TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL AND DIRECT SUPPORT

MAINTENANCE MANUAL

(INCLUDING REPAIR PARTS AND SPECIAL TOOLS LIST)

TRUCK, FIRE FIGHTING, 4X4

MODEL 1350 PKP/200 AFFF

NSN 4210-00-484-5729

ANSUL FIRE PROTECTION

HEADQUARTERS, DEPARTMENT OF THE ARMY

29 DECEMBER 1986

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistake or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommend Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, U.S. Army Troop Support Command, ATTN: AMSTR-MCTS, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. A reply will be furnished directly to you.

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S-SERIES
1978-1979-1980

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TRANSMISSION | | | | **CTS-MANUAL NO.**

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T-17	4	NEW PROCESS	2433
T-18	4	NEW PROCESS	2433
*T-128	15	FULLER	2420
*T-129	10	FULLER	2420
*T-196	10	FULLER	2699
*T-197	6	FULLER	2705
*T-316	6	FULLER	2705
*T-348	5	FULLER	2701
*T-422	13	FULLER	2706
T-425	4	NEW PROCESS	2584
*T-448	10	FULLER	2702
*T-451	4	ALLISON	2555
*T-454	4	ALLISON	2555
*T-455	7	SPICER	2703
*T-456	7	SPICER	2703
*T-459	13	FULLER	2704
*T-462	13	FULLER	2704
*T-463	6	FULLER	2705
*T-464	5	ALLISON	2629
*T-465	5	ALLISON	2629
*T-467	13	FULLER	2758
*T-468	13	FULLER	2758
*T-470	10	FULLER	2759
*T-471	9	FULLER	2727
T-495	5	IH	2643
T-496	5	IH	2643
*T-672	5	SPICER	2725
*T-673	5	SPICER	2725
*T-674	5	SPICER	2725
*T-683	6	SPICER	2729
*T-696	5	CLARK	2760
*T-697	5	CLARK	2760

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TRANSMISSION AUXILIARY

MODEL	SPEEDS	MANUFACTURE	CTS-MANUAL NO.
AT-522	3	SPICER	2124
AT-523	3	SPICER	2124
AT-524	4	SPICER	2116
*AT-536	3	SPICER	2707
*AT-552	4	SPICER	2715
*AT-554	4	SPICER	2715
*AT-566	4	SPICER	2709

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TRANSFER CASE

MODEL	SPEEDS	MANUFACTURE	CTS-MANUAL NO.
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WHEELS-TIRES

WHEELS-TIRES	2032
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ROCKFORD FAN DRIVE CLUTCH

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CHAPTER I
ROCKFORD FAN DRIVE CLUTCH

GENERAL DESCRIPTION AND OPERATION

GENERAL DESCRIPTION

The Rockford Fan Drive Clutch is a compact, spring-loaded, oil cooled, multiplate clutch designed for continuous infinite fan-to-engine pulley speed ratios assuring prescribed engine coolant temperatures and minimum engine horsepower losses.

Engine cooling temperature demands are auto- matically transmitted through a sensor (the Thermal Air Valve) to the clutch. The Rockford Fan Drive smoothly and automatically adjusts the fan to the precise speed necessary to maintain specified coolant temperature.

Fan speeds are increased or decreased smooth without the usual shock loads. Oil cooled plat permit continuous clutch slip to give variable fan speeds without clutch plate wear.

NOMENCLATURE

Rockford's Fan Drive Clutch Bracket is attached to the engine. The Bracket has as an integral part, the Fan Shaft (See Figure #1). The Shaft and Bracket Assembly acts as a bearing surface for the moving parts and as a distributor for actuating air pressure and the lubricating/ cooling oil flow.

The Input Drive of the clutch is thru the Pulley and Bearing Retainer bolted together forming the Pulley Cavity. The Pulley Cavity is sealed at the shaft by rotating seals and is supported by heavy duty tapered roller bearings.

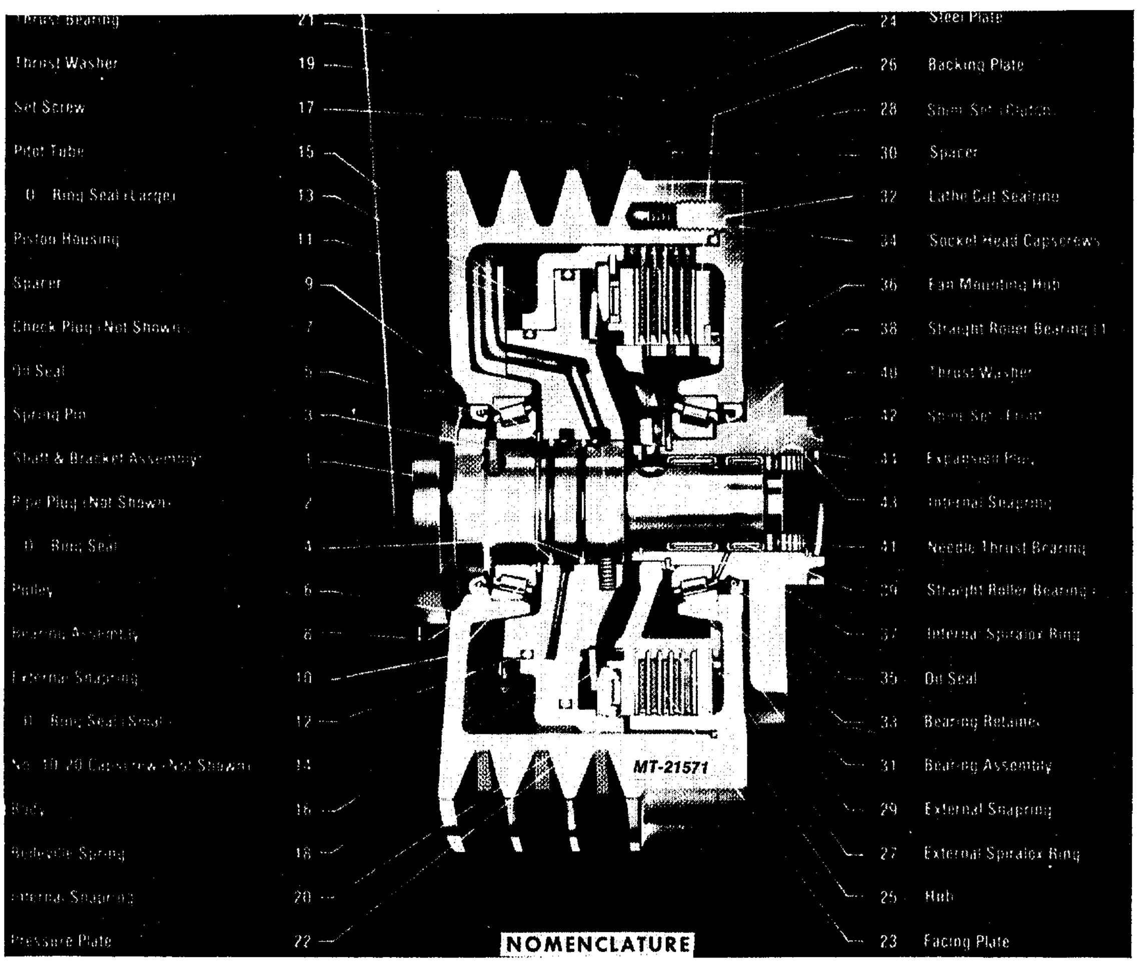


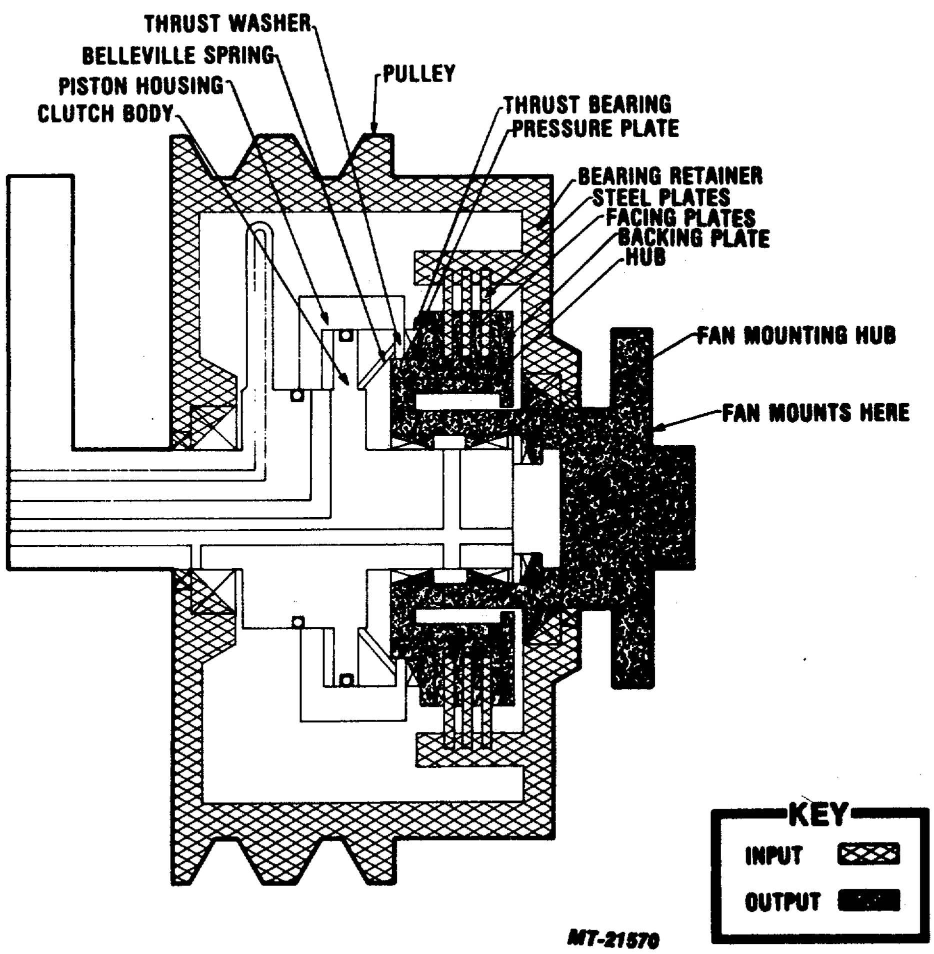
FIGURE 1

Belleville Springs (or solid Spacer Shims) in the Fan Mounting Hub preload the tapered bearings. The slotted cup section of the Bearing Retainer drives the externally tanged steel Clutch Plates.

The Output Drive of the Clutch is thru the Clutch Facing Plates which are splined to and drive the Hub. The inside diameter of the Hub is splined to and drives the Fan Mounting Hub. The fan blade is bolted directly or thru spacers to the Fan Mounting Hub.

Clutch Shims are placed on the Fan Mounting. Hub between the Hub and External Snapring to position the assembly for utilization of the optimum working range of the Belleville Spring.

The stationary Clutch Body is mounted inside the Pulley Cavity on the Fan Shaft. The Clutch Body acts as a distributor for air and oil, as an anchor for Pitot Tubes, and as a reaction member for the Belleville Spring. The Piston Housing is mounted on the outer diameter of the Clutch Body and is connected to the Belleville Spring thru the Thrust Washer. An air cavity is formed between the Piston Housing and Clutch Body.



POWER FLOW — FULL ENGAGEMENT

FIGURE 2

OPERATION

FULLY ENGAGED

The Belleville Spring reacts against the Clutch Body, pushing the Thrust Washer and Piston Housing towards the Clutch Plates. (See Figure #2). The force of the Belleville Spring thru the Thrust Washer and Thrust Bearing pushes the Pressure Plate against the Clutch Plates compressing them against the Backing Plate. When the Clutch Plates are fully compressed, the Input and Output are fully connected constituting a drive thru the clutch.

Without a supply of external air, the Fan Drive Clutch is always engaged by the force of the Belleville Spring. Incorporated with the Rockford Fan Drive Clutch is a Thermal Air Valve. (See Figure #3.) The Thermal Air Valve, located in the engine water discharge manifold, senses engine water temperature thru its Thermal tip. The valve is calibrated for a specific water temperature range. Vehicle air supply is connected to the "pressure in" opening of the Thermal Air Valve. The "pressure out" opening of the Thermal Air Valve is connected by a line to the "air in" opening of the Fan Clutch Bracket. The Thermal Air Valve controls the speed of the vehicle cooling fan by modulating the amount of air pressure supplied to engage and release the fan clutch.

When engine water temperature rises above the maximum specified temperature range of the Thermal Air Valve, expansion of the temperature sensitive wax in the Thermal Tip moves the Quill a sufficient amount to shut off the air pressure being supplied to the Fan Clutch. Air pressure in the Piston Housing Cavity exhausts through the "exhaust port" of the Thermal Air Valve. Therefore, with no air in the Piston Housing Cavity, the maximum force of the Belleville Spring is allowed to squeeze the clutch plates together locking up the Fan Clutch. The fan blade is thus driven at pulley speed.

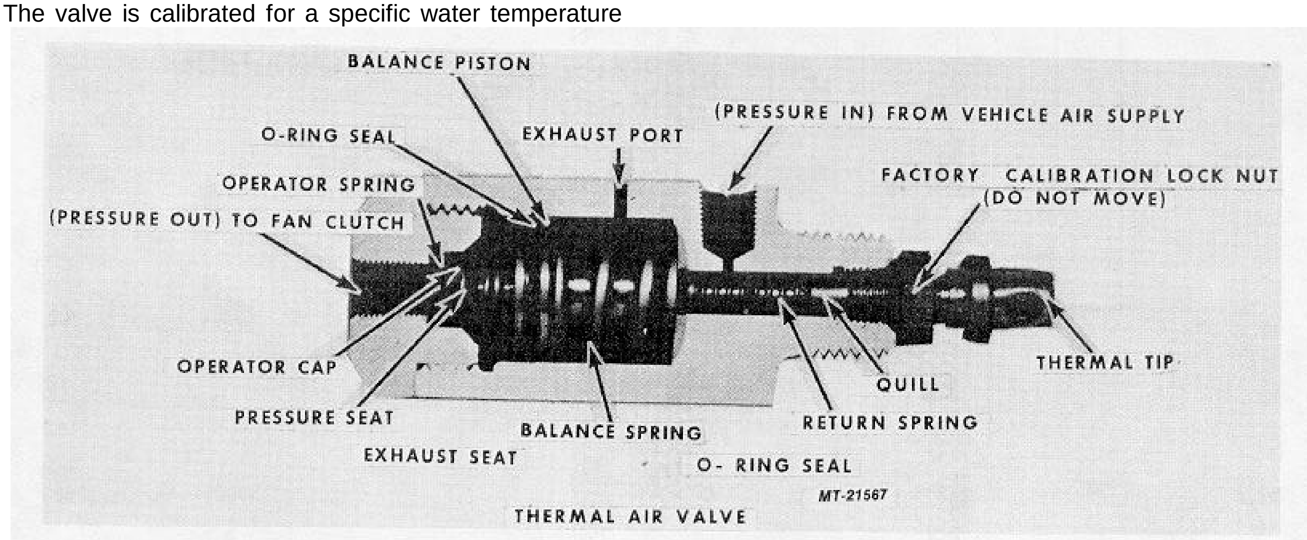


FIGURE 3

VARIABLE SPEED

As the engine water temperature cools, the temperature sensitive wax in the Thermal Tip of the Thermal Air Valve contracts. Contraction within the tip of the Thermal Air Valve reverses the movement of the Quill. As the Quill moves rearward, some air pressure is directed into the Piston Housing Cavity. (See Figure #4.) As the cooling continues and the temperature sensitive wax continues to contract, more air pressure is directed into the Piston Housing Cavity.

The gradual air pressure buildup inside the Piston Housing Cavity gradually overcomes the clamping force of the Belleville Spring reducing the torque capacity (load-carrying ability) of the clutch. The clutch plates begin to slip, reducing fan speed. If engine coolant temperature begins to increase, the above action is reversed, and the fan blade smoothly increases in speed. The infinite slip ratios of pulley speed to fan speed in the Rockford Fan Clutch are controlled by the Thermal Air Valve and its sensitivity to engine coolant temperatures.

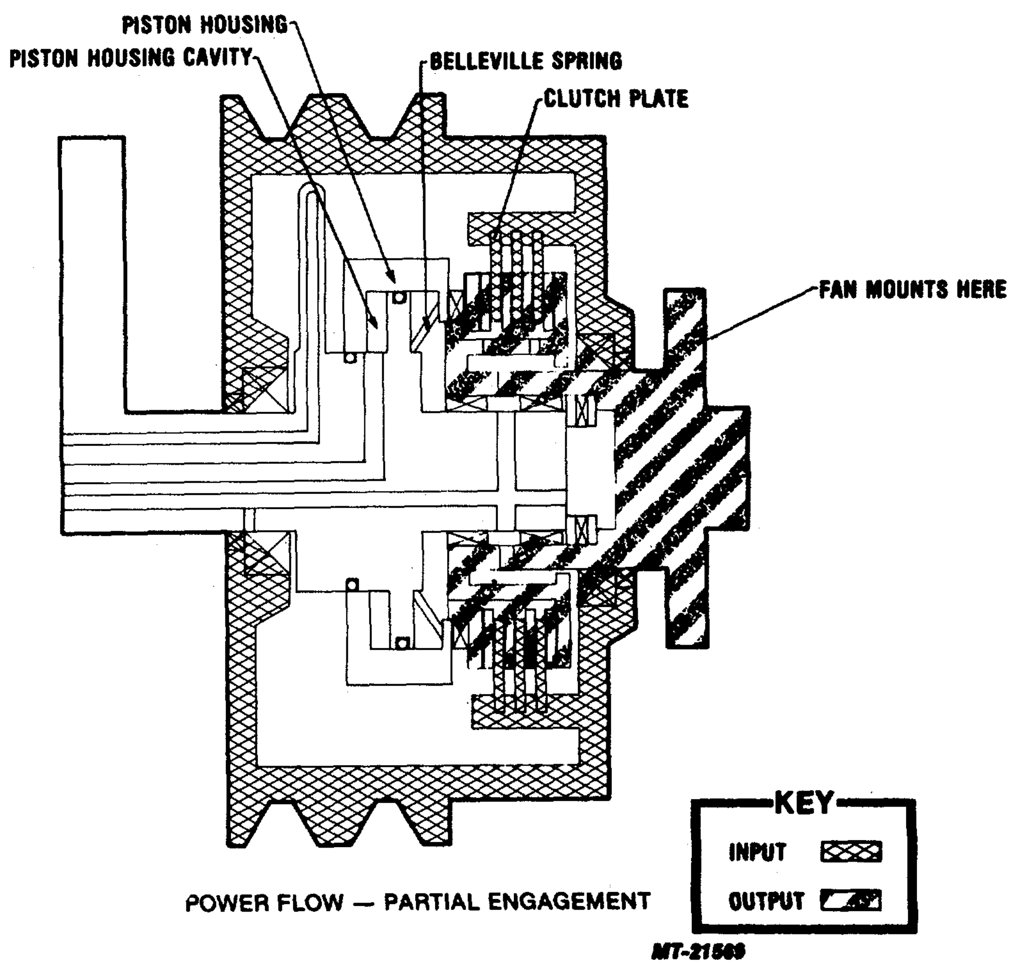


FIGURE 4

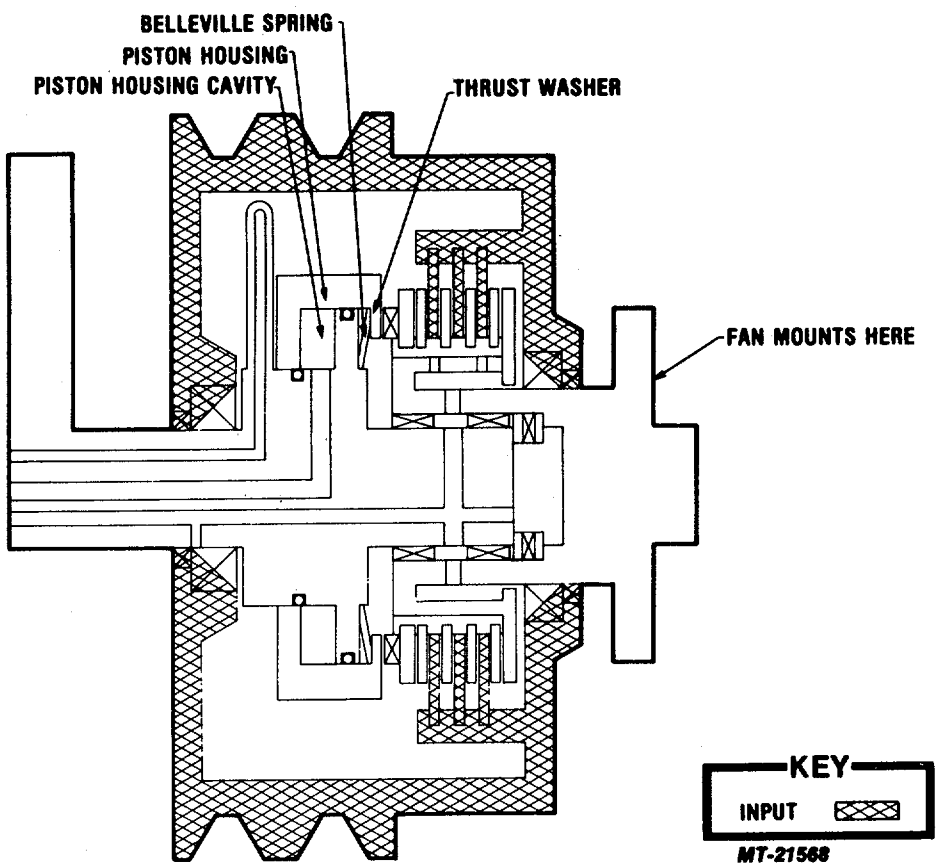
FULLY RELEASED

When engine water temperature is below the minimum specified temperature of the Thermal Air Valve, the temperature sensitive wax in the tip of the Thermal Air Valve has contracted sufficiently to pass full air pressure to the Piston Housing Cavity. Full air pressure in the Piston Housing Cavity overcomes all the Belleville Spring clamping force, moving the Piston Housing and Thrust Washer away from the clutch plates, flattening the Belleville Spring. (See Figure #5.) This action releases the clutch plates, and the drive to the fan is disconnected. At this time, the fan merely motors over at 350 450 RPM by ram action of incoming air from vehicle movement and viscous oil drag within the clutch.

REMEMBER:

a. When the maximum specified temperature limit of the Thermal Air Valve is reached, no air pressure is passed thru the Thermal Air Valve, and the Belleville Spring locks the clutch for a 1: 1 pulley-to-fan blade drive.

b. Modulated air pressure from the Thermal Air Valve produces and controls the infinite



POWER FLOW — FULL RELEASE

FIGURE 5

slip ratios of pulley RPM to fan RPM.

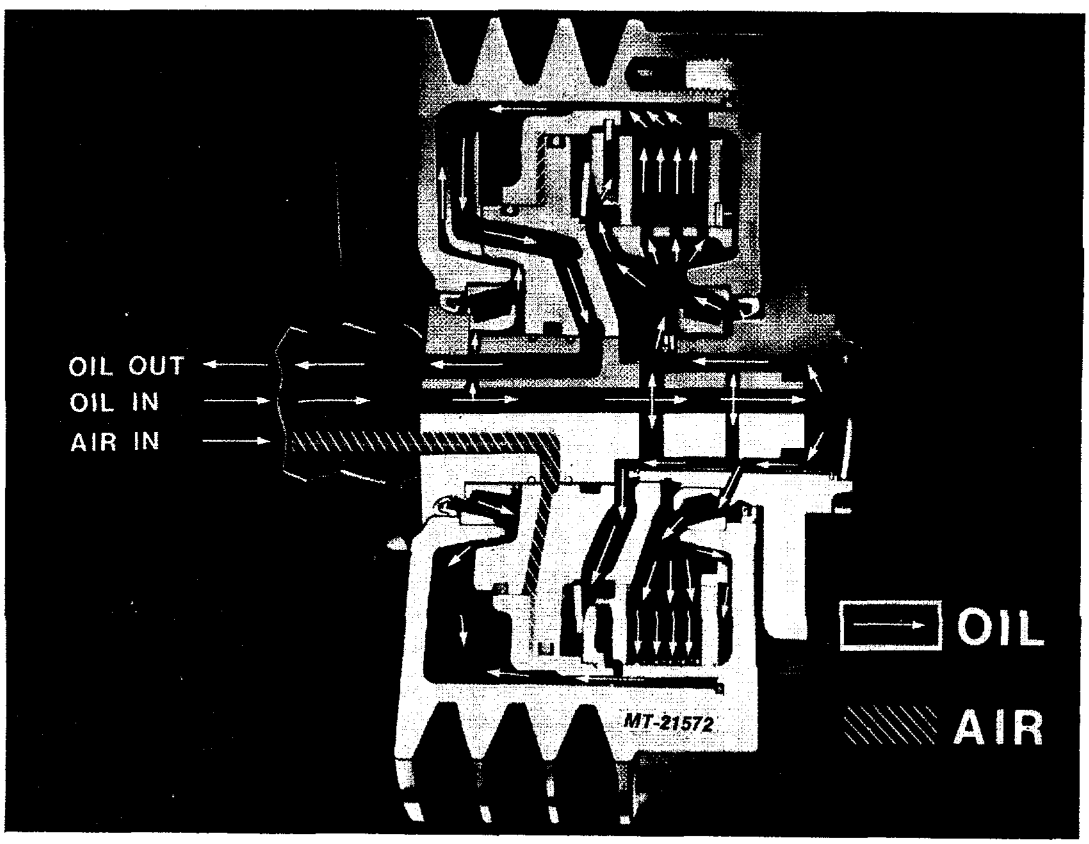
When minimum specified temperature of the Thermal Air Valve is reached, maximum air pressure is passed into the Piston Housing Cavity releasing the drive thru the clutch.

LUBRICATING & COOLING OIL

Lubricating and cooling oil is supplied to the)ckford Fan Drive Clutch from the engine oil Pressure supply system. The fan clutch oil apply originates at an engine oil pressure port rich supplies cool filtered oil. The exact location varies on different engine makes and models. An orifice fitting is placed in the engine oil pressure supply port.

The ORIFICE FITTING MUST BE INSTALLED to regulate the amount of oil supplied to the clutch. Engine oil travels thru the orifice fitting and its connecting line to the "IN" port on the Fan Clutch Bracket.

Engine oil travels thru the Bracket and into the Fan Shaft. (See Figure #6.) Orifices in the shaft distribute forced lubricating engine oil to the tapered roller bearings, needle roller bearings, and needle thrust bearings, and into the hub cavity. Centrifugal force drives oil thru holes in the hub to the clutch plates. The grooved configuration of the facing plates allows oil to pass thru the clutch plates at all times. It is this flow of cooling oil thru the clutch plates which permits continuous clutch slip and variable fan speeds without clutch plate wear.



AIR / OIL FLOW

FIGURE 6

Centrifugal force carries the oil outward to the inside diameter of the pulley, forming a band of oil around the pulley cavity. The rotational movement of the Pulley carries the oil in the direction of input rotation. Pitot Tubes are attached 180° apart to the stationary clutch body, facing into the direction of input rotation. The rotational movement of the oil rams the oil into the Pitot Tubes. The Pitot Tubes direct the oil thru a passage in the Clutch Body, Fan Shaft and Bracket to an external "out" port in the Bracket. A line from the "out" port on the bracket carries the oil to a non-pressurized port on the engine where the engine oil is returned to the engine oil sump. The return port on the engine must be non-pressurized. The location of the return port on the engine will vary with engine manufacture and model.

Rockford Fan Drive Clutches installed with engine oil lubrication are assured of a constant supply of cool, filtered oil at all times for extended bearing and clutch plate life.

CHAPTER II

INSTALLATION

FAN DRIVE SYSTEM

A. INSTALLATION SCHEMATICS

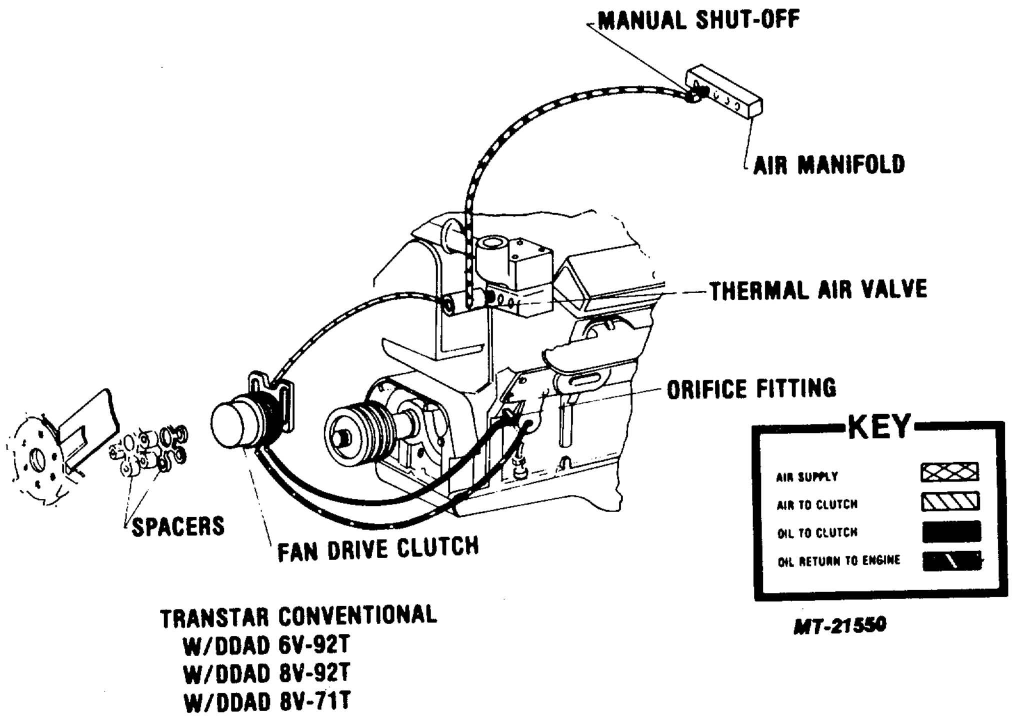


FIGURE 1

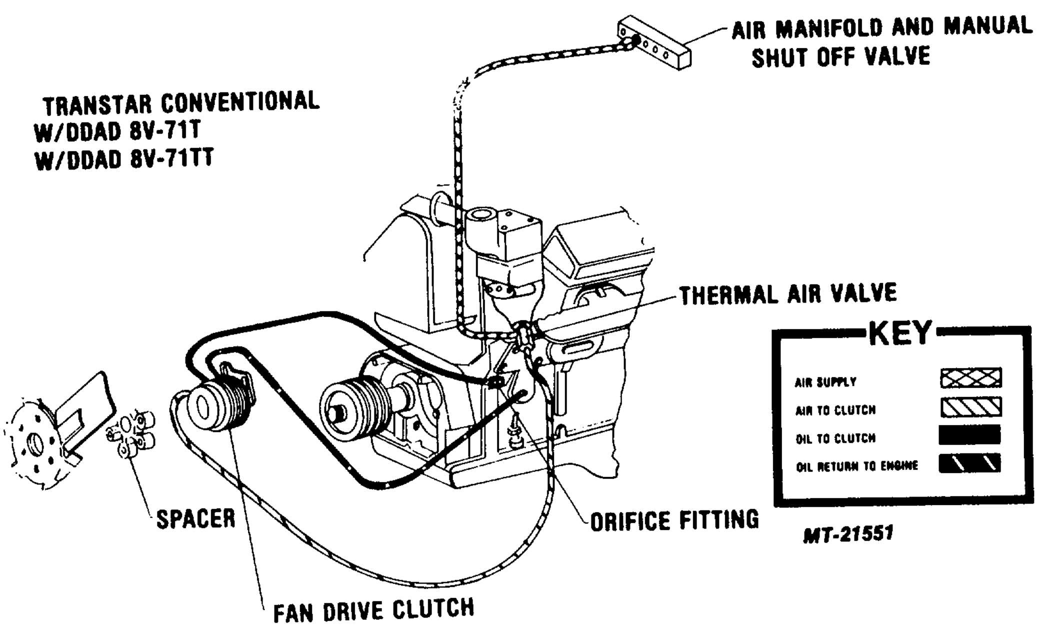


FIGURE 2

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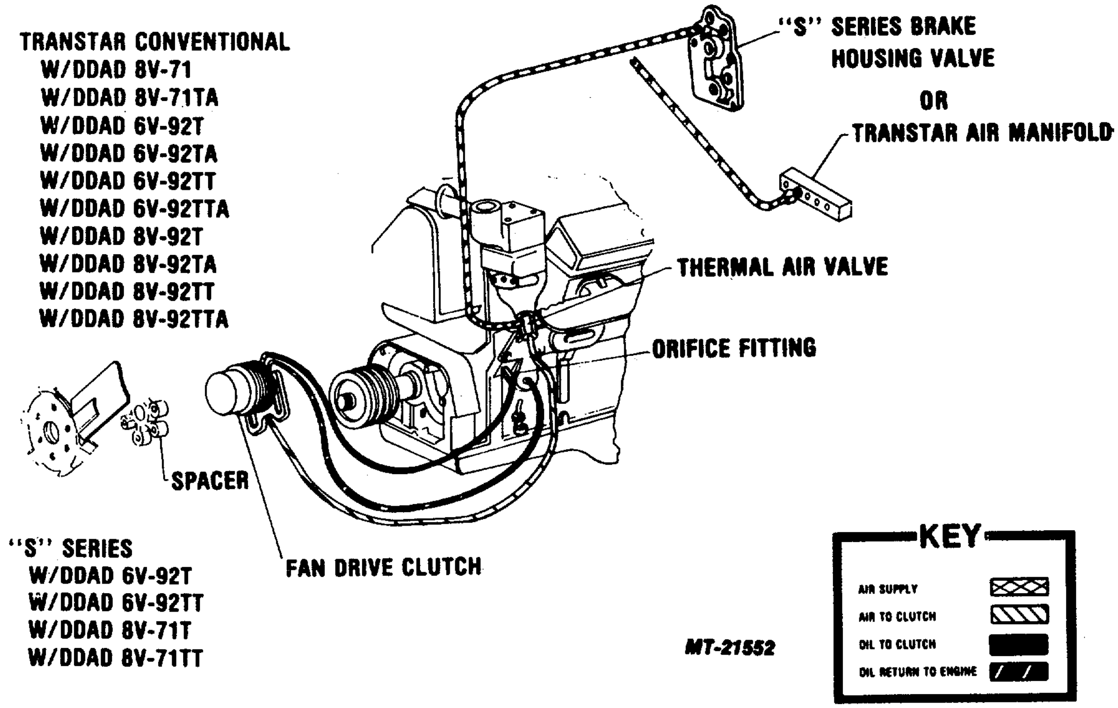

FIGURE 3

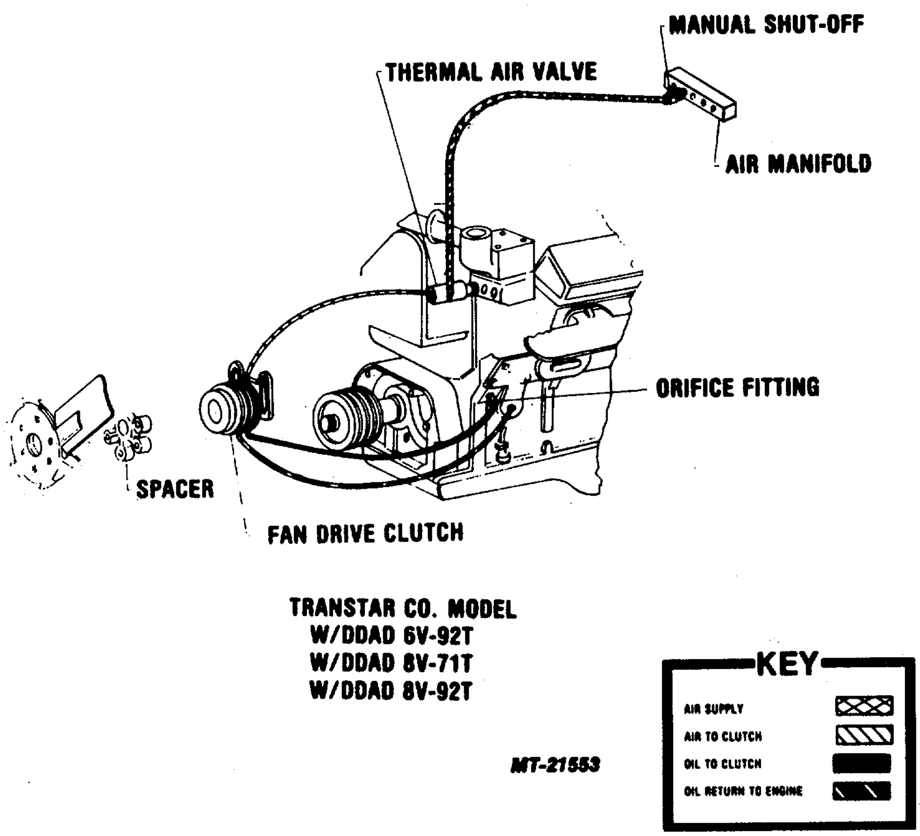

FIGURE 4

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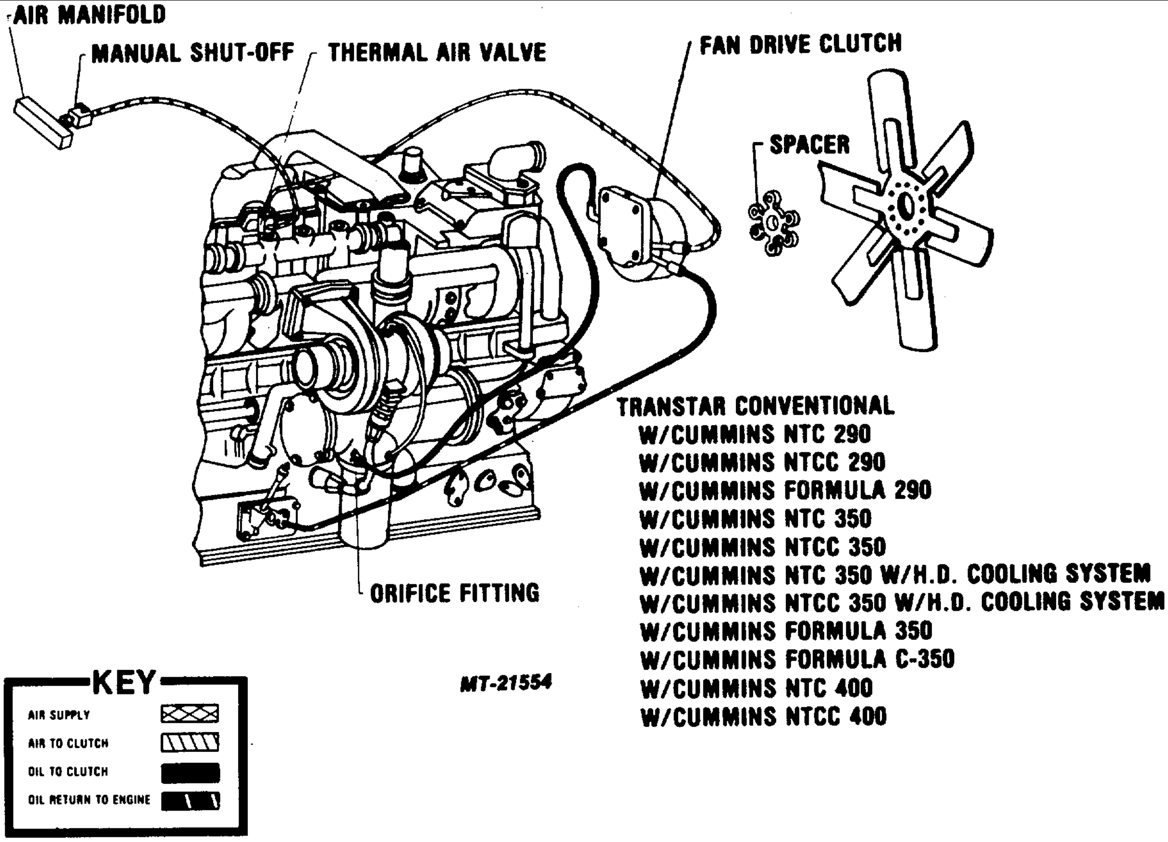

FIGURE 5

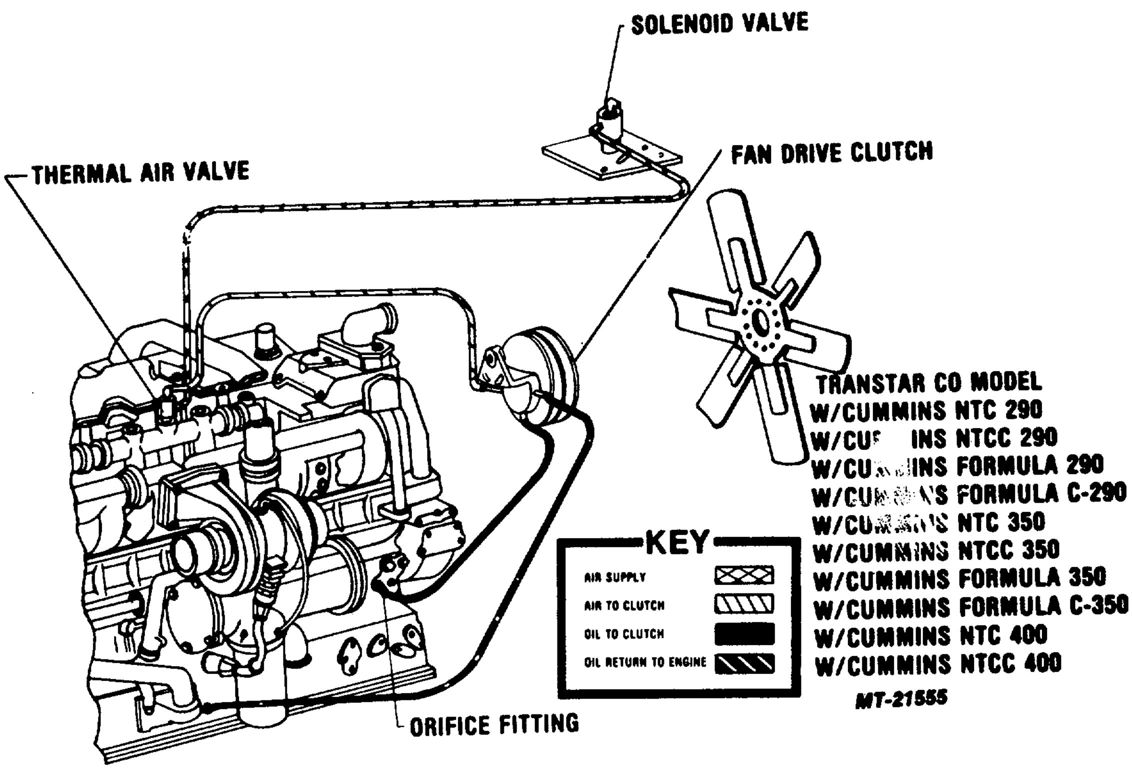

FIGURE 6

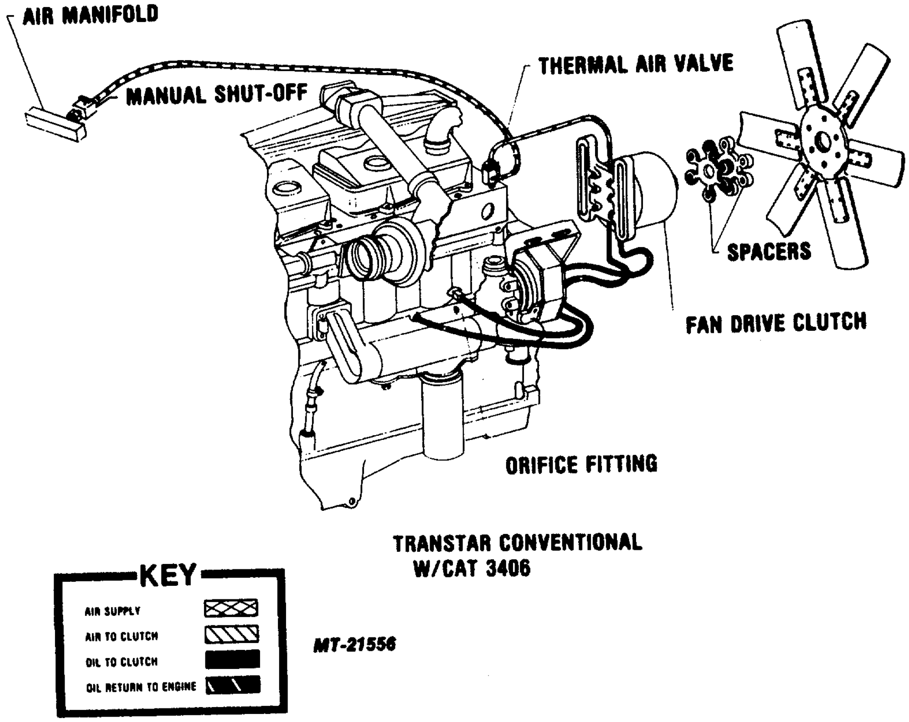

FIGURE 7

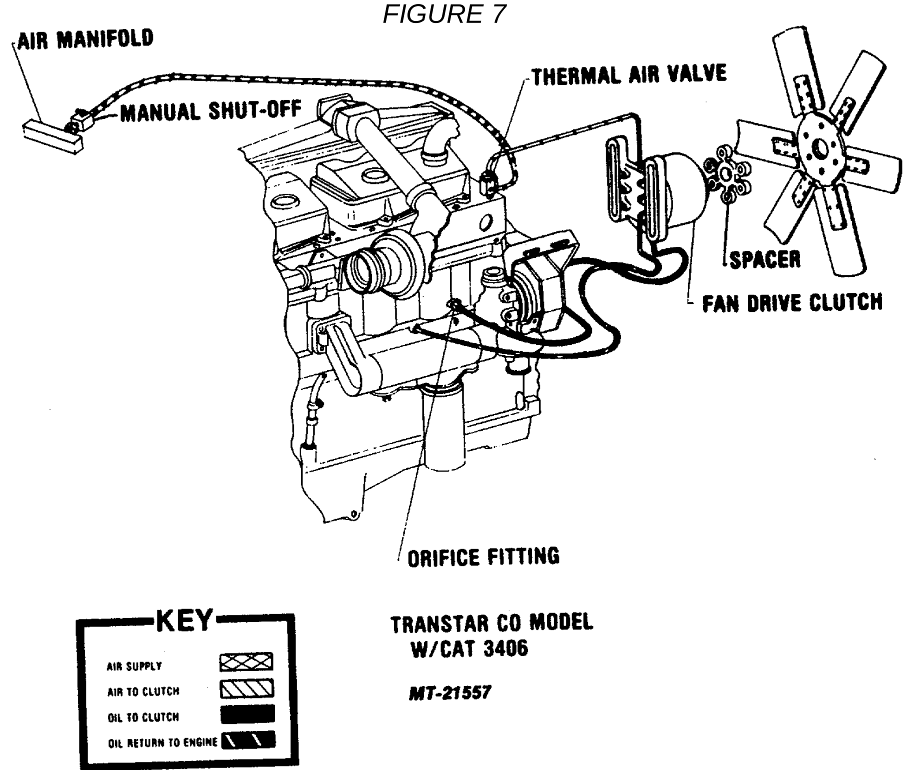

FIGURE 8

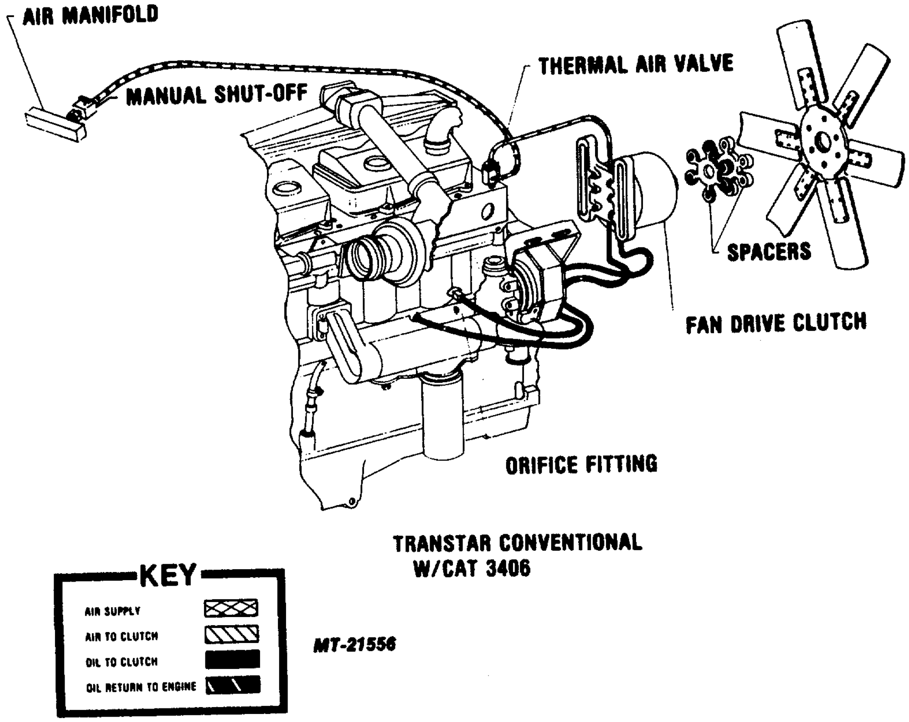

FIGURE 9

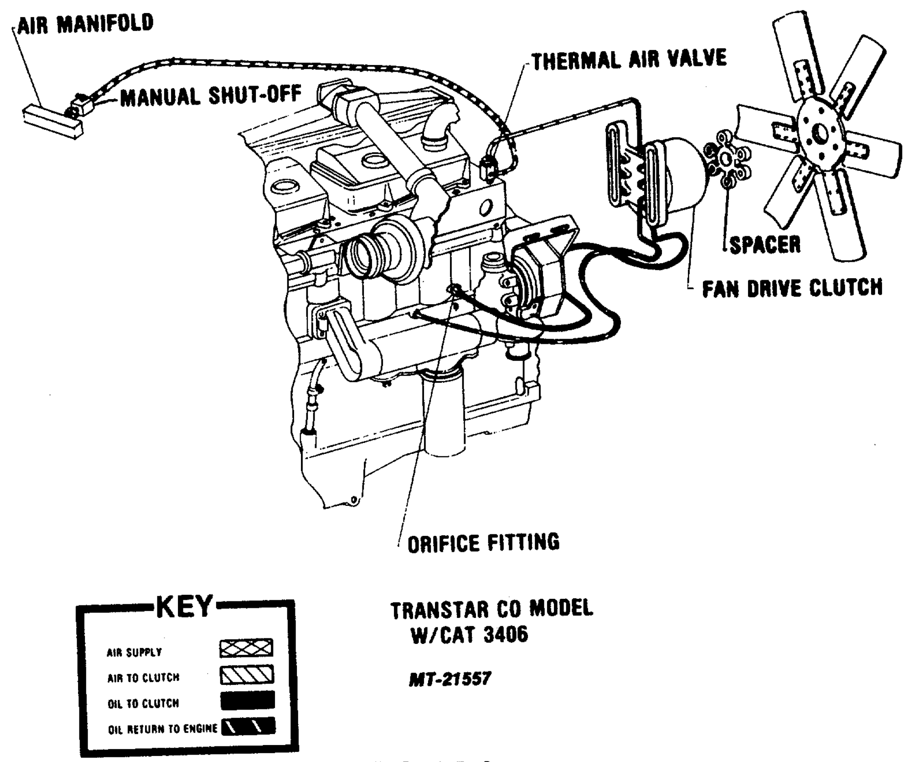

FIGURE 10

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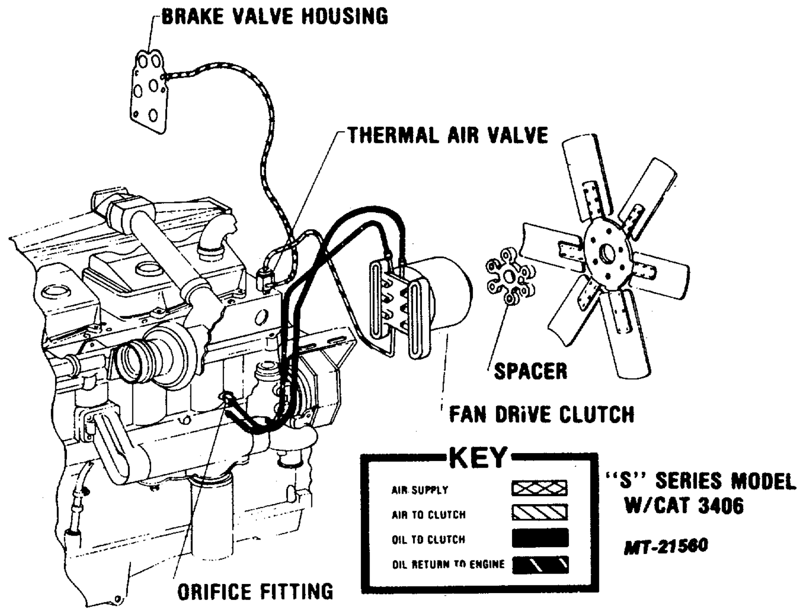

FIGURE 11

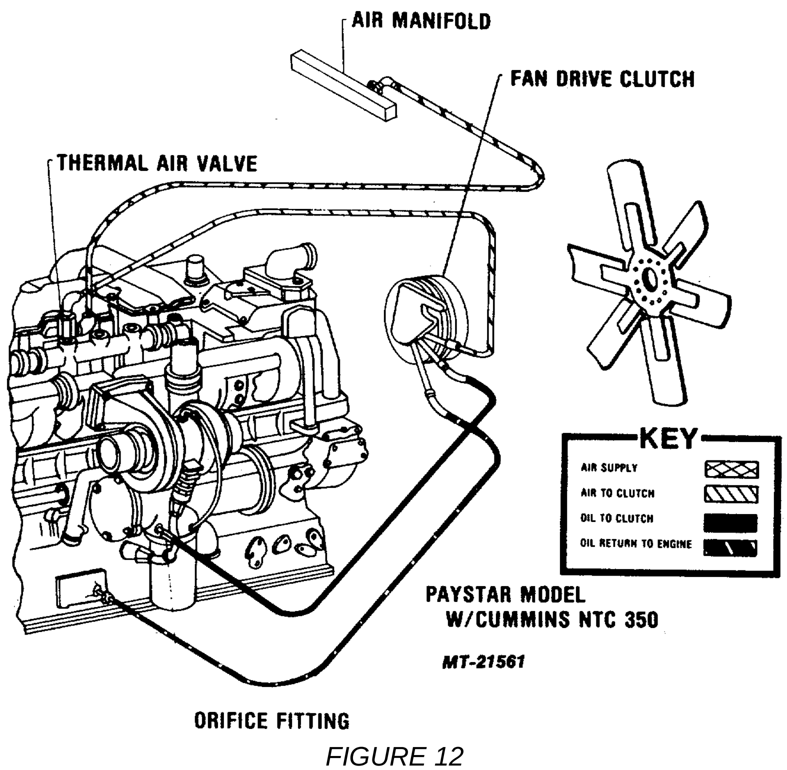

FIGURE 12

B. CLUTCH CONTROLS

TRANSTAR - "S" SERIES - PAYSTAR - without air conditioning - without shutters

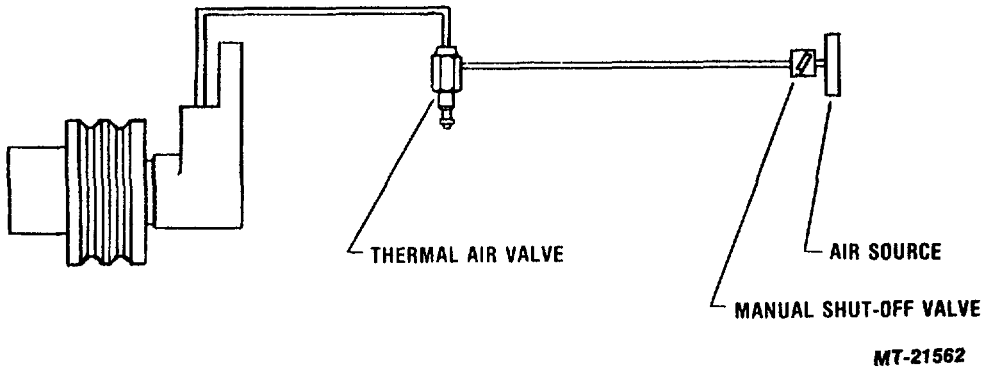

FIGURE 13

The air supply for the Rockford Fan Clutch System on Transtars, "S" Series and Paystars originates at the air manifold on the front firewall.
(See Figure 13.)

Some models have a manual shut-off valve at the air supply opening. This valve is to be used in emergencies such as a major air leak or as a check to see if the Fan Clutch is functional.

Air travels from the air manifold thru a line to the "in" port on the side of the Thermal Ail Valve. As needed, the Thermal Air Valve directs air from its top or "out" port thru a line to the "air" port in the Bracket of the Rockford Fan Drive. The temperature sensitivity of the Thermal Air Valve controls the action of the clutch and speed of the fan thru the supply of air furnished.

On "S" Series with air conditioning there is an Air Conditioning Override Solenoid in the air line between the Thermal Air Valve and the clutch. (See Figure 14.) When the cab air conditioner is on and the air conditioning freon pressure exceeds 2090 kPa (300 psi), the Air Conditioning Override Solenoid will be activated, air pressure will be cut off from the fan clutch,

“S” SERIES - with air conditioning - without shutters

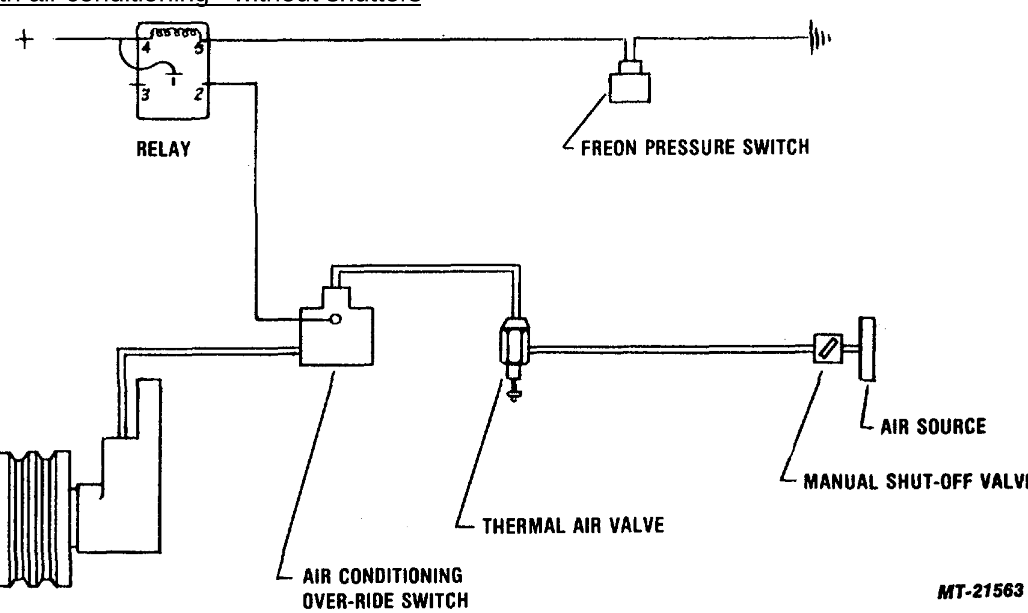

FIGURE 14

and the clutch will engage. Clutch engagement provides the fan speed necessary for cooling of the freon in the condenser. When the freon pressure drops below 1447 kPa (210 psi), the Air Conditioning Override Solenoid returns to its normal open position allowing the free flow of air. At this time the Thermal Air Valve again controls the action of the fan clutch.

The Air Conditioning Override Solenoid is controlled electrically by the Freon Pressure Switch thru the Relay. The Freon Pressure Switch is located on the compressor and the Relay is located on the firewall.

The Freon Pressure Switch protects the Compressor from extreme freon pressure. The switch is normally closed. When freon compressor head pressure reaches 2090 kPa (300 psi), the switch opens and breaks the electrical circuit. The Freon Pressure Switch is connected to terminal 5 in the Relay. The Air Conditioning Override Solenoid is connected to terminal 2 in the Relay. Breaking the circuit by the Freon Pressure Switch causes the Air Conditioning Override Solenoid to be energized, cutting off air from the fan clutch and exhausting air that was in the clutch. The fan clutch will lock up and the fan blade will turn at pulley speed.

TRANSTAR AND PAYSTAR - with air conditioning - without shutters

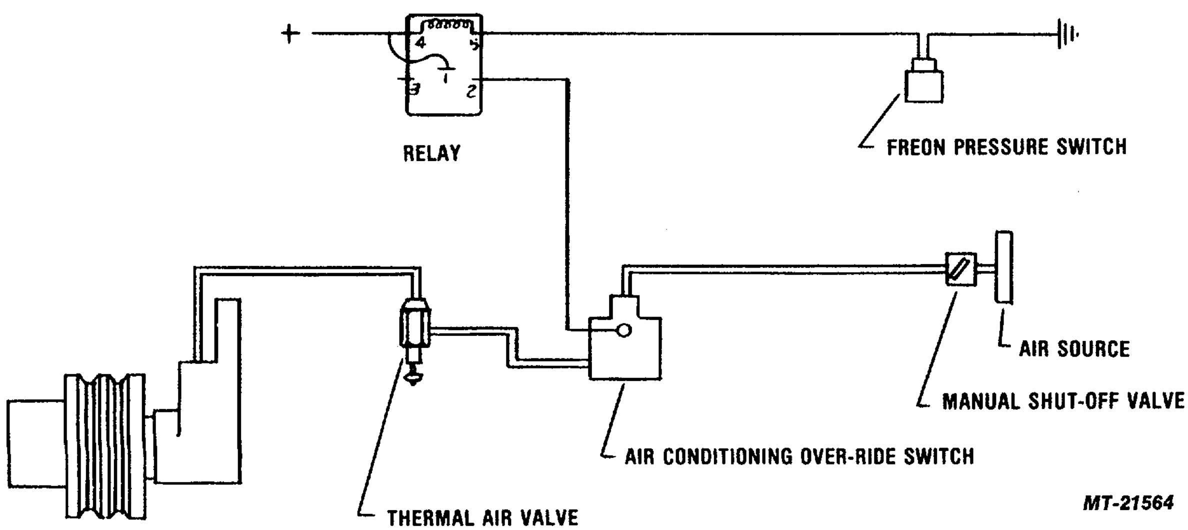

FIGURE 15

On Transtar and Paystar Models, the Air Conditioning Override Solenoid is in the air line between the Thermal Air Valve and the Air Supply Manifold. (See Figure 15.) The Freon Pressure Switch and the Air Conditioning Override Solenoid are connected to the Relay as described for the "S" Series.

Therefore, in the Transtar and Paystar models, when the rise in Freon pressure caused the Freon Pressure Switch to open, the Air Conditioning Override Solenoid is energized and shuts off the air to the Thermal Air Valve. The Thermal Air Valve slowly exhausts the air from the fan clutch and the fan blade will smoothly accelerate to pulley speed.

On Transtar and Paystar models with both Air Conditioning and Shutters, two solenoids are used in the air supply line between the Air Supply Manifold and the Thermal Air Valve one to control the fan clutch and one to control the shutters. Both solenoids are connected to the 2 terminal on the Relay and the Freon Pressure Switch is connected to terminal 5 on the Relay. (See Figure 16.)

When a rise in freon pressure causes the Freon Pressure Switch to open, both the Air Conditioning Override Solenoid and the shutter Solenoid are energized and:

1. The air supply to the Thermal Valve is

TRANSTAR AND PAYSTAR - with air conditioning - with shutters

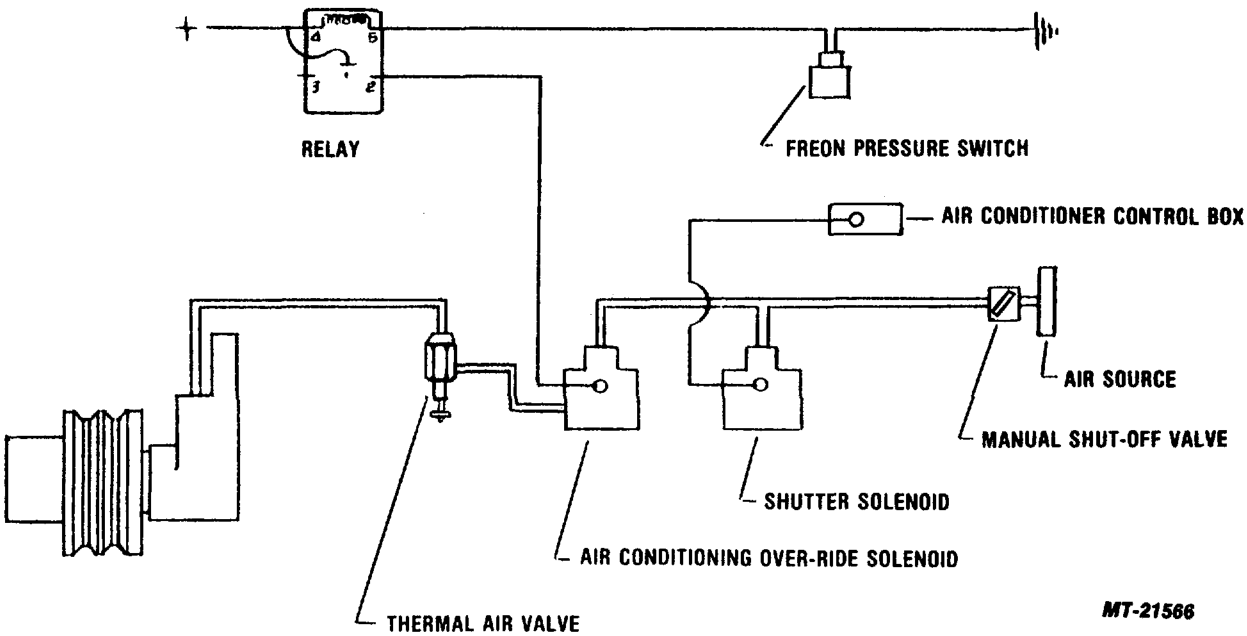

Figure 16

shut off. The Thermal Valve slowly exhausts the air in the clutch and the fan blade smoothly increases to pulley speed.

2. The air supply to the shutterstat is shut off and springs in the shutters open the shutters.

Transtar and Paystar models equipped with shutters have a "T" in the air supply line between the air supply manifold and the Thermal Air Valve. (See Figure 17.) The "T" furnishes a supply of air to the Shutter-stat controlling the shutters. The Shutter-stat should allow the shutters to be wide open before the fan starts to increase speed.

TRANSTAR AND PAYSTAR - without air conditioning - with shutters

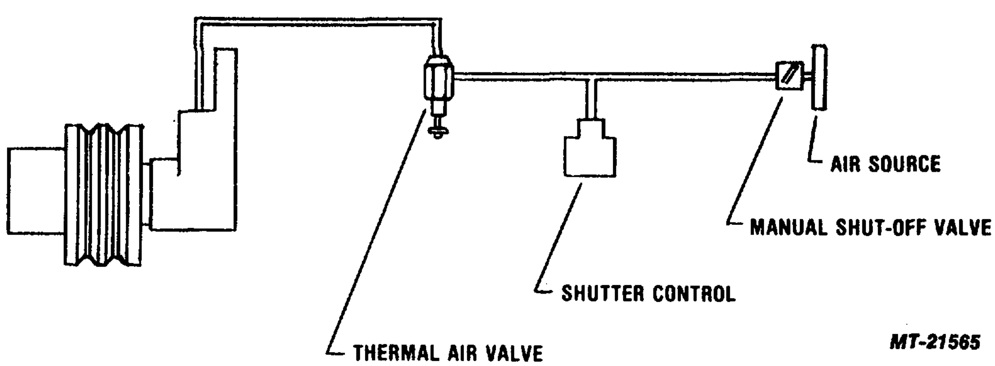

Figure 17

CHAPTER III

MAINTENANCE

The Fan Drive System requires a minimum of maintenance. A few simple checks made periodically will assure correct operation and long life.

Maintenance Checks To Be Made

CAUTION

> Observe all safety precautions when working in the area of the Fan Blade. If working with a running engine, the fan blade will come on automatically without warning when engine temperature rises.

1. Fan Bracket to engine bolts. Check torque after first week of operation and every 40,235 Km (25,000 miles) thereafter.

2. Fan blade to Fan Mounting Hub bolts. Check torque after first week of operation and every 40,235 Km (25,000 miles) thereafter.

3. Fan belts. Maintain proper belt tension as specified by the vehicle, engine or belt manufacturer.

4. Hoses and fittings. Check all hoses and fittings every 40,235 Km (25,000 miles). Replace all soft, brittle or frayed hoses. Tighten all loose or leaking fittings.

5. Thermal Air Valve. Check corrosion build-up on thermal tip after each 16,093,000 Km (100,000 miles). Clean if necessary. DO NOT DISASSEMBLE OR DISTURB SETTING.

6. Electrical. When electrical override systems for air conditioning are used, all electrical connections should be checked for tightness after each 80,465 Km (50,000 miles). All electrical lines should be checked for breaks and frays.

7. Shutters. After each 80,465 Km (50,000 miles) the shutters should be checked to make sure they completely open before the fan comes on.

8. Thermostat. The engine thermostat operation should be checked according to engine manufacturer's specifications and recommendations.

9. Fan Clutch. After each 80,465 Km (50,000 miles) the fan clutch should be checked for signs of internal wear as follows:

a. Bearing wear. With the engine off and no air supply to the fan clutch, push the fan blade forward-rearward. No movement of the Fan Mounting Hub should occur.

b. Clutch Plate Drive Tang wear:

With the engine off and the clutch locked up, push fan blade with a light force clockwise - counter clock-wise. No more than 9.5250mm (3/8") rotational movement should occur at the tip of a 711.2mm (28") blade.

c. Clutch Plate Wear:

Single Belleville Clutch

With the engine off and the clutch locked up, using a pull type scale connected to the fan blade one foot from the center of fan, a pull of 27.2 - 36.3 Kg (60 - 80 lbs.) should be required to rotate the blade independent of the pulley. A pull of 13.6 - 18.1 Kg (30 - 40 lbs.) at two feet from center of fan should be required to rotate blade.

Double Belleville Clutch

With the engine off and the clutch locked up, using a pull type scale connected to the fan blade one foot from the center of fan, a pull of 58.9 - 63.5 Kg (130 - 140 lbs.) should be required to rotate the blade independent of the pulley. A pull of 29.4 - 31.7 Kg (65 - 70 lbs.) at two feet from center of fan should be required to rotate blade.

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CHAPTER IV
TROUBLE SHOOTING

A. BASIC PRELIMINARY CHECKS

BEFORE troubleshooting the Fan Drive System, the following basic principles should be understood:

CAUTION

Observe all safety precautions when working in the area of the Fan Blade. If working with a running engine, the fan will come on automatically when engine temperature rises without warning..

1. The Fan Drive Clutch is NOT A SNAP OFF-SNAP ON type. It is a modulating drive with infinite variable speeds.

2. At idle with a cold engine, the Fan Drive Clutch will be disengaged, but the fan blade will turn 350 - 450 RPM due to viscous drag of the oil between the clutch plates.

3. Air pressure RELEASES the clutch. Without air pressure to the clutch it is LOCKED-UP.

4. The Thermal Air Valve receives its air supply from the vehicle system and regulates the amount of air to the clutch. Air pressure will vary from 0 - 827 kPa (0 psi to 120 psi) on a double Belleville clutch.

5. The Thermal Air Valve is sensitive to engine water temperature and should be located in the thermostat housing ahead of the thermostat. As engine water temperature rises above the minimum specified temperature, the Thermal Air Valve decreases air pressure to the clutch increasing fan speed. As engine water temperature drops, the Thermal Air Valve increases air pressure to the clutch decreasing fan speed.

6. The fan blade free-wheels when engine coolant temperature is below the minimum specified temperature because maximum air pressure is supplied to the clutch.

7. The fan blade rotates at same speed as fan pulley when engine water temperature is above maximum specified operating temperature, because no air pressure is supplied to the clutch.

8. To make accurate checks on items number 4 thru 7 above, place an air pressure gage in the air line BETWEEN the Thermal Air Valve and the Fan Drive Bracket.

9. There is no axial movement of the fan blade with or without air applied to the clutch. The Fan Mounting Hub should not move out or in, front to rear between the radiator and the engine.

10. With no air pressure to the Fan Drive Clutch, 9.5250mm (3/8") total rotational movement is allowable when measured at the tip of a 711.2mm (28") fan blade.

11. Oil lubricates the bearings and cools the clutch plates in the Rockford Fan Drive. Filtered engine oil is piped from an engine oil port thru an orifice fitting to the oil IN port on the Fan Drive Clutch Bracket. The pitot tubes inside the clutch pump the oil out of the clutch thru the oil OUT port in the Fan Drive Clutch Bracket to the engine sump. The clutch breather is plugged. No oil level checks need to be made.

B. TROUBLESHOOTING CHECK PROCEDURES

Check to be Made:	How to Check:	Adjustments/Results
1. Fan Belt Tension	Shut off engine. Check belt tension with gage.	Loosen or tighten to engine manufacturer's specifications Prevents leaks from seals and excessive belt wear.
2. Fan Bracket Bolts	Shut off engine. Use a torque wrench and socket. Check to bolt grade specs. Grade 5 or better should be used.	Tighten to specifications. Aligns pulley and belts correctly. Prevents wobble or excessive belt wear and fan blade from hitting radiator.
3. Fan Blade Bolts	Shut off engine. Use a torque wrench and socket. Check to bolt grade spec. Grade 8 bolts should be used. Run a 0.762mm (.030) feeler gage around the pulley between the end of the bolts and the pulley to assure no bolt contacts pulley.	Tighten to specifications. Eliminates vibration or noise of fan movement. Prevents fan blade from coming off into radiator and failure of clutch bearings due to bolt interference. Grade 8 bolts of correct length allow fan to freewheel and prevents bearing failures.
4. Thermal Air Valve	Place tip of valve in flowing coolant: (a) In vehicle thermo-stat housing or (b) In a container on a bench. Connect full line air pressure to "in" port in thermal air valve: (a) From vehicle supply or (b) Shop air Put air pressure gage in "out" port of thermal air valve. Heat coolant and read temperature. (a) Run engine and read temperature gage or (b) Heat coolant in container with a temperature gage.	Water temperature below thermal air valve operating temperature range, air pressure gage reads maximum pressure. Water temperature above thermal air valve operating temperature range, less than 34.5 kPa (5 psi) air pressure registers on gage.

Check to be Made:	How to Check:	Adjustments/Results
5. Pressure Inside Pulley Cavity. (Installations With Engine Oil Lubrication)	(a) Remove the 3.18mm 1/8") pipe plug from the vent port in the bracket (not from the rear of the shaft). Attach an air gage in the open port. Run engine at idle for 2-3 minutes. Air Gage should read 12 psi or less. Run engine at governed RPM for 2-3 minutes. Air gage should drop to 20.7 kPa (3 psi) or less. (b) If no 3.18mm (1/8") pipe exists, the above checks cannot be made.	(a) If air gage exceeds 83 kPa (12 psi), check installation hook-up for proper oil and air line positions. Check to insure orifice fitting is installed at engine oil supply port. If hook-up is correct and orifice is installed, replace clutch. (b) If air constantly comes out crankcase vent, replace clutch.
6. Bearing Wear	Engine off. Engine coolant cool. At fan mounting hub, pull fan blade forward and Then push towards engine. No axial movement should occur at Fan Mounting Hub.	Fan blade hub moves axially, replace clutch. No fan blade axial movement, bearings are tight. Prevents blade from going into radiator.

C. PROBLEMS AND SOLUTIONS

Problem	Check	Cure
Engine runs hot	(1) Coolant level low.	(1) Fill radiator to correct level.
	(2) Fan belts slipping	(2) Tighten to engine manufacturer's specifications.
	(3) Thermostat not operating.	(3) Replace thermostat.
	(4) Radiator or front mounted condenser plugged internally or externally.	(4) Clean radiator and/or condenser coil.
	(5) Thermal air valve not operating. Read air pressure between thermal air valve and fan clutch. If air pressure more than 34.5 kPa (5 psi) with water temperature above maximum temperature range -	(5) Replace thermal air valve.
	(6) Thermal air valve located in wrong place in cooling system.	(6) Check heat range of thermal air valve and relocate.
	(7) Fan drive does not turn fan blade at maximum pulley speed. Rear air pressure between thermal air valve and fan clutch. If air pressure less than 34.5 kPa (5 psi) with water temperature above maximum temperature range -	(7) Replace fan clutch.
	(8) Shutters inoperative and remain closed.	(8) Repair shutters and/or shutter control.
	(9) Water pump defective.	(9) Replace water pump.

Problem	Check	Cure
Engine runs cold	(1) Thermostat stuck open.	(1) Replace thermostat.
	(2) Thermal air valve closed. No air supply to fan clutch.	(2) Replace thermal air valve.
	(3) Cooling system bypassing excessive water.	(3) Repair in accordance with Engine manufacturer's recommendations.
	(4) Check air pressure in-air line to clutch. If full air pressure present and fan is locked up -	(4) Replace fan clutch.
	(5) Air conditioning/shutters/ clutch control system malfunctioning.	(5) Troubleshoot clutch control system per vehicle manufacturer's specifications.
Fan blade runs continuously at engine speed.	(1) Length of bolts that bolt fan to fan mounting hub. If bolts extend thru hub and contact pulley, fan will run continuously.	(1) Replace bolts with grade 8 bolts that fit full thread in fan mounting hub but do not extend thru.
	(2) Thermal air valve. With a cold engine, Thermal Air Valve should send 345 kPa (50 psi) air pressure to single Belle-ville clutch, 552 kPa (80 psi) air pressure to double Belleville clutch. Put pressure gage in air line between thermal air valve and fan drive bracket. If not full pressure -	(2) Replace thermal air valve.
	(3) Air supply to thermal air valve. Put pressure gage in air line to thermal air valve. Should regis-ter 345 kPa (50 psi) single Belleville or 552 kPa (80 psi) double Belleville vehicle air pressure.	(3) Find reason vehicle air system not supplying air pressure.
	(4) Manual override switch. Some vehicles are equipp-ed with a manual override switch in the cab which shuts off air to the ther-mal air valve and man-ually engages the clutch.	(4) Turn switch to "off" or replace defective switch.

Problem	Check	Cure
	(5) If vehicle is equipped with air conditioning freon compressor over-ride system -	(5) Insure full vehicle air pressure is going to thermal air valve.
	(6) With engine shut off, apply shop air directly to fan drive air connection. Fan blade should rotate freely.	(6) If blade does not rotate freely, replace fan clutch.
	(7) Air conditioning/shutter/ clutch control system malfunctioning.	(7) Troubleshoot Clutch Control System per vehicle manufacturer's specifications.
Fan Clutch does not lock up. Fan blade runs continuously at idle speed (350-450 RPM)	(1) With engine shut off, disengage air line between thermal air valve and fan drive bracket. Clutch should engage and fan blade should not rotate. If blade rotates -	(1) Replace fan clutch.
	(2) With engine stopped and air line between thermal air valve and fan bracket disconnected, fan blade can be rotated with less 22.6 Kg (50 lbs.) pull on blade.	(2) Fan clutch plates worn. Replace fan clutch.
Fan drive cycles off and on continuously.	(1) Coolant level low.	(1) Fill radiator to proper level.
	(2) Radiator partially plugged internally or externally causing too much heat retention.	(2) Clean radiator.
	(3) Manual override system. If system is electric, short or frayed wires could cause.	(3) Repair or replace defective controls.
	(4) Check air conditioner override system. Short in electrical system. Defective solenoid on freon compressor.	(4) Repair or replace defective controls.
	(5) Heat range setting of thermostat and thermal air valve not compatible -	(5) Replace either thermostat or thermal air valve with different temperature setting to obtain proper sequential operation.

Problem	Check	Cure
Fan Clutch noisy	(1) Length of bolts holding fan blade to fan hub. (2) Fan blade loose on fan hub. (3) Fan bracket mounting bolts loose. (4) Fan belts hard, cracking or fraying. (5) Disconnect air line to clutch, move fan blade tip in and out between engine and radiator. There should be no forward-rearward movement of the fan mounting hub. (6) With air line to clutch disconnected, rotate fan blade tip clockwise-counter-clockwise. 0.5250mm (3/8" max.) movement 711.2mm (28") from center of hub.	(1) Replace bolts if too long and contacting pulley. (2) Tighten fan blade bolts to specifications. Grade 8 required. (3) Tighten fan bracket mounting bolts to specifications. (4) Replace fan belts. (5) Replace fan drive. (6) Replace fan drive. Excessive wear has occurred between tangs of steel plates and driving slots in bearing retainer.
Fan squeals as it engages.	(1) Fan belts loose and slipping. (2) Bolts securing fan blade to fan hub too long and contacting front retainer. (3) Fan drive oil level low. Check for forward--reverse movement on fan blade, if any -	(1) Set fan belt tension to manufacturer's specs. (2) Remove and replace with bolts of proper length. Grade 8 bolts required. (3) Replace fan clutch. Bearings are failed. Determine cause of oil starvation
Oil level of fan drive low.	(1) Seals leaking. (2) Oil coming from breather intermittently. (3) Oil leaking from fittings or hoses. (4) Oil coming out of breather continuously. Attach air pressure gage to breather port, if more than 69 kPa (10 psi) - (5) Seals leaking due to excessive belt tension.	(1) Replace fan drive. (2) Replace breather with 3.18mm (1/8") plug. (3) Tighten fittings. Replace oil hoses if worn or damaged. (4) Fan drive bypassing air internally. Replace fan clutch. (5) Set belt tension to engine manufacturer's specifications.

Problem	Check	Cure
Oil leaking from seals.	(1) Belt tension of drive belts excessive. (2) If belt tension o.k. and seals continue to leak. (3) Bolts holding fan blade to hub. If too long and contacting pulley, replace bolts. If leak continues -	(1) Set belt tension to Engine manufacturer's specs. (2) Replace fan clutch. (3) Replace fan clutch.
Oil out of breather	(1) Oil level of fan drive with the (2) plugs on O.D. of pulley at 11 o'clock and 2 o'clock. Oil should be at 2 o'clock level. (2) With engine running, tap top of breather. Breather should not remain open. (3) Run engine. If oil continuously comes out of breather, attach pressure gage into breather port. Pressure should not exceed 83 kPa (12 psi).	(1) Replace breather with 3.18mm (1/8") plug if pulley cavity pressure is 12 psi or less. (2) Replace breather with 3.18mm (1/8") plug if pulley cavity pressure is 83 kPa (12 psi) or less. (3) Fan drive bypassing air internally if over 83 kPa (12 psi). Replace fan clutch.
Air constantly coming out of breather in oil cooler installations.	(1) With engine shut off, remove air line from Thermal Air Valve to fan drive. Air should stop.	(1) O-rings in fan drive leaking. Replace fan drive.
Air constantly coming out of vent tube of engine in engine oil installations.	(1) With engine shut off, disconnect drain line from clutch to engine. Attach pressure gage. No pressure should register. If pressure - (2) With engine shut off, disconnect air line to fan clutch. Air should stop coming out of engine vent tube.	(1) O-rings in fan clutch leaking air. Replace fan clutch. (2) O-rings in fan clutch leaking air. Replace fan clutch.
Thermal air valve hisses constantly.	(1) With engine shut off and cool engine temperature, thermal air valve should not bypass air.	(1) Replace thermal air valve. Clean or replace air filter. If air line to thermal valve is contaminated, clean and install air filter.

CHAPTER V
OVERHAUL PROCEDURE

GENERAL

A step-by-step procedure has been established assuring a properly rebuilt product capable of giving long continuous service. This procedure should be followed precisely, using care and cautions to prevent damage caused by excessive force, mishandling, or abusive assembly procedures.

Successful overhaul can only be accomplished by the use of certain special procedures and tools. The tools in the Rockford Tool Kit assure proper positioning of essential components, and are designed to guarantee assembly of parts meeting engineered specifications, and enable the completion of the overhaul in an absolute minimum amount of time.

The Rockford Fan Drive Overhaul Tool Kit, SE-2782 (shown below) may be ordered from Rockford Clutch under part number 3-462-902-24460. These tools are neatly packaged in one self-contained rugged carrying case.

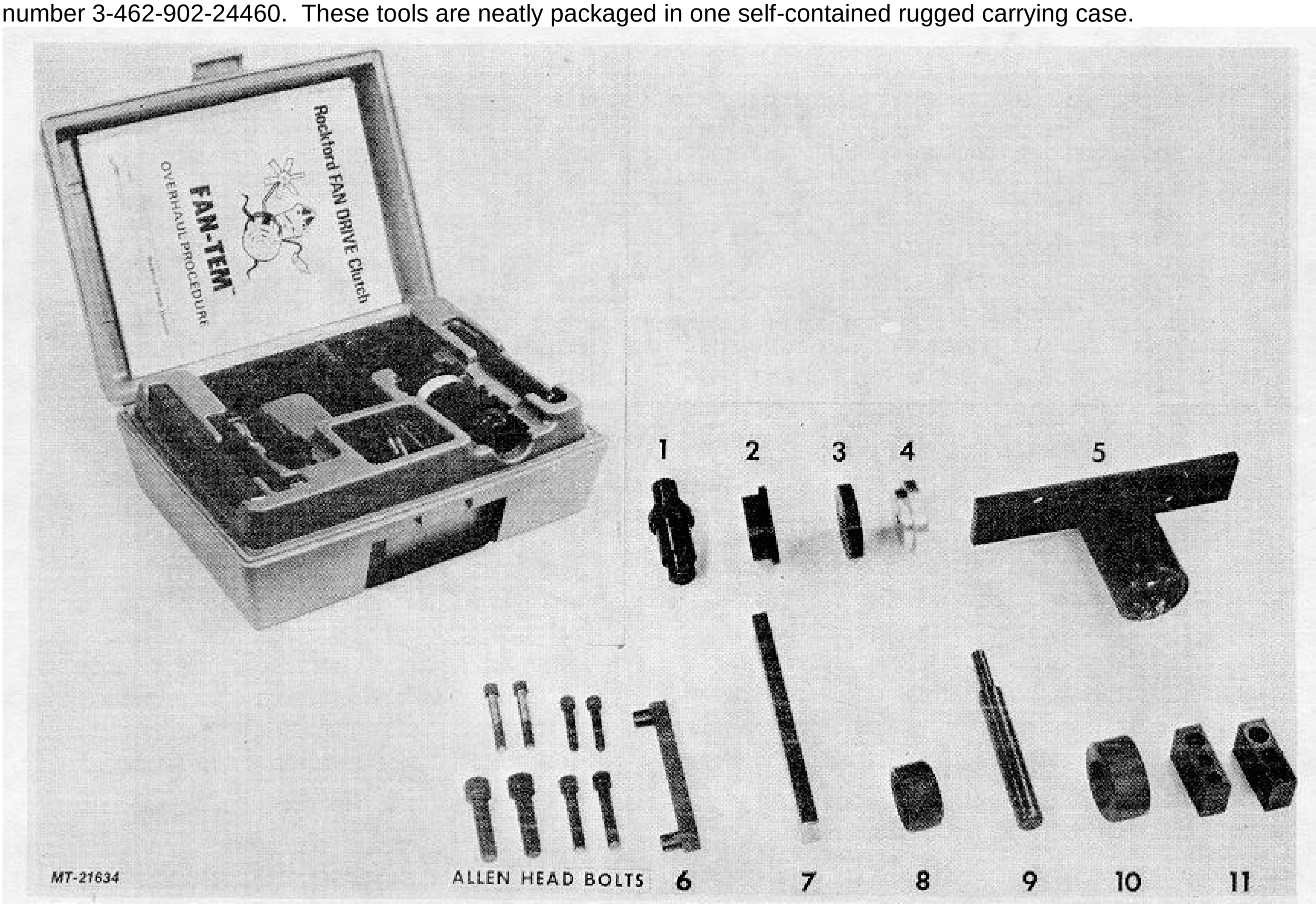


Fig. 1

LEGEND FOR FIG. 1

Item No.	Description	Tool Number
1.	Installer, Needle Bearings	SE-2782-1
2.	Installer, Bearing Cup	SE-2782-2
3.	Protector, Fan Hub	SE-2782-3
4.	Installer, Oil Seal	SE-2782-4
5.	"T" Shaped Fixture	SE-2782-5
6.	Straddle Tool	SE-2782-6
7.	Straight Edge	SE-2782-7
8.	Protector, Shaft	SE-2782-8
9.	Driver Mandel	SE-2782-9
10.	Installer, Bearing Cone	SE-2782-10
11.	Spacer Blocks	SE-2782-11

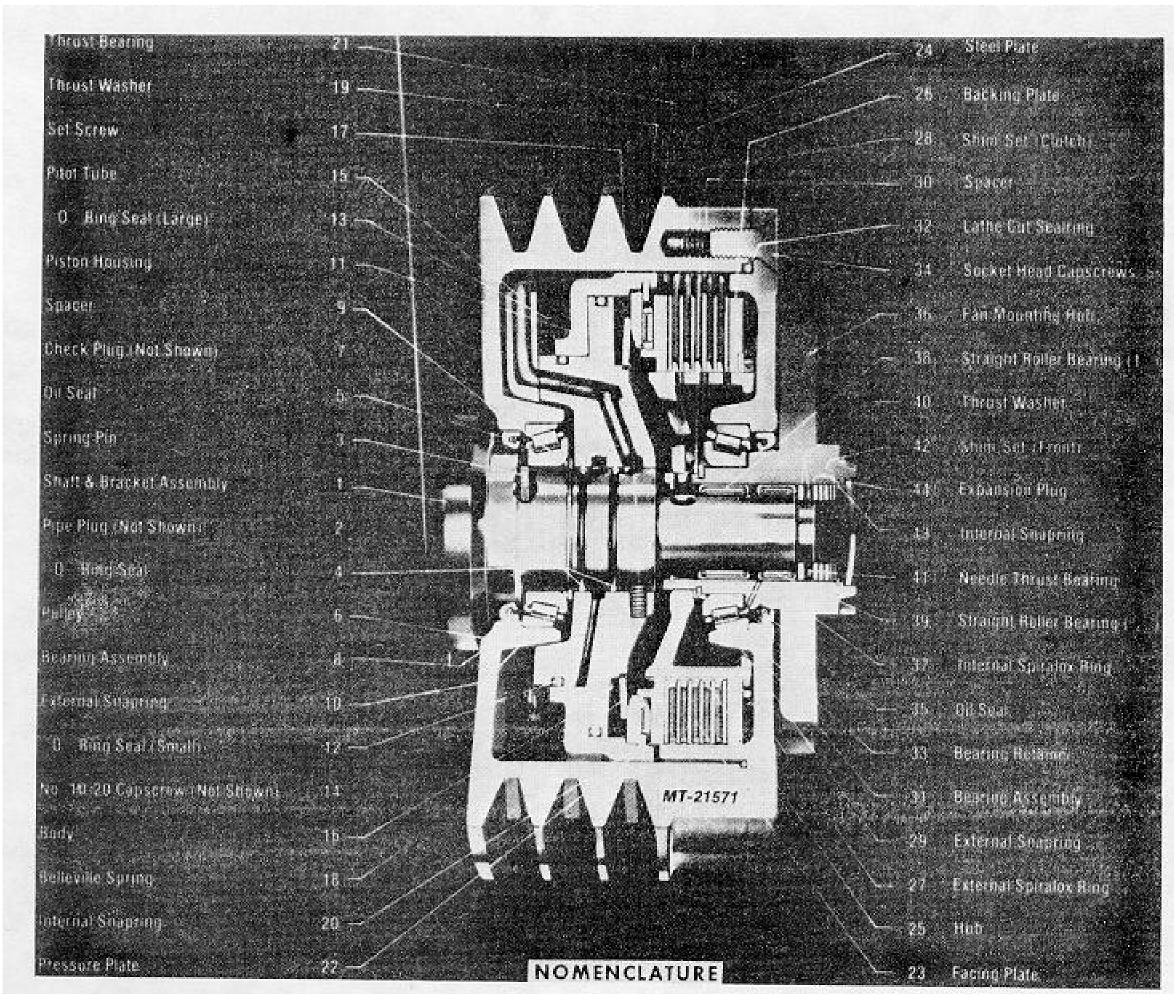


Fig. 2

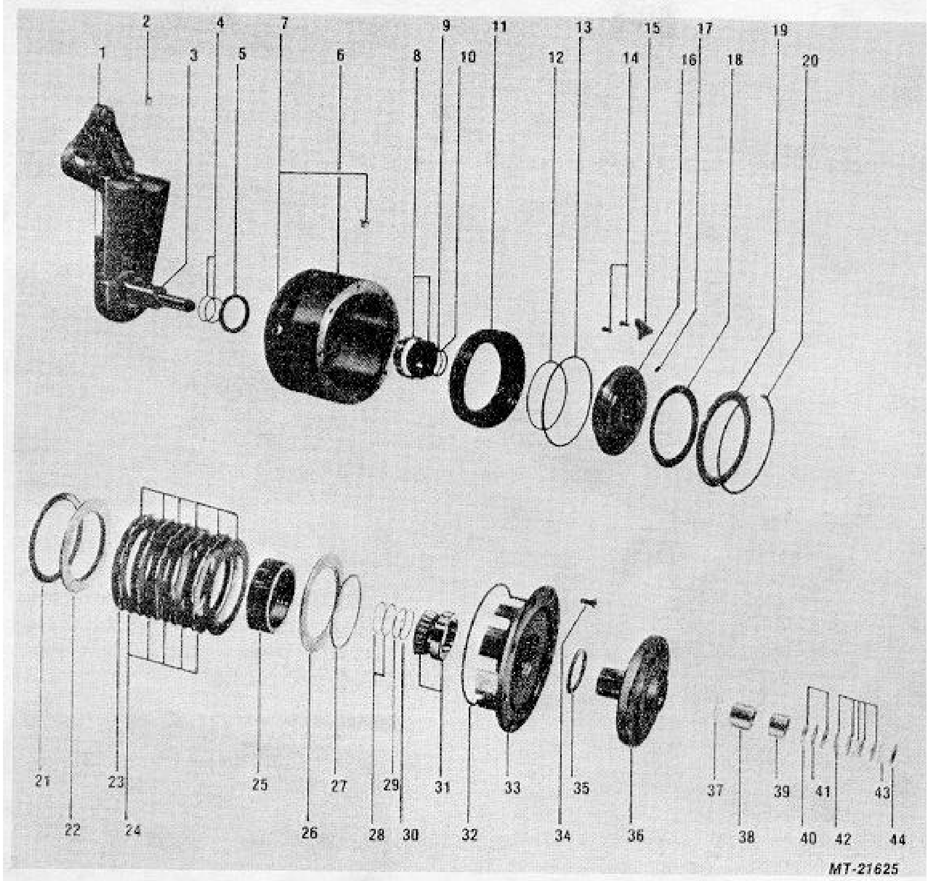


FIG. 3 EXPLODED VIEW OF FAN CLUTCH

LEGEND FOR FIG. 3

Key No.	Description	Key No.	Description
1.	Shaft and Bracket Assembly	23.	Plate, Facing
2.	Plug, Pipe	24.	Plate, Steel
3.	Spring Pin	25.	Hub
4.	"O" Ring Seal	26.	Plate, Backing
5.	Seal, oil	27.	Ring, Spiralox
6.	Pulley	28.	Shim, set, Clutch
7.	Plug	29.	Snapring
8.	Bearing, Assembly	30.	Spacer
9.	Spacer	31.	Bearing, Assembly
10.	Snapring	32.	Seal Ring
11.	Housing, Piston	33.	Retainer, Bearing
12.	"O" Ring Seal (Small)	34.	Capscrew, Socket Head
13.	"O" Ring Seal (Large)	35.	Seal, Oil
14.	Capscrews	36.	Hub, Fan Mounting
15.	Tube, Pitot	37.	Ring, Spiralox
16.	Body	38.	Bearing, Straight Roller (Long)
17.	Set Screw	39.	Bearing, Straight Roller (Short)
18.	Belleville Spring	40.	Washer, Thrust
19.	Washer, Thrust	41.	Bearing, Thrust, Needle
20.	Snap Ring	42.	Shim, Set
21.	Bearing, Thrust	43.	Snap Ring
22.	Plate, Pressure	44.	Plug, Expansion

DISASSEMBLY

1. Remove (8) Socket Head Capscrews, Fig. 4.

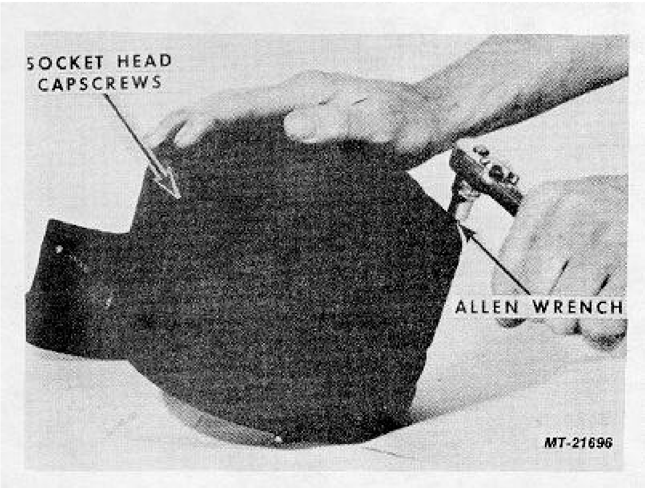


Fig. 4

2. Lift Bearing Retainer from Pulley, Fig. 5

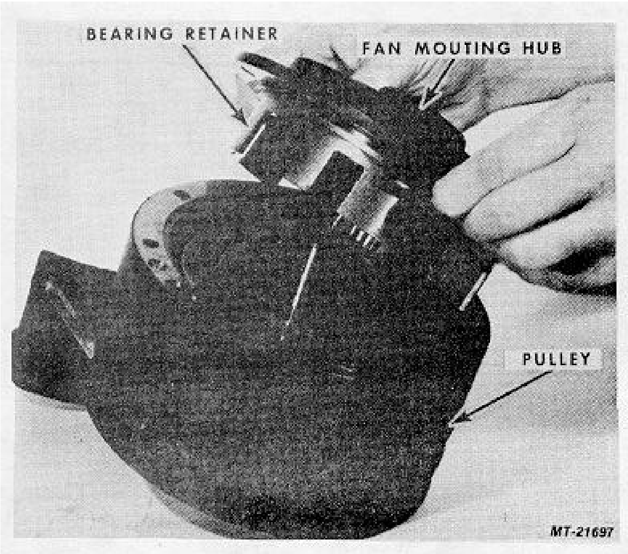


Fig. 5

3. Remove Sealring and discard, Fig. 6.

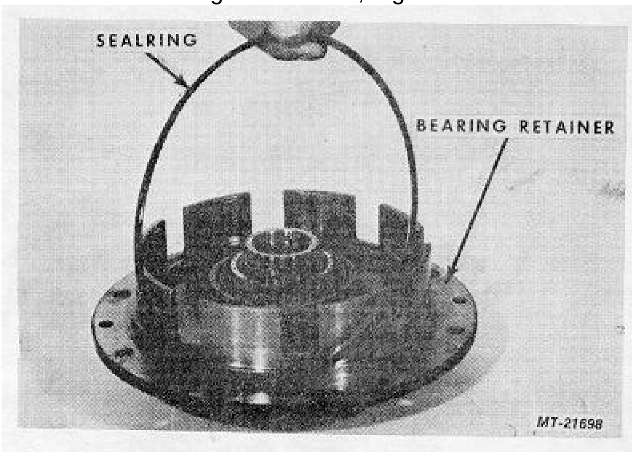


Fig. 6

4. Support beneath Fan Mounting Hub. Place installer SE-2782-10 on Bearing Assembly and press the bearing down approximately 1/16", Fig. 7.

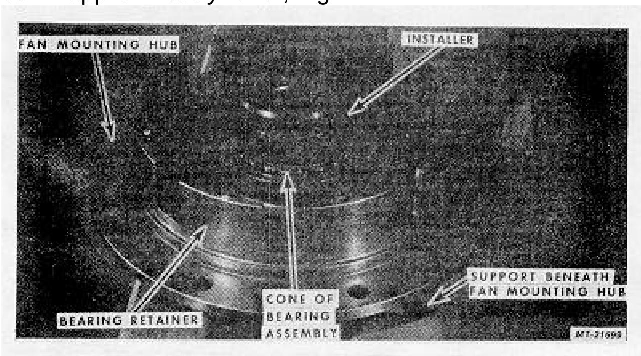


Fig. 7

5. Remove External Snapring, Fig. 8.

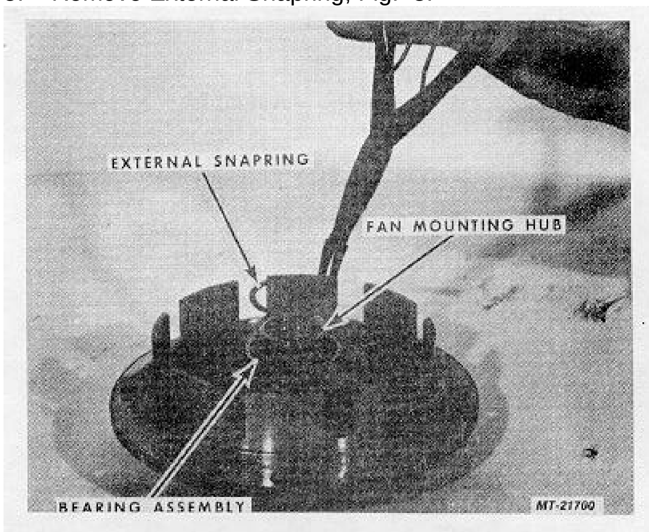


Fig. 8

6. Remove Internal Spiralox Ring, Fig. 9.

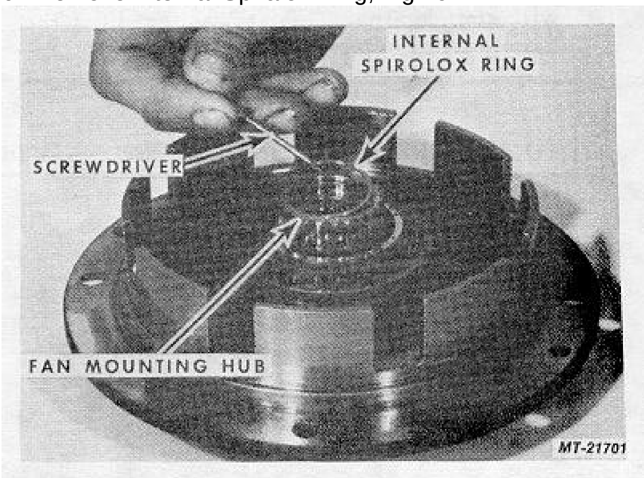


Fig. 9

7. Support beneath Bearing Retainer as close as possible to Fan Mounting Hub. Insert the short end of Installer SE-2782-1 in the end of the Fan Mounting Hub, Fig. 10.

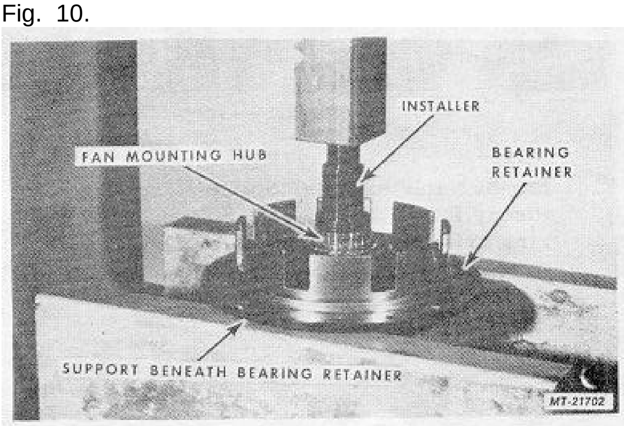


Fig. 10

8. Using short end of Installer SE-2782-1, press out Fan Mounting Hub, Fig. 11.

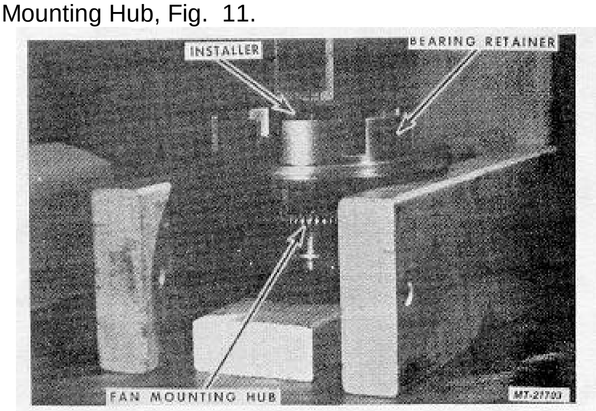


Fig. 11

9. Remove Spacer Ring and cone of Bearing Assembly, Fig. 12.

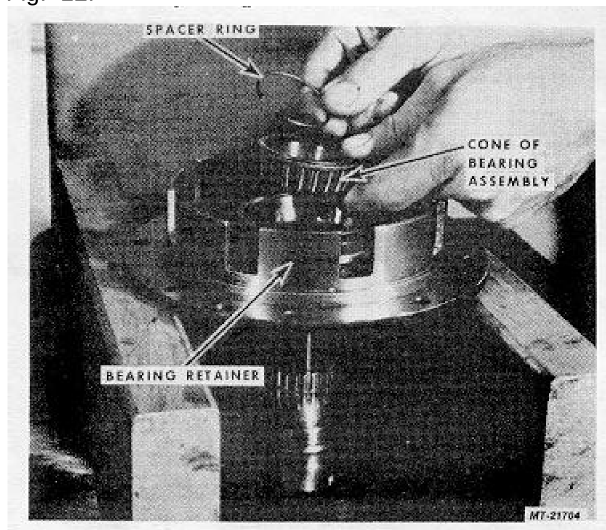


Fig. 12

10. Center shaft protector SE-2782-8 and Fan Mounting Hub Protector SE-2782-3 as shown on Oil Seal, Fig. 13.

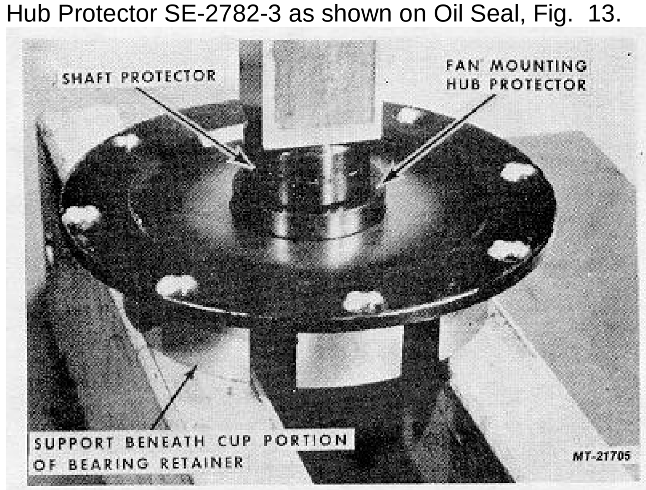


Fig. 13

11. Press out Oil Seal and the cup of Bearing Assembly, Fig. 14.

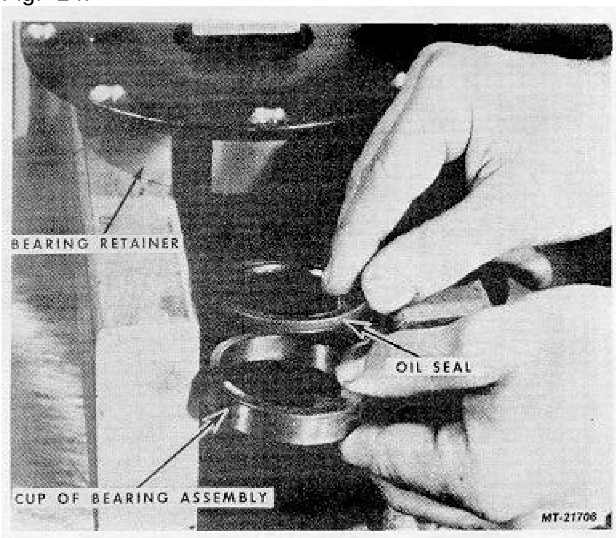


Fig. 14

12. Place Driver Mandel SE-2782-9 down through the center of Fan Mounting Hub to rest against Expansion Plug, Fig. 15. Be sure the driver mandel is resting on the Expansion Plug rather than on Bearings or Shims inside the bore.

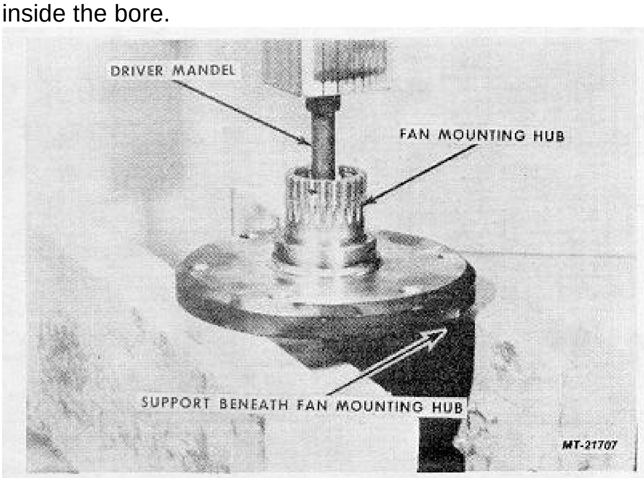


Fig. 15

13. Press out Expansion Plug, Fig. 16. The shoulder on Driver Mandel SE-2782-9 will stop against Thrust Washer after the Expansion Plug has fallen free.

IMPORTANT
DO NOT PRESS AGAINST THRUST WASHER

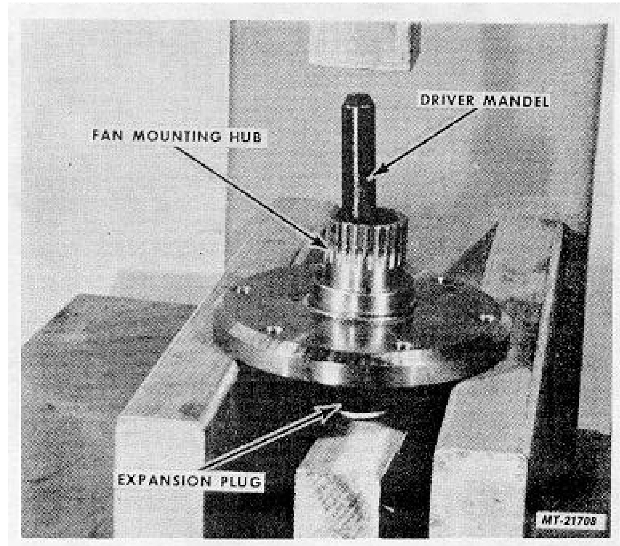


Fig. 16

14. Remove the Internal Spiralox Ring and discard, Fig. 17. The Spiralox style snapring will be replaced with a "C" shaped internal snapring upon reassembly of the Fan Clutch.

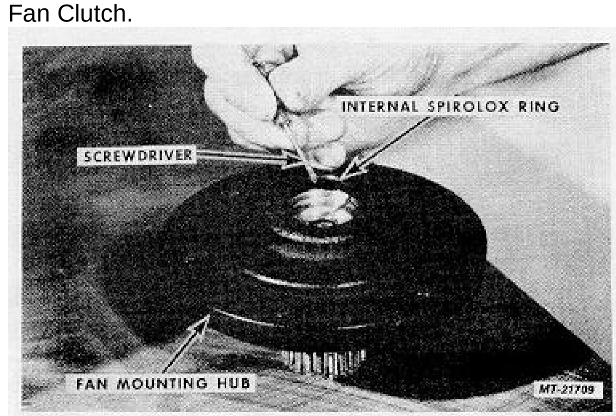


Fig. 17

15. Insert the small end of Driver Mandel, SE-2782-9 through the center hole in the washers, Fig. 18.

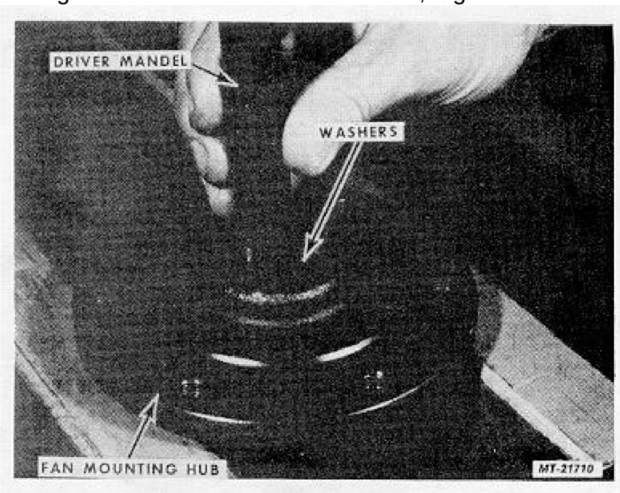


Fig. 18

16. Using Driver Mandel SE-2782-9 press Straight Roller Bearings, Thrust Washers, Thrust Bearing, Belleville Washers and Spacer Washers from the bore, Fig. 19. If the Fan Clutch has been previously overhauled, Belleville Washers may have been replaced with spacers and shims.

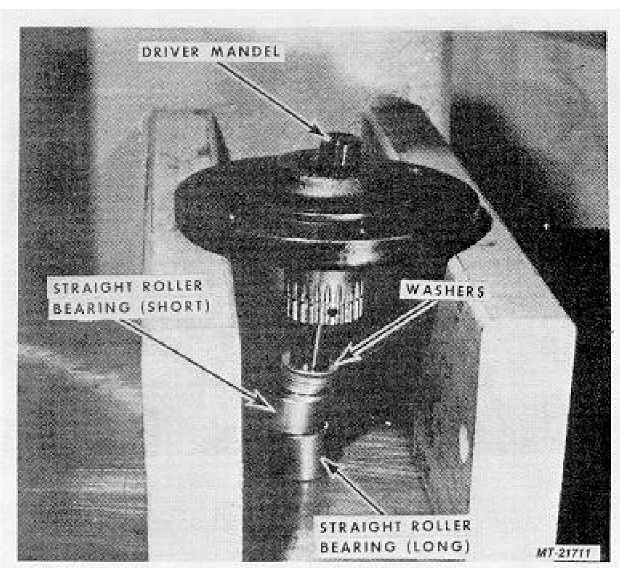


Fig. 19

17. Remove shims from against the center spline of Hub, Fig. 20. Tag undamaged shims and set aside for later use.

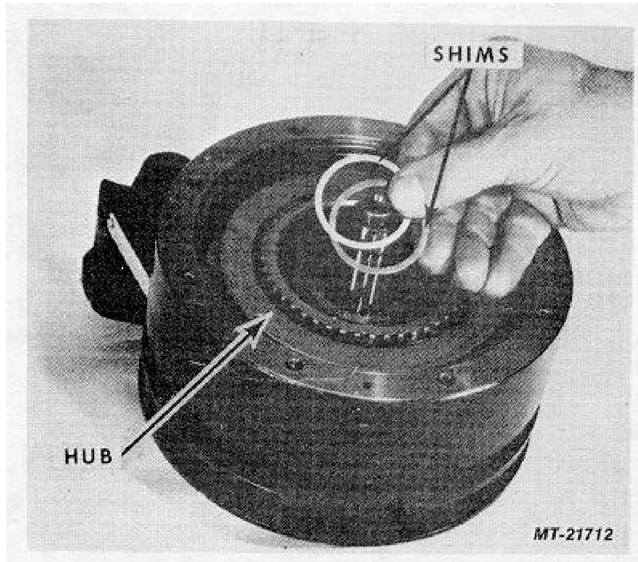


Fig. 20

18. Remove Hub with Backing Plate, Fig. 21.

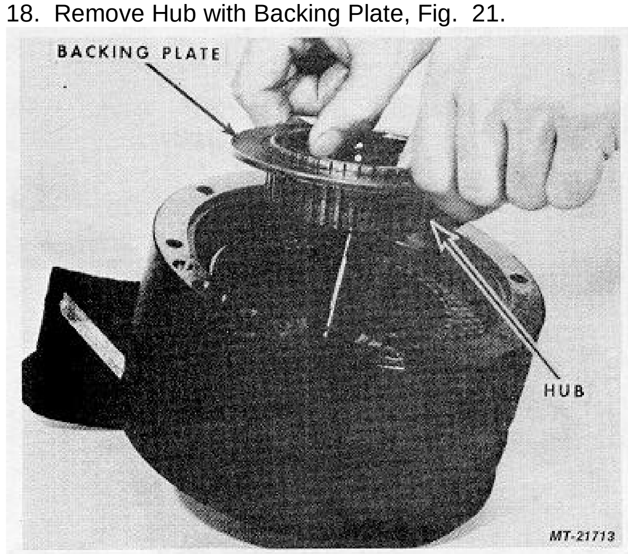


Fig. 21

19. Using screwdriver remove External Spiralox Ring and remove Backing Plate, Fig. 22.

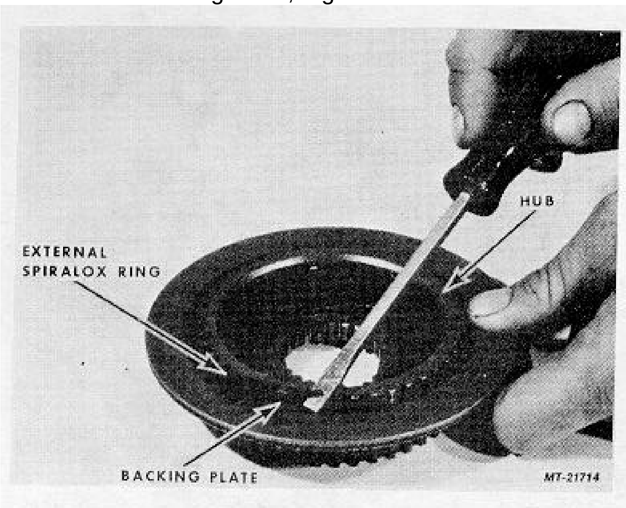


Fig. 22

20. Remove the stack of plates consisting of Facing Plates, Steel Plates, and a Pressure Plate, Fig. 23.

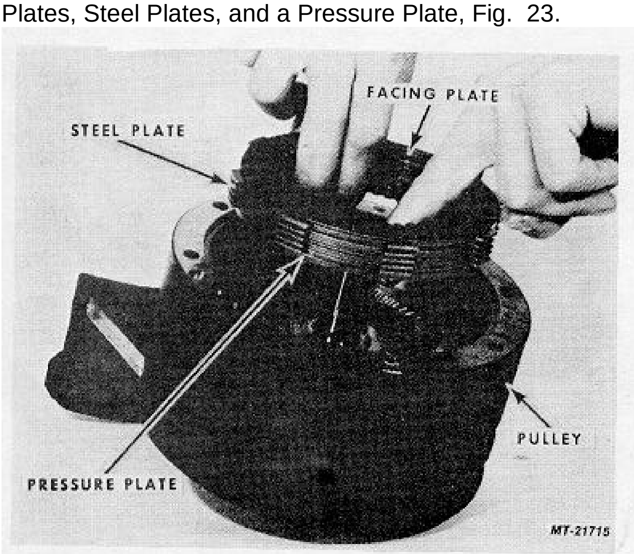


Fig. 23

21. Remove Thrust Bearing, Fig. 24.

Fig. 24

22. Loosen Set Screw until at least 1/4" of the set screw is exposed. Fig. 25.

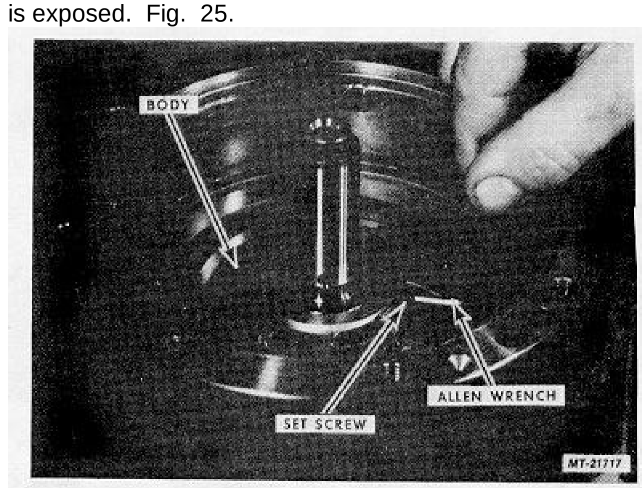


Fig. 25

23. Bump the end of the shaft on a hard wood block. The Load Cell Assembly will drop from the Shaft, Fig. 26.

IMPORTANT

Do not hit against steel or other metal object. The shaft will be damaged, causing it to be scrap

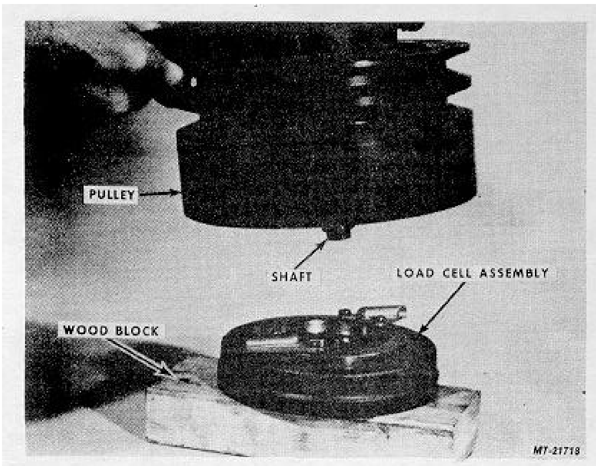


Fig. 26

24. Remove Capscrews and Pilot Tubes, Fig.27.

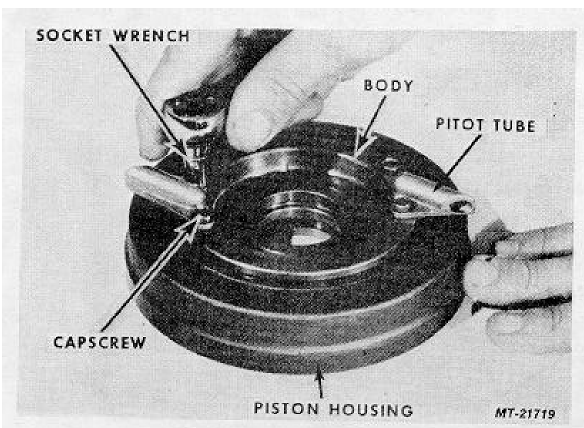


Fig. 27

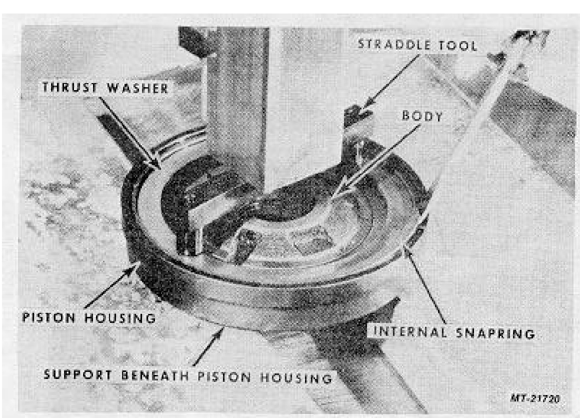


Fig. 28

25. Center Straddle Tool, SE-2782-6 on Thrust Washer. Press Thrust Washer down 1/32" to allow removal of Internal Snapring, Fig. 28. DO NOT PRESS DOWN MORE THAN 1/32". Movement will stop at that point and further force will damage parts.

26. Remove Internal Snapring, Thrust Washer and Belleville Spring, Fig. 29.

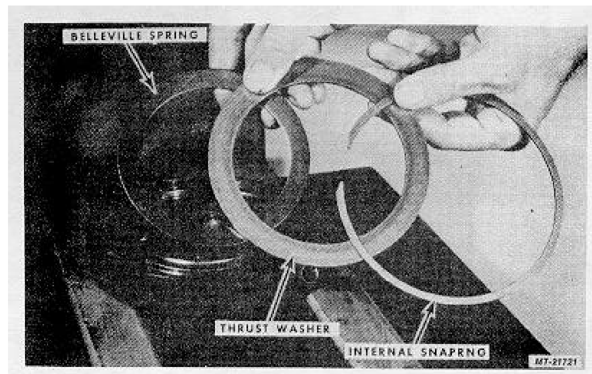


Fig. 29

27. Gently tap Piston Housing from Body, Fig. 30.

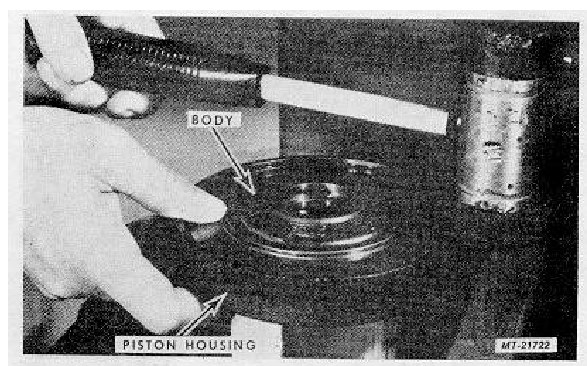


Fig. 30

28. Remove "O" Ring Seals. Fig. 31.

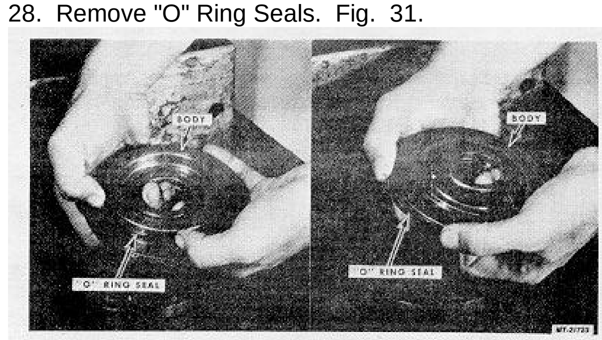


Fig. 31

29. Support beneath the bracket. Using the "T" shaped fixture SE-2782-5 press, the cone of Bearing Assembly down 1/16".

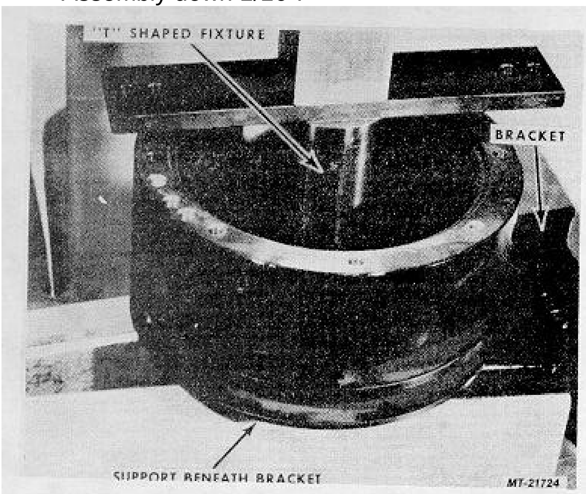


Fig. 32

30. Remove External Snapring, Fig. 33.

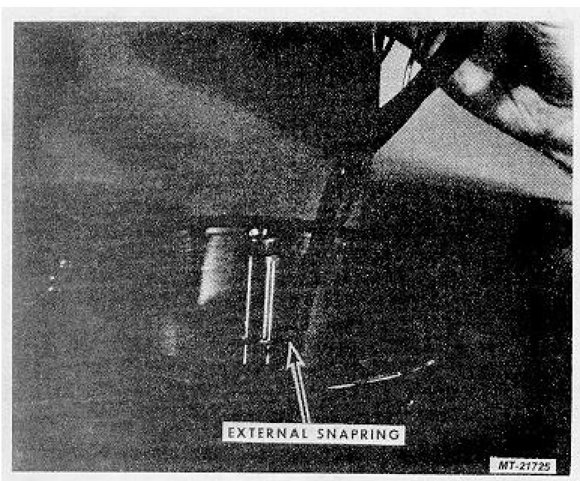


Fig. 33

31. Support beneath the Pulley. Using shaft protector SE-2782-8, press out the Shaft & Bracket Assembly.

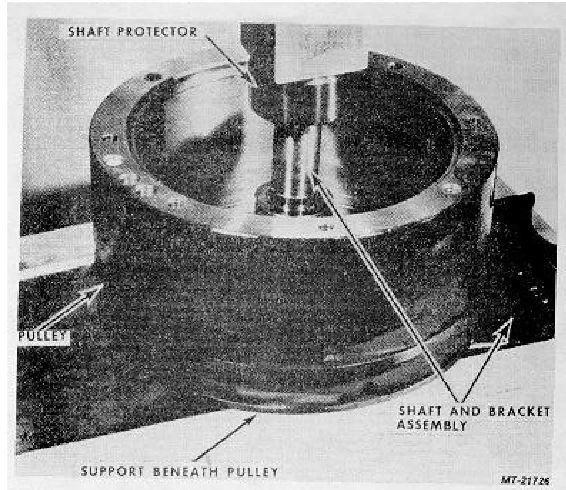


Fig. 34

32. Remove Spacer Ring and the cone of Bearing Assembly, Fig. 35.

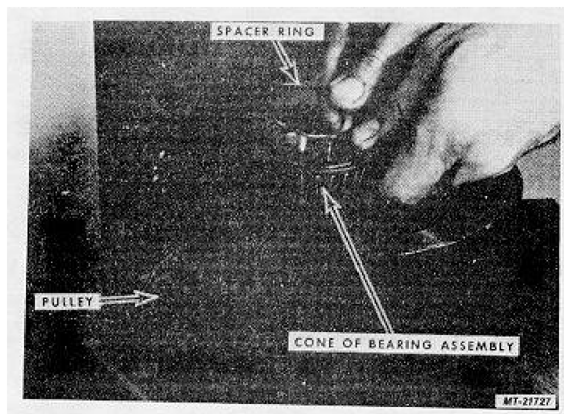


Fig. 35.

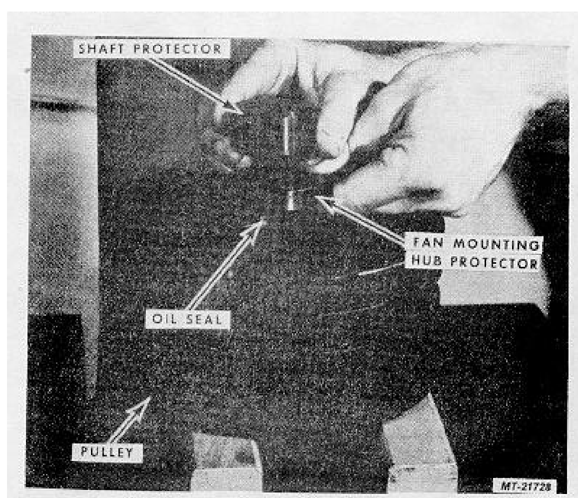


Fig. 36.

33. Place shaft protector SE-2782-8 and fan mounting hub protector SE-2782-3 on Oil Seal, Fig. 36.

34. Press out Oil Seal and the cup of Bearing Assembly, Fig. 37.

IMPORTANT

DISASSEMBLY OF THE FAN CLUTCH IS COMPLETE. DO NOT ATTEMPT TO REMOVE SHAFT FROM BRACKET.

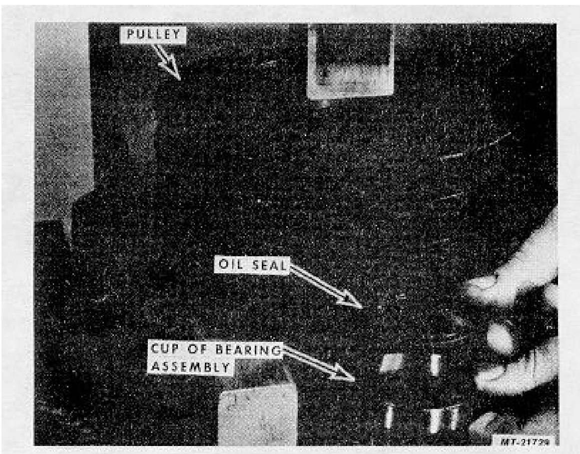


Fig. 37

PREPARATION FOR REASSEMBLY

WASH ALL PARTS THOROUGHLY IN CLEAN SOLVENT.

a. Remove all plugs and fittings from Shaft & Bracket Assembly. Flush all passageways with clean solvent. Flush from both directions.

   Replace plugs and fittings using Loctite #242 on the threads.

   Remove the breather from Bracket and replace with Pipe Plug. Use Loctite #242 on threads of the pipe plug. Discard breather.

b. Discard all "O" Rings, Sealrings and Oil Seals.

c. Discard all Bearings, Thrust Washers and Belleville Washers.

d. Check Bearing contact surfaces on shaft. If brinelling is present, replace the Shaft and Bracket Assembly.

e. Wear on tangs of Steel Plates and on slots of Bearing Retainer must not exceed .010" depth and must not have straight sides which cause a notch to be formed.

f. Discard Steel Plates and Facing Plates that have been discolored by heat. Steel Plates must be flat.

g. Facing plates are .060" thick when new and worn out at the bottom of the grooves.

h. Pressure Plate and Thrust Washer must not contain "tracks" or wear from Thrust Bearing.

i. Oil Seal contact surfaces on Shaft and Fan Mounting Hub must be smooth and unworn.

j. All snapring grooves must have straight sides and square corners.

k. Clean old Loctite and sealant from all surfaces. Check all chamfers for nicks and burrs which may cut or damage Oil Seals or "O" Ring Seals.

ASSEMBLY

1. Using Installer SE-2782-1, press Straight Roller Bearing (short) down with the long end of Installer SE-2782-1 until the tool shoulder bottoms against the end of Fan Mounting Hub, Fig. 38.

IMPORTANT

Lettering on the end of the bearing must be up (against the tool shoulder).

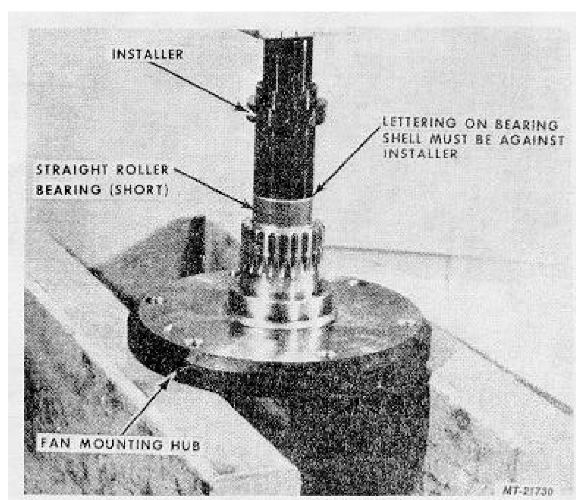


Fig. 38

2. Using Installer SE-2782-1, press Straight Roller Bearing (long) down with the short end of Installer SE-2782-1 until the tool shoulder bottoms against the end of Fan Mounting Hub, Fig. 39.

IMPORTANT

Lettering on the end of the bearing must be up (against the tool shoulder).

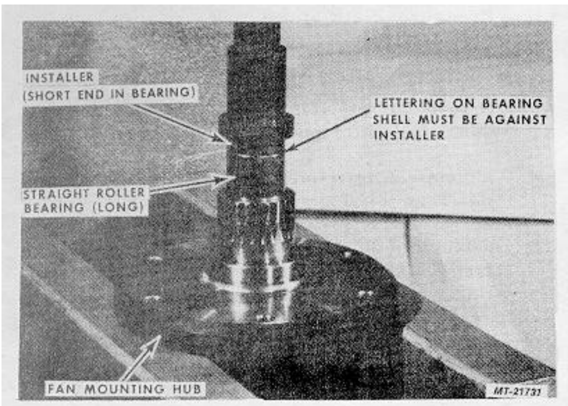


Fig. 39

3. Install Internal Spiralox Ring in the groove, Fig. 40.

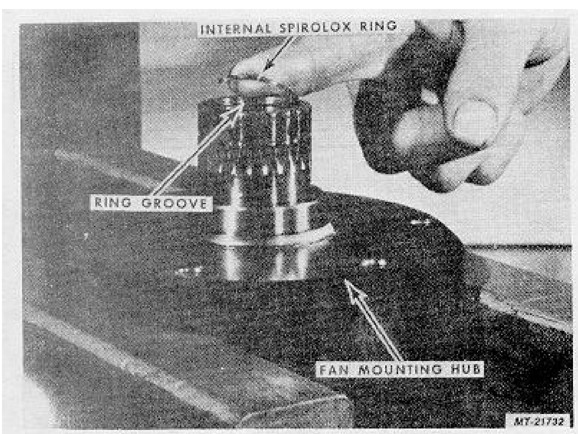


Fig. 40

4. Support Bearing Retainer with Installer SE-2782-2 located in the bearing bore of the Bearing Retainer and over "T" shaped fixture SE-2782-5, Fig. 41.

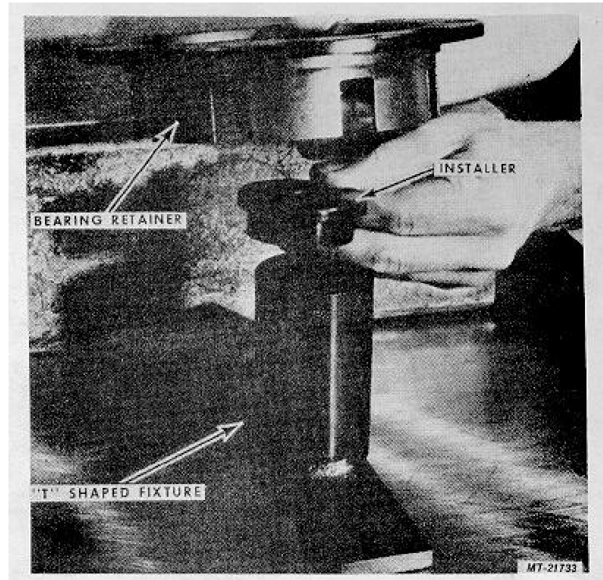


Fig. 41

5. Lubricate the seal contact diameter of Installer SE-2782-4 with engine oil. Place Oil Seal on the Installer SE-2782-4 with the lip exposed as shown. Fig. 42.

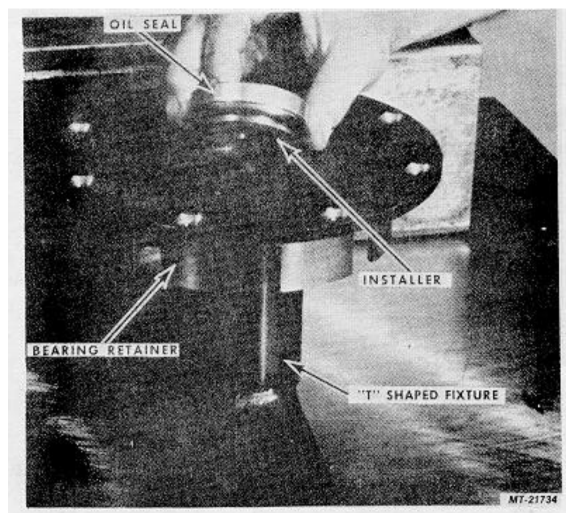


Fig. 42

6. Align Oil Seal straight with the bore and press the oil seal down until the Installer SE-2782-4 bottoms. After the Installer SE-2782-4 bottoms, rotate the Bearing Retainer to several different positions, each time pressing down to insure proper seating of the Installer SE-2782-4, Fig. 43.

IMPORTANT

An oil seal will not align itself during installation into a bore. If the oil seal is misaligned before it is installed, it will remain misaligned and will leak.

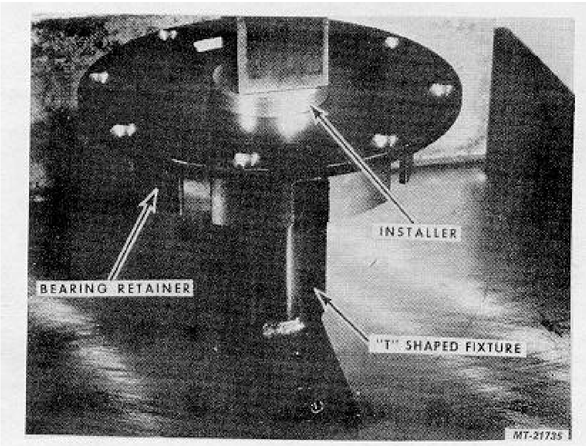


Fig. 43

7. Position Installer SE-2782-2 on the cup of Bearing Assembly and press down until the Installer bottoms, Fig. 44.

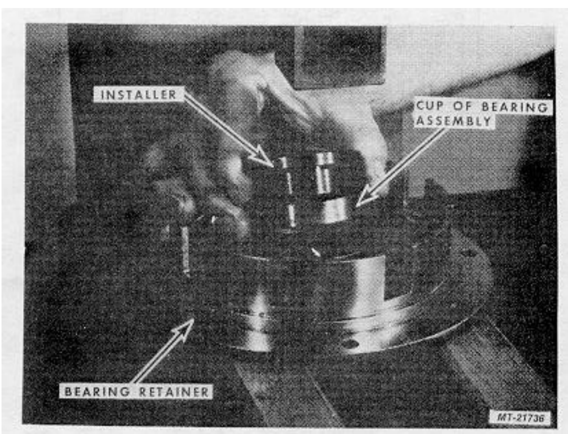


Fig. 44

8. Carefully place the Bearing Retainer Assembly on the Fan Mounting Hub Assembly.

IMPORTANT

Use proper care to prevent damaging the lip of Oil Seal, Fig. 45. Fig. 45

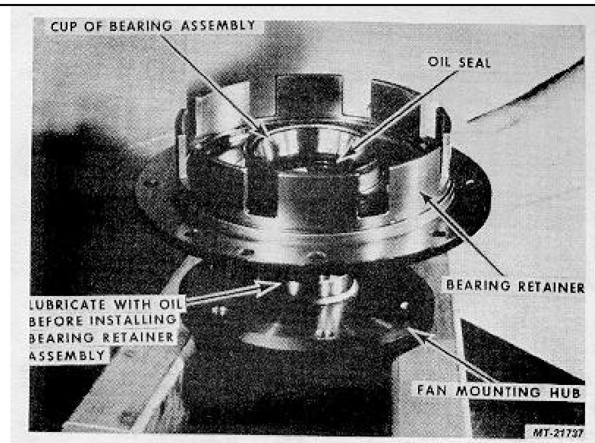


Fig. 45

9. Support beneath Fan Mounting Hub. Place the cone of Bearing Assembly on the Fan Mounting Hub and using Installer SE-2782-10 press down until Installer bottoms, Fig. 46

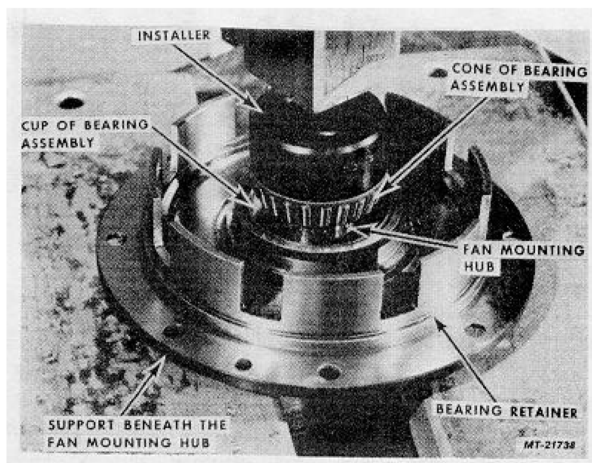


Fig. 46

10. Install Spacer Ring and External Snapring, Fig. 47.

IMPORTANT

Spacer Ring must be against the Bearing cone.

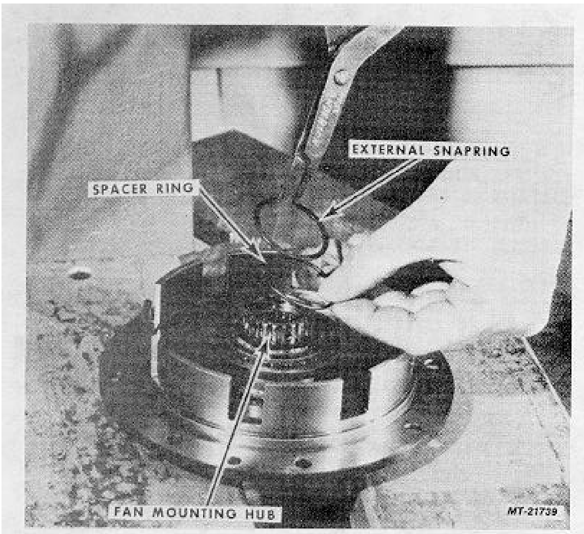


Fig. 47

11. Support beneath Bearing Retainer and use Fan Mounting Hub Protector SE-2782-3 to press Fan Mounting Hub down until Bearing Assembly is seated against the Spacer Ring and External Snapring, Fig. 48. Fan Mounting Hub will move only 1/16".

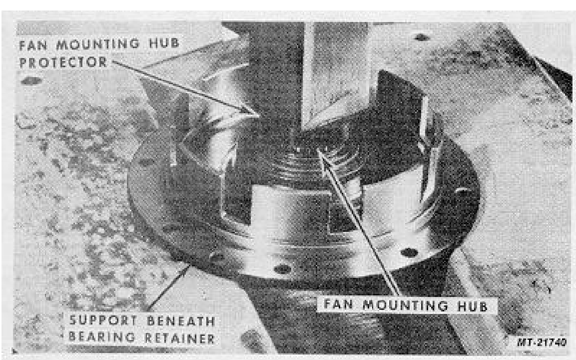


Fig. 48

12. Install Backing Plate on Hub with the recessed area of the Backing Plate up, Fig. 49.

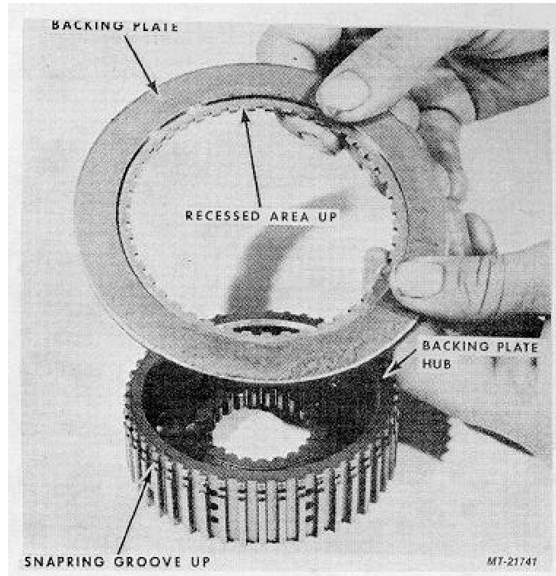


Fig. 49.

13. Install External Spiralox Ring, Fig. 50.

IMPORTANT

Be sure Spiralox is seated in the groove and is completely contained within the recessed area of the Backing Plate.

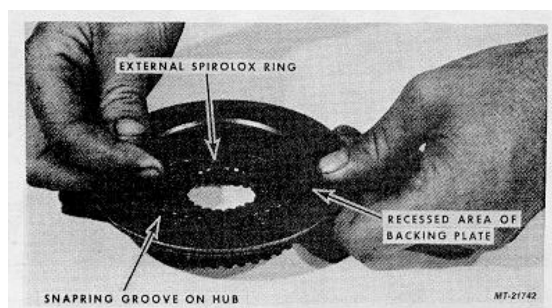


Fig. 50.

14. Place the Hub and Backing Plate Assembly on the Fan Mounting Hub spline, Fig. 51.

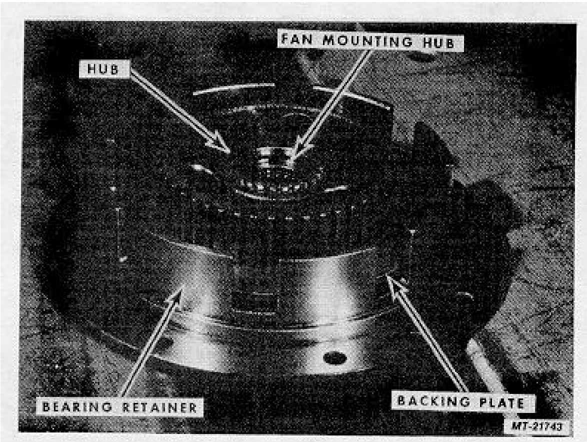


Fig. 51

15. Place one Facing Plate down onto the Backing Plate, then a Steel Plate on the Facing Plate. Alternate Facing Plates and Steel Plates until a total of six (6) Facing Plates and five (5) Steel Plates have been placed on the stack, Fig. 52.

IMPORTANT

A properly assembled plate stack will have a Facing Plate on the top and on the bottom of the stack (first and last installed).

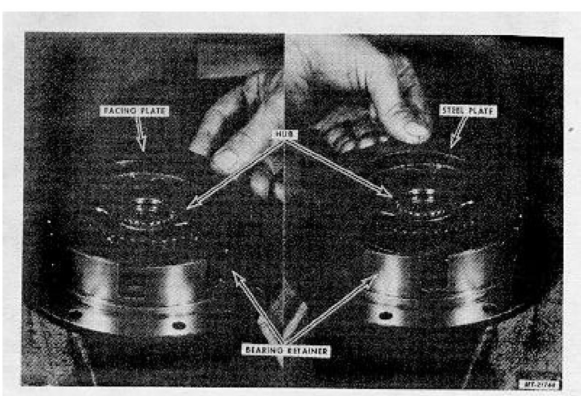


Fig. 52

16. Place Pressure Plate on top of Facing Plate with the extended portion up, Fig. 53.

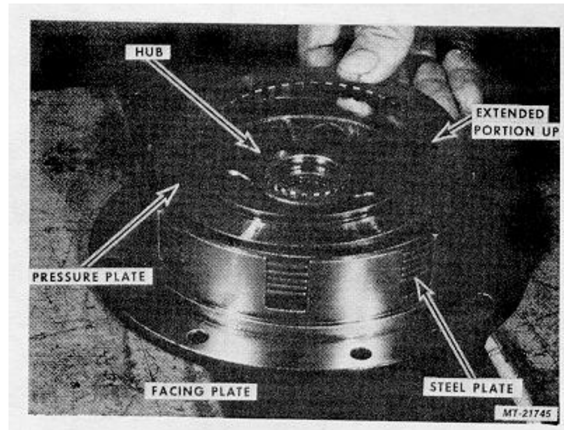


Fig. 53

17. Place "T" shaped fixture SE-2782-5 across the center of Pressure Plate, and bring the ram of the press down to create added weight, Fig. 54.

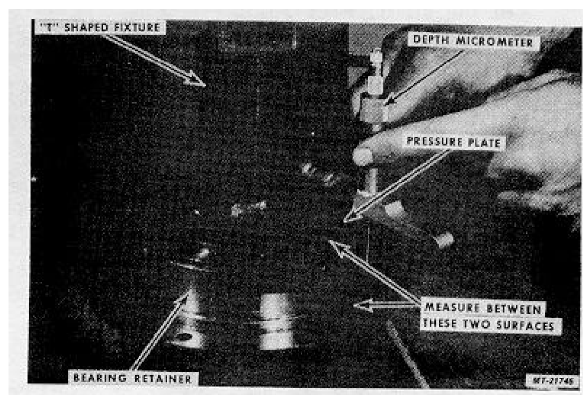


Fig. 54

With this weight slightly compressing the stack of plates to stabilize them, measure the distance between the Pressure Plate and Bearing Retainer surfaces, at two points 180° apart, Fig. 54.

IMPORTANT

Do not inadvertently place added pressure on the pressure plate with hands while taking the measurement

Record both readings and calculate dimension " B" as follows. To illustrate this calculation, let's assume readings are 1.532" and 1.516".

a. Add:

1st Reading	1.532"
2nd Reading	1.516"
Total of Readings	3.048"

b. Divide:

Above total divided by 2	1.524" = 3.048 ÷ 2

c. Add:

Answer from B) + .125	1.524"
	+ .125"
	1.649"

Dimension "B" is 1.649 in this example. This dimension "B" will be used after Step 43 in "Selection of Clutch Shims".

18. If Roll Pin was removed, reinstall it in Shaft. Roll Pin must be below the surface of the shaft, Fig. 55.

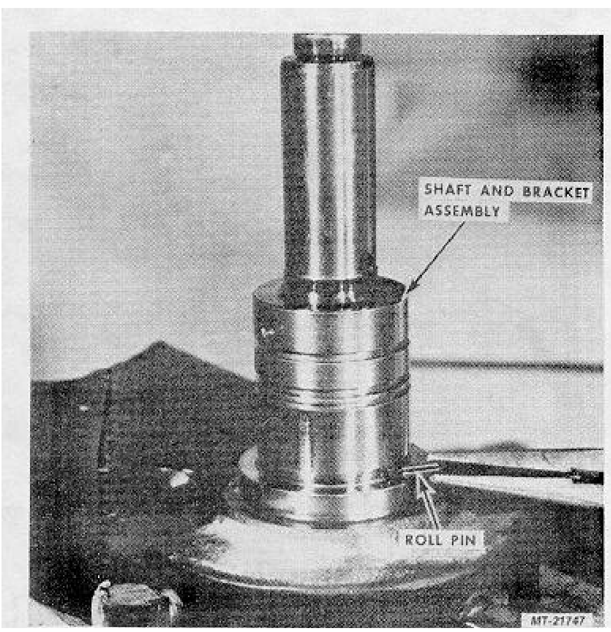
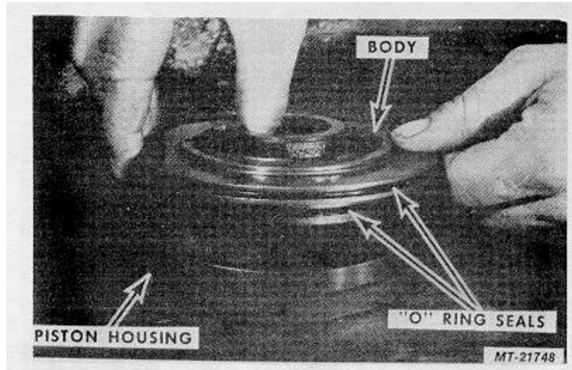


Fig. 55

19. Install "O" Ring Seals. Coat "O" Rings with a crystalline type grease or oil and install Body in Piston Housing, Fig. 56.



20. Install Belleville Spring on the Body in the concave position (middle down and outside diameter up), Fig. 57.

IMPORTANT

If clutch contains two Springs, both Belleville Springs are to be installed in the concave position.

Install Thrust Washer on top of Belleville Spring.

IMPORTANT

One side of the Thrust Washer has either a chamfer or recessed cut-out at the I.D. This chamfer or recess must be positioned against Belleville Spring.

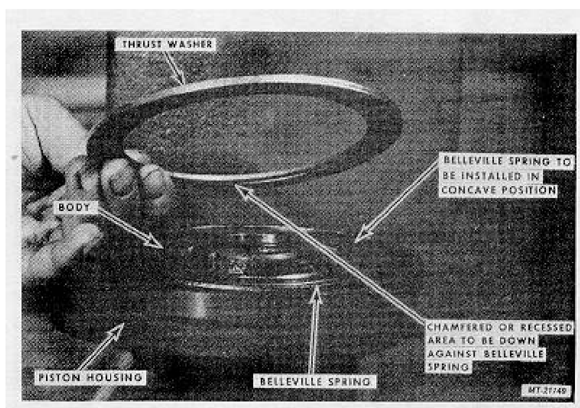


Fig. 57

21. Support beneath Piston Housing. Center Straddle Tool SE-2782-6 on Thrust Washer. Press Thrust Washer down 1/32" to allow installation of Internal Snapring, Fig. 58

IMPORTANT

Do not press down more than 1/32". Movement will stop at that point and further force will damage parts.

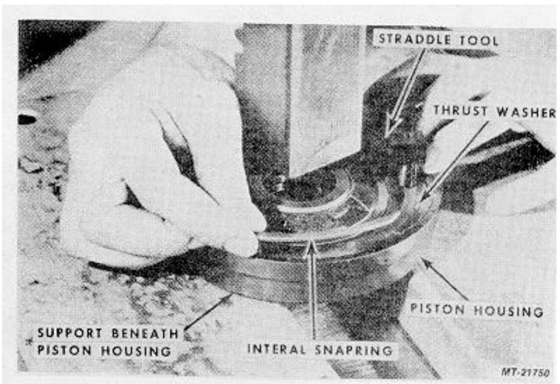


Fig. 58

22. Apply Loctite #242 to the threads of Set screw and install in the body until the plastic locking patch on the set screw begins to enter the thread, Fig. 59.

IMPORTANT

Never re-use an old set screw. The unused plastic locking patch is necessary to hold set screw tight, preventing failure.

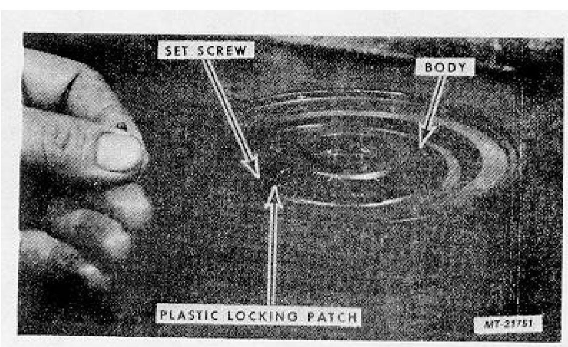


Fig. 59

23. Install Pitot Tubes with #10-24 Capscrews. Use a small amount of Loctite #242 on the thread of each capscrew and tighten each capscrew to 49 in. lb. (4 ft. lbs.) maximum, Fig. 60. DO NOT OVERTIGHTEN

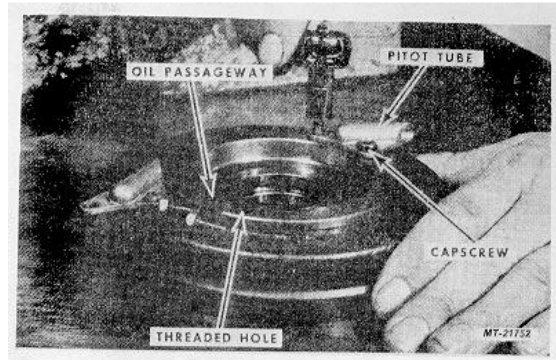


Fig. 60

24. Support Pulley with Installer SE-2782-2 located in the bearing bore of the pulley, Fig. 61.

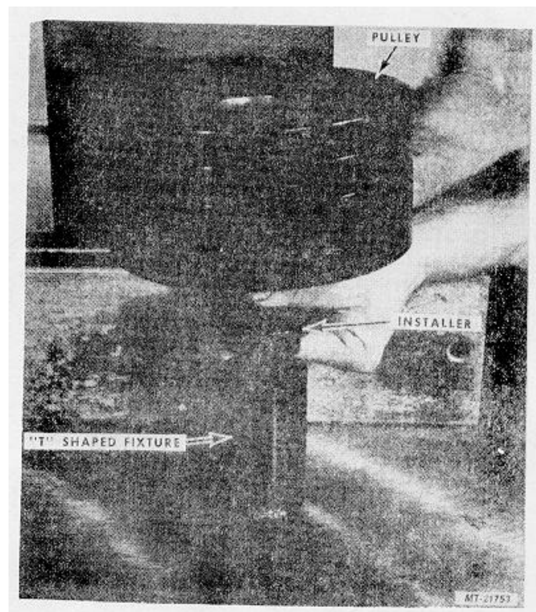


Fig. 61.

25. Lubricate the seal contact diameter of Installer SE-2782-4. Place Oil Seal on the Installer with the lip exposed as shown, Fig. 62.

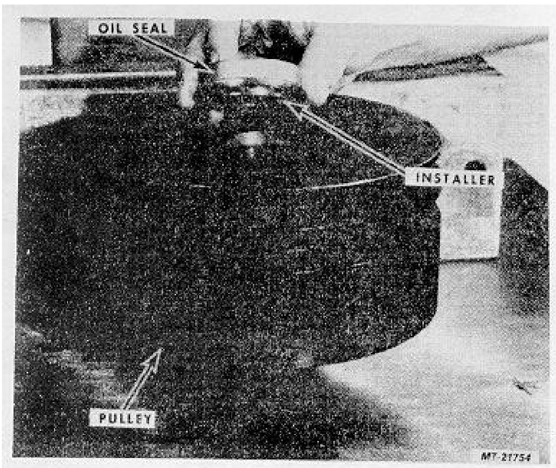


Fig. 62

26. Align Oil Seal straight with the bore and press the Oil Seal down until the Installer SE-2782-4 bottoms, Fig. 63. After the Installer bottoms, rotate the Pulley Retainer to several different positions, each time pressing down to insure proper seating of the Installer. Note an oil seal will not align itself during installation into a bore. If the oil seal is misaligned before it is installed, it will remain misaligned and will leak.

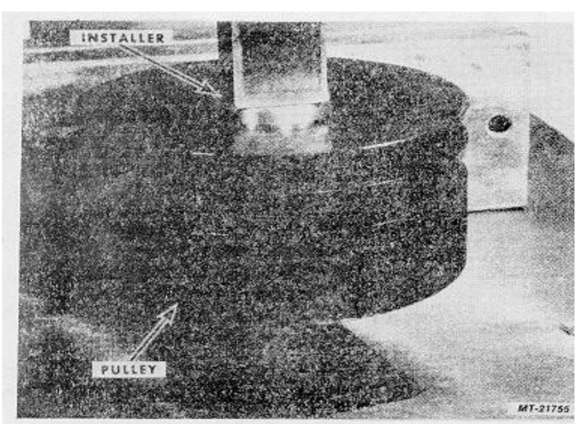


Fig. 63

27. Press the cup of Bearing Assembly down until the Installer SE-2782-2 bottoms. Fig. 64.

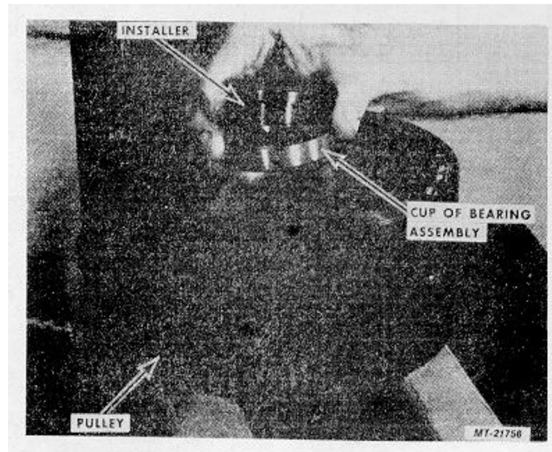


Fig. 64

28. Install the cone of Bearing Assembly in the cup of the assembly. Place "T" shaped **fixture SE-2782-5 on the Bearing, Fig. 65.**

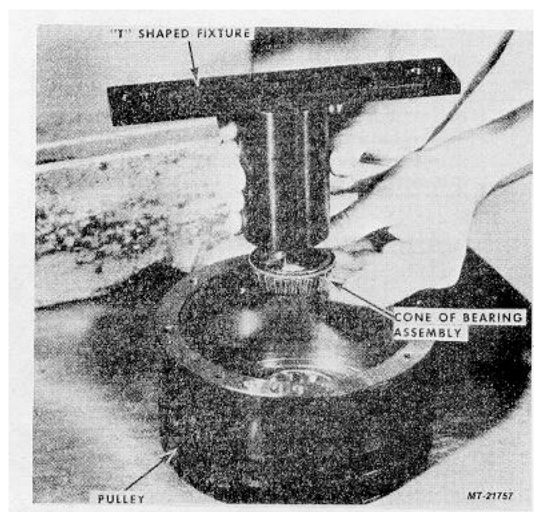


Fig. 65

29. Install proper length Bolts from the tool kit to secure the "T" shaped fixture SE-2782-5 to the Pulley and TIGHTEN the bolts, finger tight, Fig. 66.

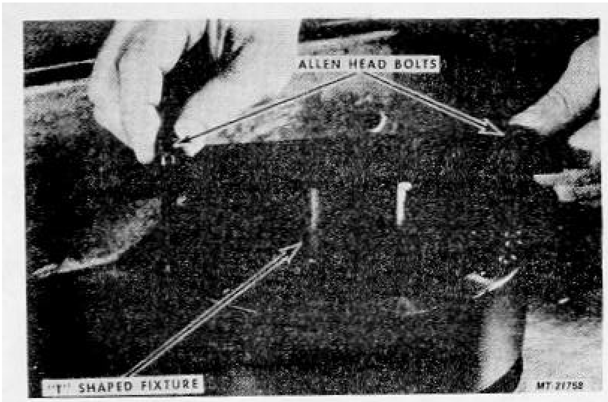


Fig. 66

30. Support beneath "T" shaped fixture SE-2782-5. Lubricate the Oil Seal contact area of the shaft and CAREFULLY install the Shaft into the Pulley. Press the shaft down until movement is stopped by the Shaft Protector SE-2782-8, Fig. 67.

IMPORTANT

Use proper care to prevent damaging the lip of Oil Seal.

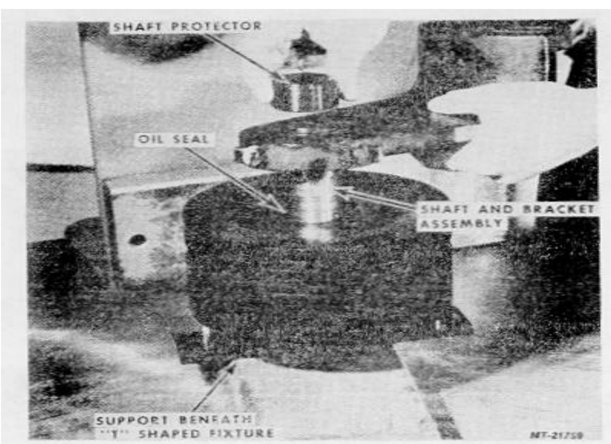


Fig. 67

31. Install Pipe Plug in the breather port, Fig. 68.

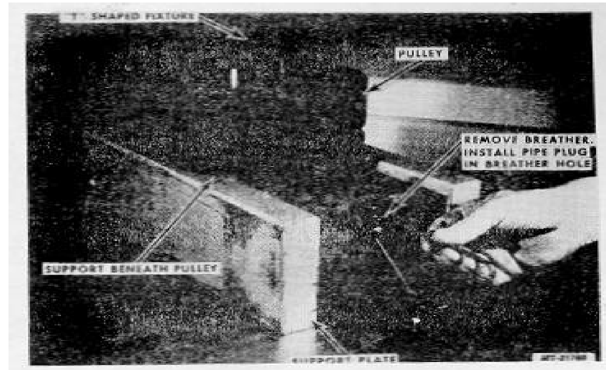


Fig. 68

IMPORTANT

Proper fan clutch operation is dependent upon proper plumbing and identification of the "Oil In", "Oil Out", "Air", and "Breather (vent)" ports in the bracket. Different bracket configurations have varied hole location patterns. Be sure the ports are properly identified when installing plugs and fittings.

32. To prevent damage to Oil Seal the shaft must be stabilized in a vertical position. If the bracket is long and extends quite a distance to the side such as is shown in Fig. 68, additional support may be needed. A short bolt and nut, Fig. 69, may be used to support the shaft in a vertical position as is shown in Fig. 70.

WARNING

DO NOT REMOVE PULLEY FROM THE SUPPORTS UNTIL AFTER BEARING RETAINER HAS BEEN BOLTED TO PULLEY, FIG. 85. OIL SEAL MAY BE DAMAGED BY A SHOULDER ON THE SHAFT AND WILL LEAK

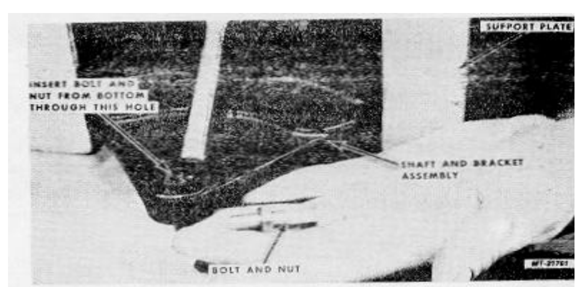


Fig. 69

33. Remove the two bolts and "T" shaped fixture SE-2782-5, Fig. 70.

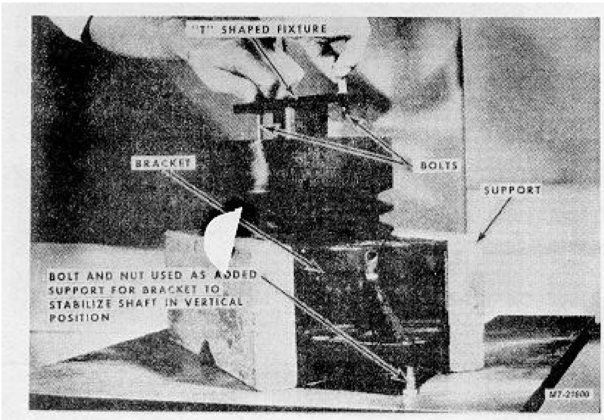


Fig. 70

34. Install Spacer Ring and External Snapring, Fig. 71.

IMPORTANT

Spacer Ring must be against the Bearing Cone.

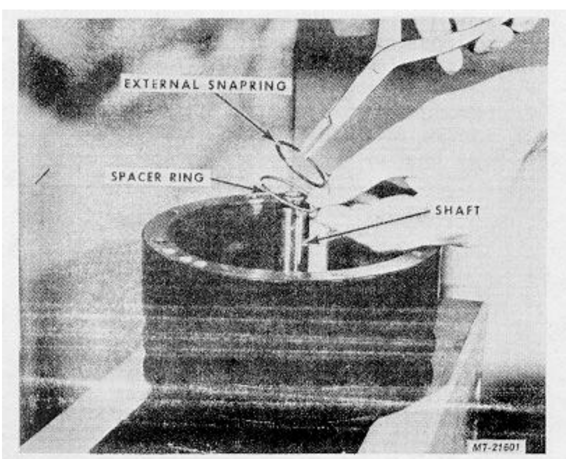


Fig. 71

35. Using Shaft Protector SE-2782-8 press down until Bearing Assembly is seated against Spacer Ring and External Snapring, Fig. 72. Shaft will move only 1/16".

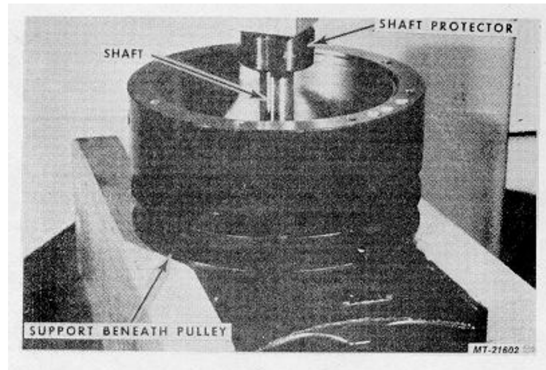


Fig. 72

36. Mark Shaft to designate the flat spot or round indentation for Set Screw, Fig. 73. (See Step 37).

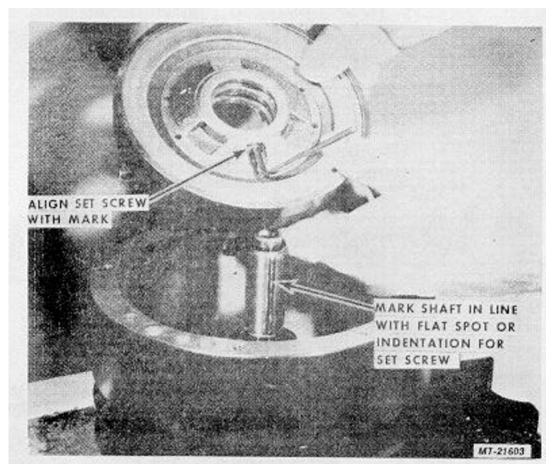


Fig. 73

37. Figure 74 illustrates the two different type shafts used in the fan drive clutch.

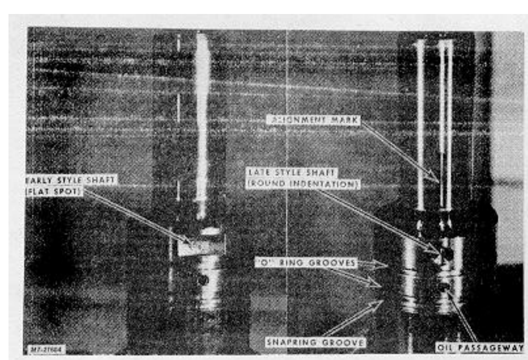


Fig. 74

38. Install two "O" Ring Seals in their grooves on Shaft and coat the "O" Rings with a crystalline type grease or oil, Fig. 75.

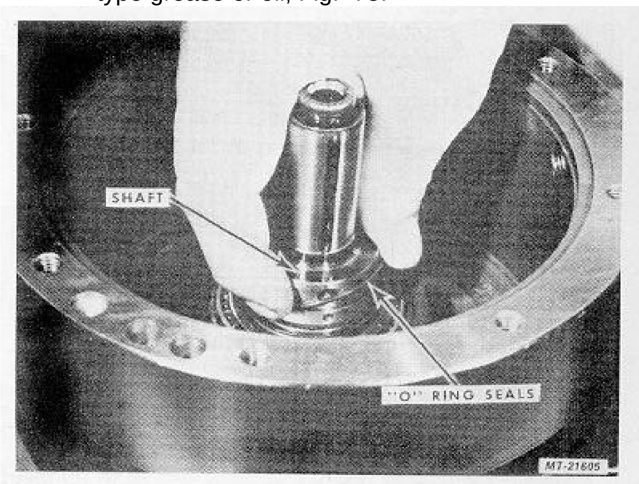


Fig. 75

39. Insert a 1/8 Allen wrench into Set Screw. The Load Cell Assembly can be lowered into position using the Allen wrench as a handle. Lower the Load Cell Assembly into position to rest against the "O" Ring Seal, Fig. 76.

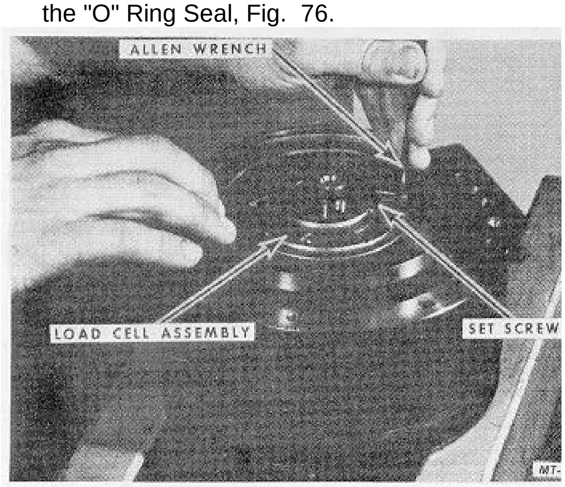


Fig. 76

40. Press the Load Cell Assembly into position, Fig. 77. Resistance will be encountered as the Body moves over "O" Ring Seals, (especially the lower "O" Ring Seal).

A chamfer on the Body will compress the "O" Ring Seals to allow the Body to pass over them, but GENTLY rocking and working the Body while applying downward pressure will be of assistance.

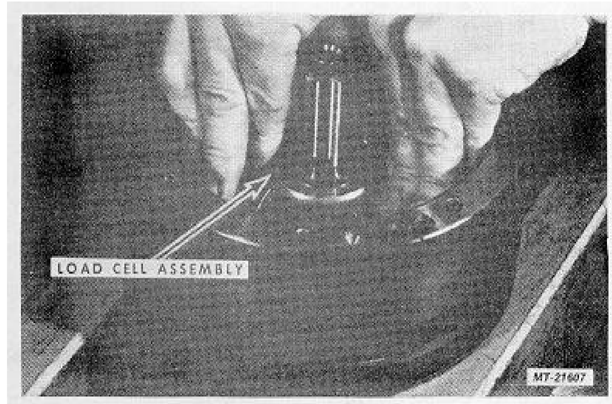


Fig. 77

41. When properly positioned and seated, the upper surface of Body will be flush with or slightly below the surface of the shoulder on Shaft, Fig. 78.

Tighten Set Screw against the shaft and torque to 5.536Nm (49 in. lbs.). Do not overtighten. Overtightening will strip threads in body.

IMPORTANT

It is extremely important the set screw be seated exactly in the center of the flat spot or round identation on the shaft. While tightening the Set Screw, slightly and GENTLY rotate the Load Cell Assembly to seek the exact center.

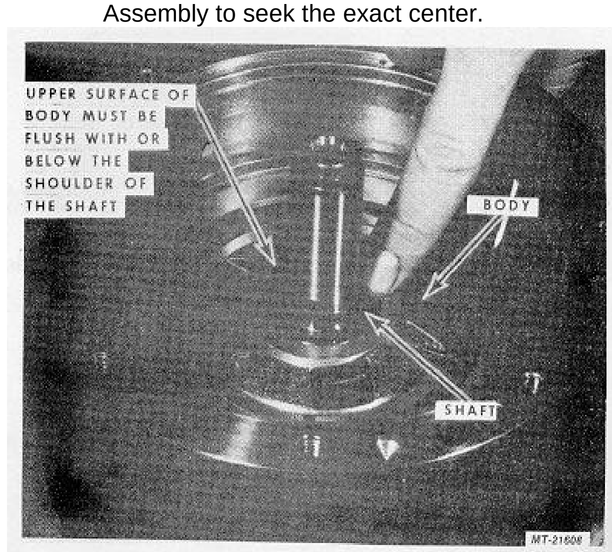


Fig. 78

42. The shaft must now be positioned in an almost exactly vertical position, Fig. 79. With one hand on the bracket, move the Shaft and Bracket Assembly to seek and find (by feel) the position where the cone of Bearing Assembly rests squarely in the cup. This position will be felt as a "secure" position.

When the position is obtained, use the weight of the press ram (locked if necessary) to stabilize the Shaft and Bracket Assembly.

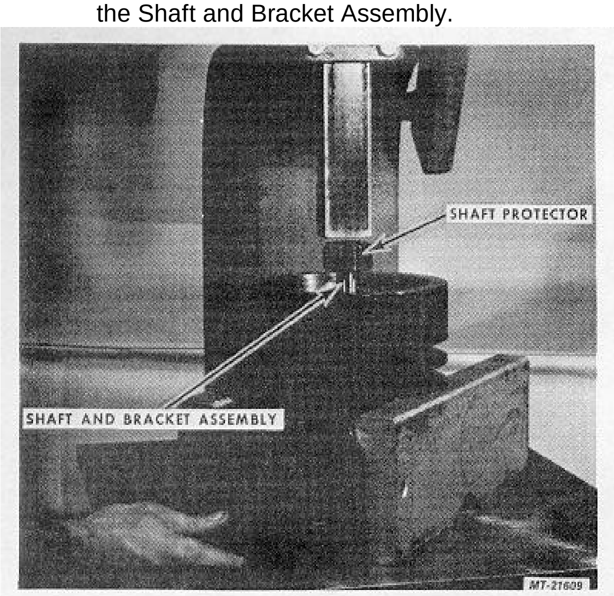


Fig. 79

43. Place Straight Edge SE-2782-7 on top of Pulley with one of the ground surfaces of the Straight Edge against the pulley surface, Fig. 80.

IMPORTANT

Do not place the tool in contact with a bolt hole.

Measure the distance between the upper surface of the Straight Edge and Thrust Washer at two points 1800 apart. Record both readings and use to calculate Dimension "A" as follows.

To illustrate this calculation, let's assume readings are 2.609" and 2.623".

a. Add:

1st Reading	2.609"
2nd Reading	2.623"
Total of Readings	5.232"

b. Divide:

Divide total by 2

$$2 \overline{)5.232"} = 2.616"$$

c. Subtract:

Above answer less 1.000"

$$\begin{array}{r} 2.616" \\ -\ \underline{1.000"} \\ 1.616" \end{array}$$

Dimension "A" is 1.616" in this example. This Dimension "A" will be used in the next step "Selection of Clutch Shims".

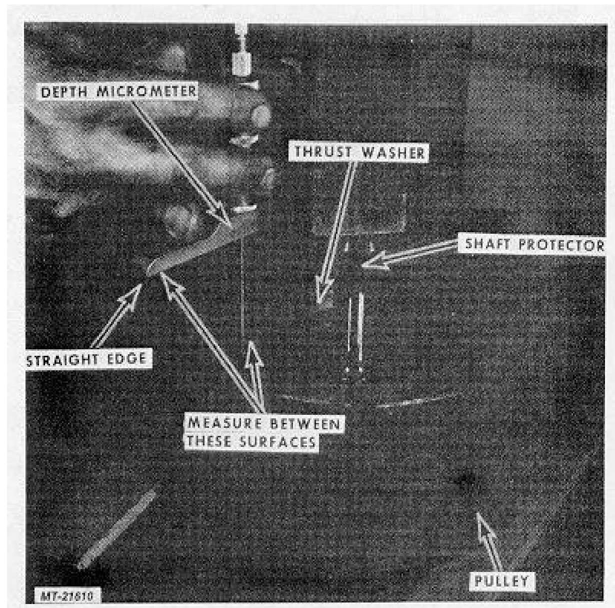


Fig. 80

SELECTION OF CLUTCH SHIMS

Calculate as follows:

(Examples obtained from Steps 17 and 43 have been used to illustrate this calculation procedure).

Dimension A (from Step 43) = 1.616i'
Dimension B (from Step 17) = 1.649"

a. Subtract:

Dimension B	=	1.649"
- Dimension A	=	1.616"
Difference	=	.033"

b. Subtract:

Design Nominal Dimension (always .068")	=	.068"
- Difference from "A' above	=	.033"
Shim Gap	=	.035"

c. Select Shims according to this chart.

If Shim Gap is: (From "B" Above)	...	Select Shims Below
.000" - .004"	......	None
.005" - .014"	......	.010"
.015" - .024"	......	.020"
.025" - .034"	......	.030"
.035" - .044"	......	.040"
.045" - .054"	......	.050"

Tag the shims and set aside for use in Step 45.

44. Install Thrust Bearing on Thrust Washer Fig. 81. Remove the stack of plates (Facing Plates and Steel Plates) with Hub and Backing Plate from the Bearing Retainer Assembly.
Align the Hub Oil passageways, tangs of Steel Plates and the oil hole in the Shaft and place the stack on top of Thrust Bearing.

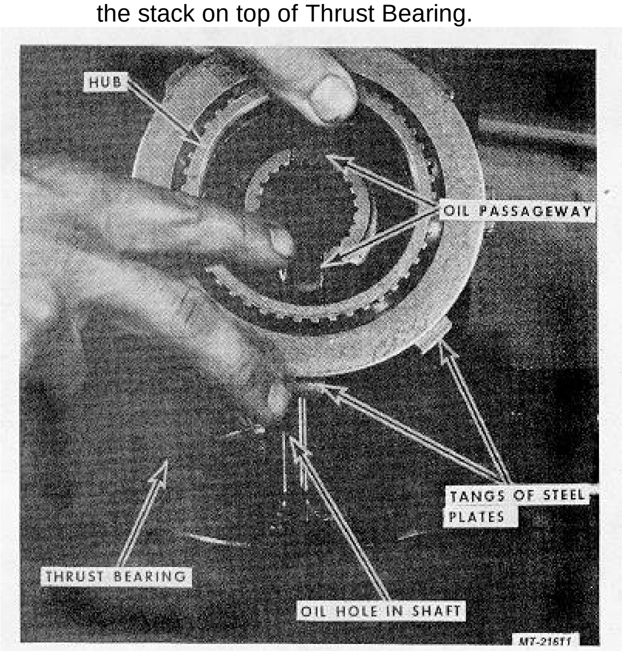


Fig. 81

IMPORTANT

Perfectly align the tangs in a vertical stack and perfectly center the Steel Plates in the stack. The outer edges can be used as a visual aid in accomplishing this.

45. Install proper Clutch Shims (as was determined by "Selection of Clutch Shims, Fig. 82).

IMPORTANT

Coating shims heavily with a crystalline grease will help retain the Shims in position while installing Bearing Retainer on pulley (Step 47).

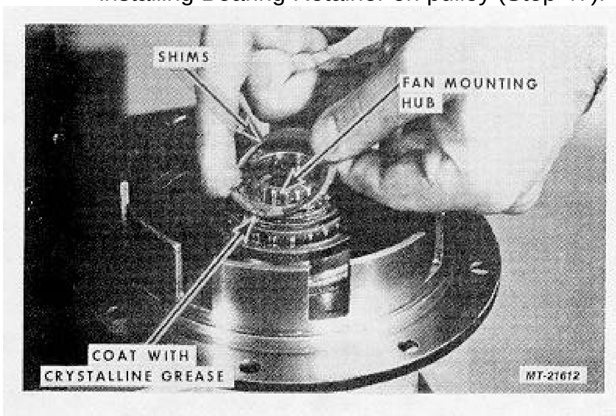


Fig. 82

46. Install Lathe Cut Sealring, Fig. 83. Be sure Sealring is not twisted. and is seated

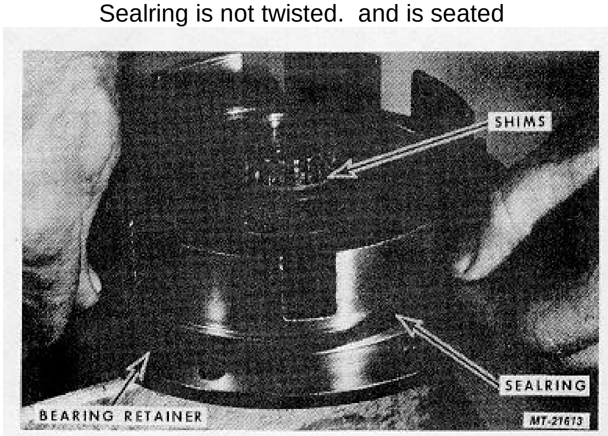


Fig. 83

47. In final assembly, the oil hole located in the spline of Fan Mounting Hub <u>must</u> be aligned with the oil passageway in Hub, Fig. 84.
Align the following and assemble the Bearing Retainer onto the Pulley:

Align: Tangs of Steel Plates
Oil Passageway in Hub
Oil Hole in Shaft
(for a locational reference)
Oil Hole in Fan Mounting Hub
A slot in Bearing Retainer

<u>DO NOT FORCE THE UNIT TOGETHER</u>. If the Bearing Retainer will not rest against the pulley, something is not perfectly aligned.

a. Tangs may have moved.

b. Hole in Fan Mounting Hub may not be perfectly aligned with slot.

c. Tanged Steel Plates may not be centered on the pulley or on the hub.

d. Bearing Retainer may be cocked on Fan Mounting Hub.

e. Hub may be upside down.

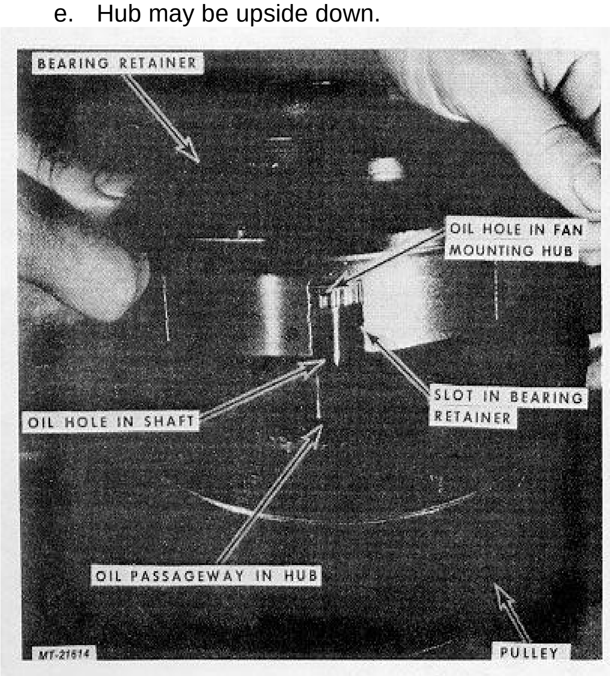


Fig. 84

48. Install eight Socket Head Capscrews and tighten with a 3/16" Allen wrench, Fig. 85. Torque to 27.116Nm (20 lb. -ft.).

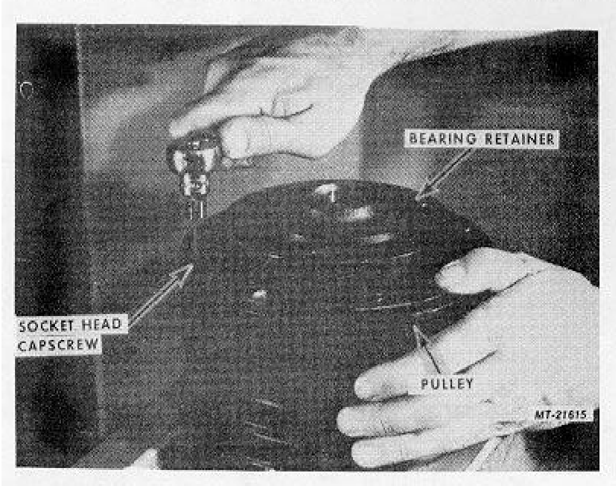


Fig. 85

49. Install one Thrust Washer, then Thrust Bearing and a second Thrust Washer, Fig. 86.

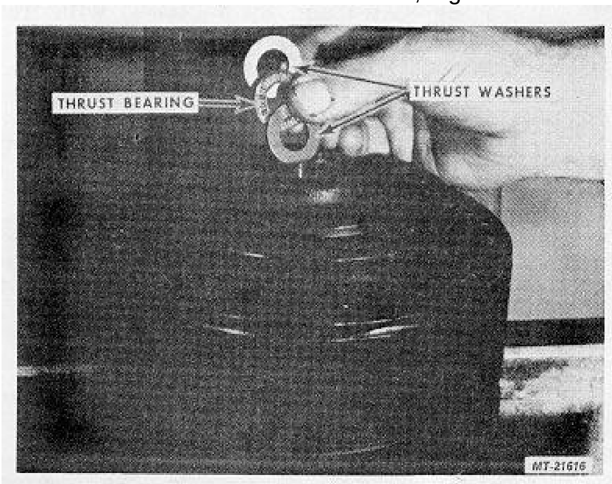


Fig. 86

50. Install the two thick shims 2.413mm (.095") and as many other shims from Shim Set as is necessary to fill the gap between Thrust Washer and the snapring groove in Fan Mounting Mounting Hub, Fig. 87.

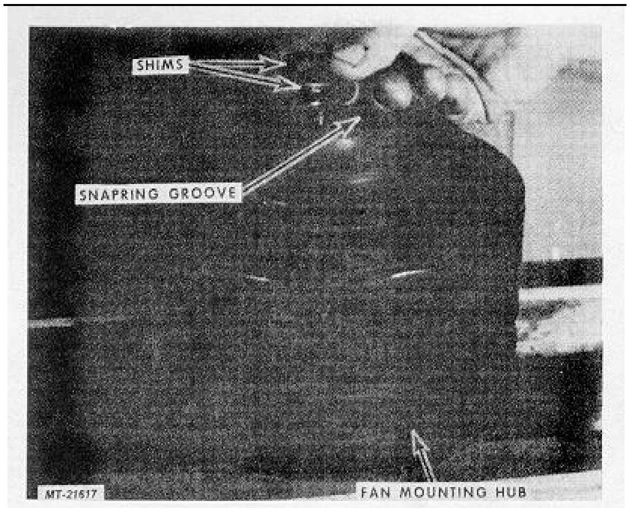


Fig. 87

51. Install Internal Snapring, Fig. 88.

IMPORTANT

Internal Snapring is made special of proper thickness for the groove. DO NOT SUBSTITUE - USE ONLY AN AUTHORIZED SERVICE REPLACEMENT PART.

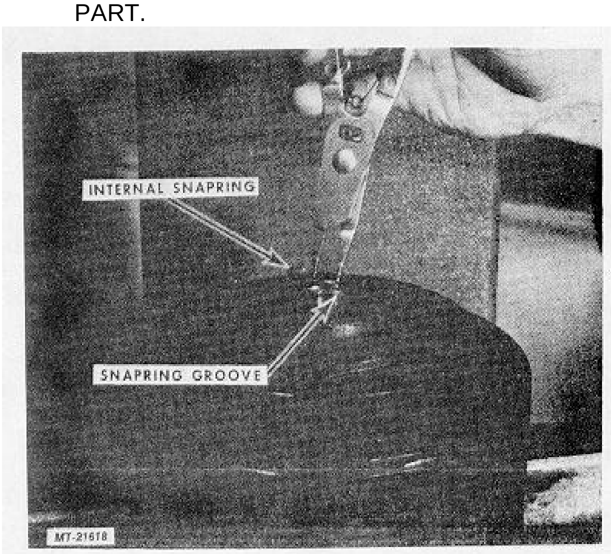


Fig. 88

52. Install Allen head bolts from the tool kit SE-2782, through two holes in the Fan Mounting Hub and tighten FINGER-TIGHT, Fig. 89. DO NOT USE A WRENCH.

IMPORTANT

Bolts must be of sufficient length to bottom against the front of Bearing Retainer.

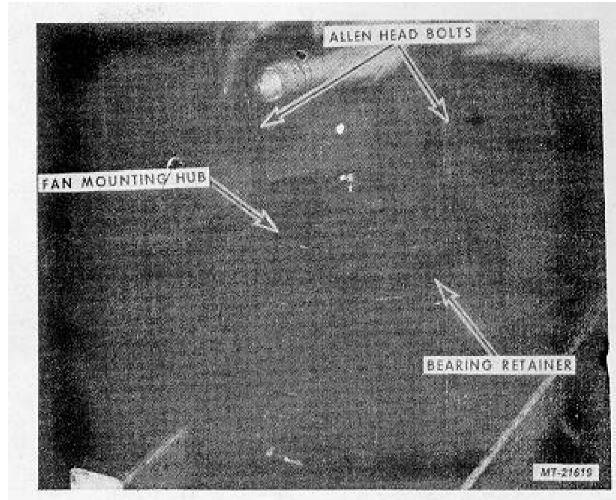


Fig. 89

53. With a Feeler Gage, measure the remaining gap between Shims and Internal Snapring, Fig. 90. Allen head bolts must be in position and finger tightened when measuring the gap.

IMPORTANT

Be sure Internal Snapring has moved to the top of the groove or a false reading will result.

Select additional shims equal to the thickness of the gap.

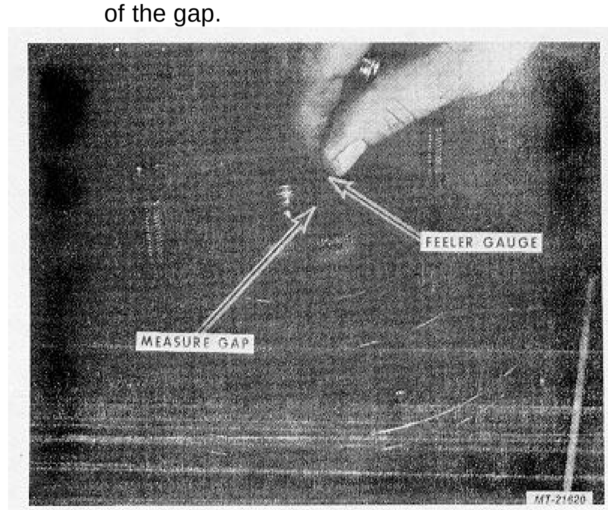


Fig. 90

54. Remove Internal Snapring and install the proper additional Shims, Fig. 91, as determined in Step 53. Replace Internal Snapring. Repeat the procedure described in Steps 53 and 54 to obtain a gap of 0.013"-0.127"mm (.0005" .003"). Be sure Internal Snapring is properly seated in the groove.

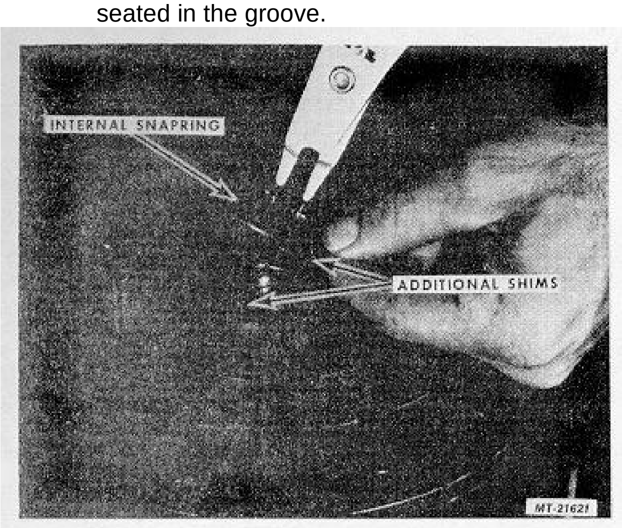


Fig. 91

55. Apply Loctite #242 around the outer edge of Expansion Plug and insert the Expansion Plug into the recessed area of the Fan Mounting Hub in the convex position. (Center dome up). Using Installer SE-2782-1, depress the center of Expansion Plug slightly to seat it, Fig. 92.

IMPORTANT

Allen Head Bolts must be installed when depressing center of expansion plug to prevent brinelling bearings. Expansion plug should be depressed approximately 1/16".

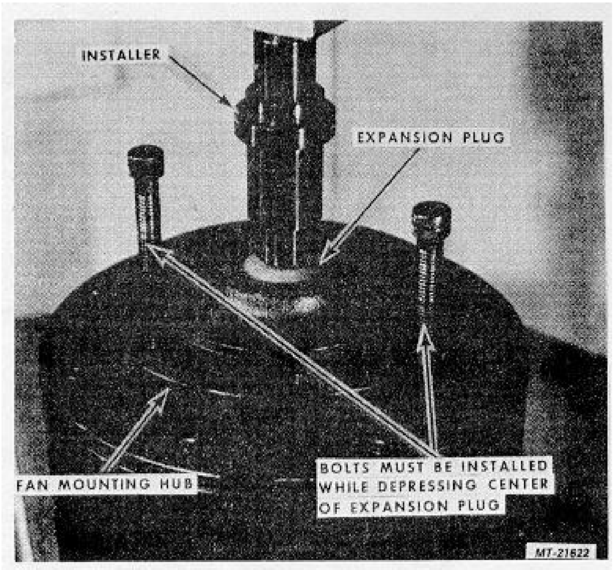


Fig. 92

TEST PROCEDURE

SET-UP "A"

Clamp the Fan Clutch in a vise using soft jaws. Clamp against the Bearing Retainer and the Pulley.

DO NOT CLAMP AGAINST THE BRACKET OF FAN MOUNTING HUB.

CLAMP AS CLOSE TO THE FAN MOUNTING HUB AS POSSIBLE WITHOUT CONTACTING IT.

TEST 1-CHECK CLUTCH RELEASE

Attach an air supply to the "Air" port located in the bracket. This position is designated by the letter "A" metal stamped near the hole.

AIR PRESSURE REQUIREMENTS:

827	kPa	(120 psi) Clutch with one Belleville Spring.
1034	kPa	(150 psi) Clutch with two Belleville Springs.

With sufficient air supplied, the Fan Mounting Hub should be able to be rotated easily. With NO air supplied, the Fan Mounting Hub should be locked up.

TEST 2-CHECK CLUTCH TORQUE CAPACITY

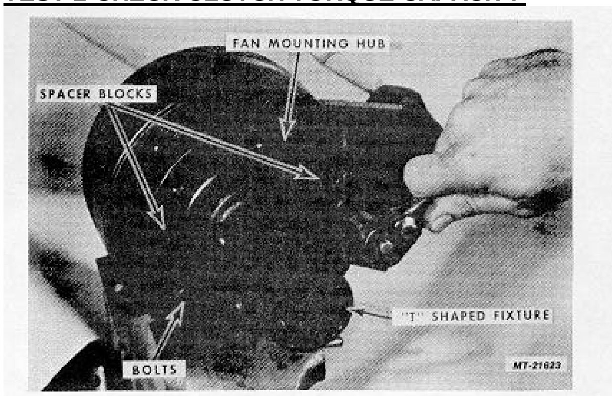


Fig. 93

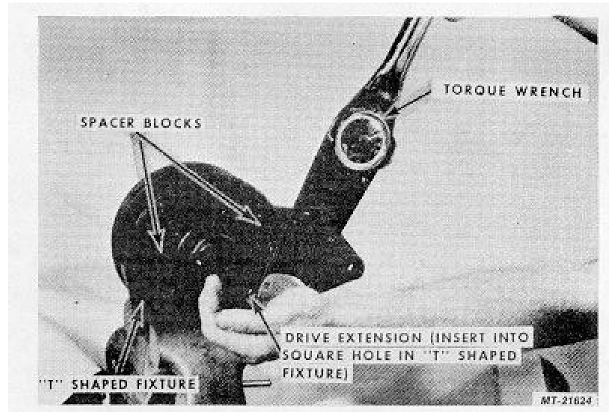


Fig. 94

DISCONNECT THE AIR SUPPLY

Bolt "T" Shaped Fixture SE-2782-5 securely to the Fan Mounting Hub using the two Spacer Blocks SE-2782-11 as spacers between the Fan Mounting Hub and "T" Shaped Fixture. Use 1 1/2" bolts from the kit SE-2782. Insert them through the appropriate size holes in the "T" Shaped Fixture and Spacer Blocks, Fig. 93.

IT IS IMPERATIVE THE PROPER SIZE HOLES IN SPACER BLOCKS SE-2782-11 BE USED.

Attach a 6" long, ½" drive socket wrench extension on the end of a torque wrench. Insert the square drive of the socket extension into the square hole in "T" Shaped Fixture SE-2782-5, Fig. 94. Determine the torque required to rotate the Fan Mounting Hub.

SPECIFICATIONS

101.686Nm (75 lb.-ft. minimum) - Clutch with one Belleville Spring.
189.814Nm (140 lb.-ft. minimum) - Clutch with two Belleville Springs.

SET-UP "B"

Mount the Fan Clutch on an engine or test fixture with a fan blade and a cooler (or proper oil supply). Attach belts and tighten tension to 67.791-108.465Nm (50 80 ft. lbs.).

Fill the Fan Clutch with oil to the two o'clock level.

Place, position, and utilize proper guards and other safety equipment so as to insure safety.

TEST 3-CHECK FOR LEAKS

Run at 2000 RPM for 15 minutes with the Fan Clutch disengaged (air supply on).
It is advisable the seal areas be thoroughly cleaned and voided of oil or grease.
Check seals, fittings, etc., for leaks.

IMPORTANT

Leaks may appear to be developing during the test but these may possibly be the crystalline grease used during assembly. A minute leak at the seals is normal. If the track of oil extending radially from the seal area does not reach the O.D. of the pulley after 15 minutes, it is considered acceptable.

CHAPTER VI

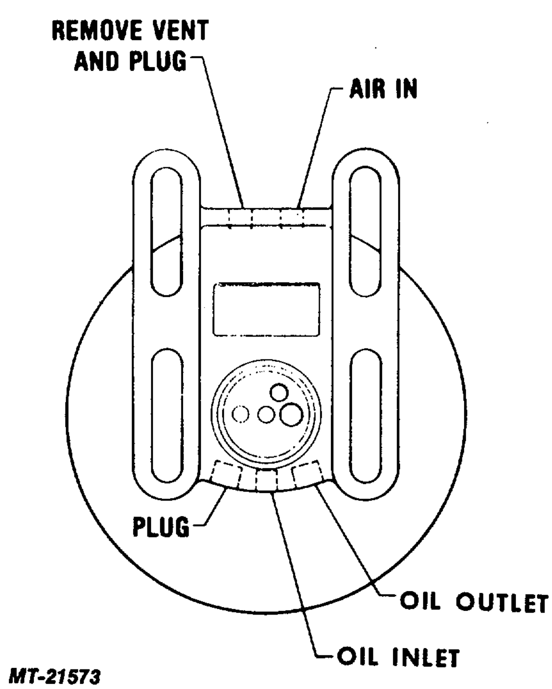
FAN CLUTCH BRACKETS

This Chapter illustrates "Oil In", "Oil Out", "Air", and "Vent" locations for all fan clutch brackets.

Find the part number located on the fan clutch bracket and refer to the listing below. The part number shown below will refer to a configuration illustrated on following pages. Specific identification of the ports is shown for each configuration.

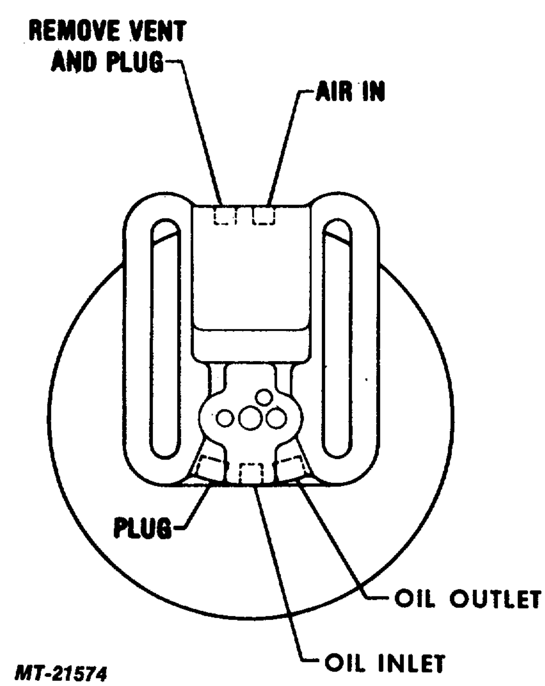
Shaft and Bracket Assembly No.	Supplier No.	Configuration No.
487251C91	21439	1
487250C91	22356	2
487253C91	22066	3
487254C91	21444	4
487252C91	21578	5
498042C1	23941	6
493043C1	23927	7
498043C1	23961	8
493042C1	23748	9
493041C1	23801	10
498044C1	24220	11
498045C1	24034	12
493044C1	23794	13

CONFIGURATION 1



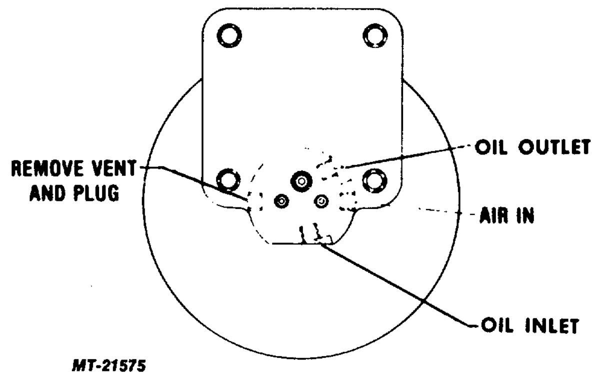
ENGINE SIDE OF DRIVE

CONFIGURATION 2



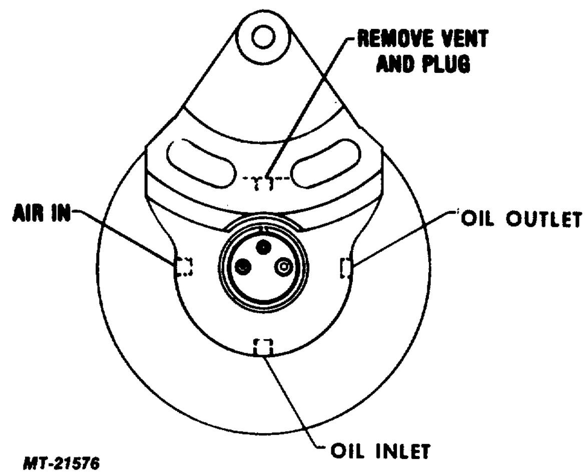
ENGINE SIDE OF DRIVE

CONFIGURATION 3



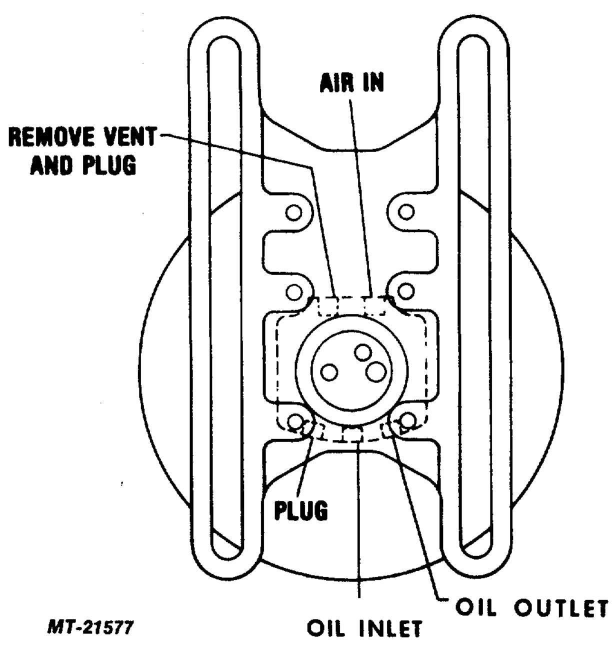
ENGINE SIDE OF DRIVE

CONFIGURATION 4



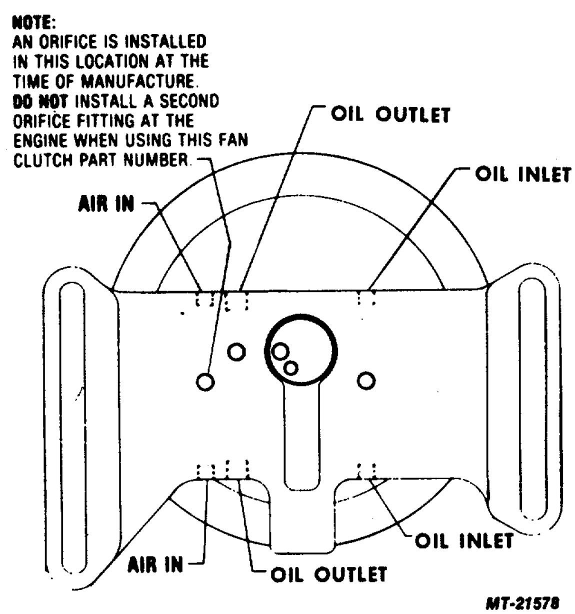
ENGINE SIDE OF DRIVE

CONFIGURATION 5



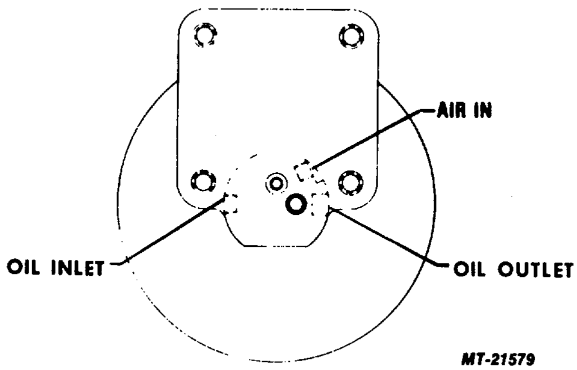
ENGINE SIDE OF DRIVE

CONFIGURATION 6



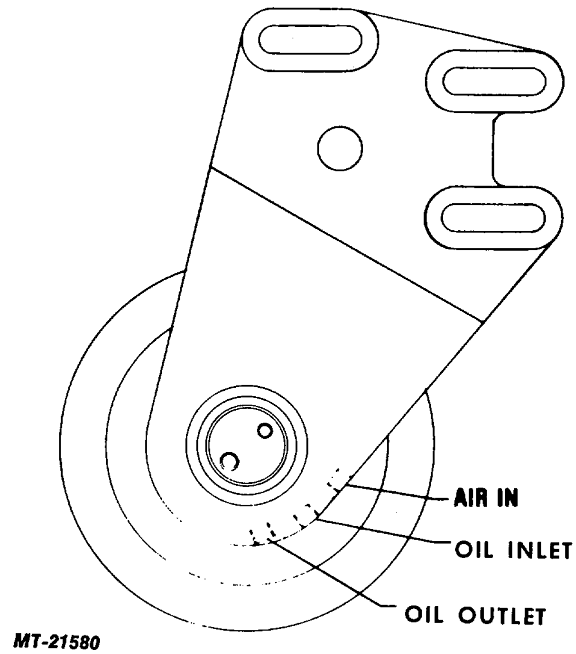
ENGINE SIDE OF DRIVE

CONFIGURATION 7



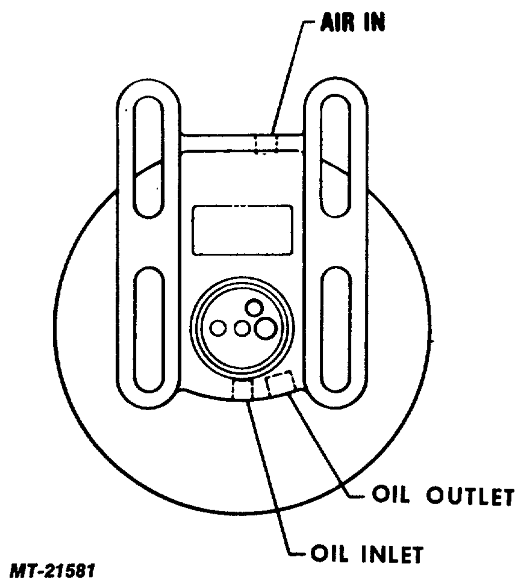
ENGINE SIDE OF DRIVE

CONFIGURATION 8



ENGINE SIDE OF DRIVE

CONFIGURATION 9



ENGINE SIDE OF DRIVE

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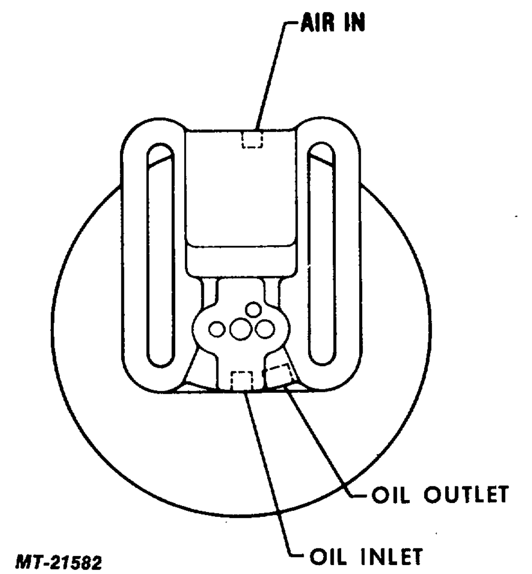
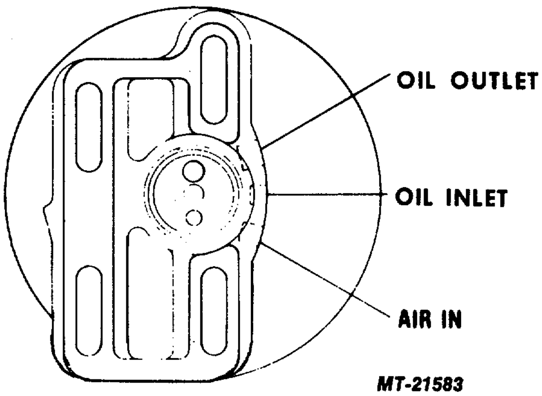


ENGINE SIDE OF DRIVE

CONFIGURATION 11



ENGINE SIDE OF DRIVE

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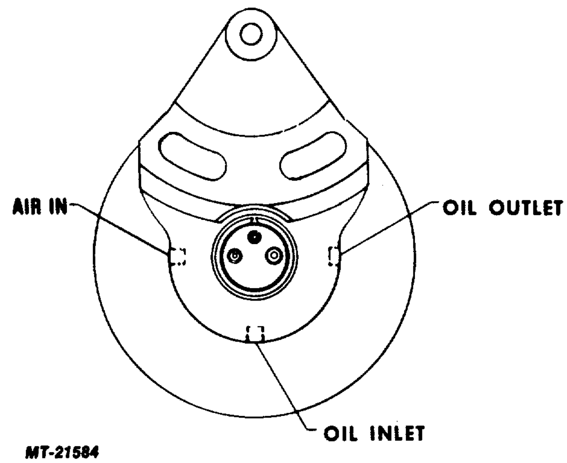

ENGINE SIDE OF DRIVE

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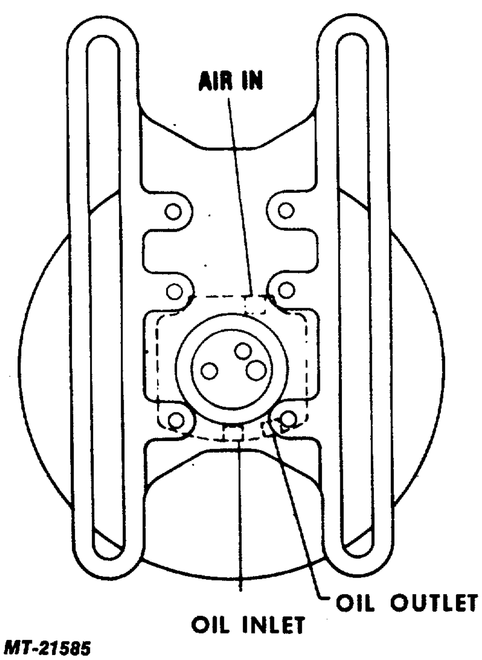

ENGINE SIDE OF DRIVE

COOLING SYSTEM

GENERAL

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INTRODUCTION

The purpose of the cooling system is to maintain the most efficient operating temperature of an engine without causing damage to the components. Approximately 1/3 of the energy produced when fuel burns is converted into power by the engine. The other 2/3 of the energy must be disposed of by the exhaust system and the cooling system or engine damage will result.

Basically, the circulation of coolant through the cooling system relies upon the water pump. The water pump draws coolant from the radiator and forces it through the water jackets and cylinder heads where it accumulates heat. The coolant then flows to the upper radiator tank and down through the radiator where it is cooled by air drawn through the radiator fins.

The damages or effects caused by cooling system neglect are usually gradual and are therefore often overlooked. This manual provides the reader basic component knowledge, maintenance procedures, service intervals, trouble-shooting and coolant and inhibitor recommendations.

COOLANT

The selection and maintenance of the engine coolant is as important to long engine life as the selection and changing of the engine lubricating oil and oil filters. The following section provides IH's recommendations for selecting the engine coolant and maintenance of the coolant inhibitors.

A. COOLANT SELECTION

IH engines will operate successfully with a water/anti-freeze mixture or inhibited water as the coolant. Never use water alone as it allows rust, scale deposits and corrosion to occur within the engine.

1. Water

Water used in the cooling system must meet the following standards:

a. Total Hardness not to exceed 170 parts per million (10 grains/gallon maximum) to prevent scale deposits. Water containing dissolved magnesium and calcium (the usual reason for water hardness) above the specified amount will cause scale deposits to develop in the engine.

b. Chlorides not to exceed 40 parts per million (2.5 grains/gallon maximum) to prevent corrosion.

c. Sulfates not to exceed 100 parts per million (5.8 grains/gallon maximum) to prevent corrosion.

d. Dissolved Solids not to exceed 340 parts per million (20 grains/gallon maximum) to minimize sludge deposits, scale deposits, corrosion or a combination of these.

If any of the above requirements cannot be met, use distilled, de-ionized or de-mineralized water. Water samples can be tested by water treatment laboratories to determine if local water supplies meet these standards. "Softened" water that is prepared using common salt (sodium chloride) contains excessive amounts of chlorides which will interfere with the water softening capabilities of coolant filters using ion-exchange resins.

2. Anti-Freeze

IH Anti-Freeze and Coolant contains all necessary inhibitors and has been tested for use in IH products. It is an ethylene glycol type anti-freeze and compatible with chromate and non-chromate type coolant filters.

Several factors should be considered for successful operation when using ethylene glycol type anti-freezes.

a. The boiling point of ethylene glycol anti-freeze solutions is higher than plain water but their ability to transfer heat is less. Therefore in hot weather, coolant temperatures will run higher than systems containing plain water. This also holds true for engine lubricating oil and transmission oil temperatures where oil to water coolers are used.

b. An anti-freeze concentration greater than 68% will adversely affect freeze protection and heat transfer rates. Anti-freeze concentrations between 68 and 100% actually have a higher freezing point than a 68% anti-freeze concentration. Due to the higher freezing point and reduced heat transfer rates, concentrations greater than 68% should not be used. It is also important to remember that anti-freeze may retain its freeze protection for more than one season but coolant conditions must be added to maintain corrosion protection. The following chart illustrates the freezing point of anti-freeze according to its percentage

Freezing Point C (F)	Percentage Anti-Freeze Concentration by Volume	Specific Gravity @ 16 deg. C (60 deg. F)
0 deg. (+32)	0	1.000
-7 deg. (+20)	15	1.025
-12 deg. (+10)	25	1.040
-18 deg. (0)	33	1.053
-23 deg. (-10)	40	1.062
-29 deg. (-20)	45	1.07"
-34 deg. (-30)	48	1.074
-40 deg. (-40)	53	1.080
-46 deg. (-50)	56	1.088
-51 deg. (-60)	59	1.092
-57 deg. (-70)	62	1.095
-63 deg. (-80)	65	1.097
-68 deg. (-90)	67	1.098
-69 deg. (-92)	68	
NOTE: As shown below, a further increase in anti-freeze volume increases the freezing point.		
-63 deg. (-80)	71	1.100
-57 deg. (-70)	75	1.106
-51 deg. (-60)	79	1.110
-46 deg. (-50)	83	1.113
-40 deg. (-40)	87	1.117
-34 deg. (-30)	91	1.119
-34 deg. (-30)	95	1.123
-22 deg. (- 8)	100	1.127

of concentration.

c. Anti-freeze containing sealer or anti-leak additives should not be used in IH engines. These additives may cause plugging problems in the cooling system and restrict coolant flow.

d. Anti-freeze formulated with methoxy propanol or propolene glycol is not recommended for use in IH engines due to a reaction with engine internal seals, coolant hoses and potential fire hazard due to lower flash points than ethylene glycol type anti-freeze.

3. Coolant Conditioners

All cooling system inhibitors, including those in anti-freeze solutions, become depleted through normal operation. If the inhibitors in antifreeze are allowed to become depleted, the antifreeze becomes corrosive and attacks and coats the metallic surfaces of the cooling system. This coating reduces the heat transfer. Cooling system conditioners which contain these inhibitors must be added to maintain corrosion protection. These conditioners are available as a liquid or in a coolant filter.

The two types of recommended conditioners are as follows:

a. IH coolant conditioner is a complete inhibitor system, of a non-chromate type, which provides corrosion protection, pH control for maintaining an acid-free coolant and water softening to prevent the formation of mineral deposits. It is compatible with both water and IH anti-freeze and coolant.

b. Coolant filters which are coolant conditioners of the universal borate type are approved for use on IH truck engines. These borate type spin-on filters are compatible with IH anti-freeze and coolant and with IH cooling conditioner water solutions.

Soluble oil is not recommended for use on IH truck engines as its use will reduce heat transfer. There are no miracle additives that will increase heat transfer or prevent overheating. Conditioned water is still the best coolant.

COOLANT SYSTEM COMPONENTS

The following is a list of the major components making up the cooling system. Points of inspection of each component are covered in general terms.

A. RADIATOR

This component is one of the most important as this is where most of the heat of the system is dissipated. The radiator is made up of the following parts:

1. Top and Bottom Tank - look for leaks, particularly where tank is soldered to core. Vibration and pulsation from pressure can fatigue soldered seams.

2. Filler Neck - the sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow loose fitting cap. Ensure overflow tube is not plugged.

3. Tubes - because these are very small, they can become clogged, or partially so, by rust and scale. The general condition of the cooling system and operating temperature are indications as to the cleanliness of the tubes. Another good test is to feel the core for cold spots.

4. Fins - these thin metal sheets radiate or pass off the heat picked up by the tubes. They should be kept free of bugs, leaves, straw and other interference to allow free passage of air. Bent fins should be straightened for maximum heat dissipation.

5. Radiator Cap - (Pressure-Sealing Type). Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of the solution due to evaporation and overflow.

   The cap (Fig. 1) has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure drops below the predetermined point.

   When removing the pressure type cap from the radiator, perform the operation in two steps. Loosen the cap to its first notch to raise the valve from the gasket and release the pressure through the overflow pipe. In the first stage position of the cap it should be possible to depress the cap approximately 3 mm (1/8"). The depression can be adjusted

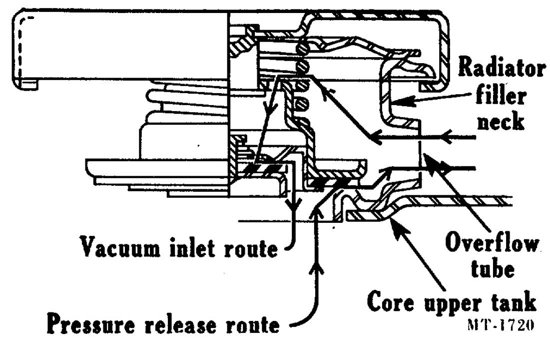

Fig. 1. Radiator Cap (Pressure Type)

   by bending the prongs on the cap. Care should be taken when bending the prongs to ensure the cap is not too loose as this would prevent proper sealing. Then slowly continue to turn cap counterclockwise until you can remove it.

NOTE: When removing the cap, loosen it slowly and then pause to allow the pressure to bleed. This will avoid possible burning by hot water or steam.

6. Reservoir System - (if so equipped). The reservoir installation consists of a simple, plastic reservoir mounted near the radiator cap, coolant lines and a special radiator cap (Fig. 2). Once the radiator cap is installed, it should not be removed except when the cooling system is cold and for refilling after the entire system is drained. With this system, coolant make-up originates from the reservoir. Coolant overflowing from the radiator enters the reservoir to be conserved until drawn back into the cooling system (engine and radiator) when it cools down. The reservoir installation provides a means of removing air from the cooling system and keeping the coolant level at a maximum fill condition.

The following illustrations explain the operation of this system under conditions that exist in the cooling system.

Fig. 3: Initial condition of the system. The reservoir is filled to the "FULL" line. The radiator has been filled to the filler neck. Engine has started and as system begins to warm up, expanding air in the system is expelled through the open vacuum valve and out the radiator overflow tube into the reservoir where it escapes at the reservoir overflow outlet.

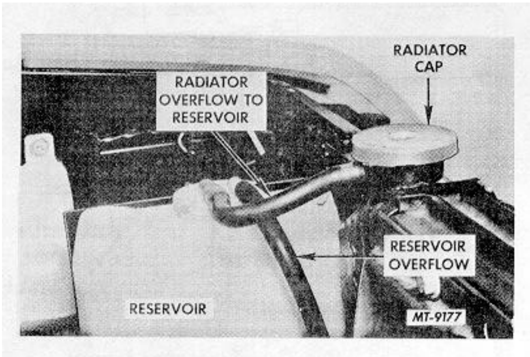

Fig. 2. Coolant System Reservoir Installation

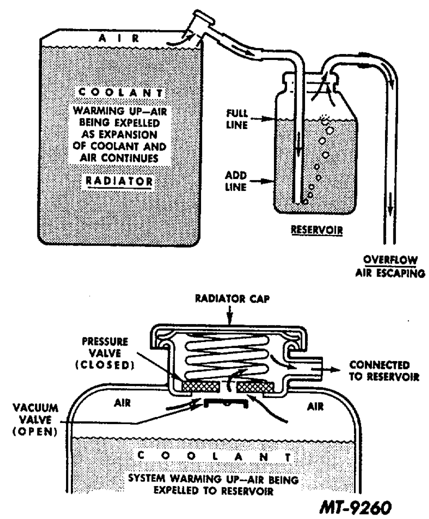

Fig. 3. System Warming Up

Fig. 4: As the cooling system approaches normal operating temperature, the vacuum valve in the radiator cap closes, the cooling system pressure rises to pressure controlled by the cap pressure valve setting and no further air or coolant escapes the cooling system.

Fig. 5: In the event the cooling system becomes overheated to the extent that pressure rises above the established setting (controlled by the pressure valve in the radiator cap), excess coolant will be expelled through the radiator overflow into the reservoir. Coolant discharged from the radiator in excess of the reservoir capacity would overflow from the reservoir. Under this circumstance the engine should be shut down, allowed to cool and the cause of the overheating corrected.

Fig. 6: After the initial cooling system fill and the

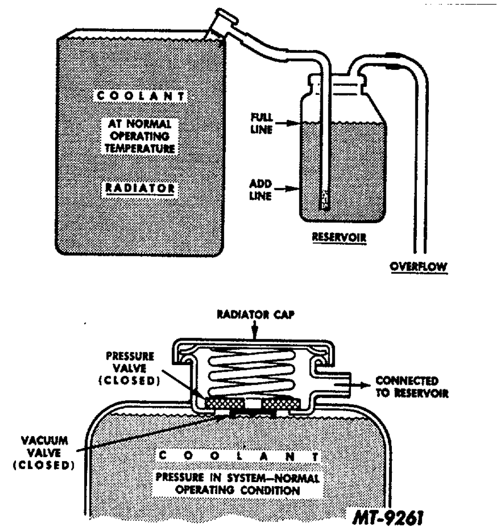

Fig. 4 Normal Operating Condition

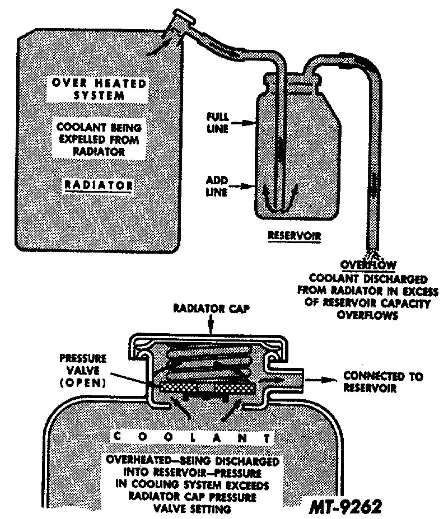

Fig. 5. Overheated System

engine and cooling system have been operated to normal temperature and the engine is then shut off, the system in cooling down will draw coolant from the reservoir to replace air expelled from the system during the warm-up period. As the warm-up and cool-down cycle is repeated during operation of the vehicle, air accumulated in the system will gradually be expelled until a maximum fill condition is reached in the cooling system. The coolant level in the reservoir will rise and fall between the "ADD" and "FULL" lines.

NOTE: Any make-up coolant is to be added to the reservoir, since the radiator cap should not normally be removed.

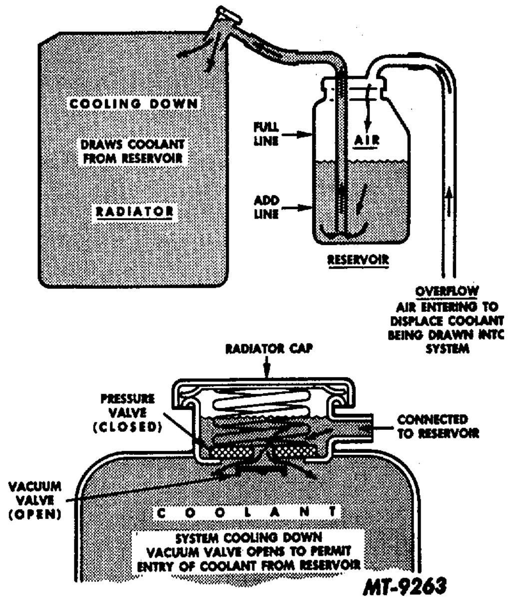

Fig. 6. System Cooling Down

For special filling of this type cooling system, refer to MAINTENANCE Section in this manual.

B. ENGINE WATER JACKET

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber and valve assemblies. Some of the coolant passages are small and can become clogged if the cooling system does not receive the proper maintenance.

Close inspection should be given to the following areas:

1. Core - Plugs These are sometimes mistakenly termed "freeze plugs". The plugs are present due to engine block casting methods and not to protect against expansion from freezing. Core plugs that show signs of leaking or rusting through should be replaced. Refer to respective Engine Manual for core plug replacement.

2. Drain Plugs - The drain plugs located in the water jacket should receive seasonal care and kept free of rust and scale.

3. Gaskets - Must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

C. WATER PUMP

The water pump circulates the coolant through the cooling system. It should be checked carefully for leaks and proper lubrication and if leaking or in bad condition, it should be rebuilt or replaced promptly. For water pump rebuild, refer to respective Engine Manual.

D. FAN AND BELTS

The fan should be checked for loose or bent blades. A loose blade could work free during operation and cause damage. A bent blade will reduce the fan's efficiency.

Fan belts must be adjusted for proper tension. Refer to respecting Engine Manual or Operator's Manual for proper belt tension.

E. THERMOSTAT

Thermostats provide a means of retarding or restricting the circulation of coolant during engine warm-up. An inoperative thermostat can cause engine overheating and a subsequent loss of coolant. Thermostats can be tested by submerging in hot water and noting the opening and closing temperature. Use an accurate high temperature thermometer for making this test. Refer to Engine Manual for proper opening and closing temperatures.

F. HOSES AND CLAMPS

Hoses and clamps should be checked regularly as they are often the source of hidden trouble. Hoses may appear in good condition on the outside but the inside may be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. Clamps should be inspected to ensure they are strong enough to hold a tight connection.

G. TRANSMISSION OIL COOLER

On some trucks equipped with automatic or semi-automatic transmissions, the transmission oil is circulated through an oil cooler or heat exchanger. The function of this unit is to control transmission temperature and thereby keep oil in the proper temperature range for its most efficient lubrication. This is accomplished by using engine heat to bring transmission temperature up or by using the cooling system to dissipate any excessive heat generated within the transmission.

Leakage due to corrosion or an improper seal will cause contamination between the cooling system and transmission.

EFFECTS OF COOLING SYSTEM NEGLECT

A neglected cooling system can lead to inefficient engine operation, either directly or indirectly. Most of the problems may be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating may lead to troubles such as the following:

1. Burned valves.
2. Pinging or knocking.
3. Vapor lock.
4. Poor lubrication-increased engine wear.
5. Sticking valve and valve lifters.
6. Short spark plug life.
7. Engine hot spots.
8. Need for higher octane fuel.

Overcooling often results in the following:

1. Excessive fuel consumption.
2. Sludge formation in crankcase.
3. Corrosive acids found in crankcase.

COOLING SYSTEM MAINTENANCE

A. COOLING SYSTEM INHIBITORS

1. Systems With Coolant Filters

   Properly inhibited coolant will keep the engine free of rust, scale deposits and corrosion. New vehicles are delivered with IH anti-freeze and coolant and may be equipped with a coolant filter. The coolant filter should be changed according to the intervals contained in the respective Operator's Manuals.

2. Systems Without Coolant Filters

   Vehicles without a cooling system must have the coolant inhibitors replenished by adding IH cooling conditioner. The conditioner should be added as recommended in the respective Operator's Manuals.

   A complete drain, flush and refill with water and conditioner, or IH anti-freeze and coolant is recommended once a year. This includes all vehicles irregardless of yearly mileage.

   If the cooling system has been permitted to become rusty or dirty, use IH cooling system cleaner and neutralizer carefully following cleaning recommendations on the container.

3. Coolant Testing for Inhibitor Strength

   Coolant should be checked for reserve alkalinity using test strips available from various sources at each oil change. Indication of a low alkalinity condition necessitates a need to add IH cooling conditioner, change cooling filter or to drain contaminated coolant.

B. DRAINING THE COOLING SYSTEM

When the cooling system of a vehicle is drained, some coolant is likely to be retained in the pockets of the cooling system. This is especially true in engines equipped with oil coolers or heat exchangers having a tube bundle. If only water with cooling conditioner is used and these engines are drained and then exposed to freezing temperatures, the water conditioner will freeze and possibly rupture one or more of the tubes. The resulting leak will be difficult to locate and could eventually damage the engine by mixing the cooling with the engine oil.

To avoid damage, take one or the following precautions when draining for shipment or storage in freezing temperature:

a. Fill the cooling system with antifreeze solution, operate engine until the thermostat opens or until circulation is observed in the radiator circuit, then drain.

b. If conditioned water is used, drain the engine, then blow out the residual solution in the cooler tubes with compressed air through one of the drain cocks or plugs on the cooler.

C. CLEANING THE **COOLING SYSTEM**

1. Coolant shut-off cocks to heaters and other accessories should be open to allow complete circulation during cleaning, flushing and draining. Run the engine with the radiator covered if necessary until temperature is up to operating range 72-84 degs. C (160-180 degs. F). Stop engine, remove radiator cap carefully (if so equipped) and drain system by opening drain cocks on radiator and crankcase.

2. Allow engine to cool, close drain cocks and pour cleaning compound into radiator according to directions. Fill system with water.

3. Place a clean drain pan to catch overflow and use to maintain level in radia-

tor. Avoid spilling solution on vehicle paint.

4. Replace radiator cap (if so equipped) and run engine at moderate speed, covering radiator if necessary, so the radiator reaches a temperature of 84 degs. C (180 degs. F) or above but does not reach the boiling point. Allow the engine to run at least two hours at 84 degs C (180 degs. F) so the cleaning solution will take effect. Do not drive vehicle or allow liquid level in radiator to drop low enough to interfere with circulation.

NOTE: Stop engine as often as necessary to prevent boiling.

5. With the engine stopped, feel the radiator with bare hands to check for cold spots, and then observe the temperature reading. Where there is no change in temperature for some time, drain the cleaning solution.

6. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (See Pressure Flushing) and repeat cleaning operation.

7. If clogging of core, indicated by low temperature spots on the core, is not relieved; radiator core must be removed for mechanical cleaning. Mechanical cleaning requires removal of upper and lower tanks and rodding out the accumulated rust and scale from the water passage of the core.

D. PRESSURE FLUSHING

1. Disconnect the upper radiator hose which connects the radiator core to the engine water outlet and remove thermostat from engine water outlet.

2. Clamp a convenient length of hose to the radiator core outlet opening and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.

3. Connect the flushing gun to compressed air and water pressure and clamp the gun nozzle to the hose attached to the radiator outlet opening.

4. With radiator cap (if so equipped) on tight, fill core with water. Apply air pressure in short blasts to prevent core damage.

5. Continue filling radiator with water and applying air pressure in short blasts until the water comes out clear.

6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill engine block with water, partly covering water inlet opening to permit complete filling.

7. Apply compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.

8. For badly clogged engine water jackets that do not respond to regular pressure flushing, remove engine cylinder head and core hole plugs and with a suitable length of small copper tubing attached to the flushing gun nozzle, flush the water jackets through the openings.

9. If the vehicle is equipped with a heater connected to the cooling system, flush the heater following the same procedure as for the radiator core.

10. After completing the flushing operation, clean out the radiator overflow pipe, inspect the water pump, clean the thermostat and the radiator cap control valve (if so equipped). Check thermostat for proper operation before installation. See "Thermostat".

11. Blow insects and dirt from radiator core air passages using water, if necessary, to soften obstructions.

E. TEST EQUIPMENT

To aid the serviceman in maintaining the cooling system at top efficiency, various items of test equipment are available. Among these are the Cooling System Pressure Tester and the Hydrometer.

1. <u>SE-1870 Cooling System Pressure Tester</u>

   This equipment may be used in detecting the hard-to-find leaks in the cooling system. Any leak from cracked or warped cylinder heads or blown gaskets (internal or external) can be located easily and in a short time with the pressure tester. Adapters are available with the tester which permit the testing of radiators on trucks having the cabover-engine design (Fig 7). Pressure caps can also be tested with the pressure tester.

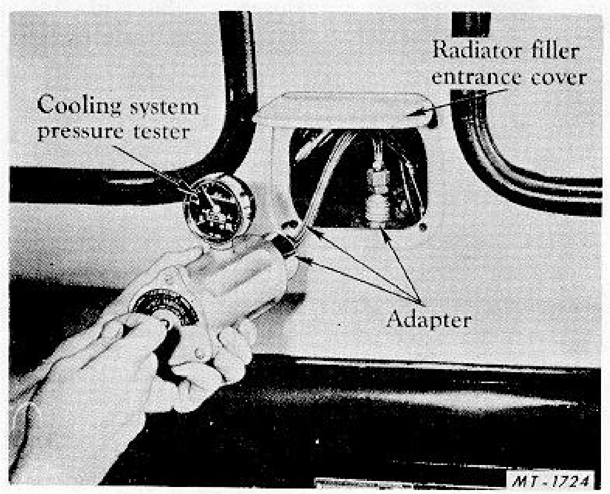

Fig. 7. Using SE-1870 Cooling System Pressure Tester with Adapter

2. Hydrometers

Hydrometers (Fig. 8) are used to test the freezing protection of an antifreeze solution and work on the principle of specific gravity or weight of the antifreeze solution. They are simple to use if used in the proper manner. When using the hydrometer, the solution must be at least 44 degs. C (110 degs. F), the temperature and level must be noted correctly and the float must be able to move freely. Read only the hydrometer scale corresponding to the type antifreeze solution in the radiator. Keep hydrometer clean inside and out and treat it with the same care as given any other precision instrument.

3. SE-2384 Pressure Tester

This tester (Fig. 9) consists of a heavy duty pump complete with adapters for remotely applying pressure to the cooling system at the radiator fill neck. The pump is equipped with a pressure gauge, manual pressure relief valve and hose assembly with twist-on clamp bracket to receive the adapters. The adapters can be quickly attached together for a small or large filler neck either with a shallow or deep neck.

4. SE-2395 Antifreeze and Battery Tester

This tester (Fig. 10) is designed for quick and accurate checking of antifreeze protection and battery specific gravity readings. Coolant may be checked hot or cold with a minimum amount of coolant or battery acid required. Operating instructions are included with the tester.

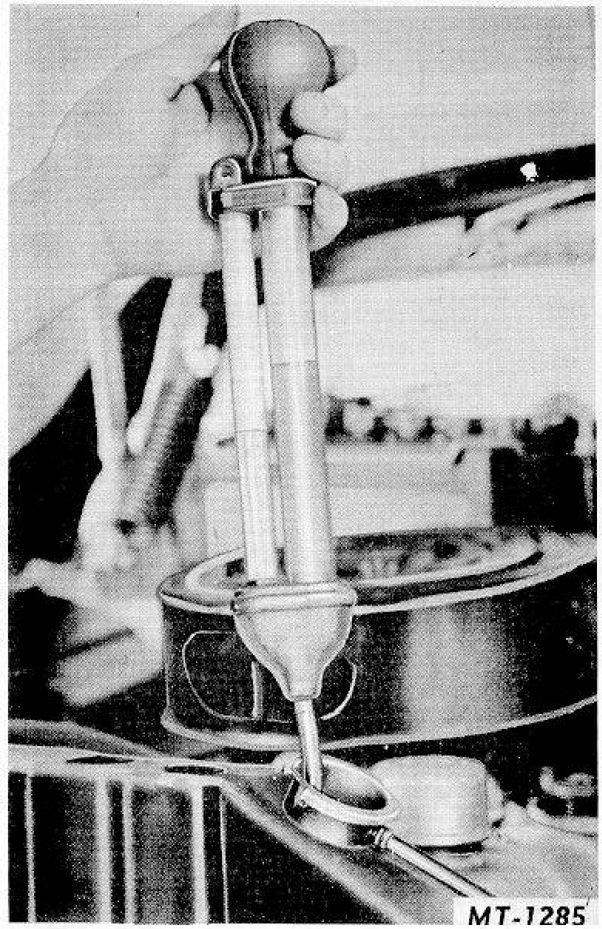

Fig 8. Using Hydrometer to Test Antifreeze Solution

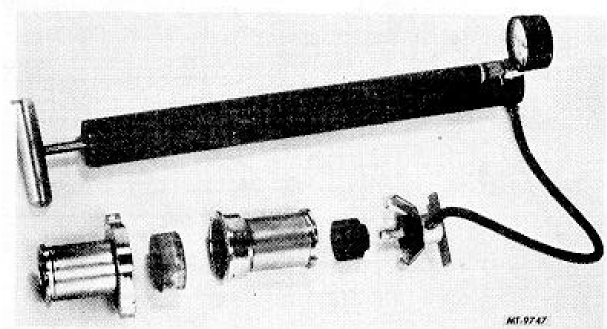

Fig 9. SE-2384 Cooling System Pressure Tester

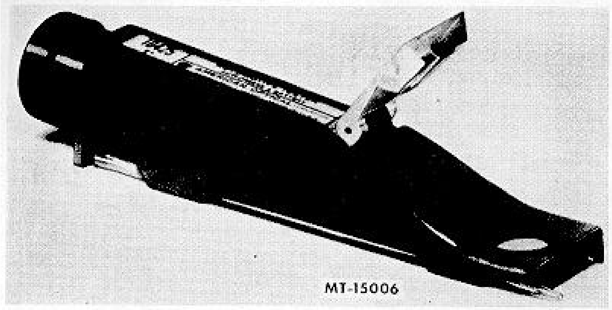

Fig. 10. SE-2395 Antifreeze and Battery Tester

TROUBLE SHOOTING

A. CAUSES OF COOLANT LOSS:

1. Leaks and seepage - may be either external or internal.

External leaks easy to locate, may occur at radiator, heater, water pump, core plug hole, hose connections, radiator cap, drain cocks and gaskets.

Internal leaks are more difficult to locate since these leaks occur at cracks and faulty head gaskets. Internal leaks are indicated by a decrease in coolant level and the presence of coolant in crankcase. Correct this condition immediately or serious damage to engine will result.

2. Boiling - may be caused by any of the following:
   a. Radiator or other parts of cooling system clogged with rust or scale.
   b. Grille or bug screen clogged.
   c. Radiator core fins damaged.
   d. Thermostat defective - stuck closed.
   e. Water pump leaking air into system.
   f. Radiator hose collapsed or rotting inwardly.
   g. Radiator pressure cap defective.
   h. Cylinder head loose causing exhaust gas leakage into cooling system.
   i. Water pump impeller corroded or loose on shaft.
   j. Antifreeze protection inadequate causing partial freeze-up.
3. After-Boil - Boiling which may occur in a cooling system after the engine is shut off even though it did not occur during operation is known as after-boil. This condition which usually happens to cooling systems that need attention, occurs because the coolant is still picking up heat from the engine and the heat is not being dispersed by circulation through the radiator. Other causes of after-boil are over-protection or use of high-temperature thermostat with alcohol type antifreeze, improper installation of the thermostat, or a thermostat that is operating improperly.
4. Foaming - Foaming of coolant may also cause coolant loss. This occurs only with a very dirty cooling system and under severe operating conditions. Usually an air or exhaust leak in the system contributes to foaming and this is caused by a faulty gasket, leaky radiator hose or water pump seal. Foam is an excellent insulator and can seriously interfere with proper circulation.

5. Evaporation - Evaporation reduces the amount of coolant in the system. This is a common occurrence where alcohol base types of antifreeze are used. A faulty pressure cap may also be the cause of evaporation.

B. CAUSE OF OVERHEATING

1. Cooling System
   a. Low coolant supply.
   b. Leaks at any of the following: gaskets, hose connections, water pump, radiator, heater, core plugs, drain cock or plugs, cracked head or block.
   c. Broken or loose fan belt.
   d. Radiator clogged.
   e. Collapsed or clogged hose.
   f. Defective pressure cap.
   g. Worn or corroded impeller on water pump.
   h. Foaming.
   i. Radiator air flow obstructed.
   j. Bent fan blade.
   k. Improper or defective thermostat.
2. Ignition System
   a. Ignition timing late.
   b. Defective spark advance.
3. Fuel System
   a. Carburetor set too lean.
   b. Valves timed late or leaking.
   c. Intake manifold leaking:
   d. Leak in vacuum operated accessories.
4. Miscellaneous
   a. Clogged muffler or tail pipe.
   b. Stiff re-built engine.
   c. Dragging brakes.
   d. Low engine oil level.
   e. Engine overloaded.

Cause of Overcooling:
1. Missing thermostat.
2. Defective thermostat stuck open.
3. Short runs and intermittent driving.

COOLING SYSTEM

AUTOMATIC RADIATOR SHUTTERS

(AIR AND VACUUM OPERATED)

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DESCRIPTION

Internal combustion engines held at a constant predetermined temperature reduce sludging, increase engine performance, increase fuel mileage, reduce engine wall wear and reduce downtime for major overhaul.

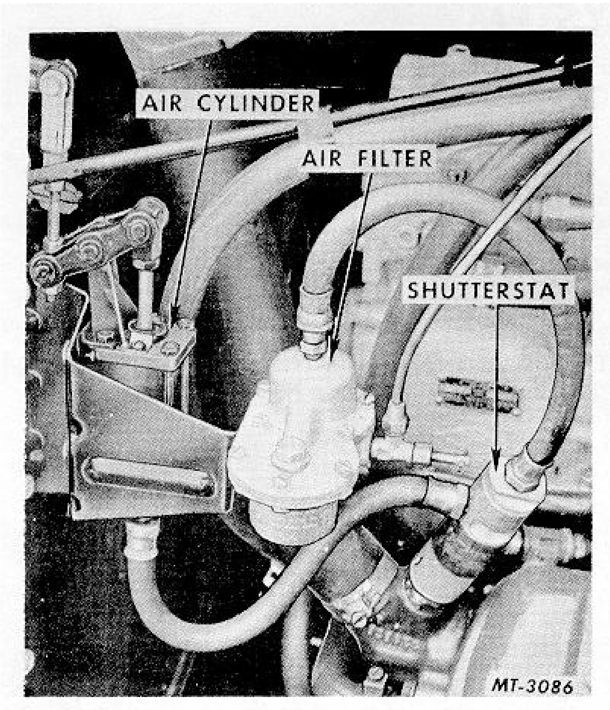

Fig. 1. Air Shutterstat (Separately Mounted Air Filter-Early Production).

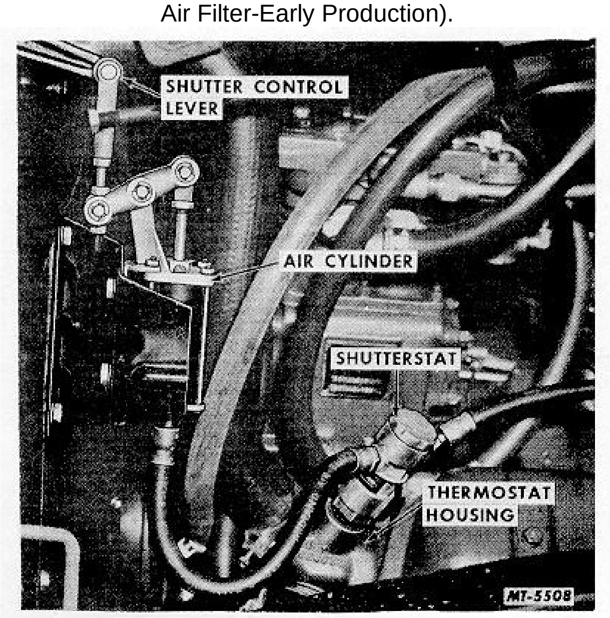

Fig. 2 Air Shutterstat (Integral Air Filter-Late Production)

The use of shutters along with the engine thermostat provides a quick warm-up period.

After the engine thermostat has opened, the shutters allow the coolant to continue to flow, whereas other methods used block all or a certain portion of the coolant in the radiator core or in a reserve tank, allowing it to become super-cooled while the temperature of the coolant in the engine is being raised to the desired temperature.

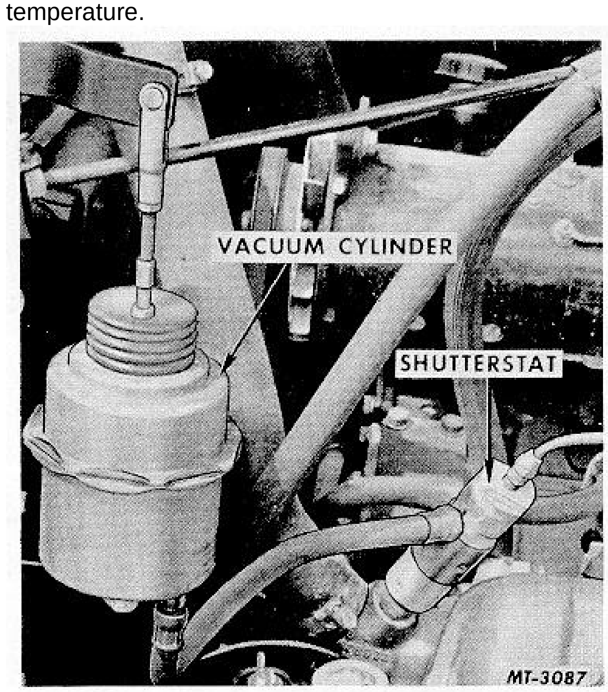

Fig. 3. Vacuum Shutterstat

CONSTRUCTION

The shutterstat is the brain center of the shutter system. It is a temperature sensing device that directs the mechanical control of the shutter blades through a vacuum or air power cylinder.

Early production air operated shutterstats utilized a separately mounted air filter, Fig. 1.

Current units have an internal air filter, Fig. 2. There is no separate filter in the vacuum operated shutter system, Fig. 3.

Fig. 4 illustrates the difference between the new and old design air operated shutterstat.

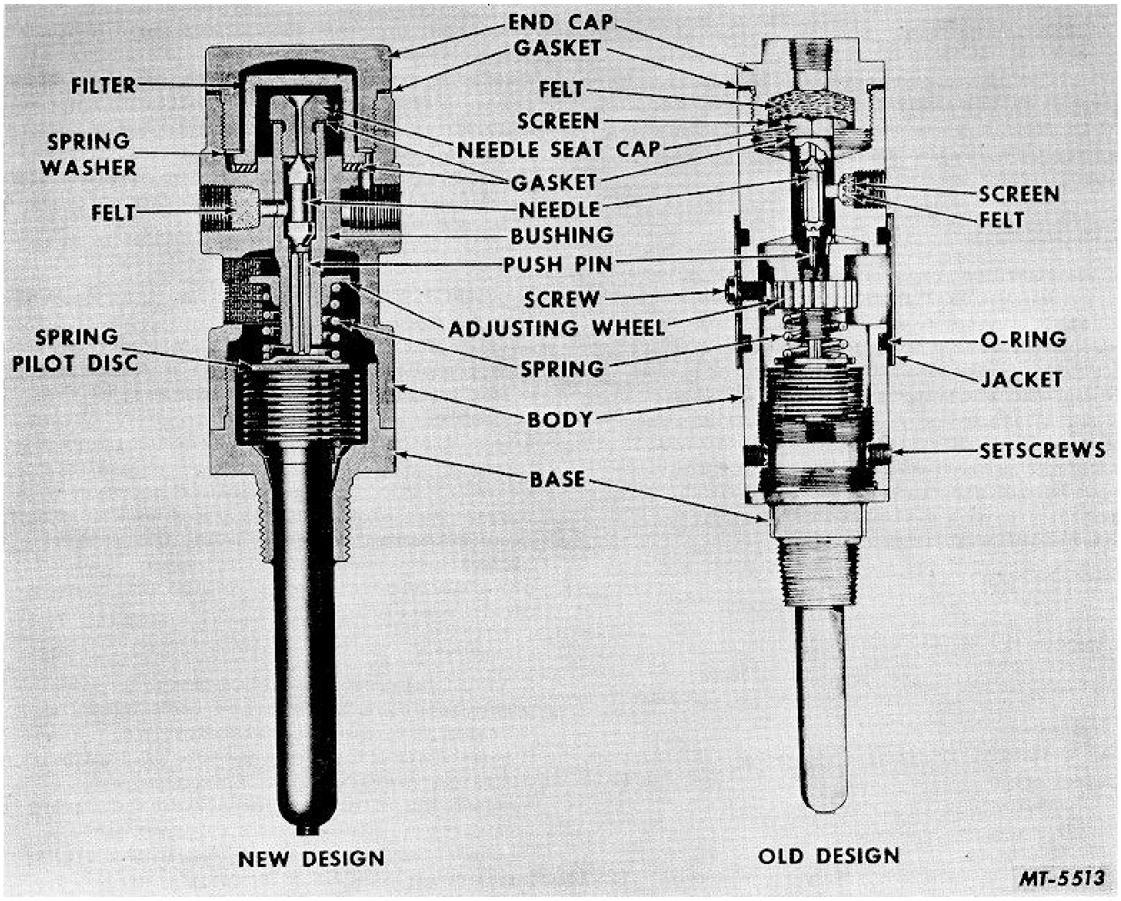

Fig. 4 Shutterstat Construction (Cross Section View)

OPERATION

Air Shutters

As line pressure develops, air will pass through the air filter into the shutterstat, past the needle valve (which is seated on the bottom seat due to engine temperature being below shutterstat setting), out the side opening of shutterstat, and into the air cylinder. When line pressure is on and temperature is below shutterstat setting, the cylinder piston will be extended to maximum length from the cylinder body and the cylinder spring will be compressed. With the piston in this position, shutter blades will be in the closed position.

When engine temperature reaches shutterstat setting, expansion of the fluid in shutterstat tube and bellows will cause the shutterstat needle valve to seat against the air inlet or upper seat. Air is now shut off to the air cylinder. Because there is no longer any line pressure being applied against the cylinder piston, the spring on the opposite side of the piston head expands and the shutter blades will move to the open position.

IMPORTANT: The air that was in the cylinder chamber and the line from the shutterstat to cylinder exhausts past the bottom of needle valve and to the atmosphere through the cover on the body. Be sure to keep this exhaust port free and clear of dirt, grease, etc. Back pressure, caused by failure to do so, will greatly shorten the life of the shutterstat through bellows failure and excessive needle travel.

With the shutter blades in the open position, engine temperature will drop off and cause contraction of the alcohol-filled tube and bellows. With this contraction, the needle valve will return to the lower valve seat. Air will again pass through shutterstat to cylinder and further exhaust of air will be shut off. The shutter is once more in the closed position.

The action, as just outlined, is a complete cycle of the air automatic shutter system. It is repeated as often as is necessary to maintain a constant engine operating temperature, under varying loads and conditions of 7° to 10° differential.

Vacuum Shutters

As vacuum develops in the reserve tank, it will follow the line into the top of the shutterstat, past the needle (which is seated on the bottom seat due to engine temperature being below shutterstat setting), out the side opening of the shutterstat into the vacuum cylinder. With the engine temperature below shutterstat setting, the cylinder piston will be drawn its maximum travel into the cylinder body and the cylinder spring will be compressed. With the piston in this position, shutter blades will be closed.

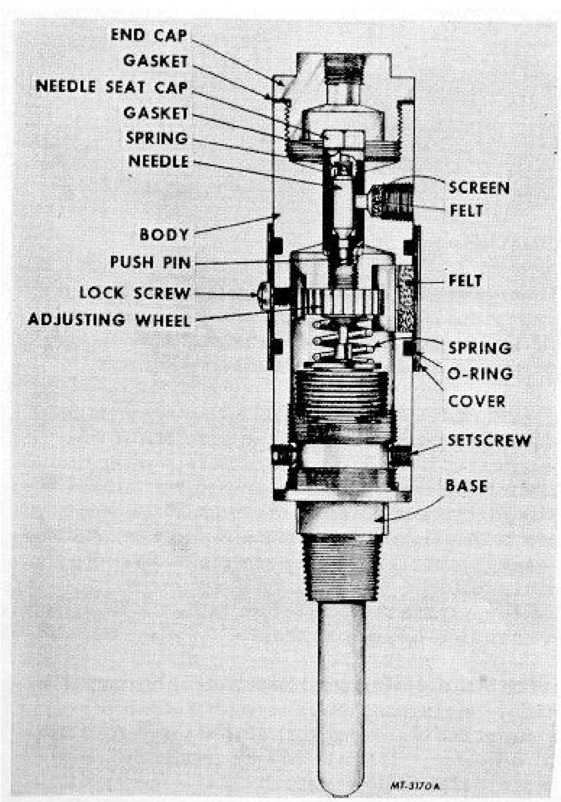

Fig. 5 Vacuum Shutterstat (Cross Section View)

When engine temperature reaches shutterstat setting, expansion of the fluid in shutterstat tube and bellows will cause shutterstat needle to seat against vacuum inlet or upper seat. Vacuum is now shut off to the vacuum cylinder. Because there is no longer any vacuum being applied to the cylinder piston, the spring on the opposite side of the piston head expands and the shutter control springs open the shutter blades.

IMPORTANT: The vacuum that was in the cylinder chamber and line from the shutterstat to cylinder is released by means of air entering through the air intake holes in the cover, past the bottom seat of the needle valve bushing and into the cylinder. The air is filtered as it passes through the breather felt, Fig. 5. Be certain to keep breather felt clean and intake holes open as restriction of air at this point will result in poor vacuum release causing the shutter blades to open slowly, remain closed or partially closed, depending on the amount of air restriction.

With the shutter blades open, engine temperature will decrease causing contraction of the shutterstat bellows. With this contraction, the needle will return to its lower valve seat. Vacuum will again form in the shutterstat and cylinder and further intake of air is prevented. The shutter blades are again in the closed position. NOTE: A spring, Fig. 18, between the needle and needle seat cap prevents air intake through the lower seat and the needle being drawn into the upper seat when vacuum is applied.

The action, as outlined above, is a complete cycle of the vacuum automatic shutter system. It is repeated as often as necessary to maintain a constant engine operating temperature under varying loads and conditions of 7° to 10° differential.

CHECKING THERMOSTAT AND SHUTTERSTAT

The opening temperature of the shutterstat should be a minimum of 10° higher than the opening temperature of the engine thermostat. To determine at what temperature the engine thermostat and shutterstat is operating, it is necessary to remove both units from the vehicle and test them as outlined below.

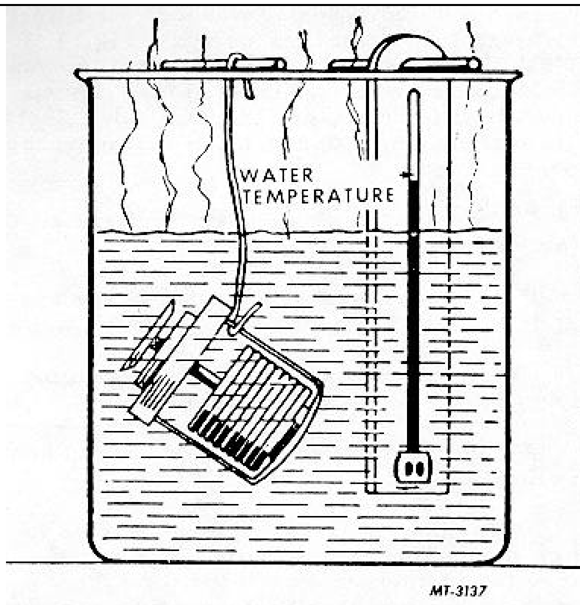

Fig. 6 Checking Thermostat Opening Temperature

<u>Testing Thermostat</u>

Suspend thermostat by its frame in a container of water so that the thermostat unit does not touch the bottom of container, Fig. 6. Heat water and measure temperature with a thermometer. When thermostat begins to open, record thermometer temperature. If thermostat valve opens at a temperature of more than 10° below or does not open at a temperature of approximately 10° above rated opening stamped on thermostat, it should be replaced.

<u>Testing Shutterstat</u>

Remove end cap from shutterstat. Suspend shutterstat and a thermometer in a one-quart glass container (preferably heat resistant glass), Fig. 7.

Fill container until water level reaches bottom of shutterstat body and place container on a hot plate. Insert locally made push pin (see insert Fig. 7) through opening in needle seat cap and rest it on shutterstat needle.

Mount dial indicator (SE-1848) as shown in Fig. 7 and set dial on zero.

Insert thermometer into container through small hole in plate using a rubber band to retain thermometer. CAUTION: Do not allow shutterstat bulb or thermometer bulb to rest.

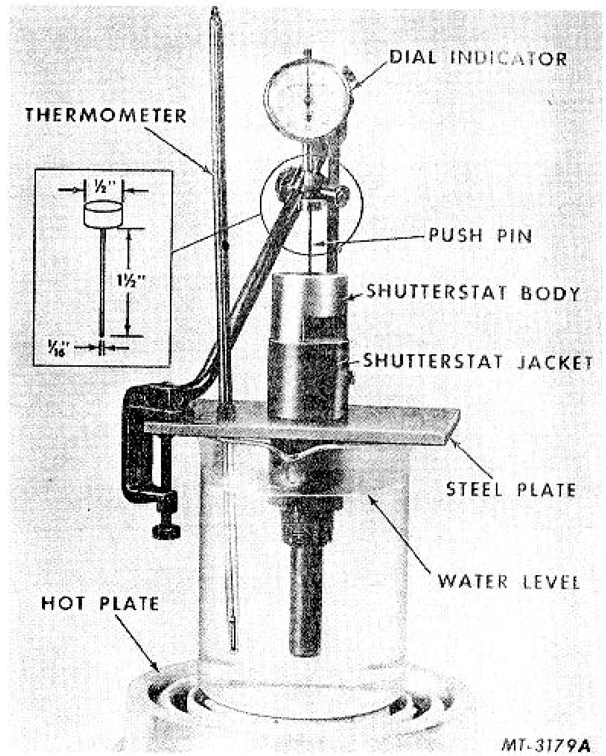

Fig. 7 Checking Shutterstat Opening Temperature

Heat water and carefully note temperature at which dial indicator starts to move. This is the temperature at which shutters will open and should be a minimum of 10° higher than thermostat opening temperature. If dial indicator moves prior to 100 above thermostat opening temperature, the shutterstat should be adjusted to a higher temperature. If the dial indicator fails to move until after 15° above the engine thermostat temperature, the shutterstat must be adjusted to a lower temperature. NOTE: Dial indicator should travel at least .0045" but not more than .005" If travel is more or less than specified, the shutterstat should be replaced with a new unit.

To check shutterstat to determine that the needle is returning to the lower seat, slowly add cold water to container. Dial indicator should return to zero. If an accurate temperature reading is required at the interval of needle closing, the container of water should be cooled very slowly. The needle closing cycle (dial indicator returning to zero) closes the radiator shutters. When installing either a new engine thermostat or shutterstat, or both, a good practice would be to test the two units that are to be used together in the same engine.

This will assure that the shutterstat is operating within the range specified and is adjusted to the 10° minimum above the engine thermostat setting.

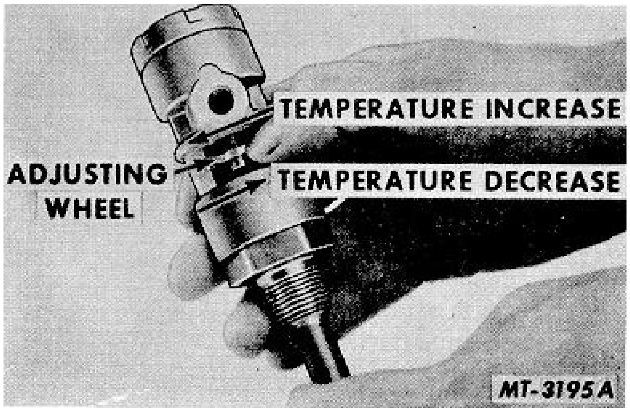

Fig. 8 Method of Adjusting Temperature Setting

To adjust shutterstat temperature setting, remove cover and loosen lockscrew (early production) or remove ratchet (late production). Turn adjusting wheel down (counterclockwise) to increase spring tension for a higher temperature setting or up (clockwise) to decrease spring tension for a lower temperature setting, Fig, 8.

Tighten lockscrew or replace ratchet. Install cover.

When adjusting shutterstat, turn the adjusting wheel only one or two notches at one time. This procedure will permit close control of the adjustment procedure. The degrees per notch will vary between shutterstat units.

The temperature setting is stamped after the part number on the end cap.

CLEANING AND INSPECTION

The shutterstat unit should be disassembled at least once a year as outlined below for cleaning purposes only. If further disassembly is required, unit should be replaced.

Remove cover from body and clean screens and felts where applicable. Remove felts or screens from air or vacuum outlet bores in body and clean them thoroughly in a commercial cleaning solvent.

Remove end cap from body using a spanner wrench. Remove spring washer, air filter element and gasket (new design), Fig. 4. Wash filter element in a commercial solvent and blow dry with compressed air. Install new air filter element gasket in body. Install air filter element and position spring washer over element.

Clean felt in end cap of air shutterstat (old design), Fig. 4.

Position new gasket over end cap and install end cap. Tighten end cap to 45 ft. lbs.

Check end cap, body and base assembly for stripped threads or cracks.

Always install new gaskets when end cap is installed.

When connecting air or vacuum lines to new design shutterstat, be careful to not turn line fittings into body too far. The ends of the fittings will close-off or restrict the passages within the shutterstat, Fig. 9. Also, if excessive amounts of sealing compound is used on fitting threads, there will be a tendency for the compound to be pushed ahead of the fitting and into the passages, Fig. 9.

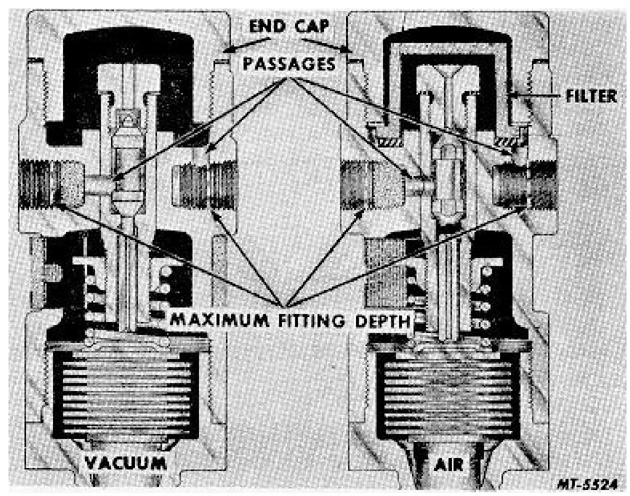

Fig. 9 Shutterstat Supply Line Fitting Locations

The end cap an, d filter element (if air operated) may be removed from shutterstat body to check fitting location of supply line to shutterstat. For remaining line, measure depth in body to felt and lightly mark fitting; then do not turn fitting into body beyond this mark. Reinstall end cap and filter element.

MAINTENANCE

Air Filter

The air filter should be taken apart and the felts (9, Fig. 10) renewed or washed thoroughly at least once each year. The bottom of the filter should be drained frequently by opening the drain cock.

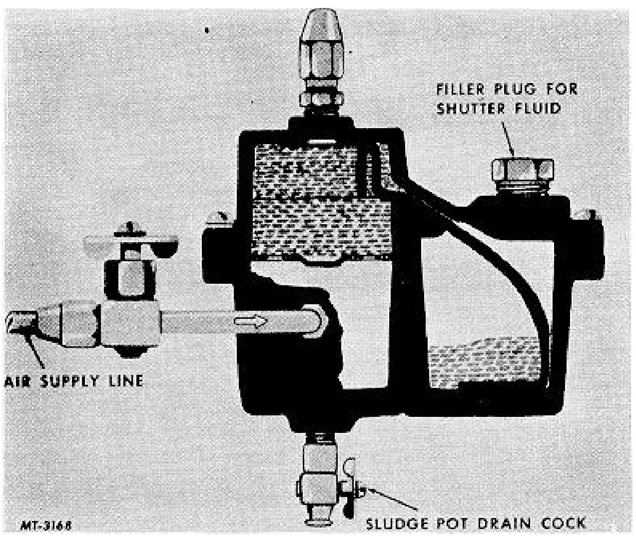

Fig. 10 Air Filter Assembly (Sectional View)

Air Cylinder

Little or no maintenance is required although it is good practice to disassemble, clean, oil, replace worn parts and reassemble once each year.

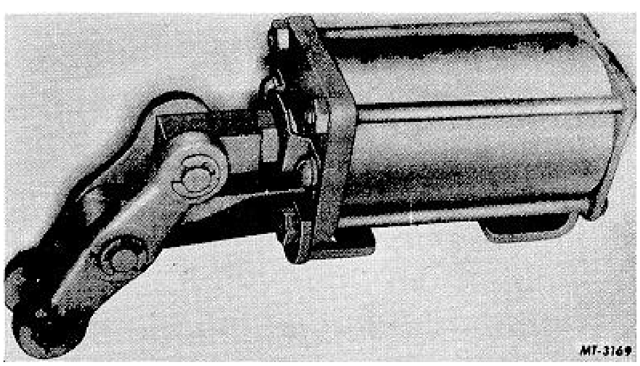

Fig. 11 Air Cylinder

Vacuum Cylinder

No maintenance is required on the vacuum cylinder. NOTE: Should the vacuum cylinder require disassembly, be certain to clamp the top and bottom portion of the cylinder together before punching out rivets.

Shutter

The shutter assembly, Fig. 12, should be checked annually for required replacement of worn rod bushings (6) and washers and blade springs (12). Be certain the shutter is not warped and the blade bushings do not bind.

Lubricate all angle bearings and control bar every 20, 000 miles. Use No. 10 oil.

NOTE: When operating vehicle in extremely dusty areas, shutter and linkage should not be lubricated. This will eliminate the accumulation of dirt and foreign matter in the shutter bushings and blades which would act as an abrasive and destroy the smooth operation of the shutter.

Adjust cylinder linkage annually to take up lost motion. Insert piece of match folder between blades. If there is a drag on match folder as it is removed, adjustment is correct. If not, apply air to operating cylinder with cylinder piston rod fully extended. Adjust linkage for proper seal. Impact air plus fan suction will provide a hurricane of air passing through a small opening if shutter is not properly sealed.

LUBRICATION

One ounce of shutter fluid should be added to the chamber of the separately mounted air filter every 1, 500 to 3, 000 miles or 45 to 90 hours.

No lubrication of the vacuum shutterstat or vacuum cylinder is required.

Lubricate shutters as outlined under MAINTENANCE, Shutter.

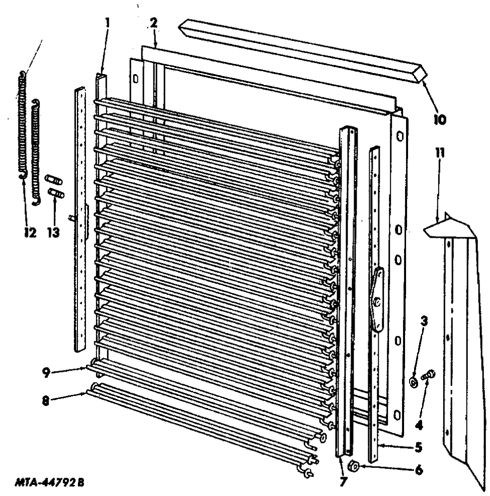

Fig. 12 Radiator Shutter (Exploded View)

Legend for Fig. 12

Key	Description
1.	ANGLE, Left
2.	FRAME (Not Serviced Separately)
3.	WASHER, Lock
4.	SCREW, Round-Head, Slot
5.	BAR
6.	BUSHING, Blade
7.	ANGLE, Right
8.	BLADE
9.	BLADE
10.	SEAL, Shutter to Radiator
11.	NOT USED
12.	SPRING, Blade
13.	PIN, (Not Serviced Separately)
14.	ROD, Shutter Control

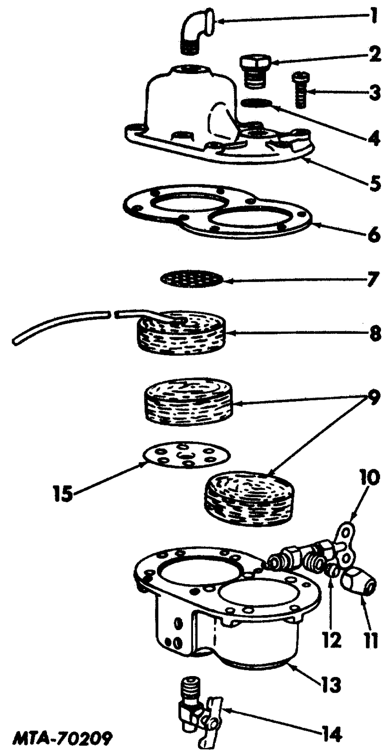

Fig. 13 Air Filter (Exploded View)

Legend for Fig. 13

Key	Description
1.	ELBOW
2.	PLUG, Filler
3.	SCREW
4.	WASHER, Seal
5.	COVER, Upper
6.	GASKET
7.	SCREEN
8.	PAD
9.	PAD, (Felt)
10.	COCK, Stop
11.	NUT
12.	SLEEVE
13.	COVER, Lower
14.	COCK, Drain
15.	DISC, Air Filter

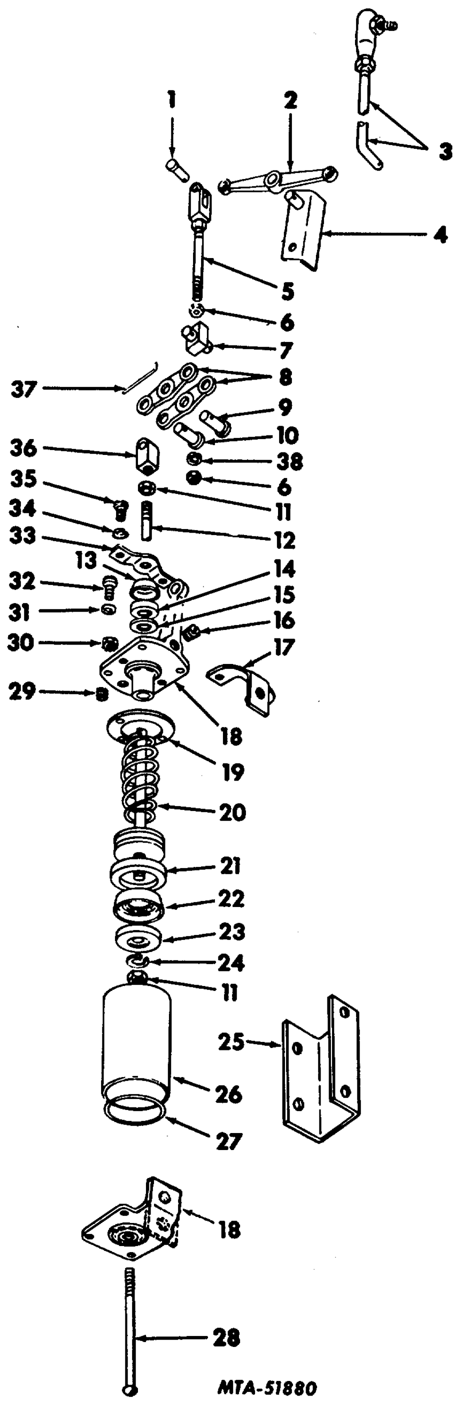

Fig. 14 Air Cylinder (Exploded View)

Legend for Fig. 14

Key	Description
1.	PIN
2.	BELLCRANK
3.	ROD, Control
4.	BRACKET
5.	ROD, Control
6.	NUT, Hex 1/4 NC
7.	BLOCK, Control Rod
8.	BELLCRANK
9.	PIN, Bellcrank
10.	PIN, Bellcrank Cylinder Rod
11.	NUT, Hex, Jam 5/16
12.	ROD
13.	CAP *
14.	FELT *
15.	WASHER *
16.	NOT USED
17.	BRACKET, Mounting
18.	BRACKET *
19.	GASKET, Cylinder Head *
20.	SPRING *
21.	FELT *
22.	CUP *
23.	BLOCK, Follower
24.	WASHER, Lock
25.	BRACKET, Mounting
26.	CYLINDER, Air
27.	RING *
28.	SCREW, Round-Head Slot
29.	NOT USED
30.	NUT, Hex, Lock
31.	WASHER, Seal 1/4
32.	SCREW, Fil-Hed.
33.	RETAINER *
34.	WASHER
35.	SCREW, Round-Head, Slot
36.	BLOCK, Rod
37.	PIN, Cotter
38	WASHER, Lock
*	Not Serviced Separately

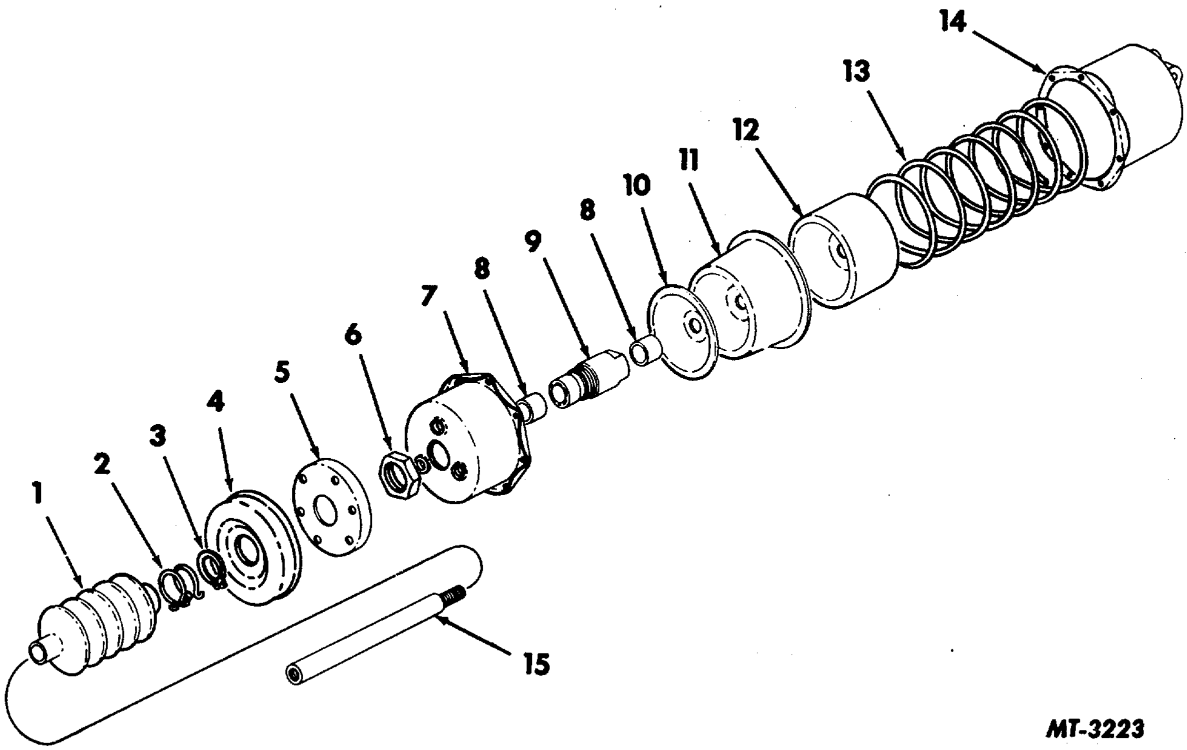

Fig. 15. Vacuum Cylinder (Exploded View)

Legend for Fig. 15

Key	Description	Key	Description
1.	BOOT, Piston Rod	9.	BEARING, Adapter
2.	SPRING, Snap Ring Boot	10.	CONE, Diaphragm Retainer
3.	RING, Snap	11.	DIAPHRAGM
4.	SHIELD, Shutter Cylinder	12.	PISTON
5.	CUP, Filter Retainer	13.	SPRING, Shutter Cylinder Piston
6.	NUT, Bearing Adapter	14.	BODY (Suction End)
7.	BODY, (Head End)	15.	ROD, Piston
8.	BUSHING, Bearing		

COOLING SYSTEM

AUTOMATIC RADIATOR SHUTTER
(With Modulated Control)

INDEX

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An internal combustion engine operated at a constant predetermined temperature has less wear and greater efficiency. To provide this constant temperature, shutters are mounted in front of the radiator. The shutter blades are opened and closed automatically by a thermostatic modulated control, Fig. 1.

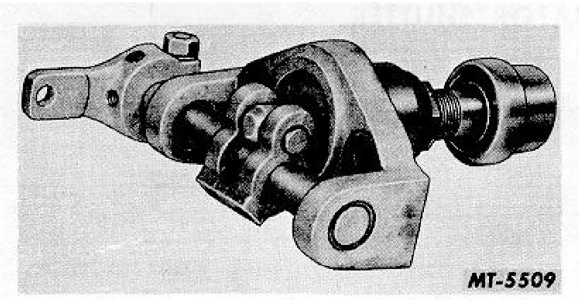

Fig. 1 Radiator Shutter Control.

The operating temperature of the engine is dependent upon the shutter control thermostat setting, therefore, it is important that a shutter control of the correct degree rating be installed (see "NOTE", page 6).

OPERATION

The modulated shutter control is mounted in the radiator bottom tank with the thermostat unit extending into the coolant. When the engine is' cold, the engine thermostat and radiator shutter blades are closed. The shutter blades are held closed by a spring in the shutter assembly. When the temperature of the coolant reaches the opening temperature of the engine thermostat, the thermostat opens allowing the coolant to circulate through the radiator. The shutter control thermostat element senses the increase in coolant temperature and expands, moving the control lever which is connected to the shutters by means of a rod. This action gradually opens the shutter blades until the coolant temperature rise is halted at the required setting.

If atmospheric temperatures should cause the coolant temperature to receed, the shutter control thermostat element contracts allowing the return spring on the shutter assembly to gradually close the shutter blades until the coolant is again raised to the required temperature.

Because of the modulated control, the shutter blades do not necessarily move from a fully closed to a fully open position or vise-versa. They open only that amount necessary to maintain a constant operating temperature. The slight temperature rise possible when an engine is shut-down will not affect the position of the shutter blades. The blades should be in the closed position when the engine temperature is cold. Failure of the shutter control thermostat will not result in engine damage because the expansive properties of the thermostat element will always keep the blades in an open position.

NOTE: Do not discard thermostat because plunger is extended.

A small spring is provided to return piston of thermostat if shutter should be held open while engine cools. However, should piston be in extended position when cold, it is necessary that thermostat be heated to operating temperature before attempting to return. Cover radiator completely and bring temperature to normal, then apply spring tension and piston will return when engine cools. If thermostat is removed, heat in circulating water and apply spring tension until it cools. NEVER FORCE piston back when cold, as serious damage will result. Should the piston not return to proper height, the neoprene diaphragm may be ruptured and thermostat will have to be replaced.

REMOVAL

Shutter Control Assembly

To remove modulated shutter control, drain coolant from radiator. Disconnect control rod from control lever. Remove the two (2) bolts securing shutter control to bottom tank of radiator and take out control assembly.

Shutter Assembly

To remove shutter assembly, take out bolts securing frame assembly and lift out shutter assembly.

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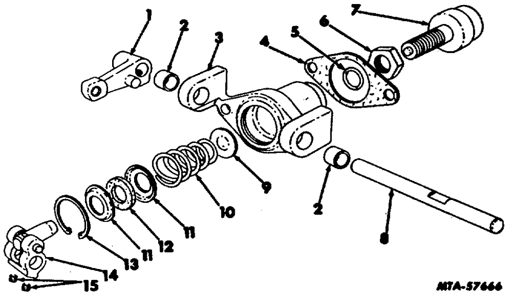

Fig. 2 Radiator Control Assembly (Exploded View).

Legend for Fig. 2

Key	Description
1.	LEVER, control
2.	BUSHING, shaft
3.	BODY
4.	GASKET, control mounting
5.	SEAL, "O" ring
6.	NUT, hex jam
7.	THERMOSTAT
8.	SHAFT, control
9.	SEAT *
10.	SPRING *
11.	SEAT *
12.	WASHER felt
13.	RING, snap
14.	PLUNGER, w/Yoke
15.	SCREW
*	Not Serviced Separately

DISASSEMBLY

Shutter Control

All key numbers refer to Fig. 2.

Loosen clamp bolt nut and socket-head setscrew in control lever (1) and remove lever. Loosen the two (2) socket-head setscrews (15) and pull control shaft (8) out of body (3); sliding plunger with yoke assembly (14) off of shaft as shaft is withdrawn.

Mount control body (3) in a vise (thermostat up) and loosen jam nut (6). Turn thermostat (7) out of body (3). Invert body in a vise and using suitable pliers remove snap ring (13). Remove body from vise and take out seat (11), felt washer (12), spring (10) and seat (9).

Adequately support control body (3) and using an adapter of correct diameter, drive bushing (2) out of body flange. An alternate method is the use of a cape chisel to collapse the bushing

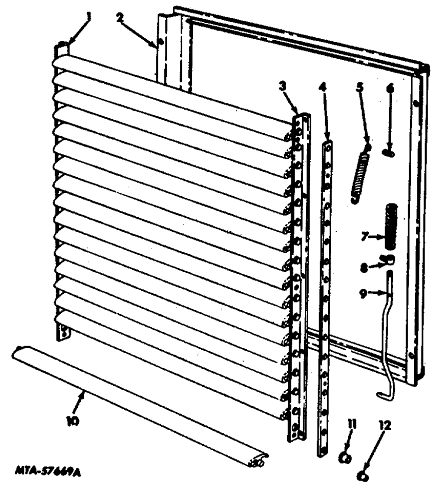

Fig. 3 Shutter Assembly (Exploded View).

Legend for Fig. 3

Key	Description
1.	ANGLE, left
2.	FRAME *
3.	ANGLE, right
4.	BAR, control
5.	SPRING, blade
6.	STUD, control bar
7.	SPRING, control rod
8.	BLOCK, control rod
9.	ROD, control
10.	BLADE, shutter
11.	BUSHING, blade pin
12.	BUSHING, blade crank
*	Not Serviced Separately

Shutter Assembly

All key numbers refer to Fig. 3.

Remove bolts attaching left angle (1) and right angle (3) to frame (2). Disconnect block (8) from control bar (4). Remove cotter pins and withdraw control rod (9) while removing block (8) and spring (7). Remove blade spring (5) and lift shutter blade assembly out of frame (2).

Pull control bar (4) off of blade crank pins.

Remove left angle (1) and right angle (3) from shutter blades (10).

CLEANING, INSPECTION AND REPAIR

Clean all parts thoroughly and examine for damage or wear. Be sure all old gasket material is removed from body. Check to see that small disc (anti-friction washer), located in bore of thermostat unit, is not stuck to lower end of piston. If disc is stuck it is very important that it be replaced. Be certain that piston is free of dirt or abrasive material. Also, see that piston is a free sliding fit in bore of thermostat unit.

Check linkage and shutter blade crank bushings for excessive wear. Replace parts where necessary.

REASSEMBLY

Shutter Control

All key numbers refer to Fig. 2.

Using proper adapter, drive or press new bushings in body flanges.

Install small disc (anti-rattle washer) into bore of thermostat unit. Lubricate piston with # 200 fluid or silicone grease and place piston into bore of thermostat unit (bulletnose end out). Assemble jam nut (6) followed by new "O" ring seal (5) on thermostat unit (7). Install thermostat into body (3). See "ADJUSTMENTS" for correct positioning of thermostat in body.

Position seat (9) in body (3), flanged side opposite thermostat side of body. Install spring (10), seat (11), felt washer (12Z) and secure in body (3) with snap ring (13).

Place plunger (14) into body. Slide control shaft (8) through one side of body flange. Mount yoke with plunger assembly (14) on shaft. Push shaft through remaining flange. Align plunger with opening in seats (11) and position yoke on shaft so that there is no interference when plunger moves in and out of body. Install and tighten socket-head setscrews in yoke. Position control lever (1) on shaft with lever pointing in opposite direction from thermostat unit. Do not tighten clamp bolt or setscrews in lever at this time. See "ADJUSTMENTS" for final positioning of lever.

Shutter Assembly

All key numbers refer to Fig. 3.

Install bushings (11) on shutter blades (10). Assemble left angle (1) and right angle (3) on ends of blades (10). Place bushings (12) on blade crank pins and install control bar (4).

Place shutter blade assembly in frame (2). Connect blade spring (5) from control bar (4) to control bar stud (6).

Insert control rod (9) and install block (8) and spring (7) on rod. Install cotter pins in control rod. Connect block (8) to control bar (4). Install bolts securing right angle (3) and left angle (1) to frame %2).

INSTALLATION

Shutter Assembly

Position shutter assembly in vehicle and install retaining bolts.

Shutter Control

Adjust thermostat location in control body (see "ADJUSTMENTS"). Place new gasket on control body and assembly body to radiator, thermostat unit extending into bottom tank. Install the two (2) bolts securing shutter control to radiator tank.

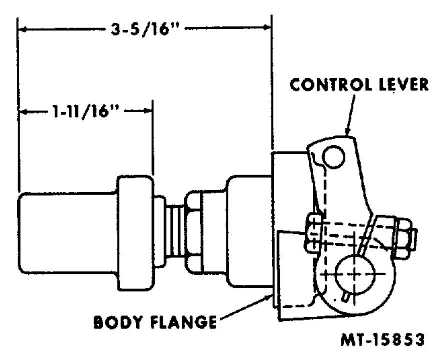

Fig. 4 Shutter Control Thermostat Unit Adjustment

ADJUSTMENTS

Thermostats with different body lengths are being used, see Figures 4 and 5. Therefore, the dimensions between the face of the body flange and end of the thermostat unit will also be different as shown in the illustrations.

When installing shutter control, control lever must be correctly positioned on shaft to properly open and close shutter blades. With engine cold (150° or below) and control rod disconnected at control lever, manually close shutter blades. This can be done by pushing back on each side at the bottom of the top blade. With the blades completely closed and shutter control plunger pushed in against piston, rotate control lever on shaft until control rod will index with hole in lever. Hold lever in this position and tighten sockethead setscrews and clamp bolt nut. Install cotter key in control rod.

Recheck linkage between shutter and control to see that all slack was removed. Check to see that shutters close tightly by attempting to insert a calling card between the blades. If not closed tightly, repeat adjustment procedure previously outlined.

Be certain shutter blades have sufficient end clearance (not exceed 1/16"). End clearance can be adjusted by loosening bolts on side of frame that retain the bushing angles. Move angle to obtain adequate clearance and while holding in this position tighten retaining bolts.

Full open position of shutter blades is at an angle of approximately 70° (not 90°). Maximum air flow is attained when blades are open from 60° to 70° (angular degrees).

LUBRICATION

Periodic inspection is advisable at which time nylon blade bushings should be cleaned with light or penetrating oil and blown out with air pressure. DO NOT oil at frequent intervals, only after cleaning or reassembly, as normal lubricating oils tend to gather dirt and dust. Light oil on linkage periodically is desirable.

Periodically remove thermostat piston. Clean piston thoroughly and lubricate with # 200 fluid or silicone grease.

TROUBLE SHOOTING

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine Running Too Hot.	1. Coolant Level Too Low.	1. Fill radiator and check for leaks.
	2. Faulty Temperature Gauge.	2. Replace gauge.
	3. Slack in Linkage.	3. Adjust linkage.
	4. Faulty Engine Thermostat.	4. Replace engine thermostat.
	5. Broken or Loose Fan Belt.	5. Replace or tighten fan belt.
	6. Faulty Water Pump.	6. Replace or repair water pump.
	7. Radiator Clogged.	7. Clean radiator.
	8. Thermostat Dimensional Setting Incorrect.	8. Remove shutter control and adjust.
	9. Incorrect Shutter Control Thermostat Temperature Range.	9. Install correct thermostat.
	10. Shutters or Linkage Binding.	10. Free shutters and linkage.
Engine Running Too Cold.	1. Faulty Temperature Gauge.	1. Replace gauge.

TROUBLE SHOOTING (Continued)

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine Running Too Cold (Continued)	2. Linkage Adjusted to Tight.	2. Adjust linkage.
	3. Thermostat Dimensional Setting Incorrect.	3. Remove shutter control and adjust.
	4. Incorrect Shutter Control Thermostat Temperature Range.	4. Install correct thermostat.
	5. Faulty Shutter Control Thermostat.	5. Replace thermostat.
	6. Shutter Linkage Binding.	6. Free linkage.

NOTE: The degree rating of the engine thermostat and shutter control thermostat should be identical.

For example, if a 180° engine thermostat is used, a 180° shutter control thermostat unit should also be used. The engine thermostat will open at approximately 180' and allow the coolant to flow to the radiator top tank. As the coolant flows down through the radiator core, a drop in coolant temperature of approximately 10' will take place. The shutter blades will remain closed until the coolant temperature in the bottom tank is raised to the arbitrary figure of 180°. This will cause the coolant temperature in the engine to actually be slightly above 180° which will keep the engine thermostat open, allowing the shutter control thermostat to control the operating temperature.

Shutter control thermostat units are available in temperature control ratings of 160°, 170°, 175° and 180°.

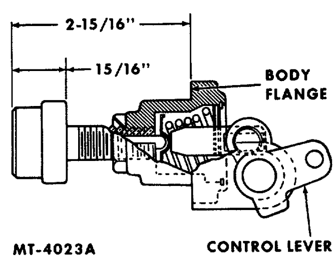

Fig. 5 Shutter Control Thermostat Unit Adjustment.

ELECTRICAL

ALTERNATOR
(DELCO-REMY)

10 SI SERIES

CODES 08084, 08130, 08132

CONTENTS

CHAPTER I

10SI SERIES TYPE 100
37, 42, 61 and 63 AMP

CHAPTER II

1OS1 SERIES TYPE 116
42 and 61 AMP

CHAPTER I

10 SI SERIES, TYPE 100

Code 08084	42 Amp
Code 08130	37 Amp (Production) 42 Amp (Service)
Code 08132	61 Amp (Production) 63 Amp (Service)

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DESCRIPTION

The alternator illustrated in Figs. 1 and 2 features a solid state regulator that is mounted inside the alternator slip ring end frame. All regulator components are enclosed into a solid mold, and this unit along with the brush holder assembly is attached to the slip ring endframe. The regulator voltage setting never needs adjusting, and no provision for adjustment is made.

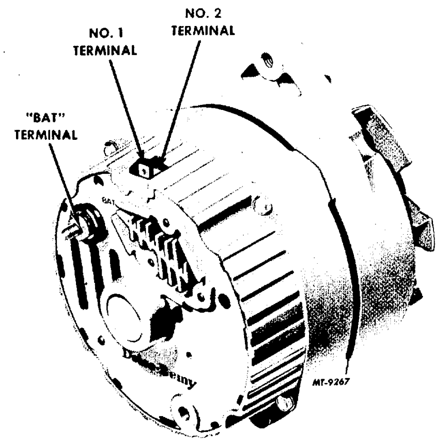

Fig. 1 Alternator

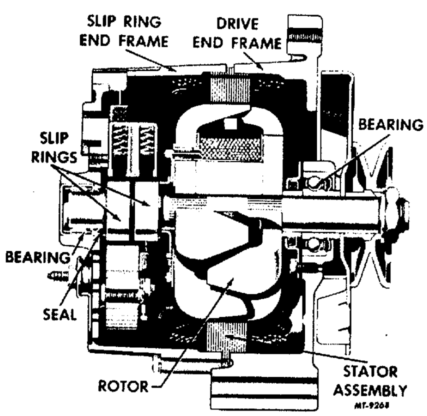

Fig. 2 Cross Sectional View

The alternator rotor bearings contain a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. Two brushes carry current through the two slip rings to the field coil mounted on the rotor and under normal conditions will provide long periods of attention-free service.

The stator windings are assembled on the inside of a laminated core that forms part of the alternator frame. A rectifier bridge connected to the stator windings contains six diodes and electrically changes the stator A. C. voltages to a D. C. voltage which appears at the alternator output terminal. Alternator field current is supplied through a diode trio which also is connected to the stator windings. A capacitor, or condenser, mounted in the end frame protects the rectifier bridge and diode trio from high voltages and suppresses radio noise.

No periodic adjustments or maintenance of any kind are required on the entire alternator assembly.

OPERATION

A typical wiring diagram is illustrated in Figure 3. The basic operating principles are explained as follows: The No. 2 terminal is connected to the battery, and the base-emitter of transistors TR3 and TR1 is connected to the battery through resistor R5, thus turning these transistors on. Also, resistors R2 and R3 are connected to the battery through terminal No. 2, but the discharge current of the battery is very low because of the resistance values of R2, R3, R5, TR1 and TR3.

When the switch is closed, current from the battery flows through the resistor to the No. 1 terminal, through resistor R1, and transistor TR3 and TR1 to ground, and then back to the battery. Also, current flows through the alternator field coil and TR1 back to the battery.

With the alternator operating, A.C. voltages are generated in the stator windings, and the stator supplies D.C. field current through the diode trio, the field, TR1, and then through the grounded diodes in the rectifier bridge back to the stator. Also, the six diodes in the rectifier bridge change the stator A.C. voltages to a D.C. voltage which appears between ground and the alternator "BAT" terminal. As alternator speed increases, current is provided for charging the battery and operating electrical accessories. Also, with the alternator operating, the same voltage appears at the "BAT" and No. 1 terminals, and the ammeter indicates that the alternator is producing voltage.

If an open should occur in the No. 2 terminal circuit, TR3 and TR 1 will turn off and no field current will flow to prevent overcharge. As turn off. With TR1 off, the field current and

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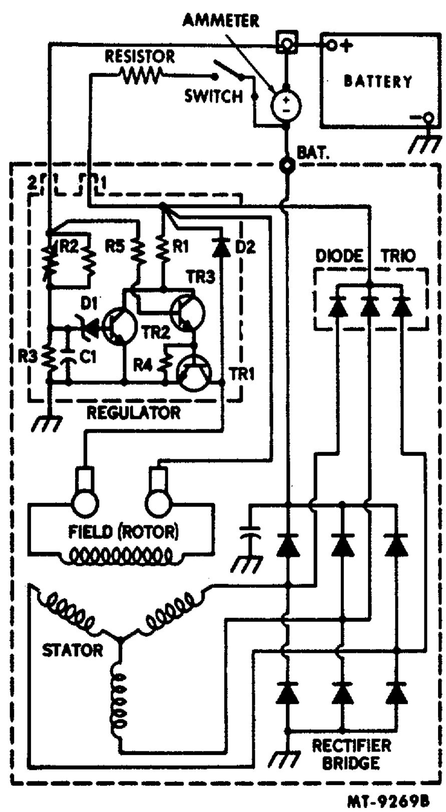


Fig. 3 Diagram of Internal Circuits

system voltage decrease, and D1 then blocks current flow, causing TR3 and TRI to turn back on. The field current and system voltage increase and this cycle then repeats many times per second to limit the output voltage to a preset value.

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TRI at high temperatures, and diode D2 prevents high-induced-voltages in the field windings when TR1 turns off.

TROUBLE SHOOTING

In order to locate and correct defects in the charging system in the shortest possible time, the following procedures should be used. Only a portion of these procedures need be performed. It will never be necessary to perform all the procedures in order to locate the trouble.

To avoid damage to the electrical equipment, always observe the following precautions:

Do not polarize the alternator.

Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.

Never operate the alternator with the output terminal open circuited.

Make sure the alternator and battery have the same ground polarity.

When connecting a charger or a booster battery to the vehicle battery, connect negative to negative and positive to positive.

Trouble in the charging system will show up as one or more of the following conditions:

An undercharged battery, as evidenced by slow cranking and low specific gravity readings.

An overcharged battery, as evidenced by excessive water usage.

Undercharged Battery

1. Insure that the undercharged condition has not been caused by accessories having been left on for extended periods.

2. Check the drive belt for proper tension.

3. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the slip connectors at the alternator and firewall and the cable clamps and battery posts.

4. With ignition switch on and all wiring harness leads connected, connect a voltmeter from:

   a. Alternator "BAT" terminal to ground.

   b. Alternator No. 1 terminal to ground.

   c. Alternator No. Z terminal to ground.

   A zero reading indicates an open between voltmeter connection and battery. Opens in the wiring harness connected between he No. 2 alternator terminal and battery may be between the terminals, at the crimp between the harness wire and terminal, or in the wire.

5. If previous Steps 1 through 4 check satisfactorily, check alternator as follows:

   a. Disconnect battery ground cable.

   b. Connect an ammeter in the circuit at the "BAT" terminal of the alternator.

c. Reconnect battery ground cable.

d. Turn on radio, windshield wipers, lights high beam and blower motor high speed. Connect a carbon pile across the battery.

e. Operate engine at moderate speed as required and adjust carbon pile as required to obtain maximum current output.

f. If ampere output is within 10 amperes of rated output as stamped on alternator frame, alternator is not defective; recheck Steps 1 through 5.

g. If ampere output is not within 10 amperes of rated output, ground the field winding by inserting a screwdriver into the test hole, Fig. 4. NOTE: Tab is within 3/4" of casting surface. Do not force screwdriver deeper than 1" into end frame.

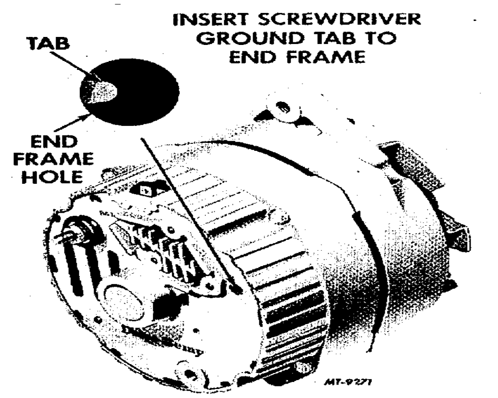


Fig. 4 Grounding Alternator Field Winding

h. Operate engine at moderate speed as required and adjust carbon pile as required to obtain maximum current output.

i. If output is within 10 amperes of rated output, replace regulator and check field winding.

j. If output is not within 10 amperes of rated output, check the field winding, diode trio, rectifier bridge and stator.

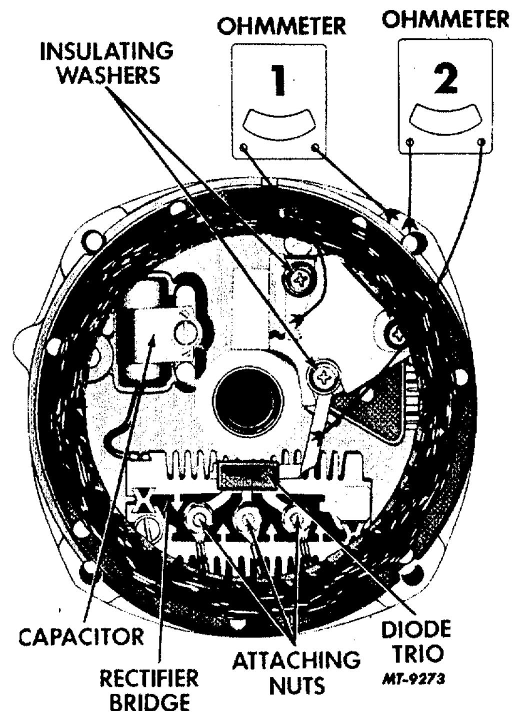
k. Remove ammeter from alternator and turn accessories off. Overcharged Battery

l. Connect a voltmeter from alternator No. 2 terminal to ground. If reading is zero, No. 2 lead circuit is open.

2. If battery and No. Z lead circuit check good but an obvious overcharge condition exists, as evidenced by excessive battery water usage, proceed as follows:

a. Separate end frames. Check field winding for shorts. If shorted, replace rotor and regulator.

b. Connect ohmmeter using lowest range scale from brush lead clip to end frame as shown in Step 1, Fig. 5, then reverse lead connections.



c. If both readings are zero, either the brush lead clip is grounded or regulator is defective.

Fig. 5 Inside View of End Frame

d. A grounded brush lead clip can result from omission of insulating washer, Fig. 5, omission of insulating sleeve over screw, or damaged insulating sleeve. Remove screw to inspect sleeve. If satisfactory, replace regulator.

DISASSEMBLY

To disassemble the alternator, remove the four thru-bolts and separate the drive end frame and rotor assembly from the stator assembly by prying apart with a screwdriver at the stator slot. A scribe mark will help locate the parts in the same position during assembly. After disassembly place a piece of tape over the slip ring end frame bearing to prevent entry

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of dirt and other foreign material and also place a piece of tape over the shaft on the slip ring end. NOTE: Use pressure-sensitive tape and not friction tape, which would leave a gummy deposit on the shaft. If brushes are to be reused, clean with a soft, dry cloth.

To remove the drive end frame from the rotor, place the rotor in a vise and tighten only enough to permit removal of the shaft nut. NOTE: Avoid excessive tightening, as this may cause distortion of the rotor. Remove the shaft nut, washer, pulley, fan, and the collar; and then separate the drive end frame from the rotor shaft.

ROTOR FIELD WINDING CHECKS

To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light or if the ohmmeter reading is high (infinite), the winding is open, Fig. 6.

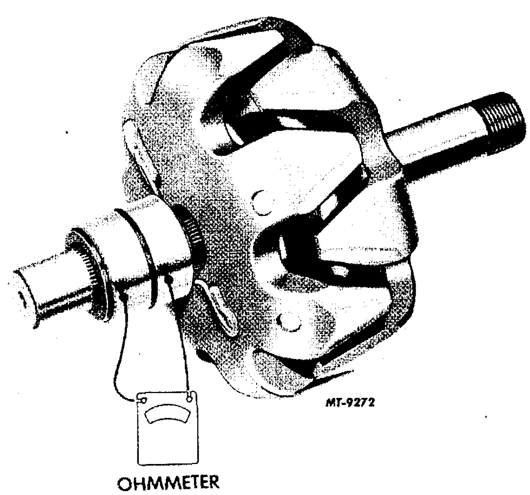

Fig. 6 Checking Rotor Winding

The winding is checked for short circuits or excessive resistance by connecting a battery and ammeter in series with the edges of the two slip rings. Note the ammeter reading and refer to specifications. An ammeter reading above the specified value indicates shorted windings; a reading below the specified value indicates excessive resistance. An alternate method is to check the resistance of the field by connecting an ohmmeter to the two slip rings, Fig. 6. If the resistance reading is below the specified value,. the winding is shorted; if above the specified value, the winding has excessive resistance. The specified resistance value can be determined by dividing the voltage by the current. Remember that the winding resistance and ammeter readings will vary slightly with winding temperature changes. If the rotor is not defective but the alternator fails to supply rated output, the defect is in the diode trio, rectifier bridge or stator.

DIODE TRIO CHECK

The diode trio is identified in Fig. 5. First connect an ohmmeter using lowest range scale from brush lead clip to end frame as shown in Step 2, Fig. 5; then reverse lead connections. If both readings are the same, check for grounded brush lead clip caused by omission of insulating washer, Fig. 5, omission of insulating sleeve over screw, or damaged insulating sleeve. Remove screw to inspect sleeve. <u>If screw assembly is correct and both ohmmeter readings are the same, replace regulator</u>.

To check the diode trio, remove it from the end frame assembly by detaching the three nuts, the attaching screw, and removing the stator assembly. Note that the insulating washer on the screw is assembled over the top of the diode trio connector. Connect an ohmmeter having a 1-1/2 volt cell, and using the lowest range scale, to the single connector and to one of the three connectors, Fig. 7. Observe the reading. Then reverse the ohmmeter leads to the same two connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors.

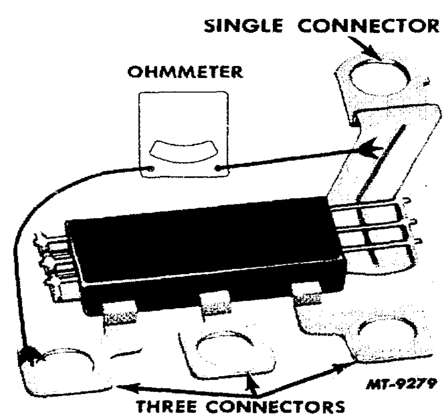

Fig. 7 Diode Trio Check

NOTE: Figs. 5 and 7 illustrate two diode trios differing in appearance. Either one of these diode trios may be used in these alternators, and the two are completely interchangeable.

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RECTIFIER BRIDGE CHECK

Note that the rectifier bridge has a grounded heat sink and an insulated heat sink connected to the output terminal. Also note the insulating washer located between the insulated heat sink and end frame, Fig. 8

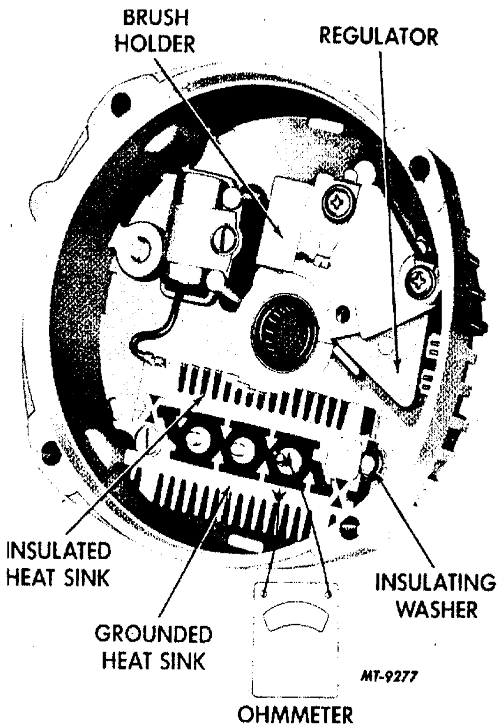

Fig. 8 Rectifier Bridge Check

To check the rectifier bridge, connect the ohmmeter to the grounded heat sink and one of the three terminals, Fig. 8. Then reverse the lead connections to the grounded heat sink and same terminal. If both readings are the same, replace the rectifier bridge. A good rectifier bridge will give one high and one low reading. Repeat this same test between the grounded heat sink and the other two terminals and between the insulated heat sink and each of the three terminals. This makes a total of six checks with two readings taken for each check. NOTE: If rectifier bridge is constructed as shown in Fig. 9, check with the rectifier bridge mounted in the end frame in the same manner as Fig. 8--except connect ohmmeter pressing down very firmly onto flat metal connector and not onto threaded stud, Fig. 9.

The ohmmeter check of the rectifier bridge and of the diode trio is a valid and accurate check. Do not replace either unit unless at least one pair of readings is the same. CAUTION: Do not use high voltage to check these units, such as a 110-volt test lamp.

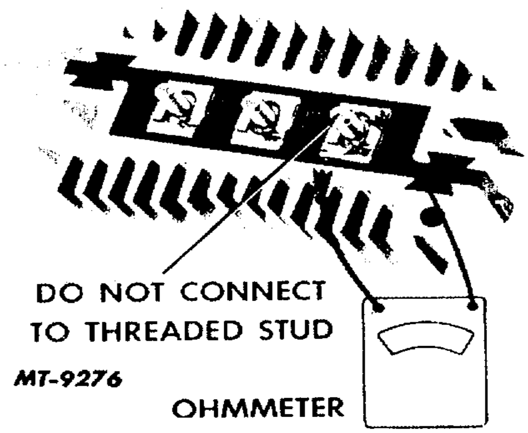

Fig. 9 Rectifier Bridge Check

To replace the rectifier bridge, remove the attaching screw and the "BAT" terminal screw and disconnect the capacitor lead. Note the insulator between the insulated heat sink and end frame, Fig. 8. Rectifier bridges may vary in appearance but are completely interchangeable in these alternators.

STATOR CHECK

The stator windings may be checked with a 110-volt test lamp or an ohmmeter. If the lamp lights or if the meter reading is low when connected from any stator lead to the frame, the windings are grounded. If the lamp fails to light or if the meter reading is high when successively connected between each pair of stator leads, the windings are open, Fig. 10.

A short circuit in the stator windings is difficult to locate without laboratory test equipment, due to the low resistance of the windings. However, if all other electrical checks are normal and the alternator fails to supply rated output, shorted stator windings are indicated. Also, a shorted stator can cause the indicator lamp to be on with the engine at low speed.

BRUSH HOLDER AND REGULATOR REPLACEMENT

After removing the three attaching nuts, the stator and diode trio screw, Fig. 8, the brush holder and regulator may be replaced by removing the two remaining screws. Note the two insulators located over the top of the brush clips in Fig. 5 and that these two screws have special insulating sleeves over the screw body above the threads. The third mounting screw may or may not have an insulating sleeve. If not, this screw must not be interchanged with either one of the other two screws, as a ground may result causing no output or uncontrolled alternator output. Regulators may vary in appearance but are completely interchangeable in these alternators

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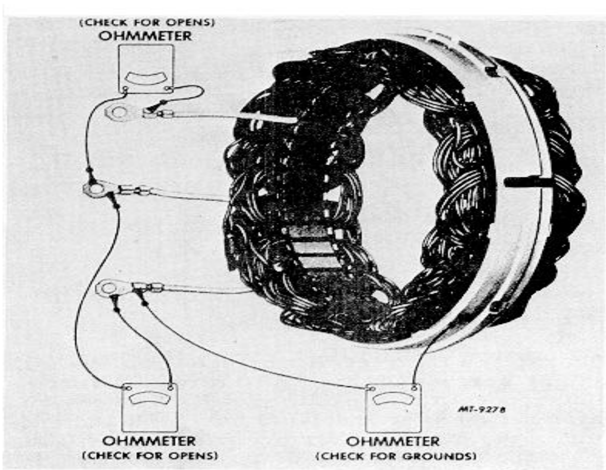

Fig. 10 Stator Windings Check

SLIP RING SERVICING

If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor and hold the polishing cloth against the slip rings until they are clean. NOTE: The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

BEARING REMOVAL AND LUBRICATION

The bearing in the drive end frame can be removed by removing the retainer plate screws and then pressing the bearing from the end frame. If the bearing is in satisfactory condition, it may be reused, and it should be filled one-quarter full with Delco-Remy lubricant No. 1948791 before reassembly. NOTE: Do not overfill, as this may cause the bearing to overheat. Use only 1948791 lubricant.

BEARING INSTALLATION

To install a new bearing, press in with a tube or collar that just fits over the outer race with the bearing and slinger assembled into the end frame as shown in Fig. 11. It is recommended that a new retainer plate be installed if the felt seal in the retainer plate is hardened or excessively worn. Fill the cavity between the retainer plate and bearing with 1948791 lubricant.

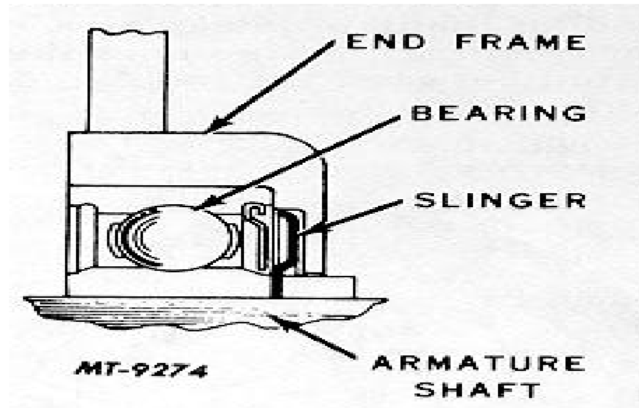

Fig. 11 Drive End Bearing (Flat Washer May Be Used Instead of Slinger)

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to relubricate and reuse the bearing. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

To install a new bearing, place a flat plate over the bearing and press in from the outside towards the inside of the frame until the bearing is flush with the outside of the end frame. Support the inside of the frame with a hollow cylinder to prevent breakage of the end frame. Use extreme care to avoid misalignment or otherwise placing undue stress on the bearing.

It is recommended that a new seal be installed whenever the bearing is replaced. Press the seal in with the lip of the seal toward the rotor when assembled--that is, away from the bearing. Lightly coat the seal lip with oil to facilitate assembly of the shaft into the bearing.

REASSEMBLY

Reassembly is the reverse of disassembly. To install the slip ring end frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal. After tightening the thru bolts, remove the brush retaining pin to allow the brushes to fall down onto the slip rings.

When installing the pulley, the pulley nut must be torqued to 60 ft. lbs. If not properly tightened, it is possible that the nut and pulley could loosen and slip on the shaft.

To assist in tightening the pulley nut, a 5/16 inch hex hole is provided in the end of the shaft for holding with an Allen wrench. Also a special 15/16 inch socket wrench, Fig. 12, which is applicable to the nut is available from the Snap-On Tool Company. This special 1/2 inch drive socket wrench is designed with a cutout to receive the Allen wrench and may be used in conjunction with a torque indicating wrench. Where desired, a length of 3/8 inch pipe may be applied to the Allen wrench to provide additional leverage for the holding effort.

The special 15/16 inch socket wrench, Fig. 12, is available from your local Snap-On representative under their number S-8183.

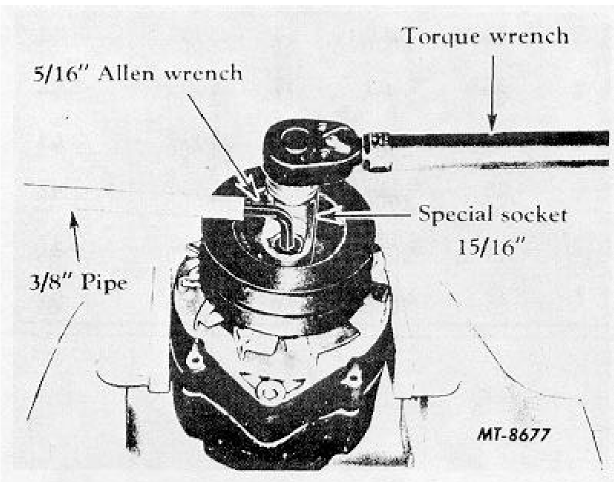

Fig. 12 Torquing Pulley Nut

ALTERNATOR BENCH CHECK

To check the alternator in a test stand, proceed as follows:

1. Make connections as shown in Fig. 13, except leave the carbon pile disconnected. NOTE: Ground polarity of battery and alternator must be the same. Use a fully charged battery and a 10 ohm resistor rated at six watts or more between the alternator No. 1 terminal and the battery.

2. Slowly increase the alternator speed and observe the voltage.

3. If the voltage is uncontrolled with speed and increases above 15.5 volts on a 12-volt system or 31 volts on a 24-volt system, check for a grounded brush lead clip. If not grounded, replace the regulator and check field winding. NOTE: The battery must be fully charged when making this check.

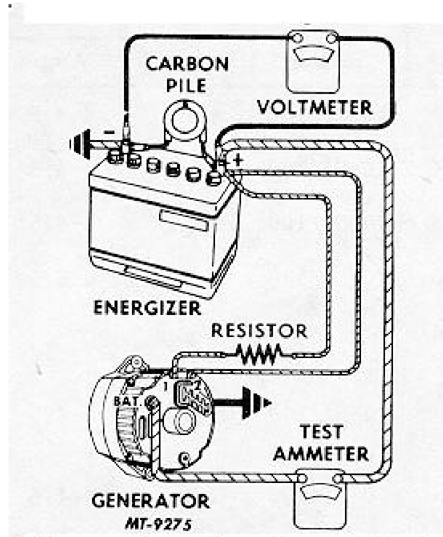

Fig. 13 Connections for Bench Check

4. If voltage is below 15.5 volts on a 12-volt system, connect the carbon pile as shown.

5. Operate the alternator at moderate speed as required and adjust the carbon pile as required to obtain maximum current output.

6. If output is within 10 amperes of rated output as stamped on alternator frame, alternator is good.

7. If output is not within 10 amperes of rated output, keep energizer or battery loaded with carbon pile and ground alternator field, Fig. 13 and Fig. 4.

8. Operate alternator at moderate speed and adjust carbon pile as required to obtain maximum output.

9. If output is within 10 amperes of rated output, replace regulator and check field winding.

10 If output is not within 10 amperes of rated output, check the field winding, diode trio, rectifier bridge and stator as previously covered.

SPECIFICATIONS

Model	Series	Ground	Field Current 27^0 C (80^0 F) Amps	Volts	Cold Output Specified Volts	Amps	Approx. RPM *	Amps	Approx. RPM *	Rated Hot Output (Amps)
1100543	10-SI/100	Neg.	4-4.5	12	* *	25	2000	38	5000	42
1100544	10-SI/100	Neg.	4-4.5	12	* *	30	2000	57	5000	61
1100554	10-SI/100	Neg.	4-4.5	12	* *	32	2000	60	5000	63
1100588	10-SI/100	Neg.	4-4.5	12	* *	22	2000	33	5000	37
1102474:										
Early Prod.	10-SI/100	Neg.	4-4.5	12	* *	30	2000	57	5000	61
Late Prod.	10-SI/100	Neg.	4-4.5	12	* *	32	2000	60	5000	63
1102848	10-SI/100	Neg.	4-4.5	12	* *	25	2000	38	5000	42
1102849	10-SI/100	Neg.	4-4.5	12	* *	32	2000	60	5000	63
1102915	10-SI/100	Neg.	4-4.5	12	* *	25	2000	38	5000	42
1103170	10-SI/100	Neg.	4-4.5	12	* *	22	2000	33	5000	37
1103182	10-SI/100	Neg.	4-4.5	12	* *	32	2000	60	5000	63

* Alternator RPM

** Voltmeter not required for cold output check.
Load battery with carbon pile to obtain maximum output.

CHAPTER II

10 SI SERIES, TYPE 116

Code 08084	42 Amp
Code 08132	61 Amp

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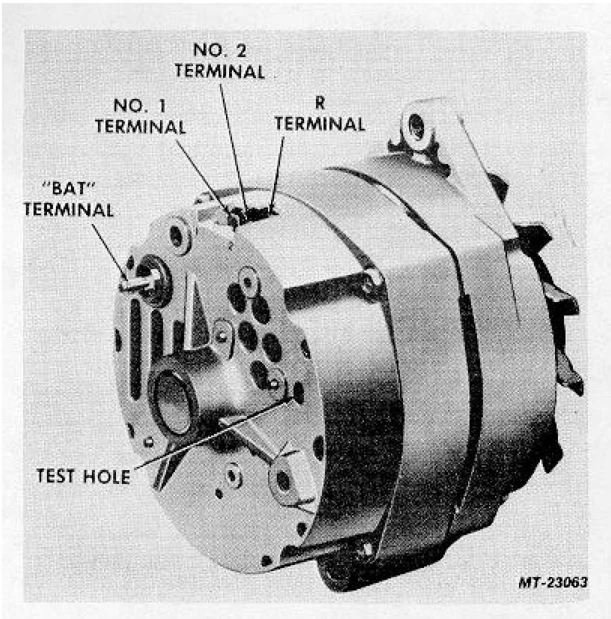

Fig. 1 Alternator

DESCRIPTION

The alternator illustrated in Figures 1 and 2 features a solid state voltage regulator mounted inside the slip ring end frame. The voltage regulator setting never needs adjusting and no provision for adjustment is provided. The "R" terminal is a male blade located next to the No. 1 and No. 2 terminals. The "R" terminal provides one half system voltage and is used on some vehicles to operate accessories.

The rotor shaft bearings contain a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. Two brushes carry current through the two slip rings to the field coil mounted on the rotor, and under normal conditions will provide long periods of attention-free service. The stator windings are assembled on the inside of a laminated core that forms part of the alternator frame. A rectifier bridge connected to the stator windings contains six diodes and electrically changes the stator a.c. voltages to a d.c. voltage which appears at the output ("BAT") terminal. Field current is supplied through a diode trio which also is connected to the stator windings. A capacitor, or condenser, mounted in the end frame, protects the rectifier bridge and diode trio from high voltages, and suppresses radio noise.

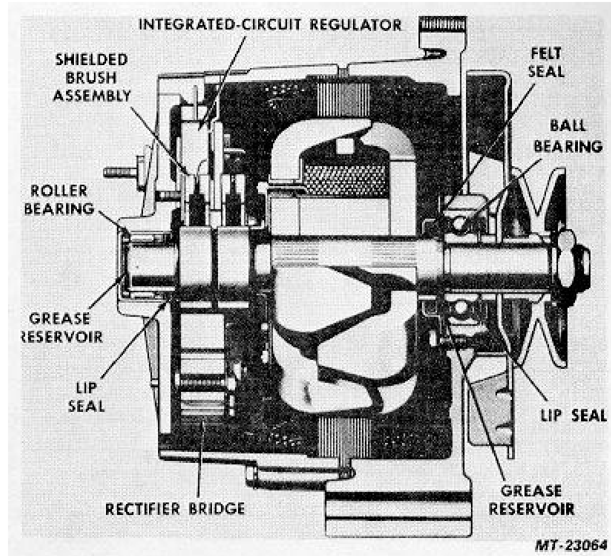

Fig. 2 Cross Sectional View

No periodic adjustments or maintenance of any kind are required on the entire alternator assembly.

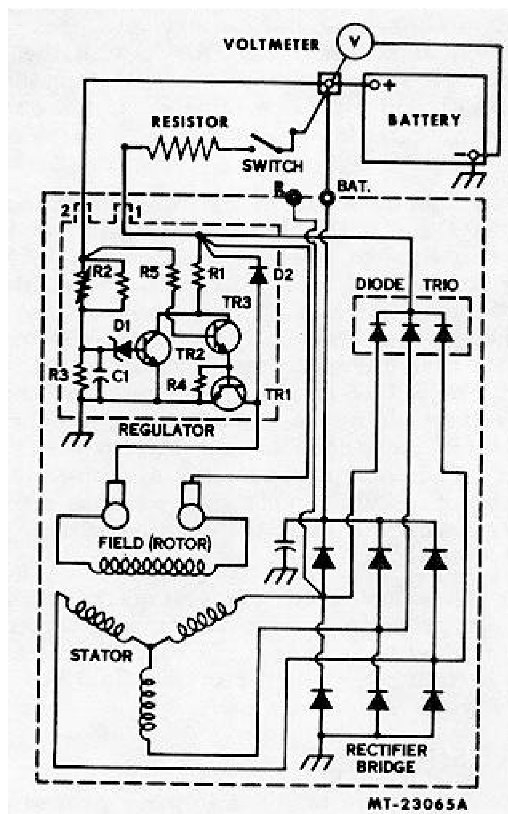

Fig. 3 Diagram of Internal Circuits

OPERATION

A typical wiring diagram is illustrated in Figure 3. The basic operating principles are explained as follows:

The No. 2 terminal is connected to the battery, and the base-emitter of transistors TR3 and TR1 is connected to the battery through resistor R5, thus turning these transistors on. Also, resistors R2 and R3 are connected to the battery through terminal No. 2, but the discharge current of the battery is very low because of the resistance values of R2, R3, RS, TR1 and TR3.

When the switch is closed, current from the battery flows through the resistor to the No. 1 terminal, through resistor R1, and transistor TR3 and TR1 to ground, and then back to the battery. Also, current flows through the alternator field coil and TR1 back to the battery. With the alternator operating, A.C. voltages are generated in the stator windings, and the stator supplies D.C. field current through the diode trio, the field, TR1, and then through the grounded diodes in the rectifier bridge back to the stator. Also, the six diodes in the rectifier bridge change the stator A.C. voltages to a D.C. voltage which appears between ground and the alternator "BAT" terminal. As alternator speed increases, current is provided for charging the battery and operating electrical accessories. Also, with the alternator operating, the same voltage appears at the "BAT" and No. 1 terminals, and the voltmeter indicates that the alternator is producing voltage.

If an open should occur in the No. 2 terminal circuit, TR3 and TR 1 will turn off and no field current will flow to prevent overcharge. As the alternator speed and voltage increase, the voltage between R2 and R3 increases to the point where zener diode D1 conducts. Transistor TR2 then turns on and TR3 and TR1 turn off. With TR1 off, the field current and system voltage decrease, and D1 then blocks current flow, causing TR3 and TRI to turn back on. The field current and system voltage increase and this cycle then repeats many times per second to limit the output voltage to a preset value.

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high-induced-voltages in the field windings when TR1 turns off.

TROUBLE SHOOTING

Close adherence to the following procedures in the order presented will lead to the location and correction of charging system defects in the shortest possible time. Usually, only a portion of these procedures need be performed. It is seldom necessary to perform all the procedures to locate the trouble.

To avoid damage to the electrical equipment, always observe the following precautions:

<u>Do not</u> polarize the alternator.

<u>Do not</u> short across or ground any of the terminals in the charging circuit except as specifically instructed herein.

<u>Never</u> operate the alternator with the output terminal open circuited.

<u>Make sure</u> the alternator and battery have the same ground polarity.

When connecting a charger or a booster battery to the vehicle battery, connect negative to negative and positive to positive.

Trouble in the charging system will show up as one of the following conditions:

An <u>undercharged</u> <u>battery</u>, as evidenced by slow cranking and low specific gravity readings.

An <u>overcharged</u> <u>battery</u>, as evidenced by excessive water usage.

To locate cause of trouble, proceed as outlined below:

1. Insure that an undercharged condition has not been caused by accessories having been left on for extended periods.

2. Check the drive belt for proper tension.

3. Test condition of battery. Recharge or replace battery as needed.

4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the slip connectors at the alternator and firewall and the cable clamps and battery posts.

5. With ignition switch on and all wiring harness leads connected, connect a voltmeter from:

   a. Alternator "BAT" terminal to ground,

   b. Alternator No. 1 terminal to ground.

c. Alternator No. 2 terminal to ground.

A zero reading indicates an open between voltmeter connection and battery. Repair if required.

6. With all accessories turned off, connect a voltmeter across the battery. Operate engine at moderate speed. If voltage is 15.5 or more, remove alternator for repair.

7. If previous Steps 1 thru 6 check satisfactorily, check alternator as follows:

a. Disconnect battery ground cable.

b. Connect an ammeter in the circuit at the "BAT" terminal of the alternator.

c. Reconnect battery ground cable.

d. Turn on accessories. Connect a carbon pile across the battery.

e. Operate engine at moderate speed as required, and adjust carbon pile as required to obtain maximum current output.

f. If ampere output is within 10 amperes of rated output as stamped on alternator frame, alternator most likely is not defective; recheck Steps 1 thru 6.

g. If ampere output is not within 10 amperes of rated output, determine if test hole (Figure 4) is accessible. If accessible, go to Step h. If not accessible go to Step 1.

h. Ground the field winding by inserting a screwdriver into the test hole (Figure 4).

CAUTION

Tab is within 3/4 inch of casting surface. Do not force screwdriver deeper than one inch into end frame.

i. Operate engine at moderate speed as required, and adjust carbon pile as required to obtain maximum current output.

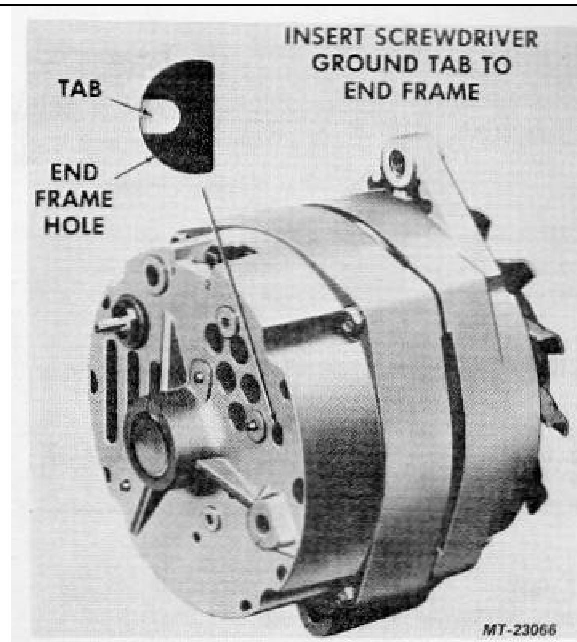

Fig. 4 End Frame Test Hole

j. If output is within 10 amperes of rated output, check field winding as covered under SERVICE PROCEDURES section, and test regulator with an approved regulator tester.

k. If output is not within 10 amperes of rated output, check the field winding, diode trio, rectifier bridge, and stator as covered under SERVICE PROCEDURES.

l. If test hole is not accessible, disassemble generator and make tests listed under SERVICE PROCEDURES.

SERVICE PROCEDURES

To repair the alternator, perform the following procedures.

DISASSEMBLY

To disassemble the alternator, remove the four thru-bolts, and separate the drive end frame and rotor assembly from the stator assembly by prying apart with a screwdriver at the stator slot. A scribe mark will help locate the parts in the same position during assembly. After disassembly, place a piece of tape over the slip ring end frame bearing to prevent entry of dirt and other foreign material. Place a piece of tape over the shaft on the slip ring end. Use pressure sensitive tape and not friction tape which would leave a gummy deposit on the shaft. If brushes are to be reused, clean with a soft dry cloth.

To remove the drive end frame from the rotor, place the rotor in a vise and tighten only enough to permit removal of the shaft nut.

CAUTION

> Avoid excessive tightening as this may cause distortion of the rotor.

Remove the shaft nut, washer, pulley, fan, and the collar, and then separate the drive end frame from the rotor shaft.

ROTOR FIELD WINDING CHECKS

To check for opens, connect the test lamp or ohmmeter to each slip ring (Figure 5). If the lamp fails to light, or if the ohmmeter reading is high (infinite), the winding is open.

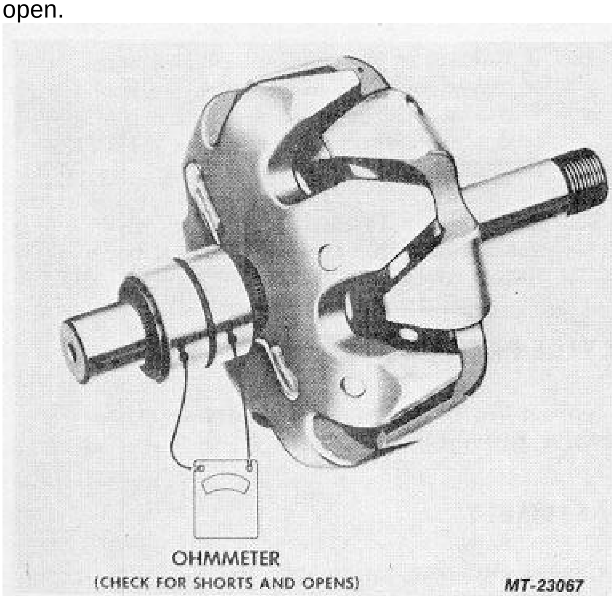

Fig. 5 Checking Rotor

Connect test lamp or ohmmeter from one slip ring to shaft. If lamp lights, or if reading is low, the rotor winding is grounded. The winding is checked for short-circuits or excessive resistance by connecting a battery and ammeter in series with the edges of the two slip rings. Note the ammeter reading. Refer to SPECIFICATIONS for specified field current value. An ammeter reading above the specified value indicates shorted windings; a reading below the specified value indicates excessive resistance.

An alternate method is to check the resistance of the field by connecting an ohmmeter to the two slip rings (Figure 5). If the resistance reading is below the specified value, the winding is shorted; if above the specified value the winding has excessive resistance. The specified resistance value can be determined by dividing the voltage by the current given in specifications.

Remember that the winding resistance and ammeter readings will vary slightly with winding temperature changes. If the rotor is not defective, but the generator fails to supply rated output, the defect is in the diode trio, rectifier bridge, stator, or regulator.

DIODE TRIO CHECK

The diode trio is identified in Figure 6. To check the diode trio, remove it from the end frame assembly by detaching the three nuts, the attaching screw, and removing the stator assembly. Note that the insulating washer on the screw is assembled over the top of the diode trio connector.

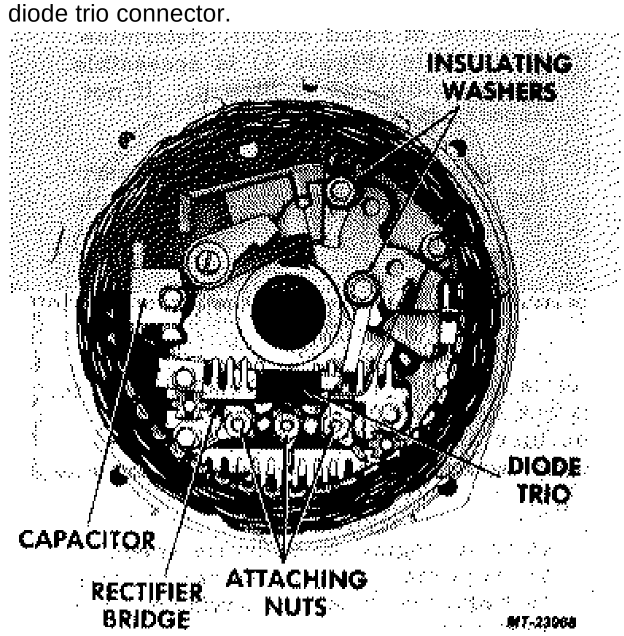

Fig. View inside End Frame

Connect an ohmmeter having a 1-1/2 volt cell, and using the lowest range scale, to the single connector and to one of the three connectors (Figure 7). Observe the reading. Then reverse the ohmmeter leads to the same two connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading.

Repeat this same test between the single connector and each of the other two connectors. Also, connect the ohmmeter to each pair of the three connectors. If any reading is zero, replace the diode trio.

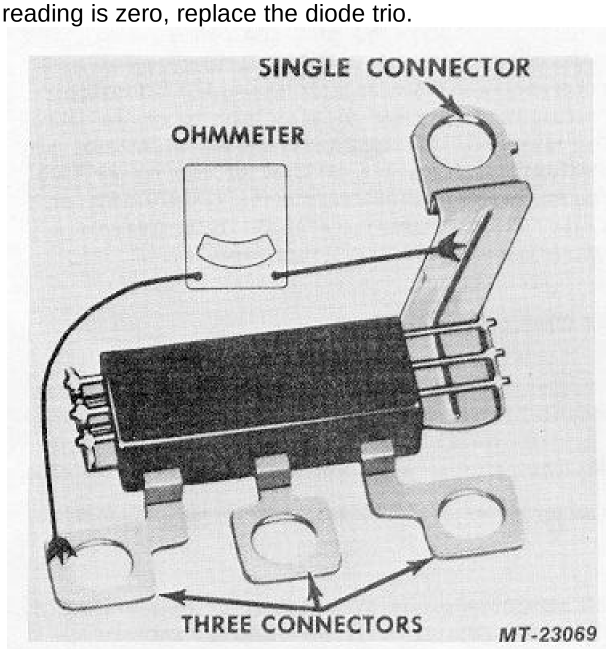

Fig. 7 Diode Trio Check

Figures illustrate two diode trios differing in appearance. Either one of these diode trios may be used in these generators, and the two are completely interchangeable.

RECTIFIER BRIDGE CHECK

Note that the rectifier bridge has a grounded heat sink and an insulated heat sink connected to the output terminal. To check the rectifier bridge, connect the ohmmeter to the grounded heat sink and one of the three terminals (Figure 8).

Important

Connect ohmmeter by pressing down very firmly onto flat metal connector.

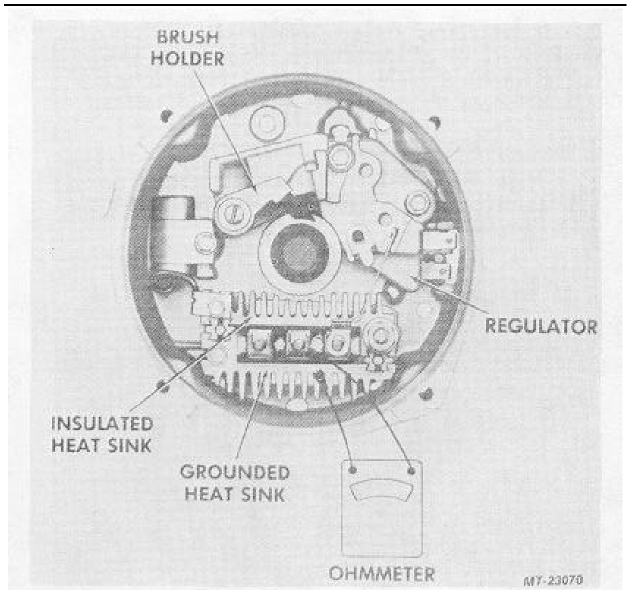

Fig. 8 Testing Rectifier Bridge

Reverse the lead connections to the grounded heat sink and same terminal. If both readings are the same, replace the rectifier bridge. A good rectifier bridge will give one high and one low reading.

Repeat this same test between the grounded heat sink and the other two terminals, and between the insulated heat sink and each of the three terminals. This makes a total of six checks, with two readings taken for each check.

The ohmmeter check of the rectifier bridge, and of the diode trio as previously covered, is a valid and accurate check. DO NOT replace either unit unless at least one pair of readings is the same.

CAUTION

DO NOT use high voltage, such as a 110-volt test lamp, to check these units.

To replace the rectifier bridge, remove the attaching screws and disconnect the capacitor lead.

STATOR CHECK

The stator windings may be checked with a 110-volt test lamp or an ohmmeter. If the lamp lights, or if the meter reading is low when connected from any stator lead to the frame (Figure 9) the windings are grounded.

If the lamp fails to light, or if the meter reading is high when successively connected between each pair of stator leads (Figure 9) the windings are open.

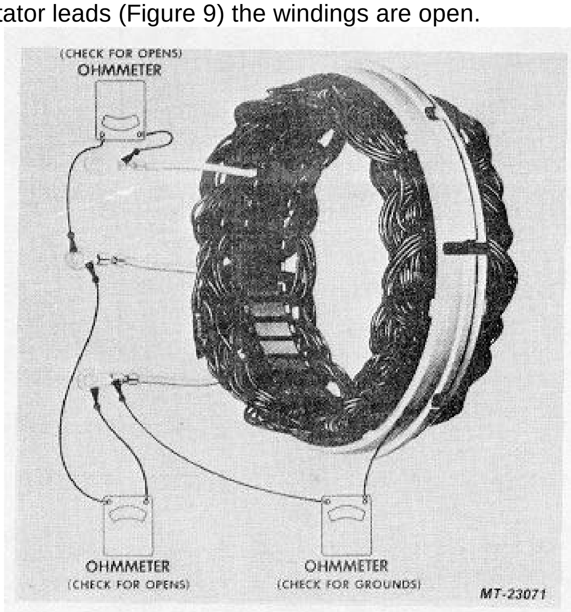

Fig. 9 Testing Stator

IMPORTANT

Ohmmeter or test light checks for opens can be made only on "Y" stators, visually identified by three stator leads crimped together. Delta windings cannot be checked for opens with an ohmmeter or test light. Usually laboratory equipment is required to check Delta windings.

A short circuit in the stator windings is difficult to locate without laboratory test equipment due to the low resistance of the windings. However, if all other electrical checks are normal and the alternator fails to supply rated output, a shorted stator winding or an open Delta winding is indicated. Check the voltage regulator before replacing stator.

BRUSH HOLDER AND REGULATOR REPLACEMENT

IMPORTANT

To determine if the regulator is defective, an approved regulator tester must be used.

After removing the three attaching nuts, the stator, and diode trio screw (Figure 8) the brush holder and regulator may be replaced by removing the two remaining screws. Note the two insulators located over the top of the brush clips in Figure 6, and that these two screws have special insulating sleeves over the screw body above the threads. The third mounting screw may or may not have an insulating sleeve. If not, this screw must not be interchanged with either one of the other two screws, as a ground may result, causing no output. Regulators may vary in appearance but are completely interchangeable.

SLIP RING SERVICING

If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor and hold the polishing cloth against the slip rings until they are clean.

CAUTION

The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

BEARING REPLACEMENT AND LUBRICATION

The bearing in the drive end frame can be removed by detaching the retainer plate screws, and then pressing the bearing from the end frame. If the bearing is in satisfactory condition, it may be reused, and it should be filled one-quarter full with Delco-Remy lubricant No. 1948791 before reassembly.

CAUTION

Do not overfill, as this may cause the bearing to overheat. Use only 1948791 lubricant.

To install a new bearing, press in with a tube or collar that just fits over the outer race, with the bearing and washer assembled into the end frame as shown in Figure 10. It is recommended that a new retainer plate be in- stalled if the felt seal in the retainer plate is hardened or excessively worn. Fill the cavity between the retainer plate and bearing with 1948791 lubricant.

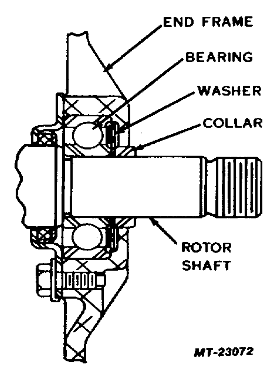

Fig. 10. Drive End Bearing Installation

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to re-lubricate and reuse the bearing. To remove the bear ing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

To install a new bearing and seal place a flat plate over the seal and press in from the outside towards the inside of the frame until the seal is flush with the outside of the end frame. Press the seal in with the lip of the seal toward the rotor when assembled, that is, away from the bearing. Place the flat plate over the bearing and push in both bearing and seal so bearing is flush with outside of end frame. See Figure 11.

Support the inside of the frame with a hollow cylinder to prevent breakage of the end frame. Use extreme care to avoid misalignment or otherwise placing undue stress on the bearing. Lightly coat the seal lip with oil to facilitate assembly of the shaft into the bearing.

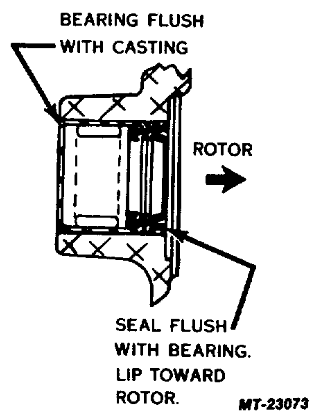

Fig. 11. Slip Ring End Bearing Installation

REASSEMBLY

Reassembly is the reverse of disassembly.

Remember when assembling the pulley to secure the rotor in a vise only tight enough to permit tightening the shaft nut to 40-60 lb.ft. If excessive pressure is applied against the rotor, the assembly may become distorted. To install the slip ring end frame assembly, re- move the tape over the bearing and shaft, and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal. After tightening the thru-bolts remove the brush retaining pin to allow the brushes to fall down onto the slip rings.

ALTERNATOR BENCH TEST

To test the alternator in a test stand, proceed as follows:

1. Make connections as shown in Figure 12 except leave the carbon pile disconnected.

IMPORTANT

Ground polarity of battery and alternator must be the same. Use a fully charged battery, and a 10 ohm resistor rated at six watts or more be- tween the No. 1 terminal and the battery. The "R" terminal need not be used.

2. Slowly increase the alternator speed and observe the voltage.

3. If the voltage is uncontrolled with speed and increases above 15.5 volts on a 12-volt system, test regulator with an approved regulator tester, and check field winding. The battery must be fully charged when making this check.

4. If voltage is below 15.5 volts on a 12-volt system, connect the carbon pile as shown.

5. Operate the alternator at moderate speed as required and adjust the carbon pile as required to obtain maximum current output.

6. If output is within 10 amperes of rated output as stamped on alternator frame, generator is good.

7. If output is not within 10 amperes of rated output, keep battery loaded with carbon pile, and ground alternator field (Figure 4).

8. Operate alternator at moderate speed and adjust carbon pile as required to obtain maximum output.

9. If output is within 10 amperes of rated output, test regulator with an approved regulator tester, and check field winding.

10. If output is not within 10 amperes of rated output, check the field winding, diode trio, rectifier bridge, and stator as previously covered.

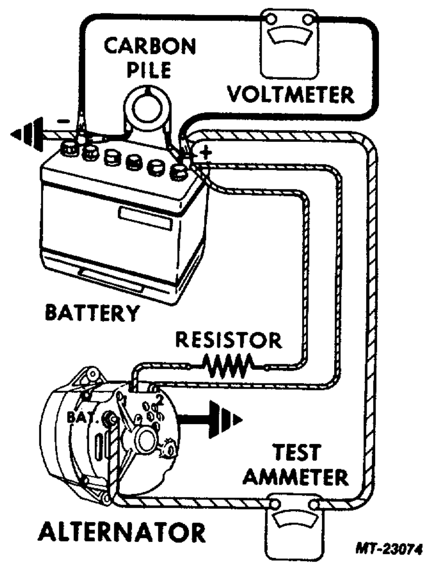

Fig. 12. Connections for Making Bench Test

SPECIFICATIONS

Model	Series /Type	Ground	Field Current 27°C Amps	(80°F) Volts	Cold Output Specified Volts	Amps	Approx. RPM *	(Amps)	Approx. RPM *	Rated Hot Output (Amps)
1102924	10-SI/116	Neg.	4-5	12	**	31	2600	39	7000	42
1102936	10-SI/116	Neg.	4-5	12	**	30	2000	57	5000	61
1102940	10-SI/116	Neg.	4-5	12	**	25	2000	38	5000	42
1103137	10-SI/116	Neg.	4-5	12	**	31	2600	39	7000	42
1103174	10-SI/116	Neg.	4-5	12	**	30	2000	57	5000	61
1103175	10-SI/116	Neg.	4-4.5	12	**	25	2000	38	5000	42

* Alternator RPM

** Voltmeter not required for cold output check.

Load battery with carbon pile to obtain maximum output.

ALTERNATOR

(MOTOROLA)

CODE	RATING
08112	37 Amp
08151	62 Amp

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SPECIFICATIONS

ALTERNATOR

Model Motorola	Ground	Field Current (80 Degrees F) Amps	Volts	Rated Hot Output (Amps)
8AL2026F	Neg.	1.8 - 2.5	12	37
8AL2033L	Neg.	1.8 - 2.5	12	62

VOLTAGE REGULATOR

Model	8RD-2001
Make	Motorola
Type	Solid State
Adjustment	None

Minimum to Maximum Voltages at Various Ambient Temperatures (10 Ampere Load)

Temperature (Degrees F)	Voltage
0	14.65 - 15.4
20	14.4 - 15.0
40	14.2 - 14.7
60	13.95 - 14.4
80	13.75 - 14.2
100	13.6 - 14.05
120	13.45 - 13.95
140	13.3 - 13.85
160	13.1 - 13.75

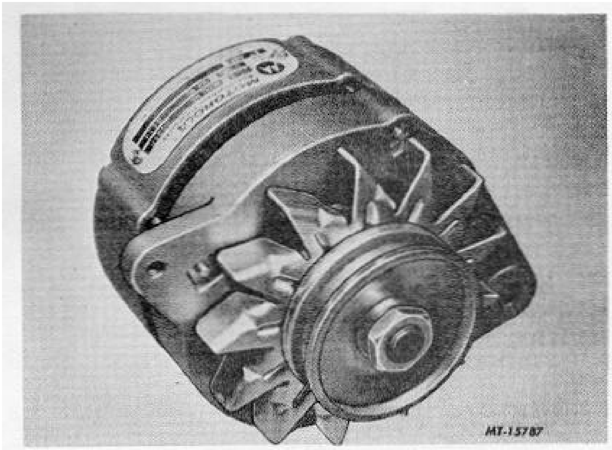

Fig. 1 Alternator

DESCRIPTION

The alternator is an electrical energy producing device designed to provide alternating current (AC) which is changed into direct current (DC) with the use of rectifier diodes.

Basically the alternator is made up of four major components--two end frames, a rotor and stator assembly.

The rotor or rotating magnetic field is mounted between the two end frames and consists of a field coil, field poles, slip rings and shaft (Fig. 2).

The field coil has many turns of wire over an iron core secured to the rotating shaft. Two iron segments with interlacing fingers make up the north and south poles envelope the field coil. Two slip rings are mounted on an insulating sleeve and insulated from one another. Both are pressed on the rotating shaft. The rotor assembly has bearings on each end of the shaft and these bearings are pre-lubricated and- require no periodic lubrication. The rotor with the bearings are supported between the two end frames.

The stator assembly consists of three separate windings mounted on a laminated iron frame. These windings are of heavy copper wire and connected together to form a "Y" or "delta" connection (depending upon alternator type).

POSITIVE AND NEGATIVE DIODE ASSEMBLIES

The positive and negative diode assemblies incorporate three silicone rectifier diodes which change the three phase alternating current (AC) produced in the stator to direct current (DC). Since the diodes will pass current in one direction only the current will pass from the alternator

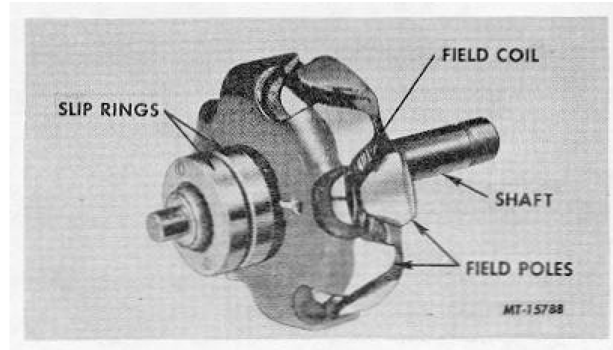

Fig. 2 Rotor

to the battery or load, but not pass current from battery to the alternator. Therefore, the alternator will not require a cutout relay.

The, 37 and 62 amp alternators differ only in type of stator windings used and the length of the rotor.

The main circuit shown in Fig. 3 illustrates the "Delta Wound" stator winding used in 62-amp alternator, while the "Delta Wound" stator winding for the 37-amp alternator is shown in the inset.

DIODE TRIO ASSEMBLY

The original diode trio assembly incorporated three (3) small diodes mounted in a circuit board. The revised trio assembly has the same diodes mounted in a small plastic box that includes the mounting stud. See Figure 15 for illustration of units.

The output leads of the diodes in the original trio are connected to the metal grommet in the center of the circuit board which is secured to the insulated regulator terminal of the alternator. The output leads in the revised trio are soldered to a plate that is secured to the trio mounting stud which also serves as the regulator terminal of the alternator. The input leads of both trios are connected to the stator windings in parallel with the positive rectifier diodes.

With the alternator in operation, a portion of AC current and voltage developed in the stator windings will be rectified by the diode trio as- sembly and appear as DC current and voltage at the regulator terminal. The voltage is sensed by the regulator which provides excitation current to the rotor (field) winding.

If one or more of the diodes in the diode trio assembly becomes opened or shorted the output of the alternator will be affected.

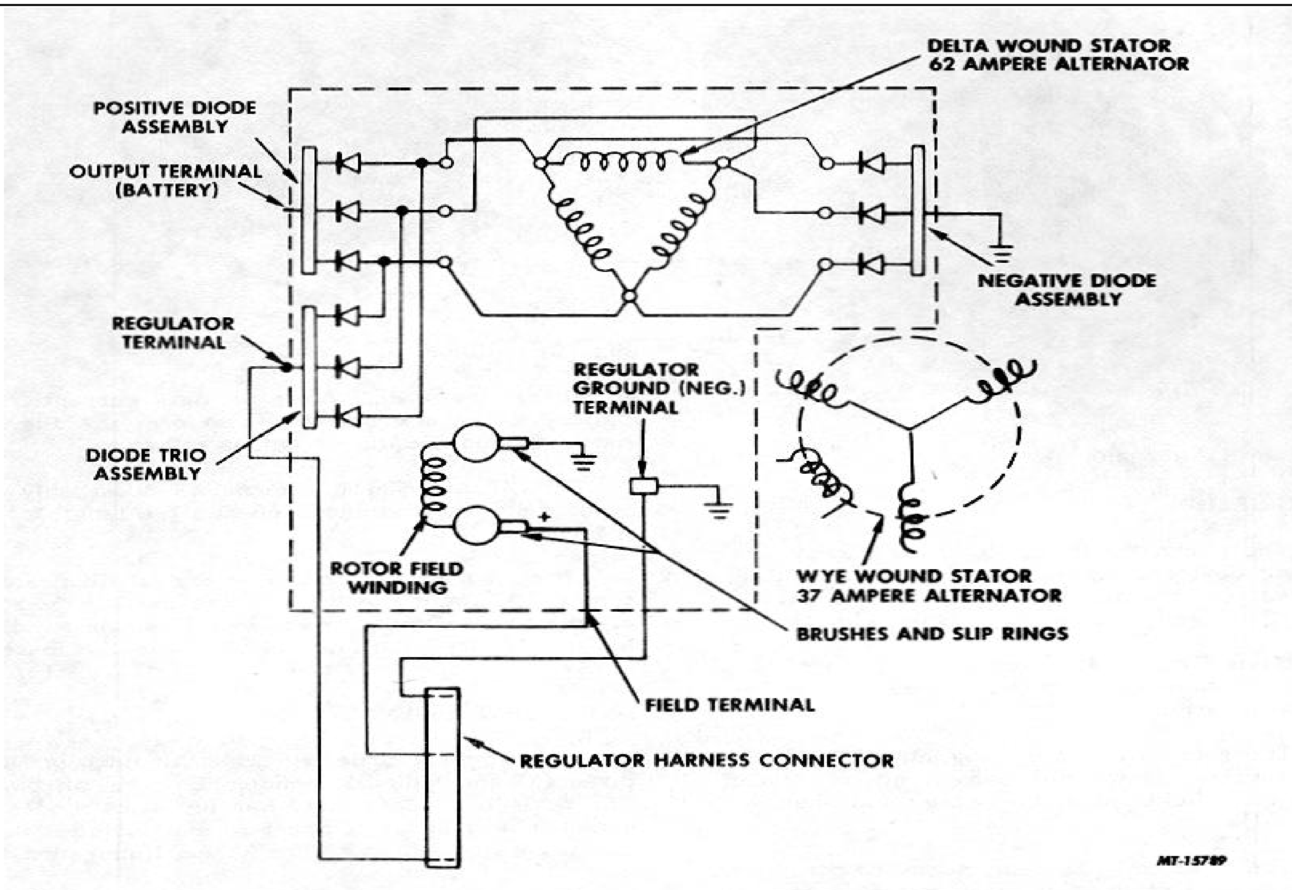

Fig. 3 Alternator Circuit

In the event that one of the diodes in the diode trio becomes degraded, however not opened or shorted, the total resistance of the assembly will increase and cause the ammeter to show a low charge rate. The diode trio assembly can be checked or tested without removing the alternator from the chassis, see DIODE TRIO TEST.

Four connections are required for regulated alternator operation--ground, field, regulator and output (Fig. 4). The ground wire is required for voltage regulator operation only and the alternator is grounded through the mounting bracket on the engine. The ground and field terminals on the alternator are connected to a two-terminal female connector in the alternator wiring harness.

NOTE

The regulator terminal is only to be used for field excitation and never should it be used as a source for lights or accessories, since the operation of the voltage regulator would be affected.

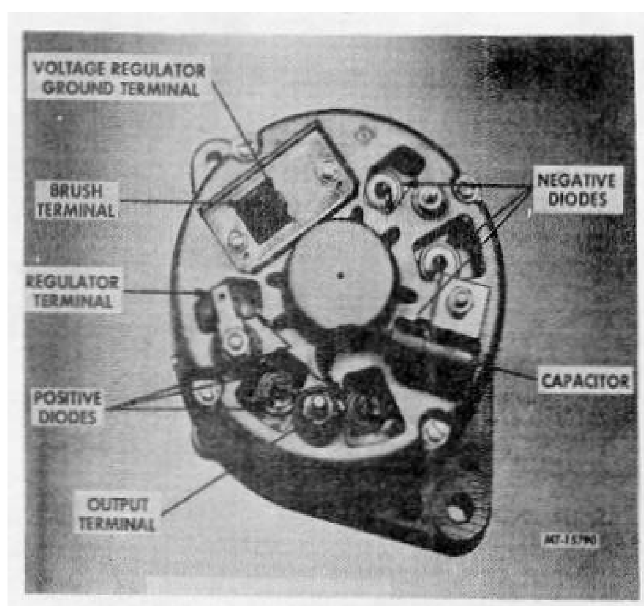

Fig. 4 Rear View of Alternator

FIELD EXCITATION CIRCUIT

The initial field excitation current is supplied from the ignition switch through the yellow wire (IGN) of the voltage regulator and through the 82 ohm resistor in the regulator (Fig. 5). The circuit is then completed through the voltage regulator to the field terminal (green wire) of the alternator, then through the field windings on the rotor to the ground brush (Fig. 3).

When the alternator is operating, the voltage regulator senses voltage at the regulator terminal and automatically provides the correct current to the field of the alternator.

CHARGING CIRCUIT

The charging circuit is made up of three main components-alternator, battery and voltage regulator (Fig. 5).

Charging of the battery is accomplished by supplying current directly from the alternator battery terminal (10-gauge wire) to the battery using the starter solenoid (battery post) as a junction point with the positive (+) battery cable. The ammeter gauge is connected in series in the 10-gauge wire.

The alternator is grounded to the engine to complete the return circuit to the negative (-) side of the battery. The amount of charge the battery receives depends upon the state of charge and condition of the battery, proper operation of the voltage regulator and the amount of current needed for other loads such as heater, lights, etc.

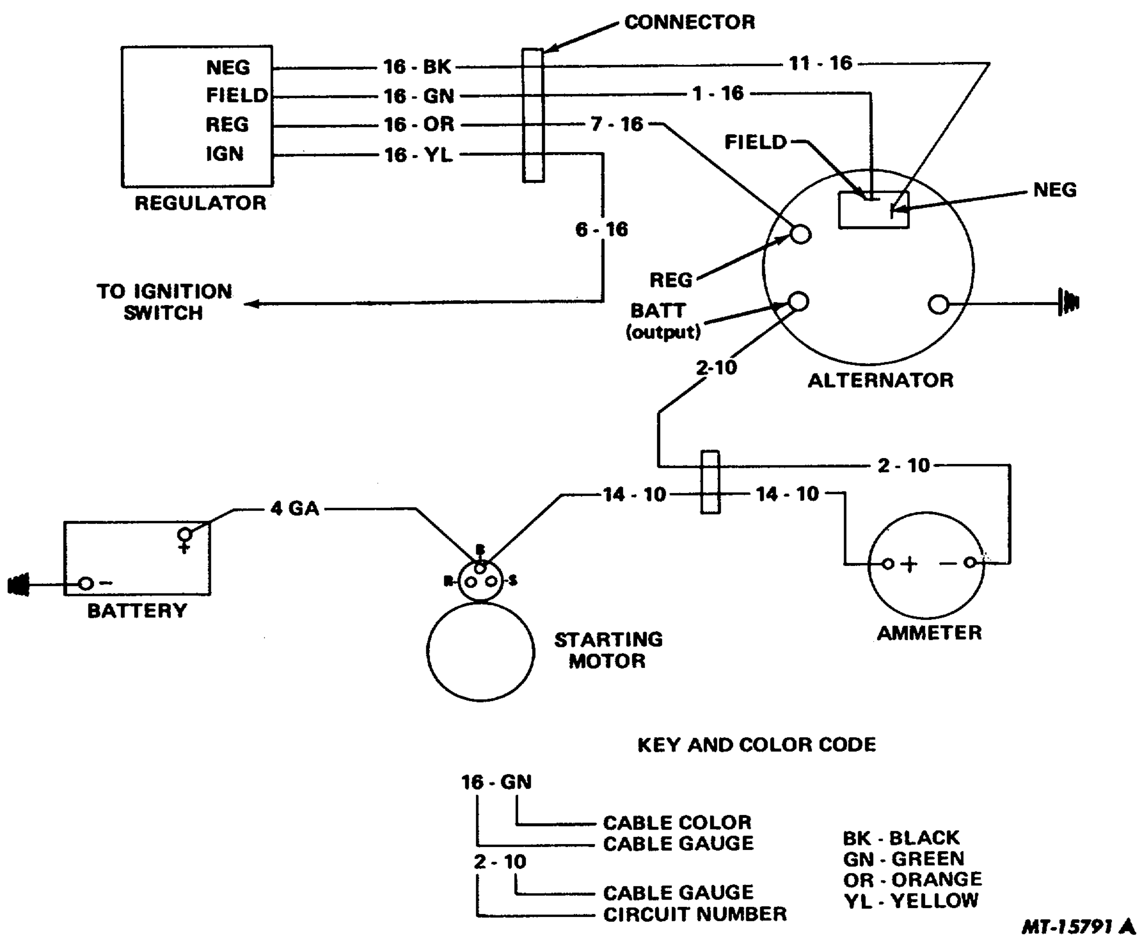

Fig. 5 Charging Circuit

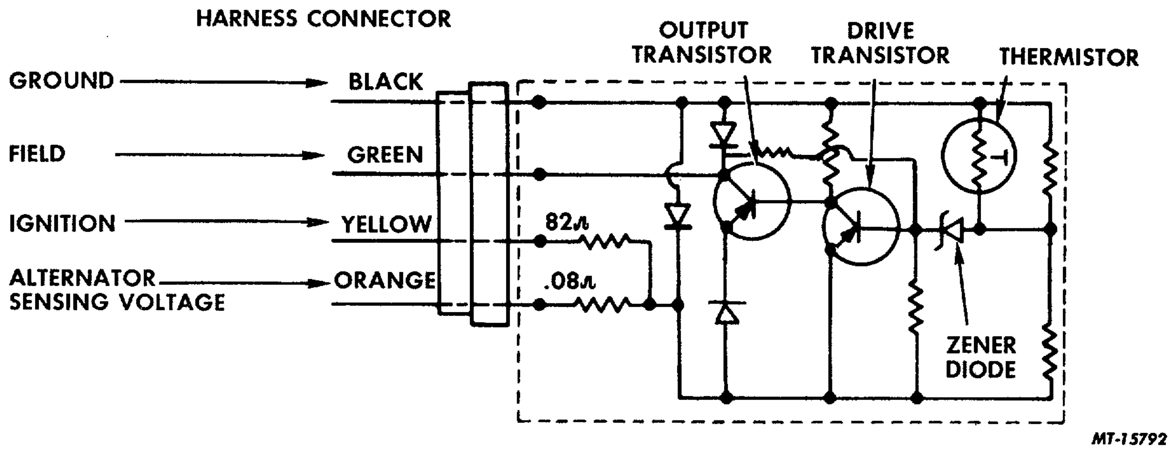

Fig. 6 Voltage Regulator Circuit

Refer to VOLTAGE REGULATOR portion of this text which covers the remainder of the charging circuit (voltage regulation and field current control).

VOLTAGE REGULATOR

The voltage regulator is an electrical switch- ing device which senses voltage at the alternator regulator terminal. The regulator automatically provides the amount of field current required by the alternator to maintain a specified system voltage at the alternator output (battery) termi- nal under any electrical load, Fig. 6).

A Zener diode is sensitive to voltage and will conduct a predetermined voltage value. The thermistor serves to tailor the Zener diode action in accordance with regulator ambient temperature changes. This provides higher system voltage during cold weather and lower system voltage during hot weather.

An .08 ohm resistor is also incorporated in the regulator to compensate for sudden load changes in the charging system.

The voltage regulator in reality has two basic circuits--a "load" circuit and a "control" circuit.

The load circuit utilizes a large output transistor to carry field current through the regulator. This transistor will conduct the heavy field current as long as the emitter and collector elements are positive and the base element is negative with respect to the emitter element. The transistor then acts much like a "turned on" switch.

The control circuit utilizes a driver transistor which is much smaller than the output transistor. This transistor will conduct when- ever the Zener diode is conducting. The collector element of the driver transistor is connected to the base element of the output transistor. When the driver transistor is conducting, the output transistor stops conducting or is "turned off." As a result, the current flow to the rotor field winding is stopped and the system voltage drops. The declining voltage causes the Zener and driver transistors to stop con- ducting and the output transistor is turned on again, restoring current flow to the rotor field winding. This switching action occurs several thousand times per second to maintain the proper system voltage value.

TROUBLE SHOOTING

In order to locate and correct defects in the charging system in the shortest possible time, the following procedures should be used. Only a portion of these procedures need be per- formed. It will never be necessary to perform all the procedures in order to locate the trouble.

To avoid damage to the electrical equipment, always observe the following precautions:

Do not polarize the alternator or disconnect regulator while alternator is operating.

Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.

Never operate the alternator with the output terminal open circuited.

Make sure the alternator and battery have the same ground polarity.

When connecting a charger or a booster battery to the vehicle battery, connect negative to negative and positive to positive.

If battery must be removed, disconnect grounded cable first and never remove alternator without disconnecting battery ground cable.

Trouble in the charging system will show up as one or more of the following conditions:

An undercharged battery as evidenced by slow cranking and low specific gravity readings.

An overcharged battery as evidenced by excessive water usage.

Check for clean and tight cable connections at the battery posts, engine block and starter relay. Inspect the fluid level in the battery and add water if necessary. At this point, if the battery does not have enough energy to crank the engine, it must be tested and re- charged. Check the condition of the complete charging system wire harness and connections. Inspect the drive belt general condition and belt adjustment (see BELT ADJUSTMENT).

For the most part a Volt- Ampere Tester (SE-2283) will be used in performing the charging system output tests and the instruction manual supplied with tester will provide the detailed instructions needed to check the charging system.

ALTERNATOR OUTPUT TEST

Be sure that all electrical equipment is turned off.

Set ground polarity switch to match vehicle ground.

Position Test Selector knob to STARTING SYSTEM, No. 1 position.

Turn Load Control knob at OFF position.

Set Volt Meter Control knob to the INT 18 position.

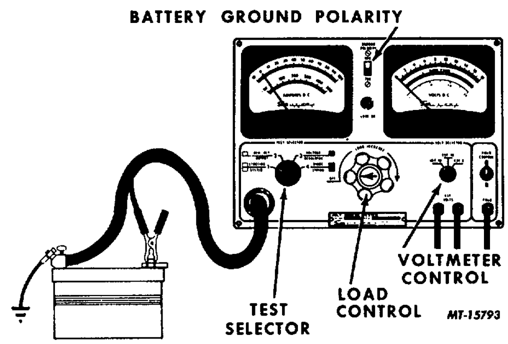

Fig. 7 Volt -Ampere Tester (SE-2283)

Connect tester harness to battery as shown in Fig. 7.

Turn ignition switch on and read the RED scale on the ammeter. Note this figure. This is the normal "ignition-on" current that runs the ignition system.

Reconnect coil high-tension wire if disconnected and start engine. Set speed at about 2000 RPM.

Set Test Selector to GEN-ALT OUTPUT, No. 2 position.

Turn the Load Control slowly until highest ammeter reading on the blue scale is obtained. This reading should be within 10 amperes of rated output of alternator being tested.

NOTE

Add peak amperage reading to "ignition-on" reading. A good alternator output will be within 5 amps of specified amperage rating.

If the alternator is good, go to VOLTAGE REGULATOR TEST.

If the output is below specifications, go to OUTPUT TEST WITH REGULATOR DISCONNECTED

ALTERNATOR OUTPUT TEST WITH REGULATOR DISCONNECTED

Perform this test only if alternator output test is below specifications.

Turn Test Selector back to STARTING SYSTEM, No. 1 position.

Stop engine, disconnect alternator field wire.

Connect the tester blue FIELD LEAD to the field terminal on the alternator. Do not make any further connections of the remaining two connectors.

Start engine.

Set Test Selector to GEN-ALT OUTPUT, No. 2 position.

Run engine to about 2000 RPM and read blue scale on ammeter. If there is no output hold Field Control Switch in "B" position.

A good alternator will read within 5 amperes of specifications. Failing test indicates faulty alternator. Passing test indicates faulty regulator. Reconnect the alternator field lead.

VOLTAGE REGULATOR TEST

Set Test Selector in VOLTAGE REGULATOR, No. 3 position. Let engine idle and cycle regulator by turning Load Control until green volt- meter reads 1/2 of system voltage (6 volts). Return Load Control to OFF. Run engine speed to about 2000 RPM. Then read green voltmeter scale.

A good regulator will read within 13.8 - 14.2 volts at 80 degrees F (see SPECIFICATIONS).

NOTE:
Voltage reading will vary due to higher or lower temperatures.

Do not leave tester in No. 3 position for more than 15 minutes when hooked up.

The voltage regulator settings cannot be changed; therefore, if voltage is not within limits it must be replaced.

DIODE TRIO TEST (ON CHASSIS)

A diode trio assembly with one or more of its diodes completely opened or shorted will cause reduced alternator output and necessitate alternator disassembly to unsolder the diode leads for testing.

This test is designed to quickly check the diode trio assembly for marginal defects which are not affecting alternator output but may be the cause of the alternator showing low charge on ammeter.

Before testing the field diode assembly, per- form the ALTERNATOR OUTPUT TEST to deter- mine if the alternator is performing at rated output. Perform this test only if the VOLTAGE REGULATOR TEST has proven the regulator in good condition.

With the connections on the Volt Amp Tester remaining as stated in ALTERNATOR OUTPUT TEST:

Start engine and operate it at approximately 2000 RPM. Set Test Selector knob on DIODE STATOR, No. 4 position.

Read the voltmeter scale with green and red slashes. Good diodes will read within the green area of scale. Do not leave tester in No. 4 position for more than 15 minutes when hooked up.

Turn Test Selector back to No. 1 position.

If the voltmeter pointer was in red--repair to alternator will be required.

DISASSEMBLY

Remove the two self-tapping screws, cover and insulator shield from brush retainer. Pull the brush assembly back just enough to clear the locating pins and then tip the brush assembly a- way from the housing, Fig. 8. Do not attempt to pull the brush assembly straight away from the alternator as the brush may drop between the slip rings and become broken.

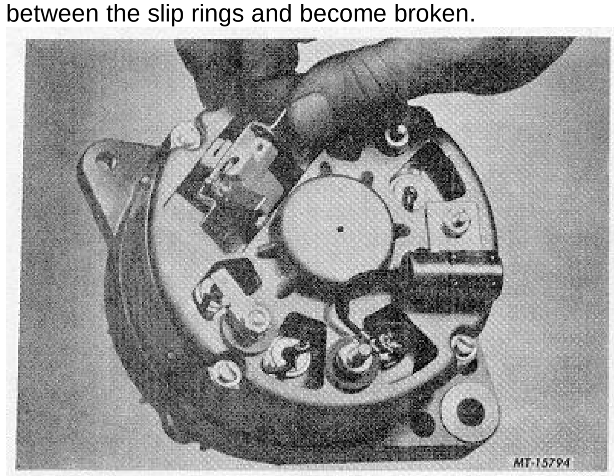

Fig. 8. Removing Brushes

To assure correct alignment of housings at reassembly, scribe an alignment mark on front and rear housings, and also the stator.

Remove the four thru-bolts and nuts. Separate the rear housing and stator from the front housing using two screw drivers to pry the stator from the front housing at two opposing thru-bolt slots, Fig. 9. Use care when prying the housing apart. Do not burr the stator core which could cause difficulty at reassembly.

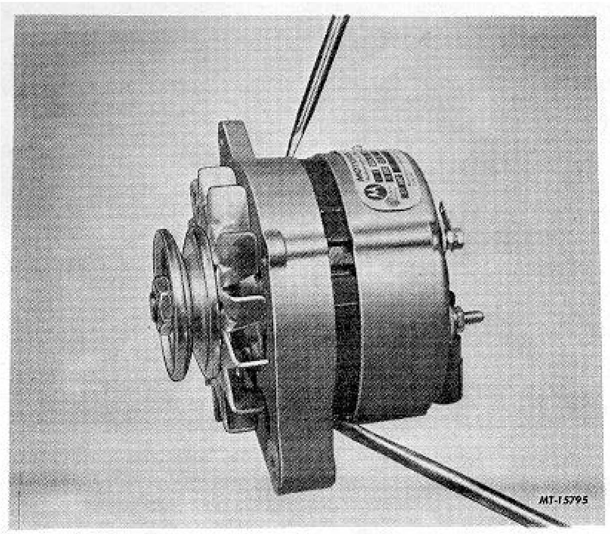

Fig. 9 Separating Rear Housing and Stator From Front Housing

NOTE

Do not insert the screw driver blades deeper than 1/16 inch to avoid damage to stator windings.

To remove the stator from the rear housing assembly, remove the four lock nuts, lock and insulating washers. The stator assembly with the diode assemblies can then be removed by hand, carefully guiding the diode terminal studs out of the rear housing. Remove any insulating sleeves remaining in terminal stud holes. The stator and diodes are removed as an assembly. Avoid bending stator wires at junctions when re- moving the positive and negative diode assemblies.

After the stator and diode assembly is removed from the rear housing, the field diode assembly is accessible, Fig. 10.

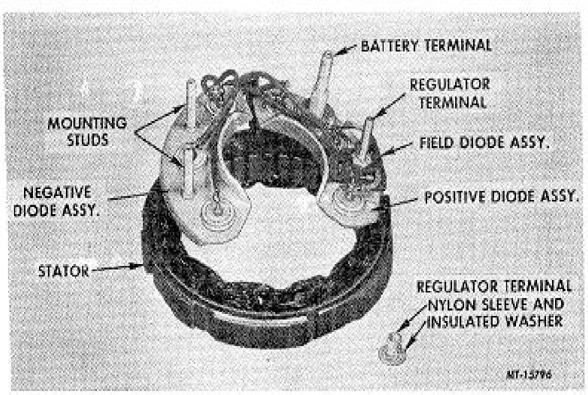

Fig. 10 Stator and Diode Assembly

Remove the nylon sleeve and insulating washer from regulator terminal. Remove the field diode assembly hold-down nut. Unsolder the field diode wires from positive diodes. Be sure to use pliers or some other device to ab- sorb heat, between the solder joint and positive diode, to avoid damage to diode.

Removal of the rotor from front housing will only be required in the event the field coil or front bearing is to be replaced.

The front and rear bearings are pre-lubricated and sealed. If the rotor is to be removed from the front housing, loosen the pulley nut; then holding the pulley in one hand, tap the rotor shaft with a soft hammer to free pulley. Remove nut, pulley, fan, woodruff key and spacer.

On the inside of the front housing there is a snap ring which must be unseated. This can be accomplished either using a snap ring pliers which has an offset (Fig. 11) or a thin blade screw driver through the opening in the front housing (with notch) and compress the snap ring. The snap ring may only be removed from the rotor assembly after the bearing has been removed.

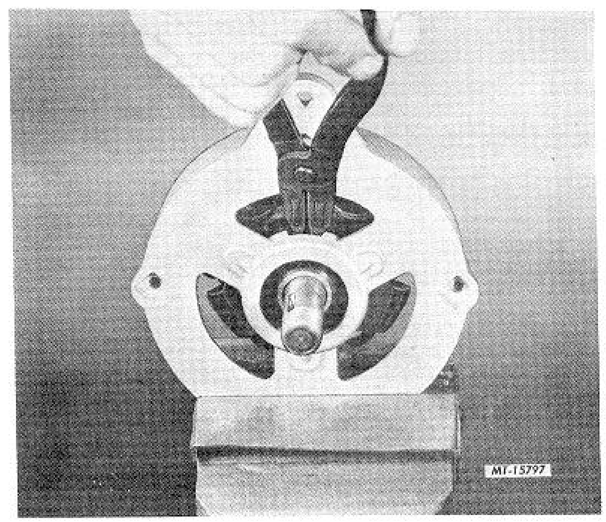

Fig. 11 Removing Snap Spring Washer

Separate the rotor and front bearing from front housing using a soft hammer and tapping on the rotor shaft.

NOTE

The snap ring must be removed from the front housing retaining groove before any attempt to remove the bearing from the housing.

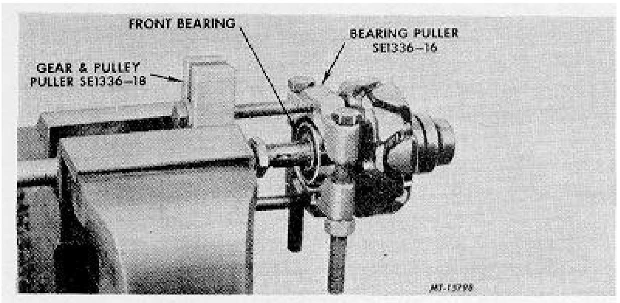

Fig. 12 Front Bearing Removal

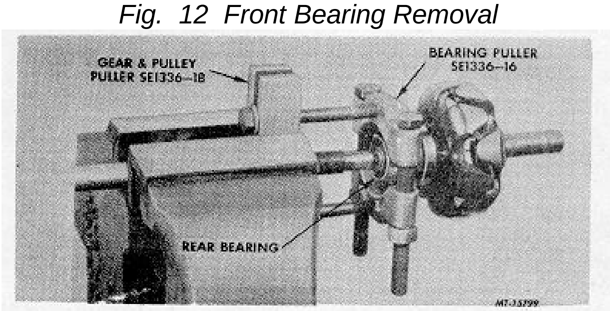

Fig. 13 Rear Bearing Removal

Remove front and rear bearings from rotor shaft using SE-1336 Gear and Bearing Puller Set, selecting SE-1336-16 Bearing Puller and SE-1336- 18 Gear and Pulley Puller, refer to Figs. 12 and 13. The pulley nut should be assembled on the shaft to prevent damage to the threads.

ALTERNATOR COMPONENT CHECKS

Rotor Field Winding Checks

The rotor should be tested for grounded, open or short circuited field coils using SE-2158 Rectifier Diode Tester.

To check for grounds connect test lead clip on one rotor slip ring touch test lead prod to rotor shaft. Lights should not glow. If lights should glow rotor is grounded.

To check for opens touch test lead clip to one slip ring and test lead prod to the other slip ring. Both lights should glow, indicating continuity of rotor circuit. However, if lights fail to glow the windings are open.

The winding is checked for short circuits by connecting a battery and ammeter in series with the two slip rings. Note ammeter reading and refer to SPECIFICATIONS. An ammeter reading above the specified value indicates shorted windings.

Brush Assembly Checks (Fig. 14)

The insulation test is accomplished by connecting an ohmmeter to the field terminal and

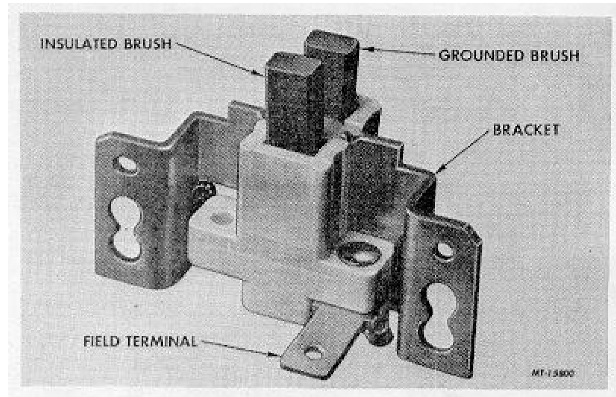

Fig. 14 Brush Assembly

bracket. Resistance should be infinite (no reading). If a low resistance is noted the brush assembly is shorted and must be replaced.

To test the continuity of the brush assembly connect an ohmmeter to the field terminal and insulated brush. Use an alligator clip to assure good contact to brush test points. Use care when making connection to brush so that it is not chipped. The resistance reading should be zero. Move brush and lead wire to make sure the brush lead wire connections are not intermittent. Resistance reading should not vary when the brush and lead wire are being moved. Then connect the ohmmeter to the bracket and grounded brush. The resistance reading should be zero also.

Diode Checks

In order to check the diodes the leads to each diode should be unsoldered. Use a pliers as a heat absorber to prevent damage to the diodes. Do not exert excessive stress on diode leads.

Use the Rectifier Diode Tester, SE-2158, to test diodes individually in the stator circuit disconnected from the stator using the instructions provided with the tester.

When using the meter on the tester to test the diodes, all meter indications should be equal

Replace the complete diode assembly if any diode in the assembly is open or shorted.

To test the field diode assembly, remove the hex nut and washer securing the field diode assembly to regulator terminal assembly. Unsolder the three leads at diode terminals to test the field diode assembly. Be sure to use pliers to absorb heat during the unsoldering operation.

Using SE-2158 Tester, check diode trio assembly for continuity from each lead separately to the center metal contact plate (mounting hole) or stud (Fig. 15). Continuity should be ob- served in one direction (polarity) only, and all diodes should be checked alike. If any one diode is found defective, replace the entire diode trio assembly.

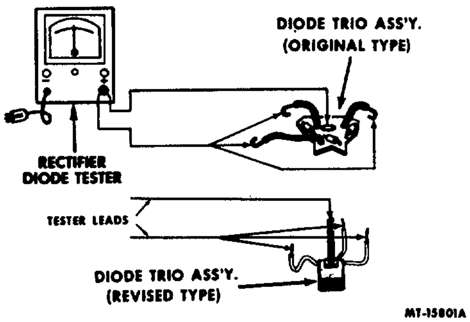

Fig. 15 Testing Diode Trio Assembly

Be sure to note the diode assembly to stator wire connections, making certain replacement diodes are connected to the same wires. Check all connections for proper soldering.

Stator Checks

When the checks on the stator are performed the diode must be unsoldered from the stator leads. The stator should be checked for shorts and opens, except "Delta Wound" stators (62-amp alternators) cannot be checked for opens unless the three windings are isolated, since the wind- ings are connected in series (Fig. 3).

To check for shorts between the stator core and windings, connect one lead of an ohmmeter or a continuity light to the stator core and the other lead to any one of the stator winding leads. The resistance should be infinite (no reading) or if test light is used the light should not operate. If a resistance reading is obtained the stator is shorted and should be replaced. Be sure to check the two remaining windings.

Use an ohmmeter or a continuity light to check the stator for opens. If the lamp fails to light or if meter reading is high where connections are made between each pair of stator leads, the windings are open.

A short circuit in the stator windings is difficult to locate without special equipment due to low resistance of the windings. If all other electrical checks are good and the alternator failed to supply the rated output it can be assumed that a short circuit in the stator is present or open in "Delta Wound" stator.

The stator leads must be soldered to the diodes before the alternator can be reassembled. Be sure to use a pliers on the diode leads to absorb the heat to prevent damage to the diodes;

REASSEMBLY

Support front housing on a flat surface and install the front bearing using a 1-1/8" socket to seat bearing. Install the snap ring in the groove in the front housing, taking care not to damage the bearing seal. Be sure that the snap ring is seated in the groove and the notches in the front housing.

Lightly lubricate the rotor shaft and position rotor shaft in bearing assembly. A press can be used to install the rotor by supporting the inner race of bearing with a tube while pressing rotor shaft, or the rotor can be installed by tapping on the end of the rotor shaft with a soft hammer.

Install the fan and pulley spacer, woodruff key, fan and pulley. Then install the lockwasher and pulley nut.

Using the 7/16" socket or a similar tool to fit the inside race of the rear bearing, press bearing on rotor shaft. Be sure bearing is seated against the shoulder of the rotor shaft.

Position the flat fiber washers and plastic sleeves on the positive (insulated) attaching studs. Carefully insert the stator in the rear housing, guiding the studs through the housing. Place the flat fiber washers, flat metal washers and lock nuts on terminal studs. Then position the capacitor on mounting stud lead on output terminal. Assemble terminal blade on regulator terminal. Install and tighten mounting stud nuts and assembly regulator terminal blade and nuts.

The rear housing is now ready to be assembled to front housing and rotor assembly. Before installing the rear housing assembly check the slip rings to be sure they are free of any grease or grime. Align scribe marks previously marked on the two housings and insert the rotor rear bearing in the rear housing. Install and tighten the thru bolts. Turn rotor to be sure it is free to turn.

Insert brush assembly in rear housing taking care not to damage brushes. Then position the insulator shield and cover over the brush assembly. Make certain the brush assembly, insulator shield and cover are positioned over the alignment pin. Install the self-tapping screws.

BELT ADJUSTMENT

A belt which has been in service for some time should first be inspected for general condition before attempting an adjustment. If it is severely cracked or oil soaked it should be replaced.

Alternator belt tension can be accomplished with the use of SE-2312 Gauge. Check tension at mid-point between the pulleys. Apply gauge to the longest belt span.

Loosen the alternator mounting bolt and the adjusting strap screw. Move the alternator away from the engine by applying pressure at the front housing with a suitable tool.

NOTE

A hole is provided in the alternator mounting bracket to accept a 1/2" ratchet for adjusting belt tension. Do not apply pressure to the rear housing as damage to the aluminum casting will occur.

Move the alternator away from the engine until the specified tension is obtained. Tighten the adjusting strap screw and mount bolt while main- taining the specified tension.

When using the SE-2312 belt tension gauge remember to set new belts (belt with less than two minutes' running time) to the "NEW" area on the gauge face and used belts (belt with two minutes or more running time) to the "USED" area on gauge.

NOTE

Where the SE-2312 belt tension gauge is not available or cannot be utilized because of interference from fan shrouds, accessories or close clearances, a deflection check can be made. Depress the belt at a point mid- way between the water pump and alternator pulleys. One-half inch (1/2") deflection is considered acceptable as a final setting after the new belt has been operated for a short period.

TROUBLE SHOOTING CHART

Alternator Will Not Charge

Check for:

Alternator belt loose.

Open or high resistance in charging or ground return circuit or battery connections.

Excessively worn, open or defective brushes.

Defective negative or positive diodes.

Regulator inoperative.

Open rotor (field coil).

Defective diode trio.

Low or Unsteady Charging Rate

Check for:

Alternator belt loose.

Excessively wom or sticky brushes.

Faulty regulator.

Intermittent or high resistance charging or ground return circuit or battery connections.

Shorted or open diode trio.

Low or Unsteady Charging Rate (Continued)

Grounded or shorted turns in rotor (field coil).

Open, grounded or shorted turns in stator.

Excessive Charging Rate (Evidence by lights and fuses burning out frequently, battery requires too frequent refilling.)

Check for:

All connections on alternator and regulator are tight.

Faulty regulator.

Noisy Alternator

Check for:

Defective or badly worn belt.

Misaligned belt or pulley.

Loose pulley.

Worn bearings.

Shorted rectifier diode.

ALTERNATOR
(DELCO-REMY)

25 SI SERIES
TYPES 400 and 450

CODES 08120, 08138
75 AMP

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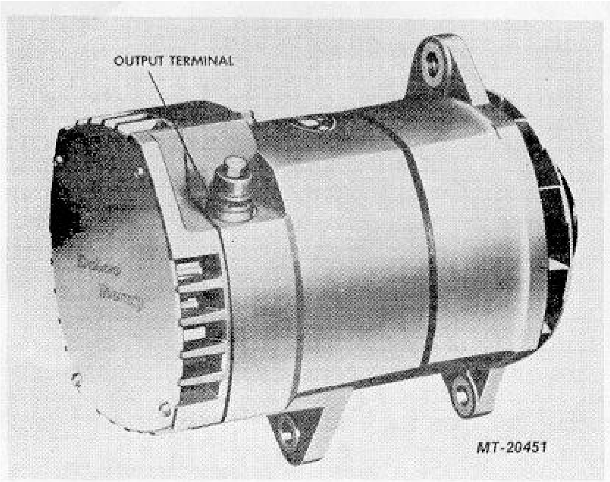

Fig. 1 25SI Series Alternator

DESCRIPTION

The 25SI series self-rectifying alternator, Figures 1 and 2, is a brushless unit featuring a built-in voltage regulator.

The only movable part in the assembly is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. All current-carrying conductors are stationary. These conductors are the field winding, the stator windings, the six rectifying diodes, and the regulator circuit components. The regulator and diodes are enclosed in a sealed compartment.

A fan located on the drive end provides airflow for cooling. Extra large grease reservoirs contain an adequate supply of lubricant so that no periodic maintenance of any kind is required.

Only one wire is needed to connect the alternator assembly to the battery along with an adequate ground return. The specially designed output terminal is connected directly to the battery.

A red output terminal is used on negative ground models and is to be connected only to battery positive. A black output terminal is used on positive ground models and is to be connected only to battery negative.

The hex head bolt on the output terminal is electrically insulated; no voltage reading can be obtained by connecting to the hex head.

An "R" terminal is provided on some units to operate auxiliary equipment.

OPERATING PRINCIPLES

Units With Regulator Type Shown in Figure 12

Typical wiring circuit diagrams for these units are shown in Figures 3 and 4. Basic operating principles are as follows.

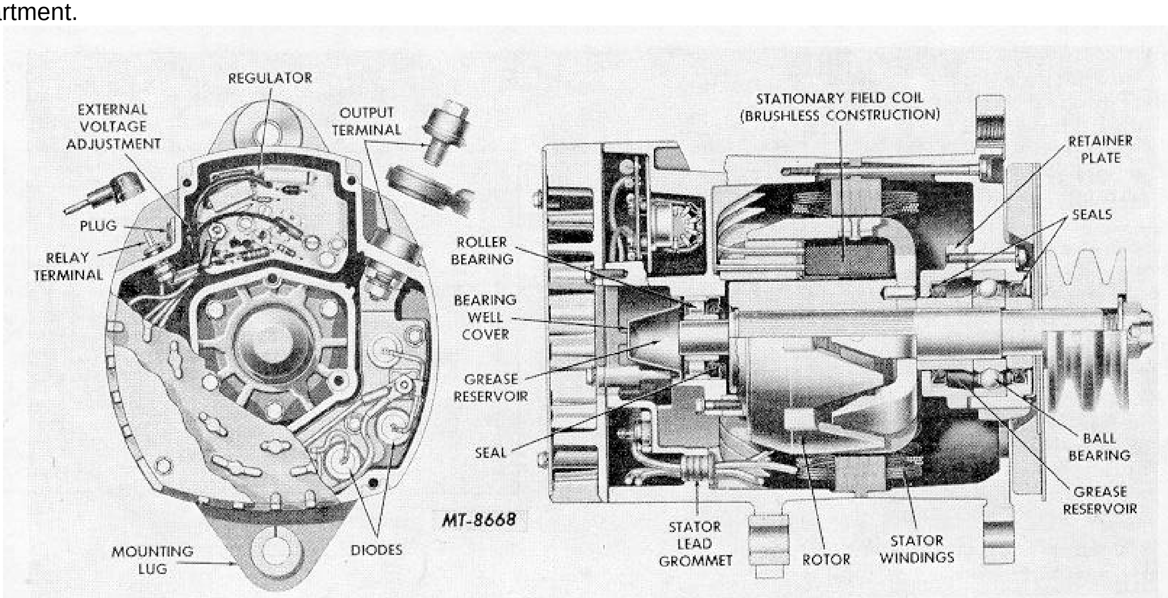

Figure 2 Sectional View of Alternator

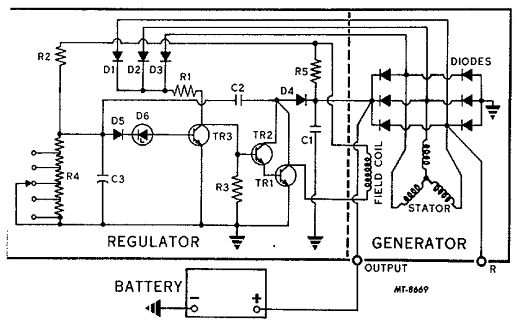

Fig. 3 Negative Ground Circuit (Units With Regulator Shown in Fig. 12)

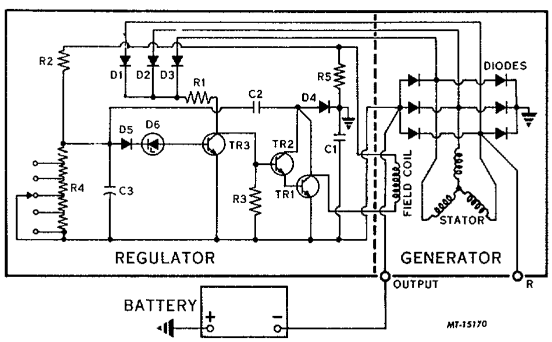

Fig. 4 Positive Ground Circuit (Units With Regulator Shown in Fig. 12)

As the rotor begins to turn, permanent magnetism therein induces voltages in the stator windings. Current then flows through diodes D1, D2 and D3, resistors R1 and R3 and the generator diodes back to the stator winding. Transistors TR1 and TR2 then turn on and the battery supplies current through resistor R5, the field coil and TR1. Current also flows from the battery through R5, R2, and R4.

As system voltage increases, a voltage across R4 is impressed across diodes D5 and D6, caused by current flow through R5, R2 and R4. When the preset voltage is reached, diodes D5 and D6 conduct, TR3 turns on, TR1 and TR2 turn off and the generator voltage decreases. Diodes D5, D6 and TR3 then turn off, TR1 and TR2 turn back on and the cycle repeats many times per second to limit the generator voltage to the adjusted value.

Capacitor C1 protects the generator diodes from high transient voltages and suppresses radio interference.

Capacitor C2 (used on 24-volt systems only) causes TR1 and TR2 to turn on and off quickly.

Diode D4 prevents high field-coil-induced voltages when TR1 and TR2 turn off.

Capacitor C3 smooths out the voltage across R4. Resistor R5 raises the generator voltage slightly as generator output increases to maintain a more nearly constant voltage across the battery by compensating for line drop.

Units With Regulator type Shown in Figure 16

Typical wiring circuit diagrams for these units are shown in Figures 5 and 6. Basic operating principles are as follows.

As the rotor begins to turn, permanent magnetism therein induces voltages in the stator windings. The voltages across the six diodes cause current to flow to charge the battery.

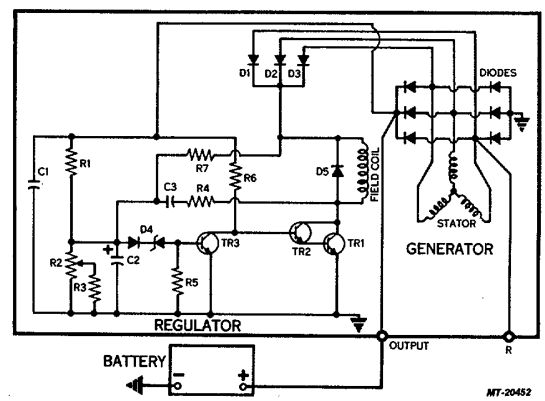

Fig. 5 Negative Ground Circuit (Units with Regulator Shown in Fig. 16)

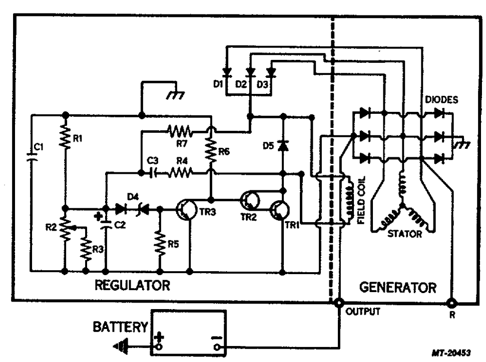

Fig. 6 Positive Ground Circuit (Units with Regulator Shown in Fig. 16)

Current from the stator flows through the three diodes to resistor R6 and the base-emitter of TR2 and TR1 to turn these transistors on. Current also flows from the stator through the diode trio D1, D2 and D3, the field coil and transistor TR1, returning to the stator through the other three diodes. All stator current, except through the diode trio D1, D2 and D3, flows through the six diodes connected to the stator.

Current flow through R1, R2 and R3 causes voltage to appear at zener diode D4. When the voltage becomes high enough due to increasing generator speed, D4 and the base-emitter of TR3 conduct current and TR3 turns on. TR2 and TR1 then turn off, decreasing the field current and the system voltage decreases. The voltage at D4 decreases, D4 and TR3 turn off, TR2 and TR1 turn back on and the system voltage increases. This cycle then repeats many times per second to limit the system voltage as determined by the setting of the potentiometer R2, R3.

Capacitor C1 protects the generator diodes from high transient voltages and suppresses radio interference.

Resistor R5 prevents current leakage through TR3 at high temperatures. Diode D5 prevents high transient voltages in the field coil when the field current is decreasing. Resistor R7, capacitor C3 and resistor R4 all act to cause transistors TR2 and TR1 to turn on and off more quickly.

TROUBLE SHOOTING PROCEDURES

Energizing Speed

The energizing speed is the speed (rpm) at which the regulator turns on to energize the field coil. This speed is higher than some speeds at which output can be obtained. Therefore, when checking output at low speeds, increase speed until the regulator turns on; then reduce speed to check the output. No output can be obtained until the regulator turns on. Once the regulator turns on, it will remain turned on until the engine is stopped.

Rated Voltage

Preferably, alternator output should be checked at the "Rated Voltage" given in Table I. However, it is permissible to check the output in amperes at any voltage within the "Operating Range" listed in the table, since the current output will be quite close to the value that would be obtained at "Rated Voltage." The voltage should never be allowed to rise above the "Operating Range" for any length of time.

TABLE I

System Voltage	Rated Voltage	Operating Range
12	14.0	13.0 - 15.0

It should be noted that the voltage may be below the "Operating Range" if the battery is in a low state of charge. However, as the battery receives a charge, the voltage will rise to some value within the "Operating Range."

Magnetizing the Rotor

The rotor normally retains magnetism to provide voltage buildup when the engine is started. After disassembly or servicing, however, it may be necessary to re-establish the magnetism. To magnetize the rotor, connect the alternator to the battery in a normal manner, then momentarily connect a jumper lead from the battery positive post to the alternator relay terminal. This procedure will restore the normal residual magnetism in the rotor.

Trouble in the vehicle charging system will be indicated by one of two conditions:

An undercharged battery as evidenced by low specific gravity readings and slow cranking.

An overcharged battery as evidenced by excessive battery water usage.

These conditions can be caused by:

I. A defective battery.

II. Poor circuit connections.

III. A defective alternator assembly.

I. Battery

Since the battery may have an internal defect, it must be checked to determine its condition. Refer to BATTERY Section of Service Manual for battery test procedure.

II. Circuit Connections

Poor circuit connections in the charging system can cause an undercharged condition only. Carefully inspect all connections including grounds between the alternator and battery for cleanliness and tightness. Insure that the battery cable clamps are clean and tight and that the battery is dry and clean.

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III. Alternator Assembly

If the battery and circuit connection checks are satisfactory, the alternator assembly may be checked either on or off the vehicle by making connections as shown in Figure 7. Remember that hex bolt on output terminal is electrically insulated. Assemble a closed end terminal clip with 12.7 mm (1/2") hole to output terminal; then connect ammeter lead clip to this terminal clip.

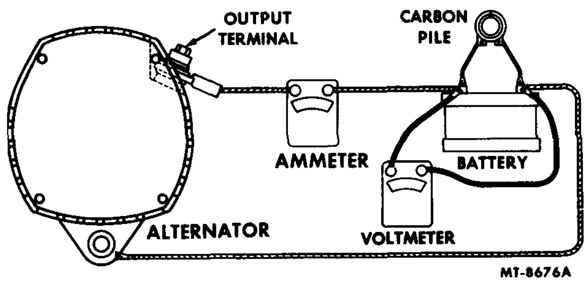

Fig. 7 Output Check

TEST PROCEDURE

With test equipment connected as shown in Figure 7, follow this procedure:

1. With all accessories and carbon pile turned off, increase engine speed as required to obtain maximum voltage reading.

2. If voltage exceeds 15 volts, remove alternator for repair as covered under REPAIR PROCEDURES.

3. If voltage does not exceed 15 volts, proceed as follows:

    a. Insure that accessories have not been left on for extended periods.

    b. Check the drive belt for proper tension.

    c. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.

    d. Connect a voltmeter from "Output" terminal on alternator to ground. A zero reading indicates an open between voltmeter connection and battery.

4. If previous Steps check satisfactorily, check alternator as follows:

    a. Disconnect battery ground cable.

    b. Connect an ammeter in the circuit at the "Output" terminal of alternator.

    c. Reconnect battery ground cable.

    d. Turn on accessories. Connect carbon pile across the battery.

    e. Operate engine at moderate speed as required, usually 4000 alternator rpm or more and adjust carbon pile as required to obtain maximum current output.

IMPORTANT

Initial voltage buildup is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.

    f. If ampere output is not within 10 amperes of rated output as stamped on alternator frame, remove alternator for repair. If ampere output is within 10 amperes of rated output as stamped on alternator frame, alternator is not defective. In this case, an adjustment of the voltage setting may correct the condition.

5. Adjust voltage setting as outlined below:

    Units with regulator shown in Figures 3, 4 and 12.

    a. Remove pipe plug from integral charging system (Figure 2).

    b. Turn adjusting screw one or two notches clockwise to raise the voltage setting and one or two notches counterclockwise to lower the voltage setting.

    c. Replace pipe plug.

    Units with regulator shown in Figures 5, 6 and 16.

    a. Remove end plate from alternator.

    b. Scrape silicone rubber coating from potentiometer to expose slotted screw (Figure 8).

    c. Turn slotted screw clockwise to increase voltage setting or counterclockwise to decrease voltage setting.

    d. Reinstall end plate.

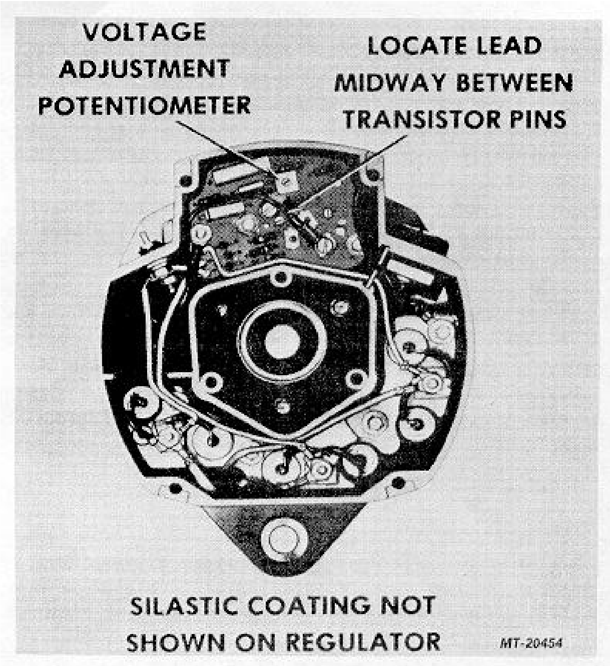

Fig. 8 Voltage Setting Adjustment (Units with Regulator Shown in Figure 16)

6. After adjusting voltage setting, check for an improved battery condition over a service period of reasonable length. <u>If adjusting the setting does not correct the battery condition, remove the generator for repair.</u>

   Remember that if the battery state of charge is low, the regulator may not be limiting the voltage, and turning the adjusting screw will show no change on the voltmeter. However, turning the adjusting screw will change the voltage setting to a new value which will be indicated by the voltmeter when the battery state of charge increases.

REPAIR PROCEDURES

If test procedures indicate the need to repair the alternator, observe the following procedure.

DISASSEMBLY

After removing the cover plate, cover and gasket, typical rectifier end frame components are exposed to view as shown in Figures 9, 10 and 11. Note carefully the proper connections; then proceed as follows:

1. To check the stator and diodes, remove the three nuts, three regulator leads, three stator leads, six diode leads and the "R" terminal

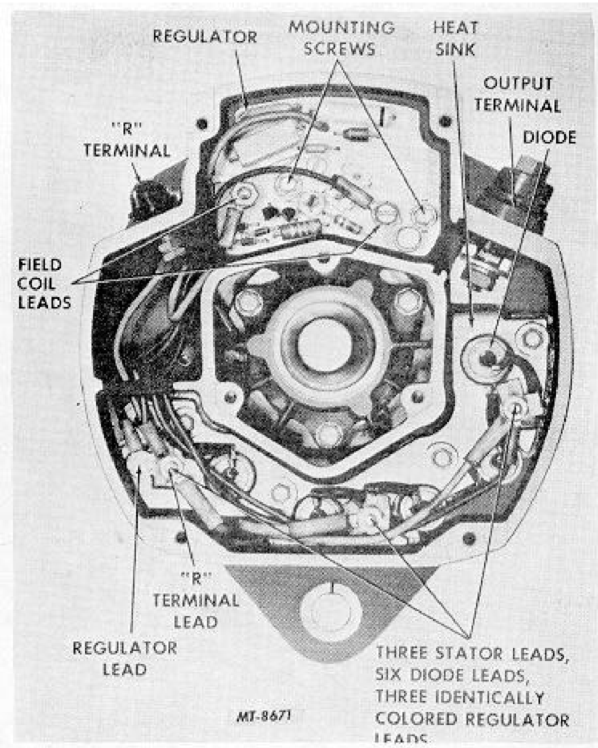

Fig. 9 End View, Cover Removed (Early Type Discrete-Component 12-Volt Regulator)

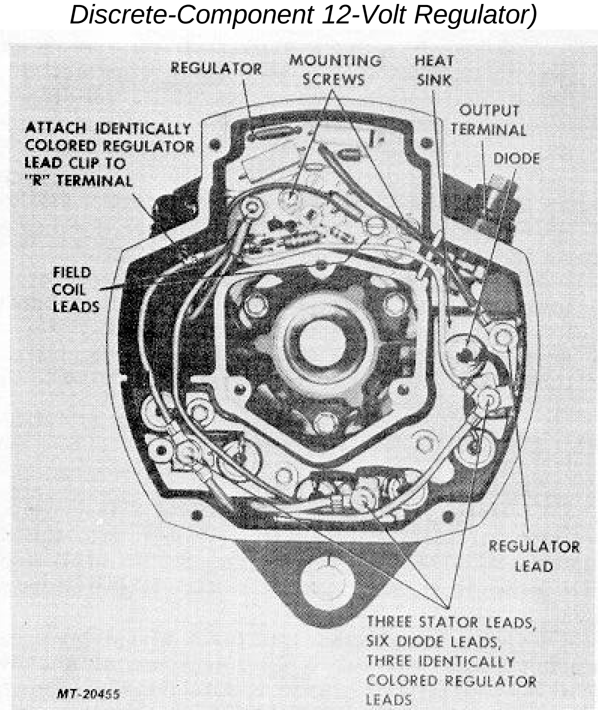

Fig. 10 End View, Cover Removed (Discrete-Component 12-Volt Regulator)

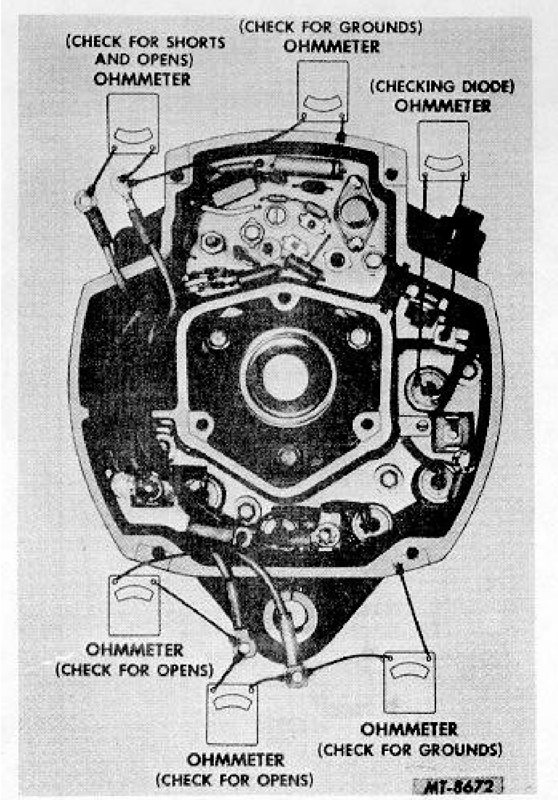

Fig. 11 Electrical Checks for All Types

lead from the three studs. During reassembly place over each stud in this order, the two diode leads, stator lead, "R" terminal lead on one stud only, regulator lead and nut.

2. To check the field coil, disconnect the two field coil leads from the regulator.

3. Later on, it may be necessary to separate the drive end frame assembly from the rectifier end frame assembly by removing the shaft nut, washer, pulley, fan slinger and thru bolts from the drive end.

FIELD COIL CHECKS (Figure 11)

To check for grounds, connect a test lamp or an ohmmeter to one field coil lead and to the end frame as illustrated. If the lamp lights or if ohmmeter reading is low, the field coil is grounded.

To check for opens, connect a test lamp or an ohmmeter to the two field coil leads as shown. If the lamp fails to light or if ohmmeter reading is high (infinite), the field coil is open.

The winding is checked for short circuits by connecting a battery and ammeter in series with the field coil. Note the ammeter reading and refer to SPECIFICATIONS. An ammeter reading above the specified value indicates shorted windings. An alternate method is to check the resistance of the field by connecting an ohmmeter to the field coil. If the resistance reading is below the specified value, the winding is shorted kV The specified resistance value can be determined by dividing the voltage by the current given in SPECIFICATIONS.

To replace the field coil, separate drive end frame from rectifier end frame, remove field coil attaching screws and pull leads and grommet through end frame hole. Place grease on grommet and pull grommet into hole during assembly.

DIODE CHECKS (Figure 11)

Check each of the six diodes by removing each diode lead from the stud and connecting an ohmmeter using the lowest range scale to the diode lead and case. Then reverse the ohmmeter lead connections to the diode lead and case. If both readings are the same, replace the diode. A good diode will give one high and one low reading.

CAUTION

Do not use high voltage such as 110 volt test lamps to check diodes.

Before replacing a diode in the rectifier end frame, the end frame must be separated from the drive end frame. Also, before replacing a diode in the heat sink or end frame, it is necessary to remove the heat sink from the end frame by detaching from the heat sink the regulator lead, the heat sink mounting screws and the generator output terminal. Note the round insulators under the heat sink mounting screws and the flat insulator located behind the heat sink. The silicone grease on both sides of the flat insulator provides the necessary heat transfer between heat sink and end frame. Reapply silicone grease during assembly, tighten heat sink mounting screws loosely, securely tighten output terminal, then securely tighten the heat sink screws.

To replace a diode in the heat sink, support heat sink and use an arbor press or vise to push the diode out. Use a suitable tool to pull the diode out of the end frame. Also use a suitable tool which fits over the outer diode edge to push the diode in, and support the heat sink or end frame with a suitable tool. Diode replacement tools are available from various manufacturers normally supplying tools and test equipment to the automotive industry.

CAUTION

Do not strike the diode, as the shock may damage it and the other diodes. Use only those diodes listed in parts list for these units. Never use substitutes.

STATOR CHECKS (Figure 11) (Omit for Overcharged Battery)

The stator windings may be checked with a 110-volt test lamp or an ohmmeter. If the lamp lights or if the meter reading is low when connected from any stator lead to the frame, the windings are grounded.

If the lamp fails to light or if the meter reading is high when successively connected between each pair of stator leads, the windings are open.

A short circuit in the stator windings is difficult to locate without laboratory test equipment due to the low resistance of the windings. However, if all other electrical checks are normal and the generator fails to supply rated output, shorted stator windings are indicated.

To replace the stator, separate drive end frame from rectifier end frame and pull leads and grommet through hole. Place grease on grommet and pull into hole during assembly.

REGULATOR REPLACEMENT OR REPAIR (Regulator shown in Figure 12 only)

If alternator component checks outlined above indicate that regulator is faulty, replace or repair the regulator.

Replacement

After disconnecting the three identically colored regulator leads, the regulator may be replaced by removing the attaching screws and disconnecting the regulator lead from the heat sink. Regulators may differ in appearance, but the various types are completely interchangeable.

Repair

The regulator can be repaired by following the procedure outlined below. The panel board (Figure 12) is shown without the sealing compound so that the seven (7) serviceable parts can be easily identified.

1. Remove screw, transistor TR1 and pry apart heat sink and panel board with screwdriver.

2. Carefully inspect printed circuit for poor solder joints.

3. Carefully inspect for broken parts.

4. Check and replace components as follows. Refer to Figure 13.

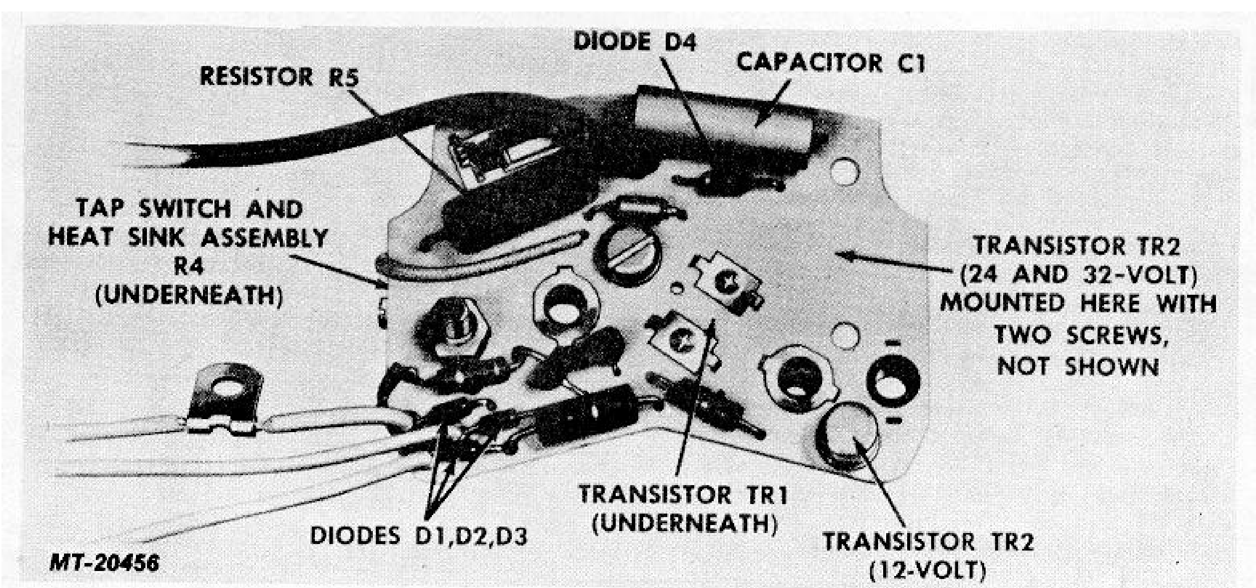

Fig. 12 Regulator Panel Board Assembly

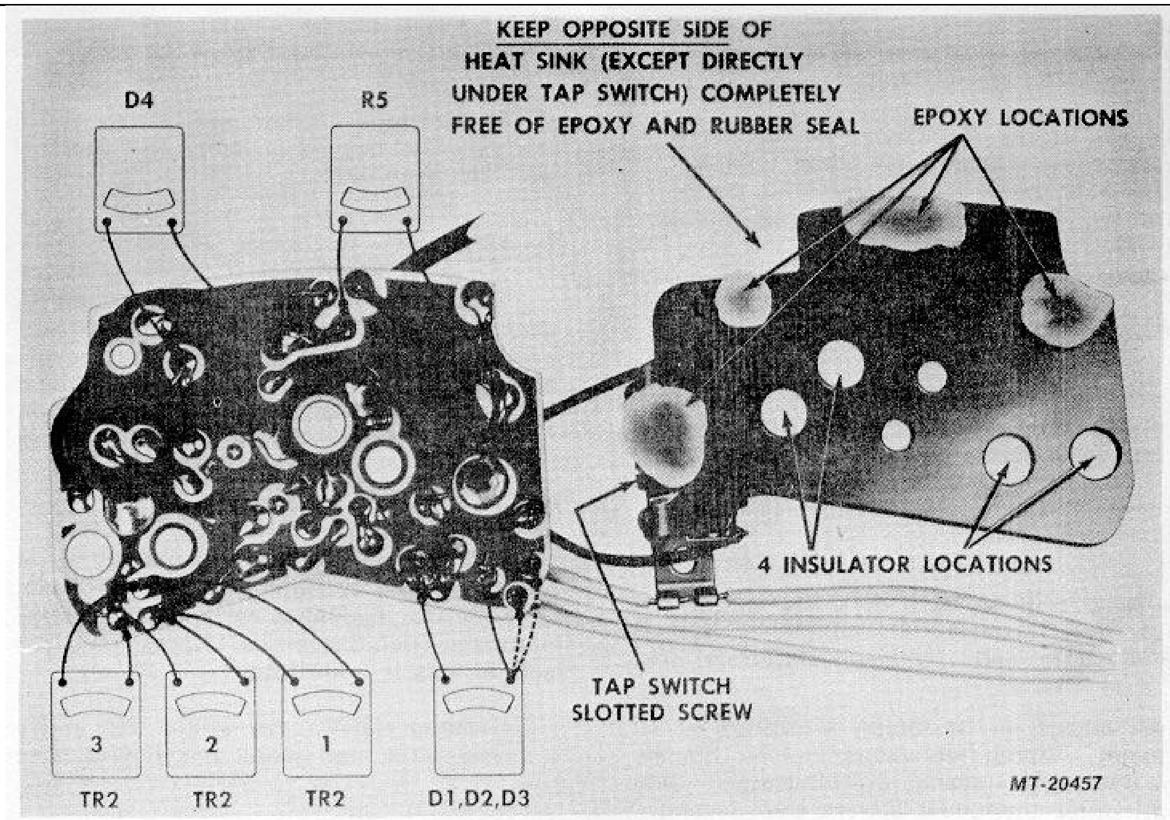

Fig. 13 Checking Regulator Components (Regulator Shown in Fig. 12)

IMPORTANT

Use 1-1/2 volt-ohmmeter on low scale. Reverse ohmmeter leads to obtain two (2) readings.

Scratch hard with a sharp tool to break through transparent coating over solder to make ohmmeter contact. Reseal after testing .

Use fifty (50) watt soldering gun.

a. Tap Switch and Heat Sink Assembly

Turn slotted screw with screwdriver to 5 positions. If screw is loose, replace assembly. Also, replace old type assemblies having brass slotted screw and attaching nut even if screw is not loose. New assemblies have aluminum slotted screw and no attaching nut. Make sure switch is epoxied to heat sink.

b. Resistor R5

If any reading is over one (1) ohm, replace resistor. Cut away sealing compound with sharp blade.

c. Transistor TR2

Step 1: Should get one low and one high reading. If not, replace transistor.

Step 2: Same as Step 1.

Step 3: Both readings should be very high. If not, replace transistor.

IMPORTANT

The replacement transistor for TR2 may be a small black unit with a red dot and a flat side. When assembled, the flat side should face towards diodes D1, D2 and D3 (Figure 12).

d. Diode D4
Should get one low and one high reading. If not, replace diode.

e. Diodes D1, D2 and D3

Check each diode separately. Should get one low and one high reading. If not, replace diode being checked.

f. Transistor TR1 (Figure 14)

Step 1: Both readings should be very high. If not, replace transistor.

Step 2: Should get one low and one high reading. If not, replace transistor.

Step 3: Same as Step 2.

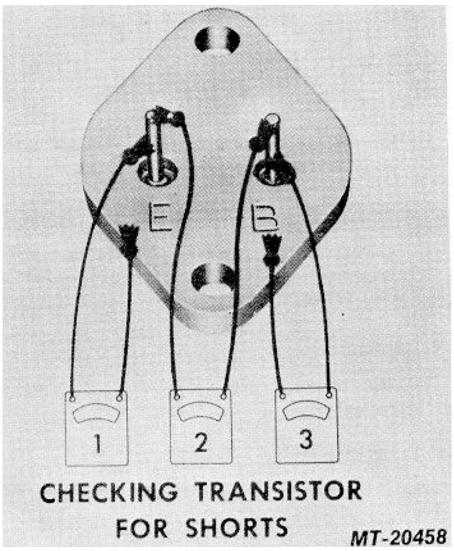

Fig. 14. Checking Transistor TR1

g. Capacitor C1 (Figure 12) Visually inspect for broken leads.

5. If no defects have been found, replace complete regulator assembly.

6. If regulator was repaired, reassemble as follows:

a. If heat sink is reused, burn away with soldering iron old epoxy separating heat sink from panel board. Apply new epoxy (Delco-Remy part number 1966807 or equivalent) at all four (4) locations on old or new heat sink (Figure 13).

IMPORTANT

Keep opposite side of heat sink (except under tap switch) perfectly clean and free of epoxy and rubber seal (Fig. 13).

b. Using four (4) insulators, assemble heat sink, panel board and transistor TR1. Use silicone grease available commercially on both sides of mica insulator located between transistor and heat sink.

c. Apply sealing compound around components as shown in Figure 15. (Use Dow Chemical RTV Silastic 732 or equivalent, available at hardware, paint and drug stores.) Keep metal clips perfectly clean and free of rubber seal.

7. Test regulator to see if it works. If satisfactory, return to service. If defective, replace complete regulator assembly.

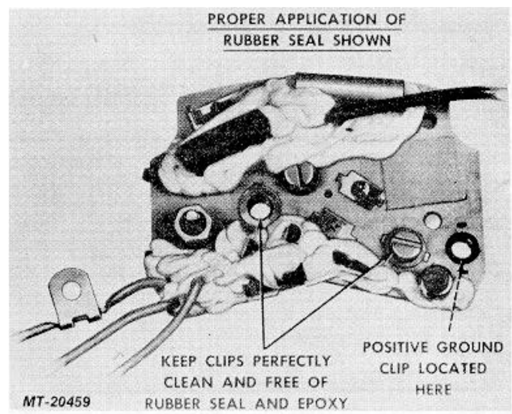

Fig. 15. Rubber Sealing Compound Applied to Regulator Components

REGULATOR REPLACEMENT OR REPAIR
(Regulator shown in Figure 16 Only)

If alternator component checks outlined previously indicate that regulator is faulty, replace or repair the regulator.

Replacement

After disconnecting the three identically colored regulator leads, the regulator may be replaced by removing the attaching screws and disconnecting the regulator lead from the heat sink.

Repair

The regulator can be repaired by following the procedure outlined below. The panel board (Figure 16) is shown without the sealing compound so that the seven (7) serviceable parts can be easily identified.

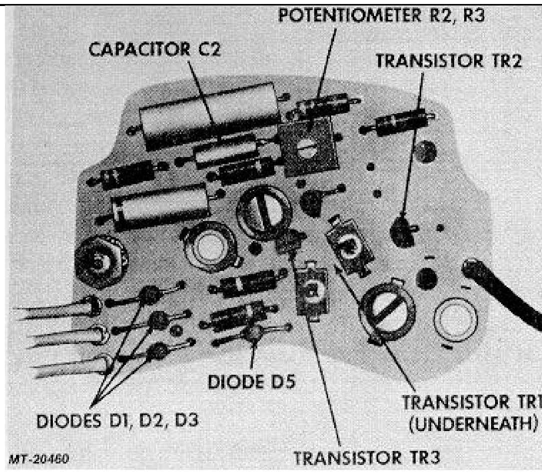

Fig. 16. Regulator Panel Board Assembly

1. Remove screw, transistor TR1 and pry apart heat sink and panel board with screwdriver.
2. Carefully inspect printed circuit for poor solder joints.
3. Carefully inspect for broken parts.
4. Check and replace components as follows. Refer to Figure 17.

IMPORTANT

Use 1-½ volt-ohmmeter on low scale.

Scratch hard with a sharp tool to break through transparent coating over solder to make ohmmeter connections. Reseal after testing.

Use fifty (50) watt soldering gun.

Ohmmeter polarity must be determined by connecting its leads to voltmeter leads. Voltmeter will read up scale when the negative leads are connected together and the positive leads are connected together. The polarity of the voltmeter leads can be determined by connecting the leads to the identified terminals of a battery.

a. Transistor TR2

Step 1: Should read about 5-50 ohms. If zero or well above 50, replace transistor.

Step 2: Should read very high. If not, replace transistor.

Step 3: Same as Step 1.

b. Transistor TR3

Step 1: Should read very high. If not, replace transistor.

Step 2: Should read about 5-50 ohms. If zero or well above 50, replace transistor.

Step 3: Same as Step 2.

c. Diode D5

Should read 5-50 ohms. If zero or well above 50, replace diode.

d. Diode Trio D1, D2 and D3

Each diode should read 5-50 ohms. If zero or well above 50, replace diode being tested.

e. Capacitor C2

Should read high. If zero, replace capacitor.

f. Potentiometer R2

IMPORTANT

Change ohmmeter to X10 or middle scale.

With ohmmeter connected, turn potentiometer slotted screw (Figure 16). Ohmmeter needle should deflect slightly. If no deflection at all, replace R2.

g. Transistor TR1

IMPORTANT

Turn ohmmeter back to low or X1 scale.

Step 1: Should read very high. If not, replace transistor.

Step 2: Should read about 5-50 ohms. If zero or well above 50, replace transistor.

Step 3: Same as Step 2.

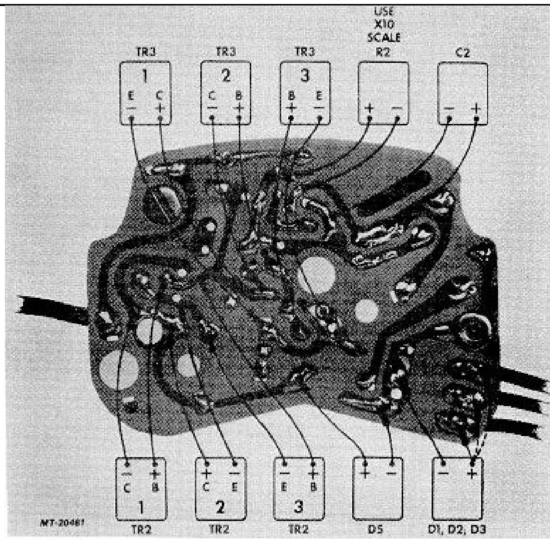

Fig. 17. Checking Regulator Components (Regulator Shown in Figure 16)

5. If no defects have been found, replace complete regulator assembly.

6. If regulator was repaired, reassemble using silicone grease on both sides of mica under transistor TR1.

7. Apply sealing compound around components as shown in Figure 15. (Use Dow Chemical RTV Silastic 732 silicone rubber seal or equivalent, available at hardware, drug and paint stores.) Keep metal clips perfectly clean and free of rubber seal.

8. Test regulator to see if it works. If satisfactory, return to service. If defective, replace complete regulator assembly.

BEARING REPLACEMENT AND LUBRICATION

The bearings normally will operate between engine overhaul periods without attention. At time of engine overhaul, the bearings and seals should be replaced and a fresh supply of lubricant added to the reservoirs.

To replace the drive end bearing:

1. Remove shaft nut, washer, pulley, fan, slinger and the four retainer plate bolts; then remove the rotor and bearing assembly from the end frame.

2. Pull the bearing from the rotor shaft, separate retainer plate and collar from shaft and discard seals in retainer plate and end frame.

3. Add high temperature ball bearing lubricant (Delco-Remy No. 1948791 or equivalent) so each reservoir between the bearing and seal after assembly will be only three-quarters full. Arrange the lubricant so at least a portion will contact the bearing after reassembly. Otherwise, the oil in the lubricant will not bleed to the bearing. Also add lubricant to each seal lip and fill the cavity with lubricant between the rubber lip and steel case of each seal. The seals must be assembled so the seal lip is toward or next to the bearing.

4. Lubricate collar; then install collar and retainer plate; then press against the inner race only to install the new bearing onto the shaft against the collar.

5. The remaining assembly procedure is the reverse of disassembly.

To replace the rectifier end frame bearing (type shown in Figures 18, 19 and 20 only):

1. Pull the old inner race from the shaft and press the new inner race onto the dimension shown in Figure 18.

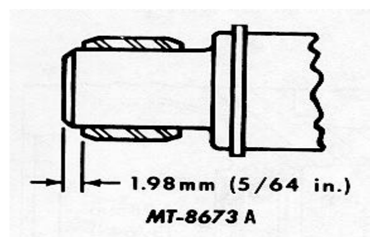

Fig. 18. Inner Race Location

2. Discard the old seal and push the old bearing out of the housing from inside toward the outside.

3. Push against the race only to install the new bearing to the dimension shown in Figure 19. To facilitate the installation, heat the end frame in an oven to 93 to 149 C (200 to 300 F). This will not damage the regulator.

4. Add high temperature ball bearing lubricant (Delco-Remy No. 1948791 or equivalent) to the bearing well cover so it is only three-quarters filled. Arrange the lubricant so at least a portion will contact the bearing after assembly. Otherwise, the oil in the lubricant will not bleed to the bearing. Press the cover into the housing.

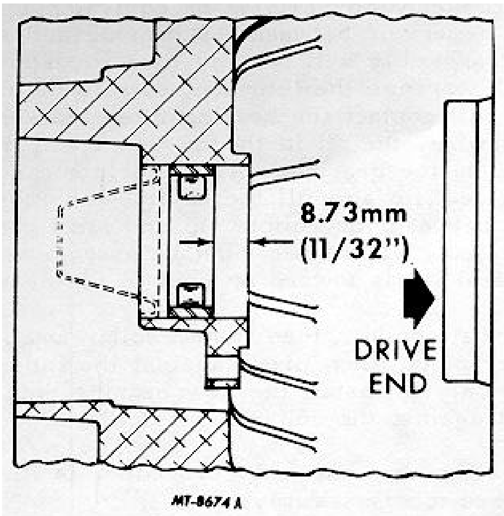

Fig. 19. Bearing Location

5. Add lubricant to the seal lip and fill the cavity with lubricant between the rubber lip and steel case of the seal. Install the seal with the lip towards the bearing to the dimension shown in Figure 20.

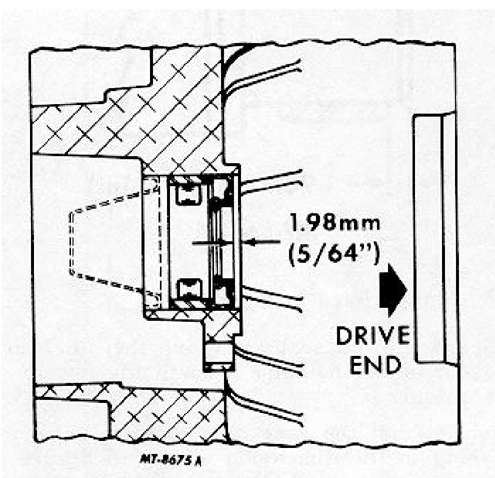

Fig. 20. Seal Location

To replace the rectifier end frame bearing (type shown in Figure 21 only):

1. Pull inner race from shaft and bearing from end frame.

2. Assemble new inner race and bearing as shown in Figure 21. Assemble bearing seal toward drive end. Press against seal end of bearing to assemble into housing.

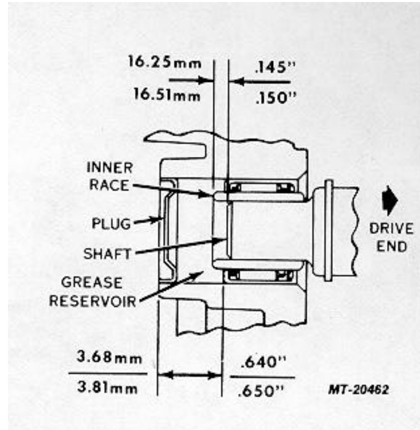

Fig. 21. Bearing Assembling Between Shaft And Housing

3. Fill grease reservoir half full of high temperature ball bearing lubricant (Delco-Remy No. 1948791 or equivalent). Arrange lubricant so a portion will touch bearing when assembled.

REASSEMBLY

In general, reassembly is the reverse of disassembly procedures.

Before installing thru-bolts, apply a small coating of thread lock adhesive (United Delco Kit X10 or equivalent) to the threads. This will prevent the bolts from backing out during operation. Tighten thru-bolts to 6.2 N·m (55 in. lbs).

Two types of output terminals have been used on this series alternator. One design features an output terminal bolt with an insulated head. The other design has a terminal bolt and adapter with an insulating boot. Either type bolt as well as the adapter should be tightened to 11.2 - 12.4 N·m (100 - 110 in. lbs). Do not overtighten bolt or adapter. Excessive tightening could damage the heat sink.

To assist in tightening the drive pulley nut, a hexagon hole is provided in the end of the rotor shaft for holding with an Allen wrench. A special socket (Snap-On No. S-8183) which is cut away to receive the Allen wrench is avail- able for use with a torque indicating wrench to tighten the nut. Where desired, a length of pipe may be applied to the Allen wrench to provide additional leverage for holding as shown in Figure 22. Tighten pulley nut to 95 - 108 N·m (70 - 80 lb. ft.).

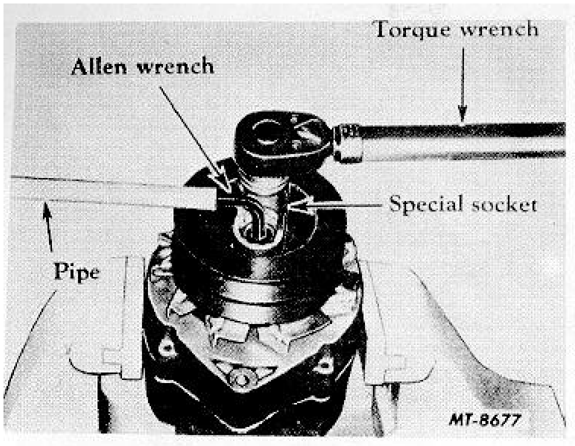

Fig. 22. Tightening Pulley Nut

After assembling alternator, magnetize the rotor as instructed under TROUBLE SHOOTING PROCEDURES.

To check output, connect test meters as shown in Figure 7 and test as instructed under TROUBLE SHOOTING PROCEDURES.

SPECIFICATIONS

Model	Series	Type	Ground	Field 26.7 C Amps	Current (80 F) Volts	Cold Amps	Output RPM **	Red Hot Output (Amps)
1117225	25SI	400	Negative	4.1 - 4.5	12	77	5000	75
*1117228	25SI	450	Negative	4.1 - 4.5	12	77	5000	75
1117235	25SI	400	Positive	4.1 - 4.5	12	75	5000	75
1117241	25SI	400	Negative	4.1 - 4.5	12	77	5000	75
*1117242	25SI	450	Negative	4.1 - 4.5	12	77	5000	75

* - Load Dump Protected
** - Alternator Speed

ALTERNATOR

(DELCO-REMY)

40SI SERIES TYPE 150

CODE 08150 105 AMP

CODE 08127 145 AMP

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PRINTED IN UNITED STATES OF AMERICA

DESCRIPTION

The Integral Charging System illustrated in Figs. 1 and 2 features a solid state regulator that is mounted inside the slip ring end frame. The regulator voltage setting can be adjusted externally by repositioning a voltage adjustment cap in the slip ring end frame. This feature is covered in detail herein. Only one wire is needed to connect the Integral Charging System to the energizer, or battery, along with an adequate ground return. An "R" terminal is provided to operate auxiliary equipment in some circuits. Also, some models have three A. C. terminals to which a transformer- rectifier combination may be connected for conversion to 110 volts D. C.

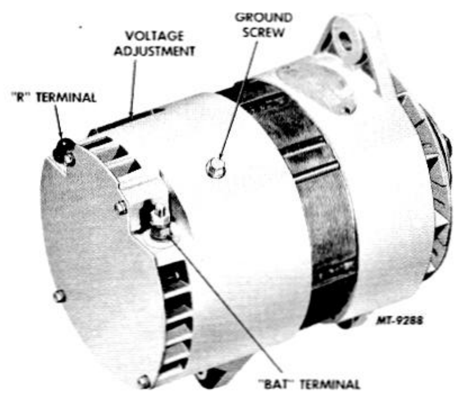

Figure. 1. Alternator

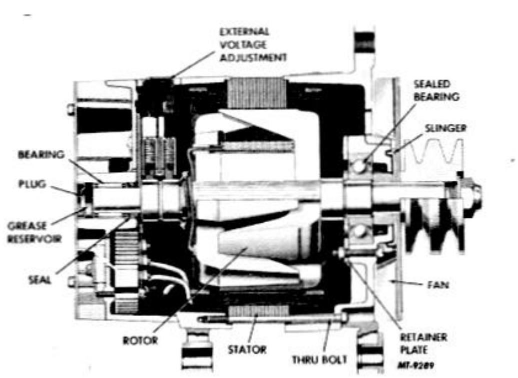

Fig. 2. Cross Sectional View

The rotor bearing in the slip ring end frame contains a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. The drive end frame bearing is sealed on both sides and is serviced by complete re- placement. Two brushes carry current through the two slip rings to the field coil mounted on the rotor and under normal conditions will provide long periods of attention- free service.

The stator windings are assembled on the inside of a laminated core that forms part of the frame. Rectifier bridges connected to the stator windings each contain six diodes and electrically change the stator A. C. voltages to a D. C. voltage which appears at the output terminal. Field current is supplied through a diode trio which also is connected to the stator windings. A capacitor, or condenser, mounted in the end frame protects the rectifier bridges and diode trio from high voltages and suppresses radio noise.

NOTE: These alternators should not be operated with an open circuit or without a battery, as damage to ,nit could result.

OPERATION

Typical wiring diagrams are illustrated in Figs. 3 and 4. The basic operating principles are explained as follows.

With the Integral Charging System operating A. C. voltages initially are generated in the stator windings by residual magnetism in the rotor. Current then flows through the diode trio, resistor R1, and resistor R4 to turn transistor TR1 on. The stator then supplies D. C. field current through the diode trio, the field, TR1, and then through the grounded diodes in the rectifier bridges back to the stator. Also, the diodes in the rectifier bridges change the stator A. C. voltages to a D. C. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the energizer or battery and operating electrical accessories.

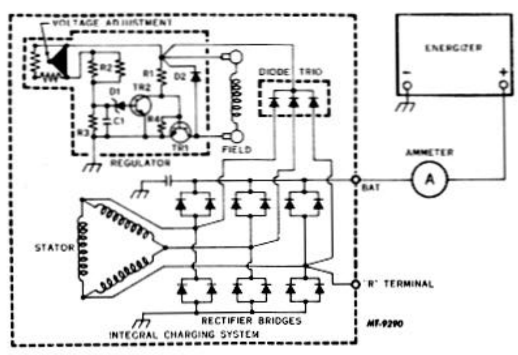

Fig. 3. Wiring Diagram of Internal Circuits (Two Rectifier Bridge Type)

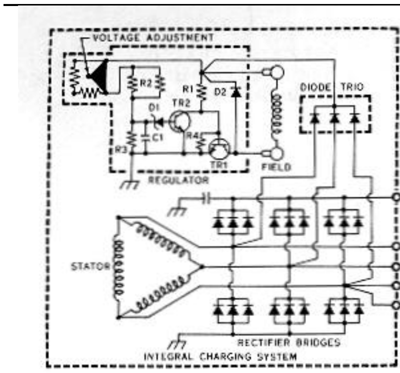

Fig. 4. Wiring Diagram of Internal Circuits (Three Rectifier Bridge Type)

As the speed and voltage increase, the volt- age between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TR2 then turns on and TR1 turns off. With TR1 off, the field current and system voltage decrease, and D1 then blocks current flow causing TR1 to turn back on. The field current and system voltage increase, and this cycle then repeats many times per second to limit the volt- age to the adjusted value.

Capacitor C1 smoothes out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high induced voltages in the field windings when TRI turns off.

TROUBLESHOOTING

In order to locate and correct defects in the charging system in the shortest possible time, the following procedures should be used. Only a portion of these procedures need be performed. It will never be necessary to perform all the procedures in order to locate the trouble.

A basic wiring diagram showing lead connections is shown in Fig. 5. To avoid damage to the electrical equipment, always observe the following precautions:

Do not polarize Integral Charging System.

Do not short across or ground any terminals in charging circuit except as specifically instructed.

Never operate alternator with output terminal open circuited.

Make sure Integral Charging System and battery have the same ground polarity.

When connecting a charger or a booster battery to vehicle battery, connect negative to negative and positive to positive.

Trouble in the charging system will show up as one or more of the following conditions:

An undercharged battery, as evidenced by slow cranking and low specific gravity readings.

An overcharged battery, as evidenced by excessive water usage.

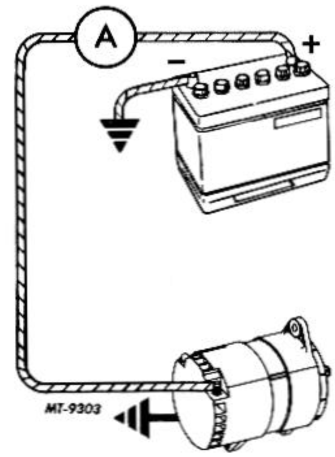

Fig. 5. Typical Wiring Diagram Showing Basic Lead Connections

Undercharged Battery

This condition, as evidenced by slow crank- ing and low specific gravity readings, can be caused by one or more of the following conditions:

1. Insure that the undercharged condition has not been caused by accessories having been left on for extended periods.

2. Check the drive belt for proper tension.

3. Check for battery or energizer defect.

4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and energizer posts.

5. Connect a voltmeter from "BAT" terminal on Integral Charging System to ground. A zero reading indicates an open between voltmeter connection and energizer.

6. If previous steps 1 through 5 check satisfactorily, check Integral Charging System as follows:

   a. Disconnect energizer ground cable.

   b. Connect an ammeter in the circuit at the "BAT" terminal of the Integral Charging System.

   c. Reconnect energizer ground cable.

   d. Turn on accessories. Connect a carbon pile across the energizer.

   e. Operate engine at moderate speed as required, usually 4000 generator RPM or more, and adjust carbon pile as required to obtain maximum current output.

      NOTE

      Initial voltage build-up is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.

   f. If ampere output is within 10 percent of rated output as stamped on generator frame, Integral Charging System is not defective. In this case, an adjustment of the voltage setting may correct the undercharged condition. Raise the setting by removing the voltage adjusting cap, rotating in increments of 90°, and then reinserting the cap in the connector body. As illustrated in Fig. 6, the cap is set for low voltage. With position 2 aligned with the arrow, the setting is increased to medium low, position 3 is medium high, and position "HI" is the highest regulator setting. After adjusting the setting, check for an improved energizer condition after a service period of reasonable length, such as one week. NOTE: The voltage adjustment in Fig. 6 is for purposes of illustration only. The actual adjustment as shipped from the factory may be in some other position, such as position 3, depending on the application requirement.

   g. If ampere output is not within 10 percent of rated output as stamped on Integral Charging System frame, <u>record the maximum amperes that can be obtained for future reference</u>, then remove the Integral Charging System for repair.

<u>Overcharged Battery</u>

1. Check the battery or energizer. NOTE: Remember that an overheated battery or energizer will be overcharged even though no charging circuit defects are present.

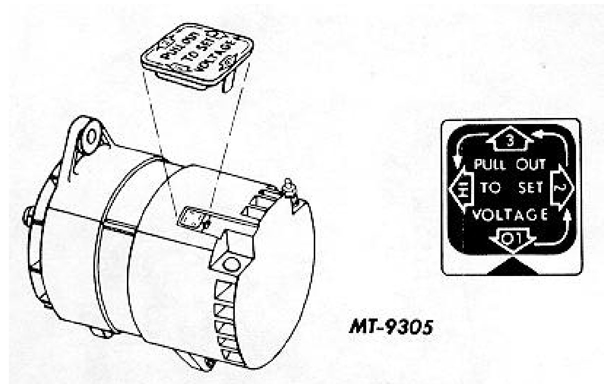

Fig. 6 Voltage Adjustment Cap

2. If energizer or battery is not defective or overheated, connect a voltmeter between Integral Charging System "BAT" terminal and ground.

3. With all accessories turned off, increase engine speed as required to obtain maximum voltage reading.

4. If voltage exceeds 15 volts on a 12-volt system or 30 volts on a 24-volt system, remove Integral Charging System for repair.

5. If voltage does not exceed the values listed in step 4 preceding, adjust voltage to a lower value by removing voltage adjusting cap and reinserting into connector body. Then check energizer or battery condition after a service period of reasonable length, such as one week. Fig. 6 is for purposes of illustration only and shows the cap adjusted for the lowest setting. The actual adjustment as shipped from the factory may be in some other position, such as position 3, depending on the application requirement. The lowest setting is with "LO" aligned with the arrow, position 2 is in medium low, position 3 is medium high, and "HI" is the highest setting.

DISASSEMBLY

1. Remove end plate from slip ring end frame.

2. Hold shaft with hex wrench inserted into hex hole in end of shaft while removing shaft nut. Remove washer, pulley, fan and slinger.

3. Remove four thru-bolts from drive end frame.

4. Separate slip ring end frame and stator assembly from drive end frame and rotor assembly.

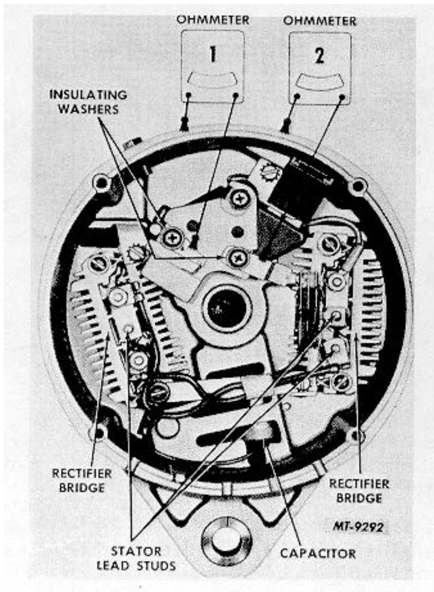

Fig. 7 End Frame View with Stator Removed (Two Rectifier Bridge Type)

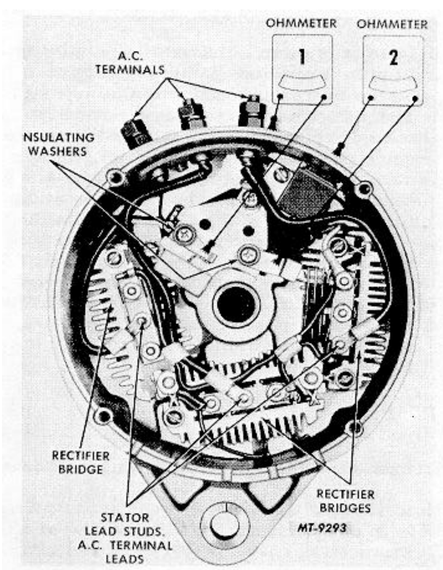

Fig. 8 End Frame View with Stator Removed (Three Rectifier Bridge Type)

5. Separate stator from end frame by removing three stator lead attaching nuts. Figs. 7 and 8 show end frame with stator removed.

6. Place tape over bearing and shaft to protect from dirt. Use pressure-sensitive to tape and not friction tape that would leave a gummy deposit.

7. Inspect all leads for burned connections or opens, and brushes for excessive wear. Inspect springs for distortion or discoloration. Replace as required. Clean brushes with a soft, dry cloth if they are to be reused. During servicing and reassembly hold brushes and springs in holder with a pin or toothpick inserted through end frame hole.

<u>Ohmmeter Checks</u>

1. Connect ohmmeter having a 1-1/2 volt cell using lowest range scale from brush lead clip to end frame as shown in step 1, Fig. 7 or 8; then reverse lead connections.

2. If both readings are zero, either the brush lead clip is grounded or regulator is defective.

3. A grounded brush lead clip can result from omission of insulating washer, Fig. 7 or 8, omission of insulating sleeve over screw, or damaged insulating sleeve. Remove screw to inspect sleeve. If satisfactory, replace regulator as covered under heading "Brush Holder and Regulator Replacement."

4. Repeat steps 1, 2 and 3 above, except connect ohmmeter as shown in step 2, Fig. 7 or 8.

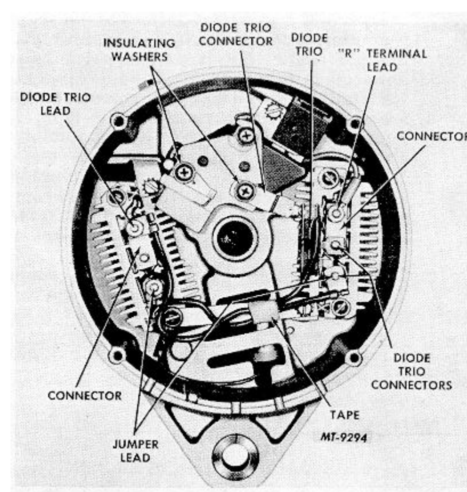

Fig. 9. End Frame View with Stator Removed (Two Rectifier Bridge Type)

Diode Trio Check
(Omit for Overcharged Battery)

The diode trio is identified in Figs. 9 and 10. To check the diode trio, remove it from the end frame assembly by detaching the nuts and attaching screw. Note that the insulating washer on the screw is assembled over the top of the diode trio connector.

NOTE

Diode trios differing in appearance may be specified for use in the same Integral Charging System, and the two are completely interchangeable.

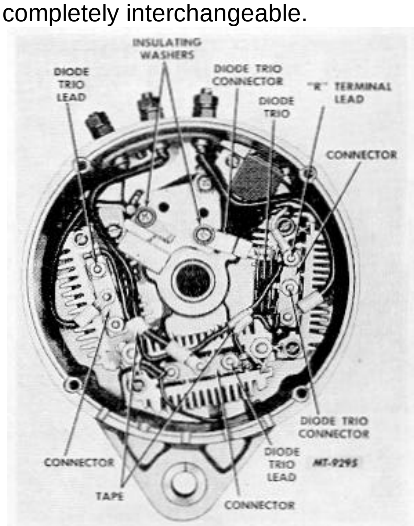

Fig. 10. End Frame View with Stator Removed (Three Rectifier Bridge Type)

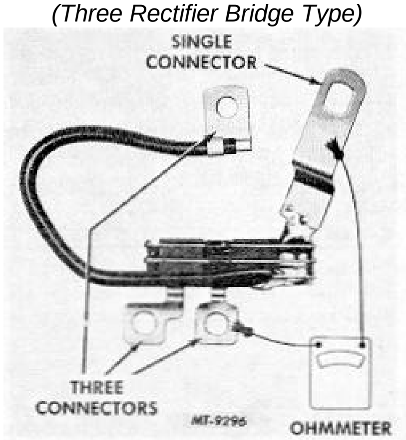

Fig. 11. Checking Diode Trio (Two Rectifier Bridge Type)

Connect an ohmmeter having a 1-1/2 volt cell, and using the lowest range scale, to the single connector and to one of the three, Figs. 11, 12 and 13. Observe the reading connectors. Then reverse the ohmmeter leads to the same two connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors.

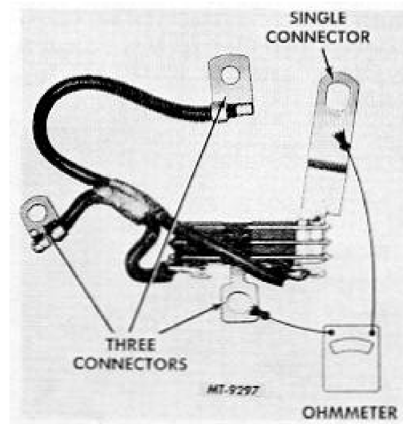

Fig. 12. Checking Diode Trio (Three Rectifier Bridge Type)

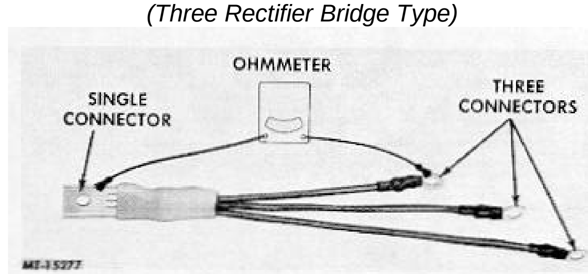

Fig. 13 Checking Diode Trio

Rectifier Bridge Check
(Omit for Overcharged Battery)

Note that each rectifier bridge has a grounded heat sink and an insulated heat sink. The insulated heat sinks are connected together and electrically are connected to the output or "BAT" terminal. Also, note the stackup of parts in Figs. 14 and 15.

To check the rectifier bridge, connect the ohmmeter to a heat sink and one of the three terminals, Figs. 14 and 15. Then reverse the lead connections to the same heat sink and same terminal.

If both readings are the same, replace the rectifier bridge by detaching the necessary screws and nuts. A good rectifier bridge will give one high and one low reading. Repeat this same test between the same heat sink and the other two terminals and between the other heat sink and each of the three terminals. This makes a total of six checks, with two readings taken for each check on each rectifier bridge. Check the other two rectifier bridges in the same manner. NOTE: If rectifier bridge is constructed with flat metal clips at the three studs, press down very firmly onto flat metal clips and not onto threaded stud, Fig. 15. Rectifier bridges differing in appearance and with or without metal clips at the three studs may be specified for use in the same Integral Charging System, and the different types are interchangeable.

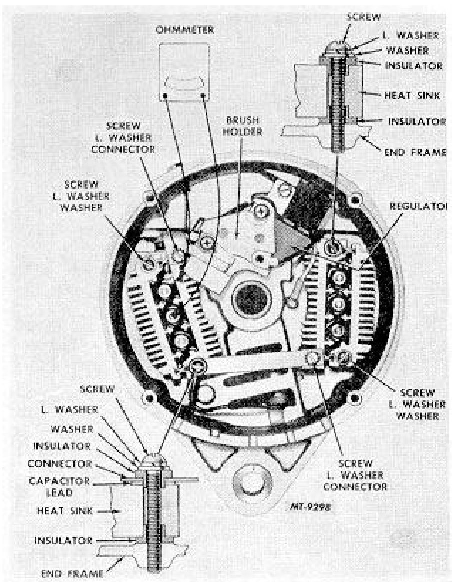

Fig. 14 Parts StackUp and Ohmmeter Check (Stator and Diode Trio Removed)

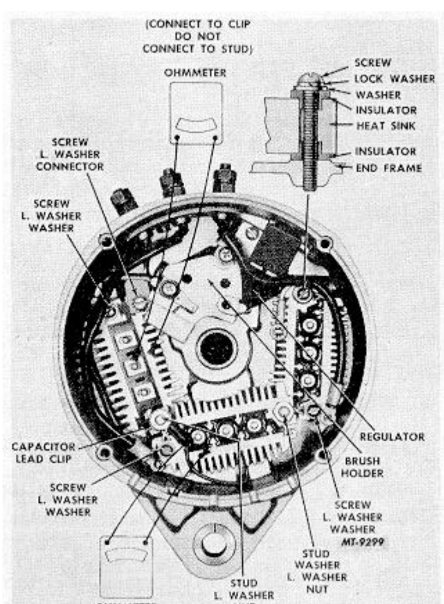

Fig. 15 Parts Stack-Up and Ohmmeter Checks (Stator and Diode Trio Removed)

The ohmmeter check of the rectifier bridge and of the diode trio, as previously covered, is a valid and accurate check. Do not replace either unit unless at least one pair of readings is the same. CAUTION: Do not use high voltage to check these units, such as a 110-volt test lamp.

Rotor Field Winding Checks

To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp rails to light or if the ohmmeter reading is high (infinite), the winding is open, Fig. 16.

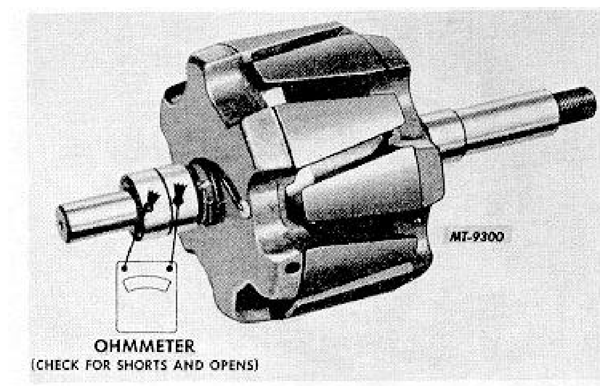

Fig. 16 Checking Rotor

The winding is checked for short circuits or excessive resistance by connecting a battery and ammeter in series with the edges of the two slip rings. Note the ammeter reading and refer to specifications. An ammeter reading above the specified value indicates shorted windings; a reading below the specified value indicates excessive resistance. If the winding is shorted, replace the rotor and the regulator as covered in "Brush Holder and Regulator Replacement" section.

NOTE

Regulator replacement may have been indicated in the previous "Ohmmeter Checks" section.

An alternate method is to check the resistance of the field by connecting an ohmmeter to the two slip rings, Fig. 16. If the resistance reading is below the specified value, the winding is shorted; if above the specified value, the winding has excessive resistance. The specified resistance value can be determined by dividing the voltage by the current. Remember that the winding resistance and ammeter reading will vary slightly with winding temperature changes.

Stator Checks
(Omit for Overcharged Battery)

The stator windings may be checked for grounds with a 110-volt test lamp or an ohmmeter. If the lamp lights or if the meter reading is low when connected from any stator lead to a clean metal part of the frame, the windings are grounded, Fig. 17. The delta windings cannot be checked for opens or for short circuits without laboratory test equipment. However, if all other electrical checks are normal and the generator fails to supply rated output but will supply at least 10 amperes output, shorted stator windings are indicated.

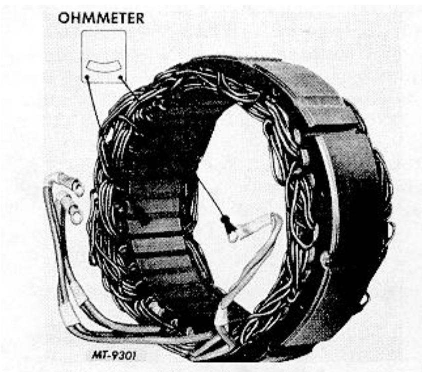

Fig. 17 Checking Stator

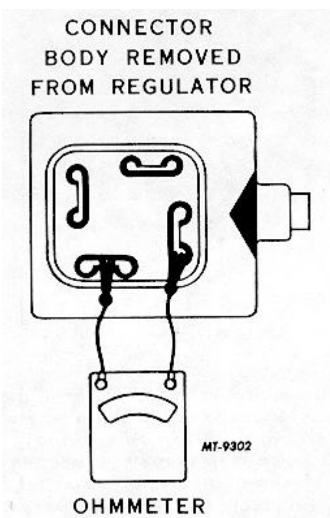

Fig. 18 Checking Connector Body

Regulator Check

Since the regulator is completely enclosed, there is no practical way to check this unit with a test instrument. If none of the previous checks show any defects and an overcharged condition was present, remove the connector body from the regulator and check with an ohmmeter using the middle range scale as shown in Fig. 18. Connect the ohmmeter to each adjacent pair of terminals making four checks in all. If any one check is infinite, replace the connector body. The connector body need not be checked for an undercharged condition.

If all of the previous checks are satisfactory, replace the regulator, provided that in the previous performance checks:

1. The maximum ampere output was less than 10 amperes, or
2. The system voltage was over 15 volts on a 12-volt system.

Brush Holder and Regulator Replacement

After removing the stator and diode trio, the brush holder and regulator may be replaced by removing the two remaining screws. Note the two insulators located over the top of the brush clips in Figs. 9 and 10 and that these two screws have special insulating sleeves over the screw body above the threads. The third mounting screw may or may not have an insulating sleeve. If not, this screw must not be interchanged with either one of the other two screws, as a ground may result, causing no output or uncontrolled output. Regulators may vary in appearance but are completely interchangeable in these Integral Charging Systems.

Slip Ring Servicing

If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor and hold the polishing cloth against the slip rings until they are clean. NOTE: The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

Bearing Replacement and Lubrication

The drive end frame bearing is sealed on both sides and cannot be lubricated. To replace the bearing, press the rotor from the end frame, remove the retainer plate and press the bearing from the end frame. Use a tube or collar that just fits over the outer race to press the new bearing into the end frame.

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to relubricate and reuse the bearing. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

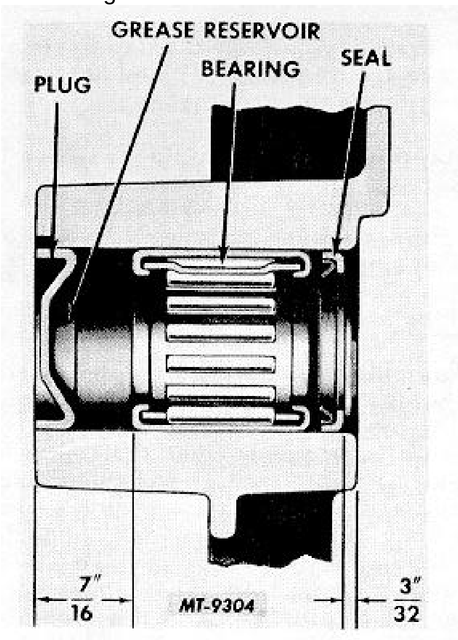

Fig. 19 Slip Ring End Bearing and Seal Locations

To install a new bearing, use the tube or collar to press the bearing in from the outside of the housing towards the inside to the dimension shown in Fig. 19. Fill the plug with Delco Remy No. 1948791 lubricant so that when pressed in flush with the end frame, the grease reservoir will be half filled. Insure that some of the lubricant will be contacting the bearing when the plug is assembled. Use a new seal and press in to the dimension shown in Fig. 19. Coat the seal lip with the lubricant to facilitate assembly of the rotor shaft into the bearing. Note that the lip of the seal is toward the bearing.

REASSEMBLY

Reassembly is the reverse of disassembly.

To install the slip ring end frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal. After tightening the thru-bolts, remove the brush retaining pin to allow the brushes to fall down onto the slip rings.

Assemble the slinger, fan, pulley, washer and nut.

When installing the drive pulley on the alternator, the pulley nut must be torqued to 60-80 ft. lbs. If not properly tightened, it is possible the nut and pulley could loosen and slip on the shaft or even come off during operation.

To assist in tightening the pulley nut, a 5/16 inch hex hole is provided in the end of the shaft for holding with an Allen wrench. Also a special 15/16 inch socket wrench, Fig. 20, which is applicable to the nut, is available from the Snap-On Tool Company. This special 1/2 inch drive socket wrench is designed with a cutout to receive the Allen wrench and may be used in conjunction with a torque indicating wrench. Where desired a length of 3/8 inch pipe may be applied to the Allen wrench to provide additional leverage for the holding effort.

The special 15/16 inch socket wrench, Fig. 20, is available from your local Snap-On representative under their number S8183.

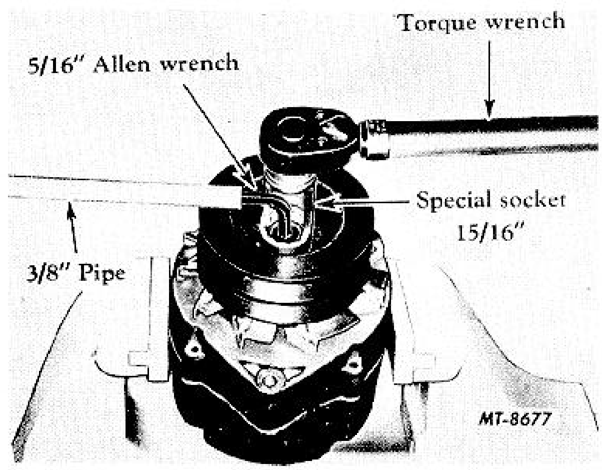

Fig. 20

MAGNETIZING THE ROTOR

NOTE: The rotor normally retains magnetism to provide voltage buildup when the engine is started. After disassembly or servicing, however, it may be necessary to re-establish the magnetism. To magnetize the rotor, connect the Integral Charging System to the battery or energizer in a normal manner, then momentarily connect a jumper lead from the battery positive post to the Integral Charging System relay terminal identified in Fig. 1. This procedure will restore the normal residual magnetism in the rotor.

ALTERNATOR BENCH CHECK

The Integral Charging System may be checked on the bench for output by connecting an ammeter in the circuit, Fig. 5, and a voltmeter from the "BAT" terminal to ground; then follow the procedure in the TROUBLE SHOOTING section.

SPECIFICATIONS

Model	Series	Ground	Field Current 27° C (80° F) Amps.	Volts	Cold Output Specified Volts	Amps.	Approx RPM	Amps.	Approx RPM	Rated Hot Output (Amps)
1117141 1117147	40-SI/150	Neg.	4-4.5	12	*	80	2000	110	5000	105
1117142 1117143 1117148 1117149	40-SI/150	Neg.	4-4.5	12	*	110	2000	150	5000	145

* Voltmeter not required for cold output check.

Load battery with carbon pile to obtain maximum output.

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PRINTED IN UNITED STATES OF AMERICA

ALTERNATOR
(DELCO-REMY)

MODEL 27 SI TYPE 200

CODE	RATING
08133	65 Amp
08134	80 Amp

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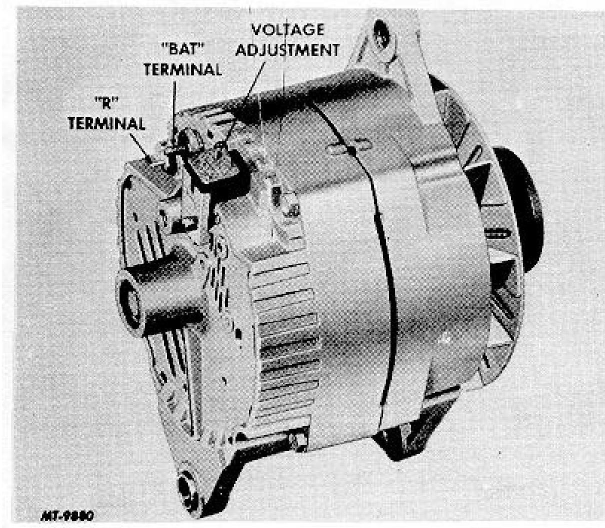

Fig. 1. 27SI Series Alternator

DESCRIPTION

The 27SI series alternator, illustrated in Figure 1, features a solid state regulator that is mounted inside the slip ring end frame. The regulator voltage setting can be adjusted externally by repositioning a voltage adjustment cap in the slip ring end frame, This feature is covered in detail in Figure 4. Only one wire is needed to connect the alternator to the battery, along with an adequate ground return. An "R" terminal is provided to operate auxiliary equipment in some circuits.

The bearings contain a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. Two brushes carry current through two slip rings to the field coil mounted on the rotor, and under normal conditions will provide long periods of attention-free service.

The stator windings are assembled on the inside of a laminated core that forms part of the frame. A rectifier bridge connected to the stator windings contains six diodes, and electrically changes the stator a.c. voltages to a d.c. voltage which appears at the output terminal. Field current is supplied through a diode trio which is connected to the stator windings. A capacitor, or condenser, mounted in the end frame protects the rectifier bridge and diode trio from high voltages and suppresses radio noise.

OPERATION

Typical wiring diagrams showing circuits are shown in Figures 2A and 2B. The basic operating principles are explained as follows:

Models 1100072, 1100073 (Fig. 2A):

With the alternator operating, a.c. voltages initially are generated in the stator windings by residual magnetism in the rotor. Current then flows through the diode trio, resistor R1 and resistor R4 to turn transistor TR1 on. The stator then supplies d.c. field current through the diode trio, the field, TR1 and then through the grounded diodes in the rectifier bridge back to the stator. Also, the diodes in the rectifier bridge change the stator a.c. voltages to d.c. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the battery and operating electrical accessories.

As the speed and voltage increase, the voltage between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TR2 then turns on and TR1 turns off. With TR1 off, the field current and system voltage decrease, and D1 then blocks current flow causing TR1 to turn back on. The field current and system voltage increase, and this cycle then repeats many times per second to limit the voltage to the adjusted value.

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high-induced voltages in the field windings when TR1 turns off.

Models 1100080, 1100081 (Fig. 2B):

With the alternator operating, a.c. voltages initially are generated in the stator windings by residual magnetism in the rotor. The diodes in the rectifier bridge change the stator a.c. voltages to a d.c. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the battery and operating electrical accessories. Current also flows from the stator and rectifier bridge through resistor R1 and resistor R4 to turn transistor TR1 on.

The stator then supplies d.c. field current through the diode trio, the field, TR1, and then through the diodes in the rectifier bridge back to the stator.

As the speed and voltage increase the voltage between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TR2 then turns on and TR1 turns off. With TR1 off, the field current and system voltage decrease and D1 then blocks current flow causing TRl to turn back on. The field current and system voltage increase and this cycle then repeats many times per second to limit the voltage to the adjusted value.

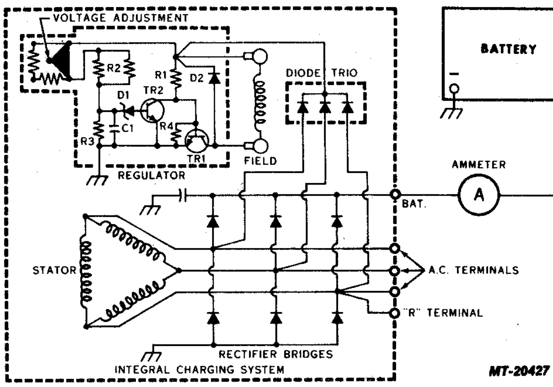

Fig.2A. Internal Wiring Diagram (Models 1100072, 1100073)

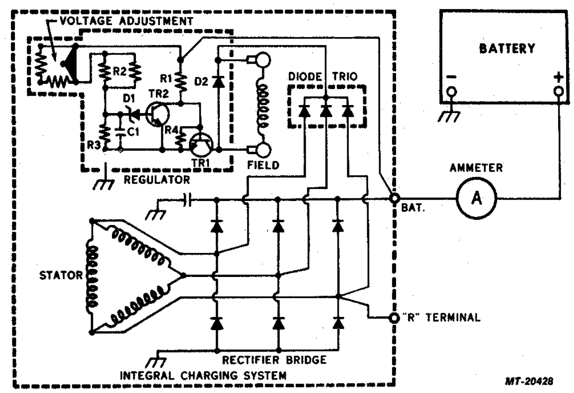

Fig. 2B. Internal Wiring Diagram (Models 1100080, 1100081)

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high-induced voltages in the field windings when TR1 turns off.

TROUBLE SHOOTING PROCEDURES

Close adherence to the following procedures in the order presented will lead to the location and correction of charging system defects in the shortest possible time. Only a portion of these procedures need be performed. It will never be necessary to perform all the procedures in order to locate the trouble.

A basic wiring diagram showing lead connections is shown in Figure 3. To avoid damage to the electrical equipment, always observe the following precautions:

1. Do not polarize the alternator.
2. Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.
3. Make sure the alternator and battery have the same ground polarity.
4. When connecting a charger or a booster battery to the vehicle battery, connect negative to negative and positive to positive.

Trouble in the charging system will show up as one or more of the following conditions:

An UNDERCHARGED BATTERY, as evidenced by slow cranking and low specific gravity readings.

An OVERCHARGED BATTERY, as evidenced by excessive water usage.

UNDERCHARGED BATTERY

This condition, as evidenced by slow cranking and low specific gravity readings, can be caused by one or more of the following conditions:

1. Insure that the undercharged condition has not been caused by accessories having been left on for extended periods.
2. Check the drive belt for proper tension.

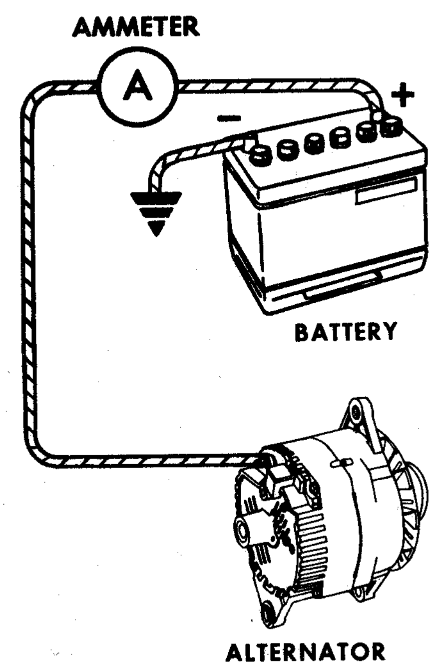

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Fig. 3. Typical Wiring Diagram Showing Basic Lead Connections.

3. If a battery defect is suspected, check battery as instructed in "BATTERY" section of the Truck Service Manual.

4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.

5. Connect a voltmeter from "BAT" terminal of alternator to ground. A zero reading indicates an open between voltmeter connection and battery.

6. If previous Steps 1 through 5 check satisfactorily, check alternator as follows;

   a. Disconnect battery ground cable.

   b. Connect an ammeter in the circuit at the "BAT" terminal of the alternator.

   c. Reconnect battery ground cable.

   d. Turn on accessories. Connect a carbon pile across the battery.

   e. Operate engine at moderate speed as required (usually 4000 generator rpm or more) and adjust carbon pile as required to obtain maximum current output.

   IMPORTANT

   Initial voltage build-up is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.

   f. If ampere output is within 10 amperes of rated output, alternator is not defective. In this case, an adjustment of the voltage setting may correct the undercharged condition. Raise the setting by removing the voltage adjusting cap, rotating in increments of 90 degrees, and then reinserting the cap in the connector body. As illustrated in Figure 4, the cap is set for medium high voltage. With position 2 aligned with the arrow, the setting is medium low, position "LO" is low and position "HI" is the highest regulator setting. After adjusting the setting, check for an improved battery condition after a service period of reasonable length, such as one week.

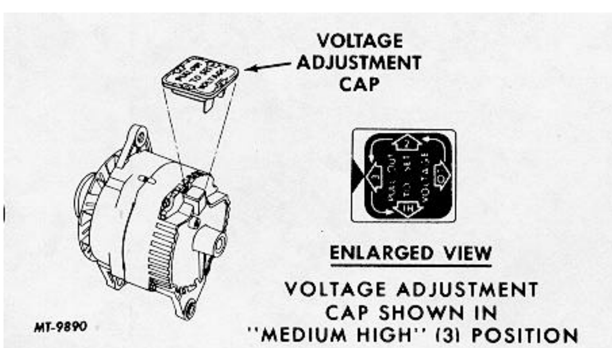

Fig. 4. Voltage Adjustment Cap

   IMPORTANT

   The voltage adjustment in Figure 4 is for purposes of illustration only. The actual adjustment may be in some other position, depending on the application requirement.

   g. If ampere output is not within 10 amperes of rated output, insert screwdriver into end frame hole to ground tab to end frame (Fig. 5) <u>Tab is within 19 mm (3/4") of casting surface. Do not force screwdriver deeper than 25 mm (1") into end frame</u>. Proceed to Step h.

   h. Operate engine a moderate speed as required and adjust carbon pile as required to obtain maximum current output.

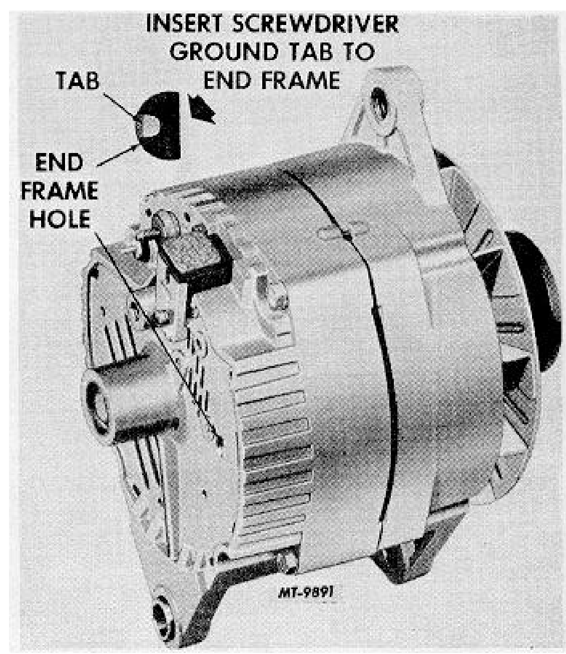

Fig. 5.

i. If output is within 10 amperes of rated output, replace regulator as covered under "REPAIR PROCEDURES" and check field winding.

j. If output is not within 10 amperes of rated output, check the field winding, diode trio, rectifier bridge and stator as covered under "REPAIR PROCEDURES."

k. Disconnect test ammeter and turn accessories "OFF.

OVERCHARGED BATTERY

1. Check the battery.

IMPORTANT

Remember that an overheated battery will be overcharged even though no charging circuit defects are present.

2. If battery is not defective or overheated, connect a voltmeter between alternator "BAT" terminal and ground.

3. With all accessories turned off, increase engine speed as required to obtain maximum voltage reading.

4. If voltage exceeds 15 volts on a 12-volt system, remove alternator for repair as covered under "REPAIR PROCEDURES."

5. If voltage does not exceed the value listed in Step 4 preceding, adjust voltage to a lower value by removing voltage adjusting cap and reinserting into connector body. Then check 7 battery condition after a service period of reasonable length, such as one week. Figure 4 is for purposes of illustration only and shows the cap adjusted for medium high setting. The actual adjustment may be in some other position, depending on the application requirement. The lowest setting is with "LO" aligned with the arrow, position 2 is medium low, and "HI" is the highest setting.

REPAIR PROCEDURES

To repair the alternator assembly, observe the following procedures.

DISASSEMBLY

1. Remove four thru-bolts from drive end frame.

2. Separate slip ring end frame and stator assembly from drive end frame and rotor assembly.

3. Separate stator from end frame by removing three stator lead attaching nuts.

4. Place tape over bearing and shaft to protect from dirt. Use pressure sensitive tape and not friction tape that would leave a gummy deposit .

5. Inspect all leads for burned connections or opens, and brushes for excessive wear. Inspect springs for distortion or discoloration. Replace as required. Clean brushes with a soft dry cloth if they are to be reused.

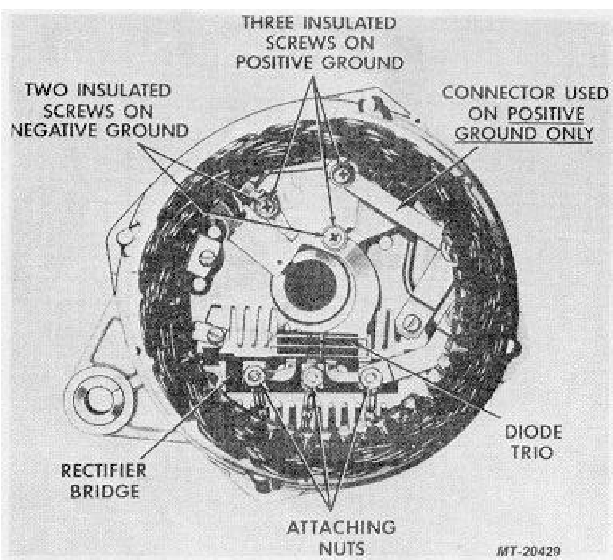

Fig. 6A. Inside View of end Frame Assembly (Models 1100072, 1100073).

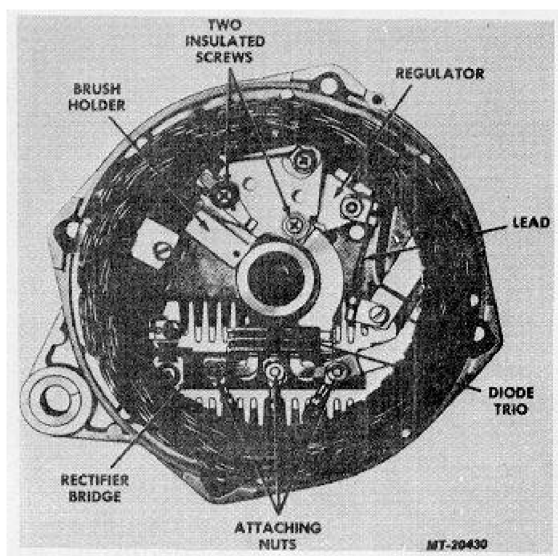

Fig. 6B. Inside View of end Frame Assembly (Models 1100080, 1100081).

During servicing and reassembly, hold brushes and springs in holder with a pin or toothpick inserted through end frame hole.

INSULATED SCREW CHECKS

Carefully inspect the regulator and brush holder mounting screws as shown in Figures 6A and 6B. Note that on negative ground systems two insulated and one grounded screw are used. On positive ground systems all three mounting screws are insulated. Damaged or missing insulators can cause damage to electrical components and improper charge to the battery.

DIODE TRIO CHECK

The diode trio is identified in Figures 6A and 6B. To check the diode trio, remove it from the end frame assembly by detaching the nuts and attaching screw. Connect an ohmmeter having a 1-1/2 volt cell, and using the low range scale to the single connector and to one of the three connectors (Fig. 7). Observe the reading. Then reverse the ohmmeter leads to the same two connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors. Note that diode trios differing in appearance may be specified for use. The two are completely interchangeable.

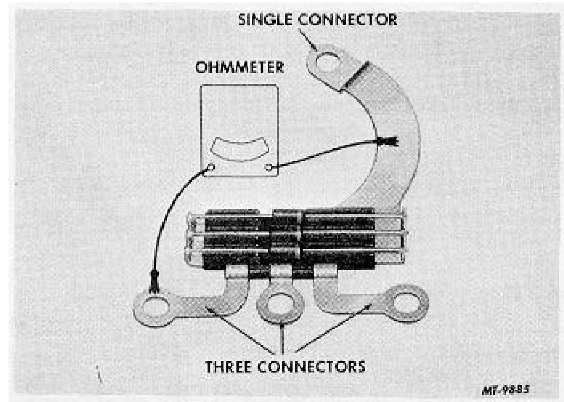

Fig. 7. Diode Trio Check

RECTIFIER BRIDGE CHECK (Omit for Overcharged Battery)

Note

that the rectifier bridge has a grounded heat sink and an insulated heat sink (Figures 8A and 8B).

To check the rectifier bridge, connect the ohmmeter to a heat sink and one to the flat metal clips and not to threaded stud. Press down

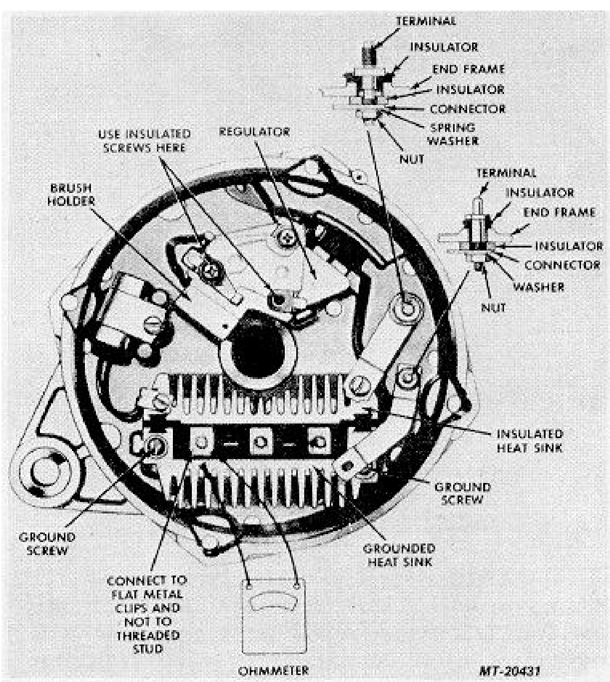

Fig. 8A. Rectifier Bridge Check (Models 1100072, 1100073)

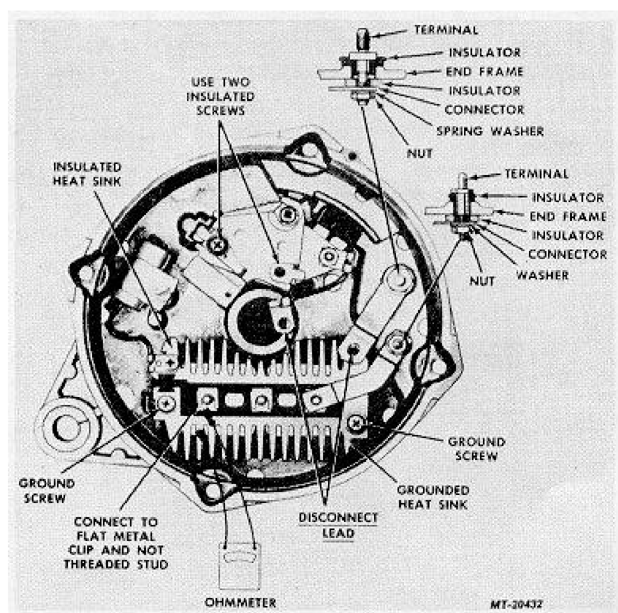

Fig. 8B. Rectifier Bridge Check (Models 1100080, 1100081) firmly onto flat metal clip. Then reverse lead connections. If both readings are the same, replace the rectifier bridge.

Repeat this same test between the same heat sink and other two metal clips and between the other heat sink and the three metal clips.

IMPORTANT

Do not use high voltage such as a 110 volt test lamp to check the rectifier bridge.

ROTOR FIELD WINDING CHECKS

To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light or if the ohmmeter reading is high (infinite), the winding is open (Figure 9).

The winding is checked for short circuits or excessive resistance by connecting a battery and ammeter in series with the edges of the two slip rings. Note the ammeter reading and refer to "SPECIFICATIONS." An ammeter reading above the specified value indicates shorted windings; a reading below the specified value indicates excessive resistance. If the winding is shorted, replace the rotor and the regulator as covered in "Brush Holder and Regulator Replacement."

An alternate method is to check the resistance of the field by connecting an ohmmeter using low scale to the two slip rings (Fig. 9). If the resistance reading is below the specified value, the winding is shorted; if above the specified value the winding has excessive resistance. The specified resistance value can be determined by dividing the voltage by the current given in "SPECIFICATIONS." Remember that the winding resistance and ammeter reading will vary slightly with winding temperature changes.

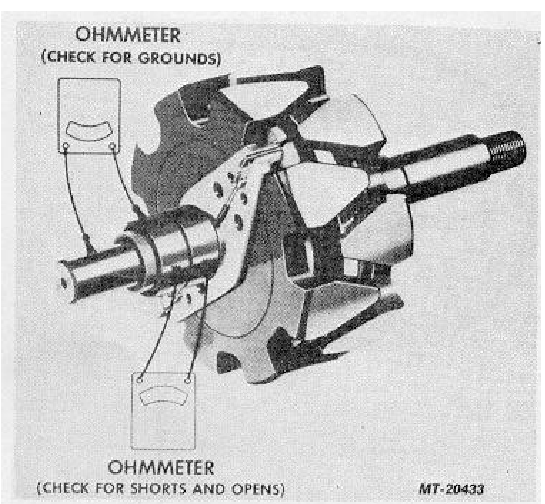

Fig. 9. Checking Rotor Winding.

To check for grounds, connect ohmmeter as shown. Replace rotor if reading is less than infinite. Use low scale on ohmmeter.

STATOR CHECKS (Omit for Overcharged Battery)

The stator windings may be checked for grounds with a 110-volt test lamp or an ohmmeter. If the lamp lights or if the meter reading is low when connected from any stator lead to a clean metal part of the frame, the windings are grounded (Fig. 10). The delta windings cannot be checked for opens or for short circuits without laboratory test equipment. However, if all other electrical checks are normal and the generator fails to supply rated output, but will supply at least 10 amperes output, shorted stator windings are indicated.

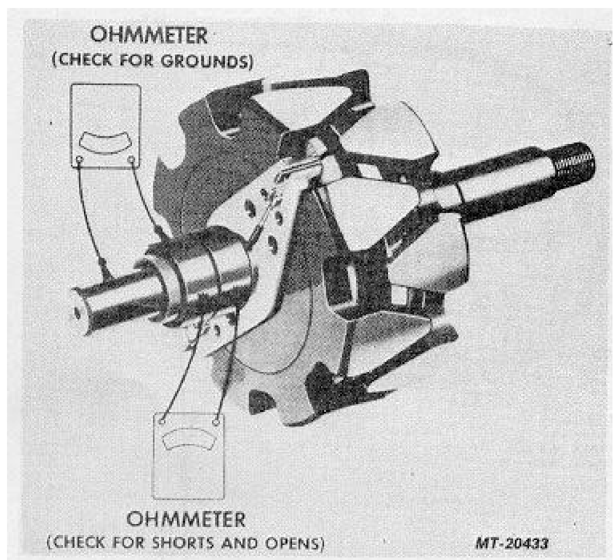

Fig. 10. Checking Stator Windings

REGULATOR CHECK

Since the regulator is completely enclosed, there is no practical way to check this unit with an ohmmeter. If none of the previous checks show any defects and an undercharged condition was present, remove the connector body from the regulator and check with an ohmmeter using the middle range scale as shown in Figure 11. Connect the ohmmeter to each adjacent pair of

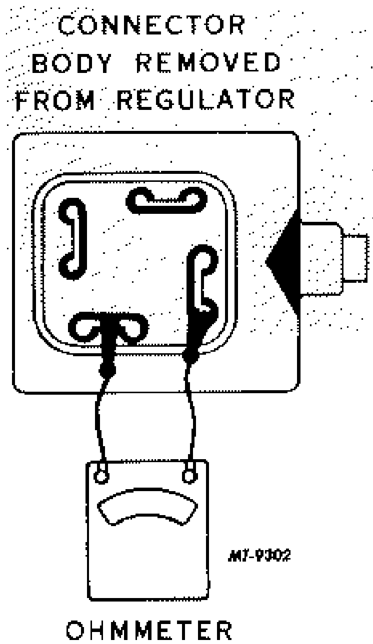

Fig. 11 Checking Regulator Connector Body

terminals, making four checks in all. If any one check is infinite, replace the connector body. The connector body need not be checked for an overcharged condition.

If all of the previous checks are satisfactory, replace the regulator, provided that in the previous performance checks the system voltage was over 15 volts on a 12-volt system.

BRUSH HOLDER AND REGULATOR REPLACEMENT

After removing the stator and diode trio, the brush holder and regulator may be replaced by removing the two remaining screws. Note the insulated screws in Figures 6A and 6B.

SLIP RING SERVICING

If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor and hold the polishing cloth against the slip rings until they are clean.

IMPORTANT

The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .05 mm (.002") maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

BEARING REPLACEMENT AND LUBRICATION

To replace the drive end bearing:

1. Remove shaft nut, pulley, fan and slinger.
2. Press rotor from end frame.
3. Remove retainer plate screws, retainer plate assembly, gasket and collar.
4. Press bearing from end frame.
5. Remove retainer plate and felt washer.
6. Install retainer plate and new felt washer.
7. Press bearing in with sealed side away from grease reservoir.
8. Fill grease cavity one-half full with high temperature ball bearing lubricant (Delco-Remy No. 1948791 or equivalent) and arrange the lubricant so a portion will touch the bearings after retainer plate attachment.
9. Attach gasket and retainer plate assembly to end frame, using new retainer plate assembly.
10. With collar on shaft, press rotor into end frame.
11. Assemble collar, slinger, fan, pulley and nut. Torque nut to 95 108 N.m (70 80 lb ft).

To assist in tightening the drive pulley nut a hexagon hole is provided in the end of the rotor shaft for holding with an Allen wrench. A special socket (Snap-On No. S8183) which is cut away to receive the Allen wrench is available for use with a torque wrench to tighten the nut. Where desired, a length of pipe may be applied to the Allen wrench to provide additional leverage for holding as shown in Figure 12.

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to relubricate and reuse the bearing. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

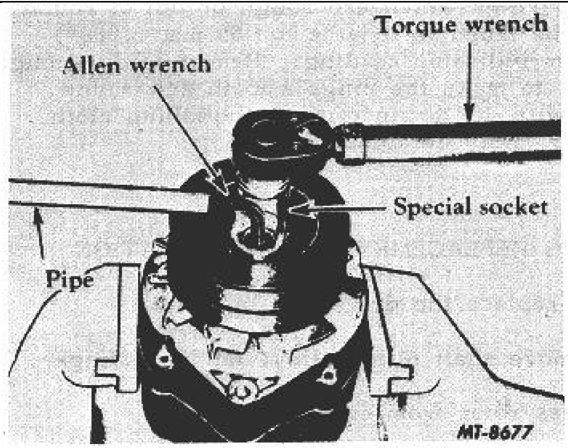

Fig. 12 Tightening Drive Pulley Nut

To install a new bearing, use the tube or collar to press the bearing in from the outside of the housing towards the inside of the dimension shown in Figure 13.

Fill the plug with high temperature ball bearing lubricant (Delco-Remy No. 1948791 or equivalent) so that when pressed in flush with the end frame the grease reservoir will be half filled. Insure that some of the lubricant will be contacting the bearing when the plug is assembled. Use a new seal and press in to the dimension shown in Figure 13. Coat the seal lip with lubricant to facilitate assembly of the rotor shaft into the bearing.

REASSEMBLY

Reassembly is the reverse of disassembly.

To install the slip ring end frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal. After tightening the thru-bolts remove the brush retaining pin to allow the brushes to fall down onto the slip rings.

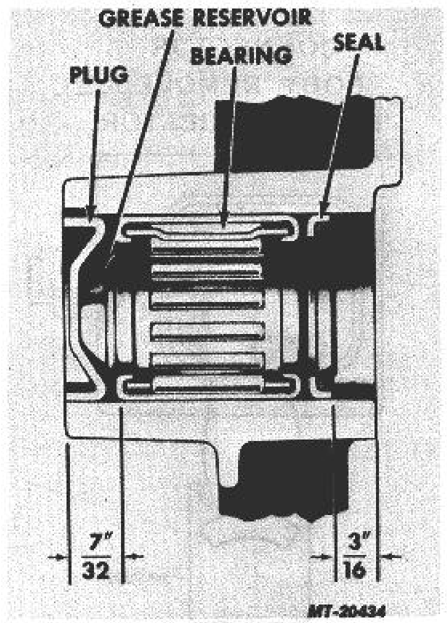

Fig. 13 Slip Ring End Bearing and Seal Location

MAGNETIZING THE ROTOR

IMPORTANT

The rotor normally retains magnetism to provide voltage build-up when the engine is started. After disassembly or servicing however, it may be necessary to reestablish the magnetism. To magnetize the rotor, connect the alternator to the battery in a normal manner; then momentarily connect a jumper lead from the battery positive post to the alternator relay terminal (identified in Fig. 1). This procedure will restore the normal residual magnetism in the rotor.

ALTERNATOR BENCH CHECK

The alternator may be checked on the bench for output by connecting an ammeter in the circuit (Fig. 3) and a voltmeter from the "BAT" terminal to ground; then follow the procedures in "TROUBLE SHOOTING PROCEDURES."

SPECIFICATIONS

		Field Current (80 F)				Cold Output				Rated Hot
Model	Series	Ground	Amps	Volts	Specified Volts	Amps	Approx. RPM *	Amps	Approx. RPM *	Output* * (Amps)
1100072	27-SI/200	Neg.	4.4 - 4.9	12	14	48	2000	61	5000	65
1100073	27-SI/200	Neg.	4.4 - 4.9	12	14	54	2000	73	5000	80
1100080	27-SI/200	Neg.	4.4 - 4.9	12	14	54	2000	73	5000	80
1100081	27-SI/200	Neg.	4.4 - 4.9	12	14	48	2000	61	5000	65

* -Alternator speed.
** -At maximum operating speed.

ALTERNATOR

(LEECE-NEVILLE)

CODE	TYPE	RATING
08141	2300JB	65 Amp
08142	2500JB	85 Amp
08143	2600JB	105 Amp
808143	2601JB	105 Amp
08144	2700JB	130 Amp
08158	2805JB	145 Amp

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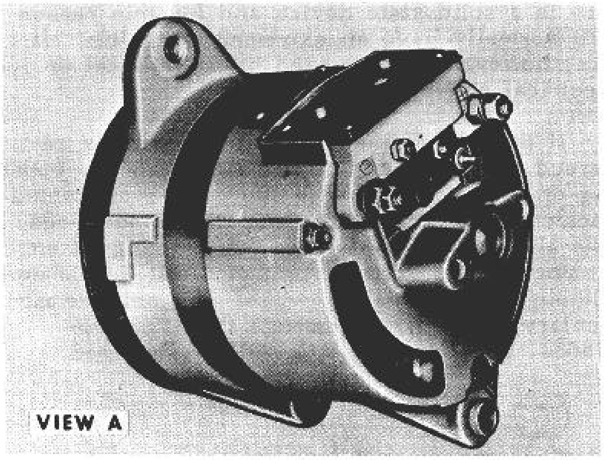
PRINTED IN UNITED STATES OF AMERICA

ALTERNATOR IDENTIFICATION CHART

IH Identification		Mfgr's Identification		
Code	Part Number	Type	Model	Rating
08141	514089-C91	2300JB	90514	65 Amp
08142	513303-C91	2500JB	90515	85 Amp
08143	513542-C91	2600JB	90516	105 Amp
808143	521092-C91	2601JB	90542	105 Amp
08144	514251-C91	2700JB	90517	130 Amp
08158	527890-C91	2805JB	90574	145 Amp



VIEW A

DESCRIPTION

These units are 14 volt self-load limiting alternators which feature a fully adjustable, built in solid state voltage regulator.

The alternators incorporate a 7/8" straight shaft, a large ball bearing at the drive end and a roller bearing at the slip ring end. The alternators have a two leg swivel mounting, one leg of which is equipped with a slide able bushing. The rotor shaft may be rotated in either direction.

Six silicon diodes mounted in heat sinks convert alternating current from the delta wound stator into direct current. A capacitor connected between the heat sinks assists in suppressing transient voltage spikes which could possibly injure the diodes.

The brushes and voltage regulator are located in a waterproof housing and may be removed for replacement or inspection without dismantling the entire machine. An external relay terminal is also provided for operation of charge light relays or other accessories which might require power from such a source.

The alternators have ungrounded output terminals so that they may be used on either positive or negative ground systems. Aside from connecting the proper vehicle wires to the correct output terminals, no other wiring is required on the alternator, eliminating field relays or ignition switch connections.

The regulator is also equipped with transient voltage protection and will withstand instantaneous opening of the charging circuit under full load conditions.

PREVENTIVE MAINTENANCE

Mounting hardware including brackets and drive belts must be periodically inspected and adjustments or repairs performed as required. It is important that mounting bolts and nuts be kept securely tightened to maintain belt alignment and prevent vibration damage which will occur if mounting bolts work loose.

Vehicle wiring must be inspected at periodic intervals for loose or corroded connections and repairs made as needed.

TROUBLE SHOOTING

Before performing trouble shooting procedures on the vehicle be absolutely certain that wiring is not defective and belts are not slipping, as these problems are common.

To determine if the problem lies in the regulator or the alternator, connect an accurate voltmeter across the battery with the engine stopped and note the reading. The engine should now be started. If the voltmeter reading rises excessively, the charging system may be defective or may require adjustment. Remove nylon screw (plug) from the regulator and with the engine at approximately 1000 RPM, attempt to bring the voltage to its proper value (13.6-14.2 approximately) by turning the adjusting screw back and forth with a small screwdriver. (See Figure 1.)

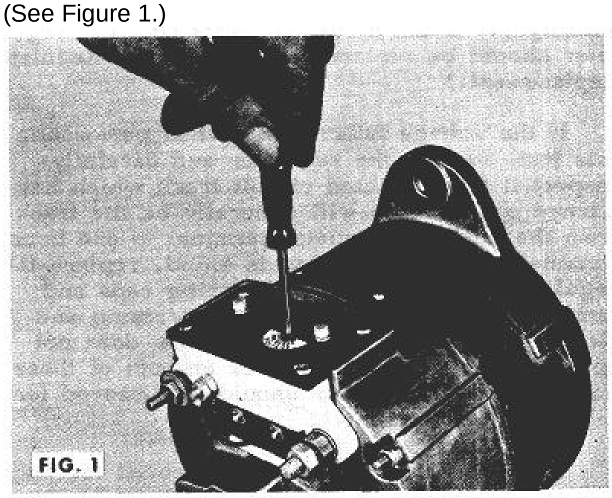


FIG. 1

If the voltage is excessively high and cannot be lowered by means of the adjustment, the regulator is probably defective and should be replaced. If the output voltage cannot be raised, either the alternator, regulator or diode trio may be at fault. To determine if the fault is in the regulator or in the alternator, perform the following test.

Connect one end of a short jumper lead to the negative alternator output terminal and connect the other end of the jumper to a short stiff piece of wire at least 1 1/2 inches long. A piece of paper clip wire will be suitable. Insert this wire into the small hole in the end of the brush holder so that it firmly contacts the outer brush terminal. (See Figure 2.)

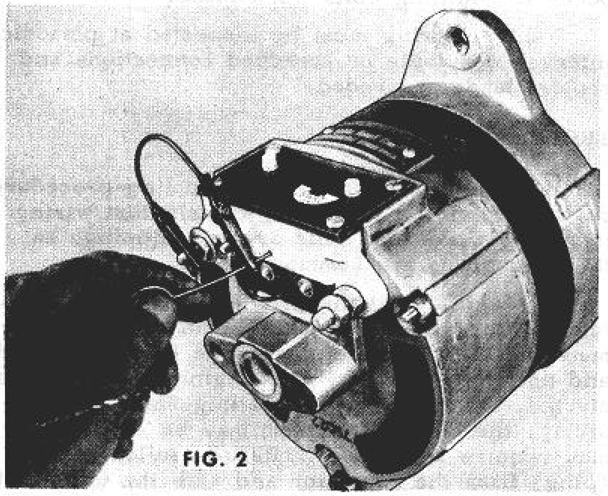


FIG. 2

Fig. 2

If the voltmeter reading now rises with the engine at a fast idle, the alternator is OK and the fault is in the regulator or diode trio. Remove the diode trio and test (see "Component Testing"). If the diode trio tests OK, the regulator should be replaced. (See Voltage Regulator Replacement.)

If the voltage fails to rise when performing this test, remove the regulator and carefully inspect it for a printed circuit track which has burned open. This will generally be the track from the positive regulator terminal to one brush terminal. If this condition is found, replace the regulator. Check the brush spring caps and their contact screws for dirt or corrosion and clean if necessary. If the alternator does not operate after performing either or both of these operations the alternator should be removed for repair or replacement.

The alternator may also be checked for output across each phase by using a test light as shown in Figure 3. The test light should be constructed from a two-filament sealed beam unit connected in such a manner that the filaments are in parallel. Such a light will act as a load as well as an indicator, and should light with equal brilliancy on each phase. If the lamp is noticeably dimmer on one or two phases, a defective diode trio, stator or power diode is indicated. If the diode trio tests OK, then the alternator must be removed and dismantled for further tests.

The voltage regulator used in these alternators is a solid state device and for this reason will normally have an extremely long life. It can, however, be damaged by mechanical or electrical abuse.

If the system polarity is inadvertently reversed by installing a battery backwards, boosting or jump starting with the jumper connected backwards or reversing the positive and negative alternator output leads when changing an alternator, the voltage regulator will be damaged. Although the polarity reversal may only be momentary and may not damage the alternator diodes, the regulator will still be damaged.

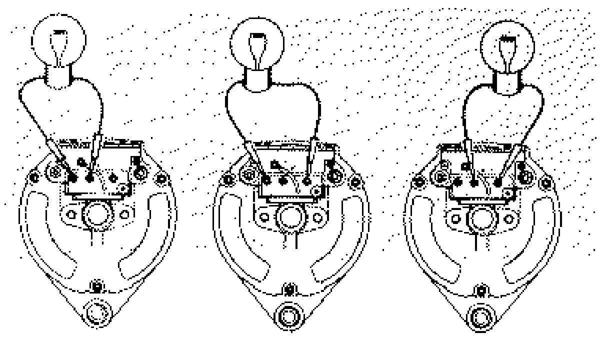


FIG. 3

ADJUSTMENT

Prior to adjusting alternator voltage, the wiring, connections and belt tension should be checked and repaired as needed. The batteries should be fully charged and the engine should be running at a fast idle. Turn off all vehicle loads such as lights, radios, heaters, air conditioners, etc., when checking or adjusting voltage. An accurate voltmeter should be connected across the batteries to determine the charging voltage. Do not rely on dash mounted vehicle instruments. These are excellent indicators but usually lack the extreme accuracy required for regulator adjustment. Remove the nylon screw (plug) from the regulator (see Figure 1), and with a small screwdriver carefully turn the adjusting screw clockwise to raise or counterclockwise to lower the voltage. The ideal voltage setting will be a value which maintains a fully charged battery without resulting in an excessive usage of battery water.

When turning the voltage adjustment screw, do not attempt to force it past its stop as damage will result. Be sure to replace the nylon screw (plug) in the regulator adjustment hole to prevent the entrance of water and dirt.

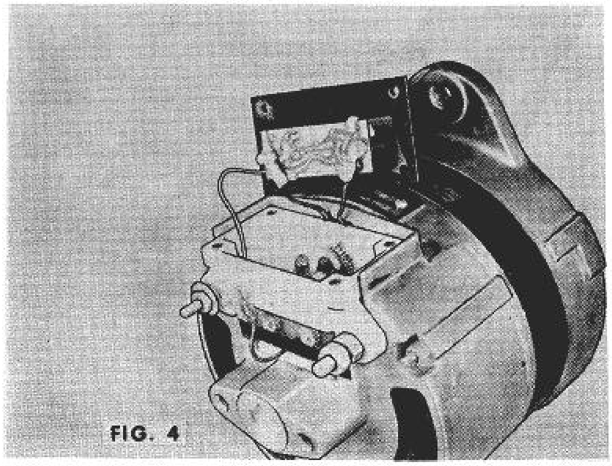


Fig. 4

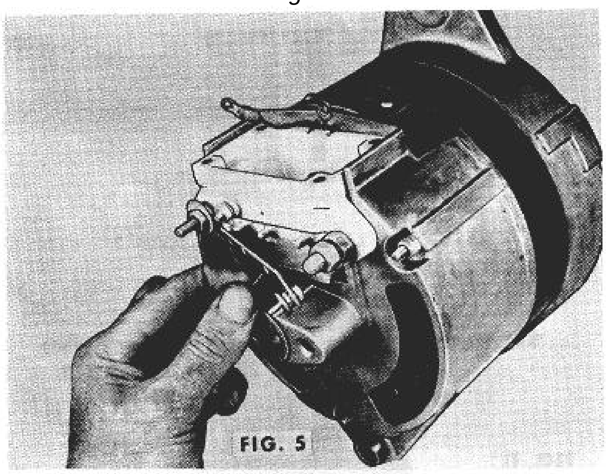


Fig. 5

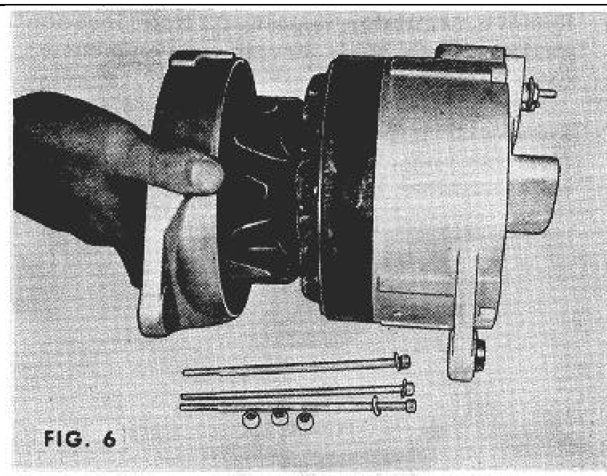


Fig. 6

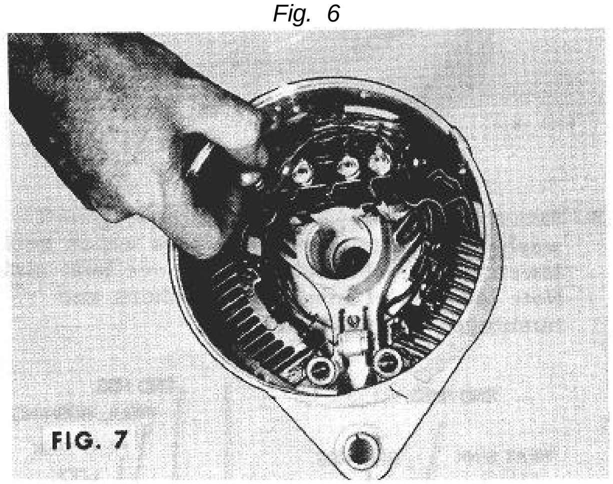


Fig. 7

DISASSEMBLY

1. Remove pulley nut, pulley, fan, key and spacer. Use a suitable puller to avoid damage to the shaft and threads.

2. Remove four screws and carefully lift regulator free of housing. Remove red and black leads from regulator, noting their position to facilitate reassembly. (See Figure 4.)
3. Remove lead from diode trio to terminal on regulator housing. Loosen inner nut, which will allow blue regulator lead to be withdrawn from under head of terminal screw. Remove regulator. (See Figure 4.)

4. Lift brush and spring assemblies out of housing. (See Figure 4.)

5. Remove three nuts and lift diode trio off of AC terminal studs. (See Figure 5.)

6. Remove three self-locking nuts and through bolts.

7. Remove rotor and drive end housing assembly from stator and slip ring end housing assembly. If drive end housing binds on stator, loosen by tapping gently on mounting ear with fibre hammer. Be sure that drive end housing separates from stator and that stator remains attached to slip ring end housing to avoid damage to stator leads. (See Figure 6.)

8. Remove three nuts which secure stator leads to terminals and remove stator.

9. Remove nuts from positive and negative output terminal bolts and remove the bolts. Note the location of the red and black regulator leads on the heat sinks. (See Figure 7.)

10. Remove three hex head screws and remove capacitor connected between the heat sinks. (See Figure 7.)

11. Remove regulator housing. Note location of gasket which seals brush compartment. (See Figure 8.)

12. Remove terminal stud insulating bushings from housing. There are two bushings in each terminal hole. (See Figure 8.)

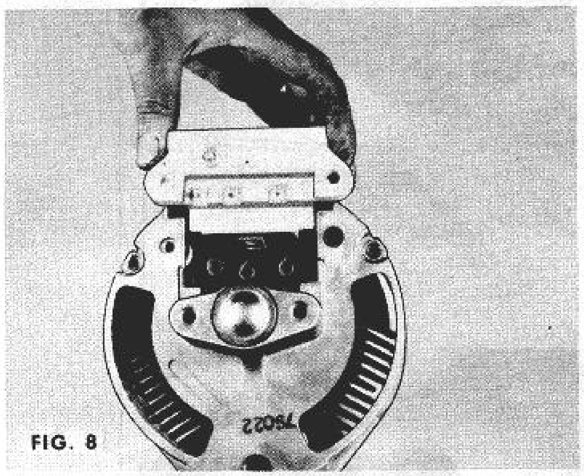


Fig. 8

13. Remove two screws, lockwashers, guard-washers and insulating washers which retain lower end of heat sinks. Remove heat sinks. Note location of insulating washers and bushings. (See Figure 9.)

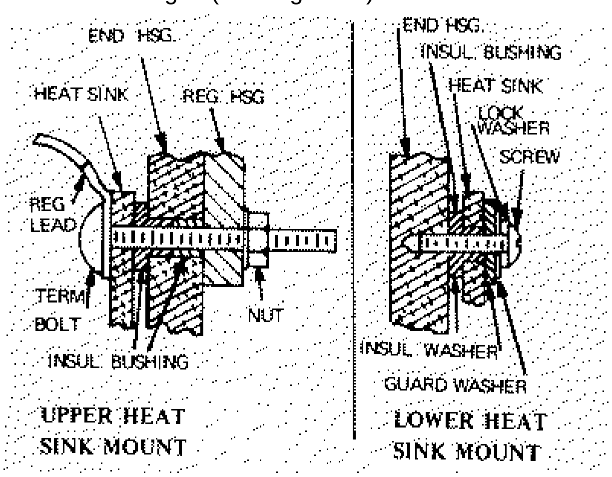


Fig. 9

14. Pry flanged dust cap out of housing. (See Figure 10.)

15. Slip ring end bearing replacement should seldom be required. If it should become necessary, however, press the bearing from the inside of the housing outward using Snap-On Tool Co., No. CG-40-11 with CG-40-4. (See Figure 11.)

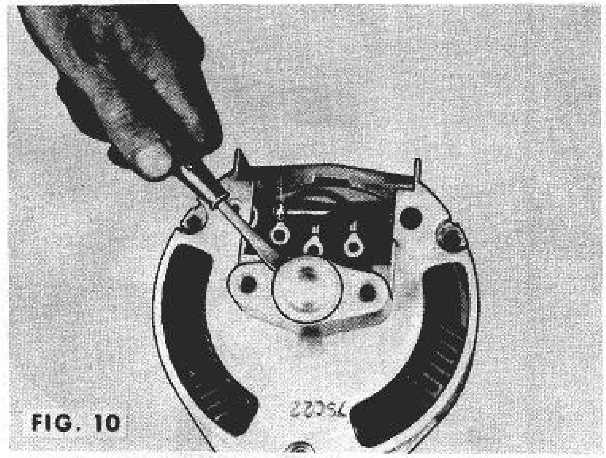


Fig. 10

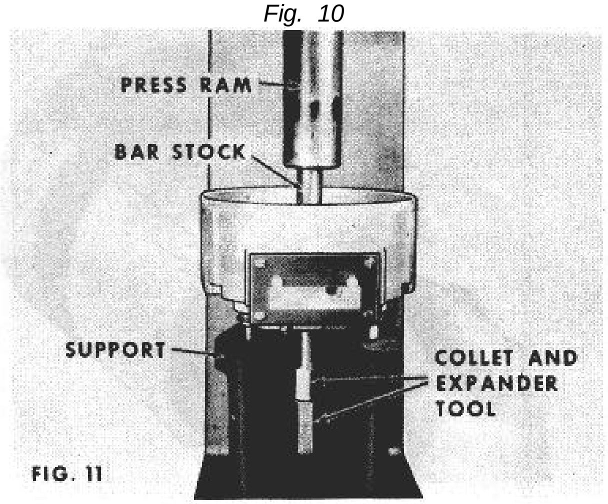


Fig. 11

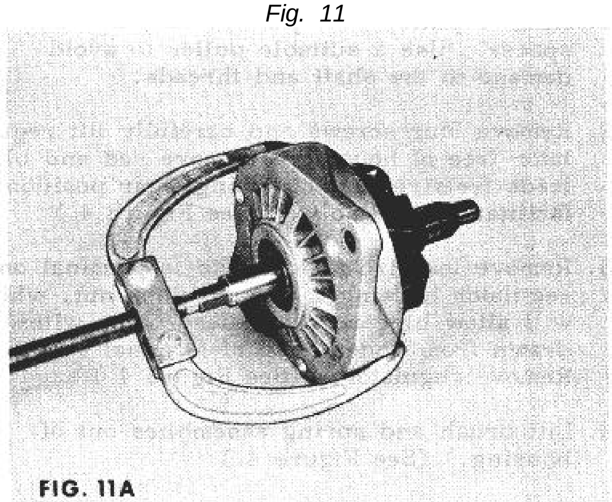


Fig. 11A

16. Using a puller or arbor press, remove the drive end housing and bearing assembly from the rotor shaft. (See Figure 11A.)

17. Remove four screws and bearing retainer; press bearing out of drive end housing. (See Figure 12.)

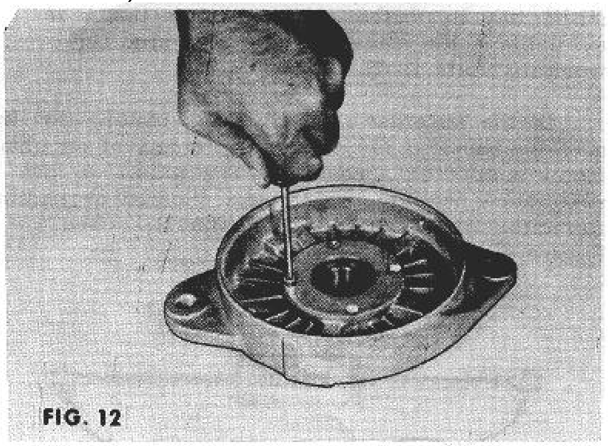


FIG. 12

COMPONENT TESTING

Before performing these tests, carefully inspect all parts for wear, cracks, breakage or other mechanical defects. Discard all damaged parts.

Diode Tests

These tests may be performed on heat sink assemblies without removing them from the end housing. If they are tested in this manner, remove the stator and be sure that the red and black leads are disconnected from the regulator and not touching each other. Be sure the diode trio has been removed from the AC studs and disconnect the capacitor across the lower end of the heat sinks.

Diodes are tested to insure that they only pass current in one direction. Diodes which do not allow current to flow in either direction are open while diodes passing current both ways are shorted. Diodes should be checked with a diode tester, but in emergencies where one is not available, an ohmmeter or a battery powered test light may be substituted.

Positive Heat Sink Tests

NOTE

The positive heat sink is the one to which the positive output terminal is connected. The square hole in the terminal end of the positive heat sink is larger than the terminal hole of the negative heat sink.

1. Connect the positive lead of the diode tester, ohmmeter or test light to the positive heat sink and touch the negative test lead to each of the three diode terminals. A high resistance should be indicated and if a test light is being used, it should not light. If any of the three diodes shows a low resistance or the test lamp lights, the diode is shorted. (See Figure 13.)

2. Reverse the test leads so that the negative test lead is connected to the positive heat sink. The positive test lead should now be touched to each diode terminal and a low resistance reading should be obtained. If a high resistance reading is obtained or the test lamp fails to light, an open diode is indicated. (See Figure 14.)

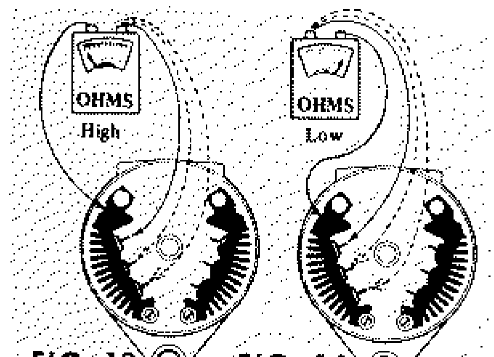


FIG. 13 FIG. 14
POSITIVE HEAT SINK TEST

Fig. 13 *Fig. 14*

Negative Heat Sink Test

1. Connect the negative test lead to the negative heat sink and touch the positive test lead to each diode terminal. If a low resistance reading is obtained or if the test lamp lights, the diode is shorted. (See Figure 15.)

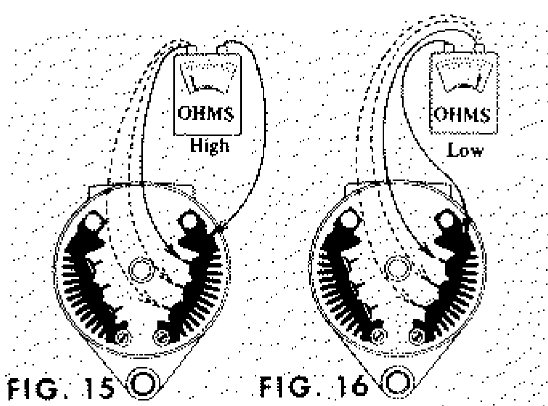


FIG. 15 FIG. 16
NEGATIVE HEAT SINK TEST

Fig. 15 *Fig. 16*

2. Reverse the test leads so that the positive test lead is connected to the negative heat sink. Touch the negative lead to each of the three diode terminals. A low resistance reading should be obtained and if a test light is being used, the lamp should light. If high resistance is indicated or the lamp does not light, the diode is open. (See Figure 16.)

   If a shorted or open diode is detected in the preceding tests, the entire heat sink assembly should be replaced.

NOTE

Heat sinks supplied as service replacements may differ slightly in thickness or general appearance from the original parts. This will in no way impair their interchangeability or reliability. To obtain the maximum serviceability, several different assemblies may be used as replacements. These will be listed in the appropriate parts list.

Diode Trio Tests

The diode trio may be tested with the same equipment which was used to check the diodes in the heat sink assemblies.

1. Connect the negative lead of the tester to the output lead of the diode trio and touch the positive tester lead to each of the three copper terminal pads. (See Figure 17.) A low resistance should be indicated and if a test lamp is being used, it should light.

2. Connect the positive terminal of the tester to the output lead of the diode trio and touch the negative lead to each of the three copper terminal pads. A high resistance should be indicated and if a test lamp is being used, it should not light. Discard any diode trio which does not pass all of these tests.

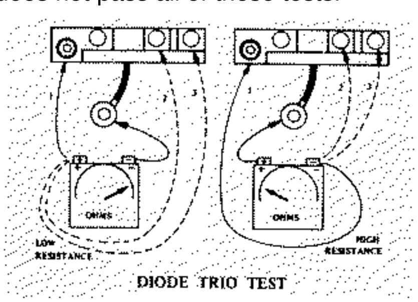


Fig. 17

Capacitor Test

The capacitor connected across the heat sinks may be tested on a capacitor tester if available. Its value is .158 MFD and 100 working volts D.C.

In the absence of a capacitor tester, the unit may be checked for shorts by means of an ohmmeter connected across the terminals. A low resistance reading indicates a shorted or leaking capacitor which should be replaced. (See Figure 18.)

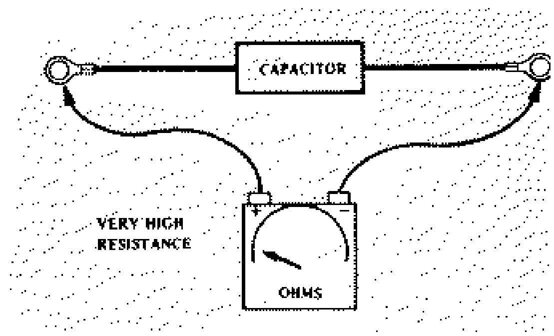


Fig. 18

Voltage Regulator Test

The regulator circuitry contains devices connected in such a manner that parallel or "sneak" circuits exist, making it impossible to electrically test each individual component, as several will be in the circuit at the same time. For this reason, point to point resistance checks with an ohmmeter may be inconclusive or misleading. The regulator can be most accurately tested by installing it in an alternator known to be serviceable.

The voltage regulator assembly consists of a number of individual components such as capacitors, resistors, diodes and transistors mounted upon and electrically connected by a printed circuit panel. Because these components are permanently fastened to the panel, their replacement is not recommended. When it has been determined that a voltage regulator is unserviceable, it should be discarded and a new assembly installed in its place. (See Figure 19.)

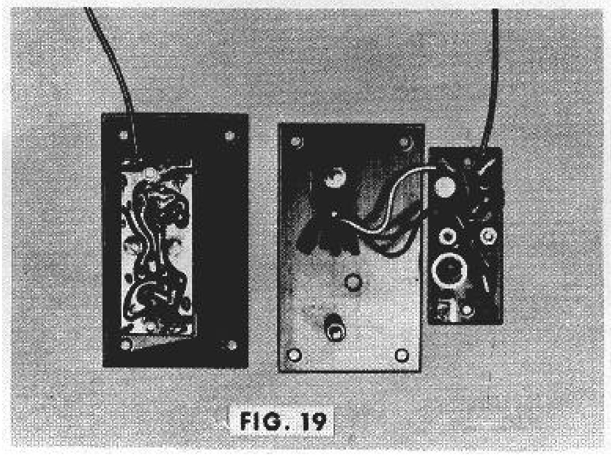


Fig. 19

Rotor Test

The rotor should be checked for grounds and proper coil resistance with an ohmmeter.

1. With the ohmmeter connected between the rotor shaft and either slip ring, no reading (infinity) should be obtained. If an ohmmeter reading other than infinity is obtained, the rotor coil is grounded and the rotor must be replaced. (See Figure 20.)

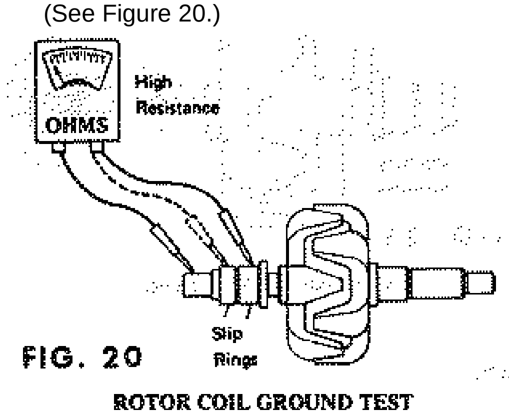


Fig. 20

2. Check rotor coil resistance by connecting the ohmmeter across the two slip rings. (See Figure 21.) The resistance of the rotor should be within the following limits:

2300JB:	
Built prior to date code 7613	2.5-3.2 Ohms
Built after date code 7613	4.9-5.5 Ohms
2500JB, 2600JB:	
Built prior to date code 7423	3.7-4.1 Ohms
Built after date code 7423	2.3-2.7 Ohms
2700JB, 2805JB	1.9-2.3 Ohms

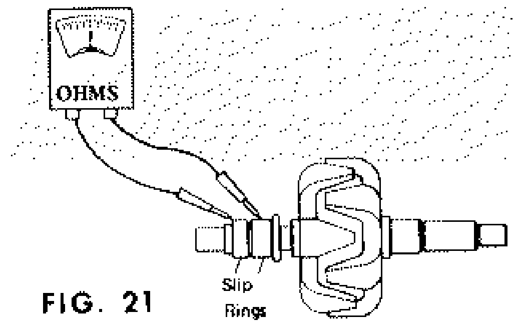


Fig. 21

Stator Test

Due to the extremely low resistance of the stator windings, it is not possible to measure their resistance with a conventional ohmmeter. The stator should, therefore, be tested for grounds and continuity between phases with a test light. A 115-120 volt test light is preferred as the higher voltages applied to the stator increase the chances of detecting a faulty or borderline unit. Do not attempt to check stators in this manner while they are still connected to the heat sinks. Remove the stator from the alternator before testing. (See Figure 22 for stator test.) Discard any stators which appear overheated and have charred insulation regardless of how they test.

Several stators are available which can be used as service replacements on these alternators. The part numbers of these stators will be listed in the appropriate parts list.

SLIP RING REPLACEMENT

The slip ring assembly used is of extremely sturdy construction and will seldom require replacement. If it should become, damaged in some way, such as dropping the rotor, it may be replaced in the following manner.

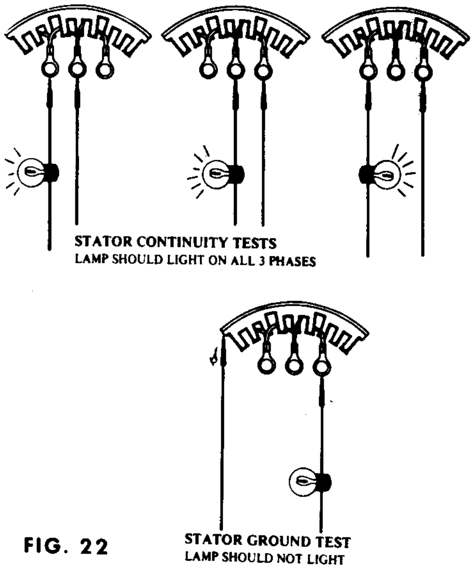


FIG. 22

1. Unsolder the slip ring leads and lift them clear of the eyelets which serve to retain them to the rotor coil leads. Do not lose or damage the eyelets. (See Figure 23.)

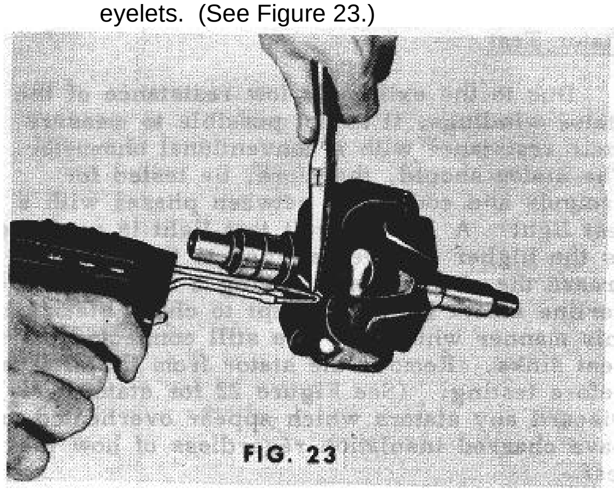


FIG. 23

2. With a suitable puller, the slip ring assembly may now be pulled from the shaft. (See Figure 24.)

3. Clean the rotor shaft and apply a small amount of Loctite to the shaft on the section normally occupied by the slip ring assembly. 4. Position the new slip ring assembly on the shaft so that the two leads are aligned with the two rotor coil eyelets on the rotor and carefully press the slip ring assembly onto the shaft.

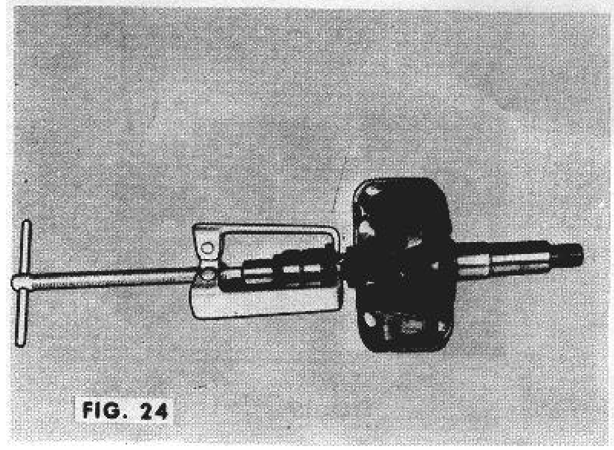


FIG. 24

Fig. 24

NOTE

There is no stop on the shaft to prevent the slip rings from being pressed on too far. It is, therefore, necessary to press the slip rings only to a point where there is 3/8" space between the inner edge of the slip rings and the rotor. (See Figure 25.)

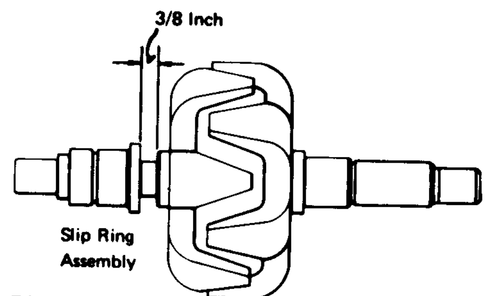


FIG. 25

LOCATION OF SLIP RING

Fig. 25

REASSEMBLY

1. If slip ring end bearing has been removed, press a new bearing in place from the outside of the housing. Bearing should be installed with seal facing in toward slip rings. When properly installed, the manufacturers part number stamped on the end of the bearing will be facing toward the outside of the housing.

NOTE

Bearing should seat against lip on inside end of bearing bore.

After bearing is installed, apply a small amount of Chevron SRI 2 grease or equivalent to rollers.

2. Reinstall heat sinks in slip ring end housing. Be sure that upper and lower insulating washers are in their proper location. Install but do not tighten lower heat sink retaining screws, lockwashers, guardwashers and insulating washers. (See Figure 9.)

   NOTE: Replacement heat sinks may differ in thickness or appearance from the original assemblies but will fit and function inter-changeably.

3. Install terminal bolts and regulator lead wires.

   NOTE: Red wire goes on positive heat sink and black wire goes on negative. Be sure that mating surfaces of heat sinks, terminals and terminal bolts are clean and free of paint to insure a good electrical connection. (See Figure 7.)

4. Install two insulating bushings on each terminal bolt and install regulator housing. Be sure that red and black regulator leads are properly routed through cutaway section of end housing and install and tighten nuts on terminal bolts. (See Figure 4.)

5. Tighten lower heat sink screws and check all leads for proper routing being sure that no lead is pinched under heat sink.

6. Reinstall capacitor.

7. Reinstall stator and terminal nuts. It is advisable to align stator and housing by temporarily installing the thru-bolts.

8. Press drive end bearing into housing and reinstall bearing retainer and four screws.

   NOTE: When installing bearing, press on outer race to avoid transmitting force through the bearing balls which could brinnell the bearing.

9. Press drive end housing and bearing on to rotor shaft.

   NOTE: Using a sleeve around the shaft, press on the inner race to avoid brinnelling the bearing.

10. Install rotor and housing assembly into stator and slip ring end housing assembly being sure that mounting ears are aligned.

11. Install three thru-bolts and self-locking nuts. Torque to 50-60 in.lbs. Place a small amount of SRI 2 grease in housing and reinstall the metal dust cap by carefully pressing it into place.

12. Install diode trio and three nuts.

13. Insert outer brush and spring assembly into the housing and compress the brush spring, using a small screwdriver or similar tool. While holding the spring compressed, insert a pin through the hole in the rear of the housing so that the spring will be held in a compressed position. (A suitable pin can be made from a piece of 1/16" drill rod.) Install and compress the remaining brush and spring assembly in a similar manner. Hold the spring in a compressed position by pushing the pin farther into the housing. (See Figure 26.)

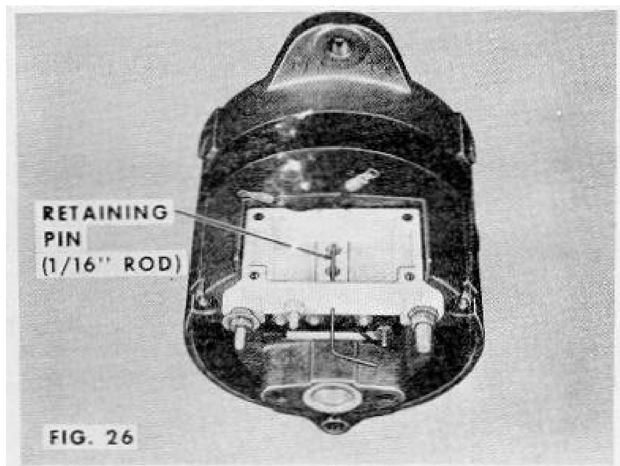


FIG. 26

14. Attach red and black leads to regulator. Attach blue regulator lead to diode terminal screw by placing the spade terminal under the head of the screw. Tighten nut on terminal under the head of the screw. (See Figure 4.) Install regulator.

   NOTE: Be sure that the red and black leads are properly routed through their slots in the regulator housing. Install four regulator screws. <u>Withdraw brush retaining pin be- fore tightening these screws</u>

15. Install diode trio lead and nut.

16. Install spacer, key, fan, pulley and nut. Torque nut to 70-80 ft.lbs.

   NOTE: Due to the design of the alternator a certain amount of shaft end play will be present in new or rebuilt units. This end play is designed into the unit and will vary between .004 to .012 inch. CAUTION: D NOT FORCE OR POUND PULLEY ON SHAFT

TESTING

Because of the integral regulator used on this alternator, the test block hookup is very simple, consisting of connecting the positive and negative output leads. If a commercial test block is not available, the test setup shown n Figure 27 may be used.

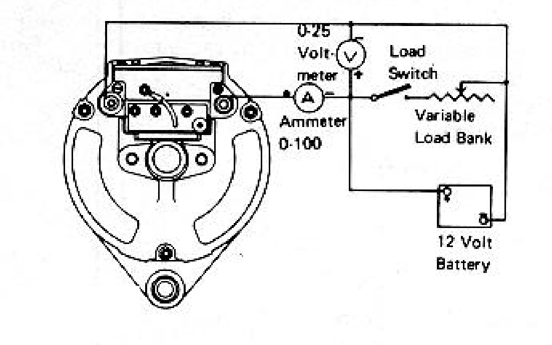


FIG. 27

Before beginning the test and after the battery has been connected, momentarily flash the field by connecting a jumper between the diode trio terminal and the alternator positive output terminal (See Figure 28.) This will restore the residual magnetism which may have been weakened by handling or repair procedures

The cut-in speed of the alternator is that rotor speed at which the unit begins to produce output. This speed should not be higher than 1500 R P.M

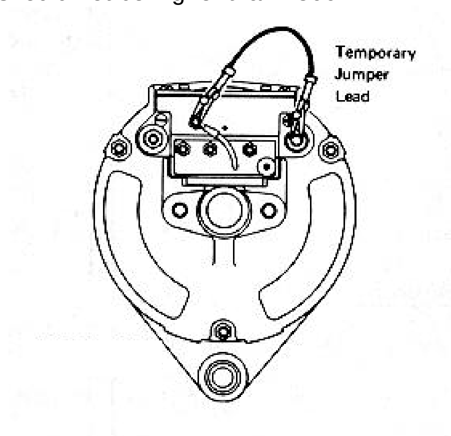


FIG. 28

VOLTAGE REGULATOR REPLACEMENT

Regulator Removal

1. Remove four screws and carefully lift regulator free of housing. Remove red and black leads from regulator noting their position to facilitate assembly of new regulator. (See Figure 4.)
2. Remove lead from diode trio to terminal regulator housing. Loosen inner nut which will allow blue regulator lead to be withdrawn from under head of terminal screw. Remove regulator. (See Figure 4.)
3. Lift brush and spring assemblies out of housing. (See Figure 4.)

Regulator Installation

1. Install brushes

   When brush springs have been compressed, hold them in place by passing a pin through the retainer hole. (See Figure 26.) A suitable pin can be made from a piece of 1/16" drill rod.

2. Attach red and black leads to regulator with shakeproof spring lockwashers and nuts supplied. Attach blue regulator lead to diode terminal screw by placing the spade terminal under the head of the screw. Tighten nut on terminal screw. (See Figure 4.) Install regulator.

   Be sure that the red and black leads are properly routed through their slots in the regulator housing. Install four regulator screws. Withdraw brush retaining pin before tightening these screws.

3. Connect diode trio lead to regulator housing.
4. Install protector caps (2) supplied to terminal screws (See Figure 1.)

Adjustment

Prior to adjusting alternator voltage, the wiring, connections and belt tension should be checked and repaired as needed. The batteries should be fully charged and the engine should be running at a fast idle. Turn off all vehicle loads such as lights, radios, heaters, air conditioners, etc., when checking or adjusting voltage. An accurate voltmeter should be connected across the batteries to determine the charging voltage. Remove the nylon screw (plug) from the regulator (see Figure 1), and with a small screwdriver carefully turn the adjusting screw clockwise to raise or counterclockwise to lower the voltage. The ideal voltage setting will be a value which maintains a fully charged battery without resulting in an excessive usage of battery water.

When turning the voltage adjustment screw, do not attempt to force it past its stop as damage will result. Be sure to place nylon screw (plug) in the regulator adjustment hole to prevent the entrance of water and dirt.

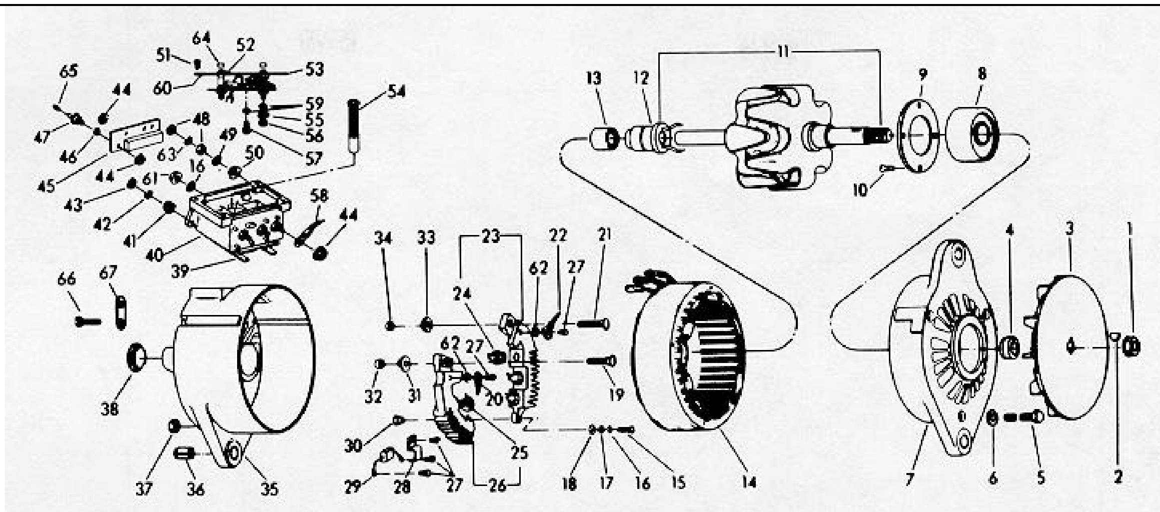


FIG. 29 EXPLODED VIEW OF ALTERNATOR

Legend for Exploded View of Alternator

Key	Description	Key	Description
1	NUT	33	BUSHING, Insulation
2	KEY, Woodruff	34	BUSHING, Insulation
3	FAN, Assembly	35	HOUSING, Slip Ring End
4	SPACER, Fan	36	BUSHING, Slideable
5	SCREW, (3)	37	NUT, (3)
6	WASHER, Belleville (3)	38	CAP, Dust
7	HOUSING, Drive End	39	GASKET
8	BEARING	40	HOLDER, Assembly
9	RETAINER, Bearing	41	NUT
10	SCREW, (4)	42	WASHER, Lock
11	ROTOR, Assembly	43	NUT
12	SLIP RING, Assembly	44	NUT, (7)
13	BEARING, Roller	45	TRIO, Diode
14	STATOR, Assembly	46	WASHER, Lock (Shakeproof)
15	SCREW, (2)	47	TERMINAL, Assembly
16	WASHER, Lock (3)	48	NUT, (2)
17	GUARD, Washer (2)	49	WASHER, Plain
18	WASHER, Insulation (2)	50	NUT
19	SCREW, Terminal (+)	51	SCREW, (4)
20	LEAD, Assembly (+)	52	SCREW (PLUG)
21	SCREW, Terminal (-)	53	REGULATOR, Voltage
22	LEAD, Assembly (-)	54	BRUSH, (2)
23	RECTIFIER, Assembly (-)	55	WASHER, Lock (2)
24	DIODE, W/Lead	56	NUT, (2)
25	DIODE, W/Lead	57	SCREW, (2)
26	RECTIFIER, Assembly (+)	58	WIRE, Terminal (3)
27	SCREW, (5)	59	WASHER, Lock, Spring (4)
28	CLAMP	60	GASKET, Regulator
29	CAPACITOR	61	NUT
30	BUSHING, Insulator (2)	62	GUARD, Washer (2)
31	BUSHING, Insulation	63	WASHER, Lock
32	BUSHING, Insulation	64	CAP, Protector (2)

ELECTRICAL

ALTERNATOR

IH

CODE	RATING
08141	65 Amp
08142	85 Amp
08143	105 Amp
08158	145 Amp

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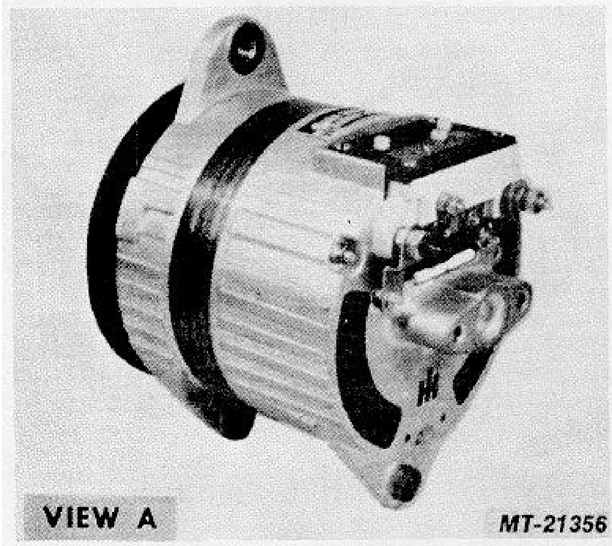
IDENTIFICATION CHART

IH Identification			
Code	Part Number	Mfgr's. No.	Rating
08141	514089-C91	2310JB	65 Amp
08142	513303-C91	2510JB	85 Amp
08143	513542-C91	2610JB	105 Amp
08158	527890-C91	2810JB	145 Amp



DESCRIPTION

The IH heavy duty alternators (View A) are 14 volt self load limiting alternators which feature a fully adjustable, built-in solid state voltage regulator.

The alternators incorporate a 22.2 mm (7/8") straight shaft, a large ball bearing at the drive end and a roller bearing at the slip ring end. The alternators have a two leg swivel mounting, one leg of which 15 equipped with a slideable bushing The rotor shaft may be rotated in either direction.

Six silicone diodes mounted in heat sinks convert alternating current from the delta wound stator into direct current. A capacitor connected between the heat sinks assists in suppressing transient voltage spikes which could possibly injure the diodes.

The brushes and voltage regulator are located in a waterproof housing and may be removed for replacement or inspection without dismantling the entire machine. An external relay terminal is also provided for operation of chargelight relays or other accessories which might require power from such a source.

The alternators have ungrounded output terminals so that they may be used on either positive or negative ground systems. Aside from connecting the proper vehicle wires to the correct output terminals, no other wiring 15 required on the alternator, eliminating field relays or ignition switch connections.

OPERATION

Current is produced by rotating a magnet called a rotor inside a stationary winding called a stator.

The rotor is electrically magnetized by a small current flowing through it via brushes riding on smooth slip rings

Alternating current is produced as the magnet poles of the rotor pass through the colt windings of the stator . For increased capacity, there are twelve (12) magnetic poles incorporated into the rotor and three (3) separate windings in the stator. Since alternating current is produced as the rotor passes the colt windings of the stator, increased engine speed produces more current.

The battery stores only direct current and cannot use alternating current. For this reason, rectifier assemblies are used to convert alternat1ng current produced in the stator to direct current. Rectifiers consist of silicon diodes which function as electrical switches and permit current flow in only one direction.

The rectifier diodes are mounted in aluminum castings, called heat sinks, which are finned to dissipate heat.

A built-in solid state voltage regulator controls alternator output and the battery's state of charge. The diode trio, so called because It consists of three (3) diodes, converts a small amount of alternator current from the stator into direct current which is used as a signal to turn on the regulator.

The regulator senses when the battery has received sufficient charge and then reduces the "field" (magnetizing) current flow to the rotor. Reducing the field current flow, in turn, reduces alternator output.

When headlights and/or accessories place a load on the battery, the regulator increases the field current flow to the rotor, thereby increasing alternator output.

PREVENTIVE MAINTENANCE

Mounting hardware including brackets and drive belts must be periodically inspected and adjustments or repairs performed as required. It is Important that mounting bolts and nuts be kept securely tightened to maintain belt alignment and prevent vibration damage which will occur If mounting bolts work loose.

Vehicle wiring must be inspected at periodic intervals for loose or corroded connections and repairs made as needed.

!

TROUBLE SHOOTING

Before performing trouble shooting procedures on the vehicle, be absolutely certain that wiring is not defective and belts are not slipping, as these problems are common.

To determine if the problem lies in the regulator or the alternator, connect an accurate voltmeter across the battery with the engine stopped, and note the reading. The engine should now be started. If the voltmeter reading rises excessively, the charging system may be defective or may require adjustment. Remove the nylon screw from the regulator and with the engine at approximately 1000 RPM, attempt to bring the voltage to its proper value (13.8-14.2 V approximately) by turning the adjusting screw back and forth with a small screwdriver (see Fig . 1) .

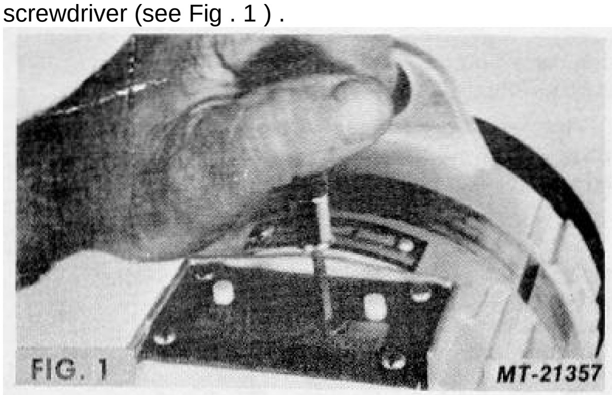


FIG. 1

If the voltage is excessively high and cannot be lowered by means of the adjustment, the regulator is probably defective and should be replaced. If the output voltage cannot be raised, either the alternator, regulator or diode trio may be at fault. To determine if the fault is in the regulator or in the alternator, perform the following test.

Connect one end of a short jumper lead to the negative alternator output terminal and connect the other end of the jumper to a short skiff piece of wire at least 38 mm (1 1/2") long. A piece of paper clip wire will be suitable. Insert this wire into the small hole in the end of the brush holder so that it firmly contacts the outer brush terminal. (see Fig. 2).

If the voltmeter reading now rises with the engine at a fast idle, the alternator is OK and the fault is in the regulator or diode trio. Remove the diode trio and test (see "COMPONENT TESTING"). If the diode trio tests OK, the regulator should be replaced.

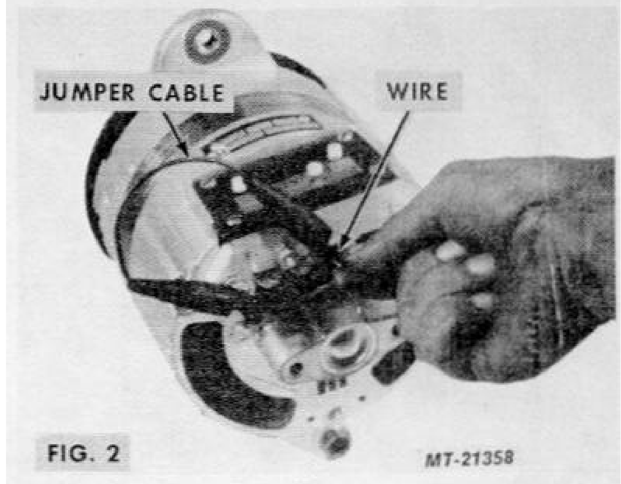


FIG. 2

If the voltage falls to rise when performing this test, remove the regulator and carefully inspect it for a printed circuit track which has burned open. If this condition is found, replace the regulator. Check the brush spring caps and their contact screws for dirt or corrosion and clean if necessary. If the alternator does not operate after performing either or both of these operations, the alternator should be removed for repair or replacement.

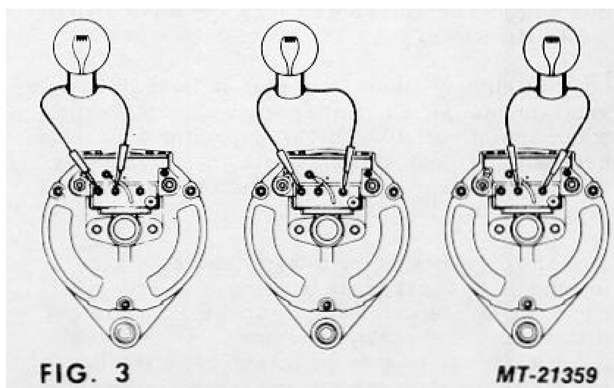


FIG. 3

The alternator may also be checked for output across each phase by using a test light as shown in Fig. 3. The test light should be constructed from a two filament sealed beam unit connected in such a manner that the filaments are in parallel. Such a light will act as a load as well as an indicator, and should light with equal brilliancy on each phase. If the lamp is noticeably dimmer on one or two phases, a defective diode trio or power diode is indicated. If the diode trio tests OK, then the alternator must be removed and dismantled for further tests.

The voltage regulator used in these alternators is a solid state device and for this reason will normally have an extremely long life. It can, however, be damaged by mechanical or electrical abuse.

If the system polarity is inadvertently reversed by installing a battery backwards, boosting or Jump starting with the jumper connected backwards, or reversing the positive and negative alternator output leads when changing an alternator, the voltage regulator will be damaged. Although the polarity reversal may only be momentary and may not damage the alternator diodes, the regulator will still be damaged

ADJUSTMENT

Prior to adjusting alternator voltage, the wiring, connections and belt tension should be checked and repaired as needed. The batteries should be fully charged and the engine should be running at a fast Idle Turn off all vehicle loads such as lights, radios, heaters air conditioners, etc when checking or adjusting voltage An accurate voltmeter should be connected across the batteries to determine the charging voltage. Do not rely on dash mounted vehicle instruments. These al e excellent indicator but usually lack the extreme accuracy required for regulator adjustment. Remove nylon screw' (plug) from the regulator (see Fig. 1), and with a small screwdriver carefully turn the amusing screw clockwise to raise or counter-clockwise to lower the voltage. The Ideal voltage setting will be a value which maintains - fully charged battery without resulting an exceeds e usage of battery water.

When turning the voltage adjustment screw, do not attempt to force it past its stop as damage will result. Be sure to replace the screw (plus) in the regulator adjustment hole to prevent the entrance of water and dirt.

DISASSEMBLY

1. Remove pulley nut, pulley, fan, key and spacer. Use a suitable puller to avoid damage to the shaft and threads.

2. Remove four screws and carefully lift regulator free of housing. Remove red and black leads from regulator, noting their position to facilitate reassembly (see Fig 4).

3. Remove lead from diode trio to terminal on regulator housing . Loosen inner nut, which will allow blue regulator lead to be withdrawn from under head of terminal screw. Remove regulator (set Fig 4).

4. Lift brush and spring assemblies out of housing (see Fig 4).

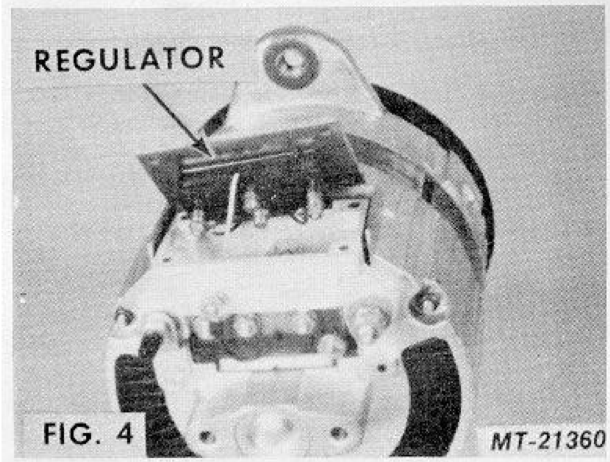


FIG. 4

5. Remove three nuts and lift diode trio off of A/C terminal studs (see Fig. 5)

6. Remove three self locking nuts and through bolts

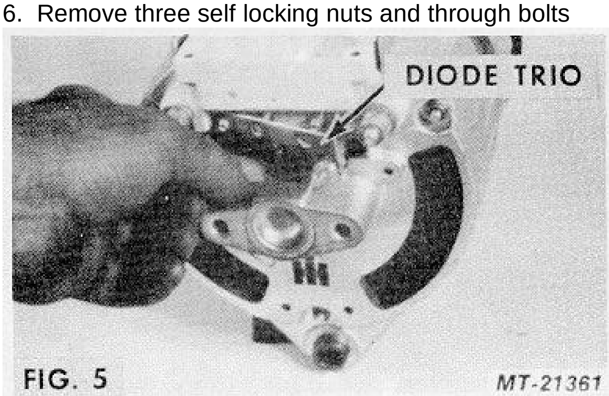


FIG. 5

7. Remove rotor and drive end housing assembly from stator and slip ring end housing assembly. If drive end housing binds on stator, loosen by tapping gently on mounting ear with fibre hammer. Be sure that drive end housing separates from stator and that stator remains attached to slip ring end housing to avoid damage to stator leads (Fig. 6).

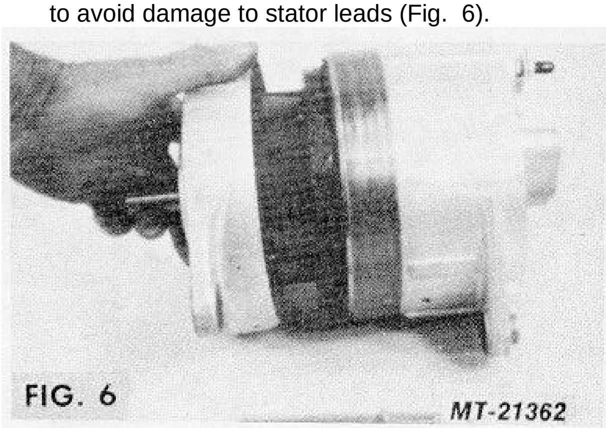


FIG. 6

8. Remove three nuts which secure stator leads to terminals and remove stator.

9. Remove nuts from positive and negative output terminal bolts and remove the bolts. Note the location of the red and black regulator leads on the heat sinks (see Fig 7)

10. Remove three hex head screws and remove capacitor connected between the heat sinks (see Fig 7),

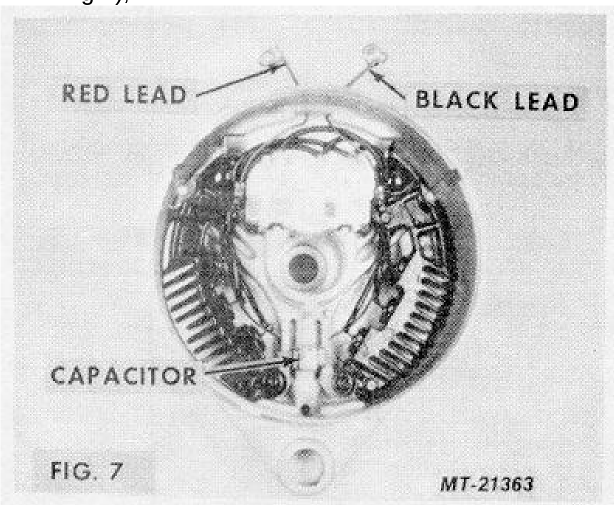
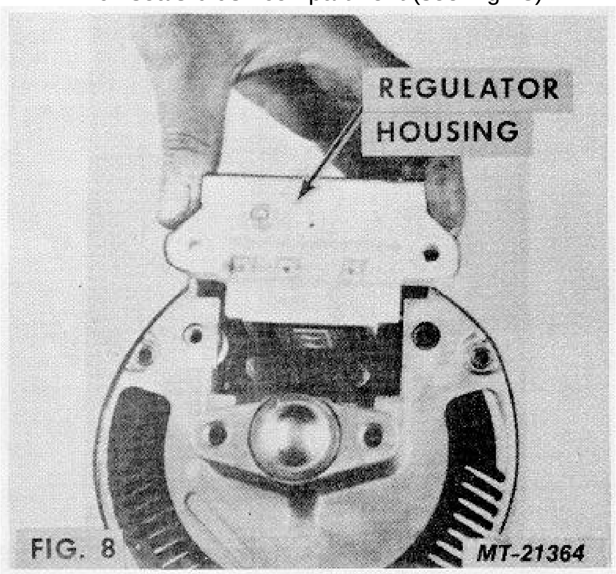


FIG. 7

11. Remove regulator housing. Note location of gasket which seals brush compartment (see Fig. 8).



12. Remove terminal stud insulating bushings from housing. There are two bushings in each terminal hole (see Fig. 8).

13. Remove two screws, lockwashers, guardwashers and insulating washers which retain lower end of heat sinks. Remove heat sinks. Note location of insulating washers and bush1ngs (see Fig. 9).

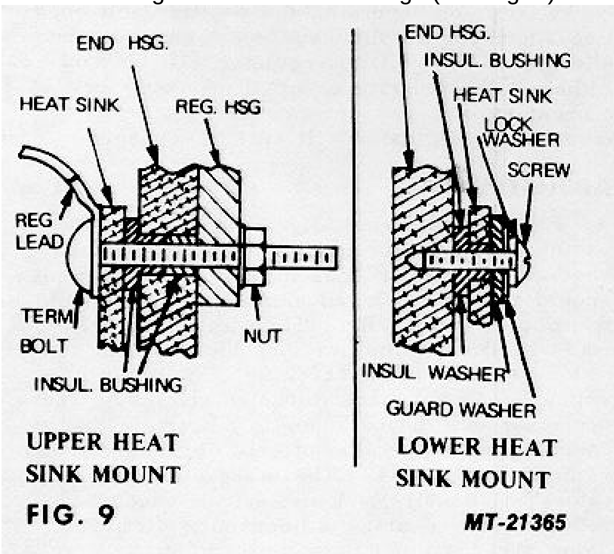


FIG. 9

14. Pry flanged dust cap out of housing (see Fig. 10).

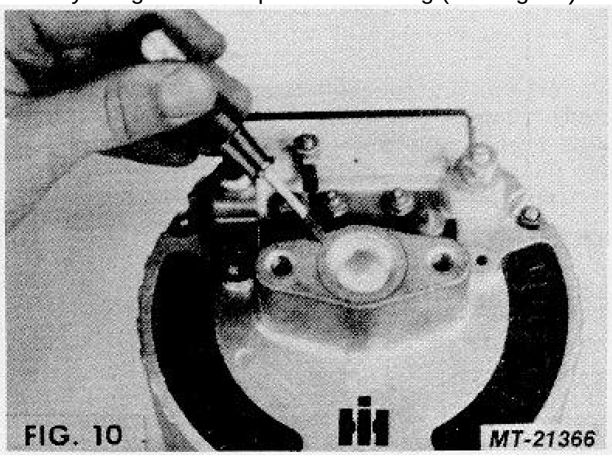


FIG. 10

15. Slip ring end bearing replacement should seldom be required. If it should become necessary, however, press the bearing from the inside of the housing outward, using Snap-On Tool Co., No. CG-40-11 with CG-40-4 (see Fig. 11).

16. Using a puller or arbor press, remove the drive end housing and bearing assembly from the rotor shaft (see Fig. 11A).

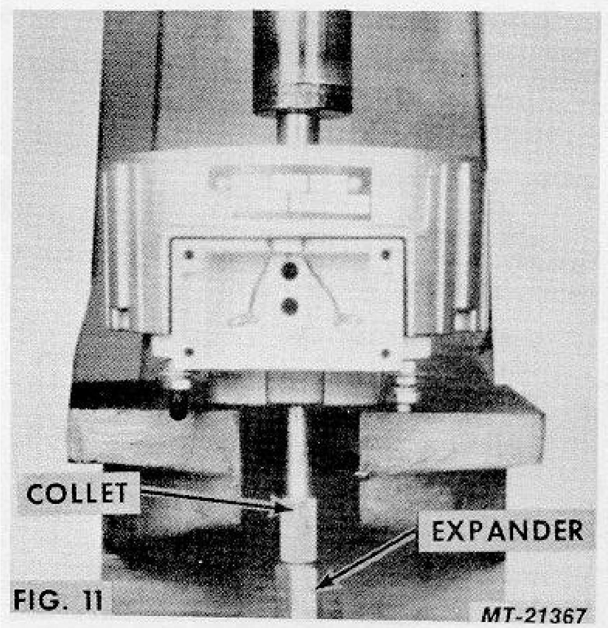


FIG. 11

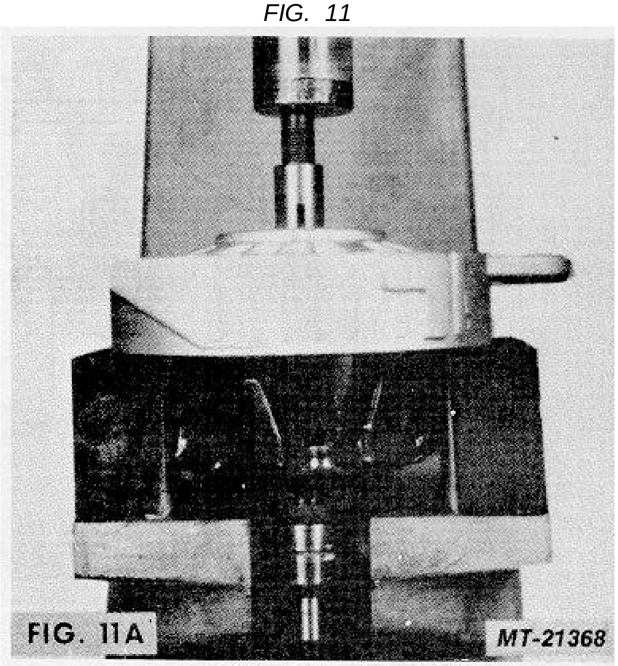


FIG. 12

17. Remove four screws and bearing retainer and press bearing out of drive end housing (see Fig. 12).

COMPONENT TESTING

Before performing these tests, carefully inspect all parts for wear, cracks, breakage or other mechanical defects. Discard all damaged parts.

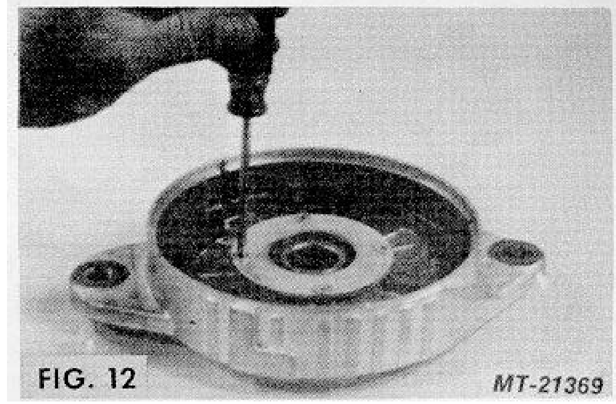


FIG. 12

DIODE TESTS

These tests may be performed on heat sink assemblies without removing them from the end housing. If they are tested in this manner, remove the stator and be sure that the red and black leads are disconnected from the regulator and not touching each other. Be sure the diode trio has been removed from the A/C studs and disconnect the capacitor across the lower end of the heat sinks.

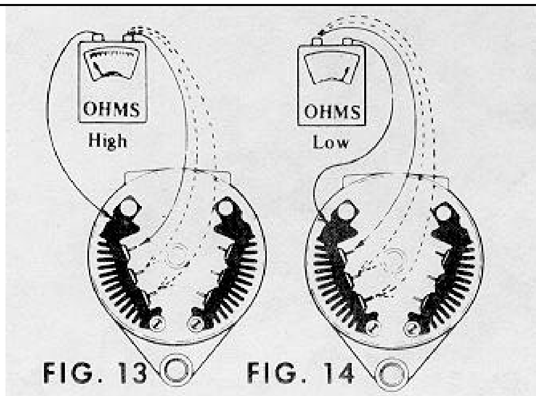
Diodes are tested to insure that they only pass current in one direction. Diodes which do not allow current to flow in either direction are open while diodes passing current both ways are shorted. Diodes should be checked with a diode tester, but in emergencies where one is not available, an ohmmeter or battery powered test light may be substituted

Positive Heat Sink Tests:

The positive heat sink is the one to which the positive output terminal is connected. The square hole in the terminal end of the positive heat sink is larger than the terminal hole of the negative heat sink

1. Connect the positive lead of the diode tester, ohmmeter, or test light to the positive heat sink and touch the negative test lead to each of the three diode terminals. A high resistance should be indicated and if a test light is belay used, it should not light. If any of the three diodes shows a low resistance, or the test lights, the diode is shorted (see FIG. 13)

2. Reverse the test leads so that the negative test lead is connected to the positive heat sink. The positive test lead should now be touched to each diode terminal and a low resistance reading should be obtained. If a high resistance reading is obtained, or the test lamp falls to light, an open diode is indicated (See Fig. 14)



POSITIVE HEAT SINK TEST

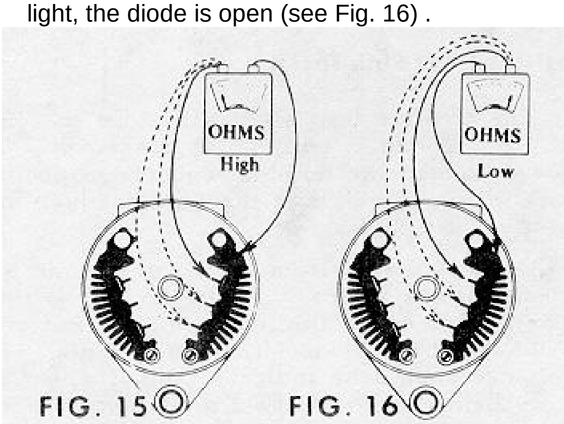
MT-21370

FIG. 13 *FIG. 14*

Negative Heat Sink Tests:

1. Connect the negative test lead to the negative heat sink and touch the positive test lead to each diode terminal. If a low resistance reading is obtained or if the test lamp lights, the diode is shorted (see Fig. 15).

2. Reverse the test leads so that the positive test lead is connected to the negative heat sink. Touch the negative lead to each of the three diode terminals. A low resistance reading should be obtained, and if a test light is being used, the lamp should light. If high resistance is indicated or the lamp does not light, the diode is open (see Fig. 16) .



NEGATIVE HEAT SINK TEST

MT-21371

FIG. 15 *FIG. 16*

If a shorted or open diode is detected in the preceding tests, the entire heat sink assembly should be replaced.

!

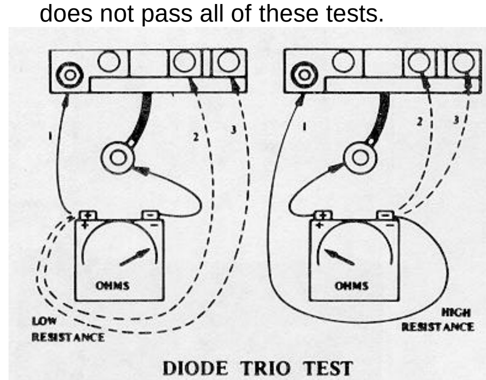
Heat sinks supplied as service replacements may differ slightly in thickness or general appearance from the original parts. This will in no way impair their interchangeability or reliability. To obtain the maximum serviceability, several different assemblies may be used as replacements. These will be listed in the appropriate parts list.

DIODE TRIO TESTS

The diode trio may be tested with the same equipment which was used to check the diodes n the heat sink assemblies.

1. Connect the negative lead of the tester to the output lead of the diode trio, and touch the positive tester lead to each of the three copper terminal pads (see Fig. 17). A low resistance should be indicated, and If a test lamp is being used, it should light.

2. Connect the positive terminal of the tester to the output lead of the diode trio and touch the negative lead to each of the three copper terminal pads. A high resistance should be indicated and if a test lamp is being used, it should not light. Discard any diode trio which does not pass all of these tests.



MT-21372

FIG. 17

CAPACITOR TEST

The capacitor connected across the heat sinks may be tested on a capacitor tester if available.

Its value is .5 MFD, and 200 working volts D.C.

In the absence of a capacitor tester, the unit may be checked for shorts by means of an ohmmeter connected across the terminals. A low resistance reading indicates a shorted or leaking capacitor which should be replaced (see Fig. 18).

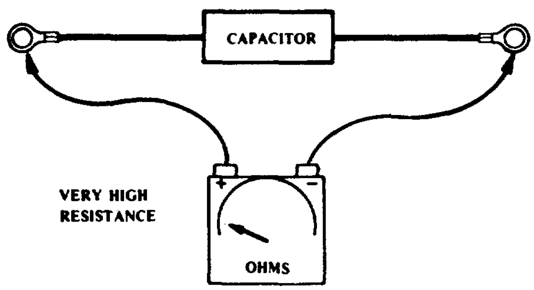


FIG. 18. MT-21373

VOLTAGE REGULATOR TEST

The regulator circuitry contains devices connected in such a manner that parallel or "sneak" circuits exist making it impossible to electrically test each individual component, as several will be in the circuit at the same time. For this reason, point to point resistance checks with an ohmmeter may be inconclusive or misleading. The regulator can be most accurately tested by installing it in an alternator known to be serviceable.

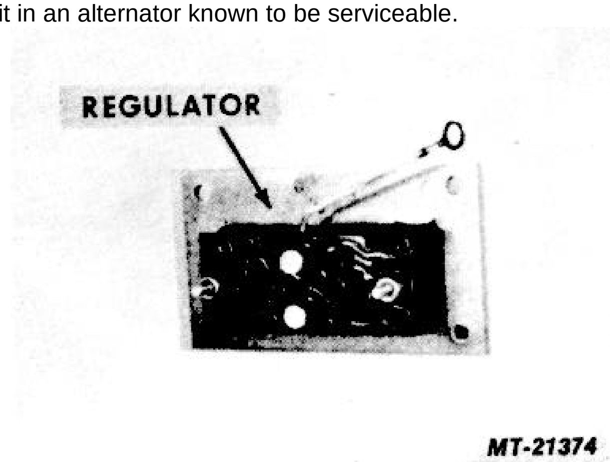


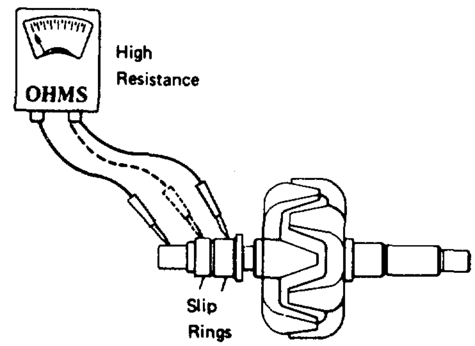
FIG. 19.Fig

The voltage regulator assembly consists of a number of individual components such as capacitors, resistors, diodes and transistors, mounted upon and electrically connected by a printed circuit panel. Because these components are permanently fastened to the panel, their replacement is not recommended. When it has been determined that a voltage regulator is unserviceable, it should be discarded and a new assembly installed in its place (see Fig. 19).

ROTOR TEST

The rotor should be checked for grounds and proper coil resistance with an ohmmeter.

1. With the ohmmeter connected between the rotor shaft and either slip ring, no reading (infinity) should be obtained. If an ohmmeter reading other than infinity is obtained, the rotor coil is grounded and the rotor must be replaced (see Fig. 20).

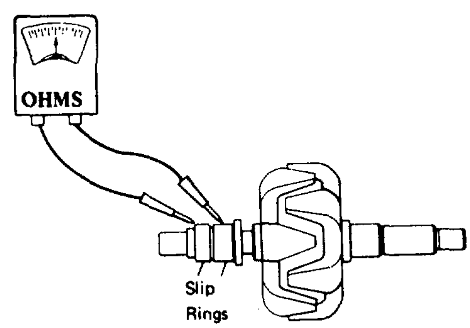


ROTOR COIL GROUND TEST

FIG. 20 MT-21375

2. Check rotor coil resistance by connecting the ohmmeter across the two slip rings (see Fig. 21). The resistance of the rotor should be within the following limits:

2310JB	4.9-5.5 Ohms
2510JB	2.3-2.7 Ohms
2610JB	2.3-2.7 Ohms
2810JB	1.9-2.3 Ohms



ROTOR COIL RESISTANCE TEST

FIG. 21 MT-21376

Discard rotors whose resistance values differ significantly from these figures.

Before condemning a rotor for an open coil, check the solder joints at the slip ring leads, as a poor connection at either of these leads will test the same as an open coil. If the proper resistance is not obtained after resoldering these connections, discard the rotor.

STATOR TEST

Due to the extremely low resistance of the stator windings it is difficult to measure their resistance with a conventional ohmmeter. The stator should therefore be tested for grounds and continuity between phases with a test light. A 12 volt test light is preferred.

Do not attempt to check stators in this manner while they are still connected to the heat sinks. Remove the stator from the alternator before testing (see Fig. 22 for stator test). Discard any stators which appear overheated and have charred insulation, regardless of how they test.

Several stators are available which can be used as service replacements on these alternators. The part numbers of these stators will be listed in the appropriate parts list.

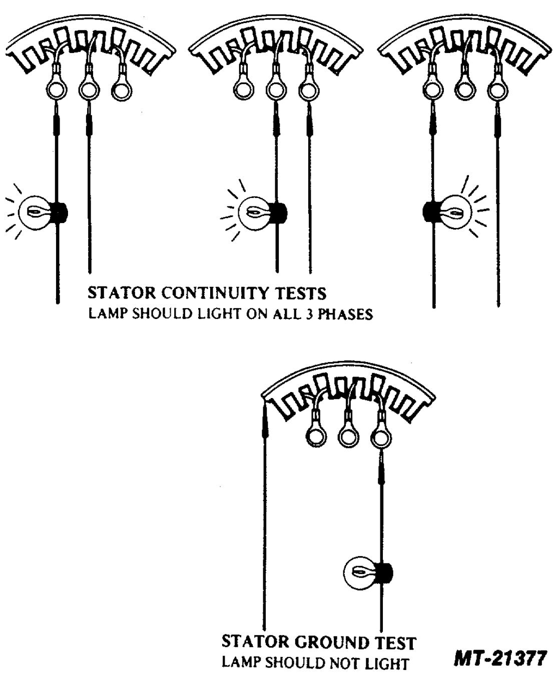


FIG. 22

SLIP RING REPLACEMENT

The slip ring assembly used in these alternators is of extremely sturdy construction and will seldom require replacement. If it should become damaged in some way, such as dropping the rotor, it may be replaced in the following manner.

1. Unsolder the slip ring leads and lift them clear of the eyelets which serve to retain them to the rotor coil leads. Do not lose or damage the eyelets (see Fig. 23).

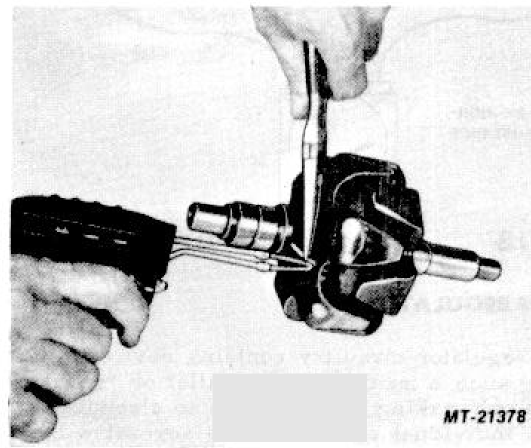


FIG. 23

2. With a suitable puller, the slip ring assembly may now be pulled from the shaft (see Fig. 24).

3. Clean the rotor shaft and apply a small amount of Loctite to the shaft on the section normally occupied by the slip ring assembly.

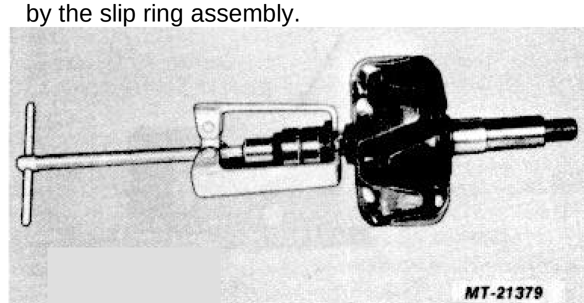
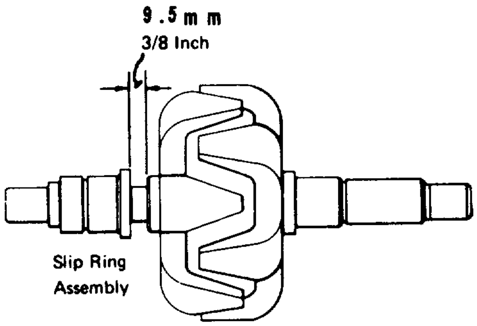


FIG. 24

4. Position the new slip ring assembly on the shaft so that the two leads are aligned with the two rotor coil eyelets on the rotor, and carefully press the slip ring assembly onto the shaft.

There is no stop on the shaft to prevent the slip rings from being pressed on too far. It is therefore necessary to press the slip rings only to a point where there is 9.5 mm (3/8") space between the inner edge of the slip rings and the rotor (see Fig. 25).



LOCATION OF SLIP RING

FIG. 25

REASSEMBLY

1. If slip ring end bearing has been removed, press a new bearing in place from the out-side of the housing. Bearing should be installed with seal facing in toward slip rings. When properly installed, the manufacturer's part number stamped on the end of the bearing will be facing toward the outside of, the housing.

Bearing should seat against lip on inside end of bearing bore. After bearing is installed, apply a small amount of grease (Chevron SRI 2 or equivalent) to rollers.

2. Reinstall heat sinks in slip ring end housing. Be sure that upper and lower insulating washers are in their proper location. Install but do not tighten lower heat sink retaining screws, lockwashers, guardwashers and insulating washers (see Fig. 9).

Replacement heat sinks may differ in thickness or appearance from the original assemblies, but will fit and function interchange- ably.

3. Install terminal bolts and regulator lead wires. Red wire goes on positive heat sink and black wire goes on negative. Be sure that mating surfaces of heat sinks, terminals and terminal bolts are clean and free of paint to insure a good electrical connection (see Fig. 7).

4. Install two insulating bushings on each terminal bolt and install regulator housing. Be sure that red and black regulator leads are properly routed through cutaway section of end housing, and install and tighten nuts on terminal bolts (see Fig. 4).

5. Tighten lower heat sink screws and check all leads for proper routing, being sure that no lead is pinched under heat sink.

6. Reinstall capacitor.

7. Reinstall stator and terminal nuts. It is advisable to align stator and housing by temporarily installing the through bolts.

8. Press drive end bearing into housing and reinstall bearing retainer and four screws.

When installing bearing, press on outer race to avoid transmitting force through the bearing balls which could brinnell the bearing.

9. Press drive end housing and bearing onto rotor shaft. Using a sleeve around the shaft, press on the inner race to avoid brinnelling the bearing.

10. Install rotor and housing assembly into stator and slip ring end housing assembly, being sure that mounting ears are aligned.

11. Install three through bolts and self locking nuts. Torque to 5.6-6.8 N·m (50-60 in. lbs.). Place a small amount of grease (Chevron SRI 2 or equivalent) in housing and reinstall the metal dust cap by carefully pressing it into place.

12. Install diode trio and three nuts.

13. Insert outer brush and spring assembly into the housing and compress the brush spring, using a small screwdriver or similar tool.

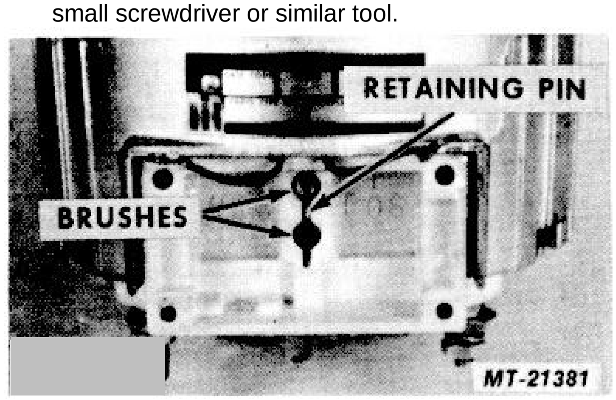


FIG. 26

While holding the spring compressed, insert a pin through the hole in the rear of the housing so that the spring will be held in a compressed position. (A suitable pin can be made from a piece of 1.6 mm (1/16") drill rod). Install and compress the remaining brush and spring assembly in a similar manner. Hold the spring in a compressed position by pushing the pin farther into the housing (see Fig. 26).

14. Attach red and black leads to regulator. Attach blue regulator lead to diode terminal screw by placing the spade terminal under the head of the screw. Tighten nut on terminal screw (see Fig. 4). Install regulator.

Be sure that the red and black leads are properly routed through their slots in the regulator housing. Install four regulator screws. Withdraw brush retaining pin before tightening these screws.

15. Install diode trio lead and nut.

16. Install spacer, key, fan, pulley and nut. Torque nut to 95-108 N·m (70-80 ft. lbs.). Due to the design of the alternator, a certain amount of shaft end play will be present in new or rebuilt units. This end play is designed into the unit and will vary between 0.1 to 0.3 mm (.004 to .012 inch).

CAUTION

DO NOT FORCE OR POUND PULLEY ON SHAFT.

TESTING

Because of the integral regulator used on this alternator, the test block hookup is very simple, consisting of connecting the positive and negative output leads. If a commercial test block is not available, the test setup shown in Figure 27 may be used.

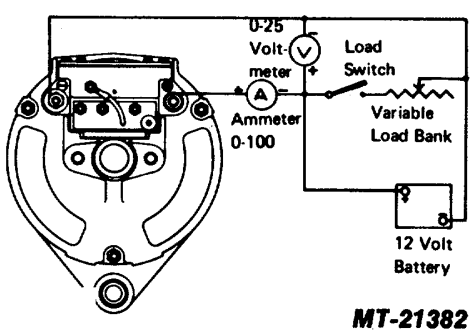


FIG. 27

Before beginning the test and after the battery has been connected, momentarily flash the field by connecting a jumper between the diode trio terminal and the alternator positive output terminal (see Fig. 28). This will restore the residual magnetism which may have been weakened by handling or repair procedures.

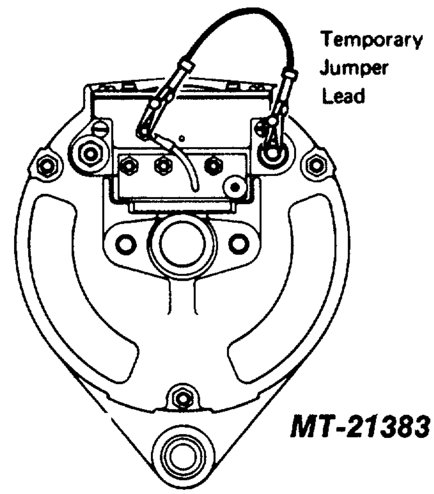


FIG. 28

VOLTAGE REGULATOR REPLACEMENT

REMOVAL

1. Remove four screws and carefully lift regulator free of housing. Remove red and black leads from regulator noting their position to facilitate assembly of new regulator (see Fig. 4).

2. Remove lead from diode trio to terminal regulator housing. Loosen inner nut which will allow blue regulator lead to be withdrawn from under head of terminal screw. Remove regulator (see Fig. 4).

3. Lift brush and spring assemblies out of housing (see Fig. 4).

INSTALLATION

1. Install brushes.

   When brush springs have been compressed, hold them in place by passing a pin through the retainer hole (see Fig. 26). A suitable pin can be made from a piece of 1.6 mm (1/16") drill rod.

2. Attach red and black leads to regulator with shakeproof spring lockwashers and nuts supplied. Attach blue regulator lead to diode terminal screw by placing the space terminal under the head of the screw. Tighten nut on terminal screw (see Fig. 4). Install regulator.

Continued on Page 14

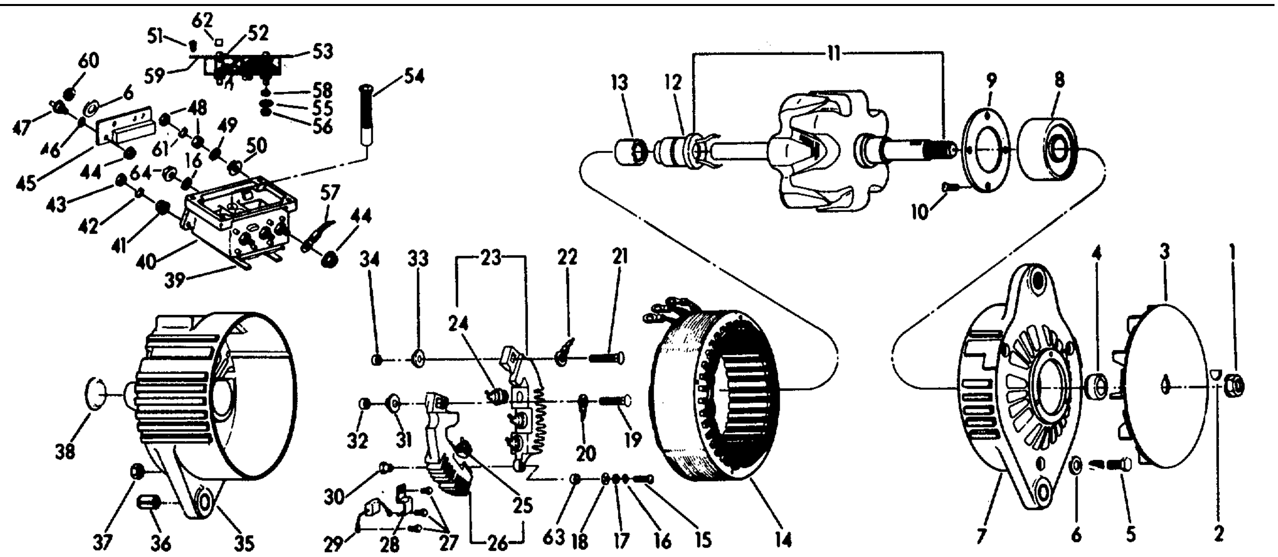


FIG. 29 EXPLODED VIEW OF ALTERNATOR

LEGEND FOR EXPLODED VIEW OF ALTERNATOR

Key	Description	Key	Description
1	NUT	33	BUSHING, Insulation
2	KEY, Woodruff	34	BUSHING, Insulation
3	FAN, Assembly	35	HOUSING, Slip Ring End
4	SPACER, Fan	36	BUSHING, Slideable
5	SCREW, (3)	37	NUT, (3)
6	WASHER, Belleville (6)	38	CAP, Dust
7	HOUSING, Drive End	39	GASKET
8	BEARING, Drive End	40	HOLDER, Assembly
9	RETAINER, Bearing	41	NUT
10	SCREW, (4)	42	WASHER, Lock
11	ROTOR, Assembly	43	NUT
12	SLIP RING, Assembly	44	NUT, (4)
13	BEARING, Roller	45	TRIO, Diode
14	STATOR, Assembly	46	WASHER, Lock
15	SCREW, (2)	47	TERMINAL, Assembly
16	WASHER, Lock (3)	48	NUT, (2)
17	GUARD, Washer (2)	49	WASHER, Plain
18	WASHER, Insulation (2)	50	NUT
19	SCREW, Terminal (+)	51	SCREW, (4)
20	LEAD, Assembly (+)	52	SCREW (Plug)
21	SCREW, Terminal (-)	53	REGULATOR, Voltage
22	LEAD, Assembly (-)	54	BRUSH, (2)
23	RECTIFIER, Assembly (-)	55	WASHER, Lock (2)
24	DIODE, W/Lead (3)	56	NUT, (2)
25	DIODE, W/Lead (3)	57	WIRE, Terminal (3)
26	RECTIFIER, Assembly (+)	58	WASHER, Lock
27	SCREW, (5)	59	GASKET, Regulator
28	CLAMP	60	NUT (3)
29	CAPACITOR	61	WASHER, Lock
30	BUSHING, Insulator (2)	62	CAP, Protector (2)
31	BUSHING, Insulation	63	BUSHING (2)
32	BUSHING, Insulation	64	NUT

Be sure that the red and black leads are properly routed through their slots in the regulator housing. Install four regulator screws. Withdraw brush retaining pin before tightening these screws.

3. Connect diode trio lead to regulator housing.

4. Install protector caps (2) supplied to terminal screws (see Fig. 1).

5. Adjust voltage output as instructed under ADJUSTMENT.

PRINTED IN UNITED STATES OF AMERICA

ALTERNATOR
(LEECE-NEVILLE)

CODE	TYPE	RATING
08152	4425JA	75 AMP
08154	4625JA	105 AMP

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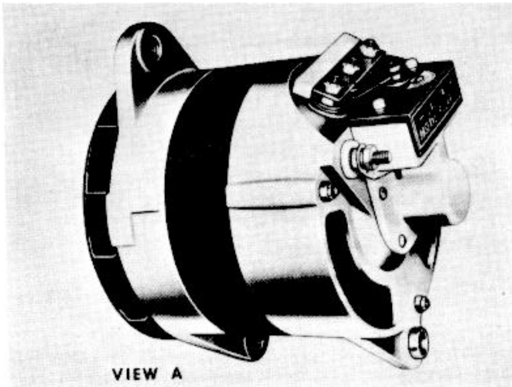
ALTERNATOR IDENTIFICATION CHART

IH Identification		Mfgr's. Identification		
Code	Part Number	Type	Model	Rating
08152	517368-C91	4425JA	90528	75 Amp
08154	520443-C91	4625JA	90529	105 Amp



DESCRIPTION

These alternators have slow speed characteristics which allow lower rotational speeds of the alternator without sacrificing any amperage out-put at idle or top speed. They are self-current limiting units with a fully adjustable solid state integral regulator. This slower operating speed substantially increases the life of wearing parts such as: brushes, bearings and seals which in turn reduce maintenance costs. These new alternators give improved electrical charging system reliability as well as maintenance cost reductions.

The overall dimensions are: Diameter 6-5/8", length 10-1/8" (shaft included) and the weight is approximately 28 pounds.

The alternator shaft may be rotated in either direction without affecting the output or cooling of the unit. These alternators have a 7/8" straight shaft, a large ball bearing at the drive end and a roller bearing at the slip ring end. Both housings incorporate large grease reservoirs and seals.

Six silicon diodes mounted in heat sinks convert alternating current from the delta wound stator into direct current. A capacitor connected between the heat sinks assists in suppressing transient voltage spikes which could possibly injure the diodes.

The brushes and voltage regulator are located in a waterproof housing that may be removed for replacement or inspection without dismantling the entire machine. A terminal is provided for connection of a charge indicator light on Negative Ground Systems only. The alternator has ungrounded output terminals so that they may be used on either positive or negative ground systems. Aside from connecting the proper vehicle wires to the correct output terminals, no other wiring is required on the alternator, eliminating field relays or ignition switch connections.

The regulator incorporates transient voltage protection.

PREVENTIVE MAINTENANCE

Mounting hardware must be periodically inspected and adjustments or repairs performed as required. It is important that mounting hardware be kept securely tightened to prevent vibration damage which will occur if mounting bolts work loose.

Vehicle wiring must be inspected at periodic intervals for loose or corroded connections and repairs made as needed.

At regular intervals inspect the brushes and brush springs. If the brushes or springs are cracked, broken or burned, they should be re- placed. Brushes worn to a length of less than 3/16 of an inch should be replaced. Refer to the regulator replacement section for proper procedure.

TROUBLESHOOTING

Before performing troubleshooting procedures on the vehicle be absolutely certain that wiring is not defective.

To determine if the problem lies in the regulator or the alternator, connect an accurate volt-meter across the battery with the engine stopped and note the reading. The engine should now be started. If the voltmeter reading rises excessively, the charging system may be defective or may require adjustment. Remove the nylon screw from the regulator and with the engine at approximately 1000 RPM, attempt to bring the voltage to its proper value (13.5 to 13.7 approximately) by turning the adjusting screw with a small screwdriver. (See Figure 1.)

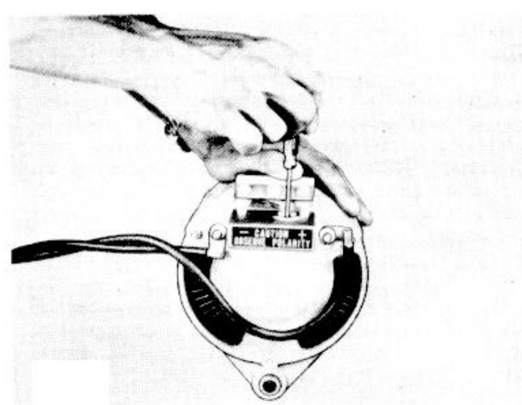


FIG. 1

If the voltage is excessively high and cannot be lowered by means of the adjustment, the regulator is probably defective and should be replaced. If the output voltage cannot be raised, either the alternator, regulator or diode trio may be at fault. To determine if the fault is in the regulator or in the alternator, perform the following test.

Connect one end of a short jumper lead to the negative alternator output terminal and connect the other end of the jumper to a short stiff piece of wire at least 1-½" long. A piece of paper clip wire will be suitable. Insert this wire into the small hole in the end of the brush holder so that it firmly contacts the outer brush terminal. (See Figure 2.)

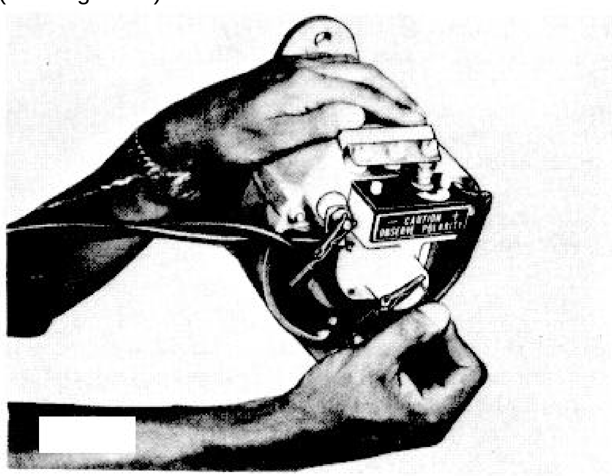


FIG. 2

If the voltmeter reading now rises with the engine at a fast idle, the alternator is OK and the fault is in the regulator or diode trio. Remove the diode trio and test. (See '"Component Testing" .) If the diode trio tests OK, the regulator should be replaced.

The alternator may also be checked for output across each phase by using a test light as shown in Figure 3. The test light should be constructed from a two-filament sealed beam unit connected in such a manner that the filaments are in parallel. Such a light will act as a load as well as an indicator and should light with equal brilliancy on each phase. If the lamp is noticeably dimmer on one or two phases, a defective diode trio, stator or power diode is indicated. If the diode trio tests OK, then the alternator must be removed and dismantled for further tests.

The voltage regulator used in these alternators is a solid state device and for this reason will normally have an extremely long life. It can, however, be damaged by mechanical or electrical abuse.

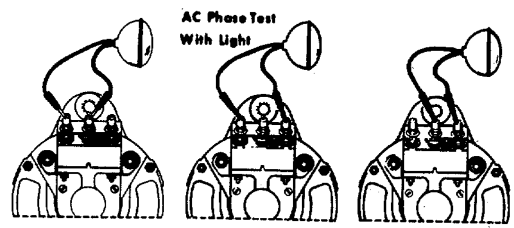


FIG. 3

If the system polarity is inadvertently reversed by installing a battery backwards, boosting or jump starting with the jumper connected backwards or reversing the positive and negative alternator output leads when changing an alternator, the voltage regulator will be damaged. Although the polarity reversal may only be momentary and may not damage the alternator diodes, the regulator will still be damaged.

ADJUSTMENT

Prior to adjusting alternator voltage, the wiring and connections should be checked and repaired as needed. The batteries should be fully charged and the engine should be running at a fast idle. Turn off all vehicle loads such as lights, radios, heaters, air conditioners, etc., when checking or adjusting voltage. An accurate voltmeter should be connected across the batteries to determine the charging voltage. Do not rely on dash mounted vehicle instruments. These are excellent indicators but usually lack the extreme accuracy required for regulator adjustment. Remove the nylon screw from the regulator (see Figure 1) and with a small screwdriver carefully turn the adjusting screw clockwise to raise or counterclockwise to lower the voltage. The ideal voltage setting will be a value which maintains a fully charged battery without resulting in an excessive usage of battery water.

When turning the voltage adjustment screw, do not attempt to force it past its stop as damage will result. Be sure to replace the nylon screw in the regulator adjustment hole to prevent the entrance of water and dirt.

REGULATOR REPLACEMENT

The entire regulator-brush housing must be removed from the alternator.

1. Remove the diode trio lead from the regulator charge light terminal.

2. Remove the 5/16-18 and ¼-20 nuts from the positive and negative alternator output terminals, which will free the regulator jumpers.

3. Remove the four 8-32 screws securing the regulator brush housing in place. Remove the assembly. Refer to Figure 4.

4. Remove the two 6-32 nuts holding the regulator and positive and negative jumpers in place.

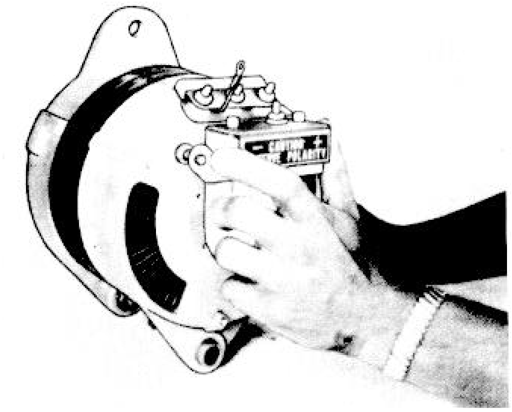


FIG. 4

5. Remove the regulator from the brush holder housing. The brushes can now be checked. Replace the brushes or regulator if necessary.

6. Reinstall the regulator and brushes in the housing; attach the jumpers and tighten the nuts holding the assemblies together.

7. Using a small screwdriver push and pin the brushes in place; start pin from outside of housing. (A suitable pin can be made using drill rod material or a 1/32" diameter drill.) Refer to Figure 27.

8. Reinstall the regulator-brush housing assembly and the "O" ring. Use a drop of Loctite Grade "A" on the four brush-housing screws.

9. Remove the retaining pin, allowing the brushes to contact the slip rings.

10. Reinstall the nuts on the alternator output terminals and reconnect the diode trio lead to the regulator charge light terminal.

11. Connect the alternator output leads to the pro- per alternator terminals. Momentarily flash the field by connecting a jumper between the charge indicator light terminal on the regulator and the positive alternator terminal. (Do this regardless of whether the alternator will be used on a positive or negative ground system.) Refer to Figure 5.

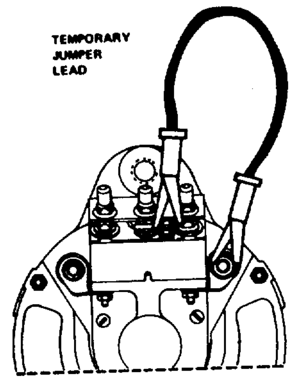


FIG. 5

DISASSEMBLY PROCEDURES

1. Remove the flange locknut or shaft nut and washer. With a gear puller remove the pulley. Next remove the fan, the drive key and fan spacer.

2. Remove the diode trio lead from the top of the regulator and remove the 5/16-18 and 1/4-20 nuts from the positive and negative alternator output terminals which will free the regulator jumpers for the regulator and brush holder housing assembly removal.

3. Remove the four 8-32 screws holding the regulator and brush holder assembly in place. Carefully remove this assembly. (See Figure 4.)

4. Remove three nuts and lift diode trio off of AC terminal studs. (See Figure 6.)

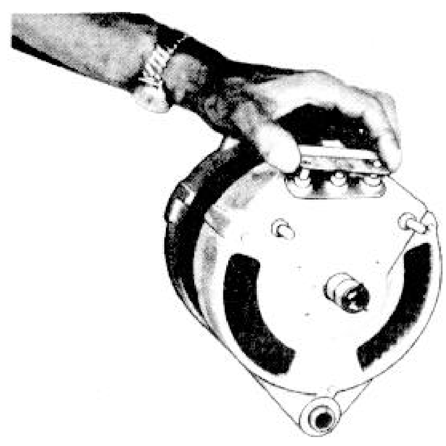


FIG. 6

5. Remove three self-locking nuts and through bolts.

6. Remove rotor and drive end housing assembly from stator and slip ring end housing assembly. If drive end housing binds on stator, loosen by tapping gently on mounting ear with fibre hammer. Be sure that drive end housing separates from stator and that stator remains attached to slip ring end housing to avoid damage to stator leads. (See Figure 7.)

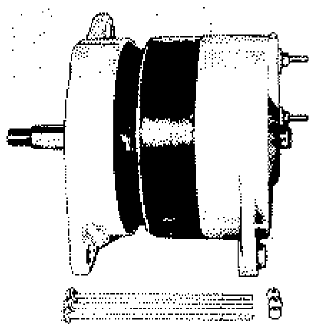


FIG. 7

7. Remove three nuts which secure stator leads to terminals and remove stator.

8. Remove nuts from positive and negative output terminal bolts and remove these bolts.

9. Remove three hex screws and remove capacitor connected between the heat sinks.

10. Remove two screws, lockwashers, guardwashers and insulating washers which retain lower end of heat sinks. Remove heat sinks. Note location of insulating washers and bushings. (See Figure 8.)

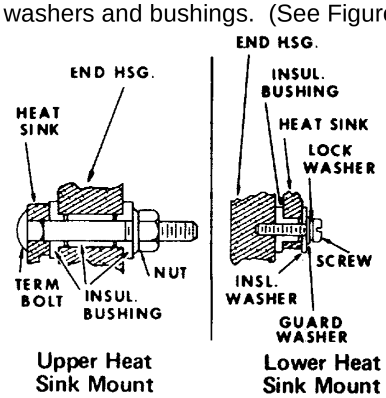


FIG. 8

11. Remove terminal stud insulating bushings from housing. There are three bushings in each terminal hole. (See Figure 8.)

12. Slip ring end roller bearing replacement should seldom be required. If it should become necessary, remove the inner seal and pull the bearing out of the housing inward, using a standard puller. The final seal may be removed, using a 1/8" (.125) pin. Using the two clearance holes, the seal can be tapped inward. (See Figure 9.)

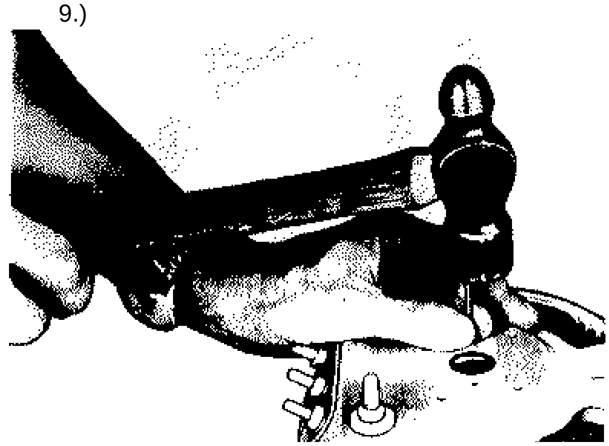


FIG. 9

13. Using a puller or arbor press, remove the drive end housing and bearing assembly from the rotor shaft. (See Figure 10.)

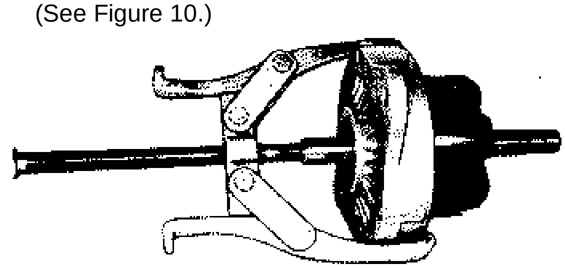


FIG. 10

14. Remove four screws and bearing retainer; press bearing and seal out of drive end housing.

COMPONENT TESTING

Before performing these tests, carefully inspect all parts for wear, cracks, breakage or other mechanical defects.

Discard all damaged parts.

Diode Tests

These tests may be performed on heat sink assemblies without removing them from the end housing. If they are tested in this manner, remove the stator. Be sure the diode trio has been removed from the AC studs and disconnect the capacitor between the lower end of the heat sinks.

Diodes are tested to insure that they only pass current in one direction. Diodes which do not allow current to flow in either direction are open while diodes passing current both ways are shorted. Diodes should be checked with a diode tester; but in emergencies where one is not available, an ohmmeter or a battery powered test light may be substituted.

Positive Heat Sink Tests

NOTE:

The positive heat sink is the one to which the positive output terminal is connected. The square hole in the terminal end of the positive heat sink is larger than the terminal hole of the negative heat sink, approximately 11/32" square.

1. Connect the positive lead of the diode tester, ohmmeter or test lamp to the positive heat sink and touch the negative test lead to each of the three diode terminals. A high resistance should be indicated and if a test lamp is being used, it should not light. If any of the three diodes shows slow resistance or the test lamp lights, the diode is shorted. (See Figure 11.)

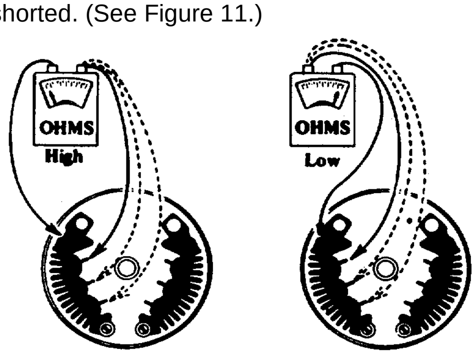


FIG. 11 *FIG. 12*
POSITIVE HEAT SINK TEST

2. Reverse the test leads so that the negative test lead is connected to the positive heat sink. The positive test lead should now be touched to each diode terminal and a low resistance reading should be obtained. If a high resistance reading is obtained or the test lamp fails to light, an open diode is indicated. (See Figure 12.)

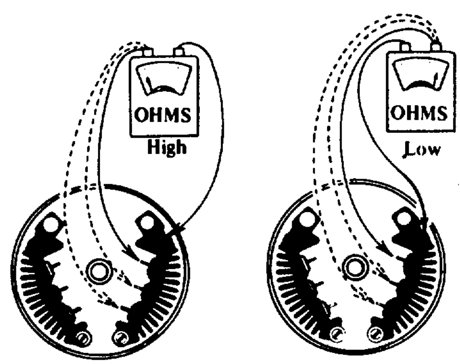
   If a shorted or open diode is detected in the preceding tests, the entire heat sink assembly should be replaced.

Negative Heat Sink Tests

NOTE

The negative heat sink terminal hole is approximately 9/32" square.

1. Connect the negative lead of the diode tester, ohmmeter or test lamp to the negative heat sink and touch the positive test lead to each of the three diode terminals. A high resistance should be indicated and if the test lamp is being used, it should not light. If any of the three diodes shows a low resistance or the test lamp lights, the diode is shorted. (See Figure 13.)



NEGATIVE HEAT SINK TEST
FIG. 13 *FIG. 14*

2. Reverse the test leads so that the positive test lead is connected to the negative heat sink. The negative test lead should now be touched to each diode terminal and a low resistance reading should be obtained. If a high resistance reading is obtained or the test lamp fails to light, an open diode is indicated. (See Figure 14.)

   If a shorted or open diode is detected in the preceding tests, the entire heat sink assembly should be replaced.

Diode Trio Test

The diode trio may be tested with the same equipment which was used to check the diodes in the heat sink assemblies.

1. Connect the negative lead of the tester to the output lead of the diode trio and touch the positive tester lead to each of the three copper terminal pads. (See Figure 15.) A low resistance should be indicated and if a test lamp is being used, it should light.

2. Connect the positive terminal of the tester to the output lead of the diode trio and touch the negative lead to each of the three copper terminal pads. A high resistance should be indicated and if a test lamp is being used, it should not light. Discard any diode trio which does not pass all of these tests.

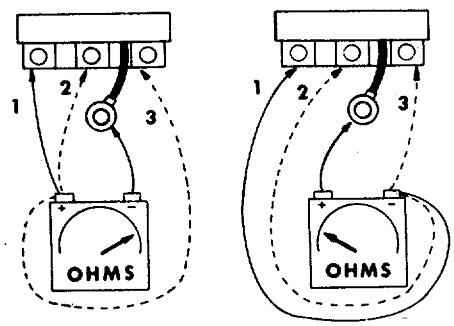


Fig. 15

Low Resistance Diode Trio Test High Resistance

Capacitor Test

The capacitor connected across the heat sinks may be tested on a capacitor tester if available. Its value is .158 MFD and 100 working volts D.C.

In the absence of a capacitor tester, the unit may be checked for shorts by means of an ohmmeter connected across the terminals. A low resistance reading indicates a shorted or leaking capacitor which should be replaced. (See Figure 16.)

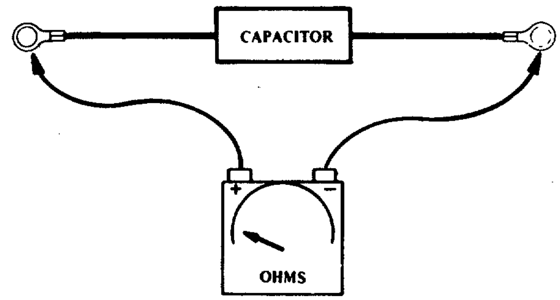


Fig. 16
CAPACITOR TEST

Voltage Regulator Test

The regulator circuitry contains devices connected in such a manner that parallel or "sneak" circuits exist, making it impossible to electrically test each individual component, as several will be in the circuit at the same time. For this reason, point to point resistance checks with an ohmmeter may be inconclusive or misleading. The regulator can be most accurately tested by installing it in an alternator known to be serviceable.

The voltage regulator assembly consists ,f a number of individual components such as capacitors, resistors, diodes and transistors, mounted upon and electrically connected by a printed circuit panel. Because these components are permanently fastened to the panel, their replacement is not recommended. When it has been determined that a voltage regulator is unserviceable, it should be discarded and a new assembly installed in its place. (See Figure 17.)

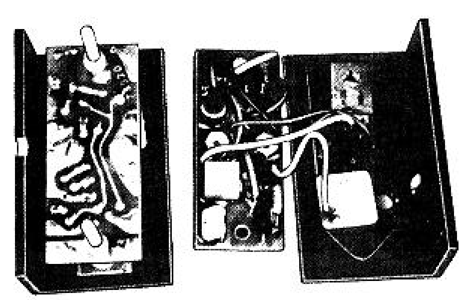


FIG. 17

Rotor Test

The rotor should be checked for grounds and proper coil resistance with an ohmmeter.

1. With the ohmmeter connected between the rotor shaft or nut and either slip ring, no reading (infinity) should be obtained. If an ohmmeter reading other than infinity is obtained, the rotor coil is grounded and the rotor must be repaired. (See Figure 18.)

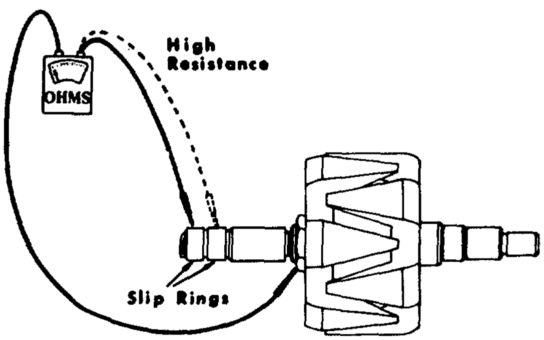


FIG. 18
Rotor Coil Ground Test

2. Check rotor coil resistance by connecting the ohmmeter across the two slip rings. (See Figure 19.) The resistance should be 3.0 3.3 ohms. If the resistance values should differ significantly from these figures then the coil will have to be replaced. Before condemning a rotor for an open coil, check the solder connections at the slip ring leads, as a poor connection at either of these leads will test the same as an open coil.

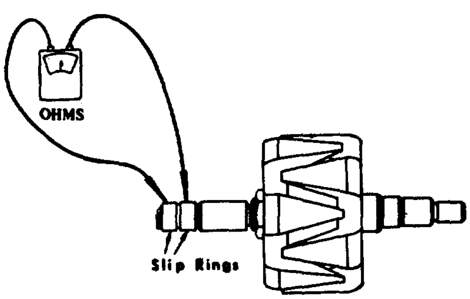


FIG. 19
Rotor Coil Resistance Test

Stator Test

Due to the extremely low resistance of the stator windings, it is not possible to measure their resistance with a conventional ohmmeter. The stator should, therefore, be tested for grounds and continuity between phases with a test light. A 115-220 volt test light is preferred as the higher voltages applied to the stator increase the chances of detecting a faulty or borderline unit. Do not attempt to check stator in this manner while they are still connected to the heat sinks. Remove the stator from the alternator before testing. (See Figure 20 for stator test.) Discard any stator which appears overheated and has charred insulation regardless of how it tests.

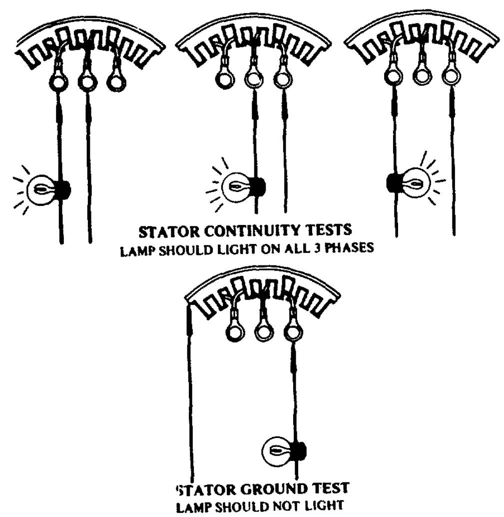


Fig. 20

SLIP RING REPLACEMENT

The slip ring assembly used in this alternator is of extremely sturdy construction and will seldom require replacement. If it should become damaged in some way, such as dropping the rotor, it may be replaced in the following manner.

1. Straighten the slip ring tabs, unsolder both connections and straighten the coil leads.

2. Using a suitable puller, remove the slip ring assembly. (See Figure 21.)

NOTE

The separator and puller shown in Figures 21 and 22 can be obtained through the Snap-On Tool Co. CG 949 Bearing Separator CG 240 Puller.

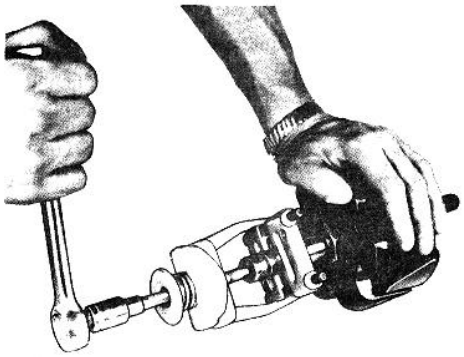


FIG. 21

3. Check for frayed or cracked insulation sleeving; replace this sleeving as necessary. Check the rotor coil resistance before replacing the slip ring assembly. The resistance should be 3.0 - 3.3 ohms.

4. Clean the rotor shaft and apply a small amount of Loctite Grade "A" to the section of the shaft where the slip ring assembly will be positioned.

5. Position the new slip ring assembly on the shaft so that the slot in the slip ring is lined up with the slot in the shaft which carries the rotor leads. Carefully press the slip ring assembly onto the shaft until the assembly is against the inner bearing race.

6. Solder the rotor coil leads to the slip ring tabs. Bend the tabs to allow clearance in the brush-regulator housing.

7. Chuck the rotor assembly in a lathe and true up the slip rings. Maximum slip ring run out is .002.

ROTOR COIL REPLACEMENT

If the preceding tests indicate an open, shorted or grounded rotor coil, it may be replaced in the following manner.

1. Remove the slip ring assembly as described in the "Slip Ring Replacement" section.

2. Remove the 1" x 14 nut and slot insulator from the rotor shaft.

3. Using a suitable puller, the inner bearing race may now be removed from the rotor shaft. (See Figure 22.)

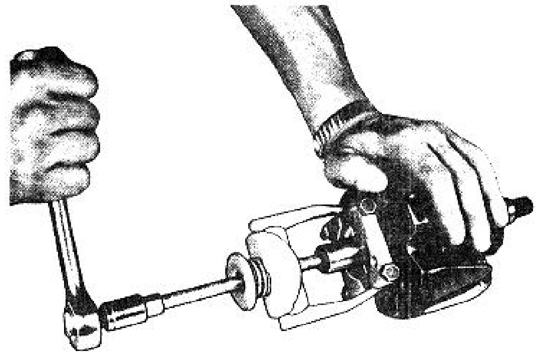


FIG. 22

4. Rotor halves, coil and hub may now be pulled from rotor shaft and separated.

NOTE

When removing hub from old rotor coil or when removing rotor halves, do not 'J pound on them in such a manner as to raise burrs on them. It is extremely important that both rotor halves fit tightly against the hub so as to maintain a good magnetic circuit. Burrs or foreign matter will prevent a tight fit and consequently reduce the alternators output.

Do not replace one rotor half or attempt to substitute one from another rotor. These pieces must be used together as supplied or the rotor will be seriously out of balance.

5. Install the new rotor coil; dress the leads to follow the route of the original coil leads.

6. Reassemble the parts in reverse order of disassembly. Be sure that no burrs or foreign matter prevent the rotor halves from seating evenly against the hub. Be sure that the plastic slot insulator is in place and use Loctite Grade "A" on the nut threads before installing the nut. Torque the nut to 110 ft.lbs.

7. The inner bearing race may be reused if not damaged. Press the used or new bearing race on the shaft. The outside diameter chamfer must be installed toward the slip rings. The inner edge should be 9/64" from the 1" x 14 threads. (See Figure 23.)

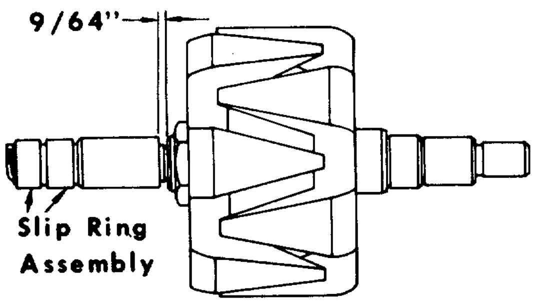


Fig. 23
Location of Slip Ring

8. After the rotor has been assembled, thoroughly paint it with Glyptol or other insulating varnish, being certain that the varnish flows around the coil and rotor iron but does not get on the slip rings, inner bearing race or shaft. After the rotor has been painted, wipe the excess varnish from the outside of the rotor to avoid rubbing against the stator when the unit is reassembled.

REASSEMBLY

1. Press drive end bearing into housing with seal facing outward. When pressing bearing apply force to outer race to avoid brinnelling the bearing by applying pressure through the balls.

2. Press the new drive end bearing seal (approximately 2" outside diameter and 1-1/8" inside diameter) into the bearing retainer. See Figure 24 for proper installation of the seal.

3. Fill the cavity of the seal completely full (1/4 ounce or 7 to 9 grams) of Chevron SRI-2 grease or equivalent and install retainer and seal assembly in housing using four flat heat screws.

4. Lubricate the bearing seal with SRI-2 grease.

5. Press housing and bearing assembly on the rotor shaft.

NOTE

Use a sleeve around the shaft so that the force will be exerted on the inner race of the bearing.

6. Reinstall the heat sinks in the slip ring end housing. Be sure that the upper and lower insulating washers and bushings are in their proper location. Refer to Figure 8 for the correct order of assembly. Be sure that the mating surfaces of the heat sinks, terminals and terminal bolts are clean and free of paint to insure a good electrical connection.

7. Reinstall the capacitor.

8. If the slip ring bearing and seals have been removed, press in a new rear seal (approximately 1-9/16" outside diameter) against the rear surface of the slip ring housing. The metal lip of the seal will contact the rear of the housing when properly installed, (See Figure 24.)

9. Fill the rear seal grease cavity with SRI-2 grease.

10. Fill the new roller bearing with SRI-2 grease. The bearing must have a minimum of 50% grease fill within the void of the outer race, cage and roller assembly.

11. Press in the slip ring roller bearing to the 15/16" dimensions shown in Figure 24.

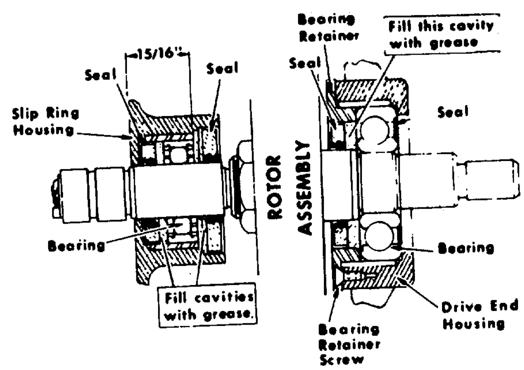


Fig. 24

12. Fill the grease cavity of the largest rear seal (approximately 211 outside diameter and 7/8" inside diameter) and press in the housing with the metal lip toward the inside of the housing. Refer to Figure 24.

13. Reinstall the stator and terminal nuts It is advisable to align the stator and housing by temporarily installing the thru bolts.

14. Place a protective cap over the slip rings before assembling the slip ring housing assembly to the rotor and drive end housing assembly. The cap protects the slip rings from contamination and aligns the seals. Refer to Figure 25 for details of cap construction.

15. Lubricate both slip ring bearing seals with SRI-2 grease.

16. Install the slip ring housing assembly over the rotor and drive end housing assembly. (Refer to Figure 26.)

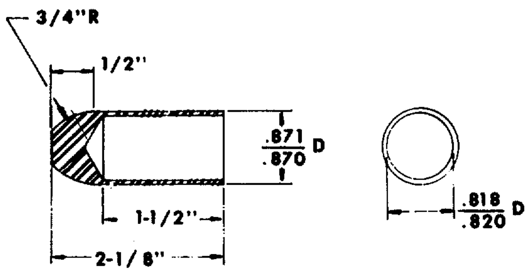


Fig. 25

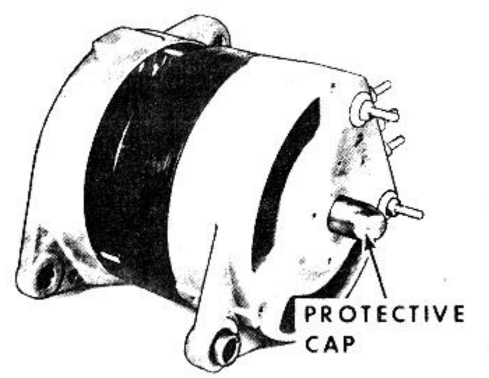


FIG. 26

17. Be sure that both housing and the stator are aligned; insert the three thru bolts and tighten the self-locking nuts to 50-60 in.lbs. torque.

18. Install diode trio on the three "AC" terminal studs as shown in Figure 6.

19. If the regulator has to be removed for brush inspection or replacement, replace the necessary parts.

20. Reinstall the regulator and brushes in the housing; attach the jumpers and tighten the nuts holding the assemblies together.

21. Using a small screwdriver, push and pin the brushes in place; start pin from outside of housing. (A suitable pin can be made using drill rod material or a 1/32" diameter drill.) (Refer to Figure 27.)

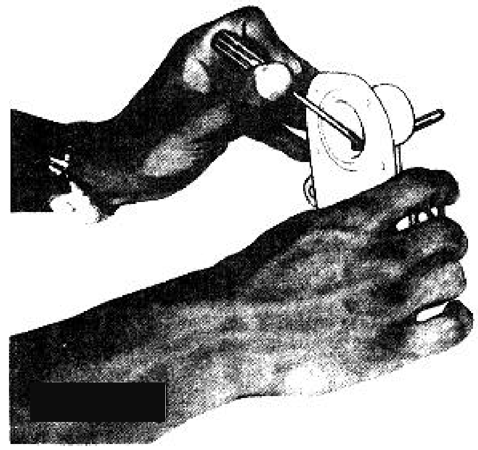


FIG. 27

22. Reinstall the regulator-brush holder housing assembly and "O" ring. Use a drop of LOCTITE GRADE "A" on the four brush housing screws.

23. Remove the retaining pin, allowing the brushes to contact the slip rings.

24. Reinstall the nuts on the alternator output terminals and reconnect the diode trio lead to the regulator charge light terminal.

TESTING

Because of the integral regulator used on this alternator, the test block hook-up is very simple, consisting of connecting the positive and negative output leads. If a commercial test block is not available, the test setup shown in Figure 28 may be used.

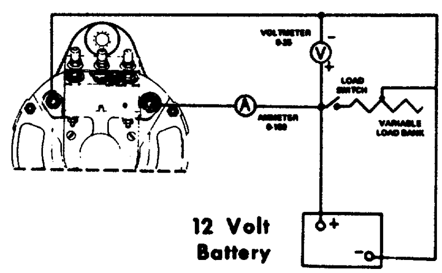


Fig. 28

Before beginning the test and after the battery has been connected, momentarily flash the field by connecting a jumper between the diode trio terminal (charge indicator light terminal) and the alternator positive output terminal. (See Figure 5.) This will restore the residual magnetism which may have been weakened by handling or repair procedures.

The cut-in speed of the alternator is that rotor speed at which the unit first begins to produce output. This speed should not be higher than 1500 rotor RPM.

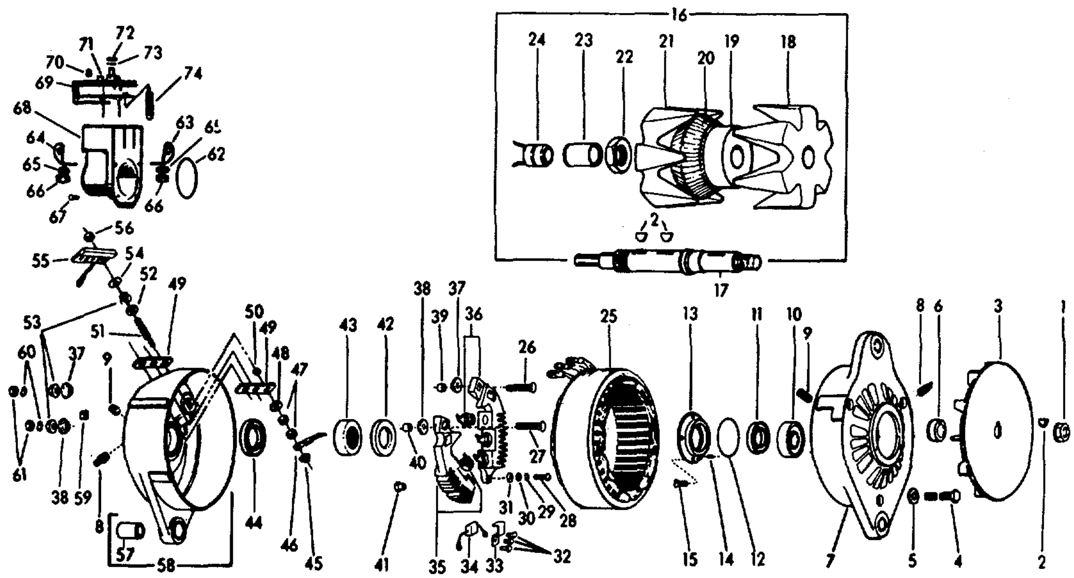


Fig. 29 EXPLODED VIEW OF ALTERNATOR

Legend for Exploded View of Alternator

Key No.	Description
1.	NUT, Flange Lock
2.	KEY, Woodruff
3.	FAN, Assembly
4.	SCREW, (3)
5.	WASHER, Belleville (3)
6.	SPACER, Fan
7.	HOUSING, Drive End
8.	Not Used
9.	Not Used
10.	BEARING
11.	SEAL, Oil
12.	Not Used
13.	RETAINER, Bearing
14.	Not Used
15.	SCREW, (4)
16.	ROTOR, Assembly
17.	SHAFT, Rotor
18.	CORE, Rotor
19.	HUB, Rotor
20.	COIL, Assembly
21.	CORE, Rotor
22.	NUT
23.	RACE, Bearing
24.	SLIP RING, Assembly
25.	STATOR, Assembly
26.	SCREW, Terminal
27.	SCREW, Terminal
28.	SCREW, (2)
29.	WASHER, Lock (2)
30.	WASHER, Guard (2)
31.	WASHER, Insulation (2)
32.	SCREW, (3)
33.	CLAMP
34.	CAPACITOR
35.	RECTIFIER, Assembly (+)
36.	RECTIFIER, Assembly (-)
.37.	BUSHING, Insulation (2)
38.	BUSHING, Insulation (2)
39.	BUSHING, Insulation
40.	BUSHING, Insulation
41.	BUSHING, Insulation (2)
42.	SEAL, Oil
43.	BEARING
44.	SEAL, Oil
45.	NUT, (3)
46.	LEAD, Terminal (3)
47.	NUT, (6)
48.	WASHER, Guard (3)
49.	INSULATOR, (2)
50.	BUSHING, Insulation (3)
51.	STUD, Terminal (3)
52.	WASHER, Guard (3)
53.	NUT, (5)
54.	WASHER, Guard (3)
55.	TRIO, Diode
56.	NUT, Lock (3)
57.	BUSHING, Slideable
58.	HOUSING, Slip Ring End
59.	NUT, Stop (3)
60.	WASHER, Lock (2)
61.	NUT, (2)
62.	RING, Sealing
63.	JUMPER
64.	JUMPER
65.	WASHER, Lock Shakeproof (2)
66.	NUT, (2)
67.	SCREW, (4)
68.	HOLDER, Brush
69.	REGULATOR, Voltage
70.	SCREW (PLUG)
71.	CAP, (2)
72.	NUT
73.	WASHER LOCK, Shakeproof
74.	BRUSH, (2)

ALTERNATOR
(DELCO-REMY)

30-SI AND 30-SI/TR SERIES

Code	Rating
08155	90 Amp
08159	90 Amp

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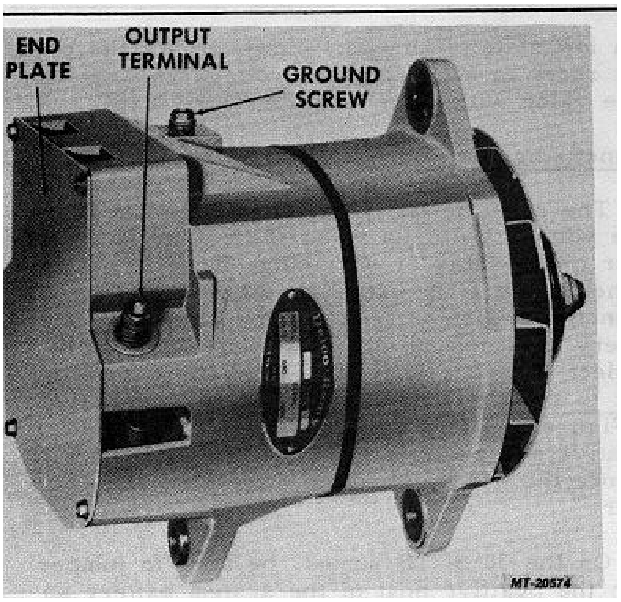

Fig. 1. 30-SI Series Alternator

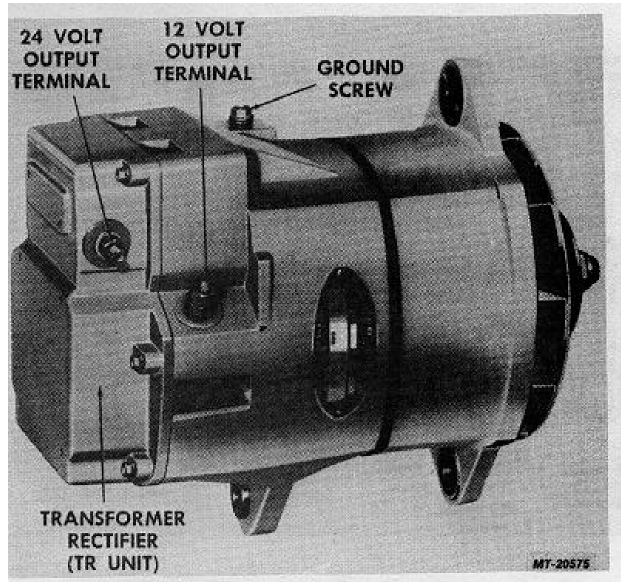

Fig. 2 30-SI/TR Series Alternator

DESCRIPTION

The 30-SI and 30-SI/TR series alternators shown in Figures 1 and 2 feature a solid state regulator mounted inside the end frame. The regulator voltage setting can be adjusted externally by repositioning a voltage regulator adjustment cap in the rectifier end frame. On some models a relay terminal provides about one half system voltage to which accessories can be connected.

The 30-SI series (Figures 1 and 3) uses one wire with an adequate ground return to charge the vehicle battery in the usual manner.

The 30-SI/TR series (Figures 2 and 4) is a standard 30-SI with a transformer-rectifier (TR) unit mounted on the end frame. The TR unit provides a separate voltage to charge a cranking battery. The cranking ("C") battery is connected in series with the system ("S") battery to provide 24 volt cranking. When the engine is running, the cranking battery is charged at a low rate to maintain its full state of charge. The vehicle electrical system, except for the cranking motor, is 12 volt. The 30-SI/TR eliminates the need for a series-parallel switch and associated wiring.

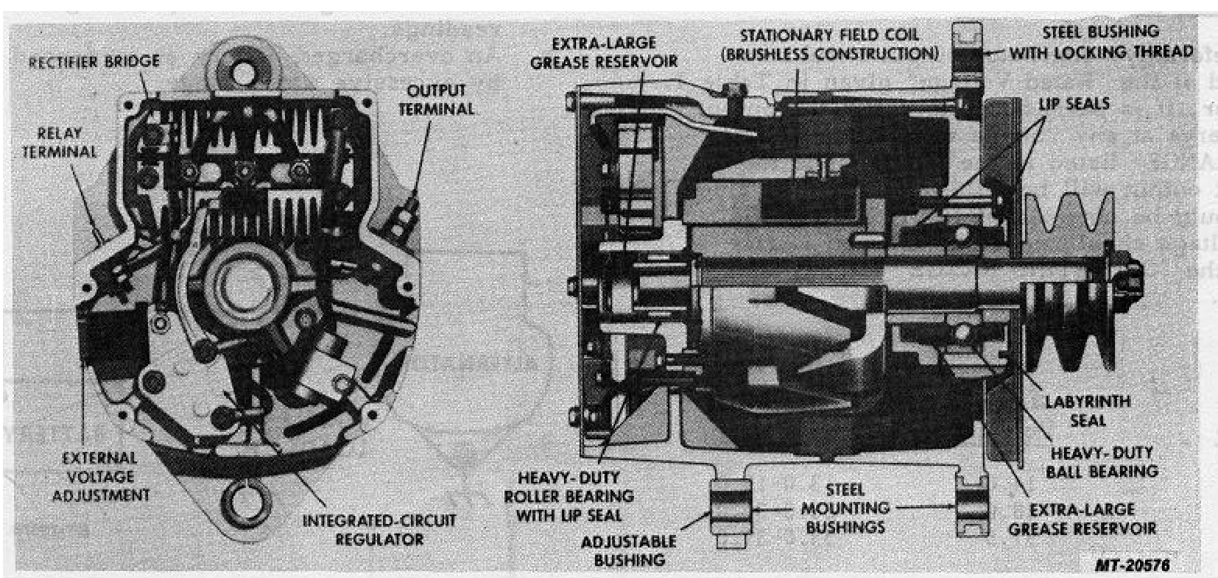

Fig.3 Cross Section View of 30-SI Series Alternator

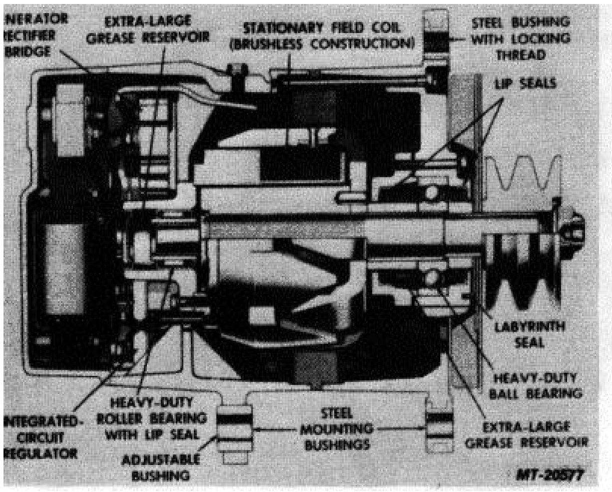

Fig. 4. Cross Section View of 30-SI/TR Series Alternator

TROUBLE SHOOTING PROCEDURES

Energizing Speed

The energizing speed is the rpm at which the regulator turns on to energize the field coil. This speed is higher than some speeds at which output can be obtained. Therefore, when checking output at low speeds, increase the speed until the regulator turns on, then reduce the speed to check the output. No output can be obtained until the regulator turns on. Once the regulator turns on, it will remain turned on until the engine is stopped.

Rated Voltage

Preferably, alternator output should be checked at the "Rated Voltage" given in Table 1. However, it is permissible to check the output in amperes at any voltage within the "OPERATING RANGE" listed in the table, since the current output will be quite close to the value that would be obtained at "RATED VOLTAGE". The voltage should never be allowed to rise above the "OPERATING RANGE" for any length of time.

TABLE 1

System Voltage	Rated Voltage	Operating Range
12	14.0	13.0-15.0
24	28.0	26.0-30.0
32	37.5	33.0-39.0

It should be noted that the voltage may be below the "OPERATING RANGE" if the battery is in a, low state of charge. However, as the battery receives a charge, the voltage will rise to 'kj some value within the "OPERATING RANGE".

Magnetizing the Rotor

The rotor normally retains magnetism to pro ' vide voltage build-up when the engine is started. After disassembly or servicing, however, it may be necessary to re-establish the magnetism. To magnetize the rotor, connect the alternator to the battery in a normal manner, then momentarily connect a jumper lead from the battery positive post to the alternator relay terminal, identified in Figure 3. This procedure applies to both negative and positive ground systems, and will restore the normal residual magnetism in the rotor.

On the 30-SI/TR series, be sure to jumper from the positive post of the system battery so that 12 volts will be applied to the relay terminal. On alternators without a relay terminal, remove the end plate and jumper from the battery positive post to one of the stator lead terminals on the rectifier bridge.

30-SI Series:

A cross-sectional view of a typical 30-SI is shown in Figure 4. A basic wiring diagram is shown in Figure 5. (For actual Wiring Schematic, refer to appropriate vehicle wiring diagram in the TRUCK SERVICE MANUAL)

Trouble in the charging system will show up as one or more of the following conditions:

a. An undercharged battery as evidenced by slow cranking and low specific gravity readings.

b. An overcharged battery as evidenced by by excessive water usage.

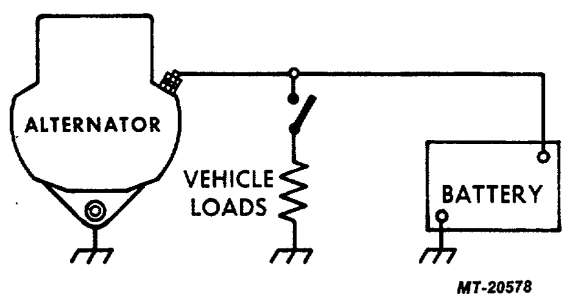

Fig. 5. Typical 30-SI Wiring Circuit

UNDERCHARGED BATTERY

This condition, is evidenced by slow cranking and low specific gravity readings, can be caused by one or more of the following conditions:

1. Insure that the undercharged condition has not been caused by accessories having been left on for extended periods.

2. Check the drive belt for proper tension.

3. If a battery defect is suspected, check battery as instructed in "BATTERY" section of the Truck Service Manual.
4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.
5. Connect a voltmeter from "BAT" terminal on alternator to ground. A zero reading indicates an open between voltmeter connection and battery.
6. If previous Steps 1 through 5 check satisfactorily, check alternator as follows:
   a. Disconnect battery ground cable.
   b. Connect an ammeter in the circuit at the "BAT" terminal of the alternator.
   c. Reconnect battery ground cable.
   d. Turn on accessories. Connect a carbon pile across the battery.
   e. Operate engine at moderate speed (to provide 4000 alternator rpm or more) and adjust carbon pile as required, to obtain maximum current output.

IMPORTANT

Initial voltage buildup is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.

   f. If ampere output is within 10 amperes of rated output, alternator is not defective. In this case, an adjustment of the voltage setting may correct the undercharged condition. Raise the setting by removing the voltage adjusting cap, rotating in increments of 90 deg., and then reinserting the cap in the connector body. As illustrated in Figure 6 the cap is set for medium high voltage. The lowest setting is with position "LO" aligned with the arrow. With position 2 aligned with the arrow, the setting is increased to medium low, position 3 is medium high, and position "HI" is the highest regulator setting. After adjusting the setting, check for an improved battery condition after a service period of reasonable length, such as one week.

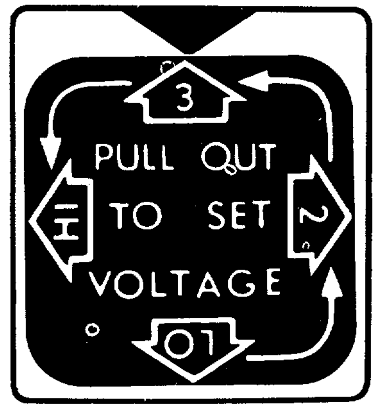

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Fig. 6. Voltage Adjustment Cap

   g. If ampere output is not within 10 amperes of rated output, remove alternator and repair as instructed under "REPAIR PROCEDURES" .

OVERCHARGED BATTERY

1. Check battery. Remember that an overheated battery may be overcharged even though no charging circuit defects are present.
2. If battery is not defective or overheated, connect a voltmeter between alternator "BAT" terminal and ground.
3. With all accessories turned off, increase engine speed as required to obtain maximum voltage reading.
4. If voltage exceeds 15 volts on a 12-volt system, 30 volts on a 24-volt system or 39 volts on a 32-volt system, #remove alternator for repair as instructed under "REPAIR PROCEDURES".
5. If voltage does not exceed the values listed in Step 4 preceding, adjust voltage to a lower value by removing voltage adjusting cap and re-inserting into connector body. Then check battery condition after a service period of reasonable length, such as one week. Figure 6 shows the cap adjusted for medium high setting. The lowest setting is with "LO" aligned with the arrow, position 2 is medium low, position 3 is medium high, and "HI" is the highest setting.

30-SI/TR Series:

A cross-sectional view of a typical 30-SI/TR is shown in Figure 4. A basic wiring diagram is shown in Figure 7. (For actual wiring schematic, refer to appropriate vehicle wiring diagram in the TRUCK SERVICE MANUAL.) The 30-SI and system battery, or "S" battery, operate together in the normal manner in the 12-volt vehicle electrical system. The transformer rectifier, or TR unit, is an "add on" unit on the 30-SI generator. It charges the cranking battery or "C" battery which is connected in series with "S" battery to provide 24 volts to the cranking motor. When the engine is running, the "C" battery "floats on the line" and receives a low charge rate from the TR unit to maintain its full state of charge.

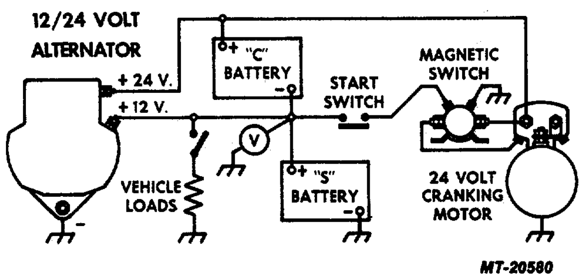

Fig. 7. Typical 30-SI/TR Wiring Circuit

UNDERCHARGED BATTERY

If <u>either</u> battery is undercharged, observe the following procedure:

1. DO NOT ALLOW LEADS OR TERMINALS TO TOUCH GROUND!

2. Completely remove the TR unit from the 30-SI generator as follows:

   a. Remove attaching screws.
   b. Pull TR unit away from 30-SI generator to expose lead connections.
   c. Detach three transformer leads from the three studs on the p0-SI rectifier bridge. Reassemble nuts onto 30-SI rectifier bridge studs.
   d. Detach remaining TR single lead from 30-SI rectifier bridge heat sink. Reattach screw.

3. The circuit is now a regular 12-volt 30-SI charging system connected to the "S" battery.

4. Check the 30-SI system as instructed in "Undercharged Battery" section, Page 5.

5. If a defect is found, repair as required and reinstall the TR unit.

6. If no defect is found, check the rectifier bridge on the TR unit as follows:

   Connect the ohmmeter to a heat sink and one of the three terminals (Fig. 8). Then reverse the lead connections to the same terminal. If both readings are the same, replace the rectifier bridge by detaching the necessary screws and nuts. A good rectifier bridge will give one high and one low reading. Repeat this same test between the same heat sink and the other two terminals and between the other heat sink and each of the three terminals. This makes a total of six checks, with two readings taken for each check on each rectifier bridge.

IMPORTANT

If rectifier bridge is constructed with flat metal clips at the three studs, press down very firmly onto flat metal clips and not only threaded stud.

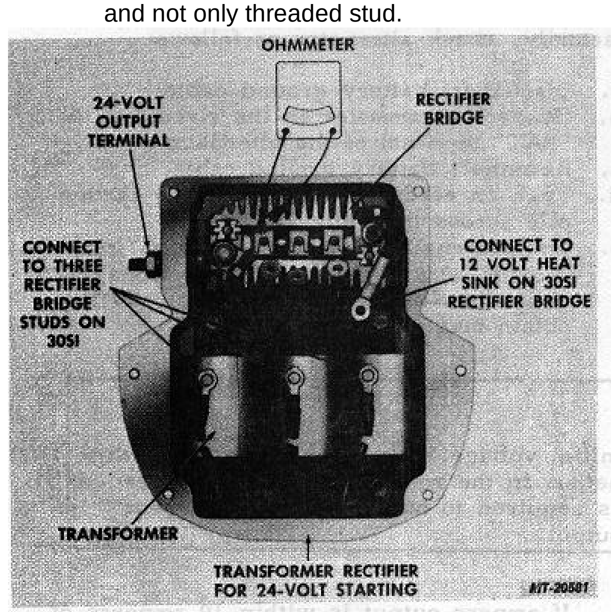

Fig. 8. Ohmmeter Checks of Rectifier Bridge Diodes in TR Unit

7. If still no defects are found, reinstall the TR unit onto the 30-SI generator.

8. Detach 24-volt lead from generator. DO NOT ALLOW LEAD TO TOUCH GROUND.

9. Connect ammeter between 24-volt TR terminal and disconnected lead.

10. Operate generator at speed sufficient to produce maximum output.

11. If "C" battery specific gravity is 1.200 or below, charge rate should be 5 amperes or more. If below 5 amperes, replace transformer in TR unit.

12. If above 5 amperes, the "C" battery specific gravity should rise above 1.200 if the engine is run a sufficient length of time.

OVERCHARGED BATTERY

1. If <u>either</u> battery is overcharged, or if both batteries are overcharged, check the overcharged battery for defects. Remember that an overheated battery may be overcharged even though no charging circuit defects are present.

2. If battery is not defective or overheated, connect a voltmeter between alternator 12-volt terminal and ground.

3. With all accessories turned off, increase engine speed as required to obtain maximum voltage reading.

4. If voltage exceeds 15 volts, remove alternator for repair as covered under "REPAIR PROCEDURES". The TR unit itself cannot cause overcharge, so it need not be checked.

5. If voltage does not exceed the value listed in Step 4 preceding, adjust voltage to a lower value by removing voltage adjusting cap and re-inserting into connector body. Then check battery condition after a service period of reasonable length, such as one week. Figure 6 shows the cap adjusted for medium high setting. The lowest setting is with "LO" aligned with the arrow, position 2 is medium low, position 3 is medium high and "HI" is the highest setting.

REPAIR PROCEDURES

Component parts and connections are shown in Figures 9, 10 and 11. Note that the diode trio has been removed in Figure 13 along with the end plate.

REGULATOR CHECK

The regulator cannot be checked with an ohmmeter. Use an approved regulator tester available from various test equipment manufacturers.

RECTIFIER BRIDGE CHECK

(Omit for .overcharged battery) To check the rectifier bridge, connect the ohmmeter to a heat sink and one of the three terminals (Step 1, Figure 13). Then reverse the lead connections to the same heat sink and same terminal.

If both readings are the same, replace the rectifier bridge by detaching the necessary screws and nuts. A good rectifier bridge will give one high and one low reading. Repeat this same test between the same heat sink and the other two terminals, and between the other heat sink and each of the three terminals. This makes a total of six checks, with two readings taken for each check on each rectifier bridge.

IMPORTANT

If rectifier bridge is constructed with flat metal clips at the three studs, press down firmly onto flat metal clips and not onto threaded stud.

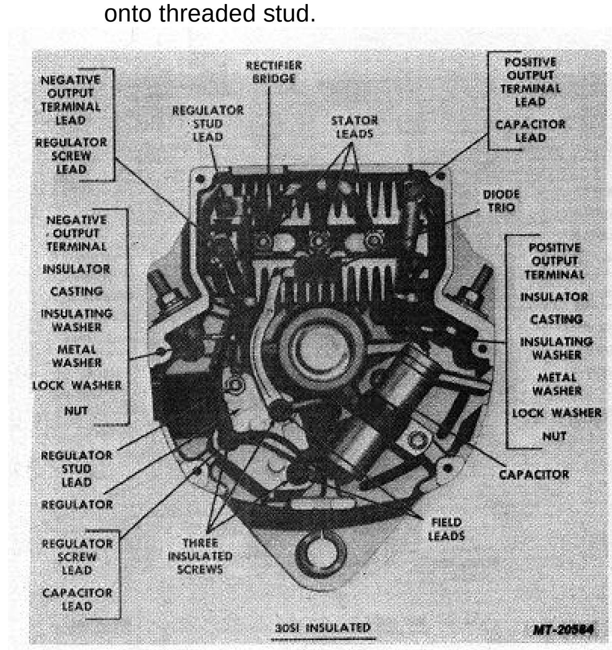

Fig. 9. Typical 30-SI (Negative Ground)

FIELD COIL CHECKS

To check for grounds, connect an ohmmeter to one field coil lead and to the end frame as illustrated in Step 2, Figure 13. If ohmmeter reading is low, the field coil is grounded.

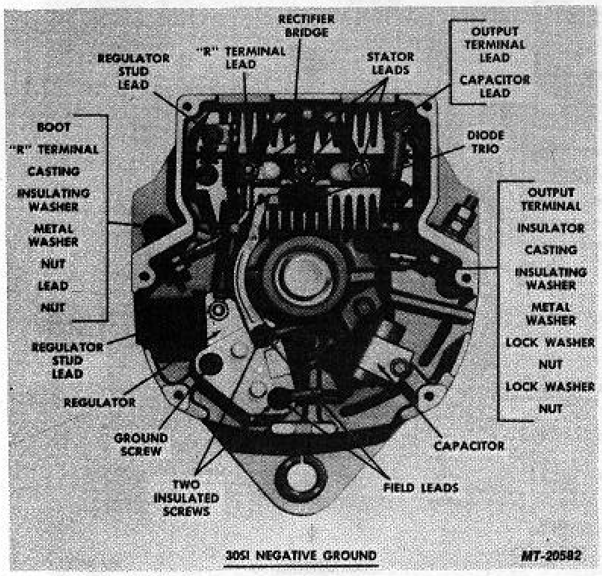

Fig 10. Typical 30-SI (Positive Ground)

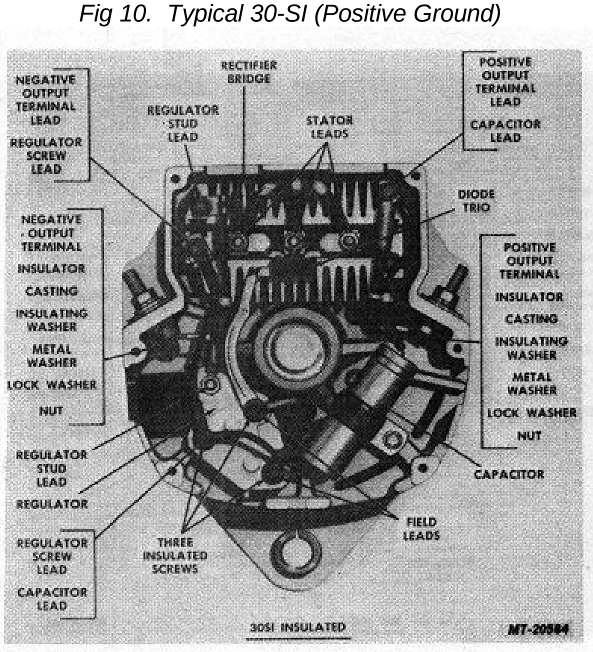

Fig. 11. Typical 30-SI (Insulated)

To check for opens, connect an ohmmeter to the two field coil leads as shown in Step 3, Figure 13. If ohmmeter reading is high (infinite), the field coil is open.

The winding is checked for short-circuits by connecting a battery and ammeter in series with the field coil. Note the ammeter reading and refer to "SPECIFICATIONS". An ammeter

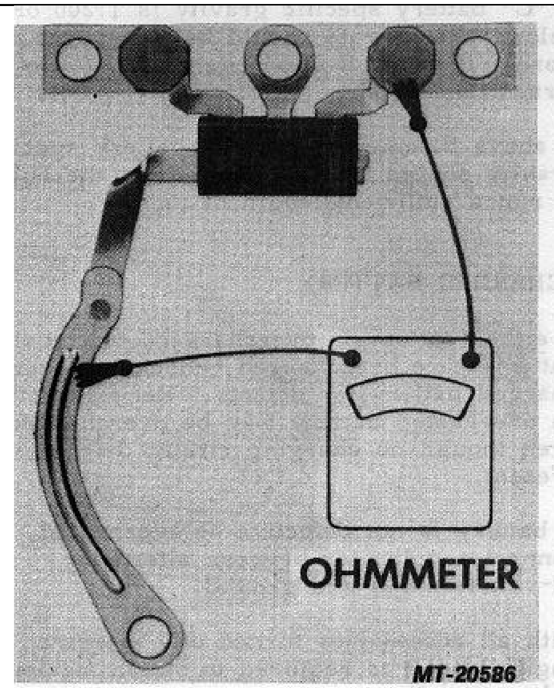

Fig. 12. Diode Trio Check

reading above the specified value indicates shorted windings. An alternate method is to check the resistance of the field by connecting an ohmmeter to the field coil. If the resistance reading is below the specified value, the winding is shorted. The specified resistance value can be determined by dividing the voltage by the current given in "SPECIFICATIONS". To replace the field coil, see the section entitled "Disassembly" .

DIODE TRIO CHECK

To check the diode trio, remove it from the end frame assembly by detaching the nuts and attaching screw. Note that the insulating washer on the screw is assembled over the top of the diode trio connector. Connect an ohmmeter having a 1 1/2 volt cell, and using the lowest range scale, to the single connector and to one of the three connectors (Fig. 12). Observe the reading. Then reverse the ohmmeter leads to the same two connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors.

STATOR CHECK

(Omit for overcharged battery.) Most stators are delta wound and only a check for grounds can be made with an ohmmeter. Connect from either lead to the frame (Step 4, Fig. 13). The reading should be infinite. If not, replace the stator. See "Disassembly".

If the regulator checks .good and if the generator fails to supply rated output, replace the stator if it is badly discolored.

DISASSEMBLY (Refer to Figure 3)

1. Remove screws and end plate.
2. Remove fan and pulley.
3. Remove 4 thru-bolts.
4. Separate Drive End frame and rotor from Rectifier End frame and stator.
5. Press rotor from end frame.
6. Remove collar from end frame.
7. Remove collar from shaft.
8. To replace field coil:
   a. Remove attaching bolts.
   b. Install new field coil and torque bolts to 6.2 N.m (55 in.lbs.).

BEARING REPLACEMENT AND LUBRICATION

1. To replace Drive End frame bearing:
   a. Remove 4 retaining plate attaching screws.
   b. Remove retainer plate and gasket.
   c. Push on inner race to remove bearing.
   d. Pull out seals from end frame and from retainer.
   e. Press in new seals with lip toward bearing.
   f. Press in new bearing against outer race.
   g. Fill retainer cavity half full with high temperature ball bearing lubricant (Delco-Remy No. 1948791 or equivalent.) Arrange lubricant so a portion will touch bearing when assembled.
   h. Assemble retainer with thru-bolts.
   i. Assemble inside collar over shaft.
   j. Assemble outer collar under seal next to bearing while supporting outer collar.
   k. Press rotor into drive end frame.
2. To replace Rectifier End Frame bearing:
   a. Pull inner race from shaft and bearing from end frame.
   b. Assemble new inner race and bearing as shown in Figure 3, with bearing seal away from grease reservoir.
   c. Fill reservoir half full with high temperature ball bearing lubricant (Delco-Remy No. 1948791 or equivalent.) Arrange lubricant so a portion will touch bearing when assembled.

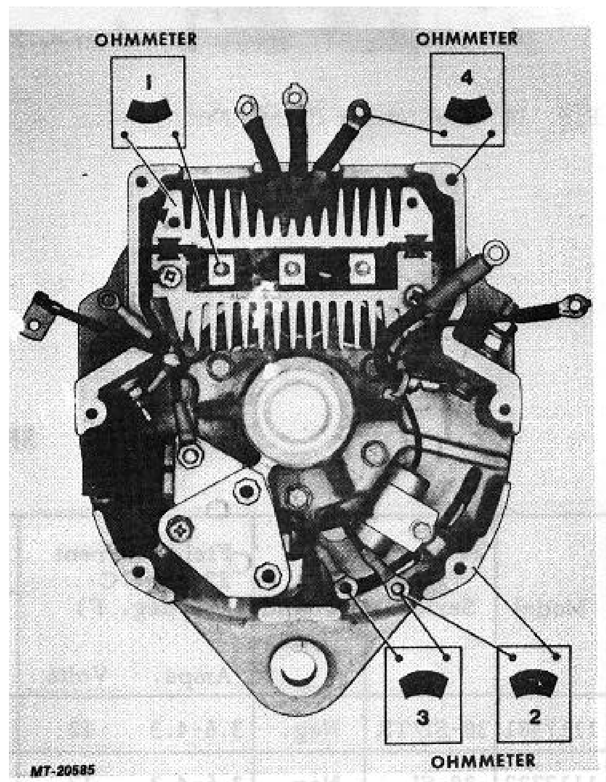

Fig. 13 Ohmmeter Checks

REASSEMBLY

Reassemble alternator components in reverse order of disassembly procedure.

To assist in tightening the drive pulley nut, a hexagon hole is provided in the rotor shaft for holding with an Allen Wrench. A special socket (Snap-On No. S-8183) which is cut away to receive the Allen wrench is available for use with a torque wrench to tighten the nut. Where desired, a length of pipe may be applied to the Allen wrench to provide additional lever- age for holding as shown in Figure 14. Tighten pulley nut to 95-108 N.m (70-80 ft.lbs.).

When installing alternator, tighten alternator mounting and adjusting strap bolts to 81-95 N.m (60-70 ft.lbs.).

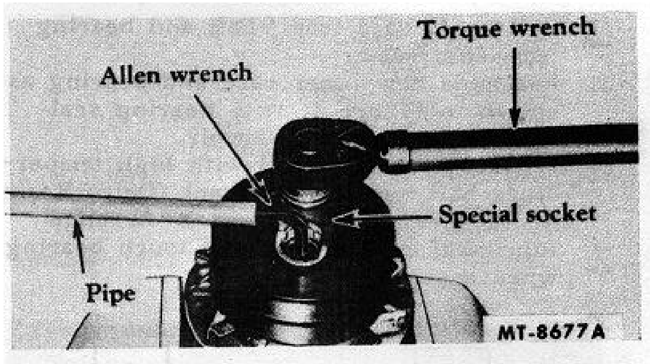

Fig. 14 Tightening Pulley Nut

SPECIFICATIONS

Model	Series	Ground	Field Current 27 deg. C (80 deg. F) Amps. Volts	Cold Output					Rated Hot Output (Amps.)
				Specified Volts	Amps.	Approx. RPM	Amps.	Approx. RPM*	
1117481	30-SI/TR	Neg.	3.6-4.3 12	13	68	2500	86	6500	90
1117732	30-SI	Neg.	3.6-4.3 12	13	72	2500	90	6500	90

* Alternator Speed.

ELECTRICAL

BATTERY

(FLEETRITE, INTERNATIONAL)

LOW MAINTENANCE AND MAINTENANCE FREE TYPES

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SAFETY PRECAUTIONS

BATTERIES CAN EXPLODE!

Batteries generate explosive gases. Keep sparks, flames, burning cigarettes or other ignition sources away at all times.

BATTERIES CONTAIN SULPHURIC ACID!

Sulfuric acid is poison and can cause severe burns.

No one should work near a battery either in a vehicle or on the bench, without knowing and observing the safety precautions described in this manual.

Service personnel should be familiar with the proper procedures to be used before attempting to test or charge a battery or to "jump" start a-vehicle having a discharged battery.

The equipment manufacturer's instructions must be followed when any equipment such as a battery charger or tester is used.

DANGER OF EXPLODING BATTERY

Hydrogen and oxygen gases are produced during normal battery operation. These gases escape through the battery vents and may form an explosive atmosphere around the battery if ventilation is poor. Explosive gases may continue to be present in and around the battery for several hours after it has been charged.

To prevent ignition of gases within the battery sparks, flames or other ignition sources should be kept well away from the battery.

Be careful that tools or other metallic objects do not fall across the battery terminals or between the ungrounded terminal and any adjacent metallic part which is grounded. Do not break "live" circuits at the terminals of batteries because a spark usually occurs at a point where a "live" circuit is broken. Make certain the charger cable clamps or booster leads are clean and making good connections. A poor connection can cause an electrical arc which could ignite the gas mixture and explode the battery.

Anyone in the vicinity of the battery when it explodes could receive injuries, including eye injury from flying pieces of the case or cover or acid thrown from the battery.

IMPORTANT

Do Not smoke, strike a match or bring any other flame into the vicinity of the battery. The eyes must be shielded when working near a battery. Never lean over a battery during charging, testing or "jump starting" operations.

HANDLING BATTERY ACID

Use extreme care to avoid spilling or splashing battery electrolyte (which is diluted sulfuric acid) as it can destroy clothing and burn the skin. When working with acid, such as filling batteries, wear safety goggles. Protective clothing is advisable.

Do not place a battery or acid within the reach of children.

Electrolyte splashed into the eyes is extremely dangerous. If this should happen, force the eye open and flood it with cool, clean water for approximately five minutes. A doctor should be called immediately.

If acid (electrolyte) is taken internally, drink large quantities of water or milk. Follow with milk of magnesia, beaten egg or vegetable oil. Call physician immediately.

If electrolyte is spilled or splashed on clothing or the body, or any any surface of the vehicle, it should be neutralized immediately with a solution of baking soda and water and then rinsed with clean water.

If it becomes necessary to prepare electrolyte of a desired specific gravity, always pour the concentrated acid into the water--do this slowly-- never pour water into acid. A dangerous "spattering" of the liquid would result. This is caused by extreme heat which is generated whenever water is mixed with strong acid. Stir the liquid continually while acid is being added.

When handling a plastic cased battery, excessive pressure placed on the end walls could cause electrolyte to spew through the vents. There- fore, always use a battery carrier to lift these batteries or lift them with your hands placed at opposite corners.

BATTERY CHARGING PRECAUTIONS

Do not attempt to charge a battery unless you are thoroughly familiar with the step by step procedure to use. Follow the manufacturer's instructions on the charger. If the instructions are no longer legible and you do not have literature containing the instructions, obtain them from the manufacturer of the charger. Never use a charger without instructions.

The room or compartment in which the battery is being charged should be well ventilated. Follow precautions to prevent battery explosion. Explosive mixtures of hydrogen gas are being generated during battery charging. This gas can be exploded by a torch, match flame, lighted cigarette, sparks from loose connections or metal tools making contact between the terminals or the ungrounded terminal and adjacent metal parts which are grounded.

Always shield eyes when working around the battery.

It is recommended that filler caps, where used, be left on the battery during charging. Additionally, a wet cloth should be placed over the battery and vent.

DO NOT ATTEMPT TO CHARGE A FROZEN BATTERY. Allow the battery to warm to 15.5° C (60° F) before placing on charge.

Always turn the charger to the "OFF" position before connecting the leads to the battery. If you have any doubts that the charger is actually "OFF", disconnect it from the power source.

Never break a "live" circuit at the battery terminals or touch the charger leads when the charger is "ON". This could create a spark which could ignite the explosive gases in the battery. Always turn the charger "OFF" before removing a charger lead from the battery.

EMERGENCY STARTING PRECAUTIONS

Each step in the procedure outlined under EMERGENCY (JUMPER) STARTING must be followed with extreme care to avoid (1) bodily injury due to a gush of electrolyte through the vents, (2) bodily injury of damage to the vehicles due to explosion of one of the batteries, or (3) damage to the electrical system of either or both vehicles.

Wear safety glasses. Never lean over the battery during the starting operation. Follow precaution to avoid making a spark or bringing a flame near the battery.

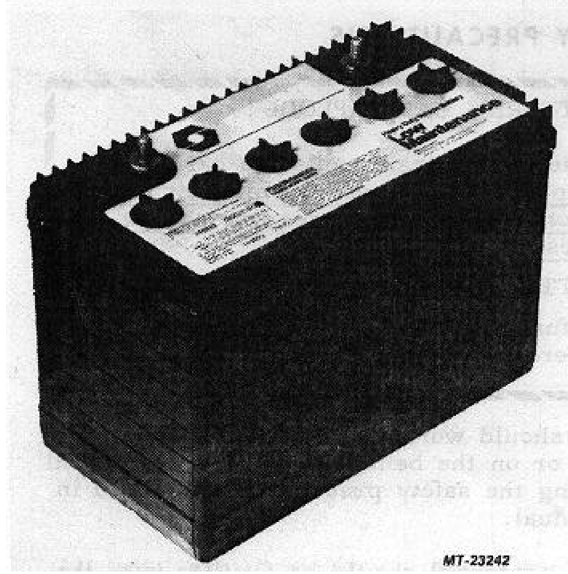

Fig. 1 Low Maintenance (Conventional) Battery

DESCRIPTION

The storage battery is an electro-chemical de- vice. It stores chemical energy which can be released as electrical energy. When the battery is connected to an external load such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

The three main functions of the automotive battery are to:

1. Supply power to the starter and ignition system so the engine can be cranked and started.

2. Supply the extra power required when the vehicle's electrical load requirements exceed the supply from the charging system.

3. Act as a voltage stabilizer in the electrical system. The battery smoothes out or reduces temporarily high voltages (transient voltages) which occur in the vehicle electrical system. This could occur in making or breaking a circuit, etc. These excessively high voltages would damage other components in the electrical system if it were not for the protection provided by the battery. The battery partially absorbs and greatly reduces these peak voltages and protects components such as diodes from being damaged.

"Fleetrite" and "International" batteries are available in conventional (low maintenance) type (Figure 1) and maintenance free type (Figure 2) as described herein.

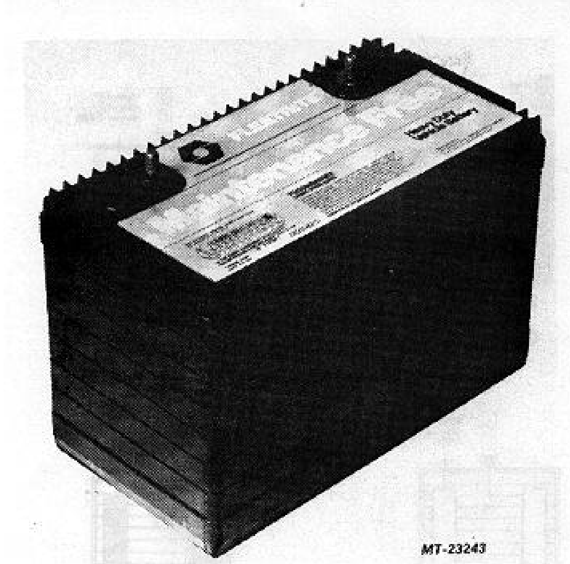

Fig. 2 Maintenance Free Type Battery

Batteries are provided with side, top stud and top post type terminals (Figure 3) for various vehicle applications.

LOW MAINTENANCE BATTERIES

These are conventional lead-acid batteries requiring normal periodic battery maintenance.

A small amount of antimony has been added to the lead to improve grid strength. The antimony tends to cause "gassing" (breaking down of water into hydrogen and oxygen gases) during battery operation, thereby lowering the electrolyte level. Hence, periodic addition of water to the battery cells is required.

"Fleetrite" and "International" batteries are provided with easily accessible cell filler caps.

MAINTENANCE FREE BATTERIES

Maintenance free batteries do not require the addition of water during normal service life. This is due to the fact that maintenance free batteries utilize calcium rather than antimony to improve grid strength. The advantage of calcium is that it greatly reduces the tendency for the battery to gas at normal charging voltages. Consequently, very little water is used.

<u>Maintenance free batteries are not sealed</u> All batteries (including maintenance-free) generate gases, especially during charge. While the volume of gases produced by the maintenance- free battery is reduced by more than 75%, there are small vent openings to allow this gas to

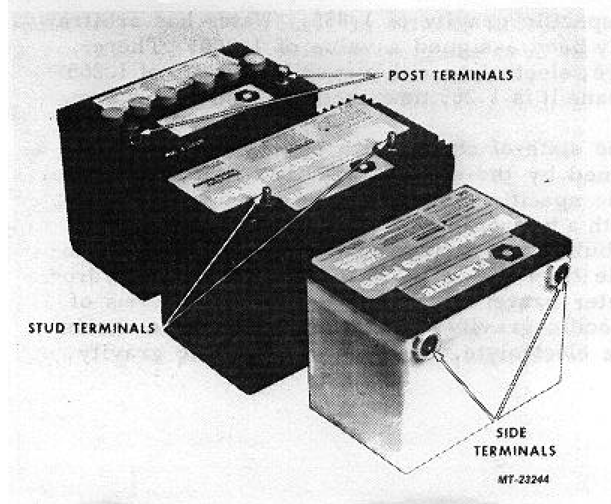

Fig. 3 Types of Battery Terminals

escape. The corrosive sulfuric acid mixture will escape if the battery is turned upside down or placed on its side.

"Fleetrite" and "International" maintenance free batteries have concealed cell caps which can be removed to permit battery testing and addition of water if required.

ELECTROLYTE AND SPECIFIC GRAVITY

The electrolyte in a lead-acid storage battery is a dilute sulfuric acid solution. The sulfuric acid in the electrolyte is one of the necessary ingredients in the chemical actions taking place inside the battery. It supplies the sulfate which combines with the active material of the plates. It is also the carrier for the electric current as it passes from plate to plate. When the battery terminals are connected to an external load, the sulfate combines with the active materials of the positive and negative plates forming lead sulfate and releasing electrical energy. Electrons flow from the negative terminal to the load (such as headlamps), and back to the positive terminal.

SPECIFIC GRAVITY

Specific gravity is a unit of measurement for determining the sulfuric acid content of the electrolyte. The recommended fully charged specific gravity of most 12-volt batteries today is 1.265 corrected to 26.7°C (80° F). A battery with a fully charged specific gravity of 1.265 contains an electrolyte with approximately 36% sulfuric acid by weight or 25% by volume. The remainder of the electrolyte is water. Pure (concentrated) sulfuric acid has a specific gravity of 1.835. Water has arbitrarily been assigned a value of 1.000. Therefore, electrolyte with a specific gravity of 1.265 means it is 1.265 times heavier than pure water.

The state-of-charge of a battery can be determined by the specific gravity of the electrolyte. The specific gravity can be measured directly with a hydrometer (Figure 4). A hydrometer is a bulb-type syringe which will extract electrolyte from the cell. A glass float in the hydrometer barrel is calibrated to read in terms of specific gravity. The lower the float sinks in the electrolyte, the lower its specific gravity.

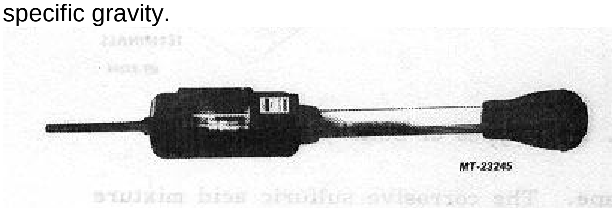

Fig. 4 Battery Hydrometer

Figure 5 graphically illustrates the relationship between specific gravity readings and the combination of the sulfate from the acid with the positive and negative plates for various states of charge. The black dots represent the sulfate radical. A fully charged battery has all of the sulfate in the acid. As the battery discharges, some of the sulfate begins to appear on the plates. The acid becomes more dilute and its specific gravity drops as water replaces some of the sulfuric acid. A fully discharged battery has more sulfate in the plates than in the electrolyte. Note that the hydrometer float sank lower and lower in the electrolyte as the specific gravity became lower.

Table 1 illustrates typical specific gravity values for a cell in various stages of charge. A fully charged specific gravity of 1.265 corrected to 26.70 C (800 F) is assumed.

TABLE 1

Specific Gravity	State of Charge
1.265	100 % charged
1.225	75 % charged
1.190	50 % charged
1.155	25 % charged
1.120	Discharged

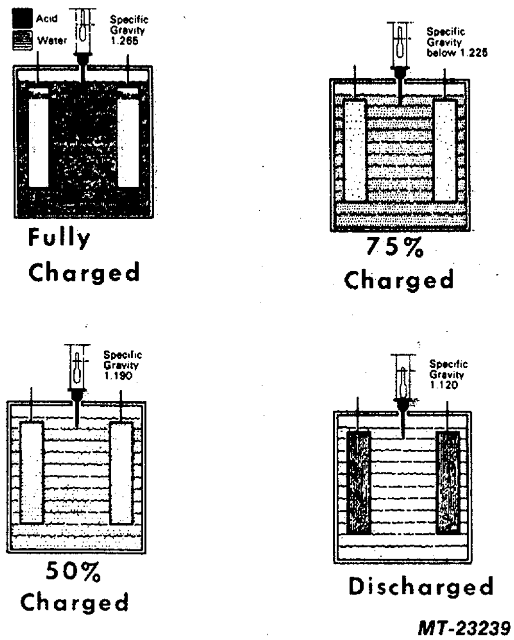

Fig. 5 Relationship of Specific Gravity To Transfer of Sulfate From Electrolyte To Plates.

HOW TO USE A HYDROMETER

Figure 6 illustrates the correct method of reading a hydrometer. The barrel must be held vertically so the float is not rubbing against the side of it. The electrolyte should be drawn in and out of the hydrometer barrel a few times to bring the temperature of the hydrometer float and barrel to that of the acid in the cell. Draw an amount of acid into the barrel so that with the bulb fully expanded, the float will be lifted free, touching neither the side, top or bottom stopper of the barrel.

When reading the hydrometer, your eye should be on a level with the surface of the liquid in the hydrometer barrel. Disregard the curvature of the liquid where the surface rises against the float stem and the barrel due to surface tension. Keep the float clean. Make certain it is not cracked.

Never take a hydrometer reading immediately after water is added to the cell. The water must be thoroughly mixed with the underlying electrolyte, by charging, before hydrometer readings are reliable. If a reading is being taken immediately after the battery has been subjected to prolonged cranking, it will be higher than the true value. The water formed in the plates during the rapid discharge has not had time to mix with the higher specific gravity acid above the plates.

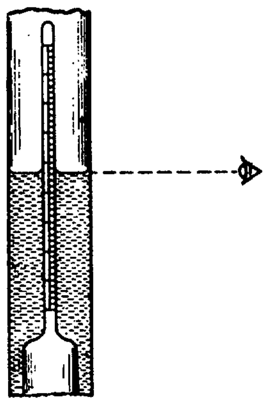

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Fig. 6 Correct Method of Reading Hydrometer (Eye on Level with Liquid Surface)

Because there are many different types of battery hydrometers available, always follow manufacturer's instructions.

TEMPERATURE CORRECTION

Hydrometer floats are calibrated to give a true reading at one fixed temperature only. A correction factor must be applied for any specific gravity reading made when the electrolyte temperature is not 26.7° C (80° F).

A temperature correction must be used because the electrolyte will expand and become less dense when heated. The float will sink lower in the less dense solutions and give a lower specific gravity reading. The opposite occurs if the electrolyte is cooled. It will shrink in volume, becoming more dense. The float will rise higher and read too high.

A correction factor of .004 specific gravity some- times referred to as 4 "points" of "gravity") is used for each 5.5° C (10°F) change in temperature. Four "points of gravity" (.004) are added to the indicated reading for each 5.5° C (100 F)
increment above 26.7° C (80° F) and four points are subtracted for each 5.5° C (10° F) increment below 26.7° C (80°F). This correction is important at extremes of temperature because it can become a substantial value.

Figure 7 illustrates the correction for hydrometer readings when the acid temperature is above or below 26.7° C (80° F). In example No. 1, in cold weather, a partially discharged battery in a vehicle at 6.7° C (+20° F) might read 1.250 indicating it was almost fully charged. However, when the correction factor is applied, the true value is only 1.226. Example No. 2 could be encountered in a battery exposed to the sun in hot weather. Also, electrolyte frequently reaches 43° C (110° F) in service in warm weather. The 1.235 specific gravity reading might indicate too low a state of charge to install in a vehicle or that there is a problem in the electrical system if the battery is in service. However, the true reading of 1.247 may not be unreasonably low depending on the length of storage of the battery or the type of service which it has been experiencing in the vehicle.

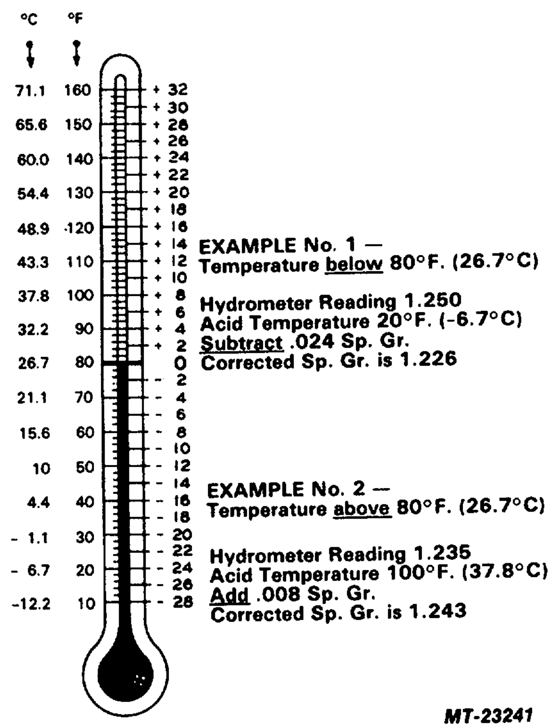

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Fig. 7 Specific Gravity Temperature Correction Values

SPECIFIC GRAVITY DETERMINES ELECTROLYTE FREEZING POINT

Specific gravity of the electrolyte determines the temperature at which a battery will be harmed or damaged by freezing. A fully charged battery can be stored at sub-freezing temperatures without freezing the electrolyte. However, as a battery approaches the discharged condition, the electrolyte will freeze at higher temperatures. Table 2 shows the approximate freezing points of electrolyte at various specific gravities.

TABLE 2

Specific Gravity	State of Charge	Freezing Point
1.265	100%	-59.5° C (-75° F)
1.225	75%	-37.2° C (-35° F)
1.190	50%	-26.1° C (-15° F)
1.155	25%	-15.0° C (+5°F)
1.120	Discharged	-9.4° C (+15°F)
Batteries must be kept fully charged when batteries or vehicles are stored in sub-freezing temperatures.		

TEMPERATURE AFFECTS BATTERY OUTPUT CAPACITY (CRANKING POWER).

Battery temperature affects the output capacity of a battery with respect to cranking an engine. The cranking power of the battery is reduced as battery temperature is lowered.

Table 3 lists the approximate percentage of out- put capacity of a fully charged battery at various temperatures.

Note that a fully charged battery at -17.8° C (00 F) gives only 40 percent of its cranking power at 26.70 C (800 F).

TABLE 3

Temperature	Percentage of Battery Capacity (Fully Charged)
26.70 C (800 F)	100%
0° C (320 F)	65%
-17.8° C (0° F)	40%
-28.8° C (-20° F)	20%
Batteries at less than the fully charged state will provide even less of their output capacity. This emphasizes the importantance of keeping vehicle batteries fully charged when low temperatures will be encountered.	

MAINTENANCE (IN VEHICLE)L

The battery is a perishable item and requires attention. With a reasonable amount of care the life of a battery can be appreciably extended. Neglect and abuse will invariably cause shorter, battery service life.

The battery should be inspected at the time of chassis lubrication or other periodic services.

Battery maintenance includes the following:

1. Inspect battery and mounting for defective cables, loose connections, loose or damaged hold down parts, damaged terminal posts or studs, clogged vents, cracked, or distorted battery case or cover, and accumulations of dirt, moisture and corrosion (Figure 8). Replace any damaged parts.

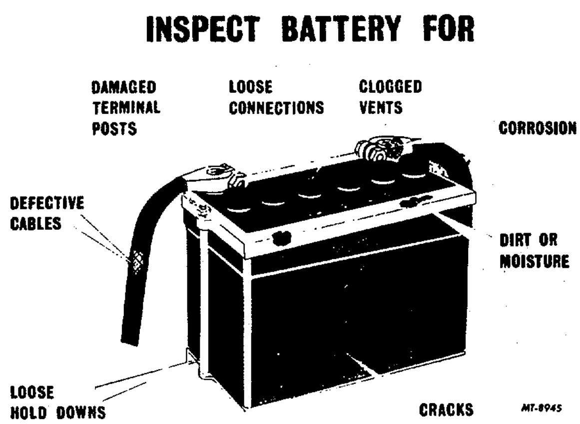

Fig. 8 Battery Maintenance Inspection

2. If corrosion is found on the terminal posts, remove the cable terminals from the battery (ground cable first) using the proper end wrench and a cable puller. A terminal cleaning brush can be used to clean tapered posts and the mating surfaces of the cable clamps. Other type terminals can be cleaned with a wire brush. The cable terminals should then be cleaned with an acid neutralizing solution of baking soda and water. Clean dirt from the battery top with a cloth wetted with baking soda and water. Then wipe with a cloth with clear water. A wire brush can be used to remove dirt, corrosion or rust from the battery tray or hold down parts.

   After rust is removed, rinse with clear water dry with air and repaint.

After cleaning, reinstall battery and hold down parts as instructed under REMOVAL AND INSTALLATION. Coat battery and cable terminals with terminal grease (IH part number 472141C1) and connect cables to battery terminals. Connect ground cable last.

3. On low maintenance (conventional) batteries check the electrolyte level. If necessary, add odorless drinking water to bring the liquid level to the level indicator. If the battery does not have a level indicator, bring the level to 13 mm (1/2 inch) above the tops of the separators. Do not overfill any cell. When a cell is overfilled, the excess electrolyte may be forced from the cell by the gas formed in the battery. This will cause excessive corrosion of adjacent metal parts, reduced performance and shorter life.

Frequent need for refilling battery cells may indicate that battery is being over-charged. Check charging system and readjust voltage regulator as needed.

Maintenance free type batteries do not require addition of water under normal operating conditions. If loss of electrolyte is suspected, check electrolyte level as instructed under TESTING and determine cause for low level.

EMERGENCY (JUMPER) STARTING

The procedure outlined below should be followed exactly if it becomes necessary to use a booster battery to start a vehicle with a discharged battery.

CAUTION

Both booster and discharged batteries must be treated carefully when using jumper cables. Be careful not to cause sparks. Observe all precautionary measures listed under SAFETY PRECAUTIONS.

Wear safety glasses or shield eyes.

Any procedure other than that outlined below could result in 1) personal injury caused by electrolyte squirting out the battery vent, 2) personal injury or property damage due to battery explosion, 3) damage to the charging system of the booster vehicle or of the immobilized vehicle.

Make sure booster and discharged batteries are the same voltage (6-volt or 12-volt).

Make certain the stalled vehicle and the one containing the booster battery do not touch. If the two vehicles are in contact, a ground connection could be established which could cause sparking when jumper cables are attached.

1. On both vehicles: Set parking brake. Place transmission in NEUTRAL or PARK. Turn lights, heater and other electrical loads "OFF". Make certain ignition key is turned "OFF".

2. Determine whether the discharged battery has the negative (-) or positive (+) terminal grounded. The ground cable is connected to the engine block, vehicle frame or other good metallic ground. The battery terminal connected to the starter relay is the one which is NOT grounded.

3. Be sure vent caps are tight on both batteries. Place a damp cloth over the vents of each battery. Make certain cloth is clear of fan blades, belts or other moving parts.

4. On negative ground vehicles, attach one end of the jumper cable to the positive (+) terminal of the booster battery and the other end of same cable to positive (+) terminal of discharged battery (Figure 9).

On positive ground vehicles, connect jumper cable between negative (-) battery terminals.

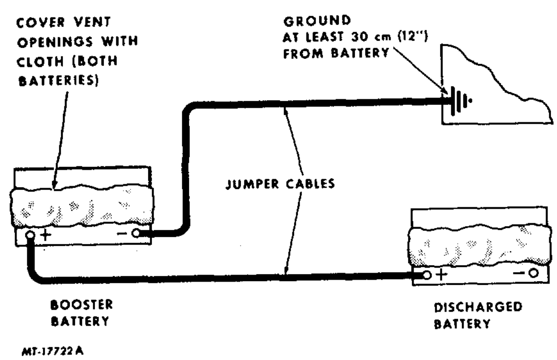

Fig. 9. Proper Jumper Cable Connections (Negative Ground Vehicles Shown)

5. On negative ground vehicles, attach one end of the remaining jumper cable to the negative terminal of the booster battery and the other end to a ground at least 304 mm (12 inches) from the battery of the vehicle being started (Figure 9). (DO NOT connect directly to the negative post of the dead battery.) The ground connection must provide good electrical conductivity and current carrying capacity.

   On positive ground vehicles, connect jumper cable between positive (+) terminal of booster battery and ground on the stalled vehicle.

CAUTION

Take care the clamps from one cable do not inadvertently touch the clamps on the other cable.

DO NOT lean over the battery when making connections.

Avoid moving, hot or electrical hazards such as fans, manifolds and spark plug terminals when connecting cables.

6. Be sure everyone is standing away from vehicles. Start the engine of the vehicle with the booster battery. Wait a few minutes, then attempt to start the engine of the vehicle with the discharged battery.

7. Do not operate the starter for more than 15 seconds. Wait at least 15 seconds between starting attempts to allow starter motor to cool. If the engine does not start after several cranking attempts, check for cause of failure to start.

8. After starting, allow the engine to return to idle speed. Remove ground cable connection from the vehicle with discharged battery. Then remove the other end of the same cable from the booster battery.

9. Remove the other cable by disconnecting from the discharged battery first and then disconnect the opposite end from the booster battery.

10. Remove and discard cloths covering battery vents.

TESTING

A battery test should be performed whenever battery trouble is suspected.

Battery testing will determine if:

1. Battery is satisfactory and can remain in service.

2. Battery should be recharged before placing it back in service.

3. Battery must be replaced.

A complete battery test, as outlined below, will include these steps:

1) Visual Inspection
2) Specific Gravity (Hydrometer) Test
3) Battery Capacity (Load) Test

CAUTION

When performing battery test, observe rules of safety. Refer to SAFETY PRE-CAUTIONS.

Always follow instructions of test equipment manufacturer.

STEP 1. VISUAL INSPECTION

a. Visually inspect the outside of the battery for obvious damage such as cracked or broken case or cover which would allow electrolyte loss. Check for terminal damage. If obvious physical damage is found, replace the battery. If possible, determine the cause of damage and correct.

b. Check electrolyte level. On maintenance free type batteries, access to battery cells can be obtained as follows:

   Side Terminal Batteries:
   Use a knife blade to cut through top plaque center section. (Cut on dotted lines.) Pry up ends of vent manifold with a screwdriver. Remove manifold by pulling straight up at the ends (Figure 10). After testing cells, reinstall manifold by placing it in position and pushing it down firmly until seated.

   Top Terminal Batteries
   Use a knife blade to cut through the top plaque center section on the dotted lines (Figure 11). After removal of the

Fig. 10. Removing Vent Manifold to Gain Access to Cells (Side Terminal Maintenance Free Battery)

section of the plaque, individual caps can be unscrewed to allow access to each cell. When reinstalling cell caps after testing, make sure caps are properly seated.

c. If electrolyte level is above the plates in all cells, proceed to Step 2.

d. If electrolyte level is below the tops of the plates in one or more cells, add water until electrolyte level is just above the tops of the separators. Charge the battery 15 minutes at 15-25 amperes to mix the water with the electrolyte. After mixing electrolyte, proceed to Step 2.

STEP 2. SPECIFIC GRAVITY (HYDROMETER) TEST

Perform specific gravity (hydrometer) test on all cells. (Refer to instructions for reading hydrometer under ELECTROLYTE AND SPECIFIC GRAVITY.)

a. Measure and record specific gravity, corrected to 26.7° C (80° F), of each cell. Compare readings obtained with Table 4 to determine battery's state of charge.

Fig. 11 Removing Section of Top Plaque to Gain Access to Cell Caps (Top Terminal Maintenance Free Battery)

TABLE 4

Specific Gravity (Corrected to 26.7° C or 80° F)	State of Charge
1.265	Fully Charged
1.225	75% Charged
1.190	50% Charged
1.155	25% Charged
1.120	Discharged

b. If specific gravity readings of all cells are 1.225 or higher when corrected to 26.7° C (80°Ω F), proceed to Step 3.

c. If specific gravity readings are low (below 1.225) but are within 50 points (.050 specific gravity) between highest and lowest cells, recharge battery as instructed under CHARGING and inspect vehicle's electrical system to determine cause for low charge. After charging battery, proceed to Step 3.

d. If specific gravity readings vary more than 50 points (.050 specific gravity) between cells, replace the battery.

Fig 12. Testing Specific Gravity

STEP 3. BATTERY CAPACITY (LOAD) TEST

Perform battery capacity (load) test using battery test equipment available commercially.

IMPORTANT

Always follow manufacturer's instructions and precautions when using battery test equipment.

A satisfactory capacity (load) test can be made only when battery electrolyte equals or exceeds 1.225 specific gravity when corrected to 26.70 C (800 F).

a. Disconnect battery cables from battery. (Disconnect ground cable first.)

b. Connect tester leads to battery terminals following tester manufacturer's instructions.

c. Apply specified test load to battery for 15 seconds or as specified in tester instructions.

Test load (amperes) is equal to one- half of the cold cranking amperes @ -18° C (00 F) rating of the battery.

Specified test loads for "Fleetrite" and "International" batteries are listed in SPECIFICATIONS.

d. Note voltage reading after 15 seconds (or other specified time interval) under load. Then remove load.

If voltage reading under load is less than permissible minimums at temperatures listed in Table 5, replace the battery.

If voltage meets or exceeds permissible minimum listed in Table 5, clean the battery and return it to service.

TABLE 5

Ambient Temperature	21° C (70° F)& above	16° C (60° F)	10° C (50° F)	4° C (40° F)	-1° C (30° F)	-7° C (20° F)	-12° C (10° F)	-18° C (0° F)
12 Volt Battery	9.6	9.5	9.4	9.3	9.1	8.9	8.7	8.5
6 Volt Battery	4.8	4.75	4.7	4.6	4.5	4.4	4.3	4.2
			Minimum	Permissible	Voltage			

CHARGING

CAUTION

Before attempting to charge a battery, be aware of all safety precautions to be followed during the charging operation. Refer to Battery Charging Precautions under SAFETY PRECAUTIONS.

Always follow battery charger manufacturer's instructions.

When possible, use a battery charger with alternator or polarity protection that prevents charging the battery in reverse polarity.

Two methods of recharging a battery, the Slow Charge Method and the Fast Charge Method, are described below.

The charge a battery receives is equal to the charge rate in amperes multiplied by the time in hours. Thus a five ampere rate applied to a battery for ten hours would be a 50 ampere-hour charge to the battery. To fully recharge a battery, you must replace the ampere-hours or ampere-minutes removed from it, plus an extra 20% charge. This is due to the fact that batteries are not 100% efficient on recharging.

The Battery Charging Guides, Tables 6 and 7, show approximately how much recharge a fully discharged battery requires. For partially discharged batteries, reduce the charging current or charging time (ampere-hours) accordingly.

For example: If the battery is 25% charged (75% discharged), reduce charging current or time by one-fourth (1/4). If the battery is 50% charged, reduce charging current or time by one-half (1/2).

If time is available, the lower charging rates in amperes are recommended.

While battery is being charged, periodically measure the temperature of the electrolyte. If the temperature exceeds 51.6° C (125° F). or if violent gassing or spewing of electrolyte occurs, the charging rate must be reduced or temporarily halted. This must be done to avoid damage to the battery.

IMPORTANT

DO NOT OVERCHARGE batteries, particularly maintenance free type batteries. Overcharging causes excessive and needless loss of water from the electrolyte.

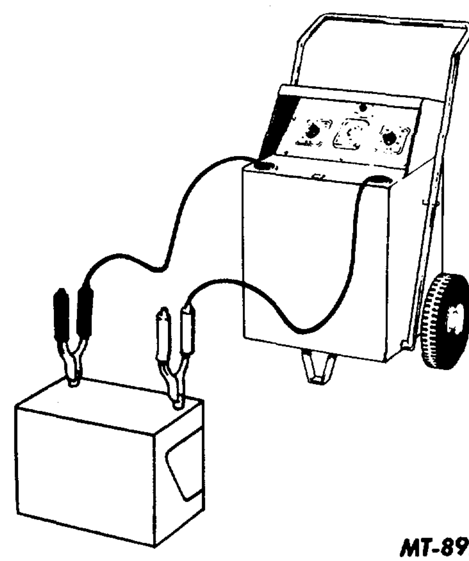

Fig. 14 Charging Battery

TABLE 6

BATTERY CHARGING GUIDE

6 and 12 Volt Low Maintenance (Conventional Batteries)
Recommended Rate* and Time for Fully Discharged Condition

Rated Battery Capacity (Reserve Minutes)	Slow Charge	Fast Charge
80 Minutes or Less	14 Hours @ 5 Amperes 7 Hours @ 10 Amperes	1-3/4 Hours @ 40 Amperes 1 Hour @ 60 Amperes
Above 80 to 125 Minutes	20 Hours @ 5 Amperes 10 Hours @ 10 Amperes	2-1/2 Hours @ 40 Amperes 1-3/4 Hours @ 60 Amperes
Above 125 to 170 Minutes	28 Hours @ 5 Amperes 14 Hours @ 10 Amperes	3-1/2 Hours @ 40 Amperes 2-1/2 Hours @ 60 Amperes
Above 170 to 250 Minutes	42 Hours @ 5 Amperes 21 Hours @ 10 Amperes	5 Hours @ 40 Amperes 3-1/2 Hours @ 60 Amperes
Above 250 Minutes	33 Hours @ 10 Amperes	8 Hours @ 40 Amperes 5-1/2 Hours @ 60 Amperes

* Initial rate for standard taper charger.

TABLE 7

BATTERY CHARGING GUIDE

12 Volt Low Maintenance Free Batteries
Recommended Rate* and Time for Fully Discharged Condition

Rated Battery Capacity (Reserve Minutes)	Slow Charge	Fast Charge
80 Minutes or Less	10 Hours @ 5 Amperes 5 Hours @ 10 Amperes	2-1/2 Hours @ 20 Amperes 1-1/2 Hours @ 30 Amperes 1 Hour @ 45 Amperes
Above 80 to 125 Minutes	15 Hours @ 5 Amperes 7-1/2 Hours @ 10 Amperes	3-3/4 Hours @ 20 Amperes 2-1/2 Hours @ 30 Amperes 1-3/4 Hours @ 45 Amperes
Above 125 to 170 Minutes	20 Hours @ 5 Amperes 10 Hours @ 10 Amperes	5 Hours @ 20 Amperes 3 Hours @ 30 Amperes 2-1/4 Hours @ 45 Amperes
Above 170 to 250 Minutes	30 Hours @ 5 Amperes 15 Hours @ 10 Amperes	7-1/2 Hours @ 20 Amperes 5 Hours @ 30 Amperes 2-1/2 Hours @ 45 Amperes
Above 250 Minutes	20 Hours @ 10 Amperes	10 Hours @ 20 Amperes 6-1/2 Hours @ 30 Amperes 4-1/2 Hours @ 45 Amperes

* Initial rate for standard taper charger.

SLOW CHARGING

The Slow Charge method uses a low charging rate for a relatively long period of time. The recommended rate for slow charging is one ampere per positive plate per cell. If the battery has nine plates per cell, normally four of the nine will be positive plates. Therefore, the slow charge rate would be four amperes. Charging periods as long as twenty-four hours may be needed to bring a battery to full charge.

The best method of making certain a battery is fully charged, but not overcharged is to measure the specific gravity of a cell once per hour. The battery is fully charged when no change in specific gravity occurs over a three hour period or when charging current stabilizes (constant voltage type charger).

If a low maintenance (conventional) battery is to be charged overnight (10-16 hours) use the specified Slow Charge rate (Table 6).

Maintenance free batteries must not be charged at rates greater than specified in the Maintenance-Free Battery Charging Guide (Table 7).

If a maintenance free battery is to be re- charged overnight, (16 hours) a timer or voltage controlled charger is recommended. If the charger does not have such controls, a 3 ampere rate should be used for batteries of 80 minutes or less capacity and 5 amperes for above 80 to 125 minutes reserve capacity batteries. Batteries over 125 minutes should be charged at the specified Slow Charge rate (Table 7).

Batteries that have stood in a discharged condition for long periods of time without a recharge, have become sulfated and must be recharged at a low rate to avoid overheating and excessive gassing. It may require two or three days of slow charging to bring a sulfated battery to a fully charged condition. Care should be taken not to overcharge maintenance free type batteries

Some batteries are so badly sulfated they can not be restored to a normal operating condition, regardless of the rate of charge or the length of time the charge is applied. Therefore, if a battery cannot be restored to a fully charged condition by slow charging, it should be rejected.

FAST CHARGING

The Fast Charge method provides a high charging rate for a short period of time. The charging rate should be limited to 60 amperes for 12-volt batteries. Maximum charging rate for 6-volt batteries (above 180 reserve capacity minutes) can be approximately double this value.

Ideally, fast charges should be limited to the charging times shown under Fast Charge in the Battery Charging Guides, Tables 6 and 7. The battery generally cannot be fully charged within these time periods; but it will receive sufficient charge (70 to 90%) for practical service. To completely recharge a battery, follow the fast charge with a slow charge until no change in specific gravity occurs over a three hour period.

A battery with electrolyte specific gravity of 1.225 or above, should never be charged at a high rate If the charger has not tapered to a low rate, adjust to a slow charge, preferably at a rate of one ampere per positive plate per cell.

CHARGING INSTRUCTIONS

Before placing a battery on charge, clean the battery terminals if necessary. Add water sufficient to cover the plates. Fill to the proper level near the end of charge. If the battery is extremely cold, allow it to warm before adding water because the level will rise as it warms. In fact, an extremely cold battery will not accept a normal charge until it becomes warm.

Following instructions of charger manufacturer, connect charger to battery.

Connect the positive (+) charger lead to positive battery terminal and negative (-) lead to negative terminal. If the battery is in the vehicle, connect the negative lead to the engine block if the vehicle has a "negative ground" (negative battery terminals is connected to ground). Connect the positive lead to ground if vehicle has a "positive ground". "Rock" the charger lead clamps to make certain a good connection has been made.

Turn the charger "ON" and slowly increase the charging rate until recommended ampere value is reached.

IMPORTANT

If smoke or dense vapor comes from the battery, shut off the charger and reject the battery. If violent gassing or spewing of electrolyte occurs, reduce or temporarily halt the charging.

If the engine does not crank satisfactorily when a recharged battery is installed, load test the battery as outlined under TESTING. If the battery passes the "Load Test", the vehicle's fuel, ignition, cranking and charging systems should be checked to locate and correct the problem. If it does not pass the load test, the battery should be replaced.

When an engine does not crank satisfactorily with a battery which was not recharged before installation, recharge the battery and subject it to the load test. If the battery fails, replace it; if it tests satisfactorily and the engine still does not crank satisfactorily check the vehicle systems mentioned above to locate and correct the problem.

REMOVAL AND INSTALLATION

REMOVAL

1. Make sure all electrical loads (lights, ignition, accessories) are turned "OFF"

2. Remove battery cover (where used).

3. Note locations of battery positive and negative terminals in relation to surrounding vehicle components. Battery must be installed in the same position.

4. Loosen battery hold-down hardware and remove battery from carrier tray.

5. Inspect battery cables and replace if necessary. Clean cable connector terminals with a wire brush.

   Clean and tighten battery cable ground, starter relay and starter connections.

6. Inspect battery hold-down hardware and battery tray. Replace worn or damaged parts. Remove corrosion with a wire brush and/or wash with a weak solution of baking soda and water. Rinse and dry. Repaint parts if needed to prevent rusting.

   Make sure no foreign objects such as stones, bolts, nuts, etc., which could damage battery are left in battery tray.

INSTALLATION

When replacing the battery, make sure that battery to be installed has sufficient capacity to cover the electrical requirements of the vehicle. Use of an under-capacity battery will result in poor performance and pre-mature battery failure. The original equipment battery can be used as a minimal guide, but is often misleading since the vehicle owner may have installed additional electrical accessories on the vehicle.

Be sure battery is at full charge when installed. If the battery has been in storage for some time or if the installation is being made in sub-freezing temperatures, the battery should be given a boost charge before being installed.

1. Place battery in battery tray with terminals in proper position. Battery should rest level in tray.

2. Install battery hold-down hardware and tighten until battery is firm and secure.

CAUTION

DO NOT overtighten battery hold-downs. Overtightening could damage battery resulting in early failure.

3. Apply a light coat of terminal grease (IH part number 472141-C1) to battery and cable terminals to inhibit corrosion.

4. Connect battery cables to battery. Check for proper battery polarity with respect to the vehicle. "Reversed" polarity may cause serious damage to the electrical system. Connect ground cable last.

   Tighten terminal fasteners as follows:
   DO NOT OVERTIGHTEN.

   Side Terminals:
   7-10 N-m (60-90 lb. in. or 5-7 lb. ft.)

   Top Terminals:
   13-20 N-m (10-15 lb. ft.)

   Taper Post Terminals:
   5.5-8 N-m (50-60 lb. in. or 4-6 lb. ft.)

IMPORTANT

New batteries must be coded to indicate month and year of installation.

5. Start engine and check operation of vehicle's charging system. If necessary, adjust or repair charging system to obtain correct charging output.

6. Install battery cover (where used).

STORAGE INSTRUCTIONS

Always store batteries in an upright position. Never allow batteries to be laid on their sides as electrolyte may escape through the vent holes.

Never stack batteries on top of one another. Simple battery storage racks can be made from loose, flat boards supported by the batteries themselves, as shown in Figure 15.

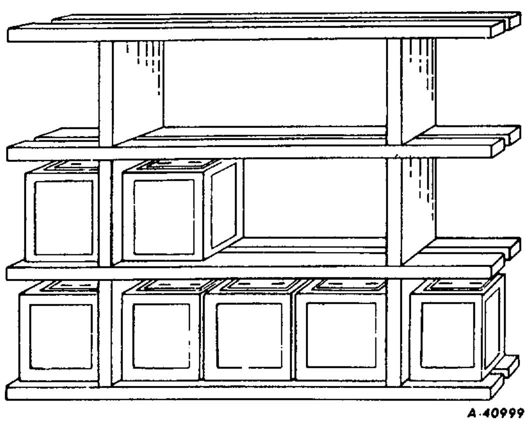

Fig. 15. Battery Storage Rack

Batteries will slowly discharge while standing and will discharge much faster when warm than when cold. On wet type conventional batteries, self-discharge can amount to about an average of .001 specific gravity per day over a 30 day period. To minimize self-discharge, store batteries in as cool a place as possible, away from heat ducts in winter and shielded from direct sunlight in summer.

Ideal storage conditions would be in a clean dry area where temperature would be stable and as cool as possible between 0° C (32° F) and 26° C (80° F). Storage in ambient temperatures above 26° C (80° F) is not recommended as this increases the rate of self-discharge. Temperatures below 0° C (32° F) should be avoided to prevent freezing should a battery become discharged.

Wet batteries in storage should be checked for state of charge every 30 days and charged when ever they fall to 1.225 specific gravity. A charge rate of one ampere for each positive plate in one cell should be used to recharge the battery.

IMPORTANT

Batteries of vehicles standing in storage should be considered as batteries in storage. Vehicles in inventory should be maintained regularly to keep their batteries clean and dry, properly filled with water and, most important, fully charged.

Because of their chemical composition, maintenance free batteries self-discharge at a slower rate than conventional batteries. When stored as recommended, a shelf life of up to twelve months or more depending upon storage temperatures, is possible before charging is required.

Maintain proper battery stock rotation. The first batteries placed in storage should be the first ones taken out. (Be sure to check date codes on the batteries and the cartons.)

If a battery has been in storage for some time, it should be charged before being installed in a vehicle.

ACTIVATING DRY CHARGED BATTERIES

Dry charged batteries provided for replacement installation must be "activated" before they can be used. Following the instructions outlined below will assure proper activation regardless of temperature and conditions of storage.

IMPORTANT

Always refer to and follow manufacturer's activation instructions furnished with battery.

1. Fill each cell of the battery to the top of the separators with the correct battery-grade electrolyte as specified by the manufacturer's instructions. Using higher or lower specific gravity electrolyte than recommended can impair battery performance. Originally filling each cell to the top of the separators permits expansion of the electrolyte as battery is boost charged.

2. Gently rock battery. This will help to force out trapped air and to saturate the plates with electrolyte.

3. Boost charge 12-volt batteries at 15 amps (6-volt and 12-volt heavy duty batteries at 30 amps) until the specific gravity of the electrolyte is 1.250 or higher and electrolyte temperature is at least 15.5° C (60° F). BOTH CONDITIONS MUST BE MET. If electrolyte bubbles violently while charging, reduce charging rate until excessive bubbling action subsides, then continue charging until 1.250 specific gravity and 15.5° C (60° F) are reached.

   If the ambient temperature is 0° C (32° F) or less, it is imperative that the above instructions be followed.

4. Check volume of electrolyte in all cells and adjust to prescribed level with additional electrolyte as required.

5. Install battery in vehicle as instructed under REMOVAL AND INSTALLATION. Be sure of proper polarity.

   Dry charged batteries may be placed in service immediately after activation. However, to insure good performance these additional steps are recommended. Check the specific gravity of all cells. Under good storage conditions, the electrolyte specific gravity on activating a dry-charged battery will drop approximately .010 and temperature will rise 4° to 5.6° C (7° to 10° F) within twenty minutes of filling the battery. A battery under these conditions requires little boost charging. However, should the specific gravity drop .030 or more with a corresponding increase in temperature, the negative plates have been oxidized and the battery should be fully recharged before use. Also, the battery should be recharged if one or more cells gas violently after the addition of electrolyte. After electrolyte is added, check the open circuit terminal voltage of the battery. If a 12-volt battery reads less than 10 volts (less then 5 volts on a 6-volt battery) this indicates a reverse cell or an "open" circuit and the battery should be replaced.

After the dry charged battery has been activated, it must be serviced, handled and kept charged like any other wet battery. After battery has been in service, add only approved water. DO NOT ADD ACID.

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SPECIFICATIONS

LOW MAINTENANCE BATTERIES

BCI Group	Battery Model	Volts	No. of Plates per Cell	Reserve Capacity (Minutes) 25 Amps at 27° C (80° F)	Cold Cranking Current (Amps) At -18° C (0° F)	Cold Cranking Current (Amps) At -29°C (-20° F)	Test Load (Amps.)
4	BDPP4 IHPP4	6	21	275	700	570	350
4H	ZBDCH4 IHCH4	6	33	420	975	775	485
4H	ZBDPH4 IHPH4	6	25	340	830	675	415
24	ZBDSP24	12	11	93	345	280	180
27H	ZBDPR27H IHPR27H	12	13	125	435	340	215
30H	ZBDPL30	12	15	165	520	430	260
31	ZBDCF31S IHCF31S	12	13	160	455	375	230
31	ZBDCL31S IHCL31S	12	17	170	600	455	300
72	ZBDPH72	12	9	63	300	240	150
74	ZBDPH74 IHPH74	12	11	100	390	315	195
4D	ZBDCM4DA IHCM4DA	12	21	275	700	570	450
8D	ZBDCM8DA IHCM8DA	12	29	440	900	700	440

MAINTENANCE FREE BATTERIES

BCI Group	Battery Model	of Volts	No. Capacity Plates per Cell	Reserve Current (Minutes) 25 Amps at 27° C (80° F)	Cold Cranking (Amps) At -18° C (0° F)	Cold Cranking (Amps) At -29°C (-20° F)	Test Load (Amps.)
31	ZBDCLM31 IHCLM31	12	17	170	625	470	310
31	ZBDCLM31S IHCLM31S	12	17	170	625	470	310
74	ZBDMF74 IHMF74	12	13	115	500	360	250

BATTERY

(DELCO)

MAINTENANCE-FREE

CONTENTS

SUBJECT	PAGE
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SAFETY PRECAUTIONS	3
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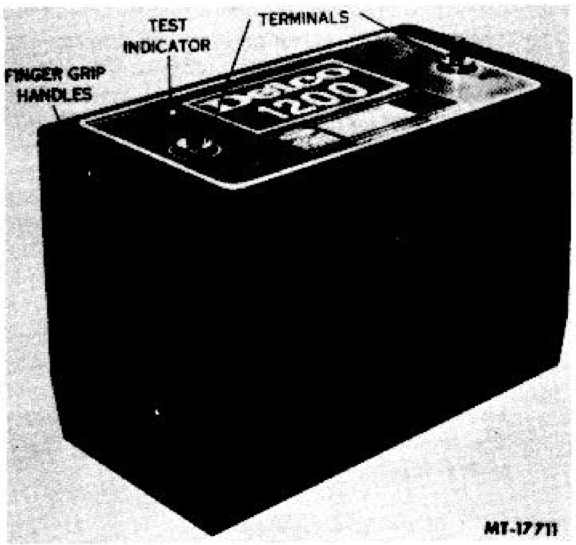


Fig. 1 Heavy Duty, Maintenance-Free Battery

DESCRIPTION

The top terminal type maintenance-free battery shown in Figure 1 is designed for use in trucks and other heavy duty applications.

Water never needs to be added to the maintenance-free battery. There are no vent plugs in the cover. The battery is completely sealed except for a small vent hole on the side. This vent hole allows what small amount of gases that are produced in the battery to escape. The special chemical composition inside the battery reduces the production of gas to an extremely small amount at normal charging voltages.

The maintenance-free battery has a strong ability to withstand damaging effects of overcharge. Also, the terminals are sealed tightly to retard leakage.

A test indicator in the battery cover can be used to determine if the battery can be tested in case of a cranking complaint. This feature is explained below.

SAFETY PRECAUTIONS

Wear safety glasses when working near batteries.

All automotive batteries generate hydrogen gas which is highly flammable. If ignited by a spark or flame, the gas may explode violently causing spraying of acid, fragmentation of the battery, and possible severe personal injuries, particularly to the eyes.

Avoid battery acid. In case of contact, flush immediately with water.

Charge batteries only in a well-ventilated area. Always be sure battery chargers are "OFF" when connecting to or disconnecting from batteries.

TEST INDICATOR

The test indicator (Figure 1) is to be used with accepted diagnostic procedures only. It is not to be used to determine if battery is good or bad. The test indicator is a built-in hydrometer in one cell and provides visual information for battery testing.

It is important when observing the test indicator that the battery be level and have a clean top to see the correct indication. A light may be required in some poorly-lit areas .

Under normal operation, two indications can be observed:

1. GREEN DOT VISIBLE (Figure 2)

   Any green appearance is interpreted as a "green dot", and the battery is ready for testing.

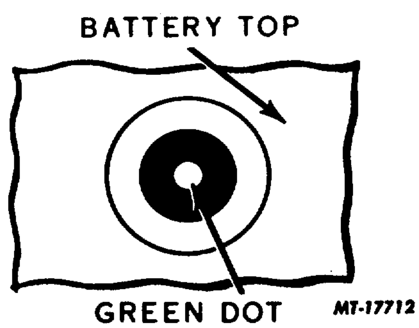


Fig. 2 Test Indicator Green Dot Visible

2. DARK (GREEN DOT NOT VISIBLE) (Figure 3)

   If there is a cranking complaint, the battery should be tested as instructed under "TESTING" and the vehicle's charging system should be checked for proper operation and adjustment.

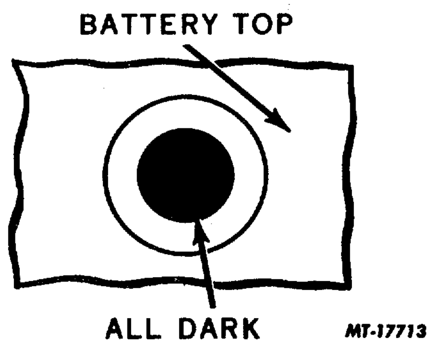


Fig. 3 Test Indicator Dark (Green Dot Not Visible)

On occasion, the test indicator may turn light yellow. This indicates a low electrolyte level. Less of electrolyte level could result from excessive over-charging, a broken case or tipping the battery over 450 on its side.

If test indicator shows light yellow, inspect battery and check charging system. Although the battery may be capable of further service, if a cranking complaint has been reported, replace the battery. DO NOT CHARGE, TEST OR JUMP START!

TESTING

1. VISUAL INSPECTION

Check for obvious damage, such as a cracked or broken case or cover that could permit loss of electrolyte. If obvious physical damage is noted, replace battery. Determine cause of damage and correct as needed.

2. OBSERVE TEST INDICATOR

a. Green Dot Visible (Figure 2)

Proceed to Step 3.

On occasion, after prolonged cranking the green dot may still be visible with the battery discharged. Should this occur, charge the battery as instructed under "CHARGING".

b. Dark (Green Dot Not Visible) (Figure 3)

Charge the battery as instructed under "CHARGING" and proceed to Step 3.

c. On occasion, the test indicator may appear light yellow. In this instance, the battery should NOT be tested. Replace the battery.

3. REMOVE SURFACE CHARGE

Disconnect battery cables and connect a 300 ampere load across terminals for 15 seconds to remove surface charge from battery. (Attach load clamps to contact lead terminal pads as instructed under "CHARGING AND TESTING ADAPTERS") .

4. LOAD TEST

a. Connect voltmeter and test load across terminals (see "CHARGING AND TESTING ADAPTERS").

b. Apply specified load (See "SPECIFICATIONS"). Read voltage after 15 seconds with load connected; then disconnect load.

c. If minimum voltage is 9.6* or more, battery is good.

d. If minimum voltage is less than 9.6*, replace battery.

*This voltage is to be used for battery ambient temperature of 21 deg. C (70 deg. F) and above. For temperatures below 21 deg. C (70 deg. F), refer to Table 1.

TABLE I

Ambient Temperature	21 C (70 F) & Above	16 C (60 F)	10 C (50 F)	4 C (40 F)	-1 C (30 F)	-7 C (20 F)	-12 C (10 F)	-18 C (0 F)
Minimum Voltage	9.6	9.5	9.4	9.3	9.1	8.9	8.7	8.5

CHARGING

Charging equipment for ordinary batteries is suitable for maintenance-free batteries.

DO NOT charge a battery if the green dot is visible in the test indicator.

On occasion, following prolonged cranking, the green dot may still be visible with the battery discharged. Should this occur, a booster charge of 20 ampere-hours is recommended.

DO NOT charge a battery if the test indicator is light yellow.

When charging battery, disconnect battery cables and connect charger to battery terminals as instructed under "CHARGING AND TESTING ADAPTERS". For typical charging rates, refer to Table 2. Note that this table recommends a maximum charge input of 75-80 ampere-hours.

To AVOID DAMAGE, charging rate must be reduced or temporarily halted if:

1. Battery case feels hot (51 deg. C/125 deg. F).

TABLE 2

BATTERY CHARGING GUIDE

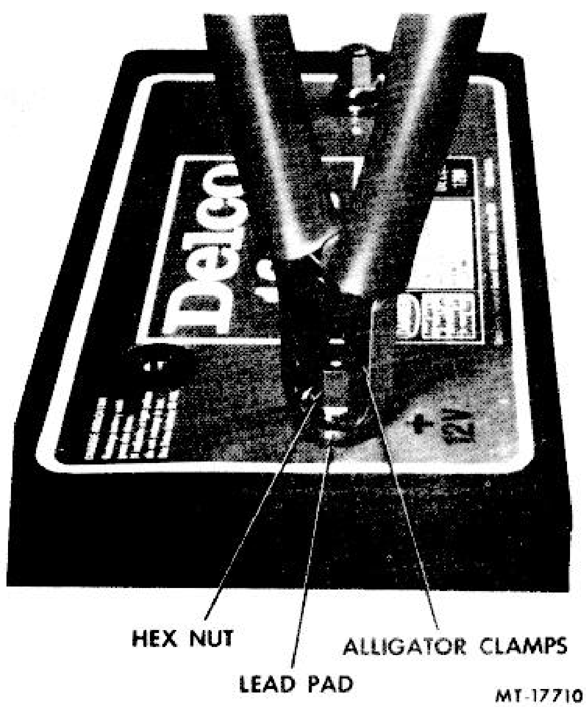
Heavy Duty Maintenance-Free

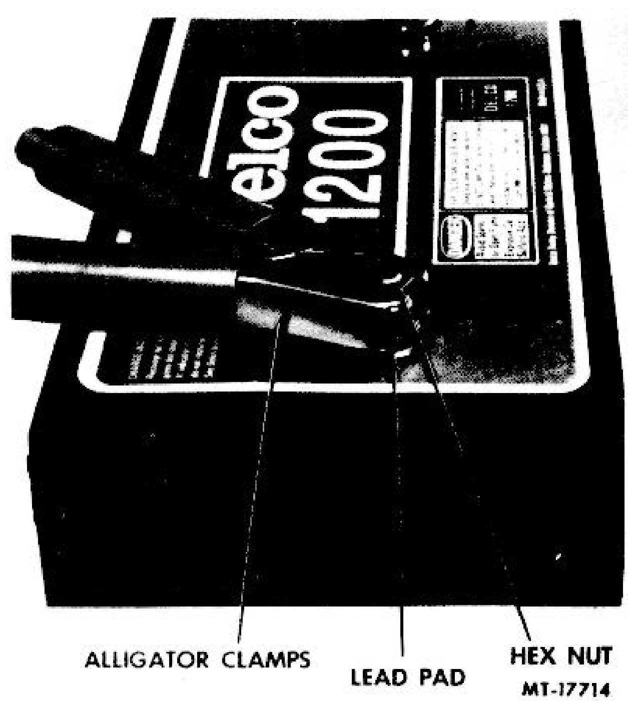
Stop charging when the green dot appears or when the maximum charge shown below is reached.

Slow Charging Rate	Fast Charging Rate
	3 3/4 Hours @ 20 A
15 Hours @ 5 A	2 1/2 Hours @ 30 A
7 1/2 Hours @ 10 A	2 Hours @ 40 A
	1 1/2 Hours @ 50 A

2. Violent gassing or spewing of electrolyte occurs.

After charging in accordance with Table 2, even though the green dot does not appear, the battery is still sufficiently charged for testing.





Figs. 4 and 5 Alligator Clamps Contacting Lead Pad for Battery Testing and Charging

CHARGING AND TESTING ADAPTERS

Heavy duty maintenance-free batteries may be charged or tested either on or off the vehicle. However, the battery terminal hex nuts (AC-Delco part number 7802) are required for testing and charging.

It is important that the alligator clamps of the tester or charger be placed between the terminal nuts and the lead pads of the terminal studs after the vehicle battery cables are detached, as shown in Figures 4 and 5. The clamps must touch the lead pads.

If this connection cannot be made because of alligator clamp design, the load for testing must be reduced as indicated in "SPECIFICATIONS ".

EMERGENCY (JUMPER) STARTING

Both booster and discharged battery should be treated carefully when using jumper cables. Be careful not to cause sparks. Follow exactly the procedure outlined below.

CAUTION

Any procedure other than the following could result in: 1) personal injury caused by electrolyte squirting out the battery vent, 2) personal injury or property damage due to battery explosion, 3) damage to the charging system of the booster vehicle or of the immobilized vehicle.

DO NOT permit vehicles to touch each other as this could establish a ground connection and counteract the benefits of this procedure.

1. Set parking brake and place automatic transmission in "PARK" (neutral for manual transmission). Turn off lights, heater and other electrical loads.

   Observe test indicator:

   If indicator is light yellow, replace battery. DO NOT attempt jump starting when indicator is light yellow.

   If test indicator is dark, with or without a green dot in the center, proceed as follows:

2. Attach one end of one jumper cable to the positive (+) terminal of the booster battery and the other end of same cable to positive (+) terminal of discharged battery (Figure 6).

   On positive ground vehicles, connect jumper cable between negative (-) battery terminals.

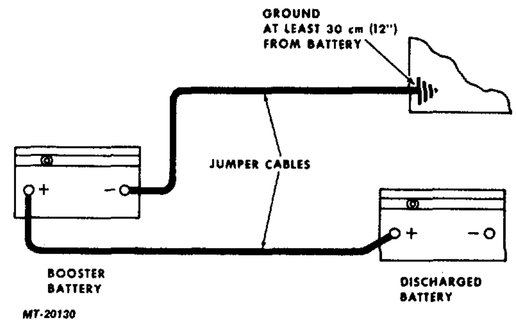


Fig. 6 Proper Jumper Cable Connections (Negative Ground Vehicles Shown)

3. Attach one end of the remaining jumper cable to the negative terminal of the booster battery and the other end to a ground at least 304 mm (12") from the battery of the vehicle being started (Figure 6). (DO NOT connect directly to the negative post of the dead battery.)

   On positive ground vehicles, connect jumper cable between positive (+) terminal of booster battery and ground on the stalled vehicle.

4. Take care that the clamps from one cable do not inadvertently touch the clamps on the other cable. DO NOT lean over the battery when making connections. The ground connection must provide good electrical conductivity and current carrying capacity. Avoid moving, hot or electrical hazards such as fans, manifolds and spark plug terminals.

5. Reverse this sequence exactly when removing the jumper cables.

INSTALLATION PROCEDURE

1. Be sure there are no foreign objects in the carrier so that the battery will rest properly in the bottom of the carrier. Hold-downs should be functional and properly tightened.

2. Cable terminals should be securely tightened, but not over 20 N.m (15 lb. ft.).

3. Connect grounded terminal of battery last to avoid short circuits or grounds which may damage the electrical system.

4. Remove circles from "service date" label to certify date.

5. If installation is performed in sub-zero temperature, it is beneficial to boost charge for 15 minutes in order to achieve maximum battery performance.

6. If engine does not crank satisfactorily-

a. and green dot is not visible in test indicator, battery should be recharged as instructed under "CHARGING".

b. and green dot is visible, battery should be checked as instructed under "TESTING".

A battery that passes the test procedure indicates a need for further checking of the vehicle's fuel, ignition, cranking and charging systems.

STORAGE PROCEDURE

Maintenance-free, heavy duty batteries have a much longer shelf life than ordinary batteries. When recommended storage and handling procedures are followed, they can be stored for over a year and installed without special preparation. Batteries left in storage for a longer period may require charging before use.

1. Storage Temperature

These batteries have a very slow self-discharge rate when kept between 0 deg. C (32 deg. F) and 27 deg. C (80 Deg. F). They should be stored at the lowest temperature possible within this range for optimum shelf life. Sustained storage above 27 deg. C rapidly increases the rate of self-discharge and should be avoided. To prevent possible freezing of the electrolyte, do not store below 0 deg. C (32 deg. F).

2. Stock Rotation

Good business practices of stock rotation should be followed. Date codes should be observed so that sales and shipments can be made on a first-in/first-out inventory basis.

3. Storage Position

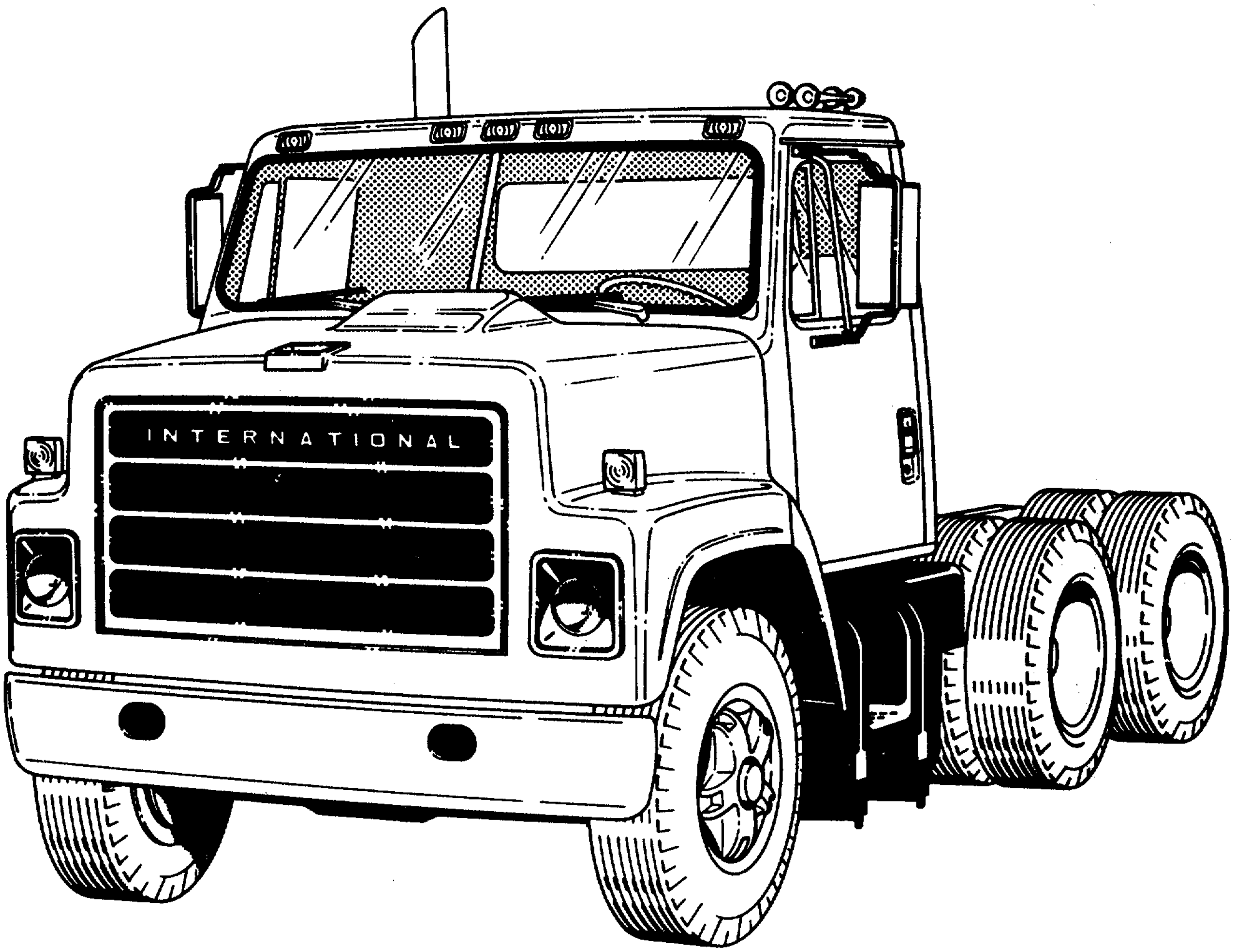
Batteries must be kept in an upright position. Although the batteries have sealed covers, it is possible for electrolyte to escape through the vent holes if the batteries are turned on their sides, or if tipped more than 45 degrees.

SPECIFICATIONS

BATTERY MODEL	VOLTS	AMPS FOR LOAD TEST	RESERVE CAPACITY (MINUTES)	COLD CRANKING CURRENT (AMPS)		MAXIMUM DIMENSIONS			APPROX. WEIGHT
				At -18°C (0°F)	At -29°C (-20°F)	LENGTH	WIDTH	HEIGHT (INCL. POSTS)	
1110	12	310*	160	625	490	330 mm (13 in.)	172mm (6-3/4 in.)	239mm (9-7/16 in.)	26.8 Kg. (59.2 lbs.)
1150	12	290*	175	580		330 mm (13 in.)	172 mm (6-3/4 in.)	239 mm (9-7/16 in.)	26.9 Kg. (59.3 lbs.)
1200	12	235*	130	475	375	330 mm (13 in.)	172 mm (6-3/4 in.)	239 mm (9-7/16 in.)	24.2 Kg. (53.2 lbs.)

*Battery tester cable clamps should be between terminal nuts and lead pads of terminals. If not possible, load value should be 275 amperes for Model 1110, 260 amperes for Model 1150, and 210 amperes for Model 1200.

ELECTRICAL
CIRCUIT DIAGRAMS
AND CIRCUIT IDENTIFICATION
S-SERIES TRUCKS



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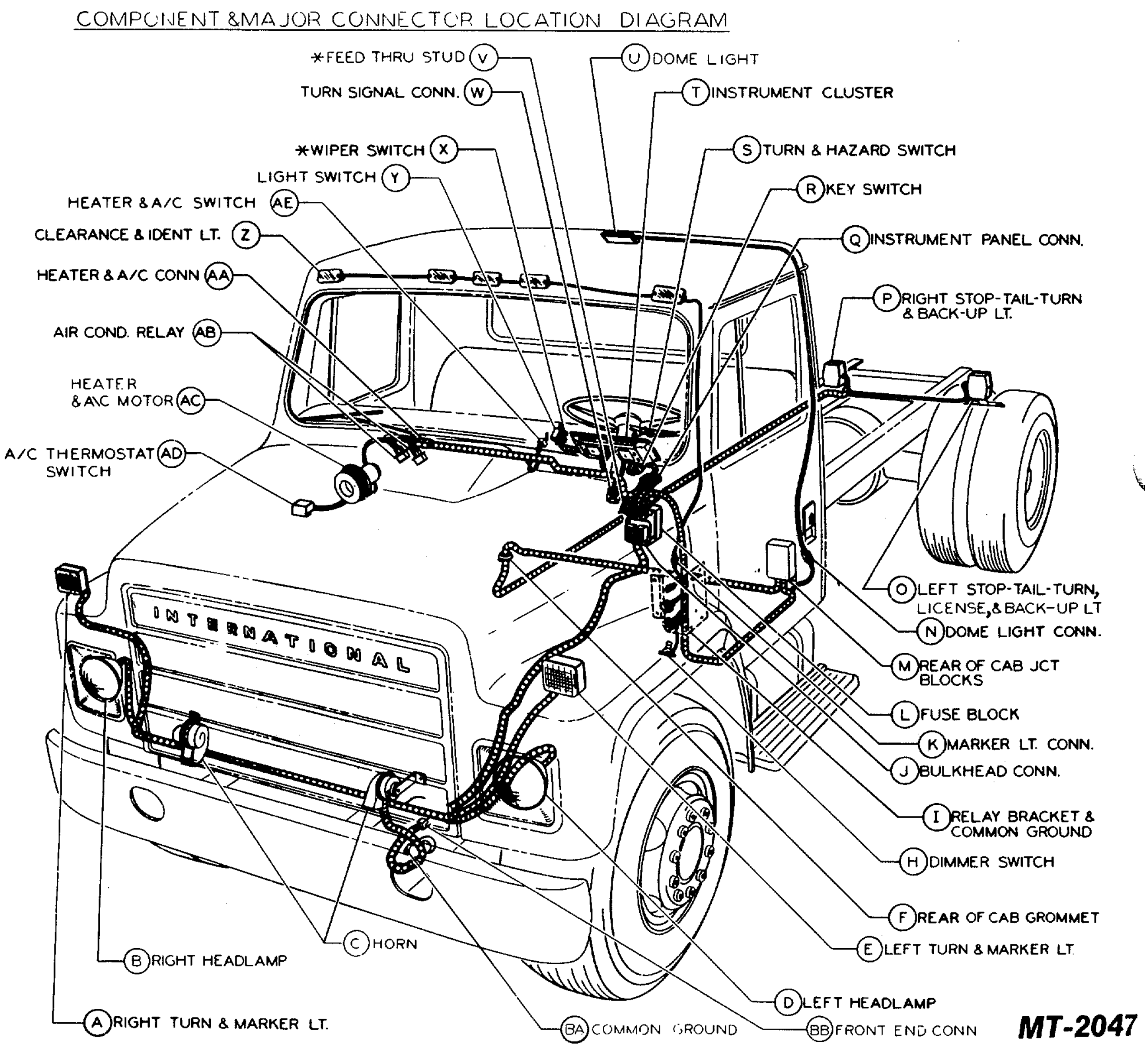


Component and Major Connector Location (On Chassis)

CIRCUIT NUMBERS & DESCRIPTION

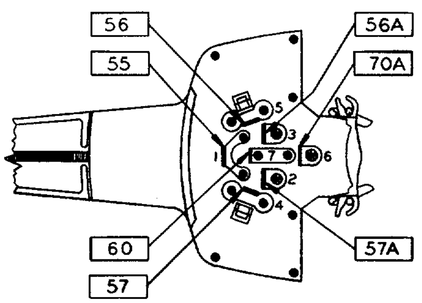
1	GENERATOR (FIELD)	51	DIMMER SWITCH
2	GENERATOR (CHARGE)	52	HEAD LIGHT-HI-BEAM
6	REGULATOR,VOLT (FIELD RELAY)	53	HEAD LIGHT-LO-BEAM
7	REGULATOR, VOLT(CHARGE)	54	PARKING LIGHTS
II	GROUND	55	DIR. SIGNAL SWITCH
14	MAIN FEED	56	DIR. SIGNAL LIGHTS-LEFT
15	KEY SWITCH	57	DIR. SIGNAL LIGHTS-RIGHT
16	IGNITION	58	CLEAR., IDENT. & MARKER LIGHTS
17	STARTING CONTROL	60	HAZARD SWITCH
18	GLOW PLUG,PRE HEATER	62	PANEL LIGHTS
19	FUEL SHUT-OFF	63	DOME &/OR COURTESY LIGHTS
21	ETHER	68	TAIL LIGHT
23	MAGNETIC FAN	70	STOP LIGHT
24	EXHAUST BRAKE	71	BACK-UP LIGHT
28	INSTRUMENT	72	TRAILER
29	ENG WATER TEMP	75	HEATER
30	ENG OIL TEMP	76	DEFROSTER
31	TRANS OIL TEMP	77	AIR CONDITIONER
32	AXLE OIL TEMP	78	HEATED MIRROR
33	ENG OIL LEVEL	80	ACCESSORY FEED
34	WATER LEVEL	82	WINDSHIELD WIPER
35	ENG OIL PRESSURE	84	CIGAR LIGHTER
36	FUEL LEVEL	85	HORN
37	FUEL PUMP	86	RADIO
40	AIR PRESSURE WARNING	87	WINDSHIELD WASHER
41	VACUUM WARNING	92	TRANSMISSION
42	FRT AXLE WARNING	93	AXLE SHIFT
43	P.D. LOCK WARNING	94	WHEELLOCK (ANTI-SKID BRAKES)
44	BRAKE SYSTEM WARNING	95	EXHAUST EMISSION
50	LIGHT SWITCH		

MT-20473

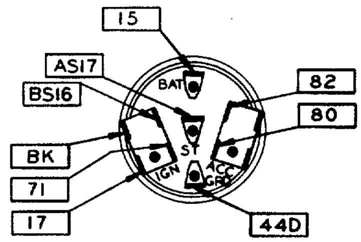
CIRCUIT NUMBERS MAY REQUIRE SUFFIX LETTER IDENTIFICATION WHEREVER BRANCHES OF THE MAIN CIRCUIT ARE ENCOUNTERED.

Circuit Identification

ELECTRICAL

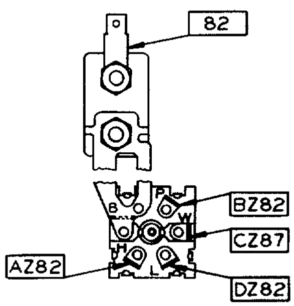


TURN SIGNAL SWITCH
LOCATION-S
VIEWED FROM TERMINAL SIDE

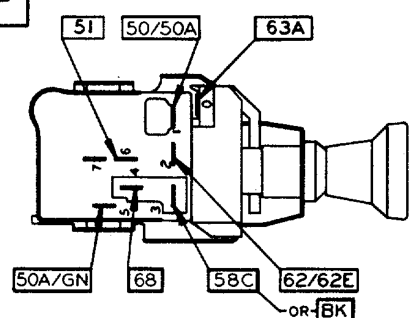


KEY SWITCH
LOCATION-R
VIEWED FROM TERMINAL SIDE

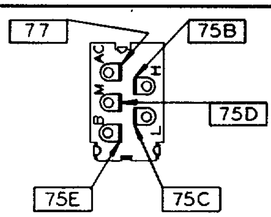
SWITCH CONTACT CHART			
SWITCH	POSITION	CONTACTS CLOSED	CONTACTS OPEN
TURN SIGNAL & HAZARD	OFF (NORMAL)	2,3. & 6	1,4,5 & 7
	LEFT TURN & LANE CHANGE	1,3 & 5 2 & 6	4 & 7
	RIGHT TURN & LANE CHANGE	1,2 & 4 3 & 6	5 & 7
	HAZARD	2,3,4,5 & 7	1 & 6
HEAD LIGHT	OFF-(KNOB IN & TURNED C.W.)	2,3 & 4	0,1,5,6 & 7
	PARK LIGHTS (KNOB IN 1 ST POS.)	1 & 7 2,3,4 & 5	0 & 6
	HEAD LIGHTS (KNOB IN 2 ND POS.)	1 & 6 2,3,4 & 5	0 & 7
	DOME-(KNOB IN & TURN C.C.W.)	0 TO GRD 3,4 & 2	1,5,6 & 7
	PANEL-(2ND POS. TURN C.C.W. TO LOCK)	0 TO GRD 1 & 6 2,3,4 & 5	7
KEY	OFF	NONE	ALL
	START	BAT-ST-IGN GRD-CASE	ACC
	IGNITION	BAT-IGN-ACC	ST-GRD
	ACCESSORY	BAT-ACC	ST-IGN-GRD
HEATER & A/C	OFF	NONE	ALL
	LOW	BAT-L-A/C	M-H
	MED	BAT-M-A/C	L-H
	HIGH	BAT-H-A/C	L-M
WIPER/ WASHER	PARK	BAT-P	W-L-H
	LOW	BAT-L	W-P-H
	HIGH	BAT-H	W-P-L
	WASHER (KNOB IN)	BAT-W	L-M-H
SHT-DN TEMP	NORMAL (BELOW 204°)	C-NC	C-NO
	ALARM (204°-210°)	C-NC C-NO	NONE
	SHUT-DOWN (ABOVE 210°)	C-NO	C-NC
SHT-DN PRESS	ENG OFF	C-NC	C-NO
	NORMAL	C-NO	C-NC
	ALARM (7 OR 11 P.S.I.)	C-NO C-NC	NONE
	SHUT-DOWN (3 OR 6 P.S.I.)	C-NC	C-NO



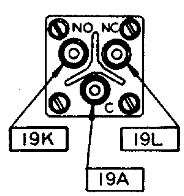
WIPER/WASHER SWITCH
LOCATION-X
VIEWED FROM TERMINAL SIDE



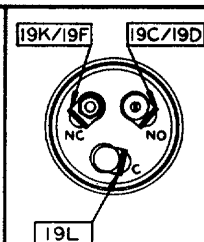
LIGHT SWITCH
LOCATION-Y
VIEWED FROM TERMINAL SIDE



HEATER/A-C SWITCH
LOCATION-AE
VIEWED FROM TERMINAL SIDE



SHT-DN TEMP SW



SHT-DN PRESS SW

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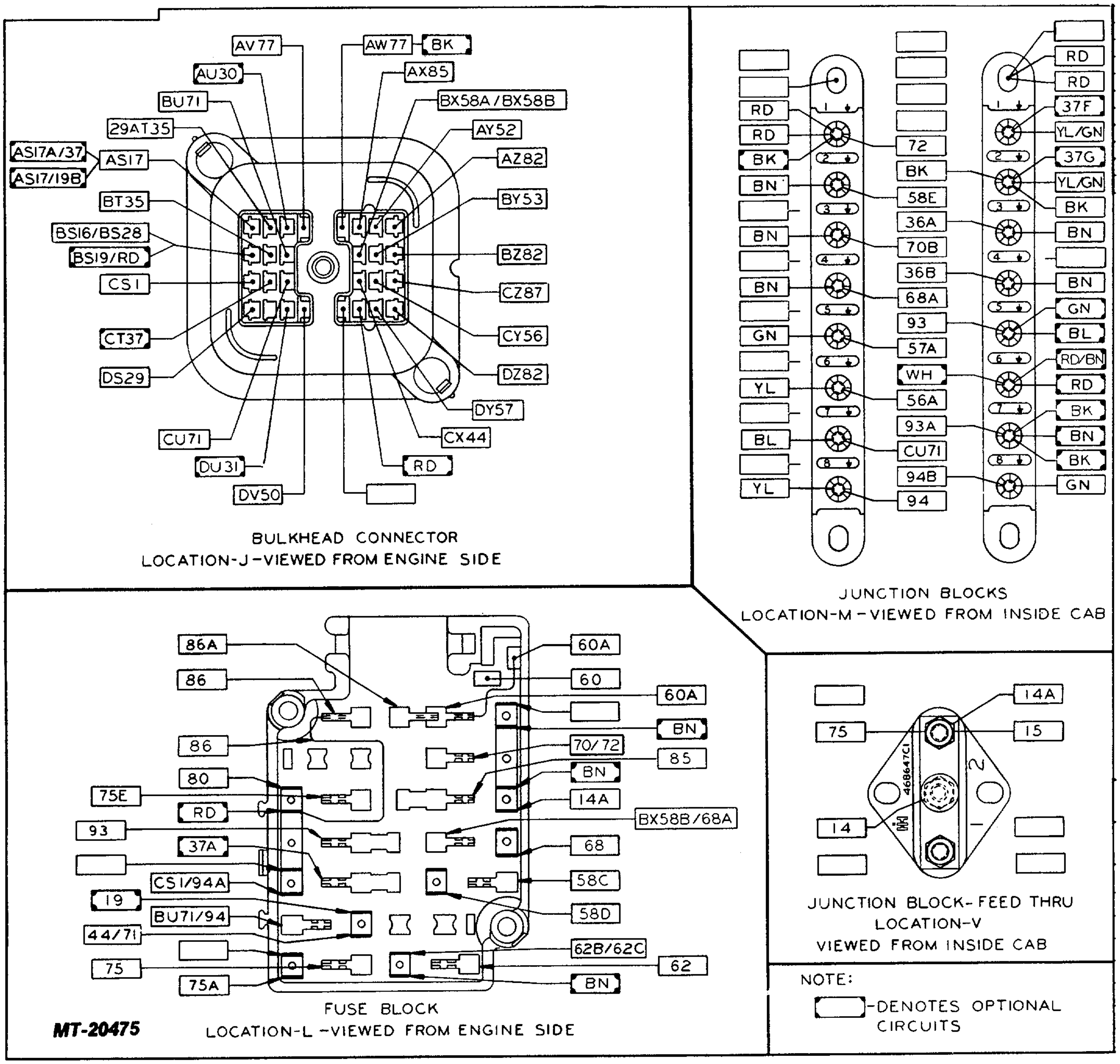
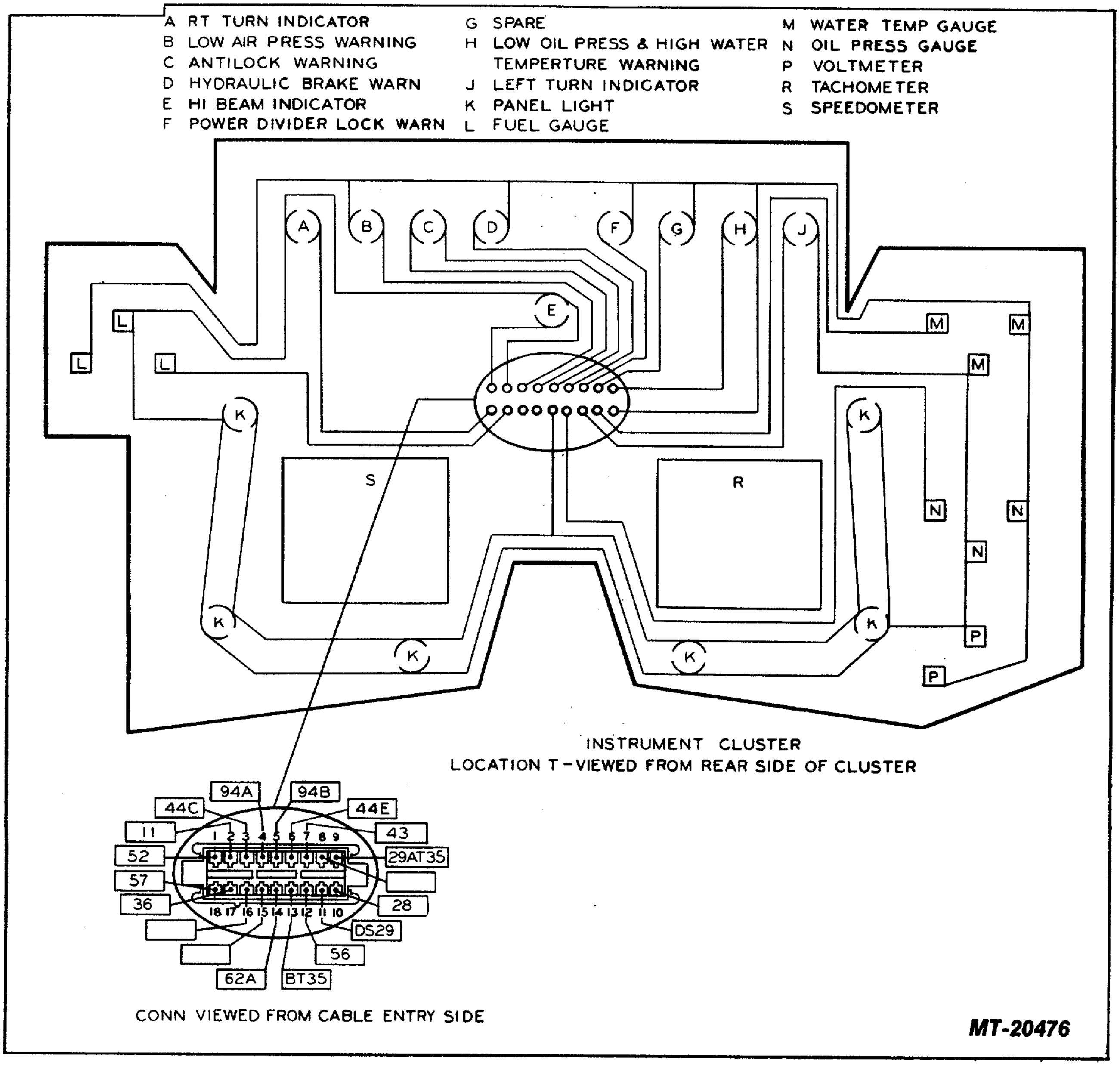
Component and Major Connectors (Use in Conjunction with Page 3)



Component and Major Connectors (Use in Conjunction with Page 3)

ELECTRICAL



Component and Major Connectors (Use in Conjunction with Page 3)

ELECTRICAL

SYMBOLS

- —11-16— TYPICAL WIRING
- —1 GA— BATTERY CABLE
- REFERENCE WIRING
- —11-16—ALTERNATE WIRING
- RESISTANCE OR RESISTOR
- RESISTANCE OR RESISTOR-VARIABLE
- FUSIBLE LINK
- SPLICE
- OR FIXED CONTACT OR COMPONENT INTERNAL CONNECTION
- NORMALLY OPEN (NO) SWITCH
- NORMALLY CLOSED (NC) SWITCH
- 15 CIRCUIT BREAKER W/AMP IDENTIFIER
- 15 INLINE FUSE W/AMP IDENTIFIER
- 15 FUSE PANEL CLIP W/MALE BLADE TERMINALS & FUSE W/ AMP IDENTIFIER
- MALE TERMINAL
- FEMALE TERMINAL
- SINGLE BODY INLINE CONNECTOR
- MULTIPLE TERMINAL INLINE CONNECTOR
- —11-16— EXTERNAL GROUND
- CASE GROUND
- TERMINAL OR CONNECTOR CAVITY
- INCANDESCENT LAMP
- ELECTROMAGNETIC COIL
- THERMAL CUTOUT (FLASHER)

WIRE COLOR CODES

BK-BLACK	RD-RED
BN-BROWN	GN-GREEN
YL-YELLOW	WH-WHITE
BL-BLUE	

KEY

11A-16 BK
- CABLE COLOR
- CABLE GAUGE
- CIRCUIT NUMBER

NOTES

1-MULTIPLE CONNECTORS AT ELECTRICAL EQUIPMENT VIEWED FROM CABLE INSERTION END UNLESS OTHERWISE SPECIFIED.

MT-20477

Definition of Symbols

ELECTRICAL

BULB CHART

BULB APPLICATION	WATTS OR CANDLEPOWER	TRADE NO.
HEADLIGHT:		6014
UPPER BEAM	60 WATTS	
LOWER BEAM	50 WATTS	
FRONT TURN	32	1156
SIDE MARKER	2	1895
PARK	3	181
STOP-TURN/TAIL-LICENSE	32/3	1157
BACK-UP	32	1156
IDENTIFICATION-CLEARANCE	3	168
FLOOD LIGHT	12	561
MIRROR LIGHT	2	1895
CLUSTER:		
ILLUMINATION	2	194
INDICATOR	2	194
WARNING	2	194
INFORMATION	2	194
CONTROL IDENTIFICATION OR WARNING LIGHT:		
ENGINE STOP	.50	*
FRONT AXLE	.50	●
GAUGE ILLUMINATION:		
ENGINE OIL TEMPERATURE	1	53
XMSN OIL TEMPERATURE	1	53
INSTR PANEL CONTROLS	.50	*
ASHTRAY	.50	●
DOME	12	211-2
RADIO	.75	1892
HEATER & A/C CONTROLS	3	168
AUTO XMSN CONTROLS	1	53

* PURCHASED LIGHT ASSEMBLY
(REF G.E. BULB NO. 2162D)

FUSE, CIRCUIT BREAKER, & FUSIBE LINK CHART

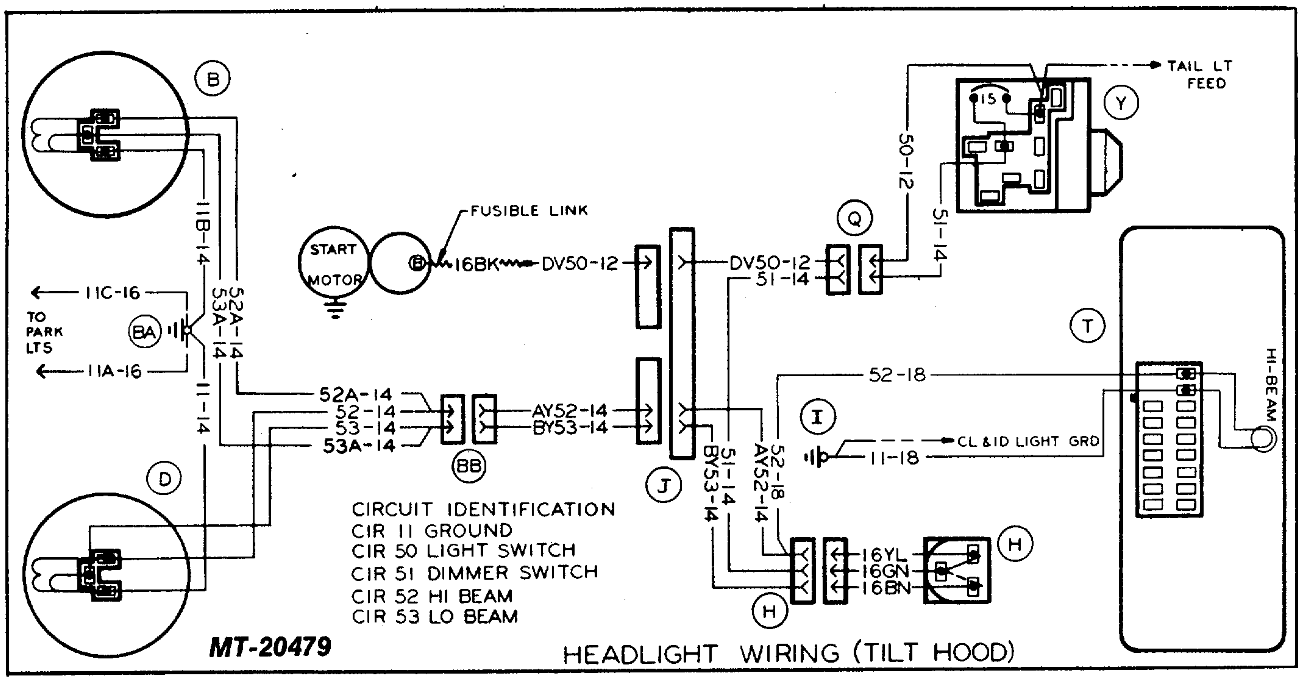
DESCRIPTION	SIZE	TYPE	LOCATION
HAZARD LIGHTS	20A	FUSE	TURN/HAZARD
TURN LIGHTS	20A	FUSE	
DOME LIGHTS	15A	FUSE *	HORN/DOME
HORN	15A	FUSE *	
STOP LIGHTS	30A	FUSE *	STOP/TRL MKR
TRAILER MARKER	30A	FUSE *	
FLOOD LIGHTS	30A	FUSE *	
TAIL LIGHTS	20A	FUSE *	TAIL/CAB MKR
CL/ID LIGHTS	20A	FUSE *	
PARK MARKER LTS	20A	FUSE *	
MIRROR LIGHTS	20A	FUSE *	
TRL MKR LIGHT REL	15A	FUSE *	MARKER
INSTR PANEL LIGHTS	4A	FUSE *	PANEL
CLUSTER PANEL LTS	4A	FUSE *	
ASHTRAY LIGHTS	4A	FUSE *	
HTR & A/C CONT ILLUM	4A	FUSE *	
XMSN & ENG OIL TEMP GAUGE ILLUM	4A	FUSE *	
RADIO	4A	FUSE *	RADIO
HEATER ONLY	20A	FUSE *	HEATER & A/C
HTR & A/C-EXCEPT HIGH POSITION	20A	FUSE *	
2 SPEED AXLE	20A	FUSE *	2 SPEED
SUBMERGED FUEL PUMP	4A	FUSE *	FUEL PUMP
BACK-UP LIGHTS	15A	FUSE *	BACK-UP/ ANTILOCK
ANTILOCK SYSTEMS	15A	FUSE X	
HTR & A/C-EXCEPT HIGH POSITION	30A	CIRCUIT BKR	HEATER & A/C
KYSOR ENGINE SHUTDOWN 2 FUSES	10A	IN-LINE FUSE	ABOVE KYSOR SW, LWR FRT LT SIDE OF CAB
	6A	IN-LINE FUSE	
HEADLIGHTS	15A	CIR BKR	INSIDE LIGHT SW
WINDSHEILD WIPER & WASHER	6A	CIR BKR	REAR OF WIPER SWITCH
HEADLIGHT FEED	16GA	BK FUSE LINK	AT START MOTOR SOL
CAB FEED	12 GA	DK BL FUSE LINK	AT START MOTOR SOL
CIGAR LIGHTER	18 GA	GN FUSE LINK	LIGHT SWITCH

FUSE IDENT SHOWN AS ON FUSE BLOCK
FUSE BLOCK MTG ON INSIDE CAB-UPPER LEFT SIDE OF DASH

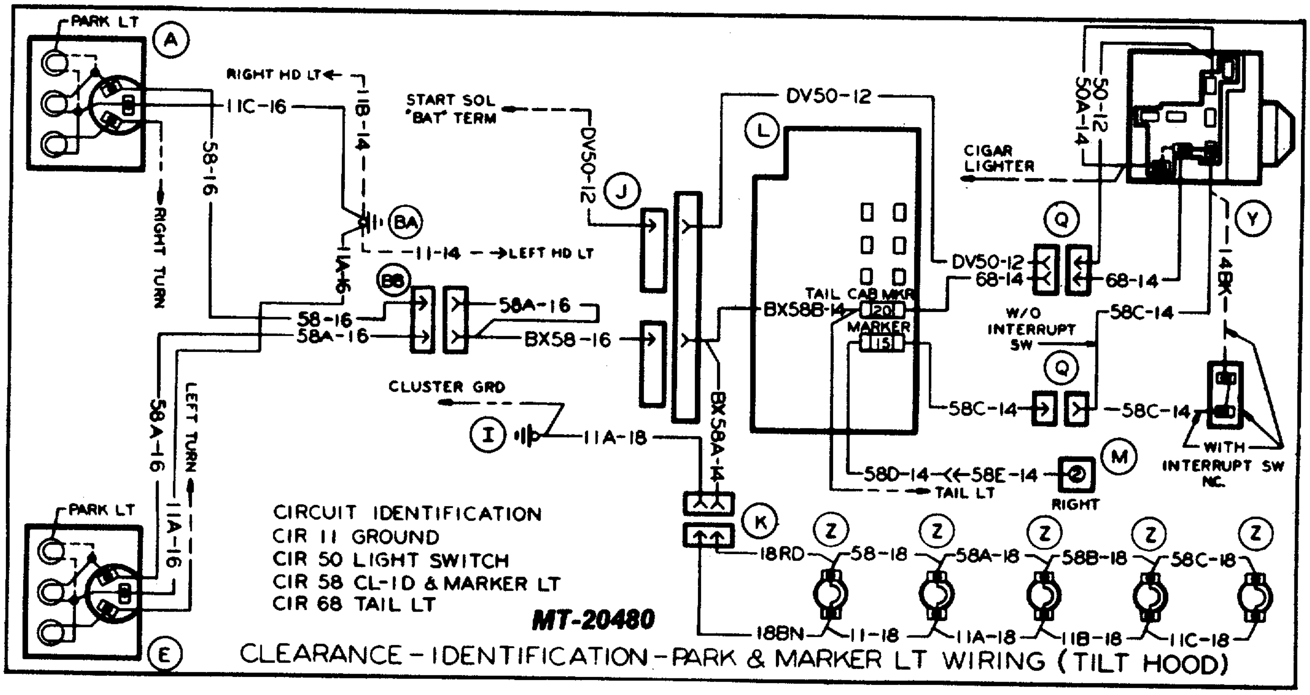
* CIRCUIT BREAKER OPTIONAL

MT-20478

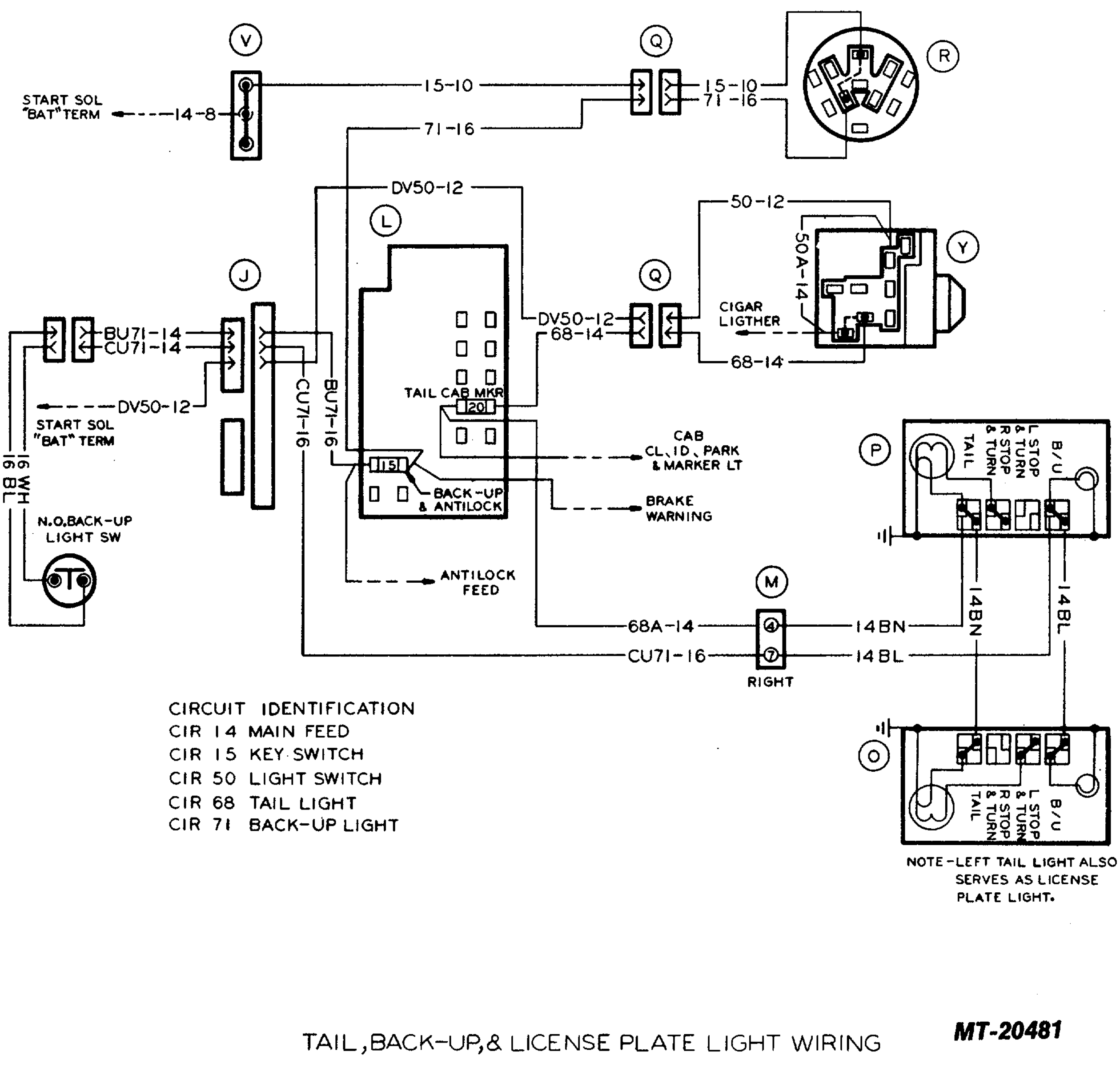
Bulb and Fuse Chart


TAIL LT FEED
FUSIBLE LINK
START MOTOR
16BK
DV50-12
51-14
50-12
11B-14
11C-16
TO PARK LTS
11A-16
52A-14
53A-14
11-14
52-14
53-14
AY52-14
BY53-14
52-18
11-18
CL & ID LIGHT GRD
HI-BEAM
16YL
16GN
16BN
CIRCUIT IDENTIFICATION
CIR 11 GROUND
CIR 50 LIGHT SWITCH
CIR 51 DIMMER SWITCH
CIR 52 HI BEAM
CIR 53 LO BEAM
MT-20479
HEADLIGHT WIRING (TILT HOOD)

Headlights



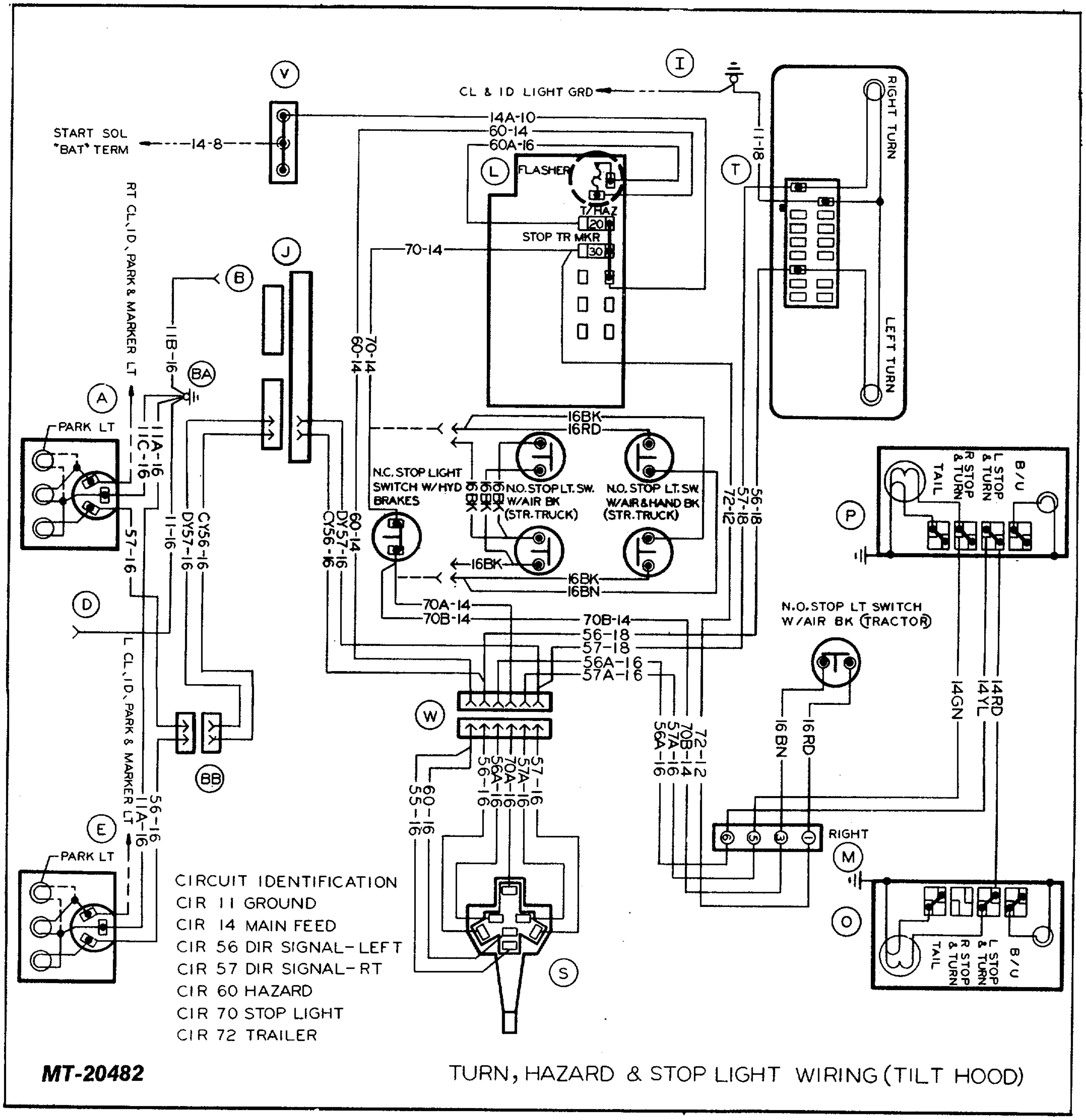
Clearance-Identification-Park-Marker Lights



CIRCUIT IDENTIFICATION
CIR 14 MAIN FEED
CIR 15 KEY SWITCH
CIR 50 LIGHT SWITCH
CIR 68 TAIL LIGHT
CIR 71 BACK-UP LIGHT

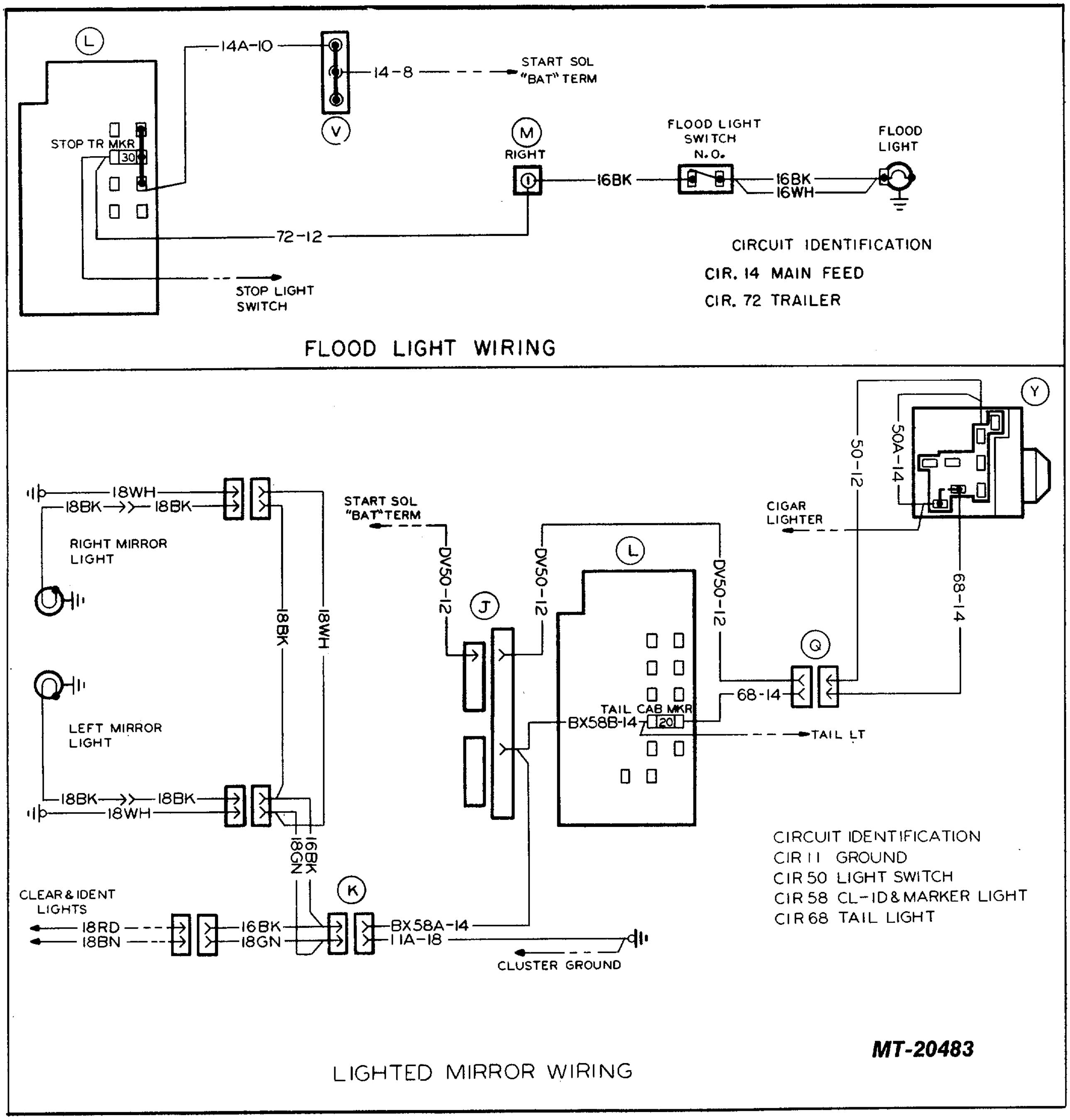
Tail-Back Up and License Plate

ELECTRICAL



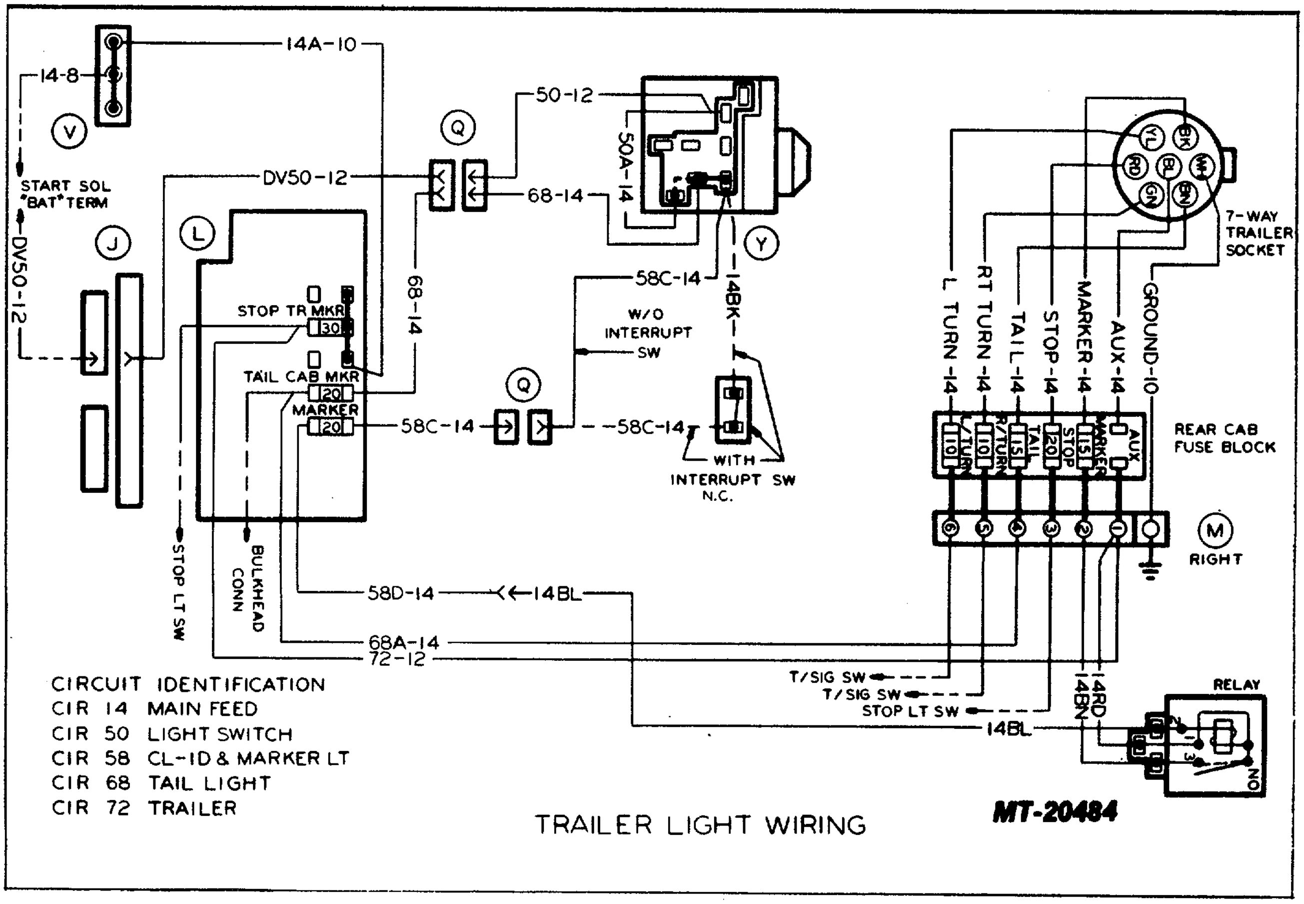
Turn-Hazard-Stop Light

ELECTRICAL



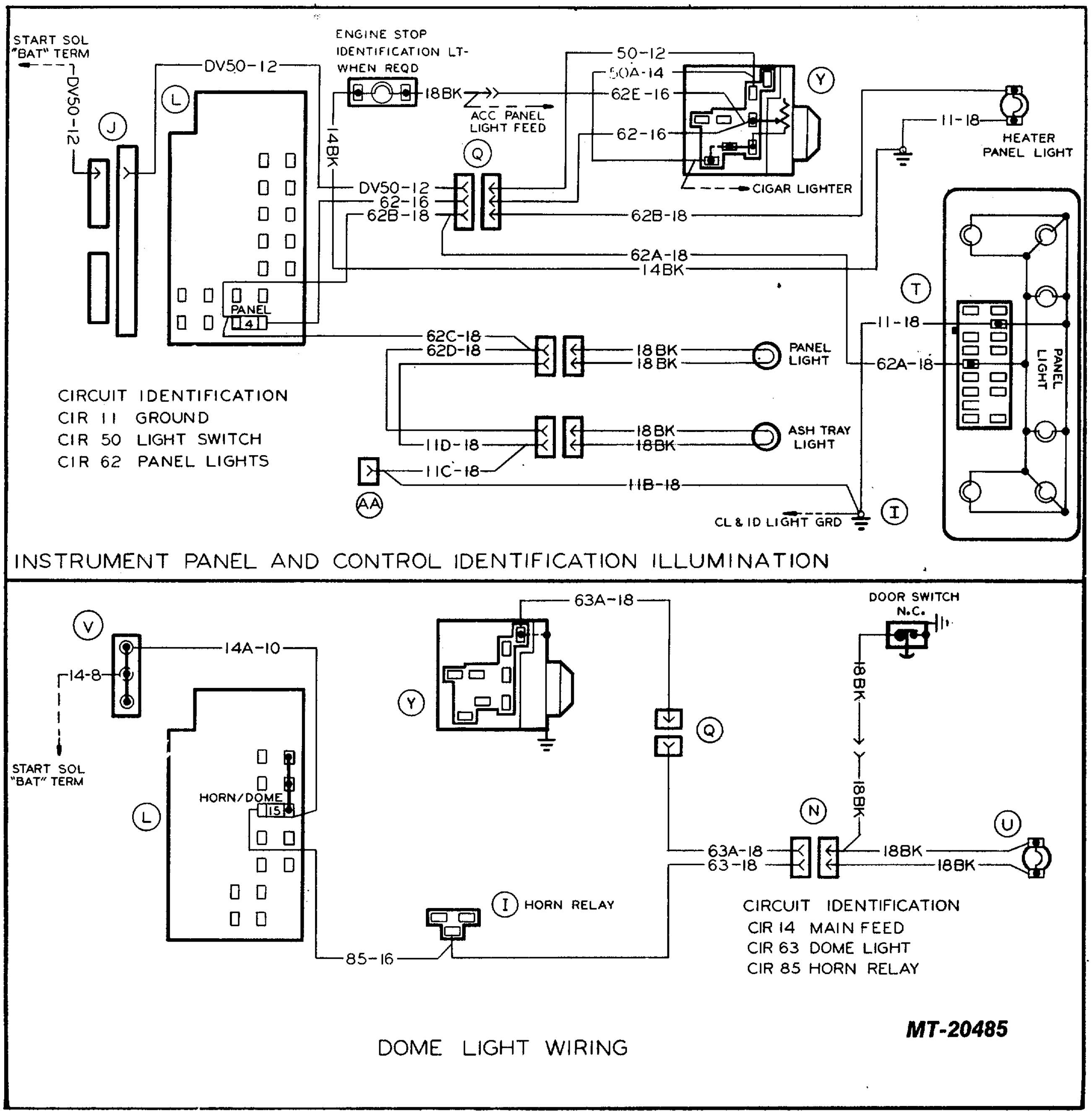
Flood Light-Mirror

ELECTRICAL



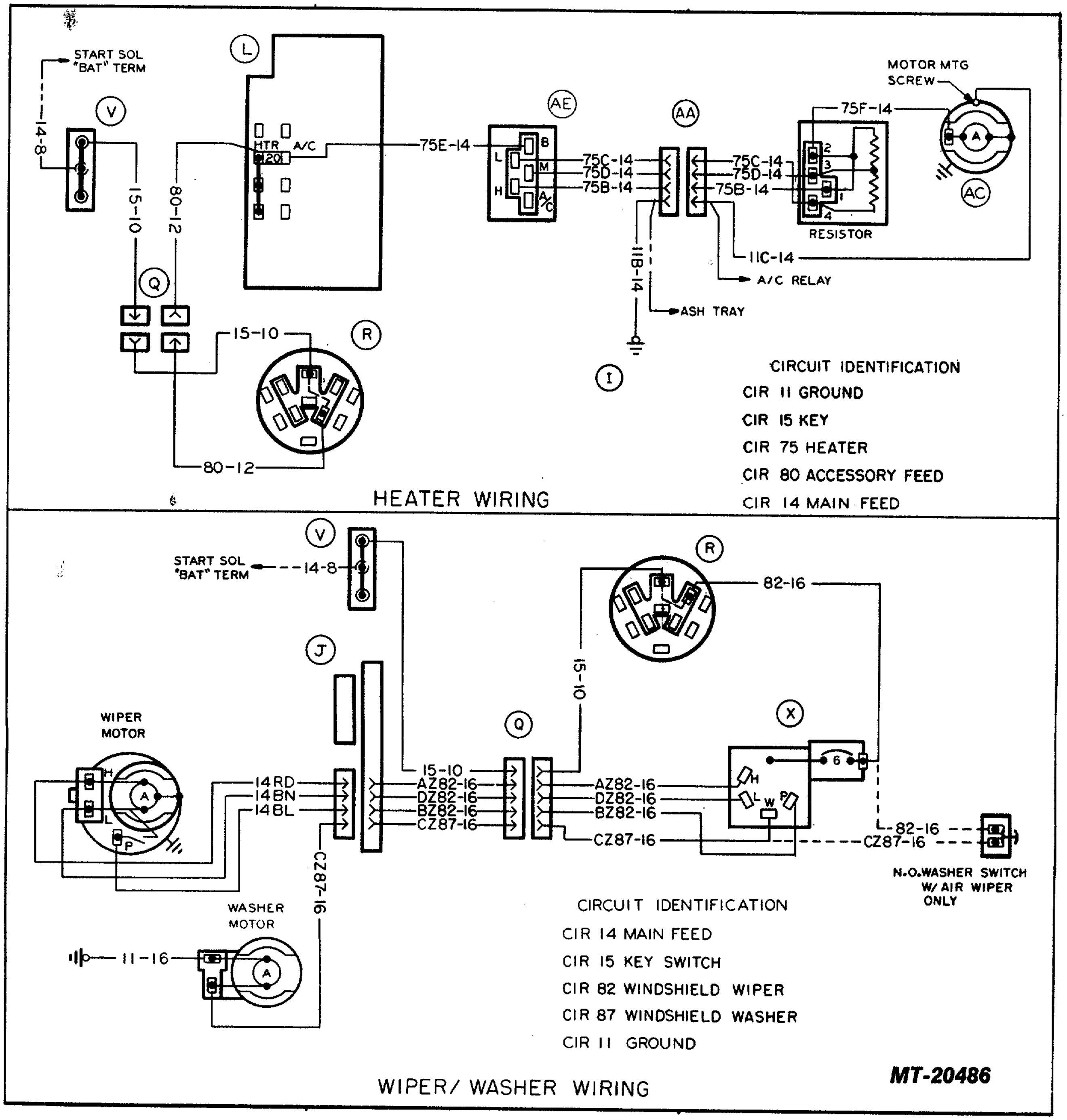
Trailer Light

ELECTRICAL



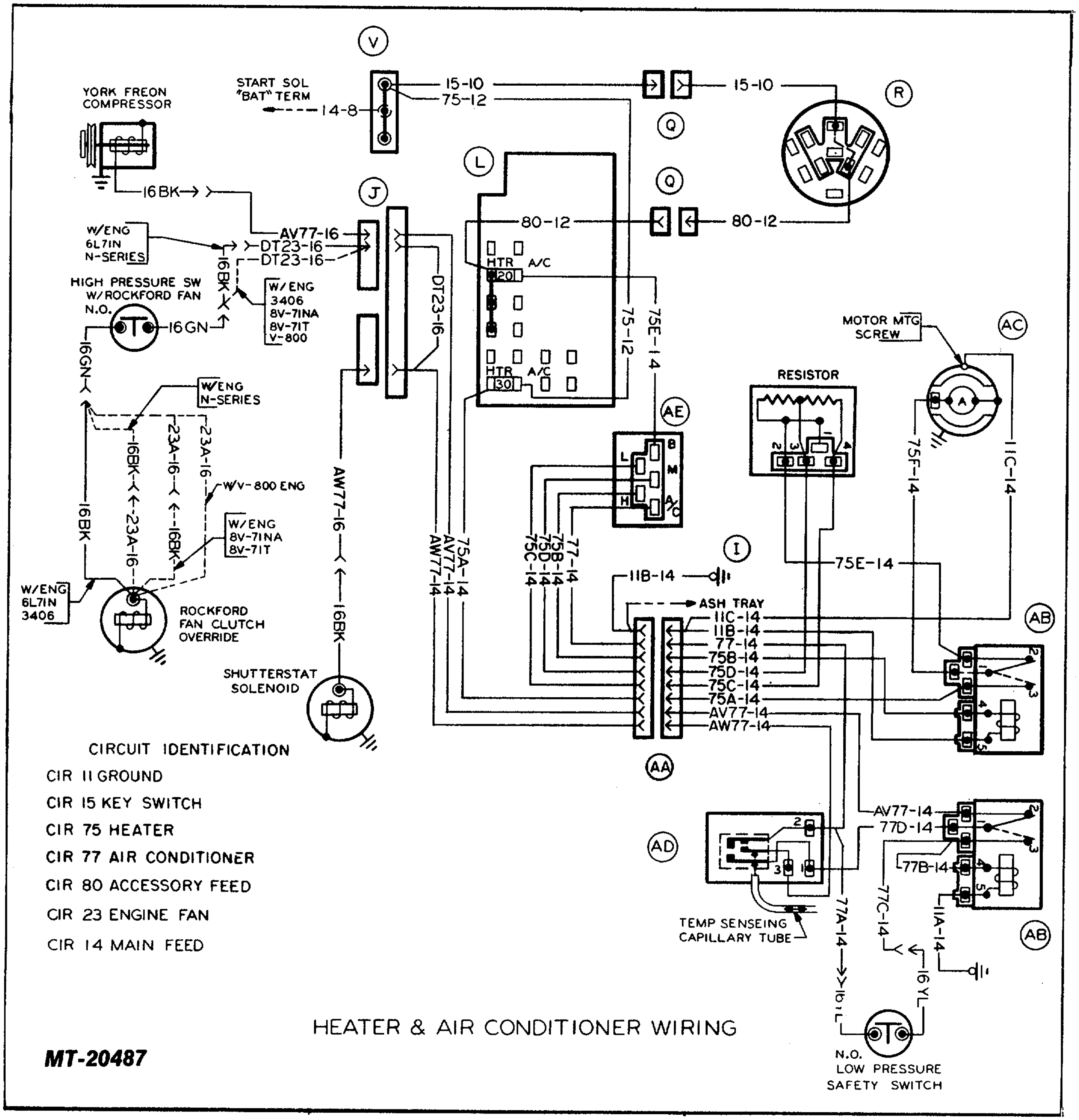
Instrument Panel-Dome Light

ELECTRICAL



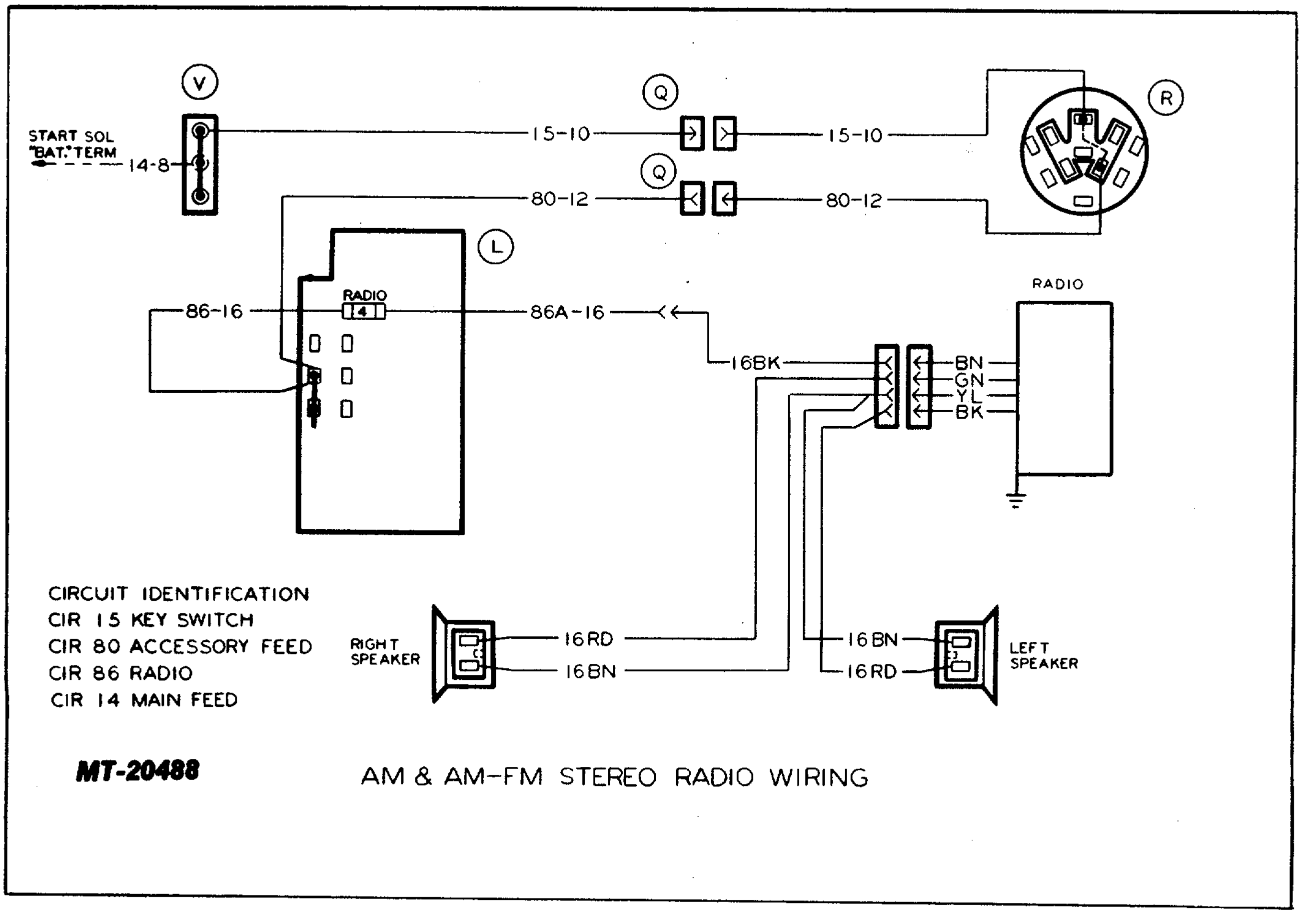
Heater-Windshield Washer-Wiper

ELECTRICAL



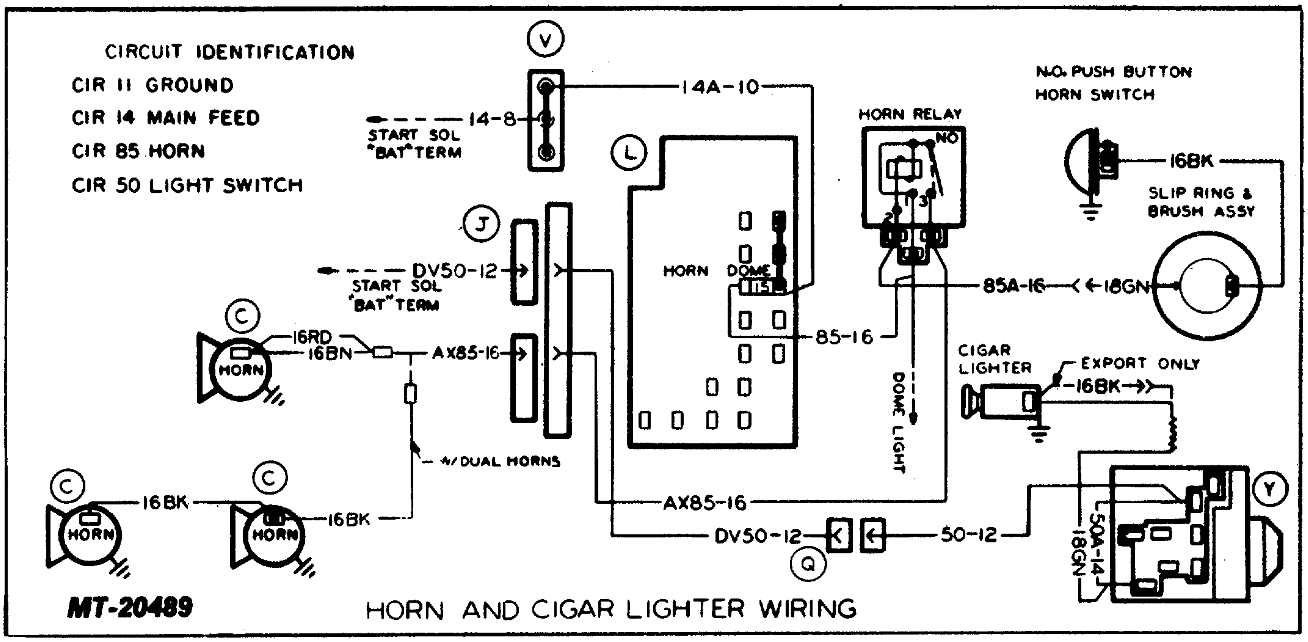
Heater-Air Conditioning

ELECTRICAL



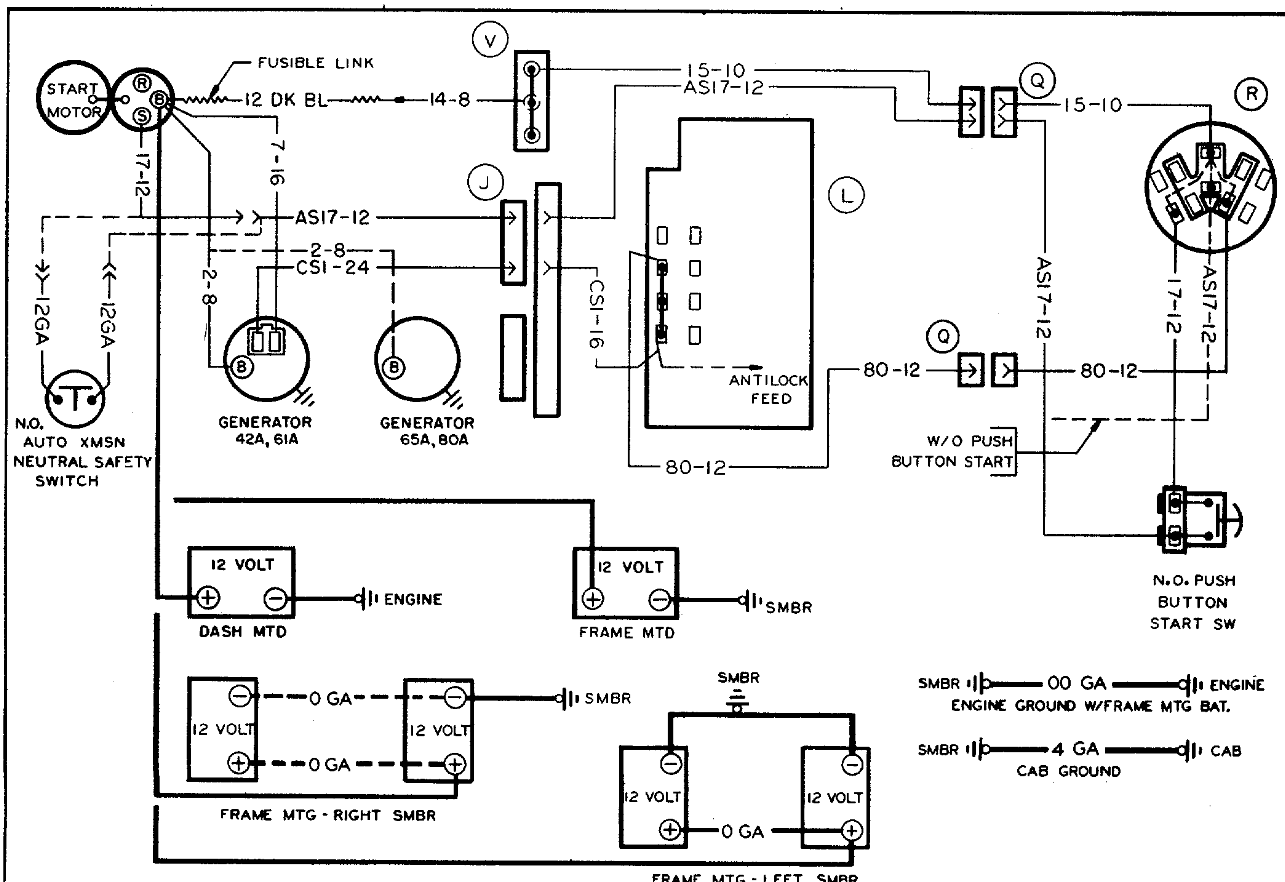
Radio

ELECTRICAL



Horn-Cigar Lighter

ELECTRICAL



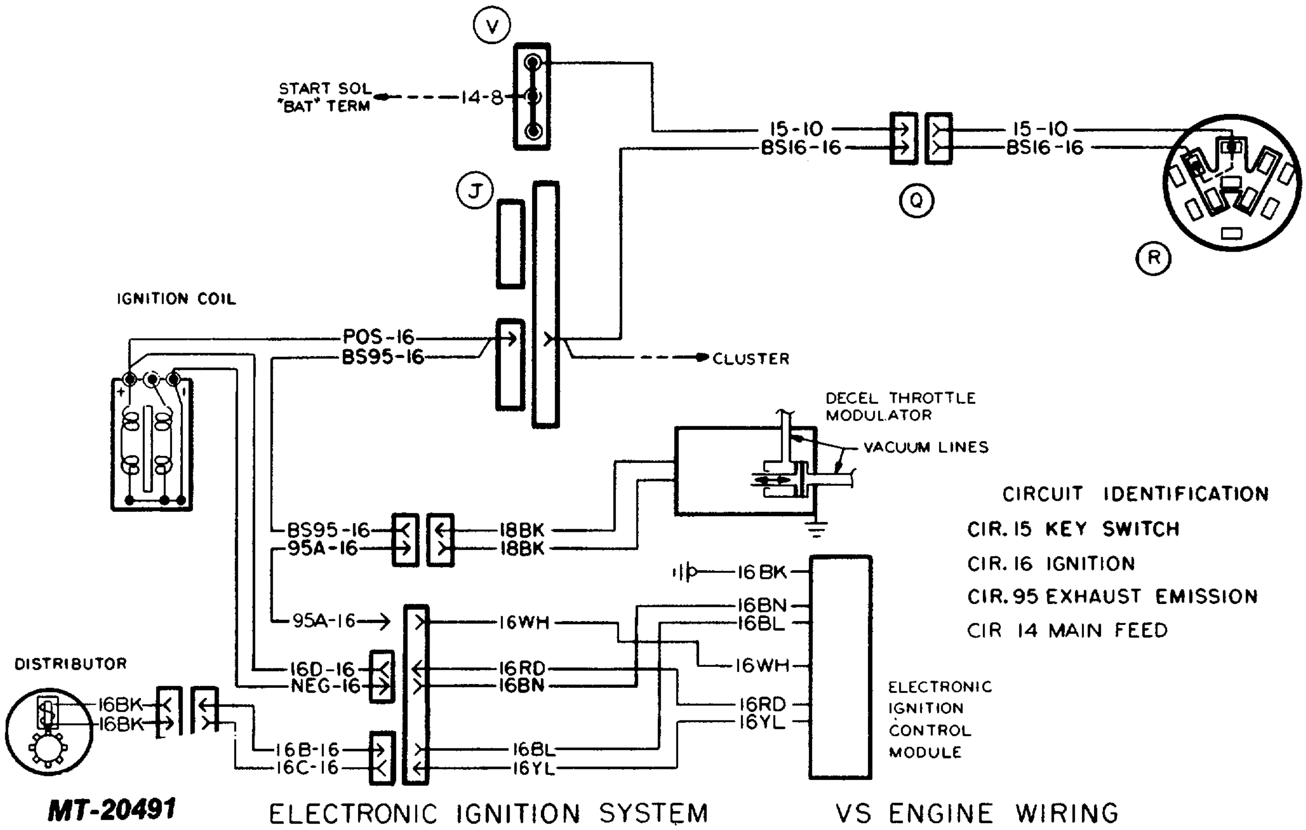
BATTERY		POSITIVE CABLE GAUGE	NEGATIVE CABLE GAUGE	ENGINE	MODEL
LOCATION	COMBINATION				
DASH PANEL	1/ 12 VOLT	2	2	MV8	LOADSTAR II & FLEETSTAR II 1900TT
LEFT SMBR	2/ 12 VOLT	0	0		
DASH PANEL	1/ 12 VOLT	0	0	VS	FLEETSTAR II 1900
LEFT SMBR	1/ 12 VOLT	000	0		
LEFT SMBR	2/ 12 VOLT	000	0		
RIGHT SMBR	1/ 12 VOLT	00	00	VS	FLEETSTAR II 2500 & 2600-CONSTR
RIGHT SMBR	2/ 12 VOLT	00	00		

CIRCUIT IDENTIFICATION
CIR 1 GENERATOR (EXCITER)
CIR 2 GENERATOR (CHARGE)
CIR 7 REGULATOR (VOLT SENSING)
CIR 14 MAIN FEED
CIR 15 KEY SWITCH FEED
CIR 17 STARTING CONTROL
CIR 80 ACCESSORY FEED

MT-20490 VS STARTING, CHARGING & MAJOR FEED & GROUND WIRING

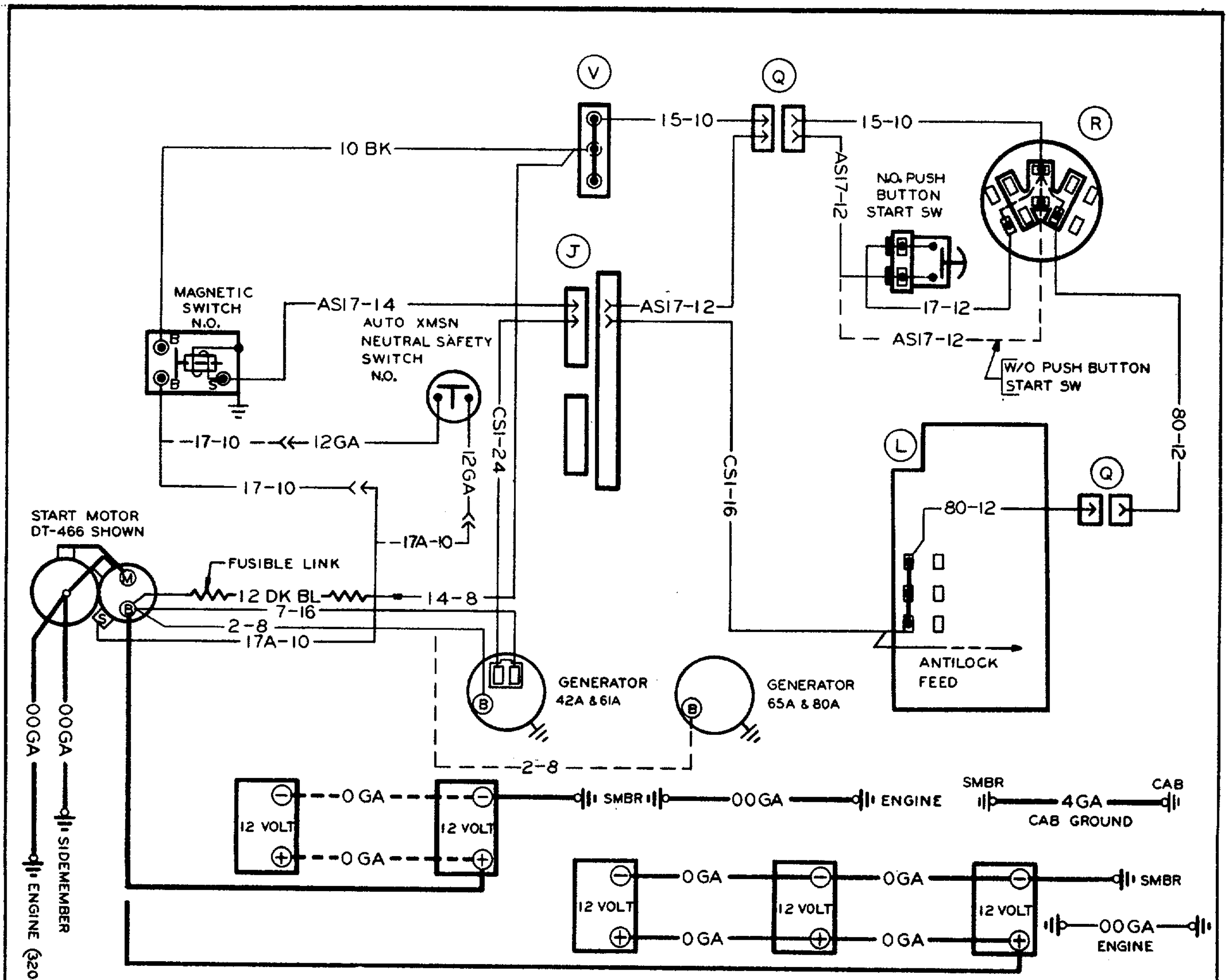
VS Engine Starting-Charging

ELECTRICAL



Electronic Ignition VS Engine

ELECTRICAL



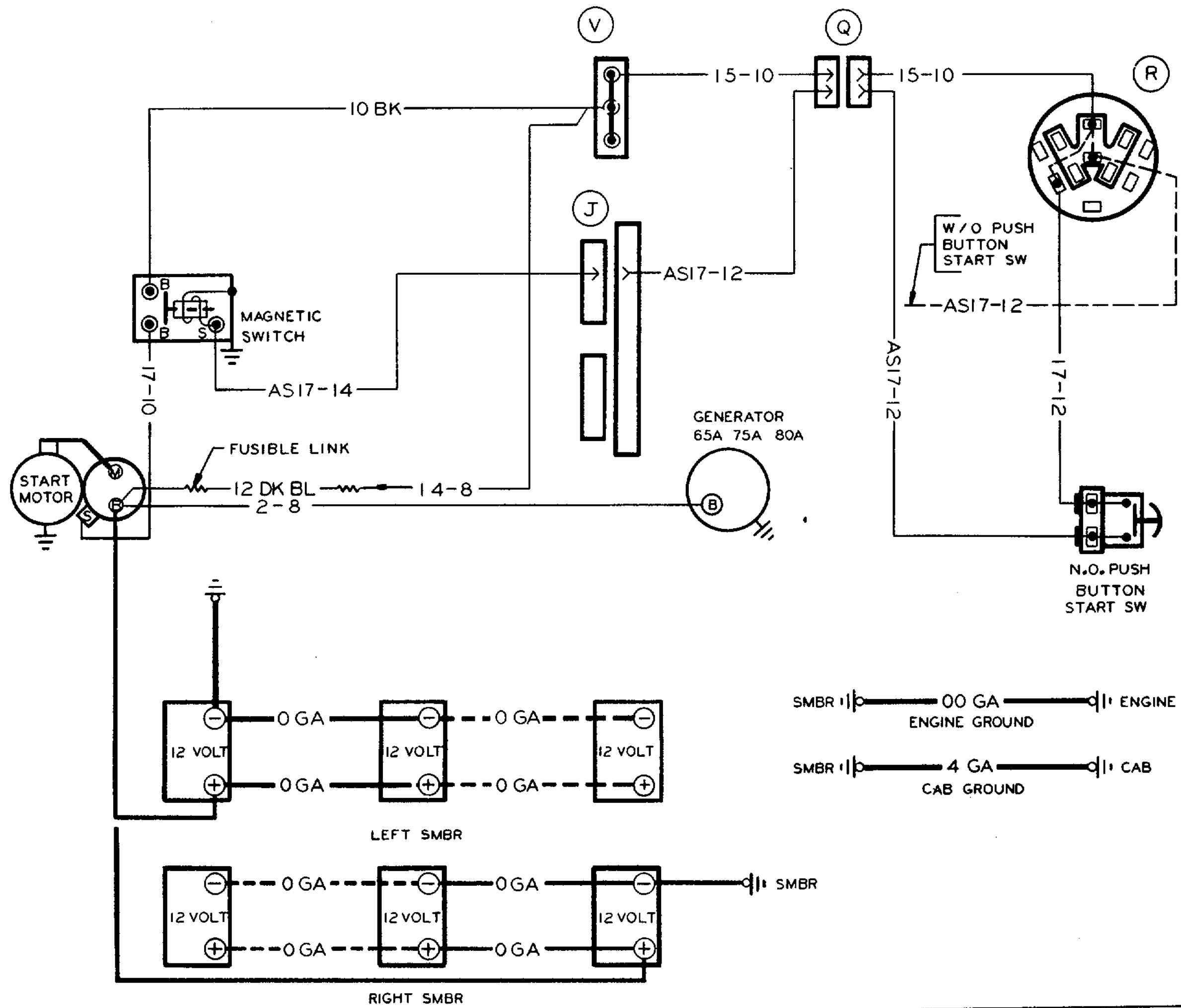
CIRCUIT IDENTIFICATION
CIR 2 GENERATOR (CHARGE)
CIR 14 MAIN FEED
CIR 15 KEY SWITCH FEED
CIR 17 STARTING CONTROL
CIR 1 GENERATOR (EXCITER)
CIR 7 REGULATOR (VOLT SENSING)
CIR 80 ACCESSORY FEED

MODEL		BATTERY LOCATION	BATTERY COMBINATION	POSITIVE CABLE GAUGE	NEGATIVE CABLE GAUGE
		LEFT SMBR	2/12 VOLT	0000	1
		LEFT SMBR	3/12 VOLT	0000	1
	DT-466	RIGHT SMBR	2/12 VOLT	0000	00
		RIGHT SMBR	3/12 VOLT	0000	00
	3208	RIGHT SMBR	2/12 VOLT	0000	00
		RIGHT SMBR	3/12 VOLT	0000	00

DT-466 & 3208 STARTING, CHARGING, & MAJOR FEED & GROUND WIRING **MT-20492**

DT-466 - CAT-3208 Starting - Charging

ELECTRICAL



CIRCUIT IDENTIFICATION

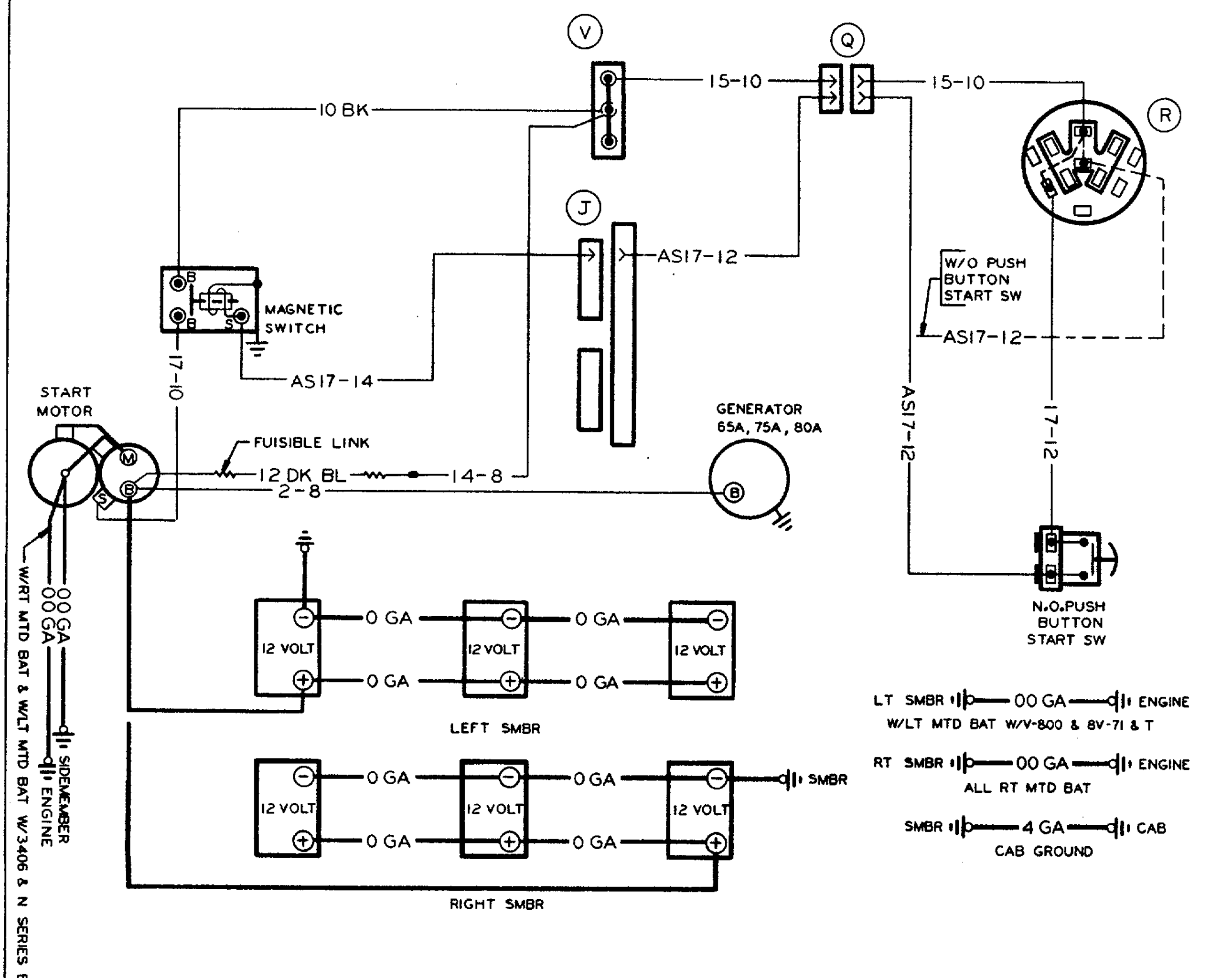
CIR 2 GENERATOR (CHARGE)
CIR 14 MAIN FEED
CIR 15 KEY SWITCH FEED
CIR 17 STARTING CONTROL

MODEL	BATTERY LOCATION	BATTERY COMBINATION	POSITIVE CABLE GAUGE	NEGATIVE CABLE GAUGE
FLEETSTAR II 2000	LEFT SMBR	2/12 VOLT	0000	0
& 2500-TRACTOR	LEFT SMBR	3/12 VOLT	0000	0
FLEETSTAR II 2500	RIGHT SMBR	2/12 VOLT	0000	00
CONSTR & 2600	RIGHT SMBR	3/12 VOLT	0000	00

MT-20493 6L71 STARTING, CHARGING, & MAJOR FEED & GROUND WIRING

6-71 Engine Starting - Charging

ELECTRICAL



CIRCUIT IDENTIFICATION

CIR 2 GENERATOR (CHARGE)

CIR 14 MAIN FEED

CIR 15 KEY SWITCH FEED

CIR 17 STARTING CONTROL

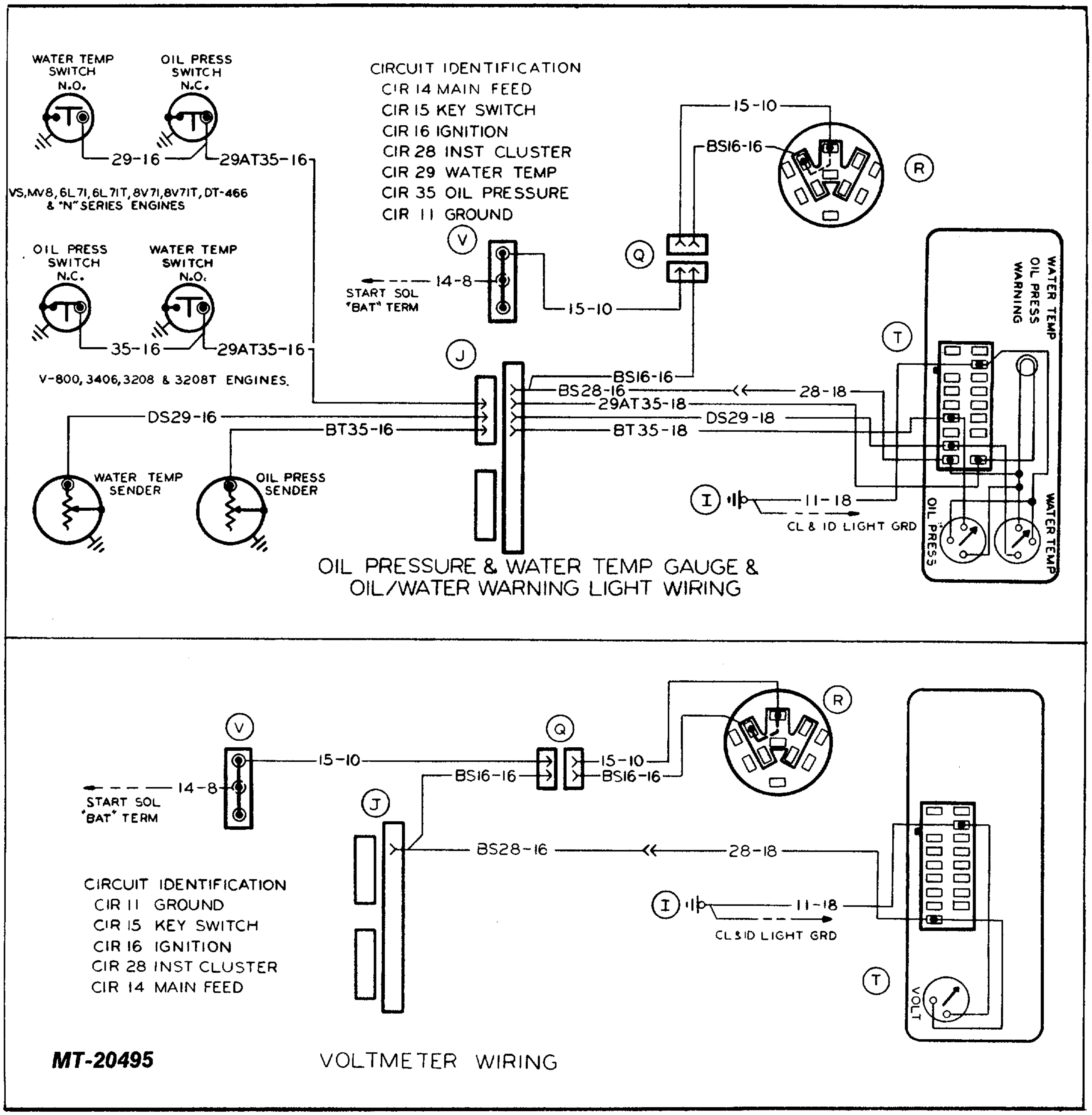
MODEL	BATTERY LOCATION	BATTERY COMBINATION	POSITIVE CABLE GAUGE	NEGATIVE CABLE GAUGE
FLEETSTAR II 2000 & 2500-TRACTOR	LEFT SMBR	3/12 VOLT	0000	0
FLEETSTAR II 2500 CONSTR & 2600	RIGHT SMBR	3/12 VOLT	0000	00

MT-20494

8V-71 & T, V-800, 3406, "N" SERIES STARTING, CHARGING, & MAJOR FEED & GROUND WIRING

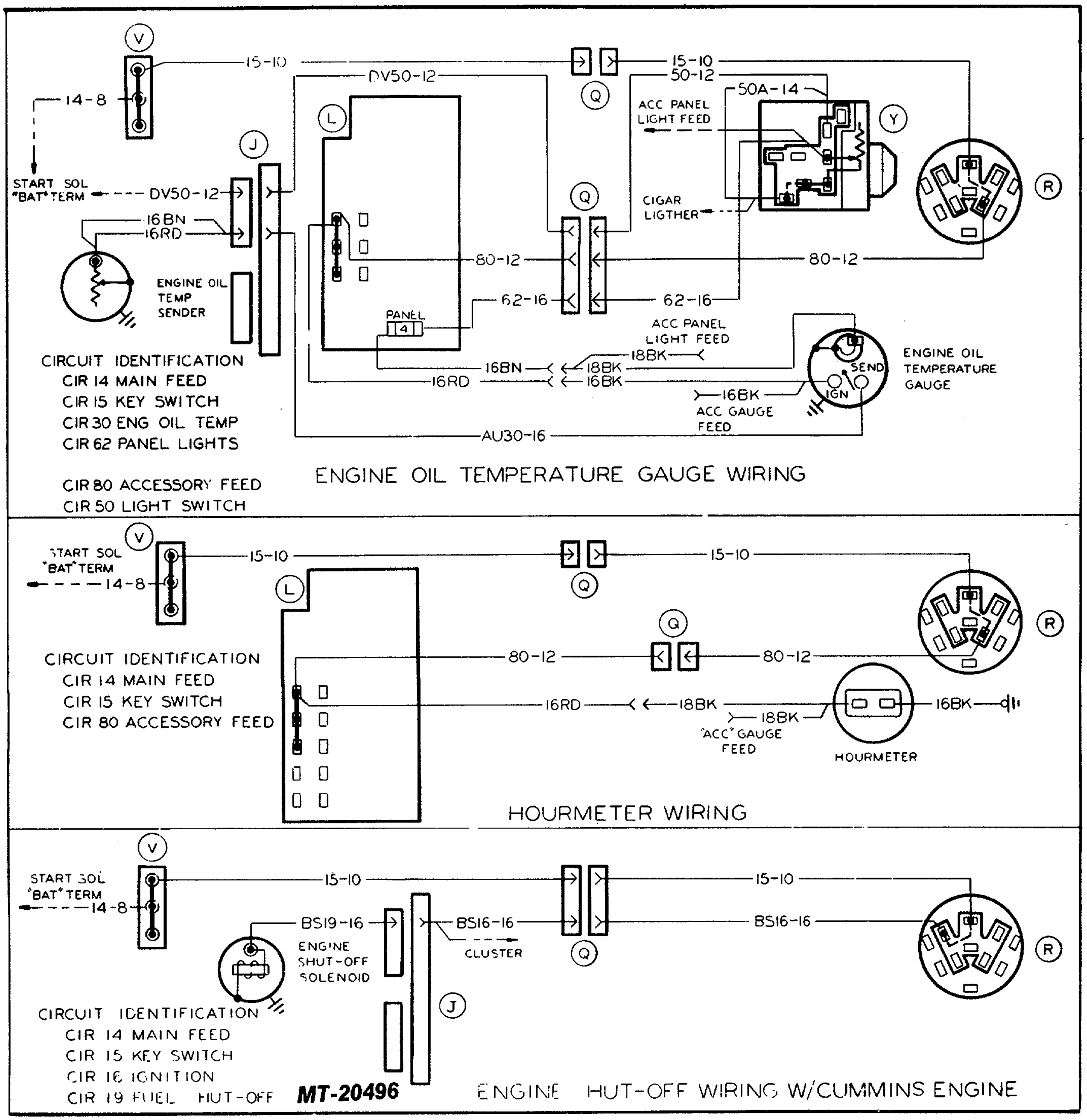
8V71 V-800 CAT-3406 N-Series Starting - Charging

ELECTRICAL



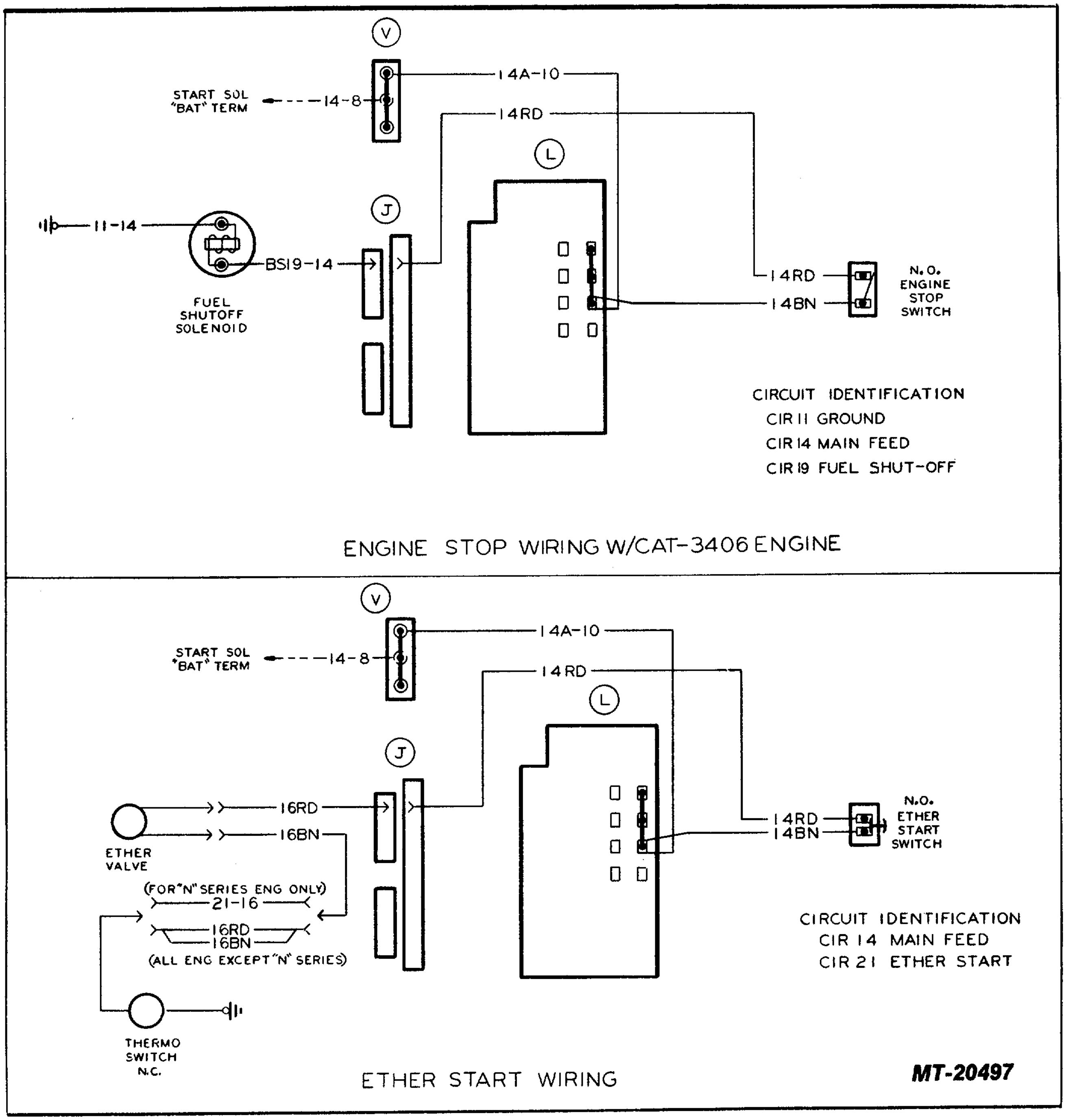
Oil Pressure - Water Temperature Gauge - Oil - Water Warning Light - Voltmeter

ELECTRICAL



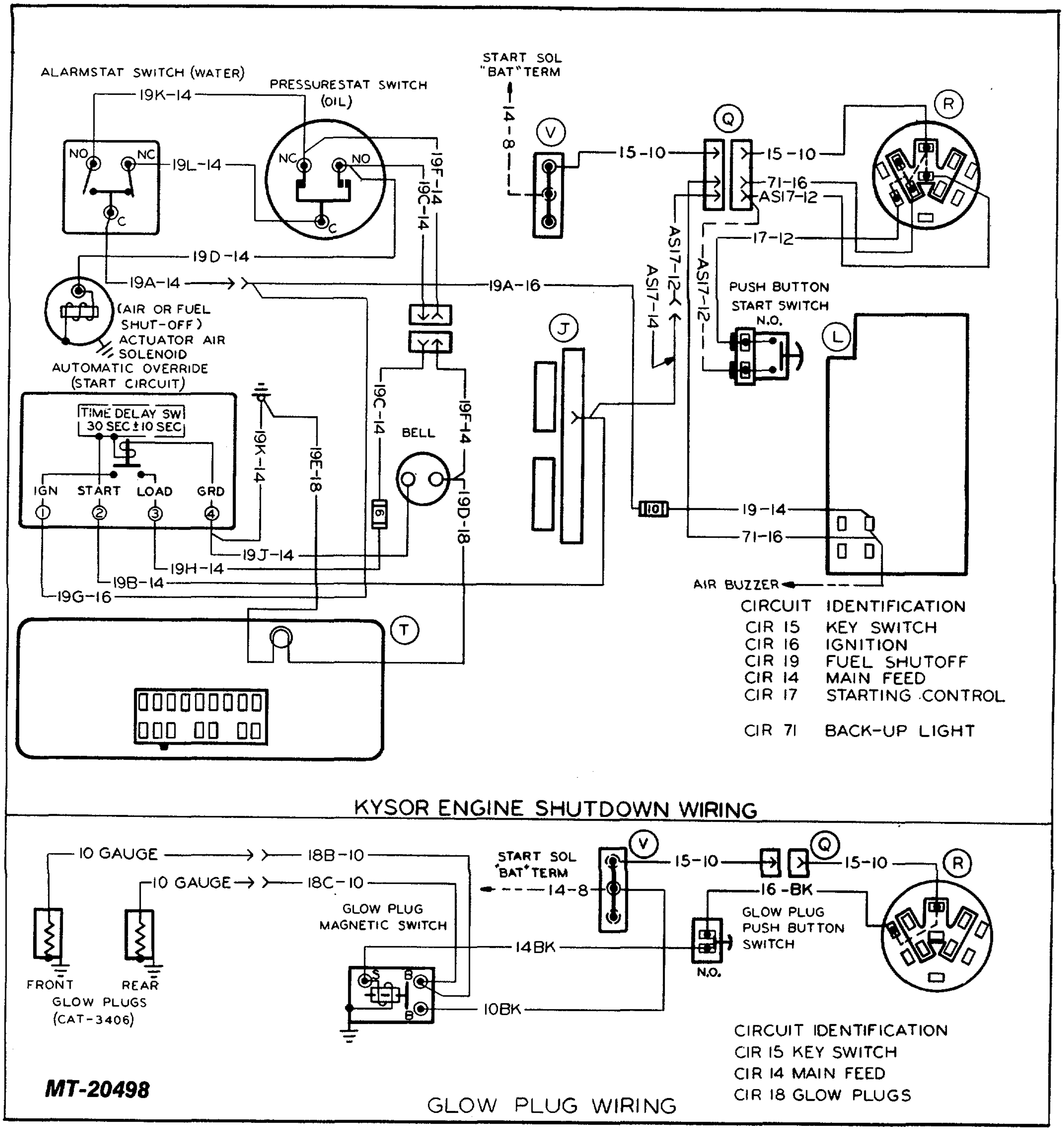
Engine Oil Temperature - Engine Shut-Off

ELECTRICAL



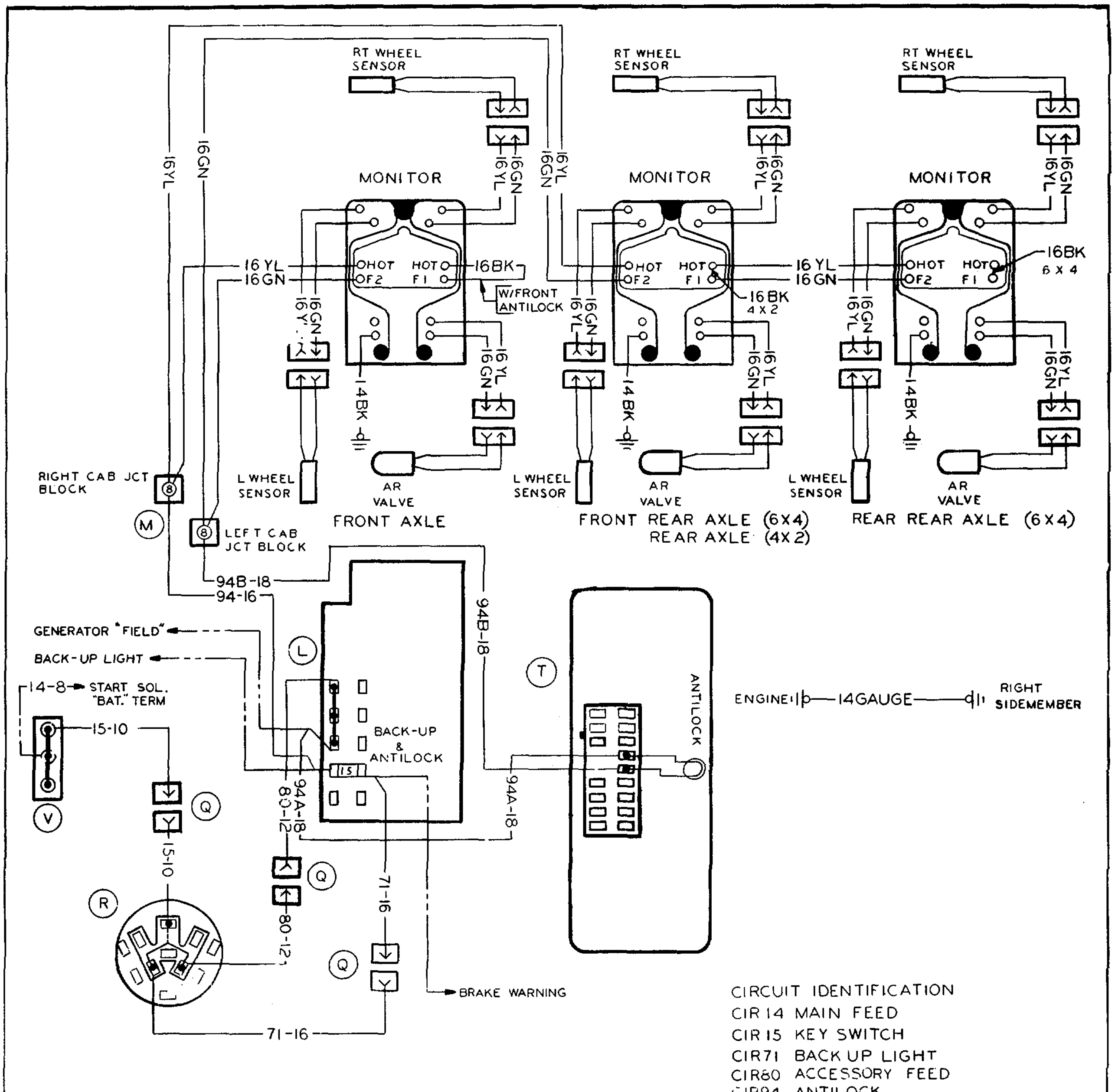
Engine Stop CAT-3406 - Ether Start

ELECTRICAL



Kysor Engine Shutdown - Glow Plug

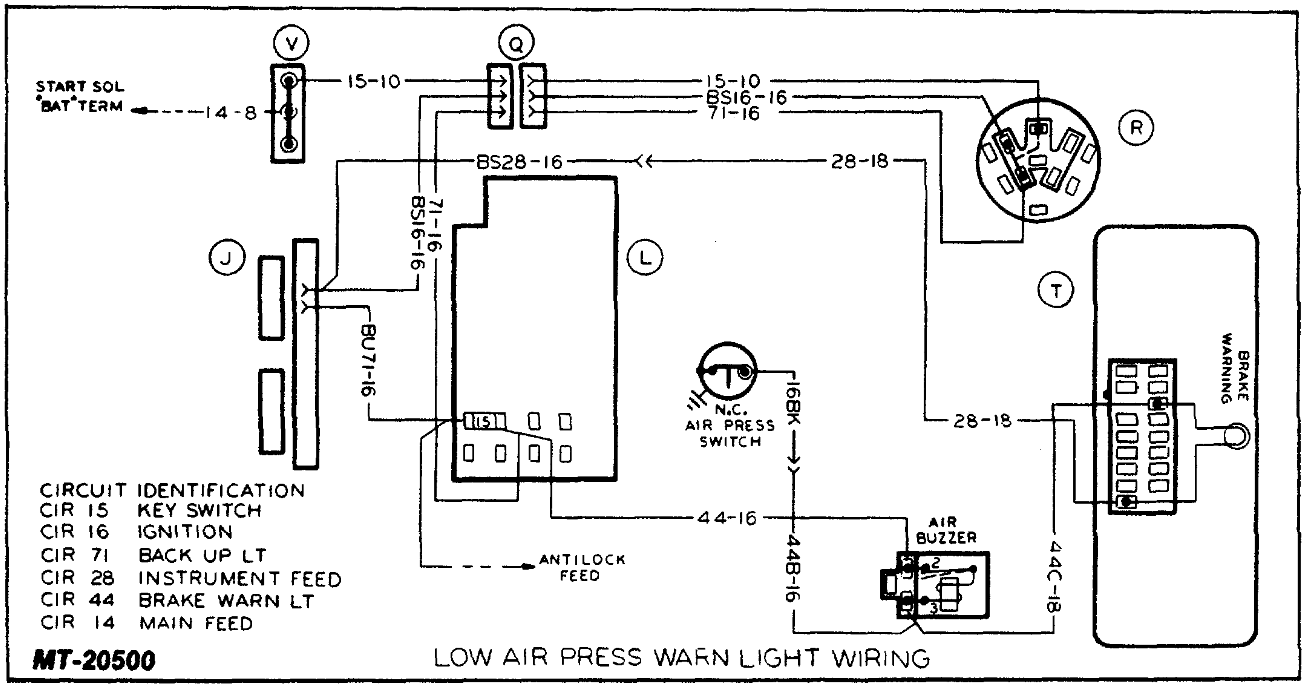
ELECTRICAL



MT-20499 AIR BRAKES ANTILOCK WIRING

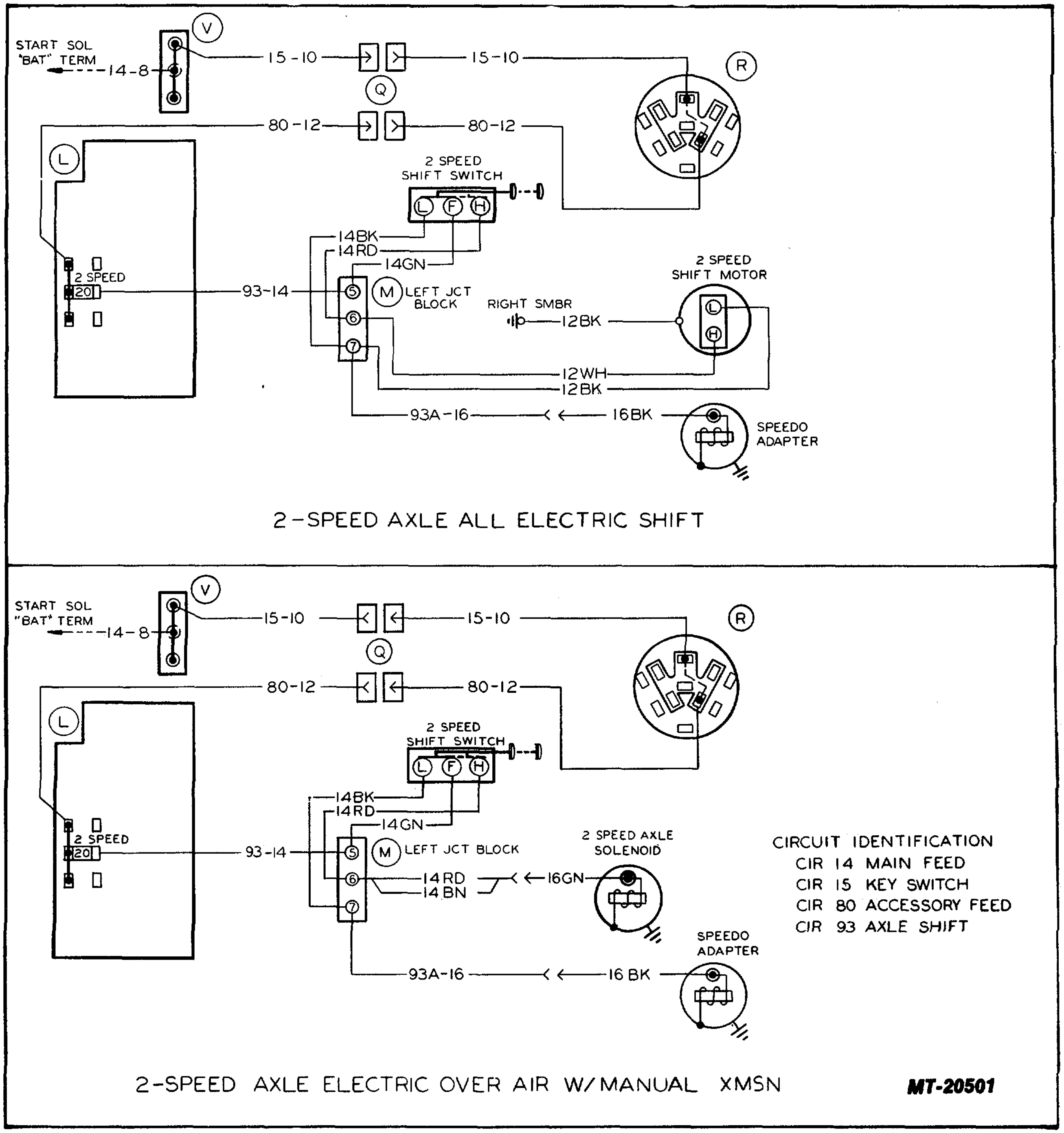
Anti-Lock Wiring (Air Brakes)

ELECTRICAL



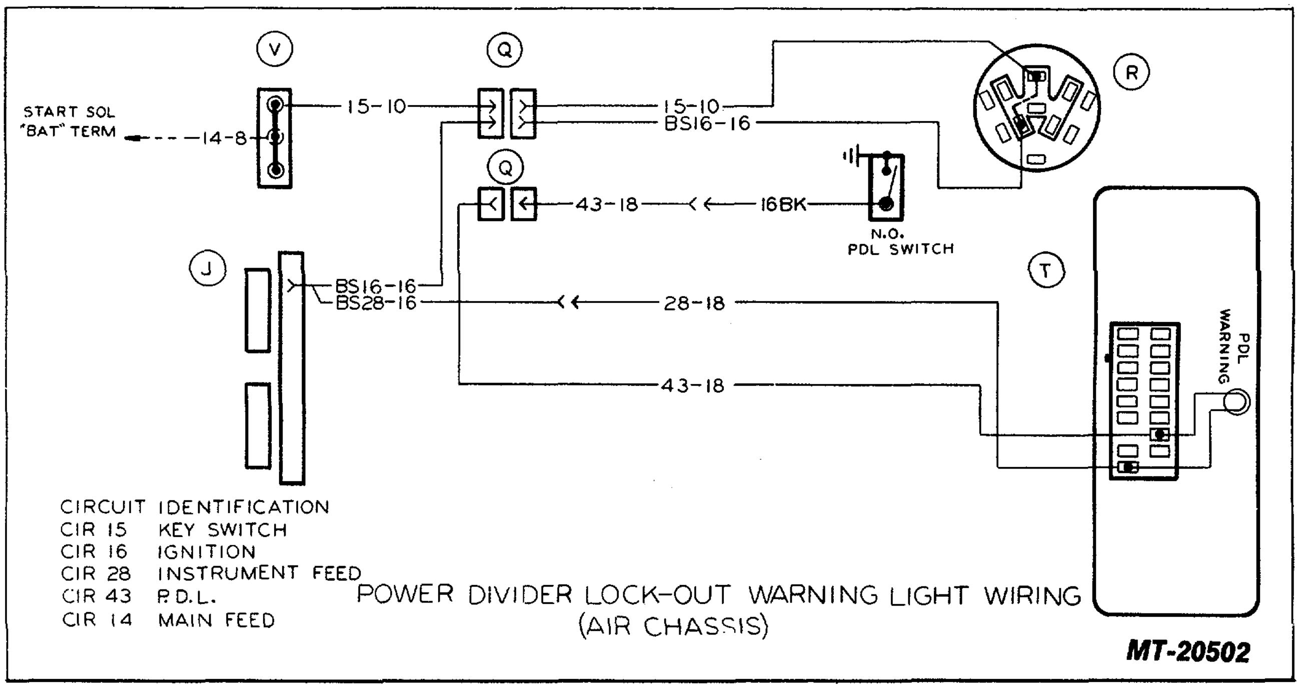
Low Air Pressure Warning Light

ELECTRICAL



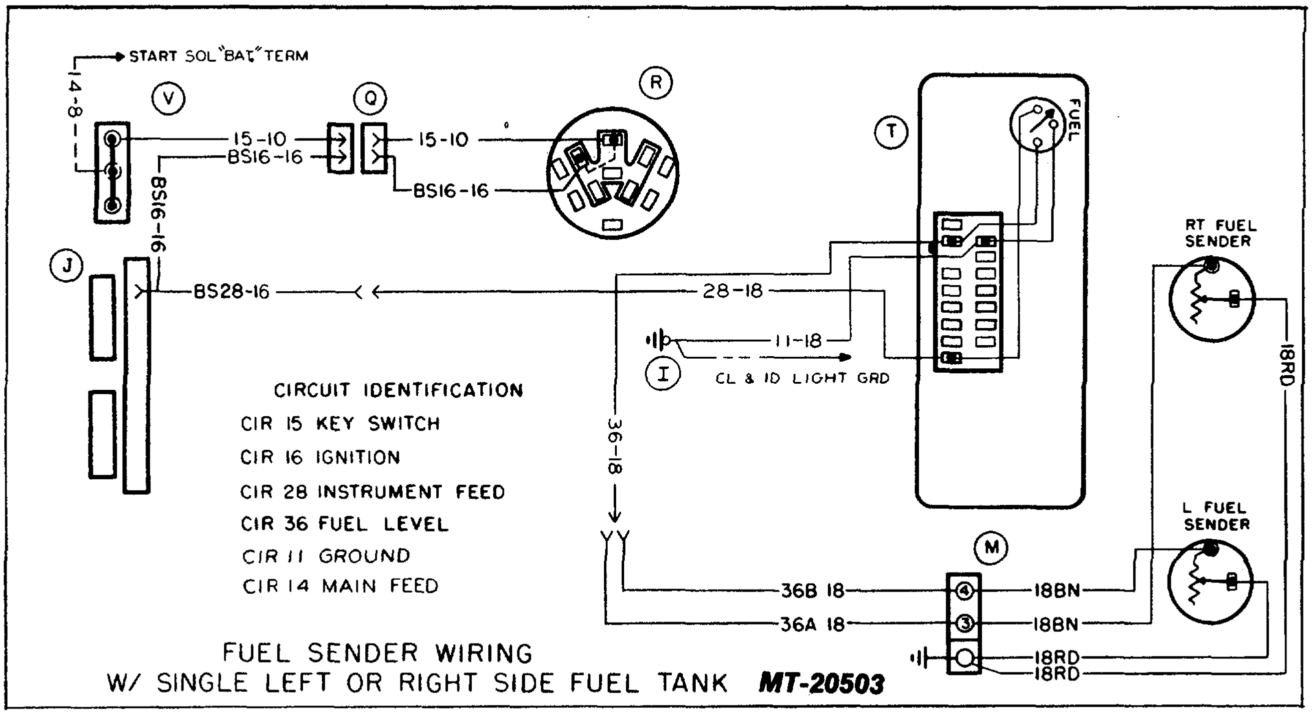
2-Speed Axle Electric - Air Shift

ELECTRICAL



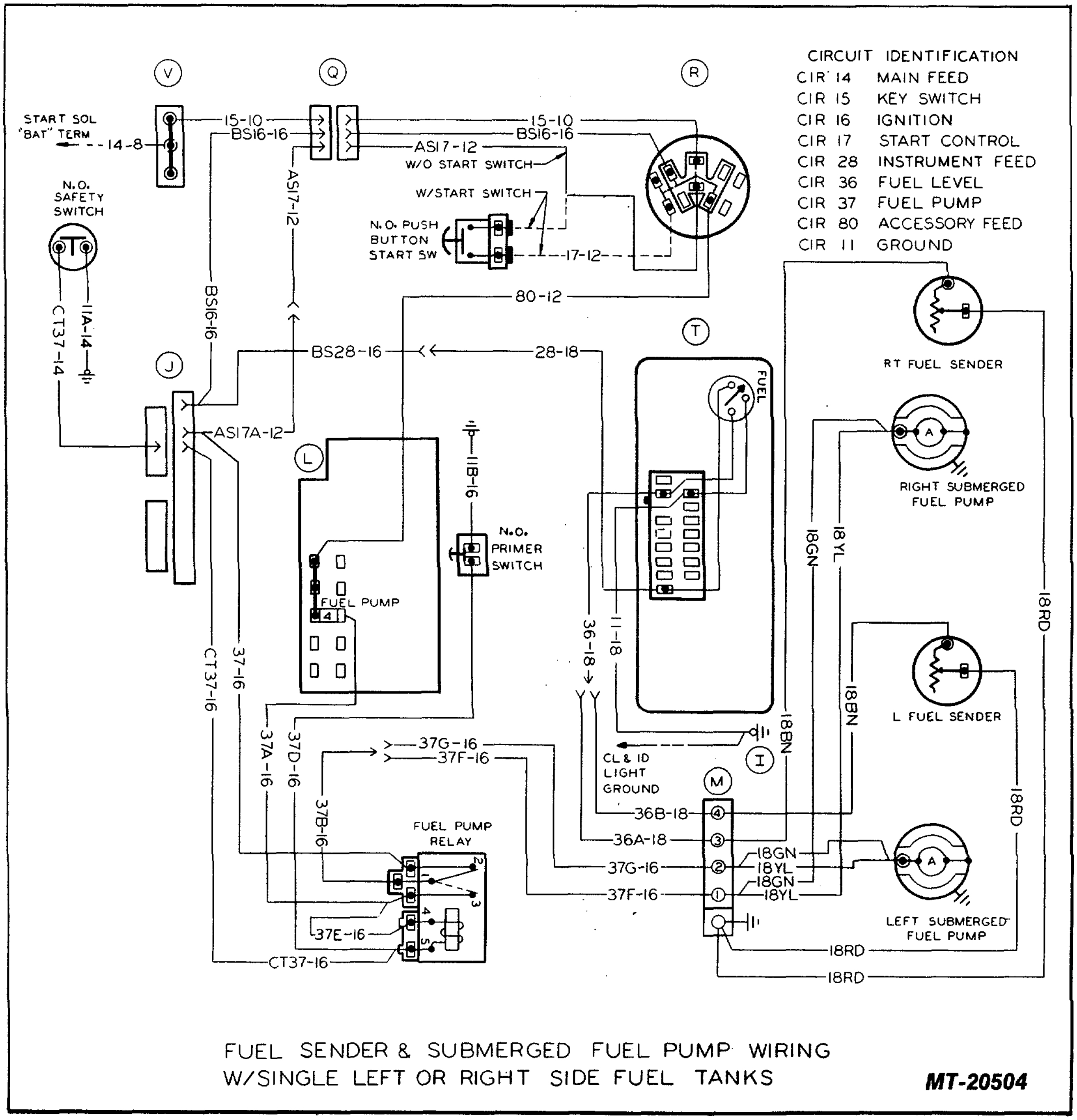
Power Divider Lock-Out Warning Light

ELECTRICAL



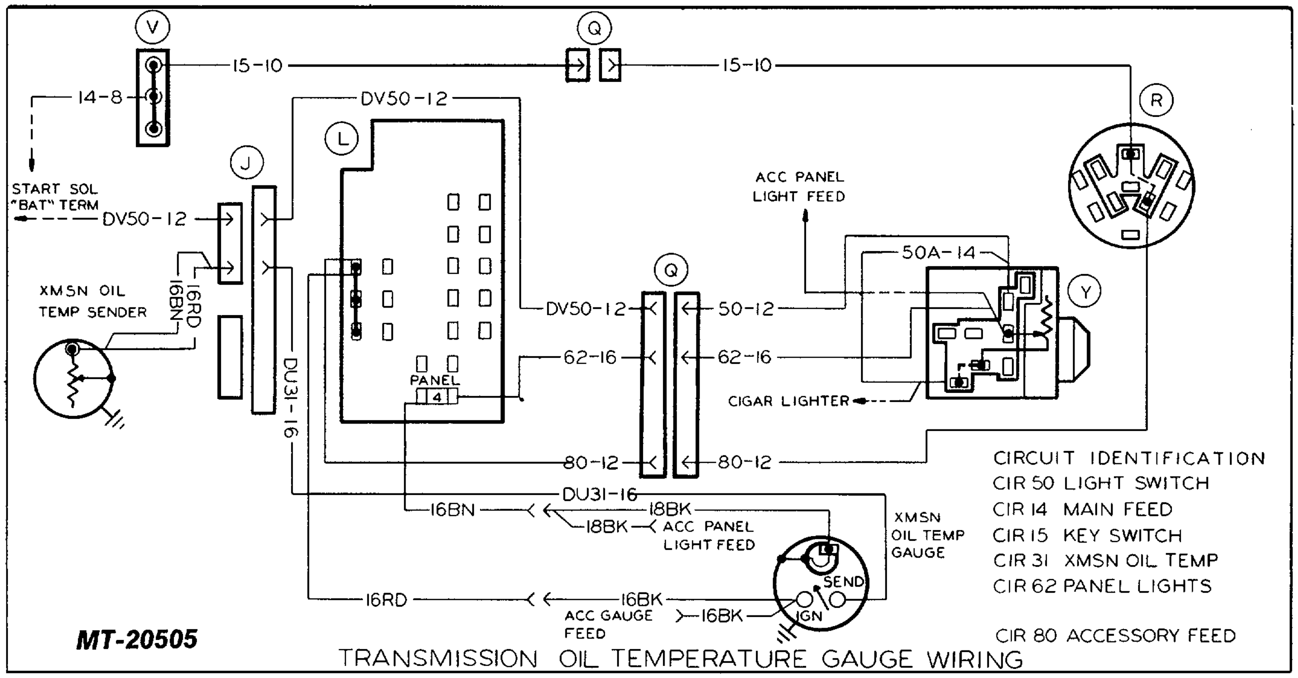
Fuel Sender

ELECTRICAL



Fuel Pump (Gasoline)

ELECTRICAL



Transmission Oil Temperature Gauge

ELECTRICAL

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Component and Major Connector Location		4-5-6
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ELECTRICAL

CIRCUIT DIAGRAMS 1979

S-SERIES TRUCKS

PRINTED IN UNITED STATES OF AMERICA

ELECTRICAL

BULB CHART

BULB APPLICATION	WATTS OR CANDLEPOWER	TRADE NO.
HEADLIGHT:		7002 RH DR, 6014
UPPER BEAM	60 WATTS	
LOWER BEAM	45 WATTS RH DR, 50 WATTS LH DR	
FRONT TURN	32	1156
SIDE MARKER	2	1895
PARK	3	181
STOP-TURN/TAIL-LICENSE	32/3	1157
BACK-UP	32	1156
IDENTIFICATION-CLEARANCE	3	168
FLOOD LIGHT	12	561
MIRROR LIGHT	2	1895
CLUSTER:		
ILLUMINATION	2	194
INDICATOR	2	194
WARNING	2	194
INFORMATION	2	194
CONTROL IDENTIFICATION OR WARNING LIGHT:		
ENGINE STOP	0.50	**
FRONT AXLE	0.50	**
GAUGE ILLUMINATION		
ENGINE OIL TEMPERATURE:	1	53
XMSN OIL TEMPERATURE	1	53
INSTR PANEL CONTROLS	0.50	**
ASHTRAY	0.50	**
DOME	12	211-2
RADIO	0.75	1892
HEATER & A/C CONTROLS	3	168
AUTOMATIC XMSN COTROLS	1	53

** PURCHASED LIGHT ASSEMBLY (REF G.E. BULB NO. 2162D)

DESCRIPTION	SIZE	TYPE	LOCATION
TRAILER AUX	—	—	FUSE BLOCK
TRAILER MARKER	15A	FUSE *	AT REAR
TRAILER STOP	20A	FUSE *	CAB
TRAILER TAIL	15A	FUSE *	JUNCTION
TRAILER RT TURN	10 A	FUSE *	BLOCKS
TRAILER L TURN	10 A	FUSE *	
LIGHT SWITCH FBC/BUS	18GA	GN FUSE LINK	LIGHT SWITCH
KEY SWITCH IGN BUS BAR	14GA	BN FUSE LINK	AMMETER
FUSE BLOCK BAT BUS BAR	14 GA	BN FUSE LINK	AMMETER
IGNITION FBC/BUS	20GA	OR FUSE LINK	KEY SWITCH
INSTRUMENT FBC/BUS	20 GA	OR FUSE LINK	KEY SWITCH

FUSE, CIRCUIT BREAKER & FUSIBLE LINK CHART

* CIRCUIT BREAKER OPTIONAL

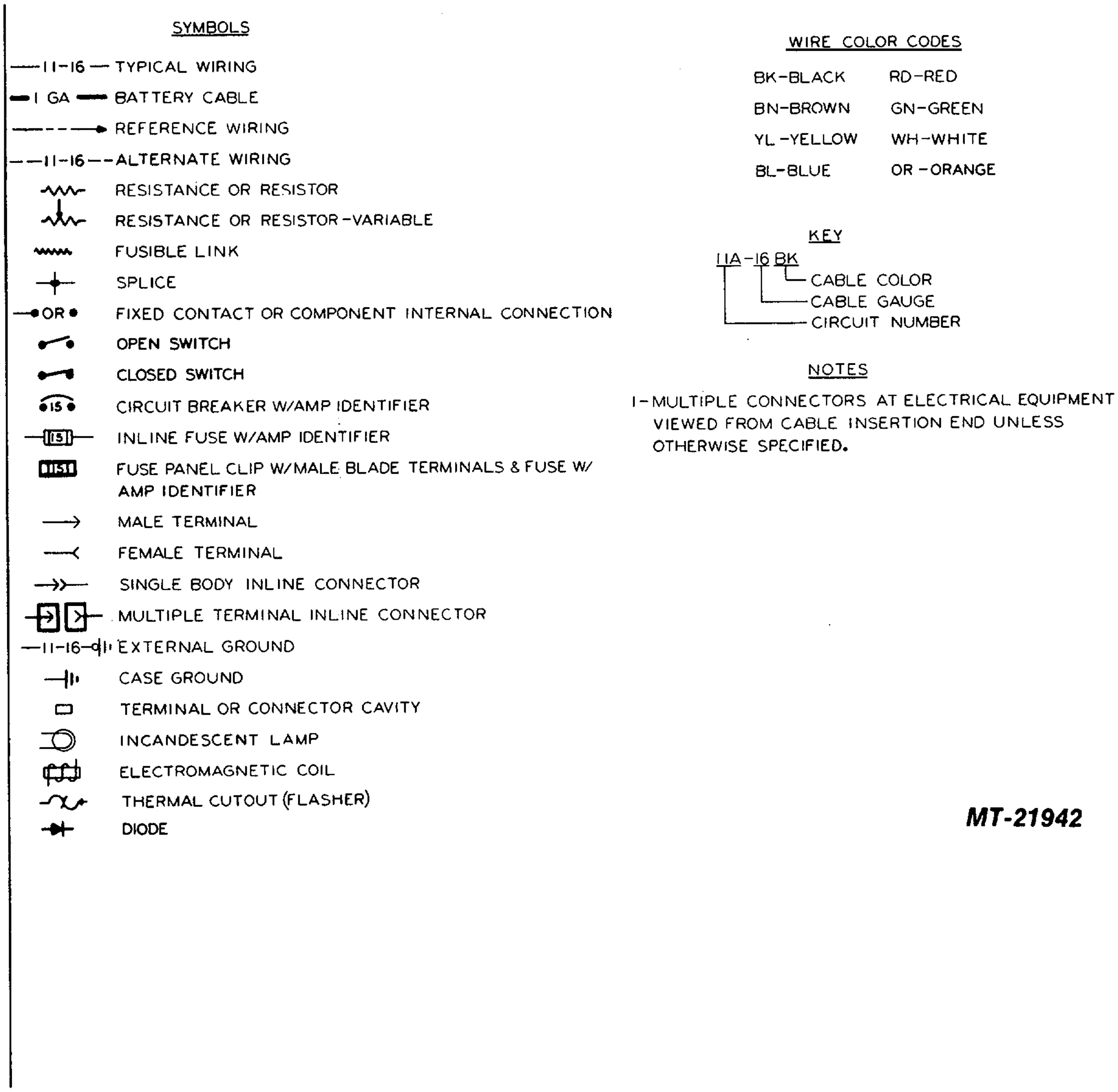
DESCRIPTION	SIZE	TYPE	LOCATION
HOURMETER	4A	FUSE	GAUGES BUS &
ETHER START	4A	FUSE *	FUEL/ETHER FBC
HAZARD LIGHTS	20A	FUSE	TURN/HAZARD
TURN LIGHTS	20A	FUSE	
DOME LIGHTS	15A	FUSE *	HORN/DOME
CIGAR LTR (FBC/BUS)	15 A	FUSE *	
HORN	15A	FUSE *	
STOP LIGHTS	30A	FUSE *	STOP/TRL MKR
TRAILER MARKER	30A	FUSE *	
FLOOD LIGHTS	30A	FUSE *	
TAIL LIGHTS	20A	FUSE *	(15A FBC/BUS)
CL/ID LIGHTS	20A	FUSE *	TAIL/CAB MKR
PARK MARKER LTS	20A	FUSE *	
MIRROR LIGHTS	20A	FUSE *	
MKR LIGHTS (FBC/BUS)	15A	FUSE *	MARKER
TRL MKR LIGHT REL	15A	FUSE *	MARKER
INSTR PANEL LIGHTS	4A	FUSE *	PANEL
CLUSTER PANEL LTS	4A	FUSE *	
ASHTRAY LIGHTS	4A	FUSE *	
HTR & A/C CONT ILLUM	4A	FUSE *	
XMSN & ENG OIL TEMP GAUGE ILLUM	4A	FUSE *	
RADIO	4A	FUSE *	RADIO
HEATER ONLY	20A	FUSE *	HEATER & A/C
HTR & A/C-EXCEPT HIGH POSITION	20A	FUSE *	
2 SPEED AXLE	20A	FUSE *	2 SPEED
SUBMERGED FUEL PUMP	4A	FUSE *	FUEL/ETHER-BUS, FUEL PUMP-TRUCK
BACK-UP LIGHTS	15A	FUSE *	BACK-UP/ ANTILOCK
ANTILOCK SYSTEMS	15A	FUSE *	
HTR & A/C HIGH POSITION	30A	CIRCUIT BKR	HEATER & A/C
KYSOR ENGINE SHUTDOWN	10A	IN-LINE FUSE	ABOVE KYSOR SW, LWR FRT LT
2 FUSES	6A	IN-LINE FUSE	SIDE OF CAB
HEADLIGHTS	15A	CIR BKR	INSIDE LIGHT SW
WINDSHEILD WIPER & WASHER	6A	CIR BKR	REAR OF WIPER SWITCH
HI-POWER PUMP (CONVENTIONAL ONLY)	50A	CIR BKR	RELAY MTG BRKT
HIGH POWER PUMP FBC/BUS	50A	CIR BKR	DASH PANEL (ENG SIDE)
CIGAR LIGHTER (CONVENTIONAL ONLY)	18 GA	GN FUSE LINK	LIGHT SWITCH
HEADLICHT FEED	16 GA	BK FUSE LINK	AT START MOTOR SOL
CAB FEED (CONVENTIONAL ONLY)	12 GA	DK BL FUSE LINK	AT START MOTOR SOL
GENERATOR FBC/BUS	20 GA	OR FUSE LINK	KEY SWITCH
HOURMETER	5A	IN-LINE FUSE	UNDER FUSE BLOCK - TRUCK
ETHER START	5A	IN-LINE FUSE	LWR EDGE INST PNL - TRUCK

FUSE IDENT SHOWN AS ON FUSE BLOCK
FUSE BLOCK MTG ON INSIDE CAB-UPPER LEFT SIDE OF DASH-CONVENTIONAL-LH DR
FUSE BLOCK MTG ON INSIDE COWL-CENTER OF INSTR PANEL-FBC/BUS
FUSE BLOCK MTG ON INSIDE CAB-UPPER RIGHT SIDE OF DASH-CONVENTIONAL-RH DR

MT-23290

Bulb And Fuse Chart

ELECTRICAL



Definition Of Symbols (All Models)

ELECTRICAL

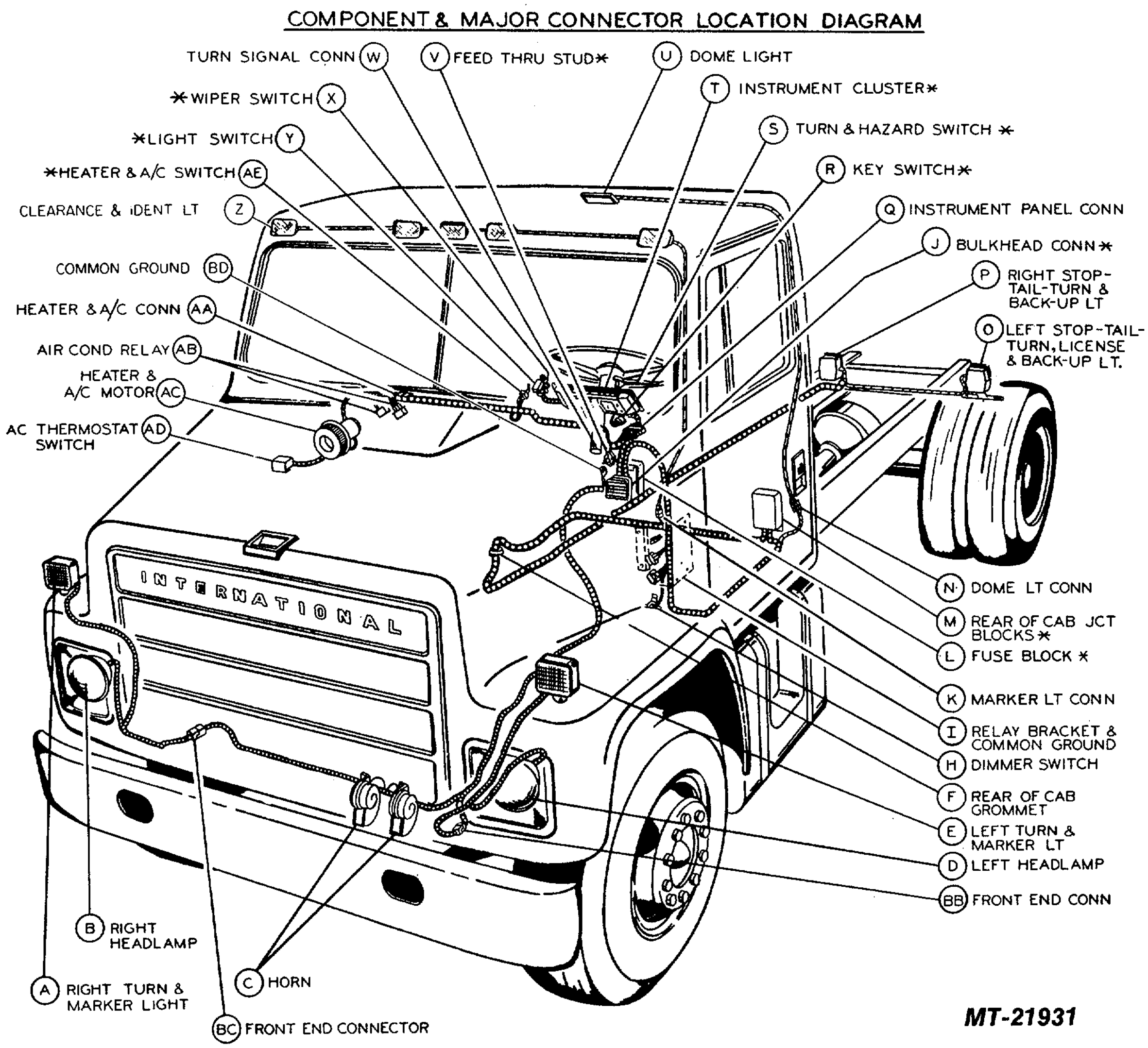
CIRCUIT NUMBERS & DESCRIPTION

1	GENERATOR (FIELD)
2	GENERATOR (CHARGE)
6	REGULATOR, VOLT (FIELD RELAY)
7	REGULATOR, VOLT (CHARGE)
11	GROUND
14	MAIN FEED
15	KEY SWITCH
16	IGNITION
17	STARTING CONTROL
18	GLOW PLUG, PRE HEATER
19	FUEL SHUT-OFF
21	ETHER
23	MAGNETIC FAN
24	EXHAUST BRAKE
28	INSTRUMENT
29	ENG WATER TEMP
30	ENG OIL TEMP
31	TRANS OIL TEMP
32	AXLE OIL TEMP
33	ENG OIL LEVEL
34	WATER LEVEL
35	ENG OIL PRESSURE
36	FUEL LEVEL
37	FUEL PUMP
42	FRT AXLE WARNING
43	P.D. LOCK WARNING
44	BRAKE SYSTEM WARNING
48	TACHOMETER
50	LIGHT SWITCH
51	DIMMER SWITCH
52	HEAD LIGHT - HI-BEAM
53	HEAD LIGHT - LO-BEAM
54	PARKING LIGHTS
55	DIR. SIGNAL SWITCH
56	DIR. SIGNAL LIGHTS - LEFT
57	DIR. SIGNAL LIGHTS - RIGHT
58	CLEAR., IDENT., & MARKER LIGHTS
60	HAZARD SWITCH
62	PANEL LIGHTS
63	DOME &/OR COURTESY LIGHTS
68	TAIL LIGHT
70	STOP LIGHT
71	BACK-UP LIGHT
72	TRAILER
75	HEATER
76	DEFROSTER
77	AIR CONDITIONER
78	HEATED MIRROR
80	ACCESSORY FEED
82	WINDSHIELD WIPER
84	CIGAR LIGHTER
85	HORN
86	RADIO
87	WINDSHIELD WASHER
88	HOURMETER
90	HY-POWER BRAKES
92	TRANSMISSION
93	AXLE SHIFT
94	WHEELLOCK (ANTI SKID BRAKES)
95	EXHAUST EMISSION

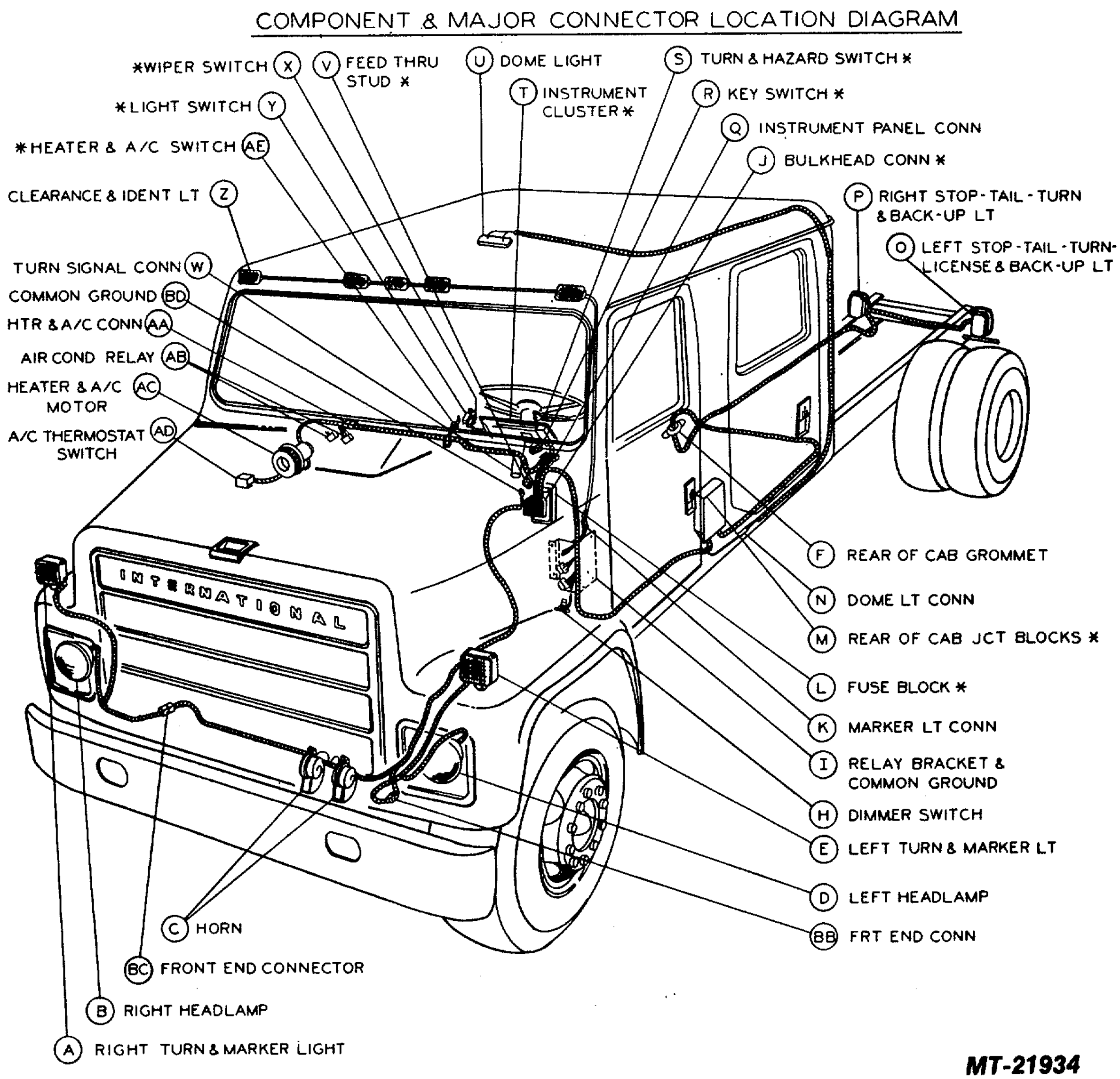
CIRCUIT NUMBERS MAY REQUIRE SUFFIX LETTER IDENTIFICATION WHEREVER BRANCHES OF THE MAIN CIRCUIT ARE ENCOUNTERED.

MT-23291

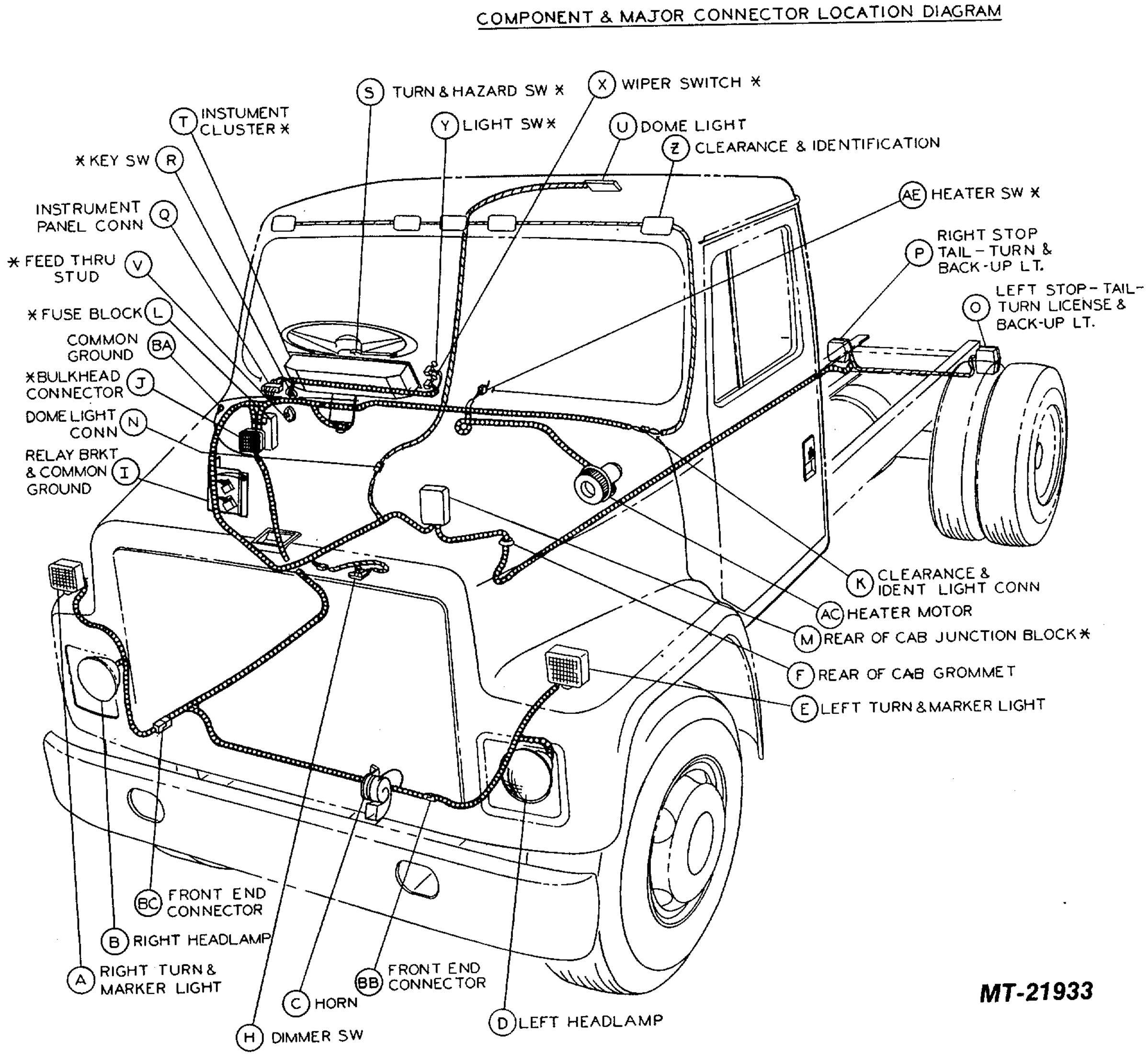
Circuit Numbers And Description (All Models)



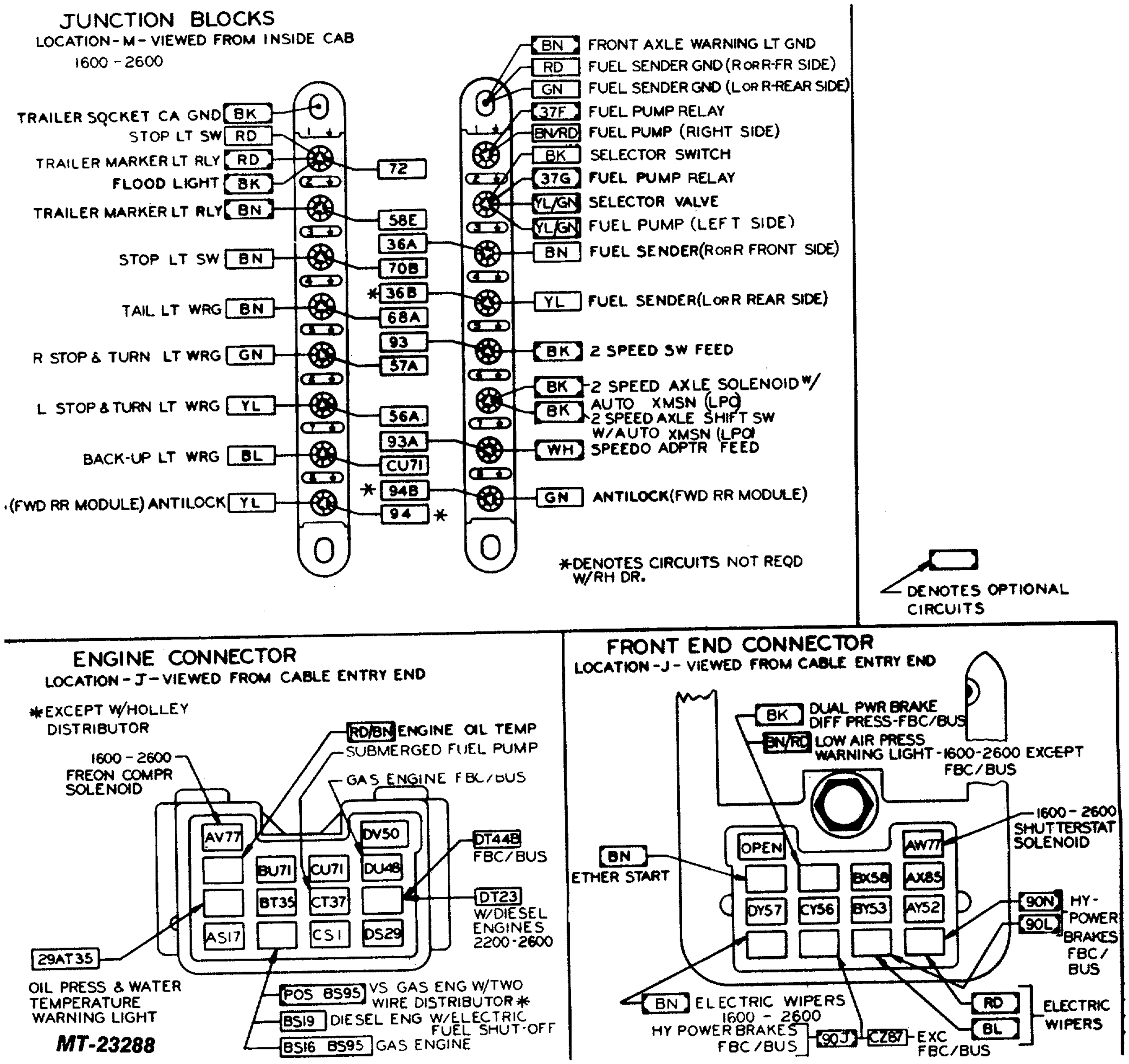
Components And Major Connector Location (On Chassis)
1600 Thru 1900 Models



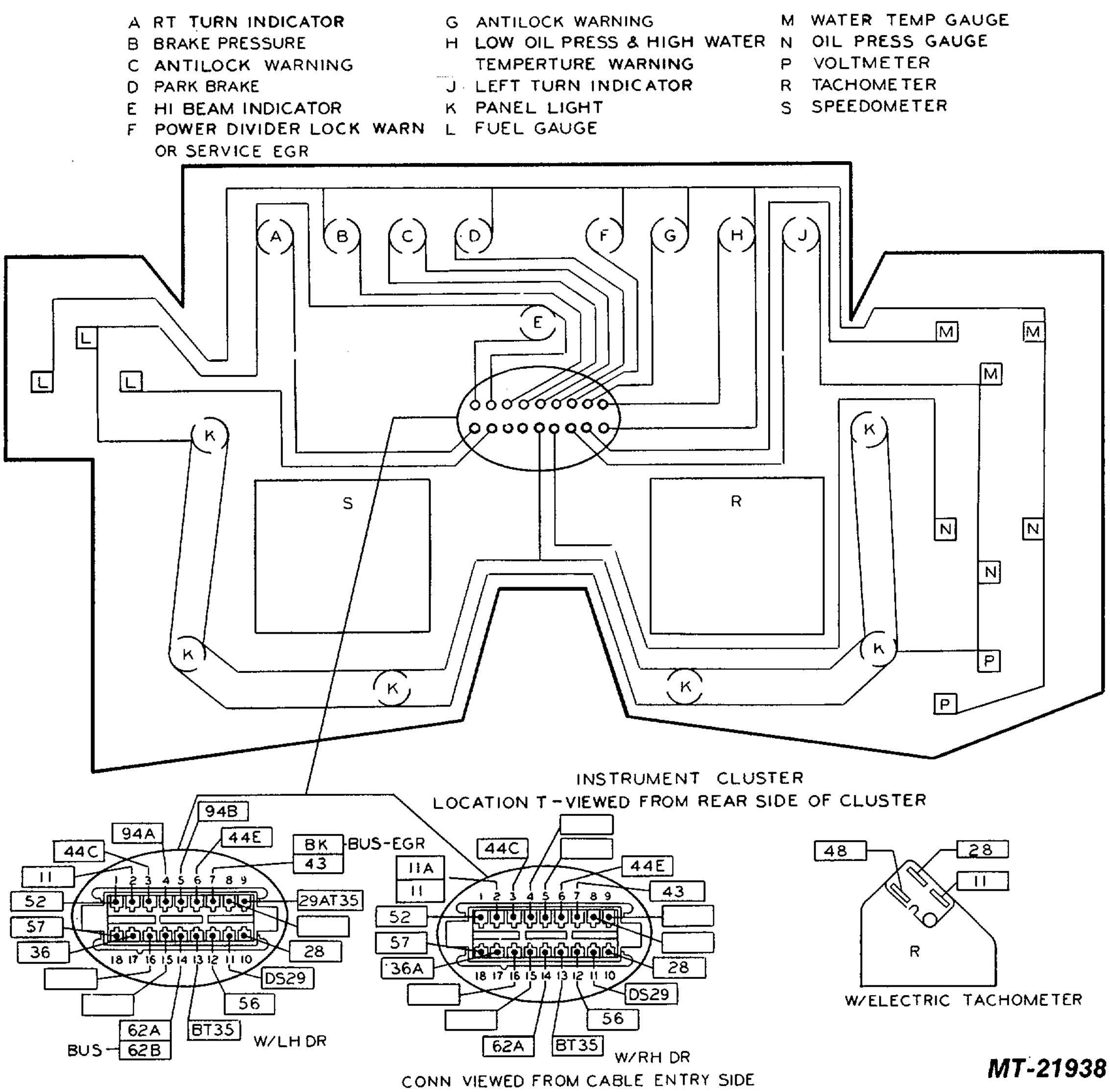
Component And Major Connector Location (On Chassis)
1600 thru 1900 Models



Components And Major Connector Location (On Chassis)
1700 thru 1900 Right Hand Drive Models

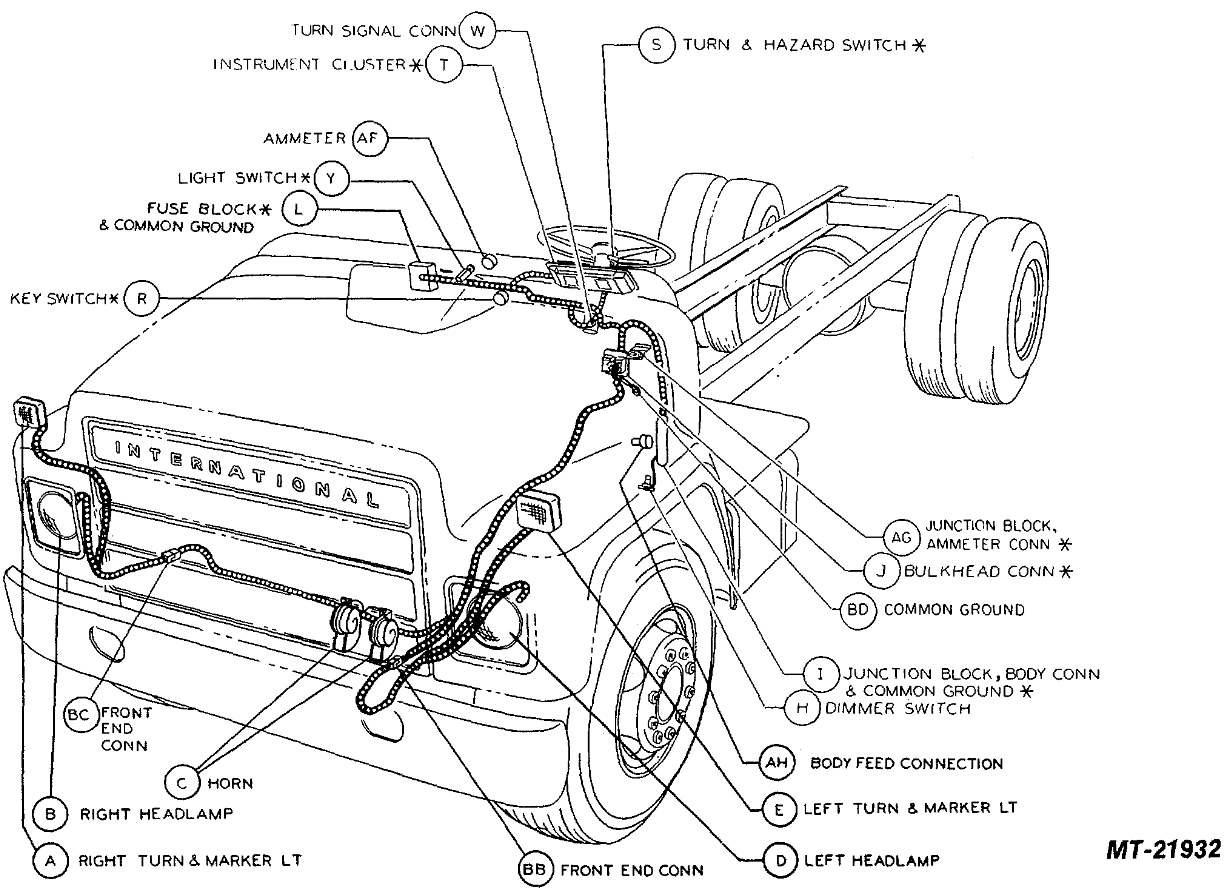


Components And Major Connectors
Junctions Blocks-Engine Connector-Front End Connector

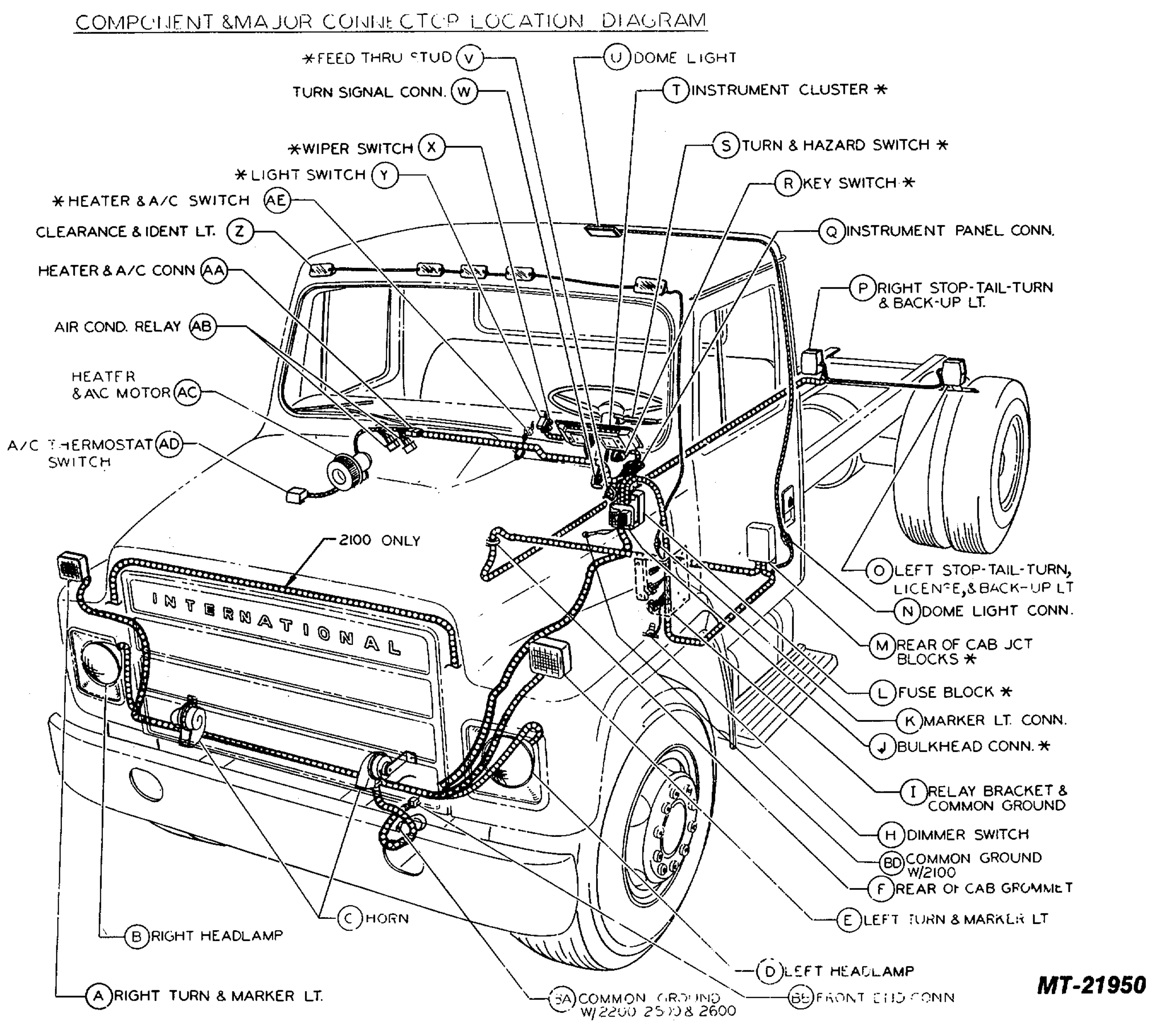


Components And Major Connectors
Instruments Cluster

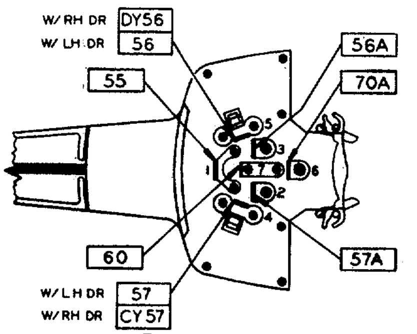
COMPONENT & MAJOR CONNECTOR LOCATION DIAGRAM



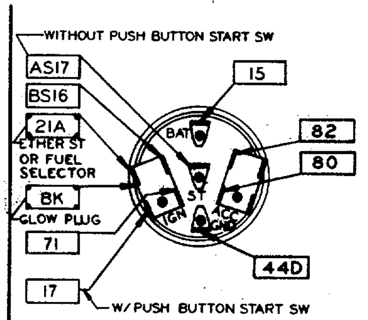
Component And Major Connector Location (On Chassis)
FBC/BUS Model



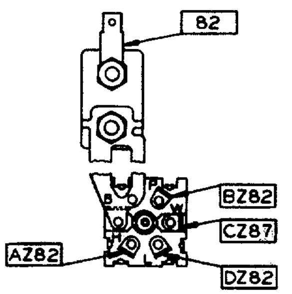
Components And Major Connector Location (On Chassis)
2100-2200-2500-2600 Models



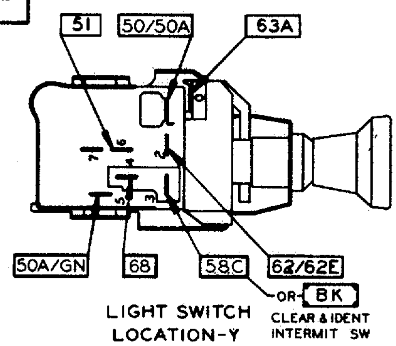
TURN SIGNAL SWITCH
LOCATION-S
VIEWED FROM TERMINAL SIDE



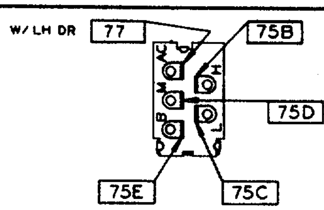
KEY SWITCH LOCATION-R
VIEWED FROM TERMINAL SIDE



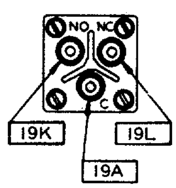
WIPER/WASHER SWITCH
LOCATION-X
VIEWED FROM TERMINAL SIDE



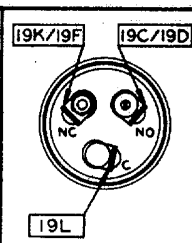
LIGHT SWITCH
LOCATION-Y
VIEWED FROM TERMINAL SIDE



HEATER/A-C SWITCH
LOCATION-AE
VIEWED FROM TERMINAL SIDE



SHT-DN TEMP SW



SHT-DN PRESS SW

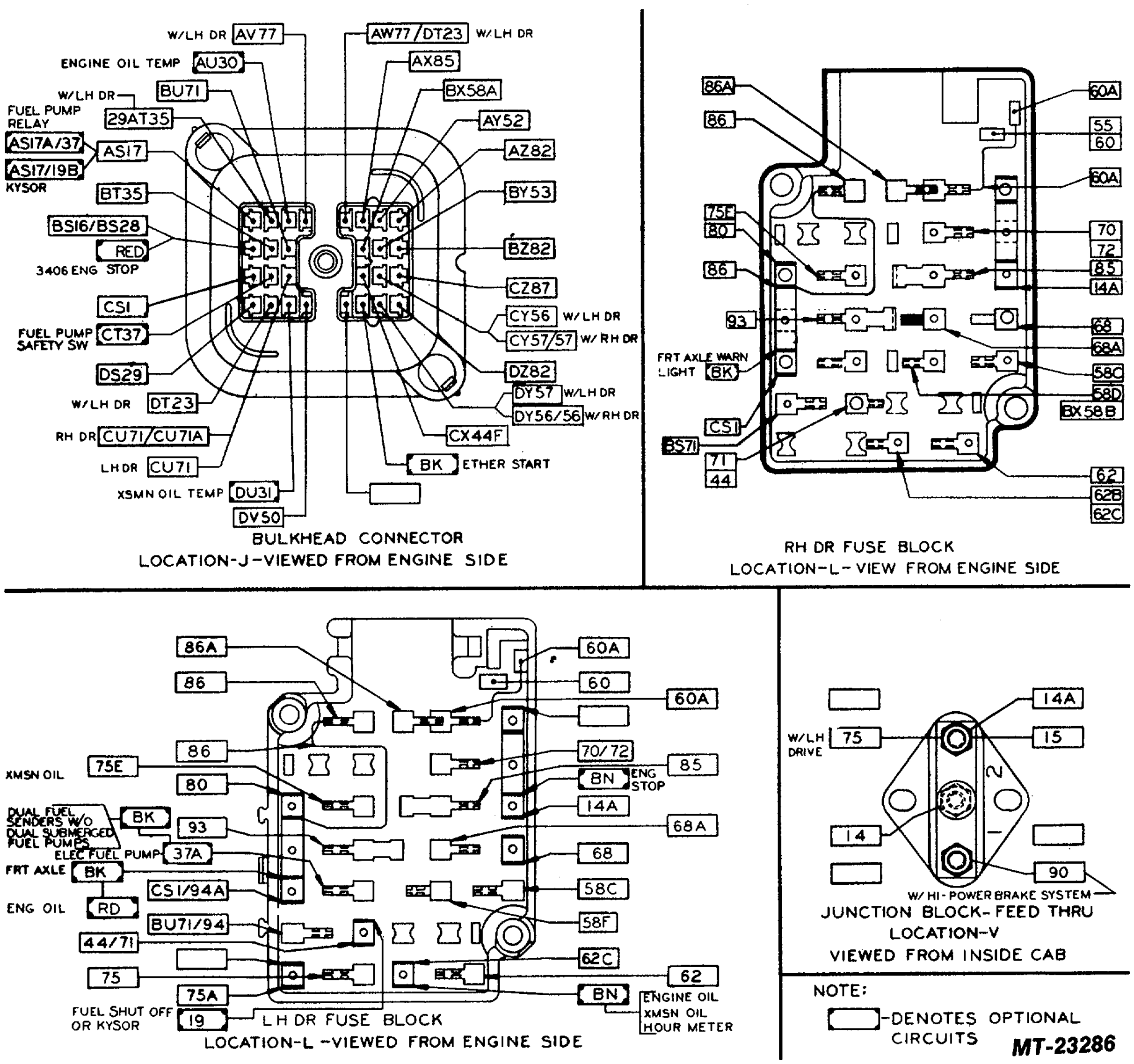
SWITCH CONTACT CHART

SWITCH	POSITION	CONTACTS CLOSED	CONTACTS OPEN
TURN SIGNAL & HAZARD	OFF (NORMAL)	2,3 & 6	1,4,5 & 7
	LEFT TURN & LANE CHANGE	1,3 & 5 2 & 6	4 & 7
	RIGHT TURN & LANE CHANGE	1,2 & 4 3 & 6	5 & 7
	HAZARD	2,3,4,5 & 7	1 & 6
HEAD LIGHT	OFF-(KNOB IN & TURNED C.W.)	2,3 & 4	0,1,5,6 & 7
	PARK LIGHTS (KNOB IN 1ST POS.)	1 & 7 2,3,4 & 5	0 & 6
	HEAD LIGHTS (KNOB IN 2ND POS.)	1 & 6 2,3,4 & 5	0 & 7
	DOME-(KNOB IN & TURN C.C.W.)	0 TO GND 3,4 & 2	1,5,6 & 7
	PANEL-(2ND POS. TURN C.C.W. TO LOCK)	0 TO GND 1 & 6 2,3,4 & 5	7
KEY	OFF	NONE	ALL
	START	BAT-ST-IGN GND-CASE	ACC
	IGNITION	BAT-IGN-ACC	ST-GND
	ACCESSORY	BAT-ACC	ST-IGN-GND
HEATER & A/C	OFF	NONE	ALL
	LOW	BAT-L-A/C	M-H
	MED	BAT-M-A/C	L-H
	HIGH	BAT-H-A/C	L-M
WIPER/ WASHER	PARK	BAT-P	W-L-H
	LOW	BAT-L	W-P-H
	HIGH	BAT-H	W-P-L
	WASHER (KNOB IN)	BAT-W	L-M-H
SHT-DN TEMP	NORMAL (BELOW 204°)	C-NC	C-NO
	ALARM (204°-210°)	C-NC C-NO	NONE
	SHUT-DOWN (ABOVE 210°)	C-NO	C-NC
SHT-DN PRESS	ENG OFF	C-NC	C-NO
	NORMAL	C-NO	C-NC
	ALARM (7 OR 11 P.S.I.)	C-NO C-NC	NONE
	SHUT-DOWN (3 OR 6 P.S.I.)	C-NC	C-NO

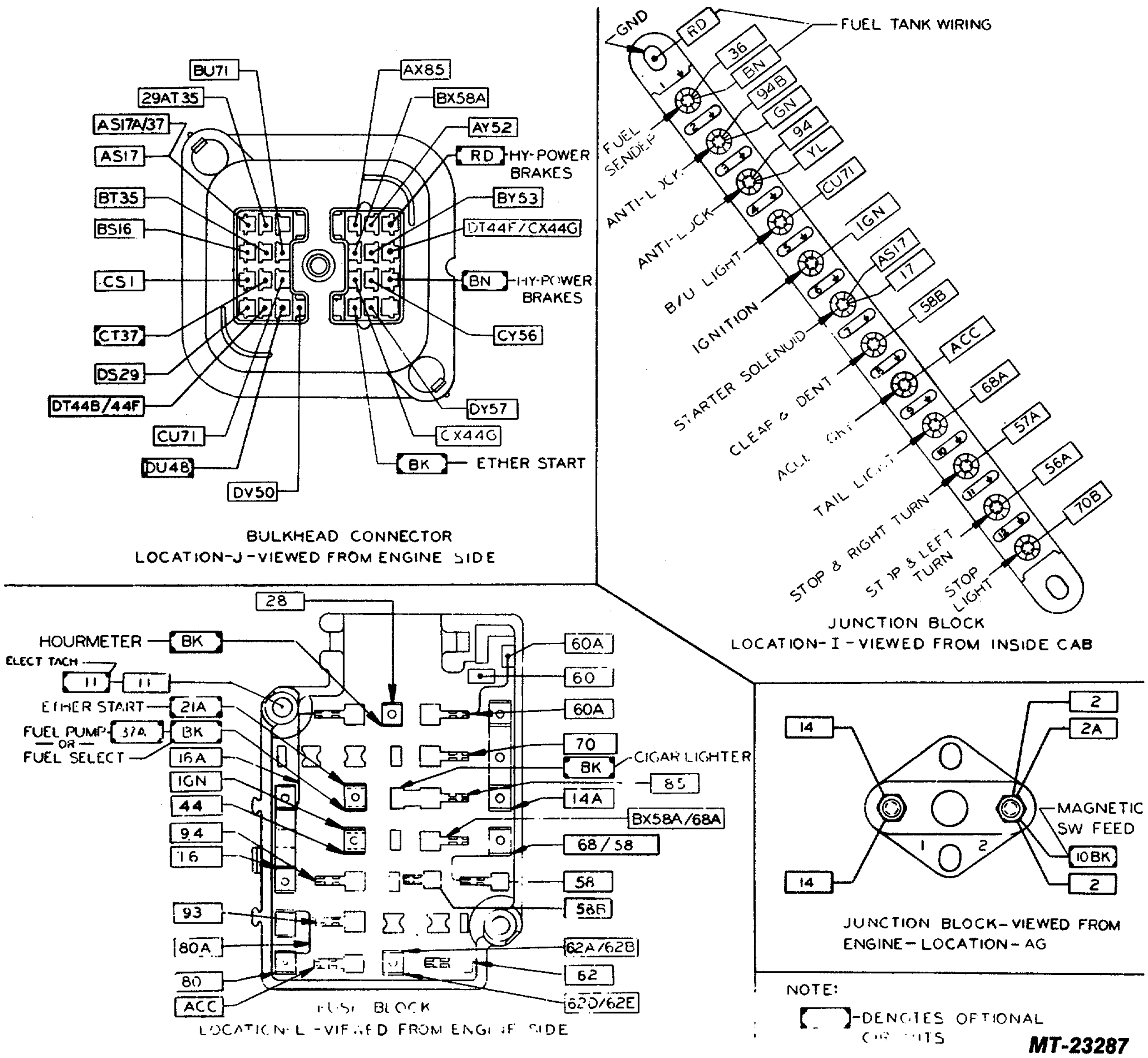
MT-23285

NOTE: [ ] DENOTES OPTIONAL CIRCUITS

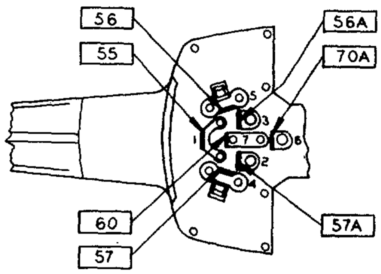
Components And Major Connectors (Not Schoolbus)
Turn Signal Switch-Key Switch-Windshield Wiper/Washer Switch
Light Switch-Heater/Air Conditioner Switch-Shut Down Temperature Switch
Shutdown Pressure Switch



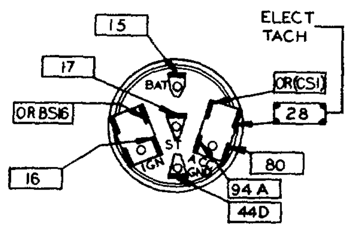
Components And Major Connectors (Not Schoolbus)
Bulkhead Connector-Fuse Blocks-Junction Block



Component And Major Connector (Schoolbus)
Bulkhead Connector-Fuse Block-Junction Block



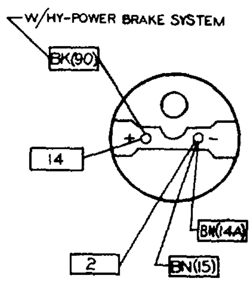
TURN SIGNAL SWITCH
LOCATION-S
VIEWED FROM TERMINAL SIDE



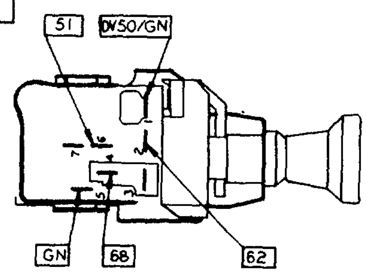
KEY SWITCH
LOCATION-R
VIEWED FROM TERMINAL SIDE

SWITCH CONTACT CHART

SWITCH	POSITION	CONTACTS CLOSED	CONTACTS OPEN
TURN SIGNAL & HAZARD	OFF (NORMAL)	2,3 & 6	1,4,5 & 7
	LEFT TURN & LANE CHANGE	1,3 & 5	4 & 7
		2 & 6	
	RIGHT TURN & LANE CHANGE	1,2 & 4	5 & 7
		3 & 6	
	HAZARD	2,3,4,5 & 7	1 & 6
HEAD LIGHT	OFF-(KNOB IN- & TURNED C.W.)	2,3&4	0,1,5,6 & 7
	PARK LIGHTS (KNOB IN- 1 ST POS.)	1 & 7	0 & 6
		2,3,4& 5	
	HEAD LIGHTS (KNOB IN- 2 ND POS.)	1 & 6	0 & 7
		2,3,4 & 5	
	DOME-(KNOB IN & TURN C.C.W.)	0 TO GND	1,5,6 & 7
		3,4 & 2	
	PANEL-(2 ND- POS. TURN- C.C.W. TO LOCK)	0 TO GND	7
		1 & 6	
		2 3 4& 5	
KEY	OFF	NONE	ALL
	START	BAT-ST-IGN	ACC
		GND-CASE	
	IGNITION	BAT-IGN-ACC	ST-GND
	ACCESSORY	BAT-ACC	ST-IGN-GND



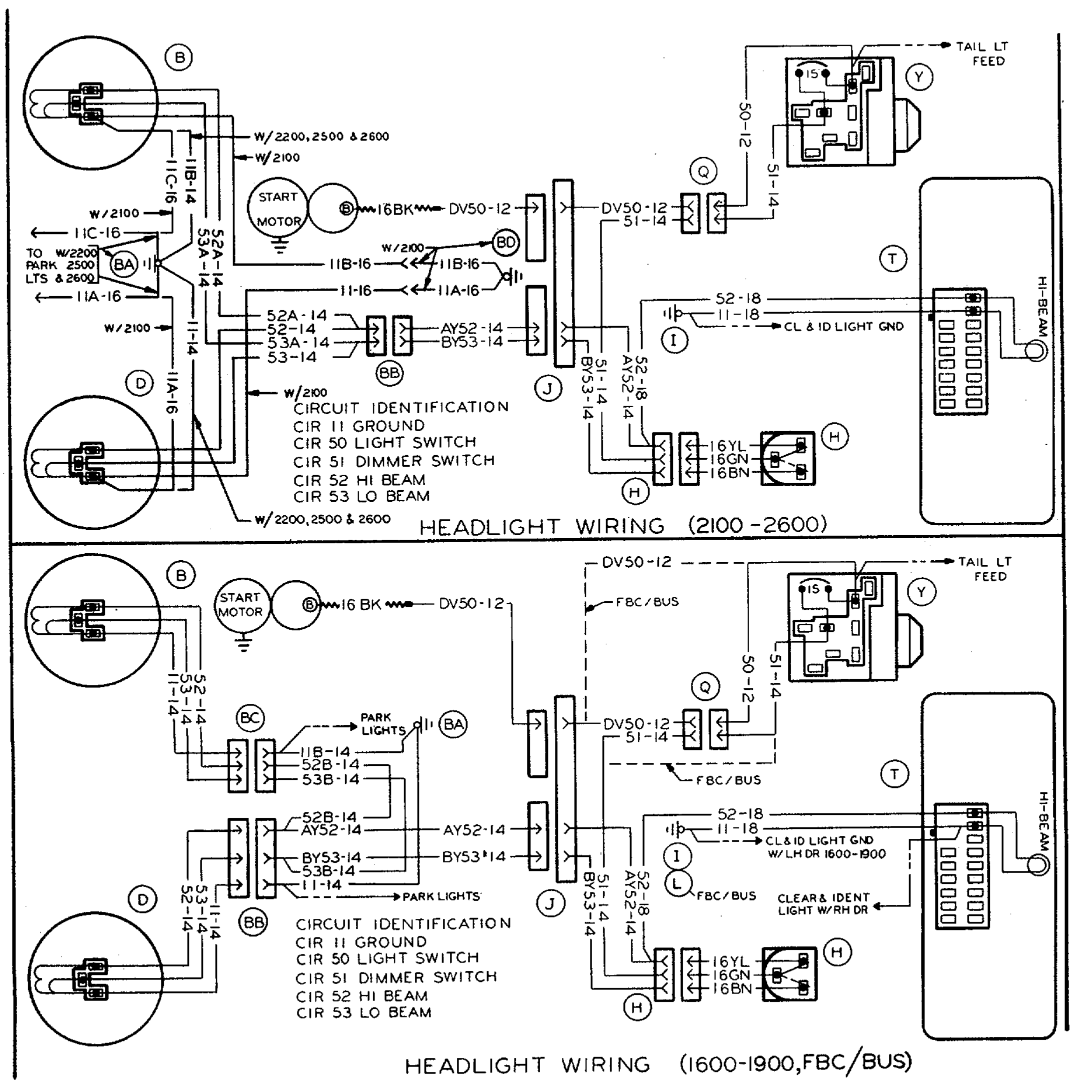
AMMETER
LOCATION -AF
VIEWED FROM TERMINAL SIDE



LIGHT SWITCH
LOCATION-Y
VIEWED FROM TERMINAL SIDE

MT-23289

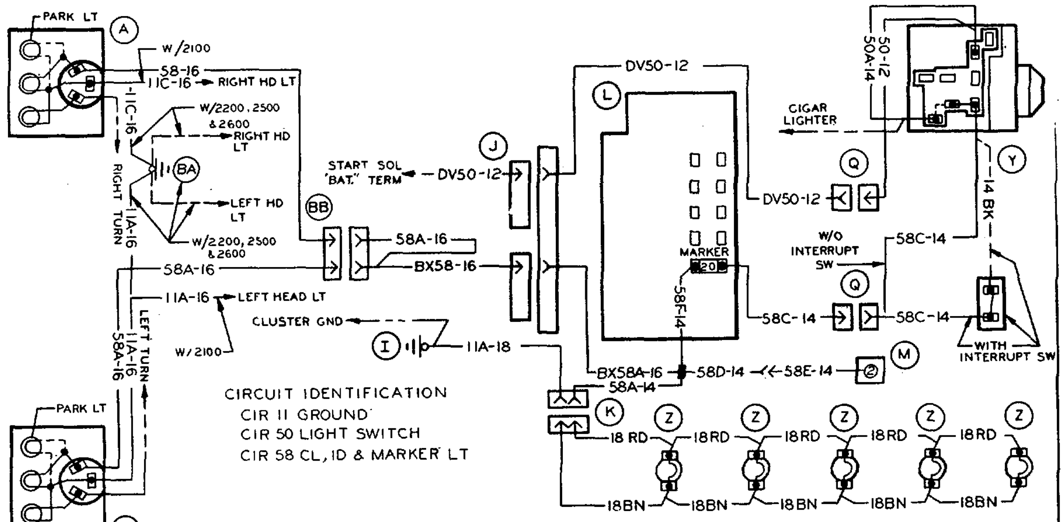
Component And Major Connectors (Schoolbus)
Turn Signal Switch-Key Switch-Ammeter-Light Switch



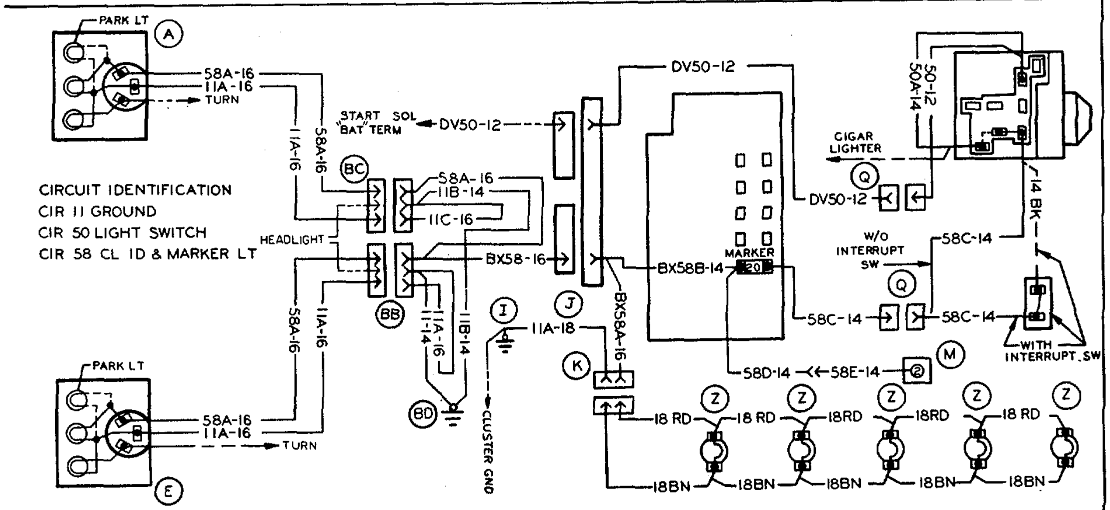
HEADLIGHT WIRING (2100-2600)

HEADLIGHT WIRING (1600-1900, FBC/BUS)

MT-21944

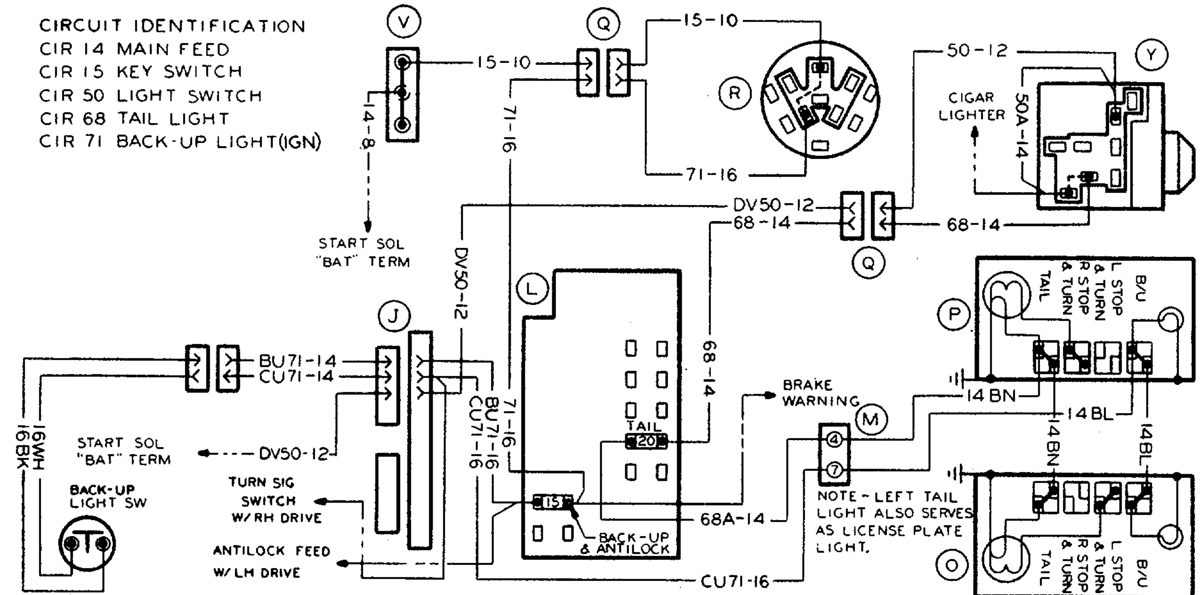


CLEARANCE - IDENTIFICATION - PARK & MARKER LT WIRING 2100-2600

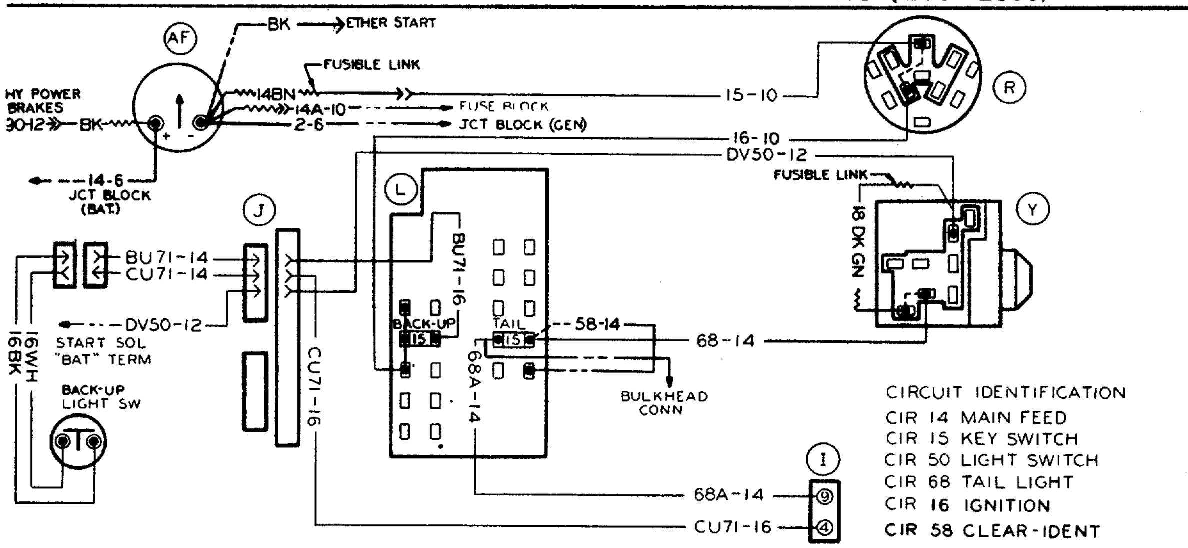


CLEARANCE — IDENTIFICATION — PARK & MARKER LT WIRING 1600 1900 RH DR

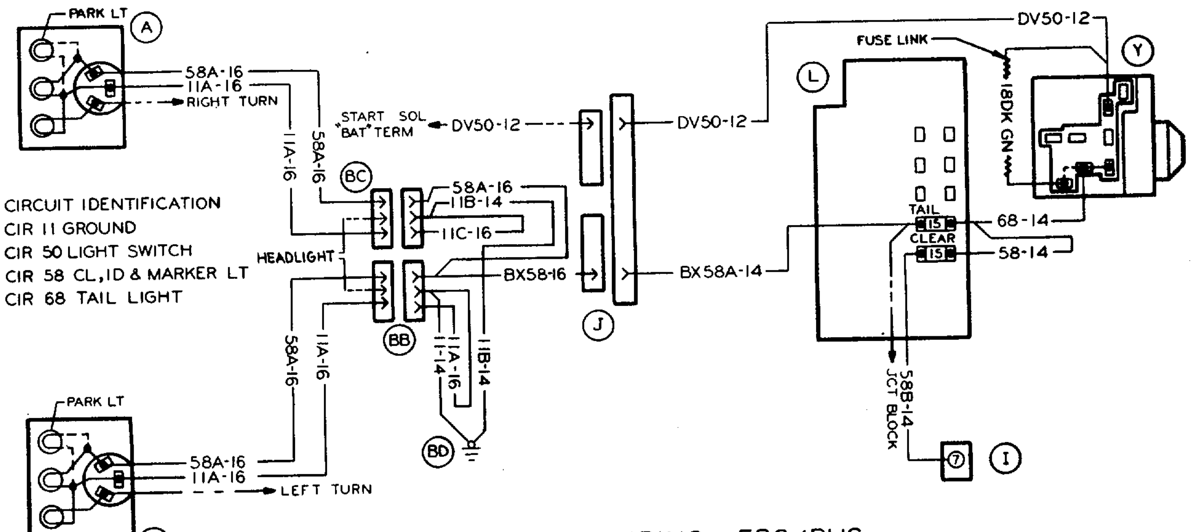
MT-21945



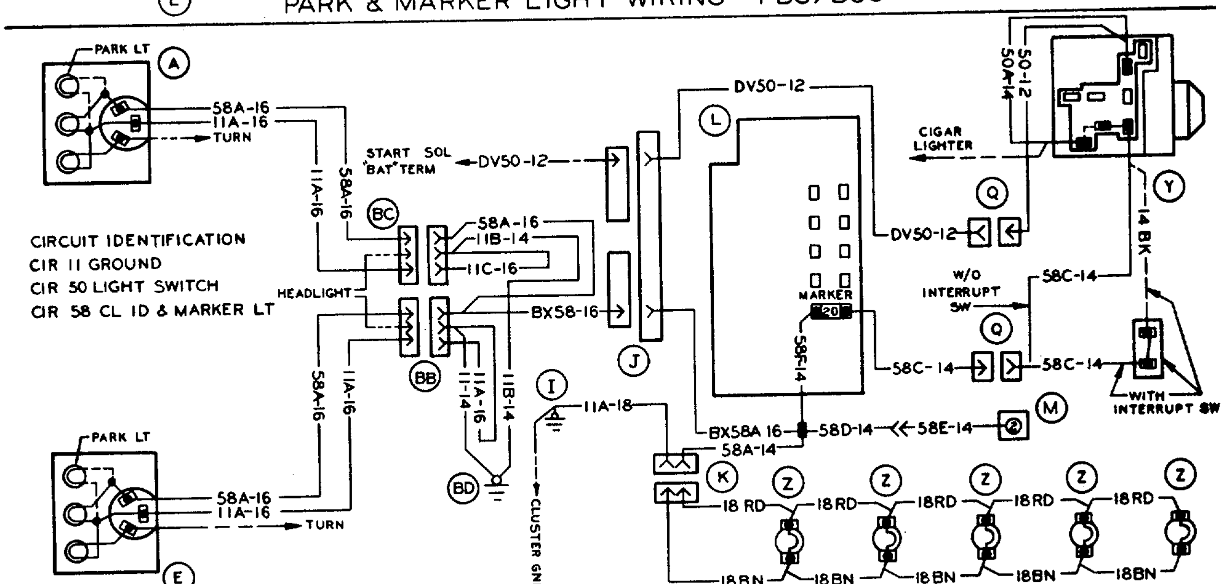
TAIL, BACK-UP & LICENSE PLATE LIGHT WIRING (1600 - 2600)



TAIL, BACK-UP & LICENSE PLATE LIGHT WIRING (FBC / BUS) **MT-23293**

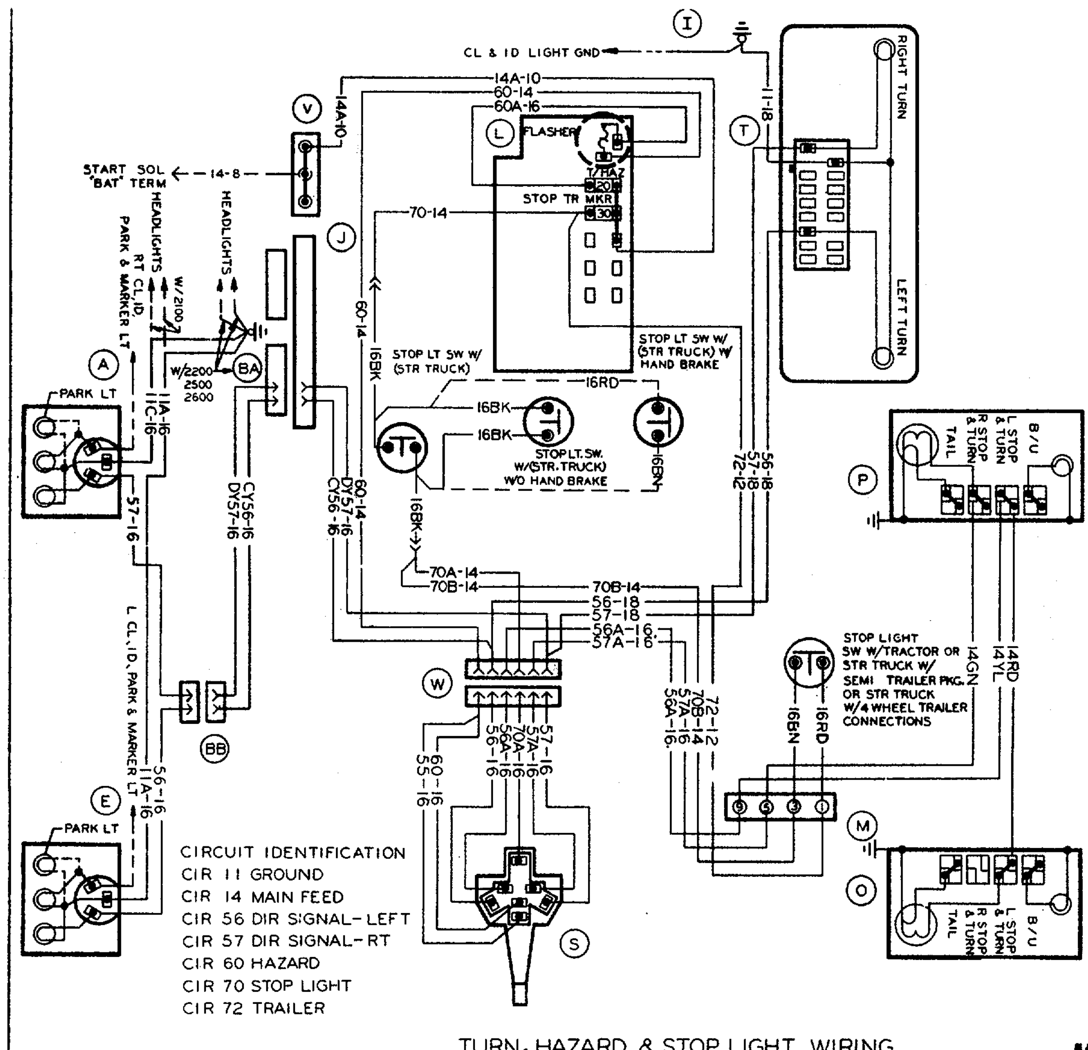


PARK & MARKER LIGHT WIRING FBC/BUS



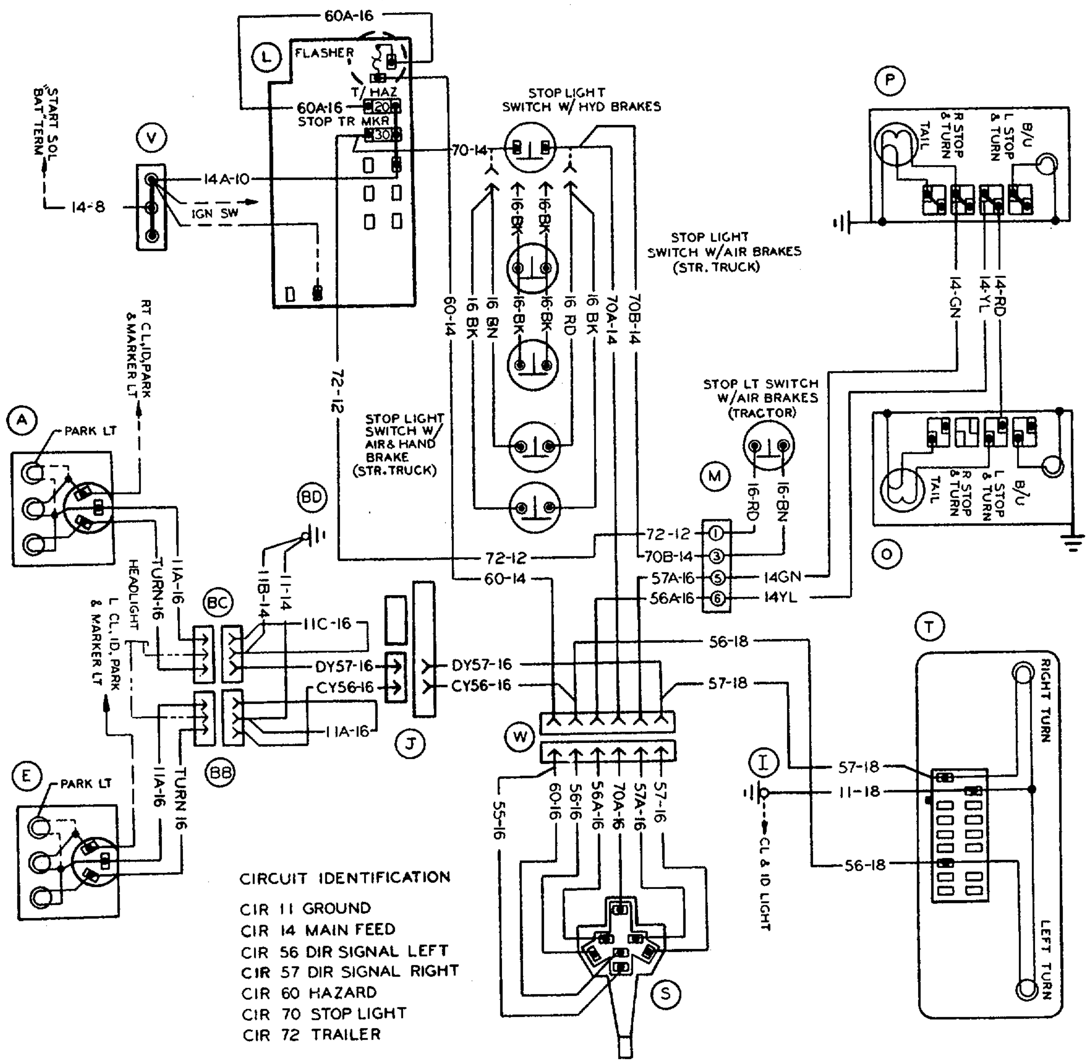
MT-23292

CLEARANCE – IDENTIFICATION – PARK & MARKER LT WIRING 1600-1900 LH DR



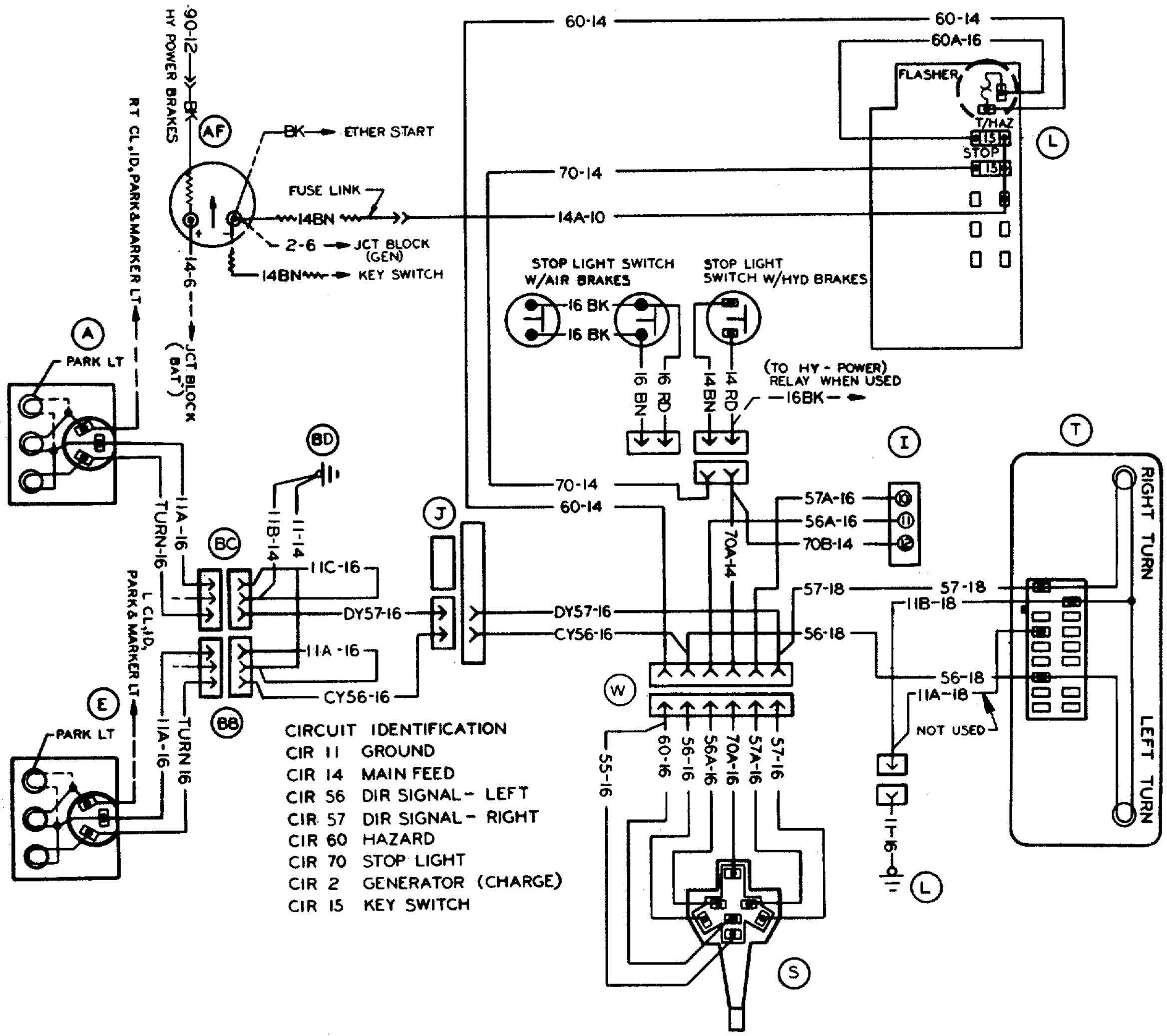
TURN, HAZARD & STOP LIGHT WIRING
2100, 2200, 2500 & 2600

MT-21948



TURN HAZARD & STOP LIGHT WIRING LH DR 1600,1700, 1800 & 1900

MT-21949

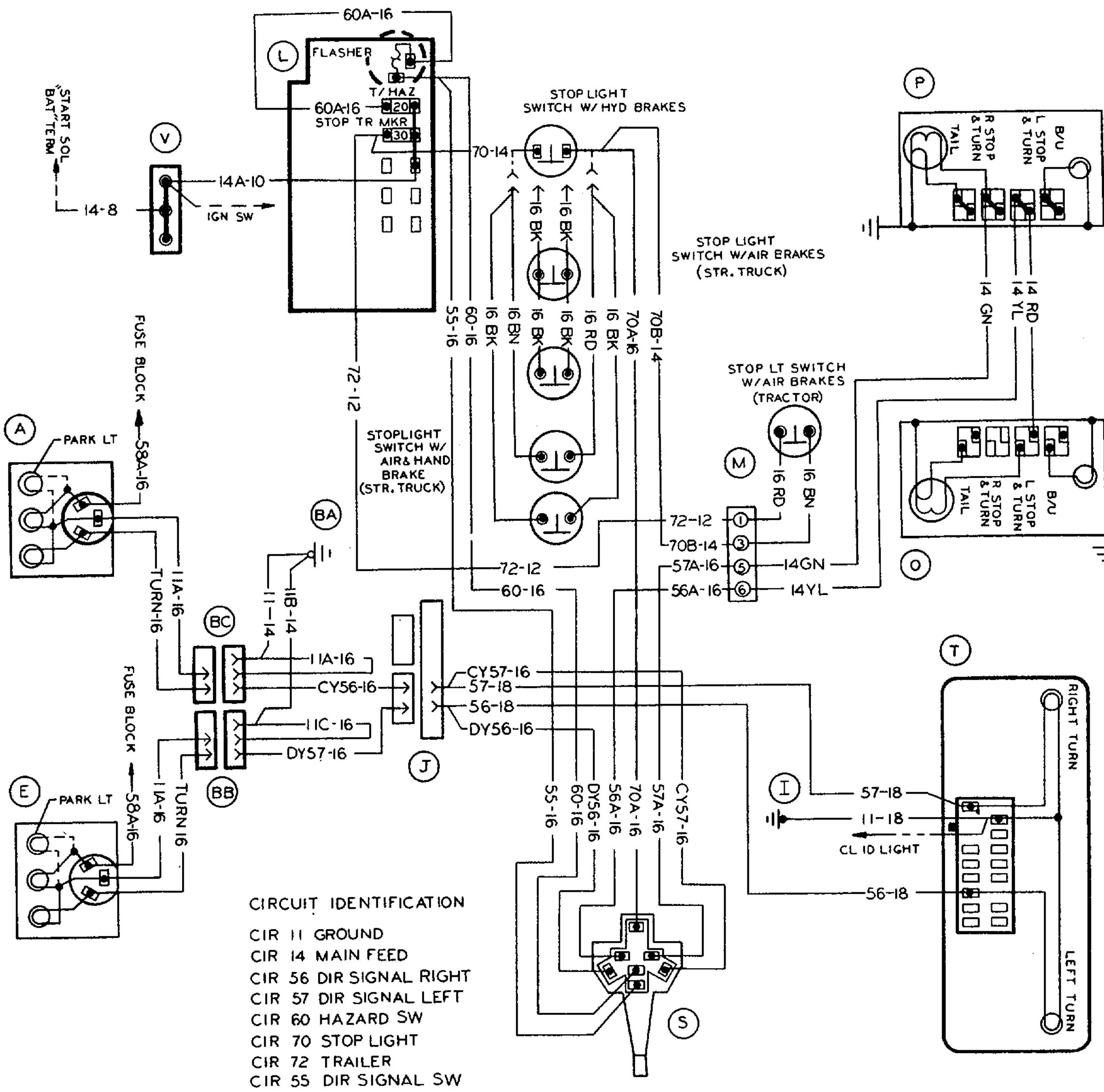


CIRCUIT IDENTIFICATION

CIR 11 GROUND
CIR 14 MAIN FEED
CIR 56 DIR SIGNAL - LEFT
CIR 57 DIR SIGNAL - RIGHT
CIR 60 HAZARD
CIR 70 STOP LIGHT
CIR 2 GENERATOR (CHARGE)
CIR 15 KEY SWITCH

MT-23294

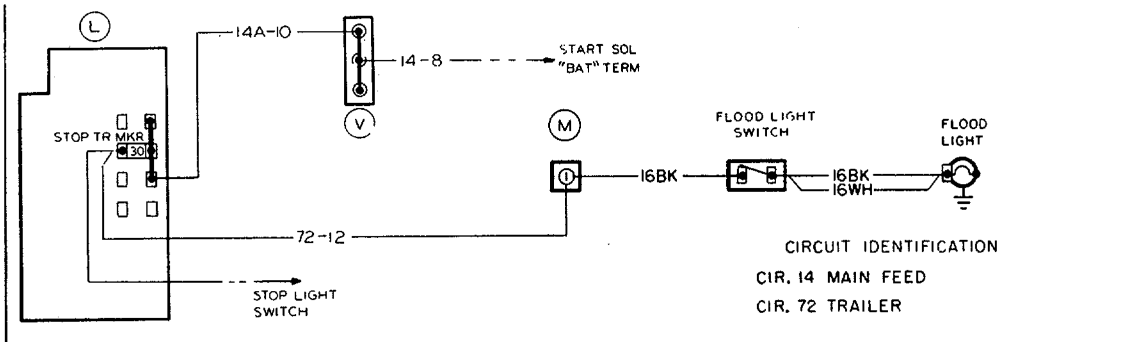
TURN HAZARD & STOP LIGHT WIRING — FBC/BUS



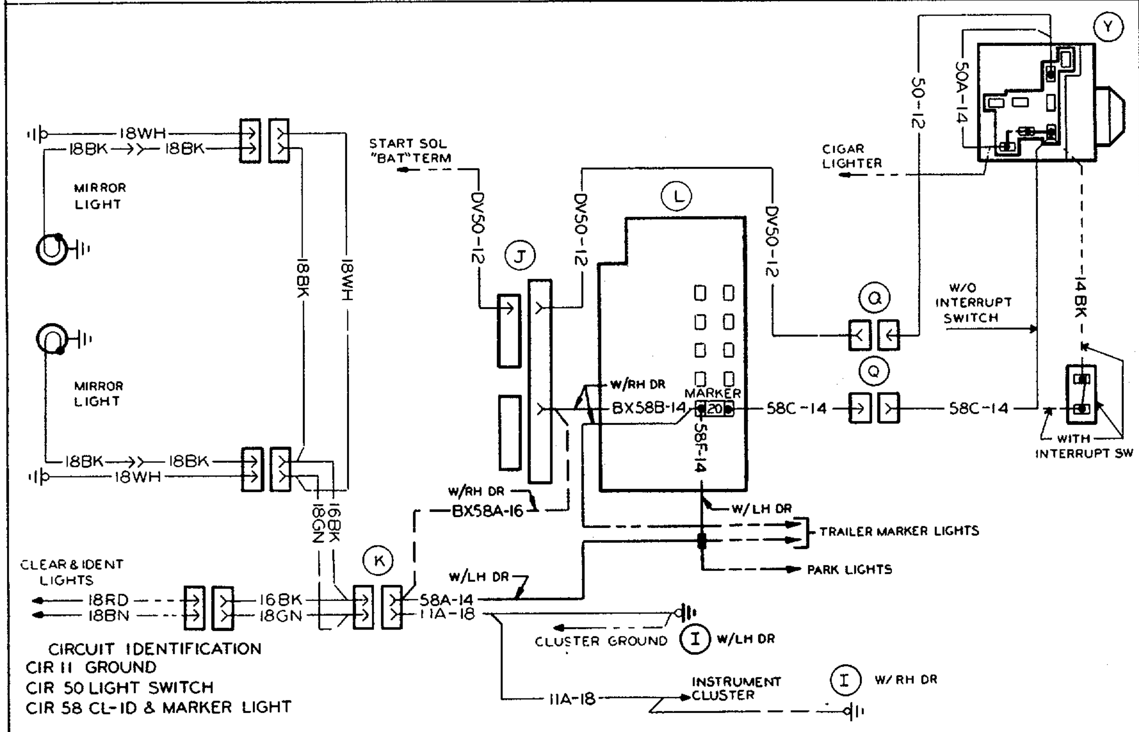
CIRCUIT IDENTIFICATION

CIR 11 GROUND
CIR 14 MAIN FEED
CIR 56 DIR SIGNAL RIGHT
CIR 57 DIR SIGNAL LEFT
CIR 60 HAZARD SW
CIR 70 STOP LIGHT
CIR 72 TRAILER
CIR 55 DIR SIGNAL SW

MT-21972 TURN HAZARD & STOP LIGHT WIRING RH DR 1700 1800 & 1900

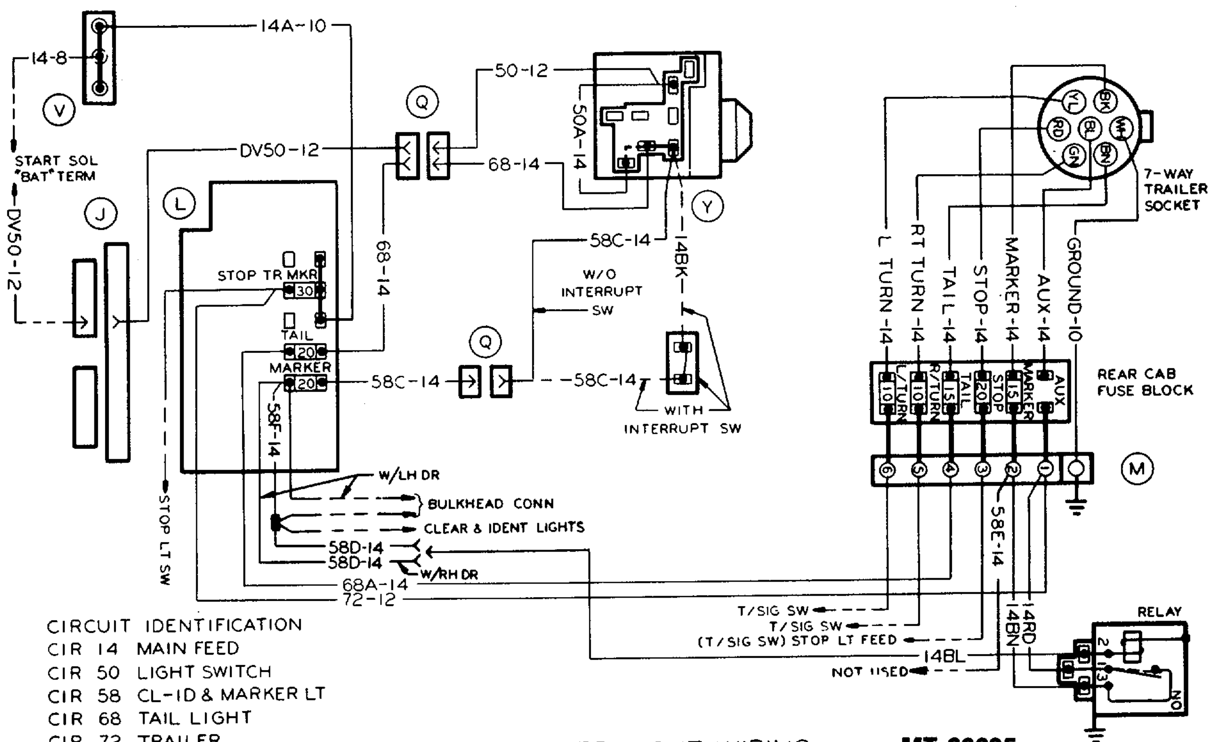


FLOOD LIGHT WIRING



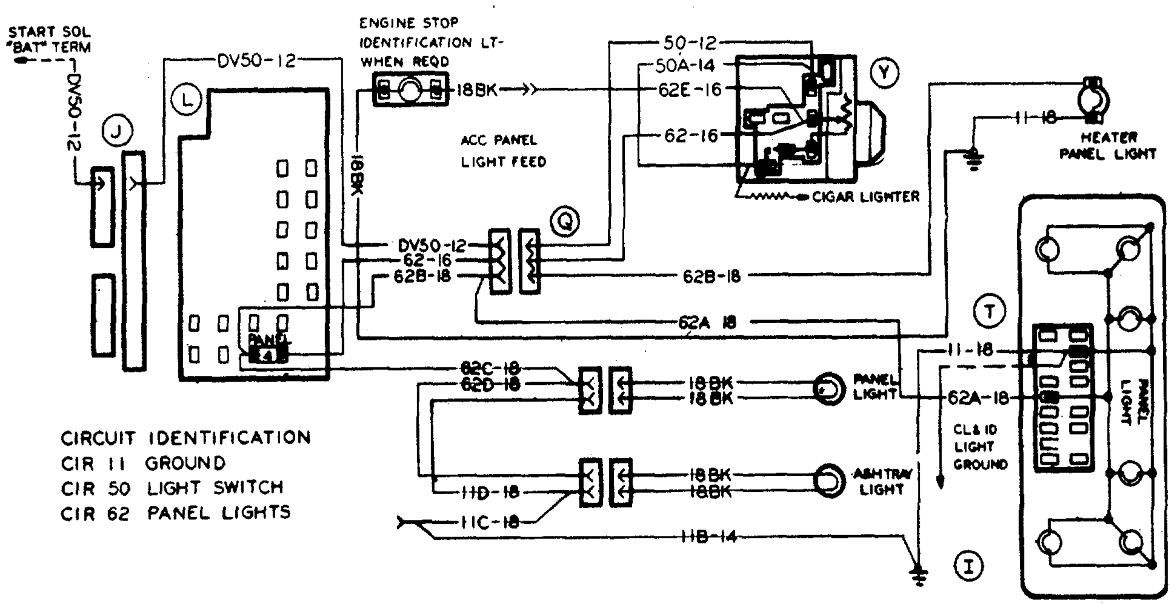
LIGHTED MIRROR WIRING

MT-21973

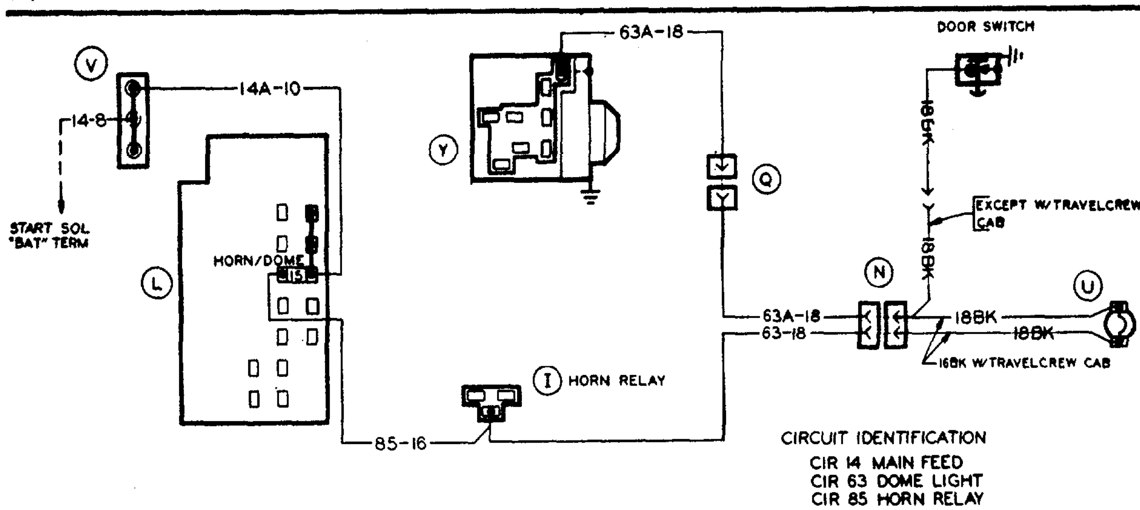


CIRCUIT IDENTIFICATION
CIR 14 MAIN FEED
CIR 50 LIGHT SWITCH
CIR 58 CL-ID & MARKER LT
CIR 68 TAIL LIGHT
CIR 72 TRAILER

TRAILER LIGHT WIRING **MT-23295**

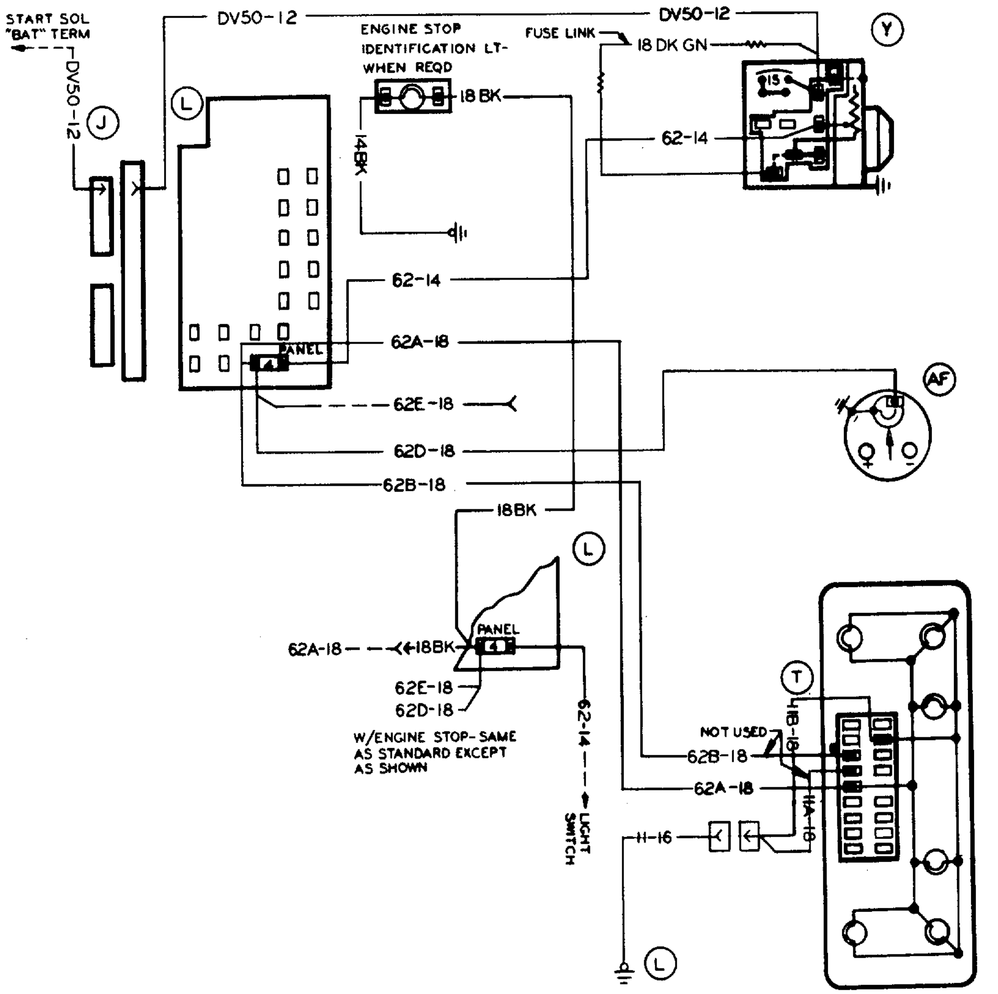


INSTRUMENT PANEL AND CONTROL IDENTIFICATION ILLUMINATION-RH DR



DOME LIGHT WIRING

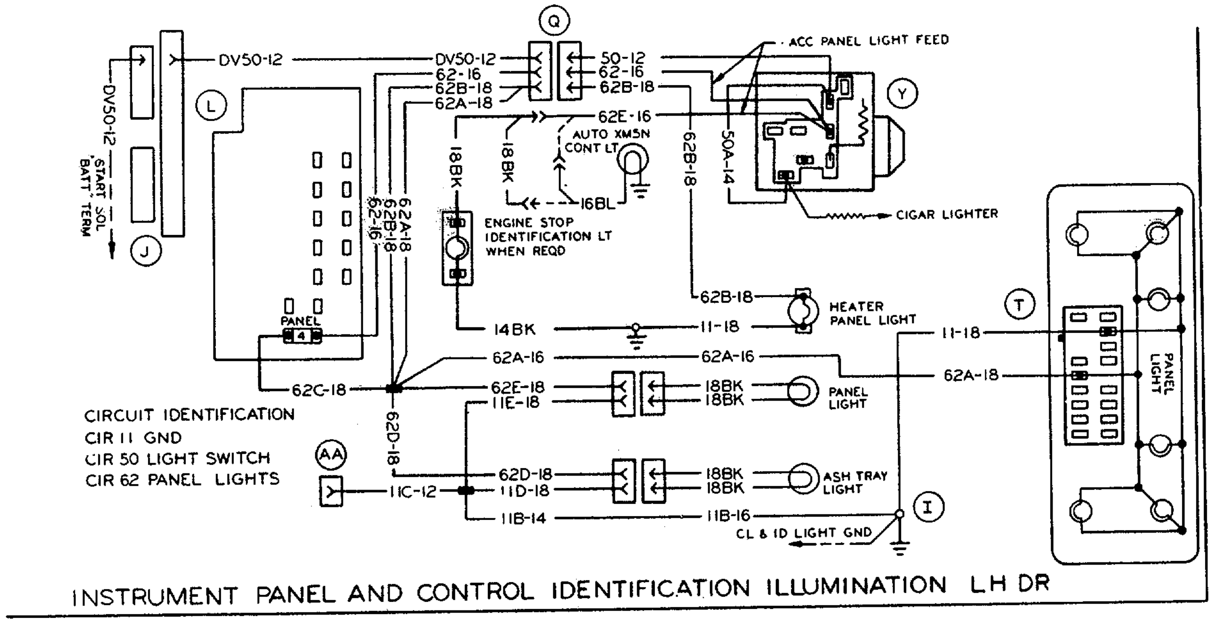
MT-23296



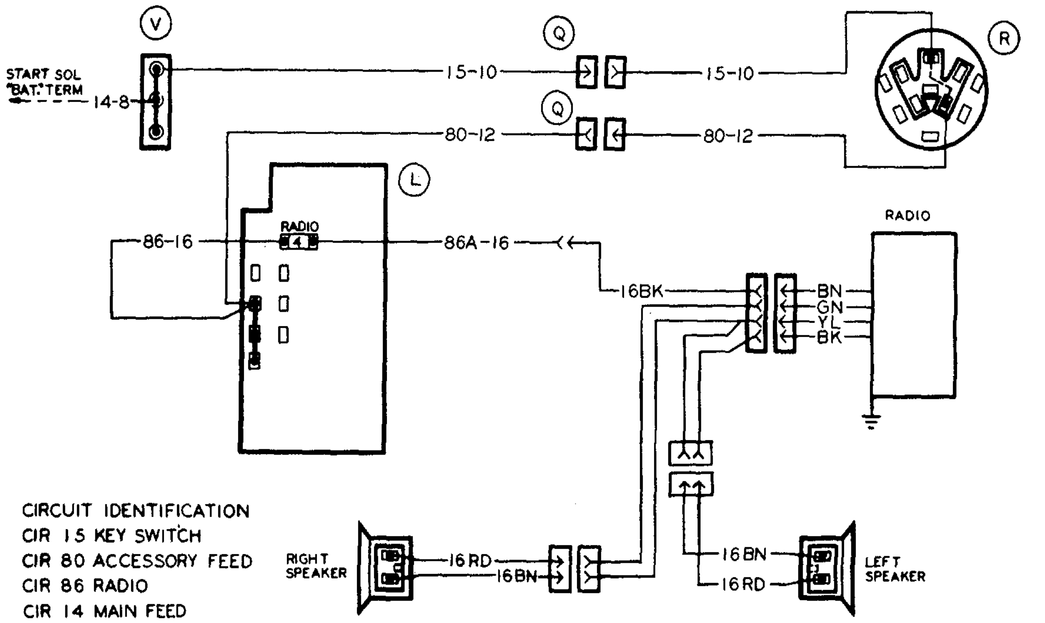
CIRCUIT IDENTIFICATION
CIR 11 GROUND
CIR 50 LIGHT SWITCH
CIR 62 PANEL LIGHTS

MT-23297

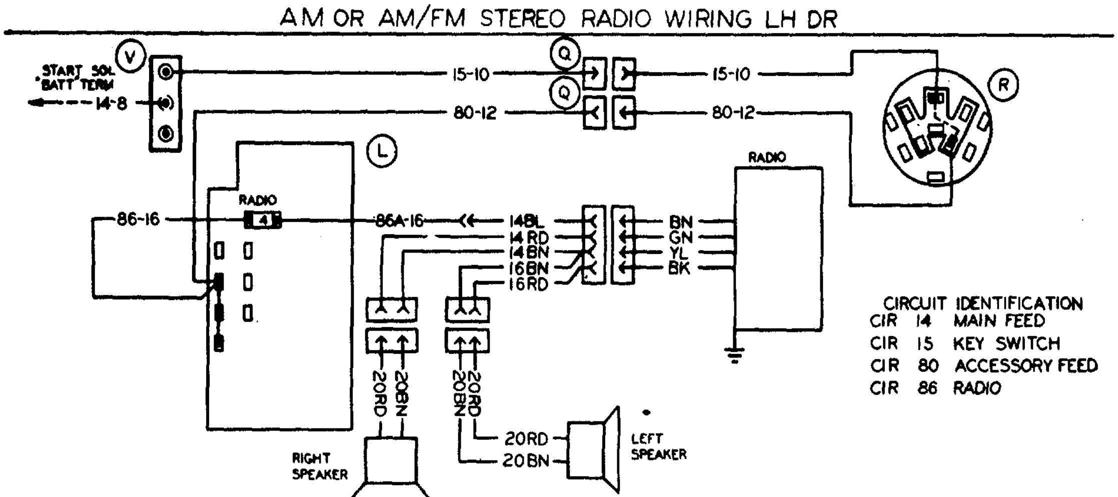
INSTRUMENT PANEL AND CONTROL IDENTIFICATION ILLUMINATION – FBC/BUS


DV50-12
"START" SOL "BATT" TERM
DV50-12
62-16
62B-18
62A-18
50-12
62-16
62B-18
ACC PANEL LIGHT FEED
62E-16
AUTO XMSN CONT LT
18BK
16BL
62B-18
50A-14
CIGAR LIGHTER
ENGINE STOP IDENTIFICATION LT WHEN REQD
PANEL
62B-18
HEATER PANEL LIGHT
14BK
11-18
11-18
62A-16
62A-16
62A-18
62C-18
62E-18
11E-18
18BK
18BK
PANEL LIGHT
CIRCUIT IDENTIFICATION
CIR 11 GND
CIR 50 LIGHT SWITCH
CIR 62 PANEL LIGHTS
62D-18
62D-18
11C-12
11D-18
18BK
18BK
ASH TRAY LIGHT
11B-14
11B-16
CL & ID LIGHT GND
PANEL LIGHT
Q
L
J
Y
T
AA
I
INSTRUMENT PANEL AND CONTROL IDENTIFICATION ILLUMINATION LH DR

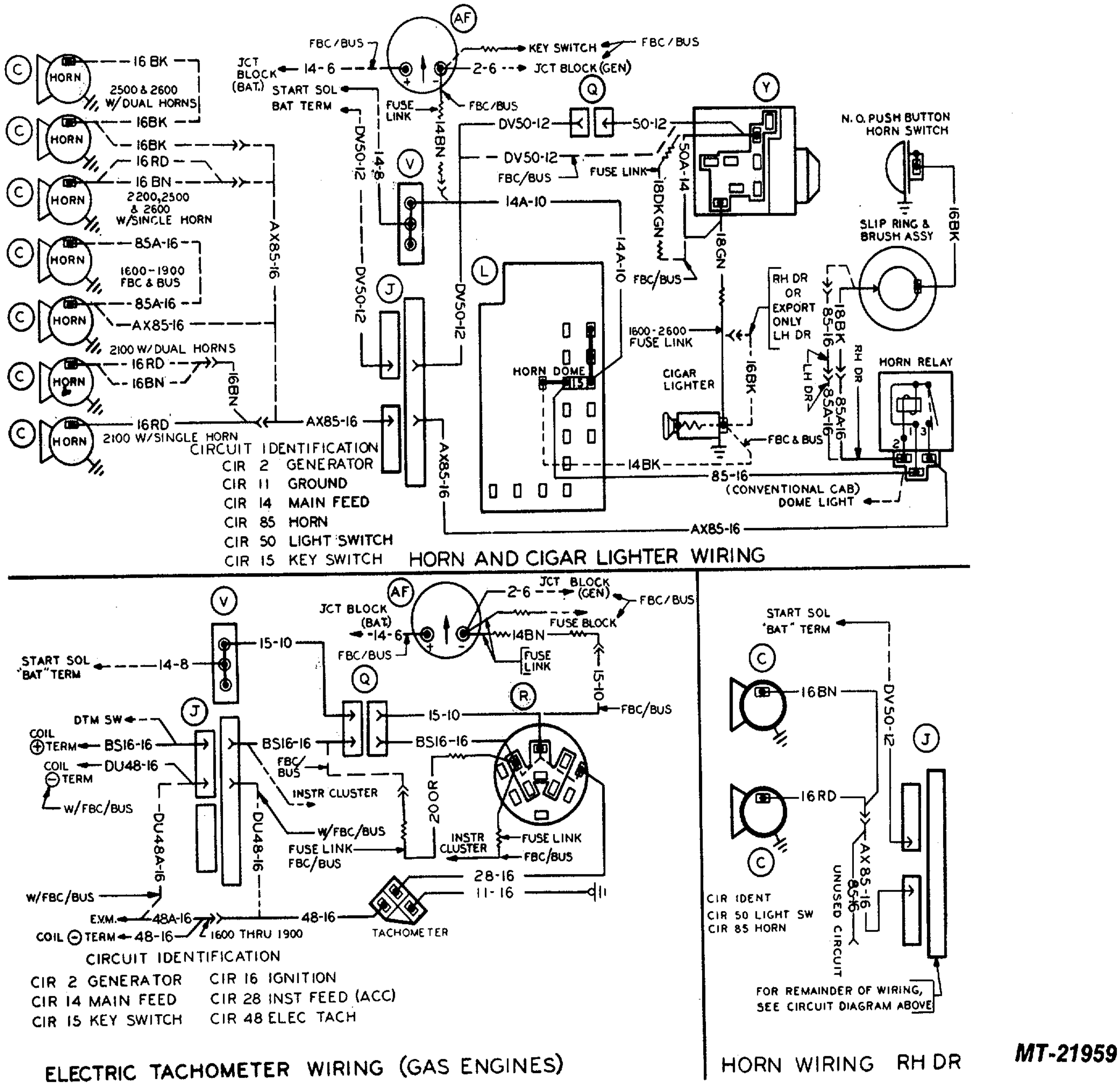
MT-21954

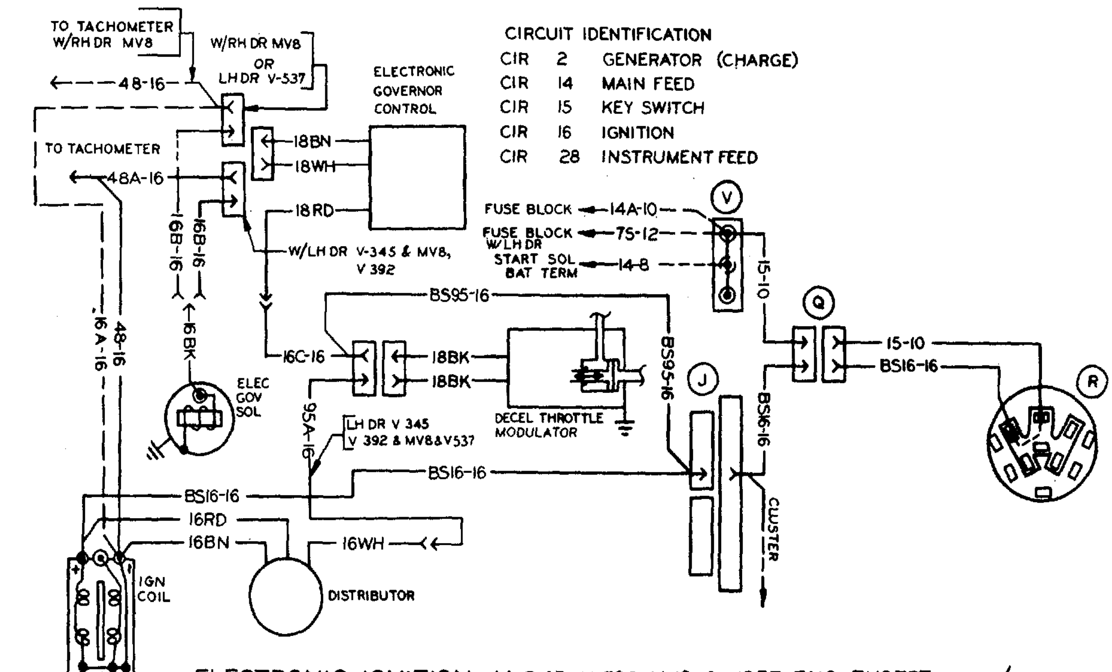


AM OR AM/FM STEREO RADIO WIRING LH DR

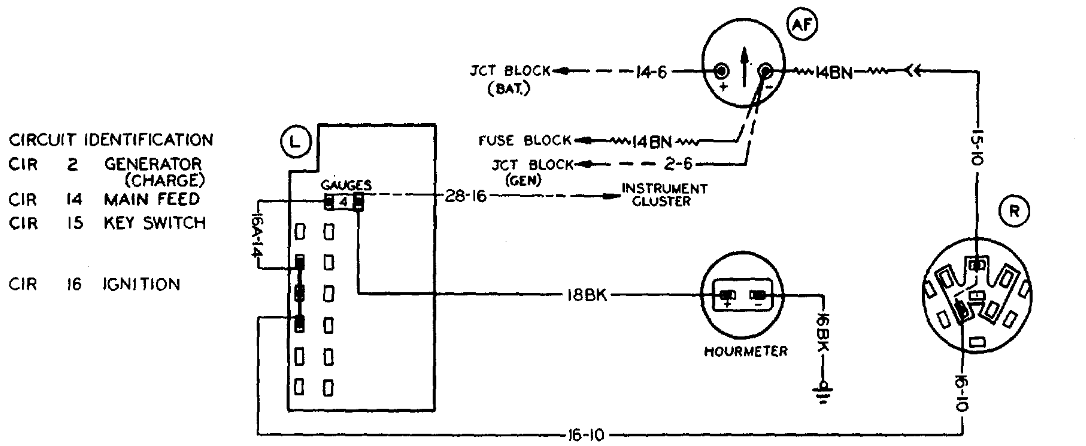


AM OR AM/FM STEREO RADIO WIRING RH DR


CIRCUIT IDENTIFICATION
CIR 2 GENERATOR
CIR 11 GROUND
CIR 14 MAIN FEED
CIR 85 HORN
CIR 50 LIGHT SWITCH
CIR 15 KEY SWITCH
HORN AND CIGAR LIGHTER WIRING
N. O. PUSH BUTTON HORN SWITCH
SLIP RING & BRUSH ASSY
HORN RELAY
CIGAR LIGHTER
HORN DOME
CIRCUIT IDENTIFICATION
CIR 2 GENERATOR
CIR 14 MAIN FEED
CIR 15 KEY SWITCH
CIR 16 IGNITION
CIR 28 INST FEED (ACC)
CIR 48 ELEC TACH
TACHOMETER
ELECTRIC TACHOMETER WIRING (GAS ENGINES)
CIR IDENT
CIR 50 LIGHT SW
CIR 85 HORN
FOR REMAINDER OF WIRING, SEE CIRCUIT DIAGRAM ABOVE
HORN WIRING RH DR
MT-21959

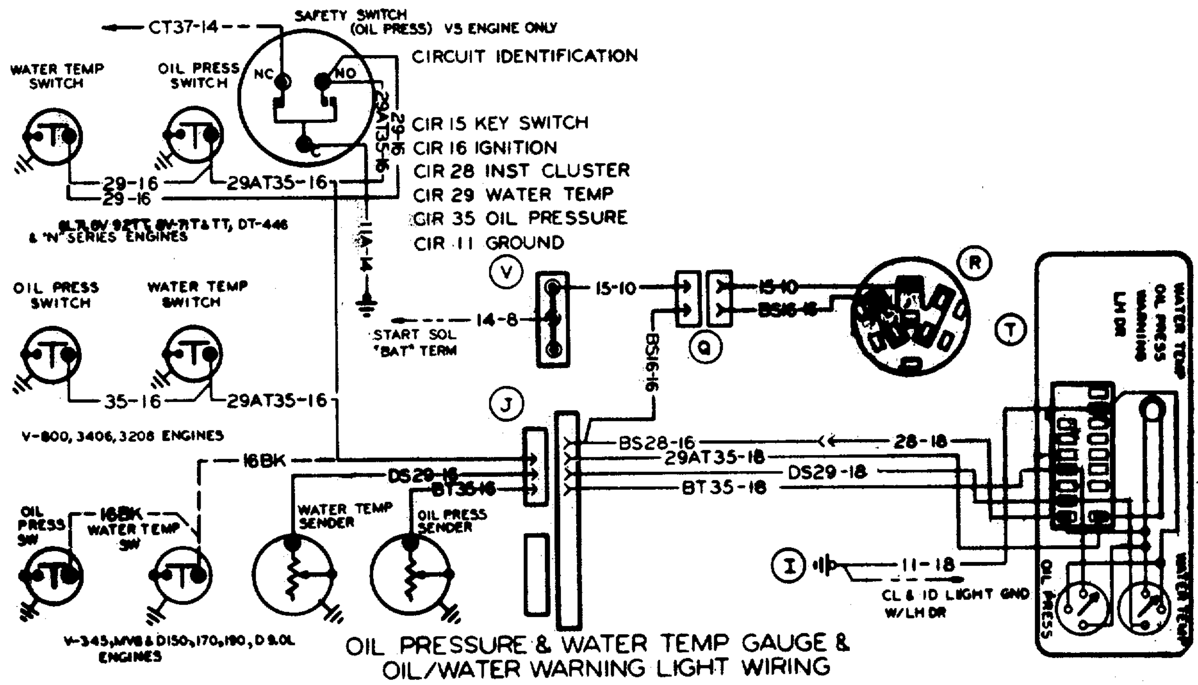


ELECTRONIC IGNITION V-345, V-392, MV8 & V537 ENG EXCEPT FBC/BUS

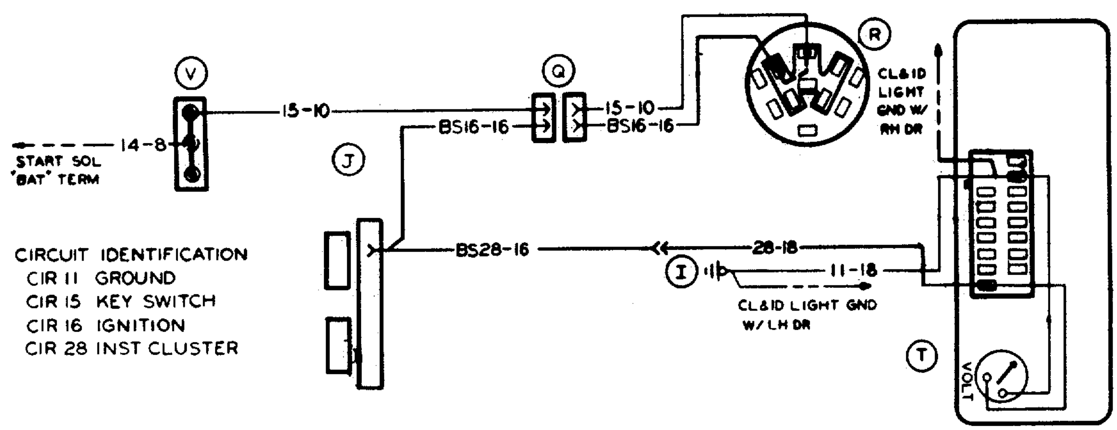


HOURMETER WIRING FBC/BUS

MT-23300

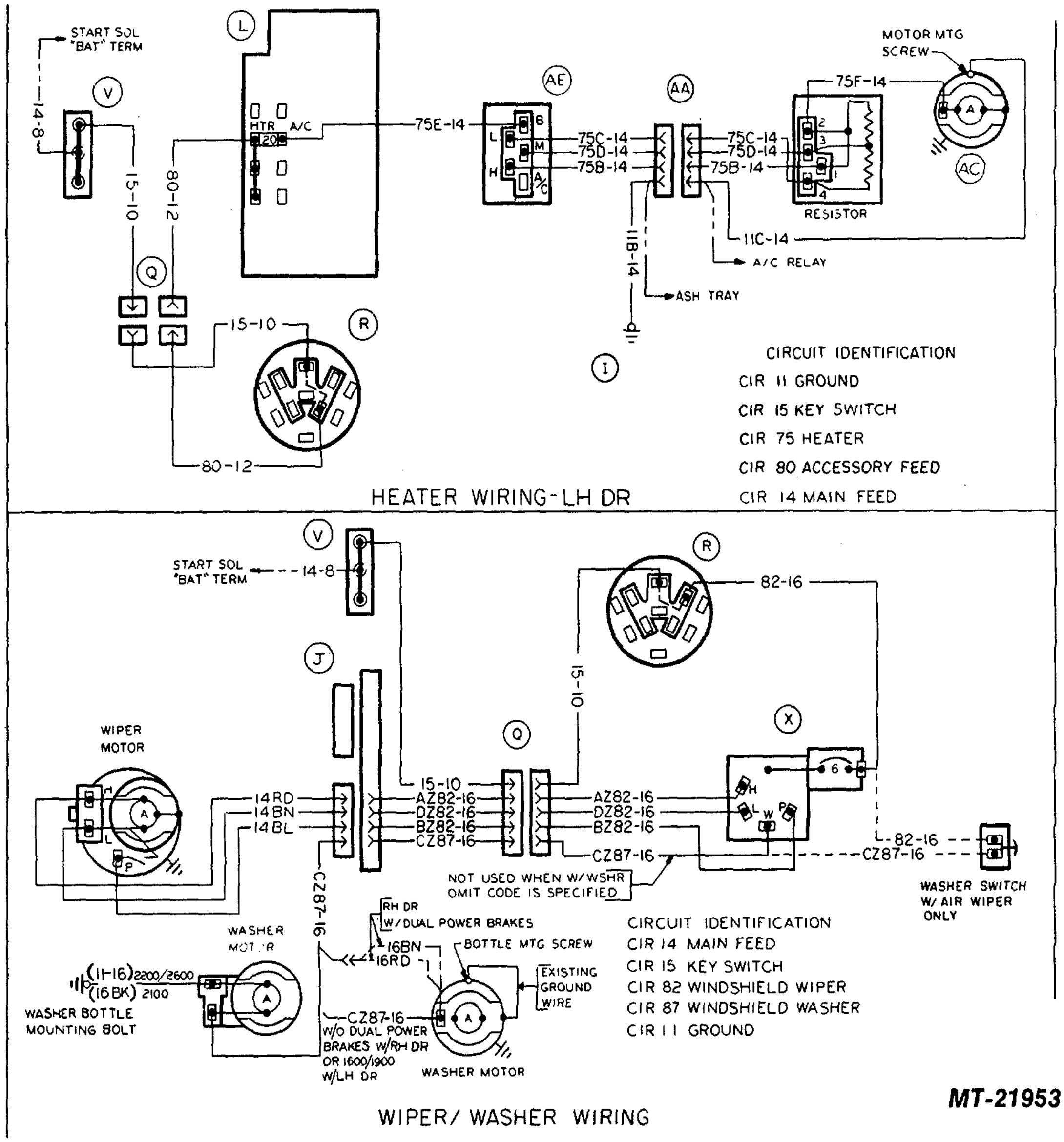


OIL PRESSURE & WATER TEMP GAUGE & OIL/WATER WARNING LIGHT WIRING EXCEPT FBC/BUS

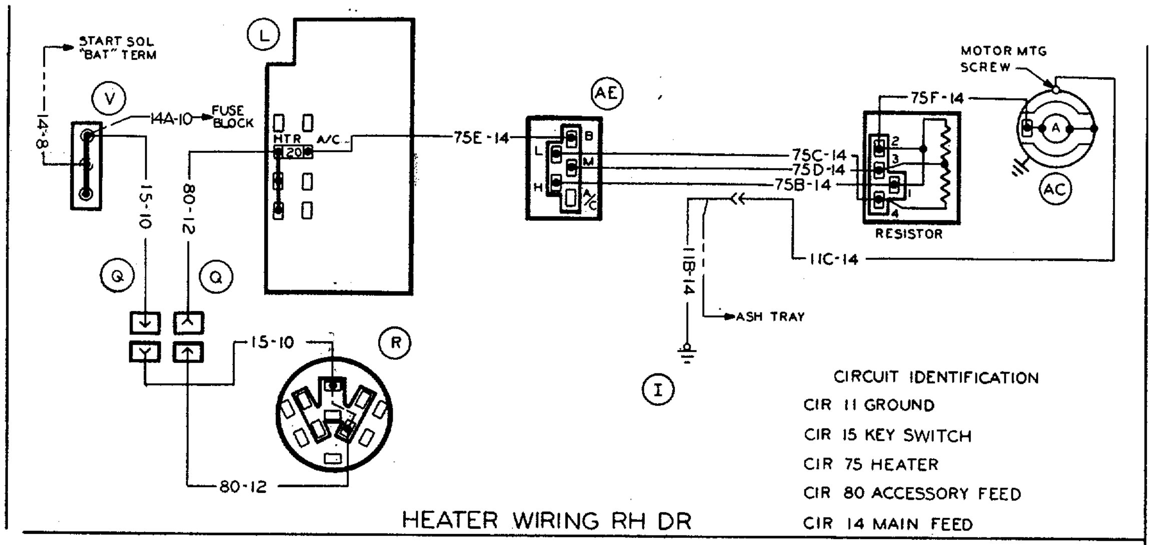


VOLTMETER WIRING EXCEPT FBC/BUS

MT-23306

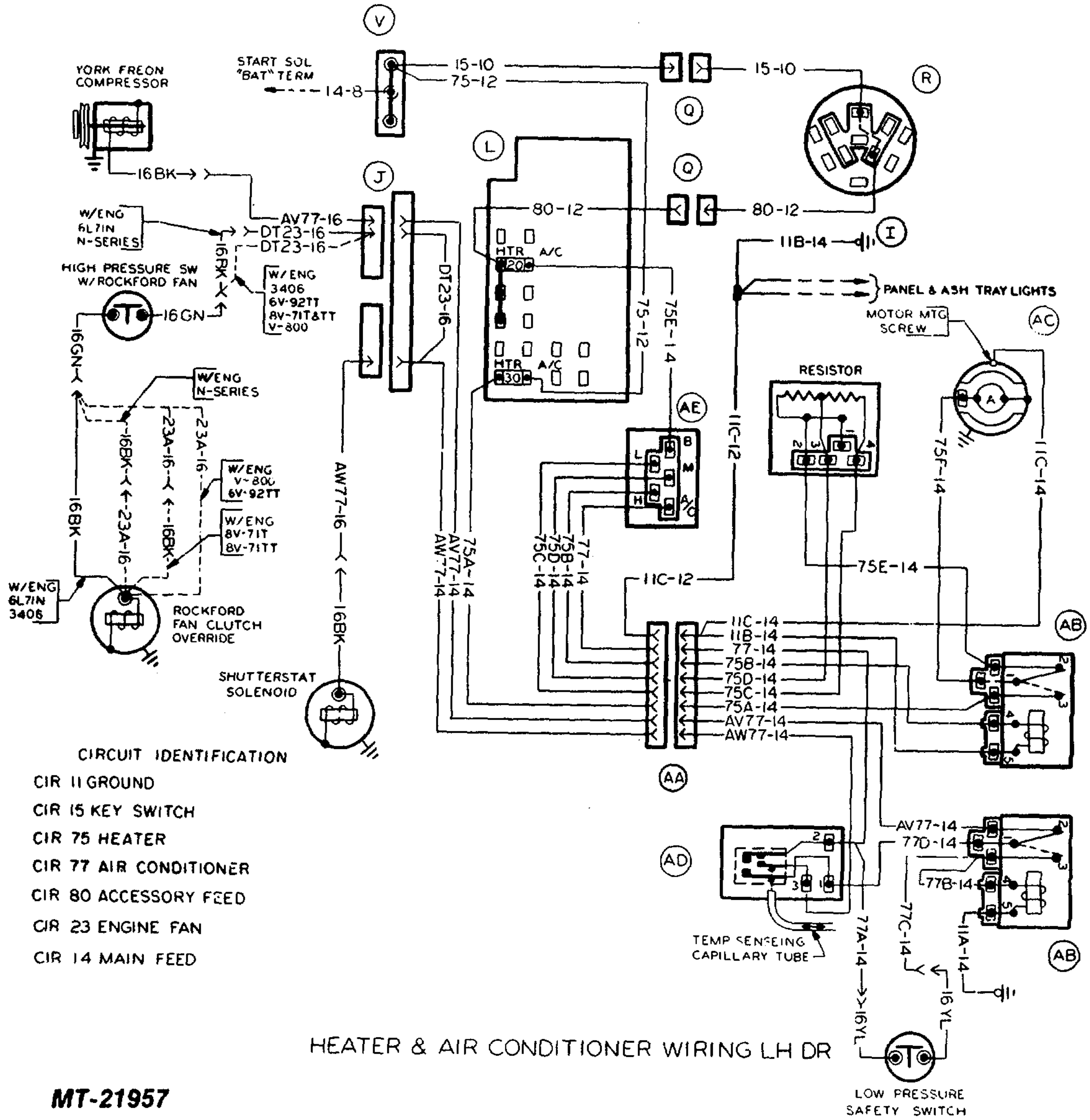

START SOL "BAT" TERM
14-8
V
L
HTR
A/C
15-10
80-12
75E-14
AE
B
M
H
75C-14
75D-14
75B-14
AA
75F-14
MOTOR MTG SCREW
RESISTOR
AC
11B-14
11C-14
A/C RELAY
ASH TRAY
Q
R
15-10
80-12
I
CIRCUIT IDENTIFICATION
CIR 11 GROUND
CIR 15 KEY SWITCH
CIR 75 HEATER
CIR 80 ACCESSORY FEED
CIR 14 MAIN FEED
HEATER WIRING-LH DR
START SOL "BAT" TERM
14-8
V
R
82-16
J
15-10
WIPER MOTOR
14RD
14BN
14BL
AZ82-16
DZ82-16
BZ82-16
CZ87-16
Q
X
L-82-16
CZ87-16
NOT USED WHEN W/WSHR OMIT CODE IS SPECIFIED
WASHER SWITCH W/AIR WIPER ONLY
RH DR W/DUAL POWER BRAKES
16BN
16RD
BOTTLE MTG SCREW
EXISTING GROUND WIRE
(11-16) 2200/2600
(16BK) 2100
WASHER BOTTLE MOUNTING BOLT
W/O DUAL POWER BRAKES W/RH DR OR 1600/1900 W/LH DR
WASHER MOTOR
CIRCUIT IDENTIFICATION
CIR 14 MAIN FEED
CIR 15 KEY SWITCH
CIR 82 WINDSHIELD WIPER
CIR 87 WINDSHIELD WASHER
CIR 11 GROUND
WIPER/ WASHER WIRING

MT-21953



HEATER WIRING RH DR

MT-21956

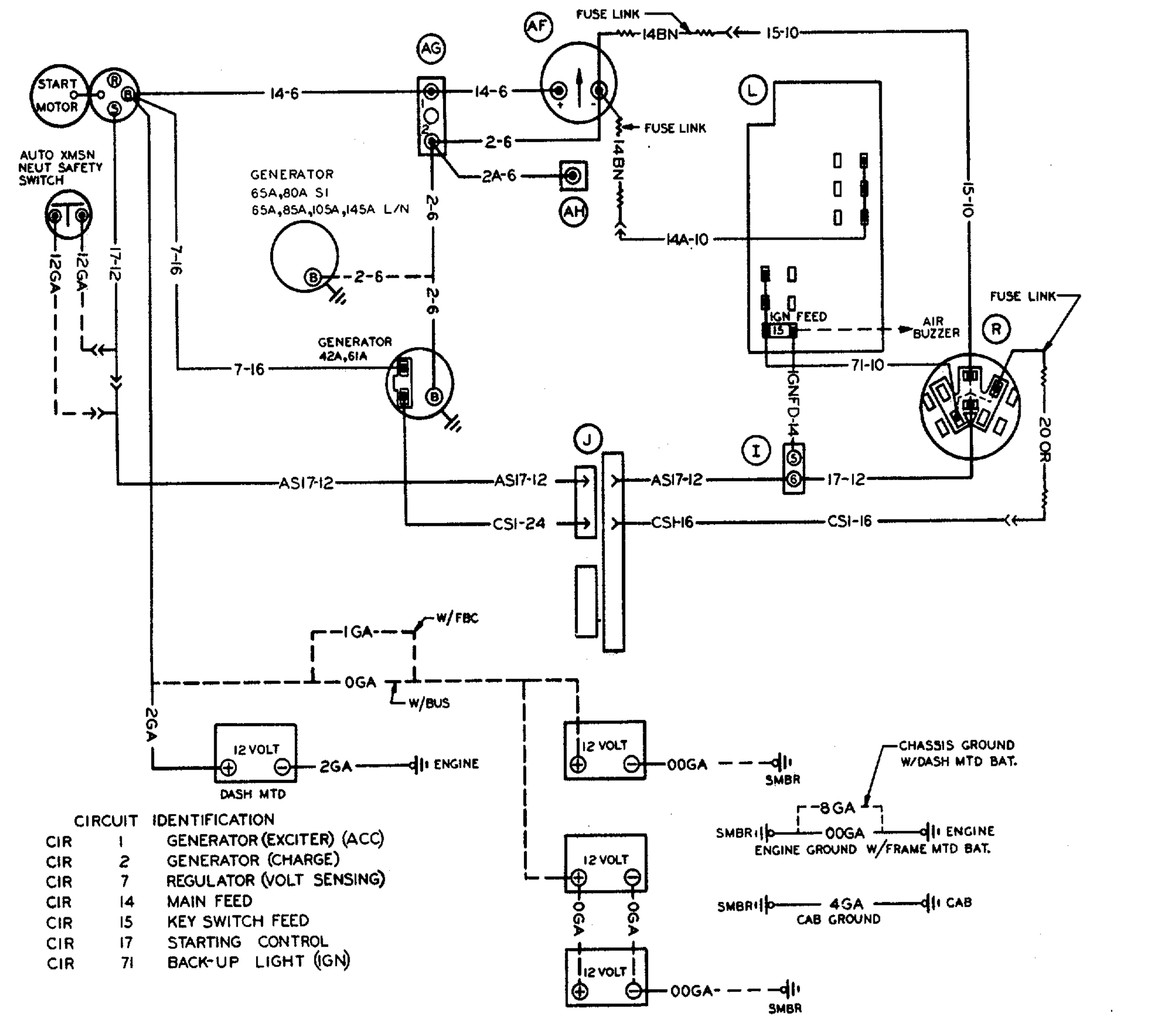


CIRCUIT IDENTIFICATION

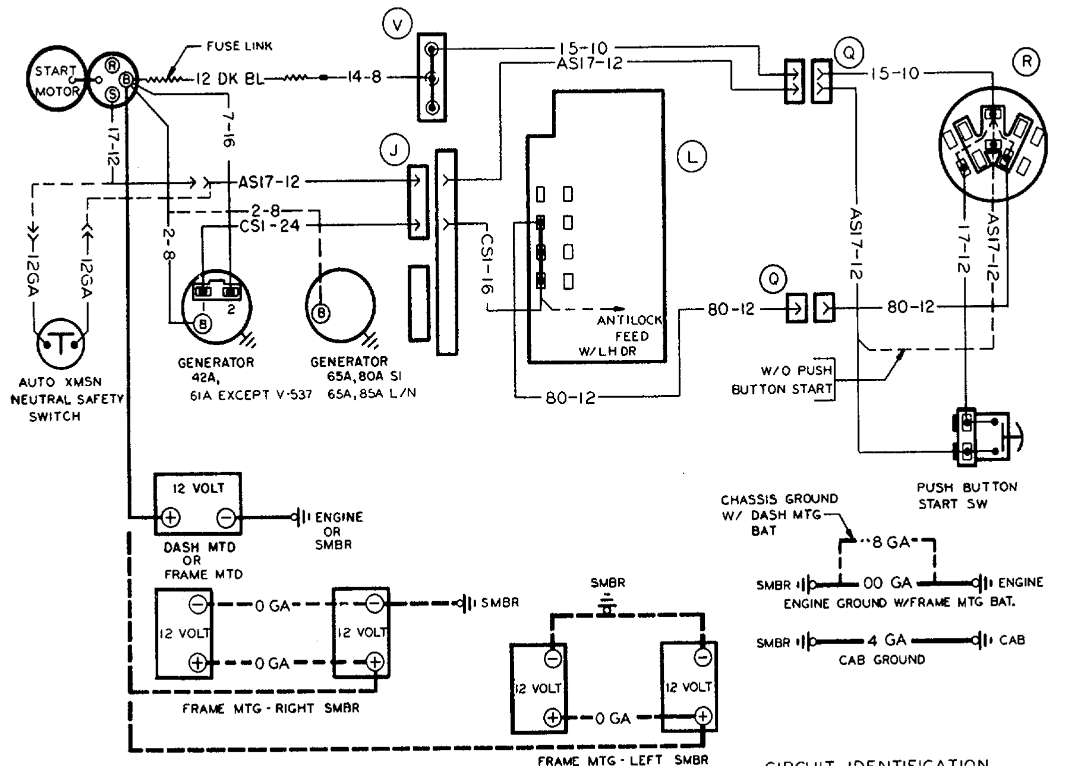
CIR 11 GROUND
CIR 15 KEY SWITCH
CIR 75 HEATER
CIR 77 AIR CONDITIONER
CIR 80 ACCESSORY FEED
CIR 23 ENGINE FAN
CIR 14 MAIN FEED

HEATER & AIR CONDITIONER WIRING LH DR

MT-21957



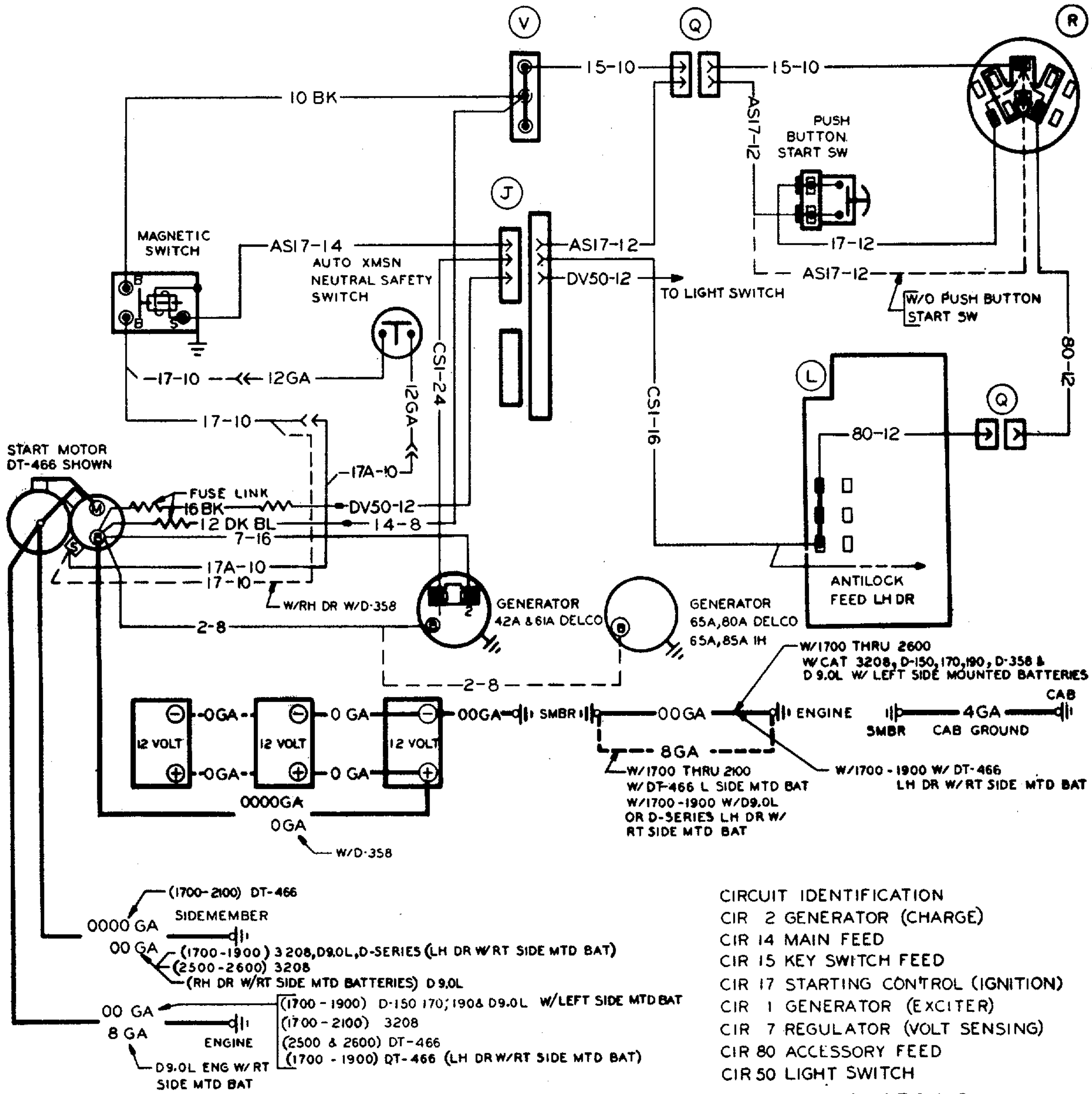
V-392, MV8 & V-345 STARTING, CHARGING & MAJOR FEED & GROUND WIRING FBC/BUS *MT-21961*



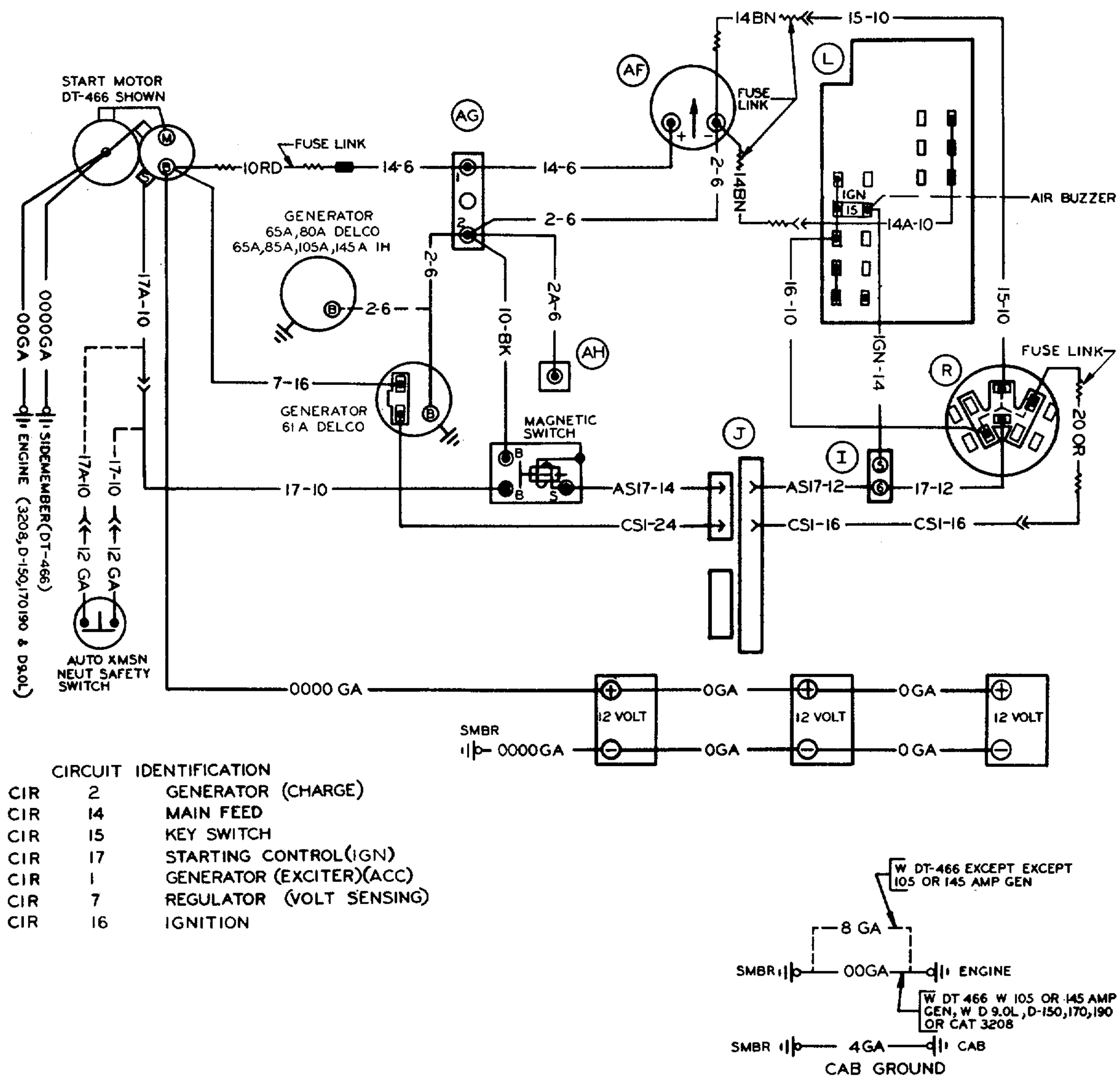
BATTERY LOCATION	BATTERY COMBINATION	POSITIVE CABLE GAUGE	NEGATIVE CABLE GAUGE	ENGINE	MODEL
DASH PANEL	1/ 12 VOLT	2	2	V-345, MV8 & V-392	1600 THRU 1900
LEFT SMBR	2/ 12 VOLT	1	00		
LEFT SMBR	1/ 12 VOLT	1	00		
LEFT SMBR	2/ 12 VOLT	1	00	V-537	2100
LEFT SMBR	1/ 12 VOLT	1	00		
RIGHT SMBR	1/ 12 VOLT	0	00	V-537	2500&2600-CONSTR
RIGHT SMBR	2/ 12 VOLT	0	00		

CIRCUIT IDENTIFICATION
CIR 1 GENERATOR (EXCITER)
CIR 2 GENERATOR (CHARGE)
CIR 7 REGULATOR (VOLT SENSING)
CIR 14 MAIN FEED
CIR 15 KEY SWITCH FEED
CIR 17 STARTING CONTROL
CIR 80 ACCESSORY FEED

V-392, V-345, MV8 & V-537 STARTING, CHARGING & MAJOR FEED & GROUND WIRING **MT-21960**

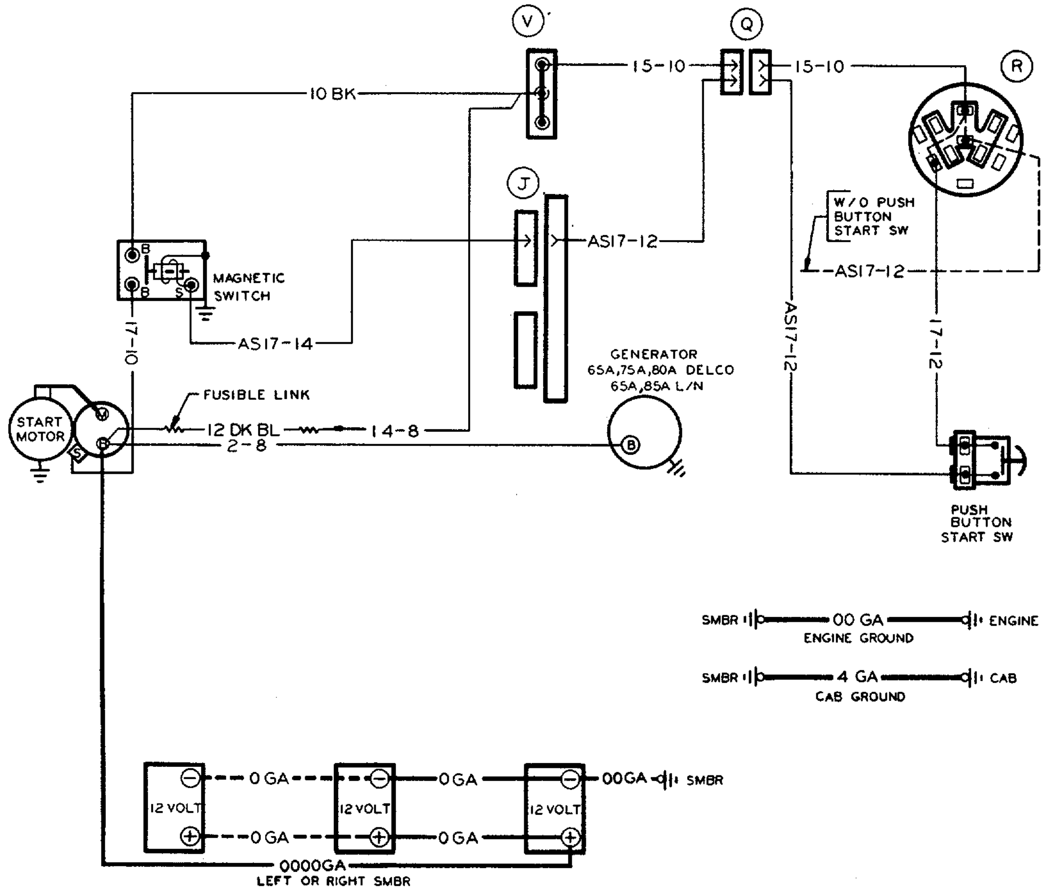


MT-23304 D-358, D9.0L. D-150, 170, 190, DT-466 & 3208 STARTING CHARGING MAJOR FEED & GROUND WIRING 1600-2100, 2500-2600 CONSTRUCTOR



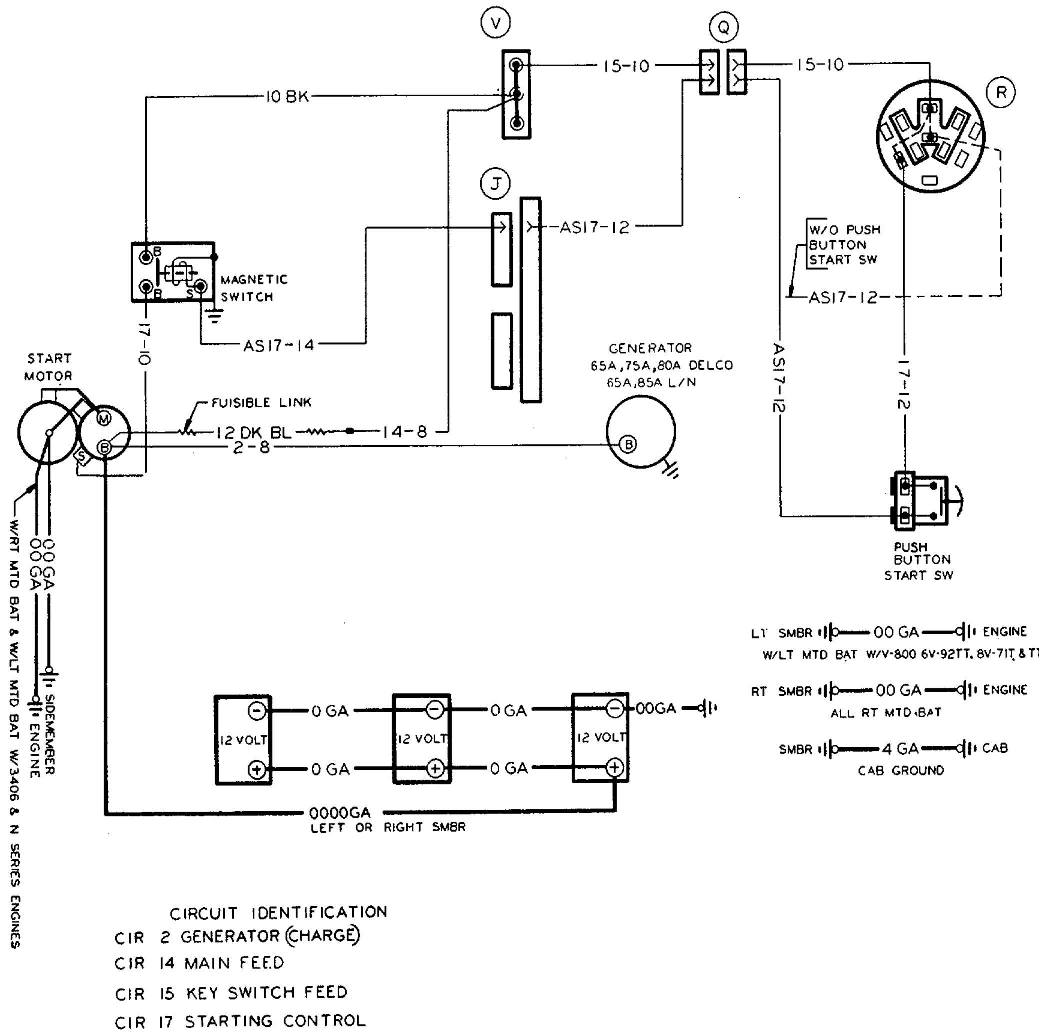
D 9.0L, D-150, 170, 190, DT-466 OR 3208 STARTING, CHARGING, MAJOR FEED & GROUND WIRING FBC/BUS

MT-23305

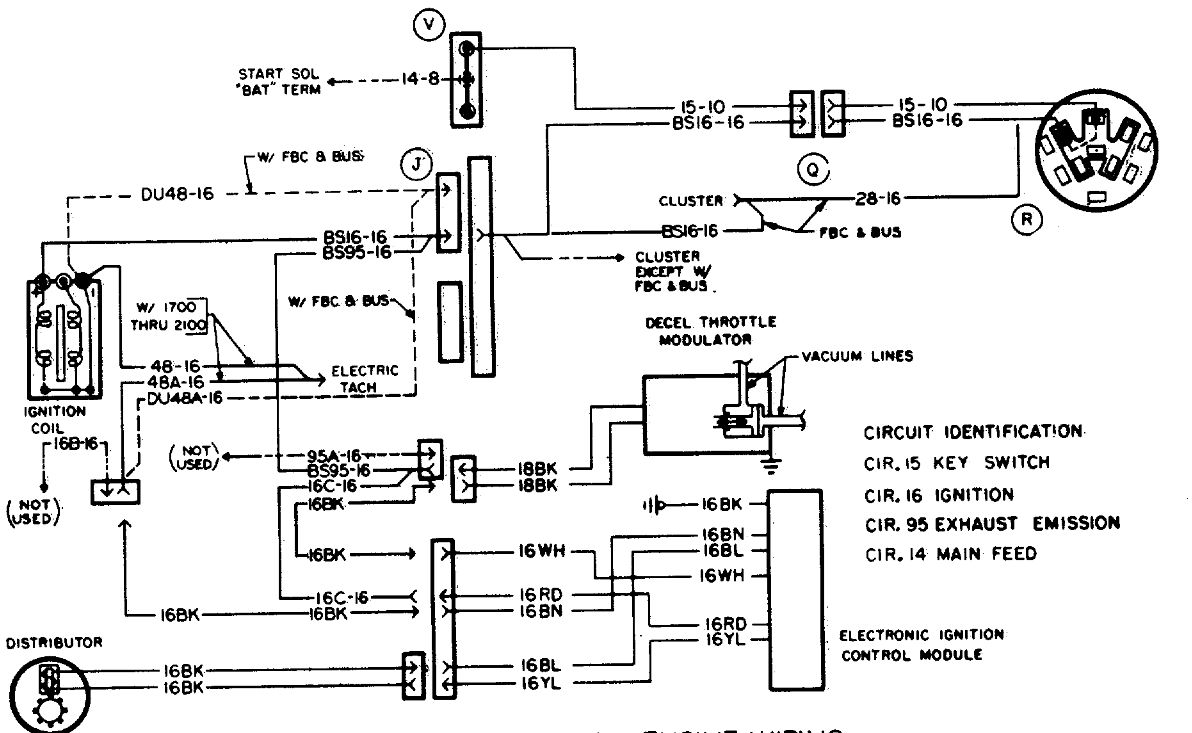


CIRCUIT IDENTIFICATION
CIR 2 GENERATOR (CHARGE)
CIR 14 MAIN FEED
CIR 15 KEY SWITCH FEED
CIR 17 STARTING CONTROL

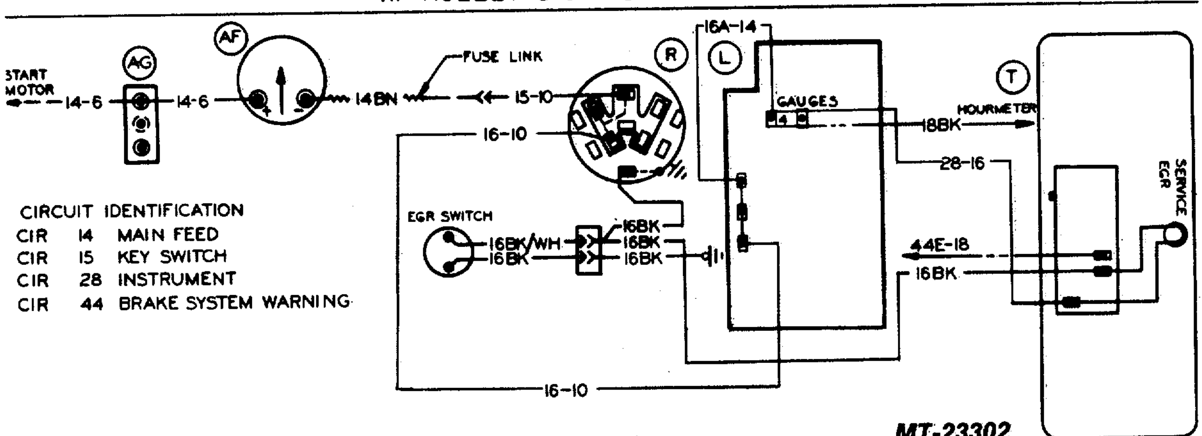
6-71 STARTING, CHARGING, & MAJOR FEED & GROUND WIRING **MT-21962**



6V-92TT,8V-71T&TT,800,3406 &N-SERIES STARTING,CHARGING & MAJOR FEED & GROUND WIRING **MT-21971**

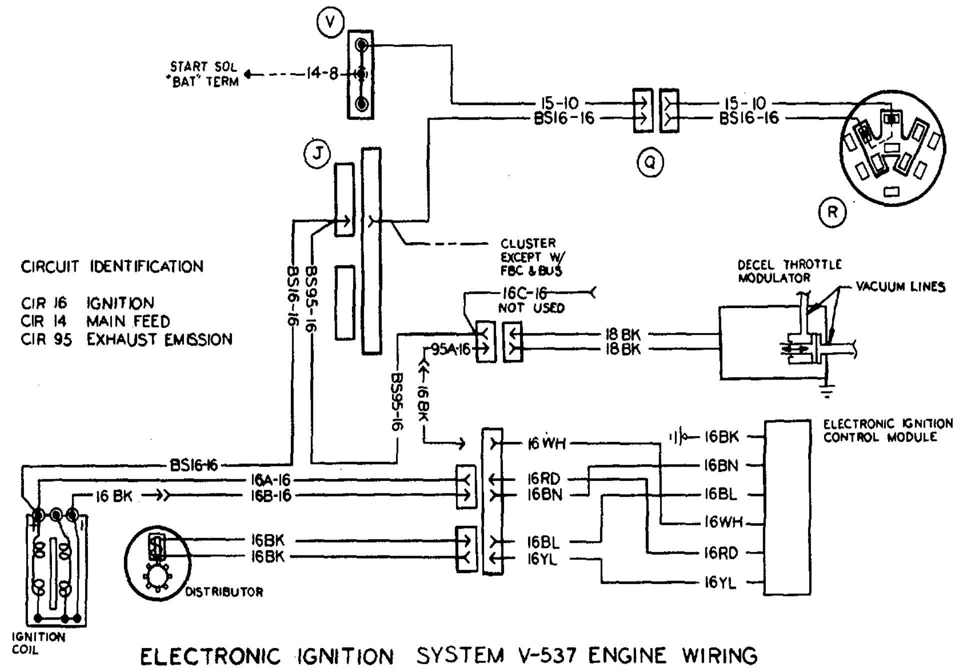


ELECTRONIC IGNITION SYSTEM MV8 ENGINE WIRING
W/ HOLLEY DISTRIBUTOR

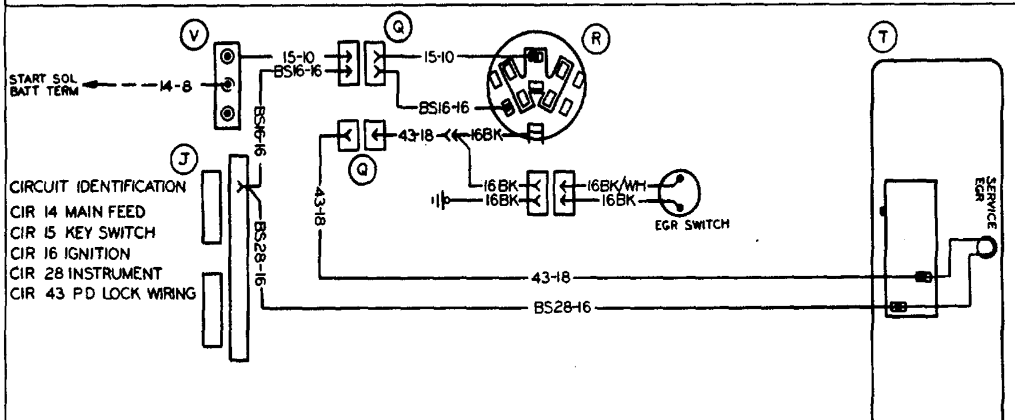


MT-23302

EGR SERVICE WARNING LIGHT WIRING W/FBC & BUS

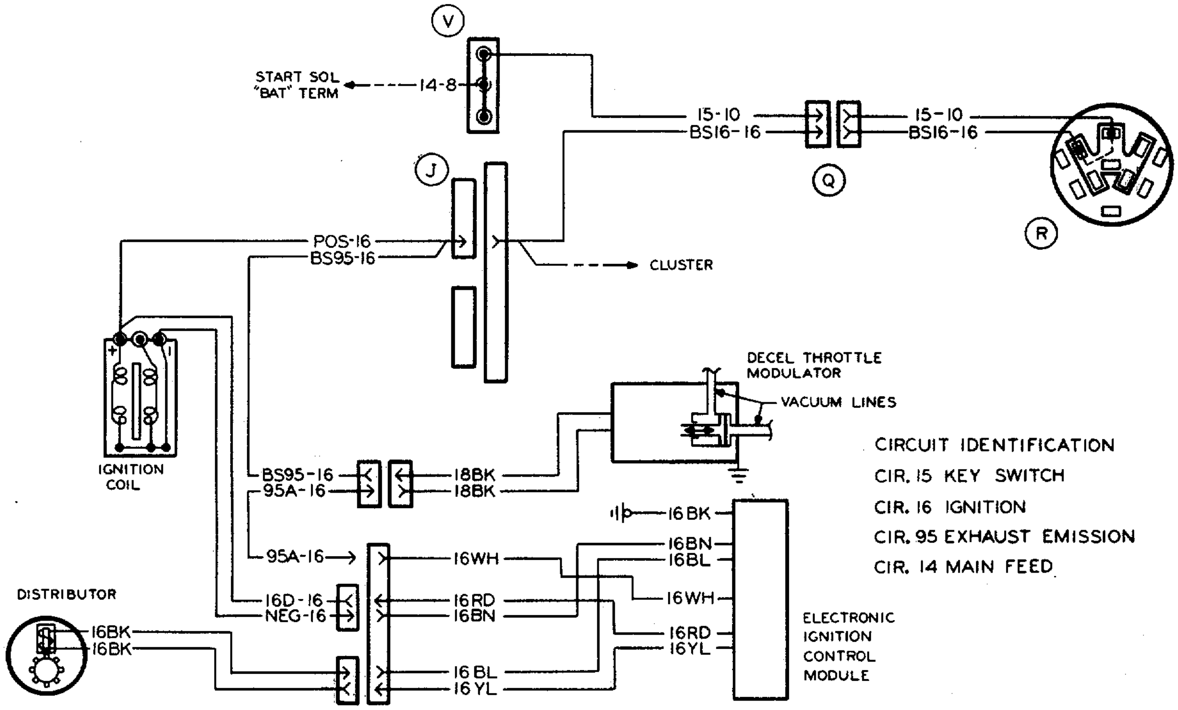


ELECTRONIC IGNITION SYSTEM V-537 ENGINE WIRING W/ HOLLY DISTRIBUTOR

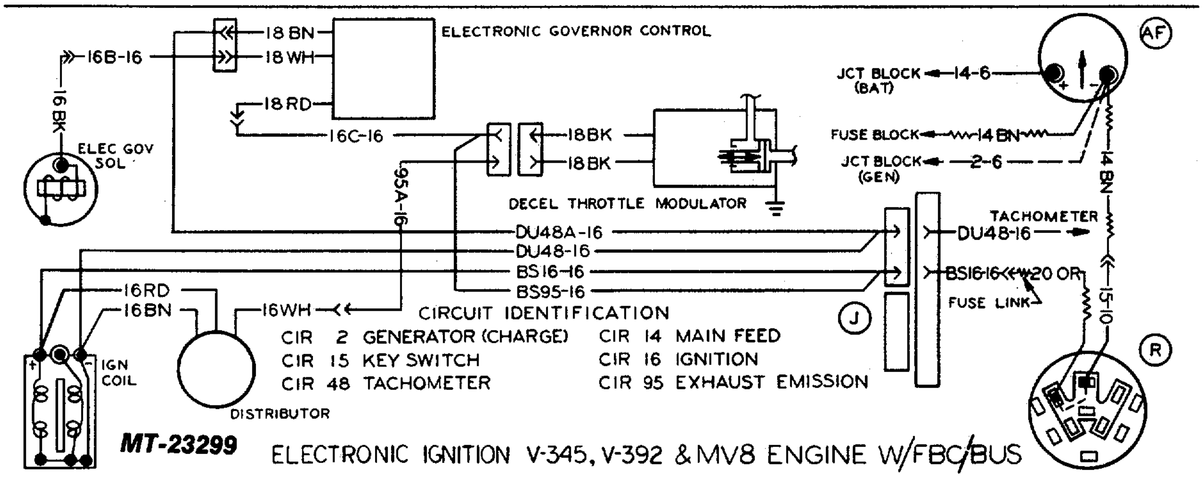


EGR SERVICE WARNING LIGHT WIRING W/1600 & 1700

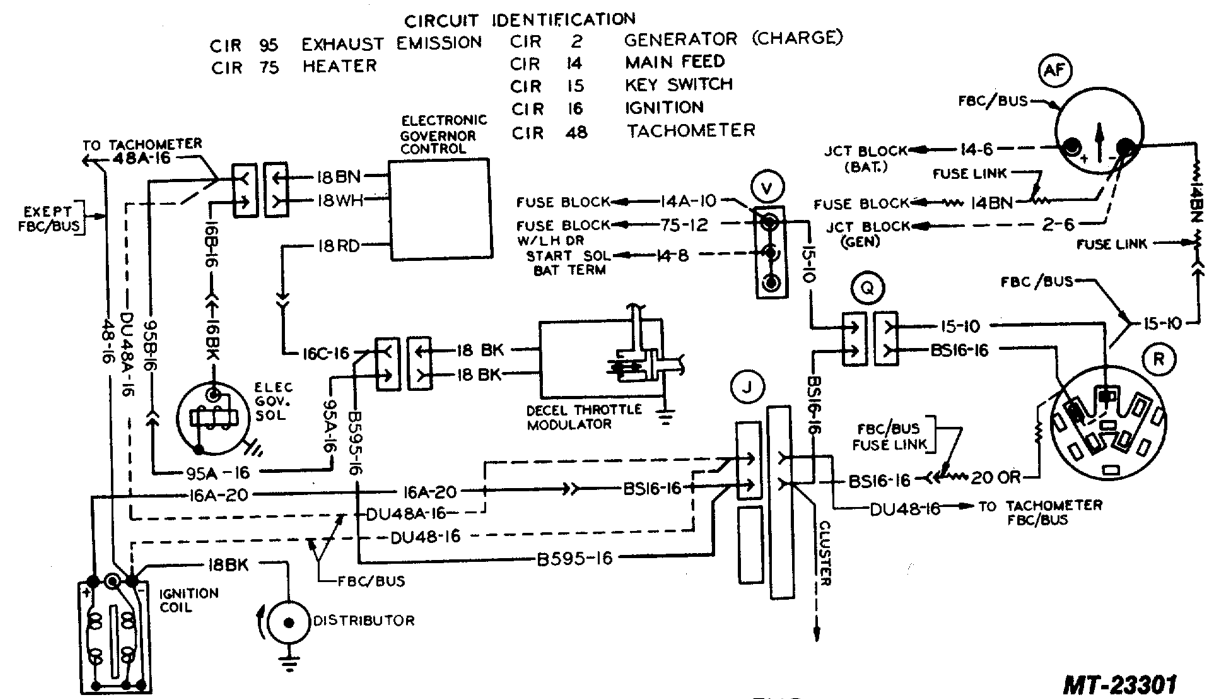
MT-21969



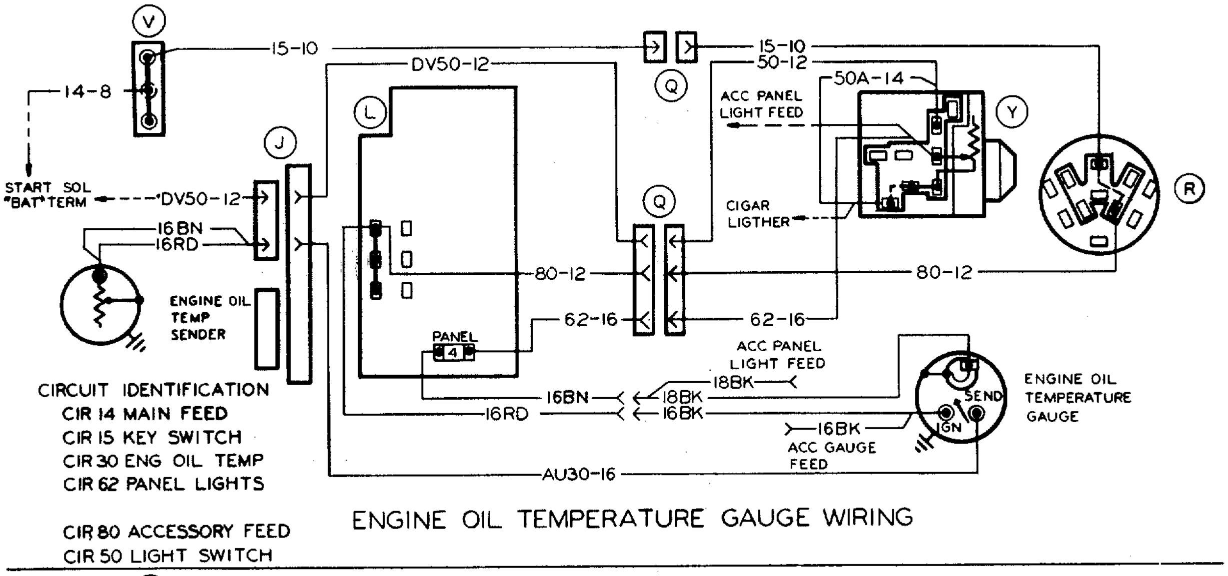
ELECTRONIC IGNITION SYSTEM V-537 ENGINE WIRING 2500 & 2600
W/2 WIRE DISTRIBUTOR & EXTERNAL IGNITION CONTROL MODULE



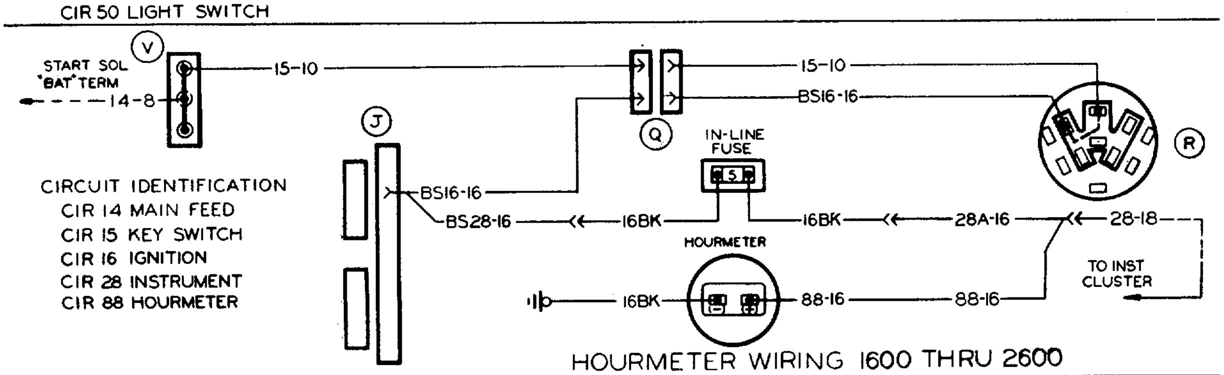
MT-23299 ELECTRONIC IGNITION V-345, V-392 & MV8 ENGINE W/FBC/BUS



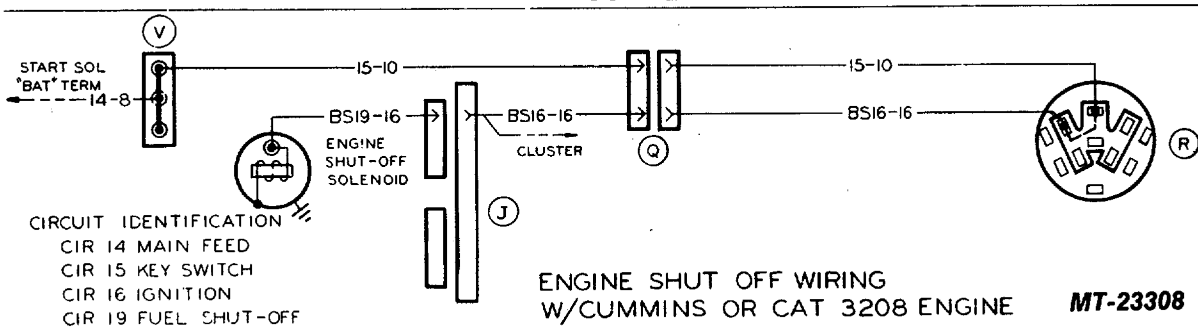
BREAKER POINT IGNITION V-345 ENG



ENGINE OIL TEMPERATURE GAUGE WIRING

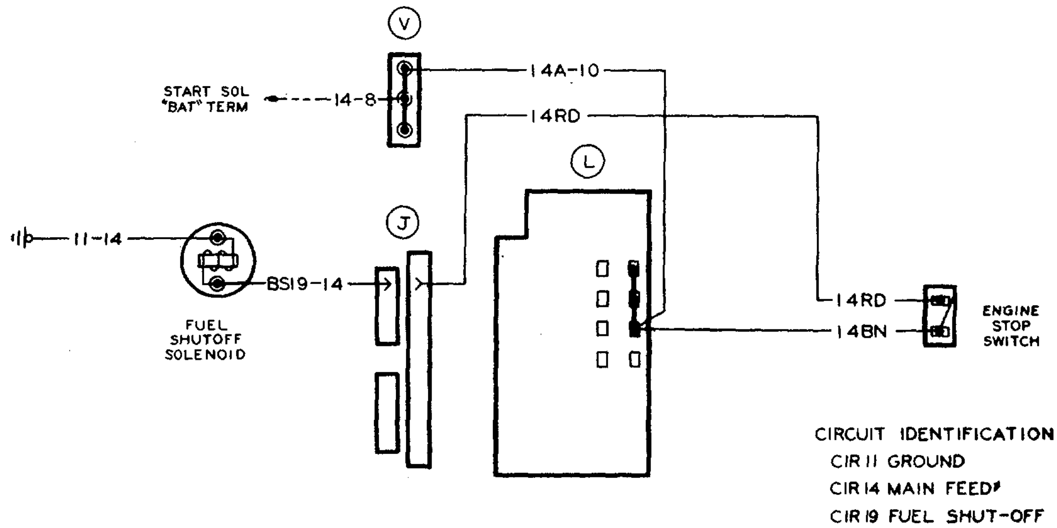


HOURMETER WIRING 1600 THRU 2600

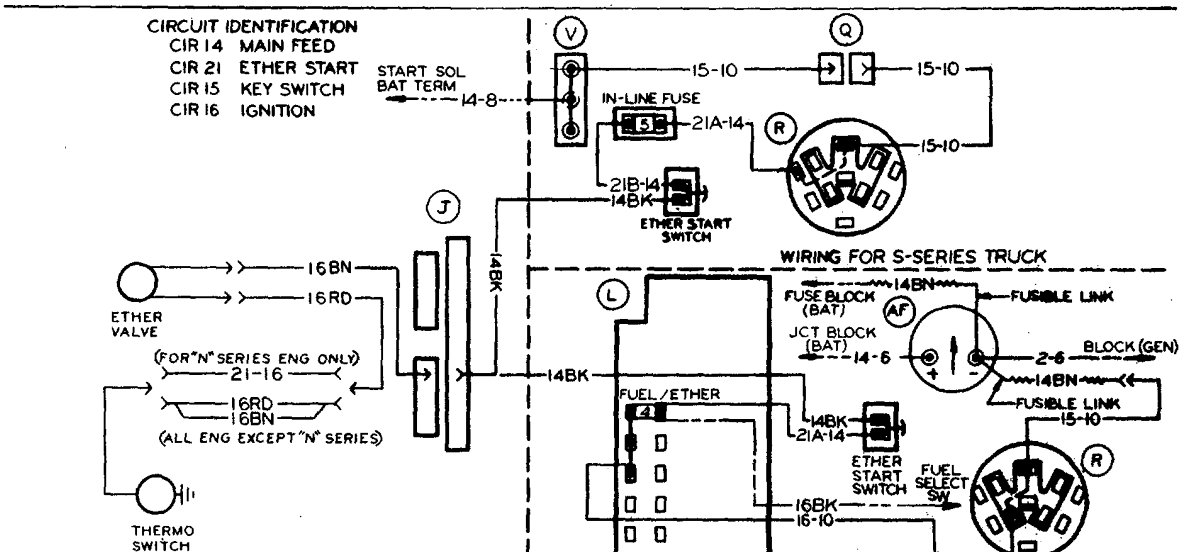


ENGINE SHUT OFF WIRING
W/CUMMINS OR CAT 3208 ENGINE

MT-23308

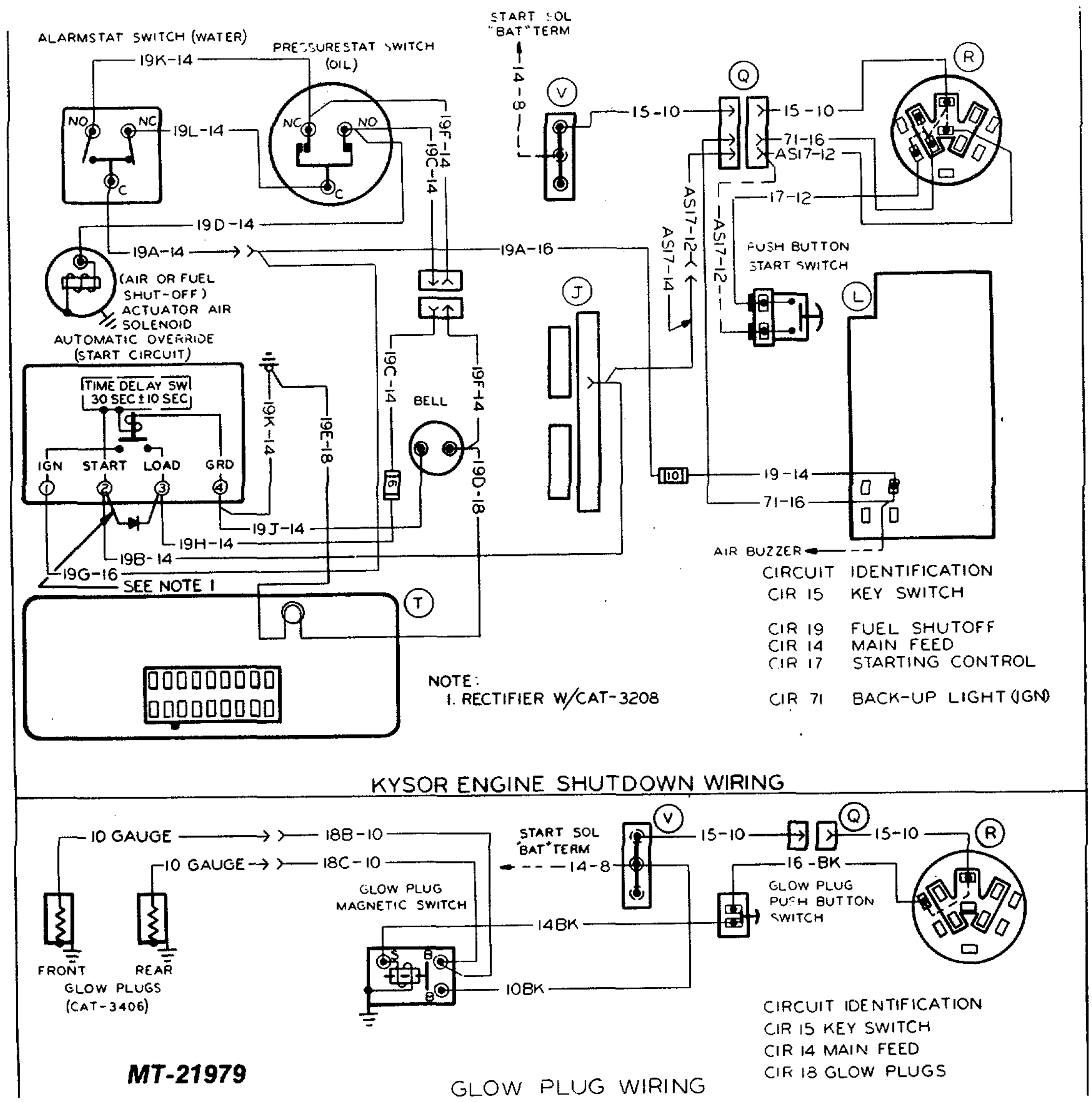


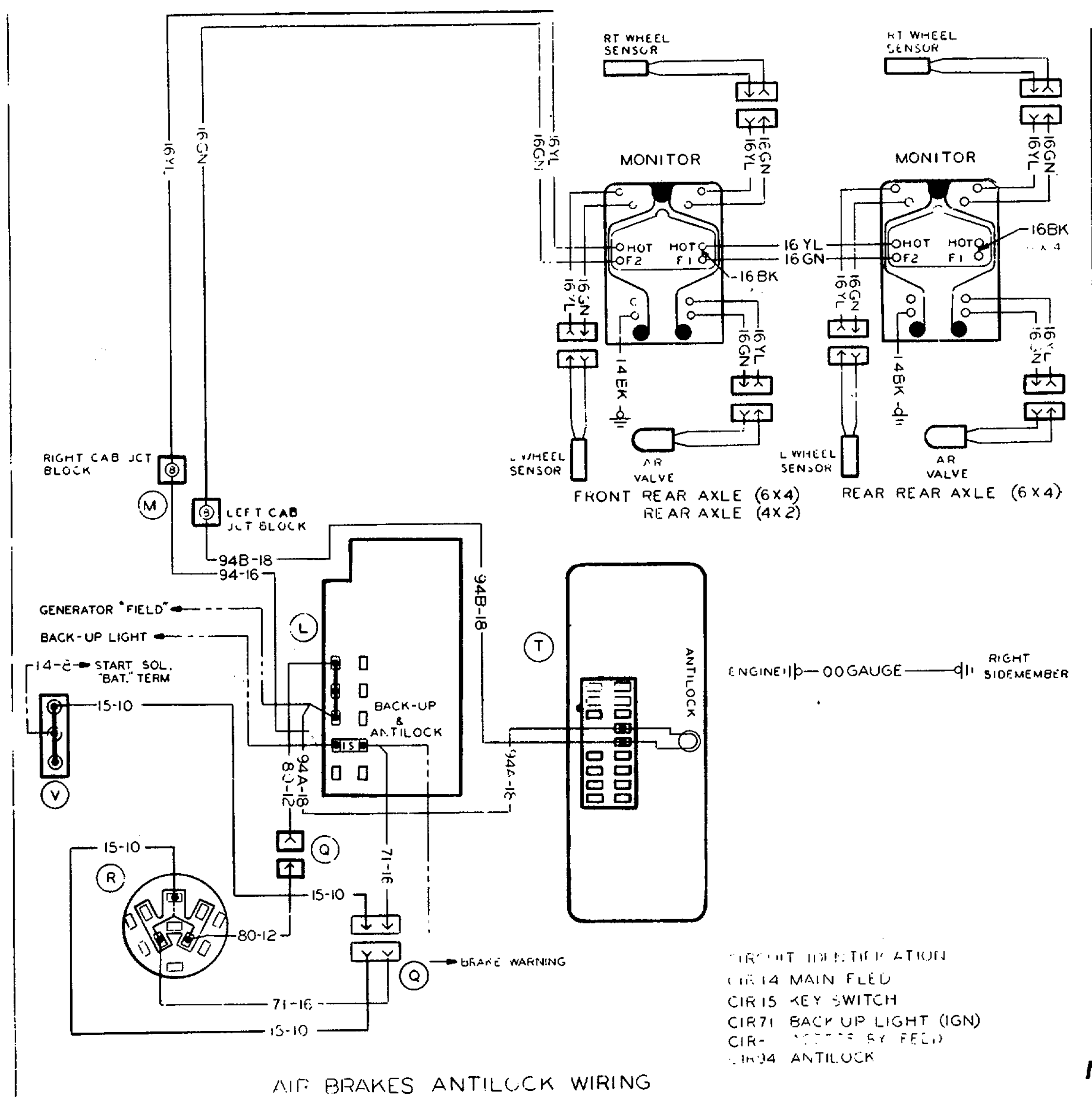
ENGINE STOP WIRING W/CAT-3406 ENGINE



MT-23309

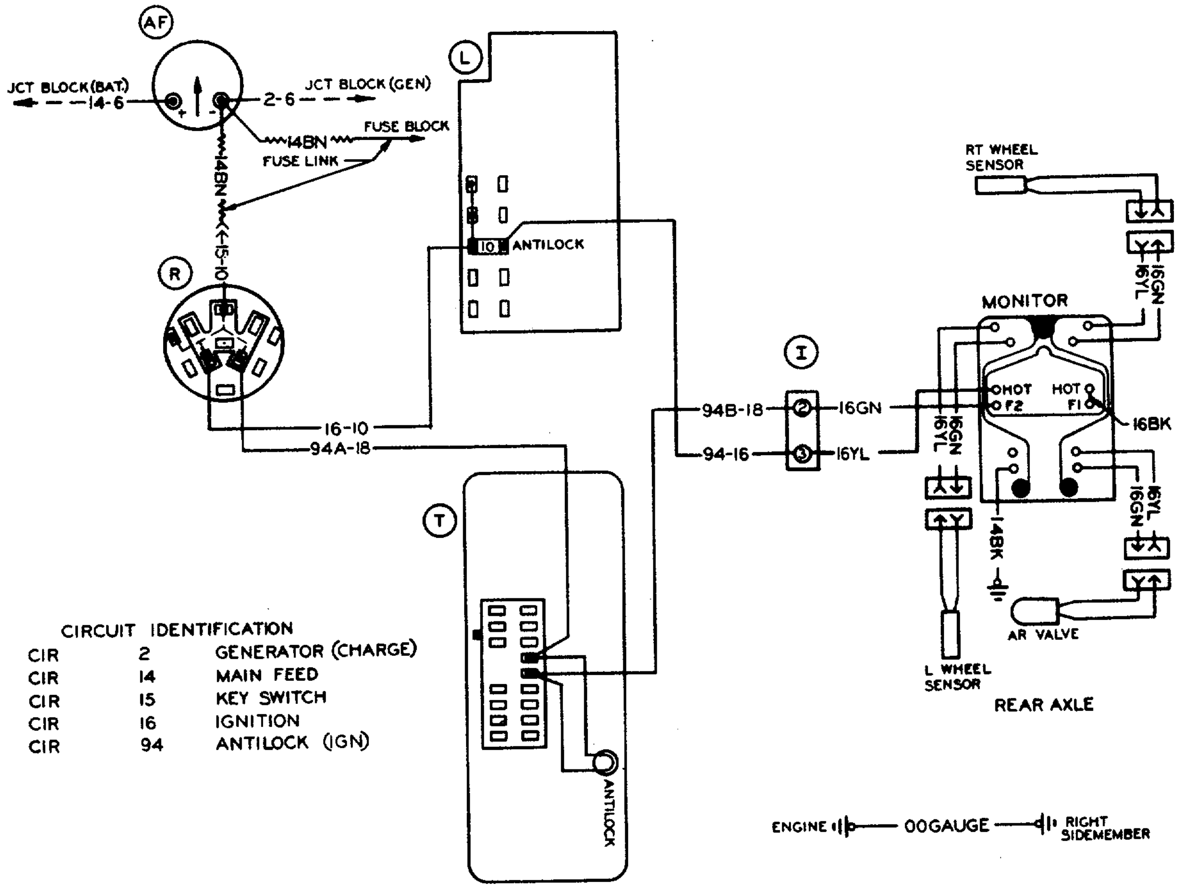
ETHER START WIRING


START SOL "BAT" TERM
ALARMSTAT SWITCH (WATER)
PRESSURESTAT SWITCH (OIL)
19K-14
19L-14
19F-14
19C-14
14-8
15-10
71-16
AS17-12
17-12
19D-14
19A-14
19A-16
(AIR OR FUEL SHUT-OFF) ACTUATOR AIR SOLENOID
AUTOMATIC OVERRIDE (START CIRCUIT)
PUSH BUTTON START SWITCH
TIME DELAY SW 30 SEC ± 10 SEC
IGN START LOAD GRD
19E-18
BELL
19D-18
19J-14
19H-14
19B-14
19G-16
SEE NOTE 1
19-14
AIR BUZZER
NOTE:
1. RECTIFIER W/CAT-3208
CIRCUIT IDENTIFICATION
CIR 15 KEY SWITCH
CIR 19 FUEL SHUTOFF
CIR 14 MAIN FEED
CIR 17 STARTING CONTROL
CIR 71 BACK-UP LIGHT (IGN)
KYSOR ENGINE SHUTDOWN WIRING
10 GAUGE
18B-10
18C-10
GLOW PLUG MAGNETIC SWITCH
16-BK
GLOW PLUG PUSH BUTTON SWITCH
14BK
10BK
FRONT REAR
GLOW PLUGS (CAT-3406)
CIRCUIT IDENTIFICATION
CIR 15 KEY SWITCH
CIR 14 MAIN FEED
CIR 18 GLOW PLUGS
MT-21979
GLOW PLUG WIRING



AIR BRAKES ANTILOCK WIRING

MT-21977

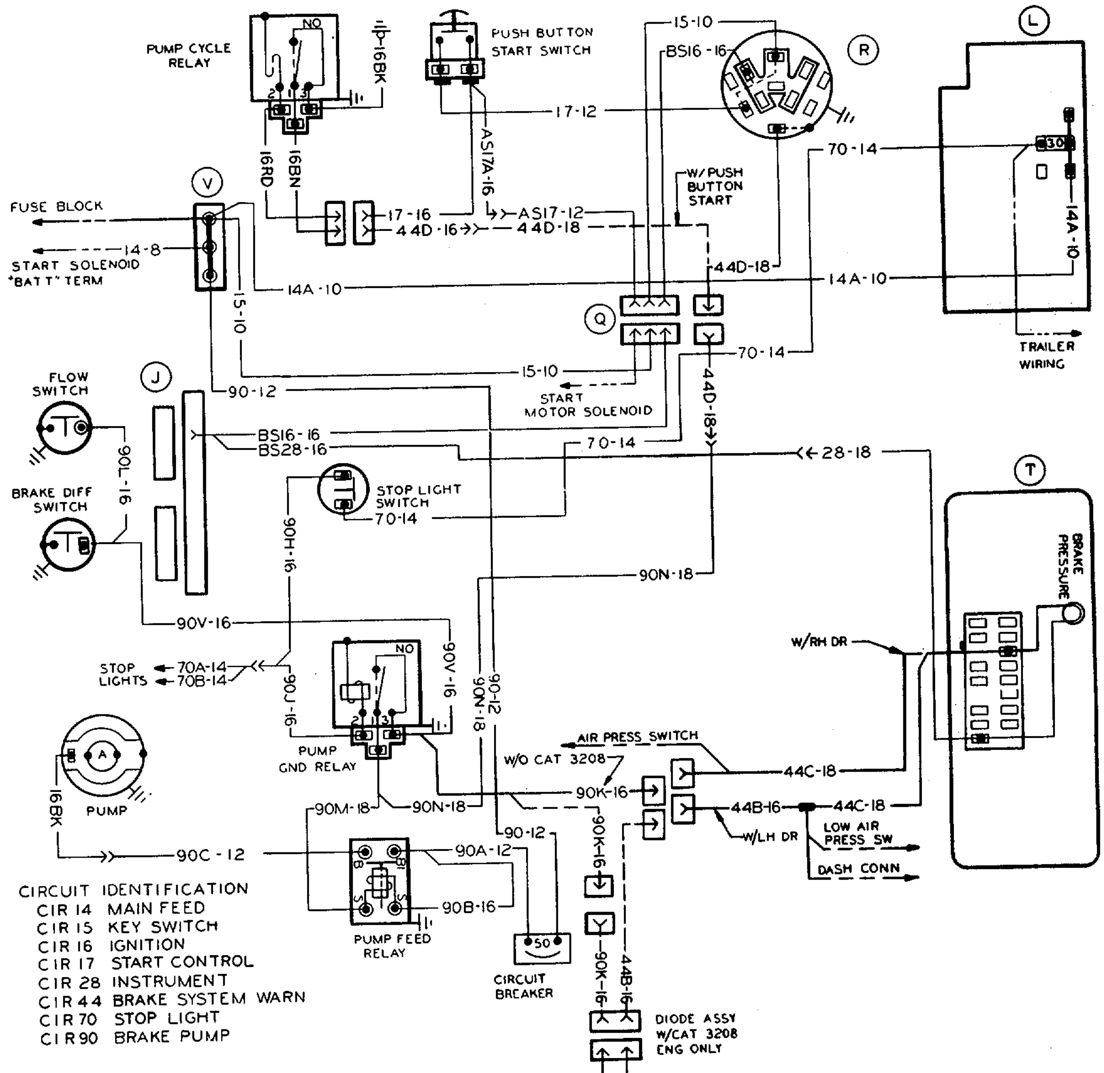


CIRCUIT IDENTIFICATION

CIR	2	GENERATOR (CHARGE)
CIR	14	MAIN FEED
CIR	15	KEY SWITCH
CIR	16	IGNITION
CIR	94	ANTILOCK (IGN)

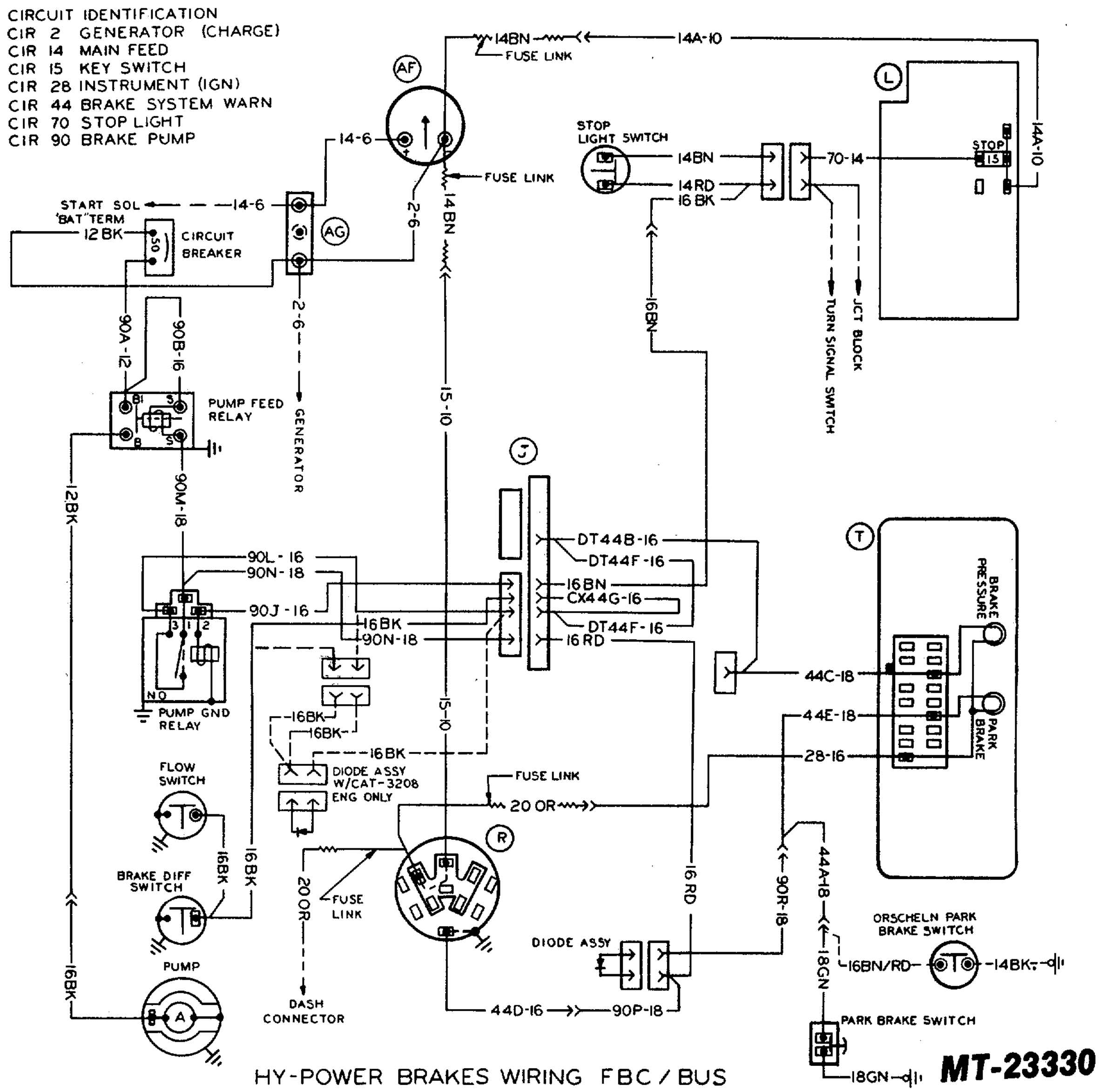
AIR BRAKES ANTILOCK WIRING FBC/BUS

MT-23310

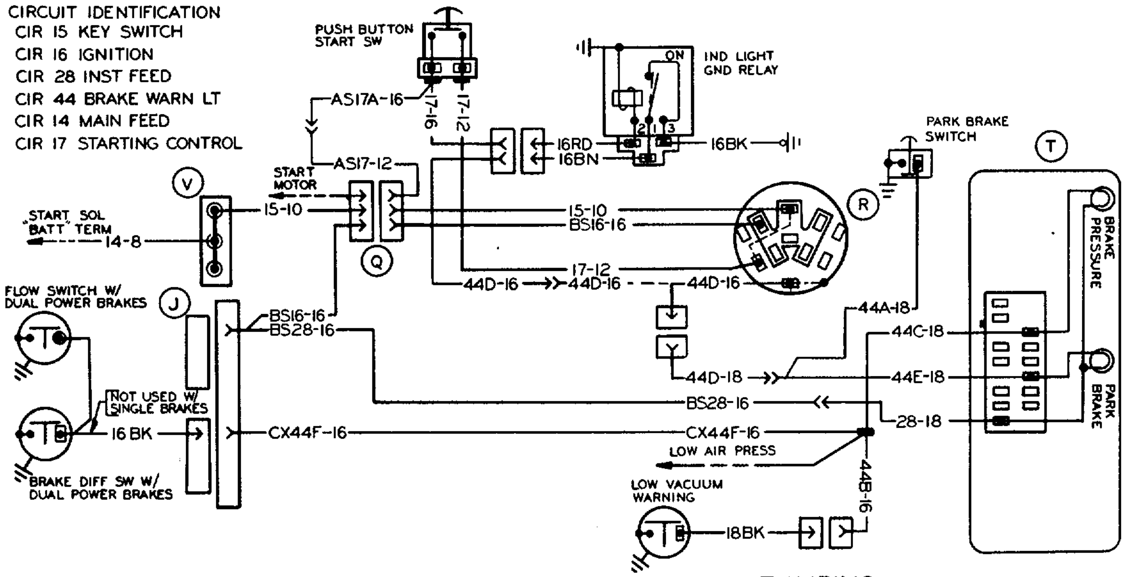


HY-POWER BRAKE WIRING

MT-23329

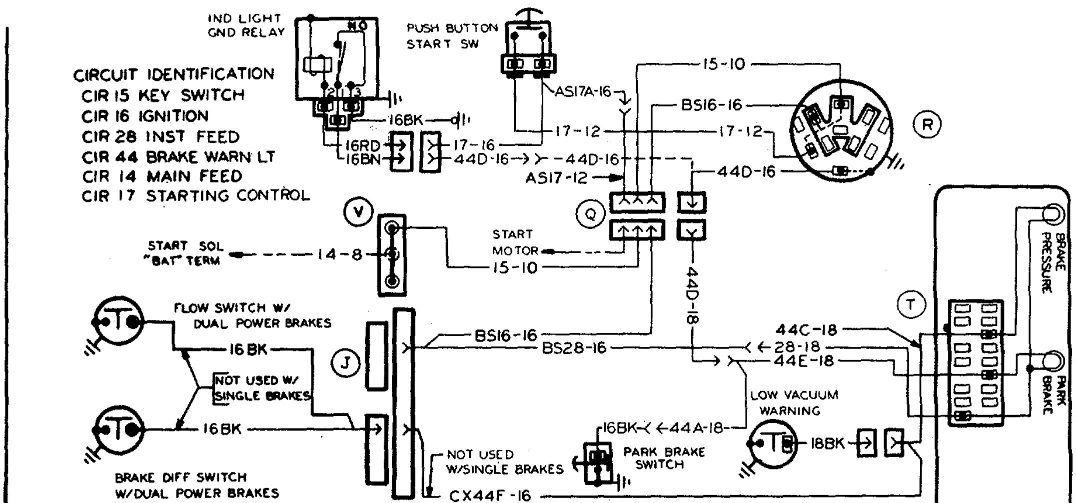


HY-POWER BRAKES WIRING FBC / BUS

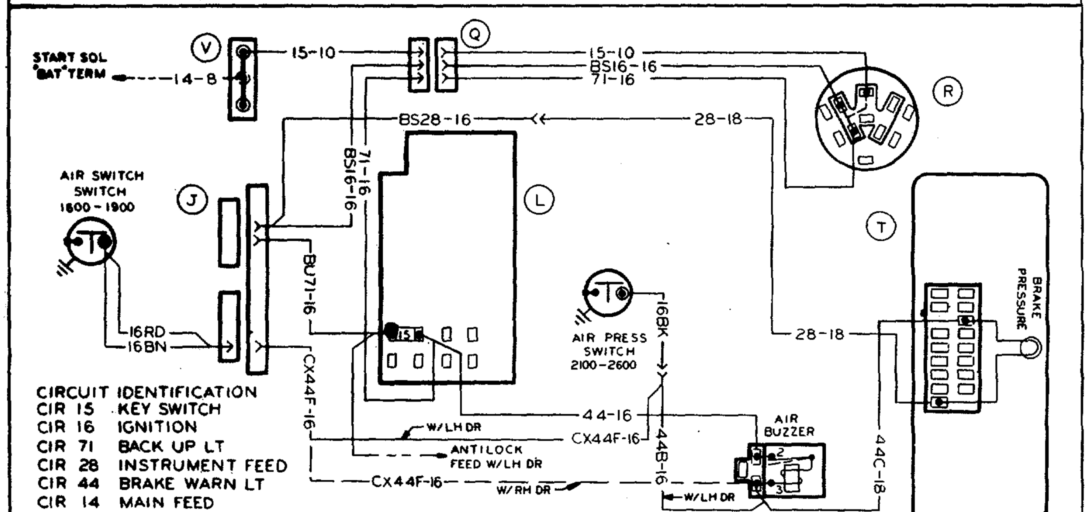


PARKING BRAKE & HYDRAULIC BRAKE PRESS WARNING LIGHT WIRING W SINGLE OR DUAL POWER BRAKES 1600 THRU 1900 LH DR

MT-21984

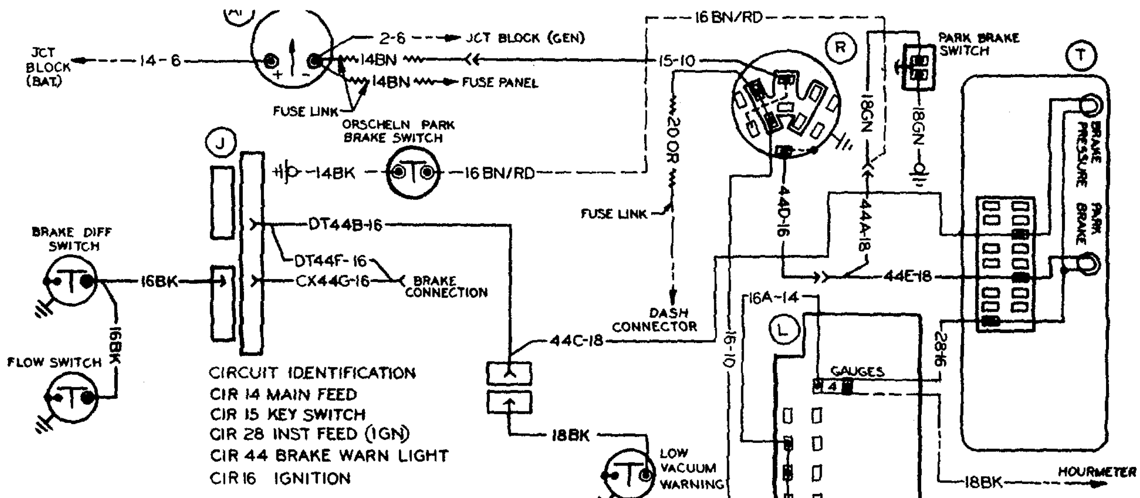


PARKING BRAKE & HYDRAULIC BRAKE PRESS WARNING LIGHT WIRING W/SINGLE OR DUAL POWER BRAKES 1700 THRU 1900 RH DR

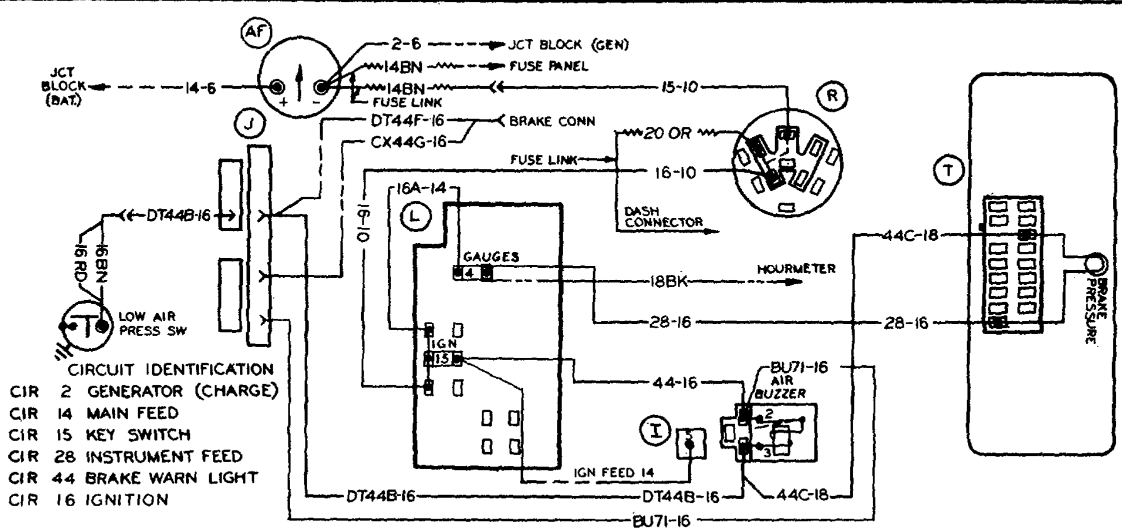


LOW AIR PRESS WARN LIGHT WIRING 1700 THRU 2600

MT-21982

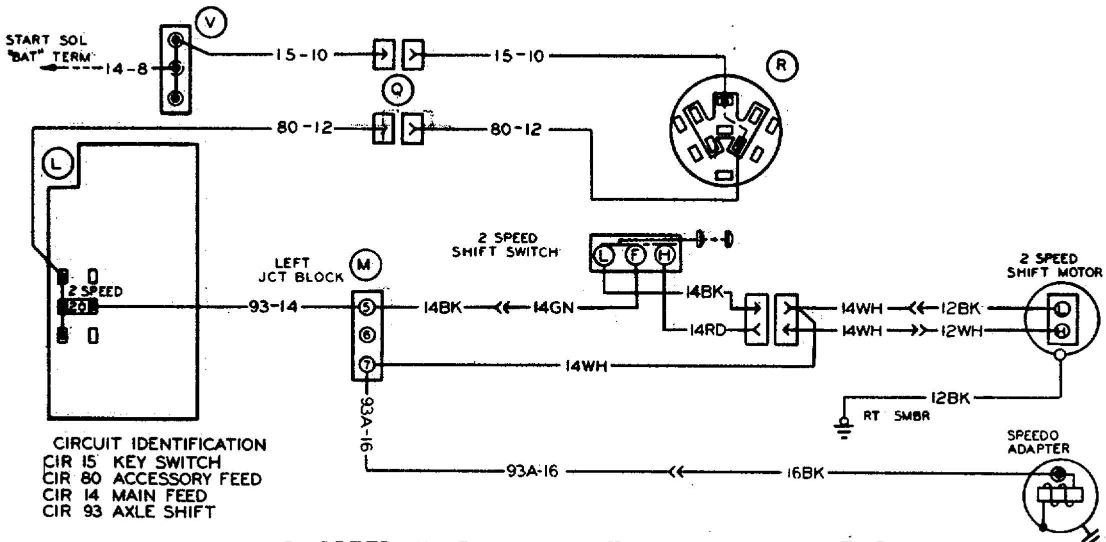


PARKING BRAKE & HYDRAULIC BRAKE PRESS WARNING LIGHT WIRING W/DUAL POWER BRAKES FBC/BUS

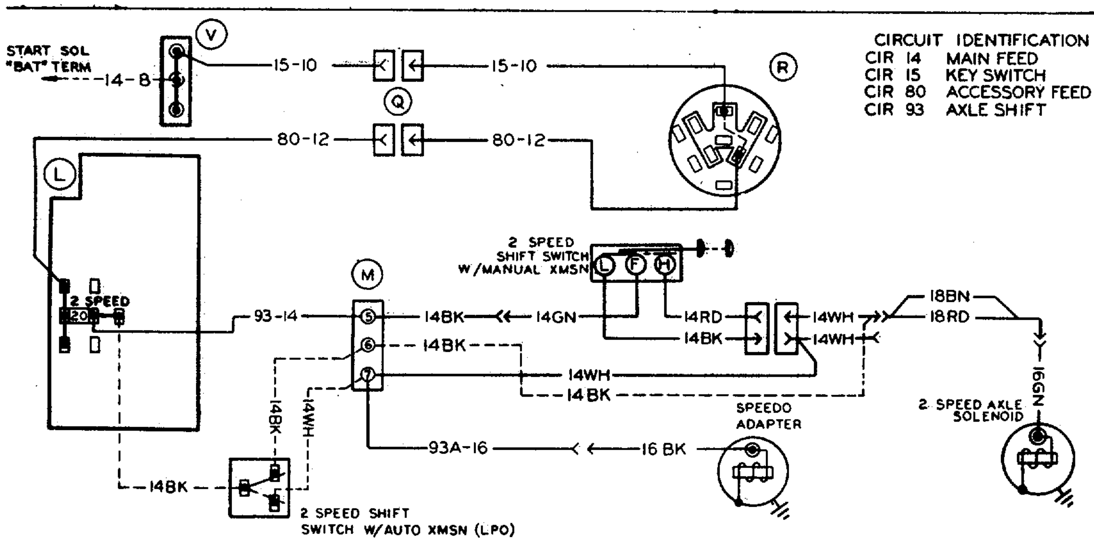


LOW AIR PRESS WARN LIGHT WIRING FBC/BUS

MT-23311

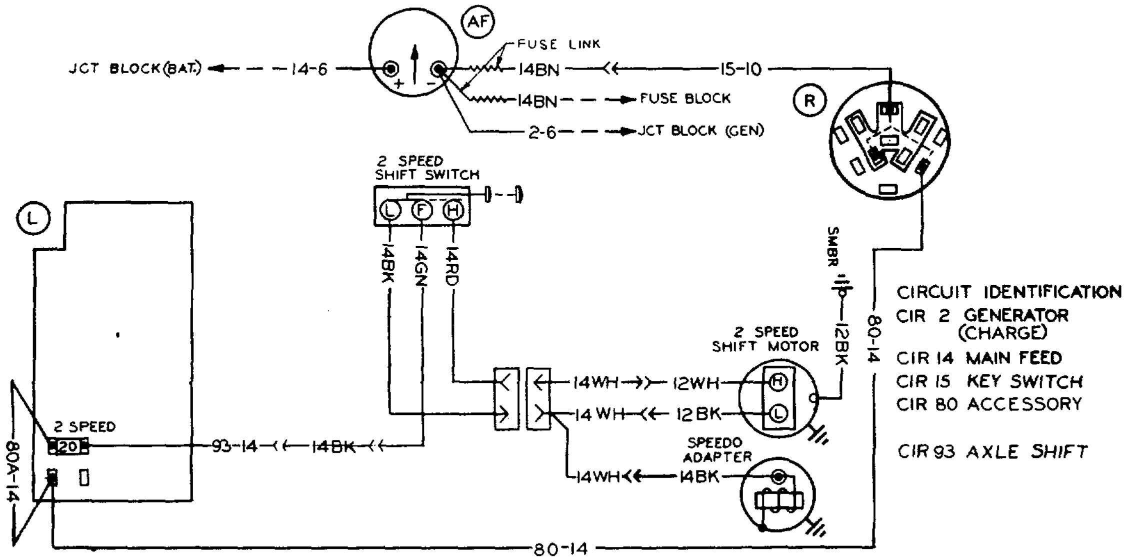


2-SPEED AXLE ALL ELECTRIC SHIFT 1600 THRU 2600

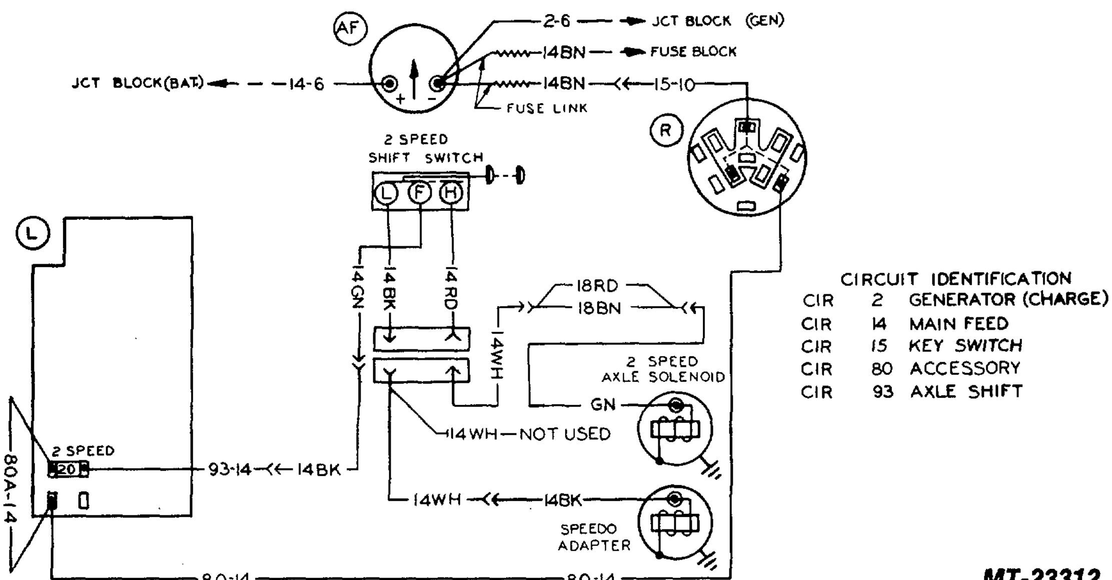


2-SPEED AXLE ELECTRIC OVER AIR 1600 THRU 2600

MT-21985

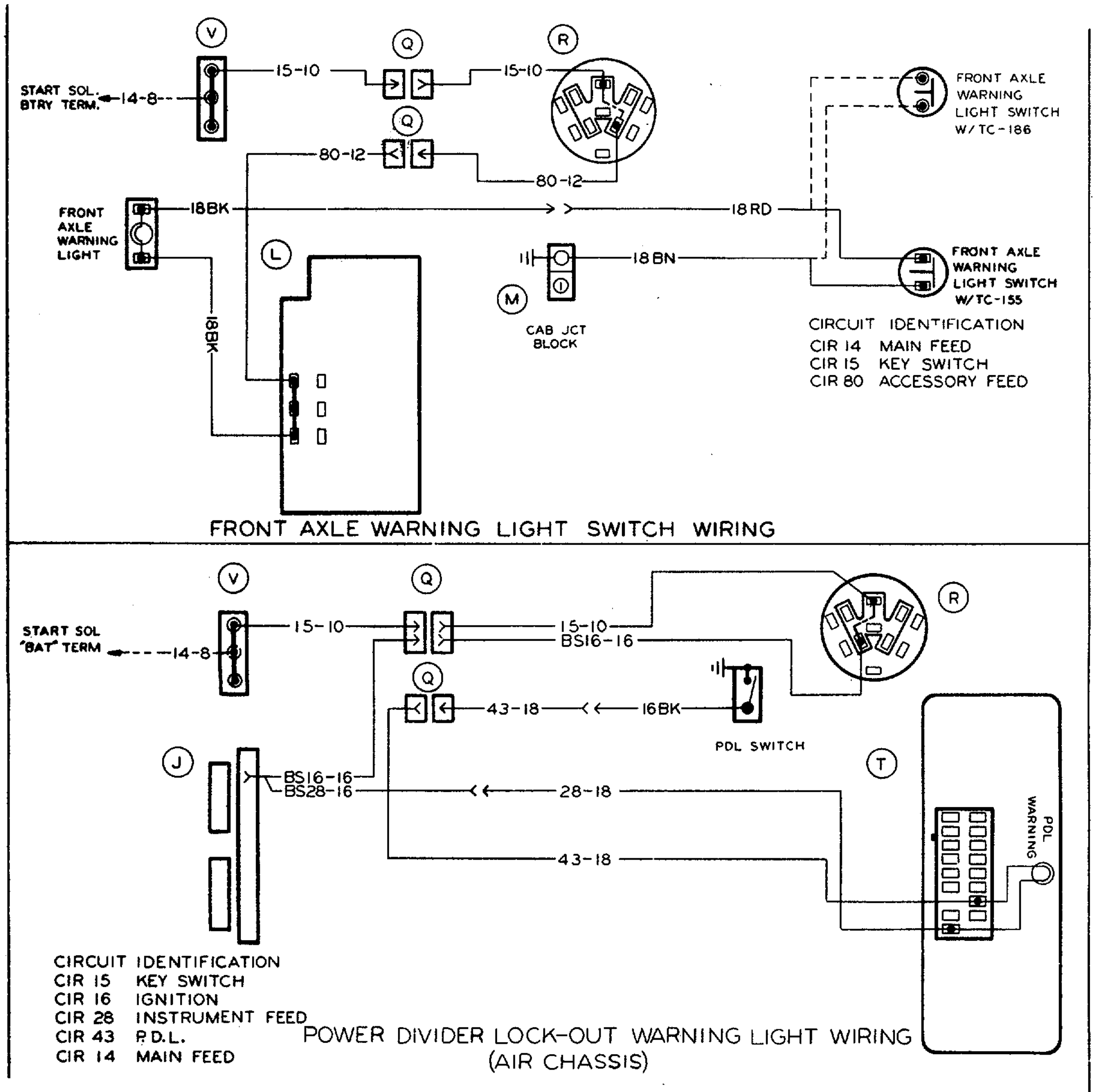


2 SPEED AXLE ALL ELECTRIC SHIFT FBC/BUS

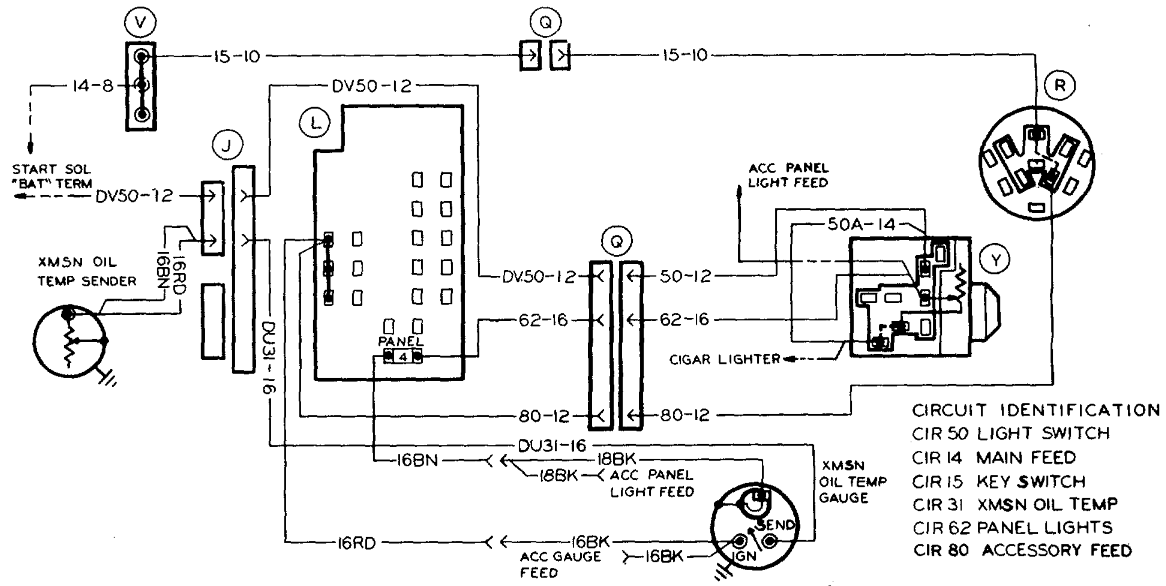


MT-23312

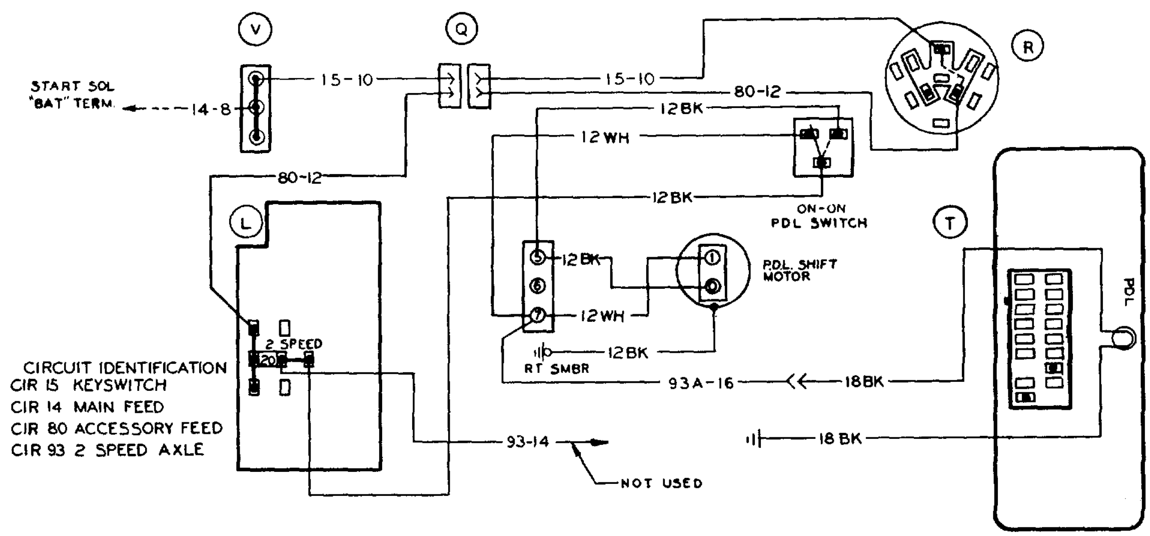
2 SPEED AXLE ELECTRIC OVER AIR FBC/BUS


START SOL. BTRY TERM.
14-8
15-10
80-12
FRONT AXLE WARNING LIGHT
18BK
18RD
18BN
CAB JCT BLOCK
FRONT AXLE WARNING LIGHT SWITCH W/TC-186
FRONT AXLE WARNING LIGHT SWITCH W/TC-155
CIRCUIT IDENTIFICATION
CIR 14 MAIN FEED
CIR 15 KEY SWITCH
CIR 80 ACCESSORY FEED
FRONT AXLE WARNING LIGHT SWITCH WIRING
START SOL "BAT" TERM
BS16-16
BS28-16
43-18
16BK
28-18
PDL SWITCH
PDL WARNING
CIRCUIT IDENTIFICATION
CIR 15 KEY SWITCH
CIR 16 IGNITION
CIR 28 INSTRUMENT FEED
CIR 43 P.D.L.
CIR 14 MAIN FEED
POWER DIVIDER LOCK-OUT WARNING LIGHT WIRING (AIR CHASSIS)

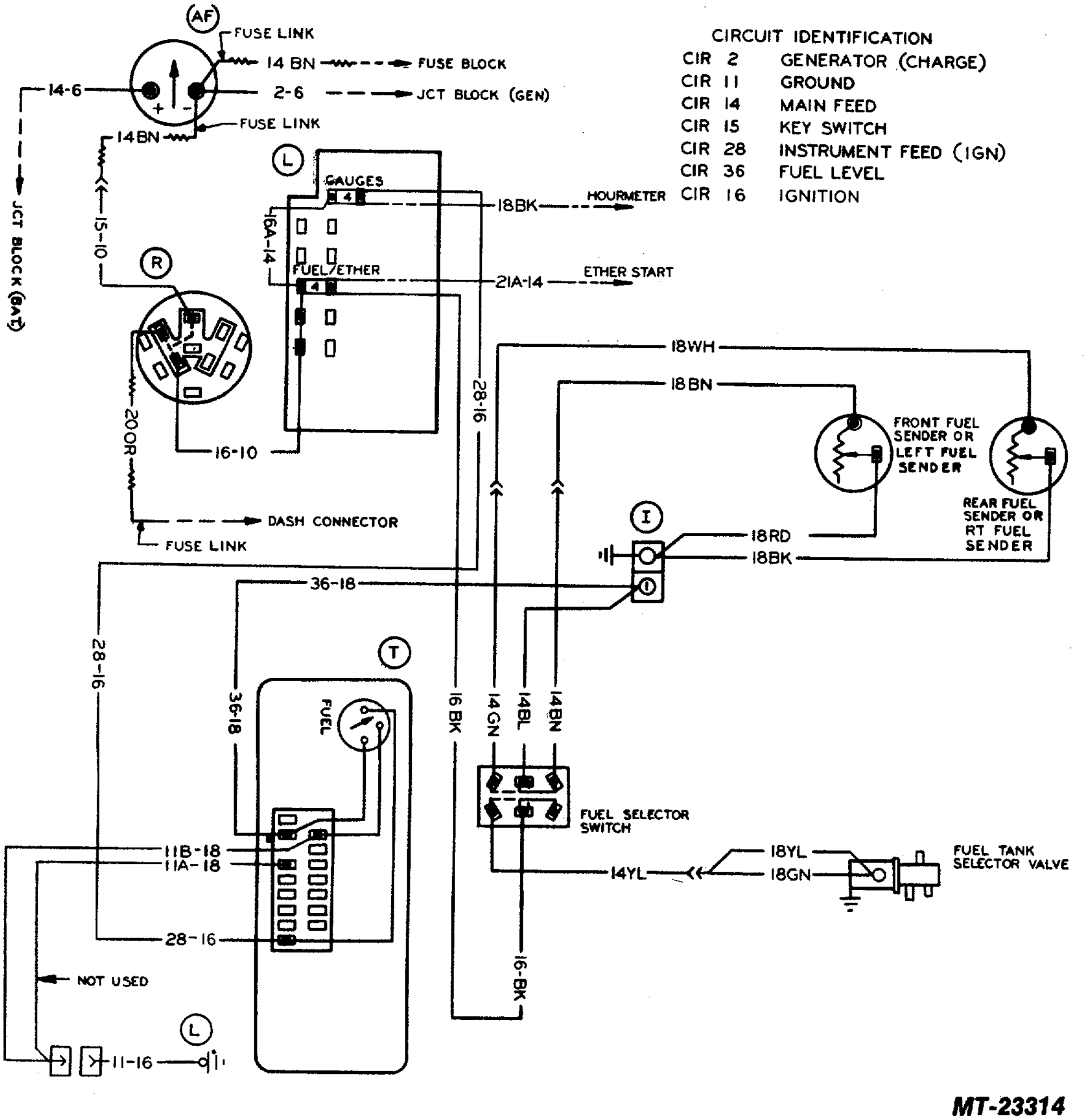
MT-21994



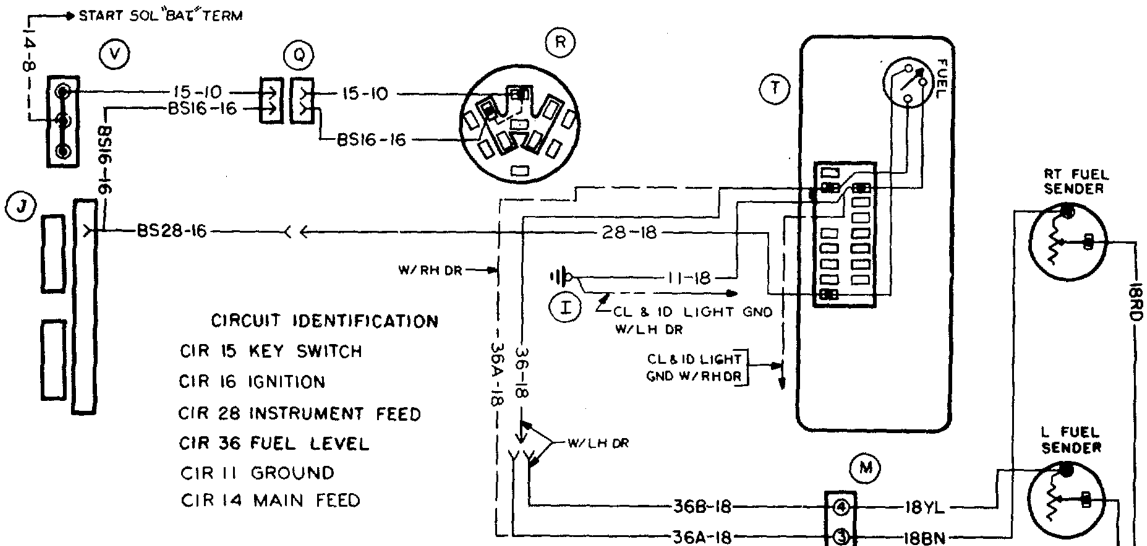
TRANSMISSION OIL TEMPERATURE GAUGE WIRING



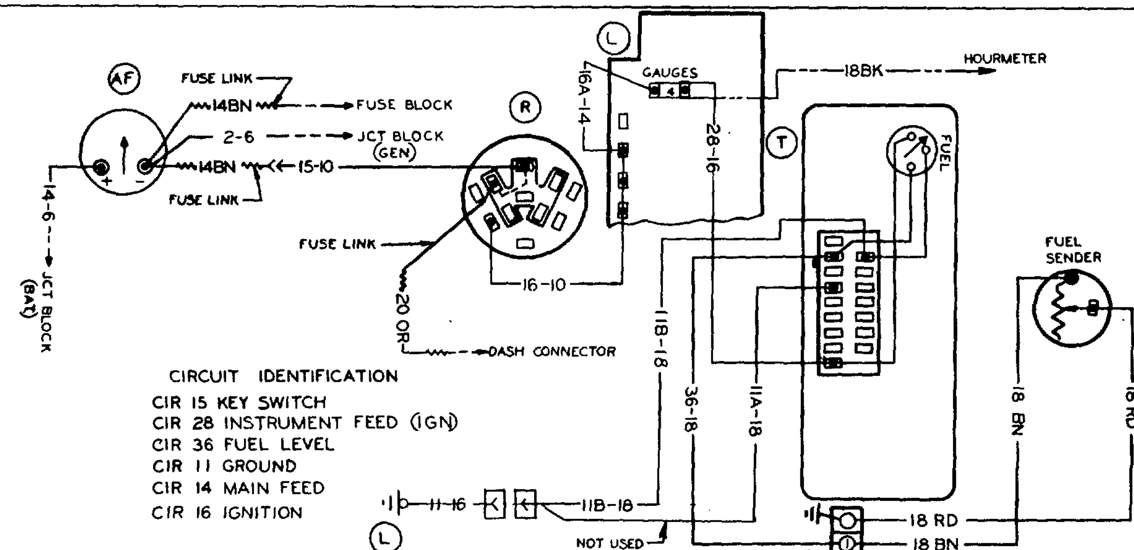
MT-23327 ELECT. POWER DIVIDER LOCK-OUT WIRING (HYD CHASSIS)



DUAL SENDERS WITH DUAL FUEL TANKS FBC & BUS W/GAS ENG. ONLY

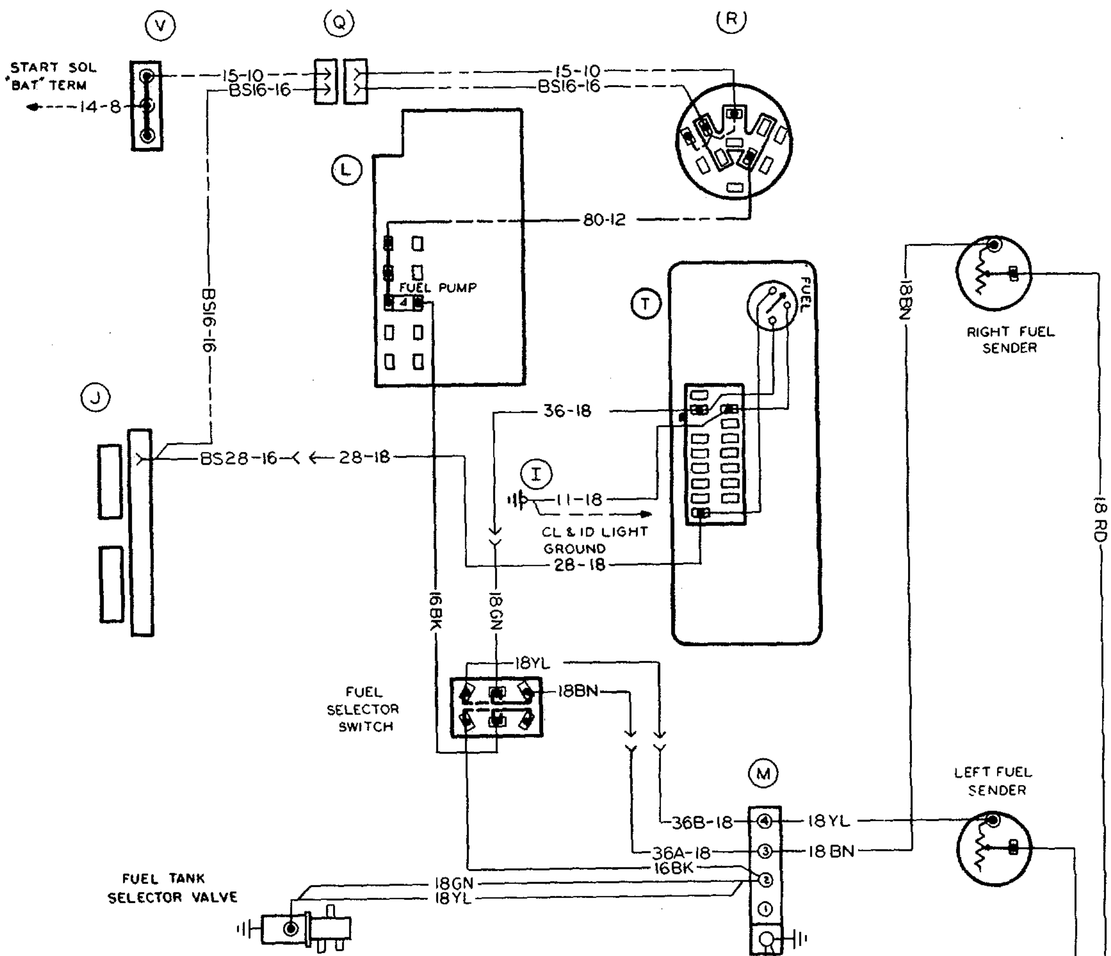


FUEL SENDER WIRING
W/ SINGLE LEFT OR RIGHT SIDE FUEL TANK 1600 THRU 2600



FUEL SENDER WIRING FBC/BUS

MT-23313

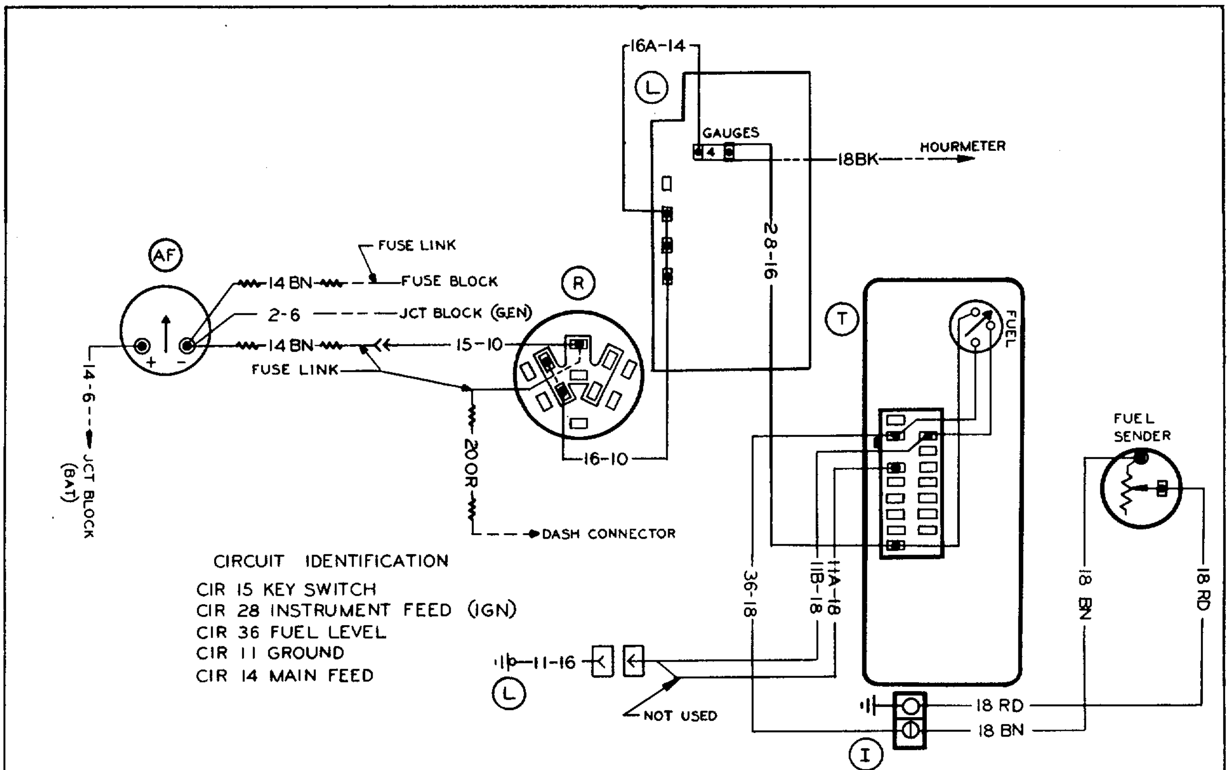


CIRCUIT IDENTIFICATION

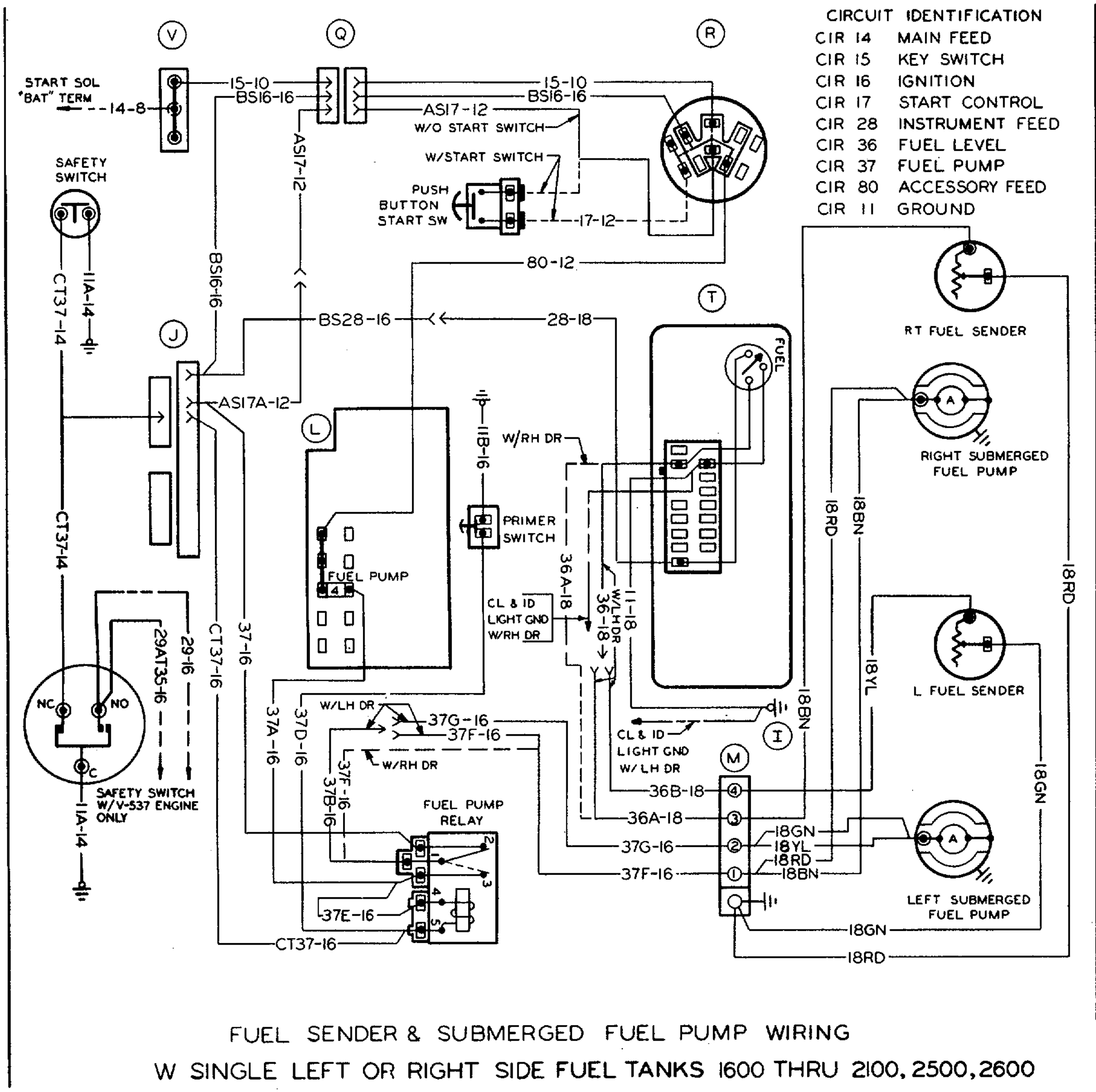
CIR 15 KEY SWITCH
CIR 16 IGNITION
CIR 14 MAIN FEED
CIR 80 ACCESSORY FEED
CIR 28 INSTRUMENT FEED
CIR 36 FUEL LEVEL
CIR 11 GROUND

DUAL SENDERS W/DUAL FUEL TANKS W/O FBC
GAS ENGINES ONLY

MT-21990

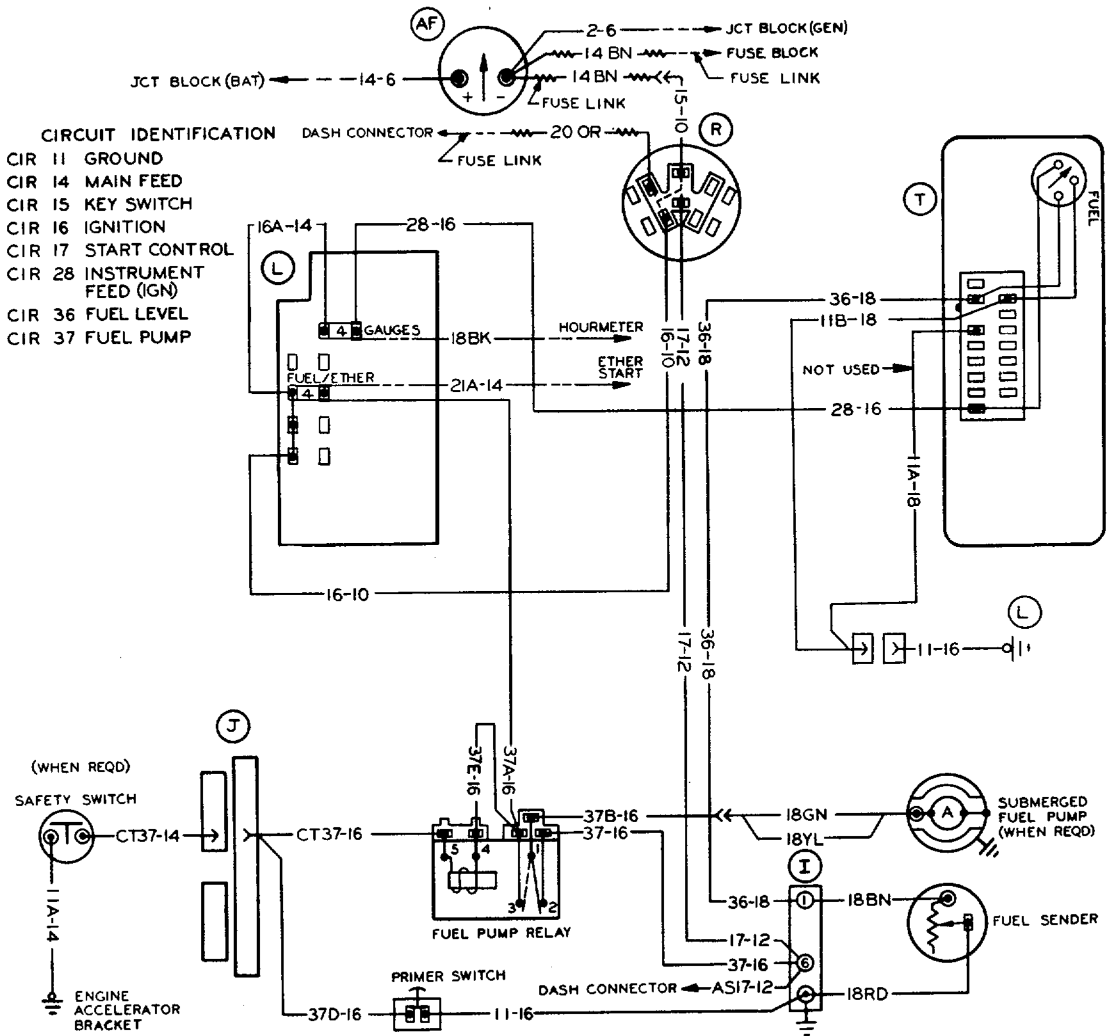


MT-23315 FUEL SENDER WIRING - DUAL TANKS W/DIESEL ENGINE FBC

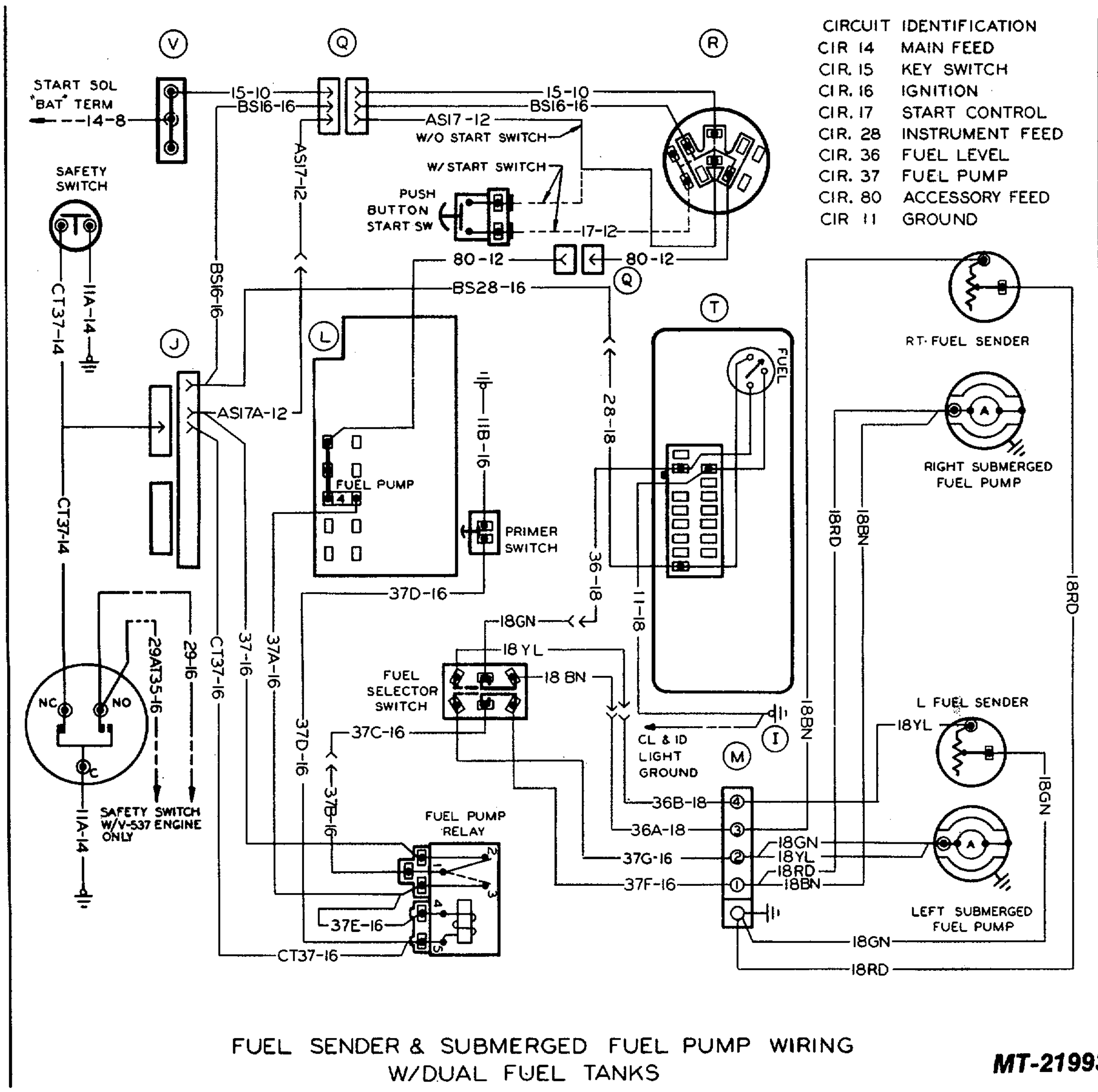


FUEL SENDER & SUBMERGED FUEL PUMP WIRING
W SINGLE LEFT OR RIGHT SIDE FUEL TANKS 1600 THRU 2100, 2500, 2600

MT-21991

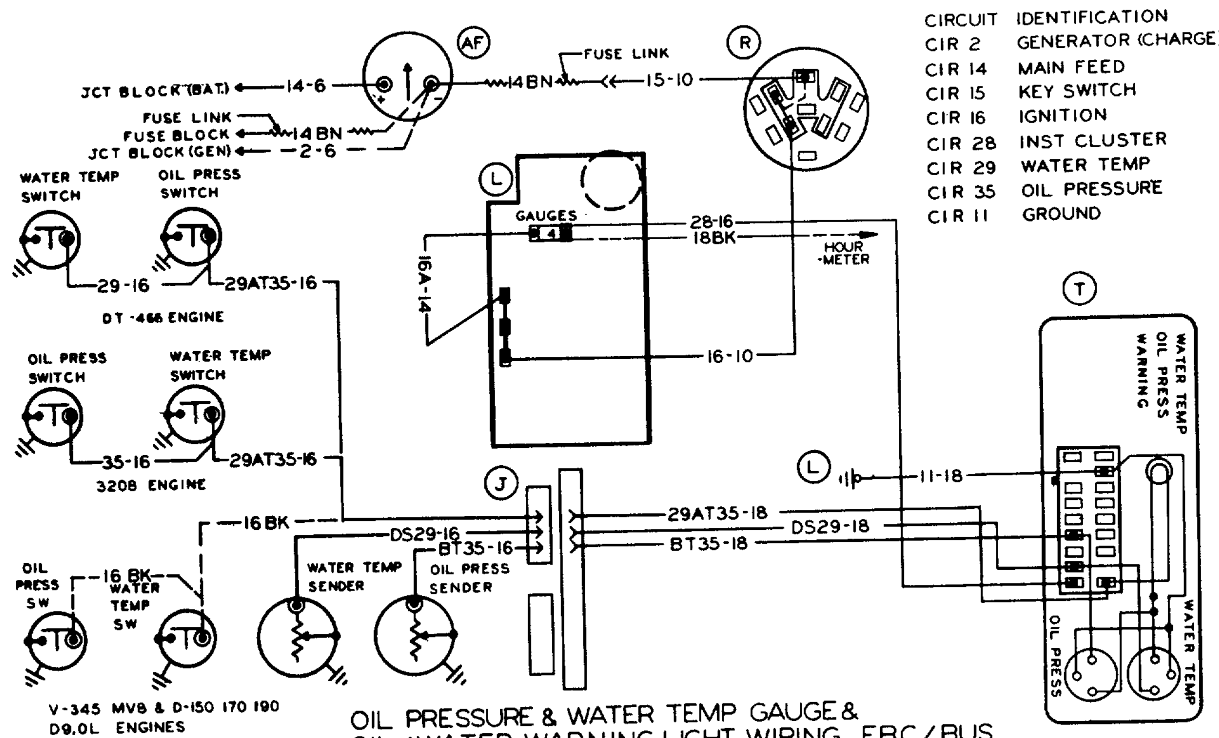


MT-23316 FUEL SENDER & SUBMERGED FUEL PUMP WIRING FBC/BUS

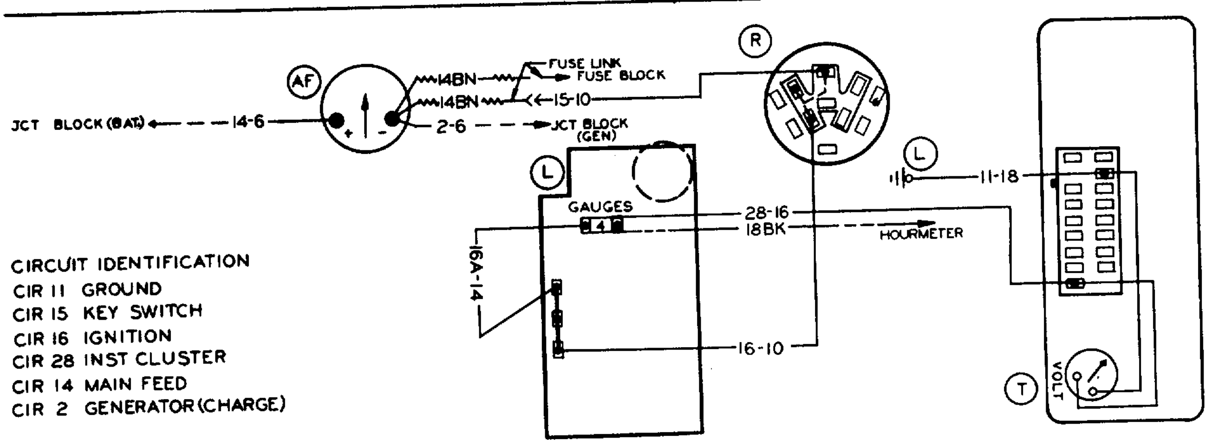


FUEL SENDER & SUBMERGED FUEL PUMP WIRING
W/DUAL FUEL TANKS

MT-21993

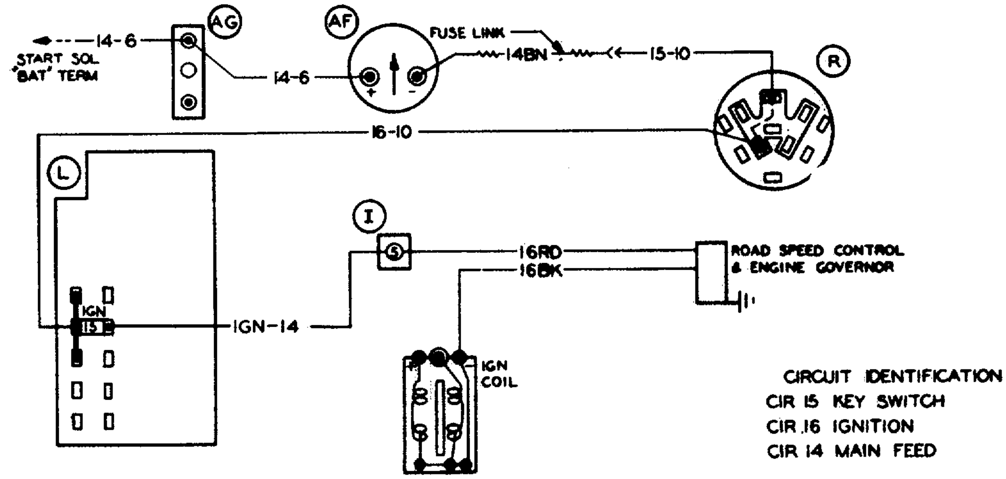


OIL PRESSURE & WATER TEMP GAUGE & OIL/WATER WARNING LIGHT WIRING FBC/BUS



VOLTMETER WIRING FBC/BUS

MT-23307



ROAD SPEED CONTROL & ENGINE GOVERNOR
W/V-345, V-392 & MV8 ENGINES W/FBC/BUS

MT-23303

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PRINTED IN UNITED STATES OF AMERICA

ELECTRICAL

CIRCUIT DIAGRAMS 1980

S-SERIES TRUCKS

PRINTED IN UNITED STATES OF AMERICA

BULB CHART

BULB APPLICATION	WATTS OR CANDLEPOWER	TRADE NO.
HEADLIGHT:		7002 RH DR 6014
UPPER BEAM	60 WATTS	
LOWER BEAM	45 WATTS RH DR 50 WATTS LH DR	
FRONT TURN	32	1156
SIDE MARKER	2	1895
PARK	3	181
STOP-TURN/TAIL-LICENSE	32/3	1157
BACK-UP	32	1156
IDENTIFICATION-CLEARANCE	3	168
FLOOD LIGHT	12	561
MIRROR LIGHT	2	1895
CLUSTER:		
ILLUMINATION	2	194
INDICATOR	2	194
WARNING	2	194
INFORMATION	2	194
CONTROL IDENTIFICATION OR WARNING LIGHT:		
ENGINE STOP	0.50	**
FRONT AXLE	0.50	**
GAUGE ILLUMINATION		
ENGINE OIL TEMPERATURE:	1	53
XMSN OIL TEMPERATURE	1	53
INSTR PANEL CONTROLS	0.50	**
ASHTRAY	0.50	**
DOME	12	211-2
RADIO	0.75	1892
HEATER & A/C CONTROLS	3	168
AUTOMATIC XMSN COTROLS	1	53

** PURCHASED LIGHT ASSEMBLY (REF G.E. BULB NO. 2162D)

DESCRIPTION	SIZE	TYPE	LOCATION
TRAILER AUX	—	—	FUSE BLOCK
TRAILER MARKER	15A	FUSE *	AT REAR
TRAILER STOP	20A	FUSE *	CAB
TRAILER TAIL	15A	FUSE *	JUNCTION
TRAILER RT TURN	10 A	FUSE *	BLOCKS
TRAILER L TURN	10 A	FUSE *	
LIGHT SWITCH FBC/BUS	18GA	GN FUSE LINK	LIGHT SWITCH
KEY SWITCH IGN BUS BAR	14 CA	BN FUSE LINK	AMMETER
FUSE BLOCK BAT BUS BAR	14 GA	BN FUSE LINK	AMMETER
IGNITION FBC/BUS	20GA	OR FUSE LINK	KEY SWITCH
INSTRUMENT FBC/BUS	20 GA	OR FUSE LINK	KEY SWITCH

FUSE, CIRCUIT BREAKER & FUSIBLE LINK CHART

* CIRCUIT BREAKER OPTIONAL

DESCRIPTION	SIZE	TYPE	LOCATION
HOURMETER	4A	FUSE	GAUGES BUS & FBC
ETHER START	4A	FUSE *	FUEL/ETHER FBC
HAZARD LIGHTS	20A	FUSE	TURN/HAZARD
TURN LIGHTS	20A	FUSE	
DOME LIGHTS	15 A	FUSE *	HORN/DOME
CIGAR LTR (FBC/BUS)	15 A	FUSE *	
HORN	15 A	FUSE *	
STOP LIGHTS	30A	FUSE *	STOP/TRL MKR
TRAILER MARKER	30 A	FUSE *	
FLOOD LIGHTS	30A	FUSE *	
TAIL LIGHTS	20A	FUSE *	(15A FBC/BUS)
CL/ID LIGHTS	20A	FUSE *	TAIL/CAB MKR
PARK MARKER LTS	20A	FUSE *	
MIRROR LIGHTS	20A	FUSE *	
MKR LIGHTS (FBC/BUS)	15A	FUSE *	MARKER
TRL MKR LIGHT REL	15A	FUSE *	MARKER
INSTR PANEL LIGHTS	4A	FUSE *	PANEL
CLUSTER PANEL LTS	4A	FUSE *	
ASHTRAY LIGHTS	4A	FUSE *	
HTR & A/C CONT ILLUM	4A	FUSE *	
XMSN & ENG OIL TEMP GAUGE ILLUM	4A	FUSE *	
RADIO	4A	FUSE *	RADIO
HEATER ONLY	20A	FUSE *	HEATER & A/C
HTR & A/C-EXCEPT HIGH POSITION	20A	FUSE *	
2 SPEED AXLE	20A	FUSE *	2 SPEED
SUBMERGED FUEL PUMP	4A	FUSE *	FUEL/ETHER-BUS FUEL PUMP-TRUCK
BACK-UP LIGHTS	15A	FUSE *	BACK-UP/ ANTILOCK
ANTILOCK SYSTEMS	15A	FUSE *	
HTR & A/C HIGH POSITION	30A	CIRCUIT BKR	HEATER & A/C
KYSOR ENGINE SHUTDOWN	10A	IN-LINE FUSE	ABOVE KYSOR SW, LWR FRT LT
2 FUSES	6A	IN-LINE FUSE	SIDE OF CAB
HEADLIGHTS	15A	CIR BKR	INSIDE LIGHT SW
WINDSHEILD WIPER & WASHER	6A	CIR BKR	REAR OF WIPER SWITCH
HI-POWER PUMP (CONVENTIONAL ONLY)	50A	CIR BKR	RELAY MTG BRKT
HIGH POWER PUMP FBC/BUS	50A	CIR BKR	DASH PANEL (ENG SIDE)
CIGAR LIGHTER (CONVENTIONAL ONLY)	18 GA	GN FUSE LINK	LIGHT SWITCH
HEADLIGHT FEED	[illegible]	BK FUSE LINK	AT START MOTOR SOL
CAB FEED (CONVENTIONAL ONLY)	12 GA	DK BL FUSE LINK	AT START MOTOR SOL
GENERATOR FBC/BUS	20 GA	OR FUSE LINK	KEY SWITCH
HOURMETER	5A	IN-LINE FUSE	UNDER FUSE BLOCK - TRUCK
ETHER START	5A	IN-LINE FUSE	LWR EDGE INST PNL - TRUCK

FUSE IDENT SHOWN AS ON FUSE BLOCK

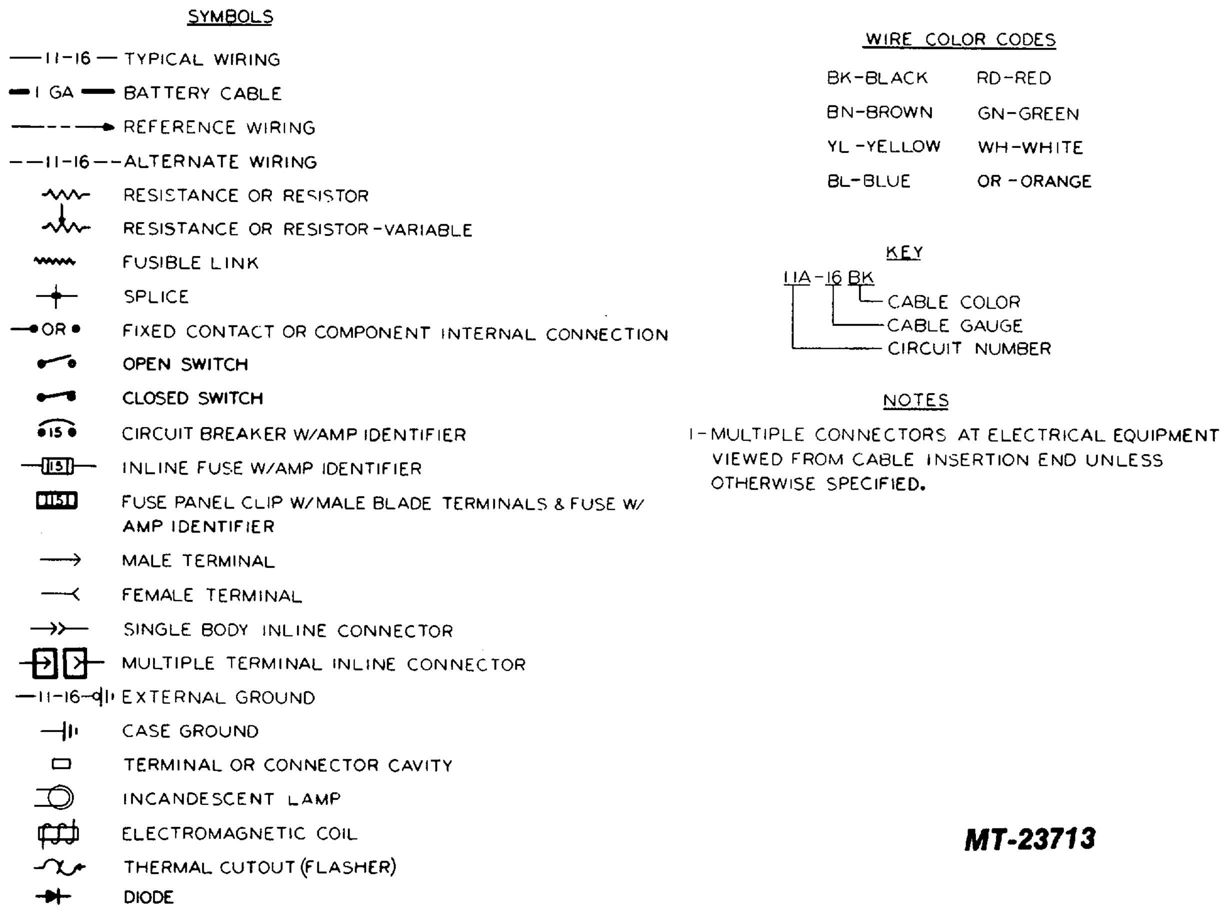
FUSE BLOCK MTG ON INSIDE CAB-UPPER LEFT SIDE OF DASH - CONVENTIONAL - LH DR

FUSE BLOCK MTG ON INSIDE COWL - CENTER OF INSTR PANEL - FBC / BUS

FUSE BLOCK MTG ON INSIDE CAB - UPPER RIGHT SIDE OF DASH - CONVENTIONAL - RH DR

MT-23712

Bulb And Fuse Chart



Definition of Symbols (All Models)

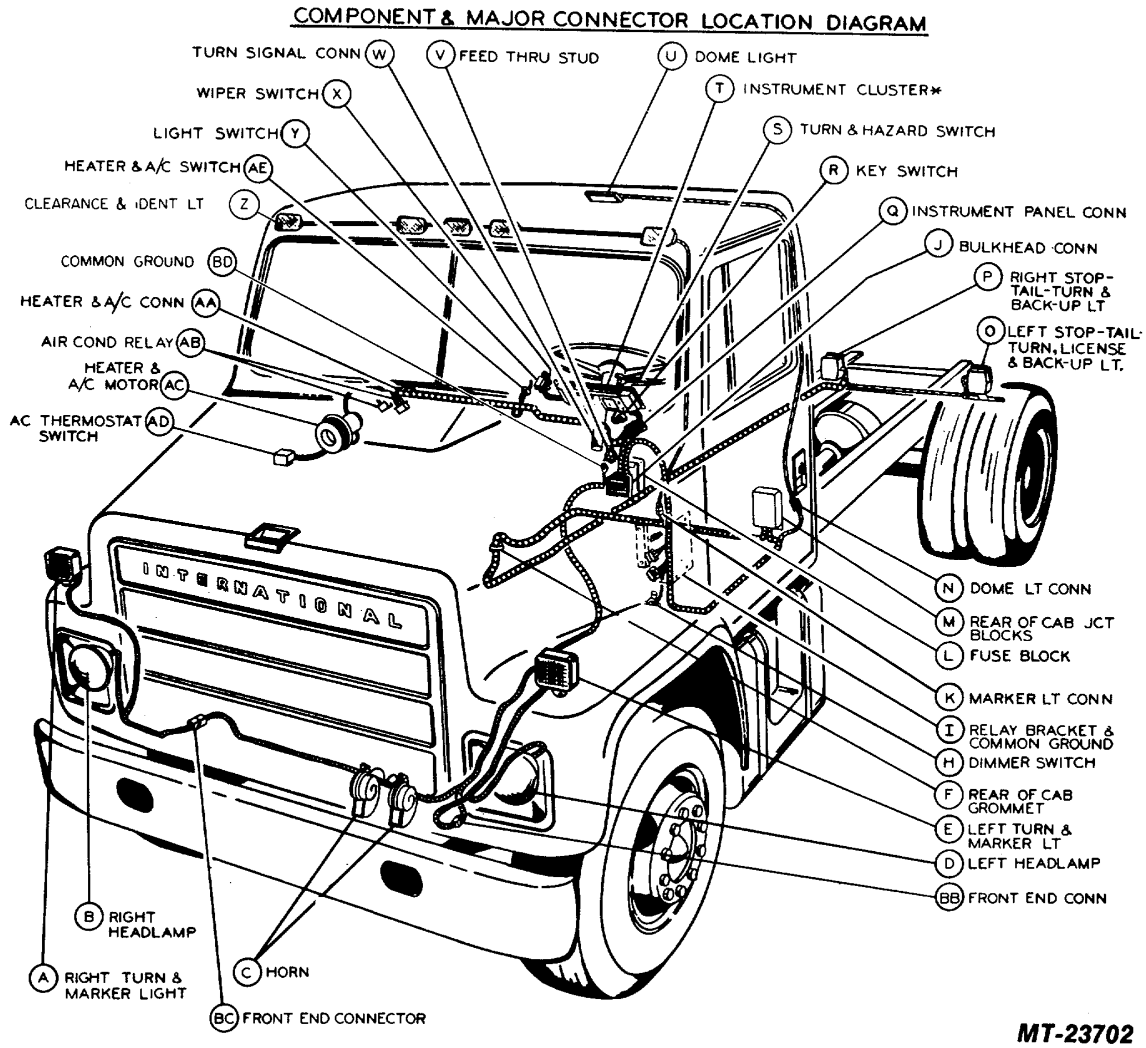
CIRCUIT NUMBERS & DESCRIPTION

1	GENERATOR (FIELD)	51	DIMMER SWITCH
2	GENERATOR (CHARGE)	52	HEAD LIGHT - HI-BEAM
6	REGULATOR, VOLT (FIELD RELAY)	53	HEAD LIGHT - LO-BEAM
7	REGULATOR, VOLT (CHARGE)	54	PARKING LIGHTS
11	GROUND	55	DIR. SIGNAL SWITCH
14	MAIN FEED	56	DIR. SIGNAL LIGHTS - LEFT
15	KEY SWITCH	57	DIR. SIGNAL LIGHTS - RIGHT
16	IGNITION	58	CLEAR., IDENT., & MARKER LIGHTS
17	STARTING CONTROL	60	HAZARD SWITCH
18	GLOW PLUG, PRE HEATER	62	PANEL LIGHTS
19	FUEL SHUT-OFF	63	DOME &/OR COURTESY LIGHTS
21	ETHER	65	TAIL LIGHT
23	MAGNETIC FAN	70	STOP LIGHT
24	EXHAUST BRAKE	71	BACK-UP LIGHT
28	INSTRUMENT	72	TRAILER
29	ENG WATER TEMP	75	HEATER
30	ENG OIL TEMP	76	DEFROSTER
31	TRANS OIL TEMP	77	AIR CONDITIONER
32	AXLE OIL TEMP	78	HEATED MIRROR
33	ENG OIL LEVEL	80	ACCESSORY FEED
34	WATER LEVEL	82	WINDSHIELD WIPER
35	ENG OIL PRESSURE	84	CIGAR LIGHTER
36	FUEL LEVEL	85	HORN
37	FUEL PUMP	86	RADIO
		87	WINDSHIELD WASHER
		88	HOURMETER
42	FRT AXLE WARNING	90	HY-POWER BRAKES
43	R.D. LOCK WARNING	92	TRANSMISSION
44	BRAKE SYSTEM WARNING	93	AXLE SHIFT
48	TACHOMETER	94	WHEELLOCK (ANTI SKID BRAKES)
50	LIGHT SWITCH	95	EXHAUST EMISSION

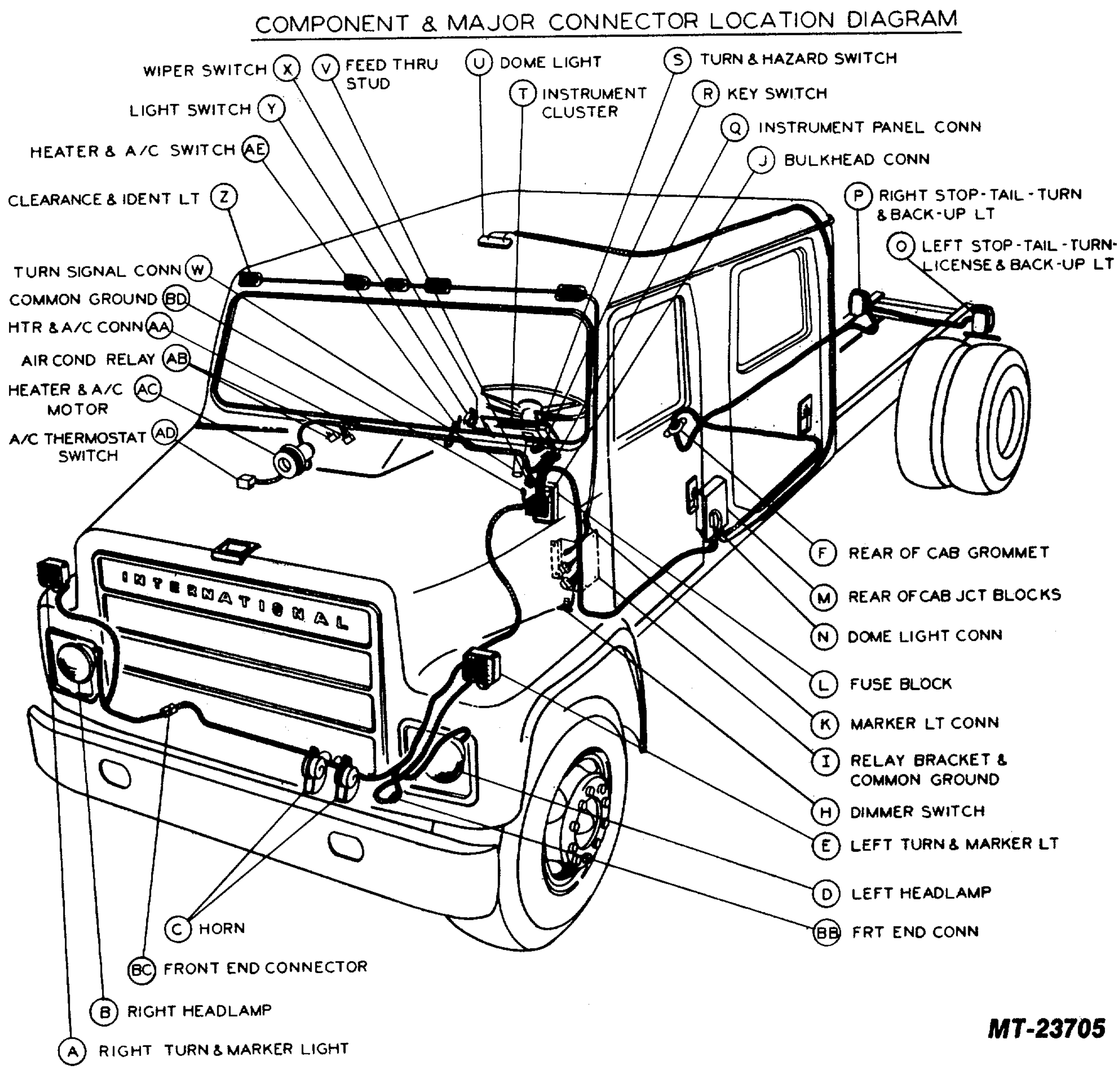
CIRCUIT NUMBERS MAY REQUIRE SUFFIX LETTER IDENTIFICATION WHEREVER BRANCHES OF THE MAIN CIRCUIT ARE ENCOUNTERED.

MT-23714

Circuit Numbers and Description (All Models)

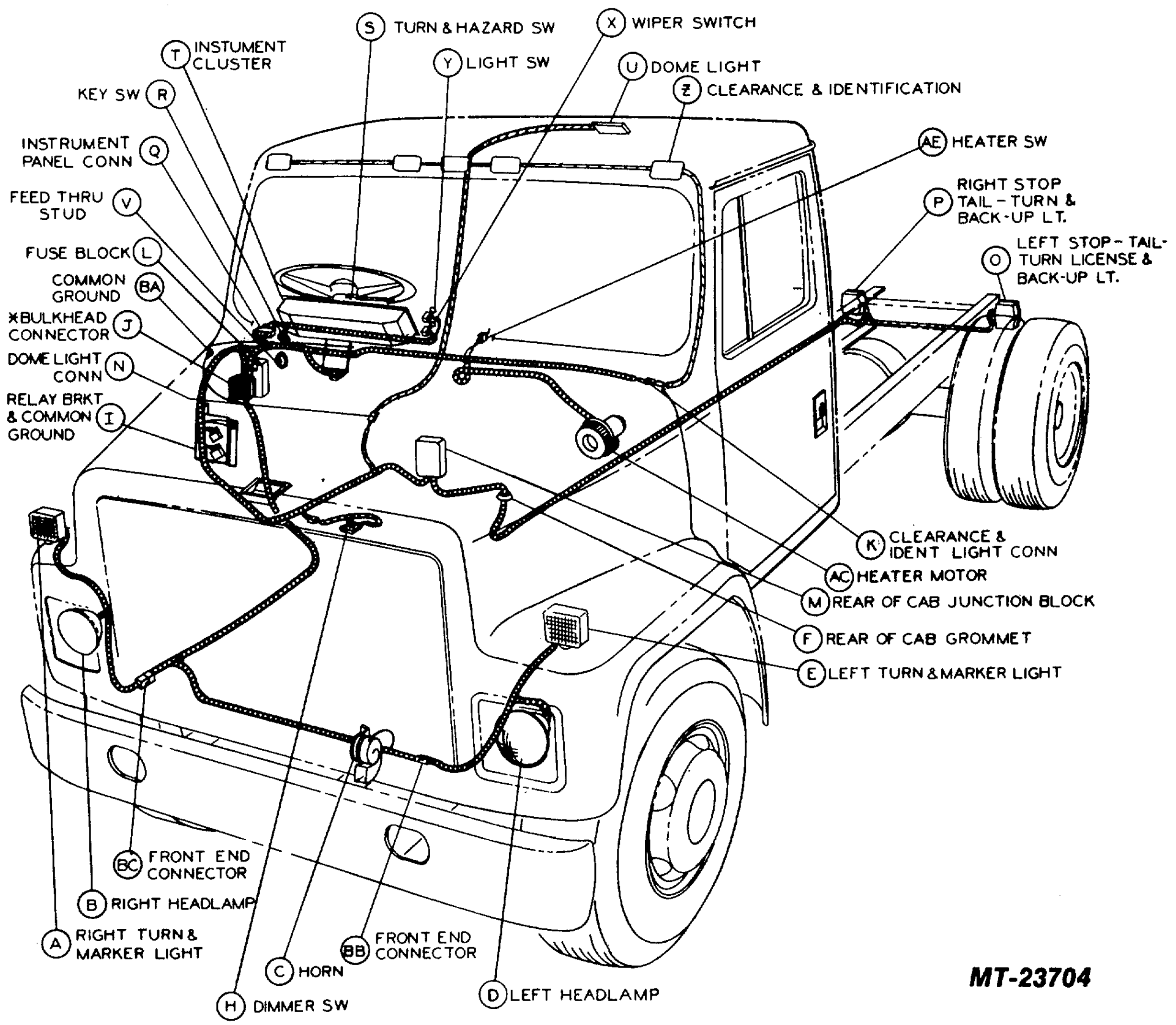


Component And Major Connector Location (On Chassis) 1600 thru 1900 Models

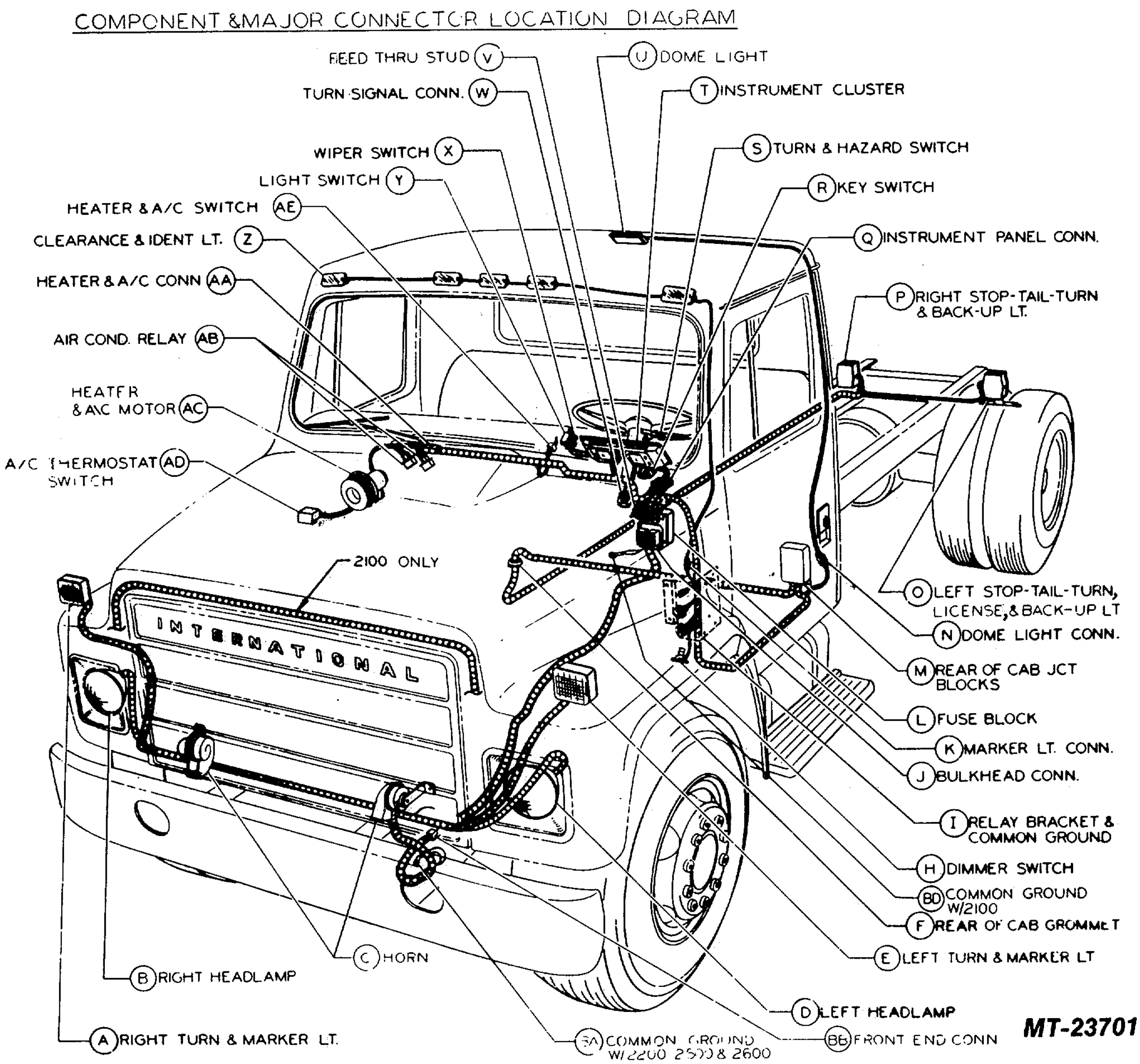


Component And Major Connector Location (On Chassis) 1700 thru 1900 Models

COMPONENT & MAJOR CONNECTOR LOCATION DIAGRAM

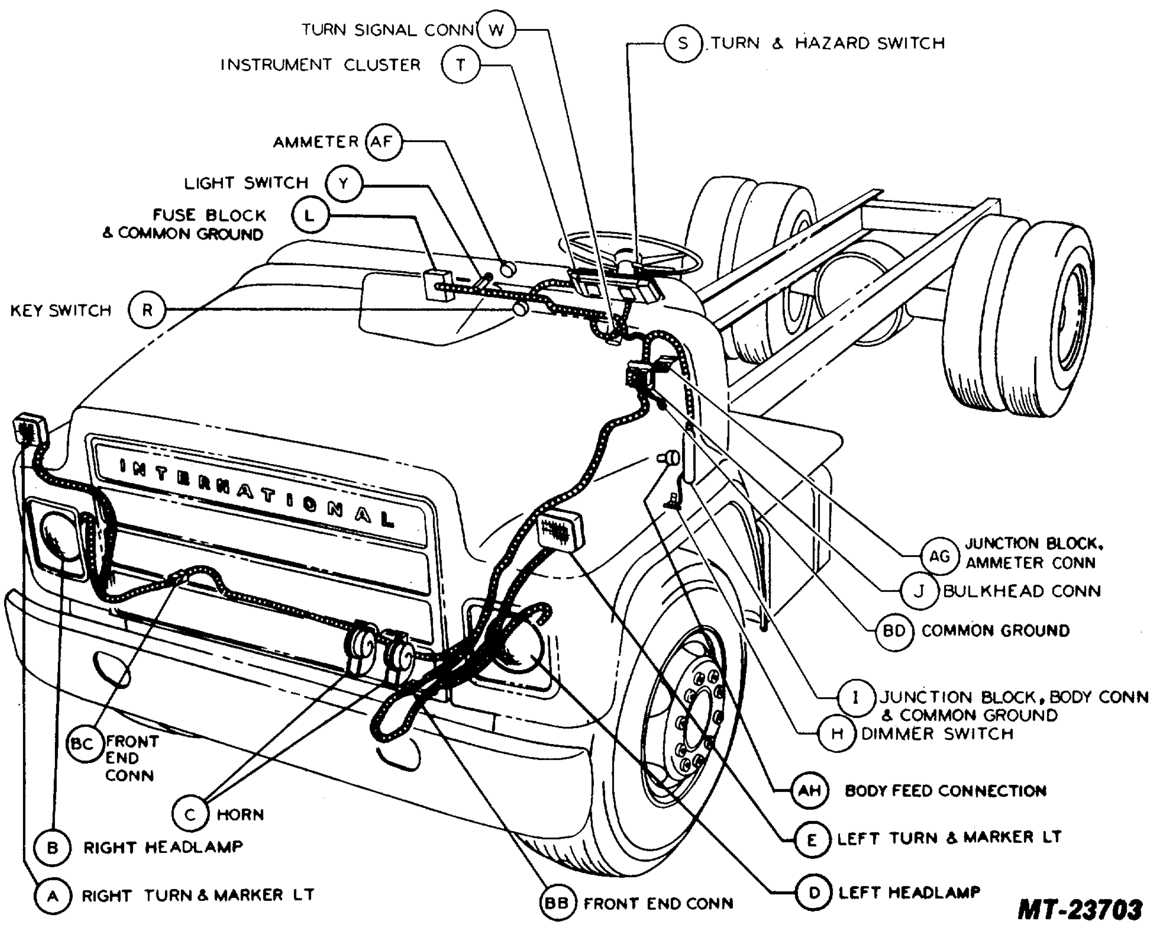


Component And Major Connector Location (On Chassis) 1700 thru 1900 Right Hand Drive Models

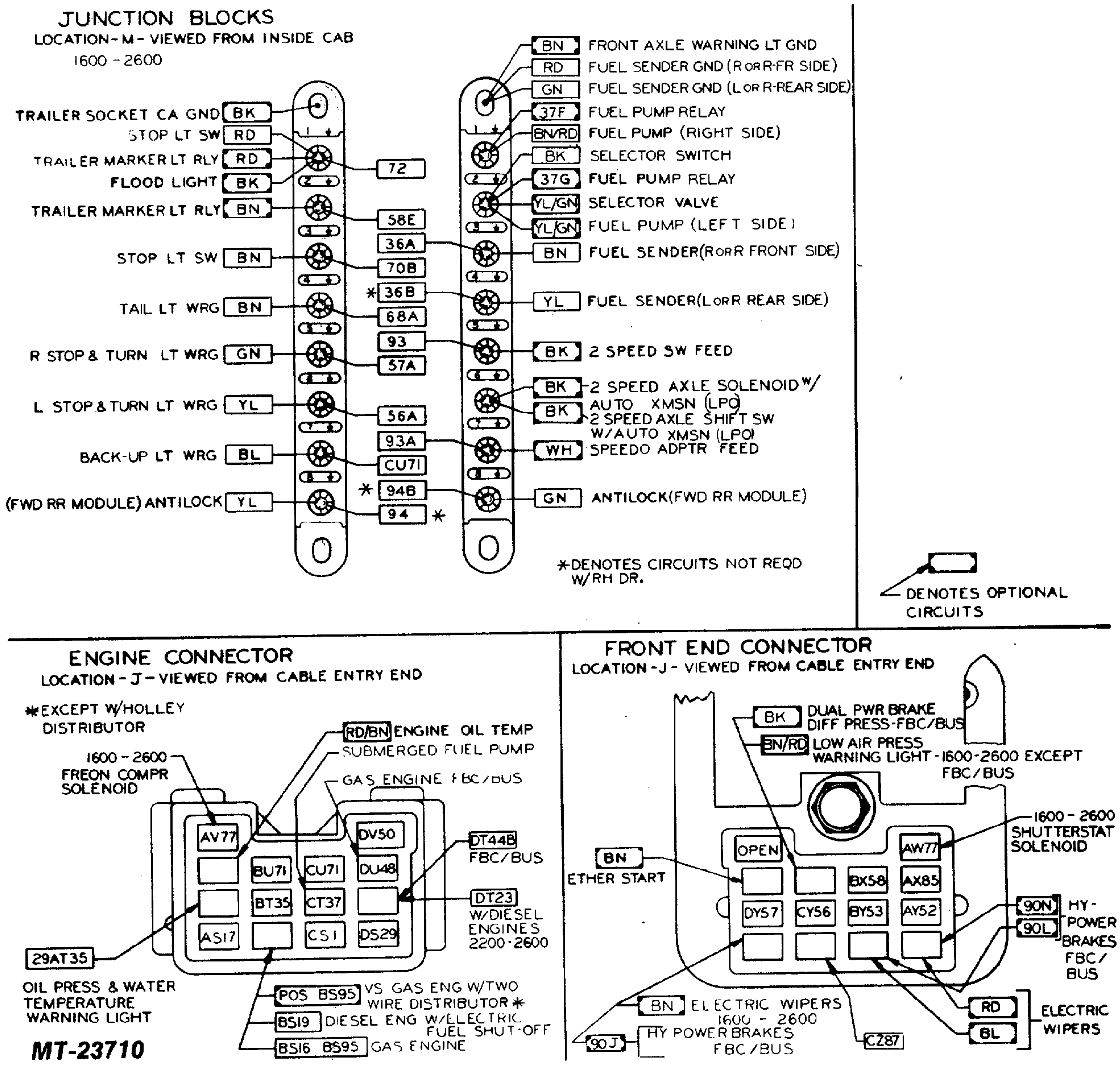


Component And Major Connector Location (On Chassis) 2100 thru 2600 Models

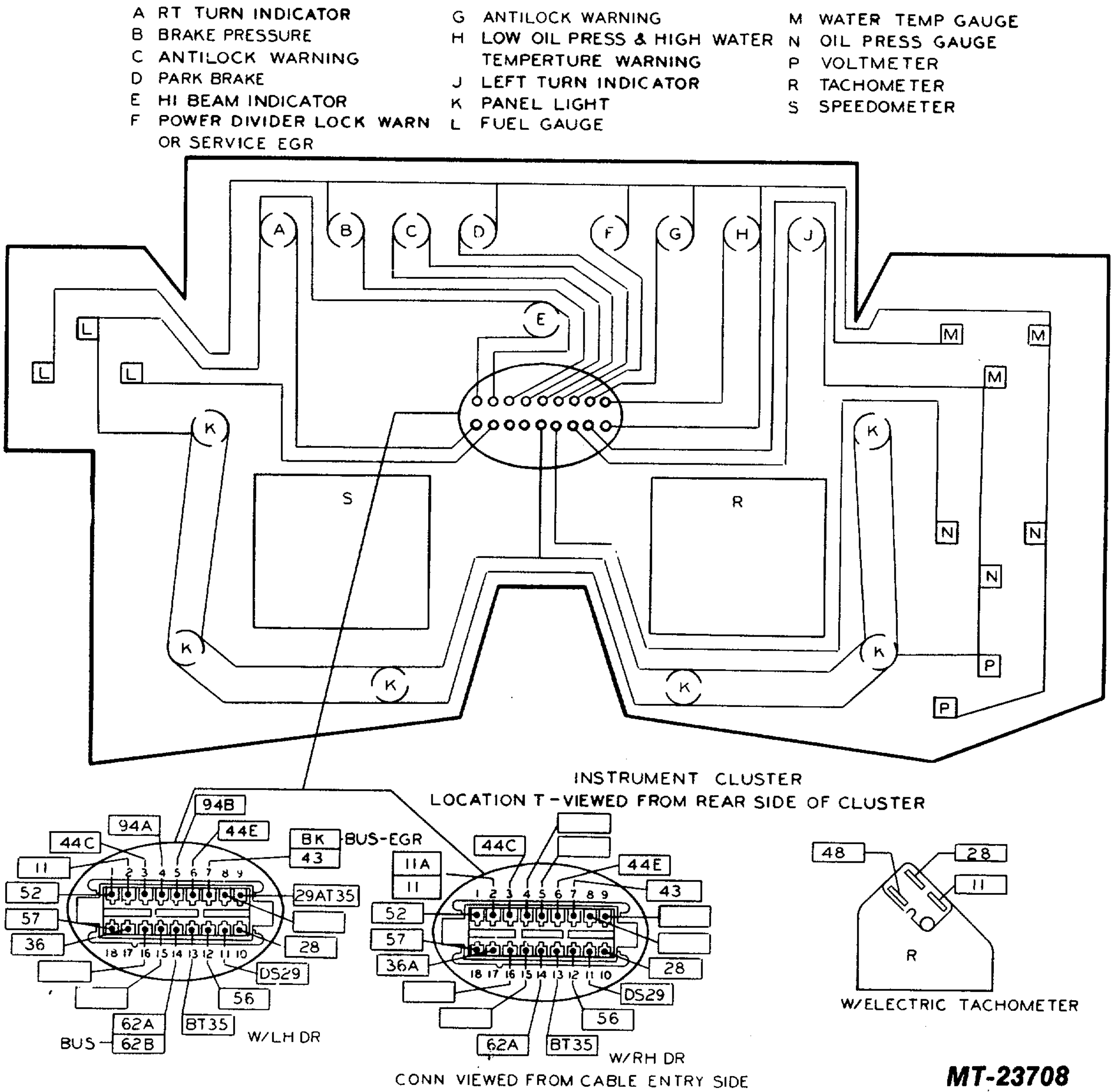
COMPONENT & MAJOR CONNECTOR LOCATION DIAGRAM



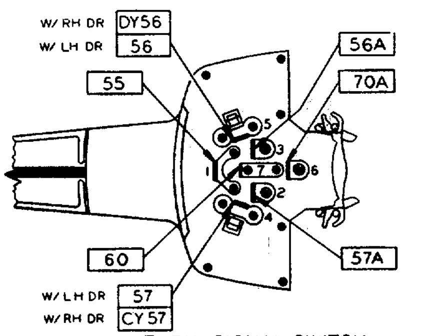
Component And Major Connector Location (On Chassis) FBC/Bus



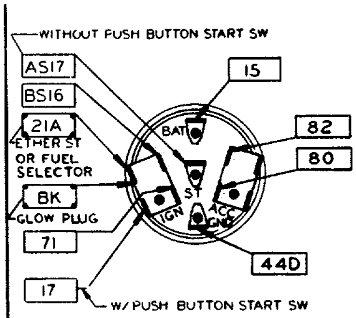
Component And Major Connectors Junction Blocks - Engine Connector - Front End Connector



Component And Major Connectors Instrument Cluster

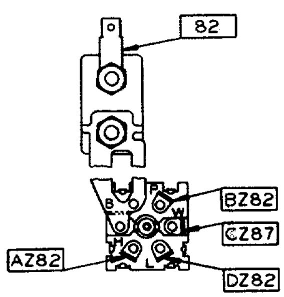


TURN SIGNAL SWITCH
LOCATION-S
VIEWED FROM TERMINAL SIDE

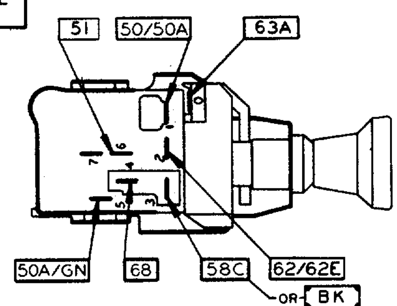


KEY SWITCH LOCATION-R
VIEWED FROM TERMINAL SIDE

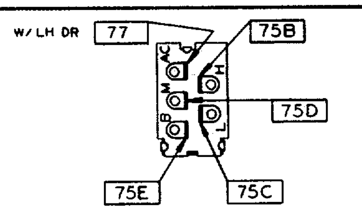
SWITCH	POSITION	CONTACTS CLOSED	CONTACTS OPEN
TURN SIGNAL & HAZARD	OFF (NORMAL)	2,3 & 6	1,4,5 & 7
	LEFT TURN &	1,3 & 5	4 & 7
	LANE CHANGE	2 & 6	
	RIGHT TURN &	1,2 & 4	5 & 7
	LANE CHANGE	3 & 6	
	HAZARD	2,3,4,5 & 7	1 & 6
HEAD LIGHT	OFF-(KNOB IN & TURNED C.W.)	2,3&4	0,1,5,6 & 7
	PARK LIGHTS (KNOB IN 1 ST POS.)	1 & 7	0 & 6
		2,3,4 & 5	
	HEAD LIGHTS (KNOB IN 2 ND POS.)	1 & 6	0 & 7
		2,3,4 & 5	
	DOME-(KNOB IN & TURN C.C.W.)	0 TO GND	1,5,6 & 7
		3,4 & 2	
	PANEL-(2ND POS. TURN C.C.W. TO LOCK)	0 TO GND	7
		1 & 6	
		2,3,4 & 5	
KEY	OFF	NONE	ALL
	START	BAT-ST-IGN	ACC
		GND-CASE	
	IGNITION	BAT-IGN-ACC	ST-GND
	ACCESSORY	BAT-ACC	ST-IGN-GND
HEATER & A/C	OFF	NONE	ALL
	LOW	BAT-L-A/C	M-H
	MED	BAT-M-A/C	L-H
	HIGH	BAT-H-A/C	L-M
WIPER/ WASHER	PARK	BAT-P	W-L-H
	LOW	BAT-L	W-P-H
	HIGH	BAT-H	W-P-L
	WASHER (KNOB IN)	BAT-W	L-M-H
SHT-DN TEMP	NORMAL (BELOW 204°)	C-NC	C-NO
	ALARM (204°-210°)	C-NC	NONE
		C-NO	
	SHUT-DOWN (ABOVE 210°)	C-NO	C-NC
SHT-DN PRESS	ENG OFF	C-NC	C-NO
	NORMAL	C-NO	C-NC
	ALARM (7 OR 11 P.S.I.)	C-NO	NONE
		C-NC	
	SHUT-DOWN (3 OR 6 P.S.I.)	C-NC	C-NO



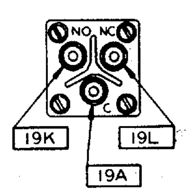
WIPER/WASHER SWITCH
LOCATION-X
VIEWED FROM TERMINAL SIDE



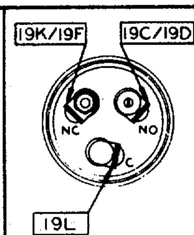
LIGHT SWITCH
LOCATION-Y
VIEWED FROM TERMINAL SIDE



HEATER/A-C SWITCH
LOCATION-AE
VIEWED FROM TERMINAL SIDE



SHT-DN TEMP SW

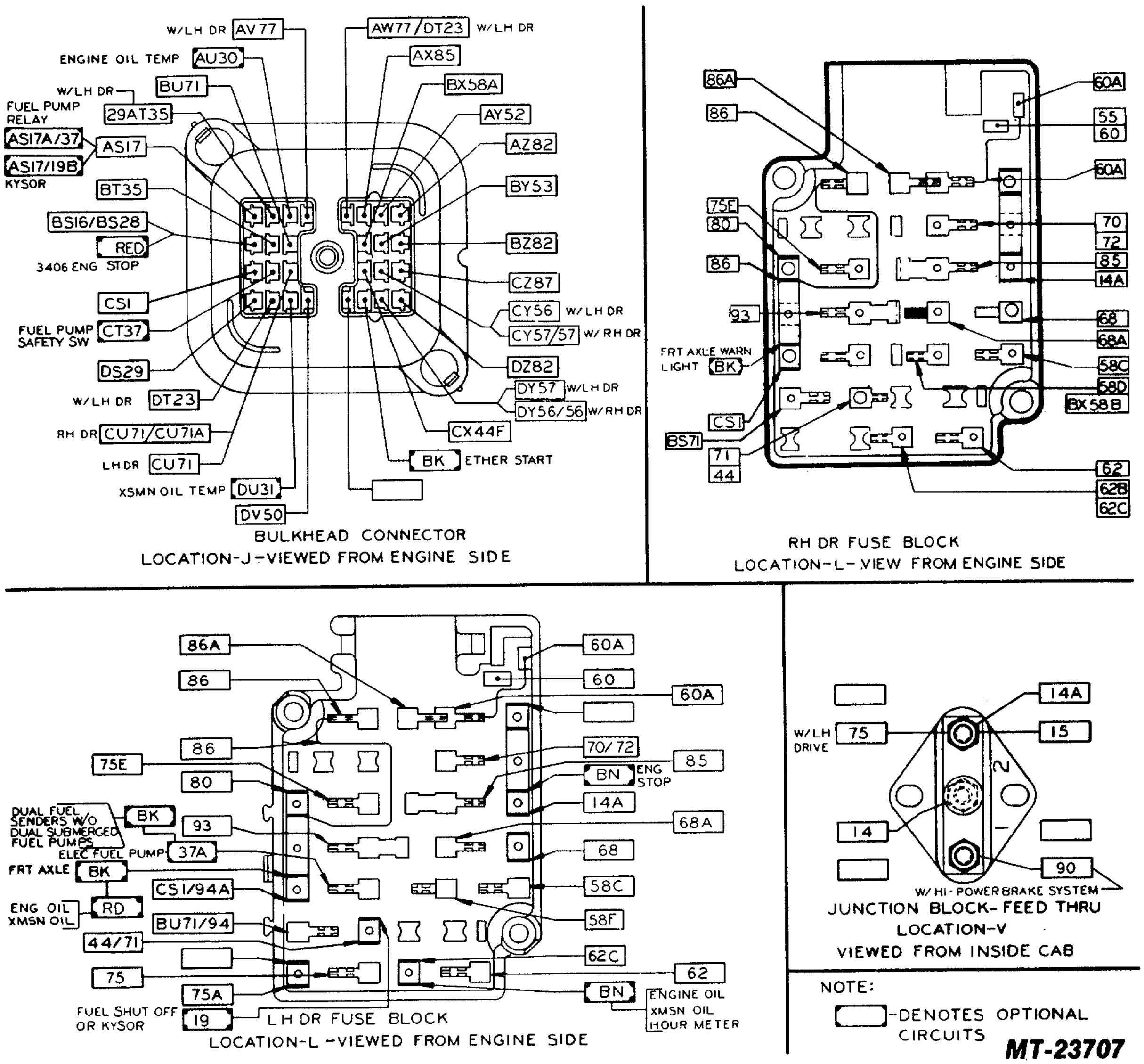


SHT-DN PRESS SW

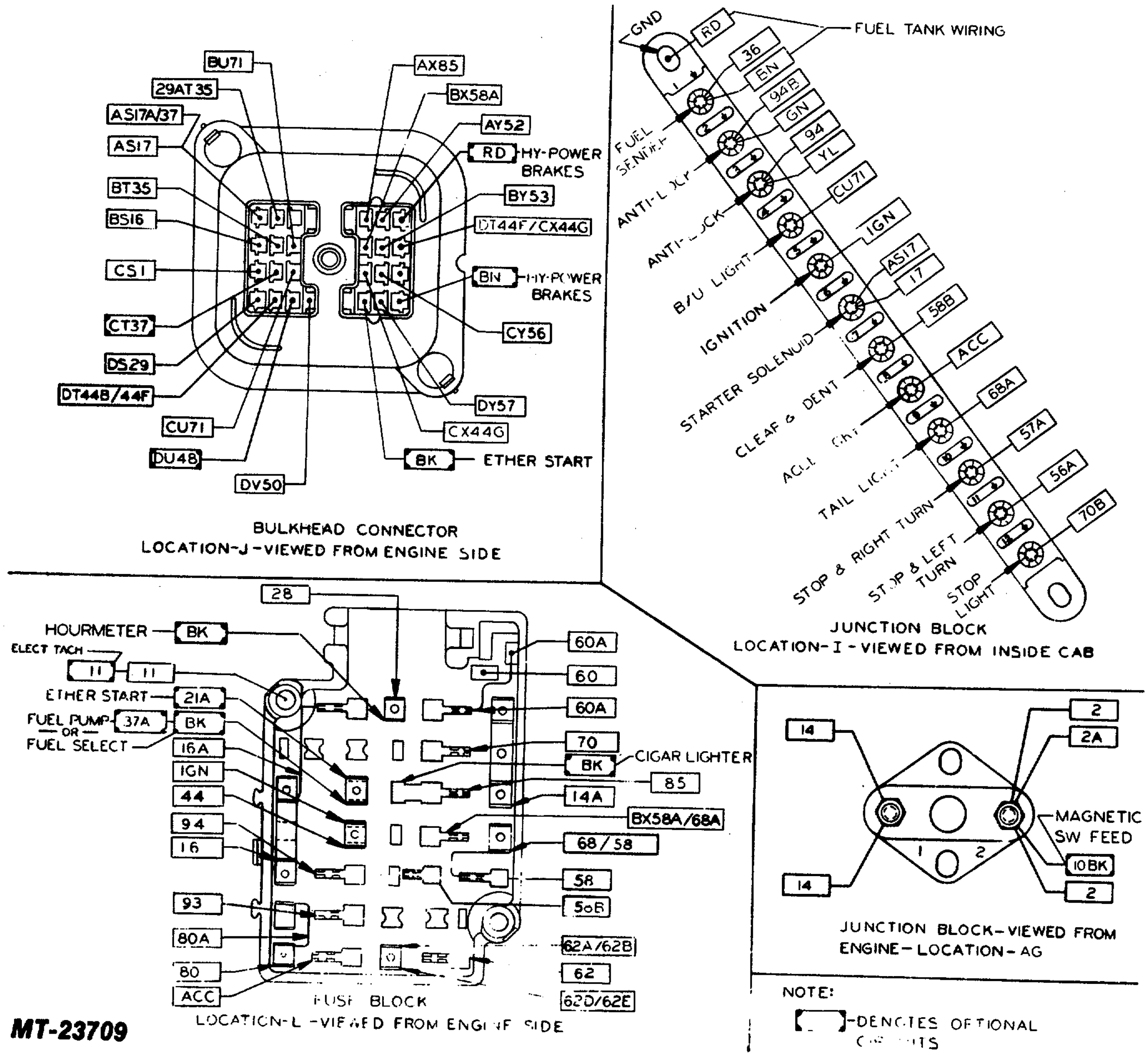
MT-23706

NOTE:
[ ] DENOTES OPTIONAL CIRCUITS

Component And Major Connectors (Not Schoolbus)
Turn Signal Switch - Key Switch - Windshield Wiper/Washer Switch
Light Switch - Heater/Air Conditioner Switch - Shut Down Temperature Switch
Shutdown Pressure Switch

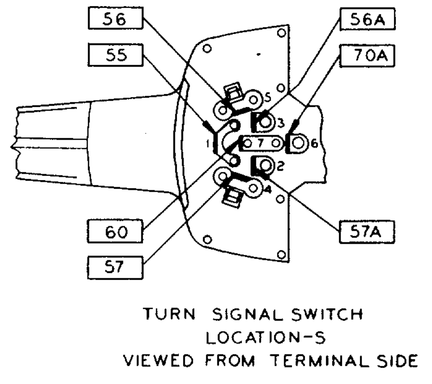


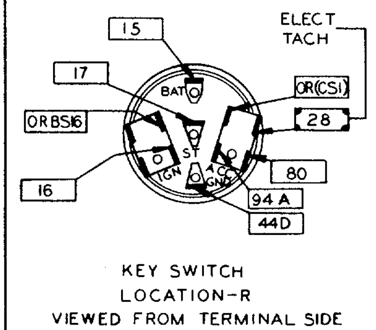
Component And Major Connectors (Not Schoolbus)
Bulkhead Connector - Fuse Blocks - Junction Block



MT-23709

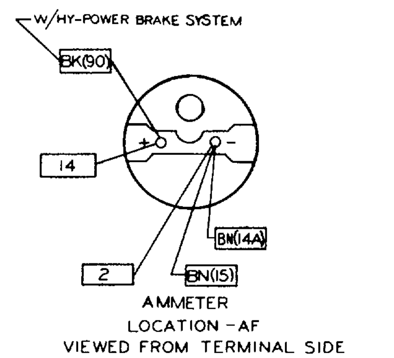
Component And Major Connector (Schoolbus)
Bulkhead Connector - Fuse Block - Junction Block

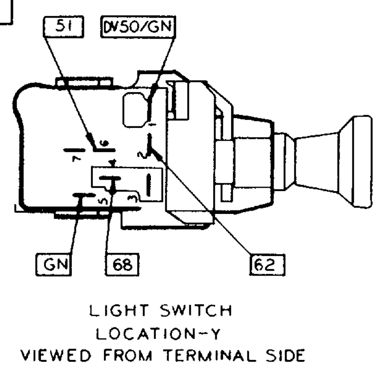




SWITCH CONTACT CHART

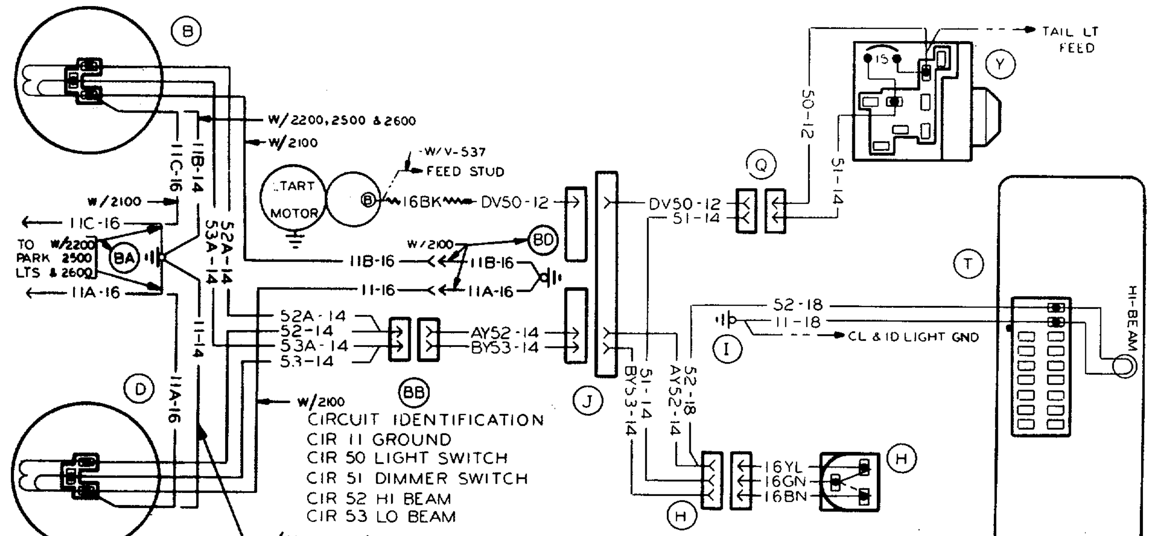
SWITCH	POSITION	CONTACTS CLOSED	CONTACTS OPEN
TURN SIGNAL & HAZARD	OFF (NORMAL)	2,3 & 6	1,4,5 & 7
	LEFT TURN & LANE CHANGE	1,3 & 5 / 2 & 6	4 & 7
	RIGHT TURN & LANE CHANGE	1,2 & 4 / 3 & 6	5 & 7
	HAZARD	2,3,4,5 & 7	1 & 6
HEAD LIGHT	OFF-(KNOB IN- & TURNED C.W.)	2,3&4	0,1,5,6 & 7
	PARK LIGHTS (KNOB IN- 1 ST POS.)	1 & 7 / 2,3,4& 5	0 & 6
	HEAD LIGHTS (KNOB IN- 2 ND POS.)	1 & 6 / 2,3,4& 5	0 & 7
	DOME-(KNOB IN & TURN C.C.W.)	0 TO GND / 3,4 & 2	1,5,6 & 7
	PANEL-(2 ND- POS. TURN- C.C.W. TO LOCK)	0 TO GND / 1 & 6 / 2 3 4& 5	7
KEY	OFF	NONE	ALL
	START	BAT-ST-IGN / GND-CASE	ACC
	IGNITION	BAT-IGN-ACC	ST-GND
	ACCESSORY	BAT-ACC	ST-IGN-GND



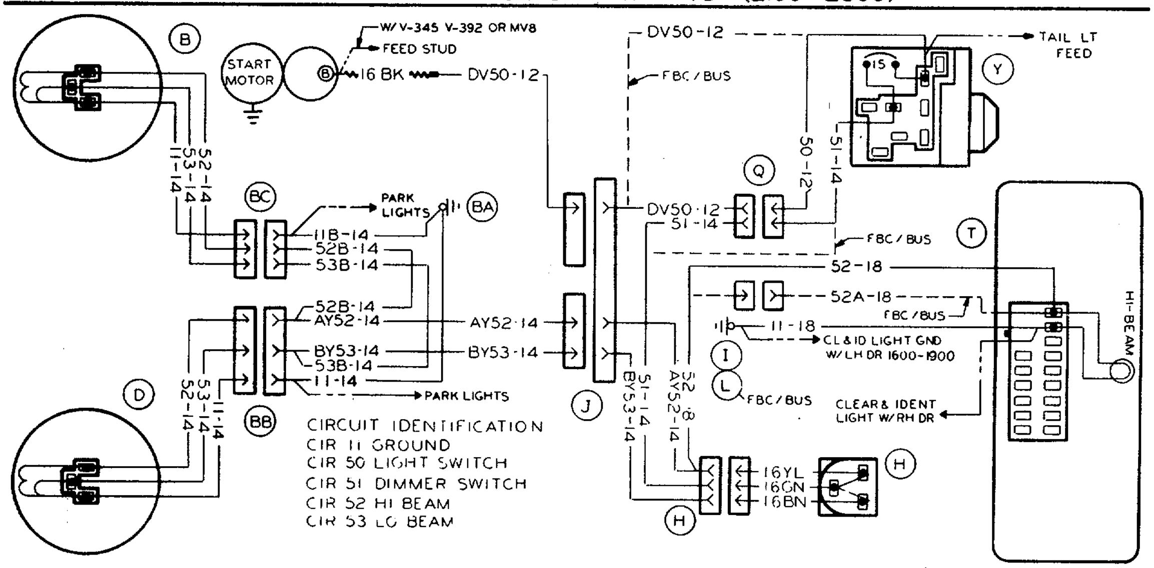


MT-23711

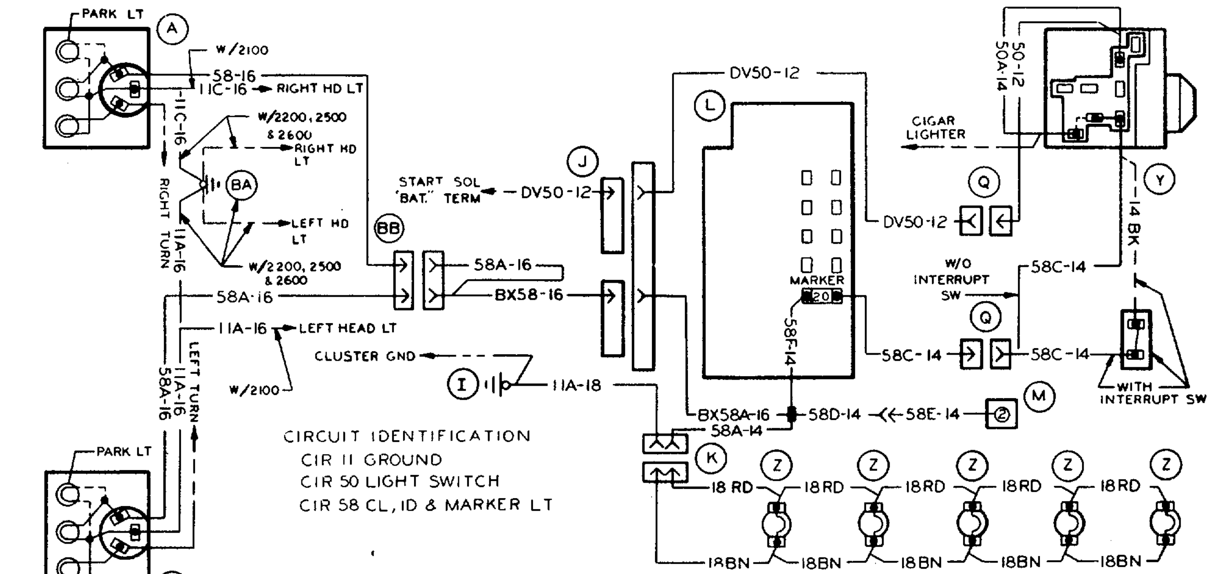
Component And Major Connectors (Schoolbus)
Turn Signal Switch - Key Switch - Ammeter - Light Switch



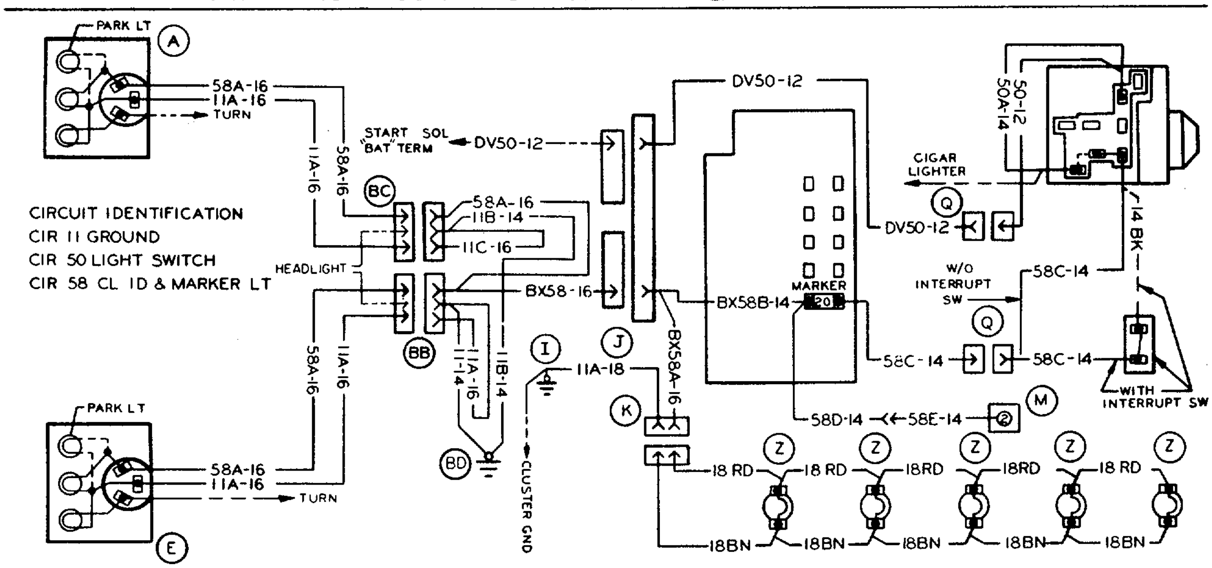
HEADLIGHT WIRING (2100-2600)



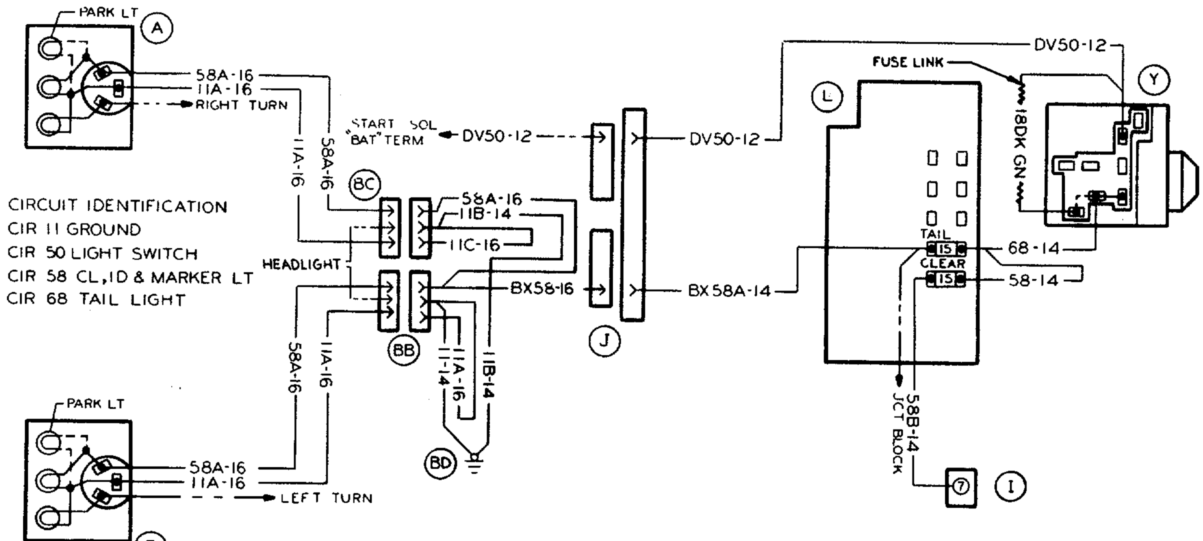
HEADLIGHT WIRING (1600-1900,FBC/BUS) **MT-23715**



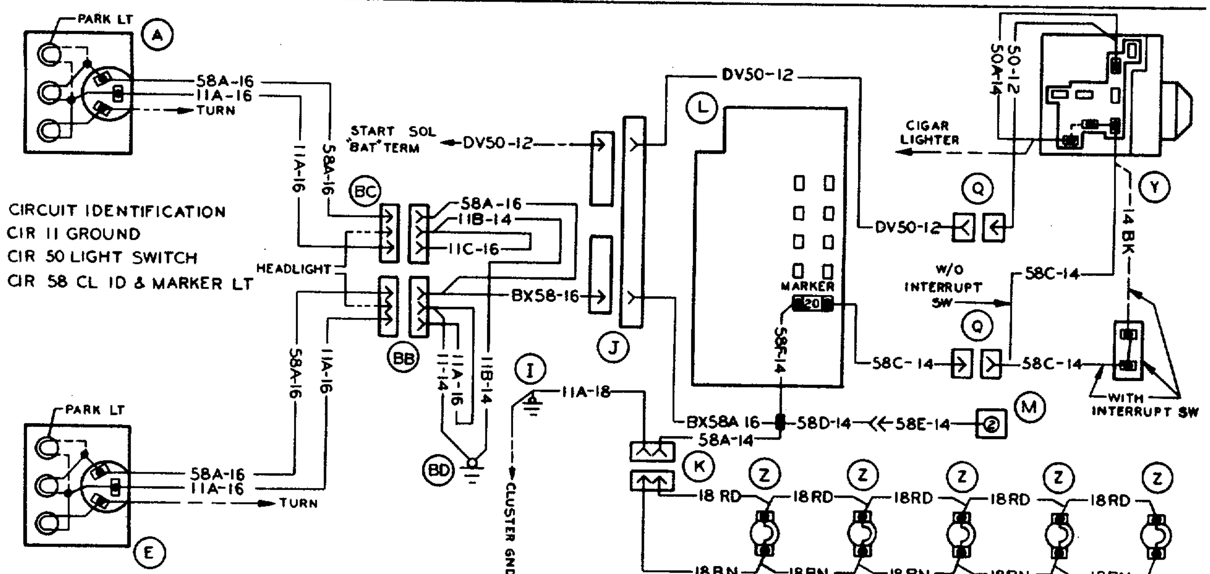
CLEARANCE - IDENTIFICATION - PARK & MARKER LT WIRING 2100 - 2600



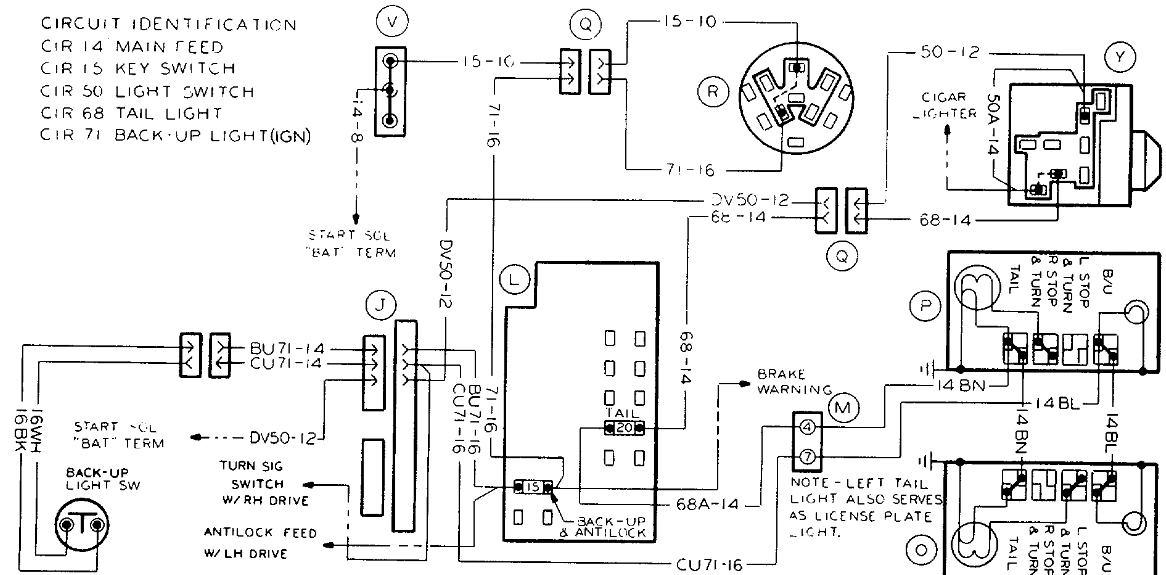
MT-23716 CLEARANCE – IDENTIFICATION — PARK & MARKER LT WIRING 1600 1900 RH DF



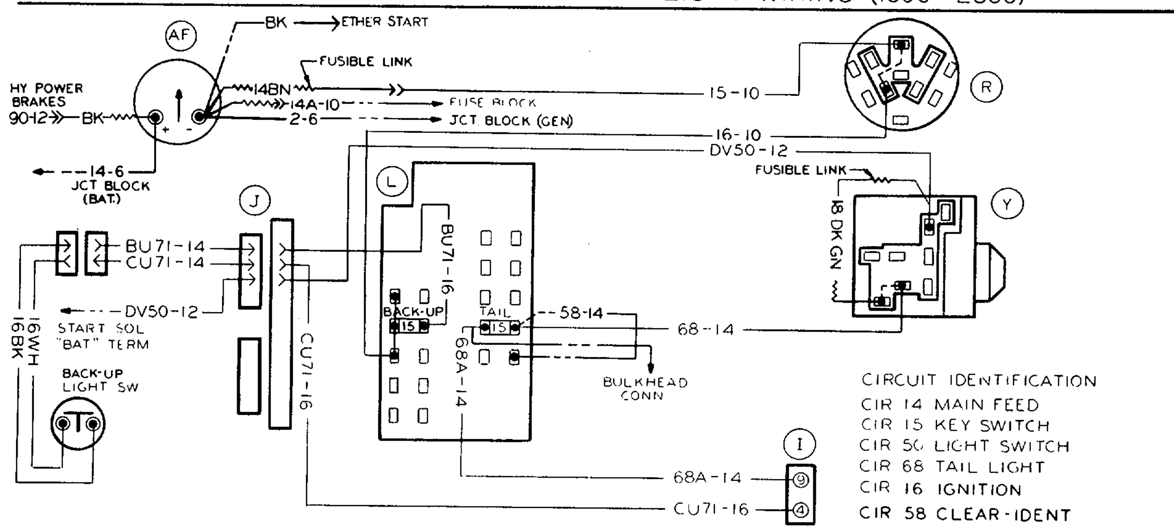
PARK & MARKER LIGHT WIRING FBC/BUS



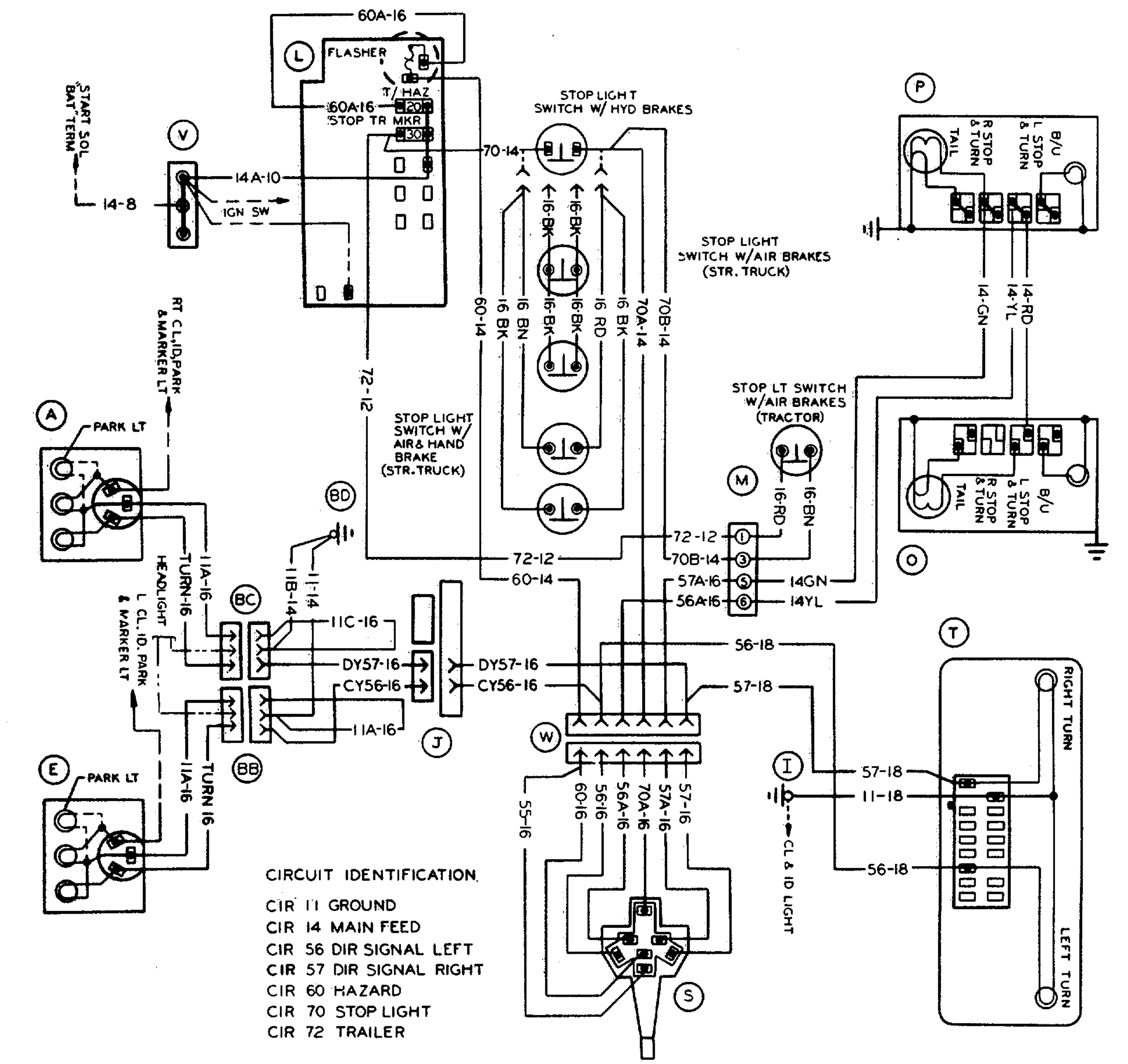
MT-23717 CLEARANCE – IDENTIFICATION – PARK & MARKER LT WIRING 1600-1900 LH DR



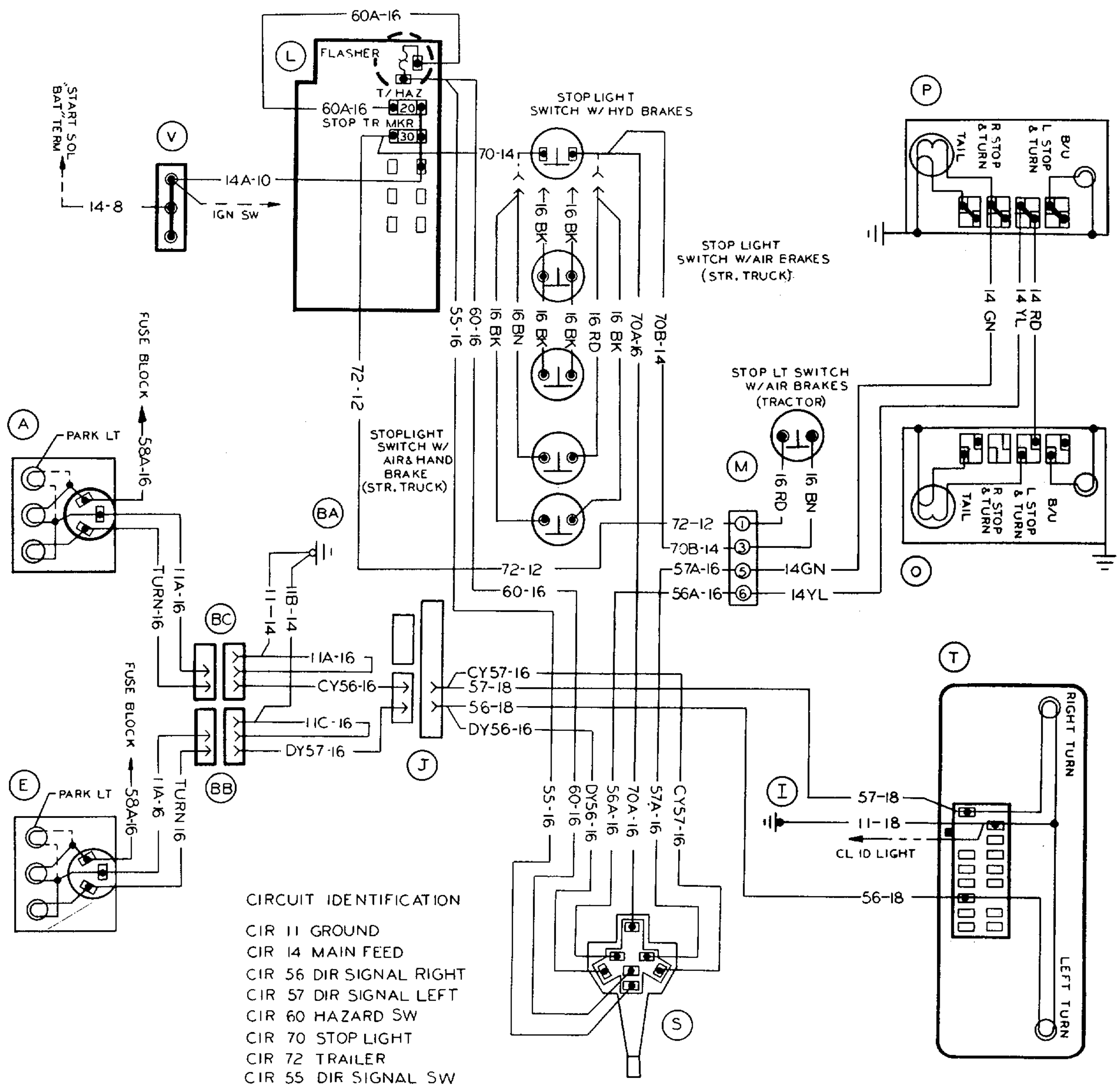
TAIL, BACK-UP & LICENSE PLATE LIGHT WIRING (1600 - 2600)



TAIL, BACK-UP & LICENSE PLATE LIGHT WIRING (FBC / BUS) **MT-23718**



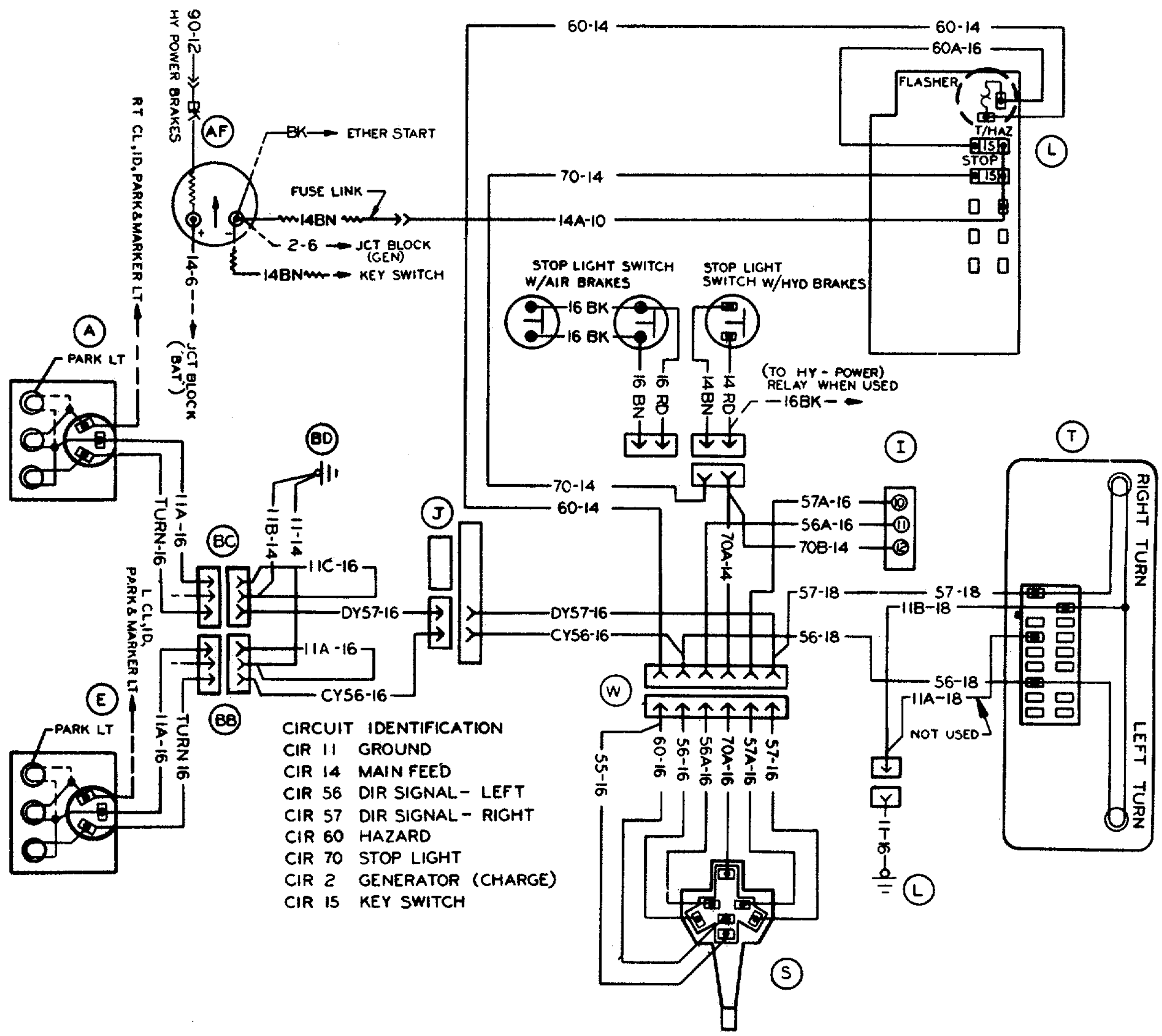
MT-23722 TURN HAZARD & STOP LIGHT WIRING LH DR 1600,1700 . 1800 & 1900



CIRCUIT IDENTIFICATION

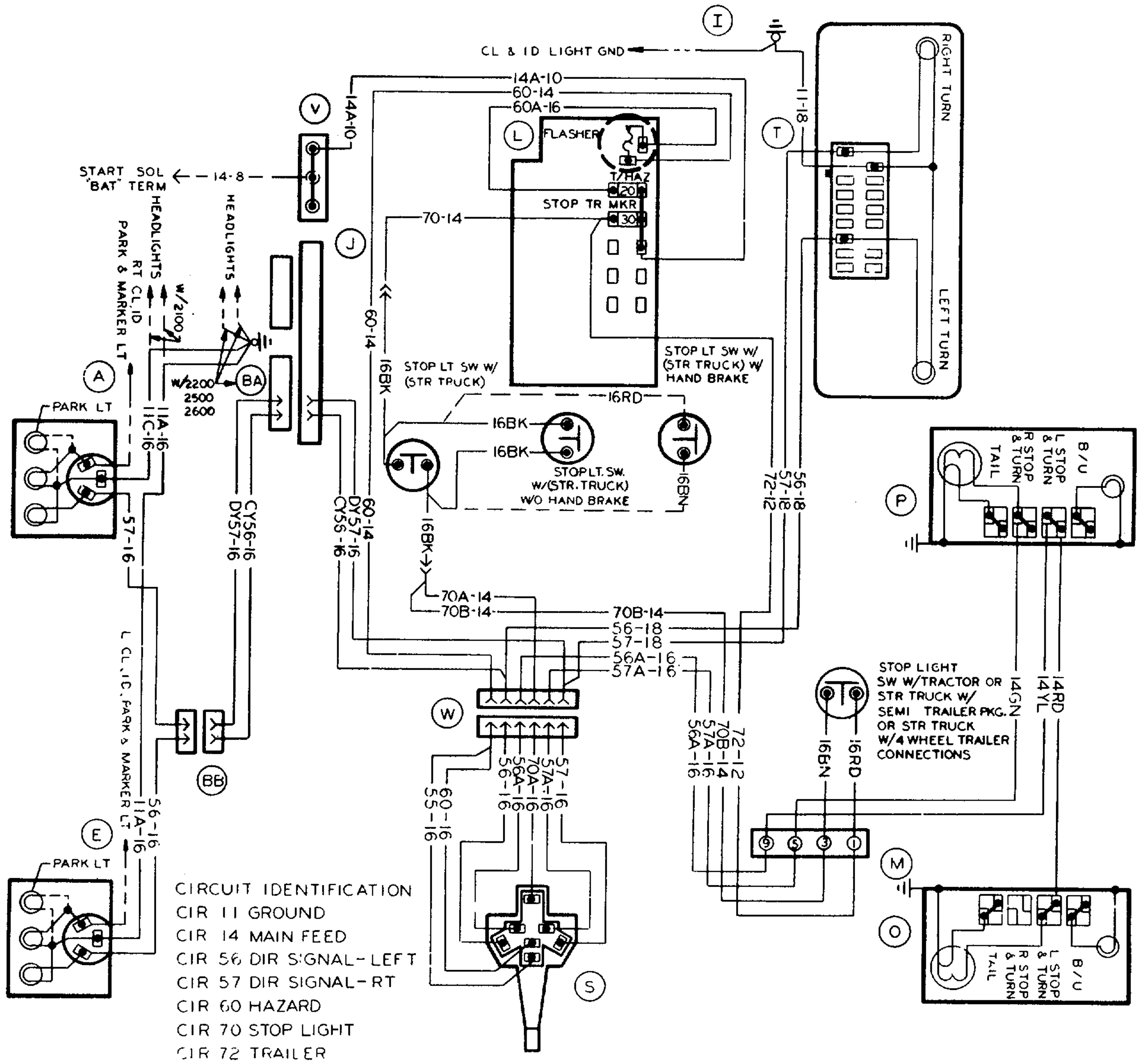
CIR 11 GROUND
CIR 14 MAIN FEED
CIR 56 DIR SIGNAL RIGHT
CIR 57 DIR SIGNAL LEFT
CIR 60 HAZARD SW
CIR 70 STOP LIGHT
CIR 72 TRAILER
CIR 55 DIR SIGNAL SW

MT-23720 TURN HAZARD & STOP LIGHT WIRING RH DR 1700 1800 & 1900



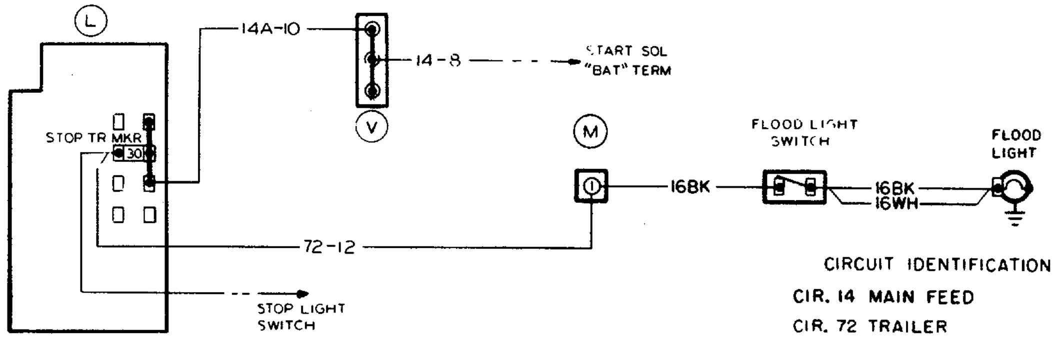
MT-23721

TURN HAZARD & STOP LIGHT WIRING - FBC/BUS

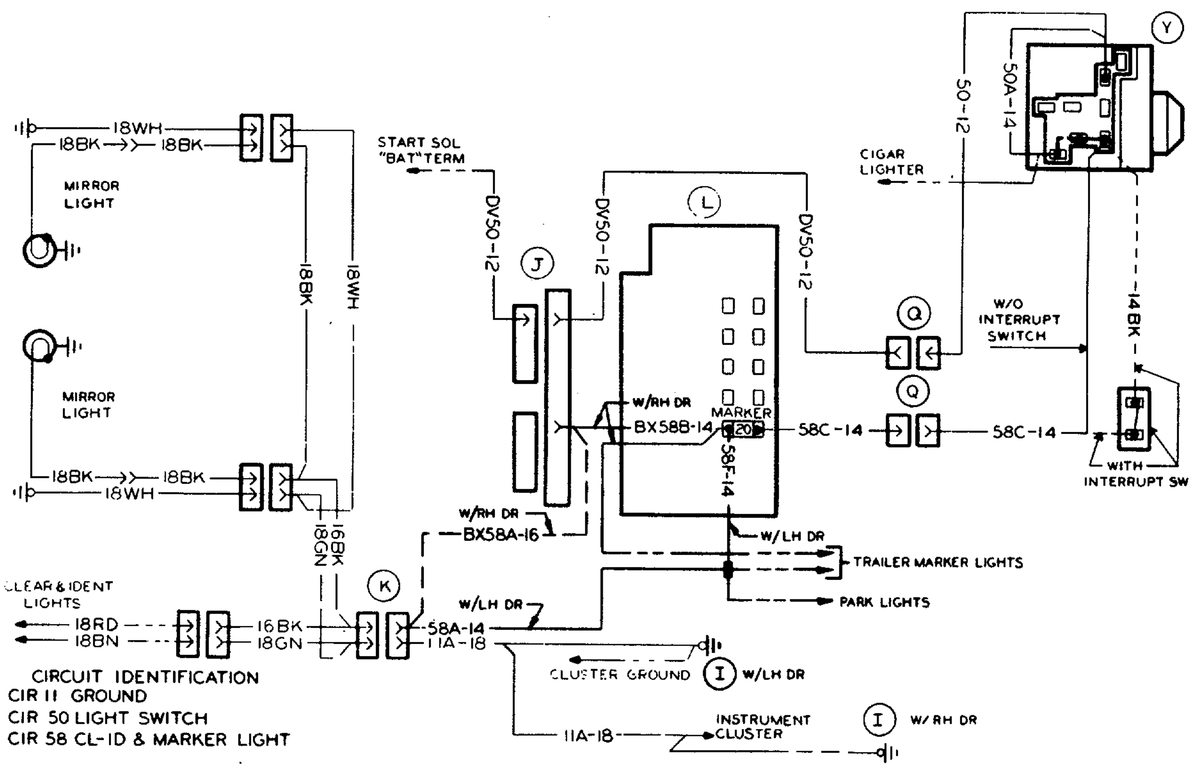


MT-23719

TURN, HAZARD & STOP LIGHT WIRING
2100, 2200, 2500 & 2600

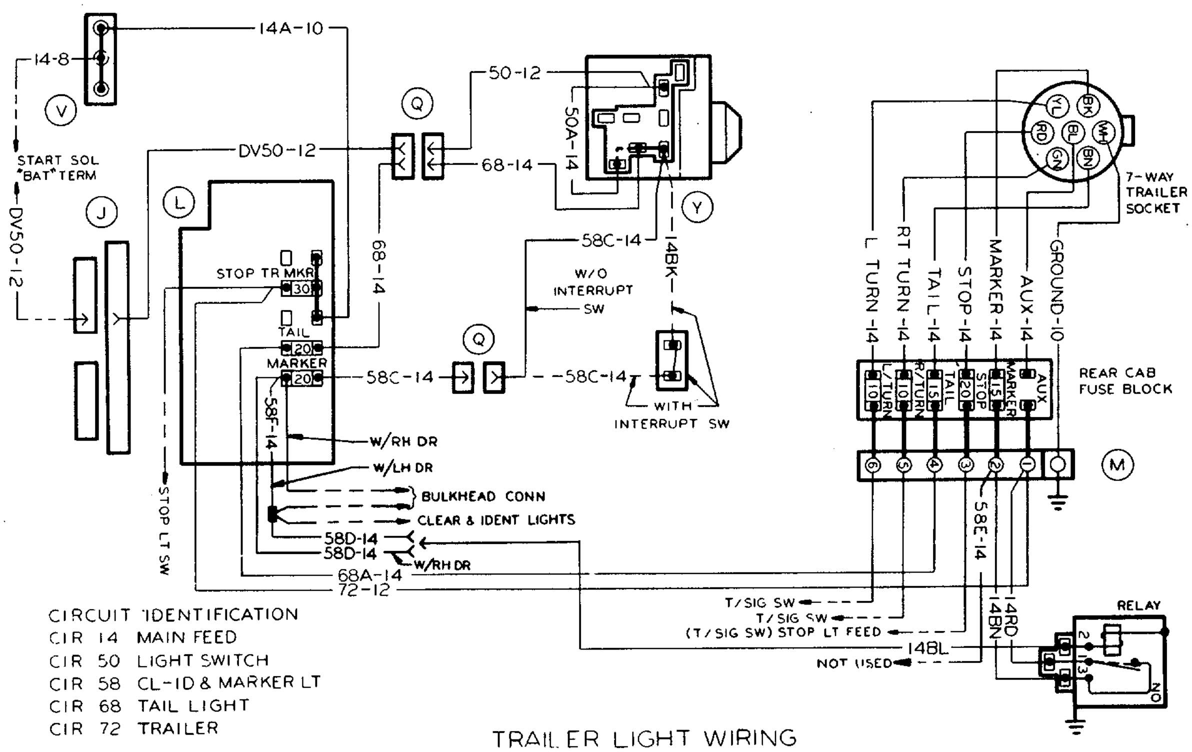


FLOOD LIGHT WIRING



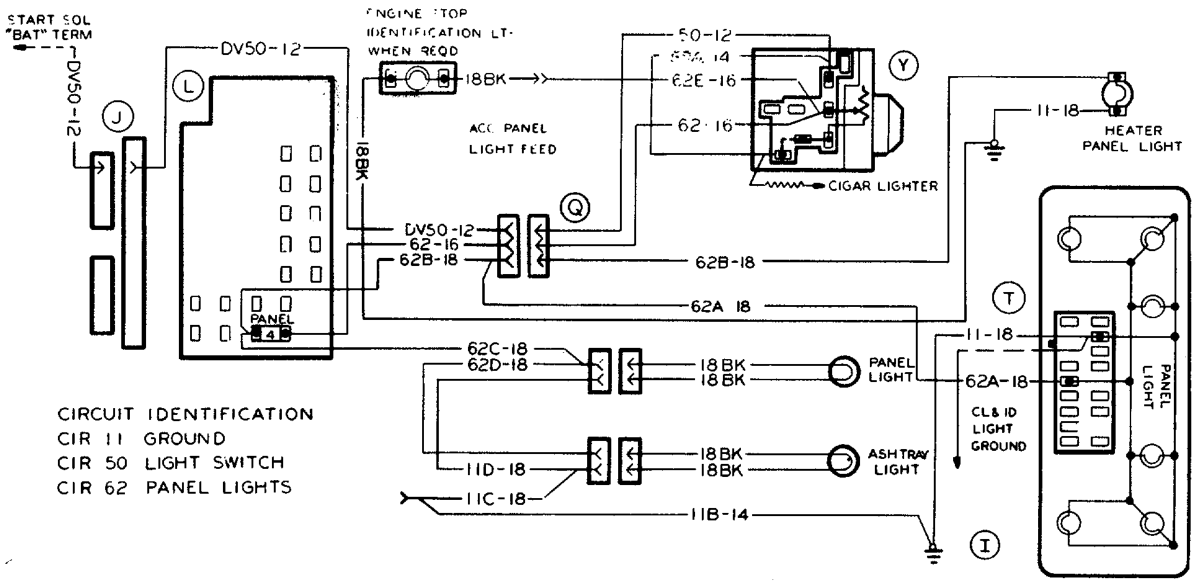
MT-23723

LIGHTED MIRROR WIRING

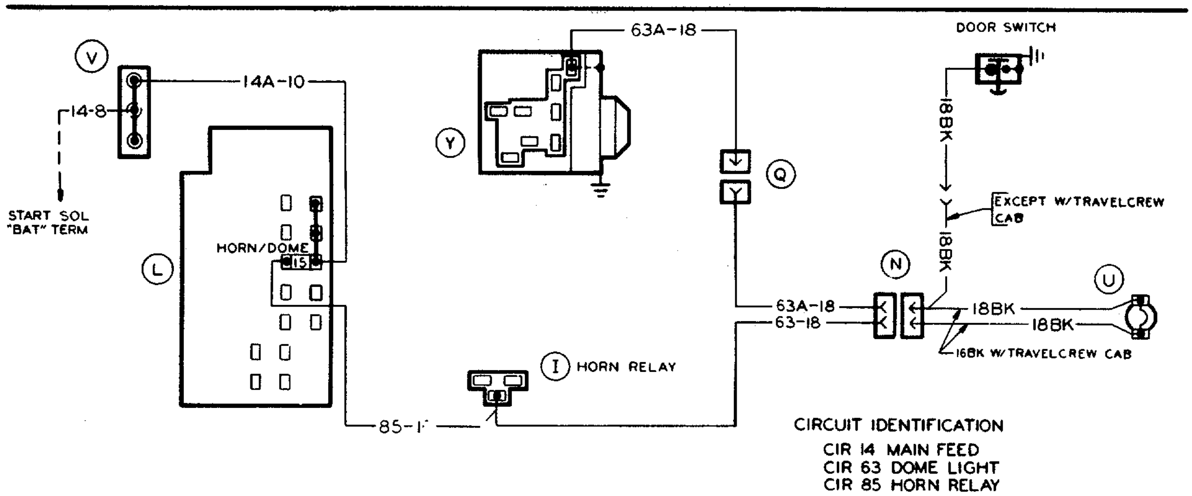


TRAILER LIGHT WIRING

MT-23724

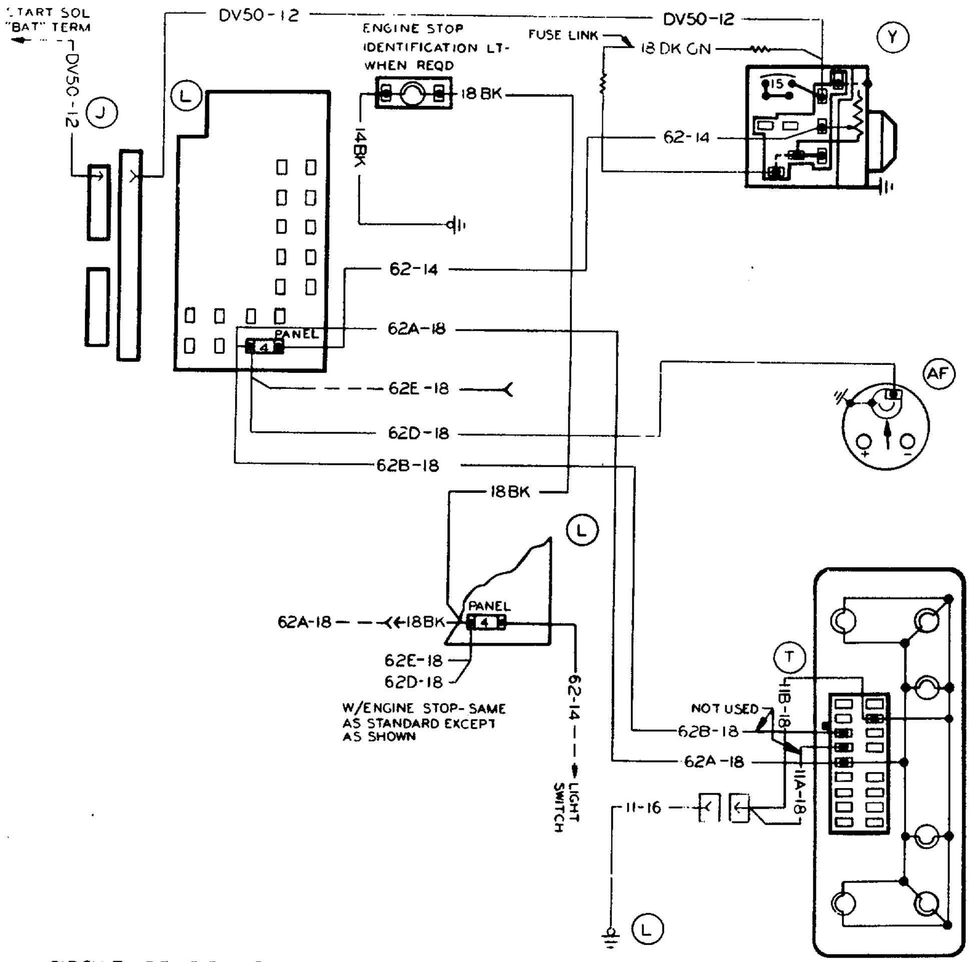


INSTRUMENT PANEL AND CONTROL IDENTIFICATION ILLUMINATION-RH DR



DOME LIGHT WIRING

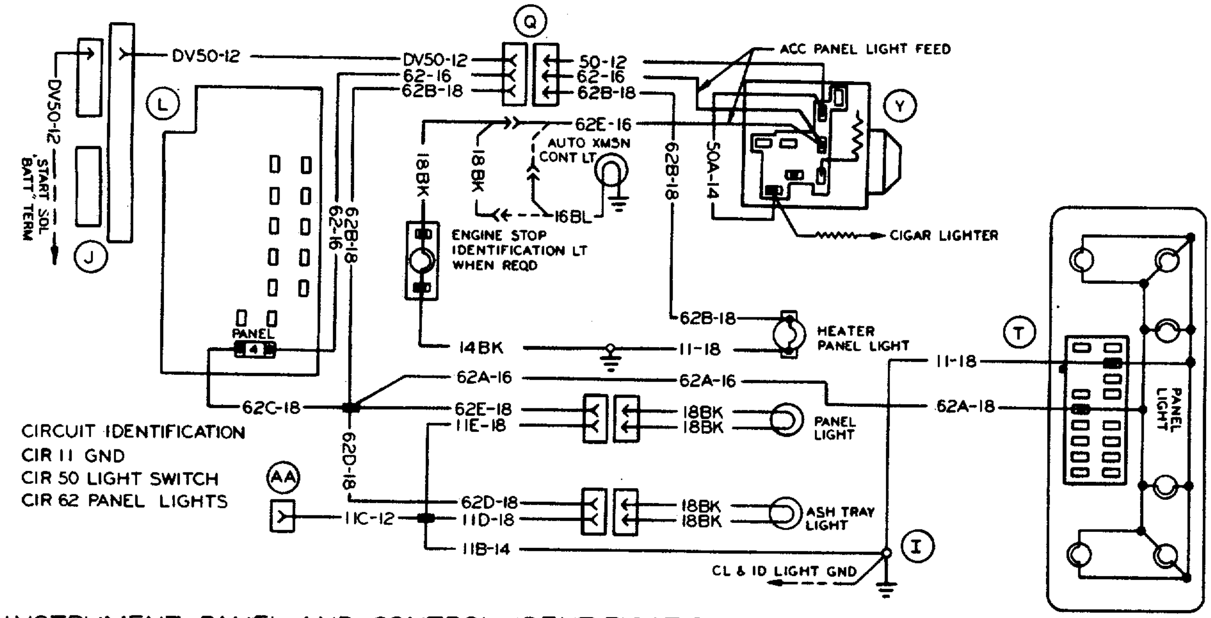
MT-23725



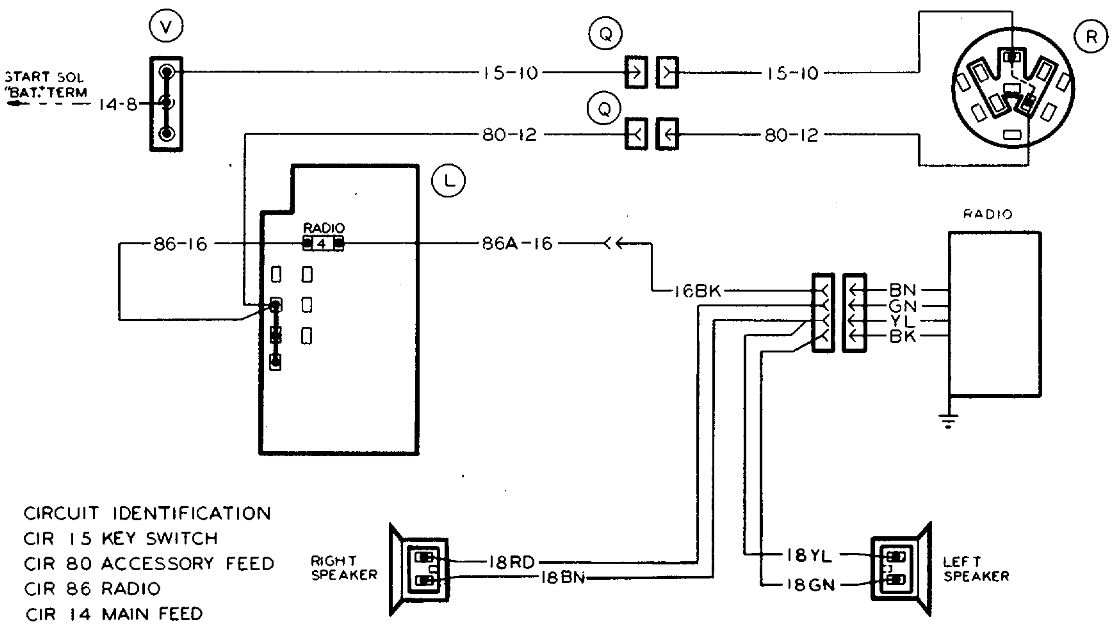
CIRCUIT IDENTIFICATION
CIR 11 GROUND
CIR 50 LIGHT SWITCH
CIR 62 PANEL LIGHTS

MT-23726

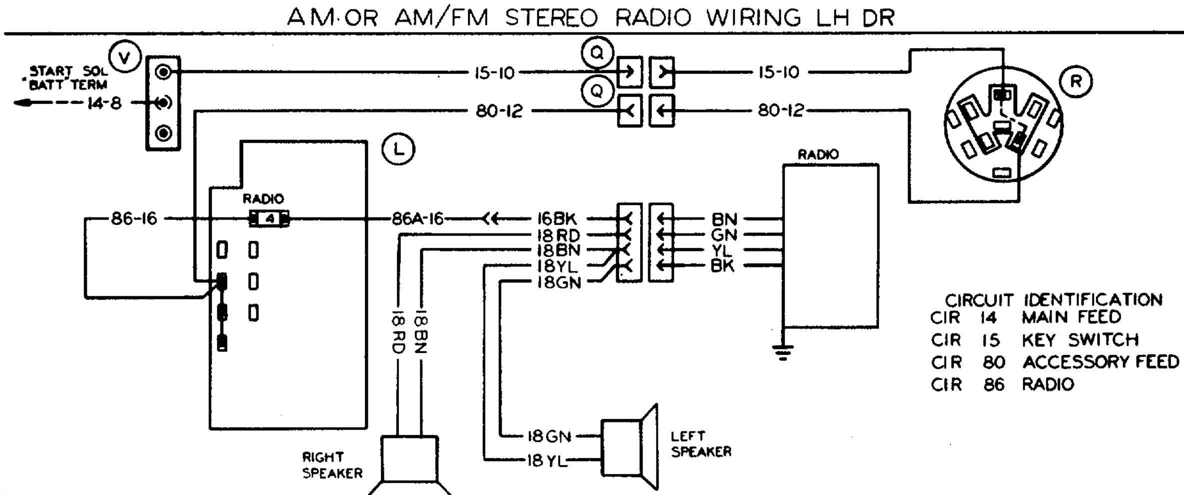
INSTRUMENT PANEL AND CONTROL IDENTIFICATION ILLUMINATION - FBC/BUS



INSTRUMENT PANEL AND CONTROL IDENTIFICATION ILLUMINATION LH DR MT-23727

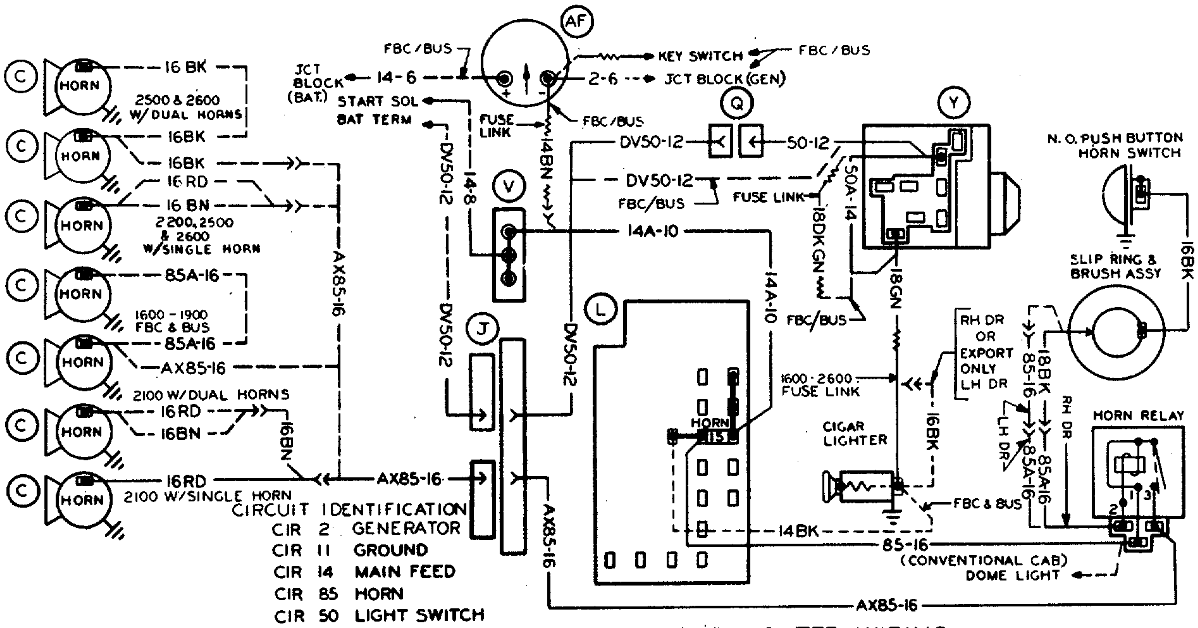


AM·OR AM/FM STEREO RADIO WIRING LH DR

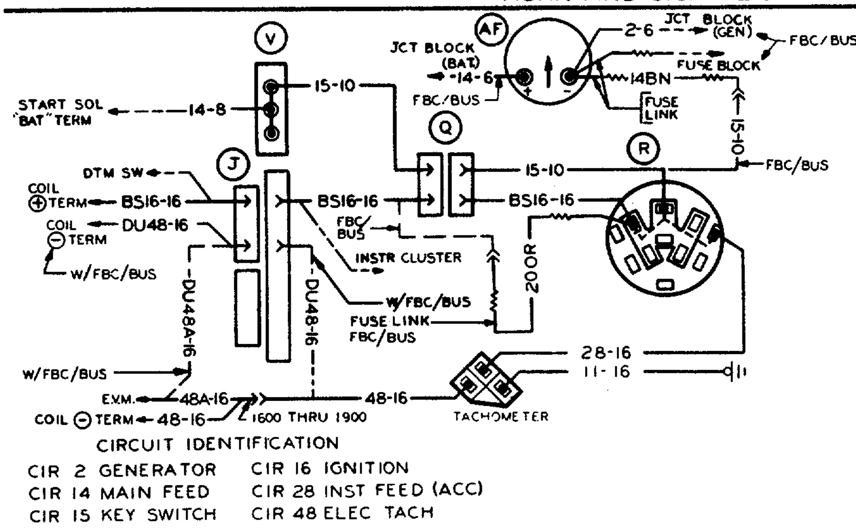


AM OR AM/FM STEREO RADIO WIRING RH DR

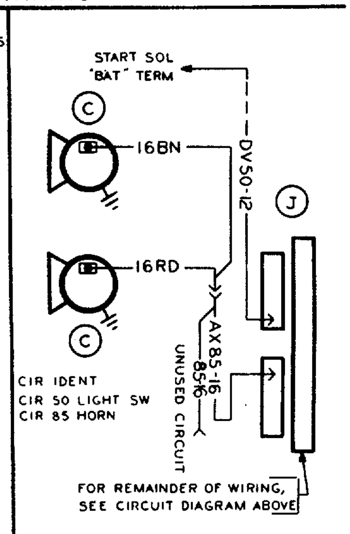
MT-23731



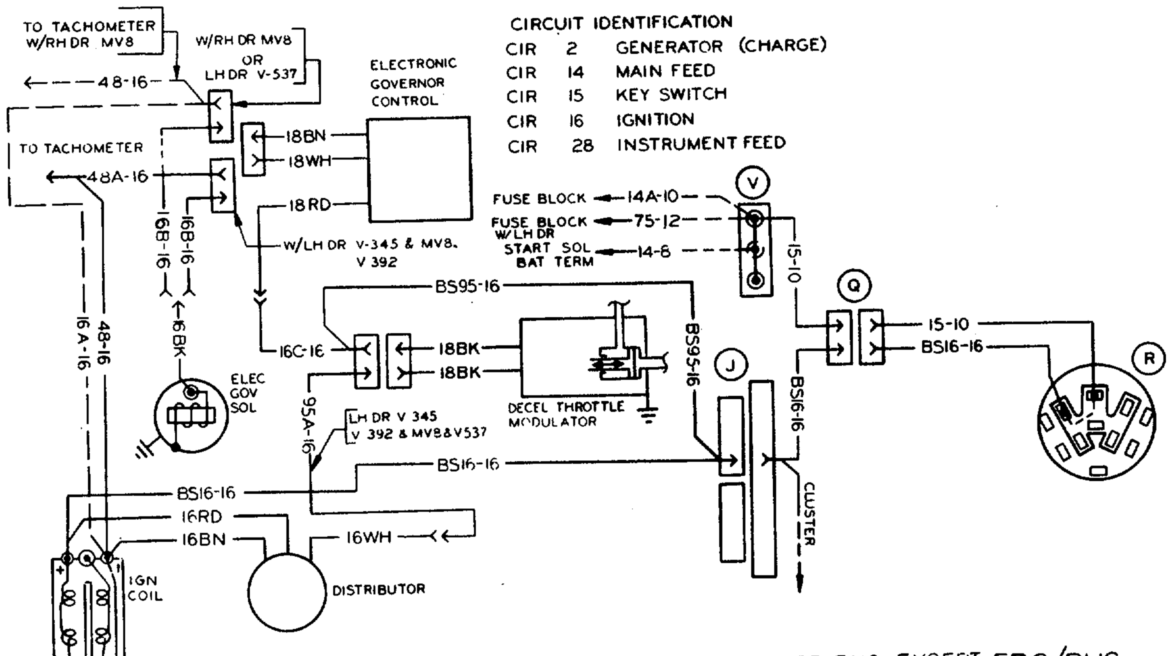
HORN AND CIGAR LIGHTER WIRING



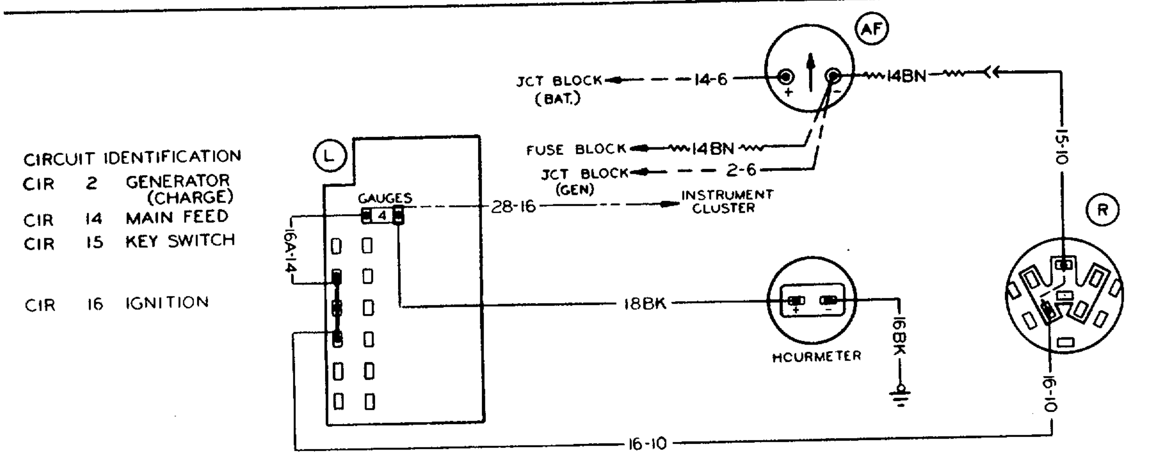
ELECTRIC TACHOMETER WIRING (GAS ENGINES) **MT-23732**



HORN WIRING RH DR

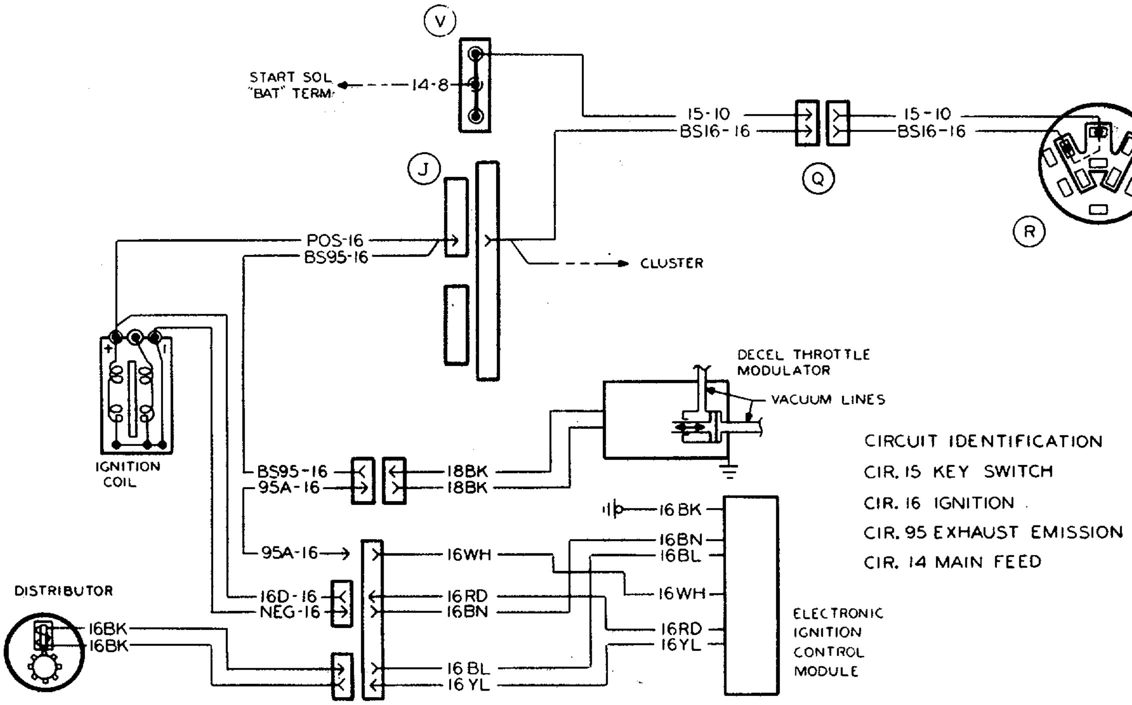


ELECTRONIC IGNITION V-345, V-392, MV8 & V537 ENG EXCEPT FBC/BUS

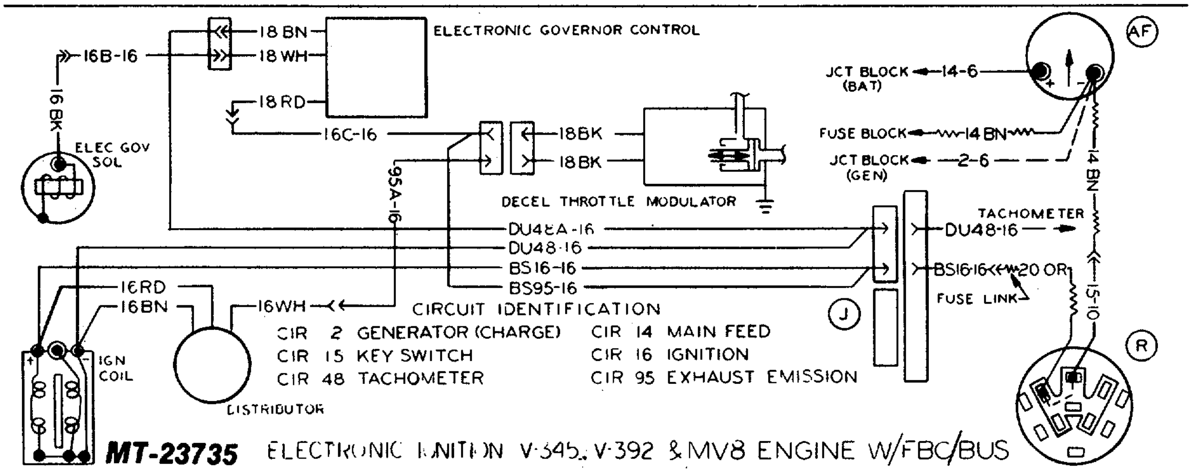


HOURMETER WIRING FBC/BUS

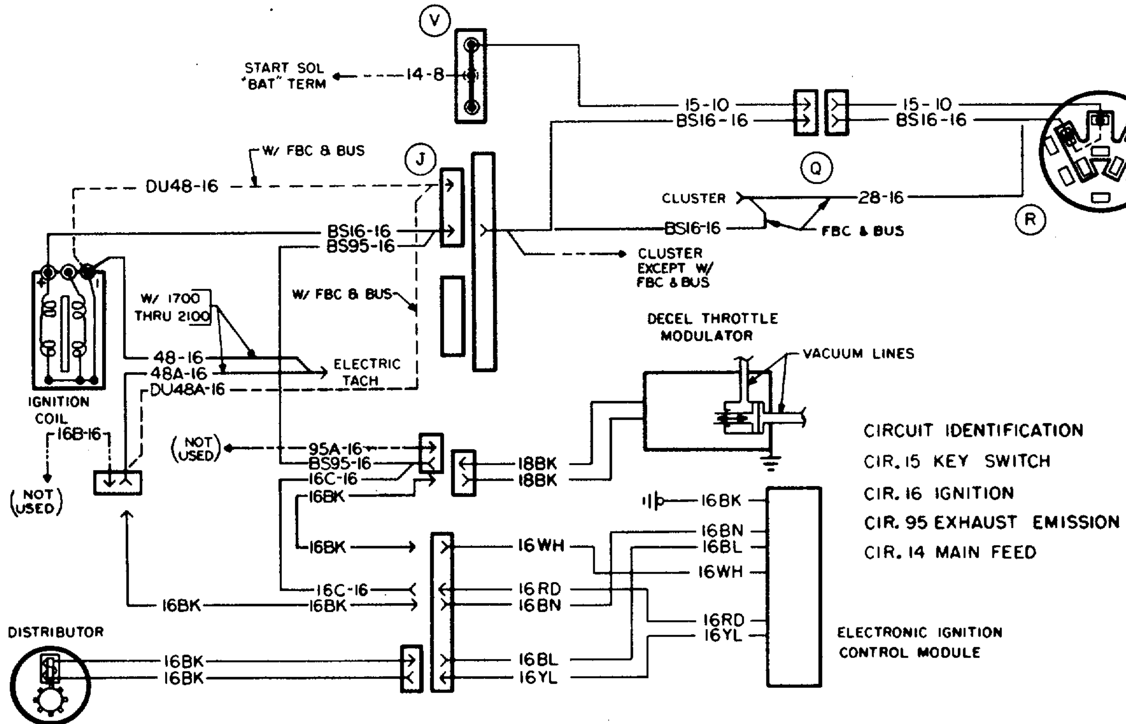
MT-23736



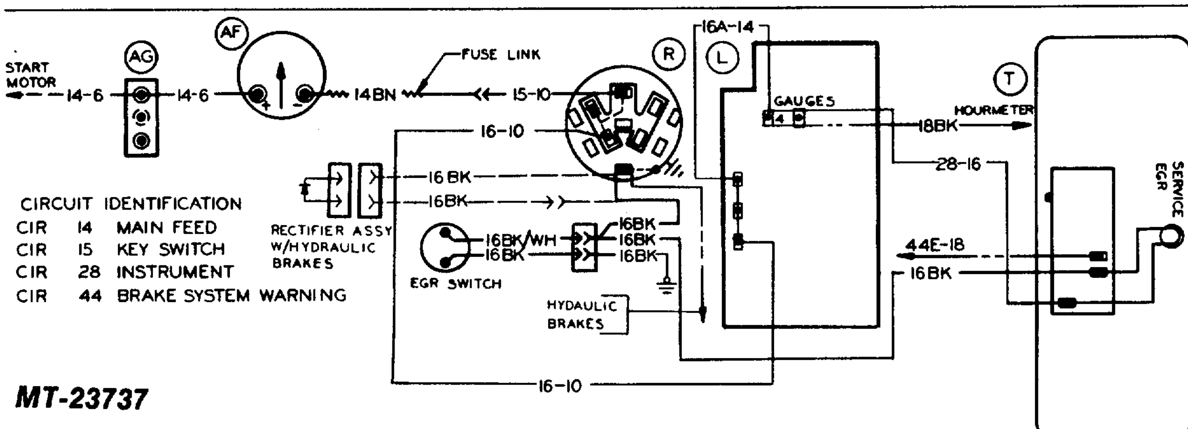
ELECTRONIC IGNITION SYSTEM V-537 ENGINE WIRING 2500 & 2600
W/2 WIRE DISTRIBUTOR & EXTERNAL IGNITION CONTROL MODULE



MT-23735 ELECTRONIC IGNITION V-345, V-392 & MV8 ENGINE W/FBC/BUS

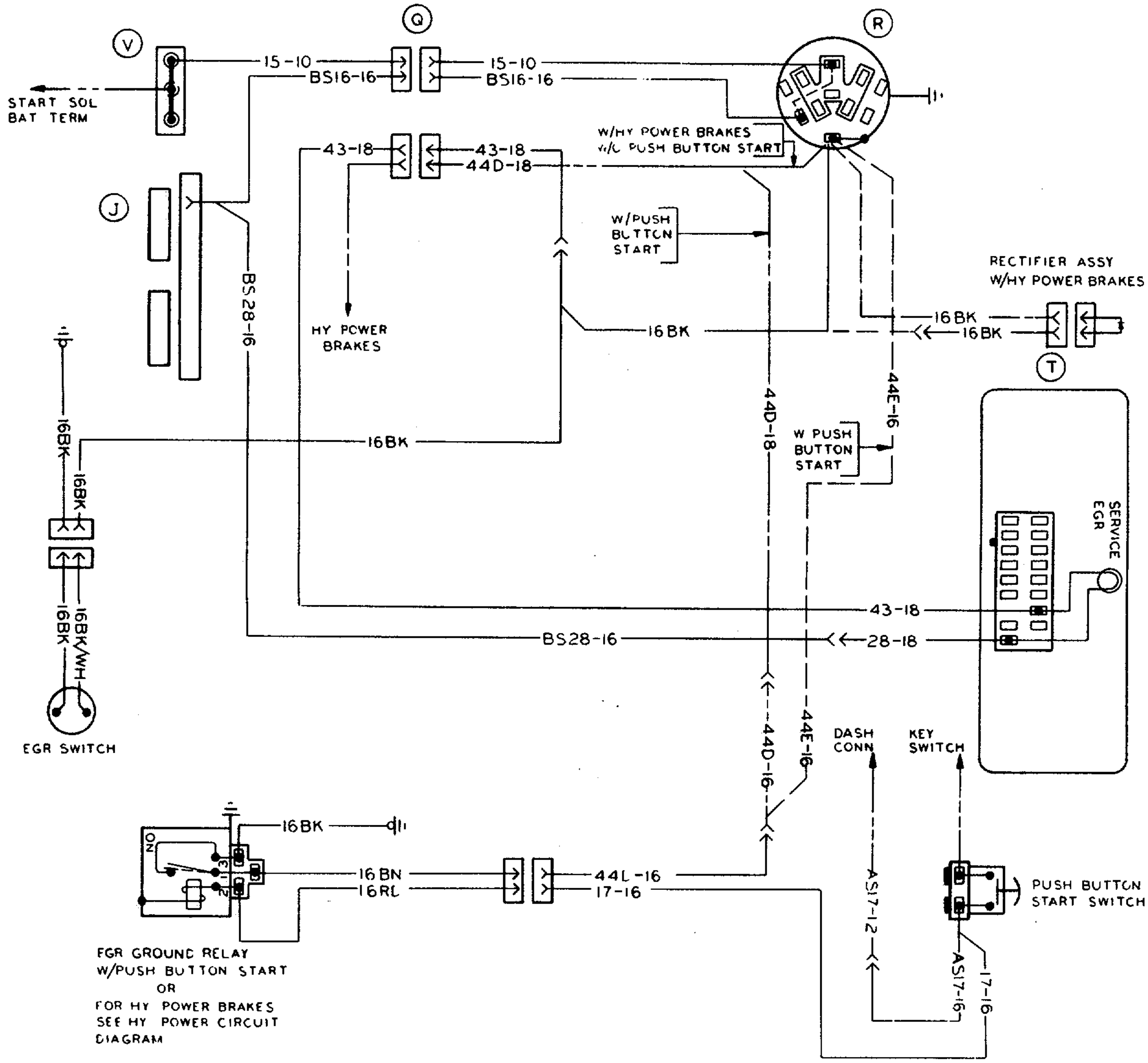


ELECTRONIC IGNITION SYSTEM MV8 ENGINE WIRING
W/ HOLLEY DISTRIBUTOR

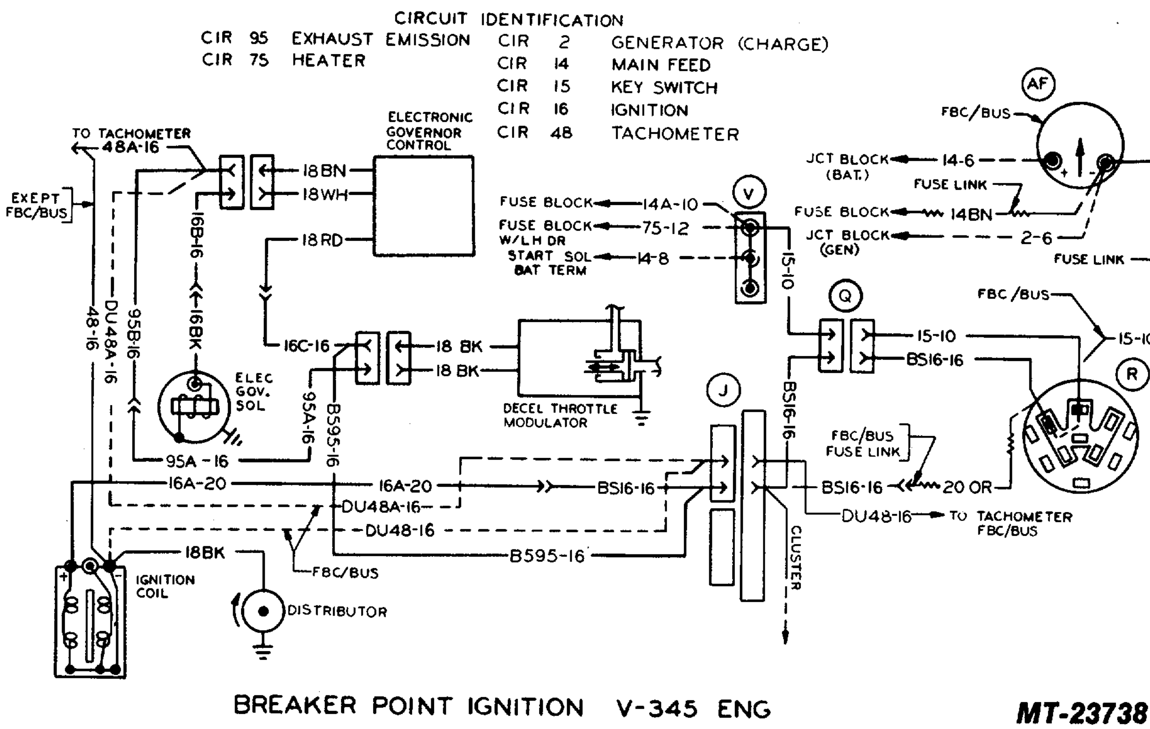


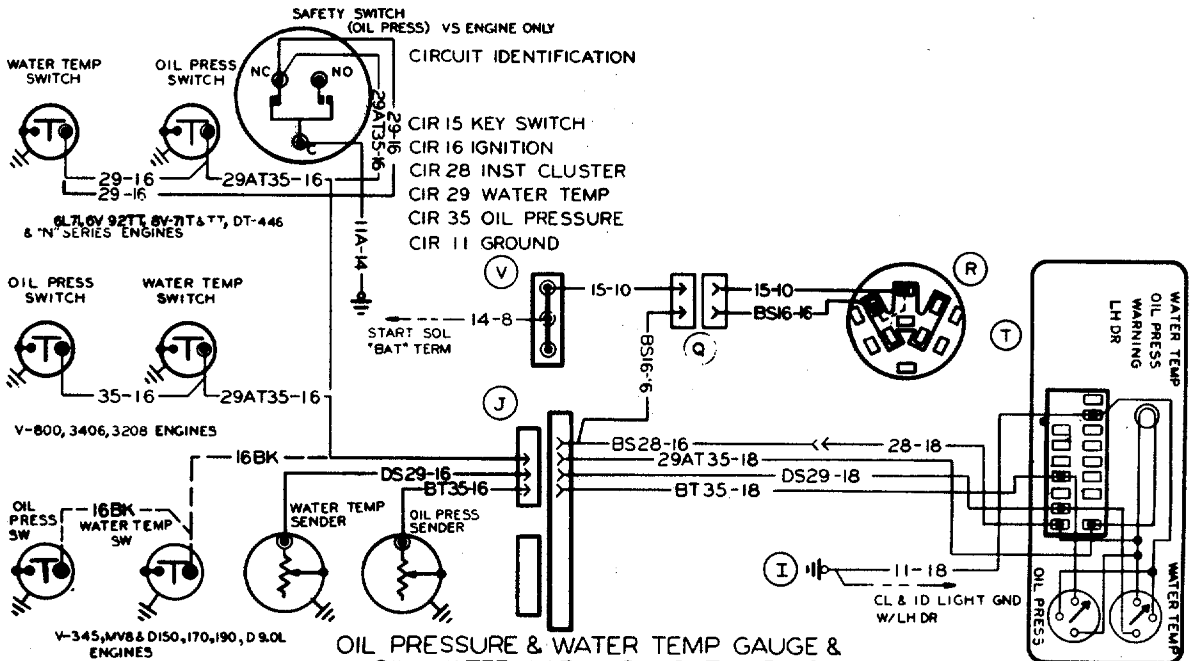
MT-23737

EGR SERVICE WARNING LIGHT WIRING W/FBC & BUS

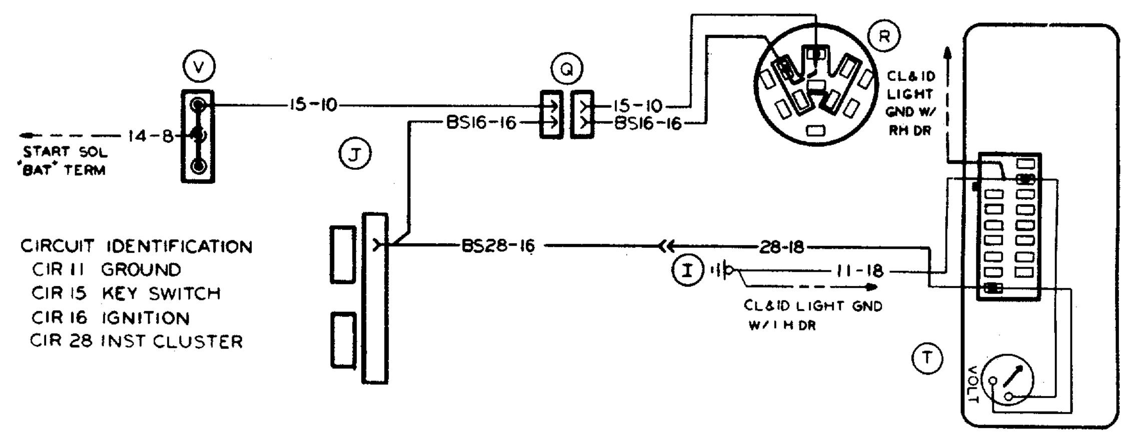


EGR SERVICE WARNING LIGHT WIRING 1600 THRU 1800 **MT-23739**


CIRCUIT IDENTIFICATION
CIR 95 EXHAUST EMISSION
CIR 75 HEATER
CIR 2 GENERATOR (CHARGE)
CIR 14 MAIN FEED
CIR 15 KEY SWITCH
CIR 16 IGNITION
CIR 48 TACHOMETER
TO TACHOMETER 48A-16
EXEPT FBC/BUS
ELECTRONIC GOVERNOR CONTROL
18BN
18WH
18RD
16B-16
16BK
95B-16
DU48A-16
48-16
ELEC GOV. SOL
16C-16
18 BK
18 BK
95A-16
B595-16
DECEL THROTTLE MODULATOR
95A - 16
16A-20
16A-20
BS16-16
DU48A-16
DU48-16
18BK
B595-16
FBC/BUS
IGNITION COIL
DISTRIBUTOR
FUSE BLOCK 14A-10
FUSE BLOCK W/LH DR 75-12
START SOL BAT TERM 14-8
15-10
BS16-16
CLUSTER
JCT BLOCK (BAT.) 14-6
FUSE LINK
FUSE BLOCK 14BN
JCT BLOCK (GEN) 2-6
FUSE LINK
14BN
FBC/BUS
FBC /BUS
15-10
15-10
BS16-16
FBC/BUS FUSE LINK
BS16-16
20 OR
DU48-16 TO TACHOMETER FBC/BUS
AF
V
Q
J
R
BREAKER POINT IGNITION V-345 ENG
MT-23738

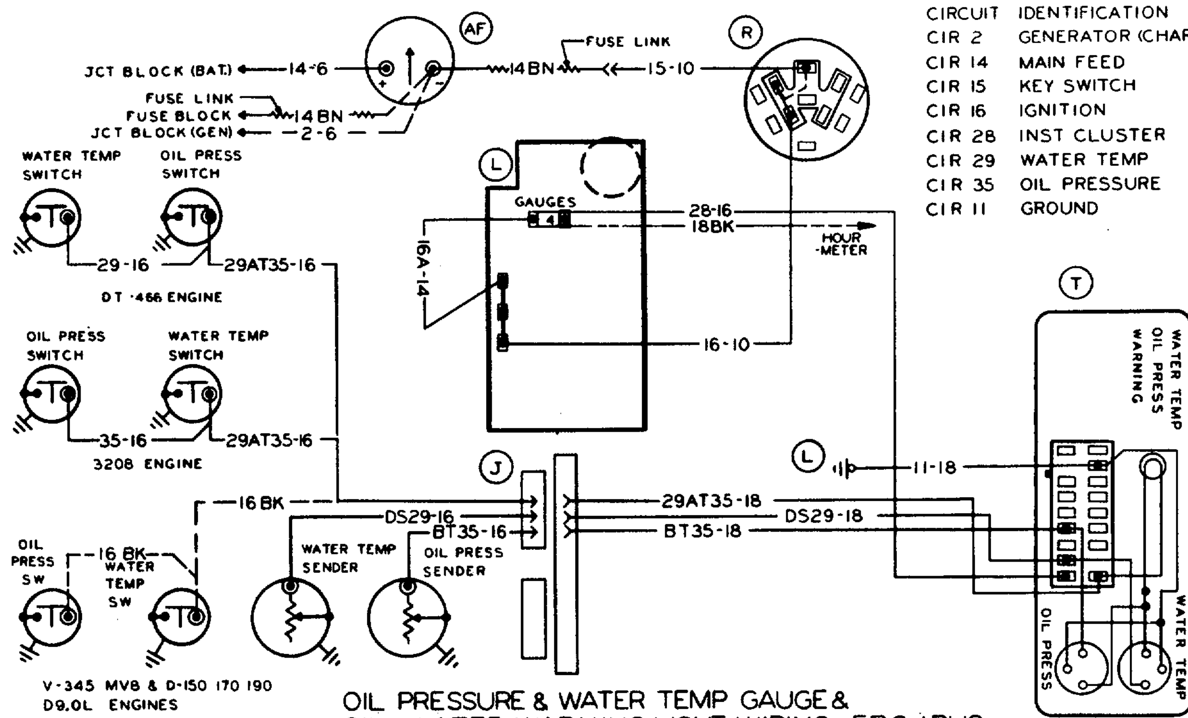


OIL PRESSURE & WATER TEMP GAUGE & OIL/WATER WARNING LIGHT WIRING EXCEPT FBC/BUS



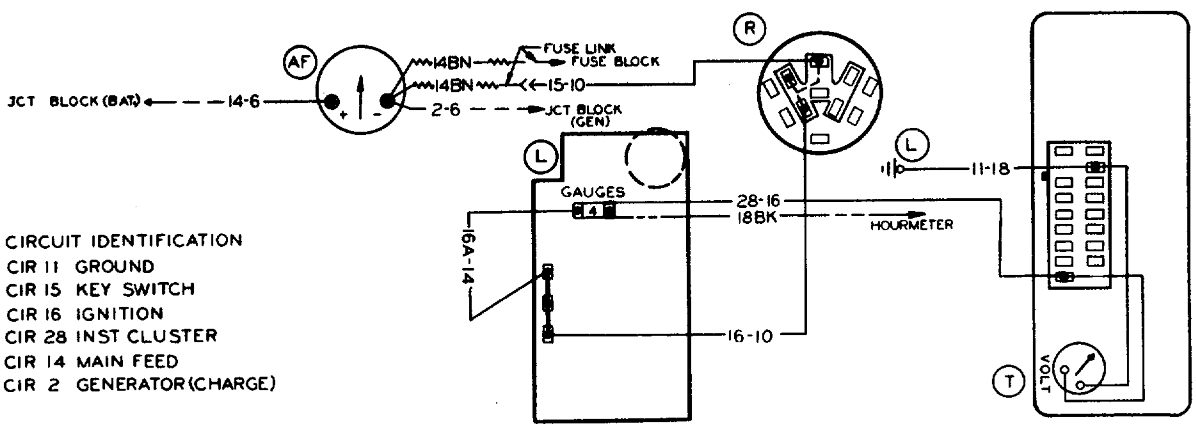
VOLTMETER WIRING EXCEPT FBC/BUS

MT-23745



OIL PRESSURE & WATER TEMP GAUGE & OIL/WATER WARNING LIGHT WIRING FBC/BUS

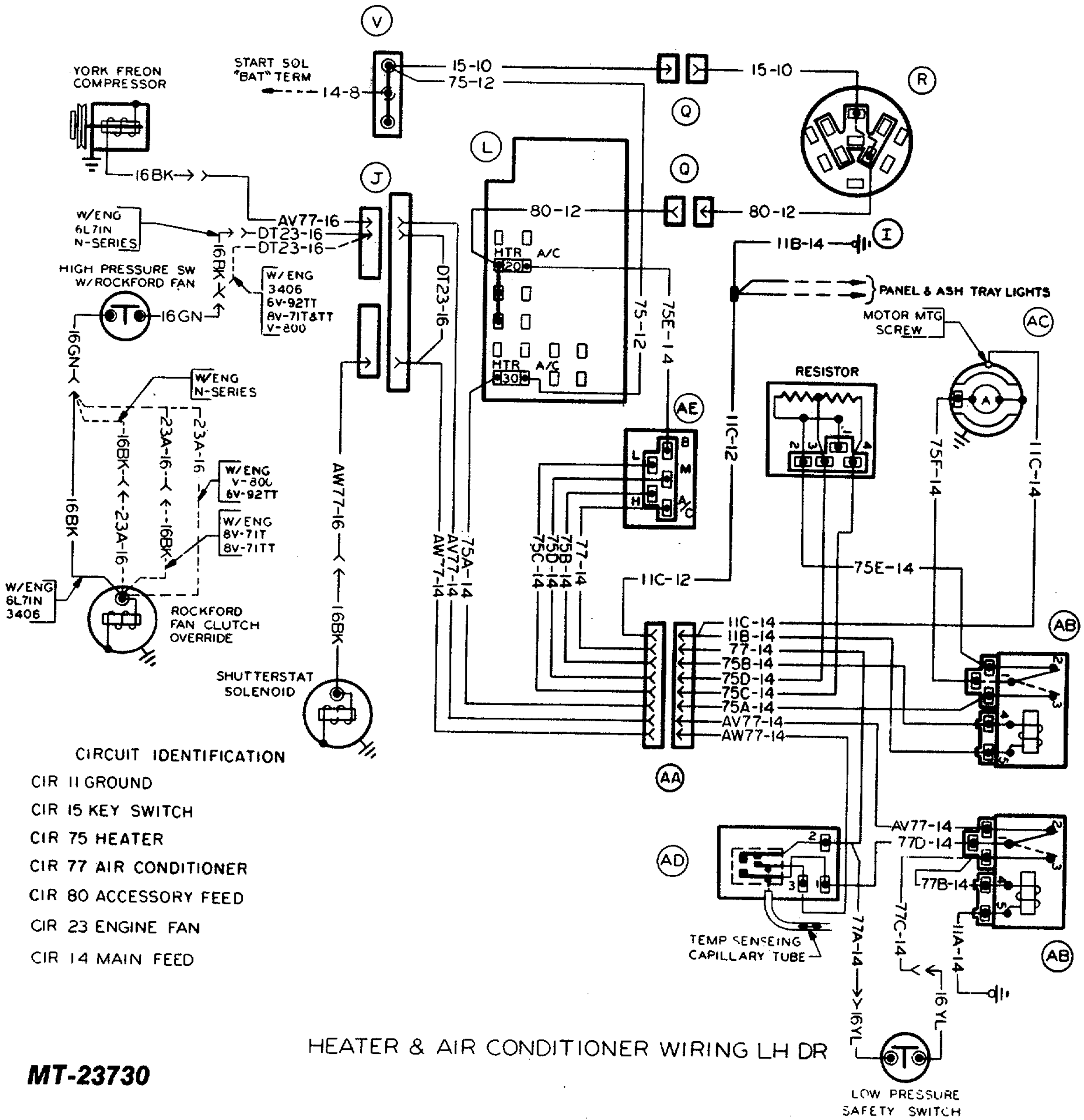
CIRCUIT	IDENTIFICATION
CIR 2	GENERATOR (CHARGE)
CIR 14	MAIN FEED
CIR 15	KEY SWITCH
CIR 16	IGNITION
CIR 28	INST CLUSTER
CIR 29	WATER TEMP
CIR 35	OIL PRESSURE
CIR 11	GROUND



CIRCUIT IDENTIFICATION
CIR 11 GROUND
CIR 15 KEY SWITCH
CIR 16 IGNITION
CIR 28 INST CLUSTER
CIR 14 MAIN FEED
CIR 2 GENERATOR (CHARGE)

VOLTMETER WIRING FBC/BUS

MT-23746

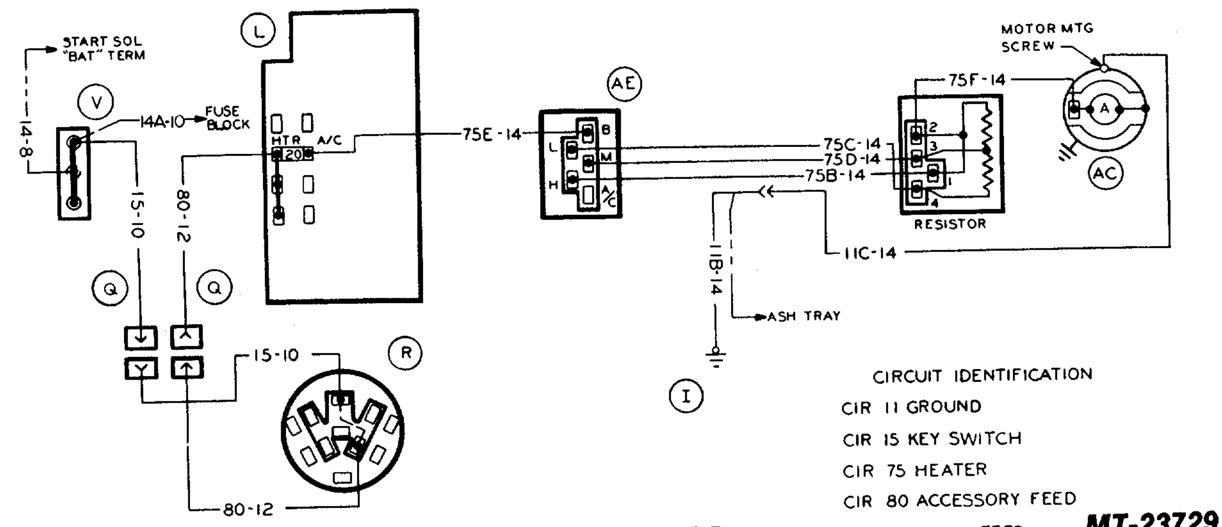


CIRCUIT IDENTIFICATION

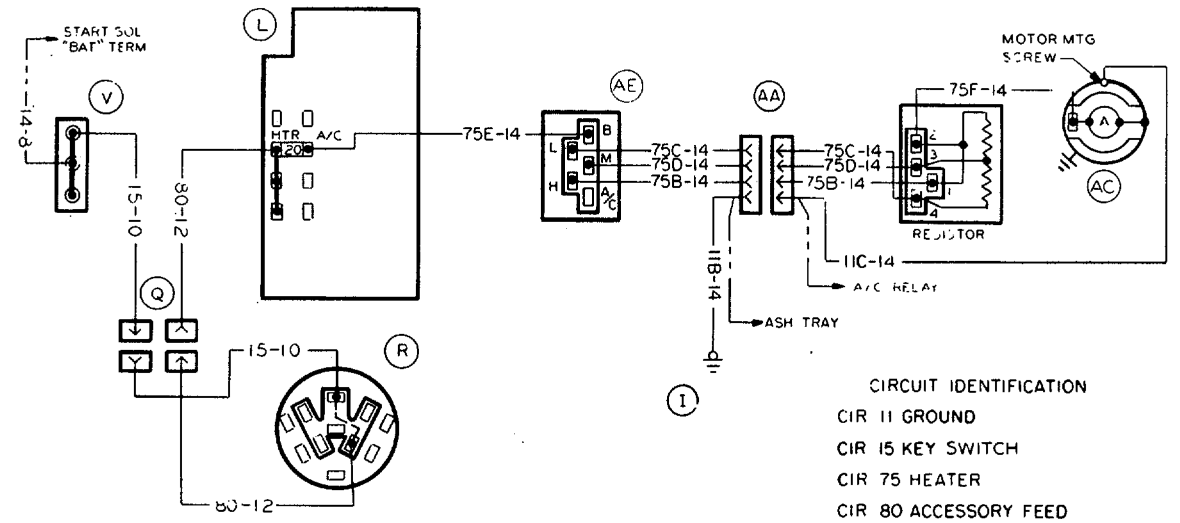
CIR 11 GROUND
CIR 15 KEY SWITCH
CIR 75 HEATER
CIR 77 AIR CONDITIONER
CIR 80 ACCESSORY FEED
CIR 23 ENGINE FAN
CIR 14 MAIN FEED

HEATER & AIR CONDITIONER WIRING LH DR

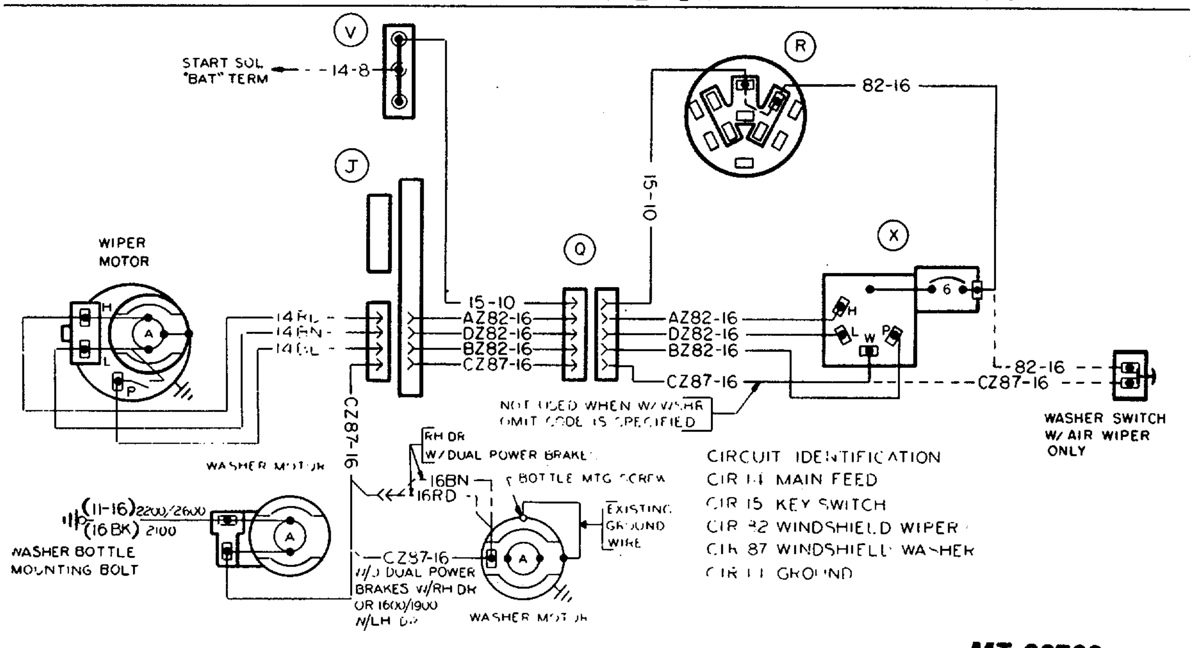
MT-23730



HEATER WIRING RH DR

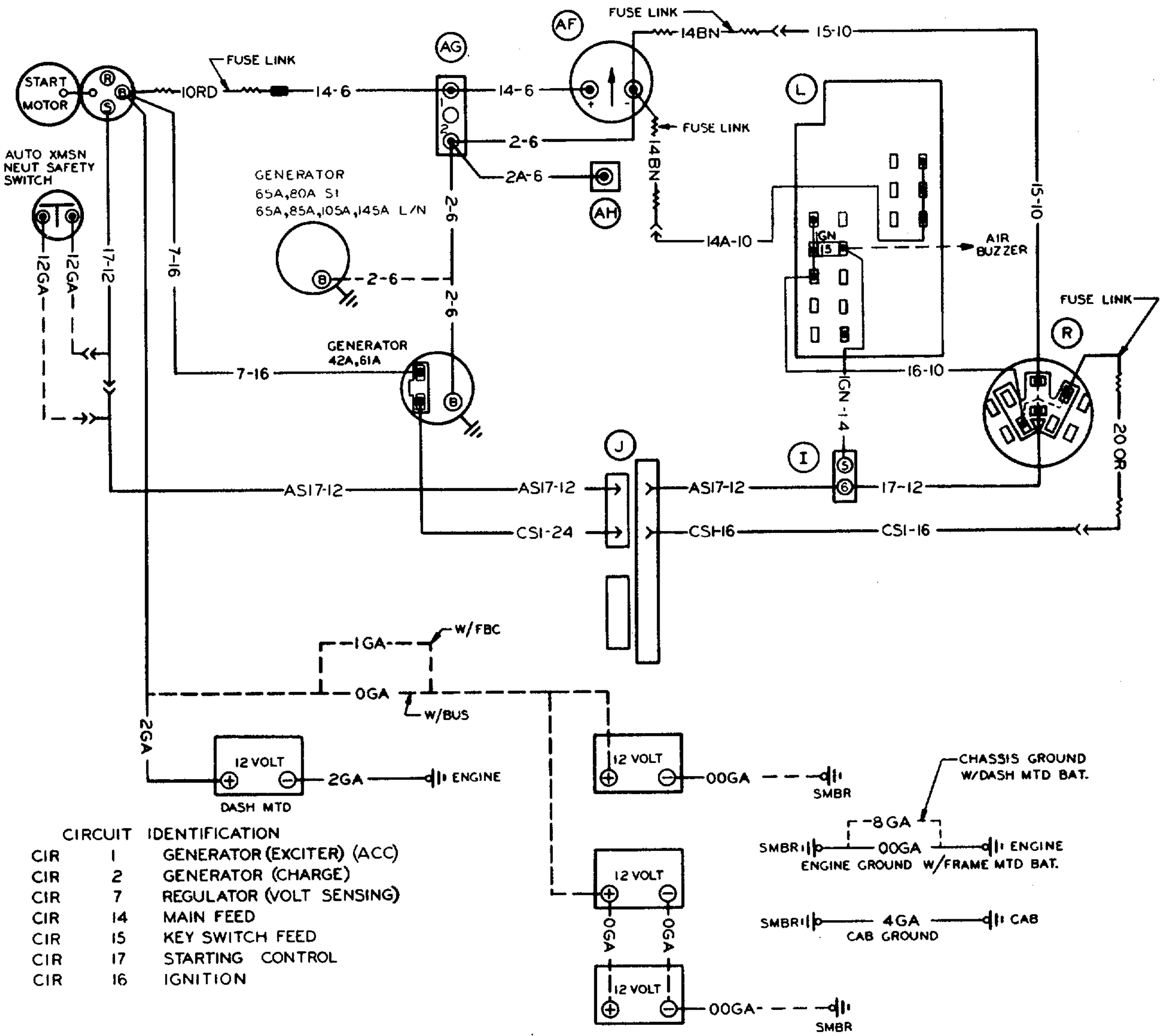


HEATER WIRING-LH DR



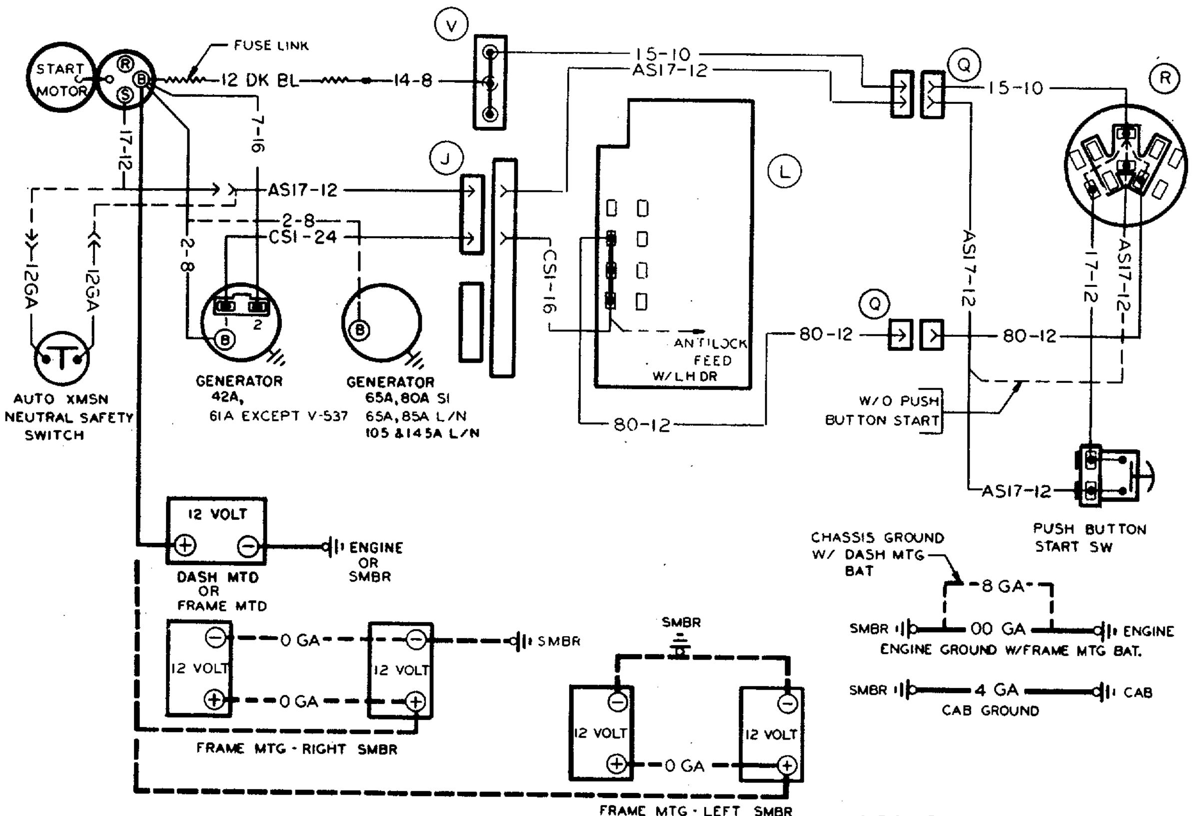
WIPER/ WASHER WIRING

MT-23728



MT-23733

V-392, MV8 & V-345 STARTING, CHARGING & MAJOR FEED & GROUND WIRING FBC/BUS

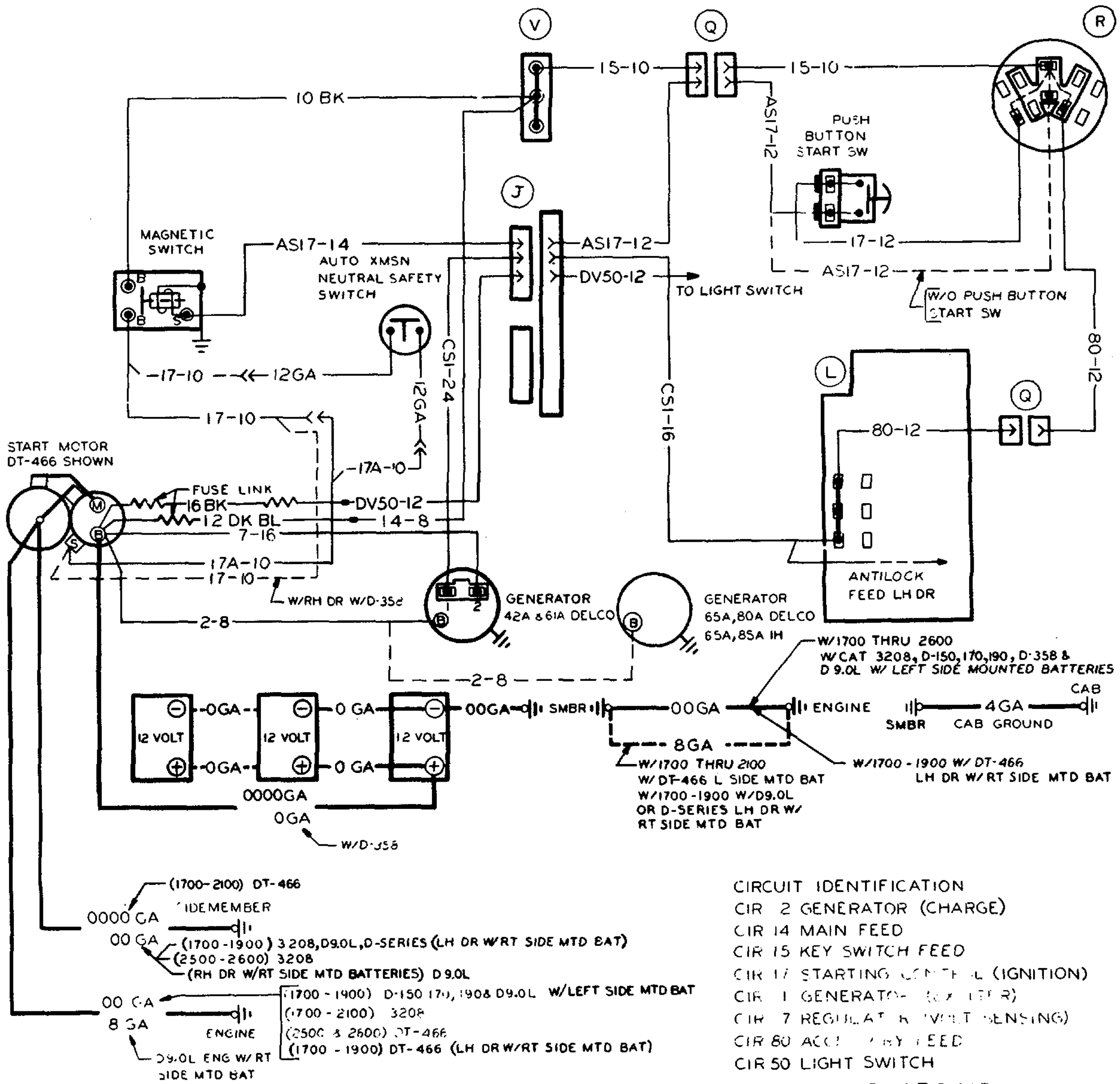


BATTERY LOCATION	BATTERY COMBINATION	POSITIVE CABLE GAUGE	NEGATIVE CABLE GAUGE	ENGINE	MODEL
DASH PANEL	1/ 12 VOLT	2	2	V-345, MV8 & V-392	1600 THRU 1900
LEFT SMBR	2/ 12 VOLT	1	00		
LEFT SMBR	1/ 12 VOLT	1	00		
LEFT SMBR	2/ 12 VOLT	1	00	V-537	2100
LEFT SMBR	1/ 12 VOLT	1	00		
RIGHT SMBR	1/ 12 VOLT	0	00	V-537	2500&2600-CONSTR
RIGHT SMBR	2/ 12 VOLT	0	00		
RIGHT SMBR	2/ 12 VOLT	2	00	V-345 V-392 & MV8	1700 THRU 1900

CIRCUIT IDENTIFICATION
CIR 1 GENERATOR (EXCITER)
CIR 2 GENERATOR (CHARGE)
CIR 7 REGULATOR (VOLT SENSING)
CIR 14 MAIN FEED
CIR 15 KEY SWITCH FEED
CIR 17 STARTING CONTROL
CIR 80 ACCESSORY FEED

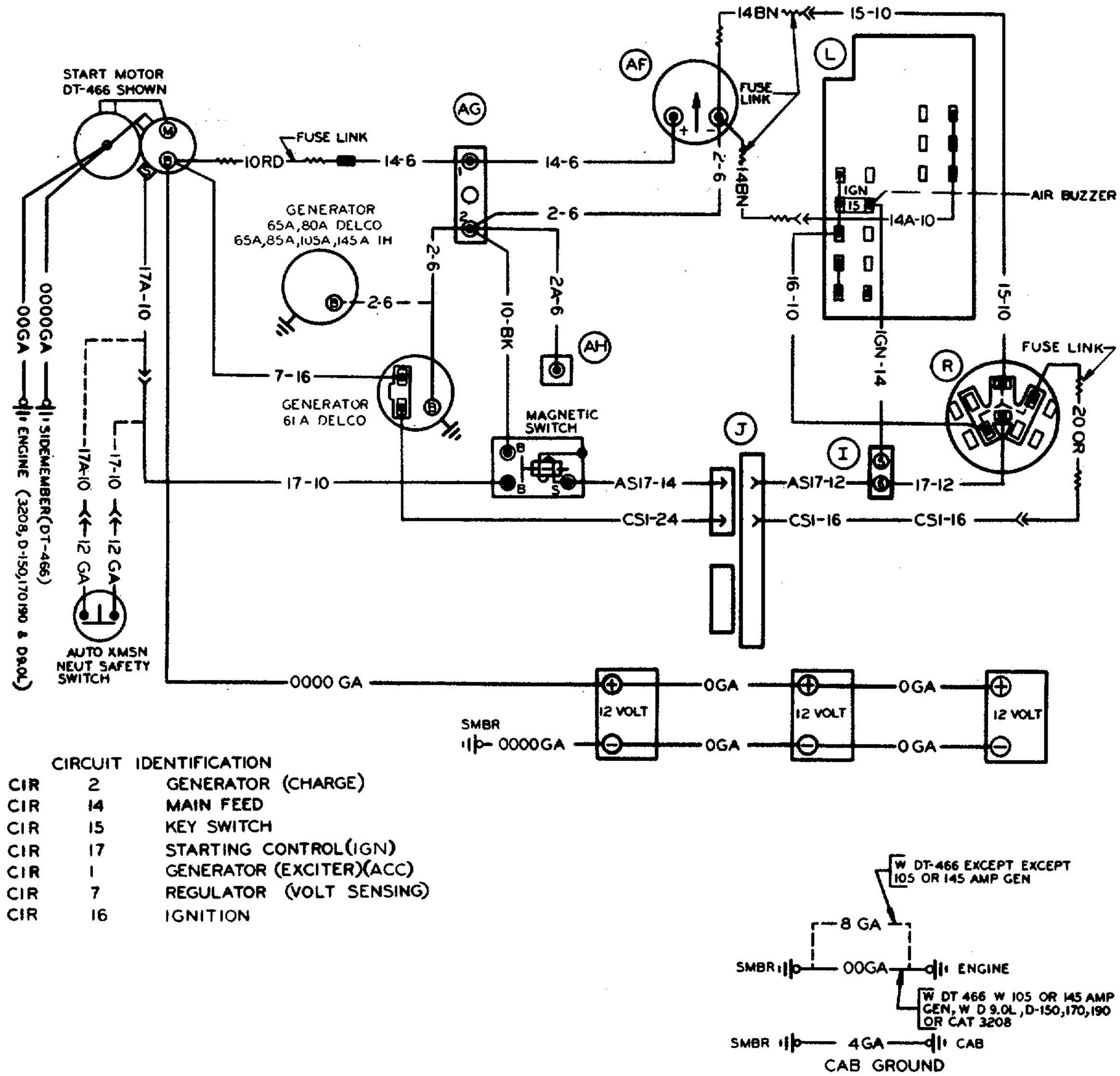
MT-23734

V-392, V-345,MV8 & V-537 STARTING, CHARGING & MAJOR FEED & GROUND WIRING



MT-23741

D-358, D9.0L, D-150, 170, 190, DT-466 & 3208 STARTING CHARGING
MAJOR FEED & GROUND WIRING 1600-2100, 2500-2600 CONSTRUCTOR

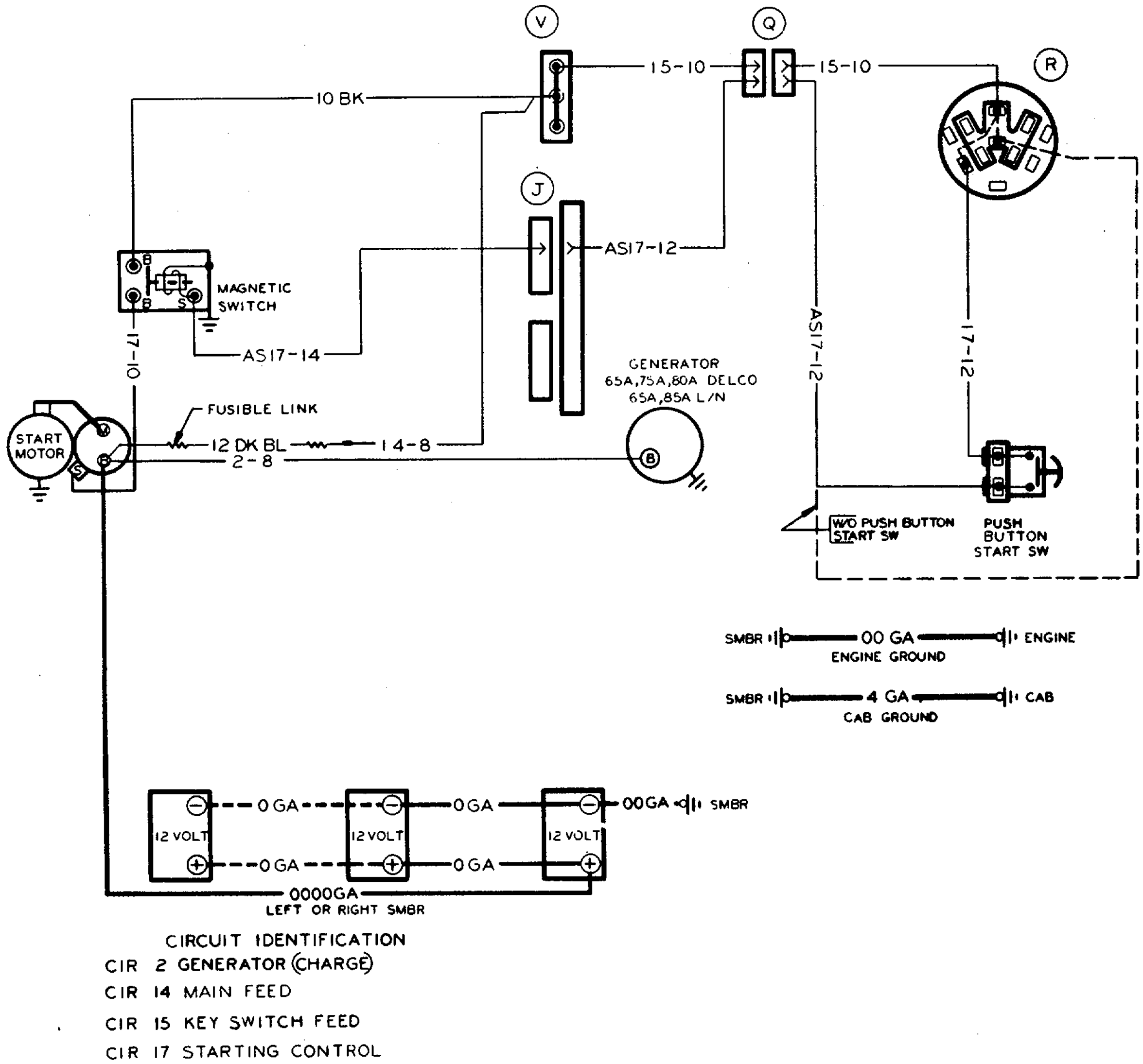


CIRCUIT IDENTIFICATION

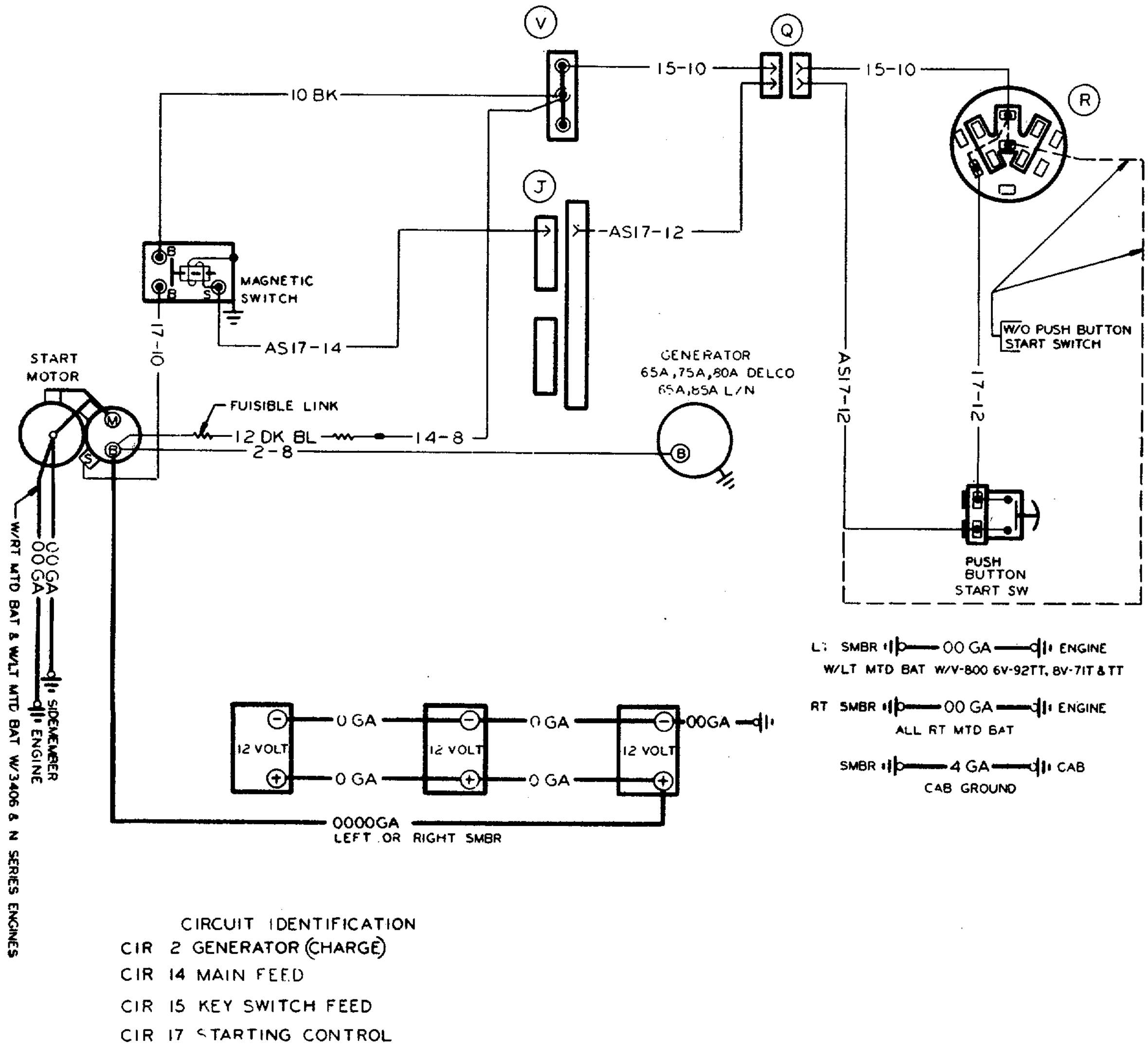
CIR	2	GENERATOR (CHARGE)
CIR	14	MAIN FEED
CIR	15	KEY SWITCH
CIR	17	STARTING CONTROL (IGN)
CIR	1	GENERATOR (EXCITER)(ACC)
CIR	7	REGULATOR (VOLT SENSING)
CIR	16	IGNITION

D 9.0L, D-150, 170, 190, DT-466 OR 3208 STARTING, CHARGING, MAJOR FEED & GROUND WIRING FBC/BUS

MT-23742

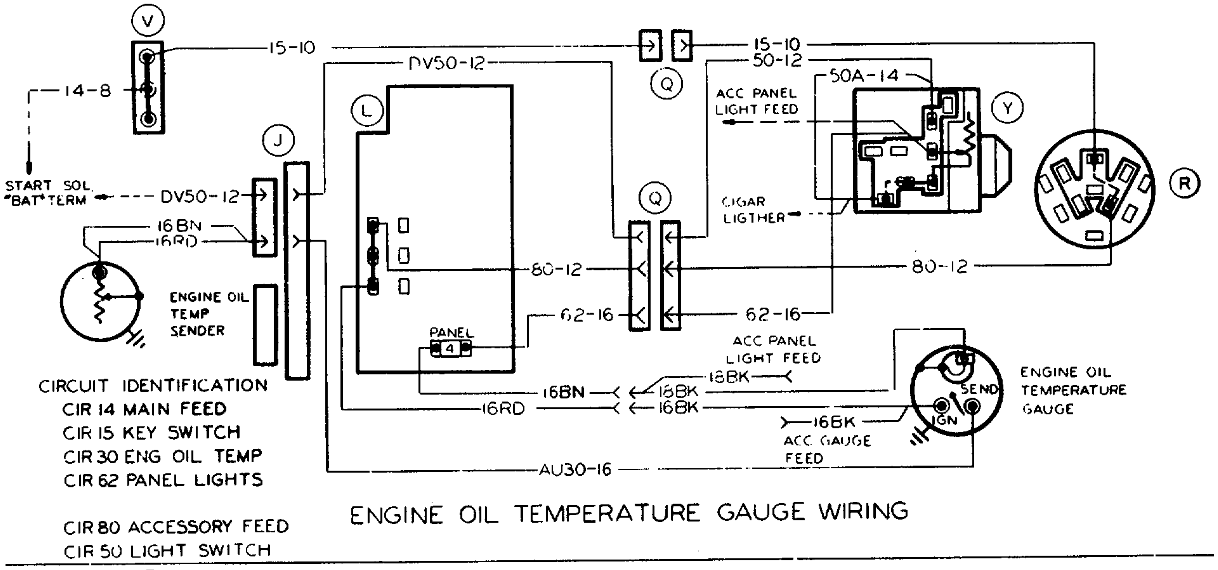


6-71 STARTING, CHARGING, & MAJOR FEED & GROUND WIRING **MT-23743**

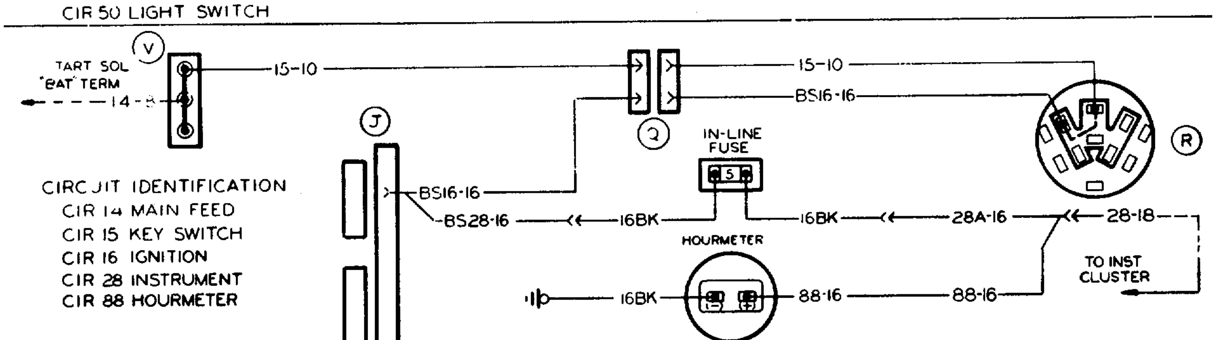


6V-92TT, 8V-71T & TT, 800, 3406 & N-SERIES STARTING, CHARGING & MAJOR FEED & GROUND WIRING

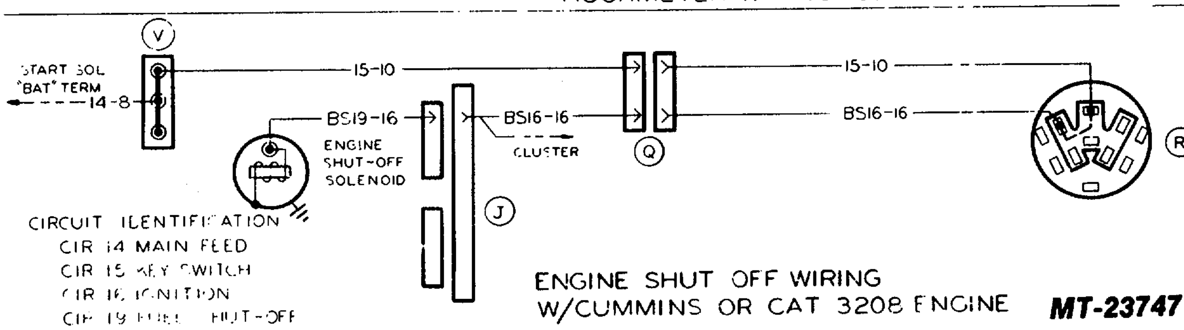
MT-23744



ENGINE OIL TEMPERATURE GAUGE WIRING

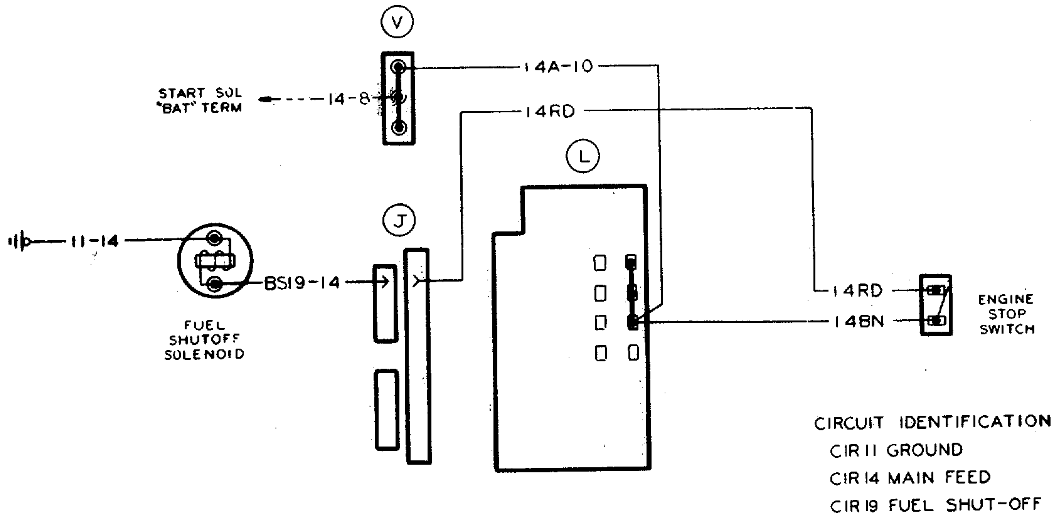


HOURMETER WIRING 1600 THRU 2600

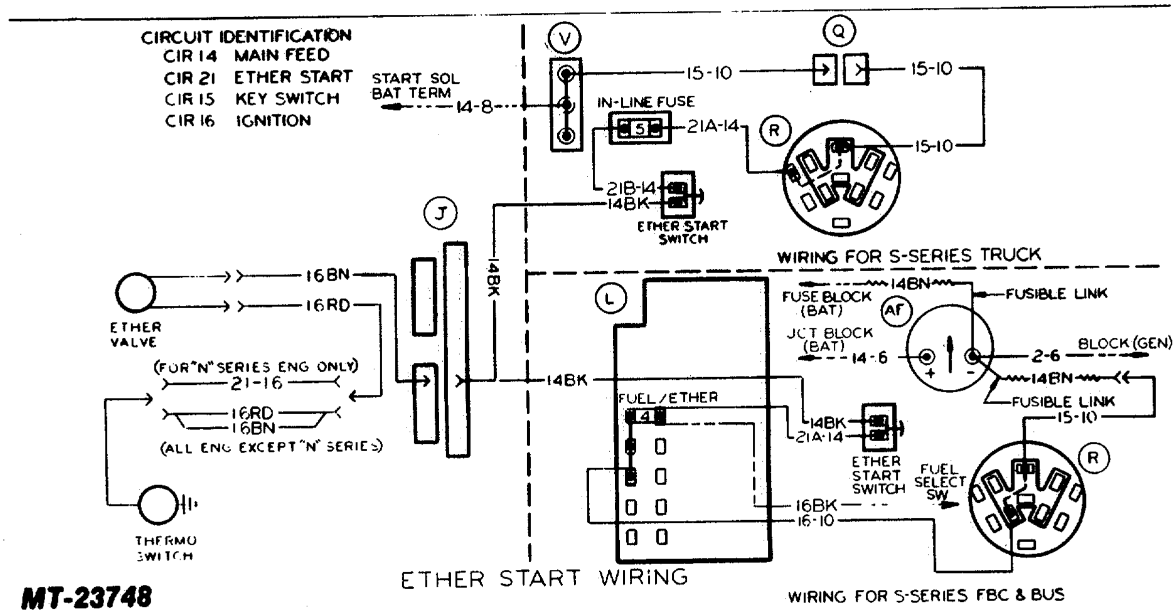


ENGINE SHUT OFF WIRING W/CUMMINS OR CAT 3208 ENGINE

MT-23747

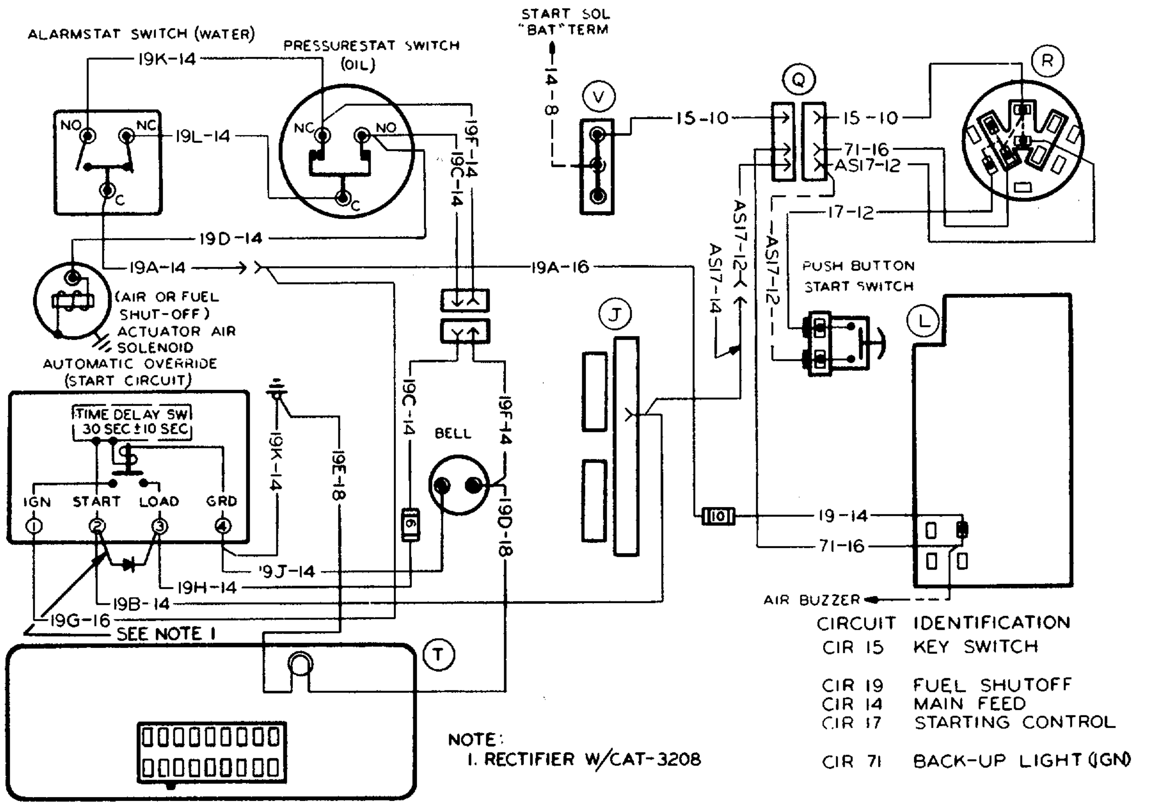


ENGINE STOP WIRING W/CAT-3406 ENGINE

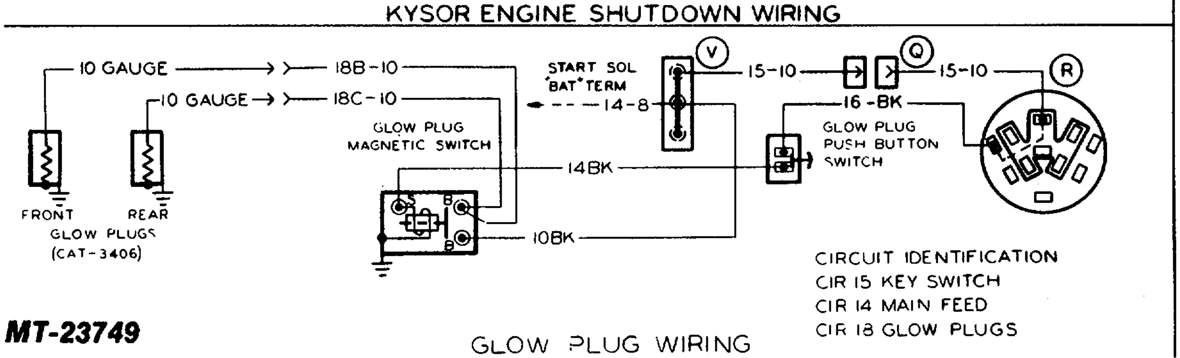


MT-23748

ETHER START WIRING

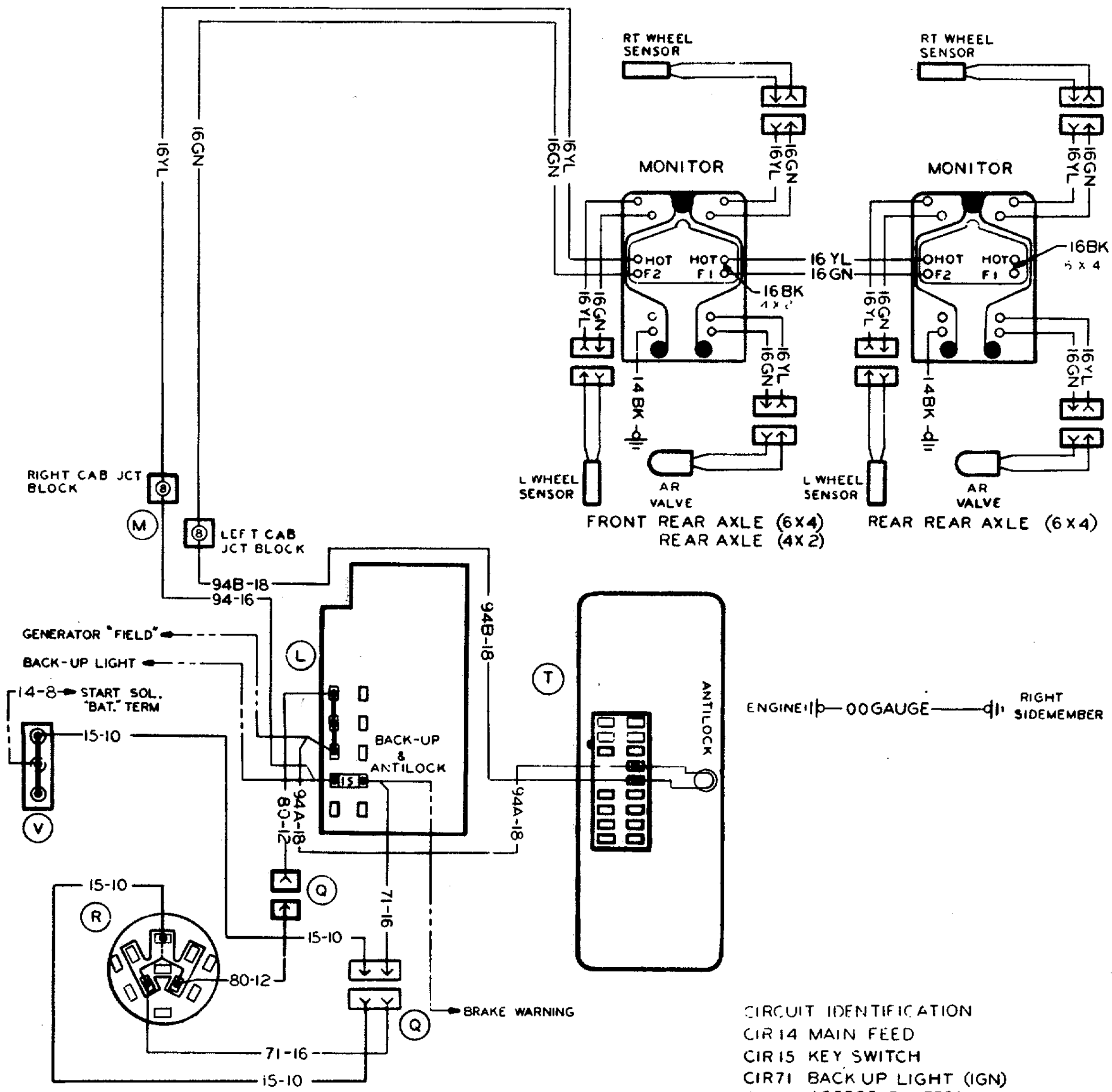


KYSOR ENGINE SHUTDOWN WIRING



MT-23749

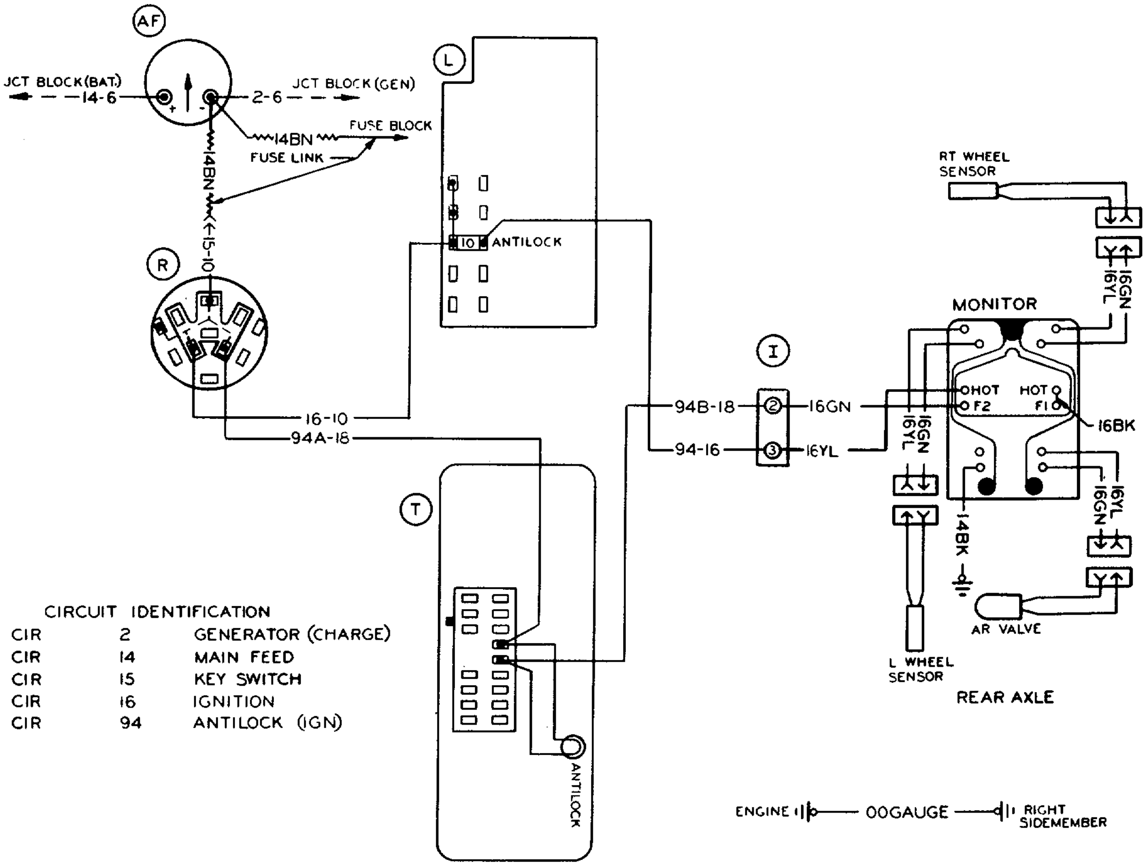
GLOW PLUG WIRING



CIRCUIT IDENTIFICATION
CIR 14 MAIN FEED
CIR 15 KEY SWITCH
CIR 71 BACK UP LIGHT (IGN)
CIR 80 ACCESSORY FEED
CIR 94 ANTILOCK

MT-23750

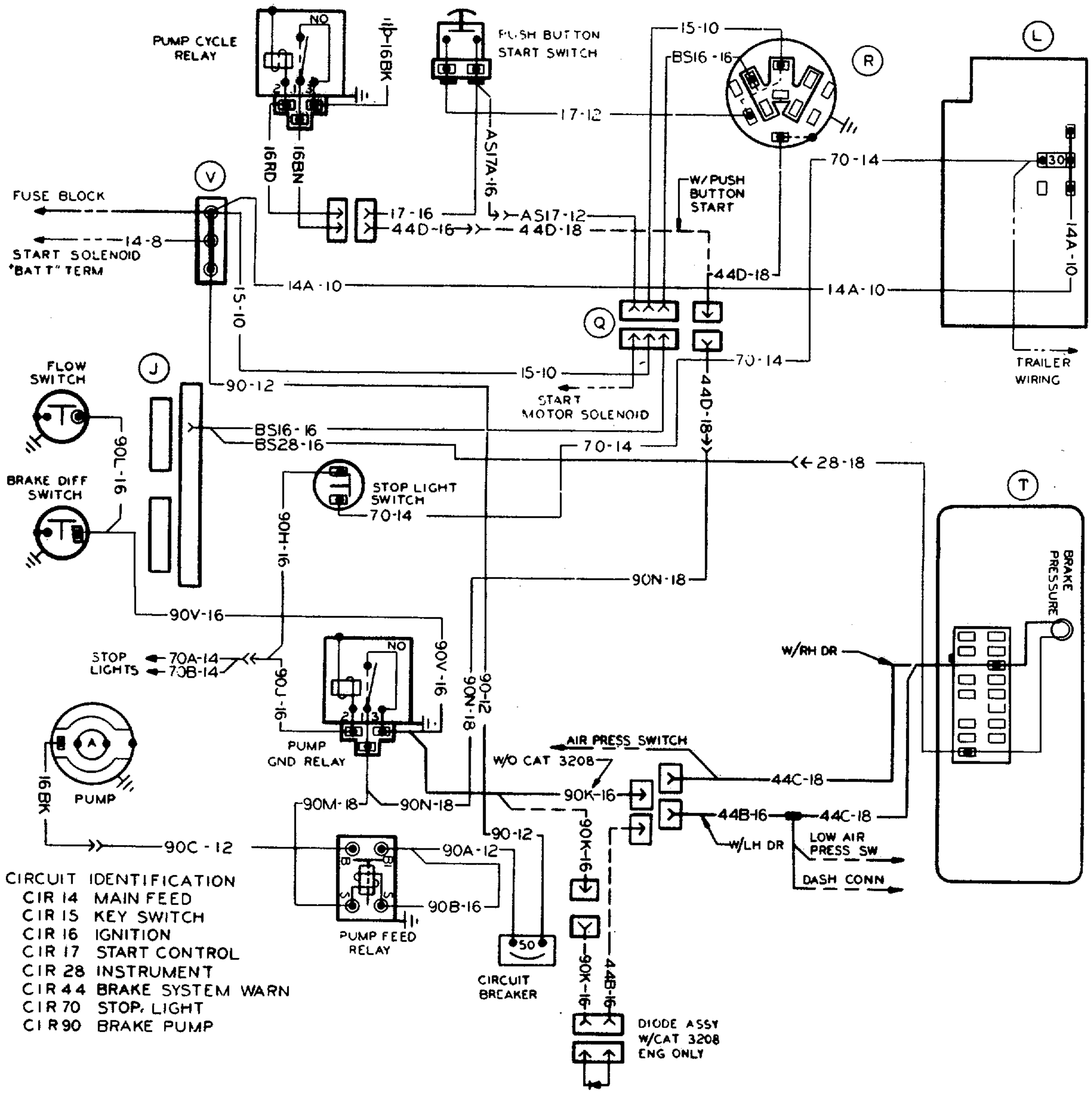
AIR BRAKES ANTILOCK WIRING



CIRCUIT IDENTIFICATION

CIR	2	GENERATOR (CHARGE)
CIR	14	MAIN FEED
CIR	15	KEY SWITCH
CIR	16	IGNITION
CIR	94	ANTILOCK (IGN)

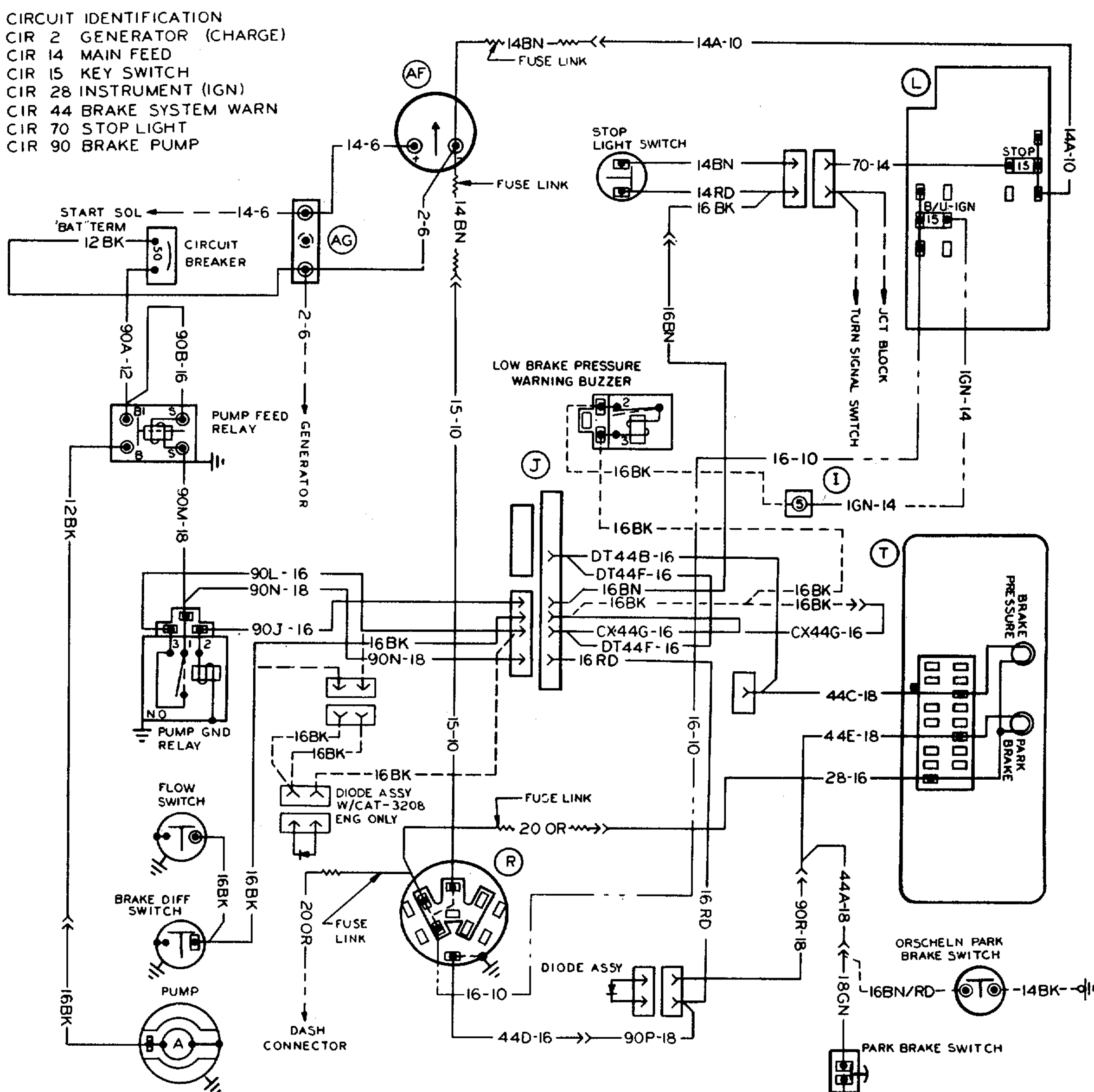
AIR BRAKES ANTILOCK WIRING FBC/BUS **MT-23751**



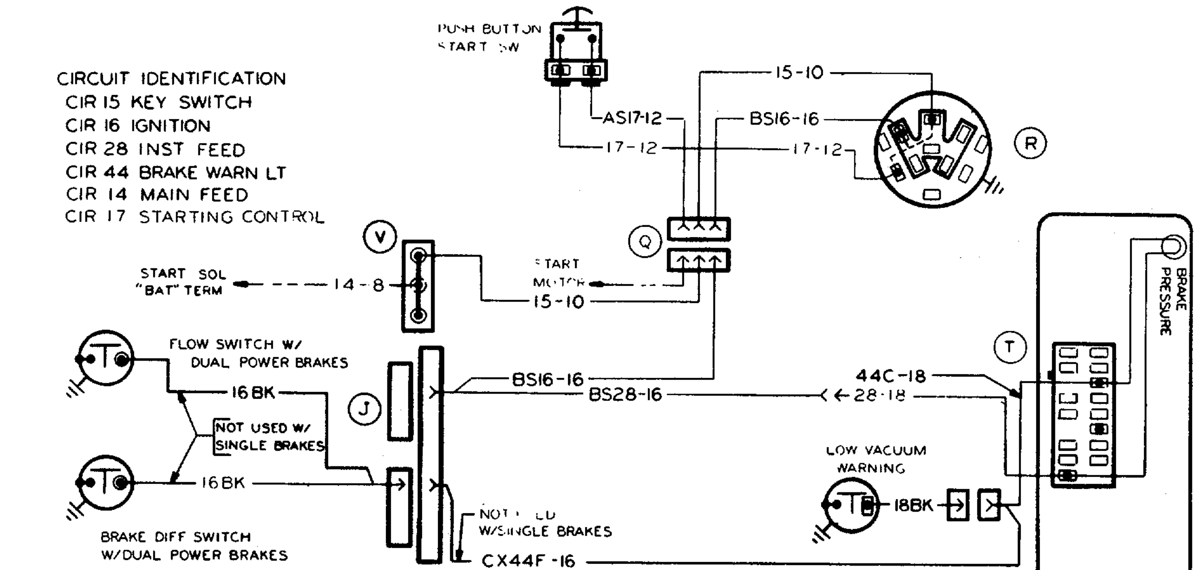
CIRCUIT IDENTIFICATION
CIR 14 MAIN FEED
CIR 15 KEY SWITCH
CIR 16 IGNITION
CIR 17 START CONTROL
CIR 28 INSTRUMENT
CIR 44 BRAKE SYSTEM WARN
CIR 70 STOP, LIGHT
CIR 90 BRAKE PUMP

HY-POWER BRAKE WIRING

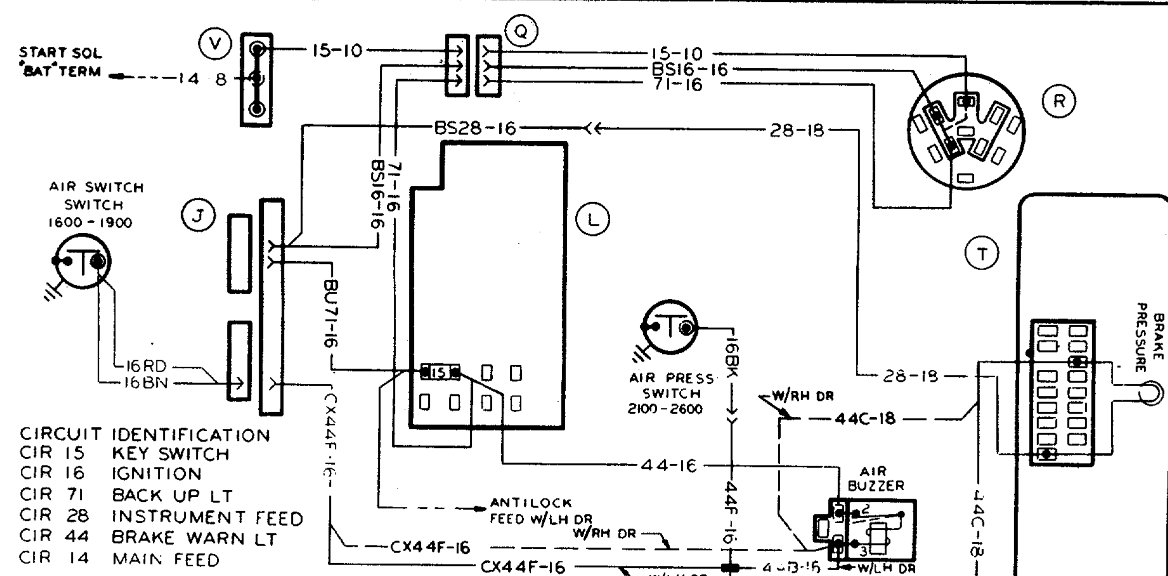
MT-23752



HY-POWER BRAKES WIRING FBC / BUS

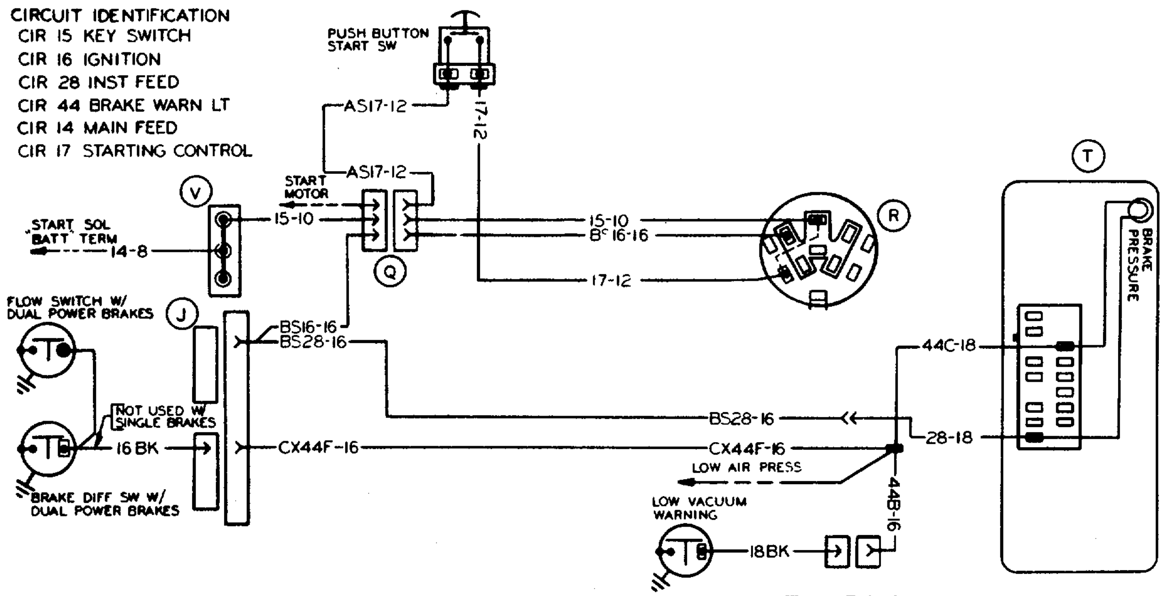


HYDRAULIC BRAKE PRESS WARNING LIGHT WIRING
W/SINGLE OR DUAL POWER BRAKES 1700 THRU 1900 RH DR



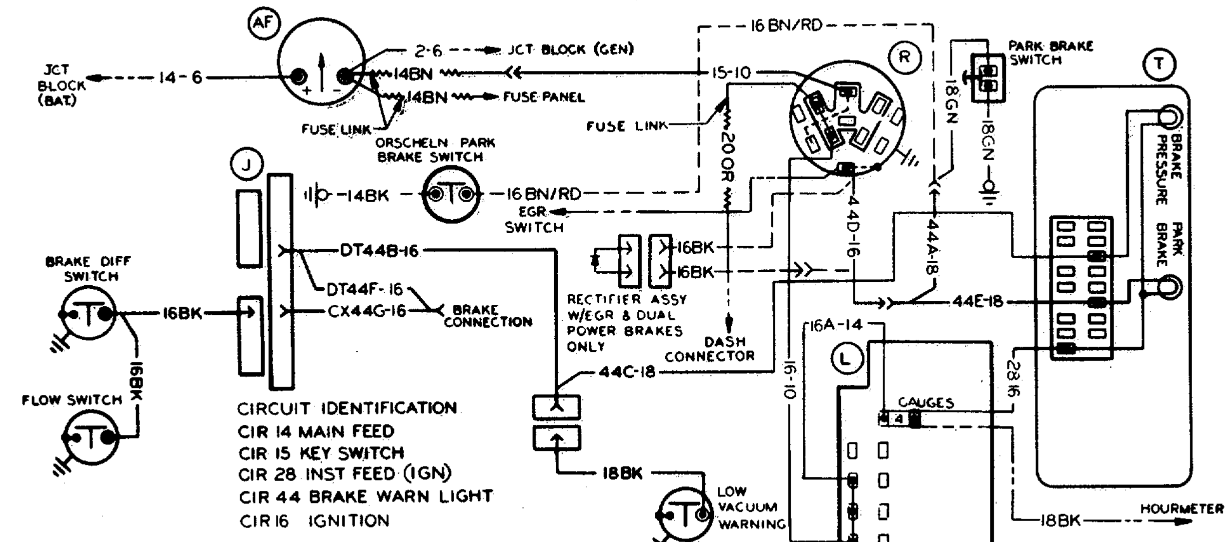
MT-23754

LOW AIR PRESS WARN LIGHT WIRING 1700 THRU 2600

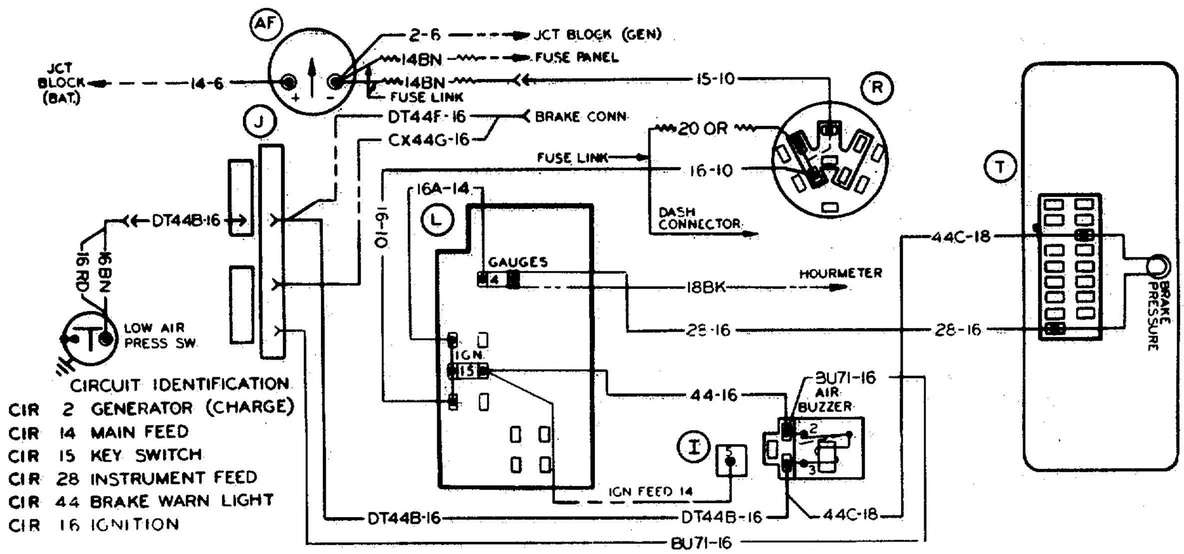


HYDRAULIC BRAKE PRESS WARNING LIGHT WIRING
W/SINGLE OR DUAL POWER BRAKES 1600 THRU 1900 LH DR

MT-23757

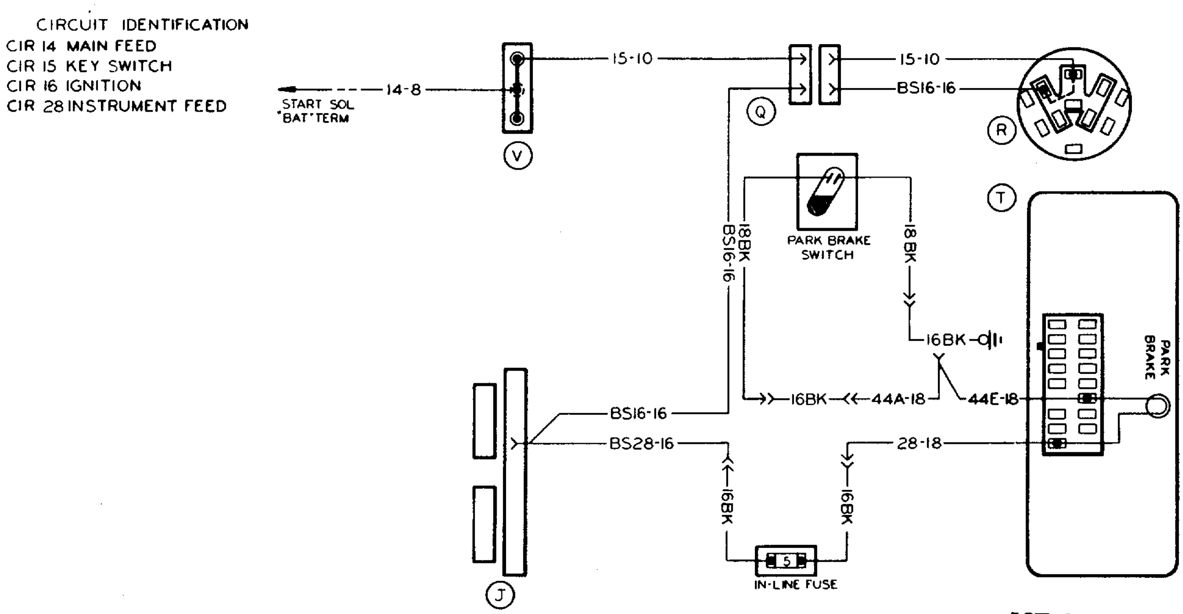


PARKING BRAKE & HYDRAULIC BRAKE PRESS WARNING LIGHT WIRING W/DUAL POWER BRAKES FBC/BUS

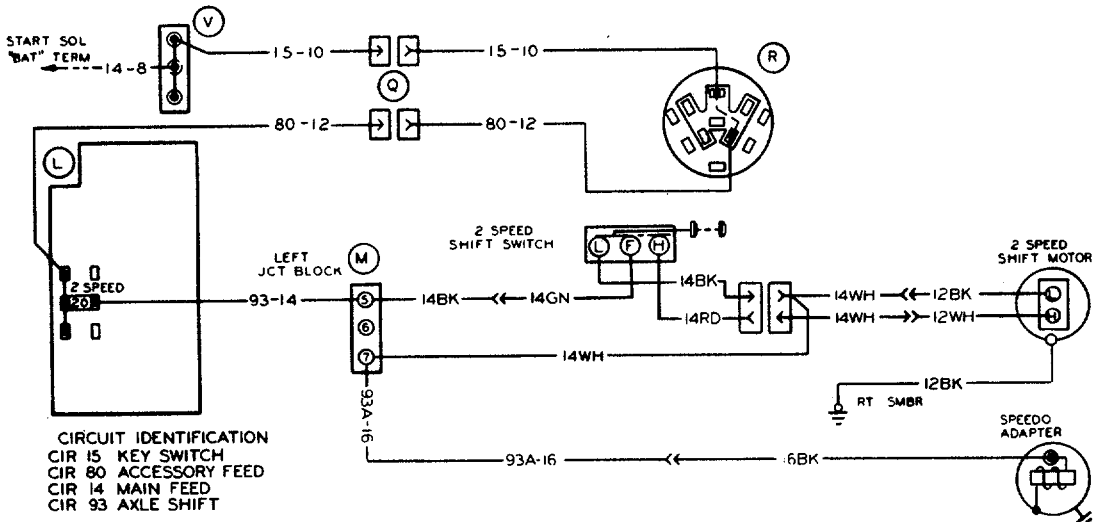


LOW AIR PRESS WARN LIGHT WIRING FBC/BUS

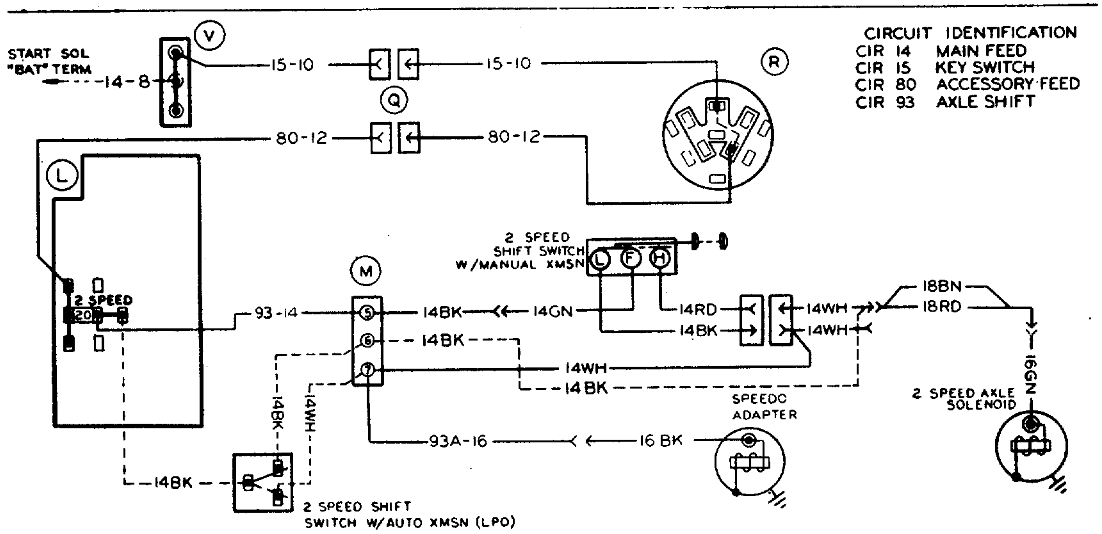
MT-23755



PARKING BRAKE WARNING LIGHT WIRING-RH DR **MT-23756**

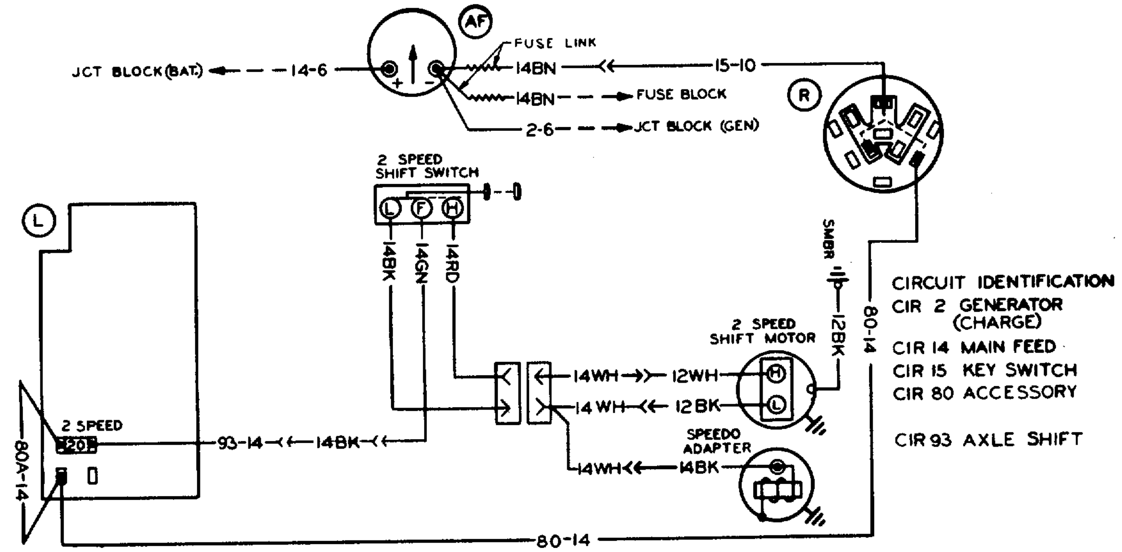


2-SPEED AXLE ALL ELECTRIC SHIFT 1600 THRU 2600

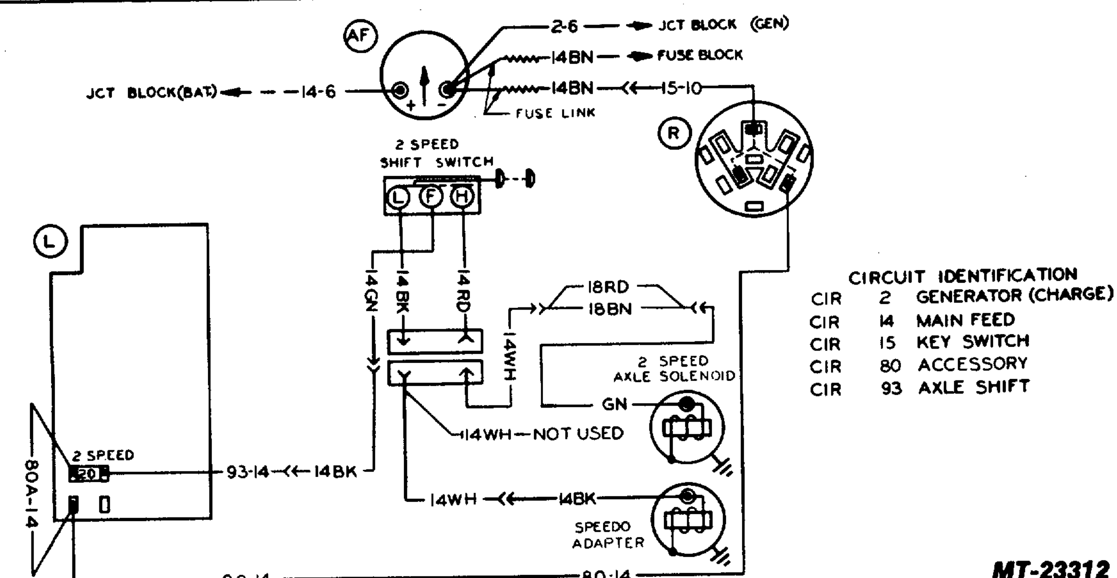


2-SPEED AXLE ELECTRIC OVER AIR 1600 THRU 2600

MT-21985

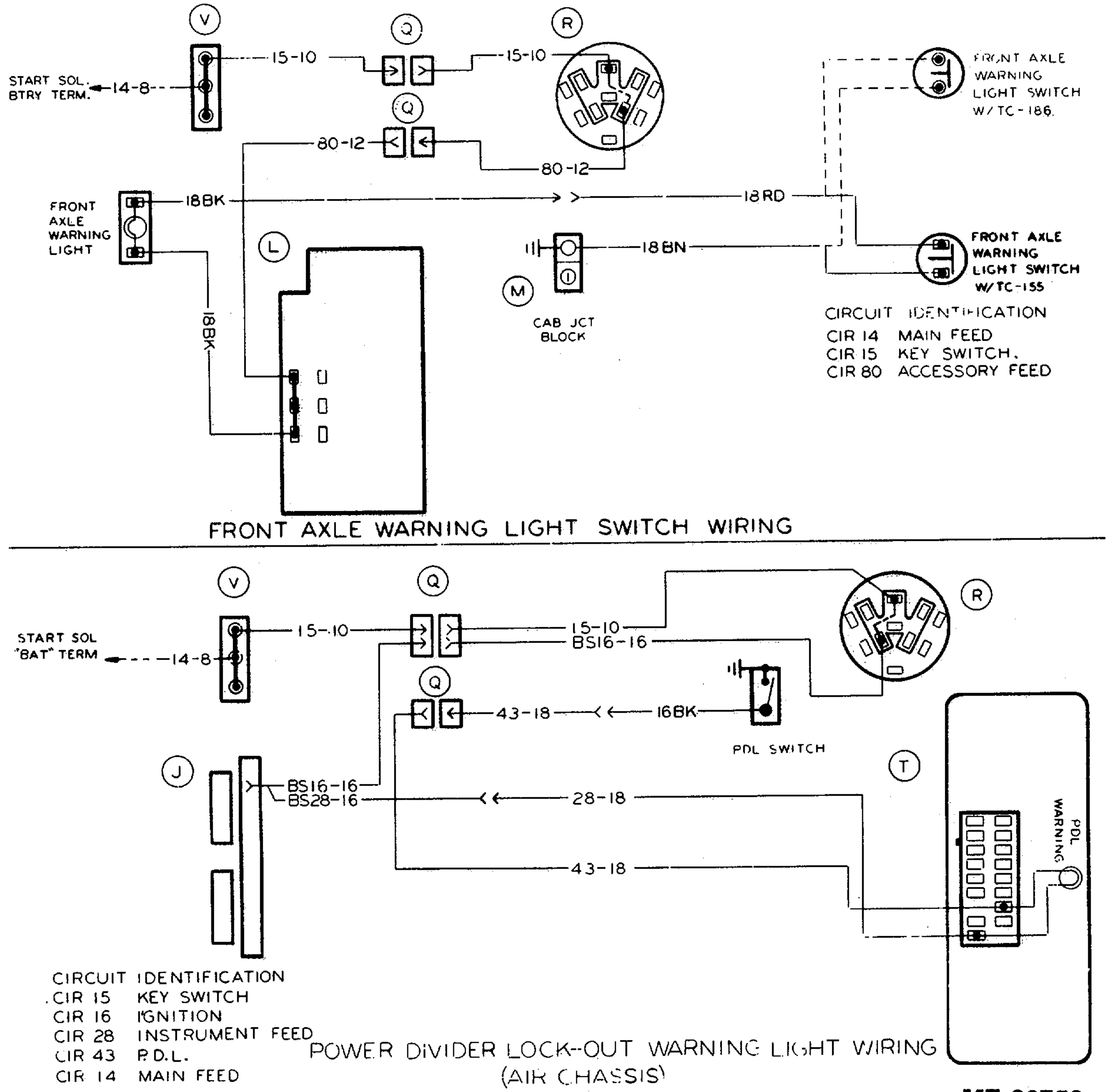


2 SPEED AXLE ALL ELECTRIC SHIFT FBC/BUS

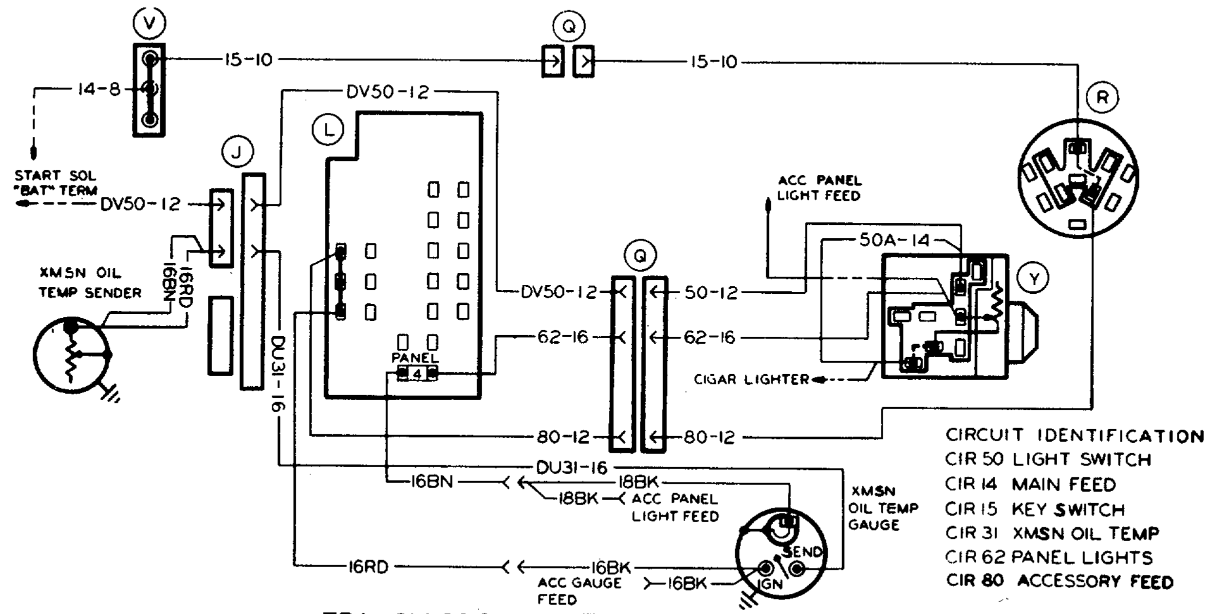


MT-23312

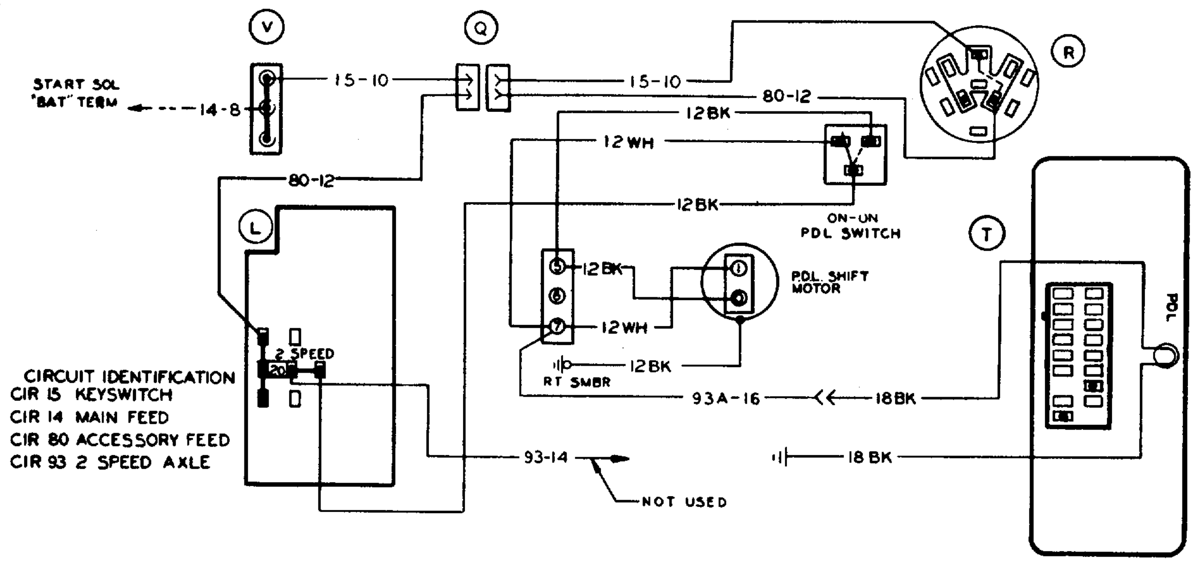
2 SPEED AXLE ELECTRIC OVER AIR FBC/BUS


V
Q
R
START SOL. BTRY TERM.
14-8
15-10
80-12
FRONT AXLE WARNING LIGHT
18BK
18RD
L
M
18BN
CAB JCT BLOCK
FRONT AXLE WARNING LIGHT SWITCH W/TC-186
FRONT AXLE WARNING LIGHT SWITCH W/TC-155
CIRCUIT IDENTIFICATION
CIR 14 MAIN FEED
CIR 15 KEY SWITCH.
CIR 80 ACCESSORY FEED
FRONT AXLE WARNING LIGHT SWITCH WIRING
START SOL "BAT" TERM
BS16-16
43-18
16BK
PDL SWITCH
J
T
BS28-16
28-18
PDL WARNING
CIRCUIT IDENTIFICATION
CIR 15 KEY SWITCH
CIR 16 IGNITION
CIR 28 INSTRUMENT FEED
CIR 43 P.D.L.
CIR 14 MAIN FEED
POWER DIVIDER LOCK-OUT WARNING LIGHT WIRING (AIR CHASSIS)

MT-23758

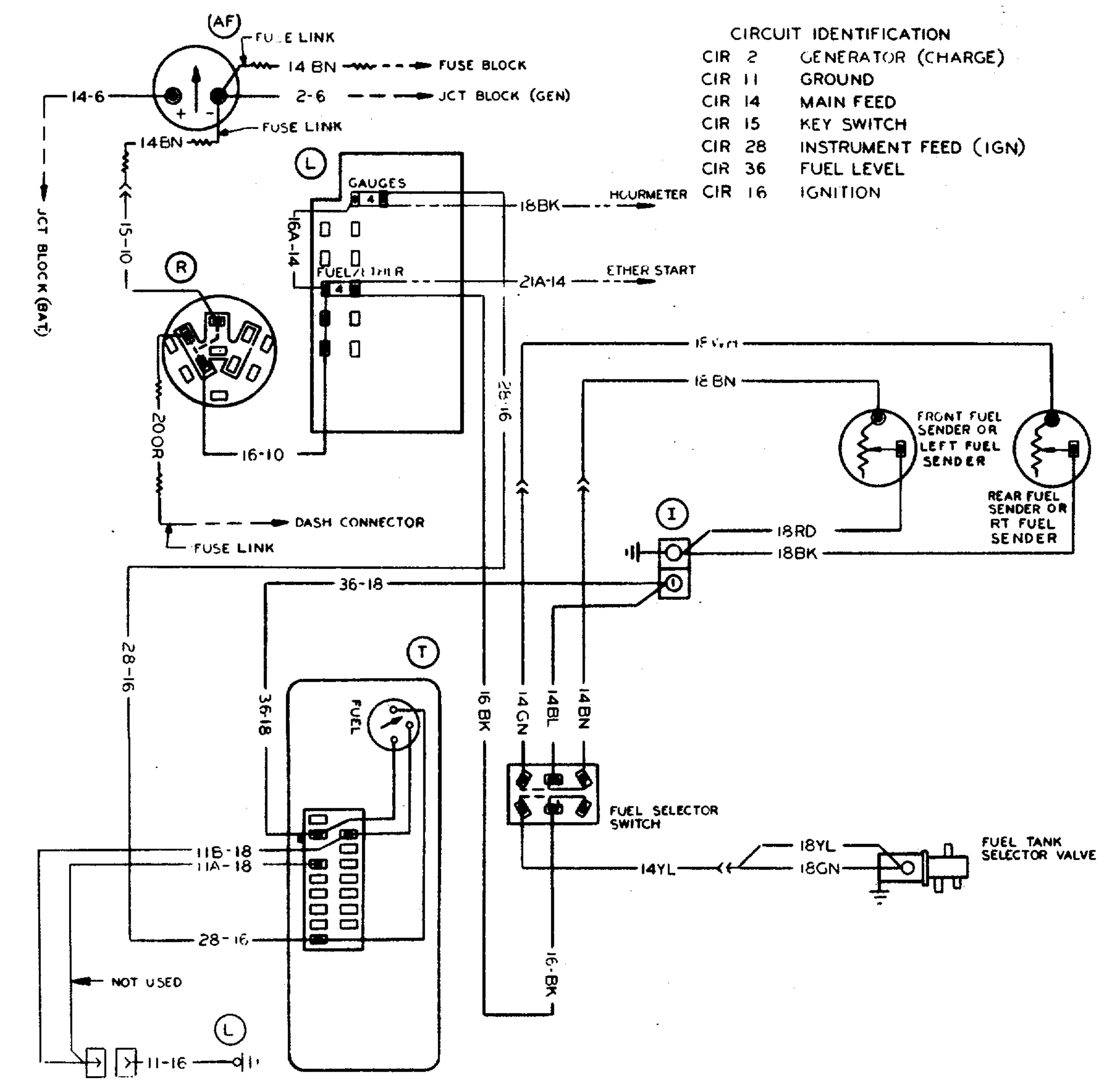


TRANSMISSION OIL TEMPERATURE GAUGE WIRING



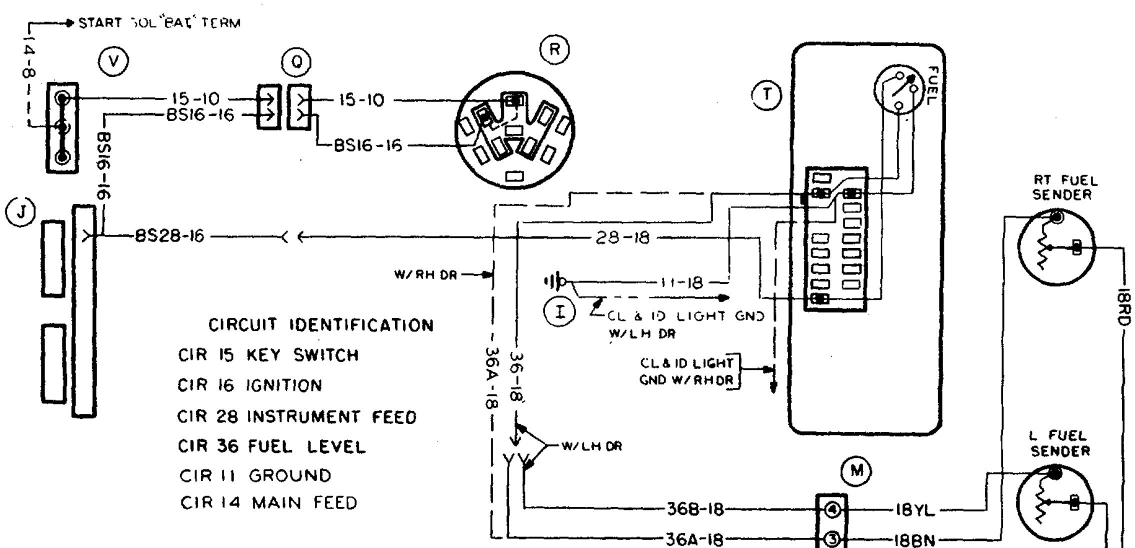
MT-23804

ELECT. POWER DIVIDER LOCK-OUT WIRING (HYD CHASSIS)

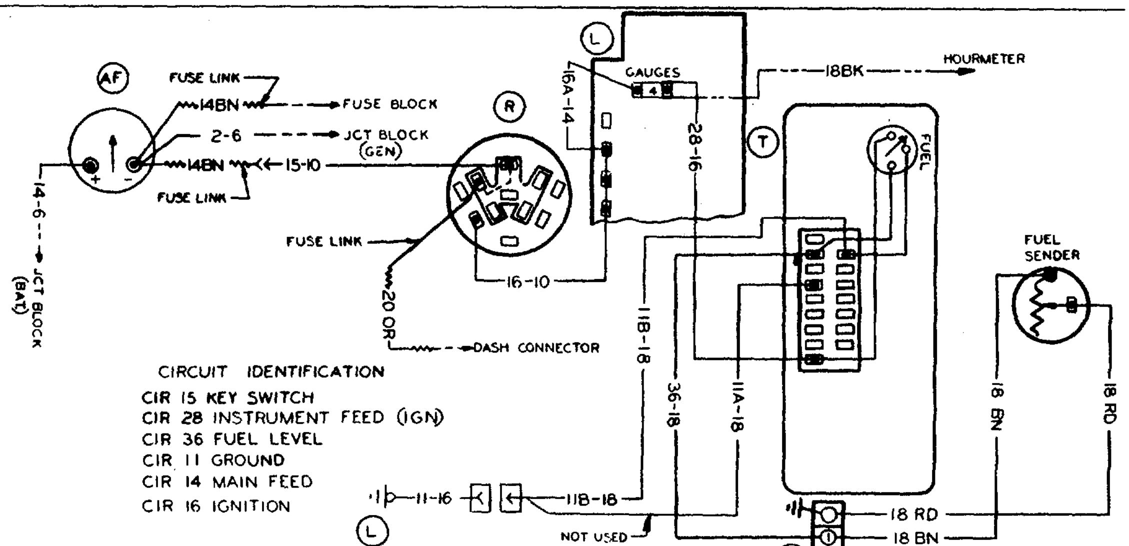


MT-23760

DUAL SENDERS WITH DUAL FUEL TANKS FBC & BUS W/GAS ENG.ONLY

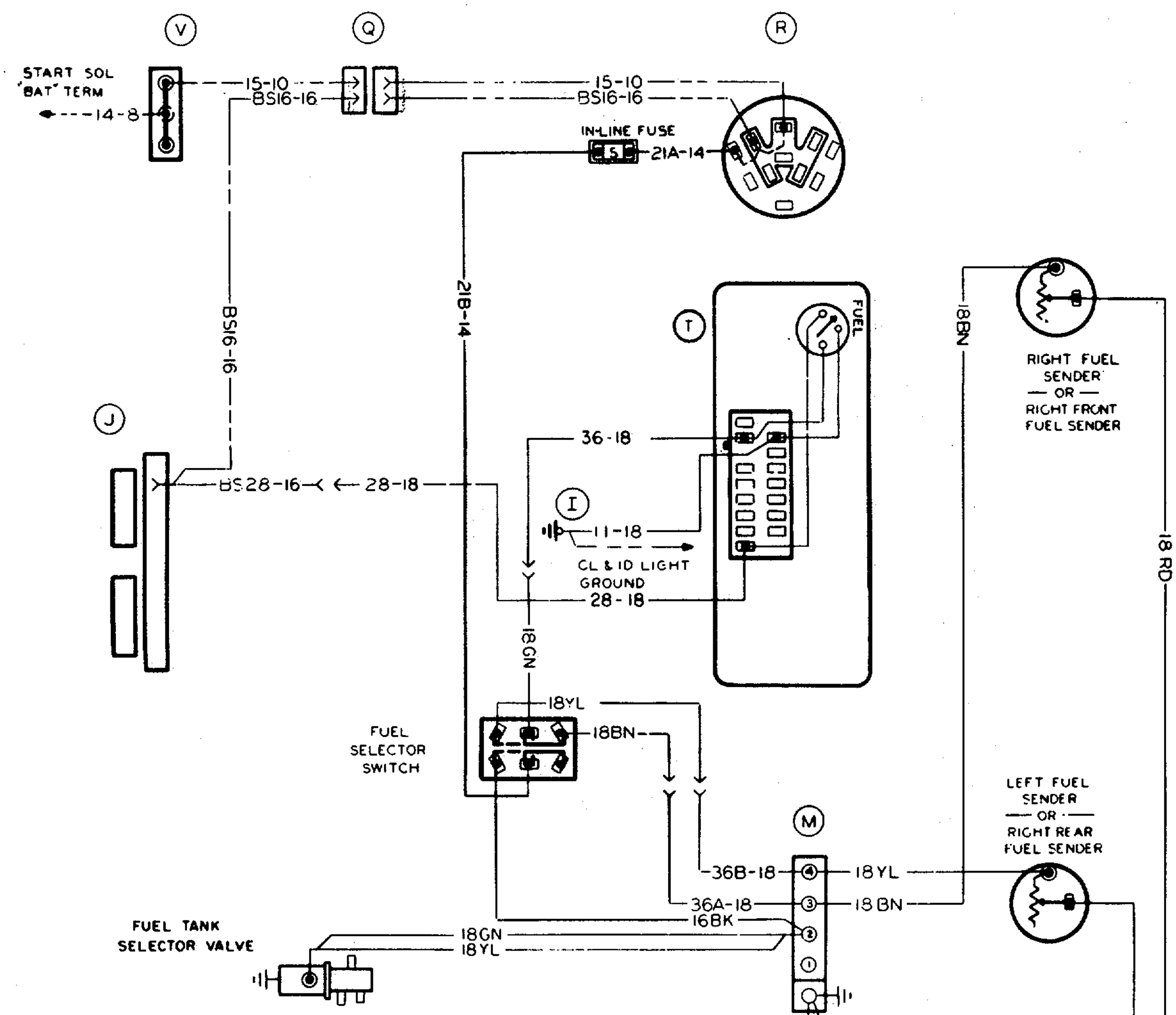


FUEL SENDER WIRING
W/ SINGLE LEFT OR RIGHT SIDE FUEL TANK 1600 THRU 2600



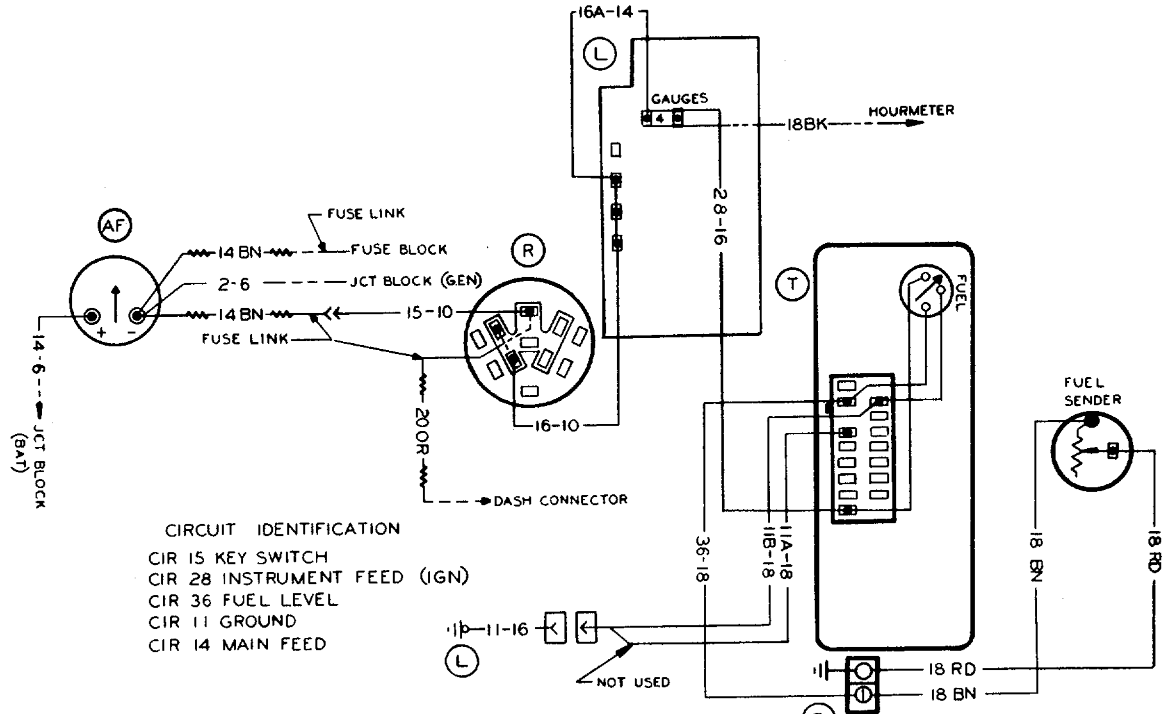
FUEL SENDER WIRING FBC/BUS

MT-23759



CIRCUIT IDENTIFICATION
CIR 15 KEY SWITCH   CIR 28 INSTRUMENT FEED
CIR 16 IGNITION   CIR 36 FUEL LEVEL
CIR 14 MAIN FEED   CIR 11 GROUND
CIR 80 ACCESSORY FEED

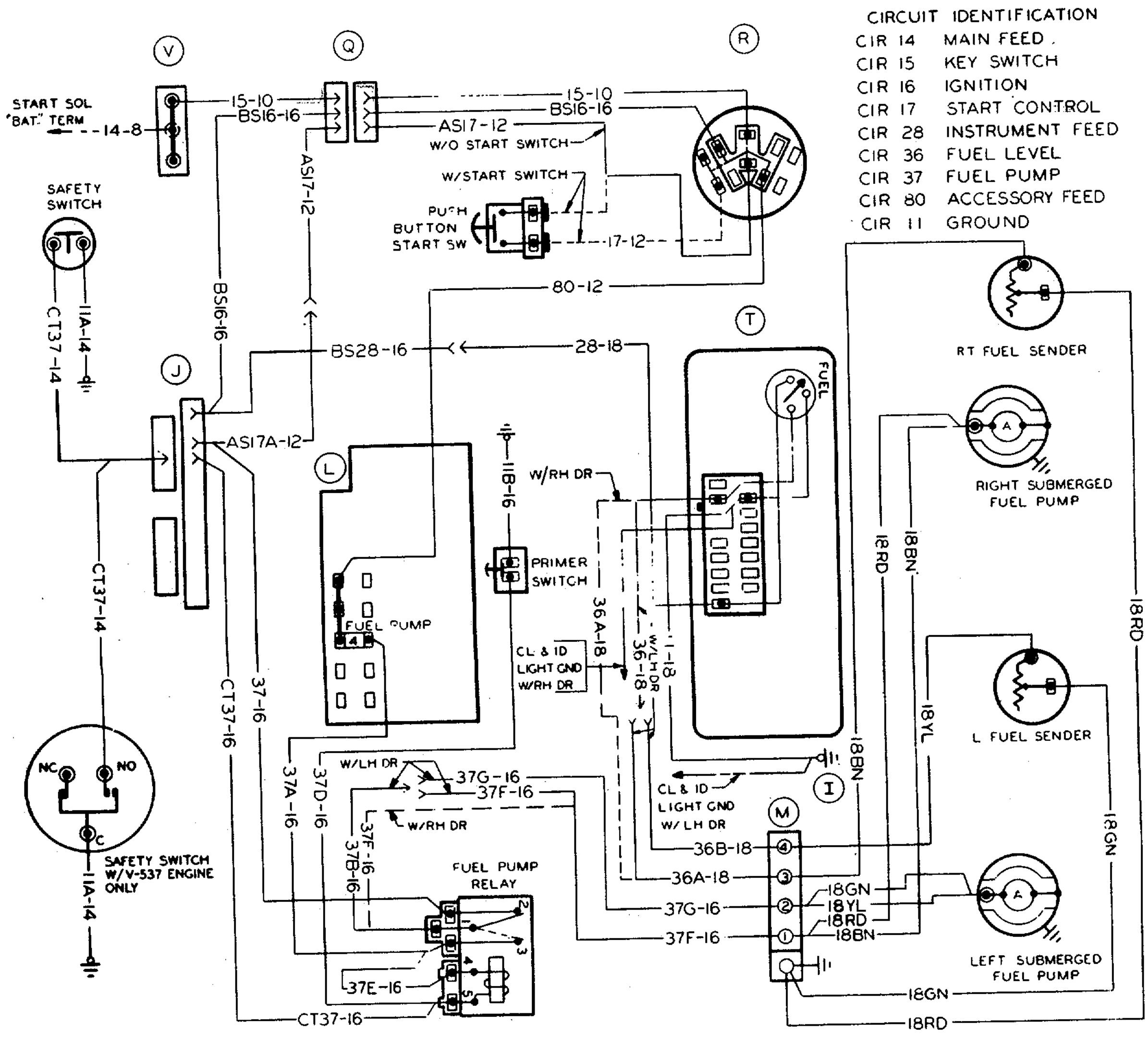
MT-23762 DUAL FUEL SENDERS WITH DUAL TANKS - W/ALL GAS ENGINE MODELS EXCEPT FBC



CIRCUIT IDENTIFICATION

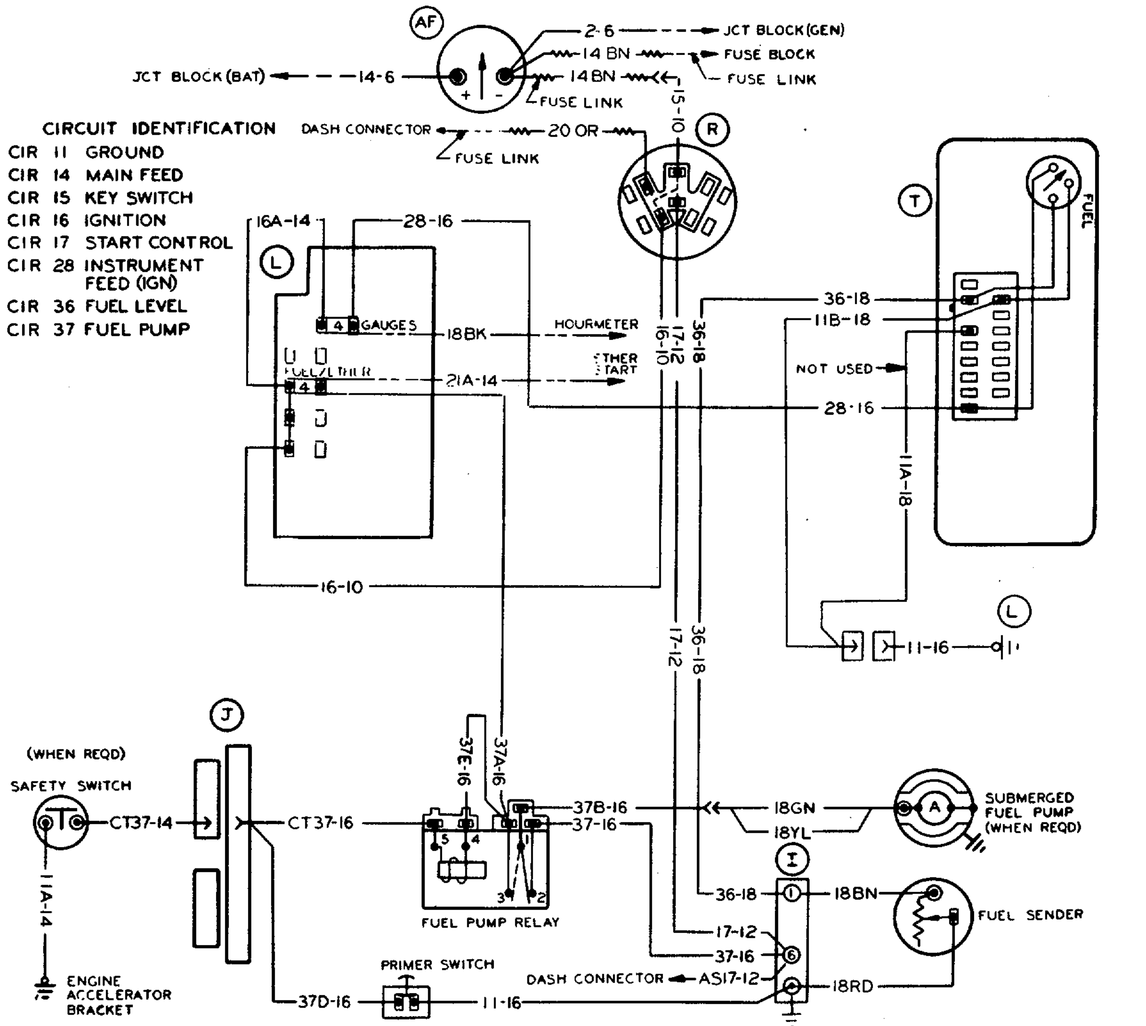
CIR 15 KEY SWITCH
CIR 28 INSTRUMENT FEED (IGN)
CIR 36 FUEL LEVEL
CIR 11 GROUND
CIR 14 MAIN FEED

MT-23761 FUEL SENDER WIRING - DUAL TANKS W/DIESEL ENGINE FBC

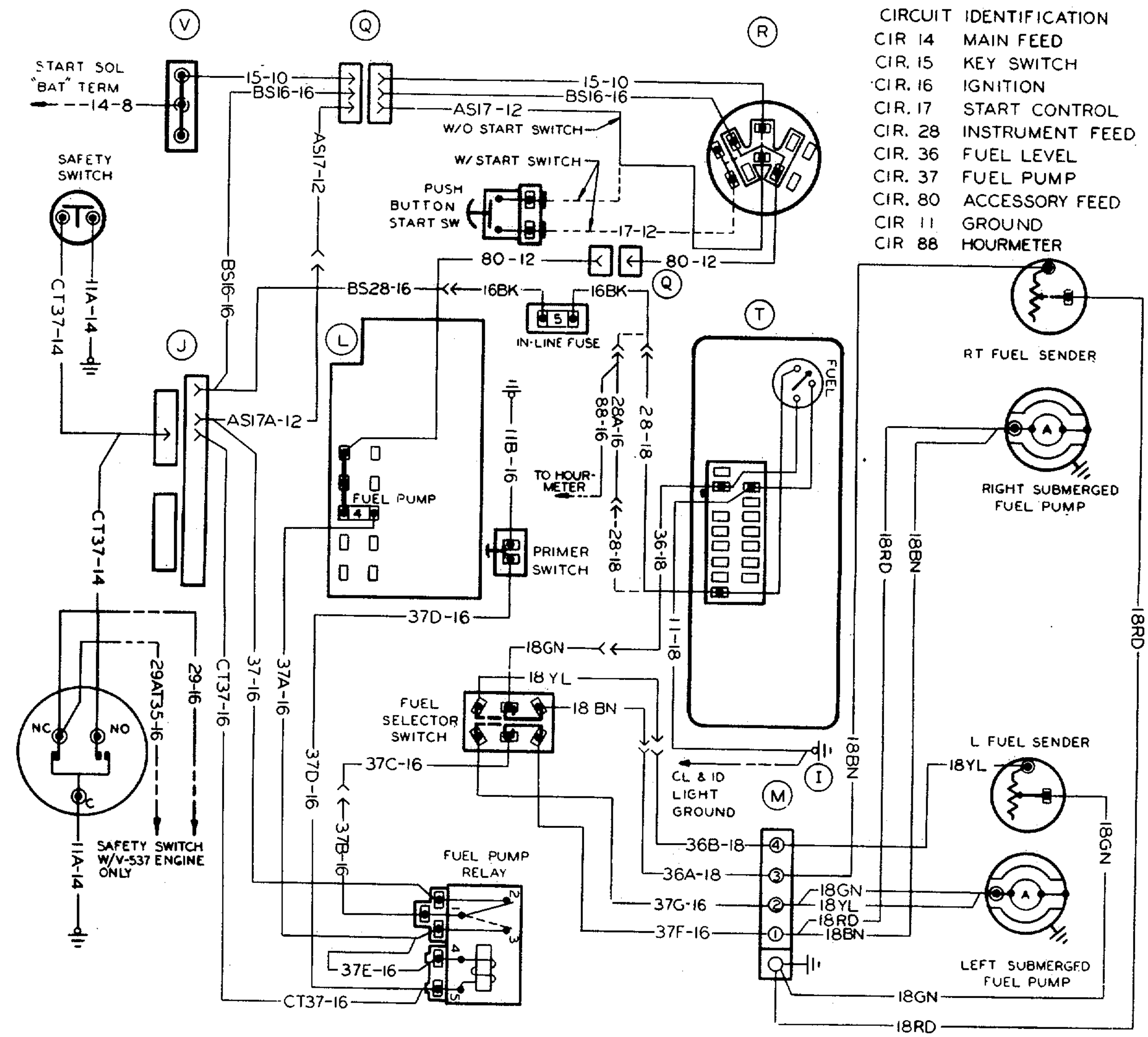


FUEL SENDER & SUBMERGED FUEL PUMP WIRING

MT-23763 W SINGLE LEFT OR RIGHT SIDE FUEL TANKS 1600 THRU 2100, 2500, 2600

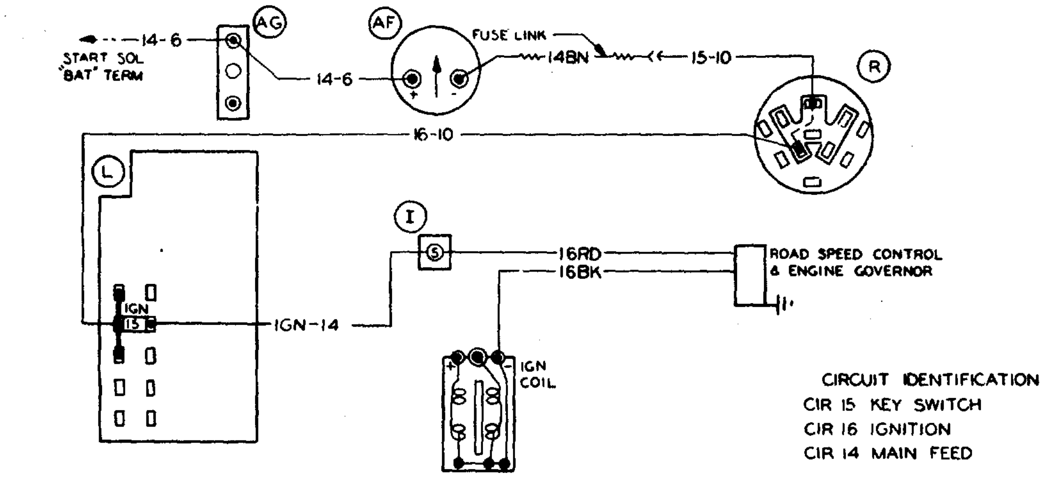


FUEL SENDER & SUBMERGED FUEL PUMP WIRING FBC/BUS **MT-23764**



MT-23765

FUEL SENDER & SUBMERGED FUEL PUMP WIRING W/DUAL FUEL TANKS



ROAD SPEED CONTROL & ENGINE GOVERNOR
W/V-345,V-392 & MV8 ENGINES W/FBC/BUS

MT-23740

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ELECTRICAL

IGNITION COILS AND CONDENSERS

(Construction, Operation, Maintenance)

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DESCRIPTION

The ignition coil is a pulse transformer that steps up the low battery or alternator voltage to the high voltage necessary to jump the gaps at the spark plugs in the engine cylinders. This voltage may reach as much as 20, 000 volts in some installations.

The ignition coil, Figs. 1 and 2, contains three essential parts: a primary winding consisting of a few hundred turns of relatively heavy wire, a secondary winding consisting of many thousand turns of very fine wire, and laminated soft iron which serves to concentrate the magnetic field. The primary winding is assembled around the outside of the secondary winding, and the laminated iron is distributed so that one portion serves as a core for the windings and the remainder as a shell around the entire subassembly. This subassembly is then placed in the coil case and the remaining space nearly filled with insulating compound or oil and the coil cap assembled into place.

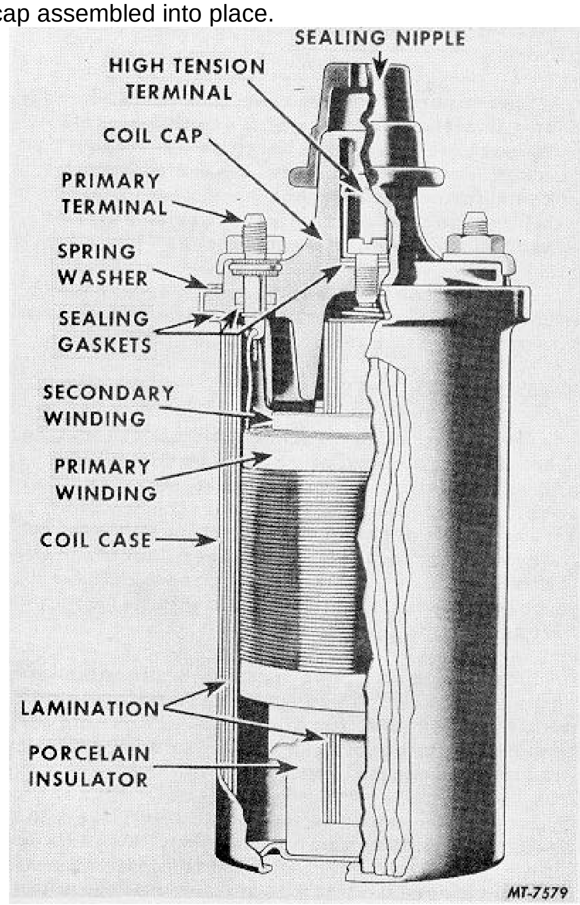

Fig. 1. Steel Encased Coil (Cutaway View)

IGNITION COIL TYPES

There are a variety of ignition coils for various types of operation, with each type of coil being supplied in several models, each designed to incorporate a specified winding to make it suitable for operation with a particular engine under specific operating conditions.

Fig. 1 illustrates an oil-filled and hermetically-sealed ignition coil housed in a one piece steel case. Hermetic sealing of the ignition coil prevents the entrance of moisture, which would ultimately cause coil failure. Moisture may enter an unsealed coil either directly in the form of rain, snow, washing water, steam and so forth, or through the "breathing" action of the coil itself. Unless a coil is hermetically sealed, it will expel air when heated and will draw in outside air when cooled. This is the action termed "breathing", and it results in a gradual accumulation of water in the coil interior because of the condensation of water vapor from the incoming air. In addition to hermetic sealing, the coils are also filled with oil to impart high dielectric strength to the insulation, thus further reducing the possibility of insulation breakdown and coil failure.

Fig. 2 illustrates a heavy- duty oil- filled and hermetically sealed ignition coil housed in a one piece die cast aluminum case. The fins cast in the case, plus the oil filling, permit improved heat radiation, which is a factor in efficient ignition coil performance.

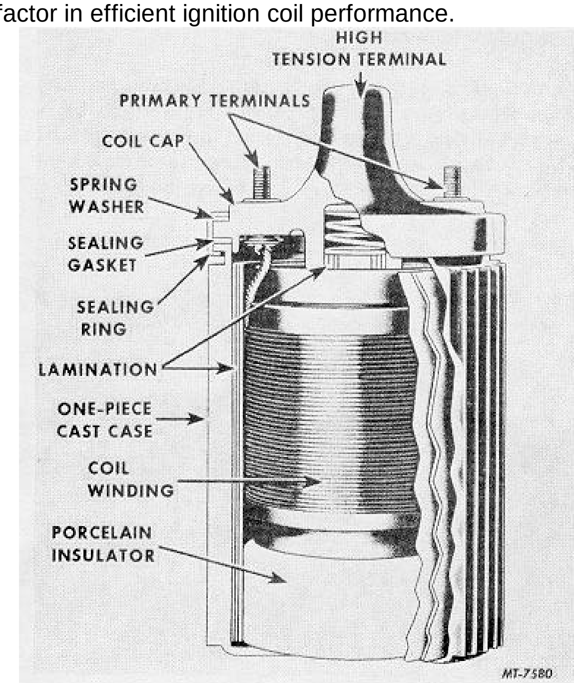

Fig. 2. Diecast Encased Heavy-Duty Coil (Cutaway View)

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The coil used with the transistor ignition system has the outward appearance of a standard coil; however, it contains special high- ratio windings that produce higher secondary voltage at all engine speeds.

COIL SERVICE

Ignition coils do not normally require any service except to keep all terminals and connections clean and tight. In addition, the coil should be kept reasonably clean, but it must not be subjected to steam cleaning or similar cleaning methods which may cause moisture to enter the coil unless it is of the hermetically sealed type. Rubber nipples on the high voltage terminals are valuable in preventing "tracing" or leakage of current across exposed surfaces.

If poor ignition performance is obtained, and the coil is suspected of being the cause, the coil may be tested on the, truck or it may be removed for the test.

COIL TESTS

Various types of testing instruments are used in testing ignition coils. One of these makes use of an open or protected spark gap, while another reports the coil condition on a meter or scope. This second type of tester is usually so designed as to permit testing of the coil without making any connection to the secondary terminal. This eliminates certain variables caused by altitude, atmosphere or spark gap electrode conditions.

The spark gap tester should always be used comparatively. That is, a coil known to be good should be compared with the questionable coil. Both coils should be at same temperature and identical test leads must be used.

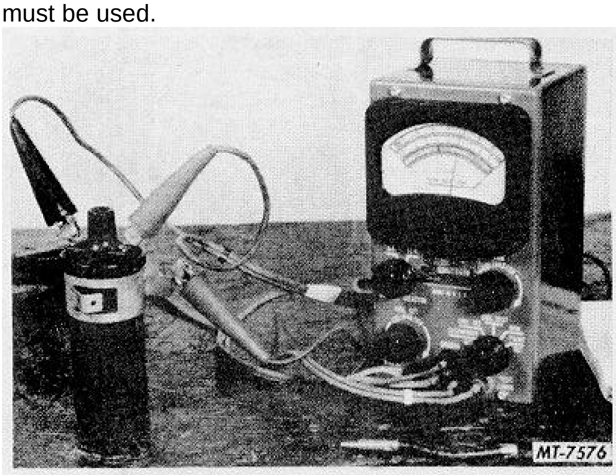

Fig. 3. Coil Tester

Before the testing instrument is used, a lamp and test point should be applied to check coil for open or grounded circuits. To test for an open primary circuit, put test points on the two primary terminals. If lamp does not light, primary circuit is open. To check secondary circuit, put one test point in high tension terminal and the other at one of the primary terminals. Lamp will not light, but tiny sparks will be noted as test points are rubbed over terminals if secondary winding is not open. If secondary is open, no sparks will occur.

Most ignition coils can be tested for grounded windings by placing one test point on a clean part of the metal container and touching the other point to primary and high tension terminals. If lamp lights or tiny sparks appear at the points of contact, windings are grounded.

NOTE: This test does not apply to secondary windings of coils used on insulated or two wire electrical systems, since these coils have one end of the secondary winding grounded to metal container. The primary winding of this type of coil, however, may be checked for ground.

When using a meter-type coil tester to test a coil without removing it from the vehicle, be very careful to avoid touching tester case to truck. Many such testers have a ground connection to the case, touching case to truck would produce a short circuit and possible serious damage to the equipment.

Details of the testing procedures and the manner in which various testers are used will be found in the tester operating instructions.

TWELVE-VOLT SYSTEM

The coil used with the 12-volt system, Fig. 4, has more turns of wire in both the primary and secondary windings and a higher ratio between windings than in 6-volt coils of same size. The increased number of turns in primary winding results in a higher inductance in this winding, which makes it possible for coil to provide a higher secondary voltage output throughout the speed range.

In order to improve ignition performance during cranking, an ignition resistor is used with the 12-volt ignition coil. This external resistor is connected in series with primary circuit between battery and coil.

Ignition resistor is wound with wire which changes resistance only slightly with temperature. This characteristic prevents excessive primary current at low temperatures, and thus reduces the tendency for distributor contact points to oxidize during cold weather.

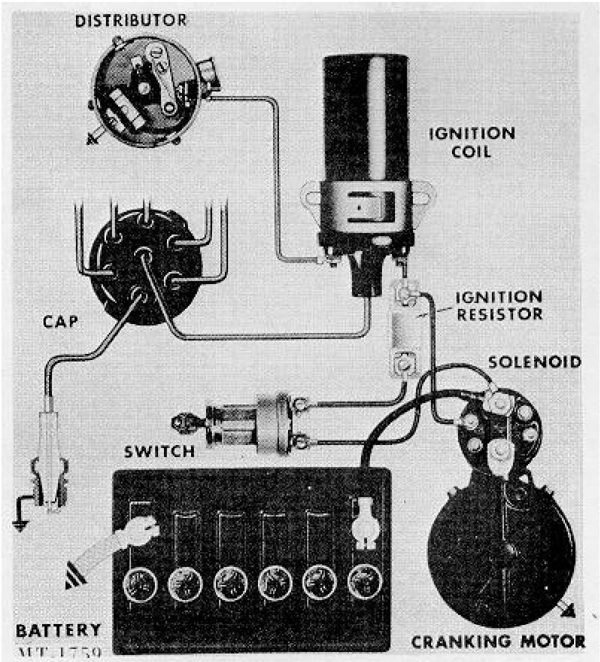

Fig. 4. Schematic Diagram of Primary and Secondary Circuits of 12-Volt Ignition System

To obtain greatly improved starting performance at low temperatures, the resistor is bypassed during cranking, thereby connecting ignition coil directly to battery. This makes full battery voltage available to coil and, thus, keeps ignition voltage as high as possible during cranking. The bypassing of ignition resistor during cranking is accomplished by use of a "finger" within the solenoid which is connected to the ignition coil. As solenoid contacts close, the ignition coil is connected to battery through the solenoid "finger". To prevent the engine from firing while making under-hood cranking tests on trucks using 12-volt system, ground distributor primary lead.

COIL POLARITY

One of the major causes for hard starting or spark plug misfiring under load results when the ignition coil lead wire to the distributor is installed on the wrong side of the coil. This condition causes reversed coil polarity.

Voltage at the spark plug terminals should always be negative. Whether it is or not depends on how the primary leads are attached to the coil. Remember, primary lead hook-up directly affects coil polarity, which in turn determines whether voltage at the spark plug terminals is negative or positive. On IH trucks the distributor wire to the coil should always be placed on the negative side of the coil if the electrical system is negative grounded, or on the positive side if the electrical system is positive grounded.

If the primary leads are incorrectly attached, the direction of current flow through the coil is reversed. Consequently, coil polarity is reversed, resulting in positive voltage being supplied to the spark plug terminals.

What difference does it make whether positive or negative voltage is supplied to the spark plug terminals? ....It directly affects the amount of voltage required to fire the spark plugs. When polarity at the spark plug terminals is positive, it's harder for the volt- age to jump across the air gap than when polarity at the plug terminal is negative. Just why this is so is related to a pair of electrical theories--the electron theory and the theory of thermionic emission.

According to the electron theory, all cur- rent flows from negative to positive. The theory of thermionic emission states essentially it's easier for electrons to leave a hot surface than a cold surface.

Combining the two theories, one finds that electrons will always leave a negative charged surface for a positive charged surface, and they will leave the negatively charged surface with more ease when the surface is heated.

Spark plug design is such that the center electrode almost always operates at a higher temperature than the ground electrode. Since it's easier for electrons to leave a hot surface, it is preferred to have the electrons "jump" from the hotter center electrode to the cooler ground electrode.

When the center electrode is negatively charged (negative voltage at the spark plug terminals), this is what happens. Stated another way, putting the negative charge on the hotter center electrode causes the gap to be ionized at lower voltage. (Ionization is necessary to permit passage of the spark through the high resistance of the gases in the cylinder.)

When positive voltage is supplied to the plug terminals, which happens when coil polarity is accidentally reversed, the hotter center electrode becomes positive charged. Consequently, electrons must leave the negative charged ground electrode and move to the positive charged center electrode. But, since the ground electrode is cooler than the center electrode (and remember, it's easier for the electrons to leave a hotter surface), it takes more voltage to make the current jump the gap -- in fact, up to 45 percent more. See Fig. 5.

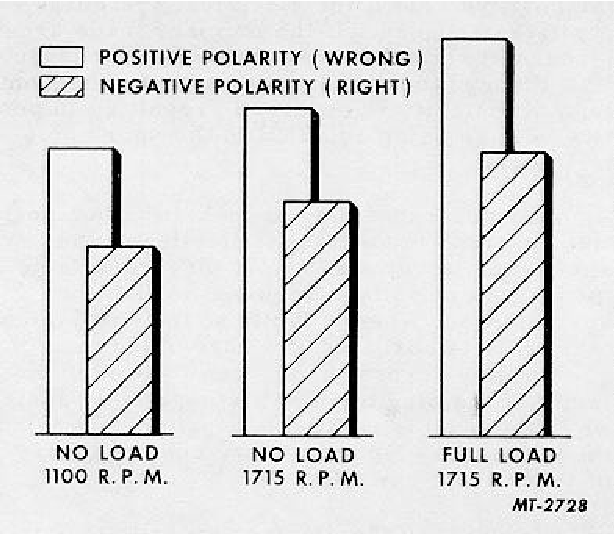

Fig. 5. Chart Showing Extra Voltage Required When Polarity Is Reversed

For a time, the engine may run fine with coil polarity reversed--until the spark plugs have been in use for some time. Then, the driver may encounter hard starting or misfiring under load, as the amount of voltage required to fire the spark plugs under these conditions is higher than at any other time.

In view of the above, it is very important that coil polarity should always be such that negative current is supplied to the spark plug terminals.

CHECKING FOR REVERSED POLARITY

A quick and easy method in checking for reversed polarity is the use of an ordinary wooden pencil, Fig. 6. Using the wooden pencil- check method, remove an ignition cable from any one of the spark plugs. Then, place the graphite tip of the pencil between the spark plug terminal and the cable and observe the spark as it jumps across the gap. If you notice the spark flaring or having an orange tinge on the spark plug side of the pencil, polarity is correct. If it flares or has a tinge on the cable side, polarity is reversed (be sure to use a wooden pencil when making this check or an uncomfortable shock may be received from the spark plugs). NOTE: The above check is used particularly on those coils not having any markings on the coil terminals. All coils recommended and used by the International Harvester Company are properly marked.

NOTE: When checking for reversed polarity, always be certain that the spark plugs are correctly gapped and in good condition.

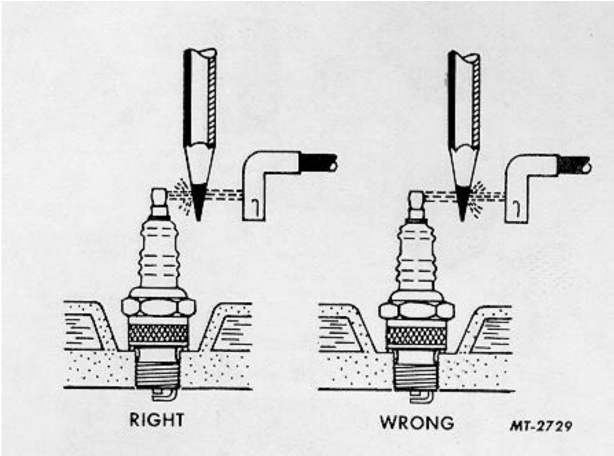

Fig. 6. Method of Checking for Reversed Polarity

CONDENSERS

The condenser which is mounted inside ignition system distributor prevents arcing of distributor points when points begin to open by providing a place for current to flow until points are safely separated. This requires special insulating between the two foil sheets which store current flow and bring it to a quick controlled stop, Fig. 7.

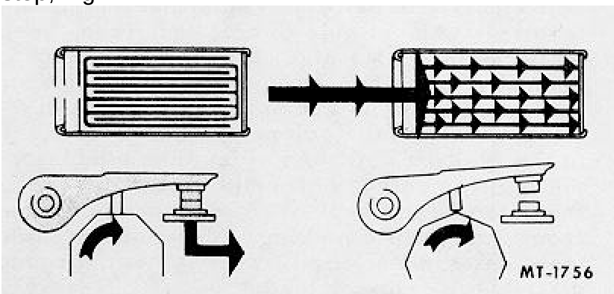

Fig. 7. Action of Current on Condenser

Ignition failures of a few years back were often the result of condenser breakdown. Subsequent investigation proved that internal moisture was responsible. With the adoption of pre-dried insulating paper and hermetic sealing in recent years, condenser breakdown has been practically eliminated. Condenser can is crimped against outer gasket and this compresses a spring at bottom of can with 40 pounds pressure to effectively seal inner and outer gasket surfaces, Fig. 8. Pressure feature provides vibration-free connections which lessen the possibility of high series resistance in condenser assembly.

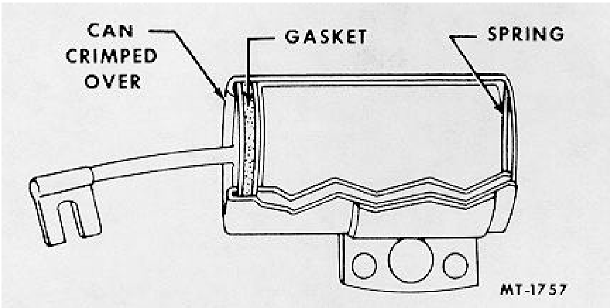

Fig. 8. Construction of Condenser

Heavy-duty condensers require more insulation between foil sheets of the winding. Since heavier insulation also increases the distance between foil sheets, more foil area is needed to obtain the same capacity. This is accomplished by using a larger assembly, Fig. 9.

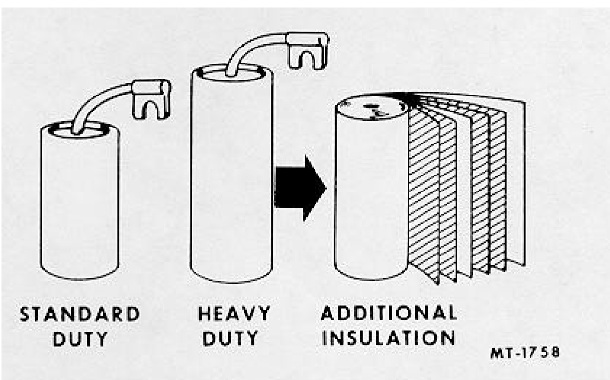

Fig. 9. Comparison Between Standard and Heavy-Duty Condenser

The quality of insulation in a condenser is checked on a scale reading in megohms (a megohm is one million ohms). When all moisture is eliminated in assembly and windings are hermetically sealed, insulating quality or dielectric strength of insulation between foil sheets will be high. If moisture is present in a condenser, insulation is low and may be said to be weak. A condenser having a resistance below 2 megohms when hot will drain sufficient energy from ignition system to cause engine missing.

Series resistance in a condenser is usually caused by loose or corroded connections. High series resistance causes a condenser to be slow in taking a charge and results in higher voltage at the separating contact points. Arcing and rapid wear of contacts along with engine missing during starting and low speed operation may be indications of this condition.

Capacity of most ignition condensers used on IH trucks is approximately .20 microfarads. This value is controlled by the area and closeness of the foil sheets. Standard condensers have two sheets of insulation assembled between foils, making a short container possible. Heavy-duty condensers have three sheets of insulation between foils and because of the greater foil area required, are housed in longer containers.

CONDENSER TESTS

To test an ignition condenser, a special condenser tester must be used, Fig. 10. Such a tester will check condenser for insulation breakdown, low insulation resistance, high series resistance and capacity. All four of these are characteristics which affect ignition performance.

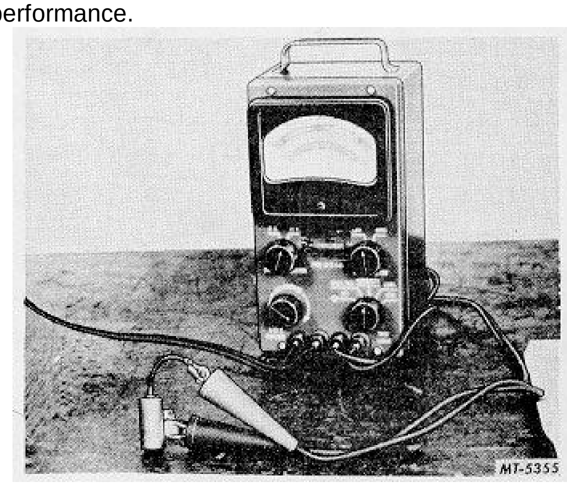

Fig. 10. Condenser Tester

DISTRIBUTOR
(PRESTOLITE IDN-4000 Series)

BREAKERLESS
WITH INTEGRAL ELECTRONIC CONTROL UNIT

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IMPORTANT

When .performing ignition system dwell tests, as prescribed in this section. Check with dwell meter owner's manual to be sure it is suitable for use with electronic ignition.

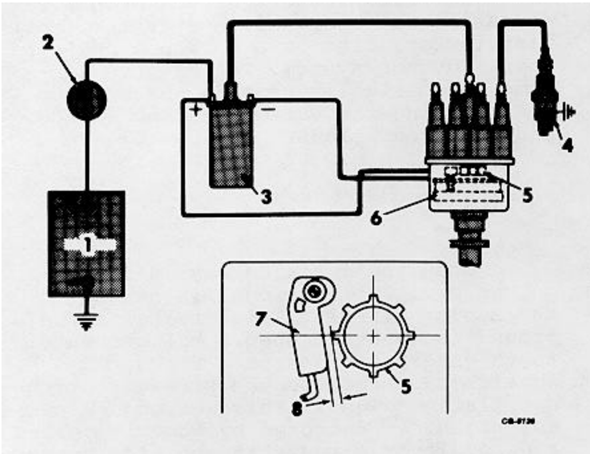


Fig. 1. Schematic View of Ignition System

1.	Battery	5.	Trigger Wheel
2.	Ignition Switch	6.	Electronic Control
3.	Ignition Coil	7.	Sensor
4.	Spark Plug	8.	Air Gap

DESCRIPTION

The electronic (breakerless) ignition system (Figure 1)consists of two major component units - a distributor and an ignition coil. These units are shown in Figure 2.

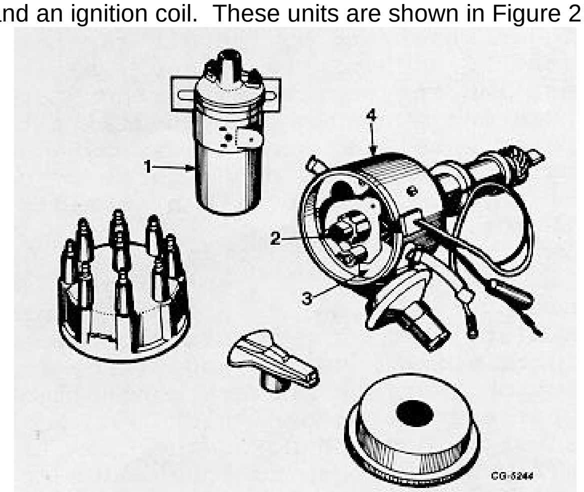


Fig. 2. Major Components of Ignition System

1.	Ignition Coil	3.	Electronic Control Unit
2.	Trigger Wheel	4.	Distributor

The distributor is conventional except that a trigger wheel and an electronic control unit (circuit board and sensor) replace the usual distributor cam, contact points and condenser. A standard type ignition coil is used.

The electronic control unit (Figure 3) is associated with the primary (low voltage) section of the ignition system. The control unit electronically "makes" and "breaks" the ignition primary circuit in response to rotation of the trigger wheel.

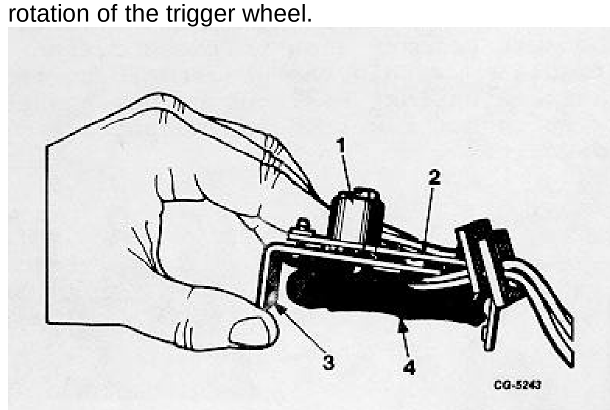


Fig. 3. Electronic Control Unit (Circuit Board, Sensor and Plate Assembly)

1.	Sensor	3.	Mounting Plate
2.	Sensor Plate	4.	Electronic Circuit Board

The control unit circuit board is a completely solid state unit designed for trouble free service. Its electronic components are permanently sealed in a waterproof and vibration resistant compound.

The sensor is a small coil, wound of fine wire, which is very simply a metal detector. The metal that the sensor detects is the teeth of the trigger wheel.

The electronic circuit board and sensor are mounted on the distributor plate assembly. The sensor leads are soldered directly to the circuit board. The electronic control unit (circuit board, sensor and plates) is provided for service as a complete assembly.

Trigger wheels of distributors for four-cylinder engines have four (4) teeth. Distributors for eight-cylinder engines have eight (8) teeth on the trigger wheel.

Distributor primary wiring consists of two leads connected to the ignition coil primary terminals. The red wire from the distributor connects to the coil positive (+) terminal. The brown wire from the distributor connects to the coil negative (-) terminal. (See Figure 4). A third (white) wire from the distributor connects to the deceleration throttle modulator (DTM), , , where used. Because primary (low voltage) current is regulated within the electronic control unit, a ballast resistor or resistance wire is not required in the primary circuit.

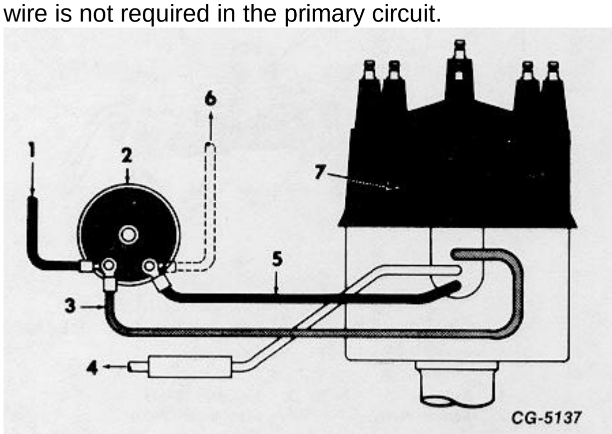


Fig. 4. Distributor Primary Wiring

1. From ignition switch
2. Ignition coil
3. Red wire
4. To decelerate throttle modulator (where used)
5. Brown wire
6. To governor control unit (where used)
7. Distributor

The secondary (high voltage) components are: coil tower, distributor cap, rotor, high tension cables and spark plugs. The new distributor cap featuring superior physical and dielectric strength incorporates male (spark plug type) terminals. A resistor type rotor, interference suppression type rotor, interference suppression type spark plugs are used to meet radio frequency interference standards.

All distributors have a mechanical (centrifugal) spark advance system. Most distributors also have a vacuum operated spark advance system. The advance systems automatically provide the optimum spark timing for various engine speed and load conditions.

OPERATION

When the ignition key is turned on, an oscillating signal is set up in the sensor circuit. This creates a field around the sensor. When a trigger wheel tooth enters the sensor's field, it squelches or reduces the strength of the oscillating signal. This weakened sensor signal is detected by what is called a demodulator circuit in the electronic circuit board. The demodulator circuit controls a transistor to turn off the current in the primary circuit of the coil. When the transistor is turned "off", it opens ("breaks") the coil primary circuit. As in a conventional system, opening the coil primary circuit induces high voltage in the coil secondary circuit which is conducted from the coil to the distributor cap and travels through the rotor and the secondary cables to the spark plugs. When the trigger wheel tooth leaves the sensor's field, the transistor is turned "on" to close ("make") the coil primary circuit.

Dwell angle is determined by the angle between adjacent teeth of the trigger wheel and by the air gap between the ends of the trigger wheel teeth and the sensor. Since there are no wearing surfaces connected with the trigger wheel and sensor, dwell remains constant and should not require adjustment for the service life of the distributor.

The mechanical (centrifugal) advance system is built internally into the distributor and consists of two flyweights which pivot on long life, low friction bearings and are controlled by calibrated springs which tend to hold the weights in the no-advance position. The flyweights respond to changes in engine (distributor shaft) speed and rotate the trigger wheel to advance the spark as engine speed increases and retard the spark as engine speed decreases.

The vacuum advance system incorporates a vacuum diaphragm unit which rotates the distributor sensor plate in response to changes in carburetor throttle bore vacuum.

The two systems, mechanical and vacuum (Figure 5) operate independently, yet work together to provide proper spark advance.

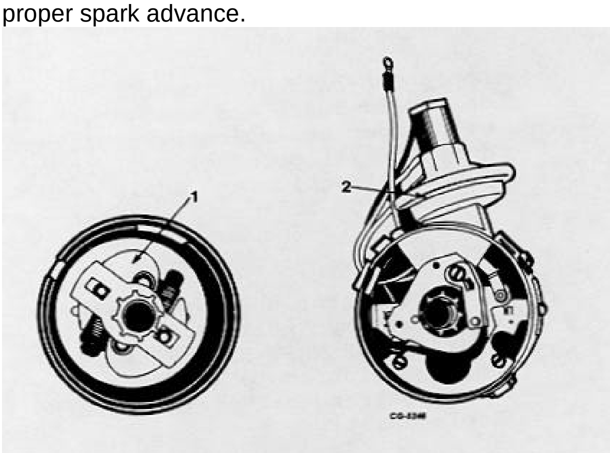


Fig. 5. Spark Advance Systems

1. Mechanical (Centrifugal) Advance Mechanism
2. Vacuum Advance Diaphragm Unit

MAINTENANCE

To perform effectively, the ignition system must be properly maintained. It is important that ignition system maintenance operations be performed at the specified time or mileage intervals.

For ignition system maintenance intervals, procedures and specifications, refer to the appropriate "Emission Con- trol Systems and Service Operations" section of the Truck Service Manual as listed below.

For vehicles built
in 1978, see CTS-2733
For vehicles built
in 1979, see CGES-135

DISTRIBUTOR SERVICE
DISTRIBUTOR REMOVAL

1. Unfasten distributor cap retaining clips. Remove distributor cap (with high tension cables) and position it out of the way.

2. Disconnect vacuum hose from distributor vacuum advance unit, if equipped.

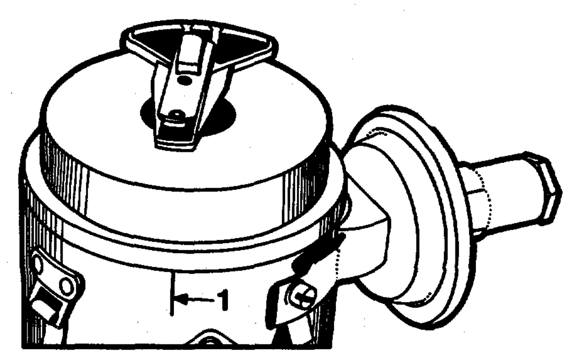
3. Disconnect distributor wiring as follows:

a. Disconnect distributor leads from positive and negative terminals of ignition coil.

b. Disconnect deceleration throttle modulator lead (white wire) at connector (where used).

4. Disconnect tachometer drive cable, if equipped.

5. Scribe a mark on distributor housing in line with tip of rotor (Figure 6) and note position of rotor and distributor housing in relation to surrounding engine parts as reference points for reinstalling distributor.



CG-5247

Fig. 6. Rotor Position Reference Mark

1. Scribe Mark

6. Remove distributor hold-down bolt and clamp.

7. Carefully withdraw distributor from engine. Do not lose gasket or "O" See Figure 7 for gasket or "O" ring location on distributor.

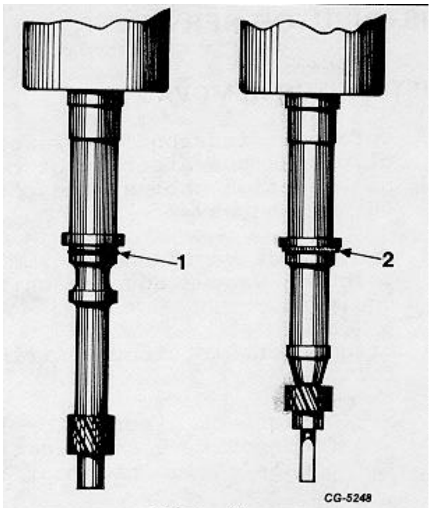


Fig. 7.

1. "O" Ring 2. Gasket

DISTRIBUTOR SHAFT AND BUSHING WEAR TEST

This procedure can be used to check condition of the distributor shaft and shaft bushings in the distributor housing.

1. Clamp distributor in a vise equipped with soft jaws and apply only enough pressure to restrict movement of distributor.

2. Remove distributor rotor and dielectric shield (dust cover).

3. Attach dial indicator to distributor housing so that indicator plunger rests against top portion of trigger wheel assembly (Figure 8).

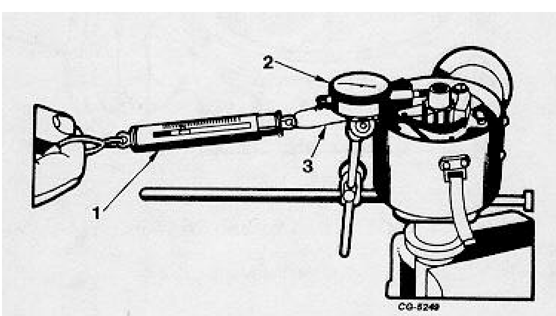


Fig. 8. Shaft and Bushing Wear Test (Checking Distributor Shaft Side Play)

1. Spring Scale
2. Dial Indicator
3. Wire Loop

4. Place one end of a wire loop around top of trigger wheel assembly (rotor shaft). Hook a spring scale in other end of wire loop and pull on a line with plunger of dial indicator (Figure 8). Wire loop must be perpendicular to shaft to assure a straight pull. Also, loop must not interfere with dial indicator mounting bracket.

5. Apply one-half (½) pound of pull on spring scale and read movement of plunger on indicator dial. Apply one-half (½) pound of pull in opposite direction and again read movement on indicator. Peak-to-peak side play is the sum of these two readings.

If distributor shaft side play exceeds maximum permissible limit (see DISTRIBUTOR TEST SPECIFICATIONS), replace distributor shaft bushings (see Distributor Housing Bushing Replacement).

DISTRIBUTOR OPERATION TEST
(On Test Stand)

Operation. of the distributor can be checked on a distributor test stand.

It is advisable to perform the distributor operation test prior to disassembly of the distributor for service. This test will give valuable information about the condition of the distributor and indicate where parts replacement may be required.

Preparation of Distributor Test Stand (Refer to Figure 9)

Additional equipment required:

Battery, 12 volt (fully charged).

Jumper Wires (2) with clips at each end.

1. Mount distributor to be tested in test stand.

2. Clip test stand distributor lead to ring connector on brown distributor lead.

3. Clip test stand ground lead to ground stud on distributor mounting frame.

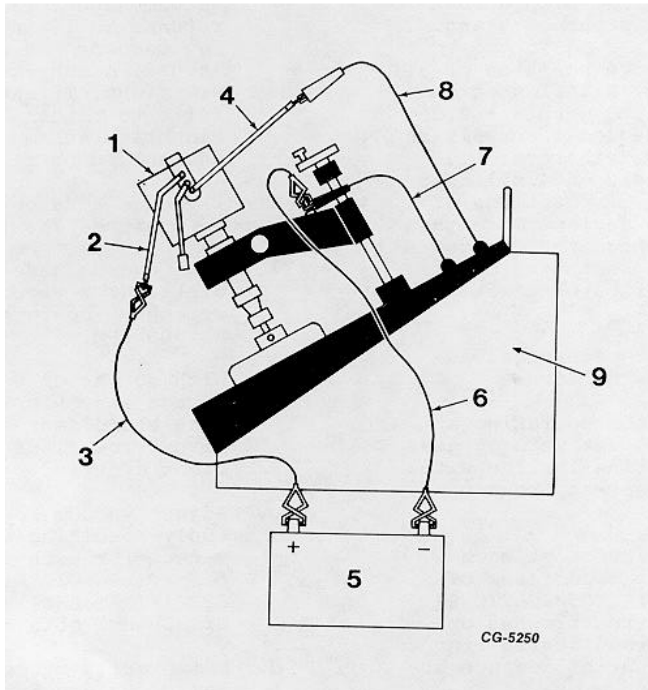


Fig. 9. Distributor-To-Test Stand Wiring

1. Distributor
2. Red Wire
3. Jumper Wire
4. Brown Wire
5. 12 Volt Battery
6. Jumper Wire
7. Test Stand Ground Lead
8. Test Stand Distributor Lead
9. Distributor Test Stand

4. Connect one jumper wire from battery negative (-) post to test stand ground stud.

5. Connect other jumper wire from battery positive (+) post to ring connector on red distributor lead. Test stand and distributor are now ready to make distributor operation test. (Refer to Operation Test Procedure.)

<u>Operation Test Procedure</u>

1. Mount distributor in test stand and connect test leads. as outlined in Preparation of Distributor Test Stand.

2. Calibrate test stand dwell meter per manufacturer's instructions.

3. Operate distributor at 300 RPM (with 12-13 volts primary input) and observe dwell reading. Dwell should be within specified limits (see DISTRIBUTOR TEST SPECIFICATIONS). If dwell is not within specified limits, check trigger wheel-to- sensor air gap.

4. Check trigger wheel tooth accuracy as follows:

a. Operate distributor at 300 RPM and set zero of test stand degree ring in line with arrow flash nearest front of stand.

b. Observe relative position of all arrow flashes. All flashes should be evenly spaced within + 2 degrees at 45 degree intervals on 8-cylinder distributors or 90 degree intervals on 4-cylinder distributors. If positions of arrow flashes deviate more than + 2 degrees check for damaged trigger wheel teeth and check for worn distributor shaft and bushings.

5. Check operation of mechanical advance mechanism as follows:

a. With distributor operating at minimum speed, set zero of test stand degree ring in line with arrow flash nearest front of stand.

b. Operate distributor at each specified test speed (see DISTRIBUTOR TEST SPECIFICATIONS) and observe arrow flashes opposite test stand degree ring to determine amount of advance at each test speed.

If advance is excessive, advance spring tension is weak. If advance is insufficient, advance spring tension is excessive, advance flyweights are sticking or trigger wheel assembly is binding on inner distributor shaft. If advance is erratic, advance flyweights are sticking or trigger wheel assembly is binding on inner distributor shaft.

6. Check vacuum advance diaphragm assembly (where equipped) as follows:

a. Using proper adapter, connect test stand vacuum hose to distributor vacuum advance diaphragm assembly.

b. Apply vacuum and check for operation of diaphragm assembly.

c. Remove vacuum hose from diaphragm assembly. Hold finger over end of hose and adjust vacuum regulator to obtain reading of 16 inches of vacuum on vacuum gauge.

d. Reconnect vacuum hose to diaphragm assembly and observe vacuum gauge. If gauge reading returns to 16 inches within a few seconds and holds 16 inches, diaphragm assembly is air tight. If gauge reading fails to return to 16 inches, diaphragm assembly is leaking and should be replaced.

7. Check vacuum advance operation (where equipped) as follows:

a. With vacuum hose connected to distributor vacuum diaphragm assembly, operate distributor at 300 RPM.

b. With no vacuum applied to diaphragm assembly, set zero of test stand degree ring in line with arrow flash nearest to front of stand.

c. Adjust vacuum regulator to apply specified amount of vacuum for each specified check point (see DISTRIBUTOR TEST SPECIFICATIONS) and note amount of advance obtained.

d. Momentarily exceed highest vacuum value specified, then reduce vacuum and again note vacuum obtained at each specified check point.

If advance is excessive during both steps "c" and "d", a weak diaphragm spring is indicated. If advance is insufficient during both steps "c" and "d", check for sticking or worn sensor advance plate.

8. If distributor passes checks out- lined in Steps 3 through 7 above, it is satisfactory for use. If distributor fails any of the checks, it should be replaced or serviced as needed.

9. Disconnect test leads and vacuum hose from distributor and remove distributor from test stand.

DISTRIBUTOR DISASSEMBLY

The procedure outlined below can be followed to disassemble the distributor for service and overhaul.

Notice that sensor mounting plate configuration and vacuum diaphragm location varies between distributors with right hand (clockwise) rotation and those with left hand (counterclockwise) rotation as shown in (Figure 10).

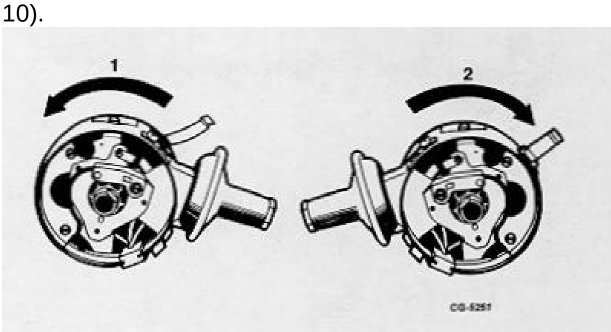


Fig. 10. Illustrating Vacuum Diaphragm Location and Distributor Rotation

1. Counterclockwise rotation
2. Clockwise rotation

1. Remove rotor and dielectric shield ("dust cover") (Figure 11)

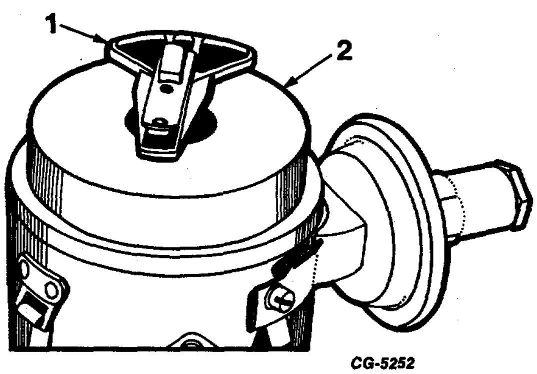


Fig. 11. Distributor Rotor and Dielectric Shield (Dust Cover).

1. Rotor 2. Dielectric Shield (Dust Cover)

2. Remove vacuum advance diaphragm rod retaining "E" clip (Figure 12) and flat washer (where used).

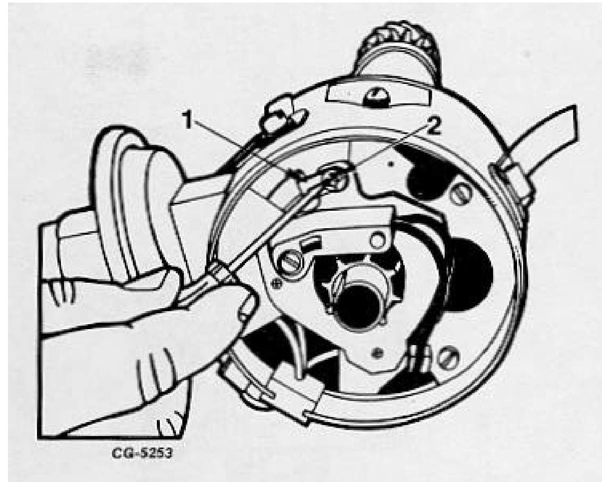


Fig. 12. Removing Diaphragm Rod Retainer

1. Diaphragm Rod 2. Retaining "E" Ring

3. Remove vacuum advance diaphragm mounting screws and remove diaphragm assembly from distributor housing (Figure 13). Remove felt washer from diaphragm rod pin on sensor advance plate. (Figure 13).

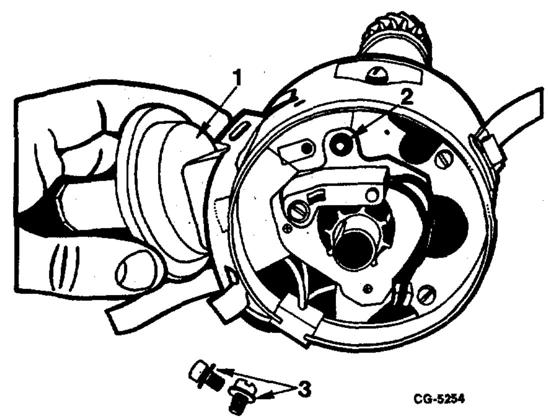


Fig. 13. Removing Vacuum Advance Diaphragm Assembly.

1. Diaphragm Assembly
2. Felt Washer
3. Retaining Screws

4. Remove electronic control unit (circuit board, sensor and plate assembly) as follows:

5.

a. Remove distributor plate (control unit) mounting screws. (Figure 14).

b. Carefully pull wiring grommet from slot in distributor housing.

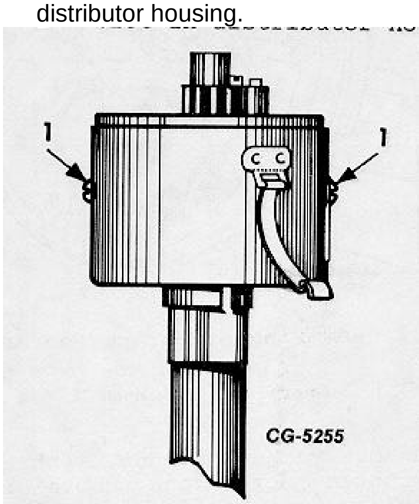


Fig. 14. Distributor Plate Mounting Screw

1. Mounting Screw

c. Lift control unit assembly out of housing.

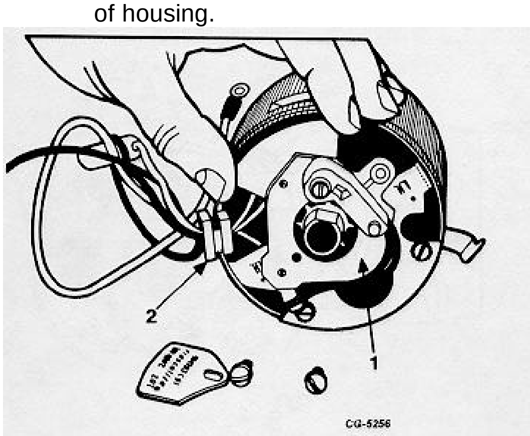


Fig. 15. Removing Electronic Control Unit

1. Electronic Control Unit
2. Grommet

5. Measure and record distributor shaft end play (Figures 16 and 17). Measure end play between thrust washer and gear (Figure 16) or thrust washer and thrust collar (Figure 17). If end play exceeds specified limits, thrust washers (upper and lower) should be replaced. Excessive end play could result in failure or improper engine timing.

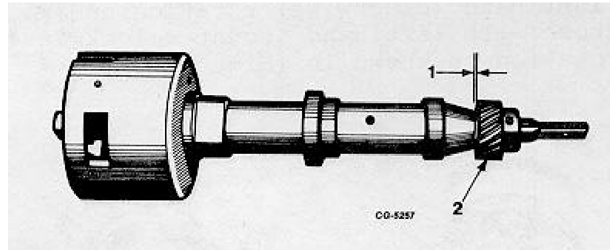


Fig. 16. Checking Distributor Shaft End Play (Thrust Washer-to-Gear Clearance) (Typical)

1. End Play 2. Driven Gear

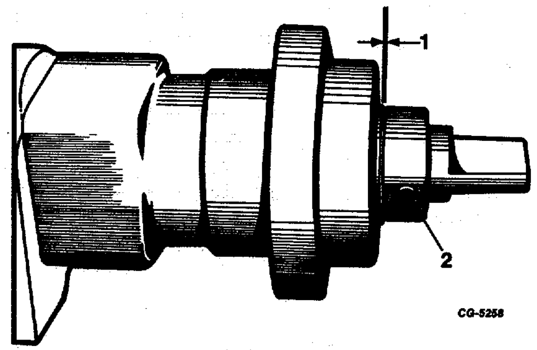


Fig. 17. Checking Distributor Shaft End Play (Thrust Washer-to-Thrust Collar Clearance) (Typical)

1. End Play 2. Thrust Collar

6. Support distributor shaft on a wood block or in a vise equipped with soft jaw shields and drive roll pin from gear or thrust collar and distributor shaft using a punch and hammer (Figure 18).

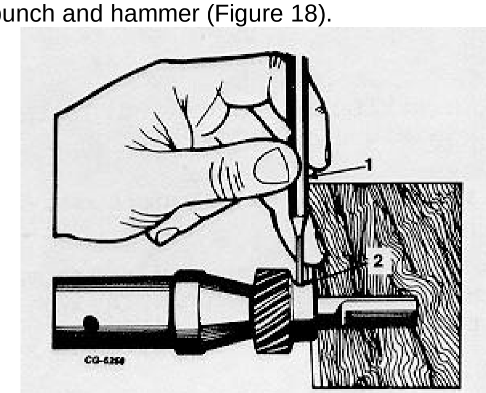


Fig. 18. Removing Distribution Driven Gear Pin

7. Place distributor housing and shaft assembly in a press and press gear or thrust collar and lower thrust washers, Figures 19 and 20, from shaft.

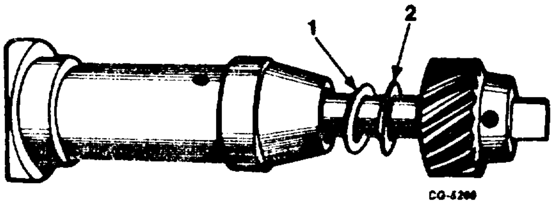


Fig. 19 Lower Thrust Washers (All Distributors Except for V-537 Engine).

1. Thrust Washer (Inner)
2. Thrust Washer (Outer)

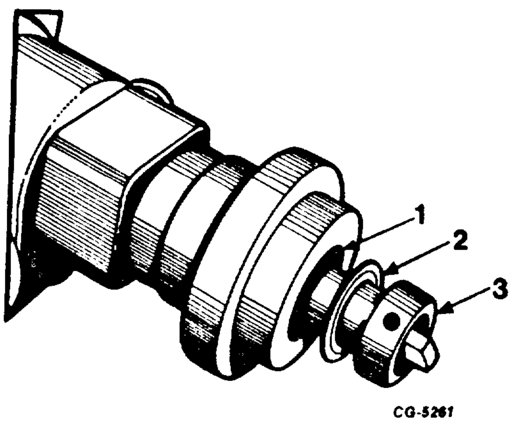


Fig. 20 Lower Thrust Washer (Distributor for V-537 Engine)

1. Seal
2. Thrust Washer
3. Thrust Collar

8. Withdraw distributor shaft assembly from distributor housing. Be careful not to lose upper thrust washer(s) (Figures 21 and 22).

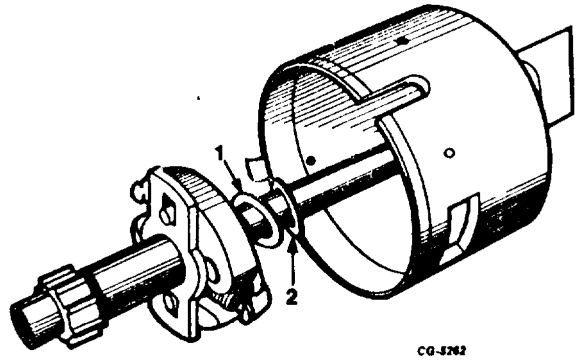


Fig. 21 Upper Thrust Washers (Distributors Without Tachometer Drive)

1. Thrust Washer (Outer)
2. Thrust Washer (Inner)

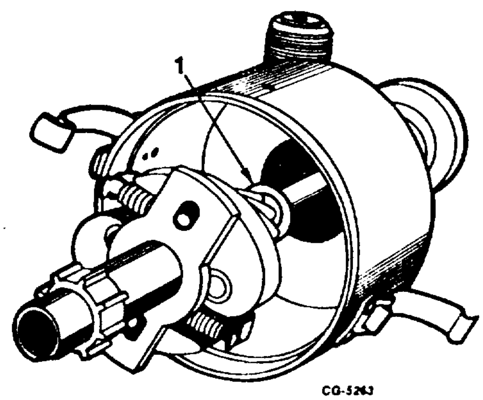


Fig. 22 Upper Thrust Washer (Distributors With Tachometer Drive)

1. Thrust Washer

CLEANING AND INSPECTION

1. Wash metal parts in cleaning solvent.

IMPORTANT

Do Not wash cap, rotor, vacuum advance diaphragm assembly or electronic control unit.

It is permissible to soak the distributor housing if the bushings are to be replaced. If bushings are not to be replaced, clean distributor housing carefully so as not to wash oil from bushings.

2. Inspect distributor shaft for wear and check its fit in bushing spin distributor housing. If shaft and bushings are worn, replace them.
3. Mount distributor shaft in "V" blocks and check shaft alignment with dial indicator. Runout should not exceed 0.05mm (.002").
4. Inspect mechanical advance weights, for free fit on their pivot pins and in slots of trigger wheel yoke with- out excessive looseness. If wear or damage is found, replace distributor- shaft assembly.
5. Inspect trigger wheel teeth for dam age. Check fit of trigger wheel assembly on distributor shaft. It should be free without roughness. If roughness or excessive looseness exists, replace distributor shaft' assembly.
6. Inspect sensor advance plate of electronic control unit. If binding or wear of pivot pin is indicated, replace control unit assembly.
7. On distributors with tachometer drive, inspect tachometer drive parts. (See Tachometer Drive Service).
8. Inspect rotor, distributor cap and high tension cables. (See Secondary Circuit Inspection Under IGNITION SYSTEM TROUBLE SHOOTING TEST.)

DISTRIBUTOR HOUSING BUSHING REPLACEMENT

The following procedures can be followed to remove and replace the distributor shaft bushings in the distributor housing. Distributor tool set SE-1955 will assist in performing these operations.

Illustrations show bushing removal and installation operations being per- formed on distributor without tachometer drive. Procedures for distributors with tachometer drive are similar.
Bushing Removal

1. On distributors without tachometer drive, use a small screwdriver to pry upper bushing grease retainer washer from distributor housing (Figure 23).

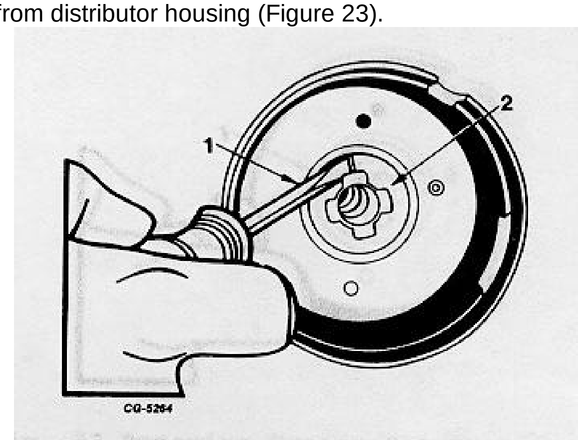


Fig. 23. Removing Grease Retainer Washer (Distributors Without Tachometer Drive)

1. Screwdriver 2. Grease Retainer

2. On distributors for V-537 engine, use a screwdriver to pry oil seal out of lower end of distributor housing (Figure 24).

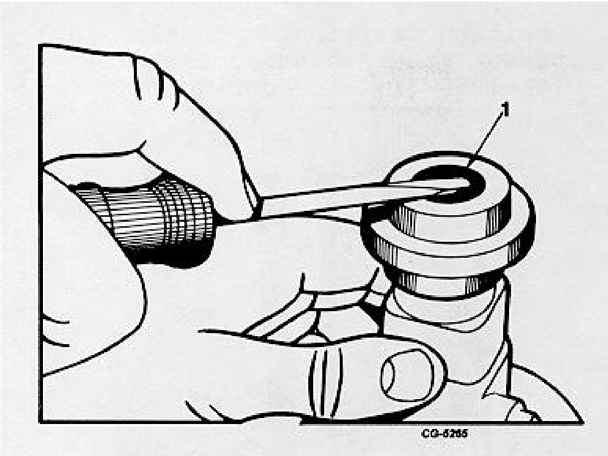


Fig. 24. Removing Lower Oil Seal (Distributors for V-537 Engine)

1. Seal

3. Install bushing remover SE-1955-5 in upper bushing (Figure 25).

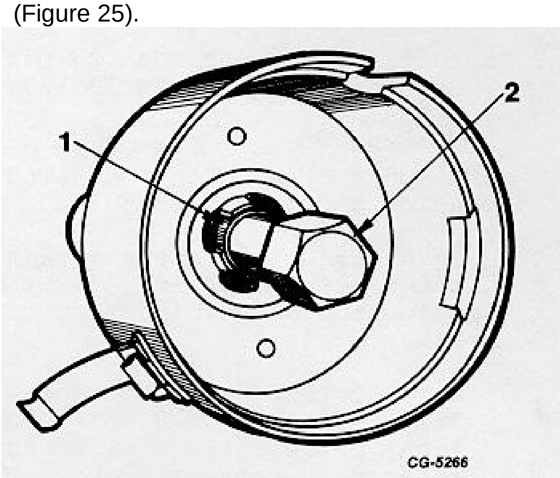


Fig. 25. Bushing Remover SE-1955-5 Installed in Upper Bushing

1. Upper Bushing 2. Remover

4. Place distributor housing on press bed. Insert knock-out bar through lower bushing and allow it to rest on bushing remover already installed in upper bushing. Press upper bushing from housing by pressing against knock-out bar (Figure 26).

   The knock-out bar can be made locally from cold rolled bar stock, 11mm (7/16 in.) in diameter by 30 cm (12 in.) long.

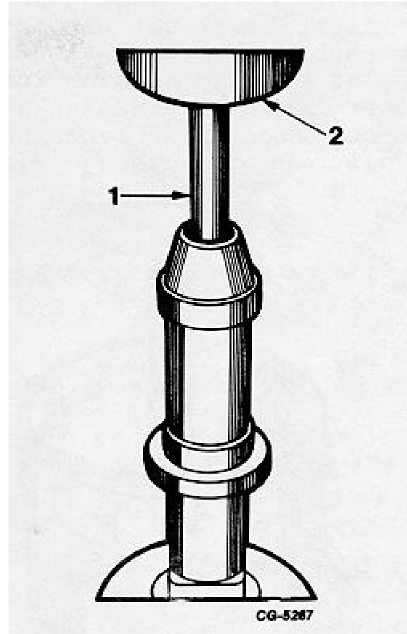


Fig. 26. Pressing Out Upper Bushing Using Knock-Out Bar

1. Knock-Out Bar 2. Press Ram

5. Install bushing remover SE-1955-5 in lower bushing (Figure 27).

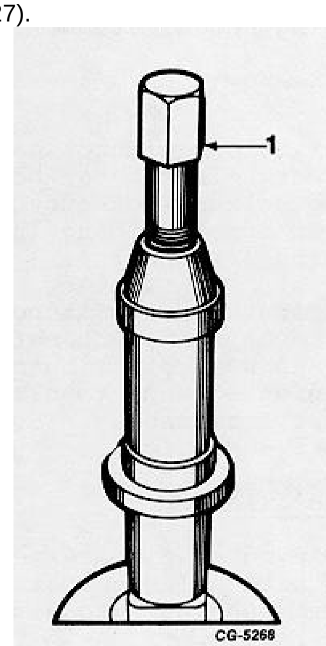


Fig. 27. Bushing Remover SE-1955-5 Installed in Lower Bushing

1. Remover

6. Place distributor housing on press bed. Insert knock-out bar through upper bushing bore and allow to rest on end of bushing remover installed in lower bushing. Pressing against knock-out bar, press lower bushing from distributor housing (Figure 28)

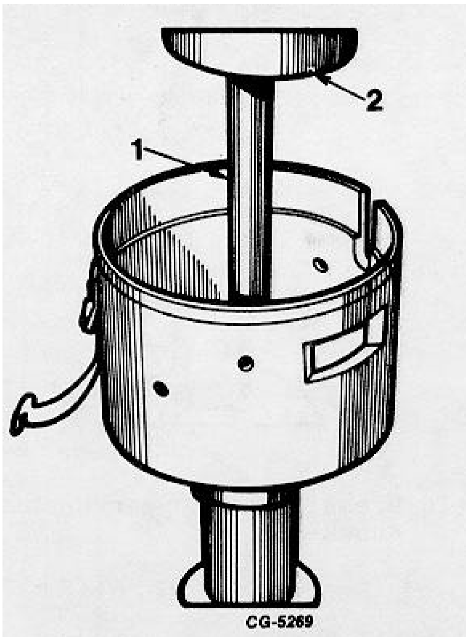


Fig. 28. Pressing Out Lower Bushing Using Knock-Out Bar

1. Knock-Out Bar 2. Press Ram

7. On distributors without tachometer drive, wash distributor housing in cleaning solvent to remove old lubricant from upper bushing lubricant reservoirs (Figure 35).

8. On distributors with tachometer drive, remove cover from tachometer drive cavity and wash distributor housing in cleaning solvent to clean old lubricant from cavity. (See Tachometer Drive Service)

<u>Bushing Installation</u>

1. Lubricate outer diameter of new upper bushing with a light coat of grease and start bushing into distributor housing bore.

IMPORTANT
On distributors without tachometer drive, groove in outside diameter of bushing must be positioned at the top (Figure 29).

2. Position distributor housing in press. Insert bushing installer (SE-1955-7) into bushing (Figure 29).

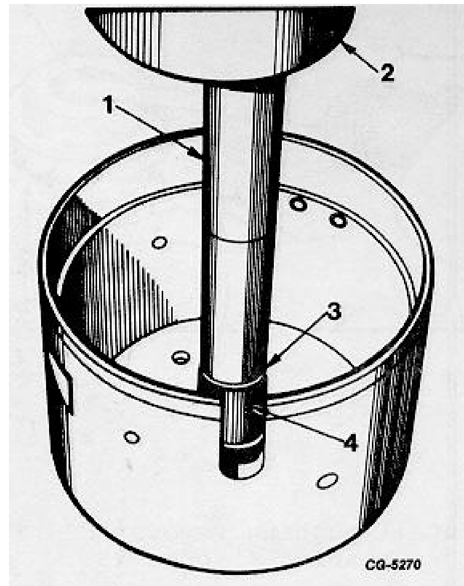


Fig. 29. Installing Upper Bushing using Bushing Installer SE-1955-7.

1. Installer 3. Groove
2. Press Ram 4. Upper Bushing

3. Press upper bushing into housing to dimension shown in Figure 30:

On distributors without tachometer drive, 2.4 mm (3/32 inch) below top of bushing support ribs.

On distributors with tachometer drive, flush to 0.8 mm (1/32 inch) below surface of tachometer drive counterbore.

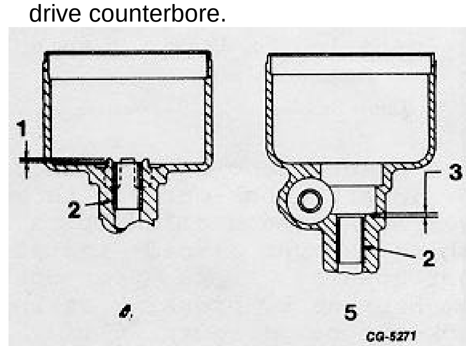


Fig. 30. Upper Bushing Location Dimensions

1. 2.4mm (3/32 in.)
2. Bushing
3. Flush to 0.8mm (1/32 in.)
4. Without Tach Drive
5. With Tach Drive

4. Lubricate outer diameter of new lower bushing with a light coat of grease and start bushing into distributor housing bore.

5. Position distributor housing in press. Insert bushing installer (SE-1955-7) into bushing (Figure 31).

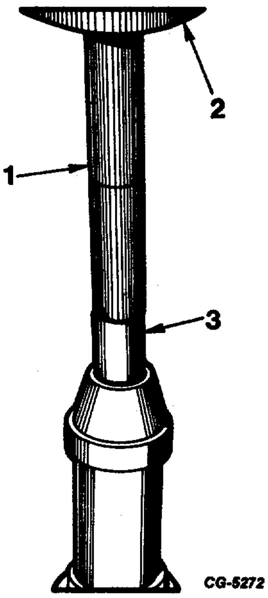


Fig. 31 Installing Lower Bushing Using Installer SE-1955-7.

1. **Installer**
2. **Press Ram**
3. **Lower Bushing**

6. Press lower bushing into housing to dimension shown in Figure 32. On distributors for all engines except V-537, 2.4 mm (3/32 inch) below bottom end of distributor housing.

   On distributors for V-537 engines, flush with surface of oil seal counterbore.

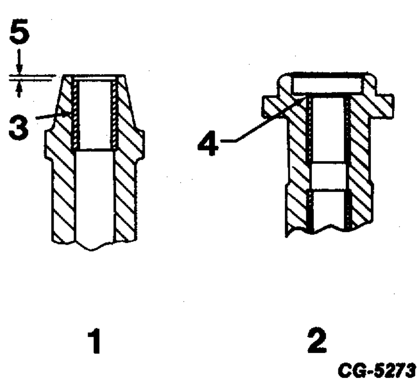


Fig. 32 Lower Bushing Location Dimensions.

1. **All distributors except for V-537 engine**
2. **Distributor for V-537 engine**
3. **Bushing**
4. **Bushing flush with housing.**
5. **24 mm (3/32 in.)**

After bushings have been installed, check fit of distributor shaft in bushings. Size bushings if necessary to obtain .008-.038 mm (.0003-.0015 inch) running clearance.

IMPORTANT

The oilite bushings should not be reamed. Swelling and burrs may be removed with a burnishing tool. For distributors without tachometer drive, use burnisher tool SE-1955-2. For distributors with tachometer drive, use burnisher tool SE-2779.

7. If shaft passes through upper bushing but binds in lower bushing, burnish lower bushing. Burnish lower bushing only. If shaft does not pass through or binds in upper bushing, burnish upper bushing first and repeat check for shaft fit. Then burnish lower bushing, if needed.

To burnish bushings:

a. Place flat end of burnisher in a vise. Coat burnisher with SAE-20 engine oil.

b. Burnish upper bushing by carefully placing distributor housing on burnisher and rotating the housing clockwise using light pressure until tool passes through bushing (Figure 33).

c. Burnish lower bushing per step "b" above.

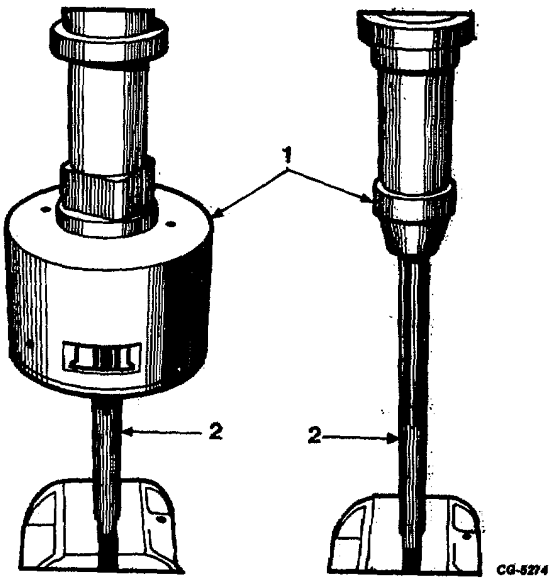


Fig. 33 Burnishing Upper and Lower Bushings Using Burnisher Tool.

1. Housing **2. Burnisher**

8. On distributors for V-537 engine, press new oil seal into lower end of housing until seal is flush with end of housing.

Lip of seal must face outward as shown in Figure 34.

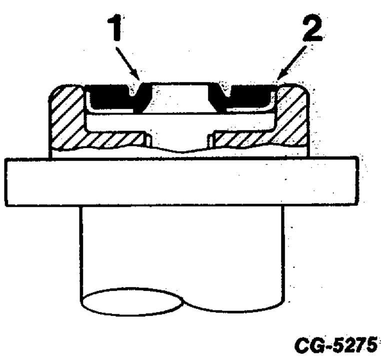


Fig. 34 Oil Seal Installation (Distributors) for V-537 Engine.

1. Lip of seal to face outward
2. Install seal flush with distributor housing

9. On distributors without-tachometer drive, fill upper bushing lubricant reservoirs as follows:

   a. Fill reservoirs (Figure 35) with lubricant (oil saturated cotton).

At distributor manufacture, reservoirs are filled with Permawick #560NP which is also recommended for use at distributor overhaul. Where this product is not available, adequate lubrication can be obtained by packing lubricant reservoirs with cotton (such as medical or cosmetic cotton balls) saturated with engine oil.

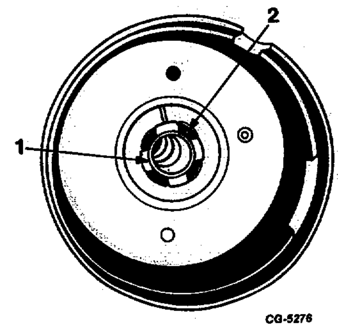


Fig. 35 Upper Bushing Lubricant Reservoirs (Distributors Without Tachometer Drive)

1. Bushing **2. Lubricant Reservoir**

   b. Wipe excess oil from floor of distributor housing and install grease retainer washer (Figure 36). Tangs of washer must lock into groove in upper bushing.

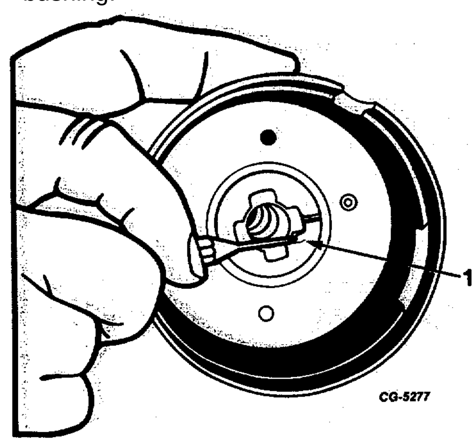


Fig. 36 Installing Grease Retainer Washer (Distributors Without Tachometer Drive)

1. Grease Retainer

MECHANICAL ADVANCE SYSTEM SERVICE

Mechanical advance system components are not provided for service individually. However, it is recommended that the mechanical advance system be disassembled for inspection and lubrication, as outlined below, at the time of distributor overhaul.

Disassembly

(Refer to Figure 37).

IMPORTANT

Mark Advance weights, weight pivot pins and trigger wheel assembly to assure reassembly in the same positions.

1. Remove felt wick.
2. Remove trigger wheel assembly retainer from distributor shaft using hooked extractor tool.

   NOTE: Do not remove trigger wheel from the trigger wheel assembly, Figure 37.
3. Slide trigger wheel assembly from distributor shaft.
4. Remove primary and secondary advance weight springs.
5. Remove advance weights and thrust washer.

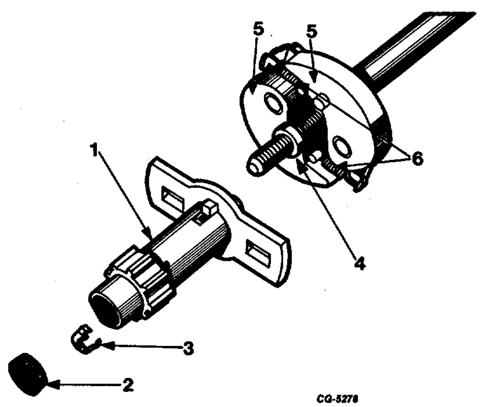


Fig. 37 Mechanical Advance System Components

1. Trigger wheel assembly	**4. Thrust washer**
2. Felt wick	**5. Weights**
3. Retainer	**6. Springs**

Inspect mechanical advance components. If wear or damage is found, replace distributor shaft assembly.

Reassembly

1. Lubricate advance weight bushings and pivot pins with a light film of premium quality grease (Mobile No. 532 or equivalent). Install weights on pivot pins.
2. Install advance springs.
3. Make sure advance weights pivot freely on pins.
4. Lubricate trigger wheel assembly pilot surface of distributor shaft with premium quality grease. Grooves in pilot diameter should be filled with lubricant. Lands between grooves should have only a thin film of lubricant.
5. Apply a light coat of premium quality grease to thrust washer and position thrust washer on distributor shaft.
6. Position trigger wheel assembly on pilot surface of distributor shaft. Align slots in trigger wheel yoke with pins on advance weights and push trigger wheel assembly into position.
7. Install trigger wheel assembly retainer. If necessary bend arms of retainer to assure that retainer grips slow in distributor shaft.
8. Install felt wick.
9. Make sure mechanical advance mechanism operates freely.

TACHOMETER DRIVE SERVICE

Tachometer Drive Gear and Bearing Replacement

Tachometer drive gear and bearing (Figure 38) can be replaced by following the procedure outlined below.

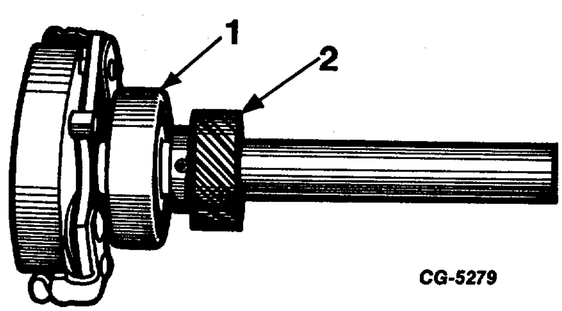


FIG. 38 Tachometer Drive Gear and Bearing

1. Bearing 2. Tachometer drive gear

1. Remove trigger wheel assembly and mechanical advance components from distributor shaft. (See Mechanical Advance System Service).

2. Support distributor shaft and drive roll pin from tachometer drive gear using punch and hammer (Figure 39).

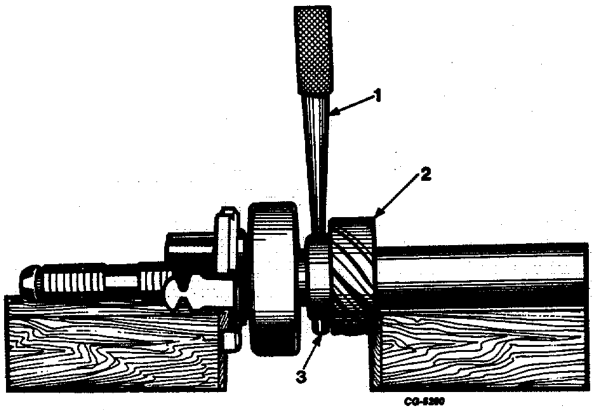


Fig. 39 Removing Tachometer Drive Gear Pin

1. **Punch**
2. **Tachometer drive gear**
3. **Roll pin**

3. Remove tachometer drive gear from distributor shaft.

4. Remove bearing from distributor shaft as follows:

   a. Position bearing puller attachment SE-1336-16 (Owatonna No. 950 or equivalent) under bearing (Figure 40).

IMPORTANT

Avoid distorting advance weight plate when installing bearing puller.

   b. Support bearing puller in press bed and press shaft from bearing.

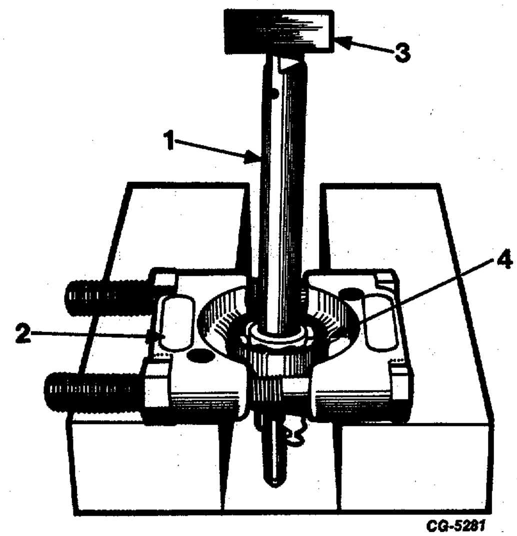


Fig. 40 Removing Tachometer Drive Bearing Using SE-1336-16 Bearing Puller

1. **Distributor shaft**
2. **Puller**
3. **Press ram**
4. **Bearing**

5. Install new bearing as follows:

   a. Using a piece of pipe-12.7 mm (1/2 inch) I.D. x 60 mm (2¼ inches) long as a support base (Figure 41), position distributor shaft in press.

   b. Place bearing on distributor shaft with sealed side toward advance weight plate.

   c. Using a piece of pipe-12.7 mm (½ inch) I.D. of suitable length as a driver tool, press bearing onto shaft to a dimension of 14.3 mm (9/16 inch) from bottom of advance weight plate to bottom of bearing (Figure 41).

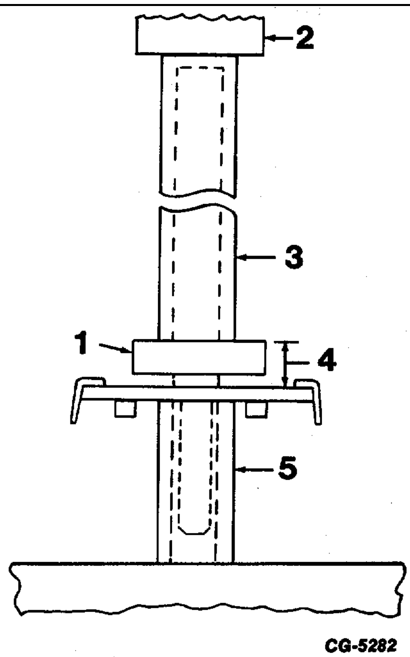


Fig. 41 Installing Tachometer Drive Bearing

1. **Bearing**
2. **Press ram**
3. **Driver tool (pipe)**
4. **14.3 mm (9/16 in.)**
5. **Support (pipe)**

6. Install new tachometer drive gear on distributor shaft. New gear will have pin hole drilled in one side only. Install as follows:

   a. Position gear on distributor shaft and align pin hole with hole in shaft.

   b. Support distributor shaft in drill press and drill hole Through other side of gear.

   c. Install roll pin.

7. Lubricate and install mechanical advance components and trigger wheel assembly (See Mechanical Advance System Service).

<u>Tachometer Driven Gear and Shaft</u>

The tachometer driven gear, shaft and bushing are not provided for service. However, at the time of distributor overhaul, these parts should be thoroughly cleaned and lubricated as outlined below.

1. Remove tachometer drive shaft cover as follows:

   a. Drill a 3mm (1/8 inch) hole in center of cover (Figure 42).

   b. Insert a hooked tool or a punch into hole in cover and pry cover from distributor housing (Figure 42).

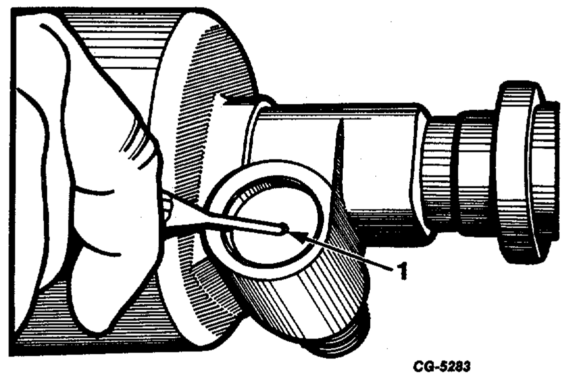


Fig. 42 Removing Tachometer Drive Shaft Cover

1. **Drill Hole in Cover.**

2. Clean old lubricant from tachometer drive gear and cavity in distributor housing. (See "IMPORTANT" under Cleaning and Inspection).

3. Inspect tachometer driven gear, shaft and bushing. If excessive wear or damage is indicated, replace distributor assembly.

4. If parts are satisfactory for reuse:

   a. Fill tachometer drive gear and cavity with ball bearing lubricant (Humble "Andok 260" or equivalent).

   b. Install new tachometer drive shaft cover in distributor housing.

DISTRIBUTOR REASSEMBLY

1. Install distributor shaft into distributor housing as outlined below:

IMPORTANT

If a new distributor shaft is being installed, a new distributor driven gear or thrust collar and new thrust washers must also be installed.

   a. Position new upper thrust washer(s) on shaft.

Distributors with tachometer drive have one thrust washer (Figure 22).

Distributors without tachometer drive have two thrust washers (Figure 21) which must be installed properly. Install outer washer (blue steel) first with lip of washer facing toward lower end of shaft. Install inner thrust washer (silver color) with lip facing lower end of shaft. Inner (silver color) washer should seat on lip of outer (blued) washer.

b. Lubricate distributor shaft engine oil.

c. Slide distributor shaft into distributor housing. Use care to avoid damaging lower oil seal where used, when install- ing shaft.

2. Position new lower thrust washer(s) on shaft.

Distributors for V-537 engine have one thrust washer (Figure 20).

All distributors except for V-537 engine have two thrust washers (Figure 19) which must be installed properly. Install inner washer (silver color) first with lip of washer facing toward distributor housing. Install outer washer (blued steel) with lip facing toward distributor housing. Outer (blued) washer should seat in inner (silver color) washer.

3. Install distributor driven gear or thrust collar as outlined below:

<u>If original distributor driven gear or thrust collar is being used:</u>

a. Position gear or thrust collar on distributor shaft and align roll pin hole in gear or thrust collar with roll pin hole in shaft.

b. Install driven gear or thrust collar roll pin.

<u>If new distributor driven gear or thrust collar is being installed:</u>

New gear or thrust collar will have pin hole drilled in one side only. Install as follows:

a. Position gear or thrust collar on distributor shaft and align hole with pin hole in shaft.

b. Support distributor assembly in drill press. Using existing hole in gear or thrust collar as a guide, drill roll pin hole in distributor shaft and other side of gear or thrust collar.

c. Install roll pin.

<u>If new distributor shaft and gear or thrust collar are being in- stalled:</u>

a. Position gear or thrust collar on distributor shaft and establish specified shaft end play. (See DISTRIBUTOR TEST SPECIFICATIONS).

b. Support distributor assembly in drill press. Using existing hole in gear or thrust collar as a guide, drill roll pin hole in distributor shaft and other side of gear or thrust collar.

c. Install roll pin.

4. Install electronic control unit (circuit board, sensor and plate assembly) as follows:

a. Lift sensor advance plate of control unit and put a small amount of premium quality grease (Mobile No. 532 or equivalent) under each of the three thrust buttons.

b. Position control unit assembly and wiring grommet in dis-tributor housing.

c. Install distributor plate (control unit) mounting screws.

5. Position vacuum advance diaphragm assembly on distributor housing and install mounting screws.

6. Install felt washer on diaphragm rod pin of sensor advance plate (Figure 13). Oil felt washer with engine oil.

Connect diaphragm rod to pin on sensor advance and install flat washer (where used) and rod retaining "E" clip. (Figure 12)

7. Adjust trigger wheel-to-sensor air gap as follows:

a. Rotate trigger wheel until one tooth is aligned with center- line of sensor (trigger wheel tooth perpendicular to flat surface of sensor). (Figure 43)

b. Using feeler gauge, measure air gap between sensor and end

end of tooth (Figure 43). Move sensor as needed to obtain specified air gap (see DISTRIBUTOR TEST SPECIFICATIONS).

Tighten sensor mounting screw and recheck air gap.

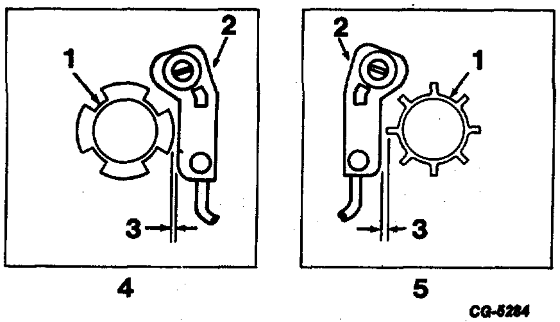


Fig. 43 Trigger Wheel-to-Sensor Air Gap

1. Trigger wheel
2. Sensor
3. Air gap
4. 4 cylinder engine
5. 8 cylinder engine

8. Mount distributor in distributor test stand. (See Distributor Operation Test).

9. Operate distributor at 300 RPM (with 12-13 volts primary input) and observe dwell reading. Dwell should be within specified limits.

   a. If dwell reading is within specified limits, trigger wheel-to-sensor gap is satisfactory.

   b. If dwell reading is not within specified limits, loosen sensor mounting screw and adjust trigger wheel-to-sensor air gap as required to obtain specified dwell. Move sensor toward trigger wheel to decrease dwell or away from trigger wheel to increase dwell. Dwell is affected approximately one-half (½) degree per .025 mm (.001 in.) of sensor movement. After correct dwell is obtained, tighten sensor mounting screw.

10. Check operation of mechanical advance mechanism as follows:

   a. With distributor operating at minimum speed, set zero of test stand degree ring in line with arrow flash nearest front of stand.

   b. Increase distributor speed, pausing at each specified test speed to note the amount of advance that is occurring. If advance at specified test speeds is not within specified limits, adjust advance spring tension by bending the spring posts (Figure 44). Bend post(s) toward distributor shaft to decrease tension (increase advance) and away from shaft to increase tension (decrease advance).

CAUTION

When making adjustments, be extremely careful not to pry against control unit electronic circuit board.

Make adjustments carefully in order to keep advance within specified limits. Adjustment is not complete until advance falls within specified limits at all test speeds.

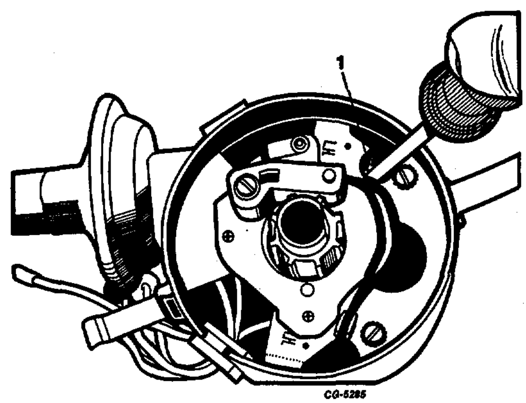


Fig. 44 Adjusting Advance Spring Tension

1. Spring Post

11. Connect test stand vacuum hose to vacuum advance diaphragm and check operation of vacuum advance. If advance does not fall within specified vacuum readings, replace vacuum diaphragm and recheck vacuum advance operation.

12. If distributor operation is satisfactory, remove distributor from test stand and install dielectric shield (dust cover) and rotor.

DISTRIBUTOR INSTALLATION

1. Clean distributor mounting area of engine block.

2. Install a new distributor mounting gasket in counterbore of engine block or install a new "O" ring seal on distributor housing, whichever is applicable.

3. Position distributor in engine. If engine was not rotated while distributor was removed.

   a. Align rotor tip with mark scribed on distributor housing during removal. Then, on distributors with driven gear mounted on lower end of distributor shaft, turn rotor about 1/8 turn clockwise past scribed mark.

   b. Slide distributor down into engine and position distributor housing in approximately the same location (in relation to surrounding engine parts) as when removed. It may be necessary to move rotor and shaft slightly to start gear into mesh with camshaft gear and/or to engage oil pump shaft drive tang, but rotor should align with scribed mark when distributor is down in place.

   c. Install distributor hold-down clamp, bolt and lock washer, but do not tighten bolt.

   If engine was rotated while distributor was removed, it will be necessary to re-establish timing as follows -

   a. Remove No. 1 spark plug (No. 8 on V-304, V-345, V-392 engines). Hold finger over spark plug hole and rotate engine until compression pressure is felt. Slowly continue to rotate engine until timing mark on crankshaft pulley lines up with specified initial timing mark on timing quadrant. (For initial timing setting, refer to tune-up data decal on engine.) Always rotate engine in direction of normal rotation. Do not "back" engine to align timing marks.

   b. Turn distributor shaft until rotor tip points in the direction of the No. 1 terminal in the distributor cap (No. 8 terminal on V-304, V-345, V-392 engines). Then, on distributors with driven gear mounted on lower end of distributor shaft, turn rotor about 1/8 turn clockwise past position of initial timing terminal.

   c. Slide distributor down into engine and position distributor housing in approximately the same location (in relation to surrounding engine parts) as when removed.

   It may be necessary to move rotor and shaft slightly to start gear into mesh with camshaft gear and/or to engage oil pump shaft drive tang, but rotor should align with the position of initial timing terminal when distributor is down in place.

   d. Install distributor hold-down clamp, bolt and lock washer, but do not tighten bolt.

4. Install distributor cap (with high tension cables) on distributor housing making sure tang on vacuum advance unit aligns with slot in distributor cap and that cap fits down snug on distributor housing.

CAUTION

If distributor cap is incorrectly positioned on distributor housing, cap or rotor may be damaged when engine is cranked.

5. Connect distributor primary wiring as follows: (See Figure 4)

   a. Connect brown distributor lead to ignition coil negative (-) terminal.

   b. Connect red distributor lead to ignition coil positive (+) terminal.

   c. Connect deceleration throttle modulator lead (white wire) to harness connector (where used).

6. Connect tachometer drive cable, if equipped.

7. Connect timing light to No. 1 spark plug (No. 8 spark plug on V-304, V-345, V-392 engines).

IMPORTANT

Do not puncture high tension cables or boots to make contact. Use proper adapters. (Figure 45).

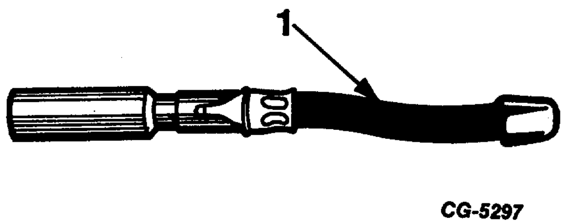


Fig. 45

1. Adapter

8. Operate engine at idle speed and observe timing marks with timing light. Rotate distributor housing as needed to align timing mark on crankshaft pulley with specified initial timing mark on timing quadrant (Figure 46). When timing is correct; tighten distributor hold down bolt and recheck timing to be sure it did not change.

9. Disconnect timing light and connect vacuum hose to distributor advance unit (where equipped).

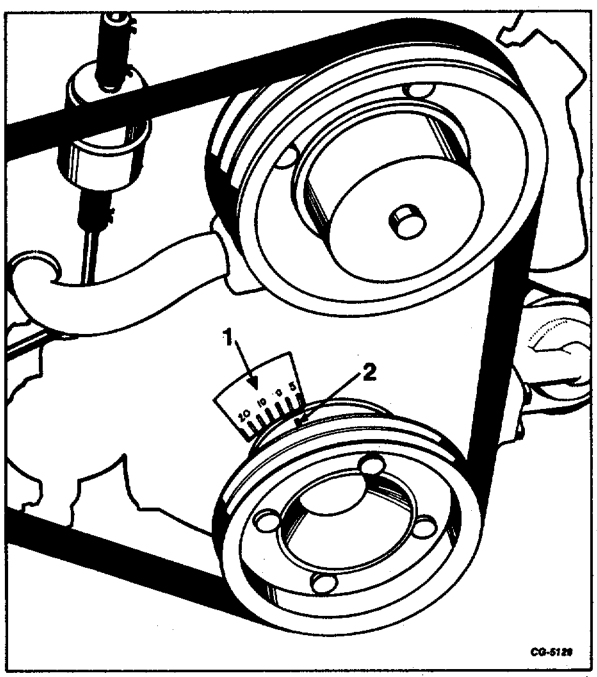


Fig. 46 Timing Marks (V-304, V-345, V-392 Engines Shown)

1. Timing quadrant
2. Timing mark

IGNITION SYSTEM TROUBLE SHOOTING TEST

The procedure outlined below can be used to check operation of the electronic (breakerless) ignition system. Electrical components (coil and electronic control unit) are not repairable. If the operation test indicates that they are faulty, replace them.

TEST EQUIPMENT

The following equipment is required to make the operation test:

D. C. Voltmeter

Insulated grippers for handling high tension cables.

Extension (adapter) to plug into high tension cable terminals.

Jumper Wire

TEST PROCEDURE

1. Test Battery Voltage.

Using voltmeter, test battery (Figure 47) voltage should be 12-13 volts for a fully charged battery. If necessary, charge or replace battery.

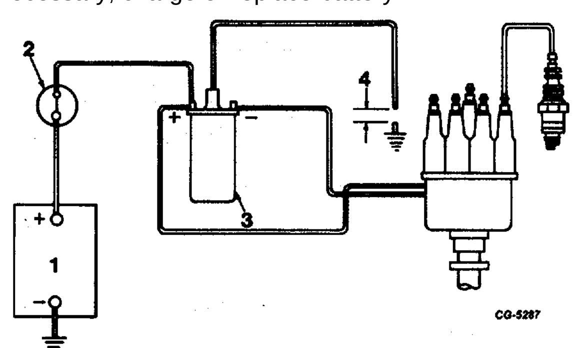


Fig.47 Testing Battery Voltage

1. battery
2. Ignition switch
3. Voltmeter
4. Ignition coil

2. Test for Spark at plug.

Disconnect high tension cable from one spark plug. (always grasp spark plug boot and use a twisting motion when removing plug cables so as not to destroy resistance wire termination.) Insert extension adaptor into boot and engage in cable terminal. Using insulated pliers, hold plug cable to create about 13 mm (1/2") gap between extension adapter and engine (Figure 48). Have an assistant crank engine. Observe for spark across gap.

Test at least two cables.

If spark occurs, ignition system is functioning. Check spark plugs and ignition timing. Then look elsewhere (engine condition, fuel system, etc.) for problem.

If no spark occurs, proceed to step 3

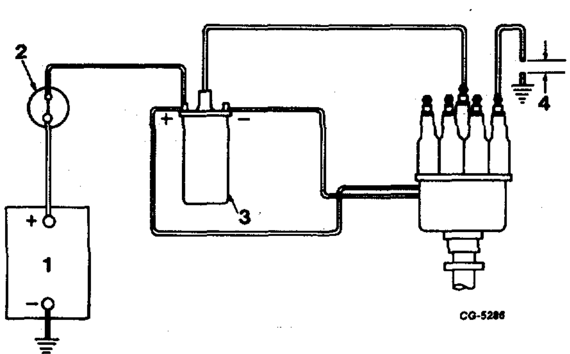


Fig. 48 Checking for Spark at Plug

1. **Battery** 3. **Ignition Coil**
2. **Ignition Switch** 4. **13mm (1/2 in) Gap**

3. Test for spark at distributor cap. Disconnect high tension cable from center tower terminal of distributor cap. Insert extension adapter into boot and engage in cable terminal. (Figure 45) using insulated pliers, hold cable to create about 13mm (1/2") gap between cable terminal and engine (Figure 48). Have an assistant crank engine. Observe for spark across gap.

If spark occurs, problem lies in distributor cap, rotor or spark plug cables. (See Secondary Circuit Inspection).

If no spark occurs, proceed to step 4.

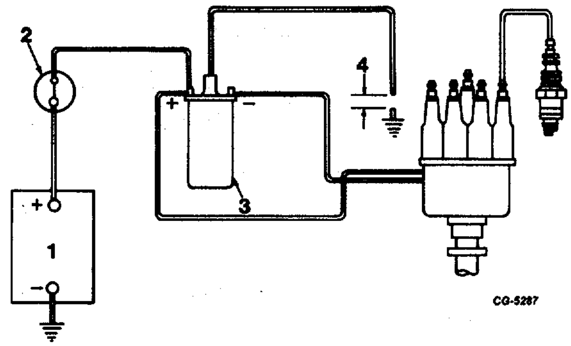


Fig. 49 Checking for Spark at Distributor Cap

1. **Battery** 3. **Ignition Coil**
2. **Ignition Switch** 4. **13mm (1/2 in.) Gap**

4. Check trigger wheel-to-sensor air gap. Remove distributor cap rotor and shield. "Bump" starter to align one of the trigger wheel teeth with the sensor coil (trigger wheel tooth perpendicular to flat surface of sensor) as shown in Fig. 50. Check air gap between trigger wheel tooth and sensor (see SPECIFICATIONS). If air gap is to specifications, proceed to step 5.

If air gap is out of specification, adjust air gap and repeat step 3. If there is still no spark, proceed to step 5.

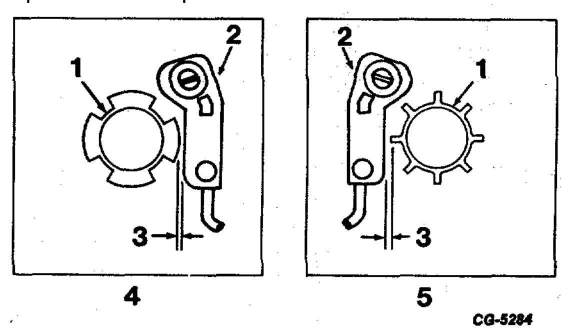


Figure 50 Trigger Wheel-to-Sensor Air Gap

1. **Trigger Wheel** 4. **Cylinder Engine**
2. **Sensor** 5. **8 Cylinder Engine**
3. **Air Gap**

5. Test primary voltage.

"Bump" starter to position sensor coil between two trigger wheel teeth (see Figure 51).

Connect voltmeter between coil positive (+) terminal and ground. Turn ignition switch "on" and observe voltmeter. If voltmeter reads battery voltage (12-13V), proceed to step 6.

If voltage is noticeably lower than battery voltage, a high resistance exists between battery (through ignition switch) and coil which must be located and repaired. (See Primary Voltage Drop Test).

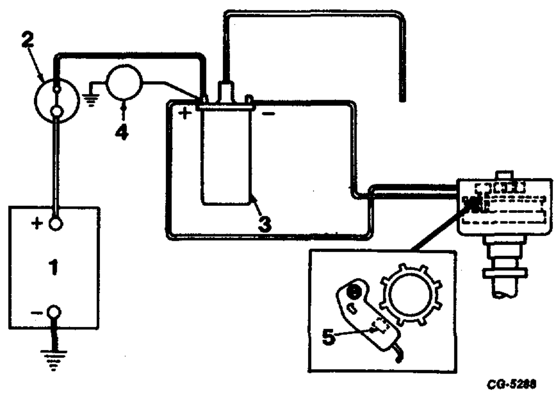


Fig. 51 Testing Primary Voltage

1. Battery **4. Voltmeter**
2. Ignition Switch **5. Sensor Coil Between Two Trigger Wheel Teeth**
3. Ignition Coil

6. Test voltage at coil negative (-) terminal.

Sensor coil should be between two trigger wheel teeth. Connect voltmeter between coil negative (-) terminal and ground (Figure 52).

With ignition switch "on", one of the following voltmeter readings will be obtained:

(A) 5 to 8 volts (normal)
(B) 12 to 13 volts (problem area)
(C) 0 to 5 volts (problem area)

A. <u>If voltage is 5 to 8 volts</u>: Proceed to Step 7.

B. <u>If voltage reading is 12 to 13 volts</u>:

Connect jumper wire between distributor housing and battery negative

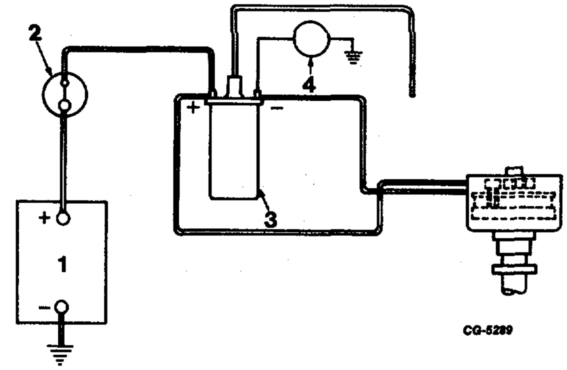


Fig. 52 Testing Voltage at Coil Negative (-) Terminal

1. Battery **3. Ignition Coil**
2. Ignition Switch **4. Voltmeter**

If voltage remains at 12-13 volts, electronic control unit in distributor is faulty and must be replaced. If voltage changes to 5-8 volts

with jumper wire connected, a problem exists in the ground circuit between the distributor and the battery. Check battery negative (-) cable (at battery and engine) and cab-to-engine ground strap and/or other ground straps. Repair as needed.

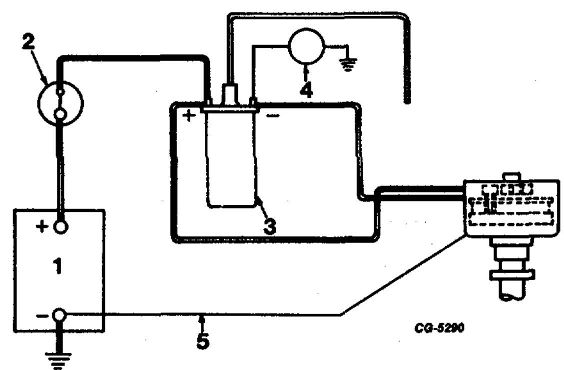


Fig. 53 Testing With Jumper Wire Between Dist. Housing and Batt.(-) Terminal.

1. Battery **4. Voltmeter**
2. Ignition Switch **5. Jumper Wire.**
3. Ignition Coil

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C. <u>If voltage is 0 to 5 volts:</u>

Disconnect voltmeter. Remove brown wire from coil negative (-) terminal. Reconnect voltmeter between coil negative (-) terminal and ground (Figure 54.). With ignition switch "on", observe voltmeter. If voltage reading is still 0 to 5 volts, coil is faulty and must be replaced.

If voltage increases to 12-13 volts electronic control unit in distributor is faulty, and must be replaced

<u>Reconnect brown wire to coil (negative (-) terminal).</u>

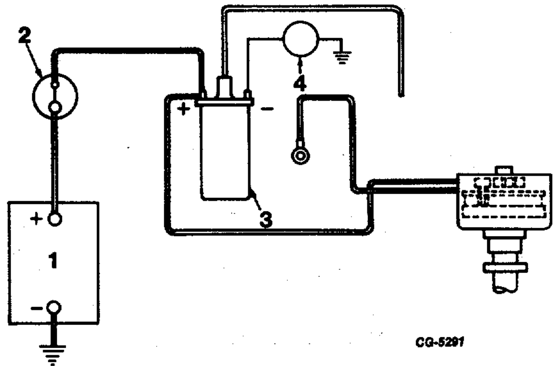

Fig. 54 Testing With Brown Wire Removed

1. Battery **3. Ignition Coil**
2. Ignition Switch **4. Voltmeter**

7. Test control unit operation. Voltmeter should be connected between coil negative (-) terminal and ground (Figure 54).

With ignition switch "on", place blade of screwdriver against face of sensor (Figure 55) while observing voltmeter. Voltage should increase to 12-13 volts.

Remove screwdriver blade. Voltage should drop to 5-8 volts.

If voltage switches up and down, proceed to step 8. If voltage does not switch up and down when screwdriver blade is placed against and then removed from face of sensor, electronic control unit in distributor is faulty and must be replaced.

8. Test Coil Operation

Re-establish the 13 mm (d inch) gap between extension adapter (connected to coil high tension cable) and engine (Figure 56).

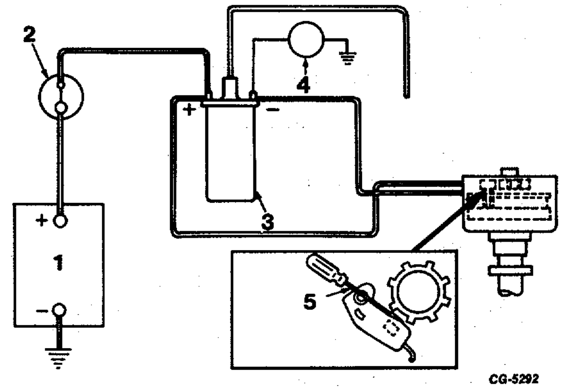

Fig. 55 Testing Electronic Control Unit Operation

1. Battery **3. Ignition Coil**
2. Ignition Switch **4. Voltmeter**
5. Screwdriver

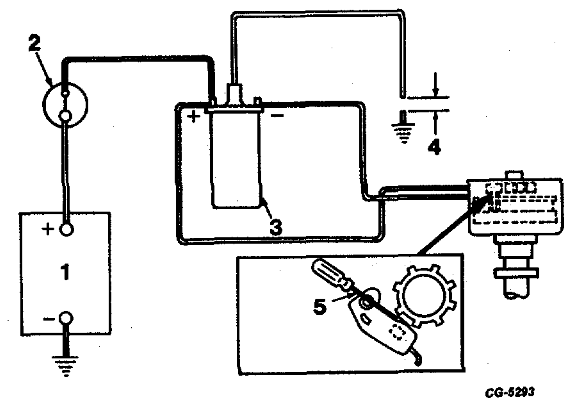

Fig. 56 Testing Coil Operation

1. Battery **3. Ignition Coil**
2. Ignition Switch **4. 13 mm (1/2 in.) gap**
5. Screwdriver

With ignition switch "on" observe for spark across gap each time screwdriver blade is placed against face of sensor.

If no spark occurs, coil is faulty and must be replaced.

9. Retest for Spark at Plug.

After replacing components, disconnect test equipment. Reinstall shield, rotor and distributor cap and reconnect coil high tension cable to distributor cap.

Recheck for spark at spark plug (Step 2).

10. Check Dwell.

    Connect dwell meter to engine. Operate engine and observe dwell reading. If necessary, re-adjust trigger wheel-to-sensor air gap to obtain specified dwell.

11. Check Timing.

    Connect timing light to engine. Operate engine at idle speed (distributor vacuum hose disconnected) and check timing. Adjust timing if necessary.

SECONDARY CIRUCIT INSPECTION

Secondary (high voltage) system components (distributor cap, rotor, coil, high tension cables and spark plugs) should be checked as possible sources of trouble before condemning the electronic units.

Distributor Cap and Rotor

Inspect distributor cap and rotor for cracks, carbon tracking, loose terminals, dirt and contamination. Clean or replace as needed.

Check rotor blade and spring for tightness. Check fit of rotor on distributor shaft. Check resistance type rotor with ohmmeter. (Figure 57). If resistance exceeds 6000 ohms, replace rotor.

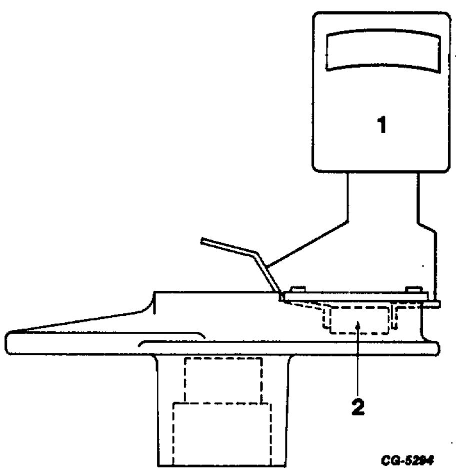

Fig. 57 Rotor Resistance Test

1. Ohms X1000 Meter 2. Resistor

Coil

Inspect coil tower for cracks or carbon tracking. Inspect primary terminals for corrosion and/or looseness. Replace coil if any of these conditions are found.

Test resistance of coil primary and secondary circuits with an ohmmeter (See Figure 58).

COIL RESISTANCE TESTS

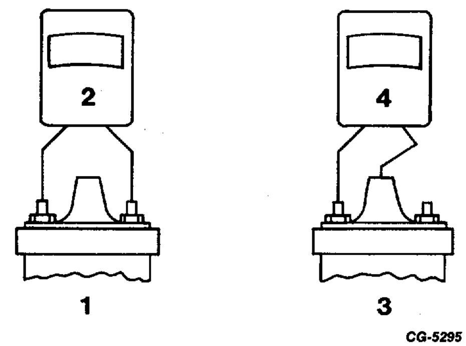

Fig. 58 Coil Resistance Tests

1. Primary Circuit 3. Secondary Circuit
2. Ohms X1 4. Ohms X1000

If coil resistance tests are made with coil mounted in vehicle, coil must be electrically isolated from the vehicle's electrical system by disconnecting primary leads from coil terminals and removing secondary cable from coil tower.

Set ohmmeter in OHM x 1 position. Connect ohmmeter between coil primary terminals. Reading should be between 1.2 and 1.4 ohms at 21 degrees C (70 degrees F).

Set ohmmeter in OHM x 1000 position. Connect ohmmeter between one coil primary terminal and the coil tower terminal. Reading should be within 9,000 to 12,000 ohms at 21 degrees C (70 degrees F).

If coil fails either resistance test, replace it.

High Tension Cables

Inspect secondary (high tension) ignition cables for deterioration, carbon tracking at terminal boots and high voltage leakage, especially at cable support brackets.

Test resistance of cables with an ohmmeter. Resistance should not exceed 30,000 ohms on cables up to 914 mm (36") long or 45,000 ohms on cables over 914 mm (36") long.

Check sealing and insulating qualities, of distributor cap, coil tower and spark plug boots. Replace if needed.

Clean cable terminals and apply a light coat of lubricant/sealer (IH part number 472141-C1) of terminals at assembly. Make sure cables seat properly on distributor cap and spark plug terminals and in coil tower terminal.

Be sure ignition cables are routed correctly. Proper routing of cables must be maintained to prevent crossfire.

PRIMARY VOLTAGE DROP TEST

This test can be used to help locate any high resistance or loose connections in primary feed circuit between the battery and the ignition coil positive (+) terminal.

<u>Test Procedure</u> (Refer to Figure 59)

1. Remove distributor cap, rotor and shield. "Bump" starter to position sensor coil between two trigger wheel teeth.

2. Connect voltmeter positive (red) lead to battery positive (+) terminal. Connect voltmeter negative (black) lead to coil positive (+) terminal.

3. Turn ignition switch "on" and observe voltmeter. A reading of less than 1 volt should be obtained.

4. Check circuit conditions by observing voltmeter while flexing (moving) the connectors at the following locations:

   a. Battery cables.

   b. Starter solenoid battery terminal.

   c. Dash panel (bulkhead) connector (where used).

   d. Ammeter terminals.

   e. Ignition switch connections.

If fluctuation or an upswing of the voltmeter needle is observed while flexing the connectors, a poor connection exists and must be corrected.

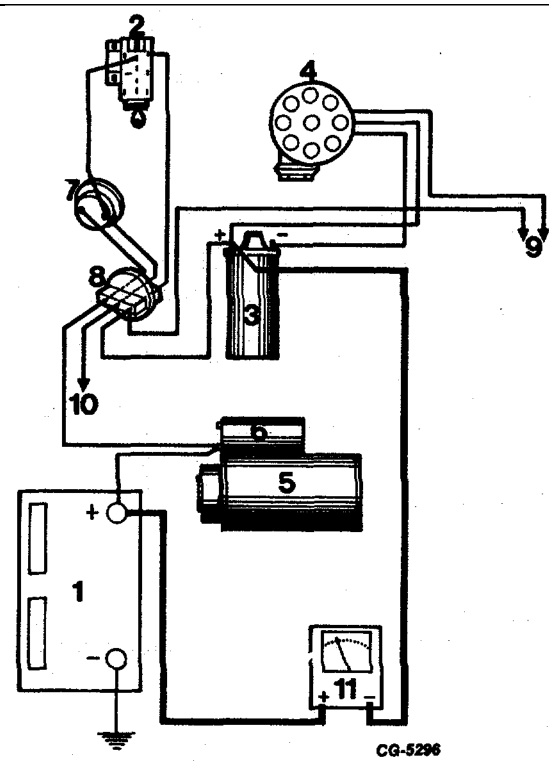

Fig. 59 Primary Voltage Drop Test

1. Battery
2. Ignition Switch
3. Ignition Coil
4. Distributor
5 Starter
6. Solenoid
7. Ammeter
8. Bulkhead Connector
9. To DTM
10. To Alternator
11. Voltmeter

Listed here are only those causes for the indicated problem conditions which are chargeable to the ignition system.

CONDITION	POSSIBLE CAUSE	REMEDY
Engine fails to start	No primary voltage to coil.	Check battery, ignition switch, primary feed and ground circuits. (Perform "Primary Voltage Drop Test"). Repair as needed.
(Perform "Ignition System Trouble Shooting Test")	Moisture in distributor cap or high tension cable boots.	Clean and dry parts. Correct cause for entry of moisture.
	Trigger wheel-to-sensor air gap incorrect.	Check air gap. Adjust if needed.
	Open rotor.	Replace rotor.
	Faulty distributor cap.	Replace cap.
	Coil high tension cable not seated in coil tower or distributor cap.	Check cable installation.
	Faulty high tension cables.	Replace cables.
	Coil open or shorted.	Test coil, replace if faulty.
	Faulty electronic control unit.	Replace control unit.
Engine backfires but fails to start.	Incorrect ignition timing.	Check timing. Adjust as needed.
	Moisture in distributor cap.	Dry cap and rotor.
	Distributor cap faulty or carbon tracked.	Check cap for loose terminals, cracks and dirt. Clean or replace as needed.
	Spark plug cables connected incorrectly.	Check cables for correct position.
Engine does not operate smoothly or engine misfires at high speed	Spark plugs fouled.	Clean and regap plugs.
	Spark plug electrodes worn (gap too wide).	Regap or replace plugs.
	Spark plug cables faulty.	Check cables, replace if needed.
	Spark advance system(s) faulty.	Check operation of advance system(s). Repair as needed.
	Worn distributor shaft bushings.	Check for worn bushings. Rebuild or replace distributor.
Excessive fuel consumption.	See causes listed under "engine does not operate smoothly."	

Erratic timing advance	Vacuum leaks in vacuum advance system.	Check vacuum hoses. Replace as needed.
	Faulty vacuum advance diaphragm assembly.	Check operation of advance diaphragm. Replace if needed.
	Sticking or worn sensor plate.	Replace electronic control unit.
	Misadjusted, damaged or weak mechanical advance springs.	Readjust spring tension. Replace distributor shaft assembly.
	Mechanical advance flyweight bushings worn.	Replace distributor shaft assembly.
	Trigger wheel assembly binding or excessively loose or distributor shaft.	Free-up and lubricate trigger wheel assembly. Replace distributor shaft assembly, if needed.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)
1978

Engine Model	4-196		V-304, V-345
Distributor: Part No. (Manufacturer's No.)	484776C91 (IDN-4001) 497600C91 (IDN-4010)	484777-C91 (IDN-4001A)	484778C91 (IDN-4002B)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)		0.1 (.008)	0.2 (.008)
Dwell, Degrees (2)		28-34	26-32
Vacuum Advance:			
Vacuum Req'd. to Start Advance	16.9-23.6	10.1-16.9	16.9-23.6
KPa (In. of Hg.)	(5-7)	(3-5)	(5-7)
Advance Check Points:			
Vacuum, KPa (In. of Hg.)	23.3 (6)	23.6 (7)	23.0 (6)
Degrees	0-1.5	2.8-5.8	0-1.5
Vacuum	30.4 (9)	43.9 (13)	27.0 (8)
Degrees	2.8-5.8	4-6	1.5-4.5
Vacuum	50.7 (15)	---	40.5 (12)
Degrees	4-6	---	4-6
Mechanical Advance:			
Distributor RPM to Start Advance	375-450	375-450	325-475
Advance Check Points:			
Distributor RPM			
Degrees			
Distributor RPM	600	600	1000
Degrees	4-6	4-6	7.5-9.5
Distributor RPM	1000	1000	1200
Degrees	8.5-10.5	8.5-10.5	9.7-11.7
Distributor RPM	1900	1900	1850
Degrees	15.2-17.2	15.2-17.2	14.0-16.0
Distributor RPM	2200	2200	2100
Degrees	15.8-17.8	15.8-17.8	15-17
Total Advance, Degrees Mechanical and Vacuum	19.8-23.8	19.8-23.8	19-23
Distributor Shaft End Play, mm (in-)	0.89-1.02 (.035-.040)		
Distributor Shaft Side Play (3)			
New, mm (in.)	0.05-0.1 (.002-.004)		
Maximum Permissible, mm (in.)	0.15 (.006)		
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)		

(1) Clearance between sensor and end of trigger wheel tooth.
(2) At 300 distributor RPM (with 12-13 volts primary input).
(3) With force of h pound applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS

(For Use With Distributor Test Stand)
1979

Engine Model	4-196	V-304, V-345
Distributor: Part No. (Manufacturer's No.)	496003-C91 (IDN-4001B)	496004-C91 (IDN-4002R)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)	0.2 (.008)	0.2 (.008)
Dwell, Degrees (2)	28-34	28-34
Vacuum Advance:		
Vacuum Req'd. to Start Advance	16.9-23.6	10.1-16.9
KPa (In. of Hg.)	(5.0-7.0)	(3.0-5.0)
Advance Check Points:		
Vacuum, KPa (In. of Hg.)	30.4 (9)	23.6 (7)
Degrees	3-6	2.8-6.0
Vacuum	37.1 (11)	43.9 (13)
Degrees	4-6	4.0-6.0
Vacuum	64.2 (19)	
Degrees	4-6	
Mechanical Advance:		
Distributor RPM to Start Advance	350-450	325-475
Advance Check Points:		
Distributor RPM	500	1000
Degrees	1.5-3.9	7.5-9.5
Distributor RPM	650	1100
Degrees	5.5-7.9	9.0-11.0
Distributor RPM	1000	2000
Degrees	8.3-10.3	13.0-15.0
Distributor RPM	1800	2100
Degrees	12.0-14.0	13.0-15.0
Distributor RPM	2200	
Degrees	13.0-15.0	
Total Advance, Degrees Mechanical and Vacuum	17.0-21.0	
Distributor Shaft End Play, mm (in.)	0.89-1.02 (.035-.040)	
Distributor Shaft Si-e Play (3) New, mm (in.) Maximum Permissible, mm (in.)	 0.05-0.1 (.002-.004) 0.15 (.006)	
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise) Right Hand (Clockwise)	

(1) Clearance between sensor and end of trigger wheel tooth.
(2) At 300 distributor RPM (with 12-13 volts primary input).
(3) With force of ½ pound applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS

(For Use With Distributor Test Stand)
1978

Engine Model	V-345	V-345	V-345, V-392	V-392
Distributor: Part No. (Manufacturer's No.)	484785C91 (IDN-4002L)	484786C91 (IDN-4007)	484783C91 (IDN-4002)	484788C91 (IDN-4002A)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)	0.2 (.008)			
Dwell, Degrees (2)	26-32			
Vacuum Advance:				
Vacuum Req'd. to Start Advance	33.8-40.5	---	16.9-23.6	16.9-23.6
KPa (In. of Hg.)	(10-12)	---	(5-7)	(5-7)
Advance Check Points:				
Vacuum, KPa (In. of Hg.)	43.9 (13)	---	27.0 (8)	27.0 (8)
Degrees	1.5-4	---	1.5-4.5	2.8-8
Vacuum	50.7 (15)	---	40.5 (12)	32.1 (9.5)
Degrees	2-4	---	4-6	6-8
Vacuum	---	---	---	64.2 (19)
Degrees	---		---	6-8
Mechanical Advance:				
Distributor RPM to Start Advance	370-580	300-500	350-475	350-475
Advance Check Points:				
Distributor RPM				
Degrees				
Distributor RPM	700	600	700	700
Degrees	0.9-2.9	1-3	4-6	3.4-5.4
Distributor RPM	1000	1000	1000	1000
Degrees	3.5-5.5	5-7	5.5-7.5	8-10
Distributor RPM	1900	1800	1900	1400
Degrees	11.2-13.2	13-15	10-12	10-12
Distributor RPM	2100	2100	2100	1800
Degrees	11.9-13.9	14.8-16.8	10.3-12.3	12-14
Total Advance, Degrees Mechanical and Vacuum	13.9-17.9	---	14.3-18.3	18-22
Distributor Shaft End Play, mm (in.)	0.89-1.02 (.035-.040)			
Distributor Shaft Side Play (3)				
New, mm (in.)	0.05-0.1 (.002-.004)			
Maximum Permissible, mm (in.)	0.15 (.006)			
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)			

(1) Clearance between sensor and end of trigger wheel tooth.
(2) At 300 distributor RPM (with 12-13 volts primary input).
(3) With force of ½ pound applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS

(For Use With Distributor Test Stand)

1979

Engine Model	V-345	V-345	V-392
Distributor: Part No. (Manufacturer's No.)	484786-C91 (IDN-4007)	484785-C91 (IDN-4002L)	484788-C91 (IDN-4002A)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)	0.2 (.008)		
Dwell, Degrees (2)	26-32		
Vacuum Advance:			
Vacuum Req'd. to Start Advance KPa (In. of Hg.)	---	33.8-40.5 (10-12)	16.9-23.6 (5.0-7.0)
Advance Check Points:			
Vacuum, KPa (In. of Hg.)	---	43.9 (13)	27.0 (8.0)
Degrees	---	1.5-4.0	2.8-8.0
Vacuum	---	50.7 (15)	32.1 (9.5)
Degrees	---	2.0-4.0	6.0-8.0
Vacuum	---	---	64.2 (19.0)
Degrees	---	---	6.0-8.0
Mechanical Advance:			
Distributor RPM to Start Advance	300-500	370-580	350-475
Advance Check Points:			
Distributor RPM	600	700	700
Degrees	1.0-3.0	0.9-2.9	3.4-5.4
Distributor RPM	1000	1000	1000
Degrees	5.0-7.0	3.5-5.5	8.0-10.0
Distributor RPM	1800	1900	1400
Degrees	13.0-15.0	11.2-13.2	10.0-12.0
Distributor RPM	2100	2100	1800
Degrees	14.8-16.8	11.9-13.9	12.0-14.0
Total Advance, Degrees Mechanical and Vacuum	14.8-16.8 (Mech. Only)	13.9-17.9	18.0-22.0
Distributor Shaft End Play, mm (in.)	0.89-1.02 (.035-.040)		
Distributor Shaft Side Play (3)			
New, mm (in.)	0.05-0.1 (.002-.004)		
Maximum Permissible, mm (in.)	0.15 (.006)		
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)		

(1) Clearance between sensor and end of trigger wheel tooth.
(2) At 300 distributor RPM (with 12-13 volts primary input).
(3) With force of ½ pound applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)
1978 And 1979

Engine Model	V-345	V-304, V-345, V-392 Low Compression
Distributor: Part No.	484797C91	484804C91
(Manufacturer's No.)	(IDN-4002N)	(IDN-4002G)
Air Gap, mm (in.)		0.2 (.008)
Trigger Wheel-to-Sensor (1)		
Dwell, Degrees (2)		26-32
Vacuum Advance:		
Vacuum Req'd to Start Advance	16.9 - 23.6	15.9 - 20.9
kPa (In.of Hg.)	(5-7)	(4.7 - 6.2)
Advance Check Points:		
Vacuum, kPa (In. of Hg.)	20.3 (6)	20.3 (6)
Degrees	0-1.4	0-2.5
Vacuum	30.4 (9)	30.4 (9)
Degrees	3-5.8	5-7.7
Vacuum	50.7 (15)	50.7 (15)
Degrees	6-8	6-8
Mechanical Advance:		
Distributor RPM to Start Advance	250-375	250-350
Advance Check Points:		
Distributor RPM	400	300
Degrees	0-2	0-1
Distributor RPM		
Degrees	-----	-----
Distributor RPM	700	700
Degrees	4-6	7.5-9.5
Distributor RPM		
Degrees	-----	-----
Distributor RPM	2000	1800
Degrees	10.5-12.5	15-17
Total Advance, Degrees		
Mechanical and Vacuum	16.5-20.5	21-25
Distributor Shaft End Play, mm (in.)	0.89 - 1.02 (.035 - .040)	
Distributor Shaft Side Play (3)		
New, mm (in.)	0.05-0.1 (.002-.004)	
Maximum Permissible, mm (in.)	0.15 (.006)	
Distributor Rotation		
(As Viewed From Top)	Right Hand (Clockwise)	

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).

(3) With force of ½ pound applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS

(For Use With Distributor Test Stand)
1978

Engine Model	MV-404	MV-446	V-537
Distributor: Part No. (Manufacturer's No.)	484790C91 (IDN-4003)	484792C91 (IDN-4003A)	484794C91 (IDN-4006)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)	0.2 (.008)		
Dwell, Degrees (2)	26-32		
Vacuum Advance:			
Vacuum Req'd to Start Advance	16.9-23.6	33.8-40.5	
kPa (In.	of Hg.)	(5-7)	(10-12)
Advance Check Points:			
Vacuum, kPa (In. of Hg.)	27.0 (8)	43.9 (13)	
Degrees	1.5-4	1.5-4	-----
Vacuum	37.1 (12)	50.7 (15)	
Degrees	2-4	2-4	
Vacuum			
Degrees	-----	-----	
Mechanical Advance:			
Distributor RPM to Start Advance	300-500	300-500	275-475
Advance Check Points:			
Distributor RPM	-----	-----	500
Degrees			.2-2.5
Distributor RPM	600	600	800
Degrees	1-3	1-3	3.7-5.7
Distributor RPM	1000	1000	1000
Degrees	5.3-7.3	5.3-7.3	5.2-7.2
Distributor RPM	1450	1450	1400
Degrees	10-12	10-12	6.4-8.4
Distributor RPM	1800	1800	1700
Degrees	10.8-12.8	10.8-12.8	6.9-8.9
Total Advance, Degrees Mechanical and Vacuum	12.8-16.8	12.8-16.8	-----
Distributor Shaft End Play, mm (in.)	0.10-0.46 (.004-.018)		0.05-0.25 (.002-.010)
Distributor Shaft Side Play (3)			0.05-0.1
New, mm (in.)	0.05-0.1 (.002-.004)		(.002-.004)
Maximum Permissible, mm (in.)	0.15 (.006)		.15 (.006)
Distributor Rotation (As Viewed From Top)	Left Hand (Counterclockwise)		Right Hand (Clockwise)

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).

(3) With force of ½ pound applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)
1979

Engine Model	MV-404	MV-446	V-537
Distributor: Part No.	484790C91	484792C91	484794C91
(Manufacturer's No.)	(IDN4003)	(IDN-4003A)	(IDN4006)
Air Gap, mm (in.)		0.2 (.008)	
Trigger Wheel-to-Sensor (1)			
Dwell, Degrees (2)		26-32	
Vacuum Advance:			
Vacuum Req'd to Start Advance	16.9-23.6	33.8-40.5	
kPa (In.of Hg.)	(50-70)	(10.0-12.0)	-----
Advance Check Points:			
Vacuum, kPa (In. of Hg.)	27.0 (8)	43.9 (13)	-----
Degrees	1.5-4.0	1.5-4.0	-----
Vacuum	37.1 (12)	50.7 (15)	-----
Degrees	2.0-4.0	2.0-4.0	-----
Mechanical Advance:			
Distributor RPM to Start Advance	300-500	300-500	275-475
Advance Check Points:			
Distributor RPM	600	600	500
Degrees	1.0-3.0	1.0-3.0	0.2-2.5
Distributor RPM	1000	1000	800
Degrees	5.3-7.3	5.3-7.3	3.7-5.7
Distributor RPM	1450	1450	1000
Degrees	10.0-12.0	10.0-12.0	5.2-7.2
Distributor RPM	1800	1800	1400
Degrees	10.8-12.8	10.8-12.8	6.4-8.4
Distributor RPM	1700		
Degrees			6.9-8.9
Total Advance, Degrees	12.8-16.8	12.8-16.8	6.9-8.9
Mechanical and Vacuum			(Mech. Only)
Distributor Shaft End Play, mm (in.)		0.10-0.46(.004-.018)	0.05-0.25 (.002-.010)
Distributor Shaft Side Play (3)		0.05-0.1	
New, mm (in.)		0.05-0.1 (.002-.004)	(.002-.004)
Maximum Permissible, mm .(in.)		0.15 (.006)	15 (.006)
Distributor Rotation (As Viewed From Top)	Left Hand (Counterclockwise)		Right Hand (Clockwise)

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).

(3) With force of ½ pound applied as side load to top of shaft.

DISTRIBUTOR
(PRESTOLITE IDN-4100 Series)

BREAKER POINT TYPE

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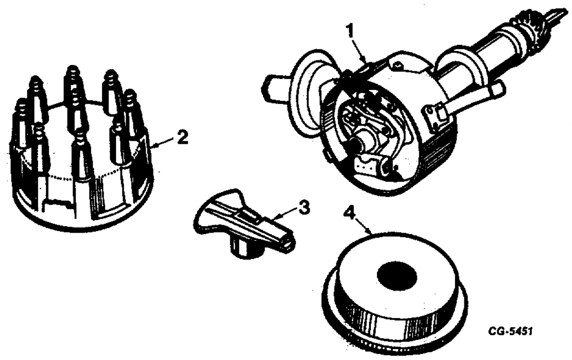

Fig. 1 Distributor Assembly

1. Distributor Assembly **3. Rotor Assembly**
2. Cap Assembly **4. Dust Cover**

DESCRIPTION

The distributor (Figure 1) is conventional with the usual distributor cam, contact points and condenser. A standard type ignition coil is used.

The distributor cap featuring superior physical and dielectric strength incorporates male (spark plug type) terminals. A resistor type rotor, interference suppression type high tension cables and resistor type spark plugs are used to meet radio frequency interference standards.

All distributors have a mechanical (centrifugal) spark advance system. Most distributors also have a vacuum operated spark advance system. The advance systems automatically provide the optimum spark timing for various engine speed and load conditions.

The mechanical (centrifugal) advance system is built internally into the distributor and consists of two flyweights which pivot on long-life, low-friction bearings and are controlled by calibrated springs which tend to hold the weights in the no-advance position. The flyweights respond to changes in engine (distributor shaft) speed and rotate the trigger wheel to. advance the spark as engine speed increases and retard the spark as engine speed decreases.

The vacuum advance system incorporates a vacuum diaphragm unit which rotates the distributor sensor plate in response to changes in carburetor throttle bore vacuum.

The two systems, mechanical and vacuum (Figure 2) operate independently, yet work together to provide proper spark advance.

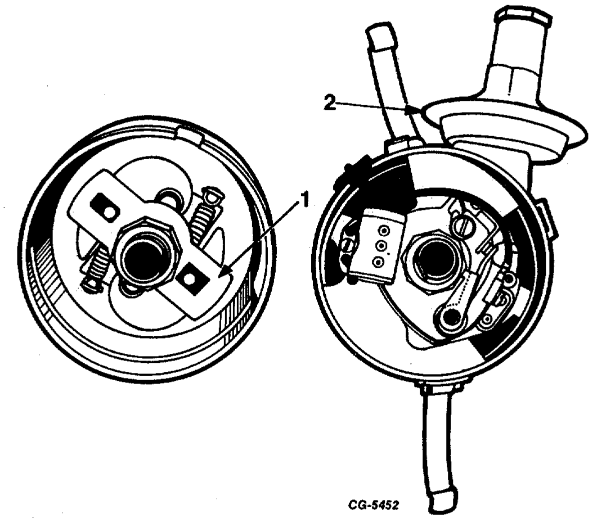

Fig. 2 Spark Advance Systems

1. Mechanical Centrifugal Advance Mechanism.
2. Vacuum Advance Diaphragm Unit.

MAINTENANCE

To perform effectively, the ignition system must be properly maintained. It is important that ignition system maintenance operations be performed at the specified time or mileage intervals.

For ignition system maintenance intervals procedures and specifications, refer to the appropriate Emission Control Systems and Service operations section of the Truck Service Manual as listed below.

For vehicles built see	CTS-2733 in 1978,
For vehicles built in 1979, see	CGES-135

DISTRIBUTOR SERVICE

DISTRIBUTOR REMOVAL

1. Unfasten distributor cap retaining clips. Remove distributor cap (with high tension cables) and position it out of the way.

2. Disconnect vacuum hose from distributor vacuum advance unit.

3. Disconnect distributor primary wire from coil.

4. Disconnect tachometer drive cable, if equipped.

5. Scribe a mark on distributor housing in line with tip of rotor (Figure 3) and note position of rotor and distributor housing in relation to surrounding engine parts as reference points for reinstalling distributor.

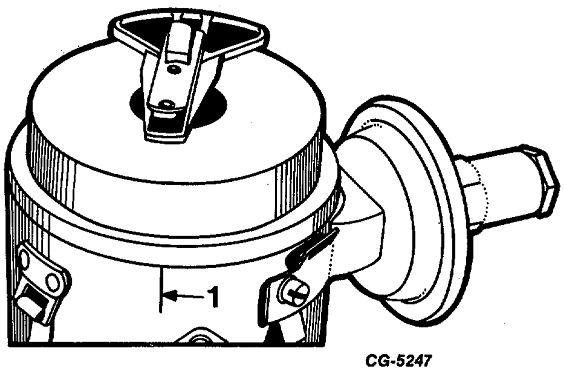

Fig. 3 Rotor Position Reference Mark

1. Scribe Mark

6. Remove distributor hold-down bolt and clamp.

7. Carefully withdraw distributor from engine. Do not lose gasket or "O" ring seal.

See Figure 4 for gasket or "O" ring location on distributor.

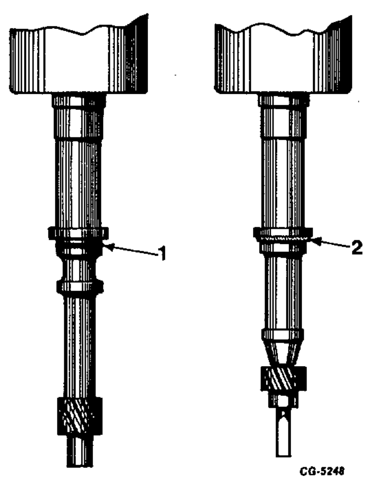

Fig. 4 Gasket and "O" Ring Configuration

1. "O" Ring 2. Gasket

DISTRIBUTOR SHAFT AND BUSHING WEAR TEST

This procedure can be used to check condition of the distributor shaft and shaft bushings in the distributor housing.

1. Clamp distributor in a vise equipped with soft jaw shields. Apply only enough pressure to restrict movement of distributor.

2. Remove distributor rotor.

3. Attach dial indicator to distributor housing so that indicator plunger rests against distributor cam (rotor shaft) assembly (Figure 5).

4. Place one end of a wire loop around top of distributor cam assembly (rotor shaft). Hook a spring scale in other end of wire loop and pull on a line with plunger of dial indicator (Figure 5). Wire loop must be perpendicular to shaft to assure a straight pull. Also, loop must not interfere with dial indicator mounting bracket.

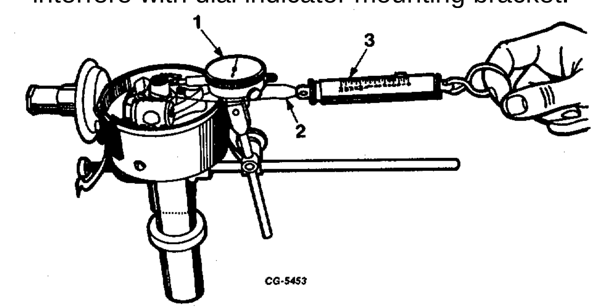

Fig. 5 Shaft and Bushing Wear Test (Checking Distributor Shaft Side Play)

1. Dial Indicator 3. Spring Scale
2. Wire Loop

5. Apply five (5) pounds of pull on spring scale and read movement of plunger on indicator dial. Apply five pounds of pull in opposite direction and again read movement on indicator. Peak-to-peak side play is the sum of these two readings.

If plunger movement (distributor shaft s e play) exceeds maximum permissible limit (see DISTRIBUTOR TEST SPECIFICATIONS), replace distributor shaft and bushings (see Distributor Housing Bushing Replacement).

DISTRIBUTOR OPERATION TEST
(On Test Stand)

Operation of the distributor can be checked on a distributor test stand. It is recommended that the distributor operation test be performed every 24,000 miles or 24 months of vehicle operation.

It is also advisable to perform the distributor operation test prior to disassembly of the distributor for service. This test will give valuable information about the condition of the distributor and indicate where parts replacement may be required.

1. Mount distributor in test stand and connect test leads as shown in Figure 6.

2. Calibrate test stand dwell meter per manufacturer's instructions.

3. Operate distributor at 300 RPM (with 12-13 volts primary input) and observe dwell reading. Dwell should be within specified limits (see DISTRI BUTOR TEST SPECIFICATIONS). If dwell is not within specified limits, check breaker point gap. Also check for worn breaker plate assembly and worn distributor shaft and bushings.

4. Check distributor cam lobe accuracy as follows:
   a. Operate distributor at 300 RPM and set zero of test stand degree ring in line with arrow flash nearest front of stand.
   b. Observe relative position of all arrow flashes. All flashes should be evenly spaced within +/-1 degree at 45 degree intervals on 8-cylinder distributors or 90 degree intervals on 4-cylinder distributors. If positions of arrow flashes deviate more than + 1 degree, check for worn distributor shaft and bushings.

5. Check operation of mechanical advance mechanism as follows:

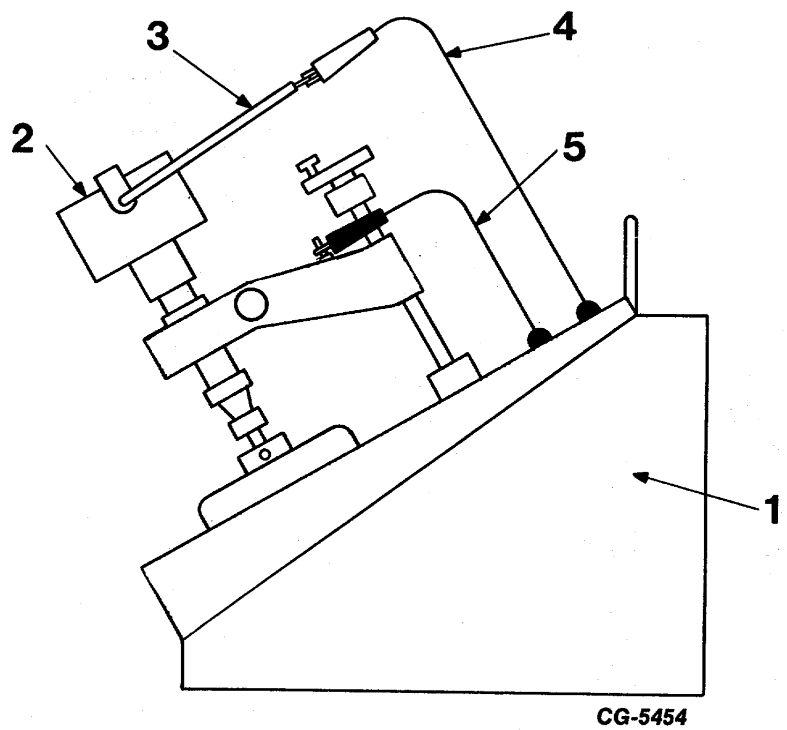

Fig. 6 Distributor-to-Test Stand Wiring Connections

1. **Distributor test stand**
2. **Distributor**
3. **Distributor lead**
4. **Test stand distributor lead**
5. **Test stand ground lead**

a. With distributor operating at minimum speed, set zero of test stand degree ring in line with arrow flash nearest from stand.

b. Operate distributor at each specified test speed (see DISTRIBUTOR TEST SPECIFICATIONS) and observe arrow flashes opposite test stand degree ring to advance at each test speed.

If advance is excessive, advance spring tension is weak. If advance is insufficient, advance spring tension is excessive, advance flyweights are sticking or distributor cam assembly is binding on inner distributor shaft. If advance is erratic, advance flyweights are sticking or cam assembly is binding on inner distributor shaft.

6. Check vacuum advance diaphragm assembly (where equipped) as follows:

a. Using proper adapter, connect test stand vacuum hose to distributor vacuum advance diaphragm assembly.

b. Apply vacuum and check for operation of diaphragm assembly.

c. Remove vacuum hose from diaphragm assembly. Hold finger over end of hose and adjust vacuum regulator to obtain reading of 16 inches of vacuum on vacuum gauge.

d. Reconnect vacuum hose to diaphragm assembly and observe vacuum gauge. If gauge reading returns to 16 inches, diaphragm assembly is air tight. If gauge reading fails to return to 16 inches, diaphragm assembly is leaking and should be replaced.

7. Check vacuum advance operation (where equipped) as follows:

a. With vacuum hose connected to distributor vacuum diaphragm assembly operate distributor at 300 RPM.

b. With no vacuum applied to diaphragm assembly, set zero of test stand degree ring in line with arrow flash nearest to front of stand.

c. Adjust vacuum regulator to apply specified amount of vacuum for each specified check point (see DISTRIBUTOR TEST SPECIFICATIONS) and note amount of advance obtained.

d. Momentarily exceed highest vacuum value specified, then reduce and again note vacuum obtained at each specified check point.

If advance is excessive during both steps "c" and "d, " a weak diaphragm spring is indicated. If advance is insufficient during both steps "c" and "d," an excessively strong diaphragm spring or incorrect diaphragm assembly is indicated. If advance is erratic in both steps "c" and "d, " check for sticking or worn advance plate assembly.

8. If distributor passes checks outlined in Steps 3 through 7 above, it is satisfactory for use. If distributor fails any of the checks, it should be replaced or serviced as needed.

9. Disconnect test lead harness and vacuum hose from distributor and remove distributor from test stand.

DISTRIBUTOR DISASSEMBLY

The procedure outlined below can be followed to disassemble the distributor for service and overhaul.

1. Remove rotor and dielectric shield ("dust cover") (Figure 7).

2. Remove vacuum advance diaphragm rod retaining "E" clip (Figure 8) and flat washer (where used).

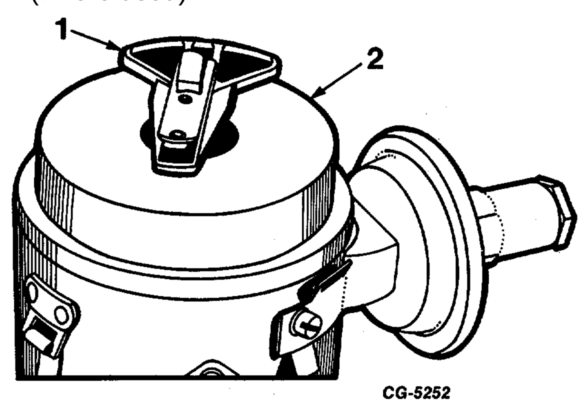

Fig. 7 Distributor Rotor and Dielectric Shield (Dust Cover)

1. Rotor
2. Dielectric Shield (Dust Cover)

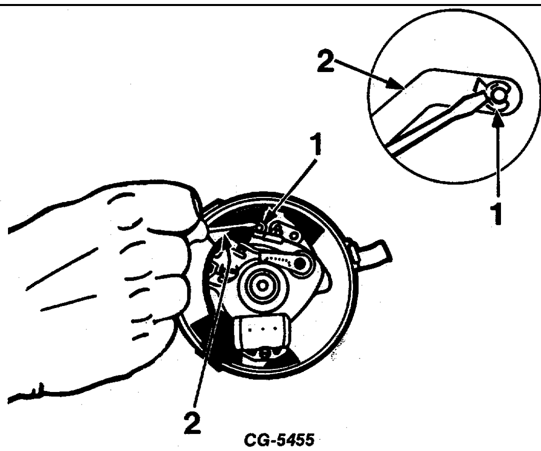

Fig. 8 Removing Diaphragm Rod Retainer

1. Retaining "E" Ring **2. Diaphragm Rod**

3. Remove vacuum advance diaphragm mounting screws and remove diaphragm assembly from distributor housing (Figure 9). Remove felt washer from diaphragm rod pin on sensor advance plate (Figure 9).

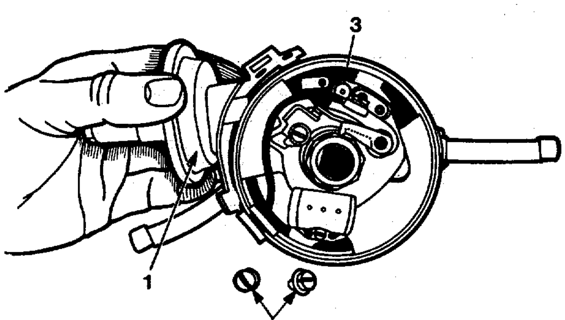

Fig. 9 Removing Vacuum Advance Diaphragm Assembly

1. Diaphragm Assembly **3. Felt Washer**
2. Retaining Screws

4. Remove breaker plate assembly as follows:

a. Remove breaker plate mounting screws.

b. Carefully pull lead wire grommet from slot in distributor housing.

c. Lift plate assembly (with contact points and condenser) out of housing (Figure 10).

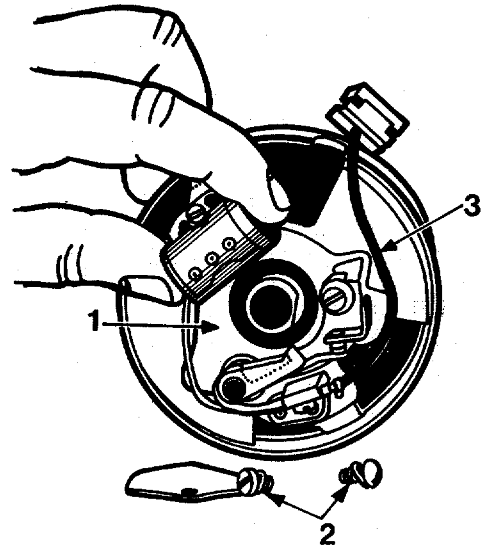

Fig. 10 Removing Breaker Plate Assembly

1. Breaker Plate **3. Primary Wire**
2. Hold Down Screws

5. Remove condenser and contact point set from breaker plate assembly as follows:

a. Loosen contact point terminal screw and disconnect the primary and condenser lead (Figure 11).

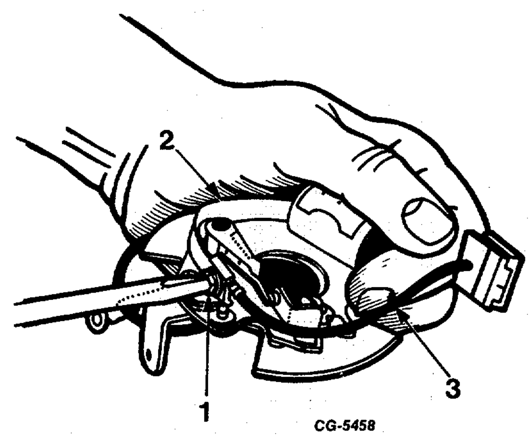

Fig. 11 Loosening Contact Point Terminal Screws

1. Terminal Screw **3. Primary Lead**
2. Condenser Lead

b. Remove condenser mounting screw (Figure 12) and lift condenser from advance plate.

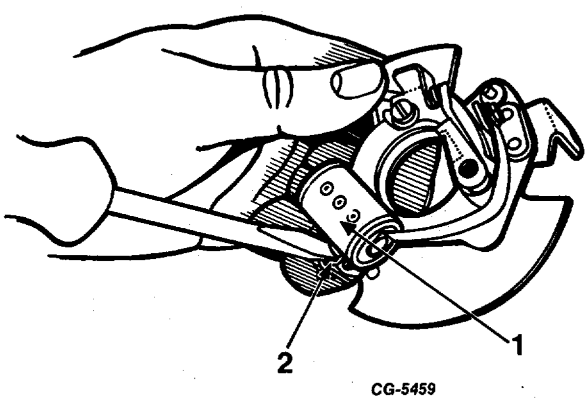

Fig. 12 Removing Condenser

1. Condenser 2. Screw

c. Remove contact point set mounting screw (Figure 13) and lift contact point set from advance plate.

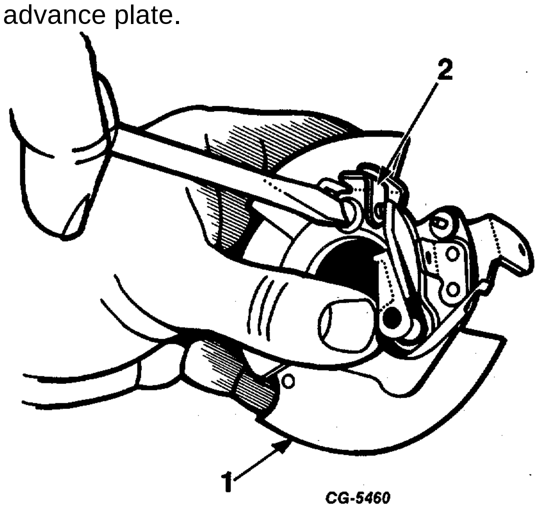

Fig. 13 Removing Contact Point Set

1. Advance Plate 2.Breaker Arm and Bracket

6. Measure and record distributor capt end play (Figure 14). Measure end play between thrust washer and gear with shaft held "bottomed" in housing. If end play exceeds specified limits (See DISTRIBUTOR TEST SPECIFICATIONS), thrust washers (upper and lower) should be replaced. Excessive end play could result in failure or improper engine timing.

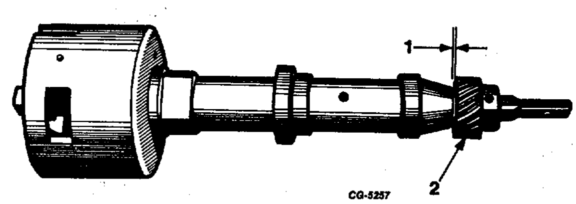

Fig. 14 Checking Distributor Shaft End Play (Thrust Washer-to-Gear Clearance)

1. End Play 2. Driven Gear

7. Support distributor shaft on a wood block or in a vise equipped with soft jaw shields and drive roll pin from gear or thrust collar and distributor shaft using a punch and hammer (Figure 15).

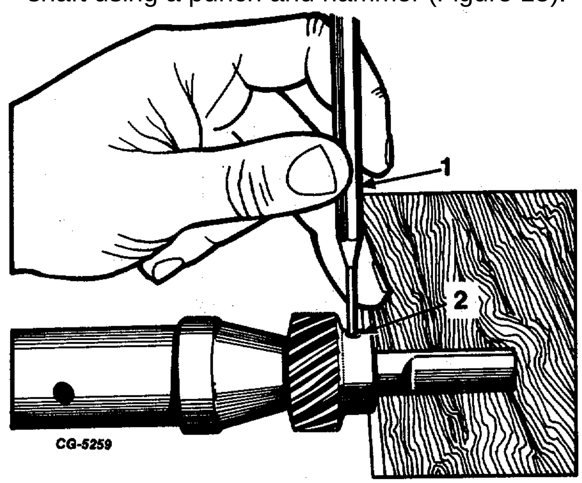

Fig. 15 Removing Distributor Drive Gear Pin

1. Punch 2. Pin

8. Place distributor housing and shaft assembly in a press and press gear and lower thrust washers (Figure 16) from shaft.

9. Withdraw distributor shaft assembly from distributor housing. Be Careful not to lose upper thrust washer(s) (Figures 17 and 18).

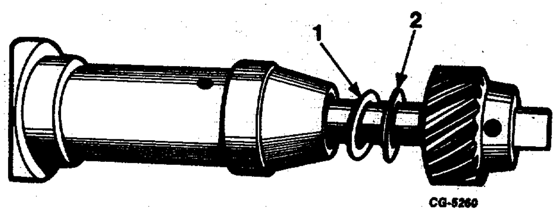

Fig. 16 Lower Thrust Washer

1. **Thrust Washer (inner)**
2. **Thrust Washer (outer)**

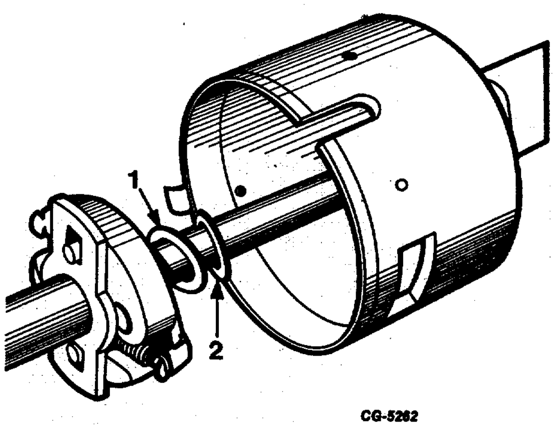

Fig. 17 Upper Thrust Washers (Distributors Without Tachometer Drive)

1. **Thrust Washer (inner)**
2. **Thrust Washer (outer)**

CLEANING AND INSPECTION

1. Wash metal parts in cleaning solvent.

IMPORTANT

Do Not wash cap, rotor, vacuum advance diaphragm assembly or condenser.

It is permissible to soak the distributor housing if the bushings are to be replaced. If bushings are not being replaced, clean distributor housing carefully so as not to wash oil from bushings

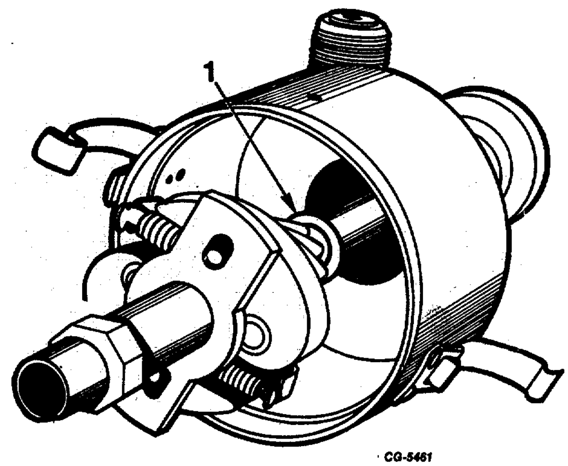

Fig. 18 Upper Thrust Washer (Distributors With Tachometer Drive)

1. **Thrust Washer**

2. Inspect distributor shaft for wear and check its fit in bushings in distributor housing. If shaft and bushings are worn, replace them.

3. Mount distributor shaft in "V" blocks and check shaft alignment with dial indicator. Runout should not exceed 0.05 mm (.002").

4. Inspect mechanical advance weights for free fit on their pivot pins and in slots of distributor cam yoke without excessive looseness. (See Mechanical Advance System Service). If wear or damage is found, replace distributor shaft assembly.

5. Check fit of distributor cam assembly on distributor shaft. It should be free without roughness. If roughness or excessive looseness exists, replace distributor shaft assembly.

6. Inspect advance plate of breaker plate assembly. If binding or wear of pivot pin or wear of thrust buttons is indicated replace plate assembly.

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7. On distributors with tachometer drive, inspect tachometer drive parts. (See Tachometer Drive Service).

8. Inspect rotor, distributor cap and high tension cables. (See secondary circuit inspection.)

DISTRIBUTOR HOUSING BUSHING REPLACEMENT

The following procedures can be followed to remove and replace the distributor shaft bushings in the distributor housing. Distributor tool set SE-1955 will assist in performing these operations.

Illustrations show bushing removal and installation operations being performed on distributor without tachometer drive. Procedures for distributors with tachometer drive are similar.

Bushing Removal

1. On distributors without tachometer drive, use a small screwdriver to pry upper bushing grease retainer washer from distributor housing (Figure 19).

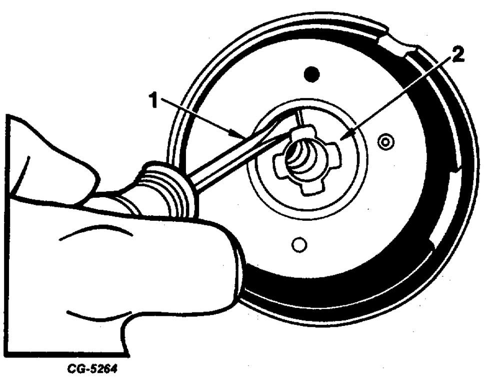

Fig. 19 Removing Grease Retainer Washer (Distributor Without Tachometer Drive)

1. Screw Driver 2. Grease Retainer

2. Install bushing remover SE-1955-5 in upper bushing (Figure 20)

3. Place distributor housing on press bed. Insert knock-out bar through bushing and allow it to rest on bushing remover already installed in upper bushing. Press upper bushing from housing by pressing against knock-out bar (Figure 21).

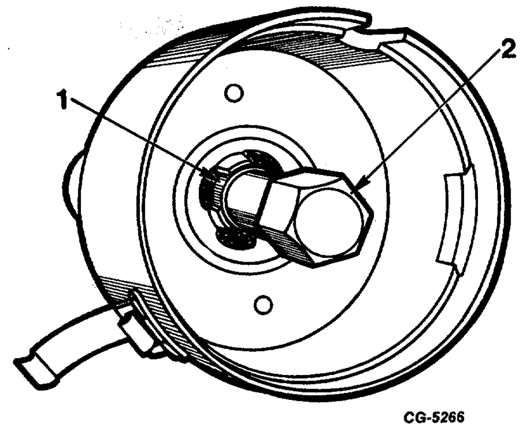

Fig. 20 Bushing Remover SE-1955-5 Installed in Upper Bushing

1. Upper Bushing 2. Remover

The knock-out bar can be made locally from cold rolled bar stock, 11 mm (7/16 in.) in diameter by 30 mm (12 in.) long.

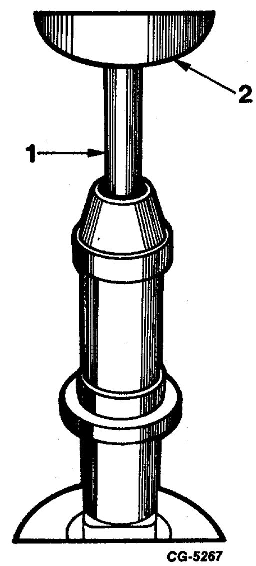

Fig. 21 Pressing Out Upper Bushing using Knock-Out Bar

1. Knock-out Bar 2. Press ram

4. Install bushing remover SE-1955-5 in lower bushing (Figure 22).

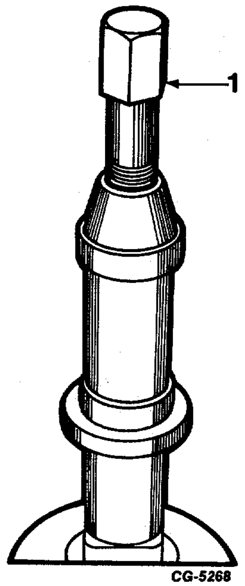

Fig 22 Bushing Remover SE-1955-5 Installed in Lower Bushing

1. Remover

5. Place distributor housing on press bed. Insert knock-out bar through upper bushing bore and allow to rest on end of bushing remover installed in lower bushing. Pressing against knock-out bar, press lower bushing from distributor housing (Figure 23).

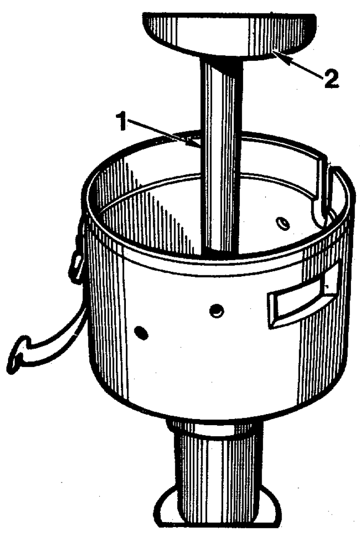

Fig. 23 Pressing Out Lower Bushing Using Knock-Out Bar

1. Knock-out Bar 2. Press Ram

6. On distributors without tachometer drive, wash distributor housing in cleaning solvent to remove old lubricant from upper bushing lubricant reservoirs (Figure 29).

7. On distributors with tachometer drive, V remove cover from tachometer drive cavity and wash distributor housing in cleaning solvent to clean old lubricant from cavity. (See Tachometer Drive Service)

Bushing Installation

1. Lubricate outer diameter of new upper bushing with a light coat of grease and start bushing into distributor.

IMPORTANT

On distributors without tachometer drive, groove in outside diameter of bushing must be positioned at the top (Figure 24).

2. Position distributor housing in press. Insert bushing installer (SE-1955-7) into bushing (Figure 24).

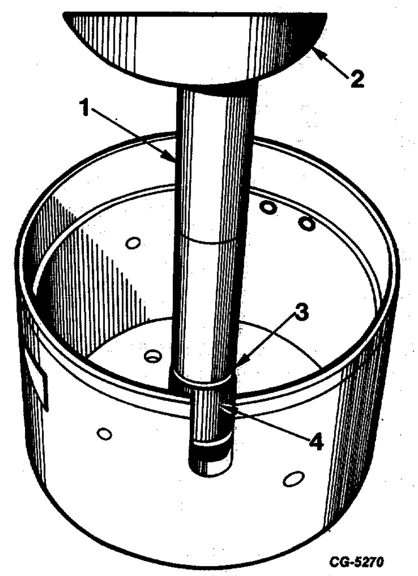

Fig. 24 Installing Upper Bushing Using Bushing Installer SE-1955-7

1. Installer	**2. Press Ram**
3. Groove	**4. Upper Bushing**

3. Press upper bushing into housing to dimension shown in Figure 25.

   On distributors without tachometer drive, 2.4 mm (3/32 inch) below top of bushing support ribs.

   On distributors with tachometer drive, flush to 0.8 mm (1/32 inch) .below surface of tachometer drive counterbore.

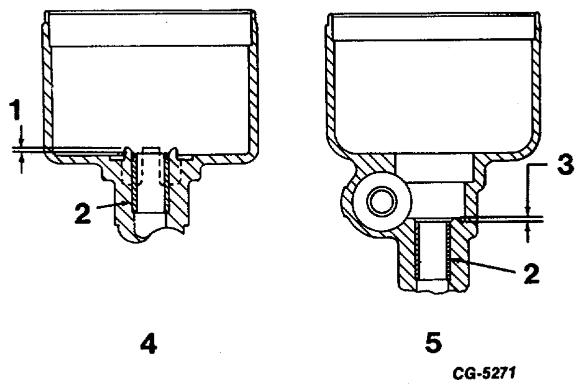

Fig. 25 Upper Bushing Location Dimensions

1. 2.4mm (3/32 in.)
2. Bushing
3. 0.8mm (1/32 in.)
4. Without Tach. Drive
5. With Tach. Drive

4. Lubricate outer diameter of new lower bushing with a light coat of grease and start bushing into distributor housing bore.

5. Position distributor housing in press. Insert bushing installer (SE1955-7) into bushing (Figure 26).

6. Press lower bushing into housing to dimension of 2.4 mm (3/32 inch) below bottom end of distributor housing (Figure 27).

7. After bushings have been installed, check fit of distributor shaft in bushings. Size bushing if necessary.

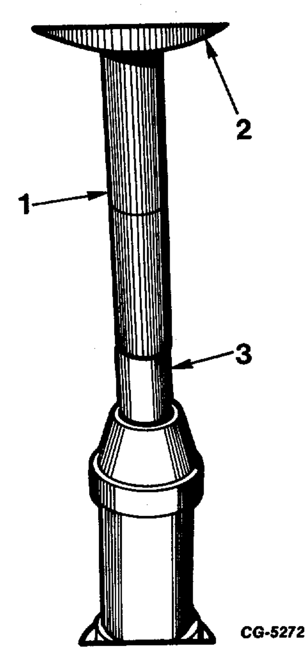

Fig. 26 Installing Lower Bushing using Bushing Installer SE-1955-7

1. Installer
2. Press Ram
3. Lower Bushing

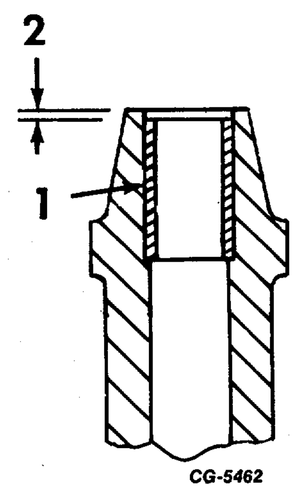

Fig. 27 Lower Bushing Location Dimension

1. Bushing **2. 24 mm (3/32 in.)**

IMPORTANT

The oilite bushings should not be reamed. Swelling and burrs may be removed with a burnishing tool.

For distributors without tachometer drive, use burnisher tool SE-1955-2.

For distributors with tachometer drive, use burnisher tool SE-2779.

If shaft passes through upper bushing but binds in lower bushing, burnish lower bushing only.

If shaft does not pass through or binds in upper bushing, burnish upper bushing first and repeat check for shaft fit. Then burnish lower bushing, if needed.

To burnish bushings:

a. Place flat end of burnisher in a vise. Coat burnisher with SAE-20 engine oil.

b. Burnish upper bushing by placing distributor housing on burnisher carefully and rotating the housing clockwise using light pressure until tool passes through bushing (Figure 28).

c. Burnish lower bushing per step "b" above.

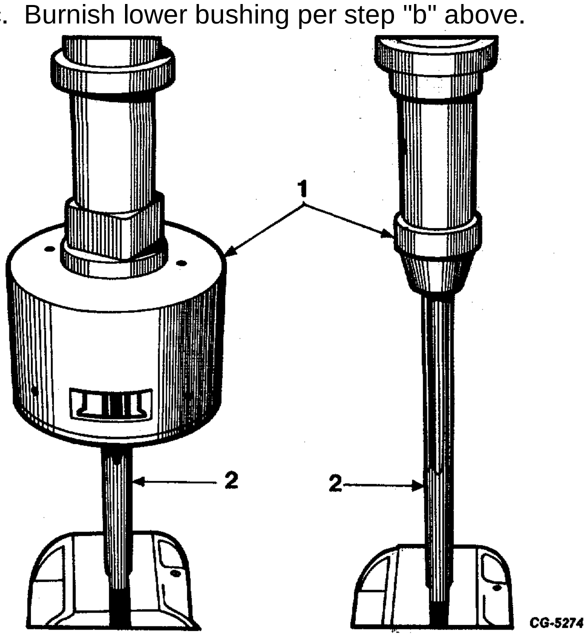

Fig. 28 Burnishing Upper and Lower Bushings Using Burnisher 1955-2

1. Housing **2. Burnisher**

8. On distributors without tachometer drive, fill upper bushing lubricant reservoirs as follows:

a. Fill reservoirs (Figure 29) with lubricant (oil saturated cotton).

At distributor manufacture, reservoirs are filled with Permawick No. 560NP which is also recommended for use at distributor overhaul. Where this product is not available, adequate lubrication can be obtained by packing lubricant reservoirs with cotton (such as medical or cosmetic cotton balls) saturated with engine oil.

b. Wipe excess oil from floor of distributor housing and install grease retainer washer (Figure 30). Tangs of washer must lock into groove in upper bushing.

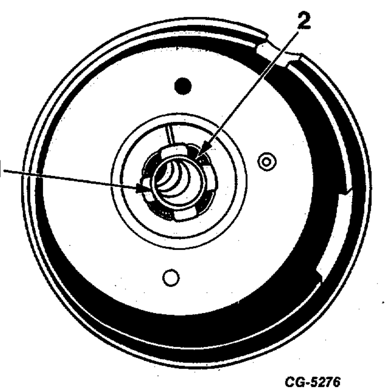

Fig. 29 Upper Bushing Lubricant Reservoirs (Distributors Without Tachometer Drive)

1. Bushing **2. Lubricant Reservoir**

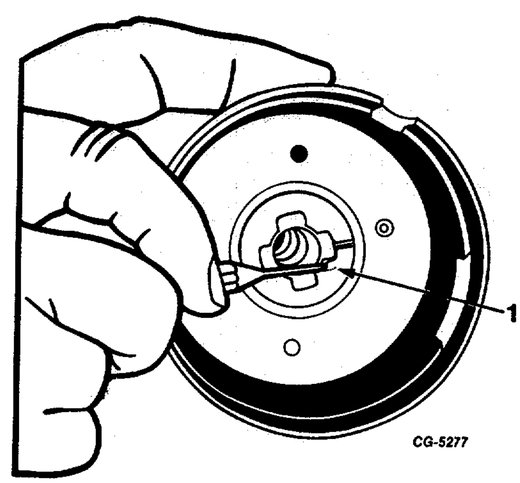

Fig. 30 Installing Grease Retainer Washer (Distributors Without Tachometer Drive)

1. Grease Retainer

MECHANICAL ADVANCE SYSTEM SERVICE

Mechanical advance system components are not provided for service individually. However, it is recommended that the mechanical advance system be disassembled for inspection and lubrication, as outlined below, at the time of distributor overhaul.

Disassembly

(Refer to Figure 31)

IMPORTANT

Mark advance weights, weight pivot pins and distributor cam assembly to assure reassembly in the same positions.

1. Remove distributor cam assembly retainer from distributor shaft using hooked extractor tool.
2. Slide cam assembly from distributor shaft.
3. Remove primary and secondary advance weight springs.
4. Remove advance weights and thrust washer.

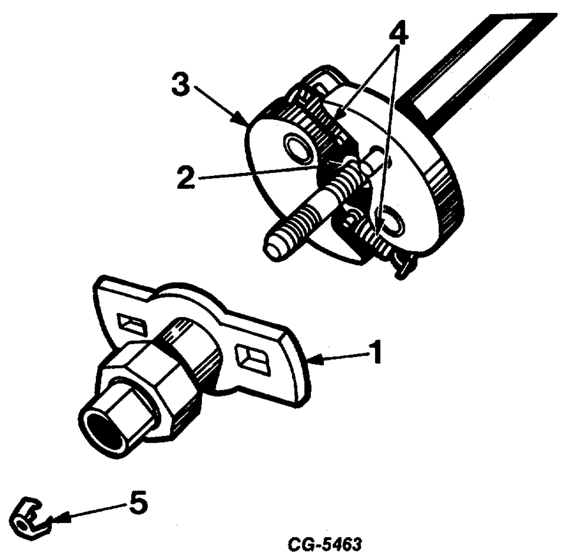

Fig. 31 Mechanical Advance System Components

1.	Cam Assembly	3.	Weights
2.	Thrust Washer	4.	Springs

5. Retainer

Inspect mechanical advance components. If wear or damage is found, replace distributor shaft assembly.

Reassembly

1. Lubricate advance weight bushings and pivot pins with a light film of premium quality grease (Mobil No. 532 or equivalent). Install weights on pivot pins.
2. Install advance springs.
3. Make sure advance weights pivot freely on pins.
4. Lubricate cam assembly pilot surface of distributor shaft with premium quality grease. Grooves in pilot diameter should be filled with lubricant. Lands between grooves should have only a thin film of lubricant.
5. Apply a light coat of premium quality grease to thrust washer and position thrust washer on distributor shaft.
6. Position cam assembly on pilot surface of distributor shaft. Align slots in cam assembly yoke with pins on advance weights and push cam assembly into position.
7. Install cam assembly retainer. If necessary, bend arms of retainer to assure that retainer grips slot in distributor shaft.
8. Make sure mechanical advance mechanism operates freely.

TACHOMETER DRIVE SERVICE

Tachometer Drive Gear and Bearing Replacement

Tachometer drive gear and bearing (Figure 32) can be replaced by following the procedure outlined below.

1. Remove distributor cam assembly and mechanical advance components from distributor shaft. (See Mechanical Advance System Service).
2. Support distributor shaft and drive roll pin from tachometer drive gear using punch and hammer (Figure 33).

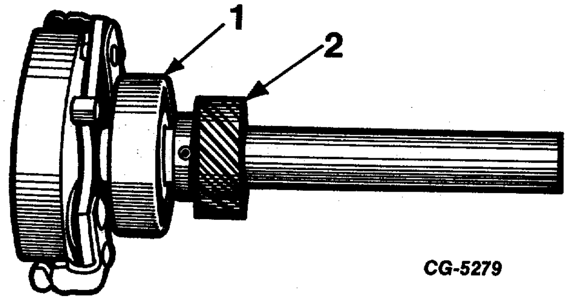

Fig. 32 Tachometer Drive Gear and Bearing

1. Bearing **2. Tachometer Drive Gear**

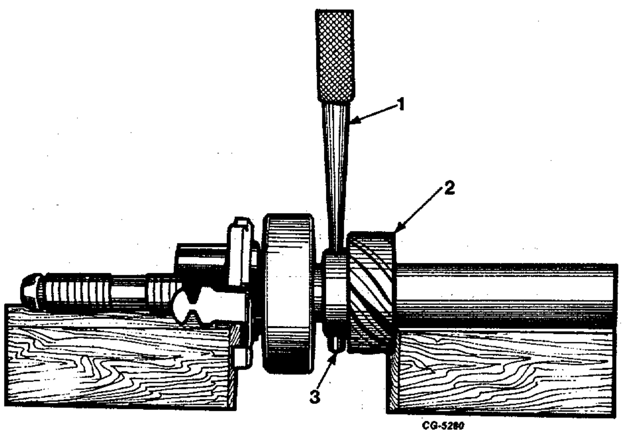

Fig. 33 Removing Tachometer Drive Gear Pin

1. Punch **2. Tachometer Drive Gear**
3. Pin

3. Remove tachometer drive gear from distributor shaft.

4. Remove bearing from distributor shaft.

a. Position bearing puller attachment SE-1336-16 (Owatonna No. 950 or Equivalent) under bearing (Figure 34).

b. Support bearing puller in press bed and press shaft from bearing.

IMPORTANT

Avoid distorting advance weight plate when installing bearing puller.

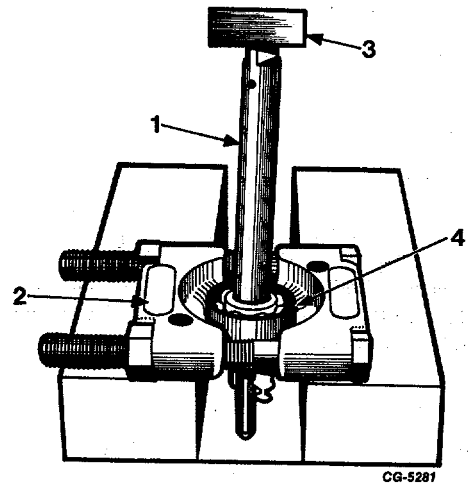

Fig. 34. Removing Tachometer Drive Bearing Using SE-1336-16 Bearing Puller

1. Distributor Shaft **3. Press Ram**
2. Puller **4. Bearing**

5. Install new bearing as follows:

a. Using a piece of pipe 13 mm (½ inch) I.D. x 60 mm (2¼ inches) long as a support base (Figure 35), position distributor shaft in press.

b. Place bearing on distributor shaft with sealed side toward advance weight plate.

c. Using a piece of pipe 13 mm (½ inch) I.D. of suitable length as a driver tool, press bearing onto shaft to a dimension of 14 mm (9/16 inch) from bottom of advance weight plate to bottom of bearing (Figure 35).

6. Install new tachometer drive gear on distributor shaft. New gear will have pin hole drilled in one side only. Install as follows:

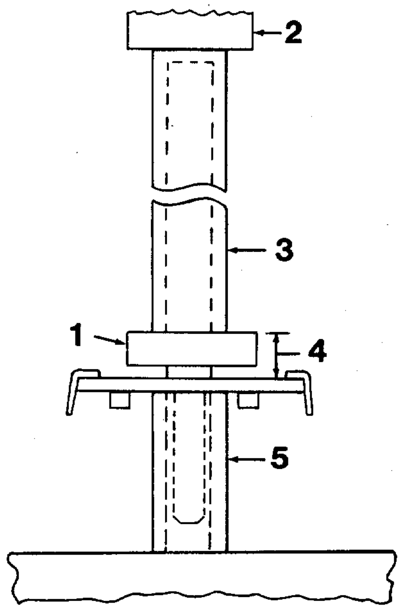

Fig. 35 Installing Tachometer Drive Bearing

1. Bearing
2. Press Ram
3. Driver Tool (Pipe)
4. 14.3mm (9/16 in.)
5. Support (Pipe)

a. Position gear on distributor shaft and align pin hole with hole in shaft.

b. Support distributor shaft in drill press and drill hole through other side of gear.

c. Install roll pin.

7. Lubricate and install mechanical advance components and cam assembly (See Mechanical Advance System Service).

Tachometer Driven Gear and Shaft

The tachometer driven gear, shaft and bushing are not provided for service. However, at the time of distributor overhaul, these parts should be thoroughly cleaned and lubricated as outlined below.

1. Remove tachometer drive shaft cover as follows:

a. Drill a 3 mm (1/8 inch) hole in center of cover (Figure 36).

b. Insert a hooked tool or a punch into hole in cover and pry cover from distributor housing (Figure 36).

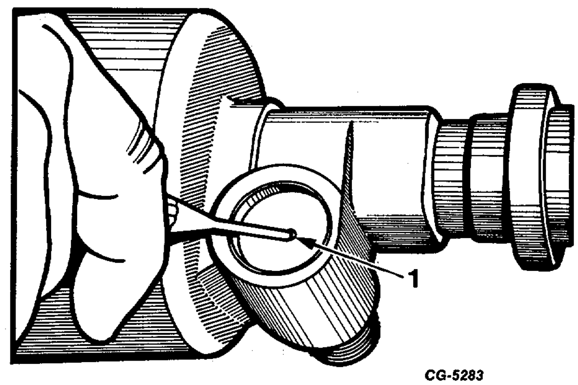

Fig. 36 Removing Tachometer Drive Shaft Cover

1. Drill Hole in Cover

2. Clean old lubricant from tachometer drive gear and cavity in distributor housing. (See "IMPORTANT" under Cleaning and Inspection).

3. Inspect tachometer driven gear, shaft and bushing. If excessive wear or damage is indicated, replace distributor assembly.

4. If parts are satisfactory for reuse:

a. Fill tachometer drive gear and cavity with ball bearing lubricant (Humble "Andok 260" or equivalent).

b. Install new tachometer drive shaft cover in distributor housing.

DISTRIBUTOR REASSEMBLY

1. Install distributor shaft assembly into distributor housing as outlined below:

IMPORTANT

If a new distributor shaft is being installed, a new distributor driven gear or thrust collar and new thrust washers must also be installed.

a. Position new upper thrust washer(s) on shaft.

Distributors with tachometer drive have one thrust washer (Figure 18). Distributors without tachometer drive have two thrust washers (Figure 17) which must be installed properly. Install outer washer (blued steel) first with lip of washer facing toward lower end of shaft. Install inner thrust washer (silver color) with lip facing lower end of shaft. Inner (silver color washer should seat on lip of outer (blued) washer.

b. Lubricate distributor shaft with engine oil.

c. Slide distributor shaft into distributor housing.

2. Position new lower thrust washers (Figure 16) on shaft. Install inner washer (silver color) first with lip of seal facing toward distributor housing. Install outer washer (blued steel with lip facing toward distributor housing. Outer (blued) washer should seat in inner (silver color) washer.

3. Install distributor driven gear as outlined below:

<u>If original driven gear is being used:</u>

a. Position gear on distributor shaft and align roll pin hole in gear with roll pin hole in shaft.

b. Install roll pin.

If new driven gear is being used:

New gear will have pin hole drilled in one side only. Install as follows:

a. Position gear on shaft and align pin hole in gear with pin in shaft.

b. Support distributor assembly in drill press and drill pin hole through other side of gear.

c. Install roll pin.

<u>If new distributor shaft and driven gear are being installed:</u>

a. Position gear on distributor shaft and establish specified shaft end play. (See DISTRIBUTOR TEST SPECIFICATIONS).

b. Support distributor assembly in drill press. Using existing pin hole in gear as a guide, drill roll pin hole in shaft and other side of gear.

c. Install roll pin.

4. Assemble contact point set and condenser to breaker plate assembly as follows:

a. Index contact point pivot post with hole in advance plate. Make sure contact point set is sealed flatly on advance plate. Install contact set mounting screw.

b. Position condenser on advance plate and install condenser mounting screw.

c. Connect condenser and primary leads to contact point terminal screw.

5. Install breaker plate assembly as follows:

a. Left advance plate and put a small amount of premium quality grease (Mobil 532 or equivalent) under each of the three thrust buttons.

b. Position plate assembly and primary wiring grommet in distributor housing and install mounting screw.

6. Install felt washer on diaphragm rod pin of advance plate (Figure 9). Oil felt washer with engine oil.

7. Position vacuum advance diaphragm assembly on distributor housing and install mounting screws.

Connect diaphragm rod in pin on advance plate and install flat washer and rod retaining "E" clip.

8. Clamp distributor in vise equipped with soft jaw shields. Apply only enough pressure to restrict distributor movement.

9. Adjust breaker arm spring tension as follows:

IMPORTANT

Correct breaker spring tension is essential for effective ignition and efficient engine performance. Spring tension that is too great will cause excessive wear of breaker arm rubbing block and distributor cam. Spring tension that is too weak is unable to keep contact points in contact when they close, particularly when engine speed is increased, causing high-speed misfiring.

a. Hook spring tension scale (SE- 2315 or equivalent) over breaker arm and pull in a straight line at a right angle to the contacts start to open-under a slow, steady pull on the scale. Tension should be within specified limits. (See DISTRIBUTOR TEST SPECIFICATIONS.)

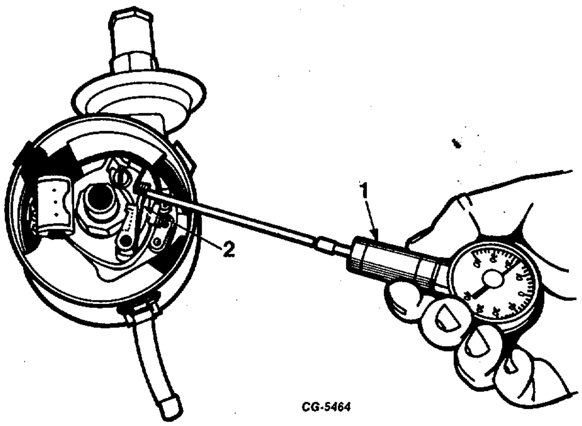

Fig. 37 Checking Breaker Spring Tension
1. Tension Gauge 2. Breaker Arm

If tension is outside of specified limits, loosen contact point terminal screw and move end of breaker spring backward or forward as necessary to obtain correct tension. Tighten terminal screw and recheck spring tension.

10. Check contact point alignment as follows:

a. Rotate distributor shaft until contacts are closed.

b. Stationary and movable contacts should be aligned and contact each other squarely.

c. If necessary, align contacts by bending stationary contact bracket only. <u>Do</u> <u>Not</u> bend movable breaker arm. Use needle nose pliers to bend the upright portion of the stationary contact bracket slightly in or out, or twist it until contact surfaces are aligned (Figure 38).

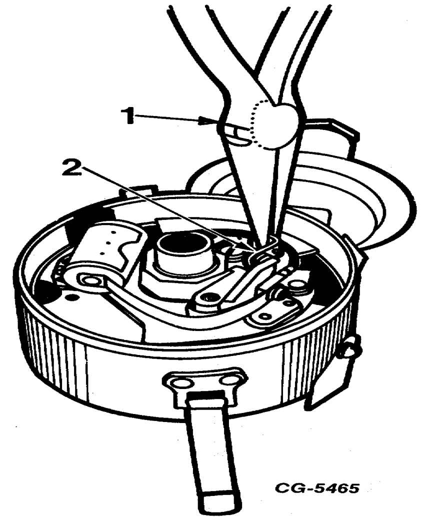

Fig. 38 Using Needle Nose Pliers to Adjust Contact Point Alignment
1. Needle Nose Pliers 2. Grounded Bracket

11. Adjust contact point gap as follow:

a. Rotate distributor shaft until breaker arm rubbing block is on highest point of a cam lobe.

b. Measure point gap by inserting feeler gauge between contacts (Figure 39). (See DISTRIBUTOR TEST SPECIFICATIONS for specified gap dimension).

c. Adjust point gap as follows:

(1) Loosen contact point set mounting screw.

(2) Insert screwdriver blade between contact bracket. Notch

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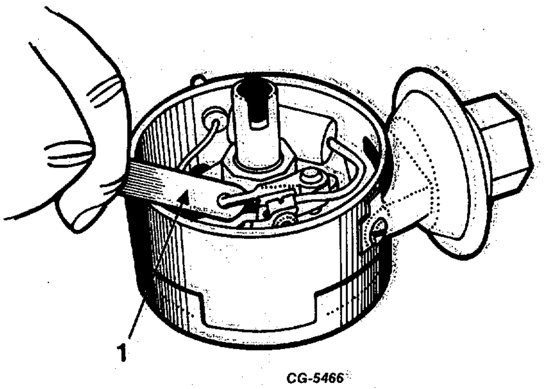

Fig. 39. Measuring Contact Point Gap
1. Feeler Gauge

in advance plate (Figure 40). Rotate screwdriver (moving contact bracket) until specified gap is obtained.

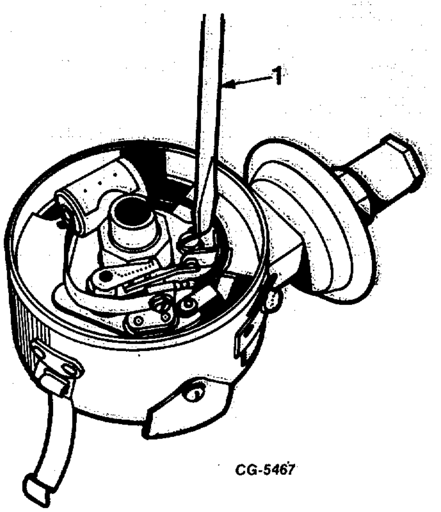

Fig. 40. Adjusting Contact Point Gap
1. Screwdriver

(3) Tighten contact point set mounting screw and recheck point gap.

d. Rotate distributor shaft and recheck point gap on several cam lobes.

12. Clean contact points as follows:

IMPORTANT

Contact surfaces- should be, cleaned; thoroughly after they: have been aligned and adjusted. Oil or perspiration on contact surfaces will cause oxidation and result in reduced contact point life.

a. Insert a piece of lintless seam- binding- tape between the contact surfaces. Wet the tape at the contacts with a medicine dropper con- taining technical grade chloroform.

b. Pull tape out from between the contacts. Wet portion of tape will remove fingerprints, oil, or residue, and the dry end of tape will remove dust particles.

c. Make certain that no lint fibers or threads are held between contact surfaces.

13. Lubricate the distributor cam with a light coating of distributor cam lubricant.

Apply lubricant to cam by placing a small amount of lubricant on fore- finger, and while holding finger lightly against the cam, rotate distributor shaft with other hand until surface of cam is coated with a film of grease. Apply lubricant sparingly. If lubricant piles up on rubbing block, remove excess with a toothpick or small blade screwdriver. Remove distributor assembly from vise.

14. Mount distributor in distributor test stand. (See Distributor Operation Test.)

15. Operate distributor and observe dwell reading. Dwell should be within specified limits. (See DISTRIBUTOR TEST SPECIFICATIONS.)

If dwell reading is not within specified limits, adjust contact point gap to obtain specified dwell.

16. Check operation of mechanical advance mechanism as follows:

a. With distributor operating at minimum speed, set zero of test stand degree ring in line with arrow flash nearest to front of stand.

b. Increase distributor speed, pausing at each specified test speed to note the amount of advance that is occurring. If advance at specified test speeds is not within specified limits, adjust advance spring tension by bending the spring posts (Figure (41). Bend post(s) toward distributor shaft to decrease tension (increase advance) and away from shaft to increase tension (decrease advance).

Make adjustments carefully to keep advance within specified limits. Adjustment is not com- plete until advance falls within specified limits at all test speeds.

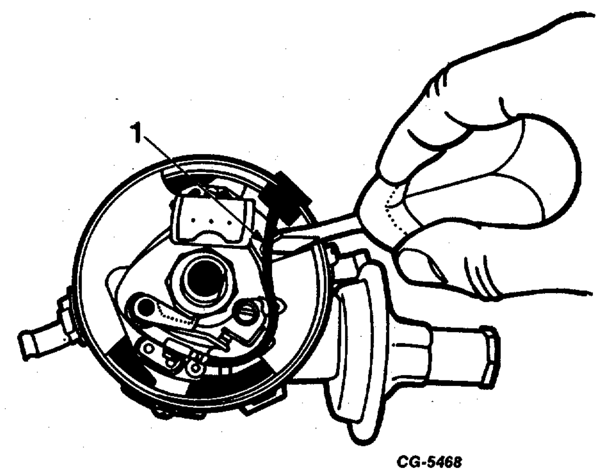

Fig. 41. Adjusting Advance Spring Tension
1. Spring Post

17. Connect test stand vacuum hose to vacuum advance diaphragm and check operation of vacuum advance. If advance does not fall within specified limits at specified vacuum readings, replace vacuum advance diaphragm and recheck vacuum advance operation.

18. If distributor operation is satisfactory, remove distributor from test stand and install dielectric shield (dust cover) and rotor.

19. **DISTRIBUTOR INSTALLATION**

1. Clean distributor mounting area of engine block.

2. Install a new distributor mounting gasket in counterbore of engine block or install a new "O" ring seal on distributor housing, whichever is applicable.

3. Position distributor in engine. If engine was not rotated while distributor was removed:

   a. Align rotor tip with mark scribed on distributor housing during removal. Then, on distributors with driven gear mounted on lower end of distributor shaft, turn rotor about 1/8 turn clockwise past scribed mark.

   b. Slide distributor down into engine and position distributor housing in approximately the same location (in relation to surrounding engine parts) as when removed.

   It may be necessary to move rotor and shaft slightly to start gear into mesh with camshaft gear and/ or to engage oil pump shaft drive tang, but rotor should align with scribed mark when distributor is down in place.

   c. Install distributor hold-down clamp, bolt and lock washer, but do not tighten bolt.

   If engine was rotated while distributor was removed, it will be neces- sary to re-establish timing as fol- lows:

   a. Remove No. 1 spark plug (No. 8 on V-304, V-345, V-392 engines). Hold finger over spark plug hole and rotate engine until compression pressure is felt. Slowly continue to rotate engine until timing mark on crankshaft pulley lines up with specified initial timing mark on timing quadrant. (For initial timing setting, refer to tune-up data decal on engine.) Always rotate engine in direction of normal rotation. Do not "back" engine to align timing marks.

b. Turn distributor shaft until rotor tip points in the direction of the No. 1 terminal in the distributor cap (No. 8 terminal on V-304, V-345, V-392 engines). Then, turn rotor about 1/8 turn clockwise past position of initial timing terminal.

c. Slide distributor down into engine and position distributor housing in approximately the same location (in relation to sur- rounding engine parts) as when removed.

It may be necessary to move rotor and shaft slightly to start gear into mesh with camshaft gear and/ or to engage oil pump shaft drive tang, but rotor should align with the position of initial timing terminal when distributor is down in place.

d. Install distributor hold-down clamp, bolt and lock washer, but do not tighten bolt.

4. Install distributor cap (with high tension cables) on distributor hous- ing making sure tang on vacuum advance unit aligns with slot in distributor cap and that cap fits down snug on distributor housing.

NOTE

If distributor cap is incorrectly positioned on distributor housing, cap or rotor may be damaged when engine is cranked.

5. Connect distributor primary wire to coil.

6. Connect tachometer drive cable, if equipped.

7. Connect timing light to No. 1 spark plug (No. 8 spark plug on V-304, V-345, V-392 engines).

IMPORTANT

Do not puncture high tension cables or boots to make contact Use proper adaptors.

8. Operate engine at idle speed and observe timing marks with timing light. (Figure 42). Rotate distributor housing as needed to align timing mark on crankshaft pulley with specified initial timing mark on timing quadrant. When timing is correct tighten distributor hold-down bolt and recheck timing to be sure it did not change.

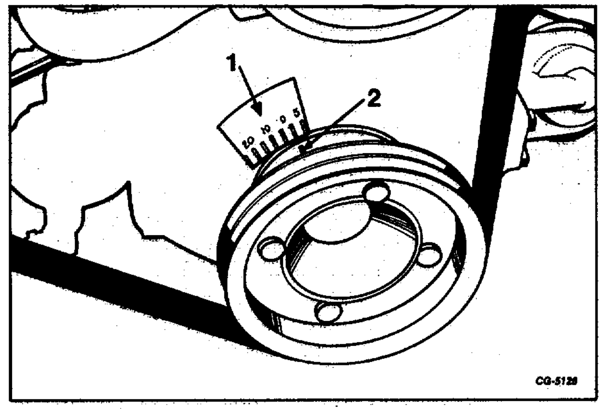

Figure 42. Timing Marks (V-304, V-345 V-392 Engines Shown)
1. T.D.C. 2. Timing Mark

9. Disconnect timing light and connect vacuum hose to distributor advance unit (where equipped).

SECONDARY CIRCUIT INSPECTION

Secondary (high voltage) system components (distributor cap, rotor, coil, high tension cables and spark plugs) should be checked as possible sources of trouble.

Distributor Cap and Rotor

Inspect distributor cap and rotor for cracks, carbon tracking, loose terminals, dirt and contamination. Clean or replace as needed.

Check rotor blade and spring for tightness. Check fit of rotor on distributor shaft. Check resistance type rotor with ohmmeter (Figure 45). If resistance exceeds 6000 ohms, replace rotor.

Coil

Inspect coil tower for cracks or carbon tracking. Inspect primary terminals for corrosion and/or looseness. Replace coil if any of these conditions are found.

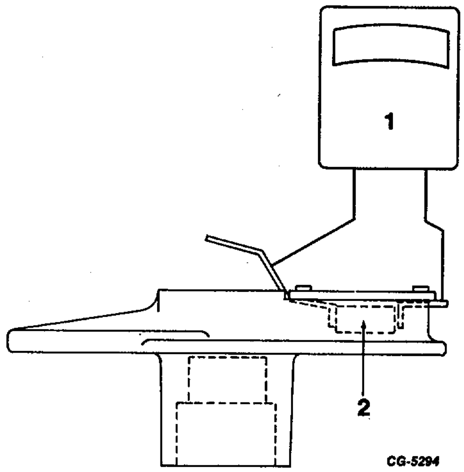

Fig. 43. Rotor Resistance Test
1. Ohms X1000 2. Resistor

Set ohmmeter in OHM x 1 position. Connect ohmmeter between coil primary 1.2 and 1.4 ohms at 21 degrees C (70 degrees F).

Set ohmmeter in OHM x 1000 position. Connect ohmmeter between one coil primary terminal and the coil tower terminal. Reading should be within 9,000 to 12,000 ohms at 21 degrees C (70 degrees F).

COIL RESISTANCE TESTS

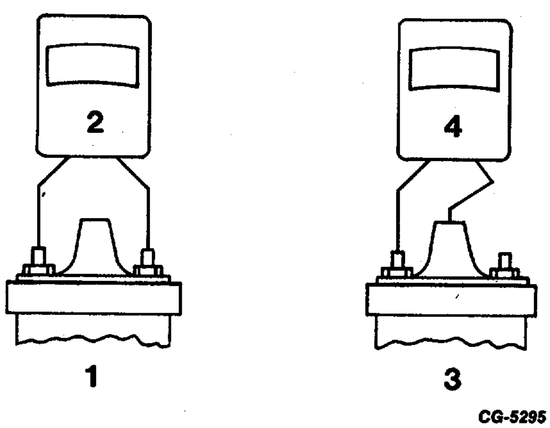

Fig. 44. Coil Resistance tests
1. Primary Circuit 3. Secondary Circuit
2. Ohms x 1 4. Ohms x 1000

If coil fails either resistance test, replace it.

<u>High Tension Cables</u>

Inspect secondary (high tension) ignition cables for deterioration, car- bon tracking at terminal boots and high voltage leakage, especially at cable support brackets.

Test resistance of cables with an ohmmeter. Resistance should not exceed 30,000 ohms on cables up to 914 mm (36") long.

Check sealing and insulating qualities of distributor cap, coil tower and spark plug boots. Replace if needed.

Clean cable terminals and apply a light coat of lubricant/sealer (IH part number 472141C1) to terminals at as- sembly. Make sure cables seat properly on distributor cap and spark plug terminals and in coil tower terminal.

Be sure ignition cables are routed correctly. Proper routing of cables must be maintained to prevent crossfire.

CONDITION	POSSIBLE CAUSE	REMEDY
Engine fails to start.	No primary voltage to coil	Check battery, ignition switch, primary feed and ground circuits.
	Moisture in distributor cap or high tension cable boots.	Clean and dry parts. Correct cause for entry of moisture.
	Contact point gap incorrect.	Inspect points Adjust gap.
	Burned or worn contact points.	Replace point set.
	Broken or open rotor.	Replace rotor.
	Faulty condenser.	Replace condenser.
	Faulty distributor cap.	Replace cap.
	Coil high tension cable not sealed in coil tower or on distributor cap.	Check cable installation.
	Faulty high tension cables.	Replace cables.
	Open or shorted coil.	Replace coil.
Engine backfires but fails to start.	Incorrect ignition timing.	Check timing. Adjust as needed.
	Moisture in distributor cap.	Dry cap and rotor.
	Distributor cap faulty or carbon tracked.	Replace cap.
	Spark plug cables connected incorrectly.	Check cables for correct position.
Engine does not operate smoothly or engine misfires at high speed.	Incorrect ignition timing.	Check timing. Adjust as needed.
	Spark plugs fouled.	Clean and regap plugs.
	Spark plug electrodes worn (gap too wide).	Regap or replace plugs.
	Faulty distributor cap.	Replace cap.
	Spark plugs cables faulty.	Check cables, replace if needed
	Contact point gap incorcorrect.	Inspect points. Adjust gap.
	Burned or worn contact points.	Replace point set.
	Improper breaker spring tension.	Check and adjust spring tension .
	Worn distributor shaft bushings, bent distributor shaft, worn distributor cam, or faulty spark advance system.	Rebuild or replace distributor.

Excessive fuel consumption	See causes listed under "Engine does not operate smoothly."	
Erratic timing advance.	Vacuum leaks in vacuum advance system.	Check vacuum hoses. Replace as needed.
	Faulty vacuum advance diaphragm assembly.	Check operation of advance diaphragm. Replace if needed.
	Sticking or worn advance plate.	Replace breaker plate assembly.
	Misadjusted, damaged or weak mechanical advance springs.	Readjust spring tension. Replace distributor shaft assembly.
	Mechanical advance flyweight bushings worn.	Replace distributor shaft assembly.
	Distributor cam assembly binding or excessively loose on distributor shaft.	Free-up and lubricate cam assembly. Replace distributor shaft assembly, if needed.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)
1978

Engine Model	4-152, 4-196	V-266,V-304,V-345,V-392		V-304
Distributor: Part No. (Manufacturers No.)	484824C91 (IDN-4101	484831C91 (IDN-4102G)	491357C91 (IDN-4102J)	484834C91 (IDN-4102)
Point Gap: mm (in)	0.35 - 0.45 (.014 -018)			
Dwell, Degrees	42 - 48	28 - 32		
Contact Point Pressure (oz)	17 - 22			
Condenser Capacity, Mfd.	.25 - .28			
Vacuum Advance:				
Vacuum Reqd to Start Adv.	16.9 - 23.6	16.9 - 23.6	16.9 - 23.6	16.9 - 23.6
KPa, (In. of Hg.)	(5 - 7)	(5 - 7)	(5 - 7)	(5 - 7)
Advance Check Points:				
Vacuum,KPa, (In. of Hg.)	20.3 (6)	20.3 (6)	30.4 (9)	20.3 (6)
Degrees	0 - 1.5	0 - 1.5	3 - 6	0 - 1.5
Vacuum	37.1 (11)	33.8 (10)	37.1 (11)	27.0 (8)
Degrees	5.7 - 8	4.2 - 7.2	4 - 6	1.5 - 4
Vacuum	50.7 (15)	50.7 (15)	50.7 (15)	40.5 (12)
Degrees	6 - 8	6 - 8	4 - 6	2 - 4
Mechanical Advance:				
Dist. RPM to Start Adv.	250 - 350	375 - 425	350 - 450	325 - 475
Advance Check Points:				
Distributor RPM	300	400	5P0	400
Degrees	0 - 1	0 - 1	1.5 - 3.9	0 - 1
Distributor RPM	---	650	650	---
Degrees	---	8.5 - 10.5	5.5 - 7.9	---
Distributor RPM	700	950	1000	1100
Degrees	7.5 - 9.5	10 - 12	8.3 - 10.3	9 - 11
Distributor RPM	---	1600	1800	---
Degrees	---	13 - 15	12 - 14	---
Distributor RPM	1800	2000	2200	2000
Degrees	15 - 17	15 - 17	13 - 15	15 - 17
Total Advance, Degrees Mechanical and Vacuum	21 - 25	21 - 25	17 - 21	17 - 21
Distributor Shaft End Play, mm (in)	0.89 - 1.02 (.035 -040)			
Distributor Shaft Side Play New, mm (in)	0.05 - 0.1 (.002 -004)			
Maximum Permissible, mm (in)	0.15 (.006)			
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)			

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)
1978

Engine Model	V-345	V-345, V-392
Distributor: Part No.	484780C91	484781C91
(Manufacturers No.)	(IDN-4102B)	(IDN-4102D)
Point Gap: mm (in)	0.35 - 0.45 (.014 -018)	
Dwell, Degrees	28 - 32	
Contact Point Pressure (oz)	17 - 22	
Condenser Capacity, Mfd.	.25 - .28	
Vacuum Advance:		
Vacuum Reqd to Start Advance KPa, (In. of Hg.)	16.9-23.6 (5 - 7)	16.9-23.6 (5 - 7)
Advance Check Points:		
Vacuum, KPa, (In. of Hg.)	27.0 (8)	27.0 (8)
Degrees	1.5 - 4.5	1.5 - 4.5
Vacuum	40.5 (12)	40.5 (12)
Degrees	4 - 6	4 - 6
Vacuum	---	---
Degrees		
Mechanical Advance:		
Distributor RPM to Start Advance	325 - 475	350 - 475
Advance Check Points:		
Distributor RPM		
Degrees		
Distributor RPM	1000	700
Degrees	7.5 - 9.5	4 - 6
Distributor RPM	1200	1000
Degrees	9.7 - 11.7	5.5 - 7.5
Distributor RPM	1850	1900
Degrees	14 - 16	10 - 12
Distributor RPM	2100	2100
Degrees	15 - 17	10.3 - 12.3
Total Advance, Degrees Mechanical and Vacuum	19 - 23	14.3 - 18.3
Distributor Shaft End Play, mm (in)	0.89 - 1.02 (.035 - 040)	
Distributor Shaft Side Play		
New, mm (in)	0.05 - 0.1 (.002 -004)	
Maximum Permissible, mm (in)	0.15 (.006)	
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)	

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)
1978

Engine Model	V-345	V-266, V-304, V-345, V-392	
	Propane	Low Compression	
Distributor: Part No. (Manufacturers No.)	484795C91 (IDN-4102C)	484799C91 (IDN-4102E)	487830C91 (IDN-4102K) 487-877C92 (IDN-4103G)
Point Gap: mm (in)	0.35 -0.45 (.014 - 018)		
Dwell, Degrees	28 - 32		
Contact Point Pressure (oz)	17 - 22		
Condenser Capacity, Mfd.	.25 - .28		
Vacuum Advance:			
Vacuum Reqd to Start Advance KPa, (In. of Hg.)	16.9 - 23.6 (5 - 7)	16.9 - 25 (5 - 7.5)	316.9 - 23.6 (5 - 7)
Advance Check Points:			
Vacuum, KPa, (In. of Hg.)	20.3 (6)	23.6 (7)	27.0 (8)
Degrees	0 - 1.4	0 - 3	2.8 - 8
Vacuum	30.1 (9)	30.1 (9)	32.1 (9.5)
Degrees	3 - 5.8	2.2 - 6.7	6 - 8
Vacuum	50.7 (15)	50.7 (15)	64.2 (19)
Degrees	6 - 8	6 - 8	6 - 8
Mechanical Advance:			
Distributor RPM to Start Advance	250 - 375	250 - 350	325 - 475
Advance Check Points:			
Distributor RPM	400	300	- - -
Degrees	0 - 2	0 - 1	- - -
Distributor RPM	- - -	- -	700
Degrees	- - -	- -	7.1 - 9.1
Distributor RPM	700	650	1000
Degrees	4 - 6	5.7 - 7.7	9.1 - 11.1
Distributor RPM	- - -	- - -	1800
Degrees	- - -	- - -	14.5 - 16.5
Distributor RPM	2000	2000	- - -
Degrees	10.5 - 12.5	12.5 - 14.5	-
Total Advance, Degrees Mechanical and Vacuum	16.5 - 20.5	18.5 - 22.5	20.5 - 24.5
Distributor Shaft End Play, mm (in)	0.89 - 1.02 (.035 - 040)		
Distributor Shaft Side Play			
New, mm (in)	0.05 - 0.1 (.002 -004)		
Maximum Permissible, mm (in)	0.15 (.006)		
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)		

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)
1979

Engine Model	V-345		V-392
Distributor: Part No. (Manufacturers No.)	500159-C91 (IDN-4109)	500142-C91 (IDN-4102L)	500160-C91 (IDN-4102N)
Point Gap: mm (in)	0.35 - 0.45 (.014 -018)		
Dwell, Degrees	28 - 32		
Contact Point Pressure (oz)	17 - 22		
Condenser Capacity, Mfd.	25 -28		
Vacuum Advance:			
Vacuum Reqd to Start Advance	33.8 - 40.5	16.9 - 23.6	
KPa, (In. of Hg.)	- - -	(10.0 - 12.)	(5.0 - 7.0)
Advance Check Points:			
Vacuum, KPa, (In. of Hg.)	- - -	43.9 (13)	27.0 (8.0)
Degrees	- - -	1.5 - 4.0	2.8 - 8.0
Vacuum	- - -	50.7 (15)	32.1 (9.5)
Degrees	- - -	2.0 - 4.0	6.0 - 8.0
Vacuum	- - -	- - -	64.2 (19.0)
Degrees	- - -	- - -	6.0 - 8.0
Mechanical Advance:			
Distributor RPM to Start Advance	300 - 500	370 - 580	350 - 475
Advance Check Points:			
Distributor RPM	600	700	700
Degrees	1.0 - 3.0	0.9 - 2.9	3.4 - 5.4
Distributor RPM	1000	1000	1000
Degrees	5.0 - 7.0	3.5 - 5.5	8.0 - 10.0
Distributor RPM	1800	1900	1400
Degrees	13.0 - 15.0	11.2 - 13.2	10.0 - 12.0
Distributor RPM	2100	2100	1800
Degrees	14.8 - 16.8	11.9 - 13.9	12.0 - 14.0
Total Advance, Degrees Mechanical and Vacuum	14.8 - 16.8 (Mech Only)	13.9 - 17.9	18.0 - 22.0
Distributor Shaft End Play, mm (in)	0.89 - 1.02 (.035 -040)		
Distributor Shaft Side Play New, mm (in)	0.05 - 01 (.002 -004)		
Maximum Permissible, mm (in)	0.15 (.006)		
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)		

DISTRIBUTOR

(HOLLEY) MODEL 1530

(BREAKERLESS)

ELECTRONIC IGNITION SYSTEM

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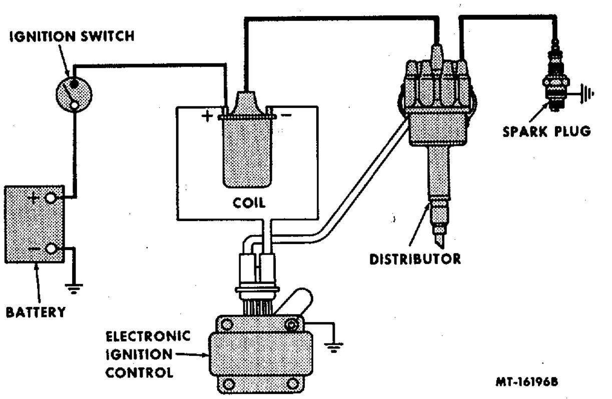


Fig. 1 Schematic View of IH Electronic (Breakerless) Ignition System

DESCRIPTION

The electronic (breakerless) ignition system (Fig. 1) consists of three major component units: a distributor, an ignition coil and an electronic ignition control. These components are shown in Fig. 2.

The distributor is conventional except that a sensor and trigger wheel replace the usual contact points, condenser and distributor cam.

A standard type ignition coil is used.

The electronic ignition control is a completely solid state unit designed for trouble free service. Its component parts are permanently sealed in a waterproof and vibration resistant compound enclosed in an aluminum case. The ignition control unit electronically "makes" and "breaks" the ignition primary circuit in response to triggering signals from the sensor in the distributor.

Because primary (low voltage) current is regulated within the electronic ignition control, a ballast resistor or resistance wire is not required. All ignition system wiring connectors are water resistant. Interference suppression type, high tension ignition cables are used to meet radio frequency interference standards.

OPERATION

The sensor is a small coil, wound of fine wire, which receives an alternating current signal from the electronic ignition control. The sensor is, very simply, a metal detector. The metal that the sensor detects is the teeth of the trigger wheel. Trigger wheels of distributors for four-cylinder engines have four (4) teeth. Distributors for eight-cylinder engines have eight (8) teeth on the trigger wheel. Whenever the leading edge of a trigger wheel tooth lines

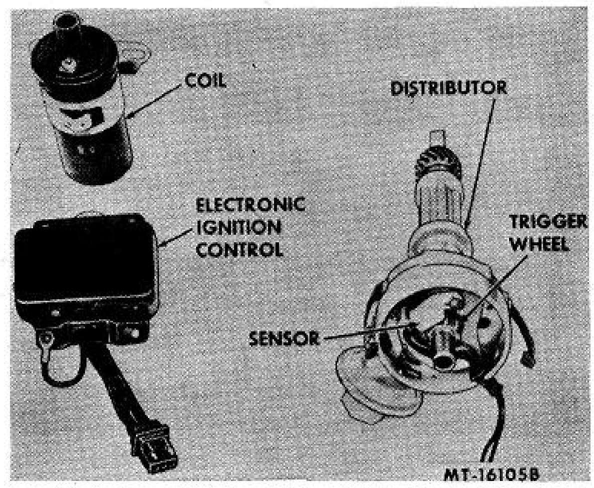


Fig. 2 Components of IH Electronic (Breakerless) Ignition System (Typical)

up with the center of the sensor coil, a signal is sent to the electronic ignition control. When the electronic ignition control receives the signal from the sensor, it opens ("breaks") the coil primary circuit. As in a conventional system, opening the coil primary circuit induces high voltage in the coil secondary circuit which is conducted from the coil to the distributor cap and travels through the rotor and the secondary cables to the spark plugs.

Dwell angle is determined by the angle between adjacent teeth of the trigger wheel and by the air gap between the ends of the trigger wheel teeth and the sensor. Since there are no wearing surfaces connected with the trigger wheel and sensor, dwell remains constant and should not require adjustment for the service life of the distributor.

All distributors have a mechanical spark advance system to establish the optimum spark timing setting for various engine speed and load conditions.

The mechanical (centrifugal) advance system is built internally into the distributor and consists of two flyweights which pivot on long life, low friction bearings and are controlled by calibrated springs which tend to hold the weights in the no-advance position. The flyweights respond to changes in engine (distributor shaft) speed and rotate the trigger wheel to advance the spark as engine speed increases and retard the spark as engine speed decreases. Mechanical advance characteristics can be adjusted by bending the hardened spring tabs to alter spring tension.

Some distributors also have a vacuum spark advance system. The vacuum, advance, system, incorporates a. vacuum diaphragms unit which rotates the distributor sensor plate in response to changes in carburetor throttle bore vacuum.

The two systems, (mechanical and vacuum) operate independently, yet work together-to provide-proper spark advance.

For engines equipped with governor, the distributor incorporates a governor control unit. This unit consists of a, rotating, centrifugally operated valve which is driven, by. the distributor shaft. Some distributors are- also equipped with a mechanical tachometer drive which- is driven by the distributor shaft;

MAINTENANCE

To perform effectively, the: ignition system must be properly maintained. It is important that the ignition system maintenance operations outlined below be performed at-the specified time and mileage intervals.

Every 19,000 Kilometers (12,000 Miles) or 12 Months (Whichever occurs first)

1. Install new spark plugs. Set spark plug gap to specified dimension.

2. Inspect low tension ignition wiring. Replace any frayed or damaged wires. Make sure terminal connections are clean and tight.

3. Clean distributor cap, and rotor and inspect for cracks and burned or corroded terminals. Clean dirt and corrosion from cable sockets in cap. Replace cap or rotor if defective.

4. Inspect and test continuity of high tension ignition cables. Replace- cables showing cracks, deterioration, open circuits or excessive resistance. Make sure ignition cables seat firmly in distributor cap, coil and on spark plugs.

5. Add one or two drops of light engine oil to felt wick located under distributor rotor.

6. Inspect trigger wheel and sensor- for- damage. If damage is indicated, remove- distributor from engine and service as needed.

7. Connect oscilloscope or dwell meter to. engine. Operate engine at specified curb idle speed and observe dwell reading. If dwell reading is not within specified limits-, stop engine and adjust trigger wheel-to-sensor air gap to obtain specified dwell. Dwell decreases as sensor is moved closer to- trigger wheel and increases as sensor is moved away from trigger wheel-. Dwell: is affected, approximately one-half (1/2) degree per .001" of sensor movement;

NOTE

Dwell meters, which receive input signals from the ignition system primary circuit must be modified (circuitry, revised) by the tester manufacturer in order to obtain accurate readings when used with the electronic ignition system.

8. Using oscilloscope, check spark plug firing voltage, spark plug variation and coil output. If coil output readings are, not within specified limits, test operation of coil and replace if necessary.

9. Operate engine at idle speed and check ignition timing with timing, light.

Every 39,000 Kilometers (24,000 Miles) or 24 Months (Whichever occurs, first)

1. Test operation- of ignition coil and replace if necessary.

2. Remove distributor from engine. Check distributor-shaft end play and side, play. Check distributor operation in a distributor test stand. Make any necessary adjustments or repairs.

NOTE

Distributor test stands must be modified, to test operation of distributors used with the electronic ignition system (see "Preparation of Distributor Test Stand" under Distributor-Operation Test;

3. On distributors with governor air inlet filter mounted on governor- valve housing, remove filter and check for-filter- restriction by blowing through end of outlet pipe. If air does not pass freely; replace filter.

NOTE

On vehicles operated in dusty conditions, check for filter restriction more frequently.

4. Inspect and test resistance of high tension ignition cables,. Replace- cables if cracked, deteriorated or if resistance exceeds specified maximum value. Make-sure- ignition cables seat firmly in distributor cap and coil sockets and on spark plugs. Make- sure cable boots are pushed down and seated securely.

Every 78,000 Kilometers- (48,000 Miles) or 48 Months (Whichever occurs first)

1. Replace governor air. inlet filter (where equipped).

IGNITION SYSTEM OPERATION AND TROUBLE SHOOTING TEST

The procedure outlined below can be used to check operation of the electronic (breakerless) ignition system. Electrical components (sensor, coil and electronic ignition control) are not repairable. If the operation test indicates that they are faulty, replace them.

IMPORTANT

Certain precautions must be observed when servicing the electronic ignition system (see SERVICE PRECAUTIONS).

TEST EQUIPMENT

The following equipment is required to make the operation test.

D.C. Voltmeter
Tester, SE-2503 (distributor sensor substitute)
Insulated Pliers (grippers) for handling high tension cables.
Tester, SE-2734 (shorting switch)
Ohmmeter

TEST PROCEDURE

1. Using voltmeter, test battery. Voltage should be 12 to 13 volts for a fully charged battery. If necessary, charge or replace battery.

2. Disconnect distributor sensor wiring connec- tor from electronic ignition control and plug tester (SE-2503) into ignition control (Fig. 3) or remove distributor cap and "bump" starter to position sensor coil between two trigger wheel teeth.

Connect voltmeter between coil positive (+) terminal and ground (Fig. 3).

Turn ignition switch "ON." Voltmeter should read within 1 volt of battery voltage. If voltage at coil positive terminal is satisfactory, proceed to Step 5.

If voltage at coil positive terminal is notice ably lower than battery voltage, a high resistance exists between battery (through ignition switch) and coil which must be repaired. Inspect primary circuit as instructed on page 10 and perform Steps 3 and 4.

IMPORTANT

Turn ignition switch "OFF" between tests.

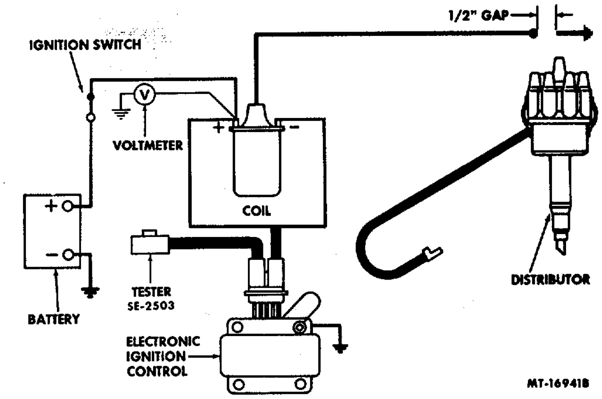


Fig. 3 Primary Voltage Test - Voltmeter Connected to Coil Positive (+) Terminal

3. To test primary battery circuit, tester (SE- 2503) should be connected to ignition control or sensor coil should be positioned between/ two trigger wheel teeth per Step 2..

Connect voltmeter positive lead to battery positive post and voltmeter negative lead to coil positive terminal (Fig. 4).

Turn ignition switch "ON." Voltmeter should read less than one volt.

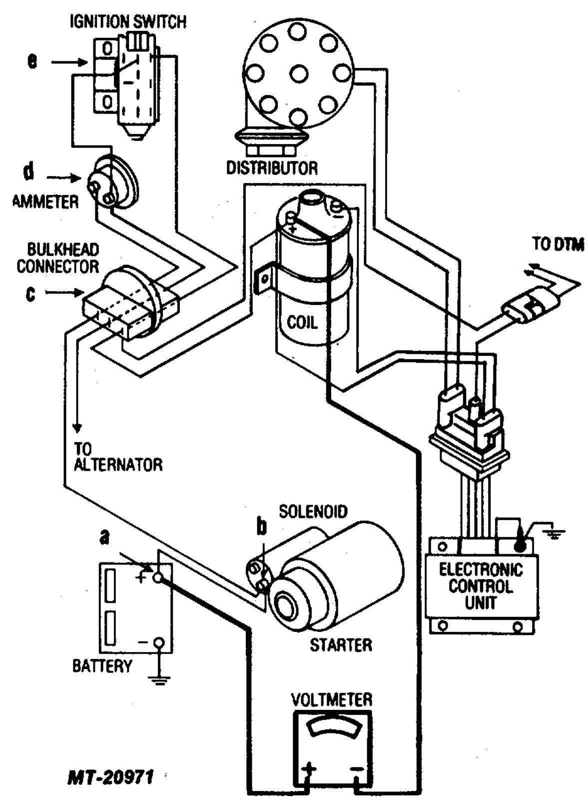


Fig. 4 Primary battery Circuit Test

Check for poor circuit conditions by flexing (moving) connectors at the following points while observing voltmeter.

a. Battery positive cable.
b. Starting motor solenoid.
c. Dash panel connector.
d. Ammeter.
e. Ignition switch.

If movement of any connection causes fluctuation or an upswing of the voltmeter needle, a poor connection exists and must be corrected.

4. To test primary ground circuit, tester (SE-2503) should be connected to ignition control or sensor coil should be positioned between two trigger wheel teeth per Step 2.

Connect voltmeter positive lead to ground terminal on electronic ignition control and voltmeter negative lead to battery negative post (Fig. 5).

Turn ignition switch "ON." Voltmeter should read zero volts.

Observe voltmeter and flex (move) connections

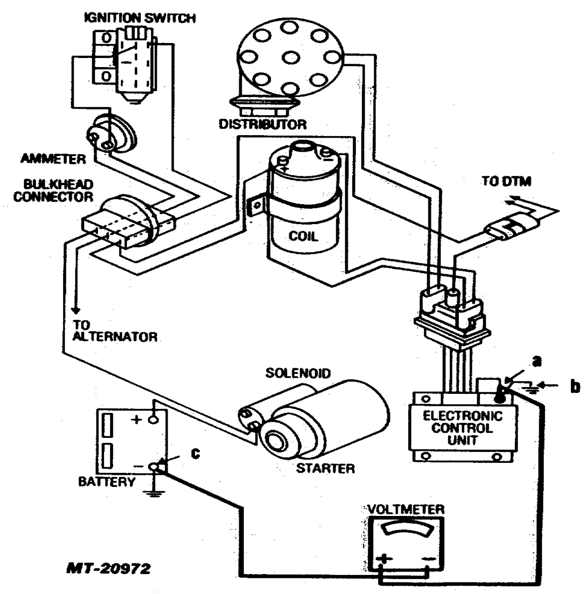


Fig. 5 Primary Ground Circuit Test

at the following points:

a. Ground terminal on electronic ignition control (terminal -to vehicle ground).
b. Cab-to-engine ground strap and/or other ground straps.
c. Battery negative cable (at engine block and at battery post).

If movement of any connector causes fluctuation or upswing of voltmeter needle, a poor connection exists and must be corrected.

5. If tester (SE-2503) was used in previous steps, disconnect tester and reconnect sensor wiring connector to ignition control.

Disconnect high tension cable from one spark plug. (Always grasp spark plug boot and use a twisting motion when removing plug cables so as not to destroy resistance wire termination.) Insert extension adapter into boot and engage in cable terminal. Using insulated pliers, hold plug cable to create about 12.7 mm (1/2") gap between extension adapter and engine. Have an assistant crank engine.

If spark occurs, ignition system components are capable of producing spark. Inspect primary wiring and perform Step 9 to determine cause for intermittent ignition failure.

If no spark occurs, check trigger wheel to sensor air gap. Reset gap to .2 mm (.008") and retest for spark at plug.

If still no spark occurs, proceed to Step 6.

6. Disconnect high tension cable from center tower terminal of distributor cap. Using insulated pliers, hold cable to create about 12.7 mm (1/2") gap between cable terminal and engine (Fig. 6). Have an assistant crank engine.

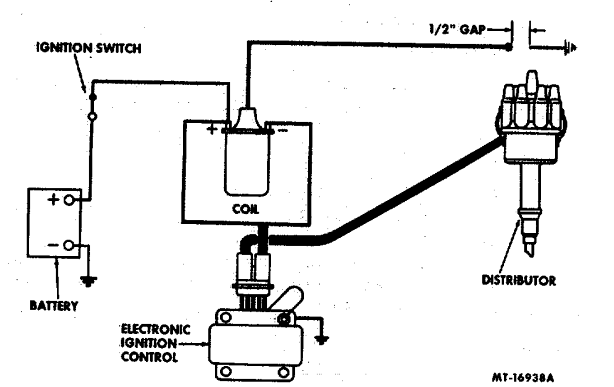


Fig. 6 Test for Spark at Distributor Cap

If spark occurs, distributor cap, rotor or spark plug cables are faulty. (Inspect secondary circuit components as instructed on Page 9.)

If no spark occurs, proceed to Step 7.

7. High tension cable should be disconnected from distributor cap center tower. Discon- nect distributor sensor wiring connector from electronic ignition control and plug tester (SE-2503) into ignition control. Using insulated pliers, hold high tension cable to create about 12.7 mm (1/2") gap between cable terminal and engine (see Fig. 7). Turn ignition switch "ON." Press tab on tester and observe for spark between cable terminal and engine.

If spark occurs, distributor sensor or primary wiring between ignition control and distributor is faulty and must be replaced. (See Sensor Wiring Connector Check, page 10.)
If no spark occurs, proceed to Step 8.

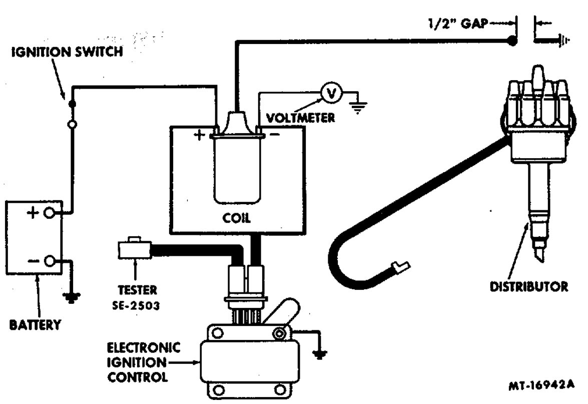


Fig. 7. Sensor and Sensor Wiring Test

8. Tester (SE-2503) should be connected to electronic ignition control. Connect volt- meter between coil negative (-) terminal and ground (see Fig. 8). With ignition switch "ON," one of the following voltmeter readings will be obtained:

(A) 5 to 8 volts (normal).

(B) Above 8 volts (problem area).

(C) Below 5 volts (problem area).

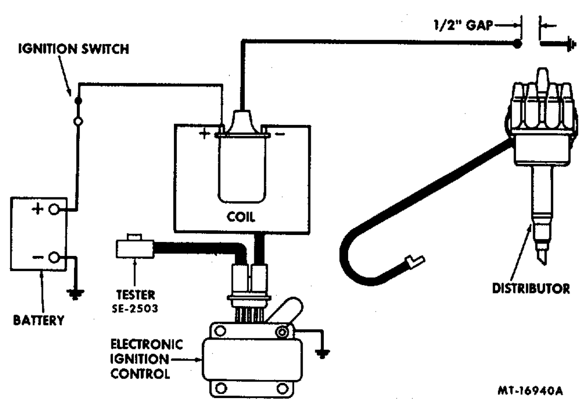


Fig. 8. Ignition Control and Coil Test - Volt-meter Connected to Coil Negative (-) Terminal

(A) <u>If voltage is 5 to 8 volts</u>

Hold high tension cable to create about 12.7 mm (1/2") gap between cable terminal and engine ground. Press tab on tester. Voltage should increase to 12 to 13 volts and a spark should occur. Release tab on tester, voltage should drop to 5 to 8 volts.

If voltage does not switch up and down, replace electronic ignition control. If volt- age switches up and down but no spark occurs between ignition cable and ground, replace coil.

Proceed to Step 9

(B) <u>If voltage is above 8 volts</u>

The problem lies in the ground circuit, ignition control connector harness or the electronic control.

(1) Unplug primary wiring (coil-to-ignition control) connector at electronic con- trol unit. Connect voltmeter from the harness male terminal to ground, then from the harness female terminal to ground (see Fig. 8a).

With ignition switch "ON," a reading of 12 to 13 volts should be obtained at both terminals. If voltmeter reading is zero volts at either terminal, replace harness between coil and electronic ignition control.

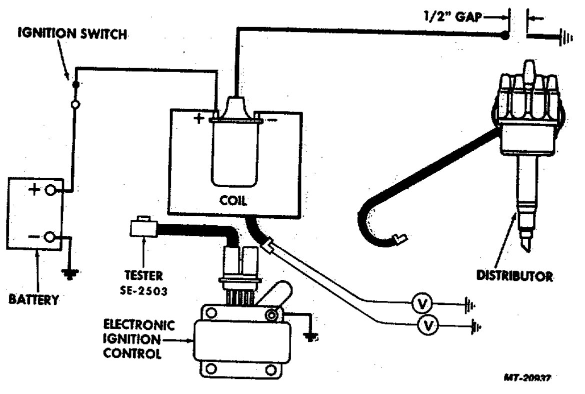


Fig. 8a

(2) If voltmeter reading of 12 to 13 volts is obtained at both connector terminals, per (1) above, reconnect wiring harness to control unit. Reconnect voltmeter from coil negative (-) terminal to ground. (Voltage will still be above 8 volts with ignition switch "ON.") Connect a jump- er wire from electronic control ground lead to battery negative terminal (see Fig. 8b).

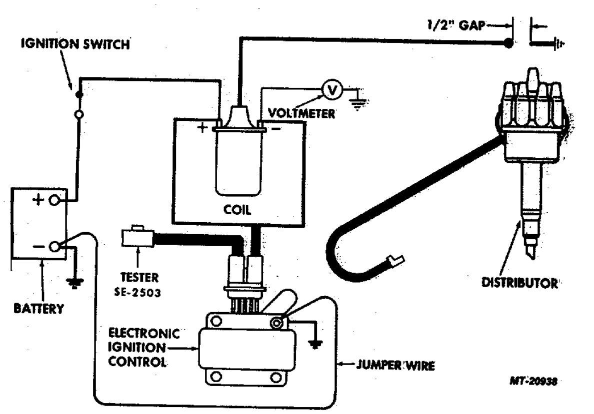


Fig. 8b

Observe voltmeter. If voltmeter read- ing remains 12 to 13 volts, the electronic ignition control is faulty and must be re- placed. If voltmeter now indicates be- tween 5 and 8 volts; the problem lies in ground circuit between electronic ignition control and battery negative terminal. Locate and repair ground circuit (ground eyelet at electronic ignition control, chassis ground strap, cab-to-engine ground strap or battery ground cable).

After making repairs, press tab on tester; voltage- should increase- to 12 to 13 volts and a spark should- occur from high tension cable terminal to engine ground. If voltage does not switch up and- down, the control unit must be replaced. If voltage switches up and down but no spark occurs, the coil is faulty and must be replaced.

Proceed to Step 9.

(C) <u>If voltage is- below 5 volts</u>

The coil, primary, winding is open or harness lead from coil negative terminal to control unit is grounded.

Disconnect wire from coil negative terminal (Fig. 8c) and recheck voltage. If voltage remains below 5, replace coil. If volt meter now indicates above 8 volts, locate and repair grounded harness lead between coil and ignition control.

After making repairs, press tab on tester; voltage should increase- to 12 to 13 volts and a spark should occur from high tension cable terminal to engine ground. If voltage does not switch up and down, the control unit must be replaced. If voltage switches up and down but no spark occurs, the coil is faulty and must be replaced.

Proceed to Step 9.

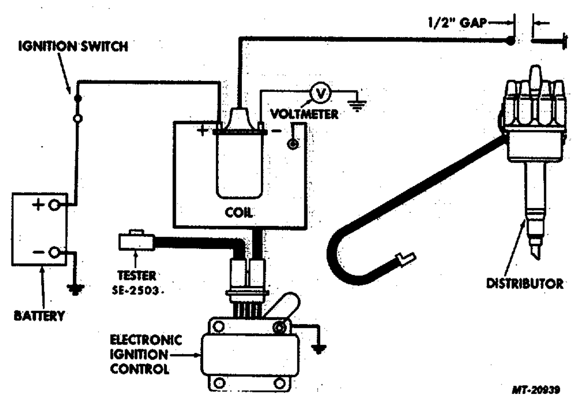


Fig. 8c.

9. Intermittent ignition failure may be caused by malfunction of an integrated circuit in the oscillator section of the electronic ignition control. This test will determine if problem is caused by the integrated circuit.

a. Make sure all vehicle lights and accessories are, "OFF."

b. Voltmeter should be connected between coil negative (-) terminal and ground. With ignition switch "ON," voltage should be 5 to 8 volts.

c. Disconnect tester (SE-2503) from electronic ignition control. Connect tester (SE-2734) between ignition control and sensor wiring connector (see Fig. 9).

d. Recheck for 5 to 8 volts between coil negative (-) terminal and ground. If voltmeter indicates battery voltage, bump starter to rotate distributor (move trigger wheel tooth away from sensor) to obtain voltmeter reading of 5 to 8 volts.

e. Press button on tester. Voltage should increase to battery voltage. Release button on tester. Voltage should return to 5 to 8 volts. Press and release button at least five (5) times. If voltage remains at battery voltage or hesitates before returning to 5 to 8 volts after button is released, replace ignition control.

f. Repeat above steps to test new control. Replace it if it fails test.

Proceed to Step 10.

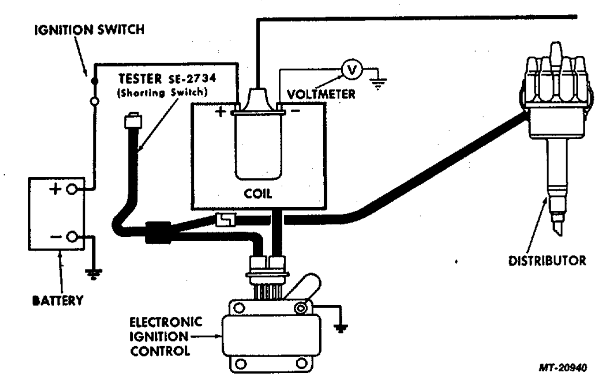


Fig. 9 Ignition Control Intermittent Failure Test (Tester SE-2734 Connected to System)

10. Check fit of sensor-to-ignition control and coil-to-ignition control connector terminals as follows (see Fig. 9a).

a. Clean terminals with cotton swab soaked in alcohol.

b. Insert shank end of a No. 16 drill (.177" diameter) into female terminals of connectors. Drill shank should fit snugly in terminal.

c. If necessary, use pliers to crimp terminal to obtain a tighter fit. Be careful not to distort shape of terminal or damage rubber connector cover.

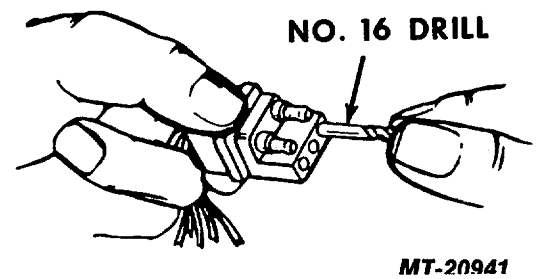


Fig. 9a Checking Fit of Terminal Connectors

Coat terminals of connectors with lubricant/ sealer (IH part number 472141-C1) before assembly. Make sure connector halves are completely together. Check size and lubricate terminals of new parts at installation.

11. After replacement of components, disconnect test equipment. Reconnect coil high tension to distributor cap. Make sure all wiring connections are tight. Retest for spark at spark plug.

12. Connect dwell meter to engine. Operate engine at idle speed and check dwell. If necessary, readjust trigger wheel-to-sensor air gap to obtain specified dwell.

13. Connect timing light to engine. Operate engine at idle speed (distributor vacuum hose disconnected) and check timing. Adjust timing if necessary.

SECONDARY CIRCUIT INSPECTION

Secondary (high voltage) system components (distributor cap, rotor, coil tower, spark plug and coil high tension cables and spark plugs) should be checked as possible sources of trouble before condemning the electronic units. Inspect distributor cap, rotor and coil towers for cracks, carbon tracking, dirt and contamination. Clean or replace as needed. Check rotor blade and spring for tightness. Check fit of rotor on distributor shaft. Check resistance type rotor with ohmmeter. If resistance exceeds 6000 ohms, replace rotor.

Inspect secondary ignition cables for evidence of deterioration, burning and high voltage leakage, especially at cable support brackets. Test secondary cables with an ohmmeter. Resistance should not exceed 30,000 ohms on cables up to 914 mm (36") long or 45,000 ohms on cables over 914 mm (36") long.

Inspect spark plug insulators for cracks and clean off any oil or dirt before assembling cables to spark plugs.

Be sure ignition cables are routed correctly and that cable terminals seat properly in distrib utor cap and on spark plugs. Check sealing and insulating qualities of distributor cap, coil tower and spark plug boots. Replace if needed.

PRIMARY CIRCUIT INSPECTION

Inspect low tension ignition wiring. Replace any frayed or damaged wires. Make sure terminal connections are clean and tight. On vehicles where ignition primary circuit is routed through a dash panel wiring connector, be sure connector terminals are clean and tight (locking tongs engaged).

Make sure electronic ignition control mounting bolts are tight.

Two useful tests for checking the primary circuit are the Primary Battery Circuit Test and the Primary Ground Circuit Test (Steps 3 and 4 of the Operation and Trouble Shooting Test). Also, see Sensor Wiring Connector Check below.

SENSOR WIRING CONNECTOR CHECK

Intermittent or complete failure of the electronic ignition system may be caused by excessive resistance at the molded, two-way connectors in the sensor circuit. High resistance can result from loose physical fit between male and female terminals or oxidation (corroding) of terminals. Because of the low voltage carried in the sensor circuit, a very thin film of corrosion (often nearly invisible) may cause failure of the circuit. In some cases oxidation is aggravated by a lack of lubricant/sealer in connectors permitting entry of moisture.

When diagnosing ignition system problems, always check for poor contact at wiring connectors before condemning the distributor sensor and/or the electronic ignition control unit. Sometimes engine can be started by disconnecting and reconnecting the plug or by squeezing or wiggling the connector. This indicates a faulty connector.

To overcome sensor wiring connector problems, late production vehicles are equipped with distributor sensors having lead wires of sufficient length to plug directly into the connector body of the electronic ignition control unit. This change eliminates the two-way molded connectors used previously to connect the distributor sensor to the engine wiring harness and engine wiring harness to ignition control.

The long lead sensor (IH Part No. 487847-C91) should be installed to replace existing (short lead) sensor and sensor circuit in engine wiring harness. Only the new (long lead) sensors are provided for service. Instructions for installing the long lead sensor are provided with the sensor.

DISTRIBUTOR SERVICE

Distributor Removal

1. Unfasten distributor cap retaining clips. Remove distributor cap (with high tension cables) and position it out of the way.

2. Disconnect vacuum hose from distributor vacuum advance unit.

3. Disconnect distributor primary wiring connector.

4. Disconnect governor piping and tachometer drive cable, if equipped.

5. Scribe a mark on distributor housing in line with tip of rotor (Fig. 10) and note position of rotor and distributor housing in relation to surrounding engine parts as reference points for reinstalling distributor.

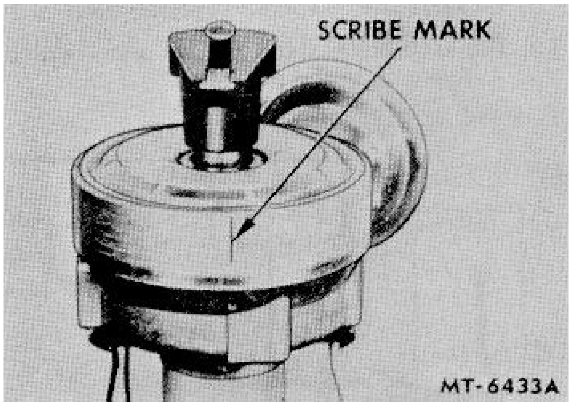


Fig. 10 Rotor Position Reference Mark

6. Remove distributor hold-down bolt and clamp.

7. Carefully withdraw distributor from engine. Do not lose gasket or "O" ring seal.

Distributor Shaft and Bushing Wear Test

This procedure can be used to check condition of the distributor shaft and shaft bushings in the distributor housing.

1. Clamp distributor in a vise equipped with soft jaws and apply only enough pressure to restrict movement of distributor.

2. Remove distributor rotor.

3. Attach dial indicator to distributor housing so that indicator plunger rests against trigger wheel (Fig. 11).

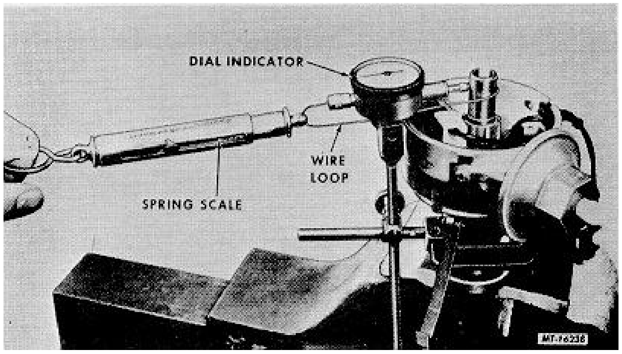


Fig. 11 Shaft and Bushing Wear Test (Checking Distributor Shaft Side Play)

4. Place one end of a wire loop around top of trigger wheel assembly (rotor shaft). Hook a spring scale in other end of wire loop and pull on a line with plunger of dial indicator (Fig. 11). Wire loop must be perpendicular to shaft to assure a straight pull. Also, loop must not interfere with dial indicator mounting bracket.

5. Apply five (5) pounds of pull on spring scale and read movement of plunger on indicator dial. If plunger movement (distributor shaft side play) exceeds maximum permissible limit (see SPECIFICATIONS), replace distributor shaft and bushings (see Distributor Housing Bushing Replacement).

Distributor Operation Test (On Test Stand)

Operation of the distributor can be checked on a distributor test stand. It is recommended that the distributor operation test be performed every 24,000 miles or 24 months of vehicle operation.

It is also advisable to perform the distributor operation test prior to disassembly of the distributor for service. This test will give valuable information about the condition of the distributor and indicate where parts replacement may be required.

A. Preparation of Distributor Test Stand
In order to test the breakerless distributor on the test stand, an electronic ignition control (same as used on vehicle), a 12-volt battery and test lead harness(es) must be connected to the distributor and the test stand as shown in Fig. 12. The required parts (available through regular parts channels) are:

Item	IH Part No.
Control, Electronic Ignition	451565-C2
Harness, Test Lead (control to test stand)	460000-C91
Harness, Test Lead (control to distributor) (See *, Fig. 12)	460001-C91
Battery, 12 Volt (fully charged)	-----------------
Clip, Connector	(Obtain locally)

Prepare test stand and distributor as outlined below (refer to Fig. 12).

1. Mount electronic ignition control on frame of distributor test stand. Ground electronic control of test stand by mounting control via bolt hole with ground wire attached.

2. Following color code, connect end of test lead harness 460001-C91 (identified by blue and yellow wires) to terminal connector of electronic ignition control. (See *, Fig. 12)

3. Following color code, connect molded two way connector of test lead harness 460000-C91 (identified by red and brown wires) to terminal connector of electronic ignition control.

4, Attach battery connector clip to ring terminal on red wire of test lead harness 460000-C91.

5. Mount distributor to be tested in test stand.

6. Connect molded two-way connector of test lead harness 460001-C91 (identified by blue and yellow wires) to sensor lead of distributor. (See *, Fig. 12)

7. Clip test stand distributor lead to ring connector on brown wire of test lead harness 460000-C91.

8. Connect battery connector clip on end of red wire of test lead harness 460000-C91 to positive (+) terminal of 12-volt battery.

9. Connect test stand ground lead to negative (-) terminal of 12-volt batter).

Test stand and distributor are now ready to make distributor operation test (refer to Operation Test Procedure below).

After distributor test is completed, disconnect test lead harness (460000-C91) and test stand ground lead from battery. The electronic ignition control and test lead harnesses connected to it

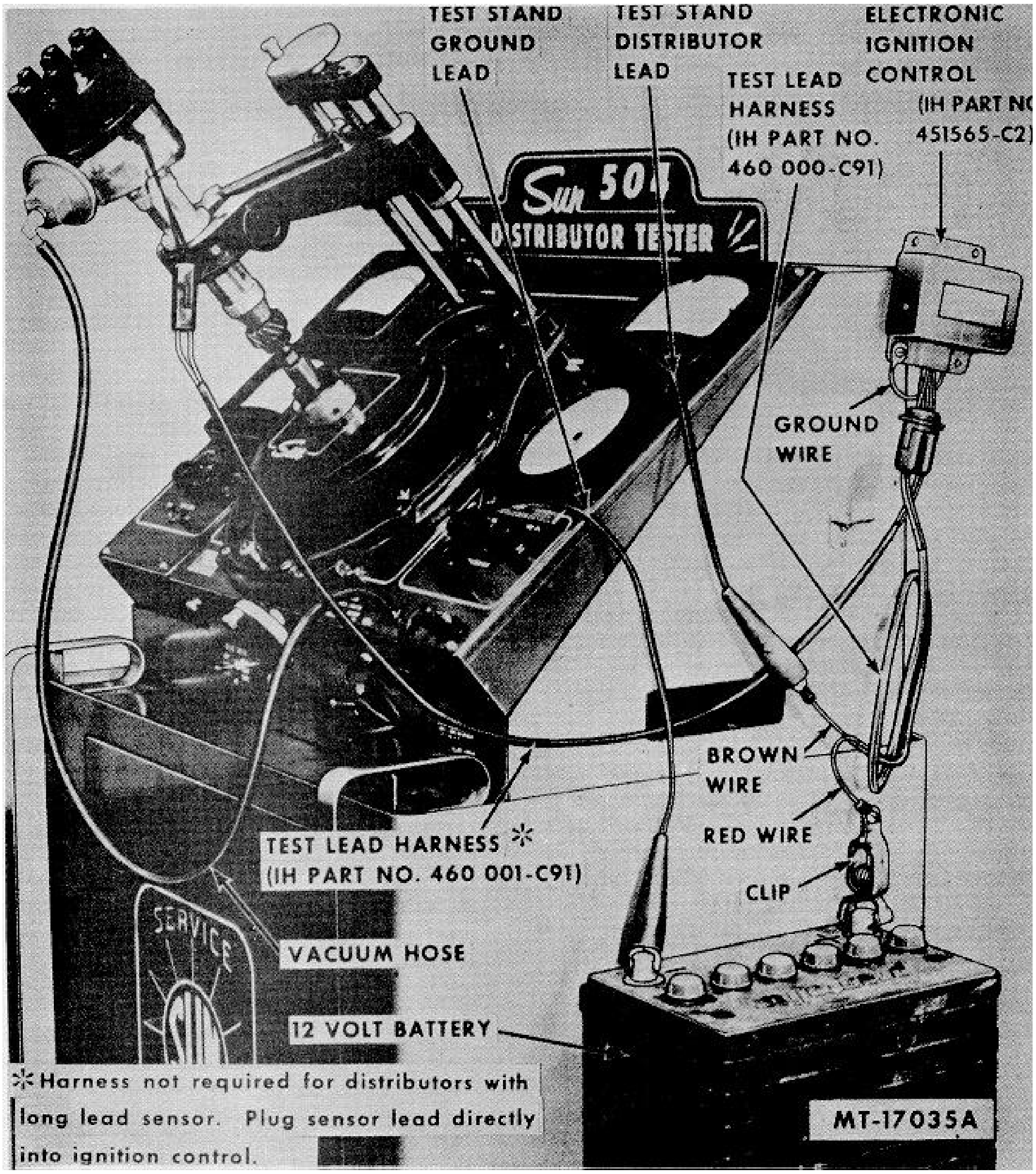


Fig. 12 Distributor Mounted in Test Stand.

may be left mounted on the test stand for future use. To test breakerless distributors, mount in stand and connect test leads per Steps 5 through 9 above. To use the test stand to test breaker point type distributors, disconnect test stand distributor lead from test lead harness (460000-C91) and also reconnect test stand ground lead to ground stud on distributor mounting frame.

B. Operation Test Procedure

1. Mount distributor in test stand and connect test leads as outlined in Preparation of Distributor Test Stand.

2. Calibrate test stand dwell meter per manufacturer's instructions.

NOTE

On some test stands it will be necessary to calibrate the dwell meter as follows:

a. Turn test stand motor switch "ON." Back off speed control to stop distributor rotation.

b. Turn dwell meter switch to 8-cylinder position.

c. Rotate distributor slowly (by hand) in direction of normal rotation until dwell meter hand starts to swing toward dwell meter set line. Continue rotating distributor until meter hand reaches its full travel.

NOTE

If meter hand starts to reverse, continue to rotate distributor in normal direction of rotation until meter hand again swings toward meter set line.

d. Adjust dwell meter calibrator knob until meter hand aligns with set line.

3. Operate distributor at 300 RPM (with 12-13 volts primary input) and observe dwell reading. Dwell should be within specified limits (see DISTRIBUTOR TEST SPECIFICATIONS). If dwell is not within specified limits, check trigger wheel-to-sensor air gap. Also check for worn sensor plate assembly and worn distributor shaft and bushings.

4. Check trigger wheel tooth accuracy as follows:

   a. Operate distributor at 300 RPM and set zero of test stand degree ring in line with arrow flash nearest front of stand.

   b. Observe relative position of all arrow flashes. All flashes should be evenly spaced within ± 1 degree at 45 degree intervals on 8-cylinder distributors or 90 degree intervals on 4-cylinder distributors. If positions of arrow flashes deviate more than + 1 degree, check for damaged trigger wheel teeth and check for worn distributor shaft and bushings.

5. Check operation of mechanical advance mechanism as follows:

   a. With distributor operating at minimum speed, set zero of test stand degree ring in line with arrow flash nearest front of stand.

   b. Operate distributor at each specified test speed (see DISTRIBUTOR TEST SPECIFICATIONS) and observe arrow flashes opposite test stand degree ring to determine amount of advance at each test speed.

   If advance is excessive, advance spring tension is weak. If advance is insufficient, advance spring tension is excessive, advance flyweights are sticking or trigger wheel assembly is binding on inner distributor shaft. If advance is erratic, advance flyweights are sticking or trigger wheel assembly is binding on inner distributor shaft.

6. Check vacuum advance diaphragm assembly (where equipped) as follows:

   a. Using proper adapter, connect test stand vacuum hose to distributor vacuum advance diaphragm assembly.

   b. Apply vacuum and check for operation of diaphragm assembly.

   c. Remove vacuum hose from diaphragm assembly. Hold finger over end of hose and adjust vacuum regulator to obtain reading of 16 inches of vacuum on vacuum gauge.

   d. Reconnect vacuum hose to diaphragm assembly and observe vacuum gauge. If gauge reading returns to 16 inches within a few seconds and holds 16 inches, diaphragm assembly is air tight. If gauge reading fails to return to 16 inches, diaphragm assembly is leaking and should be replaced.

7. Check vacuum advance operation (where equipped) as follows:

   a. With vacuum hose connected to distributor vacuum diaphragm assembly, operate distributor at 300 RPM.

   b. With no vacuum applied to diaphragm assembly, set zero of test stand degree ring in line with arrow flash nearest to front of stand.

   c. Adjust vacuum regulator to apply specified amount of vacuum for each specified check point (see DISTRIBUTOR TEST SPECIFICATIONS) and note amount of advance obtained.

   d. Momentarily exceed highest vacuum value specified, then reduce vacuum and again note vacuum obtained at each specified check point. If advance is excessive during both steps "c" and "d," a weak diaphragm spring is indicated. If advance is insufficient during both steps "c" and "d," an excessively strong diaphragm spring or incorrect diaphragm assembly is indicated. If advance is erratic in both steps "c" and "d," check for sticking or worn sensor plate assembly.

8. If distributor passes checks outlined in Steps 3 through 7 above, it is satisfactory for use. If distributor fails any of the checks, it should be replaced or serviced as needed.

9. Disconnect test lead harness and vacuum hose from distributor and remove distributor from test stand.

Distributor Disassembly

The following procedure can be followed to disassemble the distributor for service, and overhaul.

Notice that sensor mounting plate configuration and vacuum diaphragm location varies between distributors with right hand (clockwise) rotation and those with left hand (counterclockwise) rotation as shown in Fig. 13.

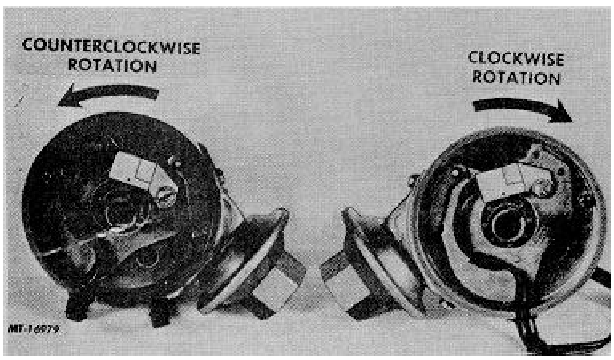


Fig. 13 Illustrating Vacuum Diaphragm Location per Distributor Rotation

1. Remove rotor and dust cover (Fig. 14).

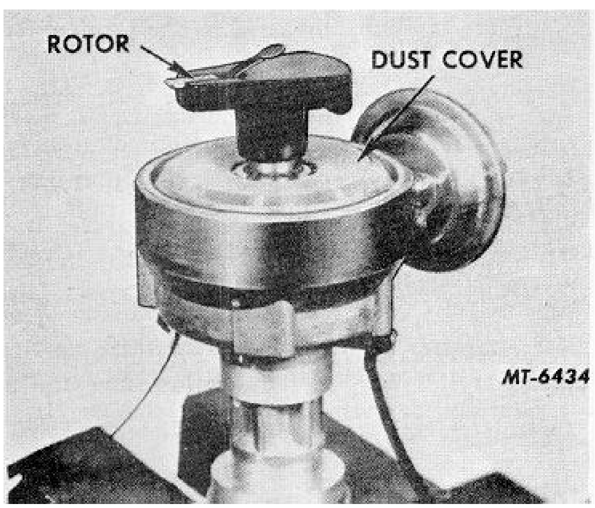


Fig. 14 Distributor Rotor and Dust Cover

2. Remove vacuum advance diaphragm rod retaining "E" ring (Fig. 15).

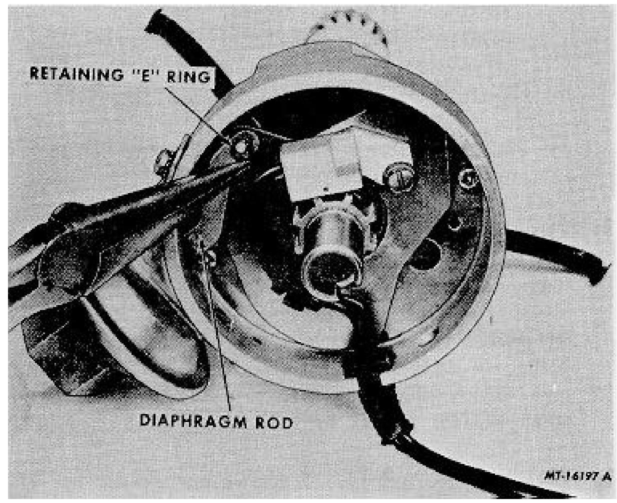


Fig. 15 Removing Diaphragm Rod Retainer

3. Remove vacuum advance diaphragm mounting screws and remove diaphragm assembly from distributor housing (Fig. 16).

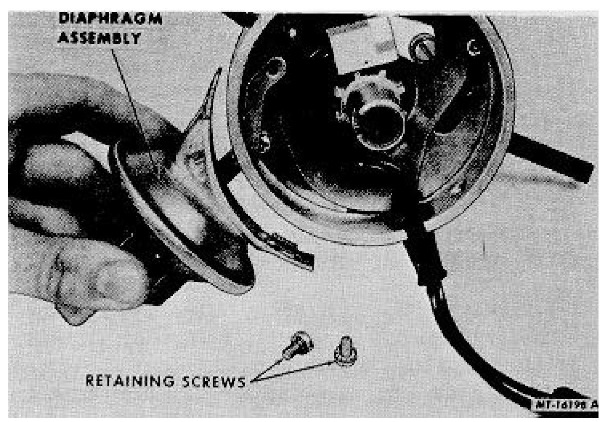


Fig. 16 Removing Vacuum Advance Diaphragm

4. Carefully pull sensor wiring seal/retainer from slot in distributor housing. Remove sensor plate mounting screws and lift sensor plate assembly from distributor housing (Fig. 17).

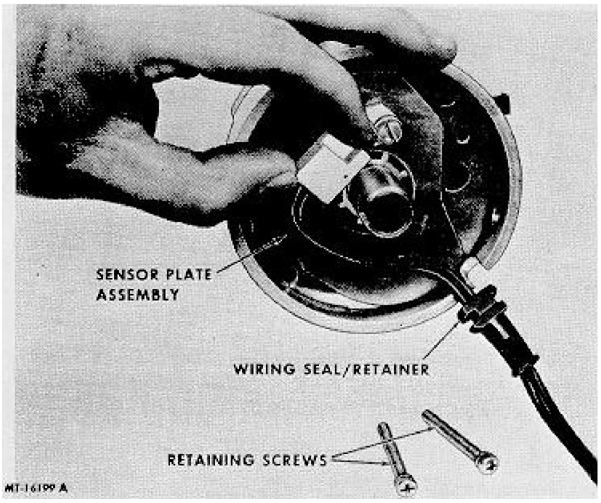


Fig. 17 Removing Sensor Plate Assembly

5. Remove sensor mounting screw (Fig. 18). Disengage wiring clip from plate and remove sensor.

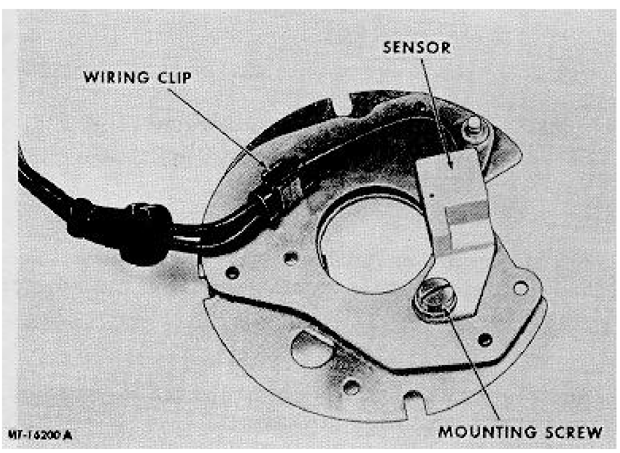


Fig. 18 Removing Sensor

6. To separate upper and lower plates, remove retaining spring from bottom side of lower plate (Fig. 19).

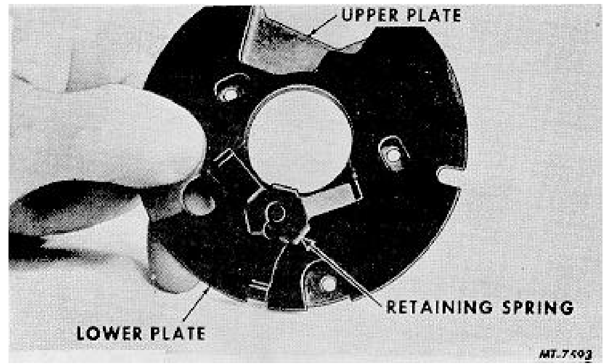


Fig. 19 Plate Retaining Spring

7. Separate upper and lower plates and remove three thrust buttons from upper plate (Fig. 20).

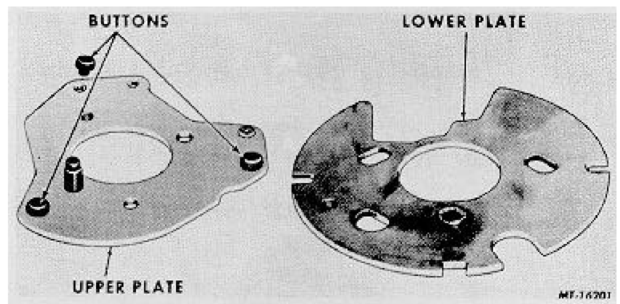


Fig. 20 Upper and Lower Plates Separated

8. Remove felt lubrication wick from trigger wheel assembly (rotor shaft).

9. Remove trigger wheel assembly retainer from distributor shaft using hooked extractor tool or small screwdriver (Fig. 21).

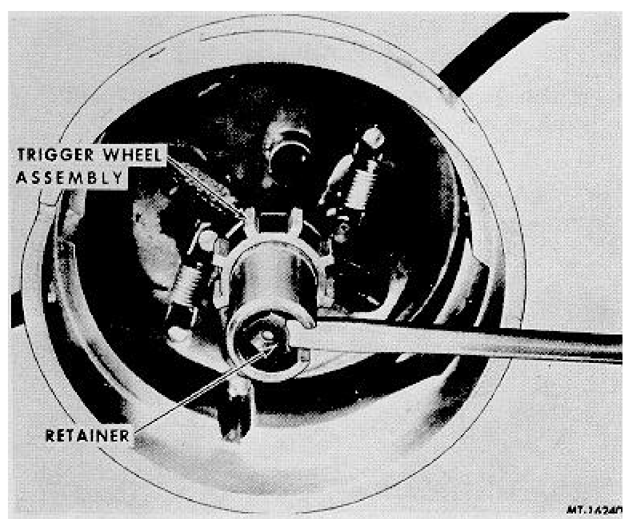


Fig. 21 Removing Trigger Wheel Assembly Retainer

10. Slide trigger wheel assembly from distributor shaft and remove slider blocks (Fig. 22).

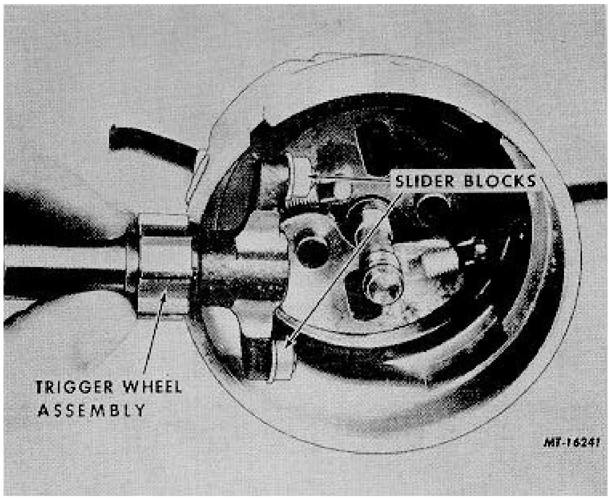


Fig. 22 Removing Trigger Wheel Assembly

11. Remove primary and secondary advance weight springs (Fig. 23)

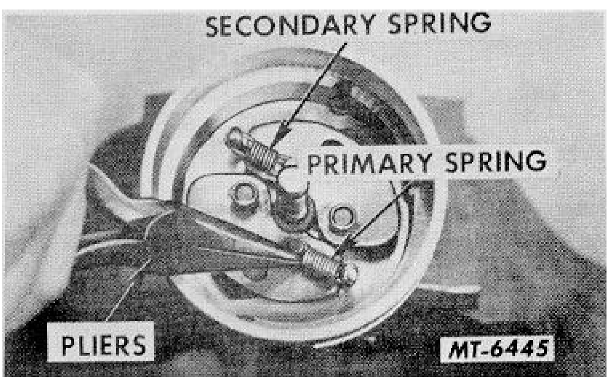


Fig. 23 Removing Advance Springs

12. Remove advance weights, bushings and thrust washers (Fig. 24).

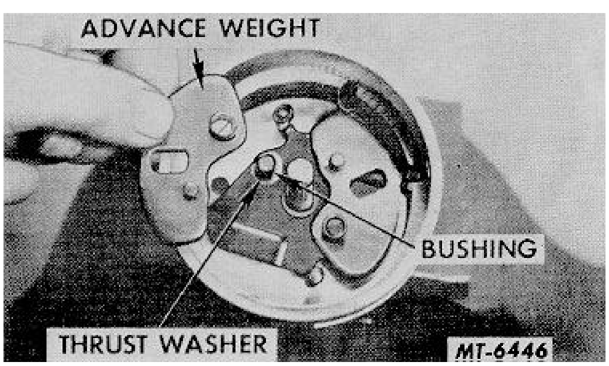


Fig. 24 Removing Advance Weights

13. Measure and record distributor shaft end play (Figs. 25 and 26). Improper end play could result in failure or improper engine timing. If end play exceeds specified limits, replace distributor shaft and gear. On distributors having gear-to-housing thrust washer, measure end play between gear and thrust washer. If end play is excessive, replace thrust washer.

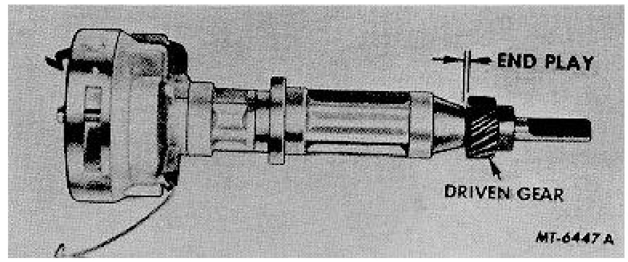


Fig. 25 Checking Distributor Shaft End Play (Housing-to-Drive Gear Clearance) (Typical)

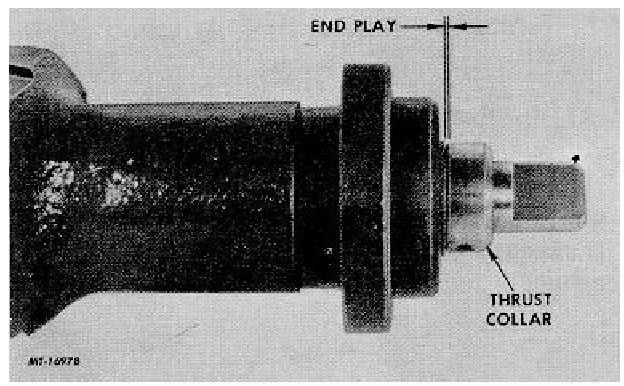


Fig. 26 Checking Distributor Shaft End Play (Housing-to-Thrust Collar Clearance) (Typical)

14. On distributors without governor valve, remove distributor driven gear and distributor shaft per Steps 17, 18 and 19 below.

15. On distributors with governor valve, remove governor valve as follows:

    a. Remove governor air inlet filter (if equipped).

    b. Remove governor seal wire and remove governor valve housing cover band and gasket (Fig. 27).

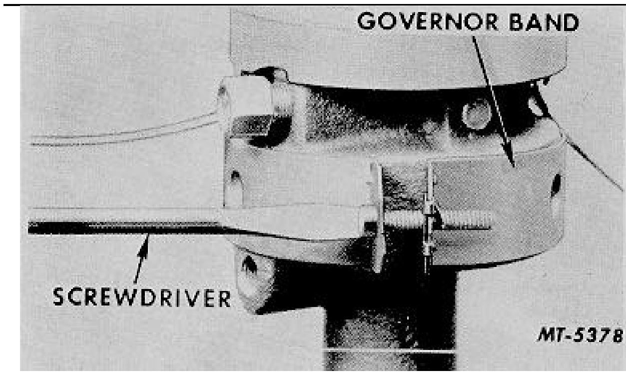


Fig. 27 Removing Governor Valve Housing Cover Band

c. Using Allen wrench, remove governor valve adjusting plug (Fig. 28).

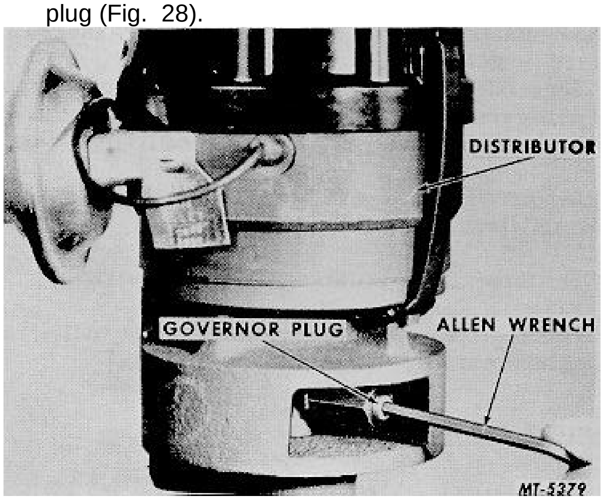


Fig. 28 Removing Governor Valve Adjusting Plug

d. Bend back tabs on counterweight lock (Fig. 29).

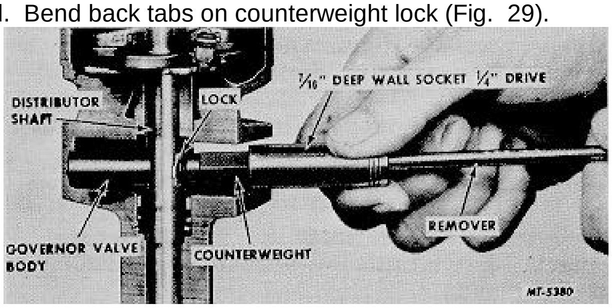


Fig. 29 Governor Valve Removal Using SE-2072-1 Remover (Distributor housing cut away for illustration purposes).

e. Position 7/16" deep wall socket (use socket similar to Snap-On STMD-14) over remover tool SE-2072-1 and insert slotted end onto adjusting screw and socket over hexagon counterweight (Fig. 29).

Hold remover tool stationary and loosen counterweight (hex nut) until adjusting screw becomes disengaged (Fig. 30).

f. Remove governor valve body and adjusting screw from distributor shaft and remover tool (Fig. 30).

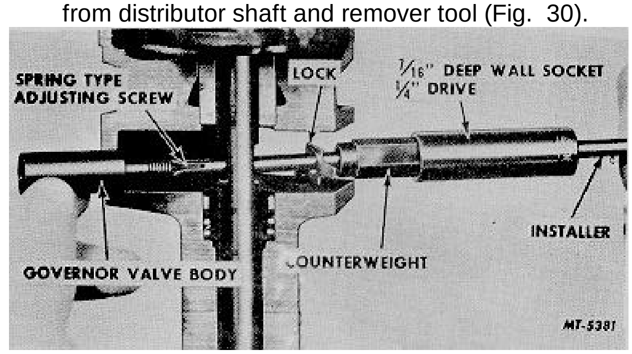


Fig. 30 Governor Valve Separated from Distributor Shaft

g. Remove distributor driven gear and distributor shaft per Steps 17, 18 and 19 below.

16. On distributors with tachometer drive, remove tachometer drive parts as follows:

a. Remove tachometer drive cover plate (Fig. 31).

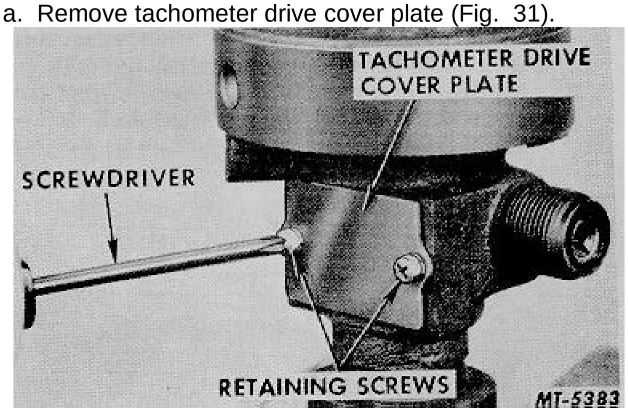


Fig. 31 Removing Tachometer Drive Cover Plate

b. Remove tachometer driven gear shaft plug and bushing (Fig. 32).

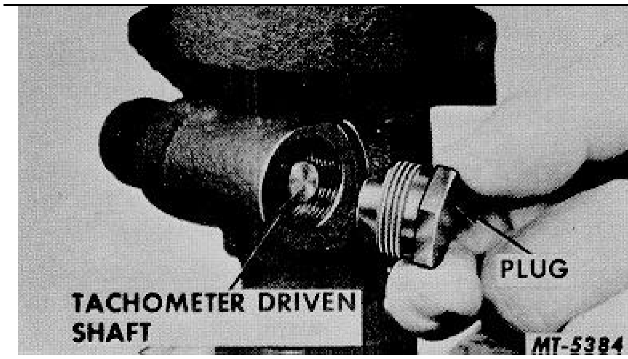


Fig. 32 Removing Tachometer Driven Shaft Plug

c. Remove tachometer driven gear and shaft (Fig. 33).

Fig. 33 Removing Tachometer Driven Gear And Shaft

d. Measure and record the distributor shaft end play and the location of the tachometer drive gear (Fig. 34). This information will be required to reassemble the distributor. If end play exceeds specified limits, replace distributor shaft and gear. On distributors having gear-to-housing thrust washer, measure end play between gear and thrust washer. If end play is excessive, replace thrust washer.

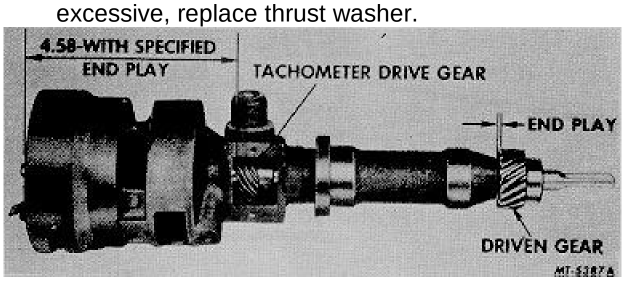


Fig. 34 Locating Tachometer Drive Gear

e. Using a drift punch and hammer, remove tachometer drive gear pin (Fig. 35).

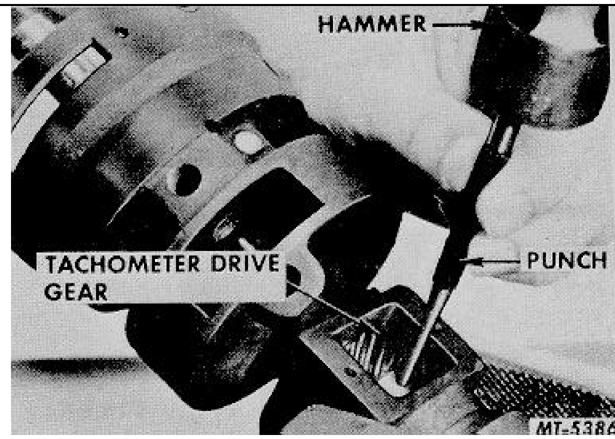


Fig. 35 Removing Tachometer Drive Gear Pin

17. Support distributor driven gear on a vise equipped with soft jaw shields and drive roll pin from gear or thrust collar and distributor shaft using a drift punch and hammer.
18. Place distributor housing and shaft assembly in a press and press gear or thrust collar (and thrust washer, where used) from shaft. On distributors with tachometer drive, press shaft from tachometer drive gear.
19. Withdraw distributor shaft from housing.

On vehicles with tachometer drive, withdraw tachometer drive gear from housing.

Cleaning and Inspection

1. Wash all parts in cleaning solvent except cap, rotor, sensor, sensor plate assembly and vacuum diaphragm assembly. It is permissible to soak the distributor housing if the bushings are to be replaced. If bushings are not being replaced, clean distributor housing carefully so as not to wash oil from bushings.

2. Inspect sensor plate assembly for damage or excessive wear and replace if necessary.

3. Inspect distributor shaft for wear and check its fit in bushings in distributor housing. If shaft and bushings are worn, replace them.

4. Mount distributor shaft in "V" blocks and check shaft alignment with dial indicator. Runout should not exceed .002".

5. Inspect advance weights for wear or burrs and for free fit on their pivot pin bushings. Replace pivot pin bushings if necessary.

6. Inspect trigger wheel teeth for damage. If damage is evident, replace trigger wheel assembly. Check fit of trigger wheel assembly on distributor shaft. It should be free without roughness. If roughness or excessive looseness exists, replace trigger wheel assembly and distributor shaft.

7. Inspect rotor, distributor cap and spark plug cables for damage and replace if necessary. Rotor must fit tight on trigger wheel assembly (rotor shaft).

8. On distributors with governor valve, inspect governor valve components for wear or damage (see Governor Valve Service).

9. On distributors with tachometer drive, inspect tachometer drive parts for wear or damage and replace if necessary. If tachometer drive and driven gears are worn or damaged, replace both gears. Do not run a new gear against an old one.

Governor Valve Service

The governor valve body may be disassembled for cleaning by following the procedure outlined below. Valve body components (Fig. 36) are not provided for service individually. Use care in handling these parts.

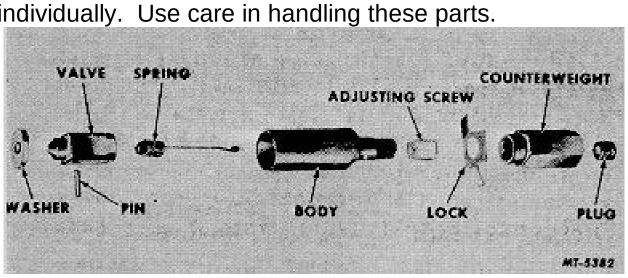


Fig. 36 Exploded View of Governor Valve Assembly

1. Remove governor valve from distributor following instructions outlined in Step 15 of Distributor Disassembly.

2. Remove the snap ring from governor body.

3. Remove the flat washer from body.

4. Spread the hook open on the end of the governor valve spring and remove the spring type adjusting screw.

5. Turn the valve body over and remove valve and spring assembly.

6. Clean all dirt and foreign matter from valve body and valve assembly with cleaning solvent. If any of the components of the valve assembly are worn or damaged, replace with a complete governor valve body assembly.

7. Reassemble governor valve.

8. Install governor valve in distributor housing per Step 6 of Distributor Reassembly.

Distributor Housing Bushing Replacement

The following procedures can be used to remove and replace the distributor shaft bushings in the distributor housing. Distributor tool set SE-1955 will assist in performing these operations.

For Distributors Without Governor or Tachometer Drive:

1. Install bushing remover SE-1955-5 in upper bushing (Fig. 37).

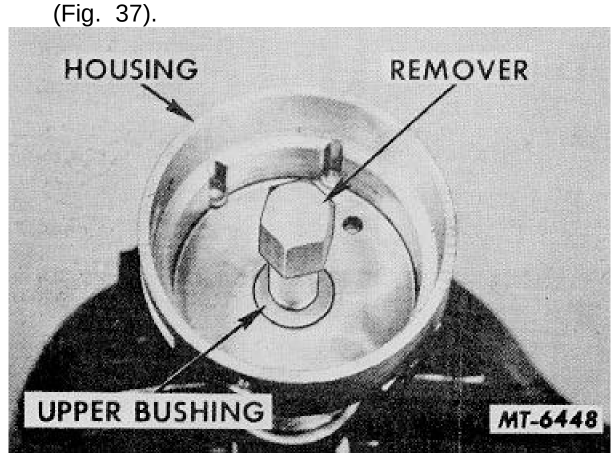


Fig. 37 Bushing Remover SE-1955-5 Installed in Upper Bushing

2. Place distributor housing on press bed. Insert knock-out bar (make locally from cold rolled bar' stock 7/16" diameter x 11" long) through lower bushing and allow to rest on end of bushing remover installed in upper bushing. Pressing against knock-out bar, press upper bushing from housing (Fig. 38).

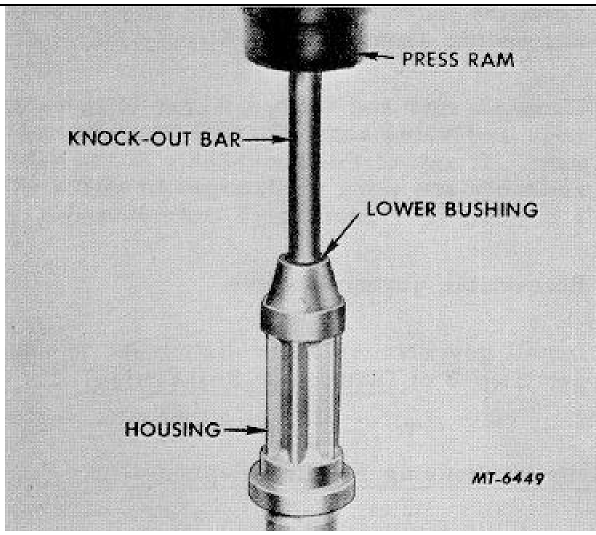


Fig. 38 Pressing Out Upper Bushing Using Knock-Out Bar

3. Install bushing remover SE-1955-5 in lower bushing (Fig. 39).

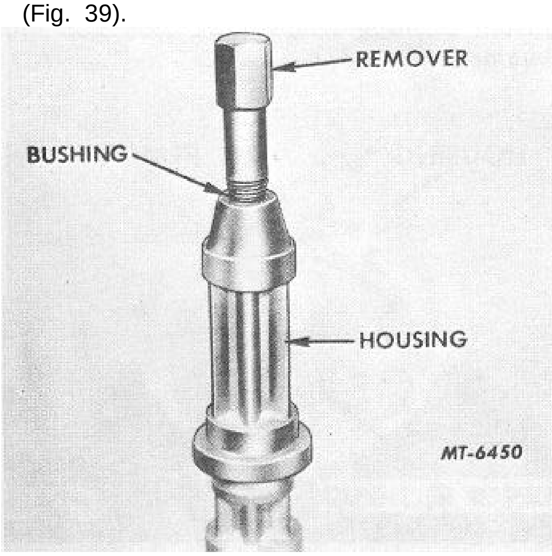


Fig. 39 Bushing Remover SE-1955-5 Installed in Lower Bushing

4. Place distributor housing on press bed. Insert knock-out bar through upper bushing bore and allow to rest on end of bushing remover installed in lower bushing. Pressing against knock-out bar, press lower bushing from distributor housing (Fig. 40).

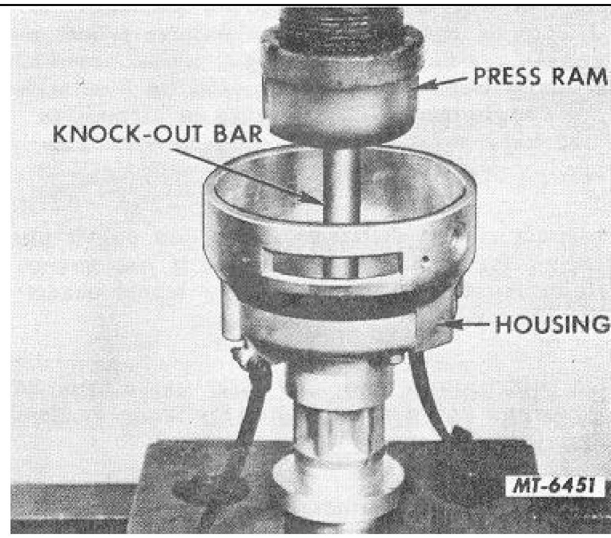


Fig. 40 Pressing Out Lower Bushing Using Knock-Out Bar

5. Lubricate outer diameter of new upper bushing with a light coat of grease and start bushing into distributor housing bore.

6. Position distributor housing in press and insert bushing installer SE-1955-8 into bushing (Fig. 41).

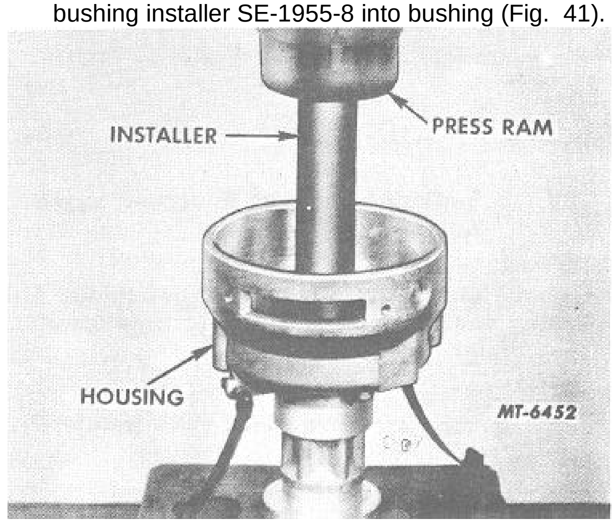


Fig. 41 Installing Upper Bushing Using Bushing Installer SE-1955-8

7. Press upper bushing into housing to a dimension of 1-51/64" from top of housing to top of bushing. Use a straight edge and scale to measure this distance (Fig. 42).

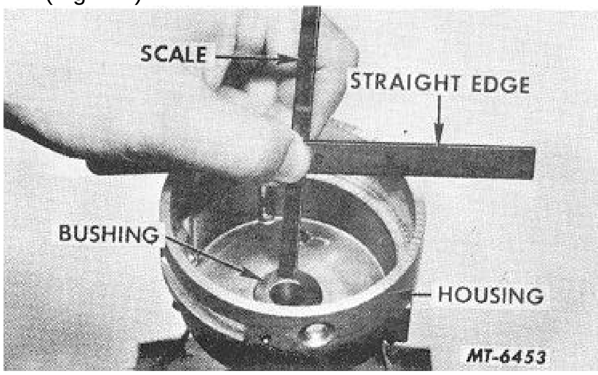


Fig. 42 Using Straight Edge and Scale to Locate Upper Bushing in Distributor Housing

8. Lubricate outer diameter of new lower bushing with a light coat of grease and start bushing into distributor housing bore.

9. Position distributor housing on press. Insert bushing installer SE-1955-8 into bushing and press bushing in flush with bottom of housing (Fig. 43).

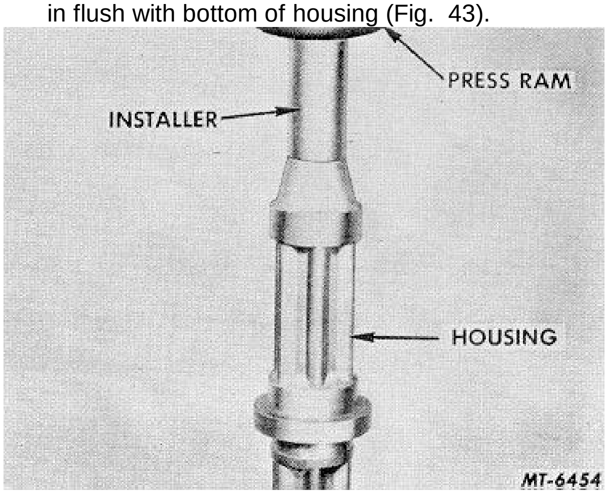


Fig. 43 Installing Lower Bushing Using Bushing Installer SE-1955-8

10. Size new bushings as follows:

NOTE: The oilite bushings are made of powdered metal and should never be reamed. Swelling and burrs may be removed with a burnishing tool (SE-1955-2) which is ground to burnish rather than ream the bearing surface.

a. Place flat end of burnisher SE-1955-2 in a vise. Coat burnisher with SAE-20 engine oil.

b. Burnish upper bushing by placing distributor housing on burnisher carefully and rotating the housing clockwise using light pressure until tool passes through bushing (Fig. 44).

c. Burnish lower bushing per step "b" above.

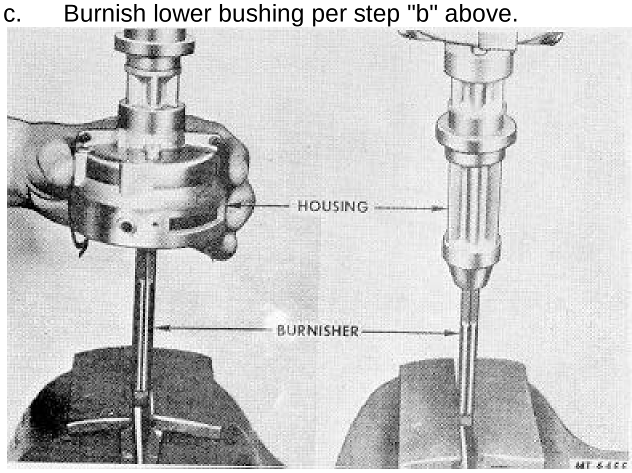


Fig. 44 Burnishing Upper and Lower Bushings Using Burnisher SE-1955-2

<u>For Distributors With Governor or With Governor and Tachometer Drive:</u>

1. Install remover (SE-1955-5) in upper bushing (Fig. 45).

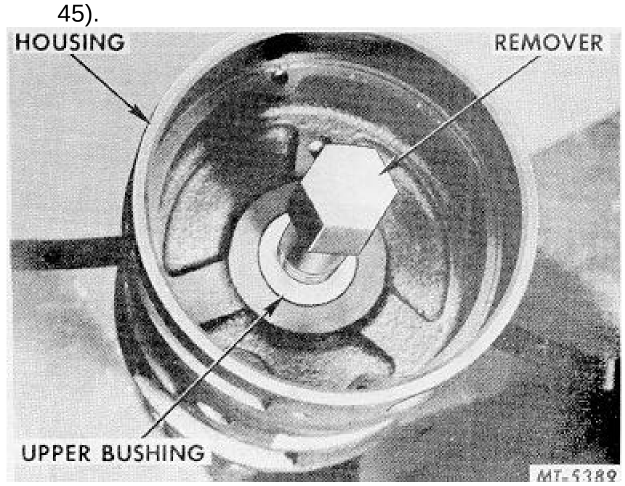


Fig. 45 Installing Remover SE-1955-5 In Upper Bushing

2. Place distributor housing on press bed and insert knock-out bar (make locally from cold rolled stock 7/16" diameter x 11" long) and press out upper bushing (Fig. 46).

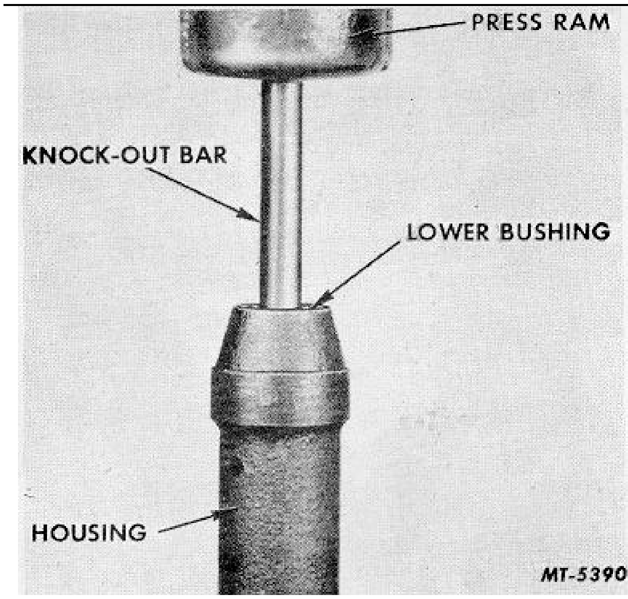


Fig. 46 Pressing Out Upper Bushing Using Knock-Out Bar

3. Install remover (SE-1955-5) in lower bushing (Fig. 47).

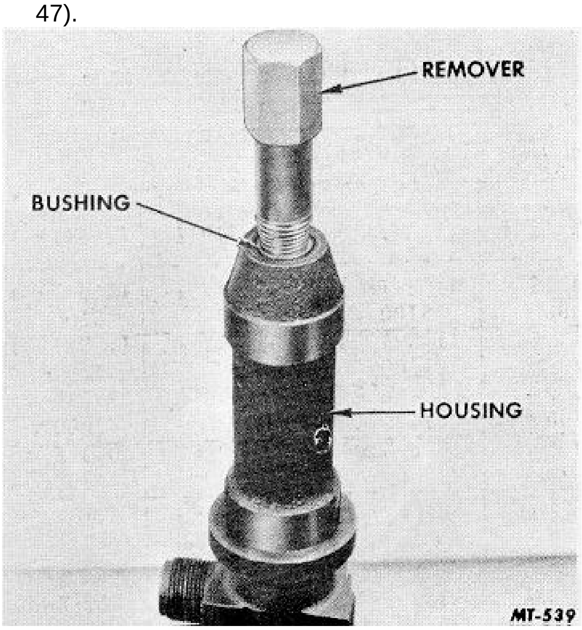


Fig. 47 Installing Remover SE-1955-5 In Lower Bushing

4. Place distributor housing on press and insert knock-out bar and press out lower bushing (Fig. 48).

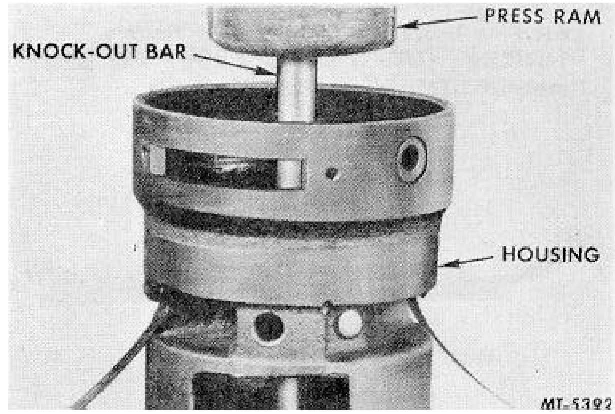


Fig. 48 Pressing Out Lower Bushing Using Knock-Out Bar

5. On distributors equipped with tachometer drive, place tachometer drive opening of distributor housing over a 7/,8" socket on press bed and insert-knock-out bar (made locally from cold rolled steel 7/16" diameter x 4" long) and press out tachometer bushing (Fig. 49).

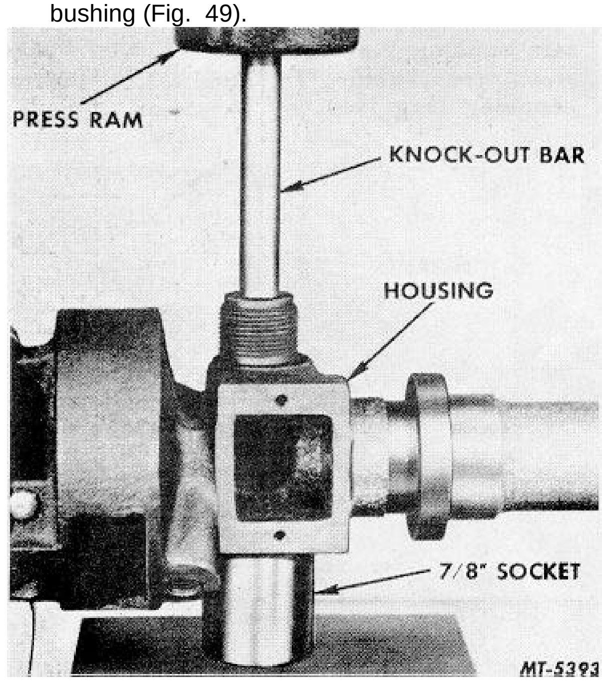


Fig. 49 Pressing Out Tachometer Drive Bushing Using Knock-Out Bar

6. Remove vacuum seals, washers, spacer and retainer from the housing using a knock-out bar as shown in Fig. 50. This bar can be made locally from cold rolled steel 5/16" diameter x 10" long and shaped to dimensions

as shown in inset (Fig. 50). It should be noted when removing the seals, washers, spacer and retainer using this method that the seals will be damaged and must be replaced.

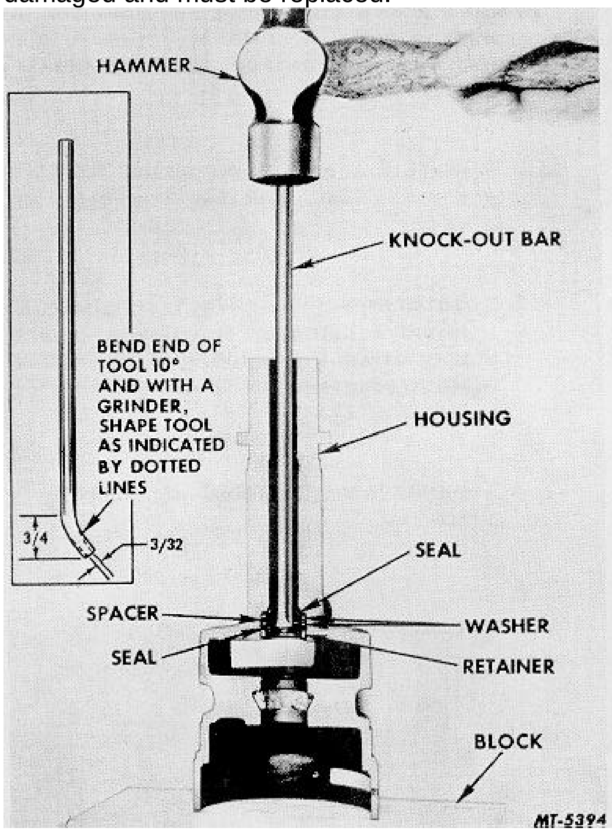


Fig. 50 Removal of Seals, Washers, Spacer And Retainer from Distributor Housing (Housing cut away for illustrative purposes)

7. Slide the lower oil seal, washer, spacer, washer and upper oil seal in the bore of the distributor housing until they rest against the shelf at the bottom of the counterbore. The lower oil seal has the lip facing downward while the upper seal lip faces upward (Fig. 50). Then position the retainer on top of upper seal and with installer (SE-1955-8, Fig. 51) press retainer into housing to a dimension of 3.615 - 3.617" from top of retainer to top edge of distributor housing.

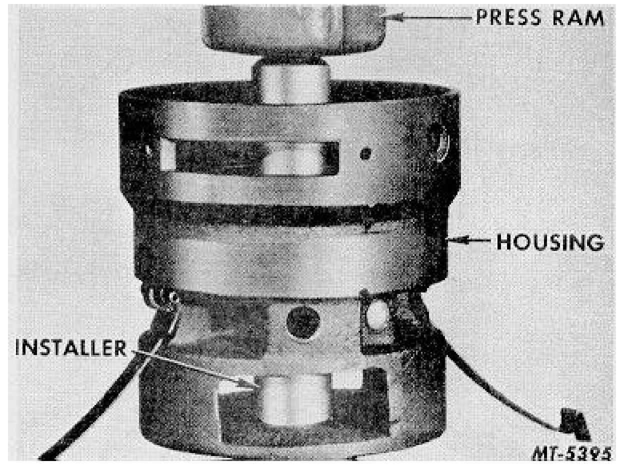


Fig. 51 Pressing Seal Retainer into Housing Using Installer SE-1955-8

8. Lubricate outer diameter of new upper bushing with a light coat of grease and start bushing into distributor housing bore.

9. Position distributor housing in press and insert bushing installer (SE-1955-8) into bushing (Fig. 52).

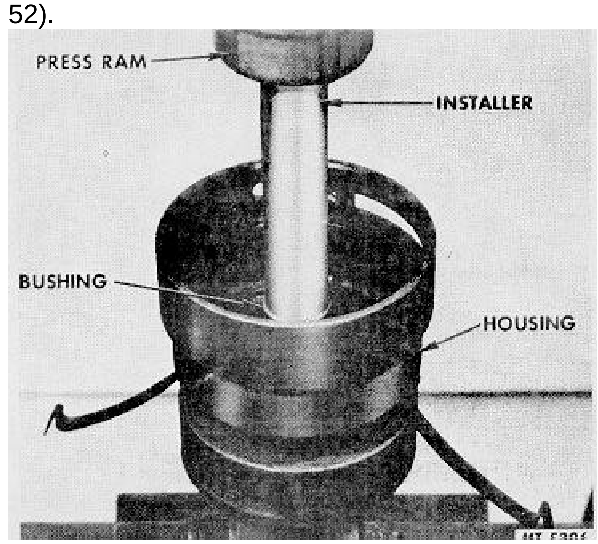


Fig. 52 Using Installer SE-1955-8 to Install Upper Bushing.

10. Press upper bushing into housing to a 1-51/64" diamension from top of housing to top of bushing. Use a straight edge and scale to measure this distance (Fig. 53).

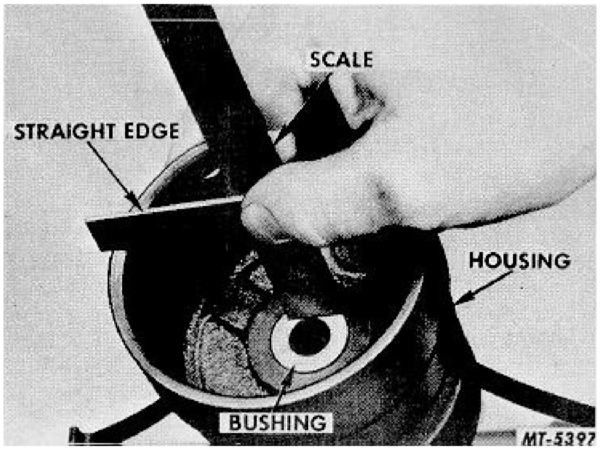


Fig. 53 Using Straight Edge and Scale to Locate Upper Bushing in Housing

11. Lubricate outer diameter of new lower bushing with a light coat of grease and start bushing into distributor housing bore.

12. Position distributor housing in press and insert bushing installer (SE-1955-8) into bushing and press bushing in flush with bottom of housing (Fig. 54).

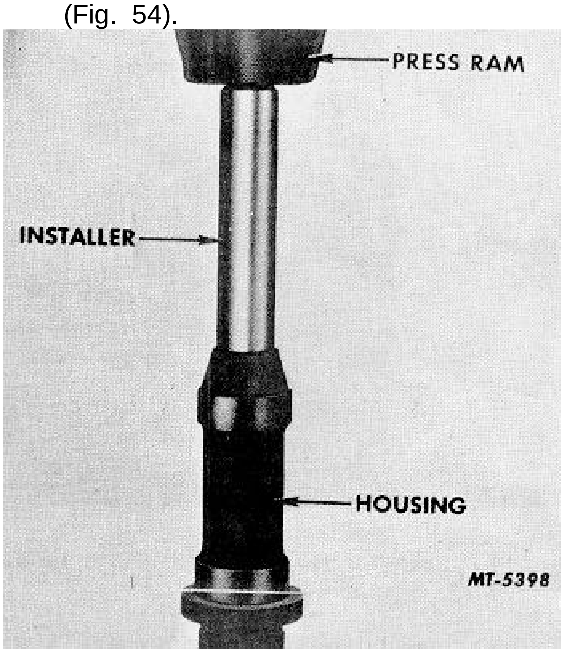


Fig. 54 Pressing Lower Bushing into Housing Using Installer SE-1955-8

13. Size new distributor shaft bushings as follows:'

    NOTE: The oilite bushings are made of powdered metal and should never be reamed. Swelling and burrs may be removed with a burnishing tool (SE-1955-2) which is ground to burnish rather than ream the bearing surface.

    a. Place flat end of burnisher SE-1955-2 in a vise. Coat burnisher with SAE-20 engine oil.

    b. Burnish upper bushing by placing distributor housing on burnisher carefully and rotating the housing clockwise using light pressure until tool passes through bushing (Fig. 55).

    c. Burnish lower bushing per step "b" above.

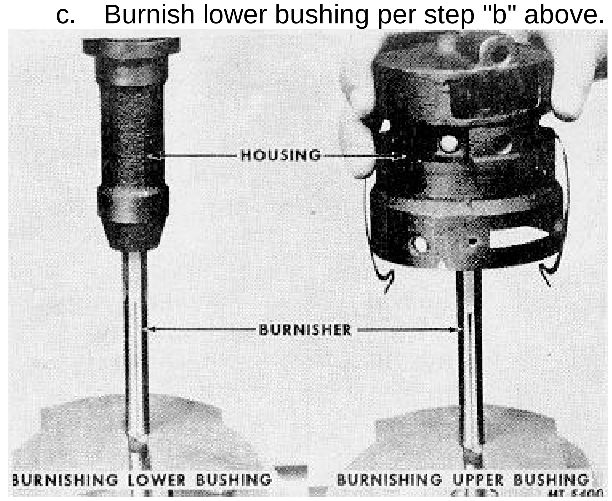


Fig. 55 Burnishing Upper and Lower Bushings Using Burnisher SE-1955-2

14. On distributors with tachometer drive, install tachometer shaft bushing as follows:

    a. Lubricate outer diameter of bushing with a light coat of grease and start bushing into distributor housing bore.

b. Place tachometer opening of distributor housing over a 7/8" socket on press bed and using installer (SE-1722) press bushing in until flange just seats against housing (Fig. 56).

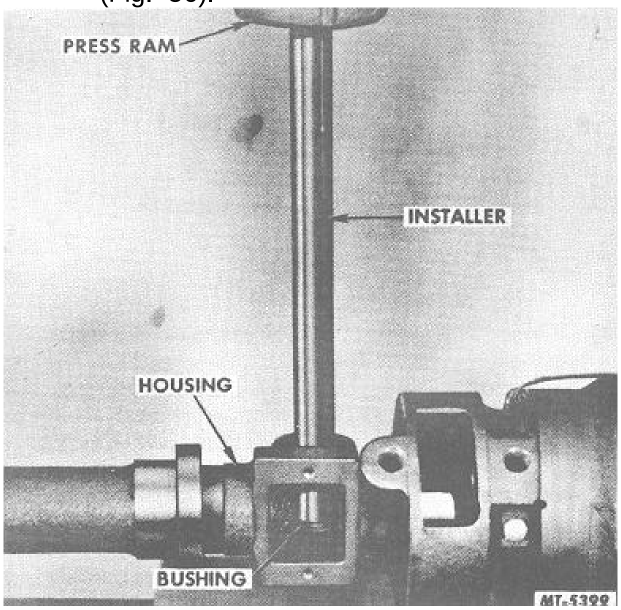


Fig. 56 Installing Tachometer Drive Shaft Bushing Using Installer SE-1722

Distributor Reassembly

1. Assemble mechanical advance components to distributor shaft as follows:

   a. Install new Teflon bushings in bores of advance weights.
   b. Install new Teflon thrust washers on advance weight pins and install advance weights on pins (Fig. 23, Page 13).
   c. Install new advance springs.

   d. Make sure advance weights pivot freely on pins.

2. Install distributor shaft into distributor housing as outlined below.

   NOTE: If a new distributor shaft is being installed, a new distributor driven gear or thrust collar and a new tachometer drive gear must also be installed.

Distributors Without Tachometer Drive

a. Lubricate distributor shaft with engine oil.

b. Slide distributor shaft into distributor housing. Use care to avoid damaging governor housing seals, where used, when installing shaft.

Distributors With Tachometer Drive

a. Position tachometer drive gear in distributor housing with hub of gear facing downward.
b. Lubricate distributor shaft with engine oil.
c. Slide distributor shaft into distributor housing. Use care to avoid damaging governor housing seals.
d. Start distributor shaft into bore of tachometer drive. If original shaft and gear are being installed, align roll pin hole in gear with roll pin hole in shaft.
e. Support distributor assembly in press and press distributor shaft into tachometer gear. If original shaft and gear are being installed, press gear onto shaft until roll pin hole in gear aligns with pin hole in shaft.

   If a new shaft and gear are being installed, gear should be installed on shaft to a dimension of 4.58 inches from top of housing to top of gear with shaft held "bottomed" in housing (See Fig. 34, Page 15).

3. Install distributor driven gear or thrust collar as outlined below:

If original distributor driven gear or thrust collar is being used:

a. Start gear or thrust collar on distributor shaft and align roll pin hole in gear or thrust collar with roll pin hole in shaft. Where used, place new gear-to-housing thrust washer on distributor shaft before installing gear.

b. Support distributor assembly in press and press gear or thrust collar onto shaft until pin hole in gear or thrust collar aligns with hole in shaft.

c. Check for specified shaft end play. Measure as clearance between gear or thrust collar and lower end of distributor housing with shaft held "bottomed" in housing (See Figs. 25 and 26, Page 13). On distributors with gear-to-housing thrust washer, measure end play as clearance between gear or thrust collar and thrust washer.

d. Install driven gear or thrust collar roll pin.
e. On distributors with tachometer drive, rotate shaft to check for interference between tachometer drive gear and distributor housing. If clearance is satisfactory at both upper and lower limits of distributor shaft end play, install tachometer drive gear roll pin.

If new distributor driven gear or thrust collar is being installed:

a. Start new gear or thrust collar onto distributor shaft. Where used, place new gear-to-housing thrust washer on distributor shaft before installing gear.
b. Support distributor assembly in press and press gear or thrust collar onto shaft until specified shaft end play is obtained. Measure as clearance between gear or thrust collar and lower end of distributor housing (see Figs. 25 and 26, Page 13). On distributors with gear-to-housing thrust washer, measure end play as clearance between gear (or thrust collar) and thrust washer.
c. Support distributor assembly in drill press. Using roll pin hole in gear as a guide, drill roll pin hole in distributor shaft.
d. Install roll pin.

e. On distributors with tachometer drive, rotate shaft to check for interference between tachometer drive gear and distributor housing.

   If clearance is satisfactory at both upper and lower limits of distributor shaft end play, support distributor in drill press. Using roll pin hole in tachometer drive gear as a guide, drill roll pin hole in distributor shaft. Install roll pin.

4. Install trigger wheel assembly on distributor shaft as follows:

   a. Make sure mechanical advance components are properly in place on distributor shaft.

   b. Lubricate trigger wheel assembly pilot surface of distributor shaft with distributor cam lubricant. Grooves in pilot diameter should be filled with lubricant. Lands between grooves should have only a thin film of lubricant. Reservoir in center should be filled with lubricant to depth of lands (Fig. 57).

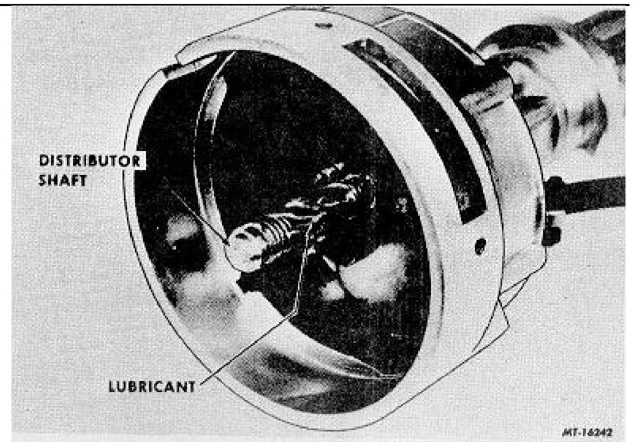


Fig. 57 Trigger Wheel Pilot Lubrication

   c. Install new slider blocks on trigger wheel assembly. Place trigger wheel assembly on pilot surface of distributor shaft. Align flats on slider blocks with slots in advance flyweights and push trigger wheel assembly into position. Install trigger wheel assembly retainer. Remove any excess lubricant from base of trigger wheel assembly.

   d. Saturate felt wick with engine oil. Squeeze excess oil from wick and install wick in top bore of trigger wheel assembly (rotor shaft).

   e. Make sure mechanical advance mechanism operates freely.

5. On distributors with tachometer drive, install tachometer drive parts as follows:

   a. Lubricate tachometer drive gear on distributor shaft with a coat of ball bearing lubricant (Humble "Andok 260" or equivalent).
   b. Lubricate tachometer driven gear and shaft with a coat of ball bearing lubricant.

   c. Lubricate tachometer drive shaft bushings with a light coat of ball bearing lubricant.

   d. Install tachometer driven gear and shaft into distributor housing (Fig. 32, Page 15).
   e. Install tachometer driven gear shaft plug (Fig. 32, Page 15).
   f. Fill tachometer drive gear cavity in distributor housing with ball bearing lubricant.

g. Using a new gasket, install tachometer drive cover plate screws and lock washers. Tighten screws securely.

6. On distributors equipped with governor valve, assemble governor valve to distributor shaft as follows:
   a. Position 7/16" deep socket, governor counterweight and counterweight lock on installer tool SE-2072-1. Engage counterweight in socket (See Fig. 29, Page 14).
   b. Place slotted end of installer tool through horizontal hole in distributor shaft, starting from side nearest vertical hole (see Fig. 58). Place governor valve body on slotted end of installer tool (Fig. 30, Page 14) and engage tang of governor adjusting screw into slot in end of installer tool (Fig. 58).

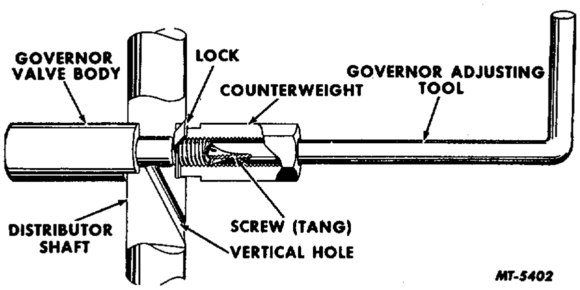


Fig. 58 Governor Valve Assembly

   c. Push governor body and governor counterweight together toward center of distributor shaft and thread counterweight into governor valve body while holding installer tool stationary.
   d. Tighten counterweight to 50-60 inch-pounds and bend lock tabs down against flats of counterweight to lock.
   e. Preset the governor valve by turning installer tool clockwise gently to bottom the spring screw. Do not force the tool when bottoming the screw. Then turn the tool counterclockwise approximately 3-1/2 turns.

      NOTE: This is merely a preliminary governor setting. Final governed speed adjustment must be made on the engine per instructions given under GOVERNOR ADJUSTMENT (On Engine).
   f. Install governor valve adjusting plug and tighten with Allen wrench (Fig. 28, Pg. 14).
   g. Reinstall governor clamp and gasket assembly.
   h. Install governor seal wire through head of clamp screw and around clamp. Do not compress seal until after governed speed adjustment is made on engine.
   i. Install governor air inlet filter (if equipped).

7. Assemble sensor plate assembly as follows:
   a. Install three thrust buttons in upper plate (Fig. 20, Page 12). Lubricate buttons with distributor cam lubricant.
   b. Assemble upper plate to lower plate and secure with retaining spring (Fig. 19, Page 12).
   c. Position sensor on upper plate and install sensor mounting screw. (Do not tighten screw.) Engage wiring clip into hole in plate.

8. Position plate assembly in distributor housing Install sensor plate mounting screws and tighten alternately and evenly. Position sensor wiring seal/retainer (Fig. 17, Page 12) into slot in distributor housing.

9. Position vacuum advance diaphragm assembly on distributor housing and install mounting screws.

10. Connect diaphragm rod to pin on sensor plate assembly and install rod retaining "E" ring.

11. Adjust trigger wheel-to-sensor air gap as follows:
    a. Rotate trigger wheel' until one tooth is aligned with centerline of sensor (trigger wheel tooth perpendicular to flat surface of sensor). (Fig. 59)
    b. Using feeler gauge, measure air gap between sensor and end of tooth (Fig. 59). Move sensor as needed to obtain specified air gap (see SPECIFICATIONS). Tighten sensor mounting screw and recheck air gap.

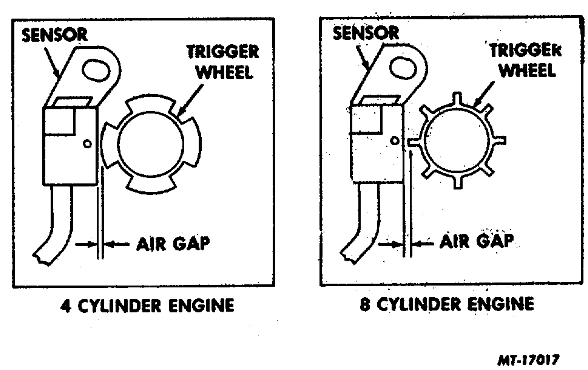


Fig. 59 Trigger Wheel-to-Sensor Air Gap

12. Mount distributor in distributor test stand (see Distributor Operation Test).

13. Operate distributor at 300 RPM (with 12-13 volts primary input) and observe dwell reading. Dwell should be within specified limits.
    a. If dwell reading is within specified limits, trigger wheel-to-sensor gap is satisfactory.
    b. If dwell reading is not within specified limits, loosen sensor mounting screw and adjust trigger wheel-to-sensor air gap as required to obtain specified dwell. Move sensor toward trigger wheel to decrease dwell or away from trigger wheel to increase dwell. Dwell is affected approximately one-half (1/2) degree per .001" of sensor movement. After correct dwell is obtained, tighten sensor mounting screw.

14. Check operation of mechanical advance mechanism as follows:
    a. With distributor operating at minimum speed, set zero of test stand degree ring in line with arrow flash nearest front of stand.
    b. Increase distributor speed, pausing at each specified test speed to note the amount of advance that is occurring. If advance at specified test speeds is not within specified limits, adjust advance spring tension by bending the spring posts (Fig. 60). Bend post(s) toward distributor shaft to decrease tension (increase advance) and away from shaft to increase tension (decrease advance). Make adjustments carefully in order to keep advance within specified limits. Adjustment is not complete until advance falls within specified limits at all test speeds.

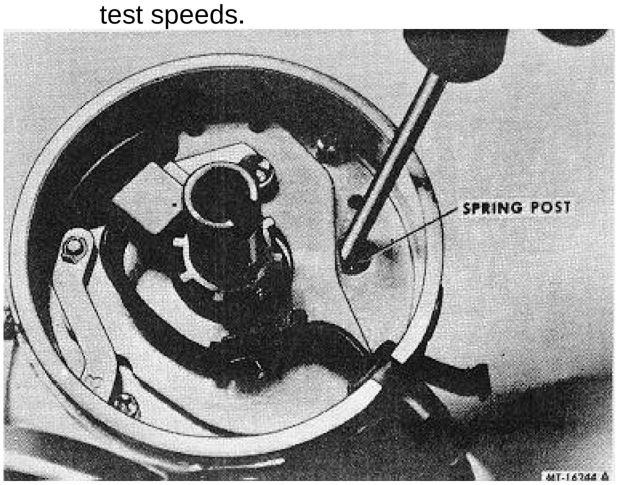


Fig. 60 Adjusting Advance Spring Tension

15. Connect test stand vacuum hose to vacuum advance diaphragm and check operation of vacuum advance. If advance does not follow within specified limits at specified vacuum readings, replace vacuum diaphragm and recheck vacuum advance operation.
16. If distributor operation is satisfactory, remove distributor from test stand and install dust cover and rotor.

<u>Distributor Installation</u>

1. Clean distributor mounting area of engine block.
2. Install a new distributor mounting gasket in counterbore of engine block or install a new "O" ring seal on distributor housing, whichever is applicable.

3. Position distributor in engine. If engine was not rotated while distributor was removed--
    a. Align rotor tip with mark scribed on distributor housing during removal. Then, on distributors with driven gear mounted on lower end of distributor shaft, turn rotor about 1/8 turn clockwise past scribed mark.
    b. Slide distributor down into engine and position distributor housing in approximately the same location (in relation to surrounding engine parts) as when removed.
    NOTE: It may be necessary to move rotor and shaft slightly to start gear into mesh with camshaft gear and/or to engage oil pump shaft drive tang, but rotor should align with scribed mark when distributor is down in place.
    c. Install distributor hold-down clamp, bolt and lock washer, but do not tighten bolt.

    If engine was rotated while distributor was removed, it will be necessary to re-establish timing as follows--
    a. Remove No. 1 spark plug (No. 8 on V-304, V-345, V-392 engines). Hold finger over spark plug hole and rotate -engine until compression pressure is felt. Slowly continue to rotate engine until timing mark on crankshaft pulley lines up with specified initial timing mark on timing quadrant. (For initial timing setting, refer to tune-up data decal on engine.) Always rotate engine in direction of normal rotation. Do not "back" engine to align timing marks.

    b. Turn distributor shaft until rotor tip points in the direction of the No. 1 terminal in the distributor cap (No. 8 terminal on V-304, V-345, V-392 en-

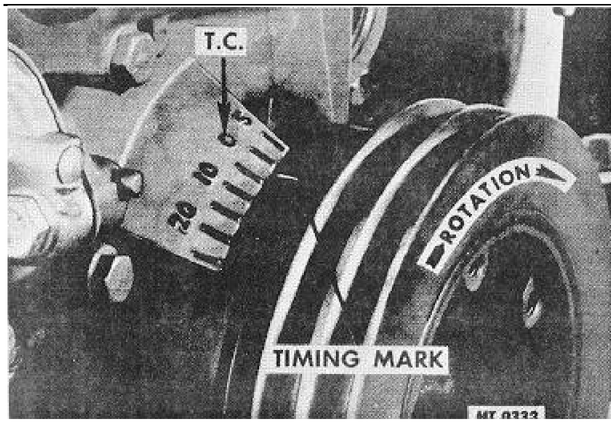


Fig. 61 Timing Marks (V-304, V-345, V-392 Engines Shown)

gines). The initial timing terminal is identified by a dab of paint on the cap. Then, on distributors with driven gear mounted on lower end of distributor shaft, turn rotor about 1/8 turn clockwise past position of initial timing terminal.

c. Slide distributor down into engine and position distributor housing in approximately the same location (in relation to surrounding engine parts) as when removed.
NOTE: It may be necessary to move rotor and shaft slightly to start gear into mesh with camshaft gear and/or to engage oil pump shaft drive tang, but rotor should align with the position of initial timing terminal when distributor is down in place.
d. Install distributor hold-down clamp, bolt and lock washer, but to not tighten bolt.

4. Install distributor cap (with high tension cables) on distributor housing making sure tang on vacuum advance unit aligns with slot in distributor cap and that cap fits down snug on distributor housing.

NOTE: If distributor cap is incorrectly positioned on distributor housing, cap or rotor may be damaged when engine is cranked.

5. Connect distributor primary wiring connector.
6. Connect timing light to No. 1 spark plug (No. 8 spark plug on V-304, V-345, V-392 engines).
NOTE: Do not puncture high tension cables or boots to make contact. Use proper adapters.
7. Operate engine at idle speed and observe timing marks with timing light. Rotate distributor housing as needed to align timing mark on crankshaft pulley with specified initial timing mark on timing quadrant. When timing is correct, tighten distributor holddown bolt and recheck timing to be sure it did not change.

8. Disconnect timing light and connect vacuum hose to distributor advance unit (where equipped).

GOVERNOR ADJUSTMENT (ON ENGINE)

On engines equipped with governor, the governed speed can be checked and adjusted as follows:

1. Connect test tachometer to engine (if not equipped).

2. Race engine for a brief interval at full throttle and note engine speed registered on tachometer. Governed top speed should not exceed specified limit.

3. If necessary, adjust governor as follows:
   a. Remove seal wire and remove governor valve housing cover band and gasket (Fig. 27, Page 14).
   b. With ignition "OFF," turn engine over until governor adjusting hole plug appears in access opening of governor housing.
   c. Using 1/8" Allen wrench, remove governor adjusting hole plug (Fig. 28, Page 14).
   d. Insert slotted end of governor adjusting tool through governor adjusting hole and engage adjusting screw tang, as shown in Fig. 58, Page 24. Turn adjusting screw clockwise to decrease governed speed or counterclockwise to increase governed speed. One-fourth (1/4) turn of screw will effect governed speed approximately 100 RPM. Remove adjusting tool.
   e. Reinstall plug in adjusting hole and tighten securely with 1/8" Allen wrench.
4. Restart engine. Accelerate to full throttle and again observe governed speed. If needed, readjust governor per Step 3.
5. Reinstall governor housing cover band and gasket.
6. Install new governor seal wire through holes provided in flanges of cover band. Thread end of seal wire through holes in lead seal and compress seal.

SERVICE PRECAUTIONS

The following precautions must be observed when performing service operations on the electronic ignition system:

1. Do not use a test lamp to check continuity of the distributor sensor unit. The fine wire (No. 38 gauge) used in construction of the sensor coil will be damaged beyond repair if subjected to a current exceeding 40 milliamps (.040 amp).
2. Do not connect distributor sensor or tester switch SE-2503 to a 12 volt circuit. When making tests, be sure to make test connections as shown under IGNITION SYSTEM OPERATION AND TROUBLE SHOOTING TEST.

3. It is important that wiring circuits of the electronic ignition system be connected properly. Damage to ignition system components or erratic spark advance can result from incorrect wiring connections. Whenever engine wiring harness is disconnected from the electronic ignition control and/or the ignition coil, wires should be marked or tagged to assure correct reconnection.

   Proper electronic ignition control and ignition coil primary wiring connections are shown in Fig. 62.

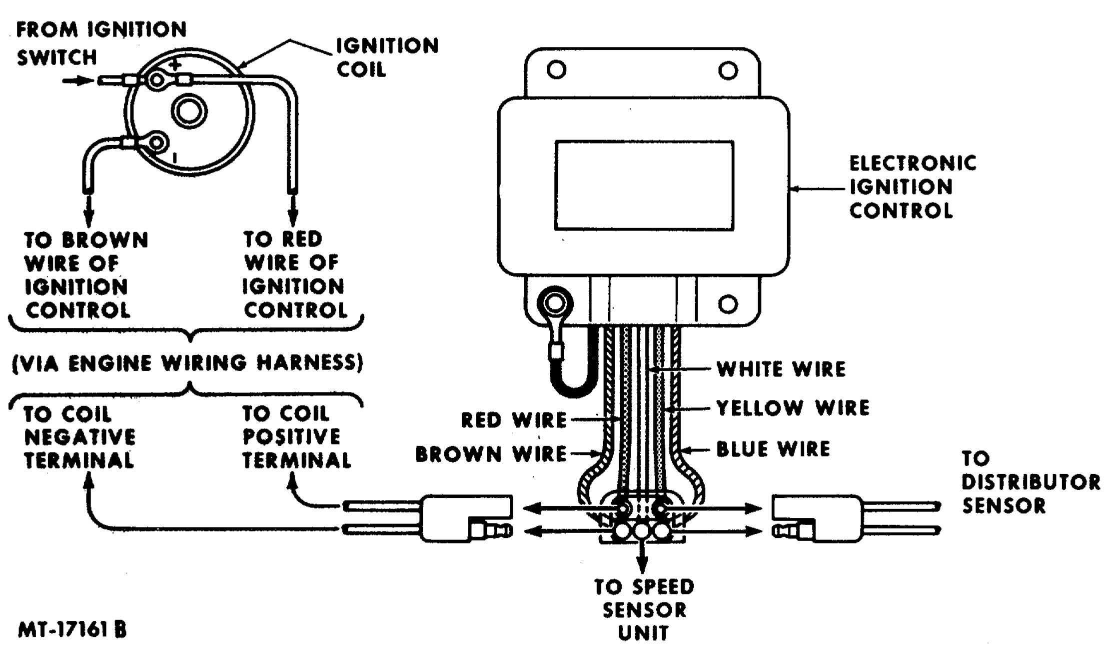
   NOTE: Engine wiring circuit numbers vary between vehicle models. For circuit identification, refer to appropriate vehicle wiring diagrams in service manual.

4. Multi-wire connectors on electronic ignition system components are treated with a special conductive lubricating/sealing compound (grease). Its purposes are to lubricate the metal contact surfaces and to prevent entry of moisture into the connection. The lubricant/ sealer should not be cleaned from the connector terminals.

   At the time of ignition system service, check fit of female terminals with shank of a No. 16 drill (.177") and coat terminals with lubricant/sealer before assembly. The lubricant/sealer compound is available through IH parts outlets under part number 472141-C1.

5. In the event of ignition coil replacement, only ignition coil IH part number 191455-R91 should be used on vehicles equipped with the IH electronic ignition system.

   Use of incorrect ignition coil could result in damage to the electronic ignition control.



TROUBLE SHOOTING GUIDE

CONDITION	POSSIBLE CAUSE	REMEDY
Engine fails to start (no spark at plugs).	No voltage to ignition system.	Check battery, ignition switch and wiring. Repair as needed.
	Electronic ignition control ground lead open, loose or corroded.	Clean, tighten or repair as needed.
	Primary wiring connectors not fully engaged.	Make sure connectors are clean and firmly seated.
	Coil open or shorted.	Test coil. Replace if faulty.
	Damaged trigger wheel or sensor.	Replace damaged parts.
	Electronic ignition control faulty.	Replace electronic ignition control
Engine backfires but fails to start.	Incorrect ignition timing.	Check timing. Adjust as needed.
	Moisture in distributor cap.	Dry cap and rotor.
	Distributor cap faulty (shorting out).	Check cap for loose terminals, cracks and dirt. Clean or replace as needed.
	Spark plug cables routed incorrectly.	Check cables for correct position.
Engine does not operate smoothly	Spark plugs fouled or faulty.	Clean and regap plugs. Replace if needed.
and/or	Spark plug cables faulty.	Check cables. Replace if needed.
engine misfires at high speed.	Trigger wheel to sensor air gap incorrect.	Set gap to specifications.
	Spark advance system(s) faulty..	Check operation of advance system(s). Repair as needed
	Worn distributor shaft bushings.	Check for worn bushings. Rebuild or replace distributor.
Excessive fuel consumption.	Incorrect ignition timing.	Check timing. Adjust as needed.
	Spark advance system(s) faulty.	Check operation of advance system(s). Repair as needed.
	Worn distributor shaft bushings.	Check for worn bushings. Rebuild or replace distributor.
Erratic timing advance.	Vacuum leaks in vacuum advance system.	Check vacuum hoses and replace as needed.
	Faulty vacuum advance diaphragm assembly.	Check operation of advance diaphragm and replace if needed.
	Misadjusted, weak or damaged mechanical advance springs.	Readjust or replace springs as needed.
	Mechanical advance flyweight bushings worn.	Replace bushings.
	Sticking or worn sensor plate assembly.	Replace sensor plate thrust buttons.

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IGNITION SPECIFICATIONS

IH Electronic (Breakerless) Ignition System
(1975 thru 1977 Vehicles)
U. S. Domestic Gasoline

ENGINE MODEL	4-196	V-304	V-345	V-392
Spark Plug Type: Scout		RJ-10Y		----
150/500 Series	----	RJ-10Y		
1600/1800 Series	----	RJ-6 (1)		
Spark Plug Gap, mm (in.): RJ-6	----	76 (.030)		
RJ-10Y	.89 (.035)			
Air Gap, Trigger Wheel-to-Sensor (2), mm (in)	0.2 (.008)			
Dwell, Degrees (3)	26 - 32			
Ignition Timing (4)	TDC	TDC (5)	TDC (6)	TDC (7)
Firing Order	1-3-4-2 ,	1-8-4-3-6-5-7-2		
Distributor Rotation (As Viewed from Top)	Right Hand (Clockwise)			
Coil Test Specifications: Primary Resistance Secondary Resistance	1.25 - 1.40 Ohms @ 24 C (75 F) 9,400 - 11,700 Ohms @ 24 C (75 F)			
Coil Output: At Cranking Speed At 2500 RPM	20 - 23 KV 20 KV Minimum			
Spark Plug Firing Voltage (at 1000 RPM)	8 - 15 KV			
Spark Plug Variation Under Load (Accelerating)	3 KV Maximum			
Ignition Cable Resistance (Maximum Permissible) Up to 914 mm (36") Long Over 914 mm (36") Long	30,000 Ohms 45,000 Ohms			
Engine Governed Speed, RPM - No Load (8)	----		4000	3800

Special Applications

ENGINE MODEL	V-345 Propane	Low Compression (Gasoline) 4-196	V-304	V-345	V-392
All specifications same as listed above for U.S. Domestic Gasoline, except as follows:					
Spark Plug Gap, mm (in)	0.38 (.015)				
Ignition Timing (4)	10 Deg. .BTDC	5 Deg. BTDC (9)			

(1) For light service, use higher heat range plug (RJ-10Y) to avoid fouling.
(2) Clearance between sensor and end of trigger wheel tooth.
(3) At specified curb idle speed.
(4) At specified curb idle speed with distributor vacuum hose disconnected and plugged.
(5) 1977 California Vehicles: 5 Degrees BTDC.
(6) 1976 California Vehicles: 5 Degrees BTDC. 1977 Calif. non-governed vehicles: 5 Deg. BTDC
(7) With "Thermo-Quad" Carburetor: 5 Degrees BTDC.
(8) Where equipped with governor.
(9) Initial advance dependent upon altitude and grade of gasoline available.
Adjust to suit local conditions.

IGNITION SPECIFICATIONS
IH Electronic (Breakerless) Ignition System
(1975 thru 1977 Vehicles)

Engine Model	MV-404	MV-446	VS-537
Spark Plug Type: Severe Service Normal Service	 RBN-4 RBN-13Y		 RN-11Y RN-12Y
Spark Plug Gap, mm (in.)	0.76 (.030)		
Air Gap, Trigger Wheel-to-Sensor (1), mm (in.)	0.2 (.008)		
Dwell, Degrees (2)	26 - 32		
Ignition Timing (3)	9° BTDC	5° BTDC	7° BTDC
Firing Order	1-2-7-3-4-5-6-8		1-8-7-3-6-5-4-2
Distributor Rotation (As Viewed From Top)	Left Hand (Counterclockwise)		Right Hand (Clockwise)
Coil Test Specifications: Primary Resistance Secondary Resistance	 1.25 - 1.40 Ohms @ 75° F 9,400 - 11,700 Ohms @ 75° F		
Coil Output: At Cranking Speed At 2500 RPM	 20 - 23 KV 20 KV Minimum		
Spark Plug Firing Voltage, At 1000 RPM	8 - 15 KV		
Spark Plug Variation Under Load (Accelerating)	3 KV Maximum		
Ignition Cable Resistance, Maximum Permissible: Up to 36" Long Over 36" Long	 30,000 Ohms 45,000 Ohms		
Engine Governed Speed, RPM -- No Load	3800		3400

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At specified curb idle speed.

(3) At idle speed. Distributor vacuum hose disconnected and plugged (where used).

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)

Engine Model	4-196		V-304		V-304/345
Distributor: Part No. (Manufacturer's No.)	464359-C91 (7247)	476165-C91 (7720)	467073-C91 (7268)	480870-C91 (7858)	461270-C91 (7014)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)	0.2 mm (.008)				
Dwell, Degrees (2)	26-32				
Vacuum Advance:					
Vacuum Req'd. to Start Advance cm of Hg. (In. of Hg.)	13-18 (5-7)	8-13 (3-5)	13-18 (5-7)	8-13 (3-5)	13-18 (5-7)
Advance Check Points:					
Vacuum, cm of Hg. (In. of Hg.)	15 (6)	----	-----	----	15 (6)
Degrees	0-1.5				0-1.5
Vacuum	23 (9)	18 (7)	27 (10.5)	15 (6)	20 (8)
Degrees	2.8-5.8	2.8-5.8	5-8	1.5-4.0	1.5-4.5
Vacuum	38 (15)	33 (13)	48 (19)	25 (10)	38 (15)
Degrees	4-6	4-6	6-8	2-4	4-6
Mechanical Advance:					
Distributor RPM to Start Advance	375-450	375-450	300-500	580-750	325-475
Advance Check Points:					
Distributor RPM	-----	-----	-----	-----	-----
Degrees					
Distributor RPM	600	600	600		1000
Degrees	4-6	4-6		-----	7.5-9.5
Distributor RPM	1000	1000	1000	1000	1200
Degrees	8.5-10.5	8.5-10.5	5-7	2.5-4.5	9.7-11.7
Distributor RPM	1900	1900	1800	2000	1850
Degrees	15.2-17.2	15.2-17.2	13-15	13.5-15.5	14-16
Distributor RPM	2200	2200	2100	2100	2100
Degrees	15.8-17.8	15.8-17.8	14.8-16.8	13.5-15.5	15-17
Total Advance, Degrees Mechanical and Vacuum	19.8-23.8	19.8-23.8	20.8-24.8	15.5-19.5	19-23
Distributor Shaft End Play, mm (in.)	0.89-1.02 (.035-.040)				
Distributor Shaft Side Play (3)					
New, mm (in.)	05-.1 (.002-.004)				
Maximum Permissible, mm (in.)	15 (.006)				
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)				

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).
(3) With force of 5 pounds applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)

Engine Model	V-345				
Distributor: Part No. (Manufacturer's No.)	448685-C91 (6757)	461272-C91 (7021) 461271-C91 (7022)	469648-C91 (7330)	469649-C91 (7331) 469650-C91 (7332)	483423-C91 (7973)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)	0.2 mm(.008)				
Dwell, Degrees (2)	26-32				
Vacuum Advance:					
Vacuum Req'd. to Start Advance cm of Hg.(In. of Hg.)	13-18 (5-7)	13-18 (5-7)	13-18 (5-7)	13-18 (5-7)	25-31 (10-12)
Advance Check Points:					
Vacuum, cm of Hg.(In. of Hg.)	15 (6)	15 (6)	20 (8)	20 (8)	
Degrees	0-1.5	0-1.5	1.5-4.0	1.5-4	-----
Vacuum	20 (8)	20 (8)	25 (10)	25 (10)	33 (13)
Degrees	1.5-4	1.5-4.5	2-4	2-4	1.5-4
Vacuum	31 (12)	38 (15)	31 (12)	31 (12)	38 (15)
Degrees	2-4	4-6	2-4	2-4	2-4
Mechanical Advance:					
Distributor RPM to Start Advance	325-475	325-475	370-580	370-580	370-580
Advance Check Points:					
Distributor RPM	400	400	---	700	---
Degrees	0-1	0-1		0.9-2.9	
Distributor RPM	---	---	700	1000	700
Degrees			0.9-2.9	3.5-5.5	0.9-2.9
Distributor RPM	1100	700	1000	1600	1000
Degrees	9-11	4-6	3.5-5.5	8.6-10.6	3.5-5-5
Distributor RPM	---	---	1900	1900	1900
Degrees			11.2-13.2	10.5-12.5	11.2-13.2
Distributor RPM	2000	2000	2100	2000	2100
Degrees	15-17	10.4-12.4	11.9-13.9	10.5-12.5	11.9-13.9
Total Advance, Degrees Mechanical and Vacuum	17-21	14.4-18.4	13.9-17.9	12.5-16.5	13.9-17.9
Distributor Shaft End Play, mm (in.)	0.89-1.02 (.035-.040)				
Distributor Shaft Side Play (3) New, mm (in.) Maximum Permissible, mm(in.)	.05-.1 (.002-.004) .15 (.006)				
Distributor Rotation (As Viewed from Top)	Right Hand (Clockwise)				

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).

(3) With force of 5 pounds applied as side load to top of shaft.

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DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)

Engine Model	V-345	V-345 (Propane)	V-304/345/392 Low Compression	
Distributor: Part No. (Manufacturer's No.)	483492-C91 (7975) 483493-C91 (7976)	463332-C91 (7115) 463330-C91 (7113) 463331-C91 (7114)	463333-C91 (7116) 463335-C91 (7118)	463334-C91 (7117) 463336-C91 (7119)
Air Gap, mm (in.) Trigger Wheel-to-Sensor (1)	0.2 (.008)			
Dwell, Degrees (2)	26-32			
Vacuum Advance:				
Vacuum Req'd. to Start Advance cm of Hg. (In. of Hg.)		13-18 (5-7)	13-19 (5-7.5)	12-16 (4.7-6.2)
Advance Check Points:				
Vacuum, cm of Hg. (In. of Hg.)		15 (6)	18 (7)	15 (6)
Degrees	-----	0-1	0-3	0-2.5
Vacuum		23 (9)	23 (9)	23 (9)
Degrees		3-6	2.2-6.7	5-7.7
Vacuum		38 (15)	38 (15)	38 (15)
Degrees		6-8	6-8	6-8
Mechanical Advance:				
Distributor RPM to Start Advance	300-500	300-375	275-350	250-350
Advance Check Points:				
Distributor RPM	-----	400	300	300
Degrees		0-2	0-1	0-1
Distributor RPM	600	----	----	----
Degrees	1-3			
Distributor RPM	1000	700	650	700
Degrees	5-7	4-6	5.7-7.5	7.5-9.5
Distributor RPM	1800	----	----	----
Degrees	13-15			
Distributor RPM	2100	2000	2000	1800
Degrees	14.8-16.8	10.5-12.5	12.5-14.5	15-17
Total Advance, Degrees Mechanical and Vacuum	14.8-16.8	16.5-20.5	18.5-22.5	21-25
Distributor Shaft End Play, mm (in.)	0.89-1.02 (.035-.040)			
Distributor Shaft Side Play (3)				
New, mm (in.)	0.05-0.1 (.002-.004)			
Maximum Permissible, mm (in.)	0.15 (.006)			
Distributor Rotation As Viewed from Top	Right Hand (Clockwise)			

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).

(3) With force of 5 pounds applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)

Engine Model	V-392			
Distributor: Part No. (Manufacturer's No.)	448686-C91 (6758)	519861-C91 (6937) 461273-C91 (6925)	467035-C91 (7254) 467034-C91 (7252)	472203-C91 (7444)
Air Gap, Trigger Wheel-to-Sensor (1) mm (in.)	0.2 (.008)			
Dwell, Degrees (2)	26- 32			
Vacuum Advance:				
Vacuum Req'd. to Start Advance cm of Hg. (In. of Hg.)	13 - 18 (5 - 7)	13 - 18 (5 - 7)	13 - 18 (5 - 7)	8 - 13 (3 - 5)
Advance Check Points:				
Vacuum, cm of Hg. (In. of Hg.)	23 (9)	15 (6)	20 (8)	18 (7)
Degrees	3 - 6	0 - 1.5	2.8 - 8	2.8 - 6
Vacuum	28 (11)	23 (9)	24 (9.5)	----
Degrees	4 - 6	2.7 - 5.7	6 - 8	
Vacuum	38 (15)	38 (15)	48 (19)	33 (13)
Degrees	4 - 6	4- 6	6- 8	4 - 6
Mechanical Advance:				
Distributor RPM to Start Advance	350 - 450	350 - 475	350 - 475	350 - 450
Advance Check Points:				
Distributor RPM	500	400	700	600
Degrees	1.5 - 3.9	0 - 1	3.4 - 5.4	4 - 6.5
Distributor RPM	650	--------		----
Degrees	5.7 - 7.9			
Distributor RPM	1000	700	1000	1000
Degrees	8.3 - 10.3	4 - 6	8 - 10	8.3 - 10.3
Distributor RPM	1800	----	1400	1900
Degrees	12 - 14		10 - 12	12.5 - 14.5
Distributor RPM	2200	2000	1800	2100
Degrees	13 - 15	10.4 - 12.4	12 - 14	13 - 15
Total Advance, Degrees Mechanical and Vacuum	17 - 21	14.4 - 18.4	18 - 22	17 - 21
Distributor Shaft End Play, mm (in.)	0.89 - 1.02 (.035 - .040)			
Distributor Shaft Side Play (3):				
New, mm (in.)	0.05 - 0.1 (.002 - .004)			
Maximum Permissible, mm (in.)	0.15 (.006)			
Distributor Rotation (As Viewed From Top)	Right Hand(Clockwise)			

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).

(3) With force of 5 pounds applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)

Engine Model	MV-404		MV-446	
Distributor: Part No. (Manufacturer's No.)	446916-C91 (7255) 446920-C91 (7310) 446921-C91 (7311)	446916-C92 (7436) 446920-C92 (7439) 446921-C92 (7440)	446917-C91 (7256) 446918-C91 (7257)	446917-C92 (7437) 446918-C92 (7438)
Air Gap, Trigger Wheel-to-Sensor (1)	0.2 mm (.008")			
Dwell, Degrees (2)	26 - 32			
Vacuum Advance: Vacuum Req'd. to Start Advance, cm of Hg. (In. of Hg.) Advance Check Points: Vacuum, cm of Hg. (In. of Hg.) Degrees	13 - 18(5 - 7) 20 (8) 1.5 - 4		25- 31 (10- 12) 33 (13) 1.5-4	
Vacuum, cm of Hg. (In. of Hg.) Degrees	31 (12) 2 - 4		38 (15) 2 - 4	
Mechanical Advance: Distributor RPM to Start Advance Advance Check Points: Distributor RPM Degrees	300 - 500 600 1-3	300 - 500 600 1-3	300 - 500 600 1-3	300 - 500 600 1-3
Distributor RPM Degrees	1000 5.3 - 7.3	1000 5.3 - 7.3	1000 5.3- 7.3	1000 5.3 - 7.3
Distributor RPM Degrees	1600 10 - 12	1450 10 - 12	1600 10 - 12	1450 10 - 12
Distributor RPM Degrees	1900 10.4 -12.4	1800 10.8 -12.8	1900 10.4 -12.4	1800 10.8 -12.8
Distributor RPM Degrees	---- ----	---- ----	---- ----	---- ----
Total Advance, Degrees Mechanical and Vacuum	12.4 - 16.4	12.8 - 16.8	12.4 -16.4	12.8- 16.8
Distributor Shaft End Play	0.1 - 0.46 mm (.004 - .018")			
Distributor Shaft Side Play (3) New Maximum Permissible	0.05 - 0.1 mm (.002 - .004") 0.15 mm (.006")			
Distributor Rotation (As Viewed from Top)	Left Hand (Counterclockwise)			

(1) Clearance between sensor and end of trigger wheel tooth.
(2) At 300 distributor RPM (with 12 - 13 volts primary input).
(3) With force of 5 pounds applied as side load to top of shaft.

DISTRIBUTOR TEST SPECIFICATIONS
(For Use With Distributor Test Stand)

Engine Model	V-537
Distributor: Part No. (Manufacturer's No.)	448195-C91 (6760)
Air Gap, Trigger Wheel-to-Sensor (1) mm (in.)	0.2 (.008)
Dwell, Degrees (2)	26 - 32
Mechanical Advance: Distributor RPM to Start Advance Advance Check Points: Distributor RPM Degrees	 275 - 475 500 2 - 2.5
Distributor RPM Degrees	800 3.7 - 5.7
Distributor RPM Degrees	1000 5.2 - 7.2
Distributor RPM Degrees	1400 6.4 - 8.4
Distributor RPM Degrees	1700 6.9 - 8.9
Distributor Shaft End Play, mm (in.)	0.05 - 0.25 (.002 - .010)
Distributor Shaft Side Play (3) New, mm (in.) Maximum Permissible, mm (in.)	 0.05 - 0.1 (.002 - .004) 0.15 (.006)
Distributor Rotation (As Viewed From Top)	Right Hand (Clockwise)

(1) Clearance between sensor and end of trigger wheel tooth.

(2) At 300 distributor RPM (with 12-13 volts primary input).

(3) With force of 5 pounds applied as side load to top of shaft.

ELECTRICAL

LIGHTS

S-SERIES
VEHICLES

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INTRODUCTION

Outlined below are service procedures covering lights used on typical S-Series vehicles. Some vehicles may be equipped with additional accessory lights which are not covered herein.

When diagnosing light failure, first check for a "blown" fuse or tripped circuit breaker. Fuse sizes and locations are listed in the circuit diagram section of the Truck Service Manual. Refer to the appropriate section covering the model year of the vehicle being serviced. If a "blown" fuse or tripped circuit breaker is found, inspect wiring circuit for cause of overload and make necessary repairs.

If fuse or circuit breaker is satisfactory, check for "burned out" light bulb and replace if necessary. Light bulb types used in various lights are listed in the LIGHT BULB CHART in this section.

If light bulb is good, check wiring and con- nectors for an "open" circuit. A 12-volt test light can be used to check circuit continuity. Refer to the appropriate wiring circuit diagram.

HEADLIGHTS

HEADLIGHT AIMING

Various types of headlight aiming equipment are available commercially. When using aiming equipment, follow instructions provided by the equipment manufacturer.

Where headlight aiming equipment is not available, headlight aiming can be checked by projecting the upper beam of each light upon a screen or chart at a distance of about 25 feet ahead of the headlights. The truck should be exactly perpendicular to the chart.

The vertical lines on the chart (Figure 1) mark the distance between the vertical center lines of the headlights and are equally spaced from the center line of the chart.

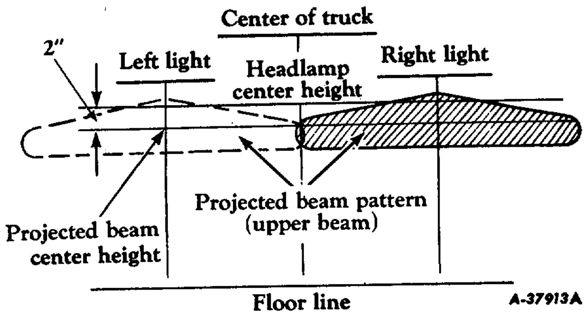

Fig. 1 Headlight Aiming Pattern

A horizontal line should be placed on the chart at a level of two (2) inches below the height of the headlight centers above the floor.

With headlights on "HIGH" beam, the "hot spot" of each projected beam pattern should be centered over the point of intersection of the vertical and horizontal lines on the chart, as shown in Figure 1.

If necessary, adjust headlights vertically and/or laterally to obtain proper aim. (See HEADLIGHT ADJUSTMENT).

IMPORTANT

Headlight aim should always be checked on a level floor with the vehicle unloaded.

In some states, the above instructions may conflict with existing laws and regulations. Where this is the case, legal requirements must be met.

Modify the instructions accordingly.

HEADLIGHT ADJUSTMENT

Adjusting screws are provided to move the headlight assembly in relation to the hood (fender) to obtain correct headlight aim.

Lateral or side-to-side adjustment is accomplished by turning adjusting screw at side of headlight (Figure 2).

Vertical or up-and-down adjustment is accomplished by turning adjusting screw at top of headlight (Figure 2).

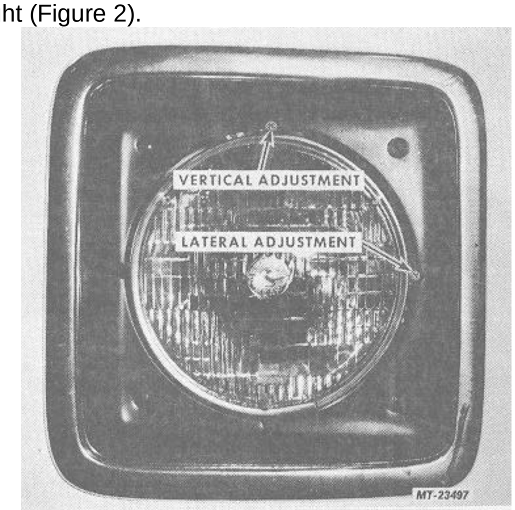

Fig. 2 Headlight Adjusting Screws

To adjust headlight aim, turn adjusting screws as required to position headlight beam pattern as shown under HEADLIGHT AIMING. Adjustments can be made without removing headlight bezels.

SEALED BEAM UNIT REPLACEMENT

1. Remove four (4) retaining screws (Figure 3) and remove headlight bezel.

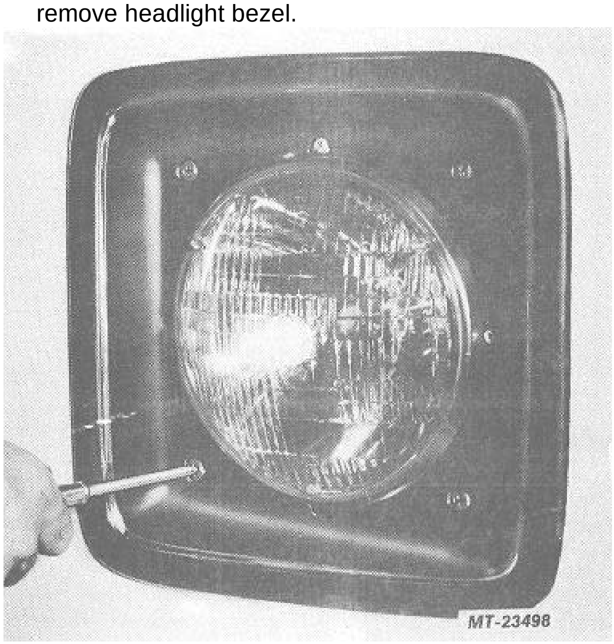

Fig. 3 Removing Headlight Bezel

2. Remove three (3) retaining screws and remove sealed beam unit retaining ring (Figure 4).

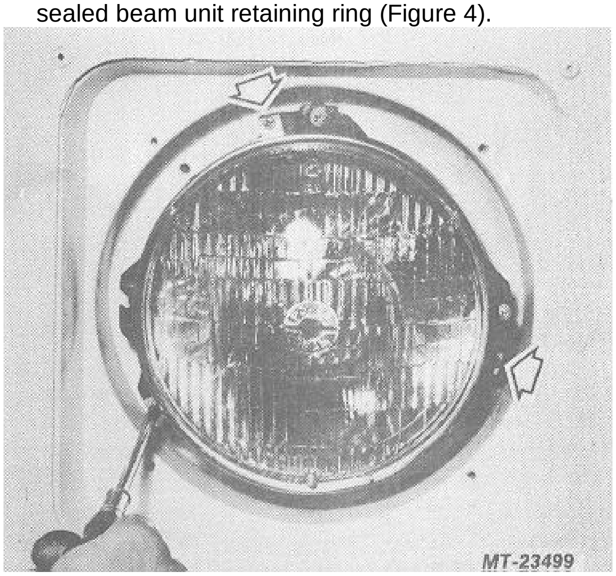

Fig. 4 Removing Sealed Beam Unit Retaining Ring

3. Pull sealed beam unit from headlight assembly. Disconnect three-way wiring connector from rear of sealed beam unit (Figure 5) and remove sealed beam unit.

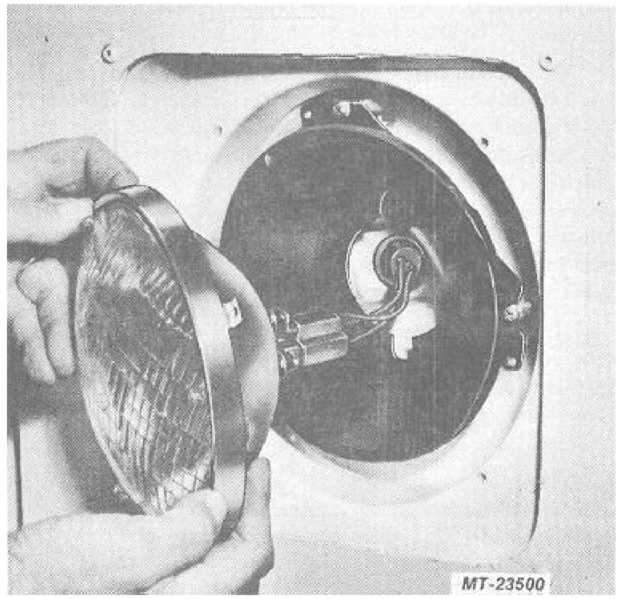

Fig. 5 Removing Sealed Beam Unit

4. Connect three-way wiring connector to new sealed beam unit.

5. Position sealed beam unit in mounting ring. Install retaining ring and secure with screws.

6. Install headlight bezel and secure with screws.

CAUTION

DO NOT overtighten bezel retaining screws. Overtightening could cause damage (stripping) of threads in hood (fender).

7. Check light operation.

HEADLIGHT ASSEMBLY REPLACEMENT

1. Remove four (4) retaining screws and remove headlight bezel (Figure 3).

2. Disconnect headlight retaining spring from headlight assembly (Figure 6).

3. Disengage headlight assembly from adjustment screws. DO NOT turn adjustment screws.

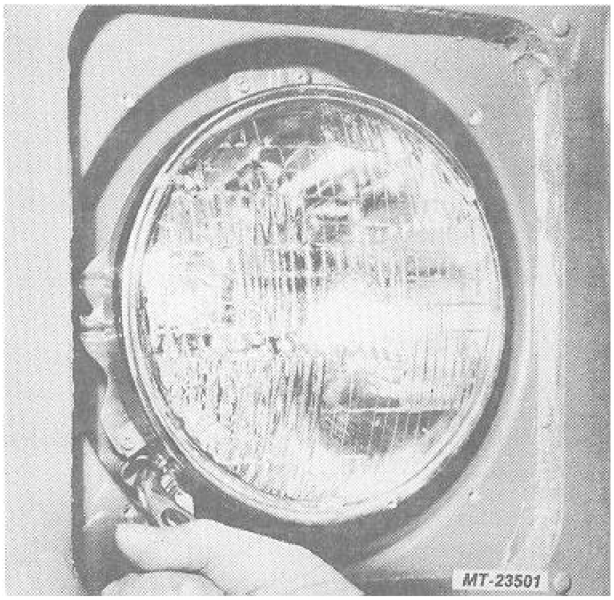

Fig. 6 Disconnecting Headlight Retainer Spring

4. Disconnect three-way wiring connector from rear of sealed beam unit and remove headlight assembly (Figure 7).

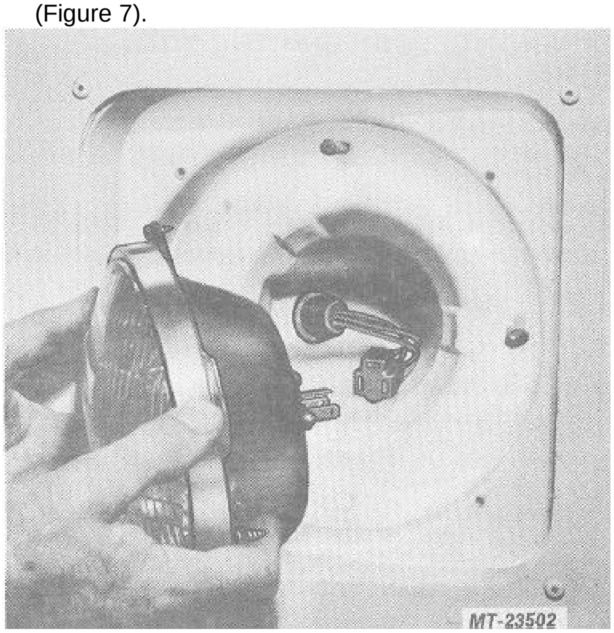

Fig. 7 Removing Headlight Assembly

5. To remove sealed beam assembly from mounting ring (if necessary):

   a. Remove three (3) retaining screws and remove sealed beam retaining ring (Figure 4).

   b. Remove sealed beam unit from mounting ring.

6. If replacement of headlight retaining spring is required:

   a. Remove spring retaining screw and remove spring from hood (fender).

   b. Position new spring on hood (fender) and secure with retaining screw.

7. If required, replace headlight adjusting screw(s) as follows: (Refer to Fig. 8).

   a. While pushing screw inward (toward rear of vehicle) rotate grommet (nut) ninety degrees (900) clockwise until front tangs of grommet align with slot in hood (fender).

   b. Extract screw (with grommet) working from wheel side of hood (fender).

   c. Position new screw and grommet assembly in hood (fender). Align front retaining tangs on grommet with slot in hood and push screw assembly forward as far as possible.

   d. Rotate grommet ninety degrees (90°) counter-clockwise until retainer tabs on rear tangs engage with slot in hood (fender) and front tangs are perpendicular to slot.

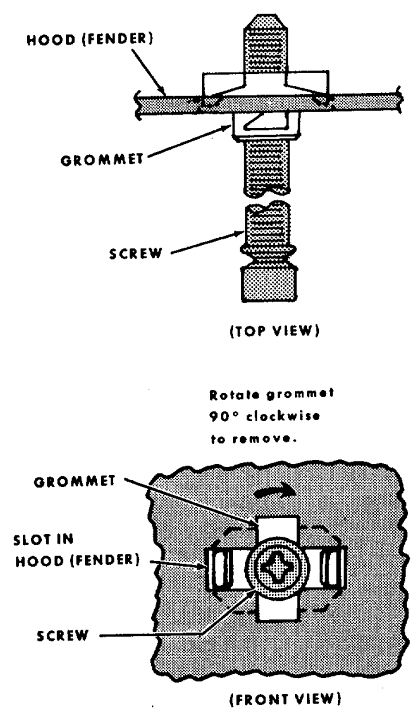

Fig. 8 Adjusting Screw Mounting Details

8. If necessary, position sealed beam unit in headlight mounting ring and secure with retaining ring and screws.

9. Connect three-way wiring connector to rear of sealed beam unit.

10. Engage mounting slots in headlight mounting ring into collar grooves of adjustment screws. Connect headlight retaining spring to headlight mounting ring.

11. Install headlight bezel and secure with screws.

CAUTION

DO NOT overtighten bezel retaining screws. . Overtightening could cause damage (stripping) of threads in hood (fender).

12. Check light operation.

13. Check headlight aim. (See HEADLIGHT AIMING).

FRONT TURN SIGNAL/MARKER LIGHTS

BULB REPLACEMENT

Procedure applies to either turn signal or side marker bulbs. Refer to Figure 9.

1. Remove lens mounting screws and remove lens.

2. Press bulb inward and turn counterclockwise to remove bulb from socket.

3. Inspect bulb socket. If rusty or corroded, replace place light assembly. Inspect lens gasket and replace if damaged.

4. Insert new bulb in socket, press inward and turn clockwise to lock in place.

5. Position lens and gasket on light body and install lens mounting screws.

6. Check light operation.

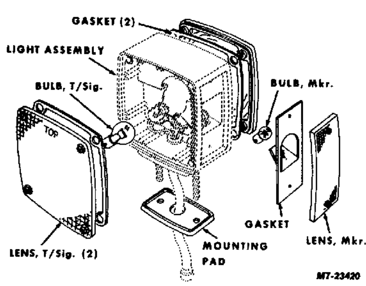

Fig. 9 Front Turn Signal/Marker Light

LIGHT ASSEMBLY REPLACEMENT

1. Disconnect wiring cable from base of light assembly.

2. Remove nuts, washers and wiring cable clip (where used) from light mounting studs. Remove nuts and washers from light guard mounting bolts (if equipped).

3. Remove light assembly (and light guard) from fender.

4. Inspect light mounting pad and replace if damaged or deteriorated.

5. Position mounting pad, light assembly (and light guard) on fender.

6. Install washers and nuts (and cable clip, where used) on light mounting studs. Install light guard mounting bolts, washers and nuts (if equipped).

7. Plug wiring cable connector into light assembly.

8. Tighten light (and light guard) mounting nuts.

9. Check light operation.

CLEARANCE AND IDENTIFICATION LIGHTS (CAB)

BULB OR LIGHT ASSEMBLY REPLACEMENT
(Refer to Figure 10).

1. Remove light mounting screws. Remove trim bezel and seal (where used).

2. Pry light assembly from mounting recess in cab.

3. Turn bulb socket about one-eighth turn counterclockwise and remove socket (with bulb) from light assembly.

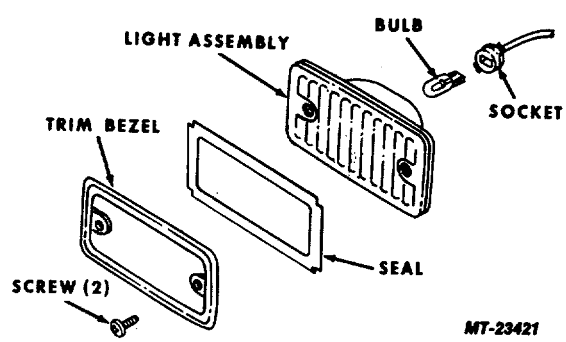

Fig. 10 Clearance Light

4. Grasp bulb and pull straight out to remove plug-in type bulb from socket.

5. Inspect light assembly and gasket and replace if damaged.

6. Push new bulb into socket.

7. Position socket (with bulb) into light assembly and turn socket one-eighth turn clockwise to secure.

8. Position light assembly (with seal and trim bezel where used) into mounting recess in cab. Secure with mounting screws.

9. Check light operation.

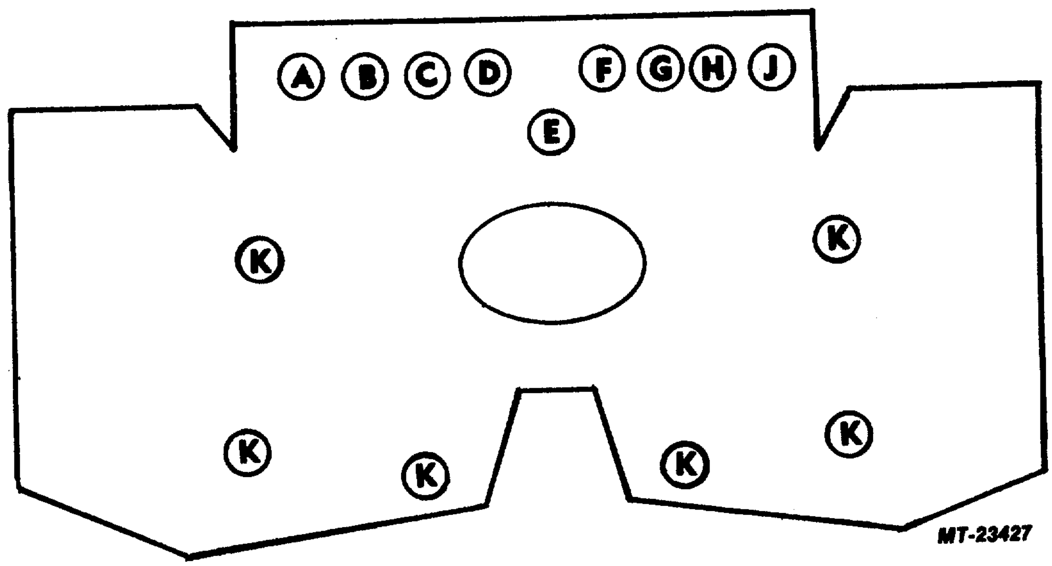

Fig. 11 Instrument Cluster Light Locations (As viewed from front of vehicle)

Legend

A. Right Turn Indicator
B. Low Air Pressure Warning
C. Antilock Warning (Some Models)
D. Park/Hydr. Brake Warning
E. High Beam Indicator
F. Power Divider Lock Warning or EGR Service Indicator
G. Antilock Warning (Some Models)
H. Low Oil Pressure/High Water Temperature Warning
J. Left Turn Indicator
K. Panel Illumination

INSTRUMENT CLUSTER LIGHTS

Locations of instrument cluster illumination, indicator and warning lights are shown in Figure 11.

BULB REPLACEMENT

Procedures for replacing bulbs in instrument cluster lights are as follows:

Indicator and Warning Lights: (A thru J. Figure 11)

1. Remove instrument cluster cover screws (5) and remove cover to expose warning and indicator lights.

2. Grasp bulb and pull straight outward to remove plug-in type bulb from socket (Figure 12).

   In some cases it may be necessary to remove socket from instrument cluster to remove bulb. See "Cluster Illumination Lights" below.

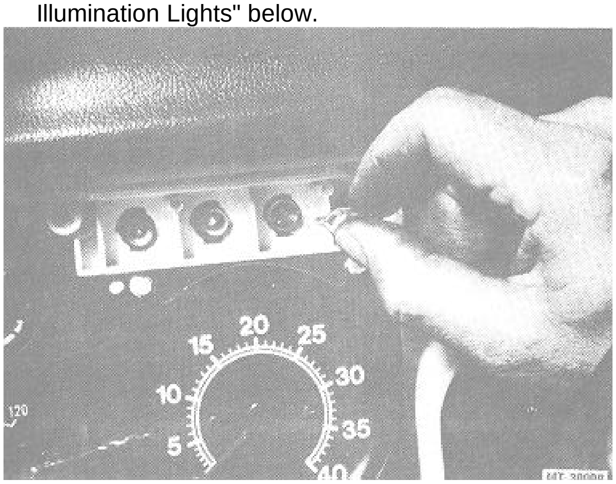

Fig. 12 Removing Bulb from Face of Cluster

3. Insert new bulb into socket.

4. Install instrument cluster cover and screws.

5. Check light operation.

Cluster Illumination Lights: (K, Figure 11)

1. Reaching up in front of instrument cluster, grasp light socket.

2. Turn bulb socket about one-eighth turn clockwise (as viewed from front of vehicle). Pull socket (with bulb) from instrument cluster (Figure 13).

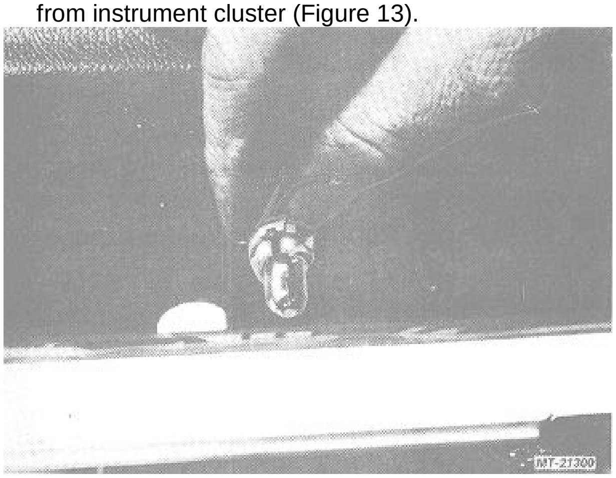

Fig. 13 Removing Bulb and Bulb Socket from Cluster

3. Grasp bulb and pull straight out to remove bulb from socket.

4. Install new bulb in socket.

5. Position socket (with bulb) into instrument cluster and turn socket one-eighth turn counterclockwise (as viewed from front of vehicle) to secure.

6. Check light operation.

DOME LIGHT

BULB REPLACEMENT

(Refer to Figure 14).

1. Pry edge of lens inward to disengage retaining clips. Remove lens.

2. Disengage bulb from terminals.

3. Position new bulb in terminals.

4. Position lens in light assembly and engage retaining clips.

5. Check light operation.

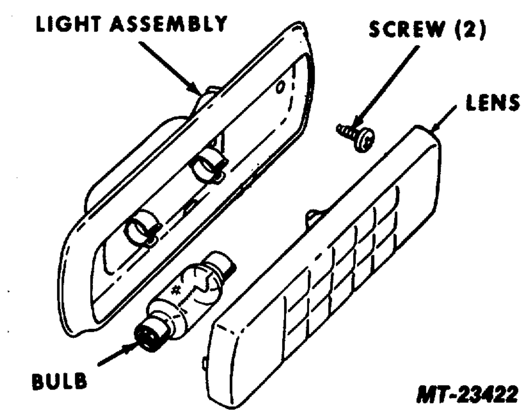

Fig. 14 Dome Light

LIGHT ASSEMBLY REPLACEMENT

1. Pry edge of lens inward to disengage retaining clips. Remove lens.

2. Remove light mounting screws.

3. Pull light assembly away from cab panel to expose wiring cable connector.

4. Disconnect wiring cable from light assembly. Remove light assembly.

5. Connect wiring cable to new light assembly.

6. Position light assembly on cab panel and secure with mounting screws.

7. Check light operation.

FLOOD (CARGO) LIGHT

BULB REPLACEMENT

(Refer to Figure 15)

1. Remove light mounting screws.

2. Pull light assembly away from mounting pad to expose wiring cable connector.

3. Disconnect wiring cable from light assembly. Remove light assembly.

4. Disengage bulb from terminals.

5. Position new bulb in terminals.

6. Connect wiring cable to light assembly.

7. Position light assembly on mounting pad and secure with mounting screws.

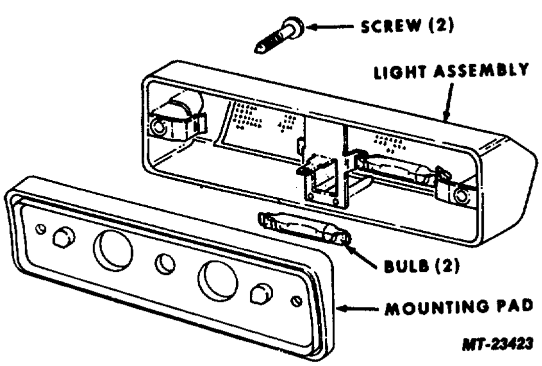

Fig. 15 Flood (Cargo) Light

LIGHT ASSEMBLY REPLACEMENT

1. Remove light mounting screws.

2. Pull light assembly away from mounting pad to expose wiring cable connector.

3. Disconnect wiring cable from light assembly. Remove light assembly.

4. Inspect light mounting pad and replace if damaged or deteriorated.

5. Connect wiring cable to new light assembly.

6. Position mounting pad and light assembly on cab and secure with mounting screws.

7. Check light operation.

TAIL, STOP, REAR TURN SIGNAL, BACK-UP LIGHTS

BULB REPLACEMENT

(Refer to Figure 16)

1. Remove lens mounting screws (4).

2. Pry lens from light assembly.

3. Press bulb in lightly and turn counterclockwise to disengage retaining pins.

4. Pull bulb from socket.

5. Inspect lens and gasket and replace if damaged.

6. Install new bulb as follows:

   a. Align retaining pins with slots in socket. Stop, tail, turn signal bulb has staggered retaining pins to assure correct positioning in socket.

   b. Push bulb into socket and turn clockwise to secure retaining pins.

7. Position gasket and lens in light assembly and secure with screws.

8. Check light operation.

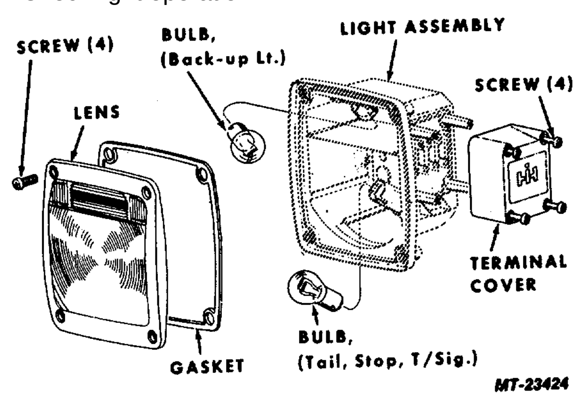

Fig. 16 Tail, Stop, Rear Turn Signal, Back-up Light

LIGHT ASSEMBLY REPLACEMENT

1. If necessary, clean dirt from threads of light assembly mounting studs.

2. Remove nuts and washers (3 each) securing light assembly to mounting bracket.

3. Remove mounting screws (4) securing terminal cover to light assembly.

4. Disconnect wiring harness connector from light assembly.
5. Inspect and clean wiring harness connector terminals. If terminals are badly corroded or damaged, replace connector.

6. To retard corrosion, coat terminals of new lamp assembly and wiring harness with grease.

7. Connect wiring harness terminal connector to light assembly.

8. Install terminal cover on light assembly and secure with mounting screws.

9. Position light assembly on mounting bracket and secure with lock washers and nuts.

10. Check light operation.

INSTRUMENT PANEL CONTROL LIGHT

(Located above headlight switch)

If bulb fails, it will be necessary to replace the light assembly as follows:

1. Remove nine (9) screws and remove instrument panel top cover.
2. If necessary pull light wiring up through hole in top of instrument panel to expose wiring connector.

3. Disconnect light assembly wiring connector from wiring harness connector (Figure 17).

4. Disengage slot of light assembly from lens to remove light assembly (Figure 17). Do not lose lens which can fall out of instrument panel when light is removed.

5. Discard old light assembly.

6. Hold lens into hole in instrument panel and snap new light assembly over lens to retain lens and light assembly.

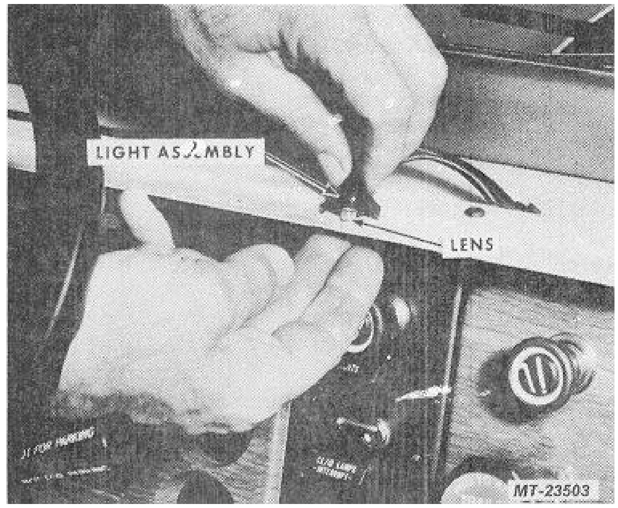

Fig. 17 Instrument Panel Control Light

7. Connect light assembly wiring connector to wiring harness connector.

8. Check light operation.

9. Install instrument panel top cover and retaining screws.

ASHTRAY LIGHT

If bulb fails, it will be necessary to replace the light assembly as follows:

1. Remove ashtray from ashtray housing.

2. Remove mounting screws* from cluster panel holding ashtray (plus radio and auxiliary gauges, where equipped).

   * without radio; 8 with radio. On 2200 series vehicles, 8 without radio, 10 with radio.

3. Tip panel outward to gain access to ashtray light (Figure 18).

4. Disconnect light assembly wiring connector from wiring harness connector.

5. Disengage slot of light assembly from lens to remove light assembly.

   Do not lose lens which can fall out of ashtray housing when light is removed.

   For light assembly and lens relationship, see Figure 17.

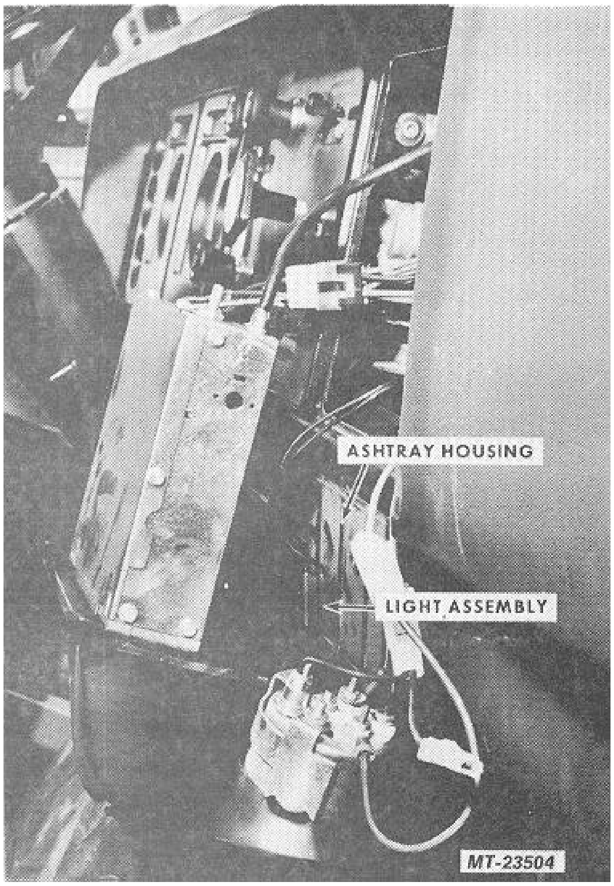

Fig. 18 Ashtray Light

6. Discard old light assembly.

7. Hold lens in hole in ashtray housing and snap new light assembly over lens to retain ions and light assembly.

8. Connect light assembly wiring connector to wiring harness connector.

9. Position cluster panel (with ashtray housing, radio, etc.) on instrument panel and secure with screws.

10. Position ashtray in ashtray housing.

11. Check light operation.

HEATER/AIR CONDITIONING CONTROL LIGHT

BULB REPLACEMENT

1. Remove control assembly mounting screws. Remove trim plate. Pull control assembly outward. It may be necessary to remove ashtray to allow movement of control assembly.

2. Rotate light socket (Figure 19) clockwise (as viewed from rear of vehicle). Pull light socket (with bulb) from control assembly.

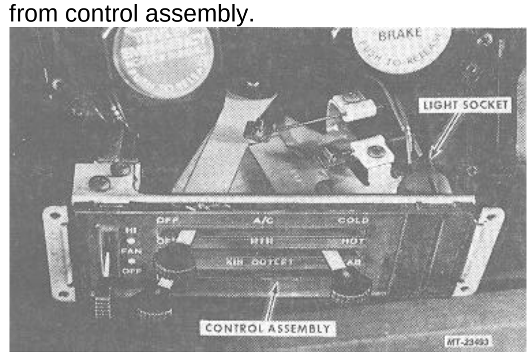

Fig. 19 Heater/Air Conditioning Control Light

3. Grasp bulb and pull straight outward to remove plug-in type bulb from socket.

4. Insert new bulb into socket.

5. Insert light socket into control assembly. Turn light socket to secure in position.

6. Position control assembly in instrument panel and install trim plate and mounting screws.

7. Check light operation.

AUTOMATIC TRANSMISSION CONTROL LIGHT

BULB REPLACEMENT

1. Grasp light socket and disengage socket from hole in control housing. DO NOT pull on wire to remove socket. (See Figure 20).

   In some cases it may be necessary to loosen control assembly left support bracket bolts to permit removal of light socket.

2. Press bulb in lightly and turn counterclockwise to disengage retaining pins.

3. Pull bulb from socket.

4. Install new bulb as follows:

   a. Align retaining pins with slots in socket.

   b. Push bulb into socket and turn clockwise to secure retaining pins.

5. Insert light socket into hole in control housing and push inward until retaining clips "snap" into position securing socket.

6. Tighten support bracket bolts (if loosened to permit light removal).

7. Check light operation.

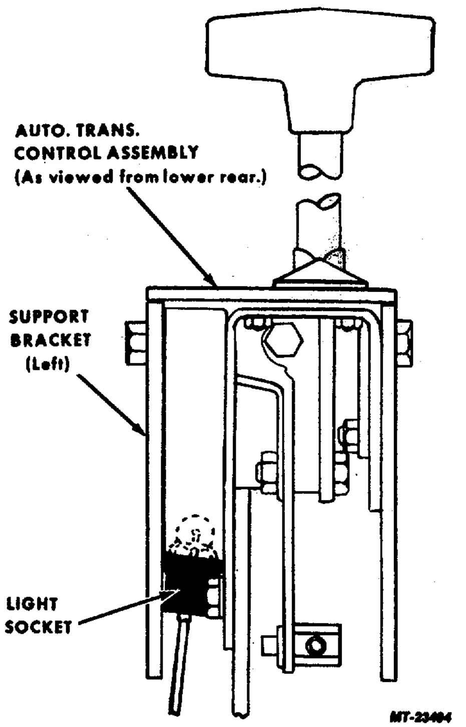

Fig. 20 Automatic Transmission Control Light

CONTROL IDENTIFICATION OR WARNING LIGHTS

(Engine Stop, Front Axle)

If bulb fails, it will be necessary to replace the light assembly as follows:

1. Pry old light assembly out of slot in instrument panel. Be careful not to scratch finish of instrument panel.

2. Disconnect light assembly from wiring harness.

3. Discard old light assembly.

4. Connect new light assembly to wiring harness.

5. Position light assembly into slot in instrument panel. Push light assembly inward until retaining tangs "snap" into position securing light to instrument panel.

6. Check light operation.

AUXILIARY GAUGE ILLUMINATION LIGHT

(Engine Oil Temperature. Transmission Oil Temperature)

BULB REPLACEMENT

1. Remove mounting screws* from cluster panel holding radio, ashtray and auxiliary gauge(s).

   * 6 without radio; 8 with radio. On 2200 series vehicles, 8 without radio; 10 with radio.

2. Tip panel outward to gain access to instrument (Figure 21).

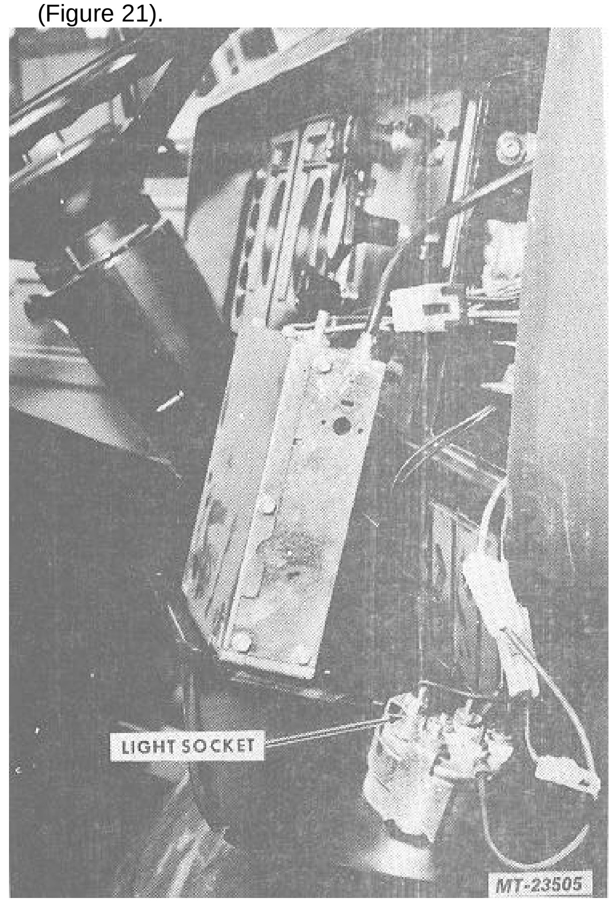

Fig. 21 Auxiliary Gauge Illumination Light (Typical)

3. Disconnect light socket from instrument.

4. Press bulb in lightly and turn counterclockwise to disengage retaining pins.

5. Pull bulb from socket.

6. Install new bulb as follows:

   a. Align retaining pins with slots in socket.
   b. Push bulb into socket and turn clockwise to secure retaining pins.

7. Insert light socket (with bulb) into instrument.

8. Position cluster panel, with radio, ashtray and gauge(s), on instrument panel and secure with screws.

LIGHT BULB CHART

APPLICATION	CANDLE POWER	TRADE NO.
Headlight	60 Watt (Upper Beam)	6014 (L.H. Dr.) 7002 (R.H. Dr.)
Front Turn Signal	32	1156
Side Marker	2	1895
Clearance-Identification	3	168
Instrument Cluster	2	194
Dome	12	211
Flood (Cargo)	12	561
Tail-Stop-Turn-License	32/3	1157
Back-Up	32	1156
Instrument Panel Controls	0.5	*
Ashtray	0.5	*
Heater/A.C. Control	3	168
Auto. Trans. Control	3	168
Control Identification or Warning Lights	0.5	*
Auxiliary Gauge Illumination	1	53

* Replace light assembly.

FUSE AND CIRCUIT BREAKER PANELS

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DESCRIPTION

All chassis incorporate safety devices to protect electrical wiring and equipment from short circuits or electrical overloads. These protective devices may be fuses, circuit breakers or fusible links.

Fuses

Fuses are designed to pass a given amount of current. The current flow limit is indicated by the rating or "Size" of the fuse (10 ampere, 14 ampere, etc.). Exceeding this limit will cause the fuse to "blow" opening the circuit.

After the cause of the overload is determined and corrected, a new fuse must be installed in the circuit. Do not replace a "blown" fuse with a fuse of higher capacity. To do so may result in damage to electrical components or wiring. Where fuse failure is encountered, correct the cause of the overload and install a new fuse of the originally specified rating.

Fuses for most vehicle wiring circuits are grouped together in a fuse panel (Figure 1). Some fuse panels have removable fuse terminals which can be replaced if damaged. Most fuse panels provide space to install additional fuse terminals if needed for installation of accessory circuits.

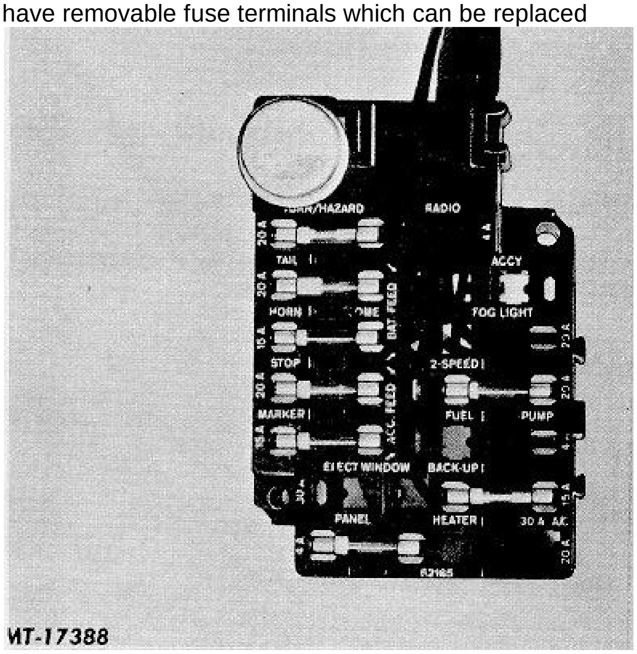

Figure 1 Fuse Panel (Typical)

Locations of fuse panels on various vehicle models are shown in this section.

Circuit Breakers

Circuit breakers are designed to open the circuit any time current demand exceeds the capacity of the breaker. In the event of short or overload, the circuit breaker will open due to excessive heat developed by the higher amperage passing through it. When the heat dissipates, the breaker will close allowing current flow again.

If the cause of the short or overload has not been removed, the circuit breaker will open again to protect the circuit. The current flow limit is indicated by the rating (capacity) of the circuit breaker-15 amperes, 20 amperes, etc. Do not replace a circuit breaker with one of a higher capacity.

Circuit breakers for vehicle wiring circuits are generally grouped together in a circuit breaker panel. Most circuit breaker panels provide space for installing additional circuit breakers if needed for installation of accessory circuits.

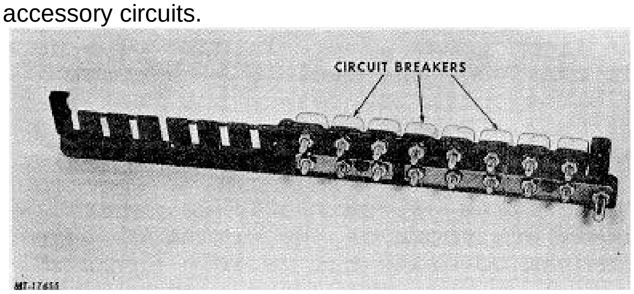

Figure 2 Circuit Breaker Panel (Typical)

Figure 2 illustrates the type of circuit breakers used in heavy duty vehicles equipped with circuit breaker panels. Figure 3 shows another type of circuit breaker which can be used to replace fuses on vehicles equipped with a fuse panel.

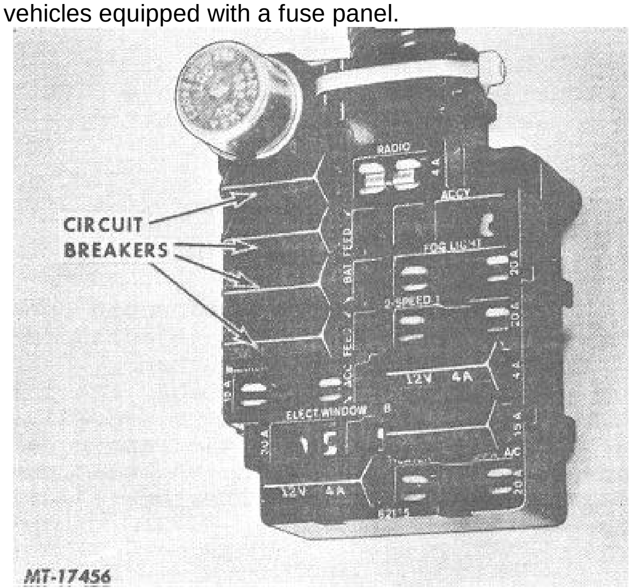

Figure 3 Fuse Panel with Fuse Replacement Type Circuit Breakers Installed

Locations of circuit breaker panels on various model vehicles are shown in this section.

Fusible Links

A third type of protective device is the fusible link. Fusible links are used to protect the wiring harness in the event of a short in an unfused circuit.

The fusible link consists of a length of light gauge wire. In case of a short or overload, the fusible link opens ("burns out") to protect the rest of the circuit. Repair consists of splicing a new fusible link into the circuit.

Locations of fusible links, where used, are shown on the wiring circuit diagram covering the vehicle involved.

FUSE PANEL AND CIRCUIT BREAKER PANEL LOCATIONS

Illustrated below are locations of fuse panels or circuit breaker panels on various vehicle models. Some heavy duty vehicles are equipped with both a fuse panel and a circuit breaker panel.

Vehicles may have additional secondary or accessory circuits not routed through the fuse or circuit breaker panel. Such circuits are protected by "in line" fuses or remote mounted circuit breakers in the current feed wiring. Refer to vehicle circuit diagrams for fuse or circuit breaker locations.

Scout II

The fuse panel on Scout II vehicles is located at the lower edge of the instrument panel to the left of the steering column as shown in Figure 4.

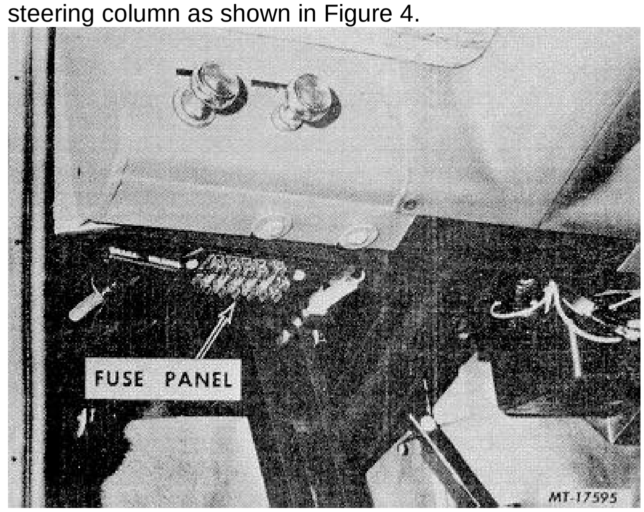

Figure 4 Fuse Panel Location Scout II Vehicles

100, 150, 200, 500 Series and 1600 Thru 1850 Loadstar Series

These vehicles have the fuse panel located to the left of the glove compartment and covered by the glove compartment door (see Figure 5).

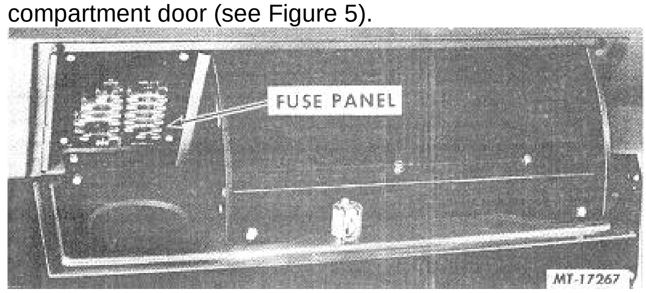

Figure 5 Fuse Panel Location 100, 150, 200, 500 and 1600 Thru 1850 Loadstar Vehicles

1610 Thru 1950 Cargostar Series

The fuse panel is located behind an access door at the right side of the instrument panel on Cargostar vehicles as shown in Figure 6.

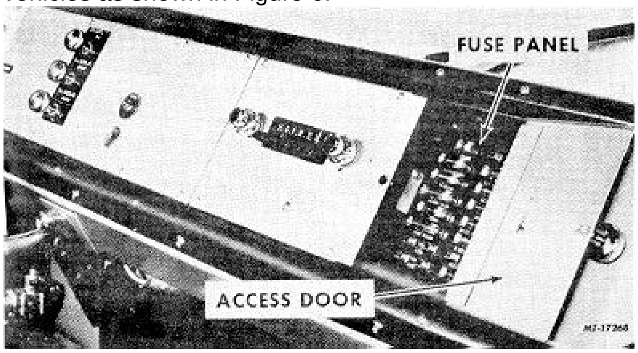

Figure 6 Fuse Panel Location 1610 Thru 1950 Cargostar Vehicles

1900 Thru 2100 Fleetstar Series

The fuse panel is located to the left of the glove compartment and covered by the glove compartment door as illustrated in Figure 7.

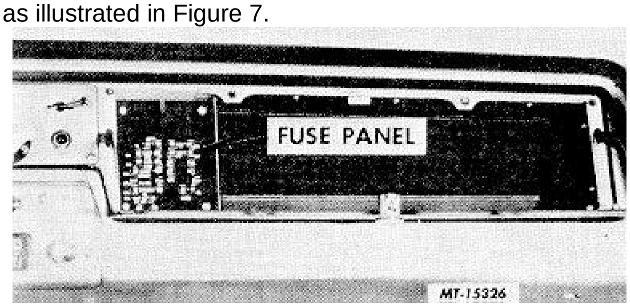

Figure 7 Fuse Panel Location 1900 Thru 2100 Fleetstar Vehicles

Fleetstar vehicles equipped with semi-trailer wiring connections also have a trailer wiring fuse panel located behind the driver's seat at the left rear corner of the cab (Figure 8).

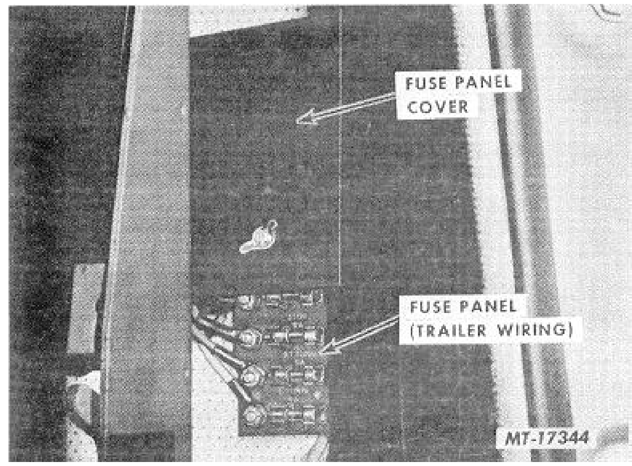

Figure 8 Trailer wiring Fuse Panel 1900 Thru 2100 Fleetstar Vehicles

4070B Transtar II Series

These vehicles are equipped with both a fuse panel and a circuit breaker panel. Both panels are located beneath a hinged access cover at the top center of the instrument panel (see Figure 9 and Figure 10).

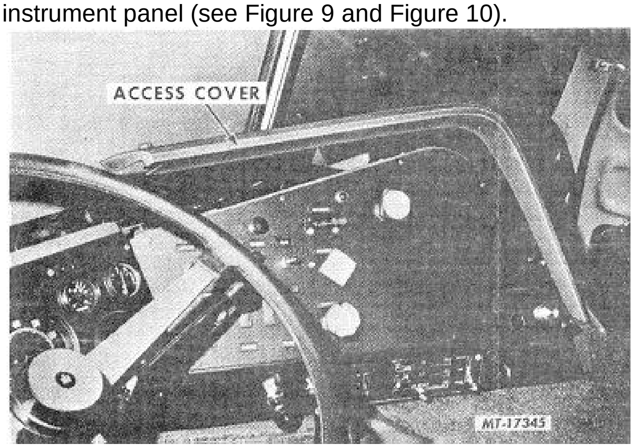

Figure 9 Fuse and Circuit Breaker Panel Access Cover-CO-4070B Transtar II Vehicles

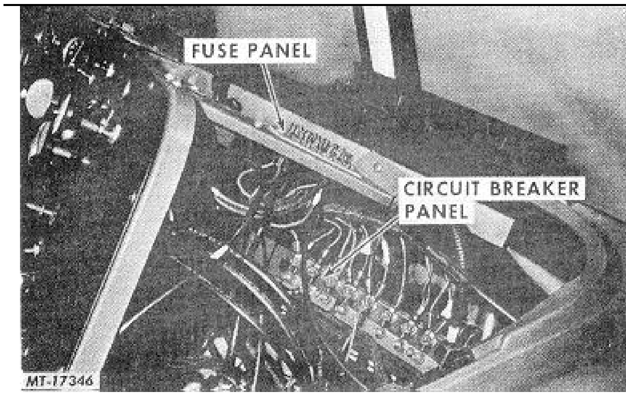

Fig. 10 Fuse Panel and Circuit Breaker Panel Locations - CO-4070B Transtar II Vehicles (Access Cover Removed for Illustration)

<u>4200, 4300 Transtar Conventional Series and 5000 Paystar Series</u>

On these vehicles, the fuse panel and circuit breaker panel are located beneath a hinged access cover at the right side of the instrument panel (Fig. 11).

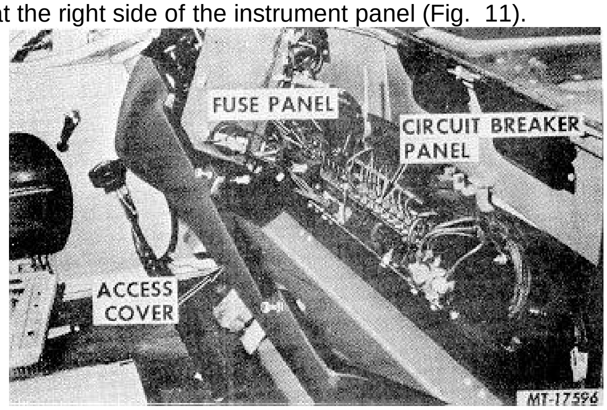

Fig. 11 Fuse Panel and Circuit Breaker Panel Locations- 4200, 4300 Transtar Conventional and 5000 Paystar Vehicles.

<u>CO-5370 Series</u>

The fuse and circuit breaker panels on these vehicles are located behind an access door at the right center of the instrument panel (Fig. 12).

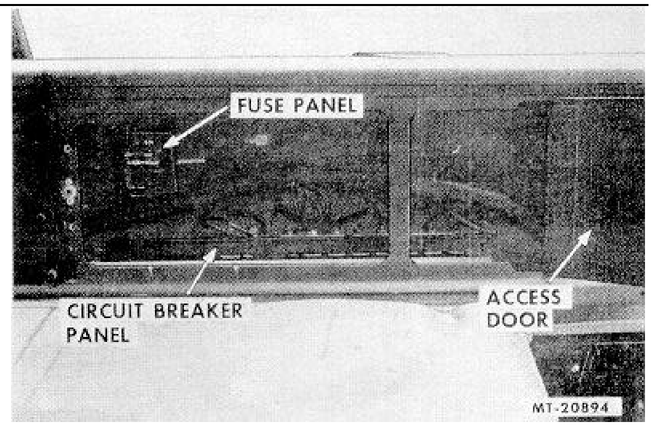

Fig. 12 Fuse Panel and Circuit Breaker Panel Locations - CO-5370 Vehicles

<u>S-Series</u>

The fuse panel is located at the upper left corner of the dash panel (above the clutch pedal) on S-Series vehicles (Fig. 13).

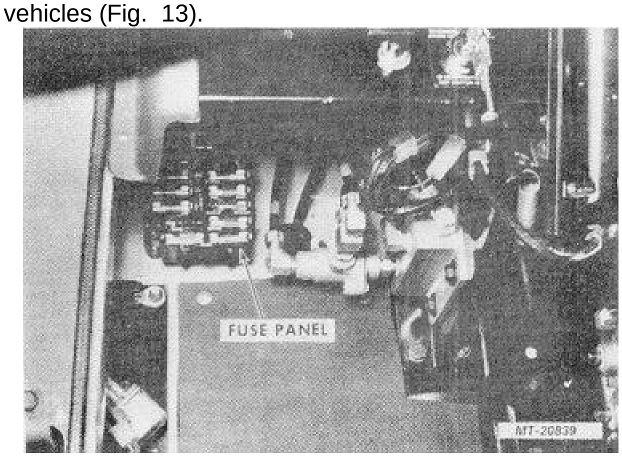

Fig. 13 Fuse Panel Location-S-Series Vehicles

S-Series vehicles equipped with trailer wiring connections also have a trailer wiring fuse panel located behind the driver's seat at the left /rear corner of the cab (Fig. 14).

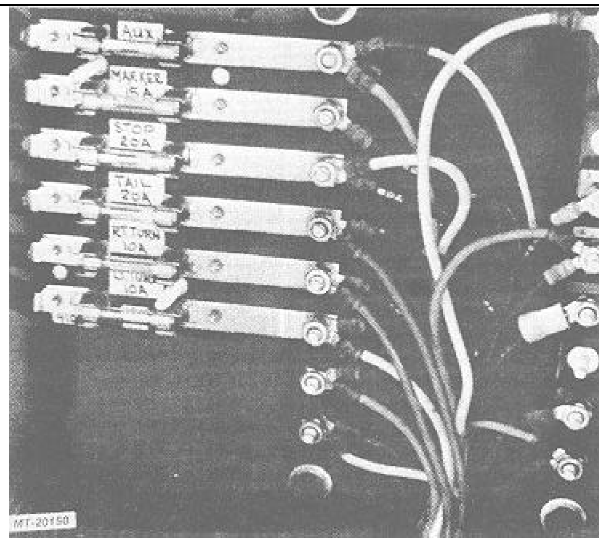

Fig. 14 Trailer Wiring Fuse Panel-S-Series Vehicles

SPARK PLUGS

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REMOVAL

When removing the spark plugs from the engine, certain items should be remembered:

1. When disconnecting ignition cables from spark plugs, do not pull on cables but grasp the cable boot and carefully pull. To pull on cable may break the conductor in the resistor-type cable.

2. Observe location and routing of cables to avoid incorrect installation. Special attention should be given in routing spark plug cables, as cross fire (carburetor spit-back), rough operating engine, or short plug life will result if incorrect wire routing is encountered. If an engine is suspected of incorrect wire routing, compare wires with an engine which is known to be correct. NOTE: Cross fire is most likely to occur on a V-8 engine between consecutively firing cylinders when these cylinders are located on the same bank.

3. After loosening each plug about two turns, blow out any accumulation of dirt around the base of plugs with compressed air. This prevents debris falling into cylinder combustion chambers when plugs are removed.

INSPECTION

Discussed in the following paragraphs are various instructions pertaining to different spark plug appearances and possible causes of their defects.

Preliminary Examination

If spark plugs in question reveal cracks, worn electrodes or other obviously unsatisfactory conditions, they should not be used again.

Gaskets

If the spark plug gaskets are not compressed, Fig. 1, it is an indication that the plugs have not been properly tightened to prevent blow-by between the spark plug and cylinder head. This condition results in excessive burning of the electrodes and overheats the insulator tip, which may cause preignition.

If the gaskets are flattened or compressed to a point where they have become distorted (out of round) or torn, Fig. 2, it is an indication that the spark plugs have been tightened to the extent that damage may have been inflicted on the plug itself.

Excessive torque will cause strain on the steel shell of the spark plug and result in cracked insulators, distortion of metal shell and gap setting, as well as blow-by between the component parts of the plug.

If the gasket is properly compressed (approximately one-half of the original thickness) showing a flat, clean, even surface, Fig. 3, it indicates that the spark plugs were properly installed.

Spark Plug Appearances

Deposits normally occur in distinct bands on insulator. The tip deposits near the electrodes are the ones which may affect spark operation. If they become conductive, their "shunt resistance" is said to drop, and the plug is short circuited.

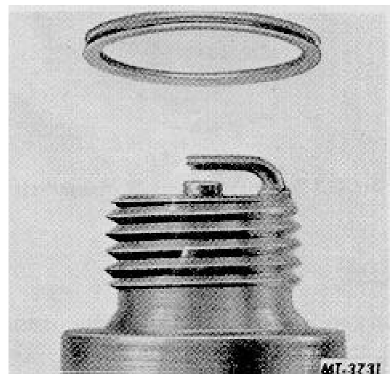

Fig. 1 Not Properly Tightened (Gasket Not Compressed)

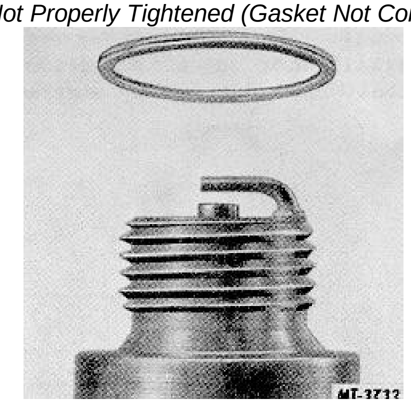

Fig. 2 Overtightened (Gasket Distorted)

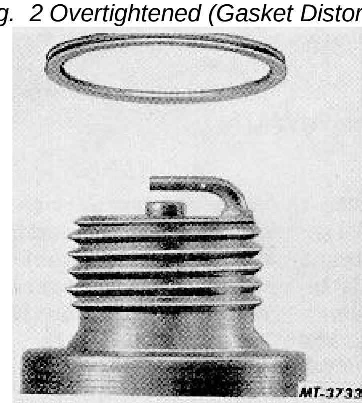

Fig. 3 Properly Torqued

Normal Conditions

Normal conditions are shown in Fig. 4. The plug shown has been running at the correct temperature. The deposits present will be light tan or gray in color with most regular grades of commercial gasoline; if LPG is used, the color will be predominately brown.

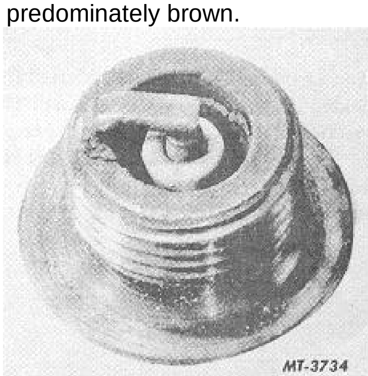

Fig. 4 Normal Spark Plug Appearance

Core Bridging

Core bridging, Fig. 5, will be encountered only rarely in automotive engines. Deposits accumulated after a long period of misfiring may be suddenly loosened when normal combustion temperatures are restored upon installing new spark plugs. During a high-speed run these materials shedding off the piston are thrown against the hot insulator surface.

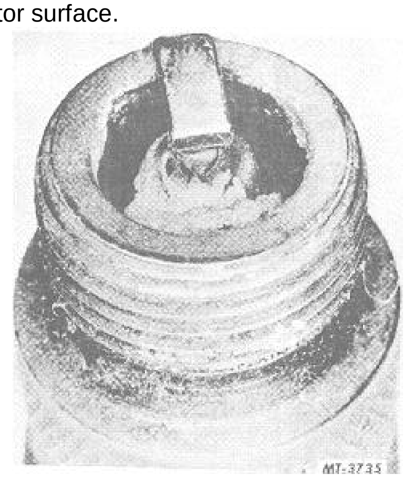

Fig. 5 Core Bridging

This action forms a bridge between the insulator and shell, resulting in a "dead short." Such evidence of excessive combustion chamber deposits will be most common where oil control is poor or where vehicles are usually driven in slow speed, start-stop service. In such instances it usually pays to physically remove accumulated deposits from the engine.

Cold Fouling

Cold fouling or carbon deposits are illustrated in Fig. 6. This dry, black appearance usually means that the next hotter plug should be substituted. However, if only one or two plugs in a set are fouled, check for sticking valves or bad ignition leads. Fouling of the entire set may be caused by a clogged air cleaner, a sticking heat riser or a faulty choke.

Fig. 6 Cold Fouling

Overheating

Overheating, illustrated in Fig. 7, is indicated by a dead white or gray insulator which appears "blistered." Electrode gap will be considerably worn. This suggests that a cooler heat range should be used; however, over advanced ignition timing, detonation and cooling system stoppages can also overheat the correct spark plug heat ranges.

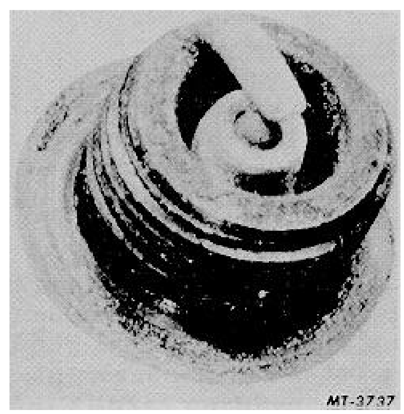

Fig. 7 Overheating

Turbulence Burning

Turbulence burning, shown in Fig. 8, causes electrodes to wear away on one side. This is the result of normal turbulence patterns in the combustion chambers of certain engines. It can be ignored if normal plug life is being obtained. If gap growth appears excessive, review the corrective measures suggested under "Overheating."

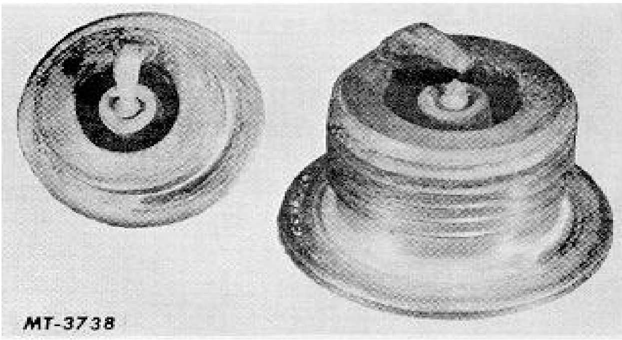

Fig. 8 Effects of Turbulence Burning

Wet Fouling

Wet fouling, shown in Fig. 9, illustrates that the plug has drowned in excess oil. In an old engine, suspect worn rings or excessive cylinder wear. In OHV engines too much oil may be coming in past the valve guides. Also, depending on cylinder location, this fouling can suggest a leaking vacuum booster pump diaphragm. Use of a hotter plug may relieve such fouling, but plugs can't take the place of needed engine overhaul. Remember that plug fouling in new engines may occur before normal oil control is achieved. In new or recently overhauled engines such fouled plugs can be cleaned and reinstalled.

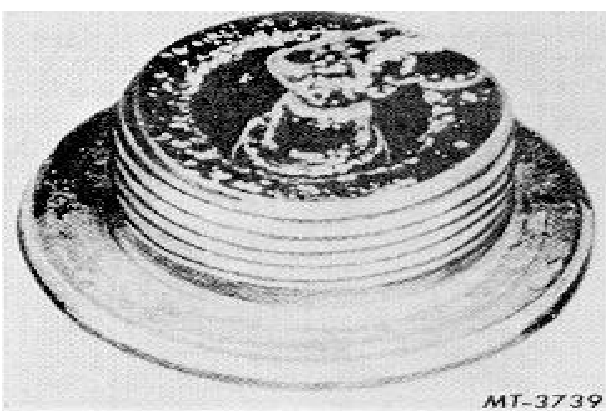

Fig. 9 Wet Fouling

Silica Deposits

Silica deposits, illustrated in Fig. 10, are hard and scratchy. This material is largely lead silicate formed when fine sand particles (silicate) combine with the anti-knock compounds in the fuel. It's most common in trucks operating in dusty areas or in sand loading operations. Such plugs cannot be cleaned. Always check for intake manifold leaks and see that the air cleaner on the engine is in good condition

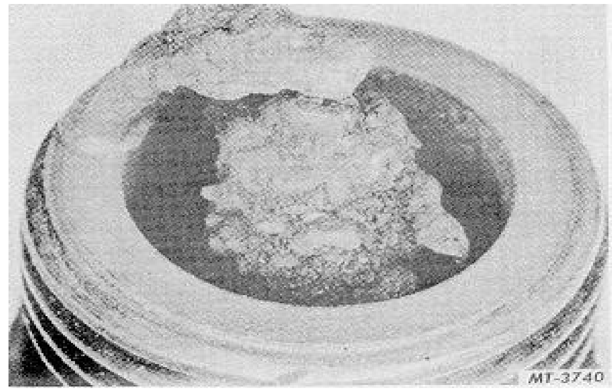

Fig. 10 Silica Deposits

Fuel Scavenger Deposits

Fuel scavenger deposits shown in Fig. 11 may be white or yellow in color. They may appear to be bad, but this is a normal appearance with certain brand fuels. Such materials are designed to change the chemical nature of deposits to lessen misfire tendencies. Notice that accumulation on the ground electrode and shell areas may be unusually heavy, but the material is easily flaked off. Such plugs can be considered normal in condition and can be cleaned with standard procedures.

Fig. 11 Fuel Scavenger Deposits

Sustained Preignition Damage

Sustained preignition damage, illustrated in Fig. 12, usually involves melting of the ceramic firing tip. Since this requires temperatures about 2700°F, other components of the engine may also have been damaged by preignition. This is another sure sign that a careful inspection of the engine and its adjustments is required.

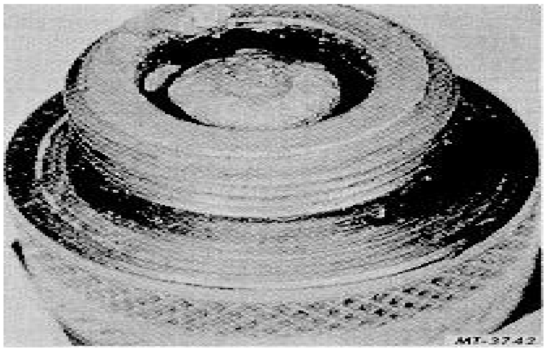

Fig. 12 Sustained Preignition Damage

Chipped Insulator

The chipped insulator shown in Fig. 13 results from bending the center electrode during regapping of the plug. Under certain conditions severe detonation can also split insulator firing ends. Obviously, the plug must be replaced.

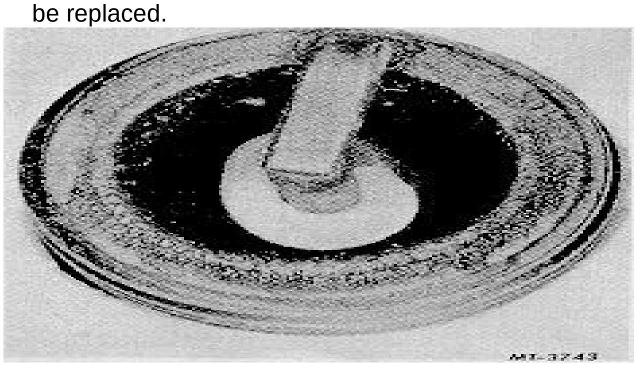

Fig. 13 Chipped Insulator

Mechanical Damage

Mechanical damage to plug shown in Fig. 14 is caused by a foreign object in the combustion chamber. Small objects can travel from one cylinder to another (because of valve overlap). Be sure to check the other cylinders to prevent recurrence of damage. When working on an engine, be certain the carburetor throat and spark plug holes are kept covered.

Fig. 14 Results of Mechanical Damage

Reversed Coil Polarity

Reversed coil polarity can often be detected by "dishing" of the ground electrode. Note in Fig. 15 that the center electrode is usually not worn badly. This source of misfiring and rough idle can be corrected by reversing the primary coil leads.

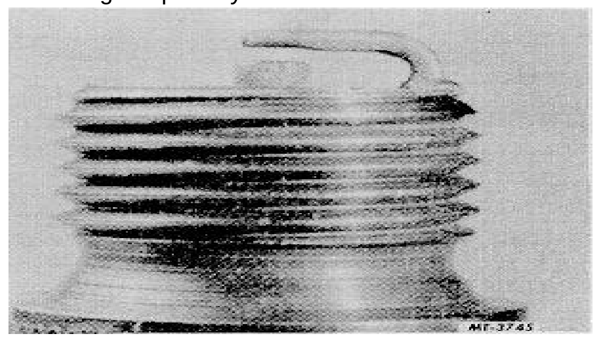

Fig. 15 Reversed Coil Polarity

Spark Plug Gap Tools

Pressure-type (plier) gap tools, if improperly used, impose a tremendously high unit pressure on the center electrode (Fig. 16). This is because of compression being exerted between the end of the center electrode and the top of the shell. If too much force is applied through leverage multiplication, the center electrode seal on any type or brand of spark plug is likely to be damaged. The conventional type gap tool, which should only contact the ground electrode, is less likely to damage the plug.

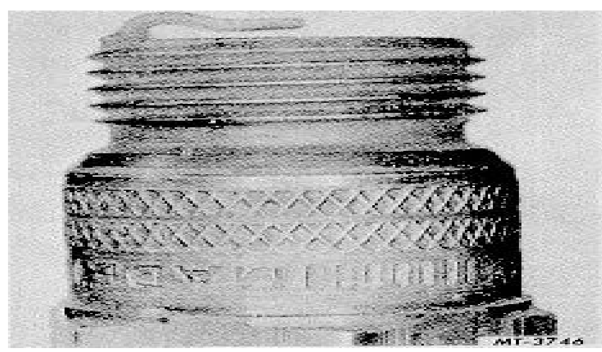

Fig. 16 Damage to Spark Plug from Pressure (Plier) Type Gap Tools

Condition of Electrodes

The extent of service and mileage to which a spark plug has been subjected is generally best indicated by the degree of wear of the electrodes, Fig. 17. When the center electrode has become worn away or the ground electrode has become so badly eroded at the sparking area that resetting of the gap is either difficult or impossible, the spark plug is not fit for further efficient engine service--even if cleaned.

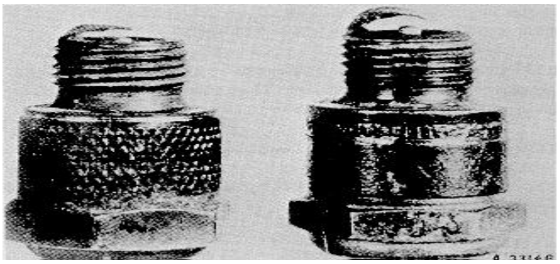

Fig. 17 Condition of Electrodes

CLEANING AND SETTING

Remove spark plug gaskets if plugs are to be cleaned.

Remove oily deposits from both firing end and outside surface of plug using a commercial cleaning solvent which dries quickly. Failure to remove oil from spark plugs will result in cleaner abrasive packing inside the firing end of spark plug if an abrasive type cleaner is used.

Use the instructions provided with the liquid spark plug cleaner and tester (SE-2190) and be sure the plugs are thoroughly dry before testing.

If an abrasive type plug cleaner is used, be sure the spark plugs are free of abrasive material before testing.

Pass a thin point file between center and ground electrodes to smooth up both surfaces.

Reset gap by moving ground side electrode only. Do not touch center electrode, as insulator tip fracture may result. Bend ground electrode toward center electrode.

Using a wire feeler gauge, gap plugs to specifications. A very slight drag should be felt when feeler gauge passes between electrodes.

Use the instructions provided with the tester to check spark plugs.

NOTE: Never assume you are simulating cranking compression when using the tester. Air pressure in a bench tester has no direct relation to engine compression for the following reasons:

1. There are no temperature effects in the bench test. Heated electrodes within warm cylinders in an engine require less voltage than under a cold bench test.

2. There is no fuel/air charge in the bench tester.

3. Since spark plug firing is dependent on engine timing, firing of the spark plugs is not always at the point of maximum compress ion.

4. There is no cylinder turbulence in the tester pressure chamber.

Because of these variables, the bench test, while useful, cannot be measured by any specific psi readings.

HEAT RANGE

Spark plug heat range is the primary factor governing spark plug performance under various service conditions. The term "heat range" simply refers to the classification of spark plugs according to their ability to transfer heat from the firing end of the plug to the cooling system of the engine.

The rate of heat transfer, or heat range, is controlled basically by the distance between the inside gasket seat and the insulator tip.

A "cold" type plug, Fig. 18, has a relatively short insulator nose and transfers heat very rapidly into the engine's cooling system. Such a plug is used in heavy-duty or continuous high speed operation to avoid overheating.

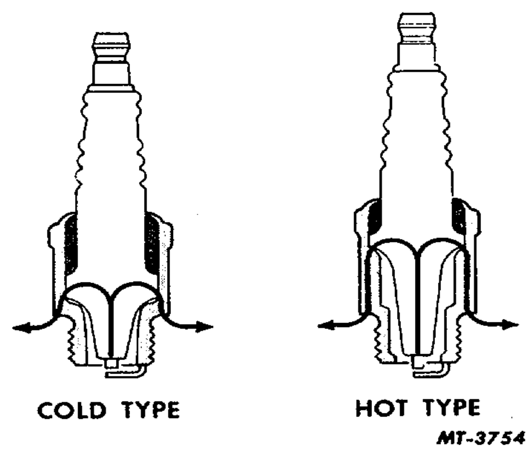

Fig. 18 Construction and Heat Flow of "Hot' and "Cold" Plugs

The "hot" type plug, Fig. 18, has a much longer insulator nose and transfers heat more slowly away from its firing end. Thus, it runs hotter and burns off combustion deposits which tend to foul the plug during prolonged idle or low-speed operation.

INSTALLATION

When installing spark plugs, always be sure gasket seats and threads are clean.

Using a torque wrench, tighten plugs to 28-30 ft. lbs.

BOOSTER GAP PLUG

For the past several years auxiliary gap (Booster Gap) spark plugs have been used in certain IH engines

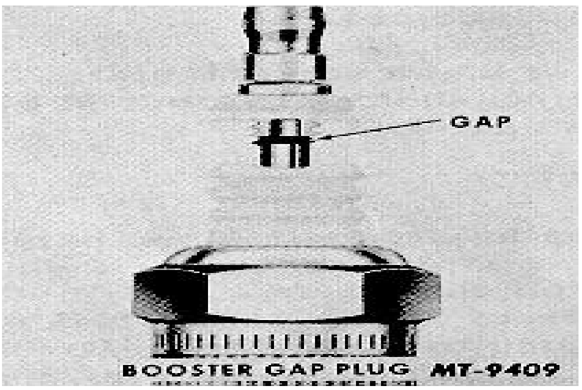

Fig. 19

Prior to IH approval, the Booster Gap design was thoroughly tested and evaluated, at which time their anti-fouling characteristics were firmly established.

What is a Booster Gap plug?

This plug has an internal air gap between the center electrode and the terminal stud.

How do they work?

Most servicemen know that misfire will occur when a conventional spark plug is fouled. As the coil attempts to build up voltage on the "dirty" firing end, it "sees" an easier path to ground over the deposits. This short circuit prevents normal voltage buildup. The Booster Gap, however, isolates the coil from the fouling deposits, allowing near normal voltage build-up. The instant the Booster Gap sparks, sufficient voltage appears across the firing gap and normal ignition results. When you remove a plug wire from a fouled plug and let the spark jump from the cable to the plug terminal to make the plug fire, you are using this same Booster Gap principle.

Where are Booster Gap plugs used?

Maximum benefit from this design is obtained in engines that operate over a wide load and speed range. For example, a heat range cool enough for highway service will have better fouling protection during stop-start city delivery service with the Booster Gap.

Furthermore, the Booster Gap has been instrumental in reducing the complaints of "breakin fouling" in new engines.

In many cases misfire due to oil fouling in older engines can be relieved simply by using the recommended heat range plug incorporating a Booster Gap.

A cure-all?

Not at all. Booster Gap plugs used where recommended and applicable to help solve fouling problems will give excellent results. However, the need for the correct selection of plugs in the proper heat range based on type of vehicle operation is important.

Where more severe conditions of fouling as a result of light service application or breakin fouling on engines occurs, the alternate recommended hotter type plug with Booster Gap should be used.

Voltage Requirements

While nominal in amount, the Booster Gap does require more voltage initially than conventional spark plugs. This higher requirement diminishes, however, after several thousand miles of use.

Most any ignition system has more than adequate reserve to supply the bit of extra voltage requirement; if you experience misfiring with Booster Gap plugs and not with conventional plugs, chances are the ignition system is marginal.

It should also be pointed out that Booster Gap plugs are not resistor plugs. If radio interference is a problem on older vehicles having non-resistor ignition cables, it may be necessary to install resistance leads (cables). Booster Gap plugs may be used in conjunction with resistance-type ignition cables to obtain interference suppression and still obtain the added benefits of the Booster Gap. This is the combination that is recommended on all gasoline-powered motor truck engines.

STARTING MOTOR

ENCLOSED SHIFT LEVER TYPE

HEAVY DUTY

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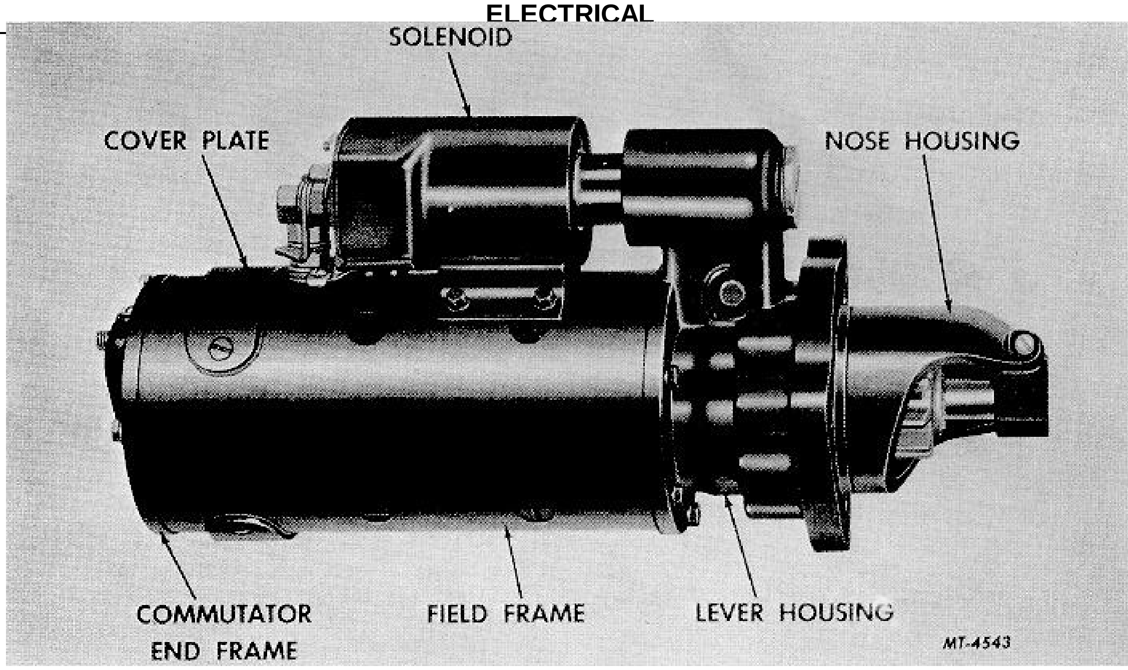

Fig. 1 Heavy Duty Starting Motor with Enclosed Shift Lever

DESCRIPTION

Heavy duty, enclosed shift lever type starting motors are designed to protect the shift lever and solenoid plunger from dirt, road splash and icing conditions.

The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange, which permits a variety of mounting applications.

NOTE: Be sure to mark the location of the nose housing in some manner to assure porper location of nose housing-to-lever housing upon reassembly of starting motor.

Either the intermediate duty or the heavy duty overrunning type sprag clutches may be used on the heavy duty starting motors with the enclosed shift lever. Both types of clutches are shifted into mesh with the flywheel ring gear by action of the solenoid. When the drive

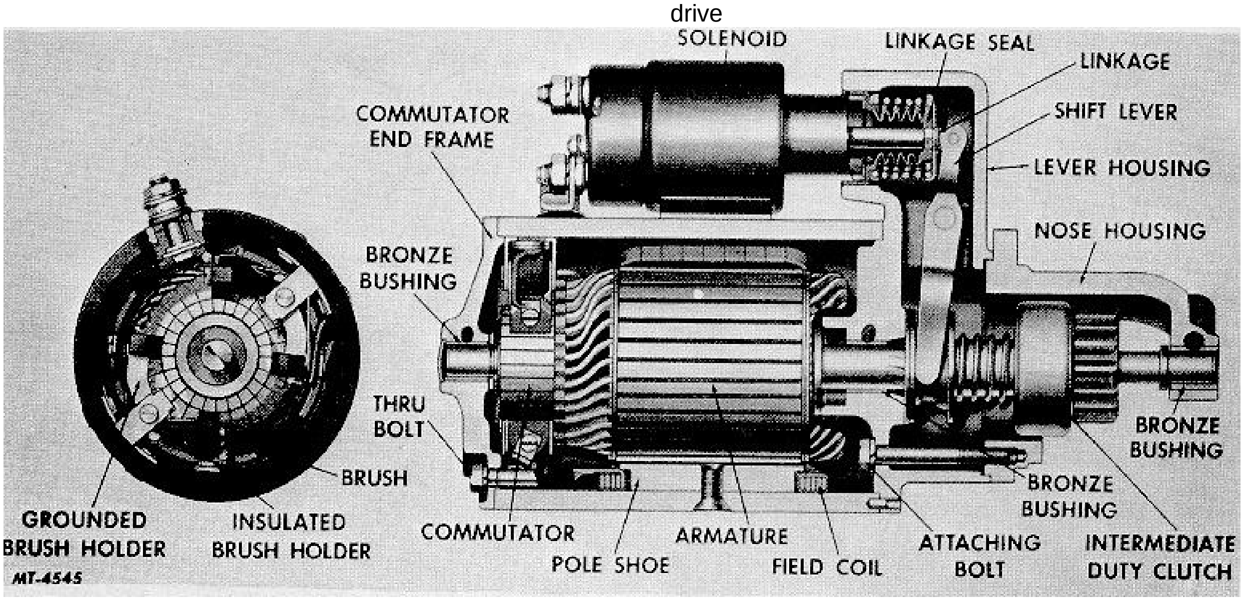

Fig. 2 Sectional View of Starting Motor with Intermediate Duty Clutch

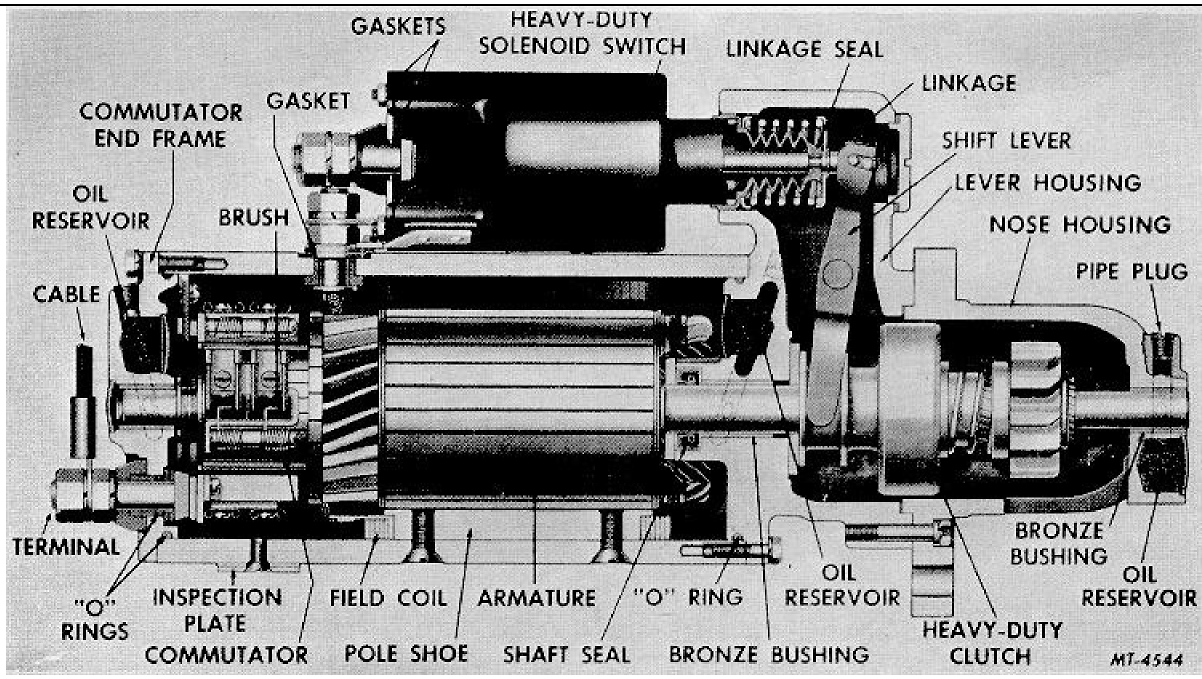

Fig. 3 Sectional View of Starting Motor with Heavy Duty Sprag Clutch

pinion is engaged with the flywheel, the pinion will not be permitted to disengage until the engine has started and the solenoid circuit is interrupted.

Some of the heavy duty starting motors feature a seal between the shaft and lever housing, and all of the heavy duty starting motors with the enclosed shift lever have a rubber boot or linkage seal over the solenoid plunger. These seals prevent the entry of dirt and oil into the motor main frame.

LUBRICATION

Lubrication is provided for the bronze bushings located in the commutator end frame, lever housing and the nose housing, by an oil saturated wick that projects through each bushing and contacts the armature shaft. Oil can be added to the wicks by removing the pipe plugs.

The starting motor should be lubricated whenever it is disassembled with SAE10 oil. All the wicks should be saturated, reservoirs filled and the splines underneath the clutch should be lubricated with a light coat of oil.

Some of the starting motors are equipped with a large oil reservoir for each wick, also "O" rings are used at various locations to resist entry of dirt and moisture. The starting motors which utilize the large oil reservoirs and the "O" ring are called "long life motors".

MAINTENANCE

On chassis operating under normal conditions no maintenance to these starting motors will be required. When the engine is overhauled the starting motor should be disassembled, inspected, cleaned, tested and any repairs made.

TROUBLE SHOOTING THE STARTING CIRCUIT

When trouble develops in the starting motor system, and the starter motor cranks the engine slowly or not at all, several preliminary checks can be made to determine whether the trouble is in the battery, starting motor, wiring circuit between them, or elsewhere. Many conditions besides defects in the motor can result in poor cranking performance.

To obtain full performance from a starting motor or to determine the cause of abnormal operation, the motor should be subjected to one or more of the following tests. These tests are performed with the starter motor removed from the engine. Failure of the motor to perform according to the specifications will require disassembly and further checks or adjustments made.

> NOTE: All starting motor tests should be made with engine and battery at room temperature (not cold).

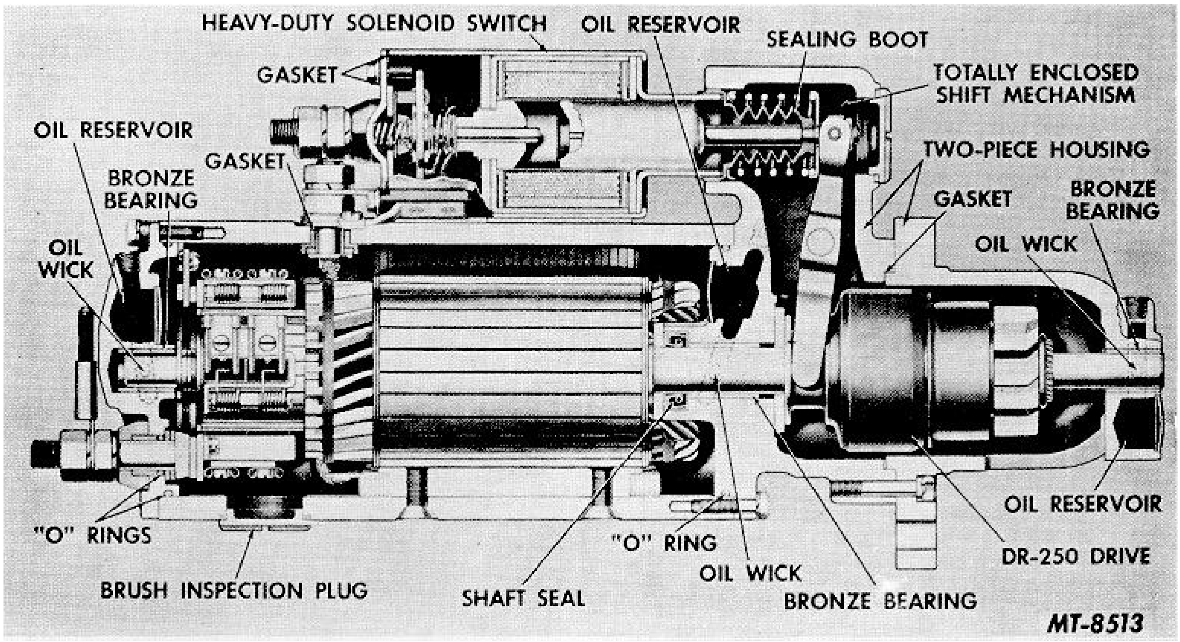

Fig. 4. Sectional View of Starting Motor with DR-250 Heavy Duty Drive

Regardless of the construction, never operate the starting motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating caused by excessive cranking will seriously damage the motor.

For the most part a volt-ampere tester (SE2283) will be used in performing the starter tests and the instruction manual supplied with the tester will provide the detailed instructions using the volt-ampere tester.

NOTE

All illustrations of starting motor and circuit tests show leads connected for NEGATIVE grounded system. Reverse the positions of the leads when testing a POSITIVE grounded system. Make sure the volt selector switch on the volt-ampere tester is positioned properly for the voltage system being inspected.

Test No. 1 -- Cranking Voltage Test

This test tells us the overall condition of battery, starter, cables or switches to determine if sufficient voltage is available to operate ignition system when starter is in operation.

Connect voltmeter leads at the starter observing the polarity, Fig. 5. Disconnect secondary coil lead to prevent engine from starting. Crank engine noting voltmeter reading (should be 9.6 volts or better with 12-volt electrical system).

If a reading of less than 9.6 volts is found, proceed to the next test.

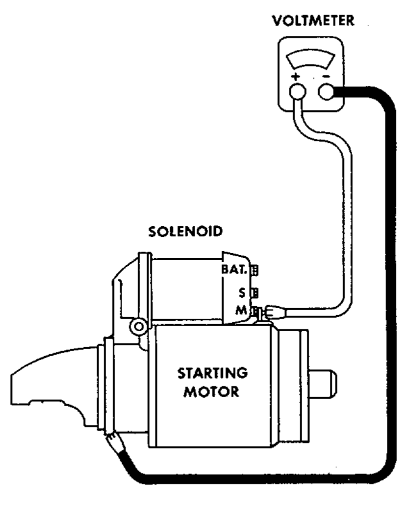

Fig. 5. Cranking Voltage Test

Test No. 2 -- Battery Capacity Test

The battery capacity test is performed to determine if the battery is in satisfactory condition. See "Battery" Section B. If the battery passes this test, continue the next test.

Test No. 3 -- Voltage Drop Test

Generally, the starting or cranking circuit is a series circuit from the battery insulated post to the starting motor solenoid, to the motor, to ground (chassis) and return to the battery ground post, Fig. 6.

In the cranking circuit we also have a cranking control circuit, Fig. 6. In this circuit the solenoid is controlled or operated by closing an ignition switch or push button starting switch at the instrument panel. In this cranking control circuit there are frequently some safety switches such as transmission "neutral safety switch" and/or vacuum-operated cutout switch.

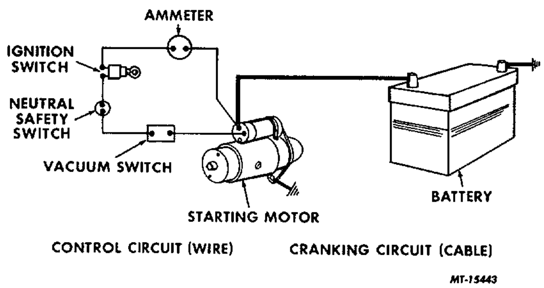

Fig. 6. Starting Motor Circuit

Excessive resistance in the starting or cranking system circuit will cause slow cranking speeds and hard starting. The starting system will function properly only when the "cranking circuit" and "control circuit" with the components are in satisfactory condition. Corrosion, loose terminal, damaged or undersized cables (wires) will cause cranking problems. In addition, the switches involved must make good electrical connections when closed.

The voltage drop test will be performed in three steps: cranking circuit, control circuit and grounded side.

Cranking Circuit: Voltage drops are measured by connecting a voltmeter in parallel across the circuit or section of a circuit being inspected, then reading the voltmeter while circuit is in operation. To test voltage drop in the cranking circuit from battery to starter, connect the voltmeter (observing the polarity and voltage rating of meter) to battery post (not clamp) to starter motor terminal as shown in Fig. 7. Prevent engine from starting during test. Crank engine and observe voltmeter reading.

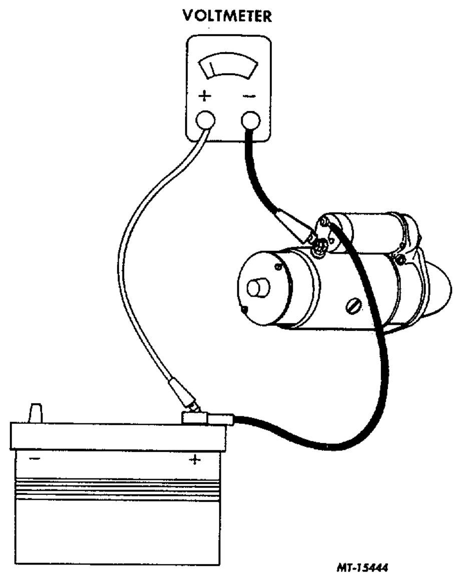

Fig. 7. Cranking Circuit Test

Values of maximum voltage drops for a standard 12-volt cranking circuit are as follows:

	Volt
Cable Under Three (3) Feet	.1
Cable Over Three (3) to Six (6) Feet	.2
Mechanical Switch	.1
Solenoid Switch	.2
Magnetic Switch	.3
Each Connection	.0

Add these values together. For example, you have a total of .5 volt and you have less than .5 volt drop, continue to grounded side test.

However, if you have more than .5 volt drop, you have an excessive voltage drop. This must be located by moving test lead from starting motor and working toward the battery. Crank engine and each move. When a noticeable decrease in the voltage reading is obtaine4 the trouble will be located between that point and the preceding point checked. Items which could be at fault can either be a damaged cable or poor connection, an undersized wire or possibly a bad solenoid (contact within the solenoid). Repair the fault.

Grounded Side: High resistance in ground circuit of starting motor system will result in hard starting and may affect the charging circuit as well.

Connect voltmeter leads to ground on starting motor and to ground post of battery. The allowable voltage drop of .2 volt is permissible. If more than .2 volt is obtained, a poor ground is present, such as a loose starting motor mounting bolt, bad battery ground connector or ground connection to engine or frame, depending upon the battery installation. The excessive voltage drop is located in much the same manner as in the preceding test working toward the battery.

Control Circuit: High resistance in the control circuit will reduce the current flow through the solenoid windings, which can cause improper function of solenoid or not at all. Improper functioning of the solenoid could result in burning of contacts in the solenoid causing high resistance in the starting motor circuit.

To complete control circuit test, check the vehicle circuit diagram to assist in locating the wires and particular switches involved in the chassis. Observe polarity of voltmeter and connect leads to battery post and solenoid switch terminal as shown in Fig. 8. Crank engine using the vehicle ignition switch or push button if equipped observing the voltmeter reading. If the voltmeter shows less than .5 volt, the circuit is in good condition. If more than .5 volt, this is an indication of excessive resistance. However, with experience, slightly higher voltage loss will be found and will be normal.

Isolate the point of high resistance by placing the voltmeter leads across each component in the circuit in turn. A reading of more than .1 volt across any one wire or switch is usually an indication of the trouble.

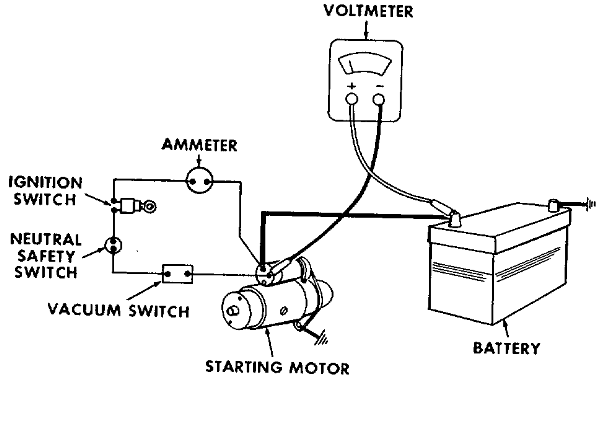

Fig. 8. Control Circuit Test

After completing the cranking voltage test, battery capacity test and the voltage drop tests, and the starting motor still fails to function, remove the motor and make the no load test as follows.

Note that the preceding tests were made in the particular order to make certain the starting motor circuit is in good condition before needless starter motor removal.

Before performing the "No Load Test" look the motor over. The pinion should be checked to be sure it is free by turning it on the screw shaft. The armature should be checked so that it is free to rotate by prying the pinion with a screw driver. Tight bearing, bent armature shaft or loose pole shoe screws could cause the armature not to turn freely. The motor should be disassembled if the armature does not turn freely. However, if the armature will rotate freely, the next step is to give the motor a no load test before disassembly.

Connect the starting motor in series with a fully charged battery of the specified voltage, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as illustrated in Fig. 9 from the motor terminal to the motor frame. An R.P.M. indicator is necessary to measure armature speed. Obtain the specified voltage by varying the resistance unit, then read the current draw and the armature speed and compare these readings with the values listed in the specifications.

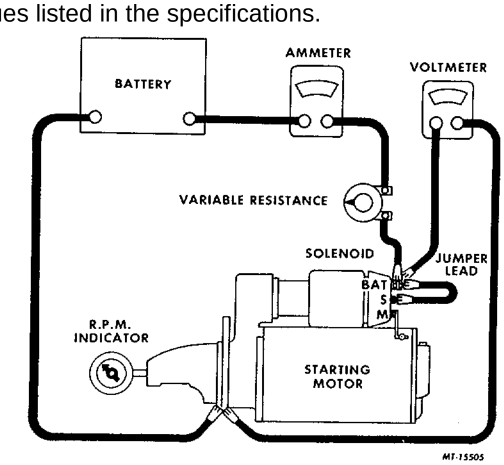

Fig. 9. No Load Test Hookup

DISASSEMBLY

If the starting motor does not perform according to the specifications it will be necessary to disassemble it for further tests of the components.

NOTE

Before starting to disassemble the starting motor etch mark the field frame, lever housing and the nose housing so they may be reassembled in the same position.

Intermediate Duty Drive Clutch Motor

1. Disconnect field coil connector from solenoid motor terminal and remove solenoid mounting screws.

2. Remove the through bolts.

3. Remove commutator end frame from field frame and frame from lever housing.

4. Remove the nose housing bolts and separate the lever housing and nose housing.

5. Remove the pinion from the armature by sliding a metal cylinder onto the shaft. With a hammer strike the metal cylinder against the retainer, drive the retainer towards the armature core and off the snap ring, Fig. 10.

6. Remove the snap ring from the groove in the armature shaft. If snap ring is too badly distorted during removal, it must be replaced.

7. Remove the armature and clutch assemblies from the lever housing.

8. Separate the solenoid from the lever housing.

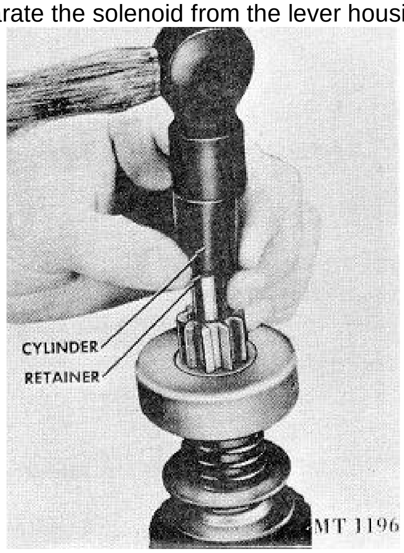

Fig. 10. Removing Retainer from Snap Ring

Heavy Duty Drive Clutch Motor

1. Disconnect field coil connector from solenoid motor terminal and lead from solenoid ground terminal.

2. Motors which have brush inspection plates, remove the plates, then remove the brush lead screws which disconnect the field leads from the brush holders.

3. Separate the commutator end frame from the field frame.

4. Separate the nose housing and field frame from the lever housing.

5. Remove the armature and clutch assembly from lever housing.

6. Separate solenoid from lever housing by pulling apart.

INSPECTION AND REPAIR

1. Brushes and Brush Holders -Inspect the brushes for wear. If they are worn down to one-half their original length, when compared with a new brush, they should be replaced. Clean brush holders and be sure that the brushes will not bind in the holders. The full length of the brush surface should ride on the commutator with spring tension to provide a good contact. Inspect the brush leads and screws to be sure they are tight and clean.

2. Armature -Inspect the armature to be sure there are no short circuits, open or grounds.

   a. Short circuits are located by turning the armature in a growler while holding a steel strip on the armature. The steel strip will vibrate on the area of the short circuit, see Fig. 11.

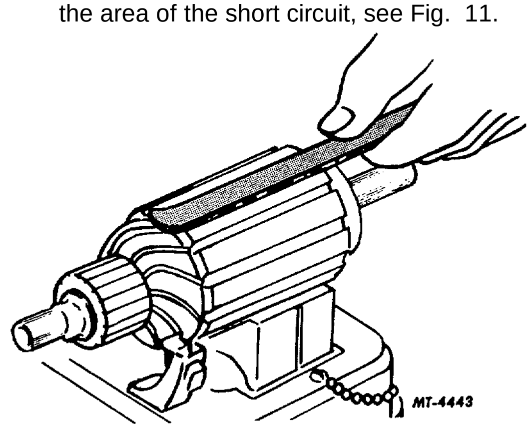

Fig. 11. Testing Armature for Short Circuits

b. Opens are usually found where the conductors are joined to the commutator. Loose or poor connections will cause arcing and burning of the commutator. If the bars are not burned too bad, re-solder the leads in the riser bars and turn the commutator down in a lathe. Then under cut the insulation between the commutator bars 1/32".

c. Grounds in the armature can be found using a test lamp and prods, see Fig. 12. If the lamp lights when one prod is positioned on the commutator and the other prod on the armature core or shaft the armature is grounded.

If the commutator is worn, dirty or out of-round or the insulation is high, the commutator should be turned down and under cut.

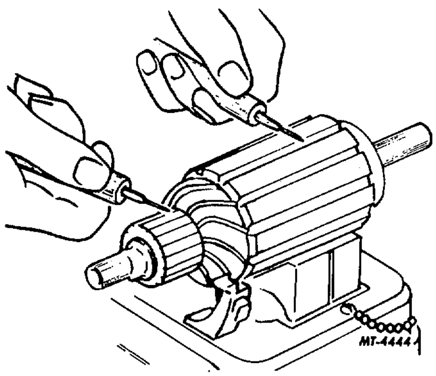

Fig. 12. Testing Armature for Grounds

3. Field Coils -- Check field coils for grounds and opens with a test lamp.
   a. Grounds-With the field coil ground disconnected, position one test prod on the field frame and the other to the field connector. If the lamp lights the field coils are grounded and must either be replaced or repaired.

   b. Opens-If the test lamp does not light when the prods are connected to the ends of coil leads, the field coils are open. A pole shoe spreader and pole shoe screw driver should be used if the field coils are to be removed. Extra caution should be taken in replacing the field coils to prevent grounding or shorting when they are tightened in place. If the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

CLUTCH ASSEMBLIES

Four kinds of clutches or motor drives (a heavy duty sprag, a Positork drive, an intermediate duty type and a splined drive) may be used on the enclosed shift lever heavy duty motors.

The intermediate clutch may be either the sprag type or the four roll type. All four types are moved into mesh with the flywheel ring gear by action of the solenoid. The pinion will remain engaged until starting is assured and the solenoid is interrupted.

Intermediate Duty Sprag Clutch

1. Remove the lock wire, collar and spring from sleeve assembly. Early design type clutches are equipped with a spring stop and a second lock wire which must be removed after removing the spring.

2. Remove the retainer ring and large washers. DO NOT remove sleeve assembly or sprags from shell assembly.

3. Lubricate the sprags and saturate the felt washer with No. 5W-20 oil. Heavier oil must not be used.

4. Reassembly is the reverse of the disassembly.

Heavy Duty Sprag Clutch and DR-250 Drive

1. Remove the cupped pinion stop and split washer. When removing the cupped pinion stop it will probably be damaged. A new one will be required at time of reassembly.

2. Remove remaining parts such as pinion washer or retainer cups and baffle if equipped. The splined drive will have a spring cup (spring inside cup).

3. DO NOT lubricate the sprags on heavy duty clutches as they are lubricated for life with a special lubricant.

4. Reassembly is the reverse of the disassembly.

Spline Drive and Positork Drive

These types of drives are serviced by complete replacement only.

REASSEMBLY

The reassembly procedure for the most part is the reverse of the disassembly.

Motors using the snap ring and retainer on the armature shaft as the pinion stop are reassembled as follows:

1. Place the clutch assembly on the armature shaft.

2. To aid in reinstalling the snap ring and retainer on the armature shaft observe the following:

a. Place the retainer on the armature shaft with the cupped surface facing the snap ring groove.

b. Place the snap ring on the end of the shaft. With a piece of wood on top of ring, force the ring over the shaft with a light hammer blow, Fig. 13. Then slide the ring down into the groove.

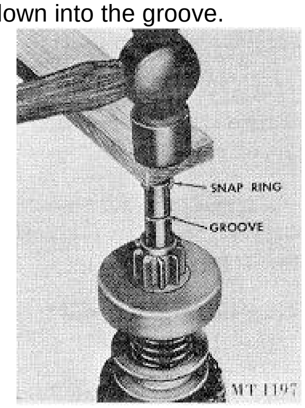

Fig. 13 Installing Snap Ring

c. To force the retainer over the snap ring, place a suitable washer over the shaft and squeeze the retainer and washer together with pliers, Fig. 14.

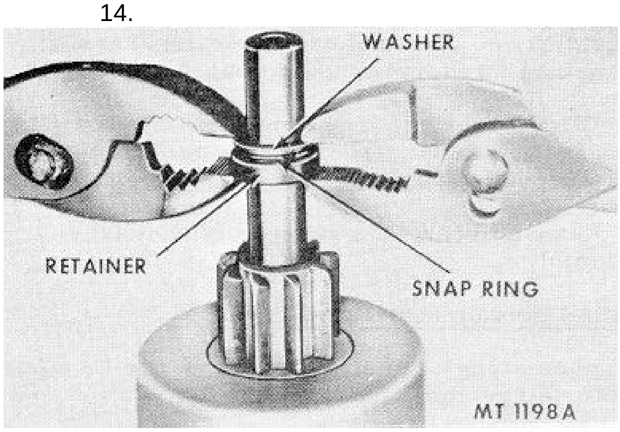

Fig. 14. Installation of Retainer

d. Remove the washer.

3. When reinstalling the field frame lever housing and nose housing align the etch marks scribed when the motor was disassembled.

4. Starting motors with the end frame which utilize eight brushes--

   a. Pull the armature out of the field frame just enough to permit the brushes to be positioned over the commutator.

   b. Push the commutator end frame and armature back against the field frame.

5. On intermediate duty clutch motors, be sure to assemble all brushes to the brush arms so the long side of the brush is toward the commutator end frame (the brush holes are offset). Otherwise, the brushes may contact the riser bars.

6. Be sure all wicks and oil reservoirs are saturated with SAE-10 oil and the splines were coated with a light coat of SAE-10 oil also. Lever housings having a bearing and seal should have the grease cavity between the bearing and seal filled with Delco-Remy Lubricant No. 1960954 or equivalent (Fig. 3 and Fig. 4).

PINION CLEARANCE

There are no provisions for adjusting the pinion clearance on motors using the intermediate duty clutch, Fig. 2. However, the pinion clearance should be checked on all motors after reassembly to insure proper clearance. Check the pinion clearance as follows:

1. Disconnect the motor field coil connector from the solenoid motor terminal. CAREFULLY INSULATE IT.

2. Connect a battery, of the same voltage as the solenoid, one lead to solenoid switch terminal and the other to the starter or solenoid frame, Fig. 15.

3. Connect a jumper wire to the starting motor terminal on the solenoid, then touch the second end to the motor frame. This will shift the pinion into cranking position and will remain until the battery is disconnected.

CAUTION

Do not keep the jumper wire connected too long as overheating of the solenoid may result.

4. Push the pinion back towards the commutator end to eliminate any over travel. Measure the distance between the pinion stop and

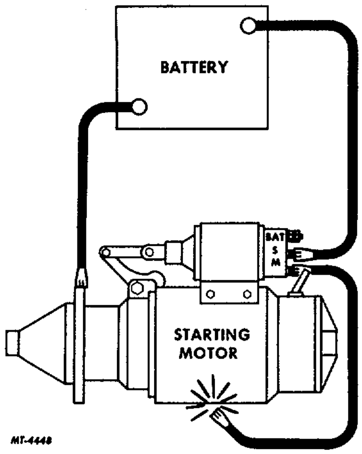

Fig. 15. Pinion Drive Clearance Check Hookup

pinion. The clearance should be:

a. Intermediate Duty Clutch -- .010 to .140 inch, Fig. 16.

b. Heavy Duty Clutch -- 23/64 inch, Fig. 16 and Fig. 17.

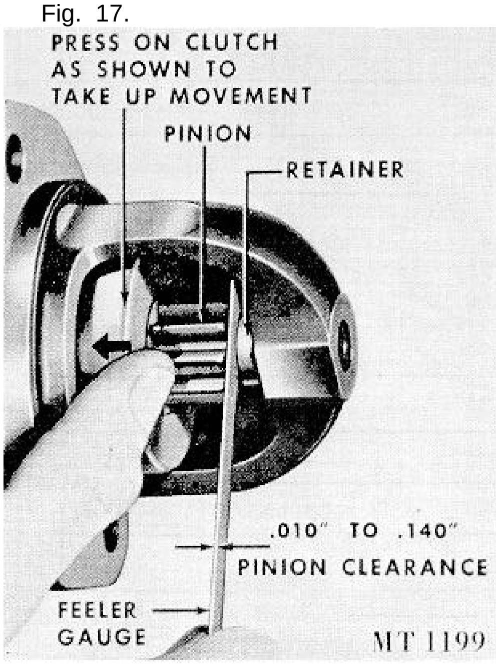

Fig. 16. Checking Pinion Clearance on Motors with the Intermediate Duty Clutch

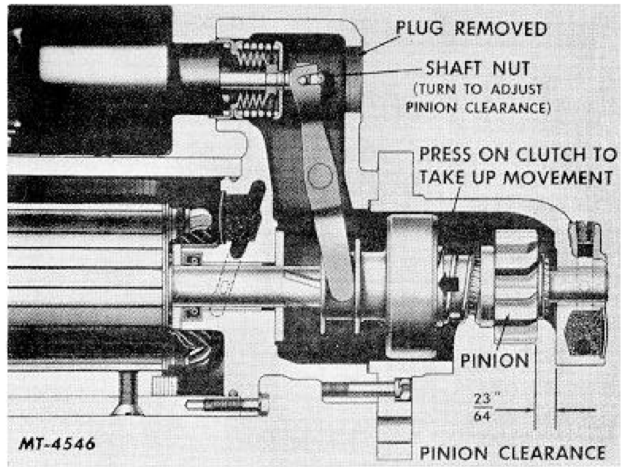

Fig. 17 Checking Pinion Clearance on Motors with the Heavy Duty Sprag Clutch

c. Motors with Spline Drive -.010 to .070 inch between spline and retainer.

5. Clearance is adjusted by removing plug and gasket on rear housing and turning the adjustment nut, Fig. 17 and Fig. 18.

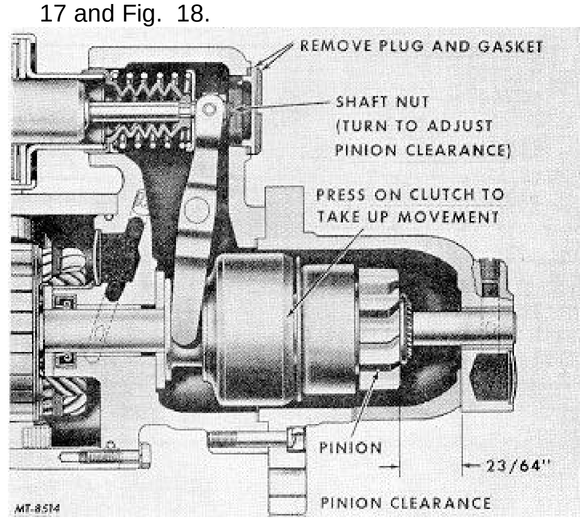

Fig. 18. Checking Pinion Clearance on Motors with DR-250 Drive

SPECIFICATIONS

Model Numbers	System Voltage	NO LOAD TEST				
		Volts	Amperes *		RPM	
			Minimum	Maximum	Minimum	Maximum
11109630 11109646 11109989	24	20	95	120	5500	7500
1113167 1113172 1113183 1113217 1113218 1113245	12	9	50	70	3500	5500
1113626 1113644 1113650 1113655	12	9	75	105	5000	7000
1113820 1113846 1113887 1113914 1113969	24	20	75	95	5500	7500
1114052	12	9	120	150	3000	4500
1114058	12	9	140	190	4000	7000
1114064						
1114066	12	9	120	150	3000	4500
1114070	12	9	140	190	4000	7000
1114071	12	9	120	150	3000	4500
1114074 1114076	12	9	140	190	4000	7000
1114085	12	9	120	150	3000	4500
1114088	12	9	140	190	4000	7000
1114089	12	9	105	135	3000	4500
1114098	12	9	140	190	4000	7000
1114101	12	9	120	150	3000	4500
1114102	12	9	140	190	4000	7000
1114107 1114112	12	9	120	150	3000	4500
1114113	12	9	140	190	4000	7000

* Includes Solenoid

Model Numbers	System Voltage	NO LOAD TEST				
		Volts	Amperes * Minimum	Amperes * Maximum	RPM Minimum	RPM Maximum
1114116	12	9	120	150	3000	4500
1114120	12	9	140	190	4000	7000
1114122	12	9	120	150	3000	4500
1114127 1114128 1114134 1114145 1114161 1114165	12	9	140	190	4000	7000
1114168	12	9	120	150	3000	4500
1114171 1114176	12	9	140	190	4000	7000
1114180 1114187 1114189 1114196	12	9	120	150	3000	4500
1114194 1114197 1114734	12	9	140	190	4000	7000

* Includes Solenoid

STARTING MOTOR

ENCLOSED SHIFT LEVER TYPE
STANDARD DUTY

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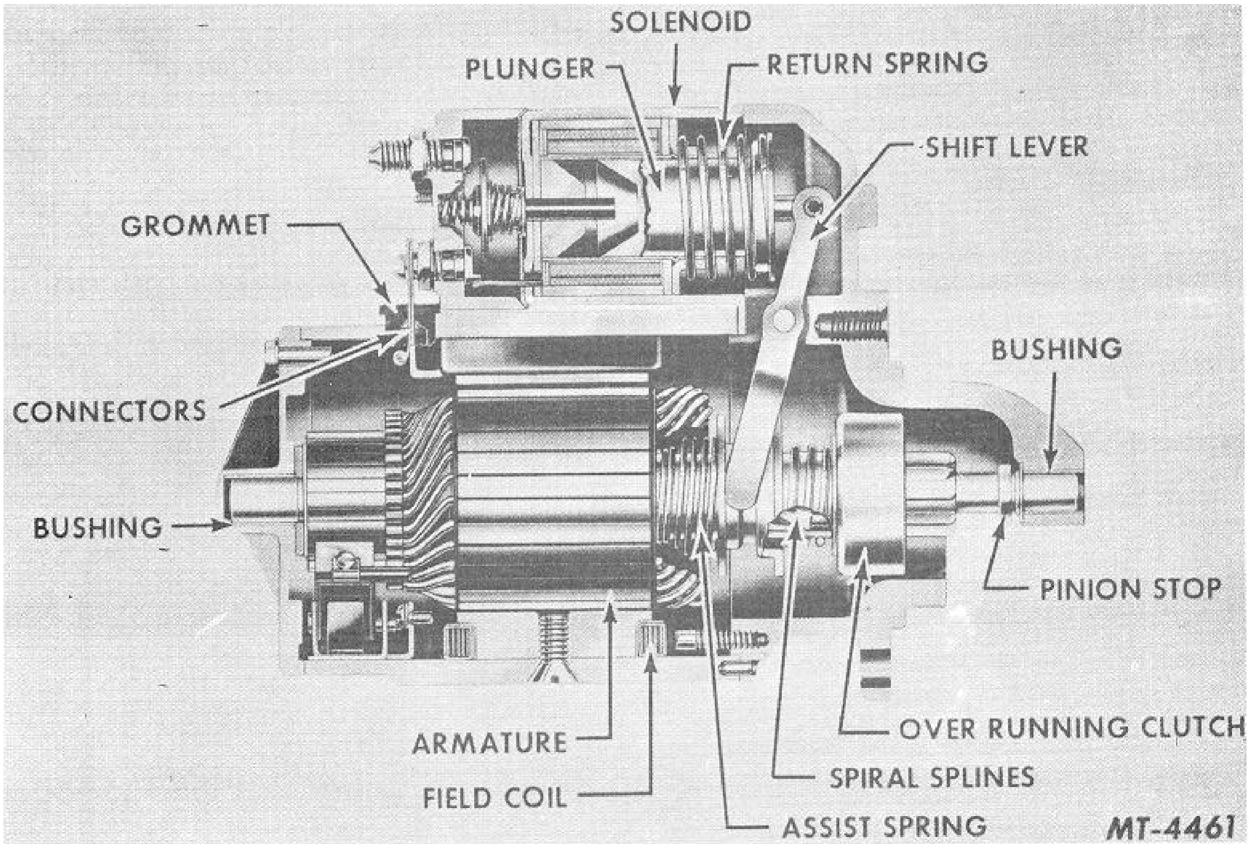

Fig. 1. Sectional View of Enclosed Shift Lever Type Starting Motor

DESCRIPTION

The enclosed shift lever type starting motor is equipped with a drive end housing which encloses the entire shifting mechanism and solenoid plunger, protecting them from road dirt, splash and icing conditions.

The solenoid is mounted on the flange of the drive end housing and operates the overrunning clutch drive by means of a linkage and shift lever. When the control switch closes the starting circuit the solenoid is energized shifting the pinion into mesh with the ring gear on the engine flywheel and closing the main contacts inside the solenoid. When the contacts inside the solenoid close, battery current is then supplied to the motor causing the armature to rotate. Torque is then transmitted by the clutch from the starting motor armature to the flywheel. To protect the armature from excessive speeds when the engine starts the clutch is designed to "overrun" or turn faster than the armature which permits the pinion to disengage itself.

LUBRICATION

Some starting motors require no lubrication except at overhaul, while other motors are equipped with lubrication fittings. The motor should be lubricated every 8000 km (5000 miles) or 300 hours of operation if a means of lubrication is provided.

1. Hinge cap oilers or oil tubes sealed with pipe plugs should have 8 to 10 drops of medium grade engine oil.

2. Grease cups should be turned down one turn or refilled if necessary.

If the motor is disassembled for any reason lubricate as follows:

1. Oil wicks should be resaturated if equipped.

2. Bushings should be coated with a medium grade of engine oil.

3. The armature shaft should be coated lightly with a medium grade of engine oil.

4. The drive assembly should be wiped clean.

CAUTION

Do not clean in any degreasing tank or with grease dissolving solvents, this will dissolve the lubricant in the clutch mechanism.

5. Relubricate the sprag clutch with a medium grade of engine oil.

CAUTION

Avoid excessive lubrication.

TROUBLE SHOOTING THE STARTING MOTOR CIRCUIT

When trouble develops in the starting motor system, and the starter motor cranks the engine slowly or not at all, several preliminary checks can be made to determine whether the trouble is in the battery, starting motor, wiring circuit between them, or elsewhere. Many conditions besides defects in the motor can result in poor cranking performance.

To obtain full performance from a starting motor or to determine the cause of abnormal operation, the motor should be subjected to one or more of the following tests. Failure of the motor to perform according to the specifications will require removal of starter and disassembly and further checks or adjustments made.

NOTE

All starting motor tests should be made with engine and battery at room temperature (not cold).

Regardless of the construction, never operate the starting motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessive cranking, will seriously damage the motor.

For the most part a volt-ampere tester (SE2283) will be used in performing the starter tests and the instruction manual supplied with the tester will provide the detailed instructions using the volt-ampere tester.

NOTE

All illustrations of starting motor and circuit tests show leads connected for NEGATIVE grounded system. Reverse the positions of the leads when testing a POSITIVE grounded system. Make sure the volt selector switch on the volt-ampere tester is positioned properly for the voltage system being inspected.

Test No. 1 -- Cranking Voltage Test

This test tells us the overall condition of battery, starter, cables or switches to determine if sufficient voltage is available to operate ignition system when starter is in operation.

Connect voltmeter leads at the starter observing the polarity, Fig. 2. Disconnect secondary coil lead to prevent engine from starting. Crank engine noting voltmeter reading (should be 9.6 volts or better with 12-volt electrical system).

If a reading of less than 9.6 volts is found, proceed to the next tests.

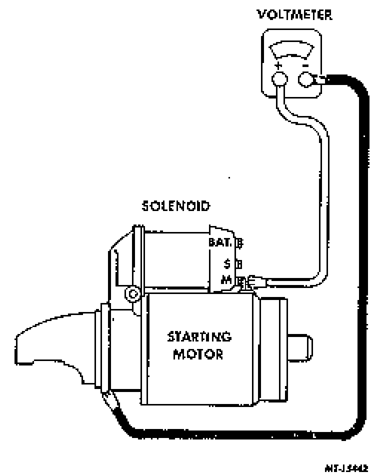

Fig. 2. Cranking Voltage Test

Test No. 2 -- Battery Capacity Test

The battery capacity test is performed to determine if the battery is in satisfactory condition. See "Battery" Section. If the battery passes this test, continue the next test.

Test No. 3 -- Voltage Drop Test

Generally, the starting or cranking circuit is a series circuit from the battery insulated post to the starting motor solenoid, to the motor, to ground (chassis) and return to the battery ground post, Fig. 3.

In the cranking circuit we also have a cranking control circuit, Fig. 3. In this circuit the solenoid is controlled or operated by closing an ignition switch or push button starting switch at the instrument panel. In this cranking control circuit there are frequently some safety switches such as transmission "neutral safety switch" and/or vacuum operated cutout switch.

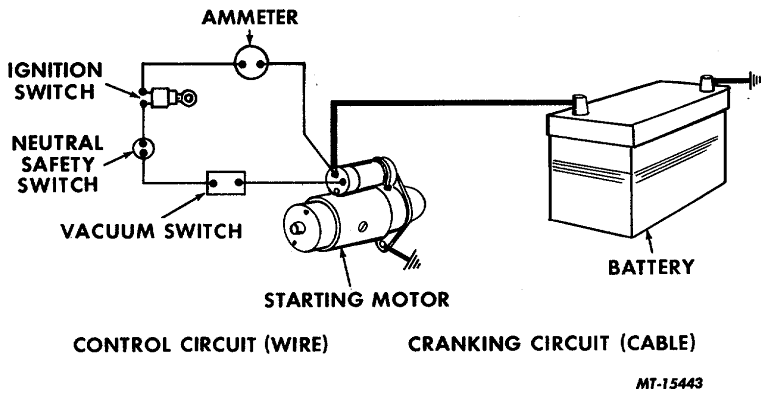

Fig. 3. Starting Motor Circuit

Excessive resistance in the starting or cranking system circuit will cause slow cranking speeds and hard starting. The starting system will function properly only when the "cranking circuit" and "control circuit" with the components are in satisfactory condition. Corrosion, loose terminal, damaged or undersized cables (wires) will cause cranking problems. In addition, the switches involved must make good electrical connections when closed.

The voltage drop test will be performed in three steps: cranking circuit, control circuit and grounded side.

Cranking Circuit: Voltage drops are measured by connecting a voltmeter in parallel across the circuit or section of a circuit being inspected, then reading the voltmeter while circuit is in operation. To test voltage drop in the cranking circuit from battery to starter, connect the voltmeter (observing the polarity and voltage rating of meter) to battery post (not clamp) to starter motor terminal as shown in Fig. 4. Prevent engine from starting during test. Crank engine and observe voltmeter reading.

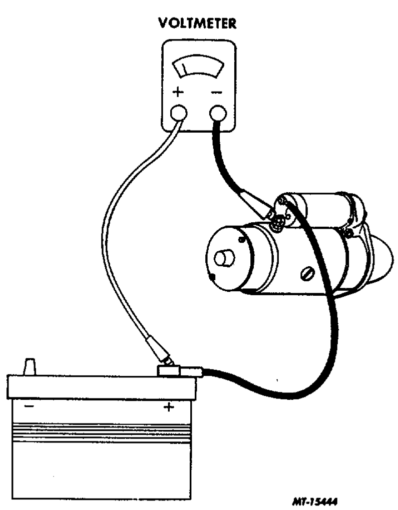

Fig. 4. Cranking Circuit Test

Values of maximum voltage drops for a standard 12-volt cranking circuit are as follows:

Cable under three (3) feet....................	.1 volt
Cable over three (3) to six (6) feet.........	.2 volt
Mechanical Switch	.1 volt
Solenoid Switch	.2 volt
Magnetic Switch................................	.3 volt
Each Connection................................ ...	.0 volt

Add these values together on the particular chassis being inspected. For example, if your total of the values from the chart is .5 volt and you have less than .5 volt drop on the chassis, continue to grounded side test.

However, if there is more than .5 volt drop you have an excessive voltage drop and this must be located by moving test lead from starting motor and working toward the battery. Crank engine with each move. When a noticeable decrease in the voltage reading is obtained, the trouble will be located between that point and the preceding point checked.

Items which could be at fault can either be a damaged cable or poor connection, an undersized wire or possibly a bad solenoid (contact within the solenoid). Repair the fault.

Grounded Side: High resistance in ground circuit of starting motor system will result in hard starting and may affect the charging circuit as well.

Connect voltmeter leads to ground on starting motor and to ground post of battery. The allowable voltage drop of .2 volt is permissible. If more than .2 volt is obtained, a poor ground is present, such as a loose starting motor mounting bolt, bad battery ground connector or ground connection to engine or frame depending upon the battery installation. The excessive voltage drop is located in much the same manner as in the preceding test working toward the battery.

Control Circuit: High resistance in the control circuit will reduce the current flow through the solenoid windings, which can cause improper function of solenoid or not at all. Improper functioning of the solenoid could result in burning of contacts in the solenoid causing high resistance in the starting motor circuit.

To complete control circuit test, check the vehicle circuit diagram to assist in locating the wires and particular switches involved in the chassis. Observe polarity of voltmeter and connect leads to battery post and solenoid switch terminal as shown in Fig. 5. Crank engine using the vehicle ignition switch or push button, if equipped, observing the voltmeter reading. If the voltmeter shows less than .5 volt, the circuit is in good condition. If more than .5 volt, this is an indication of excessive resistance. However, with experience, slightly higher voltage loss will be found and will be normal.

Isolate the point of high resistance by placing the voltmeter leads across each component in the circuit in turn. A reading of more than .1 volt across any one wire or switch is usually an indication of the trouble.

Test No. 4 -- No Load Test

After completing the cranking voltage test, battery capacity test and voltage drop tests, and the starting motor still fails to function, remove the motor and make the no load test as follows.

Note that the preceding tests were made in a particular order to make certain the starting motor circuit is in good condition before needless starting motor removal.

Before performing "No Load Test, "' look the motor over. The pinion should be checked to be sure it is free by turning it on the screw shaft. The armature should be checked so that it is free to rotate by prying the pinion with a screw driver. Tight bearing, bent armature shaft or loose pole shoe screw could cause the armature not to turn freely. The motor should be disassembled if the armature does not turn freely. However, if the armature will rotate freely, the next step is to give the motor a no load test before disassembly.

Connect the starting motor in series with a fully charged battery of the specified voltage, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as illustrated in Fig. 6 from the motor terminal to the motor frame. An RPM indicator is necessary to measure armature speed. Obtain the specified voltage by varying the resistance unit; then read the current draw and the armature speed and compare these readings with the values listed in the specifications.

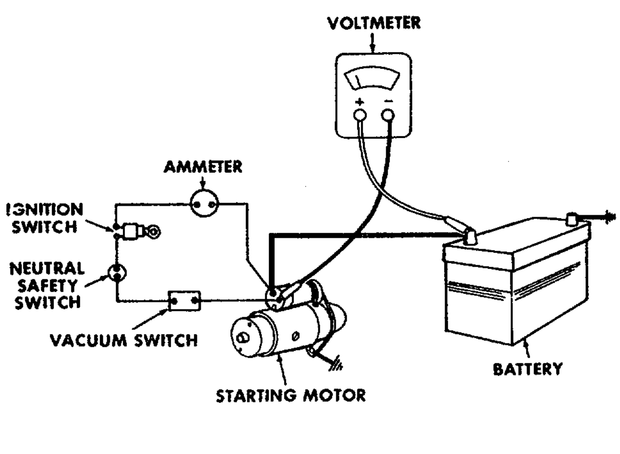

Fig. 5. Control Circuit Test

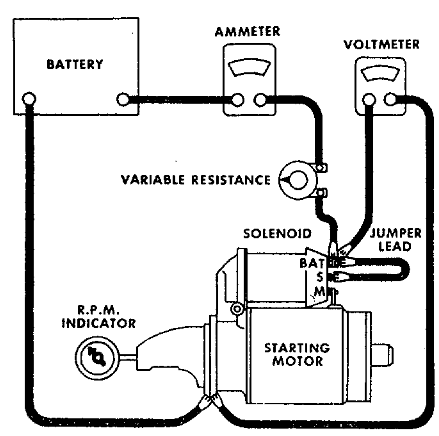

Fig. 6. No Load Test Hookup

If the starting motor does not perform according to the specifications, it will be necessary to disassemble it for further tests of the components.

1. Disconnect the field coil connections from the solenoid motor terminal.

2. Remove the thru-bolts.

3. Remove the commutator end frame and field frame assembly.

4. Remove the armature assembly from the drive housing. On some models it will be necessary to remove the solenoid and shift lever assembly from the drive housing before removing the armature assembly.

5. Remove the thrust collar from the armature shaft.

6. Remove the pinion from the armature by sliding a metal cylinder onto the shaft; with a hammer striking the metal cylinder against the retainer, drive the retainer toward the armature core and off the snap ring, Fig. 7.

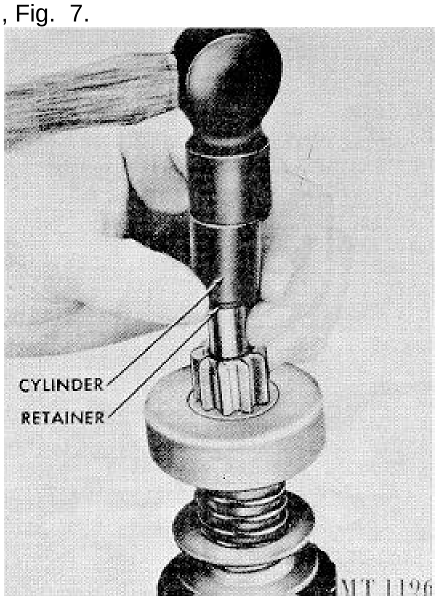

Fig. 7. Removing Retainer from Snap Ring

7. Remove the snap ring from the groove in the armature shaft.

8. Roll type clutches are designed to be serviced as a complete unit; therefore, do not disassemble. If the condition of the clutch assembly is questionable, replace it.

INSPECTION AND REPAIR

1. Brushes and Brush Holders: Inspect the brushes for wear. If they are worn down to one-half their original length, when compared with a new brush, they should be replaced.

Clean brush holders and be sure that the brushes will not bind in the holders. The full length of the brush surface should ride on the commutator with the proper spring tension (see specifications) to provide a good contact. Inspect the brush leads and screws to be sure they are tight and clean.

2. Armature: Inspect the armature to be sure there are no short circuits, opens, or grounds.

   a. Short circuits relocated by turning the armature in a growler while holding a steel strip on the armature. The steel strip will vibrate on the area of the short circuit, Fig. 8.

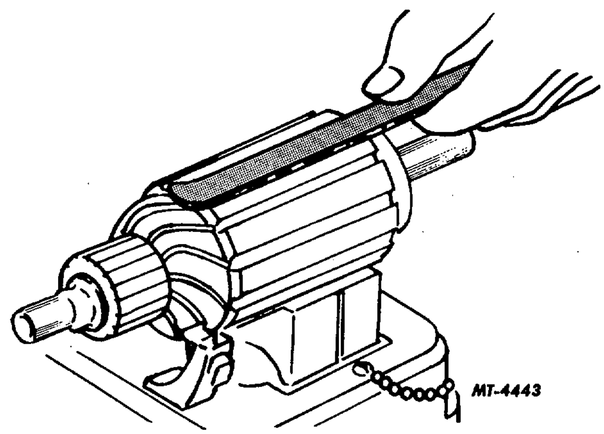

Fig. 8. Testing Armature for Short Circuits

   b. Opens are usually found where the conductors are joined to the commutator. Loose or poor connections will cause arcing and burning of the commutator. If the bars are not burned too bad, re-solder the leads in the riser bars and turn the commutator down in a lathe. Then under cut the insulation between the commutator bars 1/32".

c. Grounds in the armature can be found using a test lamp and prods, Fig. 9. If the lamp lights when one prod is positioned on the commutator and the other prod on the armature core or shaft the armature is grounded.

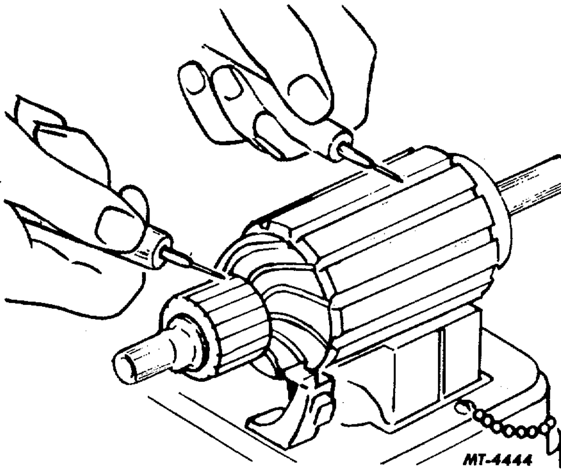

Fig. 9. Testing Armature for Grounds

If the commutator is worn, dirty, out-of round or the insulation is high, the commutator should be turned down and under cut.

3. Field Coils: Check field coils for grounds and opens with a test lamp.

    a. Grounds: With the field coil ground disconnected, position one test prod on the field frame and the other to the field connector. If the lamp lights the field coils are grounded and must either be replaced or repaired.

    b. Opens: If the test lamp does not light when the prods are connected to the ends of the coil leads, field coils are open.

A pole shoe spreader and pole shoe screw driver should be used if the field coils are to be removed. Extra caution should be taken in replacing the field coils to prevent grounding or shorting when they are tightened in place. If the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

REASSEMBLY

1. Place the clutch assembly on the armature shaft.

2. To aid in reinstalling the snap ring and retainer on the armature shaft, proceed as follows.

    a. Place the retainer on the armature shaft with the cupped surface facing the snap ring groove.

    b. Place the snap ring on the end of the shaft. With a piece of wood on top of ring, force the ring over the shaft with a light hammer blow, Fig. 10; then slide the ring down into the groove.

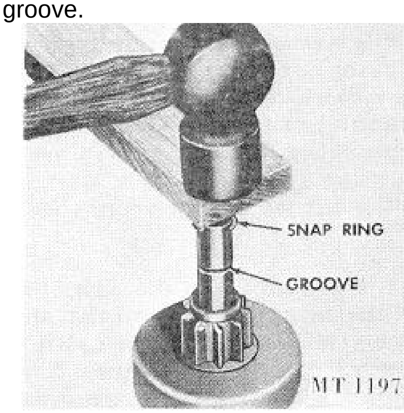

Fig. 10. Installing Snap Ring

    c. To force the retainer over the snap ring, place a suitable washer over the shaft and squeeze the retainer and washer together with pliers, Fig. 11.

    d. Remove the washer.

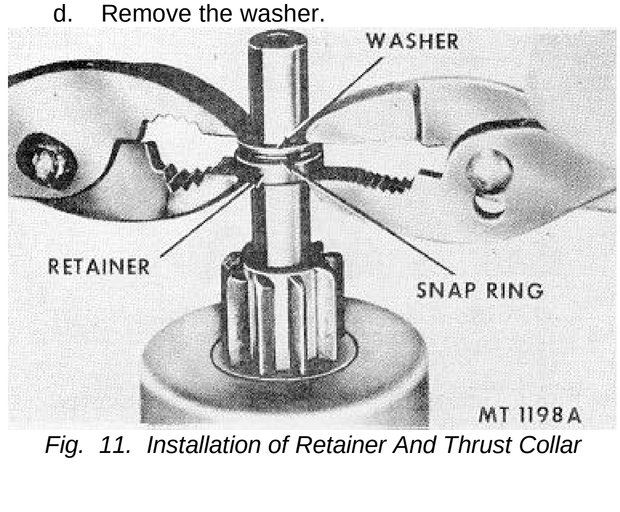

Fig. 11. Installation of Retainer And Thrust Collar

3. The remaining portion of the starting motor reassembly procedure is the reverse of the disassembly.

4. When installing the solenoid, apply sealing compound between field frame and solenoid flange.

PINION CLEARANCE

Pinion clearance should be inspected after reassembly of the motor to insure proper adjustment. Check pinion clearance following the steps listed below.

1. Disconnect the motor field coil connector from the solenoid motor terminal.

CAREFULLY INSULATE IT.

2. Connect a battery, of the same voltage as the solenoid, one lead to solenoid switch terminal and the other to the starter or solenoid frame, Fig. 12.

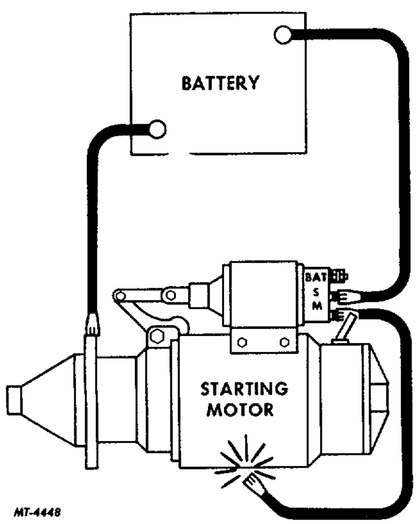

Fig. 12 Pinion Drive Clearance Check Hookup

3. Connect a jumper wire to the starting motor terminal on the solenoid; then touch the second end to the motor frame. This will shift the pinion into cranking position and remain until the battery is disconnected.

CAUTION

Do not keep the jumper wire connected too long as overheating of the solenoid may result.

4. Push the pinion back towards commutator end to eliminate any overtravel. Then measure the distance between the pinion stop and pinion. The clearance should be .01 to .14, Fig. 13.

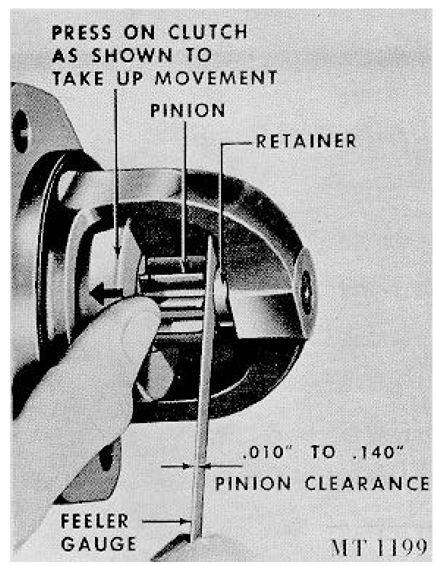

Fig. 13 Checking Pinion Clearance

There are no provisions for adjusting the pinion clearance on the enclosed shift lever type starting motors. Therefore, if the pinion clearance does not fall within the specified limits (.01 to .14), inspect the solenoid linkage or shift lever yoke buttons for excessive wear.

SPECIFICATIONS

Model Numbers	Type System (Voltage)	NO LOAD TEST					
		Volts	Minimum Amps. *	Maximum Amps. *	Minimum RPM	Maximum RPM
1107220	12	9	55	80	3500	6000
1107678	12	9	50	80	5500	10500
1107679	12	9	55	80	3500	6000
1107680	12	9	50	80	5500	10500
1107709	12	9	50	80	5500	10500
1107710	12	9	55	80	3500	6000
1107742	12	9	40	105	3500	6500
1108233	24	20	20	30	2250	2750
1108238	24	20	40	75	3300	5600
1108278	12	9	50	80	5500	10500
1108341	12	9	50	80	5500	10500
1108384	12	9	50	80	5500	10500
1108478	12	9	50	80	5500	10500
1108515	12	9	50	80	5500	10500
1108769	12	9	65	95	7500	10500
1109256	12	9	50	80	5500	9000
1109356	12	9	60	85	6800	10300
1109358	12	9	60	85	6800	10300
1109369	12	9	65	95	7500	10500
1109437	12	9	60	85	6800	]0300

* Includes Solenoid

ELECTRICAL

LIGHTING SWITCHES

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LIGHTING SWITCH (LESS PROTECTION FUSE BUT EQUIPPED WITH A CIRCUIT BREAKER).

Description And Operation

The lighting switch illustrated in Figure 1 does not incorporate fuses in the switch assembly, but is protected by a circuit breaker.

When the lighting switch knob is pulled out to the first position, the parking lights, tail lights and instrument lights are on. When the lighting switch knob is pulled out to the last position, all lights are on.

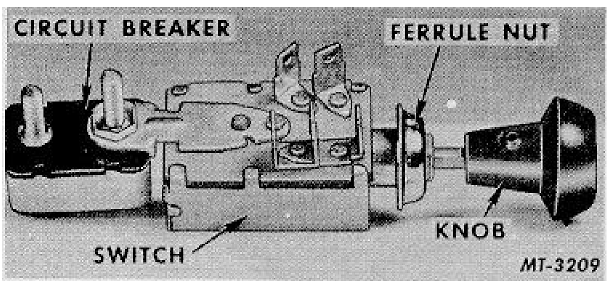

Fig. 1

Removal

1. Pull light switch knob outward to headlight position.
2. Loosen Allen screw in knob and remove knob from shaft.
3. Remove ferrule nut.
4. Disconnect all wires from the switch. Tag wires for proper installation.

LIGHTING SWITCH (LESS PROTECTION FUSE FUSE AND CIRCUIT BREAKER).

Description and Operation

This type lighting switch, Fig. 2, does not incorporate a circuit breaker or fuses as the lighting system is protected by a fuse panel.

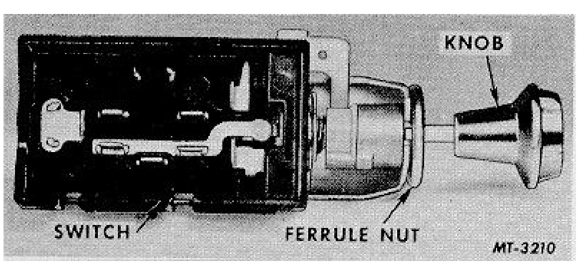

Fig. 2

The lighting switch on the instrument panel controls the headlights, parking lights, instrument panel lights, cab interior light and tail lights. When the lighting switch is pulled out halfway, both parking and tail lights are "on". To light the instrument panel, turn the light switch control to the left; a built-in rheostat controls the intensity of the panel light from "off" to full "on". To turn the cab interior light on, turn the lighting switch control counter-clockwise to the extreme left position.

Removal

1. Pull light switch outward to headlight position.
2. Depress shaft release button, Fig. 3, on switch body and pull knob and shaft out of switch body.
3. Remove ferrule nut by positioning a screw driver in the end, turn nut in a counterclockwise direction.
4. Disconnect all wires from the lighting switch and either tag them for correct installation or note the relation of each wire to its proper terminal.

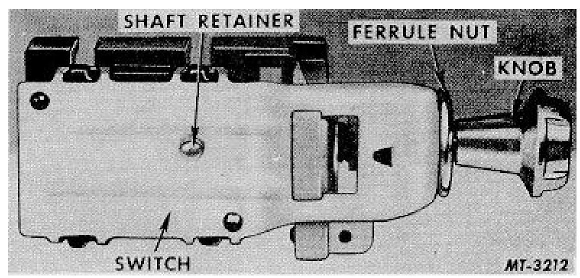

Fig. 3.

LIGHTING SWITCH (WITH PROTECTION FUSE AND CIRCUIT BREAKER).

Description and Operation

This type lighting switch, Fig. 4, incorporates 15 amperes dual thermal circuit breakers and a fuse to protect the entire light- ing system. One circuit breaker protects the- headlights and parking lights, while all other lights on the vehicle are directed through the remaining circuit breaker. In addition, the panel lights are also protected by a (4 amp) fuse. This type of circuit permits the use of the headlights to be retained if an overload or short develops in another part of the system. A current flow of more than 15 amperes will cause the points of this current limit relay to open and close as they warm and cool. Thus the current to the affected circuit is rapidly interrupted and restored until the short is located and corrected. Protection against destruction of the wiring is thereby provided and possible rapid discharge of the battery averted.

When the switch control knob is pulled out to the first position, an internal circuit is established to the switch terminals for the parking lights, instrument lights and taillights When the knob is pulled out to the last position, a circuit is established to the switch terminals for the headlights, instrument lights and tail lights. The current for the instrument lights passes through a rheostat which is regulated by the light switch knob. By turning the switch knob clockwise, the instrument lights can be dimmed or turned off completely. The cab interior light (except CO and VCO models) may be turned on while retaining use of the instrument panel lights by rotating the lighting switch knob to the extreme counter clockwise position (through the detent or "click").

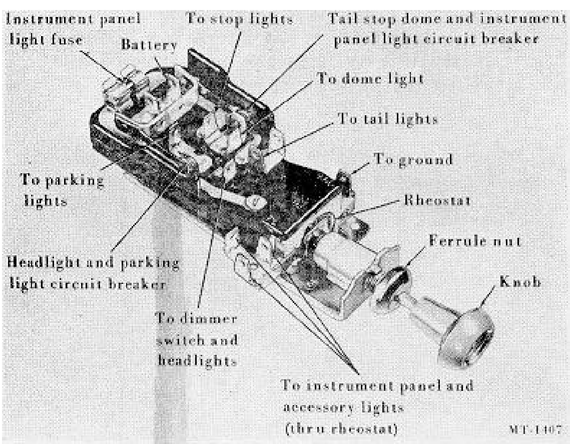

Fig. 4.

<u>Removal</u>

1. Pull light switch knob outward to headlight position.

2. Depress shaft release button, on switch body and pull switch knob and shaft out of switch body.

3. Remove ferrule nut by positioning a screw driver in the end, turn nut in a counterclockwise direction.

4. Disconnect all wires from the lighting switch and either tag them for correct installation or note the relation of each wire to its proper terminal.

SOLENOID OPERATED

SERIES-PARALLEL SWITCH

FOR 24-VOLT STARTING SYSTEM

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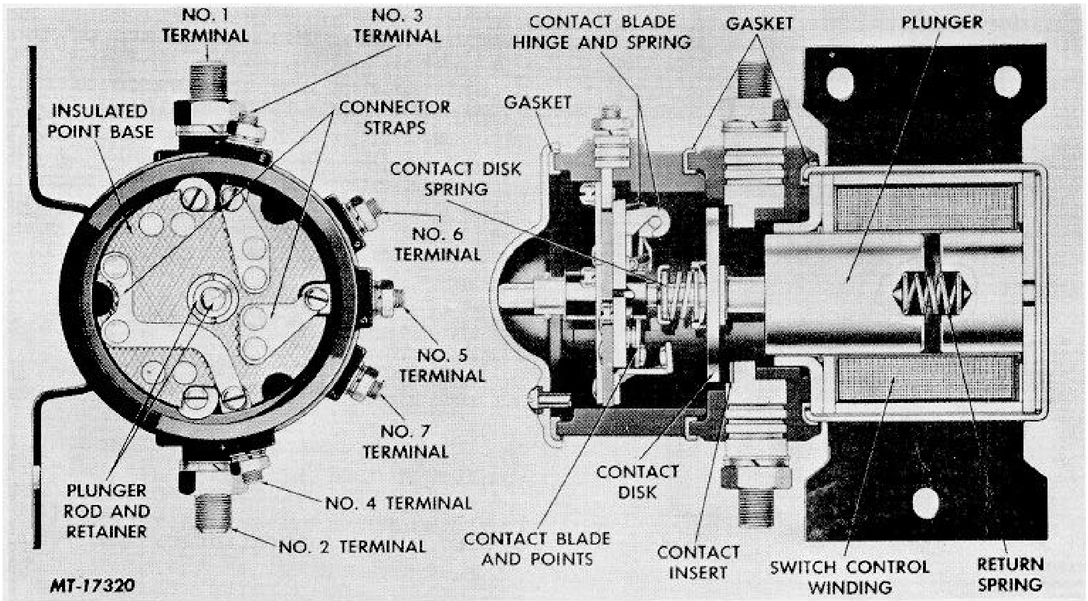

Figure 1 End and Sectional Views of Solenoid Operated Series-Parallel Switch

INTRODUCTION

The series-parallel switch is used to connect two 12-volt batteries (or two pairs of 6-volt batteries) in series for 24-volt cranking and to connect the same two 12-volt batteries (or pairs of 6-volt batteries) in parallel for 12-volt charging.

Figure 1 illustrates end and sectional views of the low weight, splash proof, series-parallel switch. This switch can be used with either a solenoid controlled cranking motor or separate magnetic switch controlled motor.

A typical wiring circuit diagram of the series-parallel system using a solenoid operated cranking motor is shown in Figure 2.

OPERATING PRINCIPLES

Cranking

The series-parallel switch normally "rests" in the 12-volt charging (parallel) position.

When the starting switch is closed to crank the engine, the solenoid coil within the series-parallel switch is energized creating sufficient magnetic force to attract the series-parallel switch plunger. Movement of the plunger then closes the two main switch terminals and connects the two 12-volt batteries (or two pairs of 6-volt batteries) in series with the starter motor to provide 24 volts for starter motor operation. At the same time, the starter solenoid coil circuit is completed by a set of points mechanically closed by the series-parallel switch plunger. This completes the battery-to-starter motor circuit and allows cranking to take place.

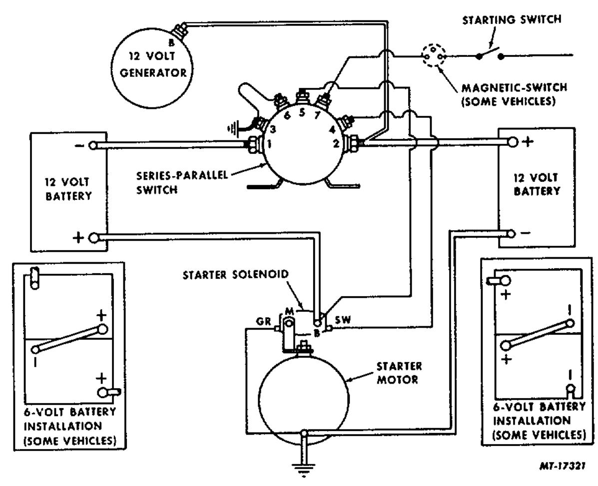

Figure 2 Series-Parallel Switch Wiring Circuits (Typical)

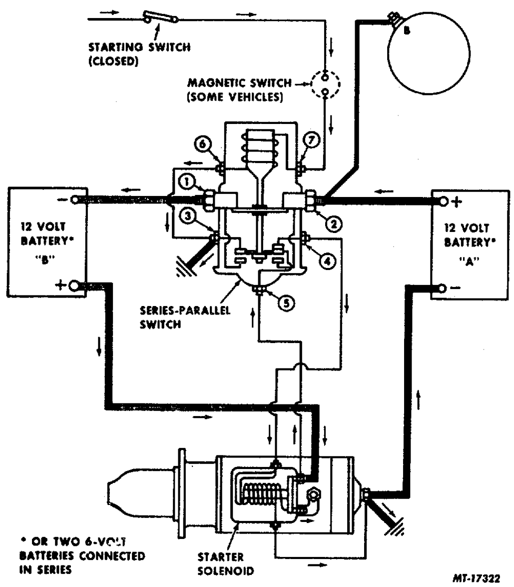

Figure 3 Current Flow Through Series-Parallel Switch During 24-Volt Cranking

Current flow through the series-parallel switch during cranking is shown in Figure 3. When series-parallel switch is energized by closing the starting switch to the switch coil (terminal #7), the switch plunger is moved into the core by the magnetic force of the coil which causes three distinct operational steps to occur. First, the normally closed points between terminals number one (#1) and number three (#3) and terminals number two (#2) and number five (#5) are opened by the moving plunger. Second, the large contact disc between terminals number one (#1) and number two (#2) is moved into contact with these terminals by the plunger as it continues to move. Third, the normally open points between terminals number four (#4) and number five (#5) are closed by the moving plunger.

Current from "A" and "B" batteries, which are placed in series by the large contact between terminals number one (#1) and number two (#2), will flow to the "BAT" terminal of the starter solenoid. From this point it will travel through the contact points between terminals number five (#5) and number four (#4) to the "SW" terminal of the solenoid. Current will continue its flow through the "hold-in" and "pull-in" coils of the solenoid to the "GRD" terminal of the solenoid, to the "GRD" terminal of the starter motor and on to the "A" and "B" batteries which are the source of current. This energizing of the solenoid will pull the drive pinion into mesh with the ring gear of the engine and close the circuit between the "BAT" and "MOT" terminals of the starter solenoid, thereby providing the full voltage of both batteries to be in series with the cranking motor. Cranking of the engine then takes place. When the starting switch is opened the series-parallel switch returns to its charging position.

Charging

After cranking has been accomplished and the starting switch is released, the series-parallel switch plunger returns to its charging (parallel) position. This allows operation of the vehicle electrical system at a system voltage of 12 volts and permits charging of both 12-volt batteries (or both pairs of 6-volt batteries) by vehicle generator operation. The current from the generator divides at the number 2 terminal of the series-parallel switch, half of it going to the "A" battery with the other half going to the "B" battery.

Figure 4 shows current flow through the series-parallel switch during vehicle operation (12-volt charging). When the series-parallel switch is in the charging position and the engine and generator are in operation, current from the generator will flow to the number two (#2) terminal of the series-parallel switch. At this point, current will divide with approximately half going through the "A" battery to ground and back to the generator. The remaining half will pass through the contact points between the number two (#2) and number five (#5) terminals through the "B" battery and the contact points between the number one (#1) and number three (#3) terminals to ground and back to the generator. Current is thereby provided for both batteries at the generator system voltage.

MAINTENANCE

In order to obtain satisfactory service from the series-parallel system, it is important to maintain all wiring and connectors in good condition. Batteries, generator, starting motor and other units must be properly maintained.

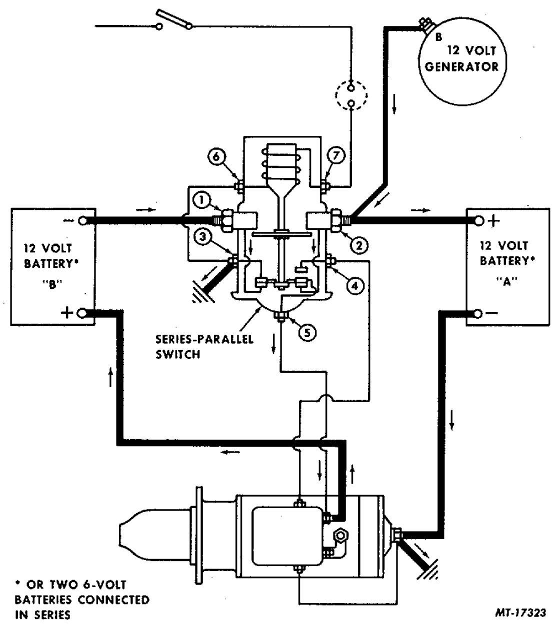

Figure 4 Current Flow Through Series-Parallel Switch During 12-Volt Charging

Because of higher circuit resistance, due to the longer charging circuit through the various contacts and connections in the series-parallel switch, it is normal for the "B" battery (or pair of batteries) to tend toward undercharge. Maintaining clean and tight connections, using batteries of the same type, size and age and occasionally switching the positions of the "A" and "B" batteries will minimize this problem.

SERVICE PROCEDURES

Some of the problems that may be encountered in series-parallel systems are covered below.

<u>Oscillating Solenoid</u>

Undercharged batteries can cause the cranking motor solenoid to oscillate when the system voltage decreases during cranking to the point where the solenoid hold-in winding can no longer hold the solenoid contacts closed. When the contacts open the cranking circuit is interrupted, the voltage increases and the cycle then repeats to cause oscillation and heavy damage to the contacts. Also, an open hold-in winding can cause the solenoid to oscillate.

Excessive resistance in the solenoid or series-parallel switch coil winding circuits, such as corroded contacts or connections, has the effect of lowering the voltage to the coil and causing the plunger to oscillate. This condition is aggravated by undercharged batteries.

Badly burned contact discs in the cranking motor solenoid or series-parallel switch causes excessive resistance in the cranking motor circuit. Even though an undercharged battery condition or excessive control circuit resistance is discovered and remedied, the cranking motor may not operate with sufficient voltage and current to crank the engine due to the badly burned points or high resistance caused by the oscillating solenoid or series-parallel switch repeatedly making and breaking the cranking circuit.

<u>Both "A" and "B" Batteries Undercharged</u>

In the event that all batteries ("A" and "B") are undercharged, the problem is not necessarily in the series-parallel switch but may be elsewhere in the charging circuit such as:

A low voltage regulator setting.

A faulty generator.

A fault in the wiring between the generator and series-parallel switch, or in the ground circuit common to both batteries.

Lack of sufficient charging for the batteries due to excessive low speed driving, stop and go driving or long periods of engine idling. (This condition indicates a need for external charging or an extra output generator to keep the batteries up to a satisfactory level of charge.)

<u>"B" Battery Undercharged</u>

As noted in the wiring diagram (Figure 4) the "A" battery (or batteries) uses heavy starting motor circuit cables during charging and the charging circuit for the "B" battery (or batteries) is much longer through the various contacts and connections in the series-parallel switch. Since there is more resistance in the longer current path, it is normal for the "B" battery to be slightly undercharged.

If the "B" battery is chronically undercharged, excessive resistance in its charging circuit is probably indicated. Excessive resistance can be caused by:

Loose or corroded wiring connections at the series-parallel switch, the magnetic switch or motor solenoid, ammeter, battery or ground.

Frayed or damaged wires.

Oxidized or burned contact points, or insufficient contact point pressure within the series-parallel switch.

A procedure for checking excessive resistance in the "B" battery charging circuit is outlined below. A broad scale voltmeter capable of reading tenths of a volt and a jumper cable of No. 4 gauge wire, or larger, with heavy alligator clips soldered to each end are required to make this test.

1. Start engine and operate at moderate speed.
2. Connect voltmeter directly across terminals of "B" battery (or pair of batteries - Figure 5) and observe and note voltage reading.

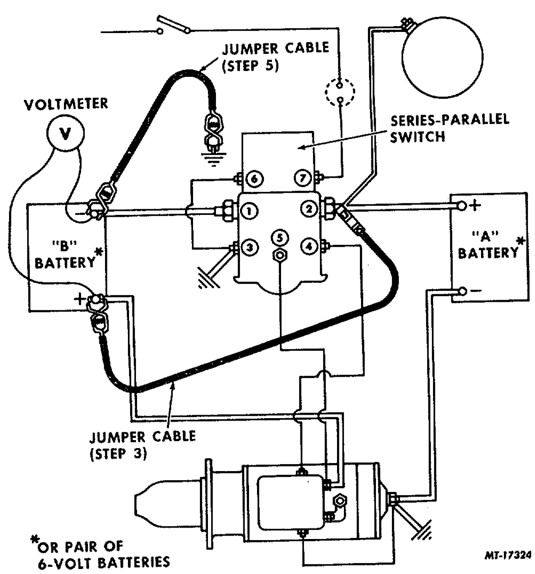

Figure 5 Voltmeter and Jumper Cable Connections for Checking Resistance in "B" Battery Charging Circuit

3. Connect heavy jumper from No. 2 terminal of series-parallel switch to ungrounded (+) terminal of "B" battery (Figure 5) and observe voltmeter.
4. An appreciable voltage increase (.5 volt or more) indicates excessive resistance in the circuits containing terminals 2 and 5 of series-parallel switch and battery terminal of starter solenoid (see Figure 4).
5. If only a very small voltage increase was obtained in Step 3, connect the jumper cable from the grounded (-) terminal of the "B" battery to a good ground on the engine (Figure 5) and again observe voltmeter.
6. An appreciable voltage increase (.5 volt or more) indicates excessive resistance in the circuit containing series-parallel switch terminals 1 and 3 (see Figure 4).

SERIES-PARALLEL SWITCH BENCH TESTS

The following bench tests can be used to check condition of series-parallel switch removed from vehicle.

Charging Terminal Continuity Test

1. Connect a continuity test lamp between terminals 1 and 3 (Figure 6). Test lamp should light.

2. Connect continuity test lamp between terminals 2 and 5 (Figure 6). Test lamp should light.

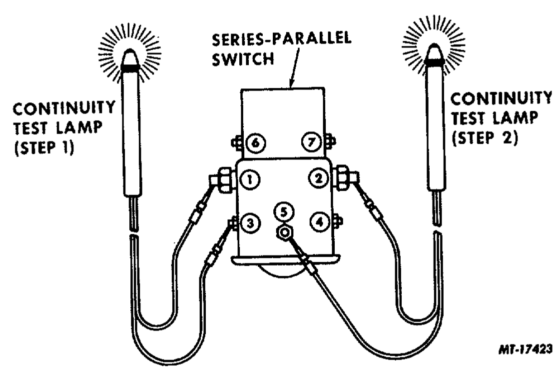

Figure 6 Continuity Test Lamp Connections for Making Charging Terminal Continuity Test

Cranking Terminal Continuity Test

1. Connect 12 volt battery between terminals 6 and 7 (Figure 7).
2. Connect continuity test lamp between terminals 1 and 2 (Figure 7). Test lamp should light.
3. Connect continuity test lamp between terminals 4 and 5 (Figure 7). Test lamp should light.
4. Disconnect battery from terminals 6 and 7.

If series-parallel switch fails either of the above tests, it should be repaired. The switch can be overhauled locally using regular hand tools. Component parts are provided for service.

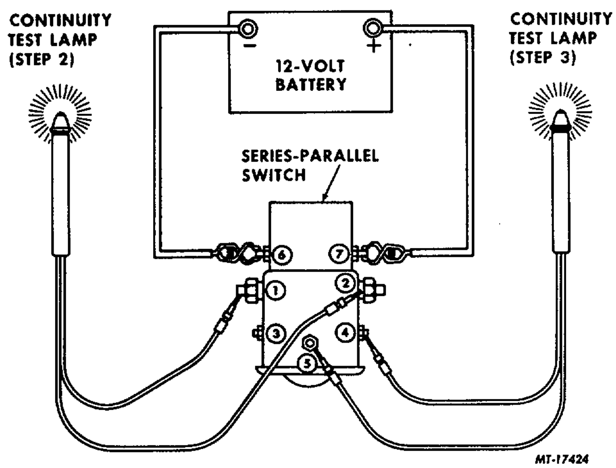

Figure 7 Battery and Test Lamp Connections for Making Cranking Terminal Continuity Test.

TROUBLE SHOOTING GUIDE		
PROBLEM	CAUSE	REMEDY
Oscillating solenoids and burned contacts.	Low battery.	If battery is worn out, replace.- If battery is good but discharged, charge battery and determine why it became discharged.
	Resistance in wiring.	Remove resistance from control and cranking circuits.
	Defective solenoid.	Replace solenoid.
Both "A" and "B" batteries undercharged.	Low regulator setting.	Adjust regulator.
	Faulty generator.	Repair generator.
	Faulty wiring.	Repair wiring.
	Faulty regulator.	Repair regulator.
	Undercapacity generator.	Replace with extra-output generator.
Battery "B" under-charged.	Excessive resistance in "B" battery circuit.	Remove resistance.

SPECIFICATIONS			
Switch Part Number	Rated Voltage	Hold-In Winding Current Consumption	
		Amps.	Volts
1119845	12	4.7 - 5	12

Due to a continuous program of research and development, some procedures, specifications and parts may be altered in a constant effort to update and improve our products.

Periodic revisions may be made to this publication and mailed automatically to distributors. It is recommended that customers contact their distributors for information on the latest revision.

INTERNATIONAL

9.0 LITER DIESEL ENGINE

FORM CGES-205
OCTOBER, 1979

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INTERNATIONAL

9.0 LITER DIESEL ENGINE

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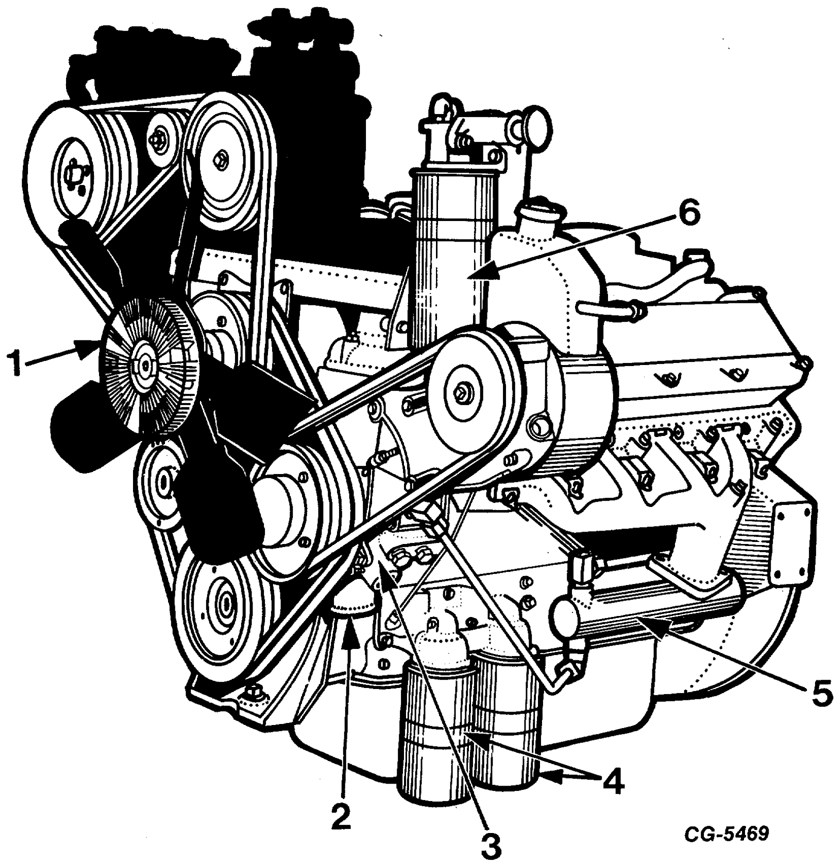


Fig. 1 Left Front View of Engine

1. Fan Modulator
2. Water Inlet
3. Water Pump
4. Oil Filters
5. Oil Cooler
6. Fuel Filter

DESCRIPTION

The International 9.0 liter diesel engine is a four cycle naturally aspirated V-8 with overhead valves. It has a displacement of 9.0 liter (551 cu. in.).

When viewing the engine from the rear, the right bank of cylinders are numbered 2, 4, 6 and 8 with 2 being at the front. Similar, the left bank of cylinders are numbered 1, 3, 5 and 7 with No. 1 being at the front. The firing order is 1-8-7-3-6-5-4-2.

The crankcase has been especially developed to withstand the loads of diesel operation and utilizes tie bolts at each main bearing to assure a rigid, inflexible support for the rotating parts. Oil galleries traverse the crankcase to deliver oil to all of the moving parts.

The crankshaft is a five main bearing unit with fore and aft thrust controlled at the center (No. 3) bearing. Precision steel backed main and connecting rod bearings are utilized. Connecting rods are of heavy-duty construction and are attached to the crankshaft, two to each bearing throw with the piston pin being of free floating type permitting the pin to move or float freely in piston and rod. The pin is held in place with pin retaining rings.

The intake and exhaust valves are both provided with inserts at the cylinder head and valve rotators are used at both intake and exhaust valves. The rotators are seated on the cylinder head. Valve dampers are also utilized with each of the valve springs.

The engine is equipped with a fully closed crankcase ventilating system. The crankcase ventilation fittings are located in the cylinder head covers and are connected by hose to the intake manifolds crossover.

The fuel injection pump is located between the cylinder heads and intake manifolds at the top of the engine. The engine governor is integral with the fuel injection pump. Operating principles and service instructions for the fuel system components are given in separate sections of the service manual. Fuel System, Section CGES-220 covers the fuel injection pump and governor. Fuel System, Section CGES-225 covers the fuel injection nozzle.

The air cleaner is remote mounted and is connected via piping to a crossover type adapter mounted on the intake manifolds.

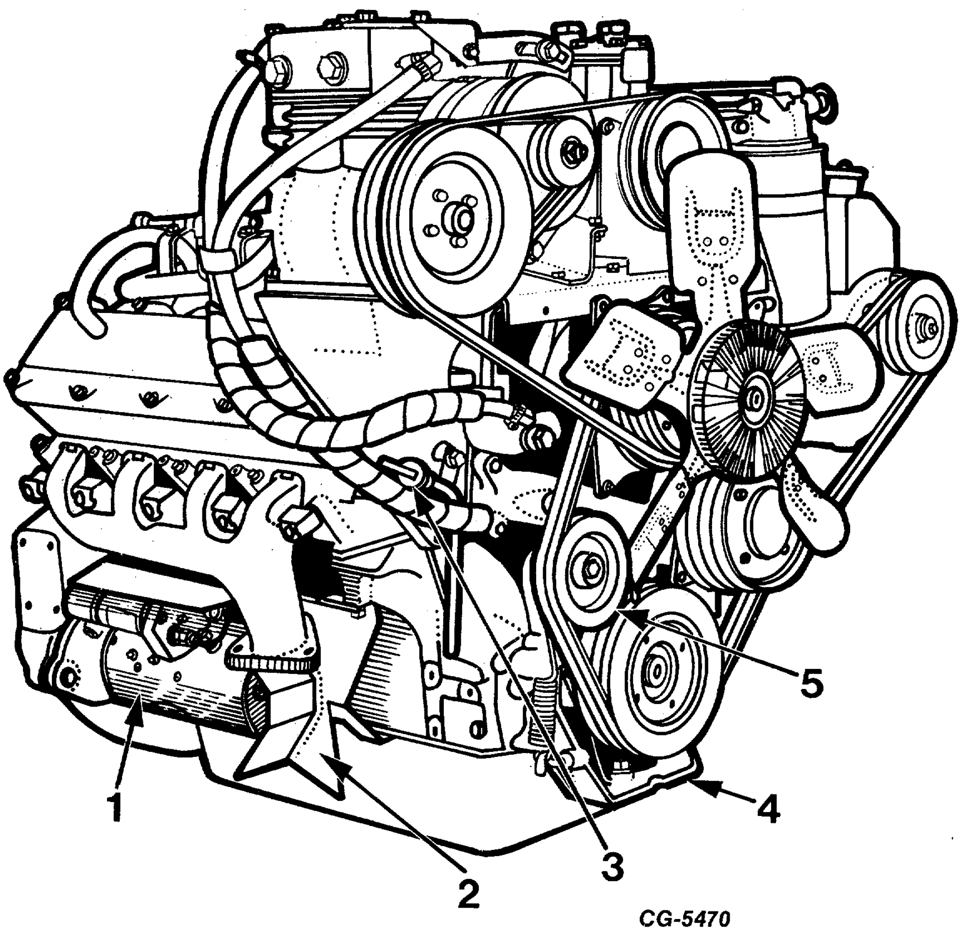


Fig. 2 Right Front View of Engine

1. Starting Motor
2. Heat Shield
3. Oil Level Dipstick
4. Front Engine Mount
5. Idler Pulley

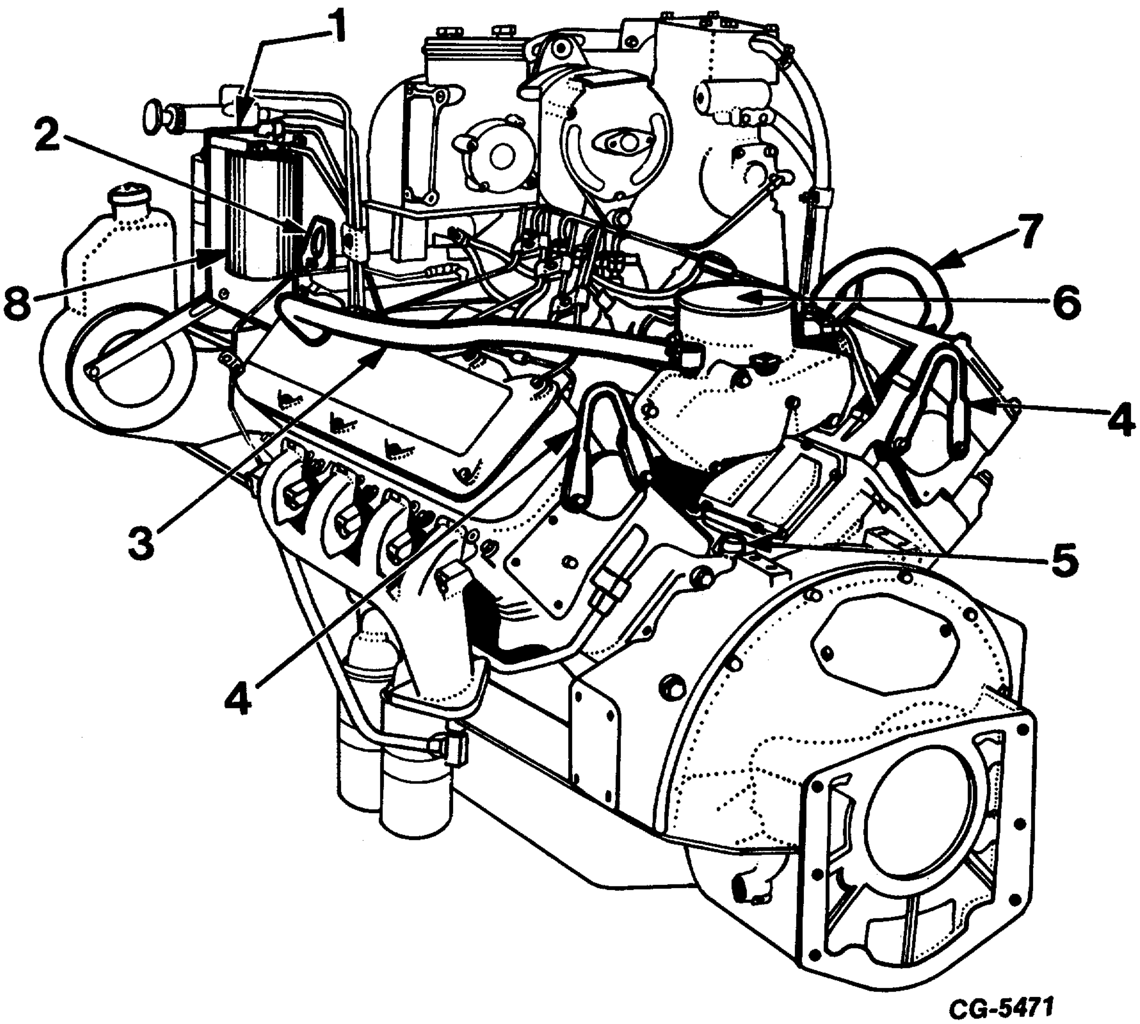
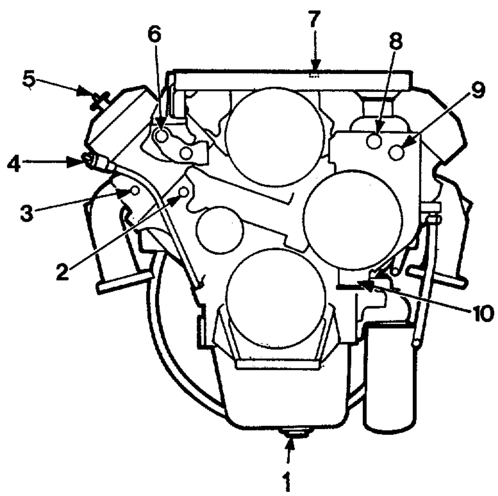


Fig. 3 Left Rear View of Engine

1. Fuel Filter Assembly Mounting Bracket
2. Lifting Eye
3. Ventilator Hose
4. Lifting Loop
5. Tachometer Drive
6. Air Intake
7. Ventilator Hose
8. Fuel Filter



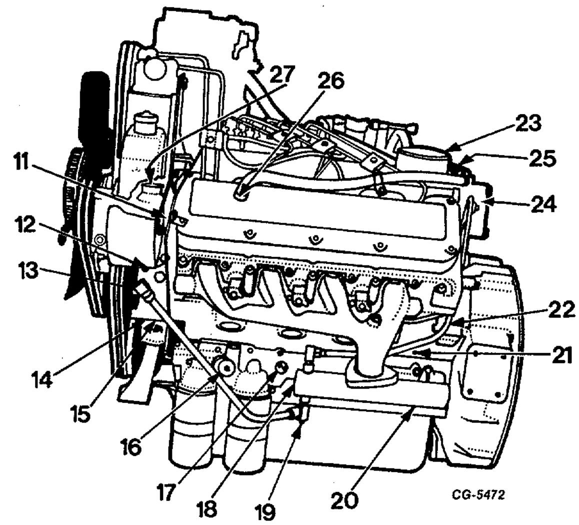


Fig. 4 Engine Showing Coolant, Oil and Air Connecting Location

1. Oil Drain
2. Air Compressor Water Supply .500" NPTF (Note: Air compressor water supply should not be "Teed" under any circumstances)
3. Air Compressor Oil Return .250" NPTF
4. Oil Level Gauge
5. Engine Oil Fill
6. Air Compressor Water Return .500" NTPF
7. Air Compressor Oil Supply
8. Engine Cooling System Air Vent .375" NPTF
9. Water Temperature Sender Switch .500" NPTF (Light)
10. Water Inlet (2.5" ID hose)
11. Water Temperature Sender .500" NPTF
12. Heater Return .500" NPTF
13. Oil Cooler Water Return
14. Heater Supply .500" NPTF
15. Surge Tank (Engine Fill). .750" NPTF
16. Oil Pressure Sender .125" NPTF
17. Low Oil Pressure Engine Shutoff Safety Switch .125" NPTF
18. Auxiliary Oil Filter Supply (Filter Hose) .250" NPTF
19. Oil Cooler, Coolant Drain
20. Auxiliary Oil Filter Return (Crankcase) .250" NPTF
21. Coolant Drain both sides of Crankcase .250" NPTF
22. Oil Cooler coolant supply (Note: Oil (Gauge) cooler should not be used to accommodate other needs)
23. Air Inlet
24. Ventilator Hose connecting location on air inlet manifold crossover (either side .500" NPTF)
25. Pipe Plug .500" NPTF
26. Ventilator Hose connecting location on Cylinder Head Cover
27. Water Outlet 2.0" ID hose

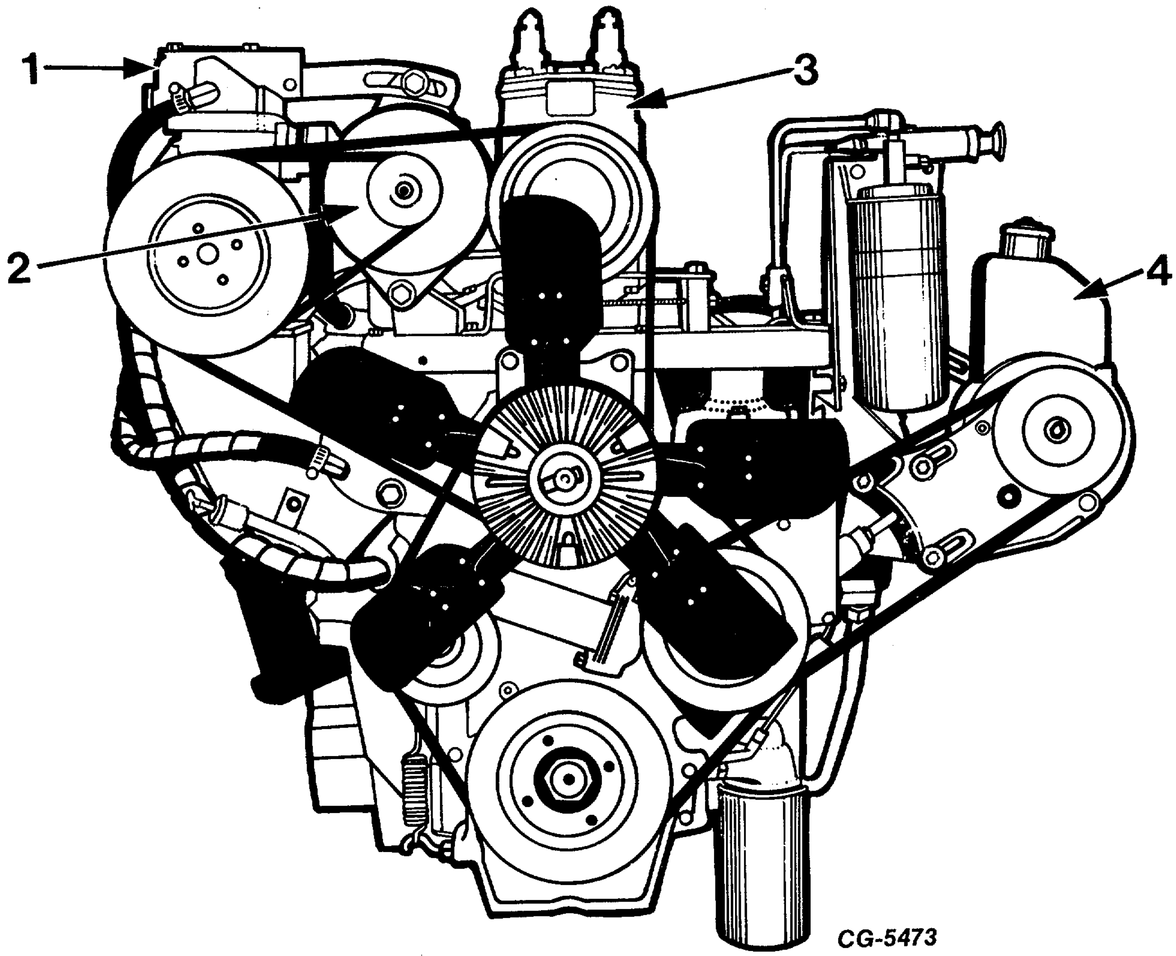


Fig. 5 Typical Accessory Location S-Series Models

1. Air Compressor
2. Alternator
3. Freon Compressor
4. Power Steering Pump

ENGINE ACCESSORIES

Typical truck application engine accessories are shown in Figure 5. The accessories shown or their location may vary between truck models or engine application.

Dual main drive belts driven by the crankshaft pulley drive the water pump and automatic temperature modulated fan. The main drive belts are held in correct tension by a spring loaded idler pulley. The idler pulley, is held in position by a pivoted idler arm to which the tension spring is attached. The idler pulley runs on a double row ball bearing, prelubricated and sealed so that further lubrication is not required. The idler arm pivots on a bushing which is oil impregnated and utilizes seals at both ends. No further lubrication of this bushing is required. The air compressor and alternator are driven by dual belts from the fan pulley. The power steering pump is driven by dual belts from the water pump pulley.

Accessory Drive Belt Tension

Accessory drive belts require correct installation, tension, alignment and maintenance. Neglect of these factors causes short belt and pulley life, cooling problems and bearing failures.

New belts, including replacement, experience a break-in period and initially loose tension during groove seating. New belt initial installation tension is higher than the retension value applied to a used belt (run five minutes or longer). This is done to minimize the number of belt adjustments and prevent belt operation under low tension during the break-in period.

Check for proper belt tension with belt Tension Gauge SE-2312.

Belt tension must be made at midpoint between pulleys at the longest belt span.

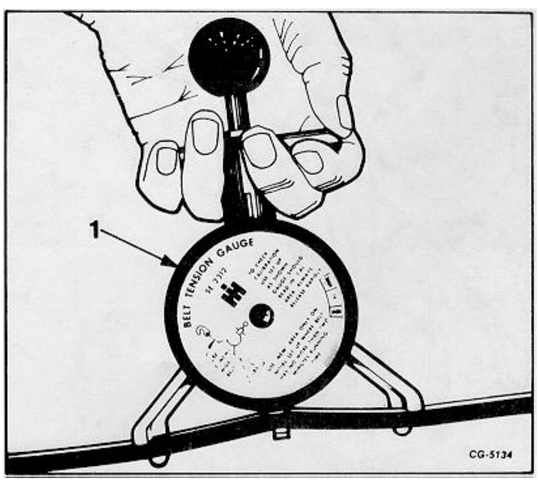


Fig. 6 Checking Belt Tension with Belt Tension Gauge SE-2312

1. Belt Tension Gauge SE-2312

(1) Grasp gauge and depress ball handle all the way down. Make certain hook extends beyond legs to pick up the belt.

(2) Apply gauge to belt. Be sure belt is positioned between nose piece and hook and that the nose piece is centered on belt.

(3) Release ball handle quickly. A slow release may prevent full return of hook, thus giving a false reading.

(4) Observe the area of gauge face indicated at the index mark. If index mark does not indicate a NEW reading on a used belt, it will be necessary to increase or decrease belt tension as required.

(5) Before changing belt tension, repeat Step 3 several times to become familiar with gauge operation. Observe gauge reading each time operation is repeated. Check tension of both belts when so equipped.

To establish tension of a loose belt, apply SE-2312 gauge to the belt and make the adjustment. Tighten belt until proper tension area is indicated on gauge. Lock adjustment and recheck belt tension. Readjust if necessary.

When using SE-2312 belt tension gauge, remember to set new belts (belt with less than five minutes running time) to the NEW area on gauge face and used belts (with more than five minutes running time) to USED area on gauge.

Belt tension may also be checked by using a straight edge and scale as illustrated (Fig. 7).

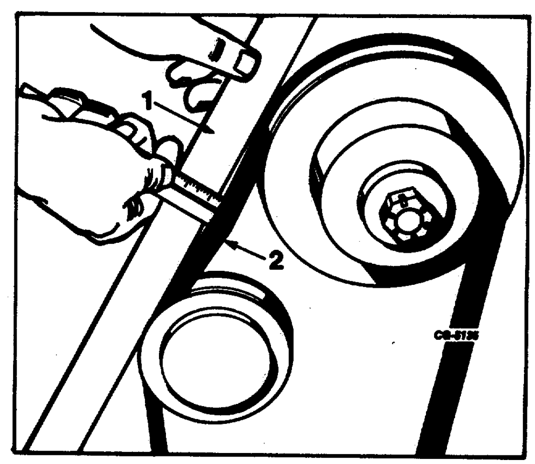


Fig. 7 Measuring Belt Tension

1. Straight Edge 2. Belt

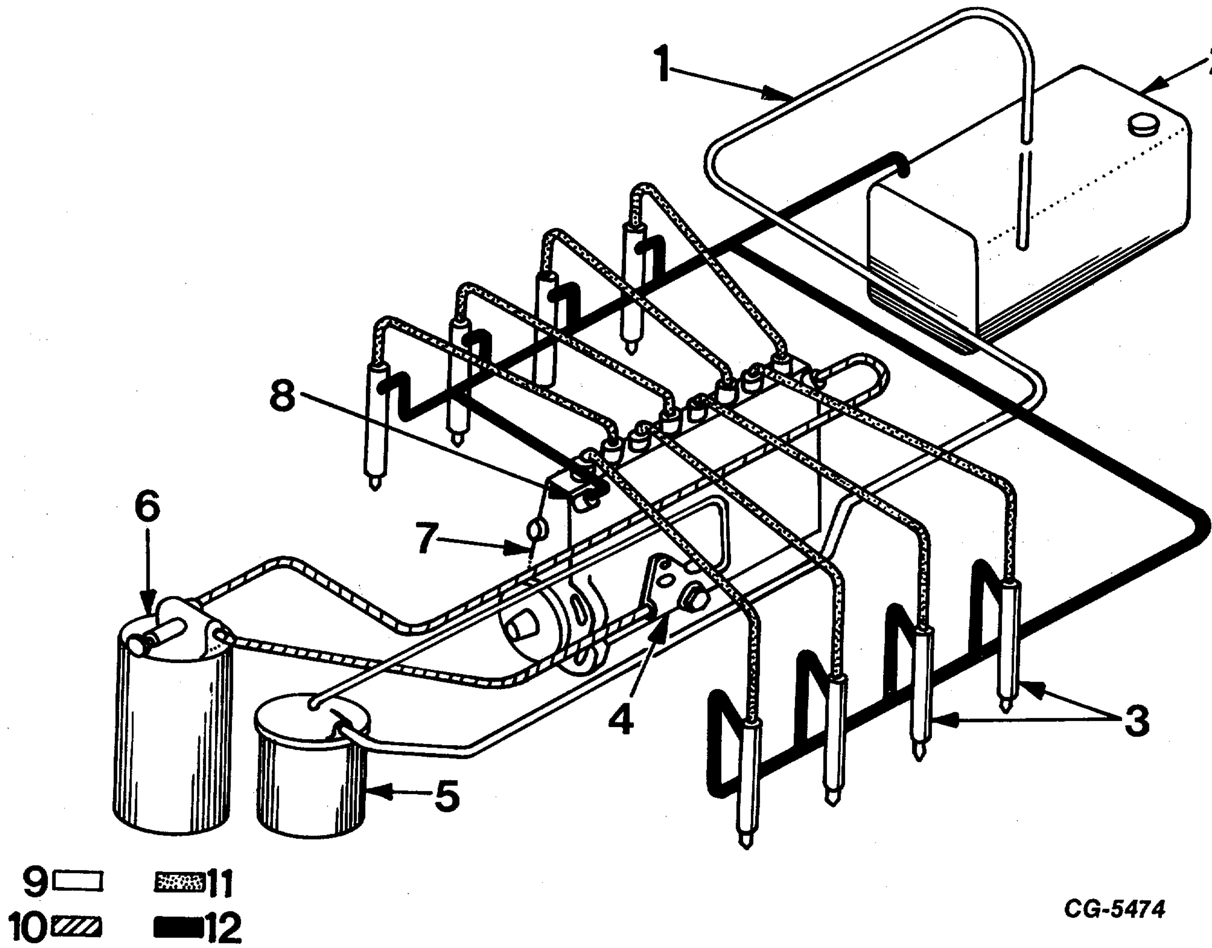


Fig. 8 Fuel System

1. Fuel Supply Line
2. Fuel Tank
3. Nozzle and Holder Assembly
4. Transfer Pump
5. Primary Filter
6. Final Filter with Primer
7. Injection Pump
8. Pressure Regulator Valve
9. Fuel Tank to Primary Filter
10. Transfer Pump to Final Filter to Injection Pump
11. Injection Lines
12. Leak-Off and Return to Tank Lines

Approximately 12.7 mm (1/2 inch) deflection should be measured. The deflection measurement should be made between pulleys at mid-point of longest belt span.

FUEL SYSTEM

Fuel is pumped from the fuel tank through the primary filter by the transfer pump, then through the final filter.

Filtered fuel is then directed to the fuel injection pump located between the cylinder banks where it is metered and delivered under high pressure to the hydraulic type injection nozzles located at each combustion chamber in the cylinder heads.

MODULATED FAN DRIVE ASSEMBLY

Torque is supplied to the input shaft of the modulated fan assembly from the fan drive hub. The input shaft transmits torque to the fan by the movement of silicon fluid between the input and output plates in the fluid filling housing. The fan drive is actuated by the positioning of a slide valve plate which controls the amount of fluid from the forward supply chamber and the rear drive chamber. Close clearance between the driving and driven members causes the driven plate to turn. The volume of fluid in the drive chambers regulates the fan speed.

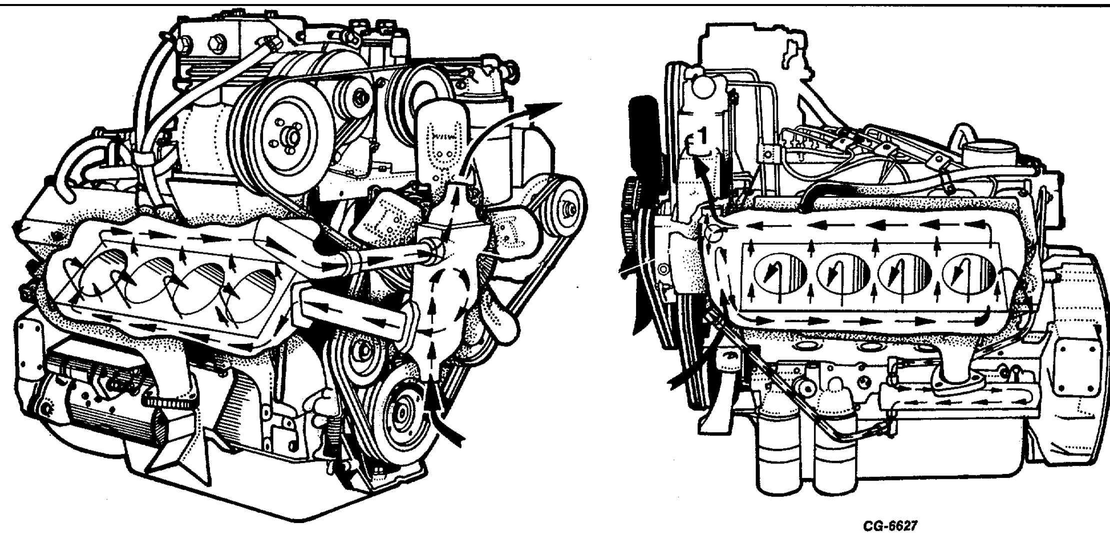


Fig. 9 Engine Coolant Flow Diagram

The valve plate is actuated by the control element, which is a bimetal coil and reacts to the air temperatures behind the radiator core operating temperature 52°C to 68°C (125°F to 155°F). When the coil is cooled by the air temperature, the coil will close the slide valve plate, restricting the flow of the silicon fluid. Through centrifugal force the fluid is allowed to re-enter the forward supply chamber through a small hole. The fan will turn at a reduced speed due to a smaller volume of fluid between the driving and driven member.

The modulated fan assembly should not be disassembled, as it is only a unit replacement item.

COOLANT FLOW

The right bank coolant is drawn from the radiator through the water pump in to the right lower crankcase via the water manifold, circulated through the crankcase and cylinder head and returned to thermostat housing through the coolant return tube.

The lift bank is cooled by coolant flow from the radiator through the water pump and into the lower crankcase through a port in the back of the water pump housing, through the crankcase and cylinder head and back to the thermostat housing located on top of the water pump housing.

Coolant is piped to the oil cooler from the rear of the lift cylinder head and back to the water pump housing.

LUBRICATING SYSTEM

Engine lubrication is provided by a system of galleries and drilled passages running through the various engine castings and moving parts. This design eliminates external or internal oil lines and assures trouble-free, efficient engine lubrication.

Figure 10 illustrates a flow diagram of the engine lubricating system.

In operation oil is forced through the engine by an internally mounted gear type oil pump which is driven through gears at the engine camshaft. Oil enters the pump through a stationary screen assembly located under the surface of the oil in the pan and above the bottom of the oil pan and attached to the oil pump body. Dual spring-loaded pressure relief valves are located in the oil pump which limit the maximum oil pressure in the system. Because of the reserve oil delivery capacity of the oil pump, the two regulator valves are required. Oil relieved by the pressure regulator valves is recirculated within the pump. This feature eliminates oil aeration, which is often caused by oil returning to the pan from the pump.

Oil leaving the oil pump passes through the oil cooler where heat from the oil is removed by the engine coolant and dissipated through the engine cooling system. From the oil cooler, the oil enters the full-flow oil filters. Each spin-on type filter has a by-pass valve which permits oil to flow to the engine in case the filter becomes clogged.

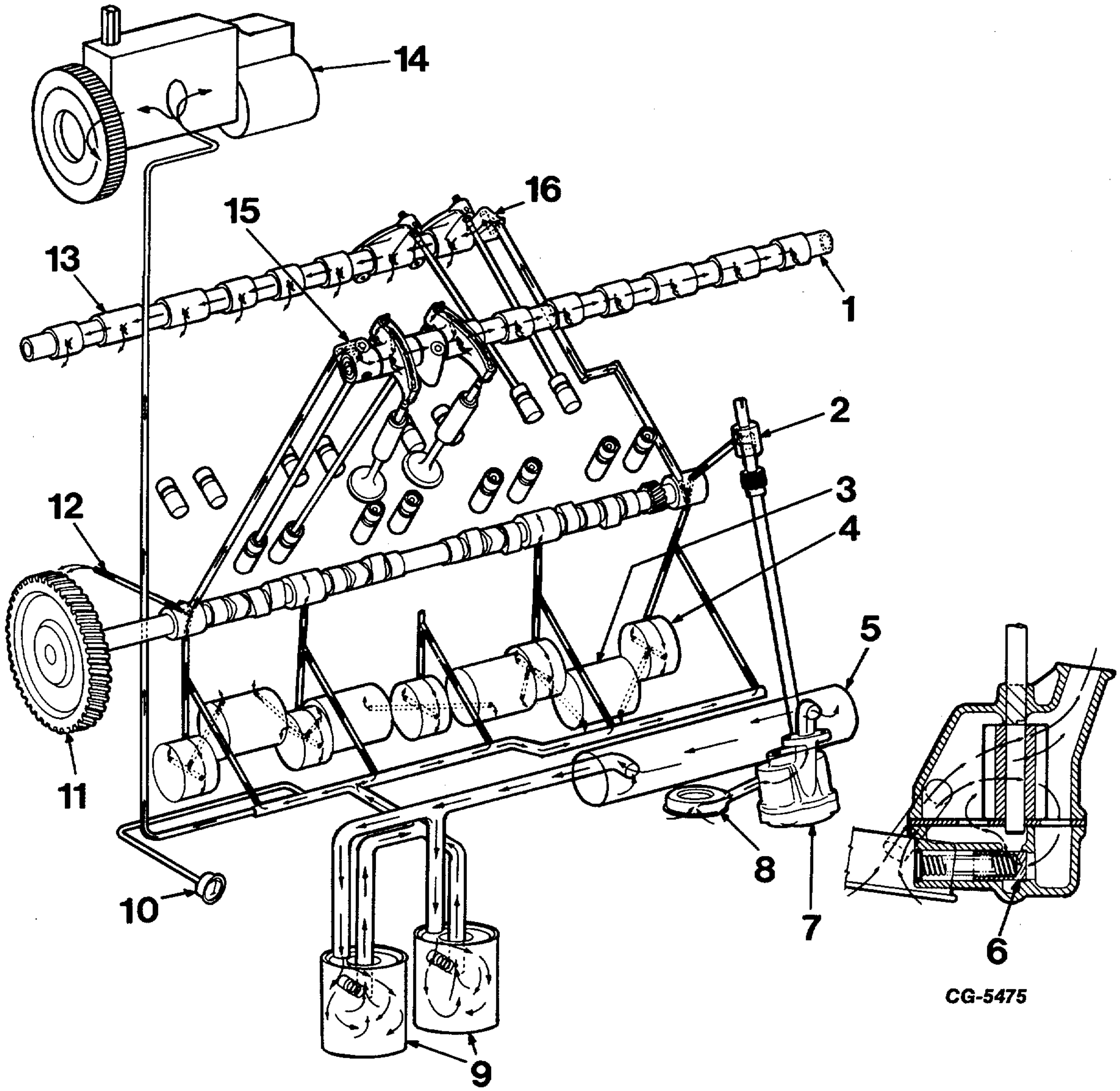


Fig. 10 Engine Lubrication System

1. Rocker Arm Shaft Left Bank
2. Oil Pump and Tachometer Shaft Upper Bushing
3. Connecting Rod Bearing
4. Main Bearing
5. Oil Cooler
6. Pressure Relief Valve
7. Oil Pump
8. Oil Pump Screen
9. Full Flow Oil Filter with By-pass Valve
10. Oil Pressure Gauge
11. Camshaft Gear
12. Oil Feed to Gears
13. Rocker Arm Shaft Right Bank
14. Injection Pump
15. Oil Feed Bracket Front Left Bank
16. Oil Feed Bracket Rear Right Bank

After passing through the cooler and filters, oil enters the main engine oil galleries which supply oil through drilled passages to the crankshaft, main and connecting rod bearings, as well as the camshaft and bearings. Oil flows from the rear camshaft bearing to the right rocker arm shaft and from the front camshaft bearing to the left rocker arm shaft. Oil delivery from the camshaft bearings also lubricates the camshaft drive gear and tachometer drive bushing located at the upper end of the oil pump drive shaft. The oil pump drive gears are lubricated from runoff or spray from the tachometer drive bushing which is directly above the pump drive gears.

The hollow rocker arm shafts are cross drilled to feed oil to each rocker arm bearing as well as the rocker arms. The rocker arms are drilled to feed oil in channels or grooves to the valve stems and push rods.

The pistons, piston rings, piston pins and valve lifters or tappets receive lubrication from oil spray thrown from the engine crankshaft. The connecting rods are not drilled for oil channels on these engines.

A passage is provided in the engine oil filter base to deliver engine oil to lubricate bearings in the fuel injection pump. The air compressor receives lubrication from this same source.

FOR SPECIFIED ENGINE OIL SEE ENGINE OPERATOR'S MANUAL

MAINTENANCE

To obtain satisfactory engine performance, the engine must be properly maintained following the maintenance schedule and instructions outlined in the vehicle operator's manual.

For fuel injection system maintenance and performance test instructions, refer to service manual sections covering fuel system components.

ENGINE REMOVAL

Engine removal procedures will differ between vehicle models. The general instructions outlined below apply to most cases.

NOTE: On some "Cargostar" vehicles, the transmission and clutch must be first removed from the vehicle to permit engine removal.

1. Drain engine coolant from radiator and engine block.

2. Drain oil from engine oil pan.

3. Disconnect battery cables.

4. Raise cab (CO models) or remove hood (conventional models).

5. Remove engine tunnel from cab floor (where required).

6. Remove radiator hoses and shutter control hoses (where used).

7. Remove air conditioning system components (where equipped). Where possible, remove units and set them aside without disconnecting freon piping. If necessary to discharge freon system, observe safety precautions.

8. Remove front bumper, engine crossmember, radiator support, radiator core assembly, as required.

9. Remove transmission shift lever island and shift rod bearing support (CO models).

10. Disconnect power steering hoses from power steering pump or remove pump from engine (where equipped).

11. Remove air cleaner piping.

12. Disconnect:

    Accelerator and throttle linkage.

    Alternator, temperature sender and oil pressure sender wiring. Air compressor piping (where equipped) Exhaust pipes from manifolds. Fuel inlet and return lines.

    Fuel shut-off (engine stop) control. Heater hoses and brackets.

    Surge tank hoses (where equipped).

    Tachometer cable.

13. Install engine lifting sling (Figure 11). Connect hoist to lifting sling.

14. Support transmission and disconnect engine from bell housing (where required).

15. Disconnect front and rear engine mountings.

16. Lift engine from chassis carefully to avoid damage to clutch driven disc.

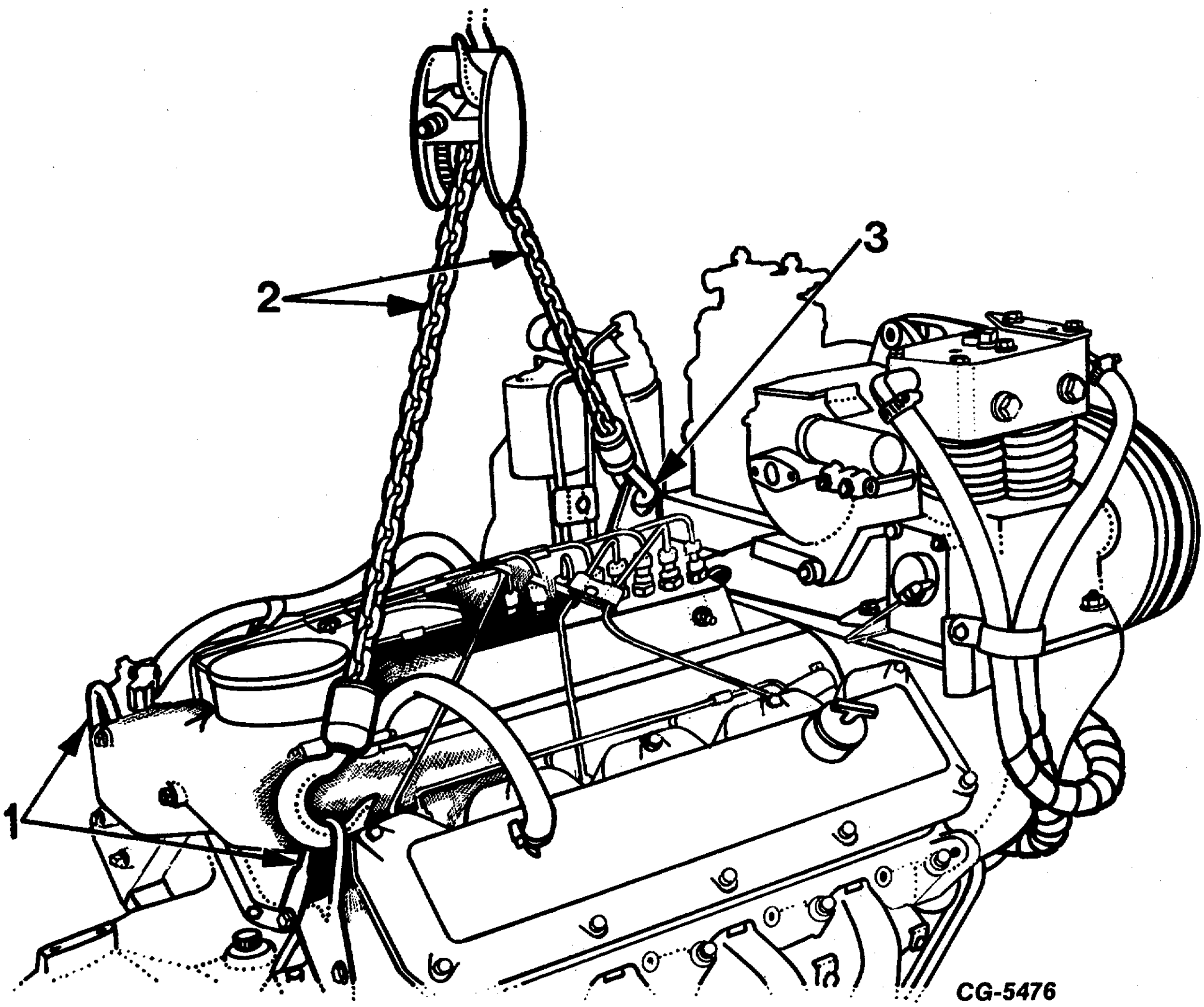


Fig. 11 Engine Lifting Sling Installation

1. Rear Lifting Loops
2. Engine Lifting Sling
3. Front Lifting Eye

ENGINE DISASSEMBLY

The disassembly sequence outlined below is intended as a guide since the actual disassembly procedure will depend upon the extent of service required and the accessory components mounted on the individual engine being serviced.

Engine disassembly can best be accomplished by mounting the engine in a rotating engine stand such as stand SE-1962.

1. Mount engine in overhaul stand as follows:

Overhaul Stand SE-1962

a. Remove right exhaust manifold.

b. Remove exhaust manifold heat shield (Figure 12).

c. Remove starting motor and adapter from flywheel housing.

d. Install overhaul stand adapter No. 975 to engine block.

e. Mount engine, with adapter, in overhaul stand (Figure 13).

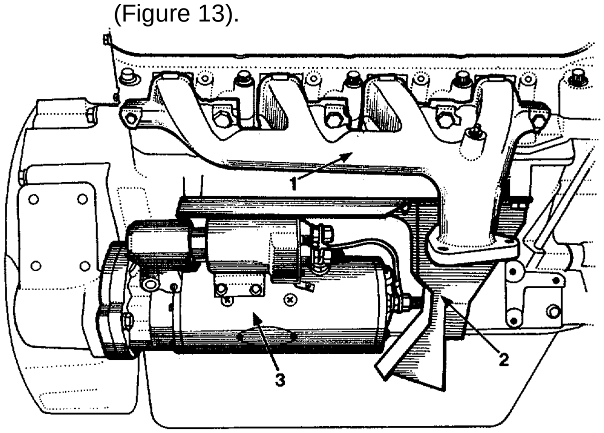


Fig. 12 Remove Exhaust Manifold, Heat Shield and Starting Motor

1. Exhaust Manifold
2. Heat Shield
3. Starting Motor

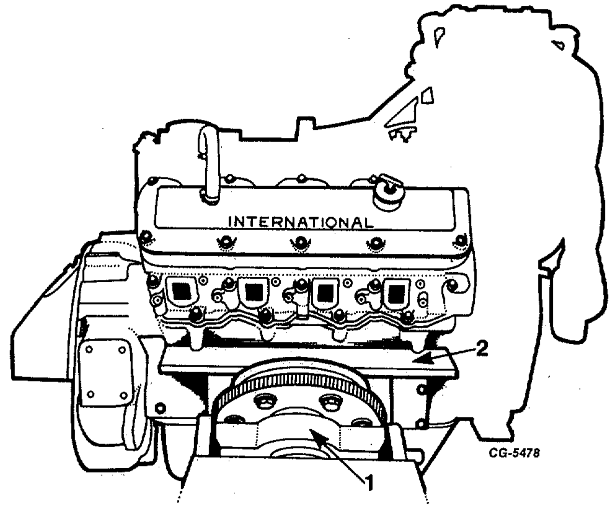


Fig. 13 Engine Mounted on Overhaul Stand

1. Overhaul Stand SE-1962 with Adapter

2. Loosen the alternator adjusting strap bolt and two mounting bolts, push alternator towards air compressor to loosen alternator drive belts (Figure 14).

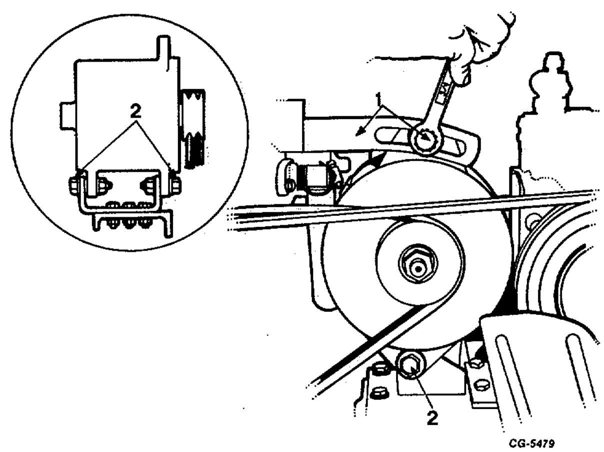


Fig. 14 Alternator Adjusting Bolt Location

1. Adjusting Strap and Bolt
2. Mounting Bolts Both Ends

3. Loosen four freon compressor mounting bolts, loosen adjusting bolt and slide freon compressor toward alternator (Figure 15).

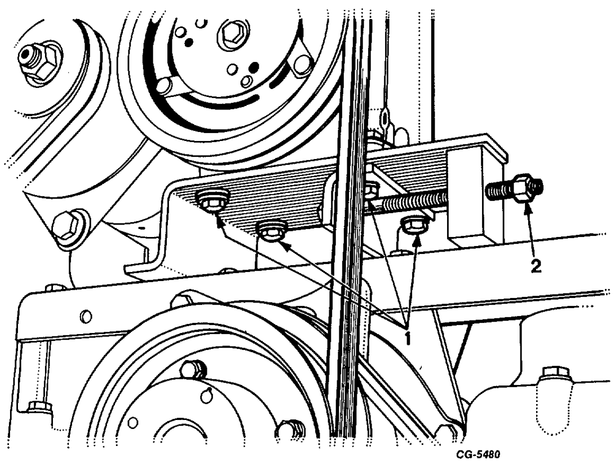


Fig. 15 Freon Compressor Adjusting and Mounting Bolts Locations

1. Mounting Bolts
2. Adjusting Bolt

4. Remove air compressor, alternator and freon compressor drive belts.

5. Remove air compressor water supply hose, water return hose and oil supply pipe (Figure 16).

6. Remove air compressor. The air compressor and mounting bracket may be removed as an assembly by removing three bolts located at the bottom of the bracket or by removing the air compressor from the bracket and then the bracket from the cylinder head (Figure 16).

7. Some truck applications will use a vacuum pump rather than an air compressor. The vacuum pump uses the same mounting bracket as the air compressor. To remove the vacuum pump disconnect the oil and air line, then the mounting bolts.

8. Remove two alternator to mounting bracket bolts. Remove alternator. Remove four mounting bracket bolts and remove bracket (Figure 17).

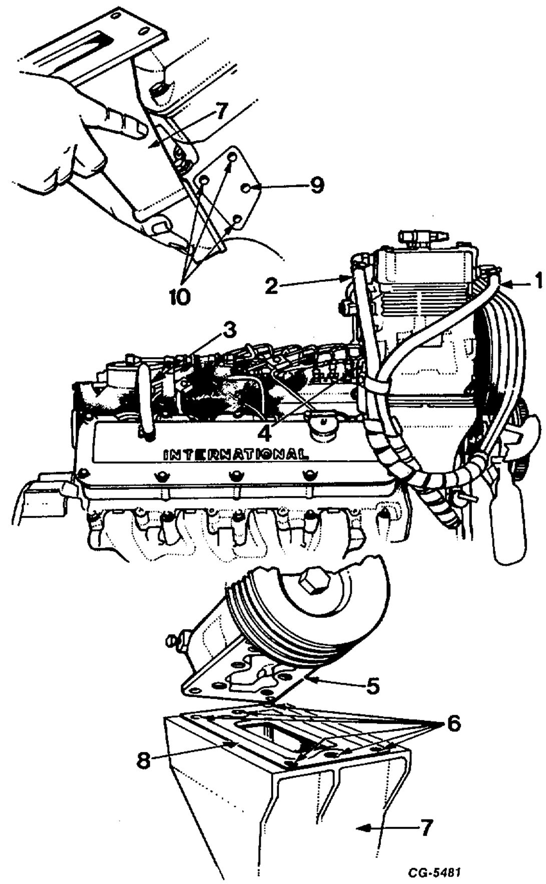


Fig. 16 Removing Air Compressor

1. Water Supply Hose
2. Water Return Hose
3. Ventilator Hose
4. Oil Supply Pipe
5. Air Compressor
6. Mounting Hole Location (Air Compressor to Mounting Brkt.
7. Air Compressor Mounting Brkt.
8. Gasket
9. Oil Return Hole
10. Mounting Hole Location (Bracket Cylinder Head)

9. The freon compressor and mounting bracket may be removed as an assembly by removing four freon compressor mounting brackets to engine accessory channel bolts. (Figure 18).

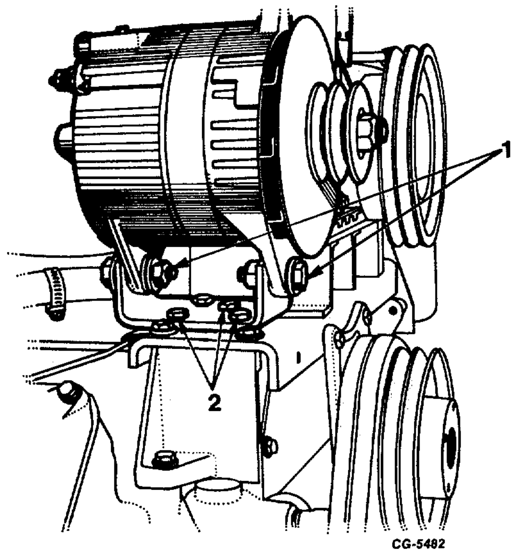


Fig. 17 Remove Alternator

1. Alternator to Mounting Bracket Bolts
2. Bracket Mounting Bolts

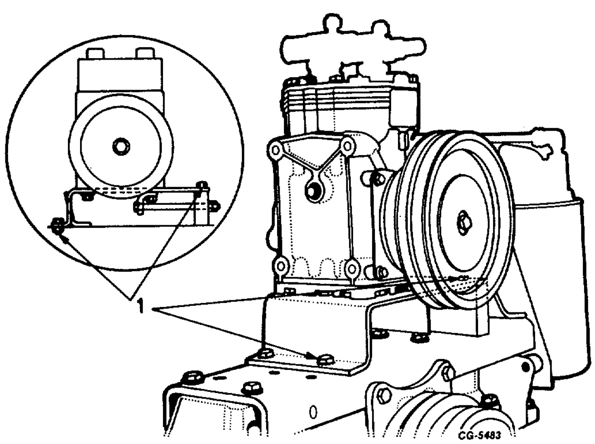


Fig. 18 Removing Freon Compressor

1. Freon Compressor Mounting Bracket to Engine Accessory Channel Bolts

10. Loosen the power steering pump adjusting bolt locknut, three bracket bolts and adjusting strap bolt at the rear of pump. Push mounting bracket inward to remove power steering pump drive belts (Figure 19).

11. The power steering pump and mounting bracket may be removed from the engine as an assembly by removing the adjusting strap bolts and three pump brackets to engine mounting bolts (Figure 19)

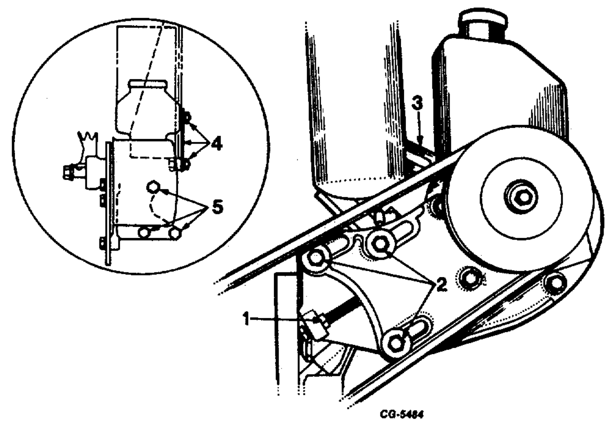


Fig. 19 Removing Power Steering Pump

1. Adjusting Bolt and Locknut
2. Bracket Bolts
3. Adjusting Strap
4. Adjusting Strap and Bolts
5. Pump Bracket to Engine Mounting Bolts

12. Remove the modulated fan drive and fan assembly from the fan pulley hub by removing four bolts and lockwashers. Remove modulated fan drive and fan assembly (Fig. 20). The fan may be removed from the modulated fan drive by removing four bolts and lockwashers (Fig. 20).

13. Pry idler pulley toward center of engine and remove main drive belts (Figure 21).

14. Remove fuel filters and fuel pipes from primer pump assembly. Remove three bolts from primer pump mounting bracket and remove bracket with pump from engine.

15. Remove four fan hub assembly mounting bolts and remove assembly (Figure 23).

    The hub pulley may be removed before or after the assembly is removed from engine.

16. Remove accessory mounting channel by removing the remaining six bolts along with the engine lifting eye (Figure 23).

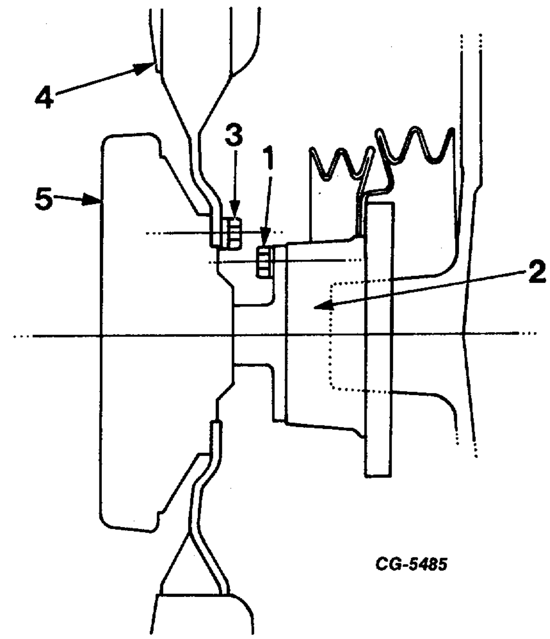


Fig. 20 Modulated Fan Drive and Fan Removal

1. Mounting Bolts, Modulated Fan Drive to Pulley Hub
2. Fan Pulley Hub
3. Mounting Bolts, Fan to Drive
4. Fan
5. Modulated Fan Drive

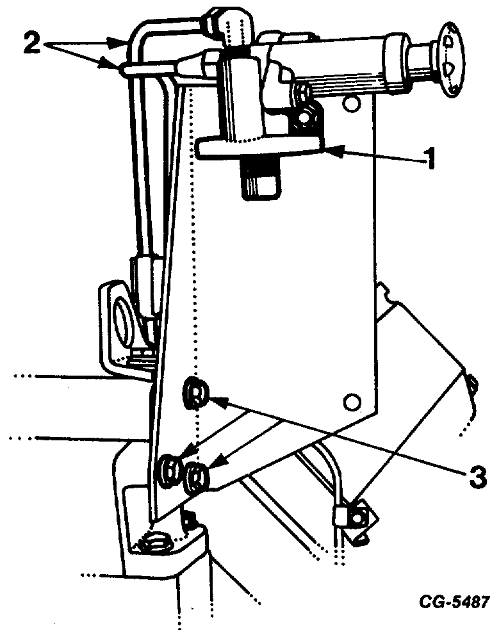


Fig. 22 Removing Primer Pump and Filter Mounting Bracket Assembly

1. Fuel Filter Base and Primer Pump Assembly
2. Fuel Pipes
3. Bracket Mounting Bolts

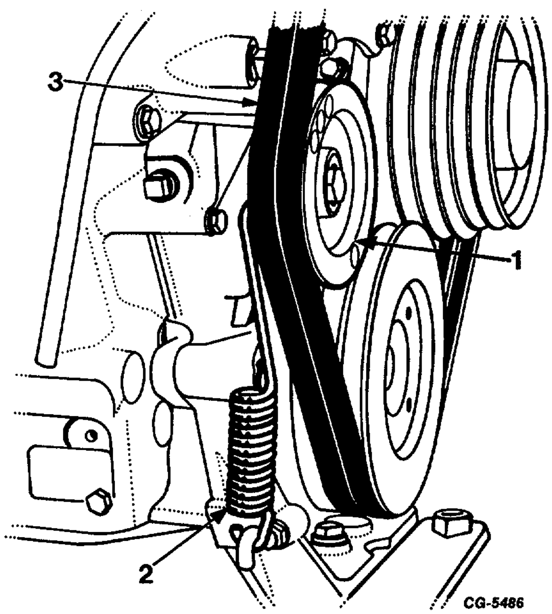


Fig. 21 Removing Main Drive Belts

1. Idler Pulley
2. Idler Pulley Tension Spring
3. Main Drive Belts

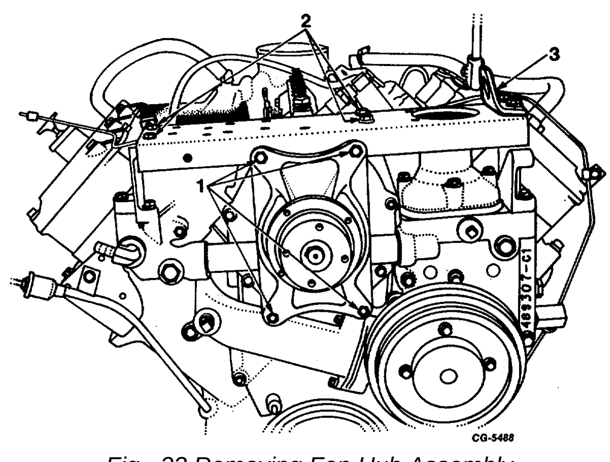


Fig. 23 Removing Fan Hub Assembly

1. Fan Hub Assembly Mounting Bolts
2. Channel Mounting Bolts
3. Engine Lifting Eye &.Mtg. Bolts

17. Remove water pump pulleys by removing four mounting bolts, then slide the front pulley, the spacer and the rear pulley off the hub (Figure 24).

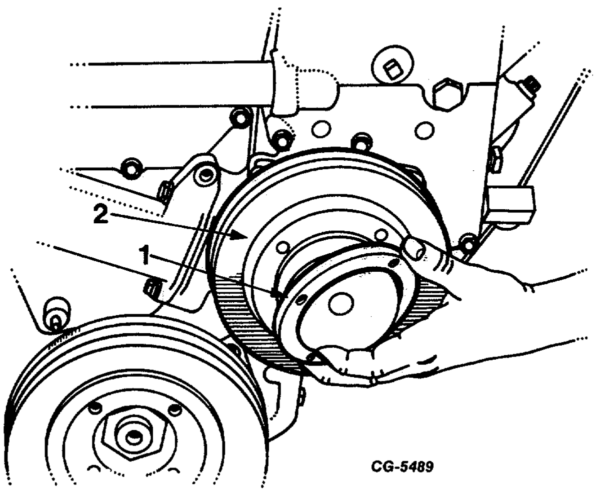


Fig. 24 Water Pump Pulley Removal

1. Between Pulleys Spacer
2. Rear Pulley

18. The water pump assembly with hub can be removed at this time or on the bench after the complete water pump housing assembly has been removed. (The water pump assembly with hub is serviced as a complete assembly). To remove the water pump assembly with hub, remove four bolts and remove assembly (Figure 25).

19. To remove water outlet and water return tube, remove two bolts from water outlet and remove assembly from cylinder head and water pump housing (Figure 26).

20. Remove water pump to crankcase manifold by removing two bolts from manifold to crankcase and two bolts from manifold (Figure 27).

21. Remove water pump housing with thermostat housing from crankcase by removing five bolts and oil cooler water return line, remove housing with water return tube (Figure 28).

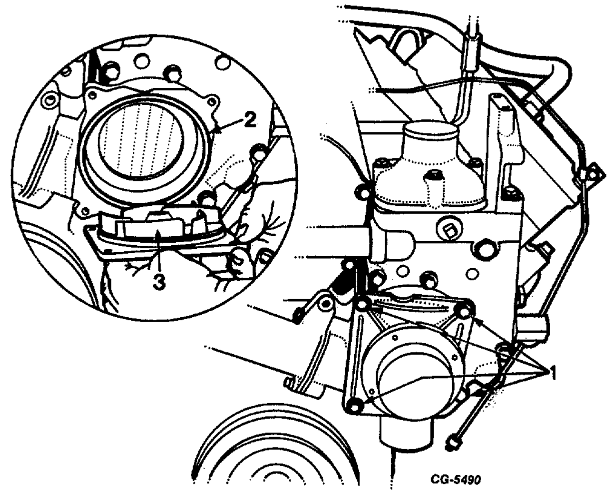


Fig. 25 Removal of Water Pump Assembly

1. Water Pump Assembly Mounting Bolts
2. Gasket
3. Gasket Impeller

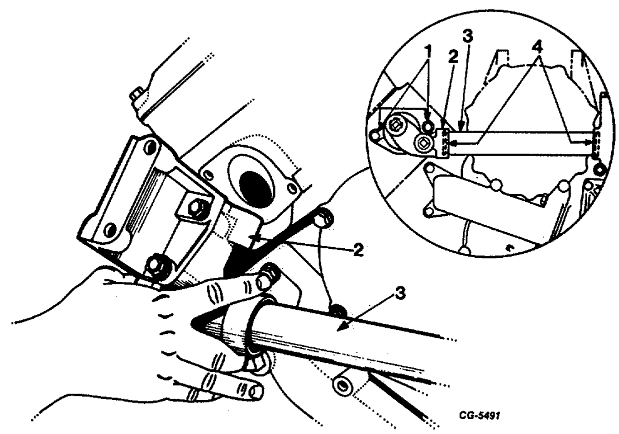


Fig. 26 Removing Water Outlet and Return Tube

1. Mounting Bolts
2. Water Outlet
3. Return Tube
4. "O" Ring

22. Remove injection pump drive gear cover by removing seven bolts, then remove cover (Figure 29). Remove the oil level dipstick by turning back-and-forth and pulling at the same time.

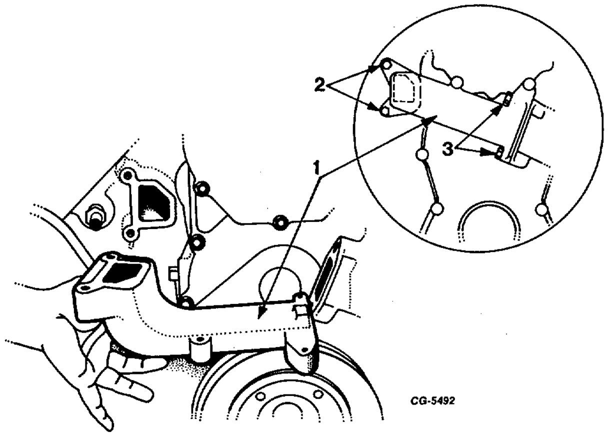


Fig. 27 Removing Water Manifold

1. Water Manifold
2. Manifold to Crank case Mounting Bolts
3. Manifold to Water Pump Mounting Bolts

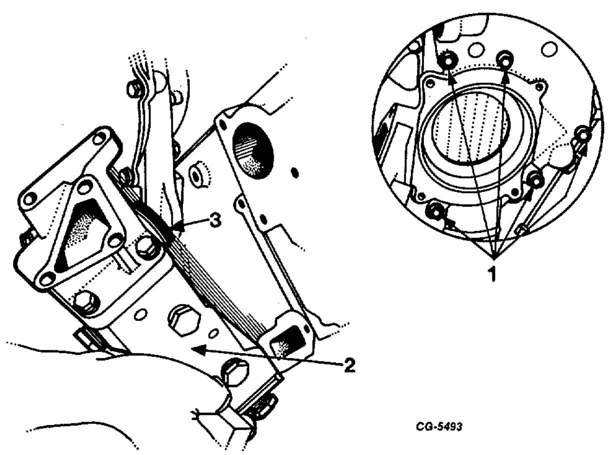


Fig. 28 Water Pump Housing Removal

1. Mounting Bolts
2. Water Pump Housing
3. Water Return Tube and "O" Ring

23. Remove four injection pump drive gear mounting bolts, remove gear (Figure 30).

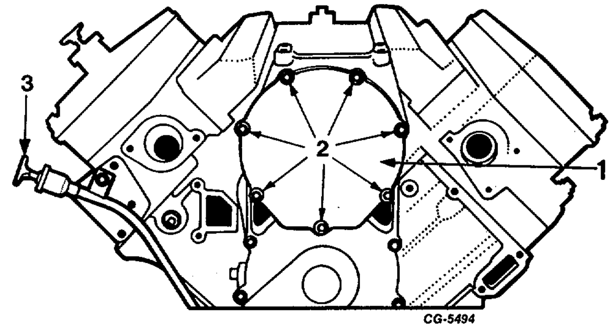


Fig. 29 Removing Injection Pump Drive Gear Cover and Dipstick

1. Injection Pump Drive Gear Cover
2. Cover Bolts
3. Oil Level Dipstick Gauge

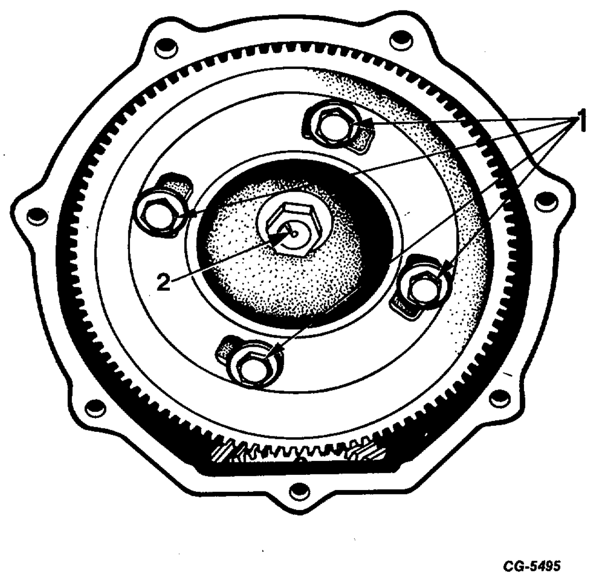


Fig. 30 Removing Injection Pump Drive Gear

1. Injection Pump Drive Gear Mounting Bolts
2. Timing Mark

NOTE: The injection pump drive gear hub does not have to be removed at this time. It may be left on pump shaft until the pump is over- hauled or set up for pump stand installation (Figures 21 & 32).

24. Remove injection pump drive gear hub retaining nut (Figure 31).

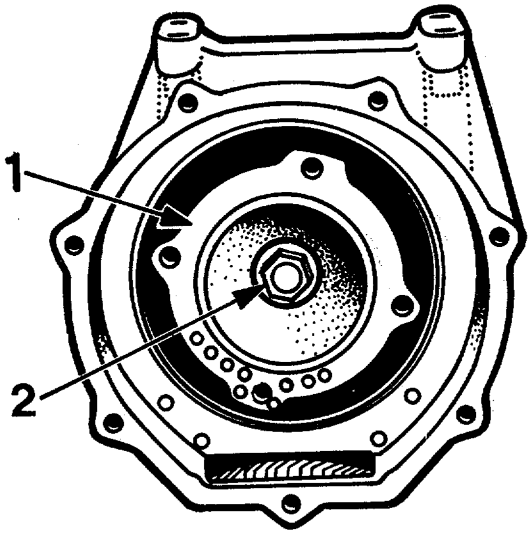


Fig. 31 Removing Gear Hub Retaining Nut

1. Injection Pump Drive Gear Hub
2. Retaining Nut

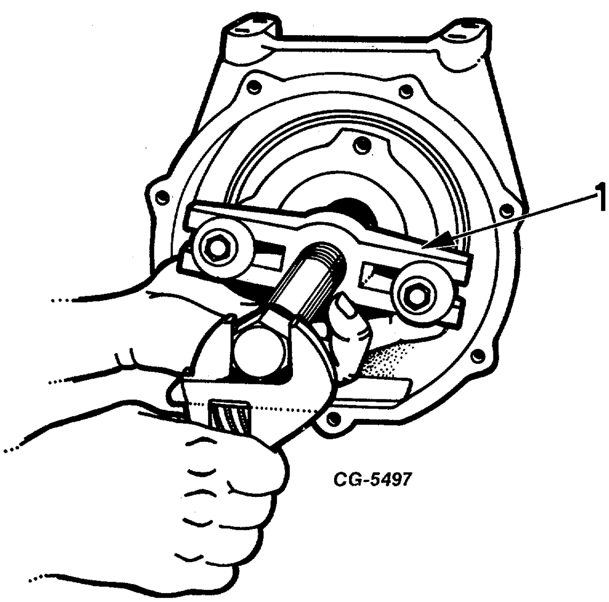


Fig. 32 Removal of Gear Hub with Puller SE-1368

1. Puller SE-1368

25. Remove injection pump drive gear hub with puller SE-1368 (Figure 32).

26. Disconnect idler arm spring from hook in front cover and remove spring from idler arm. Loosen idler arm bolt and remove idler arm and spacer from bracket (Figure 33).

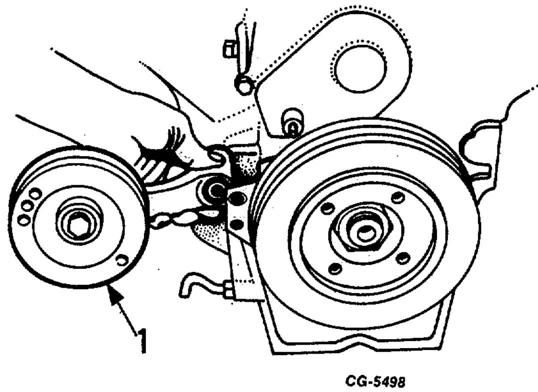


Fig. 33 Removing Idler Arm Pulley Assembly

1. Idler Arm Pulley

27. Remove left side exhaust manifold by removing five mounting bolts, remove manifold gaskets (Figure 34).

28. Disconnect oil cooler water return line from oil cooler and remove return line. Disconnect oil cooler water inlet line from engine and oil cooler and remove water inlet line. Remove four oil cooler mounting bolts and remove oil cooler (Figure 35). The oil filters may be removed at this time.

NOTE: In the event of camshaft, crankshaft, connecting rod or main bearing failure, bearing debris may become lodged in the oil cooler assembly.

Cleaning or flushing of the oil cooler assembly is not adequate and the metal residue can cause a repeat engine bearing failure.

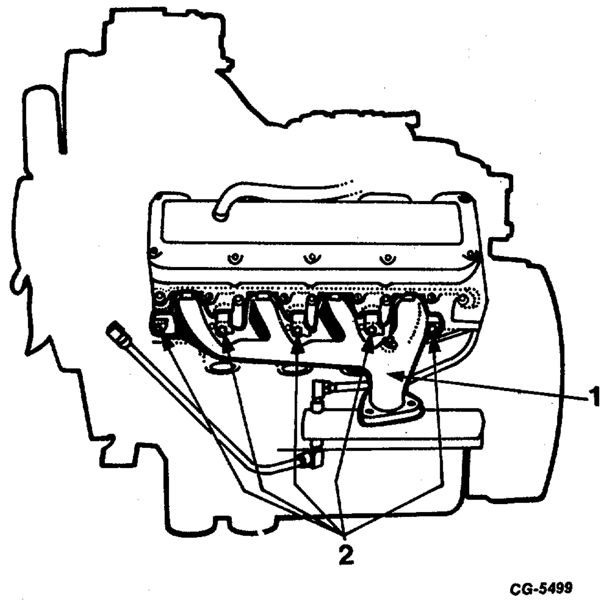


Fig. 34 Removing Exhaust Manifold Left Side of Engine

1. Exhaust Manifold
2. Mounting Bolt

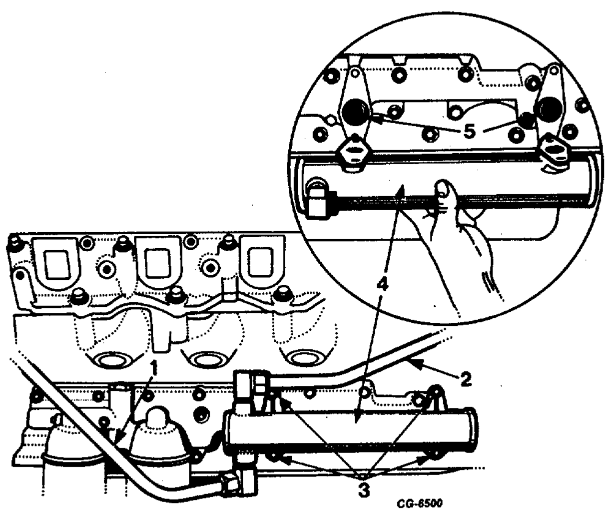


Fig. 35 Removing Oil Cooler

1. Water Outlet Line
2. Water Inlet Line
3. Mounting Bolts
4. Oil Cooler
5. "O" Rings

To prevent repeat engine failures it is recommended that the oil cooler core assembly be replaced whenever a bearing failure occurs or when an engine failure occurs that allows metal debris to circulate through the lubrication system.

29. Disconnect air compressor and injection pump oil line from oil filter base (Figure 36).

30. Remove sixteen mounting bolts from oil filter base and remove oil filter base (Figure 36).

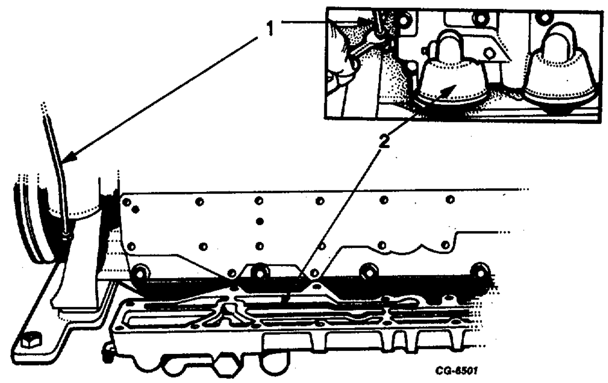


Fig. 36 Removing Oil Filter Base

1. Air Compressor and Injection Pump Oil Feed Line
2. Oil Filter Base

31. Disconnect fuel injection lines from injection pump and injection nozzles, remove lines (Figure 37.

IMPORTANT

When removing any of the fuel system lines, the lines should have dust caps installed over both ends as well as the fittings where the lines were removed. This procedure is to protect against entry of foreign matter in the fuel system. The dust caps come in various sizes and can be procured locally.

32. Disconnect left and right bank ventilator hose from air intake manifold crossover (Figure 37).

33. Disconnect ventilator hose from left valve cover (Figure 37).

34. Remove six manifold crossover mounting bolts and remove crossover from intake manifold (Figure 38).

35. Remove eight mounting bolts from the left bank intake manifold (Figures 39 and 40)

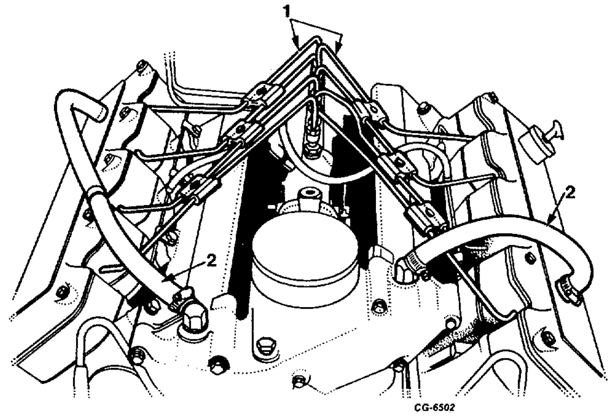


Fig. 37 Removing Injection Lines and Ventilator Hoses

1. Fuel Injection Lines
2. Ventilator Hose

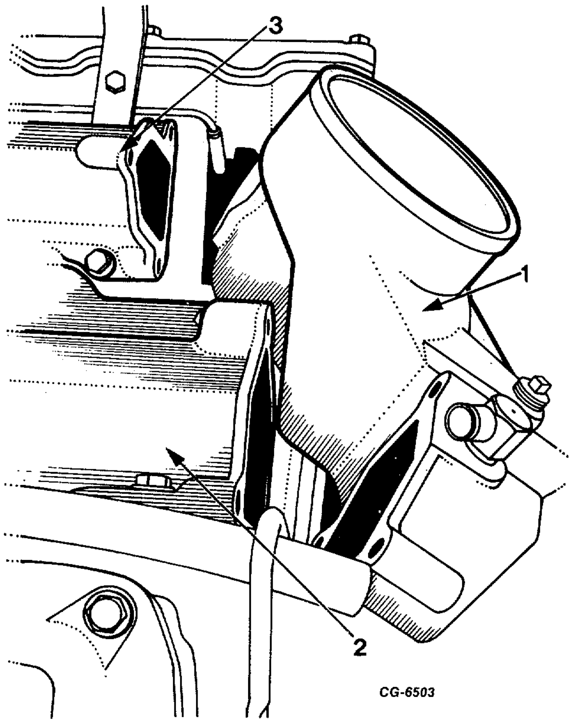


Fig. 38 Removing Intake Manifold Crossover

1. Intake Manifold Crossover
2. Left Intake Manifold
3. Right Intake Manifold

36. Disconnect leak off return hose from leak-off manifold and injection pump valve, remove hose (Figure 39).

37. Remove leak off manifold with support clips from intake manifold and disconnect from nozzle coupling hoses, remove leak off manifold (Figure 39).

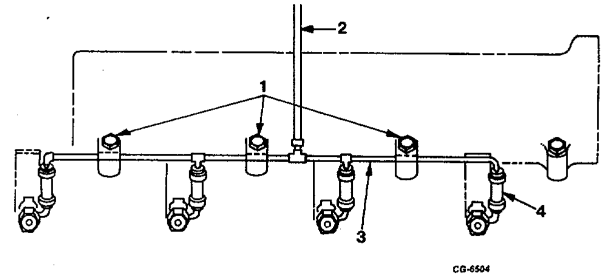


Fig. 39 Removal of Leak-Off Manifold

1. Mounting Bolts
2. Leak-Off Hose
3. Nozzle Fuel Leak-Off Manifold with Support Clips
4. Nozzle Coupling Hoses

38. Remove left intake manifold (Figure 40).

NOTE: Left and right intake manifold can be interchanged.

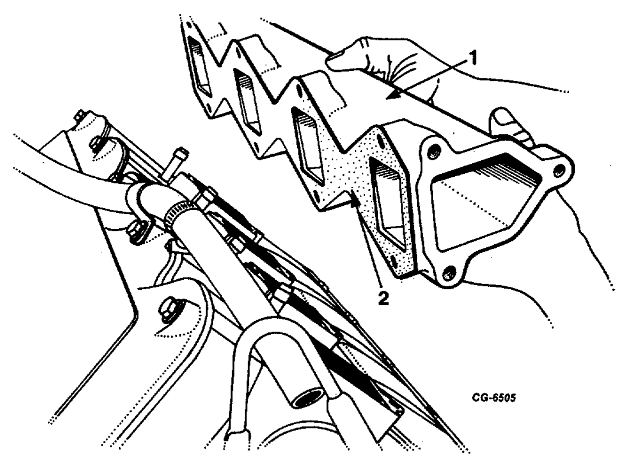


Fig. 40 Left Intake Manifold Removal

1. Intake Manifold
2. Gasket

39. Disconnect fuel supply line from transfer pump and remove (Figure 41).

40. Disconnect fuel line from transfer pump and fuel filter, remove line (Figure 41).

41. Disconnect fuel line from injection pump and primer pump, remove line (Figure 41).

42. Disconnect oil feed lines from tee fitting (line coming from oil filter base and oil feed line for air compressor or vacuum pump) (Figure 41).

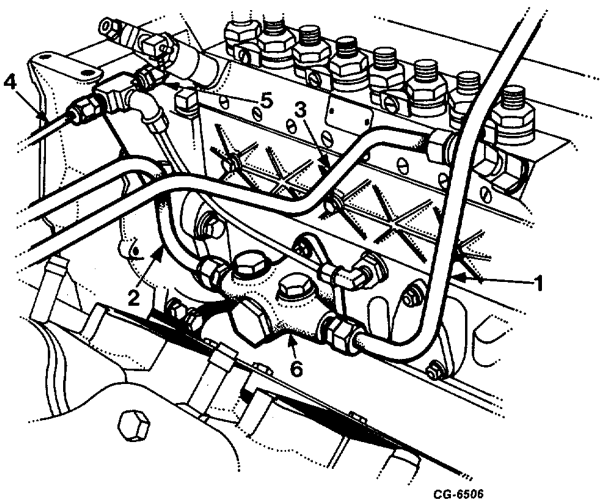


Fig. 41 Removing Fuel and Oil Lines From Injection Pump

1. Fuel Line From Primary Filter
2. Fuel Line to Final Filter
3. Fuel Line From Primer Pump
4. Oil Feed Line From Oil Filter Base
5. Oil Line to Air Compressor or Vac. Pump.

43. Remove four injection pump adapter to engine front cover mounting bolts. Remove two support bracket bolts on right side of pump and two mounting bracket nuts underneath injection pump, remove pump (Figure 42).

44. Remove two bolts from lower pump mounting bracket and remove bracket (Figure 42).

45. Remove right bank intake manifold in the same manner as the left, steps 35, 36, 37 and 38 (Figure 39 and 40).

The following steps 46 thru 52 pertain to disassembly of both cylinder heads:

46. Remove ten cylinder head cover bolts and flat washers, remove cover from cylinder head extension.

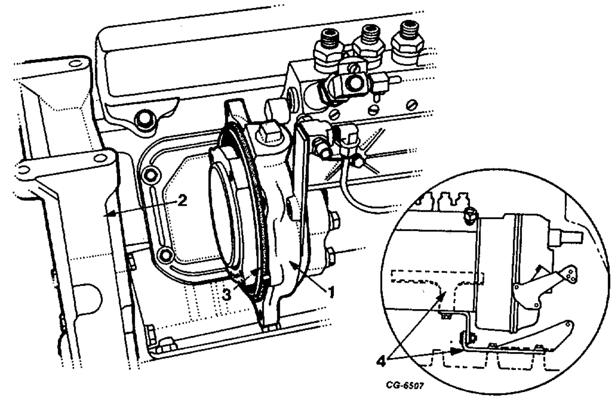


Fig. 42 Removing Injection Pump

1. Injection Pump to Engine Front Cover Adaptor
2. Engine Front Cover
3. Gasket
4. Injection Pump Mounting Bracket Locations

47. Remove five rocker arm shaft assembly mounting bolts and flat washers, remove four cylinder head extension bolts and flat washers, remove rocker arm shaft assembly (Figure 43).

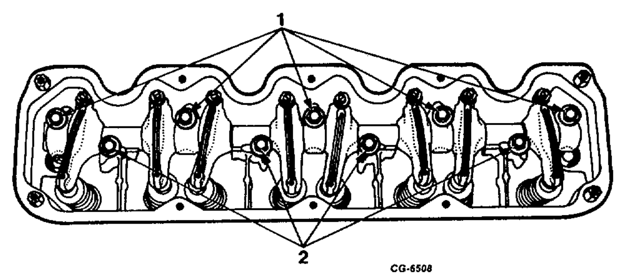


Fig. 43 Removing Rocker Arm Shaft Assembly

1. Rocker Arm Shaft Assembly Mounting Bolts
2. Cylinder Head Extension Mounting Bolts

48. Remove four corner cylinder head extension mounting bolts and remove extension.

DISASSEMBLY

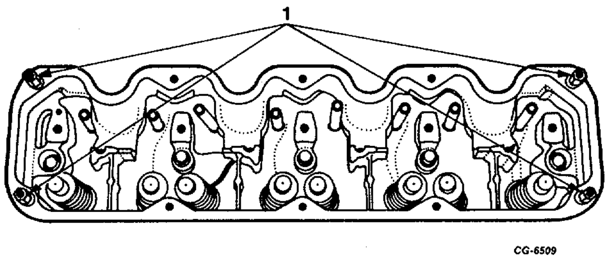


Fig. 44 Removing Cylinder Head Extension

1. Cylinder Head Extension Corner Mounting Bolts

49. Remove injection nozzles by removing the nozzle hold-down bolt, flat washer and clamp, then with slide hammer remover tool SE-1746 equipped with adapter nut installed securely on nozzle, remove nozzle, washer, seal and gasket from cylinder head (Figure 45). Be careful not to strike nozzle tips against any hard surface during removal. Cover nozzle assembly fuel inlet and leak-off openings with plastic caps to prevent entry of dirt.

    Place nozzle assemblies in a holding fixture (SE-2102) as they are removed from the heads. The fixture (Figure 46) is stamped with numbers corresponding to the cylinder numbering of the engine. Use of this fixture permits replacing nozzles in their respective ports in the cylinder heads.

50. Remove valve tips from ends of valves. Withdraw push rods from engine (Figure 47).

51. Remove fourteen cylinder head to crankcase mounting bolts (Figure 47).

52. Attach cylinder head lifting sling SE-1896 to cylinder head. Remove head and gasket, being careful not to damage location dowel sleeves (Figure 48).

53. Remove tappets using SE-2097 remover tool (Figure 49).

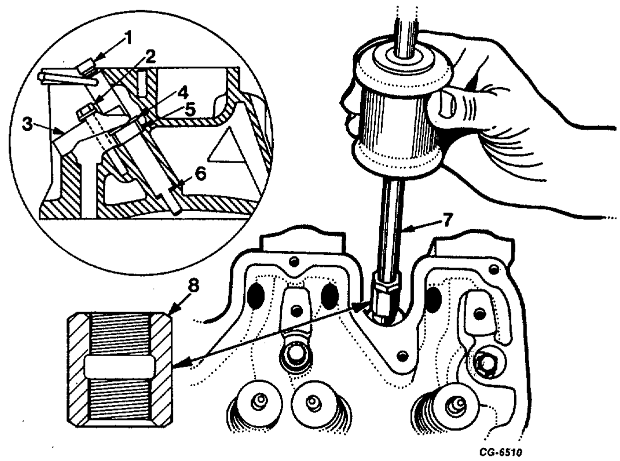


Fig. 45 Removing Injection Nozzle

1. Nozzle
2. Hold-Down Bolt and Washer
3. Clamp
4. Washer
5. Seal
6. Gasket
7. Slide Hammer Remover SE-1746
8. Drill and tap nut (Part No. 1700462-C1) to 1/2 13 UNC28 Thread

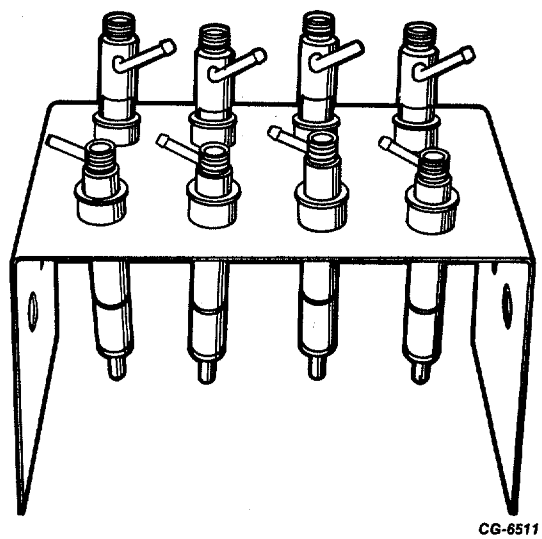


Fig. 46 Nozzle Holding Fixture SE-2102

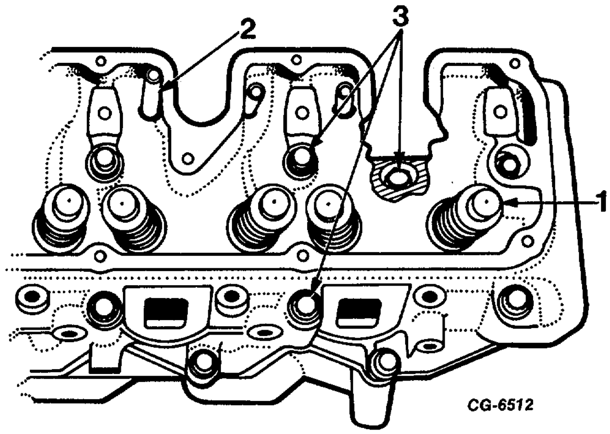


Fig. 47 Removing Valve Caps, Push Rods and Head Mounting Bolts

1. Valve Cap
2. Push Rod
3. Cylinder Head Mounting Bolts

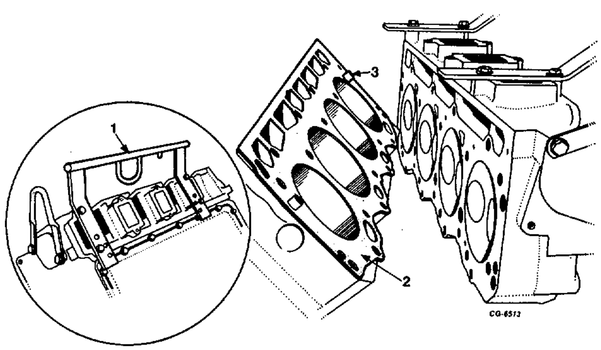


Fig. 48 Removing Cylinder Head

1. Lifting Sling SE-1896
2. Gasket
3. Dowell Sleeve

54. Remove fourteen attaching bolts in each tappet cover and remove cover and gasket (Figure 50).

55. Remove crankshaft pulley using SE-1368 puller (Figure 51).

56. If front seal wear sleeve on crankshaft pulley shows evidence of wear or damage, remove sleeve. This can be accomplished by placing crankshaft pulley in press and with an adapter (1-3/4" I.D. x 2-1/4" O.D. x 3" long), press the pulley from the wear sleeve. Be careful not to damage pulley hub surface when performing pressing operation.

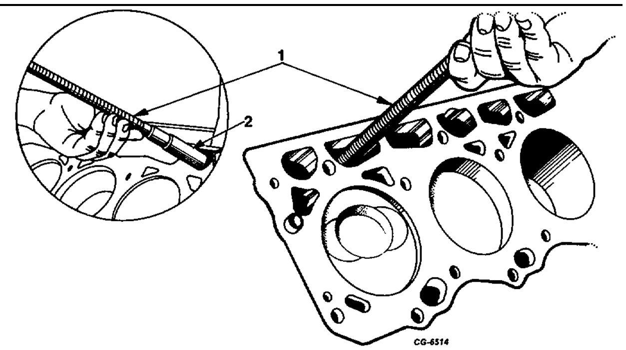


Fig. 49 Tappet Removal

1. Remover Installer Tool SE-2097
2. Tappet

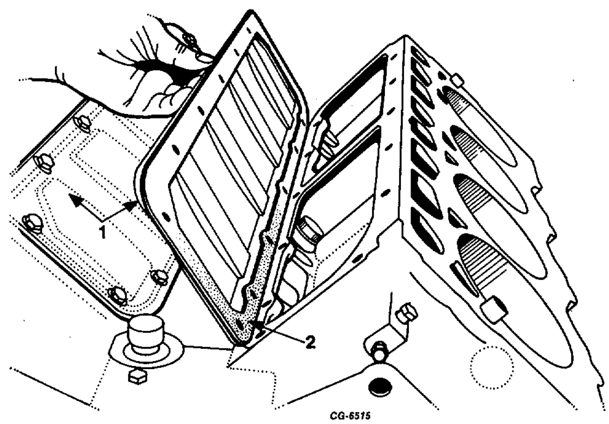


Fig. 50 Removing Tappet Cover

1. Tappet Cover
2. Gasket

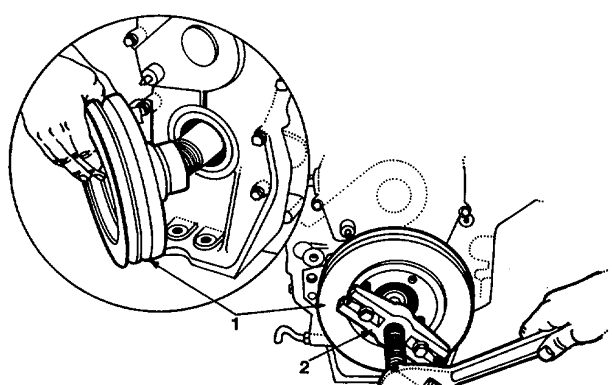


Fig. 51 Crankshaft Pulley Removal

1. Crankshaft Pulley
2. Puller SE-1368

an alternate method is to expand the wear sleeve by tapping with a flat hammer on the seal surface (Figure 52). Then with a pry bar underneath the flange of the wear sleeve, pry the sleeve from hub of crankshaft pulley. When performing the prying operation be sure not to nick, scuff or damage the hub surface.

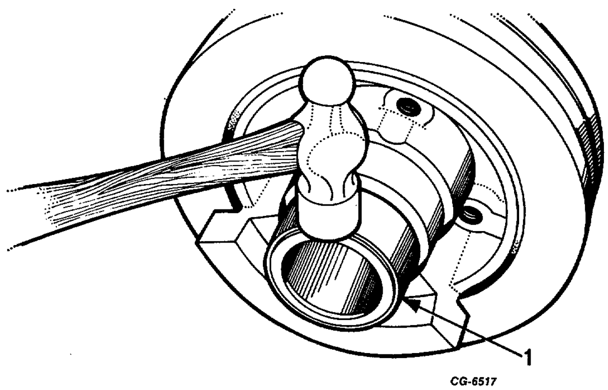


Fig. 52 Expanding Crankshaft Pulley Wear Sleeve for Removal

1. Wear Sleeve

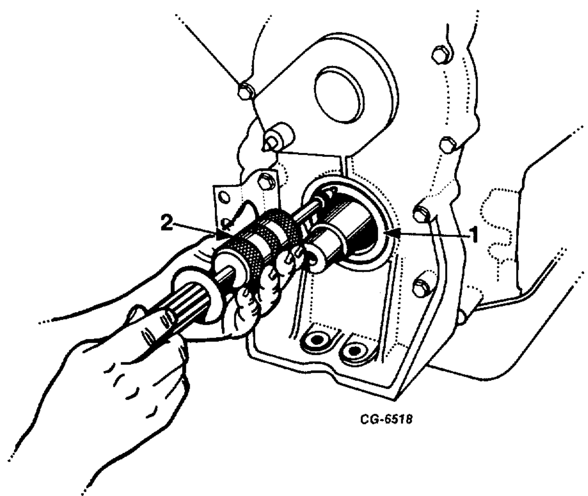


Fig. 53 Removing Front Cover Oil Seal Using SE-2091 Seal Puller

1. Oil Seal 2. Oil Seal Puller SE-2091

57. To remove, pierce seal with point of screw on end of puller. Thread screw CGES-205 into seal. Apply slide hammer to pull seal from front cover.

NOTE: When required, front cover oil seal can be removed for replacement without removing front cover by using SE-2091 oil seal puller (Figure 53).

NOTE: The front engine cover can be removed without removing the oil pan.

58. Remove ten front cover to crankcase mounting bolts (two of the ten bolts are located on the back side of the front cover under the injection pump gear opening) and three oil pan to front cover mounting bolts (Figure 54).

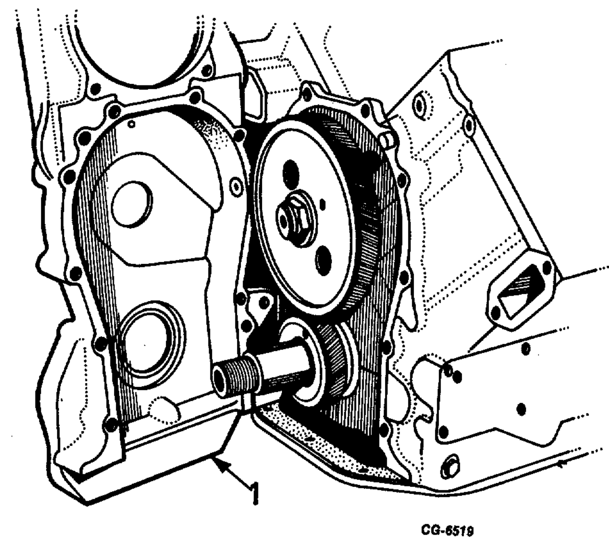


Fig. 54 Removing Front Cover

1. Front Cover

59. Mount dial indicator on front of engine and check and record camshaft gear-to-crankshaft gear backlash (Figure 55). If backlash exceeds specified limits (See SPECIFICATIONS), timing gears should be replaced.

60. Reposition dial indicator and check record camshaft end play (Figure 56). If end play exceeds specified limits (See SPECIFICATIONS) camshaft thrust plate should be replaced.

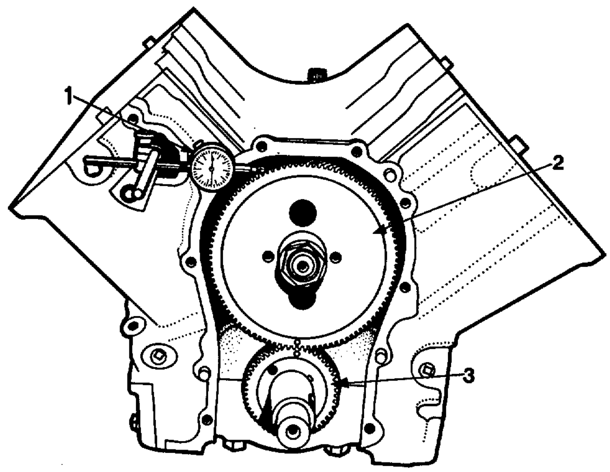


Fig. 55 Checking Camshaft and Crankshaft Gear Backlash

1. Dial Indicator
2. Camshaft Gear
3. Crankshaft Gear

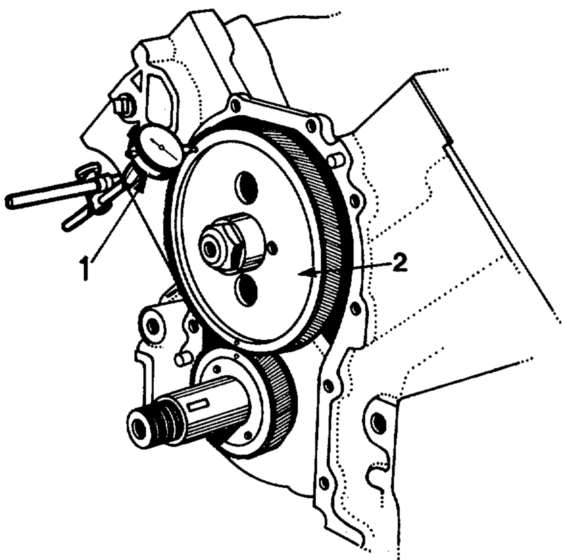


Fig. 56 Checking Camshaft End Play

1. Dial Indicator
2. Camshaft Gear

61. Remove camshaft thrust plate bolts (Figure 57). Remove camshaft gear nut. Install removal tool SE-1880 on threads of camshaft and remove camshaft, gear and spacer as an assembly (Figure 58).

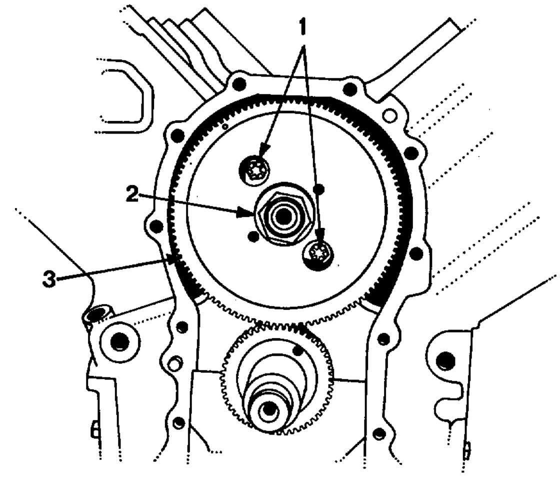


Fig. 57 Camshaft Thrust Plate Mounting Bolts

1. Thrust Plate Mounting Bolts
2. Nut and Spacer
3. Camshaft Gear

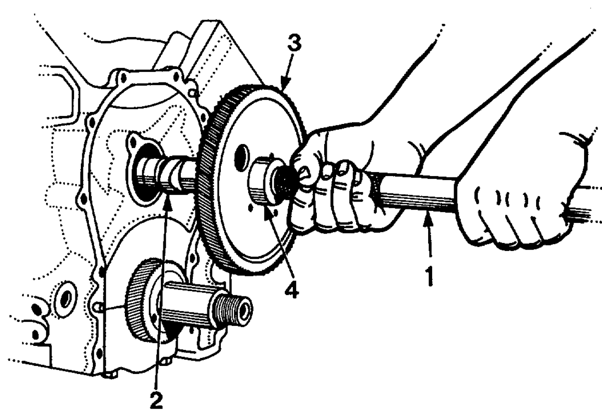
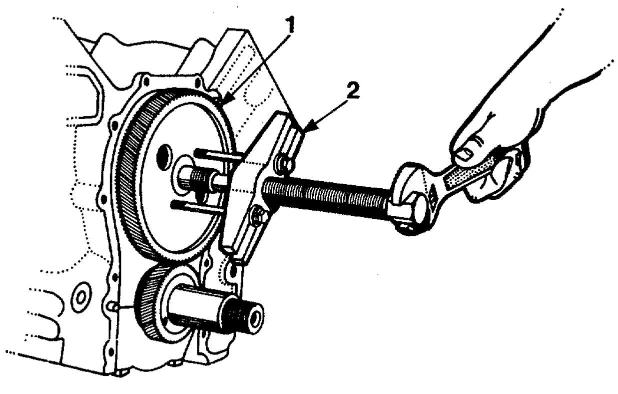


Fig. 58 Removing Camshaft, Gear and Spacer as an Assembly

1. Remover SE-1880
2. Camshaft
3. Gear
4. Spacer

NOTE: Where desired, camshaft, gear and spacer can be removed individually as follows:

a. Remove camshaft nut and spacer. Using puller SE-1368, remove camshaft gear (Figure 59).



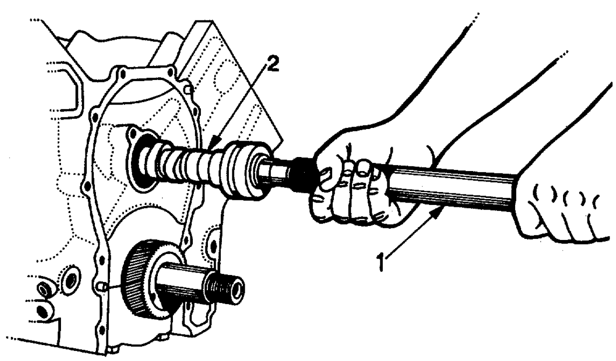
CG-6524

Fig. 59 Removing Camshaft Gear

1. Camshaft Gear 2. Puller SE-1368

b. Remove camshaft thrust flange capscrews.

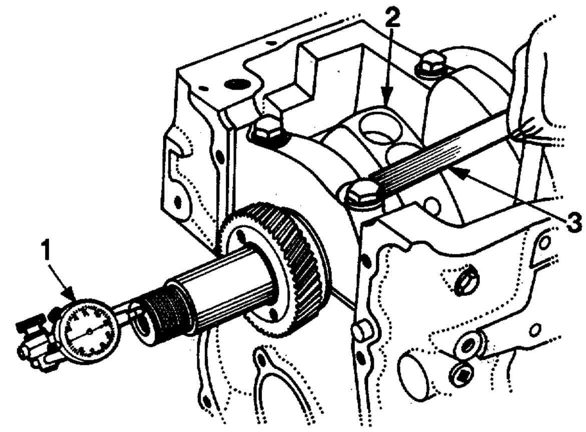
c. Install remover tool SE-1880 on threads of camshaft and remove camshaft (Figure 60).



CG-6525

Fig. 60 Removing Camshaft

1. Remover SE-1880 2. Camshaft

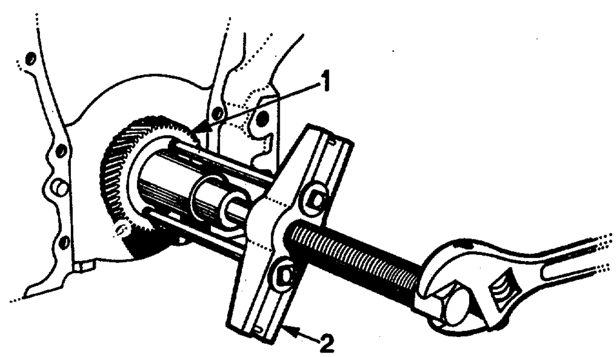


CG-6526

Fig. 61 Checking Crankshaft End Play

1. Dial Indicator 3. Pry Bar
2. Crankshaft

Remove crankshaft gear using puller SE-1368 (Figure 62)



CG-6527

Fig. 62 Removing Crankshaft Gear

1. Crankshaft Gear 2. Puller SE-1368

62. Using dial indicator, check and re- cord crankshaft end play (Figure 61). End play exceeding specified limits (See SPECIFICATIONS) indicates that crankshaft thrust bearings or thrust faces are worn.

63. Remove clutch assembly from engine flywheel.

Clutch removal procedures vary between clutch types. On the clutch assembly shown in Figure 63, the clutch plate should be held compressed by the three spacers shown prior to removing mounting bolts from cover. Loosen clutch back plate-to-flywheel and remove the clutch assembly.

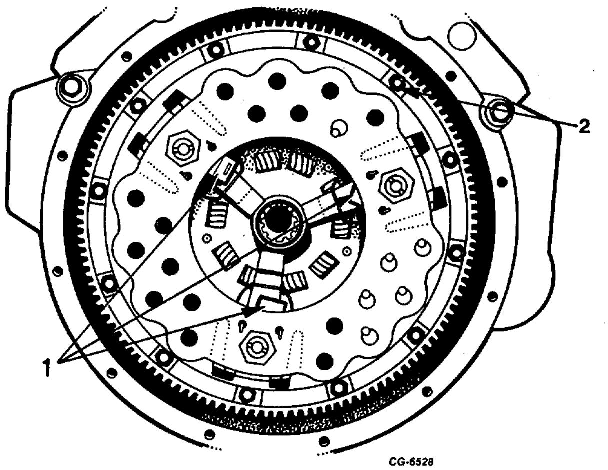


Fig. 63 Clutch Removal

1. Spacers used when removing or installing Clutch Cover (must be removed after installing)
2. Cover Mounting Bolts

64. Using a slide hammer and puller SE-1746, remove clutch pilot bearing from flywheel (Figure 64).

NOTE: It may be necessary to remove a small amount of material from the bottom of puller legs to permit installation of puller legs between flywheel and back side of pilot bearing.

65. Loosen flywheel mounting bolts and remove the flywheel assembly and roll pin from the crankshaft flange (Figure 65.)

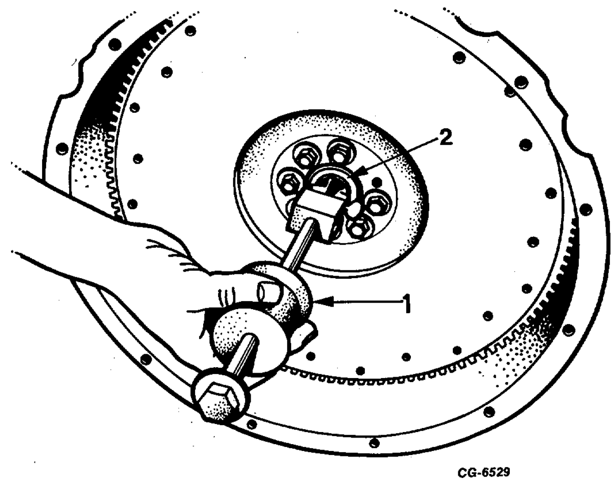


Fig. 64 Removing Clutch Pilot Bearing

1. Puller SE-1746 2. Pilot Bearing

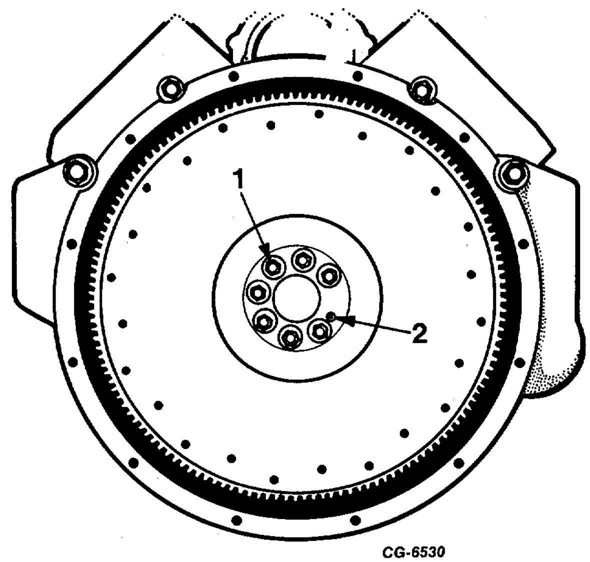


Fig. 65 Flywheel Mounting Details

1. Mounting Bolts 2. Roll Pin

NOTE: Use extreme care when removing fly-wheel housing, to avoid damaging roll pins used to align housing to crankcase.

66. To remove, pierce seal retainer with point of screw on end of remover. Thread screw into seal. Apply slide hammer to pull seal from bearing cap.

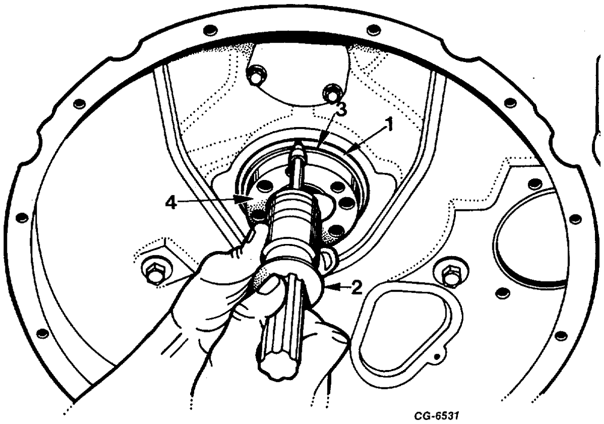


Fig. 66 Removing Rear Main Oil Seal Using SE-2091 Seal Remover

1. Rear Oil Seal **2. Seal Remover**
3. Wear Sleeve SE-2091 **4. Crankshaft**

67. Remove six flywheel housing mounting bolts and flat washers and remove flywheel housing (Figure 67).

NOTE: When required, crankshaft rear main oil seal can be removed with engine in chassis by using SE-2091 oil sealer remover (Figure 66) or, during engine overhaul when the main bearing cap is removed (Figure 75).

68. Remove three camshaft cover plate mounting bolts and lockwashers, remove cover plate and gasket from end of block (Figure 68).

69. Remove twenty three oil pan to crank-case attaching bolts and remove oil pan.

70. Remove two oil pump mounting bolts and remove pump (Figure 148).

71. To prepare for removal of piston and connecting rod assemblies, use ridge reamer tool to remove wear ridges from tops of cylinder bores.

72. Rotate crankshaft to position the journals for removal of connecting rod and piston assemblies.

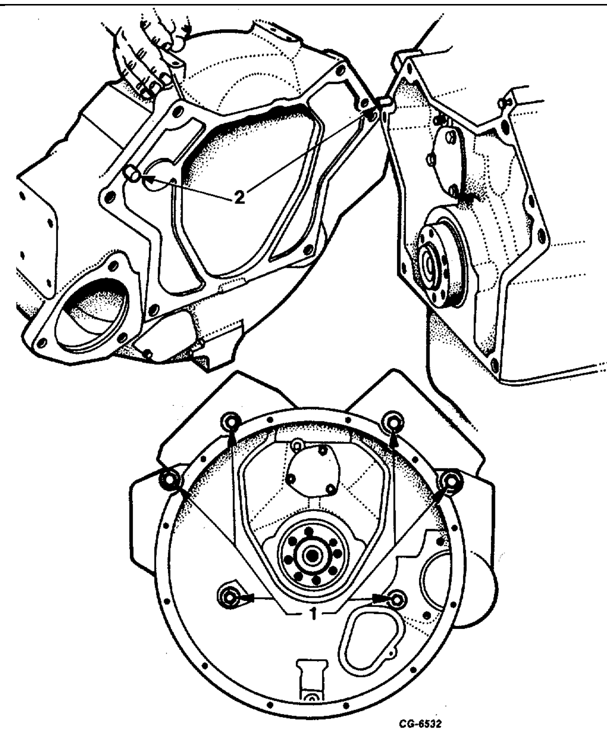


Fig. 67 Flywheel Housing Mounting Details

1. Flywheel Housing Mounting Bolts **2. Roll Pins**

73. Remove each connecting rod bearing cap and push connecting rod and piston assembly from the cylinder bore (Figures 69 and 70). Replace cap and bearing inserts on rod so that identification numbers match.

74. Remove self-locking bolts, tie bolts and washers from each crankshaft main bearing cap (Figure 71).

75. Using remover tool SE-2093 and slide hammer SE-1746, remove main bearing caps (numbers 1, 2, 3 and 4) by inserting hook end of remover tool in horizontal hole and toward centerline of crankshaft (Figure 72).

The crankshaft bearing caps are numbered to identify their position, and they must be reinstalled in their respective positions.

The center (No. 3) main bearing cap accommodates a thrust flange to control crankshaft end play (Figure 73).

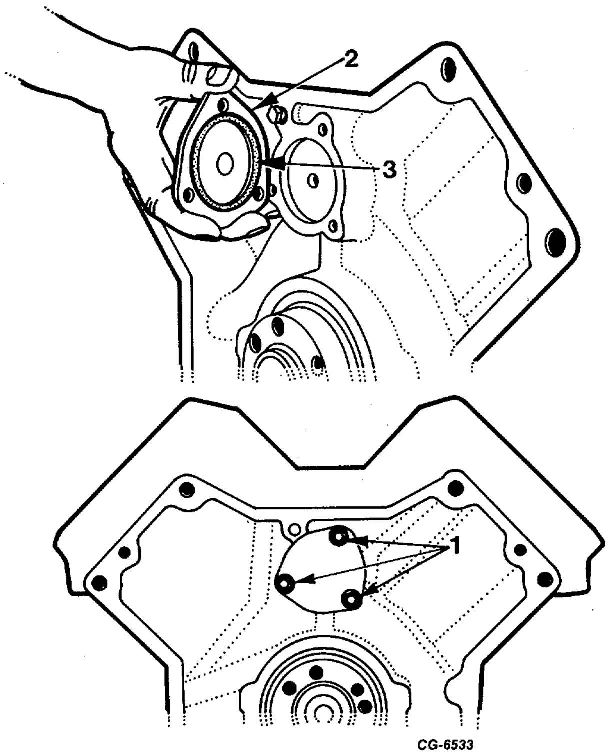


Fig. 68 Removing Camshaft Cover Plate

1. **Cover Mounting Bolts**
2. **Cover**
3. **Gasket**

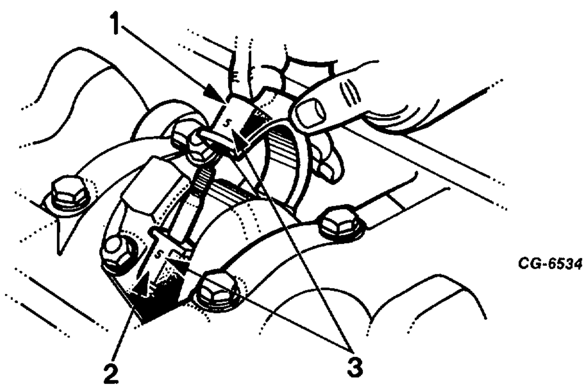


Fig. 69 Removing Connecting Rod Cap

1. **Connecting Rod Bearing Cap**
2. **Connecting Rod**
3. **Cap and Rod Identification**

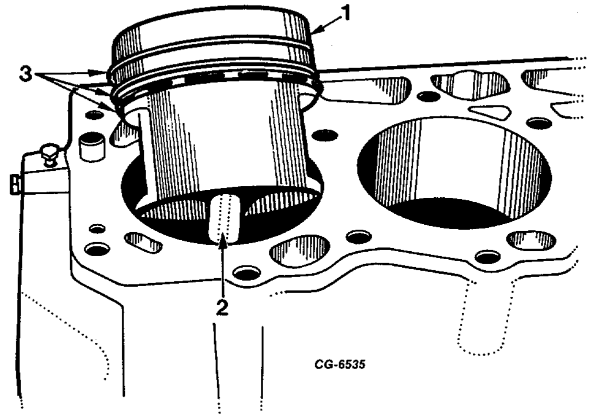


Fig. 70 Removing Piston and Connecting Rod

1. **Piston**
2. **Connecting Rod**
3. **Piston Ring**

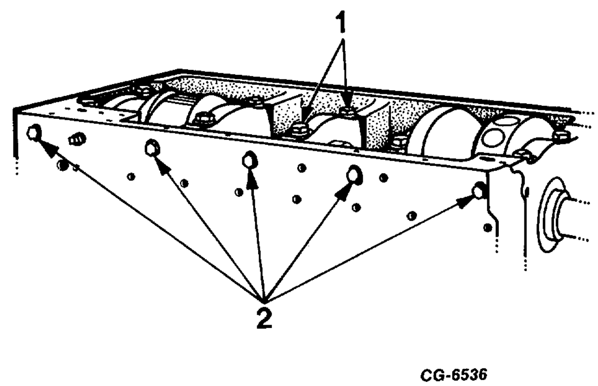


Fig. 71 Main Bearing Cap Bolts, Tie Bolts and Washer

1. **Self-Locking Bolts**
2. **Tie Bolts & Washers**

76. Use puller SE-1719 and adapter SE-1719-3 to remove rear (No. 5) main bearing cap (Figure 74). Slide hammer SE-1746 with remover tool SE-2093 may be used to remove rear bearing cap.

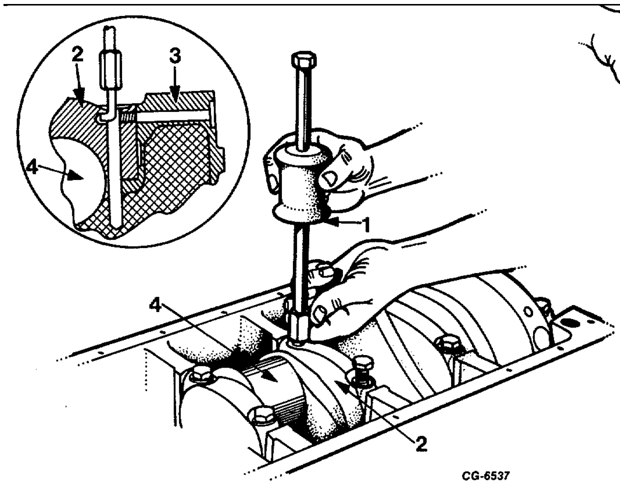


Fig. 72 Removing Main Bearing Cap (Numbers 1, 2, 3, and 4)

1. **Slide Hammer SE-1746 with Remover Tool SE-2093**
2. **Bearing Cap**
4. **Crankshaft**

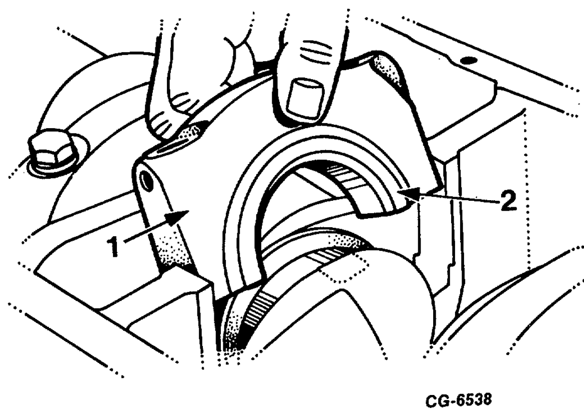


Fig. 73 Main Bearing Cap with Thrust Flanges (No. 3)

1. **Intermediate Main Bearing Cap**
2. **Thrust Flange**

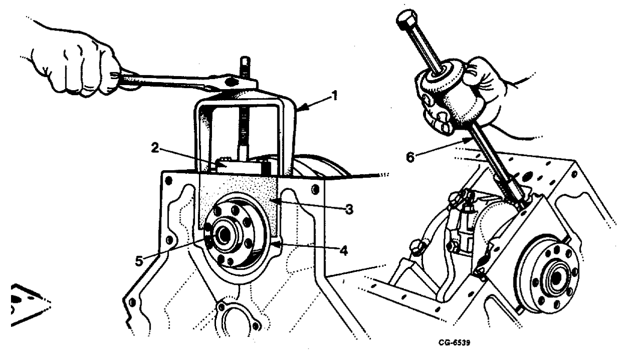


Fig. 74 Pulling Rear Main Bearing Cap (No. 5)

1. **Rear Main Bearing Cap Puller SE-1719**
2. **Adapter SE-1719-3**
3. **Rear Main Bearing Cap**
4. **Rear Seal**
5. **Crankshaft**
6. **Slide Hammer SE-1746 with Remover Tool SE-2093**

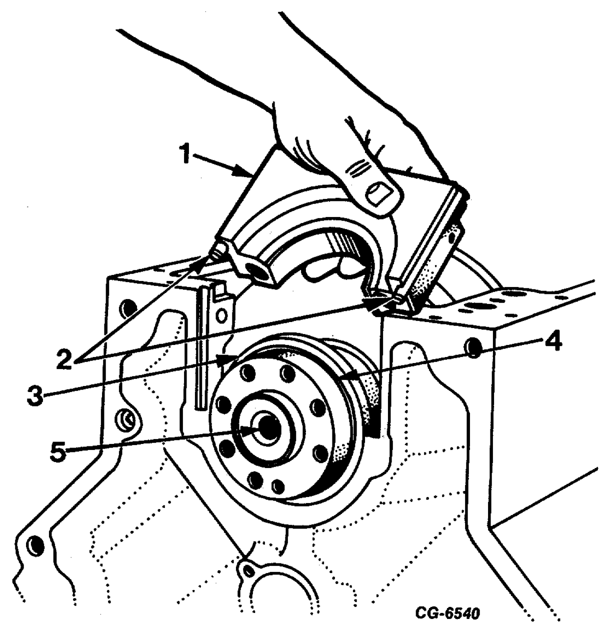


Fig. 75 Removing Rear Main Bearing Cap and Oil Seals

1. **Rear Main Bearing Cap**
2. **Side Seal**
3. **Rear Oil Seal**
4. **Wear Sleeve**
5. **Crankshaft**

Remove rear main bearing cap side seals and remove rear main bearing oil seal from crankshaft (Figure 75).

77. Using rope sling, lift crankshaft up and out of engine crankcase.

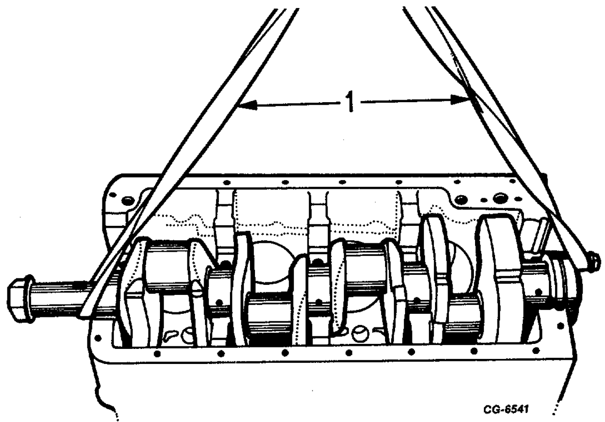


Fig. 76 Removing Crankshaft from Crankcase

1. Rope Sling

78. Check rear oil seal wear sleeve on crankshaft. If wear sleeve shows more than one wear path, it should be replaced. Wear sleeves with only one wear path can be reused by recessing oil seal into crankcase bore. (see ENGINE ASSEMBLY).

To remove wear sleeve, use a blunt chisel to mark wear sleeve surface in several places, then with a flat hammer tap seal surface until sleeve expands sufficiently to be removed. Be careful when performing the cutting operation so not to nick, scuff or damage crankshaft flange surface.

After engine has been disassembled, all parts must be thoroughly cleaned, inspected for wear and damage and then reconditioned for further use or replaced as necessary.

CYLINDER BLOCK AND CAMSHAFT BEARINGS

Cylinder Block

One of the most important phases of engine reconditioning is the thorough cleaning and inspection of the cylinder block.

Each machined surface of the cylinder block should be cleaned of all old gasket material. The pipe plugs which seal oil passages should be removed and all passages thoroughly cleaned.

Carefully inspect the cylinder block for scoring of cylinder walls, damaged bearing bores, cracks or water leaks. Small cracks may be found by coating suspected areas with a mixture of light motor oil and kerosene. After wiping area dry, immediately apply a coat of quick-drying liquid such as zinc oxide powder mixed with wood alcohol. Wherever cracks are present, a brown discoloration will appear in the white coating.

If necessary to replace an expansion type plug due to water leaks, drill a 1/2" hole in center of plug and remove by prying with a screwdriver or suitable tool.

Coat edges of plug with a suitable non-hardening sealing compound and install with concave side of plug toward the interior of cylinder block. Drive plug into place with a ball peen hammer.

The oil pump and tachometer drive shaft upper bearing should be checked for correct size. Specifications of the lower portion of this bore is 12.357-12.382mm (.4865-.4875") inside diameter. If diameter does not meet these specifications, bearing should be replaced as follows:

1. Using a drift, carefully drive bearing out of crankcase from underside.
2. Align punch mark on new bearing with rib on crankcase (Figure 77). This will index oil hole in bearing with oil passage in crankcase.
3. Press bearing in flush with top of crankcase.

Each cylinder bore should be checked for wear, out-of-round and taper using an inside reading micrometer SE-686 or dial bore gauge. SE-2331 (Figure 78).

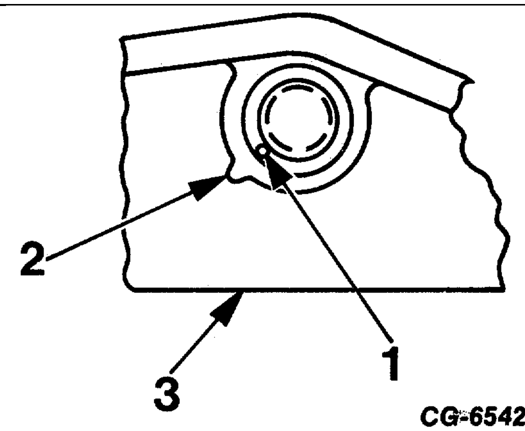


Fig. 77 Installation of Oil Pump and Tachometer Drive Shaft Bearing in Crankcase

1. Punch Mark On Bearing
2. Rib on Crankcase
3. Crankcase

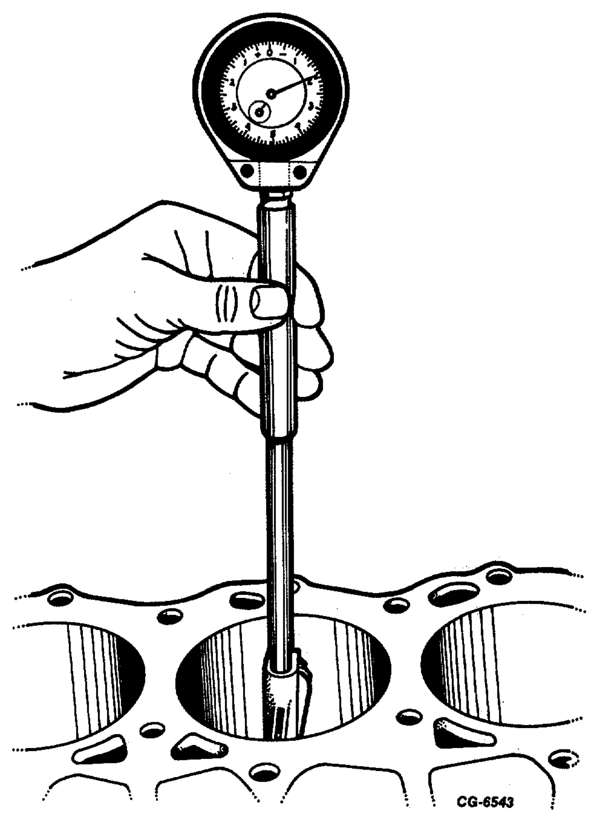


Fig. 78 Checking Cylinder Bore with Dial Bore Gauge SE-2331

When measuring cylinder bores, main bearing caps must be in place with bearing cap and tie bolts tightened to specified torque. See "TORQUE CHART."

Measure diameter of each cylinder bore at top of ring travel at right angle to centerline of crankshaft ("A", Figure 79). Record readings.

Next, measure each bore at top of ring travel with gauge aligned with centerline of crankshaft ("B", Figure 79). Record readings.

The difference between each corresponding "A" and "B" reading is the out-of-round condition at the top of the ring travel for that cylinder.

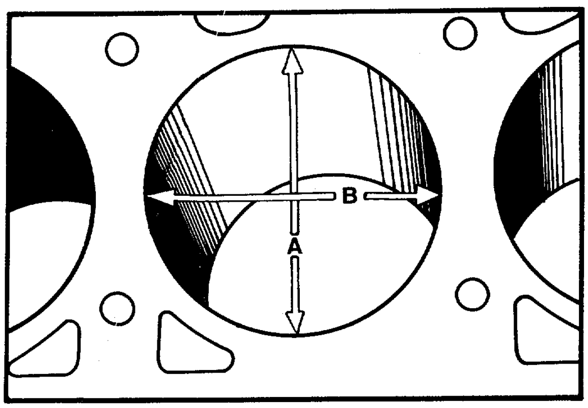


Fig. 79 Measurements for Checking Cylinder Bore Out-of-Round

Repeat the same procedure to check for out-of-round at bottom of ring travel.

The difference between diameters (at right angle to centerline of crankshaft) at top of ring travel (A Figure 80) and bottom of ring travel ("A'", Figure 80) is the taper of the cylinder bore.

If cylinder bore wear does not exceed 0.05 mm (.002") out-of-round or 0.127 mm (.005") taper, new standard size service piston rings will give satisfactory performance, provided the piston clearance is not excessive. When standard size piston rings are to be installed, cylinder bore should be deglazed.

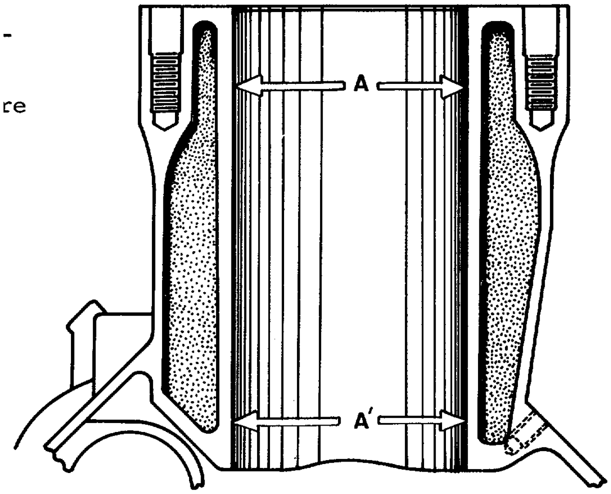


Fig. 80 Measurements for Checking Cylinder Bore Taper

If cylinder bore wear exceeds specified limits or if cylinder bores are scored or damaged, it will be necessary to rebore the cylinders to oversize diameter. Oversize selected should be large enough to permit cleaning up the cylinder bore and provide proper piston running clearance.

Deglazing Cylinder Bores

Cylinder bores can be deglazed by using the proper size SE-2314 glaze breaker brush (Figure 81).

This silicone carbide-tipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on the cylinder wall surface in a single operation. The brush contours itself to the cylinder wall and conditions the wall surface without altering cylinder bore. The glaze breaker brush is driven by a low speed (350-.500 RPM) electric drill. Most 3/8 inch capacity drills are satisfactory.

The brush should be lubricated with SAE-30 engine oil to produce a desirable wall finish. The lubricant also controls airborne abrasive particles which can be easily wiped from cylinder bore with a cloth.

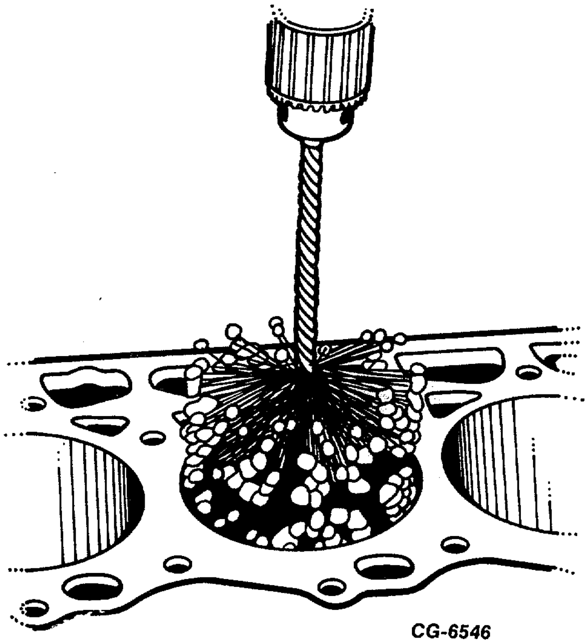


Fig. 81 Deglazing Cylinder Walls

Stroke the brush up and down in the bore at a rate of 30-40 strokes per minute for 15-20 seconds per cylinder bore. In most instances 20 seconds is adequate time for the brush to break cylinder wall glaze and produce a crosshatch pattern on the cylinder wall surface.

Thoroughly clean cylinder bore walls after deglazing. Wipe as much of the abrasive deposits from the wall as possible. Then swab out each abrasive coated cylinder with SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white cloth shows no evidence of discoloration when wiped through the cylinder bore. This usually requires three or more complete swabbing operations.

NOTE: Do not use gasoline, kerosene or commercial cleaner to clean cylinders. Solvents of this nature will not remove abrasives from the walls which can cause rapid engine wear and ring failure.

Reboring and Honing Cylinder Bores:

To avoid possible bore distortion, main bearing caps must be in place with bearing cap bolts and tie bolts tightened to specified torque when boring and honing cylinders.

Use boring equipment such as the SE1399 boring machine (Figure 82) to enlarge cylinder bores. When over sizing cylinders, bore to within 0.07 mm (.003") of required oversize diameter. This will allow enough stock for final honing to obtain exact clearance for selected oversize pistons.

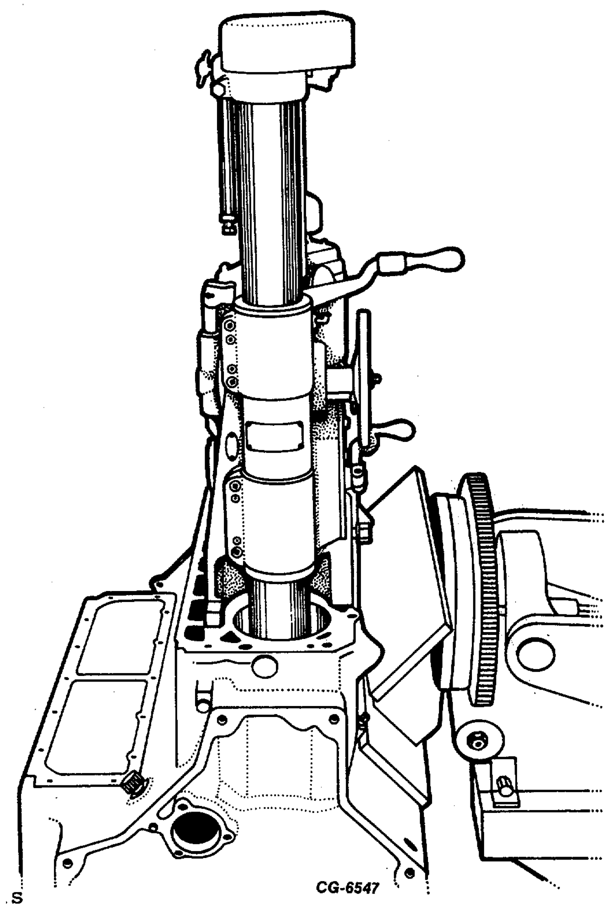


Fig. 82 Reboring Cylinder

Hone cylinder bores as needed to obtain specified piston running clearance using honing equipment such as the SE-784 cylinder hone (Figure 83).

When performing honing operation, hone should be stroked up and down to produce a crosshatch pattern on cylinder wall surface (Fig. 84). The faster hone rotates, the faster it must be stroked up and down to produce desired crosshatch pattern.

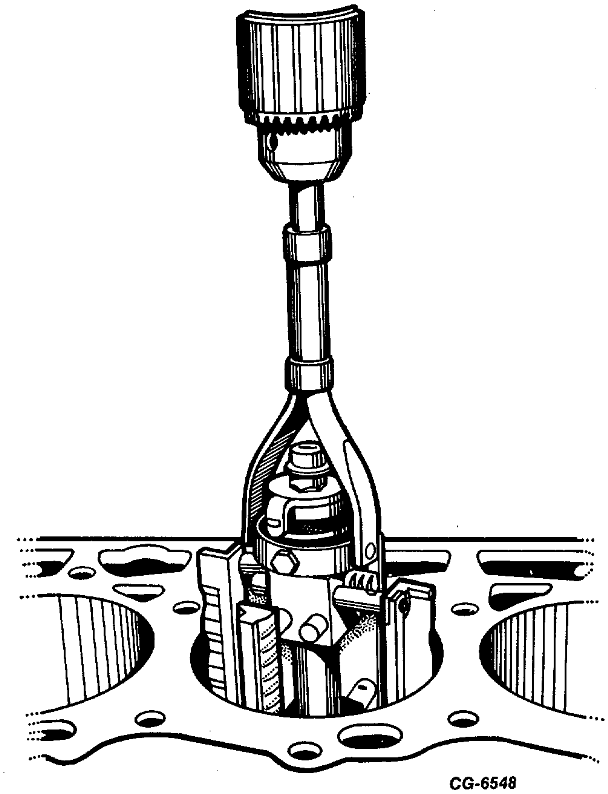


Fig. 83 Honing Cylinder Bore

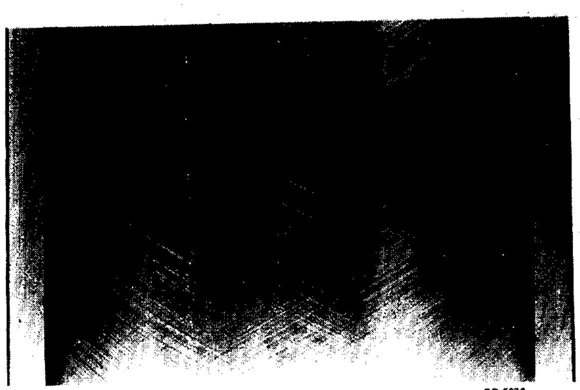


Fig. 84 Crosshatch Finish on Cylinder Wall

NOTE: After the honing operation is completed, the sharp, burred edge that develops at the bottom of a new honed cylinder should be removed manually with emery cloth.

Thoroughly clean block and cylinder bores after honing. Wipe as much of the abrasive deposits from the cylinder wall as possible. Then swab out each abrasive coated cylinder with clean SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white rag shows no evidence of discoloration when wiped through the cylinder bore. This usually requires three or more complete swabbing operations.

NOTE: DO NOT use gasoline, kerosene or commercial cleaner to clean cylinders. Solvents of this nature will not remove abrasives which can cause rapid engine wear and ring failure.

Camshaft Bearings

Using telescoping gauge and micrometer, check camshaft bearings for wear and proper running clearance. (See SPECIFICATIONS.) If bearing clearance exceeds specified limits, replace bearings. This can be accomplished using camshaft bearing remover and installer tool set SE-1897 with slide hammer and adapter from puller set SE-1879 as follows:

1. Position front adapter, SE-1897-3 in front bearing (Figure 85).
2. Position second adapter, SE-1897-1 in second bearing (Figure 85).
3. Install bar through adapters and lock second adapter on the bar with "C" washer SE-18972.
4. Using front adapter as a pilot, pull second bearing with slide hammer (Figure 85).

NOTE: Always hold adapter firmly against bearing being removed or installed to avoid damage.

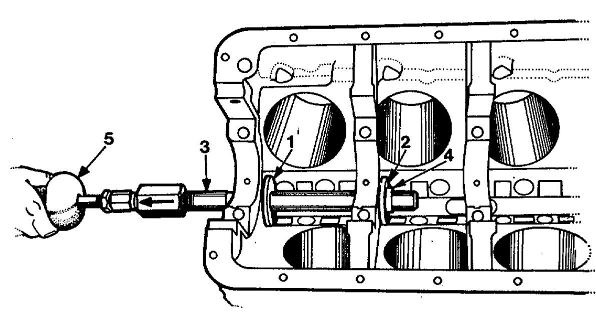


Fig. 85 Removing Second Camshaft Bearing

1. Front pilot adapter SE-1897-3
2. Second Remover adapter SE-1897-4
3. Bar
4. "C" Washer
5. Slide Hammer

5. Position new bearing on second adapter and "C" washer behind adapter (Figure 86). Align oil holes and pull in second bearing.

6. Remove "C" washer and use second adapter as a pilot. Remove front bearing by pulling bearing from case (Figure 87).

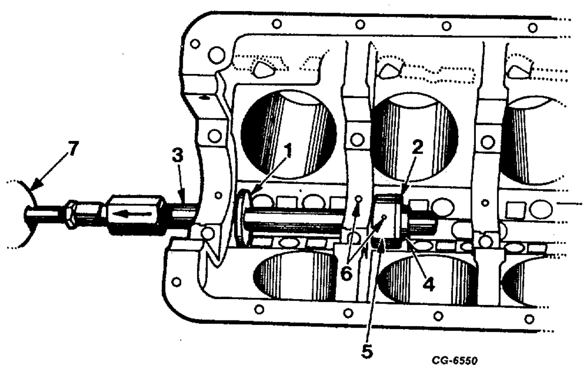


Fig. 86 Installing Second Camshaft Bearing

1. **Front pilot adapter SE-1897-3**
2. **Second adapter SE-1897-4**
3. **Bar**
4. **"C" Washer**
5. **Second Camshaft bearing**
6. **Oil holes must be aligned**

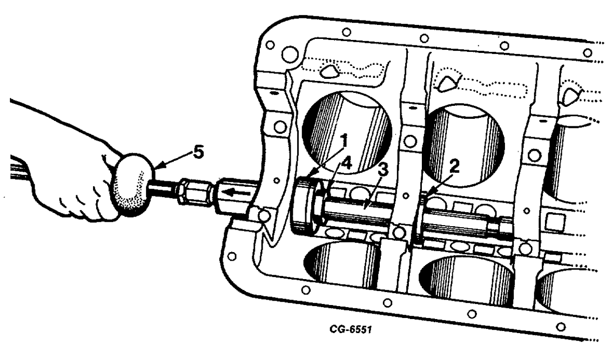


Fig. 87 Removing Front Camshaft Bearing

1. **Front Adapter SE-1897-3**
2. **Second adapter SE-1897-4**
3. **Bar**
4. **"C" Washer**
5. **Slide Hammer**

7. Remove bar and front adapter. Position new bearing on front adapter with chamfered side toward case. Slide bar into case and through second adapter serving as a pilot (Figure 88).

8. Align oil holes and in front bearing (Figure 88).

NOTE: Oil hole drilled through groove in bearing must align with main bearing oil feed hole.

9. Using third adapter SE-1897-5 and rear adapter SE-1897-6 and working from rear of crankcase, install third and rear bearings in the same manner as described above for front and second bearings.

NOTE: Oil hole in groove of rear bearing must align with feeder hole in crankcase.

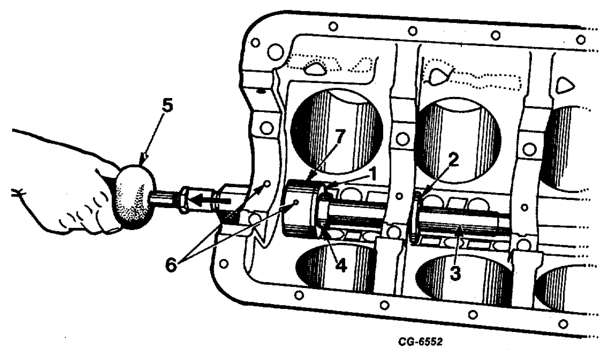


Fig. 88 Installing Front Camshaft Bearing

1. **Front adapter SE-1897-3**
2. **Second Pilot adapter SE-1897-4**
3. **Bar**
4. **"C" Washer**
5. **Slide Hammer**
6. **Oil Holes must be aligned**
7. **Front camshaft bearing**

PISTONS, PISTON PINS, PISTON RINGS AND CONNECTING RODS
Pistons

To disassemble piston from connecting rod assembly remove piston pin retaining snap rings (one on each side of piston) by using snap ring removing pliers (Figure 89). Push piston pin out with thumb. (It may be necessary to tap pin lightly to remove.) After the pin is removed, separate piston from connecting rod, taking to see that parts are marked so they may be reinstalled in their respective cylinder.

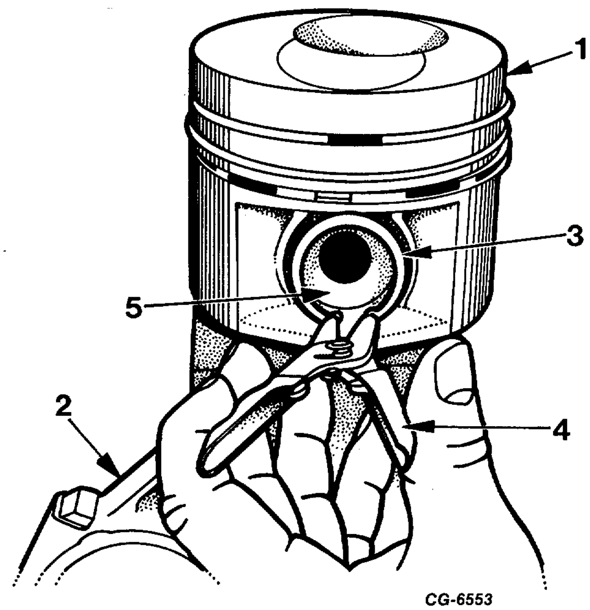


Fig. 89 Piston Pin Removal

1. **Piston**
2. **Connecting Rod**
3. **Piston Pin Retaining Snap Ring**
4. **Snap Ring Removing Pliers**
5. **Piston Pin**

Remove all old piston rings. Immerse piston in cleaning solvent and clean thoroughly.

NOTE: <u>Never use a caustic solution for cleaning aluminum pistons.</u>

Use a special ring groove cleaner or broken piston ring to clean all carbon from second compression ring groove and oil ring groove. Make sure that all oil holes are open.

The top (keystone type) groove cannot be cleaned with a ring groove cleaner or broken piston ring. It is suggested that piston be soaked in a carburetor type cleaning solution and softened deposits removed from top groove by running a heavy cord down in and around groove.

Inspect pistons for scuffed or scored skirts or cracked worn ring lands, discarding any showing such conditions.

Check fit of piston pins in pin bores of pistons. If pin bores are worn beyond specified limits, replace pistons.

To select correct size pistons for an engine overhaul, size of the cylinder bore diameters must be determined first. This can be accomplished with an inside reading micrometer or dial bore gauge. Each bore should be measured at top of ring travel and lower end of ring travel both parallel and at right angles to the crankshaft.

After cylinder bores have been measured and recorded, select a piston to fit a certain bore. This is accomplished by measuring piston at bottom of skirt across thrust faces with an out side micrometer. Piston size selected should be large enough to permit cleaning up cylinder bore and provide specified running clearance. (See Cylinder Block under CYLINDER BLOCK and CAMSHAFT BEARINGS.)

Piston Pins

Inspect piston pins and replace any which show signs of corrosion or etching.

Using a micrometer, check piston pins for wear and out-of-round. Replace worn pins.

Check fit of piston pins in pistons and connecting rods. If piston pin bores of pistons are worn excessively, replace pistons. If piston pin bushings in connecting rods are worn or out-of-round, replace bushings. (See Connecting Rods.)

Piston Rings

The pistons have three piston rings located above the piston pin. The compression rings are located in the top grooves, while the lower groove accommodates the oil control ring. Select the proper rings for the size of pistons to be used.

Prior to installing rings on pistons, each ring must be checked for proper ring gap. Push ring down into the cylinder bore, making sure ring is square with cylinder wall. Extreme care should be used during this operation. Check space or gap between the ends of ring with a feeler gauge (Figure 90). Ring gap should be within specified limits (See SPECIFICATIONS).

If gap is not within specified limits, try another ring for fit.

NOTE: <u>Do not</u> attempt to alter gap of chromefaced rings by filing ends of rings. This will damage the chrome plating.

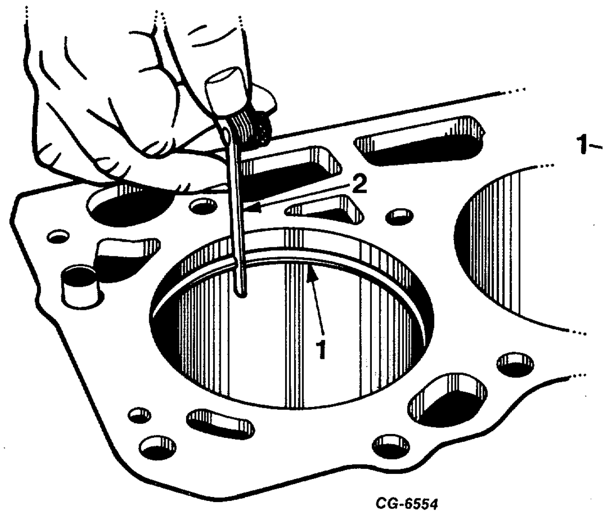


Fig. 90 Checking Ring Gap

1. Piston Ring **2. Feeler Gauge**

Each ring should be fitted and checked in the cylinder in which it is to be used and marked accordingly.

Second compression ring and oil control ring should be checked for side clearance in the groove of the piston on which they are to be installed. This is done by placing outer edge of ring in the piston groove, rolling ring entirely around piston to make sure there is no binding and ring is free in the groove. With a feeler gauge, check side clearance of each ring in its respective groove (Figure 91). See SPECIFICATIONS for proper clearance.

Prior to installing keystone type top compression piston, top ring groove must be checked for wear. Insert Perfect Circle Piston Ring Gauge No. 1 (1/8 x 15 degree) in top ring groove (Figure 92) if one or both shoulders of gauge touch the side of the piston, piston must be re-placed. Measurement should be made at several points around groove circumference.

Assemble rings on pistons to which they were fitted by using piston ring expander tool. This type of tool is recommended to avoid over-expanding and to avoid distortion (Figure 93). General practice when installing piston rings is to stagger the ring gaps. For further information refer to instructions furnished with service ring sets.

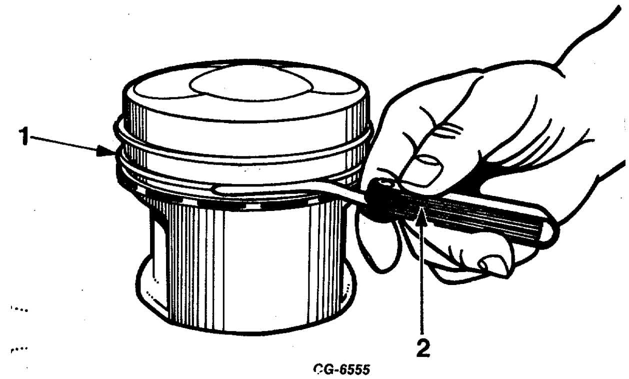


Fig. 91 Checking Ring Side Clearance

1. Piston Ring **2. Feeler Gauge**

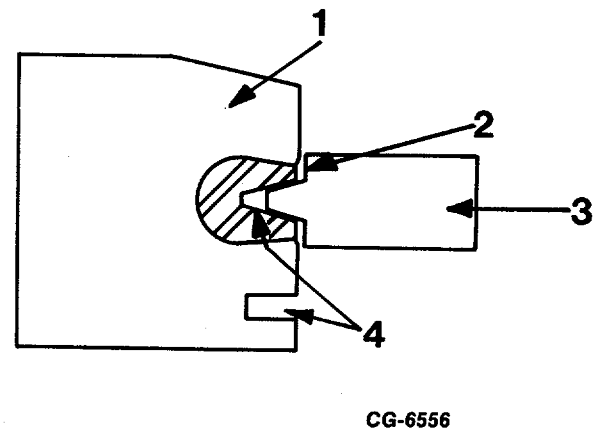


Fig. 92 Checking Top (Keystone) Ring Groove Wear

1. Piston **3. Gauge**
2. Shoulder of gauge **4. Piston ring grooves**

Connecting Rods During manufacture, the connecting rods are subjected to a special heat- treating process known as "tuffride". The "tuffride" process is applied after the connecting rod has been finished machined and imparts a very hard surface to the rod.

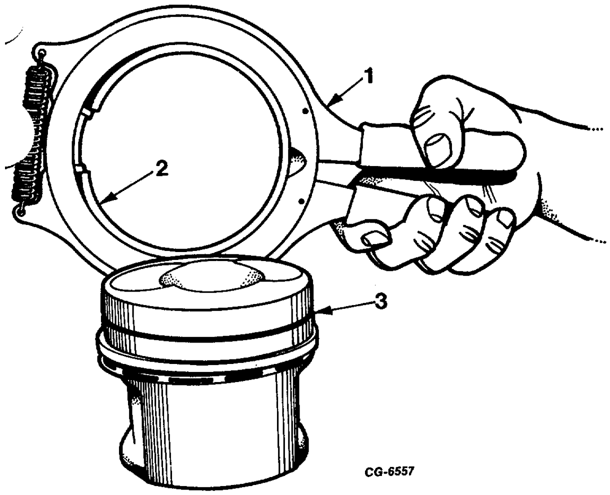


Fig. 93 Installing Piston Ring

1. Piston ring expander tool
2. Piston ring
3. Piston ring groove

Because of this special hardening of the connecting rod, no attempt is to be made to straighten or in any way bend the rod. To do so will cause minute fractures or cracks in hardened surfaces which will in turn lead to rod breakage.

When working with rods, use care to prevent rough handling, which could nick or notch rod surfaces and destroy the "tuffride" hardening. Rods must not be filed, ground or damaged in any way.

At the time of engine overhaul, connecting rods should be thoroughly cleaned and inspected for defects as outlined below.

1. Check connecting rod alignment on equipment such as the SE-1099 alignment checking fixture. Follow equipment manufacturer's instructions. Piston pin bore and connecting rod bearing bore must be parallel within .013 mm (.0005"). Replace rods that are bent. Do not attempt to straighten rods.

2. The connecting rod bearing plays a major role in distributing the proper amount of oil to piston pin, cylinder walls, piston and piston rings. This is known as oil throwoff, and the condition of the connecting rod bearing determines how well the lubrication operation is performed. Where bearing clearance is more than specified, an abnormal amount of oil is thrown onto cylinder walls, causing increased oil consumption and low oil pressure due to oil passing through the bearing surfaces too quickly. Where bearing clearances are less than the specified amount, oil flow through the bearing in insufficient to properly cool the bearing, resulting in short bearing life, improper oil throw-off and scoring of pistons and cylinder walls.

If connecting rod bearing bore is stretched or out-of-round beyond specified diameter, insert will be out-of-round and will not be held securely in connecting rod and bearing "crush" may be lost.

NOTE: For definition of bearing "crush" see <u>Crankshaft Bearings</u> under CAMSHAFT, CRANKSHAFT and RELATED COMPONENTS

A very thorough inspection of the connecting rod bore is necessary. This Inspection consists of the following:

<u>Bore Size:</u> With connecting rod cap installed and bolts tightened to specified torque, bearing bore (Figure 93) should be within specified limits (See SPECIFICATIONS).

<u>Roundness:</u> With connecting rod cap installed and bolts tightened to specified torque bearing bore out-of-round (Figure 95) should not exceed specified limits (See SPECIFICATIONS).

<u>Straightness</u>: Check for taper in bearing bore (Figure 96). Taper should not exceed limit given in SPECIFICATIONS.

<u>Surface Finish:</u> The bearing insert contact surface must be smooth (Figure 97) without indication of uneven bearing contact or movement of bearing in bore.

The precision gauge furnished with honing machine SE-2218 or similar bore gauge as shown in Figure 98 can be used to inspect condition of connecting rod bearing bore.

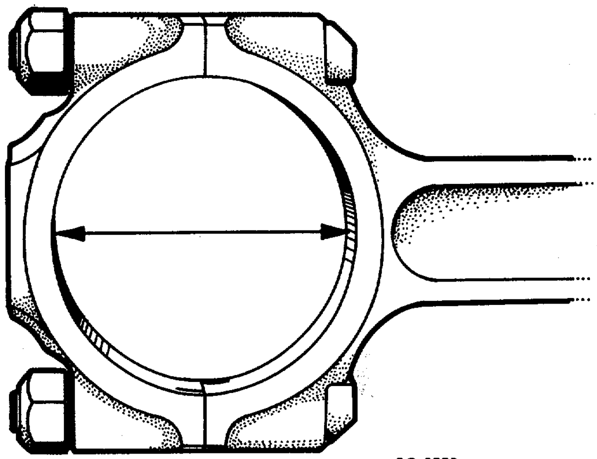


Fig. 94 Connecting Rod Bearing Bore Measurement

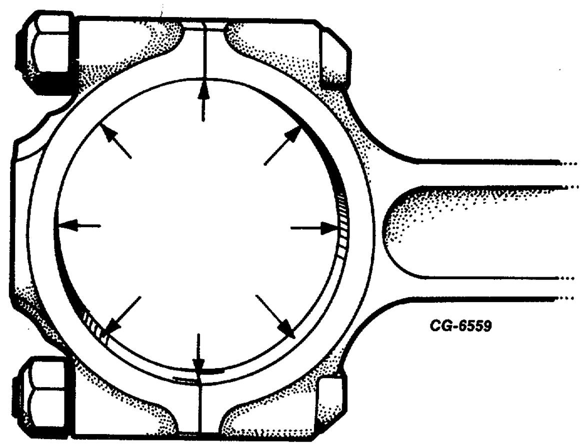


Fig. 95 Connecting Rod Bearing Bore Out-Of-Round Measurement

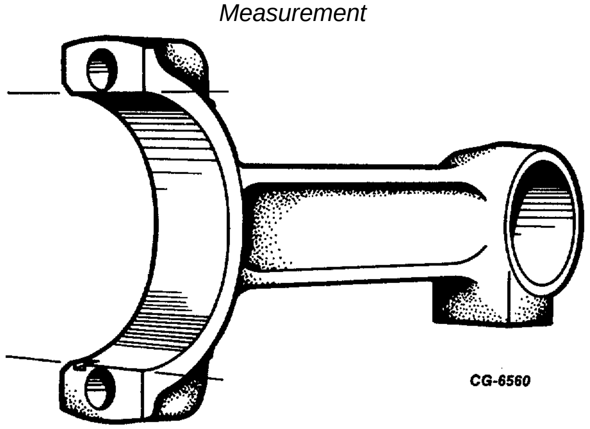


Fig. 96 Connecting Rod Bearing Bore Taper Measurement

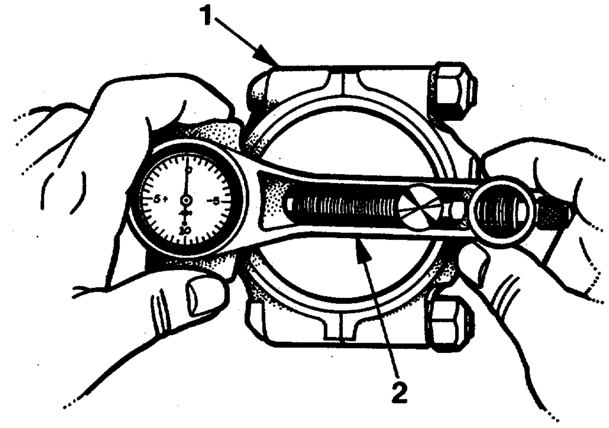


Fig. 97 Connecting Rod Bearing Bore Surfaces Finish

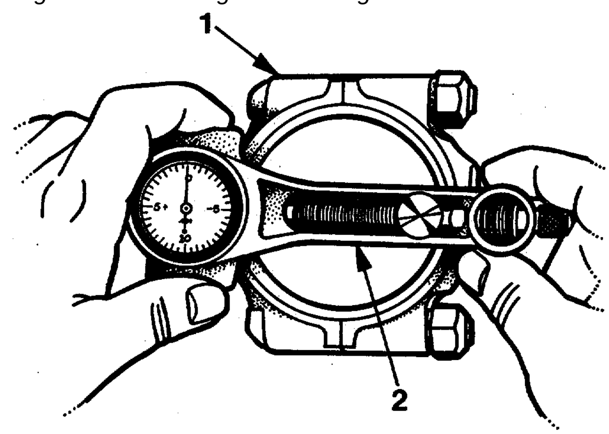


Fig. 98 Checking Connecting Rod Bearing Bore

1. Connecting Rod 2. Bore Gauge

If connecting rod bearing bore does not pass the above inspection, connecting rod must be replaced.

NOTE: When replacing connecting rods, mark (number) new rods and caps to correspond with old parts being replaced.

3. Check fit of piston pin in connecting rod piston pin bushing. If bushing is worn or out-of-round, replace bushing as follows:

   a. Insert remover end of SE-2417 remover/installer tool into bushing. Position tool and connecting rod in press using a piece of tubing 5.08 cm (2") O.D. x 4.4 cm (1.75") I.D. x 5.08 cm (2") long as a support (Figure 99). Press bushing out of rod.

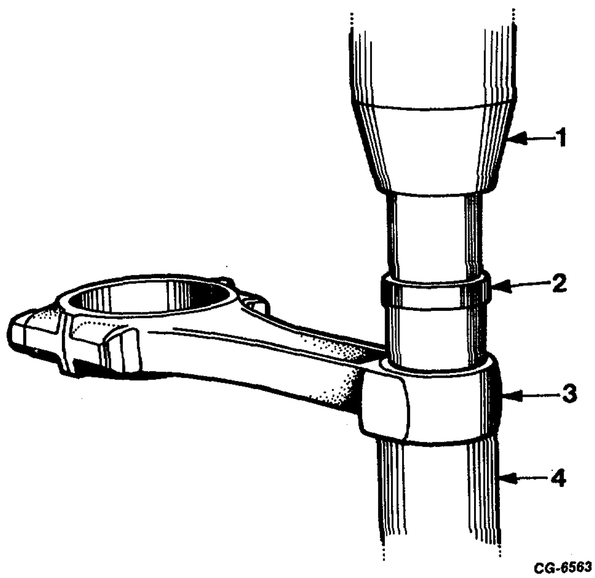


Fig. 99 Removing Piston Pin Bushing from Connecting Rod

1. Press ram **3. Connecting rod**
2. Remover **4. Tubing**

b. Place new bushing on installer end of SE-2417 remover/installer tool. Using support plate SE-1033 position connecting rod in press with large chamfer side of connecting rod bearing bore down (Figure 101). Lubricate O.D. of bushing with a commercial press fit lubricant or engine oil. Align split of bushing on a horizontal plane with balance boss of rod (Figure 100) and press bushing into rod until shoulder of installer tool is firmly seated against rod.

c. Ream or hone new piston pin bushing to provide a hand push piston pin fit.

To assemble piston to connecting rod, position rod into piston so that connecting rod bearing locators (tangs) will be toward the side marked "top" of piston or the side where the combustion cavity is close to the edge of the piston (Figure 102). Lubricate piston pin with clean engine oil. Align rod bore and piston bore and

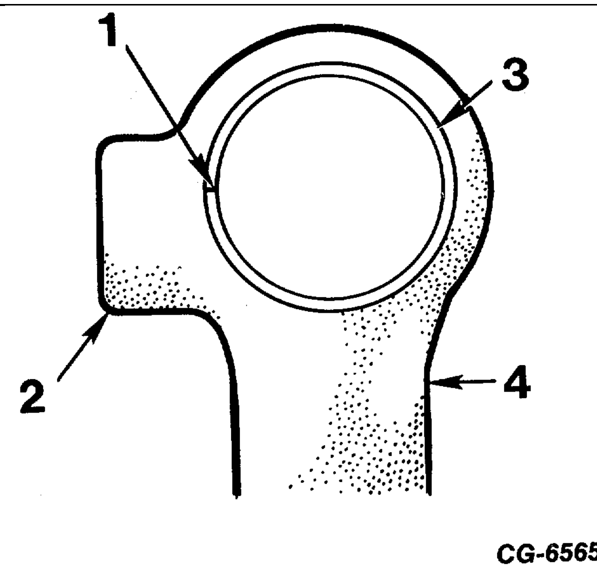


Fig. 100 Installing Piston Pin Bushing in Connecting Rod

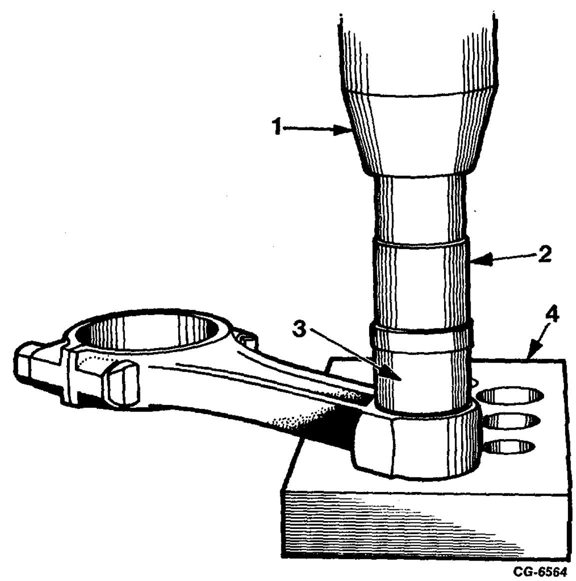


Fig. 101 Proper Location of Bushing Split When Installed in Connecting Rod

1. Press ram **3. Bushing**
2. Installer **4. Support plate**

insert piston pin. Push piston pin into place with thumb and install retainer snap rings.

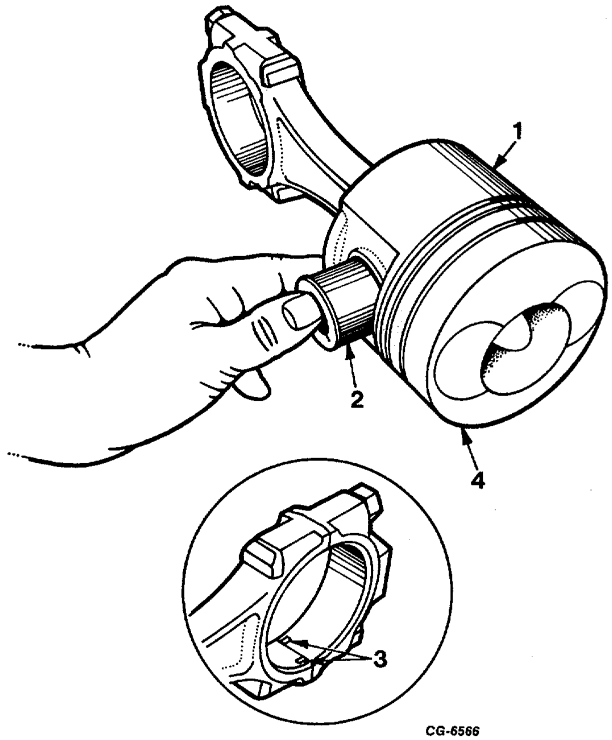


Fig. 102 Installing Piston Pin

1. Piston **3. Bearing locators (tang)**
2. Piston Pin **4. Marked top**

It is important, that rod and piston be assembled correctly, so that when piston is installed in engine, the large, chamfered side of each rod is located against crankshaft face. The chamfer provides clearance for the crankshaft fillet (Figure 103).

Connecting Rod Bolt Tightening

Correct fastening of connecting rods to the engine crankshaft is extremely important.

The major purpose of tightening connecting rod bolts and nuts to a specified torque is to obtain tension in the bolt (Figure 104) which in turn develops a clamping load or preload that exceeds any possible loading imposed on connecting rod parts during engine operation. The connecting rod must "hang on" to crankshaft and suffer all the strains of inertia and cylinder combustion impulse without permitting the least movement or flexing of the rod cap, bolts or nuts. Torque applied must be within the capacity of parts (bolt, nut, caps, connecting rods) to withstand these loads. Especially designed bolts, nuts and washers manufactured from selected materials permit application of this loading without undue stretching of bolts.

There is a relationship between torque applied and clamping effect obtained. For proper clamping, connecting rod bolts and nuts must be cleaned of all foreign matter including the anti-rust materials that may be in the threads. It is recommended that new connecting rod bolts, nuts and washers be used during reassembly.

Threads that are dry, excessively rough, battered or that are filled with dirt require considerable effort just to rotate the nut. When bolts are tightened, torque reading mounts rapidly (due to thread friction) to specified figure without approaching desired bolt tension and clamping effect. Under these conditions specified torque reading is obtained, but clamping effect might be far below requirements, leading to bearing failure or to connecting rod bolt breakage.

Proper bolt tension and clamping effect cannot be attained if bolt threads are dry. Threads of nut and bolt and contact surfaces of nut and washer should be lubricated with engine oil at installation.

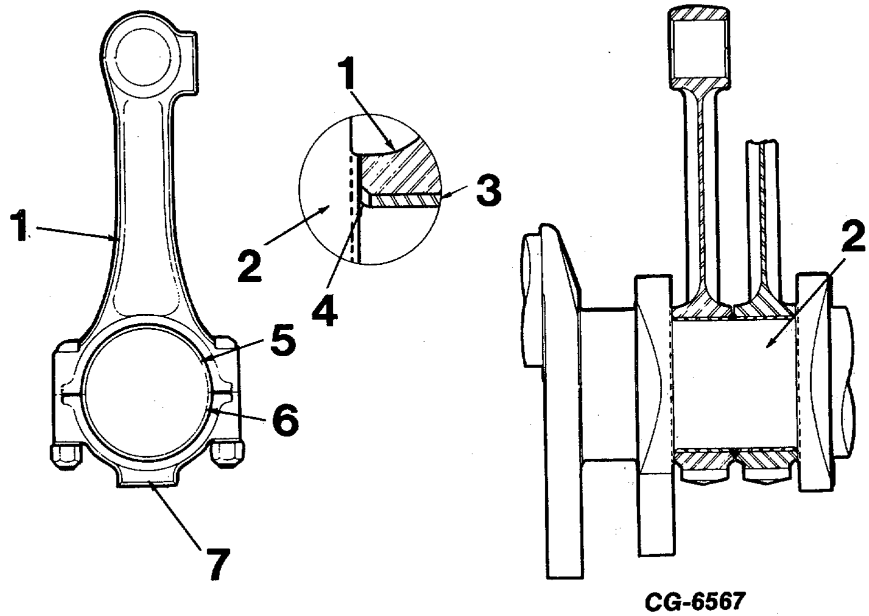


Fig. 103 proper installation of Connection Rod to Crankshaft

1. **Connecting Rod**
2. **Crankshaft**
3. **Bearing**
4. **Crankshaft fillet**
5. **Connecting rod bearing - upper**
6. **Connecting rod bearing - lower**
7. **Connecting rod bearing cap.**

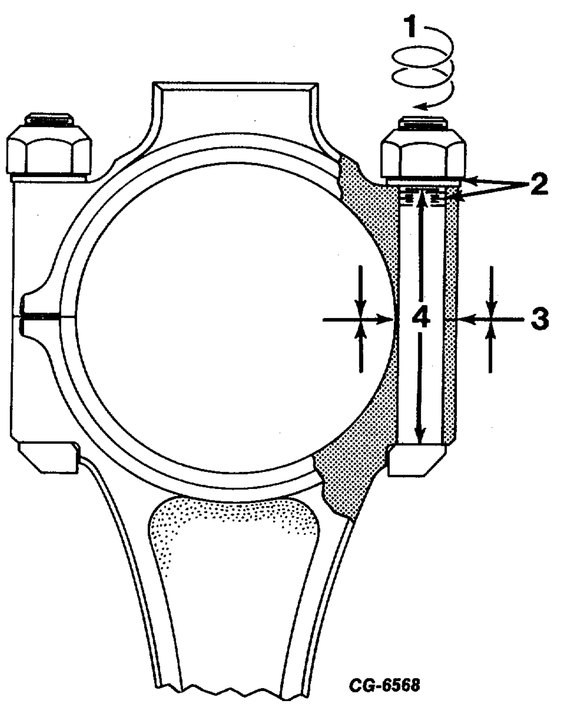


Fig. 104 Connecting Rod Cap Bolt and Nut Details

1. **Torque**
2. **Friction**
3. **Clamped**
4. **Tension**

Tighten connecting rod bolt nuts alternately and finish tightening with torque wrench to specified torque, then release torque load to zero and retorque to specified torque. (See Torque Chart.) After rod bolts have been torqued, turn nut an additional one-sixth turn or one flat of the nut. If nut is inadvertently overtightened enough to stretch the bolt, it must be replaced with a new bolt and nut. In major engine overhaul use new rod bolts, nuts and flat washers through-out.

When torquing connecting rod bolt nuts, use a torque wrench known to be accurately calibrated.

CAUTION: Do not use a power wrench for re moving or installing connecting rod bolts, nuts and washers. Such practice will cause seizure of the connecting rod bolt or nut threads.

CAMSHAFT, CRANKSHAFT AND RELATED COMPONENTS

Camshaft

Wash camshaft in cleaning solvent and remove all sludge or carbon deposits with a soft brush.

Inspect camshaft journals for signs of wear or out-or-around and replace camshaft if wear warrants. Inspect camshaft lobes. If worn, chipped or scored, replace camshaft.

Check oil pump drive gear on rear of camshaft. If teeth are worn or damaged, camshaft must be replaced, as gear is integral with shaft.

Check camshaft gear and replace if gear teeth are nicked, worn or damaged.

NOTE: Camshaft gear, crankshaft gear and injection pump drive gear are provided in matched sets and should be installed only as sets.

Inspect spacer used on front of camshaft and replace if cracked or damaged.

Crankshaft

Clean all parts with cleaning solvent, dry with compressed air, and inspect the bearings for wear and evidence of uneven bearing support. If such evidence is present, examine the bearing caps and supporting surfaces of the crankcase for high spots and burrs.

Inspect the crankshaft journals for scoring and measure the diameter of each journal, using a micrometer. Check the dimensions obtained against those listed in "SPECIFICATIONS". Measure each journal at two points, one at right angles to the other, in order to show any tendency to out-of-round. Move the micrometer over the entire width of the journal.

Hardness must be checked on every journal which incurred a bearing failure or shows evidence of overheating. All crankshafts must be hardness checked before regrinding. Bearing failures can cause overheating of crankshaft journals and reduction of hardness. When such occurs, the crankshaft strength may be unacceptably reduced. Test crankshafts as follows:

a. Using a Rockwell Hardness Tester, check main journal at least three locations.

b. Check rod journals at top, bottom and one other location. (Top and bottom determined with journal at TDC.) Top check should be made 12.7 mm (.50") from fillet (top of pin fillet is not hardened). The bottom should be checked as close to the fillet as possible.

c. Minimum hardness: 50-55 Rc. If any reading is below the minimum, the shaft must be scrapped.

NOTE: Elotherm crankshafts MUST NOT be straightened. Even slight straightening with complete absence of cracks will endanger the high strength built into the shaft.

CRANKSHAFT GRINDING

An induction-hardened fillet and journal crankshaft (Elotherm) can be reground similar to any precision crank- shafts. However, these shafts require special treatment when grinding. Before grinding, all crankshafts must be checked for hardness.

The superior strength of the fillet- hardened (Elotherm) shaft is due to the special process by which the bearing surfaces and fillets are hardened. This localized hardening greatly increases the bending strength of the crankshaft; however, in order to maintain this strength, special precautions must be taken when regrinding the Elotherm shaft. If special precautions are not taken, the crankshaft can be severely weakened. The metallurgical characteristics of the Elotherm shaft demand exacting standards and control when regrinding journals. For this reason, it is recommended that this work be done by I.H. ReNEWal stations. However, it can be reground locally where equipment and experience can produce quality standards outlined in the following instructions.

The most important consideration is to avoid any burns in the grinding operation. Refer to crankshaft under-size Grinding Limits chart.

The Elotherm crankshafts are reground similar to any precision crank-shaft with the following precautions:

1. A mechanical or an automatic wheel dresser is mandatory to prevent chatter, burning and poor surface finish. A hand stone should NEVER be used to rough or fine dress the face or radii of the wheel. The radii should blend evenly into the journal.

2. The selection of the grinding wheel is important because too hard a wheel will increase the possibility of burning. An aluminum-oxide wheel with a grit size of approximately 50 and a maximum hardness of M will produce satisfactory results, with other conditions being suitable.

3. The coolant must be such that it minimizes burning. This requires a fluid with high lubricity properties. The straight-cutting oils appear to be the best for grinding Elotherm crankshafts and are strongly recommended.

4. A grinding wheel speed of 6500 surface feet per minute with a work spindle speed of approximately 40 to 45 revolutions per minute is usually satisfactory.

   Grind all journals with crankshaft rotating in a counter-clockwise direction (viewed from front of crank-shaft), lap all journals and rear seal surface with crankshaft rotating in clockwise direction.

   CAUTION: As a normal precaution, it is re commended that a C02 fire extinguisher be near the grinding machine, just in case any excessive heat should ignite the oil. If a fire should start, it can be rapidly extinguished without causing any damage to the machine or surrounding area by following the normal fire-extinguishing procedure.

Feed rates should be slower than normal to prevent any burning.

Inspection of the crankshaft for dimensional tolerances is the same as for conventionally hardened crankshafts, except that extra care must be taken to be sure the shaft is cool before inspecting.

In addition to inspecting the dimensional tolerances, the Elotherm crank-shaft must also be carefully checked for surface defects, particularly for grinding cracks and burns. Where equipment is available, it is advisable to magnaflux Elotherm crankshafts after grinding and lapping to insure that there is no surface cracking.

Grinding Limits:

Maximum allowable taper on crankpins (rod journals) and main journals 0.0038 mm per 25.4 mm of length (0.00015 per inch of length). Crankpins and journals must be polished to 20 Micro-inch maximum - to 5 Micro-inch minimum, and must not be over 0.003 mm (0.0003 inch) out of round.

The main journal fillet radii should be 3.810 - 3.048 mm (.150 - .120 in.) with the crankpins (rod journals) fillet radii held at 4.318 - 4.064 mm (.170 - .160 in.)

The third main journal controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. For this reason the width of the third journal must be 34.620 - 34.544 mm (1.369 - 1.360 in.).

PRODUCTION SIZE	
Main Journal	79.350 - 79.502 mm (3.124 - 3.123 in.)
Crankpin (rod journal)	69.951 - 69.926 mm (2.754 - 2.753 in.)
.010 INCH UNDERSIZE	
Main Journal	79.095 - 79.070 mm (3.114 - 3.113 in.)
Crankpin (rod journal)	69.697 - 69.672 mm (2.744 - 2.743 in.)
.020 INCH UNDERSIZE	
Main Journal	78.841 - 78.816 mm (3.104 - 3.103 in.)
Crankpin (rod journal)	69.444 - 69.672 mm (2.734 - 2.743 in.)
.030 INCH UNDERSIZE	
Main Journal	78.588 - 78.562 mm (3.094 - 3.093 in.)
Crankpin (rod journal)	69.189 - 69.164 mm (2.724 - 2.723 in.)

TARASOV ETCH: In order to establish the acceptability of a regrind procedure, equipment and operator, the first reground crankshafts should be etched before lapping to determine whether the crankshaft was burned during the regrinding cycle. The best etch to use is the Tarasov etch, which will show both the rehardened and the overtempered areas. The etching procedure is as follows:

CAUTION: Due to the sharp odor and flammability of the Tarasov etch, the etching should be done in a well-ventilated area, away from any open flame.

a. Clean the surface with a scouring powder and water or a good solvent.

b. Wash thoroughly and rinse with alcohol.

c. Apply etchant No. 1 (4 parts nitric acid in 96 parts water) for approximately 16 seconds with a cotton swab.

d. Rinse with water and dry.

e. Apply etchant No. 2 (2 parts hydrochloric acid in 98 parts acetone) for approximately 15 seconds with a cotton swab.

CAUTION: Acetone is highly flammable.

f. Rinse with alcohol and dry thoroughly with compressed air.

If the crankshaft has been burned, it will show up as a change of color after the etch. Areas rehardened by excessive heat appear nearly white, while softened areas turn dark gray or black. Areas unaffected by the heat of grinding etch a light gray.

If any burns show up after the etch is used, the physical properties of the crankshaft will have been seriously reduced, and the crankshaft should be scrapped.

If burning becomes a serious problem, it can usually be eliminated by reducing the infeed rate, using a softer grade of wheel, or increasing the work spindle speed. Sometimes, a combination of these factors, along with the recommendations mentioned above, will be necessary to overcome the problem.

Examine crankshaft timing gear teeth and replace gear if teeth are worn or

NOTE: Crankshaft gear, camshaft gear and injection pump drive gear should only be re placed in matched sets.

Crankshaft Bearings

The bearing inserts used in these engines are selected fit and require no line reaming on installation. The bearings are available for service in standard sizes only.

If inspection reveals badly worn or scored bearings, replace bearings. Installation of new bearings must be closely checked to maintain proper clearance and between journals and bearing surface. A convenient and accurate method for checking clearance is with the use of Plastigage.

When installing precision-type connecting rod or main bearings, it is important that bearing shells fit tightly in bearing bore. To accomplish this, the bearing manufacturer makes the diameter at right angles to the parting line slightly larger than the actual diameter of the bore into which they are assembled. When the assembly is drawn up tight, bearings are compressed, assuring a positive contact between bearing back and bore. This increased diameter is referred to as bearing "crush." (See Figure 105)

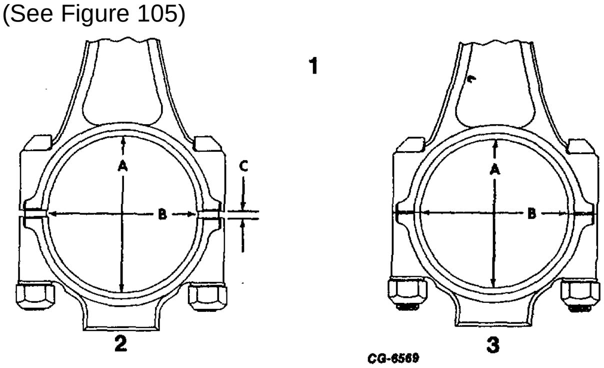


Fig. 105 Illustration of Bearing "Crush"

1. Difference between diameters (A) and (B) is bearing crush (C)

2. Diameter (A) at right angles to parting lines greater than diameter (B)

3. With bearing cap drawn up tight. diameter (A) and (B) are equal.

To obtain proper bearing assembly with correct "crush," care must be taken when tightening clamping bolts and nuts to make sure they are drawn down alternately and evenly using a torque wrench and tighten to specifications. Then back off nut and retighten to specified torque.

Rods, caps or bearing must not be lapped or reworked in any other manner in order to reduce clearance.

Premature bearing failure will result from attempts to reduce journal-to bearing running clearance by reworking bearing caps, bearings, or both, because such reworking will result in an out-of-round bore, bearing shell distortion and destroy the specifically desired "crush."

Bearing inserts are designed with the "spread" (width across the open ends) slightly larger than the diameter of crankcase bore or connecting rod bore into which they are assembled (Figure 106).

This condition causes the bearing to fit snugly in the rod bore, and the bearing must be "snapped" or lightly forced into its seat. Some of this "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition. If bearing fits loosely in bore (does not "snap" into position), bearing should be replaced.

"Spread" is originally designed into the bearing to cause it to tend to spread outward at the parting line when "crush" load is applied by tightening bolts.

Specified spread for main and connecting rod bearing inserts is given in SPECIFICATIONS.

Fitting Main Bearings

Outlined below are procedures for checking main bearing clearance, using the Plastigage method, and crankshaft end play.

IMPORTANT

To obtain an accurate reading using Plastigage, all main bearing caps must be in place and torqued to specifications.

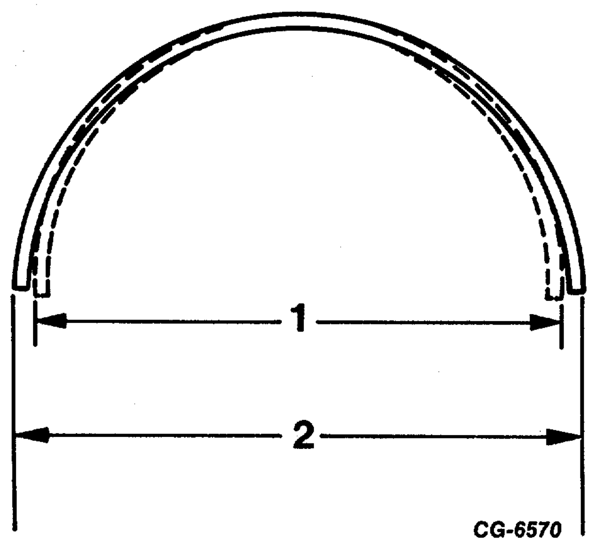


Fig. 106 Illustration of Bearing "Spread"

1. O.D. of bearing when installed is the same as the diameter of the crankcase or connecting rod bore.
2. Spread of bearing before installation

1. Remove one bearing cap and bearing insert. Remaining caps are left tight while checking the fit of this bearing.
2. Wipe the oil from all contact surfaces such as crankshaft journal, bearing insert, bearing cap, etc.
3. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately .63 mm (.25") off center. Tap bearing cap on with soft hammer until it just meets the mating surface of the crankcase. With the cap lined up with the back face of the crankcase, install cap bolts finger tight. Then install the tie bolts finger tight. Torque the cap bolts and tie bolts to proper torque according to notes on TORQUE CHART.

IMPORTANT

Do not turn crankshaft while making check with Plastigage.

4. Remove bearing cap bolts, then loosen tie bolts and remove bearing cap and insert.

5. Do not disturb Plastigage. Using Plastigage envelope, measure widest point of Plastigage (Figure 107). This reading indicates bearing clearance in thousandths of an inch.

If bearing clearance (with new bearing inserts) is not within specified limits (see SPECIFICATION), the crankshaft must be replaced.

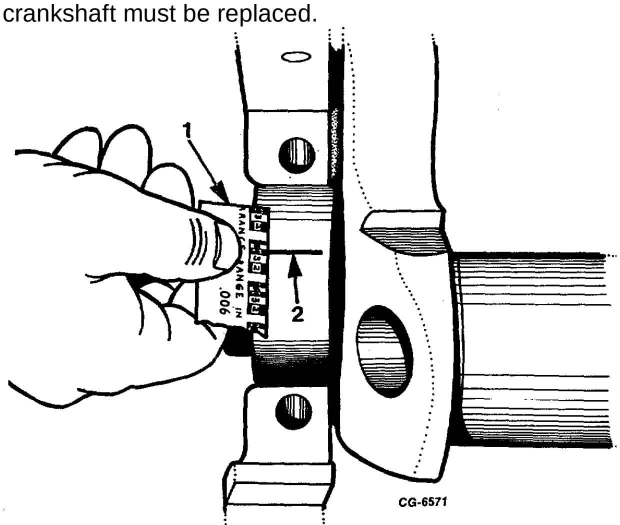


Fig. 107 Checking Main Bearing Clearance

1. Gauge 2. Plastigage flattened

6. The third (intermediate) main bearing also controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. Use a dial indicator to check crankshaft end play (Figure 61).

If end play (with new intermediate bearing insert) is not within specified limits (see SPECIFICATIONS), the crankshaft must be replaced.

Fitting Connecting Rod Bearings

The following procedure can be used to check connecting rod bearing clearance, using Plastigage, and connecting rod end clearance.

NOTE: To obtain an accurate reading using Plastigage, both connecting rods (right bank and left bank) must be in place on each crankshaft rod journal and torqued to specifications.

1. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.

2. Place a piece of Plastigage on bearing surface the full width of bearing about ¼" off center.

3. Install cap and tighten bolts and nuts to 68 N-m (50 lb.-ft.) torque.

NOTE: Do not turn crankshaft while Plastigage is in place.

4. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage (Figure 108). This reading indicates bearing clearance in thousandths of an inch.

If bearing clearance (with new bearing inserts) is not within specified limits (See SPECIFICATIONS), the crankshaft must be replaced.

Check connecting rod end clearance using a feeler gauge as shown in Figure 109. End clearance should be within specified limits. (See SPECIFICATIONS.)

Excessive clearance may require replacement of rods or shaft. Lack of clearance could indicate a damaged rod or perhaps a rod bearing out of position.

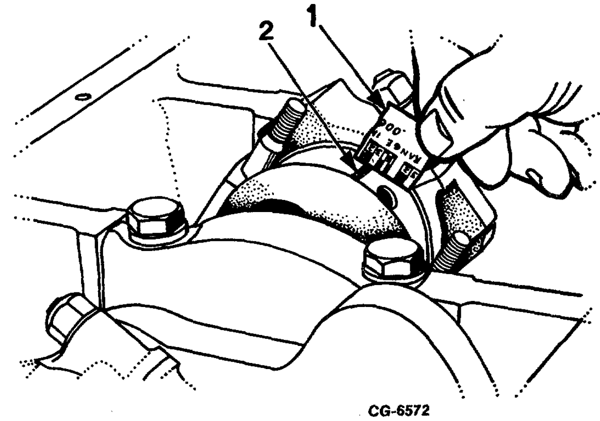


Fig. 108 Checking Connecting Rod Bearing Clearance

1. Gauge 2. Plastigage flattened

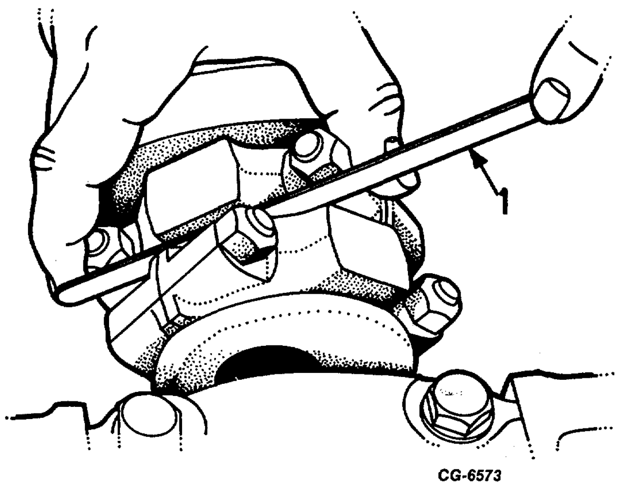


Fig. 109 Checking Connecting Rod End Clearance

1. Feeler Gauge

Flywheel and Ring Gear

Clean flywheel assembly with cleaning solvent, removing all traces of oil and grease. Inspect clutch mating surface of flywheel for scoring, cracks, heat checking and warping. Check flywheel mounting bolt holes and mounting face for indications of wear and looseness. If damage is evident, replace flywheel.

Check clutch pilot bearing for wear or damage and replace if needed. If pilot bearing does not fit snugly in flywheel bore, replace flywheel.

Inspect flywheel (starter) ring gear. If teeth are damaged or if ring gear is loose on flywheel, replace ring gear.

To replace flywheel ring gear, heat gear with a torch and remove it from flywheel with a hammer and drift. Heat new ring gear with a torch, heating evenly all the way around. While ring gear is hot, install gear on flywheel and allow it to cool.

CYLINDER HEADS, VALVES AND RELATED COMPONENTS
Cylinder Heads

The cylinder head assemblies are interchangeable from one cylinder bank to another. Cylinder head gasket is also interchangeable.

SE-1896 cylinder head sling can be can be used as a holding fixture to protect machined surfaces during cleaning and miscellaneous disassembly operations.

With valves in place to protect seats, clean carbon deposits from combustion chambers and valve heads with a wire brush and scraper. Wash cylinder head in cleaning solvent to remove dirt and grease from all surfaces and dry thoroughly. Check all water passages to make sure they are clean and open.

Remove valves from cylinder head as follows:

a. Place head assembly in vertical position. Apply valve spring compressor and remove valve keepers or locks (Figure 110). It may be necessary to strike valve ends with a light, soft hammer to loosen valve keepers.

b. Release spring compressor and remove spring retainer, valve spring and damper assembly, valve stem seal and Rotocoil assembly (Figure 111).

NOTE: Keep valves and their related parts together so they may be reinstalled in their respective positions.

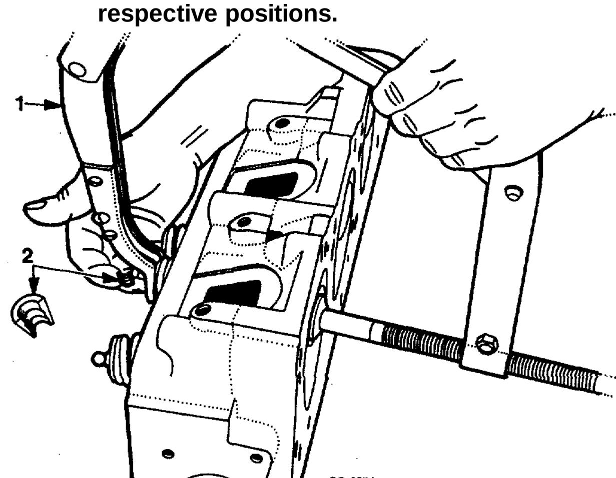


Fig. 110 Removing Valve Keepers

1. Valve Spring Compressor
2. Valve Keeper

After removing valves, examine cylinder heads for water leaks or cracks in combustion chambers, exhaust ports, or around valve seats. Inspect the machined or gasket surfaces for scratches or mars which may cause leakage after assembly.

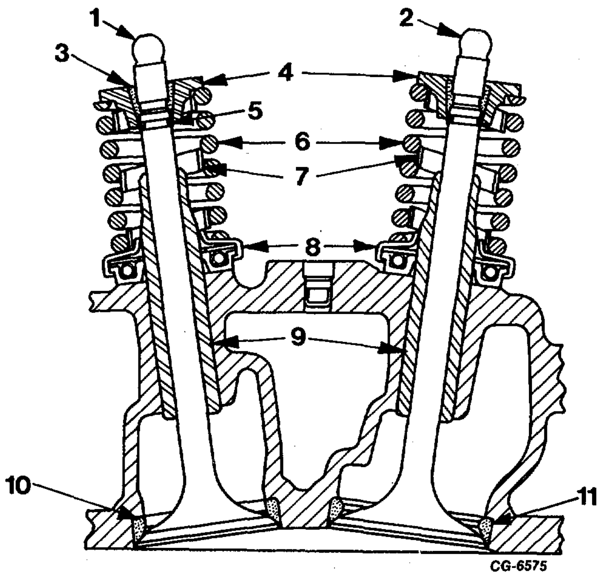


Fig. 111 Sectional View of Valve Installation

1.	**Exhaust valve**	**7.**	**Damper**
2.	**Intake Valve**	**8.**	**Roto coil**
3.	**Valve keeper**	**9.**	**Valve guide**
4.	**Retainer**	**10.**	**Exhaust seat**
5.	**Oil seal**	**11.**	**Intake seat**
6.	**Spring**		

Check gasket surface of cylinder head for trueness with a straightedge. Test by attempting to insert a .006" feeler gauge ribbon between straightedge and cylinder head. If this is possible, replace cylinder head.

NOTE: Cylinder heads are not to be resurfaced.

Valves

Remove all carbon from valve stems and valve heads using a fine wire brush or buffing wheel.

Inspect each valve, discarding any that show evidence of burned, warped or bent condition. Measure each valve stem for wear. If worn beyond specified limits (see SPECIFICATIONS), replace valve. Check fit of valve stems in valve guides for proper running clearance. (See SPECIFICATIONS). Replace valve guides if needed.

If valves are in serviceable condition, reface as needed. See specifications for valve face dimensions. Grinding wheels of refacing equipment should be carefully dressed to specified valve angle. During grinding, remove only the minimum amount of material necessary to true up the valve face.

IMPORTANT

New valves need not be refaced; however, all valves should be carefully inspected for damaged seat faces or for a run-out condition due to a bent valve stem. Use Tool SE-2614 for checking valve stem run-out.

Inspect valve keepers for excessive wear and replace in pairs as required. When installing a new valve, always use new valve keepers.

Valve Guides

Using appropriate size brush (SE-1300), clean valve guide bores (Figure 112).

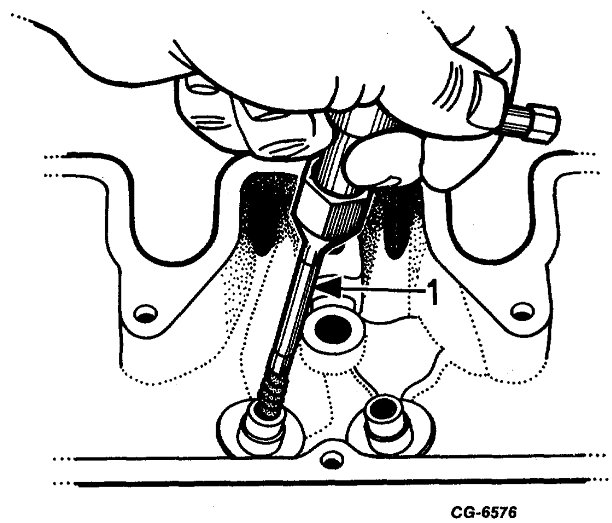


Figure 112 Cleaning Valve Guide Bore

1. Cleaning Tool

Using equipment such as SE-1826 small bore guage (and micrometer) or SE-2506 valve guide guage, check valve guide bores (Figure 113). (See SPECIFICATIONS for proper guide bore diameter.) Replace guides having bore diameters outside recommended limits, are bell-mouthed more than .0005" or which show egg-shaped wear.

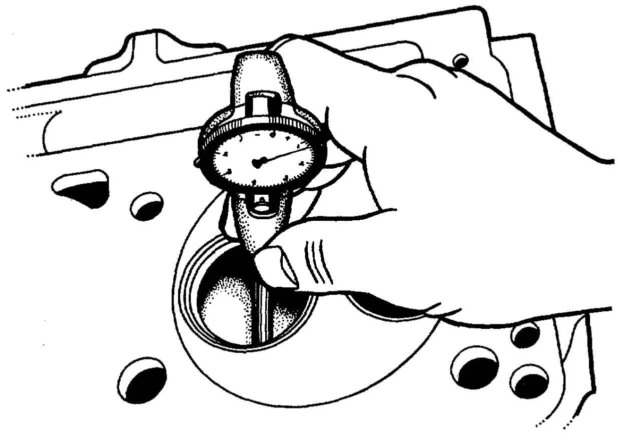


Fig. 113 Checking Valve Guide Bore

Excessive guide clearance prevents adequate cooling of the valve through the guide and allows valve to tilt or tip which may cause valve breakage at high engine speed. These conditions prevent good seating and promote leakage past valve face.

Replace valve guides as follows:

1. Remove cylinder head sling and position cylinder head (combustion chamber side up), on support fixture SE2104 in press bed (Figure 114). Support fixture is designed to position valve guides vertically under press ram.

2. Using remover tool SE-1722 (Figure 113) press valve guide from cylinder head. All guides must be pressed out from the combustion chamber side through the top of the head.

3. Turn cylinder head over (top side up) on support stand in press bed.

4. Adjust valve guide installer tool SE-1943 (Figure 115) for specified valve guide height above cylinder head. (See SPECIFICATIONS). Tool is designed to install both intake and exhaust guides.

5. Insert top end of valve guide into installer tool. Lubricate O.D. of valve guide with a commercial press-fit lubricant. Press valve guide into cylinder head (Figure 116) until installer tool rests firmly on top of head, thus obtaining proper valve guide height.

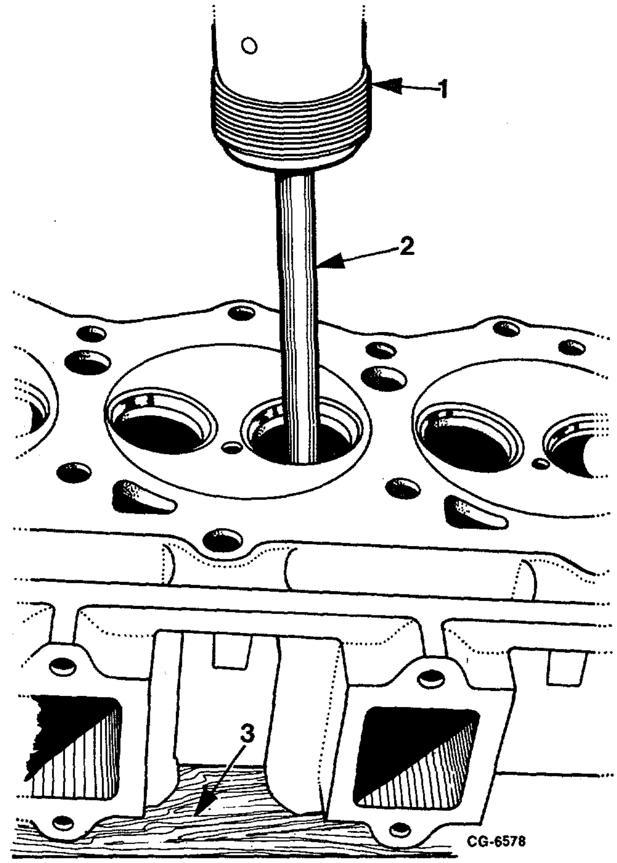


Fig. 114 Removing Valve Guide

1. Press Ram
2. Remover Tool SE-1722
3. Support Fixture SE-2104

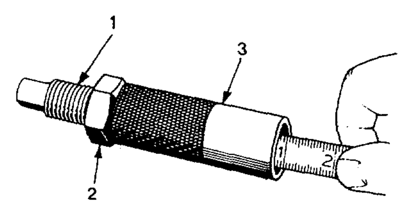


Fig. 115 Adjusting Valve Guide Installer for Proper Height

1. Adjusting Screw **3. Body**
2. Lock Nut

6. Replacement guides are designed to give proper clearance when installed in the cylinder head. Reaming is not required, but care must be taken to insure the ends of the guides are not burred during installation. After guides are installed, insert SE-2215 Reamer to insure the guides have not been distorted during installation and to remove any burrs.

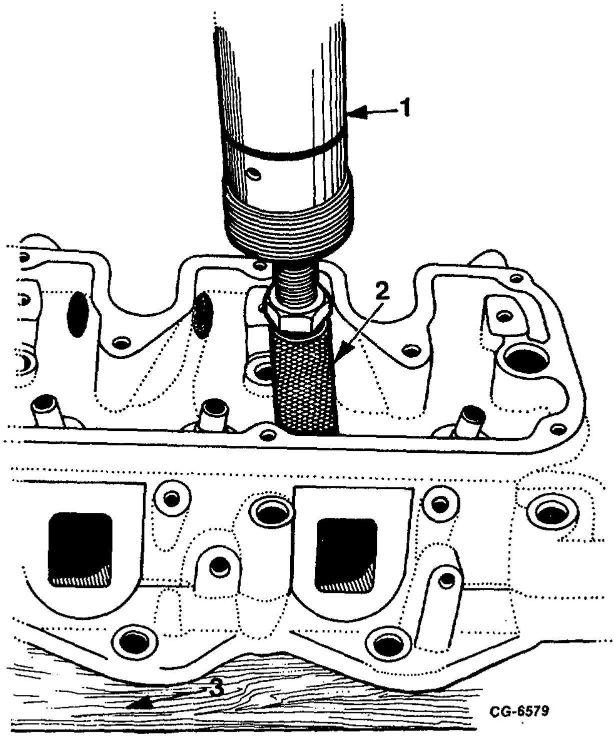


Fig. 116 Installing Valve Guide

1. **Press ram**
2. **Installer**
3. **Support fixture SE-2104**

Inspect valve seat inserts for looseness, burned or cracked condition. Replace inserts showing indications of damage or excessive grinding. Replace valve seat inserts as follows:

1. Using remover tool SE-1951 (Figure 117) to remove intake valve inserts. Position remover collet to insert and turn coned screw out to expand collet jaws, providing a firm grip under insert ring. Use a slide hammer to remove insert.

NOTE: The SE-1951 valve seat remover tool CANNOT be used for 9.0 liter engine exhaust valve seat removal. Model HC-104A Universal Valve Seat Puller may be used for 9.0 liter engine exhaust valve seat removal. This tool can be ordered from:

Winona Tool Manufacturing Company
4730 West Highway 61
Winona, Minnesota 55987

2. Select inserts of proper size O.D. (Inserts are provided in oversizes for use in previously serviced heads.)

3. Use counterbore tool such as SE-1797 (Figure 118) to clean up (or machine to desired oversize) the valve seat insert counterbores in cylinder head. Follow equipment manufacturer's instructions.

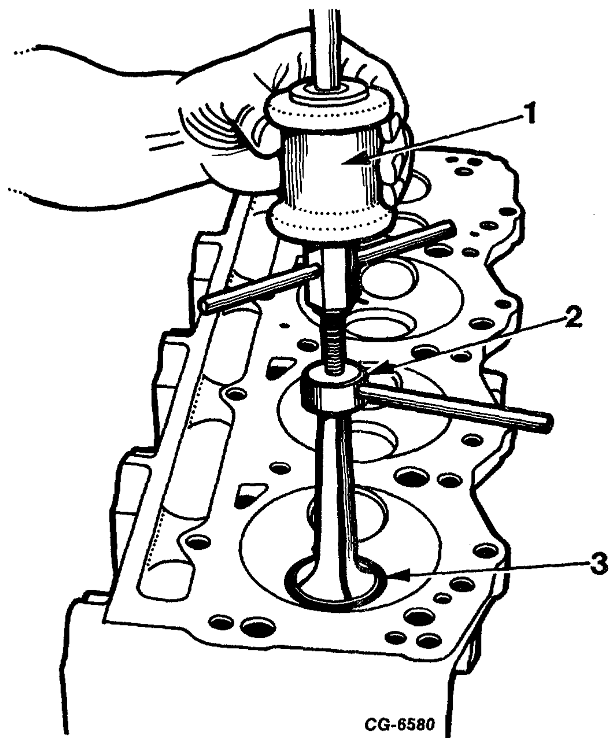


Fig. 117 Removing Valve Seat Insert

1. **Slide Hammer**
2. **Remover Tool SE-1951**
3. **Intake Valve Seat Insert**

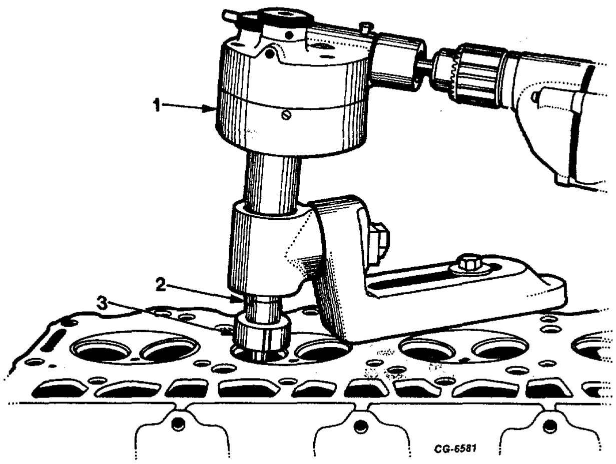


Fig. 118 Machining Valve Seat Insert Counterbore

1. **Cutter Drive Unit SE-1797**
2. **Drive Shaft**
3. **Cutter**

4. Using insert installer tool from counterbore tool set SE-1797 (Figure 119) install valve seat inserts. Chill inserts thoroughly with dry ice or other means. Position insert on installer tool and drive into cylinder head counterbore until firmly seated.

5. Stake valve seat inserts securely in place. Use peening tool SE-2094 (Figure 120) or a dull pointed chisel 6.35 mm (¼") wide to peen cylinder head metal over outer edge of insert. Peen material all the way around insert except injection nozzle area on intake valve insert.

To insure a good compression tight fit with valves, reface valve seats with precision equipment such as the SE-1631 or SE-1804 valve seat grinder (Figure 121). Grind seats to specified angle and seat width (See SPECIFICATIONS).

During grinding operation remove only the minimum amount of material necessary to true up the seat. If the seat is wider than specified, it will be necessary to grind from the top of the seat until the proper seat width is obtained.

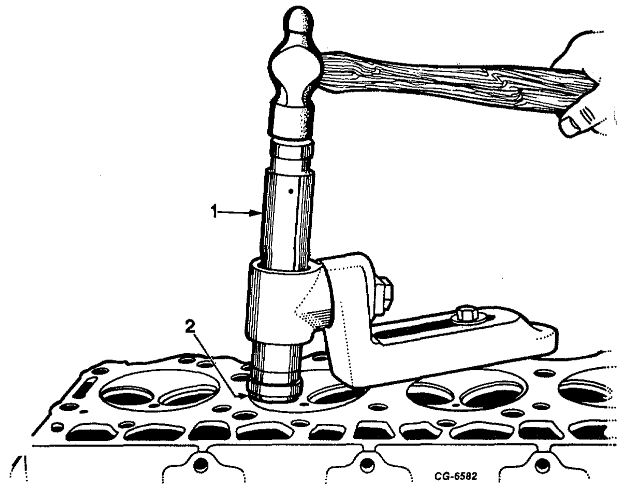


Fig. 119 Installing Valve Seat Insert

1. Driver **2. Seat**

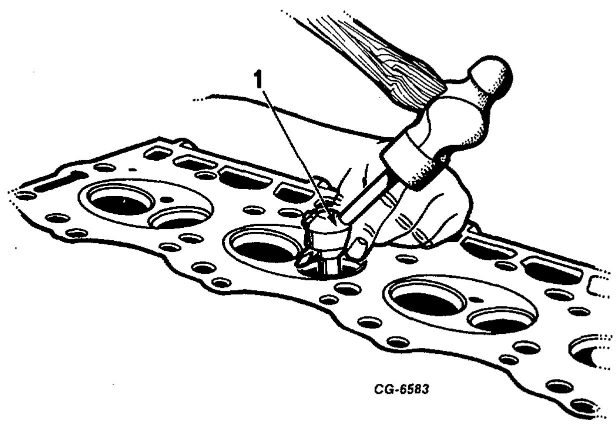


Fig. 120 Staking Valve Seat Insert in Cylinder Head with Peening Tool

1. Peening Tool SE-2094

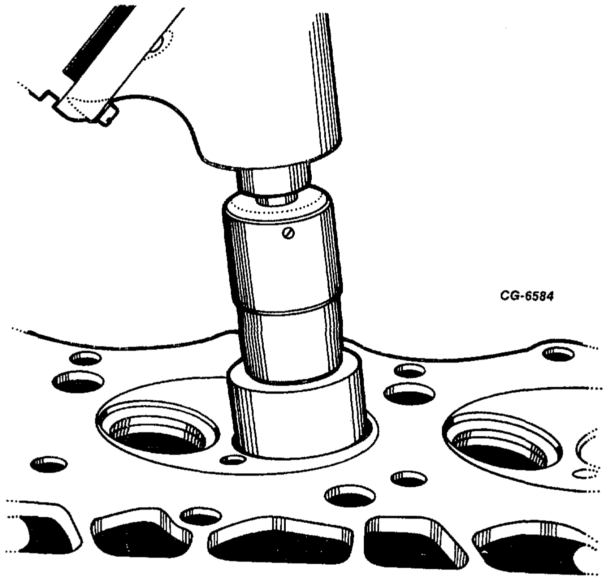


Fig. 121 Grinding Valve Seat

After grinding seats, check each seat for run-out using dial indicator or runout gauge from SE-1631 seat grinder set (Figure 121). Seat run-out should not exceed specified limits (see SPECIFICATIONS).

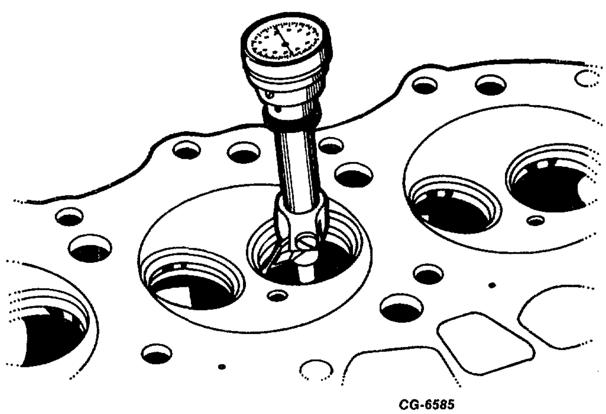


Fig. 122 Checking Seat Run-Out

It is important to have the finished seat face contact the approximate center of the valve face. To check face contact, place a thin coat of Prussian Blue on valve face. Position valve in cylinder heat and tap valve lightly to its seat. Inspect each valve for seat dimensions as outlined in specifications and make any necessary corrections. Corrections should always be made on seat and not valve face. When seat contact is satisfactory, mark each valve for installation in its respective seat.

NOTE: This test is merely for proof of results of defacing and reseating operations. Do not attempt to lap valves and seats. A poor grind job cannot be corrected by lapping. A nearly perfect seat is often destroyed by attempting to lap the valves to their seats.

After valve grinding operation has been performed, check valve recession in cylinder head. Valve recession is the distance valve head is located from cylinder head gasket surface. (See SPECIFICATIONS.) To check the minimum and maximum recession, the valves should be positioned in their respective ports to which they were ground. Check valve recession by placing depth gauge SE-2515 on the valve edge and "0" gauge as illustrated (Figure 123). Then move depth gauge to gasket surface of cylinder head and compare reading with specification (Figure 123). This check must be made to assure clearance between top of piston and head of valves. If recession does not meet the minimum specified clearance, valve insert will have to be reground starting from the top of seat until proper clearance is obtained. However, if clearance is larger than specified, valve insert must be replaced and a grinding operation performed.

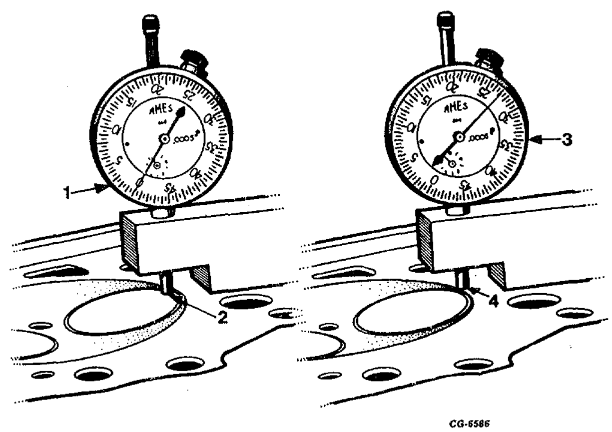


Fig. 123 Checking Valve Recession

1. Depth Gauge Set at Zero
2. Valve Edge
3. Depth Gauge Reading Recession
4. Cylinder Head Gasket Surface

Valve Springs

Inspect valve springs and dampers for wear or fatigue marks. Spring ends must be flat and square to prevent lateral loads on valve stem. Out-of-square springs place a side force on the stem causing rapid guide wear.

Using spring tester such as SE-2241 (Figure 124) check springs for proper tension (See SPECIFICATIONS). Weak valve spring tension can result in valve "float" (unsatisfactory closing) and valve bounce, which is common cause of seat pounding and valve breakage.

Replace valve springs and dampers lowing evidence of wear, cracks or improper tension.

NOTE: Because of the possibility of fatigue cracks, valve springs and dampers should be replaced on the same basis as recommended for valves which have been in service for long periods.

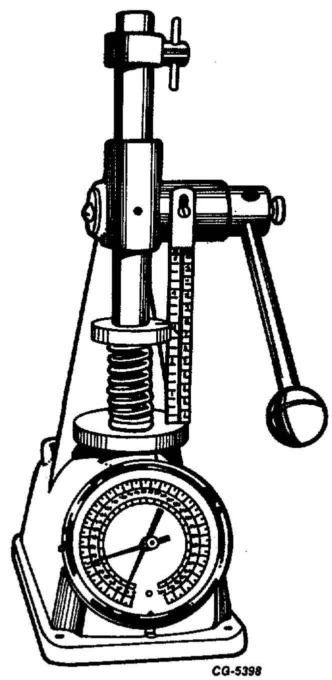


Fig. 124 Checking Valve Spring Tension

Inspect valve spring retainers and roto-coil assemblies for wear. Rotate Roto-coil assemblies by hand to check for rough or irregular operation. Replace if wear or roughness is indicated.

Reinstall valves in cylinder head as follows: Wipe valve faces and seats with cleaning solvent to remove all dirt or foreign material. Coat valve stems and faces with oil and install valves in the seats to which they were checked. Install Roto-coil assembly, valve spring and damper assembly, valve stem seal and spring retainer (Figure 111). Compress valve spring with valve spring compressor and install valve spring retainer locks. Be sure retainer and locks are correctly seated on all valves.

Rocker Arm Assemblies and Push Rods

Rocker arm assemblies are removed from engine as a unit. There are two different shapes of rocker arms used in each complete rocker arm assembly. Each rocker arm is stamped the words "INT." or “EXH." for identification. Figure illustrates the different types of rocker arms and their locations.

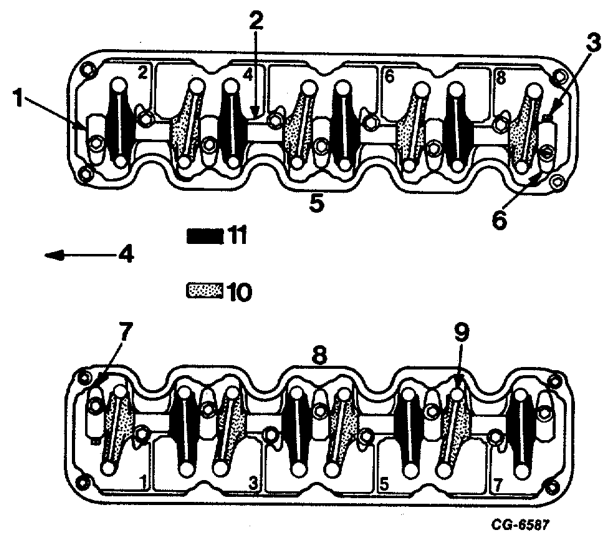


Fig. 125 Rocker Arm Installation

1. Plug	**8. Left bank**
2. Support	**9. Valve tappet adjusting screw and nut**
3. Lock bolt	**10. Exhaust valve rocker arm**
4. Front of engine	**11. Intake valve rocker arm**
5. Right bank	
6. Oil feed support	
7. Oil feed support	

Service rocker arm assemblies as follows:

1. Starting from end opposite oil feed support, slide supports and rocker arms from shaft. Keep parts in order so they may be replaced in their original position if in satisfactory condition.

2. Remove capscrew and lockwasher from oil feed support and press support from shaft.

3. Remove plugs from each end of shaft.

4. Clean all parts thoroughly, making sure all oil passages are open.

5. Inspect rocker arm shaft. Check on a surface plate for signs of bending; check for wear from rocker arms. If a shaft is bent or shows excessive wear, it must be replaced.

6. Inspect valve stem cap and contact pad surface of rocker arm. If rocker arm pad wear is excessive, resurface pad but do not remove more than .010" of material from surface. If valve stem cap shows excessive wear, replace cap.

7. Check rocker arm bore for wear or scoring. Check the rocker arm-to-shaft running clearance. (See SPECIFICATIONS).

8. To assemble, align oil hole in oil feed support with cross hole in end of rocker arm shaft (Figure 126). Then press oil feed support on shaft, indexing oil holes.

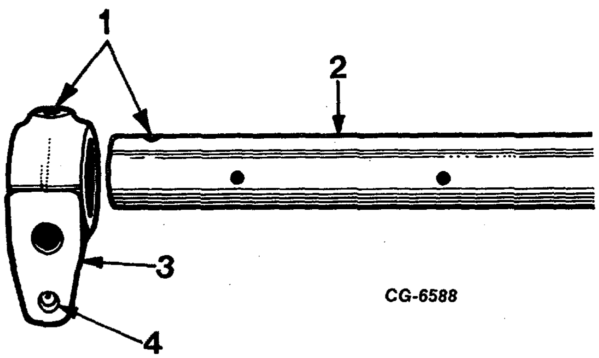


Fig. 126 Aligning Holes in Rocker Arm Shaft and Support

1. Index Holes **3. Oil Feed Support**
2. Rocker Arm Shaft **4. Oil Feed Orifice**

NOTE: If oil holes are not indexed when performing pressing operation, they can be aligned by installing oil feed support in a bise (Figure 127) and using a drift punch rotate shaft to permit tightening support screw finger tight. Using this method will eliminate the possibility of bottoming bolt against shaft, which could result in stripping threads in support. After support has been secured to shaft use a fine oil stone to remove any burrs caused by using drift punch in hole to turn shaft.

9. Place rocker arms, rocker arm shaft spacers and remaining supports on shaft making sure rocker arm shaft-to-arm oil feed holes are in a downward position. This will properly position rocker arm shaft oil feed holes so that oil feed hole in right rocker arm shaft assembly will be toward the rear, while oil feed hole in left rocker arm shaft assembly will be toward the front. See Figure 125 for correct installation.

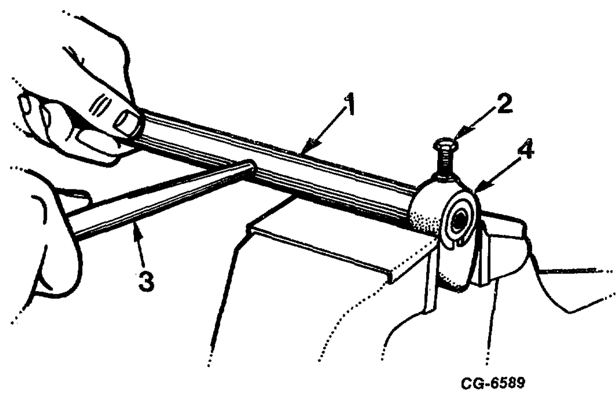


Fig. 127 Turning Rocker Arm Shaft to Align Screw Holes

1. Rocker Arm Shaft **3. Drift Punch**
2. Bolt **4. Oil Feed Support**

10. After rocker arm shaft has been completely assembled, a wire (Figure 128) can be used to hold assembly together for installation on cylinder head.

Clean and inspect all valve push rods. Check push rods for straightness by rolling on a flat surface. Replace any that are bent or have loose ends.

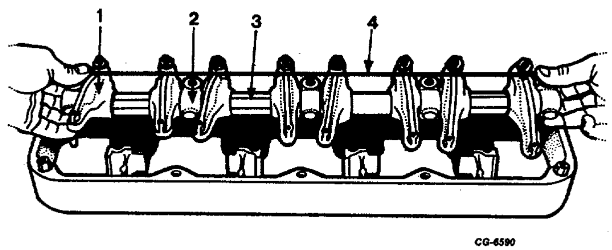


Fig. 128 Method of Holding Rocker Arm Assembly Together for Installation

1. Rocker Arm
2. Support
3. Spacer
4. Temporary Assembly Holding Wire

Manifolds

Intake manifolds-should be thoroughly cleaned and examined for cracks. Place mounting surface (outlets) of manifold on a smooth flat surface and check for warpage. Replace manifold if cracked or warped.

NOTE: Do not surface grind intake manifold to correct warpage. Any attempt to resurface intake manifolds will create misalignment of ports to cylinder heads and air cleaner mounting.

Exhaust manifolds are cast in one piece. Examine exhaust manifolds for cracks or burning and check for warping by placing inlet ports on a flat surface. Minor warpage can be corrected by surface grinding. If warpage is extreme, replace manifold.

LUBRICATING SYSTEM COMPONENTS

Oil Pump

Recommended oil pump inspection and repair procedures are as follows:

1. Wash all pump parts and screen assembly in cleaning solvent.

2. With cover, plate and gaskets removed and gears and shaft in place, exert pressure against gears with thumb to push gears away from the outlet side of pump

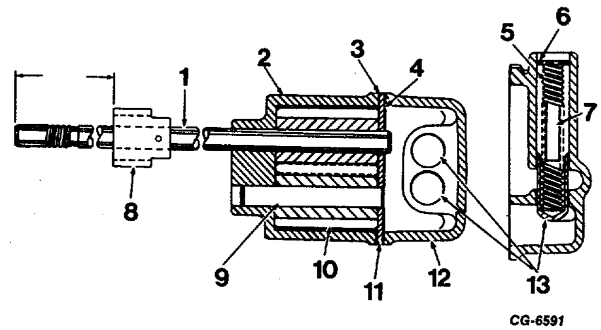


Fig. 129 Sectional View of Oil Pump Assembly

1. Shaft
2. Body
3. Gasket-Use as Required to Provide Gear End Play
4. Gasket
5. Spring
6. Retaining Ring
7. Guide
8. Drive Gear
9. Idler Shaft
10. Idler Gear
11. Plate
12. Cover
13. Relief Valve (Two Used)

3. While holding gears in this manner, measure clearance between outside diameter of gear and bore of housing (Figure 130). Clearance should be within limits given in SPECIFICATIONS.

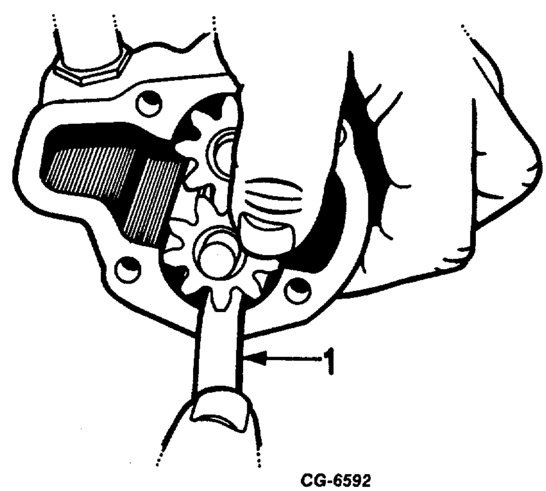


Fig. 130 Measuring Pump Gear-to-Body Clearance

1. Feeler Guage

4. If clearance is not within specified limits (See SPECIFICATIONS), obtain new pump.

5. Check pump shaft clearance in the bore. If worn beyond limits given in SPECIFICATIONS, replace pump assembly.

6. Check backlash between pump body gears. If this exceeds figure shown in SPECIFICATIONS, replace pump.

7. Establish body gear end clearance. Oil pump cover plate-to-body gaskets control clearance (end play) between pump body gears and pump cover plate. Add or remove gaskets to obtain specified clearance. (See SPECIFICATIONS).

8. Inspect relief valves and replace if worn or damaged.

9. Check relief valve springs for proper tension. (See SPECIFICATIONS) Replace springs if weak or damaged.

10. When installing pump gears and shaft, these parts should be oiled liberally with engine oil for initial lubrication.

11. When installing oil pump drive gear on shaft, gear should be pressed on to a 7.3 cm (2-7/8") dimension from top of gear to end of shaft (Figure 129).

12. Installation of pump screen must be made after pump assembly has been installed on engine. (See ENGINE ASSEMBLY.)

Oil Filter and Cooler Base

At the time of engine overhaul, oil filter and cooler base should be serviced as follows:

1. Remove all gasket material from filter/cooler base. Wash base in cleaning solvent and dry carefully.

2. Inspect gasket surfaces of base for nicks or scratches which could cause leakage. Replace base if damaged (Figure 131).

Oil Cooler

The following operations should be performed on the oil cooler during engine overhaul.

1. Remove fittings from coolant openings of cooler.

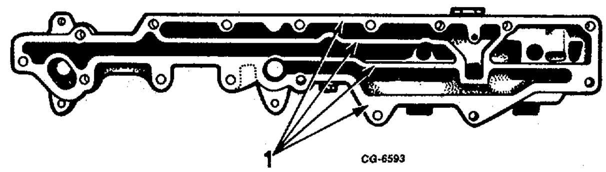


Fig. 131 Oil Filter and Cooler Base

1. Gasket Surfaces

2. Looking through coolant openings, inspect coolant portion of cooler for deposits of lime or other contaminants and for evidence of oil leakage. Replace cooler if heavy deposits or oil leakage are found.

3. Pressure test cooler for leakage as follows (Figure 132):

   a. Plug one coolant opening.

   b. Using necessary adapter fittings and air control valve (Radiator drain valve will work) connect an air pressure gauge to the other coolant opening (Figure 132).

   c. Pressurize coolant portion of cooler with air (Do Not exceed 517 kPa (75 psi) air pressure). Close air control valve, release supply air and check pressure gauge for leak-off.

   d. Replace cooler if leakage is indicated.

Alternate Method:

   a. Plug one coolant opening of oil cooler.

   b. Using necessary adapter fittings connect other coolant opening to source of regulated air pressure.

   c. Completely submerge oil cooler in a container of water, if leakage is observed, replace oil cooler.

Oil Pan

The pan should be thoroughly cleaned in cleaning solvent to remove any foreign material from around baffle plates, which are spot welded in place. Inspect oil pan for cracks or deformation and straighten or weld.

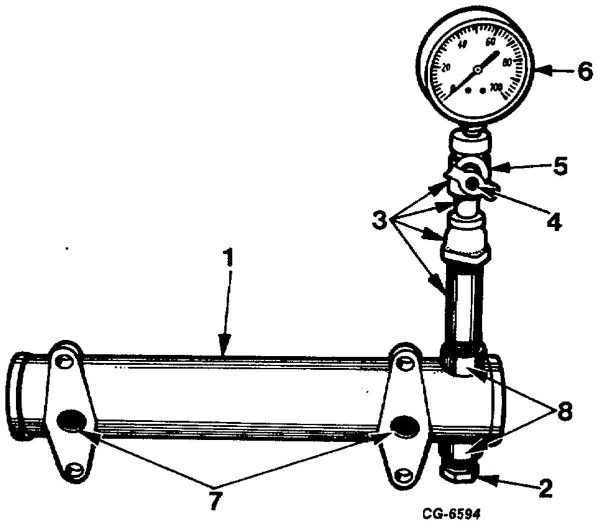


Fig. 132 Oil Cooler Leakage

1. **Oil Cooler Assembly**
2. **Plug**
3. **Necessary Adapter Fittings**
4. **Supply Air Input**
5. **Air Control Valve**
6. **Air Pressure Gauge**
7. **Oil Openings**
8. **Coolant Openings**

Remove all gasket material from oil pan flange.

Check oil pan drain plug and drain plug boss for fit and thread wear. If plug is loose or threads are damaged, repair threads or replace oil pan.

COOLING SYSTEM COMPONENTS
Water Pump

The water pump assembly is composed of a pulley hub and a housing which accommodates a shaft and bearing assembly, seal and impeller as shown in Figure 133. The water pump will be sold only as a complete assembly along with its mounting gasket.

1. When removing water pump all gasket material should be cleaned from the water pump. Inspect the water pump for damaged impeller, cracks and other faulty conditions. If any defects are noted, the water pump must be replaced as an assembly.

2. If the pulley hub must be replaced, apply locquic primer T and Loctite AA to hub and bearing shaft assembly prior to assembly.

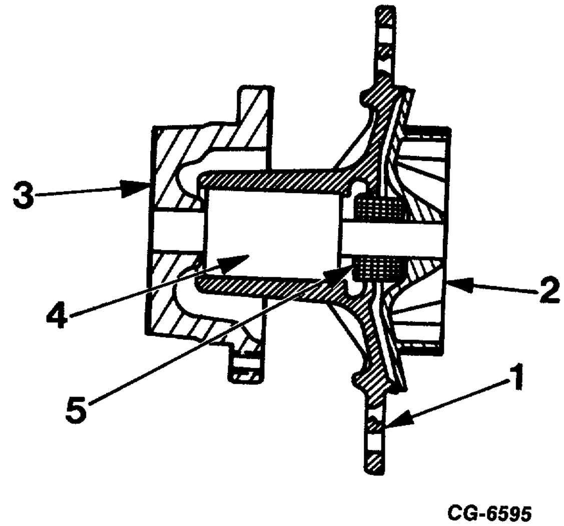


Fig. 133 Sectional View of Water Pump Assembly

1. **Water Pump Housing**
2. **Impeller**
3. **Hub**
4. **Bearing Assembly**
5. **Seal**

Press the hub on to the shaft using pulley hub installer SE-2085 as shown in Figure 134.

NOTE: When pressing the hub on the water pump assembly, special care must be taken, so as not to disturb the impeller's position on the shaft.

Check impeller running clearance as follows:

1. Position suitable amount of moulding clay on two impeller vanes (Figure 135).

2. Position gasket on water pump housing. Install pump assembly into pump body and tighten mounting screws.

IMPORTANT

Be careful not to rotate impeller or hub.

3. Remove pump assembly and check thickness of moulding clay (Figure 136). If clearance exceeds specifications, the water pump must be replaced.

4. Position gasket on water pump housing. Install pump assembly into pump body and tighten mounting screws.

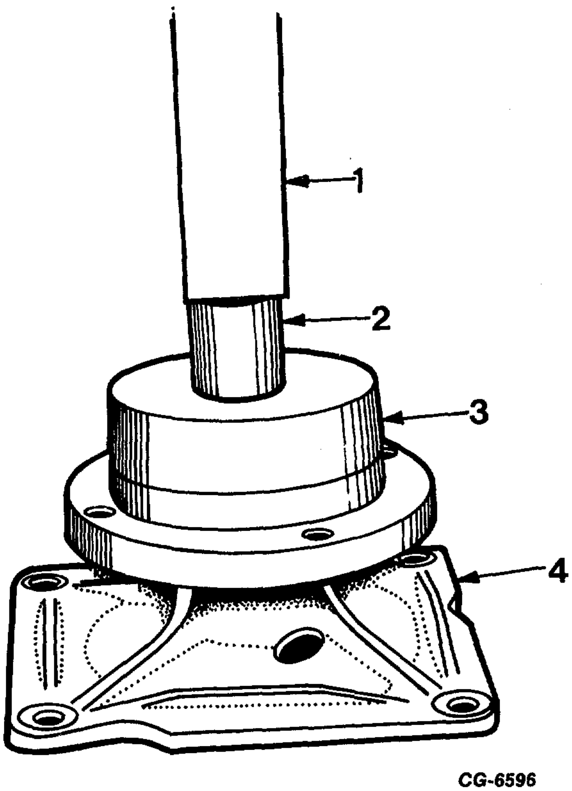


Fig. 134 Installing Pulley Hub

1. Press Ram **3. Pulley Hub**
2. Installer SE-2085 **4. Housing**

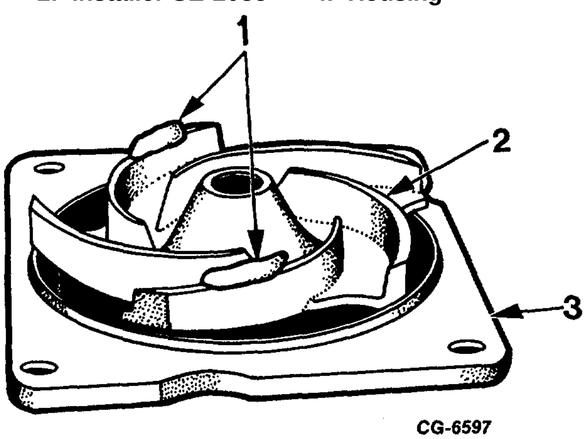


Fig. 135 Moulding Clay Mounted on Impeller Vanes to Check Impeller Clearance

1. Moulding Clay **3. Housing**
2. Impeller

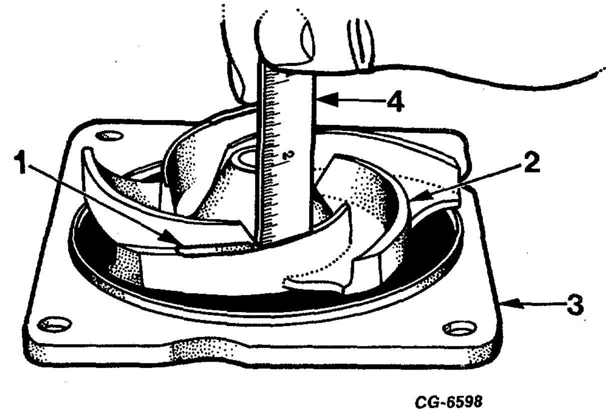


Fig. 136 Measuring Thickness of Moulding Clay to Determine Impeller Clearance

1. Moulding Clay **3. Housing**
2. Impeller **4. Scale**

FAN MOUNTING

The fan mounting assembly consists of; fan mounting body, bearing and shaft assembly, snap ring and drive hub (Figure 137).

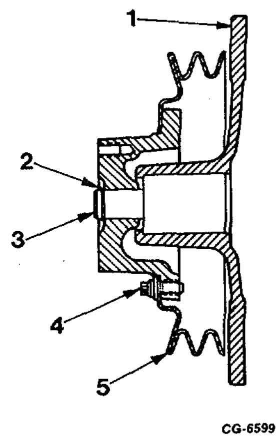


Fig. 137 Fan Mounting Section View

1. Fan Mounting Body **4. Pulley to Hub Mounting Bolt**
2. Snap Ring
3. Bearing and Shaft **5. Pulley Assembly**

Fan mounting bearing must be replaced if looseness or wobble is indicated.

Drive hub and bearing removal:

1. Remove drive pulley mounting bolts and remove pulley.
2. Remove snap ring from shaft.
3. Using remover adapter tool press hub from shaft (Figure 138).

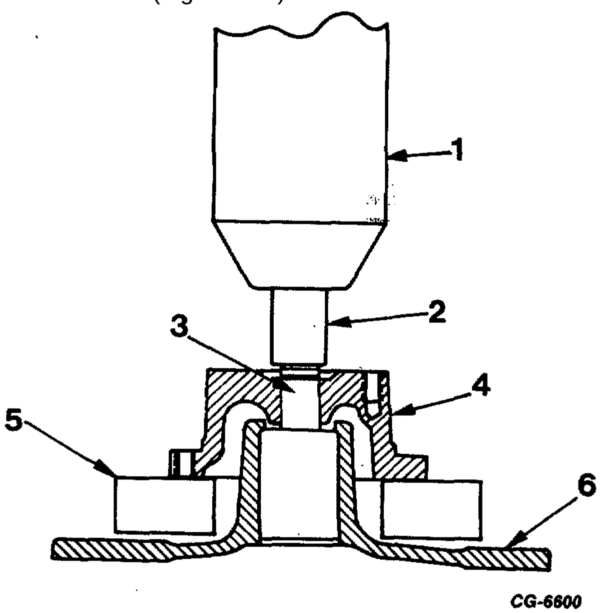


Fig. 138 Fan Mounting Drive Hub Removal

1. Press Ram	**4. Drive Hub**
2. Remover Adapter	**5. Support Block**
3. Bearing and Shaft	**6. Fan Mounting Body Assembly**

4. Using remover adapter tool, press bearing and shaft assembly from fan mounting body (Figure 139).

Drive hub and bearing installation:

1. Press new bearing and shaft assembly in fan mounting body.
2. Apply Locquic Primer T and Loctite AA to hub and bearing shaft.
3. Press on drive hub.
4. Reinstall snap ring.

Idler Pulley

Check idler pulley bearing for looseness (wear) or rough operation.

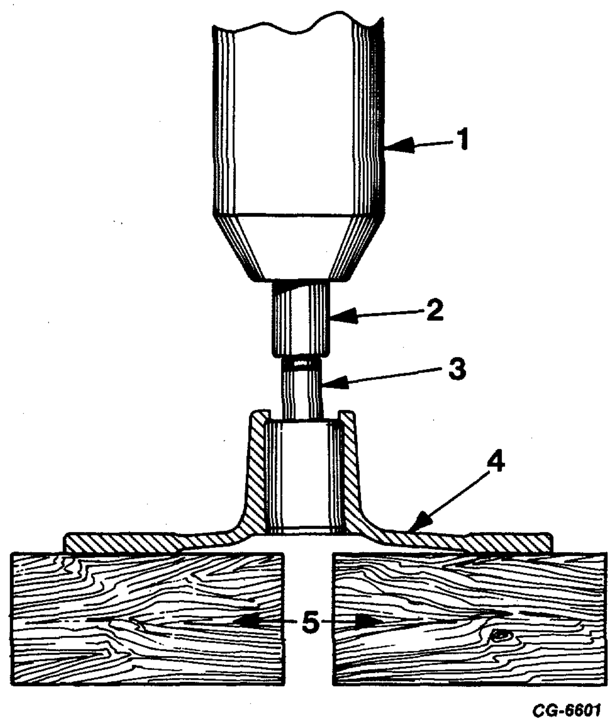


Fig. 139 Removing Bearing and Shaft Assembly

1. Press Ram	**4. Fan Mounting Body**
2. Remover Adapter	**5. Support Blocks**
3. Bearing and Shaft Assembly	

Check idler arm support bushing for looseness (wear).

If necessary, replace pulley bearing and/or support bushing (Figure 140) as outlined below.

Pulley Bearing Replacement:

1. Remove nut from idler bearing shaft.
2. Remove idler pulley and shaft from idler arm.
3. Remove bearing shields and shaft from idler pulley bearing and remove two snap rings (one each side of bearings).
4. Using remover tool SE-1955-8 with a flat washer 15.875 mm (5/8"), I.D. x 23.813 mm (15/16") O.D. x 2.381 mm (3/32") thick, press bearing from pulley.
5. Clean pulley carefully. Inspect for cracks or other damage. Replace pulley if damaged.

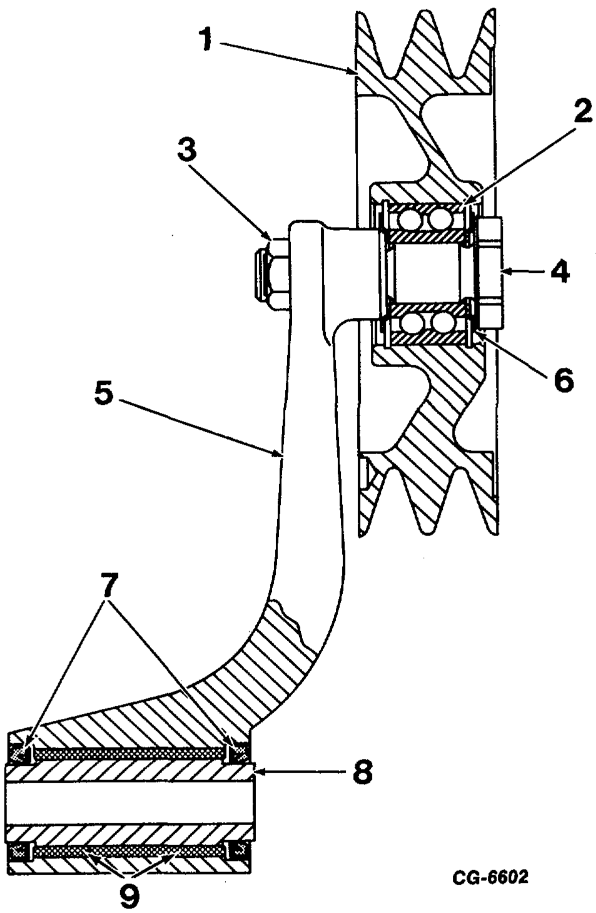


Fig. 140 Sectional View of Idler Pulley Assembly

1. Pulley
2. Bearing
3. Nut
4. Bolt
5. Idler Arm
6. Shield
7. Seals
8. Spacer
9. Bushing

6. Install one snap ring in bore of pulley. Make certain snap ring is seated securely. Support pulley on a press plate, then press new bearing into pulley bore until bearing seats against snap ring.

IMPORTANT

Use care not to press bearing assembly. Press on bearing outer race to prevent damage to bearing.

After bearing is pressed into place, install other snap ring. The new bearing is pre-lubricated and requires no further attention.

7. Place one bearing shield on shaft and insert shaft into bearing. Install other shield on opposite side of bearing.

8. Thread bearing shaft into idler arm and install nut on shaft and tighten securely.

Support Bushing Replacement:

1. Press spacer from idler arm using remover tool SE-1722.

2. Remove both seals from idler arm using remover SE-1746 and slide hammer.

3. With the use of remover tool SE-10361, remove bushing from idler arm.

4. Using installer tool SE-1946-1, press new bushing into idler arm bore until it is just flush with edge of bore.

5. Place new seal in one counterbore of idler arm with lip of seal facing inward. Using 13/16" socket, press seal in until it bottoms in counterbore. Do not damage seal.

6. Install spacer in idler arm bushing.

7. Turn idler arm over and install opposite seal per Step 5.

ENGINE REASSEMBLY

NOTE: Throughout the engine assembly procedures outlined below, instructions are given for prelubricating bearings and other running parts with engine oil. This is important to assure initial lubrication of these parts when engine is started. If engine is to be stored before installation in a vehicle, it is recommended that these parts be prelubricated with a coat of waterproof grease (Lubriplate 630AA or equivalent). The grease will not drain off parts during storage, will prevent rusting and provide initial lubrication.

1. Mount cylinder block in engine stand. Rotate engine stand so that bottom of cylinder block faces upward.

2. Install cylinder block drain plugs (or drain cocks) and tighten securely.

3. Wipe main bearing bores of cylinder block and main bearing caps to remove any dirt or dust. Make sure main bearing inserts are clean.

4. Lubricate upper (block) half of each bearing insert on both sides with clean engine oil and place in position in bearing bore of block. Make sure that bearing inserts are fully seated with oil holes in inserts aligned with oil passages in block and that locking tangs are engaged. Following the same procedure, place lower half of bearing inserts in bearing caps.

5. Wipe crankshaft main bearing journals. Lower crankshaft into place in cylinder block bearing inserts.

6. Place bearing caps (with inserts) over crankshaft journals, making sure number on cap is toward right side of engine. Install new self-locking cap bolts and flat washers.

   NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with clean engine oil.

7. Tighten bearing cap bolts snugly (not to specified torque). Using a soft hammer, tap each bearing cap until rear machined face of cap is flush with machined face of cylinder block on both sides of crankshaft. Alignment of these machined faces assures proper cap location.

   Tighten bearing cap bolts to specified torque (see TORQUE CHART).

8. Install bearing cap tie bolts and special washers and tighten to specified torque. (See TORQUE CHART).

   NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with clean engine oil.

9. Using dial indicator check crankshaft end play (Figure 61).

10. If rear oil seal wear sleeve was removed from crankshaft at engine disassembly, install new wear sleeve as follows:

    a. Install aligner studs SE-2092-3 into end of crankshaft flange (Figure 141).

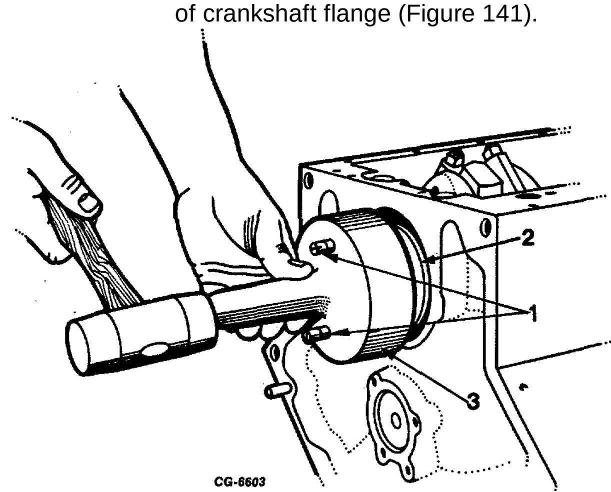


Fig. 141 Installing Oil Seal Wear Sleeve

1. Aligner Studs 3. Installer
2. Wear Sleeve

    b. Coat crankshaft flange with engine oil. Position wear sleeve on crankshaft flange with large chamfer toward rear of crankshaft.

    c. Position installer tool SE-2092-1 over aligner studs (Figure 141) and drive wear sleeve onto crankshaft flange until installer tool seats against crankcase. This will correctly locate wear sleeve (Figure 139).

d. Remove installer tool and aligner studs.

11. Install rear oil seal as follows:

a. Install aligner studs SE-2092-3 into end of crankshaft flange (Figure 142).

b. Lubricate crankshaft flange and wear sleeve and seal bore of crankcase and bearing cap with engine oil.

c. Place new oil seal over crankshaft flange, aligning seal with crankcase bore.

d. Position installer tool SE-2092-1 over aligner studs (Figure 140) and drive oil seal into crankcase as follows:

(1) Where a new seal is being installed against a new wear sleeve, place seal flush with rear of crankcase (Figure 143).

(2) Where a new seal is being installed against a used wear sleeve, recess seal into crankcase bore (Figure 143) to allow lip of seal to ride upon unworn surface of wear sleeve. (If wear sleeve shows more than one wear path, replace wear sleeve.)

e. Remove installer tool and aligner studs.

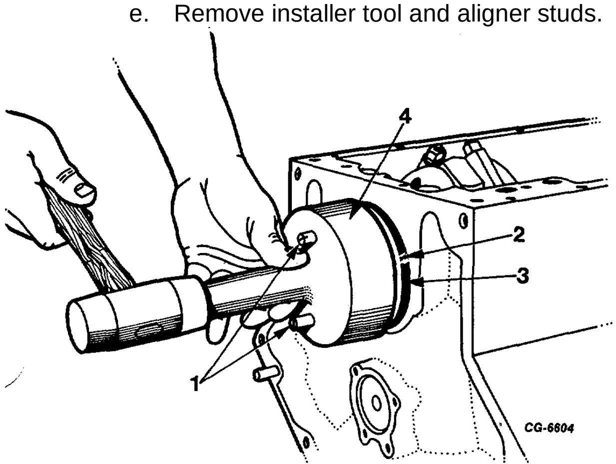


Fig. 142 Installing Rear Oil Seal

1. Aligner Studs
2. Wear Sleeve
3. Rear Oil Seal
4. Installer

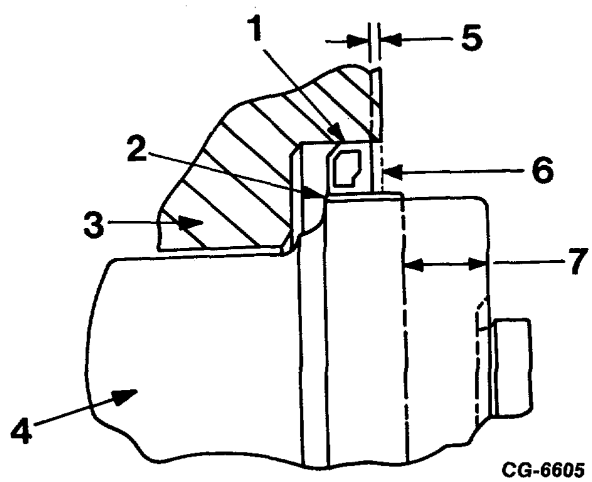


Fig. 143. Sectional View Showing Proper Location of Wear Sleeve and Rear Oil Seal

1. Seal
2. Wear Sleeve
3. Crankcase
4. Crankshaft
5. 2.15mm (.085") with used Wear Sleeve Recess Seal to this Dimension
6. With New Wear Sleeve Install Seal Flush with end of Crankcase.
7. 16.65mm (.656") Wear Sleeve to this Dimension.

Install rear main bearing cap side oil seals (Figure 144). Use an installer made from 3.18 mm (1/8") welding rod. To make tool, puddle a ball on end of rod and file ball to approximately 3.97 mm (5/32") diameter. Lubricate seals with a light coat of engine oil.

13. Position gear key in keyway of crankshaft. Lubricate inside diameter of crankshaft gear with a commercial press-fit lubricant. Install crankshaft gear using installer tool set SE-1900 (Figure 145).

14. Position camshaft thrust plate on camshaft. Position gear key in keyway of camshaft. Lubricate inside diameter of camshaft gear with press-fit lubricant and press gear on camshaft.

15. Install camshaft (with gear and spacer) as follows:

a. Install installer tool SE-1880 on threads of camshaft (Figure 58).

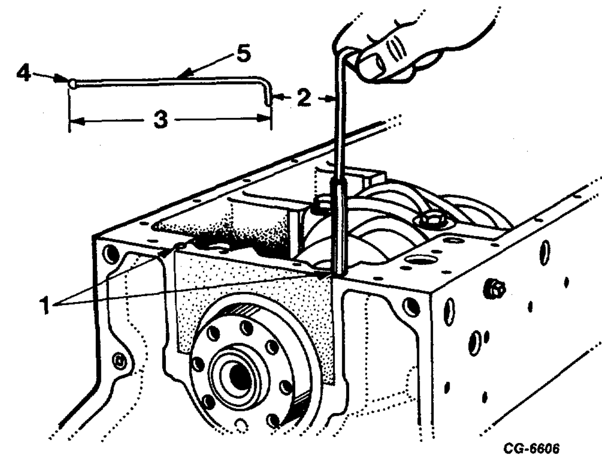


Fig. 144 Installing Rear Main Bearing Cap Side Oil Seals

1. Bearing Cap Side Seals
2. Installer Tool
3. 203.2 mm (8")
4. 3.9687 mm (5/32") Diameter
5. 3.1750 mm (1/8") Welding Rod Long

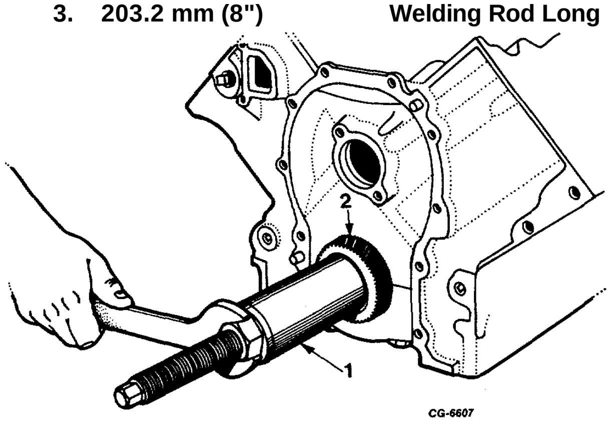


Fig. 145 Installing Crankshaft Gear

1. Installer **2. Crankshaft Gear**

b. Coat camshaft lobes, bearing surfaces camshaft bushings and camshaft gear teeth with heavy duty hypoid axle lubricant.

c. Insert camshaft (with gear and spacer into cylinder block (Figure 58).

d. Align timing marks on camshaft gear and crankshaft gear (Figure 146) and position camshaft into camshaft bushings. Remove installer tool.

e. Install camshaft thrust flange bolts (Figure 57) and tighten to specified torque. (See TORQUE CHART).

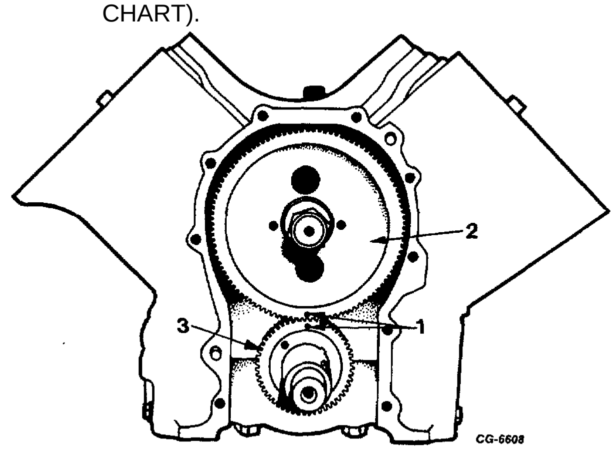


Fig. 146 Aligning Timing Marks on Camshaft and Crankshaft Gears

1. Timing Marks **3. Crankshaft Gear**
2. Camshaft Gear

f. Install camshaft gear nut and tighten to specified torque. (See TORQUE CHART)

g. Rotate crankshaft and camshaft to see that gears do not bind or interfere. Using dial indicator, check camshaft end play (Figure 55) and camshaft gear-to-crankshaft gear backlash.

IMPORTANT

Where desired, camshaft, thrust plate and camshaft gear can be installed individually. Using installer tool SE-1880, install camshaft in cylinder block (Figure 60). Install camshaft thrust flange and tighten bolts to specified torque. Using SE-1900 installer and SE-1900-2 adapter, install camshaft gear on camshaft (Figure 147).

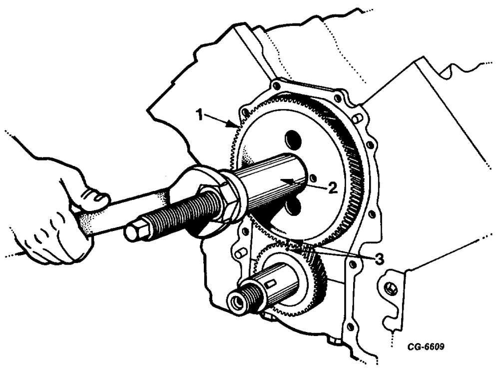


Fig. 147 Installing Camshaft Gear

1. Camshaft Gear 3. Timing Marks
2. Installer

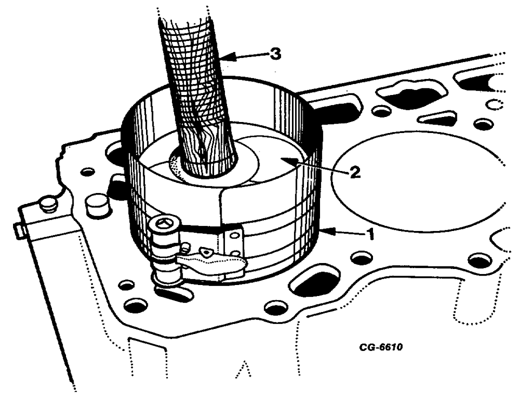


Fig. 148 Installing Piston and Connecting Rod Assembly

1. Ring Compressor 3. Hammer Handle
2. Piston

16. Install piston and connecting rod assemblies as follows:

   a. Turn cylinder block to vertical position with front end facing upward. Turn No. 1 crankpin to the top of its stroke.

   b. Coat No. 1 piston and piston rings with clean engine oil and install piston ring compressor on piston.

   c. Coat No. 1 cylinder bore with clean engine oil. Position piston and rod assembly in cylinder bore with word "TOP" marked on piston toward centerline of engine block. Carefully push piston and rod assembly through ring compressor (Figure 148) until piston is in cylinder bore. <u>Avoid striking cylinder bore with connecting rod</u>.

   d. Coat crankshaft journal and connecting rod bearings with clean engine oil. Pull connecting rod down onto crankshaft journal. Install connecting rod cap to rod with marked sides matching.

   e. Install new bearing cap bolts, nuts and flat washers. Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil and install bolts.

IMPORTANT

When installed properly, the large chamfered side of the rod and cap will be on the fillet side of the crankpin (Figure 103). Tighten bolts to specified torque shown in TORQUE CHART, then release torque load to zero and retighten to specified torque. After bolts have been torqued, turn each nut an additional one-sixth turn or one flat of the nut.

   f. Install remaining piston and connecting rod assemblies in the same manner.

   g. Recheck connecting rod end play.

17. Position oil pump in cylinder block and check for correct alignment. Pump shaft should rotate freely without binding (Figure 147).

18. Rotate cylinder block to horizontal position with top of block facing upward. Place flywheel housing in position over two aligning roll pins and tap into cap-screws (with flat washers) and tighten in sequence shown in Figure 150.

IMPORTANT

The two lower mounting bolts should be wrapped with two turns of Teflon thread tape to prevent oil leakage.

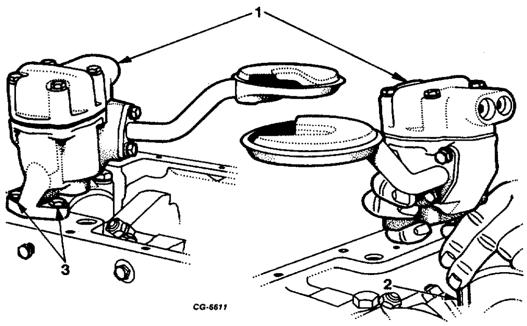


Fig. 149 Installing Oil Pump

1. Oil Pump
2. Checking Oil Pump Shaft Alignment to Block
3. Oil Pump Mounting Bolts

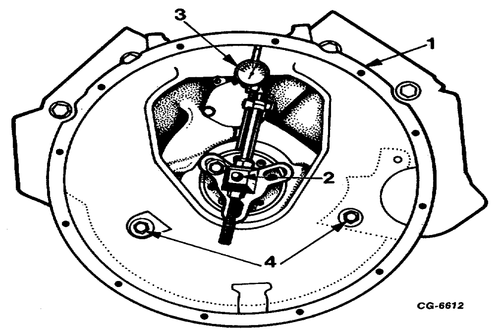


Fig. 150 Checking Flywheel Housing Alignment

1. Flywheel Housing
2. Aligner
3. Dial Indicator
4. Wrap Bolt Thread

19. Using aligner tool SE-1834 and dial indicator, check flywheel housing alignment (Figure 150). Run-out (out-of-round) should not exceed specified limits. (See SPECIFICATIONS.)

IMPORTANT

If flywheel housing alignment out-of-round exceeds specified limit or if either flywheel housing or crankcase is being replaced remove roll pins, align flywheel housing with dial indicator and ream roll pin holes with standard tapered reamer, 12.7 mm (% inch) to accommodate oversize roll pins (Figure 150).

If possible, align flywheel housing while engine is in engine stand with cylinder block in vertical position (Flywheel housing facing up).

20. Position flywheel (with ring gear) on roll pin in crankshaft flange. Install flywheel mounting bolts in flywheel mounting bolts in flywheel and crankshaft flange and tighten to specified torque. (See TORQUE CHART)

21. Coat the O.D. of the clutch pilot bearing and I.D. of flywheel bore with Loctite grade B. Then install clutch pilot bearing into the flywheel. Do not allow Loctite to contact inside of bearing or between flywheel and crankshaft.

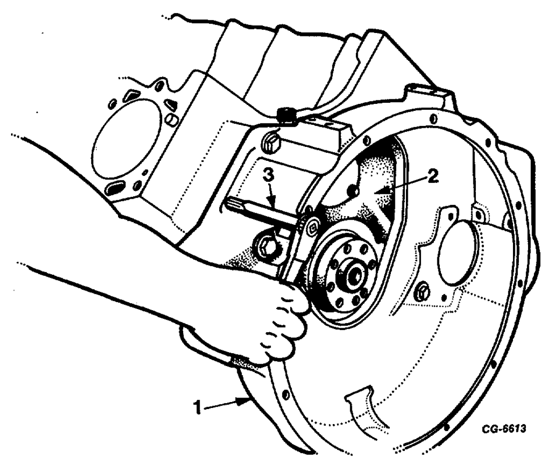


Fig. 151 Reaming Flywheel Housing-to-Crankcase Roll Pin Holes

1. Flywheel Housing
2. Crankcase
3. Reamer

22. Install clutch assembly on engine flywheel.

Clutch installation procedures vary between clutch types. With clutch assembly shown in Figure 152 proceed as follows:

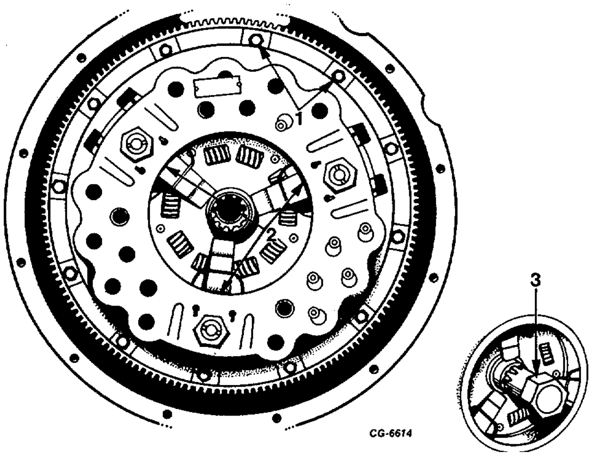


Fig. 152 Clutch Installation

1. Cover Retaining Bolts **3. Aligning Tool**
2. Spacer Block

a. Position clutch driven disc against flywheel so that long portion of hub is toward the rear. Place clutch in position on flywheel over clutch driven disc. Locate arrow or inspection mark (usually a dab of white paint) on flange of clutch backing plate or cover as near as possible to letter "L" on flywheel and install two or three mounting bolts and lockwashers loosely.

b. Insert a clutch aligning arbor or a transmission main drive gear shaft through clutch driven disc hub splines and into clutch pilot bearing. Hold clutch driven disc in position and install remaining mounting bolts and lockwashers in the flange of clutch backing plate or cover.

c. Tighten all bolts alternately, evenly and securely. Remove three retaining bolts and flat washers, retaining clips or wood blocks which were installed to hold clutch compressed.

IMPORTANT

The clutch will not operate properly unless retaining bolts, clips or wood spacer blocks are removed.

23. Position a new front cover gasket over dowel pins in crankcase. Install engine front cover (Figure 54).

24. Install front cover oil seal as follows!

a. Position front cover oil seal on tool pilot (small diameter) of SE-2096 installer with wiping lip of seal toward outer end of pilot.

b. Lubricate seal bore of front cover with engine oil.

c. Place installer over end of crankshaft and drive seal into cover (Figure 153). Seal is properly located when inner shoulder on tool contacts machined surface of front cover.

IMPORTANT
Tool can also be used to install oil seal where cover is removed from engine by placing front cover in a press and press seal in until flange of tool contacts machined surface on front cover.

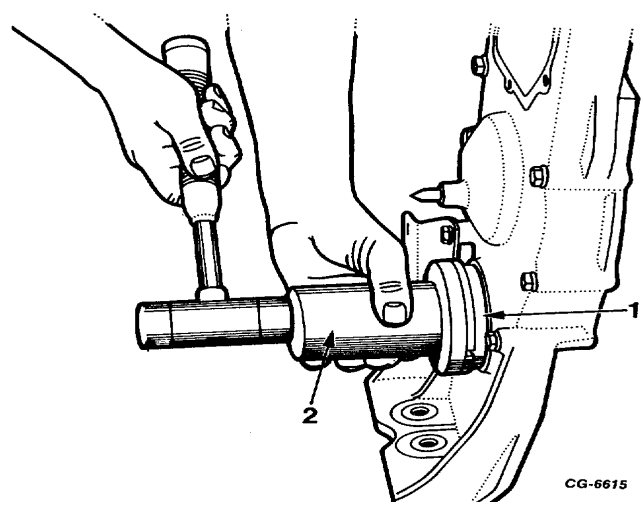


Fig. 153 Installing Engine Front Cover Oil Seal

1. Oil Seal **2. Installer Tool SE-2096**

25. If front oil seal wear sleeve was removed from crankshaft pulley at engine disassembly, install new wear sleeve as follows:

a. Coat crankshaft pulley hub with a non-hardening sealer. Position pulley on press bed.

b. Heat wear sleeve in boiling water and position on pulley hub. Using handle and 7.3 cm (2-7/8 inch) diameter adapter from SE-1905 tool set, press wear sleeve onto pulley hub until flush with end of hub (Figure 154).

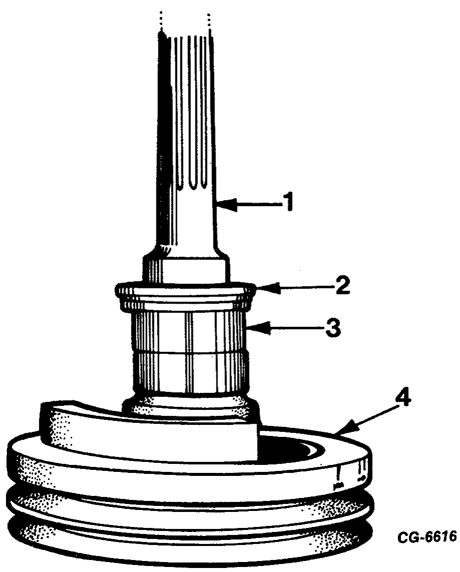


Fig. 154 Installing Front Oil Seal Wear Sleeve

1. Handle 3. Wear Sleeve
2. Adapter 4. Crankshaft Pulley

26. Position pulley key in keyway of crankshaft. Lubricate inside diameter of crankshaft pulley with press-fit lubricant. Install crankshaft pulley using installer tool SE-1900 (Figure 155). Install crankshaft pulley nut and flat washer. Tighten pulley nut to specified torque. (See TORQUE CHART).

IMPORTANT

Wear sleeve surface on crankshaft damper should be lubricated with clear engine oil to prevent seal damage.

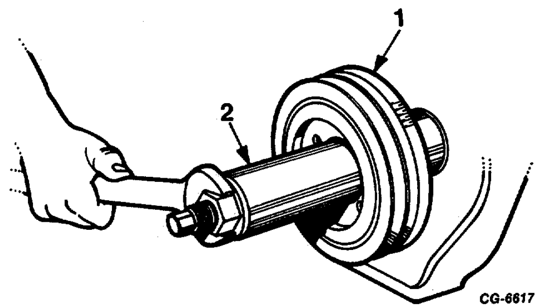


Fig. 155 Installing Crankshaft Pulley

1. Crankshaft Pulley 2. Installer SE-1900

27. Turn engine with oil pan mounting surface up. Position new gasket on crankcase and install oil pan.

28. Position new tappet cover gasket on crankcase and attach tappet cover. (Figure 50).

29. Install tappets using installer tool SE-2097 (Figure 49).

30. Install cylinder heads as follows:

a. Position new cylinder head gaskets over the aligning dowel sleeves of each cylinder bank. Make sure all bolt holes in gaskets align with holes in crankcase.

b. Using lifting sling SE-1896, place one cylinder head in the proper cylinder bank. Align head with dowel sleeves in crankcase. Loosely install all cylinder head bolts (Figure 48).

IMPORTANT

Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil.

Repeat these operations to install opposite cylinder head.

c. Following sequence shown in (Figure 156) tighten cylinder head bolts evenly to specified torque. (See TORQUE CHART).

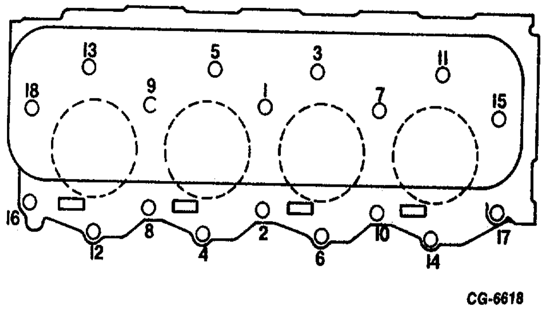


Fig. 156 Cylinder Head Bolt Tightening Sequence

31. Place new extension gasket on each cylinder head and install extension. (Figure 44)

32. Insert valve lifter push rods in their respective positions.

33. Position a valve cap (Figure 47) on each valve stem.

Install rocker arm assemblies as follows:

a. Loosen rocker adjusting screw locknuts and back off adjusting screws.

b. Position rocker arm assembly on extension, making sure rocker arms align with valve stems and rocker arm shaft spacer split is facing center extension mounting bolts. After torquing bolts make sure spacers have free movement.

c. Making sure there is no interference between rocker arms and push rods, tighten rocker arm support bolts to specified torque (see TORQUE CHART).

d. Position push rods under rocker arm adjusting screws and tighten screws until they just touch push rods with corresponding piston on compression stroke. It will be necessary to rotate the engine to accomplish this on all cylinder.

34. Adjust rocker arm to valve tip (tappet) clearance as follows:

a. Rotate engine in operating direction until No. 1 intake valve just starts to open. Then adjust intake and exhaust valves on No. 6 cylinder to specified clearance (See SPECIFICATIONS).

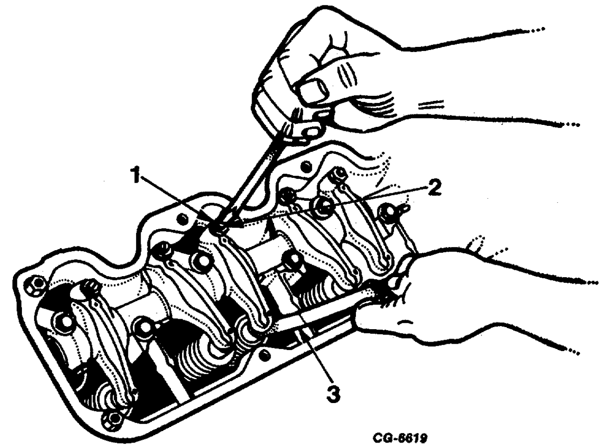


Fig. 157 Valve Adjustment

1. Adjusting Screw Lock Nut
2. Adjusting Screw
3. Feeler Gauge

b. Adjust remaining valves by rotating engine through firing order With No. 8 intake just opening, adjust valves on No. 5 cylinder; No. 7 intake just opening, adjust valves No. 4 cylinder; No. 3 intake just opening, adjust valves on No. 2 cylinder; No. 6 intake just opening, adjust valves on No. 1 cylinder; No. 5 intake just opening, adjust valves on No. 8 cylinder; No. 4 intake just opening, adjust valves on No. 7 cylinder, and No. 2 intake just opening, adjust valves on No. 3 cylinder.

35. Position rocker arm cover gasket on each extension and attach cover.

36. Install injection nozzles as follows:

a. Install injection nozzle washer, dirt seal and tip gasket on injector assembly. Use new gasket every time injector nozzle is removed.

b. Install nozzle assembly carefully into its bore so that nozzle tip does not strike against recess wall. (Leak-off tube to be positioned toward intake manifold). Install clamp, mounting bolt and attach leak-off lines to leak-off manifold (Figures 39 and 45).

37. Install injection pump mounting brackets to injection pump (Figure 41).

38. Position mounting gasket on injection pump adaptor and mount injection pump to front engine cover.

IMPORTANT

Use only 9.53 mm x 25.4 mm (3/8 x 1"). Patch bolts for mounting injection pump to front engine cover (Figure 42).

39. Secure injection pump mounting brackets to crankcase (Figure 42).

40. Position right cylinder bank intake manifold and gasket. Place mounting bolt through leak-off manifold mounting clip and intake manifold (Figure 39). Tighten bolts.

41. Connect primary filter output line to input side of transfer pump (Figure 41).

42. Connect fuel line to output side of transfer pump (line leading to primer pump) (Figure 41).

43. Connect fuel line from final filter to injection pump (Figure 41).

44. Connect oil line from oil feed line tee to injection pump (Figure 41).

45. Position left cylinder bank intake manifold and gasket. Place mounting bolt through leak-off manifold mounting clip and intake manifold (Figures 39 and 40). Tighten bolts.

46. Connect leak-off return hose (both banks) from leak-off manifold to valve on injection pump (Figure 39).

47. Install intake manifold crossover and gasket (Figure 38).

48. Connect ventilator hose (both banks) to intake manifold crossover and rocker arm covers (Figure 37).

49. Install fuel injection lines from injection pump to injection nozzles (Figure 37). Torque line nuts to specifications.

50. Install oil filter and cooler base as follows:

    a. Insert two bolts in each end of base and in the middle of base.

    b. Position gasket against base and just start threads of bolts in gasket.

    c. Place base with gasket against crankcase and start bolts.

    d. Install remaining bolts and tighten all alternately and evenly.

51. Position new oil cooler gaskets on oil cooler base and install cooler (Figure 35).

52. Install oil cooler water inlet and return lines (Figure 35).

53. Install oil pressure sender unit to oil filter base.

54. Connect oil feed line from oil filter base to tee at injection pump.

55. Install exhaust manifold and gasket to cylinder head and torque mounting bolts to specifications (Figure 34).

56. If injection pump drive gear hub was removed during disassembly, it must be installed, and the pump timed:

    a. Install injection pump drive gear hub, by aligning keyway in hub with key on pump shaft, slide hub on shaft and install retaining nut (Figure 31).

    b. Remove sight plug on top of adaptor. Rotate drive gear hub until scribed line on hub is aligned with pointer pin (Figure 158).

    c. Rotate engine until piston is at TDC of compression stroke and the engine timing pointer is aligned with the 16 degree mark on the crankshaft pulley. (Figure 158).

    d. Using care not to move drive gear hub, install drive gear on hub (Figure 30). Recheck hub scribed line and pointer pin alignment (Figure 158).

    The scribed line on injection pump camshaft should be at Eleven O'clock as shown.

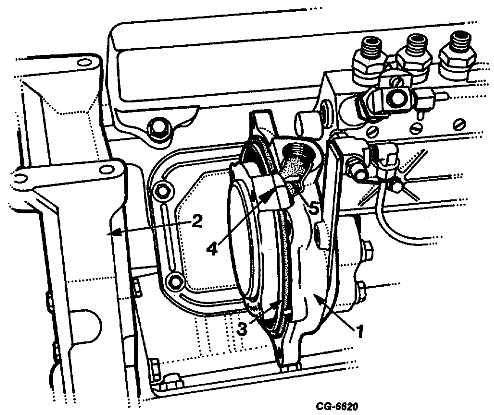


Fig. 158 Timing Injection Pump to Engine

1. **Injection Pump Adapter**
2. **Engine Front Cover**
3. **Gasket**
4. **Scribed Line On Hub**
5. **Pointer Pin**

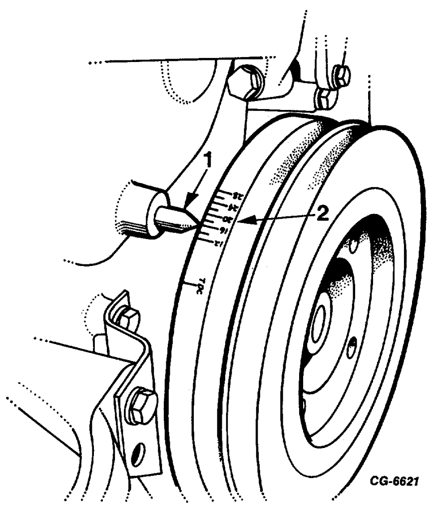


Fig. 159 Engine Timing Marks and Pointer Location

1. **Index Pointer**
2. **Timing Marks**

57. Attach injection pump drive gear cover to engine front cover (Figure 29).

58. Coat oil level dipstick tube with John Crane Co. Plastic Lead Seal No. 2 before installing in crankcase (Figure 29).

59. Place new "0" rings on water return tube, place tube in water pump housing as shown in Figure 28. Place the five mounting bolts in housing, position a service gasket over the two lower bolts and install water pump housing (Figure 28). Connect oil cooler water return pipe.

60. Position proper gasket on water manifold and attach manifold to crankcase and water pump housing (Figure 27).

61. Place new "O" rings on water return tube. Place end of tube in water outlet housing and the other end in the water pump housing, attach water outlet housing to cylinder head (Figure 26).

62. Position new gasket on water pump housing and install water pump assembly (Figure 25).

63. Place rear pulley, spacer and front pulley on water pump hub. Secure with four mounting bolts (Figure 24).

64. Install accessory mounting channel (Figure 23).

65. Install fan hub assembly as shown in Figure 23.

66. Install primer pump and filter mounting bracket assembly (Figure 21), and connect fuel lines (Figure 8).

67. Install idler pulley arm and spring (Figure 33).

68 . Push idler pulley toward center of engine and install main drive belts (Figure 21).

69. Install modulated fan drive and fan assembly to fan pulley hub (Figure 20). Secure with four mounting bolts and lockwashers.

70. Install power steering pump and mounting bracket assembly (Figure 19).

71. Install freon compressor and mounting bracket assembly on accessory channel (Figure 18).

72. Install alternator mounting bracket to accessory channel and mount alternator to bracket (Figure 17).

73. If air compressor was removed from it's mounting bracket, replace mounting gasket and mount air compressor to bracket. Mount bracket to cylinder head (Figure 16).

74. Connect water supply hose, water return hose and oil supply pipe to air compressor (Figure 16).

75. Install accessory drive belts: Power steering pump is driven from front pulley of water pump.

    Alternator is driven from rear pulley of air compressor.

    Air compressor and freon compressor are driven from front fan pulley.

76. Adjust accessory drive belts (Figures 6 and 7).

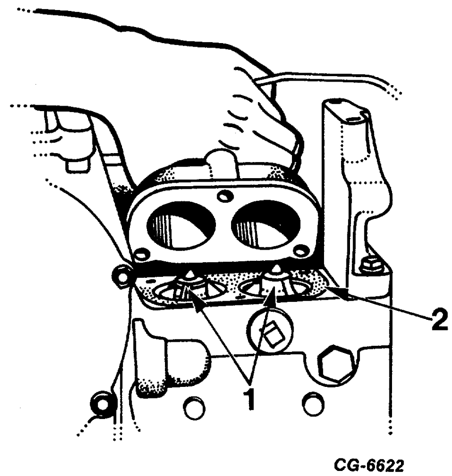
77. Check or install new thermostats (Figure 160).

Since a low operating temperature will result in loss of power and economy, only specified temperature range thermostats should be used. The thermostats should not be removed in an attempt to lower operating temperature.

Thermostat operation should be checked at the time of engine overhaul or whenever faulty operation is suspected.

To check operation, place thermostat in a pan of water, heat water, and using an accurate thermometer, observe water temperature when thermostat starts to open. Thermostat should start to open at approximately 82 degrees C (180 degrees F). Replace thermostat if defective.

When installing, position thermostats correctly in housing per instructions stamped on thermostat. Make sure thermostats are seated in housing. Use new thermostat housing gasket.



1. Thermostats **2. Gaskets**

78. Install new fuel filters (figure 161).

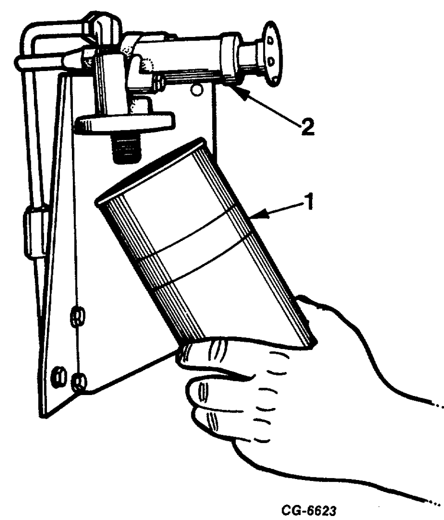


Fig. 161 Fuel Filter Installation

1. Fuel Filter **2. Primer Pump**

79. Install new oil filters and fill crankcase with proper type and quantity of oil (See oil chart).

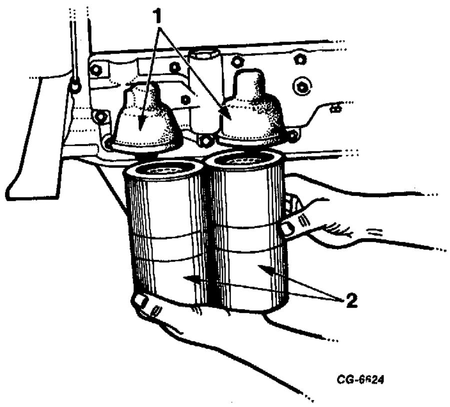


Fig. 162 Oil Filter Installation
1. Oil filter base **2. Oil filter**

80. Install engine lifting sling and connect hoist to lifting sling.

81. With hoist connected to lifting sling remove engine from overhaul stand.

82. Install right exhaust manifold, starter heat shield and starting motor (Figure 12).

83. Prime lubricating system:

When assembling the engine during overhaul it is important to prelubricate the running parts with clean engine oil to assure initial lubrication when the engine is first started.

To further assure complete initial lubrication, the engine lubricating system should be pressure primed or charged with oil. Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation which could lead to immediate or low mileage failure.

Priming can be accomplished by using the SE-1632 Oil Leak Detector as follows:

a. Using adapter fittings, connect oil line from oil leak detector to engine oil gallery.

b. Following manufacturer's instructions, fill and charge oil leak detector.

c. Inject sufficient oil into engine oil gallery to fill oil filters and charge entire system.

d. Disconnect oil leak detector.

After priming, check engine oil level and adjust (fill or drain) as needed before starting engine.

New or overhauled engines which have been in storage should be primed as outlined above, at installation.

ENGINE INSTALLATION

Engine installation procedures will differ between vehicle models. The general instructions outlined below apply to most cases.

1. Position and align engine in chassis.

2. Connect engine to bell housing and connect front and rear engine mountings.

3. Remove transmission support (where used) and remove lifting sling from engine.

4. Connect:

   Accelerate and throttle linkage.

   Alternator, temperature sender and oil pressure sender wiring.

   Air compressor piping (where equipped.

   Exhaust pipes to manifolds.

   Fuel inlet and return lines.

   Heater hoses and brackets.

   Surge tank hoses (where equipped).

   Tachometer cable.

5. Install air cleaner adapter or manifold crossover, and air cleaner piping.

6. Connect power steering hoses to power steering pump (where equipped).

7. Install transmission shift lever island and shift rod bearing support (CO models).

8. Install radiator core assembly and radiator support.

9. Install air conditioning system components (where equipped).

10. Install radiator hoses and shutter control hoses (where used).

11. Prime engine lubricating system. (See PRIMING LUBRICATING SYSTEM.)

12. Fill engine with engine oil.

13. Fill engine cooling system with coolant.

14. Fill power steering system (where equipped).

15. Connect battery cables.

16. Prime fuel system (Refer to Fuel System Section CGES-225.

17. Operate engine. Check for oil and coolant leaks. Make necessary engine operation adjustments.

18. Bleed power steering system as needed (where equipped).

19. Check air conditioning system operation and refrigerant level (where equipped). Service and adjust as needed.

20. Reinstall hood and engine tunnel (where used). Lower cab (CO models).

Engine Mountings

Typical front and rear engine mountings are shown in Figures 163 and 164.

The engine front mounting (Figure 163) utilizes a two-piece insulator with retainer. When assembling, position component parts as shown and tighten locknuts 128-142 N-m (95-105 lb. ft.) torque.

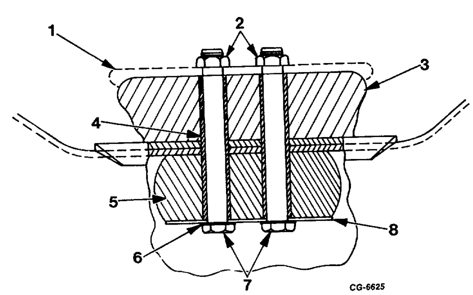


Fig. 163 Engine Front Mounting (Typical)

1. Engine Front Cover	**5. Lower Insulator**
2. Locknut	**6. Flat Washer**
3. Upper Insulator	**7. Bolts**
4. Spacer	**8. Retainer**

The engine rear mounting (Figure 164) utilizes a two-piece insulator with retaining washers. When assembling, position component parts as shown and tighten locknut 128-142 N-m (95-105 lb. ft.) torque. The engine mounting bracket-to-flywheel housing bolts should be tightened to 203 N-m (150 lb. ft.) torque.

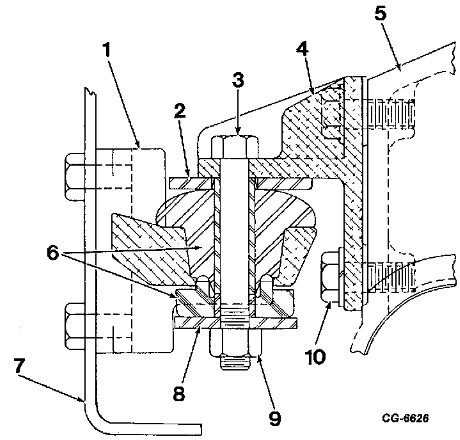


Fig. 164 Engine Rear Mounting (Typical)

1. Bracket	**6. Insulators**
2. Washer	**7. Frame Rail**
3. Bolt	**8. Washer**
4. Bracket	**9. Nut**
5. Flywheel Housing	**10. Bolt**

CRANKCASE OIL SPECIFICATIONS CHART

-70C to 49°C (20°F to 120°F)	-180C to 320C (0OF to 90OF)	-180C (Below 0OF)
SAE 30 (1)	SAE 20 (1)	. . .
SAE 10W-30, 10W-40, 20W-30 (2)	SAE 10W-30, 10W-40 20W-40 (2)	SAE 5W-20, 5W-30 (2)

(1) Single viscosity grade. (2) Multi viscosity grade.

Use engine oils meeting API service classification "IH No. 1 (CD/CC/SE)," "SE," "CC (MIL-L-46152)" or "CD (MIL-L-2104C)."

For specific information on most commercial oil brand names, write for the booklet entitled:

"LUBRICATING OIL DATE BOOK FOR HEAVY DUTY AUTOMOTIVE AND INDUSTRIAL ENGINES"

Engine Manufacturers Association
111 East Wacker Drive
Chicago, IL 60601

Use of lubricating oil specified by International Harvester is extremely important to the life of the engine. The recommended oil for 9.0 liter engines, as specified above, results from vigorous testing by IH engineers. Use of specified oil reduces piston ring sticking, piston varnishing and wear of internal engine parts. This oil is also required for compliance with your International Harvester Warranty.

9.0 Liter Crankcase Refill Capacity* 13.2L (12 Qts.) +2L (2 Qts.) with Filter Change

*Engines equipped with auxiliary filtering system require additional oil.

TORQUE CHART

Location	Recommended Torque, Newton-meters	Ft. Lbs.
Main Bearing Cap Bolts	169-183	125-135 (1)
Main Bearing Tie Bolts(1)	54-61	40-45 (1)
Camshaft Thrust Flange	54-61	40-45
Camshaft Gear Nut	271-305	(200-225)
Connecting Rod Cap Bolts	72 (2)	(55) (2)
Piston Cooling Nozzle Bolts	16-20	(12-15)
Flywheel to Crankshaft Bolts	149-156	(110-115)
Injection Pump Gear Bolts	27-34	(20-25)
Crankshaft Pulley Nut	353-393	(260-290)
Injection Pump Drive Shaft Nut	95-108	(70-80)
Cylinder Head Bolts	142-149 (4)	(105-110) (4)
Rocker Arm Support Bolts	42-47	(30-35)
Rocker Arm (Valve) Adj. Nut	24-34	(18-25)
Cylinder Head Cover Screws	5	(3)
Nozzle Hold-down Clamp	19-22	(14-16)
Mtg. Bracket to Injection Pump Bolts	27-34	(20-25)
Injection Line Connectors	21-27	(16-20)
Air Compressor Pulley Nut:		
3/4" Thread Size	54 Min. (3)	(40 Min.) (3)
7/8" Thread Size	68 Min. (3)	(50 Min.) (3)
All Other Fasteners		

Bolt Size	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8
w/Course threads N-m (lb.-ft.)	20 (15)	41 (30)	68 (50)	108 (80)	156 (115)	210 (155)	380 (280)	576 (425)
w/Fine threads	27 (20)	54 (40)	81 (60)	129 (95)	183 (135)	258 (190)	447 (330)	664 (490)

(1) Main bearing cap bolts must be torqued before tightening tie bolts.
(2) Plus an additional one-sixth turn (see text for instructions).
(3) Plus additional tightening to align key slot.
(4) Three steps in proper sequence Step 1 = 68 N-m (50ft-lbs), Step 2 = 122 N-m (90 ft-lbs), Step 3 = final.

Torque specifications based upon clean bolt threads with threads and under heads of bolts lubricated with engine oil. Always use a torque wrench known to be correct l calibrated.

SERVICE TOOL APPLICATION CHART
Cylinder Head

1. Cylinder Head Lifting Sling	SE-1896
2. Cylinder Head Holding Fixture	SE-2104 - Valves at approximately 7 degree angle in head.
3. Valve Spring Compressor	SE-1846
4. Valve Spring Tester	SE-2241
5. Valve Stem Checking Gauge	SE-2614
6. Valve Guide Bore Gauge	SE-1826 (Adjustable Gauge Type) SE-2506 (Sunnen Indicator Type)
7. Valve Guide Cleaner	SE-1300
8. Valve Guide Remover	SE-1722
9. Valve Guide Installer	SE-1943
10 . Valve Seat Insert Peening Tool	SE-2094 Inserts not peened in production.
11. Valve (intake) Seat Insert Remover	SE-1951 Use SE-1951-10 expander screw to extract intake valve seats.
12. Valve Recession Checking Gauge	SE-2515 depth gauge.
13. Valve Seat Counterbore Cutters	SE-1797.
14. Valve Seat Grinder:	
a. Stones	Stones presently included in both ME-1631 and SE-1804 sets requirements as follows: <u>Exhaust Valve Seat (450)</u> SE-1631 = 1-3/4" O.D. x 450 SE-1804 = K-87 rough; K-17 finish <u>Intake Valve Seat (450)</u> SE-1631 = 2-1/8" O.D. x 450 SE-1804 = K-98 rough; K-28 finish.
b. Tapered Pilots	Tapered pilots presently in both SE-1631 and SE-1804 sets requirement for both intake and exhaust valve guides as follows: SE-1631 = 3/8" minus .001", Standard 3/8", 3/8" plus .001", .002", .003" and .004" SE-1804 = T-374, T-375, T-376, T-377, T-378.
15. Reamer, Valve Guide I.D.	SE-2215-Service guide pre-reamed. Use reamer after installation in cylinder to clean up guide bore.
16. Rocker Arm Bushing Remover	Not required-Bushing not used. Arm machined to size.

17. Hydraulic Lifter Remover and	SE-2097-Lifters of the solid mechanical type. Tool has application with cylinder heads removed only.
Camshaft	
1. Bushing Remover and Installer	SE-1897-Adapters SE-1897-3, -4, -5 and -6 applicable.
2. Camshaft Gear Remover	SE-1368-Gear employs two (2) 3/8"-16 UNC (2B) taped holes for applying puller. Use 3-%" long hex bolts with flat washers.
3. Camshaft Gear Installer	SE-1900-Set. SE-1900-2 adapter (1" .20 Thd) will work on external threads of camshaft.
4. Camshaft Remover and Installer	SE-1880
5. Gear Backlash Check	SE-1848
6. Camshaft End Play Check	SE-1848
Crankshaft	
1. Crankshaft Pulley Puller	SE-1368-Pulley employs four (4) 3/8" -16 UNC (2B) tapped holes equally spaced for applying puller.
2. Crankshaft Pulley Installer	SE-1900-Use SE-1900-4 adapter. SE-1900-6 sleeve, SE-1900-8 screw, SE-1900-9 forcing nut and SE-1900-10 thrust washer.
3. Crankshaft Pulley Wear Sleeve Remover	Use small ball peen hammer tapping gently around circumference of wear sleeve to expand sleeve for removal.
4. Crankshaft Pulley Wear Sleeve	SE-1905-Sleeve pressed on pulley flush with end of hub.
5. Crankshaft Gear Remover	SE-1368-Gear includes two (2) 3/8" -16 UNC (2B) tapped holes for applying puller. Also puller set includes suitable pulling arms to pick up at back face of gear.
6. Crankshaft Gear Installer	SE-1900 Use SE-1900-4 adapter to apply installer.
7. Rear Main Bearing Cap Remover	SE-1719-Use SE-1719-3 adapter to apply puller. Also SE-2093 remover used with SE-1746 slide hammer applicable.
8 . Rear Main Bearing Cap Side Seal	Suitable installer tool can be made locally Installer from 1/8" diameter welding rod. Service Manual to include instructions for making locally.
9. Main Bearing Cap Remover	SE-2093-Use with SE-1746 slide hammer puller.
10. Crankshaft Rear Oil Seal Remover	SE-2091
11. Crankshaft Rear Oil Seal Installer-	SE-2092-Production seal installed flush with rear face of crankcase. Service seal installed .085" below crankcase rear face.

12. Crankshaft Rear Oil Seal Wear	Use blunt chisel to mark sleeve several places; Sleeve Remover then tap with flat hammer until sleeve expands sufficiently to be removed. Service Manual to include instructions.
13. Crankshaft Rear Oil Seal Wear Sleeve Installer	SE-2092
14. Crankshaft End Play	SE-1848
15. Clutch Pilot Bearing Remover	SE-1746
Piston and Connecting Rods	
1. Piston Pin Retaining Ring Remover	SE-1884-Snap Ring Pliers.
2. Piston Pin Bushing Remover and Installer.	SE-2417-Used with SE-1033 support plate.
3. Piston Pin Bushing Burnisher	SE-2218-Sunnen Hone Service bushing requires burnishing .001" to .003" on diameter after installation in connecting rod. Use AL-1400 Expansion Manual to burnishing bushing.
4. Piston Pin Bushing Reamer	SE-2218 Sunnen Hone Service bushing requires sizing after installation in connecting rod. Use SL-1500 mandrel and ST-1500 truing sleeve for sizing bushing to 1.5009 1.5011".
5. Piston Ring Expander	Standard automotive expander available locally applicable.
6. Piston Ring Compressor	SE-1610
7. Connecting Rod Aligner	SE-1099-Check for bent rods only. Rods incorporate special hardening process called "Tufftride" and rod straightening is not permitted.
8. Connecting Rod Out-of-Roundness Bore Gauge	SE-2331 or AG-300 gauge supplied with SE-2218 Wet Hone.
9. Connecting Rod Side Play Check	Use feeler gauge.
10. Piston Fitting	Use micrometer to measure piston O.D. Measure bore I.D. using SE-2331 or SE-686 bore gauge.
Crankcase	
1. Engine Lifting Eyes	SE-2721-or SE-2722 Load Positioning Sling.
2. Engine Overhaul Stand	SE-1962-Use No. 975 adapter with stand.
3. Cylinder Honing Equipment	SE-784
4. Cylinder Bore Gauge	SE-2331, SE-686
5. Cylinder Boring Equipment	SE-1399
6. Cylinder Glaze Breaker	SE-2314 Silicone Brush Type

7. Front Cover Oil Seal Installer	SE-2096-Production engines have oil seal installed .052" below front face in cover. Service oil seal to be installed .190" below front face in cover.
8. Front Cover Oil Seal Remover	SE-2091
9. Cylinder Compression Indicator	SE-2482 and SE-2482-6 adapter.
10. Clutch Pilot Bearing Remover	SE-1746
11. Bellhousing Aligner Fixture	SE-1834-Used with SE-1848 Dial Indicator
12. Flywheel Housing-to-Crankcase Dowel Reamer	Use standard tapered reamer to size holes for ½" diameter service replacement roll pins.
13. Core Plug Installer	Oval type expansion plugs used. Install plugs with ball peen hammer.
Injector Nozzle and Lines	
1. Nozzle Remover	Suitable adapter can be made locally from line nut for use with SE-1746 slide hammer to extract nozzle assembly from cylinder. Using nut from a discarded high pressure line, drill and tap nut with ½ 13 NC thread to receive slide hammer. Service manual to include instructions for making adapter locally.
2. Wrench, High Pressure Line Nut	Obtain locally. Snap-On AN-8508-11 11/16" crow foot wrench (93/8" drive) or similar wrench.
Engine Timing	
1. Timing Light and Tachometer	SE-2783-Use SE-2783-13 Split Nut Transducer (14mm x 1.5 Thd).

ENGINE SPECIFICATIONS 9.0 LITER DIESEL

Engine	9.0 Liter Diesel	
Number of Cylinders	8	
Bore	114.554 mm	(4.510")
Stroke	109.525 mm	(4.312")
Displacement	9.0 Liter	(551 cu in)
Compression Ratio (w/Piston Top Land Included)	19.1 to 1	
Compression Pressure (at cranking Speed, 200 RPM, Sea Level)	3103-3447 kPa (450-525 psi)	
Firing Order	1 - 8 - 7 - 3 - 6 - 5 - 4 - 2	
Fuel Injection Timing	16° BTDC (Full Load Fuel)	
Gross H.P. @ RPM (SAE J-270)	134.3 KW @2800 (180 BHP @ 2800)	
Net HP (SAE J-270)	126.1 KW @ 2800 (169 BHP @ 2800)	
Gross Torque @ RPM	543.7 N-m @ 1200 (401 Ft-Lb @ 1200)	
Net Torque @ RPM	536.9 N-m @ 1200 (396 Ft-Lb @ 1200)	
Gross HP @ RPM (SAE J-270)	123.1 KW @ 2800 (165 BHP @ 2800)	
Net HP @ RPM (SAE J-270)	114.9 KW @ 2800 (154 BHP @ 2800)	
Gross Torque @ RPM	496.2 N-m @ 1200 (366 Ft-Lb @ 1200)	
Net Torque @ RPM	488.1 Nm @ 1200 (360 Ft-Lb @ 1200)	
Idle Speed (Lo Idle)	625-675 RPM	
Governed Speed (Full Load)	2800 RPM	
Maximum Speed (Hi-Idle, No Load)		
Crankcase Refill Capacity:		
Wet Engine (w/o Filter Service)	11.4 Liters	(12 Qts.)
Drv or Rebuilt Engine	12.3 Liters	(13 Qts.)
Oil Filter Capacity (at filter change, 2 filters total)	1.9 liters	(2 Qts.)
Engine Weight (Bare Engine)	520.5 Kg	(1147.5 Lbs.)
Engine Serial Number Location	Stamped on Top of Crankcase Right Bank, Front Corner	

Camshaft:	
Bearing Journal Diameter	
Front	59.6011 59.6265 mm (2.3465 2.3475")
Second	58.8137 58.8391 mm (2.3155 2.3165")
Third	58.1533 58.1787 mm (2.2895 2.2905")
Fourth	57.0611 57.0865 mm (2.2465 2.2475")
Bearing Clearance	.0381 .0889 mm (.0015 .0035")
Thrust Taken by	Thrust Flange
End Play	.0089 .2921 mm (.0035 .0115")
Timing Gear Backlash	.0127 .1143 mm (.0005 .0045")
Crankshaft:	
Main Journal Diameter	79.324 79.350 mm (3.123 3.124")
Number of Main Bearings	5
Crankpin Diameter	69.926 69.952 mm (2.753 2.754")
Bearing Clearance	.0457 .1219 mm (.0018 .0048")
Crankshaft End Play	.1016 .2540 mm (.004 .010")
Thrust Taken By	Intermediate
Hardening Method	Elotherm (Induction Hardening)
Connecting Rods:	
Bearing Bore Diameter	74.8157 74.8284 mm (2.9455 2.9460")
Allowable Bore Out of Round	.0127 (.0005")
Allowable Bore Taper	.0127 (.0005")
Connecting Rod Bearing Clearance	.0483 .1118 mm (.0019 .0044")
Connecting Rod End Clearance	.2032 .4572 mm (.008 .018")
Bearing Insert Spread Dimensions:	
Main Bearing No. 1, 2, 4, 5,:	
Bearing O.D. Installed	84.226 84.252 mm (3.316 3.317)
Specified Spread	.762 mm Minimum (.030 Minimum)
Spread of Bearing	84.988 Minimum (3.346 Minimum)
Main Bearing No. 3 (Thrust):	
Bearing O.D. Installed	84.226 84.252 mm (3.316 3.317")
Specified Spread	.076 .406 mm (.003 .016")
Spread of Bearing	84.302 84.658 mm (3.319 3.332")

Connecting Rod Bearings:	
Bearing O.D. (Installed)	74.816 72.828 mm (2.9455-2.9460")
Specified Spread	.762 mm Minimum (.030 Minimum)
Spread of Bearing	75.578 mm Minimum (2.9755 Minimum)
Pistons:	
Material	Aluminum Alloy
Clearance in Cylinder Bore	.178 .203 mm (.007-.008")
Weight	1508 Grams (3.325 Lbs.)
Piston Pins:	
Length	82.296 82.550 mm (3.240-3.250")
Diameter	38.095 381 mm (1.4998-1.5000")
Pin Fit: (Room Temperature 700F)	
Clearance in Rod	.023 .033 mm (.0009-.0013")
Clearance in Piston	.005 .015 mm (.0002-.0006")
Piston Rings:	
Ring Diameter	114.55 mm (4.510")
Compression Rings:	
Number Per Piston	2
Size:	
Top	Tapered (Keystone Type)
2nd	2.381 mm (.09375")
Fit in Groove:	
Top	Keystone
2nd	.089-.140 mm (.0035-.0055")
Gap	.330-.584 mm (.013-.023")
Oil Control Rings:	
Number Per Piston	1
Size	4.7625 mm (.1875")
Fit in Groove	.038 .076 mm (.0015-.0030")
Gap	.330 .711 mm (.013-.028")

Intake Valves:	
Valve Lift	11.760 mm (.463")
Stem Diameter	9.4615 - 9.4742 mm (.3725 - .3730")
Clearance in Guide	020 - .058 mm (.0008 - .0023")
Face Angle	45°
Seat Angle	45°
Seat Width	2.032 - 2.286 mm (.080 - .090")
Maximum Allowable Seat Run-Out	051 mm (.002")
Maximum Allowable Face Run-Out	038 mm (.0015")
Seat Insert and Counterbore Data:	
Standard	
Insert O.D.	50.089 - 50.114 mm (1.9720 - 1.9730")
Counterbore Diameter	49.987 - 50.038 mm (1.968 - 1.970")
.05 mm (.002") Oversize	
Insert O.D.	50.114 - 50.140 mm (1.9730 - 1.9740")
Counterbore Diameter	50.038 - 50.089 mm (1.970 - 1.972")
.762 (.030") Oversize	
Insert O.D.	50.851 - 50.876 mm (2.0020 - 2.0030")
Counterbore Diameter	50.749 - 50.800 mm (1.998 - 2.000")
Valve Head Recession in Seat	
Maximum	1.372 mm (.054")
Minimum	.813 mm (.032")
Valve Tip to Rocker Arm Clearance (Hot or Cold)	.305 mm (.012")
Exhaust Valves:	
Valve Lift	12.014 mm (.473")
Stem Diameter	9.449 - 9.462 mm (.3720 - .3725")
Clearance in Guides	033 - .071 mm (.0013 - .0028")
Face Angle	45°
Seat Angle	45°
Seat Width	2.032 - 2.286 mm (.080 - .090")

Maximum Allowable Seat Run-Out	.051 mm (.002")
Maximum Allowable Face Run-Out	.038 mm (.0015")
Seat Insert and Counterbore Data:	
Standard	
Insert O.D.	45.060 - 45.085 mm (1.7740 - 1.7750")
Counterbore Diameter	44.958 - 45.009 (1.770 - 1.772")
.05 mm (.002") Oversize	
Insert O.D.	45.085 - 45.110 mm (1.7750 - 1.7760")
Counterbore Diameter	45.009 - 45.060 mm (1.7720 - 1.7740")
.381 mm (.015") Oversize	
Insert O.D.	45.441 - 45.466 mm (1.7890 - 1.7900")
Counterbore Diameter	45.339 - 45.390 mm (1.7850 - 1.7870")
.762 mm (.030") Oversize	
Insert O.D.	45.822 - 45.847 mm (1.8040 - 1.8050")
Counterbore Diameter	45.720 - 45.771 (1.800 - 1.802")
Valve Head Protrusion (above	
Cylinder Head Face)	
Maximum	1.168 mm (.046")
Minimum	.610 mm (.024")
Valve Tip to Rocker Arm Clearance	
(Hot or Cold)	.407 mm (.016")
Valve Guides:	
Overall Length	
Intake	75.413 mm (2.969")
Exhaust	75.413 mm (2.969")
Bore Diameter	9.495 - 9.520 mm (.3738 - .3748")
Height Above Top of Cylinder Head	33.02 mm (1.30")
Valve Tappets:	
Length	64.770 - 65.786 mm (2.550 - 2.590")
Diameter	25.286 - 25.298 mm (.9955 - .9960")
Clearance in Block	076 - .127 mm (.003 - .005")

Valve Springs:	
Free Length	52.705 mm (2.075")
Test Length	35.484 mm (1.397")
Load (At Test Length)	890 N (200 Lbs.)
Rocker Arms:	
Shaft Bore Diameter	21.905 - 21.968 mm (.8624 - .8649")
Clearance on Shaft	028 - .114 mm (.0011 - .0045")
Rockerarm To Valve Tip Clearance	
Intake	.305 mm (.012")
Exhaust	.407 mm (.016")
Valve Timing:	
Intake Opens (Before T.D.C.)	16°
Intake Closes (After B.D.C.)	52°
Exhaust Opens (Before B.D.C.)	68°
Exhaust Closes (After T.D.C.)	16°
Oil Pump:	
Gear to Body End Clearance	.076 - .114 mm (.003 - .0045")
Gear to Body Side Clearance	.058 - .114 mm (.0023 - .0045")
Shaft Diameter	12.459 - 12.476 mm (.4905 - .4912")
Shaft Clearance in Bore	.033 - .076 mm (.0013 - .0030")
Body Gear Backlash	.013 - .165 mm (.0005 - .0065")
Screen Distance From Oil Pan Rails	165.1 mm (6.50")
Pressure Relief Valves:	
Length	38.86 - 40.39 mm (1.53 - 1.59")
Diameter	18.90 - 18.92 mm (.744 - .745")
Relief Valve Springs:	
Free Length	98.37 mm (3.873")
Test Length	73.28 mm (2.885")
Load (At Test Length)	136 - 154 N (30.6 - 34.6 Lbs.)

Oil Pressure (SAE 20 W 40 Oil at 1050C (220OF)	
Minimum at 625-675 RPM	103.4 - 172.4 KPa (15 - 25 PSI)
Maximum at 1800 RPM	310.3 - 413.7 KPa (45 - 60 PSI)
Flywheel Housing:	
Allowable Run-Out	.254 mm (.010")
Water Pump:	
Impeller to Body Clearance	.254 - .508 mm (.010 - .020")
Injection Pump Drive:	
Drive Gear Backlash	.013 - .114 mm (.0005 - .0045")

IH DIESEL ENGINE

MODELS D-150, D-170, D-190

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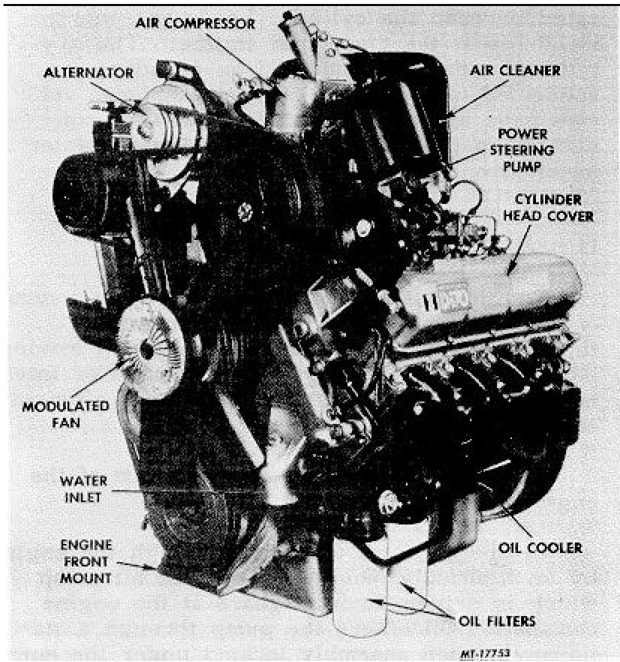

Fig. 1 Left Front View of Engine

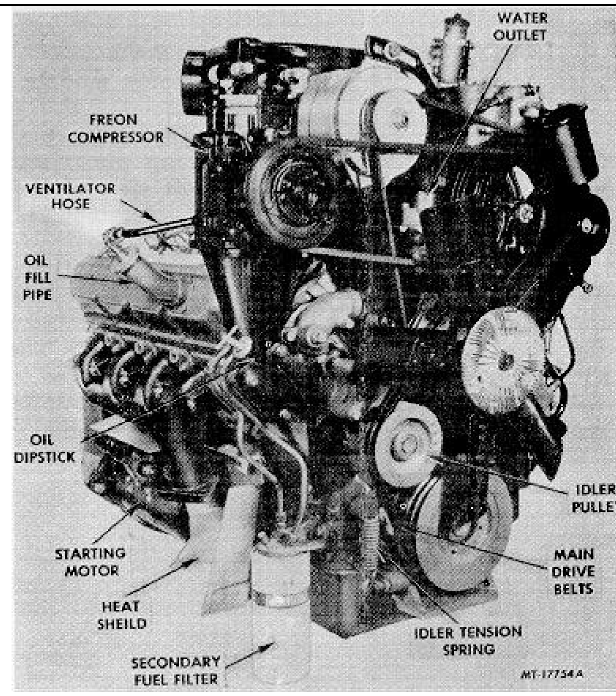

Fig. 2 Right Front View of Engine

DESCRIPTION

ENGINE

The D-150, D-170, D-190 series diesel engine (Figures 1, 2 and 3) is an overhead valve, V-type eight cylinder engine with cylinder banks spaced at 90 degrees to each other.

As viewed from the driver's seat, the right bank of cylinders is numbered 2, 4, 6 and 8 with No. 2 being at the front. Similarly, the left bank of cylinders is numbered 1, 3, 5 and 7 with No. 1 being at the front. Firing order is 1-8-7-3-6-5-4-2.

The crankcase has been especially developed to withstand the loads of diesel operation and utilizes tie bolts at each main bearing to assure a rigid, inflexible support for the rotating parts. Oil galleries traverse the crankcase to deliver oil to all of the moving parts as well as the piston cooling nozzles. The crankshaft is a five main bearing unit with fore and aft thrust controlled at the center (No. 3) bearing. Precision steel backed main and connecting rod bearings are utilized. Connecting rods are of heavy-duty construction and are attached to the crankshaft, two to each bearing throw with the piston pin being of free floating type permitting the pin to move or float freely in piston and rod. The pin is held in place with pin retaining rings.

The intake and exhaust valves are both provided with inserts at the cylinder head and valve rotators are used at both intake and exhaust valves. The rotators are seated on the cylinder head. Valve dampers are also utilized with each of the valve springs.

The engine utilizes special combustion chambers which are a part of each piston dome. With the pistons in the uppermost (T.D.C.) position, there is a limited amount of clearance between the piston head and the cylinder head and valves. This design is such that maximum compression takes place in the piston combustion chamber, raising the air intake charge to extremely high pressure and temperature. Fuel is injected into the piston combustion chamber at the correct moment to obtain efficient combustion and complete burning of the fuel. The engine is equipped with a fully closed crankcase ventilating system. The crankcase ventilator fitting is located at the rear of the right cylinder head cover and is connected by a hose to the intake manifold.

ENGINE ACCESSORIES

Typical engine accessory installations are shown in Figures 1, 2 and 3.

NOTE

Location of some engine accessories may vary between chassis models.

As seen in Figure 1, the oil cooler, dual full-flow oil filters, power steering pump and water inlet are located on the left side of the engine.

The starting motor, secondary fuel filter, oil filter pipe, oil dipstick, crankcase ventilator piping and freon compressor are located on the right side of the engine (Figure 2). The alternator, air compressor and water outlet with dual thermostats are located at the upper front of the engine.

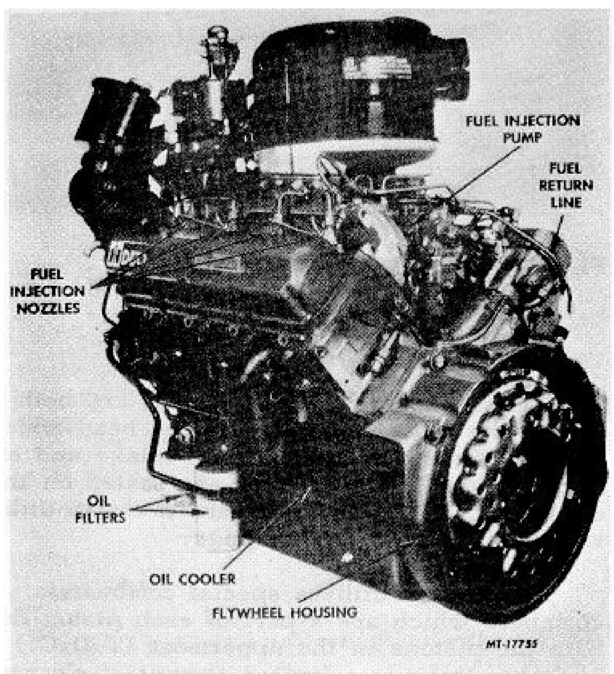

Fig. 3 Left Rear View of Engine

Dual main drive belts driven by the crankshaft pulley drive the water pump and automatic temperature modulated fan. The main drive belts are held in correct tension by a spring loaded idler pulley. The idler pulley, is held in position by a pivoted idler arm to which the tension spring is attached. The idler pulley runs on a double row ball bearing, prelubricated and sealed so that further lubrication is not required. The idler arm pivots on a bushing which is oil impregnated and utilizes seals at both ends. No further lubrication of this bushing is required. The alternator and air compressor are driven by dual belts from the water pump pulley. The freon compressor and power steering pump are driven by single belts from the air compressor pulley.

The fuel injection pump (Figure 3) is located between the cylinder heads and intake manifolds at the top of the engine. The dry type air cleaner is mounted on an adapter connected to the intake manifolds. Some vehicles have a remote mounted air cleaner connected via piping to a crossover type adapter mounted on the intake manifolds.

LUBRICATING SYSTEM

Engine lubrication is provided by a system of galleries and drilled passages running through the various engine castings and moving parts. This design eliminates external or internal oil lines and assures trouble-free, efficient engine lubrication.

Figure 4 illustrates a flow diagram of the engine lubricating system.

In operation oil is forced through the engine by an internally mounted gear type oil pump which is driven through gears at the engine camshaft. Oil enters the pump through a stationary screen assembly located under the surface of the oil in the pan and above the bottom of the oil pan and attached to the oil pump body. Dual spring-loaded pressure relief valves are located in the oil pump which limit the maximum oil pressure in the system. Because of the reverse oil delivery capacity of the oil pump, the two regulator valves are required. Oil relieved by the pressure regulator valves is recirculated within the pump. This feature eliminates oil aeration, which is often caused by oil returning to the pan from the pump.

Oil leaving the oil pump passes through the oil cooler where heat from the oil is removed by the engine coolant and dissipated through the engine cooling system. From the oil cooler, the oil enters the full-flow oil filters. Each spin-on type filter has a by-pass valve which permits oil to flow to the engine in case the filter becomes clogged.

After passing through the cooler and filters, oil enters the main engine oil galleries which supply oil through drilled passages to the crankshaft, main and connecting rod bearings, as well as the camshaft and bearings. Oil flows from the rear camshaft bearing to the right rocker arm shaft and from the front camshaft bearing to the left rocker arm shaft. Oil delivery from the camshaft bearings also lubricates the camshaft drive gear and tachometer drive bushing located at the upper end of the oil pump drive shaft. The oil pump drive gears are lubricated from runoff or spray from the tachometer drive bushing which is directly above the pump drive gears.

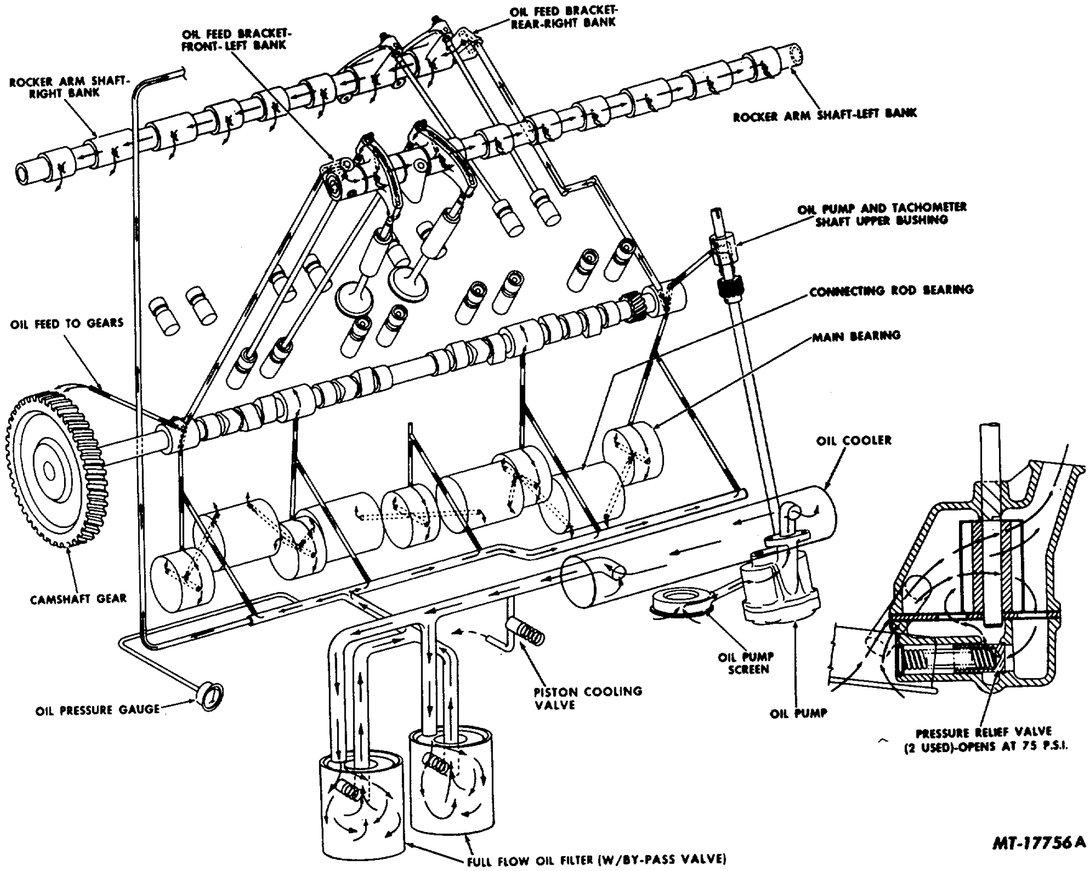

Fig. 4 Engine Lubricating System

The hollow rocker arm shafts are cross drilled to feed oil to each rocker arm bearing as well as the rocker arms. The rocker arms are drilled to feed oil in channels or grooves to the valve stems and push rods.

The pistons, piston rings, piston pins and valve lifters or tappets receive lubrication from oil spray thrown from the engine crankshaft. The connecting rods are not drilled for oil channels on these engines.

A passage is provided in the engine crankcase to deliver engine oil to lubricate bearings in the fuel injection pump. The air compressor receives lubrication from this same source.

The engine utilizes a special cooling feature at each of the pistons. Oil is delivered at regulated pressure to cooling nozzles at the lower end of each cylinder. These nozzles are directed upwards so that a jet of oil strikes the under side of each piston head, thereby utilizing engine oil to cool the piston head. A piston cooling regulator valve, located in the oil filter base, admits oil to the piston cooling nozzels. At normal engine operating condition, piston cooling gallery pressure should be within 69 kPa (10 psi) of main oil gallery pressure at rated speed.

FUEL INJECTION SYSTEM

Fuel is pumped from the tanks by an electric fuel pump (located in the fuel tank) to the primary fuel filter mounted either to the cab cowl or frame side rail (depending on chassis model). Fuel then flows from primary filter to secondary filter located on lower right front side of engine. Filtered fuel is then directed to the fuel injection pump located between the cylinder banks where it is metered and delivered under high pressure to the hydraulic type injection mozzles located at each combustion chamber in the cylinder heads. The engine governor is integral with the fuel injection pump. Operating principles and service instructions for the fuel system components are given in separate sections of the service manual. Fuel System, Section AE, CTS-2677 covers the fuel injection nozzles. Fuel System, Section AF, CTS-2678 covers the fuel injection pump and governor.

MODULATED FAN DRIVE ASSEMBLY

Torque is supplied to the input shaft of the modulated fan assembly from the water pump. The input shaft transmits torque to the fan by the movement of silicon fluid between the input and output plates in the fluid filled housing. The fan drive is actuated by the positioning of a slide valve plate which controls the amount of fluid from the forward supply chamber and the rear drive chamber. Close clearance between the driving and driven members causes the driven plate to turn. The volume of fluid in the drive chambers regulates the fan speed.

The valve plate is actuated by the control element, which is a bimetal coil and reacts to the air temperatures behind the radiator core. When the coil is cooled by the air temperature, the coil will close the slide valve plate, restricting the flow of the silicon fluid. Through centrifugal force the fluid is allowed to re-enter the forward supply chamber through a small hole. The fan will turn at a reduced speed due to a smaller volume of fluid between the driving and driven member.

When installing the modulated fan assembly on the water pump shaft, tighten the 1-1/4 x 16 left-hand thread shaft mounting nut to 40 ft. lbs. torque. The fan hold-down bolts must be tightened to 15-20 ft.lbs. torque.

The modulated fan assembly should not be disassembled, as it is only a unit replacement item.

MAINTENANCE

To obtain satisfactory engine performance, the engine must be properly maintained following the maintenance schedule and instructions outlined in the vehicle operator's manual.

For fuel injection system maintenance and performance test instructions, refer to service manual sections covering fuel system components.

ENGINE REMOVAL

Engine removal procedures will differ between vehicle models. The general instructions outlined below apply to most cases.

NOTE

On some "Cargostar" vehicles, the transmission and clutch must be first removed from the vehicle to permit engine removal. On some "Paystar" vehicles it may be necessary to remove the transmission to permit engine removal.

1. Drain engine coolant from radiator and engine block.
2. Drain oil from engine oil pan.
3. Disconnect battery cables.
4. Raise cab (CO models) or remove hood (conventional models).
5. Remove engine tunnel from cab floor (where required).
6. Remove radiator hoses and shutter control hoses (where used).
7. Remove air conditioning system components (where equipped). Where possible, remove units and set them aside without disconnecting freon piping. If necessary to discharge freon system, observe safety precautions.
8. Remove front bumper, fenders, radiator support, radiator core assembly, as required.
9. Remove transmission shift lever island and shift rod bearing support (CO models).
10. Disconnect power steering hoses from power steering pump or remove pump from engine (where equipped).
11. Remove air cleaner piping and air cleaner.
12. Disconnect:

    Accelerator and throttle linkage.

    Alternator, temperature sender and oil pressure sender wiring. Air compressor piping (where equipped).

    Exhaust pipes from manifolds.

    Fuel inlet and return lines.

Fuel shut-off (engine stop) control.

Heater hoses and brackets.

Surge tank hoses (where equipped).

Swirl destroyer control cable (where equipped).

Tachometer cable.

13. Remove thermostat housing and thermostats.

14. Install engine lifting plates (Figure 5). For front of engine (thermostat housing) use lifting plate SE-2103-1. For rear of engine (flywheel housing) use lifting eye bolt SE-1899 and plate made locally to dimensions (figure 6).

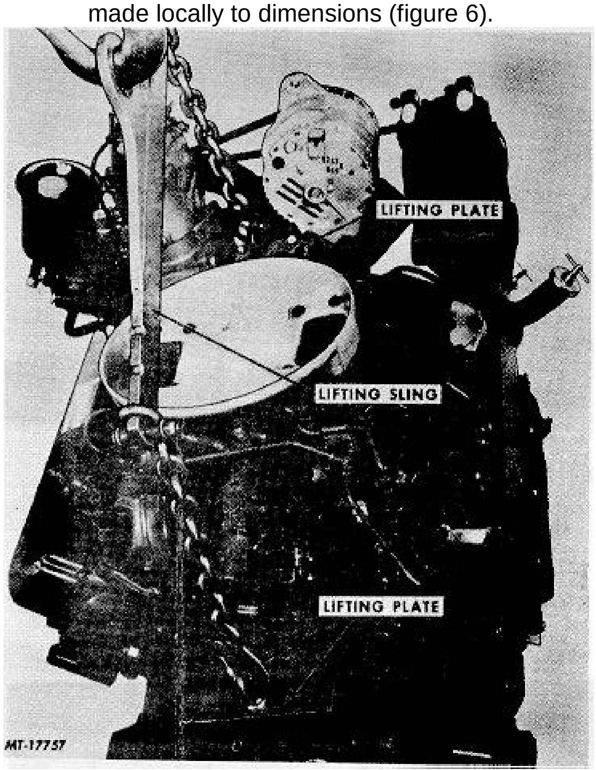

Fig. 5 Engine Lifting Sling Installation

15. Install engine lifting sling (Figure 5). Connect hoist to lifting sling.

16. Support transmission and disconnect engine from bell housing (where required).

17. Disconnect front and rear engine mountings.

18. Lift engine from chassis.

IMPORTANT

Remove engine carefully to avoid damage to clutch driven disc.

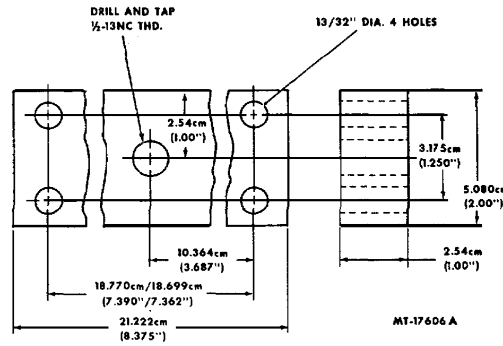

Fig. 6 Dimensions for Making Rear Lifting Plate

ENGINE DISASSEMBLY

The disassembly sequence outlined below is intended as a guide since the actual disassembly procedure will depend upon the extent of service required and the accessory components mounted on the individual engine being serviced.

Engine disassembly can best be accomplished by mounting the engine in a rotating engine stand such as stands SE-1434 or SE-1962.

IMPORTANT

Some engine components must be removed (as outlined in Step 1 below) before engine can be mounted in overhaul stand.

1. Mount engine in overhaul stand as follows:

Overhaul Stand SE-1962:

a. Remove right exhaust manifold.

b. Remove exhaust manifold heat shield (Figure 7).

c. Remove starting motor and adapter from flywheel housing.

d. Loosen both filter line nuts at top of fuel filter base (See Figure 14). Loosen three capscrews and remove filter base from engine.

e. Install overhaul stand adapter No. 975 to engine block.

f. Mount engine, with adapter, in over-haul stand (Figure 8).

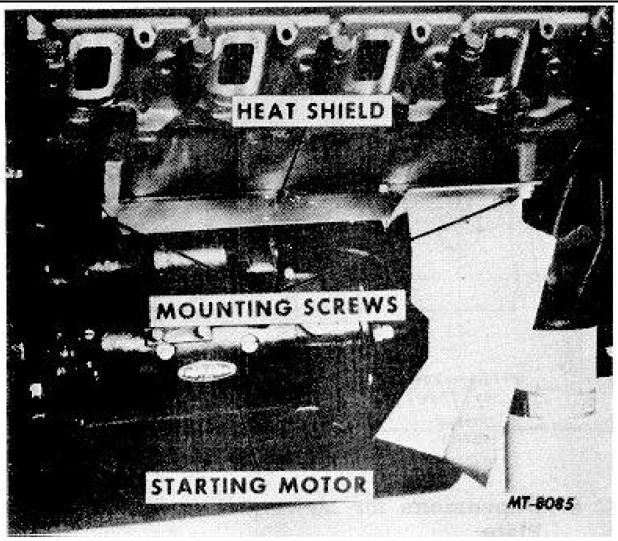

Fig. 7 Manifold Heat Shield

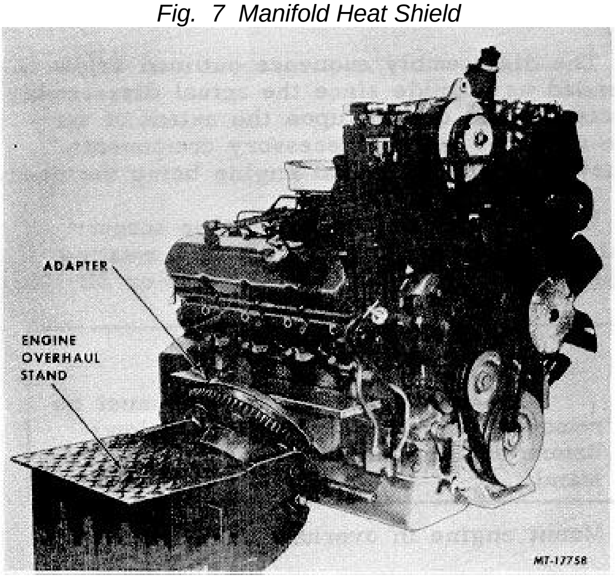

Fig. 8 Engine Mounted in SE-1962 Overhaul Stand

Overhaul Stand SE-1434:

NOTE

To accommodate engine, the rail opposite the gear box of SE-1434 engine stand must be modified (Figure 9).

a. Remove both exhaust manifolds and exhaust manifold heat shield (Figure 7).

b. Remove starting motor and adapter from flywheel housing.

c. Remove oil cooler water inlet and return lines (Figure 10).

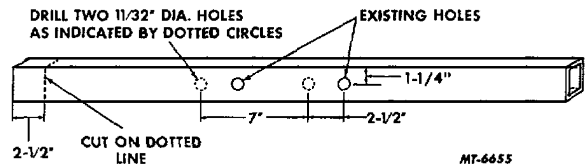

Fig. 9 Modifications Required on SE-1434 Engine Stand Rail

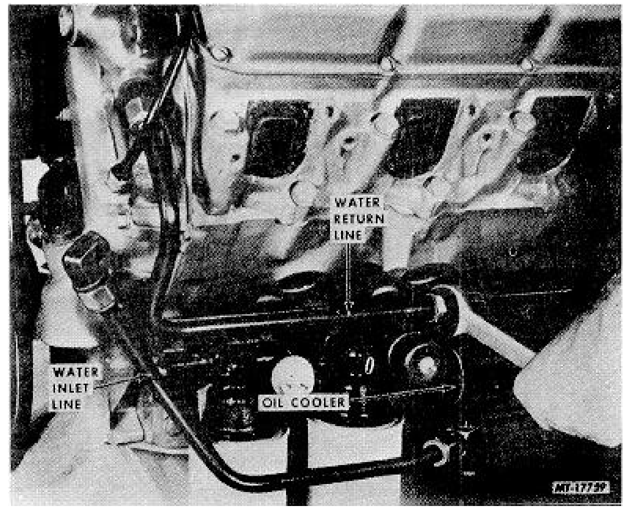

Fig. 10 Oil Cooler Water Lines

d. Remove air compressor water line (Figure 11). Also remove water line clip from power steering pump mounting bracket bolt.

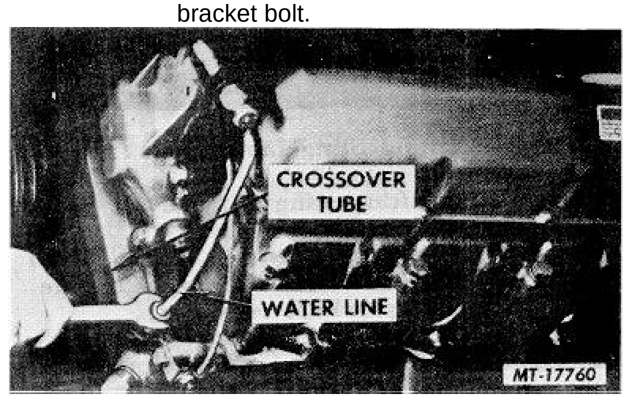

Fig. 11 Removing Air Compressor Water Line

e. Disconnect air compressor and injection pump oil line from oil filter base and from tee at air compressor mounting base.

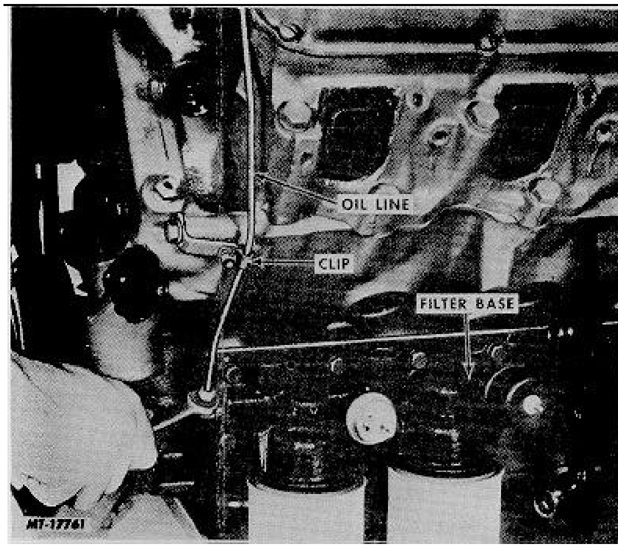

Fig. 12 Removing Air Compressor Oil Line

Disconnect clip from crossover pipe over pipe mounting bolt and remove oil line (Figure 12).

f. Remove crossover tube and gaskets from water pump body and crankcase (Figure 13).

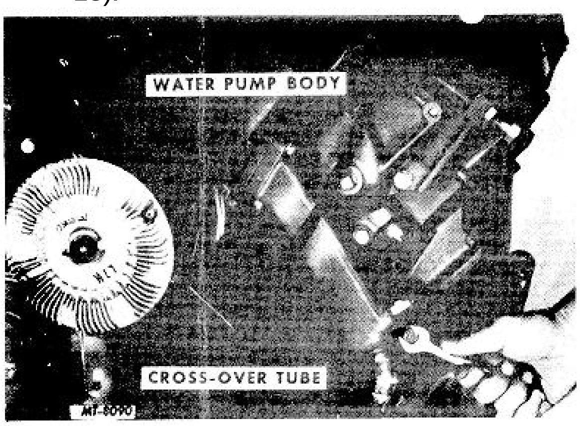

Fig. 13 Removing Crossover Tube

g. Loosen both filter line nuts at top of fuel filter base (Figure 14). Loosen three capscrews and remove filter base from engine.

h. Mount engine in overhaul stand using SE-2105 support plates and brackets (Figures 15 and 16).

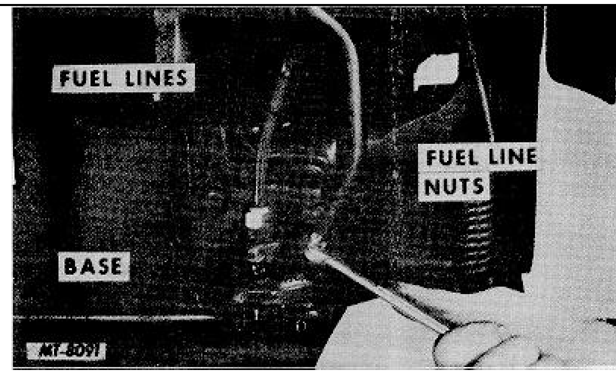

Fig. 16 Engine Stand Support Brackets and Plates (Left Side)

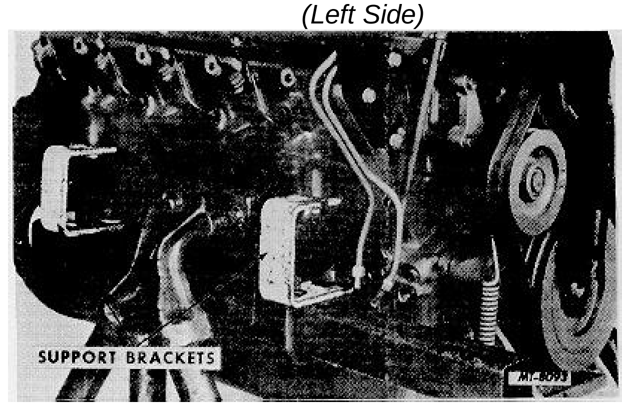

Fig. 15 Engine Stand Support Brackets (Right Side)

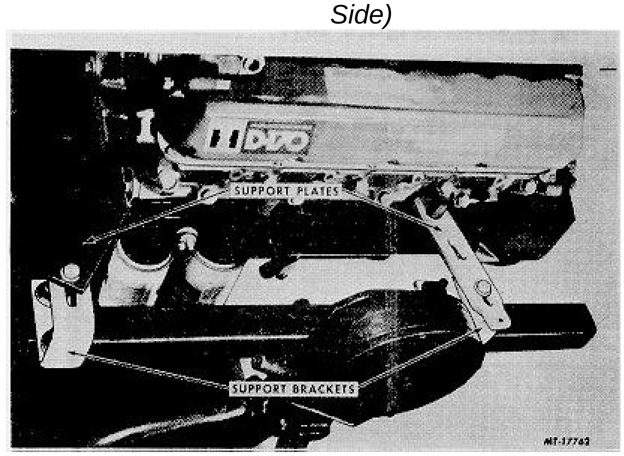

Fig. 16 Engine Stand Support Brackets and Plates (Left Side)

After engine is mounted in overhaul stand, proceed to disassemble engine as follows:

2. Loosen the power steering pump adjusting bolt locknut and mounting bracket capscrews. Push mounting bracket inward to remove power steering pump drive belt. Remove power steering pump mounting stud nuts and lockwashers and remove pump (Figure 17).

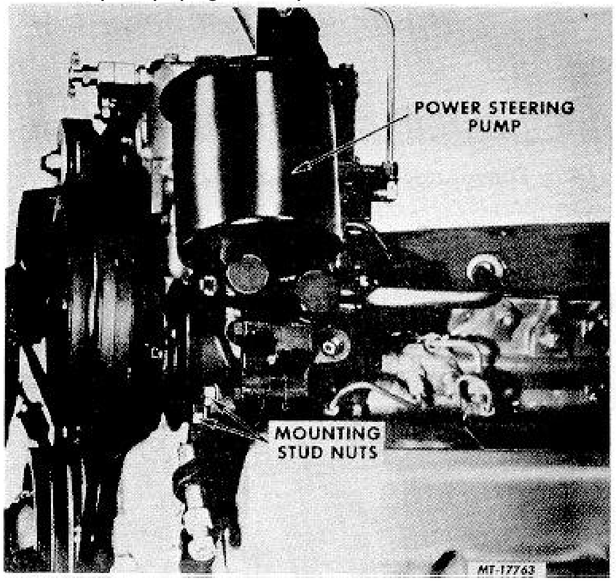

Fig. 17 Power Steering Pump Mounting Details

3. Remove two pump mounting bracket capscrews and lockwashers and remove mounting bracket (Figure 18).

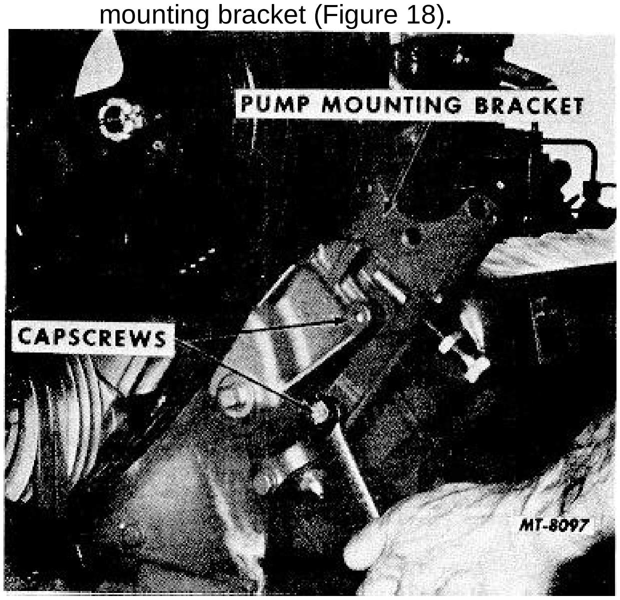

Fig. 18 Removing Power Steering Pump Mounting Bracket

4. Loosen four freon compressor mounting capscrews and push compressor inward and remove drive belt (Figure 19). Remove freon compressor mounting capscrews, lockwashers and flat washers and remove compressor.

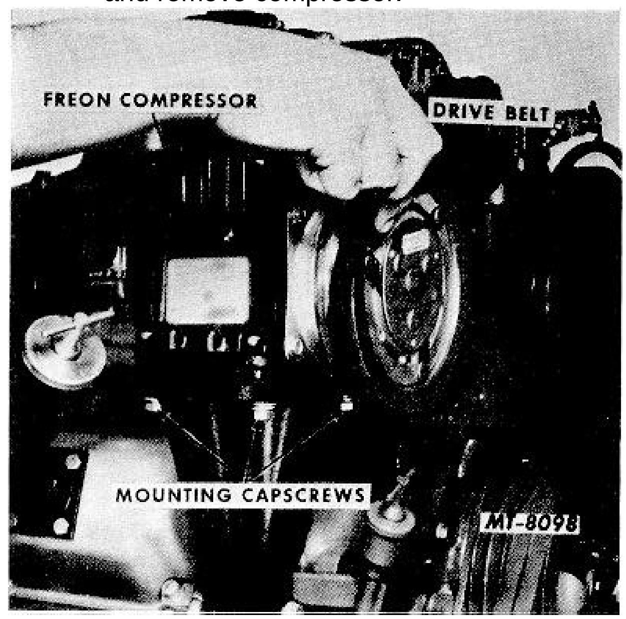

Fig. 19 Removing Freon Compressor

5. Remove freon compressor mounting bracket capscrews and lockwashers and remove bracket (Figure 20).

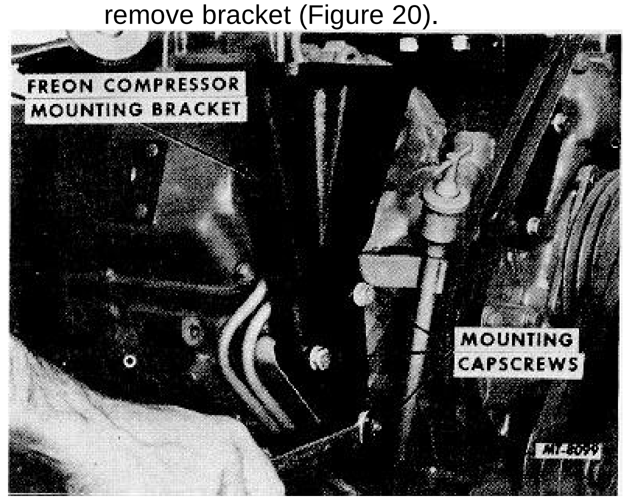

Fig. 20 Removing Freon Compressor Mounting Bracket

6. Remove oil pressure sender unit from oil filter base.

7. Remove capscrews and remove oil cooler and "O" ring gaskets from oil filter base (Figure 21).

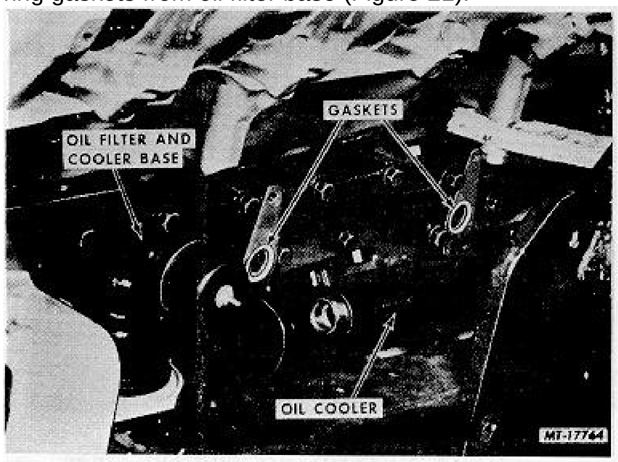

Fig. 21 Removing Oil Cooler

8. Remove both oil filters from oil filter base. Remove filter base capscrews and remove filter base and gasket from engine (Figure 22).

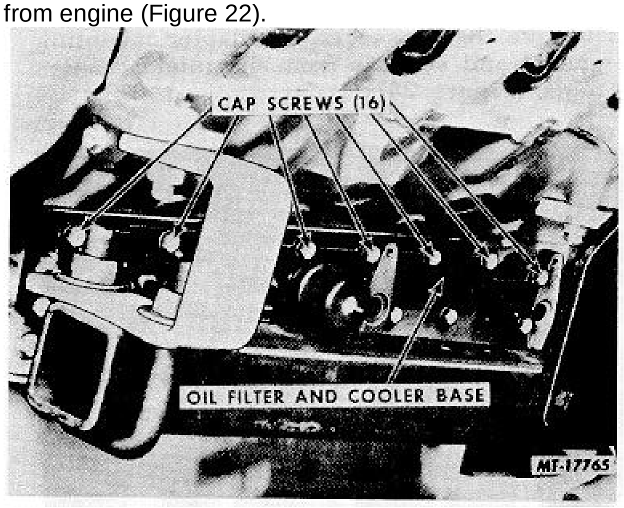

Fig. 22 Removing Oil Filter Base

9. Loosen alternator mounting bolts and remove alternator drive belts from pulleys. Remove the alternator mounting bolts and remove alternator from bracket (Figure 23).

10. Remove the modulated fan drive assembly from the water pump pulley hub using wrench SE-2107 and a heavy-duty screwdriver blade against the lug on the water

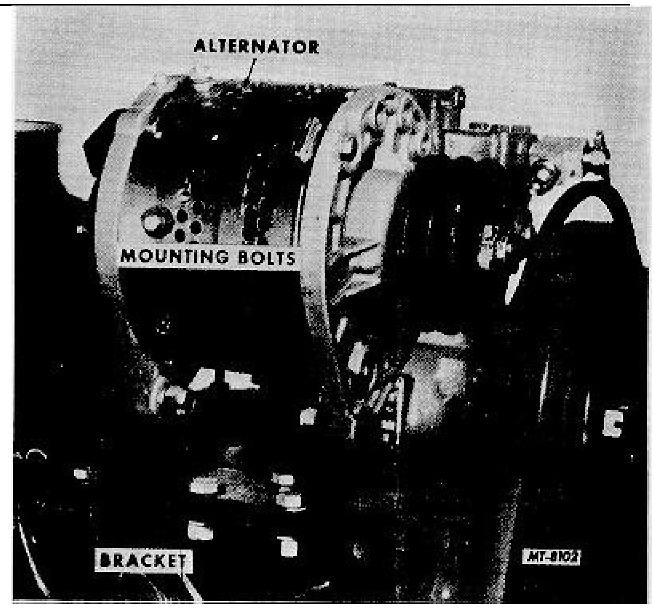

Fig. 23 Alternator Mounting Details (Typical)

pump body to form a stop against one pulley hub spoke (Figure 24).

NOTE

Do not permit the screwdriver to wedge between the water pump body and pulley hub spoke, otherwise damage to the pulley hub spoke will result. Keep the screwdriver at a right angle to the pump hub (Figure 24).

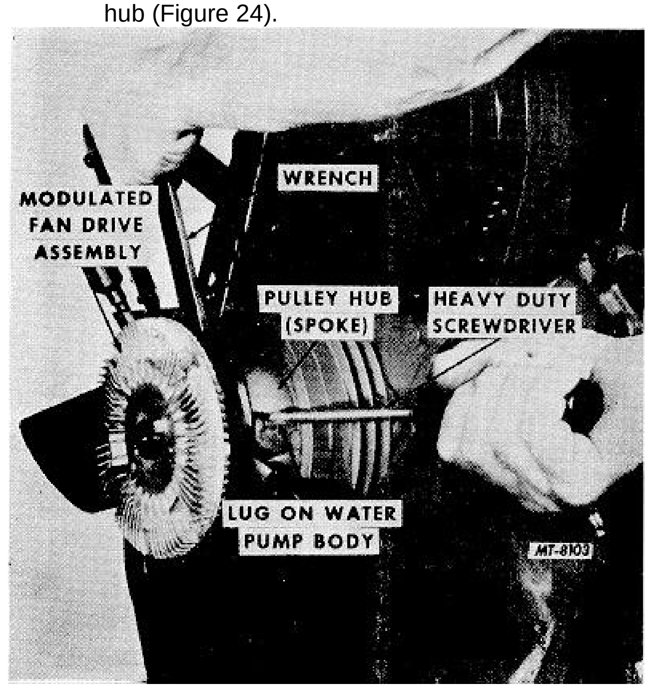

Fig. 24 Removing Modulated Fan Drive Assembly

11. Push idler pulley toward center of engine and remove main drive belts (Figure 25). Also remove accessory drive belts.

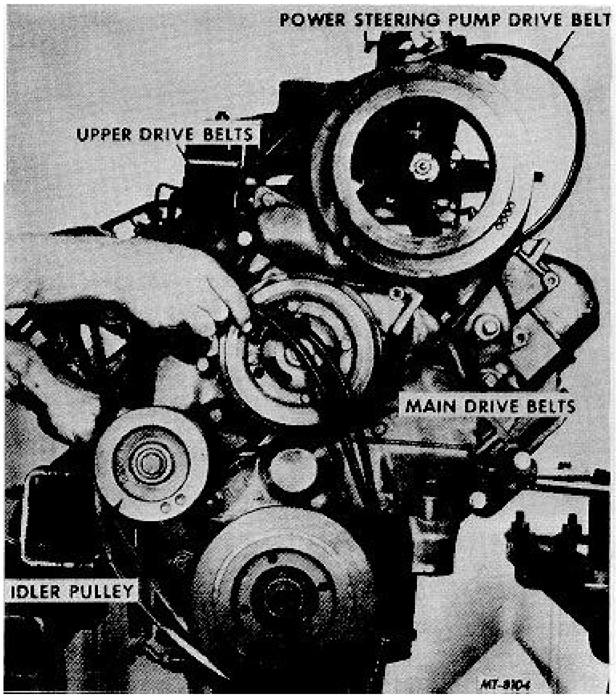

Fig. 25 Removing Drive Belts

12. Remove four capscrews and lockwashers and remove alternator mounting bracket (Figure 26).

Fig. 26 Alternator Bracket Mounting Details

13. Disconnect the air line from air compressor to crossover or air cleaner adapter plate (Figure 27). Also disconnect oil line at air compressor adapter plate (Figure 27).

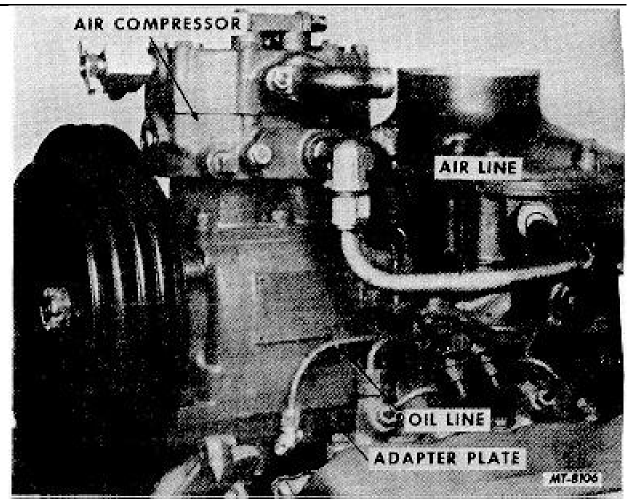

Fig. 27 Air Compressor Air and Oil Lines

14. Remove ten capscrews and lift off crossover from intake manifolds, or air cleaner adapter plate.

NOTE

The crossover is used only on certain model vehicles, while other models use an air cleaner adapter to intake manifolds.

15. Remove the crossover or adapter mounting gasket and screens from the intake manifolds (Figure 28).

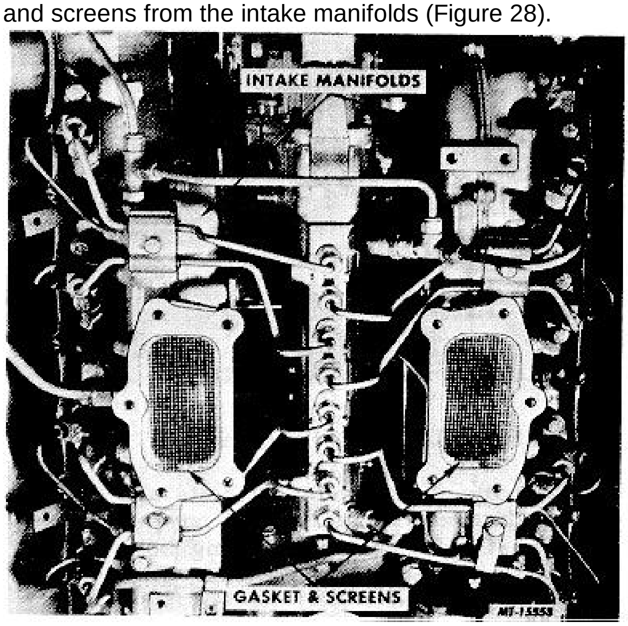

Fig. 28 Air Cleaner Adapter-to-Manifold Gaskets and Screens

IMPORTANT

After removal of gasket and screens, the intake manifold openings should be covered with tape to avoid dropping foreign matter into manifolds.

16. Loosen four capscrews and lockwashers and remove air compressor and gasket (Fig. 29).

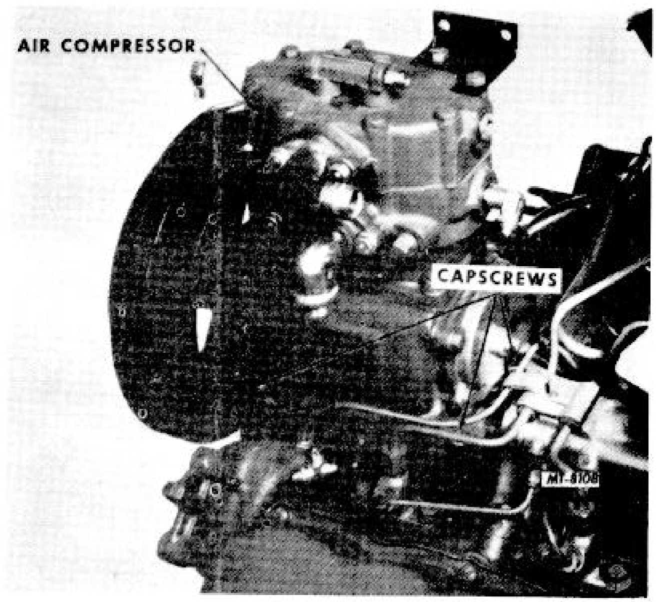

Fig. 29 Air Compressor Mounting Capscrews

17. Loosen three capscrews and lockwashers and remove air compressor adapter plate and "O" ring from front cover (Fig. 30).

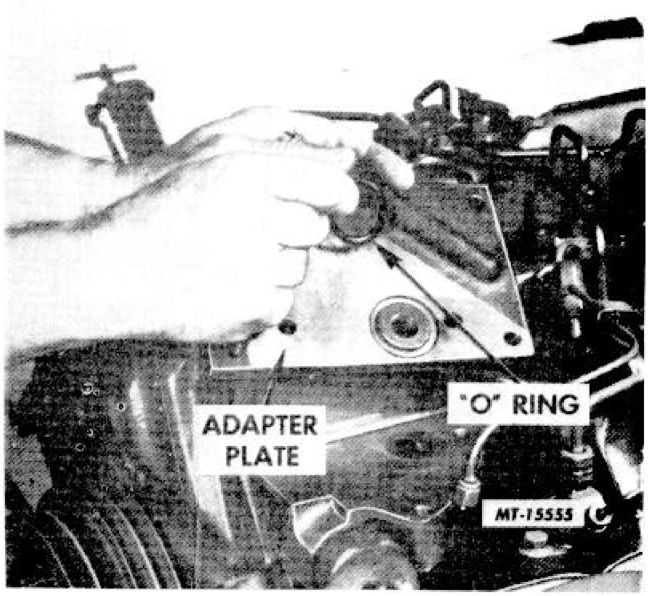

Fig. 30 Removing Air Compressor Adapter Plate and "O" Ring

18. Remove crankcase ventilator hose and clamps from right cylinder head cover to intake manifold (Fig. 31).

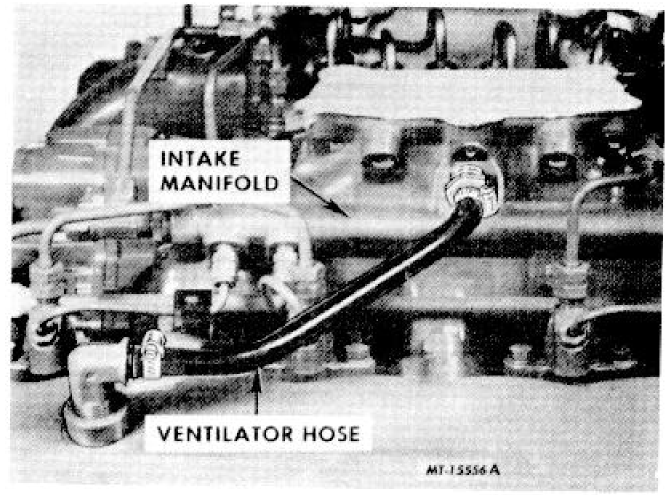

Fig. 31 Crankcase Ventilator Hose

19. Remove clips and grommets from fuel injection lines and disconnect lines from injection pump and nozzles (Fig. 32).

IMPORTANT

When removing any of the fuel systems lines, the lines should have dust caps installed over both ends as well as the fittings where the lines were removed. This procedure is to protect against entry of foreign matter in the fuel system. The dust caps come in various sizes and can be procured locally.

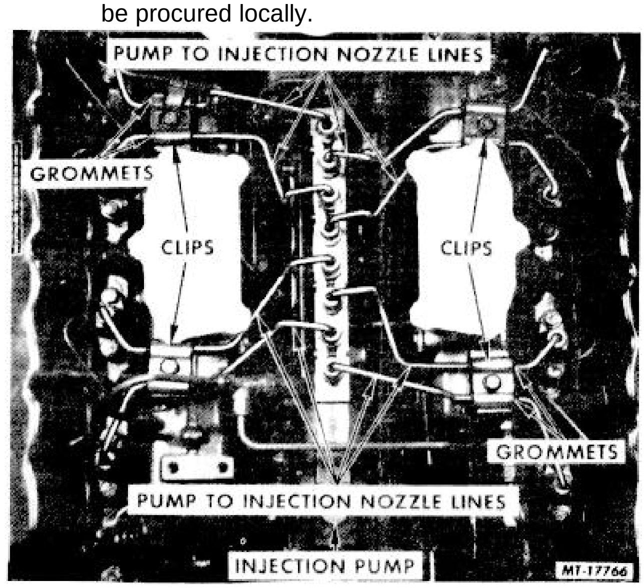

Fig. 32 Injection Lines

20. Disconnect injection nozzle leak-off lines (Figure 33). Also remove leak-off line between manifolds and leak-off line from manifold to injection pump.

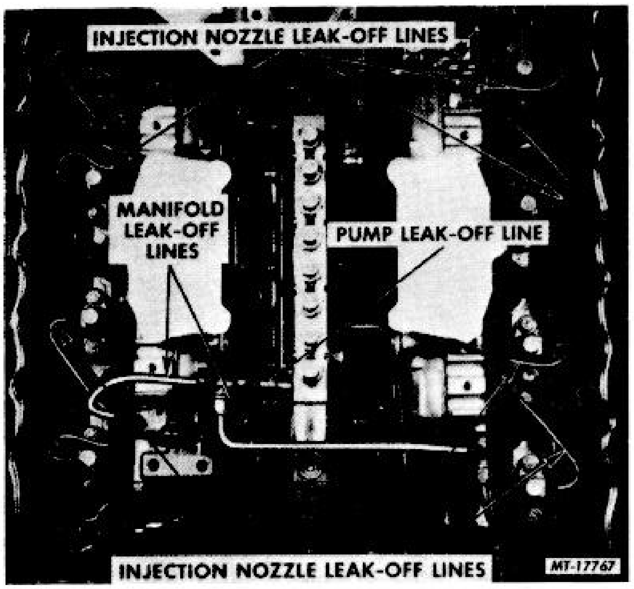

Fig. 33 Leak-Off Lines

21. Remove clip from right front of cylinder head cover and remove fuel supply line between secondary fuel filter and transfer pump.

22. Remove two clips along side of right intake manifold and remove primary to secondary fuel filter line.

23. Remove oil feed line clip on left intake manifold and remove oil feed line from injection pump . Cap fitting in pump.

24. Loosen two capscrews securing horizontal bracket to intake manifold (Figure 34).

25. Remove one capscrew securing horizontal bracket to pump and remove bracket (Figure 34).

26. Loosen brace lower capscrews to pump (Figure 34).

27. Remove two top capscrews securing braces to intake manifolds and remove braces (Figure 34).

28. Remove four capscrews and lockwashers from injection pump adapter (Figure 35).

29. Remove injection pump and gasket from front cover. Also, remove drive disc from injection pump or drive flange (Figure 36).

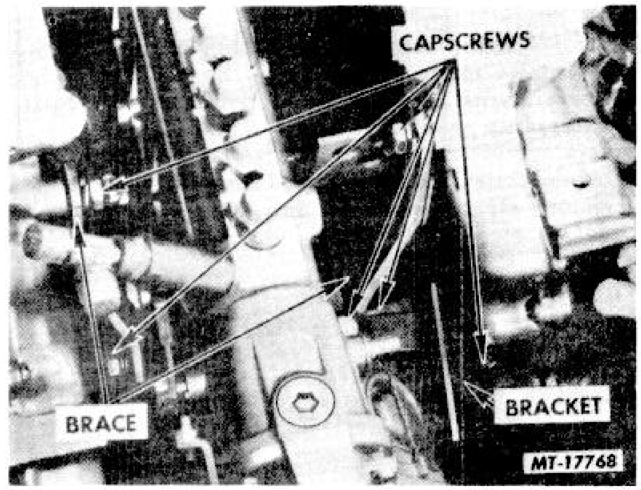

Fig. 34 Injection Pump Mounting Braces

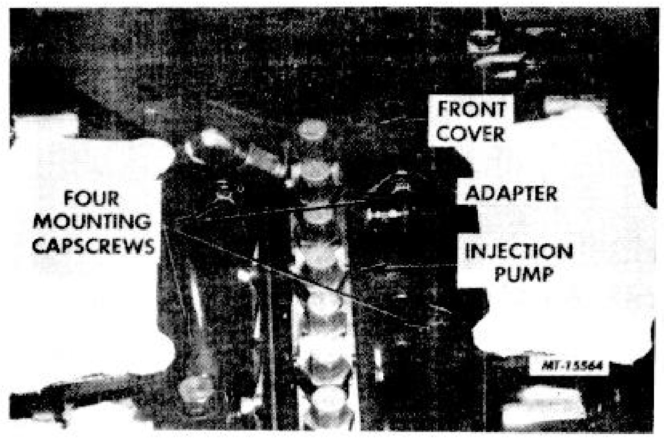

Fig. 35 Injection Pump-to-Engine Mounting

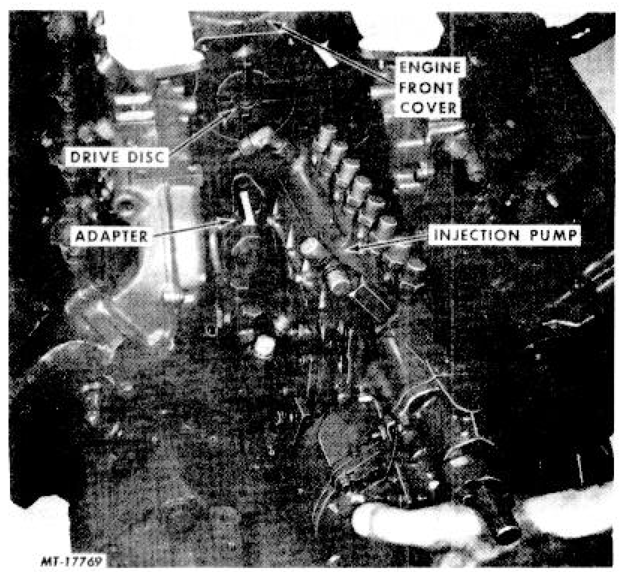

Fig. 36 Removing Injection Pump

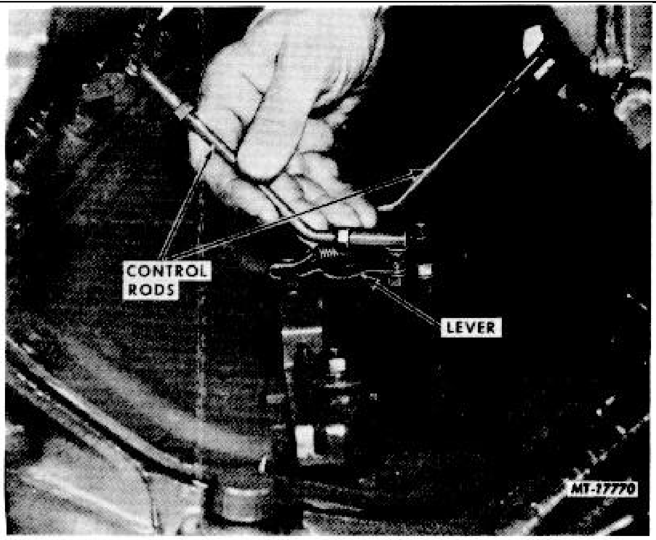

Fig. 37 Disconnecting Swirl Destroyer Linkage (Early production engines only)

30. On engines equipped with swirl destroyer, unsnap swirl destroyer linkage from ball stud at intake manifolds (Figure 37).

31. Remove intake manifold capscrews and lockwashers and remove intake manifolds and gaskets from cylinder heads (Figure 38).

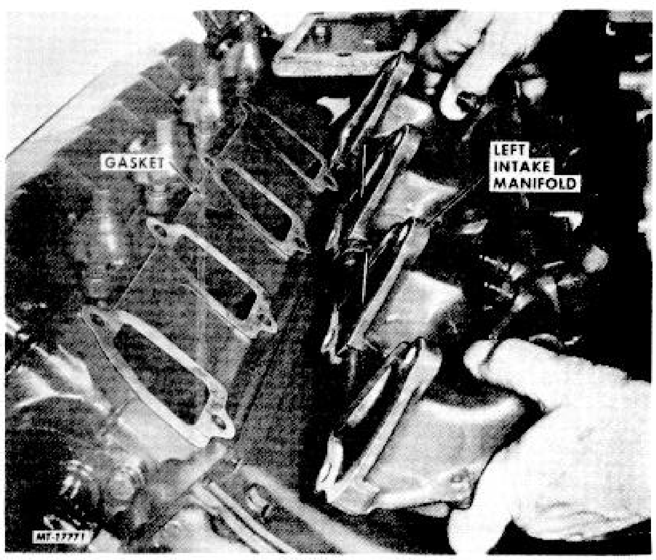

Fig. 38 Removing Intake Manifold

32. Remove water outlet mounting capscrews and lockwashers and remove dipstick tube, water outlet (with temperature sender unit), and gasket from right cylinder head (Figure 39).

33. Remove water outlet mounting capscrews and lockwashers and remove water outlet and gasket from left cylinder head.

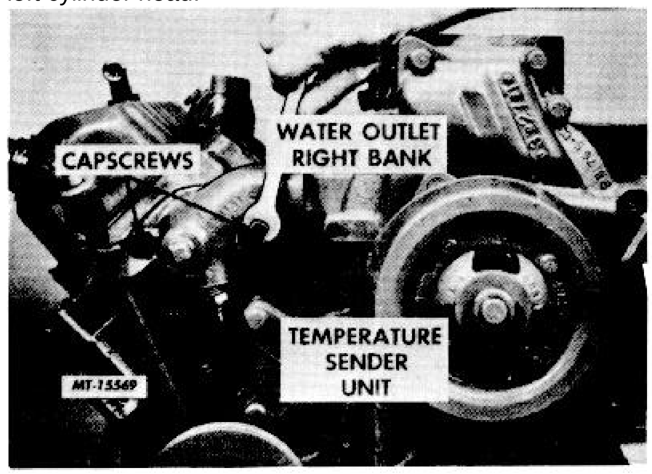

Fig. 39 Removing Water Outlet From Right Cylinder Head

34. Remove water outlet pipes and "O" ring gaskets from engine front cover (Figure 40).

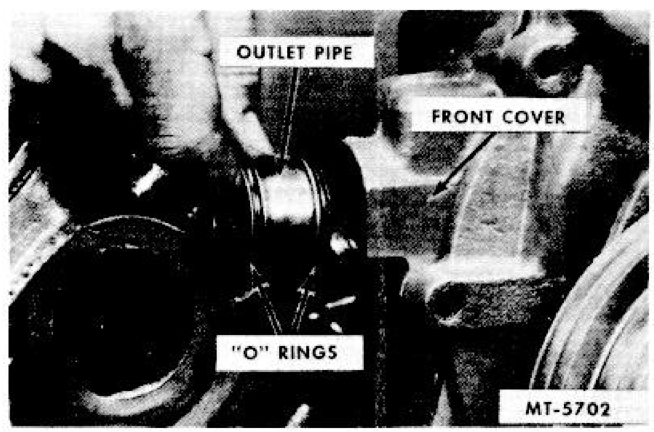

Fig. 40 Removing Water Outlet Pipe and "O" Rings

35. Remove cylinder head cover screws and flat washers and remove covers and gaskets from cylinder heads (Figure 41).

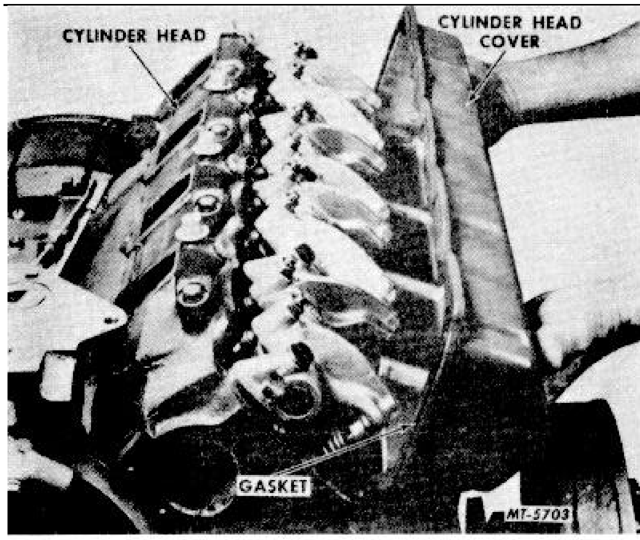

Fig. 41 Removing Cylinder Head Cover

36. Remove injection nozzle hold-down capscrews and pull nozzle assemblies (with "O" rings and gaskets) from cylinder heads (Figure 42). Be careful not to strike nozzle tips against any hard surface during removal. Cover nozzle assembly fuel inlet and leak-off openings with plastic caps to prevent entry of dirt.

Place nozzle assemblies in a holding fixture (SE-2102) as they are removed from the heads. The fixture (Figure 43) is stamped with numbers corresponding to the cylinder numbering of the engine. Use of this fixture permits replacing nozzles in their respective ports in the cylinder heads.

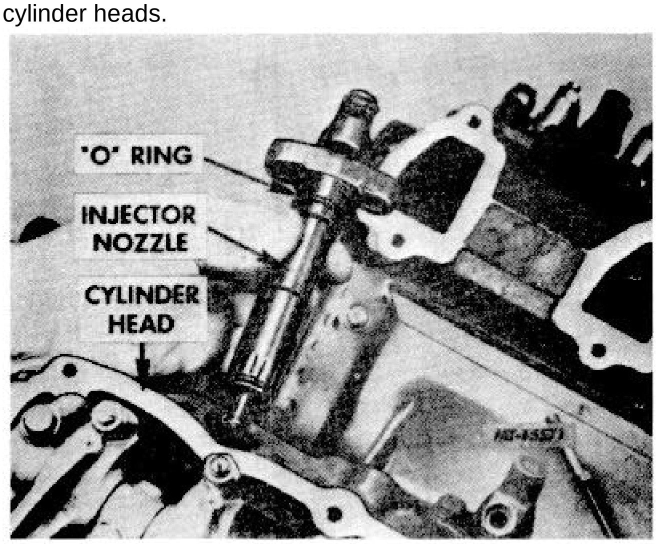

Fig. 42 Removing Injection Nozzle

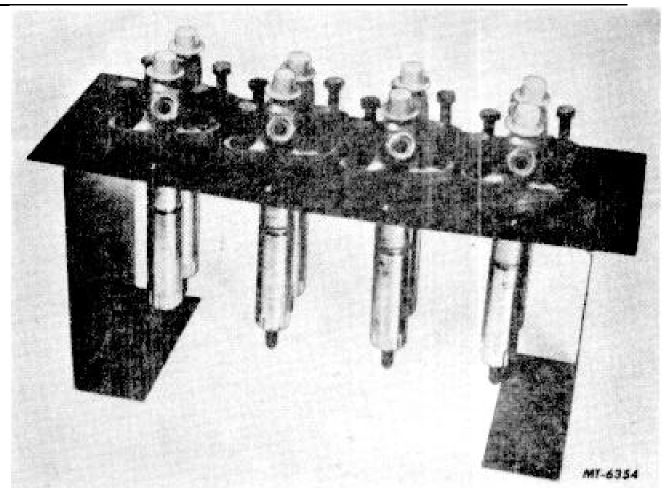

Fig. 43 Nozzle Holding Fixture

37. Remove rocker arm assemblies from cylinder heads (Figure 44). Remove valve tips from ends of valves. Withdraw push rods from engine.

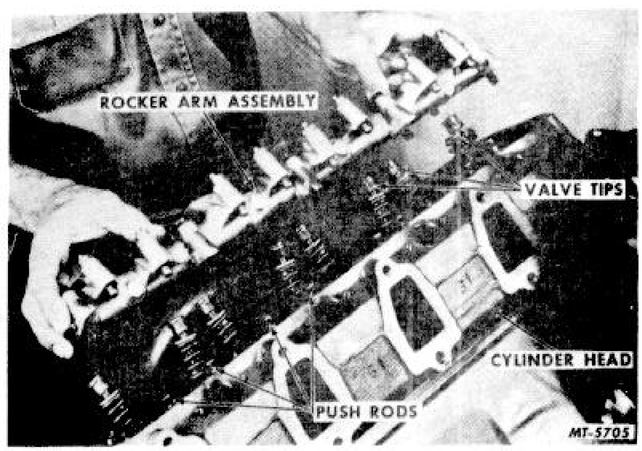

Fig. 44 Removing Rocker Arm Assembly

38. Remove cylinder block to cylinder head water pipes, cover plates and gaskets from rear of each cylinder head (Figure 45).

39. Remove cylinder head bolts and lift each head from the locating dowel sleeves in the cylinder block.

To lift cylinder heads, attach cylinder head sling SE-1896 using 3/8 NC x 3/4" capscrews (Figure 46).

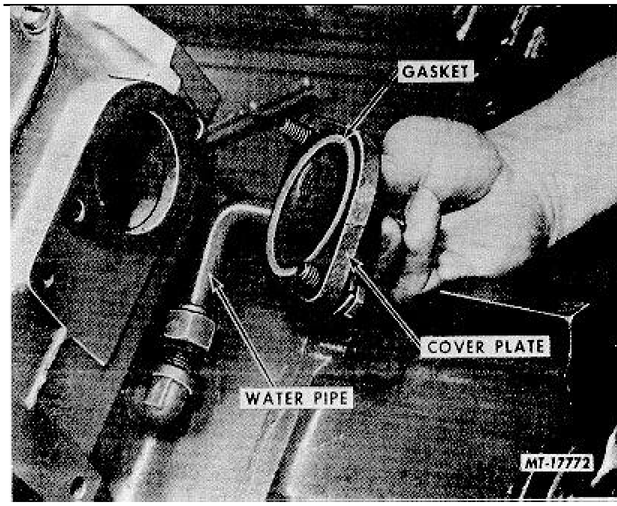

Fig. 45 Removing Cylinder Block-to-Cylinder Head Water Pipe and Cover Plate

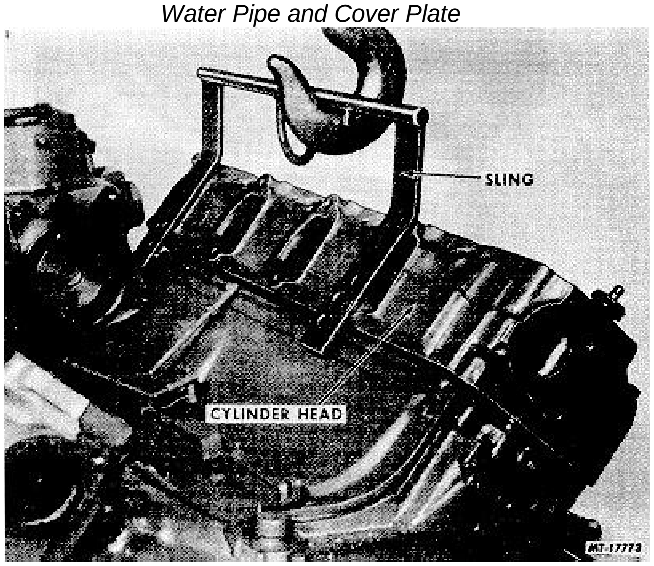

Fig. 46 Removing Cylinder Head

NOTE

If necessary, modify lifting sling SE-1896 as follows:

a. Drill four 13/32" diameter holes at locations shown in Figure 47.

b. Form a tab on the sling made from 3/8" x 3/4" cold rolled stock and weld to sling per dimension shown in Figure 47. The purpose of the tab is to hold the lifting chain or hook at a point on the sling to balance the cylinder head.

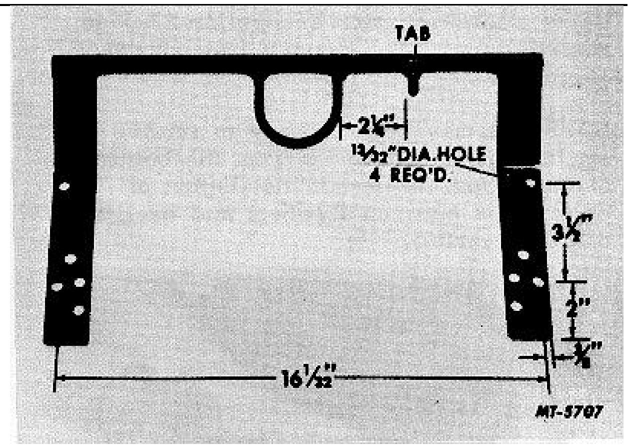

Fig. 47 Cylinder Head Lifting Sling SE-1896

40. Remove clutch assembly from engine fly-wheel.

Clutch removal procedures vary between clutch types. On the clutch assembly shown in Figure 48, the clutch plate should be compressed with the three capscrews "A" (3/8" 16 NC x 2) and flat washers prior to removing mounting screws. Otherwise, it is possible to distort the clutch cover. Loosen clutch back plate-to-flywheel retaining capscrews and remove the clutch assembly.

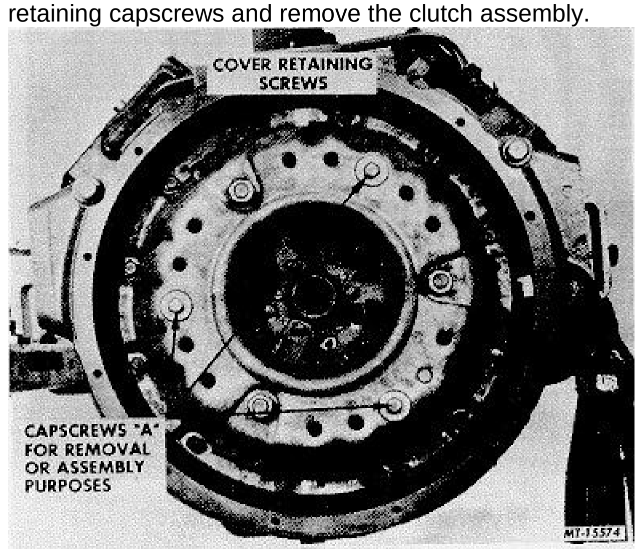

Fig. 48 Clutch Removal

41. Using a slide hammer and puller SE-1746, remove clutch pilot bearing from flywheel (Figure 49).

NOTE

It may be necessary to remove a small amount of material from the bottom of puller legs to permit installation of puller legs between flywheel and back side of pilot bearing.

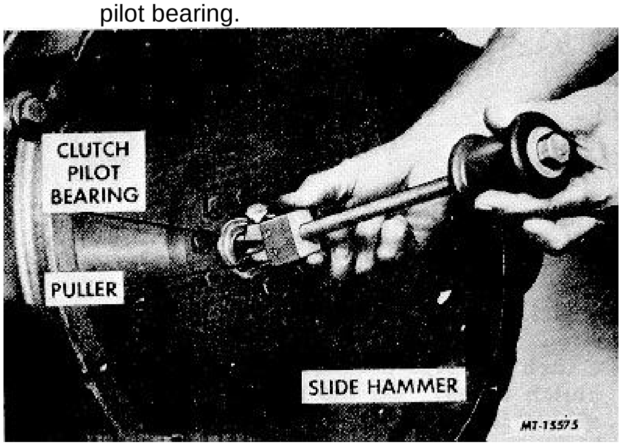

Fig. 49 Removing Clutch Pilot Bearing

42. Loosen flywheel mounting bolts and remove the flywheel assembly and roll pin from the crankshaft flange (Figure 50).

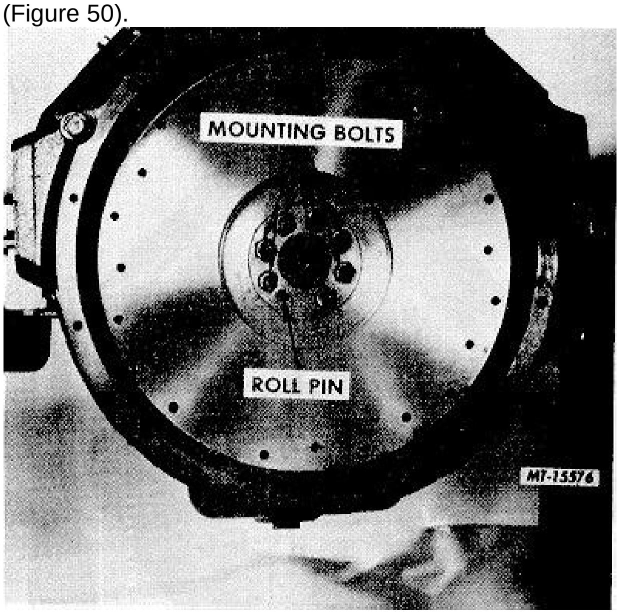

Fig. 50 Flywheel Mounting Details

43. Remove six capscrews and flat washers and remove flywheel housing (Figure 51).

NOTE

Use extreme care when removing flywheel housing, to avoid damaging roll pins used to align housing to crankcase.

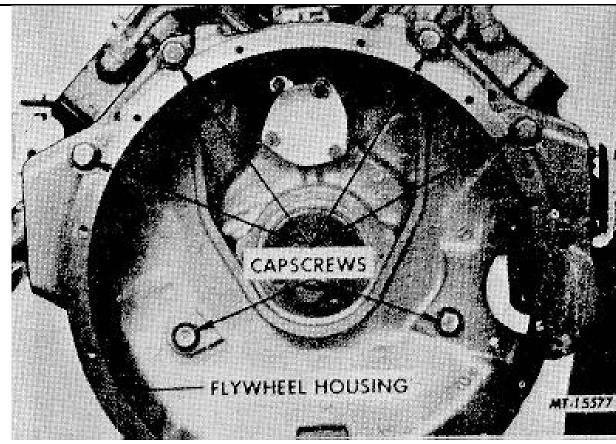

Fig. 51 Flywheel Housing Mounting Details

44. Loosen three capscrews and lockwashers and remove camshaft cover plate and gasket from end of block (Figure 52).

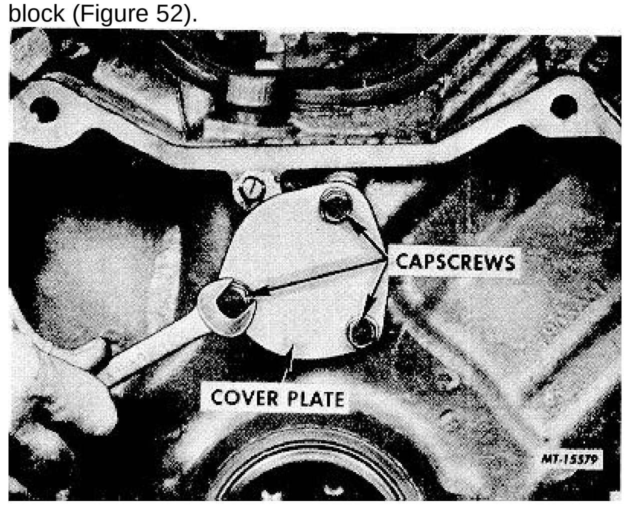

Fig. 52 Removing Camshaft Cover Plate

45. Use tappet remover tool SE-2097 to remove tappets (Figure 53).

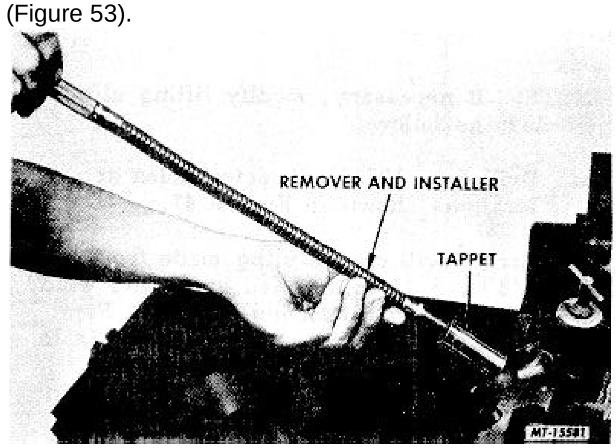

Fig. 53 Removing Tappet

46. Remove oil pan capscrews and remove oil pan and gasket.

47. On serial numbers before 51135, remove mounting nut, lockwashers, flat washers and bolts from oil pump screen brace and clamp (Fig. 54). Loosen oil pump mounting capscrews and remove oil pump from crankcase.

IMPORTANT

To permit oil pump removal, it is necessary to position the crankshaft rear counterweight away from the oil pump shaft.

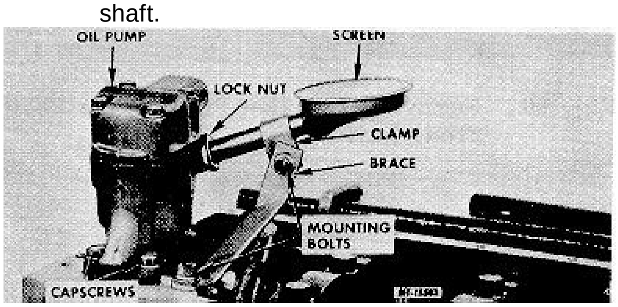

Fig. 54 Oil Pump Mounting Details for Engines Below Serial No. 51135

On engine serial numbers 51135 and up, loosen oil pump mounting capscrews and remove oil pump from the crankcase (Fig. 54A).

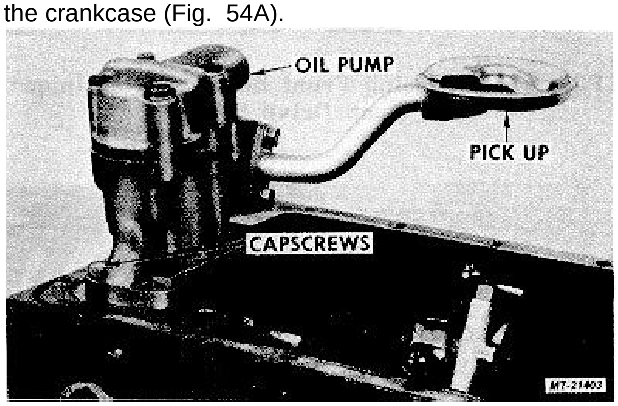

Fig. 54A Oil Pump Mounting Details for Engines With Serial No. 51135 and Up

48. Disconnect idler arm spring from hook in front cover and remove spring from idler arm. Loosen idler arm capscrew and remove idler arm and spacer from bracket (Figure 55).

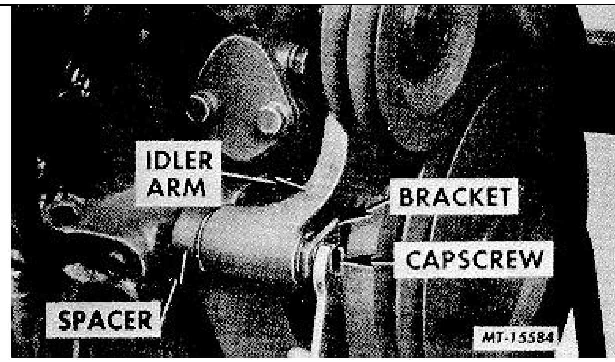

Fig. 55 Removing Idler Arm Assembly

49. Remove water pump pulley capscrews and remove pulley from hub. Remove water pump mounting screws and remove water pump and gasket from water pump body (Fig. 56).

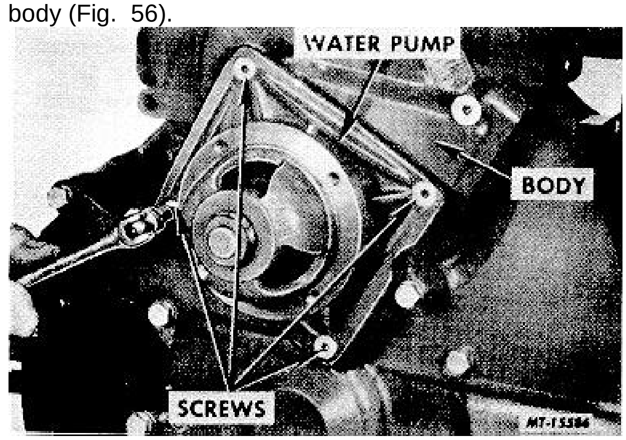

Fig. 56 Removing Water Pump

50. Remove water pump body mounting screws (Fig. 57). Lift water pump body and gasket from front cover.

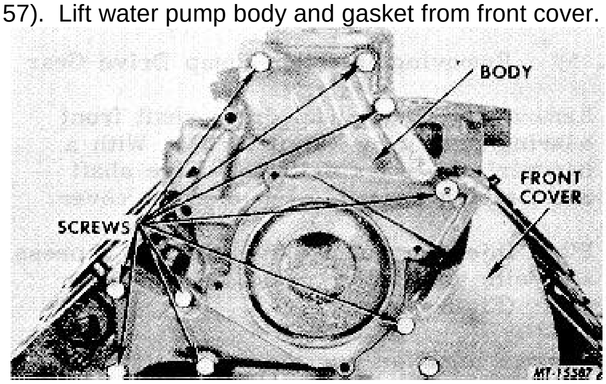

Fig. 57 Water Pump Body Mounting Details

51. Remove injection pump drive flange nut. Using puller SE-1368 and fingers, remove injection pump drive flange, retainer and grip springs (Fig. 58).

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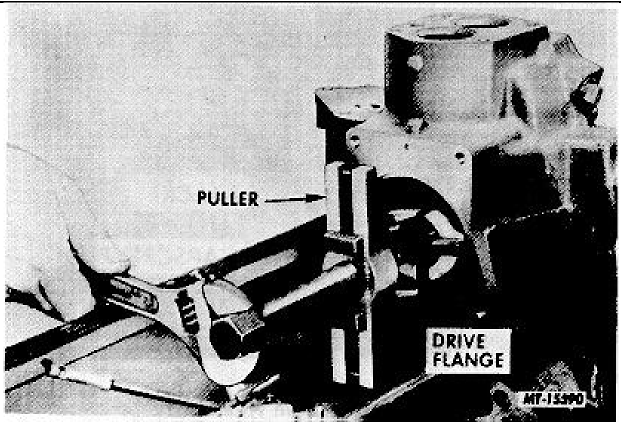

Fig. 58 Removing Injection Pump Drive Flange

52. Remove the injection pump drive gear mounting capscrews and lockwashers. With the use of a screwdriver, remove injection pump drive gear by inserting screwdriver in the injection pump oil return hole in back of gear housing and push drive gear off shaft (Figure 59).

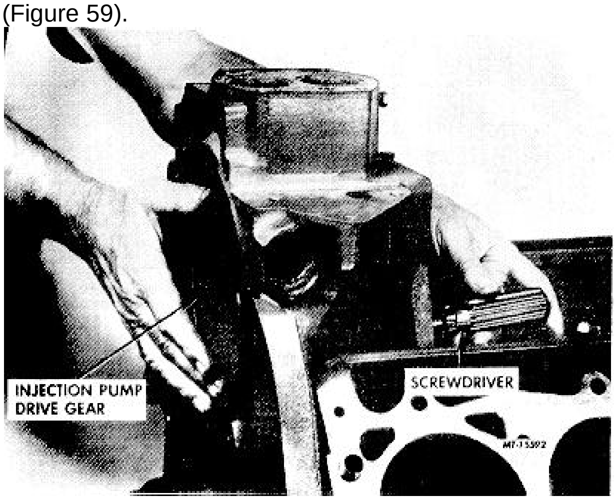

Fig. 59 Removing Injection Pump Drive Gear

53. Remove injection pump drive shaft front bearing snap ring (Figure 60). With a hammer and brass drift tap drive shaft and bearing assembly out of front cover.

54. Place injection pump drive shaft in a press and with an adapter press bearing from shaft (Figure 61).

55. Remove injection pump drive shaft rear bearing from front cover using SE-2098 remover together with handle from SE-1905 remover set (Figure 62).

56. Position a wood block between crankshaft counterweight and crankcase and remove crankshaft pulley nut and washer.

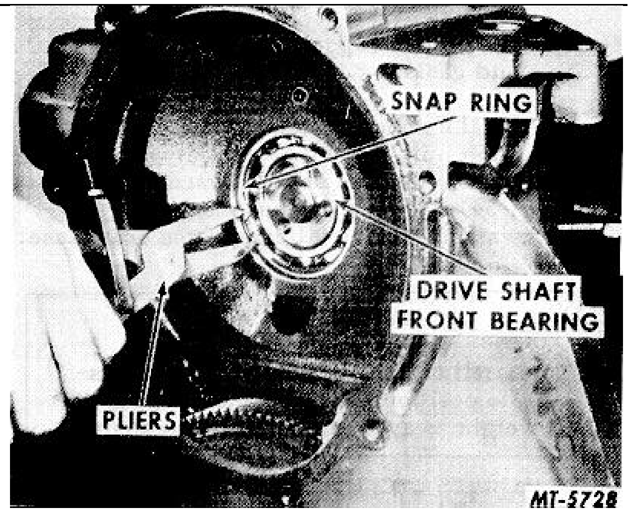

Fig. 60 Removing Injection Pump Drive Shaft Front Bearing Snap Ring.

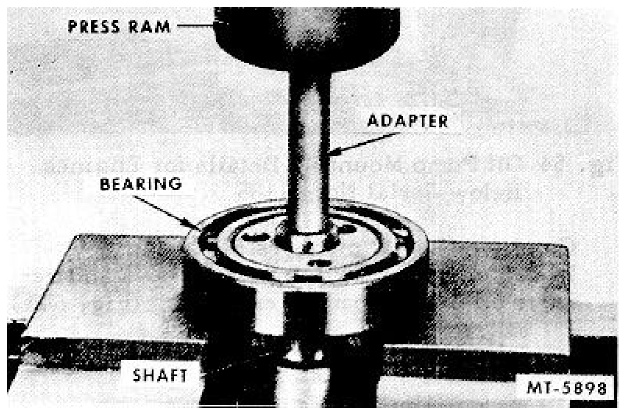

Fig. 61 Pressing Front Bearing From Injection Pump Drive Shaft

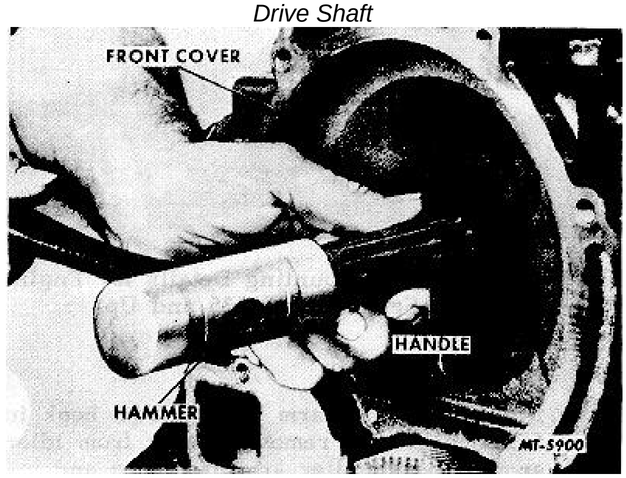

Fig. 62 Removing Injection Pump Drive Shaft Rear Bearing

With wood block still in position between crankshaft and crankcase, remove crankshaft pulley using SE-1368 puller (Figure 63).

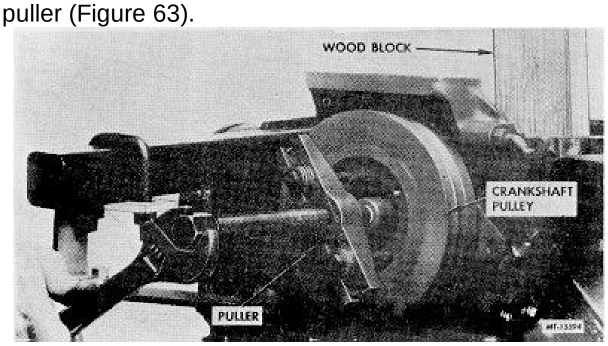

Fig. 63 Removing Crankshaft Pulley

57. If front seal wear sleeve on crankshaft pulley shows evidence of wear or damage, remove sleeve. This can be accomplished by placing crankshaft pulley in press and with an adapter (1-3/4" I.D. x 2-1/4" O.D. x 3" long), press the pulley from the wear sleeve. Be careful not to damage pulley hub surface when performing pressing operation.

An alternate method is to expand the wear sleeve by tapping with a flat hammer on the seal surface (Figure 64). Then with a pry bar underneath the flange of the wear sleeve, pry the sleeve from hub of crankshaft pulley. When performing the prying operation be sure not to nick, scuff or damage the hub surface.

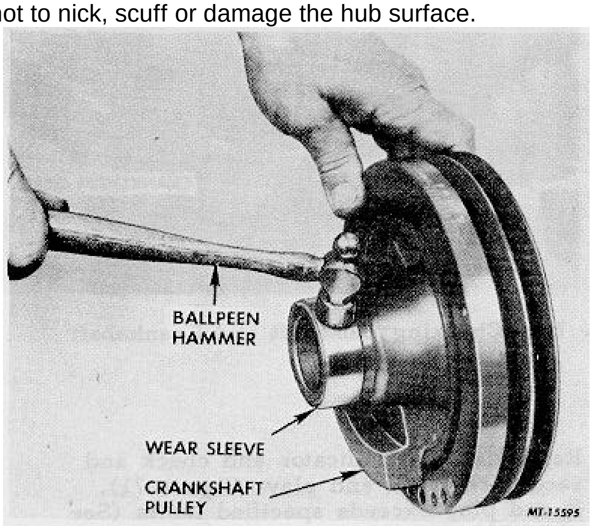

Fig. 64 Expanding Crankshaft Pulley Wear Sleeve for Removal

58. Remove two Nylok capscrews and lockwashers from rear of front cover (Figure 65).

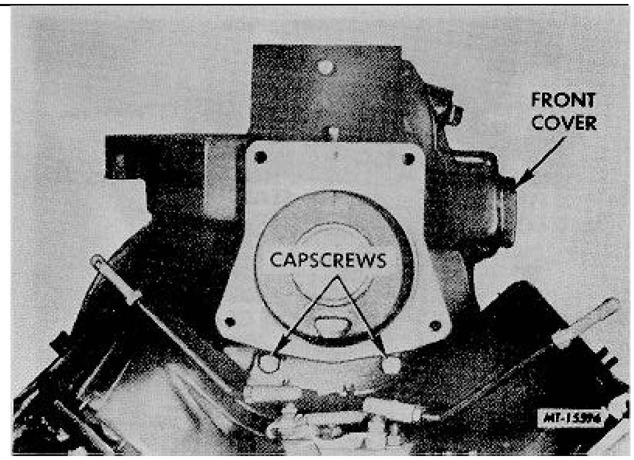

Fig. 65 Location of Nylok Capscrews at Rear of Engine Front Cover

59. Remove remaining front cover capscrews (Figure 66) except two. With help from an assistant, loosen the two capscrews and lift front cover and gasket off dowel pins in crankcase.

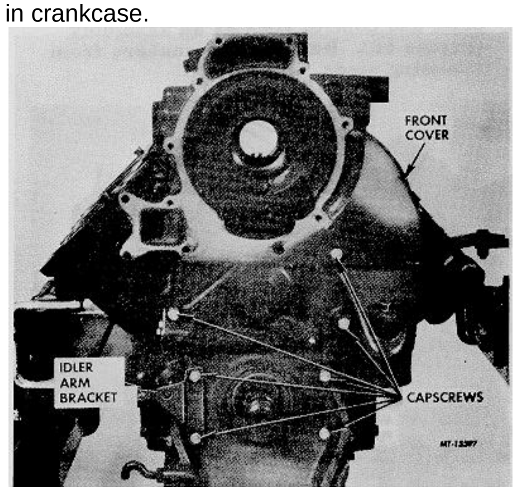

Fig. 66 Front Cover Mounting Details

60.. With a suitable drift and hammer remove front cover oil seal.

NOTE

When required, front cover oil seal can be removed for replacement without removing front cover by using SE-2091 oil seal puller (Figure 67).

To remove, pierce seal with point of screw on end of puller. Thread screw into seal. Apply slide hammer to pull seal from front cover.

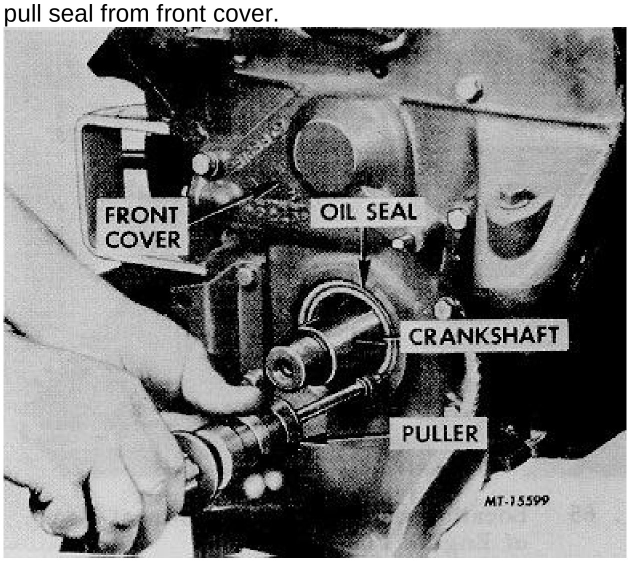

Fig. 67 Removing Front Cover Oil Seal Using SE-2091 Seal Puller

61. On engines equipped with swirl destroyer, remove spring, nuts and lockwashers and remove swirl destroyer control mounting plate and control rods as an assembly (Figure 68). Remove flat washers from mounting studs.

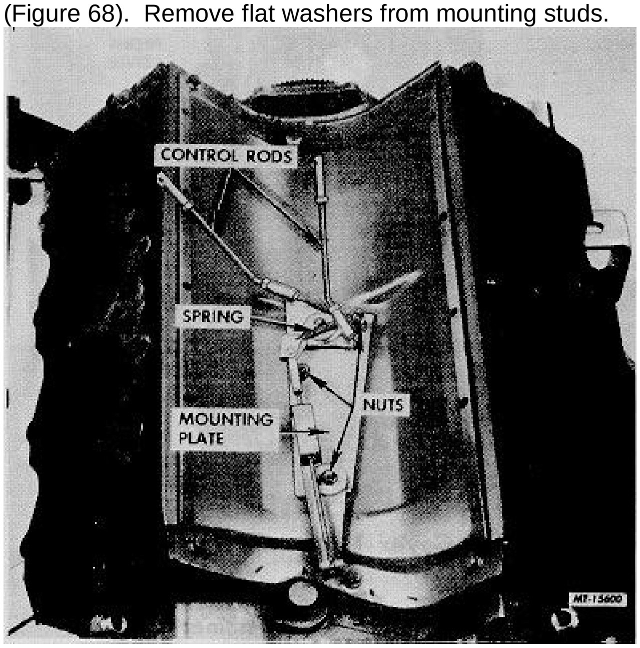

Fig. 68 Swirl Destroyer Linkage Removal (Early production engines only)

62. Remove capscrews and washers and lift off tappet cover with gasket (Figure 69).

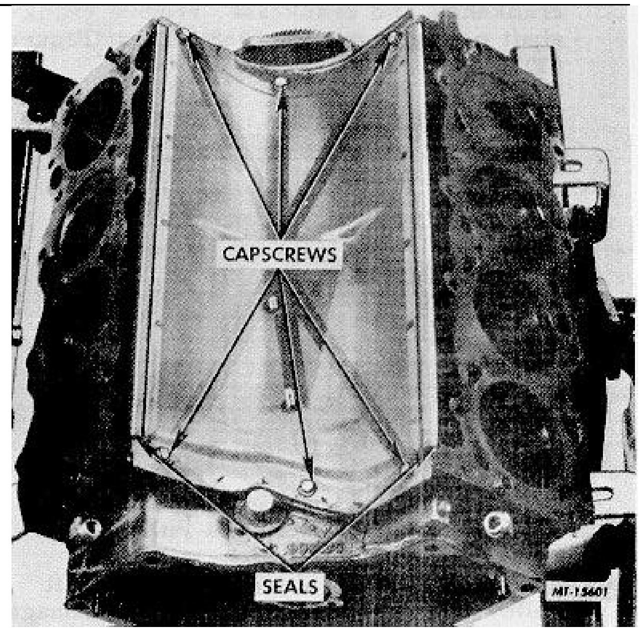

Fig. 69 Tappet Cover Removal

63. Mount dial indicator on front of engine and check and record camshaft gear-to crankshaft gear backlash (Figure 70). If backlash exceeds specified limits (See SPECIFICATIONS), timing gears should be replaced.

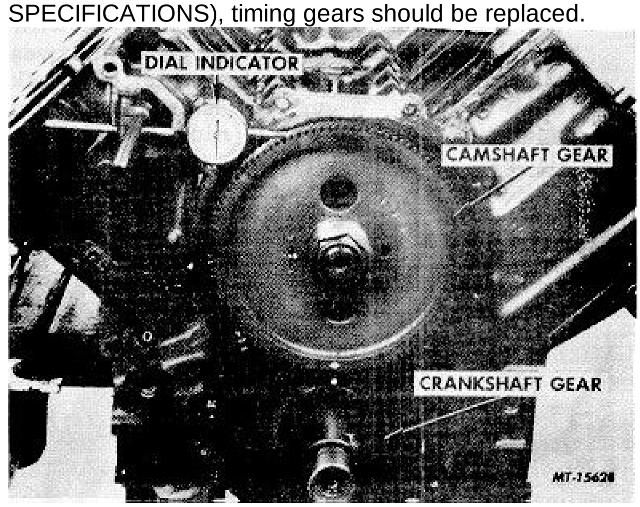

Fig. 70 Checking Camshaft and Crankshaft Gear Backlash

64. Reposition dial indicator and check and record camshaft end play (Figure 71). If end play exceeds specified limits (See SPECIFICATIONS) camshaft thrust plate should be replaced.

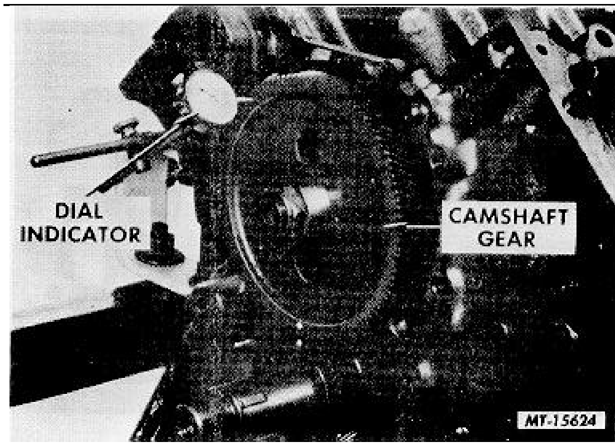

Fig. 71 Checking Camshaft End Play

65. Remove camshaft thrust plate capscrews (Figure 72). Remove camshaft gear nut. Install removal tool SE-1880 on threads of camshaft and remove camshaft, gear and spacer as an assembly (Figure 73).

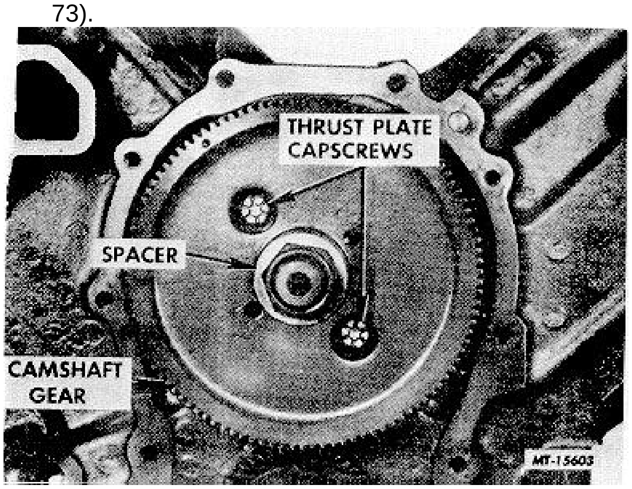

Fig. 72 Camshaft Thrust Plate Capscrews

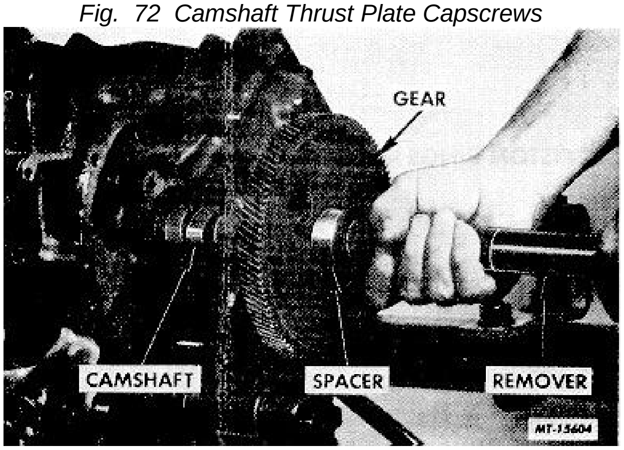

Fig. 73 Removing Camshaft, Gear and Spacer as an Assembly

NOTE

Where desired, camshaft, gear and spacer can be removed individually as follows:

a. Remove camshaft nut and spacer. Using puller SE-1368, remove camshaft gear (Figure 74).

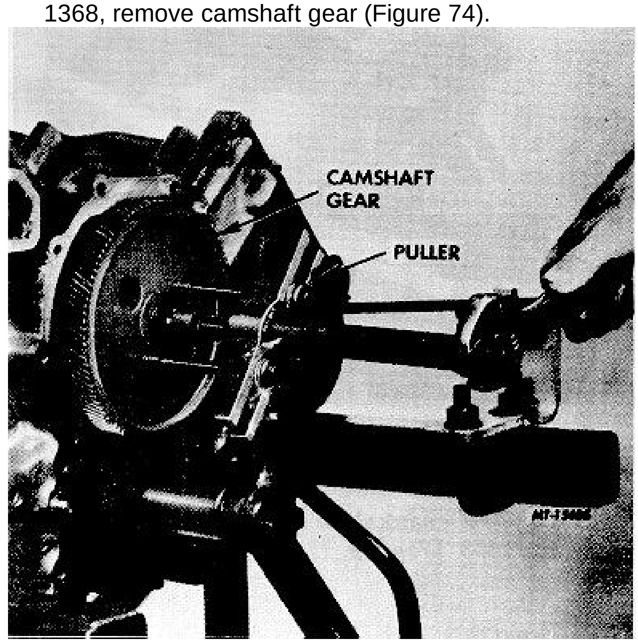

Fig. 74 Removing Camshaft Gear

b. Remove camshaft thrust flange capscrews.

c. Install remover tool SE-1880 on threads of camshaft and remove camshaft (Figure 75).

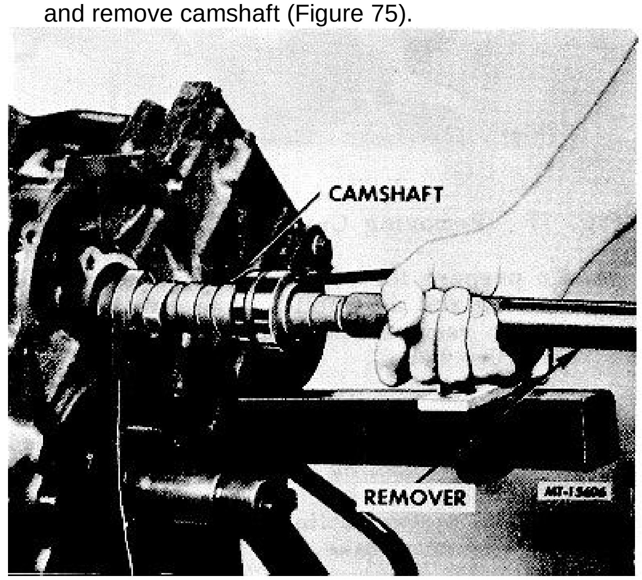

Fig. 75 Removing Camshaft

66. Using dial indicator, check and record crankshaft end play (Figure 76). End play exceeding specified limits (See SPECIFICATIONS) indicates that crankshaft thrust bearings or thrust faces are worn.

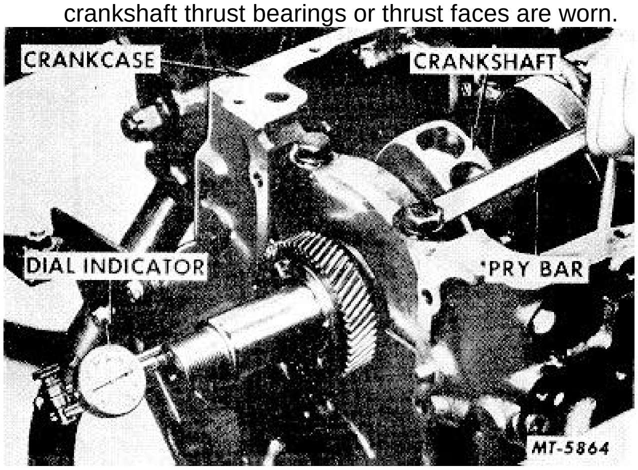

Fig. 76 Checking Crankshaft End Play

67. Remove crankshaft gear using puller SE-1368 (Figure 77).

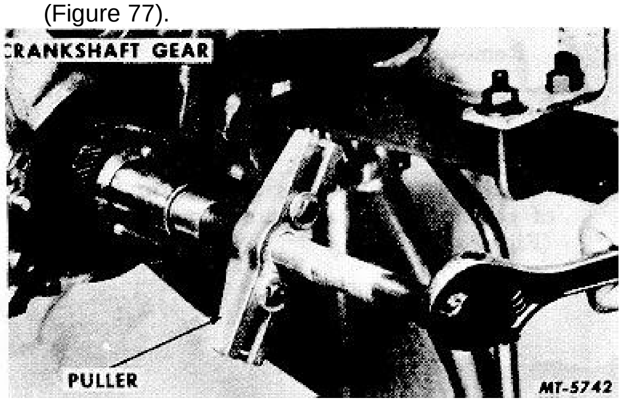

Fig. 77 Removing Crankshaft Gear

68. To prepare for removal of piston and connecting rod assemblies, use ridge reamer tool to remove wear ridges from tops of cylinder bores.

69. Rotate crankshaft to position the journals for removal of connecting rods assemblies and piston cooling nozzles (Figure 78).

Remove piston cooling nozzles from both sides of crankcase.

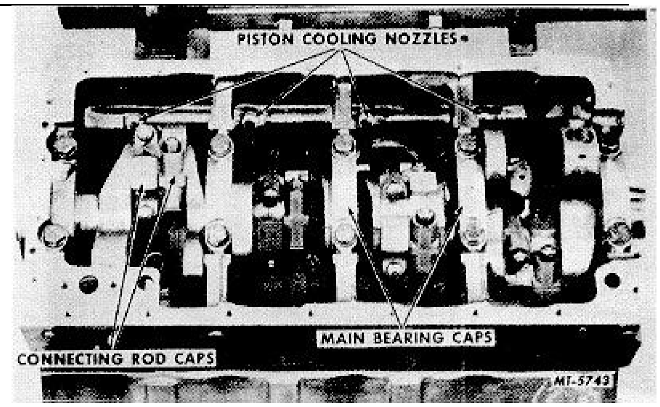

Fig. 78 Crankshaft Bearing Caps and Piston Cooling Nozzles

70. Remove each connecting rod bearing cap and push connecting rod and piston assembly from the cylinder bore (Figures 79 and 80). Replace cap and bearing inserts on rod so that identification numbers match.

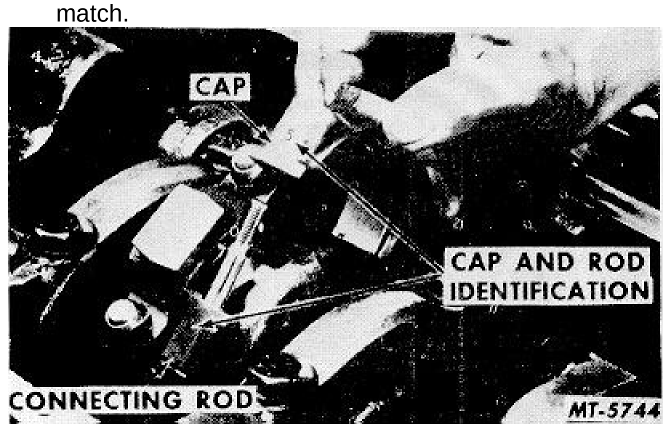

Fig. 79 Removing Connecting Rod Cap

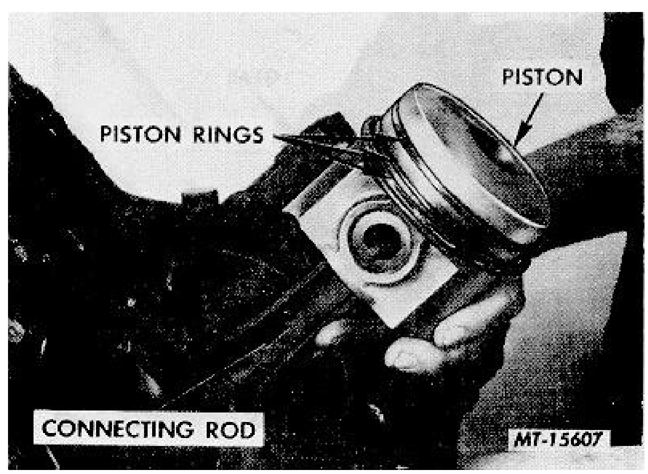

Fig. 80 Removing Piston and Connecting Rod

71. Remove self-locking bolts, tie bolts and seal washers from each crankshaft main bearing cap (Figure 81).

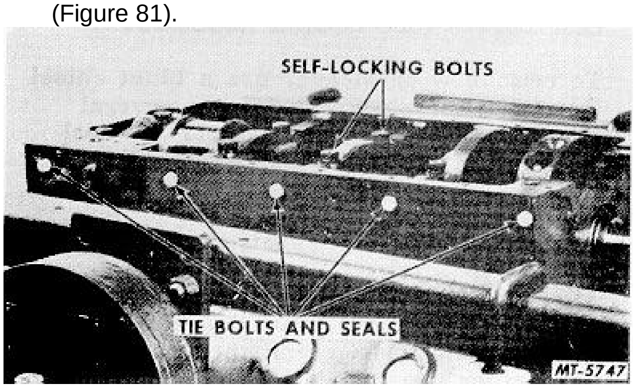

Fig. 81 Main Bearing Cap Bolts, Tie Bolts and Seals

72. Using remover tool SE-2093 and slide hammer SE-1746, remove main bearing caps (numbers 1, 2, 3 and 4) by inserting hook end of remover tool in horizontal hole and toward centerline of crankshaft (Figure 82).

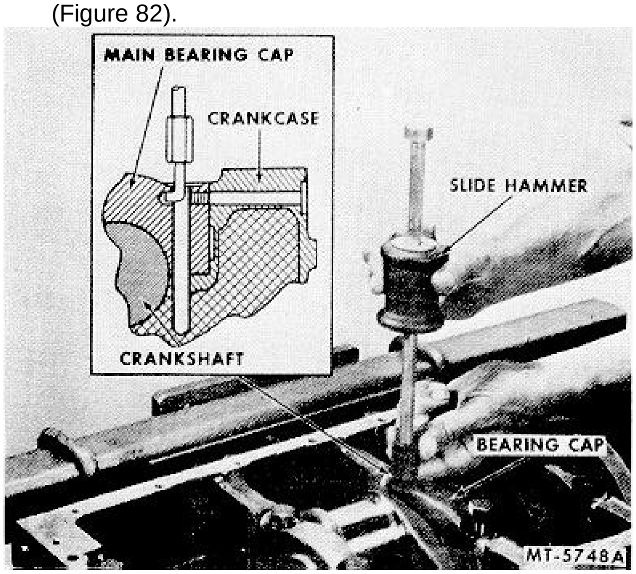

Fig. 82 Removing Main Bearing Cap (Nos. 1, 2, 3 and 4)

The crankshaft bearing caps are numbered to identify their position, and they must be reinstalled in their respective positions. The center (No. 3) main bearing cap accommodates a thrust flange to control crankshaft end play (Figure 83).

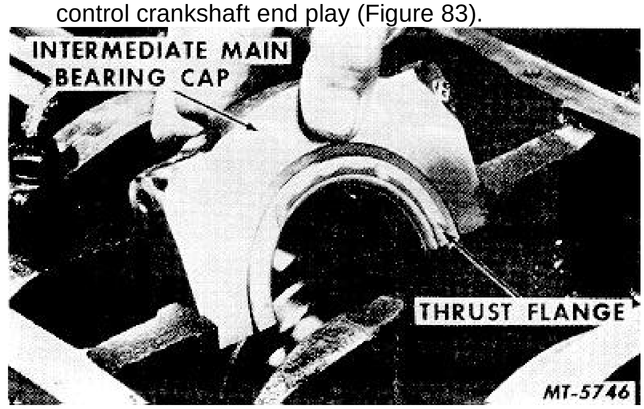

Fig. 83 Main Bearing Cap with Thrust Flanges (No. 3)

73. Use puller SE-1719 and adapter SE-1719-3 to remove rear (No. 5) main bearing cap (Figure 84).

Remove rear main bearing cap side seals and remove rear main bearing oil seal from crankshaft (Figure 85). The center (No. 3) main bearing cap accommodates a thrust flange to control crankshaft end play (Figure 83).

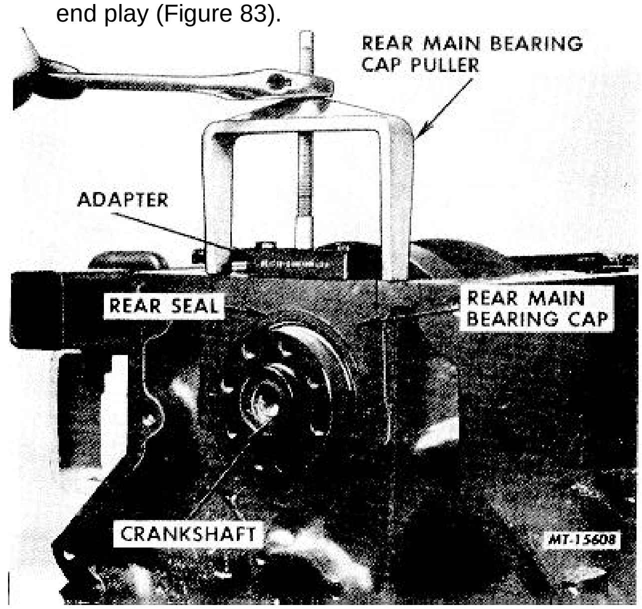

Fig. 84 Pulling Rear Main Bearing Cap (No.5)

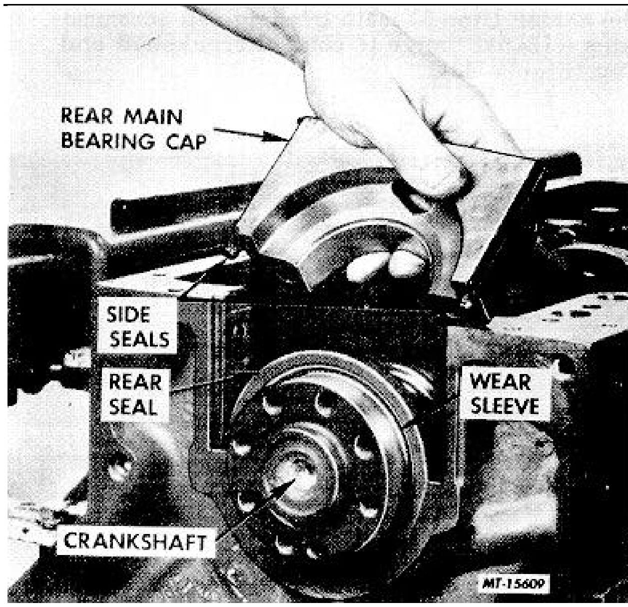

Fig. 85 Rear Main Bearing Cap Oil Seals

NOTE

When required, crankshaft rear main oil seal can be removed with engine in chassis by using SE-2091 oil sealer remover (Figure 86).

To remove, pierce seal retainer with point of screw on end of remover. Thread screw into seal. Apply slide hammer to pull seal from bearing cap.

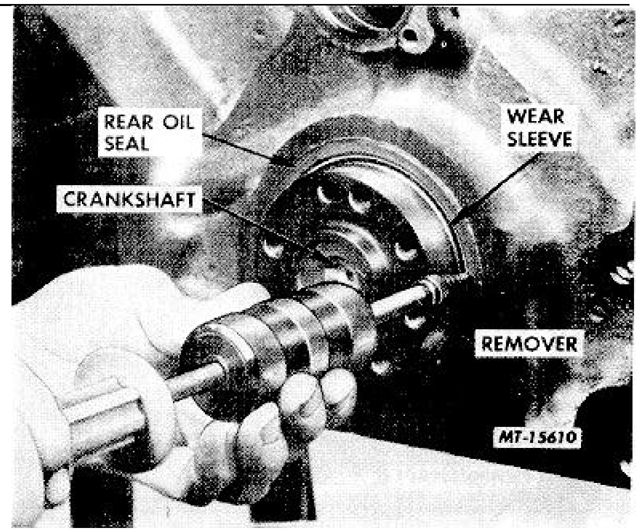

Fig. 86 Removing Rear Main Bearing Cap Oil Seal Using SE-2091 Seal Remover

74. Using rope sling, lift crankshaft up and out of engine crankcase.

75. Check rear oil seal wear sleeve on crankshaft. If wear sleeve shows more than one wear path, it should be replaced. Wear sleeves with only one wear path can be reused by recessing oil seal into crankcase bore. (See ENGINE ASSEMBLY.)

    To remove wear sleeve, use a blunt chisel to mark wear sleeve surface in several places, then with a flat hammer tap seal surface until sleeve expands sufficiently to be removed. Be careful when performing the cutting operation so not to nick, scuff or damage crankshaft flange surface.

    After engine has been disassembled, all parts must be thoroughly cleaned, inspected for wear and damage and then reconditioned for further use or replaced as necessary.

CLEANING, INSPECTION and RECONDITIONING

CYLINDER BLOCK AND CAMSHAFT BEARINGS

Cylinder Block

One of the most important phases of engine reconditioning is the thorough cleaning and inspection of the cylinder block.

Each machined surface of the cylinder block should be cleaned of all old gasket material. The pipe plugs which seal oil passages should be removed and all passages thoroughly cleaned.

Carefully inspect the cylinder block for scoring of cylinder walls, damaged bearing bores, cracks or water leaks. Small cracks may be found by coating suspected areas with a mixture of light motor oil and kerosene. After wiping area dry, immediately apply a coat of quick-drying liquid such as zinc oxide powder mixed with wood alcohol. Wherever cracks are present, a brown discoloration will appear in the white coating.

If necessary to replace an expansion type plug due to water leaks, drill a 1/2" hole in center of plug and remove by prying with a screwdriver or suitable tool.

Coat edges of plug with a suitable non-hardening sealing compound and install with concave side of plug toward the interior of cylinder block. Drive plug into place with a ball peen hammer.

The oil pump and tachometer drive shaft upper bearing should be checked for correct size. Specifications of the lower portion of this bore is 12.357-12.382 mm (.4865-.4875") inside diameter. If diameter does not meet these specifications, bearing should be replaced as follows:

1. Using a drift, carefully drive bearing out of crankcase from underside.
2. Align punchmark on new bearing with rib on crankcase (Figure 87). This will index oil hole in bearing with oil passage in crankcase.
3. Press bearing in flush with top of crankcase.

Each cylinder bore should be checked for wear, out-of-round and taper using an inside reading micrometer SE-686 or dial bore gauge. SE-2331 (Figure 88).

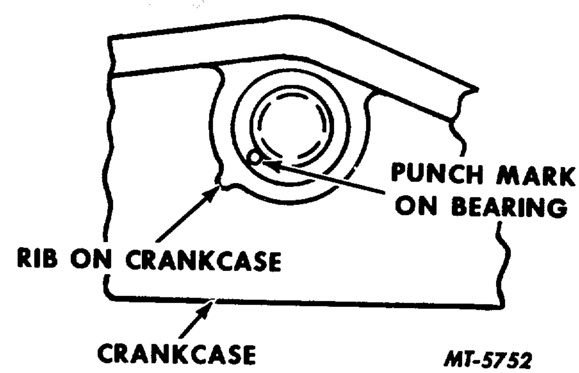

Fig. 87 Installation of Oil Pump and Tachometer Drive Shaft Bearing in Crankcase.

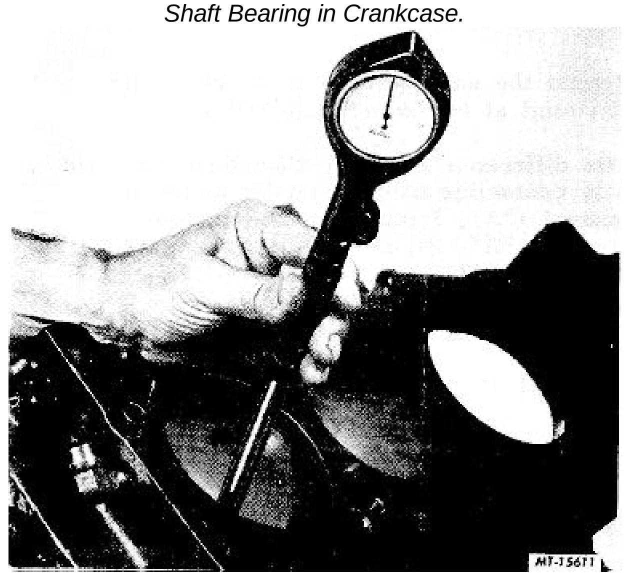

Fig. 88 Checking Cylinder Bore with Dial Bore Gauge

When measuring cylinder bores, main bearing caps must be in place with bearing cap and tie bolts tightened to specified torque. See "TORQUE CHART."

Measure diameter of each cylinder bore at top of ring travel at right angle to centerline of crankshaft ("A", Figure 89). Record readings.

Next, measure each bore at top of ring travel with gauge aligned with centerline of crankshaft ("B", Figure 89). Record readings.

The difference between each corresponding "A" and "B" reading is the out-of-round condi-

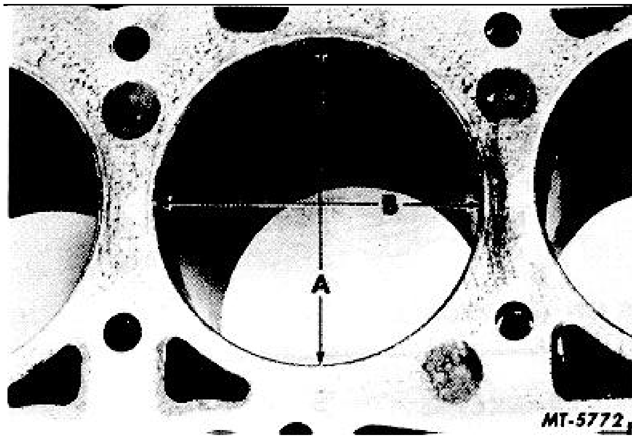

Fig. 89 Measurements for Checking Cylinder Bore Out-of-Round

tion at the top of the ring travel for that cylinder.

Repeat the same procedure to check for out-of-round at bottom of ring travel.

The difference between diameters (at right angle to centerline of crankshaft) at top of ring travel ("A", Figure 90) and bottom of ring travel ("A", Figure 90) is the taper of the cylinder bore.

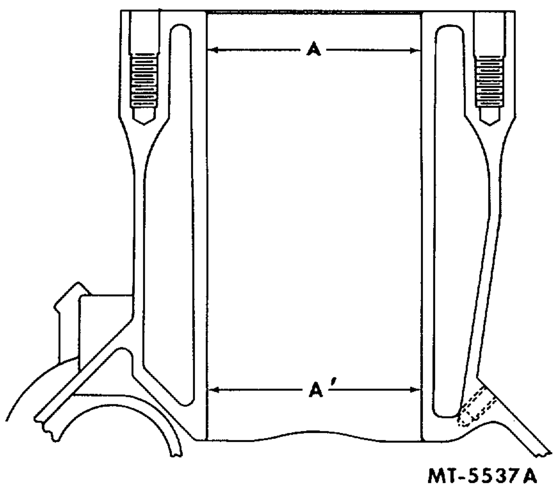

Fig. 90 Measurements for Checking Cylinder Bore Taper

If cylinder bore wear does not exceed 0.05 mm (.002") out-of-round or 0.127 mm (.005") taper, new standard size service piston rings will give satisfactory performance, provided the piston clearance is not excessive. When standard size piston rings are to be installed, cylinder bore should be deglazed.

If cylinder bore wear exceeds specified limits or if cylinder bores are scored or damaged, it will be necessary to rebore the cylinders to oversize diameter. Oversize selected should be large enough to permit cleaning up the cylinder bore and provide proper piston running clearance.

Deglazing Cylinder Bores

Cylinder bores can be deglazed by using the proper size SE-2314 glaze breaker brush (Figure 91).

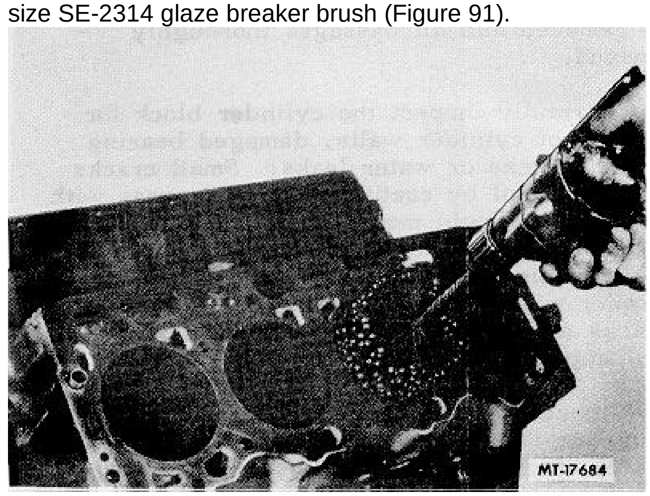

Fig. 91 Deglazing Cylinder Walls

This silicone carbide-tipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on the cylinder wall surface in a single operation. The brush contours itself to the cylinder wall and conditions the wall surface without altering cylinder bore. The glaze breaker brush is driven by a low speed (350-500 RPM) electric drill. Most 3/8 inch capacity drills are satisfactory.

The brush should be lubricated with SAE-30 engine oil to produce a desireable wall finish. The lubricant also controls airborne abrasive particles which can be easily wiped from cylinder bore with a cloth.

Stroke the brush up and down in the bore at a rate of 30-40 strokes per minute for 15-20 seconds per cylinder bore. In most instances 20 seconds is adequate time for the brush to break cylinder wall glaze and produce a crosshatch pattern on the cylinder wall surface.

Thoroughly clean cylinder bore walls after deglazing. Wipe as much of the abrasize deposits from the wall as possible. Then swab out each abrasive-coated cylinder with SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white cloth shows no evidence of discoloration when wiped through the cylinder bore. This usually requires three or more complete swabbing operations.

NOTE

Do not use gasoline, kerosene or commercial cleaner to clean cylinders. Solvents of this nature will not remove abrasives from the walls which can cause rapid engine wear and ring failure.

Reboring and Honing Cylinder Bores:

SE-1434 engine roll-over stand can be readily adapted to hold the cylinder bores in a vertical position for boring and honing (Figure 92).

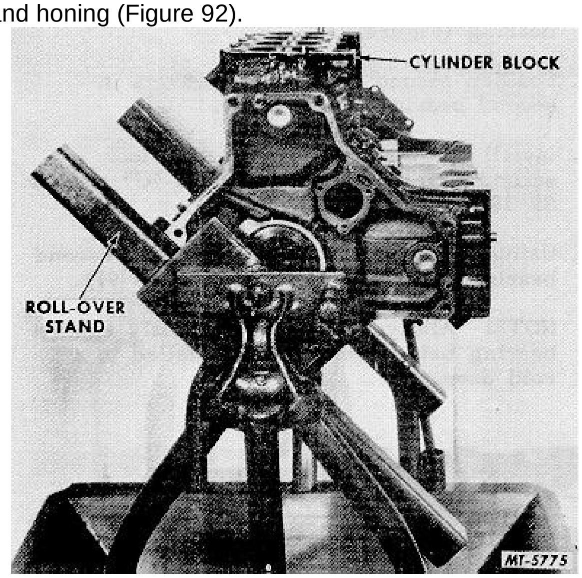

Fig. 92 Cylinder Bores Turned Vertically for Boring and Honing

Attach a 2" x 3" x 13" long angle iron to one of the roll-over rails. Use the engine oil pan as a template (Figure 93) and drill four holes as indicated by arrows. The cylinder block is then mounted across the rotating rails and turned 45 degrees to position the cylinder bores vertically for boring and honing operation. The angle iron will not interfere with the engine mountings and can be left permanently attached. If desirable, a suitable floor stand can be constructed to support the cylinder block.

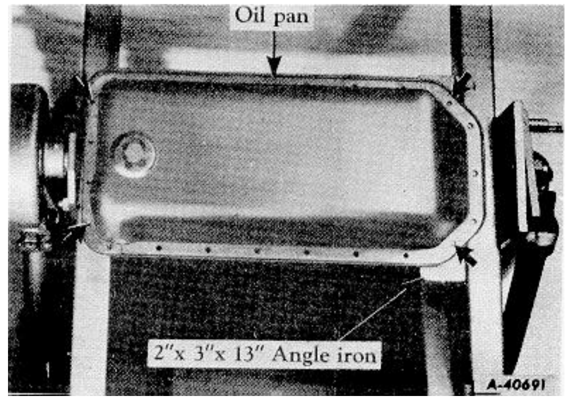

Fig. 93 Using Oil Pan as Drilling Template

To avoid possible bore distortion, main bearing caps must be in place with bearing cap bolts and tie bolts tightened to specified torque when boring and honing cylinders.

Use boring equipment such as the SE-1399 boring machine (Figure 94) to enlarge cylinder bores. When oversizing cylinders, bore to within 0.07 mm (.003") of required oversize diameter. This will allow enough stock for final honing to obtain exact clearance for selected oversize pistons.

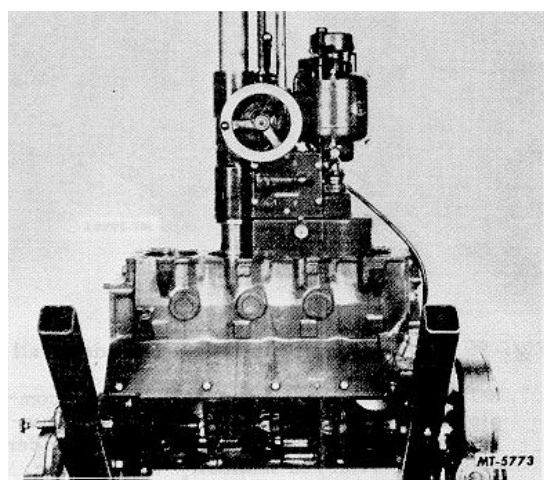

Fig. 94 Reboring Cylinder

Hone cylinder bores as needed to obtain specified piston running clearance using honing equipment such as the SE-784 cylinder hone (Figure 95).

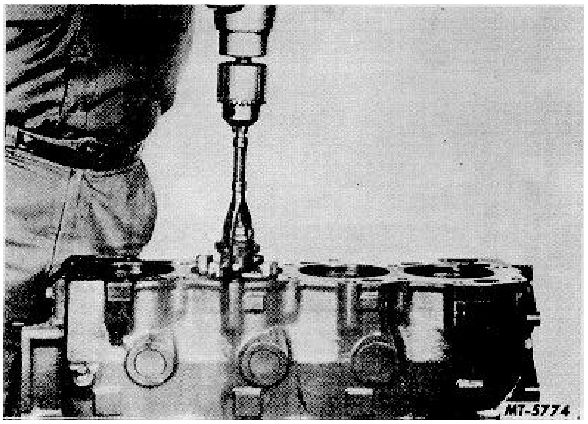

Fig. 95 Honing Cylinder Bore

When performing honing operation, hone should be stroked up and down to produce a cross-hatch pattern on cylinder wall surface (Figure 96). The faster hone rotates, the faster it must be stroked up and down to produce desired cross-hatch pattern.

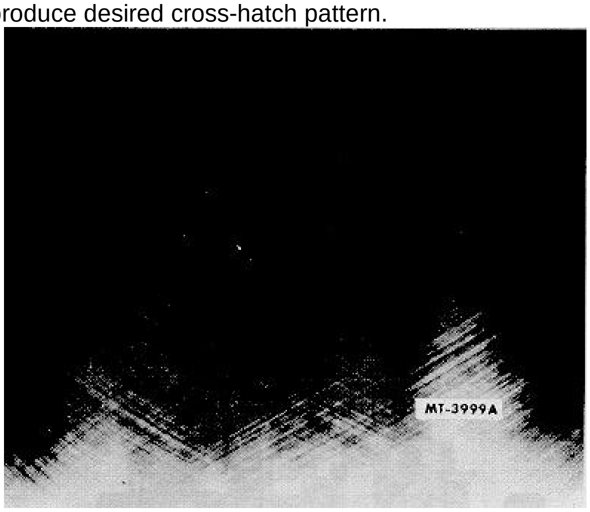

Fig. 96 Cross-hatch Finish on Cylinder Wall

NOTE

After the honing operation is completed, the sharp, burred edge that develops at the bottom of a new honed cylinder should be removed manually with emery cloth.

Thoroughly clean block and cylinder bores after honing. Wipe as much of the abrasive deposits from the cylinder wall as possible. Then swab out each abrasive-coated cylinder with clean SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white rag shows no evidence of discoloration when wiped through the cylinder bore.

This usually requires three or more complete swabbing operations.

NOTE

Do not use gasoline, kerosene or commercial cleaner to clean cylinders. Solvents of this nature will not remove. abrasives which can cause rapid engine wear and ring failure.

Camshaft Bearings

Using telescoping gauge and micrometer, check camshaft bearings for wear and proper running clearance. (See SPECIFICATIONS.) If bearing clearance exceeds specified limits, replace bearings. This can be accomplished using camshaft bearing remover and installer tool set SE-1887 with slide hammer and adapter from puller set SE-1879 as follows:

1. Position front adapter, SE-1897-3 in front bearing (Figure 97).
2. Position second adapter, SE-1897-4 in second bearing (Figure 97).
3. Install bar through adapters and lock second adapter on the bar with "C" washer SE-1897-2
4. Using front adapter as a pilot, pull second bearing with slide hammer (Figure 97).

NOTE

Always hold adapter firmly against bearing being removed or installed to avoid damage.

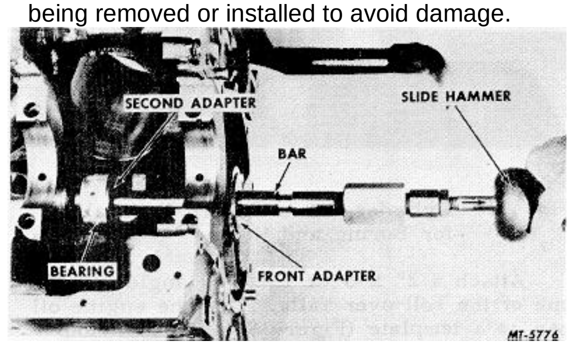

Fig. 97 Removing Second Camshaft Bearing

5. Position new bearing on second adapter and "C" washer in front of adapter (Figure 98). Align oil holes and push in second bearing.
6. Remove "C" washer and use second adapter as a pilot. Remove front bearing by driving bearing into case (Figure 99).

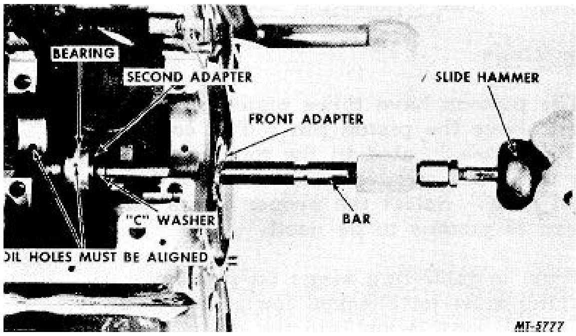

Fig. 98 Installing Second Camshaft Bearing

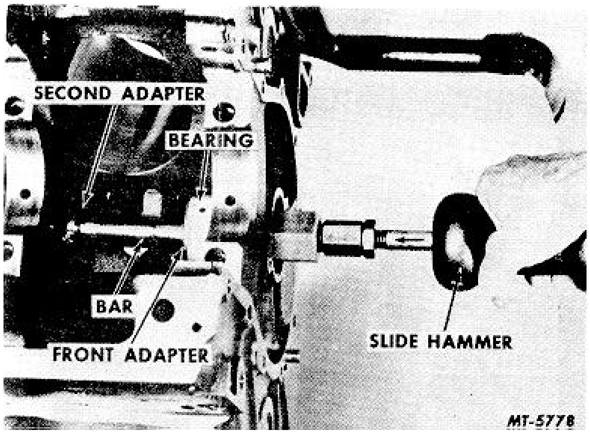

Fig. 99 Removing Front Camshaft Bearing

7. Remove bar and front adapter. Position new bearing on front adapter with chamfered side toward case. Slide bar into case and through second adapter serving as a pilot (Figure 100).

8. Align oil holes and drive in front bearing (Figure 100).

NOTE

Oil hole drilled through groove in bearing must align with main bearing oil feed hole.

9. Using third adapter SE-1897-5 and rear adapter SE-1897-6 and working from rear of crankcase, install third and rear bearings in the same manner as described above for front and second bearings.

NOTE

Oil hole in groove of rear bearing must align with feeder hole in crankcase.

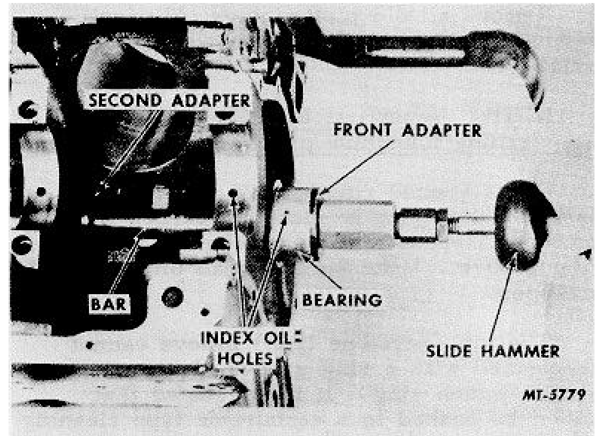

Fig. 100 Installing Front Camshaft Bearing

PISTONS, PISTON PINS, PISTON RINGS AND CONNECTING RODS

Pistons

To disassemble piston from connecting rod assembly remove piston pin retaining snap rings (one on each side of piston) by using snap ring removing pliers (Figure 101). Push piston pin out with thumb. (It may be necessary to tap pin lightly to remove.) After the pin is removed, separate piston from connecting rod, taking precautions to see that parts are marked so they may be reinstalled in their respective cylinder.

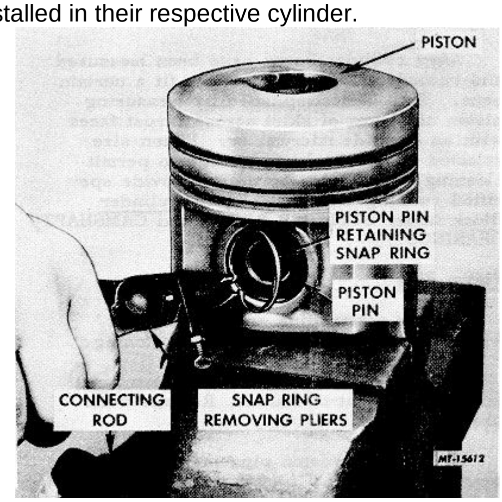

Fig. 101 Piston Pin Removal

Remove all old piston rings. Immerse piston in cleaning solvent and clean thoroughly.

NOTE

Never use a caustic solution for cleaning aluminum pistons.

Use a special ring groove cleaner or broken piston ring to clean all carbon from second compression ring groove and oil ring groove. Make sure that all oil holes are open.

The top (keystone type) groove cannot be cleaned with a ring groove cleaner or broken piston ring. It is suggested that piston be soaked in a carburetor type cleaning solution and softened deposits removed from top groove by running a heavy cord down in and around groove.

Inspect pistons for scuffed or scored skirts or cracked worn ring lands, discarding any showing such conditions.

Check fit of piston pins in pin bores of pistons. If pin bores are worn beyond specified limits, replace pistons. To select correct size pistons for an engine overhaul, size of the cylinder bore diameters must be determined first. This can be accomplished with an inside reading micrometer or dial bore gauge. Each bore should be measured at top of ring travel and lower end of ring travel both parallel and at right angles to the crankshaft.

After cylinder bores have been measured and recorded, select a piston to fit a certain bore. This is accomplished by measuring piston at bottom of skirt across thrust faces with an out side micrometer. Piston size selected should be large enough to permit cleaning up cylinder bore and provide specified running clearance. (See Cylinder Block under CYLINDER BLOCK and CAMSHAFT BEARINGS.)

Piston Pins

Inspect piston pins and replace any which show signs of corrosion or etching. Using a micrometer, check piston pins for wear and out-of-round. Replace worn pins.

Check fit of piston pins in pistons and connecting rods. If piston pin bores of pistons are worn excessively, replace pistons. If piston pin bushings in connecting rods are worn or out-of-round, replace bushings. (See Connecting Rods.)

Piston Rings

The pistons have three piston rings located above the piston pin. The compression rings are located in the top grooves, while the lower groove accommodates the oil control ring. Select the proper rings for the size of pistons to be used.

Prior to installing rings on pistons, each ring must be checked for proper ring gap. Push ring down into the cylinder bore, making sure ring is square with cylinder wall. Extreme care should be used during this operation. Check space or gap between the ends of ring with a feeler gauge (Figure 102). Ring gap should be within specified limits (See SPECIFICATIONS).

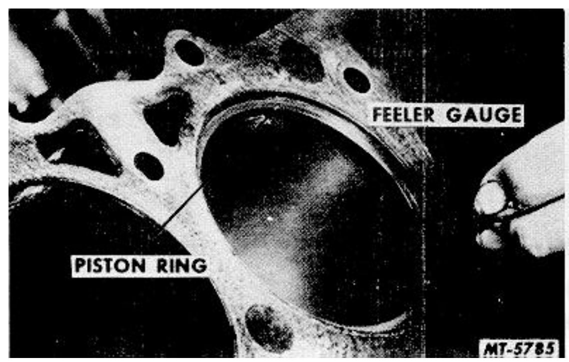

Fig. 102 Checking Ring Gap

If gap is not within specified limits, try another ring for fit.

NOTE

Do not attempt to alter gap of chrome-faced rings by filing ends of rings. This will damage the chrome plating.

Each ring should be fitted and checked in the cylinder in which it is to be used and marked accordingly.

Second compression ring and oil control ring should be checked for side clearance in the groove of the piston on which they are to be installed. This is done by placing outer edge of ring in the piston groove, rolling ring entirely around piston to make sure there is no binding and ring is free in the groove. With a feeler gauge, check side clearance of each ring in its respective groove (Figure 103). See SPECIFICATIONS for proper clearance.

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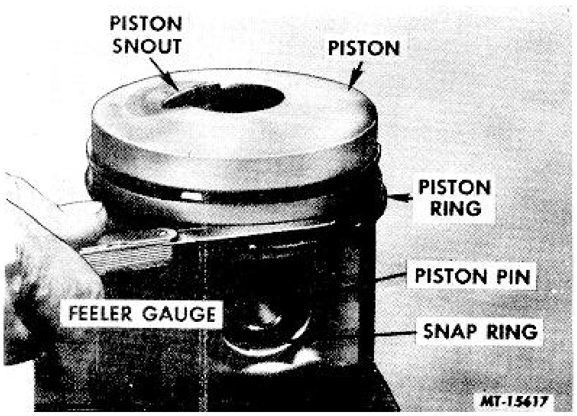

Fig. 103 Checking Ring Side Clearance

Prior to installing keystone type top compression piston, top ring groove must be checked for wear. Insert Perfect Circle Piston Ring Gauge No. 1 (1/8 x 15 degree) in top ring groove (Figure 104) if one or both shoulders of gauge touch the side of the piston, piston must be replaced. Measurement should be made at several points around groove circumference.

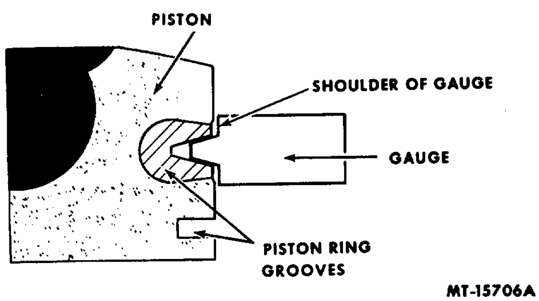

Fig. 104 Checking Top (Keystone) Ring Groove Wear

Assemble rings on pistons to which they were fitted by using piston ring expander tool SE-1149-3. This type of tool is recommended to avoid over-expanding and to avoid distortion (Figure 105). General practice when installing piston rings is to stagger the ring gaps. For further information refer to instructions furnished with service ring sets.

Connecting Rods

During manufacture, the connecting rods are subjected to a special heat-treating process known as "tufftride". The "tufftride" process

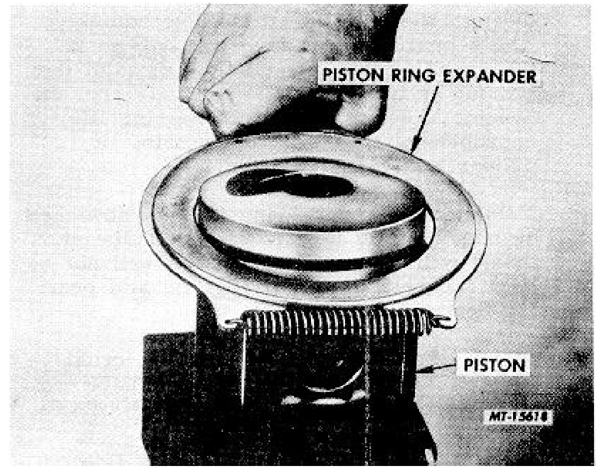

Fig. 105 Installing Piston Ring

is applied after the connecting rod has been finished machined and imparts a very hard surface to the rod.

Because of this special hardening of the connecting rod, no attempt is to be made to straighten or in any way bend the rod. To do so will cause minute fractures or cracks in hardened surfaces which will in turn lead to rod breakage.

When working with rods, use care to prevent rough handling, which could nick or notch rod surfaces and destroy the "tufftride" hardening. Rods must not be filed, ground or damaged in any way.

At the time of engine overhaul, connecting rods should be thoroughly cleaned and inspected for defects as outlined below.

1. Check connecting rod alignment on equipment such as the SE-1099 alignment checking fixture. Follow equipment manufacturer's instructions. Piston pin bore and connecting rod bearing bore must be parallel within .013 mm (.0005"). Replace rods that are bent. Do not attempt to straighten rods.

2. The connecting rod bearing plays a major role in distributing the proper amount of oil to piston pin, cylinder walls, piston and piston rings. This is known as oil throw-off, and the condition of the connecting rod bearing determines how well the lubrication operation is performed. Where bearing clearance is more than specified, an abnormal amount of oil is thrown onto cylinder walls, causing increased oil consumption and low oil pressure due to oil passing

through the bearing surfaces too quickly. Where bearing clearances are less than the specified amount, oil flow through the bearing is insufficient to properly cool the bearing, resulting in short bearing life, improper oil throw-off and scoring of pistons and cylinder walls.

If connecting rod bearing bore is stretched or out-of-round beyond specified diameter, insert will be out-of-round and will not be held securely in connecting rod and bearing "crush" may be lost.

NOTE

For definition of bearing "crush" see <u>Crankshaft Bearings</u> under CAMSHAFT, CRANKSHAFT and RELATED COMPONENTS.

A very thorough inspection of the connecting rod bore is necessary. This inspection consists of the following:

<u>Bore Size</u>

With connecting rod cap installed and bolts tightened to specified torque, bearing bore (Figure 106) should be within specified limits (See SPECIFICATIONS).

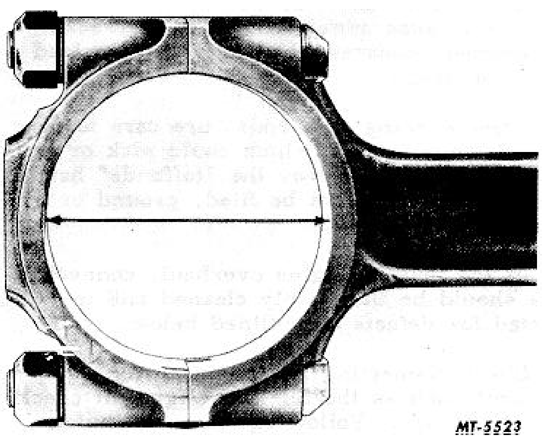

Fig. 106 Connecting Rod Bearing Bore Measurement

<u>Roundness</u>

With connecting rod cap installed and bolts tightened to specified torque bearing bore out-of-round (Figure 107) should not exceed specified limits (See SPECIFICATIONS).

<u>Straightness</u>

Check for taper in bearing bore (Figure 108). Taper should exceed limit given in SPECIFICATIONS.

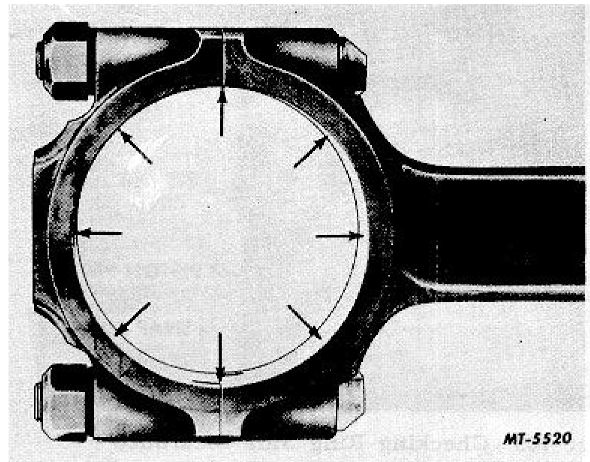

Fig. 107 Connecting Rod Bearing Bore Out-Of-Round Measurement

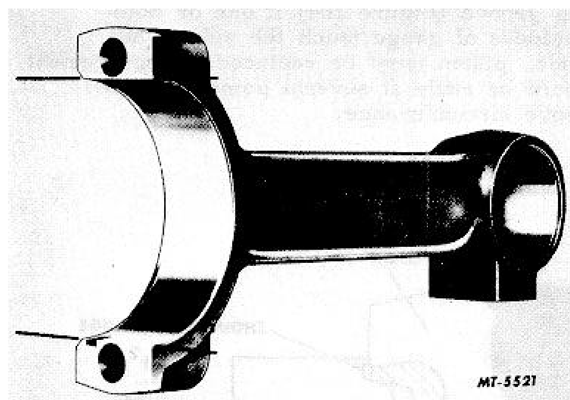

Fig. 108 Connecting Rod Bearing Bore Taper Measurement

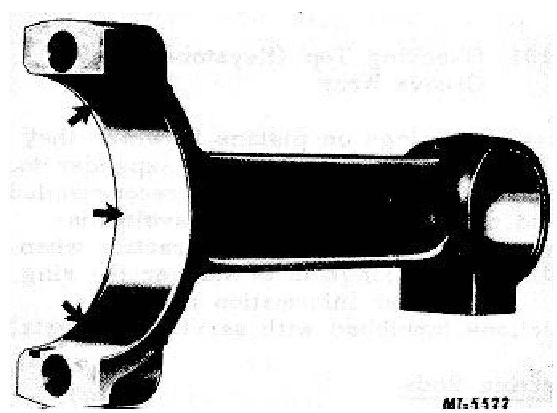

Fig. 107 Connecting Rod Bearing Bore Surface Finish

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Surface Finish: The bearing insert contact surface must be smooth (Figure 109) without indication of uneven bearing contact or movement of bearing in bore.

The precision gauge furnished with honing machine SE-2218 or accurate bore gauge SE-2087 (Figure 110) can be used to inspect condition of connecting rod bearing bore.

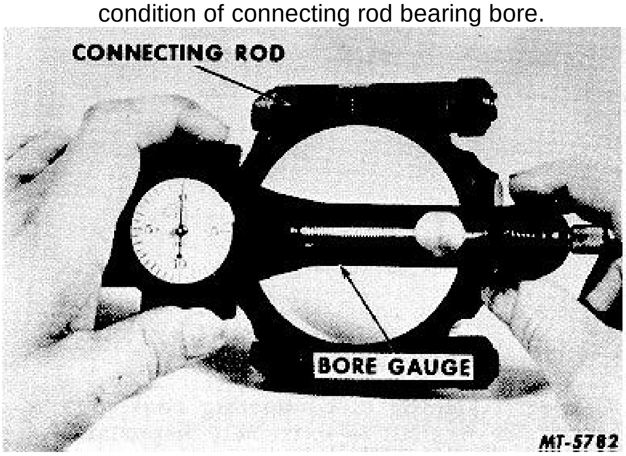

Fig. 110 Checking Connecting Rod Bearing Bore

If connecting rod bearing bore does not pass the above inspection, connecting rod must be replaced.

NOTE: When replacing connecting rods, mark (number) new rods and caps to correspond with old parts being replaced.

3. Check fit of piston pin in connecting rod piston pin bushing. If bushing is worn or out-of-round, replace bushing as follows:

a. Insert remover end of SE-2417 remover/ installer tool into bushing. Position tool and connecting rod in press using a piece of tubing 5.08 cm (2") O.D. x 4.4 cm (1.75") I.D. x 5.08 cm (2") long as a support (Figure 111). Press bushing out of rod.

b. Place new bushing on installer end of SE-2417 remover/installer tool. Using support plate SE-1033, position connecting rod in press with large chamfer side of connecting rod bearing bore down (Figure 112). Lubricate O.D. of bushing with a commercial press fit lubricant or engine oil. Align split of bushing on a horizontal plane with balance boss of rod

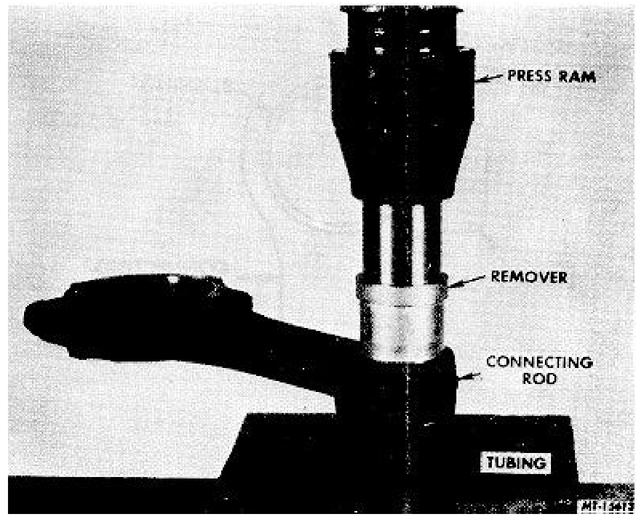

Fig. 111 Removing Piston Pin Bushing from Connecting Rod

(Figure 113) and press bushing into rod until shoulder of installer tool is firmly seated against rod.

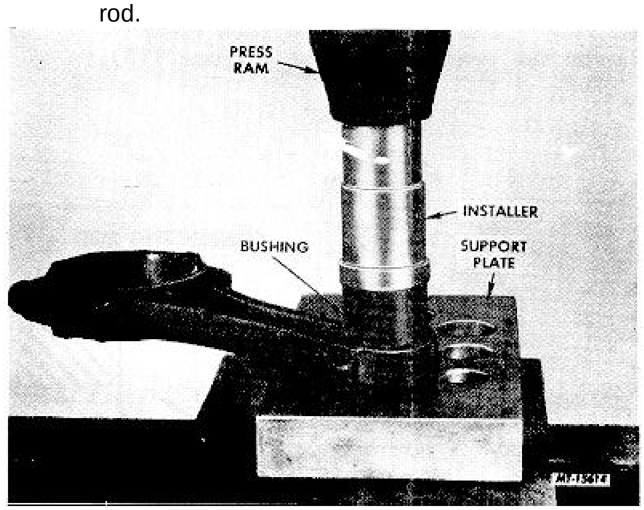

Fig. 112 Installing Piston Pin Bushing in Connecting Rod

c. Ream or hone new piston pin bushing to provide a hand push piston pin fit.

To assemble piston to connecting rod, position rod into piston so that connecting rod bearing locators (tangs) will be toward the snout side (or side marked "top") of piston (Figure 114). Lubricate piston pin with clean engine oil. Align rod bore and piston bore and insert piston pin. Push piston pin into place with thumb and install retainer snap rings.

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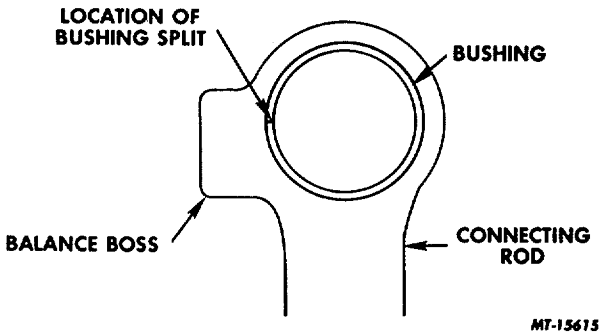

Fig. 113 Proper Location of Bushing Split When Installed in Connecting Rod

It is important, that rod and piston be assembled correctly, so that when piston is installed in engine, the large, chamfered side of each rod is located against crankshaft face. The chamfer provides clearance for the crankshaft fillet (Figure 115).

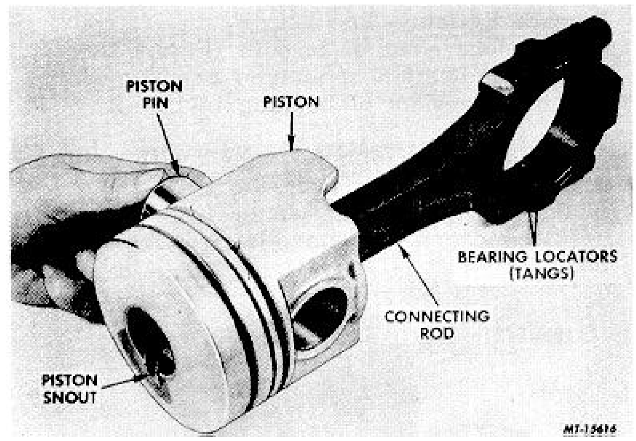

Fig. 114 Installing Piston Pin

Connecting Rod Bolt Tightening

Correct fastening of connecting rods to the engine crankshaft is extremely important. How well this job is performed determines to a large extent what kind of connecting rod bearing wear will be realized.

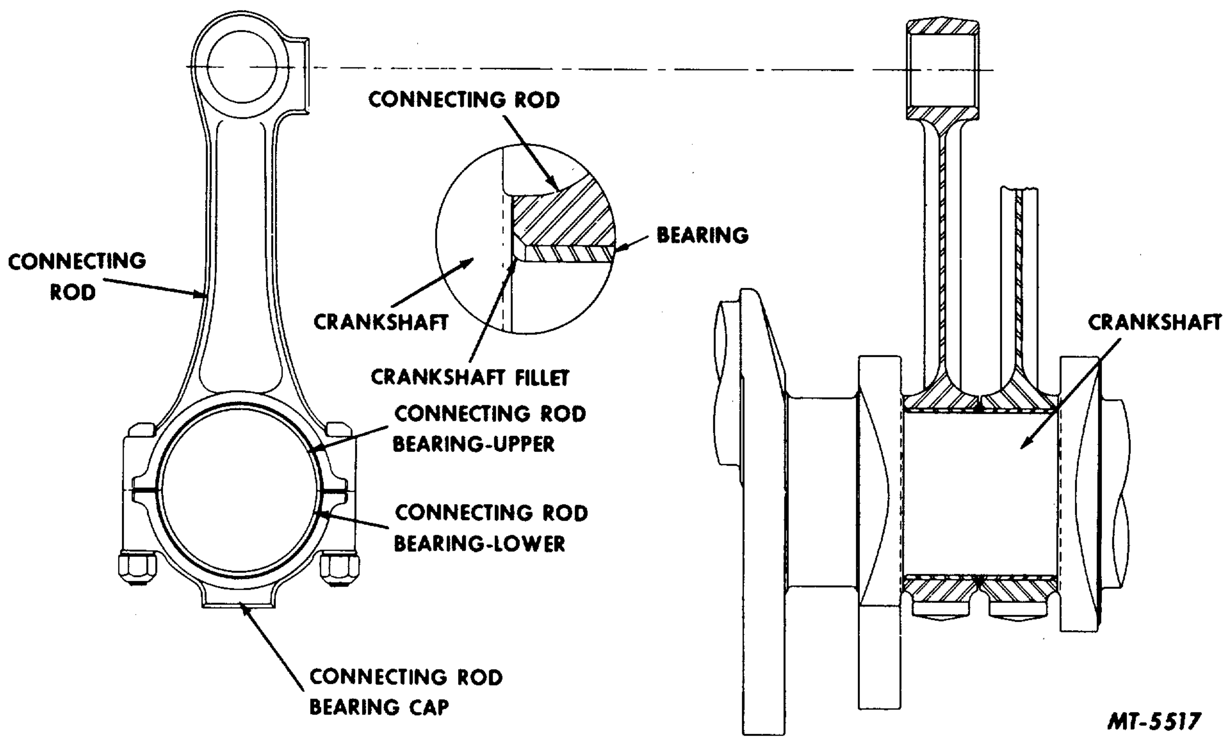

Fig. 115 Proper Installation of Connection Rod to Crankshaft

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The major purpose of tightening connecting rod bolts and nuts to a specified torque is to obtain tension in the bolt (Figure 116) which in turn develops a clamping load or preload that exceeds any possible loading imposed on connecting rod parts during engine operation. The connecting rod must "hang on" to crankshaft and suffer all the strains of inertia and cylinder combustion impulse without permitting the least movement or flexing of the rod cap, bolts or nuts. Torque applied must be within the capacity of parts (bolt, nut, caps, connecting rods) to withstand these loads. Especially designed bolts, nuts and washers manufactured from selected materials permit application of this loading without undue stretching of bolts.

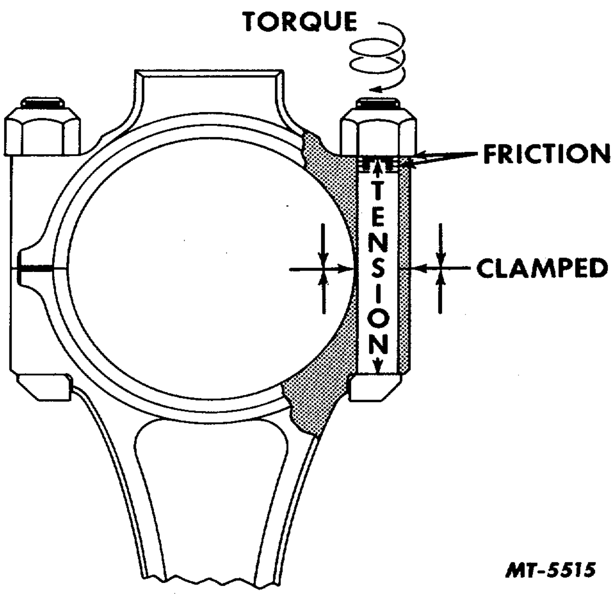

Fig. 116 Connecting Rod Cap, Bolt and Nut Details

There is a relationship between torque applied and clamping effect obtained. For proper clamping, connecting rod bolts and nuts must be cleaned of all foreign matter including the antirust materials that may be in the threads. It is recommended that new connecting rod bolts, nuts and washers be used during reassembly.

Threads that are dry, excessively rough, battered or that are filled with dirt require considerable effort just to rotate the nut. When bolts are tightened, torque reading mounts rapidly (due to thread friction) to specified figure without approaching desired bolt tension and clamping effect. Under these conditions specified torque reading is obtained, but clamping effect might be far below requirements, leading to bearing failure or to connecting rod bolt breakage.

Proper bolt tension and clamping effect cannot be attained if bolt threads are dry. Threads of nut and bolt and contact surfaces of nut and washer should be lubricated with engine oil at installation.

Tighten connecting rod bolt nuts alternately and finish tightening with torque wrench to specified torque, then release torque load to zero and retorque to specified torque. (See Torque Chart.) After rod bolts have been torqued, turn nut an additional one-sixth turn or one flat of the nut. If nut is inadvertently overtightened enough to stretch the bolt, it must be replaced with a new bolt and nut. In major engine overhaul use new rod bolts, nuts and flat washers throughout.

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When torquing connecting rod bolt nuts, use a torque wrench known to be accurately calibrated.

> CAUTION: Do not use a power wrench for removing or installing connecting rod bolts, nuts and washers. Such practice will cause seizure of the connecting rod bolt or nut threads.

CAMSHAFT, CRANKSHAFT AND RELATED COMPONENTS

Camshaft

Wash camshaft in cleaning solvent and remove all sludge or carbon deposits with a soft brush.

Inspect camshaft journals for signs of wear or out-of-round and replace camshaft if wear warrants. Inspect camshaft lobes. If worn, chipped or scored, replace camshaft.

Check oil pump drive gear on rear of camshaft. If teeth are worn or damaged, camshaft must be replaced, as gear is integral with shaft.

Check camshaft gear and replace if gear teeth are nicked, worn or damaged.

> NOTE: Camshaft gear, crankshaft gear and injection pump drive gear are provided in matched sets and should be installed only as sets.

Inspect spacer used on front of camshaft and replace if cracked or damaged.

Crankshaft

Wash and clean crankshaft with cleaning solvent or steam.

Inspect crankshaft for cracks and scored, grooved or worn main bearing and connecting rod journals. Measure crankshaft journals with a micrometer. If journals show excessive wear, replace crankshaft.

During manufacture, the crankshaft is subjected to a special heat-treating process known as "tufftride". The "tufftride" process is applied after the crankshaft has been finish ground and imparts a very hard surface to the crankshaft. This hardening minimizes journal wear and provides greater crankshaft life.

Because of this special hardening of the crankshaft, no attempt is to be made in regrinding journals for use of undersize bearings. To do so will cause minute fractures at the fillet areas which will lead to crankshaft breakage.

Examine crankshaft timing gear teeth and replace gear if teeth are worn or damaged.

> NOTE: Crankshaft gear, camshaft gear and injection pump drive gear should only be replaced in matched sets.

Crankshaft Bearings

The bearing inserts used in these engines are selected fit and require no line reaming on installation. The bearings are available for service in standard sizes only.

If inspection reveals badly worn or scored bearings, replace bearings. Installation of new bearings must be closely checked to maintain proper clearance between journals and bearing surface. A convenient and accurate method for checking clearance is with the use of Plastigage.

When installing precision-type connecting rod or main bearings, it is important that bearing shells fit tightly in bearing bore. To accomplish this, the bearing manufacturer makes the diameter at right angles to the parting line slightly larger than the actual diameter of the bore into which they are assembled. When the assembly is drawn up tight, bearings are compressed, assuring a positive contact between bearing back and bore. This increased diameter is referred to as bearing "crush". (See Figure 117.)

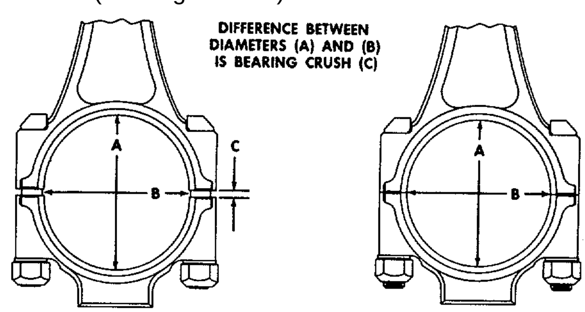

Fig. 117 Illustration of Bearing "Crush"

To obtain proper bearing assembly with correct "crush", care must be taken when tightening clamping bolts and nuts to make sure they are drawn down alternately and

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evenly using a tension wrench and tightening as specified. Then back off nut and retighten to specified torque.

Rods, caps or bearing must not be filed, lapped or reworked in any other manner in order to reduce clearance.

Premature bearing failure will result from attempts to reduce journal-to-bearing running clearance by reworking of bearing caps, bearings, or both, because such reworking will result in an out-of-round bore, bearing shell distortion and destroy the specifically desired "crush".

Bearing inserts are designed with the "spread" (width across the open ends) slightly larger than the diameter of crankcase bore or connecting rod bore into which they are assembled. (See Fig. 118.)

This condition causes the bearing to fit snugly in the rod bore, and the bearing must be "snapped" or lightly forced into its seat. Some of this "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition. If bearing fits loosely in bore (does not "snap" into position), bearing should be replaced.

"Spread" is originally designed into the bearing to cause it to tend to spread outward at the parting line when "crush" load is applied by tightening bolts.

Specified spread for main and connecting rod bearing inserts is given in SPECIFICATIONS.

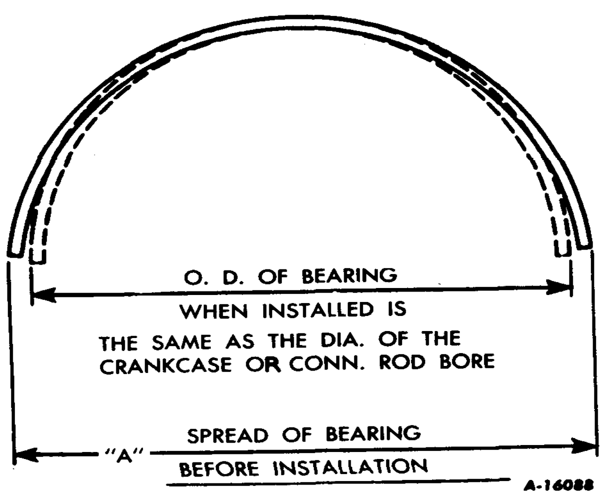

Fig. 118 Illustration of Bearing "Spread"

Fitting Main Bearings

Outlined below are procedures for checking main bearing clearance, using the Plastigage method, and crankshaft end play.

IMPORTANT

To obtain an accurate reading using Plastigage, all main bearing caps must be in place and torqued to specifications.

1. Remove one bearing cap and bearing insert. Remaining caps are left tight while checking the fit of this bearing.

2. Wipe the oil from all contact surfaces such as crankshaft journal, bearing insert, bearing cap, etc.

3. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately .63 mm (.25") off center. Tap bearing cap on with soft hammer until it just meets the mating surface of the crankcase. With the cap lined up with the back face of the crankcase, install cap bolts finger tight. Then install the tie bolts finger tight. Torque the cap bolts and tie bolts to proper torque according to notes on TORQUE CHART.

IMPORTANT

Do not turn crankshaft while making check with Plastigage.

4. Remove bearing cap bolts, then loosen tie bolts and remove bearing cap and insert.

5. Do not disturb Plastigage. Using Plastigage envelope, measure widest point of Plastigage (Fig. 119). This reading indicates bearing clearance in thousandths of an inch.

   If bearing clearance (with new bearing inserts) is not within specified limits (see SPECIFICATIONS), the crankshaft must be replaced.

6. The third (intermediate) main bearing also controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. Use a dial indicator to check crankshaft end play (Fig. 76).

   If end play (with new intermediate bearing insert) is not within specified limits (see SPECIFICATIONS), the crankshaft must be replaced.

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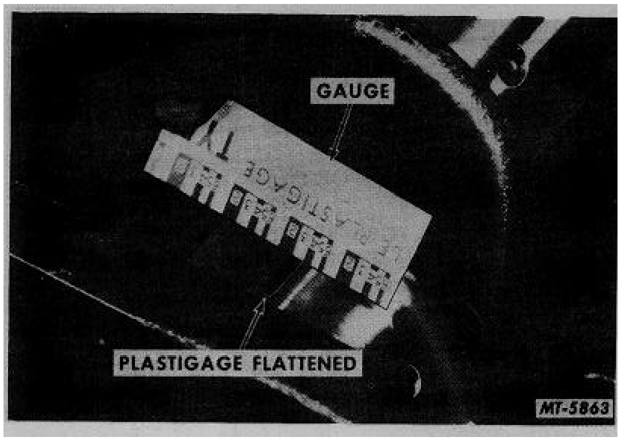

Fig. 119 Checking Main Bearing Clearance

Fitting Connecting Rod Bearings

The following procedure can be used to check connecting rod bearing clearance, using Plastigage, and connecting rod end clearance.

NOTE: To obtain an accurate reading using Plastigage, both connecting rods (right bank and left bank) must be in place on each crankshaft rod journal and torqued to specifications.

1. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.
2. Place a piece of Plastigage on bearing surface the full width of bearing about 1/4" off center.
3. Install cap and tighten bolts and nuts to 68 N-m (50 lb.-ft.) torque. NOTE: Do not turn crankshaft while Plastigage is in place.
4. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage (Figure 120). This reading indicates bearing clearance in thousandths of an inch.

   If bearing clearance (with new bearing inserts) is not within specified limits (See SPECIFICATIONS), the crankshaft must be replaced.
5. Check connecting rod end clearance using a feeler gauge as shown in Figure 121. End clearance should be within specified limits. (See SPECIFICATIONS.)

Excessive clearance may require replacement of rods or shaft. Lack of clearance could indicate a damaged rod or perhaps **a rod bearing** out of position.

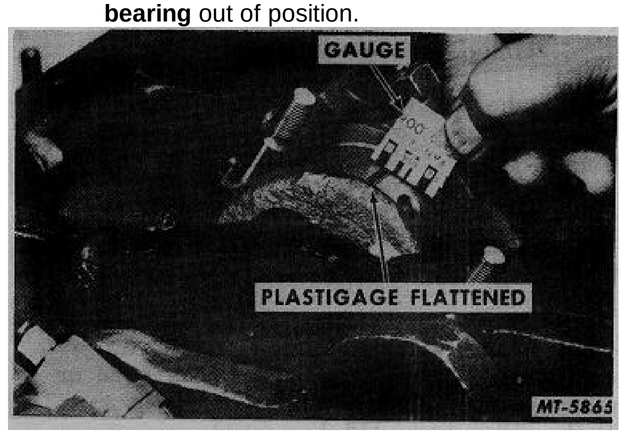

Fig. 120 Checking Connection Rod Bearing Clearance

Fig. 121 Checking Connecting Rod End Clearance

Flywheel and Ring Gear

Clean flywheel assembly with cleaning solvent, removing all traces of oil and grease. Inspect clutch making surface of flywheel for scoring, cracks, heat checking and warping. Check flywheel mounting bolt holes and mounting face for indications of wear and looseness. If damage is evident, replace flywheel.

Check clutch pilot bearing for wear or damage and replace if needed. If pilot bearing does not fit snugly in bore of flywheel, replace flywheel.

ENGINES

Inspect flywheel (starter) ring gear. If teeth are damaged or if ring gear is loose on flywheel, replace ring gear.

To replace flywheel ring gear, heat gear with a torch and remove it from flywheel with a hammer and drift. Heat new ring gear with a torch, heating evenly all the way around. While ring gear is hot, install gear on flywheel and allow it to cool.

CYLINDER HEADS, VALVES AND RELATED COMPONENTS

Cylinder Heads

The cylinder head assemblies are interchangeable from one cylinder bank to another. Cylinder head gasket is also interchangeable.

SE-1896 cylinder head sling can be used as a holding fixture (Figure 122) to protect machined surfaces during cleaning and miscellaneous disassembly operations.

With valves in place to protect seats, clean carbon deposits from combustion chambers and valve heads with a wire brush and scraper. Wash cylinder head in cleaning. solvent to remove dirt and grease from all surfaces and dry thoroughly. Check all water passages to make sure they are clear and open.

Remove valves from cylinder head as follows:

a. Place head assembly in vertical position. Apply valve spring compressor and remove valve keepers or locks (Figure 122). It may be necessary to strike valve ends with a light, soft hammer to loosen valve keepers.

b. Release spring compressor and remove spring retainer, valve spring and damper assembly, valve stem seal and Rotocoil assembly (Figure 123).

NOTE: Keep valves and their related parts together so they may be reinstalled in their respective positions.

After removing valves, examine cylinder heads for water leaks or cracks in combustion chambers, exhaust ports, or around valve seats. Inspect the machined or gasket surfaces for scratches or mars which may cause leakage after assembly.

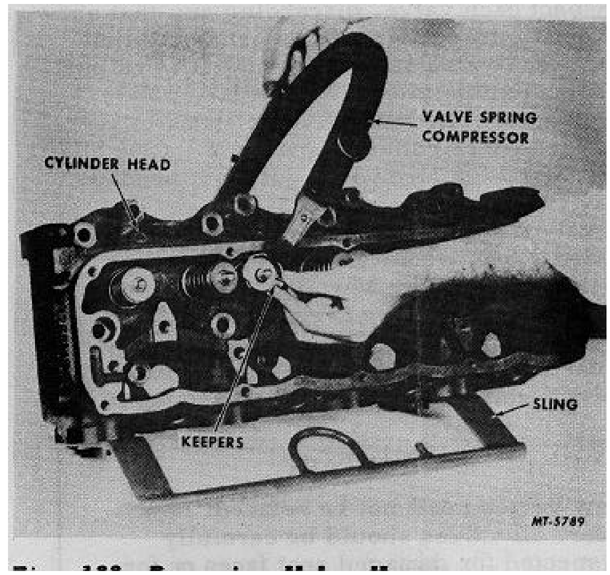

Fig. 122 Removing Valve Keepers

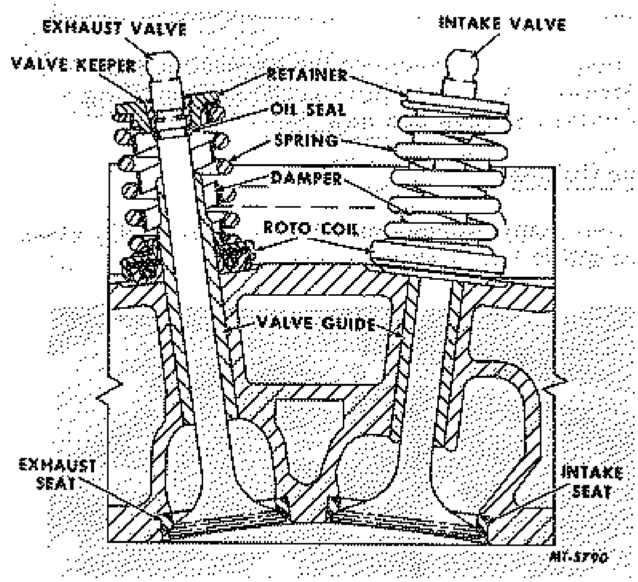

Fig. 123 Sectional View of Valve Installation

Check gasket surface of cylinder head for trueness with a straightedge. Test by attempting to insert a .006" feeler gauge ribbon between straightedge and cylinder head. If this is possible, replace cylinder head.

NOTE: Cylinder heads are not to be resurfaced.

Valves

Remove all carbon from valve stems and valve heads using a fine wire brush or buffing wheel.

ENGINES

Inspect each valve, discarding any that show evidence of burned, warped or bent condition. Measure each valve stem for wear. If worn beyond specified limits (See SPECIFICATIONS), replace valve. Check fit of valve stems in valve guides for proper running clearance. (See SPECIFICATIONS). Replace valve guides if needed.

If valves are in servicable condition, reface as needed. See specifications for valve face dimensions. Grinding wheels of refacing equipment should be carefully dressed to specified valve angle. During grinding, remove only the minimum amount of material necessary to true up the valve face.

IMPORTANT

New valves need not be refaced; however, all valves should be carefully inspected for damaged seat faces or for a run-out condition due to a bent valve stem. Use Tool SE-2614 for checking valve stem run-out.

Inspect valve keepers for excessive wear and replace in pairs as required. When installing a new valve, always use new valve keepers. Valve Guides

Valve Guides

Using appropriate size brush (SE-1300), clean valve guide bores (Figure 124).

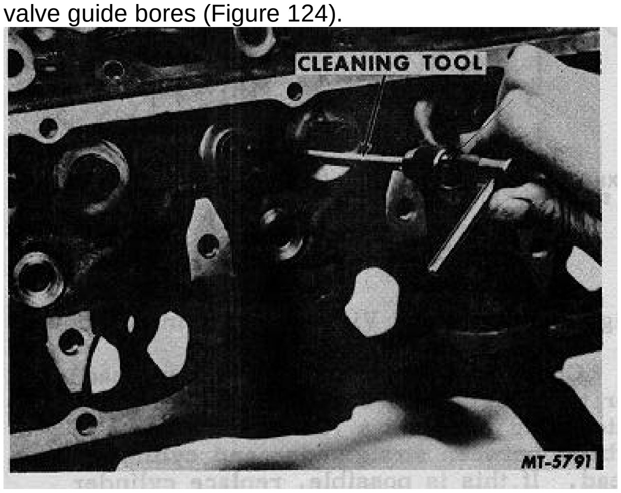

Fig. 124 Cleaning Valve Guide Bore

Using equipment such as SE-1826 small bore gauge (and micrometer) or SE-2506 valve guide gauge, check valve guide bores (Figure 125). (See SPECIFICATIONS for proper guide bore diameter.) Replace guides having bore diameters outside recommended limits, are bell-mouthed more than . 00n(" or which show egg-shaped wear.

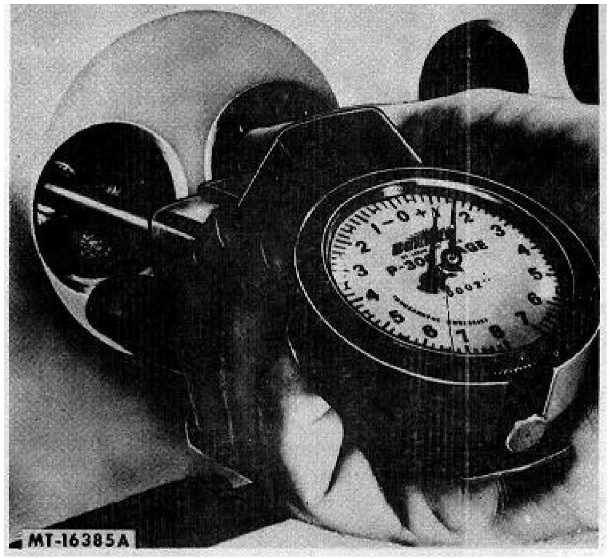

Fig. 125 Checking Valve Guide Bore

Excessive guide clearance prevents adequate cooling of the valve through the guide and allows valve to tilt or tip which may cause valve breakage at high engine speed. These conditions prevent good seating and promote leakage past valve face. Effects of a worn guide are illustrated in Figure 126.

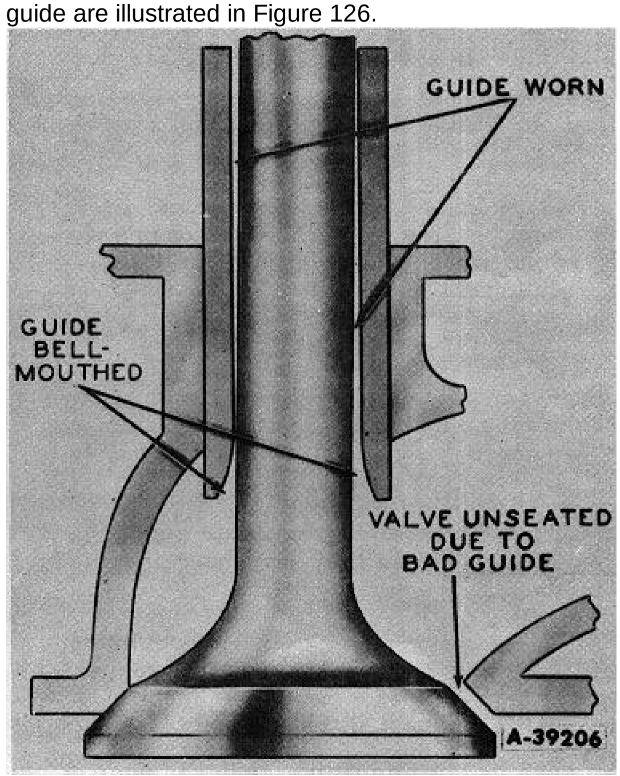

Fig. 126 Effects of Worn Valve Guides

ENGINES

Replace valve guides as follows:

1. Remove cylinder head sling and position cylinder head (combustion chamber side up) on support fixture SE-2104 in press bed (Fig. 127). Support fixture is designed to position valve guides vertically under press ram.
2. Using remover tool SE-1722 (Fig. 127) press valve guide from cylinder hear. All guides must be pressed out from the combustion chamber side through the top of the head. Fig. 127 Removing Valve Guide

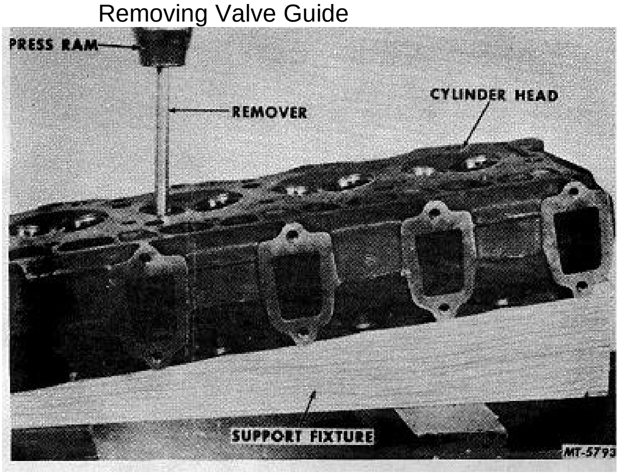

Fig. 127 Removing Valve Guide

3. Turn cylinder head over (top side up) on support stand in press bed.

4. Adjust valve guide installer tool SE-1943 (Fig. 128) for specified valve guide height above cylinder head. (See SPECIFICATIONS). Tool is designed to install both intake and exhaust guides.

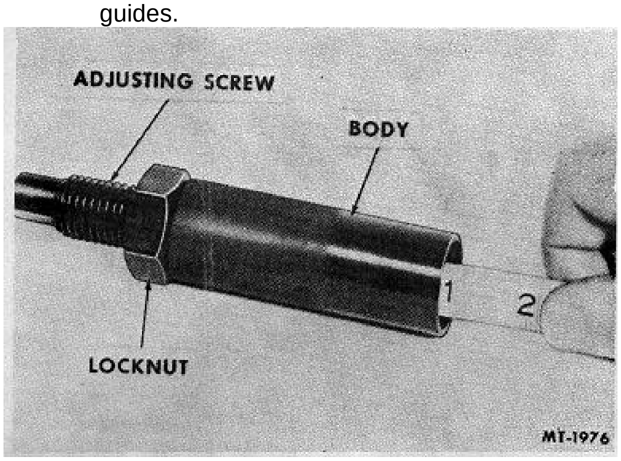

Fig. 128 Adjusting Valve Guide Installer for Proper Height

5. Insert top end of valve guide into installer tool. Lubricate O.D. of valve guide with a commercial press-fit lubricant or a mixture of engine oil and white lead. Press valve guide into cylinder head (Fig. 129) until installer tool rests firmly on top of head, thus obtaining proper valve guide height.

6. Replacement guides are designed to give proper clearance when installed in the cylinder head. Reaming is not required, but care must be taken to insure the ends of the guides are not burred during installation. After guides are installed, insert SE-2215 Reamer to insure the guides have not been distorted during installation and to remove any burrs.

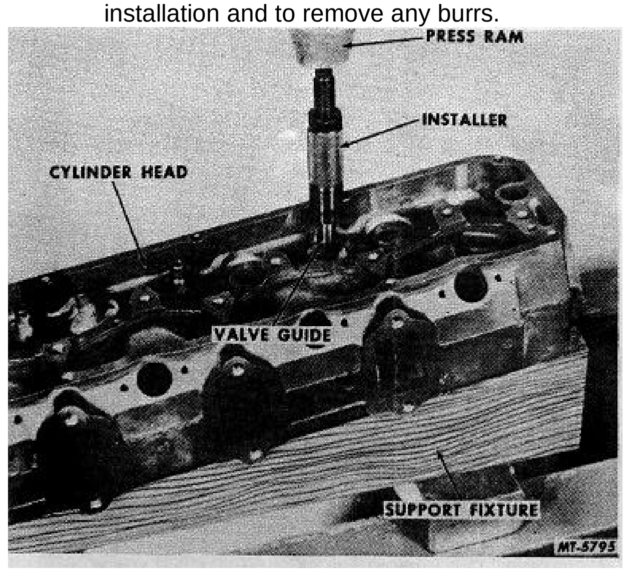

Fig. 129 Installing Valve Guide Valve Seats

<u>Valve Seats</u>

Inspect valve seat inserts for looseness, burned or cracked condition. Replace inserts showing indications of damage or excessive grinding.

Replace valve seat inserts as follows:

1. Using remover tool SE-1951 (Fig. 130) to remove inserts. Position remover collet into insert and turn coned screw out to expand collet jaws, providing a firm grip under insert ring. Use a slide hammer to remove insert.
2. Select inserts of proper size O.D. (Inserts are provided in oversizes for use in previously serviced heads.)
3. Use counterbore tool such as SE-1797 (Fig. 131) to clean up (or machine to desired oversize) the valve seat insert counterbores in cylinder head. Follow equipment manufacturer's instructions.

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ENGINES

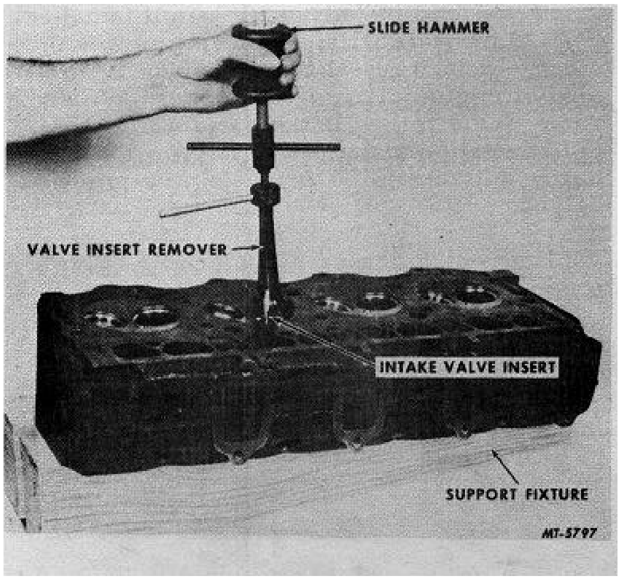

Fig. 130 Removing Valve Sear Insert

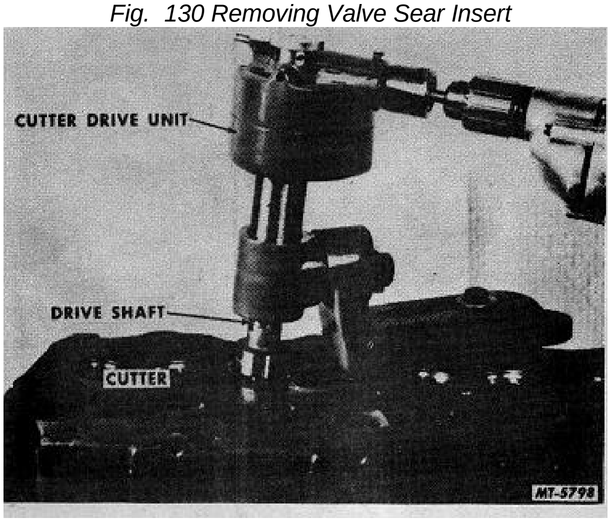

Fig. 131 Machining Valve Seat Insert Counterbore

4. Using insert installer tool from counterbore tool set SE-1797 (Figure 132) install valve seat inserts. Chill inserts thoroughly with dry ice or other means. Position insert on installer tool and drive into cylinder head counterbore until firmly seated.

5. Stake valve seat inserts securely in place. Use peening tool SE-2094 (Figure 133) or a dull pointed chisel 6.35 mm (1/4") wide to peen cylinder head metal over outer edge of insert. Peen material all the way around insert except injection nozzle area on intake valve insert.

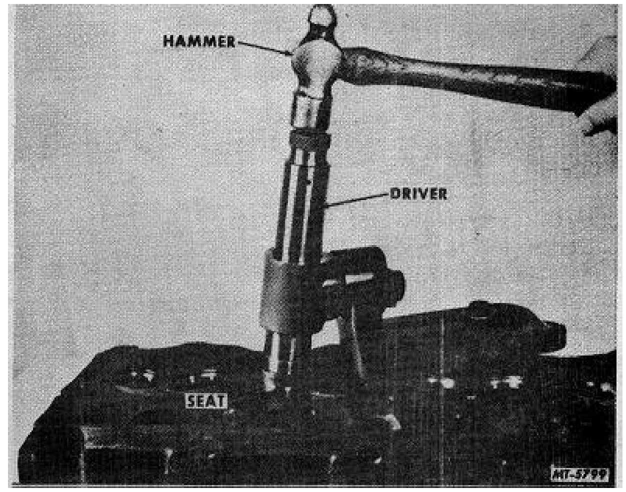

Fig. 132 Installing Valve Sear Insert

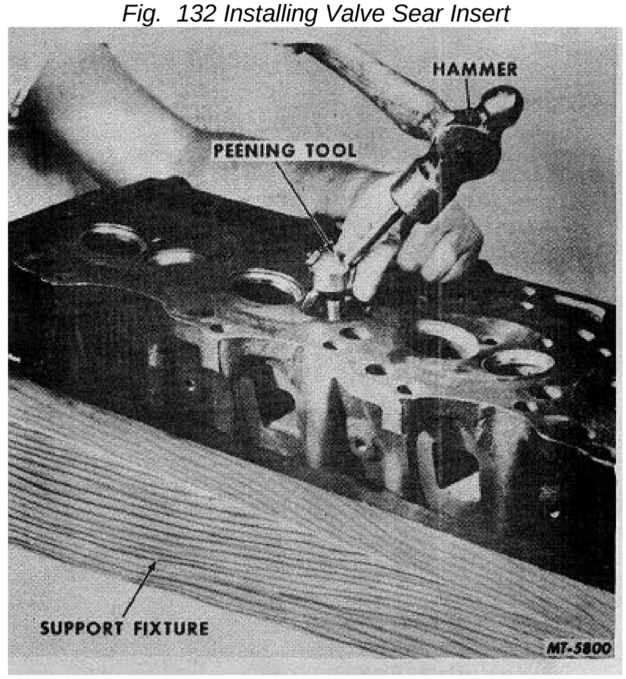

Fig. 133 Staking Valve Seat Insert in Cylinder Head with Peening Tool

To insure a good compression tight fit with valves, reface valve seats with precision equipment such as the SE-1631 or SE-1804 valve seat grinder (Figure 134). Grind seats to specified angle and seat width (See SPECIFICATIONS).

During grinding operation remove only the minimum amount of material necessary to true up the seat. If the seat is wider than specified, it will be necessary to grind from the top of the seat until the proper seat width is obtained.

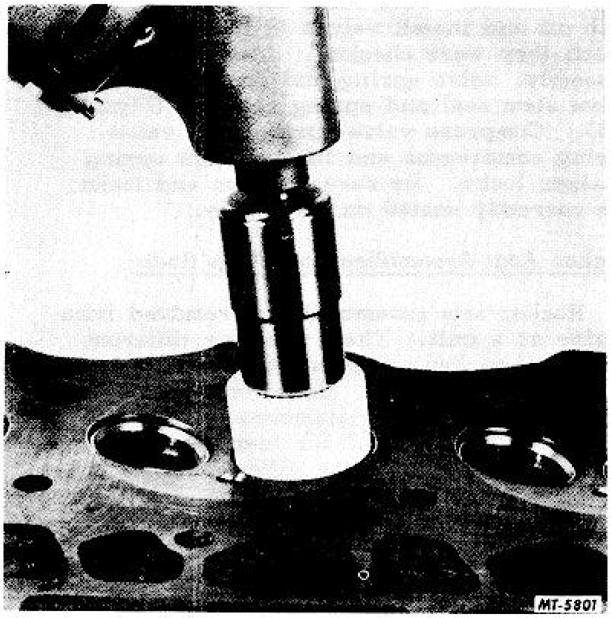

Fig. 134 Grinding Valve Seat

After grinding seats, check each seat for run-out using dial indicator or run-out gauge I from SE-1631 seat grinder set (Figure 135). Seat run-out should not exceed specified limits (See SPECIFICATIONS).

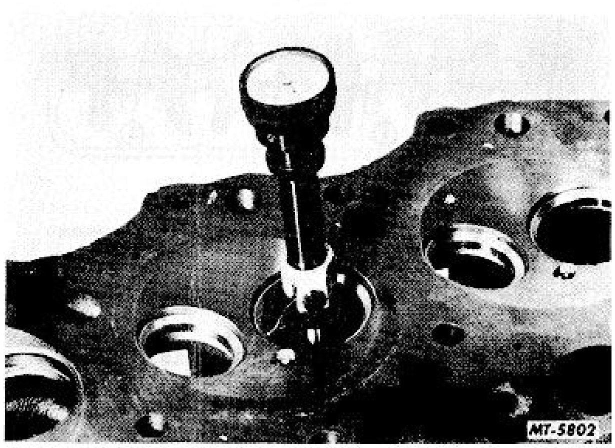

Fig. 135 Checking Seat Run-Out

It is important to have the finished seat face contact the approximate center of the valve face. To check face contact, place a thin coat of Prussian Blue on valve face. Position valve in cylinder head and tap valve lightly to its seat. Inspect each valve for seat dimensions as outlined in specifications and make any necessary corrections. Corrections should always be made on seat and not valve face. When seat contact is satisfactory, mark each valve for installation in its respective seat.

NOTE: This test is merely for proof of results of refacing and reseating operations. Do not attempt to lap valves and seats. A poor grind job cannot be corrected by lapping. A nearly perfect seat often times is destroyed by attempting to lap the valves to their seats.

After valve grinding operation has been performed, check valve recession in cylinder head. Valve recession is the distance valve head is located from cylinder head gasket surface. (See SPECIFICATIONS.) To check the minimum and maximum recession, the valves should be positioned in their respective ports to which they were ground. Use SE-2101 plate and wire gauges to check clearance (Figure 136). SE-2101 plate must be in the center of valve head and parallel with center line of valve stem. This check must be made to assure clearance between top of piston and head of valves. If recession does not meet the minimum specified clearance, valve insert will have to be reground starting from the top of seat until proper clearance is obtained. However, if clearance is larger than specified, valve insert must be replaced and a valve grinding operation performed.

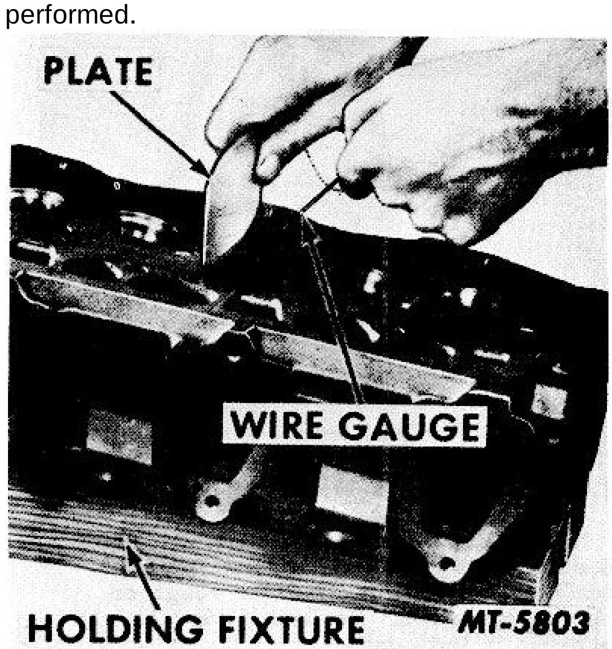

Fig. 136 Checking Valve Recession

Valve Springs

Inspect valve springs and dampers for wear or fatigue marks. Spring ends must be flat and square to prevent lateral loads on valve stem. Out-of-square springs place a side force on the stem causing rapid guide wear.

Using spring tester such as SE-2241 (Figure 137) check springs for proper tension (See SPECIFICATIONS). Weak valve spring tension can result in valve "float" (unsatisfactory closing) and valve bounce, which is common cause of seat pounding and valve breakage.

Replace valve springs and dampers showing evidence of wear, cracks or improper tension.

NOTE: Because of the possibility of fatigue cracks, valve springs and dampers should be replaced on the same basis as recommended for valves which have been in service for long periods.

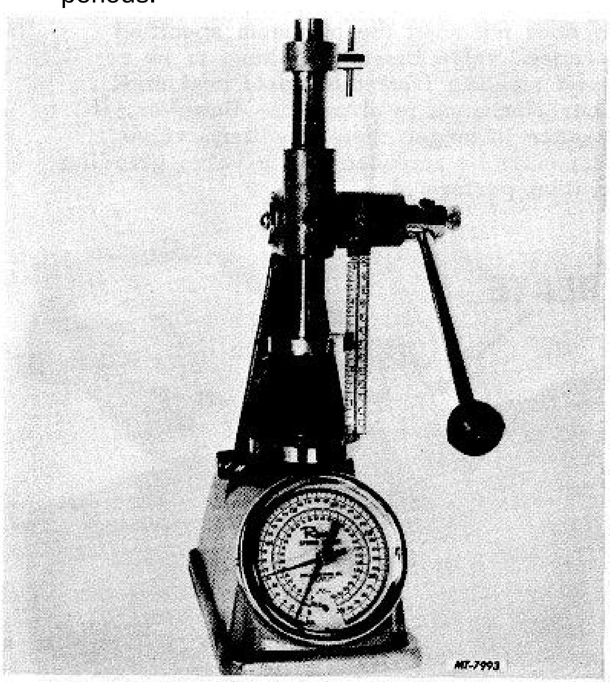

Fig. 137 Checking Valve Spring Tension

Inspect valve spring retainers and Rotocoil assemblies for wear. Rotate Roto-coil assemblies by hand to check for rough or irregular operation. Replace if wear or roughness is indicated.

Reinstall valves in cylinder head as follows: Wipe valve faces and seats with cleaning solvent to remove all dirt or foreign material. Coat valve stems and faces with oil and install valves in the seats to which they were checked. Install Roto-coil assembly, valve spring and damper assembly, valve stem seal and spring retainer (Figure 123). Compress valve spring with valve spring compressor and install valve spring retainer locks. Be sure retainer and locks are correctly seated on all valves.

Rocker Arm Assemblies and Push Rods

Rocker arm assemblies are removed from engine as a unit. There are four different shapes of rocker arms used in each complete rocker arm assembly. Each rocker arm is stamped with cylinder numbers and the words "INT." or "EX." for identification. Figure 138 illustrates the different types of rocker arms and their locations.

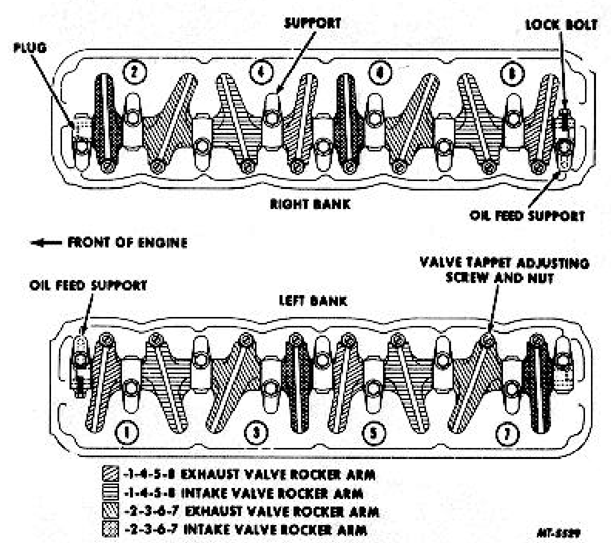

Fig. 138 Rocker Arm Installation

Service rocker arm assemblies as follows:

1. Starting from end opposite oil feed support, slide supports and rocker arms from shaft. Keep parts in order so they may be replaced in their original position if in satisfactory condition.
2. Remove capscrew and lockwasher from oil feed support and press support from shaft.
3. Remove plugs from each end of shaft.
4. Clean all parts thoroughly, making sure all oil passages are open.

5. Inspect rocker arm shaft. Check on a surface plate for signs of bending; check for wear from rocker arms. If a shaft is bent or shows excessive wear, it must be replaced.
6. Inspect valve stem cap and contact pad surface of rocker arm. If rocker arm pad wear is excessive, resurface pad but do not remove more than .010" of material from surface. If valve stem cap shows excessive wear, replace cap.
7. Check rocker arm bore for wear or scoring. Check the rocker arm-to-shaft running clearance (See SPECIFICATIONS).
8. To assemble, align oil hole in oil feed support with cross hole in end of rocker arm shaft (Figure 139). Then press oil feed support on shaft, indexing oil holes.

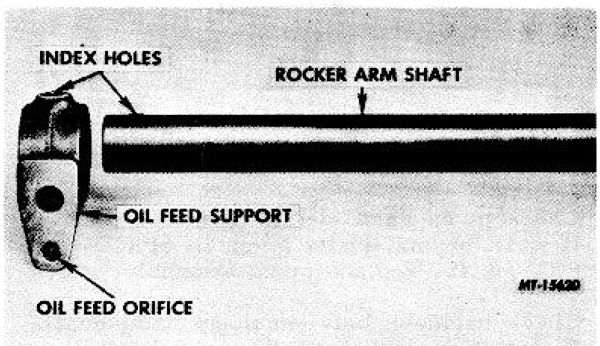

Fig. 139 Aligning Holes in Rocker Arm Shaft and Support

NOTE: If oil holes are not indexed when performing pressing operation, they can be aligned by installing oil feed support in a vise (Figure 140) and using a drift punch rotate shaft to permit tightening support screw finger tight. Using this method will eliminate the possibility of bottoming screw against shaft, which could result in stripping threads in support. After support has been secured to shaft use a fine oil stone to remove any burrs caused by using drift punch in hole to turn shaft.

9. Place rocker arms and remaining supports on shaft making sure rocker arm shaft-to-arm oil feed holes are in a downward position. This will properly position rocker arm shaft oil feed holes so that oil feed hole in right rocker arm shaft assembly will be toward the rear, while oil feed hole in left rocker arm shaft assembly will be toward the front. See Figure 138 for correct installation.

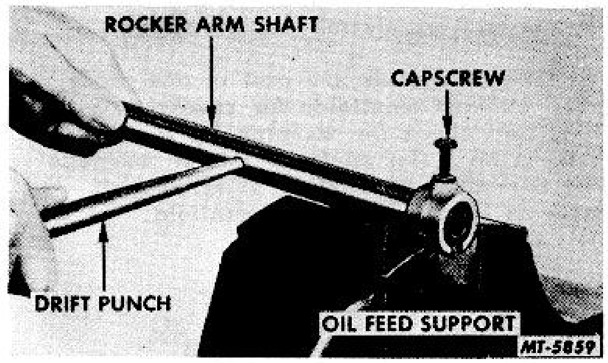

Fig. 140 Turning Rocker Arm Shaft to Align Screw Holes

10. After rocker arm shaft has been completely assembled, a spring and two cotter pins (Figure 141) can be used to hold assembly together for installation on cylinder head.

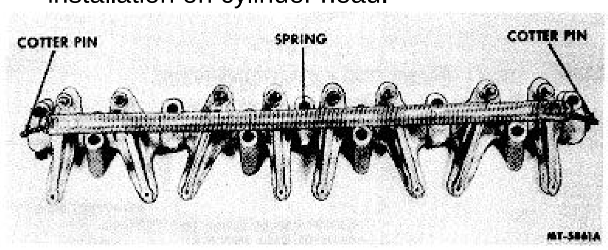

Fig. 141 Method of Holding Rocker Arm Assembly Together for Installation

Clean and inspect all valve push rods. Check push rods for straightness by rolling on a flat surface. Replace any that are bent or have loose ends.

<u>Manifolds</u>

Intake manifolds are cast in two pieces and are held together with eight (8) selftapping screws (Figure 142). During manufacture, a sealer is used between the two valves to eliminate any possibility of leakage. No attempt should be made to disassemble the two halves.

Intake manifolds should be thoroughly cleaned and examined for cracks. Place mounting surface (outlets) of manifold on a smooth flat surface and check for warpage. Replace manifold if cracked or warped.

NOTE: Do not surface grind intake manifold to correct warpage. Any attempt to resurface intake manifolds will create misalignment of ports to cylinder heads and air cleaner mounting.

Exhaust manifolds are cast in one piece. Examine exhaust manifolds for cracks or burning and check for warping by placing inlet ports on a flat surface. Minor warpage can be corrected by surface grinding. If warpage is extreme, replace manifold.

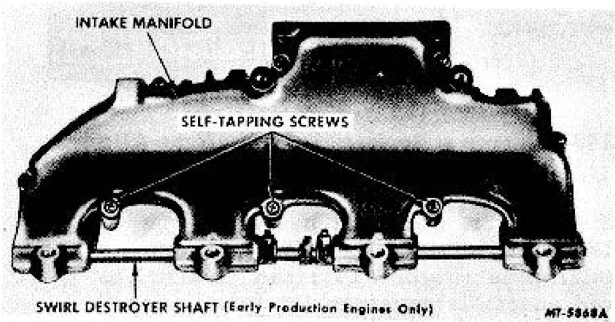

Fig. 142 Intake Manifold

LUBRICATING SYSTEM COMPONENTS

Oil Pump

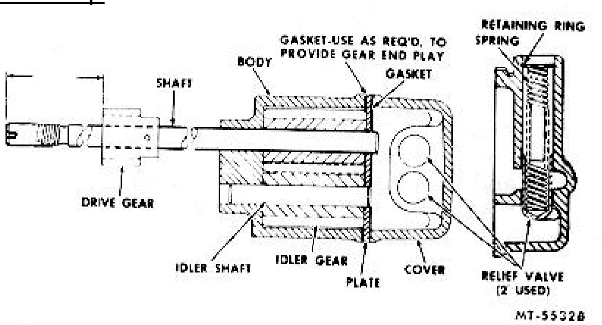

Fig. 143 Sectional View of Oil Pump Assembly

Recommended oil pump inspection and repair procedures are as follows:

1. Wash all pump parts and screen assembly in cleaning solvent.

2. With cover, plate and gaskets removed and gears and shaft in place, exert pressure against gears with thumb to push gears away from the outlet side of pump.

3. While holding gears in this manner, measure clearance between outside diameter of gear and bore of housing (Figure 144). Clearance should be within limits given in SPECIFICATIONS.

4. If clearance is not within specified limits (See SPECIFICATIONS), obtain new parts.

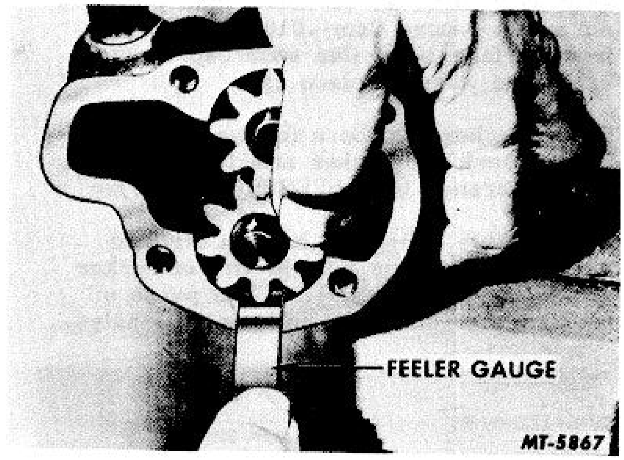

Fig. 144 Measuring Pump Gear-to-Body Clearance

5. Check pump shaft clearance in the bore. If worn beyond limits given in SPECIFICATIONS, replace pump assembly.
6. Check backlash between pump body gears. If this exceeds figure shown in SPECIFICATIONS, replace gears.
7. Establish body gear end clearance. Oil pump cover plate-to-body gaskets control clearance (end play) between pump body gears and pump cover plate. Add or remove gaskets to obtain specified clearance. (See SPECIFICATIONS.)
8. Inspect relief valves and replace if worn or damaged.
9. Check relief valve springs for proper tension. (See SPECIFICATIONS.) Replace springs if weak or damaged.
10. When installing pump gears and shaft, these parts should be oiled liberally with engine oil for initial lubrication.
11. When installing oil pump drive gear on shaft, gear should be pressed on to a 7.3 cm (2-7/8") dimension from top of gear to end of shaft (Figure 143).

12. Installation of pump screen must be made after pump assembly has been installed on engine. (See ENGINE ASSEMBLY.)

Oil Filter and Cooler Base

At the time of engine overhaul, oil filter and cooler base should be serviced as follows:

1. Remove piston cooling valve cap plug from base and remove valve spring and piston (Figure 145).

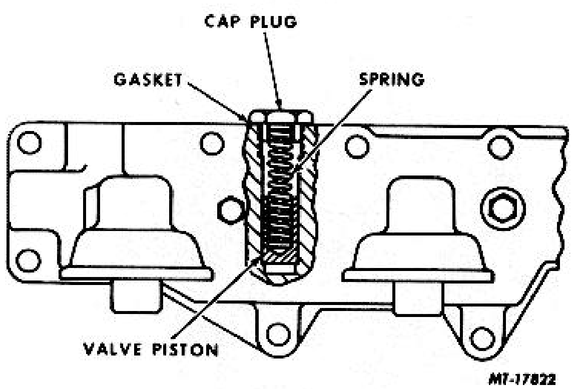

Fig. 145 Piston Cooling Valve Details

2. Remove all gasket material from filter/cooler base. Wash base and piston cooling valve parts in cleaning solvent and dry carefully.

3. Inspect gasket surfaces of base for nicks or scratches which could cause leakage. Replace base if damaged.

4. Inspect piston cooling valve piston and spring and replace if worn or damaged. Check spring for correct tension (See SPECIFICATIONS).

5. Lubricate valve piston with clean engine oil and install piston and spring in base. Using new gasket, install valve cap plug and tighten securely.

Oil Cooler

The following operations should be performed on the oil cooler during engine overhaul.

1. Remove fittings from coolant openings of cooler.
2. Looking through coolant openings, inspect coolant portion of cooler for deposits of lime or other contaminents and for evidence of oil leakage. Replace cooler if heavy deposits or oil leakage are found.
3. Pressure test cooler for leakage as follows:

   a. Plug one coolant opening.

   b. Using necessary adapter fittings, connect other coolant opening to a source of regulated air pressure.

   c. Pressurize coolant portion of cooler with air. Do not exceed 517 kPa (75 psi) air pressure.

   d. Check for air leakage from oil openings in cooler. Replace cooler if leakage is indicated.

4. Reinstall fittings in coolant openings.

Oil Pan

The pan should be thoroughly cleaned in cleaning solvent to remove any foreign material from around baffle plates, which are spot welded in place. Inspect oil pan for cracks or deformation and straighten or weld.

Remove all gasket material from oil pan flange.

Check oil pan drain plug and drain plug boss for fit and thread wear. If plug is loose or threads are damaged, repair threads or replace oil pan.

COOLING SYSTEM COMPONENTS

Water Pump

The water pump assembly is composed of a housing which accomodates a shaft and bearing assembly, slinger, seal and impeller as shown in Fig. 146.

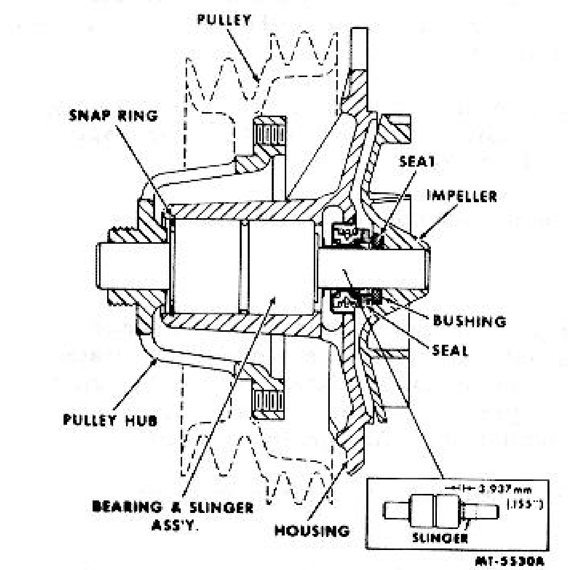

Fig. 146 Sectional View of Water Pump Assembly

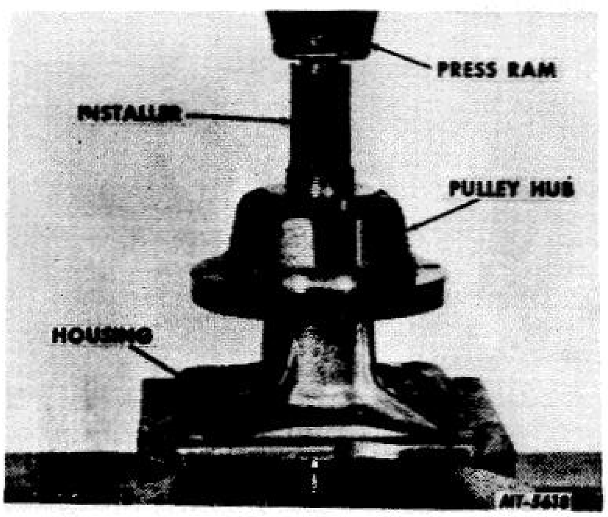

Fig. 147 Installing Pulley Hub

1. When removing water pump all gasket material should be cleaned from the water pump. Inspect the water pump for damaged impeller, cracks and other faulty conditions. If any defects are noted, the water pump must be replaced, as an assembly.
2. When replacing water pump, the hub must be transferred to the new pump. Apply locquic primer T and Loctite AA to hub and bearing shaft assembly prior to assembly.

   Press the hub on to the shaft using pulley hub installer SE-2085 as shown in Fig. 147.

Check impeller running clearance as follows:

1. Position suitable amount of moulding clay on two impeller vanes (Fig. 148).

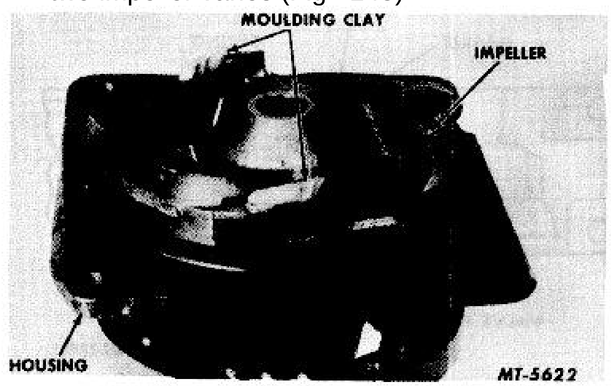

Fig. 148 Moulding Clay Mounted on Impeller Vanes to Check Impeller Clearance

2. Position gasket on water pump housing. Install pump assembly into pump body and tighten mounting screws.

IMPORTANT

Be careful not to rotate impeller or hub.

3. Remove pump assembly and check thickness of moulding clay (Fig. 149). If clearance exceeds specifications. the water pump must be replaced.

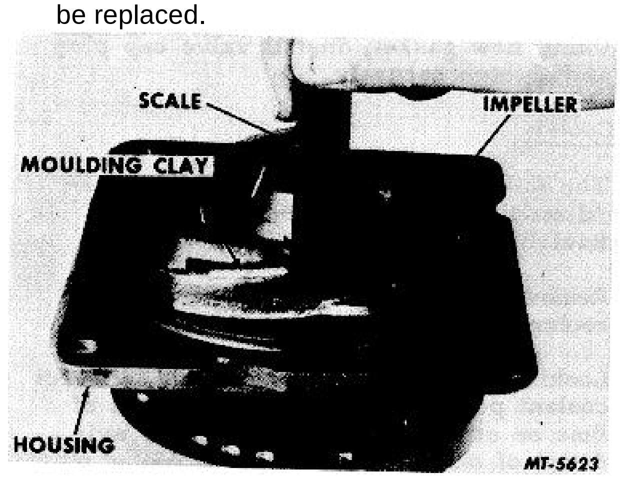

Fig. 149 Measuring Thickness of Moulding Clay to Determine Impeller Clearance

4. Position gasket on water pump housing. Install pump assembly into pump body and tighten mounting screws.

Idler Pulley

Check idler pulley bearing for looseness (wear) or rough operation.

Check idler arm support bushing for looseness (wear).

If necessary, replace pulley bearing and/or support bushing (Fig. 150) as outlined below.

Pulley Bearing Replacement:

1. Remove nut from idler bearing shaft.
2. Remove idler pulley and shaft from idler arm.
3. Remove bearing shields and shaft from idler pulley bearing and remove two snap rings (one each side of bearings).
4. Using remover tool SE-1955-8 with a flat washer 15.875 mm (5/8") I.D. x 23.813 mm (15/16") O.D. x 2.381 mm (3/32") thick, press bearing from pulley.
5. Clean pulley carefully. Inspect for cracks or other damage. Replace pulley if damaged.

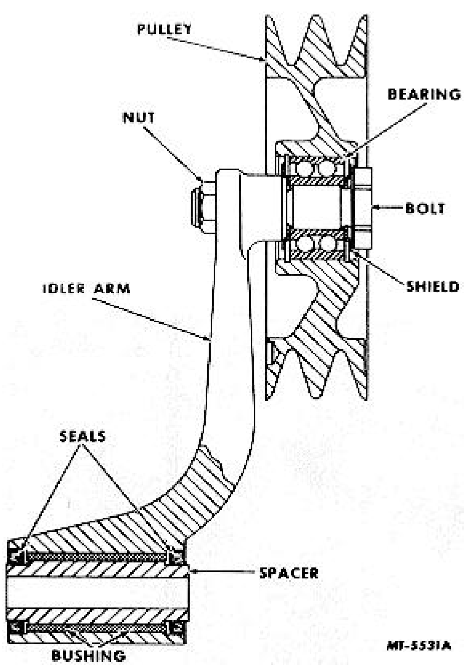

Fig. 150 Sectional View of Idler Pulley Assembly

6. Install one snap ring in bore of pulley. Make certain snap ring is seated securely. Support pulley on a press plate, then press new bearing into pulley bore until bearing seats against snap ring.

IMPORTANT

Use care not to press bearing assembly. Press on bearing outer race to prevent damage to bearing.

After bearing is pressed into place, install other snap ring. The new bearing is prelubricated and requires no further attention.

7. Place one bearing shield on shaft and insert shaft into bearing. Install other shield on opposite side of bearing.
8. Thread bearing shaft into idler arm and install nut on shaft and tighten securely.

Support Bushing Replacement:

1. Press spacer from, idler arm using remover tool SE-1722.
2. Remove both seals from idler arm using remover SE-1746 and slide hammer.
3. With the use of remover tool SE-1036-1, remove bushing from idler arm.
4. Using installer tool SE-1946-1, press new busing into idler' arm bore until it is just flush with edge of bore.
5. Place new seal in one counterbore of idler arm with lip of seal facing inward. Using 13/16" socket, press seal in until it bottoms in counterbore. Do not damage seal.
6. Install spacer in idler arm bushing.
7. Turn idler arm over and install opposite seal per Step 5.

Thermostats

Since a low operating temperature will result in loss of power and economy, only specified temperature range thermostats should be used. The thermostats should not be removed in an attempt to lower operating temperature.

Thermostat operation should be checked at the time of engine overhaul or whenever faulty operation is suspected.

To check operation, place thermostat in a pan of water, heat water and, using an accurate thermometer, observe water temperature when thermostat starts to open. Thermostat should start to open at approximately 77 degrees C (170 degrees F). Replace thermostat if defective.

When installing, position thermostats correctly in housing per instructions stamped on thermostat. Make sure themostats are seated in housing. Use new thermostat housing gasket.

ENGINE REASSEMBLY

NOTE: Throughout the engine assembly procedures outlined below, instructions are given for prelubricating bearings and other running parts with engine oil. This is important to assure initial lubrication of these parts when engine is started. If engine is to be stored before installation in a vehicle, it is recommended that these parts be prelubricated with a coat of waterproof grease (Lubriplate 630AA or equivalent). The grease will not drain off parts during storage, will prevent rusting and provide initial lubrication.

1. Mount cylinder block in engine stand. Rotate engine stand so that bottom of cylinder block faces upward.
2. Install cylinder block drain plugs (or drain cocks) and tighten securely.
3. Wipe main bearing bores of cylinder block and main bearing caps to remove any dirt or dust. Make sure main bearing inserts are clean.
4. Lubricate upper (block) half of each bearing insert on both sides with clean engine oil and place in position in bearing bore of block. Make sure that bearing inserts are fully seated with oil holes in inserts aligned with oil passages in block and that locking tangs are engaged. Following the same procedure, place lower half of bearing inserts in bearing caps.
5. Wipe crankshaft main bearing journals. Lower crankshaft into place in cylinder block bearing inserts.
6. Place bearing caps (with inserts) over crankshaft journals, making sure number on cap is toward right side of engine. Install new self-locking cap bolts and flat washers.

   NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with clean engine oil.

7. Tighten bearing cap bolts snugly (not to specified torque). Using a soft hammer, tap each bearing cap until rear machined face of cap is flush with machined face of cylinder block on both sides of crankshaft. Alignment of these machined faces assures proper cap location. Tighten bearing cap bolts to specified torque (see TORQUE CHART).

8. Install bearing cap tie bolts and special washers and tighten to specified torque. (See TORQUE CHART.)

   NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with clean engine oil.

9. Using dial indicator check crankshaft end play (Fig. 76).

10. If rear oil seal wear sleeve was removed from crankshaft at engine disassembly, install new wear sleeve as follows:

    a. Install aligner studs SE-2092-3 into end of crankshaft flange (Fig. 151).

    b. Coat crankshaft flange with engine oil Position wear sleeve on crankshaft flange with large chamfer toward rear of crankshaft.

    c. Position installer tool SE-2092-1 over aligner studs (Fig. 151) and drive wear sleeve onto crankshaft flange until installer tool seats against crankcase. This will correctly locate wear sleeve (Fig. 151).

    d. Remove installer tool and aligner studs.

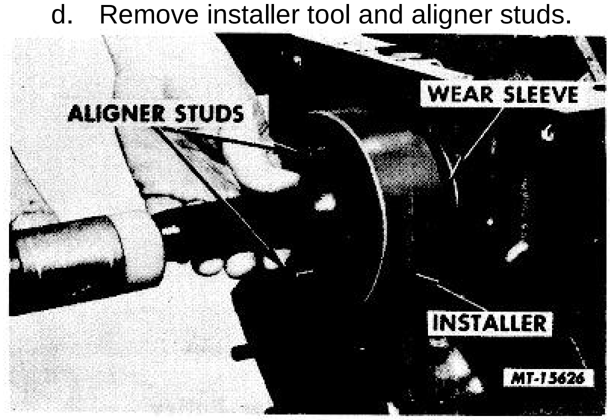

Fig. 151 Installing Oil Seal Wear Sleeve

11. Install rear oil seal as follows
   a. Install aligner studs SE-2092-3 into end of crankshaft flange (Fig. 152).
   b. Lubricate crankshaft flange and wear sleeve and seal bore of crankcase and bearing cap with engine oil.
   c. Place new oil seal over crankshaft flange, aligning seal with crankcase bore.
   d. Position installer tool SE-2092-1 over aligner studs (Fig. 152) and drive oil seal into crankcase bore as follows:

(1) Where a new seal is being installed against a new wear sleeve, place seal flush with rear of crankcase (Fig. 153).

(2) Where a new seal is being installed against a used weal sleeve, recess seal into crankcase bore (Fig. 153) to allow lip of seal to ride upon unworn surface of wear sleeve. (If wear sleeve shows more than one wear path, replace wear sleeve.)

   e. Remove installer tool and aligner studs.

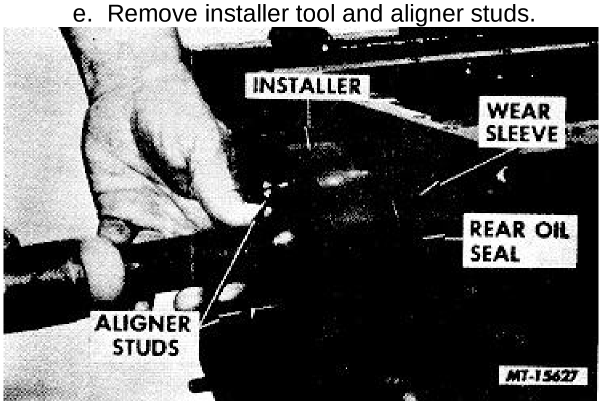

Fig. 152 Installing Rear Oil Seal

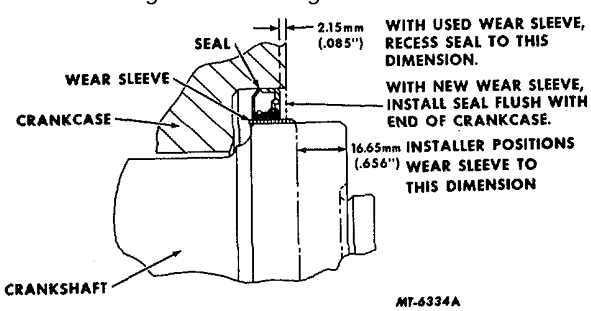

Fig. 153. Sectional View Showing Proper Location of Wear Sleeve and Rear Oil Seal

12. Install ream main bearing cap side oil seals (Fig. 154). Use an installer made from 3.18 mm (1/8") welding rod. To make tool, puddle a ball on end of rod and file ball to approximately 3.97 mm (5/32") diameter. Lubricate seals with a light coat of engine oil.

IMPORTANT

If excess material protrudes above crank- case after seal is installed, cut excess material off flush with bottom of rear main bearing cap and crankcase surfaces.

13. Position gear key in keyway of crankshaft. Lubricate inside diameter of crankshaft gear with a commercial press-fit lubricant. Install crankshaft gear using installer tool set SE-1900 (Fig. 155).

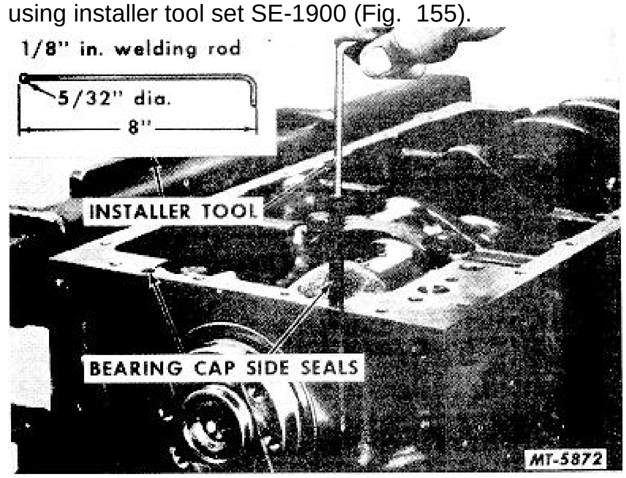

Fig. 154 Installing Rear Main Bearing Cap Side Oil Seals

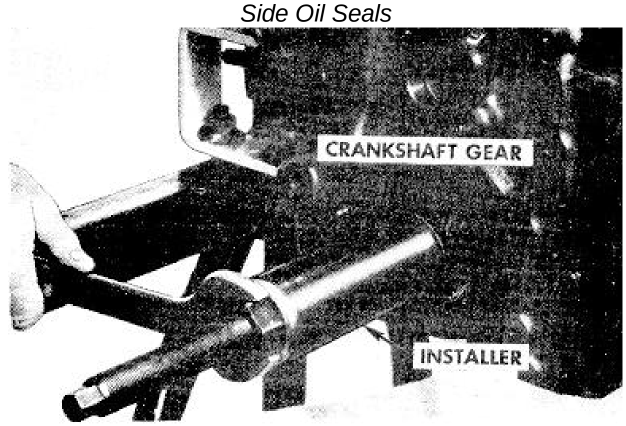

Fig. 155 Installing Crankshaft Gear

14. Position camshaft thrust plate on camshaft. Position gear key in keyway of camshaft. Lubricate inside diameter of camshaft gear with press-fit lubricant and press gear onto camshaft. Position camshaft gear spacer on camshaft.

15. Install camshaft (with gear and spacer) as follows:

a. Install installer tool SE-1880 on threads of camshaft (Fig. 73).

b. Coat camshaft lobes, bearing surfaces camshaft bushings and camshaft gear teeth with heavy duty hypoid axle lubricant.

c. Insert camshaft (with gear and space into cylinder block (Fig. 73).

d. Align timing marks on camshaft gear and crankshaft gear (Fig. 156) and position camshaft into camshaft bush- ings. Remove installer tool.

e. Install camshaft thrust flange bolts (Fig. 72) and tighten to specified torque. (See TORQUE CHART.)

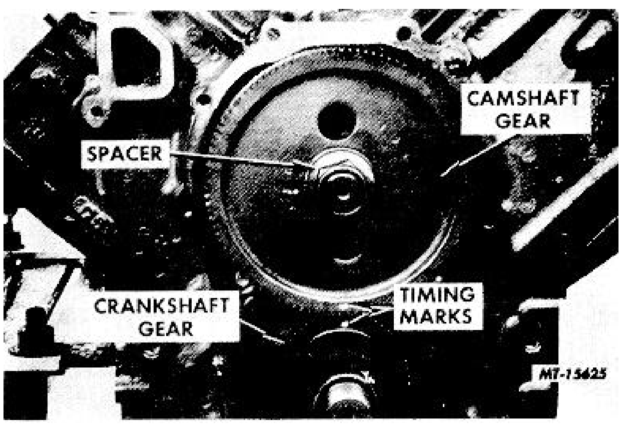

Fig. 156 Aligning Timing Marks on Camshaft and Crankshaft Gears

f. Install camshaft gear nut and tighten to specified torque. (See TORQUE CHART.)

g. Rotate crankshaft and camshaft to see that gears do not bind or interfere. Using dial indicator, check camshaft end play (Fig. 71) and camshaft gear-to-crankshaft gear backlash (Fig. 70).

IMPORTANT

Where desired, camshaft, thrust plate and camshaft gear can be installed individually. Using installer tool SE-1880, install camshaft in cylinder block (Fig. 75). Install camshaft thrust flange and tighten bolts to specified torque. Using SE-1900 installer and SE-1900-2 adapter, install camshaft gear on camshaft (Fig. 157).

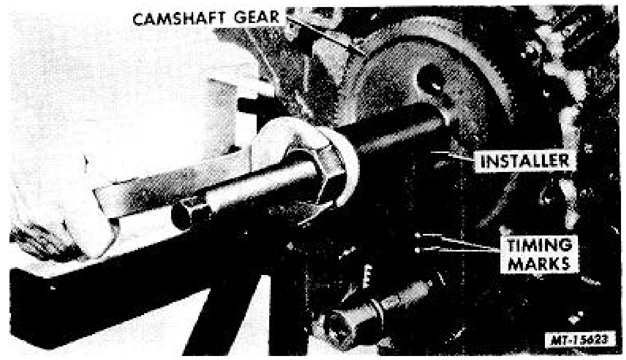

Fig. 157 Installing Camshaft Gear

16. Install piston and connecting rod assemblies as follows:

a. Turn cylinder block to vertical position with front end facing upward. Turn No. 1 crankpin to the top of its stroke.

b. Coat No. 1 piston and piston rings with clean engine oil and install piston ring with compressor on piston.

c. Coat No. 1 cylinder bore with clean engine oil. Position piston and rod assembly in cylinder bore with word "TOP" marked on piston toward center- line of engine block. Carefully push piston and rod assembly through ring compressor (Fig. 158) until piston is in cylinder bore. <u>Avoid striking cylinder bore with connecting rod</u>.

Fig. 158 Installing Piston and Connecting Rod Assembly

d. Coat crankshaft journal and connecting rod bearings with clean engine oil. Pull connecting rod down onto crank- shaft journal. Install connecting rod cap to rod with marked sides matching.

e. Install new bearing cap bolts, nuts and flat washers. Lubricate bolt threads and mating surfaces of bolt heads and washers with - engine oil and install bolts.

IMPORTANT

When installed properly, the large chambered side of the rod and cap will be on the fillet side of the crankpin (Fig. 115). Tighten bolts to specified torque shown in TORQUE CHART, then release torque load to zero and retighten to specified torque. After bolts have been torqued, turn each nut an additional one-sixth turn or one flat of the nut.

f. Install remaining piston and connecting rod assemblies in the same manner.

g. Recheck connecting rod end play.

17. Install piston cooling nozzles as follows:

a. Rotate cylinder block to horizontal position with bottom of crankcase facing upward.

b. Install one cooling nozzle making sure locating pin engages hole in crankcase (Fig. 159). Install new washers and bolt. Tighten bolt finger tight.

c. Lower piston in cylinder bore until slot in piston skirt passes over cooling noz- zle. Make sure nozzle is centered in slot of piston skirt and tighten bolt to specified torque. (See TORQUE CHART.)

d. Install remaining cooling nozzles in the same manner.

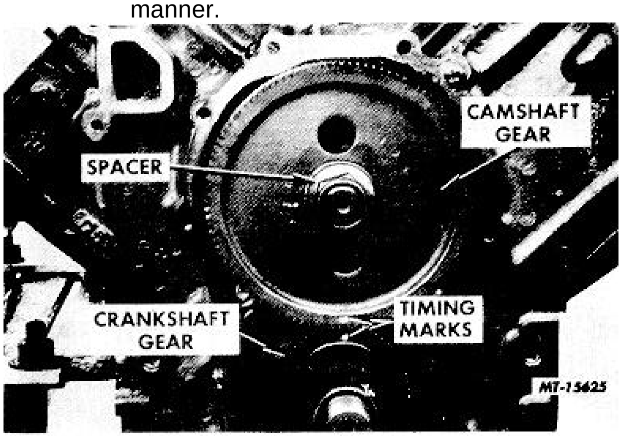

Fig. 159 Piston Cooling Nozzle Installation

18.A.. On engines with serial numbers before 51135, install oil pump and screen as follows:

a. Position oil pump in cylinder block and secure with capscrews and lockwashers.

b. Check for correct alignment of pump in block. Pump shaft should rotate freely without binding if correctly aligned (Fig. 160).

c. Assemble oil pump screen to oil pump. Tighten oil tube nut finger tight.

d. Establish correct oil pump screen position by placing a straight edge across oil pan rails of crankcase and using a scale to measure distance from bottom of straight edge to top of pump screen on both sides (Fig. 161). Pump screen should be parallel with and 165 mm (6-1/4 to 6-1/2 inch) above the pan rails. Tighten oil tube nut per specification in Torque Chart.

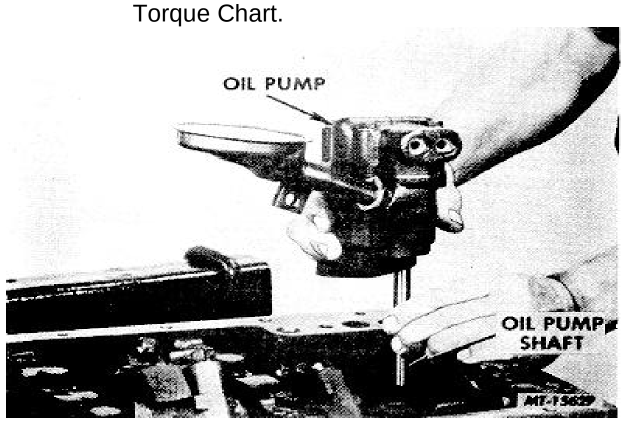

Fig. 160 Checking Oil Pump to Cylinder Block Alignment

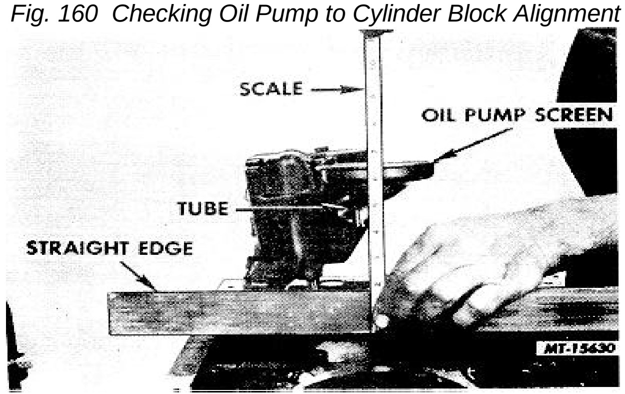

Fig. 161 Checking for Proper Location of Oil Pump Screen

e. Install pump screen clamp and brace (Fig. 162). Tighten bolts evenly so that screen does not move.

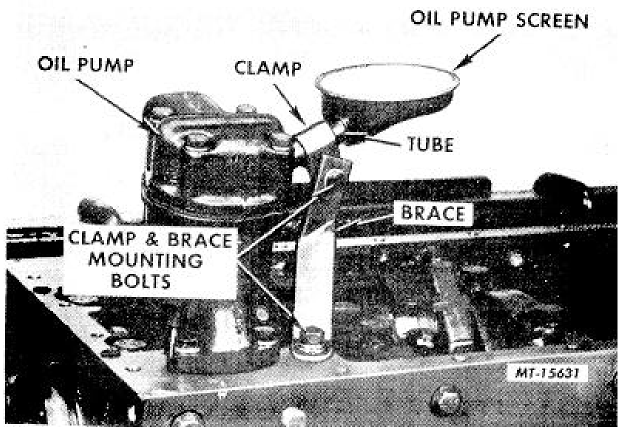

Fig. 162 Pump Screen Clamp and Brace Installation

18.B. On engines with serial number 51135 and after, install oil pump as follows:

a. Position oil pump in cylinder block and secure with cap screws and lockwashers (Fig. 163).

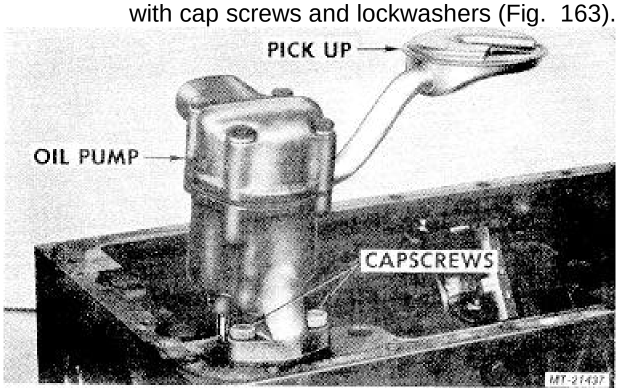

Fig. 163 Oil Pump in Cylinder Block

b. Check for correct alignment of pump in block. Pump shaft should rotate freely without binding if correctly aligned (Fig. 164).

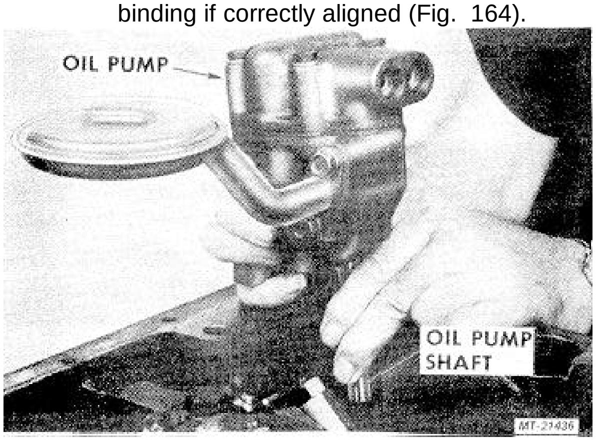

Fig. 164 Checking for Correct alignment of Pump in Block

19. Rotate cylinder block to horizontal position with top of block facing upward. Place flywheel housing in position over two aligning roll pins and tap into cap-screws (with flat washers) and tighten in sequence shown in Fig. 165.

IMPORTANT

The two lower mounting capscrews should be wrapped with two turns of Teflon thread tape to prevent oil leakage.

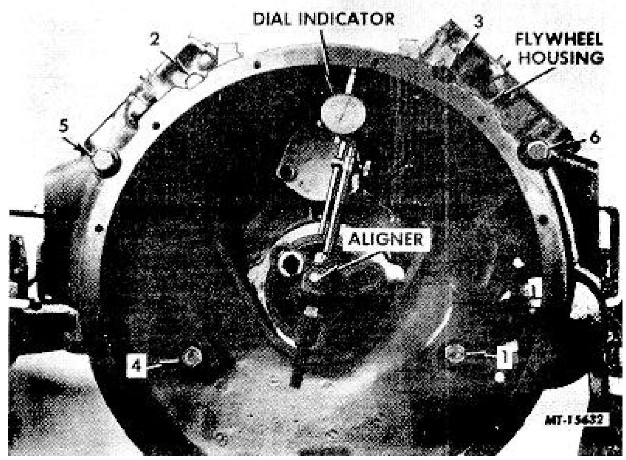

Fig. 165 Checking Flywheel Housing Alignment

20. Using aligner tool SE-1834 and dial indicator, check flywheel housing alignment (Fig. 165). Run-out (out-of-round) should not exceed specified limits. (See SPECIFICATIONS.)

IMPORTANT

If flywheel housing alignment out-of- round exceeds specified limit or if either flywheel housing or crankcase is being replaced, remove roll pins, align flywheel housing with dial indicator and ream roll pin holes with standard tapered reamer, 12.7 mm (1/2 inch) to accommodate oversize roll pins (Fig. 166).

If possible, align flywheel housing while engine is in engine stand with cylinder block in vertical position (Flywheel hous- ing facing up).

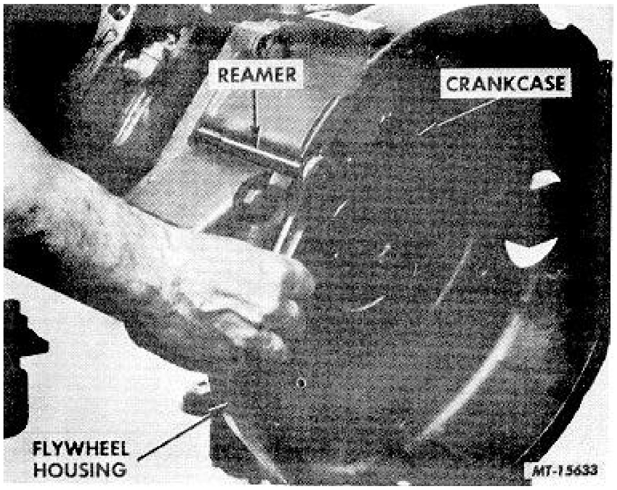

Fig. 166 Reaming Flywheel Housing-to- Crankcase Roll Pin Holes

21. Position flywheel (with ring gear) on roll pin in crankshaft flange. Install flywheel mounting capscrews in flywheel and crankshaft flange and tighten to specified torque. (See TORQUE CHART.)

22. Coat the O.D. of the clutch pilot bearing and I.D. of flywheel bore with Loctite grade B. Then install clutch pilot bear- ing into the flywheel. Do not allow Loctite to contact inside of bearing or between flywheel and crankshaft. After the Loctite grade B has been applied, allow to cure for 1 to 2 hours.

23. Install clutch assembly on engine flywheel.

Clutch installation procedures vary between clutch types. With clutch assembly shown in Fig. 167, proceed as follows:

a. Position clutch driven disc against flywheel so that long portion of hub is toward the rear. Place clutch in position on flywheel over clutch driven disc. Locate arrow or inspection mark (usually a dab of white paint) on flange of clutch backing plate or cover as near as possible to letter "L" on fly- wheel and install two or three mounting capscrews and lockwashers loosely.

b. Insert a clutch aligning arbor or a transmission main drive gear shaft through clutch driven disc hub splines and into clutch pilot bearing. Hold clutch driven disc in position and install remaining mounting capscrews and lockwashers in the flange of clutch backing plate or cover.

c. Tighten all capscrews alternately, evenly and securely. Remove three retaining capscrews and flat washers, retaining clips or wood blocks which were installed to hold clutch com- pressed.

IMPORTANT

The clutch will not operate properly unless retaining capscrews or clips are removed.

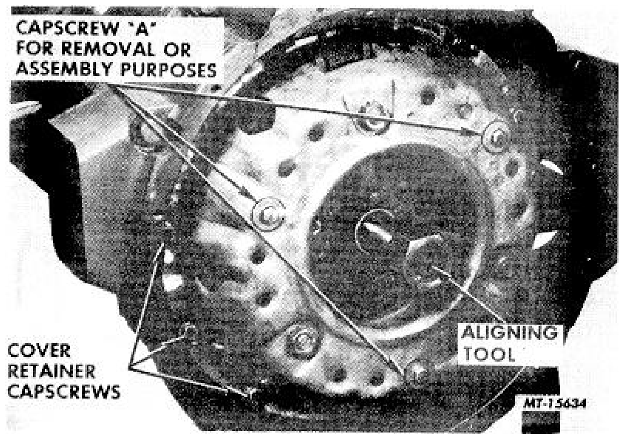

Fig. 167 Clutch Installation

24. Position the gasket on front, rear and sides of tappet cover. Install tappet cover with gasket on crankcase and secure with bolts and washers.

25. Position a new engine front cover gasket over dowel pins in crankcase. Coat right water outlet gasket with grease and position to crankcase. Install engine front cover assembly (Fig. 168) and idler arm mount- ing bracket (Fig. 66).

IMPORTANT

The second set of mounting capscrews from the bottom of front cover and the two on back side of front cover (Fig. 65) are nylok type to prevent oil leakage as these holes are drilled into and through the crankcase. It is good practice to use new nylok capscrews at these locations.

Capscrews located at rear of front cover (Fig. 66) should not be longer than 25.4 mm (1 inch). Otherwise interference between end of capscrews and camshaft gear will result.

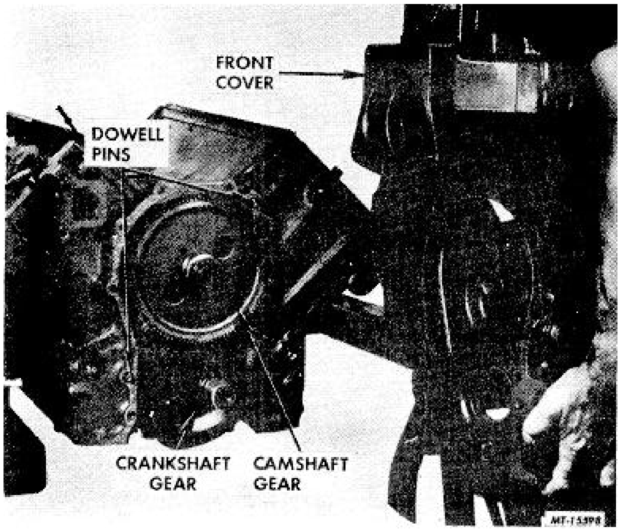

Fig. 168 Installing Engine Front Cover

26. Install front cover oil seal as follows:
    a. Position front cover oil seal on tool pilot (small diameter) of SE-2096 installer with wiping lip of seal toward outer end of pilot.

    b. Lubricate seal bore of front cover with engine oil.

    c. Place installer over end of crankshaft and drive seal into cover (Fig. 169). Seal is properly located when inner shoulder on tool contacts machined surface of front cover.

IMPORTANT

Tool can also be used to install oil seal where cover is removed from engine by placing front cover in a press and with seal in until flange of tool contacts machined surface on front cover.

27. Install injection pump drive shaft rear bearing as follows:

    a. Assemble SE-2098-2 retaining screw through bore of SE-2098-1 installer and place 14.287 cm (5-5/8 inch) diameter adapter (from SE-1905 set) over threaded end of screw. Install handle from SE-1905 set of retaining screw.
    b. Position bearing on pilot of SE-2098-1 installer and install bearing in engine front cover (Fig. 170). Bearing is properly located when adapter contacts machined pump mounting surface of front cover.

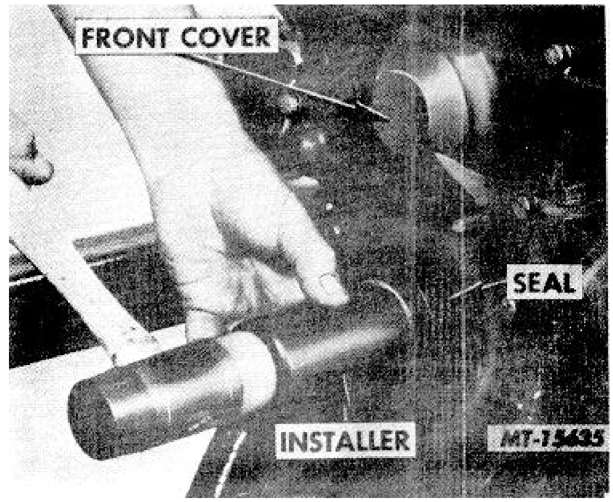

Fig. 169 Installing Engine Front Cover Oil Seal

Fig. 170 Installing Injection Pump Drive Shaft Rear Bearing

28. Install front bearing on injection pump drive shaft by placing shaft into press and with a suitable adapter press bearing onto shaft until it bottoms on the shaft flange (Fig. 171).

29. Install injection pump drive shaft (with front bearing) into engine front cover and install snap ring (Fig. 60).

30. Mesh injection pump drive gear teeth with camshaft gear teeth; then rotate pump drive shaft to align holes in shaft with mounting holes in drive gear. With a soft hammer tap gear onto drive shaft and install three capscrews and lockwashers. Tighten capscrews to specified torque. (See TORQUE CHART.)

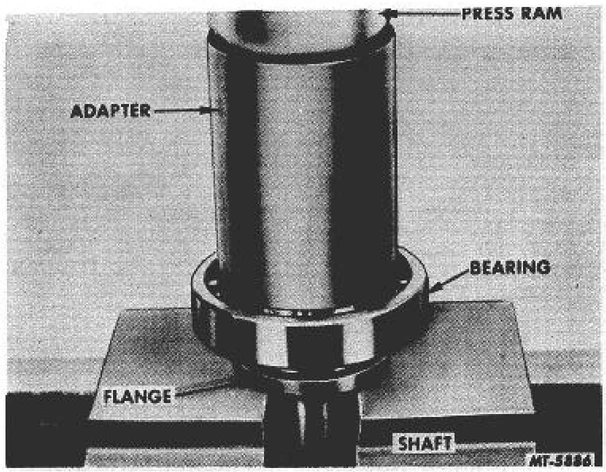

Fig. 171 Installing Injection Pump Drive Shaft Front Bearing

31 Loosely assemble injection pump drive hub, grip springs, retainer and nut on drive shaft (Fig. 172). Do not tighten retaining nut at this time.

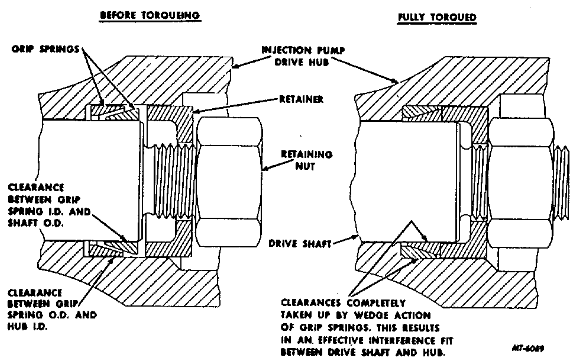

Fig. 172 Proper Assembly of Injection Pump Drive Shaft Grip Springs and Retainer

32. If front oil seal wear sleeve was removed from crankshaft pulley at engine disassembly, install new wear sleeve as follows:

a. Coat crankshaft pulley flange with a non-hardening sealer. Position pulley on press bed.

b. Heat wear sleeve in boiling water and position on pulley hub. Using handle and 7.3 cm (2-7/8 inch) diameter adapter from SE-1905 tool set, press wear sleeve onto pulley hub until flush with end of hub (Fig. 173).

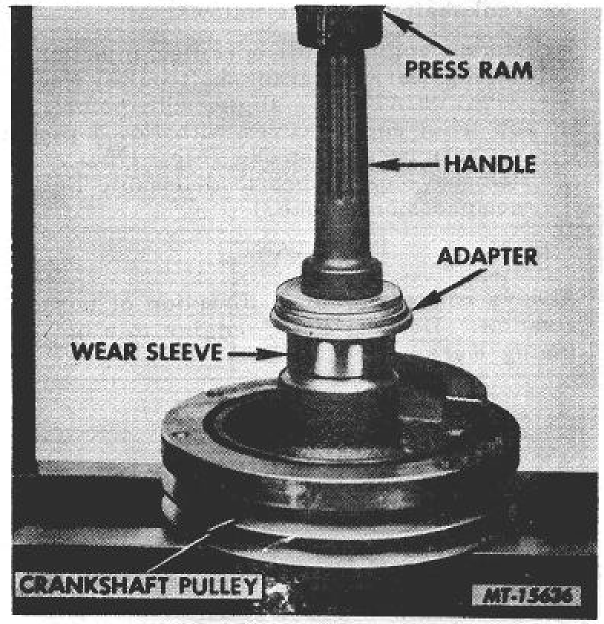

Fig. 173 Installing Front Oil Seal Wear Sleeve

33. Install idler pulley arm to mounting bracket, making sure spacer is between arm and boss on front cover (Fig. 55). Secure arm with capscrew and lockwasher.

34. Position pulley key in keyway of crankshaft. Lubricate inside diameter of crankshaft pulley with press-fit lubricant. Install crank-shaft pulley using installer tool SE-1900 (Fig. 174). Install crankshaft pulley nut and flat washer. Tighten pulley nut to specified torque. (See TORQUE CHART).

IMPORTANT

Wear sleeve surface on crankshaft damper should be lubricated with clear engine oil to prevent seal damage.

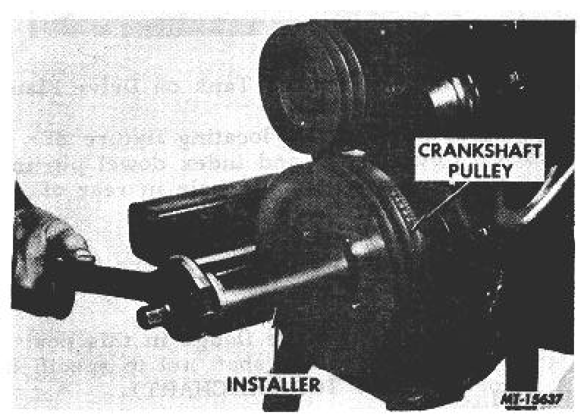

Fig. 174 Installing Crankshaft Pullet

35. Establish correct injection pump drive shaft to crankshaft timing as follows:

a. Rotate engine until specified injection timing mark on crankshaft pulley (see SPECIFICATIONS) aligns with pointer on front engine cover with No. 1 piston on compression stroke (Fig. 175). (Observe cam lobes to determine No. 1 compression stroke.)

IMPORTANT

Always rotate engine in direction of normal rotation. Do not "back" engine to align timing marks.

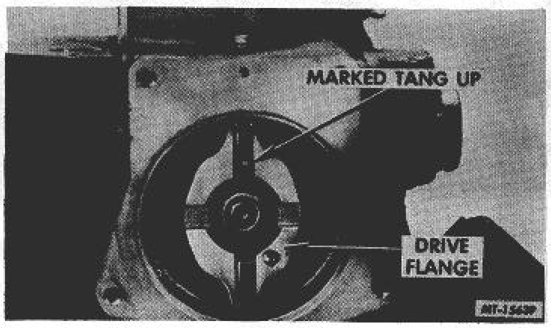

Fig. 175 Engine Timing Marks and Pointer

b. Rotate injection pump drive flange on pump drive shaft until drive tangs are vertical with marked tang "up" at 12 o'clock position (Fig. 176).

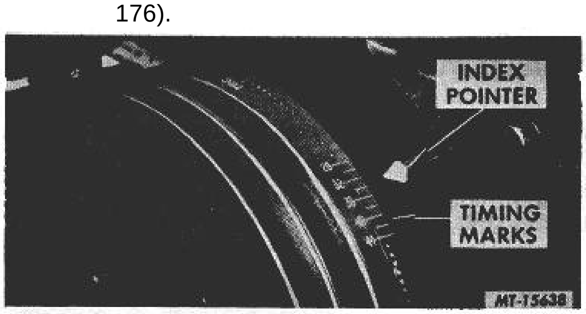

Fig. 176 Position of Marked Tank on Drive Flange

c. Place drive flange locating fixture SE-2323 over tangs and index dowel pin in tool with aligning pin hole in rear of engine front cover (Fig. 177).

d. Install mounting bolts to secure fixture to front cover.

e. While holding drive flange in this position, tighten drive shaft nut to specified torque, (See TORQUE CHART).

f. Remove drive flange locating fixture.

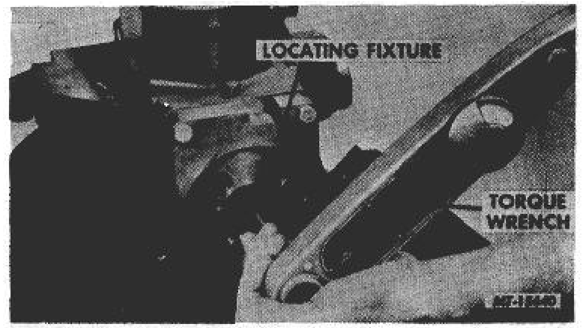

Fig. 177 Tightening Injection Pump Drive Flange Nut

36. Position a new water pump body gasket on engine front cover. Install water pump body and secure with screws and lockwashers.

37. Position new "0" ring on water pump housing. Install water pump assembly into water pump body and secure with four flat head screws.

IMPORTANT

The lower mounting hold in water pump housing utilizes a nylok screw. When installing water pump housing, it is good practice to use a new nylok screw at this location. However, if nylok tab appears to be satisfactory in old screw, it may be reused.

38. Position new oil pan gasket on engine crankcase. Install oil pan.

IMPORTANT

The second and third oil pan bolts on right pan rail should not be installed at this time, as they secure exhaust manifold heat shield.

39. Using SE-2097 tappet installer, install tappets in their respective bores in crankcase.

40. Install cylinder heads as follows:

a. Position new cylinder head gaskets over the aligning dowel sleeves of each cylinder bank. Make sure all bolt holes in gaskets align with holes in crankcase.

b. Using lifting sling SE-1896, place one cylinder head in the proper cylinder bank. Align head with dowel sleeves in crankcase. Loosely install all cylinder head bolts and flat washers.

IMPORTANT

Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil.

Repeat these operations to install opposite cylinder head.

c. Following sequence shown in Fig. 178, tighten cylinder head bolts evenly to specified torque. (See TORQUE CHART.)

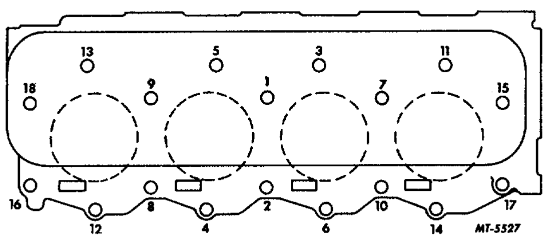

Fig. 178 Cylinder Head Bolt Tightening Sequence

41. Insert valve lifter push rods in their respective positions.

42. Position a valve tip (Fig. 44) on each valve stem.

43. Install rocker arm assemblies as follows:

a. Loosen rocker adjusting screw locknuts and back off adjusting screws.

b. Position rocker arm assembly on cylinder head, making sure rocker arms align with valve stems.

c. Making sure there is no interference between rocker arms and push rods, tighten rocker arm support bolts to specified torque (See TORQUE CHART).

d. Position push rods under rocker arm adjusting screws and tighten screws until they just touch push rods with corresponding piston on compression stroke. It will be necessary to rotate the engine to accomplish this on all cylinders.

44. Adjust rocker arm to valve tip (tappet clearance as follows:

a. Rotate engine in operating direction until No. 1 intake valve just starts to open. Then adjust intake and exhaust valves on No. 6 cylinder to specified clearance (See SPECIFICATIONS).

b. Adjust remaining valves by rotating engine through firing order -- With No. 8 intake just opening, adjust valves on No. 5 cylinder; No. 7 intake just opening, adjust valves No. 4 cylinder; No. 3 intake just opening, adjust valves on No. 2 cylinder; No. 6 intake just opening, adjust valves on No. 1 cylinder; No. 5 intake just opening, adjust valves on No. 8 cylinder; No. 4 intake just opening, adjust valves on No. 7 cylinder, and No. 2 intake just opening, adjust valves on No. 3 cylinder.

45. Insert new "0" rings and gaskets on injection nozzles and install nozzles in their respective bores in cylinder heads. Install capscrews and lockwashers and tighten alternately and evenly to specified torque (See TORQUE CHART).

IMPORTANT

These capscrews are nylok type. Good practice is to use the new capscrews at this location. However, if the nylok tab appears satisfactory on old capscrews, they may be reused.

46. Place cylinder head cover gaskets on each head and install cylinder head covers, attaching with screws and flat washers. Tighten screws to specified torque. (See TORQUE CHART.)

47. Place new "O" rings on water outlet pipe (Fig. 44) and install in right bank water outlet (Fig. 39). Position new 110"" ring gasket in water outlet. Insert outlet pipe in front cover and secure water outlet to right cylinder head with two capscrews and lockwashers. Install left bank water outlet on left cylinder head in the same manner.

48. On engines equipped with swirl destroyer, place swirl destroyer control mounting plate and linkage as an assembly over three studs on tappet cover and secure with three nuts and lockwashers.

49. On engines equipped with swirl destroyer, install swirl destroyer shafts (with plates) in intake manifolds as follows:

a. Place six bushings on swirl destroyer shaft. Note that four of the bushings have a larger inside diameter and are used over the sleeves on the shaft, while the bushings having the smaller inside diameter are used directly on the shaft (Fig. 179).

b. Position swirl destroyer shaft and plates in intake manifold ports. Slide shaft end- wise until one of the plates contacts the manifold. Back off shaft to obtain 0.12 mm (.005 inch) clearance between plate and manifold (Fig. 179). Adjust collars against manifold, allowing shaft to rotate freely, then tighten setscrews and locknuts.

c. Install rubber band to hold swirl destroyer shaft in manifold (Fig. 179) to permit assembling manifold to cylinder head.

50. Place intake manifold gaskets over cylinder head ports. Position intake manifolds on cylinder heads and secure with capscrews and lockwashers.

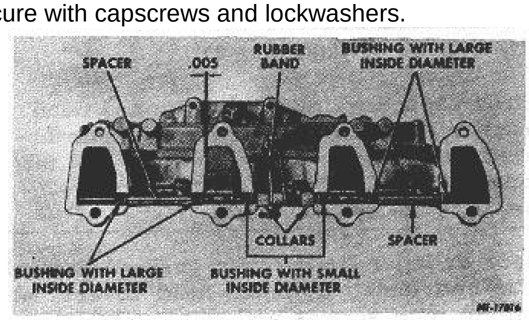

Fig. 179 Swirl Destroyer Shaft Details (Early Production Engines Only)

51. On engines equipped with swirl destroyer connect swirl destroyer actuating rods to shaft levers at intake manifolds. Adjust rod length if necessary, so that swirl destroyer plates in both manifolds are fully closed with bellcrank in START position (Fig. 180).

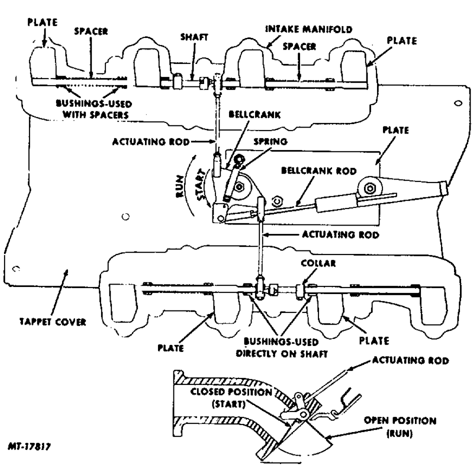

Fig. 180 Swirl Destroyer Control Linkage (Early Production Engines Only)

52. Install fuel injection pump as follows:

a. Rotate engine until specified injection timing mark aligns with pointer on front engine cover. Observe to see if injec- tion pump drive tangs at rear of engine front cover are vertical with the marked tang at 12 o'clock position (Fig. 176).

b. To verify correct alignment of drive flange tangs, install drive flange locating fixture SE-2323 on engine (Fig. 177).

IMPORTANT

If drive flange fixture cannot be installed, make sure No. 1 cylinder is on compression stroke and realign drive flange per Step 35 above.

c. Rotate injection pump camshaft so that drive flange tangs are horizontal with slash mark on end of camshaft at 10 o'clock position.

IMPORTANT

Injection pump must be correctly timed internally (Static Timing). Refer to Fuel System Section CTS-2678 of the Truck Service Manual for Static Timing check instructions.

d. Install drive coupling disc on tangs of pump drive flange. Blind hole in center of coupling faces toward pump.

e. Place new gasket on pump mounting adapter.

f. Install injection pump, making sure drive flange tangs engage with slots in drive coupling disc and that pin in pump mounting adapter engages with hole in engine front cover. Secure mounting adapter and injection pump to engine front cover with four capscrews, flat washers and lockwashers.

g. Install injection pump support braces and bracket to injection pump and intake manifold (Fig. 29). Secure braces and bracket with capscrews, flat washers and lockwashers. Tighten to specified torque (See TORQUE CHART).

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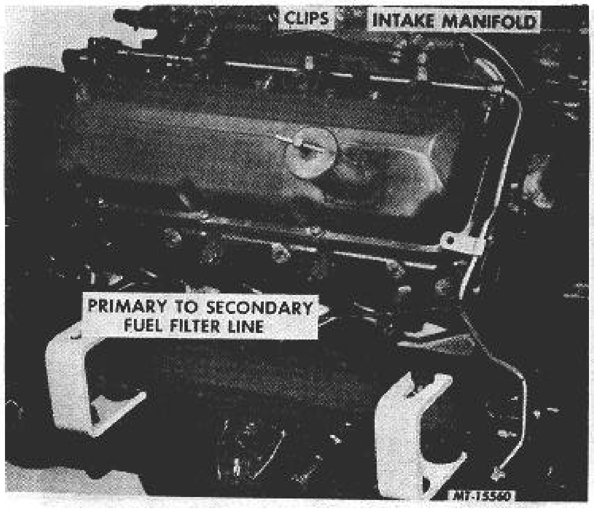

Fig. 181 Primary to Secondary Fuel Filter Line Installation

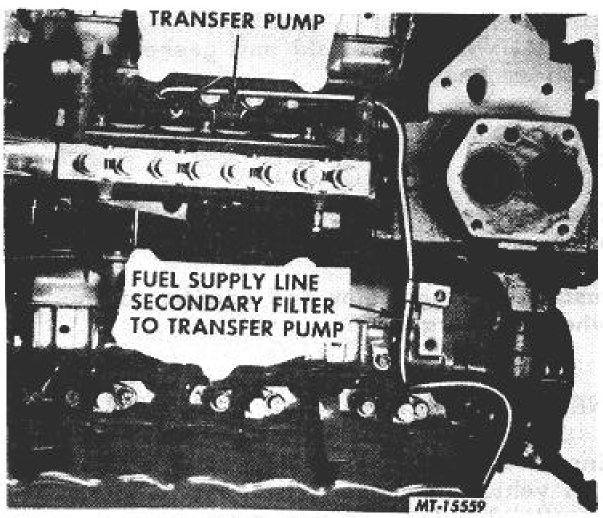

Fig. 182 Secondary Filter to Transfer Pump Fuel Line Installation

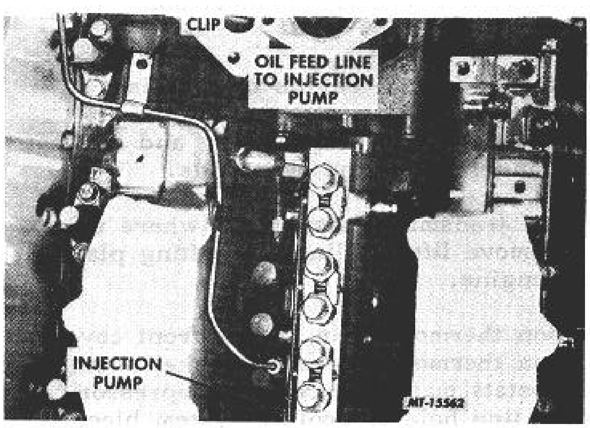

Fig. 183 Injection Pump Lube Oil Line Installation

56. Connect low pressure fuel supply line to transfer pump.

57. Remove dust caps and reinstall injection nozzle, injection pump and manifold fuel leak-off lines (Figure 33).

58. Place new "0" ring on air compressor adapter plate. Position a compressor adapter plate on engine front cover and secure with three capscrews and lockwashers.

59. Connect injection pump oil line to compressor adapter plate.

60. Place new gaskets on cylinder head cover plates (Figure 45). Install cover plates and secure with capscrews and lockwashers. Install cylinder head to cylinder block water pipes.

61. Remove dust caps from fittings and install fuel injection lines from pump to nozzles. Secure lines to intake manifold with grommets, clips and capscrews (Figure 32). Tighten injection line connectors to specified torque. (See TORQUE CHART.)

62. Remove dust caps from fittings and install crankcase ventilator pipe to right cylinder head cover and intake manifold.

63. Install water pump pulley to hub and secure with four capscrews and lockwashers.

64. Install oil dipstick tube in crankcase.

65. Position gasket on air compressor adapter plate and install air compressor.

66. Install alternator mounting bracket to intake manifold and front cover. Place alternator on mounting bracket and secure with two capscrews and nuts.

67. Install freon compressor mounting bracket and install freon compressor on mounting bracket.

68. Install power steering pump mounting bracket and install power steering pump on mounting bracket.

69. Install accessory drive belts and adjust belts by moving power steering pump, alternator and freon compressor on their mounting brackets until proper belt tension is obtained.

Position main drive belts over crankshaft and water pump pulleys. Push idler pulley toward center of engine and install belts over idler pulley.

70. Install oil filter and cooler base as follows:

a. Insert two capscrews in each end of base and in the middle of base.

b. Position gasket against base and just start threads of capscrews in gasket.

c. Place base with gasket against crankcase and start capscrews.

d. Install remaining capscrews and tighten all capscrews alternately and evenly.

71. Position new oil cooler gaskets on oil cooler base and install cooler.

72. Install oil pressure sender unit to oil filter base.

73. Remove the tape from intake manifold openings and place gasket with screen over opening with marking "Air Cleaner Side" up on each intake manifold. Install engine air cleaner adapter to intake manifold.

74. Connect the air line from air compressor to air cleaner adapter.

75. Assemble fan blade to modulated automatic fan and install fan assembly to water pump hub using SE-2107 wrench and heavy-duty screwdriver blade against lug on water pump body to form a stop against one pulley hub spoke (Figure 24). Keep screwdriver to wedge between pump body and pulley hub spoke, otherwise, damage to pulley hub spoke will result. Tighten 1-1/4" left-hand thread nut to 54.2 N-m (40 lb. ft.) torque.

76. Install engine plates and lifting sling (Fig. 5) and remove engine from overhaul stand.

77. Install secondary filter base and gasket to crankcase and connect fuel supply lines.

78. Install crossover tube and gasket to water pump body and crankcase.

79. Connect oil feed line from oil filter base to tee at air compressor adapter plate and install clip.

80. Install oil cooler water inlet and return lines.

81. Install new oil filters on filter base (Figure 184).

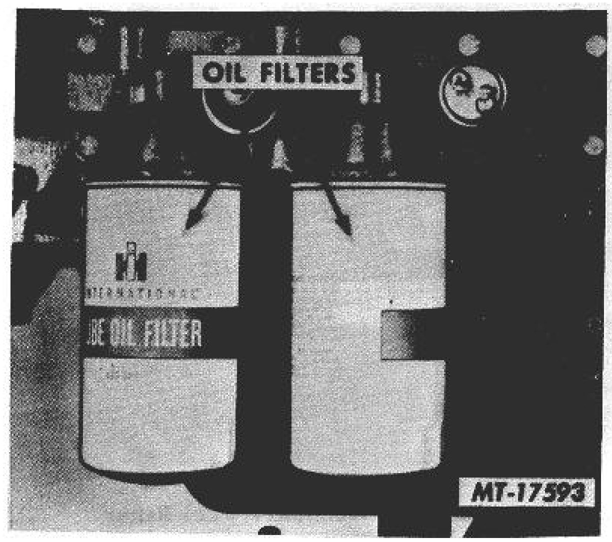

Fig. 184 Oil Filter Installation

82. Install exhaust manifold and gasket to each cylinder head.

83. Install exhaust manifold heat shield to crankcase.

84. Connect water line from crossover tube to air compressor and install clip.

85. Install starting motor and adapter to flywheel housing.

ENGINE INSTALLATION

Engine installation procedures will differ between vehicle models. The general instructions outlined below apply to most cases.

1. Install lifting plates and lifting sling on engine (See Fig. 5). Connect hoist to lifting sling.

2. Position and align engine in chassis.

3. Connect engine to bell housing and connect front and rear engine mountings.

4. Remove transmission support (where used) and remove lifting sling and lifting plates from engine.

5. Position thermostats in engine front cover. Position thermostat housing gasket over thermostats making sure air compressor return line hole or cooling system bleeder hole is open (Fig. 185). Install thermostat housing and connect air compressor water return line (where used).

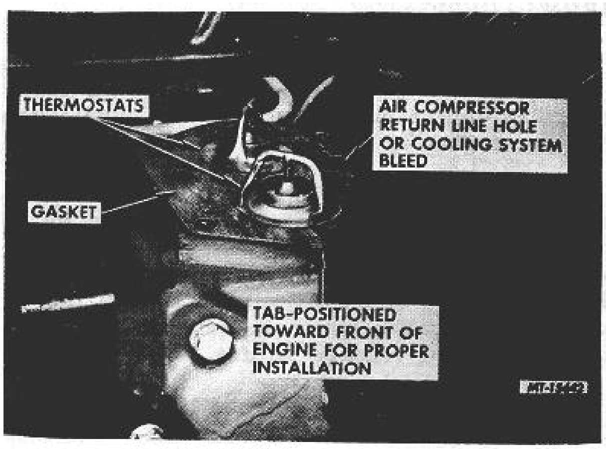

Fig. 185 Thermostat Installation

6. Connect:

   Accelerator and throttle linkage.

   Alternator, temperature sender and oil pressure sender wiring.

   Air compressor piping (where equipped).

   Exhaust pipes to manifolds.

   Fuel inlet and return lines.

   Heater hoses and brackets.

   Surge tank hoses (where equipped).

   Swirl destroyer control cable(where equipped).

   Tachometer cable.

7. Install air cleaner adapter or manifold crossover, air cleaner and air cleaner piping. Mounting details of the engine mounted type air cleaner are shown in Fig. 186.

8. Install power steering pump on engine or connect power steering hoses to power steering pump (where equipped).

9. Install transmission shift lever island and shift rod bearing support (CO models).

10. Install radiator core assembly, radiator support fenders, front bumper, etc., as required.

11. Install air conditioning system components (where equipped).

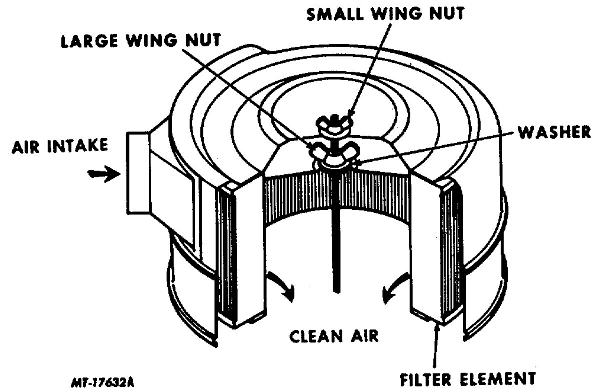

Fig. 186 Mounting Details of Engine Mounted Air Cleaner

12. Install radiator hoses and shutter control hoses (where used).

13. Prime engine lubricating system. (See PRIMING LUBRICATING SYSTEM.)

14. Fill engine with engine oil.

15. Fill engine cooling system with coolant.

16. Fill power steering system (where equipped).

17. Connect battery cables.

18. Prime fuel system (Refer to Fuel System Section CTS-2678, of Truck Service Manual.)

19. Operate engine. Check for oil and coolant leaks. Make necessary engine operation adjustments.

20. Bleed power steering system as needed (where equipped).

21. Check air conditioning system operation and refrigerant level (where equipped). Service and adjust as needed.

22. Reinstall hood and engine tunnel (where used). Lower cab (CO models).

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ENGINE MOUNTINGS

Typical front and rear engine mountings are shown in Figures 187 and 188.

The engine front mounting (Fig. 187) utilizes a two-piece insulator with retainer. When assembling, position component parts as shown and tighten locknuts 128-142 N-m (95- 105 lb. - ft.) torque.

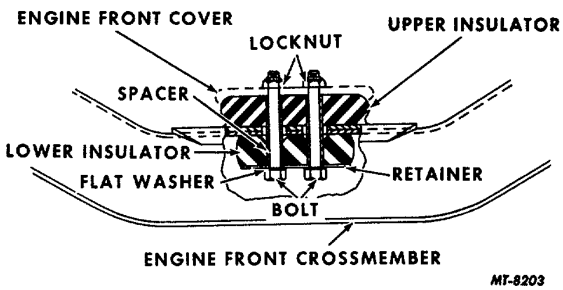

Fig. 187 Engine Front Mounting (Typical)

The engine rear mounting (Fig. 188) utilizes a two-piece insulator with retaining washers. When assembling, position component parts as shown and tighten locknut 128-142 N-m (95-105 lb. -ft.) torque. The engine mounting bracket- to-flywheel housing bolts should be tightened to 203 N-m (150 lb. -ft.) torque.

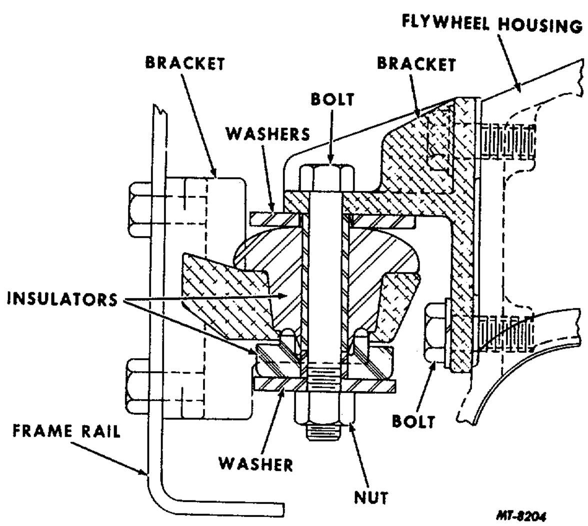

Fig. 188 Engine Rear Mounting (Typical)

PRIMING LUBRICATING SYSTEM

When assembling the engine during overhaul it is important to prelubricate the running parts with clean engine oil to assure initial lubrication when the engine is first started.

To further assure complete initial lubrication, the engine lubricating system should be pressure primed or charged with oil. Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation which could lead to immediate or low mileage failure.

Priming can be accomplished by using the SE-1632 Oil Leak Detector as follows:

1. Using adapter fittings, connect oil line from oil leak detector to engine oil gallery.

2. Following manufacturer's instructions, fill and charge oil leak detector.

3. Inject sufficient oil into engine oil gallery to fill oil filters and charge entire system.

4. Disconnect oil leak detector.

After priming, check engine oil level and adjust (fill or drain) as needed before starting engine.

New or overhauled engines which have been in storage should be primed as outlined above, at installation.

TORQUE CHART

Location	Recommended Torque, Newton-meters	Ft. Lbs.
Main Bearing Cap Bolts	169-183	125-135 (1)
Main Bearing Tie Bolts (1)	54-61	40-45 (1)
Camshaft Thrust Flange	54-61	40-45
Camshaft Gear Nut	271-305	(200-225)
Connecting Rod Cap Bolts	75	(55)2)
Piston Cooling Nozzle Bolts	16-20	(12-15)
Flywheel to Crankshaft Bolts	149-156	(110-115)
Injection Pump Gear Bolts	27-34	(20-25)
Crankshaft Pulley Nut	353-393	(260-290)
Injection Pump Drive Shaft Nut	95-108	(70-80)
Cylinder Head Bolts	142-149	(105-110)
Rocker Arm Support Bolts	42-47	(30-35)
Rocker Arm (Valve) Adj. Nut	24-34	(18-25)
Cylinder Head Cover Screws	5	(3)
Nozzle Hold-down Clamp	19-22	(14-16)
Mtg. Bracket to Injection Pump Bolts	27-34	(20-25)
Injection Line Connectors	27-34	(20-25)
Air Compressor Pulley Nut:		
3/4" Thread Size	54 Min.(3)	(40 Min.)(3)
7/8" Thread Size	68 Min.(3)	(50 Min.)(3)

All Other Fasteners:

Bolt Size	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8
w/Course threads N-m (lb. -ft.)	20(15)	41(30)	68(50)	108(80)	156(115)	210(155)	380(280)	576(425)
w/Fine threads N-m (lb.-ft.)	27(20)	54(40)	81(60)	129(95)	183(135)	258(190)	447(330)	664(490)

(1) Main bearing cap bolts must be torqued before tightening tie bolts.

(2) Plus an additional one-sixth turn (see text for instructions).

(3) Plus additional tightening to align key slot.

Torque specifications based upon clean bolt threads with threads and under heads of bolts lubricated with engine oil. Always use a torque wrench known to be correctly calibrated.

SPECIFICATIONS

ENGINE	D-150	D-170	D-190
Number of Cylinders		8	
Bore		114.3 mm (4 1/2")	
Stroke		109.5375 mm (4 5/16")	
Displacement		8.99 liters (549 cu in)	
Compression Ratio		16.6 to 1	
Compression Pressure (at Cranking Speed, Sea Level)		2584-2928 kPa (375-425 psi)	
Firing Order		1 - 8 - 7 - 3 - 6 - 5 - 4 - 2	
Fuel Injection Timing		32 degrees + 1 degree BTDC	
Gross Power Net Power Gross Torque Net Torque		Refer to Truck Service Manual, Fuel System Section CTS-2678 for this information.	
Idle Speed (Lo-Idle)		600-650 rpm	
Governed Speed (Full Load)		3000 rpm	
Maximum Speed (Hi-Idle)(No Load)		3200-3350 rpm	
Crankcase Refill Capacity:			
Wet Engine		11.4 liters (12 qts.)	
Dry or Rebuilt Engine		12.35 liters (13 qts.)	
Oil Filter Capacity (at Filter Change) (Total, 2 Filters)		1.9 liters (2 qts.)	
Engine Weight:			
Bare Engine		531.6 Kg (1172 lbs.)	
With Standard Accessories		629.6 Kg (1388 lbs.)	
Engine Serial Number Location		Stamped on Top of Crankcase Right Bank, Front Corner	
Camshaft:			
Bearing Journal Diameter:			
Front		59.58-59.61 mm (2.346-2.347")	
Second		58.80-58.83 mm (2.315-2.316")	
Third		58.14-58.17 mm (2.289-2.290")	
Fourth		57.05-57.07 mm (2.246-2.247")	
Bearing Clearance		038-.089 mm (.0015-.0035")	
Thrust Taken By		Thrust Flange	
End Play		089-.292 mm (.0035-.0115")	
Timing Gear Backlash		013-.114 mm (.0005-.0045")	

SPECIFICATIONS (Continued

ENGINE	D-150	D-170	D-190
Crankshaft:			
Number of Main Bearings		5	
Main Journal Diameter		79.34-79.36 mm (3.1235-3.1245")	
Main Bearing Clearance		033-.109 mm (.0013-.0043")	
Thrust Taken By		Intermediate Main	
End Play		102-.254 mm (.004-.010")	
Crankpin (Rod Journal) Diameter		69.93-69.95 mm (2.753-2.754")	
Connecting Rods:			
Bearing Bore Diameter		74.816-74.828 mm (2.9455-2.9460")	
Maximum Permissible Out-of-Round		0127 mm (.0005")	
Maximum Permissible Taper		0127 mm (.0005")	
Bearing Clearance		048-.112 mm (.0019-.0044")	
End Clearance		20-.46 mm (.008-.018")	
Bearing Insert Spread Dimensions:			
Main Bearing Nos. 1, 2, 4, 5:			
Bearing O.D. (Installed)		84.23-84.25 mm (3.316-3.317")	
Specified Spread		762 mm (.030") Minimum	
Spread of Bearing ("A", Fig. 118)		84.99 mm (3.346") Minimum	
Main Bearing No. 3 (Thrust):			
Bearing O.D. (Installed)		84.23-84.25 mm (3.316-3.317")	
Specified Spread		050 -.381 mm (.002-.016")	
Spread of Bearing ("A", Fig. 118)		84.28-84.65 mm (3.318-3.333")	
Connecting Rod Bearings:			
Bearing O.D. (Installed)		74.816-74.828 mm (2.9455-2.9460")	
Specified Spread		762 mm (.030") Minimum	
Spread of Bearing ("A", Fig. 118)		75.578 mm (2.9755") Minimum	
Pistons:			
Material		Aluminum Alloy	
Clearance in Cylinder Bore		15-.18 mm (.006-.007")	
Piston Pins:			
Length		82.30-82.55 mm (3.240-3.250")	
Diameter		38.095-38.1 mm (1.4998-1.5000")	
Pin Fit: At room temperature			
(21 degrees C/70 degrees F)			
Clearance in Rod		023-.033 mm (.0009-.0013")	
Clearance in Piston		005-.015 mm (.0002-.0006") Loose	
Piston Rings:			
Ring Diameter		114.3 mm (4 1/2")	
Compression Rings:			
Number per Piston		2	
Size:			
Top		Tapered (Keystone Type)	
2nd		2.83 mm (3/32")	
Fit in Groove:			
Top		Tapered	
2nd		089-.140 mm (.0035-.0055")	
Gap		33-.58 mm (.013-.023")	
Oil Control Rings:			
Number per Piston		1	
Size		4.763 mm (3/16")	
Fit in Groove		038-.076 mm (.0015-.003")	
Gap		33-.71 mm (.013-.028")	

SPECIFICATIONS (Continued)

ENGINE	D-150	D-170	D-190
Intake Valves:			
Valve Lift		11.56 mm (.455")	
Stem Diameter		9.461-9.474 mm (.3725-.3730")	
Clearance in Guide		020-.054 mm (.0008-.0023")	
Face Angle		45 degrees	
Seat Angle		45 degrees	
Seat Width		2.03-2.29 mm (.080-.090")	
Maximum Permissible Seat Run-Out		05 mm (.002")	
Maximum Permissible Face Run-Out		05 mm (.002")	
Seat Insert and Counterbore Data:			
Standard:			
insert O.D		55.98-56.0 mm (2.204-2.205")	
Counterbore Diameter		55.88-55.93 mm (2.200-2.202")	
.05 mm (.002") Oversize:			
Insert O.D		56.03-56.06 mm (2.206-2.207")	
Counterbore Diameter		55.93-55.98 mm (2.202-2.204")	
.762 mm (.030") Oversize:			
Insert O.D		56.74-56.77 mm (2.234-2.235")	
Counterbore Diameter		56.64-56.69 mm (2.230-2.232")	
Valve Head Recession (Below Cylinder Head Face):			
Minimum		69 mm (.027")	
Maximum		1.19 mm (.047")	
Valve Tip to Rocker Arm Clearance (Hot or Cold)		36 mm (.014")	
Exhaust Valves:			
Valve List		11.81 mm (.465")	
Stem Diameter		9.449-9.461 mm (.3720-.3725")	
Clearance in Guide		033-.071 mm (.0013-.0028")	
Face Angle		45 degrees	
Seat Angle		45 degrees	
Seat Width		2.03-2.29 mm (.080-.090")	
Maximum Permissible Seat Run-Out		05 mm (.002")	
Maximum Permissible Face Run-Out		05 mm (.002")	
Seat Insert and Counterbore Data:			
Standard:			
Insert O.D		49.53-49.55 mm (1.950-1.951")	
Counterbore Diameter		49.53-49.48 mm (1.946-1.948")	
.05 mm (.002") Oversize:			
Insert O.D		49.58-49.61 mm (1.952-1.953")	
Counterbore		49.48-49. 53 mm (1.948-1.950")	
.381 mm (.015") Oversize:			
Insert O.D		49.91-49.94 mm (1.965-1.966")	
Counterbore Diameter		49.81-49.86 mm (1.961-1.963")	
.762 mm (.030") Oversize			
Insert O.D		50. 29-50.32 mm (1.980-1.981")	
Counterbore Diameter		50.19-50.24 mm (1.976-1.978")	
Valve Head Recession (Below Cylinder Head Face):			
Minimum		1.07 mm (.042")	
Maximum		1.57 mm (.062")	
Valve Tip to Rocker Arm Clearance (Hot or Cold)		41 mm (.016")	

SPECIFICATIONS (Continued)

ENGINE	D-150 D	D-170	D-190
Valve Guides:			
Bore Diameter		9.495-9. 520 mm (.3738-.3748")	
Length:			
Intake		82.4 mm (3 1/4")	
Exhaust		75.2 mm (2 31/32")	
Height Above Top of Cylinder Head		30.96 mm (1 7/32")	
Valve Tappets:			
Length		64.77-65.79 mm (2.550-2.590")	
Diameter		25.286-25.298 mm (.9955-.9960")	
Clearance in Bore of Block		076-.127 mm (.003-.005")	
Valve Springs:			
Free Length		52.71 mm (2.075")	
Test Length		35.4 mm (1.397")	
Load (at Test Length)		854-925N (192-208 lbs.)	
Rocker Arms:			
Shaft Bore Diameter		21.999-22.022 mm (.8661-.8670")	
Clearance on Shaft		028-.114 mm (.0011-.0045")	
Rocker Arm to Valve Tip Clearance:			
Intake		36 mm (.014")	
Exhaust		41 mm (.016")	
Valve Timing:			
Intake Opens (Before T.D.C.)		16 degrees	
Intake Closes (After B.D.C.)		52 degrees	
Exhaust Opens (Before B.D.C.)		68 degrees	
Exhaust closes (After T.D.C.)		16 degrees	
Oil Pump:			
Gear to Body End Clearance		076-.114 mm (.003-.0045")	
Gear to Body Side Clearance		036-.137 mm (.0014-.0054")	
Shaft Diameter		12.459-12.476 mm (.4905-.4912")	
Shaft Clearance in Bore		033-.076 mm (.0013-.003")	
Gear Backlash		013-.165 mm (.0005-.0065")	
Screen Distance Above Oil Pan Rails			
for Engines before 51135		158.75 mm (6.25-6.5")	
Pressure Relief Valves			
Length		38.86-40.39 mm (1.53-1.59")	
Diameter		18.90-18.92 mm (.744-.745")	
Relief Valve Springs:			
Free Length		98.37 mm (3.873")	
Test Length		73.28 mm (2.885")	
Load (at Test Length)		136-154N (30.6-34.6 lbs.)	
Oil Pressure /SAE 30 Oil at 93°C (200°F7:			
Idle Speed (600-650 RPM)		68.9-137.9 kPa (10-20 psi)	
At Rated Speed		275.8-379.2 kPa (40-55 psi)	

SPECIFICATIONS (Continued)

ENGINE	D-150	D-170	D-190
Piston Cooling Valve:			
Valve Piston:			
Length		33.0-33-.5 mm (1.30-1.32")	
Diameter		18.87-18.92 mm (.743-.745")	
Valve Spring:			
Free Length		74.93 mm (2.95")	
Test Length		62.484 mm (2.46")	
Test Load (at Test Length)		71-84N (16-19 lbs.)	
Flywheel Housing Run-Out (Maximum Permissible)		254 mm (.010")	
Water Pump:			
Impeller to Body Clearance		254-.508 mm (.010-.020")	
Injection Pump Drive:			
Drive Gear Backlash		013-.113 mm (.0005-.0045")	
Coupling to Drive Lugs Clearance		086 mm (.0034")	

ENGINE

MODELS V-304A, V-304, V-345, V-392

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* For complete engine tune-up specifications, refer to Emission Control Systems for Gasoline Engines Service Manual; 1976 CTS-2694, 1977 CTS-2721 and 1978 CTS-2733.

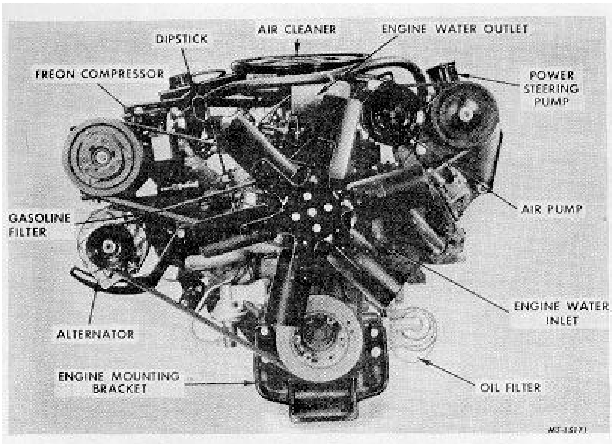


Fig. 1 Front View of Engine

GENERAL DESCRIPTION

The V-series engines covered in this section are 8-cylinder, overhead valve, 90° type. Dimensional specifications of the various models are listed under specifications. Figs. 1, 2 and 3 illustrate the complete engine assembly.

The basic unit of the engine, the cylinder block and upper crankcase are cast in one piece and is of extremely rigid construction. It provides full-length water jackets surrounding each of the cylinders. This unit forms the major section of the engine, as it is fitted with the crankshaft, camshaft, pistons and various related parts.

The crankshaft, of forged alloy steel, is supported by five insert-type main bearings. Crankshaft end thrust is controlled by the flanges of the No. 3 main bearing.

The camshaft is supported by five insert type bearings pressed into the block and is driven by a drive gear keyed to the crankshaft. The end thrust of the camshaft is controlled by a thrust flange located between the front camshaft journal and the camshaft gear.

The aluminum alloy pistons are fitted with compression rings and an oil ring and are used in the engine with forged steel connecting rods. The hardened and ground piston pins are a tight press fit in the connecting rods and pivot in the pistons. The lower end of the connecting rod and cap contain locking type bearing inserts. The rods and caps are numbered for identification and reassembly.

The hydraulic valve lifters contribute to engine quietness and maintain zero valve lash or tappet clearance. This eliminates the need for periodic valve adjustment.

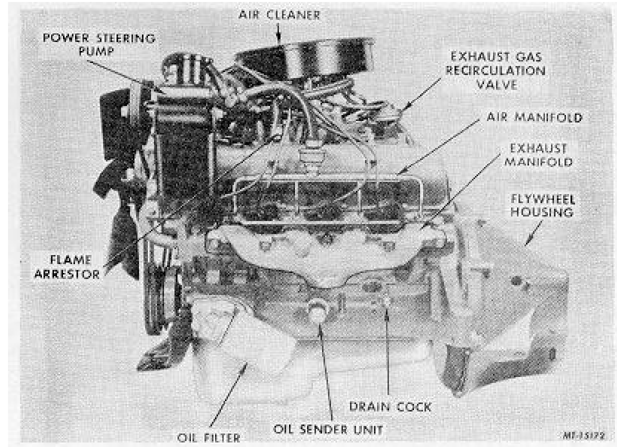


Fig. 2 Left Side View of Engine

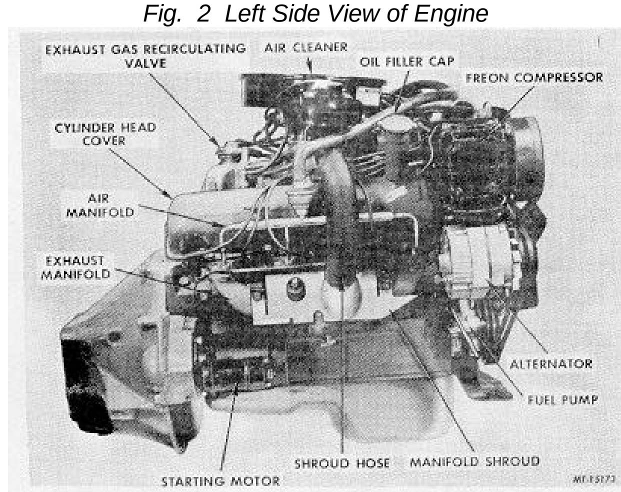


Fig. 3 Right Side View of Engine

The cylinder head assemblies feature a high turbulence type of combustion chamber which provides superior combustion characteristics to produce very high volumetric and thermal efficiencies. The cylinder heads used on the V8 engines are equipped with a positive valve rotating mechanism on the exhaust valve only. This device is called "Roto Cap" and is located at the base of each exhaust valve spring.

Another important feature of the cylinder heads is that they are completely interchangeable from one cylinder bank to another by merely changing the water pipe hole core plugs. The cylinder head gaskets are of embossed steel material, which prevents leakage of compression between the cylinder block and cylinder head. They also prevent leakage of water from the water jackets into the cylinders. The gaskets are also interchangeable from one bank to another.

A water-jacketed intake manifold reduces the effect of ambient air on the manifold runners and provides more consistent vaporization throughout all runners at any engine speed resulting in increased fuel economy.

Two water outlets from each cylinder head obtained by the use of this manifold provide a more even distribution of water throughout the heads.

Two "V" type fan belts driven by a pulley on the crankshaft drive the water pump-fan combination and alternator, while another "V" type belt driven by the water pump pulley drives the air compressor.

The water pump is mounted on the front of the engine and supplies both cylinder banks. The alternator is mounted at the upper right side of the engine with an adjustable strap to set the proper belt tension.

A dual exhaust system is used on the small model vehicles, which provides rapid cleaning of exhaust gases with a minimum of back pressure.

A gear-type oil pump is internally mounted to the bottom of the crankcase and is driven by a tang on the end of the distributor shaft. The distributor, mounted in the front end of the cylinder block assembly, is gear driven directly the camshaft, resulting in reduced spark fanning.

CYLINDER NUMBERING

When viewing the engine from the driver's seat, the right bank of cylinders is numbered 2, 4, 6 and 8--No. 2 being at the front. Similarly, the left bank of cylinders is numbered 1, 3, 5 and 7--No. 1 being at the front. The left and right sides of "V" engines with cylinders numbered in the foregoing manner are sometimes referred to as "even bank" and "odd bank." The "odd" or "even, " of course, refers to the numbers of cylinders. For easy reference each cylinder number is cast on the intake manifold directly over its respective cylinder. The firing order is 1-8-4-3-6-5-7-2. This information is also cast on the top surface of the intake manifold.

NOTE:

When timing the engine, attach the timing light to No. 8 spark plug and adjust distributor to obtain proper initial timing; see specifications and Fig. 4.

ENGINE LUBRICATION SYSTEM

Oil from the oil pan sump is forced through the pressure-feed lubrication system by an internally mounted gear type pump which is driven by the distributor drive shaft. A spring loaded relief valve in the pump limits the maximum pressure of the system. Oil relieved by the valve is directed back into the oil pan sump under the surface of the oil to eliminate seration.

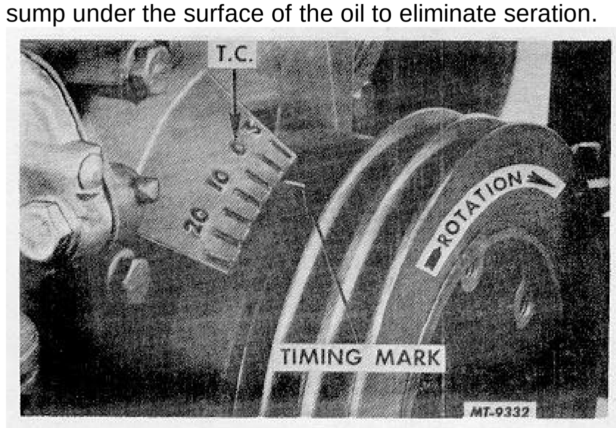


Fig. 4 Illustrating Timing Marks on Crank-shaft Pulley Hub and Engine Front Cover

The engine is equipped with a pinion type filter which filters all of the oil entering the engine. The filter has a relief valve which permits oil to bypass the filter if it becomes clogged, thereby maintaining an emergency supply of oil to the engine at all times.

NOTE:

The clogging of the filter could be brought about by neglecting to change the oil filter element at regularly established periods and based upon the condition of the oil.

The oil from the filter flows into the main oil gallery, which supplies oil to all the camshaft and main bearings through drilled passage in each main bearing web.

The right valve rocker arm assembly receives oil from a drilled passage from the fourth camshaft bearing through the block and cylinder head. The oil is directed into the No. 7 rocker arm support. The oil from the No. 7 rocker arm support flows into the rocker shaft. Metered holes in the shaft permit lubrication of each rocker arm bushing and the valve and ball joint ends of the rocker arms. The left valve rocker arm assembly is similarly lubricated through the drilled passage from the second camshaft bearing and into the No. 3 rocker arm support. The oil from each rocker arm drains into the push rod chamber through holes in the heads. Also, there are two oil galleries, one on each side of the block for lubricating the hydraulic valve lifters.

Oil passages drilled from the camshaft front bearing lubricate the distributor drive gear, timing gears and fuel pump cam.

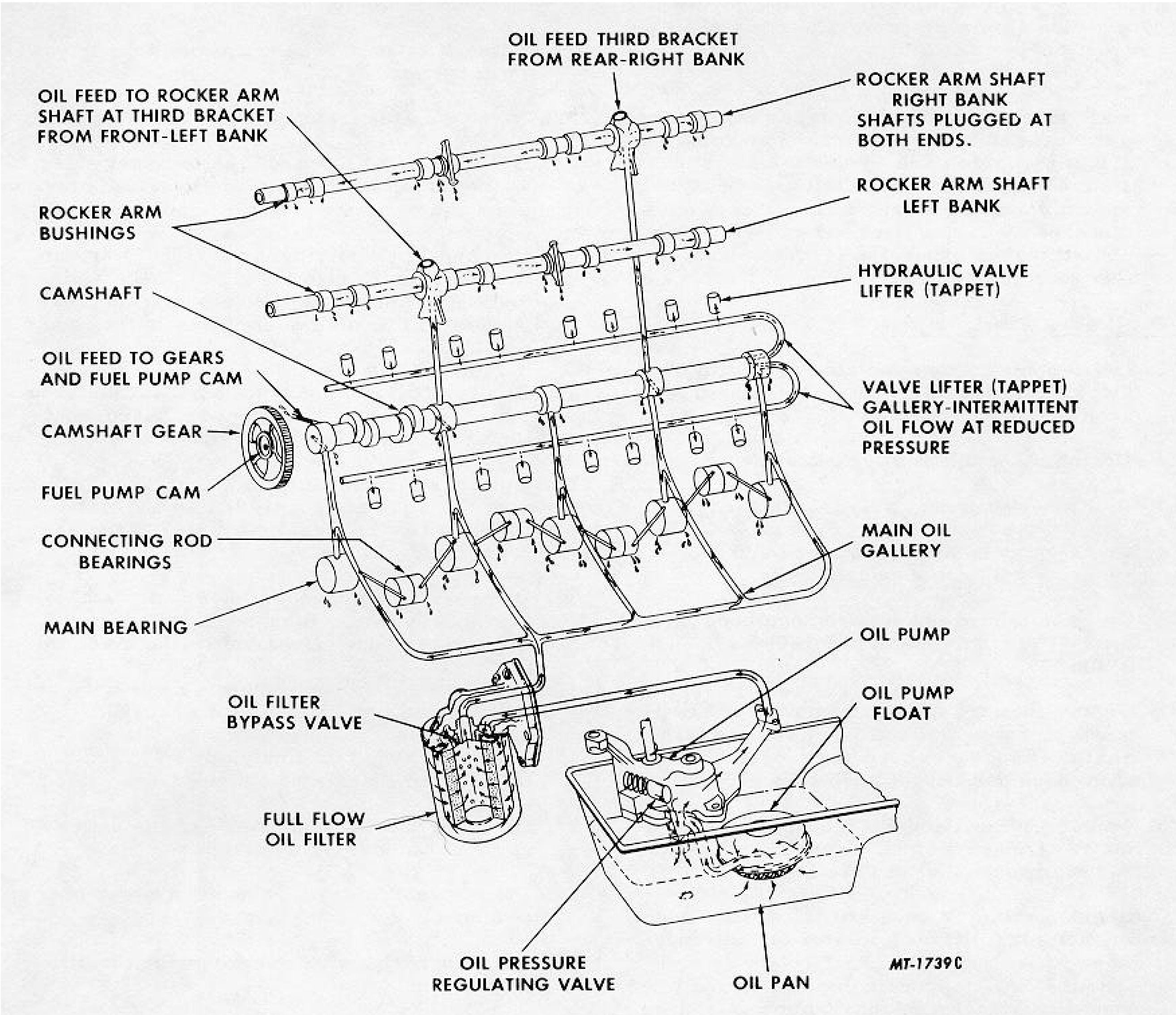


Fig. 5 Diagrammatic View of Lubricating System

Connecting rod bearings are lubricated by passages drilled from the crankshaft main journals to the connecting rod journals of the crankshaft.

Pistons, piston rings and piston pins receive lubrication from oil spray thrown from the engine crankshaft. The connecting rods on the engines are not drilled for oil channels.

Engine removal procedures will vary between vehicle models and also between individual chassis because of various equipment and accessories. The following outline covers in general the engine disconnect points and lifting instructions.

CAUTION:

On vehicles equipped with LPG fuel system be sure that proper regard for personal safety has been taken and also that shop procedures are in compliance with state and local fire regulations. LPG fuel systems are pressurized, and it is important that the tank valves are closed tightly and all fuel is exhausted from the lines before working on fuel system.

Preliminary Instructions

1. Drain coolant from radiator and cylinder block. Block drain points are located on each side of cylinder block.
2. Drain engine oil from crankcase.
3. Disconnect battery cable from battery.
4. On CO models tilt cab forward and prop securely with cab support.

   On conventional chassis remove hood hinge bracket mounting bolts and remove hood assembly.

   On cab-forward models remove hood center panel mounting bolts at cowl and radiator shell. Disconnect hood rest assemblies from hood and lift off hood assembly.

5. On conventional and CO models remove radiator. Loosen clamps on upper and lower radiator hoses and remove hoses.

   Remove radiator core and fan shroud mounting bolts and lift out radiator and shroud.

   On cab-forward models remove entire front end sheet metal (includes bumper, fenders, radiator shell, radiator and fan shroud).

Disconnect Points on Engine:

1. Remove carburetor air cleaner, shroud hose and vacuum hoses.
2. Disconnect fuel supply line from fuel pump.
3. Disconnect the governor lines and distributor- to-carburetor vacuum line if so equipped.
4. Remove vacuum hose from air pump diverter valve and manifold on cowl where equipped.
5. Remove vacuum hose from tee to solenoid vacuum valve on cowl where equipped.
6. Remove vacuum hose from low temperature control valve to vacuum solenoid valve on cowl where equipped.
7. Remove vacuum hose from manifold on cowl to carburetor.
8. Remove hoses from canister to carburetor.
9. Disconnect the left and right exhaust pipes at the manifolds. Seals are provided at each connection.
10. Disconnect the wiring harness, Fig. 6, on the alternator, also the wires at the coil and the temperature indicator wire at the sender unit located at the front of the intake manifold.
11. Remove the choke control wire at the carburetor on chassis so equipped. Disconnect the accelerator linkage at the carburetor.
12. On chassis equipped with air brakes disconnect the main air supply line at the compressor and the flexible air line at the compressor.
13. On chassis equipped with hydraulic brakes having a hydrovac disconnect the vacuum air cleaner hose at rear of intake manifold.
14. Disconnect the oil pressure sender wire at unit located on left side of crankcase.
15. Disconnect the tachometer drive at the distributor on chassis so equipped.
16. Disconnect the three wires and the battery cable at the starter solenoid.
17. Disconnect the engine ground strap at rear of engine.
18. Disconnect the wire at carburetor throttle stop solenoid.
19. Disconnect the freon compressor wire at connector.
20. Remove two capscrews, lower insulator retainers and insulators from the engine front mounting on conventional chassis. On nonconventional chassis remove two capscrews and lockwashers securing engine mounting plate to front crossmember.
21. Remove the carburetor from the intake manifold and install the lifting fixture, SE1948, to intake manifold, utilizing the carburetor mounting capscrews, Fig. 6.

NOTE:
Center balance of the engine can be obtained by positioning the ring in the various notches provided in the fixture.

22. Attach suitable hoisting equipment and apply sufficient pull to support the engine assembly.

23. Remove the four capscrews attaching the flywheel housing cover to flywheel housing.

24. Remove six capscrews securing the flywheel housing to engine.

25. The engine assembly must be pulled forward to clear the transmission main drive gear and clutch driven disc and then raised and lifted out of the chassis.

NOTE:
Extreme care must be exercised during removal of the power plant to avoid damage to the clutch driven disc.

26. The engine oil filter and starting motor must be removed before the engine can be mounted in SE-1434 engine roll-over stand.

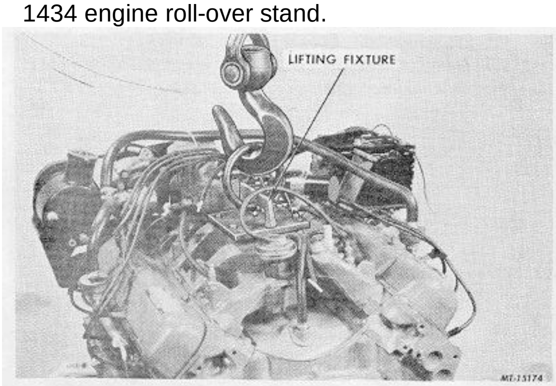


Fig. 6 Engine Lifting Sling

DISASSEMBLY OF ENGINE

Install the engine in a rotating engine overhaul stand similar to SE1434 using V8 engine support brackets and support plates for securing the engine in the stand, Figs. 7 and 8.

NOTE:
Many of the disassembly operations can be performed with the engine in the chassis. However, the following disassembly outline is performed with the engine removed from the chassis to clearly illustrate each of the units. Except where indicated, no attempt has been made to prescribe a particular sequence for removing the various units, since some can be readily removed with the engine in the chassis. The extent of the service required on a particular unit will govern the necessity for its removal.

1. Make sure all oil and water have been drained from cylinder block.

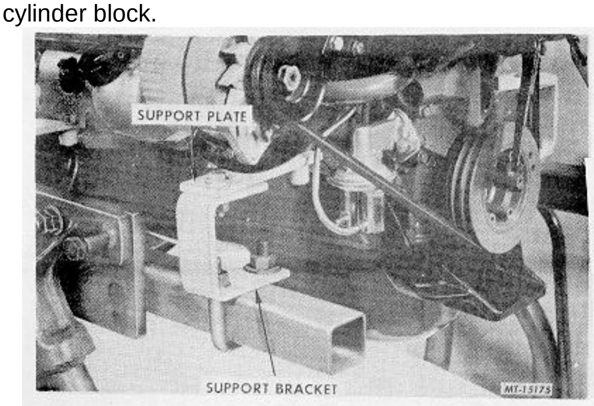


Fig. 7 Engine Stand Front Support Bracket

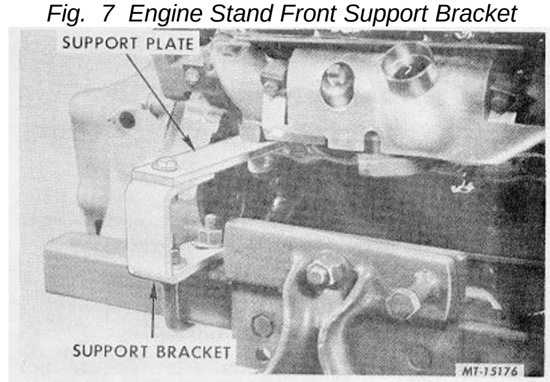


Fig. 8 Engine Stand Rear Support Bracket

2. Remove fan blade.

3. Remove air hoses from air manifold and pump. Also remove vacuum hoses from exhaust gas recirculating valve, low and high temperature control valves and distributor. Then remove crankcase ventilator valve and hose, Fig. 9.

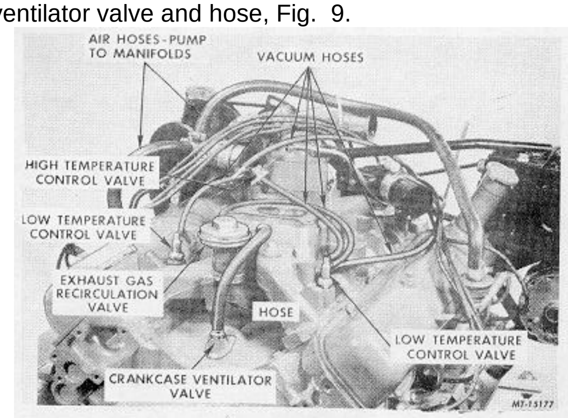


Fig. 9 Removing Air and Vacuum Hoses As Well As Crankcase Ventilator Valve and Hose

4. Remove freon compressor support brace capscrews and washers and remove brace, Fig. 10.

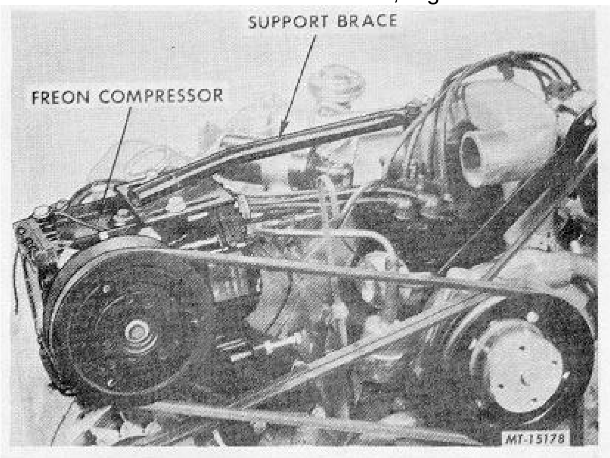


Fig. 10 Removing Freon Compressor Support Brace

5. Loosen adjusting screw locknut and screw; then remove four freon compressor mounting capscrews and remove drive belt and compressor, Fig. 11.

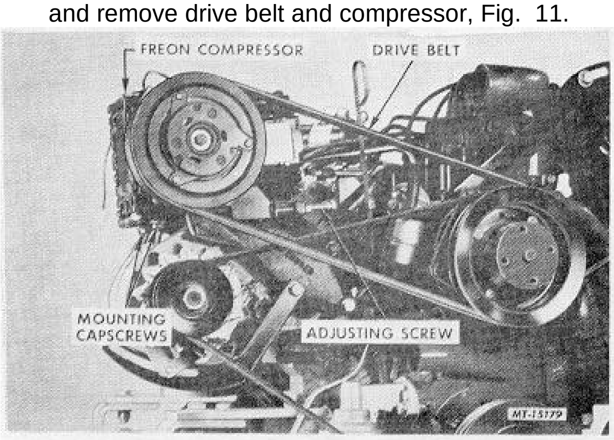


Fig. 11 Removing Freon Compressor Drive Belt and Compressor

6. Disconnect alternator at the adjusting strap and remove drive belts.

7. Remove the alternator mounting bolt and remove unit from mounting bracket, Fig. 12.

8. Remove alternator and freon compressor bracket mounting bolts.

9. If engine is equipped with air compressor, remove oil pressure line, governor line, air supply line, water hoses and hose to carburetor air cleaner. Then remove four capscrews, nuts and lockwashers, two on each side of air compressor, and remove compressor and drive belt.

10. Remove air compressor mounting bracket from engine if so equipped.

11. Remove engine front mounting bracket.

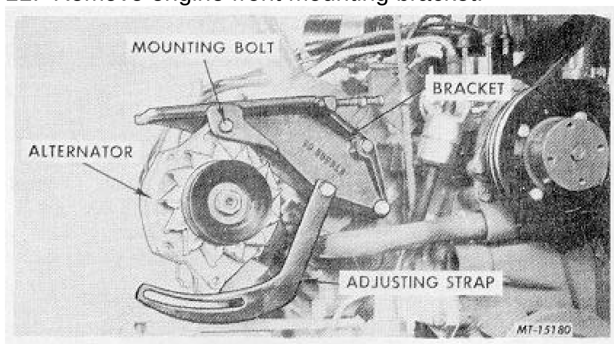


Fig. 12 Alternator Removal

12. Loosen power steering pump belt adjusting screw and pump mounting plate lock bolt. Then remove pump drive belt, Fig. 13.

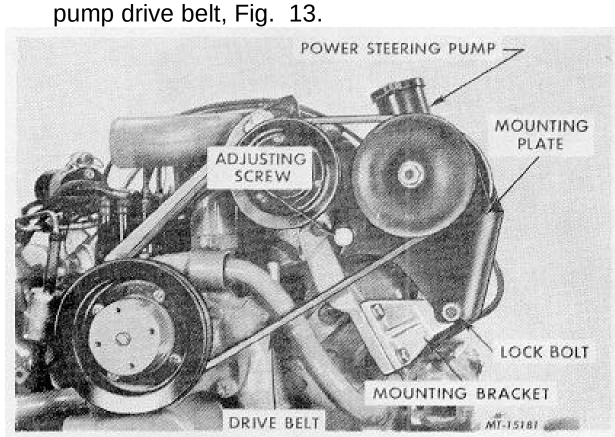


Fig. 13 Removing Power Steering Pump Drive Belt

13. Remove power steering pump and mounting bracket.

NOTE

Do not lose spacer on adjusting screw.

14. Remove air pump adjusting screw and mounting screw. Then remove air pump. Also remove adjusting strap, Fig. 14.

15. Remove flame arrestor and hose from left cylinder head cover.

NOTE

V-392 engine uses one in each cylinder head cover.

16. Disconnect the coil-to-distributor primary wire, Fig. 15.

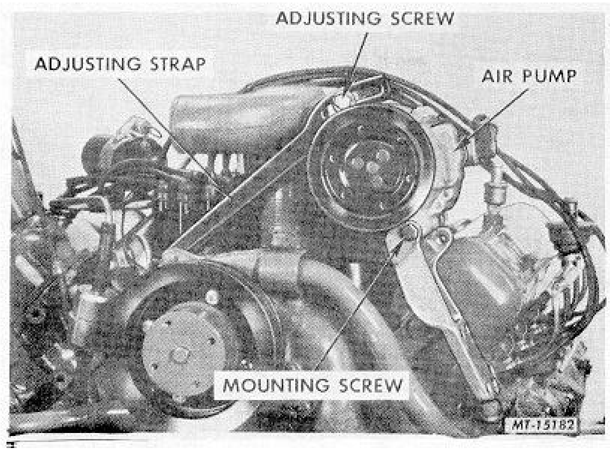


Fig. 14 Removing Air Pump and Adjusting Strap

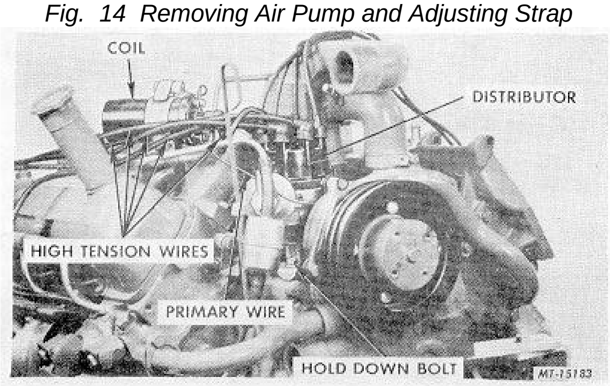


Fig. 15 Distributor Removal

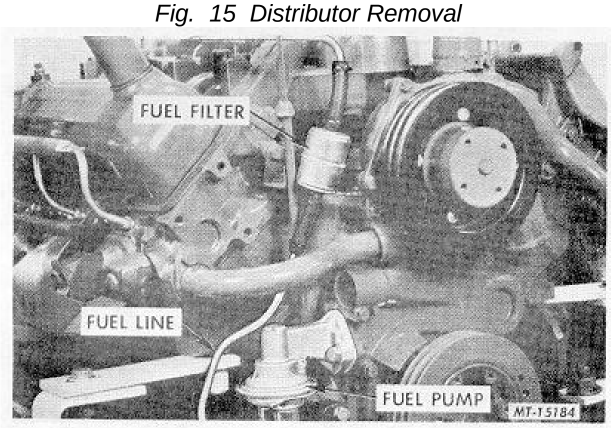


Fig. 16 Removing Fuel Line and Filter from Pump

17. Disconnect the distributor high tension wires at the coil and spark plugs. Remove the wires from retainer brackets on both cylinder head covers and remove the distributor cap and wires as an assembly.

18. Loosen the distributor hold-down bolt at the crankcase, Fig. 15, and remove the distributor and mounting gasket,

19. Remove coil and bracket from intake manifold.

20. Loosen fuel line at fuel pump and remove fuel line and filter, Fig. 16.

21. Remove high temperature vacuum control valve from thermostat housing, Fig. 17.

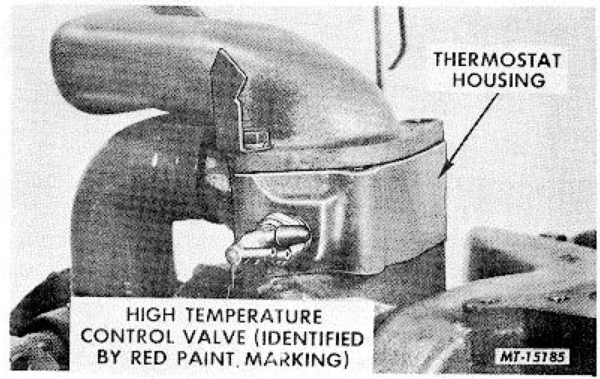


Fig. 17 Removing High Temperature Vacuum Control Valve from Thermostat Housing

22. Remove water outlet, thermostat and thermostat housing and bypass hose from intake manifold, Fig. 18. Also remove temperature sender unit.

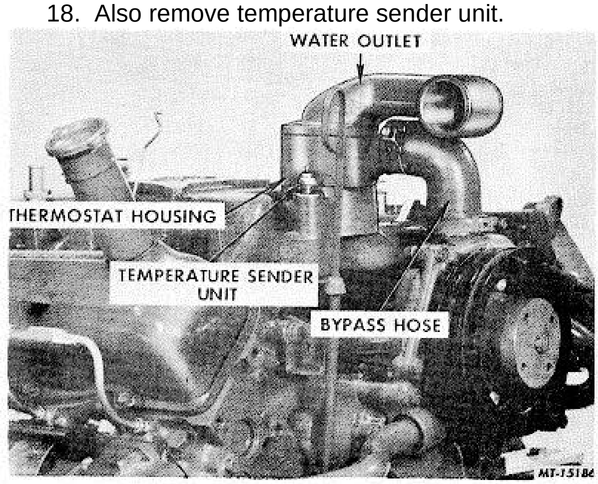


Fig. 18 Removing Water Outlet, Thermostat, Housing and Bypass Hose from Intake Manifold

23. Remove the two low temperature vacuum control valves, exhaust gas recirculating valve and gasket and automatic choke, Fig. 19.

24. Remove manifold bolts and remove intake manifold from cylinder heads, Fig. 20.

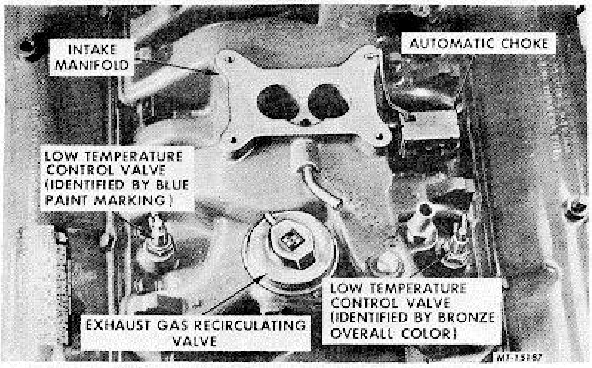


Fig. 19 Removing Low Temperature Vacuum Control Valves, Exhaust Gas Recirculating Valve and Automatic Choke

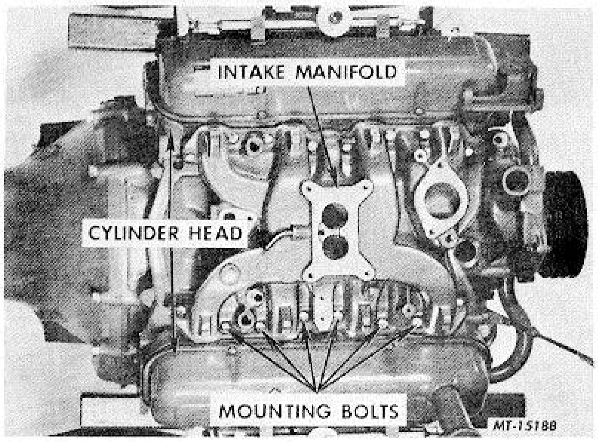


Fig 20 Intake Manifold Removal

25. OnV-304, V-345 engines loosen the water pipe mounting bolt at left cylinder head and remove pipe, clamp and O-rings from water pump and cylinder head,

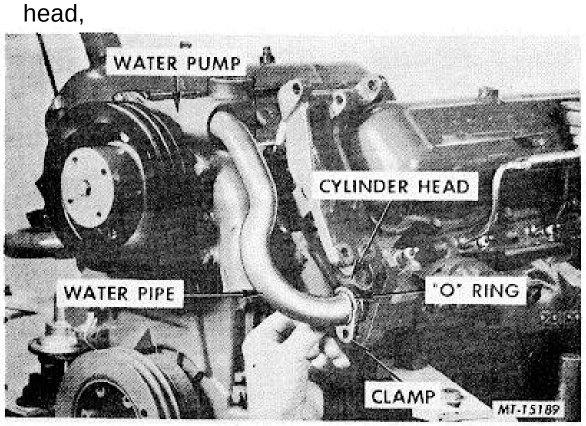


Fig. 21 On V-392 engine the water pipe is removed from the water pump and crankcase.

26. On V-304, V-345 engines loosen the water pipe mounting bolt at right cylinder head and remove pipe, clamp and 0rings from water pump and cylinder head,

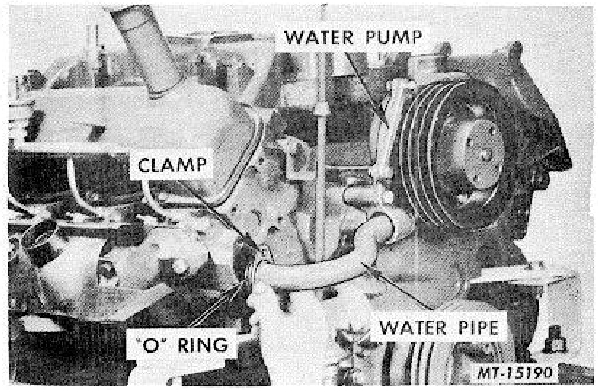


Fig. 22 On V-392 engine the water pipe is removed from the water pump and crankcase.

27. Remove the fuel pump from the engine front cover, Fig. 23.

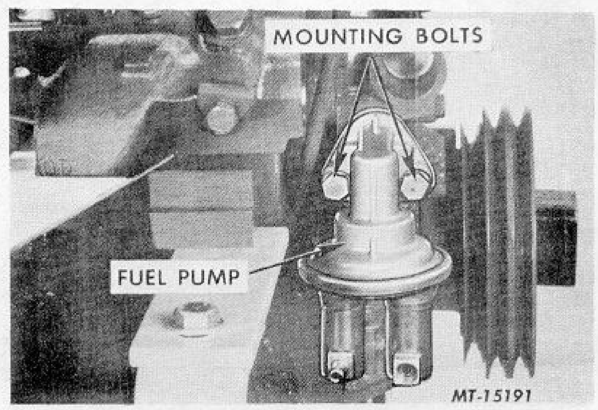


Fig. 23 Removing Fuel Pump from Engine

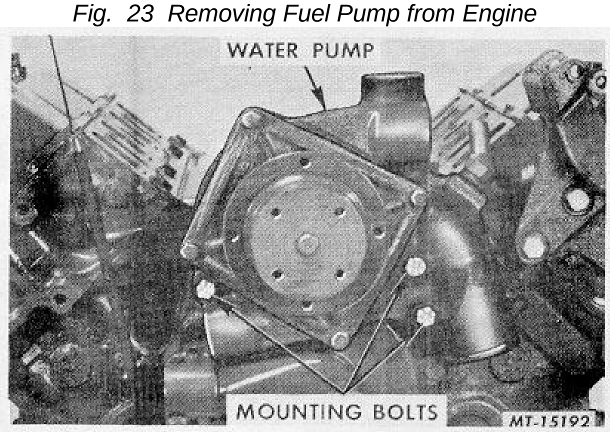


Fig. 24 Water Pump Removal

28. Remove water pump pulley.

29. Loosen the three water pump mounting bolts and remove the water pump, Fig. 24.

30. Remove air pump mounting bracket capscrews and remove bracket, Fig. 25.

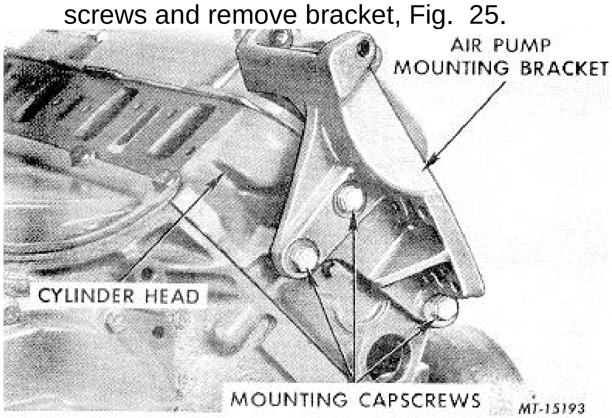


Fig. 25 Removing Air Pump Mounting Bracket.

31. Remove air manifold assembly from each cylinder head, Fig. 26.

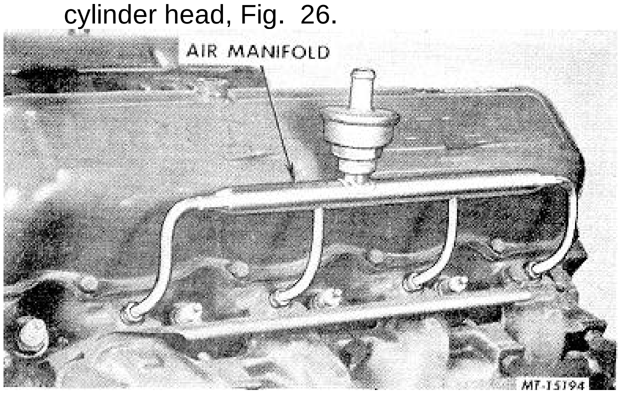


Fig. 26 Removing Air Manifold from Cylinder Head

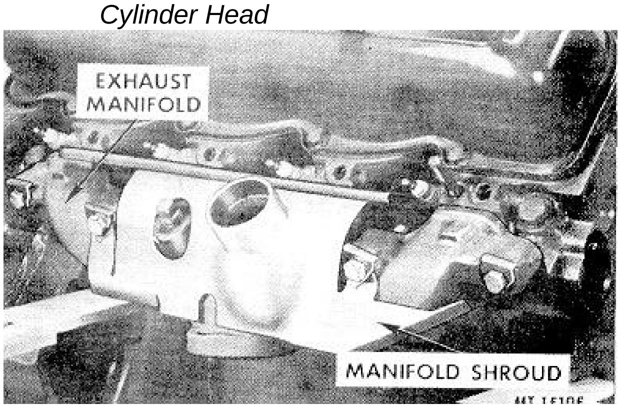


Fig. 27 Removing Heat Shroud

32. Remove the two mounting bolts securing the heat shroud to manifold and remove shroud, Fig. 27.

33. Loosen the two end bolts securing the manifold and remove the center bolt and manifold gasket, Fig. 28.

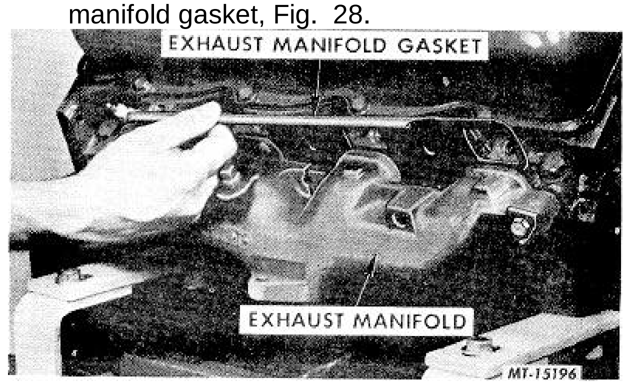


Fig. 28 Exhaust Manifold Gasket Removal

34. Remove the two remaining exhaust manifold bolts and remove the exhaust manifold, Fig. 29.

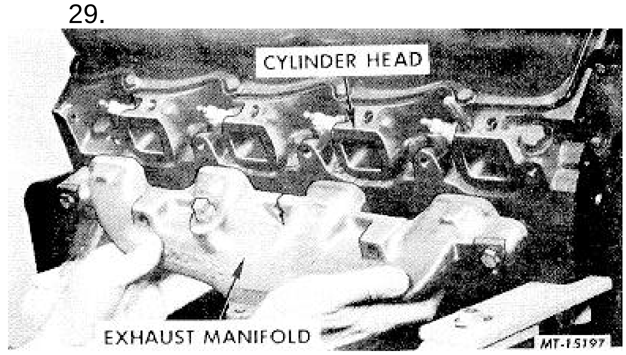


Fig. 29 Exhaust Manifold Removal

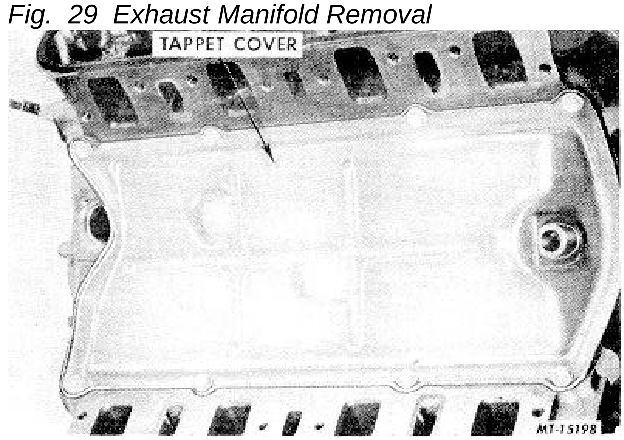


Fig. 30 Tappet Cover Removal

35. Repeat steps 33 and 34 and remove manifold from opposite cylinder head.

36. Loosen the cylinder head cover screws on both banks and remove covers and gaskets from both heads.
37. Remove any dirt or foreign matter that may have accumulated around the top edge of tappet cover. Then loosen the tappet cover mounting screws and remove tappet cover and gasket, Fig. 30.
38. Loosen the rocker arm shaft bracket mounting bolts and remove rocker arm assembly, Fig. 31. These are self-locking type bolts employing a nylon pellet which can be washed in cleaning solvent and can be reused innumerable times providing a coat of non-hardening sealing compound is applied to the bolt threads. This type bolt also provides a seal for the threads in the cylinder head and prevents oil entering the intake port, as these holes are drilled directly into the intake port of the cylinder head. In no case should a standard bolt be used in this application.

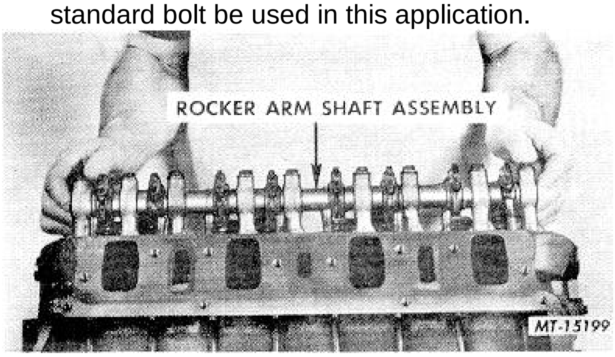


Fig. 31 Rocker Arm Shaft Assembly Removal

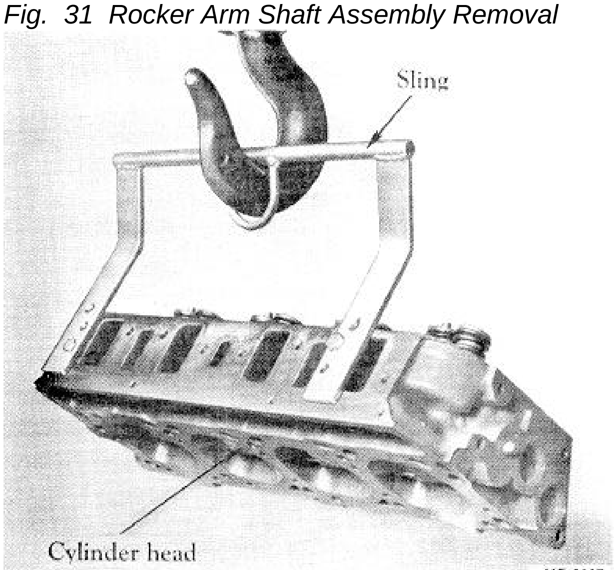


Fig. 32 Cylinder Head Sling SE-1896 Installed on Head

39. Remove the rocker arm push rods from the cylinder heads and block.
40. Remove dipstick tube bracket mounting bolt and lockwasher at front of right cylinder head. Then remove tube and dipstick.
41. Removal of cylinder heads:
    a. Install cylinder head sling SE-1896 to the cylinder head using 3/8-NC x ¾ capscrews, Fig. 32. However, before this can be accomplished with the present sling in the field, it will be necessary to rework the sling by drilling four 7/16 inch diameter holes to dimensions as shown in Fig. 33 for mounting sling to each cylinder head.
    b. Remove the cylinder head bolts and lift the head off the two locating dowel sleeves, Fig. 34. Remove the cylinder head gasket. CAUTION: Use extreme care when handling to prevent damage to gasket surfaces. Never pry between the cylinder heads and the block, as they have a finished surface and must not be damaged.

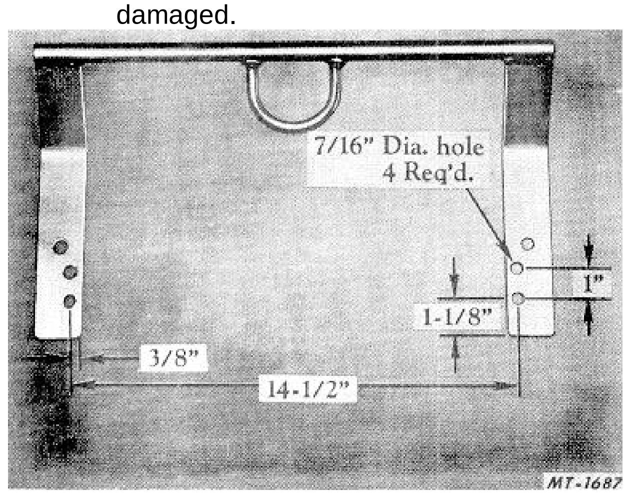


Fig. 33 Illustration for Reworking Slings in Field

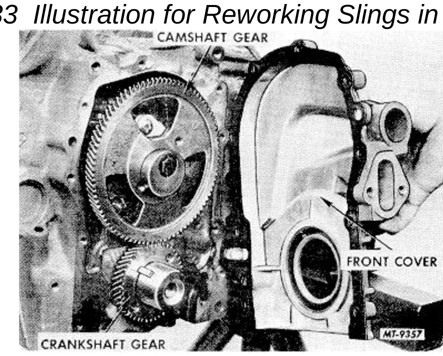


Fig. 34 Illustrating Dowel Sleeves in Block for Cylinder Head

42. Lift out all hydraulic valve lifters or tappets from the crankcase assembly, Fig. 35. This can be accomplished by rotating the camshaft so the tappets are resting on the high side of the camshaft lobes. Keep the tappets in order in storage box, SE-1894, to assure cleanliness and reinstallation in their original bores. NOTE: The tappets can be removed without disassembly of the engine. See Fig. 110.

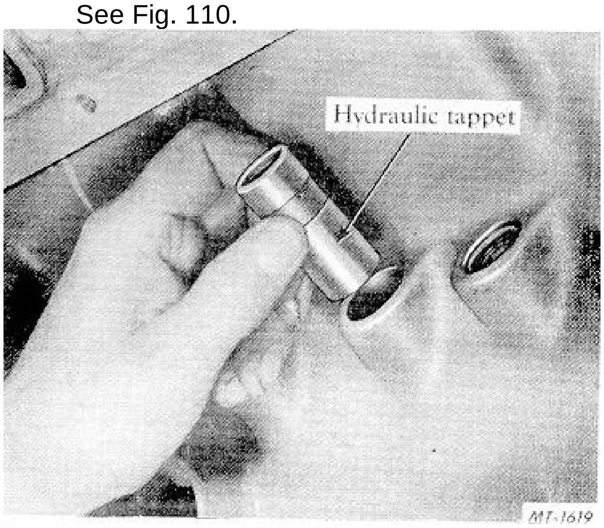


Fig. 35 Hydraulic Tappet Removal

43. Remove the four flywheel housing cover bolts and remove the cover.
44. Loosen the six flywheel housing bolts and remove the flywheel housing. NOTE: Use extreme care when removing flywheel housing to prevent damaging the dowel sleeves.

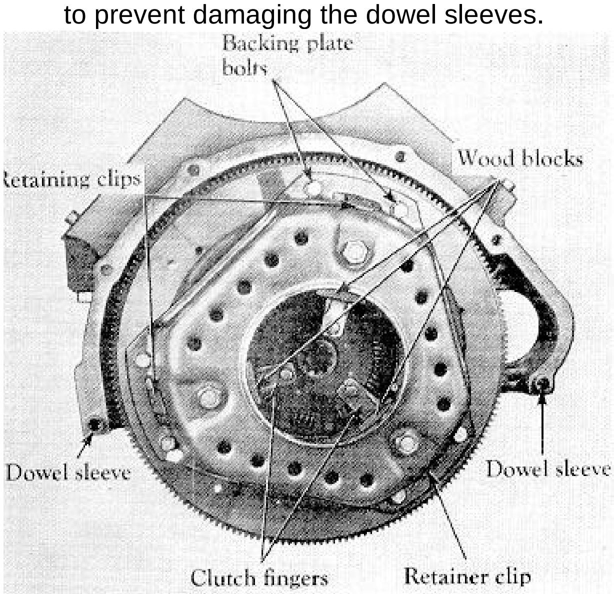


Fig. 36 Clutch Removal

45. Removal of clutch assembly:
    a. On clutch assembly shown in Fig. 36 the clutch plate should be compressed with three retaining clips between the backing plate and pressure plate lug or wood blocks (1/4" x 1" x 3") positioned between the clutch fingers and back plate. Then loosen the back plate-to-flywheel retaining bolts only enough to wedge the clips or wood blocks in plate. Turn the flywheel one-third turn and install the second clip or block in the same manner. Follow the same procedure for the third retaining clip or block. Use of these clips or blocks eliminates the possibility of distorting the clutch cover. Remove all retaining bolts and lift the clutch assembly from the flywheel.
    b. On the clutch assembly shown in Fig. 37 the clutch plate should be compressed with the three capscrews "A" (3/8" - 16 x 2") prior to removing the mounting capscrews. Otherwise, it is possible to distort the clutch cover. Loosen the clutch back plate-to-flywheel retaining capscrews and remove the clutch assembly.

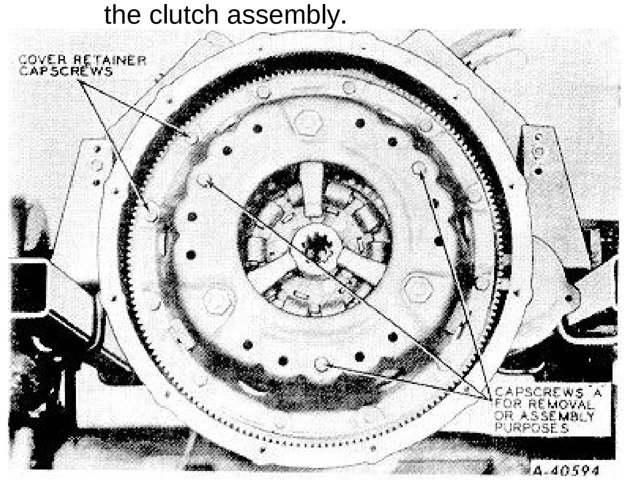


Fig. 37 Clutch Removal

46. Loosen nine mounting bolts and remove the flywheel assembly and roll pin from the crankshaft flange, Fig. 38.
47. Remove the oil pan and gasket. The pan is retained in position by 18 capscrews.
48. Remove oil pump mounting bolts. (See Fig. 39.) Lift oil pump and withdraw pump drive shaft from cylinder block to remove oil pump.

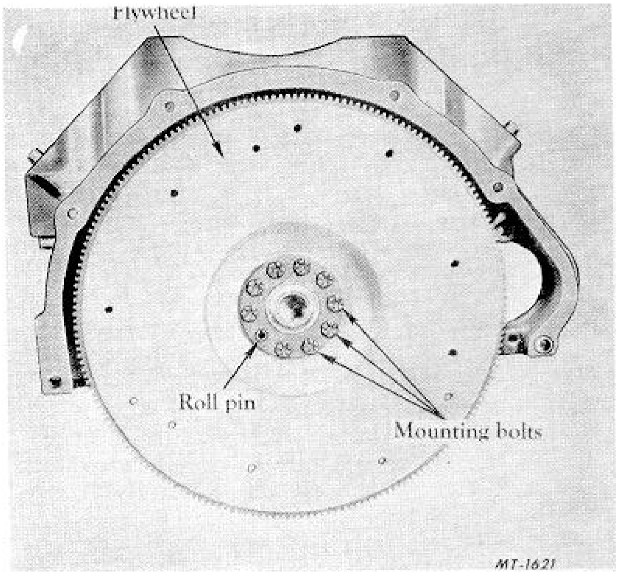


Fig. 38 Flywheel Removal

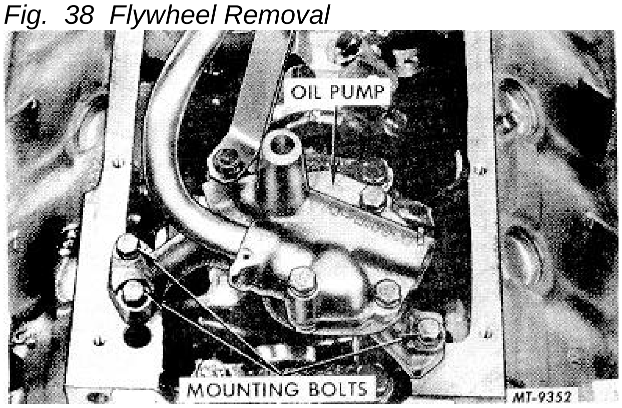


Fig. 39 Oil Pump Mounting Bolts

49. Rotate the crankshaft to position the journals for removal of the connecting rod assemblies, Fig. 40. NOTE: Before removing the piston assemblies, always remove the ridge from the top of the cylinder bore.

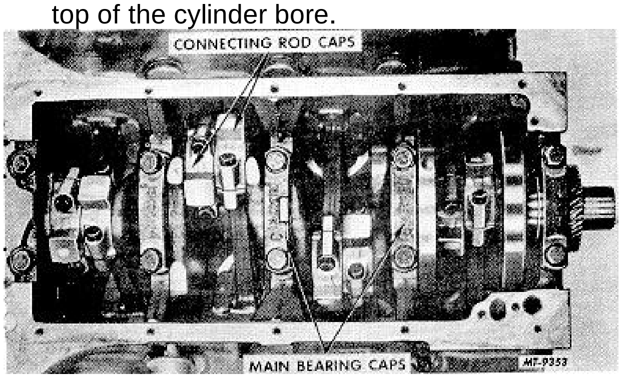


Fig. 40 Positioning Connecting Rods for Removal

50. Remove the cap and push the connecting rod and piston assembly from the cylinder bore, Figs. 41 and 42. Replace the cap and the bearing inserts on the rods so the numbered sides match. The assemblies are numbered so they can be reinstalled in their respective cylinders.

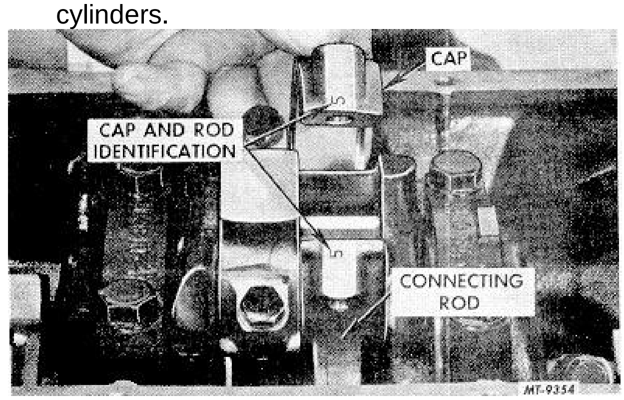


Fig. 41 Connecting Rod Cap Removal

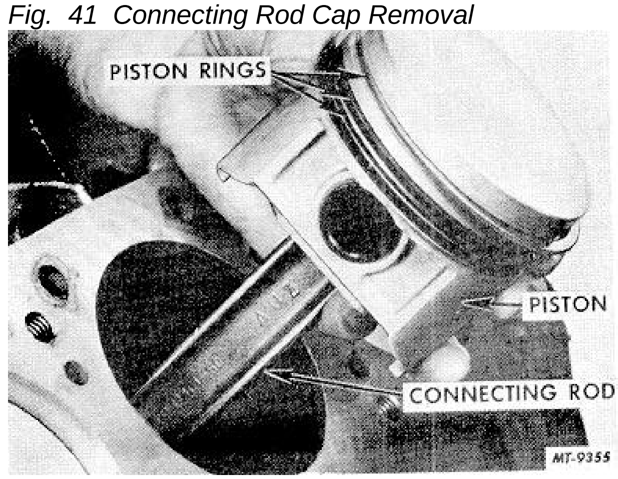


Fig. 42 Connecting Rod and Piston Removal

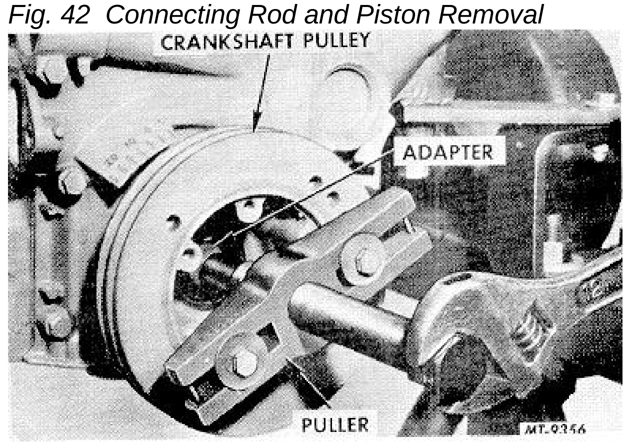


Fig. 43 Crankshaft Pulley Hub Removal Using Puller SE-1368

51. Remove the crankshaft pulley hub bolt and washer and using puller SE-1368 remove the pulley hub from the crankshaft, Fig. 43. If necessary, use an adapter or heavy flat washer between crankshaft and puller screw to prevent damage to internal threads in end of shaft.
52. Loosen the engine front cover mounting bolts and lift the cover from the crankcase, Fig. 44. Remove front cover oil seal. NOTE: Where it is the desire to replace the engine front cover oil seal while engine is in the chassis, it will be necessary to remove hood, radiator shell, radiator and crankshaft pulley. Then using puller SE-2091 remove seal as shown in Fig. 45. To reinstall the seal, follow note under step 12 outlined under "ENGINE ASSEMBLY."

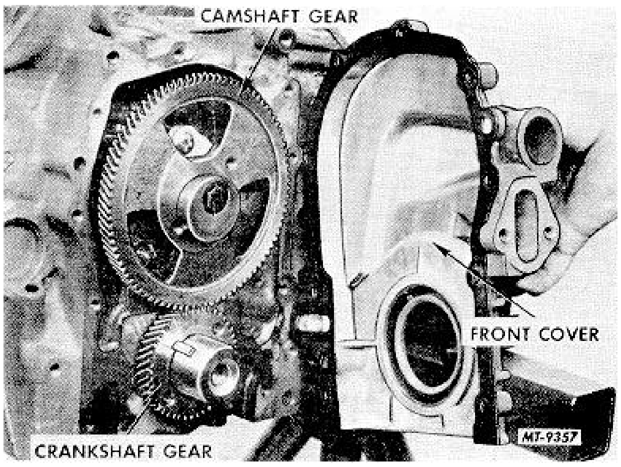


Fig. 44 Removal of Engine Front cover

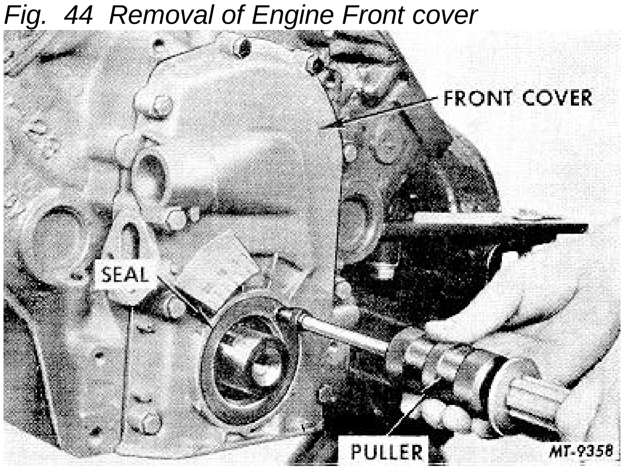


Fig. 45 Removing Engine Front Cover Seal Using Puller SE-2091

53. Remove the two slotted head screws and external tooth lockwashers securing the camshaft thrust flange to the crankcase and remove the camshaft assembly, Fig. 46. NOTE: The camshaft gear can be removed without the need for complete engine disassembly. This can be accomplished by removing the fuel pump cam bolt and fuel pump cam, Fig. 47. Then with the use of puller SE- 1368 and heavy steel washer (3/8" I. D. x 7/8" 0. D. x 3/32" thick), remove cam gear as shown in Fig. 48. (The steel washer must not contact the camshaft gear key upon gear removal.)

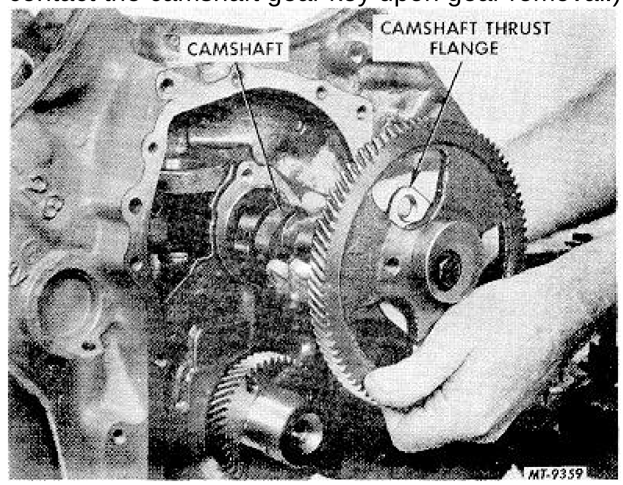


Fig. 46 Camshaft Removal

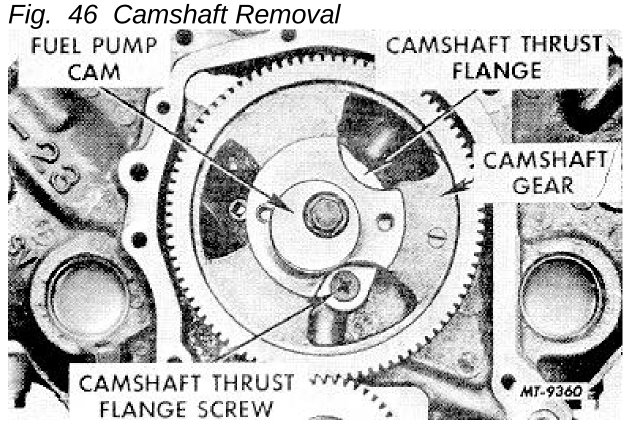


Fig. 47 Fuel Pump Cam Removal

54. Use puller SE-1368 to remove the crankshaft gear, Fig. 49. If necessary, use an adapter or heavy flat washer between crankshaft and puller screw to prevent damage to internal threads in end of shaft.

55. The crankshaft bearing caps are numbered to identify their position, and they must be reinstalled in their respective positions. The number three bearing cap accommodates a thrust flange in order to provide crankshaft end play, Fig. 50. Remove the self-locking bolts from each cap.

Remove all crankshaft main bearing caps. NOTE: To remove the rear or No. 5 main bearing cap, a puller SE- 1719 and adapter SE-1719-3 is required, Fig. 51. When removing the rear main bearing cap, the left and right side bearing cap seals are accessible.

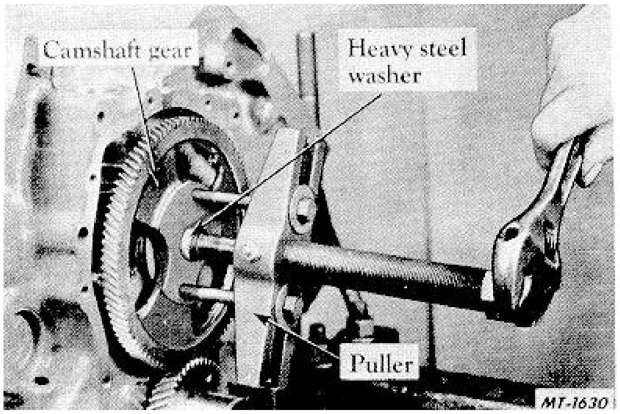


Fig. 48 Use of SE- 1368 Puller and Heavy Steel Washer for Removing Camshaft Gear

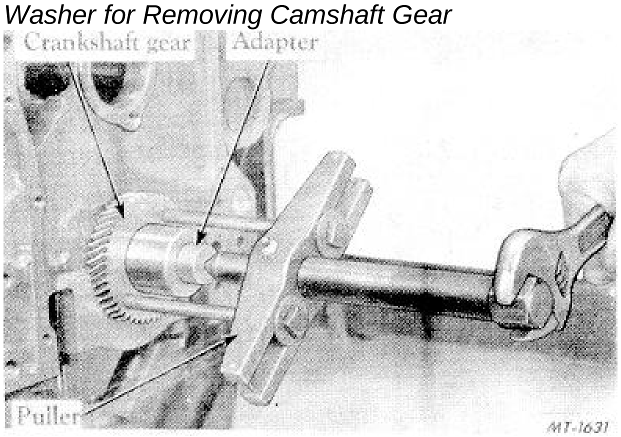


Fig. 49 Removal of Crankshaft Gear Using Puller SE- 1368

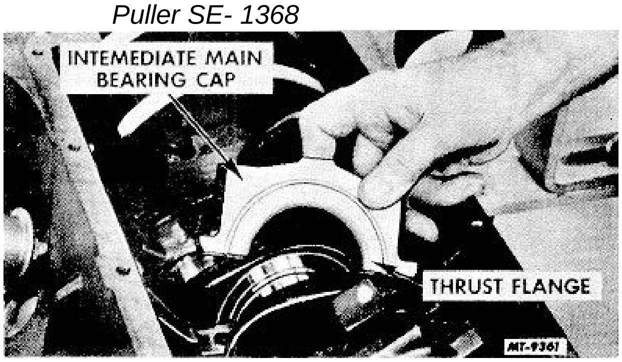


Fig. 50 Main Bearing Cap Removal

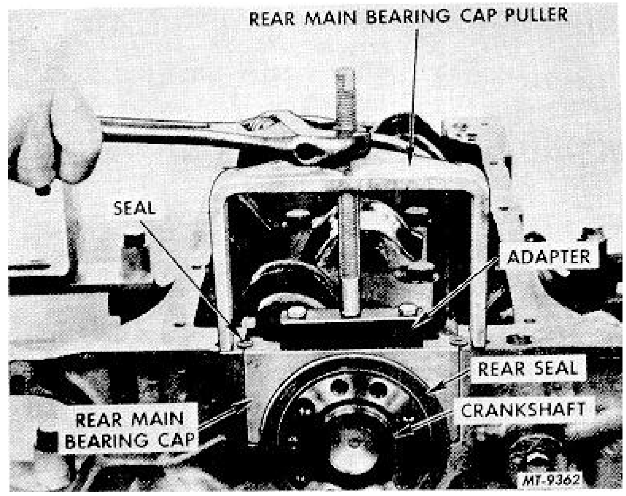


Fig. 51 Use SE- 1719 Bearing Cap Puller and Adapter SE- 1719-3 to Remove Rear Main Bearing Cap

56. Remove rear main bearing cap oil seal from end of crankshaft, Fig. 52. NOTE: Rear main bearing cap oil seal can be removed with engine in chassis providing the SE- 1941 remover is used. This can be accomplished by positioning the protector plate SE-1941-2 on the crankshaft hub to prevent damaging crankshaft flange while 'removing oil seal. Using the long notch in the protector plate, insert remover SE-1941-1 between the oil seal retainer I.D. and crankshaft flange at various locations, Fig. 53, to start seal out. A number of optional type seals are used at this application; therefore, it must be noted on some types of seals there is not sufficient clearance to insert the remover between retainer and crankshaft flange. On these type seals it will be necessary to pierce the seal retainer at a number of places using SE-1941-1 remover as shown in Fig. 54.

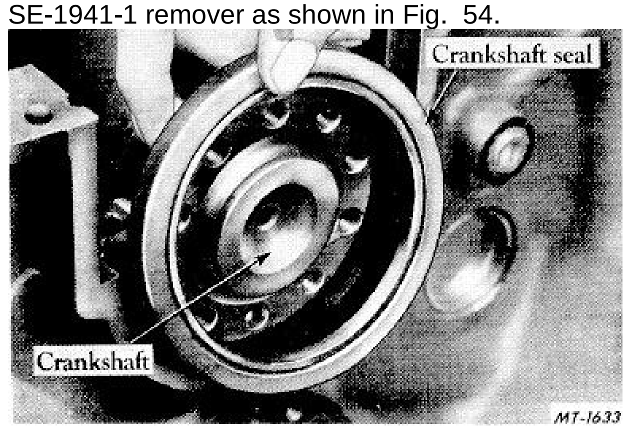


Fig. 52 Removing Rear Main Bearing Cap Oil Seal from Crankshaft

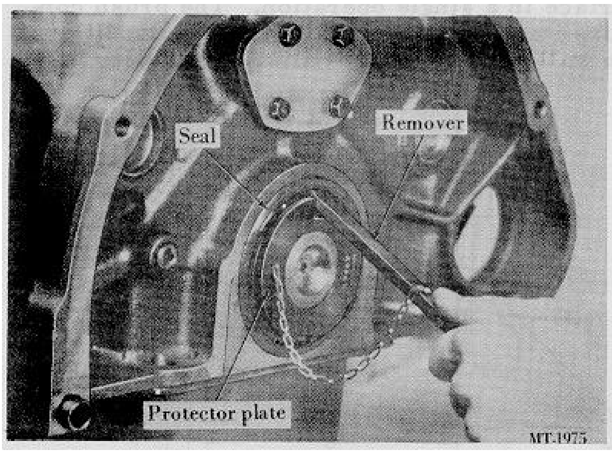


Fig. 53 Removing Rear Main Bearing Cap Oil Seal from Crankshaft with Engine in Chassis Using SE-1941 Remover

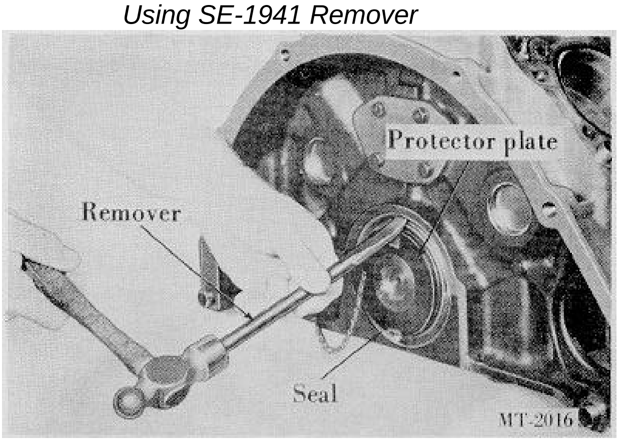


Fig. 54 Piercing Seal Retainer Using SE-1941-1 Remover

57. Lift the crankshaft straight up and out of the cylinder block.

CLEANING, INSPECTION AND RECONDITIONING

Cylinder Block

One of the most important phases of engine reconditioning is the thorough cleaning and inspection of the cylinder block.

Each machine surface of the cylinder block should be cleaned of all old gasket material. The pipe plugs which seal the oil passages should be removed and all passages thoroughly cleaned.

If it becomes necessary to remove a core plug due to water leaks, drill a 1/2" hole in the center of the plug and remove by prying with a screwdriver or suitable tool. When replacing a core plug alongside of the block, use installer SE-1725 with SE-1581-1B driver handle. Core plugs on either end of the block can be installed by using installer SE-1945 with SE-1581-1B driver handle, Fig. 55. Drive core plugs into the bottom edge of chamfer using hammer. NOTE: Coat the edges of the plugs with a suitable non-hardening sealing compound prior to installation.

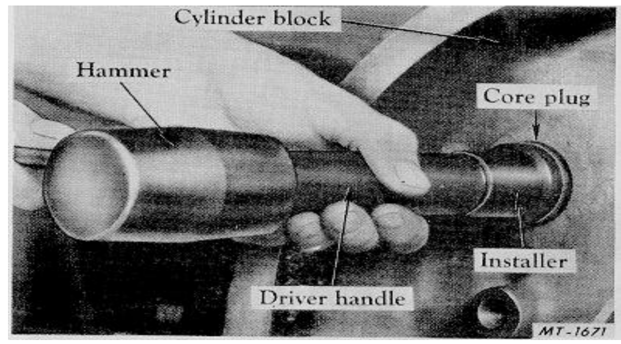


Fig. 55 Installing Core Plug in End of Block Using SE-1945 Installer with SE- 1581-1B Driver Handle

Inspection of the cylinder block should be done carefully to detect any scoring of the cylinder bores, cracks or water leaks. Small cracks may be found by coating the suspected areas with a mixture of light motor oil and kerosene. After wiping the area dry, immediately apply a coat of quick-drying liquid such as zinc oxide powder mixed with wood alcohol. Wherever cracks are present, a brown discoloration will appear in the white coating.

Check the top surface of the cylinder block for trueness with a straightedge. Test by attempting to insert a .003" feeler gauge ribbon between the straightedge and cylinder block. If this is possible, either resurface or replace the cylinder block. NOTE: When resurfacing the top of the cylinder block, do not remove more than .005" material, otherwise, contact between top of piston and head of valve may result.

Each cylinder bore should be checked with an inside- reading micrometer SE-686 or dial bore gauge SE-2331 to determine taper, out of round or worn condition, Fig. 56. Measure the diameter of the cylinder bore at the top of the piston ring travel at right angle "A, " Fig. 57, to the center line of the crankshaft. Record the readings. Next, measure each bore so the gauge reading coincides with the center line "B," Fig. 57, of crankshaft. The difference between the readings is the out-of-round condition at the top of the cylinder bore. Repeat the same Procedure at the bottom of the ring travel to check for out-of-round. The difference between the diameters measured at the top "A," Fig. 58, and bottom "B," Fig. 58, of the bore (at right angles to center line of the crankshaft) is the taper of the bore.

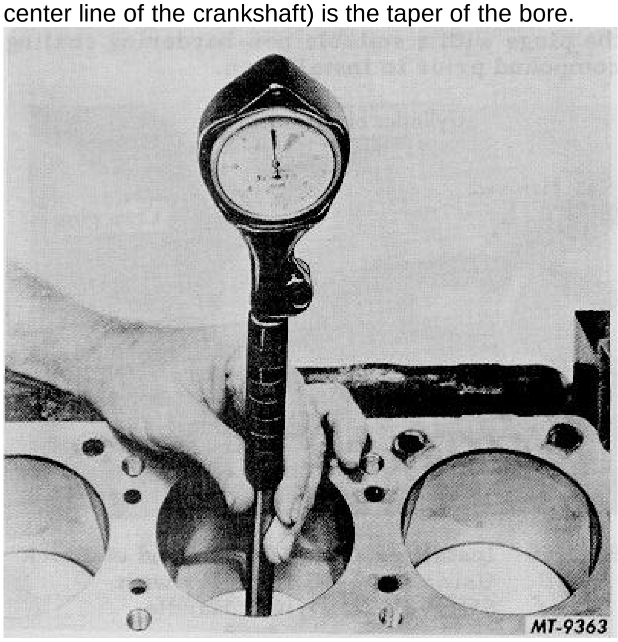


Fig. 56 Checking Cylinder Bore Using Dial Bore Gauge SE-2331

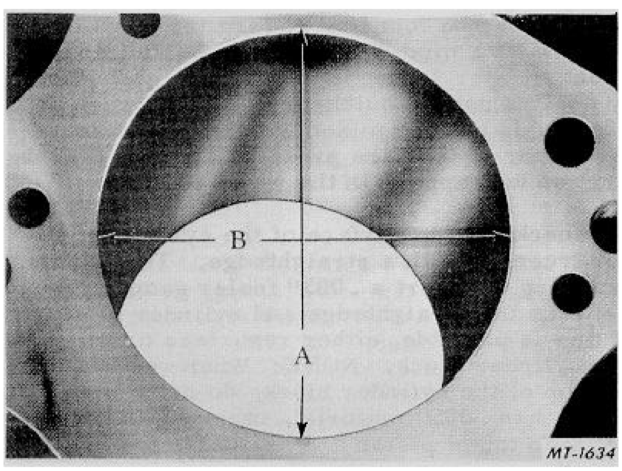


Fig. 57 Checking Cylinder Bore Out-of-Round

If the cylinder bore wear does not exceed the limits of .002" out-of-round and .005" taper, new standard size service piston rings will give satisfactory performance provided the piston clearance is not excessive.

Cylinder block bores can be deglazed with the use of SE-2314-5 glaze breaker brush, Fig. 59. This silicone carbide-tipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on the cylinder wall surface in a single operation. The brush contours itself to the cylinder wall and conditions the wall surface without altering cylinder bore.

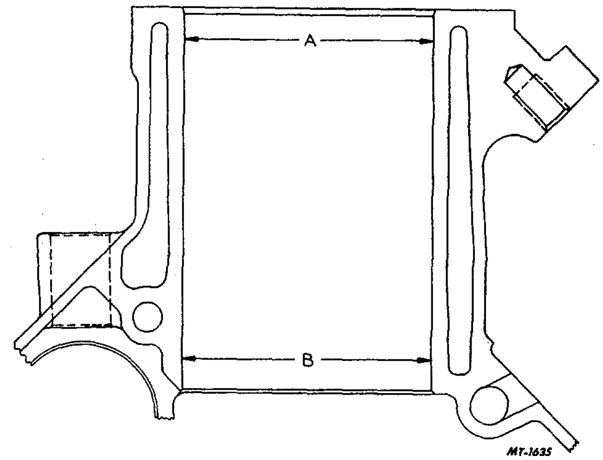


Fig. 58 Checking Cylinder Bore Taper

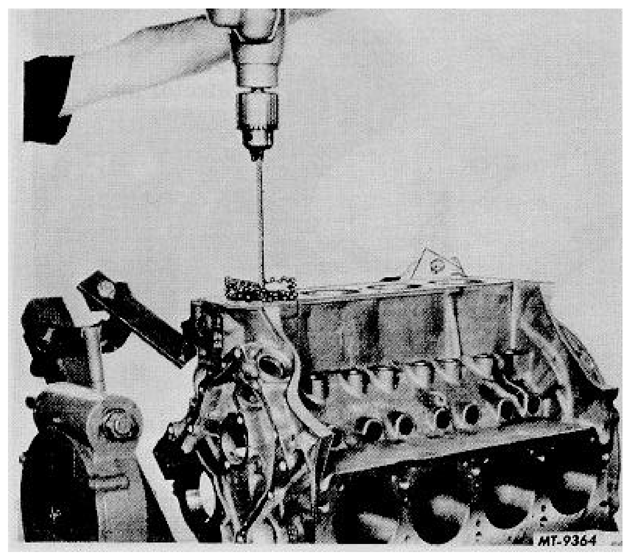


Fig. 59 Deglazing Cylinder Wall Surface Using SE-2314-5 Glaze Breaker Brush and Electric Drill

The SE-2314-4 brush (SE-2314-5 for V-392) is used in conjunction with an electric drill, Fig. 59. A slow RPM drill is recommended. Most 3/8 inch capacity electric drills are satisfactory for driving the brushes. A drill speed of 350-500 RPM has been found to be a practical speed for deglazing IH cylinder block bores.

A lubricant should be used with the silicone carbide-tipped brush to produce a desirable finish wall surface. A lightweight engine oil (SAE-30) provides adequate lubrication for deglazing cylinder block bores. The lubricant also controls airborne abrasive particles which can be easily wiped from cylinder bore with a cloth.

When conditioning cylinder block bores, stroke the brush up and down in the bore at a rate of 30-40 strokes per minute and 15-20 seconds per cylinder bore. In most instances 20 seconds is adequate time for the brush to break cylinder wall glaze and produce a cross-hatch pattern on the cylinder wall surface.

Thoroughly clean cylinder bore walls after deglazing. Wipe as much of the abrasive deposits from the wall as possible. Then swab out each abrasive-coated cylinder with SAM-10 oil and carefully wipe it out with a clean cloth. One swabbing and wiping is not sufficient. Three such complete operations are usually required more may be necessary. Continue cleaning until a clean, white cloth shows no evidence of discoloration when wiped through the cylinder bore. <u>Never use gasoline, kerosene or commercial cleaner to clean cylinders Solvents of this nature will not remove abrasives from the walls. Rapid engine wear and ring failure result from failure to properly clean abrasives from cylinders.</u>

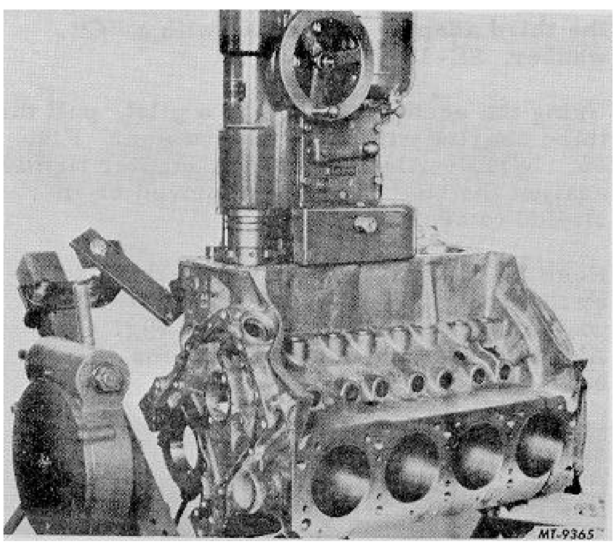


Fig. 60 Reboring Cylinder Using SE-1399 Boring Machine

However, if the wear exceeds the limits, it is recommended to rebore the cylinder or cylinders to within .003" of the required oversize diameter, Fig. 60. This will allow enough stock for the final step of honing the bores, Fig 61, so that the exact clearance may be obtained for the selected oversize piston. When performing the honing operation, the hone should be stroked up and down to produce a crosshatch pattern on the cylinder wall as shown in Fig. 62. The faster the hone rotates, the faster it must be stroked up and down to produce the desired crosshatch pattern. NOTE: After the honing, operation is completed, the sharp burred edge that develops at the bottom of a new honed cylinder should be removed manually with emery cloth. Then thoroughly clean the block and cylinder bores.

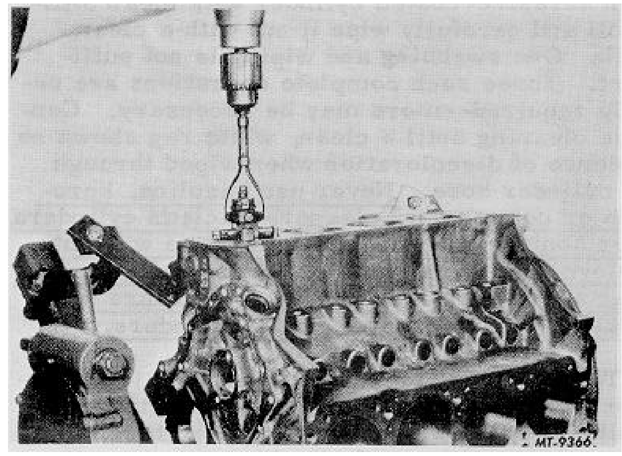


Fig. 61 Honing Cylinder Bore Using SE-784 Cylinder Grinder

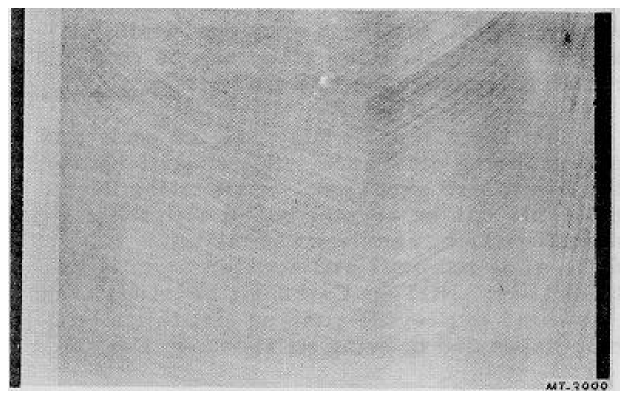


Fig. 62 Proper Honing Leaves a Crosshatch Pattern Like This on the Cylinder Wall

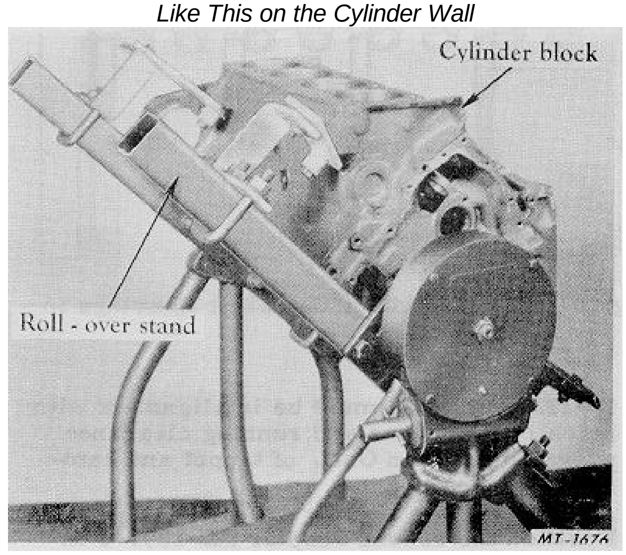


Fig. 63 Cylinder Bores Turned Vertical for Honing Operation

Wipe as much of the abrasive deposits from the cylinder wall as possible. Then swab out each abrasive-coated cylinder with clean SAE-10 oil and carefully wipe it out with a clean cloth. One swabbing and wiping is not sufficient. Three such complete operations are usually required--more may be necessary. Continue cleaning until a clean, white rag shows no evidence of discoloration when wiped through the cylinder bore. Never use gasoline, kerosene or commercial cleaners to clean cylinders after honing. Solvents of this nature will not remove abrasives from the walls. Rapid engine wear and ring failure result from failure to properly clean abrasives from cylinders.

The cylinder block can be mounted in the engine roll- over stand in a vertical position for honing cylinder bores by placing the block in a crosswise position and attaching the support brackets and support plates to the engine as shown in Fig. 63. Turn the roll-over stand 45 degrees to position the cylinder bores vertically, Fig. 63, for the honing operation. If desired, a suitable floor stand can be con-structed to support the cylinder block.

Inspect the camshaft bearings for wear and proper running clearance. See specifications. If the limits are excessive, replace the bearings This can be accomplished with the special camshaft bearing remover and installer SE-1897 and the slide hammer and adapter from puller set SE-1879. NOTE: Camshaft bearings must be installed to provide running clearance between tappet and bearing as shown in Fig. 64.

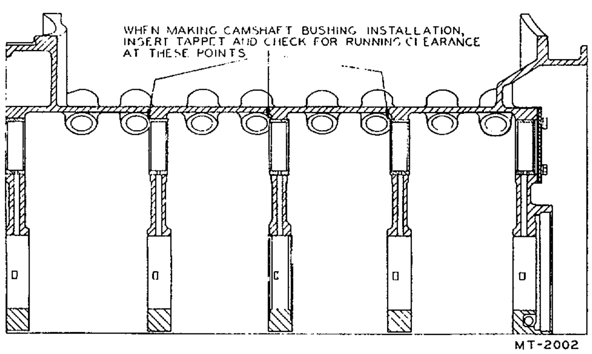


Fig. 64 Illustration of Camshaft Bearings in Crankcase

NOTE: Oil holes must be in alignment with holes in crankcase and running clearance provided between O.D. of tappet and camshaft bearing.

1. Position the second adapter SE-1897-8 in the second bearing with the flange toward the rear of the block, Fig. 65.

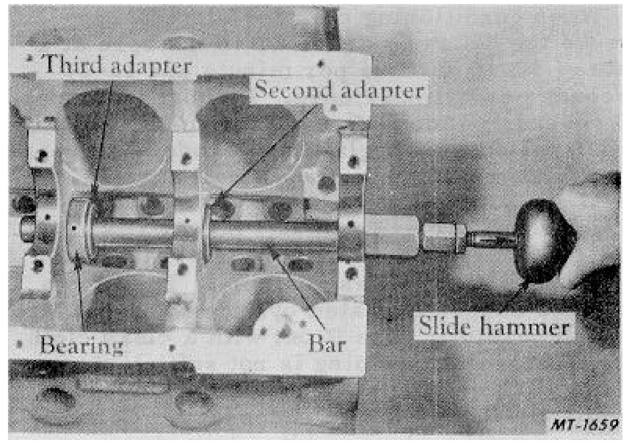


Fig. 65 Removing Third Bearing

2. Position the third adapter SE-1897-9 in the third bearing with the flange toward the rear of the block, Fig. 65.

3. Install the bar through the adapters and lock the third adapter on the bar with a "C" washer, SE-1897-2.

4. Using the second adapter as a pilot, pull the third bearing with the slide hammer, Fig. 65, NOTE: Always hold the adapter firmly against the bearing being removed or installed to avoid damage.

5. Position the new bearing on the third adapt-er and install adapter and bar with "C" washer in front of the adapter, Fig. 66. Align the oil hole and push in the third bearing.

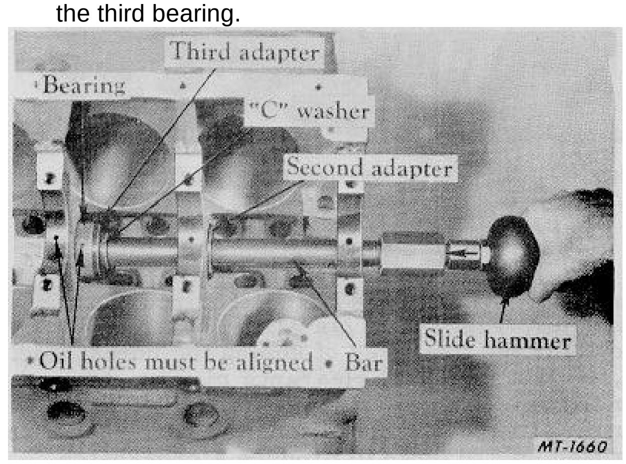


Fig. 66 Installing Third Bearing

6. Position the front adapter SE-1897-7 in the front bearing with the flange toward the front of the block, Fig. 67.

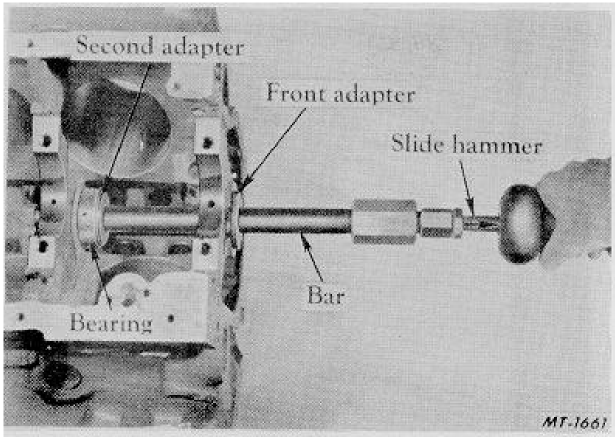


Fig. 67 Removing Second Bearing

7. With the second adapter still in position, install the bar through the adapters and lock the second adapter on the bar with "C" washer, Fig. 67.

8. Using the front adapter as a pilot, pull the second bearing with the slide hammer, Fig. 67. NOTE Always hold the adapter firm-ly against the bearing being removed or in-stalled to avoid damage.

9. Position the new bearing on the second adapter and with the adapter flange toward the front of the block, install the bar through the front and second adapter. Then install the "C" washer in front of the second adapter. Align the oil holes (with short groove) in top and (long groove) in bottom of second bearing with oil holes in block, Fig. 68. Push in second bearing,

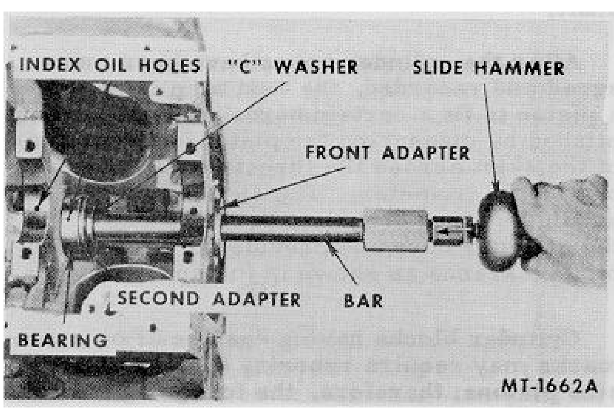


Fig. 68 Installation of Second Bearing

10. Remove the "C" washer and use the second adapter as a pilot. Remove the front bearing by driving the bearing into the block, Fig. 69.

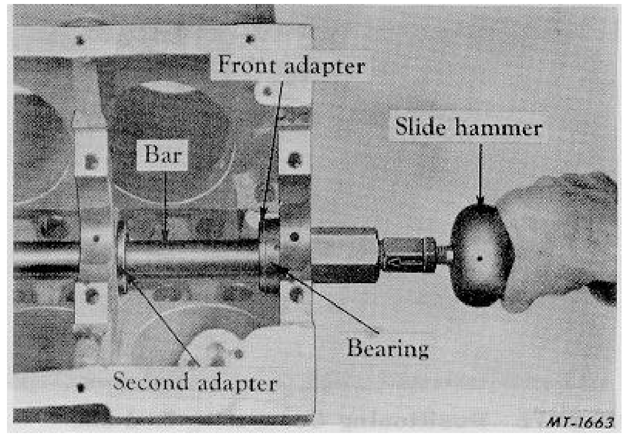


Fig. 69 Removing Front Bearing

11. Remove the bar and front adapter and position the new bearing on the front adapter. Slide the bar into the block and through the second adapter serving as a pilot, Fig. 70.

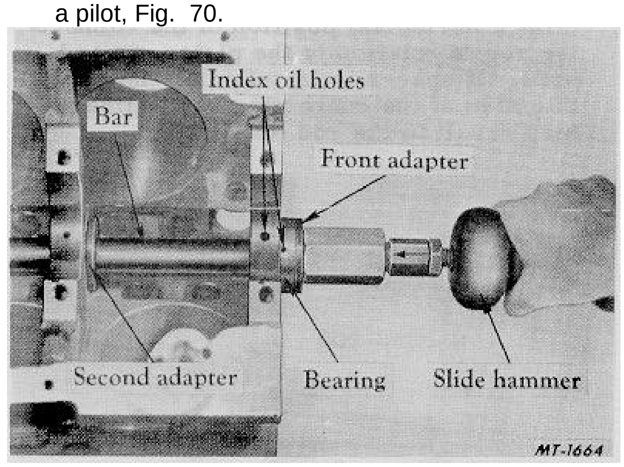


Fig. 70 Installing Front Bearing

12. Align the oil holes and drive in the front bearing, Fig. 70. NOTE: The oil hole drilled through the groove in the bearing must align with the main bearing feed hole and the other oil hole must align with oil hole in top of block.

13. The fourth and rear bearings are installed in a manner similar to the front and second bearings using fourth adapter SE-1897-10 and rear adapter SE-1897-11, working from the rear of the block.

Pistons and Piston Pins

To disassemble the piston from the connect-ing rod assembly, position the piston pin bore over the "U"-shape portion of the SE-1946-2 support plate, Fig. 71.

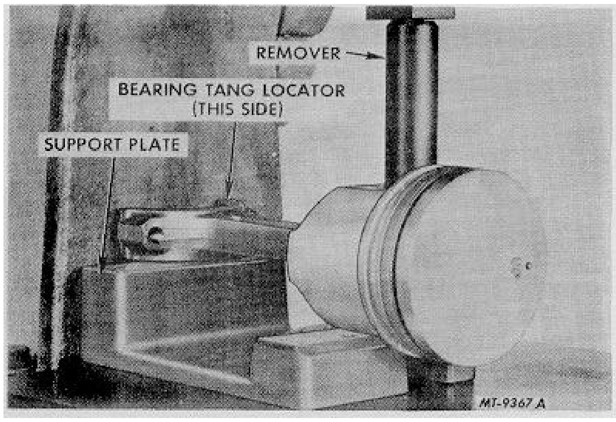


Fig. 71. Positioning Connecting Rod and Piston Assembly on SE- 1946-2 Support Plate for Disassembly

NOTE: The side marked "UP" on top of piston must be positioned in the press as shown in Fig, 71. This will permit correct installation of the spacer which maintains a horizontal position of the connect-ing rod in relation to the piston pin and bore, If spacer is installed on the opposite side of the connecting rod, damage may result to the rod or piston.

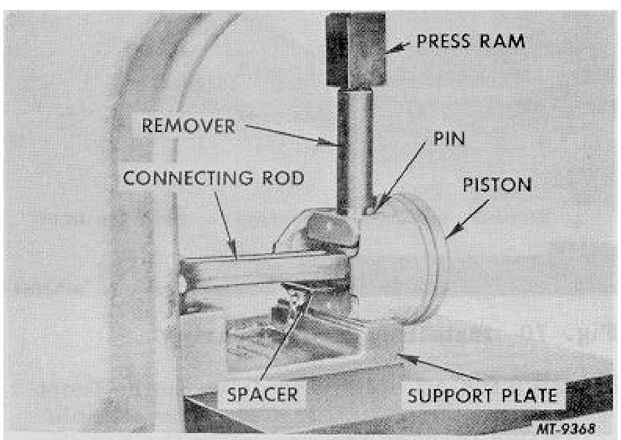


Fig. 72 Inserting Spacer SE-1946-3 and Piston Pin Remover SE-1946-1 for Pin Removal

Then insert the spacer SE- 1946-3 between the connecting rod and piston and at the same time install the piston pin remover SE-1946-1 and remove pin, Fig. 72. NOTE: So that remove SE-1946-1 can be used on piston pins utilized in V-392 engines, the pilot on the re-mover must be reworked to dimensions shown in Fig. 73. After the pin is removed, separate the piston from the connecting rod, taking precautions to see that the parts are marked so they may be reinstalled in their cylinders unless defective.

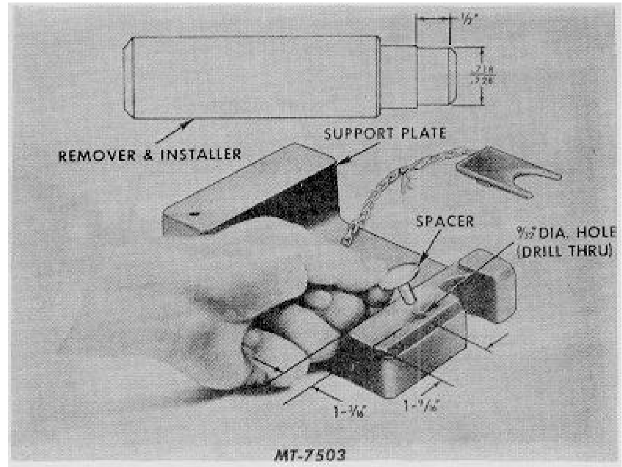


Fig. 73

Remove all old rings and immerse all parts of the piston in cleaning solvent and clean thoroughly, Use a special ring groove cleaner or broken piston ring to clean all carbon from the piston ring grooves. NOTE: <u>Never use a caustic solution for cleaning aluminum pistons</u>.

Inspect the pistons for scuffed or scored skirts or cracked or worn ring lands, discarding any showing such conditions.

To select the correct size pistons for an engine overhaul, it must be noted that the size of the cylinder bore diameters must be determined first. This can be accomplished with the use of inside reading micrometer SE-686. Each bore should be measured at the top of ring travel and the lower end of ring travel both parallel and at right angles to the crankshaft.

After the cylinder bores have been measured and recorded, the next step is to select a piston to fit a certain bore. This is accomplished by measuring the piston at the bottom of the skirt across the thrust faces with an outside micrometer. The size piston selected should be large enough to permit cleaning up the cylinder bore and provide the proper running clearance as shown in the specifications.

Cylinder blocks having deep scuff or score marks may require reboring for use of over size pistons; therefore, the foregoing information still applies.

However, when reboring the cylinder bore, it should be sized to within .003" of the desired size and then honed to provide the proper finish on the cylinder wall as well as the correct running clearance for the piston selected.

An alternate or quick-check method can be used when fitting pistons in the cylinder bore by using a feeler ribbon between the piston and cylinder 90 degrees from the piston pin hole and in line with the thrust face of the piston, Fig. 74. Apply a tension pull on scale to the feeler ribbon and check clearance (see specifications for dimension of ribbon size, etc.).

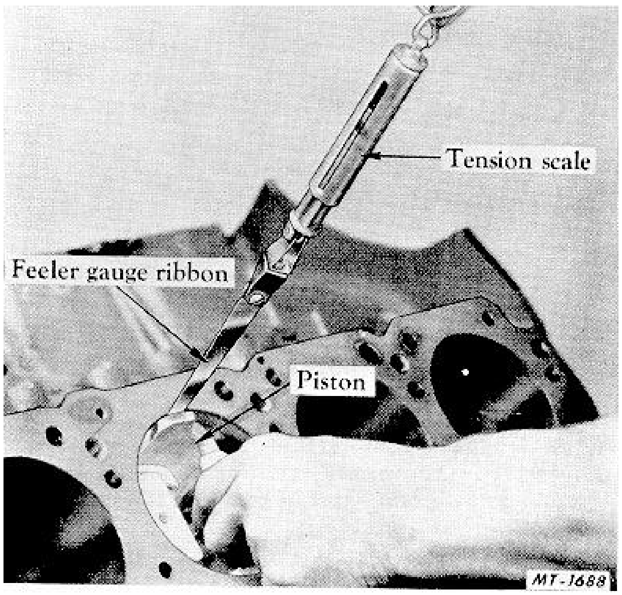


Fig. 74 Checking Piston Fit to Cylinder Bore

Inspect the piston pins for wear, and if wear is perceptible, replace the piston pins which show signs of corrosion or etching. Piston assemblies furnished for service replacement are complete with piston pins accurately fitted.

<u>Connecting Rods</u>

The connecting rod, which serves to transmit power between the piston and crankshaft, converts the reciprocating motion of the piston to rotary motion at the crankshaft. The connecting rod transmits stored-up energy in the crankshaft and flywheel back to the piston to expel exhaust gases in the cylinder. It also draws in and compresses the fuel-air mixture in the cylinder.

The connecting rod and bearing must withstand explosions, centrifugal and inertia forces and perform at high temperature. In addition, the connecting rod and bearing are subject to constantly changing heating and cooling cycles in a variety of climates and under widely varying operating conditions. These parts perform hour after hour, quite often turning over more than 150 million revolutions a year, year in and year out. Because of these facts, we can understand why the condition of the connecting rods and bearing inserts is important.

The connecting rod bearing plays a major role in distributing the proper amount of oil to the piston pin bearing surfaces, cylinder walls, piston and piston rings. This is known as oil throwoff, and the condition of the connecting rod bearing determines how well the lubrication operation is performed.

The bearing-to crankshaft clearance affects the volume of oil throwoff. Where the bearing clearance is more than specified, an abnormal amount of oil is thrown onto the cylinder walls, causing increased oil consumption and low oil pressure due to oil passing through the bearing surfaces too quickly. On the other hand, where bearing clearances are less than the specified amount, the oil that passes through the bearing is insufficient to properly cool the bearing, resulting in short bearing life and improper oil throwoff to the cylinder walls, piston pins and piston rings. This condition contributes to scoring of pistons and cylinder walls.

If the connecting rod bore is stretched or out-of-round beyond the specified diameter, the insert will be out-of-round and will not be held securely in the connecting rod, since the "crush" may be lost. Bearing failures will result from localized bearing loads or from low oil pressure, since the bearing insert locating tangs alone cannot be depended upon to keep the inserts from turning in the connecting rod bore.

When installing new connecting rod bearing inserts, a very thorough inspection of the connecting rod bore is necessary. This inspection consists of the following:

1. <u>Roundness</u>: The bore of the connecting rod when assembled and the rod bolts and special hardened washers tightened to specified torque is round and should not exceed .0005” out-of-round, Fig. 75.

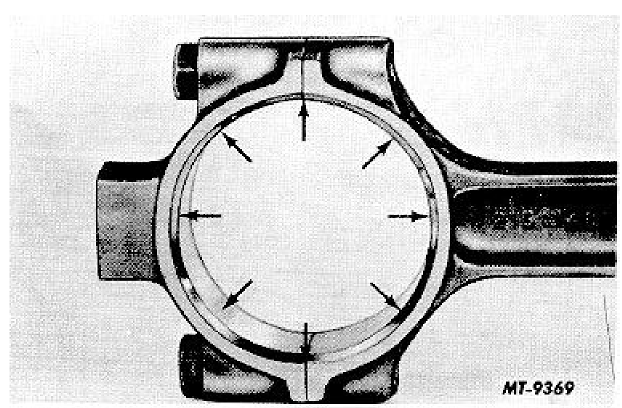


Fig. 75

2. Straightness: The connecting rod bore taper should not exceed .0005", Fig. 76.

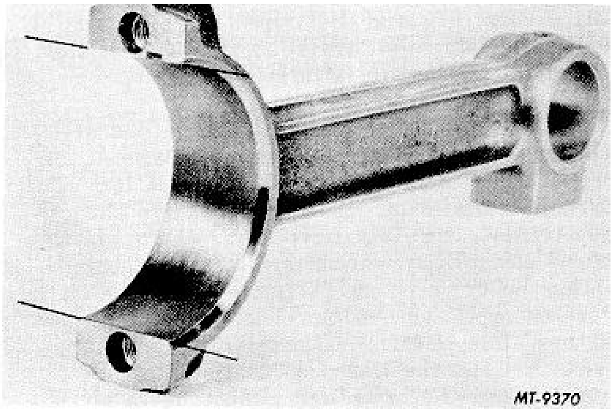


Fig. 76

3. Surface Finish: The connecting rod bore must be smooth, Fig. 77.

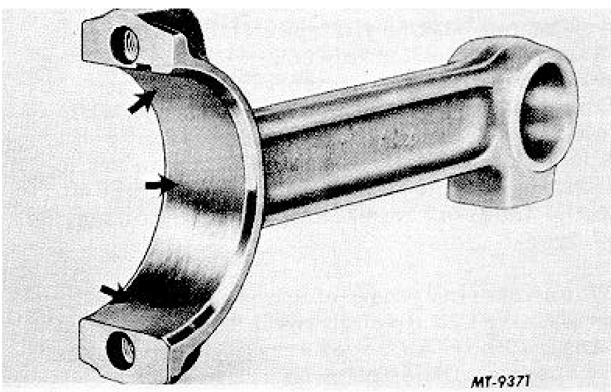


Fig. 77

4. Bore Size: To obtain the proper bearing insert crush, the bore must be of specified size (see specifications), Fig. 78.

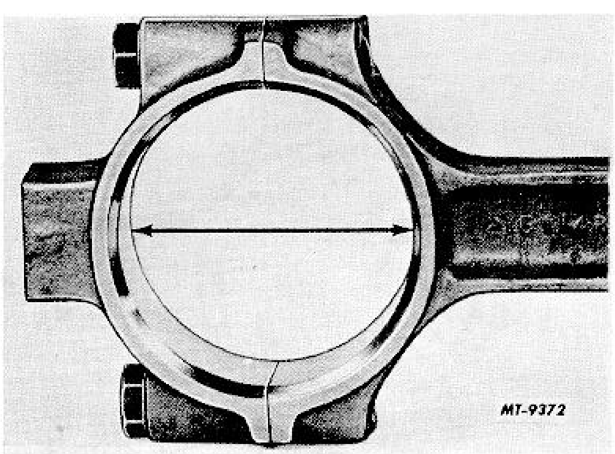


Fig. 78

This inspection can be made using the precision gauge furnished with honing machine, SE-2218, Fig. 79, or other accurate bore gauge, SE-2087.

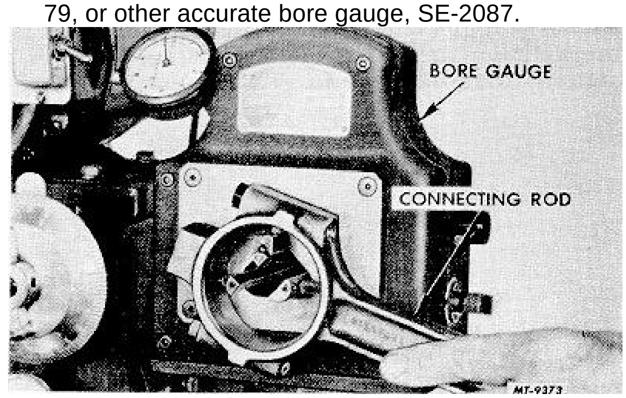


Fig. 79 Checking Connecting Rod Bore Using Precision Gauge Furnished with Honing Machine SE-2218

If the original connecting rod does not meet the above requirements, it must be replaced. If it is not replaced, the quality of the finished job will be questionable.

The connecting rod should be thoroughly cleaned and visually inspected for defects. The connecting rod bore should be checked for proper fit with the piston pin (see specifications). If inspection shows the piston pin bore is worn, a new piston with pin must be installed.

After inspection or conditioning of the connecting rod it is ready to be assembled to the piston. However, for correct assembly of the connecting rod to the piston, it must be noted that the rod bearing locators (bearing tangs) will be toward the side (marked "UP") on the piston for proper installation. This is important in that the rod and piston must be assembled correctly so that when the piston is installed in the engine, the large, chamfered side of each rod is located against the crankshaft face. The chamfer provides clearance at the crankshaft fillet, Fig. 80.

NOTE

The SE-1946-2 support plate must be reworked to incorporate a 9/32" dia. hole as shown in Fig. 73. The support can then be utilized for assembling the connecting rod to the piston on V-392 engines.

Place the piston and connecting rod in press on SE1946-2 support plate with solid portion of plate under piston pin bore and the side marked "UP" on top of piston toward the left side of press.

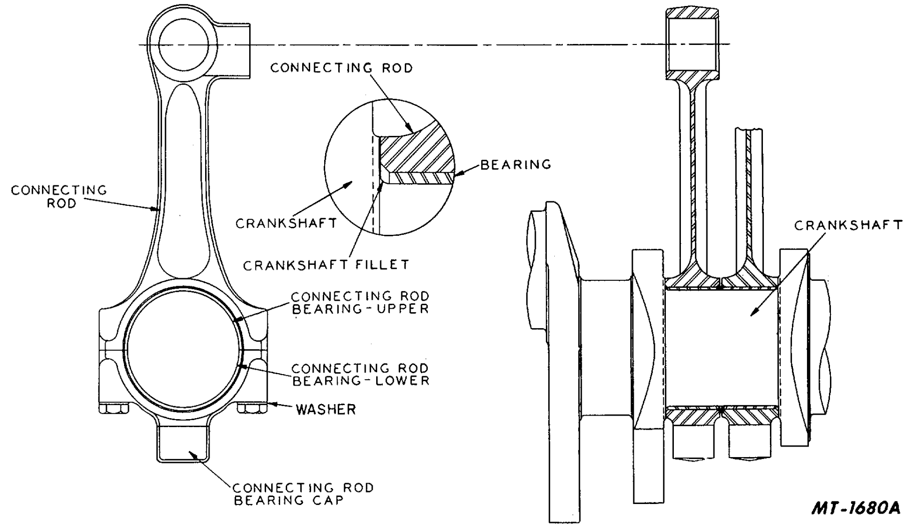


Fig. 80. Illustrating Proper Installation of Connecting Rod to Crankshaft.

NOTE

When assembling the rod and piston on V-392 engines, it will be necessary to install SE-1946-7 spacer, Fig. 73, into support plate to provide a piston pin stop on the support plate.

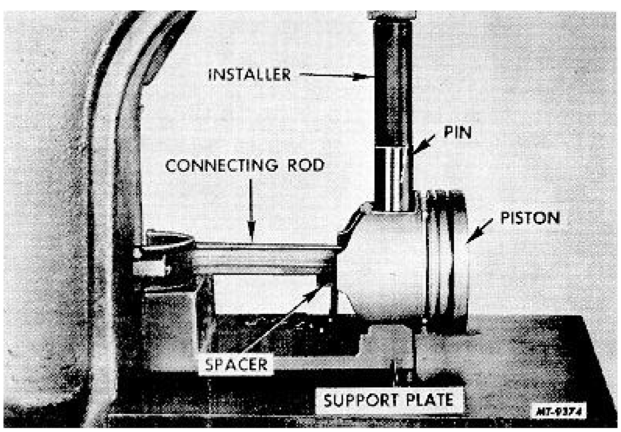


Fig. 81. Installation of Piston Pin in Connecting Rod and Piston Using Support Plate SE-1946-2 and Installer SE-1946-1.

Insert pin in piston and align with connecting rod bore. Position installer SE1946-1 in pin and locate spacer SE1946-3 between connecting rod and piston, making sure notch in spacer is aligned with piston pin bore.
Then press pin into rod and piston until it bottoms on support plate (V-304, 345), Fig. 81, or spacer (V-392), Fig. 73. Test the connecting rod and piston assembly on a connecting rod aligner and correct any misalignment.

NOTE

The SE-1946-3 spacer must be used to support the connecting rod in the piston, since this spacer is machined to locate the rod on the pin when the pin is pressed into the rod, Fig. 82.

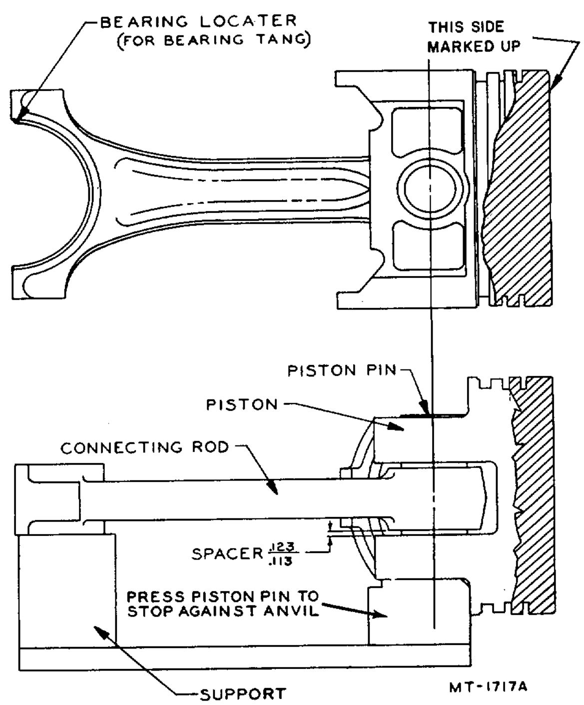


Fig. 82 Illustrating Use of SE-1946-3 Spacer for Proper Location of Piston Pin in Connecting Rod

Connecting Rod Caps and Bolts

The fastening of the connecting rods to the engine crankshaft is another important fundamental for mechanics to consider for engine rebuilding. How well this job is performed determines to a large extent what kind of connecting rod bearing wear will be realized. The correct torque application assures a good job.

NOTE

Do not use a power wrench for removing or installing connecting rod bolts, nuts and washers. Such practice will cause seizure of the connecting rod bolt or nut threads.

There are a number of conditions which affect torque and the results of torque applications. The major purpose in tightening connecting rod bolts and nuts to a specified torque is to obtain tension in the bolt, Fig. 83, which in turn develops a clamping load or preload that exceeds any possible loading imposed on parts due to engine RPM. In other words, connecting rod must "hang on" to crankshaft and suffer all the strains of inertia and cylinder combustion impulse without permitting the least movement or flexing of the rod cap, bolts or nuts. At the same time, torque applied must be within the capacity of parts (bolt, nut, caps, connecting rods) to withstand these loads.

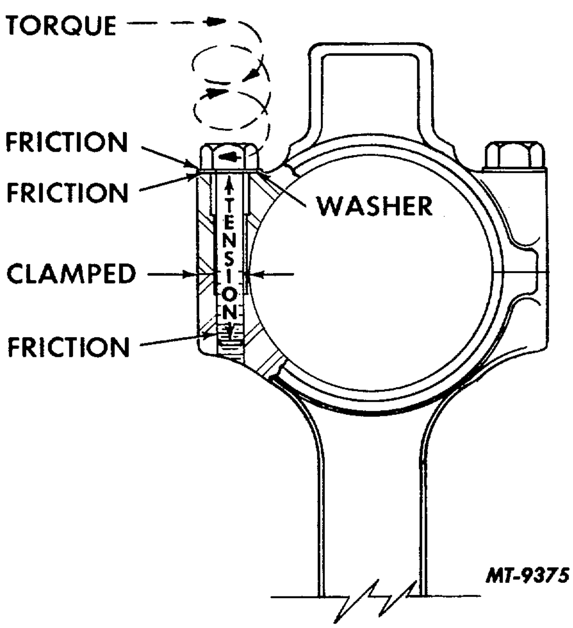


Fig. 83 Connecting Rod Cap and Bolt Details

In tightening connecting rod bolts and nuts to their specified torque figure, a definite loading is obtained between connecting rod and cap. Especially designed bolts, nuts and washers manufactured from selected materials permit the application of this loading without undue stretching of bolts. There is a relationship between the torque specifications and clamping effect or load to be applied providing certain conditions exist.

These conditions center largely around the bolt itself and its care, pointed out as follows:

Bolt and Nut Thread Condition Is Most Important:

Threads that are dry, excessively rough, battered or that are filled with dirt require considerable effort just to rotate the nut. Then when the clamping load is developed or the bolt tension is applied, the torque reading mounts rapidly (due to thread friction) to the specified figure without approaching the desired bolt tension and maximum clamping effect. Under these conditions the desired torque reading is obtained, but the clamping effect might be far below requirements, leading to bearing failure or to connecting rod bolt breakage. The proper bolt tension and clamping effect can never be attained if the nut is dry. The nut and bolt must have a film of lubricant in the thread section to be considered lubricated. It is recommended that new connecting rod bolts, nuts and washers be used during reassembly. Due to the close fit of connecting nuts on the bolts, the slightest thread imperfection increases the friction to the extent that incorrect bolt tension is likely.

Connecting rod bolts and nuts must be cleaned of all foreign matter including the antirust materials that may be in the threads. Apply light engine oil to the threads to lubricate before installation.

Tightening of Connecting Rod Bolts, Nuts and Washers:

Tighten the connecting rod bolts, nuts and flat washers alternately and finish tightening with the torque wrench to the specified torque, then release the torque load to zero and retorque to specified torque. See "TORQUE CHART." If nut is inadvertently over-tightened excessively, enough to stretch the bolt, it must be replaced with a new bolt and nut. In major engine overhaul use new rod bolts, nuts and flat washers throughout.

The application of specified torque to any particular bolt which serves to hold or clamp two parts together should be accomplished with a torque wrench known to be accurate.

Piston Rings

The pistons used in the V-type engines have three piston rings (see specifications) located above the piston pin. The compression rings are located in the top grooves, while the lower groove accommodates the oil control ring. Select the proper rings for the size of pistons to be used.

Prior to installing the rings on the pistons each ring must be checked for proper ring gap. Push the ring down into the cylinder bore making sure the ring is square with the cylinder wall. Extreme care should be used during this operation. Check the space or gap between the ends of the ring with a feeler gauge, Fig. 84. See specifications for proper ring gap.

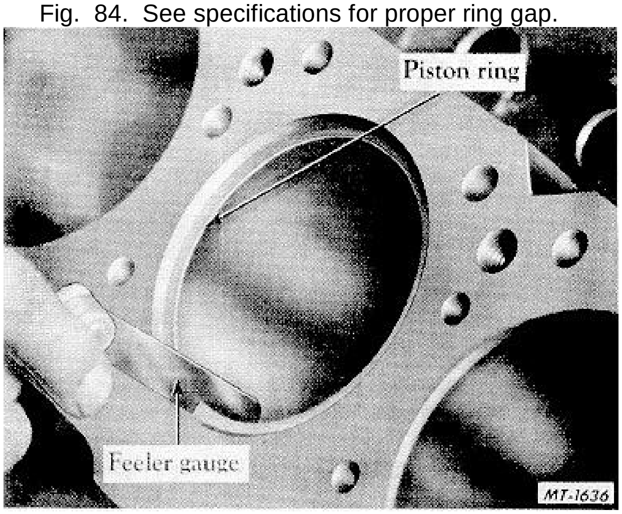


Fig. 84 Checking Ring Gap

On compression rings if the gap is less than the limit, try another ring for fit or dress the ends of the ring with a fine cut file until the correct clearance is obtained. The dressing of the piston ring ends is best accomplished by placing a file in a vise, then moving both ends of the piston ring (one at each face of the file) squarely across the cutting faces. Each ring should be fitted and checked in the cylinder in which it is to be used and marked accordingly.

Piston rings should be checked for side clearance in the groove of the piston on which they are to be installed. This is done by placing the outer edge of the ring in the piston groove, rolling the ring entirely around the piston to make sure there is no binding and the ring is free in the groove. With a feeler gauge check the side clearance of each ring in its respective groove, Fig. 85. See specifications for proper clearance.

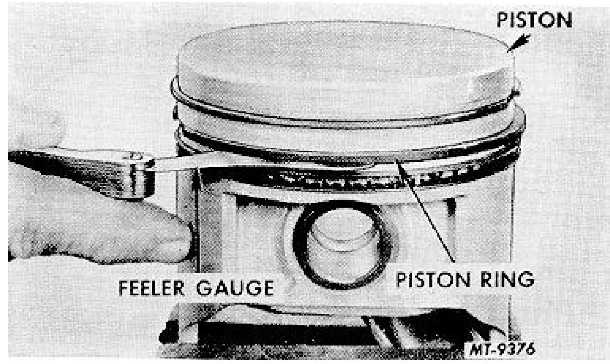


Fig. 85 Checking Ring-to-Groove Side Clearance with Feeler Gauge

Assemble the rings on pistons to which they were fitted by using a piston ring expander tool. This type of tool is recommended to avoid over-expanding and also to expand the ring to a true circle to avoid distortion, Fig. 86. General practice when installing piston rings is to stagger the ring gaps. For further information refer to the instructions furnished with the service ring sets.

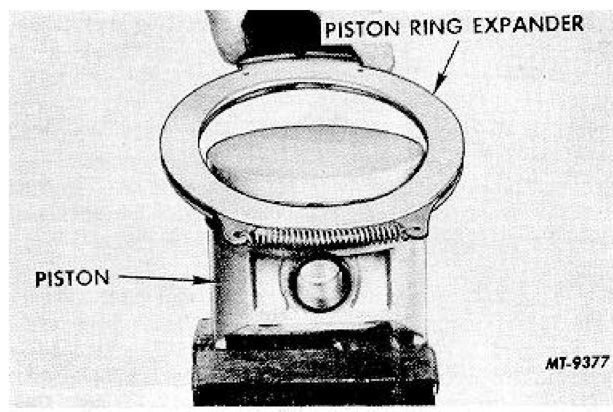


Fig. 86 Installing Piston Ring Using SE-1149 Piston Ring Expander Tool

Cylinder Heads, Valves, Valve Guides, Springs, Etc.

The cylinder heads, as removed from the engine, contain the valve mechanisms. The rocker arm assembly was removed prior to removing the heads. SE1896 cylinder head sling, Fig. 87, can be used as a holding fixture to protect machined surfaces during cleaning and miscellaneous disassembly operations.

With the valves installed to protect the seats clean the carbon deposits from the combustion chambers and valve heads with a wire brush and scraper. Wash the heads in cleaning solvent to remove dirt and grease from all surfaces and dry thoroughly. Check all water passages to make sure they are clear and open.

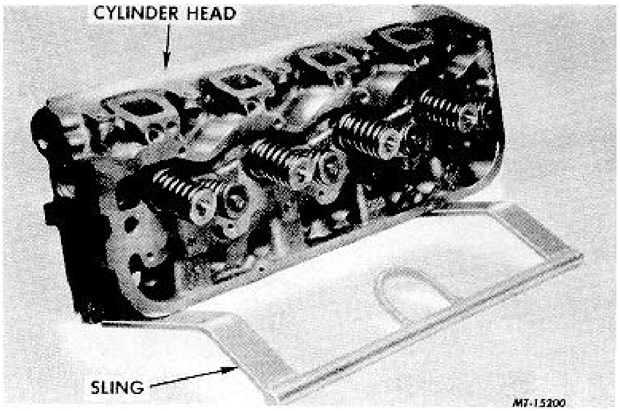


Fig. 87 Cylinder Head Sling Attached

Examine the cylinder heads for water leaks or cracks in the combustion chambers, exhaust ports or around the valve seats. Inspect the machined or gasket surfaces for scratches or mars which may cause leakage after assembly. By using the SE-1896 sling or cylinder head holding fixture SE1939, the chances of damaging the gasket surfaces are greatly reduced.

Check the gasket surface of the cylinder head for trueness with a straightedge. Test by attempting to insert a .003" feeler gauge ribbon between the straightedge and cylinder head. If this is possible, either resurface or replace the cylinder head. NOTE: When resurfacing the cylinder head, do not remove more than .005" material, otherwise, contact between top of piston and head of valve may result.

The cylinder head assemblies are interchangeable from one cylinder bank to another provided the water outlet plug is removed and installed on the rear of the head and the alternator mounting bracket is relocated on the machined pads provided. Cylinder head gasket is also interchangeable.

To disassemble the valves, turn the head assembly in a vertical position using SE1939 cylinder head holding fixture, Fig. 88, as a cradle to hold the assembly.

Apply a valve spring compressor and remove the valve keepers or locks, Fig. 88. Remove the spring compressor and disassemble the spring retainer, valve stem damper, spring, valve stem seal and RotoCap assembly from the exhaust valves. NOTE: It may be necessary to strike the valve ends with a light, soft hammer to break the valve keepers loose. From the intake valves remove the spring retainer, valve stem damper, spring, valve stem seal and valve spring seat, Fig. 89. All valves are removed in the same manner. <u>Keep valves and their related parts together so they may be reinstalled in their respective positions.</u>

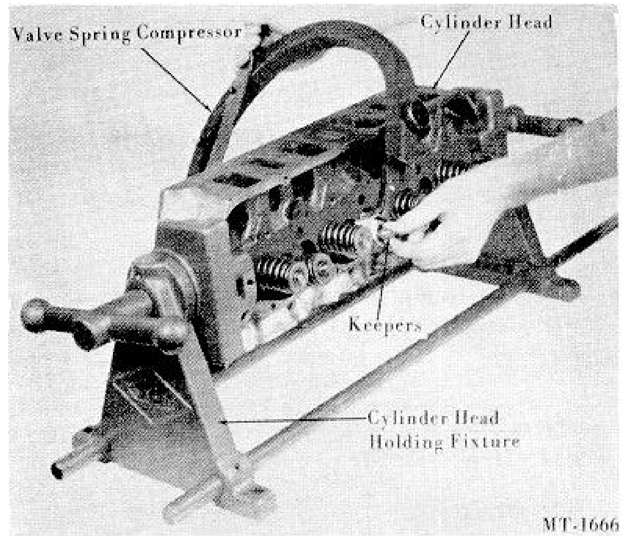


Fig. 88 Cylinder Head Holding Fixture SE1939

Remove all carbon from valve stems and head using a fine wire brush or buffing wheel. Inspect each valve, discarding any that show evidence of burned, warped or bent condition. SE-1800 valve gauge, Fig. 90, or similar tool can be used for checking stem straightness and seat run-out.

Inspect the valve springs for proper tension as outlined in specifications section. Any evidence of wear, crack, or permanent sets will require replacement. SE-2241 spring tester, Fig. 91, or similar tool can be used to check tension.

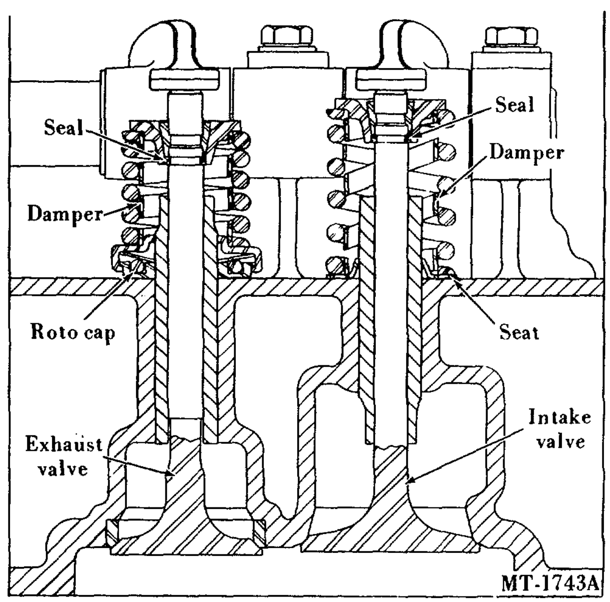


Fig. 89. Cross Section of Intake and Exhaust Valves Installed in Head.

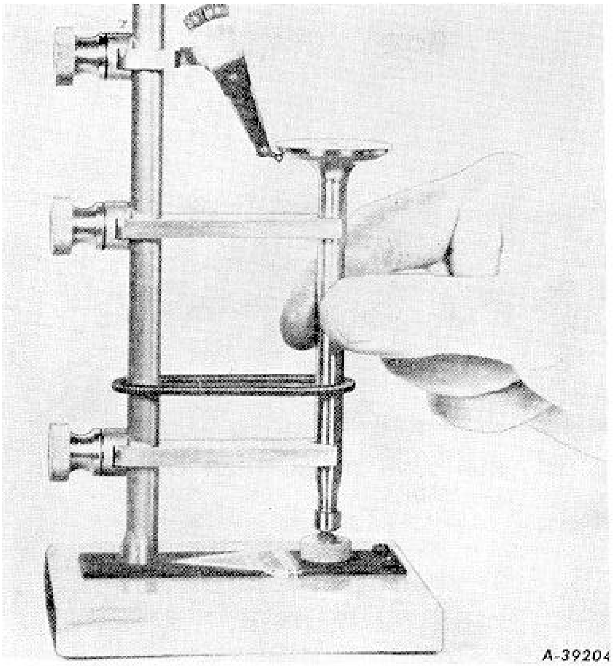


Fig. 90 Checking Valve Stem Straightness and Face Run-Out.

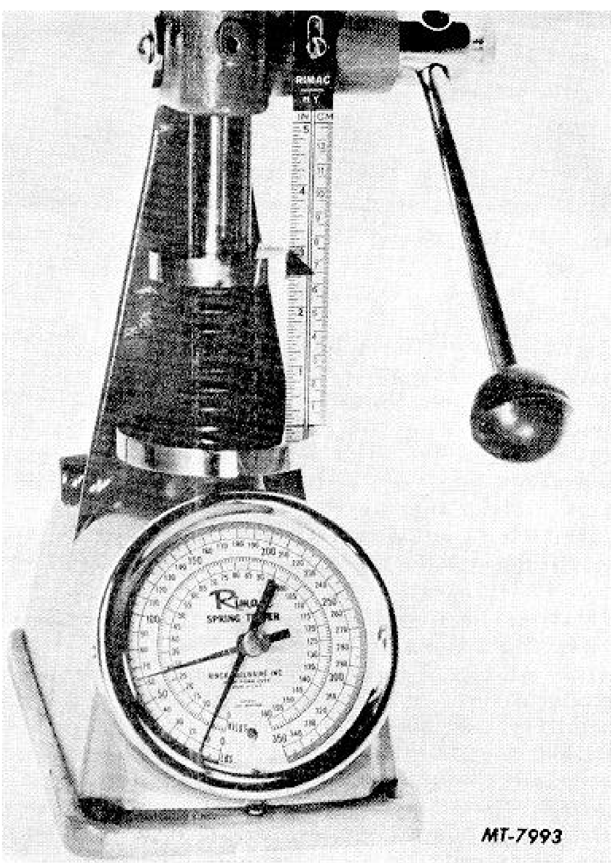


Fig. 91 Checking Spring Tension Using SE-2241.

Inspect valve locks for excessive wear and replace in pairs as required. Rotate the RotoCap assemblies and replace if any wear or irregularities are noted. Note particularly if the RotoCap feels gritty or is bound up.

Remove SE-1896 sling or SE-1939 cylinder head holding fixture and position the cylinder head with combustion chamber facing upward on support blocks, Fig. 96. This preparation is done for valve guide removal.

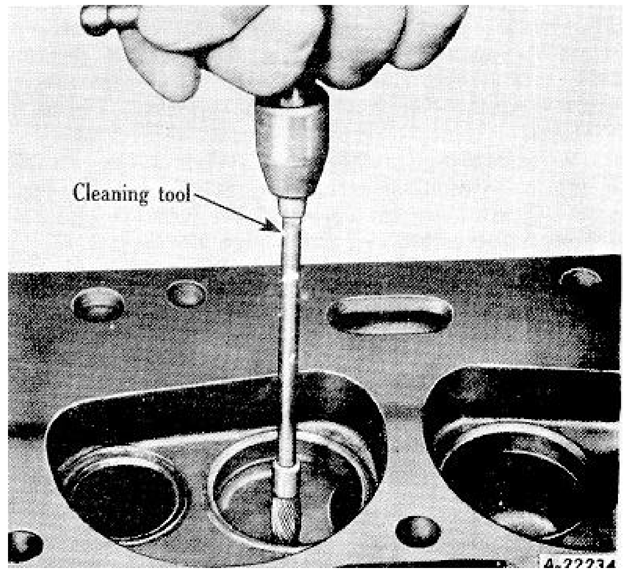


Fig. 92 Valve Guide Cleaning Tool

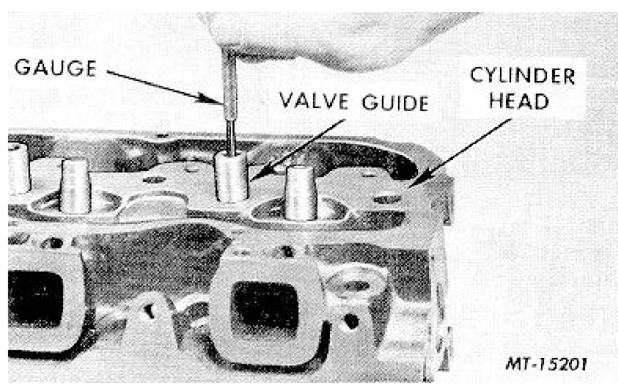


Fig. 93. Checking Valve Guide Bore Using Gauge SE-1826

Check the valve guide bore dimensions (see specifications). Prior to inspection it is necessary to clean the guides. There are many commercially available wire brushes and scrapers, Fig. 92, that clean guides very satisfactorily. Similarly, there are various instruments for measuring the guide bores-small-bore gauges, plug gauges, etc., Fig. 93. Plug gauges of the "go" and "no-go" type are most popular because of the facility with which guides can be checked. However, there are two undesirable guide conditions which are difficult to check with gauges of this type: elliptical or egg-shaped bore wear and bellmouthing at the port of the guide. Careful guide inspection will detect egg shaped wear, and the careful use of the "no go" gauge will tend to show the degree of bellmouthing. Replacement is recommended for guides having bore diameters outside the recommended limit or which are bellmouthed more than .0005" or which show egg-shaped wear. Excessive guide clearance prevents adequate cooling of the valve through the guide and also allows deposits to tilt or tip the valve, which may cause valve breakage at high engine speed. These conditions tend to prevent good seating and promote leakage across the valve face. Some of these conditions are illustrated in Fig. 94. Excessive guide clearance also affects the proper lubrication of the valve stem.

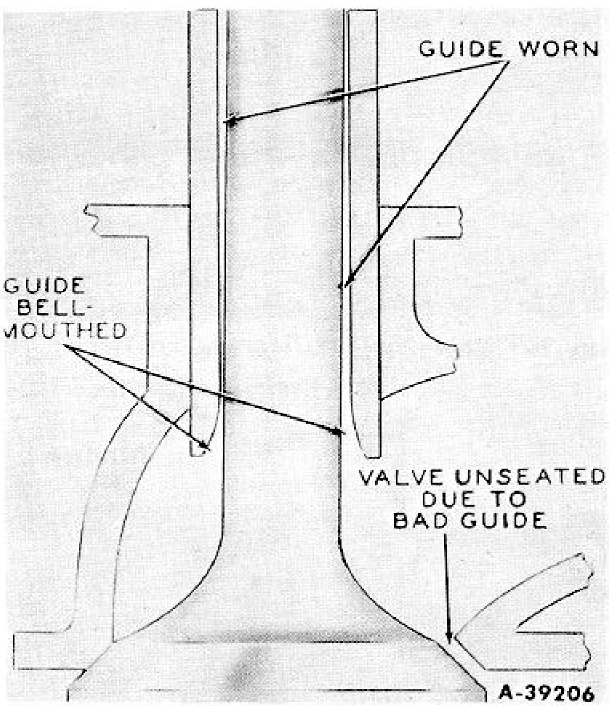


Fig. 94. Example of incorrect Valve Guide Installation

Replacement guides are designed to give proper clearance when installed in the cylinder head. Reaming is not required but care must be taken to see that the ends of the guides are not burred during installation.

Remove all guides that exceed wear limitations using SE17Z2 valve guide remover. All guides must be driven from the combustion chamber side through the top of the head as shown in Figs. 95 and 96.

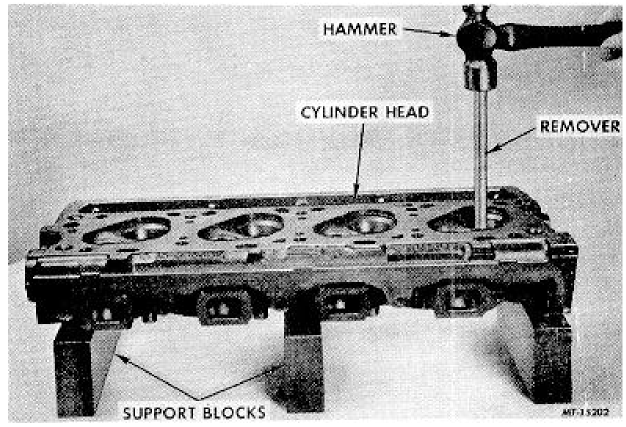
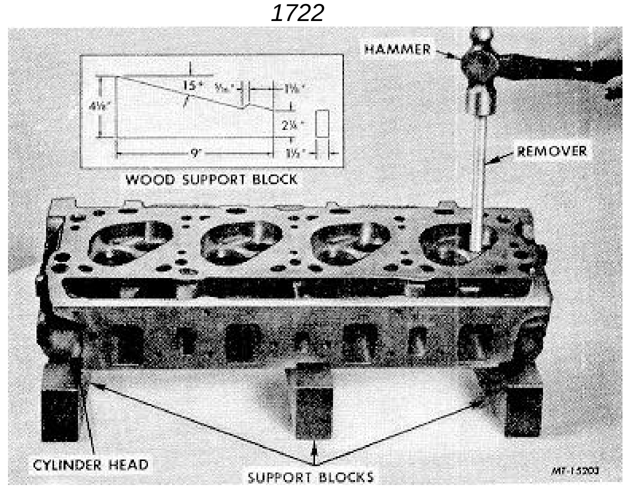


Fig. 95. Removing Intake Valve Guides with SE-1722



Removing Exhaust Valve Guides with SE-1722.

Note
These blocks can be made locally to dimensions as shown.

Turn the cylinder head over with the top side up on the wood support blocks positioned in press. Install the valve guides from the top side of cylinder head using SE1943 valve guide installer, Figs. 97 and 98. The tool is designed to install both valve guides. This can be accomplished by adjusting the installer screw in the body to a length that is equivalent to the specified height the guides are to be installed above the head. Fig. 99 illustrates the method to be used when adjusting the installer for specified guide height. Press the guides in until the installer rests firmly on top of the cylinder head, thus maintaining proper spacing. NOTE: Guides should be lubricated upon installation. Use a mixture of light engine oil and white lead. Clean away any excess lubricants. After guides are installed, insert SE-2211 reamer in the intake and exhaust guides on V-304, V-345 engines and intake guide only on V-392 engine and SE-2213 reamer in exhaust guide on V-392 engine to see that guides have not been distorted during installation and to remove any burrs.

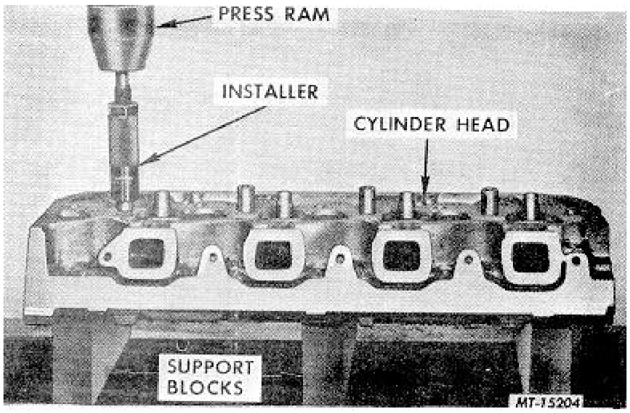


Fig. 97 Installing Intake Guides with SE-1943 Installer

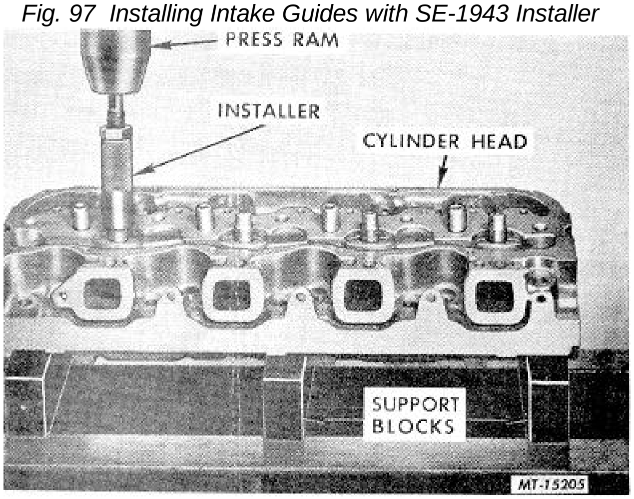


Fig. 98 Installing Exhaust Valve Guides with SE-1943 Installer

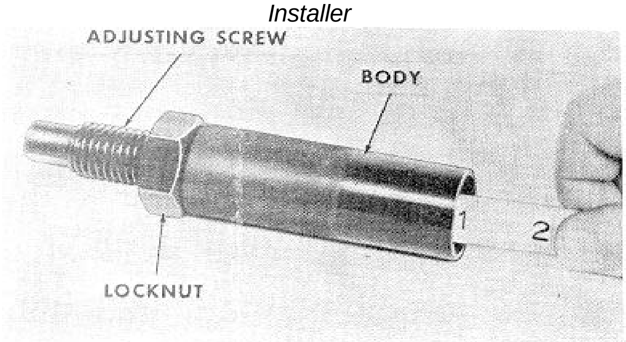


Fig. 99 Adjusting Valve Guide Installer SE1943 for Proper Height

Cylinder head core plugs should not be disturbed unless evidence of leakage exists. Remove and install plugs as inspection warrants. The plugs can be removed by drilling a small hole in the center of the plug and with a suitable pry or screwdriver remove the plug from its bore. To install a new plug, coat the outer edge with a suitable non-hardening sealing compound and with installer SE1945 and driver handle SE1581-1B install plug flush with bottom edge of chamfer in cylinder head, Fig. 100.

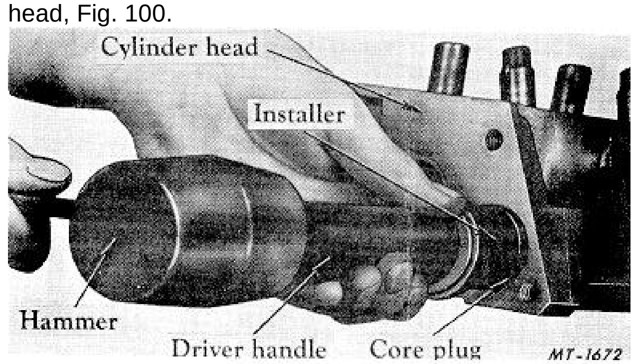


Fig. 100 Installing Cylinder Head Core Plugs Using Installer SE-1945 and Driver Handle SE-1581-1B

Inspect the valve seat inserts for looseness burned or cracked condition. Use SE-1951 exhaust valve insert remover, Fig. 101, to remove defective inserts. Position the remover collet into the insert and turn the coned screw out to expand the collet jaws, thus providing a firm grip under the insert ring. Use a slide hammer to remove the insert. NOTE: V-304A engine does not utilize exhaust valve seat inserts.

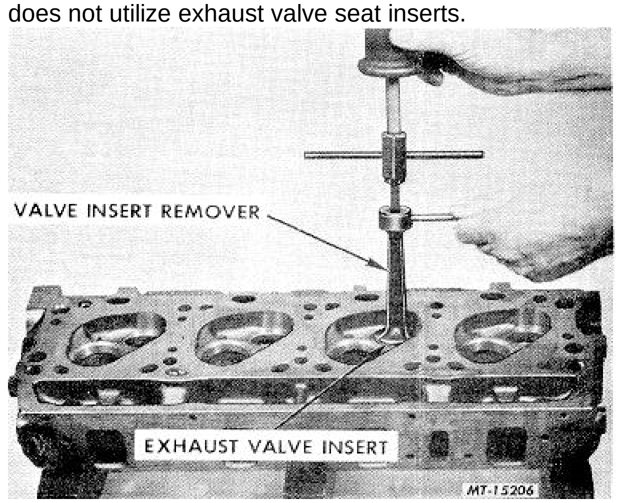


Fig. 101 Pulling Exhaust Valve Insert with SE1951 Remover

Prior to seat reconditioning it is desirable to clean the seats in order to expose any cracks or other conditions likely to promote valve failure. Such inspection is particularly important in engines equipped with hard seat inserts; cracked or loose inserts are not uncommon, and these conditions are usually the result of improper installation. Good practice requires that the insert counterbore in the cylinder head be machined prior to insert installation, Fig. 102. Cutters are available to dress both the bottom and circumferential surfaces, but regardless of the method, the bottom of the counterbore must be square to assure good seating of the insert.

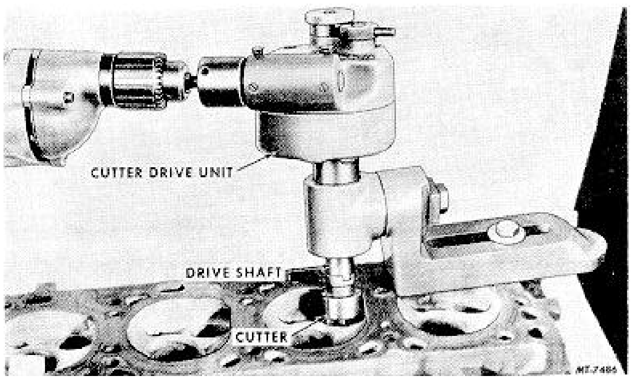


Fig. 102

Before installing inserts they should be thoroughly chilled with dry ice or other means to facilitate their installation in the cylinder head. Use the installer tool, Fig. 103, from the counterbore tool set SE1797. New inserts must also be peened securely in place.

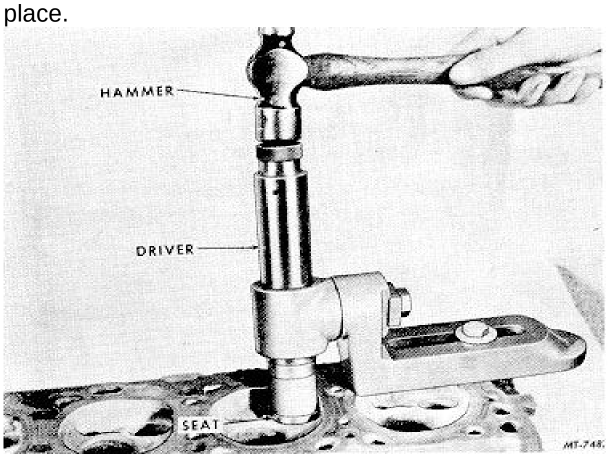


Fig. 103 Using Insert Installer from Counterbore Tool Set SE1797 for Installing Inserts in Cylinder Head

Valve seat inserts supplied for service are standard size, .015" oversize and .030" oversize. For engines using propane fuel or having sodium-cooled valves, special attention to the type of insert material used must be given.

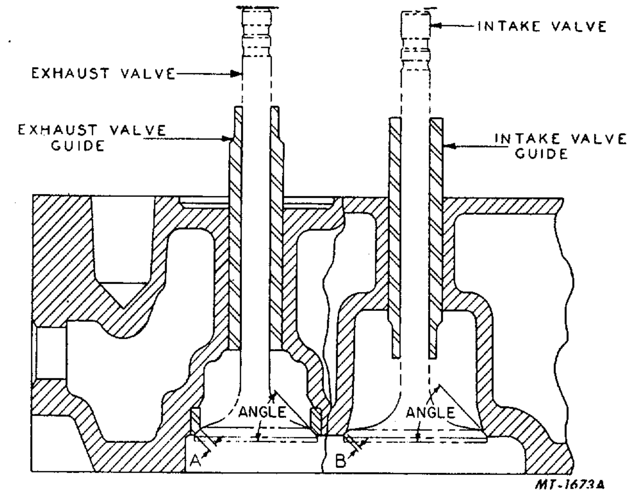


Fig. 104 Sectional View of Valves, V-304, V-345, V-392 Engines

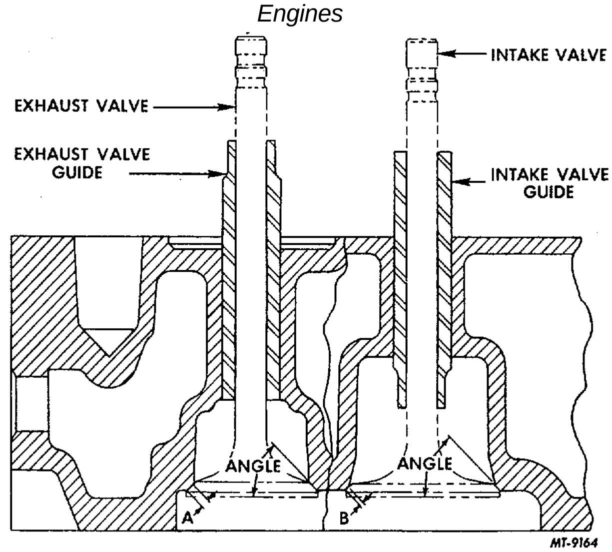


Fig. 105 Sectional View of Valves, V-304A Engine

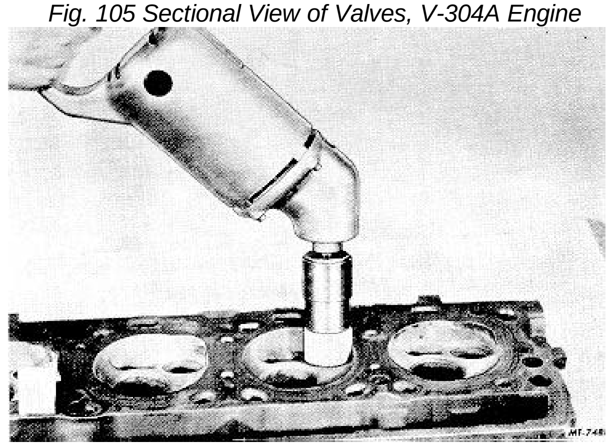


Fig. 106 Grinding Seats Using SE-1631 Grinder

The valve seats "A" and "B" in the cylinder head, Figs. 104 and 105, must also be ground true to the specifications angles and to the width shown in the specifications section. If the seat is wider than specified, it will be necessary to grind from the top and/or bottom of the seat until the proper seat width is obtained using grinder SE-1631, Fig. 106.

Use a 60° angle grinding stone to remove stock from the bottom of the seat (raise seat). Use a 30° angle stone to remove stock from the top of the seat (lower seat).

After the seat grinding operation has been performed, it is necessary to check the seat for runout, Fig. 107. Seat runout should not exceed limits as shown in specifications.

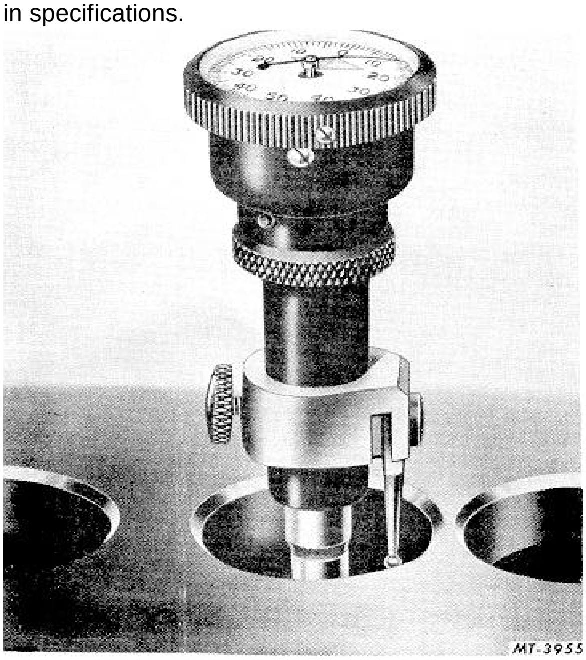


Fig. 107 Using Gauge from SE-1631 Tool Grinder Set for Checking Seat Runout

It is important to have the finished seat face contact the approximate center of the valve face. Position the valves in the cylinder head. Place a thin coat of Prussian Blue on each valve face and tap the valve lightly to its seat. NOTE: This is merely for test and proof of results of refacing and reseating operations. A poor grind job cannot be corrected by lapping. Use of lapping compounds is not recommended. A nearly perfect seat often times is destroyed by attempting to lap the valves to their seats. Inspect each valve for seat dimensions as outlined in specifications and make any necessary corrections. The corrections should always be made on the seat and not the valve face.

NOTE: New valves need not be refaced; however, all valves should be carefully inspected for damaged seat faces or for a "runout" condition due to a bent valve stem. Use SE1800 tool to determine the condition of the valve.

If the ends of the valve stems are grooved or scored, they may be ground to true up; however, remove only a minimum amount of material. Rechamfer as necessary.

Wipe valve faces and valve seats with a cleaning solvent to remove all dirt or foreign material. Coat the valve stems and faces with oil and install the valves in the same seats to which they were checked. On the exhaust valves install the RotoCap assembly, valve spring, valve stem damper, valve stem seal and spring retainer. On the intake valves install the valve spring seat, valve stem seal, valve spring, damper and spring retainer. Compress the valve springs with a valve compressor and install t:ie valve spring retainer locks. Be sure the retainer and locks are correctly seated on all valves.

Inspect the air tubes in the exhaust ports of cylinder head for corrosion or burnt condition. If tubes are burnt, replace using a round file inserted in air tube and with a rotating and push-pull method remove tube as shown in Fig. 108.

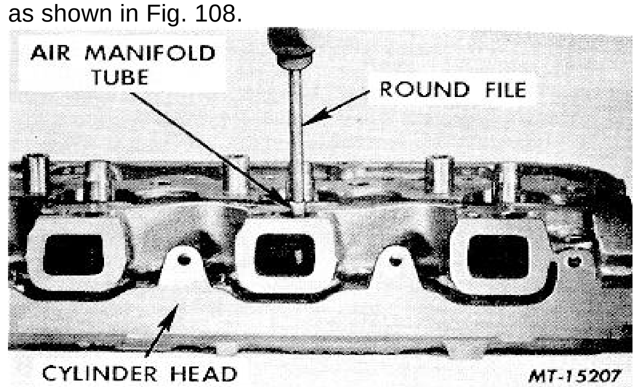


Fig. 108 Removing Air Tubes from Cylinder Head Using Round File

The cylinder head assembly complete with valves is ready for installation on the cylinder block or crankcase.

<u>Rocker Arm Assemblies and Push Rods</u>

The rocker arm assemblies are removed from the engine as a unit. Disassembly and assembly procedures are as follows. Fig. 109 illustrates the complete assembled view of the rocker arm assemblies used in the V-8 engine.

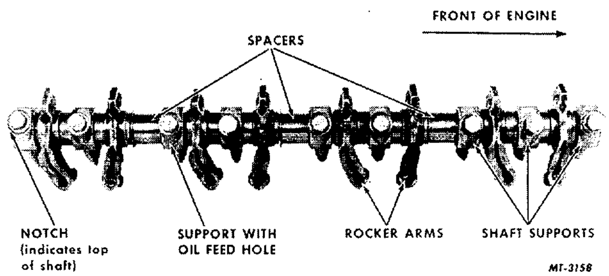


Fig. 109 Installation of Rocker Arm Assemblies on Right Bank (Even Numbers) and Left Bank (Odd Numbers)

1. Lift the rocker arm mounting bolts and flat washers from the supports and remove the supports, rocker arms and spacers. Keep parts in order so they may be replaced in their original position if in satisfactory condition.

2. Remove plugs from end of shaft.

3. Clean all parts thoroughly making sure all oil passages are open.

4. Inspect rocker arm shaft. Check on a surface plate for signs of bending; check for wear from rocker arms. If a shaft is bent or shows excessive wear, it must be replaced.

5. Inspect valve stem contact pad surface of rocker arm and resurface if wear is excessive. Do not remove more than . 010" of material when resurfacing rocker arm pads.

6. Check rocker arm bushings for proper clearance to shaft. See specifications. Replace rocker arm if bushing has excessive wear.

7. To assemble, reverse the disassembly procedure making sure the notches at the end of the rocker arm shaft are facing upward Also make sure the rocker arm shaft support incorporating the oil feed hole is located third from the rear on the right bank (even numbers) and third from the front on the left bank (odd numbers). The rocker arm shaft assemblies are interchangeable from one bank to another. NOTE: Make sure the rocker arms are correctly positioned to actuate the valves. Check all push rods for straightness by rolling on a flat surface. Replace any that are bent or have loose ends.

HYDRAULIC VALVE LIFTERS (TAPPETS)

The hydraulic valve lifter or tappet used in the "V" engine consists of a body (cylinder), plunger, plunger spring and check valve assembly and is removed from the engine as an assembly. The lifters are removed by removing the valve cover, rocker arm and shaft assembly; then lift out the push rods. Use tappet removing tool SE1877 for removing the lifters, Fig. 110. NOTE: If a tappet cannot be removed due to carbon buildup, use a carburetor solvent in the tappet bore. However, if an excessive amount of solvent is used, it will be necessary to change the oil. The lifters are also accessible by removal of the tappet cover, Fig. 35.

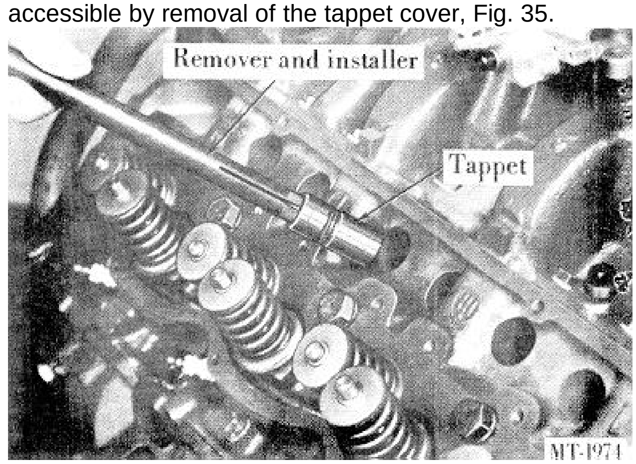


Fig. 110 Removing Tappet Using SE-1877 Remove r

NOTE: Optional sources of hydraulic valve lifters have been established. When disassembling the lifters, do not mix the components of any lifter. Fig. 111 shows the difference in construction between types "A" and "B. " Generally, the service instructions are the same for all types of hydraulic lifters. The push rods are common for all types of lifters.

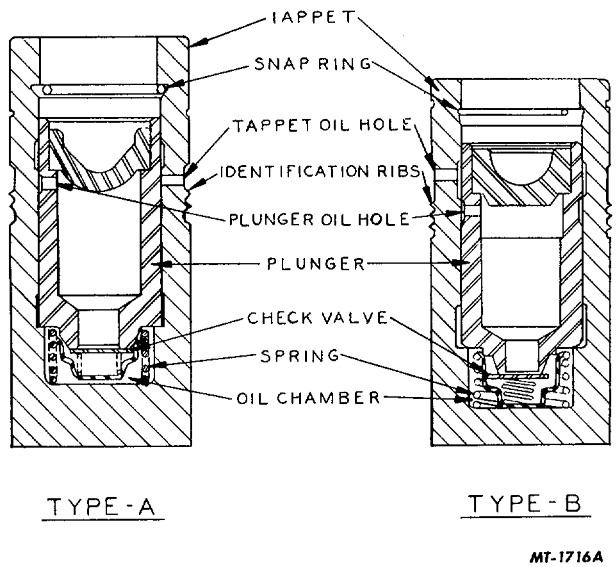


Fig. 111 Sectional View of Hydraulic Tappets Showing Types "A" and "B"

Operation of Valve Lifter

Oil from the engine lubricating system is fed to a supply chamber in the hydraulic lifter plunger from which it can flow directly through the plunger, past the check valve and into the compression space between the bottom of the body and the plunger. When the engine is started, oil pressure is built up in the system which fills the supply chamber. With the lifter on the base circle of the cam and the engine valve seated, the light plunger spring moves the plunger outwardly to remove all lash from the valve gear. As the plunger moves outward, increasing the volume in the compression chamber, the check valve moves off its seat and the chamber is supplied with oil. As the camshaft rotates and lifts the body upward, a pressure is immediately built up in the compression chamber, forcing the valve onto its seat. Further rotation of the camshaft lifting the valve gear against increasing valve spring pressure increases the oil pressure in the compression chamber, thus acting as a solid member of the valve operating mechanism. As long as the engine valve is off its seat, the load of the mechanism is carried by the column of oil. During initial running of the engine there might be some air remaining in the compression chamber which, under pressure, tends to leak i through the clearance between the plunger and cylinder, thus decreasing compression space volume. However, when the lifter is again on the base circle of the cam, the plunger moves outward, drawing in more oil so that after a number of these cycles, the air is completely eliminated and a solid column of oil is maintained in the compression space. During this period when some air is present in the compression space, the valve gear may be somewhat noisy, since, with aerated oil it has the same effect as excessive lash. However, once the unit is completely cleared of air, it then becomes a true hydraulic system.

Compensating for Valve Gear Length Changes

The compensation required to take care of variations in length from the cam to the valve seat is accomplished by the original fit of the plunger in the cylinder bore, and these parts are selectively fitted to give a predetermined slight leakage of oil (called leakdown) under load. The exact purpose of this predetermined leakage is to permit the valve to seat irrespective of the change in length between the cam and valve seat. If the valve gear is expanding, thus reducing the distance between the cam and valve seat, the load imposed by the valve spring on the lifter causes the above mentioned slight leakage between the plunger and cylinder, reducing the clearance volume and, therefore, the overall lifter length. When the valve gear length increases, as caused by lower engine temperatures, the plunger spring keeps all the valve gear parts in contact, increasing the clearance volume under the plunger. At the same time oil is immediately fed past the check valve, thus maintaining correct length under all conditions. This keeps the valve gear operating at no-lash. With this predetermined leakage it is impossible for the no-lash lifter to hold the engine valve open when it should be closed.

When the lifter body is on the base circle of the cam and the engine valve is closed, the only force tending to hold the valve open is from the light plunger spring, which obviously is much lower than the valve spring load. The only additional force tending to push the plunger upward results from pressure of the lubricating oil, but its effect is negligible, since it is controlled and only acts on the small plunger area.

During shutdown periods of the engine one or more valves are always in the lifted position, thus imposing the full valve spring load on the plunger. This causes the oil to leak out of the compression chamber through the clearance space. When the engine is again started, the particular valve that was in the open position returns to its seat and the plunger is immediately forced upward by its spring. Oil from the supply chamber is again fed into the clearance volume under the plunger so that in a very few cycles the valve gear is operating on a solid hydraulic oil column.

When to Service

1. When they are definitely noisy.

A lifter that is not functioning properly may cause a loud clacking, light clicking or intermittent noise.

Loud clacking noise is the result of excessive lash and indicates that:

a. The plunger is stuck below its normal operating position, probably plunger bottomed, and in this case the lifter must be disassembled and cleaned of dirt and varnish.

b. The check valve may not be sealing due to dirt or a damaged seat, which again necessitates cleaning and inspection.

c. Oil may contain sufficient air, which is compressible, to permit collapse or partial plunger movement beyond its normal operating position. Servicing the lifter will not help, and it is necessary to correct the cause of aeration.

Light or clicking type noise indicates that the plunger is operating only slightly below its normal position as the result of:

a. Slight leakage by the check valve or plunger. If the noise is persistent, the lifter must be removed, cleaned and checked.

b. Small amount of air in oil which can only be helped by eliminating the aeration.

NOTE: Slight clicking noises may be caused by engine parts other than lifters (see "CAUTION").

Intermittent noise is the result of:

a. Metal chips or dirt. Occasionally such material becomes lodged between the check valve and seat. Cleaning will correct this condition.

b. Slight plunger sticking caused by dirt or varnish-like substances, which necessitates cleaning and eliminating the source of varnish.

Dirt, chips, varnish, etc. generally cause only a few units to become inoperative at any one time. Aeration caused by high or low oil level, air leaks into the oil pump suction line, etc. result in all lifters becoming noisy. The cause of aeration must be corrected before the lifters will again operate quietly.

Small metal chips lodging between the plunger and cylinder tend to prevent free movement. Since loads during the lift portion of the cycle are relatively high, the plunger is forced downward, and the very light plunger spring has insufficient force to move the plunger back to normal operating position. After a few lift J cycles with metal chips between the plunger and cylinder, the plunger finally reaches a position (usually plunger bottomed) where there is excessive lash in the valve train with resulting noisy operation.

The type of varnish resulting from a mixture of permanent antifreeze and oil is very "tacky" and, particularly when cold, will prevent free movement of the plunger. The resulting action is the same as that caused by a chip in the clearance space. The entire engine must be cleaned and the cause of leakage corrected.

Varnish of the type resulting from fuels and lubricants, unless excessive amounts are created by poor crankcase ventilation or extremely bad lubricants, seldom causes sticking in the lifter. However, if such deposits do form and cause trouble, it is then necessary to correct crankcase ventilation, lubricant or fuel.

2. When engine is overhauled.

Lifters will need to be removed and normal varnish deposits cleaned off whenever a change has been made that will increase the distance from the cam to the valve tip. This change may cause the plunger to be forced into a varnish deposit accumulated above the original travel of the plunger. Since the plunger previously had not been required to operate in this position, the lifter must be removed and cleaned of all varnish deposits so the plunger can move freely.

The following will cause increased valve train length:

a. Grinding valve tips.

b. Valve train parts not put back in their respective locations.

c. Installing new parts.

Even when doing a valve grind job, it may not be necessary to disturb the lifters. However, it may be found occasionally that worn valve tips will need to be ground to give a smooth surface. In this case the length from cam to valve tip would be increased, which necessitates cleaning the lifter as mentioned above.

As a general rule, hydraulic lifters should be left alone when they are functioning satisfactorily and the valve train or gear remains reasonably quiet. The hydraulic lifter is a fairly simple positive action device which will continue to deliver trouble-free service under all normal engine operating conditions. The major cause of hydraulic lifter problems, where any exist, are usually due to grit, dirt or metal chips carried to the lifter with the engine oil.

To minimize lifter contamination, a special box or container should be used to store the lifters when they are first removed from the engine or after they have been cleaned and tested. Keep the lifters in this container until ready for installation in the engine. The container should be numbered to assure return of the lifters to their original location in the engine.

> CAUTION: Even when the lifters are working correctly there are other engine noises which are often "blamed" on lifters but can usually be identified. These may be caused by: valve stem guide clearance, worn timing gears, piston slap, lifter body clearance, worn lifter face or cams, loose main or rod bearings, worn rocker arms, ignition knock, worn valve tips or tight rocker arms on shaft.

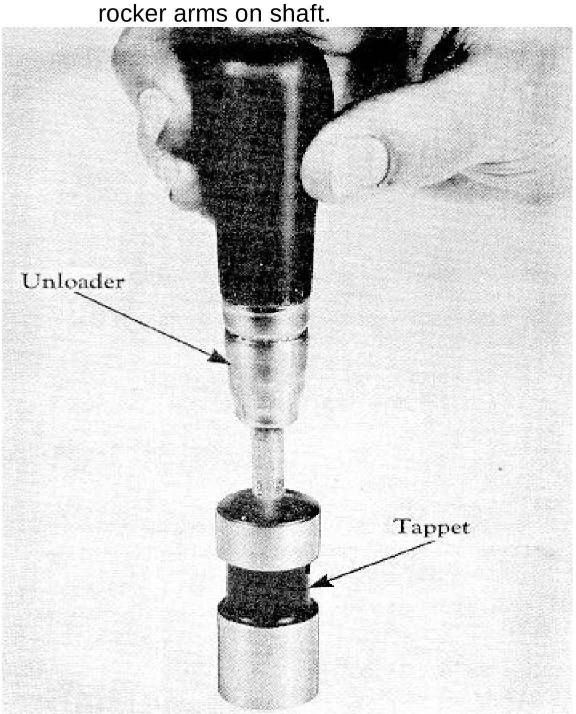


Fig. 112 Using Unloader Tool SE-1890 to Disassemble Tappet

Lifter Disassembly'

Before disassembling lifters it may be necessary to remove a portion of the oil from the lifter body. This can be accomplished by turning the tappet upside down and letting it drain for a few minutes. Then, with the end of a push rod, compress the plunger and remove the snap ring located on the inside top of the assembly. On lifters that incorporate a bleed hole in the socket they can be bled down by using unloader tool SE1890 as shown in Fig. 112. Then, with the unloader tool compress the plunger and remove the snap ring located on the inside top of the assembly.

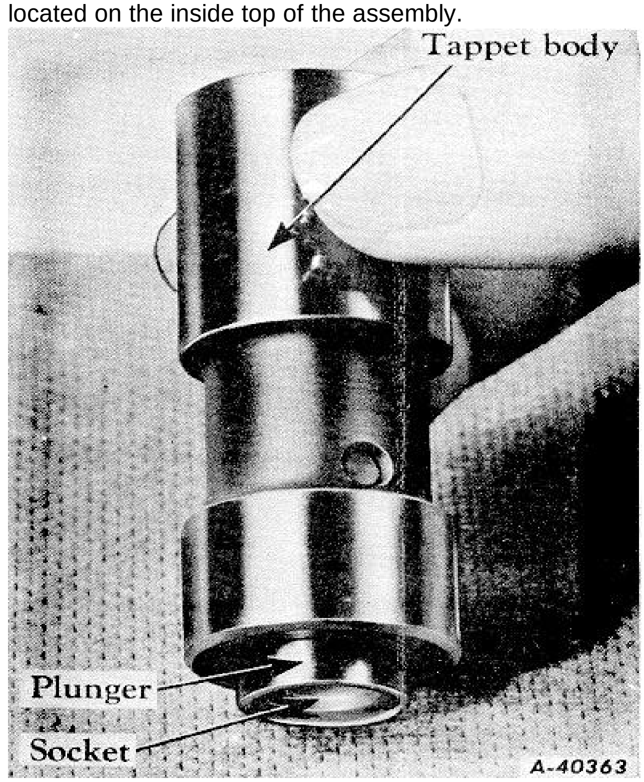


Fig. 113

Caution should be used in order that the snap ring does not "pop out" and be lost. Removal of this snap ring should allow the separate socket to be readily removed. By shaking the assembly gently, the plunger should also come out unless it is held in place by carbon and varnish deposits. If this is the case, some force will be required to remove the plunger from the body. It may be necessary to hold the assembly upside down as shown in Fig. 113 and bump the open end gently against some resilient surface (masonite). Care should be taken so the plunger or body will not be damaged.

After removing the plunger, the check valve assembly may be found to be loose on the plunger. Care should be used so that the small, flat check valve and valve retainer spring are not lost. If the check valve assembly stays attached to the plunger, it would be best to leave it in this position.

<u>Servicing the Lifter</u>

Following is the service procedure to be followed in servicing hydraulic lifters:

1. Immerse the unit in carburetor or other suitable solvent to remove excess engine oil and soften varnish deposits.
2. To avoid mixing plungers and cylinders, take one lifter apart at a time and complete all servicing before working on another. However, if tray (SE-1892), Fig. 114, is available for keeping plungers and cylinders together, all lifters can then be disassembled at the same time.

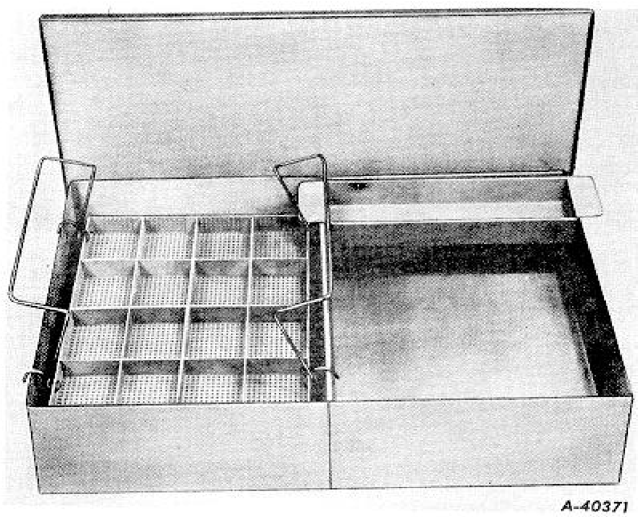


Fig. 114 Hydraulic Lifter Tray SE-189Z

3. Wash all parts in solvent and clean all varnish from the plunger and inside diameter of cylinder.
4. Inspect the plunger and cylinder walls for scratches. Look for nicks on the valve seat and examine the condition of the lifter face. Check for plugged oil holes.
5. Try the plunger for free fit in the cylinder.
6. Reassemble all parts in proper sequence, Fig. 111. NOTE: The valve lifter body is to be filled 1/3 full with clean kerosene before assembly of component parts. Also the parts are to be prelubricatedwith clean kerosene before assembly. Use of kerosene in place of engine oils provides a faster leakdown and rapid expelling of trapped air in the lifter assembly, thus eliminating the possibility of damage to the valve train when installing the push rods and rocker arm shaft assembly. Engine oil will dilute the kerosene in the lifters as soon as the engine is operated for a short period.
7. Check leakdown as follows:

<u>Leakdown Check</u>

After the unit has been washed thoroughly, determine whether the leakage past the plunger and cylinder is correct and whether or not the check valve is functioning satisfactorily. The SE-1893 leakdown tester, Fig. 115, is available for checking the leakdown rate. Instructions which accompany the tester should be followed.

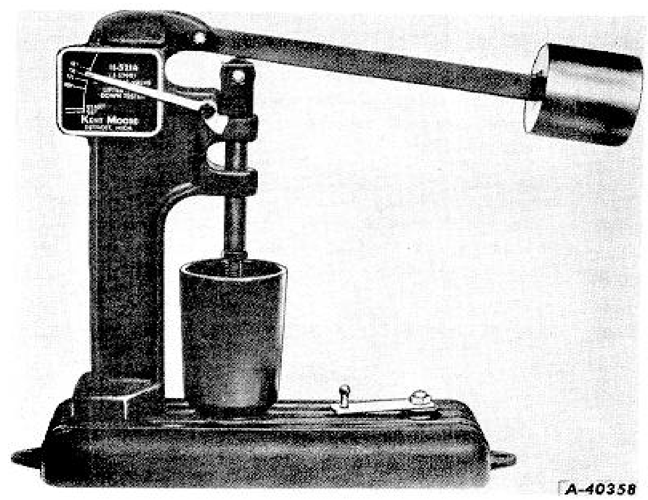


Fig. 115 SE-1893 Tester Used for Checking Leakdown Rate of Tappet

If a leakdown tester is not available, a finger check method can be used. For most purposes this is a satisfactory method. In order to check a unit in this manner, make sure there is no lubricating oil on the cylinder or plunger. Therefore, this check should be made immediately after washing in solvent. With the cylinder held in one hand, start the plunger into the cylinder (do not install the plunger spring) with the other and depress the plunger with your finger and release quickly. The plunger is now operating against air. This air is sealed in by the check valve and by the close fit of the cylinder to the plunger. It should yield slightly to the pressure of the finger on the plunger, but the plunger should kick back upon release of the pressure. If no kick-back of the plunger occurs, the unit may or may not be defective. The lack of kick-back is due to one of three conditions. First, air is escaping past the check valve because of presence of dirt which prevents proper seating of the valve. Second, air is escaping past the check valve because of a damaged seat. Third, air is escaping because the clearance between plunger and cylinder wall is too great, which indicates excessive leakdown rate.

Rewash the unit to eliminate any dirt which might still be on the check valve seat and repeat the test. If there is still no kick-back, then the check valve is damaged and the entire lifter, consisting of cylinder body and plunger, may need to be discarded. NOTE: In the event check valve leakage is encountered due to wear on the surface of the check valve, the valve can be turned over to the new, unused side. This procedure will extend the useful service life of the lifter assembly, provided all other parts of the lifter are in good condition.

In the above test procedure it is important that the pressure on the plunger be released immediately after it is depressed. If the plunger is held down too long, all of the air trapped under the plunger will leak out and the test would mean nothing.

If it is found by the test just mentioned that the unit is satisfactory, the unit is suitable for reinstallation in the engine.

Crankshaft

Wash and clean the crankshaft with cleaning solvent or steam.

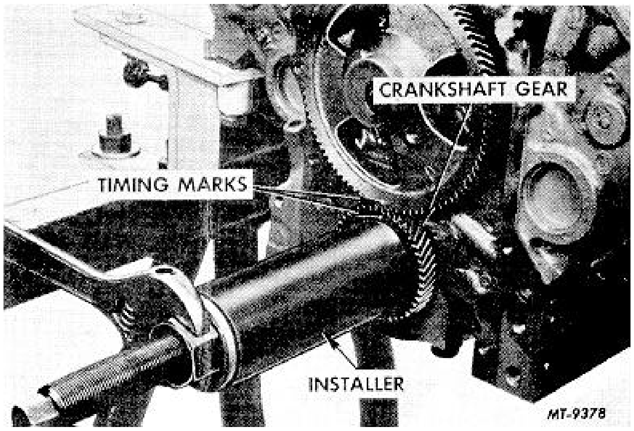


Fig. 116 Use of SE-1900 Crankshaft Gear Installer

Inspect the crankshaft for cracks, scored, grooved or worn main bearing and connecting rod journals. If the journals show wear or out-of-round in excess of .002", the shaft should be reground and undersize bearings installed or the crankshaft replaced. Use micrometers for checking.

Examine the crankshaft timing gear teeth and replace the gears if the teeth are worn or damaged. Fig. 116 shows the use of SE-1900 crankshaft gear installer when making gear replacement. NOTE: Replace the timing gear on the camshaft when replacing the crankshaft gear. These gears are provided in matched sets.

Camshaft

Wash the camshaft in cleaning solvent and remove all sludge or carbon deposits with a soft brush.

Inspect the camshaft journals for signs of wear or out of round and replace if wear warrants. See "CLEANING, INSPECTION AND RECONDITIONING Cylinder Block. "

Check the distributor drive gear on the camshaft. If the teeth are worn or damaged, the camshaft must be replaced, as the gear is integral with the shaft.

Inspect the camshaft lobes. If worn, chipped or scored, replace the camshaft.

Check the camshaft gear and replace if wear warrants or the gear teeth are nicked or otherwise damaged. When making camshaft replacement, torque the mounting bolt to the specified torque as shown in "TORQUE CHART." NOTE: The timing gears are matched and furnished in sets. These gears should be replaced in sets.

Inspect the fuel pump cam on the front of the camshaft. If worn, chipped or scored, replace the cam.

Crankshaft Bearings

The bearing inserts used in this engine are selective fit and require no line reaming on installation. The bearings are available for service in standard and undersizes for use on journals that have been reground.

If inspection reveals badly worn or scored bearings, replace the bearings. The installation of new bearings must be closely checked to maintain the proper clearance between the journals and bearing surface. A convenient and accurate method for checking the clearance is with the use of Plastigage.

Fitting Bearings

Undersize precision-type bearing shells should be installed when, because of wear, bearing-to-crankshaft running clearances are to be reduced.

Premature bearing failure will result from attempts to reduce journal-to-bearing running clearances by reworking of bearing caps, bearings, or both, because such reworking will alter the engineered fit of the bearing shells in their bores and destroy the specifically desired "crush. "

When installing precision-type connecting rod or main bearings, it is important that the bearing shells fit tightly in the rod or case bore. To accomplish this, the bearing manufacturer makes the diameter at right angles to the parting line slightly larger than the actual diameter of the bore into which they are assembled. When the assembly is drawn up tight, the bearing is compressed, assuring a positive contact between the bearing back and the bore. This increased diameter is referred to as bearing "crush, " Fig. 117.

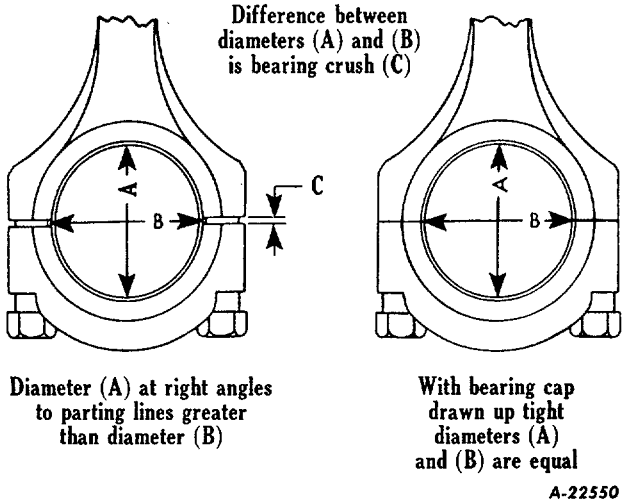


Fig. 117 Illustrating Bearing Crush

To obtain proper bearing assembly with the correct "crush," care must be taken when tightening the clamping bolts to make sure they are drawn down alternately and evenly using a tension wrench and tightening as specified.

<u>Rod caps or blocks must not be filed, lapped or reworked in any other manner in order to reduce clearance</u>. While such practice will make a tighter fit at top and bottom, it will result in an outofround bore and bearing shell distortion.

Main and connecting rod bearings are designed with the "spread" (width across the open J ends) slightly larger than the diameter of the crankcase bore or connecting rod bore into which they are assembled. For example, the width across the rod bearing not in place is approximately . 025" more than when the bearing is in position. This condition is originally designed into the bearing to cause it to tend to spread outward at the parting line when "crush" load is applied by tightening bolts. Some of this "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition.

This condition causes the bearing to fit snugly in the rod bore, and the bearing must be "snapped" or lightly forced into its seat, Fig. 118.

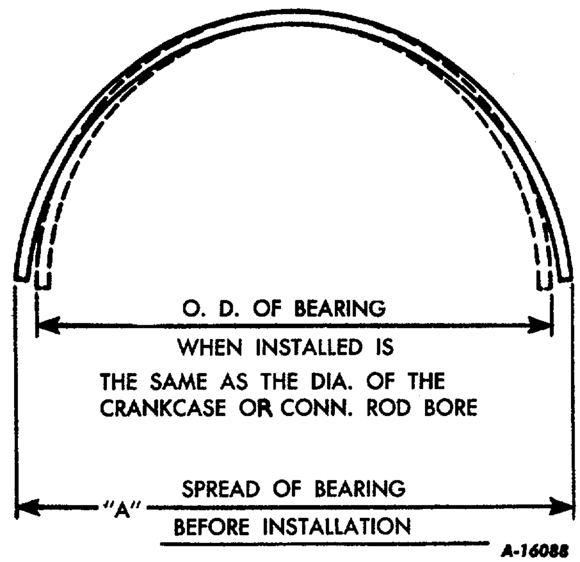


Fig. 118 Illustrating Bearing Spread

BEARING SPREAD DIMENSION

(Minimum)

Bearing O. D. (Installed)	Specified Spread	Spread of Bearing "A" Fig. 118
Connecting Rod Bearings:		
2.500	.030	2.530
Main Bearings:		
Nos. 1, 2, 4, 5		
2.942	.030	2.972
No. 3 (Thrust)		
2.942	.002-.012	2.944-2.954

Rough handling in shipment, storage and normal handling may cause bearing spread to be increased or decreased from the specified width. Bearing spread can be safety adjusted as follows, although care and judgment should be exercised in the process.

1. Excessive Spread. If measurement of spread indicates that distance "A" is excessive (see chart for specifications), place the bearing on a wood block and strike the side lightly and squarely with a soft mallet, Fig. 119. Recheck measurement and, if necessary, continue until correct width (measurement "A" in chart) is obtained.

2. Insufficient Spread. If measurement of spread indicates insufficient spread, place the bearing on a wood block and strike the back of the bearing lightly and squarely with a soft mallet, Fig. 119. Recheck measurement and, if necessary, continue until correct width (measurement "A" in chart) is obtained.

Main Bearings, Fitting

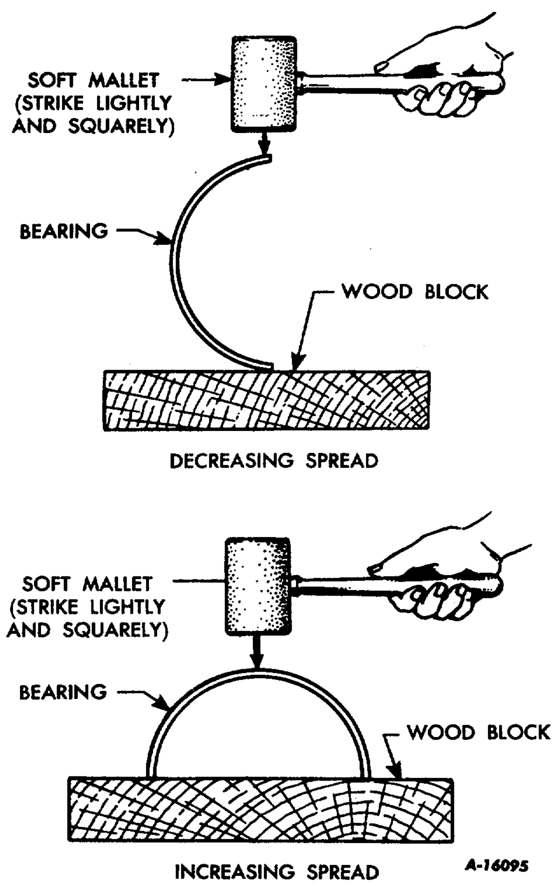


Fig. 119

To obtain an accurate reading using the Plastigage method of checking, all bearing caps must be in place and torqued to specifications.

1. Remove one bearing cap and bearing insert. Remaining caps are left tight while checking the fit of this bearing.

2. Wipe the oil from all contact surfaces such as crankshaft journal, bearing insert, bearing caps, etc.

3. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately 1/4" off center. Install bearing cap and tighten cap bolt to recommended torque.

NOTE

Do not turn crankshaft while making check with Plastigage.

4. Remove bearing cap and insert.

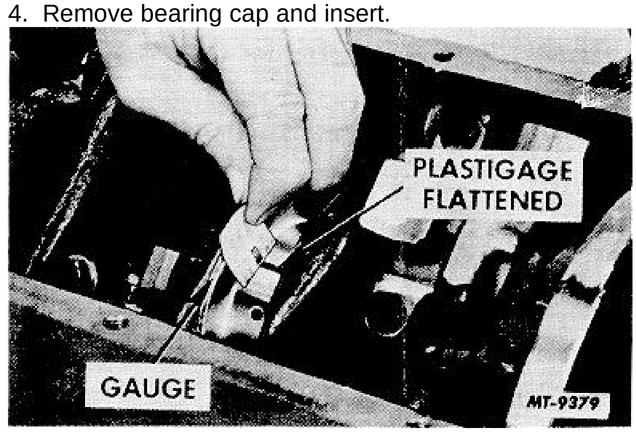


Fig. 120 Checking Main Bearing Clearances

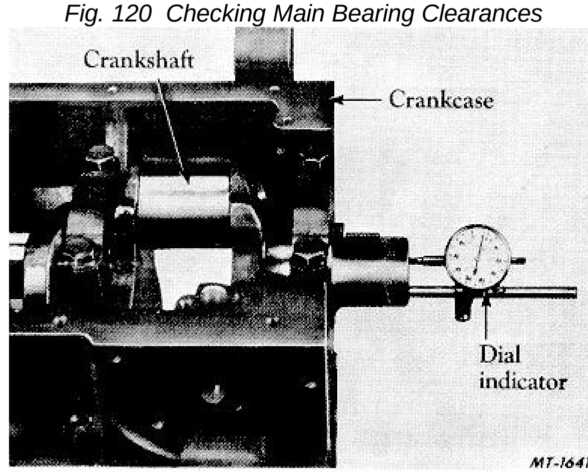


Fig. 121 Checking Crankshaft End Play

5. Do not disturb Plastigage. Using the Plastigage envelope, measure the widest point of the Plastigage, Fig. 120. This reading indicates the bearing clearance in thousandths of an inch.

6. If the bearing clearance is not within specifications, the crankshaft must be reground and undersize bearings installed. The third crankshaft bearing controls the crankshaft thrust and provides initial location of the crankshaft in relation to the crankcase. Use dial indicator, Fig. 121, to check end play.

Connecting Rod Bearings, Fitting

1. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.

2. Place a piece of Plastigage on the bearing surface the full width of the bearing about 1/4" off center.

3. Install cap and tighten to recommended torque.

NOTE

Do not turn crankshaft while Plastigage is in place

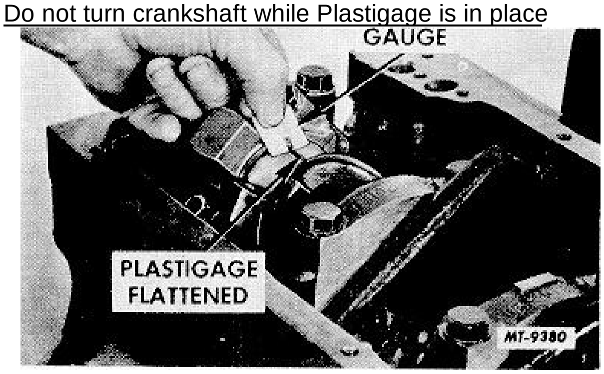


Fig. 122 Checking Connecting Rod Bearing Clearance

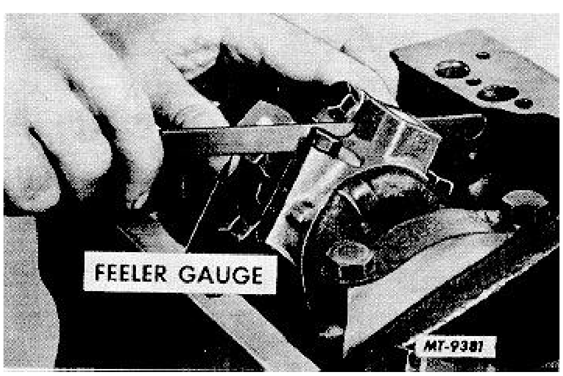


Figure 123 Checking Connecting Rod End Clearance

4. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage Fig. 122. This reading indicates the bearing clearance in thousandths of an inch.

5. Check the connecting rod end clearance using a feeler gauge as shown in Fig. 123. Excessive clearance may require replacement of rods or shaft. The check should be made to make certain that the specified running clearance exists. Lack of clearance could indicate a damaged rod or perhaps a rod bearing out of position.

Oil Pump Assembly

The oil pump, Fig. 124, consists of two gears and a pressure relief valve enclosed in a two-piece housing and driven from the distributor drive, which in turn is driven by a helical gear on the camshaft.

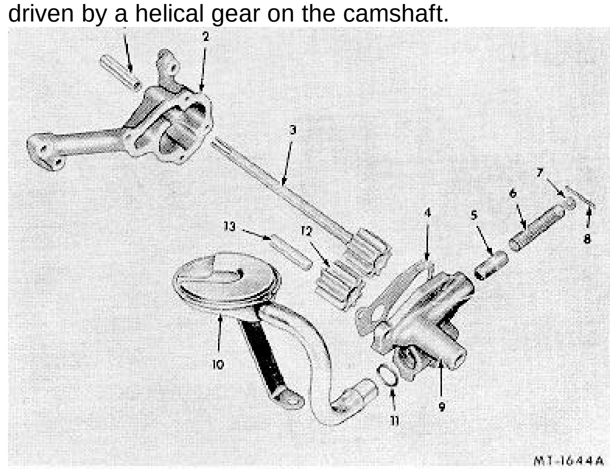


Fig. 124 Oil Pump, Exploded View

Legend for Fig. 124

Key	Description
1	SLEEVE, Oil Pump Shaft
2	BODY, Oil Pump
3	SHAFT, Oil Pump Drive, Assembly
4	GASKET
5	VALVE, Relief
6	SPRING, Relief Valve
7	WASHER
8	PIN, Cotter
9	COVER, Oil Pump
10	SCREEN, Assembly
11	SEAL, O-Ring
12	GEAR, Idler
13	SHAFT, Idler Gear

The cover is equipped with a regulator valve that limits oil pressure to approximately 43-51 psi.

The pump intake is through a screen assembly attached to the pump cover. A mesh screen filters out particles of dirt which may be present.

A thorough cleaning and inspection of the oil pump should be made whenever the oil pan is removed from the engine. The recommended inspection and repair procedures are as follows:

1. Wash all pump parts and screen assembly in cleaning solvent.

2. With pump cover removed and gears and shaft in place, exert pressure against the gears with the thumb so as to push the gears away from the outlet side of pump.

3. While holding the gears in this manner, measure the clearance between outside diameter of gear and bore of housing, Fig. 125. Clearance should be within the limits given in specifications.

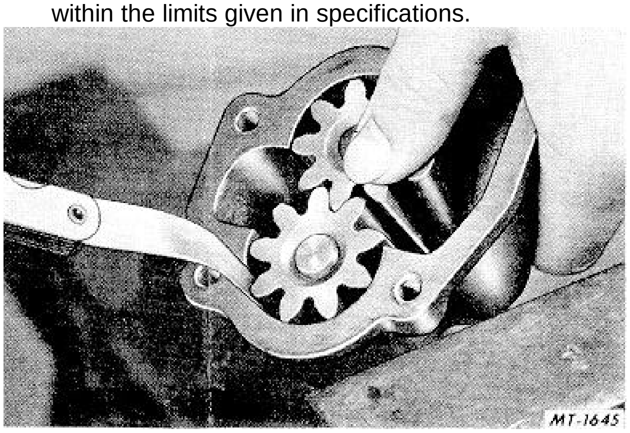


Fig. 125 Measure Pump Gear-to-Body Clearance

4. If clearance is less, obtain new parts.

5. Check the pump shaft clearance in bore. To correct for wear beyond limits given in specifications, replace pump assembly.

NOTE

It will be necessary to remove the pump shaft sleeve and discard, as new sleeve must be installed.

6. Check backlash between pump body gears. If this exceeds figure shown in specifications, replace gears.

7. Establish body gear end clearance.

NOTE

The oil pump cover gaskets control the clearance (end play) between the pump body gears and the pump cover. Add or remove gaskets to obtain desired clearance. (See specifications.)

8. When installing pump gears and shaft, these parts should be oiled liberally with engine oil for initial lubrication.

9. Before installing relief valve in pump cover be sure valve is free of burrs and valve bore is free of varnish so valve operates smoothly in its bore.

NOTE

If it becomes necessary to remove burrs from valve, make sure valve edges are not rounded.

Also check relief valve spring for prop/er tension. See specifications.

10. Install the oil pump shaft sleeve on the shaft to dimension shown in Fig. 126. Then crimp sleeve securely in place as shown in Fig. 126.

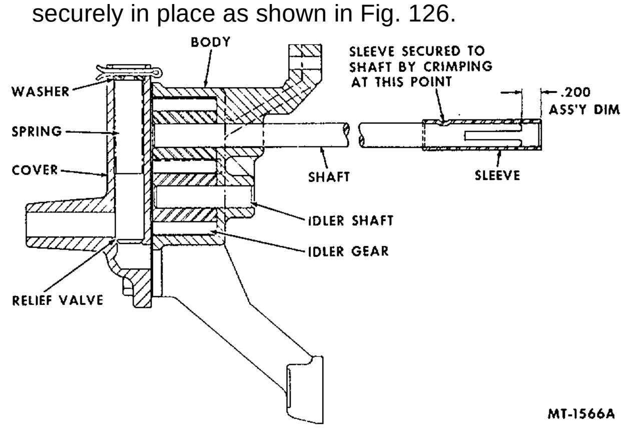


Fig. 126 Oil Pump Shaft Sleeve Installation

11. When assembling the screen assembly to the pump cover, make sure O-ring seal is in place in bore of pump cover, Fig. 127. Also retain screen assembly to pump cover

Manifolds

The intake manifold is cast in one piece and supplies both cylinder banks. Each bank has a separate exhaust manifold which is joined at the lower front of the engine with a crossover pipe.

The manifolds should be cleaned and examined for cracks or leaks. Place the exhaust manifolds on surface plates and check for warpage. If the exhaust manifolds are warped, true up on a surface grinder but replace if warpage is extreme. Warpage of the intake manifold will require replacement as any attempt to resurface the intake manifold will create misalignment of the ports to the cylinder heads.

Oil Pan

The pan should be thoroughly cleaned in cleaning solvent to remove any foreign material from around the baffle plate, which is spot welded in place. Inspect oil pan for cracks or deformation and straighten or weld.

Remove all the gasket material from the oil pan flange.

Check the oil pan drain plug and drain plug boss for fit and thread wear. If the plug is loose or the threads are damaged, repair the threads or replace the oil pan.

Flywheel and Ring Gear

Clean the flywheel and ring gear with a cleaning solvent, removing all traces of oil and grease. Inspect the flywheel ring gear. If any teeth are damaged or if the ring gear is loose on the flywheel, the ring gear must be replaced. Check the flywheel mounting bolt holes for wear; also check mounting face of flywheel for indications of looseness.

To replace the flywheel ring gear, heat the gear with a torch and remove it from the flywheel with a hammer and drift. Heat the new ring gear with a torch, heating evenly all the way around. While the ring gear is hot, install the gear on the flywheel and allow it to cool.

Water Pump

The water pump assembly is composed of a body and housing which accommodates a shaft and bearing assembly, slinger, seal and impeller. The shaft and bearing assembly is held in place in the housing by a retaining snap ring. The pulley hub is pressed onto the shaft (press fit . 001" to .0025") to dimension shown in Fig. 128.

The impeller seal assembly consists of a seal spring, seal clamp ring, flexible seal, seal spring guide and a carbon seal washer which operates against a ceramic seat.

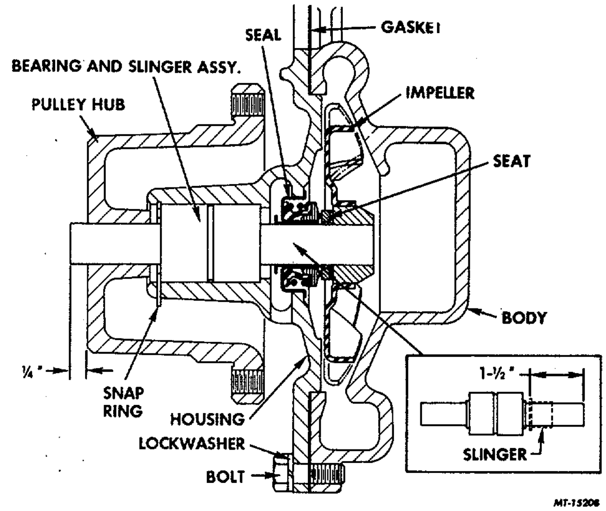


Fig. 128 Sectional View of Water Pump Assembly.

To disassemble the water pump, follow the steps outlined below.

1. Using puller SE-1336-18 remove pulley hub from shaft, Fig. 129.

Note

Make adapter and sleeve locally from dimension shown in fig. 129.

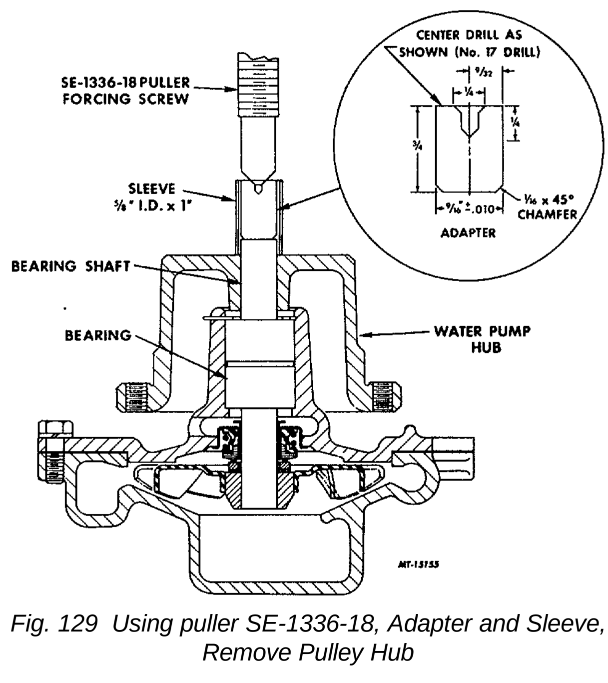


Fig. 129 Using puller SE-1336-18, Adapter and Sleeve, Remove Pulley Hub

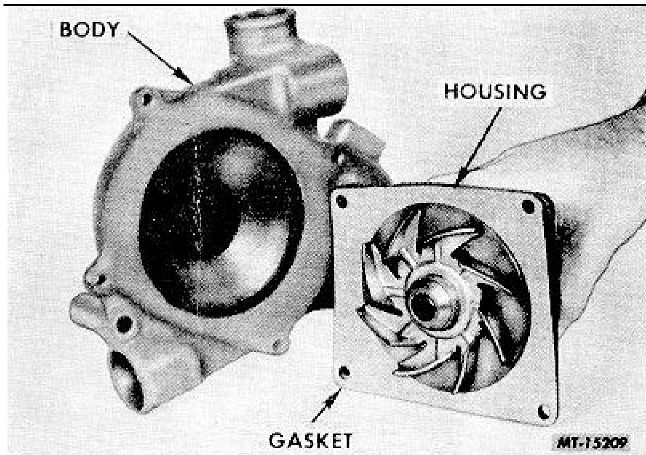


Fig. 130 Separating Pump Housing from Pump

2. Remove the pump housing-to-body bolts and lockwashers and separate the housing from body, Fig. 130. Discard gasket.

3. Remove snap ring from in front of water pump shaft bearing, Fig. 131.

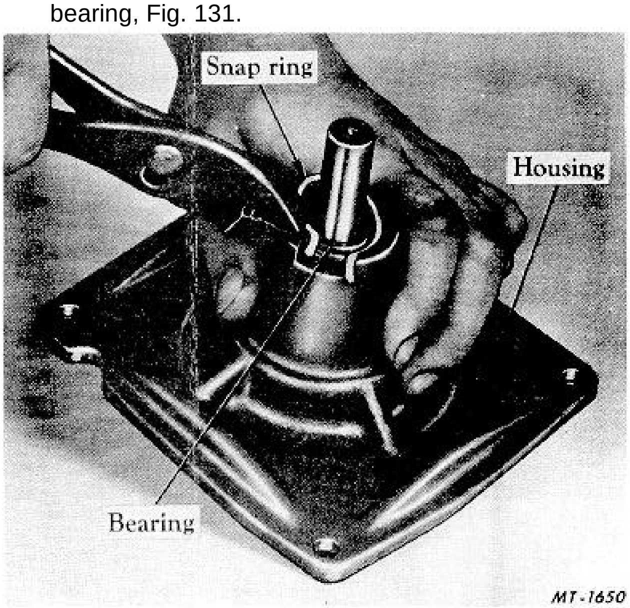


Fig. 131 Removing Snap Ring in Front of Water Pump Shaft Bearing

4. Support water pump housing on an arbor press and push shaft and bearing out of housing and impeller, Fig. 132.

NOTE

Do not attempt to remove bearing from shaft, as this is factory installed in the proper location.

5. In the event the slinger is damaged upon removal of the bearing assembly, it will be necessary to install a new slinger on the bearing shaft to a 1-1/2" dimension from rear end of shaft as shown in Fig. 128.

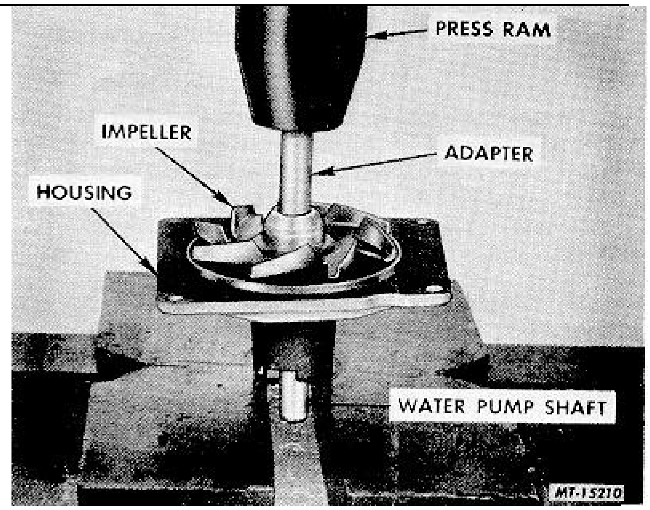


Fig. 132 Pump Shaft and Bearing Removal

6. Remove seal from housing through back side of water pump. Use a drift and drive the seal from pump housing.

7. To determine worn or damaged parts to be replaced, and when rebuilding the pump, check as follows:

a. Clean all parts (except rubber parts) in solvent.

b. Inspect pump shaft and bearing assembly for wear and replace if necessary.

c. Always use a new seal when rebuilding the pump, since the seal has been damaged on removal.

To reassemble the pump, proceed as follows:

1. Place the new water pump seal assembly on installing tool SE1721. Place pump housing in press and, after aligning seal and installing tool, press seal into housing, Fig. 133.

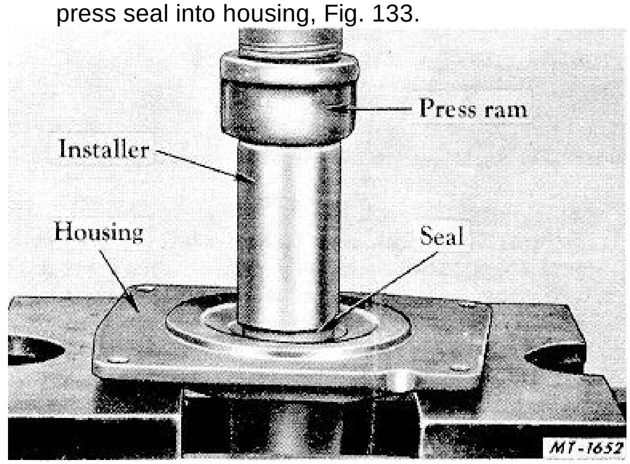


Fig. 133 Using SE-1721 Installing Tool for Water Pump Seal Assembly

2. Position the pump shaft and bearing assembly into the housing and install the bearing s nap ring.

3. Position the pulley hub on the end of shaft with the SE1950-2 installer placed o'er the pulley hub bore. Press hub on shaft until installer bottoms on end of shaft. This will properly position pulley hub on shaft, Fig. 134.

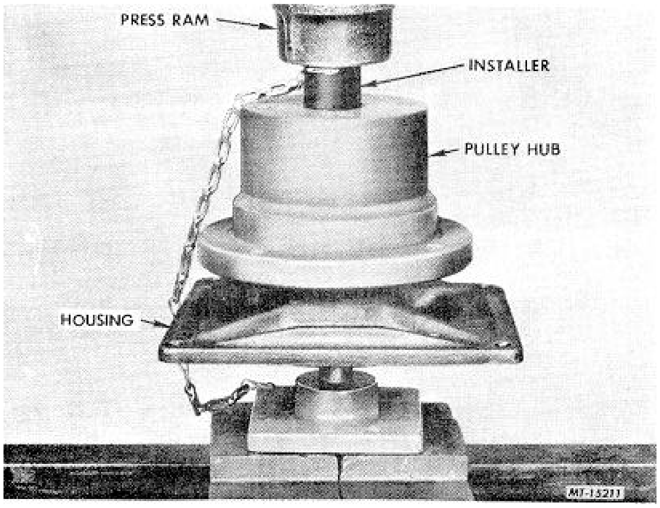


Fig. 134 Installing Pulley Hub on Shaft Using SE- 1950 Installer and Support Fixture

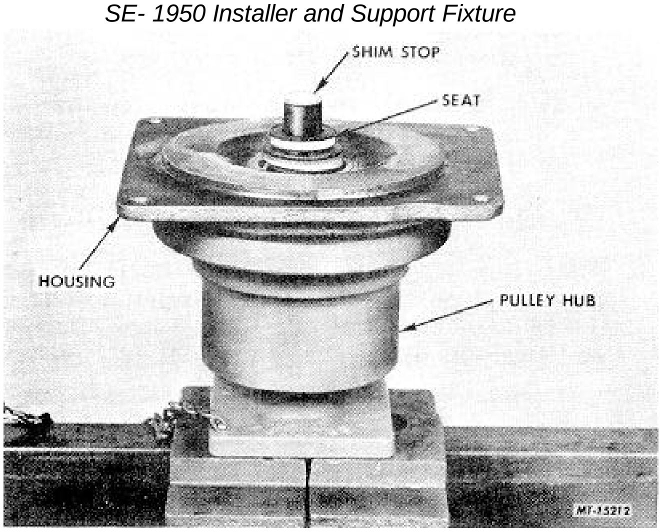


Fig. 135

4. Support bearing shaft (hub end) on press bed and then lubricate seat with engine oil and position seat onto end of bearing shaft, Fig. 135. Select the .060" shim stop from SE2086 shim set and place on impeller end of shaft, Fig. 135. The purpose of the shim stop is to limit the travel of the pump shaft in the impeller so that interference will exist between the impeller and body. The amount of this interference will be measured in item 7. The final specified running clearance is obtained in operation 10.

5. Place impeller over shim on shaft and press impeller on shaft until press ram bottoms on the shim, Fig. 136. Remove shim stop.

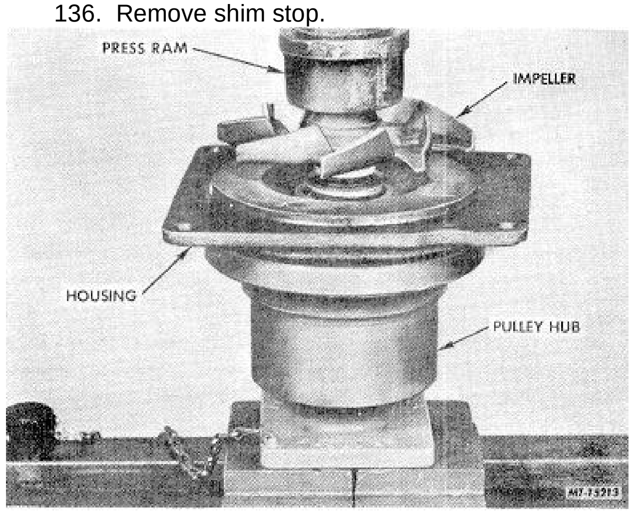


Fig. 136 Pressing Impeller on Shaft Using SE- 1950 Combination Installer and Support Fixture

6. Place pump assembly in position in the pump body and install four mounting screws finger tight, Fig. 137.

7. Use feeler gauge to check the clearance between the housing flange and pump body, Fig. 137.

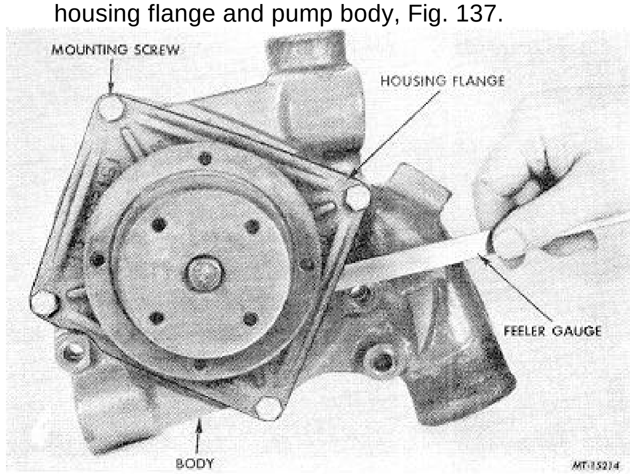


Fig. 137

8. Record this clearance and add the specified running clearance of .015".

9. The total of the two above figures should be subtracted from the original .060" shim thickness, item 4, and recorded.

10. Select the shims to provide the thickness of the above recorded figure from the SE-2086 shim set and place on the end of the shaft. Then press impeller further onto the shaft until the ram bottoms on the shim stop. This will provide the proper running clearance of .015".

NOTE

If no clearance exists between housing flange and pump body and pump impeller turns free, check total impeller running clearance as follows:

a. Position suitable amount of moulding clay on two impeller vanes, Fig. 138.

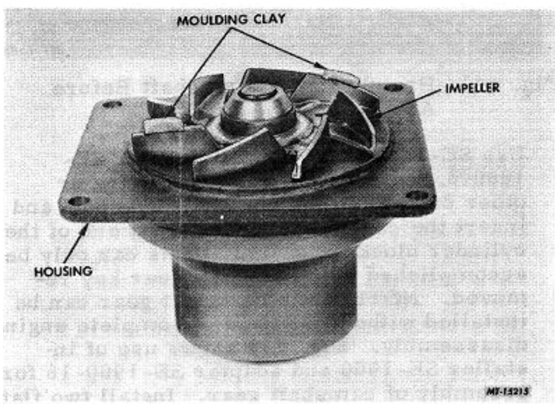


Fig. 138

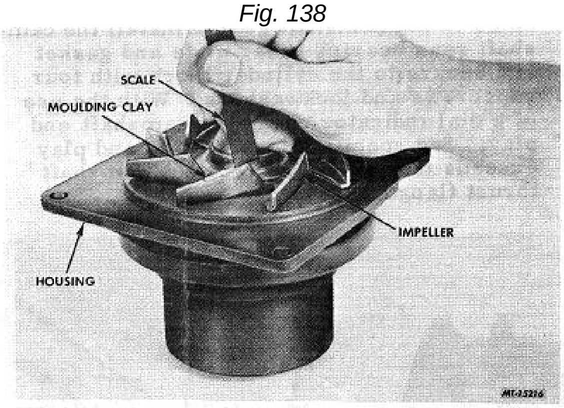


Fig. 139

b. Install pump assembly into pump body and tighten mounting screws to 40-45 ft. lbs. NOTE: Be careful not to rotate impeller or hub during check.

c. Remove pump assembly and check thickness of moulding clay, Fig. 139. If clearance exceeds the .015" dimension, the fan hub and snap ring will have to be removed and a new impeller relocated on the shaft by repeating the foregoing steps 2 through 10. NOTE: When removing a steel impeller, it will be damaged upon removal, thereby requiring a new impeller.

11. Using new gasket, install pump housing to pump body with four capscrews and lockwashers.

ACCESSORY DRIVE BELTS

Conventional "V" belts are utilized to drive the various accessories. Two belts driven from the crankshaft pulley drive the water pump, fan and alternator. Another belt, driven from the water pump pulley, drives the air or freon compressor. The power steering and air pumps are driven by a belt driven from the water pump pulley. Engines having dual belts driving the water pump and alternator should have the belts replaced in matched pairs.

Alternator belt tension can be accomplished with the use of SE-2312 gauge, Fig. 140. Check tension at mid-point between the pulleys. Apply gauge to the longest belt span. Instructions for checking are as follows:

1. Grasp gauge and depress ball handle all the way down. Make certain hook extends beyond legs to pick up the belt.
2. Apply gauge to belt, Fig. 140. Be sure belt is positioned between nose piece and hook and that the nose piece is centered on the belt.

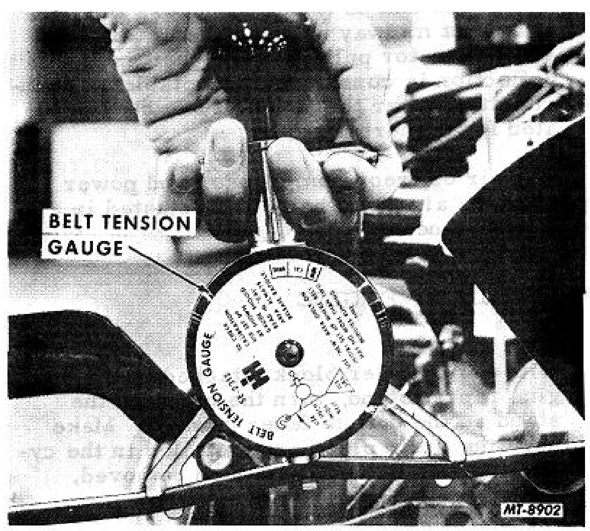


Fig. 140 Adjusting Alternator Belts Using SE-2312 Gauge

3. Release ball handle quickly. A slow release may prevent full return of the hook, thus giving a false reading.

4. Observe the area on the gauge face indicated at the index mark. If the index mark does not indicate a "NEW" reading on a new belt or a "USED" reading on a used belt, it will be necessary to increase or decrease belt tension as required.

5. Before changing belt tension, repeat step 3 several times to become familiar with gauge operation. Observe gauge reading each time the operation is repeated. NOTE: Check tension of both belts if dual belts are used.

To establish tension of a loose belt, apply SE-2312 gauge to belt and make the adjustment. Tighten belt until proper area for the belt is indicated at the index mark on gauge. Lock adjustment and recheck belt tension. Readjust as necessary.

When using the SE-2312 belt tension gauge remember to set new belts (belt with less than two minutes' running time) to the "NEW" area on the gauge face and used belts (belt with two minutes' or more running time) to the "USED" area on gauge.

NOTE
Where the SE-2312 belt tension gauge is not available or cannot be utilized because of interference from fan shrouds, accessories or close clearances, a deflection check can be made. Depress the belt at a point midway between the water pump and alternator pulleys. One-half inch (1/2") deflection is considered acceptable as a final setting after the new belt has been operated for a short period.

The air or freon compressor and power steering or air pump belts are adjusted in a similar manner.

ASSEMBLY OF ENGINE

1. With the cylinder block attached to the engine repair stand, turn the block on the stand so the bottom faces upward. Make sure the drain plugs are installed in the cylinder block if they have been removed.

2. Coat the camshaft lobes, bearing surfaces, gears and bores with heavy-duty hypoid axle lubricant, Fig. 141.

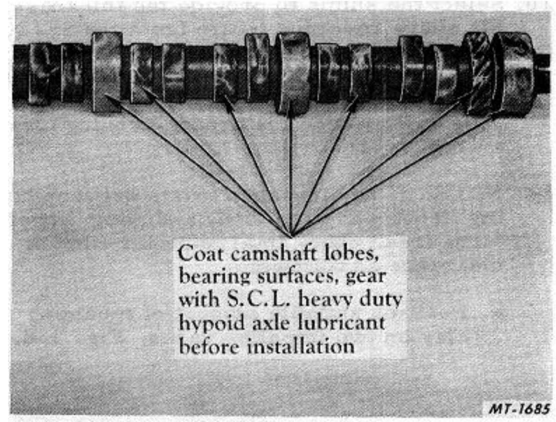


Fig. 141 Prelubricating Camshaft Before Assembly

Use SE1880 installer and adapter SE1880-2, which helps prevent nicking or other damage to the camshaft bearing, and insert the camshaft into the front end of the cylinder block, Fig. 142. This can only be accomplished with camshaft gear key removed. NOTE: The camshaft gear can be installed without the need of complete engine disassembly. Fig. 143 shows use of installer SE1900 and adapter SE-1900-16 for assembly of camshaft gear. Install two flat head screws and shakeproof washers in camshaft thrust flange, working through the holes in the camshaft gear. Install the camshaft rear bearing cover plate and gasket and secure to the cylinder block with four capscrews and lockwashers. With the use of a dial indicator check the camshaft end play. See specifications. If the end play exceeds the limits, replace the camshaft thrust flange.

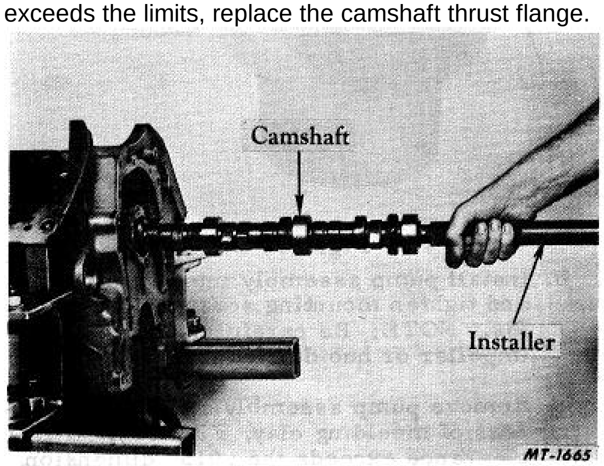


Fig. 142 Use of SE-1880 Camshaft Installer and Adapter SE-1880-2

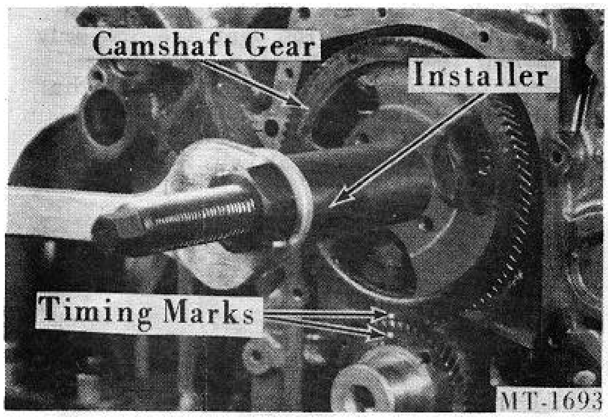


Fig. 143 Installation of Camshaft Gear Using SE-1900 Installer

3. Wipe the backs of the cylinder block half of bearings, making sure that dirt is removed. Then lubricate the block half of bearings on both sides with a light film of engine oil. Place the bearing shell halves in position in the bore of the cylinder block, making sure the bearing shells are fully seated, that the oil holes in the bearing shells line up with the oil holes in the cylinder block, and that the locking tangs on the bearing fit into the recesses. Follow the same procedure and place the bearing shell halves in the bearing caps. Place a film of engine oil on both sides of the shell surfaces and lift the crankshaft to align itself in the bearings and, at the same time, aligning the timing marks on both the camshaft and crankshaft gears, Fig. 144. Fig. 144 Aligning Timing Marks on Camshaft and Crankshaft Gears

4. Place the bearing caps and bearing lower halves over the crankshaft journals. Be sure the bearing caps are properly installed with the number toward the left side of the crankcase; at the same time use new self-locking bolts and flat washers for installing the bearing caps. Tighten the bearing caps (not to specified torque). Using a soft hammer tap the bearing cap until both machined faces of the cap are flush with the machined faces of the crankcase. Alignment of these two faces will assure proper cap location. Check this alignment at both sides (left and right) of the bearing cap. Torque the bolts to the specified torque using a tension wrench. See "TORQUE CHART." Apply the same procedure to remaining bearing caps. Recheck crankshaft end play as outlined under "Main Bearings, Fitting. "

5. Install rear main bearing cap side oil seals. Use an installer tool made from a piece of 1/8" welding rod. To make the tool, puddle a ball on the end of the rod and file the ball to approximately 5/32" diameter. See Fig. 145. NOTE: If excess material protrudes above the crankcase after the seal is installed, cut the excess material off flush with the bottom of the rear main bearing cap-to-crankcase mating surfaces.

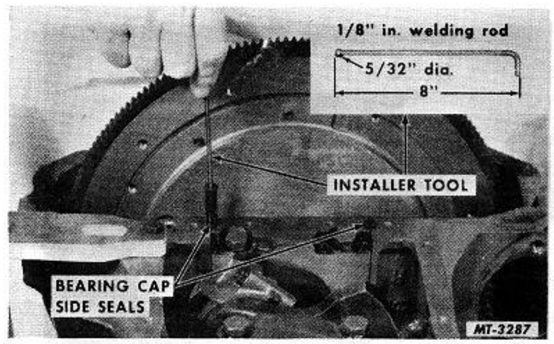


Fig. 145 Installing Rear Main Bearing Cap Side Oil Seals. Insert Shows Details of Installer Tool Which Can Be Made Locally.

6. Install crankshaft rear oil seal using SE-1942 installer as follows:

   a. Position rear oil seal on SE-1942-2 pilot from the pin side as shown in Fig. 146.
   b. Insert pilot into the SE-1942-1 installer and secure pilot with cotter pin through outer hole in pin.
   c. Place installer with pilot and seal over end of crankshaft, aligning seal with crankcase bore. Then drive seal into bore until it is flush with rear face of crankcase. See Fig. 147.

7. Rotate the crankshaft and camshaft to determine that the gears do not bind or interfere. With the use of a dial indicator, Fig. 148, check the back lash. See specifications for back lash.

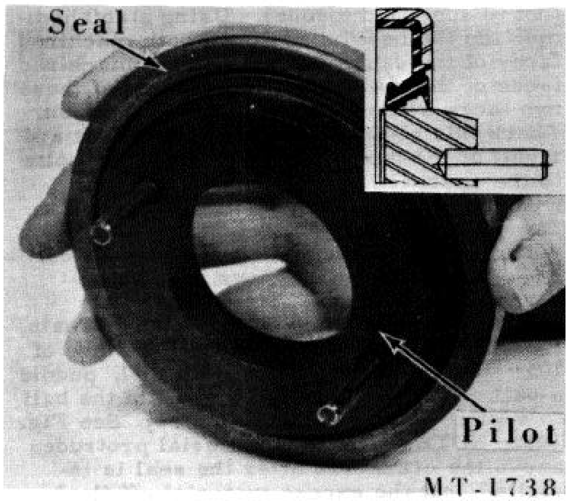


Fig. 146 Positioning Crankshaft Rear Oil Seal on SE-1942-2 Pilot

Fig. 147 Installing Crankshaft Rear Oil Seal Using SE-1942 Installer

8. Turn the cylinder block to a vertical position so the front end faces upward.

9. Turn the crankshaft so No. 1 crankpin is at the top of its stroke. Coat the cylinder bores, crankshaft journals, pistons, piston pins and piston rings with engine oil. Insert the piston into the ring compressor and install the piston assembly into its respective cylinder bore with the word "UP" marked on the piston toward the centerline of the cylinder block as shown in Fig. 149. Install the connecting rod bearings and caps, coating each bearing shell surface on both sides with engine oil. The numbered side of the cap must match and be on the numbered side of the rod. NOTE: If the connecting rods and bearing caps are properly installed, the large chamfer side of the rod and cap will be to the fillet side of the crankpin. Install new bearing cap bolts, washers and nuts where used and torque to the specified torque as shown in "TORQUE CHART.

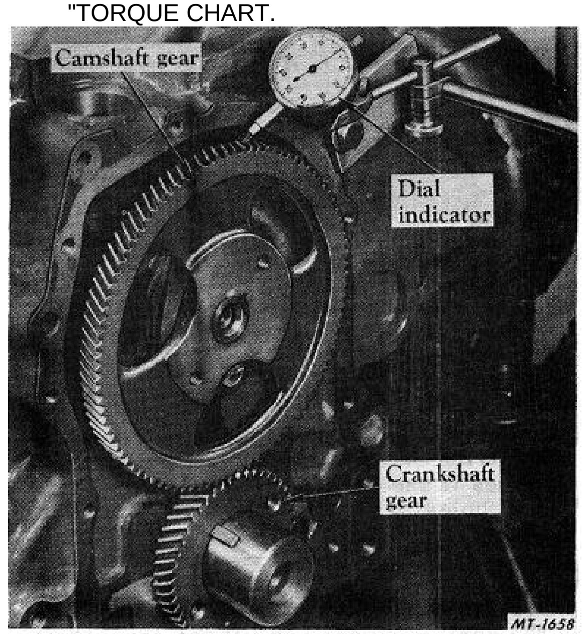


Fig. 148 Checking Camshaft and Crankshaft Gear Back Lash

Fig. 149 Installation of Piston in Cylinder Block

10. Follow the procedure outlined in step above for the remaining connecting rods and pistons.

11. Recheck connecting rod end play using a feeler gauge as outlined under "Connecting Rod Bearings, Fitting."

12. Press new oil seal in engine front cover using a wood support block and combination seal installer and front cover aligner SE1949 as shown in Fig. 150.

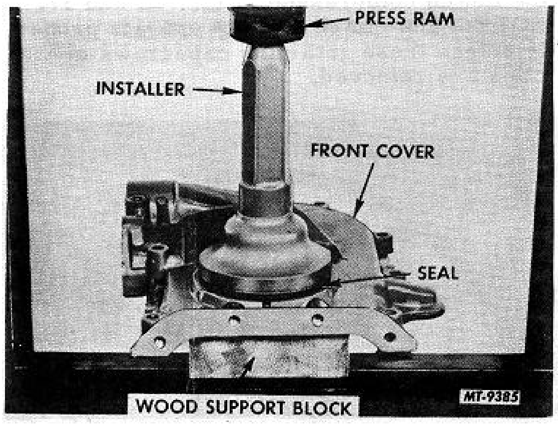


Fig. 150 Pressing New Seal in Engine Front Cover Using SE1949 Installer and Wood Support Block

NOTE

With the engine front cover assembled to the cylinder block a new oil seal can also be installed using SE1949 installer as shown in Fig. 151, providing the cover is in alignment with the crankshaft. In the event the cover is misaligned, it will be necessary to remove cover, being careful not to damage oil pan gasket. Then install seal as outlined in step 12.

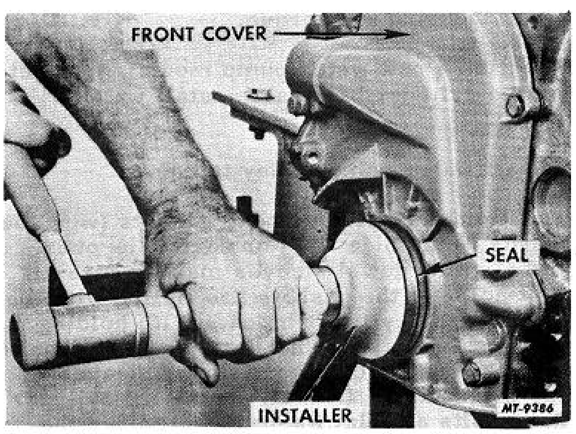


Fig. 151 Installing Engine Front Cover Oil Seal with Cover Assembled to Cylinder Block Using SE1949 Installer

13. Position a new engine front cover gasket to cylinder block and install the engine front cover assembly. NOTE: Do not tighten the mounting bolts at this time.
14. Align the engine front cover assembly to the cylinder block using SE1949 aligner as shown in Fig. 152. Then tighten the engine front cover mounting bolts.

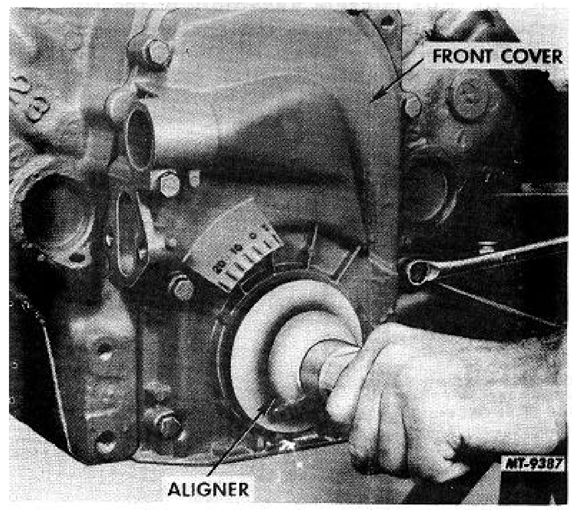


Fig. 152 Aligning Engine Front Cover Assembly to Cylinder Block Using SE-1949 Aligner

15. Install woodruff key in the crankshaft and install the crankshaft pulley using installer SE-1900 and adapter SE-1900-17, Fig. 153. Secure the pulley to shaft with washer and self-locking bolt.

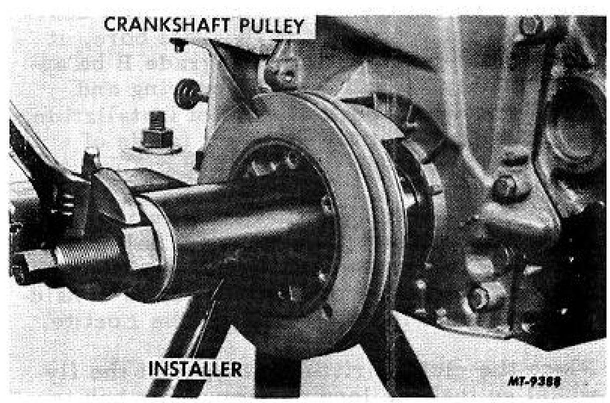


Fig. 153 Installation of Crankshaft Pulley Using SE1900 Installer

16. Install the oil pump. Secure with three bolts and lockwashers. Check alignment of pump to cylinder block for free movement of oil pump shaft. There should be no bind if the pump is correctly aligned.
17. Place the flywheel in position on the crankshaft and install roll pin. Add a sealing compound not affected by oil to the threads

of the flywheel mounting bolts. (Avoid getting sealing compound on mating surfaces of flywheel and crankshaft.) Install mounting bolts and tighten to specified torque. NOTE: For correct assembly of the flywheel, the hole having the chamfer on the inside face of the flywheel must align with the hole in crankshaft which receives the roll pin, Fig. 154.

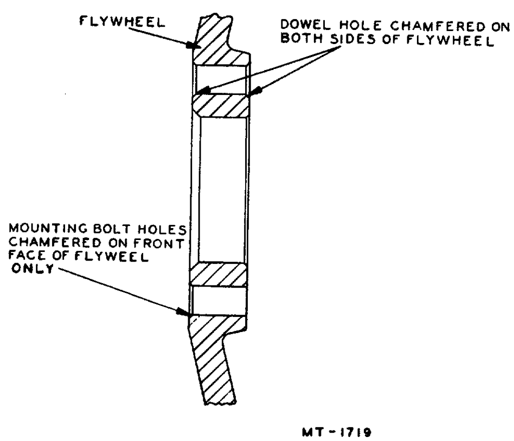


Fig. 154 Cross Section of Flywheel Hub Illustrating Dowel and Mounting Bolt Holes

18. Install the clutch pilot bearing into the flywheel. To assure that the clutch pilot bearing does not rotate in the flywheel bore, it is recommended that Loctite grade B be applied evenly around O.D. of bearing and I.D. of flywheel bore at time of installation. Do not allow Loctite to contact inside of bearing or between flywheel and crankshaft.

    After the Loctite grade B has been applied, allow to cure for 1 to 2 hours. The interval required to reassemble the vehicle from the point of clutch bearing installation is considered adequate for the curing of the Loctite.

19. Place the clutch driven disc against the flywheel so that the long portion of the hub is toward the rear. Place the clutch in position on the flywheel over the clutch driven disc, install two or three mounting capscrews and lockwashers loosely. Insert a clutch aligning arbor, if available, or a transmission main drive gear shaft, Fig. 155, through the clutch driven disc hub spline and into the clutch pilot bearing. Hold the clutch driven disc in position while completing installation of the remaining mounting capscrews and lockwashers in the flange of the clutch backing plate or cover. Tighten all capscrews alternately, evenly and securely. Remove the three retaining capscrews and flat washers or retaining clips or wood blocks which were installed to hold the clutch compressed, Figs. 36 and 37. NOTE: The clutch will not operate properly unless these retaining capscrews or clips are removed.

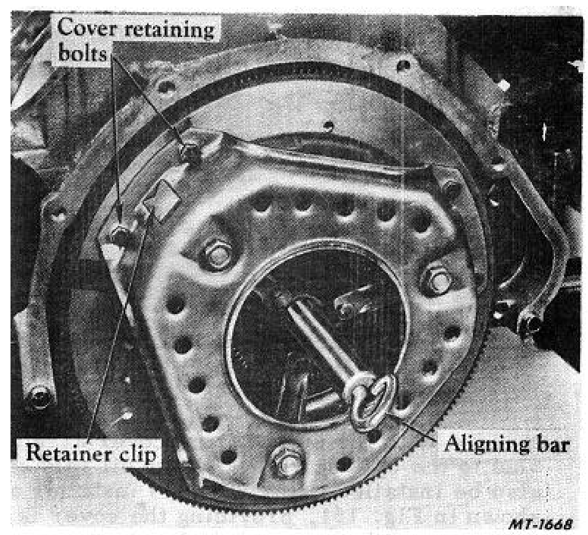


Fig. 155 Clutch Installation to Flywheel

20. Place the flywheel housing in position over two flywheel housing-to-cylinder block roll pins and tap into place with a soft hammer. Install capscrews and lockwashers in flywheel housing and torque.
21. Position a new water pump mounting gasket on the cylinder block and install water pump.
22. Install water pump pulley to hub.
23. Position new cylinder head gaskets (with the words "This Side Up") on each bank over the aligning dowel sleeves making sure all bolt holes in the gaskets are in line with the holes in the cylinder block. With holding sling SE1896 place head on the proper bank aligning the head with the dowel sleeves in the crankcase. Loosely install all cylinder head bolts and flat washers. Remove the cylinder head holding sling.
24. Repeat the above step for assembly of the opposite cylinder head.
25. Tighten the cylinder head bolts alternately and evenly in sequence as illustrated in Fig. 156 to the torque shown in "TORQUE CHART." Repeat this operation on the opposite cylinder head. The embossed steel

gasket is coated on both sides with a special substance which, subjected to heat, further seals the gasket between the head and cylinder block. Therefore, the head bolts do not need to be retorqued after 1, 000 miles of operation.

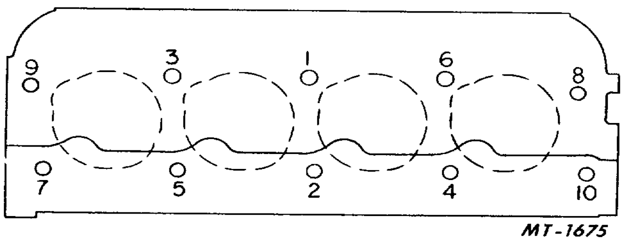


Fig. 156 Cylinder Head Mounting Bolt Tightening Sequence

26. Install the hydraulic tappets in their respective bores in the cylinder block.

27. Before inserting the valve lifter rods in their respective positions, the leading edge of the balance weight of the crankshaft pulley hub should be indexed with the number "0" on the timing indicator as shown in Fig. 157. This will prevent damaging the push rods when installing the rocker arm shaft assemblies. Insert the valve lifter rods in their respective positions.

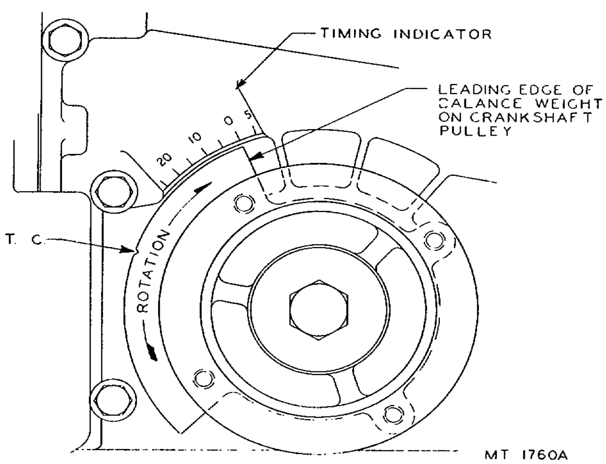


Fig. 157 Correct Position of Crankshaft Pulley Hub Balance Weight for Installing Push Rods

28. Place the rocker arm assemblies on their respective cylinder heads making sure the rocker arms are in line with the push rods and valves. Install all self-locking type bolts employing a nylon pellet and coat threads of bolts with a non-hardening sealing compound. Also install flat washers on bolts. Then tighten to specified torque. (See "TORQUE CHART.") In no case should a standard bolt be used in this application. NOTE: Do not use a power wrench to perform this operation, as it may result in distortion of push rods or damage to valves due to rocker arm assembly being drawn down faster than the leakdown of the hydraulic lifters. NOTE: If the rocker arms and supports have been correctly assembled on the shaft, the notches at the end of the rocker arm shaft will be facing downward. Also the supports incorporating the oil feed hole will be located third from the rear on the right bank (even numbers) and third from the front on the left bank (odd numbers).

29. Secure dipstick tube mounting brackets to front of right cylinder head with bolt and lockwasher.

30. Position the crankcase tappet cover gasket on the crankcase and install the tappet cover securing with eight screws and fiber washers.

31. Install air pump mounting bracket to left cylinder head, Fig. 25.

32. Place an 0ring seal on each end of the water pipe assembly making sure seal is positioned in groove on end of pipe to be installed in water pump, Fig. 19. Coat seals with hydraulic brake fluid and install the water pipes in their respective positions in the water pump and cylinder heads on V-304, V-345 engines and water pump to crankcase on V-392 engine, securing with clamps, bolts and flat washers.

33. Position the intake manifold gaskets on both cylinder heads and install the intake manifold to the cylinder heads making sure the odd numbers stamped on the manifold are positioned on the left cylinder head and the even numbers on the right cylinder head. Secure the manifold to the cylinder heads with sixteen bolts and lockwashers.

34. Position water bypass hose and two clamps on water pump connection.

35. Position thermostat housing gasket on intake manifold and place thermostat housing on gasket, Fig. 158, and into water bypass hose previously affixed to water pump.

36. Install thermostat in housing and place engine water outlet gasket on housing, Fig. 158. Then place engine water outlet on housing. Secure outlet and thermostat housing to manifold with two bolts and lockwashers and tighten water bypass hose clamps. NOTE: Make sure spark plug cable bracket is installed under water outlet mounting bolt.

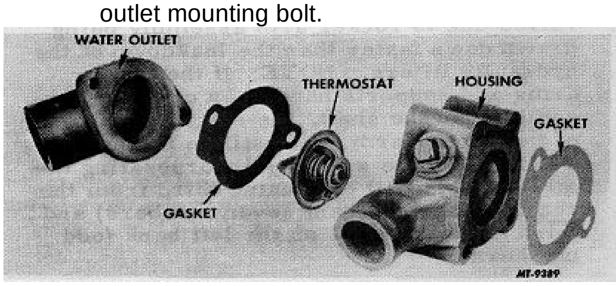


Fig. 158 Exploded View of Thermostat Housing, Thermostat and Engine Water Outlet

37. Install water temperature sender unit in the boss provided on the intake manifold.

38. Install high temperature vacuum control valve in thermostat housing, Fig. 17. This valve can be identified by a red paint marking.

39. Install low temperature vacuum control valve having a bronze overall color in right rear opening in intake manifold, Fig. 19.

40. Install another low temperature vacuum control valve having a blue paint marking on body in left rear opening in intake manifold, Fig. 19.

41. Install exhaust gas recirculating valve and gasket to intake manifold, Fig. 19.

42. Install automatic choke to right side of intake manifold, Fig. 19.

43. Position exhaust manifold to cylinder head and loosely install the two outer bolts and lock tab washers.

44. Place the exhaust manifold gasket between the cylinder head and manifold and install the remaining mounting bolts and lock tab washers. Make sure manifold shroud is installed over right manifold only. Then tighten all bolts to specified torque. See "TORQUE CHART."

45. Repeat the two steps above for the installation of the opposite manifold.

46. Install air manifold assembly to each cylinder head.

47. Install the ignition coil and bracket on the mounting boss provided on the intake manifold, securing the coil bracket with bolt and lockwasher.

48. Place the distributor mounting gasket on the cylinder block. Install the distributor assembly with clamp, hold-down bolt and lockwasher.

49. Position the fuel pump mounting gasket on the engine front cover and install the fuel pump, securing the pump with two bolts and lockwashers.

50. Place the cylinder head cover gaskets on each head and install the cylinder head covers, attaching with capscrews.

51. Install the spark plugs and gaskets in the cylinder head.

52. Install the distributor cap and thread the cables through the cable support brackets and to their respective spark plugs. Connect the high tension cable from the distributor to the coil.

53. Install alternator and freon compressor mounting bracket and alternator adjusting strap to right cylinder head.

54. Loosely install alternator to bracket and adjusting strap.

55. Loosely install freon compressor to mounting bracket if chassis is so equipped.

56. Install power steering pump mounting bracket to air pump mounting bracket.

57. Install air pump adjusting strap to water pump bolt.

58. Loosely install air pump to mounting bracket.

59. Loosely install power steering pump and mounting plate to pump mounting bracket.

60. Position power steering and air pump belt over water pump pulley and adjust belt to proper tension. Then tighten adjusting strap and mounting bolts.

61. Position the fan belts over the water pump, crankshaft and alternator pulleys. Adjust the belts by moving the alternator outward to obtain proper belt tension. Then tighten alternator mounting bolts and adjusting strap

62. Position freon compressor belt over the water pump and freon compressor pulleys. Adjust the belt by moving the freon compressor outward using adjusting screw to obtain proper belt tension. Then tighten freon compressor mounting bolts and adjusting screw locknut.

63. On chassis equipped with air brakes install compressor to mounting bracket. Then position drive belt over water pump and compressor pulleys. Adjust belt by moving compressor outward. Then connect oil pressure line, governor line, air supply line and water hoses.

64. Install the fan to water pump pulley hub with four bolts and lockwashers.

65. Install flame arrestor and hose to left cylinder head cover. NOTE: V-392 engine uses one flame arrestor in each cylinder head cover.

66. Install crankcase ventilator valve in tappet cover and connect hose to valve and tube fitting in manifold.

67. Install engine front mounting bracket.

68. Install air hoses from air pump to air manifold.

69. Connect fuel line and fuel filter at pump. Clip fuel line to coil mounting bolt.

70. Install oil pressure sending unit to left side of crankcase.

71. Position the oil pan gasket on the crankcase and install the oil pan securing with eighteen bolts and lockwashers.

72. Install flywheel housing cover plate to front of flywheel housing securing with four bolts and lockwashers.

73. Connect all vacuum hoses previously removed from the various components on engine. Refer to Figs. 159, 160 and 161 for proper vacuum hose location.

74. Assemble the lifting fixture, SE-1948, to the intake manifold. Attach suitable hoisting equipment and apply sufficient pull to support the engine assembly. Remove the engine overhaul stand brackets from the engine and lift the engine out of the stand.

    With the engine secured with hoisting equipment, assemble the following:

    a. Position the oil filter mounting gasket on the crankcase and install the oil filter base with four bolts and lockwashers. Then install spin-on oil filter.

    b. Place the starting motor into the flywheel housing and secure with two bolts and lockwashers.

ENGINE INSTALLATION

Prior to installation check to be sure that all lines, cables and parts are installed on the engine assembly that were connected to and removed with the engine. If maintenance work was done, be sure all adjustments affected are made correctly. If any components of the engine were removed and installed, check all connections and related parts to be sure the installations were accomplished correctly.

In general, the installation of the engine is performed in the reverse order of the removal. When positioning engine in the chassis, special care must be exercised during installation to avoid pinching of wiring harness between the engine and frame assembly. Lower the engine to align the transmission main drive gear spline with the clutch driven disc. The weight of the engine assembly must be supported until the six bolts securing the flywheel housing to crankcase are installed. Connect the wiring harness, lines and linkages that were disconnected during removal.

Install the radiator assembly and shroud and connect the upper and lower radiator hoses on conventional chassis.

On models other than conventional chassis, install the front end sheet metal and stay rods. Install hood assembly.

Connect the battery ground strap; fill the cooling system to the specified level. Fill the engine crankcase with specified engine oil to the proper level. (See Operator's Manual.)

Check accessory and pulley drive belts and adjust if necessary.

Start engine and operate all controls through their full range to check for proper adjustment

Inspect all hose connections for coolant leaks and air connections for air leaks.

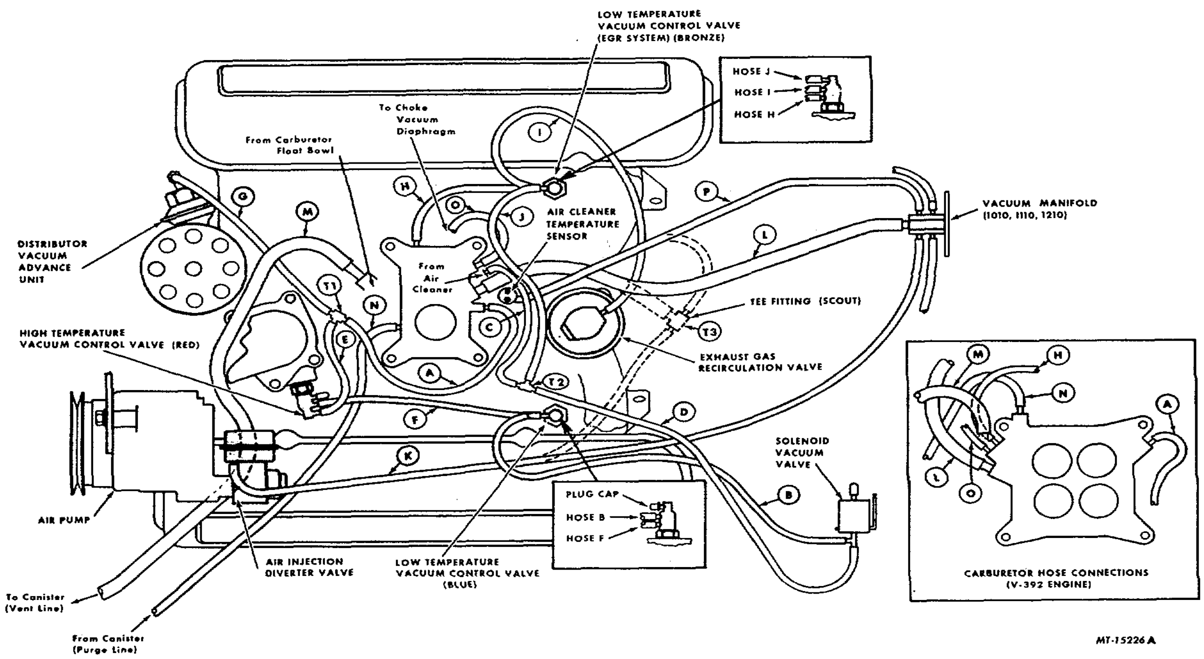


Fig. 159 Vacuum Hose Location--for 1010, 1110, 1110 4x4, 1210, 1210 4x4 Travelall and Scout II

Legend for Fig. 159

Key	Description	Key	Description
A	Carburetor Port to Tee (T1)	J	Low Temperature Vacuum Valve to Tee (T2)
B	Low Temperature Vacuum Valve to Solenoid Valve	K	Diverter Valve to Vacuum Manifold (1010, 1110, 1210) Diverter Valve to Tee (T3) (Scout)
C	Air Cleaner to Tee (T2)		
D	Tee (T2) to Solenoid Valve	L	Carburetor Port to Vacuum Manifold (1010, 1110, 1210) Carburetor Port to Tee (T3) (Scout)
E	Tee (T1) to High Temperature Vacuum Valve	M	Carburetor Float Bowl to Canister
F	High Temperature Vacuum Valve to Low Temperature Vacuum Valve	N	Canister to Carburetor Port
G	Tee (T1) to Distributor Vacuum Advance Unit	O	Carburetor Port to Choke Vacuum Diaphragm
H	Carburetor Port to Low Temperature Vacuum Valve	P	Vacuum Manifold to Air Cleaner Temperature Sensor (1010, 1110, 1210) Tee (T3) to Air Cleaner Temperature Sensor (Scout)
I	Low Temperature Vacuum Valve to Exhaust Gas Recirculation Valve		

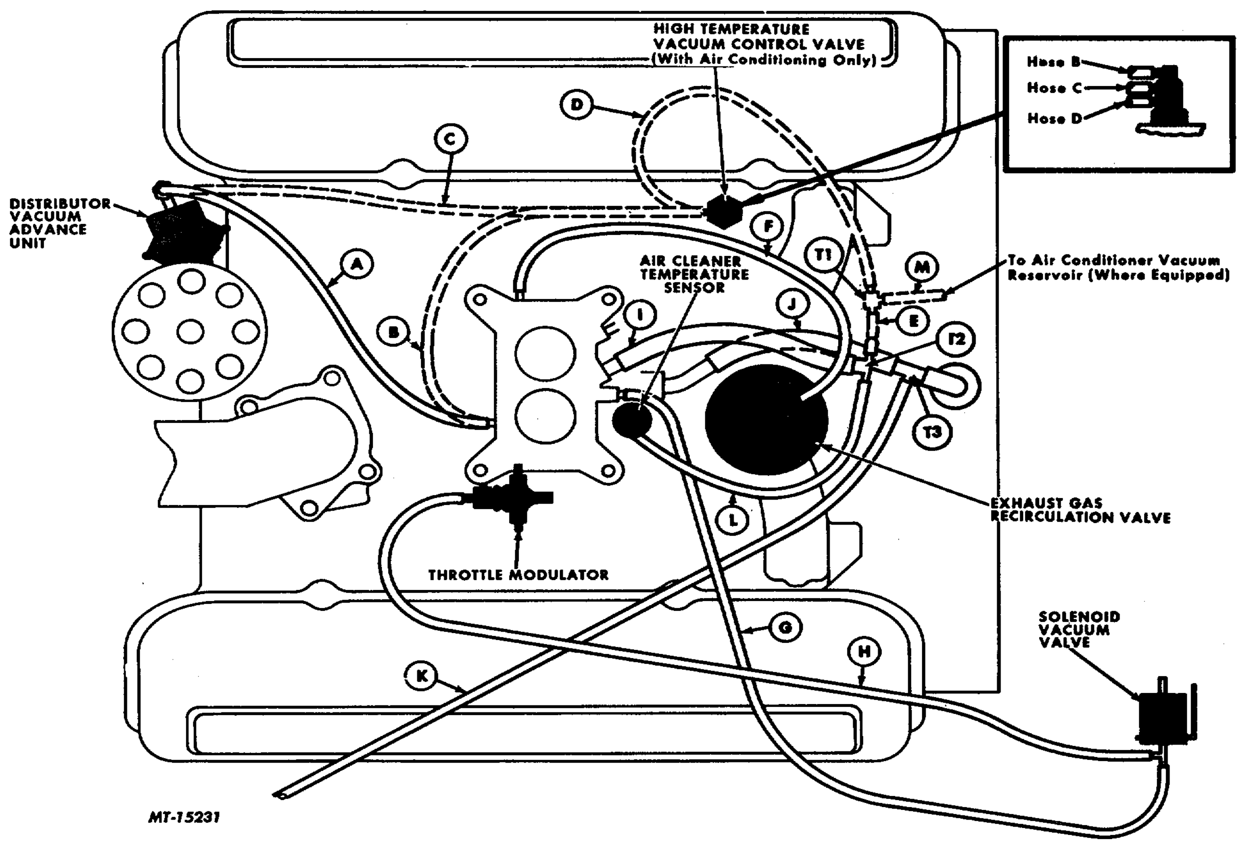


Fig. 160 Vacuum Hose Location--For 1210 Pickup through 1510

Legend for Fig. 160

Key	Description	Key	Description
A	Carburetor Port to Distributor Vacuum Advance Unit	G	Carburetor Port to Solenoid Vacuum Valve
B	Carburetor Port to High Temperature Vacuum Valve (with Air Conditioner Only)	H	Solenoid Vacuum Valve to Throttle Modulator
C	High Temperature Vacuum Valve to Distributor Vacuum Advance Unit (with Air Conditioner Only)	I	Carburetor Vacuum Port to Tee (T2)
		J	Intake Manifold Vacuum Port to Tee (T3)
D	High Temperature Vacuum Valve to Tee (T1) (with Air Conditioner Only)	K	Canister to Tee (T3)
E	Tee (T1) to Tee (TZ) (with Air Conditioner Only)	L	Tee (T2) to Air Cleaner Temperature Sensor
F	Carburetor Port to Exhaust Gas Recirculation Valve	M	Tee (T1) to Air Conditioner Vacuum Reservoir

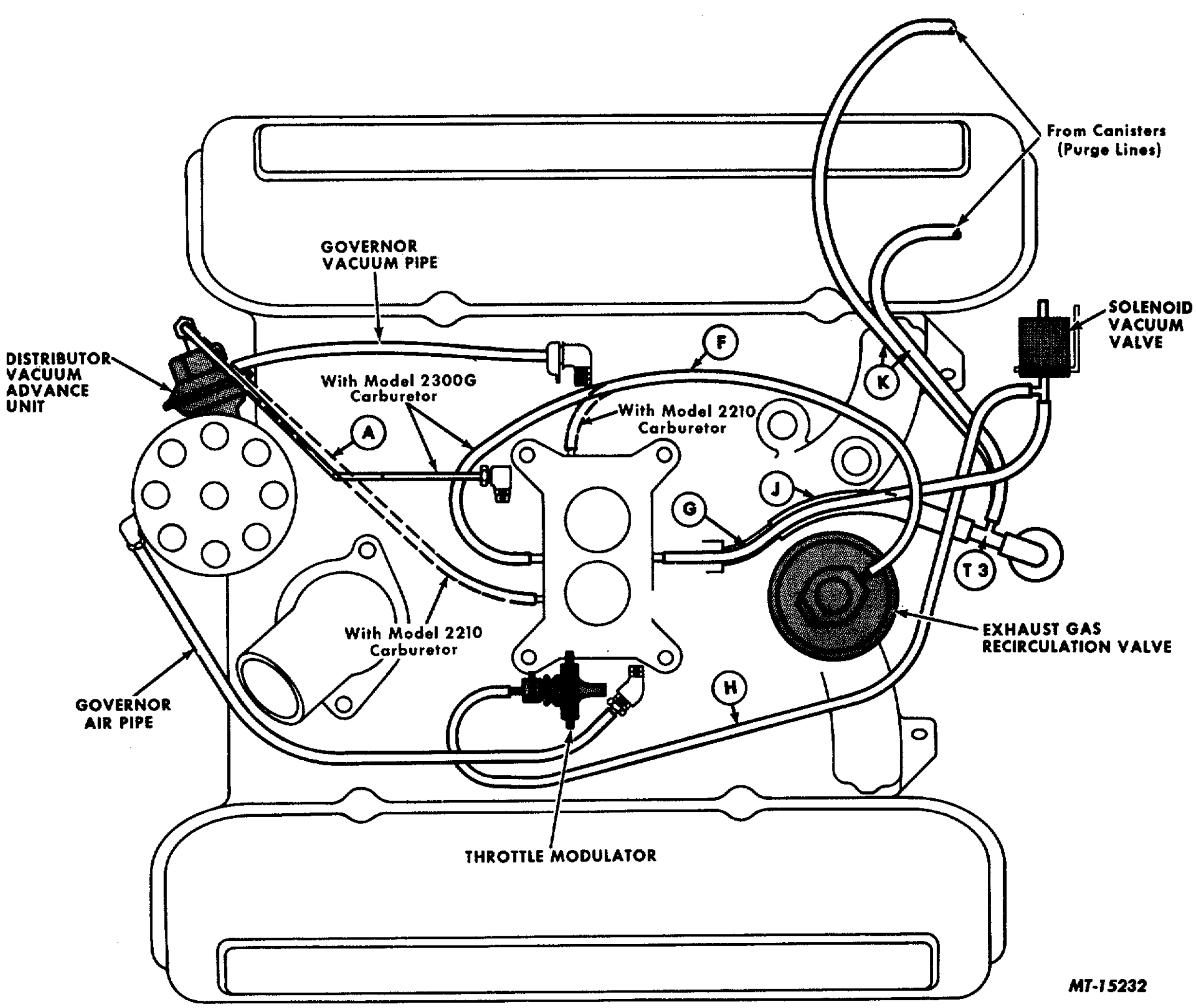


Fig. 161 Vacuum Hose Location--For 1600 through 1800

Legend for Fig. 161

Key	Description	Key	Description
A	Carburetor Port to Distributor Vacuum Advance Unit	H	Solenoid Vacuum Valve to Throttle Modulator
F	Carburetor Port to Exhaust Gas Recircu-lation Valve	J	Intake Manifold Port to Tee (T3)
G	Carburetor Port to Solenoid Vacuum Valve	K	Canister to Tee (T3)

OIL FILTER (Spin-On Type)

1. Remove oil filter assembly by turning counterclockwise with the hands or a suitable tool. Clean filter mounting pad.

2. Coat the gasket on the new filter with a film of grease.

3. Place the new filter in position on the center tube. Hand tighten 1/2 to 3/4 of a turn after gasket first contacts base of mounting pad.

4. Start engine and run for at least five minutes to warm oil and check for leaks. Also check engine oil level.

ENGINE MOUNTINGS

Front Mountings

Engine mountings vary between vehicle models. Various types of front mountings are shown in Figs. 162 and 163.

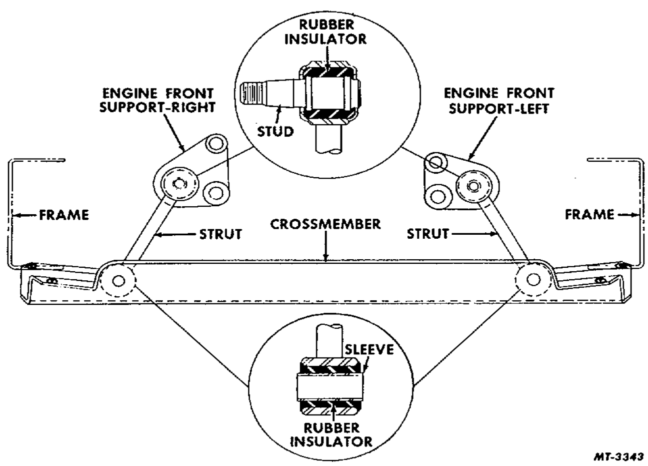


Fig. 162 Strut-Type Engine Front Mounting for Chassis with Channel Frame

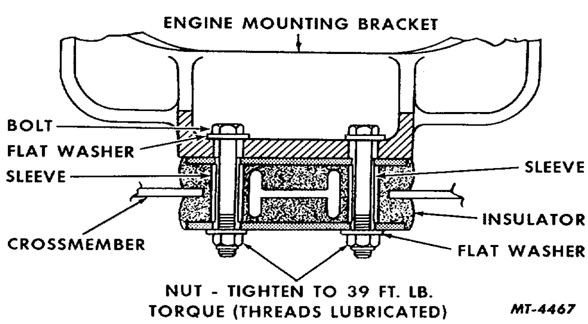


Fig. 163 Engine Front Mounting with Two-Piece Insulator

Fig. 162 illustrates strut-type engine front mountings. When installed they should be assembled as shown and all 1/2 inch bolts tightened to 35 to 45 ft. lbs. torque.

The engine front mounting shown in Fig. 163 utilizes a two-piece insulator with sleeves. When assembling, position component parts as shown and tighten elastic stop nuts to 39 ft. lbs. torque.

Rear Mountings

Two types of engine rear mountings are shown in Figs. 164 and 165.

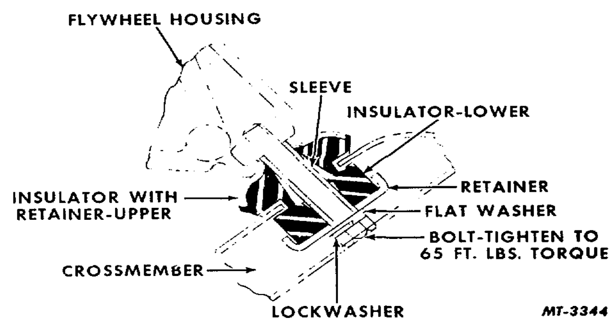


Fig. 164 Engine Rear Mounting with Two-Piece Insulator

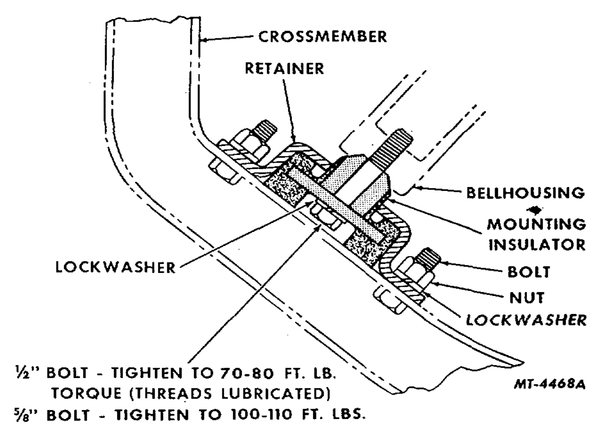


Fig. 165 Engine Rear Mounting with One Piece Insulator

When assembling rear mountings shown in Fig. 164, place the upper insulator and retainer between crossmember and flywheel housing. Make sure holes in insulator and retainer are in line with holes in flywheel housing and crossmember. Position sleeve through crossmember and into the upper insulator. Then install lower insulator and retainer under crossmember and attach to flywheel housing with bolt, flat washer and lockwasher. Tighten mounting bolts to 65 ft. lbs. torque.

The rear mounting shown in Fig. 165 utilizes a one-piece mounting insulator. When assembling this type, the insulator must be properly seated in the retainer. Install retainer with two bolts, nuts and lockwashers. Install insulator bolt from the bottom of the crossmember and tighten to torque specified.

CRANKCASE VENTILATION SYSTEM

Closed Type

Positive crankcase ventilation system, Fig. 166, utilizes the vacuum created in the intake manifold to draw clean air through the crankcase and valve chamber. Fresh air enters the cylinder head cover through the flame arrestor and the connecting hose from the air cleaner. The oil filler cap is non-vented and, therefore, requires no service. The flame arrestor in the connecting hose must be serviced at 12, 000 mile intervals.

A valve in the vacuum line to the intake manifold varies the air flow through the crankcase to meet changing conditions at all engine speeds and loads.

The system will work effectively as long as all component parts are clean and free from sludge and foreign material.

The valve should be serviced at 12, 000 mile intervals and the system inspected and cleaned. It may be necessary to inspect and clean the system more frequently under adverse driving or weather conditions.

To check the operation of the system, the valve should be removed from the tappet cover.

With the engine operating a vacuum should be felt at the end of the valve. If no vacuum is present, the valve, hose and fitting should be removed and cause of restriction determined. The inner chamber of the valve should be checked to see that it can be moved freely.

This may be accomplished by inserting a stiff wire into the valve body and observing whether or not the plunger can be readily moved.

This system prevents crankcase vapors from entering the atmosphere.

Vapors flowing through the hose are drawn into the intake manifold and burned with the normal fuel mixture.

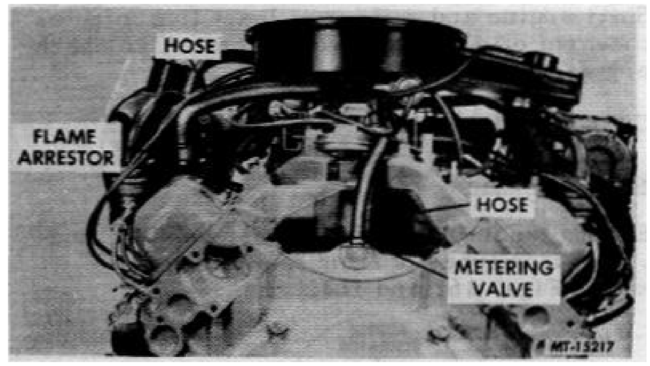


Fig. 166 Crankcase Ventilation System (Closed Type)

Fig. 167 illustrates a crankcase ventilator valve of one-piece construction. This type of valve should be serviced at 12, 000 mile intervals or less (depending upon operating conditions) and the system inspected and cleaned.

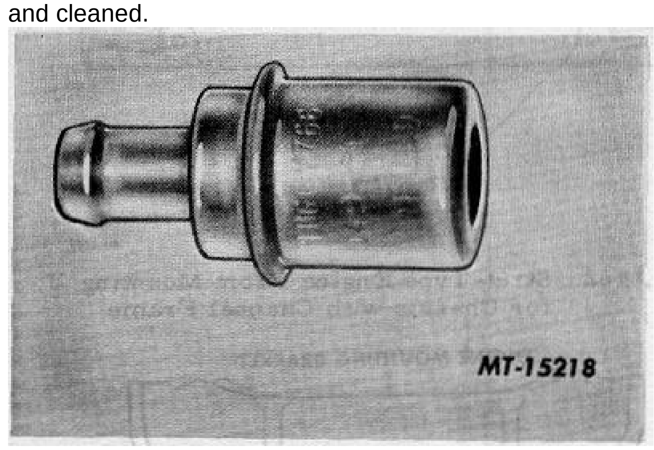


Fig. 167 Crankcase Ventilator Valve of One-Piece Construction

SPECIFICATIONS

ENGINE MODELS	V-304A	V-304	V-345	V-392
Number of Cylinders	8	8	8	8
Bore (Inches)	3-7/8	3-7/8	3-7/8	4-1/8
Stroke (Inches)	3-7/32	3-7/32	3-21/32	3-21/32
Displacement (Cu. In.)	304	304	345	392
Compression Ratio	8.19 to 1	8.19 to 1	8.28: 1	8.0 to 1
Brake H. P. (Max.)@ RPM	193.1 @ 4400	193.1 @ 4400	196.7 @ 4000	235.6 @ 4000
Brake H.P. (Net) @ RPM	180 @ 4400	180 @ 4400	168 @ 3800	191 @ 3600
Torque (Max.) Lb. Ft. @ RPM	272.5 @ 2800	272.5 @ 2800	309.0 @ 2200-2400	356.5 @ 2800
Torque (Net) Lb. Ft. @ RPM	262.0 @ 2400-2600	262. 0 @ 2400-2600	288 @ 2000	307 @ 2400
Rated H. P. (A.M.A.)	48.1	48.1	48.1	54.4
Weight (Bare) (Lbs.)	617.6	617.6	640.6	655.8
Weight (w/Std.Acces.)(Lbs.)	698	698	727	754.7
Engine Serial No. Location	Stamped on Cylinder Block Front Corner Right Bank			
Governed Speed	---	---	3800 RPM	3600 RPM
Recommended Max. Speed	3900 RPM	3900 RPM	---	---
Firing Order	1-8-4-3-6-5-7-2	Same	Same	Same

All idle speeds are set with transmission in "Neutral" and air conditioner "OFF."

CYLINDER BLOCK:				
Bore Diameter (Standard)	3.8745-3.8770	3.8745-3.8770	3.8745-3.8770	4.1245-4.1270
CRANKSHAFT:				
Number of Main Bearings	5	5	5	5
Main Journal Diameter	2.7484-2.7494	2.7484-2.7494	2.7484-2.7494	2.7484-2.7494
Main Bearing Clearance	.001-.004	.001-.004	.001-.004	.001-.004
Crankshaft End Play	.003-.008	.003-.008	.003-.008	.003-.008
Thrust Taken by	3rd Main	3rd Main	3rd Main	3rd Main
Rod Journal Dia. (Crankpin)	2.373-2.374	2.373-2.374	2.373-2.374	2.373-2.374
CAMSHAFT:				
Camshaft Journal Diameter:				
Front	2.099-2.100	2.099-2.100	2.099-2.100	2.099-2.100
Second	2.089-2.090	2.089-2.090	2.089-2.090	2.089-2.090
Third	2.079-2.080	2.079-2.080	2.079-2.080	2.079-2.080
Fourth	2.069-2.070	2.069-2.070	2.069-2.070	2.069-2.070
Rear	2.059-2.060	2.059-2.060	2.059-2.060	2.059-2.060
Bearing Clearance	.0015-.0035	.0015-.0035	.0015-.0035	.0015-.0035
Camshaft End Play	.006-.014	.006-.014	.006-.014	.006-.014
Thrust Taken by	Thrust Plate	Thrust Plate	Thrust Plate	Thrust Plate
Timing Gear Backlash	.0005-. 0045	.0005-.0045	.0005-.0045	.0005-.0045
CONNECTING RODS:				
Bearing Bore Diameter	2.4995-2.5000	2.4995-2.5000	2.4995-2.5000	2.4995-2.5000
Piston Pin Bore Diameter	1.0613-1.0617	1.0613-1.0617	1.0613-1.0617	1.0613-1.0617
Bearing Clearance	.0011-.0036	.0011-.0036	.0011-.0036	.0011-.0036
Side Clearance	.008-.016	.008-.016	.008-.016	.008-.016

ENGINE MODELS	V-304A	V-304	V- 345	V-392
PISTONS:				
Recommended Piston				
Clearance	.0035	.0035	.0035	.0035
Ring Groove Size:				
Compression Rings (2)	.095-.096	.095-.096	.095-.096	.095-.096
Oil Ring	.1885-.1895	.1885-.1895	.1885-.1895	.1885-.1895
Pin Bore Diameter	1.0630-1.0632	1.0630-1.0632	1.0630-1.0632	1.0630-1.0632
*PISTON FITTING:				
(Feeler Gauge Ribbon Checking)				
Width of Ribbon (Inch)	1/2	1/2	1/2	1/2
Thickness of Ribbon	.0035	.0035	.0035	.0035
Tension on Scales (Lbs.)	2-4	2-4	2-4	2-4
Desired Tension (Lbs.)	3		3	
3		3		
PISTON PINS:				
Length (Inches)	2-7/8	2-7/8	2-7/8	2-3/4
Diameter	1.0623-1.0625	1.0623-1.0625	1.0623-1.0625	1.0623-1.0625
Clearance in Piston	.0005-.0009L	.0005-.0009L	.0005-.0009L	.0005-.0009L
Press Fit in Rod	.0006-.0012	.0006-.0012	.0006-.0012	.0006-.0012
PISTON RINGS:				
Compression Rings (2):				
Size (Face Width)	.0930-.0935	.0930-.0935	.0930-.0935	.0930-.0939
Gap	.010-.020	.010-.020	.010-.020	.013-.023
Side Clearance (Fit in Groove)	.0015-.003	.0015-.003	.0015-.003	.0015-.003
OIL CONTROL RING:				
Size (Total2 Rails, 1 Spacer)	.1795-.1875	.1815-.1885	.1815-.1885	.1860-.1865
Gap:				
Steel Rails	.015-.055	.015-.055	.015-.055	.013-.028
Spring Spacer	No Gap at Joint		No Gap at Joint	No Gap at Joint
Side Clearance (Fit in Groove)	.000-.0084	.000-.0084	.000-.0084	.002-.0035
VALVES:				
Intake Valves:				
Face Angle	45°	45°	45°	30°
Seat Width (Inch)	1/16-3/32	1/16-3/32	1/16-3/32	1/16-3/32
Seat Run-Out (T. I. R.)(Max.)	.002	.002	.002	.002
Valve to Rocker Arm				
Clearance	None*	None*	None*	None*
Stem Diameter	.372-.373	.372-.373	.372-.373	.372-.373
Stem Clearance in Guide	.001-.0035	.001-.0035	.001-.0035	.001-.0035
Exhaust 'Valves:				
Face Angle	45°	45°	45°	45°
Seat Width (Inch)	3/32-1/8	5/64-7/64	5/64-7/64	5/64-7/64
Seat Run-Out (T. I. R.)(Max.)	.002	.002	.002	.002
Valve to Rocker Arm				
Clearance	None*	None*	None*	None*
Stem Diameter	.3715-.3725	.3715-.3725	.3715-.3725	.414-.415
Stem Clearance in Guide	.0015-.004	.0015-.004	.0015-.004	.0015-.004
Valve Guides:				
Length (Inches)	2-29/32	2-29/32	2-29/32	2-29/32
Bore Diameter	.374-.3755	.374-.3755	.374-.3755	.374-.3755 (In.) .4165-.4181(Ex.)
Distance Above Head (Inch):				
Intake (Inch)	31/32	31/32	31/32	31/32
Exhaust (Inch)	31/32	1-3/32	1-3/32	1-11/64

*Hydraulic lifters.
*This method of fitting pistons to cylinder bore is only an initial check.

ENGINE MODELS	V- 304A	V-304	V- 345	V- 392
VALVES (Continued):				
Valve Springs:				
Free Length (Inches)	2.065	2.065	2.065	2.065
Test Length (Inches)	1.429	1.429	1.429	1.429
Pressure (Lbs.) @ Test Length	188.1±8	188.18	188.18	188.1l8
Valve Lifters (Tappets):				
Diameter	.9965-.9970	.9965-.9970	.9965-.9970	.9965-.9970
Bore Diameter in Block	.9995-1.0010	.9995-1.0010	.9995-1.0010	.9995-1.0010
Clearance in Bore	.0025-.0045	.0025-.0045	.0025-.0045	.0025-.0045
Bleed-Down Rate (1/8" Travel @ 50 Lb. Loading)	8-50 Sec.	8-50 Sec.	8-50 Sec.	8-50 Sec.
Valve Lift (Inch):				
Intake	.440	.440	.440	.440
Exhaust	.395	.395	.395	.395
Rocker Arms:				
Diameter of Shaft	.8625-.8650	.8625-.8650	.8625-.8650	.8625-.8650
Bushing Bore Diameter	.8655-.8695	.8655-.8695	.8655-.8695	.8655-.8695
Clearance on Shaft	.0005-.007	.0005-.007	.0005-.007	.0005-.007
Push Rods:				
Length	8.562-8.588	8.562-8.588	9.362-9.388	9.362-9.388
Valve Timing:				
Intake Opens (before TDC)	21°	21°	21°	21°
Intake Closes (after BDC)	63°	63°	63°	63°
Exhaust Opens (before BDC)	58°	58°	58°	58°
Exhaust Closes (after TDC)	18°	18°	18°	18°
OIL PUMP:				
Body Gear End Clearance	.0015-.006	.0015-.006	.0015-.006	.0015-.006
Body to Gear Clearance	.0007-.0027	.0007-.0027	.0007-.0027	.0007-.0027
Pump Shaft Diameter	.4885-.4890	.4885-.4890	.4885-.4890	.4885-.4890
Shaft Clearance in Body	.001-.0025	.001-.0025	.001-.0025	.001-.0025
Body Gear Backlash (Max.)	.0107	.0107	.0107	.0107
Idler Shaft Diameter	.4845-.4855	.4845-.4855	.4845-.4855	.4845-.4855
Idler Gear Clearance on Shaft	.0015-.004	.0015-.004	.0015-.004	.0015-.004
Pressure Regulator Spring:				
Free Length (Inches)	2.250	2.250	2.250	2.250
Test Length (Inches)	1.812	1.812	1.812	1.812
Pressure @ Test Length	13.33	13.33	13.33	13.33
Oil Pressures:				
(With SAE-30 Oil @ 2000 F)				
Minimum (@ Idle Speed)	10-20 psi	10-20 psi	10-20 psi	10-20 psi
Maximum (@ 1800 RPM)	40-50 psi	40-50 psi	40-50 psi	40-50 psi
THERMOSTAT:				
Standard:				
Starts to Open at (Deg. F.)	167-174	167-174	167-174	167-174
Fully Open at (Deg. F)	192	192	192	192
For Use w/Shutterstat:				
Starts to Open at (Deg. F.)	157-164	157-164	157-164	157-164
Fully Open at (Deg. F.)	182	182	182	182

SPECIFICATIONS LPG ENGINES (Otherwise Same as Gasoline)

ENGINE	V-304	V-345
Brake Horsepower (Max.) @ RPM	180 @ 4400	185.8 @ 4400
Brake Horsepower (Net) @ RPM	167 @ 4400	171.5 @ 3800
Torque (Max.) Lb. Ft. @ RPM	260 @ 2800	292.2 @ 2200-2400
Torque (Net) Lb. Ft. @ RPM	247 @ 2400-2600	289 @ 2000
Compression Ratio	8.26 to 1	8.14 to 1
Weight (Bare) (Lbs.)	616	651
Weight (with Standard Accessories) (Lbs.)	739	774
Initial Timing Setting (No. 8 Cylinder)	8° BTC	10° BTC
Spark Plug Gap	.015-. 020	.015-.020

TORQUE SPECIFICATIONS

Size and Thread	Location	Recommended Wrench Torque (Ft. Lbs.)
5/16- 18 and 24	All Locations Except As Listed	14-16
5/16-18	Oil Pump Mounting	25-30
3/8-16 and 24	All Locations Except As Listed	25-30
3/8-16	Water Pump Mounting	40-45
	Clamp, Water Pipe to Cylinder Head	10-15
3/8-16	Compressor Bracket to Cylinder Head	40-45
3/8-16	Oil Filter Base to Crankcase	27-32
3/8-24	Connecting Rod Bolts (V-304, V-304A, V-345)	45-55
3/8-24	Connecting Rod Bolts (V-392)	40-45
3/8-24	Fly wheel to Crankshaft	45-55
7/16-14 and 20	All Locations Except As Listed	35-40
7/16-20	Camshaft Gear to Camshaft	55-65
1/2-13	Cylinder Head Bolts	90-100
1/2-13	Main Bearing Cap Bolts	75-85
1/2-13	Engine Mounting Bracket	70-80
1/2-13	Stabilizer Bracket to Engine (Where Used)	70-80
5/8-18	Pulley Hub to Crankshaft	100-110
3/4-16	Compressor Pulley Nut	40 (Min.)
14 mm	Spark Plugs	28-30
	Generator Pulley Nut	50-60

NOTE: All torque values based on threads-lubricated with engine oil.

ENGINE

MODELS: V-537 and V-605

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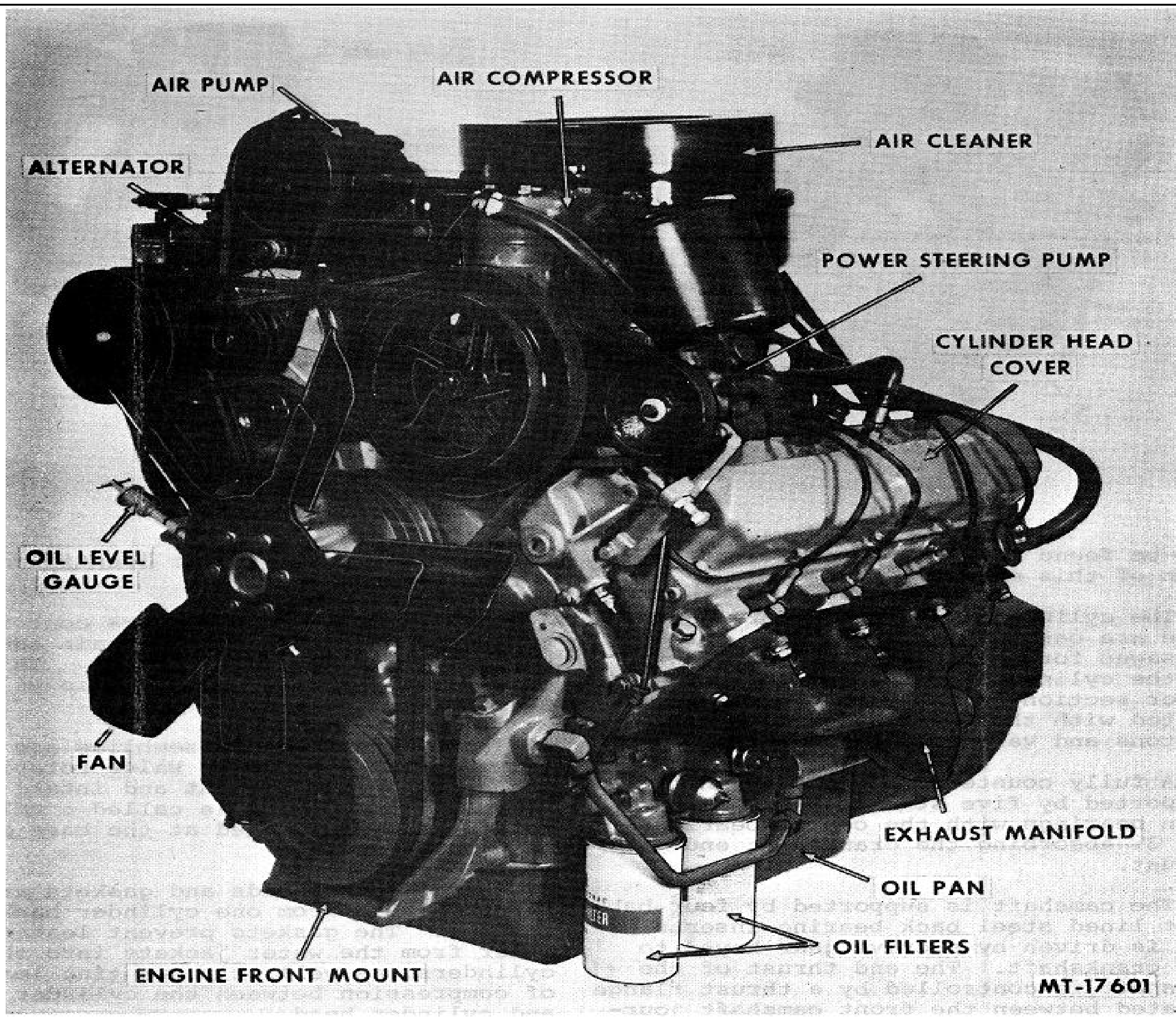

Fig. 1

INTRODUCTION AND SYSTEM DESCRIPTION

This manual section is intended to provide the reader with a thorough knowledge of a complete engine disassembly, reconditioning and assembly. The manual also covers engine removal and installation in a general manner as this will vary according to model application.

Certain components and systems are not covered in detail in this section but are covered in other manual sections. These components and systems are as follows: clutch, cooling system, electrical components and systems, fuel components and systems and various add-on accessory items.

GENERAL DESCRIPTION

The V-type engine (Figs. 1, 2 and 3) is a 900 eight cylinder overhead valve type. The specifications forthe engine

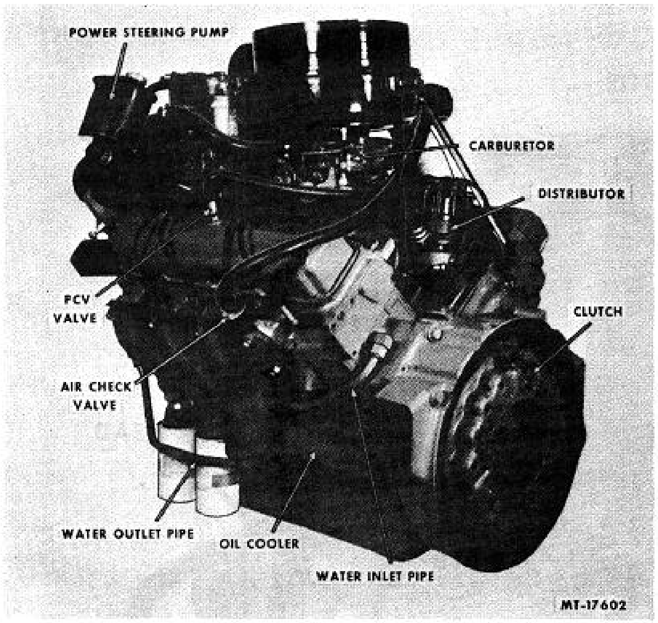

Fig. 2

can be found in the specifications section of this manual.

The cylinder block and upper crankcase are cast in one piece with cored passages for cooling the entire length of the cylinder. This unit forms the major section of the engine as it is fitted with the crankshaft, camshaft, pistons and various related parts.

A fully counterbalanced crankshaft is supported by five steel backed main bearings with the center bearing, No. 3, absorbing the crankshaft end thrust.

The camshaft is supported by four babbitt lined steel back bearing inserts and is driven by a drive gear keyed to the crankshaft. The end thrust of the camshaft is controlled by a thrust flange located between the front camshaft journal and camshaft gear.

The aluminum-alloy, solid skirt pistons are cam ground and are fitted with two compression rings and an oil ring. The full floating type piston pins are held in place by snap rings at the ends of each pin.

Forged steel connecting rods contain a bushing at the upper end for installation on the piston pin, while the lower end and cap contain the locking type selective fit bearing inserts. The rods and caps are numbered for identification during reassembly.

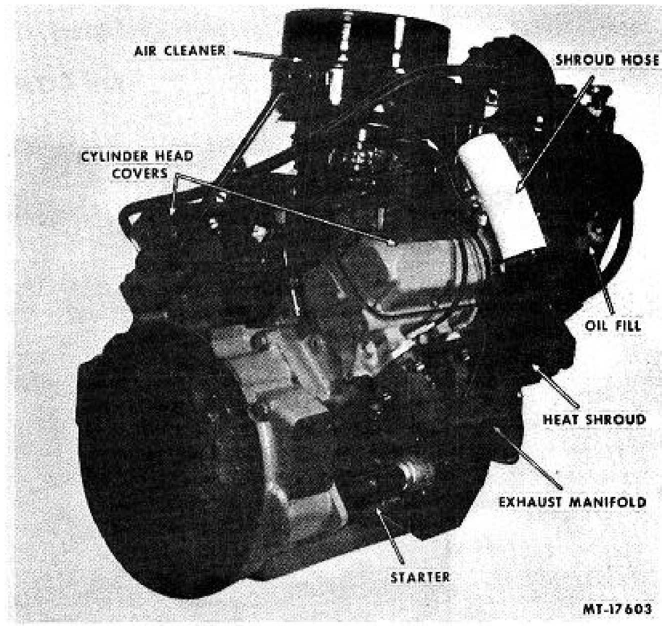

Fig. 3

The hydraulic valve lifters contribute to engine quietness and maintain zero valve lash or tappet clearance. This eliminates the need for periodic valve adjustment.

The cylinder head assemblies are equipped with a positive valve rotating mechanism on the exhaust and intake valves. This device is called a valve rotator and is located at the base of each valve spring.

The cylinder heads and gaskets are interchangeable from one cylinder bank to another. The gaskets prevent leakage of water from the water jackets into the cylinders, as well as preventing leakage of compression between the cylinder block and cylinder head.

Two "V" type fan belts, driven by a pulley on the crankshaft, drive the water pump-fan combination, while two "V" type belts, driven by the water pump pulley, drive the alternator and/or air compressor. Single "V" belts, driven from the air compressor pulley, drive the power steering pump and the freon compressor. A single "V" belt from the alternator pulley drives the air pump. This may vary dependent upon the equipment installed.

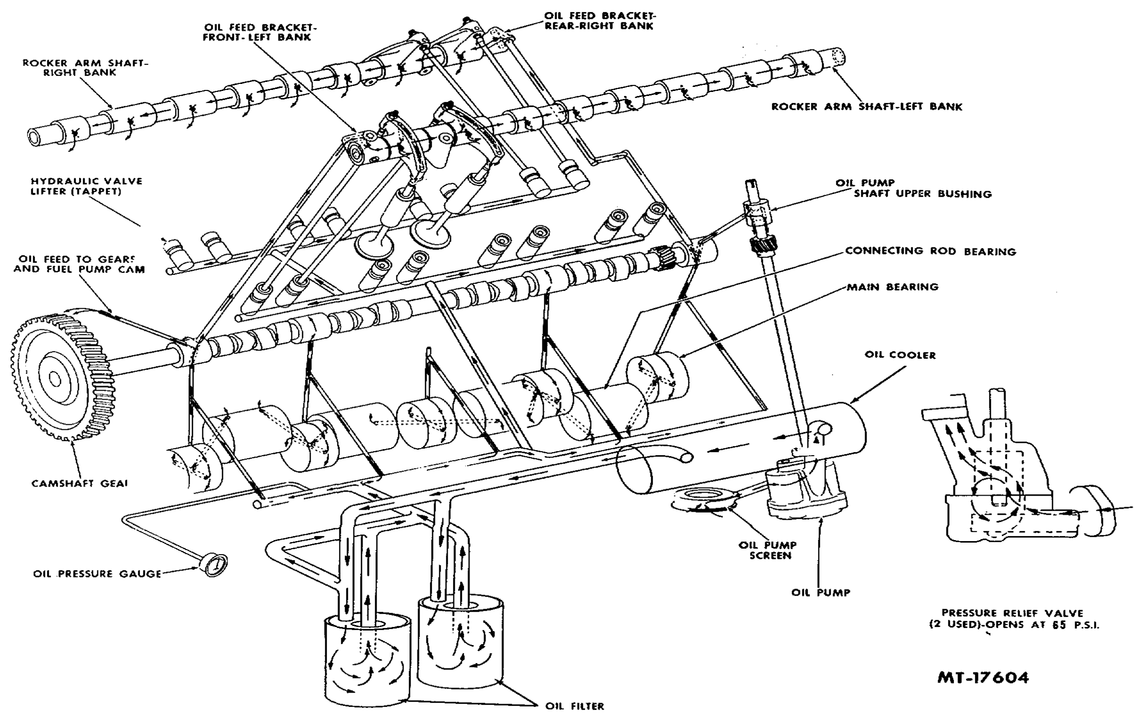

Fig. 4

The water pump is mounted integral with the front cover and supplies both cylinder banks. The alternator is mounted at the upper right side of the engine with an adjustable strap to set the proper belt tension.

A gear type oil pump is internally mounted to the bottom of the crankcase and is gear driven by the camshaft. Oil is drawn from the pan by the pump through a screen assembly.

The distributor, mounted on the rear of the cylinder block assembly, is gear driven by the oil pump shaft.

CYLINDER NUMBERING

When viewing the engine from the driver's seat, the right bank of cylinders is numbered 2, 4, 6 and 8 with No. 2 being at the front. Similarly, the left bank of cylinders is numbered 1, 3, 5 and 7 with No. 1 being at the front. For easy reference, each cylinder number is cast on the intake manifold directly over its respective cylinder. The firing order, 1-8-7-3-6-5-4-2, is also cast on the top surface of the intake manifold.

ENGINE LUBRICATION SYSTEM

Refer to the engine lubrication diagram for details of the system (Fig. 4).

The engine lubrication system consists of galleries and drilled passages running through the various engine castings and moving parts. This type of design eliminates external or internal oil lines and assures trouble-free, efficient engine lubrication.

In operation, oil is forced through the engine by an internally mounted gear type oil pump which is driven through gears at the engine camshaft. Oil enters the pump through a stationary screen assembly located under the surface of the oil in the pan and attached to the oil pump body. Dual spring-loaded pressure regulator valves are located in the oil pump which limit the maximum oil pressure in the system. Two valves are required due to the reverse oil delivery capacity of the oil pump. Oil relieved by the pressure relief valves is recirculated within the pump which eliminates oil aeration often caused by oil returning to the pan from the pump.

CRANKCASE VENTILATION SYSTEM

Crankcase emissions are controlled by the closed-type positive crankcase ventilation system. Filtered air from the carburetor air cleaner circulates through the crankcase and rocker arm covers, mixes with the crankcase vapors and is drawn through the PCV valve to the intake manifold to be burned in the combustion chambers.

The PCV valve regulates the flow of ventilating air to meet changing operating conditions and is governed by intake manifold vacuum. At low speeds or during deceleration, high manifold vacuum overcomes the spring pressure and seats the valve. As engine speed increases and manifold vacuum decreases, the spring unseats the valve, permitting a greater flow of air.

The spring type PCV valve is designed to close immediately should the engine backfire. This confines the backfire to the intake manifold, thereby minimizing the possibility of igniting explosive mixtures which may be present in the crankcase.

COOLANT SYSTEM

The water pump impeller forces coolant through the passages in the cylinder block and cylinder heads to provide a cooling medium for the components of the engine. The lubricating oil is also cooled by this coolant flow through the oil cooler. The oil cooler receives its coolant through an external pipe located at the left rear of the cylinder block and is returned through an external pipe connected to the left side of the front cover.

Two thermostats permit the coolant to be recirculated to the water pump when the engine is cold or directed to the radiator after the engine has warmed up. Drain cocks are located on both sides of the engine block and in the radiator for draining the coolant if desired.

REMOVAL OF ENGINE

Engine removal procedures will vary among vehicle models and also among individual chassis because of various equipment and accessories. The following outline covers, in general, the engine disconnect points and lifting instructions.

1. Remove front bumper if equipped with steel hood.
2. Raise hood.
3. Disconnect battery cable from battery.
4. Drain radiator and engine block.
5. Remove hood assembly.
6. Disconnect shutter cylinder air line if so equipped.
7. Disconnect radiator hoses.
8. Remove radiator support and core assembly (fiberglass hood only). If equipped with steel hood, disconnect headlamp, etc., wiring at cowl and remove radiator support and core assembly with fenders and splash panels as an assembly.
9. Remove air cleaner braces.
10. Remove air inlet hose between air cleaner and right cylinder head.
11. Remove air inlet hose to air compressor.
12. Remove air cleaner with shroud hose. Also remove stud in carburetor.
    NOTE: Cover carburetor to prevent entry of foreign material.
13. Disconnect heater hoses.
14. Disconnect wires from alternator, coil, distributor, heat sender unit and oil sender unit.
15. Remove engine ground strap.
16. Remove choke and throttle wire.
17. Disconnect tachometer cable if so equipped.
18. Remove accelerator linkage at carburetor.

19. Remove fuel line at fuel pump.

    NOTE: In models equipped with intank fuel pump, remove fuel line.

20. Disconnect exhaust pipe at the manifold.

21. Disconnect wires at the starting motor.

22. Disconnect canister vent and purge lines at carburetor if so equipped.

23. Disconnect the freon compressor wire at connector.

24. Remove the freon compressor lines at compressor.

25. Disconnect the main air supply line and the flexible air line at the compressor on chassis equipped with air brakes.

26. Disconnect the vacuum air cleaner hose at rear of intake manifold on chassis equipped with hydraulic brakes having a hydrovac.

27. Remove thermostat housing and remove distributor cap and lay loosely in "V" of engine block.

28. Disconnect governor vacuum line and remove distributor from engine.

29. Remove brace from rear of freon compressor.

30. Install lifting sling on engine (Fig. 5).

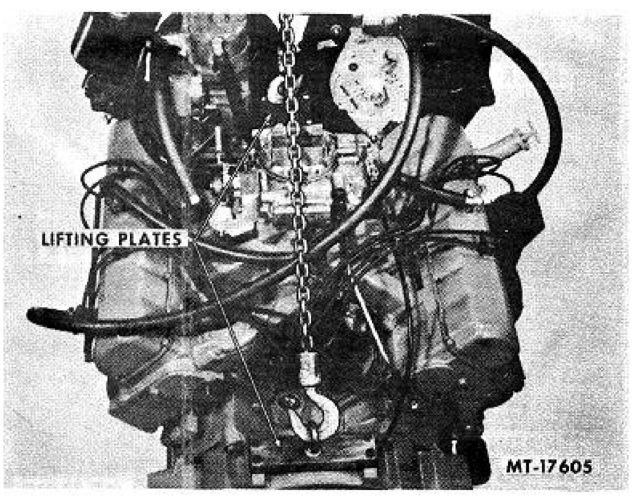

Fig. 5 Engine Lifting Sling

NOTE: Install SE-1896 Lifting Plate to thermostat housing base and make rear lifting plate locally according to dimensions (Fig. 6).

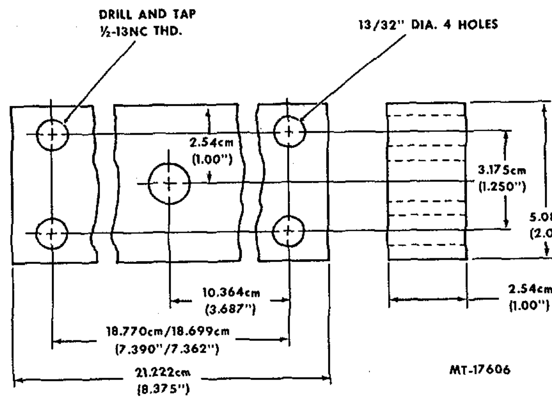

Fig. 6 Dimensions for Rear Lifting Plate.

31. Connect hoist to lifting sling.

32. Place a support under the transmission.

33. Remove the 12 capscrews securing the bell housing to the flywheel housing.

34. Remove the engine front mounting bolts and insulators.

35. Remove the engine rear mounting bolts and insulators.

36. The engine must be pulled forward to clear the transmission main drive gear and clutch driven disc; then, raise and lift out of chassis.

    NOTE: Extreme care must be exercised during removal of the power plant to avoid damage to the clutch driven disc and wiring harness.

DISASSEMBLY OF ENGINE

Prior to installing the engine in the SE-1962 Overhaul Stand, certain components must be removed. These are as follows: starter motor and heat shield and right exhaust manifold with heat shield and gasket assembly. Install the engine in the overhaul stand with the mounting plate (Fig. 7).

NOTE: Use of this overhaul stand permits raising or lowering (vertical

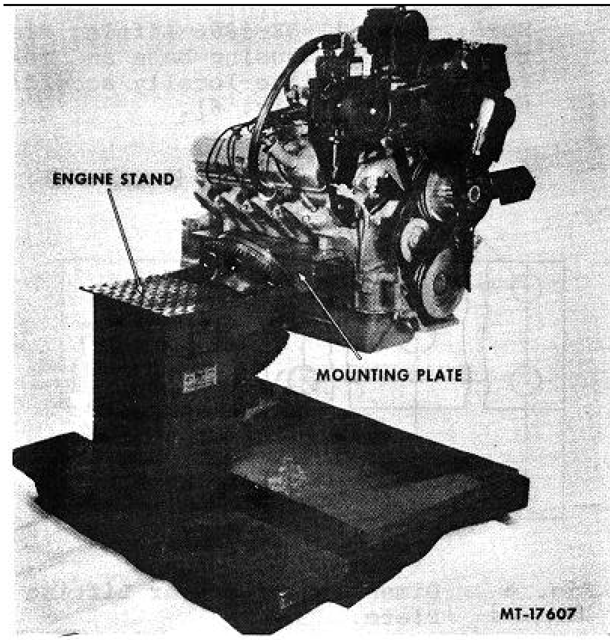

Fig. 7 Engine Installed in SE-1962 Overhaul Stand with Mounting Plate

to horizontal position) the engine as required to permit rotating the engine 3600 and is held securely in any of the eight positions provided. However, before engine rotation is performed, it is recommended the engine be stripped of as many components as possible to eliminate excessive weight and provide clearance. The engine can be raised in a vertical position over the pedestal of the stand and the pin released and crankcase rotated and locked in any one of the eight positions.

1. Make sure all oil and water have been drained from the cylinder block.

2. Remove fan blade and spacer from pulley hub.

3. Loosen freon compressor mounting capscrews (Fig. 8) and slide compressor toward centerline of engine. Remove V-belt and then the freon compressor.

4. Remove freon compressor mounting bracket by removing three capscrews and lockwashers (Fig. 9). Also remove oil level gauge assembly at this time.

5. Push idler pulley toward engine centerline and remove main drive belts (Fig. 10).

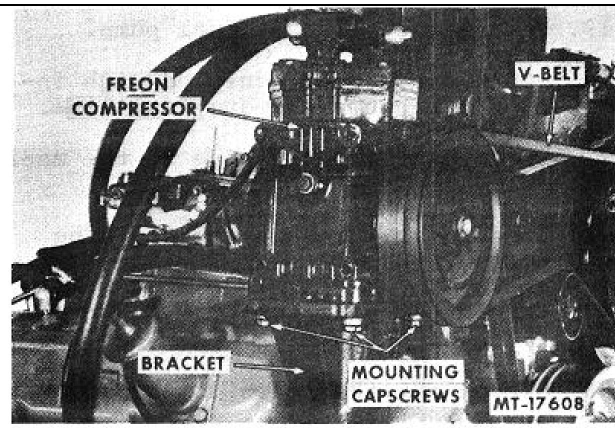

Fig.8 Freon Compressor Removal

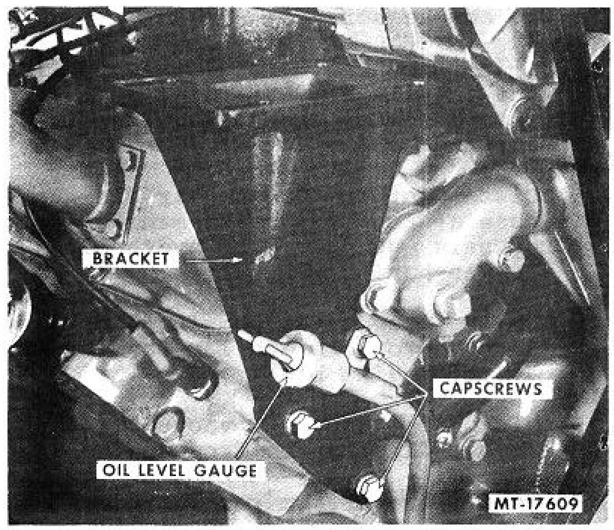

Fig.9 Freon Compressor Mounting Bracket Removal

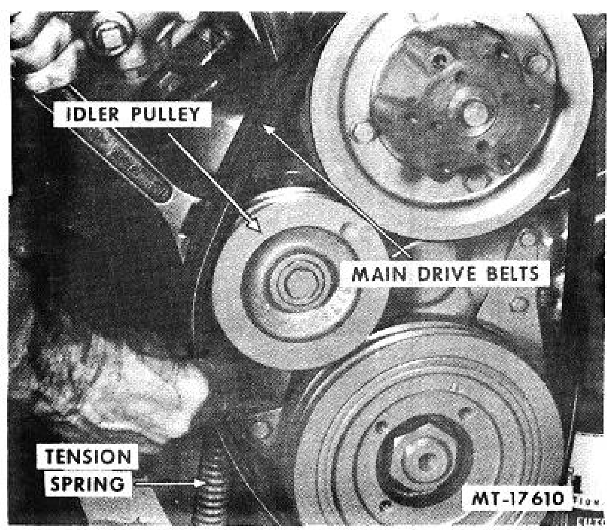

Fig.10 Removing Main Drive Belts

6. Remove idler pulley and tension spring (Fig. 11).

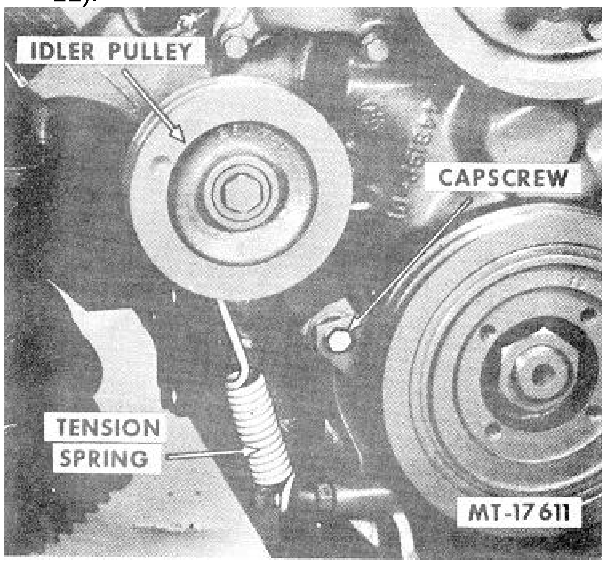

Fig. 11 Idler Pulley and Tension Spring Removal

7. Loosen alternator adjusting strap capscrew and mounting capscrew (Fig. 12) and slide alternator toward engine centerline. Remove alternator and air compressor drive belts.

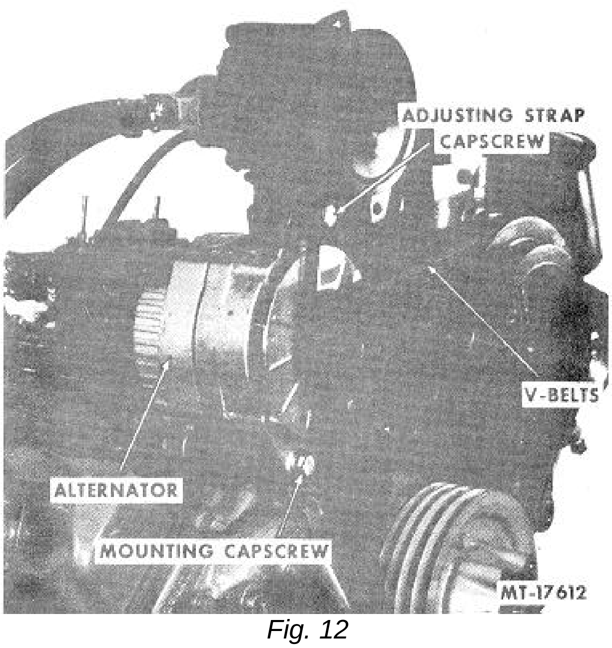

Fig. 12

8. Loosen air pump capscrews and slide air pump downward (Fig. 13). Remove air pump drive belt.

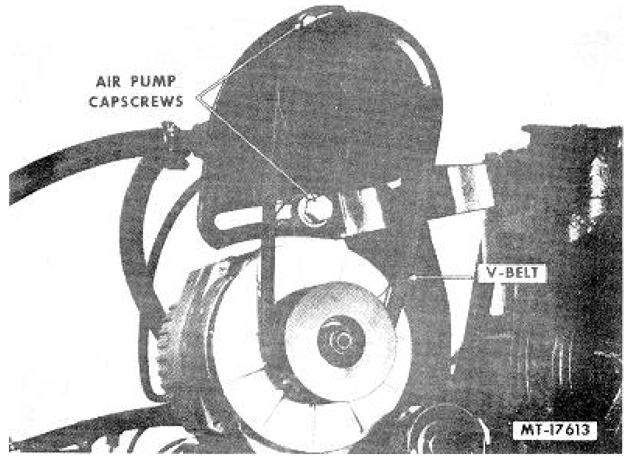

Fig. 13

9. Remove alternator by removing two mounting capscrews (Fig. 14). Also remove air hoses from divert valve and air manifold check valves.

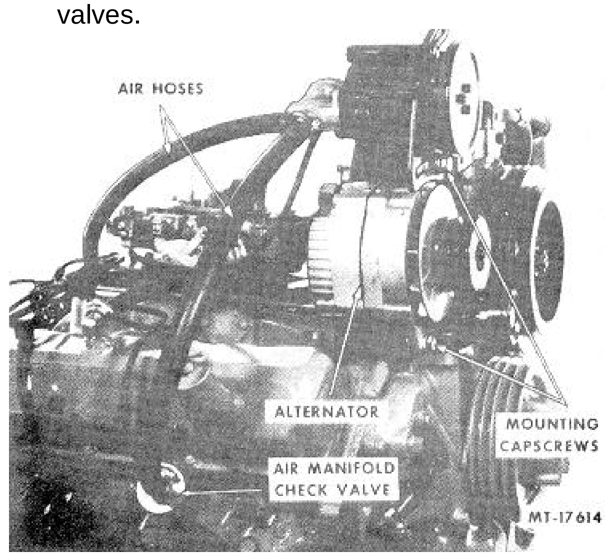

Fig. 14

10. Remove air pump pulley from pump by removing three capscrews (Fig. 15). Then remove air pump adjusting strap capscrew and mounting capscrew (Fig. 15). Then remove air pump.

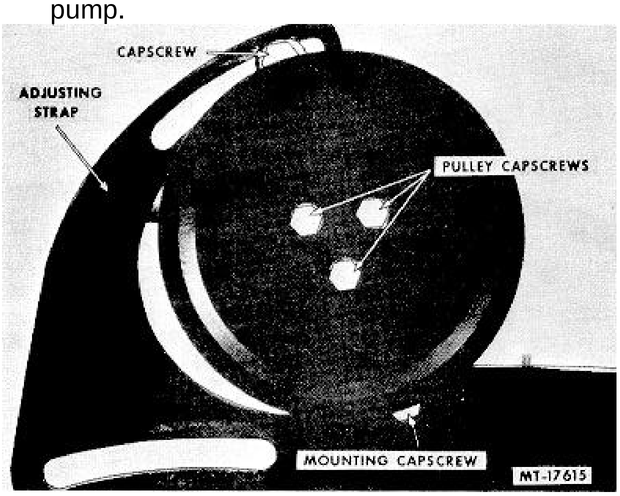

Fig. 15 Removing Air Pump Pulley and Air Pump

11. Remove air pump adjusting strap capscrew, nut and washer (Fig. 16) and remove adjusting strap.
12. Remove alternator bracket mounting capscrews and washers (Fig. 16). Remove bracket and idler pulley.

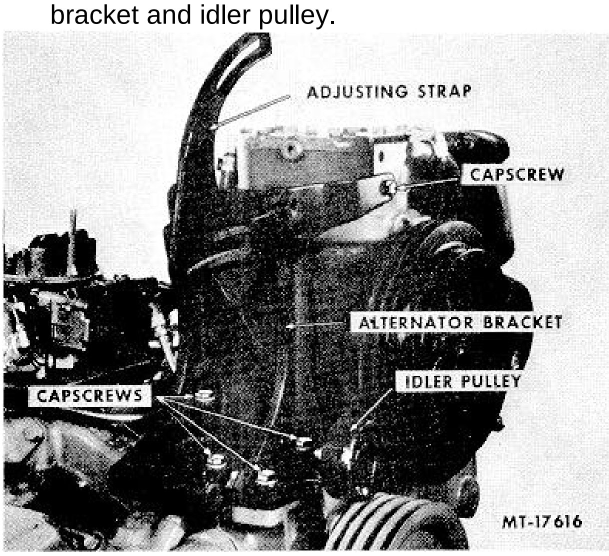

Fig. 16

13. Loosen power steering pump adjusting capscrew nut. Then back off adjusting screw (Fig. 17). Loosen bracket lower capscrew and two capscrews on the back side of the bracket. Remove power steering belt.

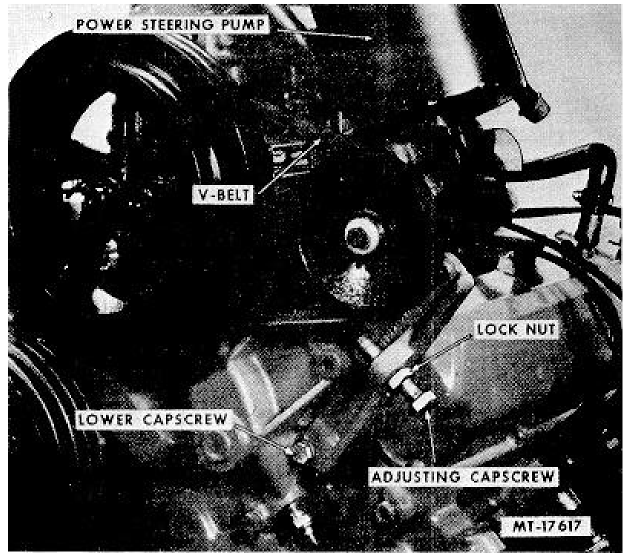

Fig. 17

14. Remove nuts from studs securing power steering pump to bracket and then remove power steering pump.
15. Remove capscrews loosened in Step 13; remove power steering pump bracket.
16. Disconnect and remove water inlet and outlet hoses to air compressor (Fig. 18). Remove oil feed line and clip and carburetor return spring. Then remove mounting capscrews and washers; remove air compressor and mounting plate.

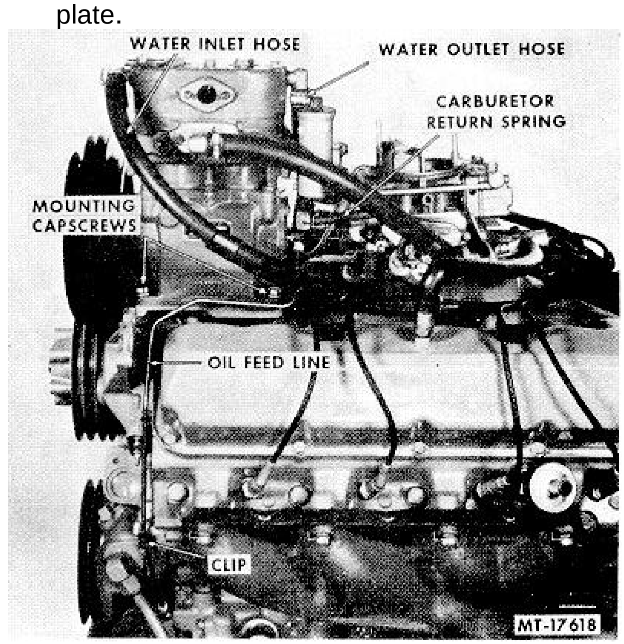

Fig. 18 Air Compressor Removal

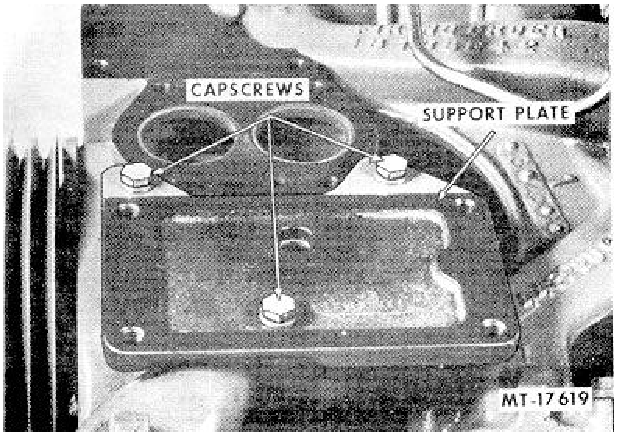

Fig. 19 Air Compressor Support Plate Removal

17. Remove three capscrews and lockwashers securing air compressor support plate to crankcase (Fig. 19).
18. Remove the air compressor support plate with "O" ring (Fig. 20).
19. Remove PCV valve and hose, high tension wires and distributor cap, air inlet hose, coil and bracket, fuel line and governor vacuum line (Fig. 21).
20. Remove carburetor, insulator, gasket and spacer from intake manifold by removing capscrews and washers or nuts and washers if so equipped (Fig. 22).
21. Remove intake manifold mounting capscrews with washers and remove intake manifold and gaskets (Fig. 23). Vacuum manifold should be removed with the intake manifold.

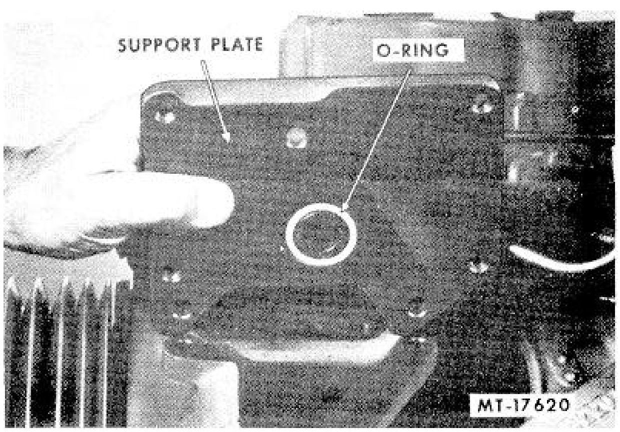

Fig. 20

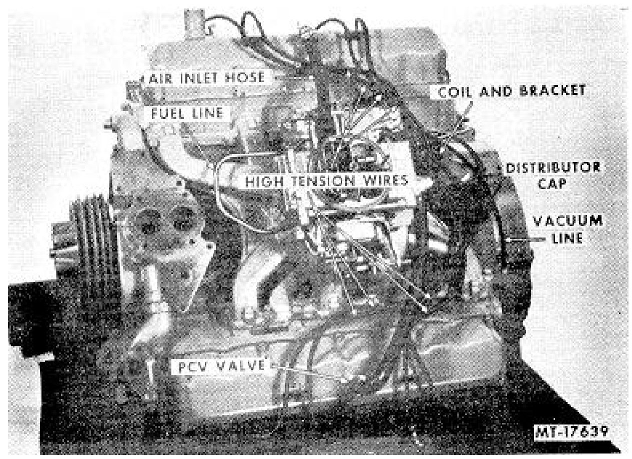

Fig. 21

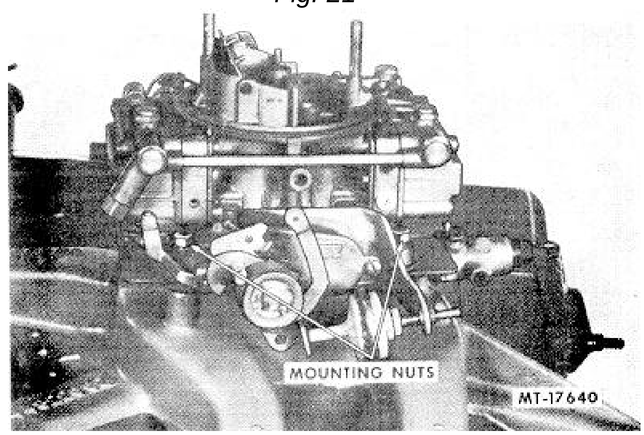

Fig. 22 Carburetor Removal

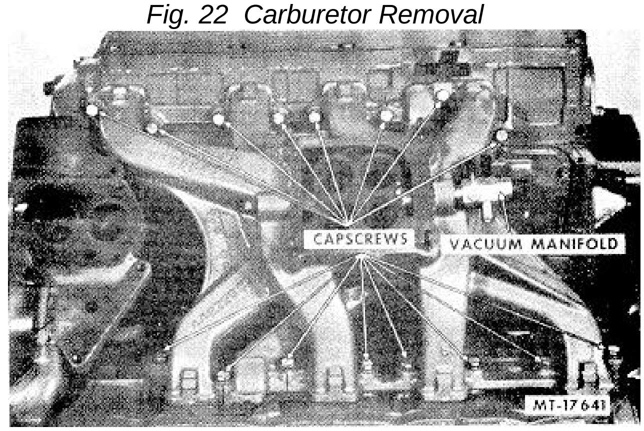

Fig. 23 Intake Manifold Removal

22. Remove air compressor oil drain line from "V" of engine (Fig. 24).

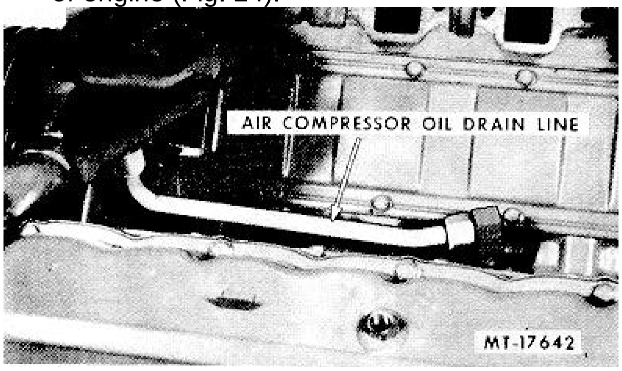

Fig. 24 Removing Air Compressor Oil Drain Line

23. Relieve tabs on left exhaust manifold using chisel or suitable tool (Fig. 25).

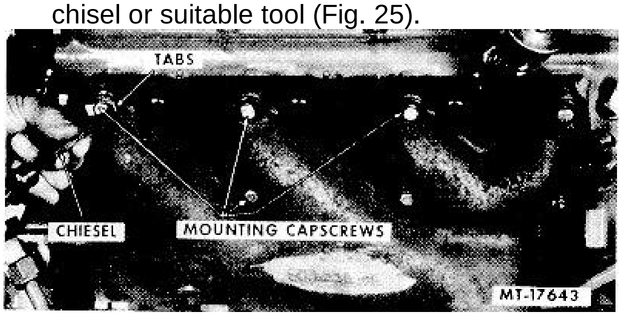

Fig. 25

24. Remove left exhaust manifold capscrews and then remove manifold and heat shield/gasket assembly.

25. Remove right bank water outlet by removing capscrews (Fig. 26).

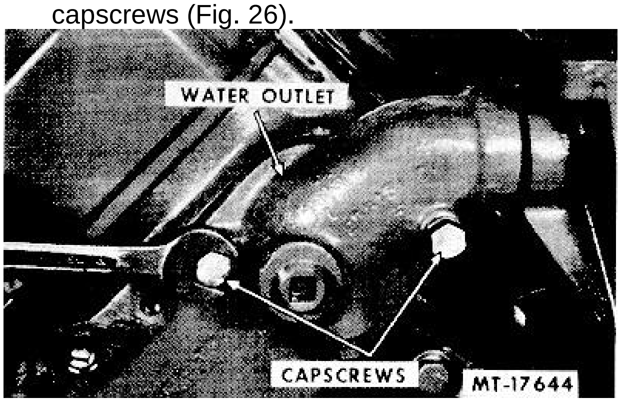

Fig. 26 Removing Right Bank Water Outlet

26. Remove right bank water outlet transfer tube with "O" rings (Fig. 27).

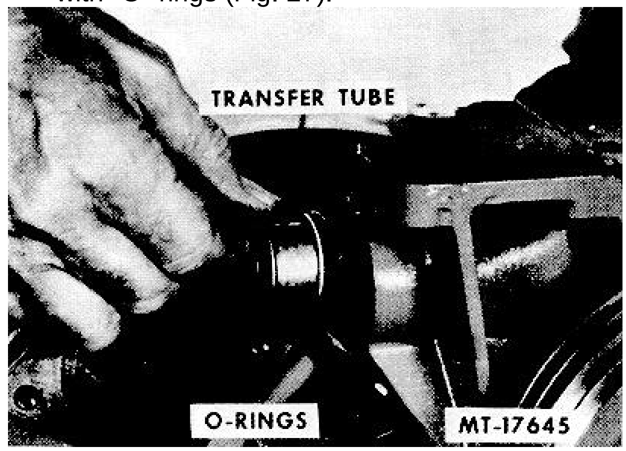

Fig. 27

27. Remove left bank water outlet and transfer tube with "O" rings.

28. Remove left cylinder head cover and gasket by removing mounting capscrews.

29. Loosen rocker arm mounting capscrews in preparation of removing the rocker arm assembly (Fig. 28). Remove rocker arm assembly from cylinder head.

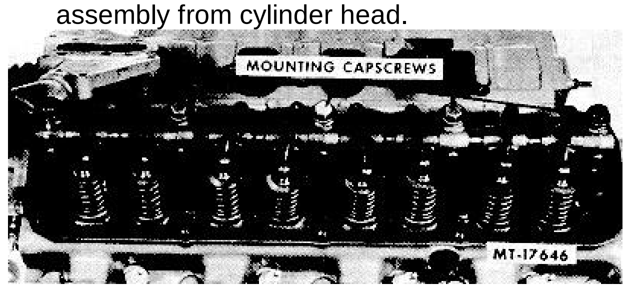

Fig. 28

30. Remove push rods from engine.

31. If no further disassembly is to be performed, use SE-1947 Remover to remove the hydraulic valve lifters or tappets (Fig. 29). If further disassembly is required, the tappets may be removed after the tappet covers are removed.

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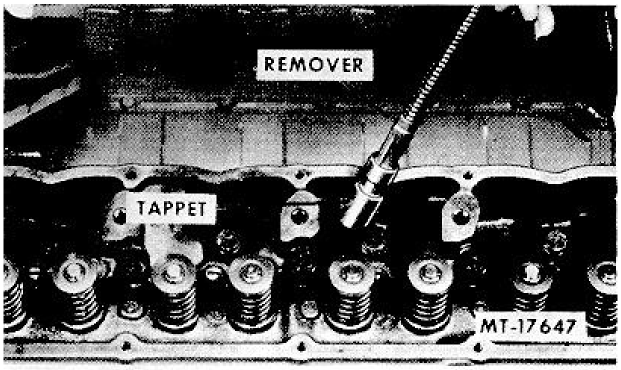


Fig. 29 Using SE-1947 Remover for Hydraulic Valve Lifters

32. Remove cylinder head bolts and using a sling, lift cylinder head off the two locating dowel sleeves (Fig. 30). Remove the cylinder head gasket.

    NOTE: Use extreme care when handling the cylinder heads to prevent damage to the gasket surfaces. Never pry between the cylinder heads and the block as they have a finished surface which must not be damaged.

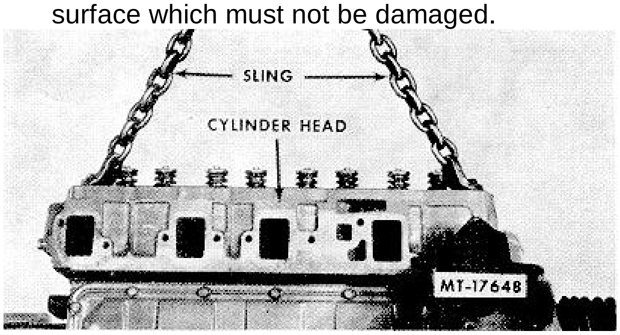


Fig. 30 Removing Cylinder Head

33. Repeat Steps 28 through 32 for the opposite bank.

34. Remove capscrews and remove tappet covers and gaskets (Fig. 31).

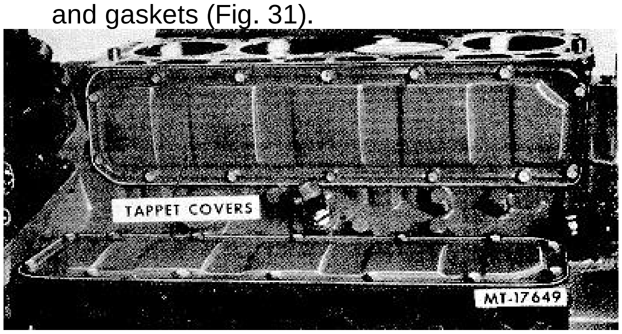


Fig. 31 Tappet Cover Removal

35. Removes tappets through tappet cover opening (Fig. 32).

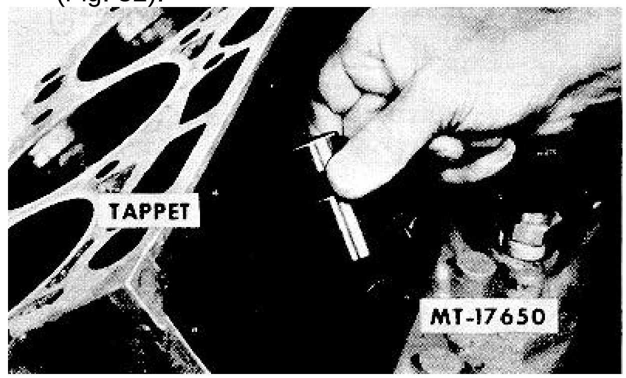


Fig. 32 Tappet Removal Through Cover Openings

36. Removal of clutch assembly:

    a. On the clutch plate shown in Figure 33, the clutch plate should be compressed with wood blocks (6 mm x 25 mm x 76 mm / 1/4" x 1" x 3") positioned between the clutch levers and backing plate. Use of these blocks eliminates the possibility of distorting the backing plate. Loosen the backing plate to flywheel retaining capscrews adjacent to each clutch lever only enough to wedge the wood block in position. Repeat this operation on each clutch lever. After all wood blocks are in place, remove all retaining capscrews and lift the clutch assembly from the flywheel.

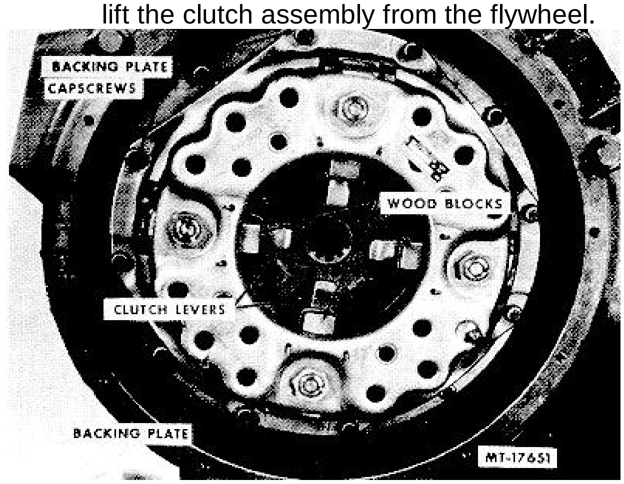


Fig. 33 Clutch Removal

b. On the clutch assembly shown in Figure 34, the clutch plate should be compressed with capscrews "A" piror to removing the mounting capscrews. Otherwise, it is possible to distort the backing plate. Loosen the clutch backing plate to flywheel retaining capscrews and remove the clutch assembly.

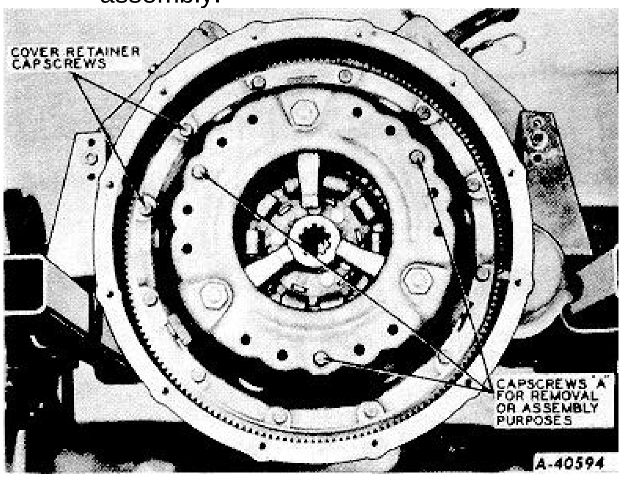


Fig. 34 Clutch Removal

37. Remove clutch pilot bearing using SE-1746 Puller with a slide hammer (Fig. 35).

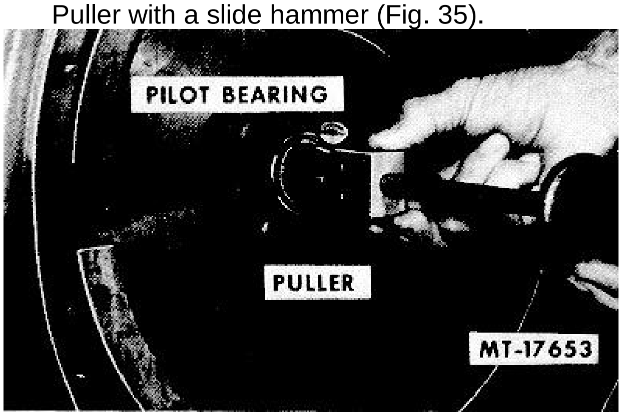


Fig. 35 Clutch Pilot Bearing Removal

38. Remove seven mounting capscrews and remove flywheel assembly and roll pin from the crankshaft flange (Fig. 36).

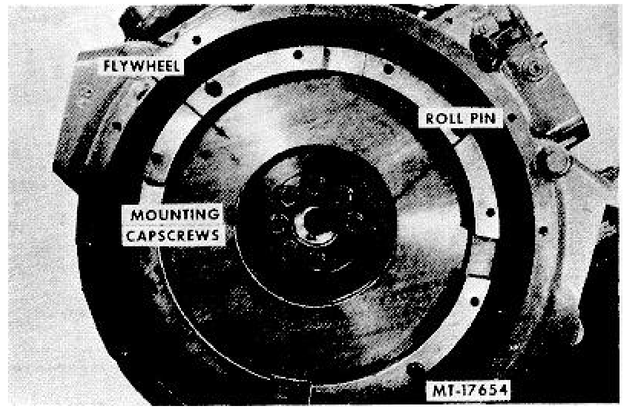


Fig. 36 Flywheel Removal

39. Remove six capscrews and flat washers and remove the flywheel housing (Fig. 37).

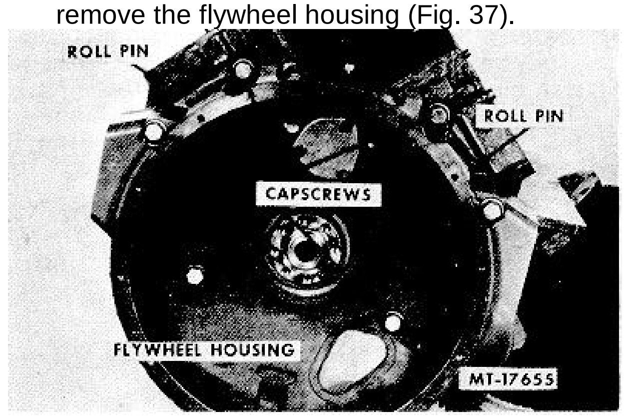


Fig. 37 Flywheel Housing Removal

40. Remove three capscrews and lockwashers and remove camshaft cover plate and gasket from end of block (Fig. 38).

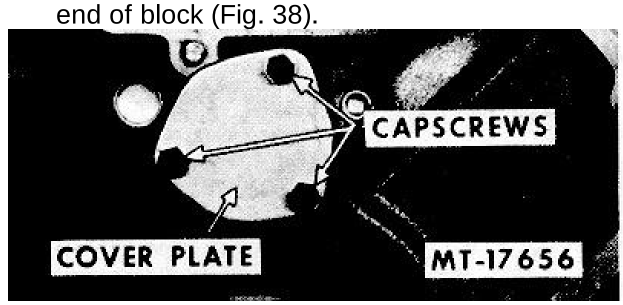


Fig. 38

41. Remove oil cooler lines and oil cooler with "O" rings (Fig. 39). Also remove outlet fitting to allow the removal of the front cover capscrew.

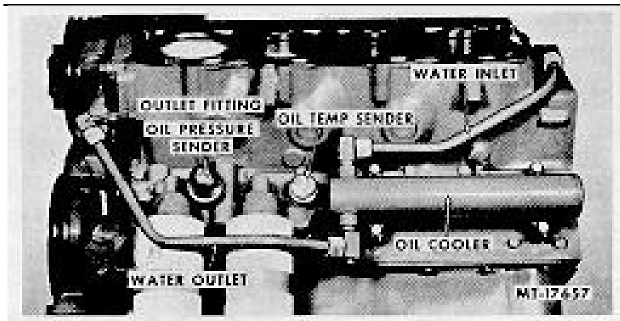


Fig. 39 Oil Cooler Removal

42. Remove oil filter and cooler base assembly with filter elements, temperature sender, pressure sender and gasket (Fig. 40).

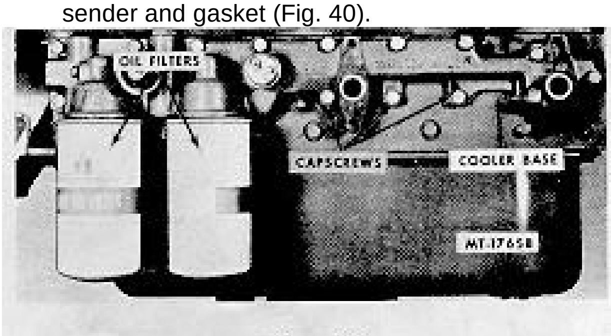


Fig. 40

43. Remove capscrews and washers and remove water pump pulley (Fig. 41).

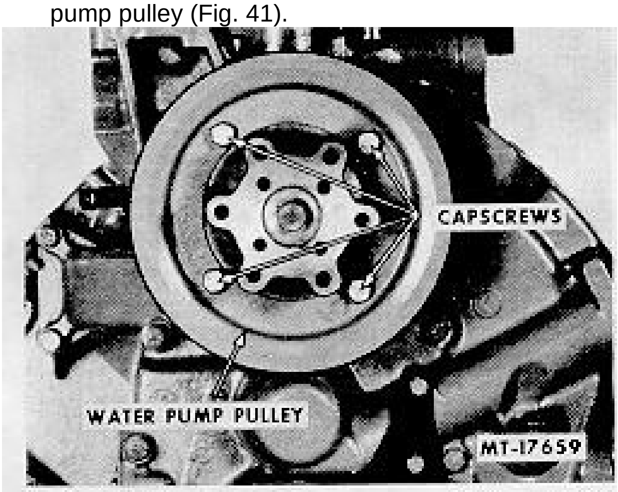


Fig. 41 Water Pump Pulley Removal

44. Remove water pump mounting capscrews and remove water pump and gasket (Fig. 42).

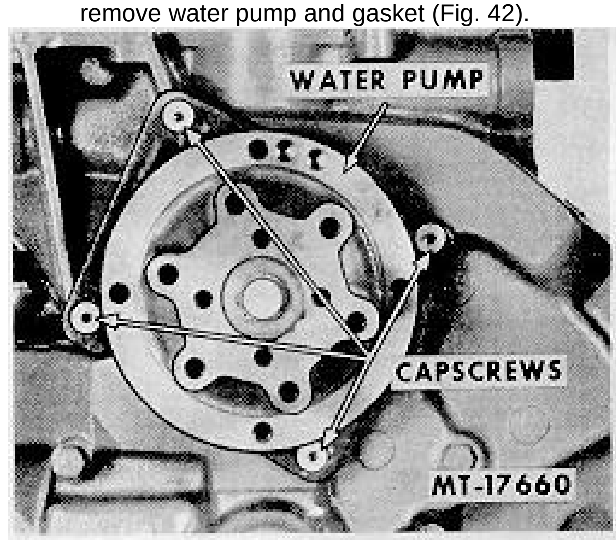


Fig. 42 Water Pump Removal

45. Remove twenty-three capscrews and remove oil pan and gasket.

46. Position a wood block between the crankshaft counterweight and crankcase and remove crankshaft pulley nut (Fig. 43).

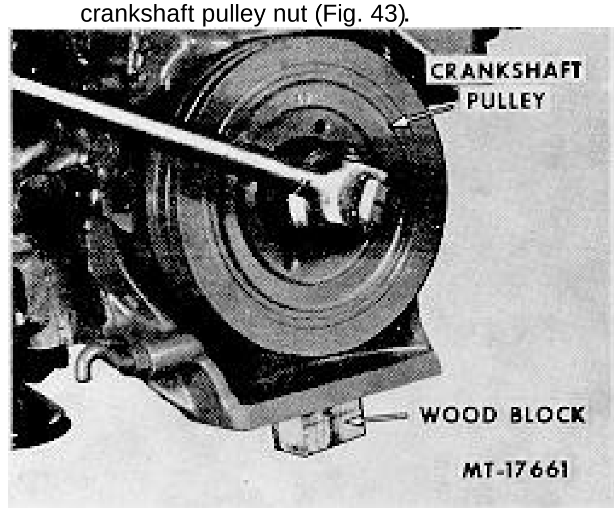


Fig. 43

47. Position wood block between crankshaft counterweight and crankcase to facilitate removal of crankshaft pulley using SE-1368 Puller (Fig. 44).

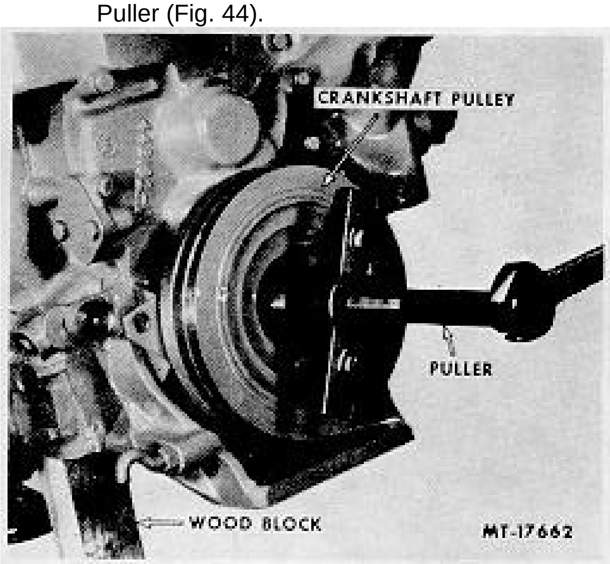


Fig. 44 Crankshaft Pulley Removal

48. Remove the engine front cover mounting capscrews from both the front (Fig. 45) and the back (Fig. 46) of the cover. Remove the front cover and gasket (Fig. 47).

NOTE: Where it is the desire to replace the engine front cover oil seal while the engine is in the chassis, it will be necessary to remove the hood, radiator shell, radiator

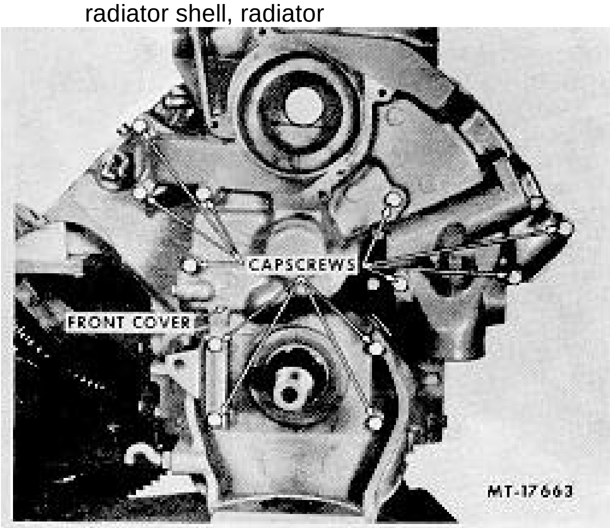


Fig. 45 Removing Capscrews In Front Of Front Cover

and crankshaft pulley. Then using SE-2091 Puller, remove seal (Fig. 48). To reinstall the seal, refer to ENGINE ASSEMBLY.

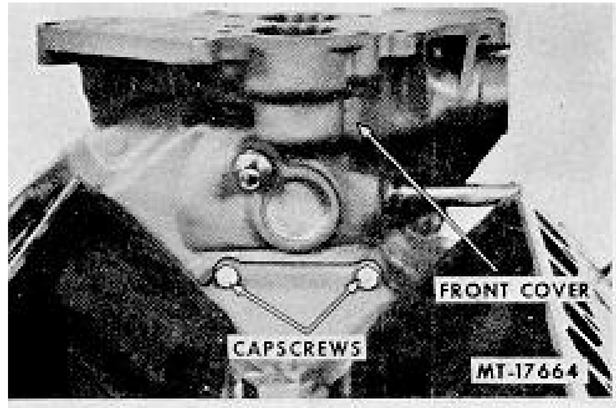


Fig. 46 Removing Capscrews in Rear of Front Cover

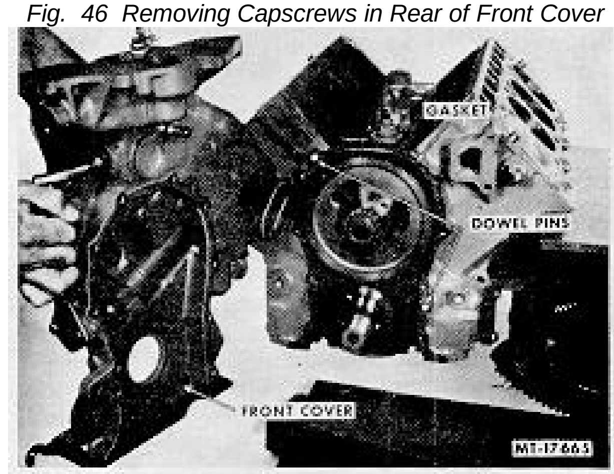


Fig. 47 Front Cover Removal

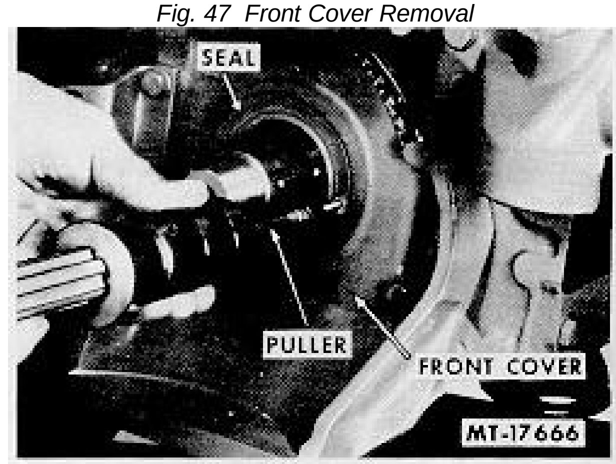


Fig. 48 Front Cover Oil Seal Removal With Cover Installed Using SE-2091 Puller

49. Remove mounting nuts, lockwashers, flat washers and bolts from oil pump screen brace and clamp. Remove brace and clamp (Fig. 49).

50. Loosen the oil pump mounting capscrews and remove the oil pump from the crankcase (Fig. 49).

NOTE: To permit oil pump removal, it is necessary to position the crankshaft rear counterweight away from the oil pump shaft.

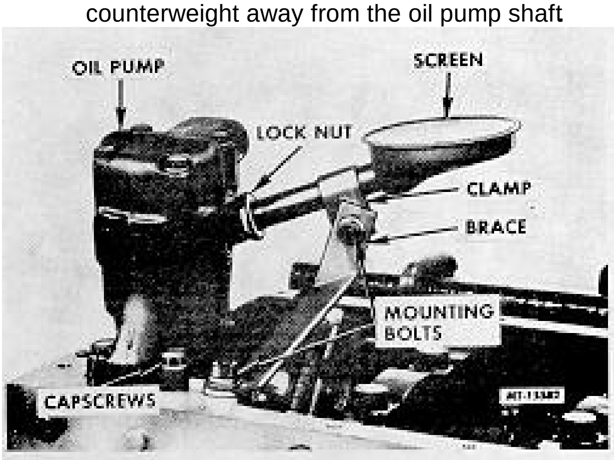


Fig. 49 Oil Pump Removal

51. Rotate the crankshaft and camshaft to insure the gears do not bind or interfere. With the use of a dial indicator (Fig. 50), check the timing gear backlash. See SPECIFICATIONS. If backlash exceeds the limit, new timing gears must be installed.

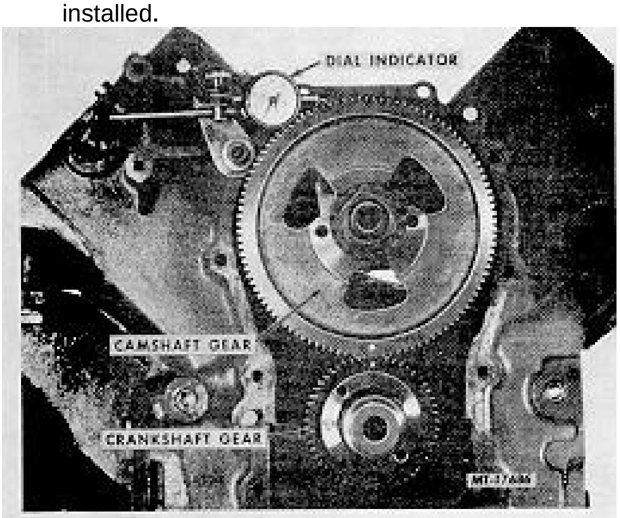


Fig. 50 Checking Crankshaft and Camshaft Backlash

52. With the use of a dial indicator (Fig. 51), check the camshaft end play. See SPECIFICATIONS. If end play exceeds the limits, replace the camshaft thrust flange.

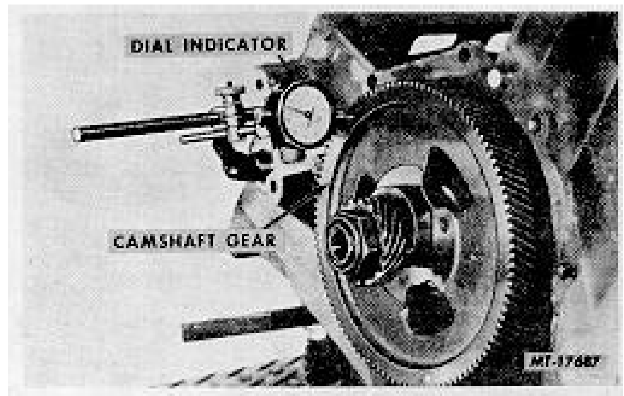


Fig. 51 Checking Camshaft End Play

53. Remove the camshaft thrust flange capscrews (Fig. 52).

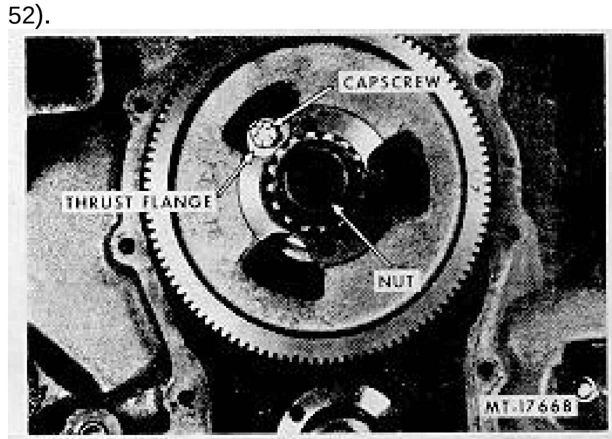


Fig. 52

54. Remove camshaft nut; then remove camshaft, gear and spacers as an assembly using SE-1880 Remover (Fig. 53).

NOTE: The distributor drive gear and the fuel pump cam are used as spacers in this application, as the fuel pump is an in-tank type and the distributor is located in the rear of the crankcase.

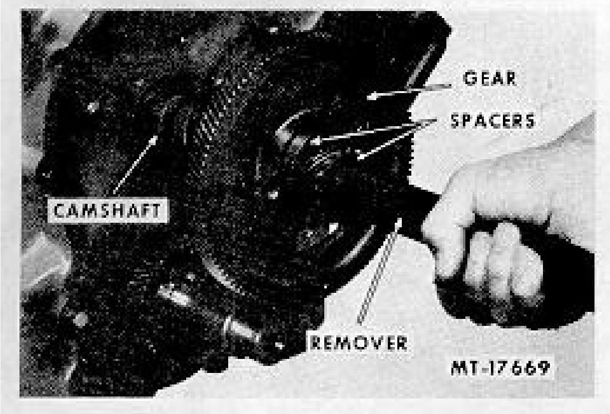


Fig. 53 Removing Camshaft Assembly Using SE-1880 Remover

NOTE: The camshaft gear, distributor gear (spacer) and fuel pump cam (spacer) can be removed without complete engine disassembly. They can be removed together using SE-1368 Puller (Fig. 54) or individually. If removed separately and the distributor gear and fuel pump cam cannot be removed by tapping with a nylon hammer, use SE-1368-5 Fingers on the distributor gear (spacer) and SE-1368-3 Fingers on the fuel pump cam (spacer) with SE-1368 Puller for removal. Then use SE-1880 Remover to remove camshaft after removing camshaft thrust flange capscrews.

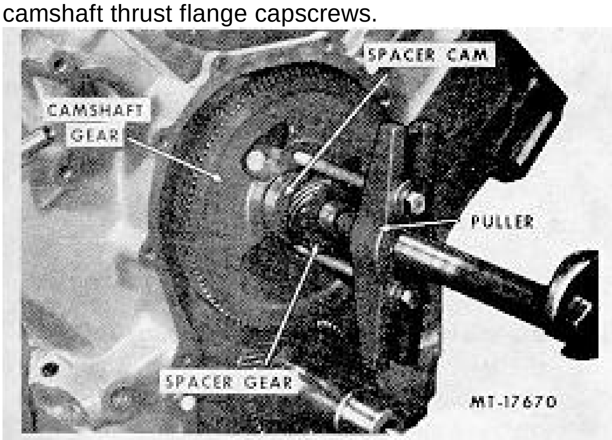


Fig. 54 Removing Camshaft Gear, Distributor Gear and Fuel Pump Cam Using SE-1368 Puller

55. At this point, the following inspections should be performed as outlined in detail in the CLEANING, INSPECTION and RECONDITIONING section.

    a. Check connecting rod end clearance.

    b. Check connecting rod bearing clearance.

56. Rotate the crankshaft to position the journals for removal of the connecting rod assemblies (Fig. 55).

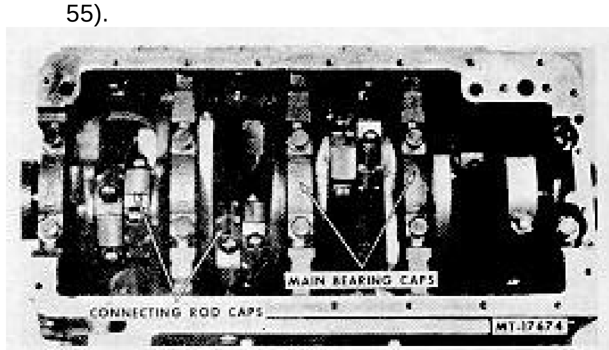


Fig. 55 Positioning Connecting Rods For Removal

57. Remove the cap and push the connecting rod and piston assembly from the cylinder bore (Figs. 56 and 57). Replace the cap and the bearing inserts on the rods so the numbered sides match. The assemblies are numbered so they can be installed in their respective cylinders.

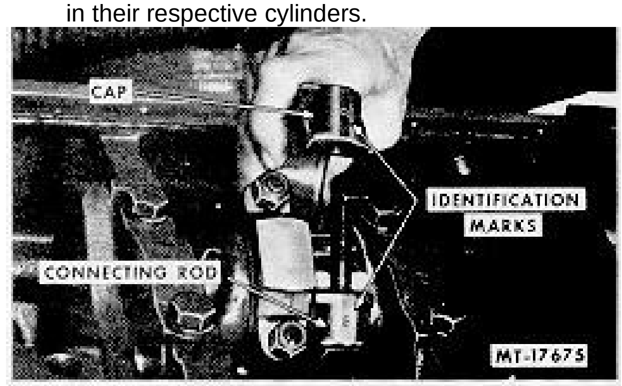


Fig. 56 Connecting Rod Removal

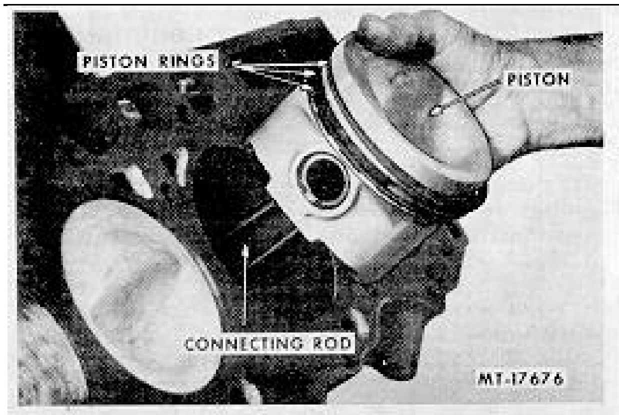


Fig. 57 Connecting Rod and Piston Removal

58. Crankshaft end play should be checked at this point with a dial indicator (Fig. 58). See SPECIFICATIONS. If the reading exceeds the limit, the third crankshaft bearing must be replaced so it controls the crankshaft thrust.

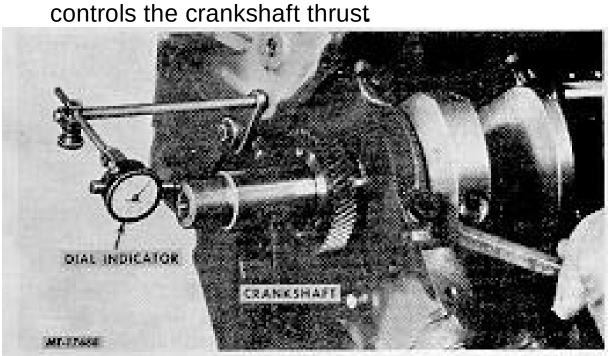


Fig. 58 Checking Crankshaft End Play

59. Remove crankshaft gear using SE-1368 Puller.

60. The crankshaft bearing caps are numbered to identify their position and must be reinstalled in their respective positions. The number three bearing cap accommodates a thrust flange to provide for crankshaft end play (Fig. 59).

    Remove the self-locking bolts and tie bolts with seal washers from each cap (Fig. 60).

    With the use of SE-2093 Remover and SE-1746 Slide Hammer, remove number 1, 2, 3 and 4 crankshaft main bearing caps (Fig. 61) by inserting hook end of remover in horizontal hole and toward centerline of crankshaft.

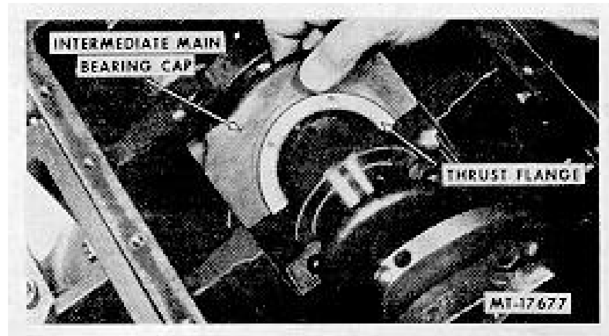


Fig. 59 Main Bearing Cap Removal

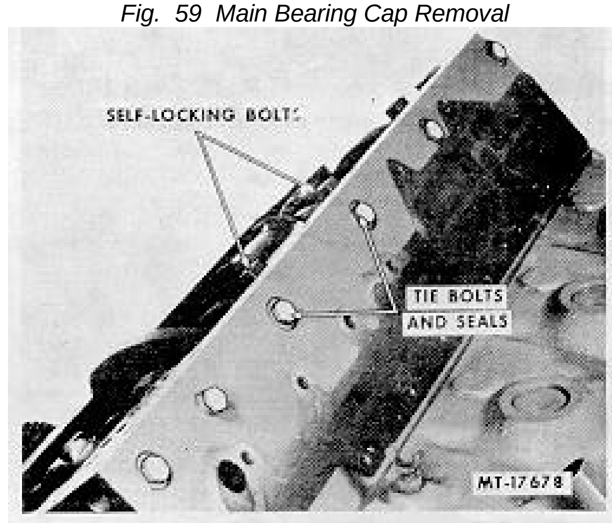


Fig. 60

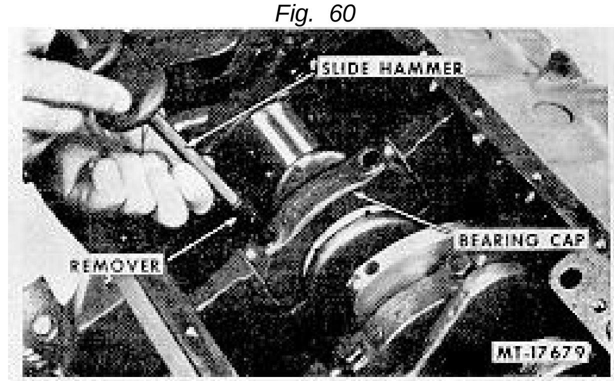


Fig. 61 Removing 1, 2, 3 and 4 Main Bearing Caps Using Slide Hammer SE-1746 and SE 2093 Remover

61. Remove the rear, or No. 5, main bearing cap using SE-1719 Puller and SE-1719-3 Adapter (Fig. 62).

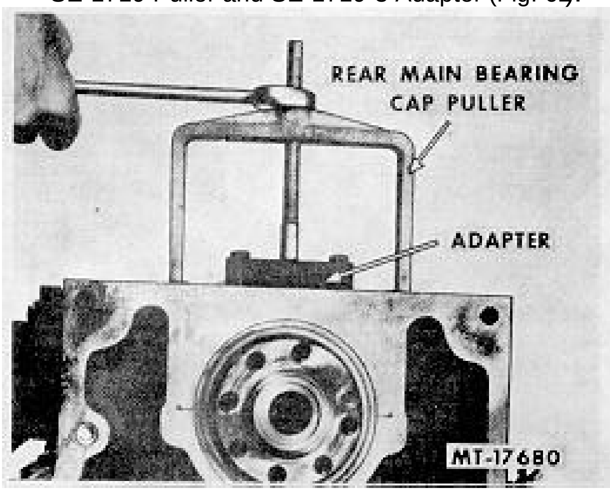


Fig. 62 Using SE-1719 Bearing Cap Puller and SE-1719-3 Adapter To Remove Rear Main Bearing Cap

62. Remove rear main bearing oil seal from end of crankshaft.

NOTE: The rear main bearing cap oil seal can be removed with the engine in the chassis, providing SE-2091 Remover is used (Fig. 63). This can be accomplished by piercing the seal with the point of the screw. Thread screw into seal and with slide hammer action, remove seal.

Fig. 63 Removing Rear Main Bearing Cap Oil Seal from Installed Crankshaft

63. Lift the crankshaft straight up and out of the crankcase.

CLEANING,INSPECTIONAND RECONDITIONING

CYLINDER BLOCK AND CAMSHAFT BEARINGS

A. General Cleaning and Measurement

One of the most important phases of engine reconditioning is the thorough cleaning and inspection of the cylinder block.

Each machined surface of the cylinder block should be cleaned of all old gasket material. The pipe plugs which seal the oil passages should be removed and all passages thoroughly cleaned

NOTE: An expansion plug must be removed in order to make the left rear oil passage pipe plug accessible.

If it becomes necessary to remove an expansion type plug due to water leaks, drill a 1/2" hole in the center of the plug and remove by prying with a screwdriver or suitable tool. When replacing the expansion plug, install the concave side of the plug on the interior of the cylinder block.

NOTE: Coat the edges of the plug with a suitable non-hardening sealing compound prior to installation.

The oil pump and distributor shaft upper bearing should be checked for correct size. The specifications of the lower portion of this bore is 12.332 mm to 12.383 mm (.4855" to .4875") inside diameter. If the diameter does not meet these specifications, the bearing should be replaced. Using a drift, carefully drive the bearing out of the crankcase from the under side.

When replacing the bearing, the rear face of the bearing must be parallel with the rear of the crankcase (Fig. 64). Press the bearing flush with the top of the crankcase. Aligning the rear face of the bearing parallel with the rear surface of the crankcase will permit aligning the oil hole in the bearing with the oil channel in the crankcase.

Inspection of the cylinder block should be done carefully to detect any scoring of the cylinder bores, cracks or water leaks. Small cracks may be found by coating the suspected areas with a mixture of light motor oil and kerosene. After wiping the area dry, immediately

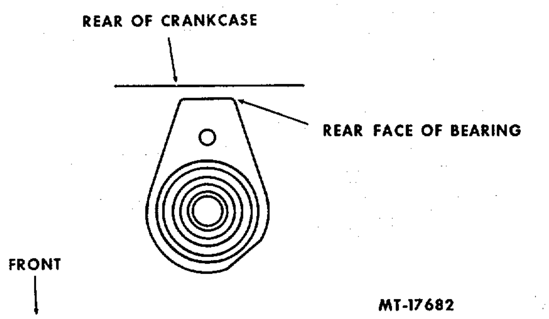


Fig. 64. Installation of Oil Pump and Distributor Shaft Bearing in Crankcase

apply a coat of quick-drying liquid such as zinc oxide powder mixed with wood alcohol. Wherever cracks are present, a brown discoloration will appear in the white coating.

NOTE:

Prior to bore measurement or bore rework, the main bearing caps must be in place and the cap and tie bolts tightened to specified torque. See TORQUE CHART.

Each cylinder bore should be checked with an inside reading micrometer SE-686 or dial bore gauge SE-2331 to determine taper, out-of-round or worn condition (Fig. 65). Measure the diameter of the cylinder bore at the too of the piston

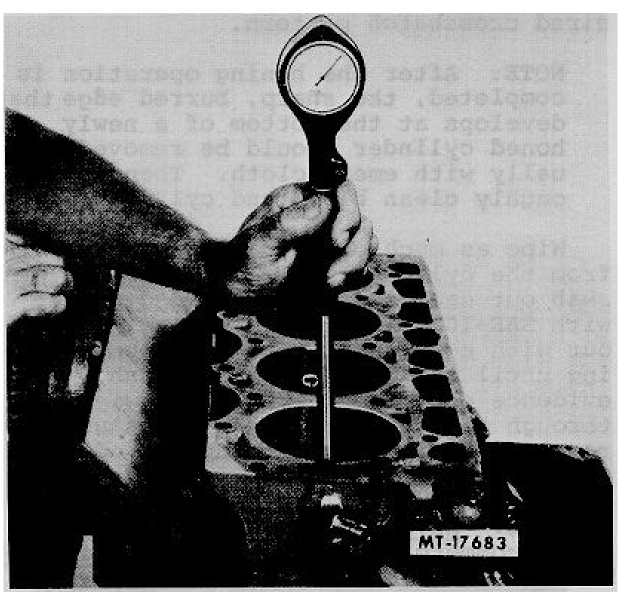


Fig. 65. Checking Cylinder Bore using Dial Bore Gauge SE-2331

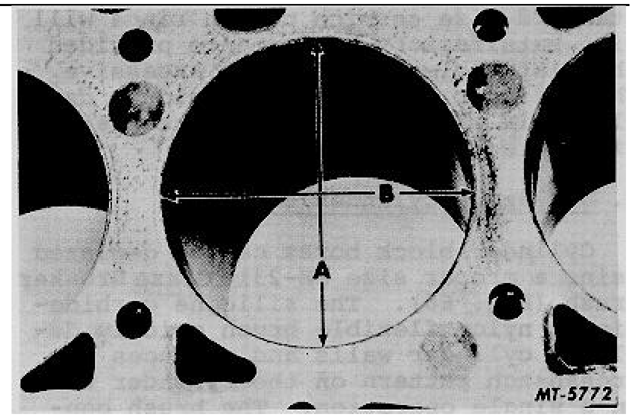


Fig. 65 Checking Cylinder Bore Using Dial Bore Gauge SE-2331

ring travel at right angle "A" (Fig. 66) to the centerline of the crankshaft. Record the reading.

Next, measure each bore so the gauge reading coincides with the centerline "B" (Fig. 66) of the crankshaft. The difference between the "A" and "B" readings is the out-of-round condition at the top of the cylinder bore. Repeat the same procedure at the bottom of ring travel to check for out-of-round.

The difference between the diameters measured at the top "A" (Fig. 67) and bottom "A' " (Fig. 67) of the bore (at right angles to the centerline of the crankshaft) is the taper of the bore.

If the cylinder bore wear does not exceed the limits of 0.05 mm (.002") out-of-round and 0.127 mm (.005") taper, new

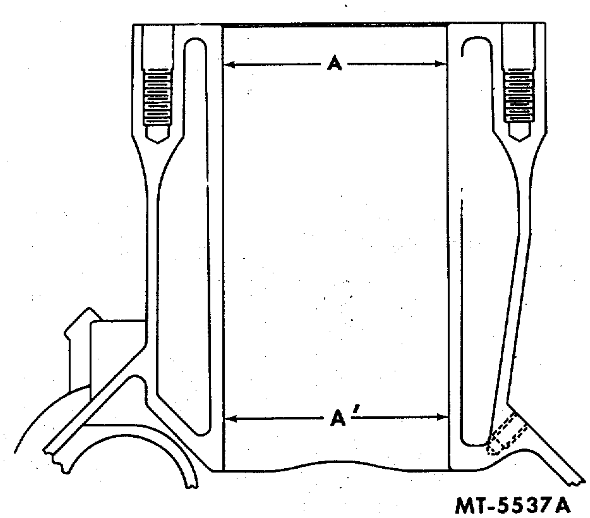


Fig. 67 Checking Cylinder Bore Taper

standard size service piston rings will give satisfactory performance provided the piston clearance is not excessive. The cylinder block bores should be deglazed if standard size service piston rings are to be installed.

B. Deglazing Cylinder Bores

Cylinder block bores can be Reglazed using a proper size SE-2314 Glaze Breaker Brush (Fig. 68). The silicone carbide tipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on the cylinder wall in a single operation. The brush conours itself to the cylinder wall and conditions the wall surface without altering the cylinder bore.

The glaze breaker brush is used in conjunction with a low RPM drill (350 -500 RPM). Most 3/8 inch capacity electric drills are satisfactory for driving the brushes.

A lightweight engine oil (SAE-30) should be used with the brush for lubrication. The lubricant also collects airborne abrasive particles and allows for easy particle removal with a cloth.

Stroke the brush up and down in the bore at a rate of 30-40 strokes per minute for 15-20 seconds per cylinder bore. In most instances 20 seconds is adequate time for the brush to break cylinder wall glaze and produce a crosshatch pattern on the cylinder wall surface.

Thoroughly clean cylinder bore walls after Reglazing. Wipe as much of the abrasive deposits from the wall as possible. Then swab out each abrasive coated cylinder with SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white

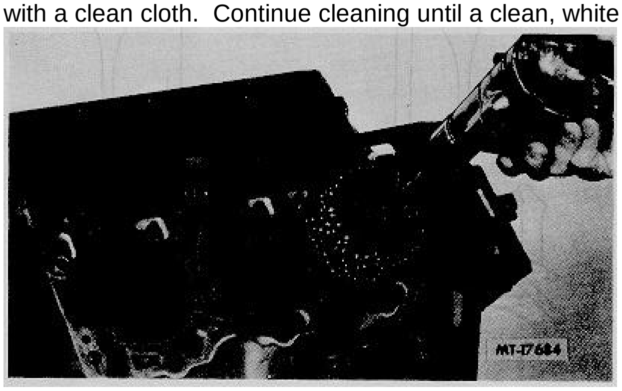


Fig. 68 Cylinder Bore Deglazing

cloth shows no evidence of discoloration when wiped through the cylinder bore. This usually requires three or more complete operations.

NOTE:

Never use gasoline, kerosene or commercial cleaner to clean cylinders. Solvents of this nature will not remove abrasives from the walls which will result in rapid engine wear and ring failure.

C. Reboring and Honing Cylinder Bores

If the wear exceeds the limits, it will be necessary to rebore the cylinder or cylinder bores to oversize diameter. Before attempting to rebore or hone the cylinders, the main bearing caps must be in place and the cap and tie bolts tightened to specified torque, otherwise bore distortion will result.

When oversizing cylinders, bore to within .076 mm (.003") of required oversize diameter (Fig. 69). This will allow enough stock for the final step of honing the bores so the exact clearance may be obtained for the selected oversize piston (Fig. 70).

When performing the honing operation, the hone should be stroked up and down to produce a crosshatch pattern on the cylinder wall (Fig. 71). The faster the hone rotates, the faster it must be stroked up and down to produce the desired crosshatch pattern.

NOTE:

After the honing operation is completed, the sharp, burred edge that develops at the bottom of a newly honed cylinder should be removed manually with emery cloth. Then thoroughly clean block and cylinder bores.

Wipe as much of the abrasive-deposits from the cylinder wall as possible. Then swab out each-abrasive-coated cylinder with SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white cloth shows no evidence of discoloration when wiped through the cylinder bore. This usually requires three or more complete operations.

NOTE:

Never use-gasoline, kerosene or commercial cleaner-to clean cylinders. Solvents of this nature will not remove abrasives from the walls which will result in rapid engine wear and ring failure

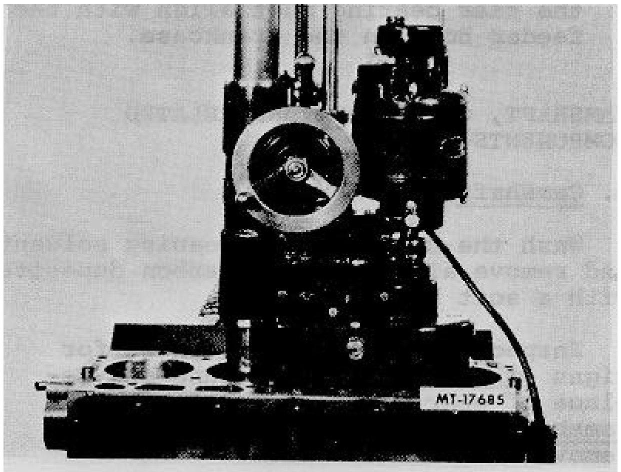


Fig. 69 Reboring Cylinder Using SE-13 Boring Machine

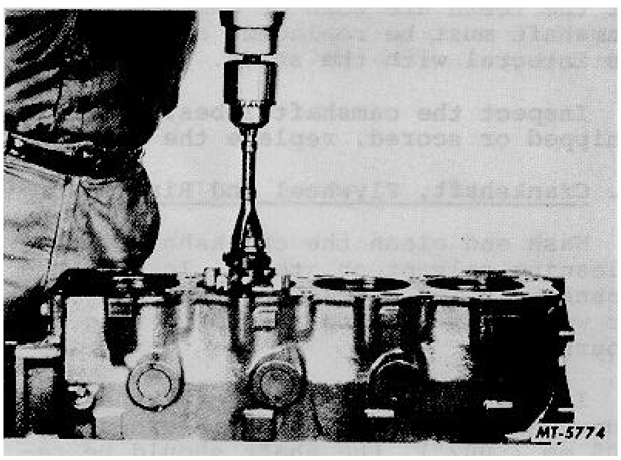


Fig. 70 Honing Cylinder Bore Using SE-784 Cylinder Grinder

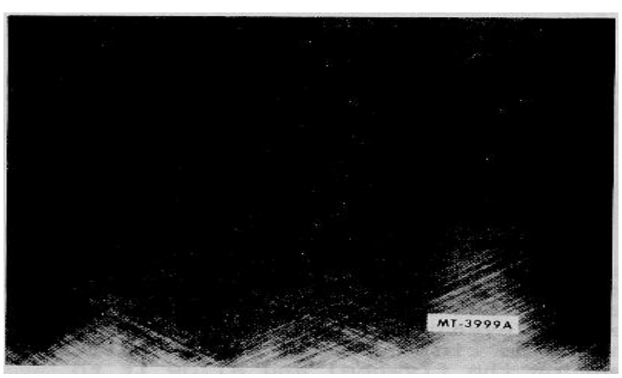


Fig. 71 Proper Honing Leaves a Crosshatch Pattern on Cylinder Wall

D. Camshaft Bearing Removal and Installation

Inspect the camshaft bearings for wear and proper running clearance. See SPECIFICATIONS. If the limits are excessive, replace the bearings. This can be accomplished with the special camshaft bearing remover and installer (SE-1897) and the slide hammer and adapter from puller set SE-1879.

The following steps should be followed when performing this operation.

1. Position the front adapter, SE-1897-3, in the front bearing (Fig. 72).

2. Position the second adapter, SE-1897-4, in the second bearing (Fig. 72).

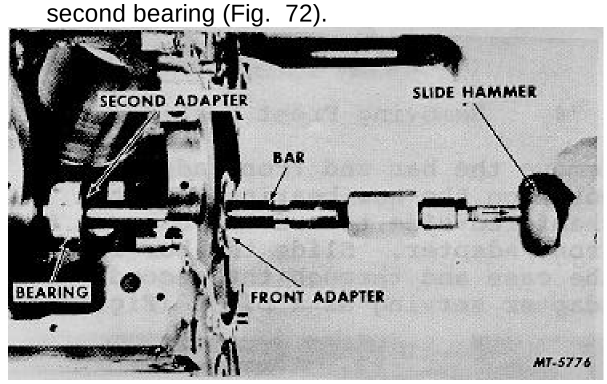


Fig. 72 Removing Second Bearing

3. Install the bar through the adapters and lock the second adapter on the bar with a "C" washer, SE-1897-2.

4. Using the front adapter as a pilot, pull the second bearing with the slide hammer (Fig. 72).

NOTE:
Always hold the adapter firmly against the bearing being removed or installed to avoid damage.

5. Position the new bearing on the second adapter and "C" washer in front of the adapter (Fig. 73). Align oil hole and push in the second bearing

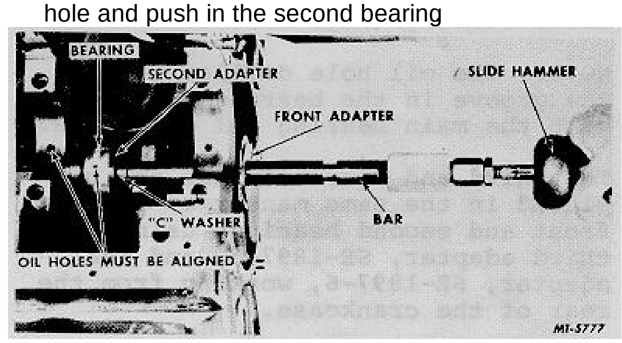


Fig. 73 Installing Second Bearing

6. Remove the "C" washer and use the second adapter as a pilot. Remove the front bearing by driving the bearing into the case (Fig. 74).

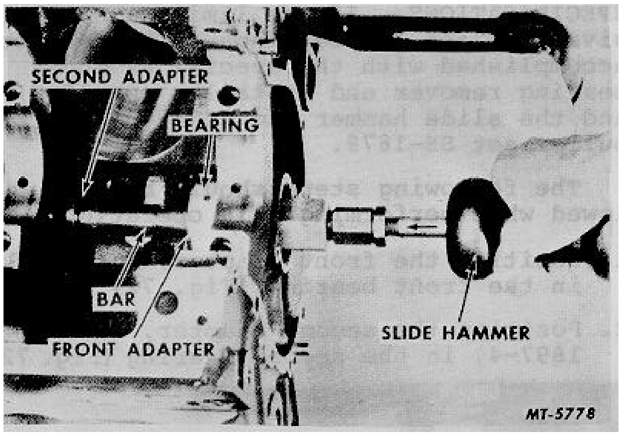


Fig. 74 Removing Front Bearing

7. Remove the bar and front adapter and position the new bearing with the chamfered side toward the case on the front adapter. Slide the bar into the case and through the second adapter serving as a Allot (Fig. 75).

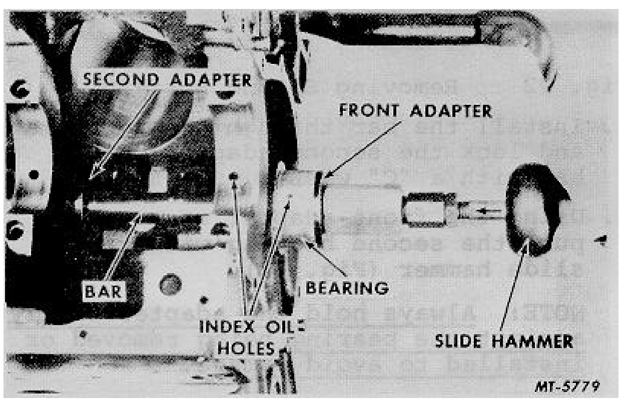


Fig. 75 Installing Front Bearing

8. Align the oil holes and drive in the front bearing (Fig. 75).

NOTE:
The oil hole drilled through the groove in the bearing must align with the main bearing oil feed-hole.

9. The third and rear bearings are replaced in the same manner as the front and second bearings using third adapter, SE-1897-5, and rear adapter SE-1897-6, working from the rear of the crankcase.

NOTE:
The oil hole in the groove of the rear bearing must align with the feeder hole in the crankcase.

CAMSHAFT, CRANKSHAFT AND RELATED COMPONENTS

A. Camshaft

Wash the camshaft in cleaning solvent and remove all sludge or carbon deposits with a soft brush. -

Inspect the camshaft journals for signs of wear or out-of-round and replace if wear warrants. Refer to Camshaft Bearing Section for bearing removal and installation.

Check the oil pump and distributor drive gear on the rear of the shaft. If the teeth are worn or damaged, the camshaft must be replaced, as the gear is integral with the shaft.

Inspect the camshaft lobes. If worn, chipped or scored, replace the camshaft.

B. Crankshaft, Flywheel and Ring Gear

Wash and clean the crankshaft with cleaning solvent or steam. Inspect the crankshaft for cracks, scored, grooved or worn main bearing and connecting rod journals.

If the journals on the crankshaft show wear or out-of-round in excess of .05 mm (.002"), the shaft should be reground and under size bearings installed or replaced. Use micrometers for checking these measurements.

Clean the flywheel and ring gear with a cleaning solvent, removing ail traces of oil and grease. Inspect the flywheel ring gear. If any teeth are damaged or if the ring gear is loose on-the flywheel the ring gear must be replaced. Check the flywheel mounting bolt holes for wear; also check mounting face of flywheel for indications of looseness.

To replace the flywheel ring gear, heat the gear wither torch and remove it from the flywheel with a hammer and drift. Heat the new ring gear with a torch, heating evenly all the way around. While the ring gear is hot, install the gear on the flywheel and allow it to cool.

C. Crankshaft Bearings

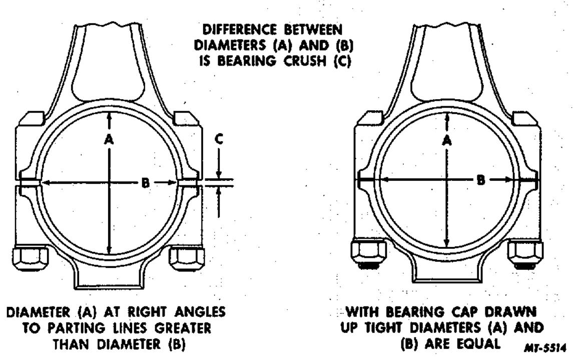
The bearing inserts used in this engine are selective fit and require no line reaming upon installation. The bearings are available for service in standard sizes and undersizes for use on journals that have been reground.

If inspection reveals badly worn or scored bearings, replace the bearings. The installation of new bearings must be closely checked to maintain the proper clearance between the journal and the bearing surface. A convenient and accurate method for checking the clearance is with the use of Plastigage.

1. General Fitting Procedures

When wear increases the bearing-to crankshaft running clearance, undersize precision-type bearing shells should be installed. Premature bearing failure will result from attempts to reduce journal-to-bearing running clearance by reworking bearing caps, bearings or both Such reworking will alter the engineered fit of the bearing shells in their bores and destroy the specifically desired "crush."

When installing precision-type connecting rod or main bearings, it is important the bearing shells fit tightly in the bore. The bearing manufacturer makes the diameter at right angles to the parting line slightly larger than the actual diameter of the bore into which they are assembled to accomplish this. When the assembly is drawn up tight, the bearing is compressed assuring a positive contact between the bearing back and the bore. This in-creased diameter is referred to as bearing "crush" (Fig. 76).



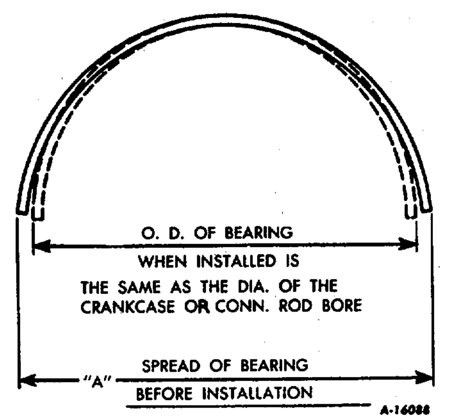
To obtain proper bearing assembly with the correct "crush," care must be taken when tightening the clamping bolts and nuts. They should be drawn down alternately and evenly to specified torque using a torque wrench. See SPECIFICATIONS.

NOTE:

Rods, caps or block must not be filed, lapped or reworked in any manner to reduce clearance. While such practice will make a tighter fit at the top and bottom, it will also result in an out-of-round bore and bearing shell distortion.

Main and connecting rod bearings are designed with the "spread" (width across the open ends) slightly larger than the diameter of the crankcase bore or connecting rod bore into which they are assembled. For examples, the width across the rod bearing not in place is approximately .635 mm -(.025") more than when the bearing is in position (Fig. 77). This condition is designed into the bearing to cause it to spread outward at the parting line when "crush" load is applied by tightening the nuts and bolts. Some of this "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition.

This condition causes the bearing to fit snugly in the respective bore. The bearing must be "snapped" or lightly forced into its seat.



BEARING SPREAD DIMENSION

	Bearing O.D. (Installed)	Specified Spread	Spread of Bearing "A" (Fig. 77)
Rod Bearings:	7.051 cm (2.776")	.076 cm - .114 cm (.030" - .045")	7.127 cm - 7.165 cm (2.806" - 2.821")
Main Bearings: No. 1, 2, 4 & 5	8.425 cm (3.317")	.076 cm - .114 cm (.030" - .045")	8.501 cm - 8.539 cm (3.347" - 3.362")
No. 3 (Thrust)	8.425 cm (3.317")	.005 cm - .038 cm (.002" - .015")	8.430 cm - 8.463 cm (3.319" - 3.332")

2. Fitting Main Bearings

To obtain an accurate reading using the Plastigage method of checking, all bearing caps and tie bolts must be in place and torqued to specifications.

a. Remove one bearing cap and insert Remaining caps are left tight while] checking the fit of this bearing.

b. Wipe the oil from all contact surfaces such as crankshaft journal, bearing insert, bearing cap, etc.

c. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately .63 mm (.25") off center. Tap bearing cap on with soft hammer until it just meets the mating surface of the crankcase. With the cap lined up with the back face of the crankcase, install ca bolts finger tight. Then install the tie bolts finger tight. Torque the cap bolts and tie bolts to proper torque according to notes on TORQUE CHART.

NOTE: Do not turn crankshaft while making check with Plastigage.

d. Remove bearing cap bolts; then loosen the tie bolts and remove bearing cap and insert. -

e. Do not disturb Plastigage. Using the Plastigage envelope, measure the widest point of the Plastigage (Fig. 78). This reading indicates the bearing clearance in thousandths of an inch.

NOTE: If the above procedure is not followed when checking bearing clearance with Plastigage, an inaccurate reading will be obtained.

f. If the bearing clearance is not within specifications, the crankshaft must be reground and undersize bearings installed. The third crankshaft bearing controls the crankshaft thrust and provides initial location of the crankshaft in relation to the crankcase. Use a dial indicator to check end play as shown in Fig. 58 of DISASSEMBLY OF ENGINE.

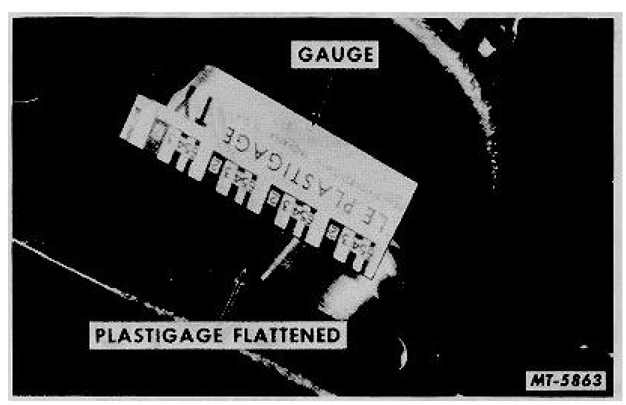


Fig. 78 Checking Main Bearing Clearance

3. Fitting Connecting Rod Bearings

a. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.

b. Place a piece of Plastigage on the bearing surface the full width of the bearing about .63 mm (.25").

c. Install cap and tighten bolts and nuts to specified torque (see TORQUE CHART).

NOTE:
Do not turn crankshaft while Plastigage is in place.

d. Remove bearing cap and use Plastigage scale to measure the widest point of Plastigage (Fig. 79). This reading indicates the bearing clearance in thousandths of

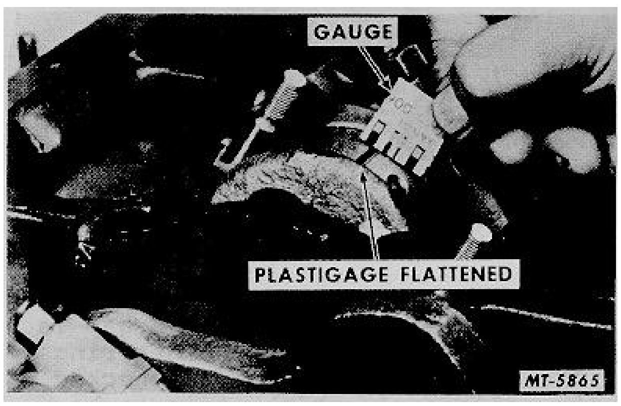


Fig. 79 Checking Connecting Rod Bearing Clearance

e. Check the connecting rod end clearance using a feeler gauge as shown in Figure 80. Excessive clearance may require replacement of rods or shaft. The check should be made to make certain that the specified running clearance exists. Lack of clearance could indicate a damaged rod or perhaps a rod bearing out of position.

Fig. 80 Checking Connecting Rod End Clearance

D. Piston and Connecting Rod Assembly

1. Disassembly and Cleaning

The piston and connecting rod assemblies should be removed from the cylinder block as explained in Steps 56 and 57 of DISASSEMBLY OF ENGINE.

To disassemble the piston from the connecting rod assembly, remove the piston pin retaining snap rings (one on each side of piston) by using snap ring removing pliers, SE-1884, and piston vise, if available (Fig. 81).

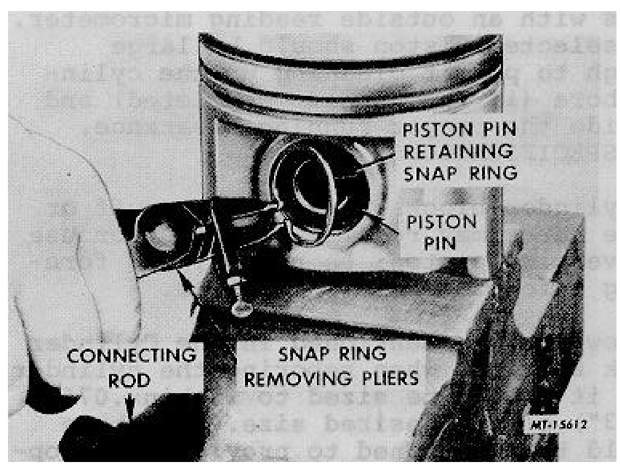


Fig. 81 Piston Pin Retainer Removal

Push the piston pin out with thumb. If pin does not come out easily, use a piston pin remover, SE-1888, or suitable tool to remove pin. After the pin is removed, separate the piston from the connecting rod, taking precautions to see the parts are marked so they may be installed in their respective cylinders, unless defective.

Remove all old rings and immerse all parts of the piston in cleaning solvent and clean thoroughly. Use a special ring groove cleaner or broken piston ring to clean all carbon from the piston ring grooves. Make sure all oil holes are open.

NOTE:
Never use a caustic solution for cleaning aluminum pistons.

2. Piston and Piston Pins

Inspect the pistons and pins for any wear, corrosion or etching condition. Discard any that reveal any conditions of this nature.

To select the correct size pistons for an engine overhaul, the size of the cylinder bore diameter must first be determined. See Figs. 65, 66 and 67 with accompanying text in CLEANING, INSPECTION AND RECONDITIONING covering Cylinder Block.

After the cylinder bores have been measured and recorded, select a piston to fit a certain bore. This is accomplished by measuring the piston at the bottom of the skirt across the thrust faces with an outside reading micrometer. The selected piston should be large enough to permit cleaning up the cylinder bore (if not already completed) and provide the proper running clearance. See SPECIFICATIONS.

Cylinder blocks having deep scuff or score marks may require reboring for use of oversize piston; therefore, the foregoing information still applies.

However, as mentioned in the Cylinder Block section, when reboring the cylinder bore it should be sized to within .076 mm (.003") of the desired size. The bore should then be honed to provide the proper finish on the cylinder wall, as well as the correct running clearance for the piston selected.

3. Piston Rings

The pistons used in the "V" type engines have three piston rings (see SPECIFICATIONS), located above the-piston pin. The compression rings are located in the top grooves while the lower groove accommodates the oil control ring Select the proper rings for the piston to be used.

Prior to installing the rings on the pistons, each ring must be checked for proper ring gap. Push the ring down into the cylinder bore, making sure the ring is square with the cylinder wall. Check the space or gap between the ends of the ring with a feeler gauge (Fig. 82). See SPECIFICATIONS.

NOTE:
Extreme care should be taken during this operation.

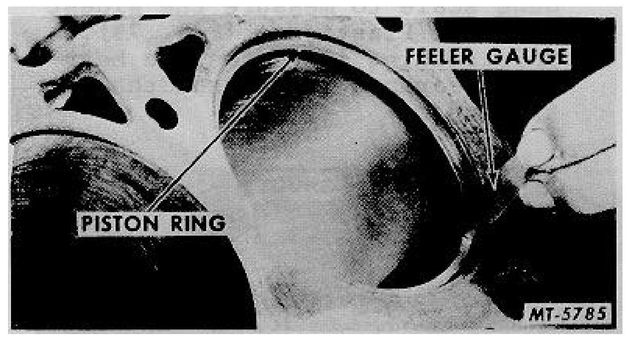


Fig. 82 Checking Ring Gap

On compression rings, if the gap is less than the limit, try another ring for fit. Each ring should be checked in the cylinder in which it is to be used and marked accordingly.

Piston rings should be checked for side clearance in the groove of the piston on which they are to be installed. This is done by placing the outer edge of the ring in the piston groove, rolling the ring entirely-around the piston to make sure there is no binding and the ring is free in the groove. With a feeler gauge, check the side clearance of each ring in its respective groove (Fig. 83). See SPECIFICATIONS.

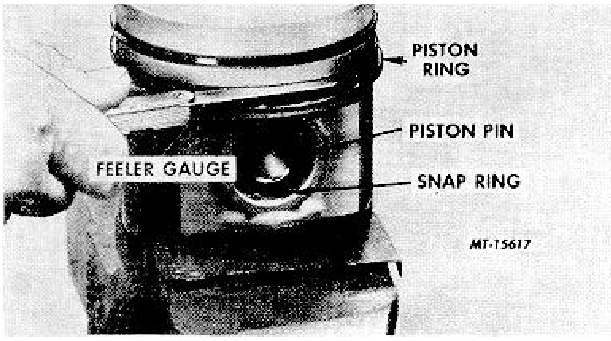


Fig. 83 Checking Ring-to-Groove Side Clearance with Feeler Gauge

Assemble the rings on pistons to which they were fitted by using a piston ring expander tool. This tool is recommended to avoid over-expanding and distortion (Fig. 84). General practice is to stagger the ring gaps. For further information, refer to the instructions furnished with the service ring sets.

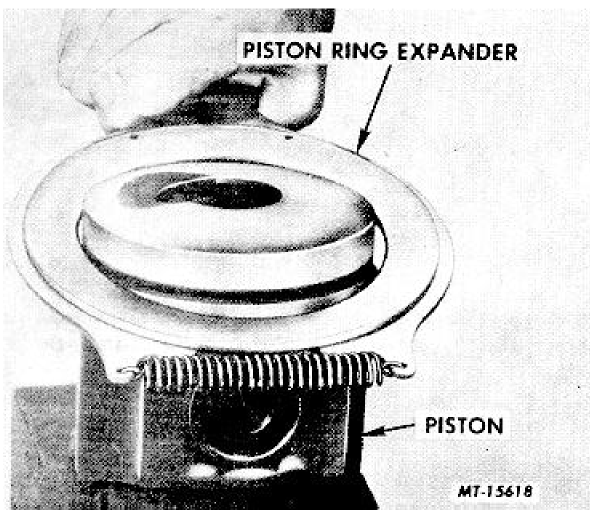


Fig. 84 Installing Piston Ring Using SE-1149 Piston Ring Expander Tool

4. Connecting Rod

a. Inspection

After the piston has been removed from the connecting rod, the rod should be thoroughly inspected for defects. The connecting rod bushing should be checked for proper clearance with the piston pin. See SPECIFICATIONS. If inspection shows the piston pin bushing is worn, the bushing must be removed as described later in this section.

Connecting rods may be checked for alignment using SE-1099 checking fixture.

The pin and bearing bores must be parallel within .013 mm (.0005"). Follow tool manufacturer's instructions supplied with equipment for checking alignment.

The connecting rod bearing plays a major role in distributing the proper amount of oil to the piston pin bearing surfaces, cylinder walls, piston and piston rings. This is known as oil throw-off. The condition of the connecting rod bearing determines how well the lubrication operation is performed.

The bearing-to-crankshaft clearance affects the volume of oil throw-off. Where the bearing clearance is more than specified, an abnormal amount of oil is thrown onto the cylinder walls causing increased oil consumption and low oil pressure due to oil passing through the bearing surfaces too quickly. Where bearing clearances are less than specified, the oil that passes through the bearing is insufficient to properly cool the bearing. This results in short bearing life and improper oil throw-off to the cylinder walls, piston pins and piston rings. See SPECIFICATIONS. This condition contributes to scoring of pistons and cylinder walls.

If the connecting rod bore is stretched or out-of-round beyond the specified diameter, the insert will be out-of-round and will not be held securely in the connecting rod, since the "crush" may be lost. Bearing failures can result from localized bearing loads or from low oil pressure. The bearing insert tangs will keep the inserts from turning in the connecting rod bore under normal conditions but may move and fail due to the foregoing reasons.

When installing new connecting rod bore inserts, a very thorough inspection of the connecting rod bore is necessary. This inspection consists of the following:

(1) Bore Size: To obtain the proper bearing insert crush, the bore must be of a specified size (Fig. 85). See SPECIFICATIONS.

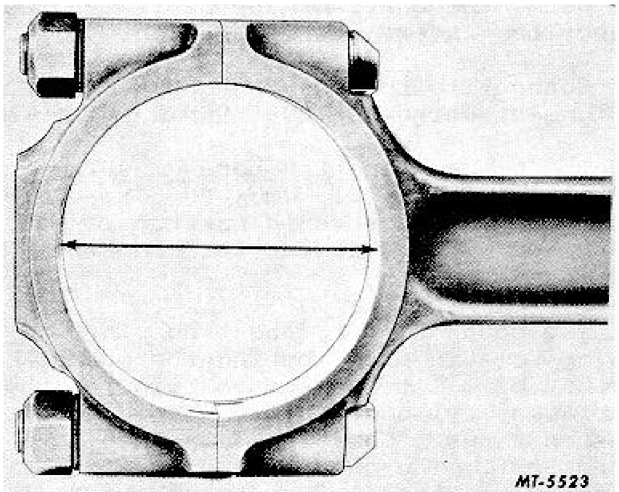


Fig. 85

(2) Roundness: The bore of the connecting rod, when assembled and the rod bolts, nuts and special hardened washers tightened to specified torque, is round and should not exceed .013 mm (.0005") out-of-round (Fig. 86). This out-of-round inspection can be made using precision gauge furnished with

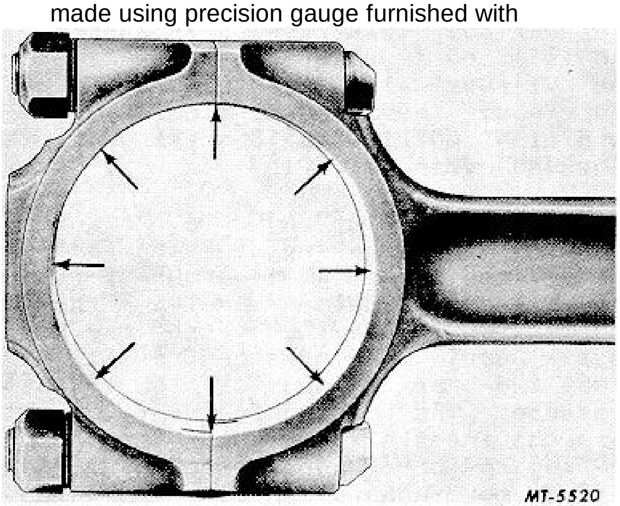


Fig. 86

honing machine, SE-2218, or other accurate bore gauge such as SE-2087. Instructions are furnished with the gauges.

(3) Surface Finish: The connecting rod bore must be smooth (Fig. 87).

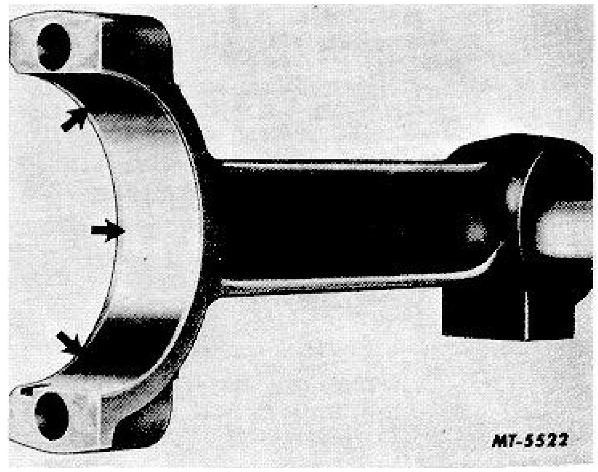


Fig. 87

(4) Straightness: The connecting rod bore taper should not exceed .013 mm (.0005") (Fig. 88).

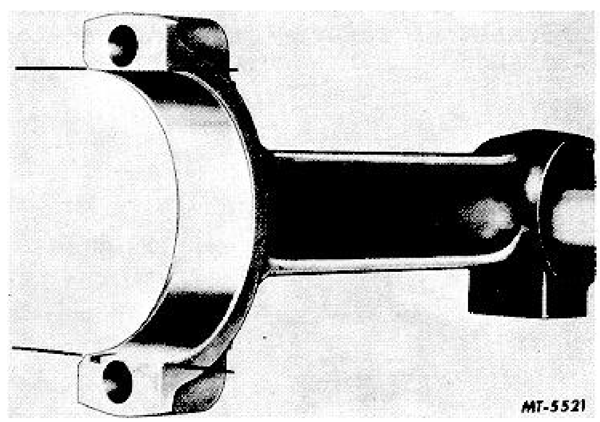


Fig. 88

If the connecting rod does not meet the foregoing requirements, it must be replaced.

b. Bushing Removal and Installation

The connecting rod bushings should be checked for proper clearance with the piston pin. See SPECIFICATIONS. If inspections show the piston pin bushings are worn, new bushings must be installed.

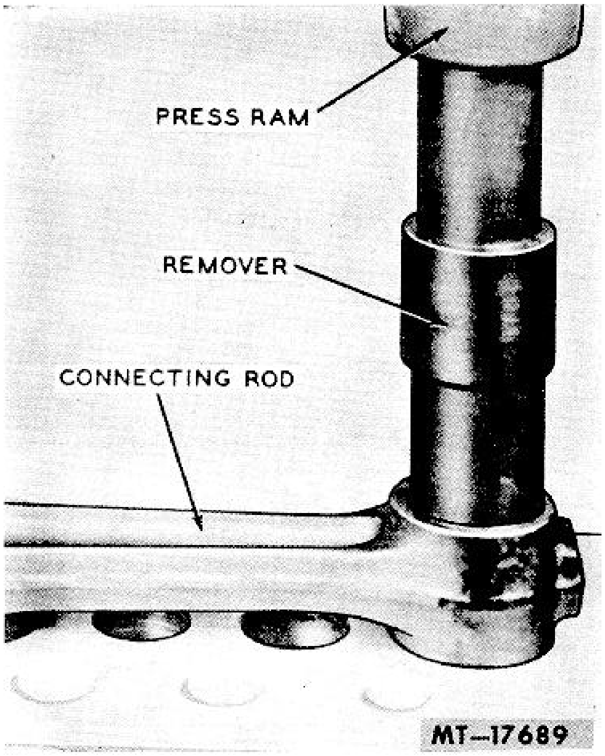


Fig. 89 Using SE-1885 Remover and SE-1033 Support Plate to Remove Connecting Rod Bushing

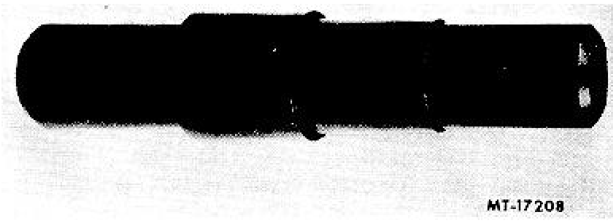


Fig. 90 SE-1885 Remover and Installer

Remove the old bushing by first placing the connecting rod under the hydraulic press on a support plate. Then using the proper end of remover SE-1885, remove the bushing (Fig. 89).

To install a new bushing, place it in position with the oil grooves or chevrons pointing downward toward the connecting rod cap and the split located as shown in Fig. 91. Using the support plate and the opposite end of the SE-1885 Remover and Installer Tool (Fig. 90), press the bushing in until the shoulder of the installer is firmly seated on the connecting rod.

After installation, ream the piston pin bushing to proper size using SE-2218 Honing Machine and equipment (see SPECIFICATIONS).

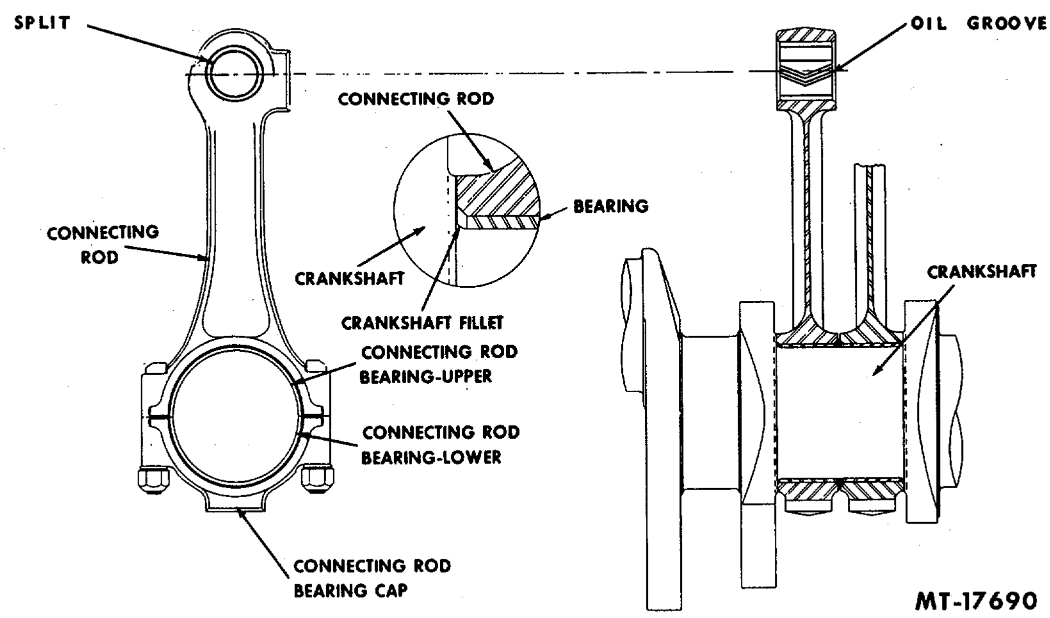


Fig. 91 Illustrating Proper Installation of Connecting Rod and Bushing

5. Installing Piston on Connecting Rod

After inspection and reconditioning of the connecting rods and pistons, they are ready to be assembled. The connecting rod locators (bearing tangs) must be toward the dome side (marked "UP") of the piston for proper installation. Assembly in this manner insures that when the pistons are installed in the engine, the chamfered side of each rod is located against the crankshaft face. This chamfer provides clearance at the crankshaft fillet (Fig. 91).

Place the piston in a piston vise and with the piston heated to approximately 93° C (200° F) in a piston heater or boiling water, position the connecting rod in the piston and install the piston pin. The pin should be a "palm-push" fit under these conditions. Install a piston pin retainer at each end of the pin, making sure the retainers seat fully and with tension in the grooves. Test the connecting rod and piston assembly on a connecting rod aligner and correct any misalignment.

6. Connecting Rod Nuts and Bolts

There are a number of conditions which affect torque and the results of torque application. The major purpose in tightening connecting rod bolts and nuts to a specified torque is to obtain tension in the bolt (Fig. 92). This, in turn,

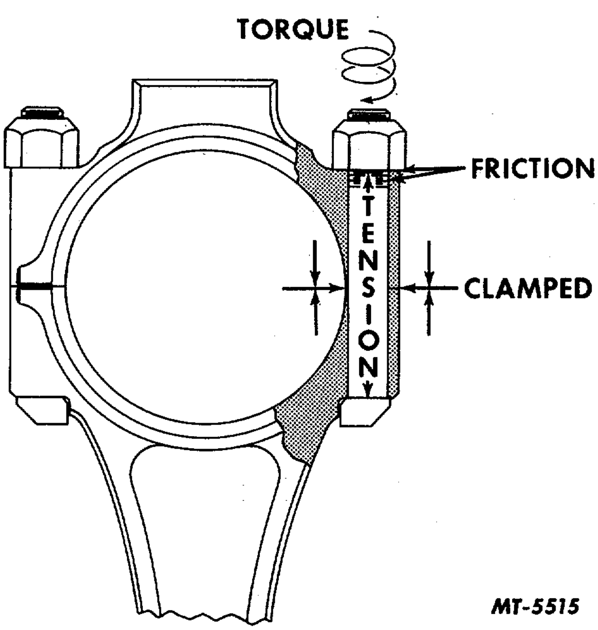


Fig. 92

develops a clamping load, or preload, that exceeds any possible loading imposed on parts due to engine rpm. The connecting rods must "hang on" to the crankshaft and suffer all the strains of inertia and cylinder combustion impulse without permitting the least movement a or flexing of the rod cap, bolts or nuts. At the same time, torque applied must be within the capacity of the parts (bolt, nut, caps and connecting rods) to withstand these loads.

NOTE:

Do not use a power wrench for removing or installing connecting rod bolts, nuts and washers. Such practice will cause seizure off the connecting rod bolt or nut threads.

There is a relationship between the torque specifications and the clamping effect or load to be applied providing certain conditions exist. These conditions center largely around the bolt itself and its care, pointed out as follows.

a. Bolt and Nut Thread Condition

Threads that are dry, excessively rough, battered or that are filled with dirt require considerable effort to rotate the nut. When the clamping load is developed or the bolt tension is applied, the torque reading mounts rapidly (due to thread friction) to the specified figure without approaching the desired bolt tension and maximum clamping effect. Under these conditions, the desired torque reading is obtained, but the clamping effect might be far below requirement. This can lead to bearing failure or connecting rod bolt breakage.

The proper bolt tension and clamping effect can never be attained if the nut and bolt are dry. The nut and bolt should have a film of lubricant in the thread sections. Due to the close fit of the connecting rod nuts on the bolts, the slightest thread imperfection increases the friction to the extent that incorrect bolt tension is likely. For this reason, it is recommended that new connecting rod bolts, nuts and washers be installed during reassembly.

Connecting rod bolts and nuts must be cleaned of all foreign matter including the antirust materials that may be in the threads. Apply light engine oil to the threads before installation.

b. Connecting Rod Bolt and Nut Installation

Tighten the connecting rod nuts alternately with a torque wrench to the specified torque (see TORQUE CHART). If nut is overtightened enough to stretch the bolt, the nut and bolt must both be replaced. It is recommended that new rod bolts, nuts and washers be installed in major engine overhaul.

NOTE:
This operation should be performed with a torque wrench known to be accurate.

E. Timing Gears

Examine the camshaft and crankshaft timing gear teeth and replace the gears if the teeth are worn or damaged.

NOTE:
These gears are provided in matched sets and must be replaced in this manner.

Removal, end play and backlash of these gears are covered in pages 17, 18 and 19 of the ENGINE DISASSEMBLY section.

CYLINDER HEAD AND RELATED COMPONENTS

A. General

The cylinder heads as removed from the engine contain the valve mechanisms. The rocker arm assemblies were removed prior to removing the cylinder heads.

With the valves installed to protect the seats, clean the carbon deposits from the combustion chambers and valve heads with a wire brush and scraper. Wash the heads in cleaning solvent to remove dirt and grease from all surfaces and dry thoroughly. Check all water passages to insure they are clear and open.

Examine the cylinder heads for water leaks or cracks in the combustion chambers, exhaust ports or around the valve seats. Inspect the machined or gasket surfaces for scratches, mars or warpage which may cause leakage after assembly.

The cylinder head assemblies are interchangeable from one cylinder bank to another provided the water outlet plate is removed and installed on the rear of the head. Cylinder head gaskets are also interchangeable.

B. Valve Mechanism and Valve Guides

To disassemble the valves, turn the cylinder head assembly in a vertical position. Apply a valve spring compressor and remove the valve keepers or locks. Remove the spring compressor and assemble the spring and oil shield retainer assembly, spring assembly and valve rotator (Fig. 93). Remove all valve assemblies in the same manner.

NOTE:
Keep valves and their related parts together so they may be reinstalled in their respective positions.

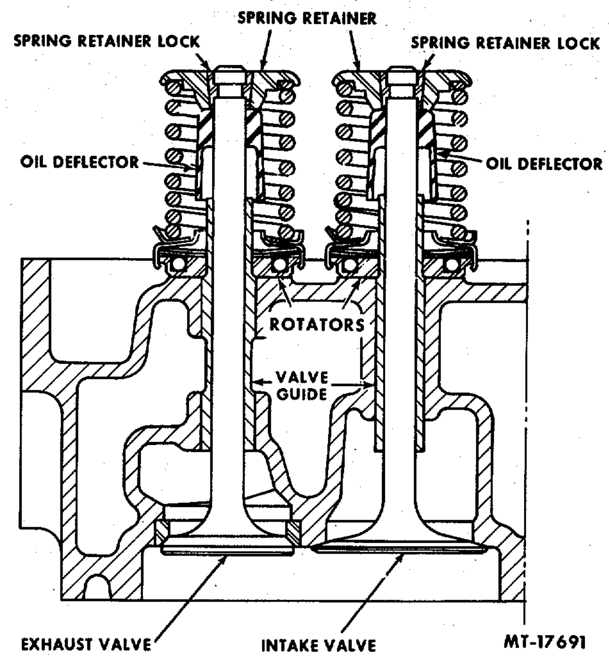


Fig. 93 Cross Section View of Intake And Exhaust Valves Installed in Head

Inspect the valve springs for proper tension (see SPECIFICATIONS). Any evidence of wear, cracks or permanent sets will require replacement. SE-2241 tester or similar tool can be used to check tension.

Inspect the keepers or locks for excessive wear and replace in pairs as required. Rotate the rotator assemblies and replace if any wear or irregularities are noted. Note particularly if the rotators feel gritty or are bound up.

Prior to valve guide bore inspection, it is necessary to clean the guides. Use SE-1300-3 valve guide cleaner or similar tool to clean the guides.

Use SE-2506 (Fig. 94) or other suitable small bore gauge to check valve guide bores. Careful guide inspection can detect undesirable egg-shaped wear or bell-mouthing. Replacement is recommended for guides having bore diameters beyond the recommended limit, those bell-mouthed more than .013 mm (.0005") or guides which show egg-shaped wear (see SPECIFICATIONS).

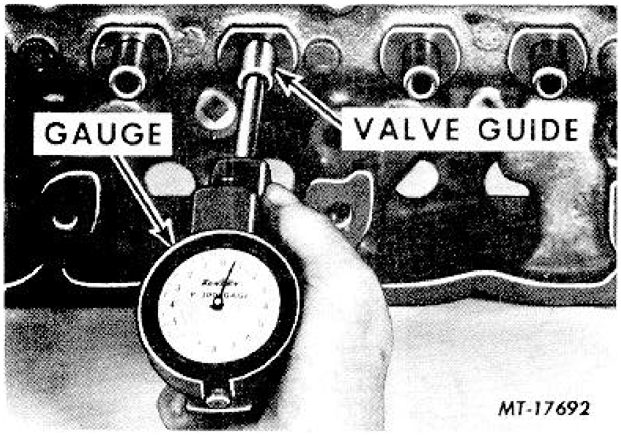


Fig. 94 Checking Valve Guide Bore Using SE-2506 Gauge

Excessive guide clearance prevents adequate cooling of the valve through the guide and also allows deposits to tilt or tip the valve. This could cause valve breakage at high engine speeds. These conditions also tend to prevent good seating and promote leakage across the valve face. Excessive guide clearance also affects lubrication of the valve stem.

Replacement guides are designed to give proper clearance when installed in the cylinder head. Reaming is not required but care must be taken to see that the ends of the guides are not burred during installation.

Position the cylinder head in SE-1889 Holding Fixture with the combustion chambers up for removal of faulty guides. Support blocks with an 11 degree angle can be made locally to substitute for the SE-1889 Holding Fixture.

Remove all guides that exceed wear limitations using SE-1722 Remover. All guides must be removed from the combustion chamber side through the top of the head (Fig. 95).

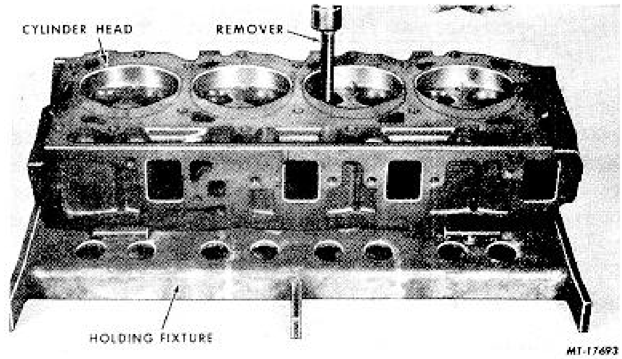


Fig. 95 Using SE-1722 Remover and SE-1889 Holding Fixture to Remove Valve Guides

Turn the cylinder head over with the top side up on the support fixture positioned in the press. Lubricate guides with a mixture of light engine oil and white lead. Install valve guides from the top side of the cylinder head using SE-1943 Valve Guide Installer (Fig. 96). The tool is designed to install both intake and exhaust valve guides. This can be accomplished by adjusting the installer screw in the body to a depth that is equivalent to the specified height the guides are protruding above the head. Press the guides in until the installer rests firmly on top of the cylinder head, thus maintaining proper spacing. Clean away any excess lubricant. Install all valve guides in a similar manner.

Replacement guides are designed to give proper clearance when installed in the cylinder head. Reaming is not required, but care must be taken to insure the ends of the guides are not burred during installation. After guides are installed, insert SE-2214 Reamer to insure the guides have not been distorted during installation and to remove any burrs.

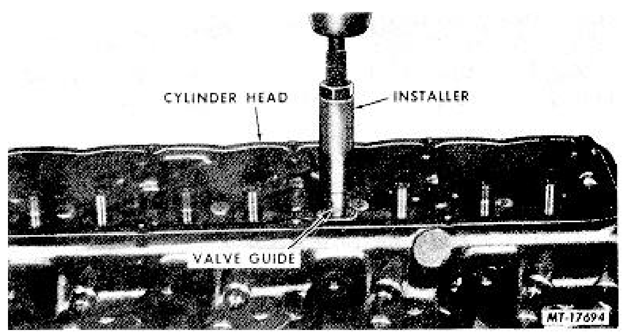


Fig. 96 Installing Valve Guides Using SE-1943 Installer

C. Valve Seat Inserts

Prior to seat inspection and reconditioning, it is desirable to clean the seats to expose any cracks or other conditions likely to promote valve failure. Inspect the inserts for these conditions and remove all defective inserts.

Production engines are equipped with exhaust valve seat inserts only. Valve seat inserts supplied for service are standard size, .381 mm (.015") oversize and .762 mm (.030") oversize for exhaust valves and standard and .762 mm (.030") oversize for intake valves.

Good practice requires that the insert counterbore in the cylinder head be machined prior to insert installation using SE-1797 counterbore tool (Fig. 97). Tool cutters are available to dress both the bottom and circumferential surfaces, but regardless of the method, the bottom of the counterbore must be square to assure good seating of the insert.

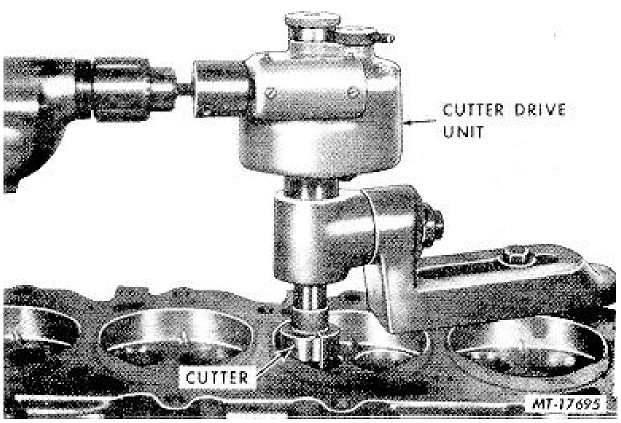


Fig. 97 Using SE-1797 Counterbore Tool For Machining Cylinder Head For Insert Ring Installation

After machining the counterbore in the cylinder head, the counterbore and insert must be thoroughly cleaned and dried. After cleaning the counterbore, it is recommended that a light oil be used in the counterbore to reduce friction when installing the inserts.

NOTE:
Do not peen, freeze or use a percussion process for insert installation.

Press insert into the counterbore until it seats firmly against the counterbore surface using the installer tool from SE-1797 Counterbore Tool Set (Fig. 98).

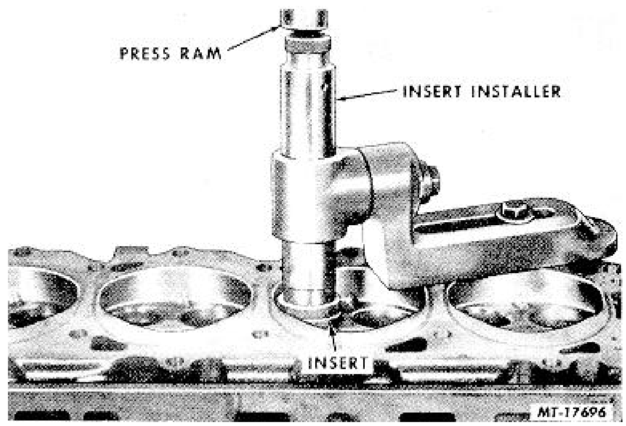


Fig. 98 Using Insert Installer from SE-1797 Tool Set to Press In Intake

The valve seats in the cylinder head must be ground true to the angles and widths, "A" and "B," shown in the specifications section (Fig. 99).

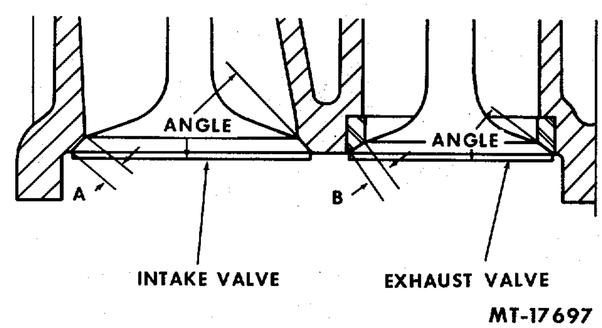


Fig. 99 Example of Sectional View Of Valve Seats

If the seat is wider than specified, it will be necessary to grind from the top and/or bottom of the seat until the proper seat width is obtained using SE-1804 or SE-1631 Grinder Set (Fig. 100).

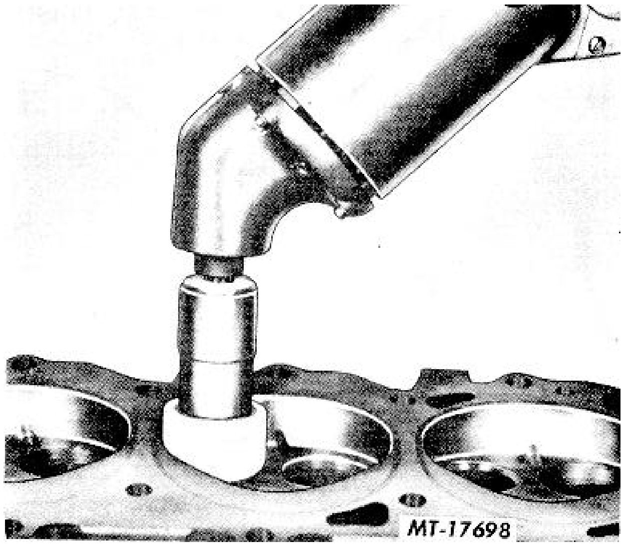


Fig. 100 Grinding Seats Using SE-1631 Grinder

After the seat grinding operation has been performed, it is necessary to check the seat for runout (Fig. 101). Seat runout should not exceed limits as shown in specifications.

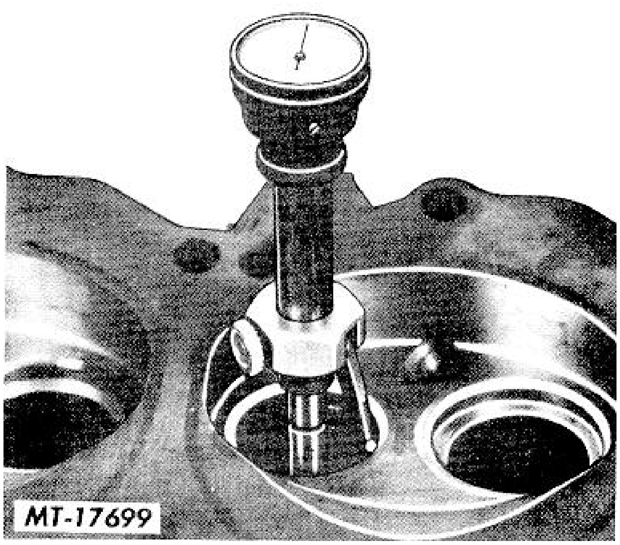


Fig. 101 Using Gauge from SE-1631 Tool Grinder Set for Checking Seat Runout

It is important to have the finished seat face contact the approximate center of the valve face. After the valves have been cleaned and inspected, place a thin coat of Prussian Blue on each valve face and tap the valve lightly to its seat in the cylinder head.

NOTE:

This test is-for proof of results of the refacing and reseating operations. A poor grind job cannot be corrected by lapping. Use of lapping compounds is not recommended. Inspect each valve for seat dimensions as outlined in the specifications and make any necessary, corrections. The corrections should always be made on the seat and not the valve face.

D. Valves

Remove all carbon from valve stems and head using a fine wire brush or buffing wheel. Inspect each valve, discarding any that show evidence of a burned, warped or bent condition. SE,1800 Valve Gauge (Fig. 102) or similar tool can be used for checking stem straightness and seat runout-. New valves need not be refaced; however, all valves should be carefully inspected for damaged seat faces or for a runout condition due to a bent valve stem.

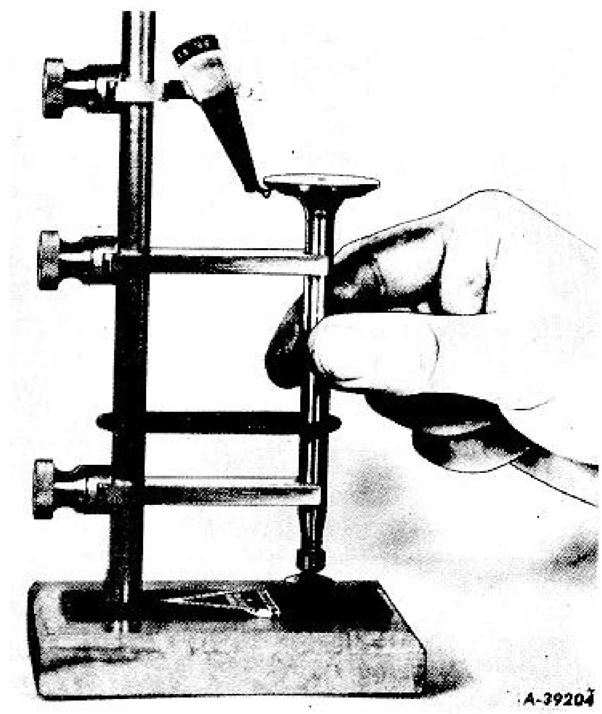


Fig. 102 Checking Valve Stem Straightness and Face Runout

If the ends of the valve stems are grooved or scored, they may be ground to true up. However, remove only a minimum amount of material. Rechamfer as necessary.

Wipe valve faces and valve seats with a cleaning solvent to remove all dirt or foreign material. Coat the valve stems and faces with oil and install the valves in the same seats to which they were checked. Install the valve rotator, spring assembly and spring, and oil shield retainer assembly. Compress the valve springs with a valve spring compressor and install the valve keepers or locks. Insure the retainer and locks are correctly seated on all valves.

The cylinder head assembly complete with valves is ready for installation on the cylinder block or crankcase.

E. Rocker Arm Assembly and Push Rods

The rocker arm assemblies are removed from the engine as a unit (Fig. 28). Each rocker arm is marked with an "A" or "B" for identification purposes (Fig. 103). There are two different shapes of rocker arms used on one complete rocker arm assembly. The oil is fed through a support located on the rocker arm shaft at the front on the left bank and at the rear on the right bank (Fig. 103). Rocker arm shafts are hollow to provide for passage of oil to each rocker arm. When removing the components from the assembly, keep all parts in order so they may be returned to their original position if in satisfactory condition.

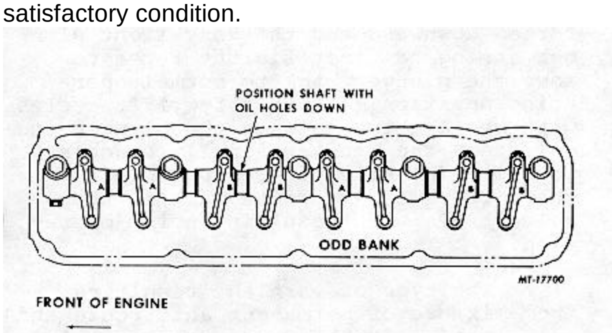


Fig. 103 Rocker Arm Assembly

Remove rocker arm shaft end plugs. Wash all parts thoroughly in cleaning solvent to remove sludge or carbon deposits from oil holes and slots. Carefully inspect all parts for wear or defects while cleaning. Check the rocker arm shafts for bent condition or for wear from rocker arms. Replace the shafts if either condition is apparent. Defective spacers must also be replaced. Inspect rocker arm for wear at contact surface. Replace any that are defective. The valve stem contact pad of the rocker arm may be resurfaced if wear is noted. However, the pad thickness must not materially be decreased more than .025 mm (.010").

F. Hydraulic Valve Lifters (Tappets)

The hydraulic valve lifters or tappets consist of a body (cylinder), plunger, plunger spring and check valve assembly and is removed from the engine as an assembly. See Figure 29 of DISASSEMBLY OF ENGINE. The lifters are removed after removing the valve cover, rocker arms and push rods.

> NOTE: If a tappet cannot be removed due to carbon build-up, use a carburetor solvent in the tappet bore. However, if excessive solvent is used, it is necessary to change the oil.

1. Operation of Valve Lifter

Oil from the engine lubricating system is fed to a supply chamber in the hydraulic lifter plunger from which it can flow directly through the plunger, past the check valve and into the compression space between the bottom of the body , and the plunger. When the engine is started, oil pressure is built up in the system which fills the supply chamber. With the lifter on the base circle of the cam and the engine valve seated, the light plunger spring moves the plunger outwardly to remove all lash from the valve gear. As the plunger moves outward increasing the volume in the compression chamber, the check valve moves off its seat and the chamber is supplied with oil. As the camshaft rotates and lifts the body upward, a pressure is immediately built up in the compression chamber, forcing the valve onto its seat. Further rotation of the camshaft lifting the valve gear against increasing valve spring pressure increases the oil pressure in the compression chamber, thus acting as a solid member of the valve operating mechanism. As long as the engine valve is off its seat, the load of the mechanism is carried by the column of oil.

During initial running of the engine, there might be some air remaining in the compression chamber which, under pressure, tends to leak through the clearance between the plunger and cylinder, thus decreasing compression space volume. However, when the lifter is again on the base circle of the cam, the plunger moves outward, drawing in more oil so that after a number of cycles, the air is completely eliminated and a solid column of oil is maintained in the compression space. During this period when some air is present in the compression space, the valve gear may be somewhat noisy, since it has the same effect as excessive lash with aerated oil. However, once the unit is completely cleared of air, it then becomes a true hydraulic system.

The compensation required to take care of variations in length from the cam to the valve seat is accomplished by the original fit of the plunger in the cylinder bore. These parts are selectively fitted to give a predetermined slight leakage of oil (called leakdown) under load. The purpose of this predetermined leakage is to permit the valve to seat irrespective of the change in length between the cam and valve seat. If the valve gear is expanding, thus reducing the distance between the cam and valve seat, the load imposed by the valve spring on the lifter causes the above mentioned slight leakage between the plunger and cylinder, reducing the clearance volume and, therefore, the overall lifter length. When the valve gear length increases, as caused by lower engine temperatures, the plunger spring keeps all the valve gear parts in contact, increasing the clearance volume under the plunger. At the same time oil is immediately fed past the check valve, thus maintaining correct length under all conditions. This keeps the valve gear operating at no-lash. With this predetermined leakage, it is impossible for the no-lash lifter to hold the engine valve open when it should be closed.

When the lifter body is on the base circle of the cam and the engine valve is closed, the only force tending to hold the valve open is from the light plunger spring, which obviously is much lower than the valve spring load. The only additional force tending to push the plunger upward results from pressure of the lubricating oil, but its effect is negligible since it is controlled and only acts on the small plunger area.

During shutdown periods of the engine, one or more valves are always in the lifted position, thus imposing the full valve spring load on the plunger. This causes oil to leak out of the compression chamber through the clearance space. when the engine is again started the particular valve that was in the open position returns to its seat and the plunger is immediately forced upward by its spring. Oil from the supply chamber is again fed into the clearance volume under the plunger so that in a very few cycles, the valve gear is operating on a solid hydraulic oil column.

2. When to Service

A. Loud clacking, light clicking or intermittent noise is attributed to a lifter.

Dirt, chips, varnish, etc. generally cause only a few units to become inoperative at any one time. Aeration caused by high or low oil level air leaks into the oil pump suction line, etc., result in all lifters becoming noisy. The cause of aeration must be corrected before the lifters will again operate quietly.

Small metal chips lodging between the plunger and the cylinder tend to prevent free movement. Since loads during the lift portion of the cycle are relatively high, the plunger is forced downward and the very light plunger spring has insufficient force to move the plunger back to normal operating position. After a few lift cycles with metal chips between the plunger and cylinder, the plunger finally reaches a position (usually plunger bottomed) where there is excessive lash in the valve train with resulting noisy operation.

The type of varnish, resulting from mixture of permanent antifreeze and oil, is very "tacky" and, particularly when cold, will prevent free movement of the plunger. The resulting action is the same as that caused by a chip in the clearance space. The entire engine must be cleaned and the cause of the leakage corrected.

Varnish of the type resulting from fuels and lubricants, unless excessive amounts are created by poor crankcase ventilation or extremely bad lubricants, seldom causes sticking in the lifter. However, if such deposits do form and cause trouble, it is then necessary to correct crankcase ventilation, lubricant or fuel.

(1) Loud clacking noise is the result of excessive lash and indicates that:

a. The plunger is stuck below its normal operating position, probably plunger bottomed and in this case the lifter must be disassembled and cleaned of dirt and varnish.

b. The check valve may not be sealing due to dirt or a damaged seat, which also necessitates cleaning and inspection.

c. Oil may contain sufficient air, which is compressible, to permit collapse or partial plunger movement beyond its normal operating position. It is necessary to locate and correct the cause of aeration. Just servicing the lifter will not help.

(2) Light clicking type noise indicates that the plunger is operating only slightly below its normal position as the result of:

a. Slight leakage by the check valve or plunger. If the noise is persistent, the lifter must be removed, cleaned and checked.

b. Small amount of air in oil which can only be helped by eliminating the aeration.

(3) Intermittent noise is usually the result of:

a. Metal chips or dirt. Occasionally such material becomes lodged between the check valve and seat. Cleaning will correct this condition.

b. Slight plunger sticking caused by dirt or varnish-like substance which necessitates cleaning and eliminating the source of varnish.

B. When engine is overhauled.

Lifters will need to be removed and normal varnish deposits cleaned off whenever a change has been made that will increase the distance from the cam to the valve tip. This change may cause the plunger to be forced into a varnish deposit accumulated above the original travel of the plunger. Since the plunger previously had not been required to operate in this position, the lifter must be removed and cleaned of all varnish deposits so the plunger can move freely.

The following will cause increased valve train length:

(1) Grinding valve tips.
(2) Valve train parts not put back in their respective locations.
(3) Installing new parts.

Even when doing a valve grind job, it may not be necessary to disturb the lifters. However, it may be found occasionally that worn valve tips will need to be ground to give a smooth surface. In this case the length from cam to valve tip would be increased which necessitates cleaning the lifter as mentioned above.

As a general rule, hydraulic lifters should be left alone when they are functioning satisfactorily and the valve train or gear remains reasonably quiet. The hydraulic lifter is a fairly simple positive action device which will continue to deliver trouble-free service under all normal engine operating conditions. The major cause of hydraulic lifter problems where any exist are usually due to grit, dirt or metal chips carried to the lifter with the engine oil.

To minimize lifter contamination, a special box or container should be used to store the lifters when they are first removed from the engine or after they have been cleaned and tested. Keep the lifters in this container until ready for installation in the engine. The container should be numbered to assure return of the lifters to their original location in the engine.

NOTE: Even when the lifters are working correctly, there are other engine noises which are often "blamed" on lifters but can usually be identified. These may be caused by: valve stem guide clearance, worn timing gears, piston slap, lifter body clearance, worn lifter face or cams, loose main or rod bearings, worn rocker arms, ignition knock, worn valve tips or tight rocker arms.

3. Lifter Disassembly

Before disassembling lifters it may be necessary to remove a portion of the oil from the lifter body. This can be accomplished by turning the tappet upside down and letting it drain for a few minutes. Then with the end of a push rod, compress the plunger and remove the snap ring located on the inside top of the assembly.

Caution should be used in order that the snap ring does not "pop out" and become lost. Removal of this snap ring should allow the separate socket to be readily removed. By shaking the assembly gently, the plunger should also come out unless it is held in place by carbon and varnish deposits. If this is the case, some force will be required to remove the plunger from the body. It may be necessary to hold the assembly upside down and bump the open end gently against some resilient surface (masonite, etc.). Care should be taken so the plunger or body will not be damaged.

After removing the plunger, the check valve assembly may be found to be loose on the plunger. Care should be taken so the small, flat check valve and valve retainer spring are not lost. If the check valve assembly stays attached to the plunger, it would be best to leave it in this position.

4. Servicing the Lifter

The following is the service procedure to be followed in servicing hydraulic lifters:

a. Immerse the unit in carburetor or other suitable solvent to remove excess engine oil and soften varnish deposits.

b. To avoid mixing plungers and cylinders, take one lifter apart at a time and complete all servicing before working on another.

c. Wash all parts in solvent and clean all varnish from the plunger and inside diameter of the cylinder.

d. Inspect the plunger and cylinder walls for scratches. Look for nicks on the valve seat and examine the condition of the lifter face. Check for plugged oil holes.

e. Try the plunger for free fit in the cylinder.

f. Reassemble all parts in proper sequence.

NOTE: The valve lifter body is to be filled 1/3 full with clean kerosene before assembly of component parts. The parts are to be prelubricated with clean kerosene before assembly. Use of kerosene in place of engine oils provides a faster leakdown and rapid expelling of trapped air in the lifter assembly, thus eliminating the possibility of damage to the valve train when installing the push rods and rocker arm shaft assembly. Engine oil will dilute the kerosene in the lifters as soon as the engine is operated for a short period.

5. Leakdown Test

The SE-1893 leakdown tester (Fig. 104) may be used for checking the leakdown

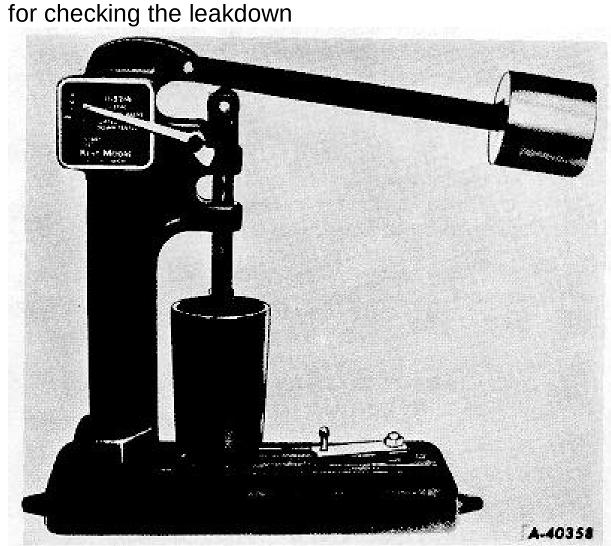


Fig. 104. SE-1893 Tappet Leakdown Tester

rate, if available. Instructions should be followed.

If the leakdown tester is not available, a finger check method can be used. In order to check a unit in this manner, make sure there is no lubricating oil on the cylinder or plunger such as immediately after washing in solvent. With the cylinder held in one hand, start the plunger into the cylinder (do not install the plunger spring) with the other. Depress the plunger with your finger and release quickly. The plunger is now operating against air which is sealed in by the check valve and by the close fit of the cylinder to the plunger. It should yield slightly to the pressure of the finger on the plunger, but the plunger should kick back upon release of the pressure. If no kickback of the plunger occurs, the unit may or may not be defective.

The lack of kickback is due to one of three conditions.

First, air is escaping past the check valve because of presence of dirt which prevents proper seating of the valve.

Second, air is escaping past the check valve because of a damaged seat.

Third, air is escaping because the clearance between the plunger and cylinder wall is too great which indicates excessive leakdown rate.

Rewash the unit to eliminate any dirt which might still be on the check valve seat and repeat the test. If there is still no kickback, the check valve is damaged and the entire lifter, consisting of cylinder body and plunger, may need to be discarded.

In the above test procedure it is important that the pressure on the plunger be released immediately after it is depressed. If the plunger is held down too long, all the air trapped under the plunger will leak out and the test would be inaccurate.

The unit is suitable for reinstallation in the engine if the test is satisfactory.

NOTE: In the event check valve leakage is encountered due to wear on the surface of the check valve, the valve can be turned over to the unworn side. This procedure will extend the useful service life of the lifter assembly, provided all other parts of the lifter are in good condition.

LUBRICATION SYSTEM COMPONENTS

A. Oil Pump Assembly

The engine oil pump is a high capacity conventional gear type unit driven from a spiral gear on the engine camshaft (Fig. 105). Two identical pressure relief valves are used to accommodate the pump's capacity. When the oil pressure reaches to specified setting, the relief valves operate to permit the oil to circulate within the pump. The oil pump gear end play is adjusted by gaskets between the pump body and gear plate. The oil pick-up screen assembly is fixed in place and is located so the oil is drawn from the oil pan under the surface of the oil supply.

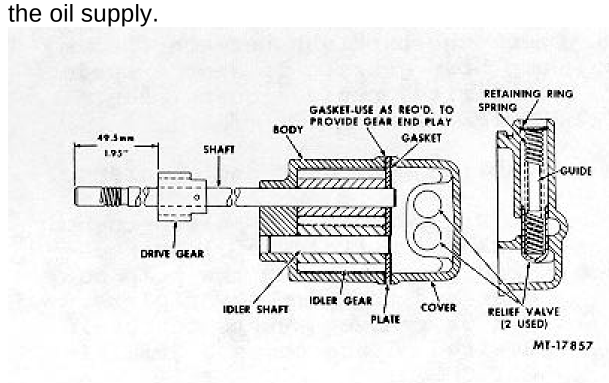


Fig. 105. Sectional View of Oil Pump Assembly

The recommended inspection and repair procedures are as follows:

1. Wash all pump parts and screen assembly in cleaning solvent.

2. With the cover, plate and gaskets removed and the gears and shaft in place, exert pressure against the gears with the thumb so as to push the gears away from the outlet side of the pump.

3. While holding the gears in this manner, measure the clearance between the outside diameter of the gear and the bore of the housing (Fig. 106), see SPECIFICATIONS. If clearance is excessive, obtain new parts.

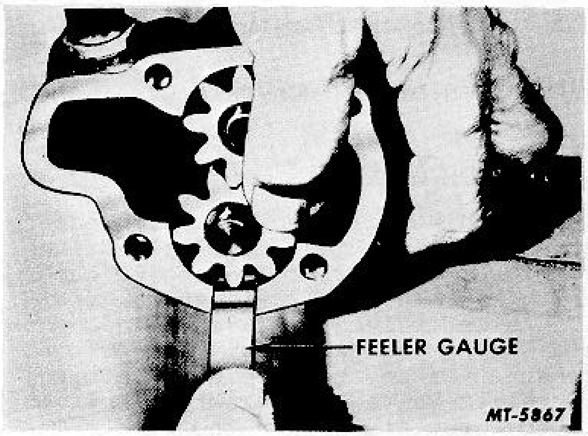


Fig. 106. Measuring Pump Gear-to-Body Clearance

4. Check pump shaft clearance in the bore. If wear exceeds limits, replace pump assembly, see SPECIFICATIONS.

5. Check the backlash between the pump body gears. If wear exceeds the limits, replace gears, see SPECIFICATIONS.

6. Establish body gear end clearance.

NOTE: The oil pump plate-to-body gaskets control the clearance (end play) between the pump body gear and the pump cover plate. Add or remove gaskets to obtain desired clearance, see SPECIFICATIONS.

7. Lubricate pump gears and shaft liberally with engine oil before installation.

8. Press the oil pump drive gear on the shaft to the dimension shown in Figure 105.

9. Install the pump screen after pump installation on the engine.

B. Oil Filter and Cooler Base Assembly

During engine overhaul, the oil filter and cooler base assembly should be thoroughly washed in cleaning solvent.

Inspect the gasket surfaces of the base for nicks or scratches which could cause leakage. Replace base if damaged.

NOTE: The oil filter and cooler base is equipped with a piston cooling valve assembly located between the two filters. This valve L is non-functional in this engine as piston cooling nozzles are not installed. However, if leakage is detected around the plug, a new gasket should be installed.

C. Oil Cooler

The following operations should be performed on the oil cooler during engine overhaul:

1. Remove fittings from coolant openings of cooler.

2. Looking through coolant openings, inspect the coolant portion of cooler for deposits of lime or other contaminants and for evidence of oil leakage. Replace cooler if heavy deposits of contaminants or oil leakage are found.

3. Pressure test cooler for leakage (Fig. 107) as follows:

   a. Plug one coolant opening.

   b. Using necessary adapter fittings, connect other coolant opening to a source of regulated air pressure.

   c. Pressurize coolant portion of cooler with air. Do not exceed 517 kPa (75 psi) air pressure.

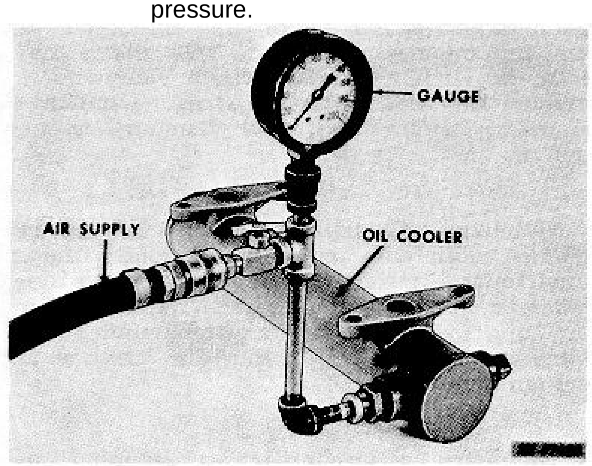


Fig. 107. Pressure Testing Oil Cooler

d. Check for air leakage from oil openings in the cooler. Replace cooler if leakage is indicated.

4. Reinstall fittings in coolant openings.

D. Oil Pan

The pan should be thoroughly cleaned in cleaning solvent to remove any foreign material from around the baffle plates which are spot welded in place. Inspect oil pan for cracks or deformation and straighten or weld.

Remove all gasket material from oil pan flange.

Check oil pan drain plug and drain plug boss for fit and thread wear. If plug is loose or threads are damaged, repair threads or replace oil pan.

MANIFOLDS AND CRANKCASE VENTILATION

A. Intake Manifold

The intake manifold is cast in one piece and supplies both cylinder banks. It should be cleaned and examined for cracks and leaks. Warpage of the intake manifold will require replacement as any attempt to resurface the intake manifold will create misalignment of the ports to the cylinder heads. The intake manifold contains the cylinder numbering and the firing order.

B. Exhaust Manifolds

Each bank has a separate exhaust manifold which should be cleaned and examined for cracks. Place the exhaust manifold on surface plates and check for warpage.

C. Crankcase Ventilation

The crankcase ventilation valve located in the left cylinder head cover varies the air flow through the crankcase to meet changing conditions at all engine speeds and loads. The system will work effectively as long as all component parts are clean and free from sludge and foreign material.

The valve should be serviced and the system inspected and cleaned at intervals set forth in the "Operator's Manual." It may be necessary to inspect and clean the system more frequently under adverse driving or weather conditions.

To check the operation of the system, first remove the valve from the cylinder head cover. Start the engine and check to insure a vacuum can be felt at the end of the valve. If no vacuum is detected, the valve hose and fitting should be removed and the cause of the restriction determined. The inner chamber of the valve should be checked by inserting a stiff wire into the valve body to see that it can be moved freely. Check the hoses for condition and replace if needed.

COOLING SYSTEM COMPONENTS

A. Oil Cooler

Refer to LUBRICATION SYSTEM COMPONENTS.

B. Water Pump

All gasket material should be cleaned from the water pump. Inspect the water pump for damaged impellers, cracks and other faulty conditions. If any defects are noted, the water pump must be replaced as an assembly. When replacing water pumps, the hub must be transferred to the new pump. Apply Locquic Primer T and Locktite AA to hub and bearing shaft assembly prior to assembly. Press the hub on to the shaft to the dimension shown in Fig. 108. Install outside retaining ring.

NOTE: When pressing the hub on the water pump assembly, special care must be taken so as not to disturb the impeller's position on the shaft.

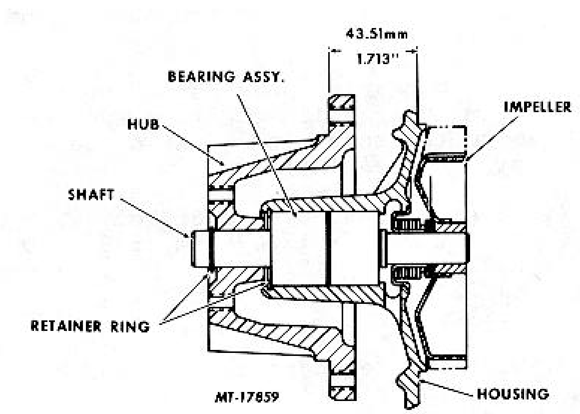


Fig. 108. Sectional View of Water Pump

C. Thermostats

Since a low operating temperature will result in a loss of power and economy, only thermostats of the specified temperature range should be used. The thermostats should not be removed in an attempt to lower operating temperature.

Thermostat operation should be checked during engine overhaul or whenever faulty operation is suspected.

To check operation, place thermostat in a pan of water; heat water and, using an accurate thermometer, observe water temperature when thermostat starts to open. Thermostat should start to open at approximately 77 degrees C (170 degrees F). Replace thermostat if defective.

When installing, position thermostats correctly in housing per instructions stamped on thermostat. Insure thermostats are seated in housing. Use new thermostat housing gasket.

D. Idler Pulley

Check idler pulley bearing for looseness (wear) or rough operation.

Check idler arm support bushing for looseness (wear).

If necessary, replace pulley bearing and/or support bushing (Fig. 109) as outlined below.

Pulley Bearing Replacement

1. Remove nut from idler bearing shaft.
2. Remove idler pulley and shaft from idler arm.
3. Remove bearing shields and shaft from idler pulley bearing and remove two snap rings (one on each side of bearing).
4. Using SE-1955-8 Remover Tool with a flat washer 15.875 mm (5/8") ID x 23.813 mm (15/16") OD x 2.381 mm (3/32") thick, press bearing from pulley.
5. Clean pulley carefully. Inspect for cracks or other damage. Replace pulley if damaged.

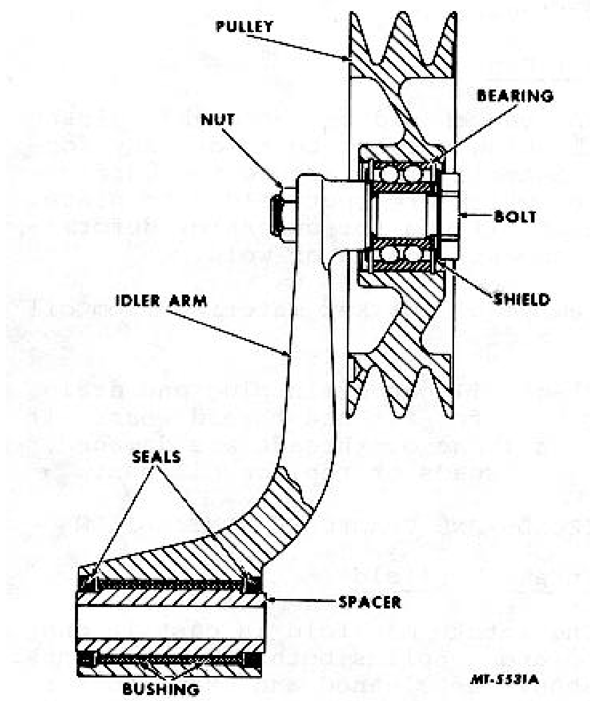


Fig. 109. Sectional View of Idler Pulley Assembly

6. Install one snap ring in bore of pulley. Insure snap ring is seated securely. Support pulley on a press plate, then press new bearing into pulley bore until bearing seats against snap ring.

NOTE: Use care not to press bearing assembly. Press on bearing outer race to prevent damage to the bearing.

7. After bearing is pressed into place, install other snap ring. The new bearing is prelubricated and requires no further attention.
8. Place one bearing shield on shaft and insert shaft into bearing. Install other shield on opposite side of bearing.
9. Thread bearing shaft into idler arm and install nut on shaft and tighten securely.

Support Bushing Replacement

1. Press spacer from idler arm using SE-1722 Remover Tool.

2. Remove both seals from idler arm using SE-1746 Remover and slide hammer.

3. Using SE-1036-1 Remover Tool, remove bushing from idler arm.

4. Using SE-1946-1 Installer Tool, press new bushing into idler arm bore until it is flush with the edge of the bore.

5. Place new seal in one counterbore of idler arm with lip of seal facing inward. Using 13/16" socket, press seal in until it bottoms in counterbore. Do not damage seal.

6. Install spacer in idler arm bushing.

7. Turn idler arm over and install opposite seal per Step 5.

ASSEMBLY OF ENGINE

NOTE: Throughout the engine assembly procedure, instructions are given for prelubricating bearings and other running parts with engine oil. This is important to assure initial lubrication of these parts when the engine is started. If engine is to be stored before installation in a vehicle, it is recommended that these components be lubricated with a coat of waterproof grease (Lubriplate 630AA or equivalent). This grease will not drain off parts during storage, will prevent rusting and provides initial lubrication.

1. Mount cylinder block in engine stand. Rotate engine stand so the bottom of the engine block faces upward.

2. Install cylinder block drain plugs (or drain cocks) and tighten securely. Install camshaft cover plate and gasket.

3. Wipe main bearing bores of cylinder block and main bearing caps to remove any dirt or dust. Insure main bearing inserts are clean.

4. Lubricate upper (cylinder block) half of each bearing insert on both sides with clean engine oil and place in position in bearing bore of block. Insure bearing inserts are fully seated with insert oil holes aligned with oil passages in block and locking tangs are engaged. Following the same procedure, place lower half of bearing inserts in bearing caps.

5. Wipe crankshaft main bearing journals. Lower crankshaft into place in cylinder block bearing inserts.

6. Place bearing caps (with inserts) over crankshaft journals, insuring number on cap is on side opposite the oil pump. Install new self-locking cap bolts and flat washers.

   NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with clean engine oil.

7. Tighten bearing cap bolts snugly (not to specified torque). Using a soft hammer, tap each bearing cap until rear machined face of cap is flush with machined face of cylinder block on both sides of crankshaft. Alignment of these machined faces assures proper cap location. Tighten bearing cap bolts to specified torque (see TORQUE CHART).

8. Install bearing cap tie bolts and special washers and tighten to specified torque (see TORQUE CHART).

   NOTE: Lubricate bolt threads with clean engine oil. Apply EC-971 Sealer under tie bolt washers prior to installation

9. Check crankshaft end play using dial indicator (see Figure 58).

10. Install crankshaft rear oil seal using SE-2092 Installer as follows:

    a. Install two aligner studs into end crankshaft flange.

    b. Lubricate crankshaft flange and seal bore of crankcase and bearing cap with engine oil.

    c. Place seal over end of crankshaft, aligning seal with crankcase bore. Position SE-2092-1 Installer (Fig. 110) over the aligner studs. Drive seal into bore until seal is in proper location (Fig. 111). Remove installation tools.

Fig. 110. Installing Rear Oil Seal Using SE-2092 Installer

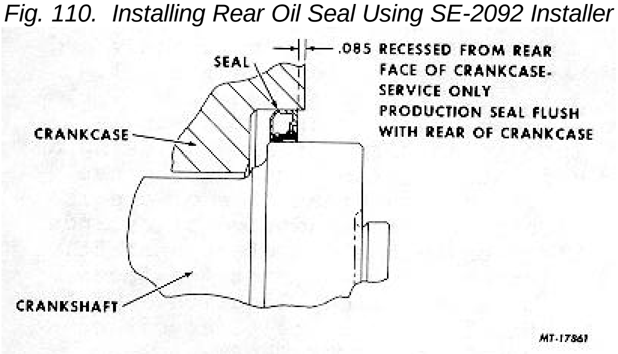


Fig. 111. Proper Location of Rear Oil Seal

11. Insert rear main bearing cap side oil seals (Fig. 112). Use an installer made from 3.18 mm (1/8") welding rod approximately 203.2 mm (8") long. To make the tool, puddle a ball on end of rod and file. ball to approximately 3.97 mm (5/32") diameter. Lubricate seals with a light coat of engine oil.

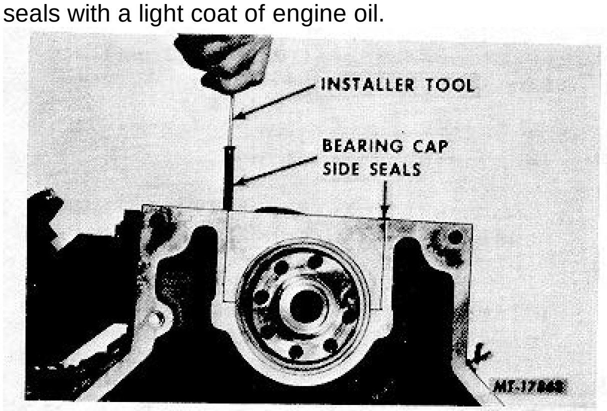


Fig. 112. Installing Rear Main Bearing Cap Side Oil Seals

NOTE: If excess material protrudes above the crankcase after the seal is installed, cut the excess material off flush with the bottom of the rear main bearing cap-to-crankcase mating surfaces.

12. Position gear key in keyway of crankshaft. Lubricate inside diameter of crankshaft gear with a commercial press-fit lubricant. Install crankshaft gear using SE-1900 Installer Tool Set (Fig. 113).

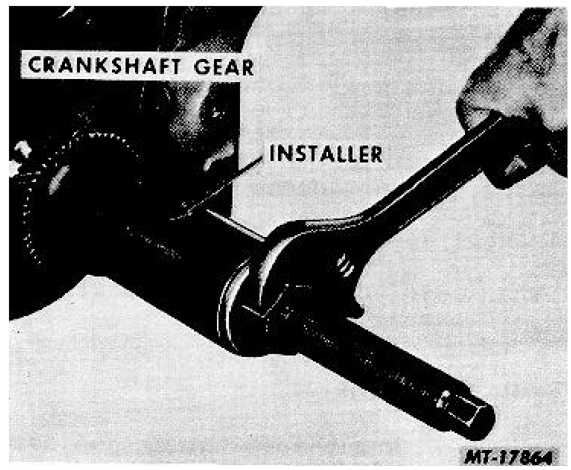


Fig. 113. Installing Crankshaft Gear Using SE-1900 Installer

13. Install camshaft (with gear and spacers) as follows:

   a. Position installer tool SE-1880 on threads of camshaft (Fig. 53).

   b. Coat camshaft lobes, bearing surfaces, camshaft bushings and camshaft gear teeth with heavy duty hypoid axle lubricant.

   c. Insert camshaft (with gear and spacers) into cylinder block (Fig. 53).

   d. Align timing marks on camshaft gear and crankshaft gear (Fig. 114) and position camshaft into camshaft bushings. Remove installer tool.

   e. Install camshaft thrust flange capscrews (Fig. 52) and tighten to specified torque (see TORQUE CHART).

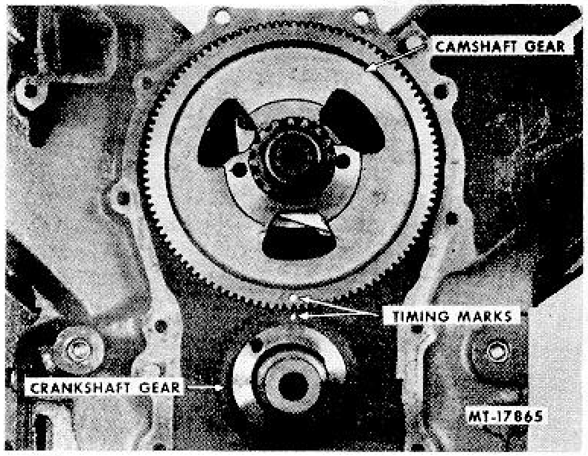


Fig. 114. Aligning Timing Marks on Camshaft and Crankshaft Gears

f. Install camshaft gear nut and tighten to specified torque (see TORQUE CHART).

g. Rotate crankshaft and, camshaft to insure gears do not bind or interfere. Check camshaft end play (Fig. 51) and camshaft gear to-crankshaft gear backlash (Fig. 50) with dial indicator.

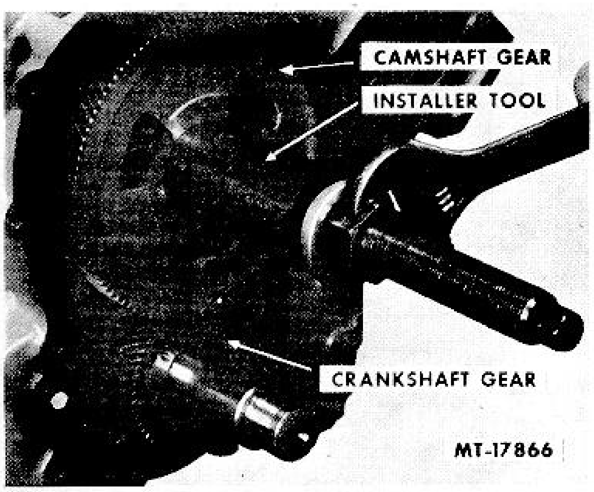


Fig. 115. Installing Camshaft Gear With SE-1900 Installer Tool

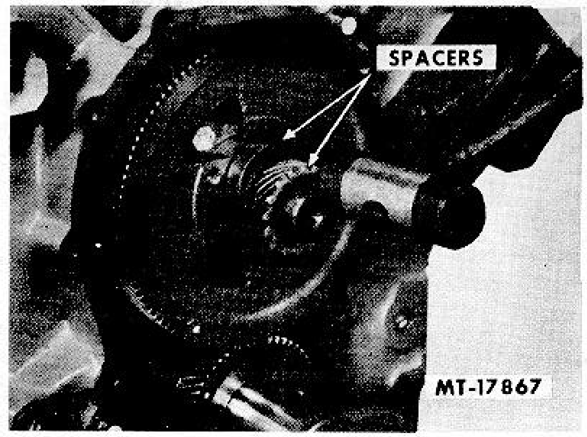


Fig. 116. Installing Camshaft Spacers With Soft Hammer

NOTE: The camshaft, thrust plate, camshaft gear and spacers can be installed individually.

Using installer tool SE-1880, install camshaft in cylinder block. Install camshaft thrust flange and tighten bolts to specified torque (see TORQUE CHART).

Using SE-1900 installer and SE1900-2 adapter, align timing marks and install camshaft gear on camshaft (Fig. 115). Use a soft hammer to tap spacers in position (Fig. 116).

Complete operation by following Steps f and g of Item 13.

14. Install piston and connecting rod assemblies as follows:

   a. Turn cylinder block to vertical position with front end facing upward. Turn No. 1 crankpin to top of its stroke.

   b. Coat No. 1 piston and piston rings with clean engine oil and install piston ring compressor on piston.

c. Coat No. 1cylinder bore with clean engine oil. Position piston and rod assembly in cylinder bore with dome side of piston (marked "UP") toward centerline of engine block. Carefully push piston and rod assembly through ring compressor (Fig. 117) until piston is in cylinder bore. Avoid striking cylinder bore with connecting rod.

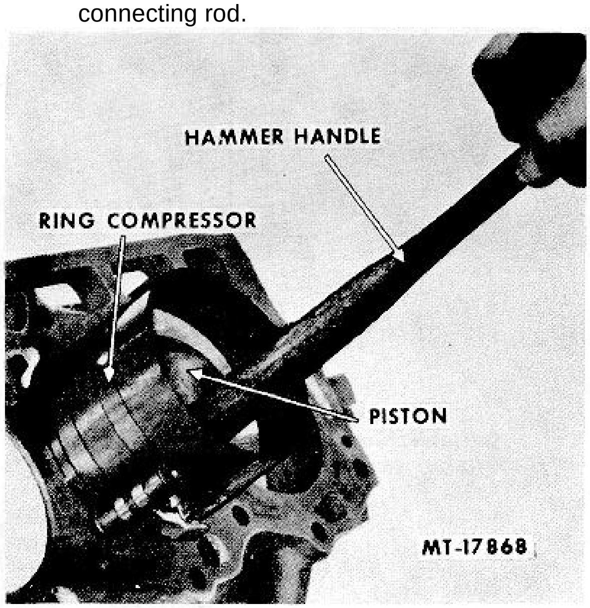


Fig. 117. Installing Piston and Connecting Rod Assembly

d. Coat crankshaft journal and connecting rod bearings with clean engine oil. Pull connecting rod onto crankshaft journal. Install connecting rod cap to rod with marked sides matching.

e. Install new bearing cap bolts, nuts and flat washers. Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil and install bolts.

NOTE: When installed properly, the large chamfered side of the rod and cap will be on the fillet side of the crankpin (Fig. 91). Tighten bolts to specified torque shown in the TORQUE CHART.

f. Install remaining piston and connecting rod assemblies in the same manner.

g. Recheck connecting rod end play (Fig. 80).

15. Install oil pump and screen as follows:

a. Position oil pump in cylinder block and secure with capscrews and lockwashers.

NOTE: In engines having a rear mounted distributor, the oil pump must be installed so slot in end of shaft is position as shown in Fig. 118 when pump drive gear is meshed with camshaft gear and No. 1 cylinder is in firing position.

b. Check for correct alignment of pump in block. Pump shaft should rotate freely without binding-if correctly aligned (Fig. 118).

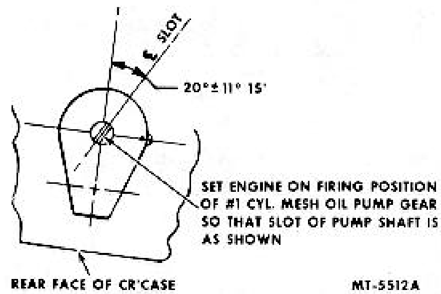


Fig. 118

c. Tighten screen assembly with approximately 3-1/2 turns to give proper location.

d. Establish correct oil pump screen position by placing a straightedge across the oil pan rails of crankcase. Using a scale, measure the distance from bottom of straightedge to top of pump screen on both sides (Fig. 119). Pump screen should be parallel with and at the specified distance above the pan rails.

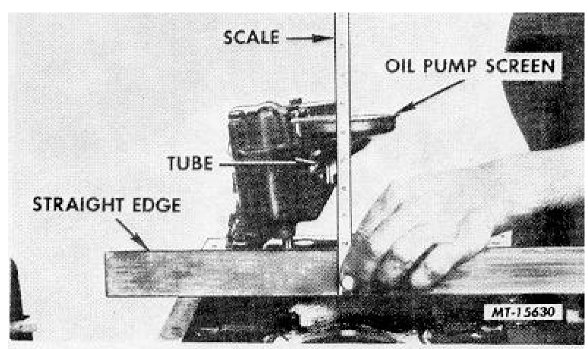


Fig. 119. Check for Proper Location of Oil Pump Screen

e. Tighten oil tube nut to proper torque (see TORQUE CHART).

f. Install pump screen clamp and brace. Tighten bolts evenly so the screen does not move.

16. Rotate cylinder block to horizontal position with top of block facing upward. Place flywheel housing in position over two aligning roll pins and tap into place with soft hammer. Install connecting capscrews (with flat washers) and tighten in sequence shown in Figure 120.

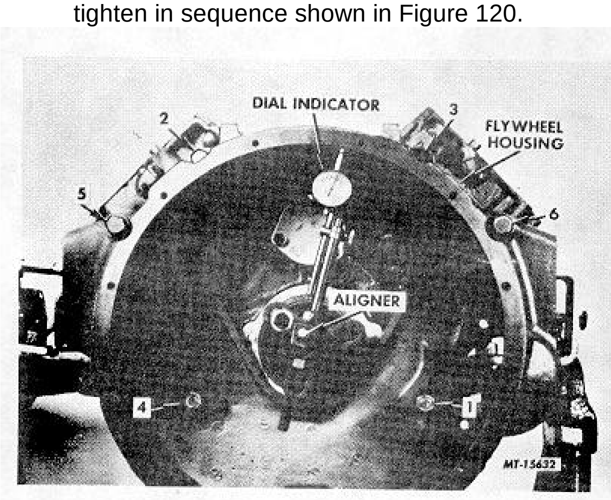


Fig. 120. Mounting and Alignment of Flywheel Housing

NOTE: The two lower mounting capscrews should be wrapped with two turns of Teflon thread tape to prevent oil leakage.

17. Using aligner tool SE-1834 and dial indicator, check flywheel housing alignment (Fig. 120). Runout (out-of-round) should not exceed specified limits (see SPECIFICATIONS).

NOTE: If flywheel housing alignment exceeds specified limit or if either flywheel housing or crankcase is being replaced; remove roll pins, align flywheel housing with dial indicator and ream roll pin holes with standard tapered reamer, 12.7 mm (.5"), to accommodate oversize roll pins (Fig. 121). If possible, align flywheel housing while engine is in engine stand with cylinder block in vertical position (flywheel housing facing up).

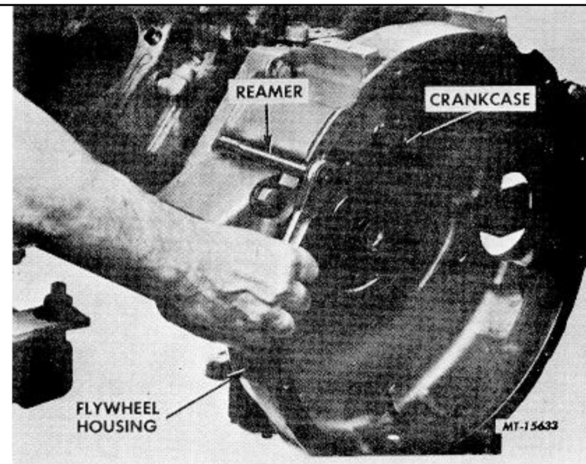


Fig. 121. Reaming Flywheel Housing-to-Crankcase Roll Pin Holes

18. Position flywheel (with ring gear) on roll pin in crankshaft flange. Install flywheel mounting capscrews in flywheel and crankshaft flange and tighten to specified torque (see TORQUE CHART).

19. Coat the O.D. of the clutch pilot bearing and I.D. of flywheel bore with Loctite (Grade B). Install clutch pilot bearing into the flywheel. Do not allow Loctite to contact inside of bearing or between flywheel and crankshaft. Allow Loctite one to two hours to cure after application.

20. Install clutch assembly as follows:

NOTE: Clutch installation procedures vary between clutch types (refer to Figures 33 and 34).

a. Position clutch driven disc against flywheel so the long portion of the hub is toward the rear. Place clutch in position on flywheel over clutch driven disc. Locate arrow or inspection mark (usually a dab of white paint) on flange of clutch backing plate or cover as near as possible to letter "L" on the flywheel and install two or three mounting capscrews and lockwashers loosely.

b. Insert a clutch aligning arbor or a transmission main drive gear shaft through clutch driven disc hub splines and into clutch pilot bearing (Fig. 122). Hold clutch driven disc in position and install remaining mounting capscrews and lockwashers in the flange of clutch backing plate or cover.

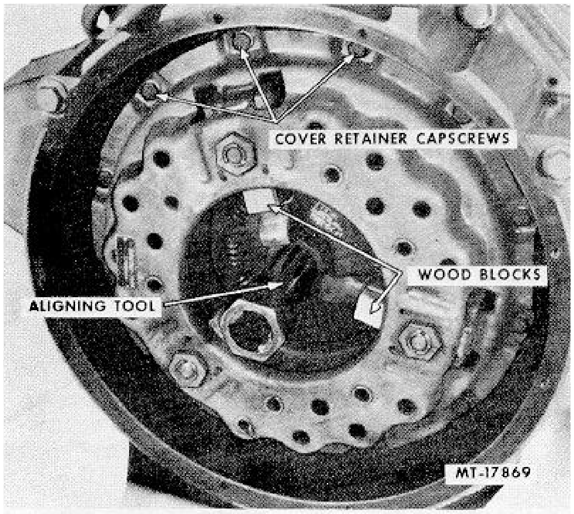


Fig. 122. Clutch Installation

c. Tighten all capscrews alternately, evenly and securely. Remove three retaining capscrews and flat washers, retaining clips or wood blocks which were installed to hold clutch in compressed position.

NOTE: The retaining capscrews or clips must be removed for the clutch to operate properly.

21. Position a new engine front cover gasket over the dowel pins in the crankcase and new gaskets at the water outlets. Install engine front cover assembly with idler arm mounting bracket and timing indicator.

NOTE: Capscrews located at rear of front cover should not be longer than 2.54 cm (1") or interference with the camshaft gear will result.

22. Install front cover seal as follows:

a. Position front cover oil seal on tool pilot (small diameter) of SE-2096 installer with wiping lip of seal toward outer end of pilot.

b. Lubricate seal bore of front cover with engine oil.

c. Place installer over end of crankshaft and drive seal into cover (Fig. 123). Seal is properly located when inner shoulder of tool contacts machined surface of front cover.

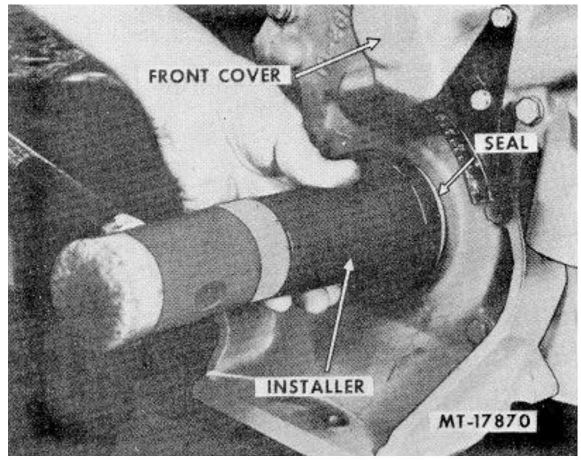


Fig. 123. Installing Engine Front Cover Oil Seal

NOTE: SE-2096 Installer can also be used to install the seal when the front cover is removed from the engine. Place the front cover in a press and, with seal positioned on installer, press seal in until flange of tool contacts the machined surface of the front cover.

23. Install idler pulley assembly to mounting bracket, insuring spacer is between arm and boss on front cover (Fig. 11). Secure arm with capscrew and lockwasher.

24. Position pulley key in keyway of crankshaft. Lubricate inside diameter with press-fit lubricant. Install crankshaft pulley using installer tool SE-1900 (Fig. 124). Install crankshaft pulley nut and flat washer. Tighten pulley nut to specified torque (see TORQUE CHART).

25. Position new gasket on water pump housing. Install water pump assembly with four flat head screws (Fig. 42).

26. Install new oil pan gasket on engine crankcase. Install oil pan.

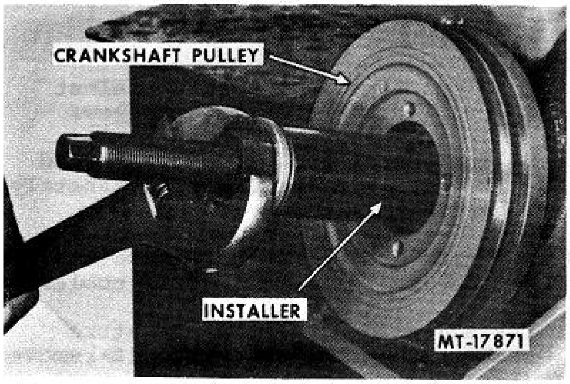


Fig. 124 Installing Crankshaft Pulley

27. Install tappets in their respective bores in the crankcase.

NOTE: If cylinder heads and tap- pet covers are installed, use SE-1947 Installer and Remover for tappet installation.

28. Install tappet covers with gaskets.

29. Install cylinder heads as follows:

a. Position new cylinder head gaskets over the aligning dowel sleeves of each cylinder bank. Insure all bolt holes in gaskets align with holes in crankcase.

b. Using a chain sling (see Fig. 30), place one cylinder head on the proper cylinder bank. Align head with dowel sleeves in crankcase. Loosely install all cylinder head bolts and washers.

NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil.

c. Following sequence shown in Fig. 125, tighten cylinder head bolts evenly to specified torque (see TORQUE CHART).

d. Repeats Steps a through c for installation of opposite cylinder head.

30. Insert valve lifter push rods in their respective positions.

31. Install rocker arm assemblies on their respective cylinder head. Insure to position shaft with oil

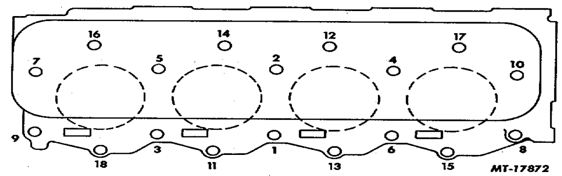


Fig. 125 Cylinder Head Bolt Tightening Sequence

holes down. Torque mounting bolts to specified torque (see TORQUE CHART). Refer to "Rocker Arm Assembly and Push Rods," page 37, for further in- formation on rocker arm assembly.

32. Install air compressor oil drain line in "V" of engine (Fig. 24).

33. Install left and right bank water out let transfer tubes with "O" rings. Install water outlets and gaskets on both banks. Refer to Figures 26 and 27.

34. Install right and left cylinder head covers and gaskets on respective cylinder heads. Oil fill tube is located on right cylinder head cover.

35. Install intake manifold and gaskets (Fig. 23). Secure with mounting bolts and washers (see TORQUE CHART). If vacuum manifold has been removed, install it in the proper location.

NOTE: Install extension clip under mounting bolt and washers located second from rear on right side of manifold.

36. Install spark plugs in the cylinder head and tighten to specified torque (see TORQUE CHART).

37. Install carburetor manifold-to-plate gasket, spacer plate and insulating gasket on intake manifold. Install carburetor with capscrews and washers or nuts and washers if so equipped (see TORQUE CHART).

38. Install PCV valve and hose (Fig. 21).

39. Install high tension wires and distributor cap (Fig. 21). Let the distributor cap lay loose in the "V" of the engine until distributor is installed.

40. Install the air inlet hose on the elbow on the right cylinder head cover with a hose clamp (Fig. 21).

41. Install the coil and bracket with lockwashers, flat washers and capscrews. Install fuel line and clip and governor vacuum line. Refer to Figure 21.

42. Install the air compressor support plate and "O" ring with three capscrews and lockwashers (Figs. 19 and 20).

43. Install air compressor and gasket with four capscrews and lockwashers. Install oil feed line and clip and carburetor return spring. Install water inlet and outlet hoses to air compressor (refer to Fig. 18).

44. Install power steering pump bracket with capscrews and washers and install power steering pump (refer to Fig. 17).

45. Install alternator bracket and idler pulley with capscrews and washers. Install air pump adjusting strap with capscrew and washer (refer to Fig. 16).

46. Install alternator with mounting capscrews and washers (Fig. 14).

47. Install air pump with capscrews and washers (Fig. 14). Install air pump pulley with three capscrews and lockwashers (Fig. 15).

48. Install air hoses between divert valve of air pump and air manifold check valves (Fig. 14).

49. Install freon compressor mounting bracket with three capscrews and lockwashers (Fig. 9). Install oil level gauge.

50. Install freon compressor loosely in place with mounting capscrews., flat washers and lockwashers (Fig. 8).

51. Install water pump pulley with capscrews and lockwashers (Fig. 41).

52. Install oil filter and cooler base as follows:

    a. Insert two capscrews in each end of the base and in the middle of base.

    b. Position gasket against base and start threads of capscrews, in gasket.

    c. Place base with gasket against crankcase and start capscrews.

    d. Install remaining capscrews and tighten all capscrews alternately and evenly.

53. Position new oil cooler gaskets on oil cooler base and install cooler.

54. Install oil filters, temperature sender and pressure sender if removed (Fig. 39).

55. Install accessory drive belts and adjust belt tension by moving power steering pump, alternator, air pump and freon compressor on their mounting brackets until proper belt tension is obtained. Refer to specific Operator's Manual for proper tension.

56. Position main drive belts over crankshaft and water pump pulleys. Push idler pulley toward centerline of engine and install belts over the idler pulley.

57. Install fan blade and spacer.

58. Install left exhaust manifold with gasket.

59. Install engine lifting plates and lifting sling (Fig. 5) and remove engine from overhaul stand.

60. Install brace on rear of freon compressor.

61. Install starter motor and heat shield (Fig. 3).

62. Install right side exhaust manifold with heat shield and gasket (Fig. 3).

NOTE: Certain components must be installed after engine installation in the vehicle. These areas are covered under ENGINE INSTALLATION.

INSTALLATION OF ENGINE

Engine installation procedures will vary between vehicle models. The general instructions are outlined below.

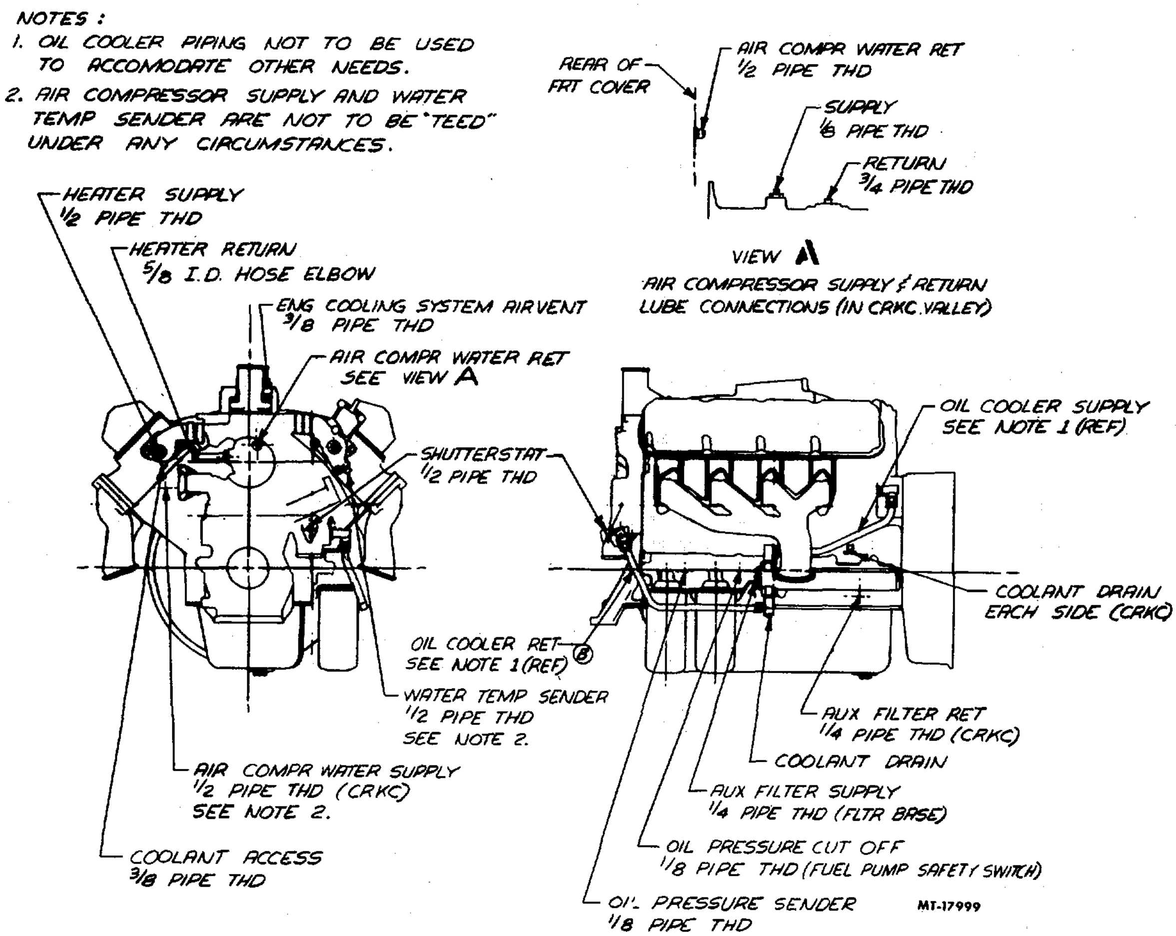


Fig. 126 Engine Connecting

1. If, removed, install lifting plates and lifting sling on engine (Fig. 5). Connect hoist to lifting sling
.
2. Position and align engine in chassis.
3. Connect engine to bell housing and connect front and rear engine mountings
4. Remove transmission support (if applicable) and remove lifting sling and lifting plates from engine.
5. Position thermostats in engine front cover. Position thermostat housing gasket over thermostats insuring the cooling system air vent opening is clean and the gasket tab is toward the front of the engine. Install thermostat housing.
6. Connect the following, if so equipped (refer to Fig. 126).

   a. Heater supply and return hoses.
   b. Air compressor water supply and return lines.
   c. Air compressor oil supply and re turn lines.
   d. Oil pressure connections.
   e. Oil cooler water supply and return lines.
   f. Water temperature sender.
   g. Shutterstat assembly.
   h. Auxiliary filter supply and return lines.

7. Connect the following:

   a. Accelerator and throttle linkage.

b. Alternator wiring.

c. Exhaust Pipes to manifold.

d. Fuel lines.

e. Surge tank hoses, if so equipped.

f. Tachometer cable.

8. Install air cleaner with piping. Connect fresh air hose to air cleaner connection.

9. Install EGR assembly, if so equipped.

10. Connect power steering hoses, if so equipped.

11. Install radiator core assembly, radiator support, fenders, front bumper, etc. as required.

12. Connect air conditioning system components, if so equipped.

13. Connect radiator hoses and shutter control hoses, if applicable.

START-UP OF ENGINE

The following steps should be followed for the initial start-up of the engine:

1. In addition to prelubricating running engine parts, the engine lubricating system should be pressure primed or charged with oil using SE-1632 Oil Leak Detector as follows:

a. Using adapter fittings, connect oil line from oil leak detector to engine oil -gallery.

b. Following manufacturer's instructions, fill and charge oil leak detector.

c. Inject sufficient oil into engine lubrication system to fill oil-filters and charge entire system.

d. Disconnect oil leak detector.

e. Check engine oil level and bring to specified level before starting engine.

NOTE: New or overhauled engines which have been in storage should be primed as outlined above at installation.

2. Fill engine cooling system to specified level with coolant.

3. If applicable, fill power steering system with specified amount of oil.

4. Connect battery cables.

5. Operate engine. Check for oil and coolant leaks. Make necessary engine operation adjustments.

6. If applicable, bleed power steering system as needed.

7. If applicable, check air conditioning system operation and refrigerant level. Service and adjust-as needed.

8. Reinstall hood and engine tunnel, if applicable. Lower cab (CO models).

TROUBLE-SHOOTING

PROBABLE CAUSE	REMEDY
ENGINE WILL NOT TURN OVER	
1. Cranking motor inoperative.	
a. Battery weak or faulty.	Charge or replace battery.
b. Cables and terminals faulty.	Inspect battery cables, wiring and wiring connections. Replace cables if necessary.
c. Ignition switch defective.	Replace ignition switch.
d. Cranking motor defective.	Check motor and make necessary corrections.

PROBABLE CAUSE	REMEDY
ENGINE WILL NOT TURN OVER (Continued)	
2. Engine oil too heavy for operation in low temperature range.	Use grade of oil specified in Operator's Manual.
3. Internal seizure.	Determine cause for seizure and correct.
ENGINE TURNS OVER BUT WILL NOT START	
1. Cranking speed too low.	
a. Battery weak or faulty.	Charge or replace battery.
b. Cables and terminals faulty.	Inspect battery cables.
c. Cranking motor defective.	Check motor and make necessary corrections.
2. Fuel system faulty.	
a. No fuel in tank.	Fill tank with fuel.
b. Fuel in-line filter clogged.	Replace in-line filter.
c. Water in gasoline. Refill with clean fuel	Drain tank, fuel pump and carburetor.
d. Fuel lines clogged.	Clean fuel lines.
e. Fuel pump defective.	Test fuel pump; replace if necessary.
f. Carburetor flooded. before again attempting to start engine.	Open choke valve. Wait a few minutes
3. Air intake restricted or exhaust systems restricted.	Service air cleaner; check for restrictions.
4. Ignition system faulty.	
a. Wet or fouled spark plugs.	Remove and dry plugs; remove carbon; reset plug gap.
b. Cracked or broken spark plug insulator.	Replace damaged plugs.
c. Spark plug or ignition wiring loose or defective.	Check for loose or corroded terminals. Check for cracked or broken wiring.
d. Damaged trigger wheel or sensor.	Replace damaged part.
e. Trigger wheel to sensor air gap incorrect.	Set gap to specification.
Broken distributor rotor.	Replace rotor.
g. Broken distributor cap.	Replace cap.
h. Dirty or pitted distributor cap terminals.	Clean terminals; replace cap if necessary.

PROBABLE CAUSE	REMEDY
ENGINE TURNS OVER BUT WILL NOT START (Continued)	
4. Ignition system faulty (continued).	
i. Electronic control faulty.	Replace electronic control.
j. Ignition coil defective.	'Test coil; replace if necessary.
k. Ignition switch defective.	Connect jumper wire from "BAT" to "IGN" terminal of switch. Try to start engine. If engine starts, switch is defective and should be replaced.
MISSING AND BACKFIRING BUT FAILS TO START	
1. Water in gasoline.	Drain tank, fuel pump and carburetor. Fill with clean gasoline.
2. Air leaks around intake manifold.	Check manifold gasket. Tighten manifold bolts to specified torque
3. Improper firing order.	Check ignition cables for correct installation at spark plugs and distributor cap in accordance to engine firing order.
4. Distributor not correctly timed to engine.	Check and adjust timing.
5. Distributor cap shorting out.	Check for loose or corroded terminals, dirt or cracks.
MISFIRING OR CUTTING OUT AT HIGH SPEED	
1. Ignition system faulty.	
a. Spark plugs fouled or worn.	Clean and test spark plugs; replace if necessary.
b. Damaged trigger wheel or sensor.	Replace damaged part.
c. Distributor advance not operating.	Repair as needed; replace worn or damaged parts.
d. Defective coil.	Test coil; replace if necessary.
2. Fuel system faulty.	
a. Partially closed choke plates.	Check and readjust choke control.
b. In-line fuel filter clogged.	Replace in-line fuel filter.
c. Defective fuel pump.	Test fuel pump; replace if necessary.
d. Dirt in main jet.	Clean carburetor.
e. Accelerating pump inoperative.	Repair or replace.
f. Float level too low.	Check float level and reset if necessary.

PROBABLE CAUSE	REMEDY
MISFIRING OR CUTTING OUT AT HIGH SPEED (Continued)	
3. Engine compression low.	Refer to "Loss of Compression."
EXCESSIVE DETONATION (PING)	
1. Low octane fuel.	Use a good grade of gasoline.
2. Ignition system faulty.	
a. Fouled spark plugs.	Clean and regap plugs; replace if necessary.
b. Spark advanced too far.	Check and adjust timing.
c. Damaged trigger wheel or sensor.	Replace damaged part.
3. Fuel system faulty.	
a. Float level set too low.	Clean float level and adjust if necessary.
b. Main metering system too lean.	Correct as necessary.
4. Engine overheated.	Refer to "Engine Overheated."
5. Cylinder heads not bolted down tight.	Tighten cylinder head bolts to specified torque following correct bolt tightening sequence.
ENGINE DOES NOT OPERATE SMOOTHLY	
1. Damaged trigger wheel.	Replace trigger wheel.
2. Cracked distributor cap.	Replace cap.
J. Worn or bent distributor shaft.	Replace shaft and shaft bushing.
4. Trigger wheel-to-sensor air gap incorrect.	Set gap to specifications.
5. Leak in vacuum advance diaphragm or connections.	Replace diaphragm; check all connections.
6. Carburetor float level too high.	Check float level and reset if necessary.
7. Fuel mixture too rich.	Adjust fuel mixture.
ENGINE DOES NOT DEVELOP FULL POWER	
1. Intake air restricted.	Clean air cleaner; check for restrictions.
2. Exhaust system restricted.	Remove restriction.

PROBABLE CAUSE	REMEDY
ENGINE DOES NOT DEVELOP FULL POWER (Continued)	
3. Ignition system faulty.	
a. Ignition timing incorrect.	Check and adjust timing.
b. Spark plugs fouled or worn.	Clean and regap plugs; replace if necessary.
c. Trigger wheel-to-sensor air gap incorrect.	Set gap to specifications.
d. Distributor advance mechanism not operating.	Repair as necessary; replace worn or damaged parts.
e. Defective coil.	Test coil; replace if necessary.
4. Fuel system faulty.	
a. Fuel pump defective.	Test fuel pump; replace if necessary.
b. Governor worn or out of adjustment.	Check and adjust governor; replace worn or damaged parts.
c. Throttle linkage restricted, worn or out of adjustment.	Check linkage; repair as needed.
d. Choke plate partially closed.	Check choke control linkage; readjust if necessary.
e. Float level set too low.	Check float level and reset if necessary.
f. Accelerating pump inoperative.	Repair or replace.
g. Power or economizer valve inoperative.	Replace.
5. Air leaks around intake manifold.	Check manifold gasket; tighten manifold bolts to specified torque.
6. Engine compression low.	Refer to "Loss of Compression."
LOSS OF OIL PRESSURE	
1. Low oil level.	Add oil to correct level.
2. Clogged oil filter element.	Change filter element.
3. Oil pressure indicator defective.	Repair or replace as needed.
4. Oil leaks.	Check for leaks and correct as needed.
5. Oil pump screen clogged.	Clean pump screen and oil pan.
6. Oil pressure relief valve sticking or broken relief valve spring.	Clean valve or replace spring.
7. Oil pump worn.	Repair or replace.

PROBABLE CAUSE	REMEDY
LOSS OF OIL PRESSURE (Continued)	
8. Worn main connecting rod or camshaft bearings.	Replace worn bearings.
EXCESSIVE OIL CONSUMPTION	
1. Oil leaks.	Check for leaks and correct as needed.
2. Incorrect grade of lubricating oil.	Use grade of oil specified in Operator's Manual.
3. Engine overheated.	Refer to "Engine Overheated."
4. Excessive oil in crankcase.	Drain to correct level.
5. Stuck oil control rings, worn valve guides, pistons, rings and cylinder walls.	Replace worn parts; rebore cylinder block if necessary.
LOSS OF COMPRESSION	
1. Valves sticking.	Clean valve guides and stems; replace worn parts.
2. Valve mechanism parts worn or broken.	Replace worn or damaged parts.
3. Cylinder heads not bolted down tight.	Tighten cylinder head bolts to specified torque following correct bolt tightening sequence.
4. Damaged cylinder head gaskets.	Replace gaskets.
5. Worn or damaged pistons, rings and cylinder walls.	Replace worn parts; rebore cylinder block if necessary.
ENGINE OVERHEATED	
1. Coolant level low.	Add to correct level; check for cause of coolant loss.
a. Radiator cap loose or missing.	Tighten or replace cap.
b. Leaks in cooling system.	Correct as necessary.
c. Leaking cylinder head gasket or cracked heads or cylinder block.	Replace cylinder head gasket; check for cracks; replace heads or block if necessary.
2. Engine overloaded.	Reduce load on engine; use lower gear.
3. Dirt and trash on outside of radiator.	Clean radiator fins with air or water pressure.
4. Fan belt slipping.	Replace fan belts.

PROBABLE CAUSE	REMEDY
ENGINE OVERHEATED (Continued)	
5. Cooling system clogged.	Drain and flush cooling system.
6. Thermostats or radiator shutters inoperative.	Replace thermostats or repair shutters as needed.
7. Water pump defective.	Replace water pump.
8. Low oil pressure.	Refer to "Loss of Oil Pressure."
EXCESSIVE FUEL CONSUMPTION	
1. Air cleaner restricted or air cleaner oil level too high.	Service air cleaner.
2. Leaks in fuel system.	Check for leaks; repair as needed.
3. Ignition system faulty.	
a. Spark plugs fouled or worn.	Clean and regap plugs; replace if necessary.
b. Ignition timing incorrect	Check and adjust timing.
c. Trigger wheel-to-sensor air gap incorrect.	Set air gap to specification.
d. Low voltage to spark plugs caused by defective coil.	Test coil; replace if necessary.
4. Fuel system faulty.	
a. Fuel pump pressure too high.	Check fuel pump; replace if necessary.
b. Choke plate partially closed.	Check choke control linkage; readjust if necessary.
c. Leaking needle valve.	Replace needle valve and seat.
d. Float level too high.	Check float level and reset if necessary.
e. Power or economizer valve inoperative.	Replace.
SMOKY EXHAUST	
1. Engine overloaded.	Reduce load on engine; use lower gear.
2. Air intake restricted.	Service air cleaner; check for restriction.
3. Ignition timing incorrect.	Check and adjust timing.
4. Incorrect grade of lubricating oil.	Use grade of oil specified in Operator's Manual.

PROBABLE CAUSE	REMEDY
SMOKY EXHAUST (Continued)	
5. Fuel mixture too rich.	Adjust fuel mixture.
6. Defective fuel pump.	Check fuel pump; replace if necessary.
7. Engine compression low.	Refer to "Loss of Compression."
8. Stuck oil control rings; worn valve guides, pistons, rings and cylinder walls.	Replace worn parts; rebore cylinder block if necessary.
ENGINE NOISES	
1. A sharp rap at idle speed indicates a loose piston pin. The pin at fault can be found by shorting out the spark plugs one at a time. The noise will disappear when the cylinder with the faulty pin is shorted out.	Replace piston pin.
2. A flat slap, when advancing engine speed under load, indicates a loose piston.	Replace piston and rebore cylinder block if necessary.
3. A metallic knock when idling or retarding engine speed, which disappears under load , indicates worn or loose connecting rod bearings. The bearing at fault can be found by shorting out the spark plugs one at a time. The noise will disappear when the cylinder with the faulty bearing is shorted out.	Replace worn bearings; check crankshaft journals for wear.
4. Constant loud clacking, light clicking or intermittent noise indicates faulty hydraulic valve lifters (tappets).	Clean or replace valve lifters (tappets).
GOVERNOR FAILS TO OPERATE OR OVERRUNS RATED SPEED	
1. Speed setting too high.	Adjust governor.
2. Loose or faulty connection at carburetor throttle body.	Tighten or repair connection.
3. Vacuum leaks in lines or diaphragm.	Repair as needed.
4. Governor valve worn or not seating; governor valve spring worn.	Inspect governor valve; replace worn parts.
5. Governor jets in carburetor plugged or restricted.	Clean jets.
6. Worn or incorrect governor spring in carburetor.	Replace spring.
GOVERNOR RESTRICTS ENGINE FROM REACHING RATED SPEED	
1. Speed setting too low.	Adjust governor to obtain rated engine speed.
2. Governor valve spring broken.	Replace spring.

TORQUE CHART

Location	Recommended Torque Newton Meters	1bf-ft
Air Cleaner-to-Cylinder Head	41 - 52	30 - 38
Camshaft Timing Gear	163 - 177	120 - 130
Camshaft Thrust Flange	54 - 61	40 - 45
Carburetor Mounting Capscrews or Nuts	8 - 11	6 - 8
Connecting Rod	88 - 95(3)	65 - 70 (3)
Crankcase Tie Bolts	61 - 68 (1)	45 - 50 (1)
Crankshaft Pulley	353 - 393	260 - 290
Cylinder Head Mounting	109 - 122 (2)(3)	80 - 90(2) (3)
Distributor Hold Down Clamp	16 - 20	12 - 15
Exhaust Manifold	41 - 52	30 - 38
Flywheel-to-Crankshaft	149 - 163	110 - 120
Idler Pulley	95 - 115	70 - 85
Intake Manifold	41 - 52	30 - 38
Main Bearing Cap	170 - 183 (1)(3)	125 - 135 (1)(3)
Oil Pan-to-Crankcase	10 - 13	7 - 10
Oil Pump-to-Crankcase	38 - 49	28 - 36
Rocker Arm Support Bracket	95 - 115	70 - 85
Spark Plugs	34 - 41	25 - 30
Tappet Cover-to-Crankcase	10 - 13	7 - 10
Valve Cover-to-Cylinder Head	10 - 13	7 - 10
Water Pump Hub-to-Front Cover	16 - 19	12 - 14

(1) Main bearing caps must be torqued before tie bolts.
(2) Bolts to be retorqued after engine warm-up.
(3) Bolt heads and underheads to be lubricated with engine oil before assembly.

ALL OTHER FASTENERS

Bolt Size	Newton Meters Grade 5	Newton Meters Grade 8	1bf-ft Grade 5	1bf-ft Grade 8
1/4	10 - 12	13 - 16	90 - 110*	115 - 140*
5/16	18 - 21	24 - 30	155 - 190*	215 - 265*
3/8	28 - 37	41 - 52	21 - 27	30 - 38
7/16	46 - 57	68 - 81	34 - 42	50 - 60
1/2	68 - 81	95 - 115	50 - 60	70 - 85
9/16	102 - 122	142 - 170	75 - 90	105 - 125
5/8	142 - 170	197 - 237	105 - 125	145 - 175
3/4	237 - 292	339 - 407	175 - 215	250 - 300
7/8	392 - 475	543 - 678	290 - 350	400 - 500
1	567 - 712	847 - 1017	425 - 525	625 - 750

* 1bf-in

SPECIFICATIONS

	V-537 Engine	V-605 Engine
GENERAL		
Number of Cylinders	8	
Bore	117.48 mm (4.625")	
Stroke	101.60 mm (4.000")	114.30 mm (4.500")
Rated Power (A.M.A.)	51.0 kw (68.5 hp)	
Displacement	8800 cm^3 (537 in^3)	9914 cm^3 (605 in^3)
Brake Power (Net) @ RPM (2 bbl)	155 kw (208 hp) @ 3200	----
Brake Power (Net) @ RPM (4 bbl)	175 kw (236 hp) @ 3200	191kw (257 hp) @ 3200
Torque (Net) @ RPM (2 bbl)	562 N.m (415 000 -ft) @ 2000	----
Torque (Net) @ RPM (4 bbl)	581N.m (429 1bf-ft) @ 2200	581 N.m (429 1bf-ft) @ 2000
Compression Ratio	7.5:1	
Firing Order	1 - 8 - 7 - 3 - 6 - 5 - 4 - 2	
Ignition Setting	70 BTC	
Engine Timed From (Cylinder No.)	1 or 6	
Spark Plug Gap	.76 mm (.030")	
Weight (W/Standard Accessories)	469 kg (1034 lbs)	
Engine Serial Number Location	Stamped on Top of Crankcase Right Bank, Front Cover	
Engine Coolant Capacity	17.6 litre (18.6 qt)	
Oil Capacities: Dry or Rebuilt Engine (W/Filter)	14.2 litre (15 qt)	
Wet Engine (W/Filter)	13.2 litre (14 qt)	
Oil Cooler	.47 litre (.5 qt)	
Oil Filter (each)	.95 litre (1 qt)	
Governed RPM (No Load)	3400	
Air Gap, Trigger Wheel-to-Sensor	.20 mm (.008")	
Dwell (Degrees)	24 - 34	
Curb Idle, RPM *	500 - 550	

* Transmission in Neutral, Air Conditioning OFF.

	V-537 Engine	V-605 Engine
CRANKSHAFT		
Number of Main Bearings	5	
Main Journal Diameter	79.337 - 79.362 mm (3.1235 - 3.1245")	
Rod Journal Diameter (Crankpin)	66.624 - 66.650 mm (2.6230 - 2.6240")	
Main Bearing Clearance	.038 - .090 mm (.0015 - .0035")	
Crankshaft End Play	.152 - .305 mm (.006 - .012")	
Thrust Taken By	Intermediate Main	
CAMSHAFT		
Camshaft Journal Diameter:		
Front	59.652 - 59.741 mm (2.3485 - 2.3520")	
Second	58.865 - 58.953 mm (2.3175 - 2.3210")	
Third	58.204 - 58.293 mm (2.2915 - 2.2950")	
Fourth	57.112 - 57.201 mm (2.2485 - 2.2520")	
Camshaft Bearing Clearance	.025 - .140 mm (.0010 - .0055")	
Camshaft End Play	.089 - .292 mm (.0035 - .0115")	
Thrust Absorbed By	Thrust Flange	
Timing Gear Backlash	.030 - .200 mm (.001 - .008")	
CONNECTING RODS		
Crankshaft End:		
Bore	70.498 - 70.510 mm (2.7755 - 2.7760")	
Running Clearance	.028 - .091 mm (.0011 - .0036")	
Side Clearance	.20 - .48 mm (.008 - .018")	
Bearing Spread Dimensions	Refer to Page 26	
Maximum Permissible Taper	.013 mm (.0005")	
Maximum Permissible Out-of-Round	.013 mm (.0005")	
Piston End:		
Bore without Bushing	35.833 - 35.871 mm (1.41075 - 1.41225")	
Bore with Bushing	33.343 - 33.348 mm (1.3127 - 1.3129")	

	V-537 Engine	V-605 Engine
PISTON PINS		
Length	10.63 - 10.64 mm (3.260 - 3.265")	
Diameter	4.2765 - 4.2768 mm (1.3118 - 1.3119")	
Pin Fit [Room Temp. - 21° C (70° F)]:		
Recommended Clearance in Rod	.020 - .028 mm (.0008 - .0011")	
Recommended Clearance in Piston	.003 - .010 mm (.0001 - .0004")	
PISTONS		
Material	Aluminum Alloy	
Recommended Piston Clearance	.030 - .056 mm (.0012 - .0022")	
Pin Bore Diameter	33.325 - 33.330 mm (1.3120 - 1.3122")	
Ring Groove Size:		
Compression Rings (2)	.125 - .127 mm (.0955 - .0965")	
Oil Ring	.247 - .249 mm (.1855 - .1895")	
PISTON RINGS		
Compression Rings (2):		
Size (Face Width)	2.313 - 2.375 mm (.0925 - .0935")	
Gap:		
Top	.30 - .56 mm (.012 - .022")	
Second	.36 - .61 mm (.014 - .024")	
Side Clearance (Fit in Groove)	.05 - .10 mm (.002 - .004")	
Oil Control Ring (1):		
Size (Face Width	4.724 - 4.737 mm (.1860 - .1865")	
Gap	.30 - .56 mm (.012 - .022")	
Side Clearance (Fit in Groove)	.05 - .10 mm (.002 - .004")	
VALVES		
Intake Valves:		
Face Angle	15°	
Seat Width	1.52 - 2.29 mm (.060 - .090")	

	V-537 Engine	V-605 Engine
—Intake Valves (Continued)		
Guide Seat Runout (TIR Max.)	.020 mm (.015")	
Lift	11.811 mm (.04650")	
Stem Diameter	11.026 - 11.046 mm (.4341 - .4349")	
Stem Clearance in	.041 - .086 mm (.0016 - .0034")	
Exhaust Valves:		
Face Angle	45°	
Seat Width	2.29 - 3.05 mm (.090 - .120")	
Seat Runout (TIR Max.)	.020 mm (.015")	
Lift	11.811 mm (.4650")	
Stem Diameter	11.019 - 11.036 mm (.4338 - .4345")	
Stem Clearance in Guide	.051 - .094 mm (.0020 - .0037")	
Valve Guides:		
Length	77.72 mm (3.060")	
Bore Diameter	11.087 - 11.113 mm (.4365 - .4375")	
Distance Above Head:		
Intake	26.4 mm (1.04")	
Exhaust	26.4 mm (1.04")	
Valve Springs:		
Free Length	52.71 mm (2.075")	
Test Length	35.48 mm (1.397")	
Test Length Pressure	890 N (200 1bf)	
Valve Lifters (Tappets):		
Diameter	1.306 - 1.307 mm (.9955 - .9960")	
Clearance in Bore	.08 - .12 mm (.003 - .005")	
Bleed Down Rate [3.18 mm (1/8") Travel at 222 N (50 1bf)]	8 - 50 Secs.	
Valve Timing:		
Intake Opens (Before TDC)	22°	
Intake Closes (After BDC)	66°	
Exhaust Opens (Before BDC)	62°	
Exhaust Closes (After TDC)	26°	

	V-537 Engine V-605 Engine
VALVES (Continued)	
Valve Rocker Arm:	
Clearance in Shaft	.0008 - .0092 mm (.0006 - .007")
OIL PUMP	
Body-Gear End Clearance	.076 - .114 mm (.003 - .0045")
Body-Gear Clearance	.018 - .069 mm (.0007 - .0027")
Gear Backlash	.0006 - .0085 mm (.0005 - .0065")
Oil Pressure with SAE-30 Oil at 930 C (2000 F):	
@ 800 RPM (Engine)	69 - 138 kPa (10 - 20 psi)
@ 3600 RPM (Engine)	310 - 379 kPa (45 - 55 psi)
FLYWHEEL HOUSING	
Maximum Permissible Runout	.25 mm (.010")
THERMOSTAT 770 C (1700 F)	
Starts to Open	75° - 79° C (167° - 174° F)
Fully Open	90° C (194° F)

ENGINE

MODELS: MV-404, MV-446

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TORQUE AND SPECIFICATIONS CHARTS: 66

*For complete engine tune-up specifications and troubleshooting guide, refer to Emission Control Systems for Gasoline Engines Service Manual; 1976 CTS-2694, 1977 CTS-2721, 1978 CTS-2733 and 1979 CGES-135.

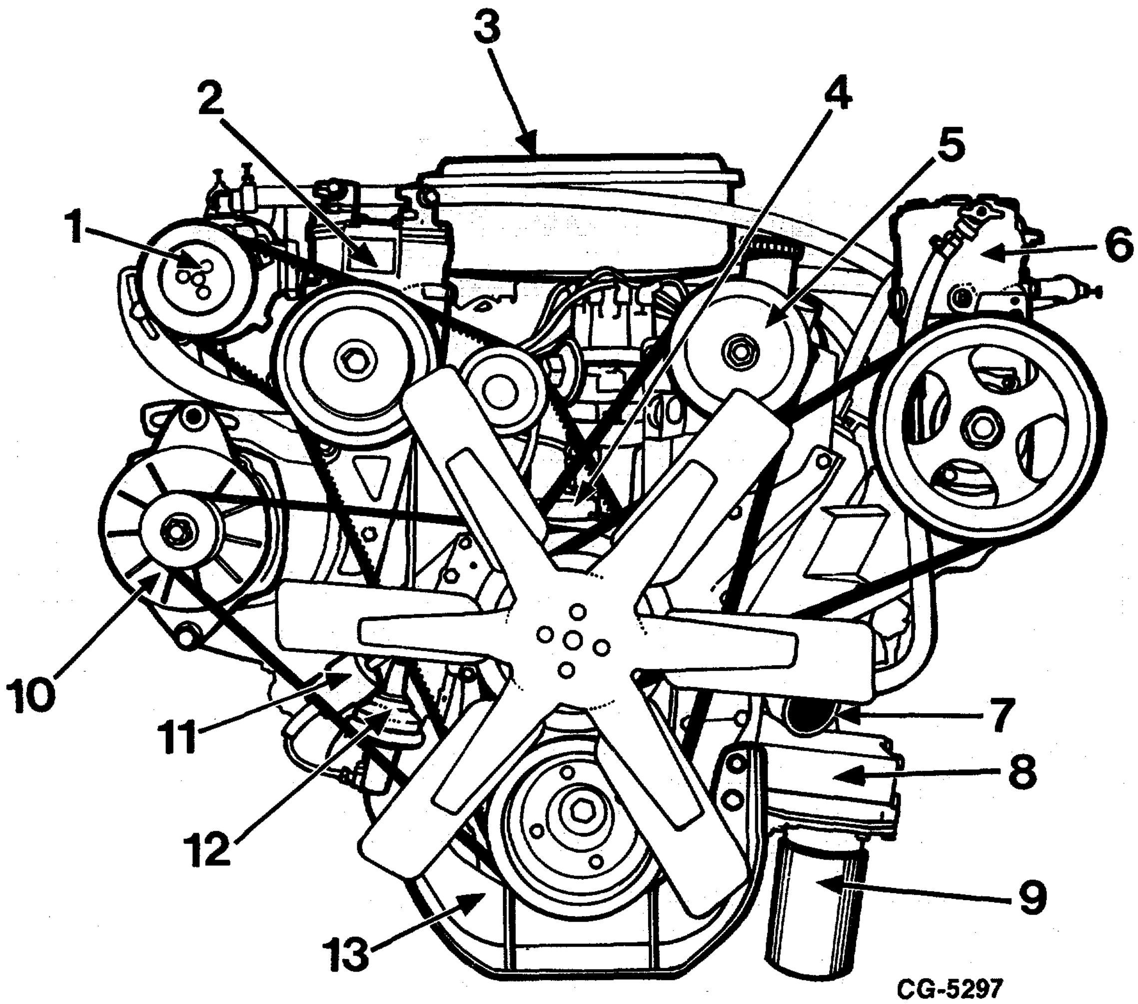

Fig. 1 Front View of Engine

1. Air pump
2. Freon compressor
3. Air cleaner
4. Engine water inlet
5. Power steering pump
6. Air compressor
7. Engine water outlet
8. Oil Cooler
9. Oil filter
10. Alternator
11. Gasoline filter
12. Fuel pump
13. Engine mounting bracket

ENGINE DESCRIPTION

The V-Series engines covered in this section are 8-cylinder, overhead valve, 900 type. Dimensional specifications of the various models are listed under "Specifications." Figures 1, 2 and 3 illustrate the complete engine assembly.

The basic unit of the engine, the cylinder block and upper crankcase, is cast in one piece and is of extremely rigid construction. It provides full-length water jackets surrounding each of the cylinders. This unit forms the major section of the engine as it is fitted with the crankshaft, camshaft, pistons and various related parts.

The forged alloy steel crankshaft is supported by five insert-type main bearings. Crankshaft end thrust is controlled by the flanges of the No. 3 main bearing.

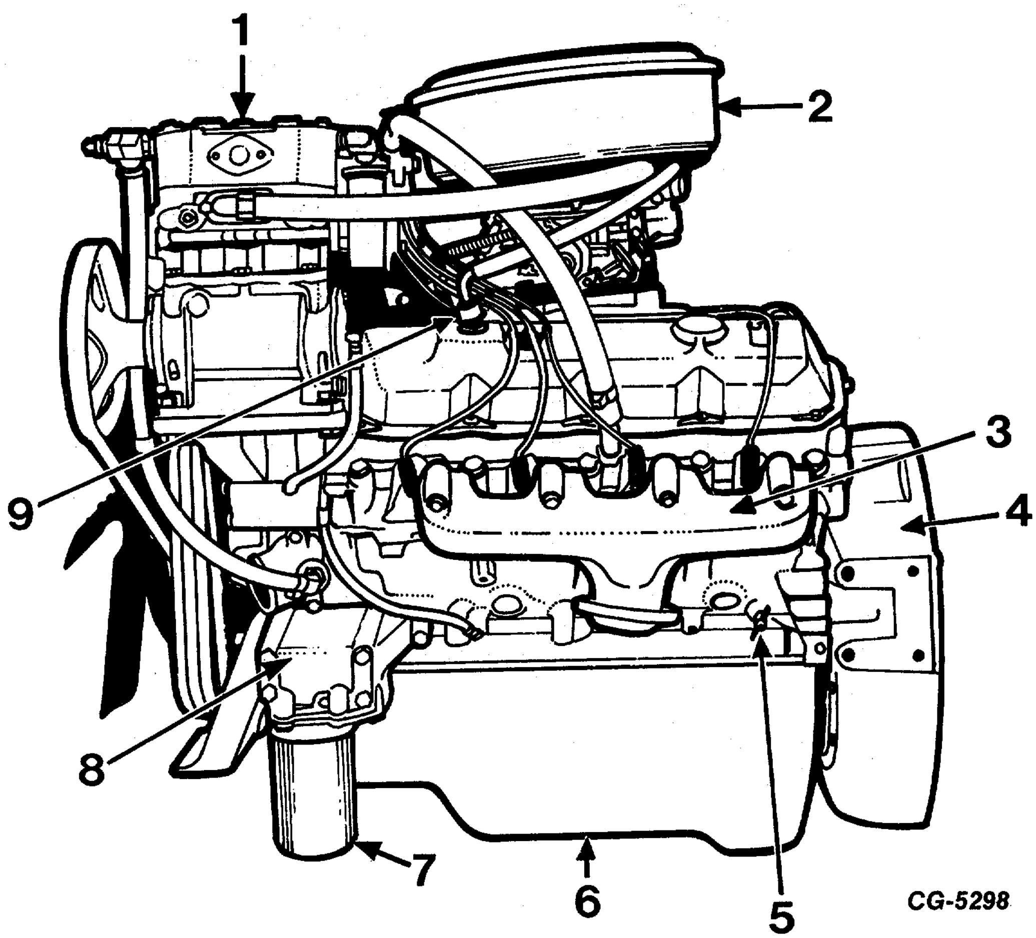

Fig. 2 Left Side View of Engine

1. Air compressor
2. Air cleaner
3. Exhaust manifold
4. Flywheel housing
5. Drain cock
6. Oil pan
7. Oil filter
8. Oil cooler
9. Flame arrestor

The camshaft is supported by five insert-type bearings pressed into the block and is driven by a drive gear keyed to the crankshaft. The end thrust of the camshaft is controlled by a thrust flange located between the front camshaft journal and the distributor drive gear.

The aluminum-alloy pistons are fitted with compression rings and an oil ring and are used in the engine with forged steel connecting rods. The full-floating type piston pins are held in place in the pistons at the ends of the pins by snap rings. The lower end of the connecting rod and cap contain locking type bearing inserts. The rods and caps are numbered for identification and reassembly.

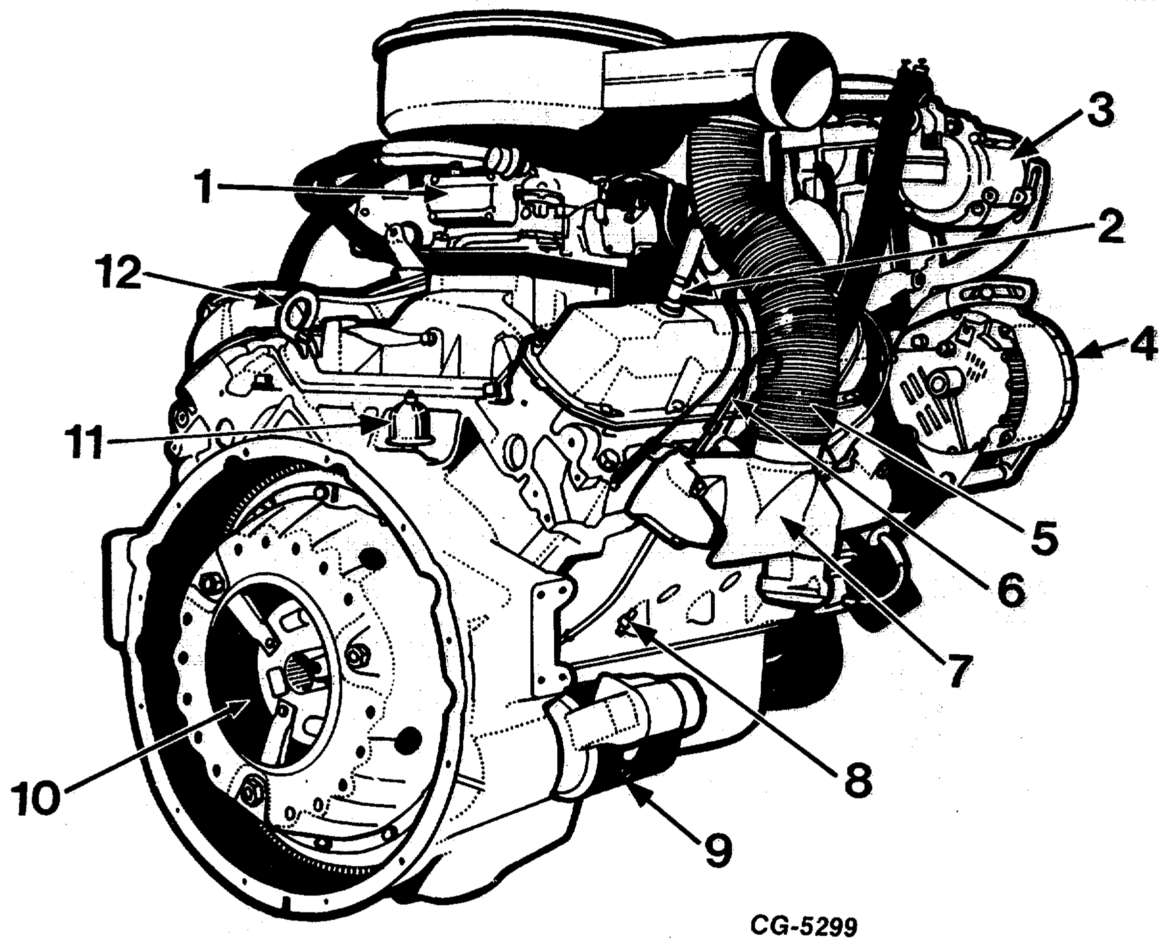

Fig. 3 Right Rear View of Engine

1. Carburetor
2. PCV valve
3. Air pump
4. Alternator
5. Shroud hose
6. Dipstick
7. Manifold shroud
8. Drain cock
9. Starting motor
10. Clutch
11. Oil pressure sending unit
12. Lifting eye

The hydraulic valve lifters minimize engine noise and maintain zero valve lash or tappet clearance. This eliminates the need for periodic adjustment.

The cylinder head assemblies feature a high turbulence-type of combustion chamber which provides superior combustion characteristics to produce very high volumetric and thermal efficiencies. The cylinder heads used on the engines are equipped with a positive valve rotating mechanism on the exhaust valve only. This device is called a "Roto Coil" and is located at the base of each exhaust valve spring. The cylinder heads also incorporate an integral air manifold.

Another important feature of the cylinder heads is that they are completely interchangeable from one cylinder bank to the other bank. The cylinder head gaskets are made of composition material which prevents compression leakage between the cylinder block and cylinder head. The gaskets also prevent leakage of water from the water jackets into the cylinders. The gaskets are also interchangeable from one bank to another.

When viewing the engine from the driver's seat, the cylinders on the left bank are numbered 2, 4, 6 and 8 with No. 2 being at the front. Similarly, the cylinders on the right bank are numbered

1, 3, 5 and 7 with No. 1 being at the front. The right and left sides of "V" engines with cylinders numbered in the foregoing manner are sometimes referred to as "even bank" and "odd bank." The "odd" or "even" refers to the numbers of the cylinders. For easy reference each cylinder number is cast on the intake manifold directly over its respective cylinder. The firing order is 1-2-7-3- 4-5-6-8. This information is also cast on the top surface of the intake manifold.

Two "V" type fan belts driven by a pulley on the crankshaft drive the water pump-fan combination and alternator while another "V" type belt driven by the water pump pulley drives the air compressor.

The water pump is mounted on the front of the engine and supplies both cylinder banks. The alternator is mounted on the right side of the engine with an adjustable strap to set the proper belt tension.

A gear-type oil pump is internally mounted to the bottom of the crankcase and is driven by a tang on the end of the distributor shaft. The distributor, mounted in the front end of the cylinder block assembly, is gear driven directly by the camshaft resulting in reduced spark fanning.

NOTE: When timing the engine, attach the timing light to the No. 1 spark plug and adjust distributor to obtain proper initial timing; see specifications and Figure 4.

ENGINE LUBRICATION SYSTEM

The oil pump is located in the left front corner of the oil pan. The pump is driven from an extension on the distributor which is gear driven from the camshaft. It draws oil from the oil pan sump through a screen and tube assembly. The oil pump contains an internal bypass set at 50 psig. The oil is filtered only, or cooled and filtered, before entering the crankcase. Filter and cooler contain bypass systems which allow oil to bypass them in the event that either or both become plugged.

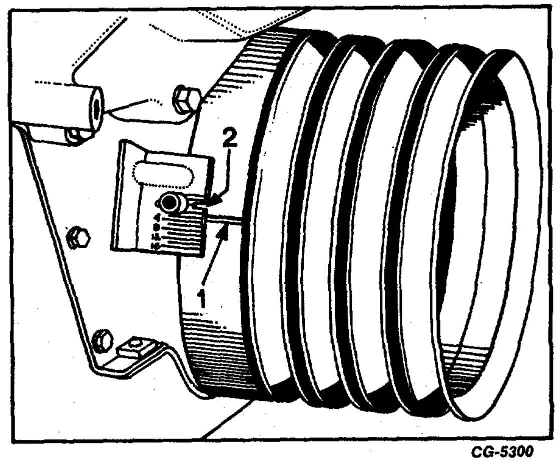

Fig. 4 Illustrating Timing Marks on Crankshaft Pulley Hub and Engine Front Cover

1. Timing mark
2. T.D.C.

From the filter, oil feeds the main oil gallery which is cross-drilled five places. The cross-drilling intersects vertical drilling which feeds the main bearings and camshaft bearings. The front cross-drilling intersects two additional vertical drillings to provide full-main oil gallery pressure to the individual tappet gallery. Oil is metered through the tappets, up the push rods, across the rocker arms and onto the valve tips. A front cam shaft thrust plate meters oil forward to lubricate the camshaft drive gear, distributor gear and fuel pump cam. Oil returns to the oil pan through drilled holes at the front and rear of the cylinder head. These holes match with holes in the crankcase to provide passage through the crankcase into the oil pan.

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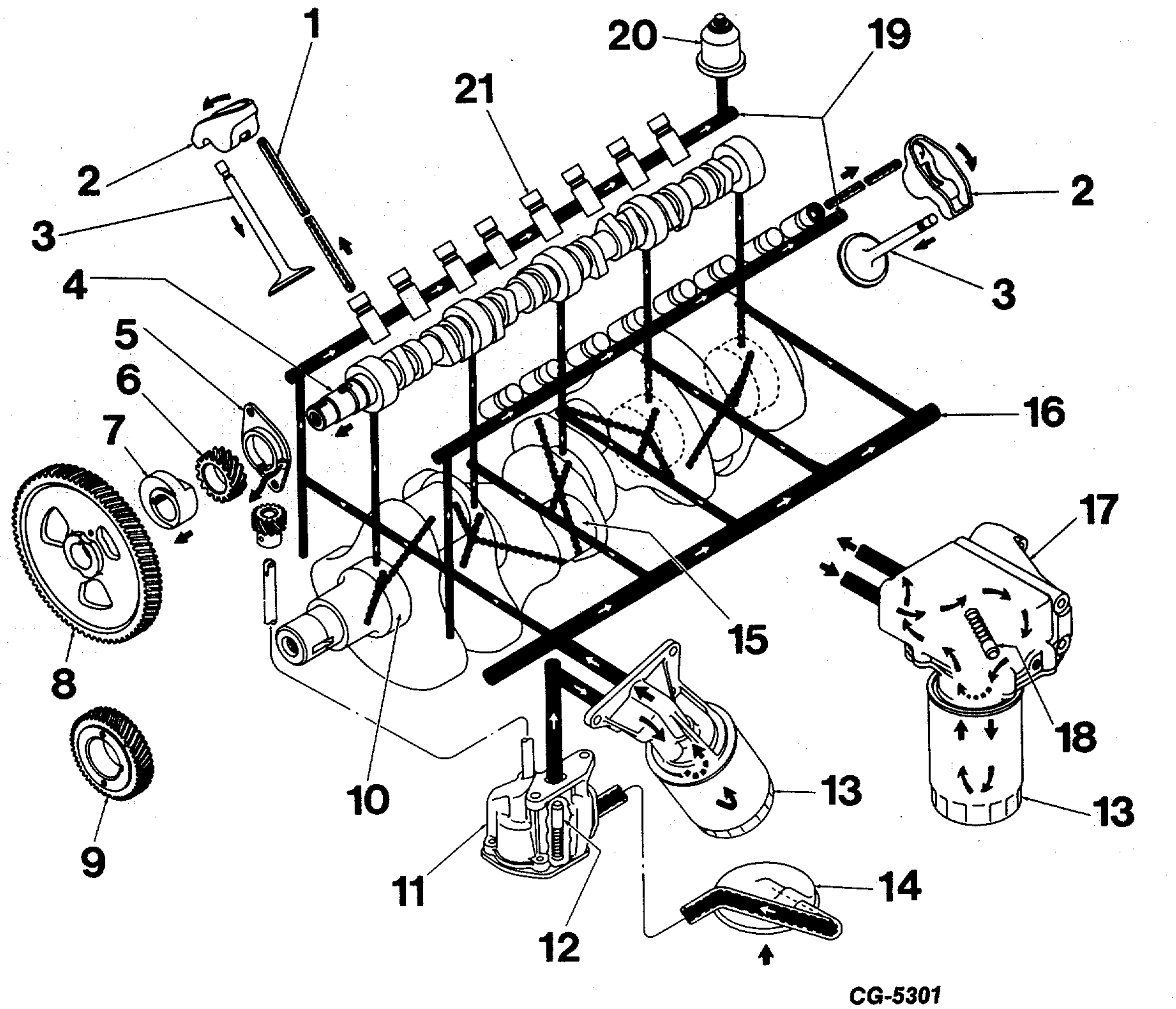

Fig. 5 Diagrammatic View of Lubricating System

1. Push rod
2. Rocker arm
3. Valve
4. Camshaft
5. Camshaft thrust flange
6. Distributor drive gear
7. Fuel pump cam
8. Camshaft gear
9. Crankshaft gear
10. Main Bearing
11. Oil pump
12. Pressure control valve
13. Oil filter
14. Oil pump float
15. Connecting rod bearings
16. Main oil gallery
17. Oil cooler
18. Cooler by-pass valve
19. Valve lifter (tappet) oil gallery
20. Oil pressure sender unit
21. Hydraulic valve lifter (tappet)

ENGINE LUBRICATION PRIMING

When assembling the overhauled engine, it is necessary to thoroughly lubricate the various running parts with clean engine oil to assure initial lubrication when engine is first started. However, to further make certain that complete initial lubrication is available, the engine lubricating system should be pressure primed or charged with oil. The oil leak detector, SE-1632, can be used for this purpose. Attach the line from the oil leak detector to a suitable fitting such as the main oil gallery plug located on the left side of the crankcase. Inject sufficient oil into the engine to fill the oil filter and charge the entire system. Use only clean engine oil of the grade to be used for engine break-in. New or overhauled engines that have been in storage over an extended period should also be primed in a similar manner. In addition to priming engines that have been stored, the engines should be turned over a few times while being primed.

NOTE: Disconnect the coil primary wire when performing this operation to prevent the engine from starting.

When the priming procedure is used, make certain the oil level is checked before the engine is put into service. Caution should be taken so as not to overfill or have insufficient oil as a result of using the pressure priming procedure.

Priming the engine will minimize the possibility of scuffing or heat buildup in the areas of friction, which could lead to immediate or eventual failures.

OIL FILTER (Spin-On Type)

Replace the oil filter by using the following procedure:

1. Remove oil filter assembly by turning counterclockwise with the hands or a suitable tool. Clean the filter mounting pad.

2. Coat the gasket on the new filter with a film of grease.

3. Place the new filter in position on the center tube. Hand tighten 1/2 to 3/4 turn after the gasket first contacts the base of the mounting pad.

4. Start engine and run for at least five minutes to warm oil and check for leaks. Also check engine oil level.

ENGINE MOUNTINGS

Engine mountings may vary between vehicle models. The mountings illustrated are both of the two-piece insulator type.

Front Mountings

The engine front mounting shown in Figure 6 utilizes a two-piece insulator with sleeves. When assembling, position component parts as shown and tighten hex head bolt to 75 to 85 ft. lbs.

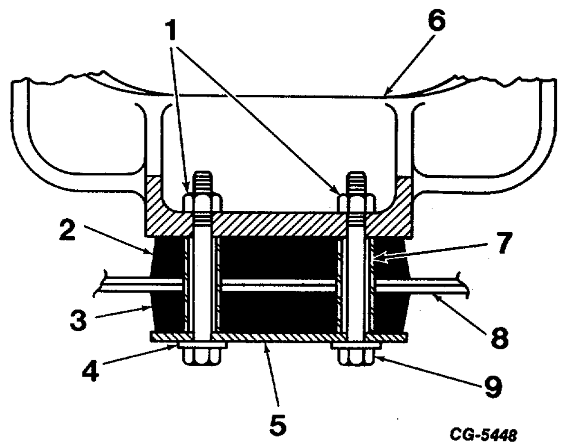

Fig. 6 Engine Front Mounting with Two-Piece Insulator

1. Tighten to 75 - 85 ft. lbs. torque (threads lubricated)
2. Insulator - upper
3. Insulator - lower
4. Hardened washer
5. Retainer
6. Engine mounting bracket
7. Sleeve
8. Crossmember
9. Bolt

Rear Mountings

The engine rear mountings shown in Figure 7 also utilizes a two-piece insulator. When assembling, position component parts as shown and tighten nuts to 160 to 175 ft. lbs.

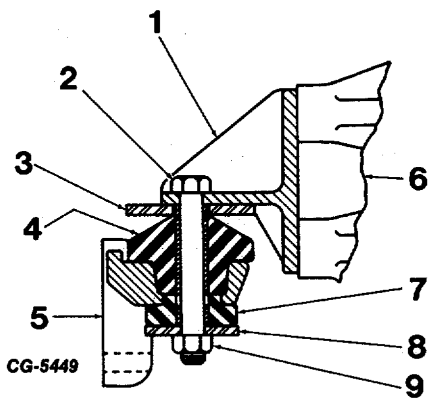

Fig. 7 Engine Rear Mounting with Two-Piece Insulator

1. Bracket
2. Bolt-torque to 160-175 ft. lbs.
3. Washer
4. Upper insulator
5. Bracket to frame rail
6. Flywheel housing
7. Lower insulator
8. Washer
9. Locknut

CRANKCASE VENTILATION SYSTEM

The purpose of this system is to pre-vent crankcase vapors from entering the atmosphere by drawing the vapors into the intake manifold and burning them with the normal fuel mixture. The system utilizes the vacuum created in the intake manifold to draw clean air through the crankcase and valve chamber. Fresh air enters the cylinder head cover through the flame arrestor by route of the connecting hose from the air cleaner. The flame arrestor must be serviced at intervals according to the "Operator's Manual."

The crankcase ventilator valve, Figure 8 located in the right cylinder head cover varies the air flow through the crankcase to meet changing conditions at all engine speeds and loads. The system will work effectively as long as all component parts are clean and free from sludge and foreign material.

The valve should be serviced and the system inspected and cleaned at intervals set forth in the "Operator's Manual." It may be necessary to inspect and clean the system more frequently under adverse driving or weather conditions.

To check the operation of the system, first remove the valve from the cylinder head cover; then with the engine operating, a vacuum should be felt at the end of the valve. If no vacuum is present, the valve, hose and fitting should be

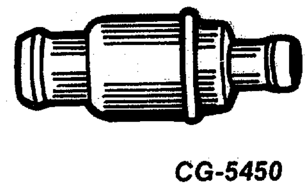

Fig. 8 Crankcase Ventilator Valve of One-Piece Construction

removed and cause of the restriction determined. The inner chamber of the valve should be checked by inserting a stiff wire into the valve body to see that it can be moved freely. Upon re- installation, the crankcase ventilation valve should be installed as indicated on the valve by an arrow.

The oil filter cap is non-vented, and therefore, requires no service.

ENGINE REMOVAL

Engine removal procedures will vary between vehicle models and also between individual chassis because of various equipment and accessories. The following outline covers, in general, the engine disconnect points and lifting instructions.

Preliminary Instructions

1. Remove front bumper, if equipped with steel hood.
2. Raise hood.
3. Disconnect battery cable from battery.
4. Drain radiator and engine block. See Figures 2 & 3 for location of engine coolant drain cocks.
5. Drain oil from engine oil pan.
6. Remove hood assembly.
7. Disconnect shutter cylinder air line, if so equipped.
8. Disconnect radiator hoses.
9. Remove radiator support and core assembly (fiberglass hood only). If equipped with steel hood, disconnect headlamp, etc., wiring at cowl and remove radiator support and core assembly with fenders and splash panels as an assembly.

10. Remove air cleaner.
11. Disconnect heater hoses.
12. Disconnect wires from alternator, coil, distributor, heat sender unit and oil sender unit.
13. Remove engine ground strap.
14. Remove choke and throttle wire.
15. Disconnect tachometer cable, if so equipped.
16. Remove accelerator linkage at carburetor.
17. Remove fuel line at fuel pump.
18. Disconnect exhaust pipe at manifold.
19. Disconnect wires at starting motor.
20. Disconnect canister vent and purge lines at carburetor, if so equipped.
21. Disconnect the freon compressor wire at connector.
22. Remove the freon compressor lines at compressor.
23. On chassis equipped with air brakes, disconnect the main air supply line and the flexible air line at the compressor.
24. On chassis equipped with hydraulic brakes having a hydrovac, disconnect the vacuum air cleaner hose at rear of intake manifold.
25. Install lifting sling, Figure 9.
26. Connect hoist to lifting sling.
27. Place a support under the transmission.
28. Remove the 12 bolts securing the bell housing to flywheel housing.
29. Remove the engine front mounting bolts and insulators.
30. Remove the engine rear mounting bolts and insulators.
31. The engine must be pulled forward to clear the transmission main drive gear and clutch driven disc; then, raise and lift out of chassis.

NOTE: Extreme care must be exercised during removal of the power plant to avoid damage to the clutch driven disc and wiring harness.

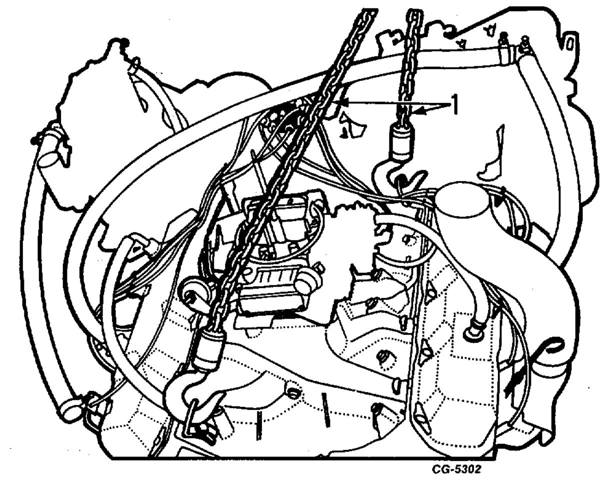

Fig. 9 Engine Lifting Sling

1. Lifting Sling

ENGINE INSTALLATION

Prior to installation check to be sure that all lines, cables and parts are installed on the engine assembly that were connected to and removed with the engine. If maintenance was performed, be sure all adjustments affected are made correctly. If any components of the engine were removed and installed, check all connections and related parts to insure the installations were accomplished correctly.

In general, the installation of the engine is performed in the reverse order of the removal. When positioning the engine in the chassis, special care must be exercised during installation to avoid pinching of the wiring harness between the engine and frame assembly.

Lower the engine to align the transmission main drive gear spline with the clutch driven disc. The weight of the engine assembly must be supported until the twelve bolts securing the bell housing are installed. Connect the wiring harness, lines and linkages that were disconnected during removal.

Install the radiator assembly and shroud and connect the upper and lower radiator hoses on the conventional chassis.

On conventional chassis, install the front end sheet metal and stay rods.

Install the hood assembly

Connect the battery ground strap and fill the cooling system to the specified level. Fill the engine crankcase with specified engine oil to the proper level. Refer to the Operator's Manual for this information. However, if equipped to prime the lubricating system, refer to "Lubrication System Priming" and follow the procedure described.

Check accessory and pulley drive belts and adjust if necessary.

Start engine and operate all controls through their full range to check for proper adjustment.

Inspect all hose connections for coolant leaks and air connections for air leaks.

ENGINE DISASSEMBLY

Install the engine in the SE-1962 Overhaul Stand with mounting plate, Figure 10.

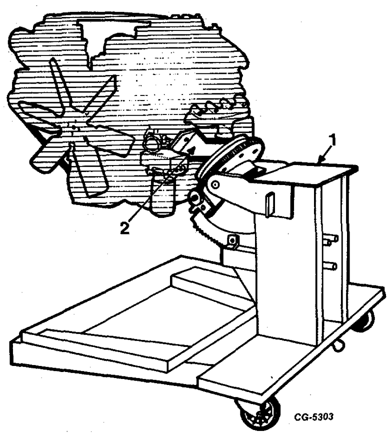

Fig. 10 Engine Installed in SE-1962 Overhaul Stand With Mounting Plate

1. Engine stand 2. Mounting plate

NOTE: Use of this overhaul stand permits raising or lowering (vertical to horizontal position) the engine as required to permit rotating the engine 360° and is held securely in any of the eight positions provided. However, before engine rotation is performed, it is recommended the engine be stripped of as many components as possible to eliminate excessive weight and provide clearance. The engine can be raised in a vertical position over the pedestal of the stand and the pin released and crankcase rotated and locked in any one of the eight positions.

1. Make sure all oil and water have been drained from the cylinder block.
2. Remove fan blade with spacer and front engine mount.
3. Disconnect water inlet, water outlet, air inlet and oil feed lines from air compressor, Figure 11.

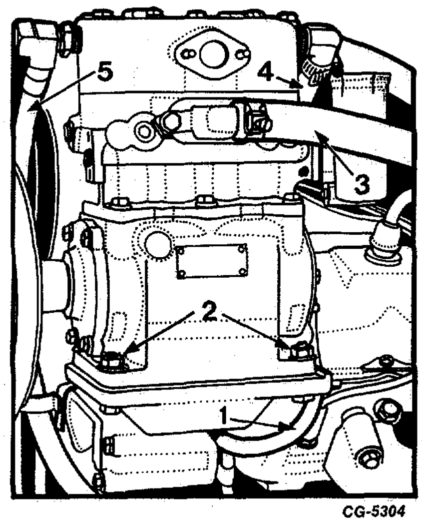

Fig. 11 Air Compressor Removal

1. Oil feed line 4. Water inlet line
2. Nuts 5. Water return line
3. Air inlet line

4.Loosen four nuts on bracket and slide compressor inward, Figure 11. Remove V-belt and water pump front pulley.

5. Remove nuts, bolts and flat washers from bracket and remove air compressor with gasket. Remove water inlet and outlet hoses.

6. Remove bolts and lockwashers securing air compressor bracket to the engine, Figure 12. Remove bracket with "O" - ring.

7. Loosen alternator adjusting strap bolt and mounting bolt, Figure 13. Remove two V-belts.

8. Remove alternator adjusting strap bolt and mounting bolt with flat washers. Remove alternator from bracket.

9. Remove alternator bracket and adjusting bracket by removing bolts and flat washers, Figure 14.

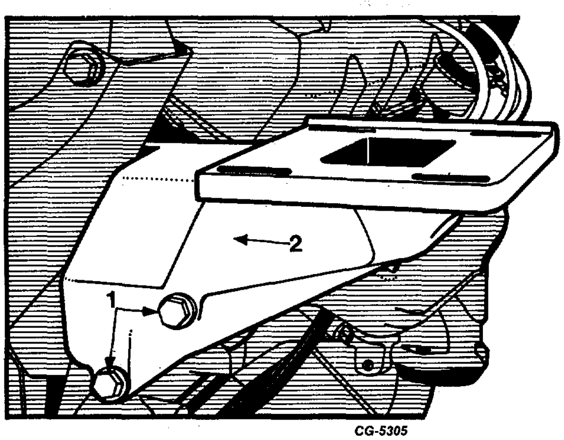

Fig. 12 Removing Air Compressor Bracket

1. Bolts 2. Bracket

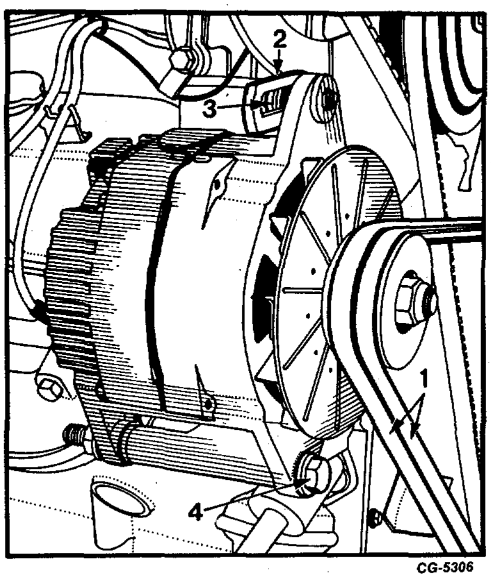

Fig. 13 Removing Alternator V-Belts

1. V-Belts 3. Bolts
2. Adjusting strap 4. Mounting bolt

10. Loosen bolts on freon compressor idler pulley and remove V-belt, Figure 15. Remove bolts and remove idler pulley.

11. Remove hoses to left and right cylinder head check valves from the air pump, if so equipped. Remove air pump adjusting strap bolt and flat washer and air pump mounting bracket bolt, nut and flat washer, Figure 16. Remove air pump.

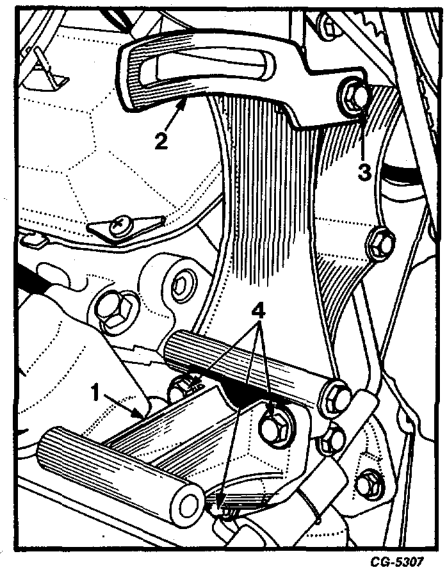

Fig. 14 Removing Alternator Brackets

1. Bracket 3. Bolts
2. Adjusting strap 4. Bolts

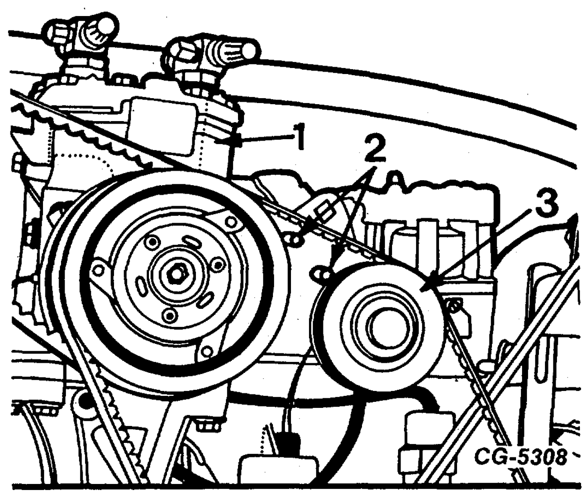

Fig. 14 Removing Freon Compression V-Belts

1. Freon compressor 3. Idler Pulley
2. Bolts

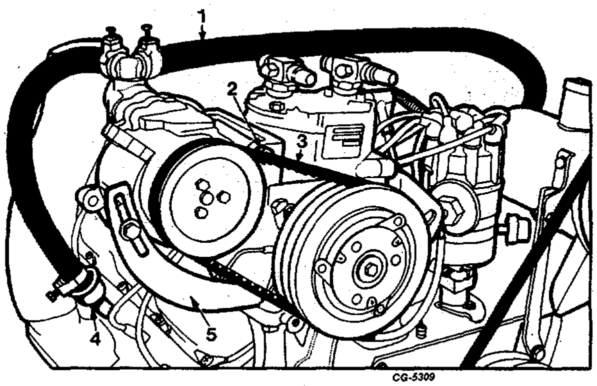

Fig. 16 Air Pump Removal

1. Hose to left head check valve
2. Mounting bolt
3. V-belt
4. Right head check valve
5. Adjusting strap '

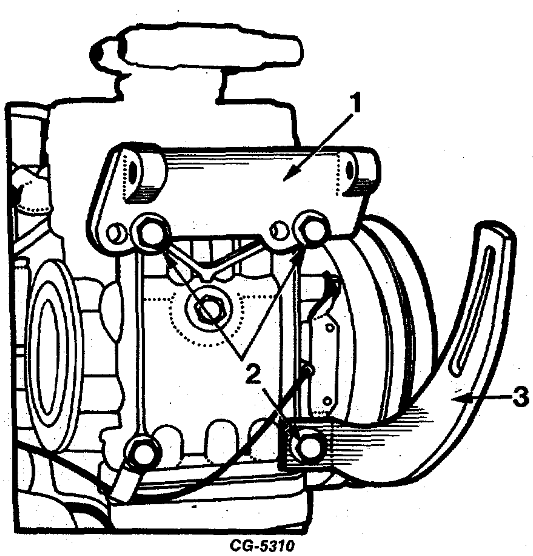

Fig. 17 Removing Air Pump Brackets

1. Bracket
2. Bolts
3. Adjusting Strap

12. Remove air pump mounting brackets by removing bolts and flat washers. Remove adjusting strap and spacer by removing bolt and flat washer, Figure 17.

13. Remove idler pulley bracket from freon compressor by removing bolts and flat washers, Figure 18.

NOTE: Bottom bolts have two hardened flat washers each.

14. Remove shroud hose from exhaust manifold, Figure 18.

15. Remove freon compressor from bracket by removing four bolts and lockwashers, Figure 19.

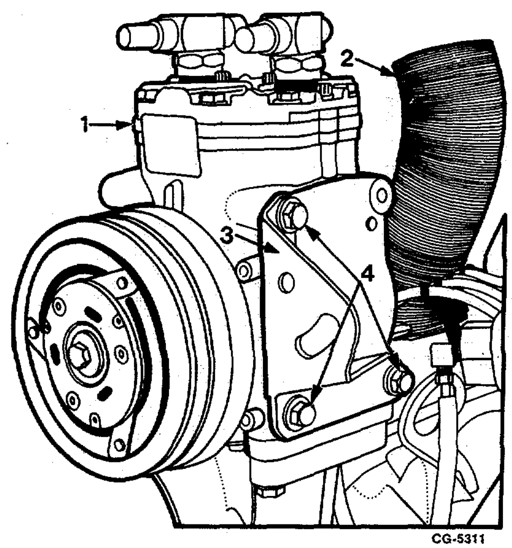

Fig. 18 Removing Freon Compressor Idler Pulley Bracket

1. Freon compressor
2. Shroud hose
3. Bracket
4. Bolts

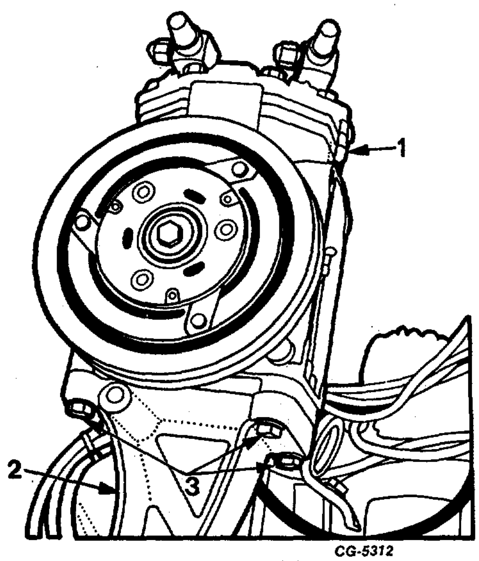

Fig. 19 Freon Compressor Removal

1. **Freon compressor**
2. **Bracket**
3. **Bolts**

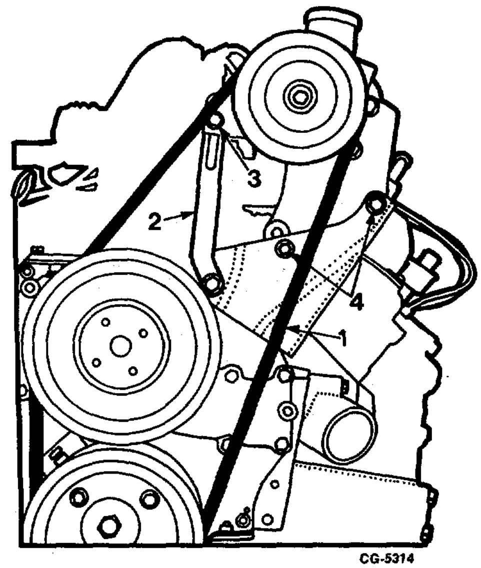

Fig. 21 Removing Power Steering V-Belt

1. **V-Belt**
2. **Adjusting strap**
3. **Bolt**
4. **Bolts**

16. Remove freon compressor bracket, Figure 20.

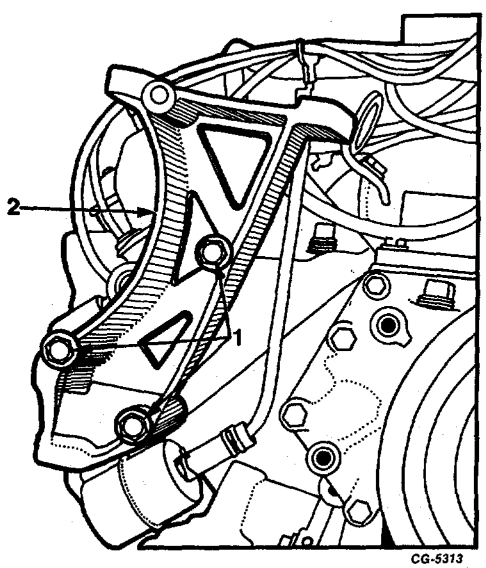

Fig. 20 Freon Compressor Bracket Removal

1. **Bolts**
2. **Bracket**

17. Loosen power steering adjusting strap bolt and two bracket bolts to facilitate removing V-belt, Figure 21.

18. Remove power steering pump pulley mounting bolt and flat washers, Figure 22.

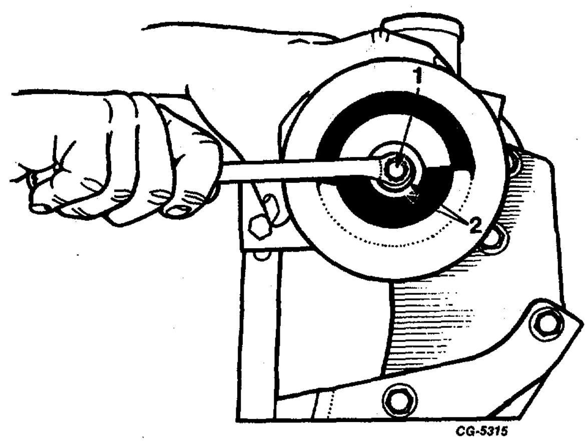

Fig. 22 Removing Power Steering Pump Pulley Bolt

1. **Mounting Bolt**
2. **Flatwashers**

19. Use SE-2420 Puller and wrench to remove power steering pulley, Figure 23.

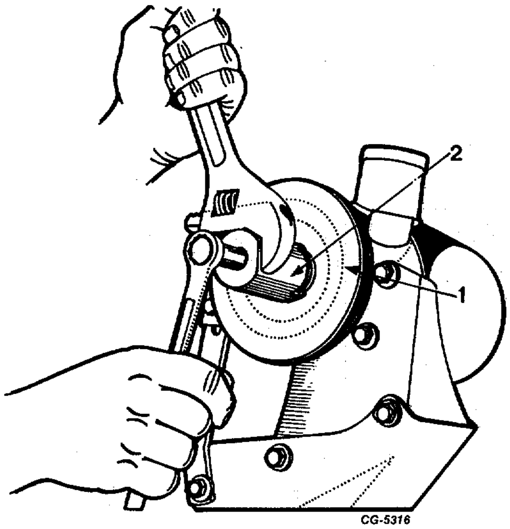

Fig. 23 Using SE-2420 Puller to Remove Power Steering Pump Pulley

1. **Pulley**
2. **Puller**

20. Remove bolts and flat washers securing power steering pump to bracket, Figure 24. Remove adjusting strap bolt and remove power steering pump with side bracket.

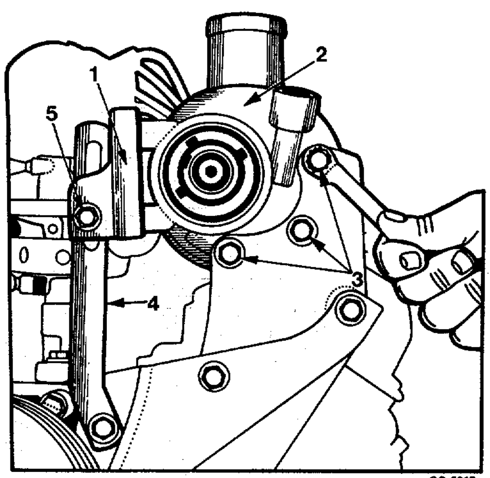

Fig. 24 Removing Power Steering Pump

1. **Side bracket**
2. **Pump**
3. **Bolts**
4. **Adjusting Strap**
5. **Adjusting Bolt**

21. Remove power steering bracket with adjusting strap, Figure 25.

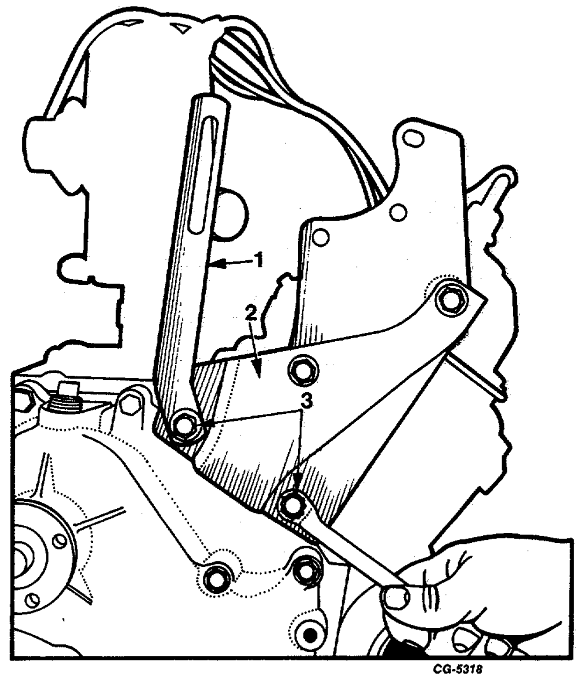

Fig. 25 Removing Power Steering Bracket and Strap

1. **Adjusting strap**
2. **Bracket**
3. **Bolts**

22. Remove starting motor bolts and lockwashers, Figure 26. Remove starting motor.

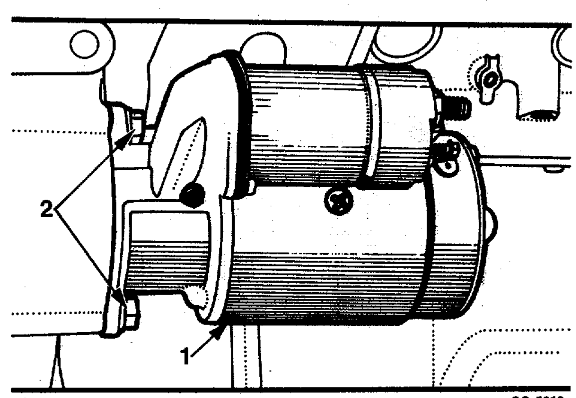

Fig. 26 Starting Motor Removal

1. **Starting motor**
2. **Bolts**

23. Remove bolts and flat washers securing oil filter and cooler (if so equipped) to the crankcase, Figure 27. Remove oil filter, cooler and gasket.

NOTE: If the vehicle is not equipped with an oil cooler, the filter and filter base may be removed by removing three bolts and flat washers.

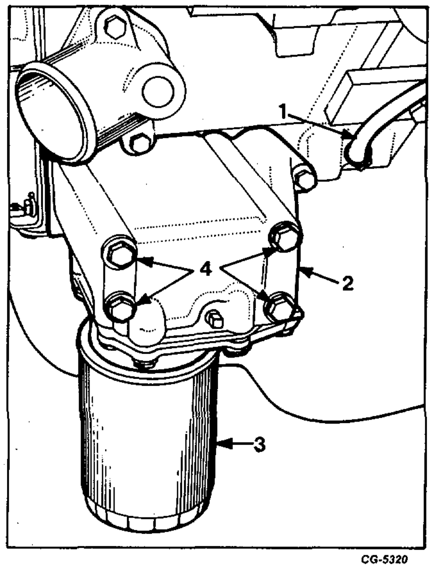

Fig. 27 Oil Cooler and Filter Removal

1. **Oil feed to air compressor**
2. **Oil cooler**
3. **Oil filter**
4. **Mounting bolts**

24. Remove oil feed line to air compressor, Figure 27.

25. Remove low temperature vacuum control valve, exhaust gas recirculating valve, gasket and hoses, if so equipped. Cap or plug all openings.

26. Disconnect the distributor high tension wires at the coil and spark plugs. Always grasp spark plug boat and use a twisting motion when removing spark plug cables so as not to destroy resistance wire termination. Remove the wires with the slideout brackets on both cylinder head covers and remove the distributor cap and wires as an assembly, Figure 28.

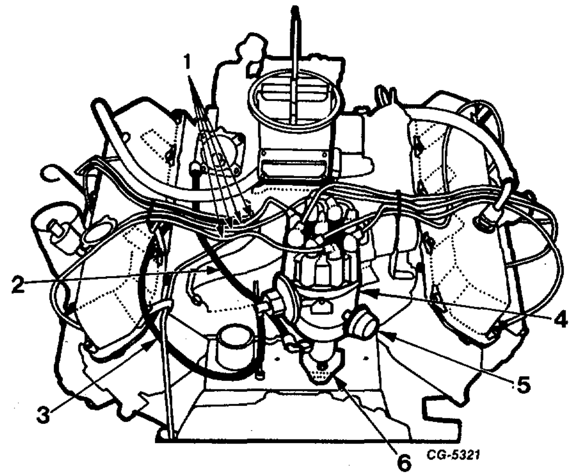

Fig. 28 Distributor and Wiring Removal

1. **High tension wires**
2. **Governor line**
3. **Vacuum line**
4. **Distributor**
5. **Filter**
6. **Hold down bracket**

27. Loosen the distributor hold-down bolt at the crankcase, Figure 28. Disconnect the vacuum line and governor line at the carburetor. Remove the distributor, governor line, vacuum line and "0" - ring.

28. Remove carburetor return spring and bracket from intake manifold, Figure 29.

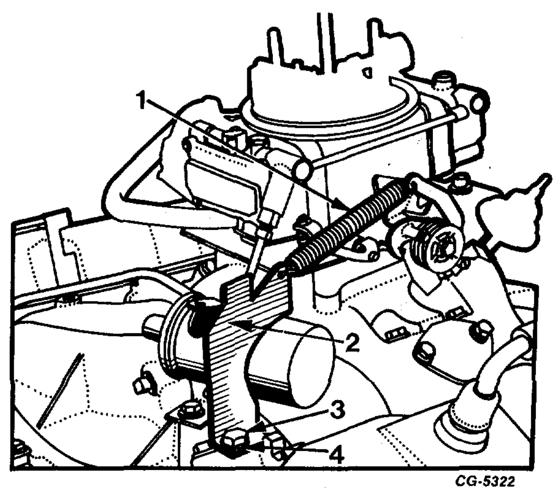

Fig. 29 Removing Return Spring and Bracket

1. **Return spring**
2. **Bracket**
3. **Bolt**
4. **Lockwasher**

29. Remove coil and bracket from intake manifold, Figure 30. Also, remove flame arrestor and hose from left cylinder head cover.

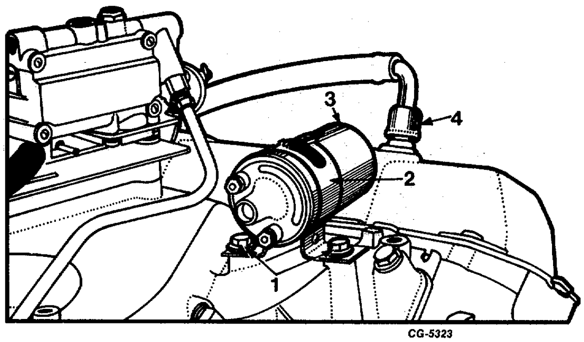

Fig. 30 Coil Removal

1. **Mounting bolts**
2. **Bracket**
3. **Coil**
4. **Flame arrestor**

30. Remove fuel line with bracket, reinforcement washer and fuel filter, Figure 31. Remove PCV valve and hose.

NOTE: Cap or plug all openings or fittings.

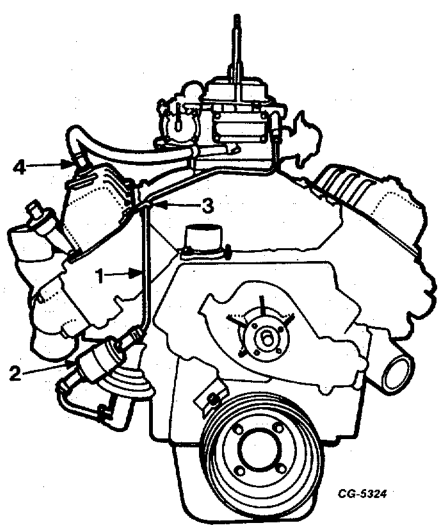

Fig. 31 Fuel Line Removal

1. **Fuel line**
2. **Filter**
3. **Bracket**
4. **PCV valve**

31. Remove carburetor nuts and washers Figure 32. Remove carburetor, two gaskets and spacer plate.

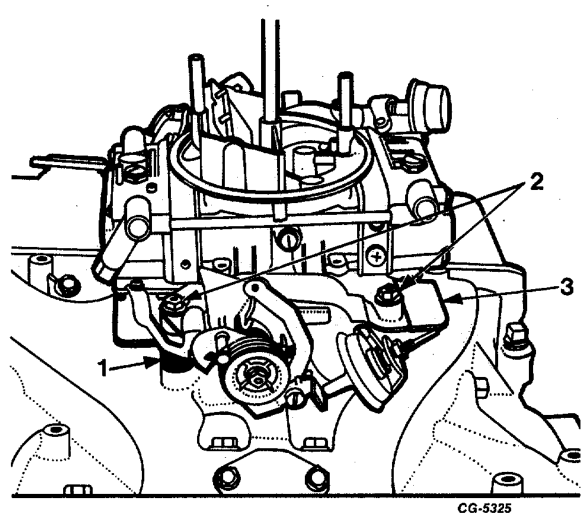

Fig. 32 Removing Carburetor

1. **Spacer**
2. **Nuts**
3. **Gasket**

32. Remove bolts and hardened washers securing fuel pump to the crankcase, Figure 33. Remove fuel pump and gasket.

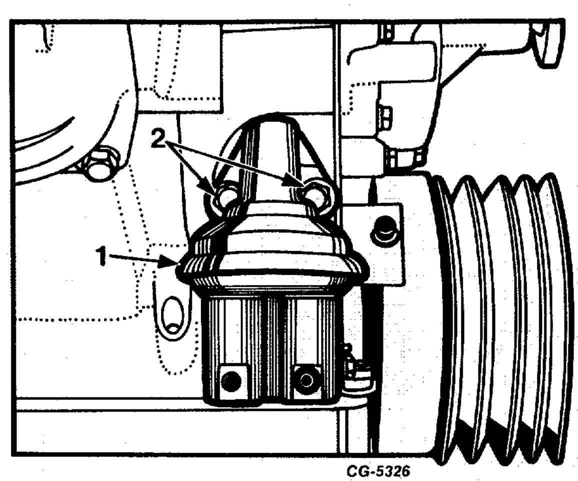

Fig. 33 Fuel Pump Removal

1. **Fuel pump**
2. **Bolts**

33. Remove two bolts and flat washers from engine water outlet, Figure 34. Remove engine water outlet, thermostat and gasket from engine.

34. Remove water temperature sender unit, Figure 34.

35. Remove water inlet housing and gasket by removing bolts and washers securing them to the crankcase, Figure 35.

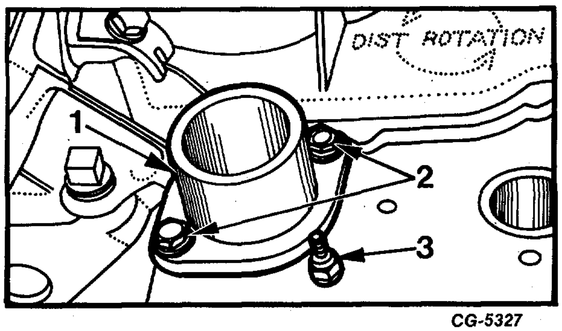

Fig. 34 Thermostat and Sender Unit Removal

1. **Engine water outlet**
2. **Bolts**
3. **Water temp. sender unit**

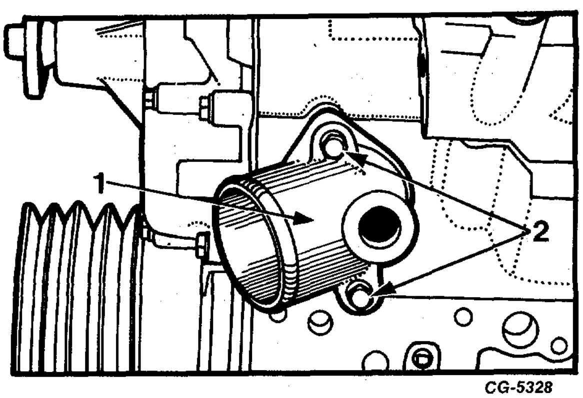

Fig. 35 Water Inlet Housing Removal

1. **Water inlet housing**
2. **Bolts**

36. Remove twelve mounting bolts and flat washers securing intake manifold to cylinder heads, Figure 36. Remove intake manifold.

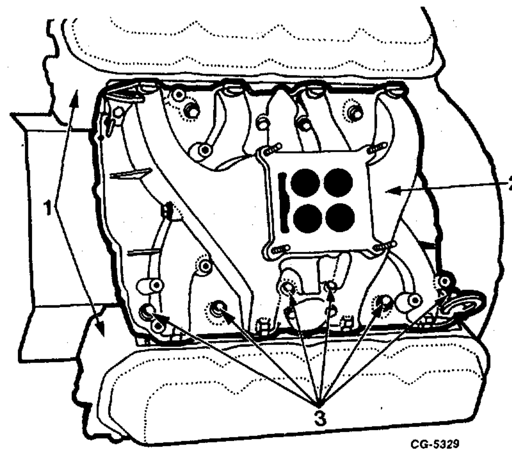

Fig. 36 Intake Manifold Removal

1. **Cylinder heads**
2. **Intake manifold**
3. **Mounting bolts**

37. Remove any dirt or foreign matter that may have accumulated around the top edge of the tappet cover; then remove tappet cover and intake manifold gasket assembly, Figure 37.

NOTE: The tappet cover and intake manifold gaskets are serviced as one unit.

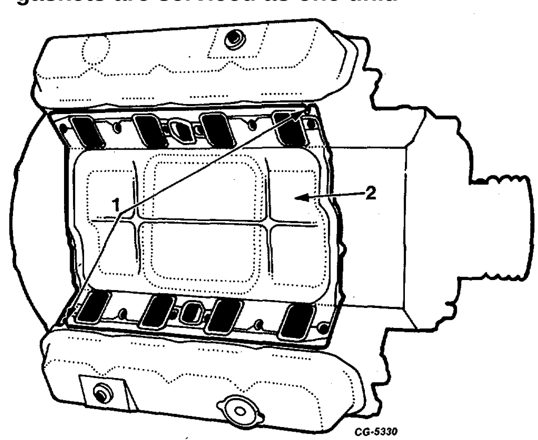

Fig. 37 Removing Tappet Cover and Intake Manifold Gasket Assembly

1. **Roll pins**
2. **Tappet cover and intake manifold gasket assembly.**

38. Remove intake manifold seals, Figure 38.

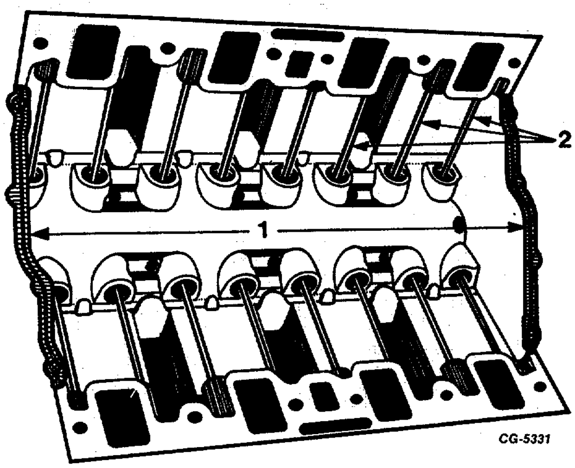

Fig. 38 Intake Manifold Seals

1. **Intake manifold seals**
2. **Push rods**

39. Remove manifold heat shroud from right exhaust manifold, Figure 39.

40. Remove oil level gauge from tube, Figure 39.

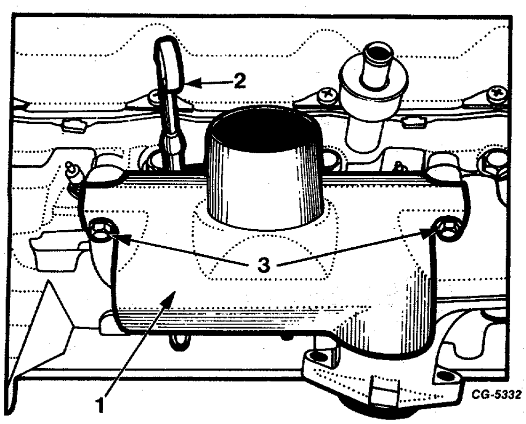

Fig. 39 Head Shroud Removal

1. **Heat shroud**
2. **Mounting bolts**
3. **Oil level gauge**

41. Remove right exhaust manifold and gasket by removing remaining six manifold bolts, Figure 40. Remove air manifold check valve.

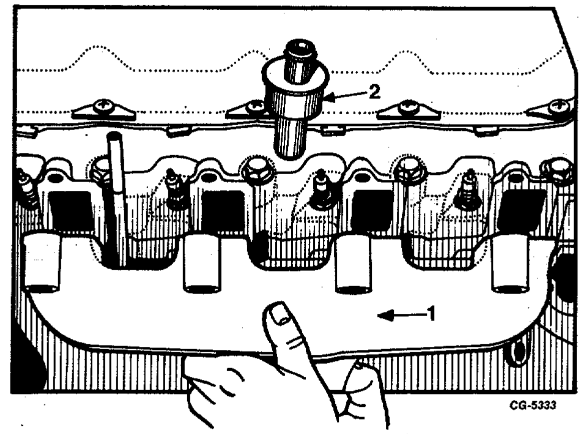

Fig. 40 Removing Right Exhaust Manifold

1. **Exhaust manifold**
2. **Air manifold check valve**

42. Repeat Step 41 and remove manifold and gasket from opposite cylinder head and opposite air manifold check valve.

43. Remove cylinder head cover bolts on both banks and remove covers and gaskets from both heads, Figure 41.

NOTE: The cylinder head covers use oil deflector baffles to direct the path of the oil from the push rods.

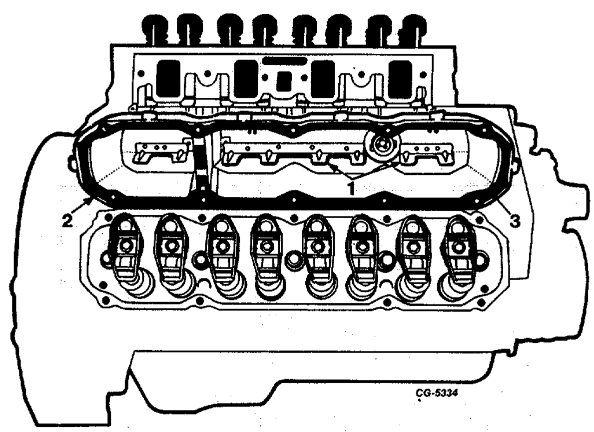

Fig. 41 Removing Cylinder Head Covers

1. **Oil deflector baffles**
2. **Cylinder head cover**
3. **Gasket**

44. Remove flange head bolts securing rocker arms to cylinder heads, Figure 42. Remove rocker arms and pivots j from cylinder. heads.

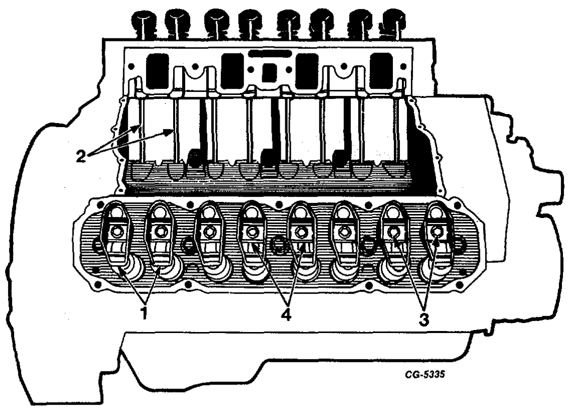

Fig. 42 Rocker Arm Removal

1. Rocker arms **3. Bolts**
2. Push rods **4. Pivots**

45. Remove push rods from engine.

46. Repeat Steps 44 and 45 on opposite cylinder head.

47. Lift out all hydraulic valve lifters or tappets from the crankcase assembly, Figure 43. This can be accomplished by rotating the camshaft so the tappets are resting on the high side of the camshaft lobes. Keep the tappets in order in storage box, SE-1894, to assure cleanliness and reinstallation in their original bores.

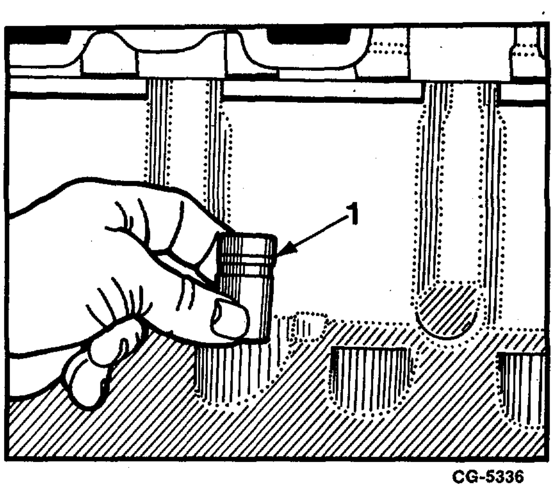

Fig. 43 Hydraulic Tappet Removal

1. Hydraulic tappet

48. Remove cylinder head bolts and lift cylinder heads off the two locating dowel sleeves, Figure 44. Remove the cylinder head gasket.

CAUTION: Use extreme care when handling to prevent damage to gasket surfaces. Never pry between the cylinder heads and the block as they have a finished surface and must not be damaged.

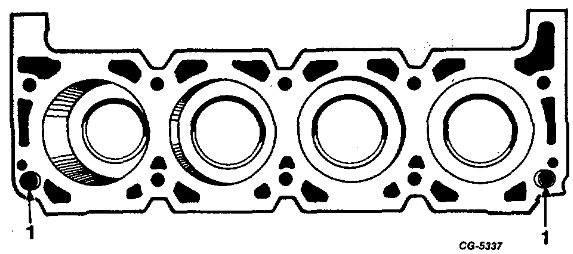

Fig. 44 Dowel Sleeves in Block for Cylinder Head

1. Dowel sleeves

49. Repeat Step 48 and remove opposite cylinder head.

50. Remove bolts and lockwashers securing water pump to engine, Figure 45. Remove water pump and gasket.

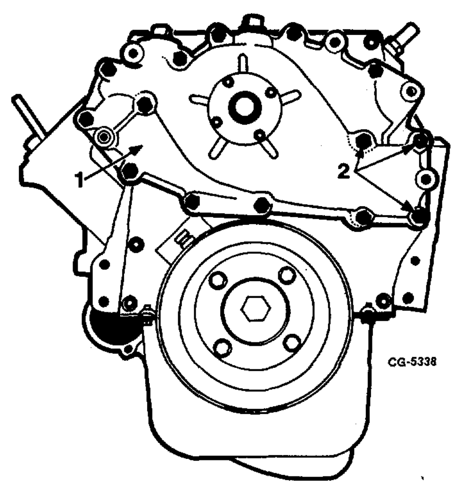

Fig. 45 Water Pump Removal

1. Water pump
2. Mounting bolts

51. Remove bolts and lockwashers securing crankshaft pulley to damper, Figure 46. Remove crankshaft pulley.

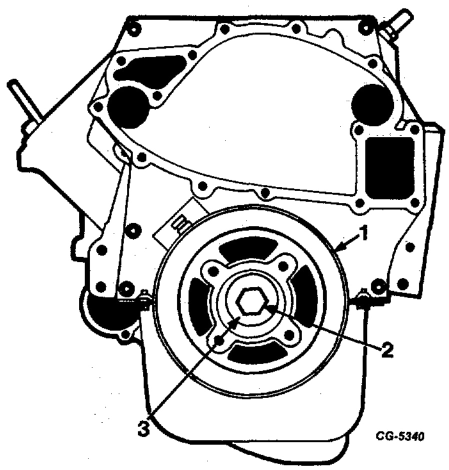

Fig. 46 Crankshaft Pulley Removal

1. Crankshaft Pulley **2. Mounting bolts**

52. Remove crankshaft damper bolt and washer. Figure 47.

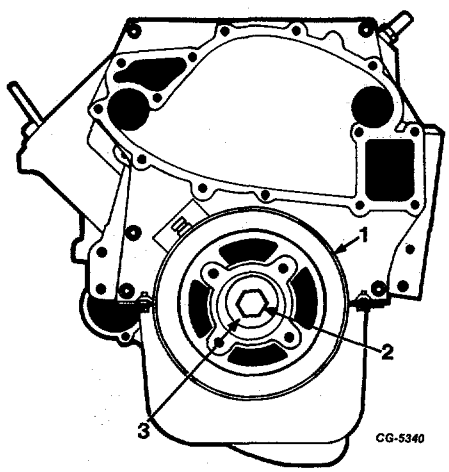

Fig 47

1. Crankshaft damper **3. Washer**
2. Bolt

53. Remove crankshaft damper using SE1368 Puller, Figure 48.

54. The clutch plate should be compressed with three bolts "A" (3/8" 16 x 2") prior to removing the mounting capscrews, Figure 49. This is done to prevent distortion of the clutch cover. Then loosen the clutch back plate-to-fly-wheel retaining capscrews and remove the clutch assembly. Remove main drive gear pilot bearing.

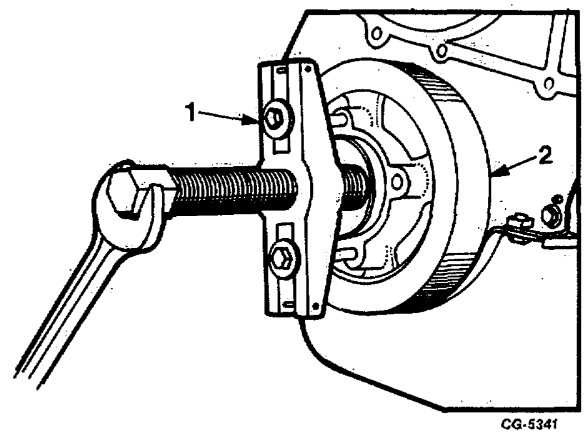

Fig. 48 Using SE-1368 Puller to Pull Crankshaft Damper

1. Puller **2. Pulley damper**

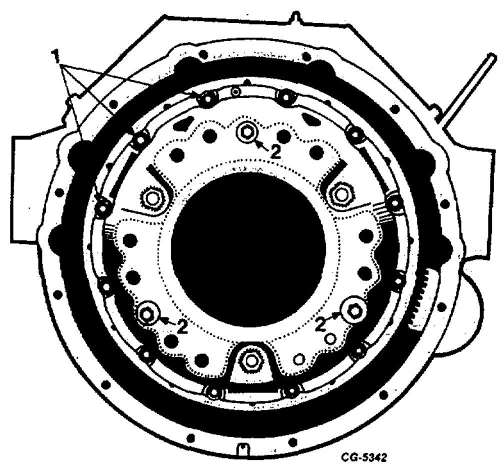

Fig. 49 Clutch Removal

1. Cover Retainer Bolts
2. Bolts "A" for Removal or Assembly Procedures

55. Remove ten mounting bolts and remove the flywheel assembly from the crankshaft flange, Figure 50.

56. Remove oil pan from engine.

57. Remove the engine front cover mounting bolts and lift the cover from the crankcase, Figure 51.

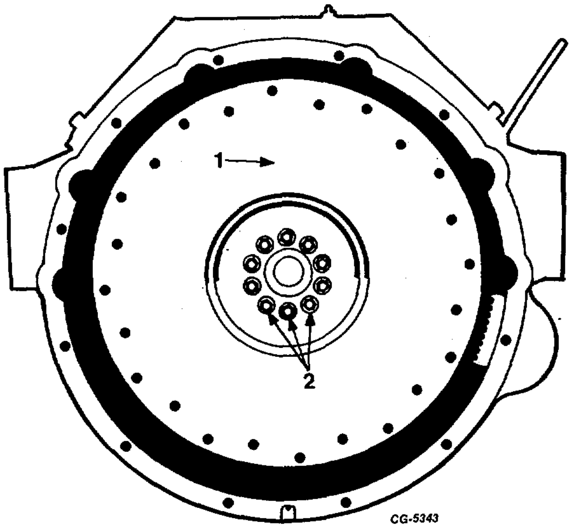

Fig. 50 Flywheel Removal

1. Flywheel **2. Mounting bolts**

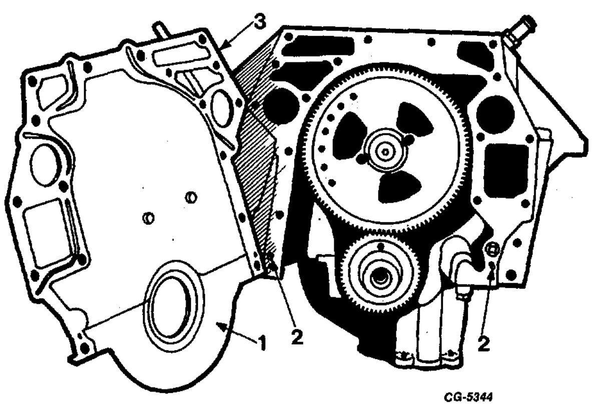

Fig. 51 Removal of Engine Front Cover

1. Front Cover **3. Gasket**
2. Dowel pins

58. Press front cover oil seal from front cover using a 3-1/4" O.D. flat disc from the SE-1905 Set, Figure 52.

NOTE: Where it is the desire to replace the engine front cover oil seal while the engine is in the chassis, it will be necessary to remove the hood, radiator shell, radiator and crankshaft pulley. Then using puller, SE-2091, remove seal as shown in Figure 53. To reinstall the seal, follow note under Step 15 outlined under "Engine Assembly."

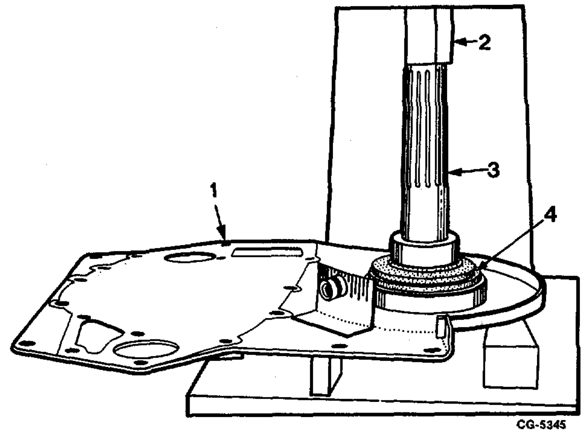

Fig. 52 Front Cover Oil Seal Removal with Cover Removed Using SE-1905 Handle and 3-1/4" O. D. Disc

1. Front cover **3. Handle**
2. Press ram **4. Disc**

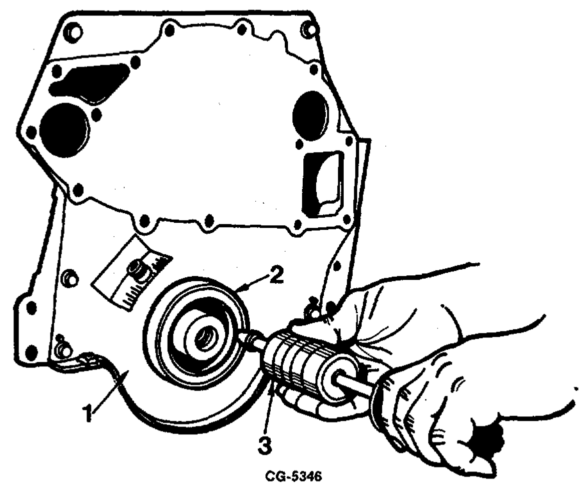

Fig. 53 Front Cover Oil Seal Removal with Cover Installed Using SE-2091 Puller

1. Front cover **3. Puller**
2. Seal

59. Remove retainer plate bolts and remove retainer plate with rear oil seal and gasket, Figure 54.

60. Remove bolts from flywheel housing and remove flywheel housing, Figure 55.

NOTE: Use extreme care when removing flywheel housing to prevent damaging the dowel pins.

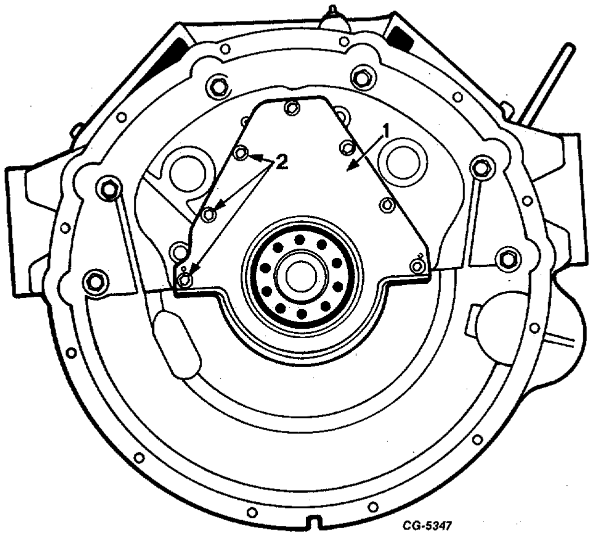

Fig. 54 Rear Oil Seal Retainer Plate Removal

1. **Retainer plate**
2. **Bolts**

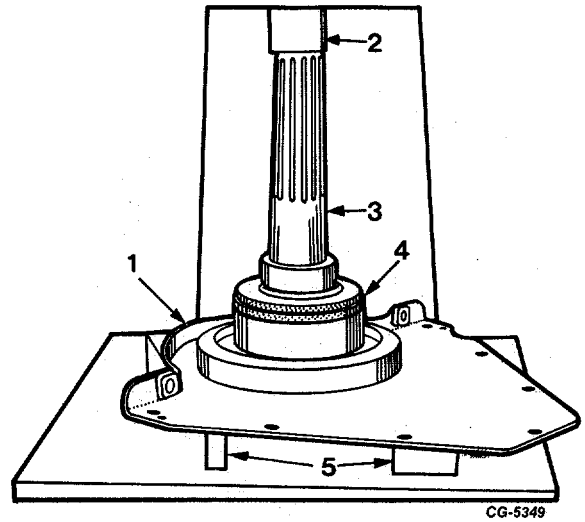

Fig. 56 Rear Oil Seal Removal

1. **Retainer plate**
2. **Press ram**
3. **Handle**
4. **Disc**

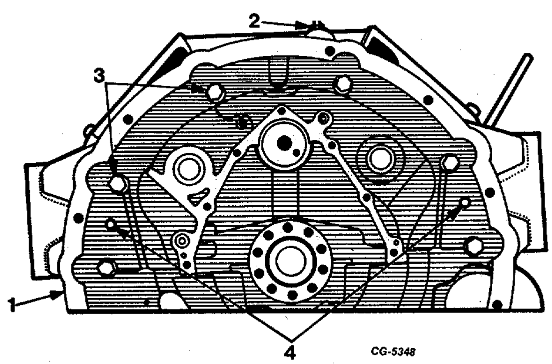

Fig. 55 Flywheel Housing Removal

1. **Flywheel housing**
2. **Oil pressure sending unit**
3. **Mounting bolts**
4. **Dowel pins**

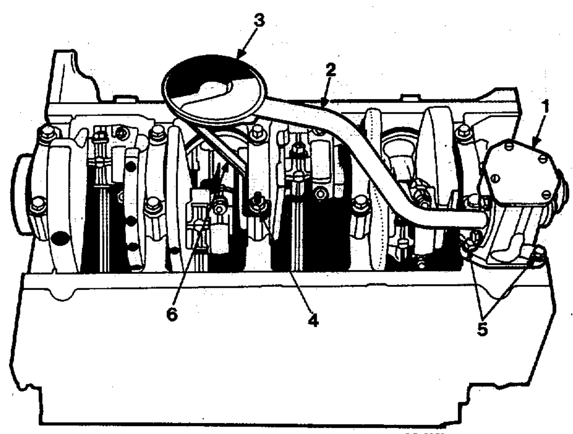

Fig. 57 Oil Pump Removal

1. **Pump**
2. **Tube**
3. **Screen**
4. **Mounting nut**
5. **Mounting bolts**
6. **Bracket**

61. Remove oil pressure sending unit from rear of engine, Figure 55.

62. Press rear oil seal from retainer plate using handle from SE-1905 and 4-1/8" disc, Figure 56.

63. Remove oil pump and pick up tube mounting bolts and nut, Figure 57. Lift oil pump and withdraw pump drive shaft from cylinder block.

64. Remove oil level gauge tube.

65. Rotate the crankshaft to position the journals for removal of the connecting rod assemblies, Figure 58.

NOTE: Before removing the piston assemblies, always remove the ridge from the top of the cylinder bore.

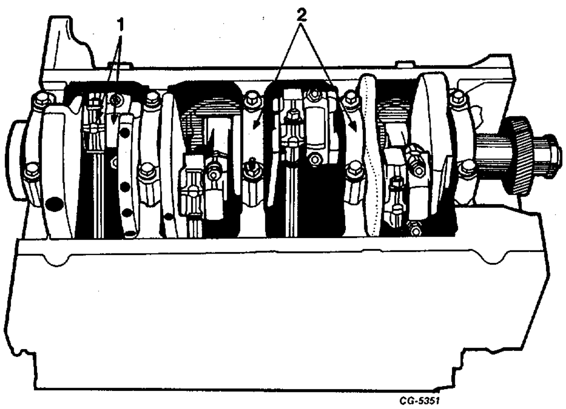

Fig. 58 Positioning Connecting Rods for Removal

1. **Connecting rod caps**
2. **Main bearing caps**

66. Remove the cap and push the connecting rod and piston assemblies from the cylinder bore, Figures 59 and 60. Replace the cap and the bearing inserts on the rod so the numbered sides match. The connecting rod and piston assemblies are numbered so they can be reinstalled in their respective cylinders.

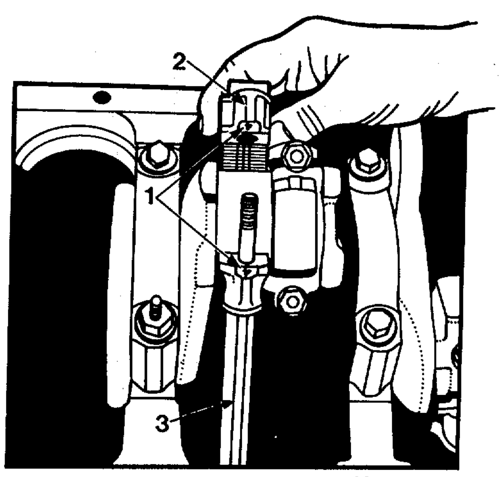

Fig. 59 Connecting Rod Cap Removal

1. **Cap and rod identification**
2. **Cap**
3. **Connecting rod**

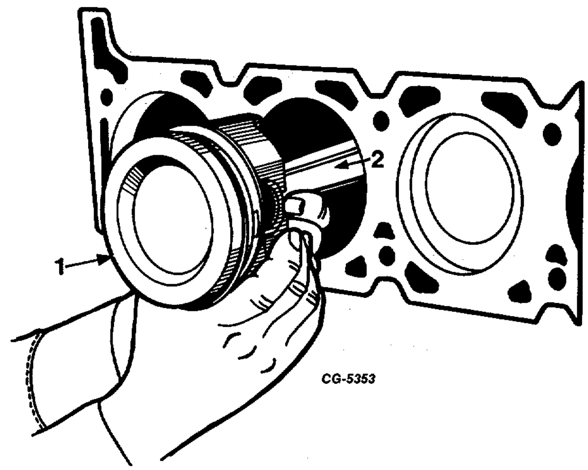

Fig. 60 Connecting Rod and Piston Removal

1. **Piston**
2. **Connecting Rod**

67. Remove the two bolts and lockwashers securing the camshaft thrust flange to the crankcase, Figure 61.

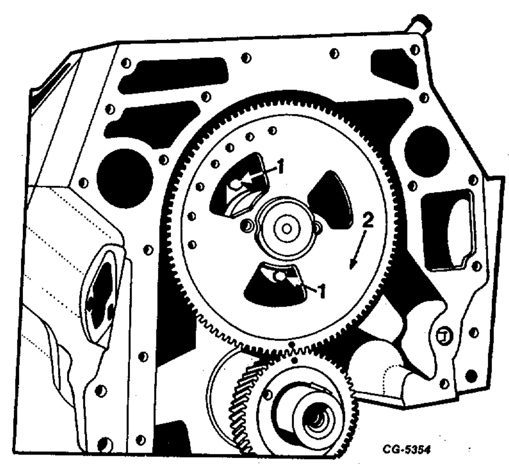

Fig. 61 Thrust Flange Bolt Removal

1. **Thrust flange bolts**
2. **Camshaft gear**

68. Remove the camshaft assembly, Figure 62.

IMPORTANT: Use extreme caution when handling the camshaft assembly to prevent chipping the distributor gear teeth.

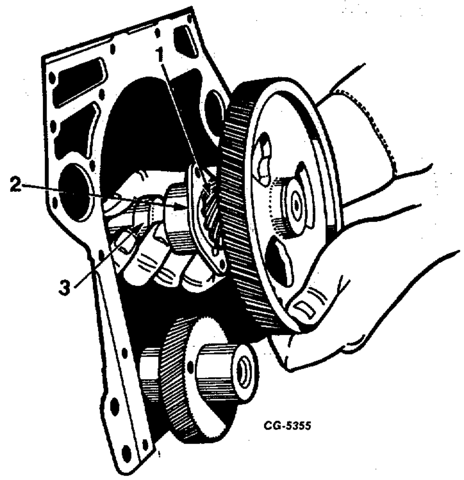

Fig. 62 Camshaft Removal

1. **Distributor gear**
2. **Camshaft thrust flange**
3. **Camshaft**

NOTE: Fuel pump cam located forward of distributor gear.

NOTE: The camshaft gear, distributor gear and fuel pump cam can be removed without complete engine disassembly. This can be accomplished using the following procedure:

a. Remove camshaft allen screw, Fig.63.

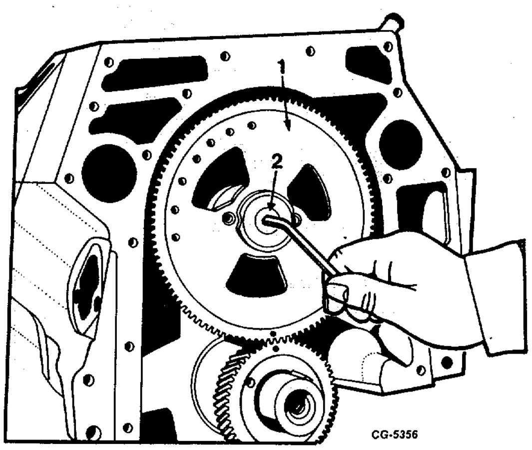

Fig. 63

1. **Gear** 2. **Allen screw**

b. Remove camshaft gear using SE-1368 Puller, Figure 64.

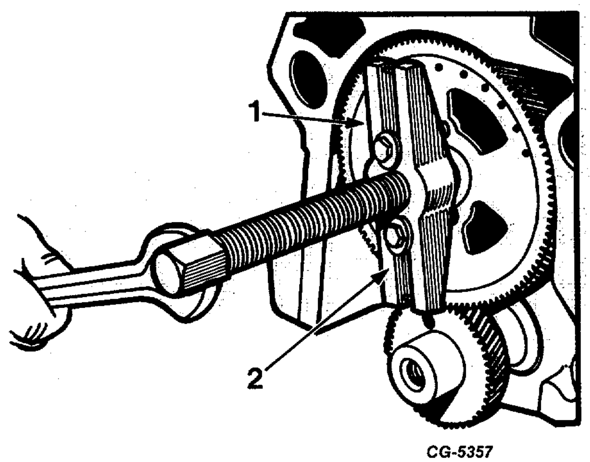

Fig. 64

1. **Camshaft gear** 2. **Puller**

c. Remove fuel pump cam using SE-1368 Puller and SE-1368-3Fingers, Figure 65.

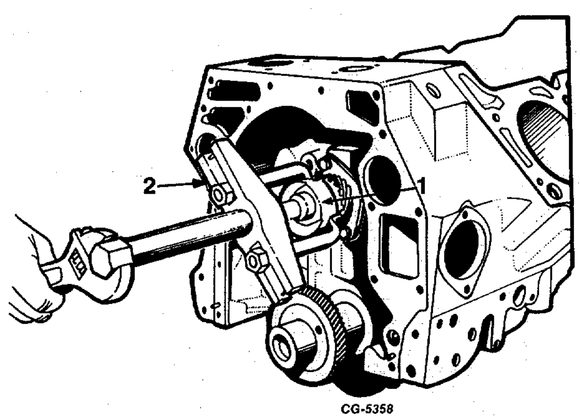

Fig. 65

1. **Fuel pump cam** 2. **Puller**

d. Remove distributor gear using SE-1368 Puller and SE-1368-5 Fingers, Figure 66.

IMPORTANT: Use extreme caution so as not to chip the distributor gear teeth.

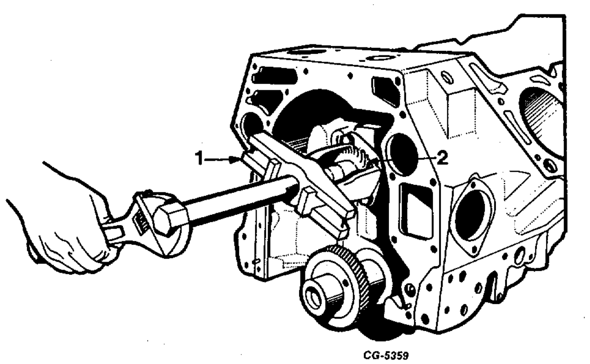

Fig. 66

1. Puller 2. Distributor Gear

69. Use SE-1368 Puller to remove the crankshaft gear, Figure 67. If necessary, use an adapter or heavy flat washer between the crankshaft and puller screw to prevent damage to the internal threads.

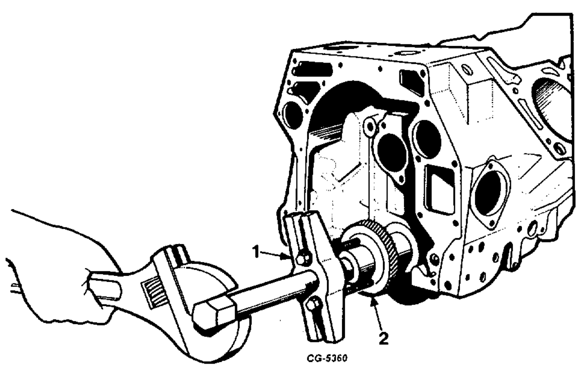

Fig. 67 Using SE-1368 Puller to Remove Crankshaft Gear

1. Puller 2. Crankshaft gear

70. The crankshaft bearing caps are numbered and arrowed to the front to identify their respective positions for reinstallation. The number three bearing cap accommodates a thrust flange to limit crankshaft end play, Figure 68. Remove bolts from bearing caps and remove all main bearing caps.

71. Lift the crankshaft straight up and out of the cylinder block. Remove upper bearing inserts.

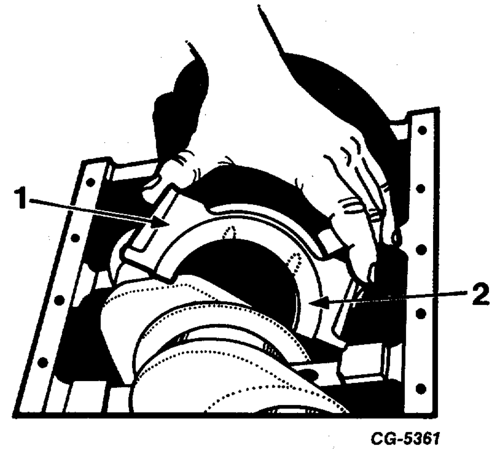

Fig. 68 Main Bearing Cap Removal

1. Number 3 main bearing cap
2. Thrust flange

ENGINE OVERHAUL

Cylinder Block

One of the most important phases of engine reconditioning is the thorough cleaning and inspection of the cylinder block.

Each machined surface of the cylinder block should be cleaned of all old gasket material. The pipe plugs which seal the oil passages should be removed and all passages thoroughly cleaned.

Remove the main oil gallery plug and use SE-2334-2 Brush (3/8" diameter) to clean the main oil gallery, Figure 69. Replace oil plug after coating with a suitable nonhardening sealing compound.

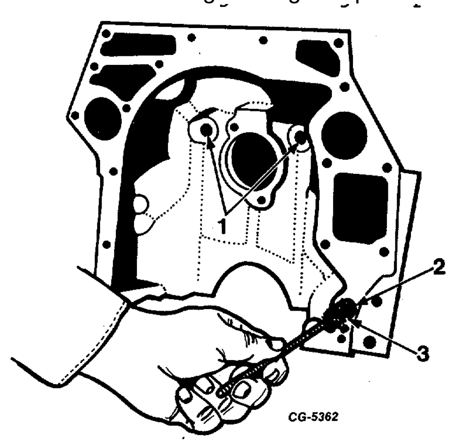

Fig. 69 Cleaning Main Oil Gallery with SE-2334-2 Brush

1. Tappet oil galleries 3. Brush
2. Main oil gallery

Remove the tappet oil gallery plugs by drilling a small hole in the plug and prying with a screwdriver or suitable tool. Clean the tappet oil galleries with SE-2334-1 Brush (5/16" diameter). Replace the tappet gallery plugs flush to .060" below crankcase surface using tool shown in Figure 70. The tool may be made locally from cold rolled steel to the dimensions shown in Figure 70.

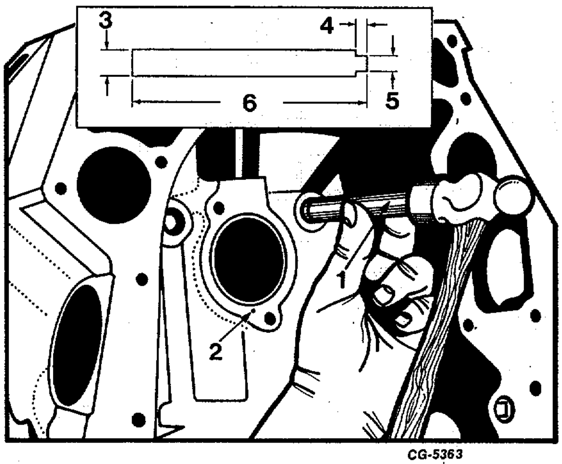

Fig. 70 Tappet Oil Gallery Plug Installation

1. Installer tool	**4. .200**
2. Oil hole	**5. .410**
3. .490	**6. .450**

NOTE: Coat the edges of the plugs with a suitable nonhardening sealing compound prior to installation.

If it becomes necessary to remove an expansion type plug due to water leaks, drill a 1/2" hole in the center of the plug and remove by prying with a screwdriver or suitable tool. When installing the expansion plug, the concave side of the plug must be installed on the interior of the cylinder block. Coat the edges of the plug with a suitable nonhardening sealing compound and install using a 1" diameter brass drift and hammer.

Inspection of the cylinder block should be done carefully to detect any scoring of the cylinder bores, cracks or water leaks. Small cracks may be found by coating the suspected areas with a mixture of light motor oil and kerosene. After wiping the area dry, immediately apply a coat of quick drying liquid such as zinc oxide powder mixed with wood alcohol. Wherever cracks are present, a brown discoloration will appear in the white coating.

Check the top surface of the cylinder block for trueness with a straightedge. Test by attempting to insert a .006" feeler gauge ribbon between the straightedge and cylinder block. If this is possible, replace the cylinder block.

Each cylinder bore should be checked with an inside reading micrometer SE686 or dial bore gauge SE-2331 to determine taper, out-of-round or worn condition, Figure 71. Measure the diameter of the cylinder bore at the top of the piston ring travel at right angle "A", Figure 72, to the centerline of the crankshaft. Record the readings. Next, measure each bore so the gauge reading coincides with the centerline "B4", Figure 72, of crankshaft. The difference between "A" reading and "B" reading is the out-of-round condition at the top of the cylinder bore. Repeat the same procedure at the bottom of the ring travel to check for out-of-round. The difference between the diameters measured at the top "A" and the bottom "B", Figure 73, of the bore (at right angles to centerline of the crankshaft) is the taper of the bore.

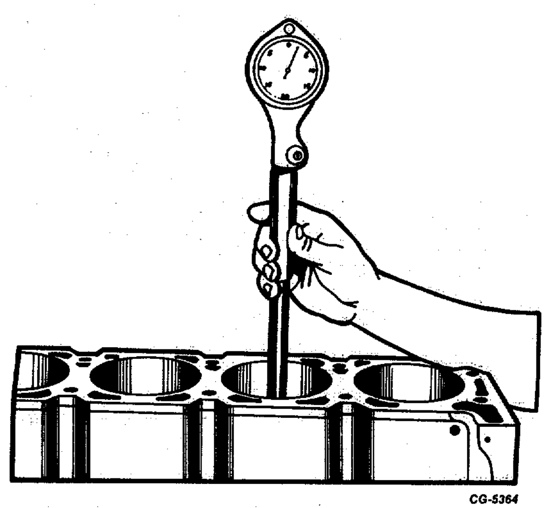

Fig. 71 Checking Cylinder Bore Using Dial Bore Gauge SE-2331

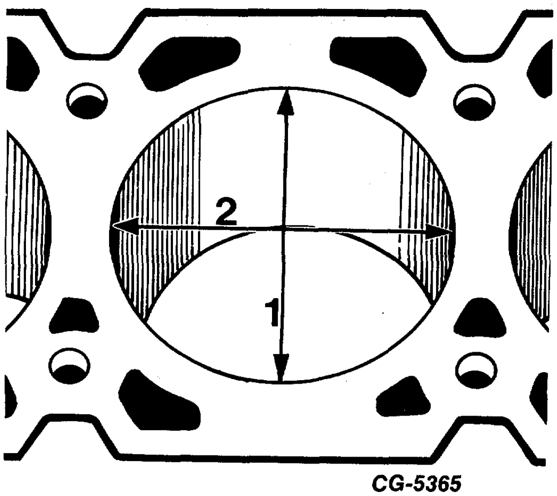

Fig. 72 Checking Cylinder Bore Out-of-Round

1. "A" 2. "B"

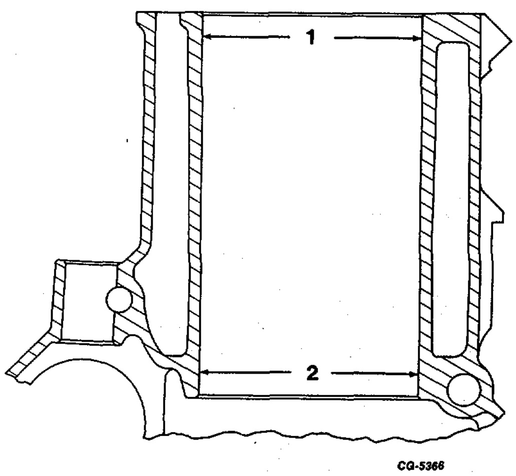

Fig. 73 Checking Cylinder Bore Taper

1. "A" 2. "B"

If the cylinder bore does not exceed the limits of .002" out-of-round and/or .005" taper, new standard size service piston rings will give satisfactory performance provided the piston clearance is not excessive.

Cylinder bore blocks can be deglazed by the use of SE-2314-5 glaze breaker brush, Figure 74. This silicon carbidetipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on the cylinder wall surface in a single operation. The brush contours itself to the cylinder wall and conditions the wall surface without altering the cylinder bore.

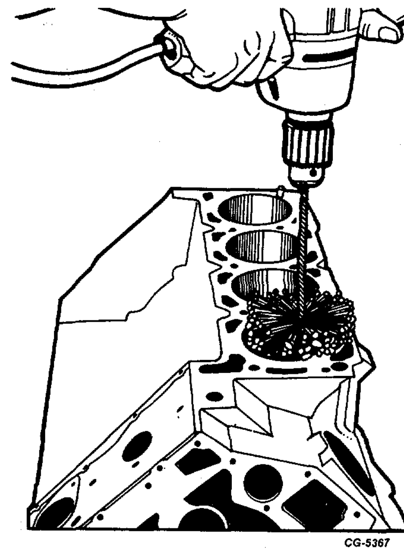

Fig. 74 Deglazing Cylinder Wall Surface Using SE-2314-5 Glaze Breaker Brush and Electric Drill

The SE-2314-5 brush is used in conjunction with an electric drill, Figure 74. A slow RPM drill is recommended. Most 3/8" capacity electric drills are satisfactory for driving the brushes. A drill speed of 350 500 RPM has been found to be a practical speed for deglazing IH cylinder block bores.

A lubricant should be used with the silicone carbide-tipped brush to produce a desirable finish on the wall surface. A lightweight engine oil (SAE-30) provides adequate lubrication for deglazing cylinder block bores. The lubricant also controls airborne particles which can be easily wiped from the cylinder bore with a cloth.

When conditioning cylinder block bores, stroke the brush up and down in the bore at a rate of 30 40 strokes per minute for a duration of 15 20 seconds per cylinder bore. In most instances, 20 seconds is adequate time for the brush to break cylinder wall glaze and produce a crosshatch pattern on the cylinder wall surface.

Thoroughly clean cylinder bore walls after deglazing. Wipe as much of the abrasive deposits from the wall as possible. Then swab out each abrasive-coated cylinder with SAE-10 oil and carefully wipe it out with a clean cloth. One swabbing and wiping is not sufficient. Three complete operations are usually required more may be necessary. Continue cleaning until a clean, white cloth shows no evidence of discoloration when wiped through the cylinder bore. Never use gasoline, kerosene or commercial cleaners to clean cylinders. Solvents of this nature will not remove abrasives from the walls. Rapid engine wear and ring failure results from failing to properly clean abrasives from the cylinders.

However, if the wear exceeds the previously mentioned limits, it is recommended to rebore the cylinder of cylinders to within .003" of the required oversize diameter, Figure 75. This will allow enough stock for the final step of honing the bores, Figure 76, so that the exact clearance may be obtained for the selected oversize piston. When performing the honing operation, the hone should be stroked up and down to produce a crosshatch pattern on the cylinder wall as shown in Figure 77. The faster the hone rotates, the faster it must be stroked up and down to produce the desired crosshatch pattern.

NOTE: After the honing operation is completed, the sharp burred edge that develops at the bottom of a newly honed cylinder should be removed manually with emery cloth. Then thoroughly clean the block and cylinder bores.

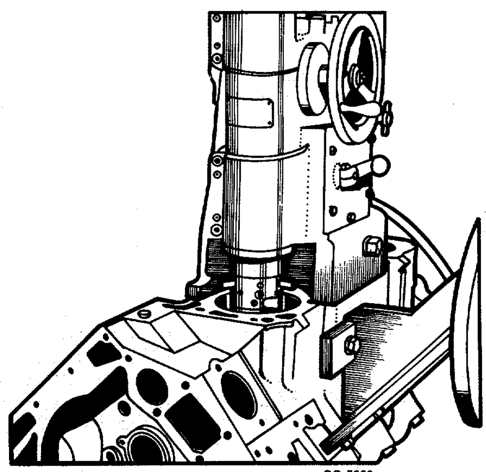

Fig. 75 Reboring Cylinder Using SE-1399 Boring Machine

Wipe as much of the abrasive deposits from the cylinder wall as possible. Then swab out each abrasive-coated cylinder with clean SAE-10 oil and carefully wipe it with a clean cloth. One swabbing and wiping is not sufficient. Three complete operations are usually required more may be necessary. Continue cleaning until a clean, white rag shows no evidence of discoloration when wiped through the cylinder bore. Never use gasoline, kerosene or commercial cleaners to clean cylinders after honing. Solvents of this nature will not remove abrasives from the walls. Rapid engine wear and ring failure result from failing to properly clean abrasives from the cylinders.

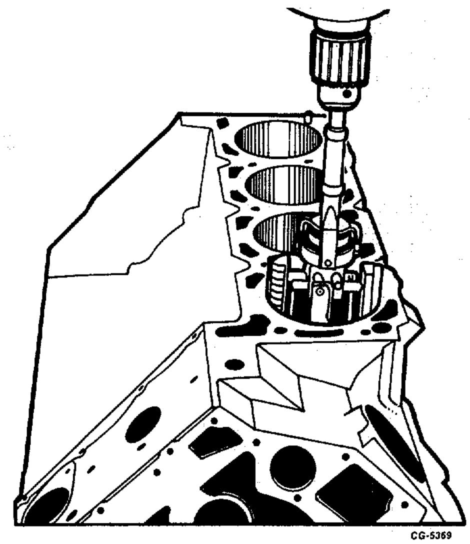

Fig 76 Honing Cylinder Bore Using SE-784 Cylinder Grinder

Inspect the camshaft bearings for wear and proper running clearance. See "Specifications." If the limits are exceeded, replace the bearings. This can be accomplished with the special camshaft bearing remover and installer SE-1897 with two SE-1897-7 adapters and the slide hammer and adapter from puller ' set SE-1879.

NOTE: Oil holes must be in alignment with holes in the crankcase.

1. Position one adapter SE-1897-7 in the second bearing with the flange toward the rear of the block,Fig. 78.

2. Position another adapter SE-1897-7 in the third bearing with the flange toward the rear of the block, Figure 78.

3. Install the bar through the adapters and lock the third bearing adapter on the bar with a "C" washer SE1897-2.

4. Using the second bearing adapter as a pilot, pull the third bearing with the slide hammer, Figure 78.

NOTE: Always hold the adapter firmly against the bearing being removed or installed to avoid damage.

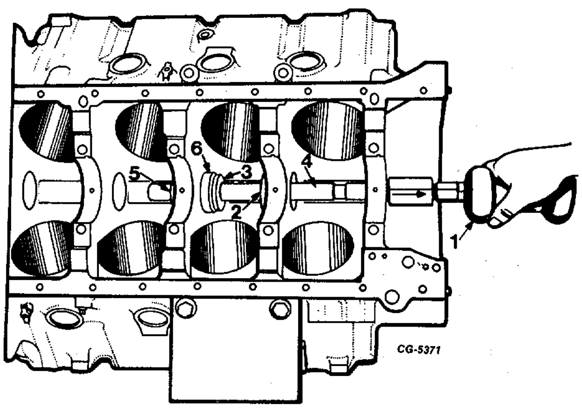

Fig. 78 Removing Third Bearing

1. Slide hammer	**4. Bar**
2. Second adapter	**5. C-washer**

3. Third adapter 6. Bearing

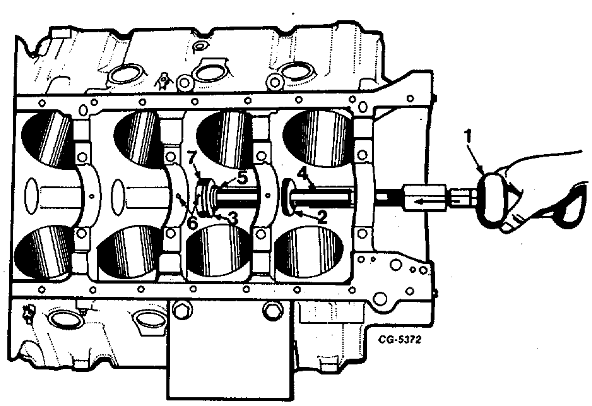

Fig. 79 Installing Third Bearing

1. Slide hammer	**4. Bar**
2. Second adapter	**5. C-washer**
3. Third adapter	**6. Align oil holes**
7. Bearing	

5. Position the new bearing on the third adapter and install adapter and bar with a "C" washer in front of the adapter, Figure 79. Align the oil hole and push in the third bearing.

6. Position the front adapter SE-1897-7 in the front bearing with the flange toward the front of the block, Figure 80.

7. With the second adapter still in position, install the bar through the adapters and lock the second adapter on the bar with "C" washer, Figure 80.'

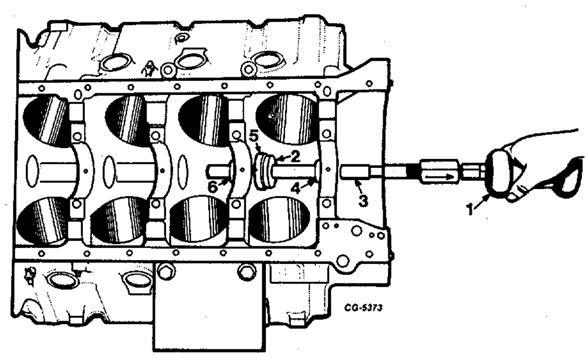

Fig. 80 Removing Second Bearing

1. Slide hammer	**4. Front adapter**
2. Second adapter	**5. Bearing**
3. Bar	**6. C-washer**

8. Using the front adapter as a pilot, pull the second bearing with a slide hammer, Figure 80.

NOTE: Always hold the adapter firmly against the bearing being removed or installed to avoid damage.

9. Position the new bearing on the second adapter and with the adapter flange toward the front of the block, install the bar through the front and second adapter. Then install "C" washer in front of the second adaptor. Align the oil hole and push in second bearing, Figure 81.

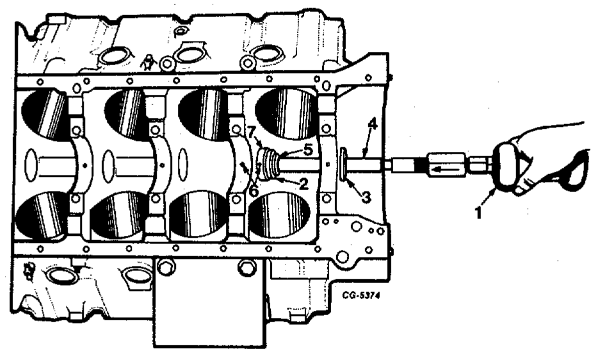

Fig. 81 Installing Second Bearing

1. **Slide hammer**
2. **Second adapter**
3. **Front adapter**
4. **Bar**
5. **C-washer**
6. **Index oil holes**
7. **Bearing**

10. Remove the "C" washer and use the second adapter as a pilot. Pull the front bearing from the crankcase, Figure 82.

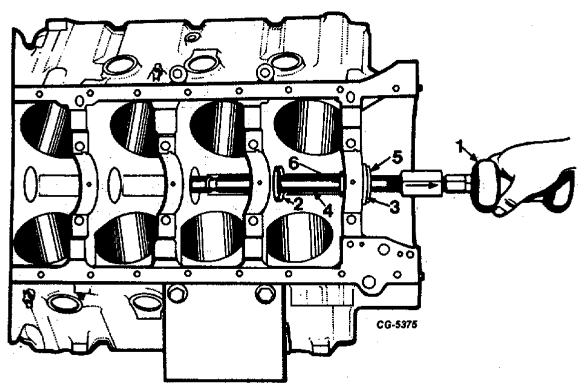

Fig. 82 Removing Front Bearing

1. **Slide hammer**
2. **Second adapter**
3. **Bearing**
4. **Bar**
5. **Front adaptor**
6. **C-washer**

11. Remove the bar and front adapter and position the new bearing on the front adapter. Slide the bar into the block and through the second adapter serving as a pilot, Figure 83.

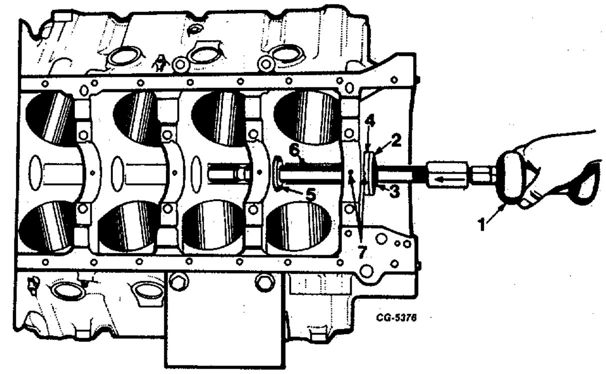

Fig. 83 Installing Front Bearing

1. **Slide hammer**
2. **Front adapter**
3. **C-washer**
4. **Bearing**
5. **Second adapter**
6. **Bar**
7. **Index oil holes**

12. Align the oil holes and drive in the front bearing, Figure 83.

13. The fourth and rear bearings are installed in a manner similar to the front and second bearings using SE m 1897-7 adapters and working from the rear of the block.

Pistons and Piston Pins

To disassemble the connecting rod from the piston and piston pin assembly, remove the piston pin retainers from each end of the pin using Tru-Arc pliers, Figure 84.

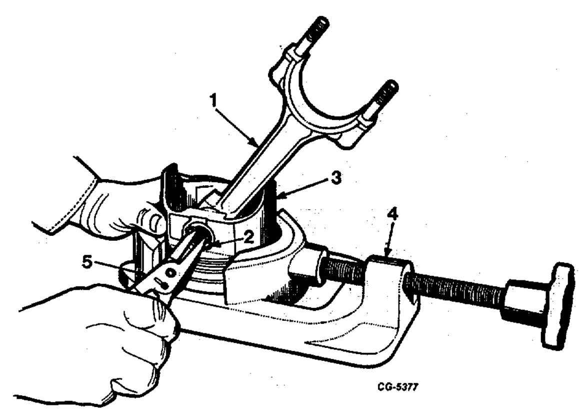

Fig. 84 Removing Piston Pin Retainers

1. **Connecting rod**
2. **Retainer**
3. **Piston**
4. **Piston vise**
5. **Pliers**

Heat piston in boiling water or piston heater and after placing piston in vise, drive pin from assembly with a suitable remover or brass drift and soft hammer, Figure 85.

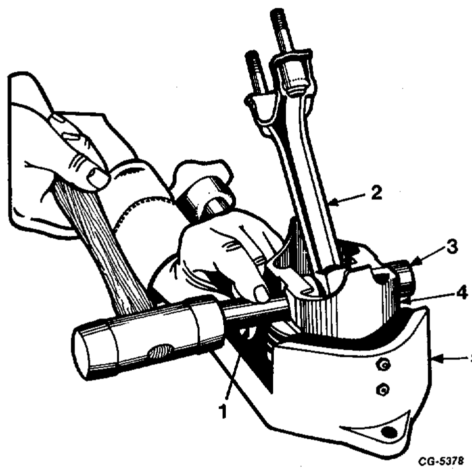

Fig. 85 Removing Piston min

1. **Brass drift**
2. **Connecting rod**
3. **Pin**
4. **Piston**
5. **Piston vise**

After the pin is removed, separate the piston from the connecting rod, taking precaution to see that the parts are marked so they may be reinstalled in their respective cylinders unless defective.

NOTE: Pistons should also be marked at this time to insure they are reinstalled in the same position on the connecting rod as they were removed, Figure 86. Mark the pistons so that the mark will not be removed during cleaning operation. If new pistons are installed, piston may be installed either way on the connecting rod.

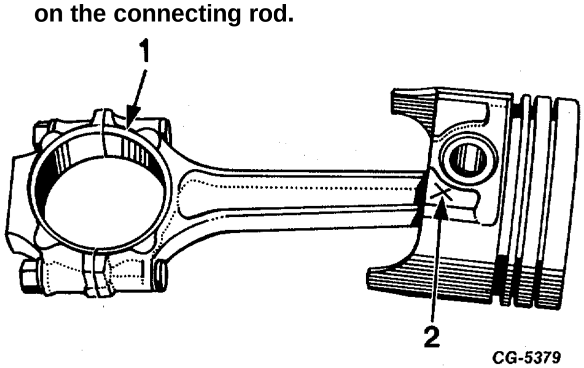

Fig. 86 Mark Piston for Identical Reinstallation on Connecting Rod

1. **Large chamfer**
2. **Place mark here**

Remove all old rings and immerse all parts of the piston in cleaning solvent and clean thoroughly. Use a special ring groove cleaner on broken piston ring to clean all carbon from the piston ring grooves.

NOTE: Never use a caustic solution for cleaning aluminum pistons.

Inspect the pistons for scuffed or scored skirts or cracked or worn ring lands, discarding any showing such condition.

To select the correct size pistons for an engine overhaul, the size of the cylinder bore diameters must be determined first. This can be accomplished with the use of an inside reading micrometer SE-686 or dial bore gauge SE-2331. (Refer to Figure 71.) Each bore should be measured at the top of ring travel and the lower end of ring travel both parallel and at right angles to the crankshaft.

After the cylinder bores have been measured and recorded, the next step is to select a piston to fit a certain bore. This is accomplished by measuring the piston at the top of the skirt across the thrust faces with an outside micrometer, Figure 87. The size piston selected should be large enough to permit cleaning up the cylinder bore and provide the proper running clearance as shown in the specifications.

Cylinder blocks having deep scuff or score marks may require reboring for use of oversize pistons; therefore, the foregoing information still applies.

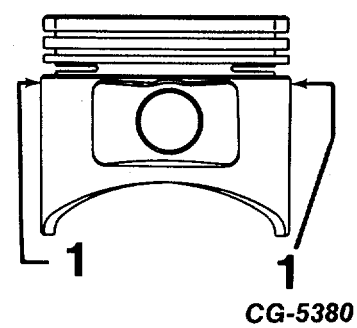

Fig. 87

1. **Measure piston at this area for fitting.**

However, when reboring the cylinder bore, it should be sized to within .003" of the desired size and then honed to provide the proper finish on the cylinder wall as well as the correct running clearance for the piston selected.

Piston pins should be inspected and measured for wear. If piston pins show signs of corrosion or etching or are not within specifications, they should be replaced with new pins. See "Specifications." Piston assemblies furnished for service replacement are complete with piston pins accurately fitted.

Connecting Rods

The connecting rod and bearing must withstand extreme forces and high temperatures. In addition, the connecting rod and bearing are subject to changing temperature cycles in a variety of climates and under widely varying operating conditions.

The connecting rod bearing plays a major role in distributing the proper amount of oil to the piston pin bearing surfaces, cylinder walls, piston and piston rings. This is known as oil throwoff and the condition of the connecting rod bearing determines how well the lubrication operation is performed.

The bearing-to+crankshaft clearance affects the volume of oil throw-off. Where the bearing clearance is more than specified, an abnormal amount of oil is thrown onto the cylinder walls causing increased oil consumption and low oil pressure due to oil passing through the bearing surfaces too quickly. Where bearing clearances are less than the specified amount, the oil that passes through the bearing is insufficient to properly cool the bearing, resulting in short bearing life and improper oil throw-off to the cylinder walls, piston pins and piston rings. This condition contributes to scoring of pistons and cylinder walls.

If the connecting rod bore is stretched or out-of-round beyond the specified diameter, the insert will be out-of-round and will not be held securely in the connecting rod since the "crush" may be lost. Bearing failures can result from localized bearing loads or from low oil pressure. The bearing insert locating tangs will keep the inserts from turning in the connecting rod bore under normal conditions but may move and fail due to the foregoing reasons.

When installing new connecting rod bore inserts, a very thorough inspection of the connecting rod bore is necessary. This inspection consists of the following:

1. Bore Size: To obtain the proper bearing insert crush, the bore must be of a specified size, Figure 88. See "Specifications."

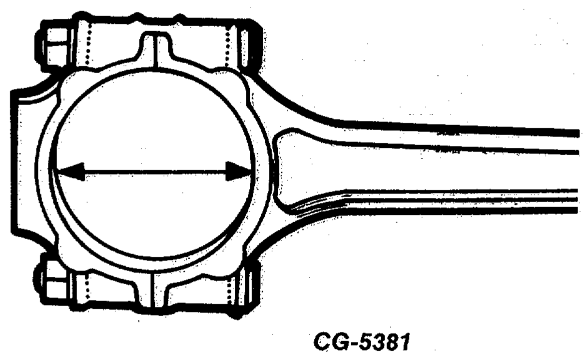

Fig. 88

2. Roundness: The bore of the connecting rod when assembled and the rod bolts, nuts and special hardened washers tightened to specified torque is round and should not exceed .005" out-of-round, Figure 89.

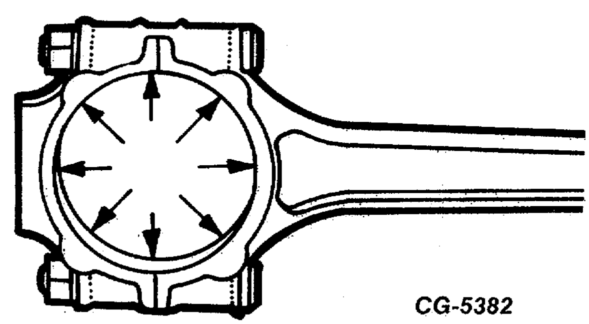

Fig. 89

3. Surface Finish: The connecting rod bore must be smooth, Figure 90.

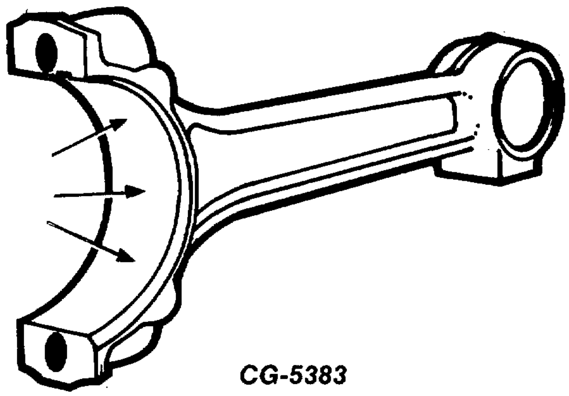

Fig. 90

4. Straightness: The connecting rod bore taper should not exceed .0005",

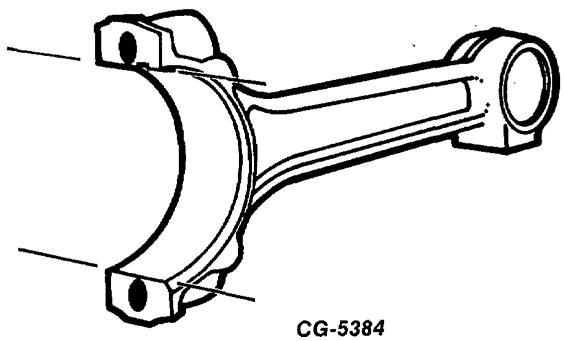

Figure 91

This inspection of the connecting rod can be made using the precision gauge furnished with honing machine, SE2218, Figure 92, or other accurate bore gauge such as SE-2087. For further information refer to the instructions furnished with the gauge.

If the original connecting rod does not meet the foregoing requirements, it must be replaced.

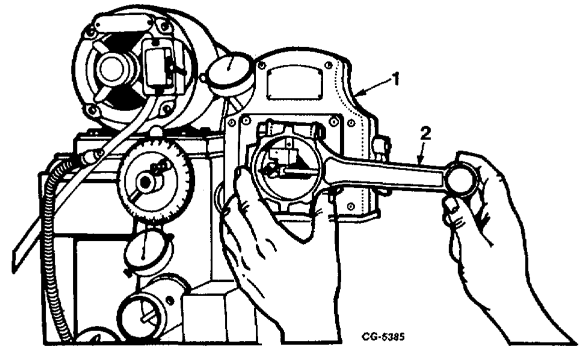

Fig. 92 Checking Connecting Rod Bore Using Precision Gauge Furnished with Honing Machine SE-2218

1. Bore gauge
2. Connecting rod

The connecting rod must be thoroughly cleaned and visually inspected for defects. The connecting rod bushings should be checked for proper clearance with the piston pin. See "Specifications." The connecting rod bushings should be checked for proper clearance with the piston pin using the precision gauge furnished with honing machine, SE-2218, Figure 93, or other accurate bore gauge such as SE-2087.

Fig. 93 Checking Connecting Rod Bushing Bore Using Precision Gauge Furnished with Honing Machine

1. Bore gauge **2. Connecting rod**

If inspection shows the piston pin bushings are worn, new bushings must be installed. This can be accomplished by placing the connecting rod under a hydraulic press in line with the properly sized hole in support plate, SE-1033, and using SE-2539 tool, remove the bushing,
Figure 94.

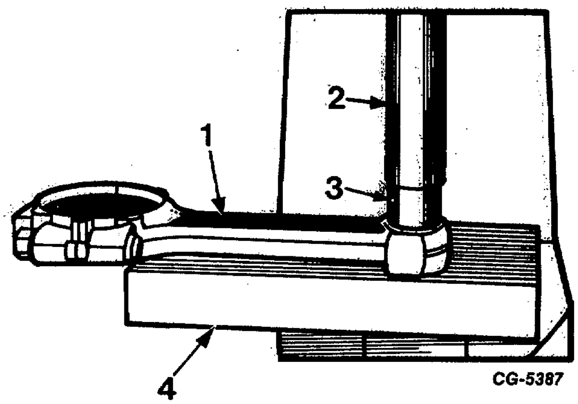

Fig. 94 Using SE-2539 Tool to Remove Worn Connecting Rod Bushing

1. **Connecting rod**
2. **Press ram**
3. **Remover**
4. **Support plate**

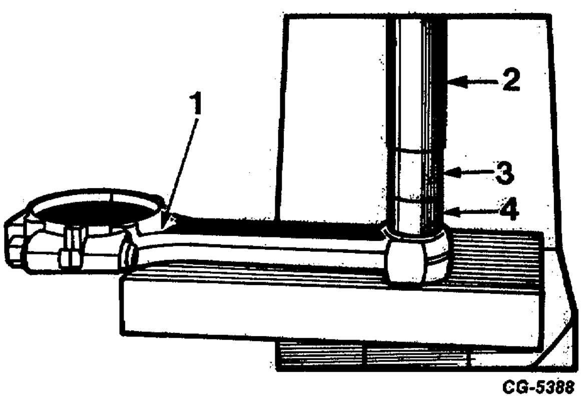

Fig. 95 Using SE-2539 Tool to Install New Connecting Rod Bushing

1. **Large chamfer side**
2. **Press ram**
3. **Installer**
4. **New bushing**

To install the new bushing, place the bushing on SE-2539 Installer and lubricate the bushing outside diameter with light oil. Place the connecting rod on a flat surface plate with the large chamfer side of the main bearing bore up. The split in the bushing must be located in the connecting rod as shown in Figure 97.

Press new bushing in until bushing contacts flat surface plate, Figure 95. If the bushing is flush on the surface plate side, the opposite side of the bushing is allowed to be flush to .010" above surface (large chamfered side of connecting rod).

After bushing has been installed in the connecting rod, it must be honed to proper size using SE-2218 Honing Machine and equipment, Figure 96. See "Specifications."

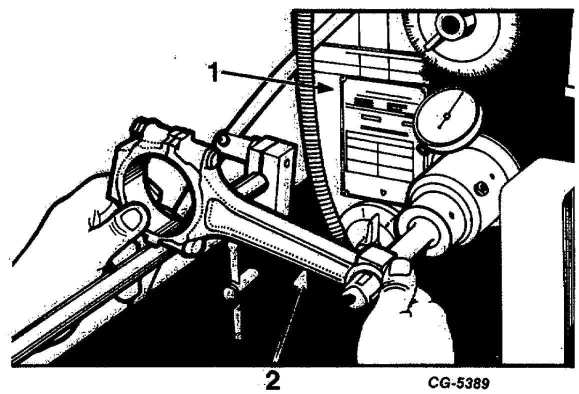

Fig. 96 Honing Connecting Rod Bushing Using SE-2218 Equipment

1. **Honing machine**
2. **Connecting rod**

Insert the piston pin into the piston and connecting rod and place retainers on each end. Make certain the retainers seat fully with tension in the grooves. Test the connecting rod and piston assembly on a connecting rod aligner. If any misalignment is encountered, a new rod or piston may be required to overcome this condition.

The piston is constructed so that it may be assembled either way on the connecting rod. However, when the piston and connecting rod are installed in the engine, the large chamfered side of each rod must be located against the crankshaft face. The chamfer provides clearance at the crankshaft fillet, Figure 97.

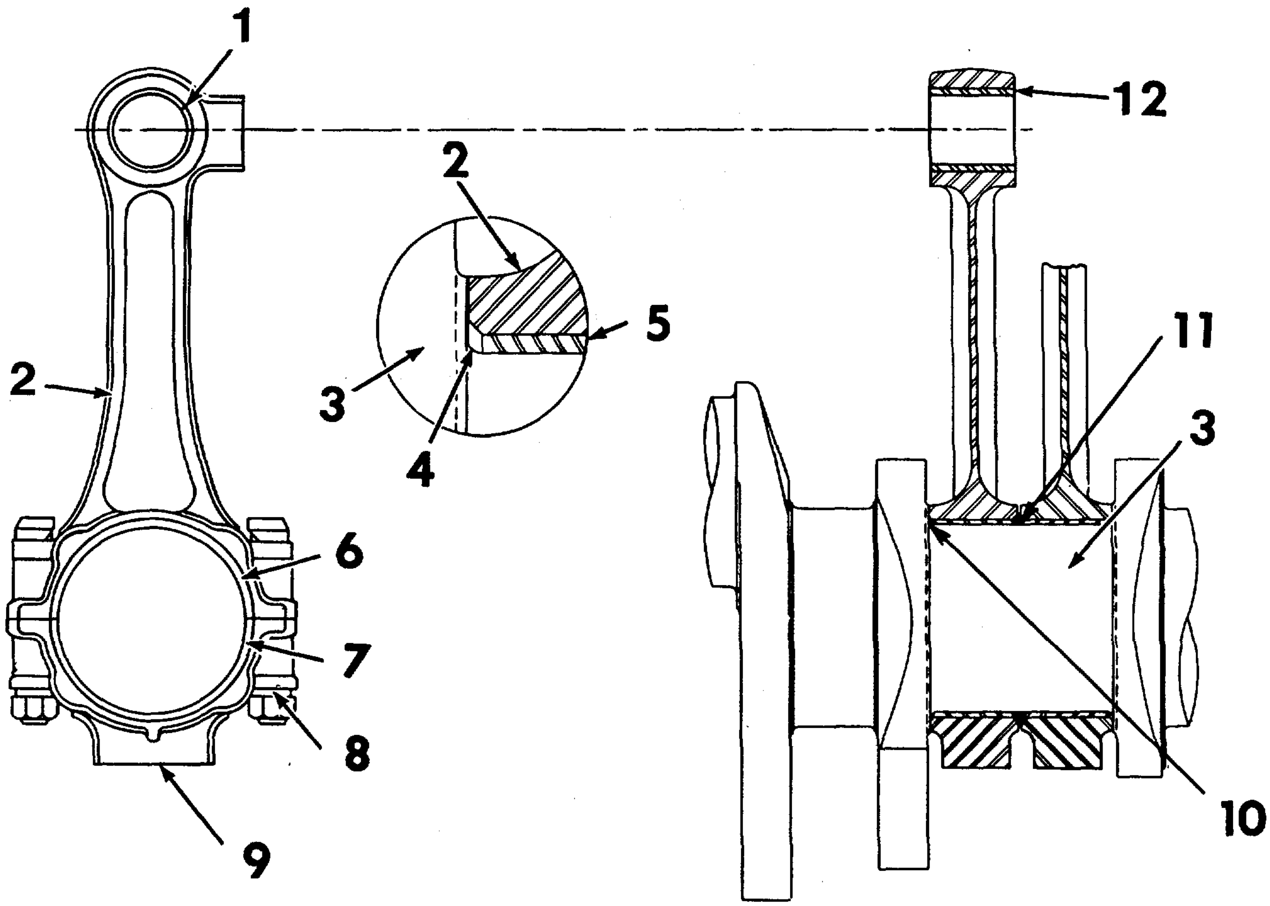

Fig. 97. Illustrating Proper Installation of Connecting Rod to Crankshaft

1. Split in bushing
2. Connecting rod
3. Crankshaft
4. Crankshaft fillet
5. Bearing
6. Connecting rod bearing-upper
7. Connecting rod bearing-lower
8. Washer
9. Connecting rod bearing cap
10. Large chamfer side
11. Small chamfer side
12. Bushing

Connecting Rod Caps and Bolts

The fastening of the connecting rods to the engine crankshaft is another important function for mechanics to consider for engine rebuilding. How well this job is performed determines to a large extent what kind of connecting rod bearing will be realized. The correct torque application assures a good job.

NOTE

Do not use a power wrench for removing or installing connecting rod bolts, nuts and washers. Such practice will cause seizure of the connecting rod bolt or nut threads.

There are a number of conditions which affect torque and the results of torque applications. The major purpose in tightening connecting rods and bolts to a specified torque is to obtain tension in the bolt, Figure 98, which in turn develops a clamping load or pre- load that exceeds any possible loading imposed on parts due to engine RPM. In other words, the connecting rods must "hang on" to the crankshaft and suffer all the strains of inertia and cylinder combustion impulse without permitting the least movement or flexing of the rod cap, bolts or nuts. At the same time, torque applied must be within the capacity of the parts (bolt, nut, caps and connecting rods) to withstand these loads.

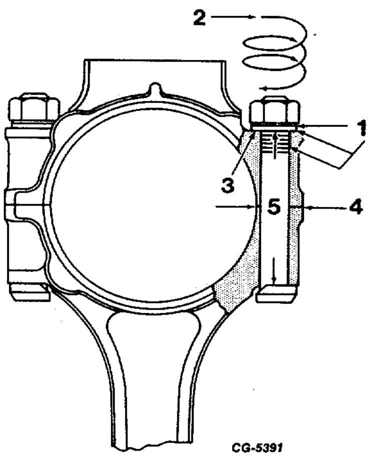

Fig. 98. Connecting Rod Cap and Bolt Details

1. Friction **4. Clamped**
2. Torque **5. Tension**
3. Washer

In tightening connecting rod bolts and nuts to their specified torque figure, a definite loading is obtained between the connecting rod and cap. Specially designed bolts, nuts and washers manufactured from selected materials permit the application of this loading without undue stretching of bolts. There is a relation- ship between the torque specifications and clamping effect or load to be applied providing certain conditions exist.

These conditions center largely around the bolt itself and its care, pointed out as follows:

1. Bolt and Nut Thread Condition:

Threads that are dry, excessively rough, battered or that are filled with dirt require considerable effort just to rotate the nut. Then when the clamping load is developed or the bolt tension is applied, the torque reading mounts rapidly (due to thread friction) to the specified figure without approaching the desired bolt tension and maximum clamping effect. Under these conditions the desired torque reading is obtained, but the clamping effect might be far below requirements, leading to bearing failure or to connecting rod bolt breakage. The proper bolt tension and clamping effect can never be attained if the nut is dry. The nut and bolt must have a film of lubricant in the thread section to be considered lubricated. It is recommended that new connecting rod bolts, nuts and washers be used during reassembly. Due to the close fit of the connecting rod nuts on the bolts, the slightest thread imperfection increases the friction to the extent that incorrect bolt tension is likely.

Connecting rod bolts and nuts must be cleaned of all foreign matter including the anti-rust materials that may be in the threads. Apply light engine oil to the threads to lubricate before installation.

2. Tightening of Connecting Rod Bolts, Nuts and Washers

Tighten the connecting rod bolts, nuts and washers alternately with the torque wrench to the specified torque. Then release the torque load to zero and retorque to specified torque. See "Torque Chart." If nut is overtightened enough to stretch the bolt, the nut and bolt both must be replaced. Use new rod bolts, nuts and flat washers in major engine overhaul.

The application of specified torque to any particular bolt or nut which serves to hold or clamp two parts together should be accomplished with a torque wrench known to be accurate.

Piston Rings

The pistons used in the V-type engines have three piston rings located above the piston pin. The compression rings are located in the top grooves while the lower groove accommodates the oil control ring. Select the proper rings for the size of pistons to be used.

Prior to installing the rings on the pistons, each ring must be checked for proper ring gap. Push the ring down into the cylinder bore making sure the ring is square with the cylinder wall. Check j the space or gap between the ends of the ring with a feeler gauge, Figure 99. See specifications for proper ring gap.

NOTE

Extreme care should be taken during this operation.

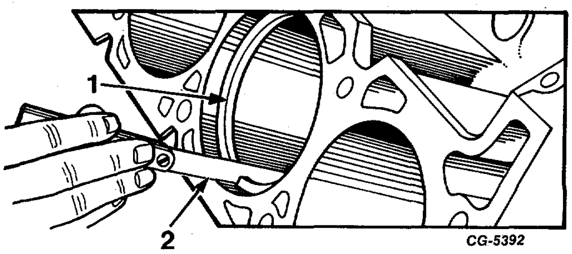

Fig. 99. Checking Ring Gap
1. Piston ring 2. Feeler Gauge

If the gap on the compression rings is less than the limit, try the next size smaller ring. Each ring should be fitted and checked in the cylinder in which it is to be used and marked accordingly.

Piston rings should be checked for side clearance in the groove of the piston on which they are to be installed. This is done by placing the outer edge of the ring in the piston groove, rolling the ring entirely around the piston to make sure the ring is free in the groove. With a feeler gauge check the side clearance

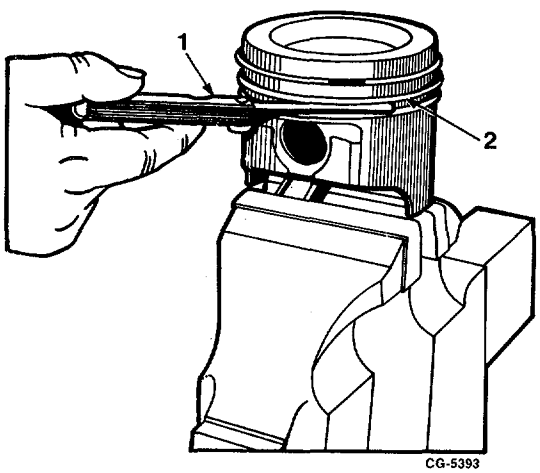

Fig. 100. Checking Ring-to-Groove Side Clearance with Feeler Gauge
1. Feeler Gauge 2. Piston ring

1. of each ring in its respective groove, Figure 100. See specifications for proper clearance.

Assemble the rings on the pistons to which they were fitted by using a piston suitable ring expander tool. This type of tool is recommended to avoid over-expanding and also to expand the ring to a true circle to avoid distortion, Figure 101. General practice is to stagger the ring gaps when installing piston rings. For further information refer to the instructions furnished with the service ring sets.

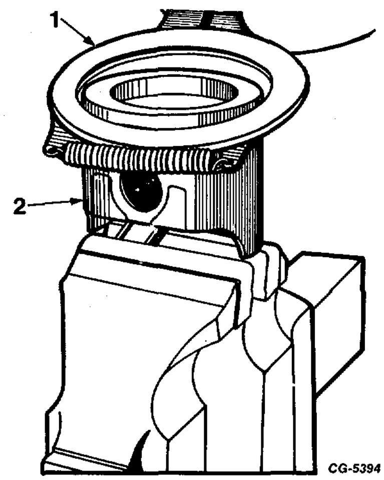

Fig. 101. Installing Piston Ring Using Suitable Piston Ring Expander Tool
1. Piston ring expander 2. Piston

Cylinder Heads, Valves, Valve Guides, Springs, Etc.

The cylinder heads, as removed from the engine, contain the valve mechanism. The rocker arms were removed prior to removing the heads. Position the cylinder head on the intake manifold surface on a clean work bench or install the cylinder head in holding fixture SE-1939 to protect the machined surfaces during cleaning and disassembly operations.

With the valves installed to protect the seats, clean the carbon deposits from the combustion chambers and valve heads with a wire brush and scraper. Wash the heads in cleaning solvent to re- move dirt and grease from all surfaces and dry thoroughly. Check all water passages to make sure they are clear and open.

Examine the cylinder heads for water leaks or cracks in the combustion chambers, exhaust ports and around the valve seats. Inspect the machined or gasket surfaces for scratches or mars which could cause leakage after assembly. The use of holding fixture SE-1939 reduces the chances of gasket surface damage. Check the gasket surface of the cylinder head for trueness with a straightedge. Test by attempting to insert a .003" feeler gauge ribbon between the straightedge and cylinder head. If this is possible, either resurface or replace the cylinder head.

NOTE

When resurfacing the cylinder head, do not remove more than .005" material. Cylinder head height measurement should be taken between the machined surface of the head and the machined surface of the bolt bosses on the exhaust manifold side of the head. The original specification for this measurement is 3.282" ± .010".

The cylinder head assemblies and head gaskets are interchangeable from one cylinder bank to another.

To disassemble the valve assembly, turn the head assembly in a vertical position either on a clean work bench or using SE-1939 cylinder head holding fixture as a cradle to hold the assembly.

Apply a valve spring compressor and remove the valve keepers or locks, Figure 102. Remove the spring compressor and dis- assemble the spring retainer, valve stem seal and Roto-Coil assembly from the exhaust valves. Remove the spring retainer, valve stem damper, spring, valve stem seal and valve spring seat from the in- take valves. All valves are removed in

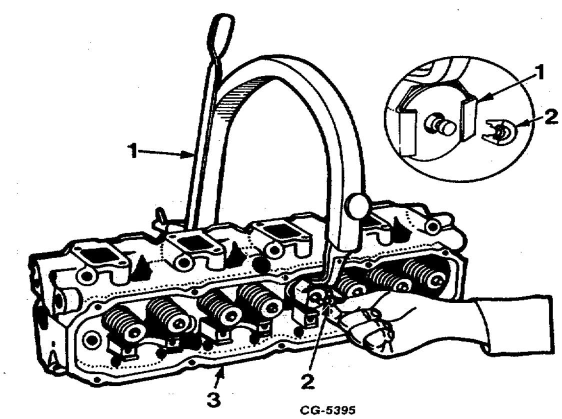

Fig. 102. Removing Valve Keepers

1. Valve spring compressor
2. Keepers
3. Cylinder head

the same manner. <u>Keep valves and their related parts together so they may be reinstalled in their respective positions</u>.

NOTE

It may be necessary to strike the valve ends with a light, soft hammer to break the valve keepers loose.

Remove all carbon from valve stems and head using a fine wire brush or buff- ing wheel. Inspect each valve, discarding any that show evidence of burned, warped or bent condition. SE-2614 valve gauge, Figure 103, or similar tool can be used for checking stem straightness and seat run-out.

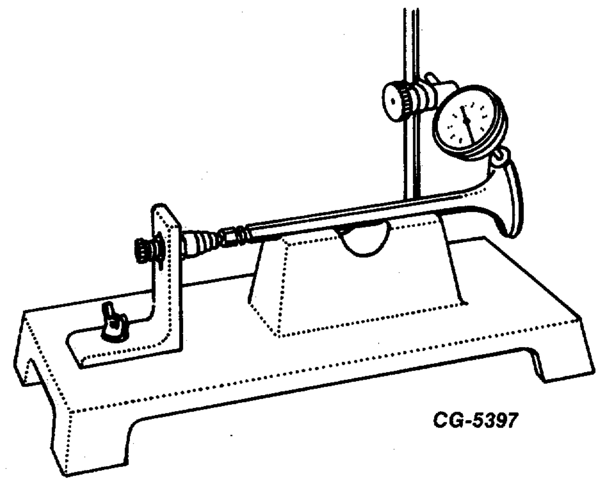

Fig. 103. Checking Valve Stem Straightness and Face Run-Out

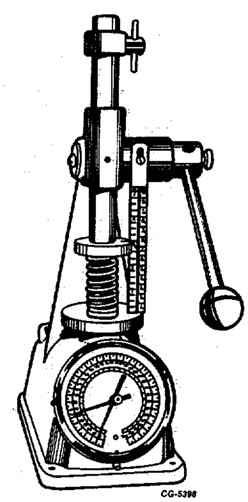

Fig. 104. Checking Spring Tension Using SE-2241 Tester

Inspect the valve springs for proper tension as outlined in specifications. Any evidence of wear, cracks or permanent sets will require replacement. SE-2241 spring tester, Figure 104, or similar tool can be used to check tension.

Inspect valve locks for excessive wear and replace in pairs as required. Rotate the Roto-Coil assemblies and re- place if any wear or irregularities are noted. Note particularly if the Roto-Coil is bound up or feels gritty.

Remove SE-1939 Holding Fixture (if installed) and position the cylinder head with combustion chamber facing upward on support blocks, Figure 108. This preparation is done for valve guide removal.

Check the valve guide bore dimensions (see specifications). Prior to inspection it is necessary to clean guides. There are many commercially available wire brushes and scrapers, Figure 105, that clean guides very satisfactorily. Similarly, there are various instruments for measuring the guide bores small-bore gauge SE-2506, plug gauges, etc., Figure 106. Plug gauges of the "go" and "no-go" type are most popular because of the facility with which guides can be checked. However, there are two undesirable guide conditions which are difficult to check with gauges of this type: elliptical or egg-shaped bore wear and bell-mouthing at the port of the guide. Careful guide inspection will detect egg-shaped wear while careful use of the "no-go" gauge will tend to show the degree of bell-mouthing. Replacement is recommended for guides having bore diameters beyond the recommended limit or which are bell-mouthed more than .0005" or which show egg-shaped wear. Excessive guide clearance prevents adequate cooling of the valve through the guide and also allows deposits to tilt or tip the valve which may cause valve breakage at high engine speed. These conditions tend to prevent good seating and promote leakage across the valve face. Excessive guide clearance also affects the proper lubrication of the valve stem.

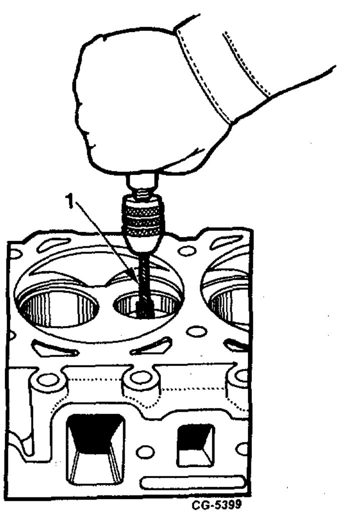

Fig. 105. Valve Guide Cleaning Tool
1. Cleaning tool

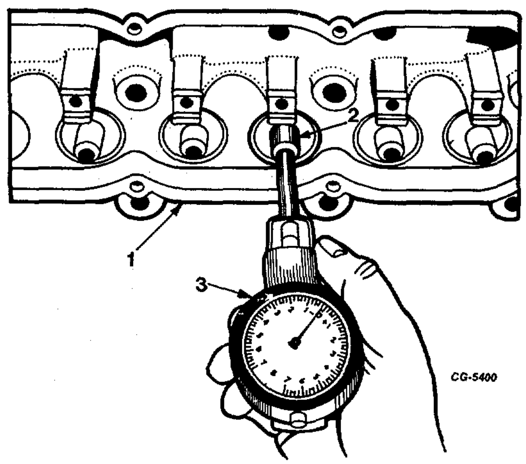

Fig. 106. Checking Guide Bore Using Gauge SE-2506

1. Cylinder head
2. Valve guide
3. Bore gauge

Replacement guides are designed to give proper clearance when installed in the cylinder head. Reaming is not required but care must be taken to see that-the ends of the guides are not burred during installation.

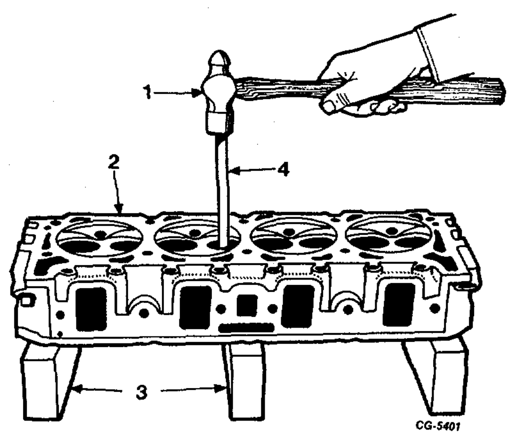

Fig. 107. Removing Valve Guides with SE-1722
1. Hammer
2. Cylinder head
3. Support blocks
4. Remover

Remove all guides that exceed wear limitations using SE-1722 valve guide remover. All guides must be driven from the combustion chamber side through the top of the head as shown in Figure 107.

NOTE

Support blocks used for removing valve guides should be 9" long x 3-5/8" high x 1-5/8" thick rectangular hardwood blocks. These blocks should not be used for installation of valve guides.

Turn the cylinder head over with the top side up on the wood support blocks positioned in the press. Install the valve guides from the top side of the cylinder head using SE-1943 valve guide installer, Figure 109. The tool is designed to install both valve guides. This can be accomplished by adjusting the installer screw in the body to a depth that is equivalent to the specified height that guides are to be installed above the head. Figure 109 illustrates the method to be used when adjusting the installer for specified guide height. Press the guides in until the installer rests firmly on top of the cylinder head, thus maintaining proper spacing.

NOTE

Guides should be lubricated with a mixture of light engine oil and white lead upon installation. Clean away any excess lubricants.

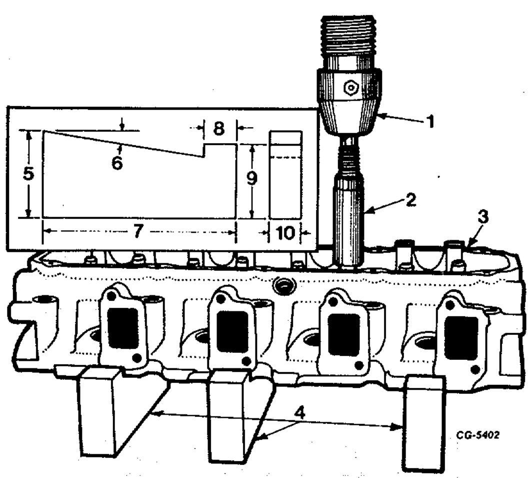

Fig. 108. Installing Valve Guides with SE-1943 Installer and Adaptor

1. Press ram
2. Installer
3. Cylinder head
4. Support Blocks
5. 4 1/8"
6. 9°
7. 9"
8. 11/2
9. 31/2
10. 11/2"

NOTE

Support blocks for installing valve guides can be made locally to the dimensions shown in the insert on Figure 108.

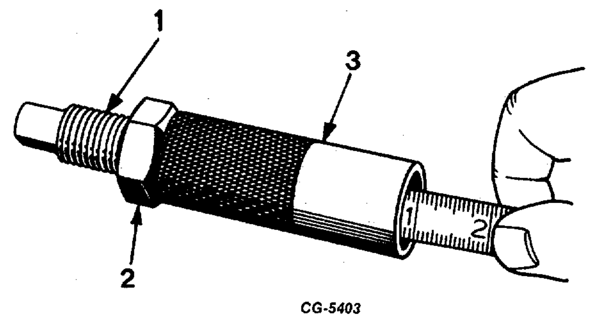

Fig. 109. Adjusting Valve Guide Installer SE-1943 for Proper Height

1. Adjusting screw 3. Body
2. Locknut

After guides are installed, insert SE-2215 reamer in the guides to see that they have not been distorted during installation and to remove any burrs.

Cylinder head core plugs should not be disturbed unless evidence of leakage exists. Remove and install plugs as inspection warrants. The plugs can be removed by drilling a small hole in the center of the plug and with a suitable pry or screwdriver, remove the plug from its bore. To install a new plug, coat the outer edge with a suitable non-hardening sealing compound and with installer SE1945 and driving handle SE-1581-1B, install plug flush with bottom edge of chamfer in cylinder head, Figure 110.

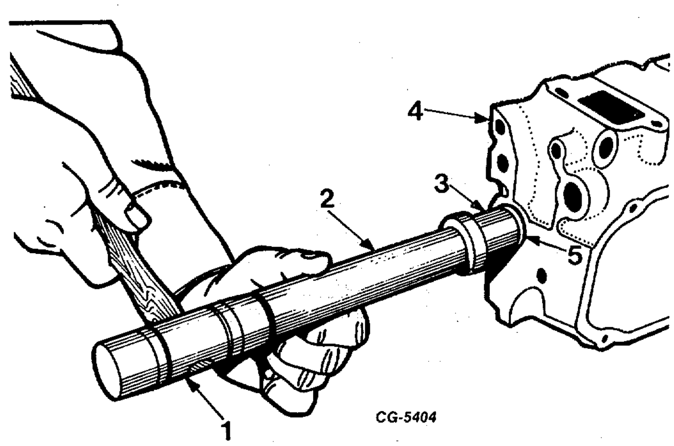

Fig. 110. Installing Cylinder Head Core Plugs Using Installer SE-1945 and Driver Handle SE-1581-1B

1. Hammer
2. Driver handle
3. Installer
4. Cylinder head
5. Core plug

Inspect the exhaust valve seat inserts for looseness, burned or cracked / condition. Use SE-1951 valve insert remover,)Figure 111, to remove defective inserts. Position the remover collet into the insert and turn the coned screw out to expand the collet jaws, thus providing / a firm grip under the insert ring. Use a slide hammer to remove the insert.

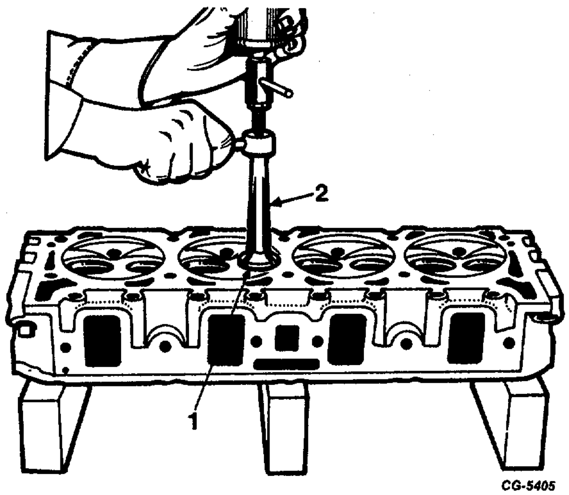

Fig. 111. Pulling Exhaust Valve Insert with SE-1951 Remover

1. Exhaust valve insert
2. Valve insert remover

Prior to seat reconditioning, it is desirable to clean the seats in order to expose any cracks or other conditions likely to promote valve failure. Such inspection is particularly important in engines equipped with hard seat inserts; cracked or loose inserts are not uncommon and are usually caused by improper installation. Good practice requires that the insert counterbore in the cylinder head be machined prior to insert installation, Figure 112. Cutters are available to dress both the bottom and circumferential surfaces, but regardless of the method, the bottom of the counterbore must be square to assure good seating of the insert.

Before installing inserts they should be thoroughly chilled with dry-ice or other means to facilitate their installation in the cylinder head. Use the installer tool, Figure 113, from the counterbore tool set SE-1797. Valve seat inserts supplied for service are standard size, .015" oversize and .030" oversize.

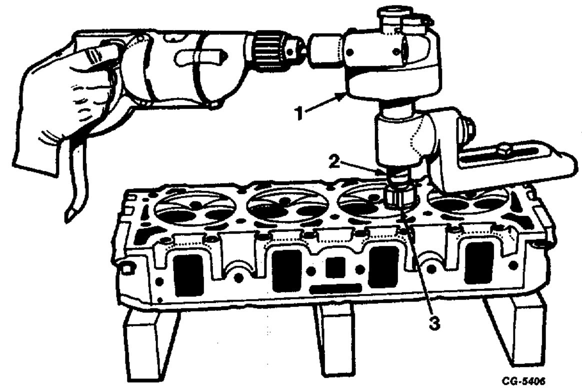

Fig. 112

1. *Cutter drive unit*
2. *Drive shaft*
3. Cutter

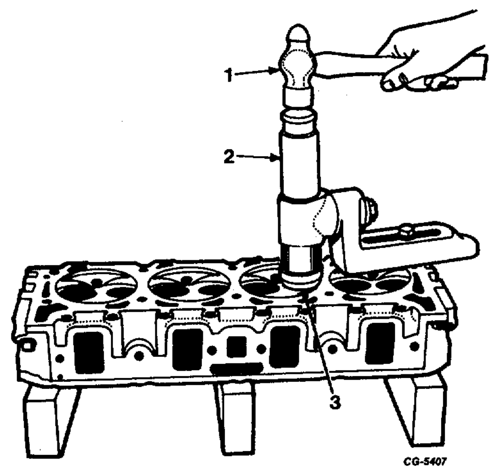

Fig. 113. Using Insert Installer from Counterbore Tool Set SE-1797 for Installing Inserts in Cylinder Head

1. Hammer
2. Driver
3. Seat

The valve seats "A" and "B" in the cylinder head, Figure 114, must also be ground true to the angles and width shown in the specifications section. If the seat is wider than specified, it will be necessary to grind from the top and/or bottom of the seat until the proper seat width is obtained using grinder SE- 1631, Figure 115.

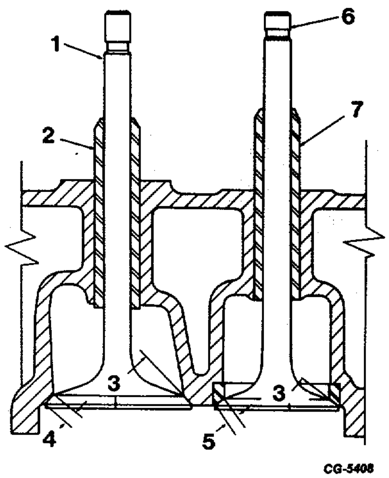

Fig. 114. Sectional View of Valves

1. Intake valve
2. Intake valve guide
3. Angle
4. A
5. B
6. Exhaust valve
7. Exhaust valve guide

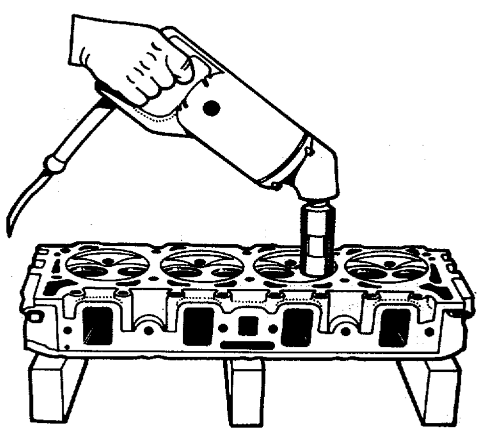

Fig. 115. Grinding Seats Using SE-1631 Grinder

Use a 600 angle grinding stone to re- move stock from the bottom of the seat (raise seat). Use a 300 angle stone to remove stock from the top of the seat (lower seat).

After the seat grinding operation has been performed, it is necessary to check the seat for run-out, Figure 116. Seat run-out should not exceed limits as shown in specifications.

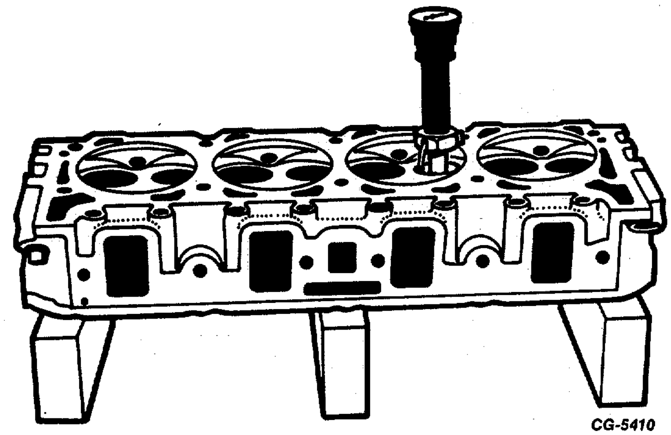

Figure 116. Using Gauge from SE-1631 Tool Grinder Set for Checking Seat Run-Out

It is important to have the finished seat face contact the approximate center of the valve face. Position the valves in the cylinder head. Place a thin coat of Prussian Blue on each valve face and tap the valve lightly to its seat.

NOTE

This is merely for test and proof of results of refacing and reseating operations. A poor grind job cannot be corrected by lapping. Use of lapping compounds is not recommended. A nearly perfect seat often-times is destroyed by attempting to lap the valves to their seats. Inspect each valve for seat dimensions as outlined in specifications and make any necessary corrections. The corrections should always be made on the seat and not the valve face.

NOTE

New valves need not be refaced; however, all valves should be carefully inspected for damaged seat faces or for a run-out condition due to a bent valve stem. Use SE-2614 tool to determine the condition of the valve.

If the ends of the valve stems are grooved or scored, they may be ground to true up; however, remove only a minimum amount of material. Rechamfer as necessary.

Wipe valve faces and valve seats with a cleaning solvent to remove all dirt or foreign material. Coat the valve stems and faces with oil and install the valves in the same seats to which they were checked. On the exhaust valves, install the Roto-Cap assembly, valve spring, valve stem damper, valve stem seal and spring retainer. On the intake valves, install the valve spring seat, valve stem seal, valve spring, damper and spring retainer.

NOTE

Care should be taken to see the valve stem seals are installed correctly. If they are not, their effectiveness in directing oil to the valve guide could be reduced, Figure 117. Notice the valve stem seal is under the spring retainer.

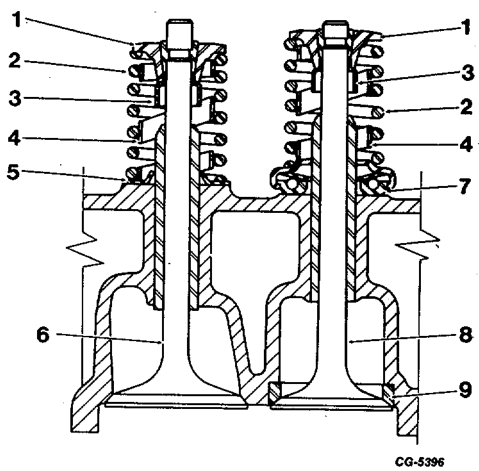

Fig. 117. Cross Section of Intake and Exhaust Valves Installed in Head

1. Retainer
2. Spring
3. Seal
4. Damper
5. Seat
6. Intake valve
7. Roto coil
8. Exhaust valve
9. Insert

Compress the valve springs with a valve spring compressor and install the valve spring retainer locks. Be sure the retainer and locks are correctly seated on all valves.

The cylinder head assembly complete with valves is ready for installation on the cylinder block or crankcase.

Rocker Arm Assembly

Individually mounted rocker arms are retained by flange head retaining bolts and pivot balls, Figure 118. All parts must be retained in the same order as /they were on the engine.

Clean all parts with a good cleaning solvent and use compressed air to clean out the oil passages in the rocker arms.

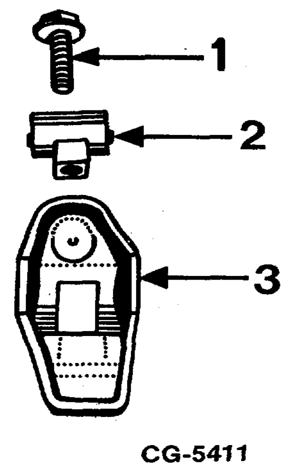

Fig. 118

1. *Retaining bolt*
2. *Pivot ball*
3. *Rocker arm*

Inspect the pivot surface of each rocker arm and pivot ball and replace any parts which are scuffed, pitted or excessively worn. Inspect the valve stem contact surface of each rocker arm and replace any rocker arm which is deeply pitted. Inspect the rocker arm retaining bolts for excessive wear or looseness in the cylinder head: replace if condition exists.

Push Rods

The push rods are hollow and serve as oil galleries to lubricate each individual rocker arm assembly. Prior to installation the push rods should be cleaned thoroughly and inspected for wear and deposits which may restrict the flow of oil to the rocker arm assemblies.

Check all valve lifter push rods for straightness by rolling on a flat surface,

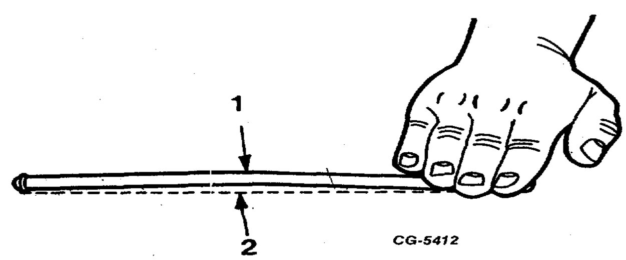

Figure. 119

Fig. 119. Checking Push Rod for Straightness

1. Bent valve lifter rod
2. Flat surface

Hydraulic Valve Lifters (Tappets)

The hydraulic valve lifter or tappet consists of a body (cylinder), plunger, plunger spring and check valve assembly and is removed from the engine as an assembly. The lifters are removed after removing the valve cover, rocker arms and push rods.

NOTE

If a tappet cannot be removed due to carbon buildup, use a carburetor solvent in the tappet bore. However, if any excessive amount of solvent is used, it will be necessary to change the oil.

Optional sources of hydraulic valve lifters have been established. When disassembling the lifters, do not mix the components of any lifter. Figure 120, illustrates the difference in construction between types "A" and "B." Generally, the service instructions are the same for all types of hydraulic lifters. The push rods are common for all types of lifters.

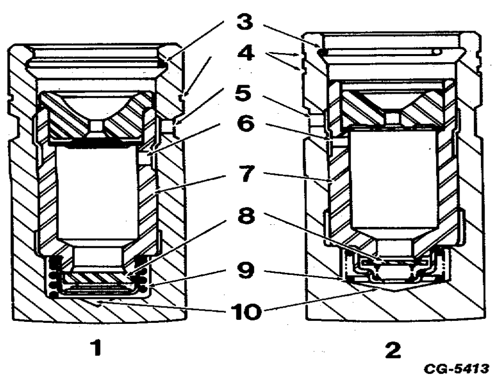

Fig. 120. Sectional View of Hydraulic Tappets Showing Types "A" and "B"

1. Type A
2. Type B
3. Snap ring
4. Identification rules
5. Tappet oil hole
6. Plunger oil hole
7. Plunger
8. Check valve
9. Spring
10. Oil Chamber

I. Operation of Valve Lifter

Oil from the engine lubricating system is fed to a supply chamber in the hydraulic lifter plunger from which it can flow directly through the plunger, past the check valve and into the compression space between the bottom of the body and the plunger. When the engine is started, oil pressure is built up in the system which fills the supply chamber. With the lifter on the base circle of the cam and the engine valve seated, the light plunger spring moves the plunger outwardly to remove all lash from the valve gear. As the plunger moves outward increasing the volume in the compression chamber, the check valve moves off its seat and the chamber is supplied with oil. As the camshaft rotates and lifts the body upward, a pressure is immediately built up in the compression chamber, forcing the valve onto its seat. Further rotation of the camshaft lifting the valve gear against increasing valve spring pressure increases the oil pressure in the compression chamber, thus acting as a solid member of the valve operating mechanism. As long as the engine valve is off its seat, the load of the mechanism is carried by the column of oil. During initial running of the engine, there might be some air remaining in the compression chamber which, under pressure, tends to leak through the clearance between the plunger and cylinder, thus decreasing compression space volume. However, when the lifter is again on the base circle of the cam, the plunger moves outward, drawing in more oil so that after a number of cycles, the air is completely eliminated and a solid column of oil is maintained in the compression space. During this period when some air is present in the compression space, the valve gear may be somewhat noisy, since it has the same effect as excessive lash with aerated oil. However, once the unit is completely cleared of air, it then becomes a true hydraulic system.

The compensation required to take care of variations in length from the cam to the valve seat is accomplished by the original fit of the plunger in the cylinder bore. These parts are selectively fitted to give a predetermined slight leakage of oil (called leakdown) under load. The purpose of this predetermined leakage is to permit the valve to seat irrespective of the change in length between the cam and valve seat. If the valve gear is expanding, thus reducing the distance between the cam and valve seat, the load imposed by the valve spring on the lifter causes the above mentioned slight leakage between the plunger and cylinder, reducing the clearance volume and, therefore, the overall lifter length. When the valve gear length increases, as caused by lower engine temperatures, the plunger spring keeps all the valve gear parts in contact, increasing the clearance volume under the plunger. At the same time oil is immediately fed past ? the check valve, thus maintaining correct length under all conditions. This keeps the valve gear operating at no-lash. With this predetermined leakage, is impossible for the no-lash lifter to hold the engine valve open when it should be closed

When the lifter body is on the base circle of the cam and the engine valve is closed, the only force tending to hold the valve open is from the light plunger spring, which obviously is much lower than the valve spring load. The only additional force tending to push the plunger upward results from pressure of the lubricating oil but its effect is negligible since it is controlled and

During shutdown periods of the engine, one or more valves are always in the lifted position thus imposing the full valve spring load on the plunger. This causes oil to leak out of the compression chamber through the clearance space. /When the engine is again started, the particular valve that was in the open position returns to its seat and the plunger is immediately forced upward by its spring. Oil from the supply chamber is again fed into the clearance volume under the plunger so that in a very few cycles, the valve gear is operating on a solid hydraulic oil column.

II. When to Service

A. Loud clacking, light clicking or intermittent noise is attributed to a lifter.

Dirt, chips, varnish, etc., generally cause only a few units to become inoperative at any one time. Aeration caused by high or low oil level air leaks into the oil pump suction line, etc., result in all lifters becoming noisy. The cause of aeration must be corrected before the lifters will again operate quietly. Small metal chips lodging between the plunger and the cylinder tend to prevent free movement. Since loads during the lift portion of the cycle are relatively high, the plunger is forced ? downward and the very light plunger spring has insufficient force to move the plunger back to normal operating position. After a few lift cycles with metal chips between the plunger and cylinder, the plunger finally reaches a position (usually plunger bottomed) where there' is excessive lash in the valve train with resulting noisy operation.

The type of varnish, resulting from a mixture of permanent antifreeze and oil, is very "tacky" and, particularly when cold, will prevent free movement of the plunger. The resulting action is the same as that caused by a chip in the clearance space. The entire engine must be cleaned and the cause of the leakage corrected.

Varnish of the type resulting from fuels and lubricants, unless excessive amounts are created by poor crankcase ventilation or extremely bad lubricants, seldom causes sticking in the lifter. However, if such deposits do form and cause trouble, it is then necessary to correct crankcase ventilation, lubricant or fuel.

1. Loud clacking noise is the result of excessive lash and indicates that:

   a. The plunger is stuck below its normal operating position, probably plunger bottomed and in this case, the lifter must be disassembled and cleaned of dirt and varnish.

   b. The check valve may not be sealing due to dirt or a damaged seat, which also necessitates cleaning and inspection.

   c. Oil may contain sufficient air, which is compressible, to permit collapse or partial plunger movement beyond its normal operating position. It is necessary to locate and correct the cause of aeration. Just servicing the lifter will not help.

2. Light clicking type noise indicates that the plunger is operating only slightly below its normal position as the result of:

   a. Slight leakage by the check valve or plunger. If the noise is persistent, the lifter must be removed, cleaned and checked.

b. Small amount of air in oil which can only be helped by eliminating the aeration.

3. Intermittent noise is usually the result of:

a. Metal chips or dirt. Occasionally such material becomes lodged between the check valve and seat. Cleaning will correct this condition.

b. Slight plunger sticking caused by dirt or varnish-like substances, which necessitates cleaning and eliminating the source of varnish.

B. When engine is overhauled.

Lifters will need to be removed and normal varnish deposits cleaned off whenever a change has been made that will increase the distance from the cam to the valve tip. This change may cause the plunger to be forced into a varnish deposit accumulated above the original travel of the plunger. Since the plunger previously had not been required to operate in this position, the lifter must be removed and cleaned of all varnish deposits so the plunger can move freely.

The following will cause increased valve train length:

1. Grinding valve tips.

2. Valve train parts not put back in their respective locations.

3. Installing new parts.

Even when doing a valve grind job, it may not be necessary to disturb the lifters. However, it may be found occasionally that worn valve tips will need to be ground to give a smooth surface. In this case the length from cam to valve tip would be increased, which necessitates cleaning the lifter as mentioned above.

<u>As a general rule, hydraulic lifters should be left alone when they are functioning satisfactorily and the valve train or gear remains reasonably quiet</u>. The hydraulic lifter is a fairly simple positive action device which will continue to deliver trouble-free service under all normal engine operating conditions. The major cause of hydraulic lifter problems, where any exist are usually due to grit, dirt or metal chips carried to the lifter with the engine oil.

To minimize lifter contamination, a special box or container should be used to store the lifters when they are first removed from the engine or after they have been cleaned and tested. Keep the lifters in this container until ready for installation in the engine. The container should be numbered to assure return of the lifters to their original location in the engine.

NOTE

Even when the lifters are working correctly, there are other engine noises which are often "blamed" on lifters but can usually be identified. These may be caused by: valve stem guide clearance, worn timing gears, piston slap, lifter body clearance, worn lifter face or cams, loose main or rod bearings, worn rocker arms, ignition knock, worn valve tips or tight rocker arms.

III. Lifter Disassembly

Before disassembling lifters it may be necessary to remove a portion of the oil from the lifter body. This can be accomplished by turning the tappet up-side down and letting it drain for a few minutes. Then with the end of a push rod, compress the plunger and re-move the snap ring located on the in- side top of the assembly.

Caution should be used in order that the snap ring does not "pop out" and become lost. Removal of this snap ring should allow the separate socket to be readily removed. By shaking the assembly gently, the plunger should also come out unless it is held in place by carbon and varnish deposits. If this is the case, some force will be required to remove the plunger from the body. It may be necessary to hold the assembly upside down and bump the open end gently against some resilient surface (masonite, etc.). Care should be taken so the plunger or body will not be damaged.

After removing the plunger, the check valve assembly may be found to be loose on the plunger. Care should be taken so the small, flat check valve and valve retainer spring are not lost. If the check valve assembly stays attached to the plunger, it would be best to leave it in this position.

IV. Servicing the Lifter

The following is the service procedure to be followed in servicing hydraulic lifters:

A. Immerse the unit in carburetor or other suitable solvent to remove excess engine oil and soften varnish deposits.

B. To avoid mixing plungers and cylinders, take one lifter apart at a time and complete all-servicing before working on another. However, if tray SE-1892, Figure 121, is available for keeping plungers and cylinders together, all lifters may then be disassembled at the same time.

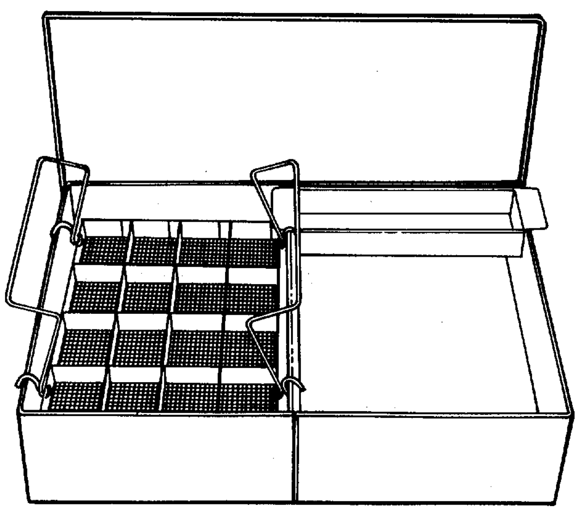

Fig. 121. Hydraulic Lifter Tray SE-1892

C. Wash all parts in solvent and clean all varnish from the plunger and in- side diameter of the cylinder.

D. Inspect the plunger and cylinder walls for scratches. Look for nicks on the valve seat and examine the condition of the lifter face. Check for plugged oil holes.

E. Try the plunger for free fit in the cylinder.

F. Reassemble all parts in proper sequence Figure 120.

NOTE

The valve lifter body is to be filled 1/3 full with clean kerosene before assembly of component parts. The parts are to be prelubricated with clean kerosene before assembly. Use of kerosene in place of engine oils provides a faster leakdown and rapid expelling of trapped air in the lifter assembly, thus eliminating the possibility of damage to the valve train when installing the push rods and rocker arm shaft assembly. Engine oil will dilute the kerosene in the lifters as soon as the engine is operated for a short period.

G. After the unit has been washed thoroughly, determine whether the leakage past the plunger and cylinder is correct and if the check valve is functioning correctly. This may be done using one of the two following methods:

l. The SE-1893 leakdown tester, Figure 122, may be used for checking the leakdown rate if available. Instructions which accompany the tester should be followed.

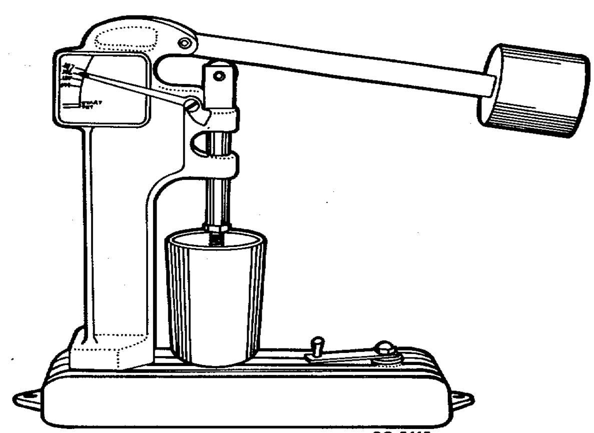

Fig. 122. SE-1893 Tester Used for Checking Leakdown Rate of Tappet

2. If the leakdown tester is not avail able, a finger check method can be used. In order to check a unit in this manner, make sure there is no lubricating oil on the cylinder or plunger such as immediately after washing in solvent. With the cylinder held in one hand, start the

plunger into the cylinder (do not install the plunger spring) with the other. Depress the plunger with your finger and release quickly. The plunger is now operating against air which is sealed in by the check valve and by the close fit of the cylinder to the plunger. It should yield slightly to the pressure of the finger on the plunger, but the plunger should kick-back upon release of the pressure. If no kick-back of the plunger occurs, the unit may or may not be defective. The lack of kick-back is due to one of three conditions.

First, air is escaping past the check valve because of presence of dirt which prevents proper seating of the valve. Second, air is escaping past the check valve because of a damaged seat. Third, air is escaping because the clearance between the plunger and cylinder wall is too great, which indicates excessive leakdown rate.

Rewash the unit to eliminate any dirt which might still be on the check valve seat and repeat the test. If there is still no kickback, the check valve is damaged and the entire lifter, consisting of cylinder body and plunger, may need to be discarded.

NOTE

In the event check valve leakage is encountered due to wear on the surface of the check valve, the valve can be turned over to the unworn side. This procedure will extend the useful service life of the lifter assembly, provided all other 'parts of the lifter are in good condition.

In the above test procedure it is important that the pressure on the plunger be released immediately after it is depressed. If the plunger is held down too long, all the air trapped under the plunger will leak out and the test would be inaccurate.

The unit is suitable for reinstallation in the engine if the test is satisfactory.

Crankshaft

Wash and clean the crankshaft with cleaning solvent or steam.

Inspect the crankshaft for cracks, scored, grooved or worn main bearing and connecting rod journals. If journals show wear or out-of-round in excess of .002", the shaft should be reground and undersize bearings installed or the crankshaft replaced. Use a micrometer for checking.

Examine the crankshaft timing gear teeth and replace the gears if the teeth are worn or damaged.

NOTE

Replace the timing gear on the camshaft when replacing the crankshaft gear. These gears are serviced in matched sets.

Camshaft

Wash the camshaft in cleaning solvent and remove all sludge or carbon deposits with a soft brush.

Inspect the camshaft journals for signs of wear or out-of-round and replace if wear warrants. See ENGINE OVERHAUL - Cylinder Block.

Inspect the camshaft lobes. If worn, chipped or scored, replace the camshaft.

Inspect the distributor drive gear and camshaft gear and replace if wear warrants or the gear teeth are nicked or otherwise damaged.

Inspect the fuel pump cam. If worn, chipped or scored, replace the cam.

NOTE

If the distributor drive gear, fuel pump cam and camshaft gear were removed without complete engine disassembly, they may be reinstalled as follows:

1. Install distributor drive gear against thrust flange on camshaft using SE-1900-14 sleeve with SE- 1900-16 adapter, Figure 123. A thrust bearing is also used under the forcing screw nut to reduce friction.

IMPORTANT: Use extreme caution so as not to chip the distributor gear teeth.

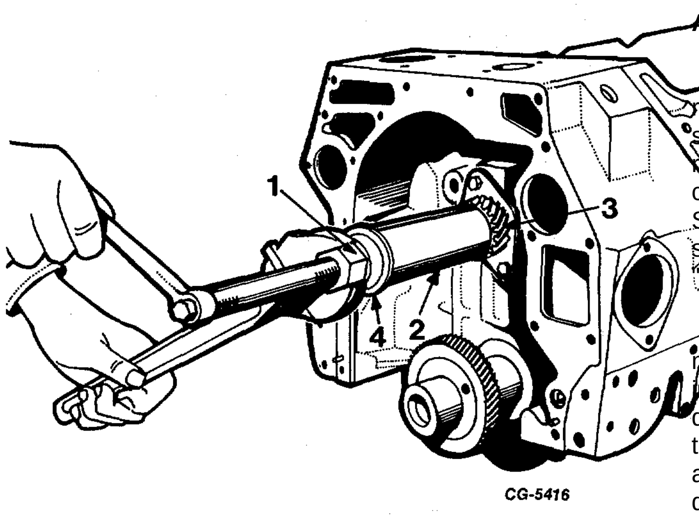

Fig. 123. Installing Distributor Drive Gear Using SE-1900 Tool Set with Thrust Bearing

1. Nut 3. Distributor drive gear
2. Sleeve 4. Thrust bearing

2. Install fuel pump cam against distributor drive gear on camshaft using SE-1900-14 sleeve with SE- 1900-16 adapter and thrust bearing in a manner similar to Step 1.

3. Install camshaft gear against fuel cam on camshaft using SE-1900-14 sleeve with SE-1900-16 adapter and thrust bearing in a manner similar to step 1.

4. Install camshaft gear allen screw and torque to specified torque. See "Torque Chart."

Crankshaft Bearings

The bearing inserts used in this engine are selective fit and require no line reaming upon installation. The bearings are available for service in standard and undersizes for use on journals that have been reground.

If inspection reveals badly worn or scored bearings, replace the bearings. The installation of new bearings must be closely checked to maintain the pro/per clearance between the journal and the bearing surface. A convenient and accurate method for checking the clearance is with the use of Plastigage.

A. General Fitting Procedures

When wear reduces the bearing-to crankshaft running clearance, undersize precision-type bearing shells should be installed. Premature bearing failure will result from attempts to reduce journal-to-bearing running clearances by reworking bearing caps, bearings or both. Such reworking will alter the engineered fit of the bearing shells in their bores and destroy the specifically desired "crush."

When installing precision-type connecting rod or main bearings, it is important the bearing shells fit tightly in the bore. The bearing manufacturer makes the diameter at right angles to the parting line slightly larger than the actual diameter of the bore into which they are assembled to accomplish this. When the assembly is drawn up tight, the bearing is compressed assuring a positive contact between the bearing back and the bore. This increased diameter is referred to as bearing "crush," Figure 124.

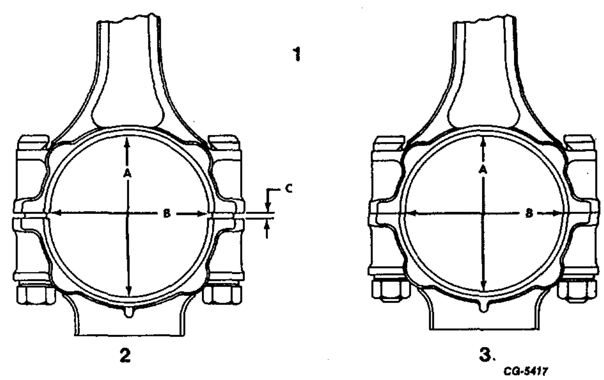

Fig. 124. Illustrating Bearing Crush

1. Difference between diameters (A) and (B) is bearing crush (C)
2. Diameter (A) at right angles to parting lines greater than diameter (B).
3. With bearing cap drawn up tight diameters (A) and (B) equal.

To obtain proper bearing assembly with the correct "crunch," care must be taken when tightening the clamping bolts and nuts to make sure they are drawn down alternately and evenly using a tension wrench and tightened as specified.

Rod caps or blocks must not be filed, lapped or reworked in any other manner in order to reduce clearance. While such practice may make a tighter fit at top and bottom, it will result in an out-of round bore and bearing shell distortion.

Main and connecting rod bearings are designed with the "spread" (width across the open ends) slightly larger than the diameter of the crankcase bore or connecting rod bore into which they are assembled. For example, the width across the rod bearing not in place is approximately .025" more than when the bearing is in position. This condition is designed into the bearing to cause it to spread outward at the parting line when "crush" load is applied by tightening the nuts and bolts. Some of this "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition.

This condition causes the bearing to fit snugly in the respective bore. The bearing must be "snapped" or lightly forced into its seat, Figure 125

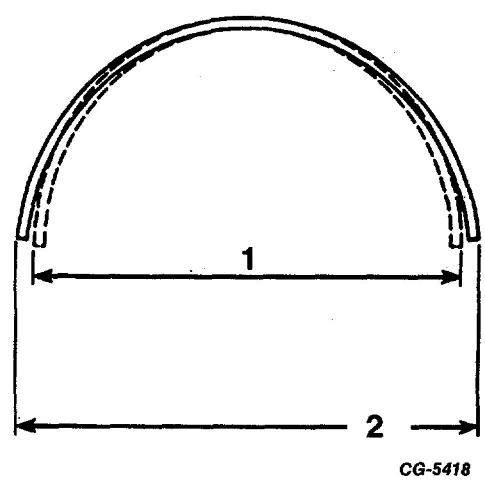

Fig 125. Illustrating Bearing Spread

1. O.D. of bearing when installed is the same as the diameter of the crankshaft or conn. rod bore.
2. Spread of bearing before installation

BEARING SPREAD DIMENSIONS

Bearing O.D. (Installed)	Specified Spread	Spread of Bearing "A" Fig. 122
Connecting Rod Bearings		
2.6245-2.6250	.030-.0305	2.6545-2.6555
Main Bearings No's 1, 2, 4 & 5		
3.3160-3.3152	.0200-.0208	3.336
No. 3 (Thrust) 3.3160-3.3152	.0020-.0168	3.318-3.332

B. Fitting Main Bearings

To obtain an accurate reading using the Plastigage method of checking, all bearing caps must be in place and torqued to specifications.

1. Remove one bearing cap and insert. Remaining caps are left tight while checking the fit of this bearing.

2. Wipe the oil from all contact surfaces such as crankshaft journal, bearing insert, bearing caps, etc.

3. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately 1/4" off center. Install bearing cap and tighten cap bolt to re- commended torque.

NOTE

Do not turn crankshaft while making check with Plastigage.

4. Remove bearing cap and insert.

5.. Do not disturb Plastigage. Using the Plastigage envelope, measure the widest point of the Plastigage, Figure 126. This reading indicates the bearing clearance in thousandths of an inch.

6. If the bearing clearance is not within specifications, the crank- shaft must be reground and under- side bearings installed.

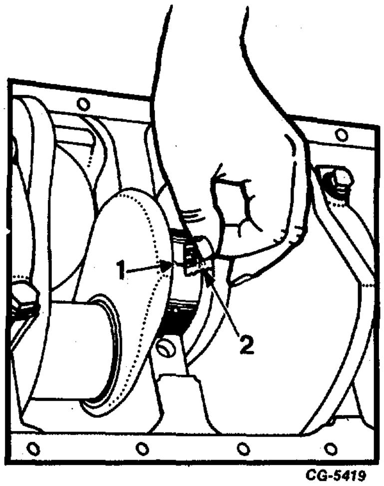

Fig. 126. Checking Main Bearing Clearance

1. Plastigage flattened 2. Gauge

7. The third crankshaft bearing controls the crankshaft thrust and provides initial location of the crankshaft in relation to the crankcase. Use dial indicator to check end play, Figure 127.

C. Fitting Connecting Rod Bearings

1. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.

2. Place a piece of Plastigage on the bearing surface the full width of the bearing about ¼" off center.

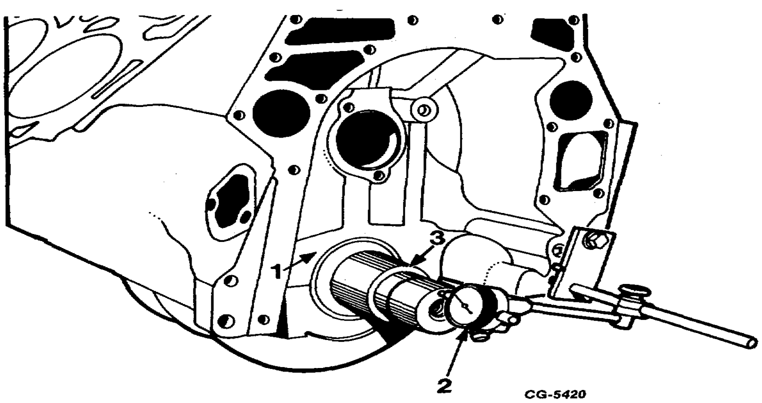

Fig. 127. Checking Crankshaft End Play

1. Crankcase 3. Crankshaft
2. Dial indicator

3. Install cap and tighten to recommended torque.

NOTE

Do not turn crankshaft while Plastigage is in place.

4. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage, Figure 128. This reading indicates the bearing clearance in thousandths of an inch.

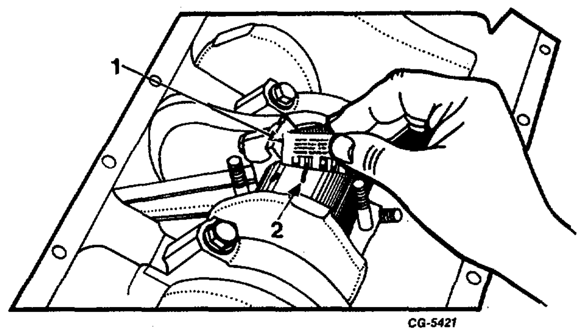

Fig. 128. Checking Connecting Rod Bearing Clearance

1. Gauge 2. Plastigage flattened

5. If the bearing clearance is not within specifications, the crankshaft must be reground and under- size bearings installed.

6. Check the connecting rod end clearance using a feeler gauge as shown in Figure 129. Excessive clearance may require replacement of rods or shaft. The check should be made to make certain the specified running clearance exists. Lack of clearance could indicate a damaged rod or a rod bearing out of position.

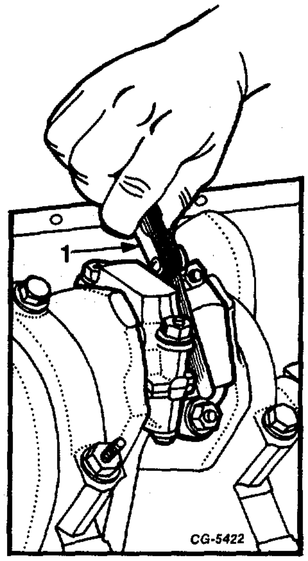

Fig. 129. Checking Connecting Rod End Clearance

1. Feeler gauge

Oil Pump Assembly

The oil pump, Figure 130 consists of two gears and a pressure relief valve enclosed in the body. The pump is driven from the distributor drive gear which, in turn, is driven by a helical gear on the camshaft.

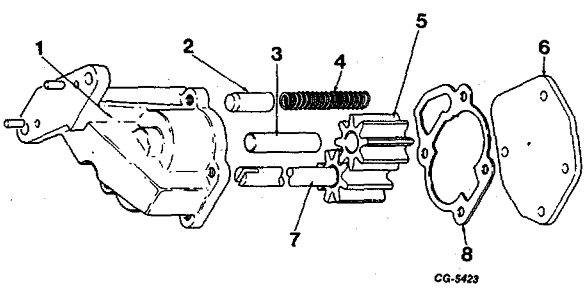

Fig. 130. Exploded View of Oil Pump

1. Body	5. Idler gear
2. Valve	6. Cover
3. Idler shaft	7. Drive shaft and gear
4. Spring	8. Gasket

The body is equipped with a regulator valve that limits oil pressure to approximately 50 psi.

The pump intake is through a screen assembly attached to the pump body. A mesh screen filters out particles of dirt which may be present.

A thorough cleaning and inspection of the oil pump should be made whenever the oil pan is removed from the engine. The recommended inspection and repair procedures are as follows:

1. Wash all pump parts and screen assembly in cleaning solvent.

2. With pump cover removed and gears and shaft in place, exert pressure against the gears with the thumb so as to push the gears away from the outlet side of the pump.

3. While holding the gears in this manner, measure the clearance between the outside diameter of the gear and the bore of the housing, Figure 131. Clearance should be within the limits given in the specifications.

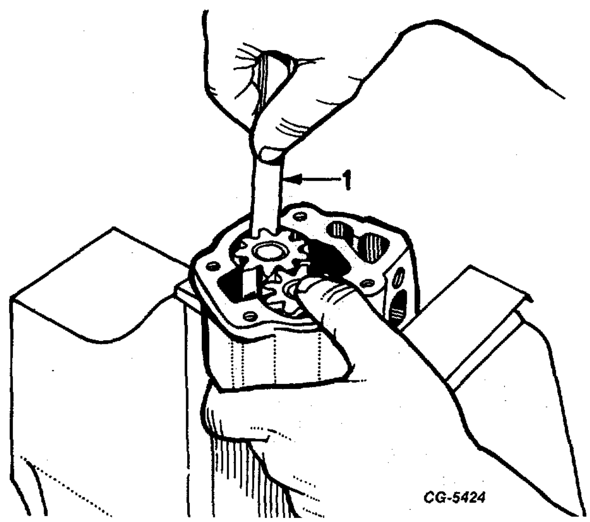

Fig. 131. Measure Pump Gear-to-Body Clearance
1. Gauge

4. If clearance is less than specifications, obtain new parts.

5. Check the pump shaft clearance in the bore. To correct for wear beyond limits given in specifications, replace pump assembly.

6. Check backlash between pump body gears. If this exceeds the figure shown in the specifications, replace gears.

7. Establish body gear end clearance.

NOTE
The oil pump cover gasket controls the clearance (end play) between the pump body gears and the pump cover. Add or remove gaskets to obtain desired clearance. See "Specifications."

8. When installing pump gears and shaft, these parts should be oiled liberally with engine oil for initial lubrication.

9. Before installing the relief valve in the pump body, insure valve is free of burrs and the valve bore is free of varnish so the valve operates smoothly in its bore.

NOTE
If it becomes necessary to remove burrs from the valve, insure valve edges are not rounded.

10. Check relief valve spring for proper tension. See SPECIFICATIONS.

11. When assembling the screen assembly to the pump body make sure the gasket is in place. Then tighten bolts securely, Figure 132.

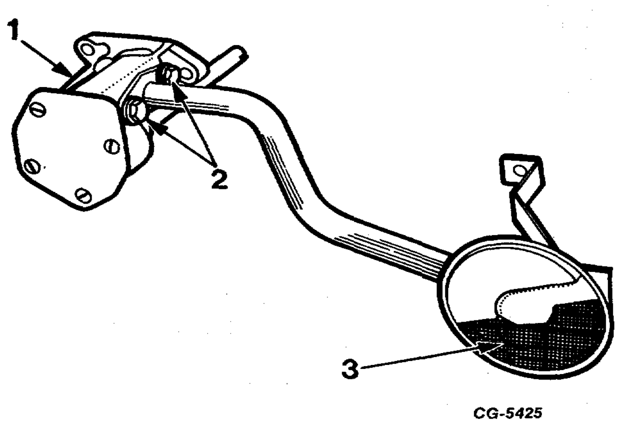

Fig. 132. Oil Pump and Screen Assembly

1. Oil pump 2. Bolts 3. Screen assembly

1. **Oil Cooler and Filter Base**

Figure 133 illustrates an exploded view of the oil cooler and filter base. Upon engine overhaul, the oil cooler and filter base, if so equipped, should be disassembled and the cooler element cleaned in a commercial radiator type solvent. Then flush the element with clean water until rinse water runs clear.

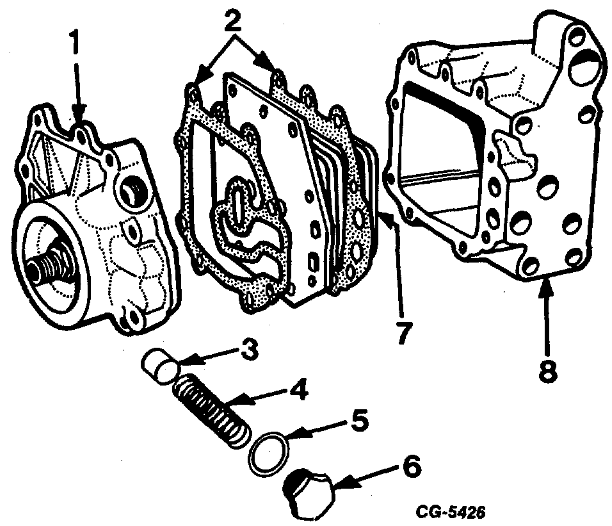

Fig. 133. Exploded View of Oil Cooler and Filter Base

1. Filter base
2. Gaskets
3. Valve
4. Spring
5. O-ring
6. Plug
7. Cooler element
8. Cooler body

Check the relief valve spring for proper tension, see SPECIFICATIONS. Also, check the valve for burrs or scratches. Small burrs or scratches may be removed with crocus cloth.

When reassembling the oil cooler, use new gaskets and tighten the bolts securely.

NOTE
On engines not equipped with the oil cooler, the filter base should be cleaned and passages checked clear of restrictions.

Oil Cooler Pressure Test

Where conditions indicate the need for testing the engine oil cooler core assembly for leaks, the core inlet and outlet openings must be closed off and the assembly pressurized. Instructions for pressure testing the oil cooler core assembly are as follows:

1. Attach test plate and gasket to core assembly mounting face flange (Figure 134). The test plate must be made locally according to the dimensions in the insert in Figure 134. Obtain engine oil cooler housing gasket from service parts stock.

NOTE

The oil inlet opening in the cooler core assembly is located in one of two locations. Therefore, the test plate must include a tapped hole for either location to permit applying air pressure to the core. Install test plate pipe plug at oil inlet hole not in use.

2. Install pressure gauge, air control valve and quick connect air coupler to test plate (Figure 134). Apply 80 to 100 lbs. of air pressure to the core assembly.

3. Immerse oil cooler core assembly in a container of water. If a leak is observed, replace core assembly.

CAUTION

Use adequate safety precautions when performing pressure test.

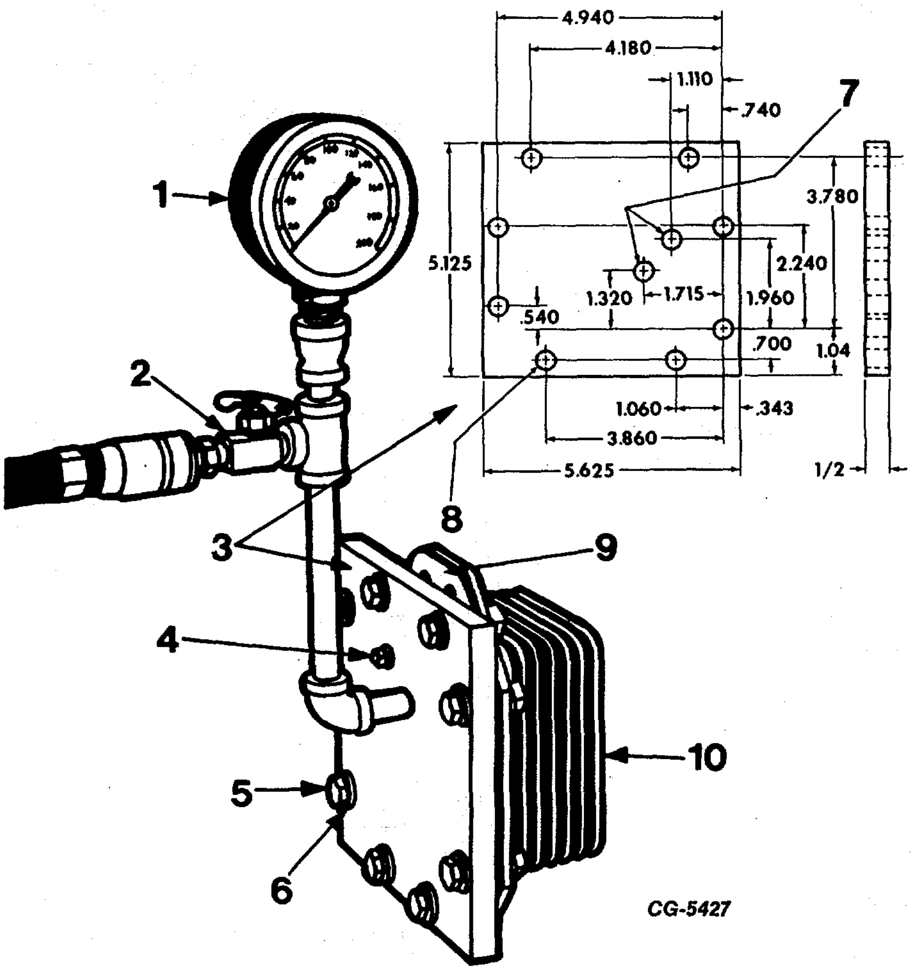

Fig. 134. Pressure Testing Engine Oil Cooler Core Assembly

1. Pressure gauge
2. Air control valve
3. Test plate (make locally)
4. Pipe plug 1/8 NPT
5. Hex head bolts 5/16 NC x 1/2 - (8 required)
6. Flat washers - (16 required)
7. Drill & tap 1/8 PT THD, this side two holes
8. .375 Dia. - (8 holes)
9. Gasket, oil cooler housing IH No. 446647-C1
10. Core assembly, oil cooler

Oil Pan

The pan should be thoroughly cleaned in cleaning solvent to remove any foreign material from around the baffle plate which is spot welded in place. Inspect oil pan for cracks or deformation and straighten or weld.

Remove all gasket material from the oil pan flange.

Check the oil pan drain plug boss for fit and thread wear. If the plug is loose or the threads are damaged, repair the threads or replace the oil pan.

Manifolds

The intake manifold is cast in one piece and supplies both cylinder banks. It should be cleaned and examined for cracks or leaks. Warpage of the intake manifold will require replacement as any attempt to resurface the intake manifold will create misalignment of the ports to the cylinder heads. The intake manifold also contains the direction of distributor rotation, firing order and the cylinder numbers Figure 135.

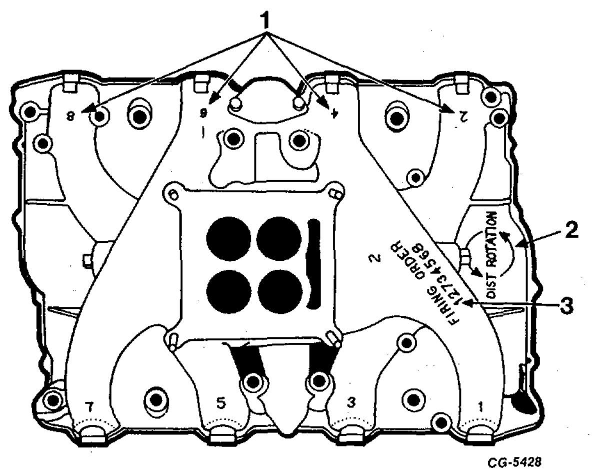

Fig. 135 Illustration of Information Contained on Intake Manifold

1. **Cylinder number**
2. **Direction of distributor rotation**
3. **Firing order**

Each bank has a separate exhaust manifold which should both be cleaned /and examined for cracks or leaks.

Flywheel and Ring Gear

Clean the flywheel and ring gear with a cleaning solvent, removing all traces of oil and grease. Inspect the flywheel ring gear. If any teeth are damaged or if the ring gear is loose on the flywheel, the ring gear must be replaced. Check the flywheel mounting bolt holes for wear; also check mounting face of flywheel for indication of looseness.

To replace the flywheel ring gear, heat the gear with a torch and remove it from the flywheel with a hammer and drift Heat the new ring gear evenly all the way around with a torch. While the ring gear is hot, install the gear on the fly-wheel and allow it to cool.

Water Pump and Coolant Flow

Coolant enters the engine at the lower left hand corner of the crankcase. The coolant then flows into the water pump where it is mixed with a quantity of bypassed hot coolant. The water pump discharges into both the right and left of the crankcase. The circulation of the coolant is from front to rear of the crankcase, then flows up into the cylinder head via three holes. The flow continues forward through the cylinder head. In flowing through the cylinder head the coolant is forced through a zig-zag path to insure maximum scrubbing of critical areas of the cylinder head such as exhaust valve seats and spark plugs.

The coolant exits the cylinder heads into a common cavity at the front of the crankcase. Temperature sending unit is located in this cavity. From this cavity the coolant flows into the chassis radiator or back into the water pump via a variable orifice bypass.

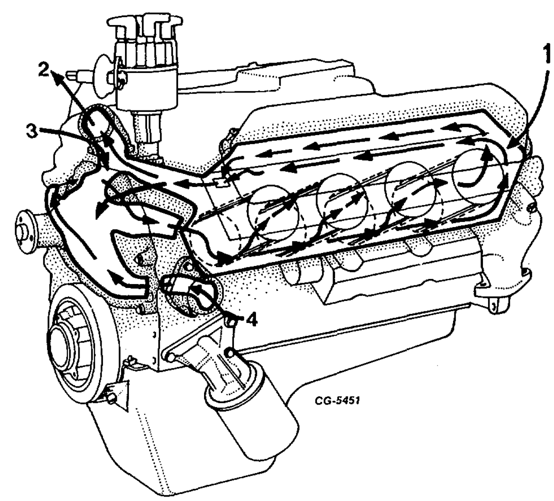

Fig. 136 Coolant Flow Cut-Away

1. **Full pressure flow to rear of crankcase-up-and to front of lead.**

2. Outlet 3. Bypass 4. Inlet

The amount of coolant directed to the radiator is modulated by the thermostat that opens the outlet to the radiator and reduces the orifice size of the coolant bypass. Figure 136.

Secondary cooling systems include the engine oil cooler, chassis heater and air compressor.

The oil cooler is mounted at the lower left corner of the crankcase. The cool-and flows from the left bank crankcase water jacket through the cooler and into crankcase inlet area. The amount of coolant flowing through the cooler is metered by the diameter of the outlet hole on the oil cooler housing.

Coolant for the air compressor is tapped off the front of the cylinder head, left bank, flows through the air compressor and back into the crankcase coolant inlet casting. Coolant for the chassis heater is picked up off the rear of the right cylinder head and returned to the suction side of the coolant pump. The centrifugal water pump is serviced only as a complete assembly, Figure 137.

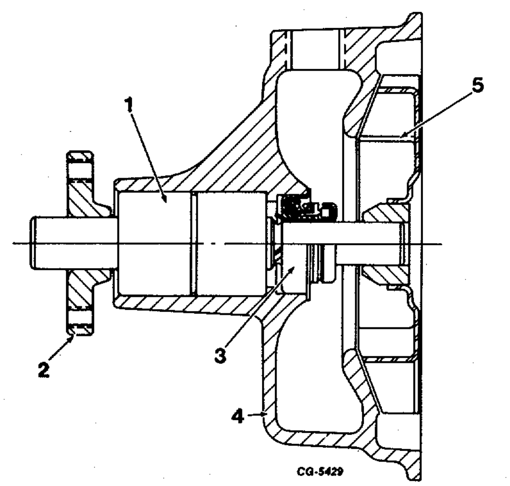

Fig. 137 Section View of Water Pump Assembly

1. **Bearing assembly**
2. **Pulley hub**
3. **Seal**
4. **Housing**
5. **Impeller**

Engine Assembly

1. With the cylinder block attached to the engine repair stand, turn the block on the stand so the bottom faces upward. Make sure the drain plugs are installed in the cylinder block if they have been removed.

2. Coat the camshaft lobes, bearing surfaces, gears and bores with engine oil.

3. Install camshaft into bore with fuel pump cam, distributor drive gear, camshaft gear and thrust flange installed on shaft.

   NOTE: If gears and fuel pump cam have been removed, use SE-1880 installer and SE-1880-2 adapter to install camshaft, Figure 138. This will help prevent nicking or other damage to the camshaft bearings. Install distributor drive gear, fuel pump cam and camshaft gear as outlined under Camshaft Engine Overhaul.

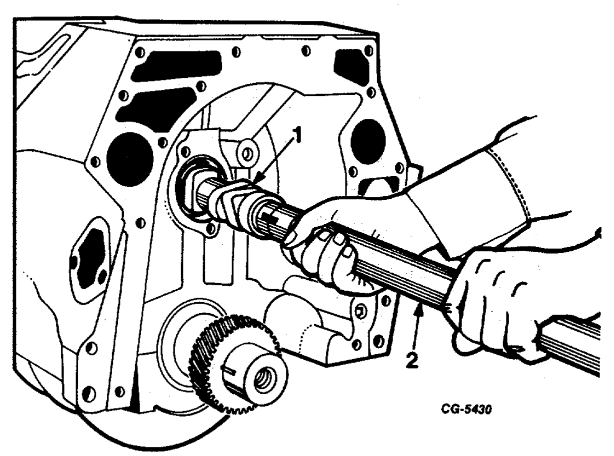

Fig. 138 Use of SE-1880 Camshaft Installer and SE-1880-2 Adapter

1. **Camshaft**
2. **Installer**

4. Install two bolts and lockwashers in camshaft thrust flange, working through the holes in the camshaft gear. See "Torque Chart" for proper torque.

5. With the use of a dial indicator, check the camshaft end play, Figure 139. See "Specifications." If the end play exceeds the limits, replace the camshaft thrust flange.

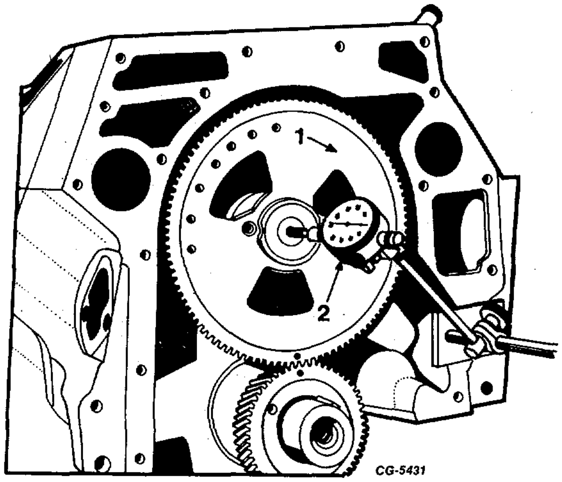

Fig. 139 Checking Camshaft End Play

1. Camshaft gear **2. Dial indicator**

6. Wipe the backs of the cylinder block half of the bearings, making sure the dirt is removed. Lubricate the block half of the bearings on both sides with a light film of engine oil. Place the bearing shell halves in position in the bore of the cylinder block, making sure the bearing shells are fully seated, the oil holes in the bearing shells line up with the oil holes in the cylinder block and the locking tangs on the bearings fit into the recesses. Follow the same procedure and place the bearing shell halves in the bearing caps. Place a film of engine oil on both sides of the shell surfaces and

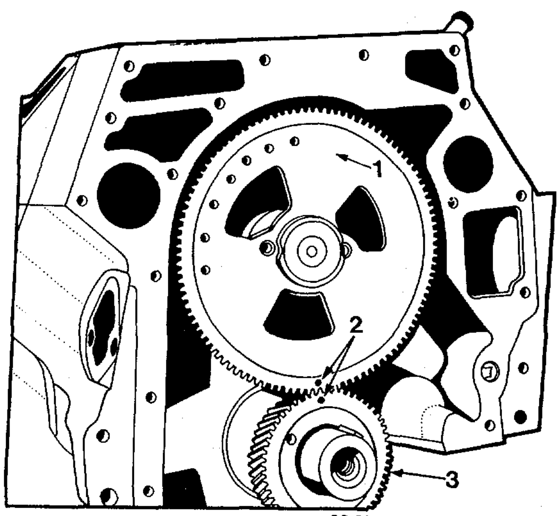

Fig. 140 Aligning Timing Marks on Camshaft and Crankshaft Gears.

1. **Camshaft gear**
2. **Timing marks**
3. **Crankshaft gear**

install the crankshaft, aligning itself in the bearing while, at the same time, aligning the timing marks of both the camshaft and crankshaft gears, Figure 140

NOTE: If crankshaft gear has been removed, it may be installed with the crankshaft in the engine using SE-1900 Installer with SE-1900-18 Adapter and thrust bearing to reduce friction, Figure 141.

7. Place the bearing caps and bearing lower halves over the crankshaft journals. Be sure the bearing caps are properly installed with the number toward the left side of the crankcase and the arrow, pointing toward the front of the engine. Use new self locking bolts for installing the bearing caps. Finger tighten the bearing caps. Using a soft hammer, tap the number 1, 2 and 4 bearing caps until the rear machined faces of the caps are flush with the machined faces of the crankcase.

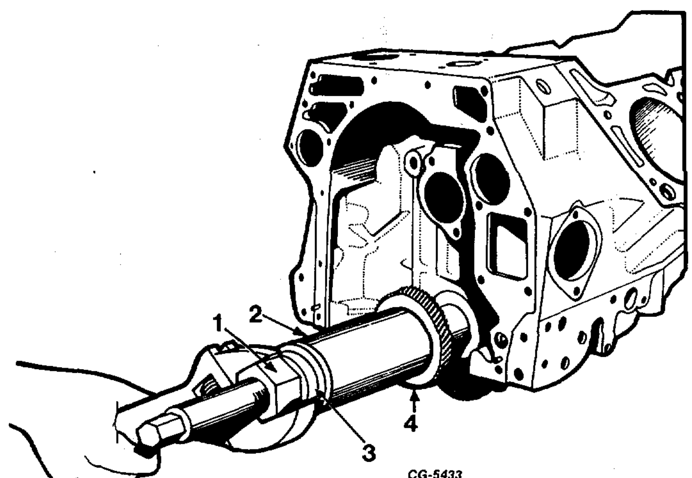

Fig. 141 Installing Crankshaft Gear with SE-1900 Installer and SE-1900-18 Adapter

1. **Nut**
2. **Sleeve**
3. **Thrust bearing**
4. **Gear**

Repeat the same operation for bearing cap number 5 only aligning the front face of the cap with the crankcase. The number 3 bearing rear thrust flanges must be flush with each other. Aligning caps in this manner will assure proper cap location. Check this alignment at both sides (left and right) of the bearing cap. Torque the bolts to specified torque using a tension wrench. See "Torque Chart."

Apply the same procedure to the remaining bearing caps. Recheck the crankshaft end play as outlined under "Fitting Main Bearings."

8. Install flywheel housing on crankcase. Torque bolts to specified torque. See "Torque Chart." Install oil pressure sending unit.

9. Press crankshaft rear oil seal into retainer plate using SE-1905 installer and 5-¼" O.D. adapter, Figure 142. The seal must be installed from the crankcase side of the retainer flush with the seal bore inner surface.

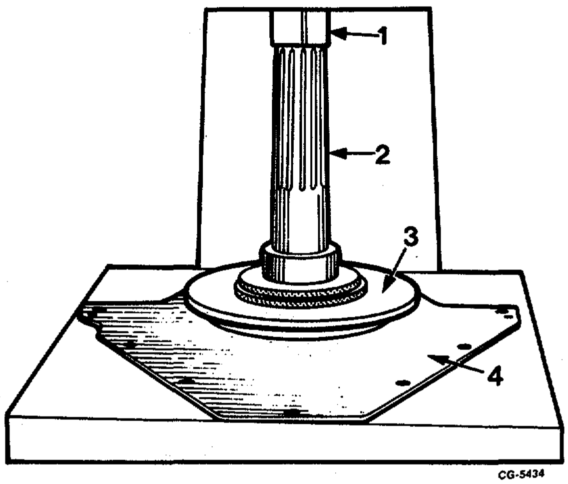

Fig. 142 Pressing Rear Oil Seal into Retaining Plate Using SE-1905 Installer with 5-¼ " O.D. Adapter

1. Press ram **3. Adapter**
2. Installer **4. Retainer**

NOTE: Wipe inside of retainer plate clean to insure a proper fit.

10. Use SE-1942-2 Pilot to install rear oil seal and retainer with gasket on crankcase, Figure 143. Dowel pins are provided for proper alignment. Torque bolts to specified torque. See "Torque Chart."

NOTE: Drill two 25/64" diameter holes in SE-1942-2 Pilot according to the dimensions on Figure 144 to accept two 3/8" diameter x 4" pilot studs. The pilot studs serve as a safety measure to retain the pilot on the crankshaft where seal replacement is performed with engine in the vehicle.

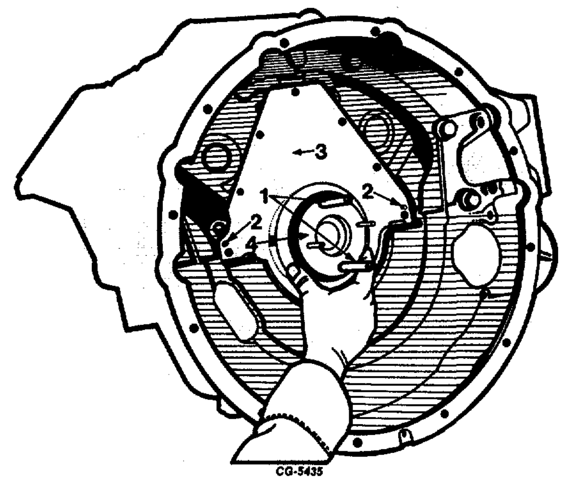

Fig. 143 Installing Retainer with Rear Oil Seal Using SE-1942-2 Pilot

1. Pilot studs **3. Retainer**
2. Dowel pins **4. Pilot**

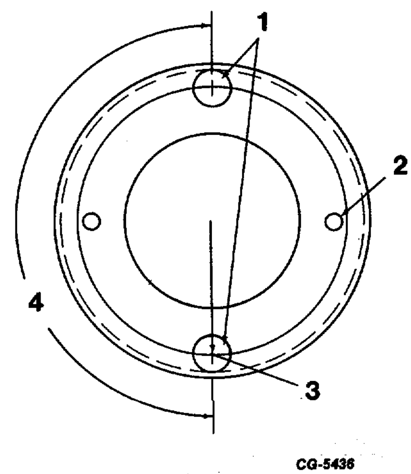

Fig. 144 Dimensions for Rework of SE-1942-2 Pilot

1. 25/64" dia. holes
2. Existing guide pin holes
3. 1.59375R
4. 180°

11. Rotate the crankshaft and camshaft to determine that the gears do not bind or interfere. With the use of a dial indicator, Figure 145, check the backlash. See "Specifications" for backlash.

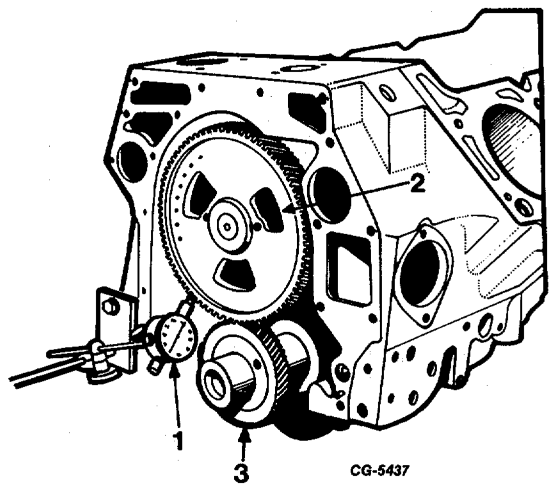

Fig. 145 Checking Camshaft and Crankshaft Gear Backlash

1. Dial indicator
2. Camshaft gear
3. Crankshaft gear

12. Turn the crankshaft so No. 1 crankpin is at the top of its stroke. Coat the cylinder bores, crankshaft journals, pistons, piston pins and piston rings with engine oil. Insert the piston into the ring compressor and install the piston assembly into its respective cylinder bore, Figure 146. Make certain the odd numbers stamped on the connecting rods (1-3-5-7) are facing toward the right side of the cylinder block, while even numbers (2-4-6-8) are facing the left side of the cylinder block. Install the connecting rod bearings and caps, coating each bearing shell surface on both sides with engine oil. The numbered side of the cap must match and be on the numbered side of the rod.

    NOTE: If the connecting rods and bearing caps are properly installed, the large chamfer side of the rod and cap will be to the fillet side of the crankpin. Install new bearing cap bolts, washers and nuts and tighten to the specified torque as shown in "Torque Chart."

13. Follow the procedure outlined in Step 12 for the remaining connecting rods and pistons.

14. Recheck connecting rod end play using a feeler gauge as outlined under "Fitting Connecting Rod Bearings" in CLEANING, INSPECTION AND RECONDITIONING.

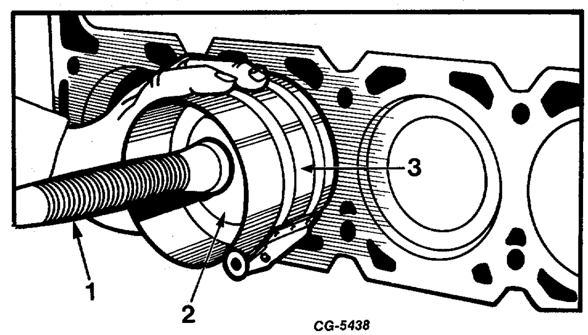

Fig. 146 Installation of Piston in Cylinder Block

1. Hammer handle
2. Piston
3. Ring Compressor

15. Press new oil seal in engine front cover using SE-1949 installer and support blocks, Figure 147. Install oil seal flush to .010" below front face of front cover.

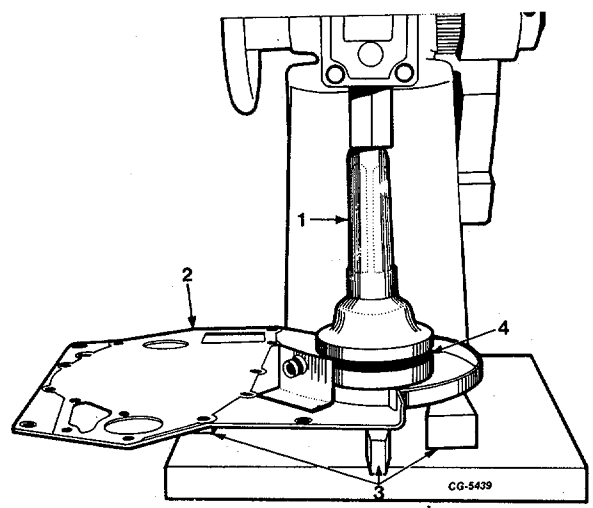

Fig. 147 Pressing New Seal in Engine Front Cover Using SE-1949 Installer and Support Blocks

1. Installer | **3. Support blocks**
2. Front Cover | **4. Oil Seal**

NOTE: With the engine front cover assembled to the cylinder block, a new oil seal can also be installed using SE-1949 installer as shown in Figure 148. Install oil seal flush to .010" below front face of front cover.

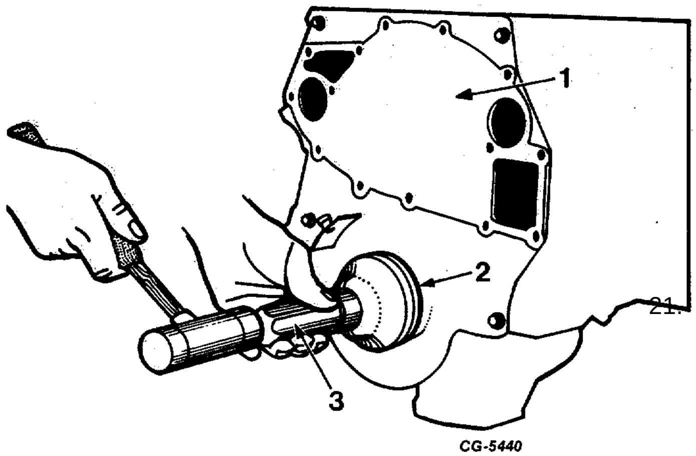

Fig. 148 Installing Engine Front Cover Oil Seal with Cover Assembled to Cylinder Block Using SE-1949 Installer

1. Front cover **2. Oil seal**

16. Position a new front cover gasket to the cylinder block and install the engine front cover assembly. Dowel pins are provided for proper alignment.

17. Install woodruff key in the crankshaft and install the crankshaft vibration damper using SE-1900 installer and SE-1900-18 adapter, Figure 149, with thrust bearing to reduce friction. Install damper bolt and washer and tighten to specified torque. See "Torque Chart."

18. Install crankshaft pulley on vibration damper with bolts and lockwashers. Tighten to specified torque. See "Torque Chart."

19. Install oil pump, pick-up tube and screen assembly. Check alignment of pump to cylinder block for free movement of oil pump shaft. There should be no bind if the pump is correctly aligned.

20. Place the flywheel in position on the crankshaft. Apply a sealing compound not affected by oil to the threads of the flywheel mounting bolts. Avoid getting sealing compound on mating

surfaces of flywheel and crankshaft. Install mounting bolts to specified torque. Fig. 149 Installing Crankshaft Vibration Damper Using SE-1900 Installer and SE-1900-18 Adapter

1. Damper **3. Thrust bearing**
2. Sleeve **4. Nut**

21. Install the clutch pilot bearing into the flywheel. To assure the clutch pilot bearing does not rotate in the flywheel bore, it is recommended that Loctite grade B be applied evenly around the O.D. of the bearing and the I.D. of the flywheel bore at the time of installation. Do not allow Loctite to contact inside of bearing or between flywheel and crankshaft.

After the Loctite grade B has been applied, allow to cure for 1 to 2 hours. The interval required to reassemble the vehicle from the point of clutch bearing is considered adequate for the curing of Loctite.

22. Place the clutch driven disc against the flywheel so the long portion of the hub is toward the rear. Place the clutch in position on the flywheel over the clutch driven disc, install two or three mounting bolts and lockwashers loosely. Install a clutch aligning arbor, if available, or a transmission main drive gear shaft, Figure 150, through the clutch driven disc hub spline and into the clutch pilot bearing. Hold the clutch driven disc in position while completing installation of the remaining mounting bolts and lockwashers in the flange of the clutch backing plate or cover. Tighten all bolts

alternately, evenly and securely. Remove the three retaining bolts and flatwashers which were installed to hold the clutch compressed, Figure 49

NOTE: The clutch will not operate properly unless these retaining bolts and flatwashers are removed.

23. Position a new water pump mounting gasket on the cylinder block and install water pump.

NOTE: Use a nonhardening sealing compound on the water pump capscrews and torque to specified torque.

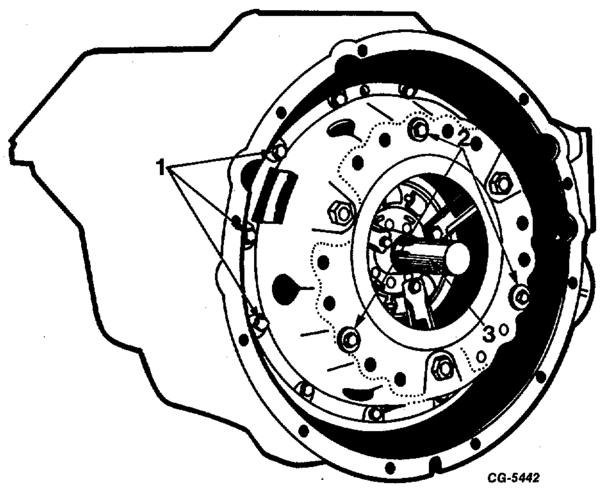

Fig. 150 Clutch Installation to Flywheel

1. **Cover retaining bolts**
2. **Retaining bolts for compressing clutch**
3. **Aligning bar**

24. Position new cylinder head gaskets (insure the stamped "Front" is to the front of the engine) on each bank over the aligning dowel sleeves insuring that all bolt holes in the gaskets are in line with those on the cylinder block. Place cylinder head on the proper bank aligning the head with the dowel sleeves in the crankcase. Loosely install all cylinder head bolts and flatwashers.

25. Repeat Step 24 for the opposite cylinder head.

26. Tighten the cylinder head bolts alternately and evenly in sequence as illustrated in Figure 151 to the torque shown in the "Torque Chart." Repeat this operation on the opposite cylinder head. It is not necessary to retorque the cylinder head bolts after a run-in period.

27. Install the hydraulic tappets in their respective bores in the cylinder block.

28. Insert the valve lifter (push) rods in their respective positions.

29. Place the rocker arms and pivots on their respective cylinder heads making sure the rocker arms are in line with the push rods and valves. Install mounting bolts and tighten to specified torque. See "Torque Chart."

30. Position the intake manifold seals in position in front and rear of crankcase. See Figure 38.

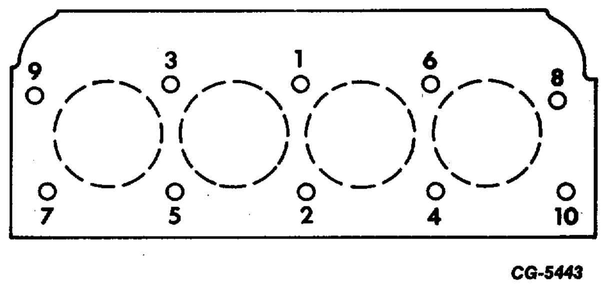

Fig. 151 Cylinder Head Mounting Bolt Tightening Sequence

31. Position the tappet cover and intake manifold gasket assembly on the crankcase. Note the roll pins provided for proper alignment.

32. Place intake manifold in position making sure the direction of distributor rotation is located at the front of the engine. Secure the manifold to the cylinder heads with bolts and washers. Tighten to specified torque.

NOTE: Use nonhardening sealing compound on bolts prior to installation. Also, insure that lifting eyes are installed under the right front and left rear bolts.

33. Place the cylinder head cover gaskets in each cover and install the cylinder head cover with the oil filler cap on the right cylinder head securing with screws and washers. Repeat this operation for opposite cover.

NOTE: Do not install screw and washer that secures the fuel line bracket to the right cylinder head cover at this time. However, insure that cable support brackets are installed.

34. Install engine oil level gauge assembly.

35. Install the spark plugs in the cylinder head and tighten to specified torque. See "Torque Chart."

36. Position left exhaust manifold and gasket to cylinder head and install bolts and lock tab washers. Tighten to specified torque. See "Torque Chart." Bend lock tabs against bolt head.

37. Repeat Step 36 for installation of the opposite exhaust manifold with gasket and manifold heat shroud.

38. Install air manifold check valves in their respective cylinder heads.

39. Install thermostat in crankcase and place engine water outlet gasket on crankcase, Figure 152. Then secure engine water outlet to crankcase with two bolts and lockwashers according to specified torque. See "Torque Chart."

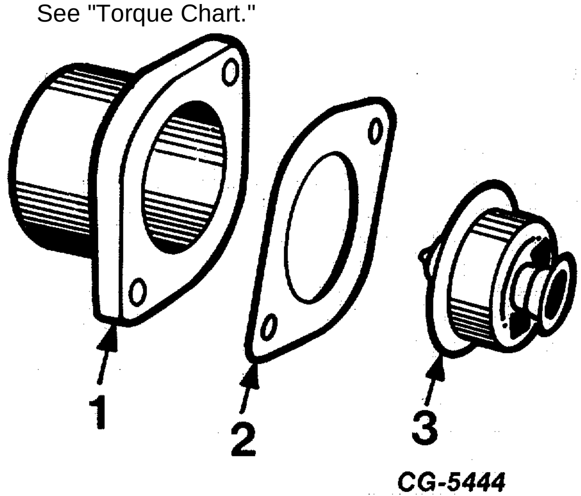

Fig. 152 Exploded View of Thermostat, Gasket and Engine Water Outlet

1. **Engine water outlet**
2. **Gasket**
3. **Thermostat**

40. Install water temperature sender in top front of crankcase. Refer to Figure 34 in "Engine Disassembly."

41. Install low temperature vacuum control valve, exhaust gas recirculating valve and gasket, if so equipped.

NOTE: If not equipped with these valves, install cover plate and gasket on intake manifold and plug from crankcase if removed.

42. Install the ignition coil and bracket on the mounting boss provided on the intake manifold securing the bracket with bolts and lockwashers.

43. Install carburetor return spring bracket on intake manifold with bolt and flatwasher. Refer to Figure 29 in "Engine Disassembly."

44. Install carburetor with two gaskets and spacer plate over studs in intake manifold. Secure with nuts and washers. Attach return spring between carburetor and bracket installed in Step 43.

45. Install the distributor assembly with clamp, hold-down bolt, lockwasher and "O"-ring in crankcase.

46. Install vacuum line and governor line from the distributor to the carburetor connections.

NOTE: Ensure governor line is sealed at both connections.

47. Install all cable brackets for high tension lines.

48. Install distributor cap and thread the cables through the cable support brackets to their respective spark plugs. Connect the high tension cable from the distributor to the coil.

49. Install fuel pump with gasket to the crankcase with two bolts and hardened washers.

NOTE: When installing the fuel pump mounting bolts, it is necessary to tighten the bolts evenly. If they are not installed evenly the operating arm on the fuel pump will not be in correct position with the fuel pump cam on camshaft.

50. Install fuel line with filter between the fuel pump and carburetor. Secure fuel line bracket to right cylinder head cover with screws and washer.

51. Install flame arrestor and hose to left cylinder head cover, Figure 153. Install opposite end of hose to air cleaner after its installation.

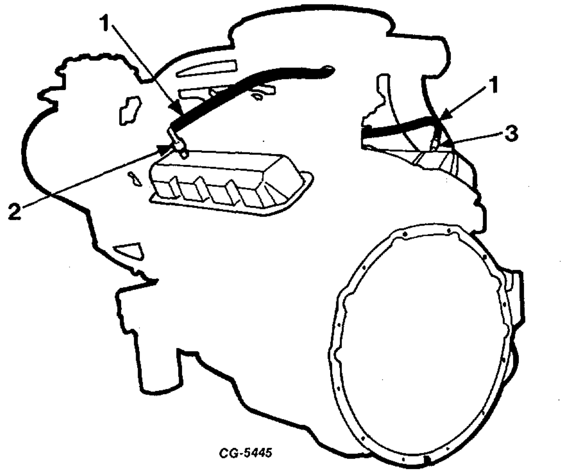

Fig. 153 Flame Arrestor and Crankcase Ventilator Valve Installation

1. **Hose**
2. **Flame arrestor**
3. **Crankcase ventilator valve**

52. Install crankcase ventilator valve in right cylinder head cover and connect hose to valve and tube fitting in carburetor, Figure 153.

53. Install engine water inlet and gasket with two bolts and lockwashers.

54. Install oil pan on crankcase using the liquid gasket material, Figure 154.

NOTE: Caution should be taken not to apply excessive amounts which could contaminate the engine oil.

55. Install oil filter and cooler with gasket, if so equipped, to the crankcase. Also install air compressor oil feed line to crankcase. Refer to Figure 27 for location.

NOTE: If the vehicle is not equipped with an oil cooler, install filter base and filter with gasket.

56. Place the starting motor into the flywheel housing and secure with two bolts and lockwashers.

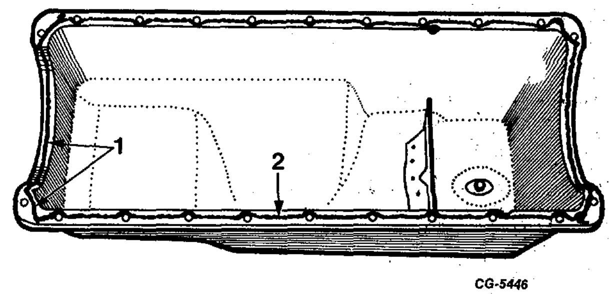

Fig. 154 Application of Liquid Gasket Material on Oil Pan

1. **1/8" bead at corners and both ends**
2. **1/16" bead on both sides**

57. Install power steering pump bracket and adjusting bracket. Refer to Figure 25.

58. Loosely install power steering pump with side bracket to pump mounting bracket.

59. Place power steering pump pulley on shaft aligning the pulley with the keyway and tap gently with a soft hammer. Use a 5/16" x 18" x 1-¼" long bolt and washers to pull the' pulley against the shoulder of the pump, Figure 155. Then replace the long bolt with the shorter bolt and tighten to specified torque.

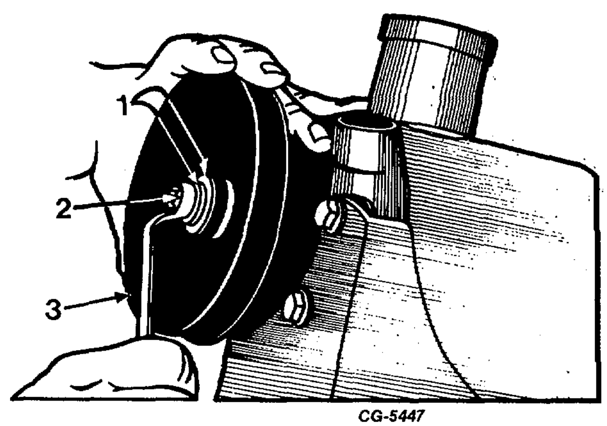

Fig. 155 Pulling Power Steering Pulley Against Shoulder of Pump

1. **Washers**
2. **Bolt**
3. **Pulley**

60. Place the water pump pulley on the shaft and install V-belt over crankshaft, water pump and power steering pulleys.

61. Install freon compressor bracket to right cylinder head. Refer to Figure 20.

62. Place freon compressor on bracket and secure it with four bolts and lockwashers.

63. Install idler pulley bracket on freon compressor with bolts and washers.

NOTE: The bottom two bolts utilize two hardened washers each. Refer to Figure 18.

64. Install air pump mounting bracket and adjusting strap with spacer on right side of freon compressor.

65. Install air pump loosely on bracket. Place V-belt on air pump and freon compressor pulleys. Connect air hoses between air pump and air manifold check valves. Refer to Figure 16 for location.

66. Install V-belt on freon compressor, idler, water pump and crankshaft pulleys.

67. Place alternator bracket and adjusting strap in position and secure with bolts and flat washers.

68. Install alternator loosely in position on bracket and adjusting strap. Install two V-belts alternator, water pump and crankshaft pulleys.

69. Place air compressor bracket with "O"-ring in position and secure with bolts and washers.

70. Place air compressor with gasket in position on bracket and secure with bolts, nuts and washers. Install water return, water inlet, air inlet and oil feed lines. Refer to Figure 8 for proper locations.

1. Install V-belt on air compressor and water pump pulleys.

2. Place fan blade and spacer in position and secure with bolts and lockwashers.

3. Adjust all belts to proper tension according to "Accessory Drive Belts" in CLEANING, INSPECTION AND RECONDITIONING.

74. Install low temperature vacuum control valve and exhaust gas recirculating valve hoses if so equipped.

75. Install engine front mounting bracket.

76. Attach suitable hoisting equipment to the lifting eyes and apply sufficient pull to support the engine assembly. Remove the engine overhaul stand bracket from the engine.

Accessory Drive Belts

Conventional "V" belts are utilized to drive the various accessories. Four belts, driven from the crankshaft pulley, drive the freon compressor, alternator, water pump, fan and power steering pump. Another belt, driven from the water pump pulley, drives the air compressor and another belt, driven from the freon compressor pulley, drives the air pump. Engines having dual belts driving the water pump and alternator should have the belts replaced in matched pairs.

Alternator belt tension can be accomplished with the use of SE-2312 gauge, Figure 156. Check tension at midpoint between the pulleys. Apply gauge to the longest belt span. Instructions for checking are as follows:

1. Grasp gauge and depress ball handle all the way down. Make certain hook extends beyond legs to pick up the belt.

2. Apply gauge to belt, Figure 156. Be sure belt is positioned between nose piece and hook and that the nose piece is centered on the belt.

3. Release ball handle quickly. A slow release may prevent full return of the hook, thus giving a false reading.

4. Observe the area of the gauge face indicated at the index mark. If the index mark does not indicate a NEW reading on a new belt, or a USED reading on a used belt, it will be necessary to increase or decrease belt tension as required.

5. Before changing belt tension, repeat Step 3 several times to become familiar with gauge operation. Observe gauge reading each time the operation is repeated.

NOTE: Check tension of both belts when so equipped.

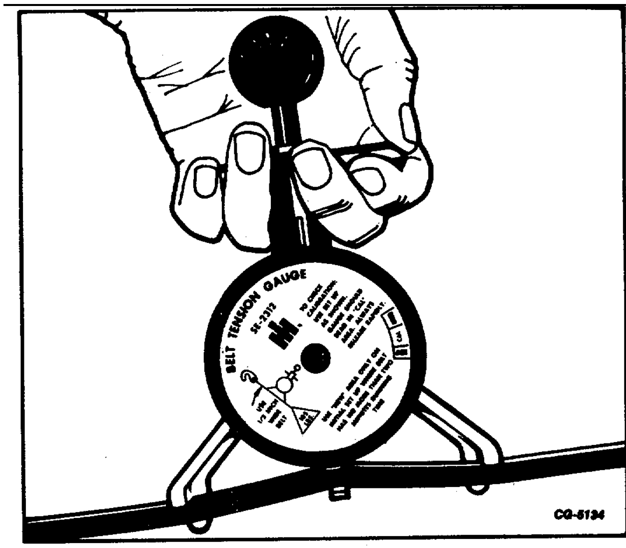

Fig. 156 Testing Alternator Belts Using SE-2312 Gauge

To establish tension of a loose belt, apply SE-2312 gauge to the belt and make the adjustment. Tighten belt until proper area for the belt is indicated at the index mark on the gauge. Lock the adjustment and recheck belt tension. Readjust as necessary.

When using the SE-2312 belt tension gauge, remember to set new belts (belt with less than two minutes running time) to the NEW area on the gauge face and used belts (more than two minutes running time) to the USED area on the gauge.

NOTE: Where the SE-2312 belt tension gauge is not available or cannot be used because of interference with fan shroud, accessories or close clearances, a deflection check can be made. Depress the belt at a point midway between the water pump and alternator pulleys. One-half inch (1/2") deflection is considered acceptable as a final setting after the belt has been operated for a short period of time.

The air or freon compressor and power steering or air pump belts are adjusted in a similar manner.

TORQUE SPECIFICATIONS

Size and Thread	Location	Recommended Wrench Torque (Ft. Lbs.)
5/16-18 and 24	All Locations except as Listed	10-15
5/16-18	Rocker Arm Post	18-22
5/16-18	Rocker Arm Cover	4-7
3/8-16 and 24	All Locations except as Listed	27-37
3/8-24	Connecting Rod	38-44
7/16-14 and 20	All Locations except as listed	45-60
7/16-20	Camshaft Screw	12-18
1/2-13 and 20	All Locations except as Listed	65-85
1/2-13	Main Bearing Caps	90-100
1/2-13	Cylinder Head Bolts	100-110
5/8-11	Crankshaft Vibration Damper	80-100
14mm	Spark Plug	12-18
	Generator Pulley Nut (10 SI Alternator)	40-60
	Generator Pulley Nut (27 SI & L/N 105 Alternator)	70-80

SPECIFICATIONS

ENGINE MODELS	MV-404	MV-446
Number of Cylinders	8	8
Bore (Inches)	4.125	4.125
Stroke (Inches)	3.740	4.180
Displacement (Cu. In.)	399.9	446.9
Compression Ratio	8:1	8:1
Rated H.P. (A.M.A.)	54.5	54.5
Weight (Bare) (Lbs.)	740	737
Weight (w/Std. Acces.) (Lbs.)	942	1030
Engine Serial No. Location	Stamped on top of cylinder block in front of distributor.	
Firing Order	1-2-7-3-4-5-6-8	1-2-7-3-4-5-6-8

SPECIFICATIONS

ENGINE MODELS	MV-404	MV-446
CYLINDER BLOCK:		
Bearing Bore	3.3152-3.3162	3.3152-3.3162
Bore Diameter (Standard)	4.125	4.125
CRANKSHAFT:		
Number of Main Bearings	5	5
Main Journal Diameter	3.1228-3.1236	3.1228-3.1236
Main Bearing Clearance	.0010-.0036	.0010-.0036
Crankshaft End Play	.0025-.0085	.0025-.0085
Thrust Taken by	3rd. Main	3rd. Main
Rod Journal Dia. (Crankpin)	2.4980-2.4990	2.4980-2.4990
CAMSHAFT		
Camshaft Bore	2.1515-2.1525	2.1515-2.1525
Number of Camshaft Bearings	5	5
Camshaft Journal Diameter	2.0990-2.1000	2.0990-2.1000
Bearing Clearance	.001-.0035	.001-.0035
Camshaft End Play	.001-.009	.001-.009
Thrust Taken by	Thrust Plate	Thrust Plate
Timing Gear Backlash	.009-.0067	.0009-.0067
CONNECTING RODS:		
Bearing Bore Diameter	2.6245-2.6250	2.6245-2.6250
Bearing Clearance	.0011-.0036	.0011-.0036
Side Clearance	.008-.020	.008-.020
PISTONS:		
Recommended Piston Clearance	.0012-.0022	.0012-.0022
Ring Groove Size:		
Compression Rings (2)	.0955-.0965	.0955-.0965
Oil Ring	.1885-.1895	.1885-.1895
Pin Bore Diameter	1.0203-1.0205	1.0203-1.0205
PISTON PINS:		
Length (Inches)	2.815-2.825	2.815-2.825
Diameter	1.0199-1.0201	1.0199-1.0201
Clearance in Piston	.0002-.0006	.0002-.0006
Clearance in Rod	.0004-.0008	.0004-.0008
PISTON RINGS:		
Compression Rings (2):		
Size (Face Width)	.0925-.0935	.0925-.0935
Gap	.013-.023	.013-.023
Side Clearance (Fit in Groove)	.002-.004	.002-.004
Oil Control Ring:		
Number Used on Each Piston	1	1
Size	.1855-.1865	.1855-.1865
Ring Diameter	4.125	4.125
Gap	.013-.023	.013-.023
Side Clearance (Fit in Groove)	.002-.004	.002-.004
VALVES:		
Intake Valves:		
Face Angle	45°	45°
Seat Width (Inch)	.060-.090	.060-.090
Seat Run-Out (T.I.R.) (Max.)	.002	.002
Valve to Rocker Arm Clearance	None*	None*
Stem Diameter	.37215-.37285	.37215-.37285
Stem Clearance in Guide	.00115-.00285	.00115-.00285

*Hydraulic Lifters.

SPECIFICATIONS

ENGINE MODELS	MV-404	MV-446
VALVES: (Continued)		
Exhaust Valves:		
Face Angle	45°	45°
Seat Width (Inch)	.085-.115	.085-.115
Seat Run-Out (T.I.R.) (Max.)	.002	.002
Valve to Rocker Arm Clearance	None*	None*
Stem Diameter	.37165-.37235	.37165-.37235
Stem Clearance in Guide	.00165-.00235	.00165-.00235
Valve Guides:		
Length (Inches)	2.600	2.600
Bore Diameter	.374-.375	.374-.375
Distance Above Head (Inch):		
Intake (Inch)	.838	.838
Exhaust (Inch)	1.122	1.122
Valve Springs:		
Free Length (Inches)	2.065	2.065
Test Length (Inches)	1.429	1.429
Pressure (Lbs.) @ Test Length	188.1 ± 8	188.1 ± 8
Valve Lifters (Tappets):		
Diameter	.9040-.9045	.9040-.9045
Bore Diameter in Block	.9058-.9068	.9058-.9068
Clearance in Bore	.0013-.0028	.0013-.0028
Bleed-Down Rate (1/8" Travel @ 50 Lb. Loading)	20-110 Sec.	20-110 Sec.
Valve Lift (Inch):		
Intake	.435	.435
Exhaust	.435	.435
Push Rods:		
Length	10.294	10.294
Valve Timing:		
Intake Opens (before TDC)	14	14
Intake Closes (after BDC)	70	70
Exhaust Opens (before BDC)	59	59
Exhaust Closes (after TDC)	25	25
OIL PUMP:		
Body Gear End Clearance	.0015-.0065	.0015-.0065
Body to Gear Clearance	.0014-.0054	.0014-.0054
Pump Shaft Diameter	.4885-.4890	.4885-.4890
Shaft Clearance in Body	.001-.0025	.001-.0025
Body Gear Backlash (Max.)	.0107	.0107
Idler Shaft Diameter	.4845-.4855	.4845-.4855
Idler Gear Clearance on Shaft	.0015-.004	.0015-.004
Pressure Regulator Spring:		
Free Length (Inches)	2.600	2.600
Test Length (Inches)	1.58	1.58
Pressure @ Test Length	8	8
Oil Pressures:		
(With SAE-30 Oil @ 200° F)		
Minimum (@ Idle Speed)	8-20 psi	8-20 psi
Maximum (@ 1800 RPM)	44-50 psi	44-50 psi
THERMOSTAT:		
180°		
Start to Open at (Deg. F.)	175-182	175-182
Fully Open at (Deg. F.)	202	202

*Hydraulic Lifters.

ENGINE MODELS	MV-404	MV-446
THERMOSTAT: (Continued)		
192°		
Start to Open at (Deg. F)	188-195	188-195
Fully Open at (Deg. F)	212	212
OIL COOLER PRESSURE REGULATOR SPRING:		
Free Length (Inches)	2.567	2.567
Test Length (Inches)	1.400	1.400
Pressure Test Length	3.680	3.680

TURBOCHARGER

(V-800 AND DT-466 ENGINES)

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N O T E

Due to the similarities in design of the V-800 and DT-466 turbochargers, typical illustrations will be used in this manual section, unless a specific difference must be indicated.

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DESCRIPTION

The turbocharger is essentially an exhaust driven blower (Fig. 1). Its purpose is to increase engine power by supplying compressed air to the combustion chambers permitting greater fuel consumption at an efficient air-fuel ratio.

The turbocharger consists basically of the turbine wheel and shaft assembly, turbine wheel housing, compressor wheel and housing and the center housing.

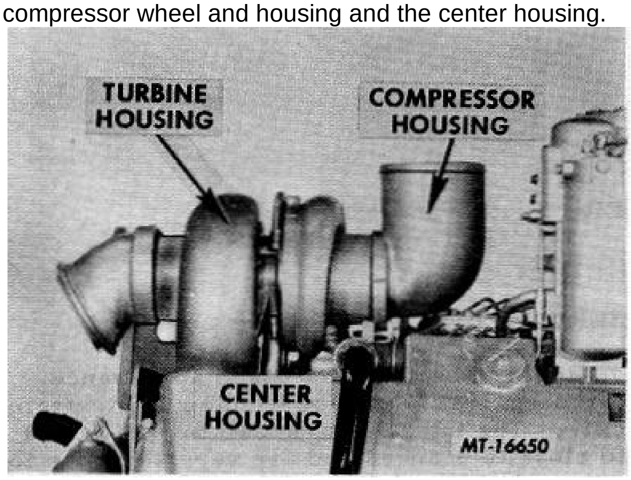

Fig. 1 Turbocharger

The turbine wheel housing, bolted to the center housing, receives exhaust gases from the engine. The exhaust gases spin the turbine wheel and shaft in the range of 70, 000 rpm at rated engine speed and load. This motion is transferred to the compressor wheel secured to the other end of. the shaft.

Outside air, after passing through the air cleaner, is piped to the compressor wheel housing which is clamped to the center housing. Here the air is compressed and directed into the intake manifold.

The center housing supports the shaft on two bearings. These bearings "float" on a film of oil and touch neither the housing or shaft. Oil to cool and lubricate the bearings is supplied under pressure through passages in the center housing. A sealing ring at each end of the shaft prevents oil from leaking into the turbine wheel or compressor wheel housings and also prevents exhaust gases or compressed air from leaking into the center housing. A thrust collar and thrust washer absorb any slight axial movement of the shaft.

OPERATION

In a naturally aspirated or normal breathing engine, air enters the engine at atmospheric pressure, mixes with a specified amount of fuel and is burned in the combustion chamber, producing a certain amount of power.

It was found that if more air could be put into the combustion chamber (Fig. 2), more fuel could be burned and greater power produced from the same size engine. This increased amount of air or air-fuel mixture forced into the combustion chamber became known as a "supercharge."

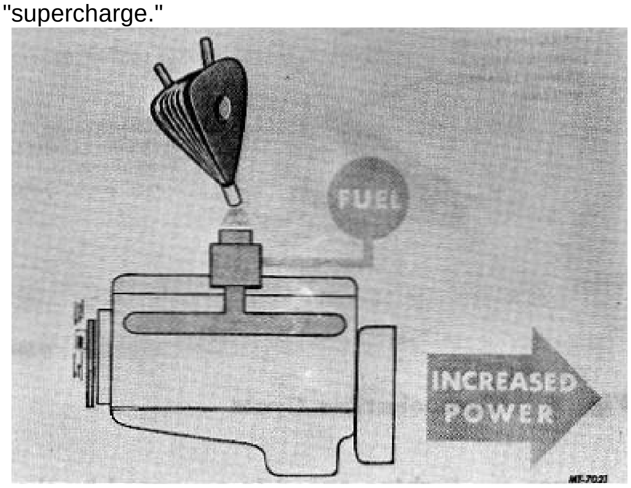

Fig. 2 Air Being Forced Into Engine

On a turbocharged diesel engine (Fig. 3), the turbocharger supplies air under pressure to the intake manifold which provides a greater amount of air to the combustion chamber. The fuel injection system is calibrated to inject the correct amount of fuel for the increased volume of air.

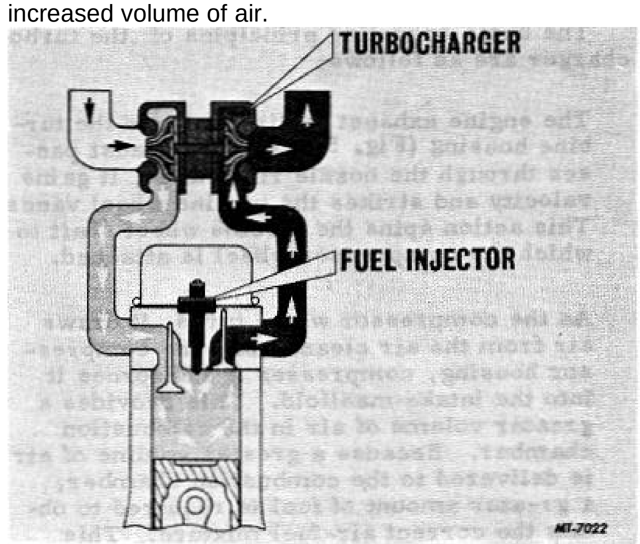

Fig. 3

The turbocharger, in addition to exhaust volume and velocity, depends upon exhaust heat. Under loaded conditions at maximum fuel delivery, the turbocharger becomes very efficient and supplies the increased air volume needed to support proper combustion (Fig. 4).

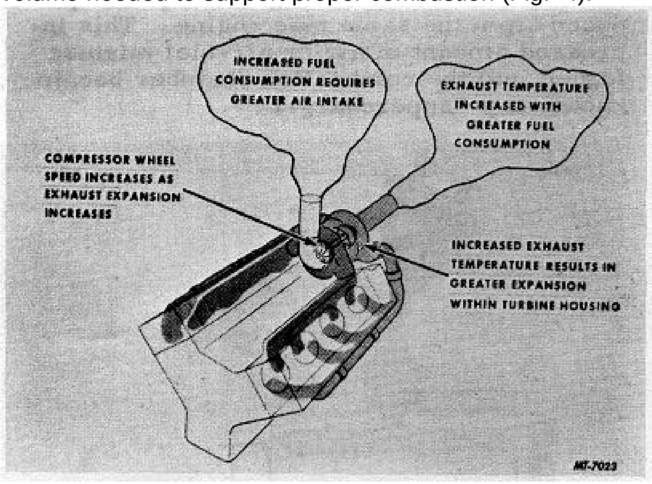

Fig. 4 Turbocharger Cycle

Since the turbine speed is governed by the exhaust energy of the engine at any speed, the turbocharger delivers the correct volume of air at any throttle position. Also, less air resistance at higher elevations allows the turbocharger to spin faster and maintain correct air delivery, thereby avoiding the power loss and excessive smoking that occurs on naturally aspirated and supercharged engines at high altitude.

The basic operating principles of the turbocharger are as follows:

The engine exhaust is directed into the turbine housing (Fig. 5). As the exhaust passes through the nozzle ring vanes, it gains velocity and strikes the turbine wheel vanes. This action spins the turbine wheel shaft to which the compressor wheel is attached.

As the compressor wheel turns, it draws air from the air cleaner into the compressor housing, compresses it and forces it into the intake manifold. This provides a greater volume of air in the combustion chamber. Because a greater volume of air is delivered to the combustion chamber, a greater amount of fuel is required to obtain the correct air-fuel mixture. This increased consumption of fuel at the correct air-fuel ratio results in increased power output.

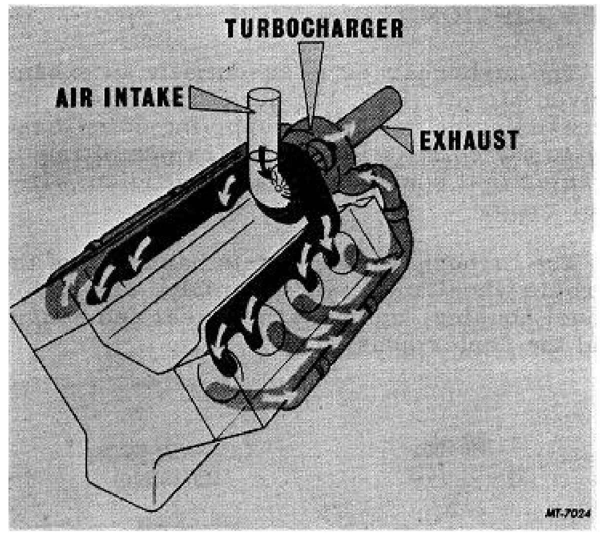

Fig. 5 Air and Exhaust Flow In Turbocharged Engine

SERVICE PRECAUTIONS

Regardless of their rugged appearance, turbochargers are to be handled with extreme care. The internal parts are manufactured to close tolerances and are very sensitive to accumulations of dirt, nicks and scratches. Care must be taken to prevent damage to the components while they are on the workbench.

The turbine wheel, compressor impeller, shaft and related parts form a balanced assembly which rotates at very high speeds. Bending of the turbine or compressor vanes or removal of any vane material during servicing could cause a serious out-of-balance condition which could quickly destroy the turbocharger.

The greater air flow requirements of a turbocharged engine makes it extremely important that the air intake system be kept clean. The air cleaner must be serviced at recommended intervals to avoid power loss due to air cleaner restriction and to prevent possible entry of dirt into the turbocharger and engine.

Turbocharging an engine is more than merely bolting on the turbocharger and driving away. The installation must be carefully engineered to provide the best performance and avoid "overcharging" which could be destructive. Also, the engine must be designed to handle the greater air and fuel flow, higher pressures and temperatures, and increased torque and power output.

After assembly, all openings in the turbocharger should be capped or taped closed, or the entire turbocharger should be encased in a clean polyethylene bag to prevent entry of foreign material. Keep openings covered until the unit is installed on the engine.

To prevent damage to the bearings, the turbocharger must be prelubricated at installation or if the engine has not been operated for a long period of time. To prelubricate the bearings, place 4 to 5 ounces of clean oil into the turbocharger oil inlet opening.

GENERAL MAINTENANCE
AND CLEANING PROCEDURES

General Handling

1. Prevent the entrance of foreign material by covering or plugging all openings into the turbocharger when handling or assembling the unit. Covers must remain in place until the turbocharger is installed and all connections are secured.

2. All connections to the turbocharger (manifolds and piping) must be clean and free of foreign material, since serious damage to the turbocharger or engine could result. All connections must be airtight.

3. Exhaust stacks of extra long length and other fixtures must not be rigidly attached to the turbocharger.

4. For initial running when installing a new or rebuilt turbocharger or after the engine has been in storage for 30 days or more or when engine oil filters have been changed, it is recommended that 4 to 5 ounces of oil (same type and grade as used in the crankcase) be put into the oil inlet opening in the turbocharger with a squirt can. This will provide sufficient lubrication for the turbocharger bearings until normal engine lubrication is established. Connect the oil inlet line.

5. If engine oil becomes contaminated by water, the turbocharger must be drained to prevent sludge formation. It is recommended that after an engine overhaul, an oil inlet filter (see "Engine Service Manual") be installed and used during the first 5 to 25 hours of operation and then removed, as this filter can clog with carbon that is normally suspended in the oil of a diesel engine.

6. It is imperative that the air cleaner service outlined in the Operator's Manual be rigidly followed because of the oil carry-over and power losses that can be incurred with a restricted air cleaner.

NOTE

Air flow requirements for diesel turbo-charged engines are considerably greater than for a non-turbocharged engine of the same size running at the same speed. Air inlet accessories must minimize the restriction at this higher air flow and maintain performance of the turbocharger unit.

7. The engine crankcase breather should be cleaned periodically to be sure that there is no restriction.

8. During normal operation, the turbocharger should be free from vibration or unusual noises.

9. The exhaust stack should be covered to prevent water from entering and damaging the turbine during shutdown periods or when unit is being transported.

10. Periodic inspection of the compressor wheel should be made to check for soft carbon deposits, damaged blades, interference or excessive end play.

COMPRESSOR CLEANING PROCEDURE

1. The frequency of cleaning the compressor end of the turbocharger depends on the condition under which the engine is operated. Before cleaning, inspect the components for signs of rubbing or other defects which might not be evident after cleaning.

2. Refer to respective engine section for removal of turbocharger from engine.

3. Remove the compressor housing (Key 6, Fig. 6 and Key 9, Fig. 7).

4. To prevent damaging the compressor wheel, rest the unit on wooden blocks in a pan or container for cleaning fluid. The compressor wheel must be down and the shaft vertical. NEVER REST THE WEIGHT OF THE UNIT ON THE WHEEL.

5. Fill the container only up to the edge of the compressor housing, using a good grade metal cleaner or equivalent. Never use a caustic solution.

NOTE

Do not allow the cleaning fluid to get to the rotating housing.

6. After deposits have softened, remove with a soft brush or plastic blade scraper.

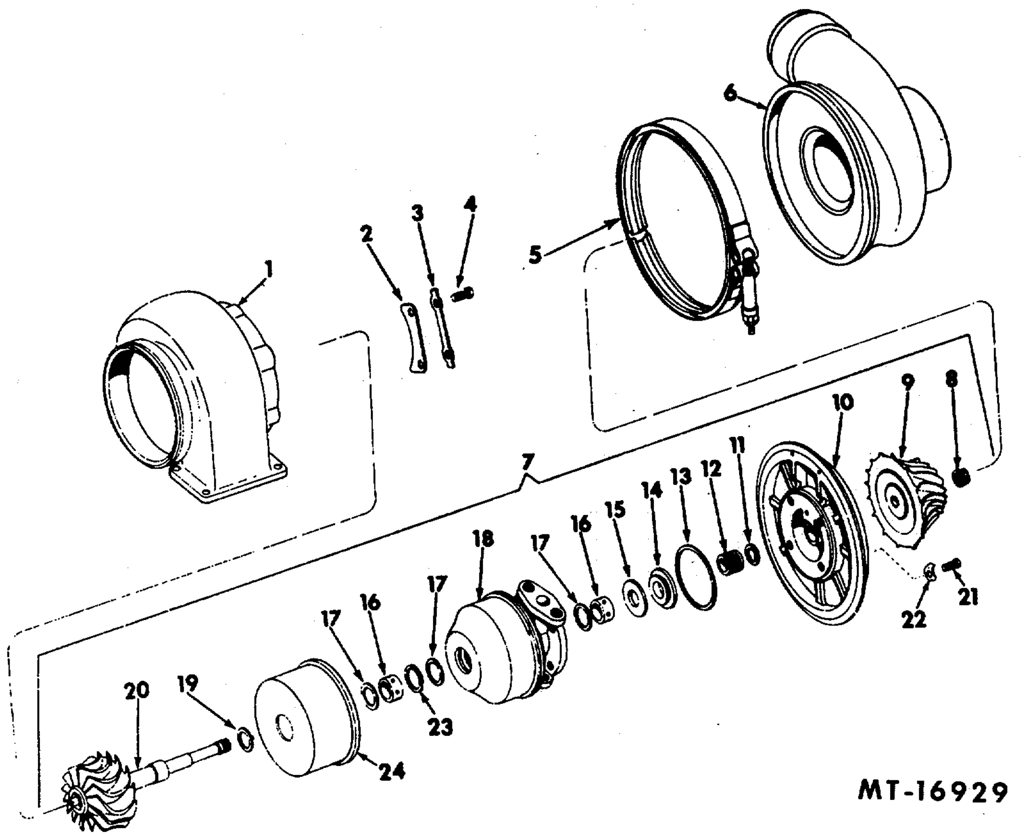

Fig. 6 V-800 Turbocharger (Exploded View)

Key	Description	Key	Description
1	HOUSING, Turbine	13	RING, Plate Seal
2	CLAMP, Housing (3)	14	COLLAR, Thrust
3	PLATE, Lock (3)	15	BEARING, Inboard Thrust
4	SCREW, Hex Hd Cap (6)	16	BEARING, Shaft (2)
5	CLAMP, V-Band'	17	RING, Retaining (3)
6	HOUSING, Compressor	18	HOUSING, Rotating
7	CORE ASSEMBLY	19	RING, Piston Seal
8	NUT, Impeller Lock	20	WHEEL and SHAFT, Turbine
9	WHEEL, Impeller	21	SCREW, Hex Hd Cap (4)
10	PLATE, Back	22	PLATE, Bolt Lock (4)
11	RING, Piston	23	WASHER, Bearing (2)
12	SPACER, Thrust	24	SHROUD, Turbine Wheel

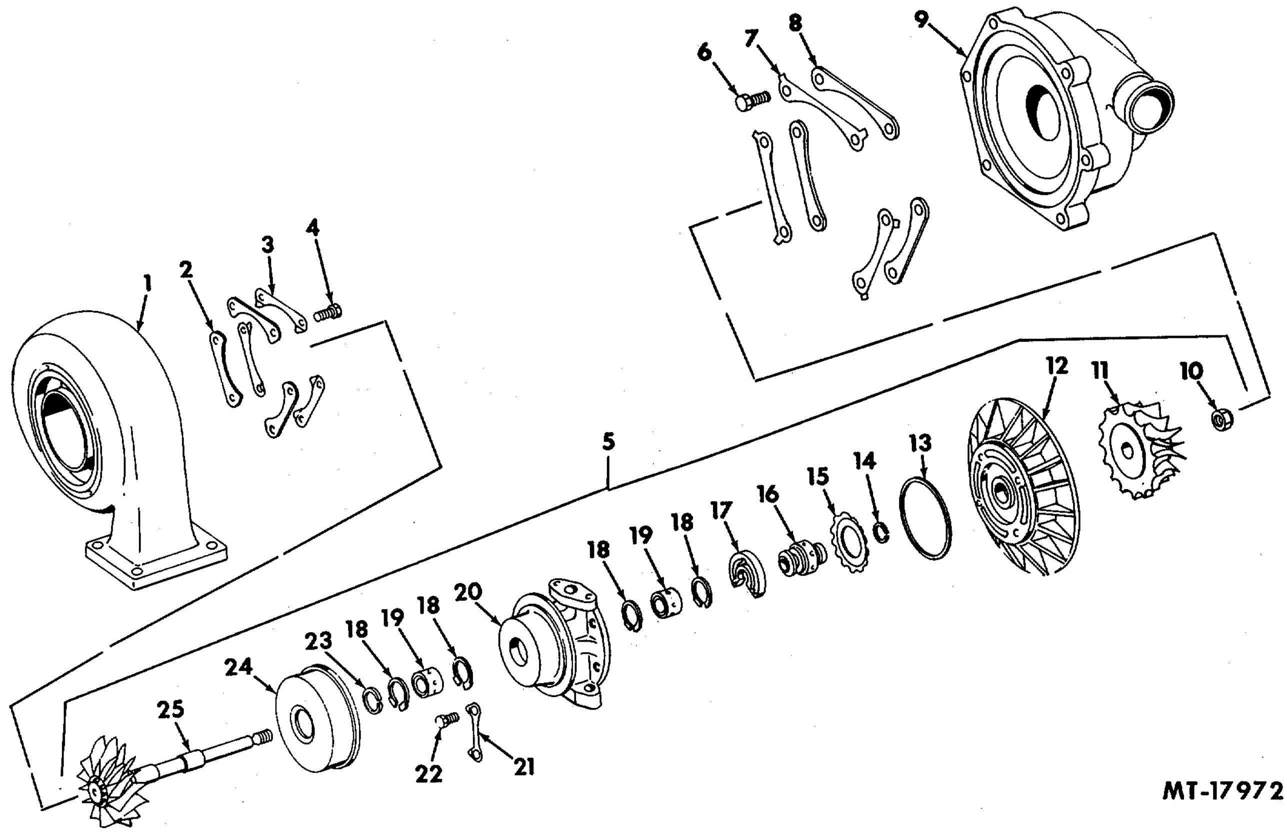

Fig. 7 DT-466 Turbocharger (Exploded View)

Key	Description	Key	Description
1	HOUSING, Turbine	13	RING, Plate Seal
2	CLAMP, Housing (3)	14	RING, Piston
3	PLATE, Lock (3)	15	SPRING, Plate
4	SCREW, Hex Hd Cap (6)	16	WASHER, Thrust
5	CORE ASSEMBLY	17	COLLAR, Thrust
6	SCREW, Hex Hd Cap (6)	18	RING, Retaining (4)
7	PLATE, Lock (3)	19	BEARING, Housing (2)
8	CLAMP, Housing (3)	20	HOUSING, Center
9	HOUSING, Compressor	21	PLATE, Lock
10	NUT, Impeller Lock	22	SCREW, Hex Hd Cap (4)
11	WHEEL, Impeller	23	RING, Seal
12	PLATE, Back	24	SHROUD, Turbine
25	WHEEL, Turbine		

7. Wash the compressor cover in cleaning fluid and dry thoroughly.

8. Assemble the compressor cover and install turbocharger. Refer to "Engine Service Manual" for installation procedures.

PREDISASSEMBLY CHECKS

Make the following checks and if the turbocharger meets these requirements, it can be considered satisfactory and reinstalled on the engine. If it does not meet the requirements, it must be rebuilt (refer to "Disassembly").

Check for Free Rotation

1. Stand the turbocharger on bench with shaft in a horizontal position.

2. Wheels must spin freely when turned by hand.

Check Axial End Play

1. Clamp turbocharger in a vise and position a dial indicator with a magnetic base on the frame of the vise (Fig. 8). (Any type base may be used as long as a similar position can be obtained.) Place the foot of the indicator on the turbine end of the shaft.

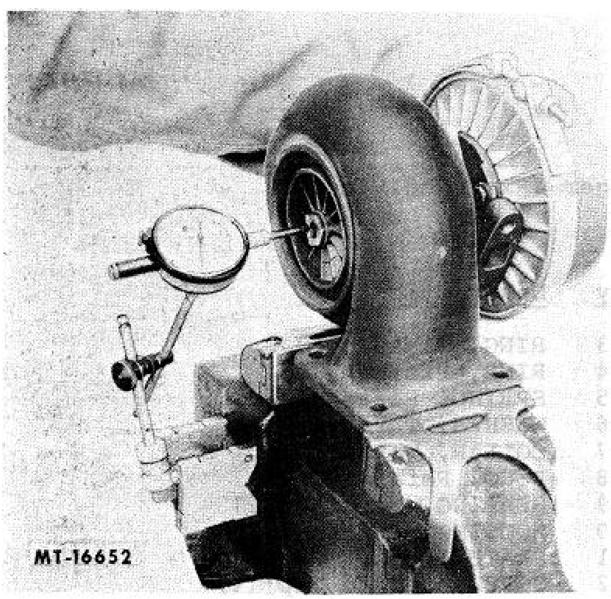

Fig. 8 Checking Axial End Play

2. Move the shaft back and forth by hand and record the reading. 3, If the reading exceeds the specifications, the turbocharger must be disassembled and repaired (see "Specifications")

Check Radial Shaft Movement

1. Remove the protective cover from the oil drain port in the center housing.

2. Install a two inch contact point extension on the dial indicator and position the indicator as shown in Fig. 9. The indicator contact point must contact the turbine shaft through the oil drain port in the center housing.

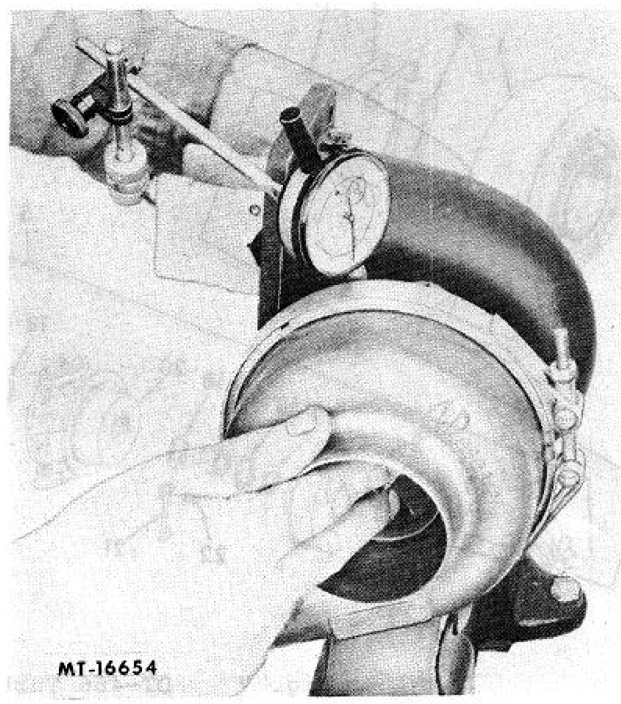

Fig. 9 Checking Radiator Shaft Movement With Housing Installed

3. Hold both ends of the rotating assembly and move the shaft up and down, parallel to the extension of the dial indicator (Fig. 9). Be sure to exert equal pressure on both ends of the rotating assembly.

4. If the readings are not within specifications, the turbocharger must be disassembled and repaired (see "Specifications").

5. If the indicator readings taken in Step 3 were satisfactory, but interference between the compressor housing and compressor wheel is suspected, punch mark the compressor housing, center housing and back plate to facilitate reassembly and remove the compressor housing and diffuser.

6. Install the dial indicator as outlined in

Step 2 and recheck the radial shaft movement as outlined in Step 3 (Fig. 10). If the readings exceed those obtained in Step 3, indications are that the compressor wheel is contacting the compressor housing and servicing is required.

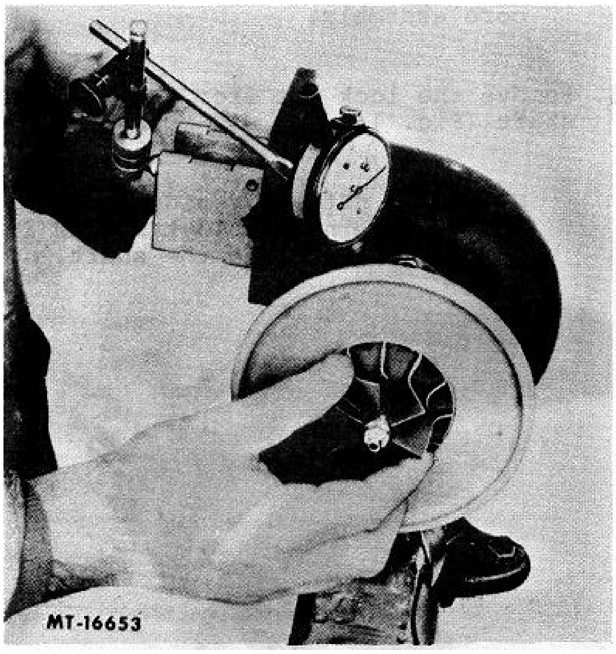

Fig. 10 Checking Radial Shaft Movement with Compressor Housing Removed

Compressor End

Check for dirt accumulation inside the compressor housing.

Compressor Wheel

Examine carefully for bent blades, evidence of rubbing on O.D., face and back of wheel, and for pieces of blade broken off. If any of these conditions exist, wheel must be replaced.

Turbine Wheel

Remove core assembly from turbine housing. Examine wheel carefully for evidence of rubbing on housing. Check for bent or broken blades. Do not attempt to straighten blades.

DISASSEMBLY

1. Cover intake and exhaust ports. Wash the exterior of the turbocharger.

NOTE

Use a commercially approved cleaner only. A caustic solution will damage certain parts and should not be used.

2. Place turbocharger on bench.

3. Mark the assembled position of parts (Fig. 11) as follows:

   a. Compressor housing-to-back plate.

   b. Back plate-to-center housing.

   c. Center housing-to-turbine housing.

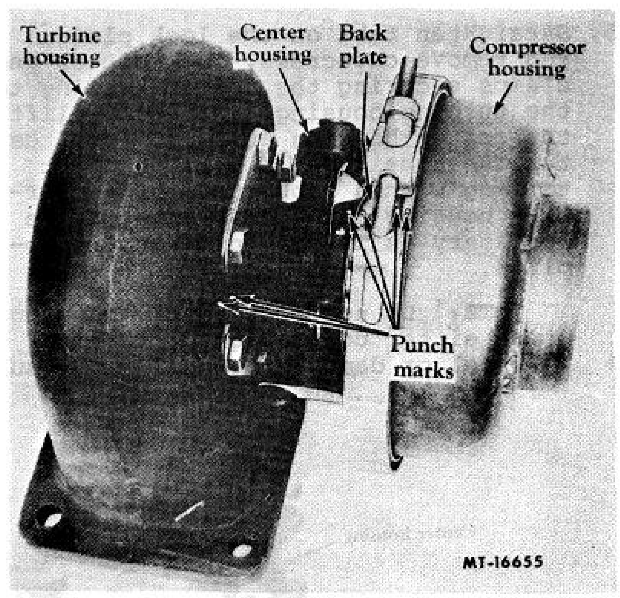

Fig. 11 Related Positions of Parts

4. Remove the clamp or capscrews and lock plates and stand the turbocharger on the bench as shown in Fig. 12. Carefully lift the turbine housing with center housing attached from the compressor housing. A light

tapping with a rubber mallet on the compressor mounting flange may be necessary as lifting pressure is applied.

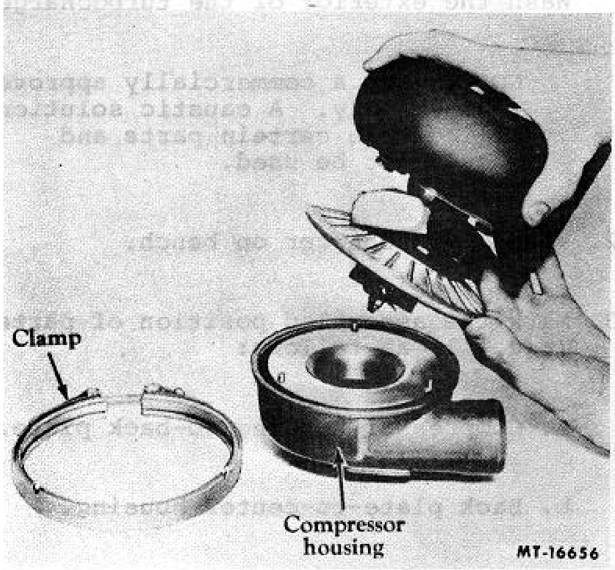

Fig. 12 Removing Compressor Housing

5. Straighten tabs on the lock plates and remove capscrews, lock plates and clamps securing the center housing to the turbine housing. Carefully lift the center housing assembly from the turbine housing (Fig. 13). A light tapping with a rubber mallet on turbine housing mounting flange may be necessary as lifting pressure is applied.

NOTE

Do not rest center housing on either compressor or turbine wheel or damage to wheel will result.

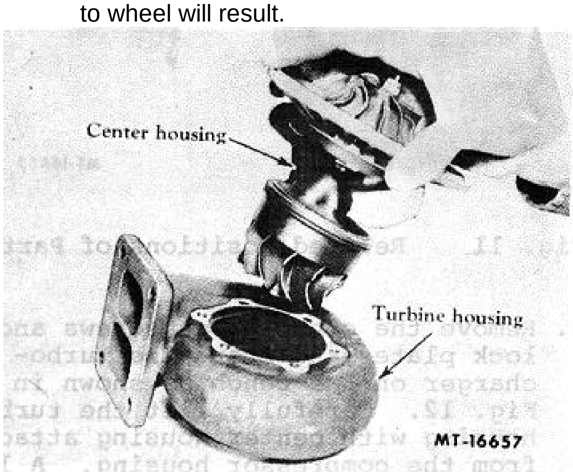

Fig. 13 Removing Center Housing From Turbine Housing

NOTE

Where it is not desired to completely disassemble the turbocharger, a replacement core assembly has been made available. When using this unit, it is only necessary to remove the turbine and compressor housings from the old unit and install them on the new core assembly.

6. Remove the lock nut from the turbine shaft (Fig. 14).

NOTE

Do not apply side thrust when loosening the lock nut as it is possible to bend the shaft.

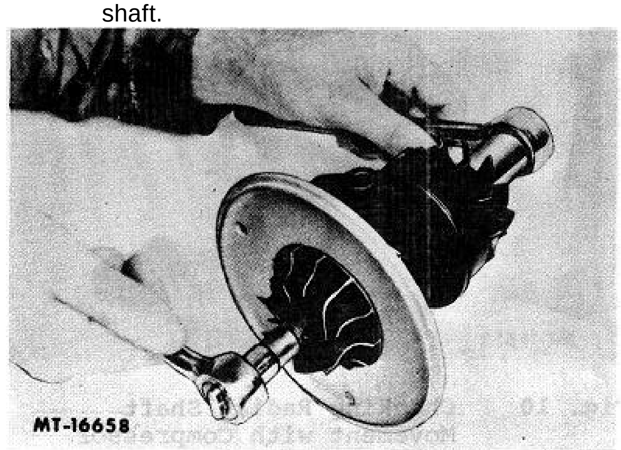

Fig. 14 Lock Nut Removal

7. On DT-466 applications, slide the compressor wheel from the turbine shaft. If carbon buildup prevents easy removal, press the shaft from the compressor wheel according to Step 9.

8. On V-800 applications, support the center housing in a container and, using enough oil to submerge the compressor wheel, heat the oil 176.5° to 185° C (35° to 375° F) (Fig. 15). Leave the compressor wheel in the oil for no longer than 10 minutes.

NOTE

Overheating may affect the hardness of the blades. Do not use direct flame heating on the compressor wheel and use asbestos gloves or other suitable material for handling the hot components.

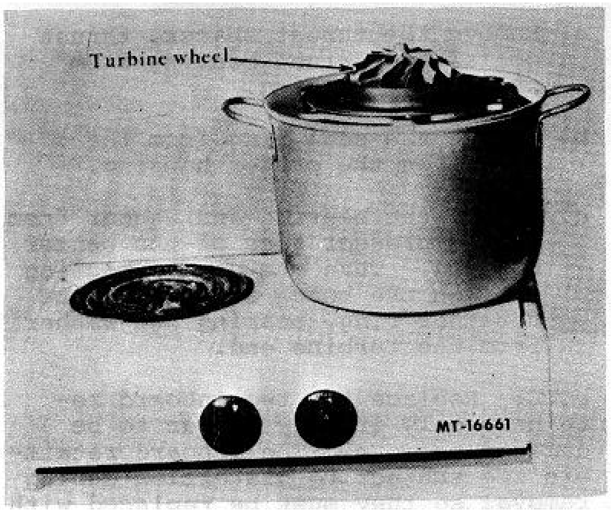

Fig. 15 Heating V-800 Turbocharger Compressor Wheel

NOTE

The DT-466 turbocharger incorporates a "slip-fit" between the shaft and the compressor wheel. Therefore, heating is not required.

9. Support the center housing assembly on the arbor press as shown in Fig. 16. Grind the radius on the end of a 1/4 inch bolt to fit the end of the shaft. Press the shaft from the compressor wheel.

NOTE

Hold the turbine wheel and shaft to prevent it and the shroud from being damaged by dropping.

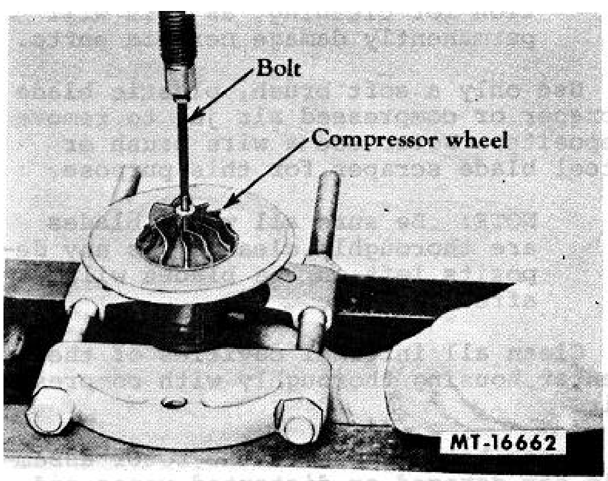

Fig. 16. Separating Compressor Wheel From Turbine Shaft.

10. Straighten the tabs on the lock plates and loosen the capscrews securing the center housing to the back plate (Fig. 17). Do not remove the capscrews in this position.

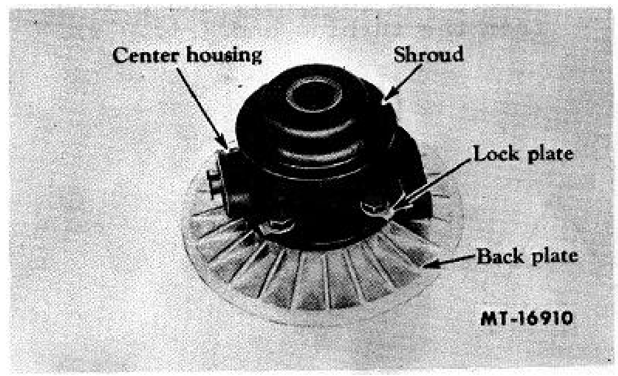

Fig. 17 Center Housing Assembly

11. Turn the center housing over on the bench and remove the capscrews and lock plates. Carefully lift the back plate from the center housing.

12. For further disassembly of the DT466 turbocharger, use the following steps:

   a. Remove the seal ring, thrust collar and thrust washer from the center housing (Fig. 18). The thrust spring located in the back plate is replaceable, but should not be removed unless replacement is necessary.

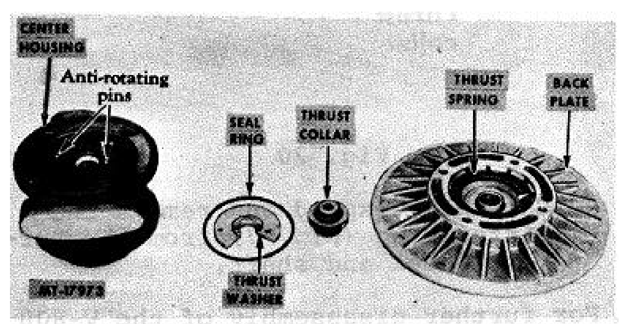

Fig. 18

b. With a sharp pick, remove the spiral bearing retainers from the bearing bore on the compressor side of the housing (Fig. 19). Remove the bearing. Turn the center housing over on the bench and remove the retainers and bearing from the turbine end (Fig. 19).

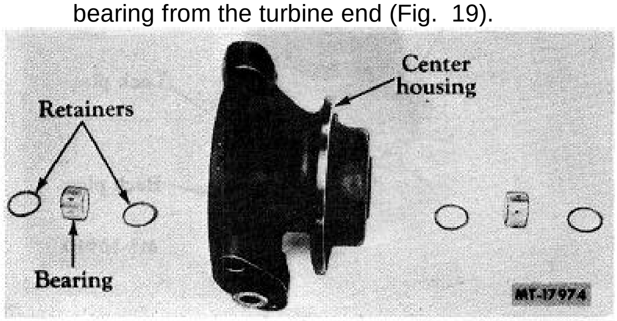

Fig. 19

NOTE

Replace the two inboard retainers only if they appear to be damaged or worn. The inboard retainers are subject to distortion during removal so they must be replaced with new retainers if removed.

c. Remove the seal ring from the thrust collar (Fig. 20). Discard the seal ring.

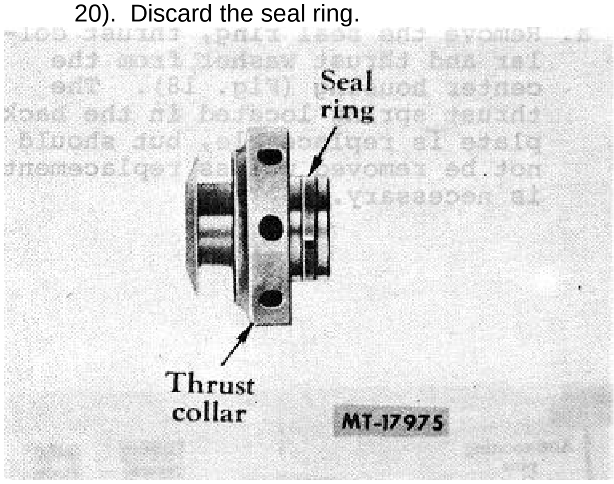

Fig. 20

d. Carefully expand and remove the piston ring (Fig. 7) from the turbine wheel and shaft.

13. For further disassembly of the V-800 turbocharger, use the following steps (refer to Fig. 6).

a. Remove the thrust spacer, thrust collar and thrust bearing from the center housing.

b. Remove the seal ring from the groove in the center housing.

c. Remove the bearing and washer from the compressor side of the center housing. Turn the center housing over on the bench and remove the retainer ring, bearing and washer from the turbine end.

NOTE

Replace the two inboard retainers only if they appear to be damaged or worn. The inboard retainers are subject to distortion during removal so they must be replaced with new retainers if removed.

d. Carefully expand and remove the piston ring from the shaft.

INSPECTION OF INTERNAL PARTS

Before cleaning, inspect all the components for signs of rubbing or other defects which might not be evident after cleaning.

Submerge and soak all parts in a good metal cleaner. The cleaning solution should be agitated to do a satisfactory job, but special care should be taken to insure the parts do not strike each other.

NOTE

Never use a caustic solution for cleaning, as this will permanently damage certain parts.

Use only a soft brush, plastic blade scraper or compressed air jet to remove deposits. Never use a wire brush or steel blade scraper for this purpose.

NOTE

Be sure all wheel blades are thoroughly cleaned, as any deposits left on the blades will affect balance.

Clean all internal cavities of the center housing thoroughly with compressed air.

Check both wheels of the rotor assembly for damaged or distorted vanes and for possible contact with their respective housings and air inlet. The spacing between the vanes and the contour must be uniform. Check for cracked, bent or damaged blades. Replace if necessary.

NOTE

Do not attempt to straighten blades.

Inspect the turbine housing for cracks or excessive scoring in the outlet contour. Inspect the compressor housing for damage.

On the DT-466 turbocharger, inspect the thrust washer and collar for wear or damage. Inspect the thrust spring in the back plate for wear or damage. This spring need not be removed unless damage is evident.

On the V-800 turbocharger, inspect the thrust spacer, thrust bearing and collar for wear or damage.

Turbine Wheel and Shaft

Inspect the bearing surfaces for excessive scratches and wear. If the shaft is only slightly scratched, it may be reused. Never grind or polish the shaft, as this will affect balance.

Inspect piston ring groove walls for v scoring. Minor scratches are acceptable.

Check carefully for cracked, bent or damaged turbine blades.

NOTE

Do not attempt to straighten blades.

Bearings

Inspect for scratches or worn surfaces. Replace bearing if tin plate is worn off.

Center Housing

Inspect for worn or scored surfaces in bearing bores.

Inspect the flanges that mate to the compressor housing for nicks or gouging. The flanges must be smooth to provide proper clearance for compressor wheel and turbine wheel.

Replace the housing if the bores are scored or show signs of excessive wear.

REASSEMBLY

When lubricating of parts is specified, use the same type oil as used in the engine.

DT-466 Turbocharger

(Reference numbers in parenthesis refer to Figure 7, unless otherwise specified.)

1. If the inboard bearing retainers (18) were removed, use a sharp pick to install new retainers into their grooves in the bore of the center housing. Insure the retainers are properly seated in the grooves.

2. Lubricate the housing beaiings (19) with clean engine oil and push them into the bores until they seat against the retainers (18). Install new outer retainers (18) after installing bearings.

3. Install the piston ring (14) into the groove on the shaft (25).

4. Place the shroud (24) over the turbine end of the center housing. Carefully insert the shaft (25) through the shroud and center housing.,

5. Install a new seal ring onto the thrust collar (Fig. 20). Install the thrust washer onto the collar with the flat surface of the washer next to the large diameter of the collar (Fig. 21).

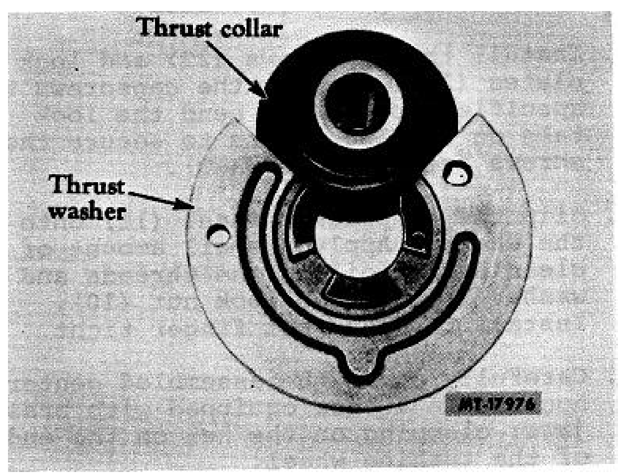

Fig. 21 Placing Thrust Washer on Collar.

6. Install the thrust collar and washer over the shaft (25), thrust washer first and engage the holes in the washer with the anti-rotating pins (Fig. 18) in the center housing.

7. Install a new seal ring (13) into the groove in the compressor side of the center housing.

8. Insure the thrust spring is correctly seated in the back plate (Fig. 22).

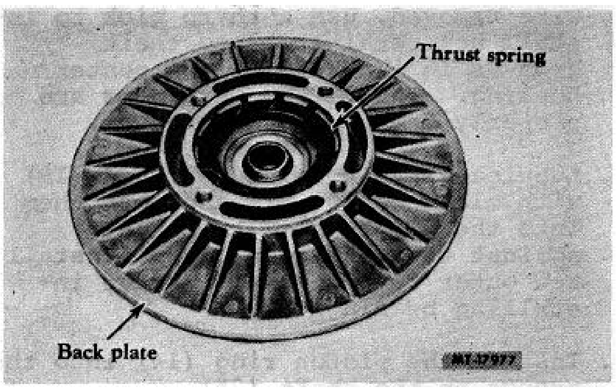

Fig. 22 Thrust Spring in Back Plate

9. Align the marks made during disassembly (Fig. 11) on the back plate (12) with those on the center housing (20) and carefully install the back plate over the shaft and thrust collar. Be careful not to damage the seal ring when engaging the thrust collar into the bore in the back plate. The back plate is easily installed if the open side of the seal ring is engaged into the back plate bore first.

10. Install the capscrews (22) and lock plates (21). Torque the capscrews to specified torque and bend the lock tabs on the lock plate to secure the screws (see TORQUE CHART).

11. Slip the compressor wheel (11) onto the shaft. Apply a small amount of clean engine oil on the threads and washer face of the lock nut (10). Install the lock nut finger tight.

12. Carefully place the assembled center housing in a vise equipped with brass jaws; clamping on the hex on the end of the turbine wheel.

13. Tighten the lock nut (10) using a double universal joint to avoid side load which could cause the shaft to bend. Upon reaching specified torque tighten an additional 1/4 turn (see TORQUE CHART).

14. Remove the assembly from the vise and spin the wheels by hand. The wheels must rotate freely; insure the turbine wheel does not rub the shroud (24).

15. Align the marks made during disassembly (Fig. 11) on the center housing with those on the turbine housing. Carefully install the turbine end of the center housing into the turbine housing.

16. Coat the threads of the capscrews (4) with anti-seizing compound. Install the clamps (2), lock plates (3) and capscrews (4). Torque the capscrews to specified torque and bend the lock tabs on the lock plates to secure the capscrews (see TORQUE CHART).

17. Align the marks (Fig. 11) on the compressor housing with those on the center housing and back plate. Carefully install the compressor housing and secure with capscrews (6), clamps (8) and lock plates (7). Torque the capscrews to specified torque and bend the lock tabs on the lock plates to secure the capscrews (see TORQUE CHART).

18. Push the shaft as far as possible from the turbine end and check for binding during rotation. Repeat check, pushing from compressor end. The shaft must rotate freely with no interference at either end of the turbocharger.

19. If the turbocharger is not to be installed immediately, lubricate internally and install protective covers on all openings.

20. Install the turbocharger on the engine according to the specified "Engine Service Manual."

V-800 Turbocharger

(Reference numbers in parenthesis refer to Figure 8, unless otherwise specified.)

1. Install new inboard bearing retainers (17), if they were removed, into their grooves in the bore of the center housing (18) so the round edge face of the retainer will be toward the bearing when installed. Insure the retainers are properly seated in the grooves.

2. Install the washers (23) into the bore of the center housing. Lubricate the bearings (16) with clean engine oil

and slip them into the bore until they bottom against the washers (23). Install new bearing retainer (17) in the turbine end of the center housing as described in Step 1.

3. Install a new piston ring (19) into the groove on the shaft (20).

4. Place the shroud (24) over the turbine end of the center housing. Carefully insert the shaft (20) through the shroud and center housing. Do not use force to compress the piston ring into place. A gentle rocking and pushing action will allow the piston ring to seat and the shaft to bottom. A thin tool, such as a dental pick, may be used as an aid in compressing the piston ring if difficulty is encountered.

5. Slip the bearing (16) over the shaft (20) insuring the hole and cutout in the bearing engage the anti-rotating pins in the center housing.

6. Install a new seal ring (11) onto the thrust spacer (12). Install the thrust spacer into the bore of the thrust collar (14).

7. Install the collar (14) with spacer (12) over the shaft (20) and onto the bearing (16).
8. Install a new seal ring (13) into the groove in the compressor side of the center housing (18).
9. Align the marks made during disassembly (Fig. 11) on the back plate (10) with those on the center housing (18) and carefully install the back plate over the shaft and thrust spacer. Be careful not to damage the seal ring (11) when engaging the thrust spacer (12) into the bore in the back plate. The back plate is easily installed if the open side of the seal ring (11) is engaged into the back plate bore first.

10. Install the capscrews (21) with lock plates (22). Torque the capscrews to specified torque and bend the lock tabs on the lock plate to secure the capscrews (see TORQUE CHART).

11. Heat the compressor wheel (9) in oil at 176.50 to 1850 C (3500 to 3750 F) (Fig. 15) for no longer than 10 minutes. Quickly install the wheel on the shaft (20) and install the lock nut (8) finger tight.

NOTE

Overheating may affect the hardness of the blades. Do not use direct flame heating on the compressor wheel and use asbestos gloves or other suitable material for handling the hot components.

12. Carefully place the assembled center housing in a vise equipped with brass jaws, clamping on the hex on the end of the turbine wheel.

13. While the compressor wheel is still hot, tighten the lock nut (8) using a double universal joint to avoid side load which could cause the shaft to bend. Torque nut to specified torque (see TORQUE CHART). Upon reaching the specified torque, tighten an additional 1/3 turn.

14. After the compressor wheel has cooled below 66° C (1500 F), remove the lock nut (8). The washer face of lock nut and front face of the compressor wheel must be smooth and clean.

15. Apply a small amount of clean engine oil to the threads and washer face of the lock nut. Install lock nut finger tight. Tighten the nut using a double universal joint to avoid side load which could cause the shaft to bend. Torque nut to specified torque (see TORQUE CHART). Upon reaching the specified torque, tighten an additional 1/3 turn.
16. Remove the assembly from the vise and spin the wheels by hand. The wheels must rotate freely. Insure the turbine wheel does not rub against the shroud (24).

17. Install the turbine and compressor housing onto the center housing as follows (reference numbers refer to Fig. 23).

    a. Align the marks made during disassembly (Fig. 11) on the center housing with those on the turbine housing (6). Carefully install the turbine end of the center housing into the turbine housing.

    b. Coat the capscrews (3) with anti-seizing compound. Install clamps (5), lock plates (4) and capscrews (3). Torque the capscrews to specified torque and bend the lock.

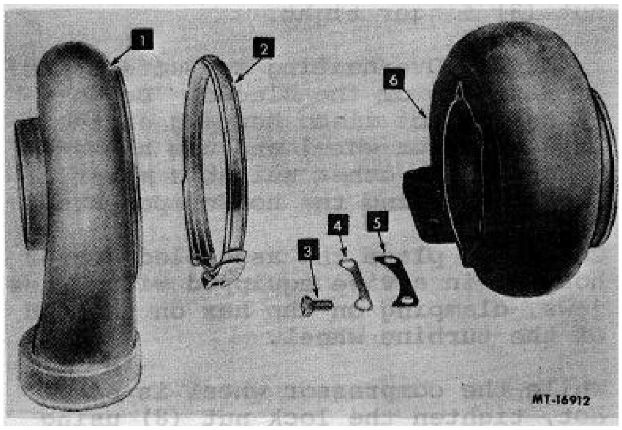

Fig. 23 Compressor and Turbine Housing

Legend for Fig. 23

Key	Description
1	Compressor Housing
2	Clamp
3	Capscrew
4	Lock Plate
5	Clamp
6	Turbine Housing

tabs on the lock plates to secure the capscrews (see TORQUE CHART).

c. Align the marks (Fig. 11) on the compressor housing (1) with those on the center housing and back plate. Carefully install the compressor housing. Install the clamp (2) and torque the clamp nut to specified torque (see TORQUE CHART).

18. Push the shaft as far as possible from the turbine end and check for binding during rotation. Repeat check, pushing from the compressor end. The shaft must rotate freely with no interference at either end of the turbocharger.

19. If the turbocharger is not to be installed immediately, lubricate internally and install. protective covers on all openings.

20. Install the turbocharger on the engine according to the specific "Engine Service Manual."

RUN-IN CHECKS

1. Operate the engine observing the turbocharger for any of the following:
   a. Unusual turbocharger noise.
   b. Lubrication leaks.
   c. Insecure fastening to the engine.
   d. Excessive vibration.
   e. Excessive exhaust smoke.
   f. Air leaks in the air cleaner-to turbocharger or turbocharger-to intake manifold ducting.
2. Investigate and correct any of these conditions immediately to avoid possible turbocharger or engine failure.
3. Retighten capscrews, hold-down nuts, air connections and oil connections to and from the turbocharger after the initial warm-up.

   [Refer to "Engine Diagnostic Manual" (IH No. 1,085,678-R1) for diagnostic procedures, equipment and specifications.]

SPECIFICATIONS

Description	DT-466	V-800
Turbine Shaft Axial End Play	02 - .10 mm (.001 - .004")	08 - .20 mm (.003 - .008")
Turbine Shaft Radial Shaft Movement	08 - .15 mm (.003 - .006”)	08 - .15 mm (.003 - .006”)

TORQUE CHART		
Description	DT-466	V-800
Back Plate-to-Center Housing Capscrews	4.5 - 6.8 N.m (40 - 60 lbf-in)	9.0 - 11.3 N.m (80 - 100 lbf-in)
Shaft Lock Nut (Hot)	N.A.	13.6 N.m (120 lbf-in)
Shaft Lock Nut (Final Time)	2.0 - 2.3 N.m (18 - 20 lbf-in) *	2.0 - 2.3 N.m (18 - 20 lbf-in) **
Center Housing-to-Turbine Housing Capscrews	11.3 - 14.7 N.m (100-130 lbf-in)	18.1 - 21.5 N.m (160-190 lbf-in)
Compressor Housing Clamp Nut	N.A.	11.3 - 14.7 N.m
	(100-130 lbf-in)	
Center Housing-to-Compressor Housing Capscrews	12.4 - 14.7 N.m (110-130 lbf-in)	N.A.

* Turn lock nut additional 1/4 turn after reaching torque value.
** Turn lock nut additional 1/3 turn after reaching torque value.

TROUBLE SHOOTING		
CONDITION	POSSIBLE CAUSE	REMEDY
Shaft and Turbine Wheel		
a. Bearing surfaces scratched and worn.	a. Dirty or insufficient oil. Wheel overspeeding.	a. Replace.
b. Discoloration. oil. deeply scratched.	b. Overheating or insufficient discolored and not	b. Reuse if slightly
c. Worn on one side only.	c. Operating with unbalanced wheel.	c. Replace.
d. Cracked, bent or damaged blades.	d. Foreign objects, heat or fatigue.	d. Replace.
Bearings		
a. Both ID and OD scratched and worn.	a. Dirty or insufficient oil. Wheel overspeeding.	a. Replace.
b. Seized on shaft or excessive OD wear.	b. Overheating or lubrication failure.	b. Replace.
c. Worn on one side only.	c. Operating with unbalanced wheel.	c. Replace.
Bearing Housing		
a. Bore scratched or worn.	a. Dirty or insufficient oil.	a. Replace.
b. Carbon deposits.	b. Oil leaking; overfueling.	b. Clean housing. Remove any restriction from air intake system or oil drain.

CONDITION	POSSIBLE CAUSE	REMEDY
Compressor End		
Dirty.	a. Excessive intake restriction or a restricted oil drain line.	a. Check for clogged air cleaner element, collapsed hose or leaks in air inlet pipe. Clean compressor end and oil drain line.
	b. Insufficient air filtration.	b. Secure the connections between the air cleaner and turbocharger.
	c. Long period of operation without cleaning.	c. Disassemble and clean the unit.
Compressor Wheel		
a. Rubbing on OD of blades.	a. Worn bearing or unbalanced turbine wheel.	a. Replace parts as necessary.
b. Rubbing on cover or back face.	b. Insufficient clearance, cover damaged or thrust washer worn.	b. Improper end play. Replace damaged or worn parts.
c. Inlet leading edge of blades either worn or pieces broken off.	c. Loose pieces in air intake system.	c. Check air intake system for loose nuts, bolts or other foreign material. Replace wheel assembly.
Shaft Rotation		
Wheel drags	a. Carbon buildup behind turbine wheel or dirt accumulation behind compressor wheel.	a. Disassemble and clean the unit.
	b. Bearing worn excessively or seized to shaft due to dirty oil or low oil pressure.	b. Replace bearing and change oil.
Shaft End Play		
a. End play exceeds specifications.	a. Thrust bearing or thrust rings worn or distorted.	a. Replace parts as necessary.
b. End play less than specifications.	b. Carbon buildup behind turbine wheel or dirt buildup behind compressor wheel.	b. Disassemble and clean the unit.
Turbine Wheel Radial Movement		
a. Radial movement exceeds specifications.	a. Worn bearings or shaft, or bore in bearing housing worn.	a. Replace worn parts.

FRAMES

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GENERAL

Since the frame is depended upon to keep the major components of a vehicle in their relative positions, it is highly important that the frame be kept in good condition at all times.

TYPES

Because International chassis are manufactured with frame rails of either cold rolled steel, heat treated steel, or aluminum alloy, each must be handled in a specific manner to assure maximum service life.

IDENTIFICATION

No unusual difficulty should be encountered in identifying aluminum alloy frames. These side rails and cross members are made of thicker material than are the components of a comparative size steel frame. If there is any doubt, use a file to expose the material hardness or color. There are several methods of identifying heat treated frame rails, the most common of which is a stencil marking on the inside middle section of the rail or a stencil mark on one of the cross members. The stencil notes that the rail is heat treated and rail flanges must not be drilled or welded. This is to caution against the welding of additional brackets or cross members or the welding of full length reinforcement rails. Minor repairs as indicated in later paragraphs are acceptable.

A number of the heat treated frame rails have small patches covering "Brinell" test mark along the inside (web) of the rail. These patches are at about three or four foot intervals The patch can be removed to expose the "Brinell" marking.

Some rails are stamped "H" for heat treated, on the upper face of the rail flange about three inches from the rail end.

ALIGNMENT

Method Of Checking

A satisfactory method of checking the frame and axle alignment, particularly when a body and cab is on a chassis, is to mark on a level floor all points at which measurements are to be taken. Tack or tape pieces of paper to the floor directly under each point of measurement on the chassis as indicated by the letter "K" in Figs. 1 and 2. Use a plumb bob since the points of measurement must be accurately marked in relation to the frame in order to obtain. a satisfactory alignment check.

After each measurement point has been carefully marked on the floor, proceed as follows:

1. Locate center line of chassis by measuring front and rear end widths, using marks on floor. If frame widths check, draw center line on floor, full length of chassis. If frame widths do not check, lay out center line as follows:

2. Center line can be drawn through the intersection of any one pair of equal diagonals (A-A, B-B, C-C, D-D) and center point of one end of frame or through points of intersection of any two pairs of equal diagonals.

3. Measure distance from center line to opposite points marked over entire length of frame. Measurements should not vary more than 1/8" at any point.

4. Measuring diagonals (A-A, B-B, C-C, D-D) will indicate point where misalignment occurs. If diagonals in each pair check within 1/8", that part of frame included between points of measurement may be considered in satisfactory alignment. These diagonals should intersect within 1/8" of center line.

Axle Alignment With Frame

After determining that the frame is properly aligned, the axle alignment with the frame should be checked by comparing diagonals. Dimensions for side elevation of frame should be checked at the points indicate(d should not vary more than 1/8".

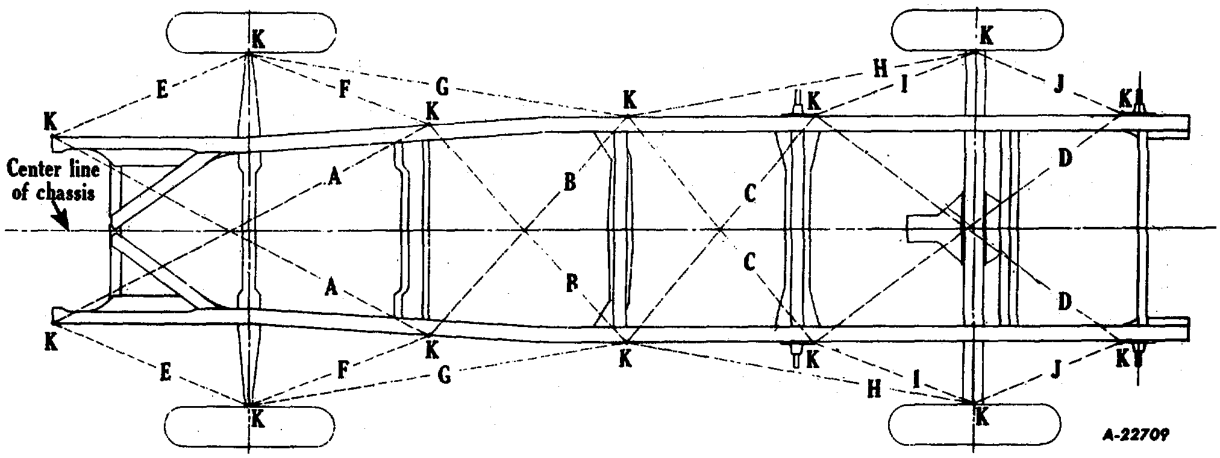
REPAIR AND REINFORCEMENTS
(Non Heat Treated Frames)

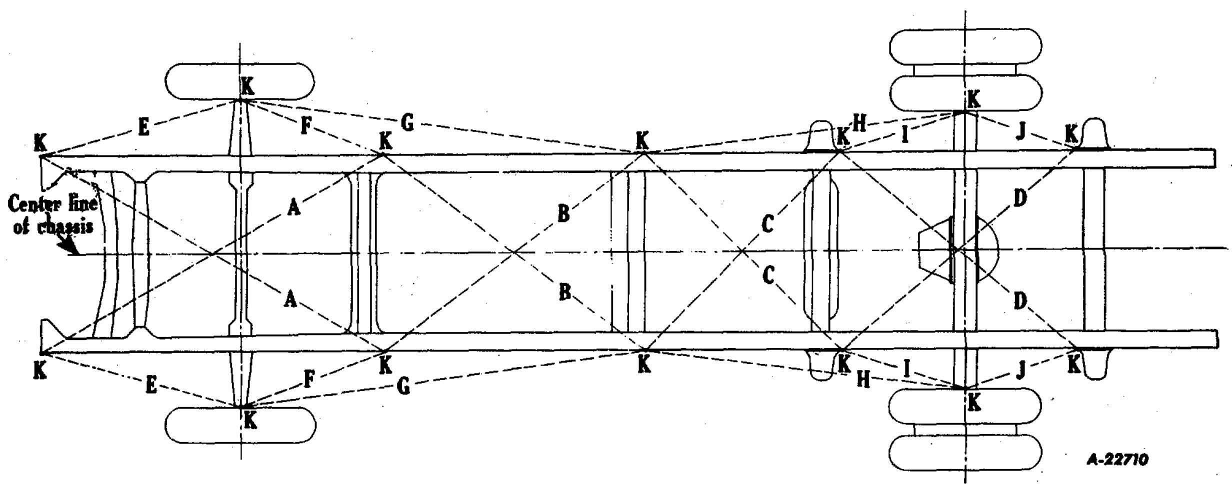
Cutting

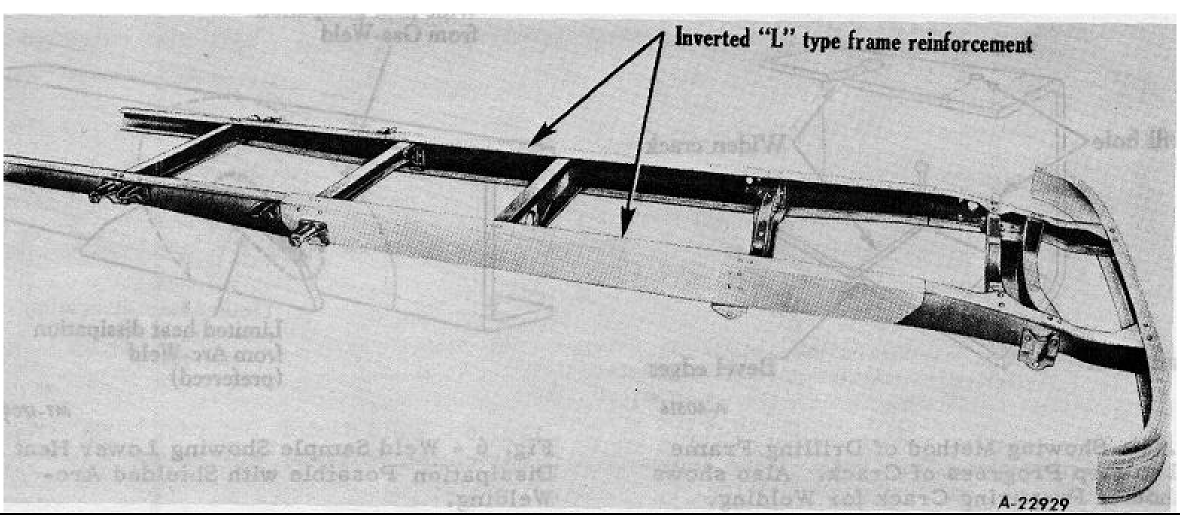
Whenever it is necessary to cut the frame, the side rail should be cut at an angle of 45 degrees. This method distributes the cut and weld over a greater area than a cut made at right angles with the rail.

Reinforcing

Reinforcements can be made with flat, channel or angle stock. Because of difficulties encountered when inserting channel reinforcements into the frame side rails, the use of angle reinforcements is acceptable. When ever possible, the reinforcement should extend from the front axle to slightly beyond the rear spring front mounting bracket as shown in Fig. 3. This procedure, of course, may be impractical because of the position of attached units and existing cross members. The reinforcement thickness should not exceed that of the side rail to be reinforced.







Riveting

Hot rivets are acceptable, as they can be more easily driven with hand tools. Cold rivets should only be used where tools of sufficient power to properly set the rivets are provided.

Rivets should be from 50% to 100% as heavy in diameter as the total thickness of the plates to be riveted.

Welding

Electric arc-welding is recommended for all frame welding. The reinforcements should be welded to the frame after the reinforcements are riveted. All unused holes should be filled with welding material. The welding rod should be substantially the same material as that used in the frame.

Preparation Of Frame For Repair

Before welding the reinforcement to the cracked section of the frame side rail, certain preparations are necessary to insure strength and stableness of repair. To prevent further spreading of the crack, a hole should be drilled at the starting point of the crack, Fig. 4. Widen the crack its full length, using two hacksaw blades together. Groove or bevel both sides of the crack to permit the weld to penetrate to the surface and establish a solid contact between the reinforcement and the frame side rail. Grooving can be accomplished by grinding or with a cape chisel.

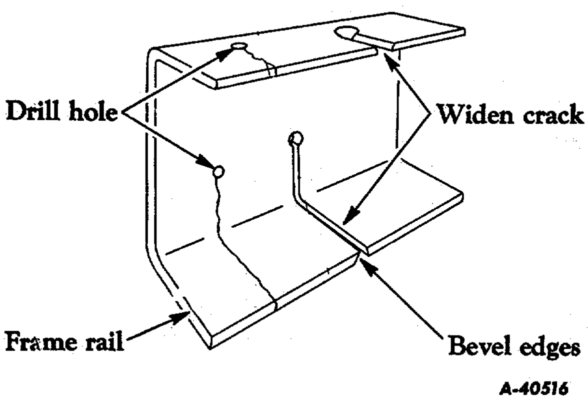


Fig. 4. Showing Method of Drilling Frame Rail to Stop Progress of Crack. Also shows Method of Preparing Crack for Welding.

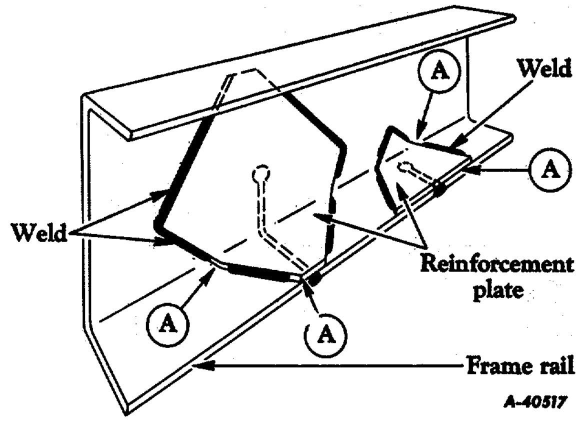


Fig. 5. Suggested Types of Reinforcing Plates and Method of Attaching to Frame Rail.

IMPORTANT

Do not weld into the corners of the frame or along the edges of the frame side rail flanges "A", Fig. 5. Welding at these points tends to weaken the frame and encourage development of new cracks.

Use only the shielded-arc method for all frame welding. Heat generated during welding is localized and burning of material is minimized whenever this method is used. (Fig. 6) Additional advantages are that the finished weld can be ground, filed, and drilled as necessary.

With the reinforcement positioned in the frame side rail, follow the welding patterns shown in Fig. 5 as closely as possible.

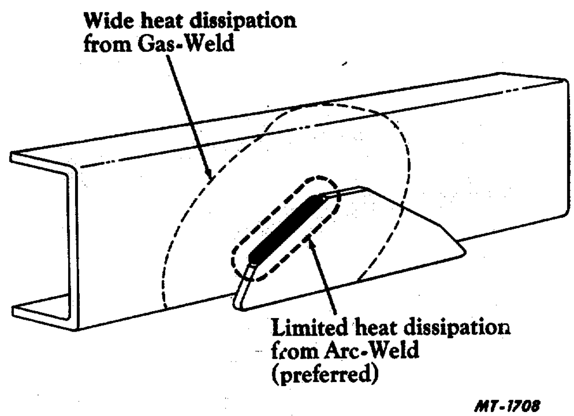


Fig. 6. Weld Sample Showing Lower Heat Dissipation Possible with Shielded Arc-Welding.

Important

In addition to the specific recommendations given in these paragraphs, always remember the following general rules of welding "good housekeeping".

1. Surface areas and edges to be joined must be clean and free of oil or grease.

2. Always avoid craters, notching, and undercutting.

3. Peen new welds to relieve stresses caused by shrinkage.

Positioning of Frame Reinforcements

Whenever practical, the welding of frame reinforcements should be confined to the web of the side rail rather than the flanges. This procedure provides the strongest possible assembly.

Avoid at all times welds made square with the side rail, either on webs or flanges. When welds are made at an angle of at least 30 degrees from square, there is less possibility of setting up dangerous stress concentrations in the rail. Physical tests of the strength of various welds have shown that a weld made at an angle of at least 30 degrees from the direction of strain will retain the original physical properties of the complete rail section.

Frame Straightening

Use of heat is not recommended when straightening frames. Heat weakens the structural characteristics of frame members and all straightening should be done cold. Frame members (except aluminum) which are bent or buckled sufficiently to show cracks or weakness after straightening, should be replaced or reinforced.

Repair and Reinforcements
(Aluminum Alloy Frames)

The cutting and welding of aluminum alloy frames for repair or reinforcement can be accomplished providing correct procedures are followed and proper welding equipment is utilized. The use of heat for straightening aluminum frame rails is not recommended.

BOLT SPECIFICATIONS AND TORQUES

While most IH frames are of riveted construction, there are some frames which are assembled with bolts and nuts. Bolting, though more costly does provide the field with a time saving advantage when replacing crossmembers or frame attaching parts.

If bolting is used for altering or adding to the frame, the following precautions must be observed.

NOTE

Bolts to be used for installing fifth wheels must be 5/8" diameter high strength material such as I. H. type 8 (SAE grade 8) bolts. Type 8 bolts can be identified by the six redial lines on the head of the bolt. Nuts must be of corresponding type.

The torque value for tightening these bolts is 220-250 ft. lbs. and is based on new bolts and nuts lubricated with engine oil. If frame components are aluminum, flat washers must be used next to the aluminum whether under head, nut or both.

Proper tightening of bolts and nuts is most important, since the strength of the joint depends on the maximum clamping force between the members.

REPAIR AND REINFORCEMENTS
(Heat Treated Frames)

With the use of heat treated frame rails in International vehicles, it becomes advisable to outline some of the procedures to be followed whenever these frames require repair.

Heat treated frame rails must not, of course, be intermixed with non-heat treated rails. If one side rail is to be replaced, the new rail material must match the old frame rail.

Preparation Of Frame For Repair

A good method to follow when repairing a cracked frame where the crack is accessible from both sides is as follows:

a. Grind a V notch or groove extending along the full length of the crack and slightly beyond each end of the crack. A heavy copper strip or "chill" should be clamped to the rail side away from the groove to help control the temperature and cooling rate. See Fig. 7.

NOTE

Discarded short lengths of heavy copper electrical bus bars make suitable chills.

b. Preheat the frame rail along the crack area to 500-600 degrees to burn off excess oil or paint then permit heated area to cool to 200 degrees or below before welding is started. Under no circumstances should the rail be heated to a temperature exceeding 900-950 degrees F. since this is the tempering temperature of the rail.

c. Either alternating current or direct current reversed polarity, combined with a short arc and a beading or narrow weave technique may be used. Direct current reversed polarity is recommended or preferred.

d. Slag should be removed after each pass and an interpass or constant temperature of 200 degrees should be maintained.

e. When sufficient metal has been deposited, the weld bead should be ground flush, Fig. 7, with the surface being repaired.

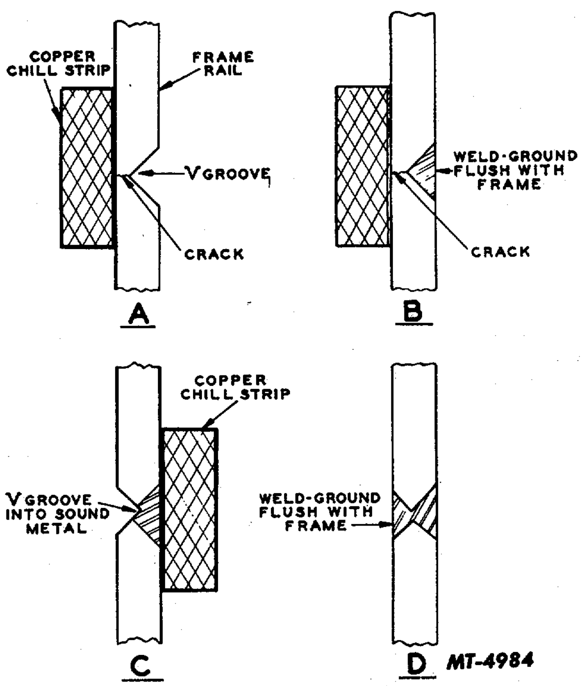


Fig. 7.

f. Where both sides of the frame rail are accessible, a V-groove is ground from the side opposite the repair and the procedure outlined above repeated. Dependent upon accessibility, "chill" strips should be used wherever possible. The V-groove ground on the opposite side of the repair should be deep enough to enter the sound metal of the first weld repair "C" of Fig. 7.

Frame

Welds on heat treated material tend to reduce physical properties in the weld heat-affected zone. Because of this, it is recommended that all reinforcements be designed so that all welds are parallel, rather than perpendicular to the frame rail edges. Welds perpendicular to the flange edges will reduce the carrying capacity of the rail, Fig. 8 and 9.

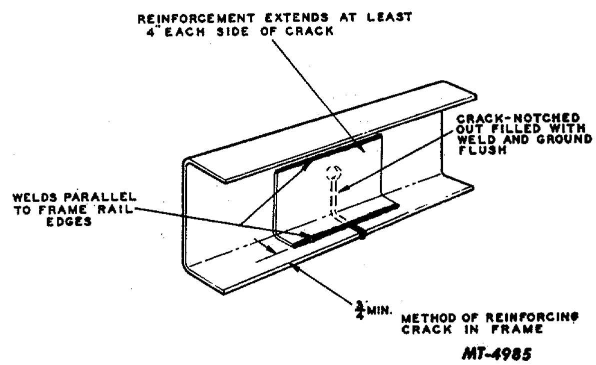


Fig. 8.

The edge of the reinforcement flange to the edge of side rail flange dimension should be held to a minimum of three quarters of an inch to keep the heat-affected zone from extending to the sidemember flange edge. Wherever possible, it is recommended that plug welds of the type shown in Fig. 9, be substituted for edge welds when assembling the reinforcement to the side rail. Plug welds offer the advantages of a reduced heat-affected zone plus increased flexibility and reduced stress concentrations. When using this method, one half inch (minimum) diameter holes should be drilled and chamfered in the reinforcement on Z" center to center distances. At no time should these holes be drilled in the frame rail being repaired. The reinforcement should then be installed in its proper position on the sidemember and the holes filled with weld material.

Again a minimum dimension of ¾" should be maintained between the weld and the edge of the sidemember flange. The voltage, amperage and pre-heat specifications listed below should be followed.

Welding Position	Amperes	Voltage
Downhand	130/140	21/23
Overhead	130/140	21/23
Vertical Up	110/120	22/24

Use low hydrogen electrodes which have superior crack resistance and notch toughness similar to AWS-E11018. This type electrode should be stored in a moisture-free container to avoid porosity during welding.

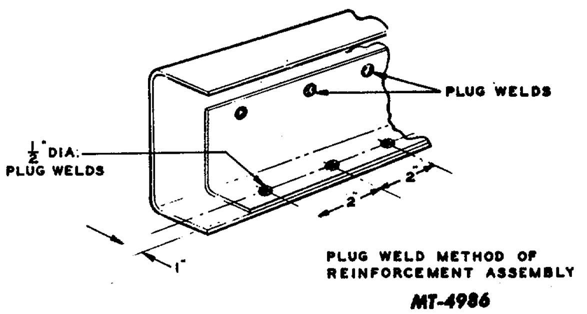


Fig. 9

Full Length Reinforcement

When heat treated frames are to be reinforced over a greater portion of their length, frame channel reinforcements should be installed using bolts. Bolts of high strength material conforming to SAE grade 5 or better should be used. The bolts and nuts should be inspected periodically and kept tight, since the strength of the reinforcement depends somewhat on the maximum clamping force between the members.

Drilling

The drilling of heat treated frame rails presents no unusual difficulty. Standard high speed drills of good quality will serve provided they are sharpened properly and not overheated during sharpening or use. There are,. however, special high speed twist drills available having special materials which will hold a cutting edge longer. These drills are expensive and require especially rigid support, otherwise drill breakage will result.

When drilling heat treated rails, like in any other drilling operation, sufficient pressure must be applied to the drill bit to maintain continuous cutting. The drill point should frequently be drenched with cutting oil (soluble oil) to help cool the drill. Avoid letting a drill bit turn in the work without cutting. To do so will usually overheat and ruin the drill.

The drill must be held steady during the drilling operation. Avoid wobble or change of drill angle during the drilling operation.

Frame Straightening

When heat treated frame rails have been bent or twisted, they should not be heated for straightening. This work should be done with the frame rails cold. Heating for straightening purposes is likely to destroy the rail temper in localized areas, which will bring about rail failures.

FIFTH WHEEL MOUNTING

The following information has been prepared to avoid any unnecessary drilling of standard non-heat treated and heat treated frame rails, especially at the frame rail flange when the fifth wheel is being installed.

In no instance should welding be used to attach the fifth wheel or mounting parts to the frame rails. The application of the weld is likely to reduce the strength of the rail in the area of the weld. Bolts must be used throughout the fifth wheel installation. The only exception to welding in the fifth wheel installation is the locating block installation at each corner as shown in Figs. 10 and 11.

Figs. 10 and 11 show two methods of mounting the fifth wheel. Fig. 10 shows mounting where the deck plate is attached at frame rail level. This mounting can be modified to raise the fifth wheel; however, the mounting should be changed to that shown in Fig. 11. The mountings illustrated in Figs. 10 and 11 should not be utilized without the use of a deck plate.

Low Mounting

With reference to this type mounting Fig. 10 shows the various details to follow. Note that the drawing shows a 4 x 3-½" mounting angle at the frame rail which is cut out at the spring hanger to provide 1/8" clearance.

Where rivets are present the mounting angles must be drilled to provide clearance for rivet heads (C on drawing). This applies to rivets in the frame flange as well as frame side.

Bolts must be used throughout the installation of the fifth wheel mounting. However, locating blocks can be welded to the mounting angles as shown in Fig. 10. These blocks must be welded in place before the angles are installed on the frame rail.

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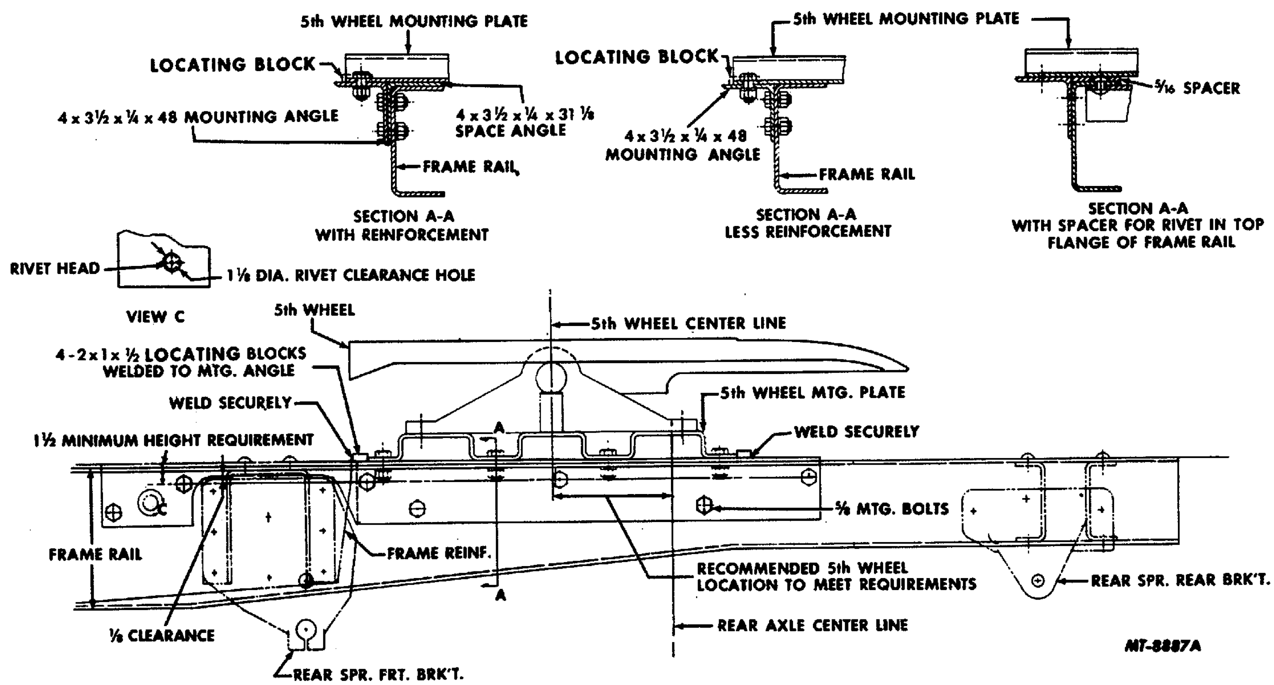

Fig. 10. Low Mounted Fifth Wheel

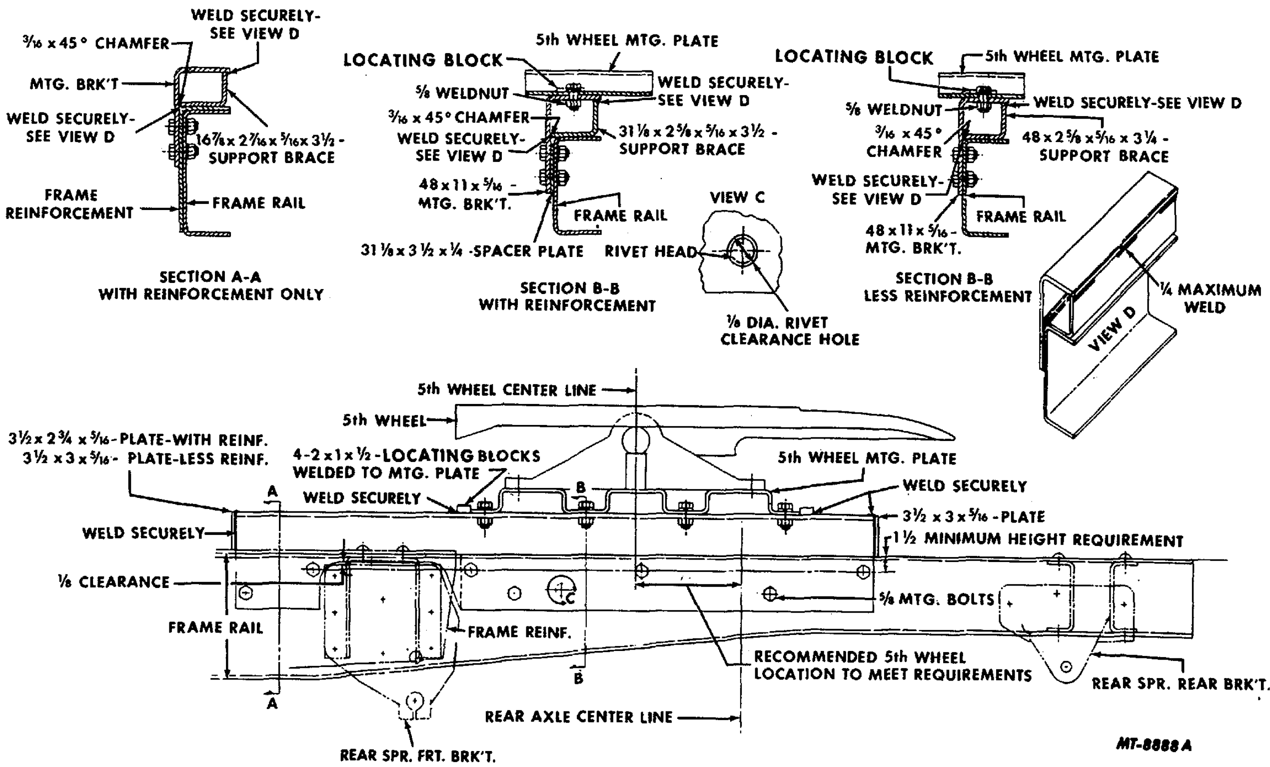

Fig. 11. High Mounted Fifth Wheel

Fig. 10 shows the mounting with reinforced and non-reinforced frame rail. (Section A-A.) Where the mounting is made on a reinforced rail, an additional 4 x 3-½" angle is utilized as a spacer. (A-A reinforced.)

The illustration, Fig. 10, represents a typical installation. Wheel base or fifth wheel location requirements may dictate some modification or deviation from that shown.

High Mounting

Where the fifth wheel is to be in a raised position, the mounting details shown in Fig. 11 are to be followed.

With reference to Fig. 11, it will be noted that the support plates or spacers are fabricated to minimize weight and assure sufficient fifth wheel support. Note also that these fabricated sections are extended well forward of the rear spring front brackets. Here again, welding applied to these parts should be performed off the vehicle to avoid heating the frame rail. When welding the spacer or support plate, apply short runs of weld alternately on each side of the plate as shown in View D. This procedure will minimize warpage of the plate during welding.

Fig. 11 shows details of the mounting with reinforced and non-reinforced frame rail. (Sections A-A and B-B.)

Fig. 11 is also a typical installation and can be varied to suit requirements. NOTE: Holes drilled should be 1/32" oversize. Additional bolts can be added where need is indicated.

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

R. L. DILWORTH
Brigadier General, United States Army
The Adjutant General

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THE METRIC SYSTEM AND EQUIVALENTS

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3.2808.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 grams = .35 ounce
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu in.
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Square measure

1 sq. centimeter = 100 sq. millimeters =.155 sq. in.
1 sq. decimeter = 100 sq. centimeters = 15.5 inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 feet
1 sq. dekameter (are) = 100 sq. meters = 1.076.4 sq. ft.
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 hectometers = .386 sq. miles

Liquid Measure

1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons
1 liter = 10 deciliters = 33.81 fl. ounces
1 centiliter = 10 milliliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3 38 fl. ounces
1 metric ton = 10 quintals = 1.1 short tons

Approximate Conversion Factors

To change	To	Multiply by
inches	centimeters	2.540
feet	meters	.305
yards	meters	.914
miles	kilometers	1.609
sq. inches	sq. centimeters	6.451
sq. feet	sq. meters	.093
sq. yards	sq. meters	.836
sq. miles	sq. kilometers	2.590
acres	sq. hectometers	.405
cubic feet	cubic meters	.028
cubic yards	cubic meters	.765
fluid ounces	milliliters	29.573
pints	liters	.472
quarts	liters	.946
gallons	liters	3.785
ounces	grams	28.349
pounds	kilograms	.454
short tons	metric tons	.907
pound inches	newton-meters	.11296

To change	To	Multiply by
ounce inches	newton-meters	.0070062
centimeters	inches	.394
meters	feet	3.280
meters	yards	1.094
kilometers	miles	.621
sq. centimeters	sq. inches	.155
sq. meters	sq. yards	10.764
sq. kilometers	sq. miles	1.196
sq. hectometers	acres	2.471
cubic meters	cubic feet	35.315
milliliters	fluid ounces	.034
liters	pints	2.113
liters	quarts	1.057
grams	ounces	.035
kilograms	pounds	2.205
metric tons	short tons	1.102
pound-feet	newton-meters	1.356

Temperature (Exact)

°F Fahrenheit temperature	5/9 (after subtracting 32)	Celsius Temperature °C

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