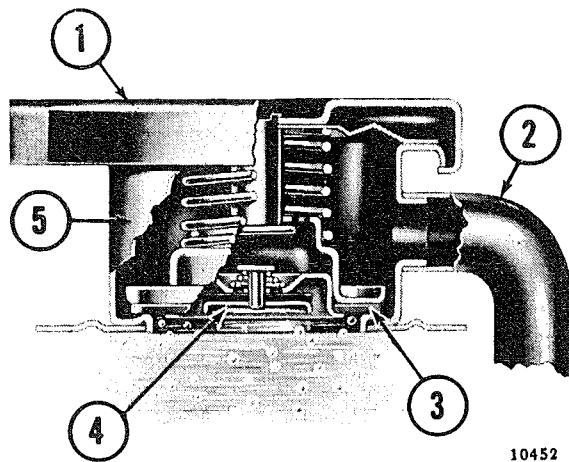
ute. Remove the cap and recheck the coolant level. Add more coolant, if necessary, to bring the level back to the top of the radiator. If the cooling system is filled when the engine is cold, recheck coolant level after the engine has warmed up. This will ensure that the thermostat has opened, allowing complete cooling system circulation. The cooling system should be flushed twice a year and checked for leaks, preferably in the spring and fall the time of changing the antifreeze. Always correct any cooling system leaks before installing antifreeze. A corrosion inhibitor should be used in the cooling system to prevent the formation of rust scale. A quality-brand antifreeze containing a corrosion inhibitor should be used. When the antifreeze is drained in the spring, a corrosion inhibitor should be added with the water.

3. Draining Cooling System

To completely drain the cooling system, it is necessary to open the drain in the bottom of the radiator and also a drain on the left side of the engine block. Remove the radiator cap to break any vacuum that may have developed. Should the cooling solution be lost from the system and the engine become overheated, do not refill the system immediately but allow the engine to cool or refill slowly while the engine is running. If cold solution poured into the radiator while the engine is overheated, there is danger of cracking the engine block and cylinder heads.

4. Radiator Pressure Cap

Modern models are now equipped with pressure caps which reduce evaporation of cooling solution and make the engines more efficient by permitting slightly higher operating temperatures. When operated properly, the pressure cap permits pressure



10452

65—RADIATOR PRESSURE CAP INSTALLED

- Pressurized Cap 4—Vacuum Release Valve
- Overflow Tube 5—Radiator Neck
- Pressure Seal

build-up in the cooling system during periods of severe heat load. This pressure increases the boiling point of the coolant and thus reduces overflow losses. The effectiveness of the cap is limited by its opening pressure and the boiling point of the coolant. The pressure cap employs a spring-loaded, rubber-faced pressure seal which presses against a seat in the radiator top tank. Spring pressure determines the opening pressure of the valve. A typical pressure cap is shown in Fig. 65. A vacuum release valve is employed to prevent undesirable vacuum build-up when the system cools down. The vacuum release valve is held against its seat under light spring pressure. Vacuum in the system is relieved by the valve which opens at 1/2 to 1 psi [0,035 a 0,07 kg./cm²] vacuum. Although the mechanism of the pressure cap requires no maintenance, the cap should be inspected periodically for cleanliness and freedom of operation. The pressure cap gasket and radiator filler neck seat should also be inspected to be sure they are providing a proper seal. If the rubber face of the valve is defective, a new cap should be installed. Filler neck reseating tools are commercially available to correct minor defects at the surface of the seat. Follow instructions of the reseating tool manufacturer.

WARNING: Use extreme care in removing the radiator pressure cap. In overheated systems, the sudden release of pressure can cause a steam flash and this flash, or the loosened cap, can cause serious personal injury.

To remove the radiator pressure cap when the engine coolant temperature is high or boiling, place a cloth over the pressure cap and turn counterclockwise about 1/4 turn until the first (pressure release) stop is reached. Keep the cap in this position until all pressure is released. Then, push cap down and turn still further until cap can be removed. To install the pressure cap, place it in position and turn it clockwise as far as it will go. To prevent any possibility of damage to engine accessories resulting from coolant overflow, the surge tank should have a rubber hose leading from the overflow tube. The hose should be 9/32" [7,14 mm.] I.D. to enable installation to be made without a clamp. The hose should be 22" [56 cm.] long and drop straight down alongside the block.

G-5. Engine Block

Any coolant leaks at the engine block water joints are aggravated by pump pressure in the water jacket and by pressure developed in the cooling system when the pressure cap is in place. Small leaks, showing up only as moist spots, often cannot be detected when the engine is hot except by the appearance of rust, corrosion, and dye stains where leakage evaporated. Also, expansion and contraction of the engine block resulting from extreme temperature changes can aggravate leaks. For these reasons, when checking for coolant leaks,

inspect the block when it is cold and while the engine is running.

A leaking drain cock that cannot be closed should be replaced. Leaking core hole expansion plugs should be replaced.

If tightening gasketed joints will not correct leakage, install new gaskets. Use a sealing compound where recommended.

G-6. Radiator

The radiator is the "reverse flow" type. This system causes the fluid to be drawn through the air stream created by the fan twice, providing a more efficient cooling system. The radiator is drained by opening the drain in the bottom of the radiator. Maintenance of the radiator consists of keeping the exterior of the radiator core clean, the interior free from rust and scale, and the radiator free from leaks. The exterior of the radiator core should be cleaned each 1000 miles [1.600 km.] or 30 days, whichever occurs first, if the vehicle is subjected to considerable off-the-road operation. Cleaning should be performed by blowing out with air from the rear. A visual inspection is not sufficient, as the accumulation of small particles of foreign material on core surfaces can restrict cooling without closing the core openings. Radiator leakage occasionally results from corrosion perforation of the thin metal, but most leakage results from mechanical failure of soldered joints when too much strain has been put on the joint. Fractures occur most often at the joint where the radiator inlet and outlet pipes are attached to the tanks. When the seams break, the entire soldered joint is exposed and can corrode, but breakage rather than corrosion is the primary cause of seam leakage.

Examine the radiator carefully for leaks before and after cleaning. Cleaning may uncover points of leakage already existing but plugged with rust. White, rusty, or colored leakage stains indicate previous radiator leakage. These spots may not be damp if water only or methyl-alcohol-base antifreeze is in the cooling system, since such coolants evaporate readily. An ethylene-glycol-base antifreeze shows up existing leaks, as it does not evaporate.

When the pressure cap opens, the sudden surge of vapor or liquid must blow out through the overflow pipe. If the overflow pipe is dented or clogged, the pressure caused by obstruction may cause damage to the radiator or hose connections in the cooling system. To remove clogging material, run a flexible wire through the overflow pipe.

The radiator is supported on two brackets welded to the frame front tubular cross member. The fan shroud is bolted to the radiator. The radiator and shroud assembly is positioned by a brace between the shroud and front engine support. To remove the radiator, first drain the coolant. Next, remove the fan blade assembly from fan shaft. Then disconnect upper and lower radiator hoses. Remove radiator brace. Remove bolts in cross member

brackets. Place front wheels in straight ahead position. Lower radiator. Jack up front of vehicle and remove radiator and shroud assembly.

G-7. Antifreeze Solutions

When water freezes, it expands approximately 9 percent in volume. When water confined in a cooling system freezes, it exerts tremendous pressures, causing serious damage. To prevent freezing, antifreeze is added to the water which lowers the freezing point of the coolant. The two antifreezes commonly used today have either a methanol or ethylene glycol base, and contain corrosion inhibitors. Methanol is usually cheaper than ethylene glycol and a slightly less quantity is needed for the same protection. However, methanol will evaporate with the water when the vehicle is operated at warmer temperatures, and must be replaced. Ethylene glycol will not evaporate at normal operating temperatures, and any evaporation losses need only be replaced with water. Methanol solution is injurious to vehicle finishes. Should any be spilled on the vehicle, it should be washed off immediately with a good supply of cold water without wiping or rubbing. Under ordinary conditions, ethylene glycol is not injurious to car finish. A table in the specifications data at the end of this section gives the protection obtained by the addition of various amounts of both methanol and ethylene glycol. Antifreeze should be drained and discarded in the spring, the cooling system flushed and refilled with water and a corrosion inhibitor. In the fall, a fresh filling of antifreeze should be used. Although the old antifreeze has freeze protection, the corrosion inhibitors in the antifreeze are no longer effective in protecting the cooling system from corrosion.

Before installing antifreeze, inspect the cooling system to be sure it is clean, leak-tight, and otherwise in proper operating condition. Drain the cooling system. See Par. G-3. Pour in 3 quarts [3 ltr.] of clean water, add the required quantity of antifreeze, then add clean water to within 1" [2,54 cm.] of the top. Run the engine until it is warm. Then check the solution level and antifreeze protection.

WARNING: Drinking ethylene glycol antifreeze or its solutions can be harmful or fatal. Do not use antifreeze containers for food or beverages.

G-8. Thermostat

The cooling system is designed to provide adequate cooling under most adverse conditions. However, it is necessary to employ some device to provide quick warming and to prevent overcooling during normal operation. Automatic control of engine operating temperature is provided by a water flow control thermostat installed in the water manifold at the left side of the engine cylinder heads.

The thermostat is a full bypass type, heat-operated valve. It should always be maintained in working order and the vehicle should never be driven

without one installed, as there would then be no control of engine temperature. The temperature at which the thermostat opens is preset and cannot be altered. The standard thermostat is designed to start opening at 160°F. [71°C.] and be fully open at 180°F. [82°C.].

When the thermostat is not operating properly, the engine may run too hot or too cold. Overheating may damage the thermostat so that its valve will not function properly. Rust can also interfere with thermostat operation. To test the thermostat, place it in water heated approximately 25°F. [17°C.] above the temperature stamped on the thermostat valve. Submerge the bellows completely and agitate the water thoroughly. The valve should open fully. Next, place the thermostat in water heated approximately 10°F. [11°C.] below the temperature stamped on the thermostat valve. Submerge the bellows completely and agitate the water thoroughly. The valve should close completely. If the thermostat fails either of these tests, it should be replaced with a new one of the same type and rating.

-9. Radiator Hoses and Heater Hoses

Rubber hoses, air, heat, and water deteriorate radiator and heater hoses in two ways: by hardening or cracking which destroys flexibility and causes leaks; by softening and swelling which produces lining failure and hose rupture. Examine hoses spring and fall for possible need of replacement or tightening. If hoses are collapsed, cracked, or indicate a soft condition on the inside, they should be replaced.

When installing hose, clean the pipe connections and apply a thin layer of nonhardening sealing compound. Hose clamps should be properly located over the connections to provide secure fastening. In the pressurized cooling system pressure can blow off improperly installed hoses.

Inspect to see that the alternator drive belt is not fitting into the radiator hoses. If this condition would be found to exist, clamp the hose or hoses involved away from any possible interference with the alternator drive belt.

-10. Heat Indicator

The heat indicator is operated electrically and is connected by a single wire to a sealed bulb sending it mounted in the rear end of the water manifold.

-11. WATER PUMP

The engine circulating water pump is of extremely simple construction and requires no maintenance other than adjustment of drive belt tension. The shaft and bearings are permanently assembled and fabricated, and the seal is of the permanent, non-adjustable type. The centrifugal impeller is pressed at the inner end of the shaft, and the drive hub, to which the belt drive pulley is attached, is pressed at the outer end. Rebuilding consists of installing a new shaft, bearing, and seal kit.

The water pump is mounted on the front cover and driven by a pulley and V-belt. It receives its

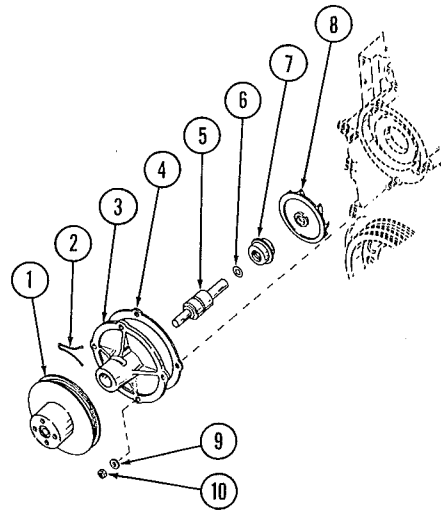


FIG. 66—WATER PUMP, EXPLODED VIEW

1—Pulley	6—Sealing Ring
2—Lock Wire	7—Seal
3—Housing	8—Impeller
4—Gasket	9—Lock Washer
5—Shaft and Bearing	10—Nut

power from the crankshaft pulley. The proper tension on the belt is very important to the function of the pump. Check the belt periodically to see that it is not worn or stretched. If the belt is in good condition, adjustment will take up any slack caused by stretching.

G-12. Disassemble Water Pump

- Press the pump pulley from the pump shaft.
- Remove the lock wire that attaches the housing to the shaft. Remove the housing.
- Press the impeller from the shaft. Remove the seal and sealing ring.

G-13. Inspect and Repair Water Pump

- Examine the seal seat in the housing. If it is worn or scored, replace the housing.
- Examine the impeller blades for chipping or nicks. Replace a damaged impeller.

G-14. Assemble Water Pump

- Position the housing on the shaft and bearings. Attach with the lock wire.
- Position the sealing ring on the shaft with 0.094" [2,387 mm.] clearance between the ring and the bearing face on the shaft. Coat the housing face of the seal with Permatex and seat the seal in the housing counterbore.
- Press the impeller on the pump shaft. Make sure there is 0.035" to 0.045" [0,889 a 1,143 mm.]

clearance between the impeller and the face of the housing. Measure the clearance at several points around the circumference to make sure it is within the limits.

d. Press the pump pulley on the shaft. The pulley should be installed so there is a distance of 3.851" [9,781 cm.] between the fan mounting side of the pulley and the engine mounting face of the housing.

NOTE: Make sure a new gasket is used whenever the water pump is installed on the engine.

G-15. Water Manifold

The water manifold is located along the right side of the cylinder heads. It supplies coolant to the cylinder heads. When servicing the water manifold, use Permatex on all plugs or fittings during assembly to avoid seepage.

G-16. Adjust Belt

The water pump pulley and fan are belt-driven from the crankshaft pulley. The same belt drives the alternator. Adjust belt tension by loosening the bolt in the alternator adjusting strap. Move the alternator out on the strap to tighten the belt; move it in on the strap to loosen the belt. Tighten the bolt when the tension is correct.

G-17. Engine Overheating

An engine will not be damaged by high coolant temperatures unless the coolant boils. The pressurized cooling system used on these vehicles raises the boiling point of the coolant. The following table lists the boiling point of water and anti-

freeze solutions at atmospheric pressure and at 13 psi as used in this cooling system.

System Pressure	Methyl Alcohol	Water	Ethylene Glycol
None	179°F. [91,5°C.]	212°F. [100°C.]	223°F. [106,1°C.]
9 psi [0,637 kg/cm ²]	202°F. [94,4°C.]	236.5°F. [113,6°C.]	248.5°F. [120,2°C.]
13 psi [0,914 kg/cm ²]	209.5°F. [98,6°C.]	245°F. [118,3°C.]	257.5°F. [125,2°C.]

The antifreeze solutions listed protect to -20° F. [-28,9°C.]. Should overheating be encountered, and the fault is believed to be in the cooling system, check the cooling system for the following:

- a. Proper coolant level. See Filling Cooling System Par. G-2.
- b. Poor air flow. Check for dirty radiator core. (See Radiator Par. G-6.) Check for faulty belt pulley operation, worn or loose fan belt, or damaged fan. Clean, repair, replace, or adjust as necessary.
- c. Foaming coolant. Check for air leaks at water pump, hose connection, and filler cap. Tighten, repair, or replace as necessary.
- d. Surging or "after boil." Check pressure cap and replace if valves or gasket are faulty. Install lower temperature thermostat, if necessary.
- e. External leaks. Check the following for leaks: Hoses and clamps, water pump, radiator, head gaskets, core plugs, and drain cocks, as well as the cylinder head or block for cracks.
- f. Internal leaks. Check for faulty head gaskets, cracked cylinder head or block.
- g. Poor coolant flow. Check hose condition, water pump, fan belt, and repair or replace as necessary. Inspect block for rust or scale, and clean and flush the system, if necessary.
- h. Be sure a thermostat is installed. See Thermostat Par. G-8.
- i. Check the temperature gauge. See Par. H-51.

G-18. SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Overheating:	
Lack of coolant	Refill radiator.
Thermostat inoperative	Replace.
Water pump inoperative	Overhaul or replace.
Excessive piston blowby	Check pistons, rings, and cylinder walls.
Fan belt broken	Replace.
Radiator clogged	Reverse flush.
Air passages in core clogged	Clean with water and air pressure.
Excessive carbon formation	Remove.
Muffler clogged or bent exhaust pipe	Replace.
Loss of Cooling Liquid:	
Loose hose connections	Tighten.
Damaged hose	Replace.
Leaking water pump	Replace.
Leak in radiator	Remove and repair.
Leaky cylinder head gasket	Replace.
Crack in cylinder block	} Small crack can be closed with Radiator Sealer.
Crack in cylinder head	

G-19. ANTIFREEZE CHART

Antifreeze			Protection to Temperature Shown			
Quarts U. S.	Quarts Imperial	Liters	Methyl Alcohol		Ethylene Glycol	
			Fahr.	Cent.	Fahr.	Cent.
12-Quart System						
2	1-2/3	2	15°	- 9,5°	19°	- 7,2°
3	2-1/2	2-3/4	3°	-16,1°	10°	-12,2°
4	3-1/3	3-3/4	-12°	-24,4°	0°	-17,7°
5	4-1/4	4-3/4	-31°	-35,0°	-15°	26,1°
6	5	5-2/3	-50°	-45,5°	-34°	-36,6°

G-20. COOLING SYSTEM SPECIFICATIONS

	SPECIFICATIONS	METRIC
RADIATOR CAP: Location Relief Valve Pressure	In Engine Compartment 13 psi	0,914 kg./cm ²
HERMOSTAT: Type Location Starts to Open-Standard Starts to Open-High Temperature	Full Bypass Water Manifold 160° F. 180° F.	. . . . . 71° C. 82° C.
WATER PUMP: Type Location Drive	Centrifugal Front of Block V-Belt	. . . . .. . . . .. . . . .
RADIATOR TYPE	Tube and Fin	. . . . .
FAN: Number of Blades Spacing Diameter	4 70 and 140 degrees 18"	. . . . . . . . . . 45,72 cm.
ALTERNATOR AND WATER PUMP: Drive	From Crankshaft
COOLING CAPACITY	12 qt.	11,3 ltr.

ELECTRICAL SYSTEM

Contents

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ALTERNATOR AND REGULATOR	H-3	HORN	H-59
Assembly	H-30	INDICATORS AND GAUGES	H-51
Disassembly	H-24	LIGHTING SYSTEM	H-52
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ALTERNATOR BENCH TESTS	H-19	Maintenance	H-33
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H-1. GENERAL

Use caution around the high voltage of the 24-volt system, as accidental short circuits are capable of damaging electrical units. Arcs around the 12-volt batteries are apt to ignite gas that may be escaping from them. In the following paragraphs will be found information about the batteries, alternator, voltage regulator, and starting motor. These units, with the connecting wires, make up the engine electrical system. The wiring diagram will show the different circuits of the engine electrical system and the various units which make up those circuits. With plastic-covered wiring harnesses, use only rubber-insulated wiring clips.

H-2. Batteries

The batteries act as storage reservoirs of electrical energy produced by the alternator. To store sufficient energy for operation of the electrical system (starter, lights, etc.) when the alternator is not producing, the batteries and battery wiring must receive regular attention. At each 1000 miles [1.600 km.], or when the vehicle is lubricated, check the battery condition with a hydrometer and check the electrolyte level in each cell. At each 10,000 miles [16.000 km.], clean and inspect the batteries as outlined below.

WARNING: Do not allow flames or sparks to be brought near the vent openings of the batteries since hydrogen gas may be present in the batteries and might explode.

WARNING: The liquid in the batteries (electrolyte) is a solution of sulphuric acid which, on contact, can injure skin or eyes, or damage clothes. If it is spilled on the skin or spattered in the eyes, promptly flush it away with quantities of clear

water only. If the acid is spilled on clothes, wet it thoroughly with a weak solution of ammonia, or with a solution of sodium bicarbonate or baking soda.

NOTE: When installing a battery, make sure the negative terminal is grounded. Reverse polarity in the ignition system can cause an otherwise top performing engine to become rough and sluggish.

Battery Inspection

a. Check the specific gravity of the electrolyte in each cell of the batteries. A hydrometer reading of 1.260 indicates that the battery is fully charged. If the reading is 1.225 or below, the battery needs recharging. If one or more cells is 25 or more "points" (0.025) lower than the other cells, this indicates that the cell is shorted, and the cell is about to fail, or there is a crack in the battery partition in the case. Unless the battery is repaired or replaced, battery trouble will soon be experienced.

b. Check the electrolyte level in each cell, add distilled water to maintain the solution 3/8" [9.5 mm.] above the plates. Avoid overfilling. Replace the filler caps and tighten securely. It is important to keep the electrolyte level above the plates at all times because plates that are exposed for any length of time will be seriously damaged.

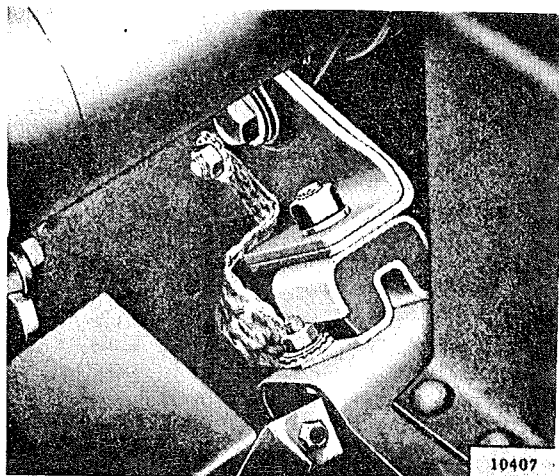
c. Check the wing nuts on the hold-down frame for tightness. Tighten them only with finger pressure, never with pliers or a wrench. Excessive pressure could damage the battery case.

d. Clean the battery terminals and cable connectors. Prepare a strong solution of baking soda and water and brush it around the terminals to remove any corrosion that is present. The cell caps must be tight and their vents sealed to prevent cleaning solution entering the cells. After cleaning, coat the terminals with heavy grease.

Inspect the battery cables and replace if badly corroded or frayed. Check tightness of terminal screws to ensure good electrical connections. Check tightness of the negative ground cable connection to the frame to ensure a good ground connection.

Load-test the batteries. Connect a voltmeter across each battery. Run the starting motor for 15 seconds. If the voltage does not drop below 10 volts each battery, the battery is satisfactory. If the voltage falls below the figure given, but the specific gravity is above 1.225, the condition of the battery is questionable.

Be sure the engine ground strap connection (Fig. 67) is tight at both connections. It is located on the left front engine support. If these connections are loose or dirty, hard starting or failure to start may result.



3. 67—ENGINE GROUND STRAP LOCATION

4. ALTERNATOR AND REGULATOR

The alternator is an air-cooled, 30-ampere, 24-volt unit with a matched transistorized regulator.

The alternator charging circuit consists of the battery, alternator, voltage regulator, ignition switch, and charge indicator light; refer to Fig. 68. The alternator differs from a generator in that the stator is stationary, and is called the stator, while the field rotates, and is called the rotor. With this alternator construction, the higher current lines involved in the stator may be conducted to an external circuit through fixed leads and connections, rather than through a rotating commutator and brushes, as in the DC generator.

The alternator employs a three-phase stator winding.

The rotor consists of a field coil encased between three poled interleaved sections, producing a three-pole magnetic field with alternating north and south poles. By rotating the rotor inside the stator, an alternating current is induced in the stator windings. This alternating current is changed to direct current by diodes and conducted to the output terminal of the alternator.

Six silicon diode rectifiers act as electrical one-way valves. Three of the diodes have negative polarity and are grounded. The other three diodes have positive polarity and are connected to the output terminal. The diodes are pressed into heat sinks. There are two heat sinks, one positive and the other negative.

Since the diodes have a high resistance to the flow of current in one direction and a low resistance in the opposite direction, they are connected in a manner which allows current to flow from the alternator to the battery in the low resistance direction. The high resistance in the opposite direction prevents the flow of current from the battery to the alternator. Because of this feature, no circuit breaker is required between the alternator and the battery.

Residual magnetism in the rotor field poles is negligible. Therefore the starting field current must be supplied by the battery. It is connected to the field winding through the ignition switch and resistor. As in a generator, the alternator voltage is regulated by varying the field current. In these alternator systems, this is accomplished electronically in the transistorized voltage regulator. No current regulator is required since all alternators have self-limiting current characteristics.

The entire DC output of the alternator has to pass through the isolation diode. The isolation diode is not essential for rectification. Its purpose is three-fold.

- a. It provides an automatic solid state switch for indicating the alternator charge-discharge rate on the ammeter.
- b. It automatically connects the voltage regulator to the alternator and battery when the alternator is operating.
- c. It eliminates electrical leakage across the alternator diodes so that leakage is negligible when the vehicle is not in use.

The silicon isolation diode is mounted in a separate aluminum heat sink. The alternator is designed to supply the electrical demands of the battery and the accessory circuits through a wide range of engine speeds.

The principal components of the alternator are the stator, the rotor, the slip ring end head, the drive end head, the diode rectifiers, and the isolation diode.

- a. The stator consists of a laminated iron core on which the three-phase windings are wound in slots around the inside circumference. A pair of leads is connected to each of the three points of the winding. One of each pair of leads connects to a negative diode rectifier, and one to a positive diode rectifier.
- b. The rotor consists of a single field coil encased between two six-fingered, interleaved iron sections assembled to the shaft. The two ends of the field coil are connected to two slip rings which are insulated from each other and from the shaft.
- c. The slip ring end head supports the rectifier heat sinks, a prelubricated ball bearing in which the rotor shaft rotates, and the brush holders and brushes.

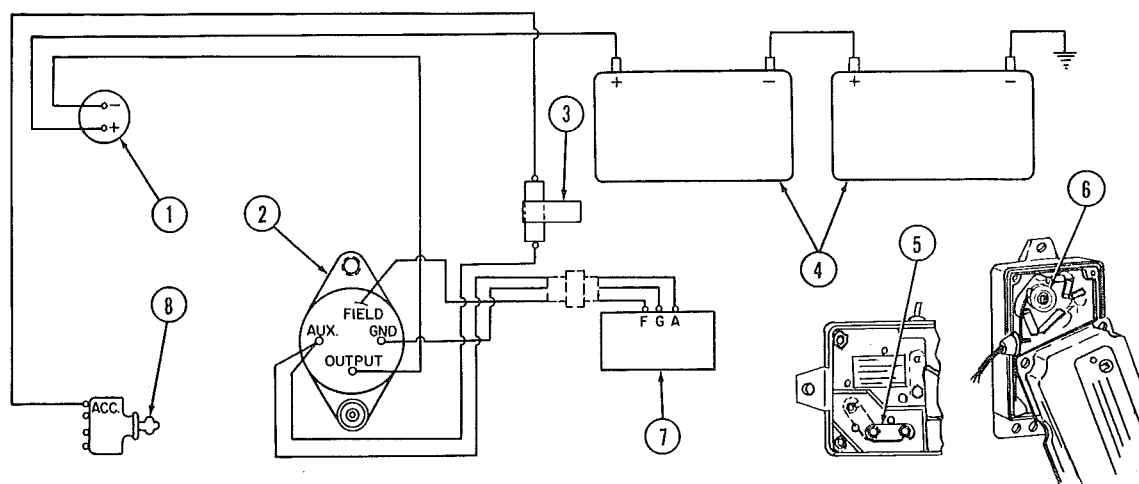


FIG. 68—BATTERY CHARGING CIRCUIT

1—Ammeter
2—Alternator

3—Resistor
4—Batteries

5—Voltage Regulator Adjusting Strap
6—Variable Voltage Control

7—Regulator
8—Ignition Switch

d. The drive end head supports a prelubricated ball bearing in which the drive end of the rotor shaft rotates.

e. The diode rectifiers are pressed in the rectifier brackets or heat sinks and are connected to the stator leads.

f. The isolation diode is pressed in the aluminum heat sink mounted to the rear of the alternator. The complete assembly is covered with a red insulating coating.

For repairing the alternator, many of its major components are furnished as complete assemblies including a complete brush assembly which requires no soldering or unsoldering of leads; two complete rectifying diode assemblies which eliminate the need for removing and replacing individual diodes; a complete isolation diode assembly; and a rotor assembly complete with shaft, pole pieces, field coil, and slip rings.

The transistorized voltage regulator is an electronic switching device. It senses the voltage appearing at the auxiliary terminal of the alternator and supplies the necessary field current for maintaining the system voltage at the output terminal. The output current is determined by the battery electrical load, such as head lamps, heater, etc.

The transistorized voltage regulator should not need adjustment. In case adjustment seems necessary, however, an adjustable strap is shipped, secured to the bottom of the regulator. Instructions printed on the bottom of the regulator show how the strap is to be positioned to increase or decrease the voltage by 0.6 volts. Further adjustment can be made by turning the variable voltage control under the top cover with a No. 2 Phillips screw driver.

H-4. Alternator Precautions

The following precautions must be observed to prevent damage to the alternator and regulator.

a. Never reverse battery connections. Always check the battery polarity with a voltmeter before making connections to be sure that all connections correspond to the battery ground polarity of the vehicle.

b. Booster batteries for starting must be properly connected. Make sure that the negative cable of the booster battery is connected to the negative terminal of the battery in the vehicle. Connect the positive cable of the booster battery to the positive terminal of the battery in the vehicle.

c. Disconnect the battery cables before using a fast charger.

d. Never use a fast charger as a booster for starting the vehicle.

e. Never disconnect the voltage regulator while the engine is running.

f. Do not ground the alternator output terminal.

g. Do not operate the alternator on an open circuit with the field energized.

h. Do not attempt to polarize an alternator.

These precautions are stated here as an aid to service personnel. They are also restated at appropriate places in the text of this section of the manual.

H-5. CHARGING SYSTEM SERVICE

H-6. Service Diagnosis

In diagnosing a suspected malfunction of the alternator charging system, consider the complete electrical power plant of the vehicle, including the alternator, regulator, ignition switch, ammeter, battery, and all associated wiring. If it is suspected that the alternator is not fully charging the battery and fulfilling the electrical requirements of the electrical system, make the following checks before checking the alternator itself:

a. Test the condition of the battery and state of charge (Par. H-2). If the battery is not fully

arged and in good condition, use a replacement ttery for making Alternator System Tests.

CAUTION: Make certain that the negative battery st is connected to ground when making the ttery installation. Serious damage to the alter- tor can result if battery polarity is reversed.

Check fan belt for proper tension (Par. G-16).

CAUTION: To increase belt tension, apply pres- re to alternator front housing only. Permanent mage can result if pressure is applied to rear using.

Check the wiring of the charging circuit (Fig. 68) d make sure connections are tight and not cor- ded.

7. Alternator On-Vehicle Tests

any of the alternator system tests can be com- eted with the alternator on the vehicle. For this ason, the following test procedure is recom- ended and given in detail in the following para- aphs.

Isolation Diode Test to determine if the isolation ode is open or shorted is given in Par. H-9.

Alternator System Test to determine if the charg- g system is functioning properly, and, if not, to tain information on probable causes of the trouble given in Par. H-10.

Alternator Output Test to isolate the trouble to e alternator or regulator is given in Par. H-11.

Regulator Test to determine the condition of e regulator is given in Par. H-12.

Battery Charging Circuit Test to isolate the ndition to the battery charging circuit or the gative ground return circuit is given in Par. .14.

Alternator Field Current Test to determine the ndition of the field circuit (brushes and rotor) given in Par. H-15.

Brush Test to determine the condition of the ush is given in Par. H-17.

Rotor In-Vehicle Test to determine whether e rotor coil is open or shorted is given in Par. .18.

Conduct further tests with the alternator re- oved and disassembled. With this done, the ndition of the rotor, the rectifying and isolation des, and the stator can be further tested.

When the trouble has been isolated and cor- cted, install the alternator and voltage regulator he vehicle and check their operation with the ernator system test.

e a commercial alternator tester such as the n Electric model VAT-20 (Volt Ampere Tester) equivalent commercial tester to make all cessary tests on the alternator system.

a commercial tester is used, follow the recom- ended testing procedure outlined by the tester unufacturer.

If a commercial tester is not available, follow the testing procedure as outlined in this manual.

H-8. Test Equipment

a. Volt Ampere Tester such as the Sun Electric model VAT-20, or equivalent, with meter ranges shown below:

DC ammeter — 0 to 60 amperes

DC ammeter — 0 to 5 amperes

DC voltmeter — 0 to 16 volts

Rheostat — 40 ohms capable of handling 3 amperes

Carbon Pile — 45 amperes

b. Diode Rectifier Tester C-3829 or, Sun Electric model RDT, or equivalent.

c. 24-volt DC test lamp.

d. Ohmmeter of any commercial type is not absolutely necessary, but can be helpful.

H-9. Isolation Diode Check

If it is suspected that the battery is discharging with the ignition switch off and all accessories turned off, the cause could be a shorted isolation diode. In most cases, the ammeter would indicate a discharge with the ignition off if the isolation diode were shorted.

If there is no evidence of alternator output when the engine is running, the cause could be an open isolation diode. In most cases, this would be indicated by the ammeter indicating a discharge when the engine is running.

Check the condition of the isolation diode with the ignition off, the regulator connected to the alter- nator, and all the accessories off. Connect a 24- volt DC test lamp to the output terminal and the auxiliary terminal. Then reverse the test probes. The test lamp should light in one direction, but should not light in the other direction. If the lamp lights in both directions, the isolation diode is shorted. If the test lamp does not light in either direction, the isolation diode is open.

If the isolation diode is shorted or open, replace the heat sink and diode as an assembly. At the time of manufacture, the diode is pressed into the heat sink and the complete assembly is insulated from the alternator housing. If the diode is checked with a diode tester, voltage at the auxiliary ter- minal should not exceed 0.1 volt. Voltage in excess of 0.1 volt indicates excessive leakage through the isolation diode. Replace the isolation diode assem- bly.

H-10. Alternator System Test

This test checks the current output of the alternator to determine if the system is functioning properly. For proper connections, refer to Fig. 69.

a. With the engine off, disconnect the output cable from the alternator output terminal and connect an ammeter with a range of 0 to 60 amperes in series with the output terminal and output cable.

b. Connect a carbon pile load to the negative side of the ammeter and negative battery terminals.

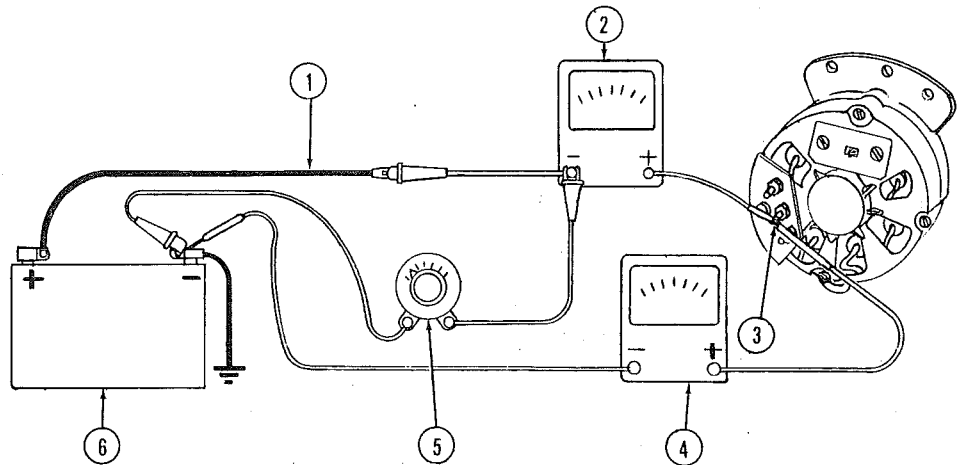


FIG. 69—ALTERNATOR SYSTEM TEST

- | | | |
|---------------------------|------------------------------|---------------|
| 1—Alternator Output Cable | 3—Alternator Output Terminal | 5—Carbon Pile |
| 2—Ammeter | 4—Voltmeter | 6—Battery |

c. Connect a voltmeter to the alternator output terminal and negative battery terminal.

d. If the engine is cold, run it 15 minutes to warm. With the engine warm and running, slowly increase the load with carbon pile and increase engine speed until alternator's minimum rated current output is reached.

Acceptable current output is 5 amperes below the alternator rated output. The voltage at the output terminal should be at least 26 volts, but not more than 30.

If voltage exceeds 30 volts at rated current output, replace or check the voltage regulator.

CAUTION: Remove carbon pile load immediately after engine is stopped to avoid discharging the battery when alternator is not operating.

If the system operates normally at low engine speeds, but rated output cannot be obtained at high engine speeds, check the fan belt for proper tension (Par. G-16).

If the current output is below normal and the auxiliary terminal voltage exceeds 26 volts, check the isolation diode (Par. H-9) or replace with a diode known to be good.

If the minimum rated current output of 30 amperes is obtained at the specified output terminal voltage (26 to 30 volts), check the battery charging circuit (Par. H-14) and then repeat this test.

If ampere output is below the minimum alternator rating or the output terminal voltage is below 26 volts, proceed to the Alternator Output Test (Par. H-11).

H-11. Alternator Output Test

This test excludes the regulator from the alternator system, thereby isolating the problem to either the regulator or alternator.

CAUTION: Do not under any circumstances disconnect alternator field terminal wire while alternator is operating.

a. With the engine off, connect voltmeter, ammeter, and carbon pile as described in Par. H-10 and shown in Fig. 69.

b. Disconnect field terminal wire and disconnect regulator three-prong plug.

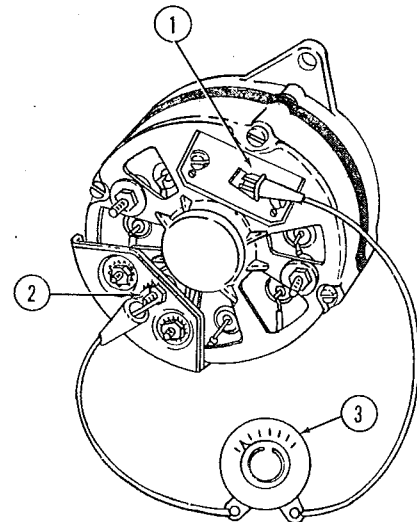


FIG. 70—ALTERNATOR OUTPUT TEST

- | |
|-------------------|
| 1—Field Terminal |
| 2—Output Terminal |
| 3—Field Resistor |

Connect a variable resistor (40-ohm, 3-ampere) m output terminal to field terminal as shown Fig. 70.

CAUTION: A fully charged battery does not present a load to the alternator. If maximum field current is applied to the alternator field with no load on the alternator, the output voltage of the alternator will exceed the safe maximum value (30 volts) and overcharging of the battery with possible damage to the alternator may occur. Therefore, field resistor must be set at maximum resistance at the beginning of the test and some load (carbon pile) must be presented to the alternator.

With the field resistor set at maximum resistance, start engine and observe voltage at output terminal. This voltage must not exceed 30 volts. Increase alternator load to reduce voltage if necessary. Increase load with carbon pile and decrease field resistance while maintaining less than 30 volts at output terminal. Continue to decrease the field resistance while increasing output load until there is no resistance in the field circuit. With resistance in the field circuit, maximum field current is being applied to field coil. Minimum rated current output is obtained with least 26 volts but less than 30 volts at the output terminal, the alternator is functioning properly.

CAUTION: Do not exceed rated current output of alternator by increasing load on alternator.

If minimum rated current output cannot be obtained, proceed with the tests and checks given in the following paragraphs and isolate the cause. When rated alternator current output is obtained, check field resistor wire. If resistor wire is in good condition, replace regulator (Par. H-13) and repeat Alternator System Test (Par. H-10).

NOTE: The system is designed to produce slightly higher output at low operating temperatures and less output at higher temperatures to accommodate the varying demands of electrical power normally consumed at these temperatures.

g. The resistor supplies the initial field current required to start the alternator. Check the resistor for continuity with an ohmmeter; the resistance should be 150 ohms. Replace the resistor if resistance is not correct. Make certain the resistor wires make good electrical contact at the auxiliary terminal and the ignition switch.

H-12. Regulator Test

Check the regulator with an alternator that is functioning properly. If the alternator is questionable, perform the Alternator Output Test (Par. H-11) which excludes the regulator from the charging system and, therefore, tests the condition of the alternator alone.

- a. Connect a 60-ampere ammeter and a carbon pile load as shown in Fig. 69.
- b. Connect a DC voltmeter (30-volt range) with an accuracy of ±0.1 volt to the output terminal and negative battery terminal. See Fig. 71.
- c. Start engine, increase load with carbon pile, and increase engine speed, if necessary, to obtain 10-ampere output current. Operate for 15 minutes to stabilize temperature.

Output terminal voltage must be 28.4 ±0.4 volts at regulator ambient temperature of 70° to 80° F. [26,5° a 31,5°C.]. Measure ambient temperature of regulator by placing a thermometer 1" [2,54 cm.] away from regulator case. If the ambient temperature is other than 75° F. [29°C.], see table for correct voltage output.

If voltage output is not within limits specified, replace regulator and repeat this test.

Increase load with carbon pile and engine speed until minimum rated current output is reached. Voltage at output terminal should be at least 26 volts, but should not exceed maximum limits in the table.

H-13. Voltage Regulator Removal and Installation

The voltage regulator is a transistorized unit. It cannot be disassembled and does not usually need adjustment. If found to be defective in any way, replace it as a unit.

The transistorized voltage regulator is mounted in the frame channel by three mounting screws. Wiring connections to the charging circuit are made through a three-prong connector.

Terminal Voltage Output (10-ampere Load)	TEMPERATURE								
	Degrees Fahrenheit								
	0°	20°	40°	60°	80°	100°	120°	140°	160°
	Degrees Centigrade								
	-18°	-6.6°	4.5°	15.5°	26.6°	38°	49°	55°	71°
Minimum	29.20	28.86	28.64	28.32	28.00	27.68	27.32	26.96	26.64
Maximum	30.12	29.73	29.36	28.98	28.60	28.32	28.04	27.78	27.50

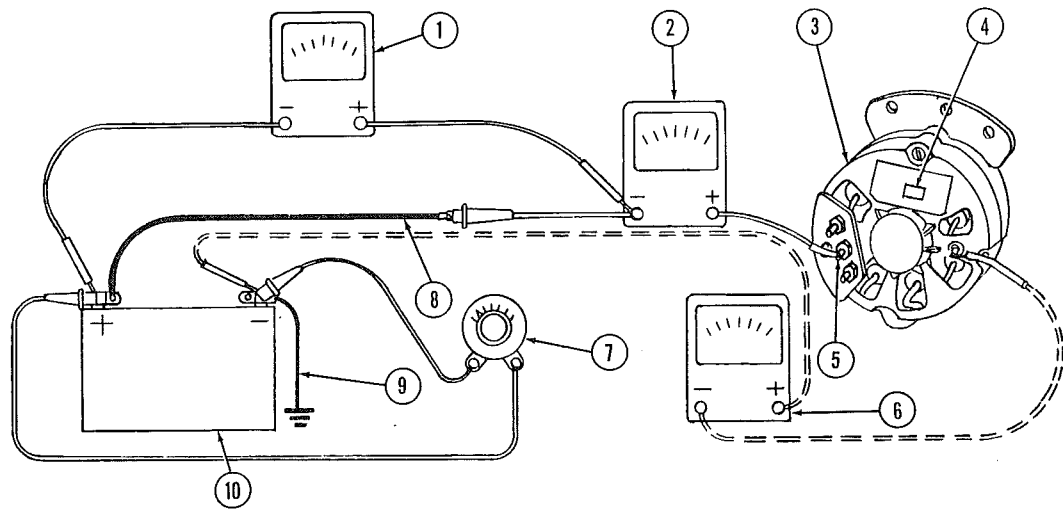


FIG. 71—BATTERY CHARGING CIRCUIT TEST

1—Voltmeter
2—Ammeter
3—Alternator

4—Ground Terminal
5—Output Terminal
6—Voltmeter

7—Carbon Pile
8—Alternator Output Cable

9—Ground
10—Battery

To remove the regulator, disconnect the three-prong connector and remove the three mounting screws. Installation of the regulator is the reverse of the removal.

H-14. Battery Charging Circuit Test

Perform this test with a fully charged battery in good condition, so that the current output can be completely controlled with the external load (carbon pile). Clean and tighten battery connections prior to test.

- a. Connect an ammeter in series with the alternator output terminal and output cable as shown in Fig. 71.
- b. Connect a carbon pile load to the positive and negative battery terminals as shown in Fig. 71.
- c. Start engine and adjust engine speed and carbon pile load for 10-ampere alternator output current.
- d. With engine speed and carbon pile adjusted to 10-ampere output current, measure the charging circuit voltage drop from the negative side of the ammeter to the positive battery terminal (Fig. 71). The voltage drop must not exceed 0.3 volt. If the voltage drop exceeds 0.3 volt, check all wiring and connections in charging circuit. A voltage drop test across each connection will locate the faulty connection. Clean and tighten all connections and repeat test.
- e. With 10-ampere alternator output current, measure the voltage drop of the battery ground return circuit. Connect the voltmeter from the alternator ground terminal to negative battery terminal (Fig. 71). Voltage drop must not exceed 0.15 volt. If voltage drop exceeds 0.15 volt, check

battery ground cable connections at engine and grounding straps between body and engine. Make certain alternator is well grounded through its mounting bracket to engine.

H-15. Alternator Field Circuit Test

This test checks the condition of the field circuit (brushes and rotor) by measuring the output at the auxiliary terminal and field terminal of the alternator. When measuring the voltage at the auxiliary and field terminals, consider the entire field circuit. From the field terminal, the circuit is through the insulated brush to a slip ring and through the rotor windings to the other slip ring which is grounded through the grounded brush.

a. Start engine and read the voltage at the auxiliary terminal of the alternator by placing a voltmeter between the negative terminal of the battery and the auxiliary terminal of the alternator.

If the voltmeter reads over 24 volts, replace the isolation diode assembly, as it is probably open.

b. If there is no voltage or a very low voltage reading at the auxiliary terminal, first shut off the engine, and then turn on the ignition key with the engine not running. Again measure the voltage at the auxiliary terminal. Voltage reading should be approximately 1.5 volts.

c. Turn off the ignition switch, and pull the plug on the field terminal of the alternator back slightly so that the voltage on the field terminal can be measured. When the voltmeter leads are connected between the negative terminal of the battery and the field terminal of the alternator, turn on the ignition switch (with the engine not running) and measure the voltage. The voltage at the field

terminal with the ignition on and the engine not running should be approximately 1 volt.

With the ignition switch on, if the voltages at the auxiliary and field terminals are not correct, turn the ignition switch off and disconnect the plug to the voltage regulator. Then turn the ignition switch on again. With the regulator disconnected, the ignition switch on, and the engine not running, the voltage at the auxiliary terminal should be nearly full battery voltage. If this is so, the defect is in the field of the alternator itself or in the regulator, and not in the wiring from the battery.

To isolate the cause to the regulator or alternator, plug in a regulator known to be working and repeat the above tests at the auxiliary and field terminals. If the condition is corrected, replace the voltage regulator. If the same incorrect readings are obtained, the trouble is in the field circuit within the alternator. Probable causes are an open circuit or poor contact between the slip rings and brushes, worn brushes, or an open or shorted rotor winding. To isolate the cause, proceed with tests given in Par. H-16, H-17, and H-18 before removing the alternator.

16. Brush Removal and Inspection

Refer to Fig. 72.

The brushes can be removed and inspected while the alternator is in the vehicle.

Disconnect the plug to the field terminal. Remove the two screws and brush cover. Remove the brush and holder assembly. Inspect brushes for excessive wear and proper tension. Install the brush by reversing the above procedure.

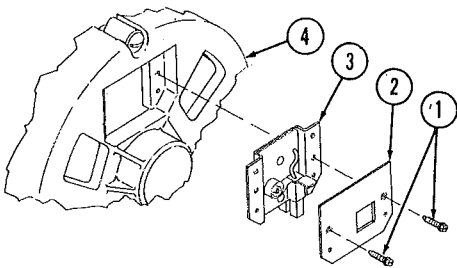


FIG. 72—BRUSH REMOVAL

- | | |
|---------|-----------------------------|
| 1—Screw | 3—Brush and Holder Assembly |
| 2—Cover | 4—Alternator |

17. Brush Insulation and Continuity Tests

Refer to Fig. 73.

Connect leads of a 24-volt test lamp to field terminal and bracket. Test lamp should not light. If it does, the brush is shorted and must be replaced. Connect one lead of an ohmmeter to field terminal and the other lead to insulated brush. Resistance reading should be zero. Move brush and brush lead wire to make certain that the brush lead wire

connections are not intermittent. Resistance reading should not vary when brush and lead wire are being moved.

c. Connect ohmmeter leads to bracket and grounded brush. Resistance reading should be zero. Repeat same test on brush lead wire as described in step b.

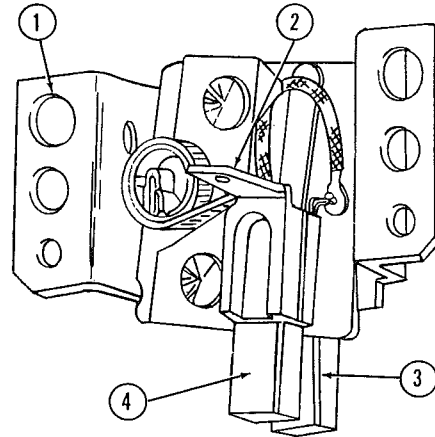


FIG. 73—INSULATION AND CONTINUITY TEST POINTS

- | | |
|------------------|-------------------|
| 1—Bracket | 3—Grounded Brush |
| 2—Field Terminal | 4—Insulated Brush |

H-18. Rotor In-Vehicle Test

With the brushes removed, check the rotor to see if it has an open or grounded field coil.

a. To check for an open field winding, connect test lamp between the slip rings. If the lamp fails to light, the windings are open.

b. To check for a grounded field coil, connect the test lamp from either slip ring to the rotor shaft or rotor poles. If the lamp lights, the field windings are grounded.

c. To check for a short circuit in the rotor windings, remove the alternator. Refer to Par. H-21 for rotor bench tests.

H-19. Alternator Bench Tests

When the various tests given in Par. H-9 through H-18 have determined a fault within the alternator itself, remove the alternator from the vehicle and perform the following tests in sequence to isolate the trouble to a particular component of the alternator. Note that certain tests can be performed when the alternator is removed, but before it is disassembled.

H-20. Alternator Removal

NOTE: Brushes and the isolation diode can be removed from the alternator without removing unit from vehicle.

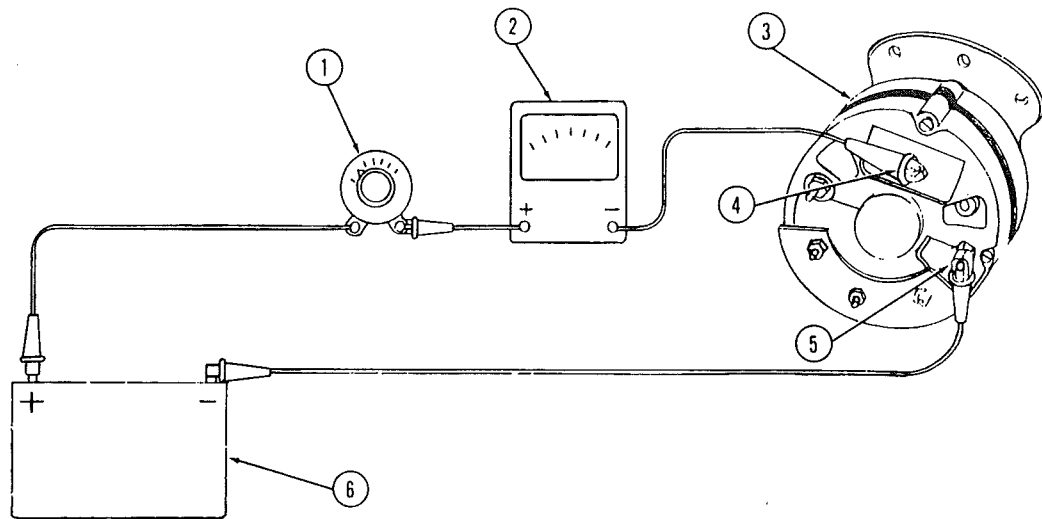


FIG. 74—ROTOR TEST

1—Rheostat
2—Ammeter

3—Alternator
4—Field Terminal

5—Ground Terminal
6—Battery

- a. Disconnect or unplug all connections at alternator.
- b. Remove nut and bolt at alternator support bracket. Remove nut, bolt, washer, and adjustment bracket. Remove belt from alternator pulley. The alternator is now free to be removed from the vehicle.

Reinstall repaired or known good brush and repeat test. If the field current is above the maximum value specified, the field coil is either shorted to the rotor or the field coil has shorted turns. If the field current is zero, the field coil or coil-to-slip ring connection is open. If the field current is considerably less than the value specified, a

H-21. Rotor Tests

This test checks the condition of the rotor (field coil) for an open or shorted field winding, excessively worn or sticky brushes, and open connections. It should be performed with the brush assembly installed in the alternator.

- a. Check the field coil for a short circuit by connecting a fully charged 25.2-volt battery and an ammeter in series with the two slip rings, as shown in Fig. 74. Place a rheostat in series in the circuit to protect the instruments and components of the alternator. Set the rheostat to maximum resistance (40 ohms) before making connections.
- b. Slowly reduce resistance of rheostat to zero. Then take reading on ammeter. With full battery voltage applied to the field coil, the field current of the alternator should be between 1.5 and 2.5 amperes.
- c. Turn the rotor by hand, noting reading. Rotating the rotor will indicate if brushes are making good electrical contact. A slight fluctuation of reading (0.2 ampere) is to be expected. If field current is not within limits, inspect brushes and slip rings for excessive dirt, sticky or broken brushes, and bad connections. Check brush assembly for short and continuity (Par. H-17).

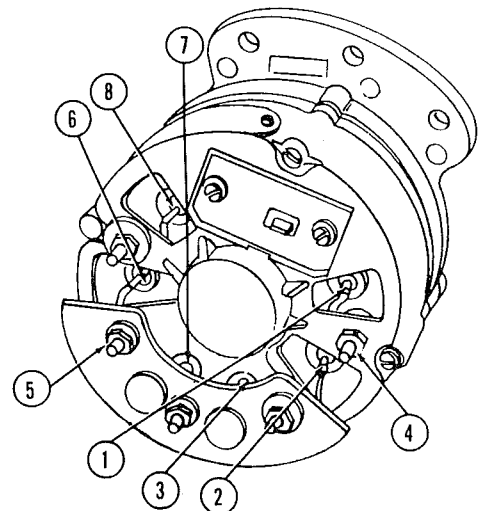


FIG. 75—IN-CIRCUIT RECTIFIER DIODE TEST POINTS

1—Negative Diode Terminal
2—Negative Diode Terminal
3—Negative Diode Terminal
4—Ground Terminal
5—Auxiliary Terminal
6—Positive Diode Terminal
7—Positive Diode Terminal
8—Positive Diode Terminal

coil-to-slip ring connection or poor brush-slip ring connection is indicated.

If the rotor is found to be defective in above tests, repeat the above tests when the rotor is removed from the alternator by connecting the circuit (Fig. 74) to the rotor slip rings to obtain findings. Field current will be approximately 0.2 ampere higher than the maximum value in use of the normal brush-to-slip ring contact resistance that reduces field current slightly. If the rotor is defective, replace it.

2. Rectifier Diode Test (In-Circuit)

Refer to Fig. 75.

If the output of the alternator is below rated capacity (Par. H-11), check the rectifying diodes for opens or shorts. If Diode Rectifier Tester C-3829, or equivalent (H-8b), is available, this test can be made without disassembling the alternator. If the tester is not available, disassembly is necessary; check diodes with a test lamp as outlined in Par. H-29.

Plug the Diode Tester C-3829, or equivalent, into a 120-volt outlet.

To test the negative diode, connect the alligator clip of the tester to point 4 and touch the barrel of one of the negative diodes with the test probe of the tester. Then successively check between points 4 and 2, and 4 and 3. The metering for each of these diodes should be the same and there should be a negative deflection on the scale. A meter reading of 2 or over indicates a satisfactory diode.

To test the positive diode, connect the alligator clip of the tester to point 5, and touch the barrel of one of the positive diodes with the probe of the tester. Then successively check between points 5 and 7, and 5 and 8. The metering for each of these diodes should be the same and should be a positive deflection on the

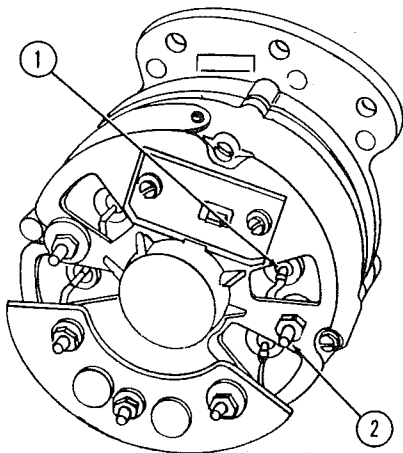


FIG. 76—IN-CIRCUIT STATOR LEAKAGE TEST POINTS

1—Negative Diode Terminal 2—Ground Terminal

scale. A meter reading of 2 or over indicates a satisfactory diode.

d. If meter readings are not as specified, disassemble the alternator and individually test the diodes as outlined in Par. H-29.

H-23. In-Circuit Stator Leakage Test

When making this test, consider the rectifier diodes that are connected to the stator winding. The negative rectifier diode will conduct in one direction. A shorted negative rectifier diode would make the stator appear shorted. For this reason, check the rectifier diode and the stator individually after the alternator has been disassembled to localize the problem.

CAUTION: Do not use a 120-volt test lamp. Use a 24-volt DC test lamp only. Otherwise, diodes will be damaged.

a. Connect the test lamp to a diode terminal and the ground terminal, as shown in Fig. 76.

b. Reverse test probes. The test lamp should light in one direction, but not in the other direction. If the test lamp does not light in either direction, all three rectifiers in the negative diode assembly are open. If the test lamp lights in both directions, the stator winding is shorted to the stator or one of the negative rectifier diodes is shorted.

H-24. Alternator Disassembly

Refer to Fig. 77.

a. Remove the brush assembly by removing two tapping screws and cover. Then pull the brush assembly straight out until the brushes are clear of the rotor assembly. Lift the brush assembly out of the housing.

b. Remove the isolation diode assembly by removing the nuts.

c. Remove the fan, pulley, lock washer, nut, and spacer. With the nut removed, the other parts will slide off the rotor shaft.

d. Separate the front housing from the rear housing by removing bolts and nuts. Then insert blades of two small screwdrivers in the stator slots between the stator and the front housing. Wedge apart the halves of the alternator.

CAUTION: Take care not to insert a screwdriver blade deeper than 1/16" [0,16 cm.] below a stator. Otherwise damage to the stator windings may result. It may be necessary to apply pressure at several points around the stator to extract the rotor and front housing as an assembly. Be careful not to burr the stator core as this would make reassembly difficult.

e. Remove the two rectifying diode heat sink assemblies and the stator as a complete unit from the rear housing by removing nuts and lock nuts. Note that the negative diode assembly is insulated from the alternator housing by insulated washers and insulated sleeves.

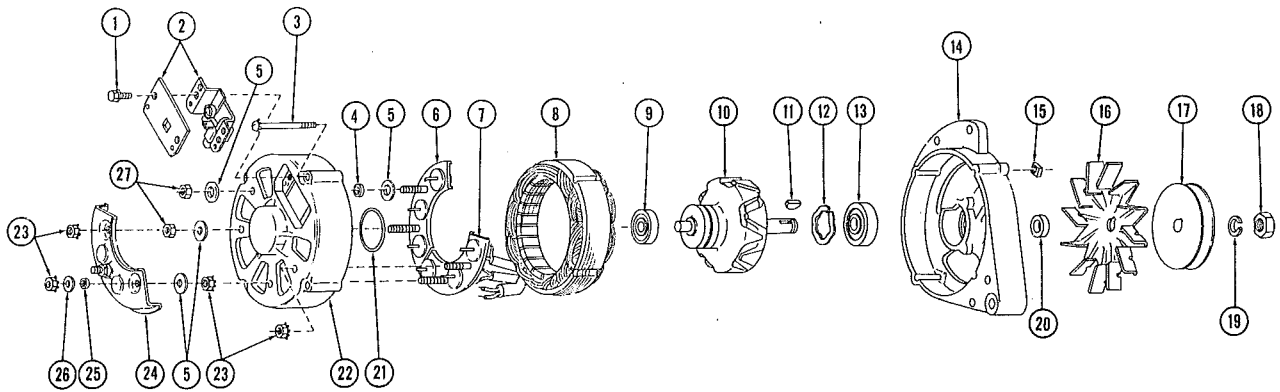


FIG. 77—ALTERNATOR, EXPLODED VIEW

- | | | | |
|--|--------------------------------------|--------------------------------|--------------------------------------|
| 1—Screw | 7—Negative Diode Rectifying Assembly | 15—Square Nut | 22—Rear Housing |
| 2—Brushes and Holder Assembly with Cover | 8—Stator Assembly | 16—Alternator Fan | 23—Hex Lock Nut |
| 3—Thru Bolt | 9—Rear Bearing | 17—Pulley | 24—Isolation Diode Dual Assembly |
| 4—Positive Diode Insulating Sleeve | 10—Rotor Assembly | 18—Pulley Mounting Nut | 25—Isolation Diode Insulating Sleeve |
| 5—Insulation Diode Insulating Washer | 11—Woodruff Key | 19—Pulley Mounting Lock Washer | 26—Isolation Diode Insulating Washer |
| 6—Positive Diode Rectifying Assembly | 12—Front Bearing Retainer | 20—Spacer | 27—Hex Nut |
| | 13—Front Bearing | 21—Rear Bearing Retainer | |
| | 14—Front Housing | | |

f. Test the diode and stator assemblies as outlined in Par. H-27. For additional testing (Par. H-28 and H-29) or to replace a diode heat sink assembly, unsolder the three soldered connections at the diodes to separate the heat sink from the stator.

CAUTION: When unsoldering the stator wires from the rectifier diode assembly, provide a heat sink to the diode terminal with a pair of long-nose pliers to dissipate the heat away from the diodes.

g. To remove the rotor assembly from the front housing, remove the Woodruff key and split spring washer (bearing retainer).

h. With the Woodruff key removed and the split spring washer loose, remove the rotor from the front housing by tapping the rotor shaft on a soft wood surface.

i. Remove the front and rear bearings from the rotor shaft by using Bearing Remover C-3934, or an equivalent puller, for the front bearing, as shown in Fig. 78, and Bearing Remover C-3936, or an equivalent puller, for the rear bearing, as shown in Fig. 79.

H-25. General Inspection

a. Wipe all parts clean and visually inspect for wear, distortion, and signs of overheating or mechanical interference.

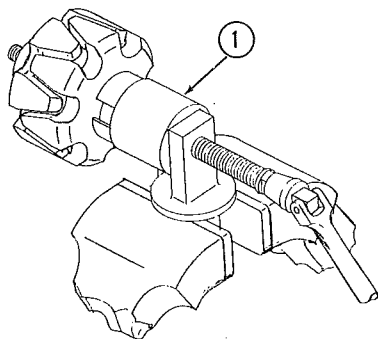


FIG. 78—REMOVING FRONT BEARING

- 1—Front Bearing Remover

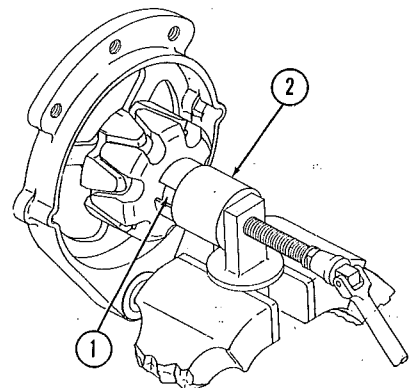


FIG. 79—REMOVING REAR BEARING

- 1—Rear Bearing 2—Rear Bearing Remover

Check the bearings for roughness or excessive clearance. Replace if found defective.

NOTE: New bearings are prelubricated. Additional lubrication is not required.

If excessively dirty, wipe the alternator end using clean with a cloth dampened in solvent, but do not buff, as this will destroy special treatment given to inhibit corrosion.

26. Out-of-Circuit Rotor Test

Refer to Par. H-18 and H-21 for tests to be performed on the rotor. If these tests were not performed while the alternator was assembled, they can be performed with the alternator removed following the procedures given in the following paragraphs.

27. Out-of-Circuit Stator Leakage Test

Disassemble the alternator and remove the rectifier diode plates and stator, as shown in Fig. 80, as an assembly.

A 100-ohm ohmmeter or 24-volt test lamp may be used. Connect one ohmmeter or test lamp probe to one of the rectifier diode terminals and the other to the stator, as shown in Fig. 80.

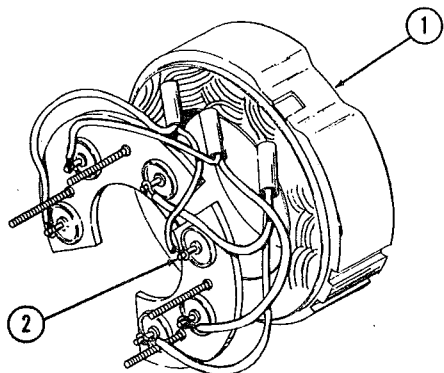


FIG. 80—STATOR LEAKAGE TEST POINTS

1—Stator 2—Diode Terminal

Resistance reading should be infinite or test lamp should not light. If resistance reading is not infinite or test lamp lights, high leakage or short exists between stator winding and stator.

In either case, separate the diode heat sinks from the stator (Par. H-24f) to ascertain whether the stator should be replaced (Par. H-24).

28. Stator Coil Leakage and Continuity Test

This test checks for shorts or leakage between stator coil windings. To make the test, the winding action must be separated as shown in Fig. 81. An ohmmeter or 24-volt or 120-volt test lamp may be used.

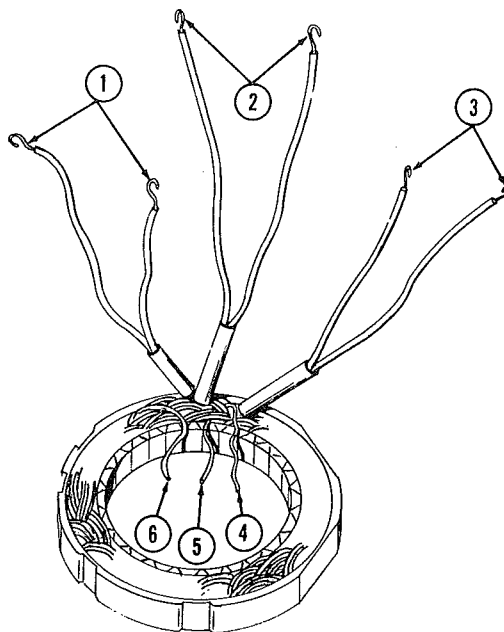


FIG. 81—STATOR LEAKAGE AND CONTINUITY TEST POINTS

1—Test Point 4—Test Point
2—Test Point 5—Test Point
3—Test Point 6—Test Point

a. Connect one of the ohmmeter or test lamp probes to test point 4, as shown in Fig. 81. Connect the other test probe to test point 5 and then to test point 6. Resistance should be infinite or test lamp should not light.

b. Connect one test probe to point 5 and the other to point 6. Resistance should be infinite or test lamp should not light. In either test, if the resistance reading is not infinite or the test lamp lights, high leakage or a short exists between stator windings. Replace stator.

c. Measure resistance of each winding in stator between test points 4 and 1, 5 and 3, and 6 and 2, in Fig. 81. Resistance should be approximately 0.1 ohm.

An extremely accurate instrument would be necessary to ascertain shorted turns. Only an open condition can be detected with a commercial ohmmeter. If the alternator has been disassembled because of an electrical malfunction, replace stator only after all components have been checked and found to be satisfactory.

H-29. Out-of-Circuit Rectifier Diode Test

With the rectifier diode heat sinks disconnected from the stator assembly (Par. H-24f), the diodes can be individually checked with the Diode Tester C-3829, or equivalent.

Fig. 82 shows the test point location for either a positive or negative diode. Plug Diode Tester C-3829, or equivalent, into a 120-volt AC outlet.

Connect alligator clip to diode plate stud, and the probe of the tester to each of the three diode terminal test points. Negative diodes will give a negative deflection of the needle, and positive diodes will give a positive deflection. The meter reading should be the same for each of the diodes and should be 2 or over for a good diode. If a diode is faulty, replace the entire diode heat sink assembly.

NOTE: Positive diodes are identified by red printing on the diode; negative diodes are identified by black printing.

H-30. Alternator Assembly

Refer to Fig. 77.

a. Install front bearing in front housing. Press the bearing into place on an arbor press. Position the split spring washer in the front bearing housing on top of the bearing with the ears of the washer centered in casting slot.

b. Place the rear bearing on the rotor shaft front end, using Bearing Installer C-3935, or equivalent socket, to fit inner race of bearing, as shown in Fig. 83.

c. Place the rotor assembly into position in the front housing by tapping rotor shaft on a soft wood surface.

d. Position diode assemblies and stator as a unit into the rear housing. Make certain that insulator washers and insulator sleeves are correctly positioned on the negative (black printing) diode assembly.

e. Place the subassembly halves of the alternator (front housing and rear housing). Slide the front housing over the stator. Install the bolts and nuts.

f. Position the spacer and Woodruff key on the rotor shaft and slide on the fan and pulley. Position the alternator in a vise with the clamps of

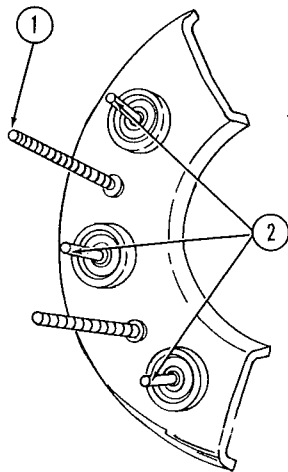


FIG. 82—RECTIFIER DIODE TEST POINTS

1—Diode Plate Stud 2—Diode Terminal

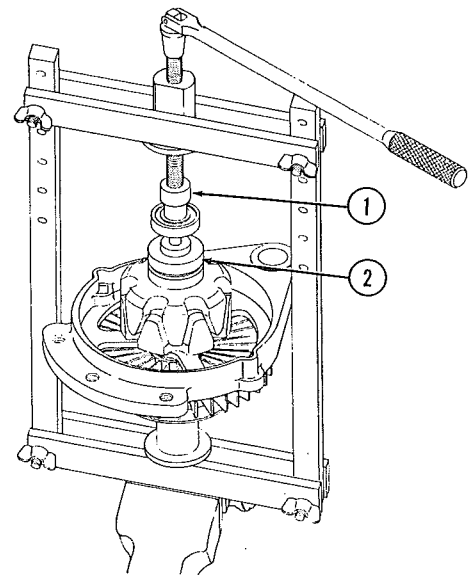


FIG. 83—INSTALLING REAR BEARING

1—Rear Bearing Installer 2—Rotor Shaft

the vise held to the pulley (Fig. 84). Position the pulley so it is just starting to slide over the Woodruff key. Press it into position by tightening nut with a wrench. When the pulley is properly positioned, remove the nut, place the lock washer on the rotor shaft, and again replace the nut.

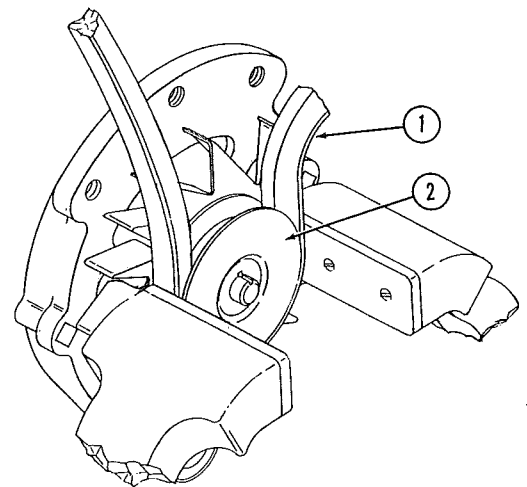


FIG. 84—INSTALLING PULLEY

1—Belt 2—Pulley

g. Install the isolation diode assembly and secure to the positive and negative diode assembly studs with lock nuts. Make sure the isolation diode is insulated from the negative diode stud.

h. Install the brush housing in position in the rear housing. Install the brush housing cover and the tapping screws.

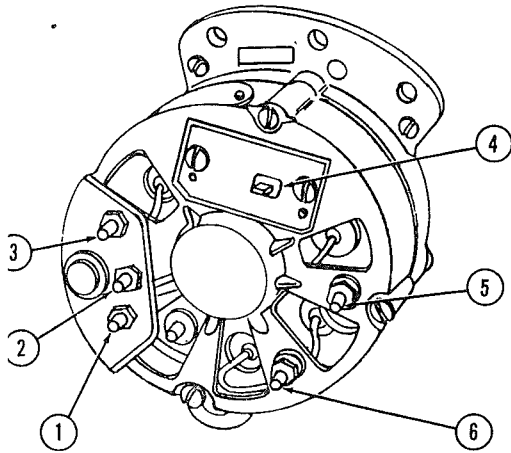


FIG. 85—WIRE LOCATIONS FOR ALTERNATOR HOOKUP

- | | |
|----------------------|-------------------|
| 1—Auxiliary Terminal | 4—Field Terminal |
| 2—Output Terminal | 5—Ground Terminal |
| 3—Auxiliary Terminal | 6—Ground Terminal |

Turn the rotor by hand, listening carefully to be certain there is no interference between the rotor and the stator winding.

Check to make sure the positive diode assembly and isolation diode assembly are properly insulated. Connect a 24-volt test lamp to the auxiliary and ground terminals. Reverse the test lamp probes. The lamp should light in one direction, and not the other.

31. Alternator Installation

When installing the alternator, reverse the procedure given in Par. H-20, adjusting the fan belt to its proper tension once the alternator is installed,

as described in Par. G-16. Connect wires as shown in Fig. 85.

H-32. STARTING MOTOR

The starting motor consists of an armature and commutator on a shaft, field coils, pole shoes, drive mechanism, and brushes. The shaft is mounted in sleeve-type bushings in the housings. Four field coils are mounted in the frame, with pole shoes in the center of each coil. The starting motor has an integral overrunning clutch to drive the engine flywheel ring gear when starting. A magnetically actuated solenoid switch, mounted on the frame of the starting motor, acts to shift the overrunning clutch to engage the ring gear. Fig. 87 illustrates the construction of the starting motor. The motor is energized through the starting circuit as shown in Fig. 86. Two 12-volt batteries, connected in series, power the system.

H-33. Maintenance Procedure

A periodic inspection should be made of the starting circuit. While the interval between these checks will vary according to the type of service, it should, under normal conditions, be made every 500 hours of operation. At this check, the following points should be inspected.

H-34. Wiring

Inspect the starting circuit (Fig. 86) to make sure that all connections are clean and tight. Check for worn or damaged insulation on the wires. Perform a voltage-loss test to make sure there is no loss of starting motor efficiency resulting from high resistance connections. Voltage loss from the battery terminal to the starting motor terminal should not exceed 0.30 volt for each 100 amperes. Voltage loss between the battery ground post and the starting motor frame should not exceed 0.10 volt for each 100 amperes. If the voltage loss is greater than these limits,

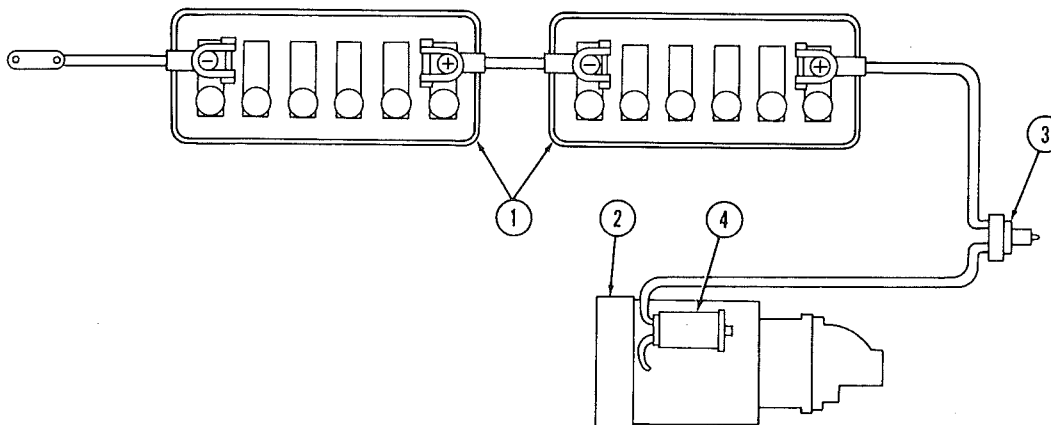


FIG. 86—STARTING CIRCUIT

- | | | | |
|-----------|------------------|------------------|-------------------|
| 1—Battery | 2—Starting Motor | 3—Starter Switch | 4—Solenoid Switch |
|-----------|------------------|------------------|-------------------|

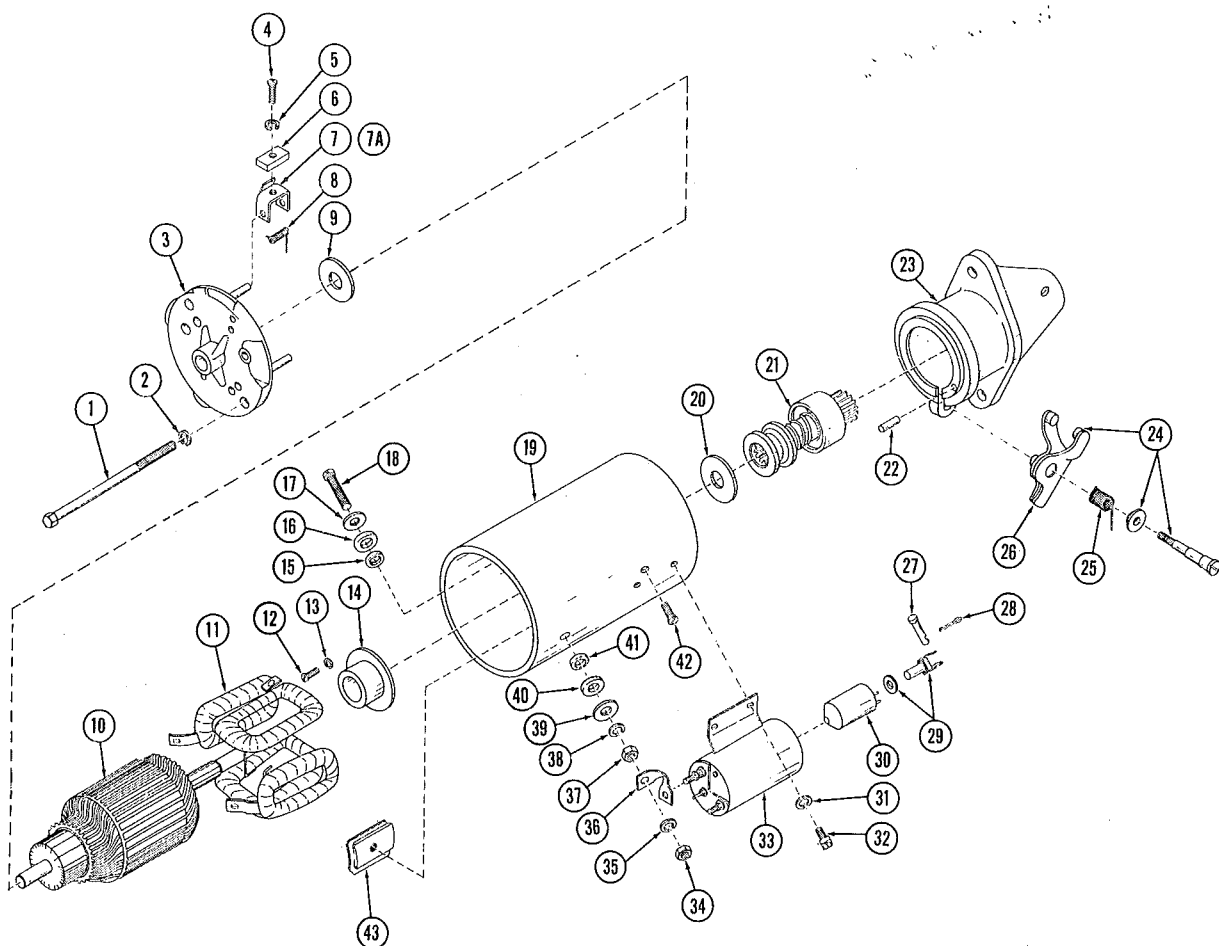


FIG. 87—STARTING MOTOR, EXPLODED VIEW

- | | | | |
|-----------------------|-----------------------------|----------------------------|----------------------------|
| 1—Thru Bolt | 13—Lock Washer | 22—Dowel Pin | 33—Starter Solenoid Switch |
| 2—Lock Washer | 14—Center Bearing Plate | 23—Drive Housing | 34—Nut |
| 3—Commutator End Head | 15—Terminal Stud | 24—Lever and Shaft | 35—Lock Washer |
| 4—Screw | 16—Terminal Stud | 25—Lever Return Spring | 36—Connector |
| 5—Lock Washer | 17—Terminal Stud Plain | 26—Shift Lever | 37—Lock Washer |
| 6—Brush | 18—Terminal Stud | 27—Shift Lever Pin | 38—Plain Washer |
| 7—Brush Holder | 19—Field Frame | 28—Cotter Pin | 39—Terminal Stud |
| 8—Brush Spring | 20—Brake Washer | 29—Shift Lever Link | 40—Terminal Stud |
| 9—Thrust Washer | 21—Overrunning Clutch Drive | 30—Solenoid Switch Plunger | 41—Pole Shoe Screw |
| 10—Armature | | 31—Lock Washer | 42—Pole Shoe |
| 11—Field Coil | | 32—Screw | |
| 12—Screw | | | |

measure the voltage loss over each part of the circuit until the resistance causing the voltage loss is located and corrected.

H-35. Commutator

Sluggish starting motor operation may be caused by a dirty commutator or worn brushes. The commutator on the 24-volt starting motor cannot be cleaned while the starting motor is mounted on the engine; it will be necessary to remove it and proceed as for an overhaul. If the com-

mutator in the starting motor is rough or worn, remove the motor for cleaning and reconditioning.

H-36. Overhaul Procedure

At periodic intervals, the starting motor circuit should be thoroughly checked and the motor removed from the engine for cleaning and checking.

H-37. Disassembly

To remove the starting motor from the engine, disconnect the leads and cover the battery lead

th a short piece of hose to prevent short circuiting. Take out the flange bolts holding the motor to the flywheel housing. The motor will then lift off and can be taken to the bench for a complete overhaul.

When disassembling the motor, each part should be removed, cleaned, and inspected for wear or damage. Refer to Fig. 87. The overrunning clutch drive should be cleaned and inspected for wear and a distorted spring. Bearings should be checked for proper clearance and fit. All insulation should be free of oil and in good condition. The armature, field coils, and brushes should be checked for grounds and open circuits.

38. Brushes

The brushes should make full contact on the commutator. Worn brushes should be replaced. Check brush spring tension with a spring scale. Hook the scale under the brush holder near the brush and pull on a line parallel with the side of the brush. Take the reading just as the brush leaves the commutator. It is important that the brush spring tension be kept within the limits specified at the end of this section. If the tension is too low, there will be a loss of efficiency from poor brush contact. Too great tension will cause excessive brush and commutator wear. To change the tension, twist the spring at the holder with long-nosed pliers. Worn brushes should be replaced.

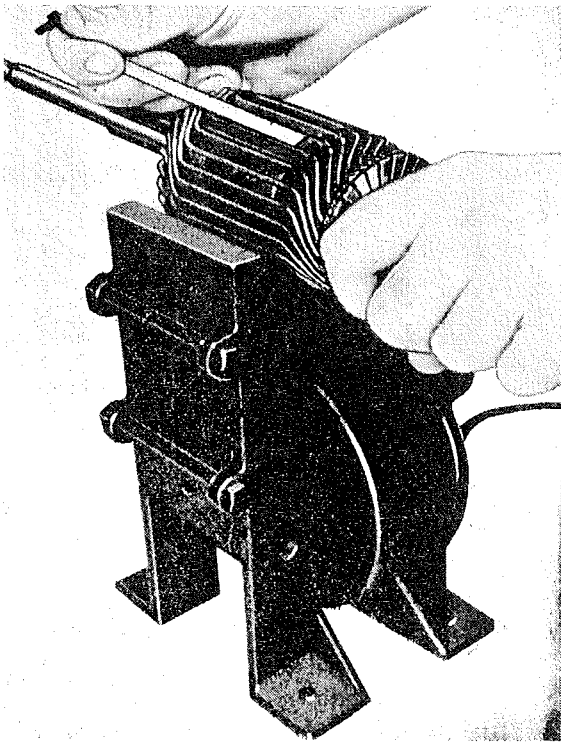


FIG. 88—GROWLER

Brushes that are soldered to the field coil should be unsoldered and the loop in the field coil lead should be opened. Insert the new brush pigtail to its full depth in the loop. The new brush lead should be tightly clinched in the terminal and then soldered to make a strong, low-resistance connection.

H-39. Commutator

Check the commutator for wear and discoloration. If the commutator is rough or worn, the armature should be removed and the commutator turned down in a lathe.

H-40. Armature

The armature should be visually inspected for mechanical defects before being checked for shorted or grounded coils. For testing armature circuits, it is advisable to use a light and a set of test probes.

To test the armature for grounds, touch one point to a commutator segment and touch the core or shaft with the other probe. Do not touch the points to the bearing surface or to the brush surface, as the arc formed will burn the smooth finish. If the lamp lights, the coil connected to the commutator segment is grounded.

To test for shorted armature coils, a growler (Fig. 88) is necessary. The armature is placed against the core and a steel strip is held on the armature. The armature is then rotated slowly by hand. If a shorted coil is present, the steel strip will become magnetized and vibrate.

H-41. Field Coils

Using test probes, check the field coils for both openings and grounds. To test for grounds, place one probe on the motor frame or pole piece and touch the other probe to the field coil terminals. If a ground is present, the lamp will light.

To test for open circuits, place the probes on the field coil terminal and an insulated brush. If the light does not light, the coil is open circuited.

H-42. Brush Holder Inspection

Using test probes, touch the insulated brush holder with one probe and a convenient ground on the commutator end head with the other probe. If the lamp lights, it indicates a grounded brush holder.

H-43. Motor Assembly

When assembling absorbent bronze bearings, always use the proper arbor, as these arbors are designed to give the proper bearing fit. Soak the bearing in oil before assembling in the bearing bore. Brushes should be correctly installed and connected, as previously outlined, in order to be sure of proper starting motor efficiency. Refer to Fig. 87.

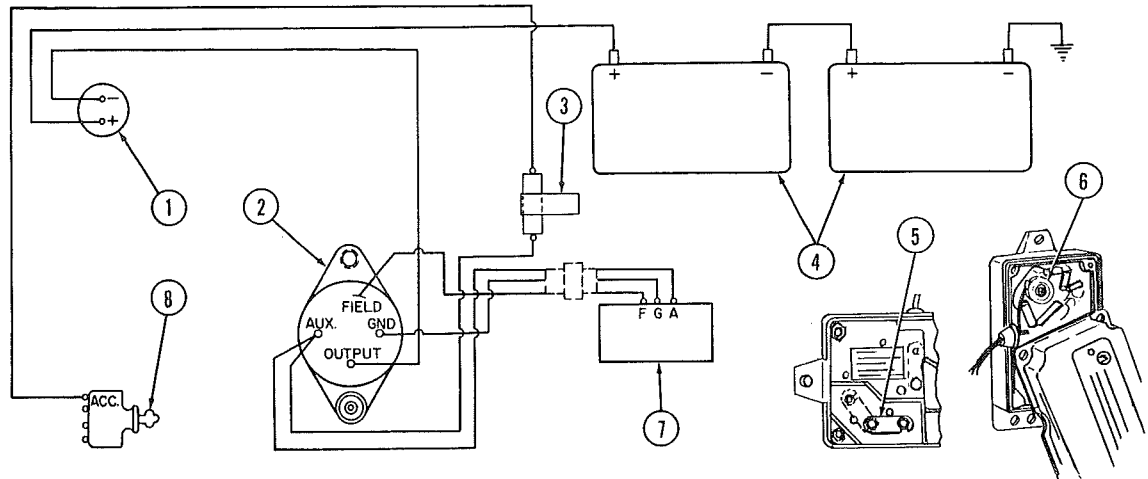


FIG. 68—BATTERY CHARGING CIRCUIT

- | | | | |
|--------------|-------------|-------------------------------------|-------------------|
| 1—Ammeter | 3—Resistor | 5—Voltage Regulator Adjusting Strap | 7—Regulator |
| 2—Alternator | 4—Batteries | 6—Variable Voltage Control | 8—Ignition Switch |

d. The drive end head supports a prelubricated ball bearing in which the drive end of the rotor shaft rotates.

e. The diode rectifiers are pressed in the rectifier brackets or heat sinks and are connected to the stator leads.

f. The isolation diode is pressed in the aluminum heat sink mounted to the rear of the alternator. The complete assembly is covered with a red insulating coating.

For repairing the alternator, many of its major components are furnished as complete assemblies including a complete brush assembly which requires no soldering or unsoldering of leads; two complete rectifying diode assemblies which eliminate the need for removing and replacing individual diodes; a complete isolation diode assembly; and a rotor assembly complete with shaft, pole pieces, field coil, and slip rings.

The transistorized voltage regulator is an electronic switching device. It senses the voltage appearing at the auxiliary terminal of the alternator and supplies the necessary field current for maintaining the system voltage at the output terminal. The output current is determined by the battery electrical load, such as head lamps, heater, etc.

The transistorized voltage regulator should not need adjustment. In case adjustment seems necessary, however, an adjustable strap is shipped, secured to the bottom of the regulator. Instructions printed on the bottom of the regulator show how the strap is to be positioned to increase or decrease the voltage by 0.6 volts. Further adjustment can be made by turning the variable voltage control under the top cover with a No. 2 Phillips screw driver.

H-4. Alternator Precautions

The following precautions must be observed to prevent damage to the alternator and regulator.

a. Never reverse battery connections. Always check the battery polarity with a voltmeter before making connections to be sure that all connections correspond to the battery ground polarity of the vehicle.

b. Booster batteries for starting must be properly connected. Make sure that the negative cable of the booster battery is connected to the negative terminal of the battery in the vehicle. Connect the positive cable of the booster battery to the positive terminal of the battery in the vehicle.

c. Disconnect the battery cables before using a fast charger.

d. Never use a fast charger as a booster for starting the vehicle.

e. Never disconnect the voltage regulator while the engine is running.

f. Do not ground the alternator output terminal.

g. Do not operate the alternator on an open circuit with the field energized.

h. Do not attempt to polarize an alternator.

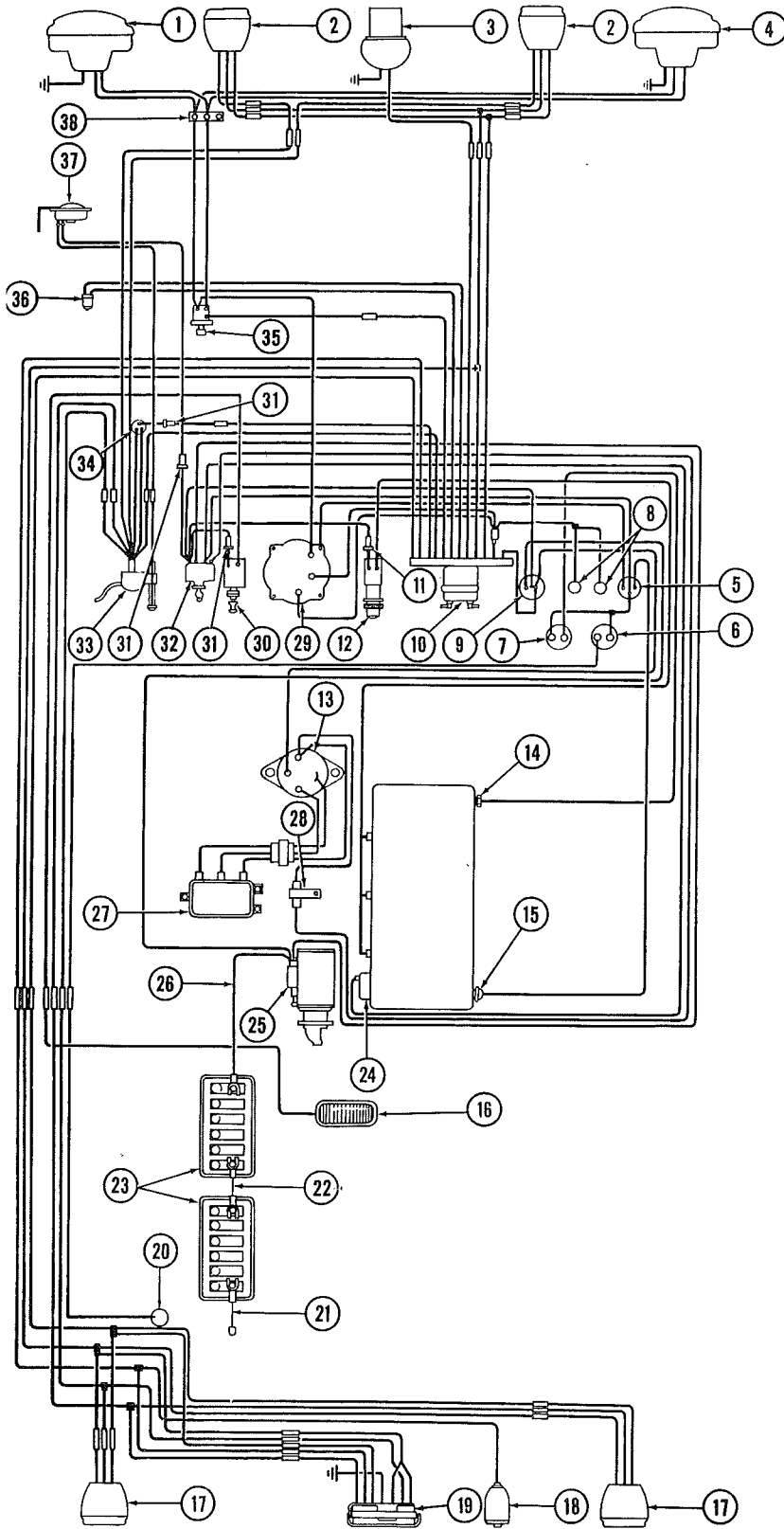
These precautions are stated here as an aid to service personnel. They are also restated at appropriate places in the text of this section of the manual.

H-5. CHARGING SYSTEM SERVICE

H-6. Service Diagnosis

In diagnosing a suspected malfunction of the alternator charging system, consider the complete electrical power plant of the vehicle, including the alternator, regulator, ignition switch, ammeter, battery, and all associated wiring. If it is suspected that the alternator is not fully charging the battery and fulfilling the electrical requirements of the electrical system, make the following checks before checking the alternator itself:

a. Test the condition of the battery and state of charge (Par. H-2). If the battery is not fully



- 1—Left Headlight
- 2—Parking Signal and Blackout Marker Light
- 3—Blackout Driving Light
- 4—Right Headlight
- 5—Oil Pressure Gauge
- 6—Fuel Pressure Gauge
- 7—Temperature Gauge
- 8—Panel Light
- 9—Ammeter
- 10—Light Switch
- 11—Glow Plug Fuse (20 amp)
- 12—Glow Plug Switch
- 13—Alternator
- 14—Heat Indicator Plug
- 15—Oil Pressure Sending Unit
- 16—Dome Light
- 17—Tail and Stop Light
- 18—Blackout Stop Light
- 19—Trailer Receptacle Cover
- 20—Fuel Gauge (Tank Unit)
- 21—Battery Ground Cable
- 22—Battery-to-Battery Cable
- 23—Battery (24 volt)
- 24—Fuel Pump
- 25—Starting Motor
- 26—Battery Positive Cable
- 27—Voltage Regulator
- 28—Alternator Resistor
- 29—Speedometer
- 30—Dome Light Switch
- 31—Dome Light Fuse (9 amp)
- 32—Ignition and Starter Switch
- 33—Directional Signal Switch
- 34—Directional Signal Flasher
- 35—Foot Dimmer Switch
- 36—Stop Light Switch
- 37—Horn Assembly
- 38—Junction Block

FIG. 90—WIRING DIAGRAM

H-44. Lubrication

Absorbent bearings should be soaked in oil and the bearings seats should be given a light wipe of oil.

H-45. Bench Test

The motor should first be checked to see that the free running voltage and current are within specifications. To test, connect the motor to a battery, ammeter, and voltmeter. If the current is too high, check the bearing alignment and end play to make sure there is no binding or interference. Using a spring scale and torque arm, check the stall torque to see that the motor is producing its rated cranking power. The stall torque will be the product of the spring scale reading and the length of the arm in feet. If the torque is not up to specifications, check the seating of the brushes on the commutator and the internal connection of the motor for high resistance. Check the overrunning clutch to see that the shift movement is according to specification.

H-46. Overrunning Clutch Drive

The starter is equipped with an overrunning clutch drive which provides a positive means of engaging the drive pinion with the engine flywheel ring gear to crank the engine and to disengage the pinion from the flywheel ring gear as the engine starts.

H-47. Overrunning Clutch Lubrication

A periodic cleaning and relubrication of the drive is advisable. Frequency depends on the type of service to which the vehicle is subjected and the locale of operation. Remove the starting motor from engine and remove the overrunning clutch from starting motor. Remove the lock wire and collar from the sleeve assembly; refer to Fig. 89. Remove the spring. Lubricate the sprags in the sleeve and shell assembly. Saturate the felt washer with light oil. Position the spring and collar on the sleeve assembly; attach with the lock wire. Assemble the starting motor and install it on the engine.

H-48. Starting Switch

The starting switch is a solenoid type which electrically closes the circuit between the battery and starting motor. When ignition key is turned to the extreme right, a contact is made which energizes the solenoid winding and closes the circuit. The solenoid is spring loaded and the circuit is opened when ignition key is allowed to return to "Ignition On" position. No repairs or adjustments can be made on this switch and if trouble develops in one, it must be replaced by a new switch.

H-49. Ignition Switch

The ignition switch serves both to energize the ignition system and engage the starter switch. With

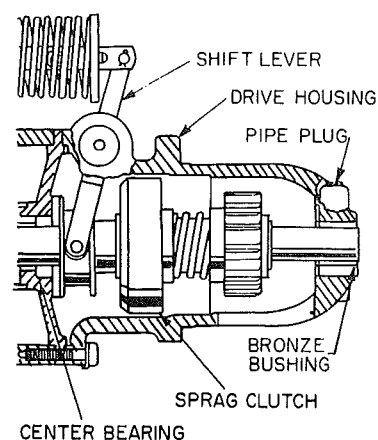


FIG. 89—OVERRUNNING CLUTCH DRIVE

the key in the vertical position, the electrical system is OFF. Turning the key to the left energizes only the instruments and auxiliary equipment such as radio and heater. Turning the key to the right energizes the ignition system and auxiliary equipment. Turning the key "hard right" engages the starter switch.

To remove the lock cylinder from the switch, first turn the key to the left (ignition-auxiliary) position. Then insert a short piece of wire or a paper clip into the lock release hole in the switch body. Pressing in on the wire will compress the lock cylinder retainer, allowing the cylinder to be removed. Either part, the lock cylinder or the switch unit, may be replaced as needed.

Switches are held in place by a threaded bezel nut. Lock cylinders are 1-17/32" [39 mm.] long. Be sure to get the correct replacement when changing lock cylinders.

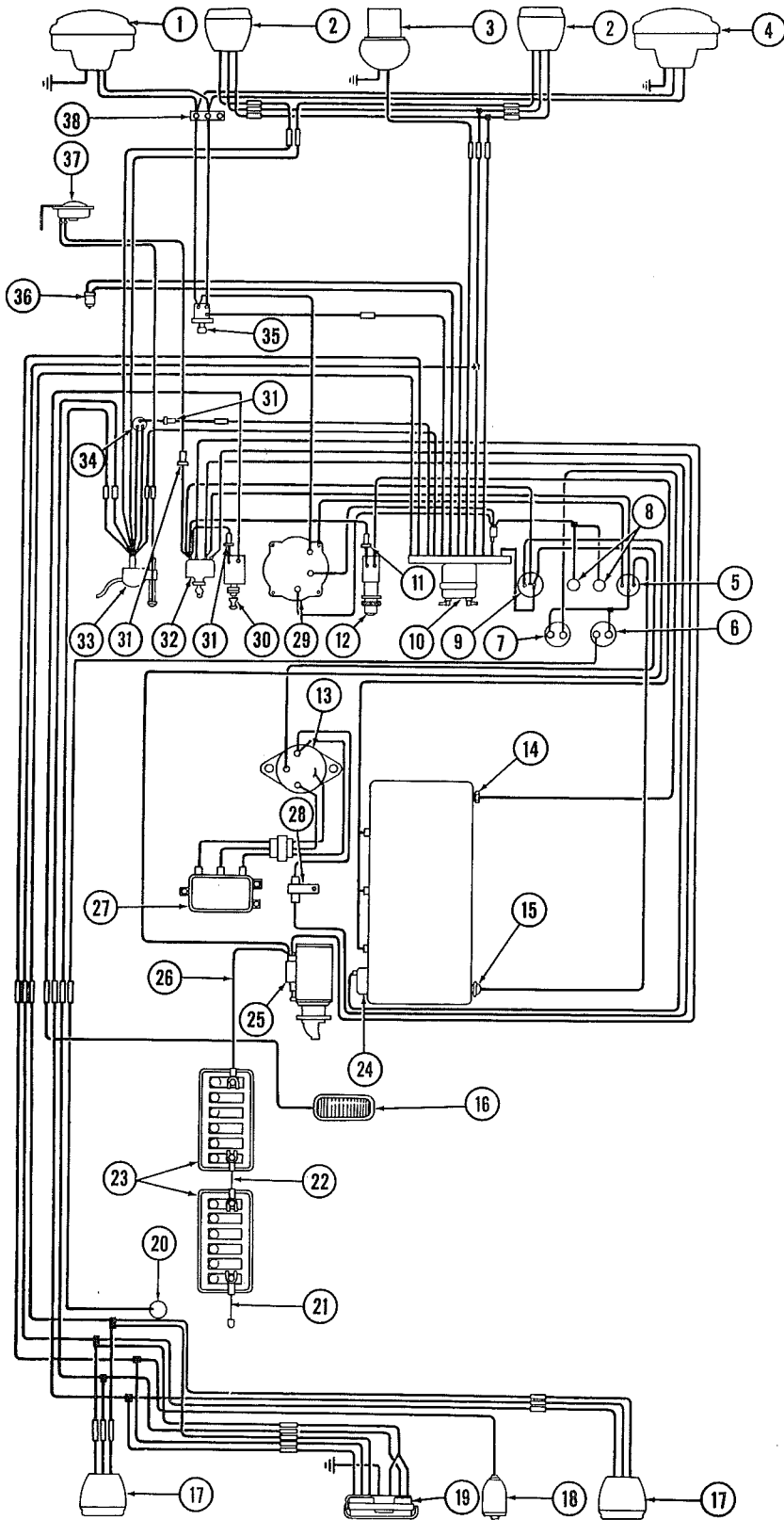
H-50. Fuse Replacement

Check with specifications and use the correct size fuse. A fuse with too small an amperage will blow on ordinary current. A fuse with too large an amperage will let too much current flow, which may damage the wiring or set fire to the vehicle. When installing a fuse, be sure fuse clips in the fuse receptacle are clean. If they are not, wipe them clean and bright with emery cloth. Be sure receptacle clips hold fuse tightly to avoid poor contact. If the fuse turns easily in the clips, remove the fuse, squeeze the clips tighter together, and then reinstall the fuse.

H-51. Indicators and Gauges

To remove the instruments, the instrument panel must be removed. Detailed instructions for removing the instrument panel are given in Par. S-13.

The indicators and gauges on the instrument panel are electrically operated.



- 1—Left Headlight
- 2—Parking Signal and Blackout Marker Light
- 3—Blackout Driving Light
- 4—Right Headlight
- 5—Oil Pressure Gauge
- 6—Fuel Pressure Gauge
- 7—Temperature Gauge
- 8—Panel Light
- 9—Ammeter
- 10—Light Switch
- 11—Glow Plug Fuse (20 amp)
- 12—Glow Plug Switch
- 13—Alternator
- 14—Heat Indicator Plug
- 15—Oil Pressure Sending Unit
- 16—Dome Light
- 17—Tail and Stop Light
- 18—Blackout Stop Light
- 19—Trailer Receptacle Cover
- 20—Fuel Gauge (Tank Unit)
- 21—Battery Ground Cable
- 22—Battery-to-Battery Cable
- 23—Battery (24 volt)
- 24—Fuel Pump
- 25—Starting Motor
- 26—Battery Positive Cable
- 27—Voltage Regulator
- 28—Alternator Resistor
- 29—Speedometer
- 30—Dome Light Switch
- 31—Dome Light Fuse (9 amp)
- 32—Ignition and Starter Switch
- 33—Directional Signal Switch
- 34—Directional Signal Flasher
- 35—Foot Dimmer Switch
- 36—Stop Light Switch
- 37—Horn Assembly
- 38—Junction Block

FIG. 90—WIRING DIAGRAM

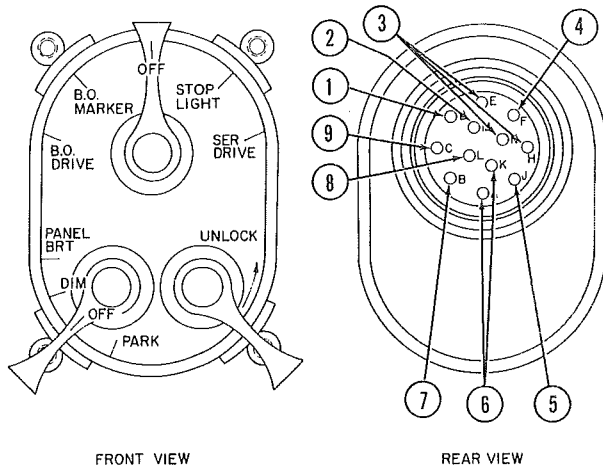


FIG. 91—MAIN LIGHT SWITCH

- | | |
|----------------------------|--------------------------------|
| 1—B. O. Driving | 6—Stop Light Switch |
| 2—Foot Dimmer Switch | 7—Instrument Panel Connector |
| 3—Tail and Stop Lamp | 8—Park Signal and B. O. Marker |
| 4—Ammeter | 9—Directional Signal |
| 5—Directional Flasher Fuse | |

The fuel gauge is connected by a single wire to a float and slide rheostat sending unit in the fuel tank.

The temperature gauge is connected by a single wire to a resistance-type sending unit mounted on the engine.

The ammeter indicates the rate of charge from the alternator to the battery or the rate of discharge of the battery. When the alternator is charging the battery, the ammeter reads in the positive (+) range; when the battery is discharging, the ammeter indicates in the negative (-) range. The oil pressure gauge is connected by a single wire to a diaphragm switch located on the engine. When the engine oil pressure is low or zero and the ignition switch is on, the oil pressure gauge will indicate the engine oil pressure.

If the gauges fail, check the wiring for a poor connection. The wiring of the complete vehicle is shown in Fig. 90. If the connections are in good condition and the gauge does not register,

replace the gauge or the sending unit. Check the gauge against a gauge known to be good to determine if the fault is in the gauge or the sending unit.

H-52. Lighting System

The wiring of the lighting system is shown in the wiring diagram, which indicates the various units in relation to their position in the vehicle. The wires in the various circuits are of different colors or are marked by tracers woven in the insulation to aid when checking individual circuits.

H-53. Main Light Switch

The main light switch consists of two separate switch controls, one to control the selection of drive lamps on the vehicle and the other to control the selection of panel and parking lamps; refer to Fig. 91. A third lever on the front of the switch is a lock lever which must be placed in the release position to operate either of the other two switch levers. This prevents the accidental movement of either lamp selector switch. The drive lamp selector switch lever has the following positions:

B.O. DRIVE—This position turns on the blackout driving lights for night driving under blackout conditions.

B.O. MARKER—This position turns on the blackout marking lights for parking or stopping under blackout conditions.

OFF—This position prevents any of the associated lights (blackout drive and marker, stop and tail light, and head lamps) from being lighted.

SER. DRIVE—This position turns on the head lamps.

The panel and park selector switch lever has the following positions:

PANEL BRT.—This position turns on the panel lights at normal brightness.

DIM—This position turns on the panel lights at a dimmed light level.

OFF—This position prevents either the panel lights or the parking lights from being lighted.

PARK—This position turns on the parking lights. The light switch is shown in Fig. 91.

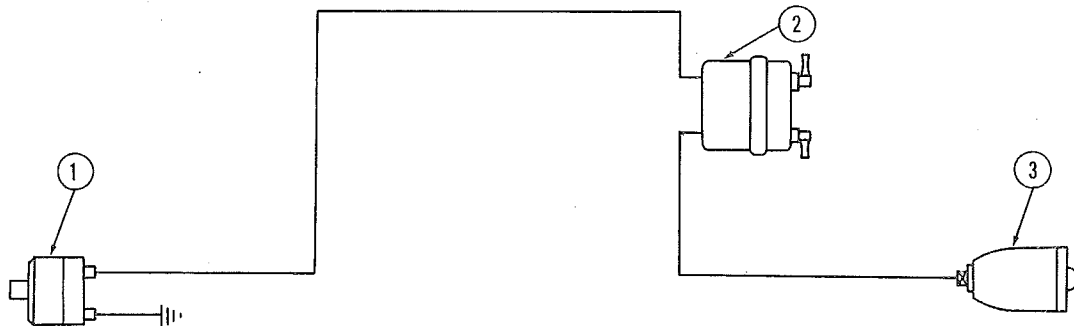


FIG. 92—STOP LIGHT CIRCUIT

1—Stop Light Switch

2—Main Light Switch

3—Tail Light

e switch is removed from the instrument panel by first removing the screws and switch covers. Remove the four screws and remove the main light switch from the instrument panel.

It is necessary to install a new light switch, refer to the wiring diagram (Fig. 90) and the structure of the rear connector on the switch (Fig. 91) which indicates the correct wires to install the terminals.

54. Stop Light Switch

The stop light switch is of the diaphragm type and is located in the front end of the brake master cylinder. Should the switch become inoperative, it is necessary to install a new one. Fig. 92 shows the wiring of the stop light circuit.

55. ELECTRICAL CIRCUITS

Before testing electrical circuits, make sure that the battery is satisfactory or install a fully charged battery. Also, check the starting motor itself for excessive draw.

Turn on the ignition and measure the voltage drop across each portion of the energized circuit with a voltmeter.

NOTE: Most voltage drops will be found at the connections of wires to terminals. Dirt oxidation, etc., can cause excessive resistance at these points. Measure voltage drops in wires shown in Fig. 93 to take this into account.

With a voltmeter, check the continuity of any circuit that does not seem to be operating properly. Make sure the voltage drop over wires is less than 0.05. Refer to the wiring diagram (Fig. 90) for circuits and connections. Replace any non-operating or high resist-

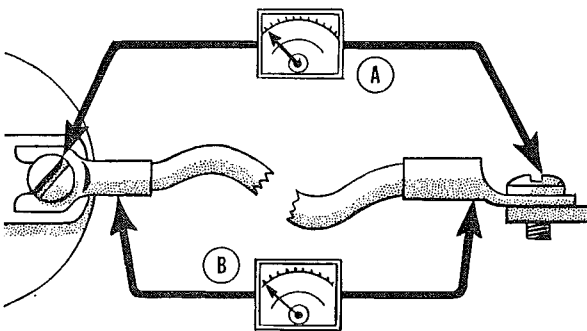


FIG. 93—VOLTAGE DROP TEST

RIGHT WAY—Voltmeter indicating drop across wire and connections.

WRONG WAY—Voltmeter indicating drop across wire only. Does not show bad connection.

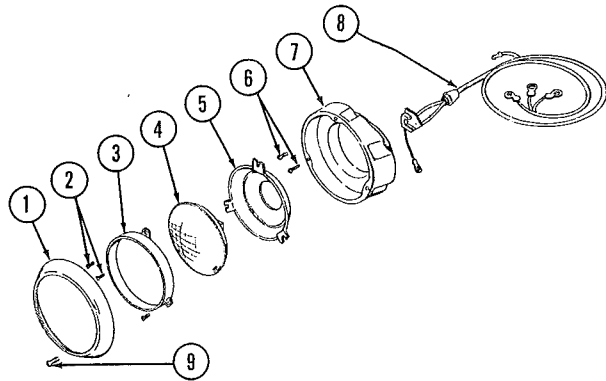


FIG. 94—HEAD LAMP

- | | |
|--------------------|-------------------|
| 1—Door | 6—Adjusting Screw |
| 2—Retaining Screw | 7—Housing |
| 3—Retaining Ring | 8—Wires |
| 4—Sealed Beam Unit | 9—Door |
| 5—Mounting Ring | |

ance components. Make sure all connections are clean and tight.

c. Check for voltage drop in battery ground cable. Clean the battery posts, cable terminals, and ground connection on the engine if a noticeable deflection occurs on voltmeter. Make sure positive cable is tight and connection is not corroded. Check cable connections and cable condition between batteries.

H-56. Head Lamps

Each sealed beam head lamp can be replaced only as a unit. Refer to Fig. 94. Aim the head lamps as directed in Par. H-57 and H-58.

H-57. Head Lamp Aiming

a. Lamps are aimed using a mechanical aiming device. Headlight aiming should always be done on low beam since this is the light intensity most often used and is also the intensity used when approaching oncoming traffic.

b. Most modern sealed beam lamps have an asymmetrical beam designed to give maximum visibility down the road with the least interference to an approaching driver. The light pattern for the lamp is shown in figure 95. Because the "hot" spot of the lamp, or area of greatest light intensity is in the upper left corner of the light pattern, it is very important that the light aiming be kept accurate.

H-58. Aiming Head Lamps

a. Install a headlight aiming device on the headlight. Follow the manufacturer's instructions to check the lamp aim.

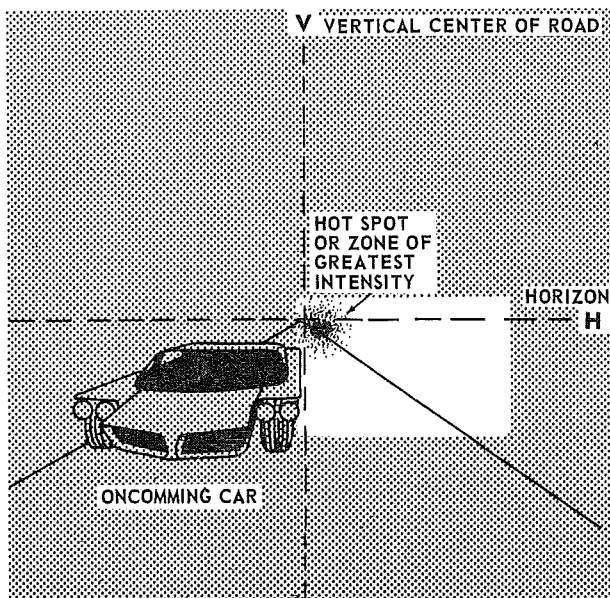


FIG. 95—HEAD LAMP AIMING CHART

- b. If the lamp is not aimed correctly, open the headlight door and turn the adjusting screws to adjust the aim.
- c. Adjust the vertical position of the lamp first. Overcorrect the vertical position; then bring it

into the correct position by turning the screw clockwise.

NOTE: Always bring the beam into final position by turning both aiming screws clockwise so the unit is held under proper tension when the operation is complete.

- d. Aim the horizontal position of the beam in the same manner.
- e. Close the headlight door and remove the aiming device.

H-59. Horn

All models are equipped with an electric warning horn which is mounted under the left front floor pan. The horn is sounded by pressing the button located at the top center of the steering wheel. To remove the horn wire, disconnect the wire at the snap connection at the base of the steering column. Pull off the rubber horn button cap and the brass contact cap from the steering wheel nut. This will expose the contact tip of the horn wire. Pull the wire out of the steering column from the top. Should it be necessary to replace the horn wire, it will be necessary to remove the steering column. The wire may be removed by unsoldering it from the contact sleeve on the steering tube. When replacing the wire, be sure to use a noncorrosive

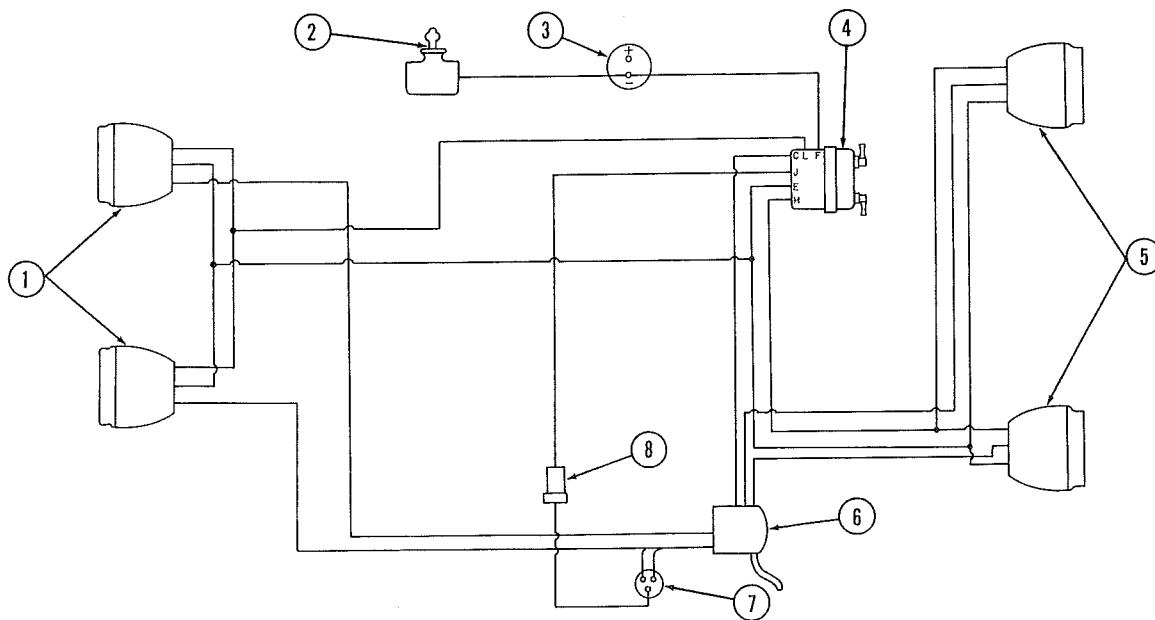


FIG. 96—DIRECTIONAL SIGNAL CIRCUIT

1—Park Signal and Blackout Lights
2—Ignition Switch

3—Ammeter
4—Main Light Switch

5—Tail and Stop Lights
6—Directional Signal Switch

7—Flasher
8—Fuse

Considering flux when soldering the wire to the contact sleeve.

60. Directional Signals

Fig. 96 shows the wiring of a composite directional signal circuit. The most frequent causes of failure in the directional signal system are loose connections and burned-out bulbs. A flashing rate approximately twice the normal rate usually indicates a burned-out bulb in the circuit. When a bulb in the signal switch is suspected, it is

advisable to make the following test to definitely locate the trouble before going to the effort of removing the signal switch. If, for example, the right rear stop light and right front parking light are inoperative and switch failure is indicated, first put the control lever in neutral position. Then disconnect the wire to the right side circuit and touch it to or bridge it to the L terminal, thus by-passing the signal switch. If the right side circuit lights, the signal switch is inoperative and must be replaced.

H-61. SERVICE DIAGNOSIS

SYMPTOMS

PROBABLE REMEDY

Battery Discharged:

- Shorted cell in battery
- Short in wiring
- Loose or dirty terminals
- Excessive use of starter
- Excessive use of lights
- Insufficient driving
- Low regulator setting
- Stuck cutout in regulator
- Low electrolyte level in cells
- Alternator not charging

- Replace battery.
- Check wiring circuit.
- Clean and tighten.
- Tune engine.
- Check battery.
- Recharge battery.
- Correct setting.
- Correct.
- Add distilled water.
- Inspect alternator and fan belt.

Alternator:

Fails to Charge:

- Open charging circuit
- Loose belt
- Worn, open, or defective brushes
- Open resistor wire
- Open isolation diode
- Regulator inoperative
- Open rotor

- Correct.
- Adjust belt.
- Replace assembly.
- Correct.
- Replace.
- Replace.
- Replace.

Low or Unsteady Charging Rate:

- Belt loose
- Intermittent or high resistance in charging, ground, or battery circuit
- Worn or sticking brushes
- Faulty regulator
- Shorted or open rectifier diode
- Grounded or shorted turns in rotor
- Open, grounded, or shorted turns in stator

- Adjust.
- Check wiring circuits.
- Replace.
- Replace.
- Replace assembly.
- Replace.
- Replace.

Excessive Charging Rate:

- Alternator or regulator connections poor
- Regulator faulty

- Tighten alternator and regulator connections.
- Replace.

Defective Alternator:

- Defective or worn belt
- Misaligned belt or pulley
- Worn bearings
- Shorted rectifier diodes

- Replace.
- Correct.
- Replace.
- Replace assembly.

H-61. SERVICE DIAGNOSIS (Continued)

SYMPTOMS	PROBABLE REMEDY
Starting Motor:	
Slow Starter Speed:	
Discharged battery or shorted cell	Recharge or repair.
Ground strap engine to frame	Clean terminals and tighten.
Loose or dirty terminals	Clean and tighten.
Dirty commutator	Clean with No. 00 sandpaper.
Worn-out brushes	Install new brushes.
Weak brush spring tension	Replace.
Worn bearings	Replace.
Burned starter switch contacts	Replace switch.
Will Not Turn Engine:	
Open circuit at starter	Correct.
Solenoid open or stuck	Replace solenoid.
Starter switch defective	Replace switch.
Starter drive broken or stuck	Repair or replace.
Battery discharged	Recharge battery; check alternator and regulator.
 Lights:	
Burn Dim:	
Loose or dirty terminals	Clean and tighten.
Leak in wires	Check entire circuit for broken insulation.
Poor switch contact	Install new switch.
Poor ground connection	Clean and tighten.
Aim head lamp beams	Use aiming chart.
 Horn Fails to Sound:	
Broken or loose electrical connection	Check wiring and connections at horn button and battery. Clean and tighten.
Battery low or dead	Check battery.
Contact points burned or broken off	Replace parts as necessary.
 Horn Sounds Unsatisfactory Tone:	
Poor electrical connection	Check connections at horn, horn button, and battery.
Battery low	Check with hydrometer.
Loose cover and bracket screws	Tighten bracket bolts at horn.
Voltage at horn too high or too low	Check with voltmeter.

H-62. ELECTRICAL SYSTEM SPECIFICATIONS

	SPECIFICATIONS	METRIC
BATTERY:		
Make	Prestolite	. . . . .
Model	11HSA-70	. . . . .
Plates per Cell	11	. . . . .
Ampere-Hour Rating	70	. . . . .
Terminal Ground	Negative	. . . . .
Specific Gravity:		
Fully Charged	1.260	. . . . .
Recharge at	1.225	. . . . .

H-62. ELECTRICAL SYSTEM SPECIFICATIONS (Continued)

	SPECIFICATIONS	METRIC
BATTERY (Continued):		
Height	9.29" max.	23,59 cm. max.
Length	10.170" to 10.230"	25,83 a 25,98 cm.
Width	6.730" to 6.790"	17,09 a 17,24 cm.
Battery Location	Left Frame Side	. . . . .
ALTERNATOR:		
Make	Motorola	. . . . .
Model	A24NCD900	. . . . .
Polarity	Negative	. . . . .
Rotation	Clockwise from Drive End	. . . . .
Current Output	30 amperes min.	. . . . .
Brushes	2	. . . . .
Field Current	26 to 30 volts	. . . . .
Resistor	150 ohms	. . . . .
VOLTAGE REGULATOR:		
Make	Motorola	. . . . .
Model	TVR 24CD19	. . . . .
Voltage	24	. . . . .
Ground Polarity	Negative	. . . . .
Operating Voltage	28.4 volts	. . . . .
STARTING MOTOR:		
Make	Delco	. . . . .
Model	1113103	. . . . .
Rotation	Clockwise	. . . . .
Brushes	4	. . . . .
Brush Spring Tension	80 ounces	2,268 kg.
Bearings	3 bronze	. . . . .
No Load Test:		
Amperes (max.)	80	. . . . .
Volts	22.5	. . . . .
RPM (min.)	3600	. . . . .
Lock Test:		
Amperes	500	. . . . .
Volts (approx)	3.5	. . . . .
Stall Torque (min.)	20 foot-pounds	2,76 kg./m.
Drive:		
Type	Overrunning Clutch	. . . . .
Pinion Meshes	Front	. . . . .
WATER PUMP PRESSURE GAUGE:		
Idle	5 to 15 psi	0,3515 a 1,0545 kg./cm ²
Normal Engine Speed	40 psi	2,812 kg./cm ²
WIPER BULB TRADE NUMBERS:		
Volts	24	. . . . .
Head Lamps	4801	. . . . .
Parking Lights	1683	. . . . .
Park and Directional Signal	1683, 1251	. . . . .
Stop, Tail, and Directional Signal	1683, 1281	. . . . .
Indicator Lamps:		
Head Lamp Beam	1829	. . . . .
Directional Signal	313	. . . . .
Instrument Lamp	1829	. . . . .
Dome Lamp	623	. . . . .
Flasher, Directional Signal	Signal Stat R432
Fuse Data:		
Directional Signal	9 amp.

CLUTCH

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ASSEMBLY	I-7	INSPECTION	I-6, I-8
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CLUTCH PEDAL ADJUSTMENT	I-2	RECONDITIONING	I-3
CRANKSHAFT PILOT BUSHING	I-10	SPECIFICATIONS	I-12
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I-1. GENERAL

The clutch is a Borg and Beck single-plate, dry disk type, with six pressure springs. The Auburn-build driven plate has a spring center vibration neutralizer and woven asbestos facings which provide smooth engagement of the engine power. The clutch has a 10" [25,4 cm.] diameter driven plate. Clutch control is through a cable near the left side of the frame, connecting the clutch pedal fulcrum to the cross shaft.

I-2. Clutch Pedal Adjustment

As the clutch facings wear, the free pedal travel diminishes. When sufficient wear occurs, it is necessary to adjust the free travel. Correct free travel is 1/2" [12,7 mm.] (Fig. 97). This free travel is essential to disengage the clutch release bearing and prevent unnecessary wear and possible clutch slippage. When adjusted as outlined below,

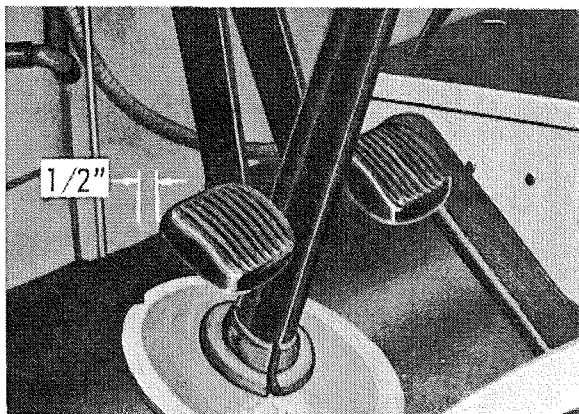


FIG. 97—CLUTCH FREE PLAY

there is a safe clearance of approximately 1/16" [1,59 mm.] between the clutch release bearing and the clutch fingers. See Fig. 98. To obtain this free travel, adjust the length of the clutch control cable so that the pedal has 1/2" free movement from the fully engaged position before any resistance is felt.

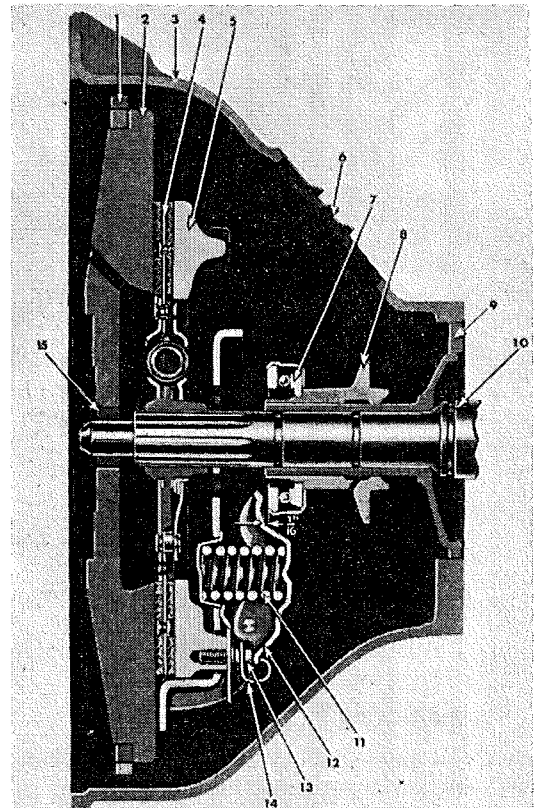


FIG. 98—CLUTCH ASSEMBLY

- 1—Flywheel Ring Gear
- 2—Flywheel
- 3—Flywheel Housing
- 4—Clutch Driven Plate and Hub
- 5—Clutch Pressure Plate
- 6—Inspection Opening Cover
- 7—Clutch Release Bearing
- 8—Clutch Release Bearing Carrier
- 9—Transmission Main Drive Gear Bearing Retainer
- 10—Transmission Main Drive Gear
- 11—Clutch Pressure Spring
- 12—Clutch Lever
- 13—Clutch Adjusting Screw
- 14—Clutch Lever Return Spring
- 15—Clutch Shaft Bushing

Adjustment is made by loosening the lock nut on the control cable clevis (Fig. 99) and removing the clevis pin. Turn the clevis until correct adjustment is obtained. Install the clevis pin and tighten lock nut. Check pedal travel and clutch action.

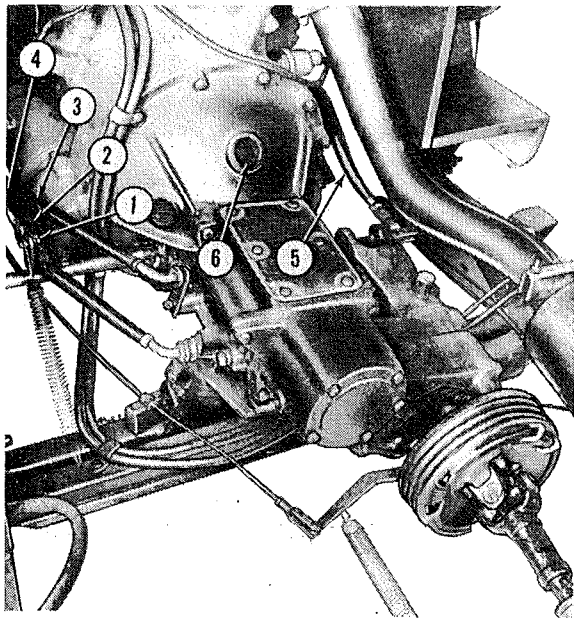


FIG. 99—CLUTCH CONTROL AND SHIFT ROD ADJUSTMENT

- | | |
|--|-----------------------------|
| 1—Clutch Control Cable Clevis | 4—Clutch Cable |
| 2—Low and Reverse Remote Control Rod | 5—Transfer Case Control Rod |
| 3—Intermediate and High Remote Control Rod | 6—Ventilator |

I. Reconditioning

When it is necessary to recondition the clutch, follow the procedure outlined in Section J for removal of the transmission and transfer case from the vehicle. Remove the clutch housing from the flywheel housing and disengage the clutch from the flywheel. Mark both the pressure plate and the flywheel so that the assembly may be installed in the same position after the repairs are made. When removing the clutch from the flywheel, loosen the screws attaching the pressure plate to the flywheel, in sequence, a little at a time, to prevent distortion of the clutch bracket.

J. CLUTCH ADJUSTMENT

The procedures for clutch adjustment given in Section I-5 through I-7 require the use of a clutch rebuilding and adjusting fixture. If the fixture is not available, use the following procedure. Make a gauge as shown in Fig. 100 from flat steel bar stock. Make three spacers 0.285" [7,24 mm.]

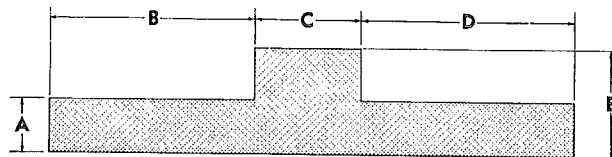


FIG. 100—GAUGE FABRICATION DIMENSIONS

- | | |
|--------------------------------|-----------------|
| A—1/2" [12,7 mm.] | D—2" [50,8 mm.] |
| B—1-15/16" [55,23 mm.] ±0.010" | ±0.010" |
| C—1" [25,4 mm.] | E—1" [25,4 mm.] |

thick from 1/2" [12,7 mm.] to 1-1/2" [38,1 mm.] steel bar stock (round or square). Attach the clutch to the flywheel with the spacers inserted under the clutch levers. Using gauge length B (Fig. 100), adjust the three lever adjusting screws until the release bearing contact on the face of the levers contacts the shoulder of the gauge.

I-5. Clutch Disassembly

The six-spring clutch pressure plate, pressure plate cover, springs, and levers can be completely disassembled for inspection or repairs as follows:

- Place clutch on a clutch rebuilding and adjusting fixture. Mark pressure plate and pressure plate cover with a prick punch to ensure realignment in original position when assembling.
- Place compression spider and nut on fixture centering screw. Tighten nut to relieve clutch spring pressure.

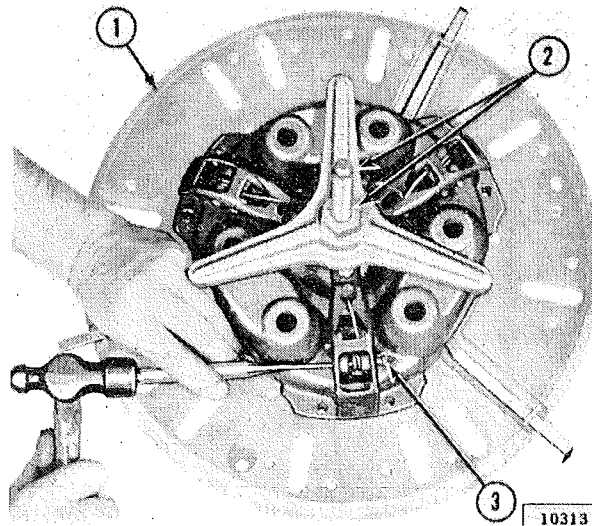


FIG. 101—DISASSEMBLING CLUTCH

- | |
|------------------------------|
| 1—Clutch Fixture |
| 2—Compression Spider and Nut |
| 3—Outer Pin |

- c. Remove retainer ring from outer pin on each lever. Drive out the outer pins only as shown in Fig. 101.
- d. Carefully back off compression spider and nut all the way until pressure plate springs are no longer compressed. Remove spider and nut.
- e. Lift off pressure plate cover and levers from pressure plate.

1-6. Clutch Inspection

After the clutch is disassembled, inspect each part for wear and replace if necessary. Check pressure plate for warpage and for scored surface. Check each pressure plate spring, using a spring testing fixture and a torque indicating wrench. See Clutch Specifications for correct spring pressure.

When using the recommended spring checking fixture, the "pounds" pressure is obtained by multiplying the torque wrench reading (in "foot-pounds") by two.

1-7. Clutch Assembly and Adjustment

Proper assembly and adjustment of the clutch is as follows:

- a. Place pressure plate on a clutch rebuilding and adjusting fixture. Position springs on pressure plate.
- b. Assemble levers to pressure plate cover and position on pressure plate and springs. Align prick punch marks made during disassembly.
- c. Install compression spider and nut to fixture. Tighten to compress clutch springs.
- d. Install and tighten bolts to hold pressure plate cover against fixture. Remove compression spider and nut.

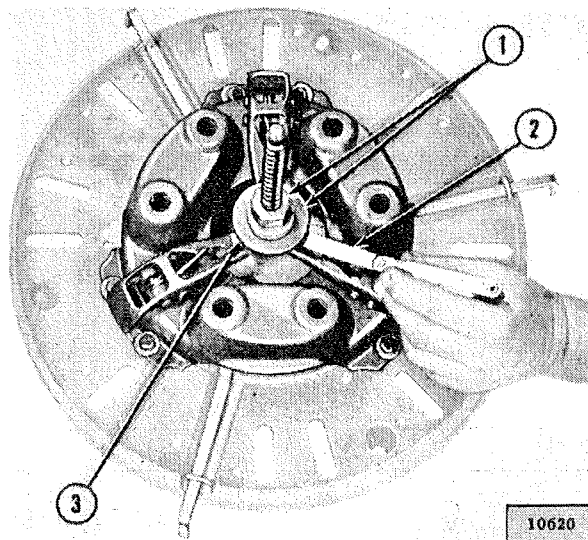


FIG. 102—ADJUSTING CLUTCH LEVERS

- 1—Compression Plate and Nut
- 2—Feeler Blade
- 3—Adjusting Screw

- e. Install outer pins and retainer rings to each lever.
- f. Sparingly apply Lubriplate to all contact and pivot surfaces of levers.
- g. Place fixture thickness spacers on fixture centering screw. Install the fixture compression plate and nut. Tighten nut until compression plate contacts the spacer.
- h. Adjust the three lever adjusting screws until a 0.002" [0,051 mm.] feeler blade has a slight drag between the compression plate and each adjusting screw. See Fig. 102.
- i. Remove compression plate and nut. Remove bolts holding pressure plate cover to fixture. Remove pressure plate assembly.

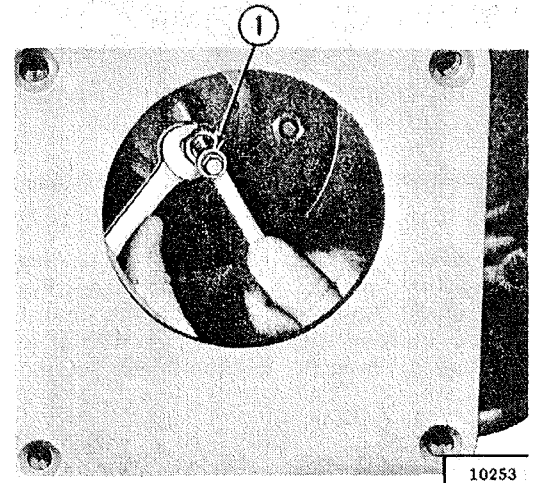


FIG. 103—REMOVING CRANKSHAFT PILOT BUSHING

- 1—Crankshaft Pilot Bushing Remover

1-8. Inspection and Installation

- a. Inspect Clutch Disc. Before the clutch disc is installed, it should be carefully inspected for warpage. If grease or oil is evident on the friction facings, the facings should be replaced and the cause of oil accumulation corrected. Excessively worn facings should also be replaced with factory recommended parts.
- b. Inspect Clutch Release Bearing and Sleeve. The clutch release bearing and bearing carrier are attached to the clutch release yoke by two return springs. Check the bearing and sleeve for evidence of grease leaks from within the bearing or for wear and looseness. Replace parts if necessary.
- c. Reassembly. To assemble the clutch to the flywheel, first put a small amount of light cup grease in the clutch shaft bushing, install the driven plate, with short end of hub toward the flywheel, then place the pressure plate assembly in position. With Clutch Plate Aligning Arbor, No. C-360, or a spare transmission main drive gear shaft, align the driven plate splines, leaving the arbor in position while tightening the pressure plate screws

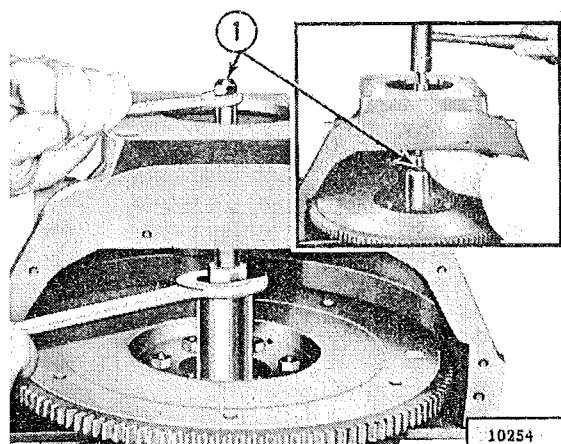


FIG. 104—INSTALLING AND BURNISHING CRANKSHAFT PILOT BUSHING

Crankshaft Pilot Bushing Installing and Burnishing Tool

ly. Make sure that the clutch release bearing return spring is hooked in place. For the nce of the assembly, reverse the operations were used in disassembly, referring to the ructions given in the Transmission section.

Finally adjust the clutch control cable so there is 1/2" [1,27 mm.] free pedal travel.

I-9. Clutch Disc

After removal of the clutch assembly, the disc should be inspected. The presence of grease or oil on the friction facing will cause the clutch to chatter and grab during engagement and possibly slip at higher speeds. If this condition is evident, the facings or disc assembly should be replaced and the cause of oil accumulation corrected. Excessively worn facings should be replaced. Only factory recommended facings and disc assemblies should be used for replacement. The clutch disc must be installed with the long end of the hub toward the transmission.

I-10. Crankshaft Pilot Bushing

Inspect the pilot bushing; if it is worn or damaged, it must be replaced. Remove the old bushing, using a crankshaft pilot bushing remover (Fig. 103). Install the new bushing on the installing and burnishing tool and drive it into place in the crankshaft with a soft mallet. The bushing will contract slightly, holding the tool in place. The rings of the tool will burnish the bushing to a smooth finish as the nut and cup of the tool are turned out and removed (Fig. 104). Apply a small amount of lubricant to the bushing bore.

I-11. SERVICE DIAGNOSIS

SYMPTOMS

PROBABLE REMEDY

ping:

- proper pedal adjustment
- weak pressure springs
- lining oil soaked
- linings worn or torn loose from plate
- stiffened clutch

- Adjust pedal free travel.
- Replace.
- Install new driven plate.
- Install new driven plate.
- Replace.

bbing or Chattering:

- heavy or worn linings
- loose engine mountings
- cracked or broken pressure plate
- improper clutch finger adjustment
- clutch plate crimp or cushion flattened out

- Install new driven plate.
- Tighten.
- Install new pressure plate.
- Readjust.
- Replace driven plate.

gging:

- too much pedal play
- improper finger adjustment
- pressure plate binds in bracket
- excessive pressure on driven plate
- stiff or loose clutch facing

- Adjust.
- Readjust.
- Adjust.
- Replace.
- Replace.

ling:

- broken or weak return springs in driven plate
- worn throw-out bearing
- clutch fingers improperly adjusted
- worn driven plate hub of transmission main gear shaft
- clutch pilot bushing in flywheel worn

- Replace.
- Replace.
- Readjust.
- Replace.
- Replace.

I-12. CLUTCH SPECIFICATIONS

	SPECIFICATIONS	METRIC
PRESSURE PLATE:		
Make	Borg & Beck	. . . . .
Type	Single Dry Plate	. . . . .
No. Springs	6	. . . . .
Spring Pressure	160 lb. at 1-5/16"	72,5 kg. -33,3 mm.
DRIVEN PLATE:		
Make	Auburn	. . . . .
Facings	Woven Asbestos	. . . . .
Diameter	10"	25,4 cm.
Thickness	0,125"	3,17 mm.
TORQUE CAPACITY	230 foot-pounds	31,8 kg./m.
CLUTCH RELEASE BEARING:		
Type	Sealed Ball Bearing Prelubricated	. . . . .
CLUTCH SHAFT BUSHING:		
Location	In Crankshaft	. . . . .
Material	Bronze Graphite	. . . . .
Size	I. D. 0.631"	16,02 mm.
CLUTCH PEDAL ADJUSTMENT	1/2"	1,27 cm.



TRANSMISSION AND TRANSFER CASE

Contents

SUBJECT	PAR.	SUBJECT	PAR.
DIAGNOSIS		TRANSFER CASE	J-10
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Transfer Case	J-20	Front Bearing Cap	J-14
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Transmission	J-21	Overhaul	J-16
Transfer Case	J-22	Rear Bearing Cap	J-15
TRANSMISSION	J-1	Removal	J-12
Assembly	J-7	Shift Linkage	J-11
Control Bracket and Housing	J-9	TRANSFER CASE AND TRANSMISSION	
Inspection	J-3	Assembly	J-8
Overhaul	J-6	Installation	J-18
Remote Control	J-2	Separation	J-5
Removal	J-4		

J-1. TRANSMISSION

The transmission is a heavy-duty, three-speed synchro-mesh type with remote control cane shift. The transmission is attached to the rear face of the flywheel bell housing and is supported on a rubber insulator at the frame center cross member which forms the rear engine support. Shift is smooth and positive through a cane type remote control lever mounted on the floor of the vehicle. Poppet balls and springs retain the gears in mesh and an interlock prevents shifting into two gears at one time.

J-2. Transmission Remote Control

If the shift is not smooth and positive, the remote control shift levers and then the linkage should be checked and adjusted before checking the transmission.

- a. Disconnect the remote control rods from the gear shift levers.
- b. Check to make certain the nut on the bolt passing through the gear shift base is securely tightened.
- c. Check for smooth and positive operation of the gear shift hand lever through the shift pattern while the remote control rods are disconnected. Where the parts of the shift tower assembly are excessively worn, enough clearance may exist between one or both control levers and the inside surface of the tower housing to cause erratic shifting. It may be possible to shift into two gears at one time or to move the hand lever out of engagement with one of the control levers while that control lever still engages the transmission in gear.

NOTE: When excessive clearance occurs, it can be corrected by installing one or more spacers, part 640778, between the remote control lever and housing on one or both sides, at point A in Fig. 105.

- d. Be sure when assembly is complete that the nut on the bolt passing through the gear shift base is securely tightened.

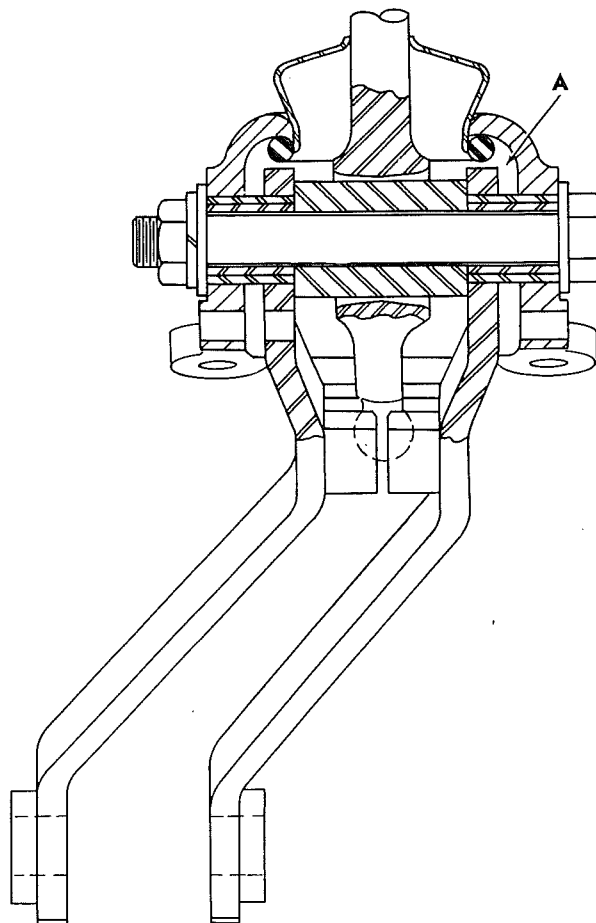


FIG. 105—REMOTE CONTROL BRACKET AND LEVER ASSEMBLY

Reconnect the remote control rods to the gear shift levers. To adjust shift rods, insert a 3/16" [7.94 mm.] diameter pin in the indexing hole at the base of the transmission selector lever spring to lock the intermediate and high lever in its neutral position. Then, with the external intermediate and high lever on the transmission case in its neutral position, adjust the shift rod to the proper length.

Align the first and reverse selector lever in neutral position parallel to the intermediate and high lever. To do this, make sure that the shift lever ball end properly engages lugs on the selector levers.

Position external first and reverse lever on transmission case in its neutral position and adjust the shift rod to the correct length. Remove the locating pin. If normal shifting cannot be produced by this procedure, the cause for difficult shifting is undoubtedly within the transmission and the transmission should be inspected in accordance with Par. J-3.

3. Transmission Inspection

If hard shifting cannot be corrected by adjustment of the remote control, the transmission should be inspected. Remove the transmission from the vehicle. See Transmission Removal Par. J-4. Remove cover plate. Check for free and complete operation of the shifting levers in all gears. If any binding is evident or if it is impossible to complete the shifting procedure, check for proper clearance between the shifting lever interlock sleeve which is positioned between the two inner shifting levers, as outlined below. Place the low and reverse shift lever in low gear position and the second and high shift lever in neutral. Using a feeler gauge, check the clearance between the end of the interlock sleeve and the notched surface of the high and second shift lever. The clearance should be between 0.001" and 0.007" [0.0254 to 0.178 cm.].

Place the low and reverse shift lever in neutral and the second and high shift lever in second gear position. Check the clearance between the end of the interlock sleeve and the notched surface of the low and reverse shift lever. Clearance should be between 0.001" and 0.007". If clearance is other than the above, an interlock sleeve of the proper length should be installed.

If it is evident that a minimum clearance of from 0.001" to 0.007" cannot be obtained between the end of the interlock sleeve and shift levers even though the longest sleeve has been installed, move the original interlock pin from the shift lever poppet spring. Replace original interlock pin with a transfer case intermediate gear needle bearing roller, Part No. 809294, which has been ground to a length of 0.780" [1.981 cm.]. The installation of this modified roller should ensure positive engagement of the ball at each end of the interlock sleeve in the respective detents of the

shifting levers as the transmission is shifted through the gear pattern.

If it is apparent that the pin is too long, causing a bind when shifting is attempted, reduce its length a little at a time from the 0.780" dimension until a smooth shift action with positive ball and detent engagement is obtained. Install this improvised pin only when the longest interlock sleeve does not provide the desired minimum clearance. When assembling the interlock sleeve, be sure that the shift lever poppet spring works freely inside the interlock sleeve and that the interlock pin, or the modified roller to be substituted, is not omitted from inside the spring. Should the notched surfaces of the shifting levers be dirty or rough, they should be thoroughly cleaned and smoothed. If notched surfaces are scored or damaged, the lever should be replaced. Recheck the clearances after installing either a new interlock sleeve or inner shift lever.

J-4. Transmission Removal

NOTE: The transfer case may be removed from the vehicle without removing the transmission. For this procedure, refer to Par. J-5.

- a. Drain the transmission and transfer case. Replace the drain plugs.
- b. Disconnect the remote control shift lever linkage at the transmission.
- c. Disconnect transfer case remote control rod at the transfer case by removing clevis pins and cotter pins at the shift rods.
- d. Disconnect the front and rear propeller shafts from the transfer case. Follow the procedure outlined in Section K.

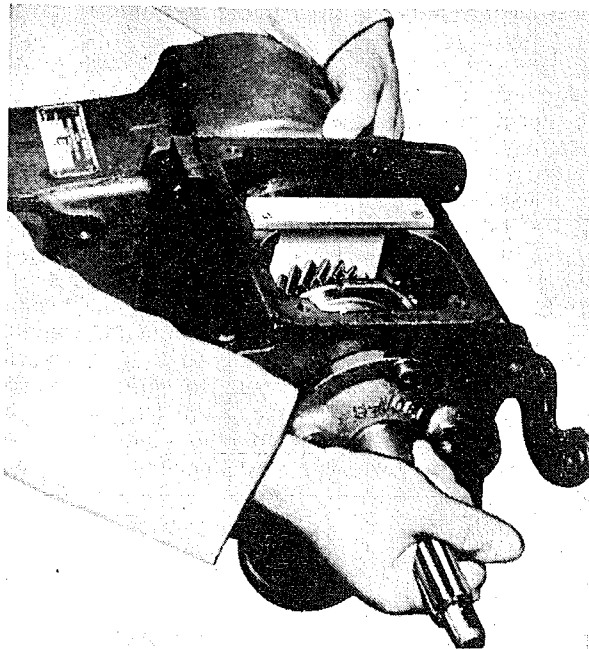


FIG. 106—MAINSHAFT RETAINING PLATE

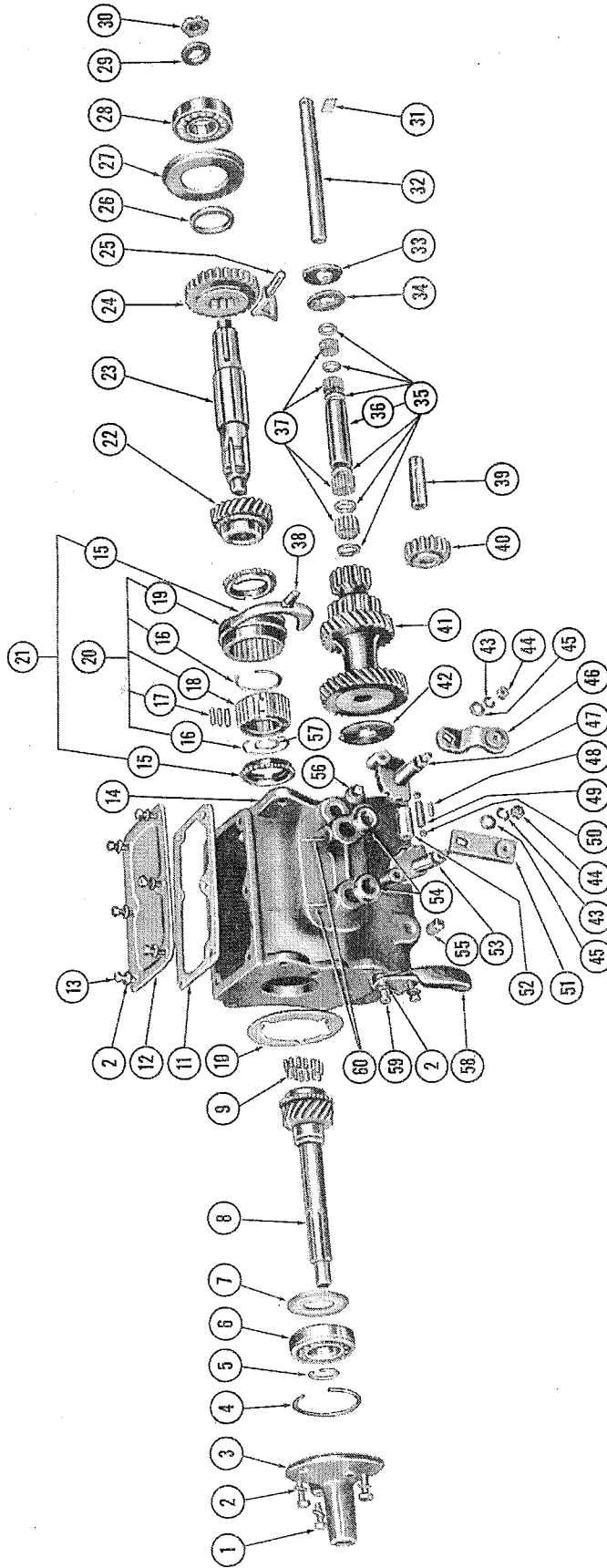


FIG. 107—TRANSMISSION

- | | | | |
|-------------------------------------|--|--|--|
| 1—Retainer Screw | 16—Synchronizer Spring | 32—Countershaft | 47—Low and Reverse Shift Lever |
| 2—Retainer Bolt Gasket | 17—Shifting Plate | 33—Rear Countershaft Washer | 48—Shift Lever Interlock Pin |
| 3—Main Drive Gear Bearing Retainer | 18—Clutch Hub | 34—Rear Countershaft Washer | 49—Shift Lever Poppet Spring |
| 4—Main Drive Gear Bearing Snap Ring | 19—Clutch Sleeve | 35—Short Countershaft Bearing Spacer | 50—Shift Lever Poppet Ball |
| 5—Main Drive Gear Snap Ring | 20—Synchronizer Unit | 36—Countershaft Bearing Spacer | 51—Intermediate and High Outer Control Lever |
| 6—Main Drive Gear Bearing | 21—Synchronizer Unit with Blocking Rings | 37—Countershaft Bearing Roller | 52—Shift Lever Interlock Sleeve |
| 7—Front Oil Retaining Washer | 22—Second Speed Gear | 38—High and Intermediate Shift Fork | 53—High and Intermediate Shift Lever |
| 8—Main Drive Gear | 23—Mainshaft | 39—Reverse Gear Shaft | 54—Shift Shaft Oil Seal |
| 9—Mainshaft Pilot Bearing Roller | 24—Low and Reverse Sliding Gear | 40—Countershaft Gear | 55—Drain Plug |
| 10—Bearing Retainer Gasket | 25—Low and Reverse Shift Fork | 41—Countershaft Gear | 56—Pipe Plug |
| 11—Case Cover Gasket | 26—Mainshaft Bearing Spacer | 42—Front Countershaft Washer | 57—Clutch Hub Snap Ring |
| 12—Transmission Case Cover | 27—Mainshaft Bearing Adapter | 43—Lock Washer | 58—Countershaft Gear Oil Collector |
| 13—Cover Screw | 28—Rear Mainshaft Bearing | 44—Nut | 59—Screw |
| 14—Transmission Case and Plug | 29—Mainshaft Washer | 45—Control Lever Washer | 60—Pin |
| 15—Transmission Blocking Ring | 30—Mainshaft Nut | 46—Low and Reverse Outer Control Lever | |

Disconnect the speedometer cable at the transfer case.

Disconnect the hand brake cable at the transmission brake.

Place jacks under the transmission and engine, protecting the engine oil pan with a block of wood. Remove the nuts holding the rear mounting to frame cross member.

Remove the transfer case snubbing rubber bolt at the cross member.

Remove the bolts holding the rear engine port cross member to the frame side rails above the cross member.

Remove bolts holding the transmission to the wheel bell housing.

Lower the jacks under the engine and transmission; slide the transmission and transfer case assembly toward the rear of the vehicle until transmission mainshaft clears the bell housing. Lower the jack under the transmission. Reverse the transmission and transfer case as an assembly from under the vehicle.

For the separation of the transmission and transfer case, refer to Par. J-5.

Transmission and Transfer Case Separation

Remove the six screws and lock washers holding the transfer case rear cover and remove cover.

Remove cotter pin, nut, and washer which hold the transfer case main drive gear on the rear end of the transmission mainshaft. If possible at this point, remove the main drive gear. If possible, see Par. d and e below.

Remove the transmission-to-transfer-case gaskets.

Separate the transfer case from the transmission. When separating the two units, use care to remove the transmission mainshaft bearing, which is in both housings, remains in the transmission housing.

Separate the two units if the transfer case main drive gear was not removed in Par. b above, follow the procedure in Par. e below.

Install Transmission Mainshaft Retaining Plate, W-194, as shown in Fig. 106, to prevent the mainshaft from pulling out of the transmission housing. Should this tool be unavailable, loop a piece of wire around the mainshaft directly back of the mainshaft second-speed gear. Install the transmission case cover right and left front holding screws part way into the transmission housing. Twist the wire and attach each end to one of the screws. Draw the wire tightly. With the mainshaft securely in place, support the transfer case and, with a rawhide mallet or brass drift hammer, tap lightly on the end of the mainshaft to loosen the gear and separate the two units.

Transmission Overhaul

Numbers in parentheses refer to items in Fig. 107. Circulation is provided between the transmission and transfer case by drilled passages

between the two units. The rear face of the transmission case is drilled with two 7/16" [11,11 mm.] holes and two 1/4" [6,35 mm.] holes. The front face of the transfer case is drilled with two 7/16" holes to register with those drilled in the transmission case.

a. Drain the lubricant and clean the case with a suitable solvent.

b. Remove screws holding the case cover (12) to top of transmission. Remove the cover.

c. Remove the three screws and washers in front main drive gear bearing retainer (3) and remove the retainer and gasket.

d. Remove two hollow head screws from front end of case, which supports the oil collector (58) inside of the case.

e. It is necessary to remove the main drive gear assembly before the shift forks can be removed (with side shift transmission). This may be accomplished by either removing the countershaft to drop the countershaft gears or by removing the main drive gear bearing from the case. Should it be necessary to remove the countershaft gear set to complete a particular job, it is better to drop this gear set. Should the trouble be confined to the mainshaft gears, remove the bearing. To accomplish this, first remove snap rings (4) and (5) and use a bearing puller. If no puller is available, the bearing can usually be removed by using two screwdrivers to carefully pry into the larger snap ring groove while tapping on the end of the shaft with a rawhide mallet. If the shaft is removed, use care not to lose the fourteen mainshaft pilot rollers (9).

f. Remove the oil collector assembly (58).

g. Remove the lock plate (Fig. 108) which is assembled in slots cut in the rear ends of the countershaft and reverse idler shafts.

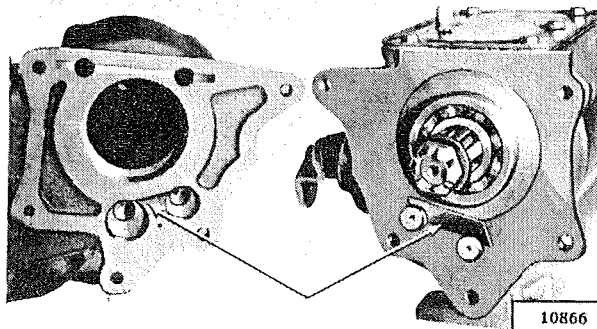


FIG. 108—SHAFT LOCK PLATE

h. Using special tool W-166 or a brass drift, drive out the countershaft (32) toward the rear. The countershaft gear set will drop to the bottom of the transmission case. If the special tool is used, the bearing rollers (37) will remain in the countershaft gear hub, and the gears and bearings may later be removed as an assembly.

- i. Remove the mainshaft retaining plate or wire previously installed to hold assembly in position.
- j. Remove the transmission mainshaft rear bearing adapter (27).
- k. Remove the mainshaft from the case. The entire assembly with the gears mounted may be removed through the rear bearing adapter plate opening.
- l. Remove the countershaft gear set and the three thrust washers. Remove the spacers and needle bearings from the gear set.
- m. Remove the reverse idler shaft and gear by driving out the shaft with a brass drift.
- n. Remove the shift lever assemblies by driving out taper pins (60) from the bottom.
- o. Remove the poppet and interlock assembly which floats between the shift lever assemblies.
- p. Remove the shift lever oil seals. Wash all parts and inspect them for wear or damage.

J-7. Transmission Assembly

Assemble the unit in the reverse order of disassembly, noting the following:

Be sure that interlock sleeve is the correct length. Clearance between the end of the interlock sleeve and a shift lever land, when one lever is in neutral position and the other shifted, must not exceed 0.007" [0,178 mm.] or be less than 0.001" measured with feeler gauges. The sleeve will not act as an interlock, to prevent shifting into two gears at the same time, if clearance is greater and hard shifting will result if less. Correct sleeve length is secured by selective fitting. The following sleeve lengths are available:

- 1.287" [32,69 mm.] marked C
- 1.291" [32,79 mm.] marked B
- 1.295" [32,89 mm.] marked A
- 1.299" [32,99 mm.] no mark
- 1.303" [33,10 mm.] marked D

The identifying letter is etched into the end of the sleeve.

Also, refer to Par. J-3 for further information on selective fitting for correct sleeve length. The countershaft gear set when assembled in the case should have 0.012" to 0.018" [0,305 a 0,457 mm.] end play. This clearance is obtained by selective thickness of the rear steel thrust washer which is available in these thicknesses:

- 0.0555" [1,410 mm.] 0.0625" [1,587 mm.]

Assemble the larger bronze washer at the front of the case with the lip entered in the slot in the case. The bronze-faced steel washer is placed next to the gear at the rear end and the steel washer is placed next to the case. Use heavy grease to hold the front washer in position. Just start the countershaft through the case to hold the rear steel washer and assemble the rear bronze-faced washer against the end of the gear when it is installed. To assemble the eighty-eight countershaft roller bearing needles and their spacers, use special tool W-166 shown in Fig. 109, with loading sleeve. Place spacer in the countershaft gear

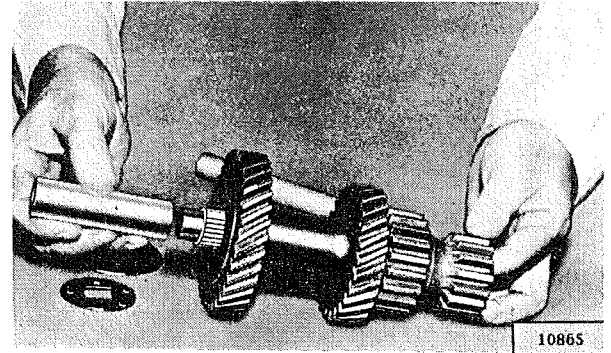


FIG. 109—COUNTERSHAFT GEAR BEARING ARBOR

hub at the center and insert the special tool through the spacer.

Place a spacing washer at each end of the long spacer and load a set of roller bearings at each end and install a spacing washer at each end followed by a set of rollers at each end and finally a spacing washer at each end, as shown in Fig. 110.

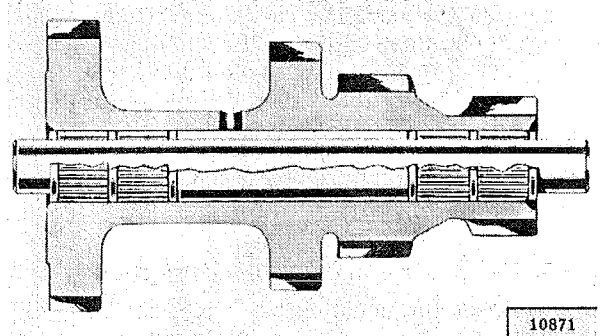


FIG. 110—COUNTERSHAFT BEARING SPACERS

Be sure the thrust washers are correctly positioned and place the countershaft gear set in its running position. Tap the countershaft through the case forcing out the special tool. When assembling the mainshaft gears, the low and reverse sliding gear is installed with the shift shoe groove toward the front. Fig. 111 shows the sequence of assembly of the synchronizer unit. To make this assembly, first install the two springs in the high and intermediate clutch hub, with the spring tension opposed.

Place the right lipped end of a spring in the slot of the hub and place the spring in the hub. Turn the hub around and make exactly the same installation with the other spring, starting with the same slot. Install the three synchronizer shifting plates in the three slots in the hub with the smooth side of the plates facing out. Hold the plate in position and slip the second-and-direct clutch sleeve over the hub with the long beveled edge toward the long part of the clutch hub. Install the two blocking rings, one on each side of the hub. Install the completed

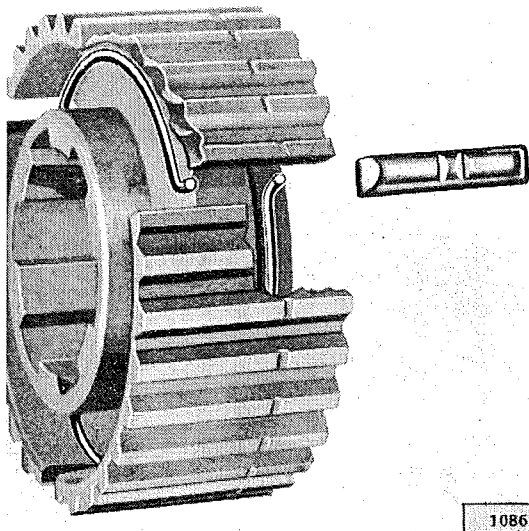


FIG. 111—SYNCHRONIZER SPRINGS

assembly on the mainshaft with the beveled edge of the clutch sleeve toward the front end of the shaft. When the mainshaft is installed, use care to position the fourteen needle bearing rollers in the mainshaft gear so they are correctly positioned. Use heavy pressure to hold them in position until assembly is completed. The transfer case should be attached to the transmission at this time. Refer to Par. J-8.

Transfer Case to Transmission Assembly

Be sure that the countershaft and reverse idler gear lock plate is in proper position and correctly fits the recess in the transfer case housing. When assembling the transmission to the transfer case, two different lengths of screws are used. One of the screws are 1-1/8" [28,6 mm.] long;

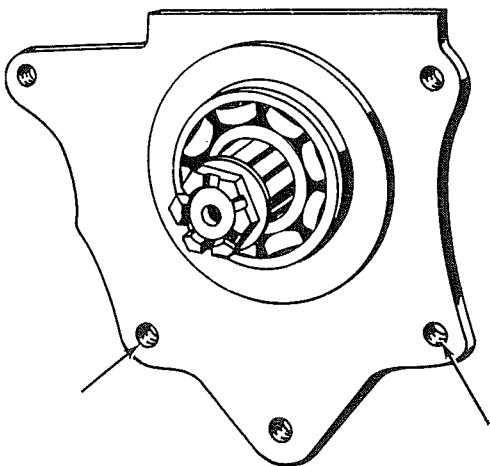


FIG. 112—TRANSMISSION ADAPTER PLATE MOUNTING HOLES

the other two are 1" [25,4 mm.] long. Install the 1" screws in the lower left and lower right holes as shown in Fig. 112. Should the longer screws be installed in these holes by mistake, the end of the screws may interfere with the operation of the gears; a leak may develop between the transmission and transfer case; or the attaching screws may loosen.

J-9. Control Bracket and Housing

If hard shifting, simultaneous shifting into two gears, or gear jumping is experienced, check for wear or damage to components of the control bracket and lever assembly. Replace worn or damaged parts.

J-10. TRANSFER CASE

The transfer case is essentially a two-speed transmission located at the rear of the standard transmission which provides a low and direct gear. It also provides a means of connecting the power to the front axle.

Transfer case gears are controlled by the driver through one rod and lever in the cab which provides two- or four-wheel drive and also a high and low gear. The shift lever to the extreme rear provides 2-wheel drive by disengaging all drive to the front wheels. First position forward provides

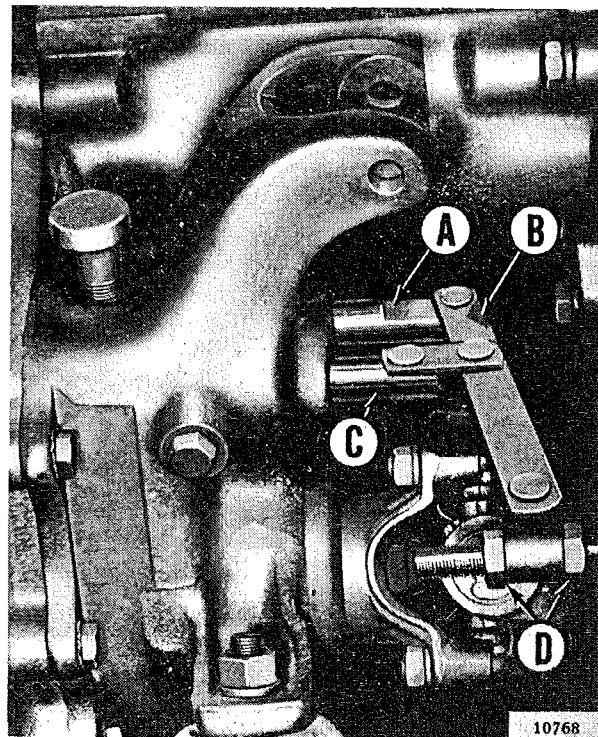


FIG. 113—TRANSFER CASE SHIFT LINKAGE

- | | |
|---------------------------------|--------------------------------|
| A—Front Axle Drive
Shift Rod | C—Auxiliary Range
Shift Rod |
| B—Linkage Lever | D—Adjusting Nuts |

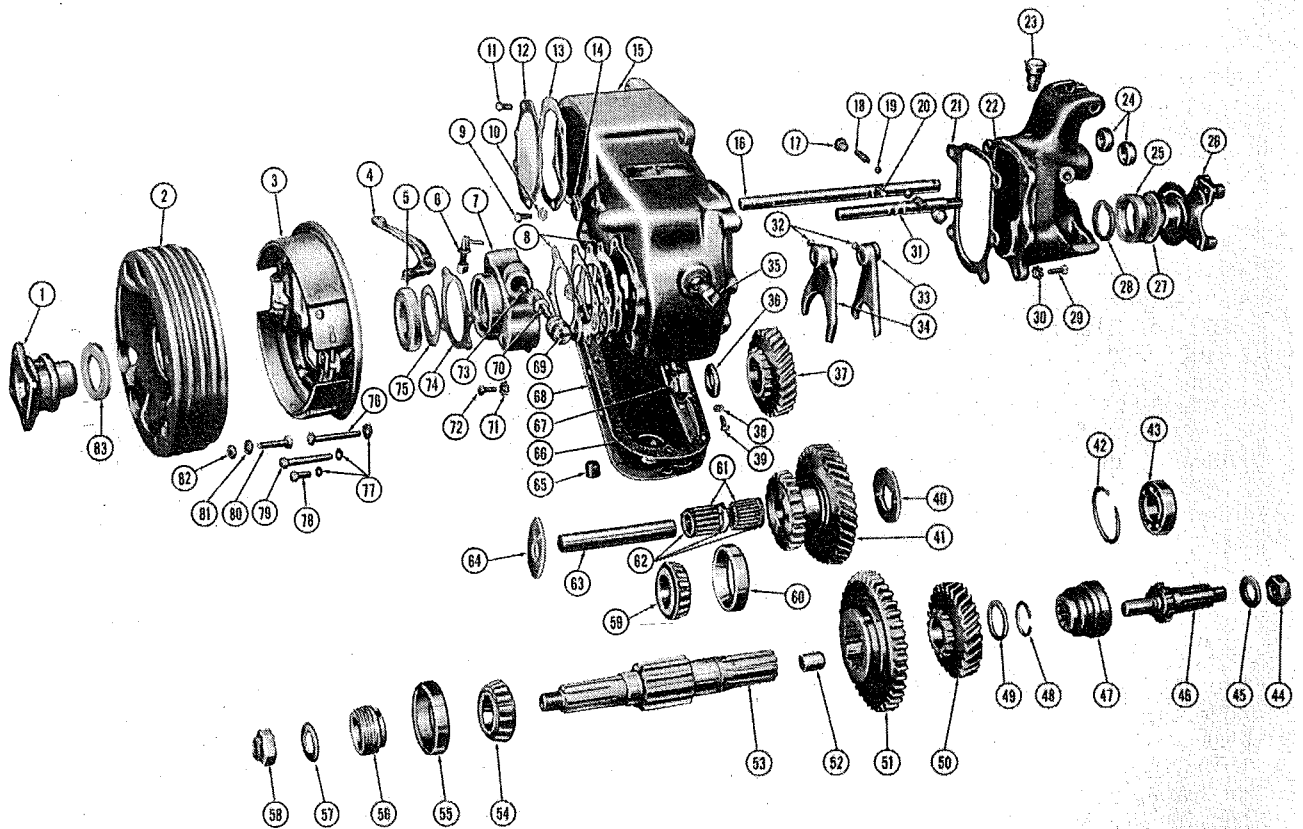


FIG. 114—TRANSFER CASE

- | | | |
|---------------------------------------|-------------------------------------|------------------------------------|
| 1—Companion Flange and Oil Seal Guard | 30—Lock Washer | 58—Companion Flange Nut |
| 2—Emergency Brake Drum | 31—Front Wheel Drive Shaft | 59—Cone and Rollers |
| 3—Emergency Brake | 32—Setscrew | 60—Output Shaft Bearing Cup |
| 4—Brake Operating Lever | 33—Front Wheel Drive Shift Fork | 61—Needle Bearing |
| 5—Bearing Cap Oil Seal | 34—Underdrive and Direct Shift Fork | 62—Bearing Spacer |
| 6—Brake Operating Lever Stud | 35—Filler Plug | 63—Intermediate Gear Shaft |
| 7—Rear Bearing Cap | 36—Mainshaft Washer | 64—Thrust Washer |
| 8—Rear Bearing Cap Shim Kit | 37—Mainshaft Gear | 65—Drain Plug |
| 9—Bolt | 38—Lock Washer | 66—Bottom Cover Gasket |
| 10—Lock Washer | 39—Bolt | 67—Mainshaft Nut |
| 11—Bolt | 40—Thrust Washer | 68—Transfer Case Bottom Cover |
| 12—Transfer Case Rear Cover | 41—Intermediate Gear | 69—Speedometer Driven Gear Sleeve |
| 13—Rear Gasket Cover | 42—Bearing Shaft Snap Ring | 70—Speedometer Driven Gear (15-T) |
| 14—Intermediate Shaft Lock Plate | 43—Output Clutch Shaft Bearing | 71—Lock Washer |
| 15—Transfer Case | 44—Companion Flange Nut | 72—Bolt |
| 16—Underdrive and Direct Shift Rod | 45—Plain Washer | 73—Speedometer Driven Gear Bushing |
| 17—Poppet Plug | 46—Output Clutch Shaft | 74—Backing Plate Gasket |
| 18—Poppet Spring | 47—Output Clutch Shaft Gear | 75—Oil Seal Gasket |
| 19—Poppet Ball | 48—Output Shaft Gear Snap Ring | 76—Bolt |
| 20—Shift Rod Interlock | 49—Thrust Washer | 77—Lock Washer |
| 21—Bearing Cap Gasket | 50—Output Shaft Gear | 78—Bolt |
| 22—Front Bearing Shaft Cap | 51—Output Shaft Sliding Gear | 79—Bolt |
| 23—Breather | 52—Pilot Bushing | 80—Bolt |
| 24—Shift Rod Oil Seal | 53—Output Shaft | 81—Lock Washer |
| 25—Bearing Cap Oil Seal | 54—Cone and Rollers | 82—Nut |
| 26—End Yoke | 55—Output Shaft Bearing Cup | 83—Output Shaft Felt Seal |
| 27—Output Shaft Seal | 56—Speedometer Drive Gear (6-T) | |
| 28—Oil Seal Gasket | 57—Plain Washer | |
| 29—Bolt | | |

h-range 4-wheel drive. Second position forward (neutral) disengages all power to the wheels and is used primarily to provide the neutral setting necessary for the use of power take-off equipment when the vehicle is stationary. The extreme forward position provides low-range 4-wheel drive.

11. Shift Linkage

Adjusting of the transfer case gears is accomplished through two shift rods at the front of the transfer case, linkage levers, and a remote control lever with adjusting nuts. See Fig. 113.

To adjust the transfer case shift linkage, insert a 3/8" [9,525 mm.] diameter pin through the hole in the lever spade end and into the hole provided in the right side of the body tunnel. The operating lever is now locked in its neutral position. Position the transfer case linkage in neutral (extreme forward) position and adjust the shift rod to its proper length. Remove the adjusting pin.

12. Transfer Case Removal

The transfer case may be removed from the vehicle without removing the transmission. Proceed as follows:

Drain transmission and transfer case and remove drain plugs.

Disconnect the hand brake cable at the transmission brake.

Disconnect front and rear propeller shafts at transfer case. See Section K.

Disconnect speedometer cable at transfer case. Disconnect transfer case remote control rod at transfer case by removing clevis pins and cotter pins at shift rods.

Remove cover plate on rear face of transfer case. Remove cotter key, nut, and washer from transmission mainshaft.

If possible, at this point remove the transfer case main drive gear from the transmission in shaft. If not possible, see step j below.

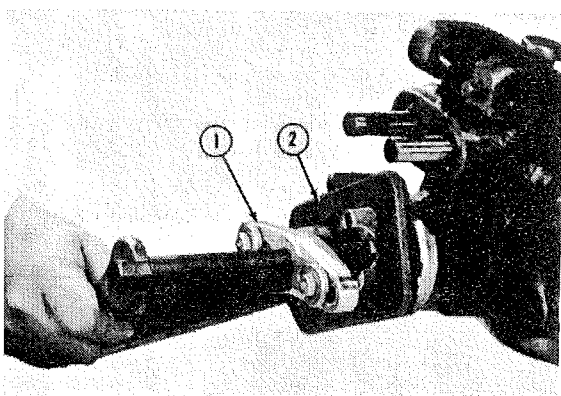


FIG. 115—UNIVERSAL JOINT FLANGE PULLER

1—U-Joint Puller W-172

2—U-Joint Flange Holding Wrench C-3281

h. Remove transfer case mounting bracket bolt and nut.

i. Remove transmission to transfer case bolts.

j. Remove transfer case. If the transfer case main drive gear has not been removed in step g above, proceed as follows: Brace the end of the transmission mainshaft so that it cannot move in the transmission, pull the transfer case to the rear to loosen the gear and remove the gear. When separating the two housings, use care that the transmission mainshaft bearing, which bears in both housings, remains in the transmission case.

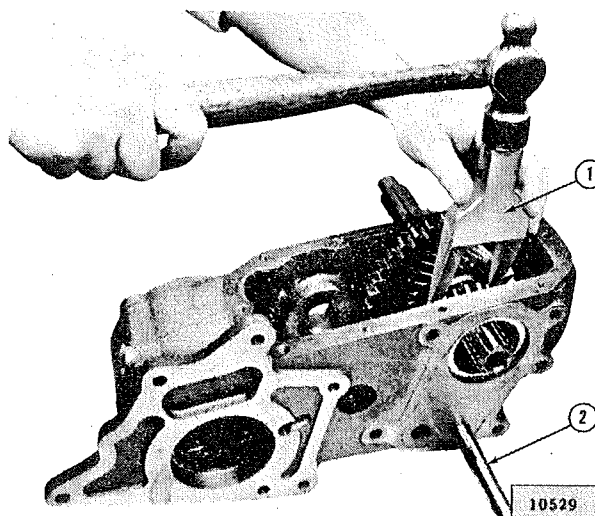


FIG. 116—BEARING CORE REMOVING WEDGE

1—Wedge W-139

2—Shift Rod

J-13. Transfer Case Disassembly

Numbers in parentheses refer to items in Fig. 114. To remove the gears and bearings from the transfer case on the bench, the following procedure is recommended:

NOTE: When removing the companion flange and end yoke from the output shafts, inspect for the presence of felt seals installed in the oil seal guards. These felt seals should be installed if they are not present.

a. Remove the companion flange nuts (44) and washers (45) using Yoke Holding Wrench C-3281. Remove rear output shaft companion flange (1) with brake drum (2) and front output shaft yoke (26) as shown in Fig. 115, using Tool W-172.

b. Remove the cover bolts (39), lock washers (38), and bottom cover (68).

c. Remove the lock plate bolt (9), lock washer (10), and lock plate (14).

d. Drive intermediate gear shaft (63) to the rear of the case with a brass punch. Do not lose the thrust washers (40) and (64) located at each end of the intermediate gear shaft (63).

- e. Remove the intermediate gear (41), two thrust washers (40) and (64), needle bearings (61), and bearing spacers (62) through the bottom of the case.
- f. Remove the poppet plugs (17), springs (18), and balls (19) on both sides of the front bearing shaft cap (22). Shift the front wheel drive shaft (31) to engaged position (shaft forward).
- g. Remove the bolts (29) and lock washers (30) holding the front bearing cap. Remove the cap as an assembly including the clutch shaft, bearing, clutch gear, fork, and shift rod. Use care not to lose the interlock (20) which floats between the shift rods.
- h. Remove the bolts (72) and lock washers (71) that secure the backing plate of the emergency brake (3) and rear bearing cap (7) with the speedometer gear assembly. Remove the entire unit as an assembly.

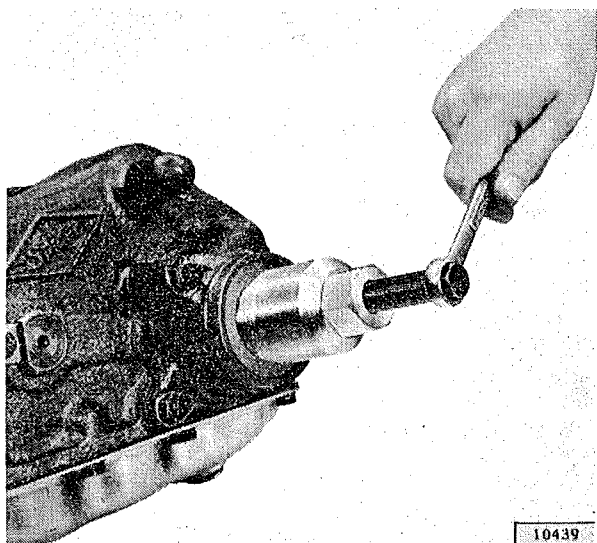


FIG. 117—PULLING OUTPUT SHAFT OIL SEAL

- i. Drive against the front end of the output shaft (53) with a rawhide hammer to drive the rear bearing cup (55) from the case. Wedge the front bearing cone and roller assembly (59) from its seat on the shaft as shown in Fig. 116. Place Tool W-141 on the output shaft between the front bearing and the output shaft gear (50). Use a rawhide hammer to drive against the rear end of the output shaft to remove the front bearing cup (60) from the case. Loosen the snap ring (48) and slide it forward on the shaft. Drive the shaft through the rear of the case. As the shaft is removed, the gears (50) and (51), snap ring (48), and thrust washer (49) will remain in the case and can be removed from the bottom. Remove the rear bearing cone and roller assembly (54) from the shaft by striking the end of the shaft lightly against a wooden block.
- j. Remove the setscrew in the sliding shift fork (34) and remove the shift rod (16).

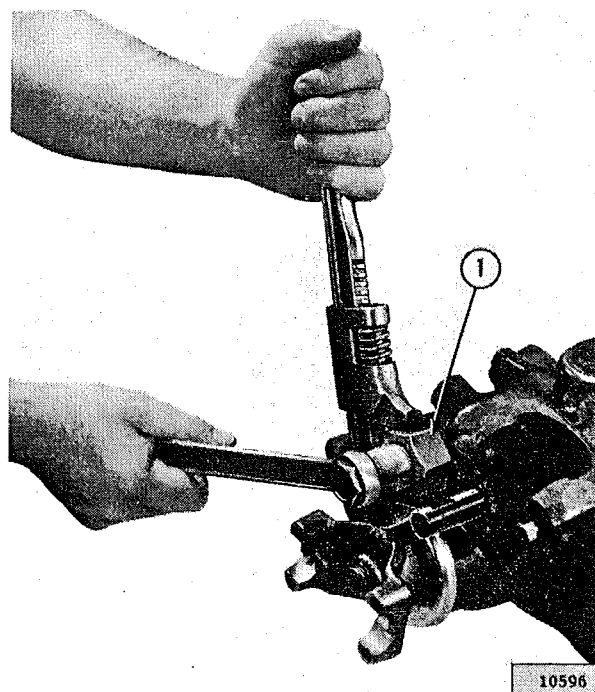


FIG. 118—SHIFT ROD OIL SEAL PULLER

1—Seal Puller

J-14. Front Bearing Cap Disassembly

Numbers in parentheses refer to Fig. 114. The front bearing cap is a separate assembly which may be removed for service. Should difficulty be experienced in this section of the transfer case, follow the sequence below for removal and disassembly:

- a. Remove the output shaft yoke as outlined in Par. J-13a. Remove the poppet balls and move the front wheel drive shaft forward as outlined in Par. J-13f.
- b. Remove the yoke oil seal (5) with Tool W-251, as shown in Fig. 117. Remove the shift rod oil seals (24) with Tool W-176, as shown in Fig. 118.
- c. Remove the front bearing cap assembly as outlined in Par. J-13g.

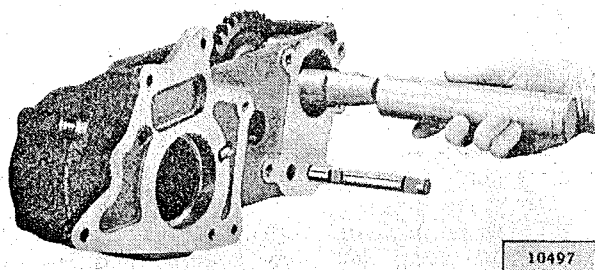


FIG. 119—OUTPUT SHAFT SNAP RING INSTALLER

Remove the setscrew from the shift fork (34) and drive shaft (31). The clutch shaft gear (47) and the shifting fork can be removed together.

Remove the output clutch shaft assembly (46), carefully pressing it through the bearing (43).

Remove the bearing retainer snap ring (42) and remove the bearing.

15. Rear Bearing Cap Disassembly

Numbers in parentheses refer to Fig. 114. The rear bearing cap is partially disassembled during the dismantling of the transfer case. The cap is, however, a separate assembly which may be removed for service. Follow the sequence below for removal and disassembly:

Remove the output shaft rear end yoke or companion flange as outlined in Par. J-13. Separate the brake drum and companion flange (1) by removing bolt (80), lock washer (81), and nut (82).

Remove the oil seal with Tool W-251, as shown in Fig. 117.

Remove the speedometer driven gear assembly (6) and (70).

Remove the cap screws attaching the rear bearing cap (7) and backing plate of the emergency brake (3) to the transfer case (15). Do not lose or damage the bearing adjusting shims (8) placed between the cap and transfer case housing.

Separate the rear cap and backing plate assembly of the emergency brake (3). See Section O for brake service.

Remove the speedometer drive gear (56).

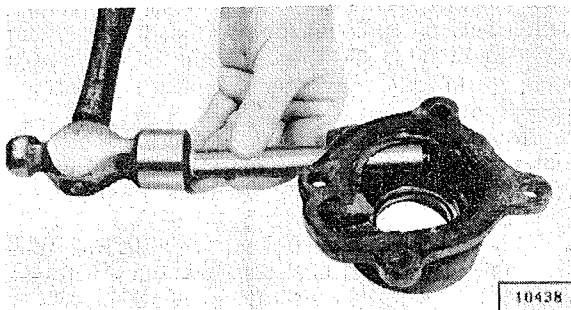


FIG. 120—SPEEDOMETER PINION BUSHING DRIVER

16. Transfer Case Overhaul

Numbers in parentheses refer to Fig. 114. The assembly of the transfer case is the reversal of the above disassembly. The output shaft snap ring (48) is installed with Tool W-131, Output Shaft Snap Ring Installing Thimble and Driver (Fig. 119). Use a piece of tubing to install the bearing cone and roller assemblies on the output shaft to prevent damage to the assemblies.

A dummy shaft is required to install the intermediate shaft. The dummy shaft should be slightly smaller in diameter than the intermediate shaft and a little shorter than the width of the intermediate gear (41). To install the intermediate gear, first load the bearing rollers and spacers on the gear using the dummy shaft. Then, supporting the front thrust washer with the fingers, position the gears and rear thrust washer and insert the shaft from the rear of the case, driving out the dummy shaft.

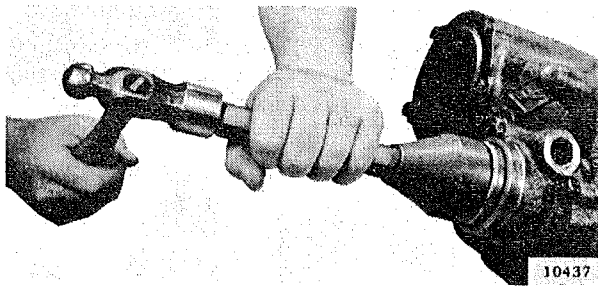


FIG. 121—OUTPUT SHAFT OIL SEAL DRIVER

If necessary, replace the speedometer driven pinion bushing (73) with Bushing Installer Tool W-133 (Fig. 120). When the rear bearing cap assembly is installed, check the end movement of the mainshaft to determine the adjustment of the tapered roller bearings. The shaft should have 0.004" to 0.008" [0,104 a 0,203 mm.] end play. Adjustment is made by selective shim installation between the cap and the case. These shims are available for the adjustment.

0.003" [0,076 mm.] 0.031" [0,787 mm.]
0.010" [0,254 mm.]

Do not install the rear cap oil seal (5) until the bearings are correctly adjusted. Install the front and rear oil seals with Oil Seal Driver Tool W-143 (Fig. 121).

When installing the end yokes on the output shafts, inspect the felt seals in each oil seal guard. The oil seal guard is part of each yoke assembly. Felt seals should be installed in the oil seal

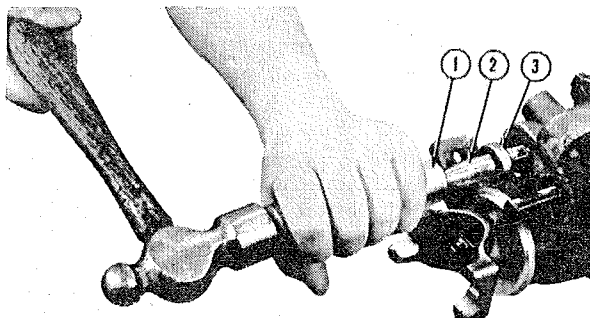


FIG. 122—SHIFT ROD OIL SEAL INSTALLER

1—Driver 2—Thimble 3—Oil Seal

guards if they are not present. When installing the shift rail oil seals with Driver W-130 (Fig. 122) in the front bearing cap, protect the seals with the thimble when passing over the shift rail notches.

J-17. Transfer Case Installation

The procedure for installing the transfer case onto the transmission is given in Par. J-8.

J-18. Transmission and Transfer Case Installation

Install the transmission and transfer case assembly into the vehicle by reversing the removal procedure given in Par. J-4. After installation, lubricate the pilot bearing in the flywheel and the transmission and transfer case as outlined in Section B. The clutch pedal must have 1/2" [1,27 cm.] free travel as described in Section I.

J-19. TRANSMISSION SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Lock in Two Gears	Replace poppet or shift levers.
Slips Out of High Gear:	
Transmission misaligned with bell housing	Align transmission case to bell housing and bell housing to engine.
End play in main drive gear	Tighten front retainer.
Damaged pilot bearing or front bearing	Replace.
Slips Out of Second:	
Worn gear	Replace.
Weak poppet spring	Replace.
Noise in Low Gear:	
Gear teeth worn	Replace gears.
Shifting shoe bent	Replace shoe.
Lack of lubrication	Drain and refill.
Grease Leak into Bell Housing:	
Gasket broken front bearing retainer	Replace.
Transmission main drive gear oil seal	Replace.

J-20. TRANSFER CASE SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Slips Out of Gear (High-Low):	
Shifting lock spring weak	Replace spring.
Bearing broken or worn	Replace.
Shifting fork bent	Replace.
Slips Out of Front Wheel Drive:	
Shifting lock spring weak	Replace.
Bearing worn or broken	Replace.
End play in shaft	Adjust.
Shifting fork bent	Replace.
Hard Shifting:	
Lack of lubricant	Drain and refill.
Shift lever stuck on shaft	Remove, clean, and lubricate.
Shifting lock ball scored	Replace ball.
Shifting fork bent	Replace fork.
Grease Leak at Front or Rear Drive:	
Grease leak at covers	Install new gaskets.
Grease leak between transmission and transfer case	Install new gaskets.
Grease leak at output shaft	Install new oil seal.

J-21. TRANSMISSION SPECIFICATIONS

	SPECIFICATIONS	METRIC
TRANSMISSION: Make Type Model Shift Lever Location Interlock Poppet Clearance	Warner Synchronous Mesh T90A Floor 0.001" to 0.007"	. . . . . . . . . . . . . . . . 0,025 a 0,177 mm.
DRIVE RATIO: Low Second Third High Reverse	2.798 to 1 1.551 to 1 — 1.000 to 1 3.798 to 1	. . . . . . . . . . . . . . . . . . . .

J-22. TRANSFER CASE SPECIFICATIONS

	SPECIFICATIONS	METRIC
TRANSFER CASE: Make Model Shift Lever	Spicer 18 Floor	. . . . . . . . . . . .
DRIVE RATIO: High Low	1.00 to 1 2.46 to 1	. . . . . . . .

PROPELLER SHAFTS AND UNIVERSAL JOINTS

Contents

SUBJECT	PAR.	SUBJECT	PAR.
SPECIFICATIONS		UNIVERSAL JOINTS	K-2
Propeller Shaft	K-5	Assembly	K-4
Universal Joints	K-6	Disassembly	K-3

K-1. GENERAL

The drive from the transfer case to the front and rear axles is through two tubular propeller shafts, each having two cardan cross (needle bearing) universal joints. Both the propeller shafts and the universal joints should be checked regularly for foreign matter around shafts, dented or bent shafts, and loose attaching bolts.

K-2. Universal Joints

Each shaft is equipped with a splined slip joint at one end to allow for variations in length caused by vehicle spring action. Slip joints are marked with arrows at the spline and sleeve yoke (Fig. 123).

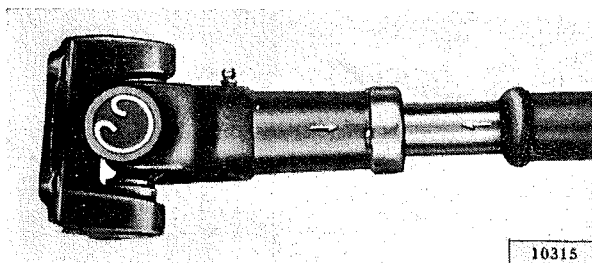


FIG. 123—ARROW MARKINGS

When installing, align the arrows in the same plane. If unmarked with arrows, align the yokes at the front and rear of the shaft in the same parallel plane. This is necessary to avoid vibration. All the universal joints used are similar in construction, except that some are of the U-bolt type and others of the snap ring type. This difference is in the attachment of the joints only.

Universal joints have needle bearings and are so designed that correct assembly is a very simple matter. No hand fitting or special tools are required, however, installation of the needle bearings is much easier if Tool No. W-148 (Fig. 124) is used.

K-3. Disassembly

This joint is illustrated in Fig. 125. To remove the snap rings (2), pinch the ends together with a pair of pliers. If the rings do not readily snap out of the groove, tap the end of the bearing (3) lightly, which will relieve pressure against the

rings. After removing the snap rings, press on the end of one bearing until the opposite bearing is pushed from the yoke arm. Turn the joint over and press the first bearing back out of that arm by pressing on the exposed end of the journal shaft (10). Use a soft ground drift with a flat face about 1/32" [0,794 mm.] smaller in diameter than the hole in the yoke arm and drive it out, otherwise there is danger of damaging the bearing. Repeat this operation for the other two bearings, then lift out journal assembly by sliding it to one side.

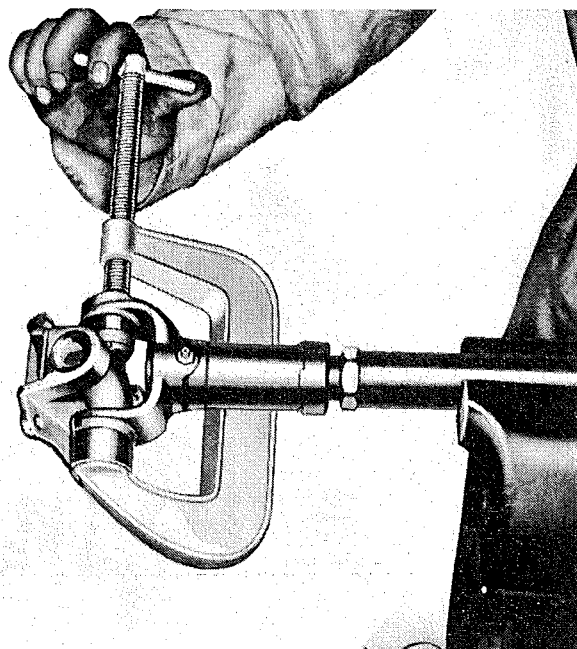


FIG. 124—UNIVERSAL JOINT BEARING CLAMP

K-4. Assembly

Wash all parts in cleaning solvent and inspect the parts after cleaning. Replace any parts that indicate extensive wear. It is advisable to install new gaskets on the journal assembly regardless of the condition of the old gaskets. Make certain that the grease channel in each journal trunnion is open.

Pack the bearing cones one-third full of lubricant and install the rollers.

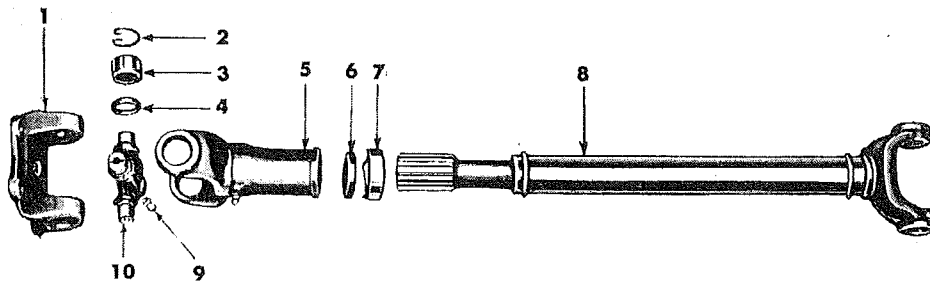


FIG. 125—PROPELLER SHAFT AND UNIVERSAL JOINTS

- 1—Universal Joint Flange Yoke
- 2—Universal Joint Bearing Snap Ring
- 3—Universal Joint Bearing Race
- 4—Trunnion Gasket
- 5—Universal Joint Sleeve Yoke Assembly
- 6—Cork Washer
- 7—Dust Cap
- 8—Propeller Shaft Tube Assembly
- 9—Hydraulic Fitting
- 10—Universal Joint Journal Assembly

Slide the bearings into the end yoke arm and seat them firmly against the bearing shoulders. Hold the bearings in a vertical position to prevent the needles from dropping out until the joint

is assembled. If the joint binds when assembled, tap the arms lightly to relieve any pressure on the bearings at the end of the journal.

K-5. PROPELLER SHAFT SPECIFICATIONS

	SPECIFICATIONS	METRIC
KEY	Spicer	. . . . .
INSIDE DIAMETER:		
Front	1-1/4"	32 mm.
Rear	2"	51 mm.
SHAFT LENGTH:		
Front	22"	56 cm.
Rear	42-5/8"	108 cm.

K-6. UNIVERSAL JOINT SPECIFICATIONS

	SPECIFICATIONS	METRIC
KEY	Spicer	. . . . .
YOKES	Cardan Cross	. . . . .
BEARING RING	Antifriction	. . . . .

FRONT AXLE

Contents

SUBJECT	PAR.	SUBJECT	PAR.
DIAGNOSIS	L-12	SPECIFICATIONS	L-13
DIFFERENTIAL	L-2	STEERING KNUCKLE OIL SEAL	L-9
INSTALLATION	L-6	STEERING KNUCKLE PIVOT PINS	L-7
OVERHAUL	L-3	STEERING TIE ROD AND BELLCRANK	L-10
REASSEMBLY	L-8	TURNING ANGLE	L-11
REMOVAL	L-4	UNIVERSAL JOINTS	L-5

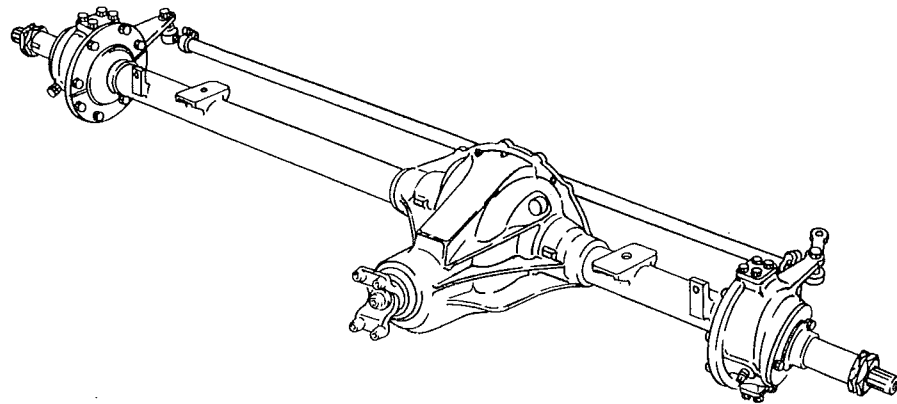


FIG. 126 — FRONT AXLE COMPLETE ASSEMBLY

L-1. GENERAL

The front axle is a live driving unit with hypoid type driving gears and spherical steering knuckles mounted on pivot pins, which ride on tapered roller bearings for ease of steering. Refer to Fig. 126. The drive is of the full floating type through axle shafts built integrally with universal joints, which revolve in the steering knuckles. The steering knuckle tie rod arm is made integrally with the knuckle. Tie rods, mounted on ball and socket connections, connect the knuckles. The tie rod is adjustable to secure correct toe-in of the front wheels. A single tie rod connects the knuckles; a second tie rod connects the right knuckle to the steering bellcrank. A steering connecting rod connects the bellcrank with the steering arm on all models.

The front axle has a spring-loaded breather installed on the differential housing cover. Check this breather at each inspection and lubrication to be sure it is not blocked.

Camber and caster of the front wheels is preset. Camber cannot be altered, but caster can be

adjusted by installing caster shims between the axle pad and the springs. For information on the steering geometry, see Section N.

Also, refer to Section P on wheels, particularly Par. P-4.

L-2. Differential Removal and Overhaul

Adjustment and overhaul of the front axle differential assembly is the same as that of the rear axle.

Information covering servicing of the differential is contained in Section M.

L-3. Front Axle Overhaul

A "live" type front axle is required to provide four-wheel drive. The differential is mounted in a housing similar to that used in the rear axle, except that the pinion shaft faces toward the rear instead of the front and to the right of the center of the axle. This design allows the placing of the front propeller shaft along the right side of the engine oil pan to avoid reducing road clearance under the engine.

The axle is of the full floating type and the axle shafts can be removed without dismantling the steering knuckle housing. Overhaul of the front differential is the same as the rear axle. Refer to Section M for full information.

4. Front Axle Removal

To remove an axle shaft and universal joint assembly, the following operations must be performed:

Remove the wheel assembly.

Remove the hub cap with a puller as shown Fig. 127.

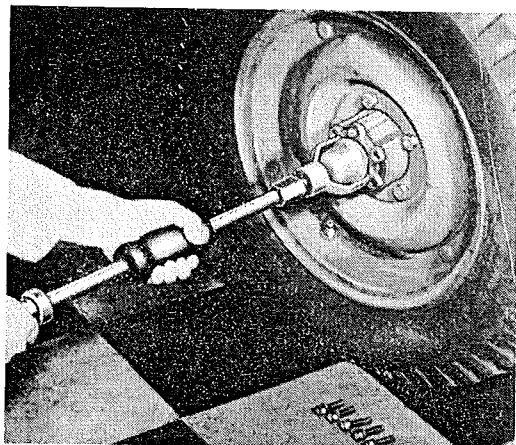


FIG. 127 — HUB CAP PULLER

Remove the axle shaft driving flange bolts. Apply the foot brakes and remove the axle shaft flange with Puller, Tool No. W-163, as illustrated in Fig. 128.

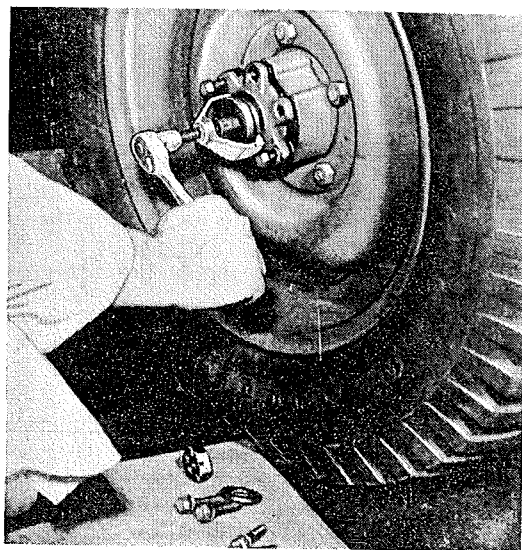


FIG. 128—FRONT AXLE SHAFT DRIVE FLANGE PULLER

e. Release the locking lip on the lock washer and remove the outer nut, lock washer, adjusting nut, and bearing lock washer. Use Wrench, Tool W-144, (Fig. 129) for removal of the nut.

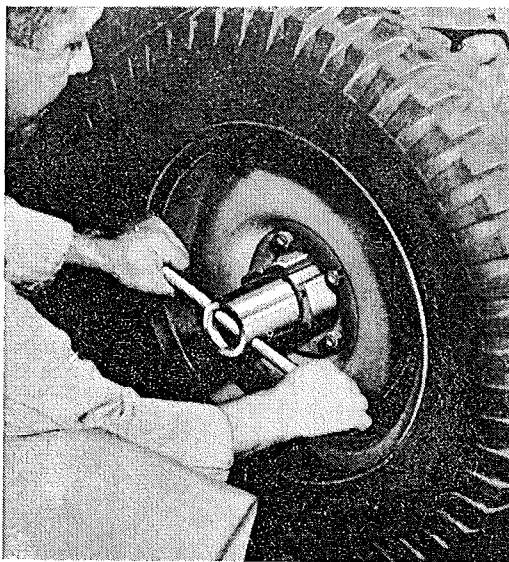


FIG. 129—FRONT WHEEL BEARING NUT WRENCH

f. Remove the wheel hub and drum assembly with the bearings. Be careful not to damage the oil seal.

g. Remove the hydraulic brake tube and the brake backing plate screws.

h. Remove spindle (6) and bushing (7) shown in Fig. 130.

i. Remove the axle shaft and universal joint assembly.

L-5. UNIVERSAL JOINTS

The universal joint is shown in Fig. 131 and 132. It is a cardan cross joint with needle bearings similar to the propeller shaft universal joint. The snap ring slots on the axle joints are in the bearing retainer (5, Fig. 131). Overhaul procedure is outlined below. Additional service information can be found in Section K.

After the axle has been removed, the universal joint may be disassembled as follows:

a. Pinch the ends of the snap ring (3, Fig. 131) together with a pair of pliers. If the rings do not readily snap out of the groove, tap the end of the bearing lightly which will relieve pressure against the rings. Remove the snap rings.

b. Press on the end of one bearing retainer (5) until the opposite bearing is pushed from the journal of the outer shaft (2).

c. Turn the joint over and press the first bearing back out of that arm by pressing on the exposed end of the universal joint journal assembly (6). Use a soft ground drift with a flat face about 1/32" (0,794 mm.) smaller in diameter than the hole in

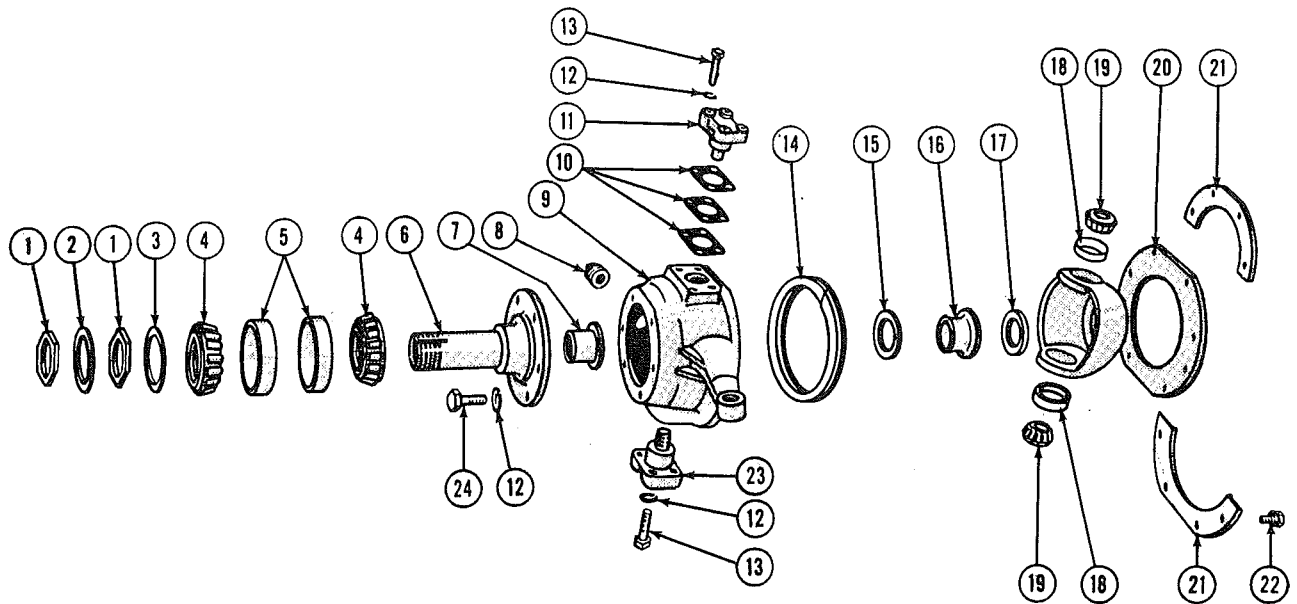


FIG. 130 - STEERING KNUCKLE AND WHEEL BEARINGS

- | | | |
|------------------------------|--------------------------------|-------------------------------|
| 1 - Bearing Adjusting Nut | 9 - Left Knuckle and Arm | 17 - Oil Seal |
| 2 - Lock Washer | 10 - Shims | 18 - Bearing Cup |
| 3 - Lock Washer | 11 - Upper Bearing Cap | 19 - Bearing Cone and Rollers |
| 4 - Bearing Cone and Rollers | 12 - Lock Washer | 20 - Oil Seal |
| 5 - Bearing Cup | 13 - Bolt | 21 - Retainer |
| 6 - Spindle | 14 - Oil Seal and Backing Ring | 22 - Bolt |
| 7 - Bushing | 15 - Thrust Washer | 23 - Lower Bearing Cap |
| 8 - Filler Plug | 16 - Axle Pilot | 24 - Bolt |

the outer shaft and drive it out, otherwise there is danger of damaging the bearings.

d. Repeat this operation for the other two bearings in the inner shaft, then lift out the universal joint journal assembly by sliding it to one side.

e. Reassembly of the joint is the reverse of disassembly. Be careful not to damage parts; see that they are free of all dirt.

L-6. Installation

Install the axle shaft and universal joint assembly in the housing as outlined below.

- a. Clean all parts thoroughly.
- b. Insert universal joint and axle shaft assembly in the housing, taking care not to knock out the

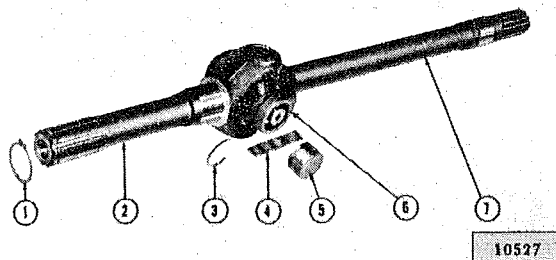


FIG. 131 - FRONT AXLE UNIVERSAL JOINT

- | | |
|-----------------------------------|---|
| 1 - Outer Axle Shaft
Snap Ring | 4 - Bearing Rollers |
| 2 - Outer Shaft | 5 - Bearing Retainer |
| 3 - Bearing Retainer
Snap Ring | 6 - Universal Joint
Journal Assembly |
| | 7 - Inner Shaft |

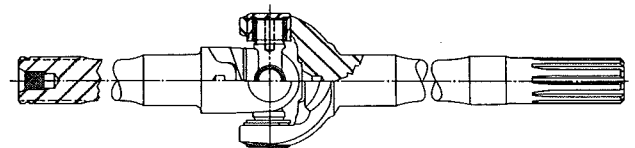
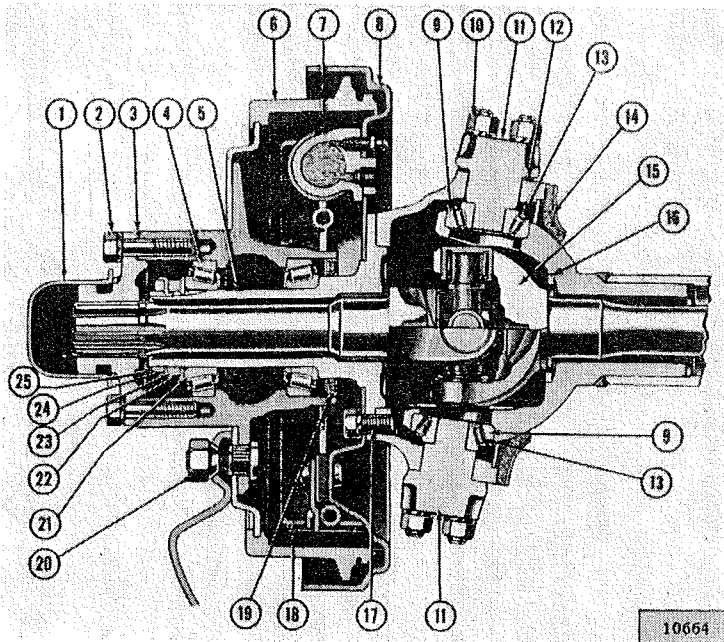


FIG. 132 - UNIVERSAL JOINT

inner oil seal. Push splined end of axle shaft into place in the differential.

- c. Install wheel bearing spindle (5, Fig. 133).
- d. Install brake tube and brake backing plate.
- e. Grease and assemble wheel bearings (4) and (21) and hub oil seal (19). Install the wheel hub and drum on the wheel bearing spindle. Install the wheel bearing washer and adjusting nut. Tighten nut with Wrench, Tool W-144, as shown in Fig. 129, until there is a slight drag on the bearings when the hub



- 1 - Wheel Hub Cap
- 2 - Driving Flange Cap Screw
- 3 - Axle Shaft Drive Flange Gasket
- 4 - Wheel Bearing Cup
- 5 - Front Wheel Spindle
- 6 - Brake Drum
- 7 - Front Brake Cylinder
- 8 - Brake Backing Plate
- 9 - Pivot Pin Bearing Cap
- 10 - Pivot Pin Bearing Cap Nut
- 11 - Pivot Pin
- 12 - Pivot Bearing Adjusting Shims
- 13 - Pivot Pin Cone and Rollers
- 14 - Steering Knuckle Oil Seal
- 15 - Front Axle Universal Joint
- 16 - Thrust Washer
- 17 - Brake Backing Plate Screw
- 18 - Brake Shoe and Lining
- 19 - Hub Oil Seal
- 20 - Wheel Hub Bolt Nut
- 21 - Wheel Bearing Cone and Rollers
- 22 - Wheel Bearing Retaining Nut
- 23 - Wheel Bearing Retaining Nut
- 24 - Wheel Adjusting Nut Lock Washer
- 25 - Wheel Bearing Retaining Nut

FIG. 133 - FRONT STEERING KNUCKLE

turned; then back off approximately one-sixth turn. Install locking washer and nut, tighten nut to place, and bend the lock washer over the lock t.

Install drive flange and gasket on hub and attach the six cap screws and lock washers.

Install snap ring at the outer end of the shaft.

Install the hub grease cap.

Install the wheel.

Check front wheel alignment as outlined in Steering Section.

Bleed the brakes.

Remove filler plug and fill universal joint using with lubricant.

L-7. Steering Knuckle Pivot Pins

The steering knuckle pivot pins pivot on tapered roller bearings. Replacement of these bearings requires removal of the hub and brake drum assembly, wheel bearings, axle shaft, spindle, steering tie rod, and steering knuckle. Disassemble the steering knuckle as follows:

a. Remove the eight bolts (22) shown in Fig. 130 which hold the oil seal retainer (21) in place.

b. Remove the four screws holding the lower pivot pin bearing cap (23). Remove the four screws holding the upper bearing cap in place. Remove the bearing cap. The steering knuckle (9) can now be removed from the axle.

c. Wash all parts in cleaning solvent. Replace any damaged or worn parts. Inspect the bearing and races for scores, cracks, or chips. Should the bearing cups be damaged, they may be removed and installed with Special Driver, Tool W-138, as shown in Fig. 134.

L-8. Reassembly

Reverse the procedure of Par. L-7 to reassemble the unit. When reinstalling the steering knuckle, sufficient shims must be installed under the top bearing cap to obtain correct preload on the bearings. Shims are available in these thicknesses:

- | | |
|--------------------|--------------------|
| 0.003" [0,076 mm.] | 0.010" [0,254 mm.] |
| 0.005" [0,127 mm.] | 0.030" [0,762 mm.] |

Install the bearing caps, lock washers, and screws, and tighten securely.

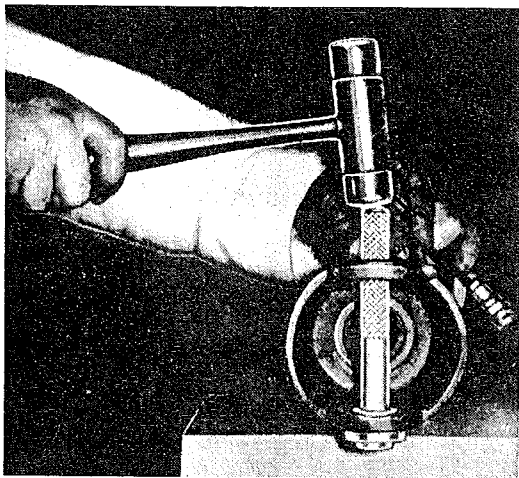


FIG. 134 - SPINDLE PIN BEARING CUP DRIVER

Check the preload on the bearings by hooking a spring scale in the hole in the knuckle arm for the tie rod socket. Take the scale reading when the knuckle has just started its sweep.

The scale reading should be 12 to 16 pounds [5,44 a 7,26 kg.] with the oil seal and axle shaft removed. Remove or add shims to obtain a scale reading within these limits. If all shims are removed and adequate preload is still not obtained, a washer may be used under the top bearing cap to increase preload. When a washer is used, shims may have to be reinstalled to obtain proper adjustment.

L-9. Steering Knuckle Oil Seal Replacement

Remove the oil steering knuckle oil seal by removing the eight screws which hold it in place. Oil seal assemblies consist of a split oil seal and backing ring assembly, an oil seal felt, and two seal retainer plate halves. Examine the spherical surface of the axle for scores or scratches which could damage the seal. Smooth any roughness with emery cloth.

Before installing the oil seal felt, make a diagonal cut across the top side of the felt so that it may be slipped over the axle. Install the oil seal assembly in the sequence given above, making sure the backing ring (of the oil seal and backing ring assembly) is toward the wheel.

After driving in wet, freezing weather, swing the front wheels from right to left to remove moisture adhering to the oil seal and the spherical surface of the axle housing. This will prevent freezing with resulting damage to the seals. Should the vehicle be stored for any period of time, coat these surfaces with light grease to prevent rusting.

L-10. Steering Tie Rod and Bellcrank

These parts of the front axle are covered in the Steering Section.

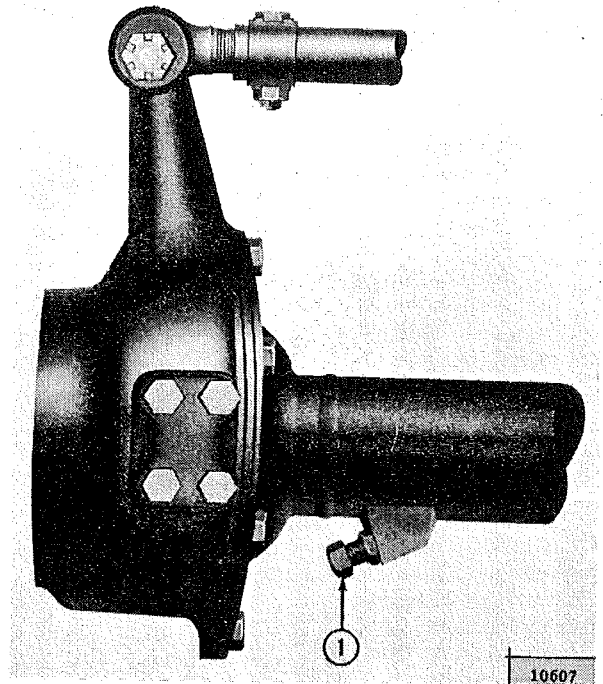


FIG. 135 — TURNING ANGLE STOP SCREW

1 — Stop Screw

L-11. Turning Angle

To avoid possible damage to the universal joints, it is advisable to check the turning angle. It should not be more than 29 degrees. To adjust the stop screw (see Fig. 135), break the weld holding the screw in position. When the proper adjustment has been made, reweld the screw in place to prevent any movement of the stop screw.

The angle is measured by placing the front wheels on turntables.

L-12. SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Hard Steering:	
Lack of lubrication	Lubricate.
Tires soft	Inflate.
Light steering	Adjust. See Steering Section.
Low Speed Shimmy or Wheel Fight:	
Spring clips and shackles loose	Readjust or replace.
Front axle shifted	Broken spring center bolt.
Insufficient toe-in	Adjust.
Improper caster	Reset.
Steering system loose or worn	Adjust or overhaul steering gear, front axle, or steering parts.
Twisted axle	Straighten or adjust.
High Speed Shimmy or Wheel Fight:	
Check conditions under "Low Speed Shimmy"	
Tire pressures low or not equal	Inflate.
Wheel out of balance	Balance.
Wheel runout	Straighten.
Radial runout of tires	Mount properly.
Wheel camber	Same on both wheels.
Front springs settled or broken	Repair or replace.
Steering knuckle arm	Straighten or replace.
Shock absorbers not effective	Replace or repair.
Steering gear loose on frame	Tighten.
Front springs too flexible	Over lubricated.
Wobble:	
Wheels unbalanced	Check and balance.
Steering:	
Improper toe-in	Adjust — check for bent steering knuckle arm.
Broken front spring main leaf	Replace.
Loose shifted	Spring center bolt broken.
Loose spring shackles or clips	Adjust or replace.
Improper caster	Reset.
Tire pressure uneven	Inflate.
Lightness in steering system	Adjust.
Loose wheel bearings	Adjust.
Front spring settled or broken	Repair or replace.
Noisy on Pull:	
Pinion and ring gear adjusted too tight	Readjust.
Pinion bearings rough	Replace.
Noisy on Coast:	
Excessive backlash at ring and pinion gears	Readjust.
End play in pinion shaft	Readjust.
Worn bearing	Replace.
Noisy on Coast and Pull:	
Pinion and pinion adjusted too tight	Readjust.
Pinion set too deep in ring gear	Readjust.
Pinion bearing loose or worn	Readjust or replace.

L-12. SERVICE DIAGNOSIS (Continued)

SYMPTOMS	PROBABLE REMEDY
Backlash:	
Axle shaft universal joint worn	Replace.
Axle shaft improperly adjusted	Readjust.
Worn differential pinion washers	Replace.
Worn propeller shaft universal joints	Repair.

Emergency

When front axle differential trouble renders the vehicle inoperative, remove the axle driving flanges, place front wheel drive lever in disengaged position, and bring vehicle in under its own power.

L-13. FRONT AXLE SPECIFICATIONS

	SPECIFICATIONS	METRIC
MAKE	Spicer	. . . . .
MODEL	44-F	. . . . .
CAPACITY	3500 lb.	1,587 kg.
DESCRIPTION	Full Floating Hypoid Gears	. . . . .
UNIVERSAL JOINTS: Standard:		
Make	Spicer	. . . . .
Type	Cardan Cross	. . . . .
KINGPIN BEARING PRELOAD	12 to 16 lb.	5,44 a 7,26 kg.
DRIVE PINION OFFSET	1.50"	38 mm.
NUMBER OF DIFFERENTIAL PINIONS	4 with Powr-Lok	. . . . .
GEAR RATIO:		
Standard	4.89:1	. . . . .
Optional	4.27:1	. . . . .
Optional	5.38:1	. . . . .
RING GEAR PITCH DIAMETER	8.5"	21,6 cm.
PINION ADJUSTMENT	Shim	. . . . .
PINION BEARING ADJUSTMENT	Shim	. . . . .



REAR AXLE

Contents

SUBJECT	PAR.	SUBJECT	PAR.
AXLE SHAFT		Pinion and Differential Case Bearings . . .	M-7
Installation	M-13	Pinion and Ring Gear Setting Gauge . . .	M-9
Removal	M-3	POWR-LOK DIFFERENTIAL OVERHAUL . . .	M-11
DIAGNOSIS	M-22	POWR-LOK SERVICING	M-5
DIFFERENTIAL	M-4	REAR AXLE	
Removal	M-6	Installation	M-13
DIFFERENTIAL BEARING PRELOAD . . .	M-12	Removal	M-2
DIFFERENTIAL CARRIER BEARING CUPS	M-8	RING GEAR BACKLASH	M-12
DRIVE PINION		SPECIFICATIONS	M-23
Adjustment	M-10	TROUBLE SHOOTING	M-14

M-1. GENERAL

A semifloating hypoid rear axle with a Powr-Lok differential is used on these vehicles. Information for front and rear axle differentials is covered in this section. Information for axle shaft adjustment is given in Section P.

NOTE: Whenever an axle differential is inspected, see if the ring gear lock straps (39, Fig. 138) are present. These straps should be installed on those axles without them.

M-2. Rear Axle Assembly Removal

To remove the rear axle assembly, proceed as follows:
 Raise the rear of the vehicle with a hoist and safely support the frame ahead of the rear springs. Remove the wheels and disconnect the propeller shaft at the rear universal joint companion flange. Disconnect the shock absorbers at the axle mounting pads. Disconnect the brake hydraulic hose at

the tee just forward of the tubing clipped to the axle. Support the axle assembly on a jack, remove the spring to axle U-bolt clips and slide the assembly from underneath the vehicle.

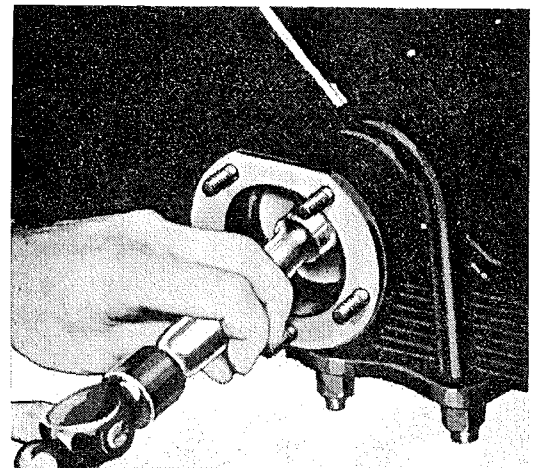


FIG. 137—OIL SEAL DRIVER

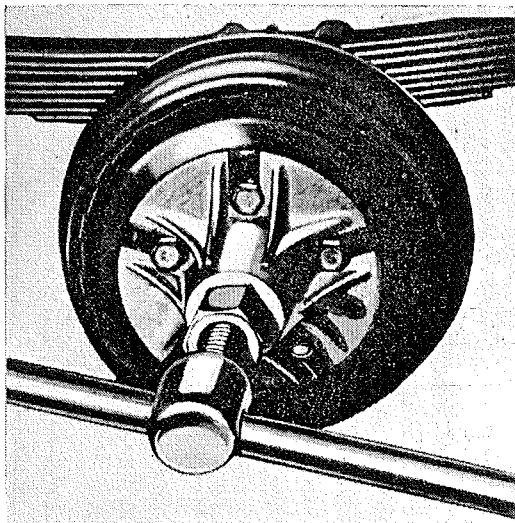


FIG. 136—REAR WHEEL HUB PULLER

M-3. Rear Axle Shaft Removal

To remove axle shafts from an axle, follow the sequence below:

- a. Jack up the wheel and remove the hub cap.
- b. Remove the axle shaft nut.
- c. Use a Puller, Tool C-319, (Fig. 136), to remove the wheel hub.
- d. Remove the screws attaching the brake dust shield, grease and bearing retainers, and brake assembly. Remove the shield and retainer.
- e. Pull out the axle shaft using care not to lose the adjusting shims. Should an axle shaft be broken, the inner end can usually be drawn out of the housing with a wire loop after the outer oil seal is removed. However, if the broken end is less than 8' [20,3 cm.] long, it will usually be necessary to remove the differential.

remove the bearing from an axle shaft, use Combination Bearing Puller W-104-A shown in 143.

When shafts are to be removed, keep the shims on each shaft separate and replace them on the axle from which they were removed to maintain correct bearing adjustment.

Assembly is the reverse of disassembly. Check axle shaft oil seal before installing the axle shaft. If replacement is necessary, use Axle Shaft Oil Seal Driver W-186 (Fig. 137). Also check the

grease retainer and replace it if there is any doubt of its condition.

Adjust the wheel bearings as outlined in Section P.

M-4. DIFFERENTIAL

Differentials of both front and rear axles are covered here. Before disassembling the differential, it is advisable to determine through inspection, the cause of difficulty or failure of the parts. Drain lubricant from the differential housing and

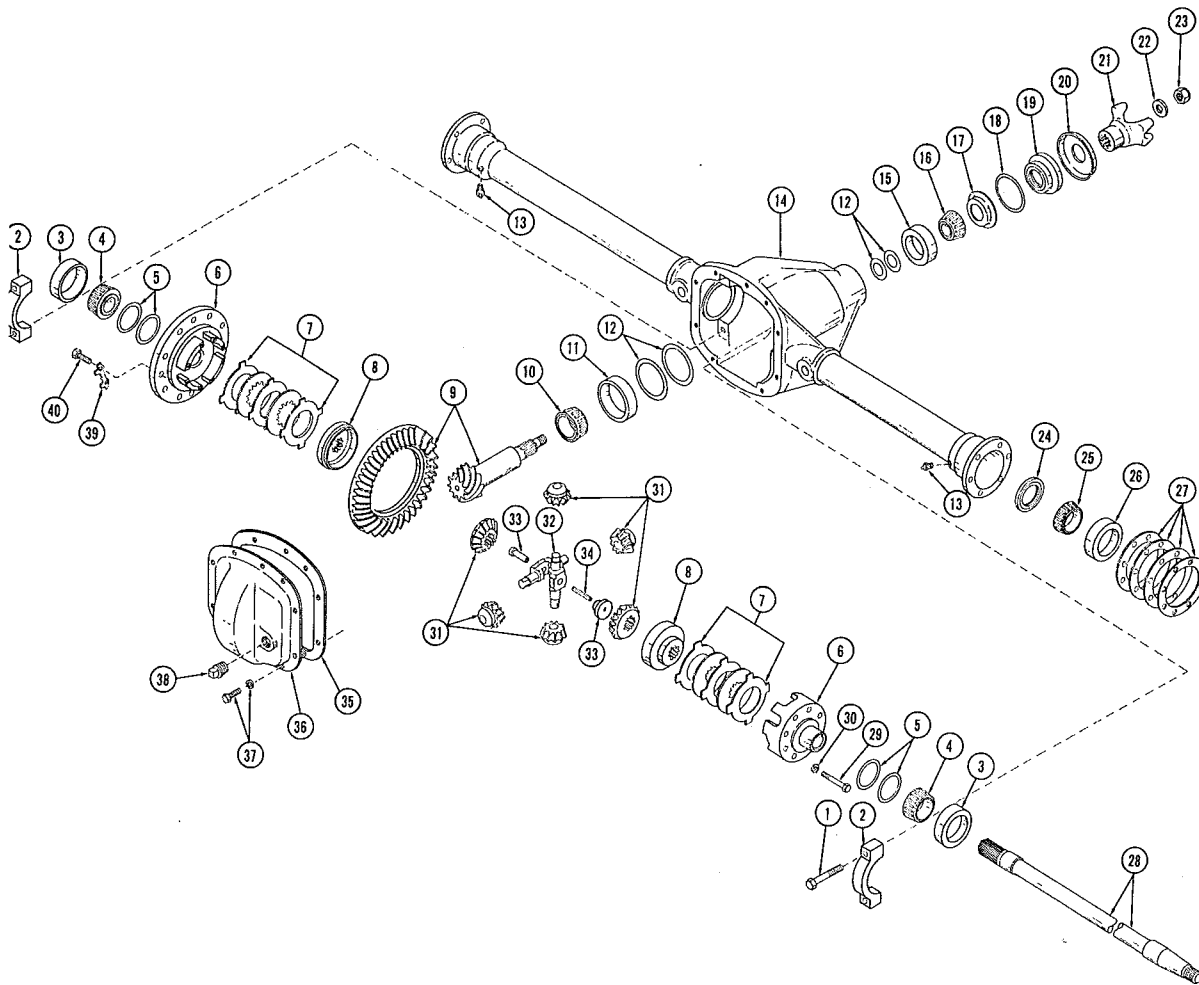


FIG. 138—REAR AXLE, EXPLODED VIEW

- | | | | |
|-----------------------------------|-----------------------------------|---------------------------------------|----------------------------|
| 1—Screw | 11—Inner Bearing Cup | 22—Washer | 32—Cross Pinion Mate Shaft |
| 2—Bearing Cap | 12—Shims | 23—Pinion Nut | 33—Axle Shaft Spacer |
| 3—Bearing Cup | 13—Fitting | 24—Oil Seal | 34—Roll Pin |
| 4—Cone and Rollers | 14—Housing | 25—Cone and Rollers | 35—Gasket |
| 5—Shims | 15—Outer Bearing Cup | 26—Cup | 36—Housing Cover |
| 6—Differential Case Flange Half | 16—Outer Bearing Cone and Rollers | 27—Shims | 37—Screw and Lock Washer |
| 7—Differential Clutch Assembly | 17—Oil Slinger | 28—Axle Shaft | 38—Filler Plug |
| 8—Side Gear Differential Ring | 18—Gasket | 29—Screw | 39—Lock Strap |
| 9—Gear and Pinion | 19—Oil Seal | 30—Washer | 40—Screw |
| 10—Inner Bearing Cone and Rollers | 20—Dust Shield | 31—Side Gear and Pinion Mate Gear Set | |
| | 21—End Yoke | | |

then remove the differential cover. Wash the differential parts thoroughly with kerosene so that parts can be carefully inspected. Should it be determined by this inspection that the differential requires overhauling, the axle must be removed from the vehicle.

M-5. Powr-Lok Servicing

Whenever a replacement Powr-Lok differential assembly is to be installed in an axle which has been previously in service and acquired mileage, be sure to record the amount of backlash between the ring gear and pinion at the time of disassembly. When the axle is again assembled, the ring gear and pinion must be set to this same amount of backlash.

NOTE: The only lubricant specified for Powr-Lok differentials is Willys Powr-Lok Differential Oil, Part No. 94557, furnished in pint cans. Ordinary multipurpose gear lubricant must not be used.

M-6. Removal

Numbers in parentheses refer to Fig. 138.

a. Remove the axle shafts (28). Refer to Par. M-3 or M-4 for rear axles and Section L for front axles.

b. Remove the housing cover (36) and four screws (1) holding the two differential side bearing caps (2) in position. Make sure there are matching letters or other marks on the caps and the housing so that each cap can be reinstalled in the same position and location from which it is removed.

c. It is necessary to spread the carrier as the differential bearing has initial preload. Use Housing Spreader, Tool W-129, as shown in Fig. 139 to

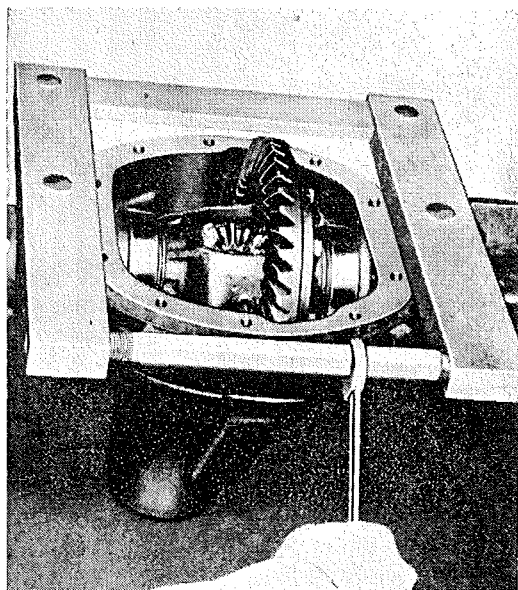


FIG. 139—DIFFERENTIAL CARRIER SPREADER

spread the housing. Install W-129-18, Hold-down Clamps, if available, to keep the spreader in position. Clamp on a dial indicator. From the side, measure the carrier spread. When the spreading force is applied, do not exceed a limit of 0.020" [0,50 mm.]. Remove the dial indicator. Carefully pry the differential case loose, using pry bars at the heads of the ring gear bolts and carrier casting.

CAUTION: Remove the spreader tool to prevent the possibility of the carrier taking a set.

d. Should the spreader tool be unavailable, use two pry bars, one on each side of the differential case opening, to pry out the differential. Insert the tip of the bars in the differential case flange halves (6) and pry against the housing (14).

e. To remove the drive pinion, first remove the universal joint end yoke assembly (21). Use Tool C-3281 to hold the shaft, as shown in Fig. 140, while removing the nut. Use Puller, Tool W-172, to remove the end yoke as shown in Fig. 141.

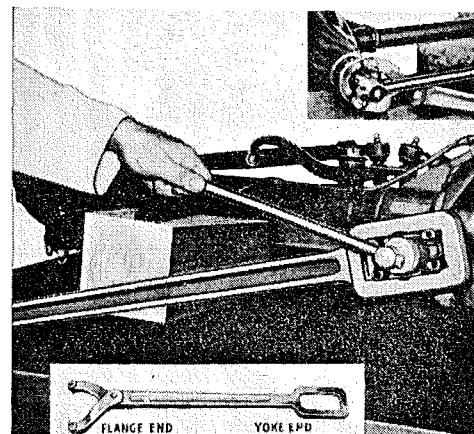


FIG. 140—FLANGE HOLDING WRENCH

f. With a hammer and brass drift, drive on the end of the pinion shaft to force the pinion into the differential housing so it can be removed.

g. Remove the pinion shaft oil seal. Use Puller, Tool W-251, as shown in Fig. 142.

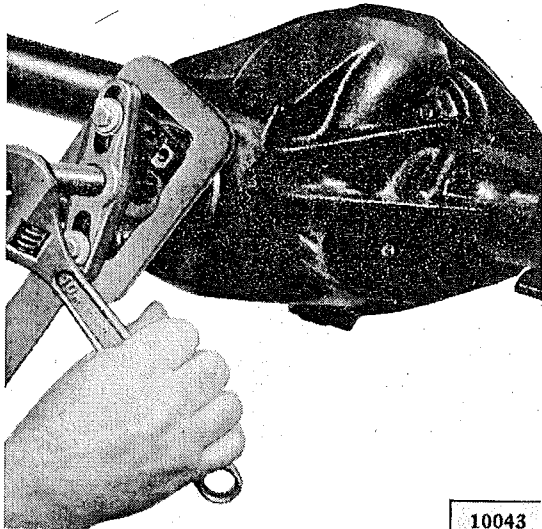
h. Wash all parts in kerosene, using care not to lose any of the shims (which adjust the pinion shaft bearings or differential side and pinion gears).

M-7. Pinion and Differential Case Bearing Removal

To remove the differential case bearings (4, Fig. 138) and pinion bearings (10) and (16), use Bearing Puller W-104-A as shown in Fig. 143.

Use of the above puller assures easy removal of bearings without damage to cages or rollers as pulling pressure is applied directly to the bearing cone.

Install the inner pinion bearing on axle pinions, install the installation sleeve of pipe with no more than $3/16$ " [4,8 mm.] wall thickness with an inner diameter of $1-21/32$ " [42,1 mm.]. Install as shown in Fig. 144.

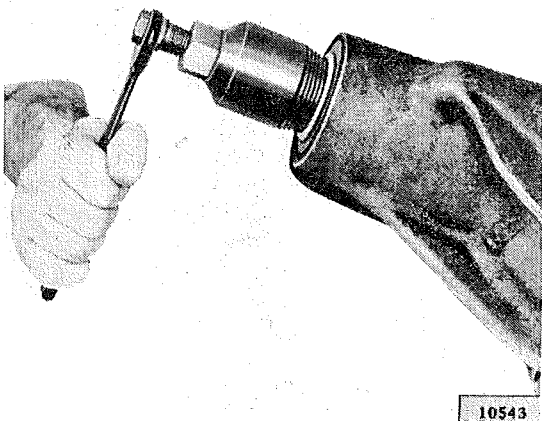


10043

FIG. 141—END YOKE PULLER

Differential Carrier Bearing Cups

To remove the inner and outer differential carrier bearing cups, use Puller W-100 (Fig. 145 and 146) with its adapter plates, which are a part of W-99, W-99-A, and W-99-B tool kits. Oil the puller screws with clean engine or machine oil. Remove the inner bearing cup first.



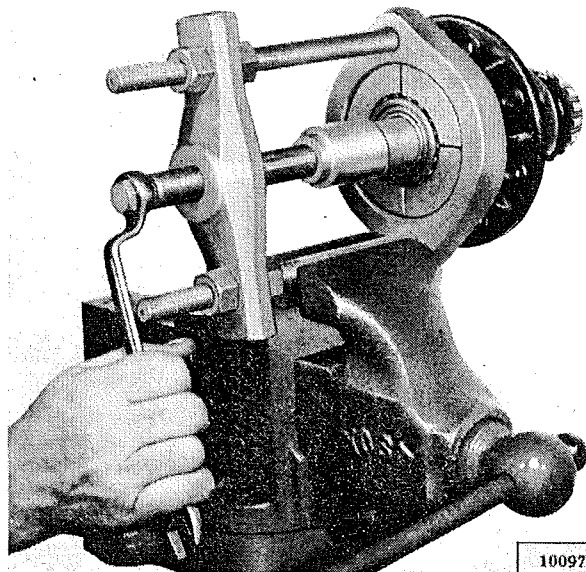
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FIG. 142—REMOVING PINION SHAFT OIL SEAL

To replace the bearing cups, Puller W-100 is used to pull the inner bearing cup into the housing. Puller W-126 is used to install the front bearing

cup as shown in Fig. 147. Procedure for removal is given below.

- a. Remove the hex nuts from each end of the W-100 Puller.
- b. Carefully insert the round adapter with two flat sides through one of the bearing cups and position it behind the inner bearing cup shoulder.
- c. Insert the short-threaded end of the main puller screw through the hole in this adapter and secure the adapter with a hex nut.
- d. Position the plate across the open face of the differential housing and secure it with a hex nut.
- e. Make sure the adapter plate sets flat against the pinion rear bearing adjusting shims. Turn down the nut to remove the bearing cup.
- f. Reposition the puller to remove the outer bearing cup. The adapter should be seated firmly against the shoulder of the cup with the long-threaded end of the main puller screw through its center. The plate is positioned against the front seat of the differential housing.



10092

FIG. 143—BEARING PULLER

- g. Make sure the adapter plate sets flat against the pinion outer bearing adjusting shims. Turn down the nut to remove the bearing cup.

M-9. Pinion and Ring Gear Setting Gauge Set

For correct and easy adjustment of the drive pinion, use a Pinion and Ring Gear Setting Gauge Set W-99-B. This set includes a tool with adapter to remove and install pinion bearing cups, a C-clamp aligning fixture that locks to the pinion shaft and aligns a dial indicator which accurately measures the distance from the pinion head to the bottom of the differential side carrier bore, master gauge blocks, and a dial indicator.

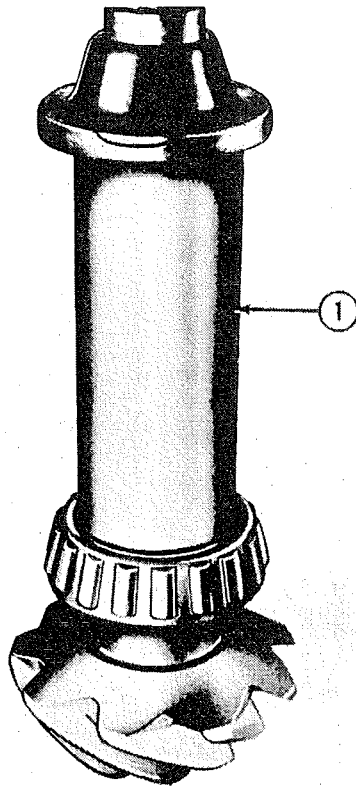
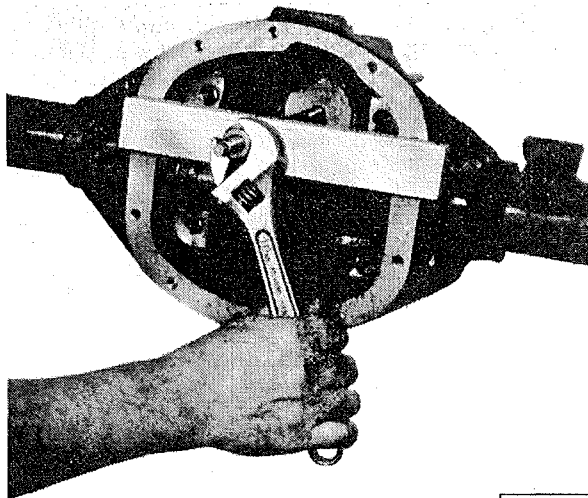


FIG. 144—PINION BEARING INSTALLING SLEEVE

1—Sleeve

M-10. Drive Pinion Adjustment

Numbers in parentheses refer to Fig. 148. Before attempting to adjust the ring gear backlash and run-out, the drive pinion should be carefully



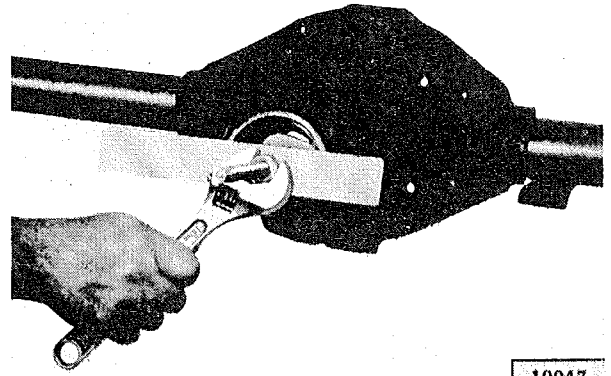
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FIG. 145—PULLING PINION SHAFT INNER BEARING CUP

checked and adjusted. The pinion is correctly positioned in relation to the ring gear by the use of shims which are placed between the inner bearing cup and the housing. These shims are available in these thicknesses:

- 0.003" [0,076 mm.] 0.010" [0,254 mm.]
- 0.005" [0,127 mm.]

Should it be necessary to remove and replace the pinion shaft bearing cups, this may best be accomplished by using pinion shaft bearing pullers as described in Par. M-8.



10047

FIG. 146—PULLING PINION SHAFT OUTER BEARING CUP

The correct gauge for setting axles covered in this book is indicated in Par. M-9.

When using this gauge, do not install the oil seal until the pinion is adjusted. Use Sleeve Tool

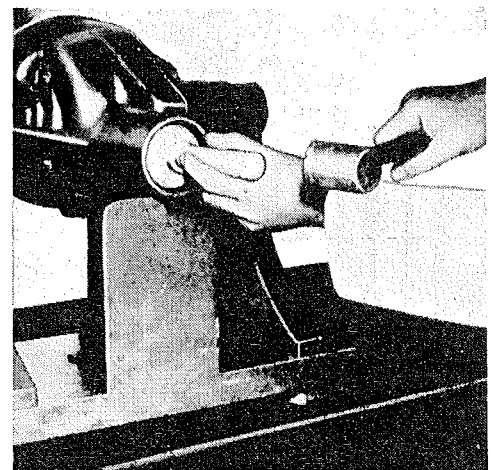
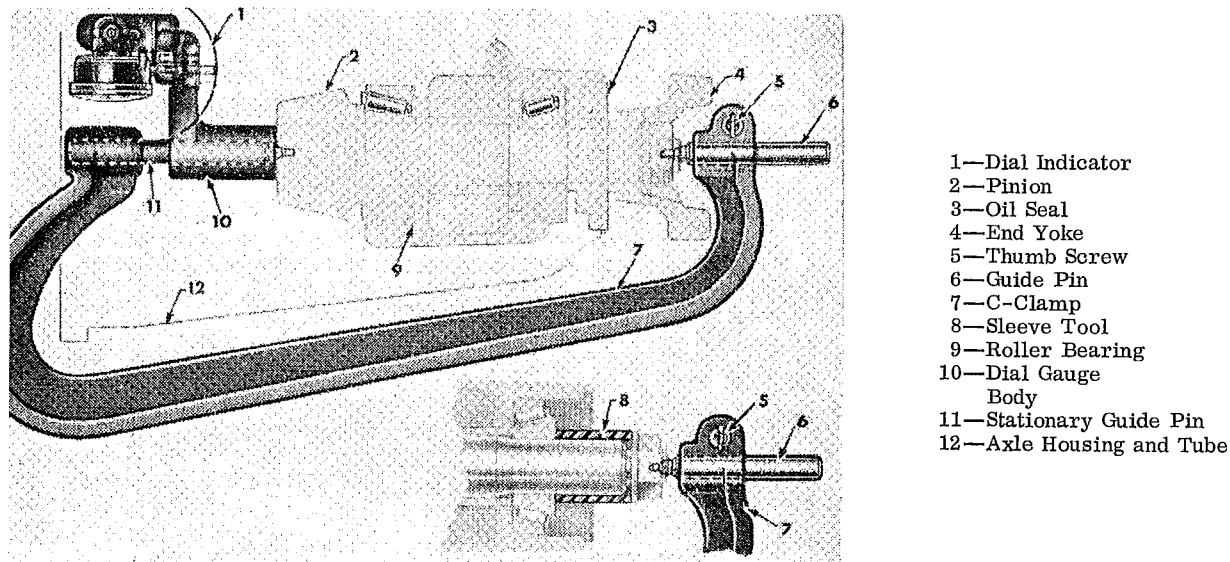


FIG. 147—PINION SHAFT FRONT BEARING CUP DRIVER

W-162-6, (8), in place of the universal joint yoke to hold the pinion in position for adjustment. This gauge is equipped with a dial indicator which measures the distance from the finished



- 1—Dial Indicator
- 2—Pinion
- 3—Oil Seal
- 4—End Yoke
- 5—Thumb Screw
- 6—Guide Pin
- 7—C-Clamp
- 8—Sleeve Tool
- 9—Roller Bearing
- 10—Dial Gauge Body
- 11—Stationary Guide Pin
- 12—Axle Housing and Tube

FIG. 148—PINION ADJUSTING FIXTURE

surface on the head of the pinion to the center of the differential carrier bearing. Establishing this distance determines the correct amount of shims to be installed to provide the correct positioning of the drive pinion. All pinions are marked on the head with a dimension indicating the proper number of thousandths of an inch by which the pinion must be adjusted, either plus or minus, from standard. For example, a pinion marked plus .003 means it must be adjusted 0.003" [0.076 mm.] further away from the ring gear center than standard and the gauge dial must read plus .003" when the pinion is correctly shimmed.

Master gauge blocks are supplied with this tool so that the original zero or standard dimension can be accurately and easily established. The gauge blocks provide seven different standards for different axles. The seven standards are indicated

with A, B, C, D, E, F, and G markings stamped on the gauge blocks. Use only the blocks listed E for the front axle Model 44 and F for the rear axle Model 53.

The dial gauge is set to the master gauge for the differential axles as shown in Fig. 149. Use the correct master gauge surface. Hold the dial indicator and gauge as shown in Fig. 149 and set the dial bezel to position the hand at zero with one-half turn tension on the gauge pin. This sets the dial to register at zero when mounted in the axle when the distance between the finished head of a standard pinion and the center of the differential carrier is spanned.

After setting the dial, use care not to jar it or turn the bezel to disturb the setting. Assemble the pinion in the case with the same thickness shim packs originally installed and without the oil seal. Use Spacer, Tool W-126-6, in place of the universal joint yoke.

Assemble the dial gauge head to the C-clamp by slipping the housing (10) over the stationary guide pin (11). Hold the gauge head and the large end of the C-clamp in one hand and position it over the pinion (2). Press the guide pin (6) at the small end of the C-clamp into the threaded end of the pinion and lock it into position with the thumb screw (5).

With the C-clamp correctly seated in the drive pinion shaft lathe center and the dial indicator contact point bearing against the differential carrier side bearing bore, as shown in Fig. 148, hold the dial gauge body (10), against the drive pinion head. Swing the dial gauge body back and forth across the bearing bore and watch the dial reading. The lowest reading indicates the center of the bearing bore and if the shim pack is of the correct thickness, the dial gauge reading will

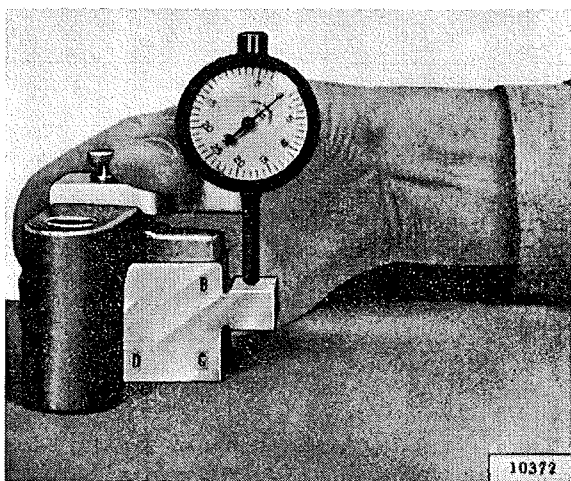


FIG. 149—PINION MASTER GAUGE

be the same as the etched marking on the pinion head.

For example, if the pinion is marked plus three, the dial should indicate plus 0.003". If the pinion is marked minus three, the dial should indicate minus 0.003". Should the dial reading fail to agree with the marking on the pinion head, note the difference and a corresponding amount of shims should be added or removed to secure the correct adjustment (reading on dial and pinion marking agree).

NOTE: To increase the dial reading, decrease shims; to decrease the dial reading, increase shims. Example: With a dial reading of minus 0.001" and a pinion marking of plus 0.002", remove 0.003" shims to obtain a higher dial reading of plus 0.002".

Recheck the adjustment if any changes are made. Be sure to set the dial to the correct face of the master gauge.

After correctly locating the pinion, adjust the pinion bearing preload. Start with approximately 0.065" [1,651 mm.] shim pack between the shoulder of the pinion and outer bearing cup. Reassemble the outer bearing, yoke, washer, and nut. Tighten to a torque of 200 to 220 foot-pounds [27,66 a 30,43 kg./m.]. Using an inch-pound torque wrench, check the rotating torque (disregard starting torque). Torque should be 10 to 25 inch-pounds [0,116 a 0,288 kg./m.]. Add or remove shims to obtain the recommended rotating torque.

Do not install the oil seal until the differential has been assembled and the entire unit checked. When installing the universal joint flange, use Flange Installing Tool W-162, Fig. 150.

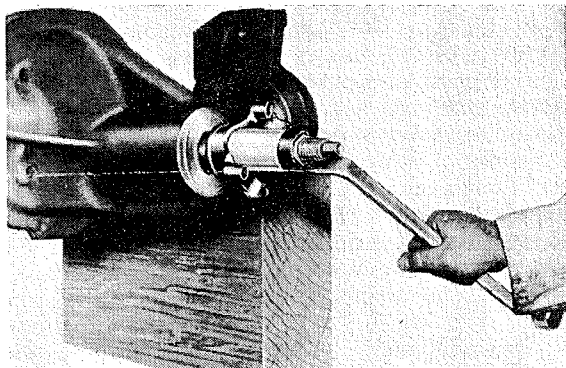


FIG. 150—UNIVERSAL JOINT FLANGE INSTALLING TOOL

M-11. Powr-Lok Differential Overhaul

The procedure for overhauling disc type Powr-Lok differentials is as follows:

a. Remove the Powr-Lok differential case assembly from the axle. Do not remove the ring gear or bearing cones unless replacement is to be made. Mark the bearing cups so they may later

be reassembled with the same bearing cones. Mark the differential case halves for correct alignment at reassembly.

Each pinion mate cross shaft should also be marked so that each pin cam surface will match with the same V-ramp in the case when reassembled.

b. Separate the case halves.

c. Remove clutch friction discs and plates. Care should be taken to see how the friction plates and friction discs and dished plates are assembled. The illustration (Fig. 138) shows the arrangement of plates and discs used for Powr-Lok differentials.

d. Remove the pinion mate cross shafts, bevel pinion mate gears, bevel side gears, and side gear rings.

e. Clean all parts thoroughly in kerosene and dry with compressed air. Inspect all parts and replace any items which appear to be worn or damaged. Inspect the plate surfaces of the case halves, the side gear rings, and the clutch plates and discs for excessive wear and scoring. Inspect the pinion mate shaft V-surfaces, and the ramp surfaces, on the case for excessive wear and pitting. Inspect the side gear and pinion gear teeth. Inspect the pinion gear races that bear on the side gear rings. Inspect the corresponding surfaces on the side gear rings. Inspect the clutch plates and discs for cracks and distortion.

In the event one or more of the clutch plates or discs needs replacing, replace the entire stack of plates and discs on each side of the pinions. These stacks are supplied in sets. Each set contains plates and discs for one differential. The differential case halves are not serviced. Should replacement be required, it will be necessary to replace the complete differential.

f. Assemble the clutch friction plates, clutch friction discs, and dished plates on the splined hub of each bevel side gear. Make sure the plates and discs are installed according to Fig. 138. The dished plates in the plate and disc set are always assembled with the convex side toward the case. As each part is reassembled in its proper position, it is necessary that it be lightly coated with Willys Powr-Lok Differential Oil, Part No. 94557.

g. Hold each differential case half on its side, and install the side gear rings with the plates and discs assembled. The side gear ring will rotate with a slight drag when properly located in the case.

h. With the ring gear flange half of the differential case in an upright position, assemble the bevel side gears, pinion mate cross shafts, and bevel pinion mate gears. Install the remaining case half on the ring gear flange half. Make sure that all markings coincide.

i. Install the differential case bolts and turn them in a few threads. Using axle shafts from the vehicle, align the splines of the side gear and the side gear ring. With these axle shafts in position, tighten the differential case bolts evenly and adequately torque to 35 to 45 foot-pounds [4,84 a 6,22 kg./m.]. Remove the axle shafts.

Check for proper assembly. Each pinion mate-
 cross shaft can be tight on its ramp or, in the
 ent there is clearance between the cross shaft
 d the ramp, the clearance should be only a
 v thousandths of an inch and it should be equal
 all four cross shaft ends.

Reinstall the unit in the axle. Other service
 erations, such as ring gear and pinion replace-
 nt, or pinion and bearing adjustments, are
 rformed in the same manner prescribed for
 ndard axles earlier in this section with the
 ception of the following torque recommendations.
 rque the differential case bearing cap screws
 to 90 foot-pounds [9,7 a 12,4 kg./m.], and the
 ver screws 15 to 25 foot-pounds [2,1 a 3,4 kg./
]. The ring gear screws on the three axle models
 ed on the Forward Controls with Powr-Lok
 ferentials should be torqued to 55 to 75 foot-
 unds [7,60 a 10,4 kg./m.].

12. Differential Bearing Preload and Ring Gear Backlash Adjustment

Numbers in parentheses refer to Fig. 138.

The adjustment of the differential bearings is
 maintained by the use of shims (5) placed between
 differential case (6) and the bearing cone and
 roller (4). To adjust the differential bearing
 preload, first install the differential case and
 bearings in the carrier without shims and with
 bearing caps (2) snug.

Hold the ring gear in contact with the pinion,
 and using a screwdriver blade to move the bearing
 caps toward the center, force shims in between
 the bearing cups and the carrier. There should
 be only 0.001" to 0.002" [0,0254 a 0,0508 mm.]
 backlash when no more shims can be forced in.
 After the shim pack for each bearing has been
 established, remove the differential assembly,
 separating the shim packs separated. Add an additional
 0.015" [0,0381 mm.] thickness of shims to the
 back on the tooth side of the ring gear.

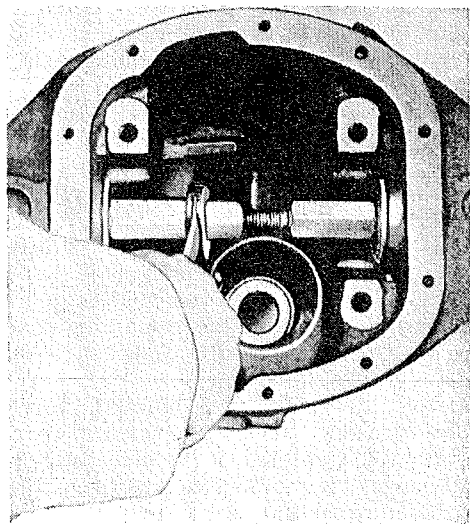


FIG. 151—INNER OIL SEAL INSTALLER

Place the differential bearing shim packs (5) on
 the differential case under each bearing. Install
 the bearings with Driver W-188.

NOTE: When overhauling the full-floating type
 differential used on front axles, check the inner
 axle oil seals to determine if they are satisfactory.
 Should new seals be required, install them with
 Tool W-128 as shown in Fig. 151.

Attach the Carrier Spreader, Tool W-129, as shown
 in Fig. 139, install a dial indicator, and spread
 the carrier a maximum of 0.020" [0,508 mm.].
 Remove the indicator, lubricate the bearings, and
 then place the differential assembly in the carrier.
 In the absence of Tool W-129, the assembly may
 be installed by cocking the bearing cups slightly
 when the differential is placed in the carrier.
 Tap the unit carefully into place, making sure the
 ring gear teeth mesh with the pinion teeth. Install
 bearing caps, matching their markings with those
 on the carrier. Apply sealing compound to the
 screw threads. Torque the screws 70 to 90 foot-
 pounds [9,68 a 12,45 kg./m.].

Install indicator to check ring gear backlash.
 Check backlash at two points. Backlash must
 be held between 0.005" to 0.010" [0,13 a 0,25
 mm.]. If backlash does not fall within specifica-
 tions, shims should be interchanged between the two
 differential bearing shim packs until correct back-
 lash is obtained.

NOTE: Changing the position of a 0.005" [0,127
 mm.] shim from one side to the other will change
 the amount of backlash approximately 0.003" [0,076
 mm.].

Check ring gear for runout. A reading in excess
 of 0.006" [0,152 mm.] indicates a sprung dif-
 ferential case, dirt between the case and the gear,
 or loose ring gear screws.

In order to assist in determining whether the gears
 are properly adjusted, when the Pinion and Ring
 Gear Gauge Set is not available, paint the bevel
 gear teeth with red lead or prussian blue and
 turn the bevel gear so the pinion will make an
 impression on the teeth. The correct procedure to
 follow in the event of an unsatisfactory tooth
 contact is shown in Fig. 152. After the differential
 has been assembled and adjusted, the pinion shaft
 oil seal (19) should be installed.

Remove the sleeve previously installed in place
 of the universal joint yoke and install the oil
 seal with Tool W-147 shown in Fig. 153.

Install the universal joint yoke with Flange In-
 stalling Tool W-162, as described in Par. M-10.
 Install pinion nut and cotter pin. Then install
 axle shafts and differential housing cover.

M-13. Installing Rear Axle in Vehicle

To install the axle under the vehicle, have the
 end of the vehicle securely supported with a chain
 hoist or a support under the frame just ahead of

the rear springs. Place the axle in position and raise it so the spring clips may be installed. Next connect the brake line hose at frame, install lock clip and attach the brake line. Connect the shock absorbers at the axle mounting pads. Connect the propeller shaft at the rear universal joint.

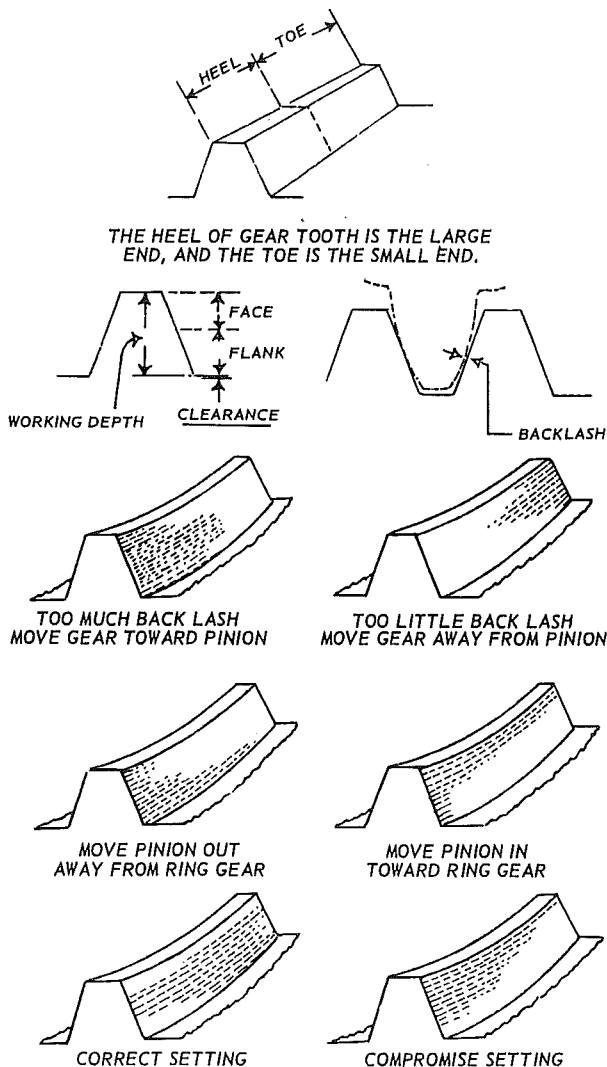


FIG. 152—GEAR TOOTH CONTACT

The wheels may then be installed and the vehicle lowered to the floor. Bleed the brakes to remove any air from the lines, first making certain that there is an ample supply of brake fluid in the master cylinder reservoir. See Brake Section for further instructions. Fill the axle housing with the proper lubricant. See Lubrication Section.

M-14. TROUBLE SHOOTING

M-15. Trouble Shooting Powr-Lok

NOTE: Extreme care must be exercised, on a Powr-Lok equipped vehicle, to be sure the transmission is in the neutral position whenever the engine is started with one wheel jacked up. Otherwise inertia forces in the wheel may actuate the differential, causing the vehicle to lurch unexpectedly and fall off the jack.

If trouble is experienced with the operation of a Powr-Lok differential, one or more of four possible conditions probably exists. These conditions and their remedies are discussed in Par. M-16, M-19, M-20, and M-21.

M-16. Powr-Lok Torque Tests

Improper operation due to inadequate torque may be determined by two different tests. Test One is for Powr-Lok differentials known to have dished plates; Test Two is for any Powr-Lok differential, but Test One is recommended if the unit has dished plates. These tests are described in the following two paragraphs.

M-17. Test One

For Powr-Lok Units with Dished Plates.

- a. Place the transmission in neutral.
- b. Raise one wheel off the floor and place a block in front and at the rear of the opposite wheel.
- c. Apply a torque wrench to the axle shaft nut of the elevated wheel.
- d. Turn wheel with torque wrench. Disregard breakaway torque and observe torque required to continuously turn wheel smoothly. Torque should read 40 foot-pounds [5,53 kg./m.] or more.
- e. Disc type differentials that do not pass this test should be overhauled as outlined in Par. M-11.

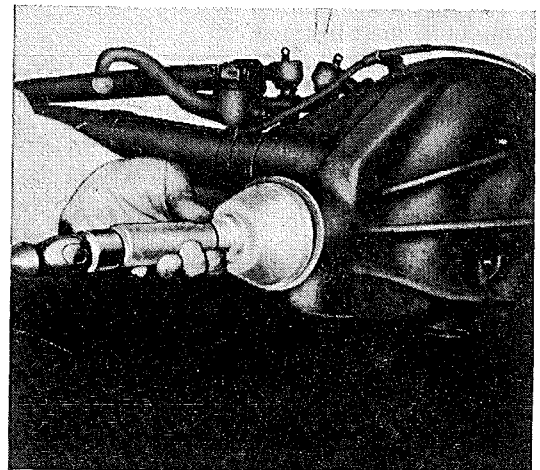


FIG. 153—PINION SHAFT OIL SEAL INSTALLER

18. Test Two

Any Powr-Lok Unit.
 Place vehicle on smooth level floor.
 Place transmission in neutral.
 Place a roller type floor jack under one wheel on the axle to be tested and raise that wheel off floor.
 Tighten brake shoe on the raised wheel until it can barely be moved when the wheel is grasped with both hands and an attempt is made to turn forward or backwards.
 Next, start engine and shift to low gear, holding clutch pedal down. With engine at idle or just above, engage the clutch easily, avoiding sudden engagement or jerk. If the Powr-Lok is operating properly, the vehicle should move forward, causing the jack to roll on the floor.
 Disc type differentials that do not pass this test should be overhauled as outlined in Par. M-11.

19. Powr-Lok Chatter

Differential chatter is usually caused by use of wrong lubricant in the axle differential. To eliminate the chatter, first drain the axle housing roughly of the old lubricant. It is necessary to rotate the wheels of the vehicle (by hand only), allow the lubricant in the Powr-Lok unit itself to drain. Flush the differential, using a light grade oil as the flushing agent. Do not use solvent. Replace the drain plug. Refill with the correct amount of Willys Powr-Lok Differential Oil, Part 94557.
 In the event the above procedure is not effective after 200 [322 km.] miles of operation, overhaul cone type differentials; replace cone type.

M-20. Powr-Lok Backlash

Excessive lost motion, or backlash in the vehicle drive line, might be the result of excessive backlash in the transmission, propeller shaft spline, universal joint, ring gear and pinion, the axle shaft spline, or the differential.
 The lost motion in the differential can be measured as follows:
 a. Jack up one rear wheel.
 b. Put the transmission in gear.
 c. Measure the travel of the jacked-up wheel on a 10" [25,4 cm.] radius from the wheel center. This total movement should not exceed 1-1/4" in a new unit. In order to restrict the backlash to the axle only, make sure that the axle and yoke of the propeller shaft does not move during the check.
 d. If all causes of backlash mentioned above have been eliminated, with the exception of the differential, and differential backlash exceeds that given in subparagraph c, overhaul the disc type differential or replace the cone type.

M-21. Rear Wheel Noise

Looseness of the rear axle shaft nut on semi-floating rear axles may produce a clicking or creaking noise. This noise can usually be stopped by torquing the nut 150 to 175 foot-pounds [20,7 to 24,2 kg./m.]. If the condition has continued for some time, slight wear may have resulted allowing the noise to persist. In this case, coat the hub, key, and key-way with white lead and torque the nut as specified. If the noise persists after this treatment, replace the worn parts.

M-22. SERVICE DIAGNOSIS

SYMPTOMS

PROBABLE REMEDY

Excessive Noisy on Pull and Coast:

Excessive backlash in bevel gear and pinion	Adjust.
End play in pinion shaft	Adjust.
Worn pinion shaft bearing	Replace.
Pinion set too deep in bevel gear	Adjust.
Pinion and bevel gear too tight	Adjust.
Wrong lubricant being used	See "Differential Chatter" under "Trouble Shooting Powr-Lok" in this Section.

Excessive Noisy on Pull:

Pinion and bevel gear improperly adjusted	Adjust.
Pinion bearings rough	Replace.
Pinion bearings loose	Adjust.

Excessive Noisy on Coast:

Excessive backlash in bevel gear and pinion	Adjust.
End play in pinion shaft	Adjust.
Improper tooth contact	Adjust.
Rough bearings	Replace.

Excessive Backlash:

Worn differential pinion gear washers	Replace.
Excessive backlash in bevel gear and pinion	Adjust.
Worn universal joints	Replace.

M-23. REAR AXLE SPECIFICATIONS

	SPECIFICATIONS	METRIC
MAKE	Spicer	. . . . .
MODEL	53	. . . . .
CAPACITY	4500 lb.	2041 kg.
DESCRIPTION	Semifloating Hypoid Gears	. . . . .
DRIVE PINION OFFSET	1.75"	44,4 mm.
NUMBER OF DIFFERENTIAL PINIONS	2 (4 with Powr-Lok)	. . . . . . . . . .
GEAR RATIO: Standard	4.88:1	. . . . .
RING GEAR PITCH DIAMETER	9.25"	23,5 cm.
PINION ADJUSTMENT	Shim
PINION BEARING ADJUSTMENT	Shim



STEERING SYSTEM

Contents

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N-1. GENERAL

The stability and proper functioning of the steering system (Fig. 154) depends in a large measure upon correct alignment. A definite procedure for inspection of the steering system is recommended. In so doing, nothing is overlooked and any trouble is ascertained in the shortest possible time. It is suggested that the following sequence be used:

- a. Equalize tire pressures and level vehicle.
- b. Inspect spindle pivot pins and wheel bearing looseness.
- c. Check wheel runout.
- d. Test wheel balance and bearing adjustment.
- e. Check for spring sag.
- f. Inspect brakes and shock absorbers.
- g. Check steering assembly and the steering connecting rod.
- h. Check caster.
- i. Check toe-in.
- j. Check toe-out on turns.
- k. Check camber.
- l. Check king pin inclination.
- m. Check tracking of front and rear wheels.
- n. Check frame alignment.

N-2. Adjustment

When adjusting a steering gear, remove all loads from the unit by disconnecting the steering connecting rod (drag link) from the steering arm and also loosen the instrument panel bracket and the steering-gear-to-frame bolts to allow the steering post to correctly align itself. When retightening the steering-gear-to-frame bolts, use a torque wrench pull of 45 to 55 foot-pounds [6,2 a 7,6 kg./m.] on the 7/16" bolts and 30 to 40 foot-pounds [4,15 a 5,5 kg./m.] on the 3/8" bolts. After tightening, recheck the steering alignment to make sure the settings were not changed.

NOTE: If the steering-gear-to-frame bolts are not properly torqued, they will eventually loosen during operation of the vehicle. Loose bolts will result in elongated bolt holes, making maintenance of bolt torque difficult, and may allow position

of the steering columns to be misaligned. Therefore, proper torquing is extremely important.

Do not tighten the steering gear to dampen out steering trouble. Adjust the steering only to remove lost motion or play within the unit.

N-3. Steering Gear Adjustment

Figures in parentheses refer to Fig. 155.

The cam and lever steering gear is illustrated in Fig. 155. It consists of a spiral cam, and a cross shaft and lever assembly with two lever studs. When the steering wheel is turned, the cam moves the studs, causing rotary movement of the cross shaft, which in turn causes angular movement of the steering arm.

Two adjustments of the steering gear are necessary: up and down play of the steering shaft, and adjustment of the lever studs (tapered pins) in the cam groove.

Adjustment of the ball thrust bearings to eliminate up and down play of the steering shaft is accomplished by removing shims (13), which are installed between the steering gear housing (7) and the upper cover (14). Before making this adjustment, loosen the housing side cover adjusting screw (18) to free the pins in the cam groove. Loosen the housing cover to cut and remove a shim or more, as required.

Install the screws and tighten. Adjustment should be made to have a slight drag but allow the steering wheel to turn freely with thumb and forefinger lightly gripping the rim. Shims installed for adjustment are 0.002", 0.003", and 0.010" [0,0508, 0,0762, 0,254 mm.] in thickness. Adjustment of the tapered pins in the cam groove is accomplished by adjusting screw (18). Unlock the adjusting screw and turn it in until a very slight drag is felt through the mid-position when turning the steering wheel slowly from one extreme position to the other.

Backlash of the pins in the groove shows up as end play of lever shaft, also as backlash of steering arm. The cam groove is purposely cut shallow in the straight ahead driving position for each

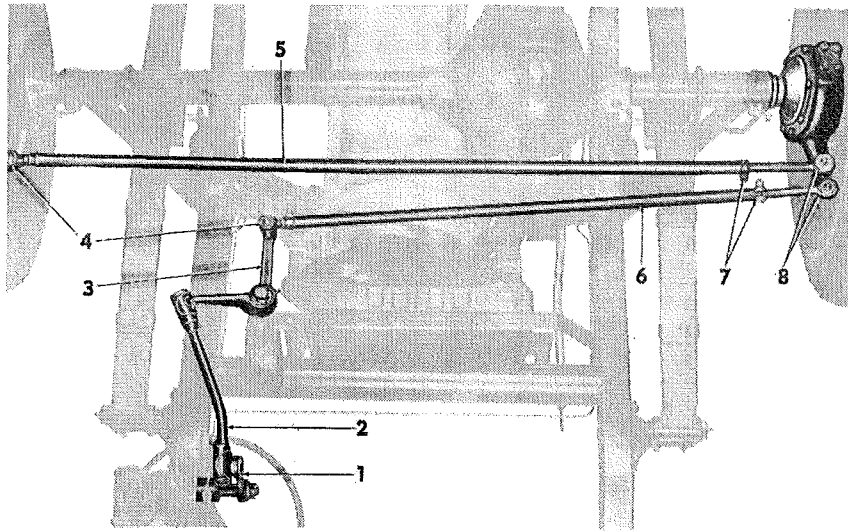


FIG. 154—STEERING SYSTEM

- | | |
|-----------------------|------------------------|
| 1—Steering Arm | 5—Tie Rod—Long |
| 2—Connecting Rod | 6—Tie Rod—Short |
| 3—Bellcrank | 7—Tie Rod Clamp |
| 4—Left Tie Rod Socket | 8—Right Tie Rod Socket |

1. This feature permits a close adjustment for normal straight ahead driving and provides precision steering, and permits take up of backlash at a point, after the wear occurs, without causing a rattle elsewhere. Always adjust within the high range through the mid-position of pin travel. Do not adjust off "straight ahead" position. Backlash in turned positions is not objectionable.

4. Steering Gear Removal

Remove the steering wheel. Use a standard steering wheel puller such as a clamp-over type with interlocking jaws. Follow the instructions of the tool manufacturer, making sure the steering wheel is protected from damage.

Remove directional signal control assembly from steering column.

Remove floor access panels at base of steering column.

Disconnect clutch cable from pedal shaft.

Remove lower left panel from instrument panel.

Remove steering column clamp (U-Bolt).

Loosen the radiator screen and swing it down for access to the steering gear.

Disconnect the steering connecting rod from steering gear arm.

Remove steering-gear-to-frame and trunion or roller mounting bolts.

Disconnect horn wire.

Remove the steering gear arm (3, Fig. 155) with a tapered wedge of suitable size.

Remove the assembly by sliding the gear housing shaft through the frame opening and pulling it out of the cab.

N-5. Steering Gear Installation

Installation of the steering gear assembly is the reverse of the removal outlined above.

N-6. Steering Gear Overhaul

Numbers in parentheses refer to Fig. 155.

a. Remove the steering wheel and horn button assembly from the end of the tube and cam assembly.

b. Loosen lock nut and unscrew adjusting screw (18) two turns.

c. Remove side cover screws (20) and washers (21), and remove side cover (22) with gasket (23).

d. Remove lever shaft (24).

e. Remove upper cover plate screws (16), and remove the cam and tube (12) and bearing assembly from the housing. Remove the snap rings (9) to permit disassembly of the cups (10) and bearing balls (11).

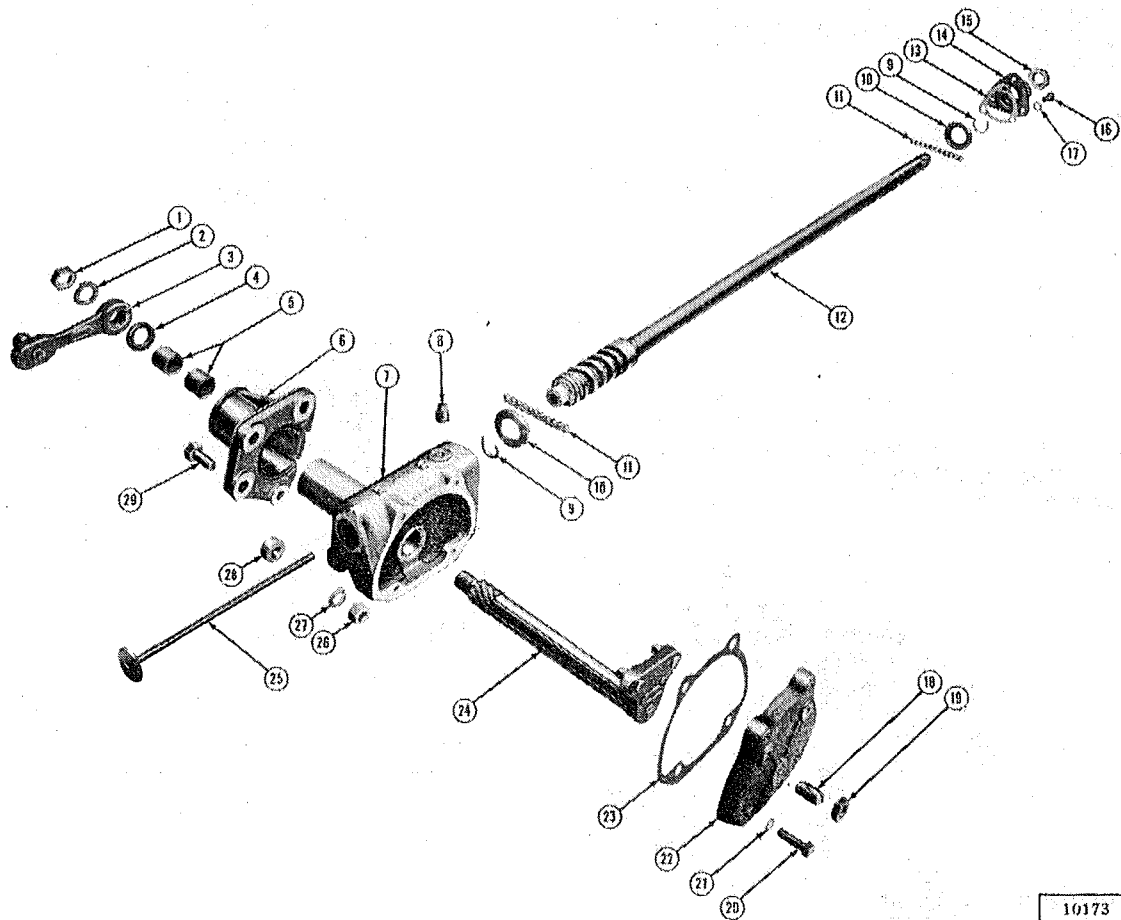
f. After dismantling, as outlined above, is completed, inspect cam grooves for wear, chipping and scoring, also the ball races on the cam ends and the separate ball cups. Existence of any of these conditions indicates the necessity for parts replacement.

g. Inspect the tapered studs mounted on the lever shaft for flat spots and chipping. In the case of either, replacement is usually advisable. Inspect the lever shaft for wear, and test the fit of the shaft in the bushings (5).

h. Inspect condition of the oil seal (4) at outer end of lever shaft and the bearing at top end of steering column.

- i. Reassemble all parts to wheel tube in reverse order of dismantling.
- j. Assemble cam, wheel tube and bearing assembly in housing, seating the lower bearing ball cup (10) in the housing.
- k. With adjusting shims in place, assemble upper cover and adjust the cam bearings.
- l. Assemble lever shaft (24) in housing and with gasket in place, assemble the side cover and set adjusting screw (18) for a minimum backlash of the studs in the cam groove, with the steering gear at the center point of travel.
- m. When assembling upper bearing spring and spring seat in jacket tube, make sure that the

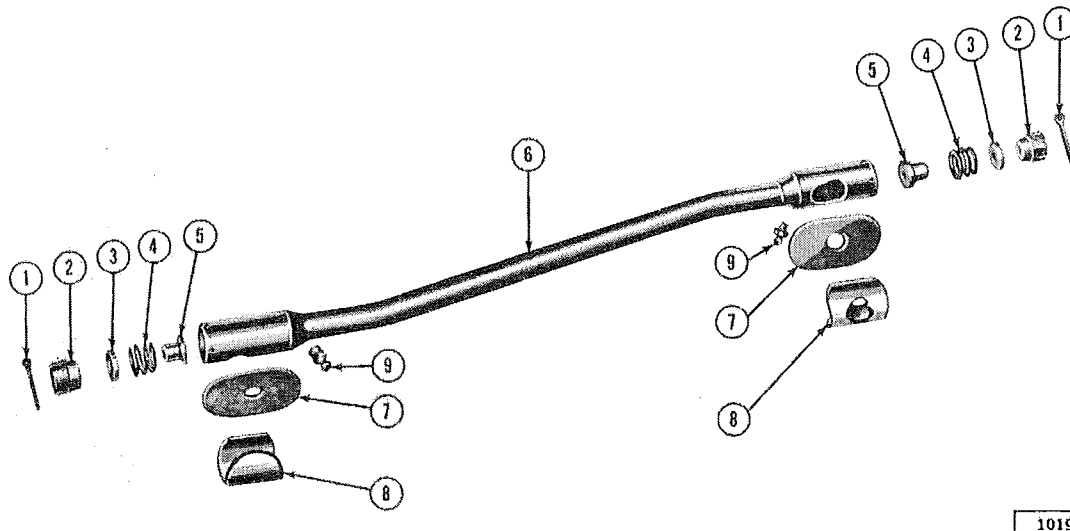
- spring seat is positioned correctly. It must be installed with the lengthwise flange down against the bearing and not up inside of spring coil.
- n. Install steering gear assembly in chassis in the reverse order in which it was removed.
- o. After installing the assembly in the vehicle, place the front wheels in the straight ahead position. Temporarily install the steering wheel to locate the mid-position of the steering gear. To locate the mid-position, turn the steering wheel as far to the right as possible, and then turn in the opposite direction as far as possible, noting the total number of turns. Turn the wheel back just half of the total movement to place the gear in mid-position.



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FIG. 155—TYPICAL STEERING GEAR

- | | | |
|-----------------------|--------------------|--------------------|
| 1—Nut | 11—Balls | 21—Washer |
| 2—Lock Washer | 12—Tube and Cam | 22—Side Cover |
| 3—Steering Arm | 13—Shims | 23—Gasket |
| 4—Oil Seal | 14—Upper Cover | 24—Shaft and Lever |
| 5—Bushing | 15—Nut | 25—Cover and Tube |
| 6—Spacer | 16—Screw | 26—Nut |
| 7—Housing | 17—Lock Washer | 27—Washer |
| 8—Filler Plug | 18—Adjusting Screw | 28—Spacer |
| 9—Ball Retaining Ring | 19—Lock Nut | 29—Bolt |
| 10—Cup | 20—Screw | |



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FIG. 156—STEERING CONNECTING ROD

- | | | |
|------------------|--------------------|-----------------------|
| 1—Cotter Pin | 4—Ball Seat Spring | 7—Dust Cover |
| 2—Adjusting Plug | 5—Plug Spring | 8—Dust Cover Shield |
| 3—Ball Seat | 6—Connecting Rod | 9—Lubricating Fitting |

With the steering gear in mid-position and the wheels in the straight ahead position, install steering gear arm (3) on lever shaft (24). The arm is correctly positioned when the lines marked on the end of the lever shaft and the face of the arm are in alignment. The arm should then point toward the ground.

7. Steering Linkage

The steering linkage must maintain constant toe-in and good steering control under all driving conditions. This requires ball joints at each end of the tie rods and steering connecting rod. All joints in the steering linkage must be kept well lubricated for easy operation and long life. Should the joints be worn, allowing excessive free motion in the linkage, the joints must be replaced. Whenever ball joints are replaced, toe-in must be reset. Because some members of the steering system may have become bent or distorted, a periodic inspection should be made.

8. Steering Connecting Rod

The steering connecting rod is of the ball and socket type. The adjusting plugs, ball seats, rings, and spring plugs for each ball joint are interchangeable, and each end is assembled with the parts in the same relative position as shown in Fig. 156. To adjust the ball joints, screw in the adjusting plug firmly against the ball, then back it one-half turn at axle end, one full turn at steering arm end. Lock with a new cotter pin inserted through the holes in the tube and the slot in the

adjusting plug. The above adjustments will give the proper spring tension and avoid any tightness when swinging the wheels from maximum left to right turn. The ball joints must be tight enough to prevent end play and yet loose enough to allow free movement.

N-9. Tie Rod

The tie rods are of three-piece construction consisting of the rod and two ball and socket end assemblies. Ball and socket end assemblies are threaded into each rod and locked with clamps around each end of the rod. Right and left hand threads on tie rod end assemblies provide toe-in adjustment without removing the tie rod ends from the steering arm. A single tie rod connects the steering knuckle arms. When wear takes place in the tie rod end ball and socket, it will be necessary to replace the ball and socket assembly and also the rubber seal.

N-10. Front Wheel Alignment

Proper alignment of front wheels must be maintained in order to insure ease of steering and satisfactory tire life. The most important factors of front wheel alignment are wheel camber, axle caster, and wheel toe-in. Wheel toe-in is the distance the wheels are closer together at the front than at the rear. Wheel camber is the amount the wheels incline outward at the top from a vertical position. Front axle caster is the amount, in degrees, that the steering pivot pins are tilted towards the front or rear of the vehicle. Positive

caster is inclination of the top of the pivot pin towards the rear of the vehicle. Zero caster is the vertical position of the pivot pin. Negative or reverse caster is the inclination of the top of the pin towards the front of the vehicle. These points should be checked at regular intervals, particularly when the front axle has been subjected to a heavy impact. When checking wheel alignment, it is important that wheel bearings and knuckle bearings be in proper adjustment. Loose bearings will affect instrument readings when checking the camber, pivot pin inclination, and toe-in.

To accurately check camber and caster, use a wheel aligning fixture. Camber and caster of the front wheels are both preset. Camber cannot be altered, but caster can be adjusted by installing caster shims between the axle pad and the springs. Wheel toe-in may be adjusted. To measure wheel toe-in, use a wheel aligning fixture or follow the procedure given in Par. N-11.

N-11. Front Wheel Toe-In

Toe-in, as illustrated in Fig. 157, is necessary to offset the effect of camber, as shown in Fig. 158. In the absence of a wheel aligning fixture, toe-in may be set by measuring between the front wheels at the edge of the rim, at the flange, or at the tire tread center. When making this adjustment, the wheels must be in a straight ahead position. It is highly important that toe-in be checked regularly and if found to be out of adjustment, correction should be made immediately. The correct toe-in of these models is found in the specifications of this section.

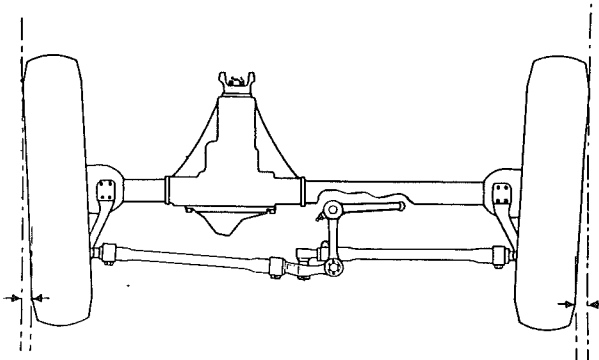


FIG. 157—FRONT WHEEL TOE-IN

N-12. Toe-In Adjustment

The toe-in may be adjusted with a line or straight edge, as the vehicle tread is the same in front and rear. To set the adjustment, both tie rods must be adjusted as outlined below: Set the tie rod end of the steering bellcrank at right angles with the front axle. Place a straight edge or line against the left rear wheel and left front wheel to determine if

the wheel is in a straight ahead position. If the front wheel tire does not touch the straight edge at both the front and rear, it will be necessary to adjust the left tie rod by loosening the clamps on each end and turning the rod until the tire touches the straight edge. Check the right hand side in the same manner, adjusting the tie rod if necessary, making sure that the bellcrank remains at right angles to the axle. When it is determined that the front wheels are in the straight ahead position, set the toe-in by shortening each tie rod approximately one-half turn.

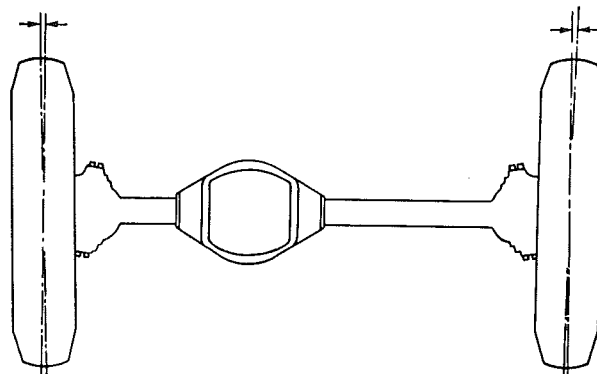


FIG. 158—WHEEL CAMBER

N-13. Front Wheel Camber

The purpose of camber (Fig. 158) is to more nearly place the weight of the vehicle over the tire contact on the road to facilitate ease of steering. The result of excessive camber is irregular wear of tires on outside shoulders and is usually caused by bent axle parts. The result of negative or reverse camber, if excessive, will be hard steering and possibly a wandering condition. Tires will also wear on inside shoulders. Negative camber is usually caused by excessive wear or looseness of front wheel bearings and axle parts, or the result of a sagging axle. Unequal camber may cause any or a combination of the following conditions: unstable steering, wandering, kick-back or road shock, shimmy, or excessive tire wear. The cause of unequal camber is usually a bent steering knuckle or axle end. Correct wheel camber is set in the axle at the time of manufacture and cannot be altered by any adjustment. It is important that the camber be the same on both front wheels. Heating of any of these parts to facilitate straightening usually destroys the heat treatment given them at the factory. Cold bending may cause a fracture of the steel and is also unsafe. Replacement with new parts is recommended rather than any straightening of damaged parts.

N-14. Axle Caster

Caster angle is established in the axle design by tilting the top of the kingpin toward the rear, and

bottom of the kingpin forward, so that an imaginary line through the center of the kingpin would strike the ground at a point ahead of the front of tire contact.

The purpose of caster (Fig. 159) is to provide steering stability which will keep the front wheels in the straight ahead position and also assist in straightening up the wheels when coming out of a turn.

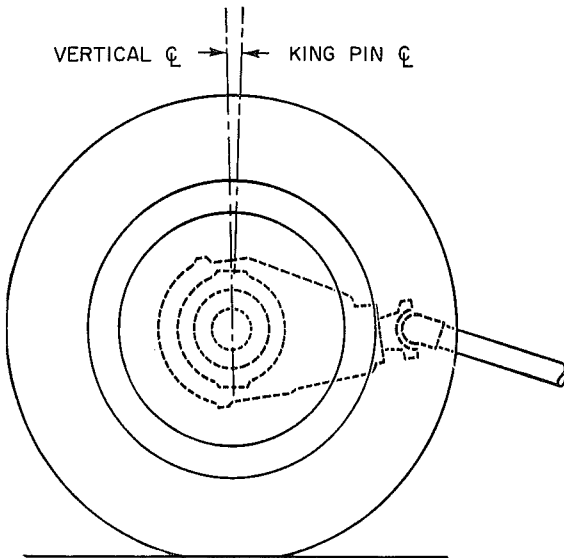


FIG. 159—AXLE CASTER

Steering of the front wheels is preset. If the angle of caster, when accurately measured, is found to be incorrect, correct it to the specification given at the end of this section by either installing new spacers or installing caster shims between the axle and the springs.

If the camber and toe-in are correct and it is known that the axle is not twisted, a satisfactory check may be made by testing the vehicle on the road. Before road testing, make sure all tires are properly inflated, being particularly careful that both front tires are inflated to exactly the same pressure.

If a vehicle turns easily to either side but is hard to straighten out, insufficient caster for easy handling of the vehicle is indicated. If correction is necessary, it can usually be accomplished by installing shims between the springs and axle pads to secure the desired result.

15. Front Wheel Turning Angle

When the front wheels are turned, the inside wheel of the turn travels in a smaller circle than the outside wheel, therefore, it is necessary for the wheels to be toe-out. This change in wheel alignment is obtained through the length and angularity of the steering knuckle arms in relation to the front axle. The left steering knuckle arm controls the relationship of the front wheels on a left turn and the right steering knuckle arm controls the relation on a right turn. Should a

steering arm become bent, the entire housing must be replaced. It is not safe to straighten the knuckle arm.

N-16. Steering Bellcrank

A steering bellcrank (3, Fig. 154) is mounted on the frame front cross member and swivels on two needle bearings. The mounting shaft is removable from the frame bracket by driving out a tapered lock pin. Should the bellcrank become bent or damaged, install a new part.

N-17. Front Wheel Shimmy

Wheel shimmy may be caused by various conditions in the wheels, axle, or steering system, or a combination of these conditions. Outlined below will be found the usual conditions of this fault:

- a. Equalize tire pressures and see that they are according to specifications.
 - b. Check the wheel bearings for looseness. Be sure that the inner wheel bearing race is not too loose on the spindle.
 - c. Remove both steering knuckles and carefully inspect the upper and lower king pin bearings. Inspect the bearing cups for evidence of brinelling, pitting, or fretting. Any bearings that show the slightest imperfection must be replaced. Adjust the king pin bearings.
- Reassemble and lubricate the front axle and steering linkage, installing new steering knuckle oil seals if present seals show any wear.
- d. Check wheel run-out. This check should include radial run-out and wheel looseness on the hub.
 - e. Test wheel balance—check for blowout patches, uniform tire tread, vulcanized tires, mud on inside of wheels, and tires creeping on the rims.
 - f. Try switching front wheels and tires to the rear, criss-crossing them in this operation.
 - g. Check for front spring sag. Also check for broken spring leaves, broken center spring bolt, loose spring clips (or tight clips), over lubrication of spring leaves, spring shackle bracket loose on frame, and loose rear spring shackle. Be sure that the shock absorbers are operating properly to eliminate bobbing of the front end.

- h. Check brakes to make sure that one does not drag.
- i. Check the steering assembly and steering connecting rod. This includes the up and down play of the steering worm shaft, end play of the cross shaft, tightness of the steering gear in the frame, tightness of steering gear arm, adjustment of the steering connecting rod, and condition of the steering tie rod ball joint ends. Adjust the steering connecting rod (drag link) to maximum safe tightness at both ends. Examine the steering bellcrank bearings, the shaft in the mounting bracket, and the mounting bracket on the frame cross member.
- j. Check front axle caster. This should be the same on both sides, otherwise a locking brake may be

indicated, causing a twisting action of the axle. Correct caster is shown in specifications at the end of this section.

- k. Check the front wheel toe-in. See Specifications.
- l. Check wheel toe-out on turns. This gives you an indication of the proper angularity of the steering knuckle arms and tells whether or not they have been bent and require replacing. These may

be checked by comparing them with new parts. If an arm is bent, check for a bent tie rod.

- m. Check wheel camber. This should be the same on both wheels as shown on the Specifications.
- n. Check the king pin inclination. See Specifications.
- o. Check the tracking of the front axle and frame alignment, which may be incorrect due to an accident.

N-18. SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Hard Steering:	
Lack of lubrication	Lubricate all connections.
Tie rod ends worn	Replace.
Connecting rod ball joints tight	Adjust.
Cross shaft improperly adjusted	Adjust.
Steering gear parts worn	Replace.
Steering Loose:	
Tie rod ends worn	Replace.
Connecting rod ball sockets worn	Replace.
Steering gear parts worn	Replace.
Steering gear improperly adjusted	Adjust.
Road Shock	Steering connecting rod too tight; axle spring clip loose; wheel bearings loose; poor shock absorber control.
Turning Radius:	
Short one side	Center bolt in spring sheered off, axle shifted, steering arm bent, steering arm not properly located on steering gear.

N-19. STEERING SPECIFICATIONS

	SPECIFICATIONS	METRIC
STEERING GEAR:		
Make	Ross	. . . . .
Type	Cam & Twin Pin Lever	. . . . .
Ratio (Variable)	19-16.7-19:1	. . . . .
BEARINGS:		
Cam-Upper	Ball	. . . . .
Cam-Lower	Ball	. . . . .
Lever Shaft	Bushing	. . . . .
Steering Column-Upper	Ball	. . . . .
LEVER SHAFT:		
Clearance to Bushing	0.0005" to 0.0025"	0,0127 a 0,0635 mm.
End Play	0.000"	0,000 cm.
Lash at Cam (Straight Ahead)	Slight Drag	. . . . .
WHEEL	17-1/4" dia.	43,8 cm.
STEERING GEOMETRY:		
King Pin Inclination	7-1/2°	. . . . .
Toe-In	3/64" to 3/32"	1,19 a 2,38 mm.
Camber	1-1/2°	. . . . .
Caster	3°	. . . . .
TURNING RADIUS	21'11"	6,68 m.
TURNING ANGLE	29°	. . . . .
OUTSIDE WHEEL ANGLE with INSIDE WHEEL at 20°	20°



BRAKES

Contents

SUBJECT	PAR.	SUBJECT	PAR.
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Hand Brake	O-8	RATTLES IN BRAKES	O-16
Brake	O-6	RELINING BRAKES	
Pedal	O-5	Transmission	O-9
DIAGNOSIS	O-17	Wheel	O-10
HYDRAULIC BRAKES	O-2	SERVICE	O-3
Bleeding Brakes	O-4	SPECIFICATIONS	O-18
Master Cylinder	O-11	SQUEAKY BRAKES	O-15

O-1. GENERAL

The service brakes are the hydraulic type. Hand brake is the transmission type.

O-2. Hydraulic Brakes

In order to thoroughly understand the operation of the hydraulic brake system, it is necessary to have a good knowledge of the various parts and their function, and to know what takes place throughout the system during the application and the release of the brakes.

The piston in the master cylinder (Fig. 160 and 161) receives mechanical pressure from the brake pedal and exerts pressure on the fluid in the lines, building up hydraulic pressure which moves the wheel cylinder pistons. The master cylinder primary cup (6, Fig. 160) is held against the piston by the piston return spring which also holds the check valve against the seat.

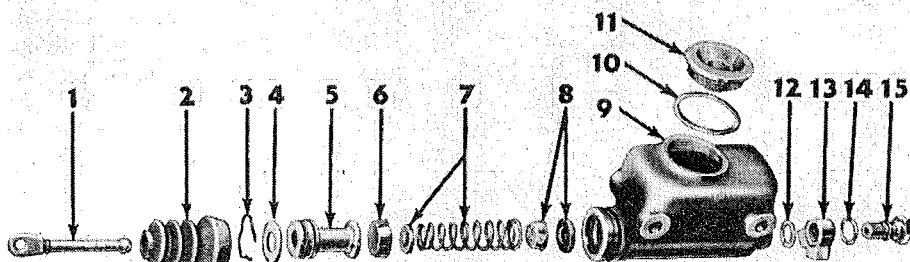
The spring maintains a slight fluid pressure in the lines and in the wheel cylinders to prevent the possible entrance of air into the system. The secondary cup, which is secured at the opposite end of the piston, prevents the leakage of fluid into the rubber boot. The holes in the piston head are for the purpose of allowing the fluid to flow from the space in back of the piston into the space between the primary cup and the check valve, keeping sufficient fluid in the lines at all times. The holes in the check valve case allow the fluid to flow through the case, around the lips of the rubber valve cup,

and out into the lines during the brake application. When the brakes are released, the valve is forced off the seat, permitting the fluid to return to the master cylinder. The piston assembly is held in the opposite end of the housing by means of a lock wire (retainer spring). The rubber boot that fits around the push rod and over the end of the housing, prevents dirt or any foreign matter from entering the master cylinder.

The wheel cylinder (Fig. 163 and 164) is a double piston cylinder, the purpose of the two pistons being to distribute the pressure evenly to each of the two brake shoes. Rubber piston cups on the pistons prevent the leakage of fluid. The rubber boots over the end of the cylinder prevent dust and dirt or foreign material from entering the cylinder. When pressure is applied to the brake pedal, the master cylinder forces fluid through the lines and into the wheel cylinders. The pressure forces the pistons in the wheel cylinders outward, expanding the brake shoes against the drums. As the pedal is further depressed, higher pressure is built up within the hydraulic system, causing the brake shoes to exert a greater force against the brake drums.

As the brake pedal is released, the hydraulic pressure is released and the brake shoe return spring draws the shoes together, pushing the wheel cylinder pistons inward and forcing the fluid out of the cylinders, back into the lines toward the master cylinder. The piston return spring in the master cylinder returns the piston to the piston stop faster than the brake fluid is forced back into the master

- 1—Push Rod
- 2—Boot
- 3—Piston Stop Lock Wire
- 4—Stop Plate
- 5—Piston
- 6—Master Cylinder Cup
- 7—Valve Spring Assembly
- 8—Valve Seat
- 9—Supply Tank
- 10—Filler Cap Gasket
- 11—Filler Cap
- 12—Outlet Fitting Gasket
- 13—Outlet Fitting
- 14—Outlet Fitting Bolt Gasket
- 15—Outlet Fitting Bolt



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FIG. 160—BRAKE MASTER CYLINDER

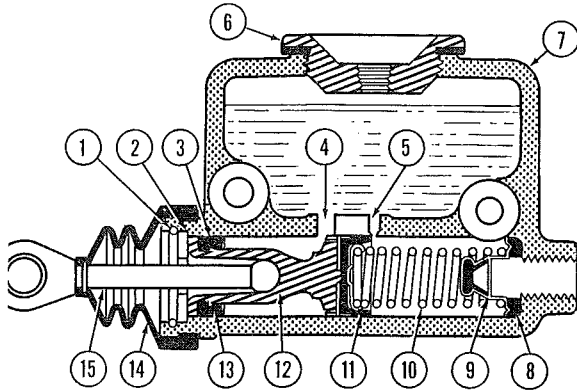


FIG. 161—BRAKE MASTER CYLINDER

- | | |
|-------------------|------------------|
| 1—Retainer Spring | 9—Check Valve |
| 2—Piston Stop | 10—Return Spring |
| 3—Cup Ring | 11—Primary Cup |
| 4—Intake Port | 12—Piston |
| 5—By-Pass Port | 13—Secondary Cup |
| 6—Fill Cap | 14—Boot |
| 7—Supply Tank | 15—Link |
| 8—Valve Seat | |

linder, which creates a slight vacuum on the head of the piston. The vacuum causes a small amount of fluid to flow through the holes of the piston head, at the lip of the primary cup, and into the forward part of the cylinder. This action keeps the cylinder filled with fluid at all times, ready for the next brake application. As fluid is drawn from the space behind the piston head, it is replenished from the reservoir through the intake port. When the piston is in fully released position, the primary cup clears the by-pass port, allowing the excess fluid to flow

from the cylinder into the reservoir as the brake shoe retracting springs in all cylinders continue to force the fluid back into the master cylinder.

NOTE: Whenever replacement of the brake shoe return spring for the cylinder end of the shoe is to be made, make sure that the replacement spring is the latest type. These later type springs have the hooked ends bent away from the center of the springs. See 3, Fig. 168.

O-3. Brake Service

To service the brakes, follow the procedure below:
a. Check the fluid level in the brake master cylinder. See Lubrication Section B.

b. Check brake pedal adjustment. See Par. O-5.

c. Check brake pedal travel. If the pedal travel is excessive, the brakes may need adjusting to compensate for lining wear or they may need relining. How much lining is left can only be determined by a visual lining inspection. See Par. O-6 for brake adjustment; Par. O-10 for relining brakes.

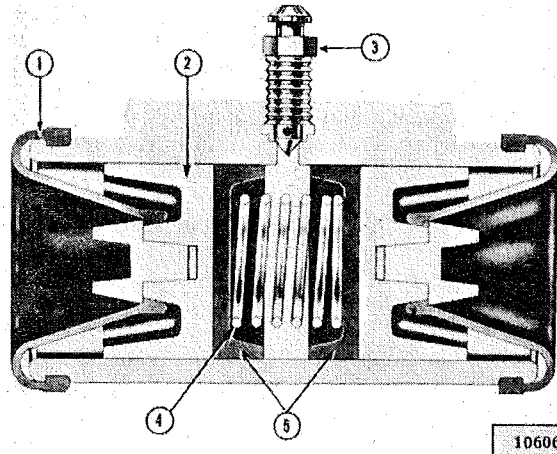


FIG. 163—BRAKE WHEEL CYLINDER

- | | |
|-----------------|----------------|
| 1—Cylinder Boot | 4—Cup Spring |
| 2—Piston | 5—Cylinder Cup |
| 3—Bleeder Screw | |

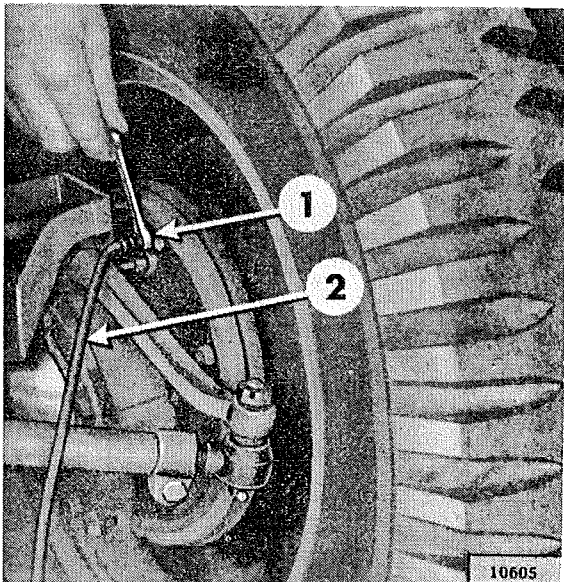


FIG. 162--BLEEDING BRAKES

- | | |
|-----------------|----------------|
| 1—Bleeder Screw | 2—Bleeder Hose |
|-----------------|----------------|

d. If the brakes pull to one side after adjustment, check tire pressures. All tires must be inflated to recommended pressures to ensure even braking. If the condition persists, examine the brake linings for foreign material and clean as necessary. If cleaning does not correct the condition, the linings should be replaced. If the side pull persists, check front wheel alignment and balance.

e. Check the brake system for leaks by applying a steady pressure on the brake pedal. A leak in the system will allow the pedal to "fall away". If the pedal "falls away", check for a leaking wheel cylinder. Remove wheels and drums, and carefully check each cylinder. Also examine all lines and

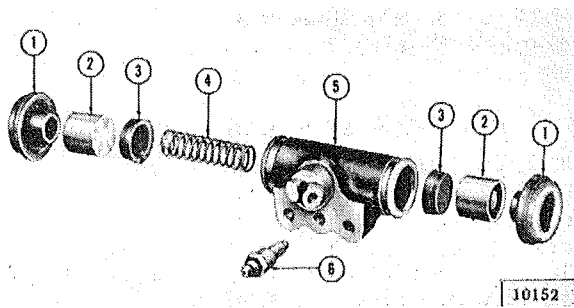


FIG. 164—BRAKE WHEEL CYLINDER

- | | |
|----------------|-----------------|
| 1—Boot | 4—Cup Spring |
| 2—Piston | 5—Cylinder |
| 3—Cylinder Cup | 6—Bleeder Screw |

fittings. Rebuild or replace all wheel cylinders (Par. O-12) if one is defective, as they are all probably in poor condition. If the leak has allowed brake fluid to get on the linings, the linings will have to be replaced.

f. A "spongy" brake pedal indicates the presence of air in the hydraulic system. This condition must be corrected by bleeding the brakes. See Par. O-4.

g. Should the brakes become locked so that the vehicle cannot be moved, the brakes may be released by opening the bleeder screw on any one of the wheel cylinders. Before the vehicle is driven, correct the cause of the condition. The cause may be either a defective master cylinder or the use of low grade brake fluid which has expanded because of heat.

O-4. Bleeding Brakes

The hydraulic brake system must be bled whenever a fluid line has been disconnected or air gets into the system. A leak in the system may sometimes be indicated by the presence of a spongy brake pedal. Air trapped in the system is compressible and does not permit the pressure, applied to the brake pedal, to be transmitted solidly through to the brakes. The system must be absolutely free from air at all times. When bleeding brakes, bleed at that wheel with the longest line from the master cylinder first, the next longest second, etc. During the bleeding operation, the master cylinder must be kept at least $3/4$ full of hydraulic brake fluid. To bleed the brakes, first carefully clean all dirt from around the master cylinder filler plug. Remove the filler plug and fill the master cylinder to the lower edge of filler neck. Clean off all bleeder connections at all four wheel cylinders. Attach bleeder hose and fixture to right rear wheel cylinder bleeder screw and place end of tube in a glass jar, and submerged in brake fluid. Open the bleeder valve one-half to three-quarters of a turn. See Fig. 162.

Depress the foot pedal, allowing it to return very slowly. Continue this pumping action to force the

fluid through the line and out of the bleeder hose which carries with it any air in the system. When bubbles cease to appear at the end of the bleeder hose, close the bleeder valve and remove the hose. After the bleeding operation at each wheel cylinder has been completed, fill the master cylinder reservoir and replace the filler plug. Do not use the liquid which has been removed from the lines through the bleeding process because of air bubbles and dirt.

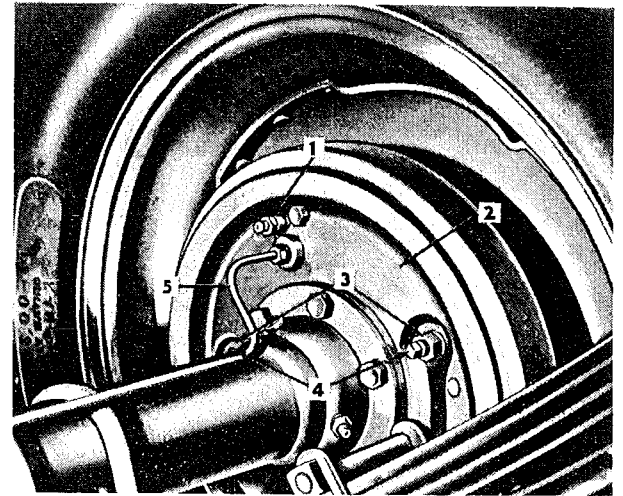


FIG. 165—BRAKE ADJUSTMENTS

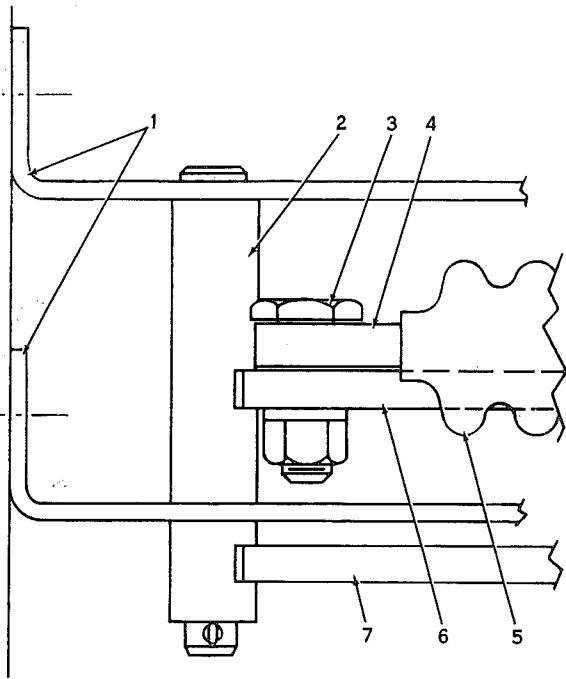
- | | |
|-----------------------|-----------------------------|
| 1—Bleeder Screw | 4—Eccentric Adjusting Screw |
| 2—Brake Backing Plate | 5—Brake Fluid Line |
| 3—Eccentric Lock Nut | |

O-5. Brake Pedal Adjustment

There should always be at least $1/2$ " [12,7 mm.] free pedal travel before the push rod engages the master cylinder piston. This adjustment is accomplished by rotating the eccentric bolt (3, Fig. 166) connecting the brake pedal and master cylinder push rod. This is done so the primary cup will clear the by-pass port when the piston is in the off position, otherwise the compensating action of the master cylinder for expansion and contraction of the fluid in the system, due to temperature changes, will be destroyed and cause the brakes to drag.

O-6. Brake Adjustment

The location of the brake adjusting eccentrics are shown in Fig. 165. First be certain that the brake pedal has $1/2$ " [12,7 mm.] free travel. Jack up the wheels to clear the floor. Adjustment is made by rotating the brake shoe eccentric (Fig. 165). With a wrench loosen the the lock nut (3) for the forward brake shoe, hold the lock nut, and with another wrench, turn the eccentric (4) towards the front of the vehicle until the brake shoes strike



G. 166—BRAKE PEDAL ADJUSTMENT SCREW

- 1—Support Bracket
- 2—Pedal Stop
- 3—Eccentric Bolt
- 4—Push Rod
- 5—Boot
- 6—Brake Pedal Shank
- 7—Clutch Pedal Shank

drum, then while turning the wheel with one hand, release eccentric until the wheel turns freely. Hold the eccentric in position and fasten the lock nut. To adjust the reverse shoe, repeat this operation, only turn the eccentric towards the back of the axle. Do this on all four brakes. Check the fluid in the master cylinder.

7. HAND BRAKE

Some vehicles are equipped with transmission hand brakes, mechanically operated through cables and

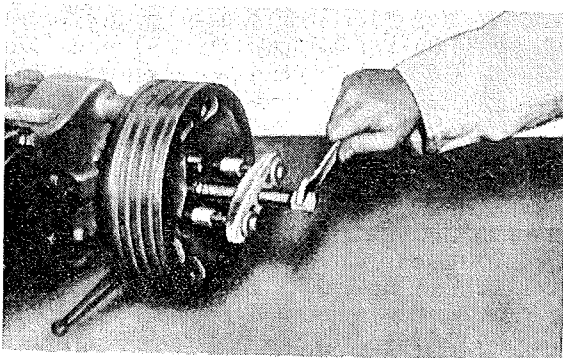


FIG. 167—TRANSFER CASE BRAKE DRUM PULLER

conduits. The transmission hand brake is an internal expanding drum-type unit mounted on the propeller shaft directly back of the transfer case.

O-8. Hand Brake Adjustment

The hand brake is located on the propeller shaft at the rear of the transfer case; see Fig. 169. The brake is operated by a cable connection from the brake handle mounted on the instrument panel. To adjust the hand brake, the following sequence should be followed.

Make sure that the brake handle on the instrument panel is fully released. Give due attention to the cable and operating linkage to see that they do not bind. If necessary, free up the cable and lubricate it.

Rotate the brake drum until one pair of the three sets of holes are over the shoe adjusting screw wheels in the brake. Use the edge of the holes in the brake drum as a fulcrum for suitable adjusting tool or a screwdriver; rotate each notched adjusting screw by moving the handle of the tool away from the center of the drive shaft until the shoes are snug in the drum. Back off seven notches on the adjusting screw wheels to secure proper running clearance between the shoes and the drum.

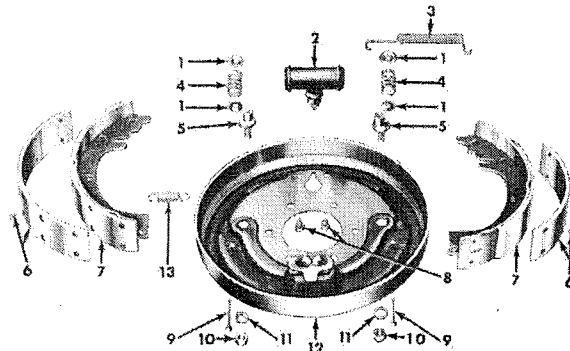


FIG. 168—WHEEL BRAKE

- 1—Spring Cup
- 2—Wheel Cylinder
- 3—Return Spring
- 4—Hold Down Spring
- 5—Eccentric
- 6—Brake Lining Set
- 7—Brake Shoe
- 8—Screw and Lock Washer
- 9—Pin
- 10—Nut
- 11—Lock Washer
- 12—Backing Plate
- 13—Return Spring

O-9. Relining Transmission Brake

To reline the brake shoes and make a major adjustment, first remove the four universal joint attaching nuts and lower the propeller shaft. Remove the retracting spring clevis pin and the spring clip. Remove the hug lock nut, the nut, and washer from the transfer case output shaft. Both the universal joint companion flange and the brake drum may be readily removed by using Puller, Tool No. W-172, which is illustrated in Fig. 167. Remove the two

brake shoe retracting springs and the shoes. Clean all parts with a suitable cleaning solution and examine them for damage or wear.

Brake shoes may be distorted by improper lining installation and the lining should be ground true after installation on the shoes. For this reason, it is recommended that new or replacement shoe and lining assemblies be installed.

To reassemble, first turn both adjusting screw wheels away from the center to "all off" position. Place a light film of grease on the brake actuating cam and install the shoes. Install the black shoe return spring next to the cam and the yellow spring next to the notch adjusting wheel screw. Place the brake drum and universal joint flange in position and install the transfer case output shaft washer, nut, and hug lock nut.

Rotate the drum until one pair of holes in the drum are opposite the two adjusting screw wheels in the brakes. Use the edge of the holes as a fulcrum and with a suitable tool or screwdriver for adjusting, rotate the adjusting screw wheels, moving the handle of the tool away from the drum until the shoes are snug in the drum.

Examine the brake operating cable to be sure that it is not worn or damaged. Free it up thoroughly and lubricate it. Make sure the operating handle on the instrument panel is fully released. Adjust clevis on the brake end of the operating cable until clevis pin will just go through the hole in the clevis and brake operating lever without slack in the cable. Tighten the clevis lock nut. After the cable is connected, back off seven notches on each adjusting screw wheel which will give the proper running clearance between the lining and drum.

Reconnect the propeller shaft. Install retracting spring clip, clevis pin, and the cotter pin; also install the retracting spring link and spring. The position of the brake operating lever (Fig. 169) must be correctly set. The position of this lever (see arrow in Fig. 169) is determined by the adjustment of the cam or brake operating link which spreads the two shoes. The operating link is adjusted by means of the special ball nut to set the operating lever with $3/32$ " [2,38 mm.] clearance between the closest point of the lever and the brake backing plate.

The position of this lever should be checked when making a major adjustment or when relining the brakes and, if found incorrect, readjust it to give this clearance before adjusting the brake cable clevis.

O-10. Relining Wheel Brakes

When necessary to reline the brakes, the vehicle should be raised so that all four wheels are free. Remove the wheels and the hubs and drums which will give access to the brake shoes (Fig. 168). Install wheel cylinder clamps or keepers to retain the wheel cylinder pistons in place and prevent leakage of brake fluid while replacing the shoes. Turn all eccentrics to the lowest side of the cam, and then remove the brake shoe return springs.

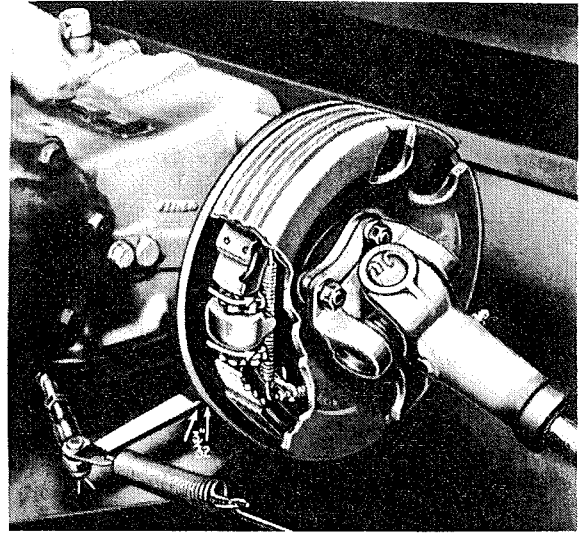


FIG. 169—TRANSMISSION HAND BRAKE

Brake shoes may be distorted by improper lining installation and linings should be ground true after installation on the shoes. For this reason, it is recommended that new or replacement shoe and lining assemblies be installed. Inspect the oil seals in the wheel hubs and if grease has been leaking, it is advisable to install new oil seals.

Install the brake shoes on the brake backing plates, removing the brake cylinder clamps. Note that the lining on the forward shoe is longer than that on the reverse shoe. The shoe having the longest lining is placed forward on all four wheels. Install the eccentrics. Check the brake shoe retaining springs to be sure that they are serviceable and install.

Should a brake drum be rough and scored, it may be reconditioned by grinding or turning in a lathe. Do not remove more than 0.030" [0,762 mm.] thickness of metal (0.060" [1,52 mm.] overall diameter). If a drum is reconditioned in this manner, either the correct oversize lining (0.030" [0,762 mm.] oversize linings supplied by Factory) must be installed or a shim equal in thickness to the metal removed must be placed between the lining and shoe so that the arc of the lining will be the same as that of the drum.

Install the hubs and drums and make a major adjustment of the brakes.

If it is found, when wheels are removed, that there is brake fluid leakage at any of the wheel cylinders, it will be necessary to recondition that wheel cylinder and bleed the brake lines. This subject is covered under Par. O-4.

NOTE: Whenever the brake lining is renewed in one front or one rear wheel, be sure to perform the same operation in the opposite front or rear wheel, using the same brake lining as to color and part number, otherwise unequal brake action will result.

11. Hydraulic Brake Master Cylinder

The brake master cylinder is located under the instrument panel in front of the steering column. Should it be necessary to recondition the master cylinder, the method of removal is obvious.

After the master cylinder (Fig. 161) has been removed, it should be dismantled and thoroughly washed in alcohol. Never wash any part of the hydraulic braking system with gasoline or kerosene.

After the parts have all been thoroughly cleaned with alcohol, make a careful inspection, renewing those parts which show signs of being deteriorated. Inspect the cylinder bore and if found to be rough, should be honed out or a new cylinder installed. The clearance between the piston and the cylinder bore should be 0.001" to 0.005" [0,025 a 0,127 mm.]. Clean out the cylinder with alcohol and with wire passed through the ports that open from the supply reservoir into the cylinder bore, make sure that these passages are free and clear of any foreign matter. It is our recommendation that a new piston, primary cup, valve, and valve seat be installed when rebuilding the master cylinder.

Install the valve seat in the end of the cylinder with the flat surface toward the valve. Install the valve assembly. Install return spring and primary cup. The flat side of the cup goes toward the piston. Install piston, stop plate, and lock wire (retainer ring).

Install fitting connection with new gasket. Fill reservoir half full of brake fluid and operate the piston with piston rod until fluid is ejected at fitting. Install the master cylinder to the frame and level to a level 1/2" [1,3 cm.] below the top of the level hole. Make the necessary connections and adjust pedal clearance to 1/2" [1,3 cm.] free play.

Bleed the brake lines as instructed in Par. O-4.

Check the entire hydraulic brake system to make sure there are no leaks.

12. Wheel Cylinders

Both front wheel cylinders and both rear wheel cylinders must have the same diameter or unequal braking will result. Make sure a replacement brake cylinder has the same part number as the original cylinder.

To remove a wheel cylinder, jack up the vehicle and remove the wheel, hub, and drum. Disconnect the brake line at the fitting on the brake backing plate. Remove the brake shoe return spring which holds the brake shoes at the toe to fall clear of the brake cylinder. Remove two screws holding the wheel cylinder to the backing plate.

Remove the rubber dust covers on ends of cylinder and then the piston and piston cups and the spring. See Fig. 163.

Wash the parts in clean alcohol. Examine the cylinder bore for roughness or scoring. Check fit of pistons to cylinder bore by using a 0.002" [0,051

mm.] feeler gauge. When reassembling the cylinder, dip springs, pistons, and piston cups in brake fluid. Install spring in center of the wheel cylinder. Install piston cups with the cupped surface towards the spring so that the flat surface will be against the piston. Install pistons and dust covers. Install wheel cylinder to the backing plate, connect brake line and install brake shoe return spring. Replace wheel, hub, and drum; then bleed the lines as instructed in Par. O-4. Adjust brakes if required.

O-13. Keep Grease and Oil Off Brakes

No brake can be expected to work well when grease or oil is allowed to leak into the drum from the rear axle. Little braking friction can be obtained between brakes and drums when the surface is covered with oil and grease.

Care should be exercised to see that excessive amounts of lubricants are not put into the front hubs or the rear axle bearings or differential. Keep the grease retainers in good condition. Whenever wheels are removed, it is advisable to wash off the drums with a suitable solvent so that all grease and dirt are removed. Should there be a quantity of grease on the linings, this can also be washed off with solvent; however, should the linings be thoroughly saturated with grease, there is nothing that can be done except to replace the lining.

O-14. TROUBLE SHOOTING

O-15. Squeaky Brakes

In most cases, squeaks are entirely eliminated by correct adjustment of the brakes. Squeaks may be caused however, by glazed linings, lining worn thin to the point of exposed rivets, or by vibration. A drum will not vibrate when the brake is securing uniform contact over the entire lining surface, except when due to improper conditions such as the linings becoming glazed. Glazed surface of the brake linings may be removed by a stiff wire brush. Occasionally squeaks are caused by roughened surface of the drum, which can usually be remedied by rubbing down with emery cloth and by wiping the braking surface clean. In extreme cases, it may be necessary to reface the drum in a lathe. Should this be done, do not remove a metal thickness greater than 0.030" [0,762 mm.] —0.060" [1,52 mm.] overall diameter.

O-16. Rattles in Brakes

See that the tension of the springs in the brakes and attached to the control system is sufficient to return brakes and brake mechanism to their normal position. Return springs are so placed that they keep all slack out of the control system by tension on all joints. Brakes will not rattle inside the drum if the springs holding the shoes are kept at the proper tension.

O-17. SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Brakes Drag:	
Brake shoes improperly adjusted	Adjust.
Piston cups enlarged	Flush all lines with alcohol. Install new cups in wheel and master cylinders.
Mineral oil or improper brake fluid in system	
Improper pedal adjustment	Adjust master cylinder eye bolt.
Clogged master cylinder by-pass port	Clean master cylinder.
One Brake Drags:	
Brake shoe adjustment incorrect	Adjust.
Brake hose clogged	Replace.
.	Replace.
.	Replace.
Wheel cylinder piston or cups defective	Replace.
Loose or damaged wheel bearings	Adjust or replace.
Brake Grabs — Vehicle Pulls to One Side:	
Grease or brake fluid on lining	Replace lining.
Dirt between lining and drum	Clean with wire brush.
Drum scored or rough	Turn drum and replace lining.
Loose wheel bearings	Adjust.
Axle spring clips loose	Tighten.
Brake backing plate loose	Tighten.
Brake lining	Different kinds on opposite wheels.
Brake shoe reversed	Forward and rear shoes misinstalled.
Tires under-inflated	Inflate.
Tires worn unequally	Replace or rotate.
Glazed or worn lining	Replace linings.
Restricted brake line	Locate and repair.
Excessive Pedal Travel:	
Normal lining wear	Adjust.
Lining worn out	Replace.
Leak in brake line	Locate and repair.
Scored brake drums	Replace or regrind.
Incorrect brake lining	Replace.
Air in hydraulic system	Fill master cylinder — bleed lines.
Spongy Brake Pedal:	
Air in lines	Bleed lines.
Brake shoe adjustment incorrect	Adjust.
Insufficient brake fluid	Fill master cylinder.
Excessive Pedal Pressure:	
Grease or brake fluid in lining	Replace lining.
Shoes improperly adjusted	Major adjustment.
Warped brake shoes	Replace.
Distorted brake drums	Replace or regrind.
Glazed or worn lining	Replace linings.
Restricted brake line	Locate and repair.
Faulty brake cylinder	Repair or replace.
Insufficient brake fluid	Fill master cylinder.
Squeaky Brakes:	
Shoes warped or drums distorted	Replace.
Lining loose	Replace.
Dirt imbedded in lining	Wire brush or replace.
Improper adjustment	Adjust.
Oil or grease on lining	Replace linings.
Glazed or worn lining	Replace linings.
Drum scored	Turn drum and replace linings.

O-18. BRAKE SPECIFICATIONS

	SPECIFICATIONS	METRIC
PE	Hydraulic Internal Expansion Nonservo Floating Shoe	. . . . .
EFFECTIVE AREA	161,16 sq. in.	1039 cm ²
TOTAL AREA	176.2 sq. in.	1150 cm ²
DRUM DIAMETER:		
Front	11"	27,9 cm.
Rear	11"	27,9 cm.
FRICTING MATERIAL	Molded Asbestos Riveted	. . . . .
FRICTING SIZE:		
Front Shoe:		
Front Wheel	12,25 x 2 x 0,212"	31,11 x 5,08 x 0,538 cm.
Rear Wheel	12,25 x 2 x 0,212"	31,11 x 5,08 x 0,538 cm.
Rear Shoe:		
Front Wheel	10,03 x 2 x 0,212"	25,48 x 5,08 x 0,538 cm.
Rear Wheel	10,03 x 2 x 0,212"	25,48 x 5,08 x 0,538 cm.
HEEL CYLINDER CORE:		
Front	1-1/8"	2,85 cm.
Rear	1"	2,54 cm.
MASTER CYLINDER BORE	1"	2,54 cm.
AVAILABLE PEDAL TRAVEL	7"	17,7 cm.
ADJUSTABLE FREE TRAVEL	1/2"	1,27 cm.
MINIMUM PRESSURE @ 100 LB. (45 kg.) PEDAL LOAD	770 psi	54,1 kg./cm ²
PARKING BRAKE:		
Type of Control	Hand Lever	. . . . .
Location of Control	Rt. of Str. Col.	. . . . .
Operation on	Rear Propeller Shaft	. . . . .
REAR PROPELLER SHAFT PARKING BRAKE:		
Type	Internal	. . . . .
Drum Dia.	8"	20,3 cm.
Lining Size (2)	8,125 x 1,75 x 0,211"	20,6 x 4,4 x 0,538 cm.
Lining Area	28.43 sq. in.	183,3 cm ²

WHEELS

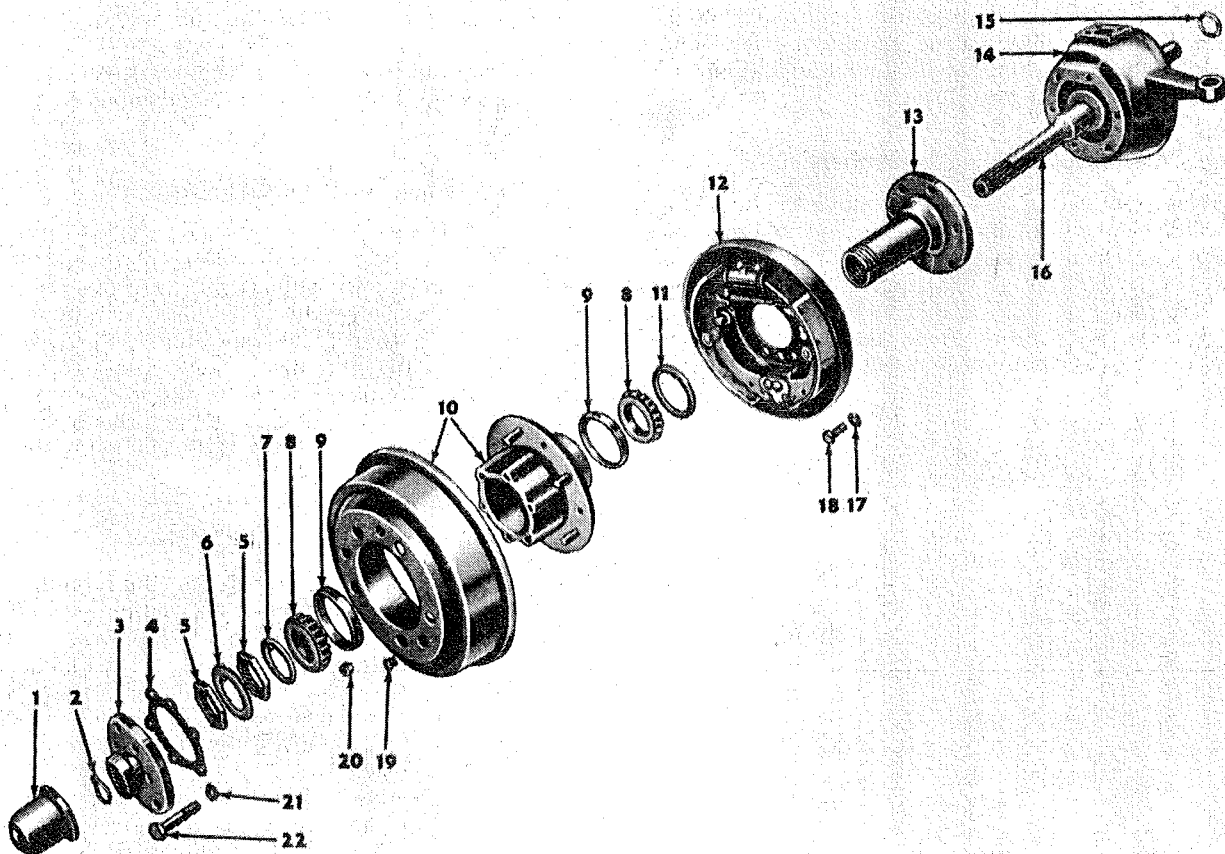
Contents

SUBJECT	PAR.	SUBJECT	PAR.
BALANCING	P-2	REAR WHEEL BEARINGS	P-5
BEARING MAINTENANCE	P-7	Adjustment	P-6
BRAKE DRUMS	P-8	SPECIFICATIONS	P-12
FRONT WHEEL BEARINGS	P-3	TIRES	P-9
Adjustment	P-4		

P-1. GENERAL

The front wheels are carried on the two opposed tapered bearings, as shown in Fig. 170. The rear wheels are carried on a single tapered roller bearing mounted on each axle shaft. See Fig. 173. These

bearings are adjustable for wear, and then satisfactory operation and long life depends upon periodic attention and correct lubrication. To check the wheel bearings for adjustment, brakes must be free and in fully released position.



10721

FIG. 170—FRONT WHEEL ATTACHING PARTS

- | | | |
|----------------|-------------------------|--------------------------|
| 1—Hub Cap | 8—Cone and Rollers | 16—Universal Joint Shaft |
| 2—Snap Ring | 9—Cup | 17—Lock Washer |
| 3—Drive Flange | 10—Hub and Drum | 18—Bolt |
| 4—Gasket | 11—Oil Seal | 19—Screw |
| 5—Nut | 12—Left Front Brake | 20—Nut |
| 6—Lock Washer | 13—Spindle and Bushing | 21—Lock Washer |
| 7—Lock Washer | 14—Left Knuckle and Arm | 22—Bolt |
| | 15—Thrust Washer | |

Wheel Balancing

Wheel balancing with the wheel on the vehicle is recommended. The wheels from any Powr-Lok should always be removed for balancing.

Front Wheel Bearings

Adjustment of the front wheel bearings is critical because it establishes the running clearance of the wheel bearings. Wheel bearing adjustment that is too tight preloads the bearings and causes them to overheat. Loose wheel bearings permit the drum hub to shift its position on the bearings, as thrust loads occur with accelerating, braking, and cornering. Loose bearings also cause erratic braking. To check the front wheel bearings, raise the front of the vehicle with a jack so that the tires clear the floor. Grip the tire and test sidewise shake of the wheel. If bearings are correctly adjusted, shake of wheel will be just perceptible and wheel will turn freely with no drag. If bearing adjustment is too tight, the rollers may break or become overheated. Loose bearings may cause excessive wear and noticeable noise. If this test indicates adjustment is necessary, proceed as follows:

Front Wheel Bearing Adjustment

1. Raise the vehicle on the jack, remove the hub cap, axle shaft nut, and washer or snap ring, and driving flange. Use Front Axle Shaft Driving Flange Puller, Tool No. W-163 (Fig. 128), and a hub cap puller shown in Fig. 127. Wheel bearing adjustment will then be accessible. Bend the lip of nut lock washer so that adjustment lock nut and lock washer

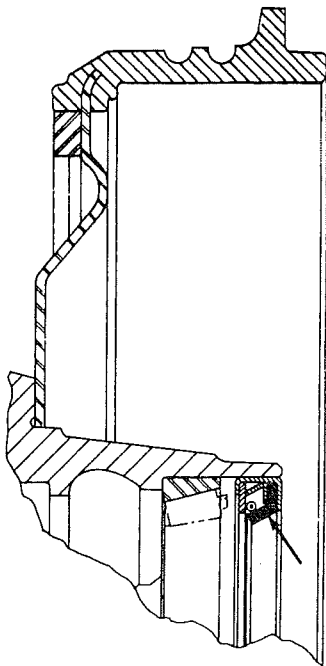


FIG. 171—FRONT WHEEL HUB OIL SEAL INSTALLATION

may be moved. Rotate the wheel and tighten the adjusting nut with Wrench, Tool W-144, until the wheel binds.

NOTE: Front tire and wheel must be rotated by hand as the adjusting nut is tightened to ensure positive seating of the bearing.

Then back off nut about one-sixth turn or more, if necessary, making sure that the wheel rotates freely without sidewise shake. Replace the lock washer and lock nut and do not fail to bend over the lock washer lip. Check the adjustment and reassemble the driving flange. Make sure the gasket (4, Fig. 170) is properly installed between the hub and the flange.

P-5. Rear Wheel Bearings

Raise wheel on which adjustment is to be made by placing a jack under the axle housing. With hands, test sidewise shake of the wheel. If bearings are correctly adjusted, shake of wheel will be just perceptible and the wheel will turn freely with no drag. If adjustment is necessary, proceed as follows:

P-6. Rear Wheel Bearing Adjustment

The bearing adjusting shims (1, Fig. 173) are placed between the brake backing plate and axle flange. To make this adjustment, remove the hub cap, the cotter pin, the axle shaft nut, and use a wheel puller to remove the wheel hub. Remove the bolts holding the brake dust shield, grease and bearing retainer, and the brake backing plate. Remove or install shims to adjust the bearings to provide 0.001" to 0.006" [0,025 a 0,152 mm.] end float of the axle shaft.

P-7. Maintenance of Wheel Bearings

Under normal operating conditions, the front wheel hub bearings require lubrication only every 6000 miles [9,600 km.]. It is necessary to disassemble and remove the bearings from all front wheels to properly lubricate them. Rear wheels are equipped with lubrication fittings. When front wheel hubs and bearings are removed for lubrication, they should be thoroughly washed in a suitable cleaning solvent. The bearings should be thoroughly dried and then given a thorough cleaning and inspection. Use a clean stiff brush to remove all particles of old lubricant from bearings and hubs. After the bearings are thoroughly cleaned, inspect them for pitted races and rollers. Also check the hub oil seals. Repack the bearing cones and rollers with grease and reassemble hub in the reverse order of the disassembly. Test the bearing adjustment as outlined in Par. P-6. When installing the hubs and drums, the hubs with the right-hand threaded studs are placed on the right side of the vehicle; the left-hand threaded studs are placed on the left side of the vehicle.

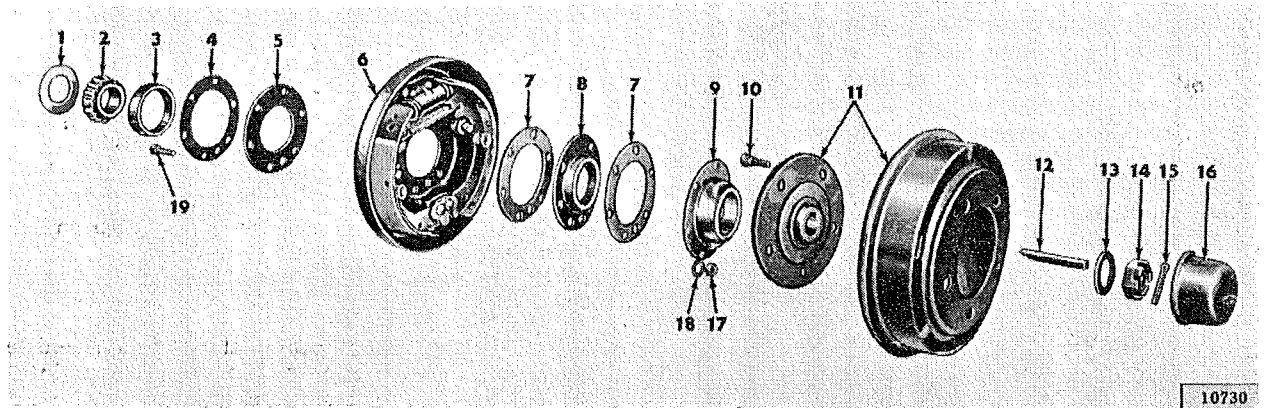


FIG. 172—REAR WHEEL AND ATTACHING PARTS

- | | | |
|--------------------|--------------------|----------------|
| 1—Oil Seal | 7—Gasket | 14—Nut |
| 2—Cone and Rollers | 8—Grease Retainer | 15—Cotter Pin |
| 3—Cup | 9—Grease Protector | 16—Hub Cap |
| 4—Shims | 10—Bolt | 17—Nut |
| 5—Bearing Retainer | 11—Hub and Drum | 18—Lock Washer |
| 6—Brake | 12—Shaft Key | 19—Bolt |
| | 13—Oil Seal | |

Do not overpack wheel bearings. Wheel bearing grease may dry out if bearings are overpacked. Overfilling the bearings and space between them in the hub will cause churning of the grease and generation of heat from the turning action of the bearings. The excessive heat may drive out the oils in wheel bearing grease and leave a dry, flaky residue that has no lubricating properties.

P-8. Brake Drums

The brake drums are attached to the wheel hubs by five serrated bolts. These bolts are also used for mounting the wheels on the hub. To remove a brake drum, press or drive out the serrated bolts and remove the drum from the hub. When placing the drum on the hub, make sure that the contacting surfaces are clean and flat. Line up the holes in the drum with those in the hub and put the drum over the shoulder on the hub. Insert five new serrated bolts through the drum and hub and drive the bolts into place solidly. Place a round piece of stock, approximately the diameter of the head of the bolt, in a vise; next place the hub and drum assembly over it so that the bolt head rests on it. Then swage the bolt into the countersunk section of the hub with a punch. The runout of the drum face should be within 0.030" [0,76 mm.]. If the runout is found to be greater than 0.030", it will be necessary to reset the bolts to correct the condition. The left hand hub bolts are identified with an L stamped on the head of the bolt. The left hand threaded nuts may be identified by a groove cut around the hexagon faces, or by the word "LEFT" on the face. Hubs containing the left-hand threaded hub bolts are installed on the left-hand side of the vehicle.

P-9. Tires

One of the most important factors of safe vehicle operation is systematic and correct tire maintenance. Tires must sustain the weight of a loaded

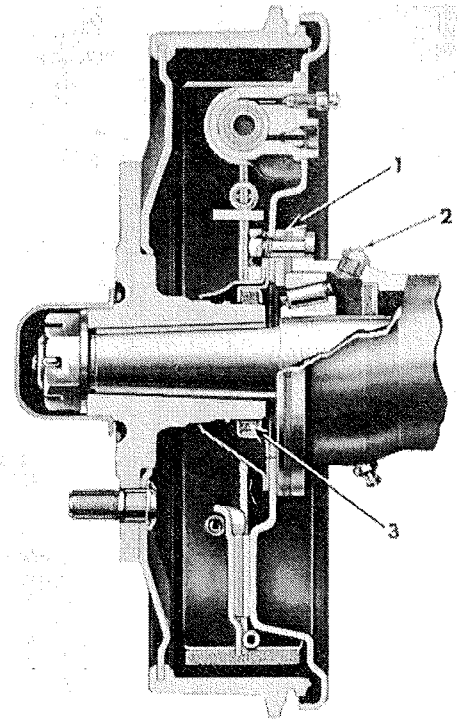


FIG. 173—REAR WHEEL HUB AND BEARING

- 1—Adjusting Shims
- 2—Grease Relief Fitting
- 3—Oil Seal

icle, withstand more than ordinary rough serv-
 , provide maximum safety over all types of
 rain, and furnish the medium on which the
 icle can be maneuvered with ease. Although
 re are other elements of tire service, inflation
 intenance is the most important and in many
 tances the most neglected. The tire pressure
 ould be constantly maintained for safe operation.

under-inflated tire is dangerous, as too much
 xing causes breakage of the casing resulting in
 lture. Over-inflation, in time, may cause a blow-
 .:

10. Tire Care

re pressure, tire rotation, wheel balance, and
 eel alignment are the four vital factors that in-
 ence the extent of tire life, and the ease and
 ety of vehicle control. Four of the most common
 e troubles are:

Excessive wear around the outer edges resulting
 m under-inflation.

Excessive wear in the center of the tread
 ulting from over-inflation.

Tire tread worn on one side indicating wheels
 ed realigning.

Cuplike depressions on one side of the tread
 licating wheels need balancing.

the vehicle normally carries a full load, 2 to
 pounds [0,14 a 0,28 kg./cm²] can be added to
 e recommended pressures. But remember that
 ing air with a light load means a harsher ride,
 es not helptires, and wears out shock absorbers.
 oss-switch the tires every 5000 miles [8.000
 .]. This practice will even out differences in
 ar and make a set of tires last longer than
 y would without cross switching. Refer to Fig.

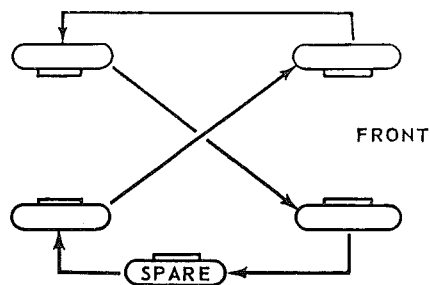


FIG. 174—TIRE ROTATION

174 for the recommended rotation method. When a
 method of tire rotation is selected, it should be
 used consistently or the full benefits of tire rota-
 tion may be lost.

P-11. Tire Removal and Installation

To remove a tire from a drop center rim, first
 deflate completely and then force the tire away
 from the rim throughout the entire circumference
 until the bead falls into the center of the wheel rim.
 With a heavy screwdriver or tire removing tool,
 used opposite the valve, remove one side of the
 tire at a time and remove the inner tube. Instal-
 lation of the tire is made in the same manner
 by first dropping one side of the tire into the center
 of the rim and with a tire tool, raise the bead
 over the wheel rim, using care not to damage the
 inner tube. When mounting the wheel, alternately
 tighten opposite stud nuts to prevent wheel run-
 out. After the nuts have been tightened with the
 wheel jacked up, lower the jack so wheel rests
 on the floor and retighten the nuts.

P-12. WHEEL AND TIRE SPECIFICATIONS

	SPECIFICATIONS	METRIC
HEELS:		
Make	Kelsey-Hayes	. . . . .
Type	Disc	. . . . .
Material	Steel	. . . . .
Rim Size	16 x 5.00	. . . . .
Flange Type	K	. . . . .
Attachment Type	Stud	. . . . .
Circle Dia.	5.50	. . . . .
Number	5	. . . . .
Size	1/2-20	. . . . .
Axle Shaft End Float	0.001"-0.006"	0,0254 a 0,152 mm.
RES:		
Size	7.50-16	. . . . .
Ply Rating	8	. . . . .
Revolutions per Mile @ 30 mph	685	. . . . .
Inflation Pressure		
Front	45	3,02 kg./cm ²
Rear	45	3,02 kg./cm ²

FRAME

Contents

SUBJECT	PAR.	SUBJECT	PAR.
ALIGNMENT	Q-2	SPECIFICATIONS	Q-6
DIMENSIONS	Q-3	STRAIGHTENING	Q-4
FRONT AXLE ALIGNMENT	Q-5		

Q-1. GENERAL

The frame is the structural center of the vehicle, for in addition to carrying the load, it provides and maintains correct relationship between other units to assure their normal functioning. Of rugged design, the frame is constructed of heavy channel steel side rails and cross members. Brackets and diagonal braces are used to maintain the proper longitudinal position of the side rails relative to each other, and at the same time, provide additional resistance to torsional strains. Vehicles which may have been in an accident of any nature, which may result in a swayed or sprung frame, should always be carefully checked for proper frame alignment, steering geometry, and axle alignment.

Q-2. Checking Frame Alignment

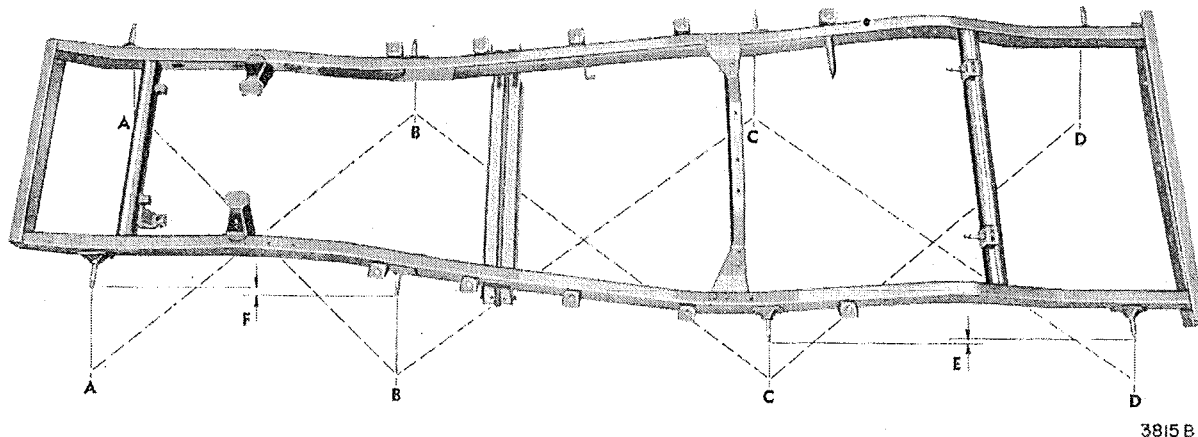
The most efficient and satisfactory method of checking frame alignment is with a frame aligning fixture which is equipped with bending tools for straightening frame parts. In the absence of such a fixture, frame alignment may be determined by using the X or diagonal method of checking from given points on each side rail. Fig. 175 illustrates this method of checking the frame. The most convenient way to make this check, particularly when the body is on the chassis, is by marking on the floor all points from which measurements should be taken. Select a space on the floor which is comparatively level. If a cement floor is available, clean it so that chalk marks will appear underneath the frame to be checked. If a wooden

floor, it is advisable to lay a sheet of paper underneath the vehicle and tack in place, dropping a plumb-bob from each point indicated, marking the floor directly underneath the point. Satisfactory checking depends upon the accuracy of the marks in relation to the frame. To reach the points shown that have been marked, have vehicle carefully moved away from layout on the floor, and proceed as directed in the following paragraphs:

a. Check frame width at front and rear end, using corresponding marks on the floor. If widths correspond to specifications given below, draw center line the full length of the vehicle, half-way between marks indicating front and rear widths. If frame width is not correct and the center line cannot be laid out from checking points at the end of frame, it can be drawn through intersections of any two pair of equal diagonals.

b. With the center line properly laid out, measure the distance from it to points opposite over the entire length of chassis. If frame is in proper alignment, measurement should not vary.

c. To locate the point at which the frame is sprung, measure the diagonals marked A-B, B-C, C-D. If the diagonals in each pair are within 1/8" [3,175 mm.], that part of the frame included between points of measurements may be considered as satisfactory alignment. These diagonals should also intersect at the center line. If the measurements do not agree within the above limits, it means that correction will have to be made between those points that are not equal.



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FIG. 175 - FRAME

Q-3. Frame Dimensions

Points for measuring frame alignment are shown in Fig. 175. The correct measurements are given in the table.

Point A is at the front of the frame.
 B and C-D are the distances between spring shackles and spring pivot bolt frame centers measured on a line parallel with the frame centerline. E and F show the shackle bolt centers in relation (above or below) to the pivot bolt centers.

B	43.90"	[111,50 cm.]
D	52.57"	[133,52 cm.]
Width Front	32"	[81,28 cm.]
Width Rear	44-1/2"	[113,03 cm.]
Above	2-3/16"	[5,56 cm.]
Above	4-21/32"	[11,83 cm.]

Q-4. Straightening Frame

In case the bending or twisting of the frame is not excessive, it may be straightened. This should be done cold, as excessive heat applied to the frame will weaken it. For this reason it is recommended that badly damaged frame parts be replaced.

Q-5. Front Axle Alignment

After it has been determined that the frame is properly aligned, the front axle alignment with the frame can be checked. The front axle is square with the frame if the distance between the front and rear axle is the same on both sides. The distance from the spring upper bushings to the front axle on both sides should be equal.

Q-6. FRAME SPECIFICATIONS

	SPECIFICATIONS	METRIC
FRAME:		
Number of Cross Members	6	. . . . .
Over All Length	171-1/2"	435 cm.
Width:		
Front	32"	81,2 cm.
Rear	44-1/2"	113,03 cm.
Section Modulus	2,581 cu. in.	42,276 cu. cm.

SPRINGS AND SHOCK ABSORBERS

Contents

SUBJECT	PAR.	SUBJECT	PAR.
SHOCK ABSORBERS	R-4	SPRINGS	R-1
SPECIFICATIONS	R-5	Remove and Replace	R-3
		Shackles and Pivot Bolts	R-2

R-1. SPRINGS

Both front and rear springs are semielliptical and are heat treated and shot peened for strength and durability.

Springs should be periodically examined for broken or shifted leaves, loose or missing rebound clips, angle of spring shackles, and position of springs on the saddles. Springs with shifted leaves do not have their normal strength. Missing rebound clips may permit the spring leaves to fan out or break on rebound. Broken leaves may make the vehicle hard to handle or permit the axle to shift out of line. Weakened springs may break, causing difficulty in steering. Spring attaching U-clips must be tight. It is suggested that they be checked at each vehicle inspection and tightened to 45 to 55 foot-pounds [6,2 a 7,6 kg./m.]. The front of the front springs and the rear of the rear springs are shackled to the frame. The rear of the front spring and front of the rear spring are pivoted on bolts attached to the frame. The springs are firmly attached to the axles by U-clips and the spring center bolts are

inserted in the axle spring saddles to prevent shifting of the axle.

R-2. Spring Shackles and Pivot Bolts

The pivoted spring ends and shackles have bronze bushings pressed into the spring eye and are pivoted on a bolt mounted on the frame hanger. See Fig. 176 and 177. These bushings should be lubricated every 1000 miles [1.600 km.]. Install the pivot bolt and tighten the retaining nut, then back it off about two cotter pin slots before installing the cotter pin. Be sure the nut is drawn up tight, however, it must be sufficiently loose to allow the spring to pivot freely, otherwise spring breakage will result.

R-3. Remove and Replace Spring

To remove a spring, it is not necessary to lower jacks at frame side rails, as spring is mounted on top of the axle. Remove the pivot bolt nut and drive out the pivot bolt. Remove the shackle.

- 1—Nut
- 2—Washer
- 3—Bushing
- 4—Nut and Lock Washer
- 5—Bracket
- 6—Spring Hanger
- 7—Bushing
- 8—Washer
- 9—Nut
- 10—Fitting
- 11—Spring
- 12—Shock Absorber
- 13—Nut
- 14—Pin
- 15—Spring Clip
- 16—Fitting
- 17—Bolt
- 18—Spring Hanger
- 19—Shackle
- 20—Washer
- 21—Axle Bumper
- 22—Bolt and Lock Washer
- 23—Clip Plate
- 24—Lock Washer
- 25—Spacer
- 26—Nut

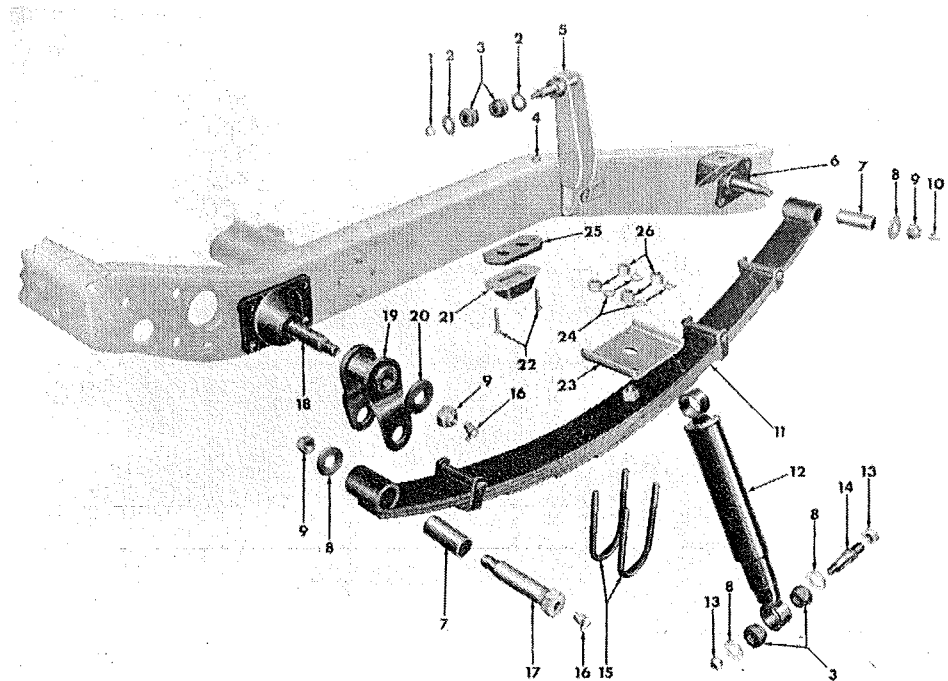


FIG. 176—FRONT SPRING AND SHOCK ABSORBER

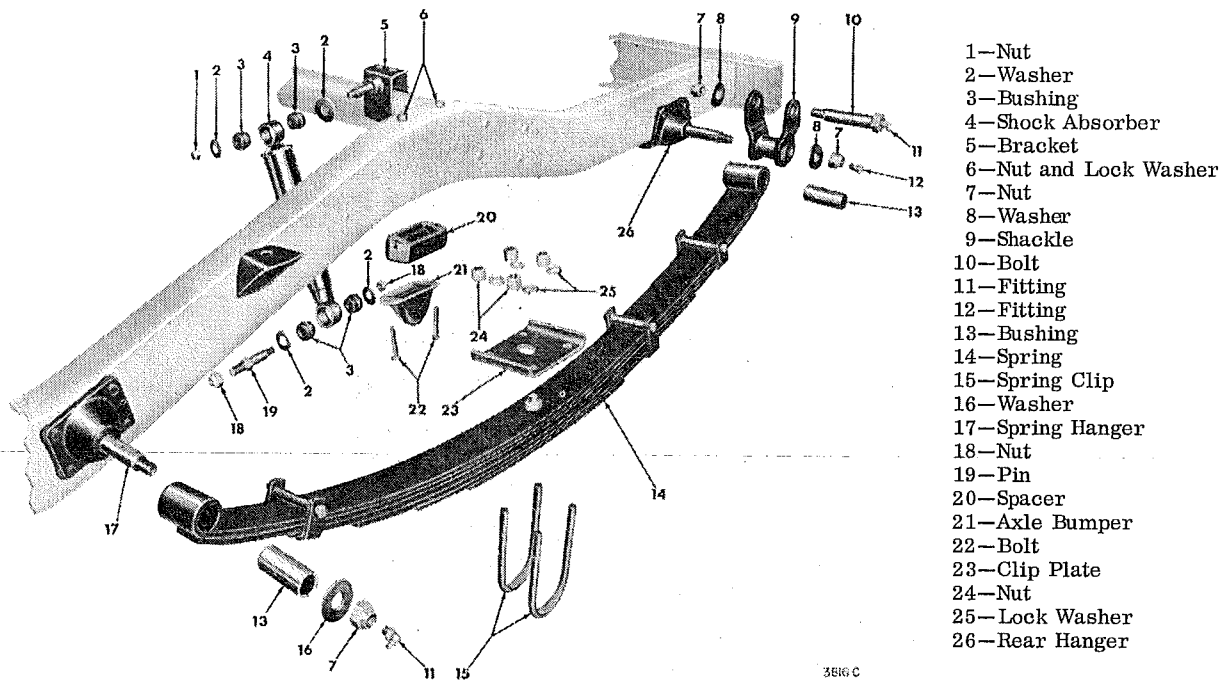


FIG. 177—REAR SPRING AND SHOCK ABSORBER

To install a spring, replace pivot bolt first and then reconnect the shackle. Raise the jack and place the spring center bolt in the axle saddle and install the axle spring clip bolts and nuts. Axle spring clip nut torque wrench reading, 45 to 50 foot-pounds [6,2 a 7,60 kg./m.]; spring pivot bolt it, 27 to 30 foot-pounds [3,73 a 4,15 kg./m.]. Avoid over tightening. Be sure the spring is free to oscillate at both ends.

-4. Shock Absorbers

The shock absorbers used are of the hydraulic direct action type, designed to absorb both upward and downward motion. They are mounted on rubber bushings at both top and bottom and their removal and installation is obvious.

They are nonrefillable and nonadjustable, and if trouble develops in one, it must be discarded and replaced with a new one, as no repairs can be made on the unit. If shock absorber is removed from the vehicle and turned upside down, it will lose its prime and become inoperative. To test a unit, it must be held in an upright position and the plunger should be worked up and down its full length of travel four or five times to determine whether its action is positive or faulty.

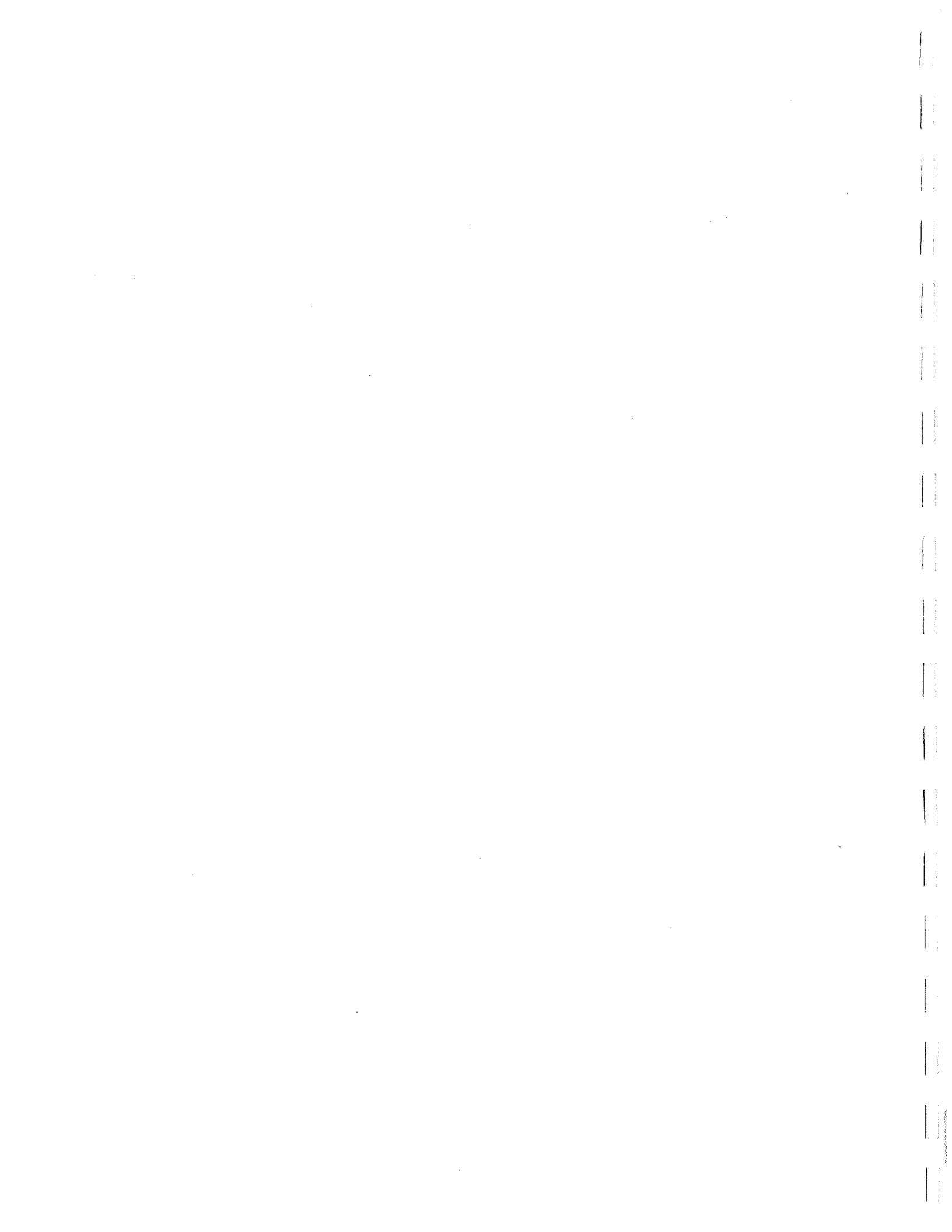
NOTE: The shock absorber stem is smoothly machined to work through a tight seal in the upper end of the piston. Do not roughen stem with pliers or similar tools during removal or installation as this will destroy the effectiveness of the seal.

R-5. SPRING AND SHOCK ABSORBER SPECIFICATIONS

	SPECIFICATIONS	METRIC
FRONT SPRINGS:		
Number of Leaves	7	. . . . .
Length	46"	116,85 cm.
Width	2-1/2"	6,35 cm.
Load to Attain Design Camber	1450 lb.	657 kg.
Stack Height	1,738"	4,414 cm.
Design Camber	+1/2"	1,27 cm.
REAR SPRINGS:		
Number of Leaves	6	. . . . .
Length	52"	132,08 cm.
Width	2-1/2"	6,35 cm.
Load to Attain Design Camber	1450 lb.	657 kg.
Stack Height	1,874"	4,760 cm.
Design Camber	+1/2"	1,27 cm.

R-5. SPRING AND SHOCK ABSORBER SPECIFICATIONS (Continued)

	SPECIFICATIONS	METRIC
FRONT SHOCK ABSORBERS:		
Type	Hydraulic	. . . .
Action	Double	. . . .
Length:		
Compressed	12-1/2"	31,75 cm.
Extended	20-1/2"	52,07 cm.
Piston Diameter	1"	2,54 cm.
REAR SHOCK ABSORBERS:		
Type	Hydraulic	. . . .
Action	Double	. . . .
Length:		
Compressed	11-5/16"	28,73 cm.
Extended	19-7/16"	49,37 cm.
Piston Diameter	1"	2,54 cm.



BODY

Contents

SUBJECT	PAR.	SUBJECT	PAR.
DOORS		Striker Plate	S-5
Adjustment	S-4	WINDOWS	S-12
Glass Removal	S-8	WINDSHIELD	S-9
Lock Cylinder	S-7	Removal	S-10
Lock Removal	S-6	Installation	S-11

S-1. GENERAL

The body is of all steel construction with mountings that provide a secure attachment to the frame. The body sections, made of heavy gauge steel and reinforced with U-sections, are welded together to form a rigid unit. Doors are of similar construction, and are attached to the body with heavy, adjustable hinges. Access to the engine is provided inside the cab by removable engine covers. The cab is insulated for heat and noise protection. Doors and windows are weatherstripped to provide protection against inclement weather.

S-2. Forward Control Cab

The 'Jeep' Forward Control cab is mounted to the frame at four anchor points; two at the rear and two at the front of the cab. By removing these four hold down bolts, the steering wheel, the miscellaneous wiring, tubing, and other chassis-to-cab connections, the cab may be lifted from the chassis.

S-3. Driver's Seat

The quick-disconnect driver's seat is designed for quick removal and also has a tilt feature. The seat may be tilted forward by loosening a wing nut at the bracket on the floor panel at the rear of the seat. To remove the seat, pull the pins at the front mounting points of the seat.

S-4. Door Adjustment

The doors are adjustable at the hinge mounting points on the door and the body. The door lock striker plate is also adjustable. These adjustments are adequate to obtain proper door alignment and adjustment under normal circumstances. The door hinges have tapped holes to receive the hinge attaching screws. The attaching holes in body and door pillars are larger than the screws, permitting adjustment in any direction.

S-5. Door Striker Plate

To prevent the door opening in the safety latched position, the door striker wedge (5, Fig. 178) must be properly positioned in relation to the cam surface (A) of the lock toggle (8). Improper safety latched position will permit the toggle to override the striker pin (6), causing the door to open.

The striker must be positioned so that the door lock toggle will be held securely in engagement with the striker pin (B). The top or wedge end of striker plate (7) must be moved outward until the wedge firmly contacts the cam surface of the lock toggle, exerting sufficient pressure to prevent toggle from overriding the striker pin. This may be accomplished by placing a suitable driver against upper inside edge of the striker plate and with a hammer, strike the driver to move the plate outward slightly. The safety latch operation must be checked intermittently with the repositioning of the striker until the correct position is obtained. The striker plate to pillar (3) attaching screws must be securely tightened after the striker plate has been properly positioned.

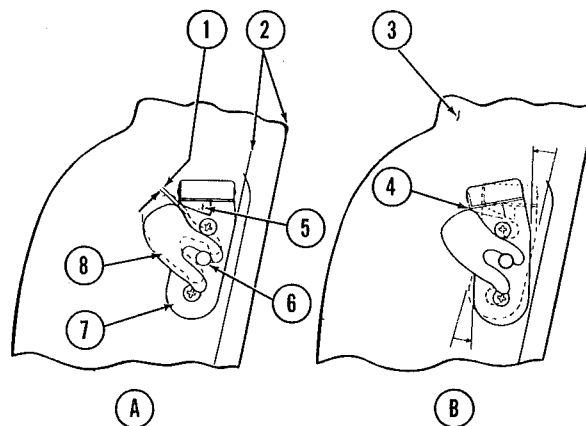


FIG. 178—LOCK TOGGLE AND STRIKER PLATE POSITION

- A—Incorrect
- B—Correct
- 1—Clearance
- 2—Parallel
- 3—Pillar
- 4—No Clearance
- 5—Wedge
- 6—Striker Plate Pin
- 7—Striker Plate
- 8—Door Lock Toggle

S-6. Door Lock Removal

To remove the inside door lock assembly, proceed as follows: (See Fig. 179)

- a. Remove door glass (See Par. S-8).
- b. Remove three screws which hold remote control assembly to inside door panel. Lower remote control arm (inside door) and unhook lock assembly.

Remove three screws which hold inside lock assembly to rear edge of door.

Remove inside lock assembly from door by pulling lock striker through rectangular hole in edge of door and lowering lock assembly through access opening in inside door panel.

Door Lock Cylinder

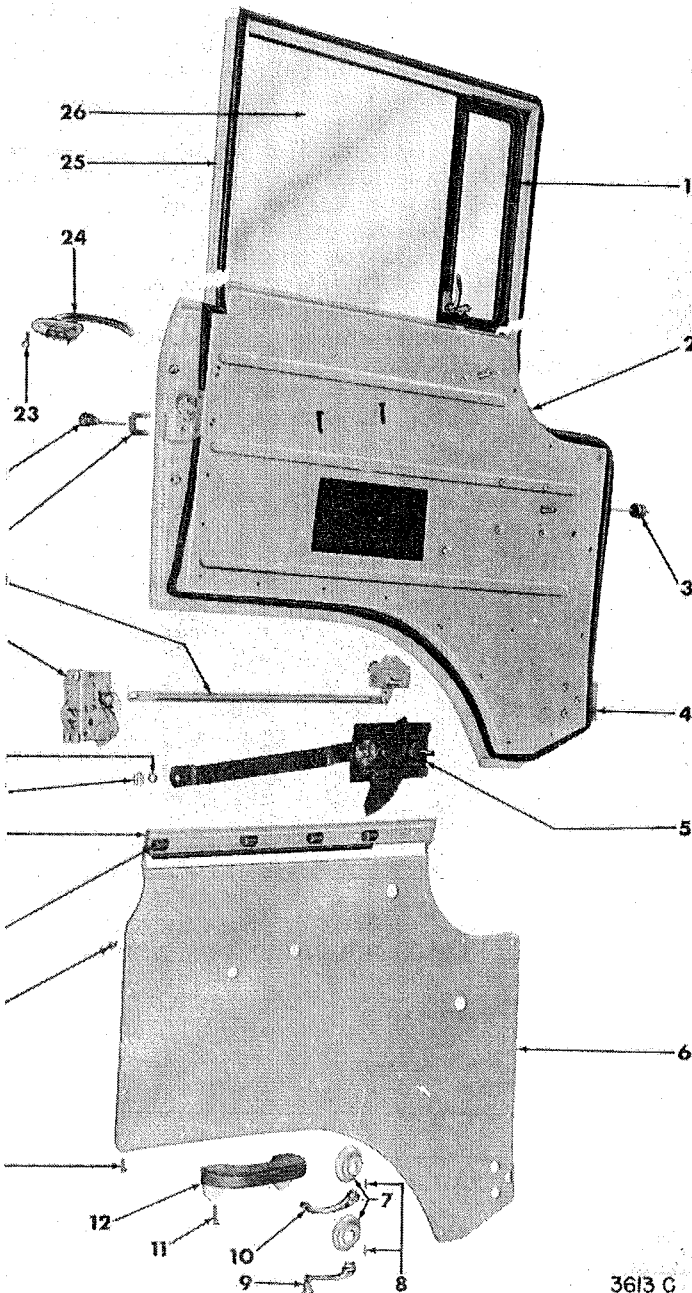
The housing and cylinder of the door lock can be removed for servicing, although the individual

components of the assembly are not available for replacement.

To remove and service the unit, proceed as follows:

a. With the door unlocked and the key in the vertical position, pull out the lock retainer (21, Fig. 179) and remove the lock cylinder assembly from the door.

b. Turn the key counterclockwise approximately 120 degrees; then remove the key and cylinder from the housing.



- 1—Vent Wing
- 2—Door
- 3—Door Check
- 4—Lower Hinge
- 5—Window Regulator
- 6—Trim Panel
- 7—Escutcheon
- 8—Pin
- 9—Window Regulator Handle
- 10—Inner Door Handle
- 11—Screw
- 12—Arm Rest
- 13—Screw
- 14—Trim Clip
- 15—Stool
- 16—Garnish Moulding
- 17—Clip
- 18—Washer
- 19—Door Lock
- 20—Door Lock Remote Control
- 21—Lock Cylinder Retainer
- 22—Lock Cylinder
- 23—Screw and Lock Washer
- 24—Outer Door Handle
- 25—Window Frame
- 26—Door Glass

3613 C

FIG. 179—DOOR

- c. To assemble the unit, hold the housing with the large bosses (on the outside of the housing) in a vertical position with the small boss to the left.
- d. Rotate the inside rear of the housing by rotating the stem adapter projecting from the rear of the housing until the round hole in the inside rear of the housing is adjacent to the leaf spring in the left-hand housing groove. This should place the oblong hole to the right.
- e. Insert the cylinder (key installed) with the prongs on the rear of the cylinder lined up with the holes on the inside rear of the housing.
- f. Press on the key and cylinder and turn the key clockwise, approximately 120 degrees, until it is in the vertical position.

S-8. Door Glass Removal

To remove door glass, proceed as follows, giving close attention to the order, position, and method of original installation of each part or assembly removed. See Fig. 179.

- a. Remove garnish molding at door-glass line.
- b. Remove arm rest.
- c. Remove inside door handle and regulator crank by pressing in on escutcheon and removing holding pins.
- d. Remove inside door trim panel.
- e. Remove access plate from inside door panel.
- f. Remove button plug from lower rear edge of door and from upper front edge of door.
- g. Remove five screws holding glass frame assembly to door; two at rear edge of door, three at upper front edge of door.
- h. Remove screw attaching lower front edge of glass frame assembly to inside door panel.
- i. Run glass down and remove "Hairpin" spring clip and washer holding window regulator arm to lower glass frame channel.
- j. Remove weatherstrip clips from rear edge of door near lock location. Remove enough weatherstrip to permit lifting glass frame assembly from door.
- k. Pull out lock retainer, at rear edge of door even with door lock, and remove the tumbler key lock assembly from outside of door.
- l. Lift glass frame assembly straight up and remove from door.

S-9. Windshield

The curved windshield is secured in the body opening with lock type weatherstrip. No difficulty should be encountered in replacing the windshield if the following instructions are followed:

S-10. Windshield Removal

Be sure the temperature of the windshield weatherstrip is 75° F. [24° C.] or above before removal is attempted.

- a. Working on the outside of the cab, insert a screwdriver or thin wedge in the separation or slit in the weatherstrip (Point A, Fig. 180) and pull the lower lip of the weatherstrip over the upper

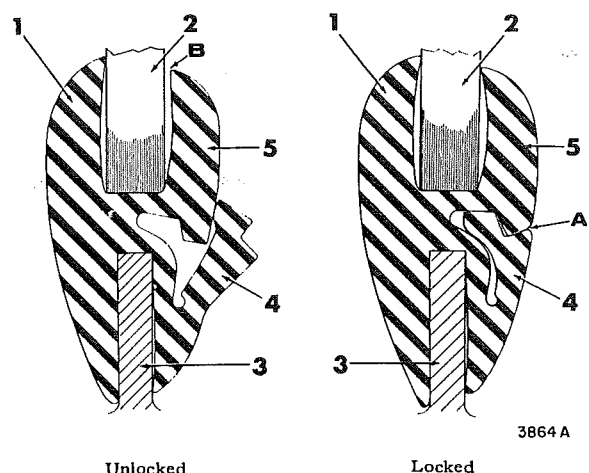


FIG. 180—WINDSHIELD WEATHERSTRIP

- | | |
|----------------|-------------|
| 1—Outer Flange | 4—Lower Lip |
| 2—Gloss | 5—Upper Lip |
| 3—Body Flange | |

lip, as shown in the unlocked position. Care must be taken when pulling the lower lip out to prevent tearing of the weatherstrip.

b. Insert a soap solution between the outside surface of the glass and the weatherstrip all the way around the windshield (Point B).

c. Push the glass out of the weatherstrip from the inside of the cab. Two men working on the inside of the cab must push on the opposite upper corners of the glass at the same time. A third man must be outside the cab to prevent the glass from falling.

S-11. Windshield Installation

a. Heat the windshield weatherstrip with a heat lamp or other suitable means until it is very pliable.

The weatherstrip must be pliable to make the installation operation easier and reduce the possibility of breaking the windshield.

b. Install the weatherstrip on the body flange in the windshield opening.

c. Apply a liberal amount of liquid soap in the windshield glass groove of the weatherstrip.

d. Place a strong cord (1/2" clothesline) across the bottom of the weatherstrip in the glass groove and allow the ends of the cord to hang down the front of the cab from each lower corner of the weatherstrip.

e. Working on the outside, two men (one at each end of the glass), lift the glass up to the windshield opening and force the upper edge of the glass into the weatherstrip glass groove across the top of the weatherstrip.

f. Next, push the windshield glass toward the cab, working the edges of the glass into the weatherstrip grooves down each side of the windshield

pening. When the windshield has been worked in place across the top and along the sides, it will lace the bottom edge of the glass against the outside lip of the weatherstrip glass groove across the bottom of the windshield opening.

. Pull the cord and push against the lower edge of the windshield glass, at the same time, pulling the outside lip of the lower glass groove into place over the lower edge of the glass.

. Apply a soap solution to the lower lip of the weatherstrip all the way around the weatherstrip.

Use a screwdriver or thin wooden wedge to pull the upper lip of the weatherstrip into place over the lower lip, as shown in the locked position (Fig. 80).

-12. Windows

The rear and side windows for the panel truck, personnel carrier, and ambulance are secured in the cab with lock type weatherstrip. Window placement is similar to that given above for the windshield.

-13. Instrument Panel Removal

Disconnect the battery.

Remove the seven screws securing the steering column to instrument panel skirt in place. Two of the screws secure the skirt to the hinge pillar, four to the front flange of the instrument panel, and one to the brace at the right end of the skirt. Remove the skirt.

Remove the four screws securing the top front edge of the instrument panel. Remove the one screw securing the right front flange of the instrument panel lower right extension. Loosen the right-hand nut on the steering column clamp. Disconnect the electrical connections from the rear of the instrument panel. Unscrew the end of the speedometer tube from the speedometer. Remove the instrument panel. When connecting the instrument panel at assembly, refer to Fig. 90. Lift the instrument panel to give clearance for removing the instrument.

Unscrew the end of the speedometer tube from the speedometer. Disconnect the fuel, temperature,

and ignition wires. Snap out the five lamp bulb sockets. Remove the four stud nuts securing the instrument cluster to the instrument panel. Remove the instrument cluster.

S-14. Body Styles

The pickup truck body consists of a cab with a steel pickup box body at the rear of the chassis. A hinged tail gate lowers to provide access to the truck box. The driver's seat is removable and a removable passenger's seat is provided on the opposite side of the engine compartment. A cover for the steel box with slatted removable bench type seats is also provided. The benches run the length of the box and can be raised against the walls.

The three door panel truck has a double rear door to give access to the truck body. The driver and passenger seats are the same as those for the pickup truck.

The personnel carrier has a side door on the right side, just behind the passenger door. Behind the engine compartment and driver's seat are two rows of double seats. A single seat is positioned in line with the passenger seat in the cab in the second row. This gives seating capacity for six in addition to the driver. The rear of the truck is free for cargo which can be easily loaded through the double doors in the rear.

The ambulance has two doors in the cab and double doors in the rear. Two padded cots run the length of the truck body. There is aisle space between the two padded cots. Each cot folds up against the wall so the body can be cleared for special equipment. The wall behind the cots is padded. The ambulance has a ventilator and a dome type flasher unit in the roof.

All seats are equipped with seat belts.

S-15. Heater

A heater is mounted in the cab of all models. In the personnel carrier and ambulance, the heat is also ducted to the rear behind the engine compartment. The heater controls are on the heater.

T-1. SPECIAL TOOLS

Below are listed the tools applicable to models covered in this manual. These special tools are essential, not only for the time they will save, but also because many operations described cannot be performed without them.

Address any correspondence concerning special tools, their application, or availability, to Willys Sales Corporation, Service Department, Toledo 1, Ohio.

Clutch Group

C-360 Arbor—Clutch Plate Aligning Arbor.

Transfer Case Group

W-130 Thimble and Driver—Transfer Case Shifter Rod Oil Seal.
 W-131 Thimble and Driver—Output Shaft Snap Ring Installing.
 W-133 Driver—Speedometer Driven Pinion Bushing.
 W-141 Ring—Transfer Case Output Shaft Front Bearing Cone Removing.
 W-143 Driver—Transfer Case Output Shaft Front and Rear Oil Seal Installer.
 W-172 Puller—Universal.
 W-176 Puller—Transfer Case Shift Rod Oil Seal.
 W-192 Pilot Pin—Transfer Case Intermediate Gear Thrust Washer.

Transmission Group

W-166 Arbor and Sleeve—Cluster Gear Needle Bearing Assembly.

Transmission Group (Cont.)

W-194 Plate—Transmission Mainshaft Retaining.

Universal Joints Group

W-148 Tool
 W-162 Tool—U-Joint Flange Installer.
 C-3281 Wrench—U-Joint Flange Holding.

Rear Axle Group

W-99-B Set—Pinion and Ring Gear Setting Gauge.
 W-100 Puller
 W-104-A Puller—Combination Bearing.
 W-126 Driver—Pinion Front Bearing Cup.
 W-126-6 Tool—Spacer.
 W-128 Installer—Differential Carrier Inner Oil Seal.
 W-129 Spreader—Axle Housing.
 W-129-18 Clamps—Hold-down.
 W-147 Driver—Pinion Shaft Oil Seal.
 W-162-6 Tool—Sleeve.
 W-186 Driver—Rear Axle Shaft Oil Seal.
 W-251 Puller—Transfer Case Output Shaft Front and Rear Oil Seal Removing; also Pinion Shaft Oil Seal.
 C-319 Puller—Rear Wheel Hub.

Front Suspension Group

W-138 Driver and Adapter—Spindle Bearing Cup Remover and Installer.
 Cap Remover and Installer.
 W-144 Wrench—Wheel Bearing Adjusting Nut.
 W-163 Puller—Front Axle Drive Flange.

T-2. LIST OF ABBREVIATIONS

	to (metric conversions)	ft. -lb.	foot-pounds of torque
BC	after bottom center	lg.	long
ap.	ampere	l.h.	left hand
PI	American Petroleum Institute	ltr.	liters
px.	approximately	m.	meters
sy.	assembly	max.	maximum
TC	after top center	mfd.	microfarads
BC	before bottom center	min.	minimum
TC	before top center	mm.	millimeters
	centigrade	mph.	miles per hour
1.	centimeter	No.	number(s)
1 ²	square centimeter	O.D.	outside diameter
1 ³	cubic centimeter	O.S.	oversize
.	candle power	oz.	ounces
. in.	cubic inches	Par.	paragraph(s)
1.	diameter	psi.	pounds per square inch
	fahrenheit	r.h.	right hand
3.	figure(s)	rpm.	revolutions per minute
1.	gallons	SAE	Society of Automotive Engineers
1.	grams	sq. in.	square inches
m.	gallons per minute	U.S.	undersize
1.	horsepower	v.	volts
1.	inside diameter	x	times or by
	kilograms	"	inches
/cm ²	kilograms per square centimeter	:	to (ratio)
/m.	kilograms per meter	°	degrees
1.	kilometers per hour	⊥	centerline
	pounds		

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