SECTION 5E3B

VCM/REAR WHEEL ANTILOCK BRAKE SYSTEM

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

This section covers diagnosis and service procedures for the vehicle control module/rear wheel antilock brake system (figure 1). This system differs from the stand-alone RWAL system in that the electronic controls are located in the same module used for engine and transmission control. This system reduces the occurrence of rear wheel lock-up during a severe brake application. It does this by regulating hydraulic pressure in the rear brake lines.

ABBREVIATIONS/DEFINITIONS

APV .... Antilock Pressure Valve
CKT .... Circuit
DLC .... Data Link Connector
DTC .... Diagnostic Trouble Code
DVM .... Digital Volt Meter
4WD .... Four-Wheel Drive
RWAL .... Rear Wheel Antilock
2WD .... Two-Wheel Drive
VSS .... Vehicle Speed Sensor
VCM .... Vehicle Control Module

BASIC KNOWLEDGE REQUIRED

Before attempting to diagnose the VCM/RWAL system, you must have a good understanding of electrical system basics and the use of circuit testing tools. Without this basic knowledge it will be difficult to use the diagnostic procedures detailed in this section.

Some electrical basics, basic troubleshooting procedures and hints, and the use of circuit testing tools are discussed in the Electrical Diagrams and Diagnosis Manual.

- BASIC ELECTRICAL CIRCUITS
  - — You should understand the basic theory of electricity, series and parallel circuits, and voltage drops across series and parallel resistor systems.
  - — You should know the meaning of volts (voltage), amps (current), and ohms (resistance).
  - — You should understand what happens in a circuit with an open wire or a wire shorted to ground or battery.
  - — You should be able to read and understand a wiring diagram.
- USE OF CIRCUIT TESTING TOOLS
  - — You should know how to use a digital volt meter (DVM) to measure voltage, current, and resistance.
  - — Be aware that when DVM use is requested, the first terminal listed in the check is intended to be connected to the positive (usually red) DVM lead.
  - — You should be familiar with the operation and capabilities of the Tech 1 scan tool and the cartridge used with it.
  - — You should know how to use jumper wires to test circuits.

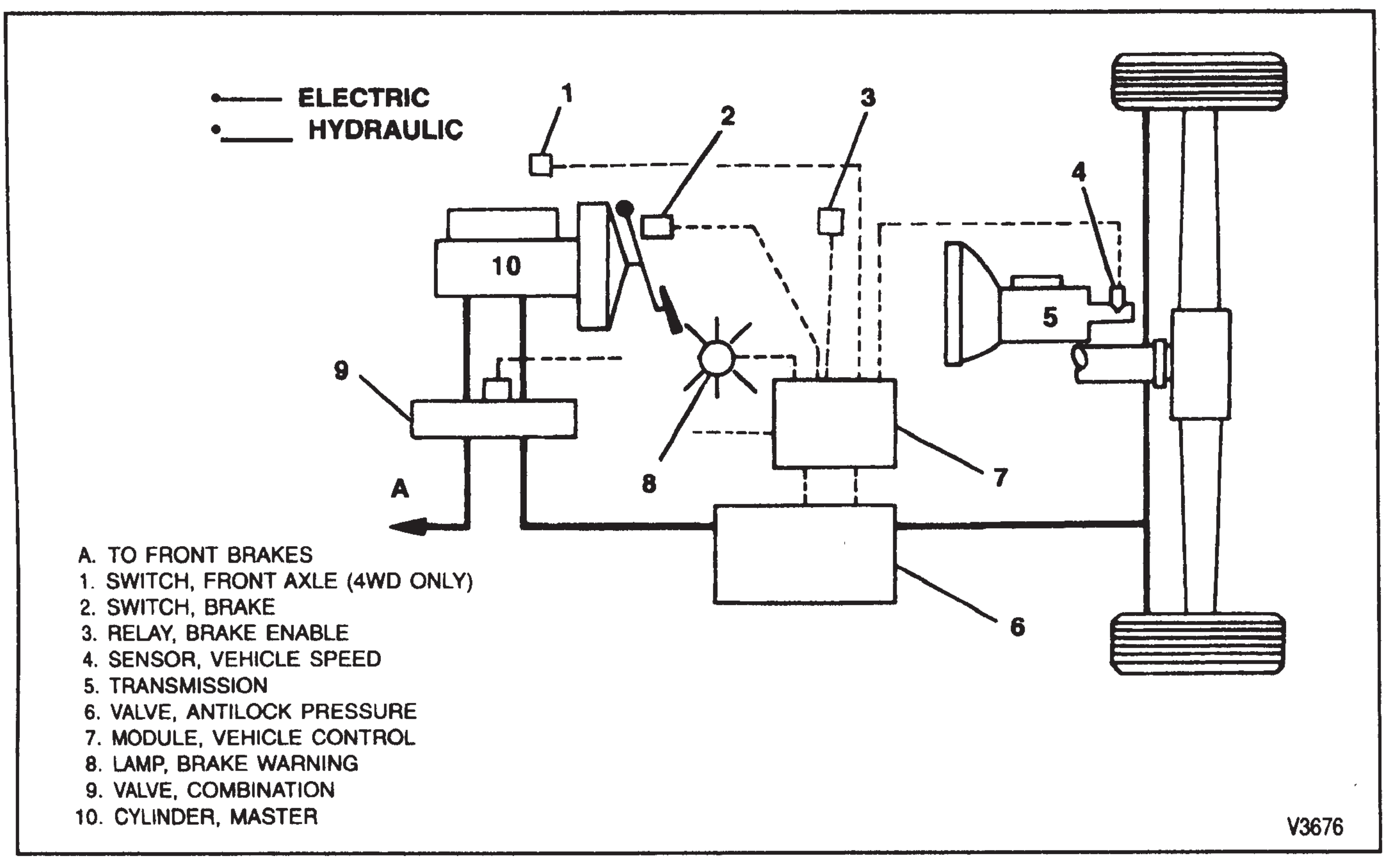


Figure 1—VCM/Rear Wheel Antilock Brake System

SYSTEM OPERATION

The purpose of the VCM/RWAL brake system is to maintain vehicle stability under severe braking conditions on most road surfaces. The VCM monitors the speed of the rear wheels during a braking maneuver. It processes these values and produces command controls to prevent the rear wheels from locking.

BASE BRAKING MODE

During normal braking, applying the brake pedal causes the voltage from the brake switch to the VCM to drop to 0 volts. The VCM then begins to monitor the vehicle speed line. The isolation valve is open and the dump valve is seated. Fluid under pressure passes through the APV and travels to the rear brake channel. The reset switch does not move because hydraulic pressure is equal on both sides of it.

ANTILOCK BRAKING MODE

During a brake application, the VCM compares vehicle speed to the program built into it. When it senses a rear wheel lock-up condition, it operates the antilock pressure valve to keep the rear wheels from locking up. To do this the VCM uses a three step cycle:

- Pressure Maintain
- Pressure Decrease
- Pressure Increase

Pressure Maintain

During pressure maintain the VCM energizes the isolation solenoid to stop the flow of fluid from the master cylinder to the rear brakes. The reset switch moves when the difference between the master cylinder line pressure and the rear brake channel pressure becomes great enough. If this happens, it grounds the VCM logic circuit.

Pressure Decrease

During pressure decrease the VCM keeps the isolation solenoid energized and energizes the dump solenoid. The dump valve moves off its seat and fluid under pressure moves into the accumulator. This action reduces rear pipe pressure preventing rear lock-up. The reset switch grounds to tell the VCM that pressure decrease has taken place.

Pressure Increase

During pressure increase the VCM de-energizes the dump and isolation solenoids. The dump valve reseats and holds the stored fluid in the accumulator. The isolation valve opens and allows fluid from the master cylinder to flow past it and increase pressure to the rear brakes. The reset switch moves back to its original position by spring force. This action signals the VCM that pressure decrease has ended and driver applied pressure resumes.

Accumulator Bleed-Down

When the brake pedal is released, the accumulator spring and piston push the stored fluid back to the master cylinder past a lip seal on the dump valve.

System Self-Test

When the ignition switch is turned "ON," the VCM performs a system self-test. It checks its internal and external circuit and performs a function test by cycling the isolation and dump valves. The VCM then begins its normal operation if no malfunctions are detected.

Brake pedal pulsation and occasional rear tire "chirping" are normal during VCM/RWAL operation. The road surface and severity of the braking maneuver determine how much these will occur. Since these systems only control the rear wheels, it is still possible to lock the front wheels during certain severe braking conditions.

TIRES AND VCM/RWAL

Spare Tire

Using the spare tire supplied with the vehicle will not affect the performance of the VCM/RWAL system.

Replacement Tire

Tire size can affect the performance of the VCM/RWAL system. Replacement tires must be the same size, load range, and construction on all four wheels.

WARNING LAMP OPERATION

BRAKE Lamp

The VCM/RWAL system uses the existing BRAKE warning lamp in the instrument cluster to indicate system operation and malfunctions. The BRAKE lamp is also used to show a hydraulic system pressure differential condition and parking brake operation.

Normal Operation

A bulb check occurs each time the ignition switch is turned "ON." The BRAKE lamp should light, remain on for about two seconds, then turn off. When system malfunctions occur, the BRAKE lamp will turn on and stay on until the malfunction is corrected. To determine the specific cause of a malfunction, refer to "Functional Test."

The BRAKE lamp will also light when the parking brake is applied or the combination valve switch is activated. Do not confuse these functions with a VCM/RWAL system malfunction.

SYSTEM COMPONENTS

VEHICLE CONTROL MODULE

The vehicle control module (VCM) mounts to a bracket behind the glove box. It contains the electronic controls for brake, engine, and transmission operation. During a severe brake application the VCM controls the

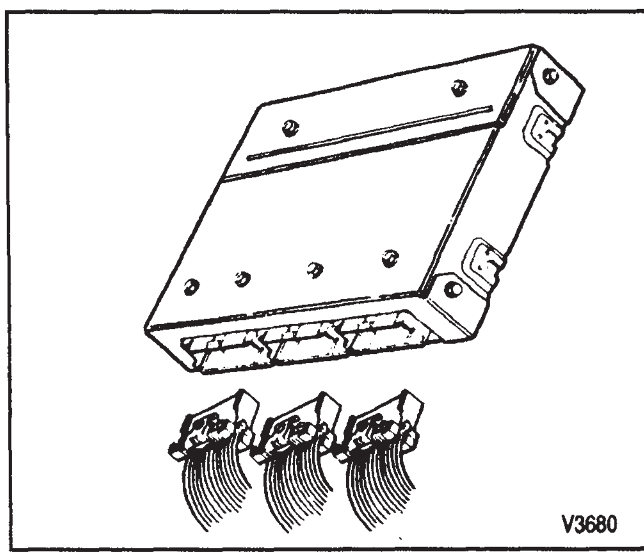


Figure 2—Vehicle Control Module

antilock pressure valve (APV) to prevent the rear wheels from locking up. The VCM receives input signals from the vehicle speed sensor (VSS), brake switch, pressure differential switch, reset switch, and front axle switch on 4WD applications.

ANTILOCK PRESSURE VALVE

The antilock pressure valve (APV) mounts to the combination valve under the master cylinder. The APV has an isolation valve to maintain or increase hydraulic pressure, a dump valve to reduce hydraulic pressure, an accumulator to store brake fluid during the dump cycle, and a reset switch to signal the VCM when pressure decrease occurs. The VCM uses the APV to control hydraulic pressure in the rear brake pipes.

VEHICLE SPEED SENSOR

The vehicle speed sensor (VSS) is located in the left rear of the transmission on two-wheel drive models and on the transfer case for four-wheel drive models. The VSS produces an AC voltage signal that varies in frequency according to the output shaft speed. The resistance value of the VSS winding should be 900 to 2000 ohms.

BRAKE ENABLE RELAY

The brake enable relay is located behind the instrument panel. It serves as the mechanism to power up the antilock brake portion of the VCM. The relay is energized when the ignition switch is "ON." The VCM uses this relay to deactivate the antilock functions when a system malfunction occurs.

DIAGNOSIS

DIAGNOSTIC PROCESS

Before beginning diagnosis on the VCM/RWAL system, you need a detailed description of when the condition occurred from the owner. This information can be useful in duplicating the condition. Always begin diagnosis with a visual inspection of all connectors, wiring, wire routing and retention, and system components. Many times a disconnected or loose connector, blown fuse, corroded terminal, or mis-routed wire is the cause of a malfunction.

If a visual inspection does not reveal the cause of a malfunction, perform the Functional Test in this section. **Always start with the Functional Test**. This is a critical step in the quick and accurate diagnosis of any malfunction. It will direct you to the specific system area that is malfunctioning and verify that the diagnostic system is functioning properly. Correct system diagnosis cannot be ensured without starting diagnosis with the Functional Test.

SELF-DIAGNOSTICS

The VCM performs self-diagnostics and can detect and often isolate system failures. When a malfunction is detected, the VCM sets a diagnostic trouble code (DTC) that represents the malfunction, turns on the BRAKE

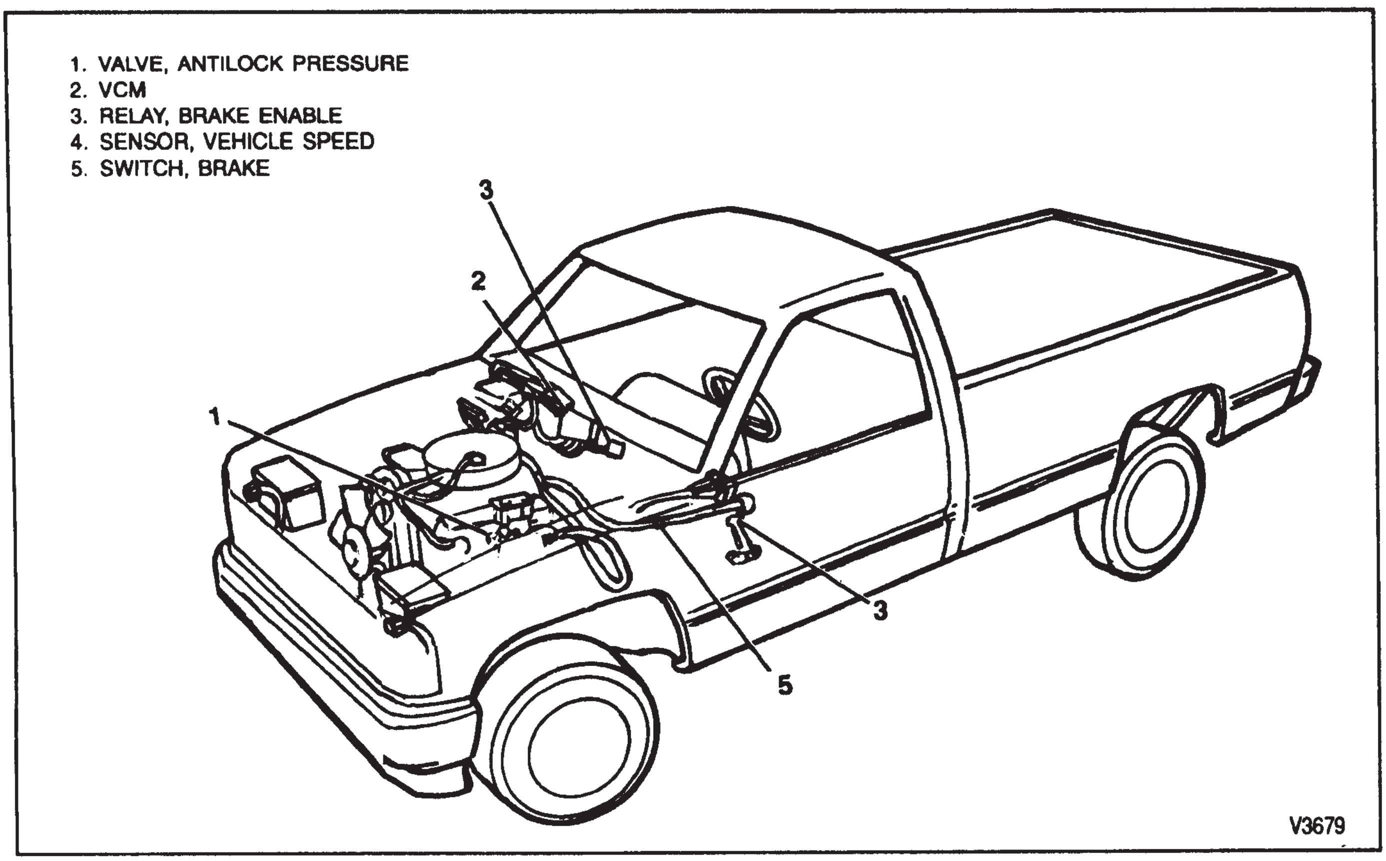


Figure 3—Component Location Views

lamp (in most instances), and disables RWAL functions as long as the BRAKE lamp remains on.

The VCM performs an automatic self-test when the ignition switch is turned "ON." The VCM cycles each valve to check component operation. If it detects an error, it sets a DTC as described above.

DISPLAYING DIAGNOSTIC TROUBLE CODES

Diagnostic trouble codes (DTCs) can be displayed using the Tech 1 scan tool or by manually grounding the data link connector (DLC) (figure 5). Ground terminal "B" to terminal "A" of the DLC and count the BRAKE lamp flashes. The engine DTCs are displayed first using the SERVICE ENGINE SOON lamp. After the engine DTCs are displayed, brake DTCs are displayed using the BRAKE lamp. Count the number of short flashes starting from the long flash. Include the long flash as a count. Sometimes the first count sequence will be short. However, subsequent counts will be accurate. If a soft DTC is stored, only the last recognized DTC will be retained and displayed on the Tech 1.

CLEARING DIAGNOSTIC TROUBLE CODES

Diagnostic trouble codes must be cleared from memory using the Tech 1. Follow the procedure in the Tech 1 owners manual.

INTERMITTENTS AND POOR CONNECTIONS

Most intermittent faults are caused by a faulty electrical connection or wiring, although a sticking relay or solenoid can occasionally be at fault. Refer to "Intermittents and Poor Connections" in the Electrical Diagrams and Diagnosis Manual for a detailed explanation of how to locate and repair intermittent conditions.

TECH 1 DIAGNOSTICS

Important

- Refer to the '88-93 Brake System Cartridge Operator's Manual for additional information about the Tech 1 and the various mode uses.

The Tech 1 has five modes to assist you in diagnosing 4WAL system malfunctions. After selecting 4WAL from the 1990-93 select system menu, the Tech 1 will automatically display the Select Mode menu. From here you can select one of five test modes by pressing the appropriate key:

- MODE F0: DATA LIST
  This mode allows you to continuously monitor 4WAL parameters. The Tech 1 displays data parameters in pairs. The display window tells you which parameters are being displayed and the value for them.
  You can program the Tech 1 to display specific pairs of parameters by following the screen commands. This allows you to monitor specific values that are not normally displayed together.
- MODE F1: FUNCTION TEST
  This mode allows you to actuate the 4WAL system. The Tech 1 will send a signal to the BPMV that causes it to cycle the system. For a short period, the BPMV will cycle the valve and activate the pump motor.
- MODE F2: TROUBLE CODE
  This mode allows you to access and clear DTCs. The screen will display the DTC and a brief description of what it represents.
- MODE F3: SNAPSHOT
  This mode provides you with a tool to help isolate an intermittent condition. You can specify a trigger condition or manually trap the data. No matter which trigger you choose, the Tech 1 captures and stores data before and after the trigger.
- MODE F4: MISC. TESTS
  This mode allows you to research the PROM ID to see which version of software is used in the BPMV, history data, history codes, and tire size calibration.

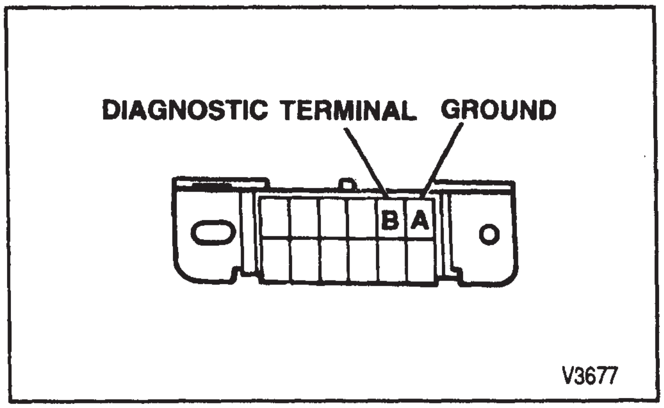


Figure 4—Data Link Connector (DLC)

MODE F3 - SNAPSHOT

The Snapshot mode provides you with a tool to help isolate an intermittent condition. In this mode, you can specify a trigger condition and BPMV diagnostic data is automatically stored before and after the trigger occurrence. You can then display any or all of the stored data.

The operation of the Snapshot mode is divided into three phases; set-up, data capture, and data display.

Set-Up Phase

1. Press F3 to enter the Snapshot mode.
2. Select trigger options are displayed in a self-scrolling menu. Press the function key next to the desired trigger condition.
   - F0: Any Code
   - F1: Single Code
   - F2: Manual Trigger
   - F3: Soft Fault
   - F4: ABS Stop
   - F5: Replay Data
3. When triggering on a single DTC, the Tech 1 will ask you to enter the desired DTC. Enter the two digit DTC followed by the ENTER key.

Data Capture Phase

1. After you specify the trigger condition, the Tech 1 starts collecting data. During this time, you can examine all of the data the same way you do in the

Data List mode. The Tech 1 will display a "W" in the lower right-hand corner while it waits for the trigger condition to occur.

2. While the Tech 1 waits for the trigger, the stored data is organized as a number of "samples." The number and state of each parameter and all DTCs are saved for each sample. If more than half of the maximum number of samples occur before the trigger, the oldest data is discarded.
3. The snapshot data is triggered when the specified trigger condition occurs.
   - F0: Any Code - The trigger occurs when the Tech 1 determines a DTC is set. If a DTC is present at the start of the test, the trigger occurs immediately.
   - F1: Single Code - The trigger occurs when the Tech 1 determines the specified DTC is set.
   - F2: Manual Trigger - The Tech 1 waits until you press the ENTER, EXIT, or F9 key to take the snapshot.
   - F3: Soft Fault - The trigger occurs when the BPMV recognizes an intermittent fault. A soft fault is an occurrence like a poor electrical connection that breaks and makes contact again while driving over a rough road.
   - F4: ABS Stop - The trigger occurs when the brake, while driving, is applied hard enough to cause the 4WAL system to activate.

Important

- While the Tech 1 is waiting for any trigger, the ENTER, EXIT, or F9 key can always be used to force a trigger.

4. After the trigger occurs, the Tech 1 continues to save data samples until it's memory is full. The Tech 1 display shows the trigger occurred by replacing the "W" in the lower right hand corner with a "T." The "T" will change to a "0" when the memory is full. The data capture terminates automatically and the Tech 1 goes on to the Data Display phase.
5. Pressing EXIT terminates the Data Capture phase and will display captured data.

Data Display Phase

1. The Data Display phase is indicated with a number (initially zero) in the lower right hand corner of the display. The number indicates which sample is being displayed. Use the arrow keys to sequence through the data.
   - Sample "-1" is the sample immediately preceding the trigger. Sample "+1" is the sample immediately after the trigger; and so on.
   - Press F4 to go to the earliest sample in memory or F6 to go to the latest sample.
   - Press F5 to return to the "0" sample.
2. Use the YES and NO keys to display the data parameters of the selected samples. If you want to see the DTCs for that sample, press the F2 key and the DTCs will be displayed.

MODE F4 - MISCELLANEOUS TESTS

This mode provides PROM ID, history data, history codes, and tire size calibration.

Prom ID

This function simply displays the version of 4WAL software in the BPMV being tested.

1. Select PROM ID by pressing F0.
2. The Tech 1 will prompt you to turn the ignition switch "OFF" then "ON."
3. The display will show the 4WAL unit software version.

History Data

This function identifies drive cycle (ignition counts) and 4WAL activation counts relative to when DTCs were stored. There are multiple blocks of history records.

1. Select HISTORY DATA by pressing F1.
2. The Tech 1 will prompt you to turn the ignition switch "OFF" then "ON."
3. The most recent history block will be displayed.
   - Use the arrow keys to scroll through the different data blocks. The most negative number being the oldest stored block.

History Code

This function identifies which DTCs are stored within each history block. This information is available in two ways. Stored Codes lists the block number and all DTCs stored in that block by number only. Enhanced Codes provides the DTC numbers and a description of the DTCs stored in the block.

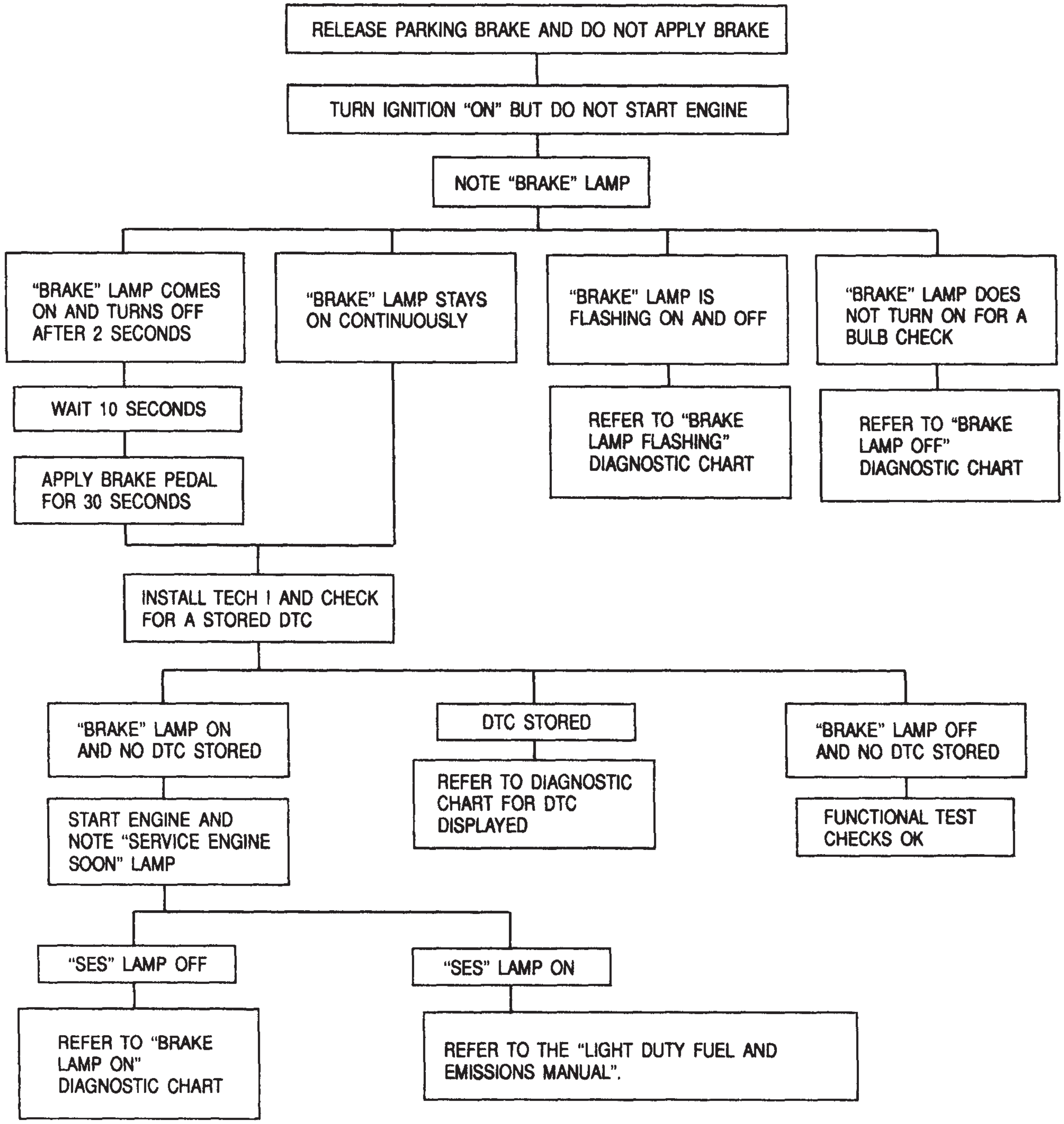
1. Select HISTORY CODE by pressing F2.
2. Select F0 for stored codes or F1 for enhanced codes.
3. The Tech 1 will prompt you to turn the ignition switch "OFF" then "ON."
4. The display will show the block number and code information.

Tire Size Cal

This function has two options; read tire size cal and new tire size cal. Read tire size cal allows you to read the tire size calibration stored in the BPMV module. New tire size cal allows you to program a new tire size calibration into the BPMV module. Only predetermined tire sizes can be selected.

1. Select TIRE SIZE CAL by pressing F3.
2. Use the arrow keys to scroll the available tire size options.
3. The arrow symbol indicates the current selected size.
4. After you select the correct size, press the ENTER key to program the new tire size calibration.

FUNCTIONAL TEST



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DIAGNOSTIC TROUBLE CODE AND SYMPTOM TABLE

Diagnostic Trouble Code	Description/Symptom	Page #
—	Brake Lamp On	5E3-10
—	Intermittent Brake Lamp	5E3-11
—	Brake Lamp Flashing	5E3-11
—	Brake Lamp Off	5E3-12
2	Open Isolation Solenoid or VCM Malfunction	5E3-14
3	Open Dump Solenoid or VCM Malfunction	5E3-16
4	Grounded Antilock Pressure Valve Reset Switch	5E3-18
5	Excessive Dump Valve Actuations During an Antilock Stop	5E3-20
6	Erratic Speed Sensor Signal	5E3-22
7	Shorted Isolation Solenoid or VCM Malfunction	5E3-24
8	Shorted Dump Solenoid or VCM Malfunction	5E3-26
9	Open or Grounded Speed Sensor Circuit	5E3-28
10	Brake Switch Circuit	5E3-30
17	Brake Enable Relay Circuit	5E3-32

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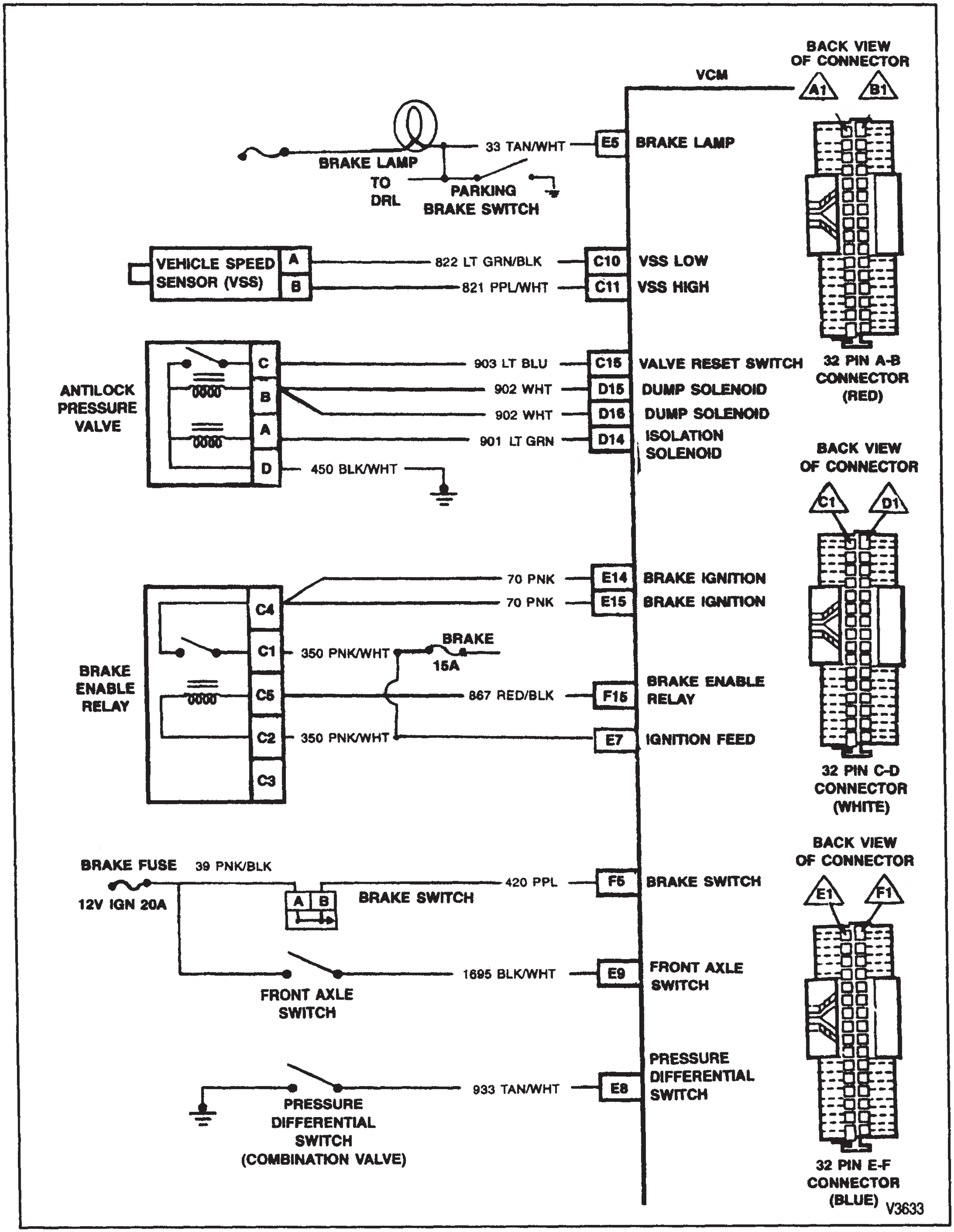
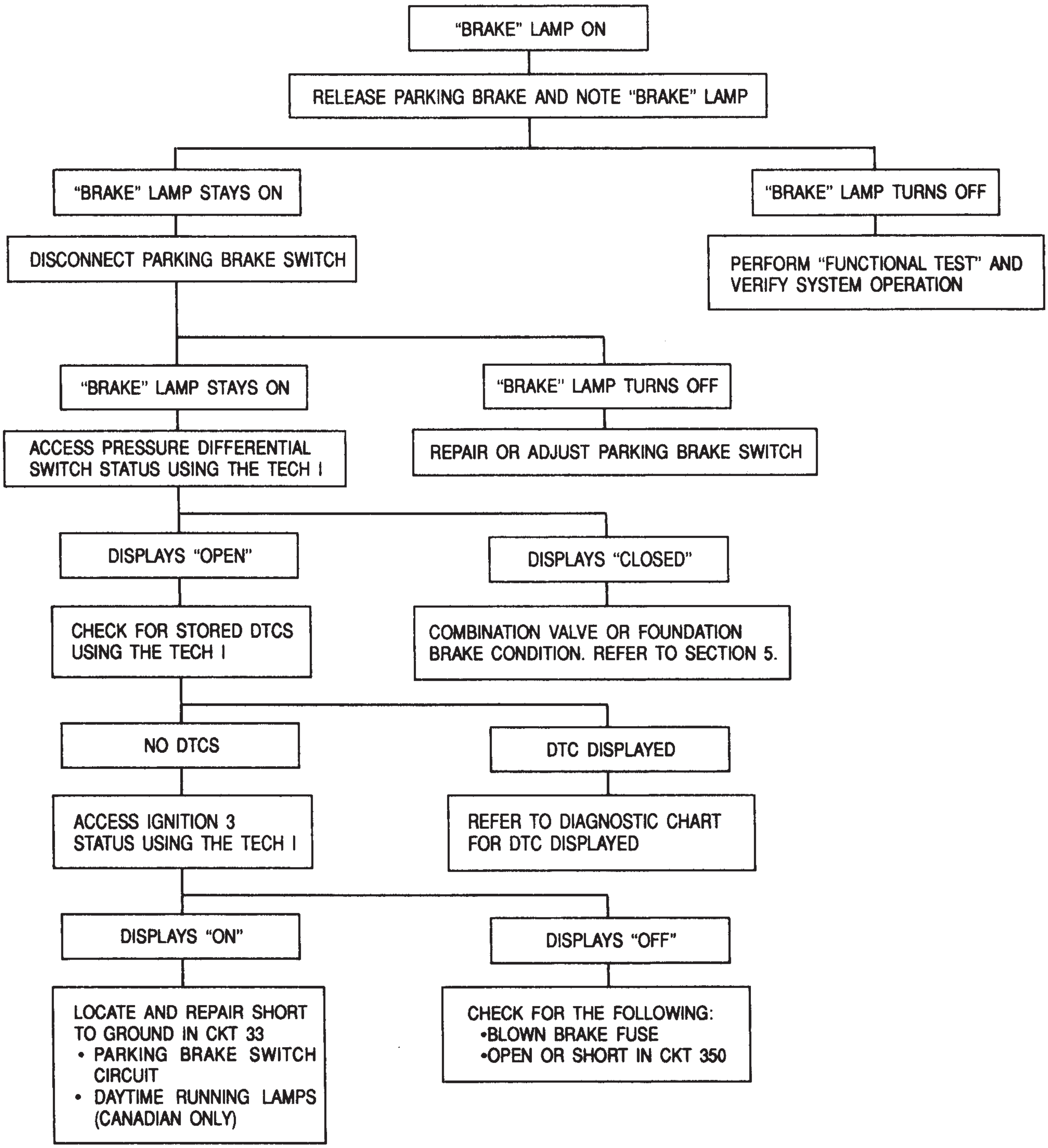


Figure 5—Wiring Diagram

BRAKE LAMP ON



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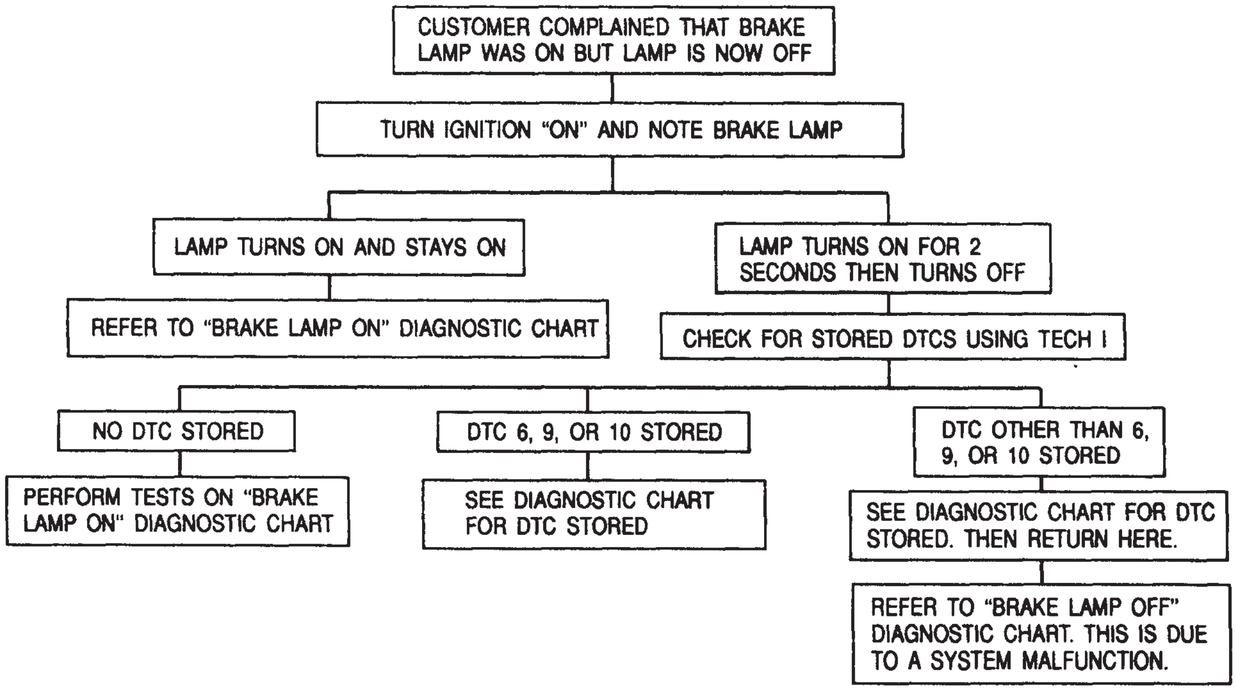
INTERMITTENT BRAKE LAMP



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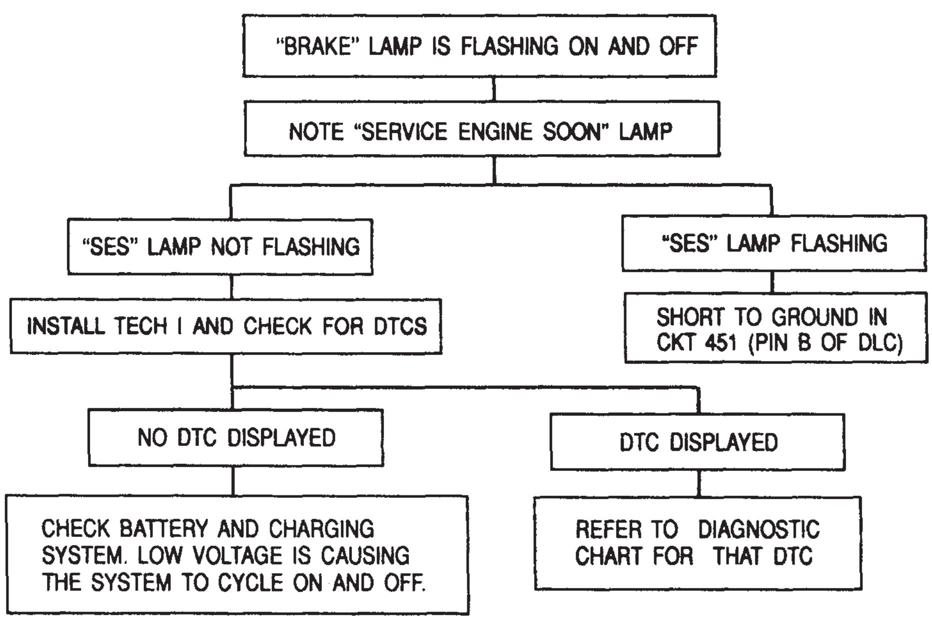
BRAKE LAMP FLASHING



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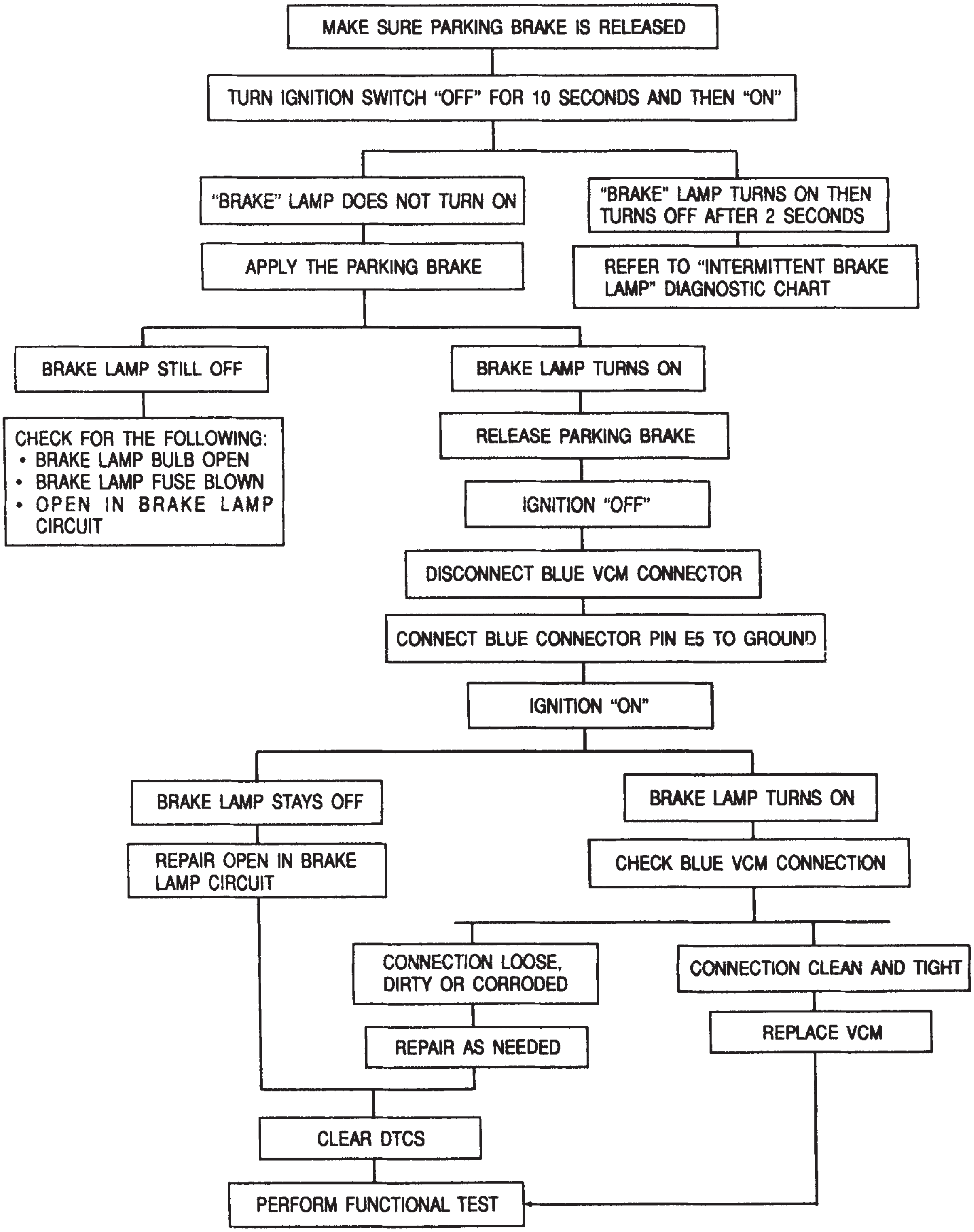
BRAKE LAMP OFF



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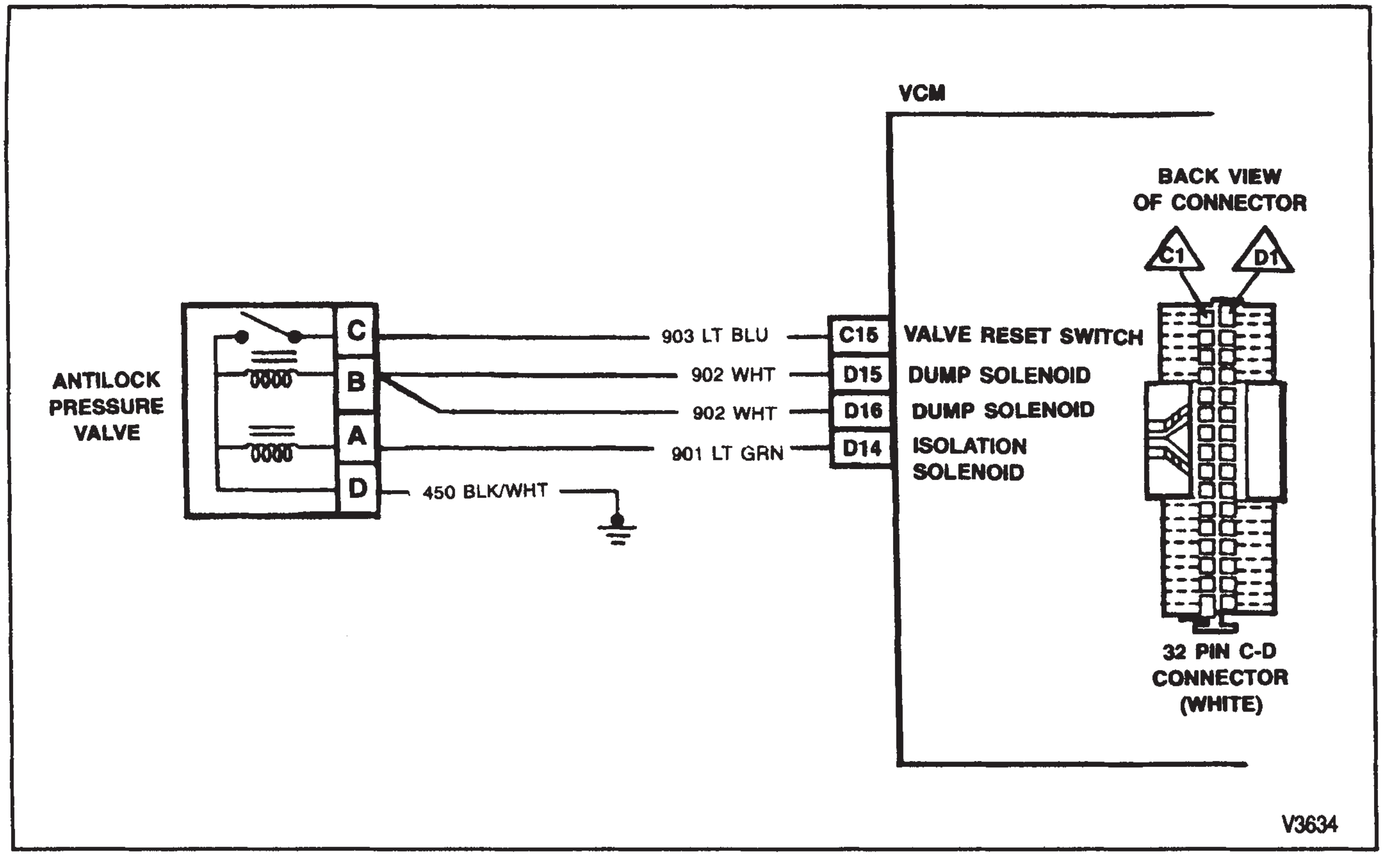


DIAGNOSTIC TROUBLE CODE 2
OPEN ISOLATION SOLENOID OR VCM MALFUNCTION

CIRCUIT DESCRIPTION:

A DTC 2 relates to an open in the APV isolation valve circuit. The VCM uses the isolation valve to maintain and increase pressure in the brake pipes during an antilock stop. An open in the solenoid winding or circuit prevents the VCM from controlling the rear wheels when a speed decrease is detected.

TEST DESCRIPTION:

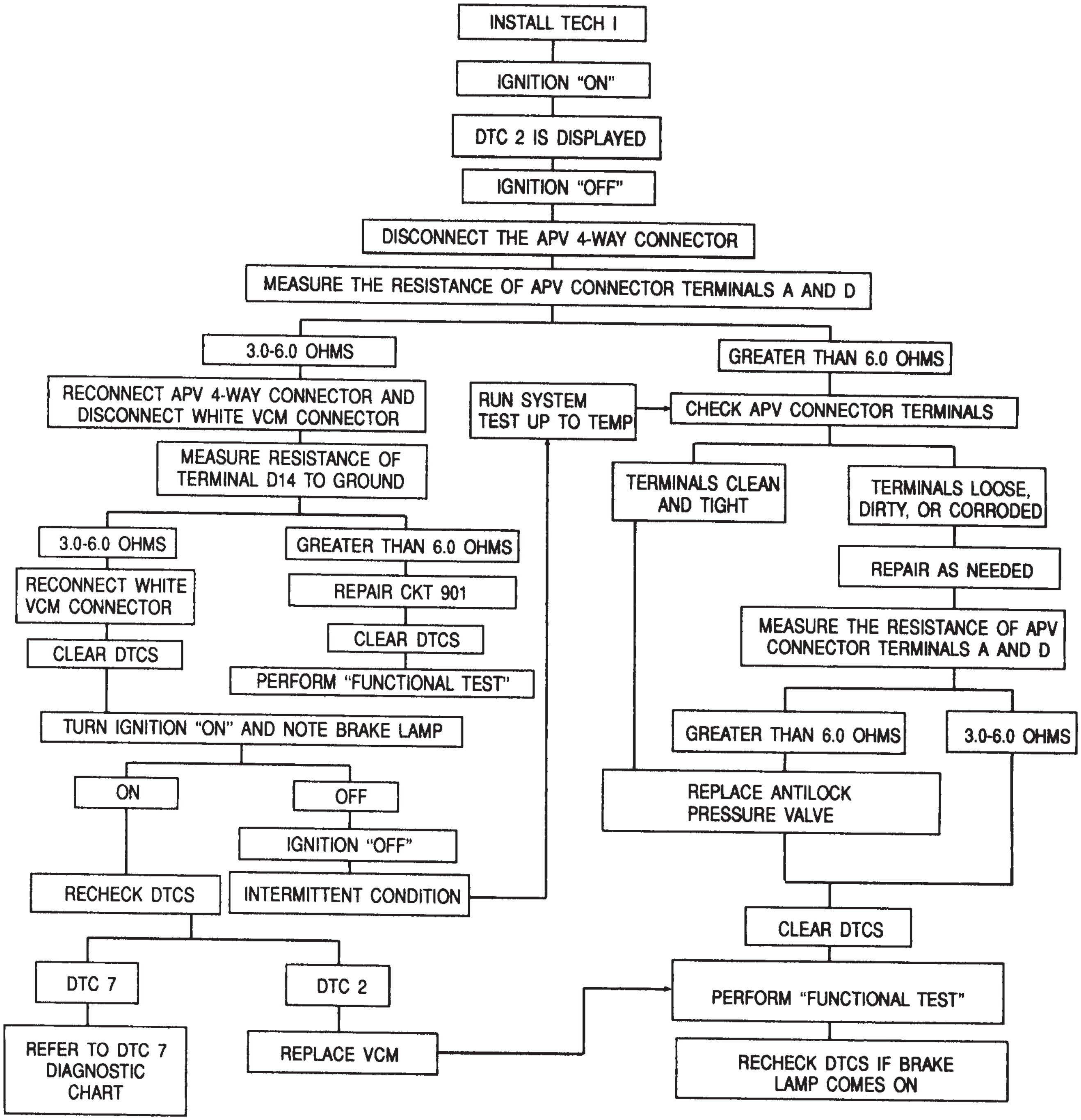
- Check for continuity through the isolation solenoid winding.
- Check for continuity to the VCM.
- Check for a consistent DTC being set.
- Check for corrosion or poor contact in the solenoid electrical terminals.
- Check the resistance of the solenoid after the terminal repair to see if it corrected the open condition.

DIAGNOSTIC AIDS:

A DTC 2 will set if the 4-way connector is disconnected and the ignition switch is turned on or the 6-way connector is plugged in before the 4-way connector with the ignition switch on.

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 2
OPEN ISOLATION SOLENOID OR VCM MALFUNCTION



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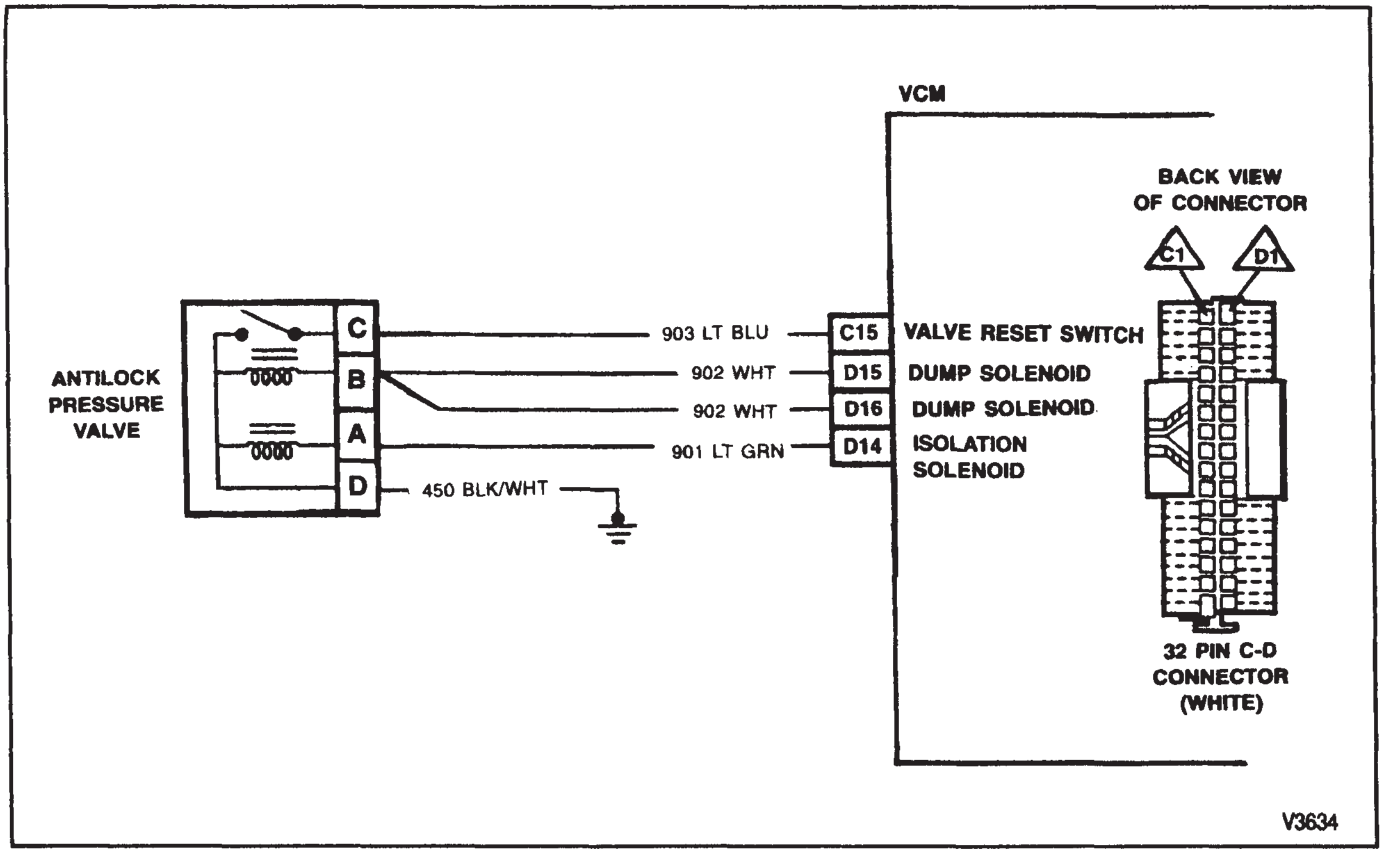


DIAGNOSTIC TROUBLE CODE 3
OPEN DUMP SOLENOID OR VCM MALFUNCTION

CIRCUIT DESCRIPTION:

A DTC 3 relates to an open in the APV dump valve circuit. The VCM uses the dump valve to reduce fluid pressure in the rear brake pipes and hoses when it senses the wheel is locking up. The fluid pressure is routed to the accumulator in the APV. An open dump solenoid prevents the VCM from reducing the pressure and the wheel will continue to lock up.

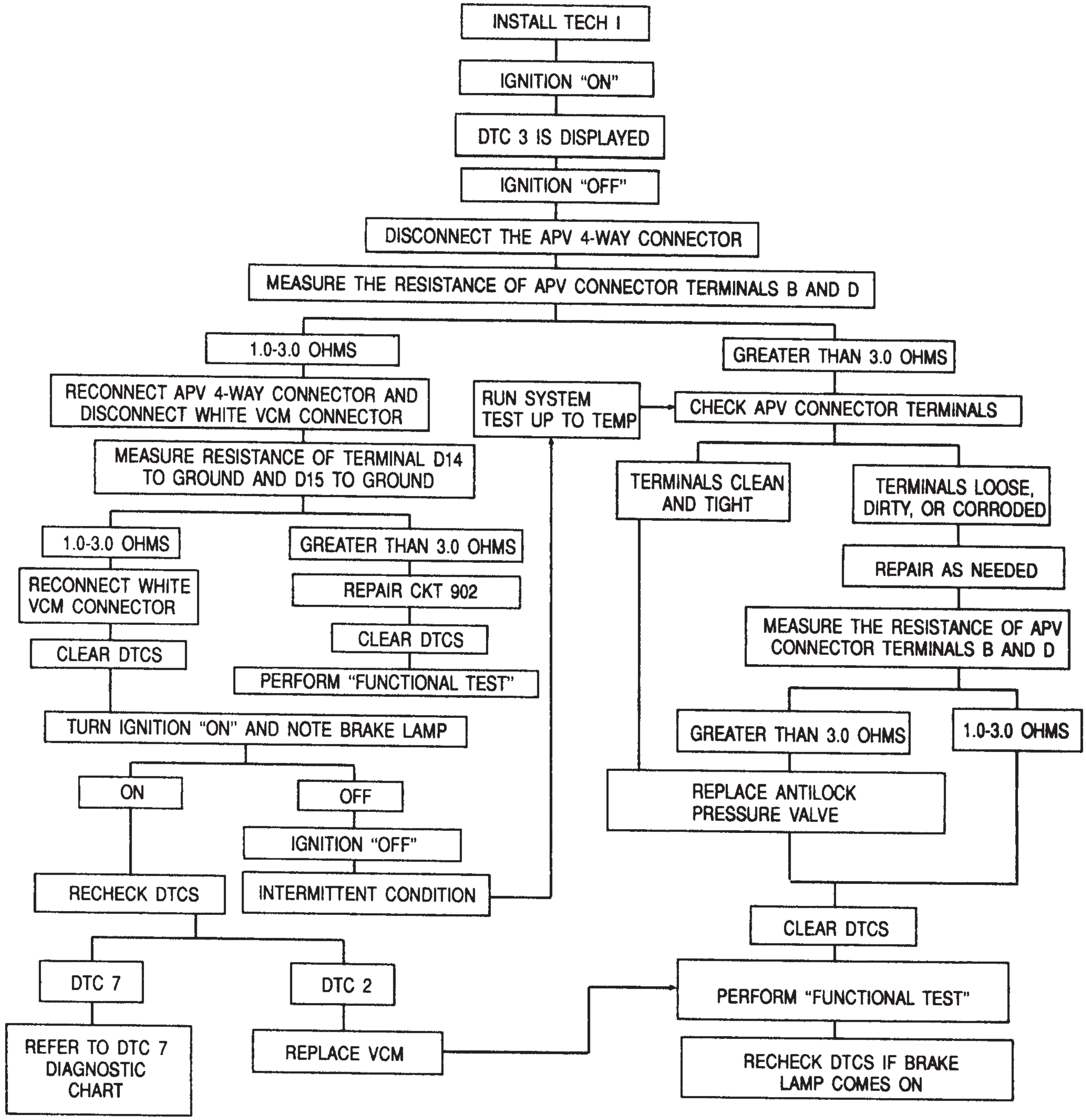
TEST DESCRIPTION:

- Check for continuity through the dump solenoid winding.
- Check for continuity to the VCM.
- Check for a consistent DTC being set after clearing the memory.
- Check for corrosion or poor contact in the solenoid electrical terminals.
- Check the resistance of the solenoid after the terminal repair to see if it corrected the open condition.

DIAGNOSTIC AIDS:

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 3
OPEN DUMP SOLENOID OR VCM MALFUNCTION



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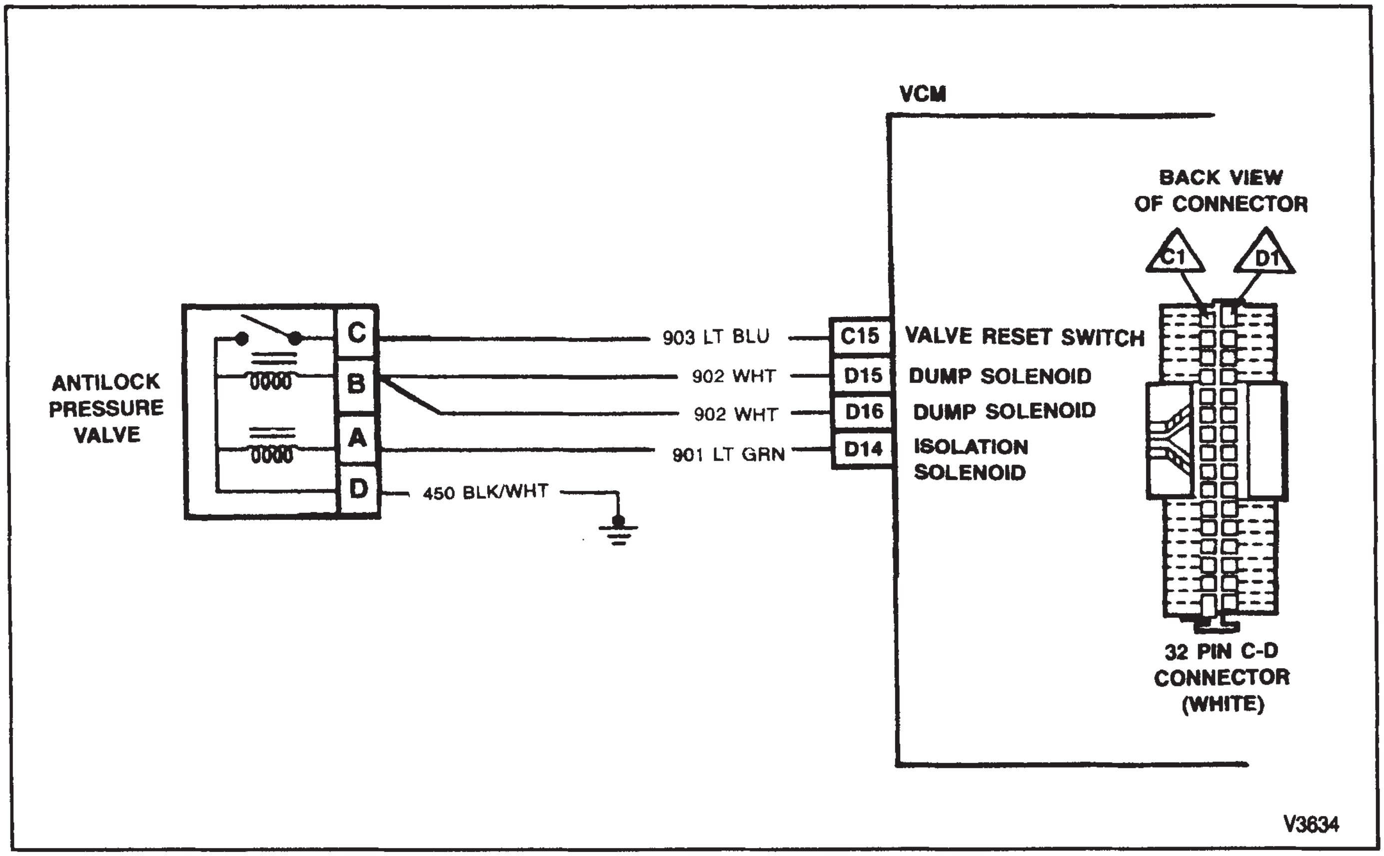


DIAGNOSTIC TROUBLE CODE 4 GROUNDED ANTILOCK PRESSURE VALVE RESET SWITCH

CIRCUIT DESCRIPTION:

A DTC 4 relates to a grounded condition in the APV reset switch. The reset switch grounds CKT 903 when there is a great enough difference between inlet and outlet pressure in the APV. An example of this is during a pressure decrease operation. With a grounded reset switch, the VCM has no way of determining if pressure changes are occurring in the APV. The reset switch is constantly signaling that pressure decrease has occurred. This DTC is set when the reset switch is signalling a pressure decrease operation while the antilock function is inactive.

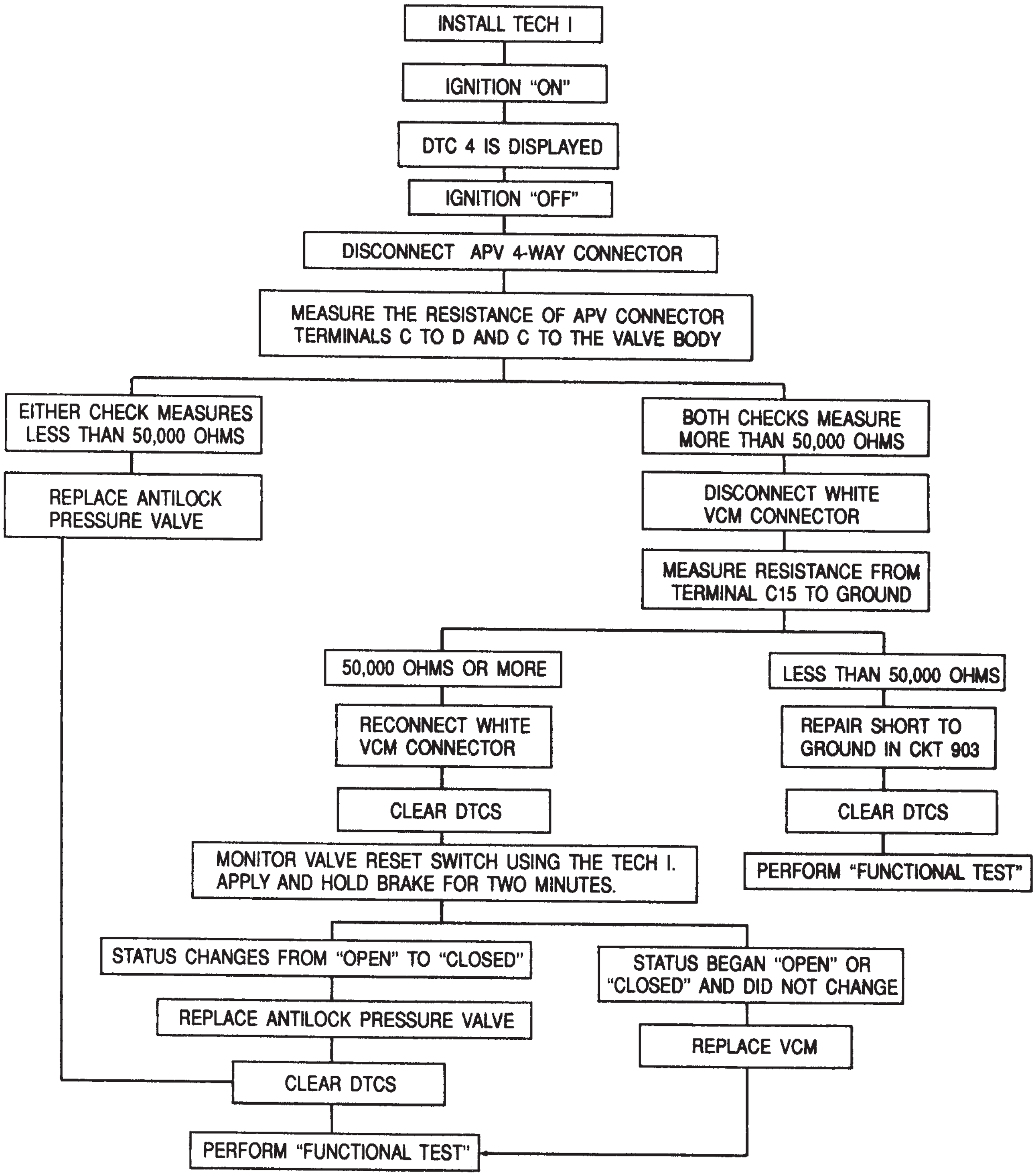
TEST DESCRIPTION:

- Check the continuity of the reset switch and check for an internal short to ground.
- Check the continuity of CKT 903 to the VCM.
- Check reset switch operation using the Tech 1.

DIAGNOSTIC AIDS:

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 4
GROUNDED ANTILOCK PRESSURE VALVE RESET SWITCH



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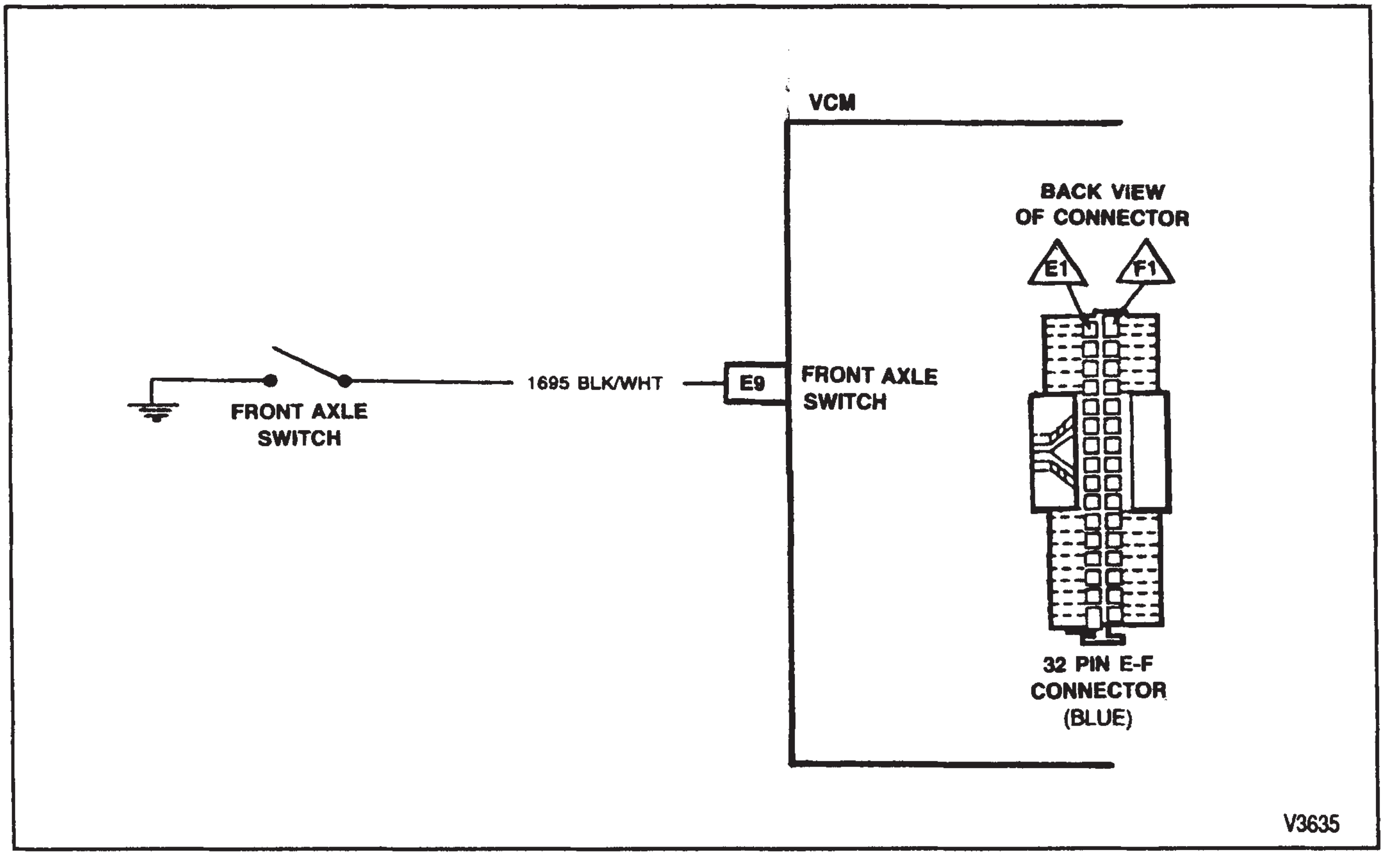


DIAGNOSTIC TROUBLE CODE 5 EXCESSIVE DUMP VALVE ACTUATIONS DURING AN ANTILOCK STOP

CIRCUIT DESCRIPTION:

A DTC 5 relates to a condition where the VCM is having to cycle the dump valve too many times during an antilock stop. This DTC is set if the VCM has to cycle the dump valve more than 16 times during a braking maneuver. A mechanical locking condition in the rear brakes or powertrain can cause this DTC to set. This DTC can also be set if the RWAL system is working with the vehicle in 4WD.

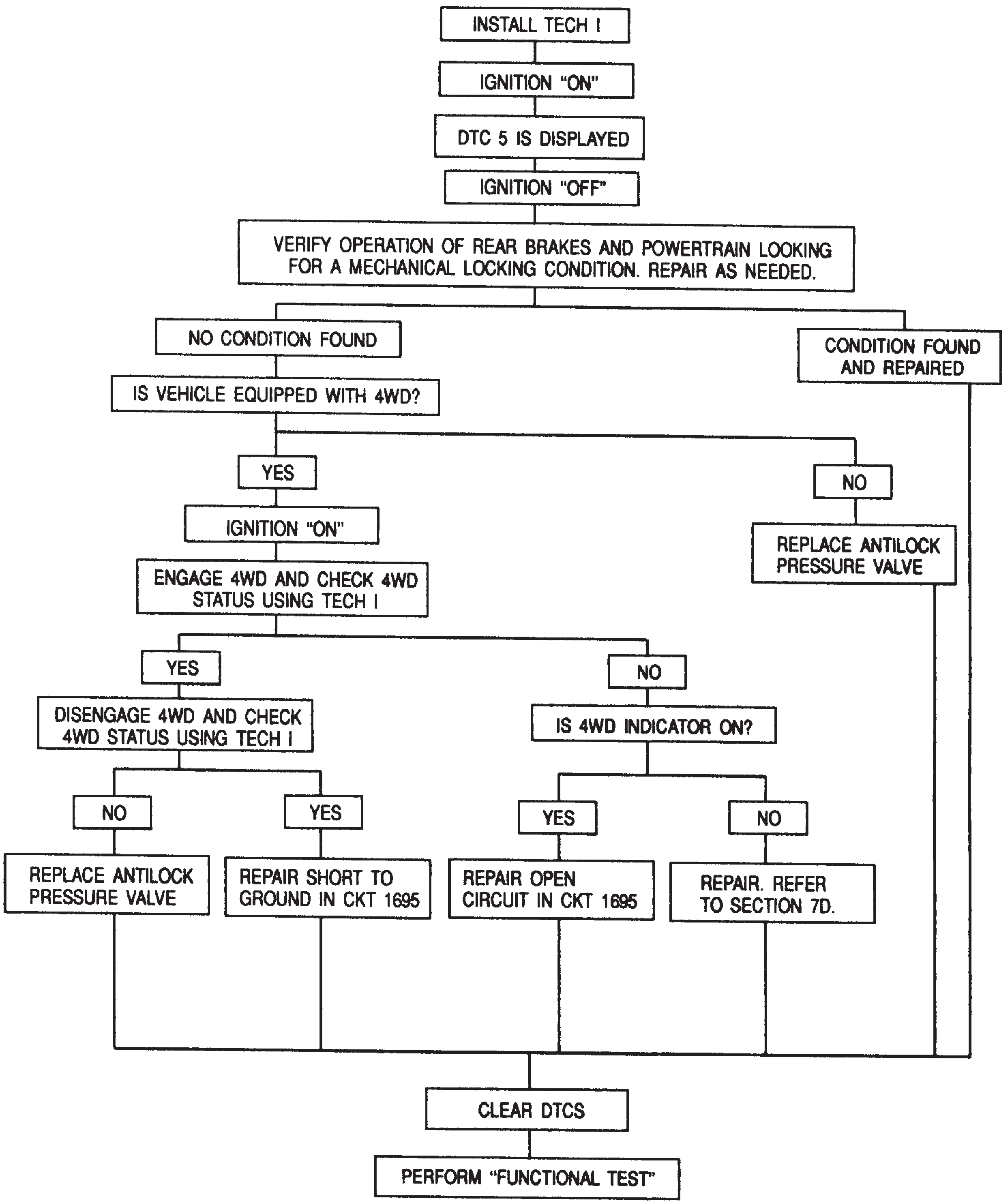
TEST DESCRIPTION:

- Check if the rear brakes or powertrain are causing the malfunction.
- This test only applies to vehicles with 4WD. Check if the front axle switch can turn on the 4WD indicator on the instrument cluster.
- Check 4WD status using the Tech 1.

DIAGNOSTIC AIDS:

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 5
EXCESSIVE DUMP VALVE ACTUATIONS DURING AN ANTILOCK STOP



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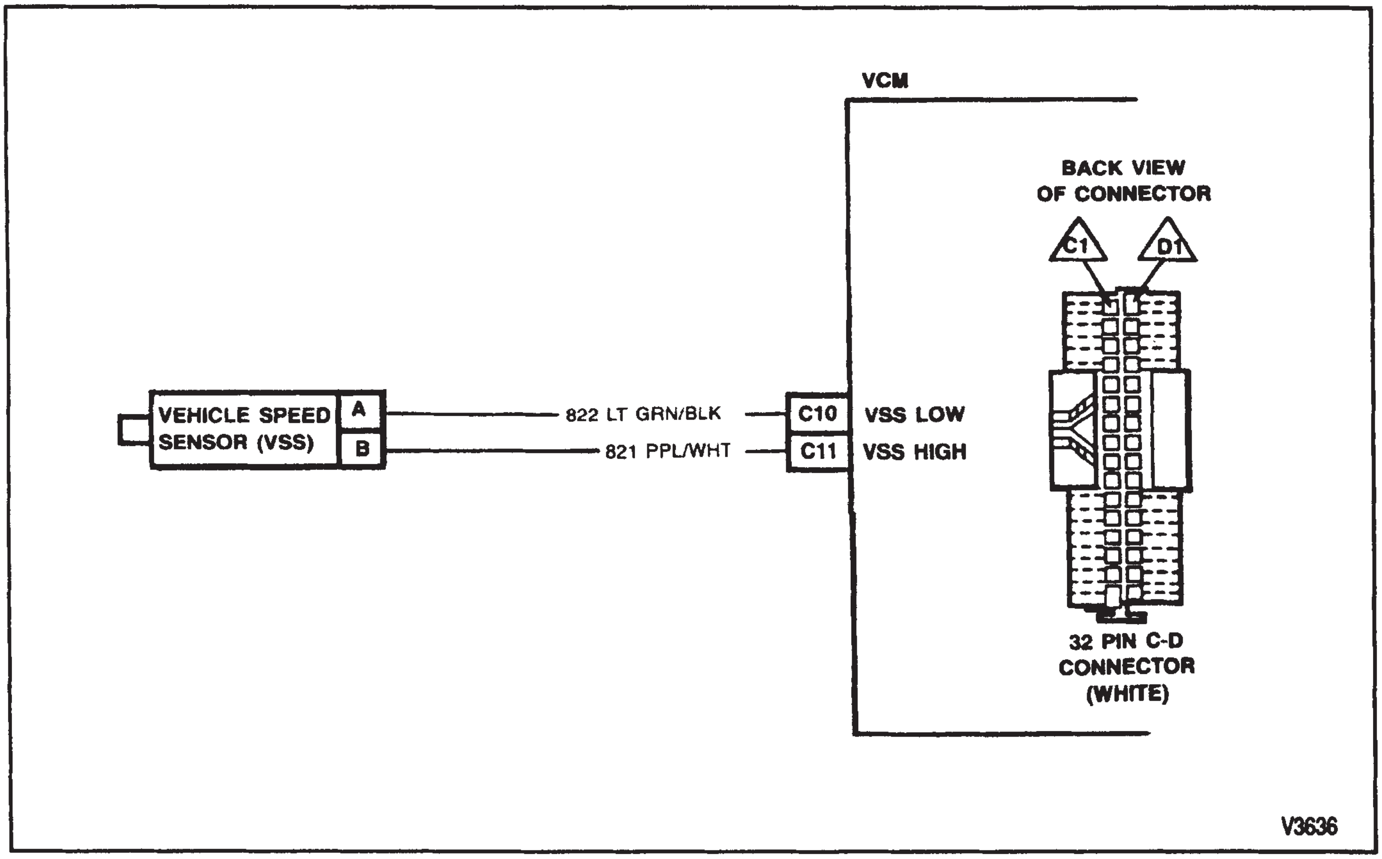


DIAGNOSTIC TROUBLE CODE 6
ERRATIC SPEED SENSOR SIGNAL

CIRCUIT DESCRIPTION:

A DTC 6 is a soft fault. If the speed sensor signal to the VCM drops out and returns often, this DTC is set in memory. The BRAKE lamp will illuminate when the DTC is set and turn off with the next ignition cycle. **Do not replace the VCM to repair this DTC.** An erratic speed signal relates to a malfunction in the VSS or speed sensor circuit. It can be set by a poor connection in the speed sensor circuit.

TEST DESCRIPTION:

- Check if all systems are receiving an erratic speed signal or if it is just the RWAL system.
- Check the VSS output using the Tech 1.
- Check the resistance of the VSS.
- Check for an open condition in CKT 821 and 822.

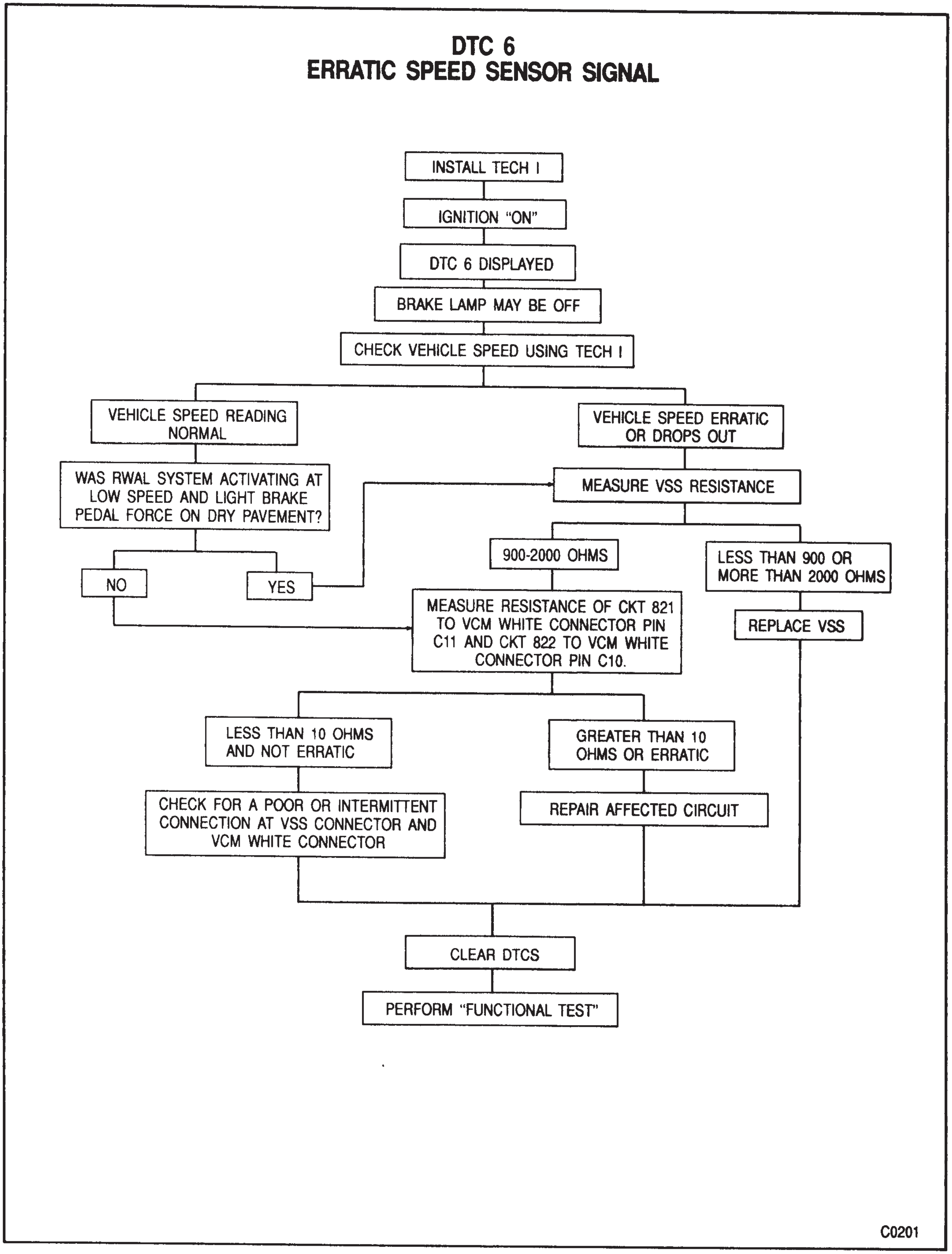
DIAGNOSTIC AIDS:

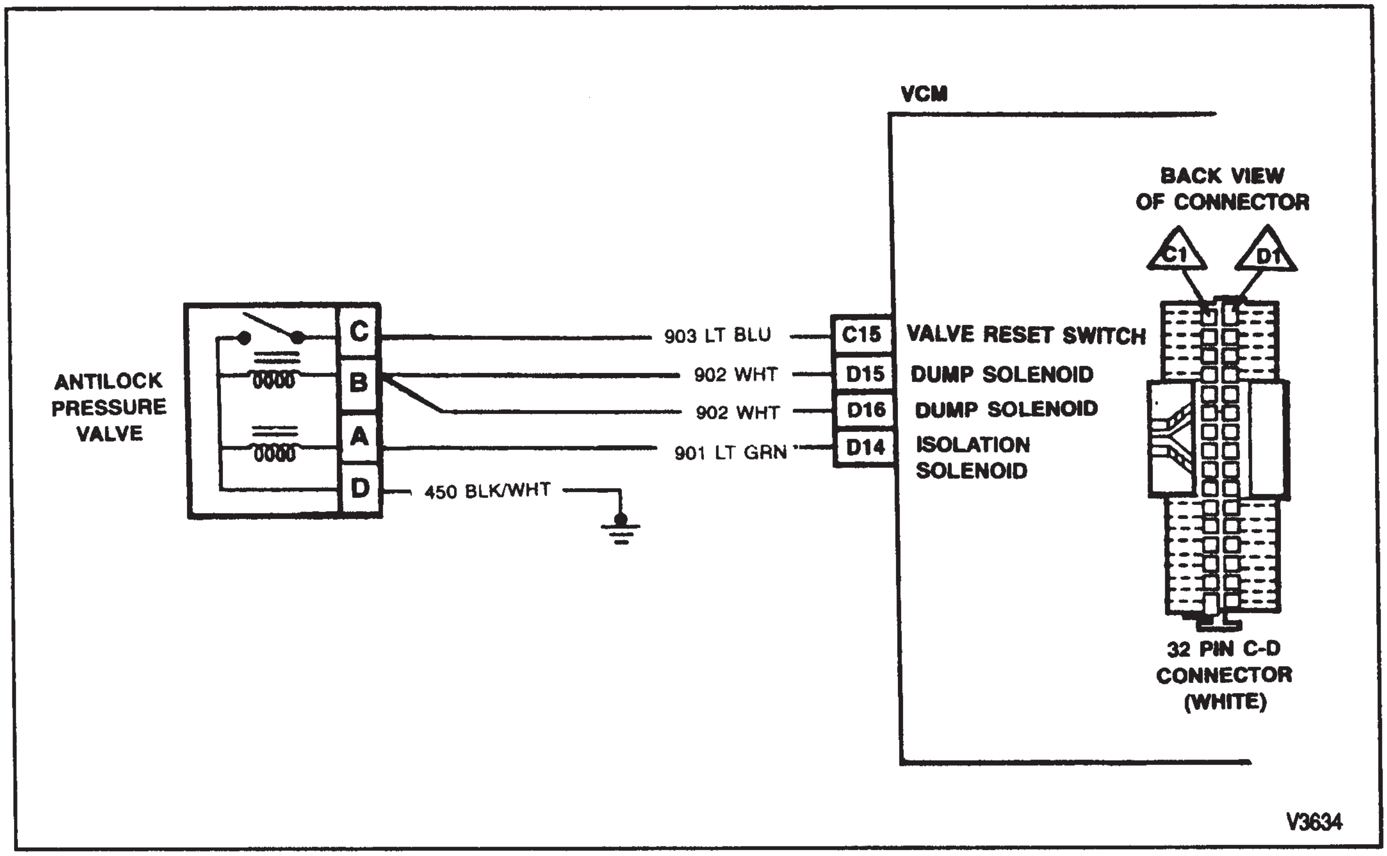
Do not replace the VCM for this DTC. A VCM malfunction will not cause this DTC to set.

If the voltage readings are low or varying, the battery, charging system, or intermittent connections could be the cause. Check these areas before replacing any components.

This DTC is a soft fault and can be set with a 2WD transmission on ice wheel spins.

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.


DTC 6
ERRATIC SPEED SENSOR SIGNAL
INSTALL TECH I
IGNITION "ON"
DTC 6 DISPLAYED
BRAKE LAMP MAY BE OFF
CHECK VEHICLE SPEED USING TECH I
VEHICLE SPEED READING NORMAL
VEHICLE SPEED ERRATIC OR DROPS OUT
WAS RWAL SYSTEM ACTIVATING AT LOW SPEED AND LIGHT BRAKE PEDAL FORCE ON DRY PAVEMENT?
MEASURE VSS RESISTANCE
NO
YES
900-2000 OHMS
LESS THAN 900 OR MORE THAN 2000 OHMS
MEASURE RESISTANCE OF CKT 821 TO VCM WHITE CONNECTOR PIN C11 AND CKT 822 TO VCM WHITE CONNECTOR PIN C10.
REPLACE VSS
LESS THAN 10 OHMS AND NOT ERRATIC
GREATER THAN 10 OHMS OR ERRATIC
CHECK FOR A POOR OR INTERMITTENT CONNECTION AT VSS CONNECTOR AND VCM WHITE CONNECTOR
REPAIR AFFECTED CIRCUIT
CLEAR DTCS
PERFORM "FUNCTIONAL TEST"
C0201



DIAGNOSTIC TROUBLE CODE 7 SHORTED ISOLATION SOLENOID OR VCM MALFUNCTION

CIRCUIT DESCRIPTION:

A DTC 7 sets when the VCM detects a short in the isolation valve solenoid or circuit. With the isolation valve shorted the VCM cannot provide any of the pressure control functions. The short can be located in the APV, VCM, or circuit between them.

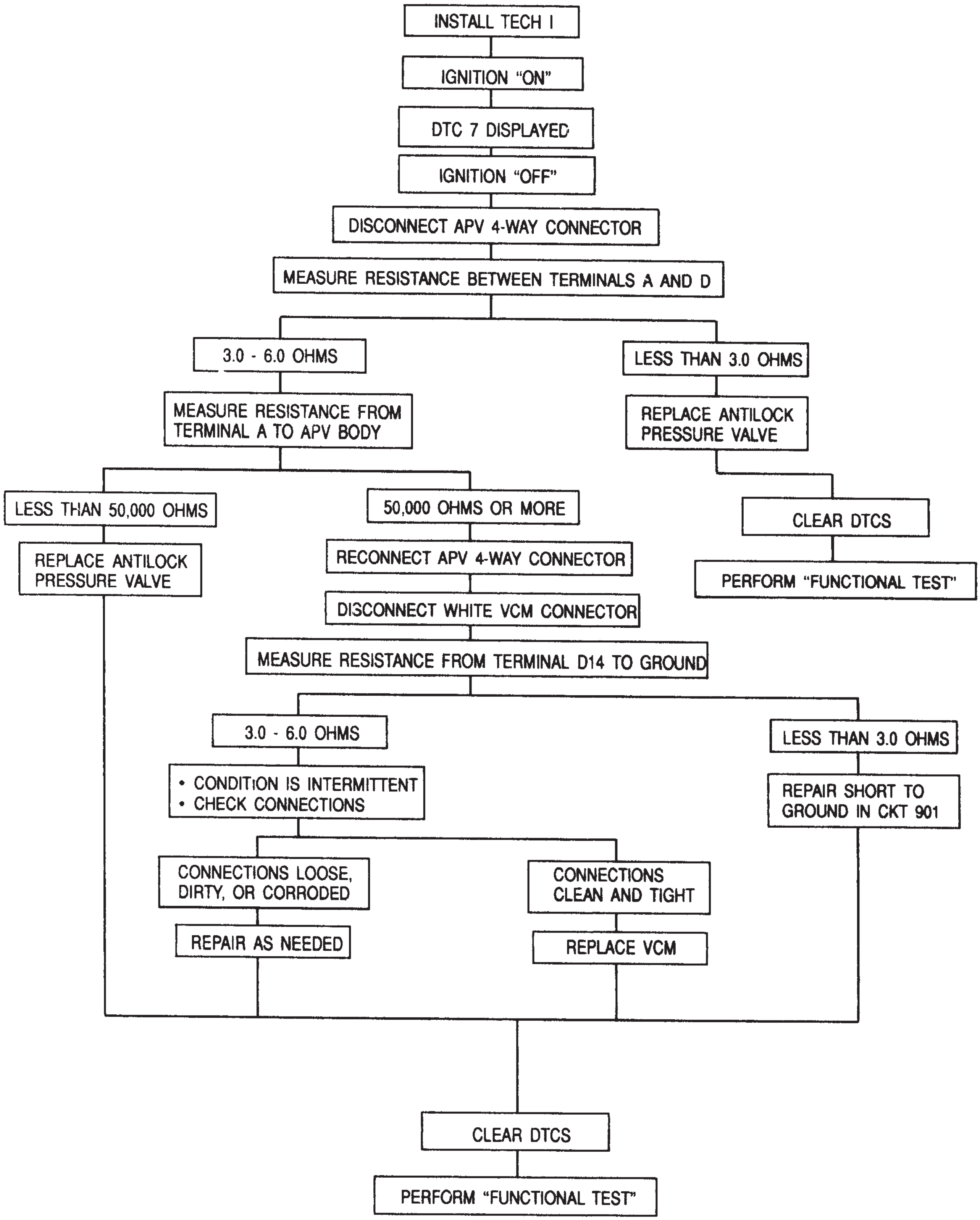
TEST DESCRIPTION:

- Check the resistance of the isolation solenoid winding.
- Check for a short to ground in the APV.
- Check for continuity to the VCM.
- Check if the connector repair corrected the condition.

DIAGNOSTIC AIDS:

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 7
SHORTED ISOLATION SOLENOID OR VCM MALFUNCTION



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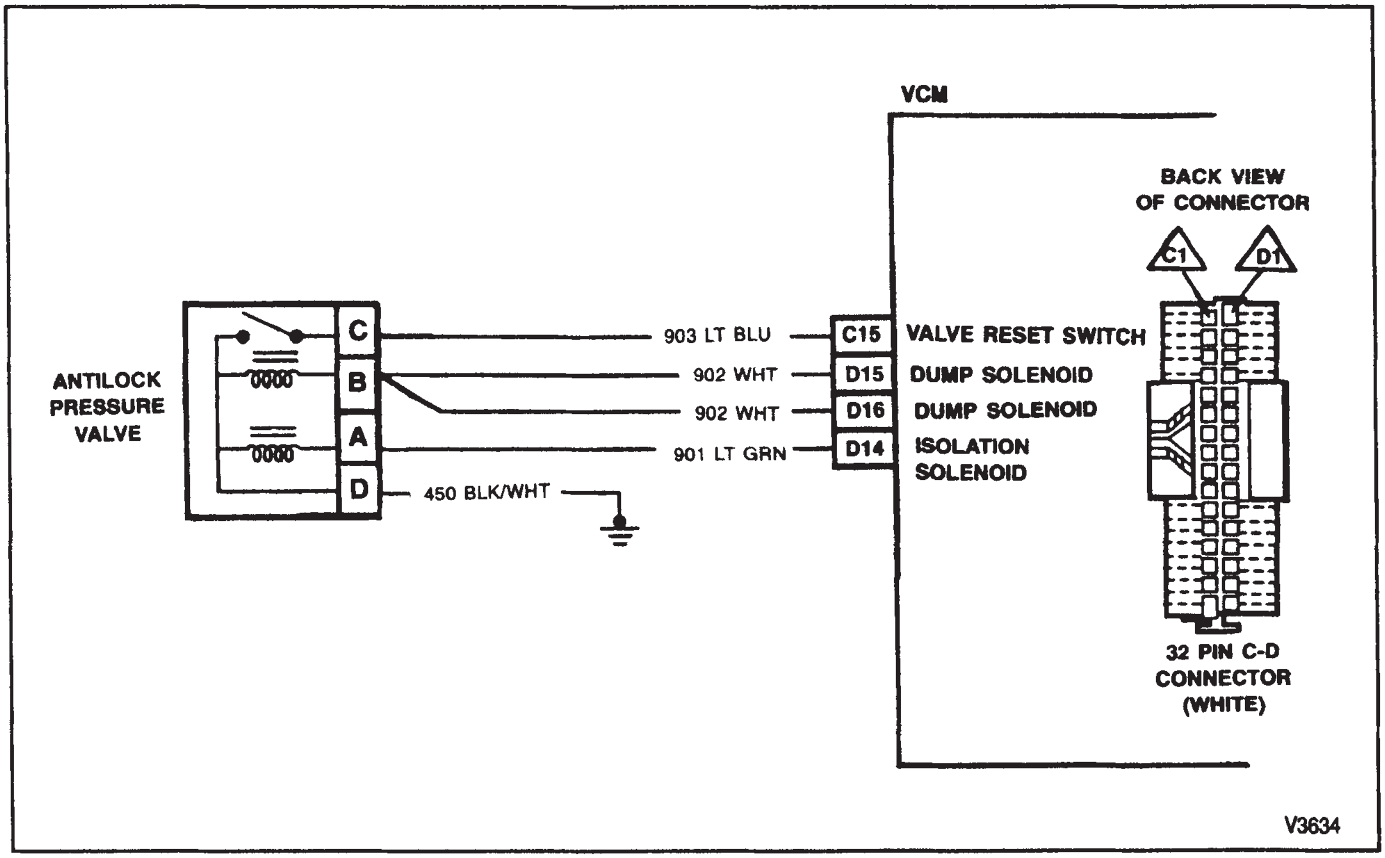


DIAGNOSTIC TROUBLE CODE 8
SHORTED DUMP SOLENOID OR VCM MALFUNCTION

CIRCUIT DESCRIPTION:

A DTC 8 sets when the VCM detects a short in the dump valve solenoid or circuit. Without the use of the dump valve, the VCM cannot allow a pressure decrease or relieve the brake fluid in the accumulator. This DTC can be caused by a short in the APV, VCM, or circuit between them.

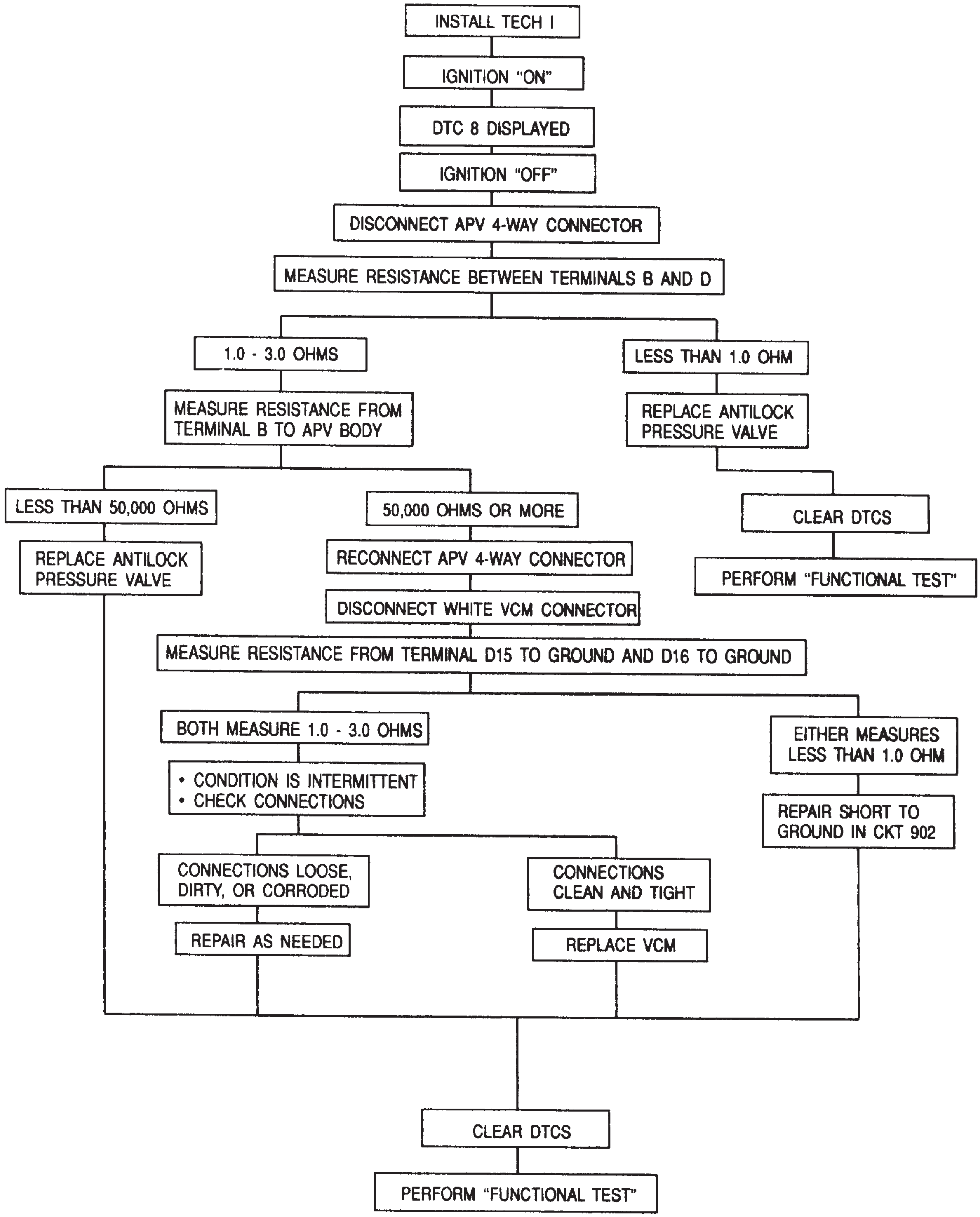
TEST DESCRIPTION:

- Check the resistance of the dump solenoid winding.
- Check for a short to ground in the APV.
- Check for continuity to the VCM.
- Check if the connector repair corrected the condition.

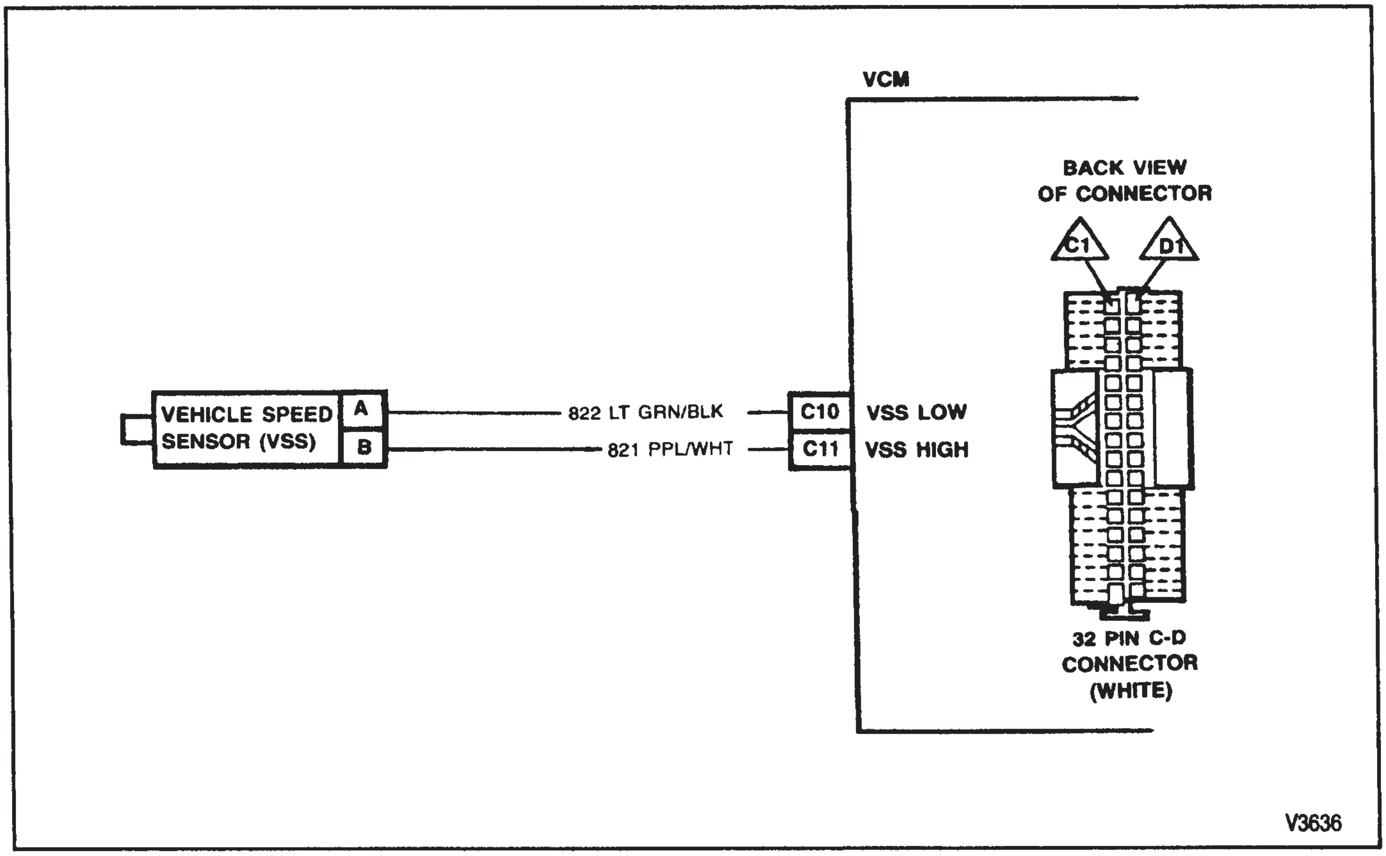
DIAGNOSTIC AIDS:

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 8
SHORTED DUMP SOLENOID OR VCM MALFUNCTION



C0203



DIAGNOSTIC TROUBLE CODE 9
VEHICLE SPEED SENSOR INPUT MISSING

CIRCUIT DESCRIPTION:

A DTC 9 is a soft fault. If the VSS signal to the VCM drops to less than one mph for a minimum of five seconds while the vehicle is in cruise mode this DTC is set in memory. The BRAKE lamp will illuminate when the DTC is set and turn off with the next ignition cycle. **Do not replace the VCM to repair this DTC.** An open or grounded speed signal relates to a malfunction in the VSS or CKTs 821 and 822.

TEST DESCRIPTION:

- Check VSS output using the Tech 1.
- Check the VSS resistance value.

DIAGNOSTIC AIDS:

Do not replace the VCM for this DTC. An VCM malfunction will not cause this DTC to set.

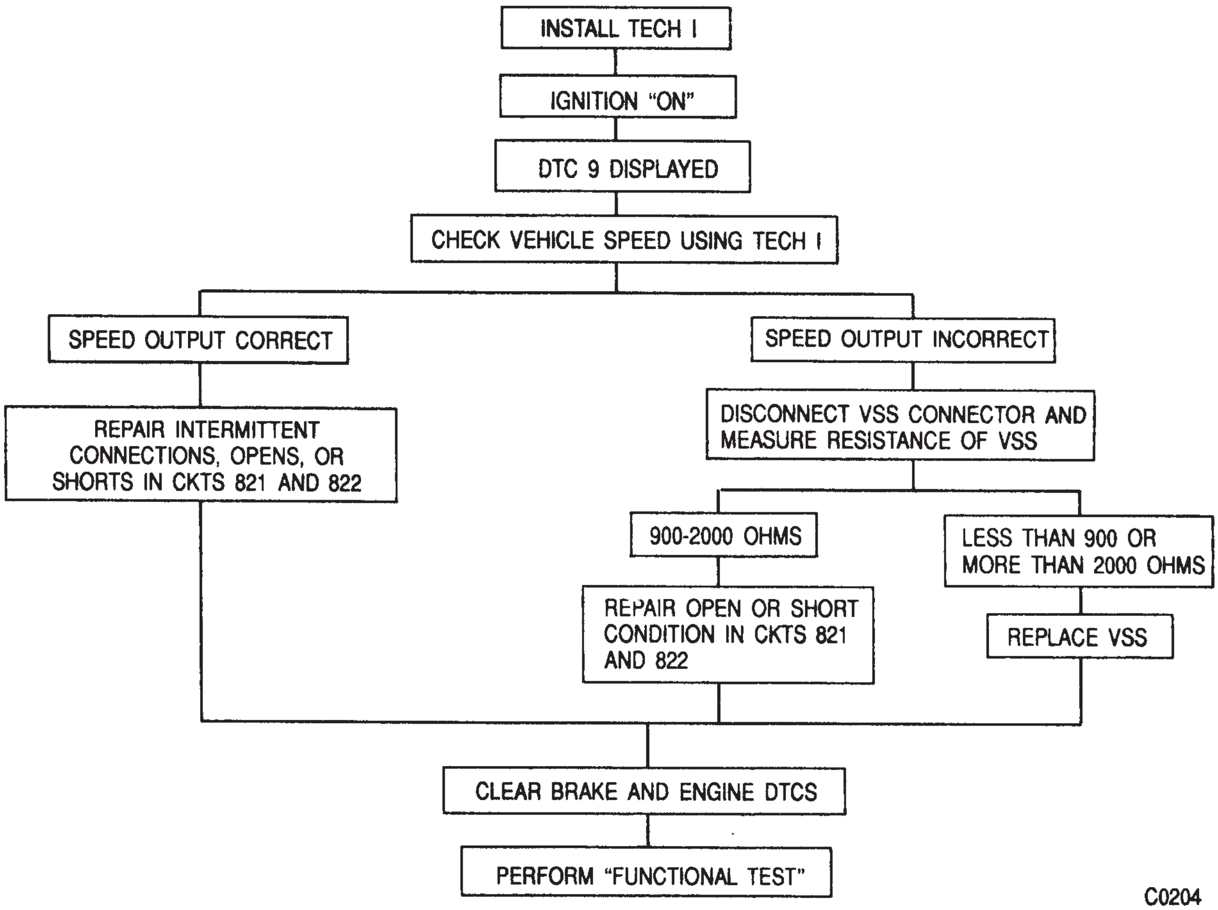
This condition can also set an engine DTC 17. This will require clearing the engine DTCs as well as the brake DTCs.

This is a soft fault that keeps the BRAKE lamp illuminated until the next ignition cycle.

If voltage readings are low or varying, the battery, charging system, or intermittent connections could be the cause. Check these areas before replacing any components.

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 9
VEHICLE SPEED SENSOR INPUT MISSING



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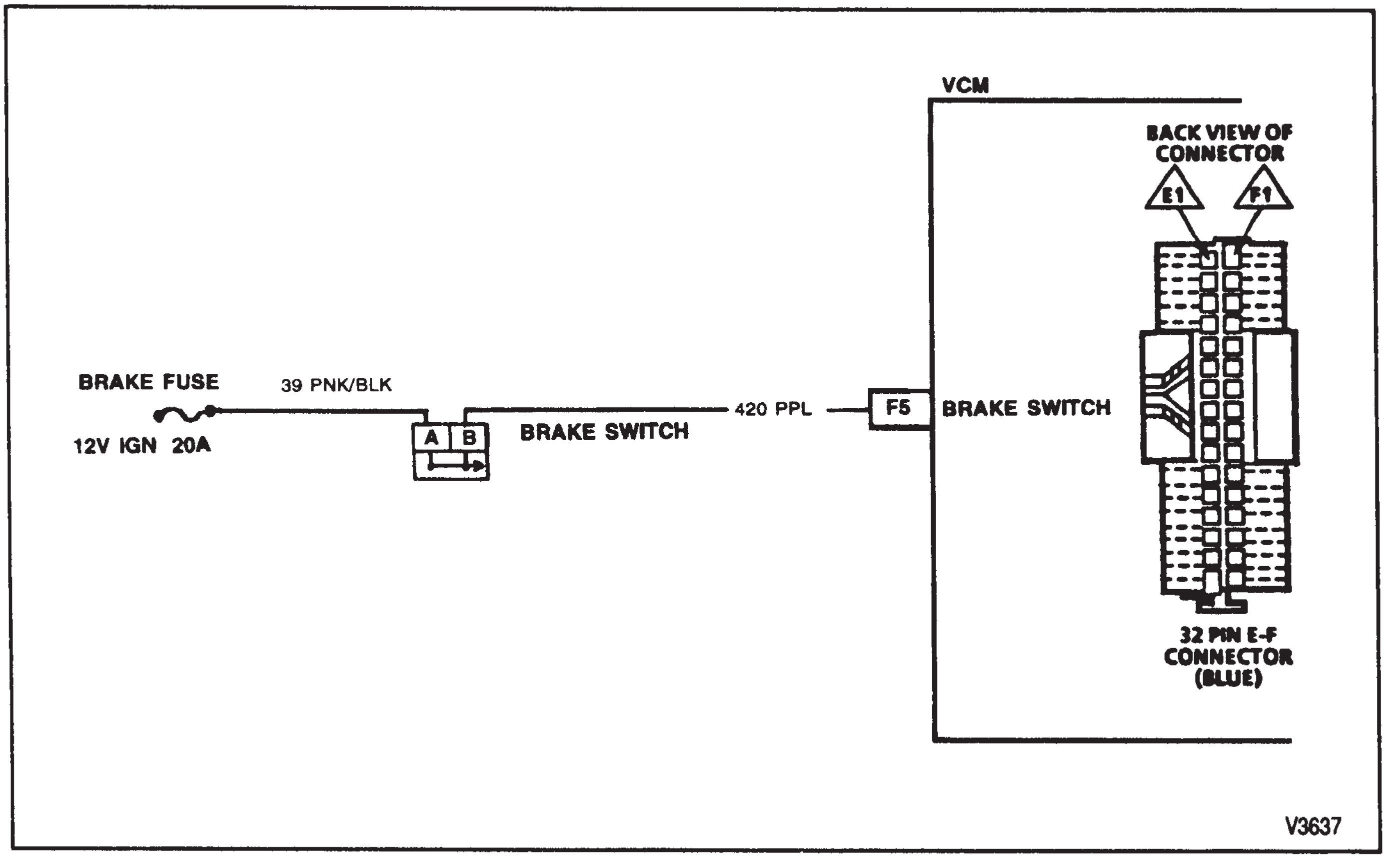


DIAGNOSTIC TROUBLE CODE 10
BRAKE SWITCH CIRCUIT

CIRCUIT DESCRIPTION:

A DTC 10 relates to the 12 volt signal in the brake switch circuit. The VCM uses this circuit to prepare for a possible antilock stop. The brake switch closes when the brake pedal is released sending 12 volts to terminal F5 of the VCM. Applying the brake pedal causes this signal to drop to less than 1 volt. When the VCM sees this drop it gets ready to control the antilock pressure valve if necessary.

TEST DESCRIPTION:

- Check brake switch status using the Tech 1.
- Check if voltage is getting through the brake switch with the brake pedal released and applied.
- Check if voltage is available to the brake switch.
- Check if voltage is reaching VCM terminal F5.
- Check the operation of the brake switch during actual driving conditions. This helps determine if the DTC is intermittent.

DIAGNOSTIC AIDS:

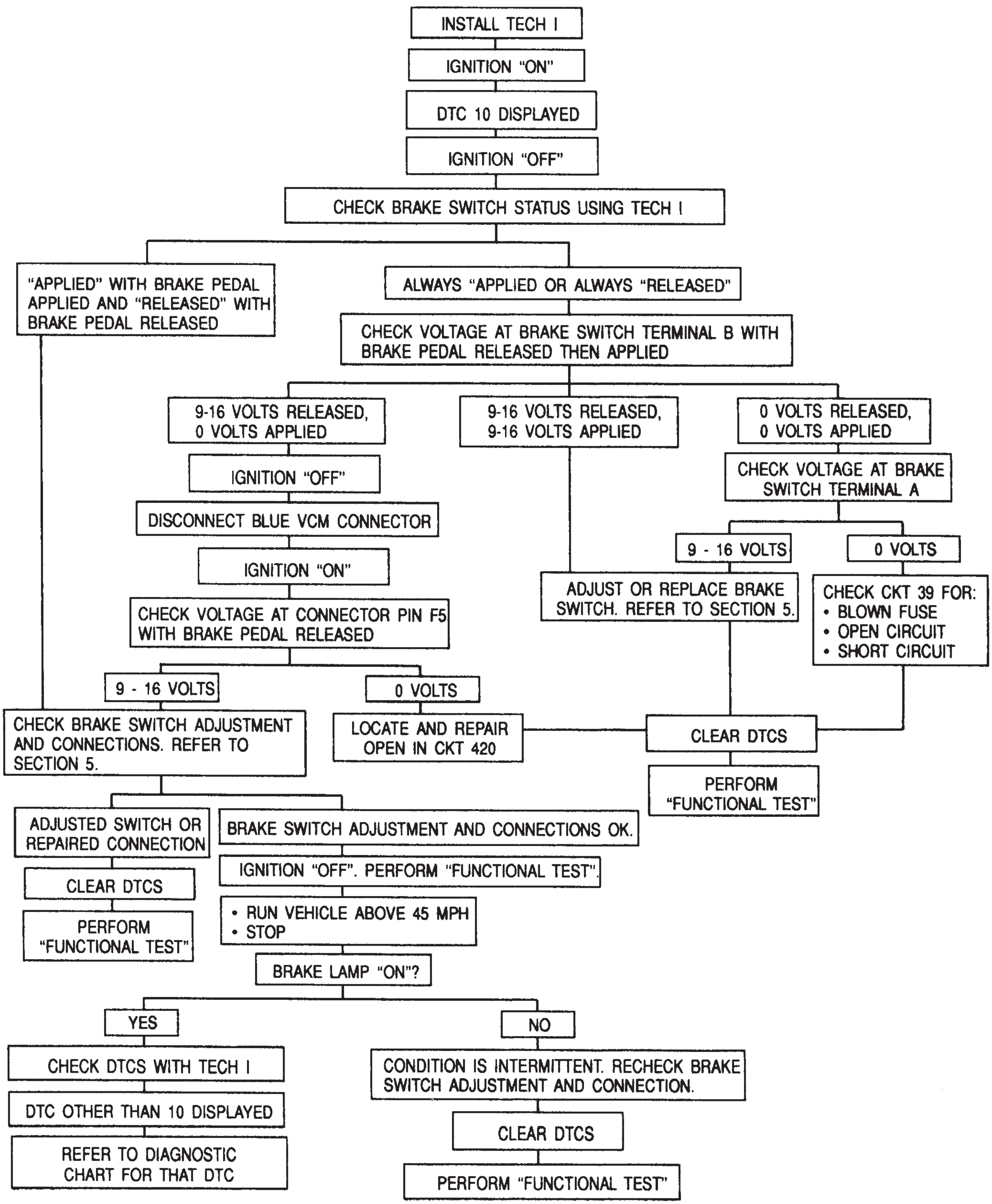
Do not replace the VCM or APV for this DTC. An VCM or APV malfunction will not cause this DTC to set.

This DTC is set when the vehicle speed reaches 37 mph or greater and there is no 12 volt signal from the brake switch.

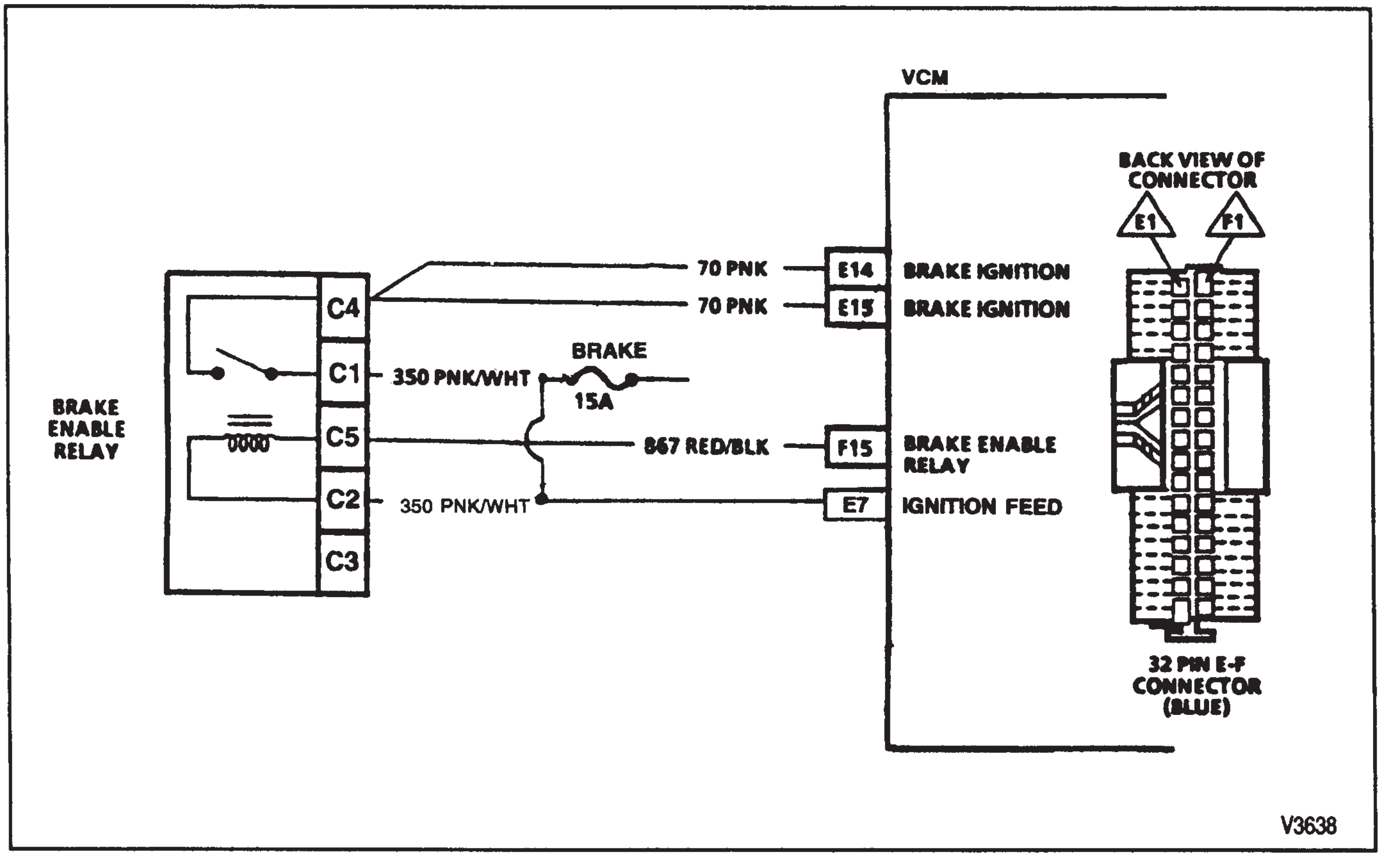
This DTC is a soft fault that turns on the BRAKE lamp until 12 volts is received from the brake switch.

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 10
BRAKE SWITCH CIRCUIT



C0205



DIAGNOSTIC TROUBLE CODE 17
BRAKE ENABLE RELAY CIRCUIT

CIRCUIT DESCRIPTION:

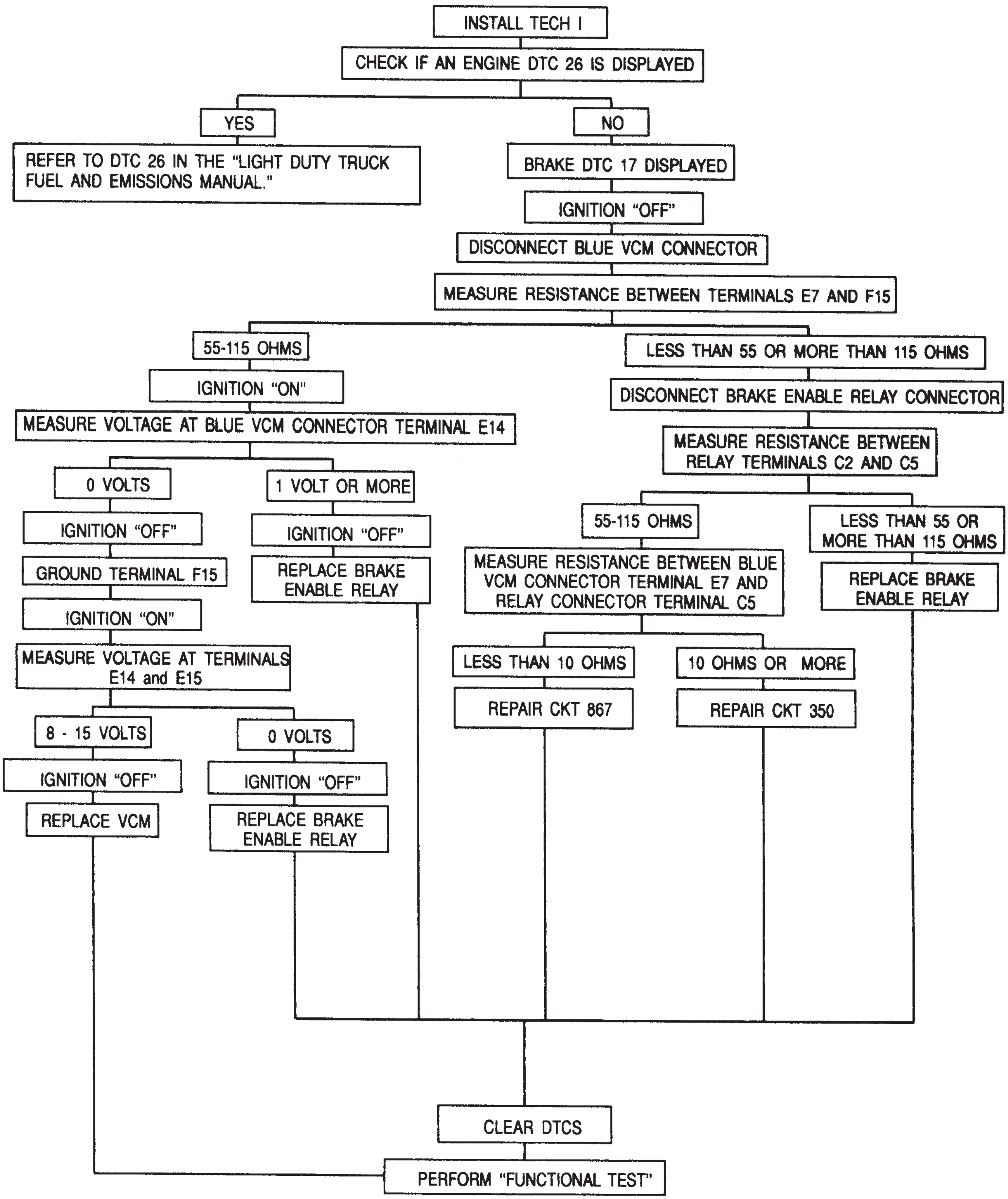
A DTC 17 relates to the function of the brake enable relay. If the VCM sees the relay constantly on, constantly off, or fluctuating between on and off, it sets this DTC in memory.

- Check if an engine DTC 26 is stored.
- Check resistance of relay solenoid winding at VCM harness.
- Check resistance of relay solenoid winding at relay.
- Check relay operation by manually grounding circuit.
- Check if relay is stuck on or off.

DIAGNOSTIC AIDS:

Do not pierce the electrical connectors, wires, seals, or insulation during testing. Doing so will break the seal and lead to corrosion and failure of the wiring and terminals.

DTC 17
BRAKE ENABLE RELAY CIRCUIT



C0206

ON-VEHICLE SERVICE

SERVICE PRECAUTIONS

The VCM/RWAL system is basically maintenance free. When working on this system, the following must be observed:

- Before doing welding work on the vehicle with an electric welding unit, turn the ignition switch "OFF" and disconnect the VCM connectors.
- Do not use a fast charger for starting the engine.
- Disconnect the negative battery cable when fast charging. Refer to SECTION 0A.
- Never disconnect the the battery from the vehicle electrical system with the engine running.
- Make sure all wiring harness connectors are securely connected.
- Always note the routing, position, mounting, and location of all components, wiring, connectors, clips, brackets, brake pipes, etc., when servicing the VCM/RWAL system. Speed sensor wiring, routing, and retention is especially important to help prevent false signals due to electrical noise picked up by the wiring. Proper system operation can only be achieved if the system is restored to its original equipment condition.

The above mentioned items do not cover every possibility, but must be followed when working on VCM/RWAL. When doing service work, become familiar with VCM/RWAL, and how it interrelates with other components on the vehicle.

CHECKING AND ADDING FLUID

For information on checking and adding fluid to the brake hydraulic system, refer to SECTION 5A.

BLEEDING SYSTEM

NOTICE: The ignition switch must be in the "OFF" position or false DTCs could be set to memory.

Tools Required:
J 39177 Combination Valve Pressure Bleeding Tool
TK 00000 Tech 1 Scan Tool
TK 02650 RWAL/4WAL Cartridge Kit

1. Install J 39177 on the combination valve.
2. Check the master cylinder reservoir fluid level and fill if needed.
3. Bleed the wheel cylinders and calipers as described in SECTION 5.
4. Turn ignition switch "ON" and do three function tests with the Tech 1 scan tool.
5. Re-bleed the rear brakes. Refer to SECTION 5.
6. Evaluate brake pedal feel and braking performance.
7. Repeat the bleed procedure if needed.

VEHICLE CONTROL MODULE

For VCM on-vehicle service information refer to the Light Duty Truck Fuel and Emissions Service Manual.

ANTILOCK PRESSURE VALVE

The APV is not serviceable. It must be replaced when the diagnostic charts show that it is the cause of a malfunction.

Remove or Disconnect (Figure 6)

NOTICE: Do not touch the electrical connections and pins or allow them to come in contact with brake fluid. This will damage the VCM.

1. Brake pipe fittings.
2. Four-way electrical connector (4).
3. Bolts holding APV to bracket.
4. Antilock pressure valve (1).

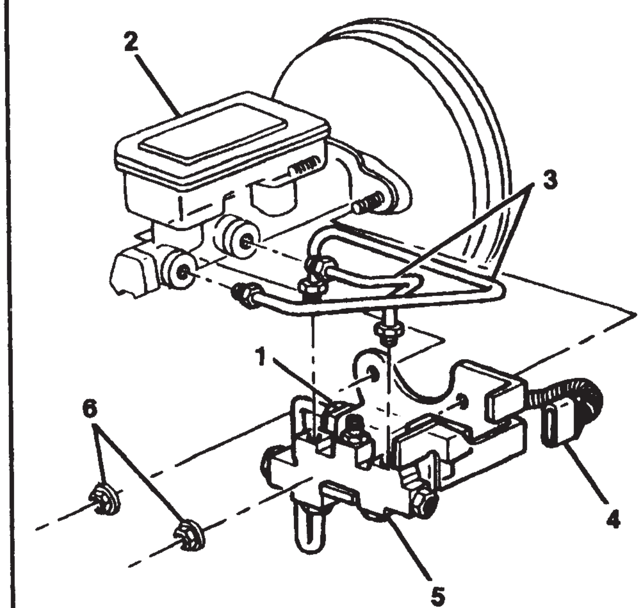
Install or Connect (Figure 6)

1. Antilock pressure valve (1).
2. Bolts.

Tighten

- Bolts to 29 N·m (21 ft. lbs.).

NOTICE: Do not touch the electrical connections and pins or allow them to come in contact with brake fluid. This will damage the VCM.



1. VALVE, ANTILOCK PRESSURE
2. CYLINDER, MASTER
3. PIPES
4. CONNECTOR, 4-WAY
5. VALVE, COMBINATION
6. NUTS

Figure 6—Antilock Pressure Valve

3. Four-way electrical connector (4).
   - If there is brake fluid on the connectors, clean them with water followed by isopropyl alcohol.
4. Brake pipe fittings.

Tighten

   - Fittings to 24 N.m (18 ft. lbs.).
5. Bleed brakes. Refer to "Bleeding System."

VEHICLE SPEED SENSOR

The VSS is not serviceable. It should be replaced when the diagnostic charts show that it is the cause of a malfunction. Refer to SECTION 7 for replacement procedures.

WARNING LAMP

For BRAKE lamp on-vehicle service information, refer to SECTION 8C.

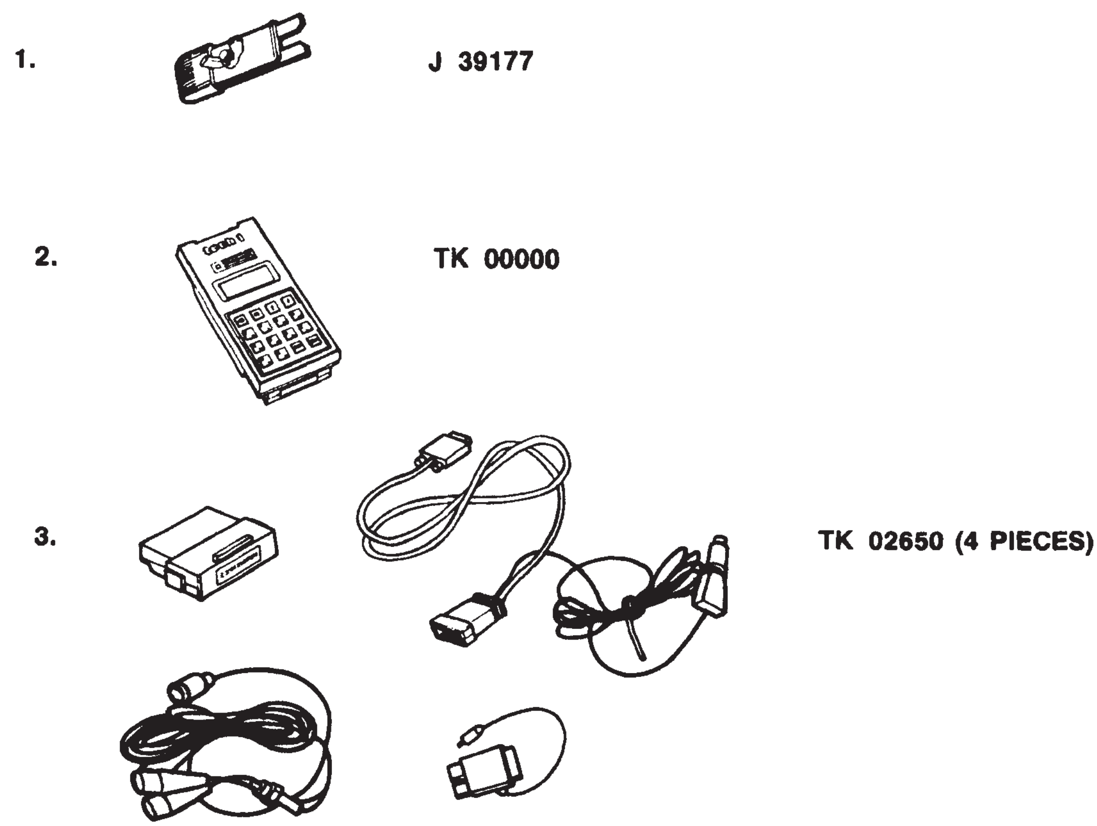
SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

	N·m	Ft. Lbs.
Antilock Pressure Valve Mounting Bolts	29	21
Brake Pipe Fittings	24	18

T2566

SPECIAL TOOLS



1. COMBINATION VALVE PRESSURE BLEEDING TOOL
2. TECH-1 SCAN TOOL
3. RWAL/4WAL CARTRIDGE KIT

F9080

SECTION 6

ENGINE

CONTENTS

GENERAL INFORMATION

Following are brief outlines of the information contained in Section 6. Use them as a guide to help locate information quickly.

SECTION 6A: ENGINE, DRIVEABILITY, AND DIAGNOSIS

This section contains information common to all engines, including:

- Use of gasket sealers.
- Diagnosis (for engine mechanical).
- Compression check procedure.
- Oil leak diagnosis.

SECTION 6A1: 2.5L L4

This section contains information for "On-Vehicle" servicing of the basic engine, such as; manifolds, cylinder head, camshaft, and piston replacement.

Detailed repair information on components such as oil pump, cylinder head, etc., is not included. Refer to the Light Duty Truck Unit Repair Manual for this information.

SECTION 6A2: 2.8L V6

This section contains information for "On-Vehicle" servicing of the basic engine, such as; manifolds, cylinder head, camshaft, and piston replacement.

Detailed repair information on components such as oil pump, cylinder head, etc., is not included. Refer to the Light Duty Truck Unit Repair Manual for this information.

SECTION 6A3: 4.3L V6

This section contains information for "On-Vehicle" servicing of the basic engine, such as; manifolds, cylinder head, camshaft, and piston replacement.

Detailed repair information on components such as oil pump, cylinder head, etc., is not included. Refer to the Light Duty Truck Unit Repair Manual for this information.

SECTION 6B1: ENGINE COOLING

This section has information on cooling system components, including:

- Diagnosis.
- Coolant Pump.
- Fan and Fan Clutch.
- Multiple Ribbed Belts.
- Drive Belt Tensioner.
- Thermostat.

SECTION 6B2: RADIATOR

This section contains information on radiators and shrouds, including aluminum radiator repair procedures.

SECTION 6C: FUEL SYSTEM

This section has been replaced by the Fuel and Emissions Service Manual. For information on fuel system components, including:

- Accelerator controls.
- Fuel tanks.
- Fuel filter, pump, and sending unit information.

Refer to the 1993 Light Duty Truck Fuel and Emissions Manual.

SECTION 6D1: BATTERY

This section contains information on batteries, battery mountings, etc.

SECTION 6D2: CRANKING SYSTEM

This section contains information on starter motors and related components.

SECTION 6D3: CHARGING SYSTEM

This section contains information on generators and related components.

SECTION 6D4: IGNITION SYSTEM

This section contains information on gasoline engine ignition systems, including distributors, spark plugs, etc.

SECTION 6D5: ENGINE WIRING

This section contains information on engine compartment wiring.

SECTION 6E: EMISSIONS

For information on Throttle Body Fuel Injection (TBI) or Central Port Injection (CPI) emission systems, refer to the 1993 Light Duty Truck Fuel and Emissions Manual.

SECTION 6F: EXHAUST

This section contains information on the exhaust system, including component replacement.

SECTION 6A

ENGINE

CONTENTS

GENERAL INFORMATION

STATEMENT ON CLEANLINESS AND CARE

- An engine is a combination of many machined, honed, polished, and lapped surfaces with very close tolerances.
- Whenever valve train components, cylinder head, crankshaft, or connecting rod components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.
- Any time the air cleaner or TBI unit is removed, the intake opening must be covered. This will protect against the entrance of foreign material that could follow the intake passage into the cylinder and cause extensive damage when the engine is started.
- When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces during initial operation. Throughout this section it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- Keep in mind while working on the engine, the 12-volt electrical system is capable of violent and damaging short circuits. When performing any work where electrical terminals could possibly be grounded, the battery ground cable should be disconnected at the battery. Refer to SECTION 0A.
- Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect cables may result in damage to wiring harnesses or other electrical parts. Refer to SECTION 0A.
- Cover or otherwise protect exposed electrical connections to prevent damage from oil and fuel.
- When raising or supporting the engine for any reason, do not use a jack under the oil pan. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen resulting in a damaged oil pickup unit.

TUNE-UP INFORMATION

All information required to tune up the vehicle's engine is given in the Engine Emission Control Label. This label is located in the engine compartment.

Information that can be found on the label includes:

- Spark plug type and gap.
- Ignition timing.
- Valve lash (if applicable).
- Emission hose routing diagram (sometimes on a separate label).

USE OF RTV SEALER AND ANAEROBIC GASKET ELIMINATOR

The two types of sealer commonly used in engines covered by this manual are RTV sealer and anaerobic "gasket eliminator" sealer.

It is important that these sealers be applied properly and in the proper place to prevent oil leaks. THE TWO TYPES OF SEALER ARE NOT INTERCHANGEABLE. Use the sealer recommended in the procedure.

- RTV (room temperature vulcanizing) sealer is used where a non-rigid part is assembled to a rigid part. Common examples are oil pans and rocker arm covers.
- Anaerobic gasket eliminator hardens in the absence of air. This sealer is used where two rigid parts (such as castings) are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using gasket eliminator.

USING RTV SEALER

1. Do not use RTV when extreme temperatures are expected, such as exhaust manifold, head gasket, or where gasket eliminator is specified.
2. When separating components sealed with RTV, use a rubber mallet and "bump" the part sideways to shear the RTV sealer. "Bumping" should be done at bends or reinforced areas to prevent distortion of parts. RTV is weaker in shear (lateral) strength than in tensile (vertical) strength.

NOTICE: Attempting to pry or pull components sealed with RTV apart may result in damage to the part.

3. Surfaces to be resealed must be clean and dry. Remove all traces of oil, grease, and old RTV sealer. Clean with a chlorinated solvent (GM P/N 1050454 or equivalent). Do not use petroleum cleaners such as mineral spirits. They leave a film onto which RTV won't stick.
4. Apply RTV to one of the clean surfaces. Use the bead size specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer in any blind threaded holes, as it may prevent the bolt from seating properly or cause damage when the bolt is tightened.
5. Assemble while RTV is still wet (within 3 minutes). Do not wait for the RTV to skin over.
6. Torque bolts to specifications, don't over-tighten.

USING ANAEROBIC GASKET ELIMINATOR

1. Clean surfaces to be resealed with a chlorinated solvent (GM P/N 1050454 or equivalent) to remove all oil, grease, and old material.
2. Apply a continuous bead of gasket eliminator to one flange.
3. Spread bead evenly with your finger to get a uniform coating on the complete flange.
4. Assemble parts in the normal manner and torque to specifications.

GASOLINE ENGINE MECHANICAL DIAGNOSIS

The following information pertains to the basic assembly only. For additional diagnosis information, refer to the following:

- Overheating or other cooling system problems; refer to SECTIONS 6B1 and 6B2.
- Cranking and ignition system problems; refer to SECTION 6D.
- Starting, driveability, fuel economy, etc. problems; refer to the 1993 Light Duty Truck Fuel and Emissions Manual.

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine Will Not Turn Over	1. Battery, cranking system, or other electrical problem. 2. Liquid in combustion chamber. 3. Seized engine.	1. Refer to SECTION 6D. 2. Remove with suction gun. 3. Repair.
Engine Cranks Normally But Does Not Start	1. Fuel or ignition system problem. 2. Restricted exhaust system. 3. Low compression due to stuck or burned valves, stuck rings, blown head gasket, etc.	1. Refer to the 1993 Light Duty Truck Fuel and Emissions Manual. 2. Repair. 3. Perform a compression test, as outlined in this section. Repair engine as necessary.

GASOLINE ENGINE MECHANICAL DIAGNOSIS (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Rough Idle	1. Fuel, ignition system, or emissions system problem. 2. Uneven cylinder compression. 3. Bent pushrod or broken valve spring. 4. Faulty engine mount.	1. Refer to the 1993 Light Duty Truck Fuel and Emissions Manual and SECTION 6D. 2. Perform a compression test, as outlined in this section. Repair engine as necessary. 3. Repair. 4. Repair or replace.
White Smoke	Usually caused by water vapor, which is a normal byproduct of combustion. Usually seen on cold days.	None required.
Black Smoke	Usually caused by rich fuel mixture.	Refer to the 1993 Light Duty Truck Fuel and Emissions Manual.
Blue Smoke	Usually caused by oil burning in the combustion chambers.	Refer to "Excessive Oil Loss" diagnosis in this section..
Excessive Oil Loss	1. External oil leaks. 2. Improper reading of dipstick. 3. Improper oil viscosity. 4. Continuous high speed driving and/or severe usage. 5. Crankcase ventilation or PCV system malfunctioning. 6. Valve guides and/or valve stem seals worn, or seals missing. 7. Piston rings not seated. 8. Broken or worn piston rings. 9. Piston improperly installed.	1. Tighten bolts and/or replace gaskets and seals as necessary. 2. Check oil with vehicle on a level surface and allow adequate drain-down time. 3. Use recommended viscosity for prevailing temperatures. 4. Continuous high speed operation and/or severe usage will normally cause decreased oil mileage. 5. Service as necessary. 6. Ream guides and install oversize service valves and/or new valve stem seals. 7. Allow adequate time for rings to seat. 8. Replace broken or worn rings as necessary. 9. Replace piston or repair as necessary.
Low Oil Pressure	1. Incorrect or faulty oil pressure switch or sensor. 2. Incorrect or faulty oil pressure gage. 3. Improper oil viscosity. 4. Diluted engine oil 5. Oil pump worn or dirty. 6. Plugged oil filter 7. Oil pickup screen loose or plugged. 8. Hole in oil pickup tube. 9. Excessive bearing clearance. 10. Cracked, porous, or plugged oil galleys. 11. Galley plugs missing or mis-installed.	1. Replace with proper switch or sensor. 2. Replace with proper gage. 3. Replace with proper oil. 4. Change engine oil and filter. Repair cause of dilution (rich mixture, etc.) 5. Clean pump and replace worn parts as necessary. 6. Replace filter and oil. 7. Clean or replace screen as necessary. 8. Replace tube. 9. Replace as necessary. 10. Repair or replace block. 11. Install plugs or repair as necessary.

GASOLINE ENGINE MECHANICAL DIAGNOSIS (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Valve Train Noise	1. Low oil pressure. 2. Loose rocker arm attachments. 3. Worn rocker arm and/or pushrod. 4. Broken valve spring. 5. Sticking valves. 6. Lifters worn, dirty, or faulty. 7. Camshaft worn or faulty. 8. Worn valve guides.	1. Repair as necessary. (See diagnosis for low oil pressure). 2. Inspect and repair as necessary. 3. Replace as necessary. 4. Replace spring. 5. Free valves. 6. Refer to "Diagnosis of Hydraulic Lifters." 7. Replace camshaft. 8. Repair as necessary.
Engine Knocks Cold And Continues For Two To Three Minutes. Knock Increases With Torque.	1. Flywheel contacting splash shield. 2. Loose or broken torsional damper or drive pulleys. 3. Excessive piston to bore clearance. 4. Bent connecting rod.	1. Reposition splash shield. 2. Tighten or replace as necessary. 3. Replace piston. 4. Replace connecting rod.
Engine Has Heavy Knock Hot With Torque Applied.	1. Broken balancer or pulley hub. 2. Loose torque converter bolts. 3. Exhaust system grounded. 4. Flywheel cracked or loose rivets on flywheel. 5. Excessive main bearing clearance. 6. Excessive rod bearing clearance.	1. Replace parts as necessary. 2. Tighten bolts. 3. Reposition as necessary. 4. Replace flywheel. 5. Repair as necessary. 6. Repair as necessary.
Engine Has Light Knock Hot In Light Load Conditions.	1. Faulty ignition control or knock sensor system. 2. Improper timing. 3. Poor quality fuel. 4. Loose torque converter bolts. 5. Exhaust leak at manifold. 6. Excessive rod bearing clearance.	1. Refer to the 1993 Light Duty Truck Fuel and Emissions Manual. 2. Adjust to specifications. 3. Use fuel of recommended grade. 4. Tighten bolts. 5. Tighten bolts and/or replace gaskets. 6. Replace bearings as necessary.
Engine Knocks On Initial Start Up But Only Lasts A Few Seconds.	1. Improper oil viscosity. 2. Hydraulic lifter bleed down.	1. Install proper oil viscosity for expected temperatures. 2. Refer to "Diagnosis of Hydraulic Lifters."
Engine Knocks At Idle Hot	1. Compressor/generator bearing. 2. Valve train. 3. Improper oil viscosity. 4. Excessive piston pin clearance. 5. Connecting rod alignment. 6. Insufficient piston to bore clearance. (Cold engine piston knock usually disappears when the cylinder's spark plug is grounded out. Cold engine piston knock which disappears in 1.5 minutes should be considered acceptable.) 7. Loose torsional damper.	1. Replace as necessary. 2. Refer to "Valve Train Noise." 3. Install proper viscosity oil for expected temperature. 4. Install new piston, pin and/or connecting rod as needed. 5. Check and replace rods as necessary. 6. Hone and fit new piston, if required. 7. Torque and/or replace worn parts.

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GASOLINE ENGINE COMPRESSION CHECK

1. Disconnect the primary terminal from the coil. Refer to SECTION 6D4.
2. Remove all spark plugs.
3. Block the throttle plate wide open.
4. Make sure the battery is fully charged.
5. Starting with the compression gage at zero, crank the engine through four compression strokes (four "puffs").
6. Make the compression check at each cylinder and record each reading.
7. If some cylinders have low compression, inject about 15 ml (one tablespoon or about 3 squirts from a pump type oil can) of engine oil into the combustion chamber through the spark plug hole.
8. Minimum compression recorded in any one cylinder should not be less than 70 per cent of highest cylinder, and no cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1035 x 70% = 725) (150 x 70% = 105).

- Normal—Compression builds up quickly and evenly to specified compression on each cylinder.
- Piston Rings Leaking—compression low on first stroke tends to build up on following strokes but does not reach normal. Improves considerably with addition of oil.
- Valves Leaking—Low on first stroke. Does not tend to build up on following strokes. Does not improve much with addition of oil.
- If two adjacent cylinders have lower than normal compression, and injecting oil into cylinders does not increase the compression, the cause may be a head gasket leak between the cylinders.

DIAGNOSIS OF HYDRAULIC LIFTERS

PROBLEM	POSSIBLE CAUSE	CORRECTION
Momentarily Noisy When Engine Is Started	This condition is normal. Oil drains from the lifters which are holding the valves open when the engine is not running. It will take a few seconds for the lifter to fill after the engine is started.	None needed.
Intermittently Noisy On Idle Only, Disappearing When Engine Speed Is Increased	1. Dirt in hydraulic lifter. 2. Pitted or damaged check ball.	1. Disassemble and clean. 2. Replace the hydraulic lifter.
Noisy At Slow Idle Or With Hot Oil; Quiet At Higher Engine Speeds Or With Cold Oil	High leak down rate.	Replace the hydraulic lifter.
Noisy At High Vehicle Speeds, Quiet At Low Speeds	1. High oil level -- Oil level above the "Full" mark allows crankshaft counterweights to churn the oil into foam. When foam is pumped into the lifters, they will become noisy since a solid column of oil is required for proper operation. 2. Low oil level -- Oil level below the "Add" mark allows the oil pump to pump air at high speeds which results in noisy lifters. 3. Oil pan bent against oil pump pickup screen. 4. Oil pump screen bent or loose.	1. Drain oil to proper level. 2. Add oil as needed. 3. Repair. 4. Repair.

DIAGNOSIS OF HYDRAULIC LIFTERS (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Noisy At Idle, Becoming Louder As Engine Speed Is Increased To 1500 RPM	1. This noise is not connected with lifter malfunction. It becomes most noticeable in the vehicle at 10 to 15 mph "L" (Low) range, or 30 to 35 mph "D" (Drive) range and is best described as a "ticking" sound. At slow idle, it may be entirely gone or appear as a light ticking noise in one or more valves. It is caused by one or more of the following: • Badly worn or scuffed valve tip and rocker arm pad. • Excessive valve stem to guide clearance. • Excessive valve seat runout. • Off square valve spring. • Excessive valve face runout. • Valve spring damper clicking on rotator.	1. Repair as necessary.
Noisy At Idle, Becoming Louder As Engine Speed Is Increased To 1500 RPM	1. Off square valve spring. Occasionally this noise can be eliminated by rotating the valve spring and valve. Crank engine until noisy valve is off its seat. Rotate spring. This will also rotate valve. Repeat until valve becomes quiet. If correction is obtained, check for an off square valve spring.	1. If the valve spring is more than 1.6mm (1/16-inch) off square, it should be replaced.
Noisy Regardless Of Engine Speed	1. Incorrect valve adjustment (excessive lash) (engines with adjustable valve lash). 2. Excessive valve lash. Check for valve lash by turning the engine so the piston in that cylinder is on TDC of the firing stroke. If valve lash is present, the pushrod can be freely moved up and down a certain amount with rocker arm held against valve. Excessive lash can be caused by: a. Worn pushrod upper end ball. b. Bent pushrod. c. Improper lubrication of the pushrod. d. Loose or damaged rocker arm. e. If pushrod and rocker arm are OK, trouble in the hydraulic lifter is indicated.	1. Adjust as specified. 2. Repair engine as needed. a. Replace pushrod and rocker arm. b. Replace pushrod. c. Replace pushrod and rocker arm. Check lubrication system feed to the pushrod. d. Replace rocker arm. e. Replace hydraulic lifter.

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OIL LEAK DIAGNOSIS

Most oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions, a fluid leak may be difficult to locate or repair. The following procedure may help in locating and repairing most leaks.

FINDING THE LEAK

1. Identify the fluid. Determine whether it is engine oil, automatic transmission fluid, power steering fluid, etc.
2. From what point is the fluid leaking? After running the vehicle at normal operating temperature, park the vehicle over a large sheet of paper. After a few minutes, you should be able to find the approximate location of the leak by the drippings on the paper.
3. Visually check around the suspected component. Check around all gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam, or spray solvent. Clean and dry the area. Operate the vehicle for several miles at normal operating temperature and varying speeds. After operating the vehicle, visually check the suspected component. If you still cannot locate the leak, try using the powder or black light and dye method.

POWDER METHOD

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the suspected area.
3. Operate the vehicle under normal operating conditions.
4. Visually inspect the suspected component. You should be able to trace the leak path over the white powder surface to the source.

BLACK LIGHT AND DYE METHOD

A dye and light kit is available for finding leaks. Refer to the manufacturer's directions when using the kit.

1. Pour specified amount of dye into leaking component.
2. Operate the vehicle under normal operating conditions as directed in the kit.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

REPAIRING THE LEAK

Once the leak has been pinpointed and traced back to the source, the cause of the leak must be determined in order to repair it properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must also be repaired. Before attempting to repair a leak, make sure the following conditions are correct, as they may cause a leak:

GASKET LEAKS

Check for:

- High fluid level or high oil pressure.
- Plugged crankcase ventilation filter or PCV valve.
- Improperly tightened fasteners or dirty/damaged threads.
- Warped flanges or sealing surfaces.
- Scratches, burrs, or other damage to the sealing surfaces.
- Damaged or worn gasket.
- Cracking or porosity of the component.
- Improper sealant used, or no sealant where required.

SEAL LEAKS

Check for:

- High fluid level or high oil pressure.
- Plugged crankcase ventilation filters or PCV valve.
- Damaged seal bore (scratched, burred, or nicked).
- Damaged or worn seal.
- Improper installation.
- Cracks in component.
- Shaft surface scratched, nicked, or damaged.
- Loose or worn bearing causing excess seal wear.

SECTION 6A1

2.5L L4
RPO L38, VIN A

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

The 2.5L engine is an in-line four-cylinder, overhead valve, liquid cooled, with cast iron block and head.

The crankshaft is supported by five main bearings, with crankshaft thrust taken at the number five (rear) bearing.

The camshaft is supported by three bearings and gear driven.

The valve train consists of roller-type hydraulic lifters, pushrods, and ball pivot-type rocker arms. Valve guides are integral in the cylinder head.

The connecting rods have precision insert type crankpin bearings. The piston pins are a press fit in the connecting rods.

The pistons are cast aluminum alloy. The piston pins are a floating fit in the pistons.

For engine identification, refer to SECTION 0A. For engine component identification, refer to figures 1 through 3.

ENGINE LUBRICATION

Refer to figure 4.

The oil pump is gear driven from the camshaft.

Oil is drawn from the oil pan through a pickup screen and tube. The gear type oil pump has a pressure regulator valve that controls lubrication system pressure by bypassing excess oil back to the oil pan sump.

Pressurized oil from the oil pump flows to the full flow filter. A bypass valve allows oil to bypass the filter if it becomes clogged or restricted.

Oil then flows into an oil passage that runs along the right side of the block and intersects the lifter bosses. Oil from this passage is then routed to the crankshaft main bearings and camshaft bearings through smaller drilled passages. Oil is supplied to the connecting rod bearings by holes drilled in the crankshaft. Oil is supplied to the rocker arms through holes in the hydraulic lifters that feed oil up the pushrods to the rocker arms. The oil is metered by discs under the pushrod seat.

Many internal parts have no direct oil feed and are supplied by either gravity or splash from other direct feed components. Timing gears are lubricated by oil that is supplied through a passage from the front of the camshaft to a calibrated nozzle above the crankshaft gear.

50. Push Rod Cover
51. Piston and Pin
52. Piston Rings
53. Connecting Rod
54. Connecting Rod Bolt
55. Connecting Rod Bearings
56. Connecting Rod Nut
57. Oil Level Indicator
58. Oil Level Indicator Tube
59. Seal
60. Guide Retainer Stud
61. Plug
62. Plug
63. Pin
64. Block Drain Bolt
65. Timing Indicator Stud
66. Bolt
67. Flywheel
68. Spacer
69. Clutch Pilot Bearing
70. Crankshaft Insert
71. Crankshaft Rear Oil Seal
72. Crankshaft Rear Bearing
73. Oil Pan Drain Screw
74. Gasket
75. Bolt
76. Oil Pan
77. Oil Pump
78. Nut
79. Pin
80. Spring
81. Bolt
82. Oil Pump Cover
83. Oil Pump Cover Gasket
84. Bolt
85. Oil Pressure Regulator Valve
86. Crankshaft Bearings
87. Crankshaft Gear
88. Crankshaft
89. Key
90. Timing Indicator
91. Oil Pump Shaft Lower Bearing
92. Plug
93. Timing Gear Oil Nozzle
94. Bolt
95. Crankshaft Pulley
96. Bolt
98. Bolt
99. Washer
100. Crankshaft Pulley Hub
101. Front Cover Seal
102. Front Cover
103. Screw
104. Camshaft Gear
105. Camshaft Thrust Bearing
106. Camshaft Gear Spacing Ring
107. Key
108. Camshaft
109. Camshaft Bearing
110. Bolt
111. Coolant Pump
112. Gasket
113. Oil Pump Shaft Upper Bearing
114. Oil Pump Drive Shaft Gear
115. Oil Pump Drive Shaft
116. Connecting Rod Cap
117. Bolt
118. Oil Pump Drive Shaft Cover Plate
119. Block
120. Cylinder Head Dowel Pin
121. Hydraulic Roller Lifter
122. Valve Lifter Guide
123. Lifter Guide Retainer
124. Main Bearing Cap
125. Bolt
126. Rear Main Bearing Cap

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Figure 1—Cylinder Block and Components

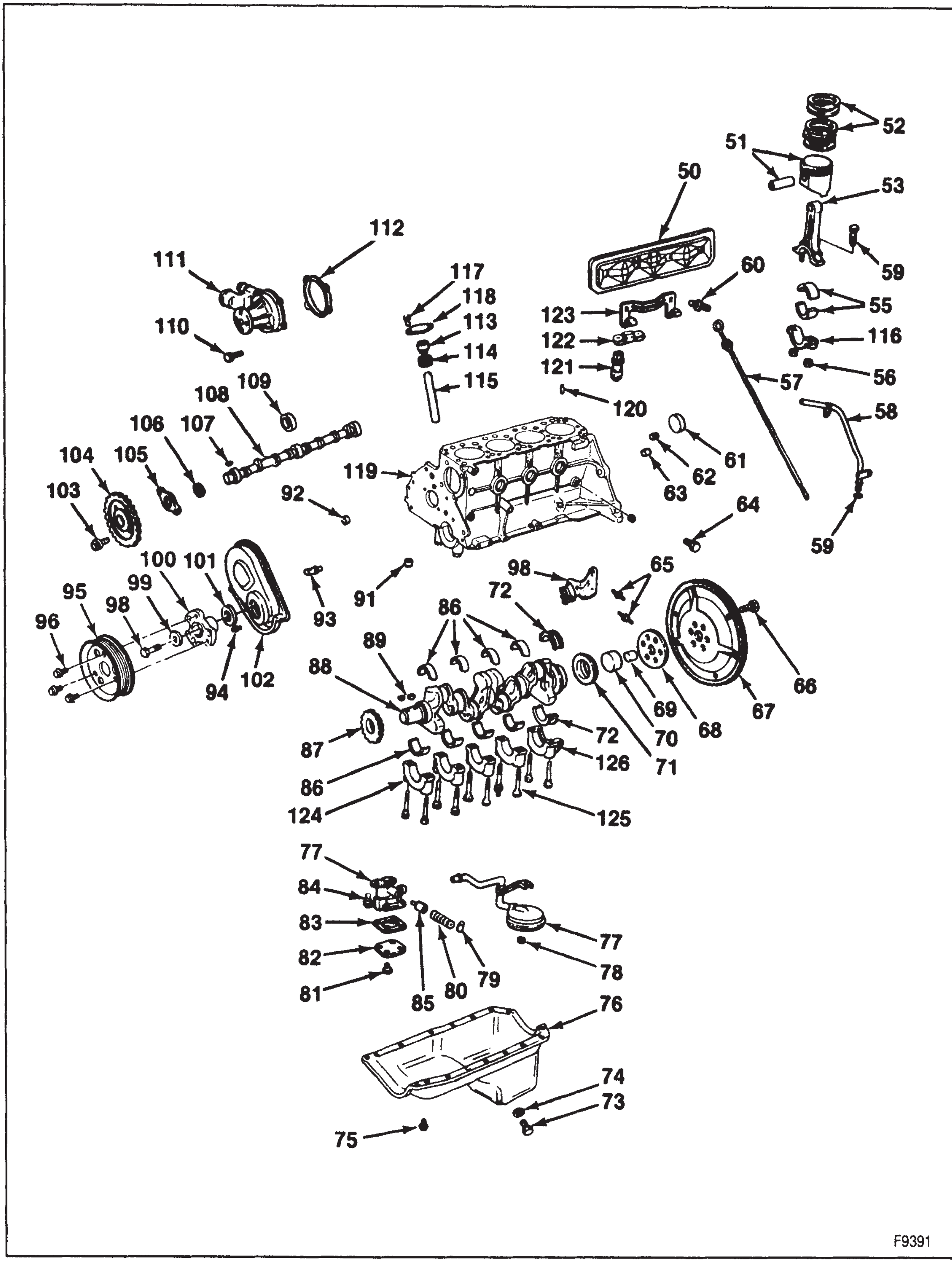
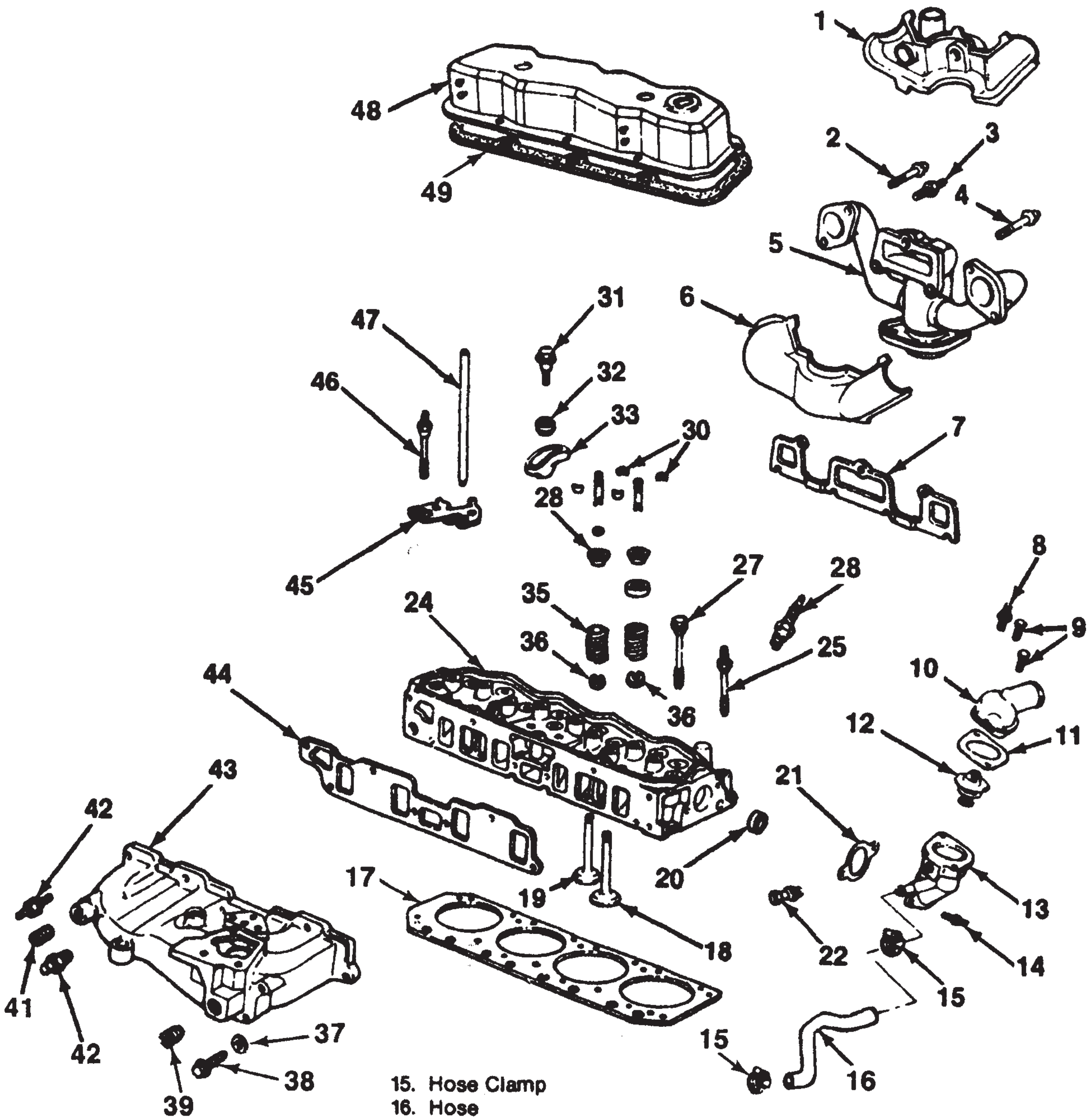


Figure 2—Cylinder Block and Components



1. Outer Engine Heat Stove
2. Bolt
3. Stud
4. Stud
5. Exhaust Manifold
6. Inner Engine Heat Stove
7. Exhaust Manifold Gasket
8. Stud
9. Bolt
10. Coolant Fitting
11. Gasket
12. Thermostat
13. Thermostat Housing
14. Bolt
15. Hose Clamp
16. Hose
17. Cylinder Head Gasket
18. Intake Valve
19. Exhaust Valve
20. Plug
21. Gasket
22. Coolant Temperature Sensor
24. Cylinder Head
25. Cylinder Head Bolt
26. Spark Plug
27. Cylinder Head Bolt
28. Valve Spring Cap
30. Valve Keys
31. Rocker Arm Ball Bolt
32. Rocker Arm Ball
33. Valve Rocker Arm
35. Valve Spring
36. Intake Valve Stem Seal
37. Washer
38. Intake Manifold Bolt
39. Plug
41. Plug
42. Intake Manifold Stud
43. Intake Manifold
44. Intake Manifold Gasket
45. Push Rod Guide
46. Cylinder Head Bolt
47. Push Rod
48. Rocker Arm Cover
49. Rocker Cover Gasket

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Figure 3—Cylinder Head, Manifolds, and Components

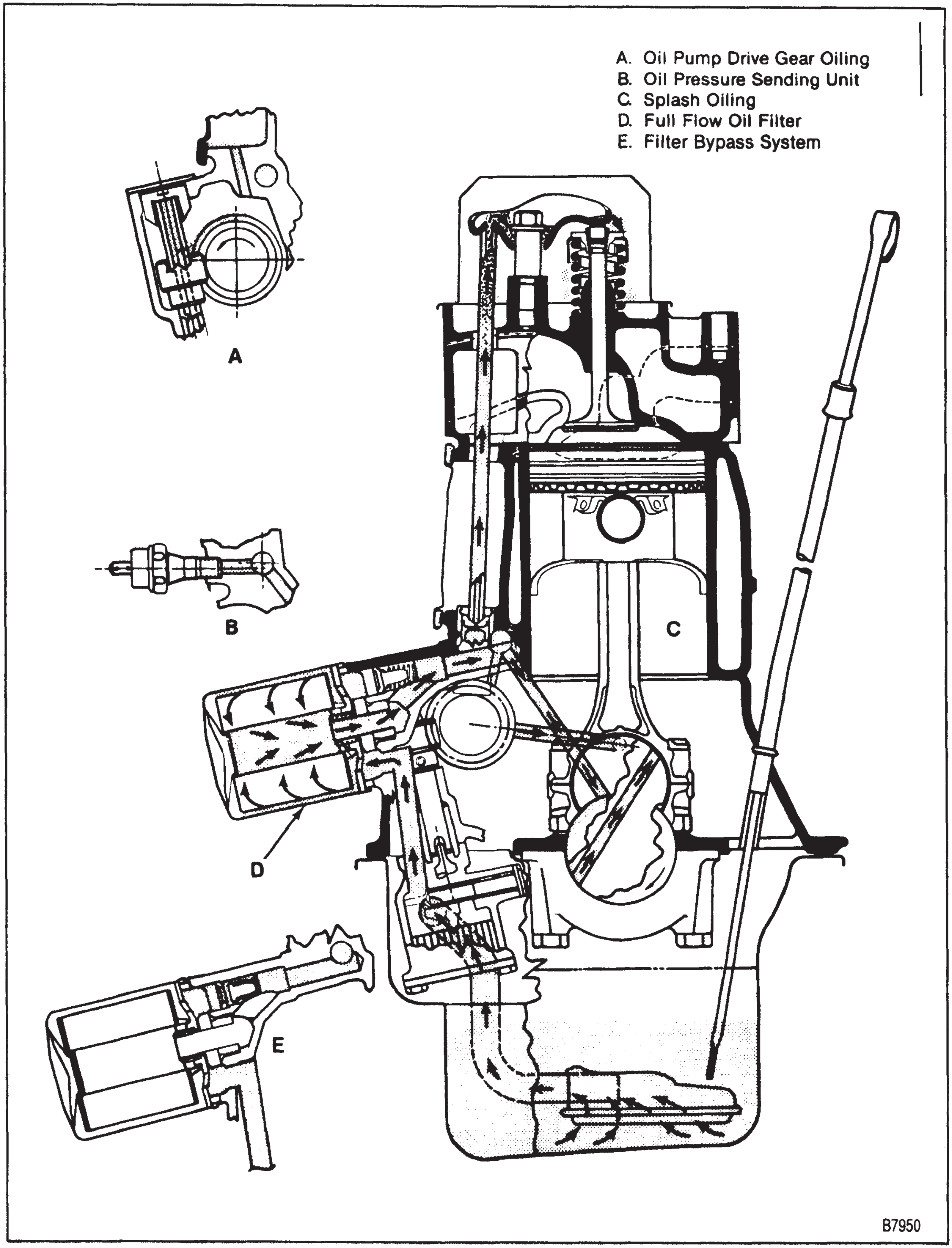


Figure 4—Engine Lubrication Diagram

ON-VEHICLE SERVICE

ROCKER ARM COVER REPLACEMENT

Remove or Disconnect

1. Negative battery cable. Refer to SECTION 0A.
2. Air cleaner assembly.
3. PCV valve and crankcase ventilation pipe.
4. EGR valve.
5. Spark plug wires at the rocker arm cover.
6. Vacuum hose and wiring harness at the coolant outlet stud and move aside.
7. Vacuum hoses at intake manifold stud.
8. Rocker arm cover bolts.

NOTICE: Do not pry on the rocker arm cover. Damage to the sealing surfaces may result.

Clean

- Gasket materal from the rocker arm cover and head. All loose gasket materal, or pieces that will cause installation interference, must be removed.
- Oil and grease from the sealing surfaces on the cylinder head and rocker arm cover. Use a suitable solvent.

Inspect

- Rocker arm cover sealing flanges for distortion.

Install or Connect

1. Rocker arm cover and gasket to the cylinder head.

NOTICE: See "Notice" on page 6A1-1.

2. Rocker arm cover bolts.

Tighten

- Rocker arm cover bolts to 8.5 N.m (75 in. lbs.).

3. Vacuum hoses at the intake manifold stud.
4. Vacuum hose and wiring harness at the coolant outlet stud.
5. Spark plug wires at the rocker arm cover.
6. EGR valve.
7. PCV valve and crankcase ventilation pipe.
8. Air cleaner assembly.
9. Negative battery cable. Refer to SECTION 0A.

ROCKER ARM AND PUSHROD REPLACEMENT

Remove or Disconnect (Figure 5)

1. Rocker arm cover, as outlined previously.
2. Rocker arm bolt (31).
   - If only the pushrod is to be replaced, back the rocker arm bolt off until the rocker arm can be swung away from the pushrod. Then pull the pushrod out.
3. Rocker arm (33) with ball (32).
4. Pushrod (47).
5. Pushrod guide (45) (if required).

Important

- Store used components in order so they can be reassembled in the same location.
- Pushrod guides are different and must be reassembled in original location. They are numbered 1 through 4, with number 1 at the front of the engine.

Inspect

- Rocker arms and balls at their mating surfaces. These surfaces should be smooth and free from scoring or other damage.
- Rocker arm areas that contact the valve stems and the sockets that contact the pushrods. These areas should be smooth and free of damage and wear.

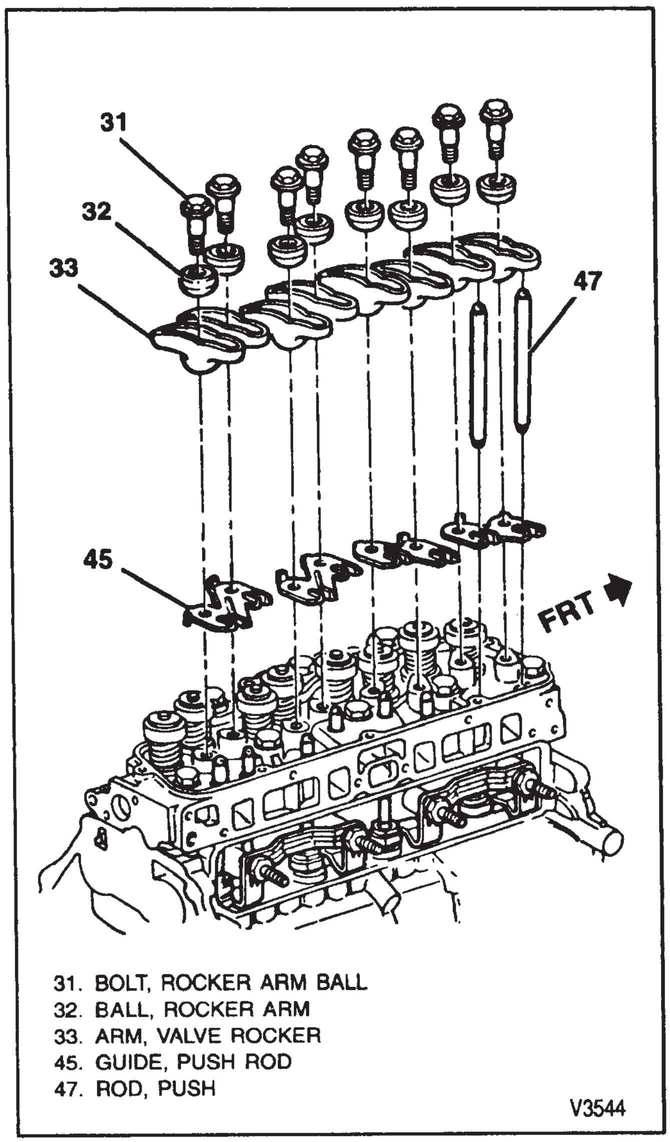


Figure 5—Valve Train Components

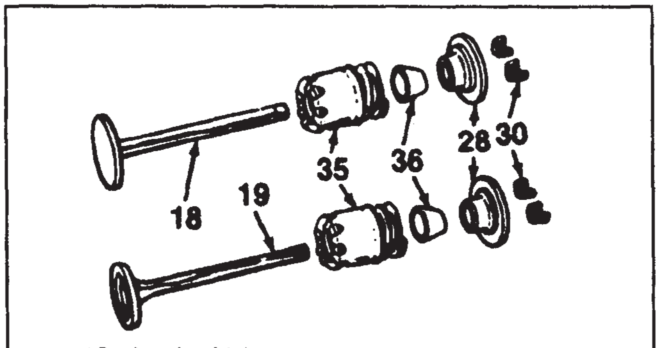


Figure 6—Valves and Components

- Pushrods for bending. Roll the pushrod on a flat surface to determine if it is bent. Replace if necessary.
- Ends of the pushrods for scoring or roughness.
- Rocker arm bolts for thread damage.
- Rocker arm bolts in the shoulder area for contact damage with the rocker arm.

Install or Connect (Figure 5)

1. Pushrod guides (45) (if removed).
2. Pushrods (47). Make sure the pushrods seat properly in the hydraulic lifters.
3. Rocker arms (33) with balls (32).

Important

- When new rocker arms and/or balls are installed, coat their bearing surfaces with "Molykote" or equivalent.

NOTICE: See "Notice" on page 6A1-1.

4. Rocker arm bolts (31).

Tighten

- Rocker arm bolts (31) to 30 N.m (22 ft. lbs.). The hydraulic lifter should be on base circle of the camshaft. DO NOT OVERTIGHTEN.

5. Rocker arm cover, as outlined previously.

VALVE STEM SEAL AND VALVE SPRING REPLACEMENT

Remove or Disconnect (Figures 6 and 7)

Tools Required:
J 23590 Air Adapter
J 5892-C Spring Compressor

1. Rocker arm cover, as outlined previously.
2. Rocker arms, balls, and bolts, as outlined previously.

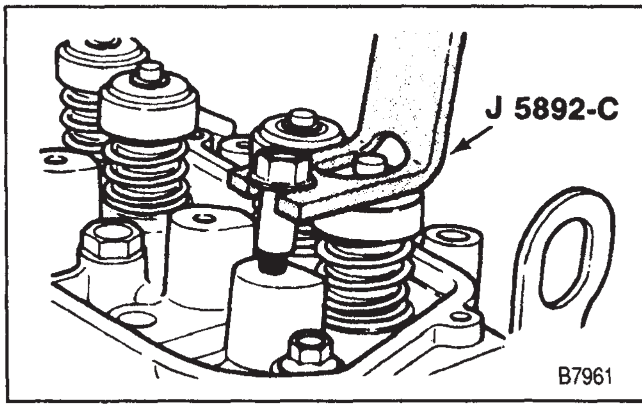


Figure 7—Compressing the Valve Spring

3. Spark plugs.
4. Valve keepers (30).
   A. Install J 23590 into the spark plug hole.
   B. Apply compressed air to hold the valves in place.
   C. Install a rocker arm bolt (figure 7).
   D. Use J 5892-C to compress the valve spring (figure 7).
   E. Remove the valve keepers (30).
   F. Carefully release the spring tension. Remove J 5892-C.
5. Cap (28) and spring with damper (35).
6. Seal (36).

Install or Connect (Figures 6 and 7)

Tools Required:
J 23590 Air Adapter
J 5892-C Spring Compressor
J 22330 Valve Stem Seal Tester

1. New seal (36). Install the seal over the valve stem and seat it against the head.
   - Lubricate the seal to aid assembly.
2. Spring with damper (35) and cap (28).
3. Valve keepers (30).
   A. With air pressure applied to the cylinder with J 23590, compress the spring with J 5892-C (figure 7).
   B. Install the valve keepers (30). Use grease to hold them in place.
   C. Remove J 5892-C and J 23590.
4. Spark plugs.
5. Rocker arms, as outlined previously.
6. Rocker arm cover, as outlined previously.

PUSHROD COVER REPLACEMENT

Remove or Disconnect (Figure 8)

1. Negative battery cable. Refer to SECTION 0A.
   - Drain the cooling system. Refer to SECTION 6B1.
2. Lower radiator and coolant pump bypass hoses.
3. Generator and bracket. Refer to SECTION 6D3.
4. Ignition coil wires.
5. Spark plug wires and bracket at the intake manifold.
6. Fuel pipes and clips at the pushrod cover.

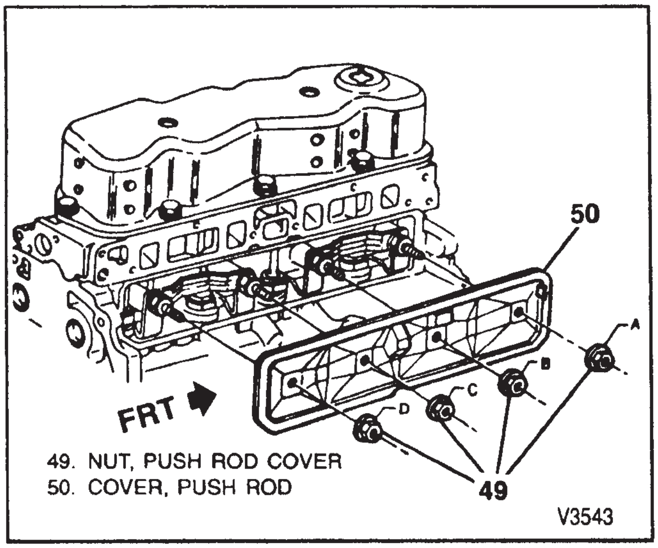


Figure 8—Pushrod Cover and Components

7. Oil pressure gage sender.
8. Wiring harness brackets from the pushrod cover.
9. Pushrod cover.
   A. Unscrew the four nuts from the cover attaching studs, reverse two of the nuts so the washers face outward and screw them back onto the inner two studs.
   B. Assemble the two remaining nuts to the same two inner studs with washers facing inward.
   C. Using a small wrench on the inner nut (on each stud), jam the two nuts tightly together.
   D. Again, using the small wrench on the inner nut, unscrew the studs until the cover breaks loose.
   E. After breaking the cover loose, remove the jammed nuts from each stud.
   F. Remove the cover from the studs.

NOTICE: See "Notice" on page 6A1-1.

Tighten

- Studs to 10 N·m (88 in. lbs.).

Clean

- Gasket material (RTV), from the pushrod cover and block. All loose gasket material (RTV), or pieces causing installation interference, must be removed.
- Oil and grease from the sealing surfaces. Use a suitable solvent.

Inspect

- Studs and rubber washers for damage. Replace as necessary.

Install or Connect (Figures 8 and 9)

- Apply a 5-mm (3/16-inch) bead of RTV sealant to the pushrod cover as shown in figure 9.

1. Pushrod cover to the block.

NOTICE: See "Notice" on page 6A1-1.

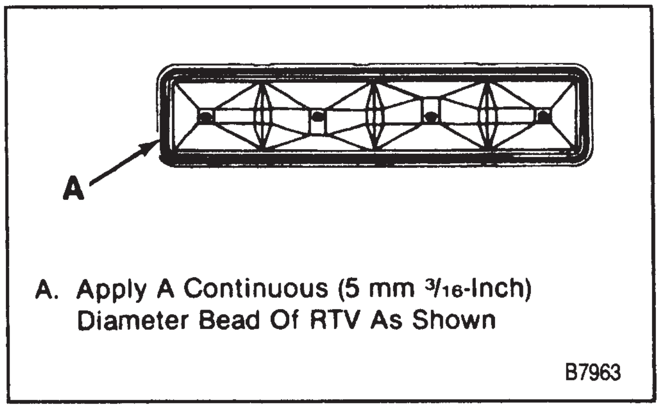


Figure 9—Applying RTV to the Pushrod Cover

2. Pushrod cover nuts.

Tighten

- Pushrod cover nuts using the sequence shown in figure 8 (A through D), to 12 N·m (106 in. lbs.).

3. Wiring harness brackets from the pushrod cover.
4. Oil pressure sender (if equipped).
5. Fuel pipe and clips.
6. Spark plug wires and bracket.
7. Ignition coil wires.
8. Generator and bracket. Refer to SECTION 6D3.
9. Lower radiator and coolant pump bypass hoses. Refer to SECTION 6B1.
10. Negative battery cable. Refer to SECTION 0A.

- Fill the cooling system with the proper quantity and grade of coolant. Refer to SECTION 0B.

HYDRAULIC LIFTER REPLACEMENT

Remove or Disconnect (Figure 10)

1. Rocker arm cover, pushrod cover, and pushrod, as described previously.
2. Stud (60) and retainer (123).
3. Guide (122).
4. Hydraulic lifter (121).

Inspect

- Hydraulic lifter for wear, scuffing, and loose roller shaft.
- Hydraulic lifter bore in the block for wear and scuffing.
- Roller for freedom of movement.
- Roller surface for flat spots or pitting.

Install or Connect (Figure 10)

1. Hydraulic lifter (121) to the block.
   - If a new hydraulic lifter is being installed, all sealer coating inside the hydraulic lifter must be removed.
   - Lubricate the hydraulic lifter body and roller with engine oil.

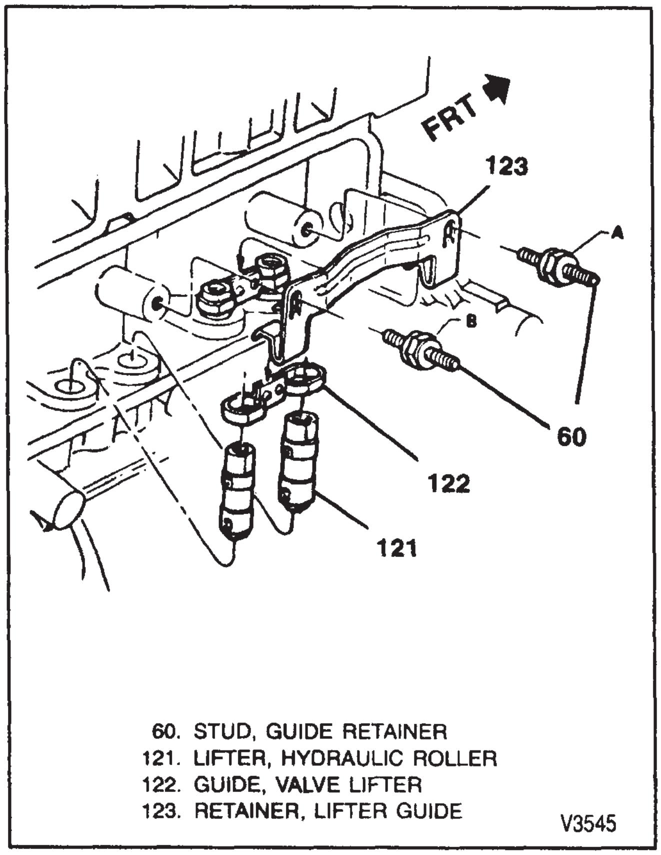


Figure 10—Hydraulic Lifters and Components

2. Guide (122).

NOTICE: See "Notice" on page 6A1-1.

3. Retainer (123) and stud (60).

Tighten

- Stud (60) using the sequence shown in figure 10 (A first, then B, for both retainers), to 10 N.m (90 in. lbs.).

4. Pushrod, pushrod cover, and rocker arm cover, as described previously.

INTAKE MANIFOLD REPLACEMENT

Remove or Disconnect (Figure 11)

1. Negative battery cable. Refer to SECTION 0A.
2. Air cleaner.
3. Wiring harnesses and connectors at the intake manifold.
4. Accelerator and cruise control cables (if equipped) with bracket.
5. EGR valve vacuum hose.
6. Emissions sensor bracket at the manifold.
7. Fuel lines, vacuum hoses, and wiring from TBI unit.
   - Drain the cooling system. Refer to SECTION 6B1.
8. Coolant pump bypass hose at the intake manifold.
9. Generator rear bracket. Refer to SECTION 6D3.
10. Vacuum hoses and pipes from the intake manifold.
11. Vacuum hose hold-down at the coolant outlet and manifold.
12. Heater hose from the intake manifold.
13. Ignition coil wires.
14. Intake manifold bolts and washers.
15. Intake manifold and gasket.

Clean

- Old gasket from the intake manifold and cylinder head.

Install or Connect (Figure 11)

1. Intake manifold and new gasket to the cylinder head.

NOTICE: See "Notice" on page 6A1-1.

2. Intake manifold bolts and washers.

Tighten

- Bolts to 34 N.m (25 ft. lbs.).

3. Ignition coil wires.

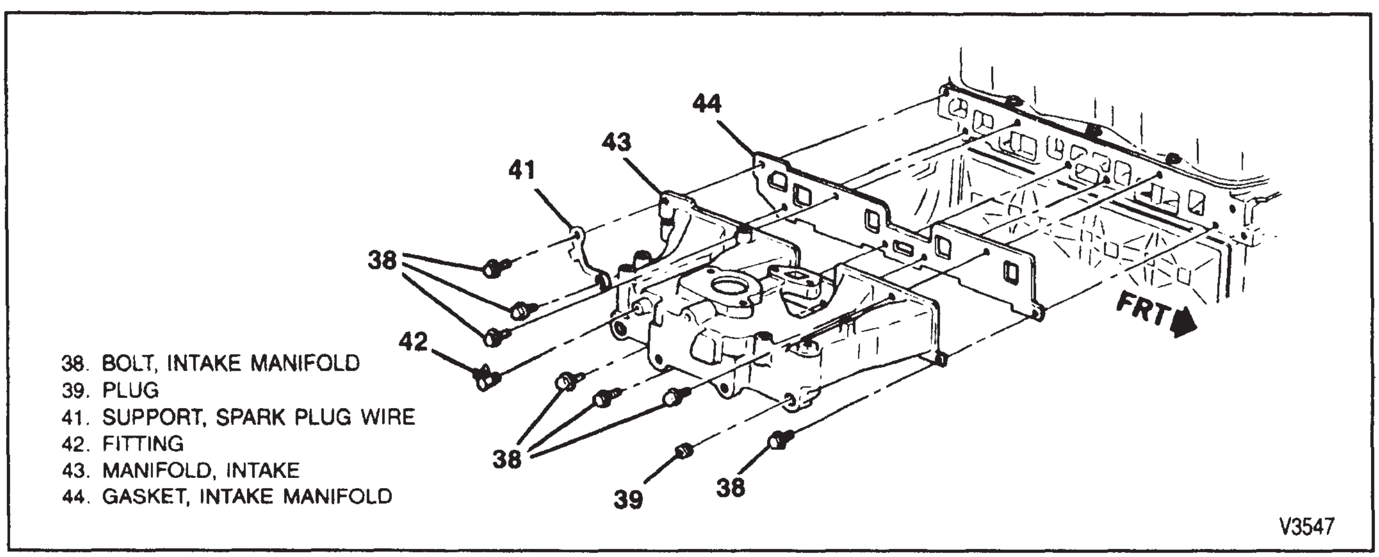


Figure 11—Intake Manifold and Components

4. Heater hose to the intake manifold.
5. Vacuum hose hold-down at the coolant outlet and manifold.
6. Vacuum hoses to the intake manifold.
7. Rear generator bracket. Refer to SECTION 6D3.
8. Coolant pump bypass hose. Refer to SECTION 6B1.
9. Fuel lines, vacuum lines, and wiring to the TBI unit.
10. Emissions sensor bracket.
11. EGR valve hose.
12. Accelerator and cruise control cables (if equipped) with bracket.
13. Wiring harnesses and connectors at the intake manifold.
14. Air cleaner.
15. Negative battery cable. Refer to SECTION 0A.

- Fill the cooling system with the proper quantity and grade of coolant. Refer to SECTION 0B.

EXHAUST MANIFOLD REPLACEMENT

Remove or Disconnect (Figure 12)

1. Negative battery cable. Refer to SECTION 0A.
2. Air cleaner and heat stove tube.
3. Air conditioning compressor and brackets (if used) and lay aside. Refer to SECTION 1B.
4. Dipstick tube bracket.
5. Exhaust pipe from the exhaust manifold.
6. Oxygen sensor wire. Remove the oxygen sensor only if the exhaust manifold requires replacement.
7. Exhaust manifold bolts and washers.
8. Exhaust manifold and gasket.

Clean

- Threads of the exhaust manifold bolts.
- Gasket surfaces on the cylinder head and exhaust manifold.

Install or Connect (Figure 12)

1. Exhaust manifold and new gasket to the cylinder head.

NOTICE: See "Notice" on page 6A1-1.

2. Exhaust manifold bolts and washers.

Tighten

- Exhaust manifold bolts using the tightening sequence shown in figure 12.
  — "A" group fasteners first, then the "B" group fasteners.
    - "A" group to 50 N·m (36 ft. lbs.).
    - "B" group to 38 N·m (28 ft. lbs.).

3. Oxygen sensor wire.
4. Exhaust pipe to the exhaust manifold.
5. Air conditioning compressor and brackets. Refer to SECTION 1B.
6. Dipstick tube bracket.
7. Air cleaner and heat stove pipe.
8. Negative battery cable. Refer to SECTION 0A.

CYLINDER HEAD REPLACEMENT

Remove or Disconnect (Figure 13)

1. Negative battery cable. Refer to SECTION 0A.
   - Drain the cooling system.
2. Air cleaner.
3. Air conditioning compressor with brackets and lay aside. Refer to SECTION 1B.
4. Rocker arm cover, as outlined previously.
5. Pushrods, as outlined previously.
6. Vacuum hoses and fuel lines and wires at TBI unit.
7. Vacuum hoses at studs on intake manifold.
8. Accelerator and cruise control cables (if equipped).
9. Generator with brackets and lay aside. Refer to SECTION 6D3.
10. Coolant pump bypass and heater hoses at the intake manifold. Refer to SECTION 6B1.
11. Exhaust pipe from the exhaust manifold.

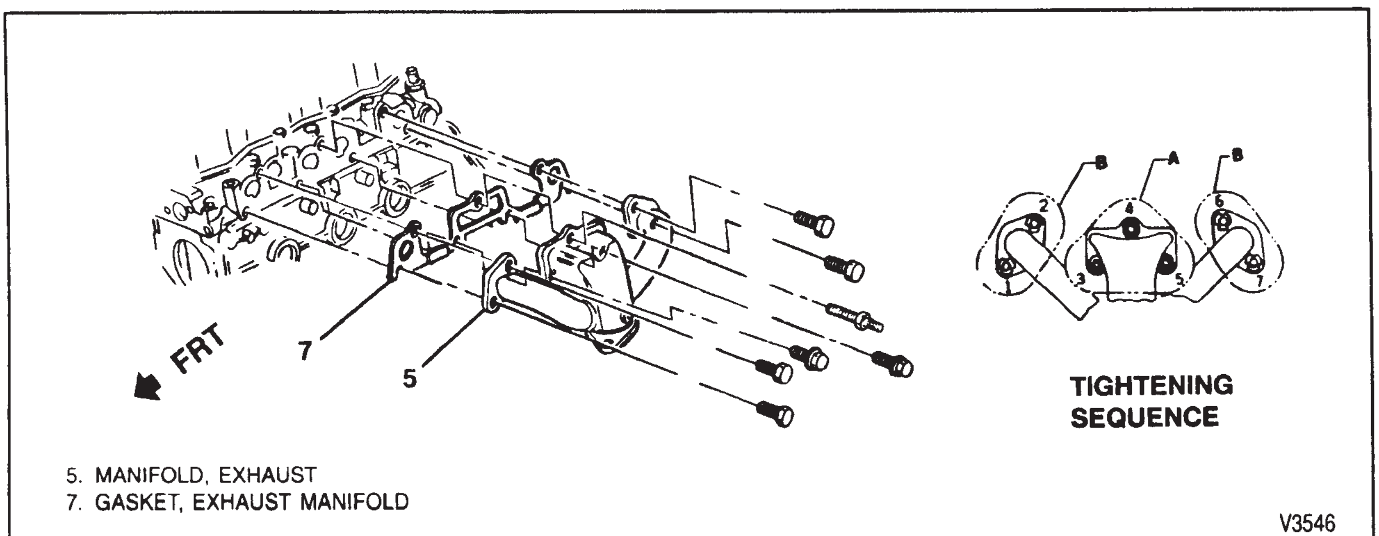


Figure 12—Exhaust Manifold and Components

12. Upper radiator hose. Refer to SECTION 6B1.
13. Vacuum tube at the coolant outlet stud.
14. Fuel filter and fuel line bracket at the rear of the cylinder head.
15. Dipstick tube.
16. Wiring harness bracket and ground strap at the rear of the cylinder head.
17. Wiring connectors from sensors at the rear of the cylinder head and thermostat housing.
18. Ignition coil wires and spark plug wires.
19. Oxygen sensor wire.
20. Cylinder head bolts.
21. Cylinder head, with the manifolds attached.
22. Cylinder head gasket.

Clean

- Carbon deposits from combustion chambers.
- All traces of old gasket from cylinder head and block.
- Cylinder head bolt threads and threads in the block.

Inspect

- Sealing surfaces of the block and cylinder head for nicks, heavy scratches, or other damage.

Install or Connect (Figure 13)

Tools Required:
J 36660 Torque/Angle Meter

- Make sure the block and cylinder head sealing surfaces are clean.

1. Cylinder head gasket to the block. Install over the dowel pins.
2. Cylinder head. Carefully guide the head into place over the dowel pins (this may require an assistant).

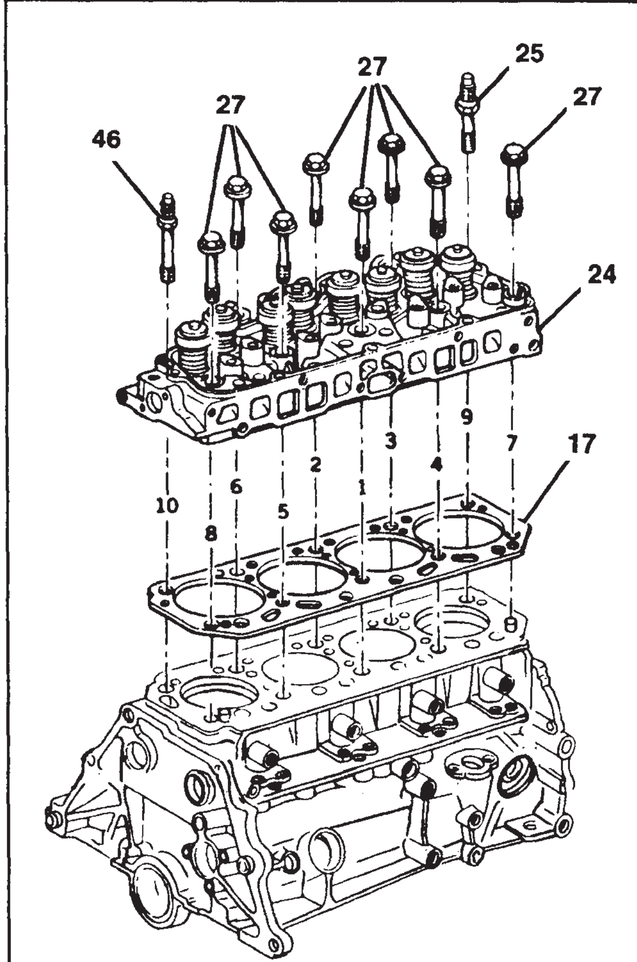
NOTICE: See "Notice" on page 6A1-1.

3. Cylinder head bolts. Refer to figure 13.
   - Coat the threads of all cylinder head bolts with sealing compound (GM P/N 1052080 or equivalent). Assemble within 15 minutes to allow sealer to cure properly.
   - Install all bolts finger tight.

Tighten

- Cylinder head bolts, as follows:
  A. Using the sequence shown in figure 13 (steps 1 through 10), tighten all bolts to 25 N·m (18 ft. lbs.).
  B. Using the sequence shown in figure 13 (steps 1 through 10), tighten all bolts except bolt #9 to 35 N·m (26 ft. lbs.).
  C. Bolt #9 to 25 N·m (18 ft. lbs.).
  D. All bolts using the sequence shown in figure 13 (steps 1 through 10), an additional 90 degrees using J 36660.

4. Oxygen sensor wire.



17. GASKET, CYLINDER HEAD
24. HEAD, CYLINDER
25. BOLT, CYLINDER HEAD
27. BOLT, CYLINDER HEAD
46. BOLT, CYLINDER HEAD

V3550

Figure 13—Cylinder Head and Components

5. Ignition coil wires.
6. Wiring connectors at sensors on cylinder head and thermostat housing.
7. Wiring harness bracket and ground strap at the rear of the cylinder head.
8. Dipstick tube.
9. Fuel filter and fuel line brackets.
10. Vacuum tube at the coolant outlet stud.
11. Upper radiator hose. Refer to SECTION 6B1.
12. Exhaust pipe to the exhaust manifold.
13. Coolant pump bypass and heater hoses. Refer to SECTION 6B1.
14. Generator and brackets. Refer to SECTION 6D3.
15. Accelerator and cruise control cables (if equipped).
16. Vacuum hoses at intake manifold studs.
17. Vacuum hoses, fuel lines, and wires to TBI unit.
18. Pushrods, as outlined previously.
19. Rocker arm cover, as outlined previously.
20. Air conditioning compressor and brackets.
21. Air cleaner.
22. Negative battery cable. Refer to SECTION 0A.

- Fill the cooling system with the proper quantity and grade of coolant. Refer to SECTION 0B.

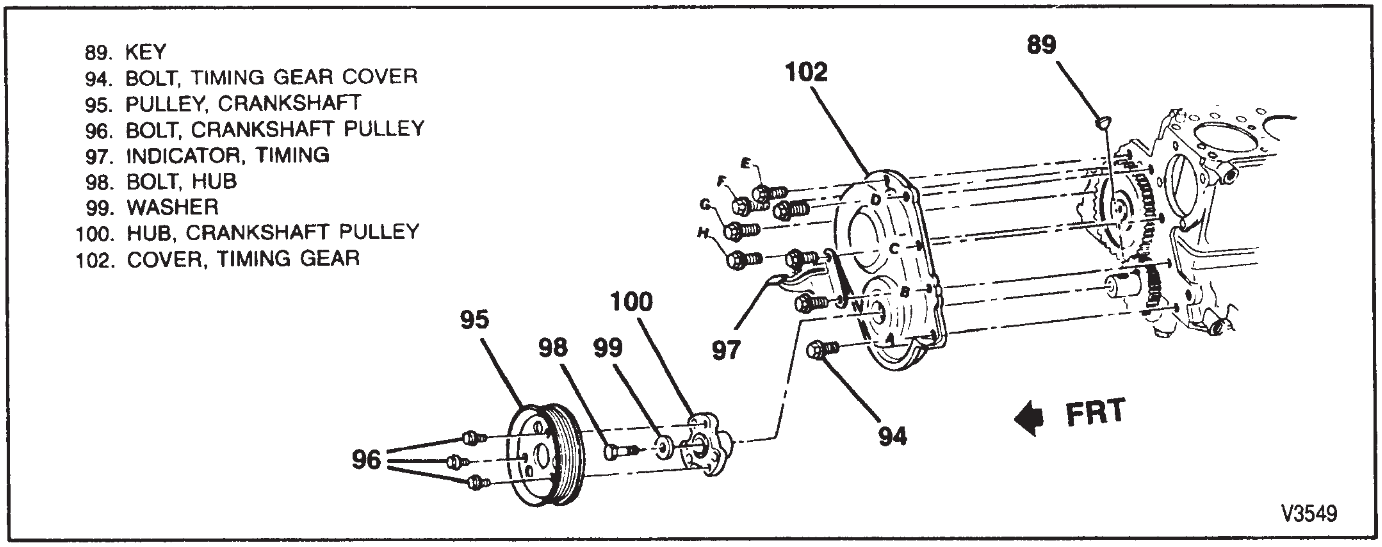


Figure 14—Timing Gear Cover and Components

CRANKSHAFT PULLEY AND CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Remove or Disconnect (Figures 14 and 15)

1. Negative battery cable. Refer to SECTION 0A.
2. Drive belt. Refer to SECTION 6B1.
3. Bolt (98).
4. Pulley and hub.
5. Crankshaft front oil seal. Pry out with a large screwdriver. Take care not to distort the timing gear cover.
6. Bolts (96) and crankshaft pulley from the hub (if necessary).

Inspect

- Oil seal contact area on the hub for grooving and roughness. Replace if necessary.

Install or Connect (Figures 14 and 15)

NOTICE: For steps 1 and 4, see "Notice" on page 6A1-1.

Tool Required:
J 34995 Centering Tool and Seal Installer

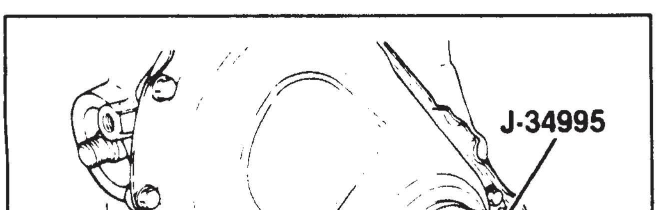


Figure 15—Installing the Timing Gear Cover

1. Crankshaft pulleys and bolts (96) to the hub. Coat the bolt threads with Drylock #209 or equivalent.

Tighten

- Bolts (96) to 34 N.m (26 ft. lbs.).

2. Crankshaft front oil seal. Use J 34995 (figure 15).
   A. Install the seal with the lip facing the rear of the engine.
   B. Remove the tool.
   C. Coat the seal lips with engine oil.
3. Crankshaft pulley and hub.
   - Slide the hub on the crankshaft until it bottoms against the crankshaft gear.
4. Bolt (98).

Tighten

- Hub retaining bolt to 220 N.m (160 ft. lbs.).

5. Drive belts. Refer to SECTION 6B1.
6. Negative battery cable. Refer to SECTION 0A.

TIMING GEAR COVER REPLACEMENT

Remove or Disconnect (Figures 14 through 16)

1. Negative battery cable. Refer to SECTION 0A.
2. Power steering fluid reservoir from the radiator shroud.
3. Upper fan shroud. Refer to SECTION 6B2.
4. Drive belt. Refer to SECTION 6B1.
5. Generator with brackets and lay aside. Refer to SECTION 6D3.
6. Crankshaft pulley and hub, as described previously.
7. Lower radiator hose clamp at the coolant pump. Refer to SECTION 6B1.
8. Timing gear cover bolts and cover.
9. Crankshaft front seal. Pry out with a large screwdriver. Take care not to distort the timing gear cover.

Clean

- Old RTV from the block, timing gear cover, and oil pan. All loose RTV, or pieces causing installation interference, must be removed.
- Oil and grease from the sealing surfaces on the block, oil pan, and timing gear cover. Use a suitable solvent.

Install or Connect (Figures 14 through 16)

Tool Required:
J 34995 Centering Tool and Seal Installer

1. Crankshaft front seal to the timing gear cover.
   A. Lubricate the seal lips with engine oil.
   B. Use J 34995 to install the seal to the cover.
   C. Leave the tool in position in the seal (figure 15).
   - Apply a 10-mm (3/8-inch) wide by 5-mm (3/16-inch) thick bead of RTV sealer to the oil pan at the timing gear cover sealing surface.
   - Apply a 6-mm (1/4-inch) by 3-mm (1/8-inch) thick bead of RTV to the timing gear cover at the block sealing surface as shown in figure 16.

NOTICE: The correct tool must be used to align the timing gear cover so the crankshaft front seal is properly centered around the crankshaft. The seal must be centered to prevent damage during hub installation.

2. Timing gear cover (with J 34995 in place) to the block (figure 15).

NOTICE: See "Notice" on page 6A1-1.

3. Bolts (94).

Tighten

- Bolts (94) using the sequence shown in figure 14 (A through H), to 10 N.m (90 in. lbs.).

4. Remove J 34995 from the timing gear cover.
5. Lower radiator hose clamp at the coolant pump. Refer to SECTION 6B1.

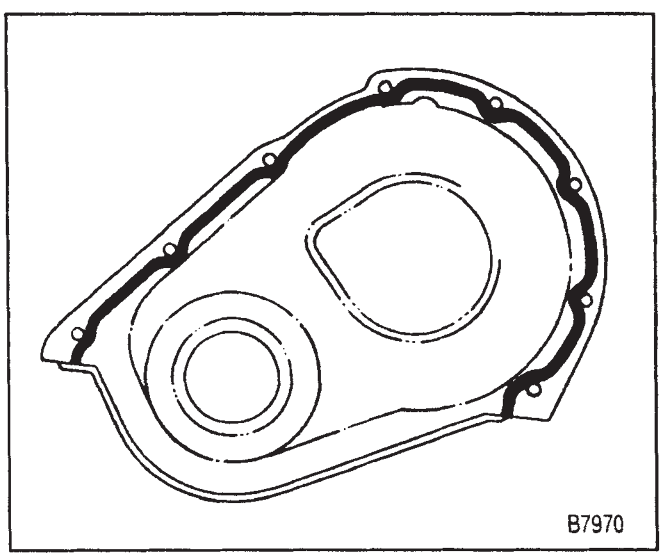


Figure 16—Applying RTV to the Timing Gear Cover

6. Crankshaft pulley and hub, as described previously.
7. Generator and brackets. Refer to SECTION 6D3.
8. Drive belt. Refer to SECTION 6B1.
9. Upper fan shroud. Refer to SECTION 6B2.
10. Power steering reservoir to the radiator shroud. Refer to SECTION 3B3.
11. Negative battery cable. Refer to SECTION 0A.

OIL PUMP DRIVE SHAFT REPLACEMENT

Remove or Disconnect (Figure 17)

1. Bolts (117).
2. Plate (118).
3. Bearing (113).
4. Shaft (115) and gear (114) assembly.

Clean

- Sealing surfaces of plate (118) and block.

Install or Connect (Figure 17)

1. Shaft (115) and gear (114) assembly. Turn the shaft until it indexes the camshaft gear pilots properly in the oil pump body.
2. Bearing (113).
3. Plate (118). Apply a 1.5-mm (1/16-inch) bead of RTV to the plate.

NOTICE: See "Notice" on page 6A1-1.

4. Bolts (117).

Tighten

- Bolts (117) to 14 N.m (124 in. lbs.).

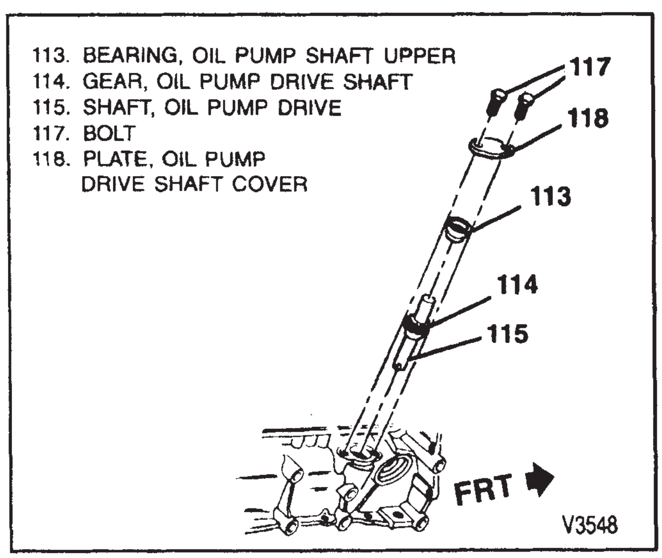


Figure 17—Oil Pump Drive Shaft and Components

OIL PAN REPLACEMENT

Remove or Disconnect (Figures 18 and 30)

1. Negative battery cable. Refer to SECTION 0A.
2. Power steering fluid reservoir from the fan shroud. Refer to SECTION 3B3.
3. Radiator fan shroud. Refer to SECTION 6B2.

- Raise the vehicle and support with safety stands.
- Drain the oil pan.

4. Strut rods.
5. Exhaust pipe at the manifolds. Refer to SECTION 6F.
6. Three way catalytic converter and exhaust pipe. Refer to SECTION 6F.
7. Flywheel cover.
8. Starter and brace.
9. Brake pipe at the crossmember.
10. Front engine mounting bolts (figure 30).
11. Oil pan bolts.
12. Oil pan.

Clean

- RTV from the sealing surfaces on the block, main bearing cap, timing gear cover, and oil pan.
- Oil and grease from the sealing surfaces. Use a suitable solvent.

Install or Connect (Figures 18 and 30)

NOTICE: For steps 2 and 3, see "Notice" on page 6A1-1.

- Apply RTV sealant to the oil pan flange and block. Refer to figure 18.

1. Oil pan.
2. Oil pan bolts.

Tighten

- Oil pan bolts to 10 N·m (90 in. lbs.).

- Lower the engine.

3. Engine mounting bolts.

Tighten

- Bolts to specifications. Refer to figure 30.

4. Brake pipe.
5. Starter and brace. Refer to SECTION 6D2.
6. Flywheel cover.
7. Three way catalytic converter and exhaust pipe. Refer to SECTION 6F.
8. Exhaust pipe to the manifolds. Refer to SECTION 6F.
9. Strut rods.

- Lower the vehicle.

10. Radiator fan shroud. Refer to SECTION 6B2.
11. Power steering reservoir. Refer to SECTION 3B3.

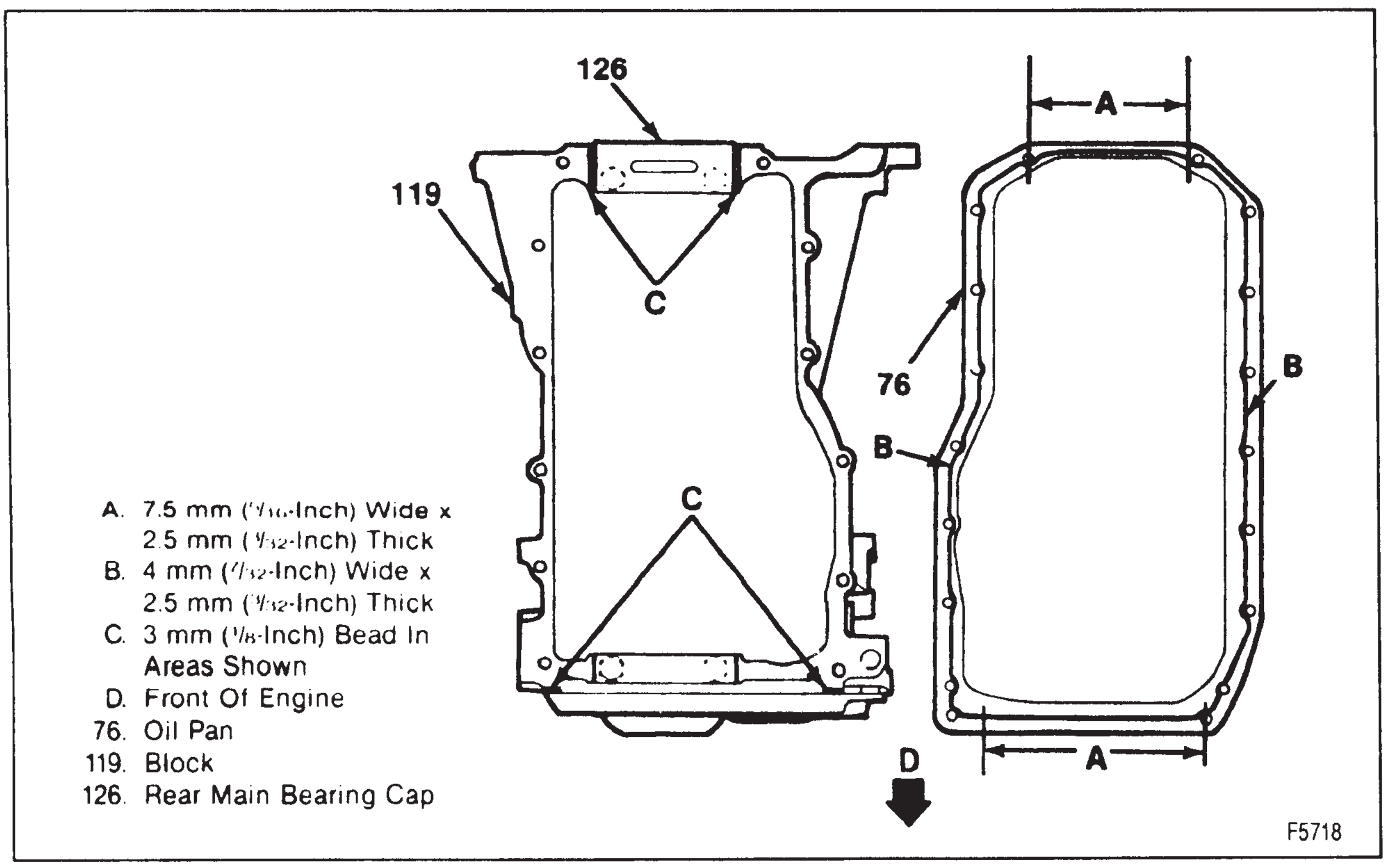


Figure 18—Applying RTV to the Oil Pan and Block

12. Proper quantity and grade of engine oil. Refer to SECTION 0B.
13. *Negative battery cable. Refer to SECTION 0A.*

OIL PUMP REPLACEMENT

Remove or Disconnect

1. Oil pan, as described previously.
2. Oil pump attaching bolts and pickup tube nut.
3. Oil pump.

Inspect

- Oil pump pickup tube for looseness. If the tube is loose, the oil pump must be replaced. A loose pickup tube can result in an air leak and loss of oil pressure.

Install or Connect

1. Oil pump.
   A. Align the oil pump shaft with the tang on the oil pump drive shaft.
   B. Position the oil pump over the oil pump drive shaft lower bushing. No gasket is used. The oil pump should slide easily into place.

NOTICE: See "Notice" on page 6A1-1.

2. Oil pump bolts.

Tighten

- Oil pump bolts to 25 N·m (18 ft. lbs.).
- Pickup tube nut to 42 N·m (31 ft. lbs.).

3. Oil pan, as described previously.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

A one-piece type seal is used.

Remove or Disconnect (Figure 19)

1. Transmission. Refer to SECTION 7.
2. Clutch (if equipped). Refer to SECTION 7.
3. Flywheel, as outlined later.

NOTICE: Care must be taken not to damage the crankshaft O.D.surface with the pry tool.

4. Crankshaft rear oil seal. Pry out with a screwdriver. Use care not to scratch the crankshaft.

Clean

- Oil seal mating surfaces on the block and crankshaft.

Inspect

- Seal bore for nicks and burrs.
- Seal mating surface on the crankshaft for scratches and nicks.

Install or Connect (Figure 19)

Tool Required:
J 34924 Seal Installer

1. Crankshaft rear oil seal. Use J 34924.
   A. Lubricate the seal ID with engine oil.
   B. Slide the seal over the mandrel of the tool until the dust lip (back of seal) mates squarely against the collar.
   C. Lubricate the seal OD with engine oil.
   D. Position the tool with the seal in place against the crankshaft. Align the dowel with the alignment tool in the crankshaft. Tighten the screws firmly.
   E. *Turn the T-handle of the tool until the collar* seats firmly against the crankcase. This will ensure the seal is seated properly.
   F. Loosen the T-handle fully. Loosen the screws and remove the tool.
2. Flywheel, as outlined later.
3. Clutch (if equipped). Refer to SECTION 7.
4. Transmission. Refer to SECTION 7.

CAMSHAFT REPLACEMENT

Remove or Disconnect (Figures 20 and 21)

1. Negative battery cable. Refer to SECTION 0A.
2. Power steering reservoir from the radiator shroud. Refer to SECTION 3B3.
3. Upper fan shroud. Refer to SECTION 6B2.
4. Drive belt. Refer to SECTION 6B1.

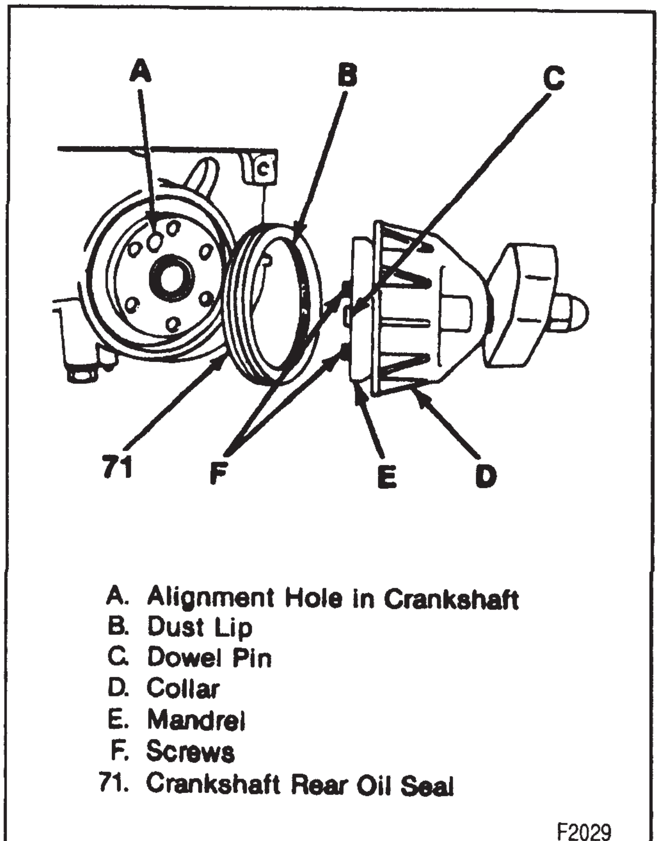


Figure 19—Installing the Crankshaft Rear Oil Seal

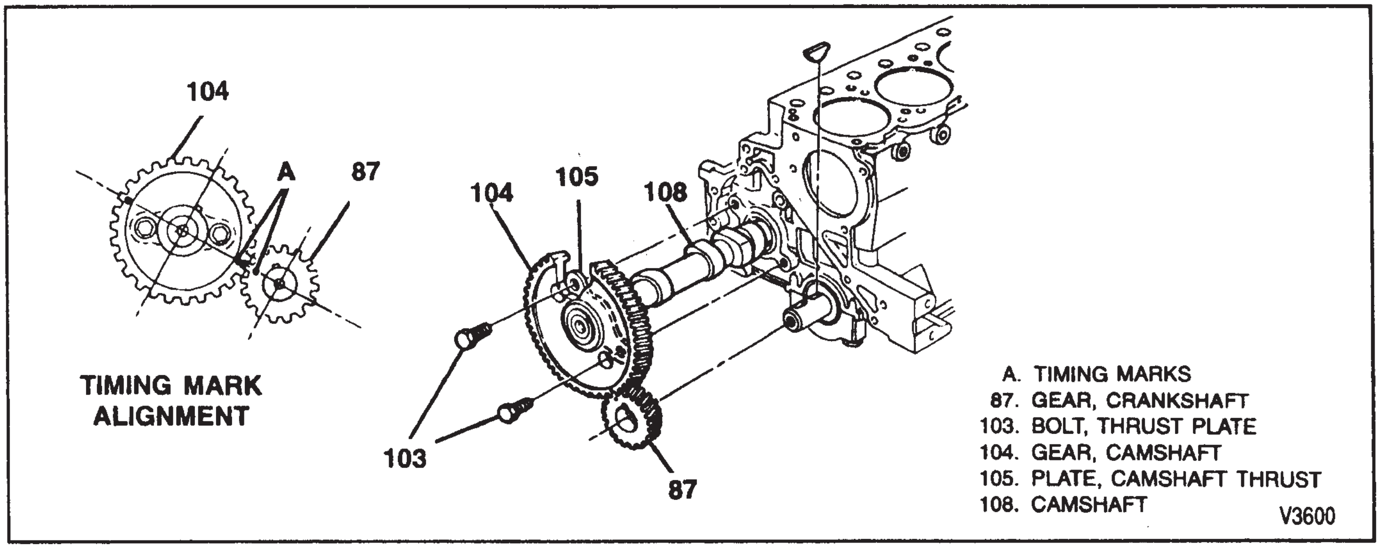


Figure 20—Camshaft and Timing Gears

5. Fan and pulley. Refer to SECTION 6B1.
6. Crankshaft pulley, as outlined previously.
7. Timing gear cover, as outlined previously.
8. Distributor. Refer to SECTION 6D4.
9. Oil pump drive shaft, as outlined previously.
10. Pushrod cover, as outlined previously.
11. Rocker arm cover, as outlined previously.
12. Hydraulic lifters and pushrods, as outlined previously.
13. Radiator. Refer to SECTION 6B2.
14. Air conditioning condenser. Refer to SECTION 1B.
15. Grille and filler panel. Refer to SECTION 2B.
16. Thrust plate bolts (103) (figures 20 and 21).
17. Camshaft. Support the camshaft carefully to avoid damage to the camshaft bearings.

Inspect

- Camshaft lobes and journals for scratches, pitting, and wear.
- Timing gear for damaged teeth.

Measure (Figure 22)

- Thrust plate to camshaft clearance. Use a feeler gage (figure 22). The proper clearance is 0.0015-0.0050 inch. If the clearance is excessive, replace the thrust plate. If the clearance is insufficient, replace the spacer ring. Refer to the Light Duty Truck Unit Repair Manual.

Install or Connect (Figure 20)

- Coat the camshaft lobes and journals with High Viscosity Oil with Zinc (GM P/N 12345501 or equivalent).

1. Camshaft (108) to the engine. Handle the camshaft carefully to prevent damage to the camshaft bearings.

Important

- Line up the timing marks on the crankshaft gear and camshaft gear (figure 20).

NOTICE: See "Notice" on page 6A1-1.

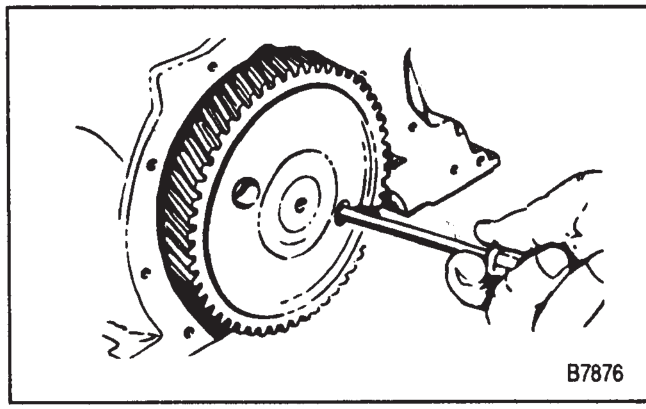


Figure 21—Removing the Camshaft Thrust Plate Bolts

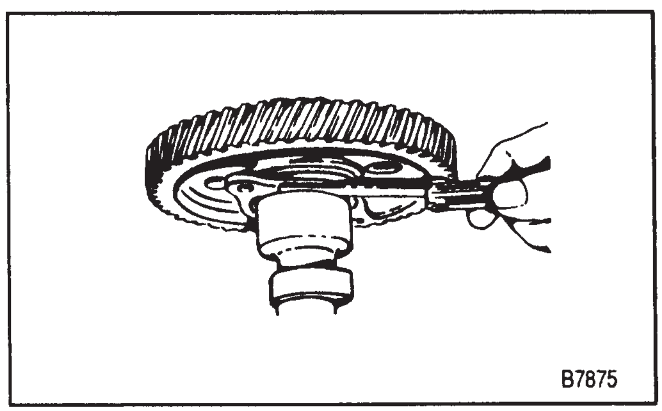


Figure 22—Measuring Camshaft to Thrust Plate Clearance (Camshaft End Play)

2. Thrust plate bolts (103).

Tighten

- Thrust plate bolts to 10 N.m (90 in. lbs.).

3. Grille and filler panel. Refer to SECTION 2B.
4. Air conditioning condenser. Refer to SECTION 1B.
5. Radiator. Refer to SECTION 6B2.
6. Hydraulic lifters and pushrods, as outlined previously.

7. Rocker arm cover, as outlined previously.
8. Pushrod cover, as outlined previously.
9. Oil pump drive shaft, as outlined previously.
10. Distributor. Refer to SECTION 6D4.
11. Timing gear cover, as outlined previously.
12. Fan and pulley. Refer to SECTION 6B1.
13. Drive belt. Refer to SECTION 6B1.
14. Upper fan shroud. Refer to SECTION 6B2.
15. Power steering reservoir to the fan shroud. Refer to SECTION 3B3.
16. Negative battery cable. Refer to SECTION 0A.
   - Fill the cooling system with the proper quantity and grade of coolant. Refer to SECTION 0B.

CONNECTING ROD AND PISTON REPLACEMENT

Remove or Disconnect (Figure 23)

1. Cylinder head, as outlined previously.
2. Oil pan, as outlined previously.
3. Ridge or deposits from the upper end of the cylinder bores.
   A. Turn the crankshaft until the piston is at BDC.
   B. Place a cloth on top of the piston.
   C. Perform the cutting operation with a ridge reamer.
   D. Turn the crankshaft until the piston is at TDC.
   E. Remove the cloth and cuttings.
4. Connecting rod cap. Check the connecting rod and cap for identification marks. Mark the parts if required. The connecting rod and cap must be kept together as mating parts.
5. Connecting rod and piston.
   A. Attach short pieces of hose to the connecting rod bolts (figure 23). This will protect the crankshaft journal during removal.
   B. Push the piston out of the bore.
   C. After removal, assemble the connecting rod and cap.

Cleaning, Inspection, and Repair

Clean, inspect, and repair or replace the components as necessary. Measure connecting rod bearing clearance, piston clearance, ring clearances, etc. Refer to the Light Duty Truck Unit Repair Manual.

The unit repair manual contains information on:

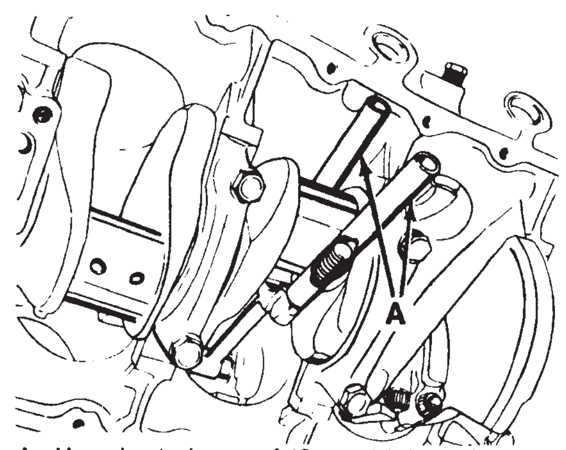
- Connecting rod and piston.
- Piston rings.
- Connecting rod and crankpin.
- Cylinder bores.

Install or Connect (Figures 21 through 24)

Tool Required:
J 8037 Ring Compressor

- Make sure the cylinder walls are clean. Lubricate the cylinder walls lightly with engine oil.
- Make sure the piston is installed in the matching cylinder.

1. Connecting rod bearings.
   A. Make sure the bearings are of the proper size.
   B. Install the bearing inserts into the connecting rod and connecting rod cap.



A. Use short pieces of 10 mm (3/8-inch) hose to protect the crankshaft journal.

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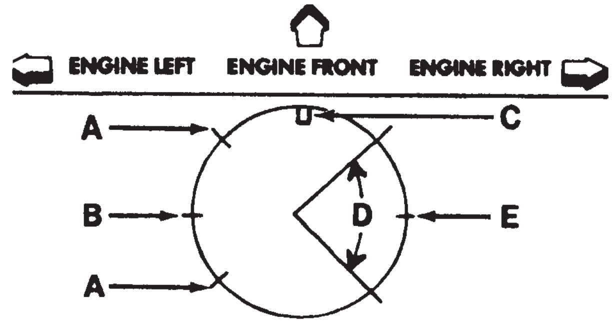
Figure 23—Replacing the Connecting Rod and Piston



A. Oil Ring Rail Gaps
B. 2nd Compression Ring Gap
C. Notch In Piston
D. Oil Ring Spacer Gap (Tang In Hole Or Slot With Arc)
E Top Compression Ring Gap

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Figure 24—Piston Ring Gap Location

   C. Lubricate the bearings with engine oil.
2. Piston and connecting rod to the proper bore.
   A. Attach short pieces of hose to the connecting rod bolts (figure 23). This will protect the crankshaft journal during installation.
   B. Locate the piston ring end gaps as shown in figure 24. Lubricate the piston and rings with engine oil.
   C. Without disturbing the ring end gap location, install J 8037 over the piston (figure 25).
   D. The piston must be installed so the notch in the piston faces the front of the engine (figure 24).
   E. Place the piston in its matching bore. Using light blows with a hammer handle, tap the piston down into its bore (figure 25). At the same time (from beneath the vehicle) guide the connecting rod to the crankpin with the hose pieces. Hold the ring compressor against the block until all rings have entered the cylinder bore.

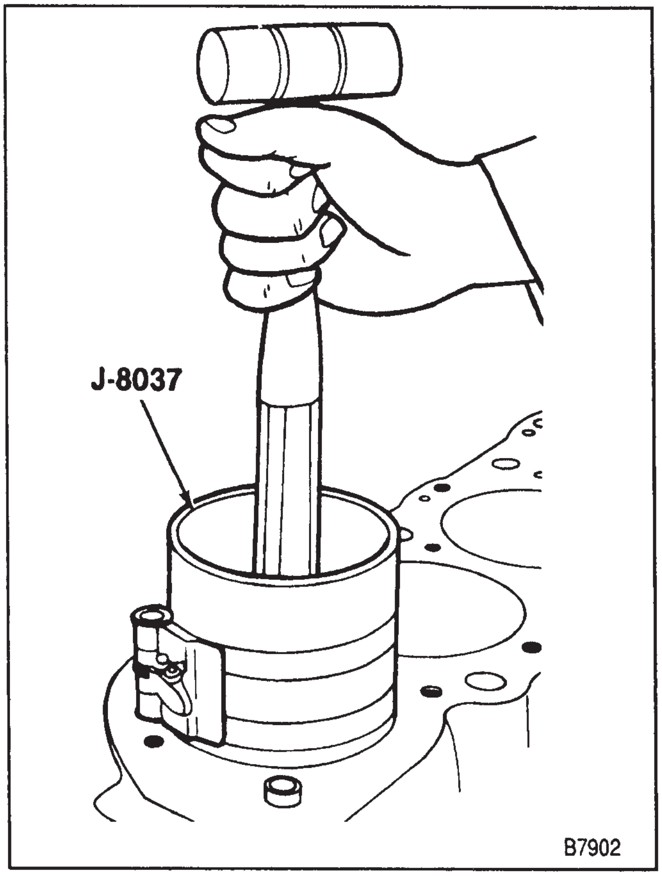


Figure 25—Installing the Piston

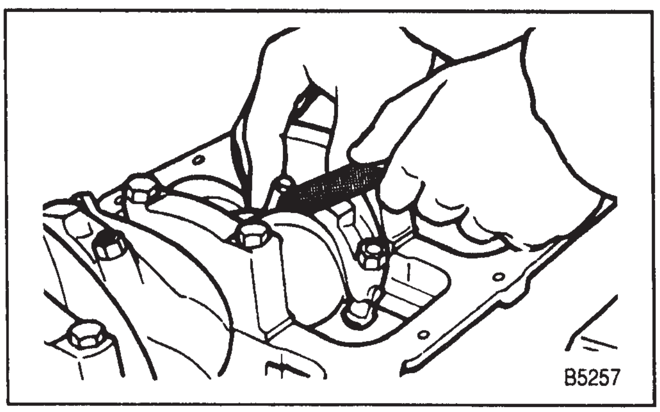


Figure 26—Measuring Connecting Rod Side Clearance

F. Remove the hose pieces from the connecting rod bolts.

Measure

- Connecting rod bearing clearance. Refer to the Light Duty Truck Unit Repair Manual.

3. Connecting rod cap and bearing.

NOTICE: See "Notice" on page 6A1-1.

4. Connecting rod bolt nuts.

Tighten

- Connecting rod bolt nuts to 40 N·m (30 ft. lbs.).

Measure

- Connecting rod side clearance. Use a feeler gage between the connecting rod and crankshaft (figure 26). The correct clearance is 0.002-0.006 inch.

5. Oil pan and cylinder head, as outlined previously.

MAIN BEARING REPLACEMENT

Remove or Disconnect

Tool Required:
J 8080 Main Bearing Remover/Installer

1. Spark plugs. Refer to SECTION 6D4.
2. Oil pan, as outlined previously.
3. Oil pump, as outlined previously.
4. Main bearing caps.
   - Check the main bearing caps for location markings. Mark the caps if necessary. The caps must be returned to their original locations during assembly.
5. Lower main bearing inserts from the main bearing caps.
6. Upper main bearing inserts.
   A. Insert J 8080 into the crankshaft oil hole (figure 27).
   B. Rotate the crankshaft to "turn" the bearing insert out of the block.

Cleaning, Inspection, and Repair

Clean, inspect, and repair or replace the components as required. Refer to the Light Duty Truck Unit Repair Manual. The unit repair manual contains information on

- Crankshaft.
- Main and connecting rod bearings.

Install or Connect (Figures 27 and 28)

Tool Required:
J 8080 Main Bearing Remover/Installer

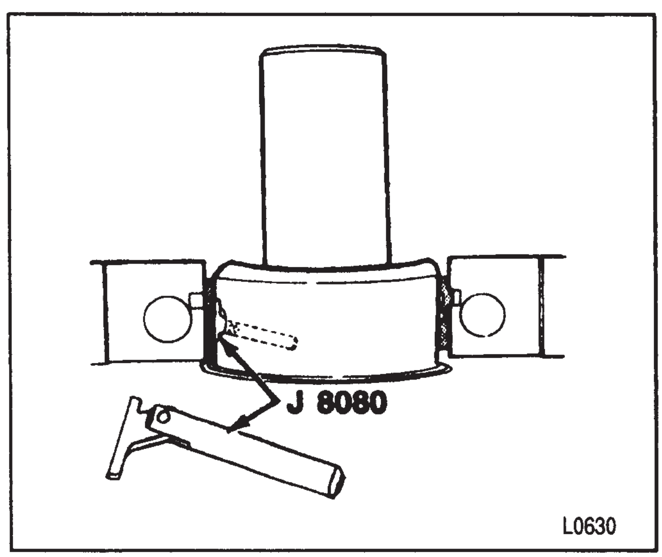


Figure 27—Removing the Upper Main Bearing Insert

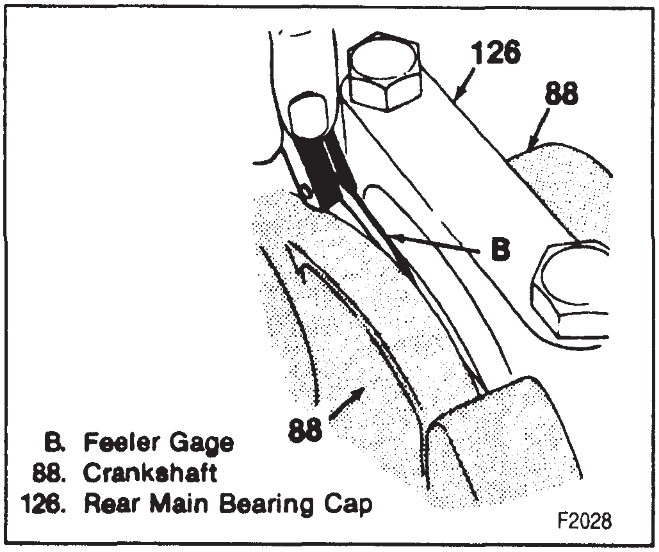


Figure 28—Measuring Crankshaft End Play

1. Upper main bearing inserts.
   A. Insert J 8080 into a crankshaft main bearing oil hole (figure 27).
   B. Apply engine oil to inserts of the proper size.
   C. Insert the plain end (without the bearing tang) of the insert between the crankshaft and the notched side of the block.
   D. Rotate the crankshaft to "roll" the insert into the block.
   E. Remove the tool.
2. Lower main bearing inserts to the main bearing caps.
   A. Make sure the inserts are the proper size.
   B. Apply engine oil to the inserts.

Measure

- Main bearing clearance. Refer to the Light Duty Truck Unit Repair Manual. If the engine is in the vehicle, the crankshaft must be supported upward to remove any clearance from the upper bearing. The total clearance can then be measured between the lower bearing and journal.

NOTICE: See "Notice" on page 6A1-1.

3. Main bearing caps (except rear cap) and bolts to the block.

Tighten

- Main bearing cap bolts to 88 N·m (65 ft. lbs.).

4. Rear main bearing cap.
   A. Apply engine oil to the bearing insert.
   B. Install the rear main bearing cap and bolts. Tighten the bolts temporarily to 14 N·m (124 in. lbs.).

Measure

- Crankshaft end play, as follows:
   A. Firmly thrust the crankshaft first rearward then forward. This will line up the rear main bearing and crankshaft thrust surfaces.
   B. Tighten the rear main bearing caps to 95 N·m (70 ft. lbs.).
   C. With the crankshaft wedged forward, measure at the front end of the rear main bearing with a feeler gage (figure 28). The proper clearance is 0.005-0.010 inch.

5. Oil pump, as outlined previously.
6. Oil pan, as outlined previously.
7. Spark plugs. Refer to SECTION 6D4.

CRANKSHAFT REPLACEMENT

1. Remove the engine, as outlined later.
2. Refer to the Light Duty Truck Unit Repair Manual for crankshaft replacement procedures.

FLYWHEEL REPLACEMENT

Remove or Disconnect (Figure 29)

1. Transmission. Support the rear of the engine. Refer to SECTION 7.
2. Clutch assembly. Refer to SECTION 7.
3. Flywheel housing.
4. Flywheel bolts, flywheel, and spacer (if used).

Inspect

- Flywheel for wear and damage. Replace if necessary. Do not machine the flywheel.
- Flywheel ring gear for broken or damaged teeth.

Install or Connect (Figure 29)

1. Spacer (if used).

NOTICE: See "Notice" on page 6A1-1.

2. Flywheel and bolts.

Tighten

- Flywheel bolts to specifications.
   - Automatic Transmissions: 75 N·m (55 ft. lbs.).
   - Manual Transmissions: 90 N·m (65 ft. lbs.).

3. Clutch assembly. Refer to SECTION 7.
4. Transmission. Refer to SECTION 7.

ENGINE MOUNTINGS

NOTICE: Broken or deteriorated mountings can cause misalignment and eventual destruction of certain drive train components. When a single mounting breakage occurs, the remaining mountings are subjected to abnormally high stresses.

INSPECTING ENGINE MOUNTINGS

Front Mountings

1. Raise the engine to remove weight from the mountings and place a slight tension on the rubber cushion. Observe both mountings while raising the engine.

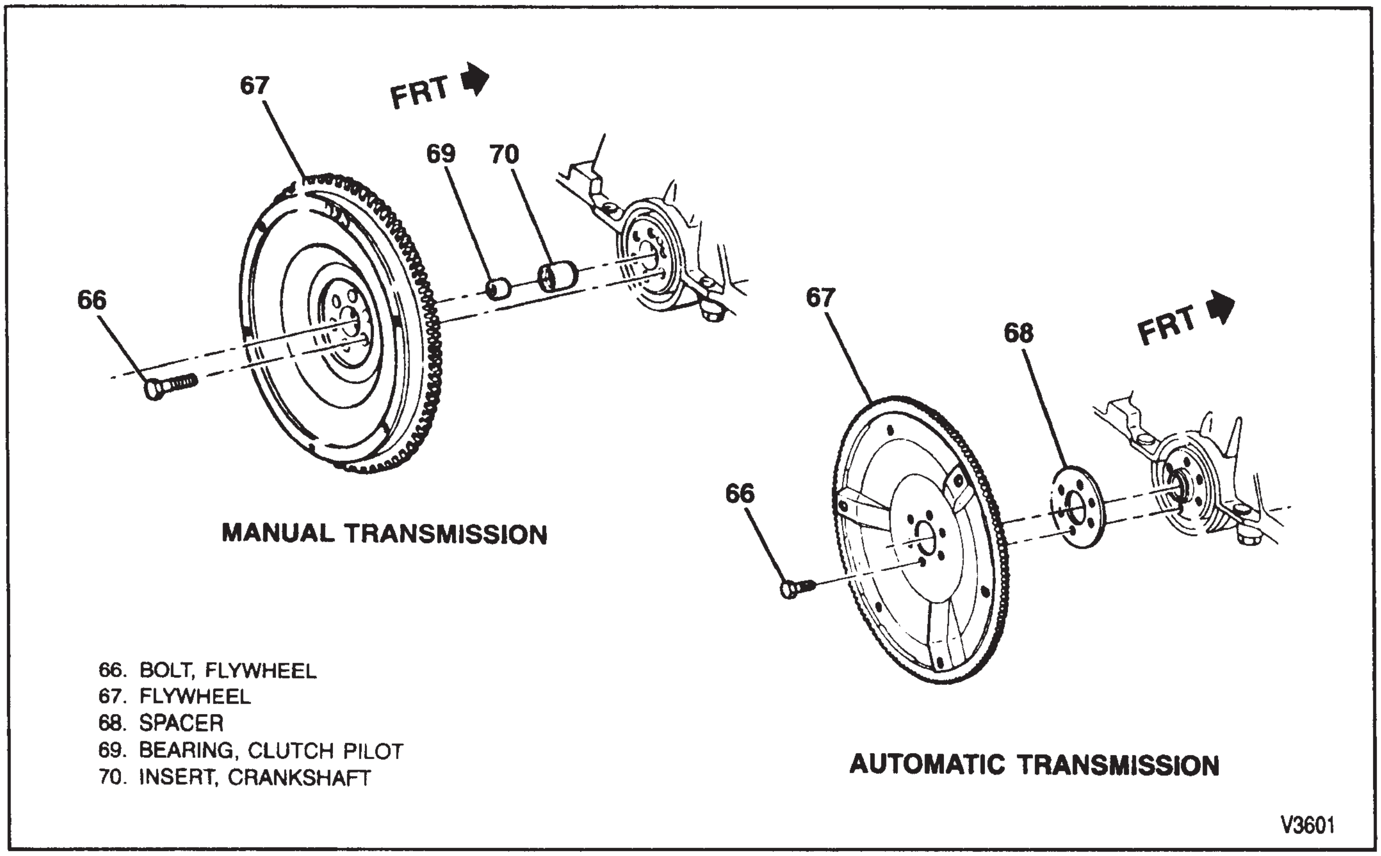


Figure 29—Flywheel and Components

2. Replace the mounting if the following conditions exist:
   - Hard rubber surface covered with heat check cracks.
   - Rubber cushion separated from the metal plate of the mounting.
   - Rubber cushion split through the center.
3. If there is movement between a metal plate of the mounting and its attaching points, lower the engine and tighten the bolts or nuts attaching the mounting to the engine, frame, or bracket.

Rear Mountings

1. Push up and pull down on the transmission tailshaft. Observe the transmission mounting.
2. Replace the mounting if the following conditions exist:
   - Rubber cushion separated from the metal plate of the mounting.
   - Mounting bottomed out (tailshaft can be moved up but not down).
3. If there is relative movement between a metal plate of the mounting and its attaching point, tighten the bolts or nuts attaching the mounting to the transmission or crossmember.

FRONT MOUNTING REPLACEMENT

Remove or Disconnect (Figure 30)

- Support the engine with a suitable lifting fixture. Do not load the engine mounting.

1. Engine mounting through-bolt and nut.
   - Raise the engine only enough to permit removal of the engine mounting.
2. Mounting assembly bolts, nuts, and washers.
3. Mounting assembly.

Install or Connect (Figure 30)

NOTICE: For steps 2 and 3, see "Notice" on page 6A1-1.

1. Mounting assembly.
2. Mounting assembly bolts, nuts, and washers.

   Tighten

   - Fasteners to specifications. Refer to figure 30.
3. Engine mounting through-bolt and nut. Lower the engine until the bolt can be inserted. Install the nut.

   Tighten

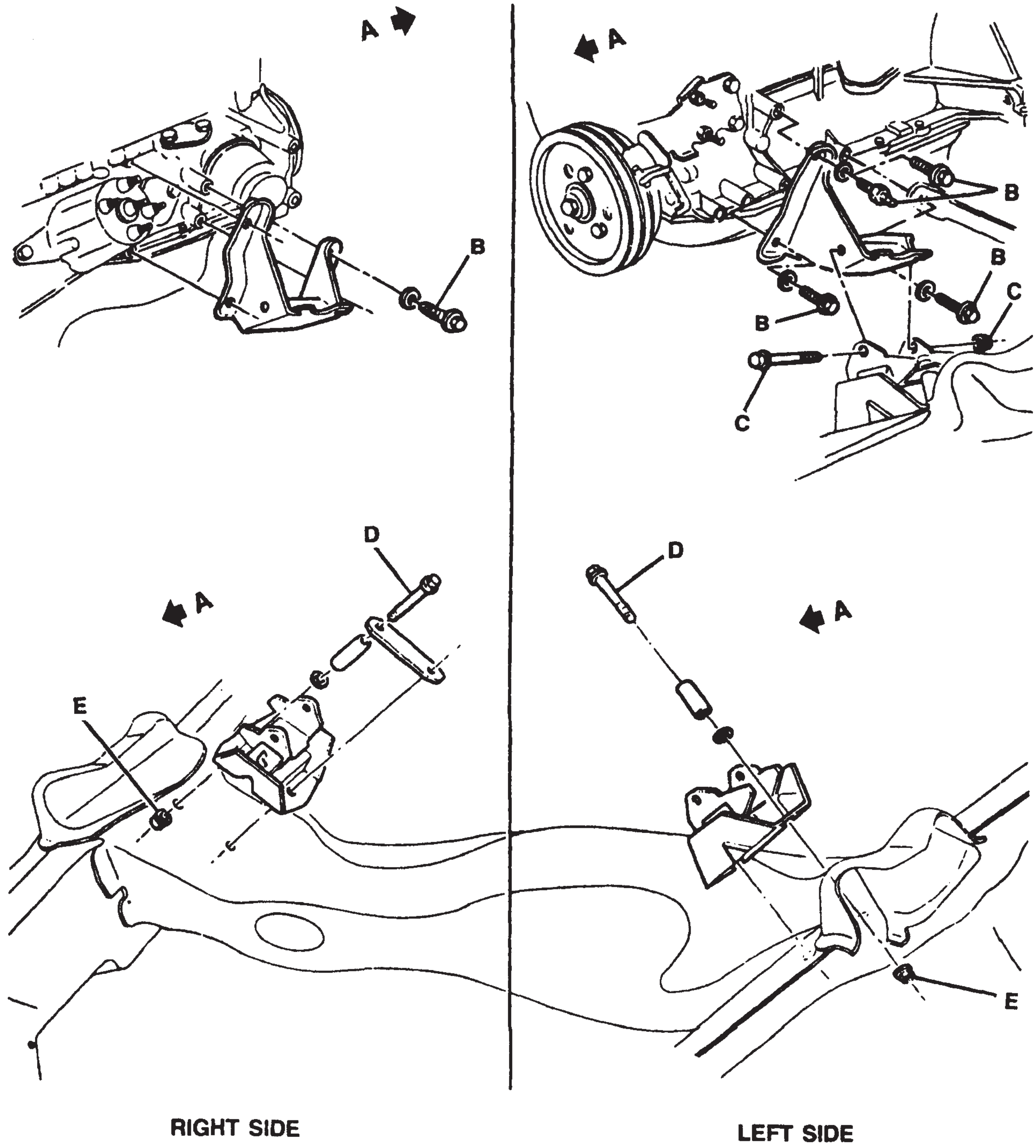
   - Through-bolt or nut to specifications. Refer to figure 30.

REAR MOUNTING REPLACEMENT

Remove or Disconnect (Figure 31)

- Support the rear of the engine to relieve the weight on the rear mountings.

1. Mounting to crossmember nut(s) and washer(s).
2. Mounting to transmission bolts and washers.



A. FORWARD
B. 60 N·m (45 FT. LBS.)
C. TORQUE BOLT TO 65 N·m (50 FT. LBS.)
OR, TORQUE NUT TO 42 N·m (30 FT. LBS.)
D. 45 N·m (34 FT. LBS)
E. 36 N·m (26 FT. LBS.)

F2682

Figure 30—Front Engine Mounting

- Raise the rear of the engine only enough to permit removal of the mounting.

3. *Mounting.*

Install or Connect (Figure 31)

NOTICE: For steps 2 and 3, see "Notice" on page 6A1-1.

1. Mounting.
   - Lower the rear of the engine.
2. Mounting to transmission bolts and washers.
3. Mounting to crossmember nut(s) and washer(s).

Tighten

- Fasteners to specifications. Refer to figure 31.

ENGINE REPLACEMENT

Remove or Disconnect

1. Negative battery cable. Refer to SECTION 0A.
2. Hood. Refer to SECTION 2B.
3. Power steering reservoir from the fan shroud. Refer to SECTION 3B3.
4. Upper fan shroud. Refer to SECTION 6B2.
5. Fan. Refer to SECTION 6B1.
6. Radiator. Refer to SECTION 6B2.
7. Air conditioning compressor (if used) from its brackets and lay aside. Refer to SECTION 1B.
8. Power steering pump from its brackets and lay aside. Refer to SECTION 3B3.
9. Air cleaner.
10. Fuel line bracket at the filter.
11. Fuel and vacuum hoses.
12. Accelerator and cruise control cables (if equipped).
13. Heater hoses.
14. Oxygen sensor and other necessary wiring.
15. Strut rod.
16. Exhaust pipe at the converter hanger. Refer to SECTION 6F.
17. Exhaust pipe at the manifold. Refer to SECTION 6F.
18. Flywheel cover.
19. Drive belt splash shield (if equipped). Refer to SECTION 6B1.
20. Starter. Refer to SECTION 6D2.
21. Flywheel to torque converter bolts. Refer to SECTION 7.
22. Two left side outer air dam bolts.
23. Lower fan shroud. Refer to SECTION 6B2.
24. *Left side body (cab) mounting bolts.*
    - Raise the left side of the body. Block in position with wooden blocks.
25. Upper transmission to engine bolts.
    - Lower the body.
26. Remaining transmission to engine bolts.
27. Engine mounting through-bolts (figure 30).
    - Lower the vehicle. Support the transmission.
    - Raise the engine and move slightly forward.
28. Wiring harness clips and ground straps at the rear of the engine.

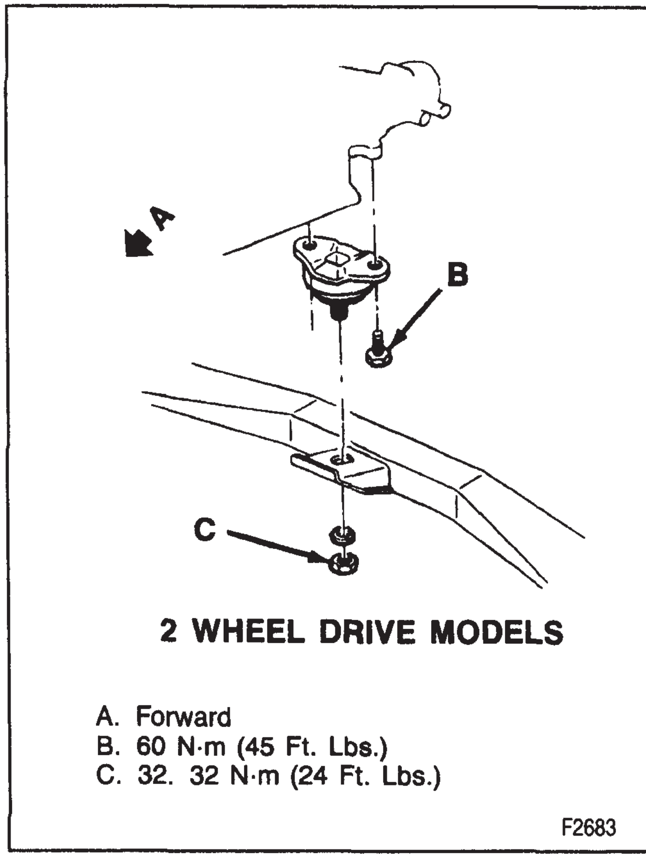


Figure 31—Rear Engine Mounting

29. Engine. Pull forward slightly, turn sideways, then remove.

Install or Connect

NOTICE: For steps 4, 5, 6, 7, 9, and 10, see "Notice" on page 6A1-1.

1. Engine to the vehicle.
2. Wiring harness clips and ground straps at the rear of the engine.
3. Engine to the transmission. Lower into position.
4. Engine mounting through-bolts.

Tighten

- Fasteners to specifications. Refer to figure 30.
- Raise the vehicle and support with safety stands.
- Remove the transmission support.

5. Lower transmission to engine bolts.
   - Raise the body. Block in position with wooden blocks.
6. Upper transmission to engine bolts.
   - Lower the body.
7. Left side body mounting bolts. Refer to SECTION 2B.
8. Lower fan shroud. Refer to SECTION 6B1.
9. Air dam bolts.
10. Flywheel to torque converter bolts. Refer to SECTION 7.
11. Starter. Refer to SECTION 6D2.

12. Drive belt splash shield (if used). Refer to SECTION 6B1.
13. Flywheel cover.
14. Exhaust pipe and new packing to the manifold. Refer to SECTION 6F.
15. Exhaust pipe at the converter hanger. Refer to SECTION 6F.
16. Strut rods.
    - Lower the vehicle.
17. Wiring connectors.
18. Heater hose.
19. Accelerator and cruise control cables (if equipped).
20. Fuel and vacuum hoses.
21. Fuel line bracket at the filter.
22. Air cleaner.
23. Power steering pump and air conditioning compressor (if used). Refer to SECTIONS 1B and 3B3.
24. Radiator. Refer to SECTION 6B2.
25. Fan. Refer to SECTION 6B1.
26. Upper fan shroud. Refer to SECTION 6B2.
27. Power steering reservoir to the fan shroud. Refer to SECTION 3B3.
28. Hood. Refer to SECTION 2B.
29. Negative battery cable. Refer to SECTION 0A.
    - Fill the engine crankcase with the proper quantity and grade of oil. Refer to SECTION 0B.
    - Fill the cooling system with the proper quantity and grade of coolant. Refer to SECTION 0B.

THREAD REPAIR

Damaged threads may be reconditioned by drilling out, rethreading, and installing a suitable thread insert. General purpose thread repair kits are available commercially.

CAUTION: Wear safety glasses to avoid eye damage.

1. Determine size, pitch, and depth of damaged thread. If necessary, adjust stop collars on cutting tool and tap to required depth.

Important

- Refer to the kit manufacturer's instructions regarding the size of drill and tap to be used.

2. Drill out damaged thread. Clean out chips.
3. Tap hole. Lubricate tap with light engine oil. Clean the thread.

Important

- Avoid build-up of chips. Back out the tap every few turns and remove chips.

4. Thread the thread insert onto the mandrel of the installer (figure 32). Engage the tang of the insert onto the end of the mandrel.
5. Lubricate the insert with light engine oil (except when installing in aluminum) and install.

Important

- When correctly installed, the insert should be flush to one turn below the surface.

6. If the tang of the insert does not break off when backing out the installer, break the tang off with a drift.

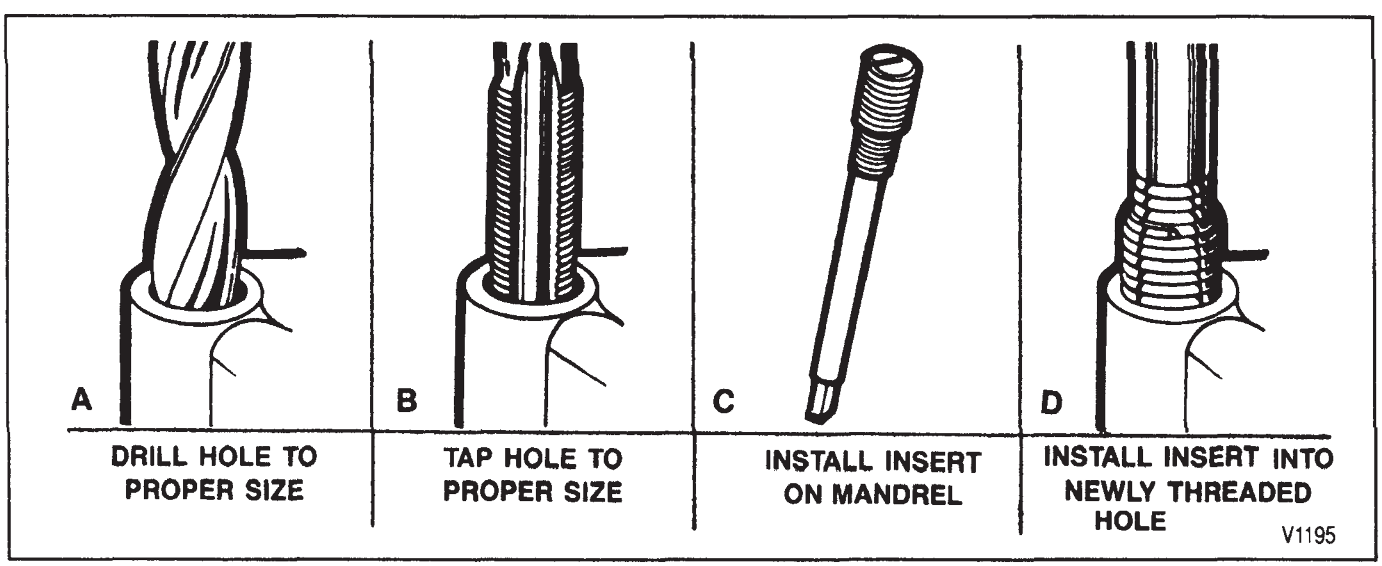


Figure 32—Repairing Thread Holes

SPECIFICATIONS

ENGINE SPECIFICATIONS (2.5L)

All Specifications are in INCHES unless otherwise noted.

GENERAL DATA:			
Type			L-4
Displacement			2.5L (151 CID)
RPO (VIN Code)			L38 (A)
Bore			4.00
Stroke			3.00
Compression Ratio			8.3:1
Firing Order			1-3-4-2
Oil Pressure			36-41 psi @ 2000 RPM
CYLINDER BORE:			
Diameter			4.000
Out Of Round			0.001 (Maximum)
Taper—Thrust Side			0.005 (Maximum)
PISTON:			
Clearance			0.0015-0.0035
PISTON RING:			
COMPRESSION	Groove Clearance	Top	0.0015-0.0030
		Second	0.0015-0.0032
	Gap	Top	0.010-0.015
		Second	0.010-0.020
OIL	Groove Clearance		0.0005-0.007
	Gap		0.015-0.055
PISTON PIN:			
Diameter			0.9270-0.9280
Clearance In Piston			0.0004-0.0006
Fit In Rod			Production: 0.0002-0.0007 Service: 0.0002-0.0023
OIL PUMP:			
Gear Lash			0.009-0.015
Gear Pocket Depth			0.995-0.998
Gear Pocket Diameter			1.503-1.506
Gear Length			0.999-1.002
Gear Diameter			1.496-1.500
Gear Side Clearance			0.004 (Maximum)
End Clearance			0.002-0.005

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SPECIFICATIONS (CONT.)

ENGINE SPECIFICATIONS (2.5L)

All Specifications are in INCHES unless otherwise noted.

CRANKSHAFT:			
Main Journal	Diameter		2.2992-2.2984
	Taper		0.0005
	Out of Round		0.0005
Main Bearing Clearance			0.0005-0.0022
Crankshaft End Play			0.005-0.010
Crankpin	Diameter		2.0001-1.9963
	Taper		0.0005
	Out of Round		0.0005
Rod Bearing Clearance			0.0005-0.0030
Rod Side Clearance			0.006-0.002
CAMSHAFT:			
Lobe Lift (Intake and Exhaust)			0.251
End Play			0.0015-0.005
Journal Diameter			1.869
Journal Clearance			0.0007-0.0027
VALVE SYSTEM:			
Lifter Type			Roller Hydraulic
Lifter Leak — Down Rate			12-90 Seconds with 50 lb. load
Lifter Body Diameter			0.8421-0.8429
Lifter Bore Diameter			0.8435-0.8445
Lifter Clearance in Bore			0.0025
Plunger Travel			0.2177
Pushrod Length			8.299
Valve Lash			NOT ADJUSTABLE
Rocker Arm Ratio			1.75:1
Face Angle (Intake & Exhaust)			45°
Seat Angle (Intake & Exhaust)			46°
Seat Runout (Intake & Exhaust)			0.002
Seat Width		Intake	0.050-0.106
		Exhaust	0.060-0.116
Stem Clearance		Intake	0.0010-0.0025
		Exhaust	0.0013-0.0030 (Upper) 0.0024-0.0041 (Lower)
Stem Diameter		Intake	0.3131-0.3138
		Exhaust	0.3129-0.3137 (Upper) 0.3118-0.3126 (Lower)
Valve Spring	Free Length		1.90
	Pressure N @ mm	Closed	71-78 lbs. @ 1.679
		Open	210-230 lbs. @ 1.239
	Installed Height		1.679

T2361

SPECIFICATIONS (CONT.)

FASTENER TIGHTENING SPECIFICATIONS

Item	N·m	Ft. Lbs.	In. Lbs.
Camshaft Thrust Plate Bolts	10	—	90
Connecting Rod Bolt Nuts	44	32	—
Coolant Outlet Housing Bolts	27	20	—
Coolant Pump	34	25	—
Crankshaft Pulley Hub To Crankshaft Bolt	220	160	—
Crankshaft Pulley To Hub Bolts	34	25	—
Cylinder Head Bolts — See Text	—	—	—
Distributor Clamp Bolt	17	13	—
Exhaust Manifold Bolts (Center Exhaust Tube)	50	36	—
Exhaust Manifold Bolts (Front and Rear Exhaust Tubes)	38	28	—
Flywheel Bolts (Automatic Transmissions)	75	55	—
Flywheel Bolts (Manual Transmissions)	90	65	—
Hydraulic Lifter Guide Retainer Stud	10	—	90
Intake Manifold Bolts	34	25	—
Main Bear Cap Bolts	95	70	—
Oil Pan Bolts (All)	10	—	90
Oil Pan Drain Plug	25	18	—
Oil Pickup Tube Nut	50	38	—
Oil Pump Cover Bolts	14	—	120
Oil Pump To Block Bolts	30	22	—
Pushrod Cover Nuts	12	—	106
Rocker Arm Bolts	30	22	—
Rocker Arm Cover Bolts	5.0	—	48
Thermostat Housing Bolts	27	20	—
Timing Gear Cover Bolts	10	—	90

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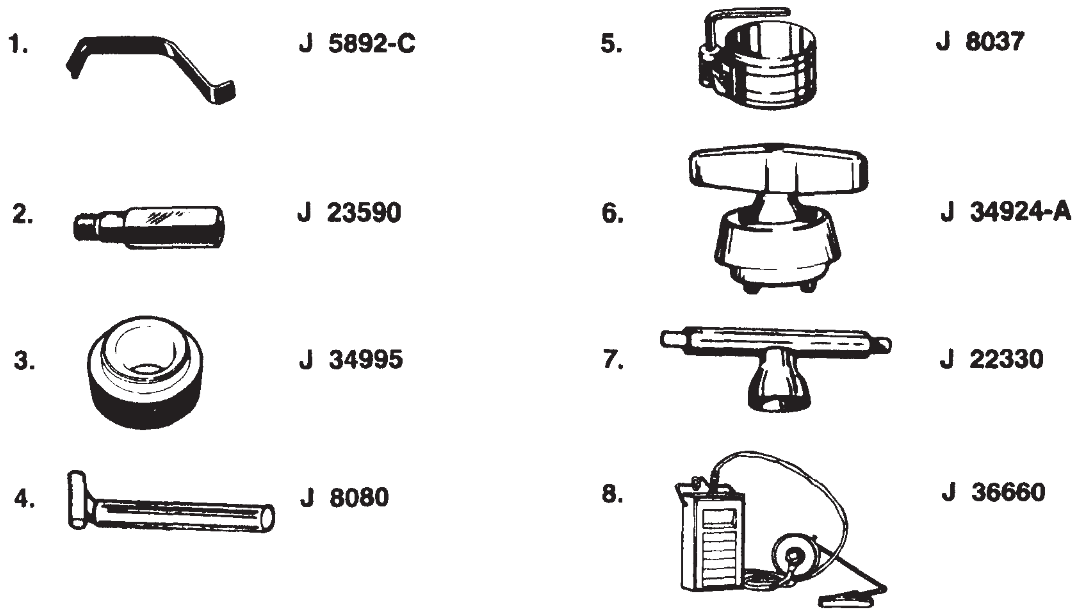
SPECIAL TOOLS



1. VALVE SPRING COMPRESSOR
2. AIR ADAPTER
3. CRANKSHAFT SEAL INSTALLER AND CENTERING TOOL
4. MAIN BEARING REPLACER
5. PISTON RING COMPRESSOR
6. REAR CRANKSHAFT SEAL INSTALLER
7. VALVE STEM SEAL TESTER
8. TORQUE/ANGLE METER

F8805

SECTION 6A2

2.8L V6
RPO LL2, VIN R

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the ocrrect part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

The 2.8L engines are 60-degree V6 type, overhead valve, liquid cooled, with cast iron block and heads.

The crankshaft is supported by four precision insert main bearings, with crankshaft thrust taken at the number three bearing.

The camshaft is supported by four plain type bearings and chain driven. Motion from the camshaft is transmitted to the valves through hydraulic lifters, pushrods, and ball type rocker arms. The valve guides are integral within the cylinder head.

The connecting rods are forged steel with precision insert type crankpin bearings. The piston pins are a press fit in the connecting rods.

The pistons are made of cast aluminum alloy. The piston pins use a floating fit within the piston.

For engine identification, refer to SECTION 0A. For engine component identification, refer to figures 1 through 4.

30. Camshaft Sprocket Bolt
35. Oil Pan Studs
36. Oil Pan Bolts
37. Oil Pan Reinforcement
38. Oil Pan Nuts
39. Oil Pump Cover
40. Oil Pump Bolt
41. Oil Pump
42. Oil Pump Shaft
43. Oil Pump Cover Gasket
44. Oil Pressure Regulator Valve Spring
45. Oil Pressure Regulator Valve
46. Regulator Valve Spring Stop Plug
47. Oil Pump Screen
48. Oil Pump Plug
49. Oil Pressure Regulator Valve Retaining Pin
50. Oil Filter Adapter Bolt
51. Oil Filter Adapter Bolt Seal
52. Oil Filter Adapter
53. Oil Filter Adapter Gasket
54. Oil Filter
56. Camshaft Sprocket
57. Timing Chain
58. Pin
59. Camshaft
60. Camshaft Bearing
61. Connectiing Rod Bolt
62. Piston Pin
63. Connecting Rod
64. Piston
65. Piston Rings
66. Connecting Rod Bearing
67. Oil Level Indicator/Gage
68. Nut
69. Oil Level Indicator Tube
70. Bolt
71. Camshaft Rear Cover
72. Camshaft Rear Cover Gasket
73. Cylinder Head Dowel Pin
74. Plug
75. Coolant Jacket Hole Plug
76. Oil and Fuel Pump Pressure Switch
77. Tee
78. Oil Filter Connector
79. Clutch Cover
80. Spring Washer
81. Bolt
82. Clutch Driven Plate
83. Flywheel Bolt
84. Groove Pin
85. Crankshaft Rear Oil Seal
86. Flywheel
87. Rear Bearing Cap O-Ring Seal
88. Crankshaft Bearing Cap
89. Oil Pan Gasket
90. Drain Plug Gasket
91. Oil Pan Drain Plug
92. Engine Wiring Harness Clip
93. Oil Pan
94. Crankshaft Bearing Cap Bolt
95. Crankshaft
96. Lower Crankshaft Bearing
97. Groove Pin
98. Torsional Damper Bolt
99. Special Washer
100. Torsional Damper
101. Crankshaft Sprocket
102. Torsional Damper Key
103. Upper Crankshaft Bearings
104. Clutch Pilot Bearing
105. Connecting Rod Cap
106. Connecting Rod Nut
107. Timing Pointer
108. Timing Pointer Screw
109. Front Cover Bolt
110. Bolt
111. Bolt
112. Coolant Pump
113. Coolant Pump Gasket
114. Crankshaft Front Oil Seal
115. Front Cover
116. Front Cover Gasket
117. Pin
118. Plug
119. Bolt
120. Timing Chain Guide Damper
121. Knock Sensor
122. Engine Block

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Figure 1—Cylinder Block and Components

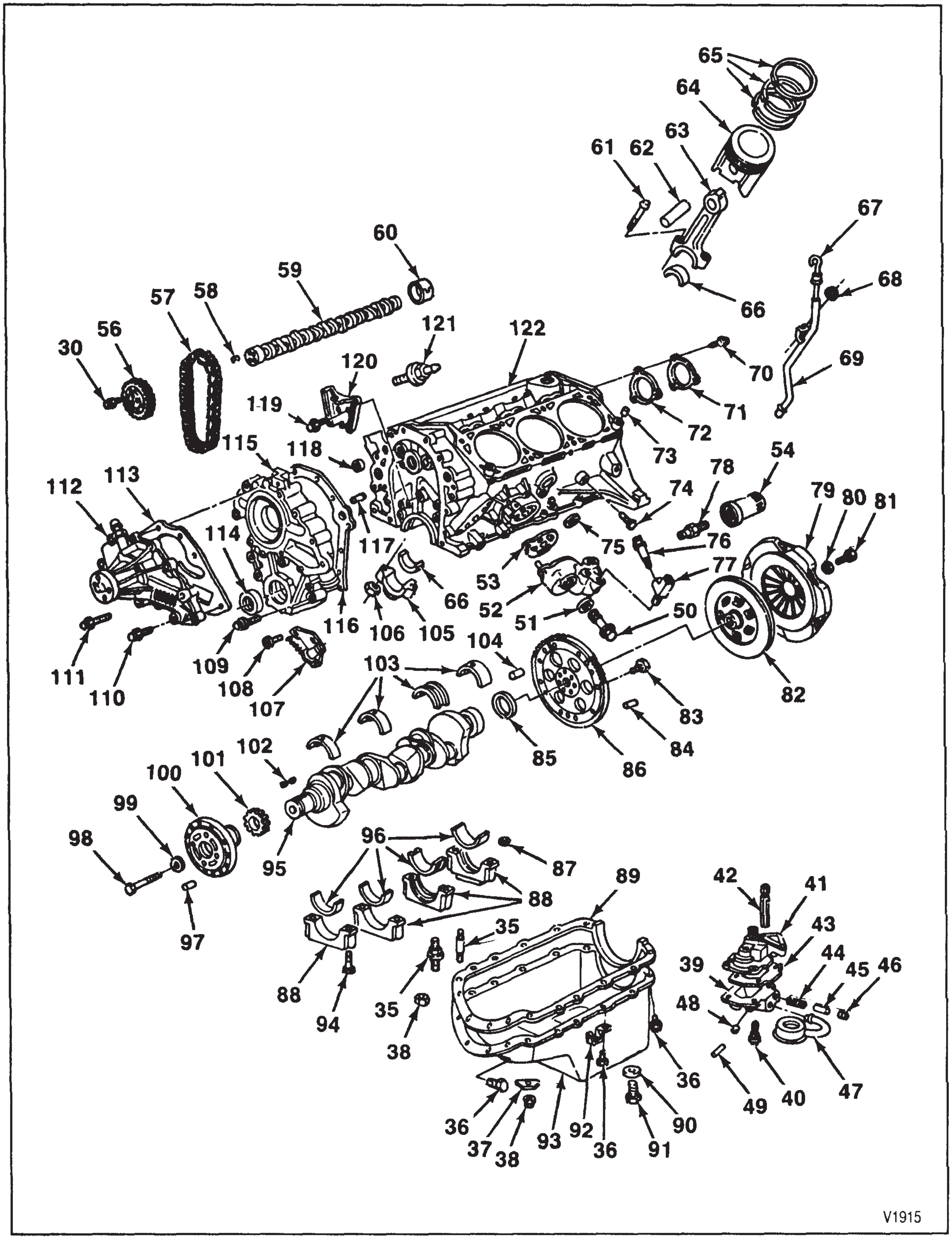


Figure 2—Cylinder Block and Components

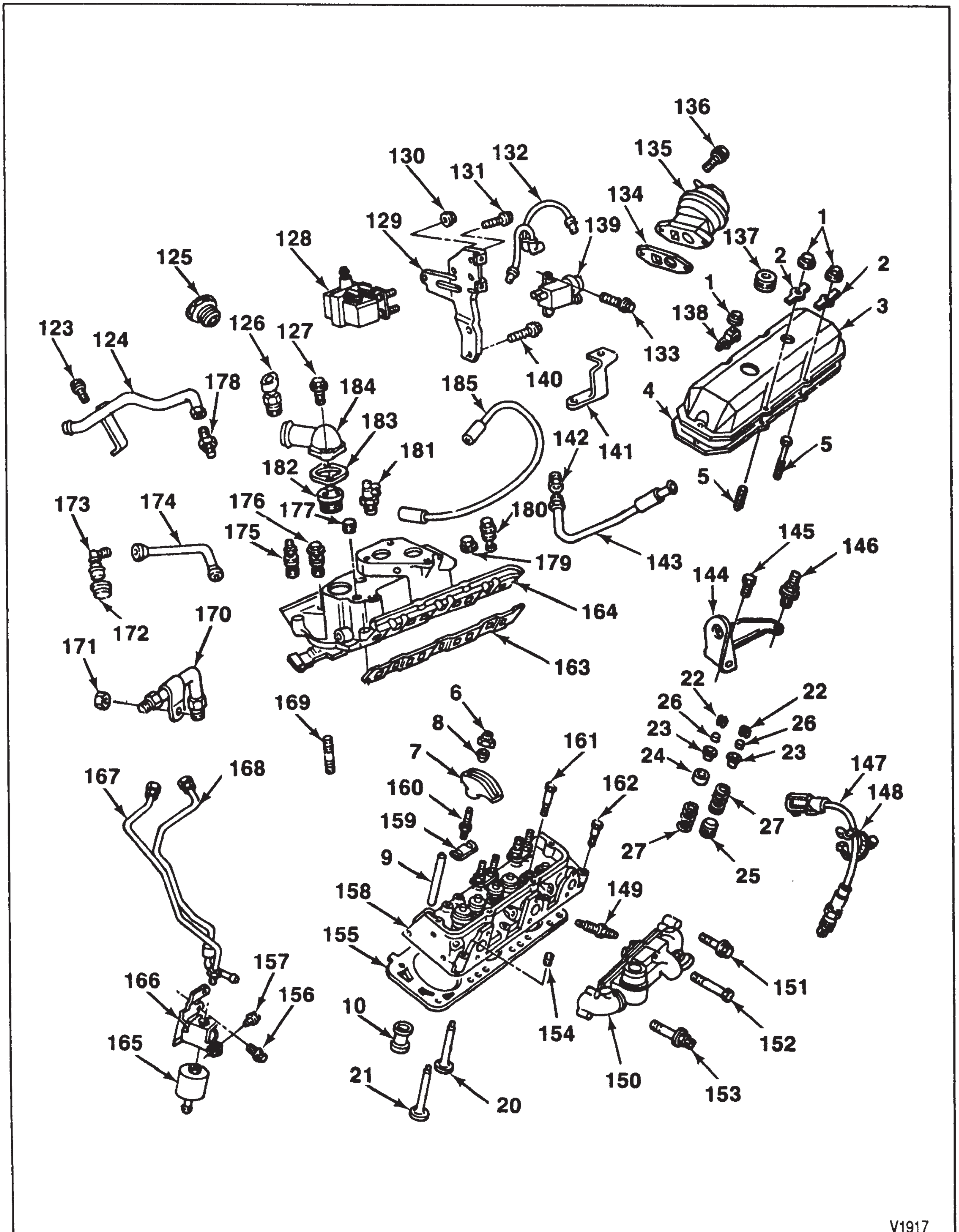


Figure 3—Cylinder Head, Manifolds, and Components

1. Rocker Cover Nut
2. Rocker Cover Reinforcement
3. Rocker Cover
4. Rocker Cover Gasket
5. Rocker Cover Stud
6. Rocker Arm Nut
7. Rocker Arm
8. Rocker Arm Ball
9. Push Rod
10. Valve Lifter
20. Intake Valve
21. Exhaust Valve
22. Valve Stem Key
23. Valve Spring Cap
24. Exhaust Valve Stem Oil Shield
25. Intake Valve Stem Seal
26. Valve Stem Oil Seal
27. Valve Spring With Damper
123. Bolt
124. Heater Inlet Pipe
125. Oil Fill Cap
126. Engine Coolant Temperature Sensor
127. Bolt
128. Ignition Coil
129. Engine Lift Bracket
130. Nut
131. Bolt
132. EGR Valve Harness
133. Bolt
134. EGR Valve Gasket
135. EGR Valve
136. Bolt
137. Crankcase Vent Tube Grommet
138. Engine Wiring Harness Clip Support
139. EGR Valve Solenoid
140. Bolt
141. Engine Wiring Harness Clip Support
142. Brake Booster Vacuum Tube Fitting
143. Brake Booster Pipe
144. Engine Lift Bracket
145. Bolt
146. Engine Lift Bracket Stud
147. Exhaust Oxygen Sensor
148. Plastic Retainer
149. Spark Plug
150. Exhaust Manifold
151. Bolt
152. Bolt
153. Stud
154. Plug
155. Cylinder Head Gasket
156. Bolt
157. Bolt
158. Cylinder Head
159. Push Rod Guide
160. Rocker Arm Ball Stud
161. Long Cylinder Head Bolt
162. Short Cylinder Head Bolt
163. Intake Manifold Gasket
164. Intake Manifold
165. Fuel Filter
166. Fuel Filter Bracket
167. Fuel Feed Pipe
168. Fuel Return Pipe
169. Intake Manifold Stud
170. Air Injection (AIR System) Pipe
171. Nut
172. Crankcase Vent Valve Grommet
173. Crankcase Vent Valve
174. Crankcase Vent Valve Tube
175. Intake Manifold Bolt
176. Intake Manifold Bolt
177. Plug
178. Heater Hose Inlet Nipple
179. Nut
180. Intake Manifold Stud
181. Thermal Vacuum Valve (TVV)
182. Thermostat
183. Coolant Outlet Gasket
184. Coolant Outlet
185. Evaporative Emission Hose

V1918

Figure 4—Cylinder Head, Manifolds, and Components

ENGINE LUBRICATION

Lubrication schematics are shown in figures 5 through 8. The gear-type oil pump is driven from the distributor shaft, which is gear driven from the camshaft. Oil is drawn into the oil pump through a pickup screen and pipe.

Pressurized oil is routed to the oil filter. A bypass valve is provided in case of excessive oil pressure. From the filter, oil is routed to the main oil gallery that supplies the left bank valve lifters with oil. From the left gallery, oil is directed to the camshaft bearings and right oil gallery.

Oil flows from the hydraulic lifters through the hollow pushrods to the rocker arms. Oil from overhead drains back to the crankcase through oil drain holes.

The timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.

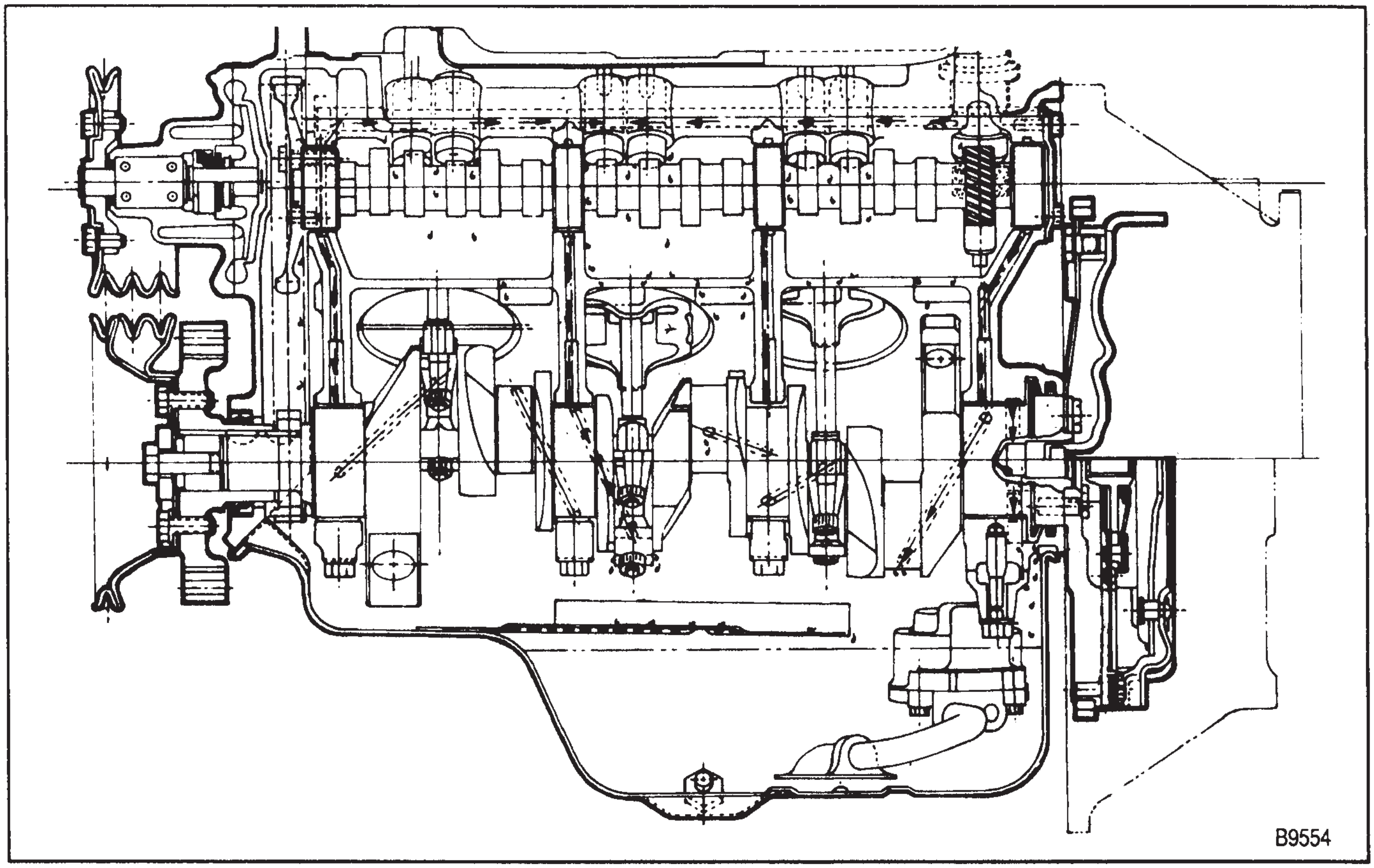


Figure 5—Engine Lubrication Diagram

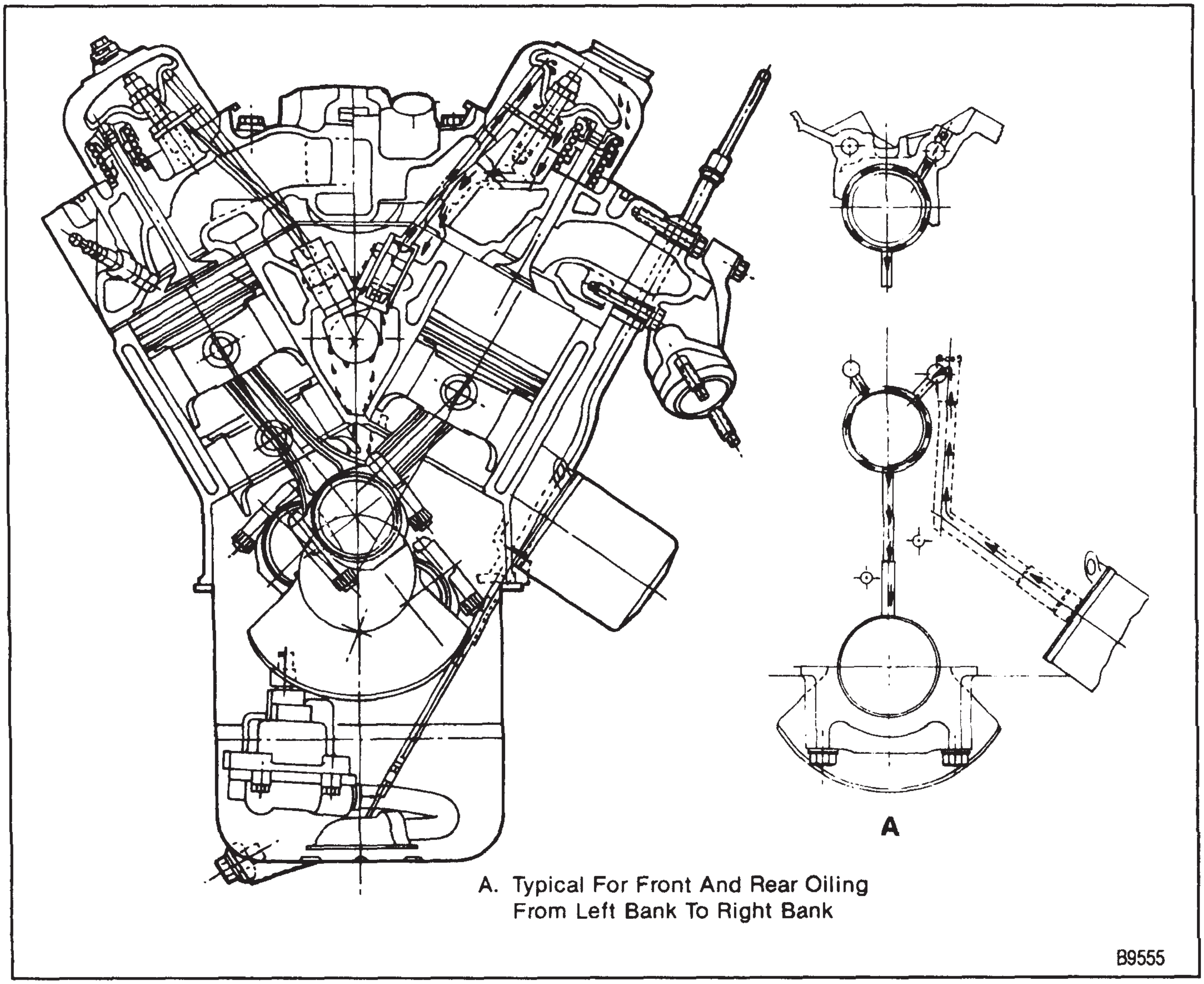
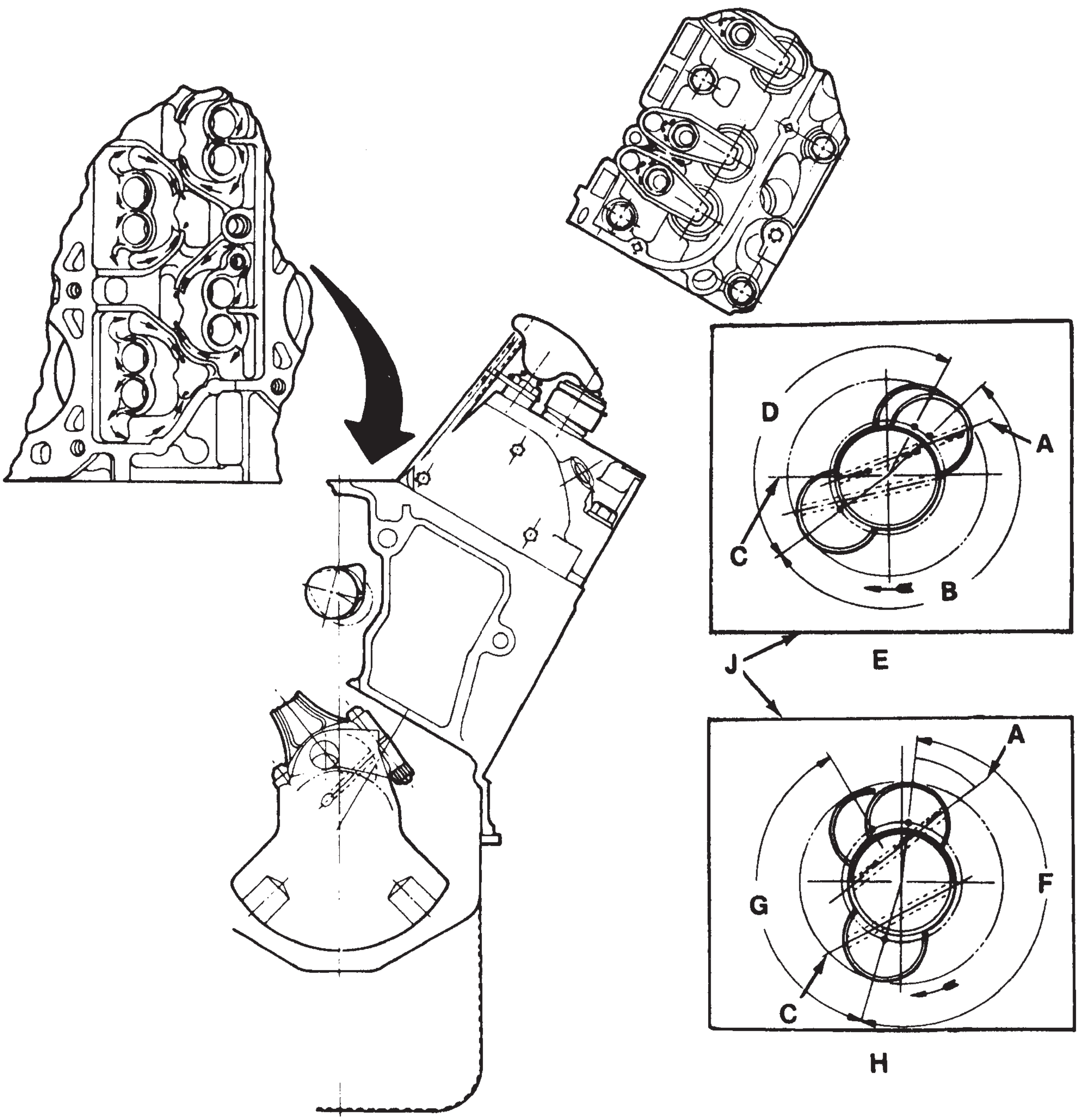


Figure 6—Engine Lubrication Diagram



A. Lubrication Begins
B. 189° Duration Of Lubrication
C. End Of Lubrication
D. Lubrication Ends 154° BTDC
E. Cylinders 2, 4 And 6
F. 190° Duration Of Lubrication
G. Lubrication Ends 134° BTDC
H. For Cylinders 1, 3 And 5
J. Views Showing Intermittent Oiling Of Connecting Rod Bearing Through Groove On Upper Half Of Main Bearings

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Figure 7—Engine Lubrication Diagram

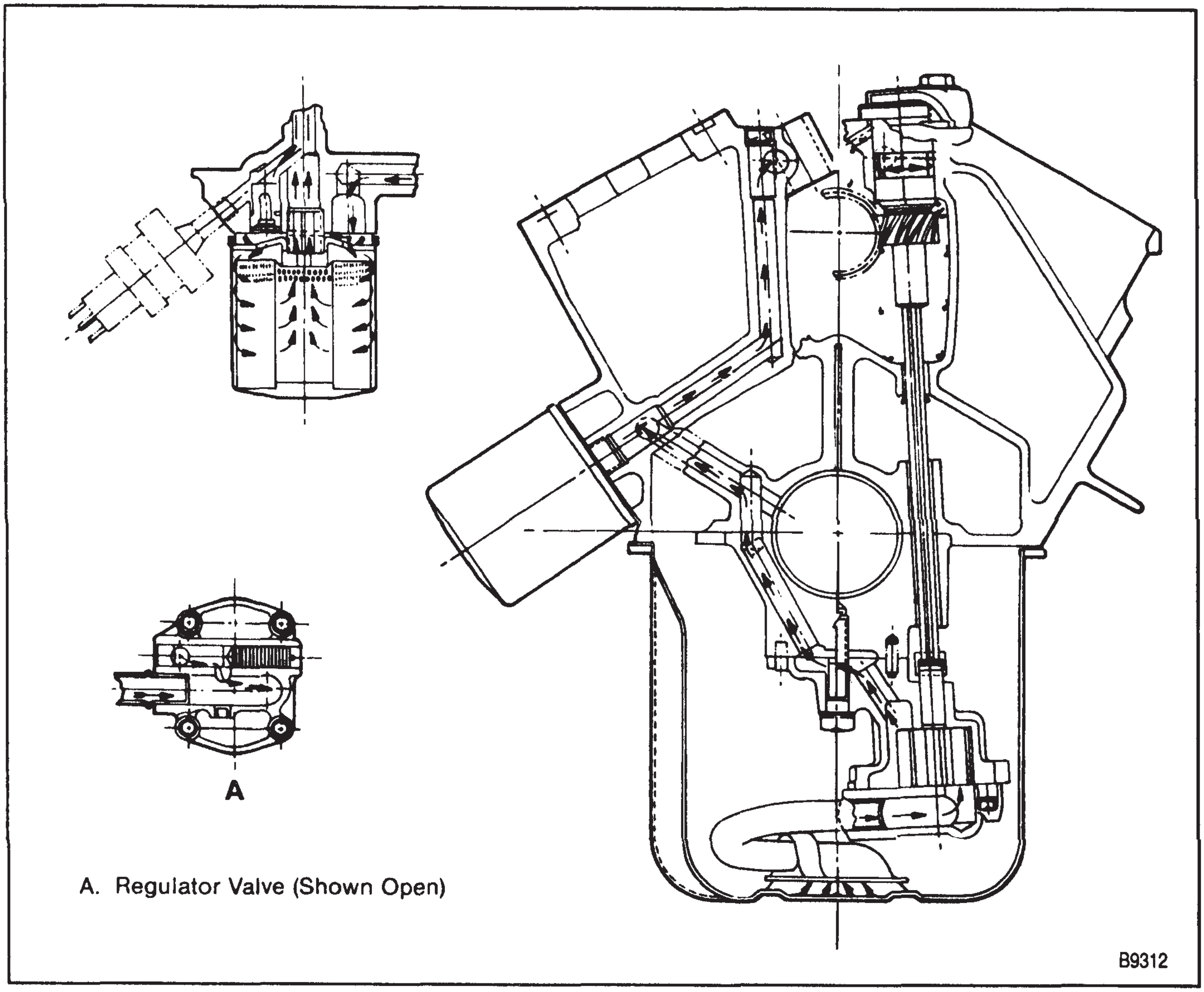


Figure 8—Engine Lubrication Diagram

ON-VEHICLE SERVICE

ROCKER ARM COVER REPLACEMENT

Right Side

Remove or Disconnect (Figure 9)

1. Negative battery cable. Refer to SECTION 0A.
2. Air cleaner.
3. Ignition coil and bracket.
4. Spark plug wires from the bracket at the rocker arm cover stud.
5. PCV valve.
6. Vacuum pipe at the manifold.
7. Throttle and cruise control cables with bracket at the TBI unit.
8. Generator and lay aside. Refer to SECTION 6D3.
9. Rocker arm cover nuts (1) and reinforcements (2).
10. Rocker arm cover and gasket.
    - If the cover sticks to the head, bump the end of the cover. If the cover still does not come loose, carefully pry until loose. DO NOT DISTORT THE SEALING FLANGE.

Clean

- All traces of the old gasket from both sealing surfaces.

Inspect

- Rocker arm cover sealing surfaces for distortion. Replace if necessary.

Install or Connect (Figure 9)

- Apply a dab of RTV sealant (GM P/N 1052917 or equivalent) at the point where the sealing area of the head meets the sealing area of intake manifold.

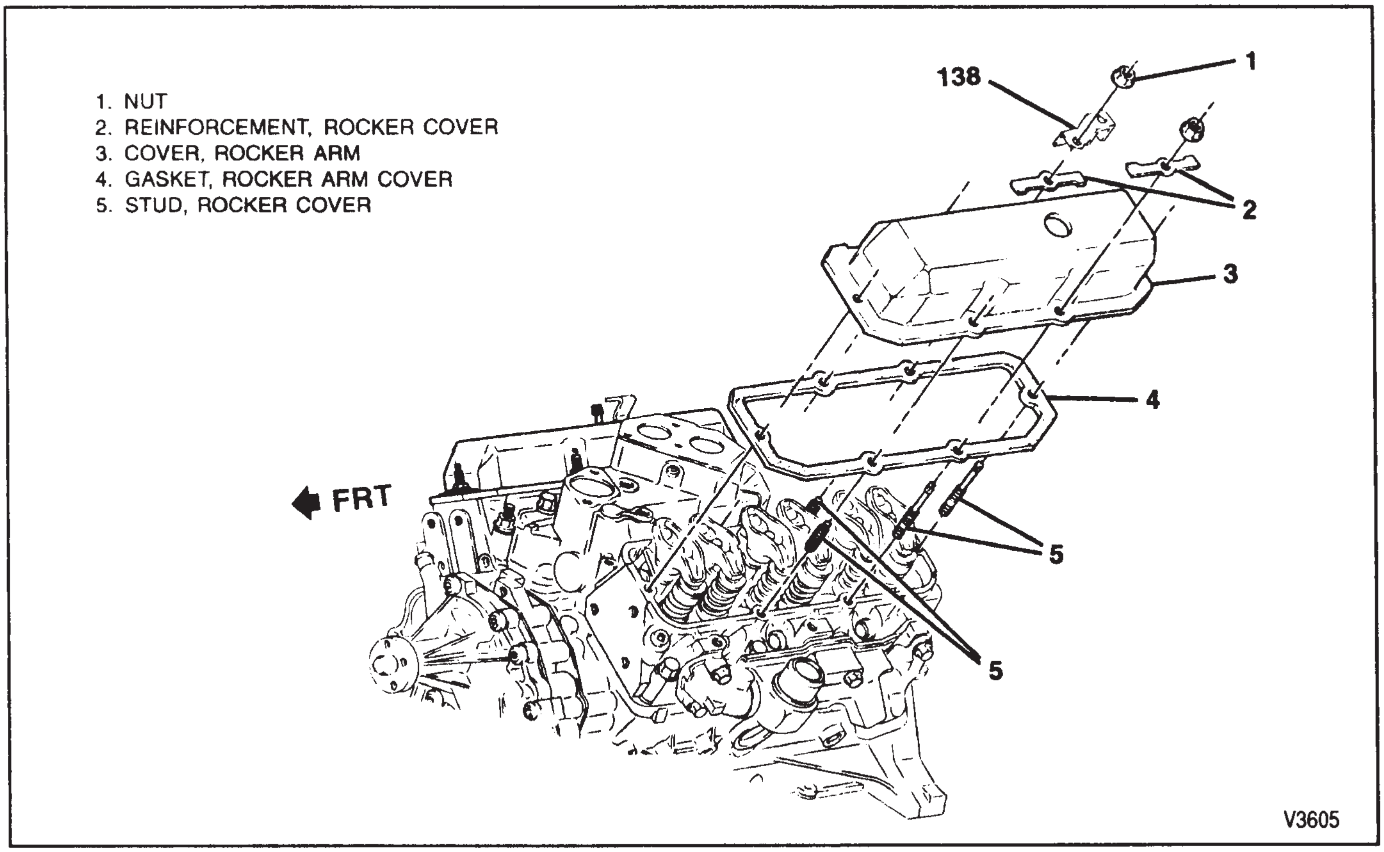


Figure 9—Rocker Arm Cover and Components

1. Rocker arm cover and new gasket.

NOTICE: See "Notice" on page 6A2-1.

2. Reinforcements (2) and nuts (1).

Tighten

- Nuts (1) to 8 N·m (72 in. lbs.).

3. Generator. Refer to SECTION 6D3.
4. Throttle and cruise control cables with bracket.
5. Vacuum pipe at manifold.
6. PCV valve.
7. Spark plug wires. Refer to SECTION 6D4.
8. Ignition coil and bracket. Refer to SECTION 6D4.
9. Air cleaner.
10. Negative battery cable. Refer to SECTION 0A.

Left Side

Remove or Disconnect (Figure 9)

1. Negative battery cable. Refer to SECTION 0A.
2. Crankcase ventilation pipe.
3. Hoses, wires, and pipe bracket.
4. Spark plug wires and clips from two retaining studs.
5. Rocker arm cover nuts (1) and reinforcements (2).
6. Rocker arm cover and gasket.
   - If the cover sticks to the head, bump the end of the cover. If the cover still does not come loose, carefully pry until loose. DO NOT DISTORT THE SEALING FLANGE.

Clean

- All traces of old gasket from both sealing surfaces.

Inspect

- Rocker arm cover sealing surfaces for distortion. Replace if necessary.

Install or Connect (Figure 9)

- Apply a dab of RTV sealant (GM P/N 1052917 or equivalent) at the point where the sealing area of the head meets the sealing area of the intake manifold.

1. Rocker arm cover and gasket.

NOTICE: See "Notice" on page 6A2-1.

2. Rocker arm cover nuts (1) and reinforcements (2).

Tighten

- Nuts (1) to 8 N·m (72 in. lbs.).

3. Spark plug wires and clips to the retaining studs.
4. Hoses, wires, and pipe bracket.
5. Crankcase ventilation pipe.
6. Negative battery cable. Refer to SECTION 0A.

ROCKER ARM AND PUSHROD REPLACEMENT

Remove or Disconnect (Figures 9 and 10)

1. Rocker arm cover. Refer to "Rocker Arm Cover Replacement."
2. Rocker arm nut (6).
   - If only the pushrod is to be replaced, back the rocker arm nut off until the rocker arm can be moved away from the pushrod. Then pull the pushrod out.
3. Rocker arm (7) with ball (8).
4. Pushrod (9).

Important

- All reusable components must be stored in an organized manner so they can be reassembled in the same location they were before disassembly.

Inspect

- Rocker arms and balls at their mating surfaces. These surfaces need to be smooth and free from scoring and other damage.
- Rocker arm areas that contact the valve stems and the sockets that contact the pushrods. These areas should be smooth and free of damage and wear.

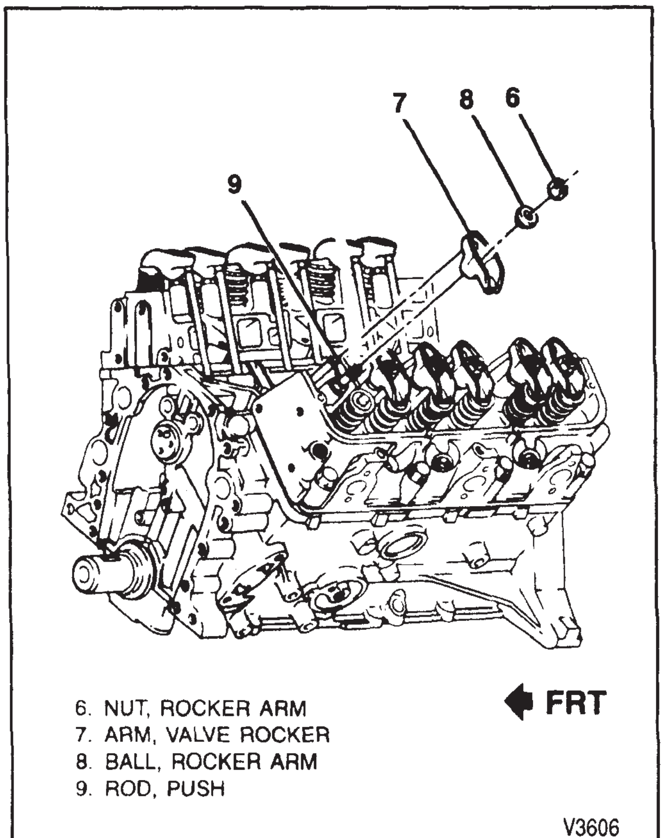


Figure 10—Rocker Arms and Pushrods

- Pushrods for bending.
  — Roll the pushrod on a flat surface to determine if it is bent.
  — Replace if necessary.
- Ends of the pushrods for scoring or roughness.

Install or Connect (Figures 9 and 10)

1. Pushrod.
   - Make sure the pushrod seats properly in the hydraulic lifter.
2. Rocker arm with ball.

Important

- When installing new rocker arms and/or balls, coat the bearing surfaces with "Molykote" or equivalent.

NOTICE: See "Notice" on page 6A2-1.

3. Rocker arm nuts.

Adjust

- Valves. Refer to "Valve Adjustment."

4. Rocker arm cover. Refer to "Rocker Arm Cover Replacement."

VALVE ADJUSTMENT

1. Rocker arm cover. Refer to "Rocker Arm Cover Replacement."
2. Rotate the crankshaft until the mark on the torsional damper lines up with the "O" mark on the timing tab and the engine is in the number one firing order position (Compression Stroke). This is known as top dead center (TDC). TDC may be determined in two different ways.
   - Place your fingers on the number one intake valve as the mark on the damper comes near the "O" mark on the timing tab. If the rocker arm is fully closed, the engine is in the number one firing position. If the rocker arm moves as the mark comes up to the timing tab, the engine is in the number four firing position and should be rotated one full turn to reach the number one firing position.
3. With the engine in the number one firing position as determined above, the following valves may be adjusted:
   - Exhaust: 1, 2, 3
   - Intake: 1, 5, 6

   (Even numbered cylinders are in the right bank; odd numbered cylinders are in the left bank; when viewed from the front of the engine).
4. Back out the adjusting nut until lash is felt at the pushrod then turn the adjusting nut in until all lash is removed. This can be determined by rotating the pushrod while turning the adjusting nut (figure 11).

When the lash has been removed, turn in the adjusting nut one and one-half additional turns (to center the lifter plunger).

5. Rotate the crankshaft one full revolution until the timing tab "O" mark and vibration damper mark are again in alignment. This is the number four firing position. The following valves may be adjusted:
   - Exhaust: 4, 5, 6
   - Intake: 2, 3, 4
6. Rocker arm covers. Refer to "Rocker Arm Cover Replacement."

VALVE STEM OIL SEAL AND/OR VALVE SPRING REPLACEMENT

Remove or Disconnect (Figures 12 and 13)

Tools Required:
J 5892-C Valve Spring Compressor
J 23590 Cylinder Inflater Air Adapter

1. Rocker arm cover. Refer to "Rocker Arm Cover Replacement."
2. Spark plug, rocker arm, and pushrod from the cylinder(s) to be serviced. Refer to SECTION 6D4.
3. Valve keepers (22), valve cap (23), oil shedder (24) (exhaust only), and valve spring and damper.
   A. Install J 23590 to the spark plug hole and apply compressed air to hold the valves in place.
   B. Use J 5892-C to hold the valve spring.
4. Valve stem seal (25).

Install or Connect (Figures 12 and 13)

Tools Required:
J 5892-C Spring Compressor
J 23590 Air Adapter

1. Valve spring and damper to the valve guide boss.
2. Valve stem seal (25) over the valve stem and valve guide boss (intake valve only).
3. Oil shedder (24) and valve rotator over the exhaust valve (21).

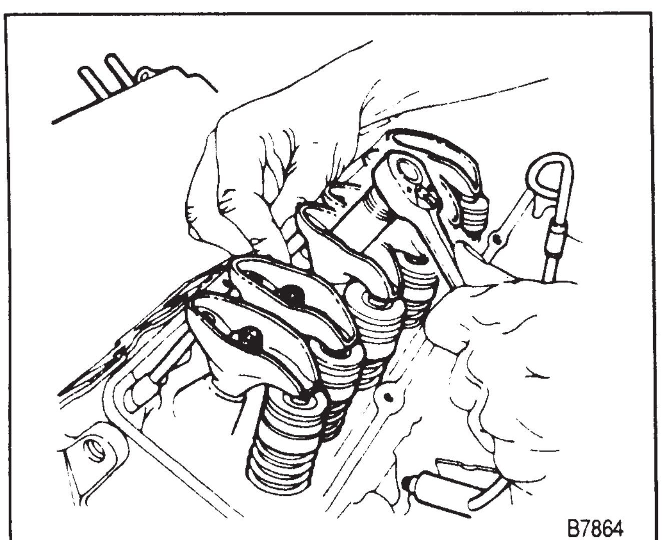
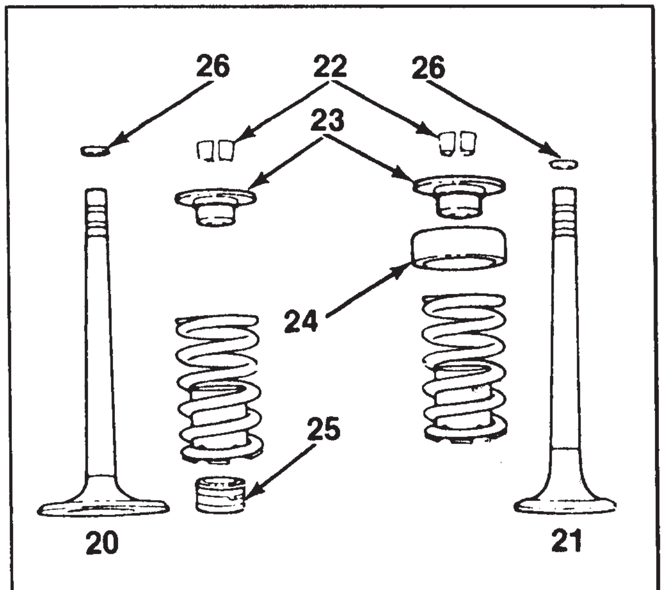


Figure 11—Adjusting the Valves



20. Intake Valve
21. Exhaust Valve
22. Valve Keepers
23. Valve Cap
24. Oil Shedder
25. Seal
26. O-Ring

Figure 12—Valves and Components

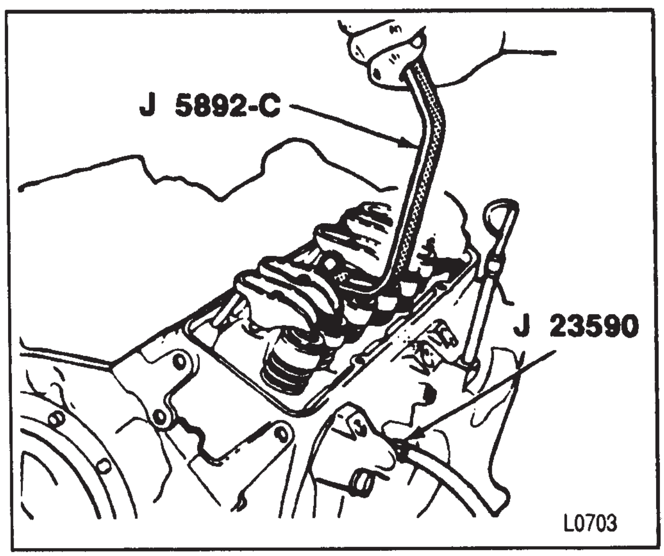


Figure 13—Compressing the Valve Springs

4. Valve spring cap (23) over the valve spring.
   - Compress the valve spring using J 5892-C.
5. O-ring (26) around the valve stem in the lower groove.
   A. Lubricate the O-ring with engine oil.
   B. Make sure the O-ring is not twisted.
6. Valve keepers (22).
   - Use grease to hold the valve keepers in place.
   - Carefully release spring tension and make sure the valve keepers stay in place.
7. Spark plugs. Refer to SECTION 6D4.

8. Rocker arms, as outlined previously.

Adjust

- Valves. Refer to "Valve Adjustment."

9. Rocker arm cover. Refer to "Rocker Arm Cover Replacement."

INTAKE MANIFOLD REPLACEMENT

Remove or Disconnect (Figure 14)

- Drain the coolant. Refer to SECTION 6B1.

1. Negative battery cable. Refer to SECTION 0A.
2. Air cleaner.
3. Wires and hoses at the TBI unit and manifold.
4. Fuel lines at the TBI unit.
5. Cables from the TBI unit.
6. Spark plug wires at the spark plugs. Refer to SECTION 6D4.
7. Wires from the ignition coil. Refer to SECTION 6D4.
8. Distributor cap with spark plug wires. Refer to SECTION 6D4.
9. Distributor hold down bracket. Refer to SECTION 6D4.
10. Distributor. Refer to SECTION 6D4.
11. EGR vacuum hose.
12. Evaporative emission hoses.
13. Pipe brackets from the rocker arm covers.
14. Rocker arm covers, as outlined previously.
15. Upper radiator hose. Refer to SECTION 6B1.
16. Heater hose. Refer to SECTION 1A.
17. Coolant sensor connectors.
18. Intake manifold bolts and nuts.
19. Intake manifold.
20. Gaskets.

Clean

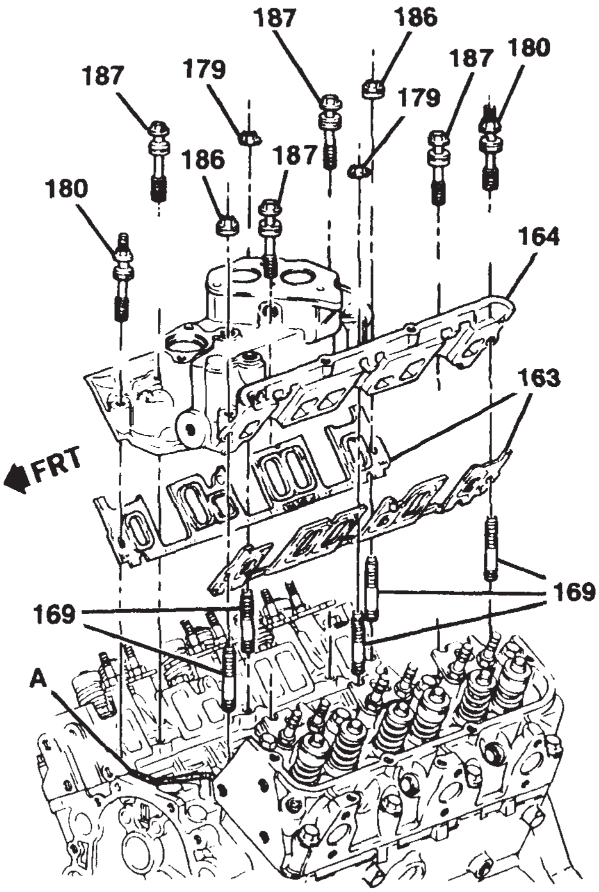
- Old gasket and RTV from the block, heads, and intake manifold. Remove all RTV that is loose or will cause interference at assembly.
- Excessive carbon deposits from the exhaust and EGR passages.
- Excessive scale and deposits from the coolant passages.

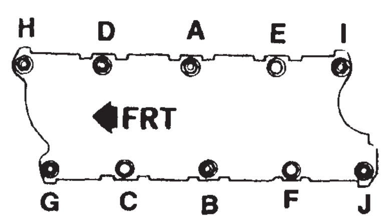
Inspect

- Manifold for cracks and gasket surface damage.

Install or Connect (Figure 14)

1. RTV to the front and rear sealing surfaces on the block (figure 14). Apply a 5-mm (3/16-inch) bead of RTV (GM P/N 1052917 or equivalent) to the front and rear of the block as shown.





A. SEALER
163. GASKET, INTAKE MANIFOLD
164. MANIFOLD, INTAKE
169. STUD
179. NUT
180. STUD
186. NUT AND WASHER
187. BOLT

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Figure 14—Intake Manifold and Components

- Make sure no oil or water is present on the surfaces to be sealed.

2. Gaskets to the cylinder head.
   - Gaskets are marked right side or left side. Use them only as indicated to maintain design efficiency of the engine.
   - Hold the gaskets in place by extending the bead of RTV (GM P/N 1052917 or equivalent) 6 mm (1/4 inch) up onto the gasket ends from the block sealing surfaces.
3. Intake manifold.
   - Make sure the areas between the case ridges and intake manifold are completely sealed.

NOTICE: See "Notice" on page 6A2-1.

4. Intake manifold bolts and nuts.
   - Use sealer (GM P/N 9985427 or equivalent) at intake manifold holes "A" and "B" only (figure 14).

Tighten

A. Nuts and bolts to 31 N·m (23 ft. lbs.) in the sequence shown in figure 14 (A through J).
B. Re-tighten using the same sequence.

5. Heater hose and radiator hose to the manifold. Refer to SECTIONS 1A and 6B1.
6. Rocker arm covers, as outlined previously.
7. Coolant sensor connectors.
8. Pipe brackets.
9. Distributor, cap, and wires. Refer to SECTION 6D4.
10. Fuel lines.
11. Cables at the TBI unit.
12. All necessary wires and hoses.
13. Air cleaner.
14. Negative battery cable. Refer to SECTION 0A.
15. Proper quantity and grade of coolant. Refer to SECTION 0B.

HYDRAULIC LIFTER REPLACEMENT

Some engines have both standard and 0.25-mm (0.010-inch) oversize valve lifters. The cylinder case will be marked with a white paint mark and 0.25 mm O. S. stamp where the oversize lifters are used (figure 15).

If lifter replacement is necessary, use new lifters with a narrow flat along the lower 3/4 of the body length. This provides additional oil to the cam lobe and lifter surfaces.

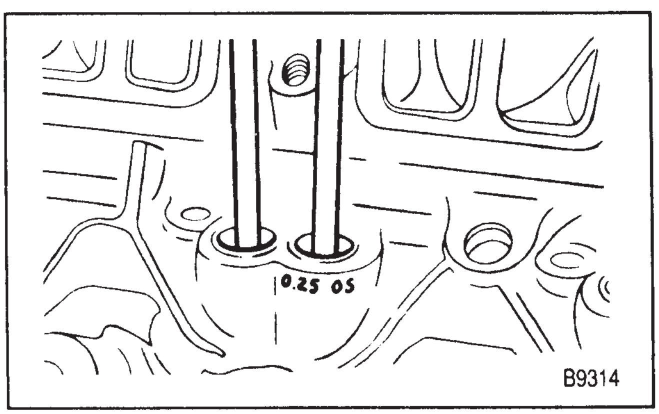


Figure 15—Oversize Lifter Marking

Remove or Disconnect (Figures 10, 16, and 17)

Tools Required:
J 3049-A Hydraulic Lifter Remover (Plier Type)
or
J 9290-1 Hydraulic Lifter Remover (Slide Hammer Type)

1. Rocker arm covers, as outlined previously.
2. Intake manifold, as outlined previously.
3. Rocker arm nuts, balls, rocker arms, and pushrods, as outlined previously.
   - Place the components in a rack so they can be installed in the same location.
4. Lifters (10).
   - Remove the lifters one at a time and place them in an organizer rack. The lifters must be installed into the same bore from which they were removed.
   - A stuck lifter can be removed using J 3049-A (figure 16) or J 9290-01 (figure 17).

Inspect

- Hydraulic lifter body for scuffing or scoring. If the lifter body wall is worn or damaged, the mating bore in the block should also be checked.

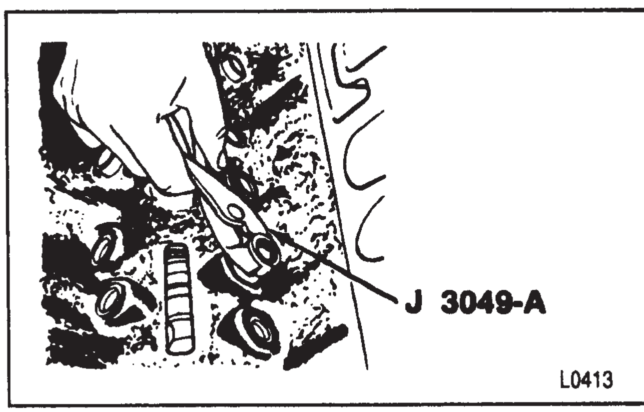


Figure 16—Removing the Hydraulic Lifter

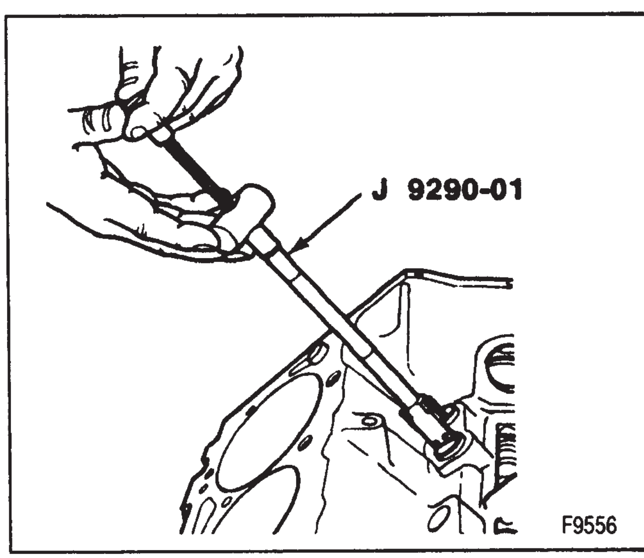


Figure 17—Removing the Hydraulic Lifter

- Check the fit of each hydraulic lifter in its mating bore in the block. If the clearance is excessive, try a new lifter.
- The hydraulic lifter foot must be smooth and slightly convex. If worn, pitted, or damaged, the mating camshaft lobe should also be checked.

HYDRAULIC LIFTER REPAIR

- Refer to the Light Duty Truck Unit Repair Manual.

Install or Connect

1. Hydraulic lifters into the block.

Important

- Lubricate the lifter foot and body with "Molykote" (or equivalent).
- Make sure the lifter foot is convex by holding a good straight edge to the surface and looking into a light source.
- When any new hydraulic lifters or a new camshaft is installed, Engine Oil Supplement (GM P/N 1051396 or equivalent) should be added to the crankcase oil.
- Replace all hydraulic lifters when a new camshaft is installed.

2. Intake manifold, as outlined previously.

NOTICE: See "Notice" on page 6A2-1.

3. Pushrods, rocker arms, balls, and rocker arm nuts, as outlined previously.

Adjust

- Valves, as outlined previously.

4. Rocker arm covers, as outlined previously.

ROCKER ARM STUDS

2.8L cylinder heads use threaded rocker arm studs. Rocker arm studs that have damaged threads should be replaced with new studs. If the threads in the head are damaged or stripped, the head can be re-tapped and a helical type insert added, as outlined in "Thread Repair." If such an insert is not available, the head should be replaced.

EXHAUST MANIFOLD REPLACEMENT

Remove or Disconnect (Figure 18)

1. Negative battery cable. Refer to SECTION 0A.
   - Raise the vehicle and support with safety stands.
2. Exhaust pipe from the manifold. Refer to SECTION 6F.
3. Four rear manifold bolts.
   - Lower the vehicle.
4. AIR system Diverter valve and heat shield (right side manifold).
5. AIR system pump and generator brackets (right side manifold). Refer to SECTION 6D3.
6. Heat stove tube (left side manifold).
7. Power steering pump bracket (left side manifold). Refer to SECTION 3B3.
8. Remaining manifold bolts.
9. Manifold.

Clean

- Mating surfaces of manifold and cylinder head.

Install or Connect (Figure 18)

NOTICE: See "Notice" on page 6A2-1.

1. Manifold and bolts.

Tighten

- Bolts to 34 N·m (25 ft. lbs.).

2. Power steering pump bracket and heat stove tube (left side manifold).

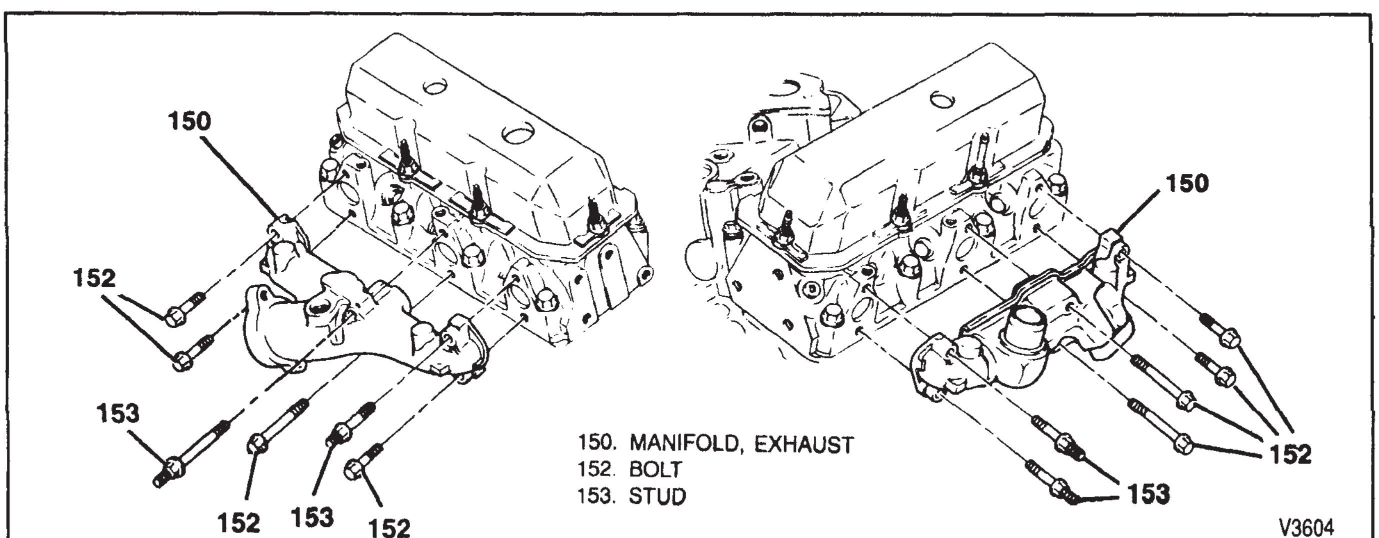


Figure 18—Exhaust Manifolds and Components

3. AIR system pump and generator brackets, AIR system diverter valve, and heat shield (right side manifold).

- Raise the vehicle and support with safety stands.

4. Exhaust pipe to the manifold. Refer to SECTION 6F.

- Lower the vehicle.

5. Negative battery cable. Refer to SECTION 0A.

CYLINDER HEAD REPLACEMENT

Remove or Disconnect

1. Intake manifold as outlined previously.
2. Coolant from the engine block.

- Raise the vehicle. Support with suitable safety stands.

3. Exhaust pipe from the manifold.

- Lower the vehicle.

4. Dipstick tube (left side only).
5. Ground strap at rear of head and sensor connector at front of head (left side only).
6. Drive belt, generator, and AIR system pump with mounting bracket (right side only). Refer to SECTIONS 6B1 and 6D3.
7. Pushrods, as outlined previously.
8. Cylinder head bolts.
9. Cylinder head.
10. Cylinder head gasket.

Clean

- Carbon deposits from combustion chambers.
- All traces of old head gasket from the cylinder head and block.
- Cylinder head bolt threads and threads in the block.

Inspect

- Sealing surfaces of the block and cylinder head for nicks, heavy scratches, or other damage.

Install or Connect

Tools Required:
J 36660 Torque/Angle Meter

1. Cylinder head gasket in place over the dowel pins with the note "This Side Up" showing.
2. Cylinder head.
   - Gasket must be fully seated on the block before cylinder head installation.

NOTICE: See "Notice" on page 6A2-1.

3. Head bolts.
   A. Coat the bolt threads with sealing compound (GM P/N 1052080 or equivalent).
   B. Install all bolts finger tight.

Tighten

A. All bolts to 55 N·m (40 ft. lbs.), using the sequence shown in figure 19.
B. In sequence, tighten all bolts an additional 90 degrees using J 36660.

4. Pushrods, as outlined previously.

Adjust

- Valves, as outlined previously.

5. Generator and AIR system pump with mounting bracket and drive belt (right side only). Refer to SECTION 6D3.
6. Ground strap and sensor connector (left side only).
7. Dipstick tube (left side only).
   - Raise the vehicle.
8. Exhaust pipe.
   - Lower the vehicle.
9. Intake manifold, as outlined previously.
10. Proper quantity and grade of coolant. Refer to SECTION 0B.

TORSIONAL DAMPER REPLACEMENT

NOTICE: The inertial weight section of the torsional damper is assembled to the hub with a rubber sleeve. The removal and installation procedures must be followed (with proper tools) or movement of the inertial weight section of the hub will destroy the tuning of the torsional damper and the engine timing reference.

The torsional damper has three timing notches on the inertia ring. The number one cylinder timing reference mark will be identified by a dab of white paint. If a new damper assembly is installed, mark the new assembly in the same place for future reference. Number one cylinder reference is the first clockwise mark from the keyway when viewing the engine from the front.

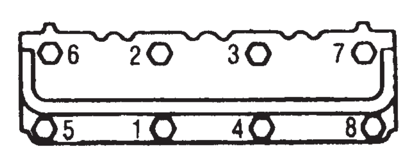


Figure 19—Cylinder Head Bolt Tightening Sequence

Remove or Disconnect

Tools Required:
J 39046 or J 24420-B Puller

1. Negative battery cable. Refer to SECTION 0A.
2. Accessory drive belt. Refer to SECTION 6B1.
3. Torsional damper retaining bolt.
4. Drive pulley from the damper.
- Raise the vehicle and support with safety stands.
5. Damper using J 39046 or J 24420-B.

Install or Connect

Tools Required:
J 29113 Torsional Damper Installer

1. Engine oil to the front cover seal contact area on the damper.
2. Sealant (GM P/N 1052366 or equivalent) on the key and the keyway.
   - Clean the key and keyway.
3. Damper over the key on the crankshaft.
4. Pull the damper onto the crankshaft.
   A. Install J 29113 into the crankshaft so at least 6 mm (0.236 inch) of thread is engaged.
   B. Pull damper into position and remove J 29113 from the damper.
5. Drive pulley to the damper.

NOTICE: See "Notice" on page 6A2-1.

6. Torsional damper retaining bolt.

Tighten

- Bolt to 95 N·m (70 ft. lbs.).
- Lower the vehicle.

7. Drive belt. Refer to SECTION 6B1.
8. Negative battery cable. Refer to SECTION 0A.

FRONT COVER REPLACEMENT

Remove or Disconnect

- Drain the cooling system. Refer to SECTION 6B1.

1. Negative battery cable. Refer to SECTION 0A.
2. Accessory drive belt. Refer to SECTION 6B1.
3. Coolant pump. Refer to SECTION 6B1.
4. Power steering pump bracket. Refer to SECTION 3B3.
5. Torsional damper, as outlined previously.
6. Lower radiator hose from the front cover. Refer to SECTION 6B1.
7. Remaining front cover bolts.
8. Front cover.
9. Gasket.

Clean

- Old gasket from the front cover and block.

Install or Connect

1. New gasket.
   - Make sure sealing surfaces are clean.
   - Use care not to damage sealing surfaces.
   - Lightly coat both sides of the gasket with anaerobic sealer.
2. Front cover.
3. Coolant pump. Refer to SECTION 6B1.

NOTICE: See "Notice" on page 6A2-1.

4. Bolts and stud.

Tighten

- Bolts and stud to specifications listed at the end of this section.

5. Lower radiator hose to the front cover. Refer to SECTION 6B1.
6. Torsional damper, as outlined previously.
7. Power steering pump mounting bracket. Refer to SECTION 3B3.
8. Accessory drive belt. Refer to SECTION 6B1.
9. Negative battery cable. Refer to SECTION 0A.
10. Proper quantity and grade of coolant. Refer to SECTION 0B.

CRANKSHAFT FRONT SEAL REPLACEMENT

With Front Cover Removed

Remove or Disconnect

- Oil seal out of the front cover.
  — Pry out with a large screw driver.

Install or Connect

Tools Required:
J 35468 Seal Installer

- New seal so the open end is toward the inside of the cover.
  — Support the cover at the seal area.
    — Drive the seal into position with J 35468.
- Lubricate the seal with engine oil before installing the torsional damper.

With Front Cover Installed

Remove or Disconnect

1. Torsional damper, as outlined previously.
2. Seal from the front cover.
   - Pry the seal out of the cover with a large screw driver, being careful not to damage the surface on the crankshaft.

Install or Connect

Tools Required:
J 35468 Seal Installer

1. New seal so the open end is toward the inside of the cover.
   - Drive the seal into place using J 35468.
2. Torsional damper, as outlined previously.
   - Lubricate the seal with engine oil before installing the torsional damper.

TIMING CHAIN AND SPROCKET REPLACEMENT

Remove or Disconnect

Tools Required:
J 5825-A Crankshaft Sprocket Puller

- Place number one piston at top dead center (exhaust stroke) with the marks on the camshaft and crankshaft sprockets aligned (number four firing) (figure 20).

1. Crankcase front cover.

Inspect

- Sprockets for chipped teeth and wear.
- Timing chain for wear.
  — If the chain can be pulled out more than 9.5 mm (3/8 inch) from the damper, replace the chain.

2. Bolts (30).
3. Camshaft sprocket and chain.
   - If the sprocket does not come off easily, a light blow on the lower edge of the sprocket (with a plastic mallet only) should dislodge the sprocket.
4. Crankshaft sprocket (if required) using J 5825-A (figure 21).

Install or Connect (Figure 20)

Tools Required:
J 5590 Crankshaft Sprocket Installer

1. Crankshaft sprocket (if removed) using J 5590 (figure 21).
   - Make sure the timing mark faces outward.

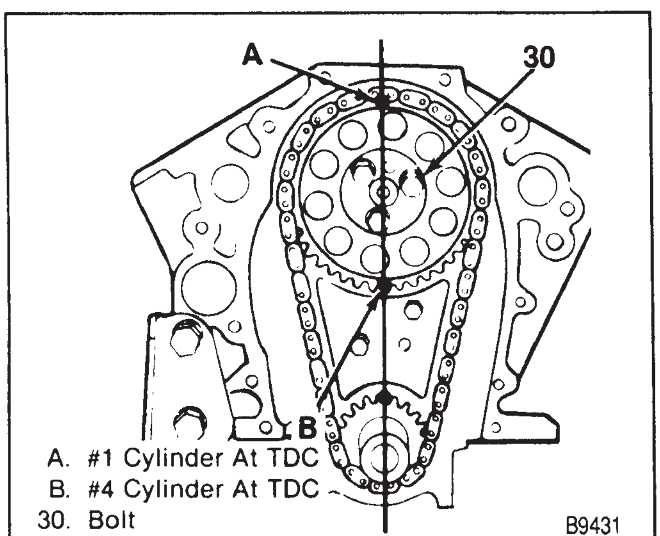


Figure 20—Camshaft Timing

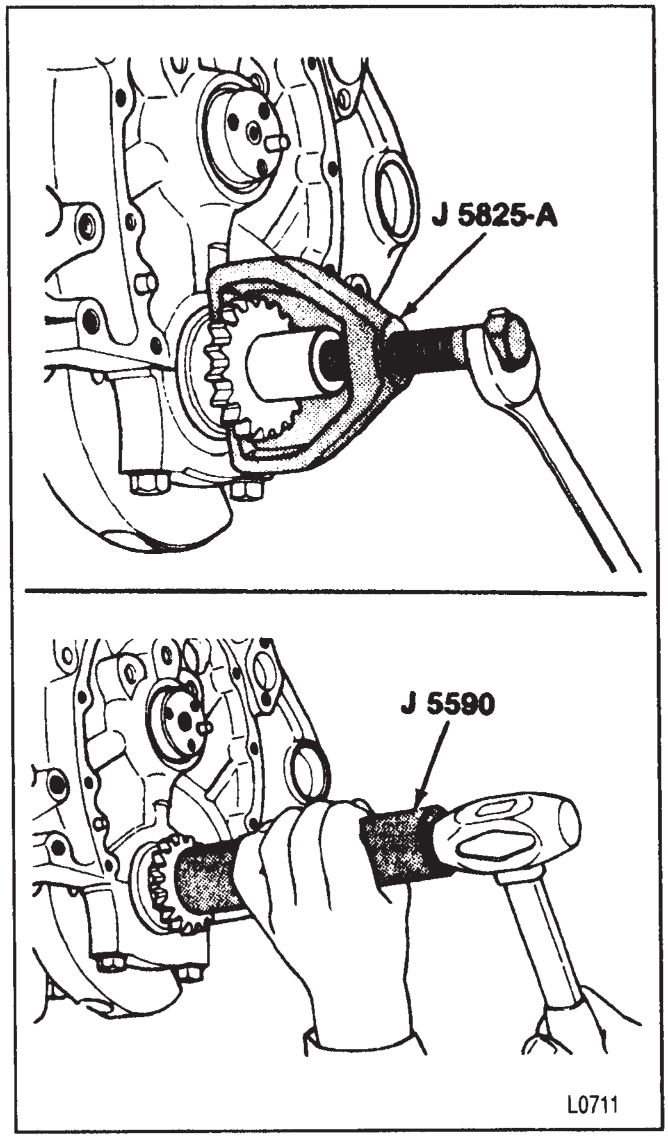


Figure 21—Replacing the Crankshaft Sprocket

2. Timing chain onto the camshaft sprocket.
   - Lubricate the thrust surface with "Molykote" or equivalent.
3. Sprocket onto the camshaft.
   A. Hold the sprocket vertically with the chain hanging down and align the marks on the camshaft and crankshaft sprockets.
   B. Align the dowel in the camshaft with the dowel hole in the sprocket.

NOTICE: See "Notice" on page 6A2-1.

4. Bolts (30).
   - Draw the camshaft sprocket onto the camshaft using the mounting bolts.

Tighten

- Bolts (30) to 23 N·m (17 ft. lbs.).

5. Crankcase front cover.
   - Lubricate the timing chain with engine oil.

OIL PAN REPLACEMENT

Remove or Disconnect (Figure 22)

1. Oil pan drain plug.
   - Drain the engine oil into a suitable container.
2. Oil filter.
3. Engine. Refer to "Engine Replacement."
4. Oil pan bolts (35) and (36).
5. Oil pan nuts (38).
6. Oil pan reinforcements (37) and clip.
7. Oil pan.
8. Oil pan gasket.

Clean

- Sealing surfaces on the engine and oil pan.

Install or Connect (Figure 22)

NOTICE: Before installing the oil pan, make sure the seal surfaces on the pan, engine block, and front cover are free of oil. Make sure that all RTV is removed from blind attaching holes to ensure proper fastener tightening can take place.

NOTICE: For steps 4, 5, and 6, see "Notice" on page 6A2-1.

1. Oil pan gasket.
   - Apply sealer (GM P/N 1052914 or equivalent) to the area shown in figure 22.
2. Oil pan to the block.
3. Reinforcements (37) and clip.
4. Oil pan bolts (35) and (36).
5. Oil pan nuts (38).
6. Oil pan drain plug.

Tighten

- Bolts (35) to 10 N·m (7 ft. lbs.).
- Bolts (36) to 25 N·m (18 ft. lbs.).
- Nuts (38) to 10 N·m (7 ft. lbs.).
- Drain plug to 20 N·m (15 ft. lbs.).

7. Engine. Refer to "Engine Replacement."
8. Oil filter.
9. Engine oil. Refer to SECTION 0B.

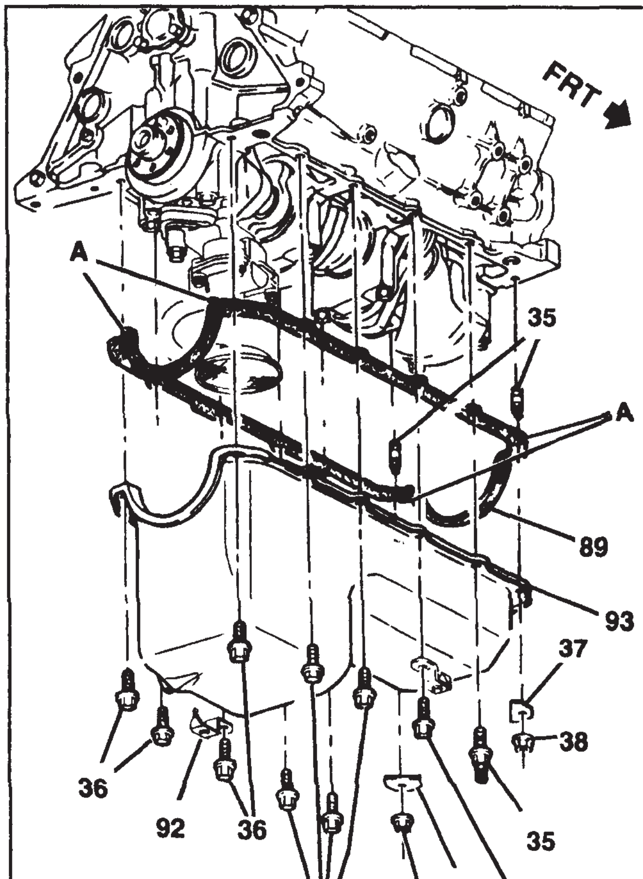
OIL PUMP REPLACEMENT

Remove or Disconnect (Figure 23)

1. Oil pan, as outlined previously.
2. Bolt (40).
3. Pump (41).
4. Shaft (42).

Inspect

- Oil pump pickup tube for looseness. If the tube is loose in the oil pump body, replace it as outlined in the Light Duty Truck Unit Repair Manual. A loose pickup tube can result in an air leak and loss of oil pressure.



A. SEALER
35. STUD, OIL PAN
36. BOLT, OIL PAN
37. REINFORCEMENT, OIL PAN
38. NUT, OIL PAN
89. GASKET, OIL PAN
92. CLIP, ENGINE WIRING HARNESS RETAINING
93. PAN, OIL

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Figure 22—Oil Pan and Components

OIL PUMP REPAIR

- Refer to the Light Duty Truck Unit Repair Manual.

Install or Connect (Figure 23)

1. Pump (41) and shaft (42) with retainer to the rear main bearing cap.
   - Align the top end of the hexagon extension shaft with the hexagon socket on the lower end of the distributor drive gear.

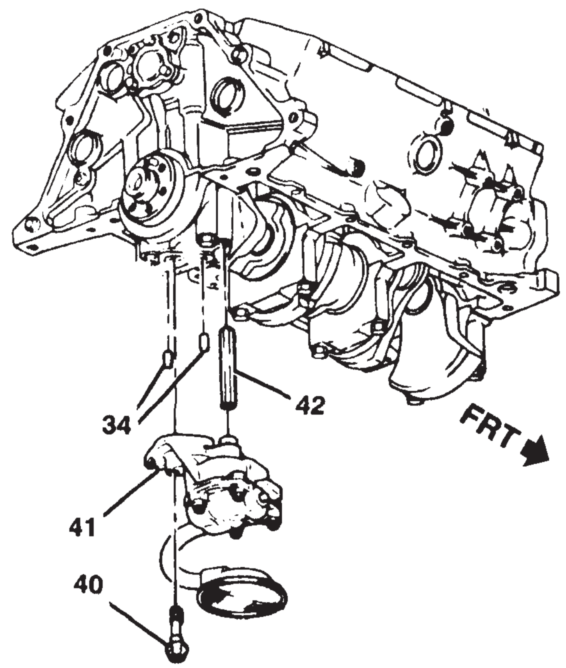
NOTICE: See "Notice" on page 6A2-1.

2. Bolt (40).

Tighten

- Bolt (40) to 41 N·m (30 ft. lbs.).

3. Oil pan, as outlined previously.



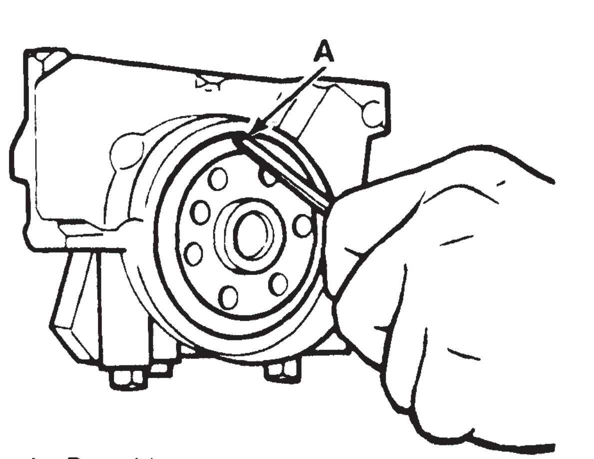
34. PIN
40. BOLT, OIL PUMP
41. PUMP, OIL
42. *SHAFT, OIL PUMP*

Figure 23—Oil Pump

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Remove or Disconnect

1. Transmission. Refer to SECTION 7.
2. Flywheel, as outlined later in this section.
3. Oil seal.
   A. *Insert a screwdriver or similar tool through the* dust lip at an angle (figure 24).
   B. Pry the seal out and be careful not to damage the outside diameter of the crankshaft.



A. Dust Lip

Figure 24—Removing the Crankshaft Rear Oil Seal

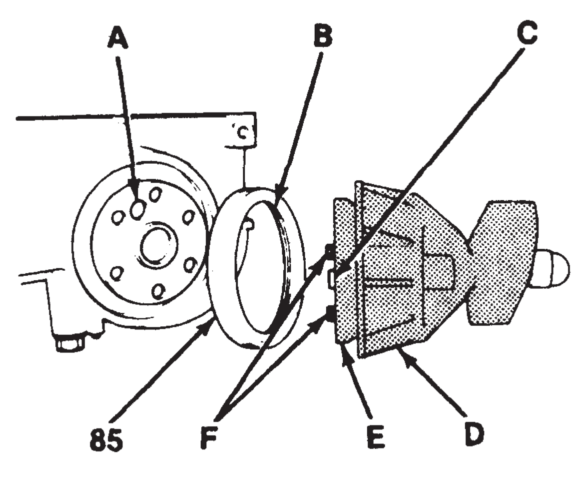
Inspect

- *Inside diameter of the bore for burrs or nicks.*
- Crankshaft for burrs or nicks on the seal contact surface. Repair or replace crankshaft as necessary.

Install or Connect

Tools Required:
J 34686 Seal Installer

1. Light coat of oil to the inside diameter of the new seal.
2. New seal over the mandrel of J 34686 until the dust lip (back of the seal) bottoms against the collar of the tool (figure 25).
3. J 34686 to the crankshaft by hand or torque the attaching screws to 4 N·m (36 in. lbs.).
   - Align the dowel pin of J 34686 with the dowel pin hole in the crankshaft.
4. Light coat of oil to the outside diameter of the seal.
5. Seal into the bore.
   A. Turn the "T" handle of the tool so the collar pushes the seal into the bore.
   B. Turn the handle until the collar of J 34686 is tight against the cylinder block to seat the seal properly.
   C. Loosen the "T" handle until it comes to a stop.
   D. Remove the attaching screws.
6. Flywheel, as outlined later in this section.
7. Transmission. Refer to SECTION 7.
   - Start the engine and check for leaks.



A. Alignment Hole in Crankshaft
B. Dust Lip
C. Dowel Pin
D. Collar (J 34686)
E. Mandrel
F. Screws
85. Crankshaft Rear Oil Seal

Figure 25—Installing the Crankshaft Oil Seal

MEASURING CAMSHAFT LOBE LIFT

Measuring lobe lift is similar to checking valve timing. If improper valve operation is indicated, measure the lift of each pushrod in consecutive order and record the readings.

Tools Required:

J 8520 Camshaft Lobe Lift Indicator

1. Remove the rocker arm, as outlined previously.
2. Position the dial indicator (part of J 8520) so the plunger rests on the pushrod end (as shown in figure 26). Make sure the pushrod is in the lifter socket.
3. Rotate the crankshaft slowly in the direction of rotation until the lifter is on the heel of the cam lobe. At this point, the pushrod will be in its lowest position.
4. Set dial indicator on zero, then rotate the crankshaft slowly, or attach an auxiliary starter switch and "bump" the engine over, until the pushrod is in the fully raised position.

Important

- Whenever the engine is cranked remotely (with a special jumper cable or other means) the distributor primary lead should be disconnected from the ignition coil.

5. Compare the total lift recorded from the dial indicator with specifications.
6. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
7. Install the rocker arm and adjust the valves, as previously outlined.

CAMSHAFT REPLACEMENT

Remove or Disconnect

1. Upper fan shroud. Refer to SECTION 6B2.
2. Radiator. Refer to SECTION 6B2.
3. Valve lifters, as outlined previously.
4. Crankcase front cover, as outlined previously.
5. Timing chain and sprocket, as outlined previously.

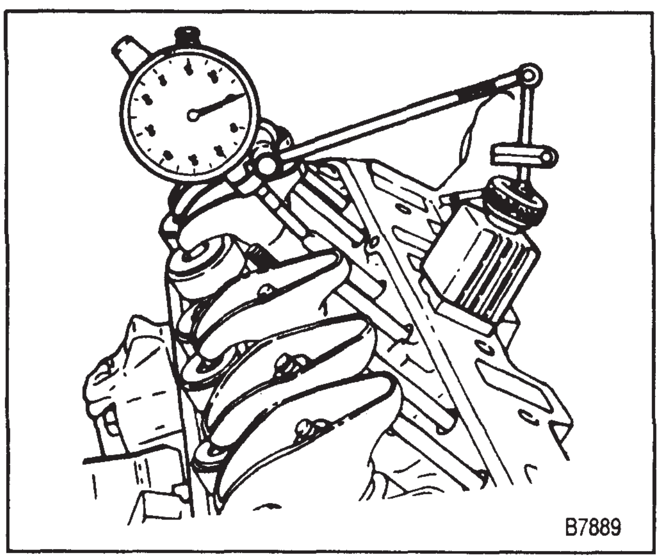


Figure 26—Measuring Camshaft Lobe Lift

6. Camshaft (figure 27).

Important

- All camshaft bearing journals are the same diameter and care must be exercised when removing the camshaft to avoid bearing damage.

Cleaning, Inspection, And Repair

Clean, inspect, and repair or replace the camshaft and related components as outlined in the Light Duty Truck Unit Repair Manual.

The unit repair manual also describes camshaft bearing replacement.

Install or Connect

- Coat the camshaft lobes and journals with High Viscosity Oil with Zinc (GM P/N 12345501 or equivalent).
- When a new camshaft is installed, install new oil and filter. It is also recommended that all valve lifters be replaced to ensure durability of the camshaft lobes and lifter feet.

1. Camshaft.

Important

- All camshaft bearing journals are the same diameter and care must be exercised when installing the camshaft to avoid bearing damage.

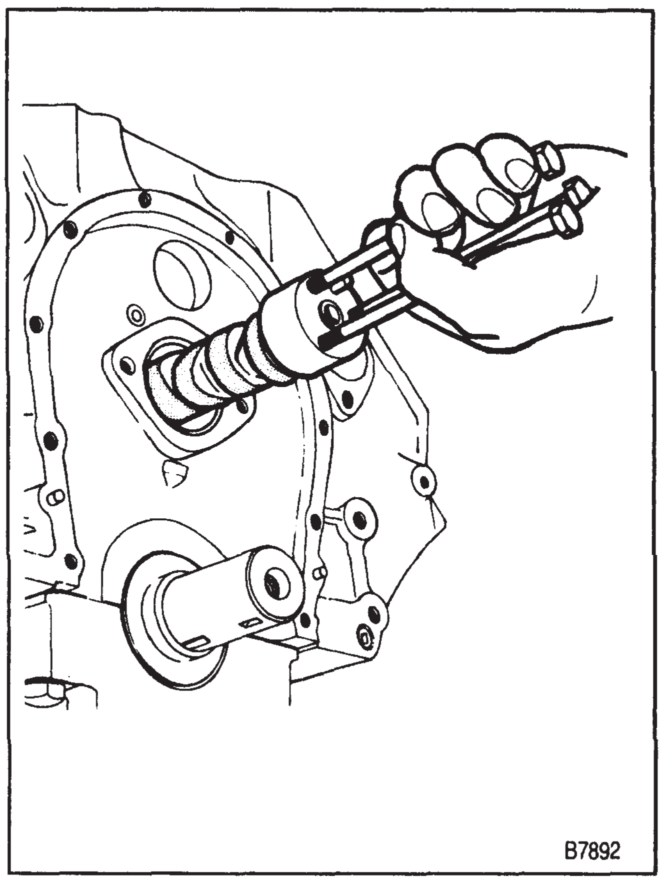


Figure 27—Replacing the Camshaft

2. Timing chain and sprocket, as outlined previously.
3. Crankcase front cover, as outlined previously.
4. Valve lifters, as outlined previously.
5. Radiator. Refer to SECTION 6B2.
6. Upper fan shroud. Refer to SECTION 6B2.

CONNECTING ROD AND PISTON REPLACEMENT

Remove or Disconnect

1. Cylinder heads, as outlined previously.
2. Oil pan, as outlined previously.
3. Ridge or deposits from the upper end of the cylinder bores.
   A. Turn the crankshaft until the piston is at BDC.
   B. Place a cloth on top of the piston.
   C. Perform the cutting operation with a ridge reamer.
   D. Turn the crankshaft until the piston is at TDC.
   E. Remove the cloth and cuttings.
   F. Use a silver pencil or quick drying paint to mark the cylinder number on all pistons, connecting rods, and caps. Starting at the front of the crankcase (viewed from the front), the cylinders in the right bank are numbered 1-3-5 and the left bank is numbered 2-4-6.
4. Connecting rod cap and bearing.
5. Connecting rod and piston (figure 28).
   - Install guide hose over the threads of the rod bolts to prevent damage to the bearing journal and rod bolts.
6. Connecting rod bearing.

Cleaning, Inspection, And Repair

Clean, inspect, and repair or replace the components as necessary. Measure connecting rod bearing clearance, piston clearance, ring clearances, etc. Refer to the Light Duty Truck Unit Repair Manual.

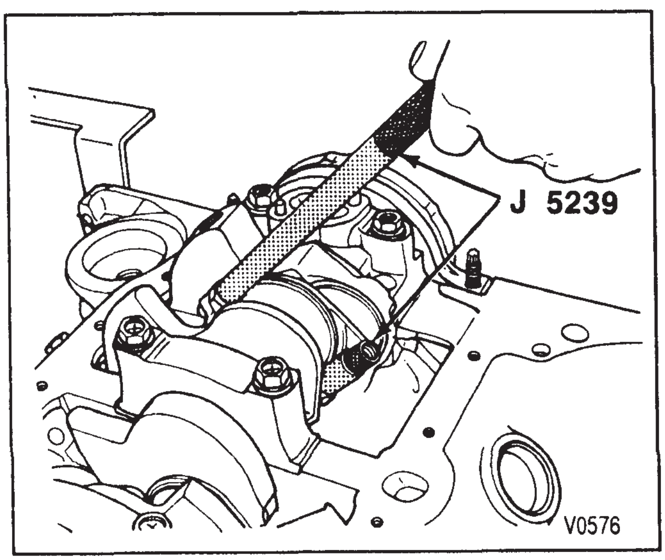


Figure 28—Replacing the Piston and Connecting Rod

The unit repair manual contains information on:
- Connecting rod and piston.
- Piston rings.
- Connecting rod and crankpin.
- Cylinder bores.

Install or Connect

Tool Required:
J 8037 Ring Compressor

- Make sure the cylinder walls are clean. Lubricate pistons, rings, and cylinder walls lightly with engine oil.

1. Connecting rod bearings.
   A. Make sure the bearing inserts are the proper size.
   B. Install the bearing inserts in the connecting rod and connecting rod cap.
   C. Lubricate the bearings with engine oil.
2. Guide hose over the connecting rod bolts to protect the crankpin journal.
3. Connecting rod and piston assemblies into the proper bores.
   A. Notch on top of the piston must be toward the front of the engine.
   B. Make sure the gap in the oil ring rails is in the up position toward the center of the engine and the gaps of the compression rings are positioned as shown in figure 29.
   C. Install with the connecting rod bearing tang slots on the side opposite the camshaft.
   D. Use J 8037 to compress the rings.
   E. Use light blows with a hammer handle to tap the piston into its bore (figure 30). At the same time, guide the connecting rod to the crankpin.
   F. Hold the ring compressor against the block until all rings have entered the cylinder bore.

Important

- Each connecting rod and bearing cap should be marked, beginning at the front of the engine. Cylinders 2, 4, and 6 are the left bank and, 1, 3, and 5 are the right bank (when viewed from the

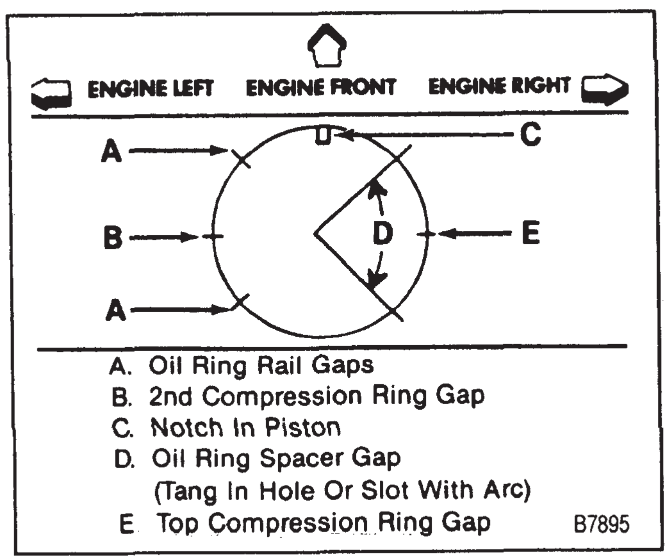


Figure 29—Piston Ring End Gap Location

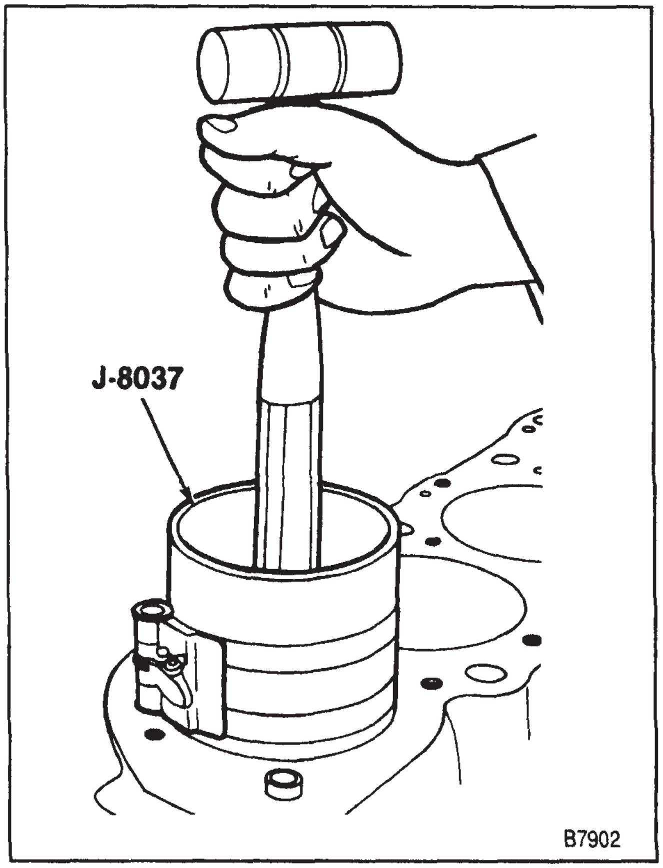


Figure 30—Installing the Piston

front of the engine). The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from block or cylinder to another, new connecting rod bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

Measure

- Connecting rod bearing clearance. Refer to the Light Duty Truck Unit Repair Manual.

4. Connecting rod cap and bearing.

NOTICE: See "Notice" on page 6A2-1.

5. Connecting rod bolt nuts.

Tighten

- Connecting rod bolt nuts to 53 N.m (39 ft. lbs.).

Measure

- Connecting rod side clearance. Use a feeler gage between the connecting rod and crankshaft (figure 31). The correct clearance is 0.36 to 0.60 mm.

6. Oil pan, as outlined previously.
7. Cylinder heads, as outlined previously.

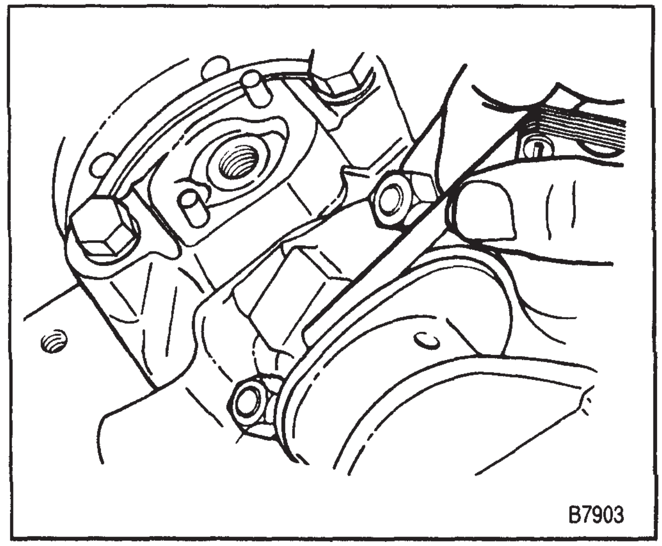


Figure 31—Measuring Connecting Rod Side Clearance

MAIN BEARING REPLACEMENT

Main bearings may be replaced without removing the crankshaft.

Remove or Disconnect

Tools Required:
J 8080 Main Bearing Remover/Installer

1. Oil pan, as outlined previously.
2. Oil pump, as outlined previously.
3. Spark plugs. Refer to SECTION 6D4.
4. Main bearing caps.
   - Check the main bearing caps for location markings. Mark the caps if necessary. The caps must be returned to their original locations during assembly.
5. Lower main bearing inserts from the main bearing caps.
6. Upper main bearing inserts.
   A. Insert J 8080 into the crankshaft oil hole (figure 32).

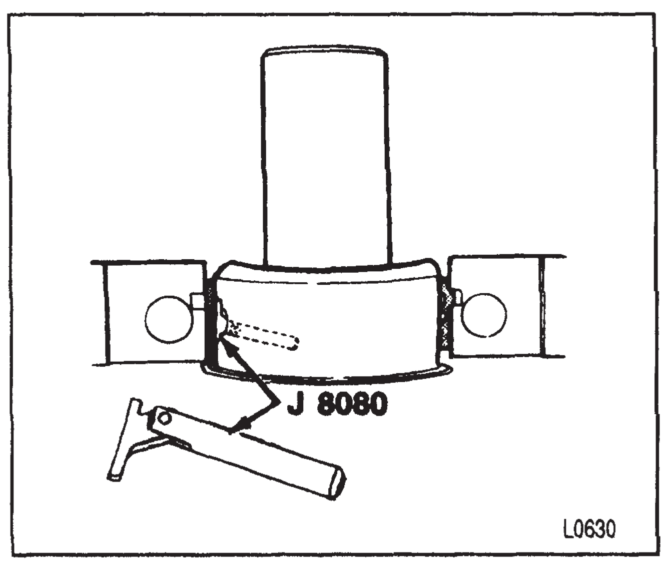


Figure 32—Removing the Main Bearing Insert

B. Rotate the crankshaft to turn the bearing insert out of the block.

Cleaning, Inspection, And Repair

Clean, inspect, and repair or replace the components as required. Refer to the Light Duty Truck Unit Repair Manual. The unit repair manual contains information on:

- Crankshaft.
- Main and connecting rod bearings.

Install or Connect

Tools Required:
J 8080 Main Bearing Remover/Installer

1. Engine oil to bearing inserts of the proper size.
2. Upper main bearing insert.
   A. Insert J 8080 into a crankshaft main bearing oil hole (figure 32).
   B. Insert the plain end (without the bearing tang) of the insert between the crankshaft and the notched side of the block.
   C. Rotate the crankshaft to roll the insert into the block.
   D. Remove J 8080.
   E. Inspect for burrs at the oil hole.
3. Lower main bearing inserts to the main bearing caps.
   A. Make sure the inserts are the proper size.
   B. Apply engine oil to the bearing inserts.
4. New O-ring into the rear main bearing cap.
5. Thin coat of anaerobic sealant (GM P/N. 1052357 or equivalent) to the rear of the block mating surface or corresponding surface of the rear main bearing cap only.
   - Do not allow sealer to contact the crankshaft or seal.
6. Main bearing caps with arrows pointing toward the front of the engine.

NOTICE: See "Notice" on page 6A2-1.

7. Main bearing cap bolts.

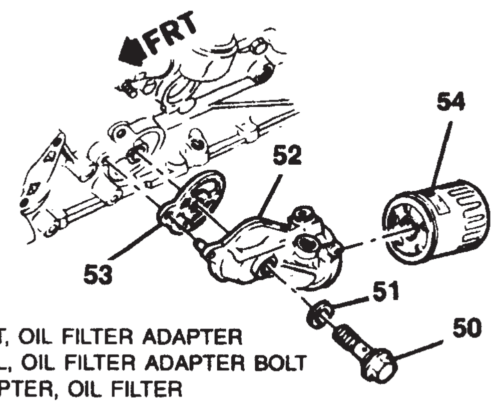
Tighten

A. All main bearing caps EXCEPT NUMBER THREE CAP to 95 N·m (70 ft. lbs.).
B. Number three main bearing cap to 15 N·m (11 ft. lbs.).Then tap the end of the crankshaft rearward, then forward with a lead hammer to line up the rear main bearing and crankshaft thrust surfaces.
C. All main bearing caps to 95 N·m (70 ft. lbs.).

OIL FILTER ADAPTER REPLACEMENT

Remove or Disconnect (Figure 33)

1. Tire and wheel. Refer to SECTION 3E.
2. Oil filter.
3. Oil cooler lines (if equipped).
4. Air cleaner duct.



50. BOLT, OIL FILTER ADAPTER
51. SEAL, OIL FILTER ADAPTER BOLT
52. ADAPTER, OIL FILTER
53. GASKET, OIL FILTER ADAPTER
54. FILTER, OIL

V3602

Figure 33—Oil Filter Adapter and Components

5. Power steering pump.
6. Engine mount through-bolt, as outlined later.
7. Engine mount bracket at the block, as outlined later.
   - Raise the engine and block in position.
8. Oil sending unit connectors.
9. Bolt (50).
10. Gasket (51).
11. Oil filter adapter (52).
12. Gasket (53).

Install or Connect (Figure 33)

1. New gasket (53).
2. Adapter.
3. Gasket.

NOTICE: See "Notice" on page 6A2-1.

4. Bolt (50).

Tighten

- Bolt (50) to 85 N·m (63 ft. lbs.).

5. Oil sending unit connectors.
6. Engine mount bracket, as outlined later.
7. Engine mount through-bolt, as outlined later.
   - Lower the engine.
8. Power steering pump.
9. Air cleaner duct.
10. Oil cooler lines.
11. Oil filter.
12. Tire and wheel. Refer to SECTION 3E.

CRANKSHAFT REPLACEMENT

1. Engine, as outlined later.
2. Flywheel, as outlined later.
   - Mount the engine in a suitable engine stand.
3. Spark plugs. Refer to SECTION 6D4.
4. Crankshaft pulley and torsional damper, as outlined previously.
5. Oil pan and oil pump, as outlined previously.
6. Timing chain and sprocket, as outlined previously.

7. Connecting rod caps.
   - Check the connecting rod caps for cylinder number identification. Mark the caps if necessary.
8. Connecting rods from the crankshaft.
   - Install guide hose over the threads of the connecting rod bolts to prevent damage to the bearing journal and rod bolts.
9. Main bearing caps, as outlined previously.
10. Crankshaft from the block.

Cleaning, Inspection, And Repair

Clean, inspect, and repair or replace the parts as outlined in the Light Duty Truck Unit Repair Manual. Refer to the unit repair manual for information on:

- Crankshaft.
- Main and connecting rod bearings.
- Measuring bearing clearance.

Install or Connect

1. Rear main bearing oil seal in the block and rear bearing cap grooves.
2. Engine oil on the seal.
   - Keep oil off of the parting line surface.
3. Main bearing inserts.
4. Engine oil on the main bearing inserts.
5. Crankshaft.
   - Be careful not to damage the bearing surfaces.
6. Thin coat of anaerobic sealant (GM P/N 1052357 or equivalent) to the rear of the block mating surface or corresponding surface of the rear main bearing cap only.
   - Do not allow sealer to contact the crankshaft or seal.
7. New O-ring to the rear main bearing cap.
8. Main bearing caps with arrows pointing toward the front of the engine.

NOTICE: See "Notice" on page 6A2-1.

9. Main bearing cap bolts.

Tighten

A. All main bearing caps EXCEPT NUMBER THREE CAP to 95 N.m (70 ft. lbs.).
B. Number three main bearing cap to 15 N.m (11 ft. lbs.).Then tap the end of the crankshaft rearward and then forward with a lead hammer to line up the rear main bearing and crankshaft thrust surfaces.
C. All main bearing caps to 95 N.m (70 ft. lbs.).

FLYWHEEL REPLACEMENT

Remove or Disconnect (Figure 34)

1. Transmission. Refer to SECTION 7.
2. Clutch. Refer to SECTION 7.
3. Bolts.
4. Flywheel.

Clean

- Mating surfaces of crankshaft and flywheel. Remove any burrs.

Inspect

- Flywheel for burning, scoring, warping, and wear. Replace the flywheel if necessary. Do not machine the flywheel.
- Flywheel ring gear for broken teeth.

Install or Connect (Figure 34)

1. Flywheel.

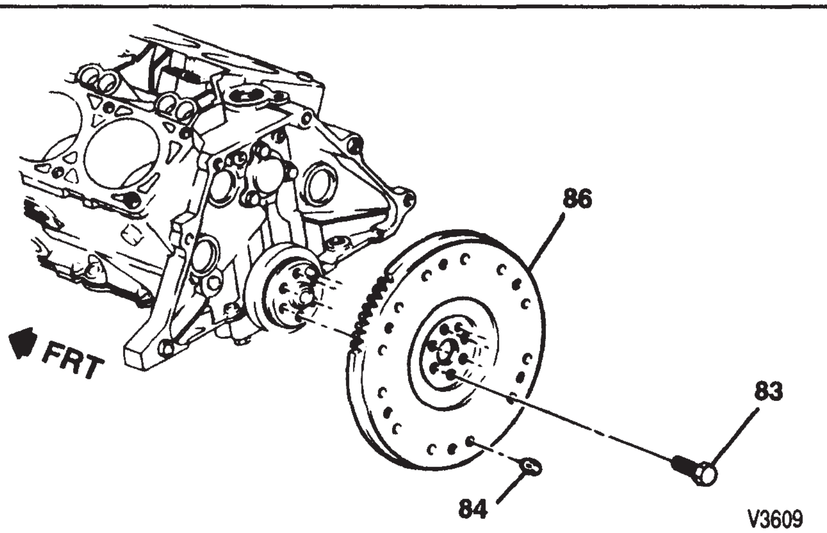
NOTICE: See "Notice" on page 6A2-1.

2. Bolts.

Tighten

- Bolts to 70 N.m (52 ft. lbs.).

3. Clutch. Refer to SECTION 7.
4. Transmission. Refer to SECTION 7.



83. BOLT, FLYWHEEL
84. PIN, GROOVE
86. FLYWHEEL

Figure 34—Flywheel and Components

ENGINE MOUNTINGS

NOTICE: Broken or deteriorated mountings can cause misalignment and eventual destruction of certain drive train components. When a single mounting breakage occurs, the remaining mountings are subjected to abnormally high stresses.

INSPECTING ENGINE MOUNTINGS

Front Engine Mountings

NOTICE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen, resulting in a damaged oil pickup unit.

1. Raise the engine to remove weight from the mountings and place a slight tension on the rubber cushion. Observe both mountings while raising the engine.
2. Replace the mounting if the following conditions exist:
   - Hard rubber surface covered with heat check cracks.
   - Rubber cushion separated from the metal plate of the mounting.
   - Rubber cushion split through the center.
3. If there is movement between a metal plate of the mounting and its attaching points, lower the engine and tighten the bolts or nuts attaching the mounting to the engine, frame, or bracket.

Rear Mountings

1. Push up and pull down on the transmission tailshaft. Observe the transmission mounting.
2. Replace the mounting if the following conditions exist:
   - Rubber cushion separated from the metal plate of the mounting.
   - Mounting bottomed out (tailshaft can be moved up but not down).
3. If there is relative movement between a metal plate of the mounting and its attaching point, tighten the bolts or nuts attaching the mounting to the transmission or crossmember.

FRONT MOUNTING REPLACEMENT

Remove or Disconnect (Figures 35 and 36)

1. Fan shroud. Refer to SECTION 6B2.
   - Raise the vehicle and support with safety stands.
2. Right wheel. Refer to SECTION 3E.
3. Engine mounting through-bolts on both sides.

NOTICE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen, resulting in a damaged oil pickup unit.

- Raise the engine and block in position.
4. Tie rod at the drag link. Refer to SECTION 3B3.
5. Stabilizer link from the control arm. Refer to SECTION 3C.
6. Lower shock absorber bolts.
7. Lower control arm pivot bolts. Refer to SECTION 3C.
   - Lower the control arm.
8. Engine mounting to frame bolts.
9. Engine mounting.

Install or Connect (Figures 35 and 36)

NOTICE: For steps 2 and 7, see "Notice" on page 6A2-1.

1. Engine mounting to the frame.
2. Engine mounting to frame bolts and nuts.

Tighten

- Bolt to 56 N.m (41 ft. lbs.).
3. Lower control arm pivot bolts. Refer to SECTION 3C.
4. Lower shock absorber bolts.
5. Stabilizer link to the control arm. Refer to SECTION 3C.
6. Tie rod to the drag link. Refer to SECTION 3B3.
   - Lower the engine.
7. Engine mounting through-bolts.

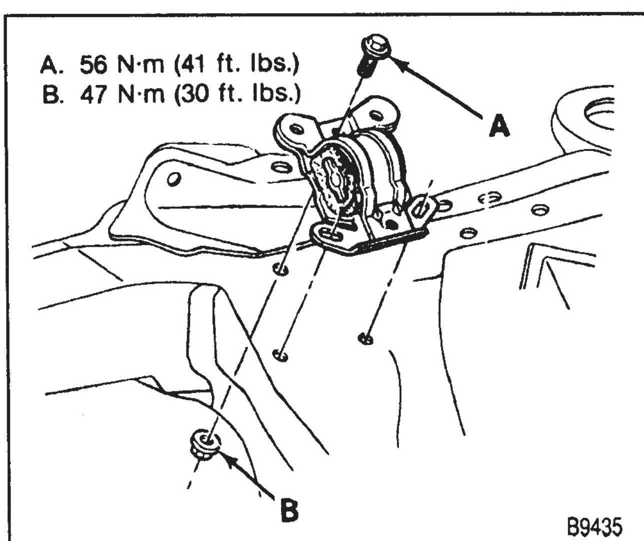


Figure 35—Front Engine Mounting to Frame

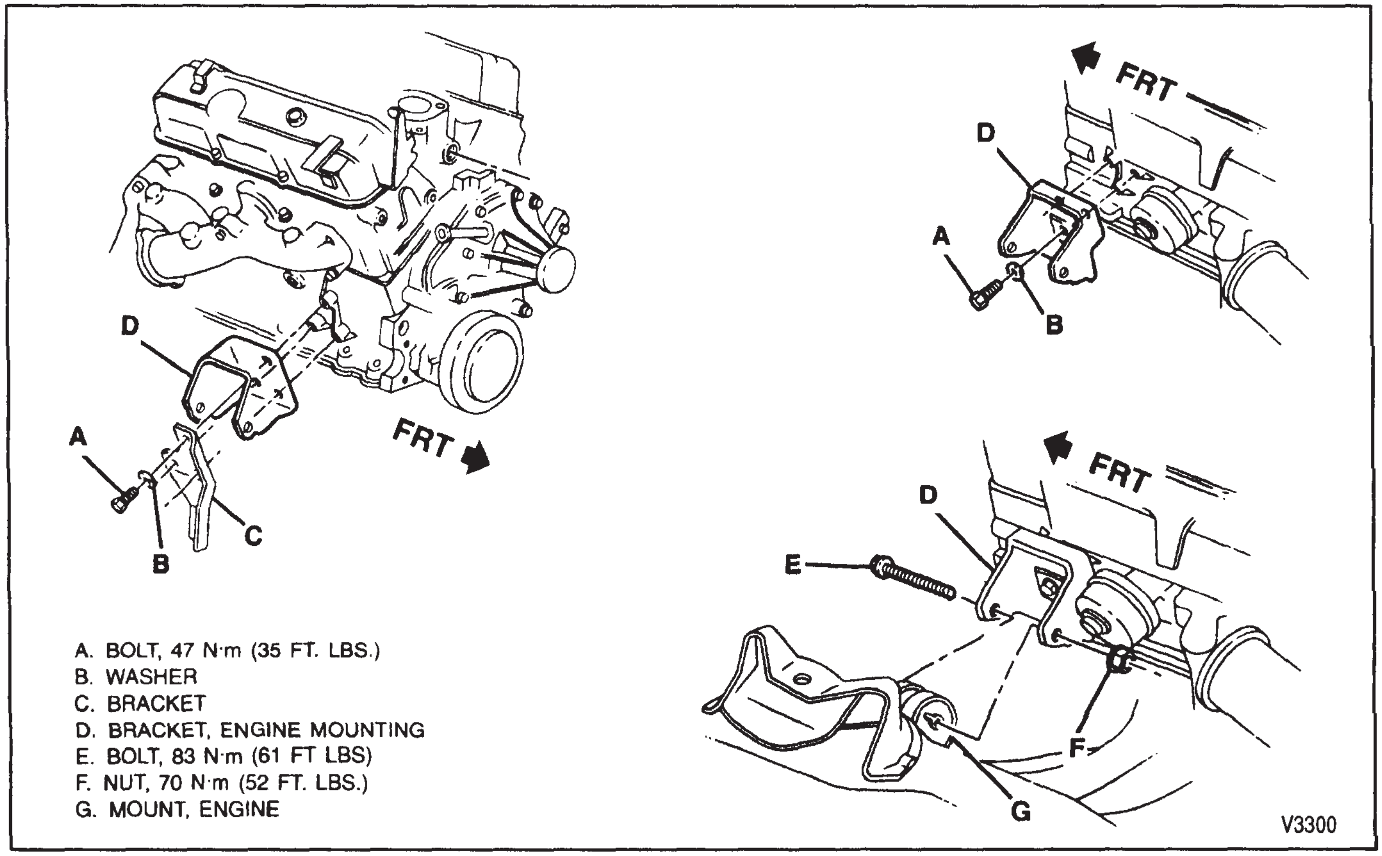


Figure 36—Front Engine Mounting to Engine

Tighten

- Through-bolt nuts to 115 N·m (85 ft. lbs.) or nuts to 72 N·m (53 ft. lbs.).

8. Right wheel. Refer to SECTION 3E.
   - Lower the vehicle.
9. Fan shroud. Refer to SECTION 6B2.

REAR MOUNTING REPLACEMENT

Remove or Disconnect (Figure 37)

1. Negative battery cable. Refer to SECTION 0A.
   - Raise the vehicle.
   - Support the rear of the engine to relieve the weight on the rear mountings.

NOTICE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen, resulting in a damaged oil pickup unit.

2. Mounting to crossmember nut(s) and washers(s).
3. Mounting to transmission bolts.
   - Raise the rear of the engine only enough to permit removal of the mounting.
4. Mounting.

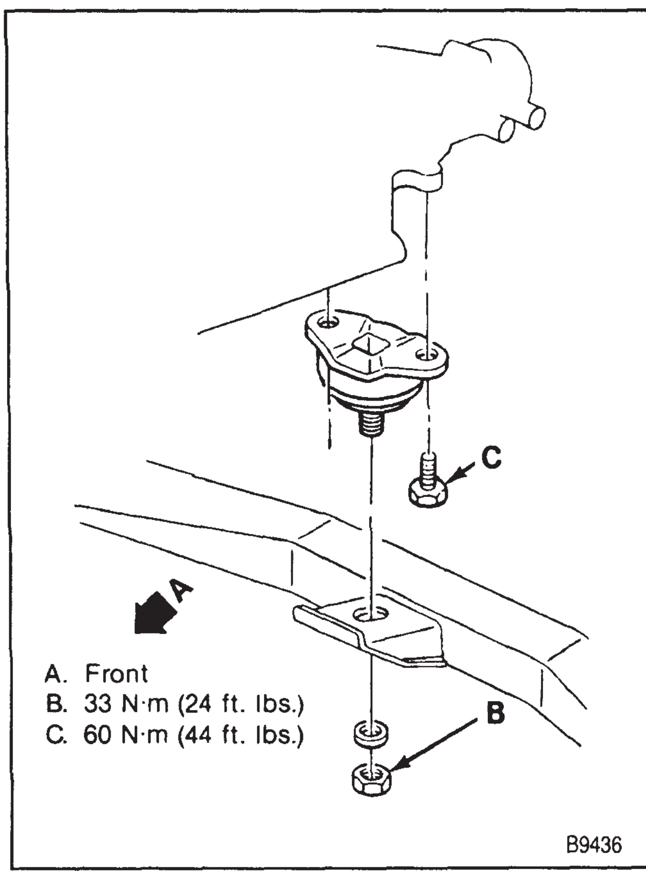


Figure 37—Rear Engine Mounting

Install or Connect (Figure 37)

NOTICE: For steps 2 and 3, see "Notice" on page 6A2-1.

1. Mounting.
   - Lower the rear of the engine.
2. Mounting to transmission bolts.
3. Mounting to crossmember nut(s) and washers(s).

Tighten

- Fasteners to specifications. Refer to figure 37.

ENGINE REPLACEMENT

Remove or Disconnect

1. Negative battery cable. Refer to SECTION 0A.
2. Hood.
   - Drain the cooling system. Refer to SECTION 6B1.
3. Upper radiator hose at the radiator. Refer to SECTION 6B1.
4. Overflow hose.
5. Upper fan shroud. Refer to SECTION 6B2.
6. Radiator. Refer to SECTION 6B2.
7. Fan. Refer to SECTION 6B1.
8. Heater hoses. Refer to SECTION 1A.
9. Air cleaner.
10. Vacuum hoses.
11. All necessary wires at the bulkhead, ground wires, and main feed wires.
12. Throttle cable and cruise control cable (if equipped).
13. Distributor cap. Refer to SECTION 6D4.
    - Raise the vehicle and support with safety stands.
14. Three way catalytic converter to exhaust pipe bolts.
15. Exhaust pipes at the manifolds. Refer to SECTION 6F.
16. Strut rods at the bell housing.
17. Flywheel cover bolts and flywheel cover (if equipped).
18. Shield at rear of catalytic converter.
19. Three way catalytic converter hanger at exhaust pipe. Refer to SECTION 6F.
20. Lower fan shroud. Refer to SECTION 6B2.
21. Fuel lines and hoses.
22. Two outer air dam bolts.
23. Left body mount bolts. Refer to SECTION 2B.
    - Install jackstands.
    - Raise the body.
24. Flywheel housing bolts.
    - Lower the body.
25. Motor mount through bolts.
26. Jackstands.
    - Lower the vehicle.
27. Air conditioning compressor (if equipped). Refer to SECTION 1B.
28. Power steering pump. Refer to SECTION 3B3.
29. Engine.
    - Support the transmission with a floor jack.

Install or Connect

NOTICE: For steps 2, 3, 4, 5, 6, 9, 14, and 17, see "Notice" on page 6A2-1.

1. Engine into the vehicle.
   - Remove the transmission support.
   - Raise the vehicle. Support with suitable safety stands.
2. Motor mount through bolts.

   Tighten

   - Bolts to specification. Refer to figures 35 and 36.
3. Lower flywheel housing bolts.
   - Raise the body.
4. Upper flywheel housing bolts.
   - Lower the body.
5. Remaining flywheel housing bolts.
6. Body mount bolts. Refer to SECTION 2B.
7. Power steering pump. Refer to SECTION 3B3.
8. Air conditioning compressor (if equipped). Refer to SECTION 1B.
9. Two outer air dam bolts.
10. Fuel lines and hoses.
11. Lower fan shroud. Refer to SECTION 6B2.
12. Three way catalytic converter hanger at exhaust pipe. Refer to SECTION 6F.
13. Shield at rear of three way catalytic converter.
14. Flywheel cover and bolts (if equipped).
15. Strut rods at the bell housing.
16. Exhaust pipes to the manifolds. Refer to SECTION 6F.
17. Three way catalytic converter to exhaust pipe bolts. Refer to SECTION 6F.
18. Distributor cap. Refer to SECTION 6D4.
19. Lower the vehicle.
    - Throttle cable and cruise control cable (if equipped).
20. All necessary wires at the bulkhead, ground wires, and main feed wires.
21. Vacuum hoses.
22. Air cleaner.
23. Heater hoses. Refer to SECTION 1B.
24. Fan. Refer to SECTION 6B1.
25. Radiator. Refer to SECTION 6B2.
26. Upper fan shroud. Refer to SECTION 6B2.
27. Overflow hose.
28. Upper radiator hose at the radiator. Refer to SECTION 6B1.
29. Coolant into the cooling system. Refer to SECTION 6B1.
30. Hood. Refer to SECTION 2B.
31. Negative battery cable. Refer to SECTION 0A.

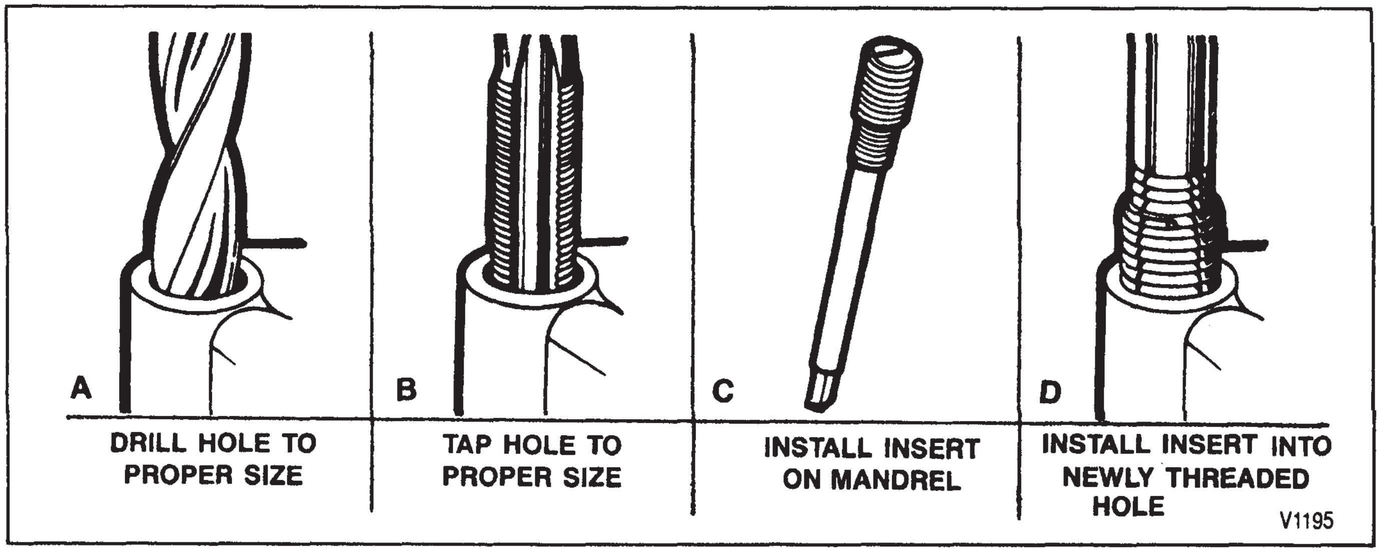


Figure 38—Repairing Thread Holes

THREAD REPAIR

Damaged threads may be reconditioned by drilling out, rethreading, and installing a suitable thread insert. General purpose thread repair kits are available commercially.

CAUTION: Wear safety glasses to avoid eye damage.

1. Determine size, pitch, and depth of damaged thread. If necessary, adjust stop collars on cutting tool and tap to required depth.

Important

- Refer to the kit manufacturer's instructions regarding the size of drill and tap to be used.

2. Drill out damaged thread. Clean out chips.
3. Tap hole. Lubricate tap with light engine oil. Clean the thread.

Important

- Avoid build-up of chips. Back out the tap every few turns and remove chips.

4. Thread the thread insert onto the mandrel of the installer (figure 38). Engage the tang of the insert onto the end of the mandrel.
5. Lubricate the insert with light engine oil (except when installing in aluminum) and install.

Important

- When correctly installed, the insert should be flush to one turn below the surface.

6. If the tang of the insert does not break off when backing out the installer, break the tang off with a drift.

SPECIFICATIONS

ENGINE SPECIFICATIONS (2.8L)

All Specifications are in MILLIMETERS unless otherwise noted.

GENERAL DATA:			
Type			60° V-6
Displacement			2.8L
RPO			LL2
Bore			89.0
Stroke			76.0
Compression Ratio			8.9:1
Firing Order			1-2-3-4-5-6
Oil Pressure			69 kPa @ 500 RPM; 205-380 kPa @ 2000 RPM (10 psi @ 500 RPM; 30-55 psi @ 2000 RPM)
CYLINDER BORE:			
Diameter			88.992-89.070
Out of Round			0.02 (Maximum)
Taper—Thrust Side			0.02 (Maximum)
PISTON:			
Clearance			0.017-0.043
PISTON RING:			
COMPRESSION	Groove Clearance	Top	0.030-0.070
		Second	0.040-0.095
	Gap	Top	0.25-0.50
		Second	0.25-0.50
OIL	Groove Clearance		0.199 (Maximum)
	Gap		0.27-1.25
PISTON PIN:			
Diameter			22.9937-23.0015
Clearance			0.0065-0.0091
Fit in Rod			0.0187-0.0515 (Press)

T2362

SPECIFICATIONS

ENGINE SPECIFICATIONS (2.8L) (CONT.)

All specifications are in MILLIMETERS unless others noted.

CRANKSHAFT:			
Main Journal	Diameter — 3 Dots		67.241-67.249
	Diameter — 2 Dots		67.249-67.257
	Diameter — 1 Dot		67.257-67.265
	Taper		0.005 (Maximum)
	Out of Round		0.005 (Maximum)
Main Bearing Clearance			0.032-0.069
Crankshaft End Play			0.06-0.21
Crankpin	Diameter — 2 Dots		50.758-50.771
	Diameter — 1 Dot		50.771-50.784
	Taper		0.005 (Maximum)
	Out of Round		0.005 (Maximum)
Rod Bearing Clearance			0.028-0.083
Rod Side Clearance			0.36-0.60
CAMSHAFT:			
Lift	Intake		6.65
	Exhaust		6.94
Journal Diameter			47.44-47.49
Journal Clearance			0.026-0.101
VALVE SYSTEM:			
Lifter			Hydraulic
Rocker Arm Ratio			1.50:1
Valve Lash	Intake		1-1/2 Turns Down from Zero Lash
	Exhaust		
Face Angle (Intake & Exhaust)			45°
Seat Angle (Intake & Exhaust)			46°
Seat Runout (Intake & Exhaust)			0.05
Seat Width	Intake		1.25-1.50
	Exhaust		1.60-1.90
Stem Clearance			0.026-0.068
Valve Spring	Free Length		48.5
	Pressure N @ mm	Closed	391 @ 40
		Open	867 @ 30
	Installed height		40
Valve Spring Damper	Free Length		47.2
	Approx. # of Coils		4

T2363

SPECIFICATIONS (CONT.)

FASTENER TIGHTENING SPECIFICATIONS

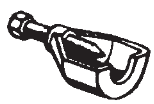
Item	N·m	Ft. Lbs.
Air Injection Tube	34	25
Air Injection Tube Nut	25	18
Camshaft Sprocket Bolts	23	17
Connecting Rod Bolt Nuts	53	39
Coolant Outlet Bolts	21	15
Coolant Pump Bolt (M6 x 1.0)	10	7
Coolant Pump Bolts (M8 x 1.25)	24	18
Coolant Pump Nut	10	7
Cylinder Head Bolts (In Sequence)	95	70
EGR Valve	25	18
Exhaust Manifold Bolts	34	25
Front Cover Bolts		
10mm Bolt (4)	50	37
8mm Bolts (6)	30	22
Flywheel Bolts	70	52
Intake Manifold Bolts (In Sequence)	21	15
Main Bearing Cap Bolts	95	70
Oil Filter Adapter	85	63
Oil Pump Bolt	41	30
Oil Pan Bolts (Rear Two)	25	18
Oil Pan Bolts, Studs, and Nuts	10	7
Oil Pan Drain Plug	25	18
Oil Pump Cover Screws	9	7
Rocker Arm Cover Bolts	8	6
Rocker Arm Studs	65	48
Spark Plugs	30	22
Timing Chain Damper	21	15
Torsional Damper Bolt	95	70

T2521

SPECIAL TOOLS

1.  J 3049-A

2.  J 5590

3.  J 5825-A

4.  J 5892-C

5.  J 8037

6.  J 8080

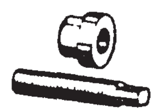
7.  J 8520

8.  J 9290-1

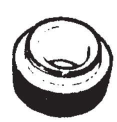
9.  J 39046

10.  J 23590

11.  J 24420-B

12.  J 29113

13.  J 34686

14.  J 35468

1. HYDRAULIC LIFTER REMOVER (PLIER TYPE)
2. CRANKSHAFT SPROCKET INSTALLER
3. CRANKSHAFT SPROCKET PULLER
4. VALVE SPRING COMPRESSOR
5. RING COMPRESSOR
6. MAIN BEARING REMOVER/INSTALLER
7. CAMSHAFT LOBE LIFT INDICATOR
8. HYDRAULIC LIFTER REMOVER (SLIDE HAMMER TYPE)
9. PULLER
10. AIR ADAPTER
11. PULLER
12. TORSIONAL DAMPER INSTALLER
13. SEAL INSTALLER
14. SEAL INSTALLER

B9306

SECTION 6A3

4.3L V6
RPO LB4, VIN Z
RPO L35, VIN W

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

For engine identification, refer to SECTION 0A. For engine component identification, refer to figures 1 through 4.

Two different 4.3L engines are covered in this section. The LB4 (VIN Z) V6 and the the L35 (VIN W) V6.

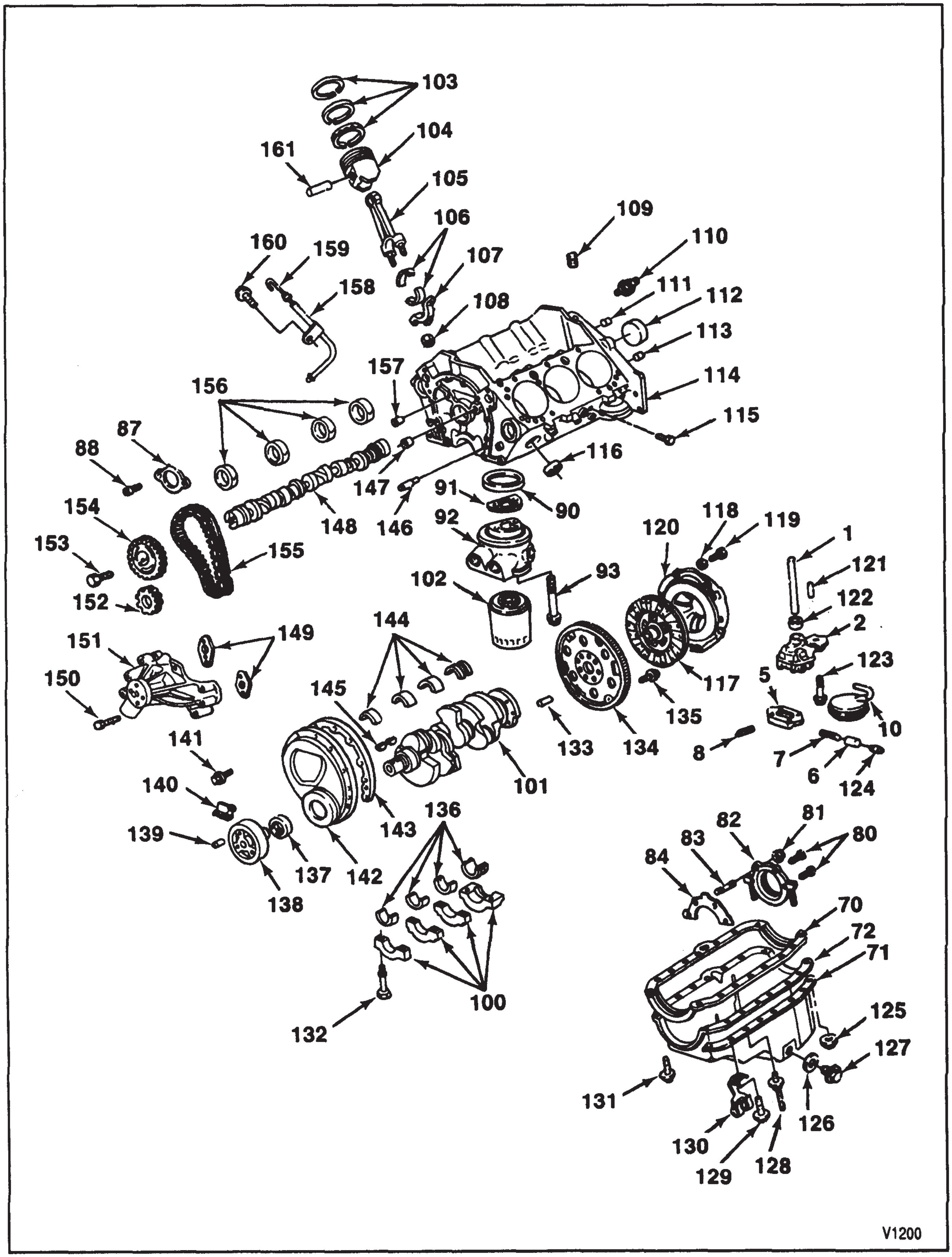


Figure 1—Cylinder Block and Components (VIN Z Engine)

1. Oil Pump Shaft Extension
2. Oil Pump Body
5. Pump Cover
6. Pressure Regulator Valve
7. Pressure Regulator Valve Spring
8. Spring Stop Retaining Pin
10. Pickup Screen and Pipe
70. Oil Pan Gasket
71. Oil Pan Reinforcement
72. Oil Pan
80. Seal Retainer Screw
81. Seal Retainer Nut
82. Seal Retainer
83. Seal Retainer Stud
84. Seal Retainer Gasket
87. Camshaft Retainer
88. Camshaft Retainer Screw
90. Seal
91. Gasket
92. Oil Filter Adapter
93. Bolt
100. Main Bearing Cap
101. Crankshaft
102. Oil Filter
103. Piston Rings
104. Piston
105. Connecting Rod
106. Connecting Rod Bearing
107. Connecting Rod Cap
108. Connecting Rod Nut
109. Plug
110. Knock Sensor
111. Plug
112. Expansion Cup Plug
113. Plug
114. Engine Block
115. Plug
116. Water Jacket Plug
117. Clutch Driven Plate
118. Spring Lock Washer
119. Clutch Cover Bolt
120. Clutch Pressure Plate Cover
121. Dowel Pin
122. Retainer
123. Oil Pump Bolt
124. Spring Stop Plug
125. Nut
126. Gasket
127. Oil Pan Drain Plug
128. Oil Pan Stud
129. Bolt
130. Clip
131. Bolt
132. Main Bearing Cap Bolt
133. Groove Pin
134. Engine Flywheel
135. Flywheel Bolt
136. Lower Main Bearing Insert
137. Crankshaft Front Oil Seal
138. Torsional Damper
139. Groove Pin
140. Timing Pointer
141. Bolt
142. Front Cover
143. Front Cover Gasket
144. Upper Main Bearing Insert
145. Woodruff Key
146. Dowel Pin
147. Oil Gallery Plug
148. Camshaft
149. Coolant Pump Gasket
150. Bolt
151. Coolant Pump
152. Crankshaft Sprocket
153. Bolt
154. Camshaft Sprocket
155. Timing Chain
156. Camshaft Bearing
157. Expansion Plug
158. Oil Level Indicator Tube
159. Oil Level Indicator
160. Bolt
161. Piston Pin

V1201

Figure 2—Cylinder Block and Components (VIN Z Engine)

4.3L engines are 90-degree V6 type, overhead valve, liquid cooled, with cast iron block and heads. Unique to the VIN W engine are a cast iron balance shaft and Central Port Injection (CPI).

The crankshaft is supported by four precision insert main bearings, with crankshaft thrust taken at the number four (rear) bearing. The bearings are retained by bearing caps that are machined with the block for proper alignment and clearances.

The camshaft is supported by four plain type bearings and is chain driven. Motion from the camshaft is transmitted to the valves by hydraulic roller lifters, pushrods and ball type rocker arms. The rocker arms are retained on individual pressed-in studs on the VIN Z engine and threaded-in studs on the VIN W engine. The valve guides are integral within the cylinder heads.

The connecting rods are forged steel, with precision insert type crankpin bearings. The piston pins are a press fit in the connecting rods.

The pistons are cast aluminum alloy. The piston pins use a floating fit in the piston.

The VIN W engine uses a cast iron balance shaft mounted in the crankcase above and in line with the camshaft. A camshaft gear drives the gear attached to the balance shaft. The front end of the balance shaft is supported by a ball bearing and the opposite end uses a needle bearing.

The two-piece central port injection (CPI) manifold assembly is used exclusively on the VIN W engine. The CPI manifold consists of upper and lower cast aluminum manifolds, with the throttle body integral in the upper manifold. The lower manifold has an exhaust gas recirculation (EGR) port cast into it for the mixture of exhaust gases with the fuel air mixture.

The intake manifolds also house the central port injection (CPI) system. This system uses a single injector to meter and distribute fuel to all the engine cylinders. The injector and pressure regulator are housed in the fuel meter body. Nylon inlet and outlet fuel lines and nylon delivery tubes connect to the CPI system. The delivery tubes independently distribute fuel to each cylinder through nozzles located at the port entrance of each manifold runner where the fuel is atomized.

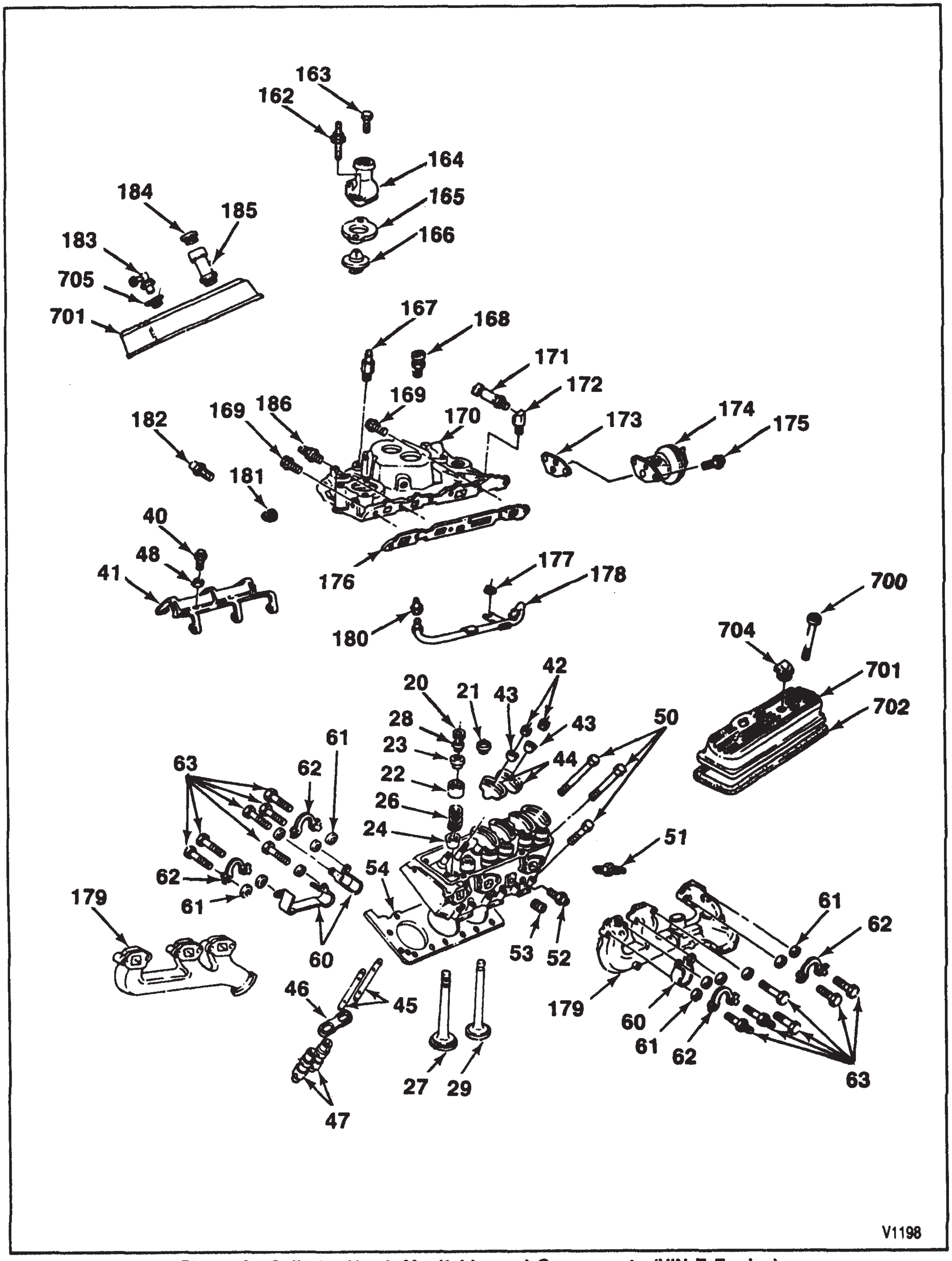


Figure 3—Cylinder Head, Manifolds, and Components (VIN Z Engine)

20. Valve Stem Key
21. Inlet Valve Spring Cap
22. Valve Stem Oil Shield
23. Valve Stem Oil Seal (O-Ring)
24. Inlet Valve Stem Seal
26. Valve Spring with Damper
27. Inlet Valve
28. Exhaust Valve Rotator
29. Exhaust Valve
40. Lifter Restrictor Retainer Bolt
41. Lifter Restrictor Retainer
42. Rocker Arm Nut
43. Rocker Arm Ball
44. Rocker Arm
45. Push Rod
46. Valve Lifter Guide (Restrictor)
47. Lifter
48. Flat Washer
50. Cylinder Head Bolt
51. Spark Plug
52. Coolant Temperature Sensor
53. Drain Plug
54. Cylinder Head Gasket
60. Heat Shield
61. Washer
62. Exhaust Manifold Lock
63. Bolt/Stud
162. Stud
163. Bolt
164. Coolant Outlet
165. Coolant Outlet Gasket
166. Thermostat
167. Vacuum Fitting
168. Engine Coolant Temperature Sensor
169. Bolt
170. Intake Manifold
171. Oil Pressure Sensor
172. Oil Pressure Fitting
173. E.G.R. Valve Gasket
174. E.G.R. Valve
175. Bolt
176. Intake Manifold Gasket
177. Nut
178. Power Booster Vacuum Pipe
179. Exhaust Manifold
180. Power Booster Vacuum Pipe Fitting
181. Plug
182. Coolant Temperature Sensor
183. Crankcase Ventilation Valve
184. Oil Filler Cap
185. Oil Filler Tube
186. Bolt
700. Rocker Arm Cover Bolt
701. Rocker Arm Cover
702. Rocker Arm Cover Gasket
704. Crankcase Vent Tube Grommet
705. Crankcase Vent Valve Grommet

V1199

Figure 4—Cylinder Head, Manifolds, and Components (VIN Z Engine)

ENGINE LUBRICATION

Lubrication schematics are shown in figures 5 and 6. The gear type oil pump is driven from the distributor shaft, which is gear driven from the camshaft. Oil is drawn into the oil pump through a pickup screen and pipe.

Pressurized oil is routed to the oil filter. In case of excessive oil pressure, a bypass valve is provided. Filtered oil flows into the main gallery and then to the camshaft and crankshaft bearings. The valve lifter oil gallery supplies oil to the valve lifters. Oil flows from the hydraulic lifters through the hollow pushrods to the rocker arms. Oil from the overhead drains back to the crankcase through oil drain holes.

The timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.

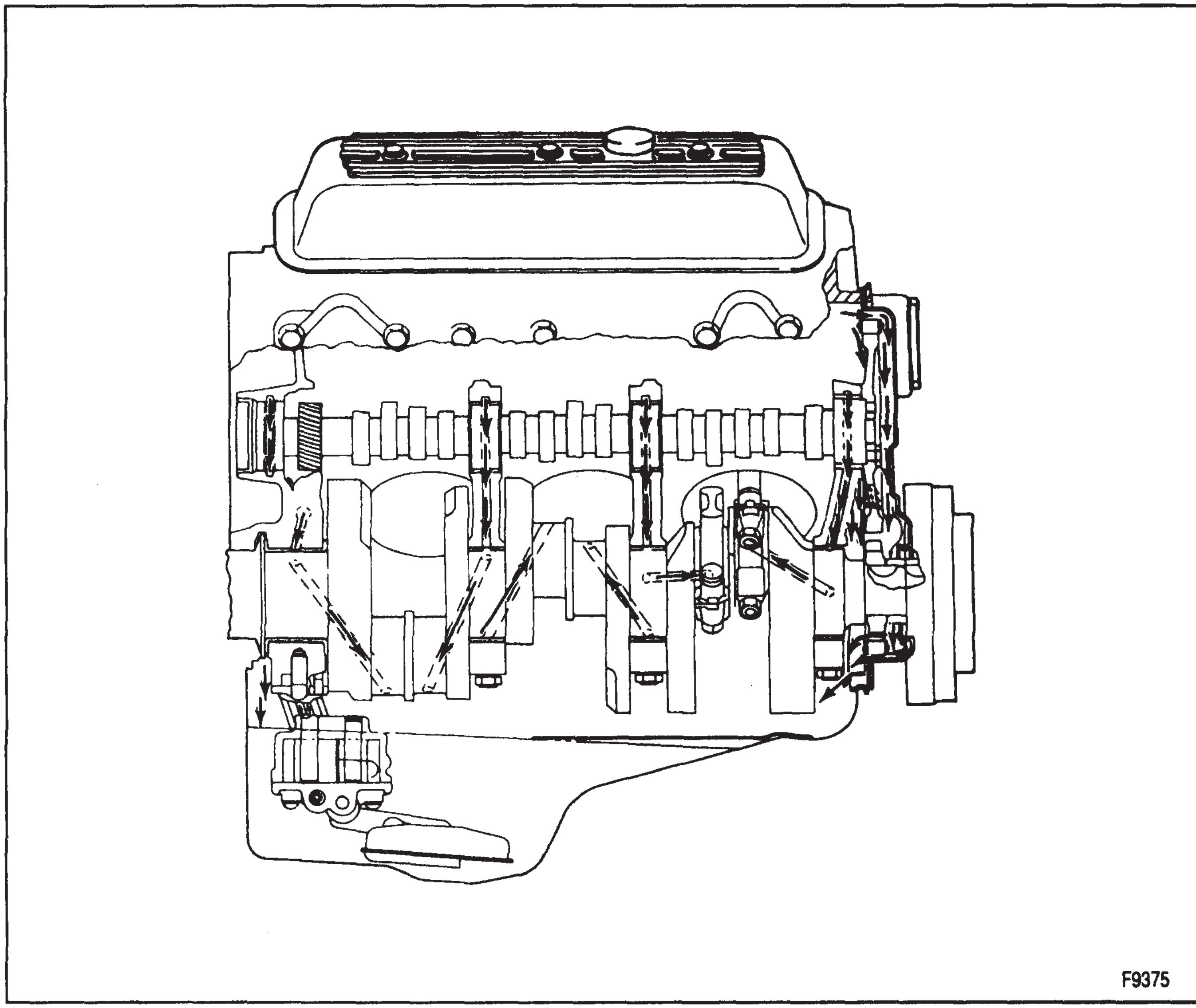
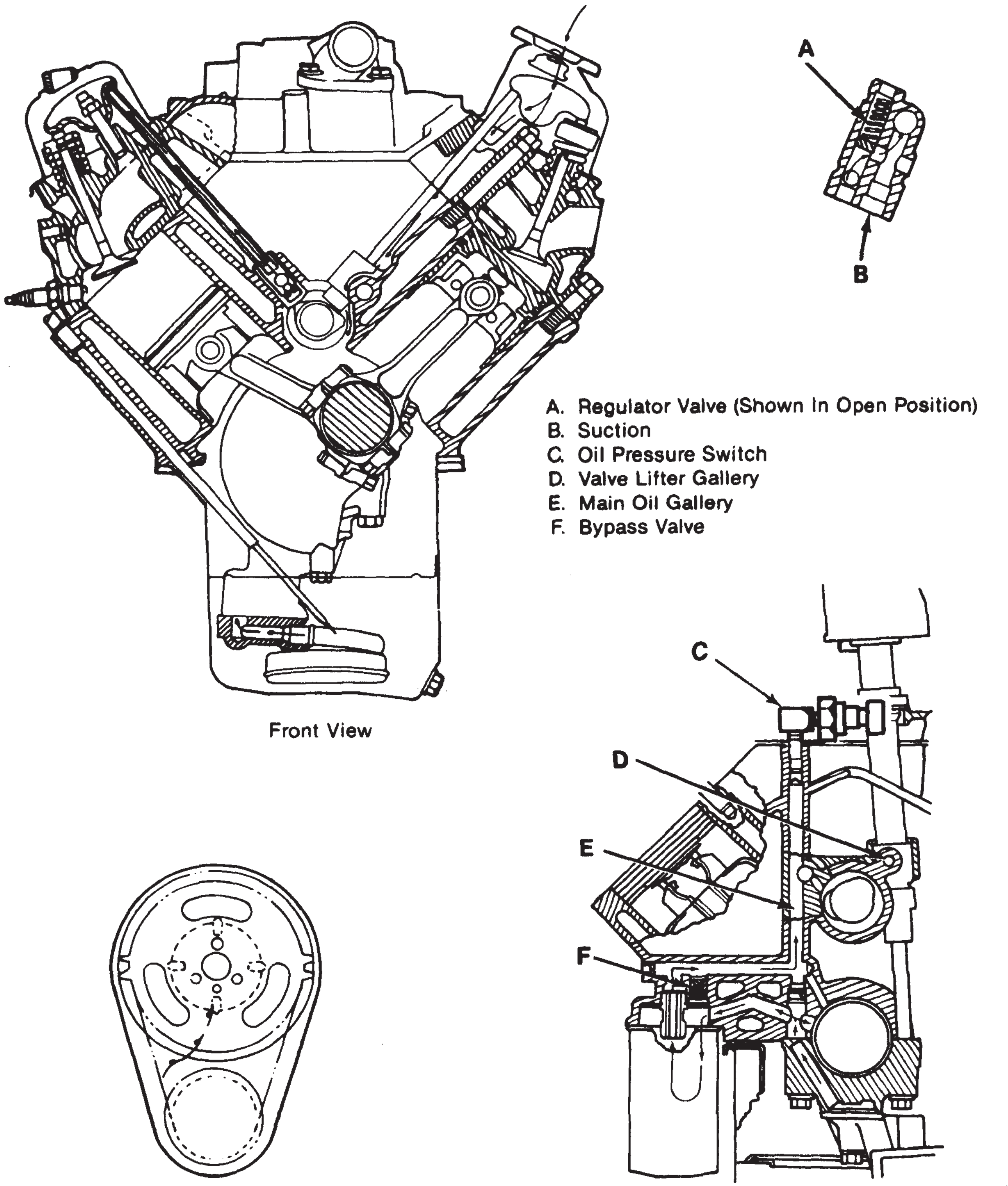


Figure 5—Engine Lubrication Diagram



Front View

Front View
Showing Path Of Oil To Timing Chain.

Rear View
Showing Main Gallery, Oil Filter And Crankshaft Oil Feed.

F9412

Figure 6—Engine Lubrication Diagram

ON-VEHICLE SERVICE

ROCKER ARM COVER REPLACEMENT

REMOVAL—RIGHT SIDE

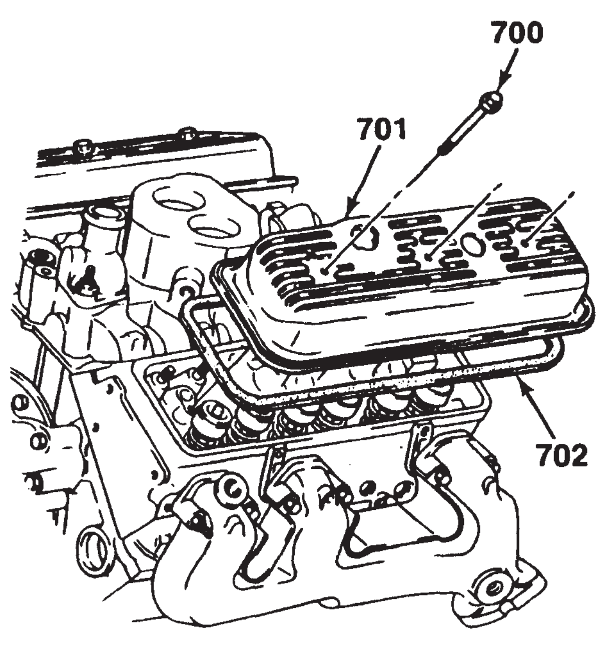
Remove or Disconnect (Figure 7)

1. Negative battery cable.
2. Air cleaner.
3. PCV valve.
4. Heater pipe at the intake manifold.
5. Emissions relays with bracket. Lay aside.
6. Wiring harnesses from the clips. Move aside.
7. Spark plug wires at clips.
8. Dipstick tube bracket at the cylinder head. Move the dipstick tube aside.
9. Rocker arm cover bolts.
10. Rocker arm cover and gasket.

REMOVAL—LEFT SIDE

Remove or Disconnect (Figure 7)

1. Negative battery cable.
2. Air cleaner and heat stove tube.
3. Crankcase ventilation pipe.
4. Fuel pipes at the TBI unit with retaining clips. Move the pipes aside.
5. Generator rear bracket.
6. Spark plug wires from clips.
7. Power brake vacuum line at the intake manifold. Move aside.
8. Rocker arm cover bolts.
9. Rocker arm cover and gasket.



700. Bolt
701. Rocker Arm Cover
702. Gasket

F5520

Figure 7—Rocker Arm Cover

CLEANING AND INSPECTION

Clean

- All traces of old gasket from the rocker arm cover and cylinder head.

Inspect

- Rocker arm cover sealing surface for distortion and damage. Replace if necessary.

INSTALLATION—RIGHT SIDE

Install or Connect (Figure 7)

1. Rocker arm cover and new gasket.

NOTICE: See "Notice" on page 6A3-1.

2. Rocker arm cover bolts and washers.

Tighten

- Rocker arm cover bolts to 10 N·m (90 in. lbs.).

3. Dipstick tube bracket.
4. Spark plug wires to the clips.
5. Wiring harnesses to the clips.
6. Emissions relays with bracket.
7. Heater pipe.
8. PCV valve.
9. Air cleaner.
10. Negative battery cable.

INSTALLATION—LEFT SIDE

Install or Connect (Figure 7)

1. Rocker arm cover and new gasket.

NOTICE: See "Notice" on page 6A3-1.

2. Rocker arm cover bolts and washers.

Tighten

- Rocker arm cover bolts to 10 N·m (90 in. lbs.).

3. Power brake vacuum line.
4. Spark plugs to the clips.
5. Generator rear bracket.
6. Fuel pipes.
7. Crankcase ventilation pipe.
8. Air cleaner and heat stove tube.
9. Negative battery cable.

ROCKER ARM AND PUSHROD REPLACEMENT

Remove or Disconnect

1. Rocker arm cover, as outlined previously.
2. Rocker arm nut.
   - If only the pushrod is to be replaced, back the rocker arm nut off until the rocker arm can be swung away from the pushrod. Then pull the pushrod out.
3. Rocker arm with ball.
4. Pushrod.

Important

- Store used components in order so they can be reassembled in the same location.

Inspect

- Rocker arms and balls at their mating surfaces. These surfaces should be smooth and free from scoring or other damage.
- Rocker arm areas which contact the valve stems and the sockets which contact the pushrods. These areas should be smooth and free of damage and wear.
- Pushrods for bending. Roll the pushrod on a flat surface to determine if it is bent. Replace if necessary.
- Ends of the pushrods for scoring or roughness.

Install or Connect

1. Pushrod. Make sure the pushrod seats properly in the hydraulic lifter.
2. Rocker arm with ball.

   Important

   - When new rocker arms and/or balls are installed, coat their bearing surfaces with "Molykote" or equivalent.
3. Rocker arm nut.

   Adjust

   - Valves as outlined later.
4. Rocker arm cover, as outlined previously.

VALVE ADJUSTMENT

VIN Z ENGINE

1. Remove the rocker arm cover as outlined previously.
2. Crank the engine until the mark on the torsional damper lines up with the "0" mark on the timing tab and the engine in the number one firing position. This may be determined by placing fingers on the number one valve as the mark on the damper comes near the "0" mark on the timing tab. If the rocker arms are not moving, the engine is in the number one firing position. If the rocker arms move as the mark comes up to the timing tab, the engine is in the number four firing position and should be turned over one more time to reach the number one position.
3. With the engine in the number one firing position as determined above, the following valves may be adjusted:
   - Exhaust: 1, 5, 6.
   - Intake: 1, 2, 3.

   (Even numbered cylinders are in the right bank; odd numbered cylinders are in the left bank, when viewed from the rear of the engine).
4. Back out the adjusting nut until lash is felt at the pushrod then turn in the adjusting nut until all lash is removed. This can be determined by rotating the pushrod while turning the adjusting nut (figure 8). When the play has been removed, turn the adjusting nut in one full additional turn (to center the lifter plunger).
5. Crank the engine one revolution until the timing tab "0" mark and torsional damper mark are again in alignment. This is the number four firing position. The following valves may be adjusted:
   - Exhaust: 2, 3, 4.
   - Intake: 4, 5, 6.
6. Install the rocker arm cover as outlined previously.

VIN W ENGINE

The VIN W engine does NOT have adjustable valve lash. When servicing the valve train requires removing and reinstalling the rocker arms, tighten the rocker arm nuts to 27 N.m (20 ft. lbs.).

VALVE STEM SEAL AND VALVE SPRING REPLACEMENT

Remove or Disconnect (Figures 9 and 10)

Tools Required:
- J 23590 Air Adapter
- J 5892-C Spring Compressor

1. Rocker arm cover, as outlined previously.
2. Rocker arms, as outlined previously.
3. Spark plugs.
4. Valve keepers (20).

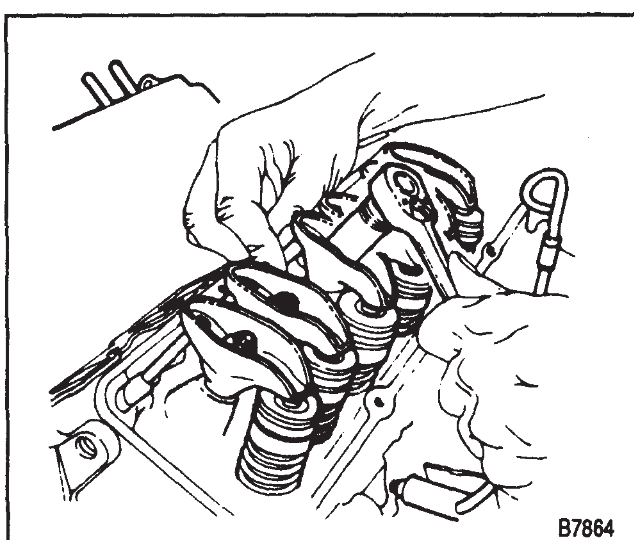


Figure 8—Adjusting the Valves (VIN Z Engine)

A. Install J 23590 into the spark plug hole.
B. Apply compressed air to hold the valves in place.
C. Install a rocker arm nut (figure 10).
D. Use J 5892-C to compress the valve spring (figure 10).
E. Remove the valve keepers.
F. Carefully release the spring tension. Remove J 5892-C.

5. Cap (21) and/or rotator (28), shield (22) and spring (26) with damper (25).
6. O-ring seal (23).
7. Seal (24) (intake valve only).

Install or Connect (Figures 9, 10 and 11)

Tools Required:
J 23590 Air Adapter
J 5892-C Spring Compressor
J 23738-A Vacuum Pump

1. New seal (24) (intake valve only). Install the seal over the valve stem and seat it against the head.

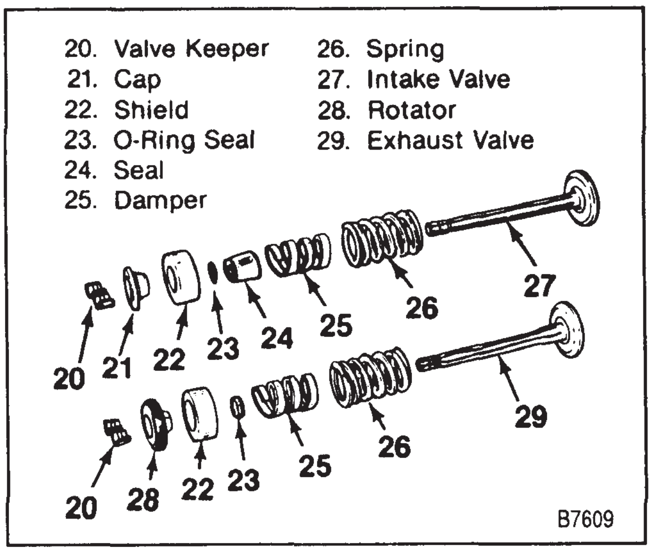


Figure 9—Valves and Components

2. Spring (26) with damper (25), shield (22) and cap (21) and/or rotator (28).
3. New O-ring seal (23) and valve keepers (20).
   A. With air pressure applied to the cylinder with J 23590, compress the spring with J 5892-C (figure 10).
   B. Lubricate the O-ring seal with engine oil. Install the seal on the valve stem. Make sure the seal is not twisted.
   C. Install the valve keepers. Use grease to hold them in place.
   D. Carefully release spring pressure. Make sure the valve keepers stay in place.
   E. Remove J 5892-C and J 23590.
   F. Check each O-ring seal for leakage (figure 11).
      a. Place the suction cup supplied with J 23738-A over the shield.
      b. Connect J 23738-A to the suction cup and apply a vacuum. Watch the vacuum pump gage. No air should be able to leak past the seal. If the seal will not hold a vacuum, it may have been damaged or improperly installed.
4. Spark plugs.
5. Rocker arms, as outlined previously.

Adjust

- Valves, as outlined previously.

6. Rocker arm cover, as outlined previously.

INTAKE MANIFOLD REPLACEMENT

VIN Z ENGINE

Remove or Disconnect (Figure 12)

1. Negative battery cable.
2. Air cleaner and heat stove tube.
   - Drain the cooling system.
3. Two braces at the rear of the fan belt tensioner.
4. Upper radiator hose.
5. Emissions relays with bracket.
6. Wiring harnesses from clips. Move aside.

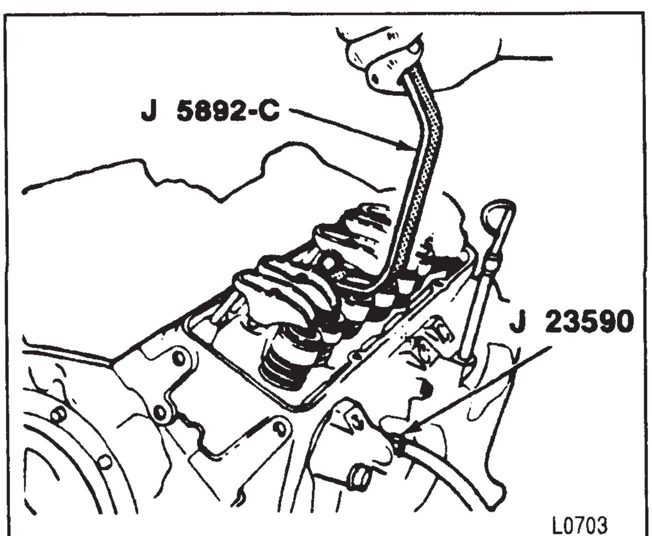


Figure 10—Compressing the Valve Springs

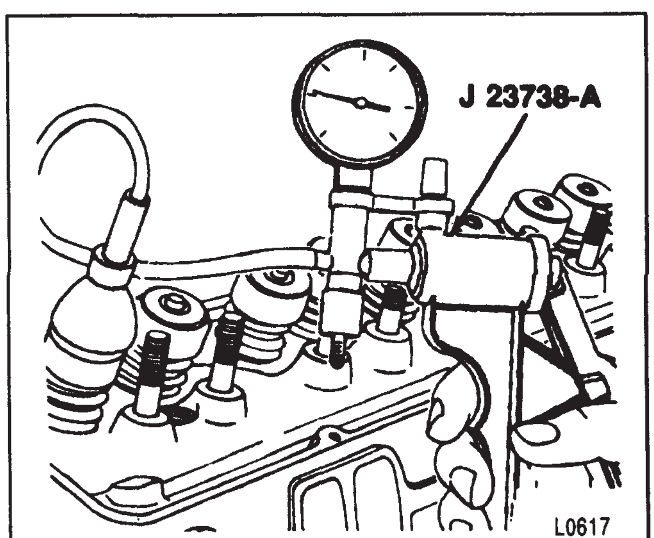


Figure 11—Testing the Valve Seals

7. Ground cable at the manifold stud.
8. Power brake vacuum pipe.
9. Heater hose pipe at the manifold.
10. Fuel pipes at the TBI.
11. Ignition coil.
12. Electrical connectors at sensors on manifold.
13. Distributor. Refer to SECTION 6D.
14. Wires and hoses at the TBI unit.
15. EGR hose.
16. Throttle, TV, and cruise control cables, as equipped.
17. Intake manifold bolts.
18. Intake manifold and gaskets.

Clean

- Old gasket and RTV from the block, heads and intake manifold. Remove all RTV that is loose or will cause interference at assembly.
- Excessive carbon deposits from the exhaust and EGR passages.
- Excessive scale and deposits from the coolant passages.

Inspect

- Manifold for cracks and gasket surface damage.

Install or Connect (Figures 12 and 13)

1. Gaskets to the cylinder head, with the port blocking plates facing the rear (figure 12).
2. RTV to the front and rear sealing surfaces on the block (figure 12). Apply a 5 mm (3/16-inch) bead of RTV (part number 1052366 or equivalent) to the front and rear of the block as shown. Extend the bead 13 mm (1/2-inch) up each cylinder head to seal and retain the gaskets.
3. Intake manifold to the engine.

NOTICE: See "Notice" on page 6A3-1.

4. Intake manifold bolts.

Tighten

- Intake manifold bolts to 48 N.m (35 ft. lbs.). Use the tightening sequence shown in figure 13.

5. Throttle, TV, and cruise control cables.
6. EGR hose.
7. Wires and hoses at the TBI unit.
8. Distributor. Refer to SECTION 6D.
9. Electrical connectors to the sensors on the manifold.
10. Ignition coil.
11. Fuel pipes.
12. Heater hose pipe.
13. Power brake vacuum pipe.
14. Ground cable at the manifold stud.
15. Wiring harnesses to the clips.
16. Emission relays with bracket.
17. Upper radiator hose.
18. Braces at rear of fan belt tensioner.
19. Air cleaner and heat stove tube.
20. Proper grade and quantity of engine coolant.
21. Negative battery cable.

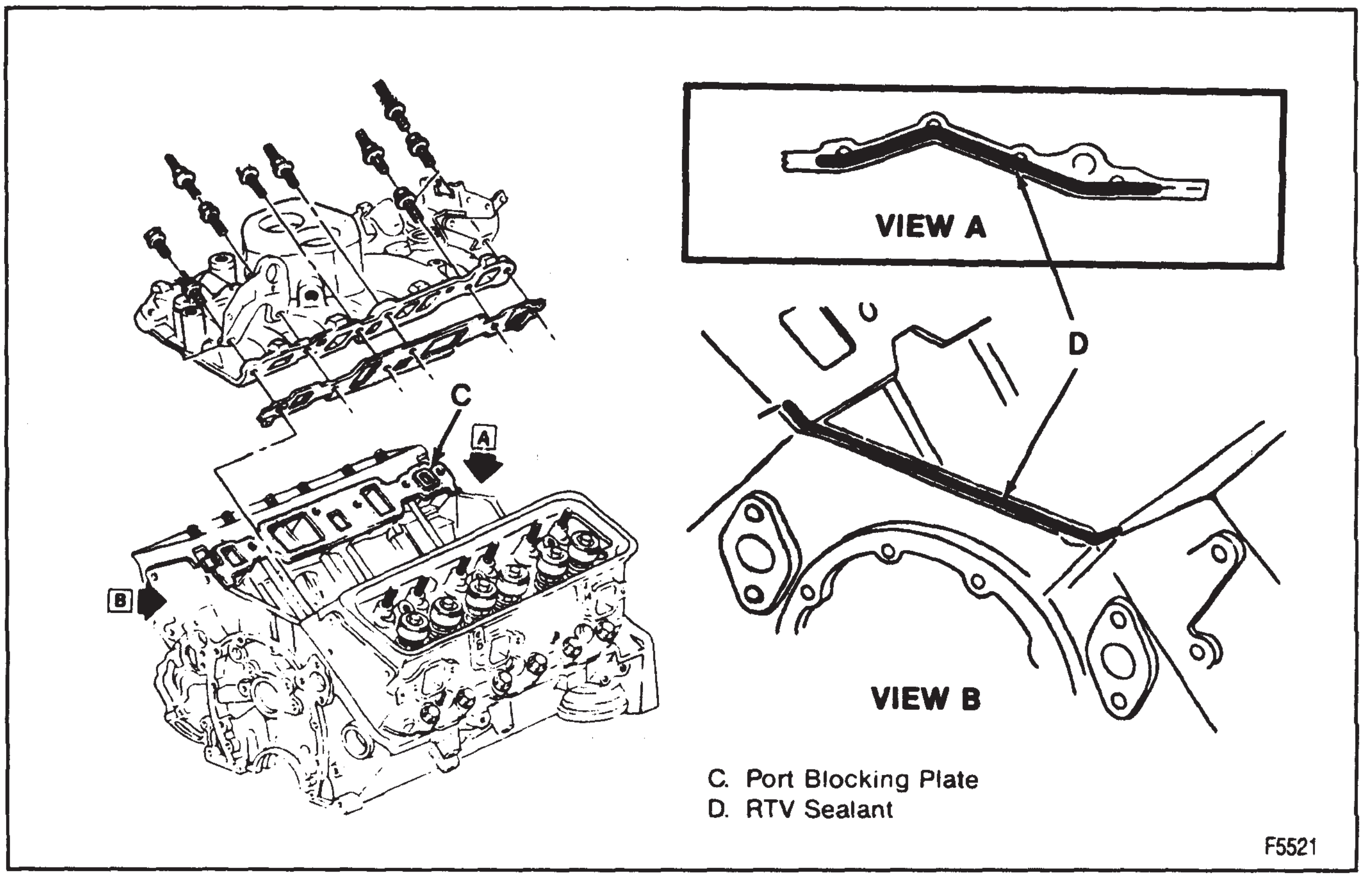


Figure 12—Intake Manifold (VIN Z Engine)

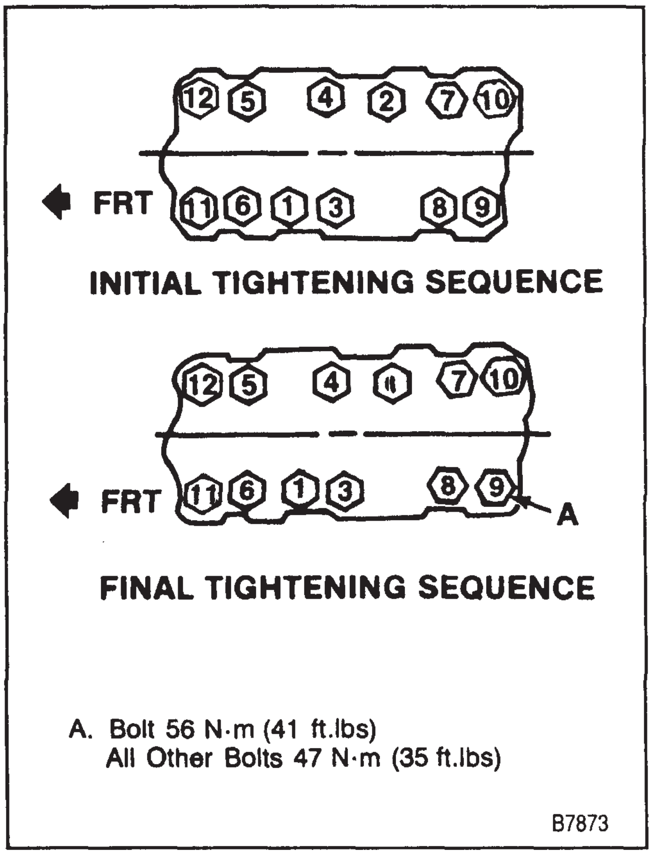


Figure 13—Intake Manifold Bolt Tightening (VIN Z Engine) Sequence

VIN W ENGINE
Upper Intake Removal

Remove or Disconnect (Figure 14)

1. Plastic cover.
2. Wire harnesses, including:
   - Throttle position sensor (TPS).
   - Idle air control (IAC) motor.
   - Manifold absolute pressure (MAP) sensor.
   - Communicator valve.
3. Throttle and TV linkage from upper intake manifold.
4. Ignition coil.
5. PCV hose at rear of upper intake manifold.
6. Vacuum hoses at front and rear of upper intake manifold.
7. Upper intake manifold bolts and studs.
   - Mark the location of all studs for proper reassembly.
8. Upper intake manifold.

Lower Intake Removal

Remove or Disconnect (Figure 14)

1. Distributor wiring and distributor.
   - Mark the relationship of the distributor housing and rotor for proper reassembly.
2. Upper radiator hose at thermostat housing.
3. Heater hose at lower intake manifold.
4. Fuel supply and return lines at rear of lower intake manifold.
5. Pencil brace (A/C compressor bracket to lower intake manifold).
6. Wire harnesses, including;
   - Fuel injector.
   - Exhaust gas recirculation (EGR) valve.
   - Coolant temperature sensor.
7. Lower intake manifold bolts.
8. Lower intake manifold.

Clean

- Old pieces of gasket from the gasket surfaces.
- Excessive carbon build-up in the exhaust passages.
- Scale and deposits from the coolant passages.
- EGR passage of excessive carbon deposits.

Inspect

- Manifold for cracks, broken flanges, and gasket surface damage.

Lower Intake Installation

Install or Connect (Figures 14 and 15)

1. Gaskets to the cylinder head with the port blocking plates facing the rear of the engine and "this side up" stamping facing up.
2. RTV to the front and rear sealing surfaces on the block. Apply a 5 mm (3/16-inch) bead of RTV (GM part number 1052366 or equivalent) to the front and rear of the block. Extend the bead 13 mm (1/2-inch) up each cylinder head to seal and retain the gaskets.
3. Lower intake manifold to engine.
   - Apply sealer, GM part number 1052080 or equivalent, to the lower intake manifold bolts.

NOTICE: See "Notice" on page 6A3-1.

4. Lower intake manifold bolts.

   Tighten

   - Bolts to 48 N·m (35 ft. lbs.) using the tightening sequence shown in figure 15.
5. Wire harnesses, including;
   - Fuel injector.
   - Exhaust gas recirculation (EGR) valve.
   - Coolant temperature sensor.
6. Pencil brace (A/C compressor bracket to lower intake manifold).
7. Fuel supply and return lines to rear of lower intake manifold.
8. Heater hose to lower intake manifold.
9. Upper radiator hose to thermostat housing.
10. Distributor wiring and distributor.
    - Note the relationship of the distributor housing and rotor made at disassembly.

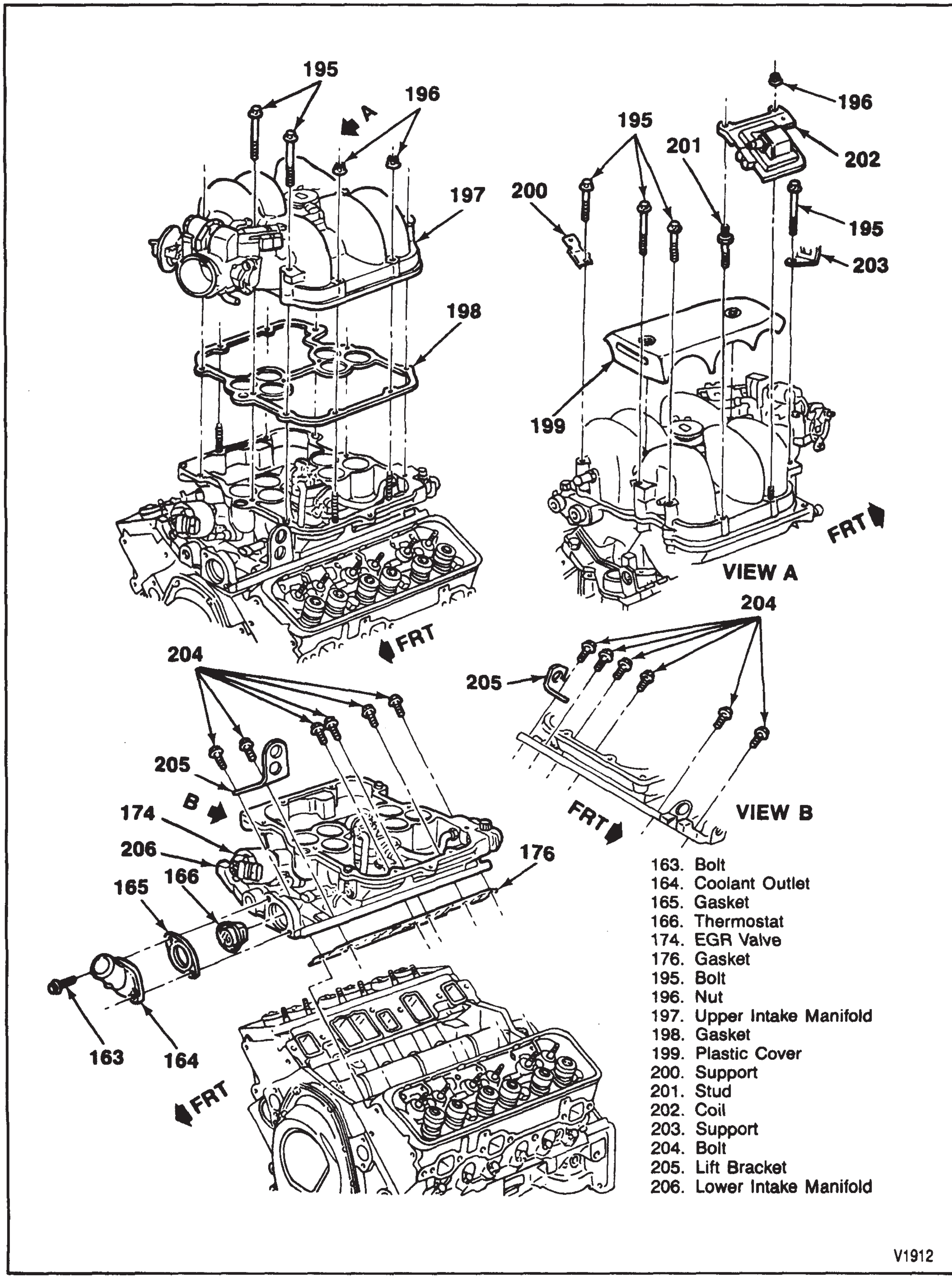


Figure 14—Intake Manifold Assembly (VIN W Engine)

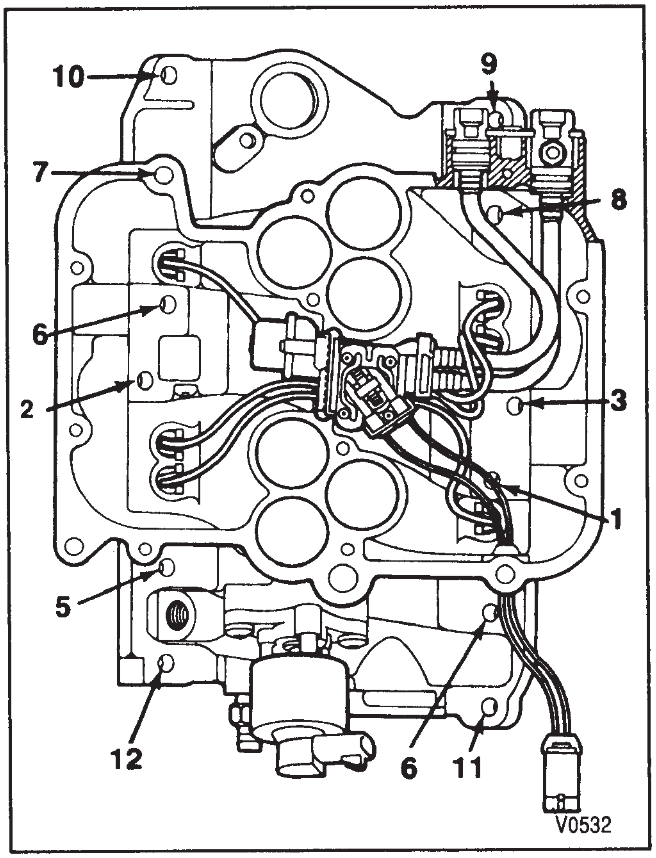


Figure 15—Lower Intake Manifold Bolt Tightening Sequence (VIN W Engine)

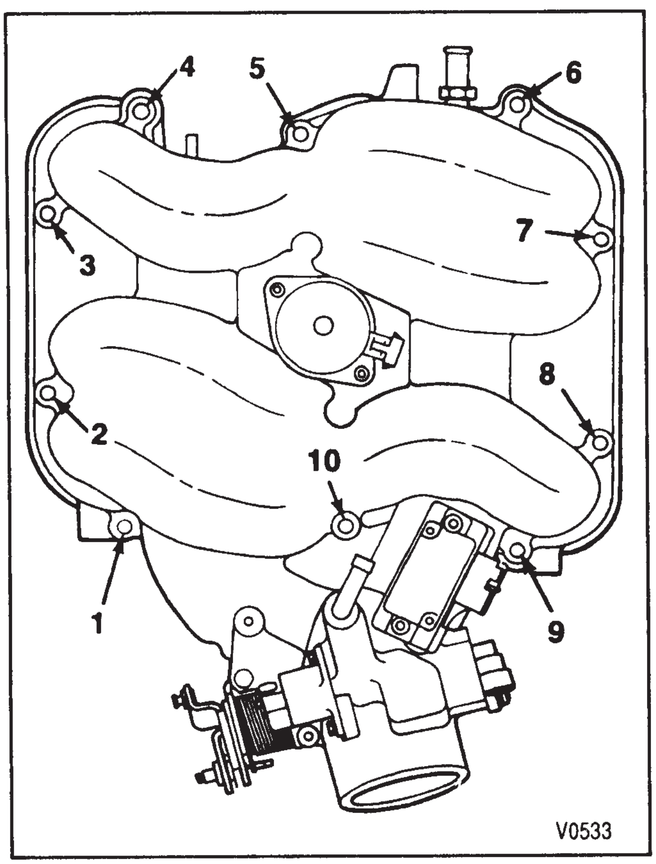


Figure 16—Upper Intake Manifold Bolt Tightening Sequence (VIN W Engine)

Upper Intake Installation

Install or Connect (Figures 14 and 16)

1. Upper intake manifold gasket with green sealing lines facing up.
2. Upper intake manifold.
   - use care not to pinch the injector wires between the upper and lower intake manifolds.

NOTICE: See "Notice" on page 6A3-1.

3. Upper intake manifold bolts. Note the marks made at disassembly for proper stud location.

Tighten

- Bolts to 14 N·m (124 in. lbs.) using the sequence shown in figure 16.

4. PCV hose to rear of upper intake manifold.
5. Vacuum hoses to front and rear of upper intake manifold.
6. Throttle and TV linkage to upper intake manifold.
7. Ignition coil.
8. Wire harnesses, including:
   - Throttle position sensor (TPS).
   - Idle air control (IAC) motor.
   - Manifold absolute pressure (MAP) sensor.
   - Communicator valve.
9. Plastic cover.

HYDRAULIC LIFTER REPLACEMENT

Remove or Disconnect (Figure 17)

1. Rocker arm cover, intake manifold, and pushrods, as outlined previously.
2. Bolts (40).
3. Retainer (41) with restrictors (46).
4. Hydraulic lifters.
   - Remove the hydraulic lifters one at a time and place them in an organizer rack. The lifters must be installed in the same bore from which they were removed.

Inspect

- Hydraulic lifter body for scuffing or scoring. If the lifter body wall is worn or damaged, the mating bore in the block should also be checked.
- Check the fit of each hydraulic lifter in its mating bore in the block. If the clearance is excessive, try a new lifter.
- Roller for freedom of movement.
- Roller for flat spots, pits and missing or broken needle bearings. If worn, pitted or damaged, the mating camshaft lobe should also be checked.

Hydraulic Lifter Repair

- Refer to the Light Duty Truck Unit Repair Manual.

Install or Connect (Figure 17)

1. Hydraulic lifters to the block. Lubricate the lifter roller and body with Engine Oil Supplement or equivalent.

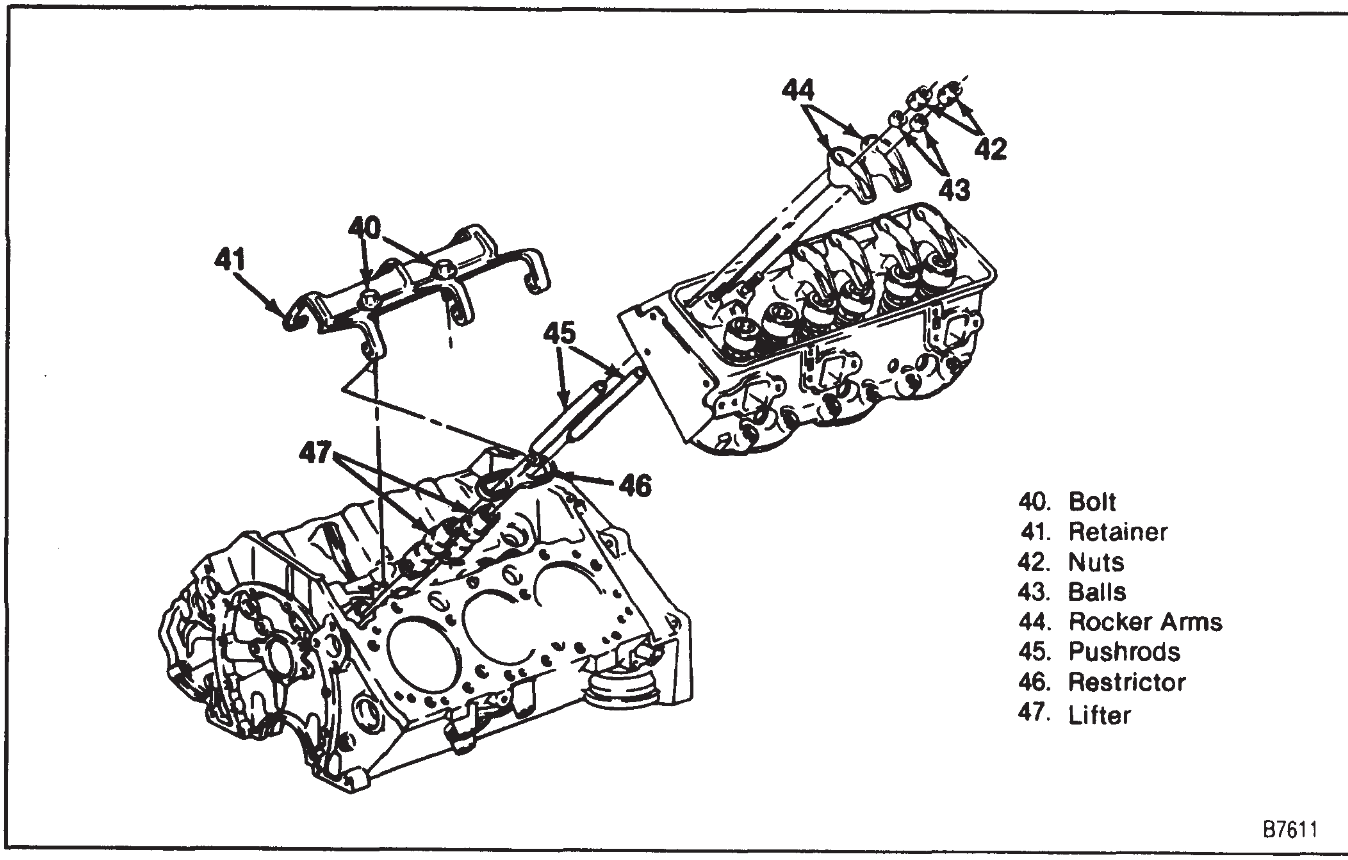


Figure 17—Hydraulic Lifters and Components

Important

- When any new hydraulic lifters or a new camshaft is installed, change the engine oil and filter. Engine Oil Supplement (or equivalent) should be added to the engine oil.
- Replace all hydraulic lifters when a new camshaft is installed.

2. Retainer (41) with restrictors (46).

NOTICE: See "Notice" on page 6A3-1.

3. Bolts (40).

Tighten

- Bolts (40) to 16.4 N·m (145 in. lbs.).

4. Intake manifold, as outlined previously.
5. Pushrod, as outlined previously.

Adjust

- Valves, as outlined previously.

6. Rocker arm cover, as outlined previously.

ROCKER ARM STUDREPLACEMENT

VIN Z ENGINE

Remove or Disconnect (Figure 18)

Tools Required:
J 5802-01 Rocker Arm Stud Remover

1. Rocker arm cover and rocker arm, as outlined previously.
2. Rocker arm stud.
   - Place J 5802-01 over the rocker arm stud.
   - Install a nut and flat washer.
   - Turn the nut to remove the stud (figure 18).

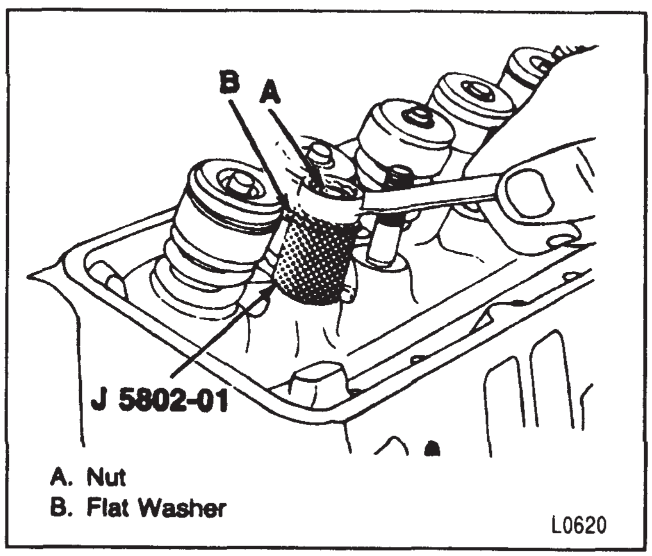


Figure 18—Removing the Rocker Arm Stud (VIN Z Engine)

Install or Connect (Figures 19 and 20)

Tools Required:
- J 5715 Reamer (0.003-inch oversize) or
- J 6036 Reamer (0.013-inch oversize)
- J 6880 Rocker Arm Stud Installer

NOTICE: Do not attempt to install an oversize rocker arm stud without reaming stud hole as this could damage the cylinder head.

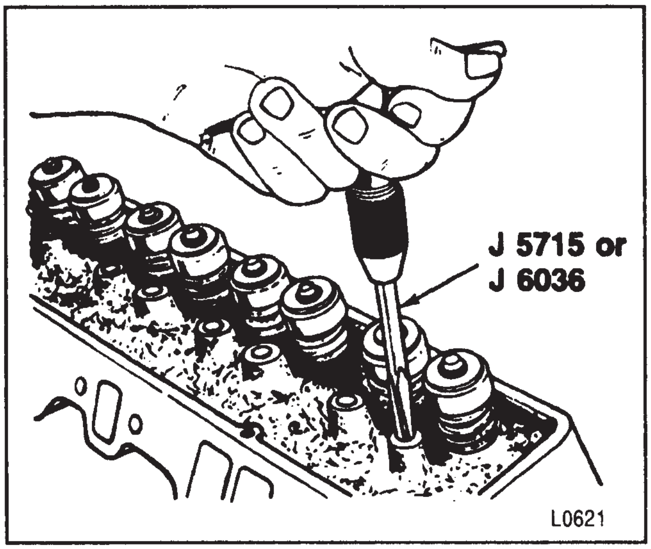


Figure 19—Reaming the Rocker Arm Stud Bore (VIN Z Engine)

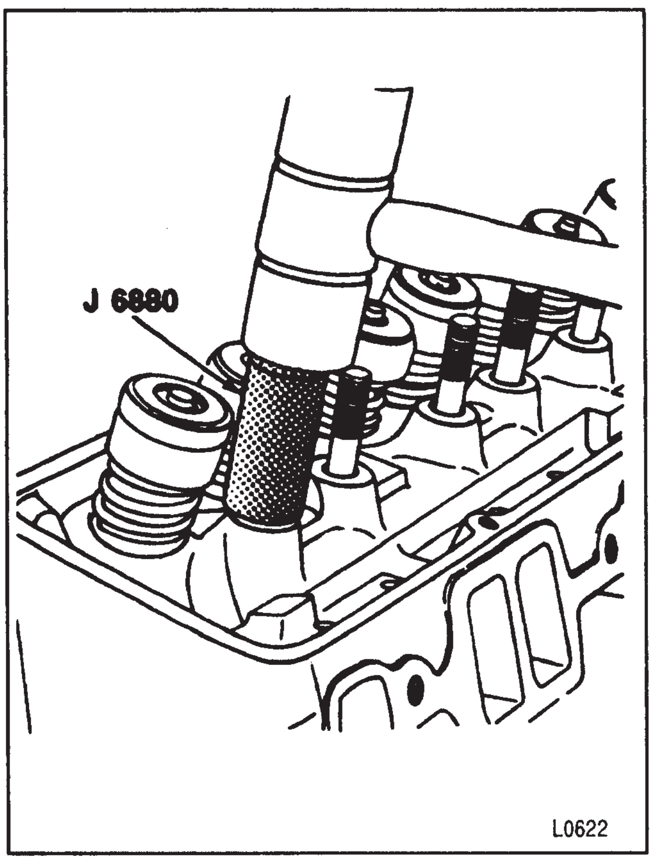


Figure 20—Installing the Rocker Arm Stud (VIN Z Engine)

- Ream the hole to the proper size for the replacement oversize rocker arm stud. Use J 5715 for 0.003-inch oversize studs; J 6036 for 0.013-inch oversize stud (figure 19).
- Coat lower end (press-fit area) of rocker arm stud with hypoid axle lubricant.

1. Rocker arm stud. Use J 6880 (figure 20). Stud is installed to proper depth when the tool bottoms on the cylinder head.
2. Rocker arm, as outlined previously.

Adjust

- Valves, as outlined previously.

3. Rocker arm cover, as outlined previously.

VIN W ENGINE

The cylinder heads on VIN W engines use threaded rocker arm studs. Rocker arm studs that have damaged threads should be replaced with new studs. If the threads in the head are damaged or stripped, the head can be re-tapped and a helical type insert added. If such an insert is not available, the head should be replaced.

EXHAUST MANIFOLD REPLACEMENT

Remove or Disconnect (Figure 21)

1. Negative battery cable.
   - Raise the vehicle. Support with suitable safety stands.
2. Exhaust pipe from the exhaust manifold.
   - Lower the vehicle.
3. Spark plug wires at the spark plugs and retaining clips.
4. Components as follows from left side manifold:
   - Air cleaner with heat stove pipe and cold air intake pipe.
   - Power steering/generator rear bracket.
   - It may be necessary on some models to disconnect the steering intermediate shaft at the steering gear and move it aside. Refer to SECTION 3F1.
5. Exhaust manifold bolts, washers and tab washers.
6. Exhaust manifold.

Clean

- Mating surfaces on the manifold and head.
- Threads on the exhaust manifold bolts.

Install or Connect (Figure 21)

1. Exhaust manifold.

NOTICE: See "Notice" on page 6A3-1.

2. Exhaust manifold bolts, washers and tab washers.

Tighten

- Bolts on center exhaust tube to 36 N.m (26 ft. lbs.).
- Bolts on front and rear exhaust tubes to 28 N.m (20 ft. lbs.).

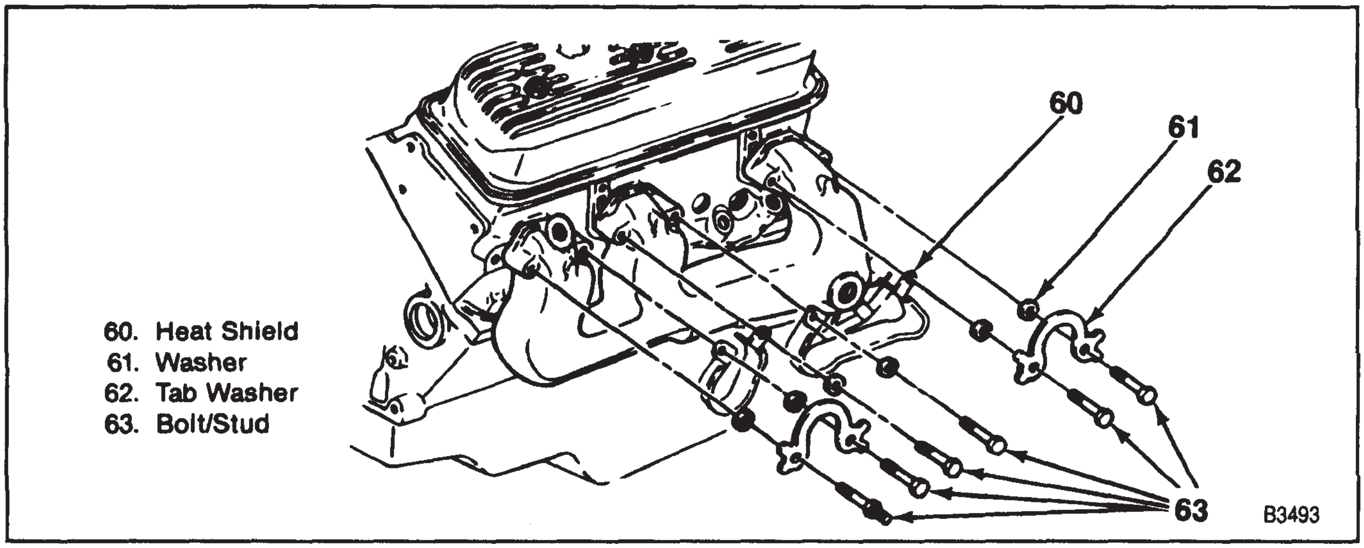


Figure 21—Exhaust Manifold

- Bend the tab washers over the heads of all bolts.

3. Components as follows for left side manifold:
   - Steering shaft (if necessary). Refer to SECTION 3F1.
   - Power steering/generator rear bracket.
   - Air cleaner with heat stove pipe and cold air intake pipe.
4. Spark plug wires.
- Raise the vehicle. Support with suitable safety stands.
5. Exhaust pipe to the manifold.
- Lower the vehicle.
6. Negative battery cable.

CYLINDER HEAD REPLACEMENT

Remove or Disconnect

1. Negative battery cable.
2. Rocker arm cover, as outlined previously.
3. Intake manifold, as outlined previously.
4. Exhaust manifold, as outlined previously.
5. Components as follows for right cylinder head:
   - Electrical connector at sensor.
   - Dipstick tube bracket at the cylinder head.
   - Air conditioning compressor. Lay aside.
   - Air conditioning compressor/belt tensioner bracket.
6. Components as follows for left cylinder head:
   - Generator. Lay aside.
   - Left side engine accessory bracket with power steering pump and brackets. Lay aside.
7. Spark plugs.
8. Pushrods, as outlined previously.
9. Cylinder head bolts.
10. Cylinder head.
11. Head gasket.

Clean

- Carbon deposits from combustion chambers.
- All traces of old head gasket from cylinder head and block.
- Cylinder head bolt threads and threads in the block.

Inspect

- Sealing surfaces of the block and cylinder head for nicks, heavy scratches or other damage.

Cylinder Head Repair

- Refer to the Light Duty Truck Unit Repair Manual.

Install or Connect (Figure 22)

1. Head gasket.
   - If a steel gasket is used, coat both sides of the gasket with sealer. Spread the sealer thinly and evenly.
   - Do not use sealer on composition steel-asbestos gaskets.
   - Place the gasket over the block dowel pins with the bead up.
2. Cylinder head. Carefully guide the cylinder head into place over the dowel pins and gasket.

NOTICE: See "Notice" on page 6A3-1.

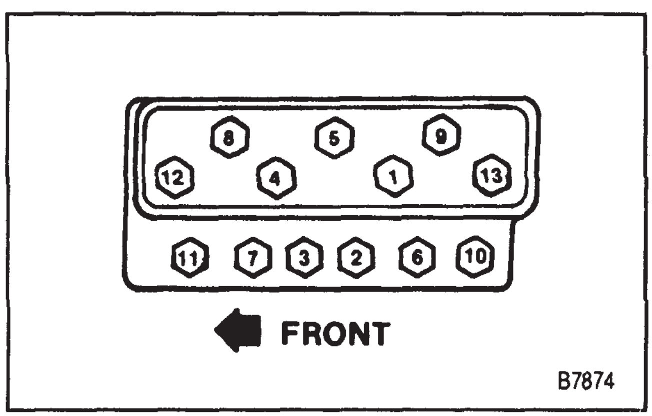


Figure 22—Cylinder Head Bolt Tightening Sequence

3. Cylinder head bolts. Coat threads of the cylinder head bolts with sealing compound (GM part number 1052080 or equivalent) and install finger-tight.

Tighten

- Cylinder head bolts in three steps using the sequence shown in figure 22.
  A. The first sequence to 34 N·m (25 ft. lbs.).
  B. The second sequence to 61 N·m (45 ft. lbs.).
  C. The final sequence to 90 N·m (65 ft. lbs.).

4. Pushrods, as outlined previously.

Adjust

- Valves, as outlined previously.

5. Spark plugs.
6. Components as follows for right cylinder head:
   - Electrical connector at sensor.
   - Dipstick tube bracket.
   - Air conditioning compressor/belt tensioner bracket.
   - Air conditioning compressor.
7. Components as follows for the left cylinder head:
   - Left side engine accessory bracket with power steering pump and brackets.
   - Generator.
8. Exhaust manifold, as outlined previously.
9. Intake manifold, as outlined previously.
10. Rocker arm cover, as outlined previously.
11. Negative battery cable.

TORSIONAL DAMPER AND CRANKSHAFT FRONT SEAL REPLACEMENT

Remove or Disconnect (Figure 23)

Tools Required:
J 23523-E Torsional Damper Puller and Installer

1. Negative battery cable.
2. Multiple ribbed belt, fan, and pulley.
3. Fan shroud assembly.
4. Accessory drive pulley.
5. Torsional damper bolt.
6. Torsional damper. Use J 23523-E (figure 23).
7. Crankshaft front seal. Pry out with a large screwdriver. Take care not to distort the timing cover.
8. Crankshaft key, if necessary.

Inspect

- Oil seal contact area on the torsional damper shaft for grooving and roughness. Replace if necessary.

Install or Connect (Figures 24 and 25)

Tools Required:
J 35468 Seal Installer
J 23523-E Torsional Damper Puller and Installer

1. Crankshaft key, if removed.

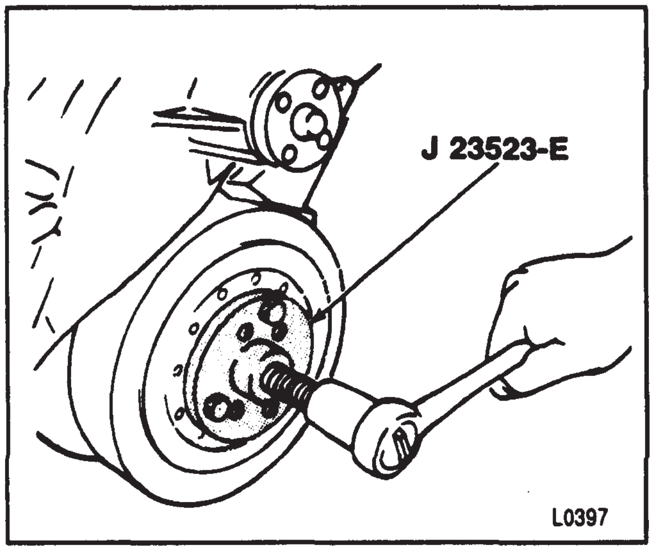


Figure 23—Removing the Torsional Damper

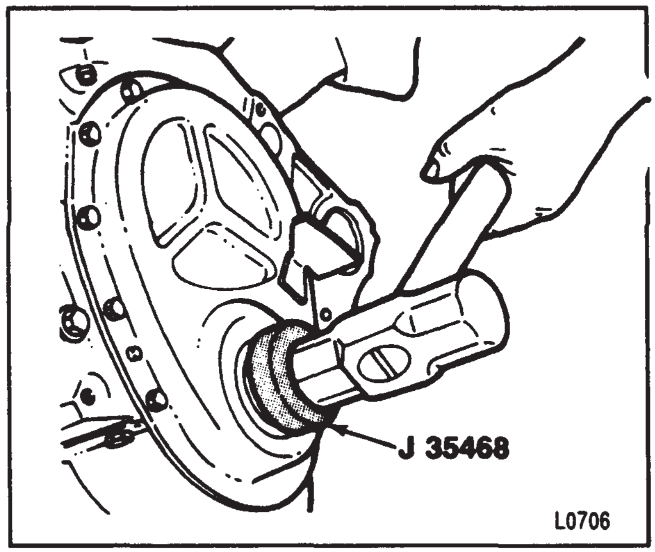


Figure 24—Installing the Crankshaft Front Oil Seal

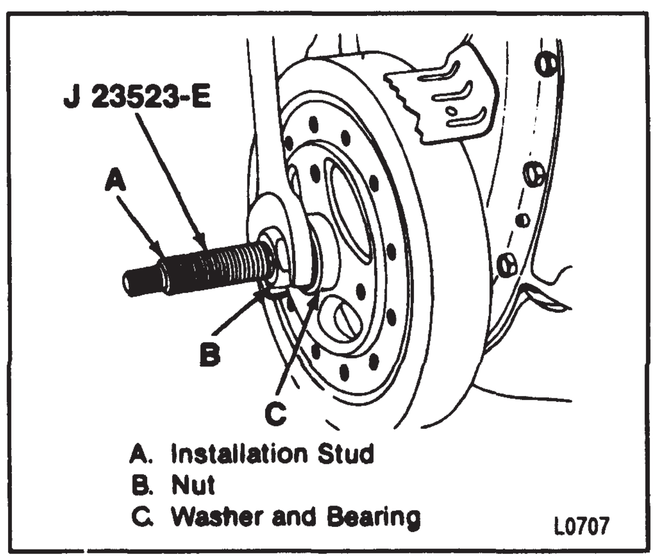


Figure 25—Installing the Torsional Damper

2. Crankshaft front seal. Use J 35468 (figure 24). The open end of the seal faces inside the engine. Coat the seal lips with engine oil.

NOTICE: The inertial weight section of the torsional damper is assembled to the hub with a rubber type material. The correct installation procedures (with the proper tool) must be followed or movement of the inertial weight section of the hub will destroy the tuning of the torsional damper.

3. Stud (item A, figure 25) to the crankshaft. Thread the stud fully into the tapped hole in the crankshaft.
4. Torsional damper over the end of the stud. Align the keyway in the torsional damper shaft with the crankshaft key.
   - Use a small amount of RTV sealant to seal the torsional damper key to crankshaft joint.
5. Bearing, washer, and nut (figure 25).
   - Turn the nut to pull the vibration damper into place.
   - Remove the tool.

NOTICE: See "Notice" on page 6A3-1.

6. Torsional damper bolt and washer.

Tighten

- Bolt to 95 N.m (70 ft. lbs.).

7. Accessory drive pulley.
8. Fan shroud assembly.
9. Fan pulley, fan, and multiple ribbed belt.
10. Negative battery cable.

FRONT COVER REPLACEMENT

Remove or Disconnect

1. Torsional damper, as outlined previously.
2. Coolant pump. Refer to SECTION 6B1.
   - Loosen the oil pan.
3. Front cover bolts.
4. Front cover.

Important

- Use care when removing the front cover from the front of the oil pan seal.

5. Front cover to the block gasket.
6. Crankshaft front seal from the front cover. Pry out with a large screwdriver. Take care not to distort the front cover.

Clean

- Old gasket from the front cover and block.
- Varnish and sludge buildup form the front cover area.

Inspect

- Front cover for distortion and damage. Replace if necessary.

Install or Connect (Figure 24)

Tool Required:
J 35468 Seal Installer

1. Front cover gasket to the front cover. Use gasket cement to hold it in place.

NOTICE: See "Notice" on page 6A3-1.

2. Front cover and bolts.
   - Use care when engaging the front of the oil pan seal with the bottom of the front cover. Lubricate the front of the oil pan seal with engine oil to aid in reassembly.

Tighten

- Front cover to block bolts to 14 N.m (124 in. lbs.).

3. Crankshaft front seal. Use J 35468 (figure 24). The open end of the seal faces inside the engine. Coat the seal lips with engine oil.
4. Oil pan.
5. Coolant pump. Refer to SECTION 6B1.
6. Torsional damper, as outlined previously.

OIL PAN REPLACEMENT

TWO WHEEL DRIVE MODELS

Remove or Disconnect (Figure 26)

- Drain the oil.

1. Engine from the vehicle.
2. Oil pan bolts, nuts, and reinforcements.
3. Oil pan.
4. Gasket.

Clean

- Sealing surfaces on the oil pan and engine block.

Inspect

- Oil pan gasket. Replace if necessary.

Install or Connect (Figure 26)

- Apply sealant (GM part number 1052080 or equivalent) to the front cover to block joint and to the crankshaft rear seal retainer to block joint. Apply the sealant for about 25 mm (1 inch) in both directions from each of the four corners.

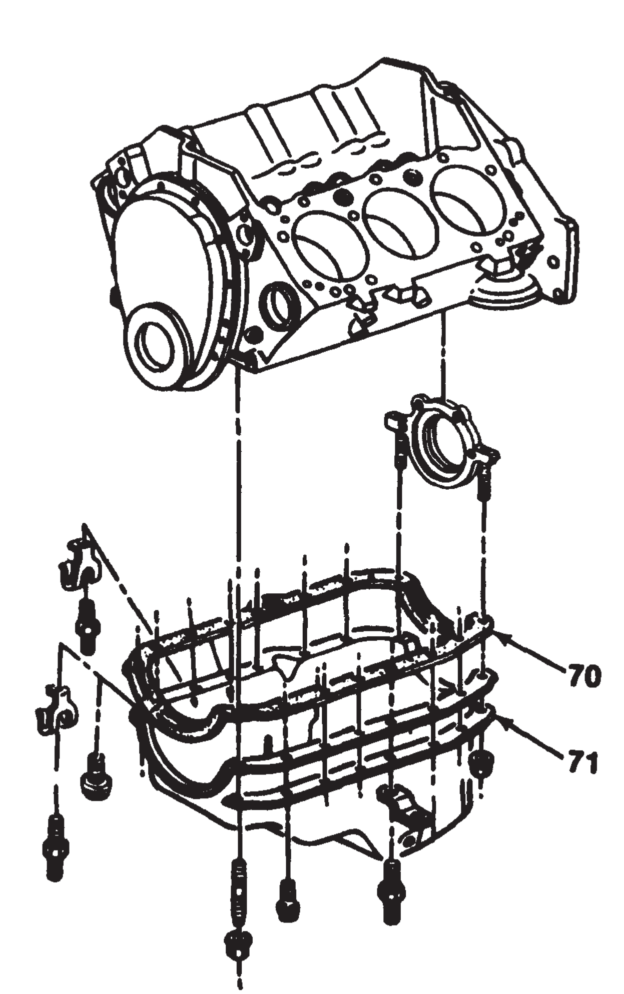
1. Oil pan gasket to the oil pan.
2. Oil pan to the engine.

NOTICE: See "Notice" on page 6A3-1.

3. Oil pan bolts, nuts, and reinforcements.

Tighten

- Oil pan bolts to 11 N.m (100 in. lbs.).
- Oil pan nuts at corners to 23 N.m (17 ft. lbs.).



70. Gasket
71. Reinforcement

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Figure 26—Oil Pan

4. Engine to the vehicle.
5. Proper quantity and grade of engine oil.

FOUR WHEEL DRIVE MODELS

Remove or Disconnect (Figure 26)

Tools Required:
J 29107 Pittman Arm Puller
J 6632-01 Pittman Arm Remover

1. Negative battery cable.
2. Dipstick.
   - Raise the vehicle. Support with suitable safety stands.
3. Drive belt splash shield.
4. Front axle shield.
5. Front skid plate.
   - Drain oil.
6. Flywheel cover.
7. Left motor mount through bolts.
8. Right motor mount through bolts.
   - Raise the engine. Block in position.
9. Oil cooler line.
10. Oil filter adapter.
11. Pitman arm bolt.
12. Pitman arm.
13. Idler arm bolts.
14. Idler arm.
15. Front differential through bolts.
16. Front propeller shaft (roll differential foward).
17. Starter bolts.
18. Starter motor and lay aside.
19. Oil pan bolts, nuts, and reinforcements.
20. Oil pan and gasket.

Clean

- Sealing surfaces on the engine and oil pan.

Inspect

- Oil pan gasket. Replace if necessary.

Install or Connect (Figure 26)

NOTICE: For steps 3, 5, 7, 9, and 11, see "Notice" on page 6A3-1.

- Apply sealant (GM part number 1052080 or equivalent) to the front cover to block joint and to the crankshaft rear seal to block joint. Apply the sealant for about 25 mm (1 inch) in both directions from each of the four corners.

1. Oil pan gasket to the oil pan.
2. Oil pan to the engine.
3. Oil pan bolts, nuts and reinforcements.

Tighten

- Oil pan bolts to 11 N·m (100 in. lbs.).
- Oil pan nuts at corners to 23 N·m (17 ft. lbs.).

4. Starter motor.
5. Starter motor bolts.

- Align differential into position.

6. Front propeller shaft.
7. Front differential through bolts.
8. Idler arm.
9. Idler arm bolts.
10. Pitman arm.
11. Pitman arm bolt.
12. Transfer case shield.
13. Flywheel cover.
14. Front skid plate.
15. Front axle shield.
16. Drive belt splash shield.

- Lower the vehicle.

17. Dipstick.
18. Proper quantity and grade of crankcase oil.
19. Negative battery cable.

OIL PUMP REPLACEMENT

Remove or Disconnect

1. Oil pan, as outlined previously.
2. Oil pump to main bearing cap bolt.
3. Oil pump.

Inspect

- Oil pump pickup tube for looseness. If the tube is loose in the oil pump body, replace it, as outlined in the Light Duty Truck Unit Repair Manual. A loose pickup tube can result in an air leak and loss of oil pressure.

Oil Pump Repair

- Refer to the Light Duty Truck Unit Repair Manual.

Install or Connect

1. Oil pump to the engine. Align the slot in the oil pump shaft with the tang on the distributor shaft. The oil pump should slide easily into place. No gasket is used.

NOTICE: See "Notice" on page 6A3-1.

2. Oil pump to main bearing cap bolt.

Tighten

- Oil pump to main bearing cap bolt to 90 N.m (65 ft. lbs.).

3. Oil pan, as outlined previously.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Remove or Disconnect (Figure 27)

1. Transmission.
2. Clutch and flywheel, if equipped.

NOTICE: Care should be taken when removing the crankshaft rear oil seal so as not to nick the crankshaft sealing surface.

3. Crankshaft rear oil seal. Insert a screwdriver into the notches provided in the seal retainer and pry the seal out (figure 27). Take care not to damage the crankshaft sealing surface.

Inspect

- Chamfer on crankshaft for grit, loose rust and burrs. Correct as necessary.

Clean

- Seal running surface on the crankshaft with a non-abrasive cleaner.

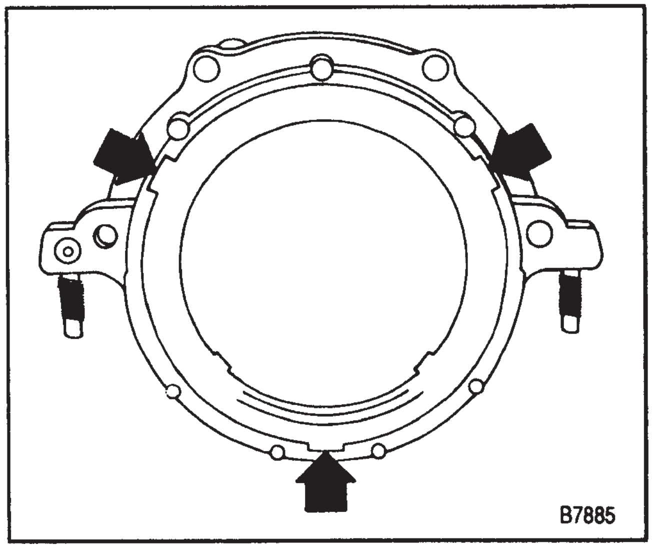


Figure 27—Seal Removal Notches

Install or Connect (Figure 28)

Tools Required:
J 35621 Seal Installer

1. Crankshaft rear oil seal (figure 28).
   A. Lubricate the inner and outer diameter of the seal with engine oil.
   B. Install the seal on J 35621.
   C. Position J 35621 against the crankshaft. Thread the attaching screws into the tapped holes in the crankshaft.
   D. Tighten the screws securely with a screwdriver. This will ensure that the seal is installed squarely over the crankshaft.
   E. Turn the handle until it bottoms.
   F. Remove J 35621.
2. Clutch and flywheel, if used.
3. Transmission.

CRANKSHAFT REAR OIL SEAL RETAINER REPLACEMENT

Remove or Disconnect (Figures 27 and 29)

1. Transmission.
2. Clutch and flywheel.
3. Oil pan, as outlined previously.

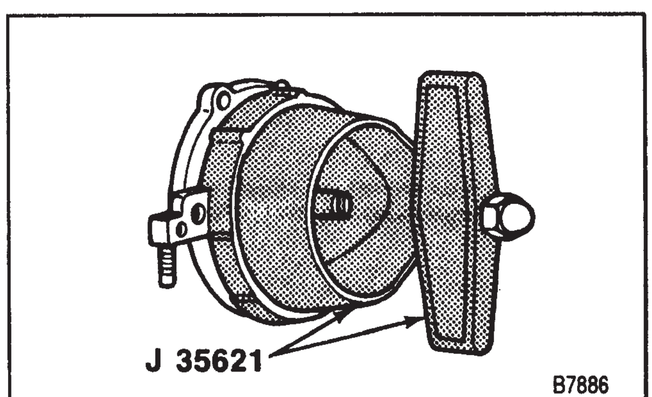


Figure 28—Installing the Crankshaft Rear Oil Seal

4. Screws (80) and nuts (81).
5. Seal retainer (82).
6. Gasket (84).
7. Crankshaft rear oil seal. Insert a screwdriver into the notches provided in the seal retainer and pry the seal out (figure 27). Take care not to damage the crankshaft sealing surface.

Clean

- Gasket surfaces on block and seal retainer.

Install or Connect (Figure 29)

- Whenever the seal retainer is removed, a new retainer gasket and rear crankshaft oil seal must be installed.

1. Gasket (84) to the block. It is not necessary to use sealant to hold the gasket in place.
2. Seal retainer (82).

NOTICE: See "Notice" on page 6A3-1.

3. Screws (80) and nuts (81).

Tighten

- Screws (80) and nuts (81) to 15 N.m (133 in. lbs.).

4. Oil pan, as outlined previously.
5. Crankshaft rear oil seal as outlined previously.
6. Clutch and flywheel.
7. Transmission.

BALANCE SHAFT REPLACEMENT (VIN W ENGINE)

Remove or Disconnect (Figures 30 through 34)

Tools Required:
J 23523-E Torsional Damper Puller and Installer.
J 26941 Needle Bearing Remover
J 38834 Balance Shaft Bearing Service Kit.

1. Negative battery cable.
2. Air cleaner and air intake duct.

- Drain the cooling system.

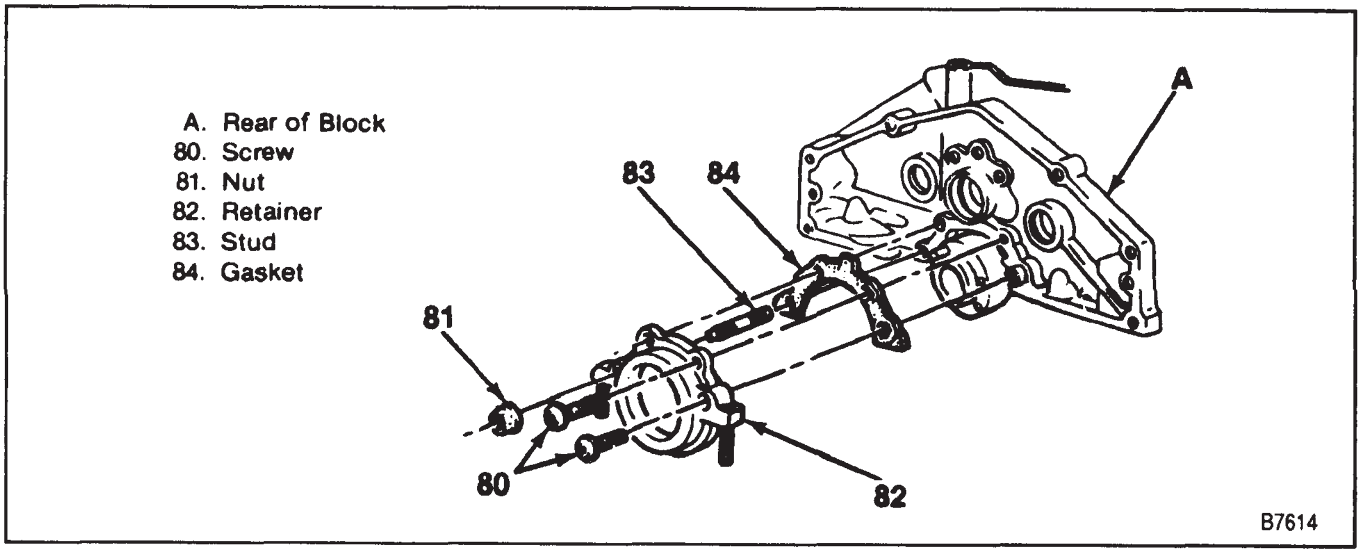


Figure 29—Crankshaft Rear Oil Seal Retainer

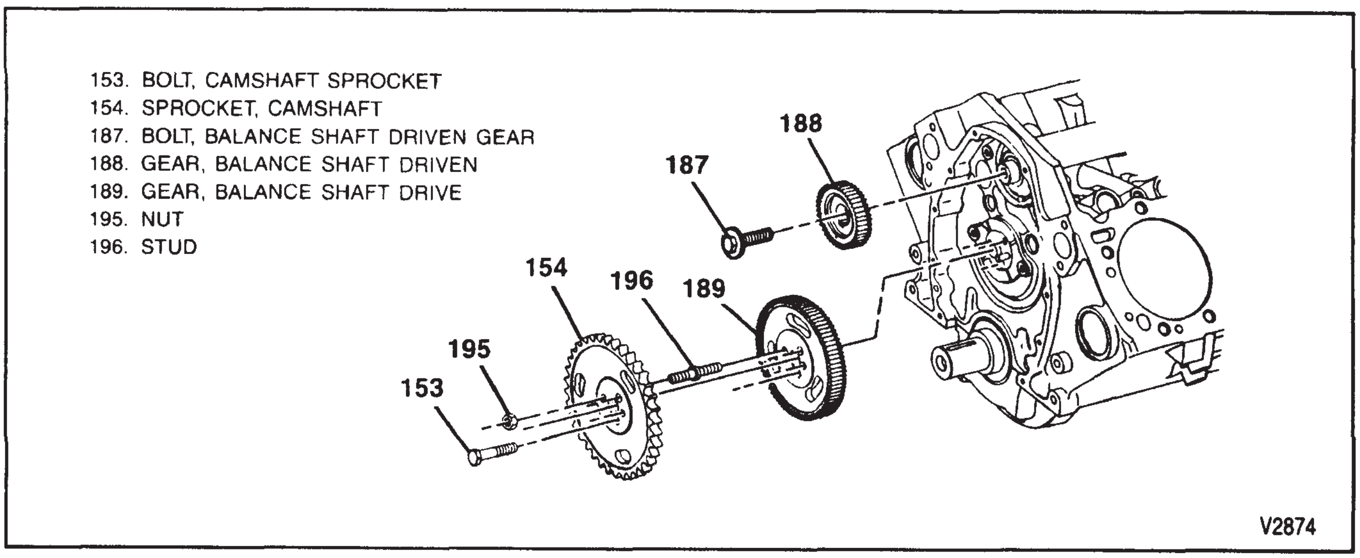


Figure 30—Balance Shaft Drive and Driven Gears (VIN W Engine)

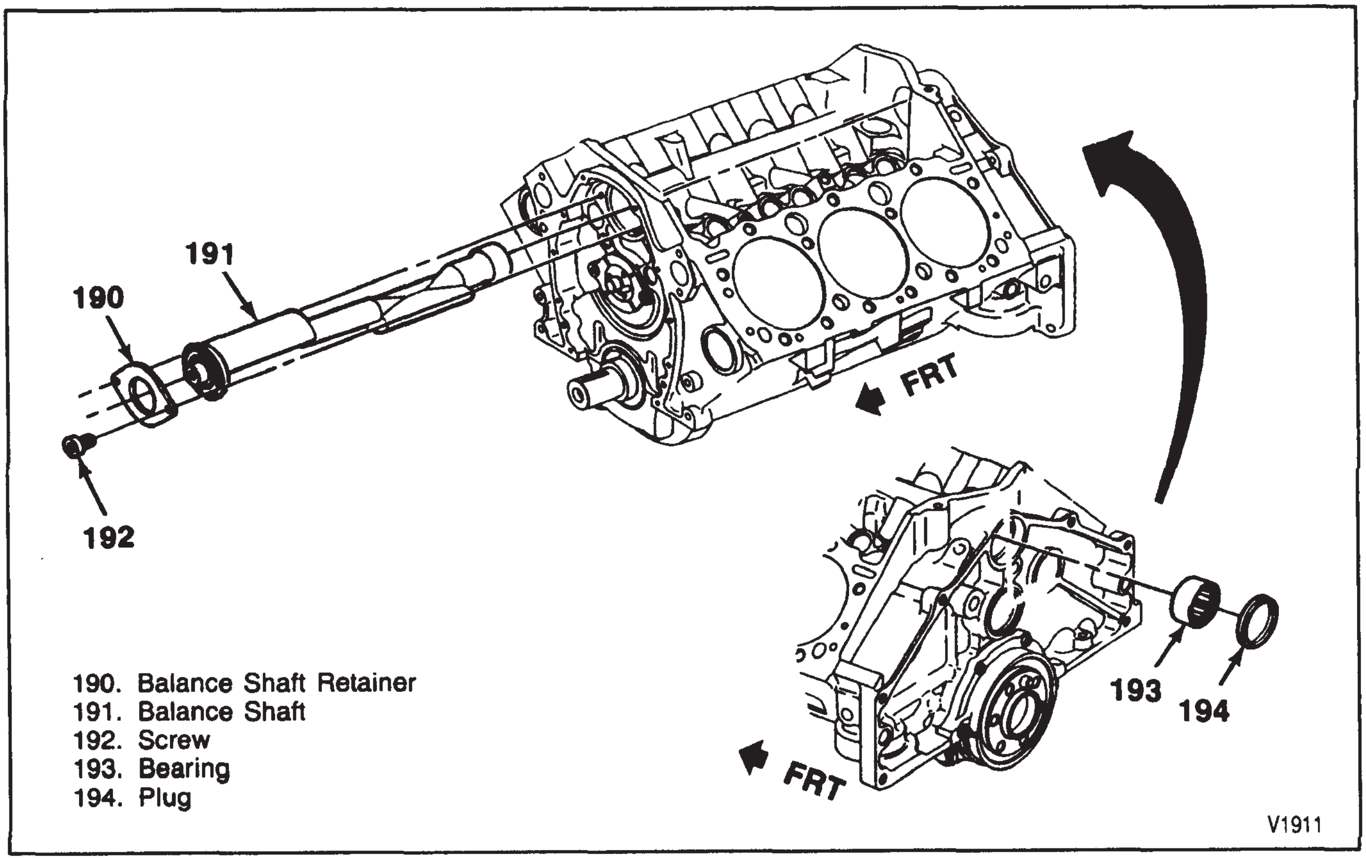


Figure 31—Balance Shaft Assembly (VIN W Engine)

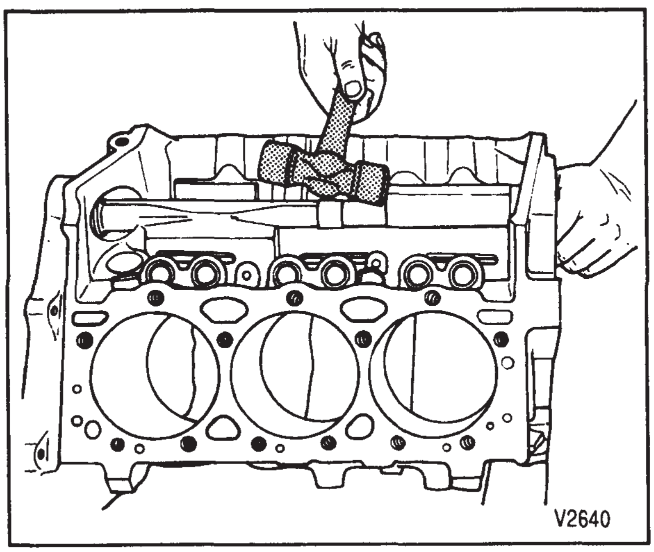


Figure 32—Removing The Balance Shaft

3. Discharge A/C system (if equipped). Refer to SEC-*TION 1B.*
4. Upper radiator shroud.
5. Oil cooler lines at the radiator.
6. Transmission cooler lines at the radiator.
7. Upper radiator hose.
8. Heater hose and overflow hose from radiator.
9. Lower radiator hose.
10. Radiator.
11. A/C condenser.
12. Fan assembly.
13. Multiple ribbed belt.

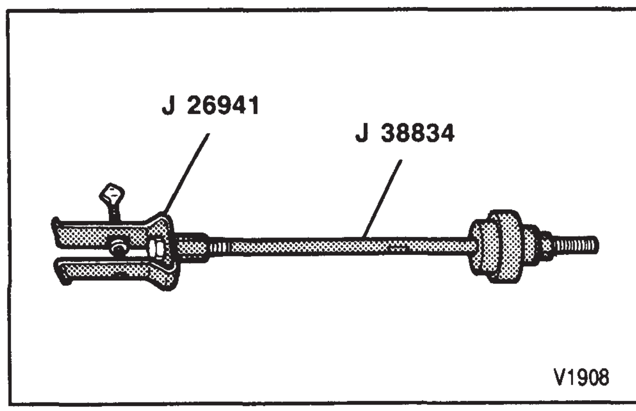


Figure 33—J 38834 Positioned to Remove Balance Shaft Rear Bearing

14. Pencil brace at coolant pump.
15. Coolant pump.
16. Torsional damper. Use J23523-E (figure 25).
17. Flywheel inspection cover.
    - Drain engine oil.
    - *Loosen the oil pan. Remove the two nuts and the* first two bolts on either side at the front of the oil pan, all other oil pan fasteners must be very loose.
18. Front cover bolts and front cover.

Important

- Use care when removing the front cover from the front of the oil pan gasket.

19. Crankshaft front oil seal from the front cover.
20. Timing chain bolts.

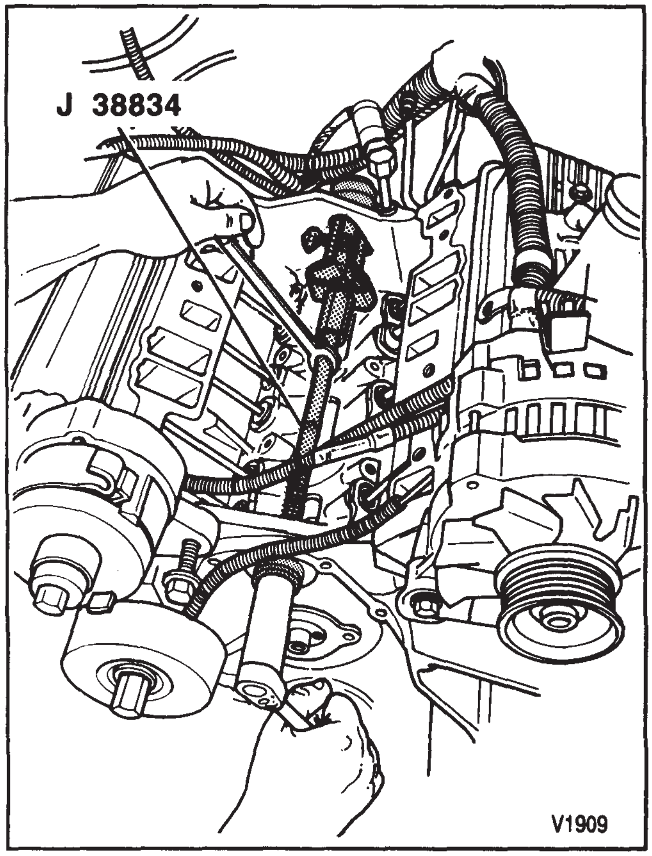


Figure 34—Removing Balance Shaft Rear Bearing

21. Timing chain, camshaft sprocket, and balance shaft drive gear.
22. Balance shaft driven gear.
23. Balance shaft retainer.
24. Intake manifold, as outlined in this section.
25. Lifter retainer.
26. Balance shaft and front bearing using a soft faced hammer (figure 32).
27. Balance shaft rear bearing using J 38834 and J 26941 (figures 33 and 34).

Important

- The balance shaft and both bearings are serviced only as a complete package.
- Use only the correct tools for bearing and shaft installation.
- The front bearing must not be removed from the balance shaft.
- The balance shaft drive and driven gears are serviced only as a set. The set includes the balance shaft driven gear bolt.

Clean

- All traces of old gasket material from gasket sealing surfaces.

Inspect

- Balance shaft drive and driven gears for nicks and burrs.

Install or Connect (Figures 30, 31 and 35 through 38)

NOTICE: For steps 3, 4, 10, 13, 16, and 18, see "Notice" on page 6A3-1.

Tools Required:
- J 23523-E Torsional Damper Puller and Installer.
- J 38834 Balance Shaft Bearing Service Kit.
- J 36996 Shaft Installer
- J 8092 Driver Handle
- J 35468 Crankshaft Seal Installer

1. Balance shaft rear bearing using J 38834 (figures 35 and 36).
   - Dip the bearing in clean engine oil before installation.
   - Install the bearing with the flat edge and the manufacturers markings facing the front of the engine.
2. Balance shaft into the block using J 36996 and J 8092 (figure 37).
   - Dip the front balance shaft bearing into clean engine oil before assembly.
3. Balance shaft bearing retainer and bolts.

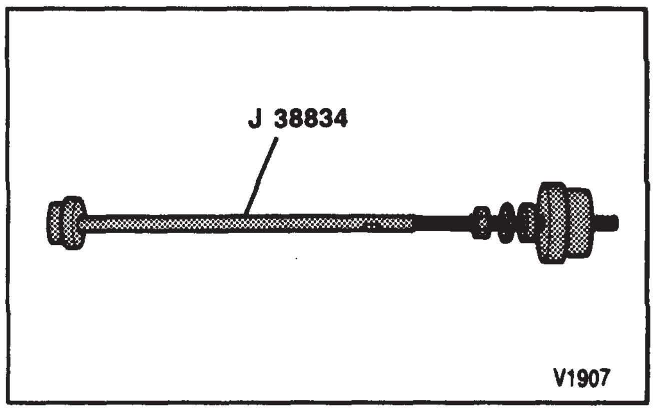


Figure 35—J 38834 Positioned to Install Balance Shaft Rear Bearing

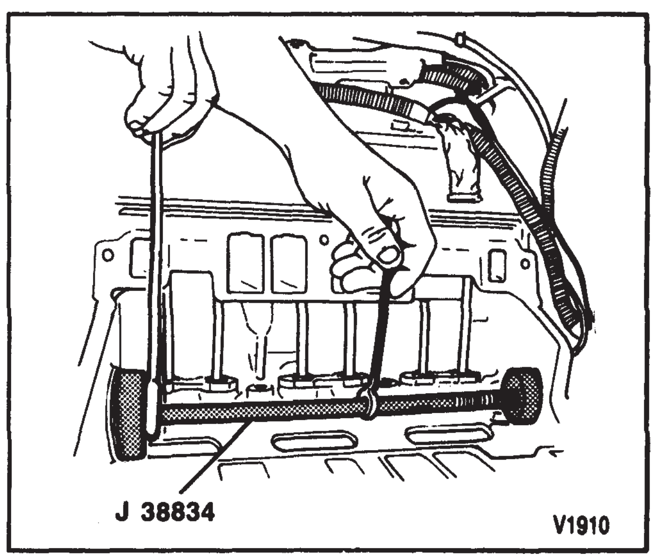


Figure 36—Installing Balance Shaft Rear Bearing

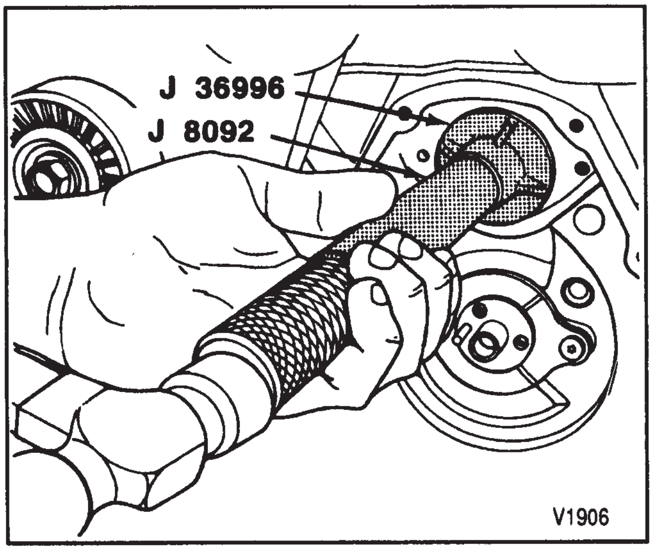


Figure 37—Installing the Balance Shaft

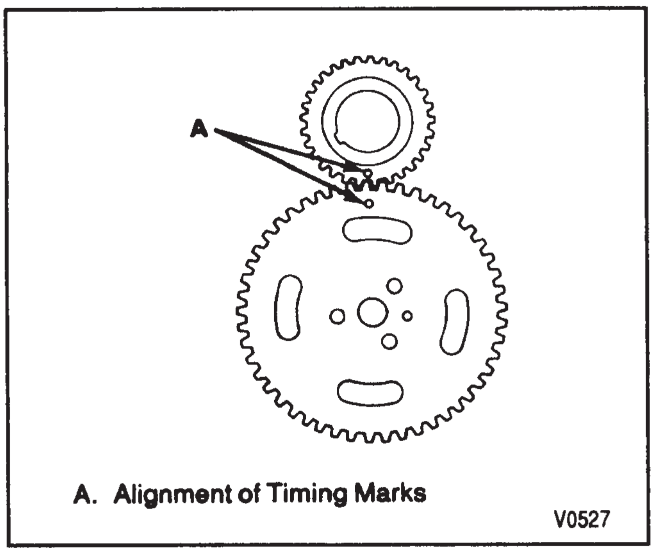


Figure 38—Balance Shaft Timing Marks

Tighten

- Bolts to 14 N·m (120 in. lbs.).

4. Balance shaft driven gear and bolt.

Tighten

- Bolt to 20 N·m (15 ft. lbs.) plus an additional 35 degrees.

5. Lifter retainer.

- Rotate the balance shaft by hand to make sure there is clearance between the balance shaft and the lifter retainer. Replace the lifter retainer if necessary.

6. Turn the camshaft so, with the balance shaft drive gear temporarily installed, its timing mark is straight up.
7. With the balance shaft drive gear removed, turn the balance shaft so the timing mark on the driven gear points straight down.
8. Balance shaft drive gear onto the camshaft.

Important

- Be sure that the timing marks on the balance shaft drive gear and the driven gear line up dot to dot (figure 38).

9. Balance shaft drive gear retaining stud.

Tighten

- Stud to 16 N·m (12 ft. lbs.).

10. Intake manifold, as outlined in this section.
11. Camshaft sprocket and timing chain.

Important

- Line up the timing marks on the camshaft sprocket and crankshaft sprocket dot to dot (figure 41). When these marks are lined up dot to dot, the number four cylinder is at top dead center of its compression stroke. The distributor rotor will need to be positioned facing the number four terminal on the distributor cap when installed.

12. Camshaft sprocket bolts and nut.

Tighten

- Bolts and nut to 28 N·m (21 ft. lbs.).

13. Distributor.
14. Distributor wiring.
15. Front cover and front cover bolts.
    - Use care when engaging the front of the oil pan seal with the bottom of the front cover. Lubricate the front of the oil pan seal with engine oil to aid assembly.
16. Crankshaft front oil seal to the front cover. Use J 35468 (figure 24).
17. Oil pan bolts, nuts, and reinforcements.
18. Flywheel inspection cover.
19. Torsional damper. Use J 23523-E (figure 25).
20. Coolant pump.
21. Pencil brace to coolant pump.
22. Multiple ribbed belt.
23. Fan assembly.
24. A/C condenser.
25. Radiator.
26. Lower radiator hose.
27. Heater hose and overflow hose to radiator.
28. Upper radiator hose.
29. Transmission cooler lines to the radiator.
30. Oil cooler lines to the radiator.
31. Upper radiator shroud.
32. Air cleaner and air intake duct.
33. Negative battery cable.

- Fill crankcase with proper quantity and grade of engine oil. Refer to SECTION 0B.
- Fill cooling system with proper quantity and grade of coolant. Refer to SECTION 0B.
- Charge A/C system. Refer to SECTION 1B.

MEASURING CAMSHAFT LOBE LIFT

Tools Required:

J 8520 Camshaft Lobe Lift Indicator

1. Remove the rocker arm as outlined previously.
2. Position the dial indicator (part of J 8520) so the plunger rests on the pushrod end, as shown in figure 39. Make sure the pushrod is in the lifter socket.
3. Rotate the crankshaft slowly in the direction of rotation until the lifter is on the heel of the cam lobe. At this point, the pushrod will be in its lowest position.
4. Set dial indicator on zero, then rotate the crankshaft slowly or attach an auxiliary starter switch and "bump" the engine over, until the pushrod is in fully raised position.

Important

- Whenever the engine is cranked remotely at the starter, with a special jumper cable or other means, the distributor primary lead should be disconnected from the ignition coil.

5. Compare the total lift recorded from the dial indicator with specifications.
6. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
7. Install the rocker arm and adjust the valves as previously outlined.

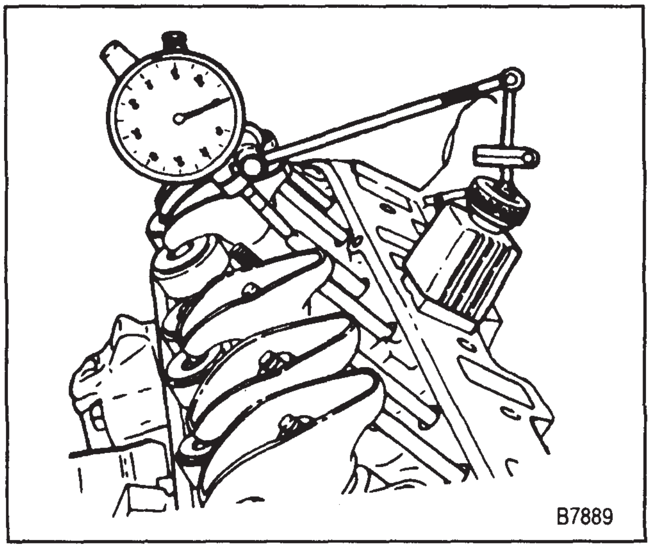


Figure 39—Measuring Camshaft Lobe Lift

CAMSHAFT REPLACEMENT

Remove or Disconnect (Figures 40 through 44)

Tools Required:

J 5825-A Crankshaft Sprocket Puller

1. Negative battery cable.
2. Air cleaner.
   - Drain the cooling system.
3. Rocker arm covers, as outlined previously.
4. Pushrods, as outlined previously.
5. Distributor.
6. Intake manifold, as outlined previously.
7. Hydraulic lifters, as outlined previously.
8. Radiator. Refer to SECTION 6B2.
9. Fan and pulley.
10. Coolant pump.
11. Torsional damper, as outlined previously.
12. Timing cover, as outlined previously.
    - Align the timing marks (figure 42).
13. Camshaft sprocket bolts and nut.
14. Camshaft sprocket, stud, balance shaft drive gear (VIN W Engine), and timing chain. The sprocket is a light interference fit on the camshaft. Tap the sprocket on its lower edge to loosen it.
15. Crankshaft sprocket, if necessary. Use J 5825-A (figure 43).
16. Screws (88) and thrust plate (87).
17. Camshaft.
    - Install two or three 5/16-18 inch bolts 100-125 mm (4-5 inches) long into the camshaft threaded holes. Use these bolts to handle the camshaft (figure 44).

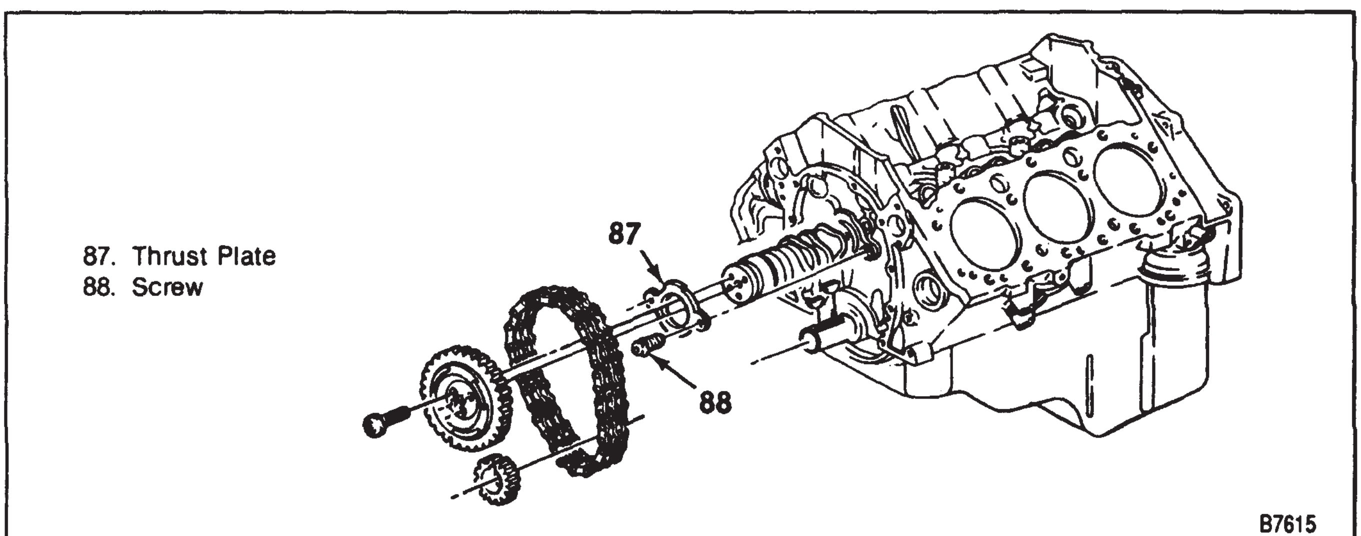


Figure 40—Camshaft and Components (VIN Z Engine)

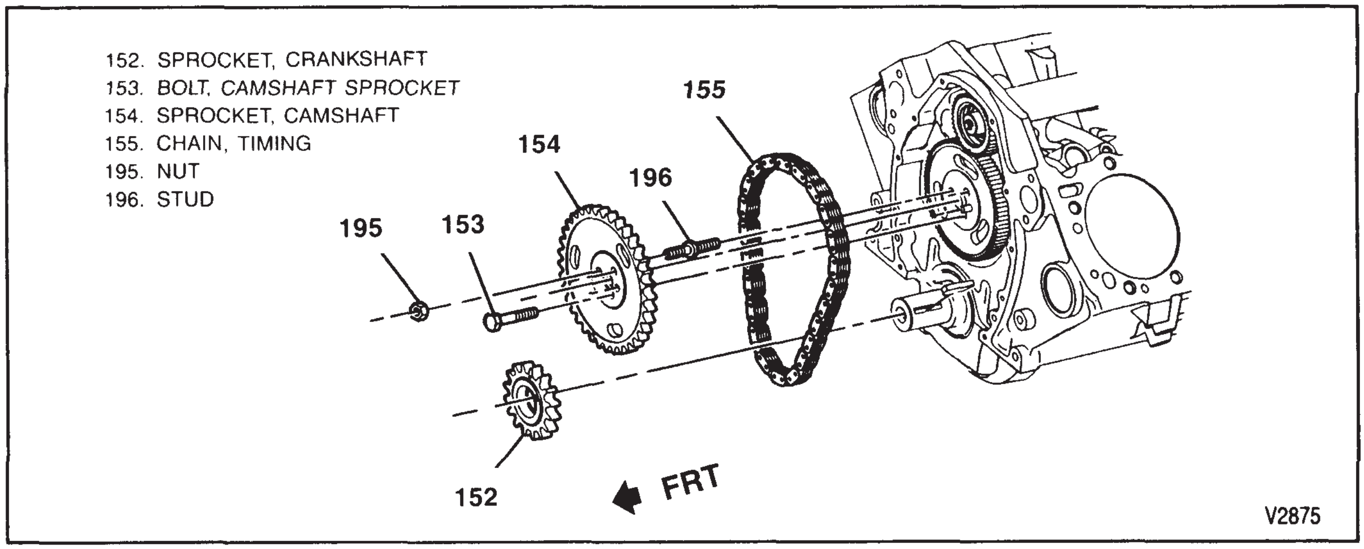


Figure 41—Camshaft and Components (VIN W Engine)

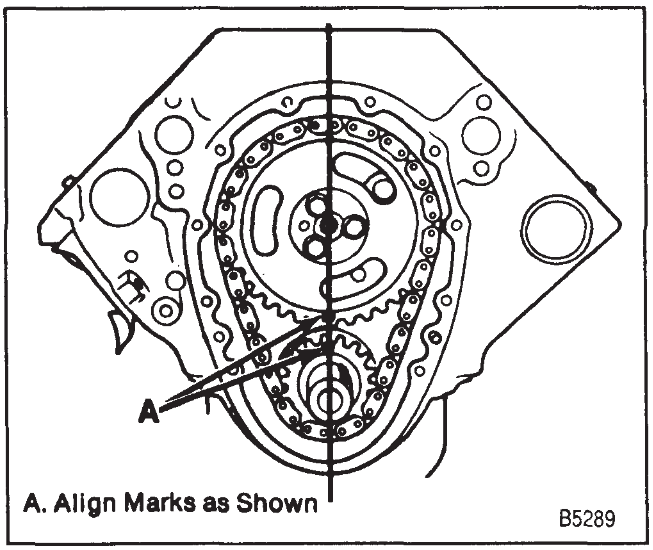


Figure 42—Timing Marks (Number 4 Firing)

- Pull the camshaft from the block. Use care to prevent damage to the camshaft bearings.

Cleaning, Inspection, And Repair

Clean, inspect, and repair or replace the camshaft and related components, as outlined in the Light Duty Truck Unit Repair Manual.

The unit repair manual also describes camshaft bearing replacement.

Install or Connect (Figures 40 through 44)

NOTICE: For steps 4 and 6, see "Notice" on page 6A3-1.

Tools Required:

J 5590 Crankshaft Sprocket Installer

- Coat the camshaft lobes and journals with a high quality engine oil supplement (GM Engine Oil Supplement or equivalent).

1. Two or three 5/16-18 bolts 100-125 mm (4-5 inches) long into the camshaft threaded holes. Use these bolts to handle the camshaft.
2. Camshaft to the engine (figure 44). Handle the camshaft carefully to prevent damage to the camshaft bearings.
3. Crankshaft sprocket. Use J 5590 (figure 43). Make sure the timing mark faces outside.
4. Thrust plate (87) and screws (88).

Tighten

- Screws to 14 N·m (120 in. lbs.).

5. Balance shaft drive gear (VIN W Engine), camshaft sprocket and timing chain. Refer to "Balance Shaft Replacement" in this section for alignment of balance shaft drive and driven gears (VIN W engine only).

Important

- Line up the timing marks on the camshaft sprocket and crankshaft sprocket dot to dot (figure 42). When these marks are lined up dot to dot, the number four cylinder is at top dead center of its compression stroke. The distributor rotor will need to be positioned facing the number four terminal on the distributor cap when installed.

6. Camshaft sprocket bolts and nut.

Tighten

- Camshaft sprocket bolts and nut to 28 N·m (21 ft. lbs.).

7. Timing cover, as outlined previously.
8. Torsional damper, as outlined previously.
9. Coolant pump.
10. Fan and pulley.
11. Radiator. Refer to SECTION 6B2.
12. Hydraulic lifters and pushrods, as outlined previously.

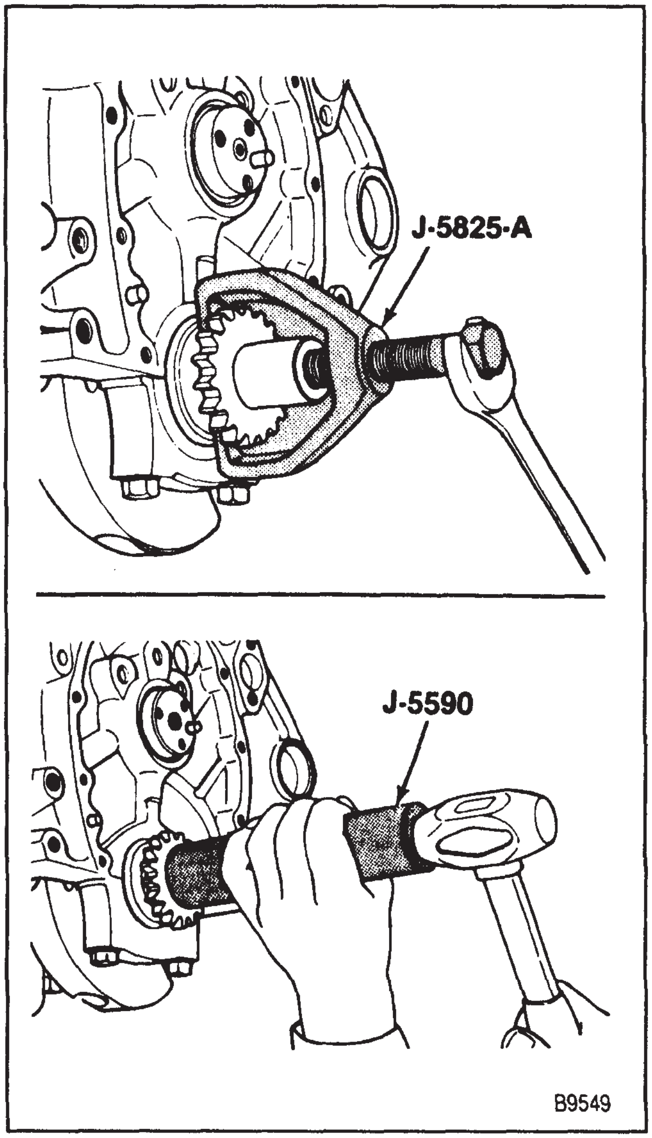


Figure 43—Replacing the Crankshaft Sprocket

Important

- Replace all hydraulic lifters, change the engine oil and filter and add GM Engine Oil Supplement (or equivalent) to the engine oil whenever a new camshaft is installed.

Adjust

- Valves. Refer to " Valve Adjustment."

13. Intake manifold, as outlined previously.
14. Distributor. Refer to SECTION 6D.
15. Rocker arm covers, as outlined previously.

- Fill the cooling system with the proper quantity and grade of coolant.

16. Air cleaner.
17. Negative battery cable.

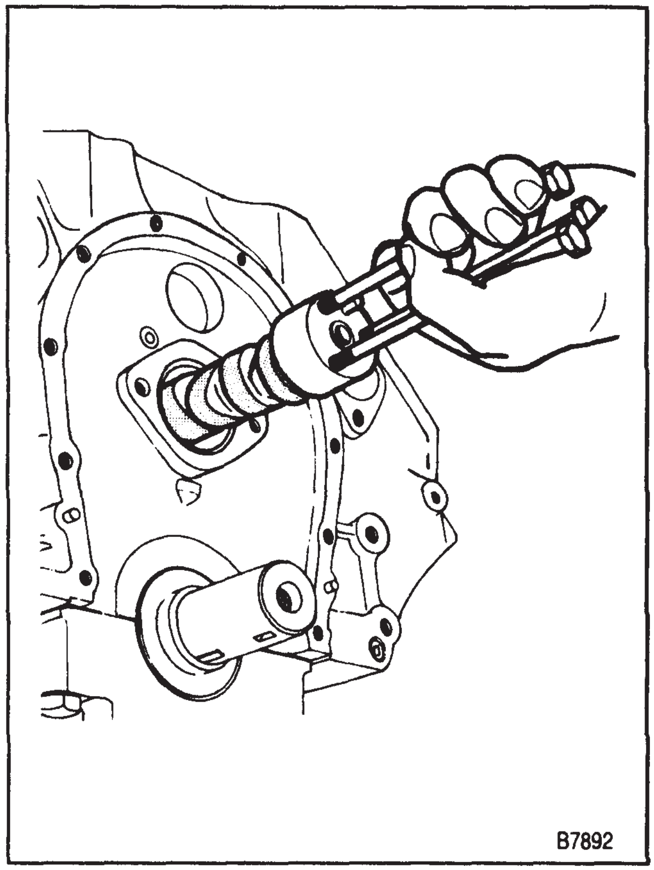


Figure 44—Replacing the Camshaft

CONNECTING ROD AND PISTON REPLACEMENT

Remove or Disconnect (Figure 45)

Tools Required:
J 5239 Guide Set

1. Cylinder head, as outlined previously.
2. Oil pan, as outlined previously.
3. Oil pump, as outlined previously (if necessary).
4. Ridge or deposits from the upper end of the cylinder bores.
   - Turn the crankshaft until the piston is at BDC.
   - Place a cloth on top of the piston.
   - Perform the cutting operation with a ridge reamer.
   - Turn the crankshaft until the piston is at TDC.
   - Remove the cloth and cuttings.
5. Connecting rod cap. Check the connecting rod and cap for identification marks. Mark the parts if required. The connecting rod and cap must be kept together as mating parts.
6. Connecting rod and piston.
   - Attach J 5239 to the connecting rod bolts (figure 45).
   - Use the long guide rod of J 5239 to push the connecting rod and piston out of the bore.
7. Connecting rod bearing.

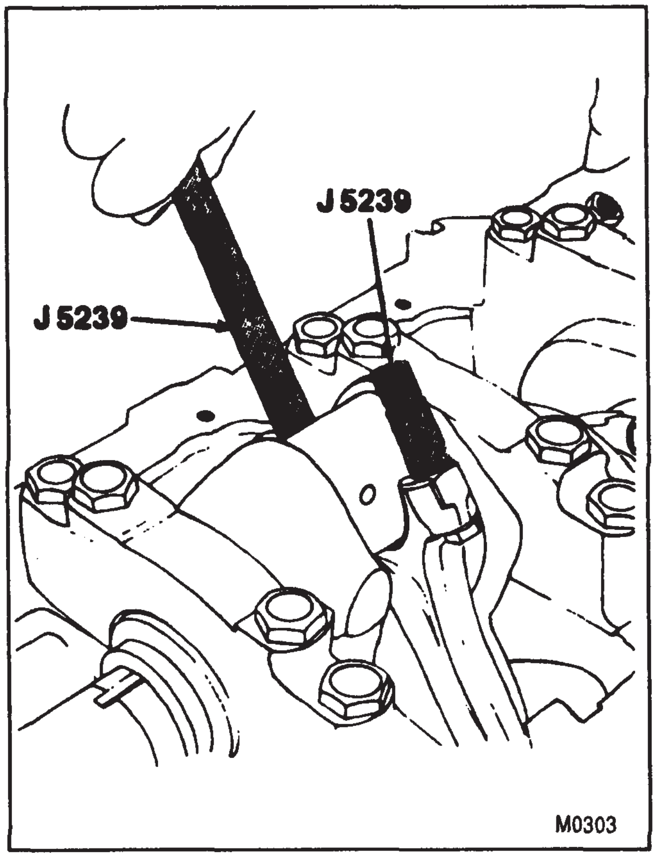


Figure 45—Replacing the Connecting Rod and Piston

Cleaning, Inspection, And Repair

Clean, inspect, and repair or replace the components as necessary. Measure connecting rod bearing clearance, piston clearance, ring clearances, etc. Refer to the Light Duty Truck Unit Repair Manual.

The unit repair manual contains information on:

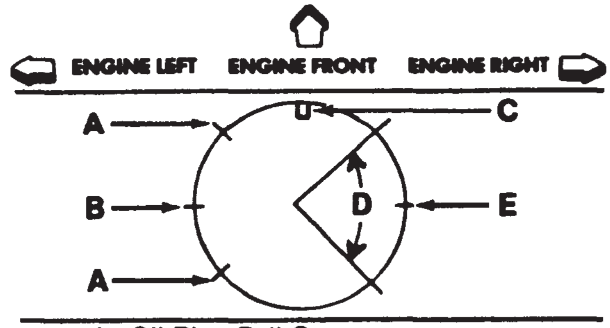
- Connecting rod and piston.
- Piston rings.
- Connecting rod and crankpin.
- Cylinder bores.

Install or Connect (Figures 45 through 48)

Tools Required:
J 5239 Connecting Rod Guide Set
J 8037 Ring Compressor

- Make sure the cylinder walls are clean. Lubricate the cylinder wall lightly with engine oil.
- Make sure the piston is installed in the matching cylinder.

1. Connecting rod bearings.
   - *Be certain that the bearing inserts are of the* proper size.
   - Install the bearing inserts in the connecting rod and connecting rod cap.
   - Lubricate the bearings with engine oil.
2. Piston and connecting rod to the proper bore.
   - With the connecting rod cap removed, install J 5239 onto the connecting rod studs.
   - Locate the piston ring end gaps as shown in figure 46. Lubricate the piston and rings with engine oil.



A. Oil Ring Rail Gaps
B. 2nd Compression Ring Gap
C. Notch In Piston
D. Oil Ring Spacer Gap
(Tang In Hole Or Slot With Arc)
E. Top Compression Ring Gap

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Figure 46—Piston Ring End Gap Locations

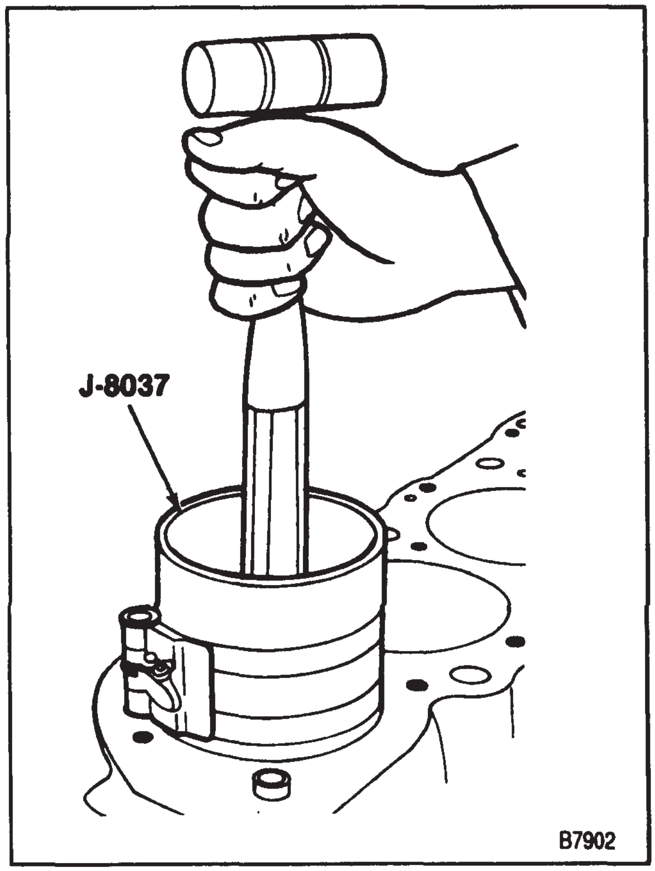


Figure 47—Installing the Piston

- Without disturbing the ring end gap location, *install J 8037 over the piston (figure 47).*
- The piston must be installed so that the notch in the piston faces the front of the engine (figure 46).
- Place the piston in its matching bore. The connecting rod bearing tang slots must be on the side opposite the camshaft. Using light blows with a hammer handle, tap the piston down into its bore (figure 47). At the same time, from beneath the vehicle guide the connecting rod to the crankpin with J 5239 (figure 45). Hold the

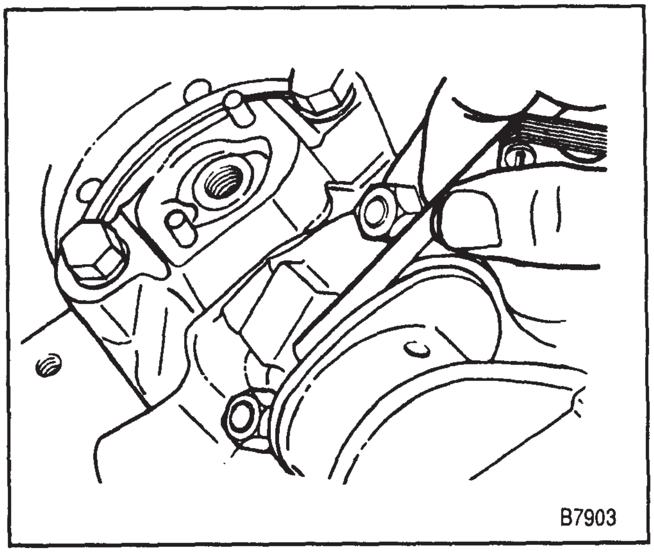


Figure 48—Measuring Connecting Rod Side Clearance

ring compressor against the block until all rings have entered the cylinder bore.

- Remove J 5239 from the connecting rod bolts.

Important

- Each connecting rod and bearing cap should be marked, beginning at the front of the engine. Cylinders 1, 3 and 5 are at the left bank and 2, 4 and 6 are the right bank. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from block or cylinder to another, new connecting rod bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

Measure

- Connecting rod bearing clearance. Refer to the Light Duty Truck Unit Repair Manual.

3. Connecting rod cap and bearing.

NOTICE: See "Notice" on page 6A3-1.

4. Connecting rod cap nuts.

Tighten

- Connecting rod cap nuts to 27 N·m (20 ft. lbs.) plus an additional 60 degrees.

Measure

- Connecting rod side clearance. Use a feeler gage between the connecting rod and crankshaft (figure 48). The correct clearance is 0.006-0.014-inch.

5. Oil pump (if removed), as outlined previously.
6. Oil pan and cylinder head, as outlined previously.

MAIN BEARING REPLACEMENT

Remove or Disconnect (Figure 49)

Tools Required:
J 8080 Main Bearing Remover/Installer

1. Spark plugs.
2. Oil pan, as outlined previously.
3. Oil pump, as outlined previously.
4. Main bearing caps.
   - Check the main bearing caps for location markings. Mark the caps if necessary. The caps must be returned to their original locations during assembly.
5. Lower main bearing inserts from the main bearing caps.
6. Upper main bearing inserts.
   - Insert J 8080 into the crankshaft oil hole (figure 49).
   - Rotate the crankshaft to "turn" the bearing insert out of the block.

Cleaning, Inspection, And Repair

Clean, inspect, and repair or replace the components as required. Refer to the Light Duty Truck Unit Repair Manual. The unit repair manual contains information on:

- Crankshaft.
- Main and connecting rod bearings.

Install or Connect (Figures 49 and 50)

Tool Required:
J 8080 Main Bearing Remover/Installer

1. Upper main bearing inserts.
   - Insert J 8080 into a crankshaft main bearing oil hole (figure 49).
   - Apply engine oil to inserts of the proper size.
   - Insert the plain end (without the bearing tang) of the insert between the crankshaft and the notched side of the block.
   - Rotate the crankshaft to "roll" the insert into the block.
   - Remove the tool.

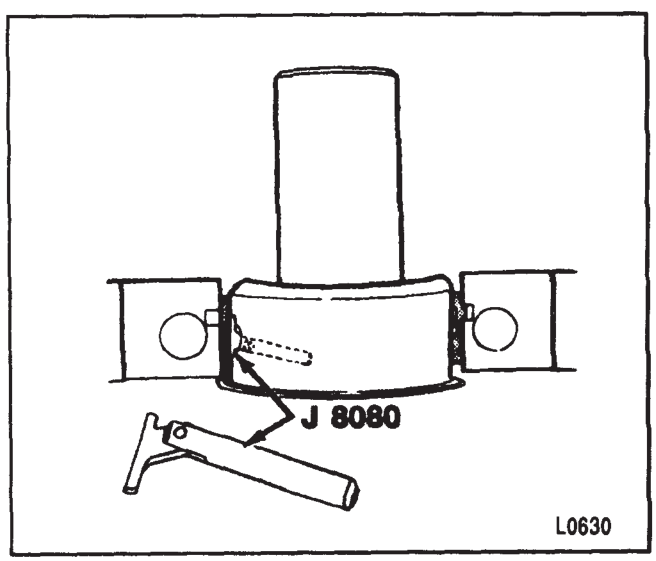


Figure 49—Removing the Main Bearing Insert

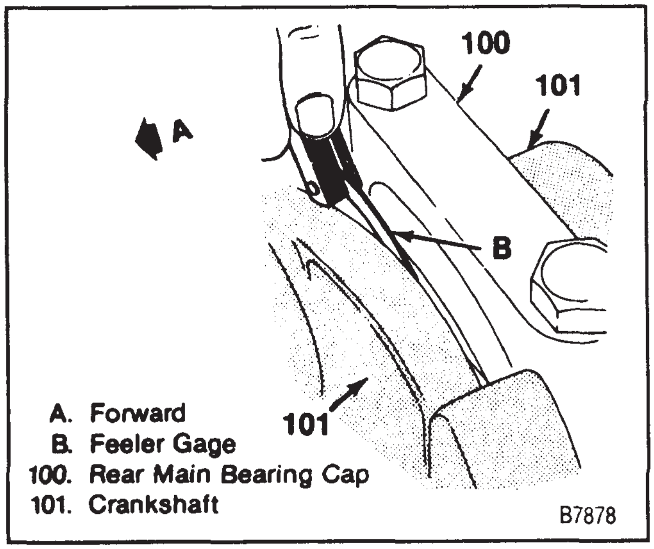


Figure 50—Measuring Crankshaft End Play

2. Lower main bearing inserts to the main bearing caps.
- Make sure the inserts are of the proper size.
- Apply engine oil to the inserts.

Measure

- Main bearing clearance. Refer to the Light Duty *Truck Unit Repair Manual. If the engine is in* the vehicle, the crankshaft must be supported upward to remove any clearance from the upper bearing. The total clearance can then be measured between the lower bearing and journal.

NOTICE: See "Notice" on page 6A3-1.

3. Main bearing caps (except rear cap) and bolts to the block.

Tighten

- *Main bearing cap bolts to 110 N·m (80 ft. lbs.).*

4. Rear main bearing cap.
   - Apply engine oil to the bearing insert.
   - Install the rear main bearing cap and bolts. Tighten the bolts temporarily to 14 N·m (10 ft. lbs.).

Measure

- Crankshaft end play, as follows:
  - Tap the end of the crankshaft first rearward then forward with a lead hammer. This will line up the rear main bearing and crank*shaft thrust surfaces.*
  - Tighten the rear main bearing cap bolts to 110 N·m (80 ft. lbs.).
  - With the crankshaft forced forward, measure at the front end of the rear main bearing with a feeler gage (figure 50). The proper clearance is 0.002-0.006 inch.
  - If correct end play cannot be obtained, be certain that the correct size rear main bearing has been installed. Production engines may have rear main bearings that are 0.008-inch wider across the thrust faces than standard. Refer to the Light Duty Truck Unit Repair Manual for more information.

5. *Oil pump, as outlined previously.*
6. Oil pan, as outlined previously.
7. Spark plugs.

OIL FILTER ADAPTER AND OIL PIPE ADAPTER REPLACEMENT

Remove or Disconnect (Figure 51)

1. Negative battery cable.
2. Oil filter.
3. Oil cooler lines.
4. Bolts (93).
5. Oil filter or oil pipe adapter (92).
6. Seal (90).

Install or Connect (Figure 51)

1. New seal (90) and oil filter/oil pipe adapter (92) to the block.

NOTICE: See "Notice" on page 6A3-1.

2. Bolts (93).

Tighten

- Bolts (93) to 20 N·m (15 ft. lbs.).

3. Oil cooler lines.
4. Oil filter.

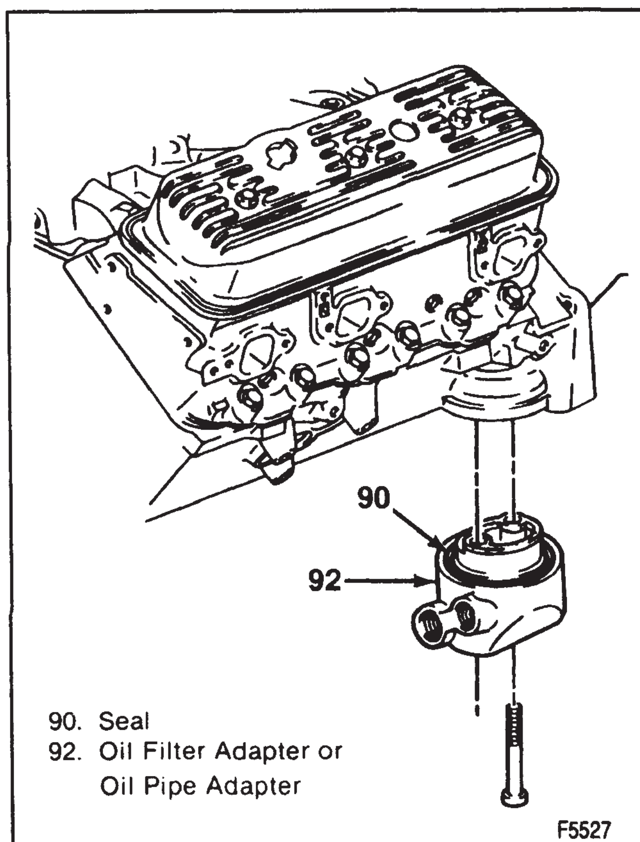


Figure 51—Oil Filter/Oil Pipe Adapter

- Add engine oil as needed.

5. Negative battery cable.

REMOTE OIL FILTER ADAPTER REPLACEMENT

Remove or Disconnect (Figure 52)

1. Negative battery cable.
2. Bolt and oil pipe (97) from oil filter adapter (95).
3. O-rings (97).
4. Oil pipes to oil cooler and O-rings (if used).
5. Bolts and bracket (96).
6. Oil filter adapter.

Install or Connect (Figure 52)

NOTICE: For steps 1 and 2, see "Notice" on page 6A3-1.

1. Oil filter adapter (95), bolts and bracket (96).

Tighten

- Bolts to 23 N.m (16 ft. lbs.).

2. Oil pipes, new O-rings and bolts to the oil filter adapter.

Tighten

- Bolts to 35 N.m (25 ft. lbs.).

3. Negative battery cable.

REMOTE OIL FILTER PIPE REPLACEMENT

Remove or Disconnect (Figure 52)

1. Negative battery cable.
2. Bolts at oil pipe adapter (92) and oil filter adapter (95).
3. Clips (100).
4. Oil pipe assembly (97).
5. O-rings (98 and 99).

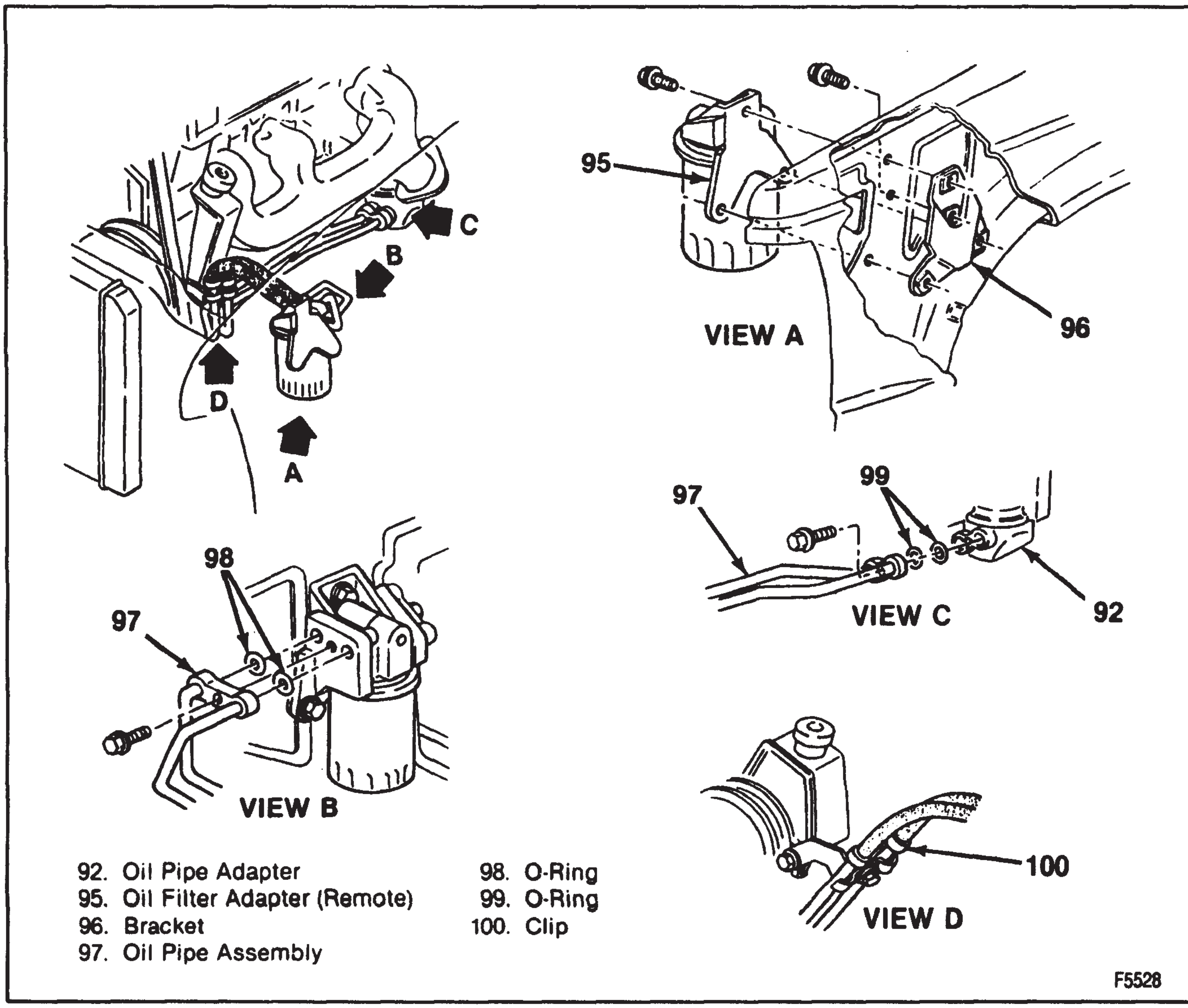


Figure 52—Remote Oil Filter

Install or Connect (Figure 52)

1. New O-rings (98 and 99).

NOTICE: See "Notice" on page 6A3-1.

2. Oil pipe assembly (97) and bolts.

Tighten

- Bolts to 35 N·m (26 ft. lbs.).
- Route the flexible hoses as shown in figure 52. Make sure the hoses do not chafe against other components.

3. Clip (100).
4. Negative battery cable.

CRANKSHAFT REPLACEMENT

1. Remove the engine, as outlined previously.
2. Refer to the Light Duty Truck Unit Repair Manual for crankshaft replacement procedures.

FLYWHEEL REPLACEMENT

Remove or Disconnect

1. Transmission, flywheel housing and clutch.
2. Flywheel bolts.
3. Flywheel.

Clean

- Mating surfaces of crankshaft and flywheel. Remove any burrs.

Inspect

- Flywheel for burning, scoring, warping and wear. Replace the flywheel if necessary. Do not machine the flywheel.
- Flywheel ring gear for worn or broken teeth.

Flywheel Ring Gear Replacement

1. Use a torch to heat the gear around the entire circumference, then drive the gear off the flywheel, using care not to damage the flywheel.

NOTICE: Never heat starter gear to red heat as this will change metal structure.

2. Uniformly heat the flywheel gear to temperature which will expand the gear to permit installation. Temperature must not exceed 204°C (400°F).
3. As soon as the gear has been heated, install on the flywheel.

Install or Connect

1. Flywheel.

NOTICE: See "Notice" on page 6A3-1.

2. Flywheel bolts.

Tighten

- Flywheel bolts to 100 N·m (75 ft. lbs.).

3. Clutch, flywheel housing and transmission.

ENGINE MOUNTINGS

NOTICE: Broken or deteriorated mountings can cause misaligned and eventual destruction of certain drive train components. When a single mounting breakage occurs, the remaining mountings are subjected to abnormally high stresses.

INSPECTING ENGINE MOUNTINGS

Front Engine Mountings

NOTICE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen, resulting in a damaged oil pickup unit.

1. Raise the engine to remove weight from the mountings and to place a slight tension on the rubber cushion. Observe both mountings while raising the engine.
2. Replace the mounting if the following conditions exist:
   - Hard rubber surface covered with heat check cracks.
   - Rubber cushion separated from the metal plate of the mounting.
   - Rubber cushion split through the center.
3. If there is movement between a metal plate of the mounting and its attaching points, lower the engine and tighten the bolts or nuts attaching the mounting to the engine frame or bracket.

Rear Mountings

1. Push up and pull down on the transmission tailshaft. Observe the transmission mounting.
2. Replace the mounting if the following conditions exist:
   - Rubber cushion separated from the metal plate of the mounting.
   - Mounting bottomed out (tailshaft can be moved up but not down).
3. If there is relative movement between a metal plate of the mounting and its attaching point, tighten the bolts or nuts attaching the mounting to the transmission or crossmember.

FRONT ENGINE MOUNTING REPLACEMENT

Remove or Disconnect (Figure 53)

- Raise the vehicle. Support with suitable safety stands.

1. Cab or body mounting bolts. Raise the body and block in position.
2. Engine mounting through-bolts on both sides.

NOTICE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen, resulting in a damaged oil pickup unit.

- Raise the engine and block in position.

3. Engine mounting to frame bolts.
4. Engine mounting.

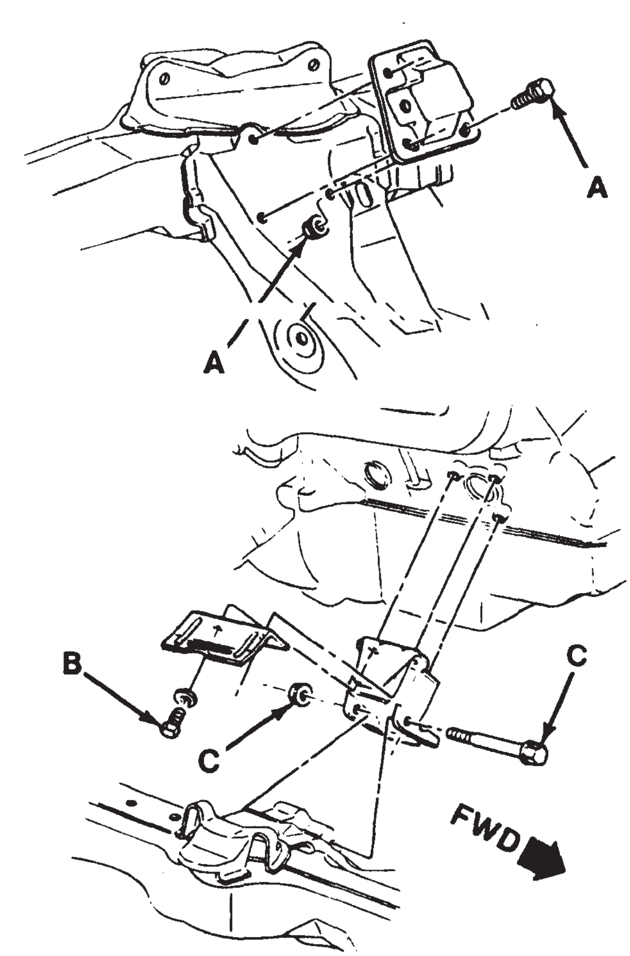
Install or Connect (Figure 53)

NOTICE: For steps 2 and 3, see "Notice" on page 6A3-1.

1. Engine mounting to the frame.
2. Engine mounting to frame bolts and nuts.

Tighten

- Bolts to 57 N.m (42 ft. lbs) or nuts to 47 N.m (35 ft. lbs.).



A. Torque Bolt to 57 N·m (42 ft. lbs.) or, Torque Nut to 47 N·m (35 ft. lbs.)
B. 47 N·m (35 ft. lbs.)
C. 70 N·m (52 ft. lbs.)

F5529

Figure 53—Front Engine Mountings

- Lower the engine.

3. Engine mounting through-bolts.

Tighten

- Through-bolts or nuts to 70 N.m (52 ft. lbs.).
- Lower the vehicle.

REAR MOUNTING REPLACEMENT

Remove or Disconnect (Figure 54)

- Support the rear of the engine to relieve the weight on the rear mountings.

1. Mounting to crossmember nut(s) and washer(s).
2. Mounting to transmission bolts and washers.

- Raise the rear of the engine only enough to permit removal of the mounting.

3. Mounting.

Install or Connect (Figure 54)

1. Mounting.

- Lower the rear of the engine.

2. Mounting to transmission bolts and washers.

NOTICE: See "Notice" on page 6A3-1.

3. Mounting to crossmember nut(s) and washer(s).

Tighten

- Fasteners to specifications. Refer to figure 54.

ENGINE REPLACEMENT

TWO WHEEL DRIVE MODELS

Remove or Disconnect

1. Negative battery cable.
2. Hood.

- Drain the cooling system.

3. Upper radiator hose at the radiator.
4. Overflow hose.
5. Upper fan shroud.
6. Transmission and engine oil cooler lines (if equipped).
7. Radiator.
8. Fan.
9. Heater hoses.
10. Air cleaner.
11. Vacuum hoses.
12. All necessary wires at the bulkhead, ground wires, and main feed wires.
13. Throttle cable and cruise control cable (if equipped).
14. Distributor cap.

- Raise the vehicle.

15. Converter to exhaust pipe bolts.
16. Exhaust pipes at the manifolds.
17. Strut rods at the bell housing.
18. Flywheel cover bolts and flywheel cover (if equipped).
19. Torque converter bolts.

20. Shield at rear of catalytic converter.
21. Converter hanger at exhaust pipe.
22. Lower fan shroud.
23. *Fuel lines.*
    - Loosen all fuel line clamps and fasteners from the TBI or CPI unit to the rear of the transmission. Without damaging them, move them to the rear of the engine compartment and tie them in place with a suitable strap.
24. Two outer air dam bolts.
25. Left body mount bolts.
    - Install jackstands.
    - Raise the body.
26. Bell housing bolts.
    - Lower the body.
27. Motor mount through bolts.
28. Jackstands.
    - Lower the vehicle.
29. Air conditioning compressor (if equipped).
30. Power steering pump (if equipped).
    - Support the transmission with a floor jack.
31. Engine.

Install or Connect (Figures 53 and 54)

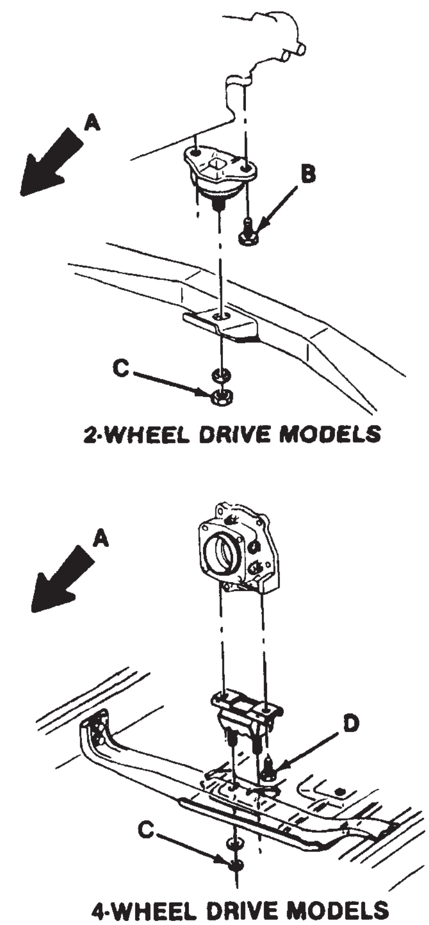
NOTICE: For steps 3, 4, 5, 6, 7, 10, 15, and 16, see "Notice" on page 6A3-1.

1. Engine into the vehicle.
2. Remove the transmission support.
    - Raise the vehicle.
3. Motor mount through bolts.

Tighten

- Bolts to specification. Refer to figures 53 and 54.

4. Lower bell housing bolts.
    - Raise the body.
5. Upper bell housing bolts.
    - Lower the body.
6. Remaining bell housing bolts.
7. Body mount bolts.
8. Power steering pump (if equipped).
9. Air conditioning compressor (if equipped).
10. Two outer air dam bolts.
11. Fuel lines and all clamps.
12. Lower fan shroud.
13. Converter hanger at exhaust pipe.
14. Shield at rear of catalytic converter.
15. Torque converter bolts.
16. Flywheel cover and bolts (if equipped).
17. Strut rods at the bell housing.
18. Exhaust pipes to the manifolds.
19. Converter to exhaust pipe bolts.
    - Lower the vehicle.
20. Distributor cap.
21. Throttle cable and cruise control cable (if equipped).
22. All necessary wires at the bulkhead, ground wires, and main feed wires.
23. Vacuum hoses.
24. Air cleaner.



A. Forward
B. 60 N·m (45 Ft. Lbs.)
C. 32 N·m (24 Ft. Lbs.)
D. 55 N·m (40 Ft. Lbs.)
E. 30 N·m (22 Ft. Lbs.)

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Figure 54—Rear Engine Mountings

25. *Heater hoses.*
26. Fan.
27. Radiator.
28. Transmission oil cooler lines (if equipped).
29. Upper fan shroud.
30. Overflow hose.
31. Upper radiator hose at the radiator.
32. Coolant into the cooling system.
33. Hood.
34. Negative battery cable.

FOUR WHEEL DRIVE MODELS

Remove or Disconnect

1. Negative battery cable.
2. Underhood light (if equipped).
3. Hood.
    - Raise the vehicle. Support with suitable safety stands.
4. Body mounts on utility vehicles. Loosen front and remove two body mounts on chassis cab models.
5. Front air dam end bolts.

6. Top transmission to engine bolts.
 • Lower the body.
 • Support transmission with a suitable fixture.
7. Remaining transmission to engine bolts.
8. Second crossmember.
9. Exhaust pipes at manifolds.
10. Catalytic converter hanger.
11. Torque converter cover bolts.
12. Front propshaft at front differential.
13. Torque converter cover.
14. Transmission cooler lines at engine clips.
15. Motor mount bolts.
16. Flexplate to torque converter bolts.
17. Front splash shield.
18. Lower fan shroud bolts.
 • Lower the vehicle.
 • Drain the cooling system.
19. Upper fan shroud.
20. Radiator hoses at the radiator.
21. Oil filter pipe at the remote oil filter.
22. Radiator.
23. Fan.
24. Air cleaner.
25. Air conditioning compressor (if equipped).
26. Power steering pump (if equipped).
27. Fuel lines.
   • Loosen all fuel line clamps and fasteners from the TBI or CPI unit to the rear of the transmission. Without damaging them, move them to the rear of the engine compartment and tie them in place with a suitable strap.
28. Necessary wires, vacuum lines, and emission hoses.
29. Accelerator cable, TV cable, and cruise control cable (if equipped).
30. Engine wiring harness at bulkhead connector.
31. Heater hoses at the engine.
 • Support the transmission.
32. Engine.

Install or Connect (Figures 53 and 54)

NOTICE: For steps 2, 3, 4, 5, 12, and 15, see "Notice" on page 6A3-1.

1. Engine into the vehicle.
 • Raise the vehicle.
2. Motor mount through bolt.

Tighten

 • Bolts to specifications. Refer to figures 53 and 54.

3. Lower transmission to engine bolts.
 • Raise the body.
4. Upper transmission to engine bolts.
 • Lower the body.
5. Body mount bolts.
6. Flexplate to the torque converter.
7. Torque converter cover.
8. Front propshaft.
9. Catalytic converter hanger.
10. Exhaust pipe to the manifolds.
11. Crossmember.
12. Lower fan shroud bolts.
13. Front splash shield.
14. Transmission cooler lines at the engine clips.
15. Front air dam bolts.
 • Lower the vehicle.
16. Engine wiring harness at bulkhead connector.
17. Accelerator cable, TV cable, and cruise control cable (if equipped).
18. Heater hoses.
19. Wires, vacuum lines, and emission hoses.
20. Fuel lines and all clamps.
21. Power steering pump (if equipped).
22. Air conditioning compressor (if equipped).
23. Fan.
24. Radiator.
25. Oil filter pipe at the remote oil filter. Use new O-rings.
26. Radiator hoses.
27. Drive belts.
28. Fan shroud.
29. Coolant into the cooling system.
30. Hood.
31. Underhood light.
32. Negative battery cable.

THREAD REPAIR

Damaged threads may be reconditioned by drilling out, rethreading and installing a suitable thread insert.

Tools Required:

General purpose thread repair kits are available commercially.

CAUTION: Wear safety glasses to avoid eye damage.

1. Determine size, pitch, and depth of damaged thread. If necessary, adjust stop collars on cutting tool and tap to required depth.

Important

 • Refer to the kit manufacturer's instructions regarding the size of drill and tap to be used.

2. Drill out damaged thread. Clean out chips.
3. Tap hole. Lubricate tap with light engine oil (except when installing in aluminum) . Clean the thread.

Important

 • Avoid build-up of chips. Back out the tap every few turns and remove chips.

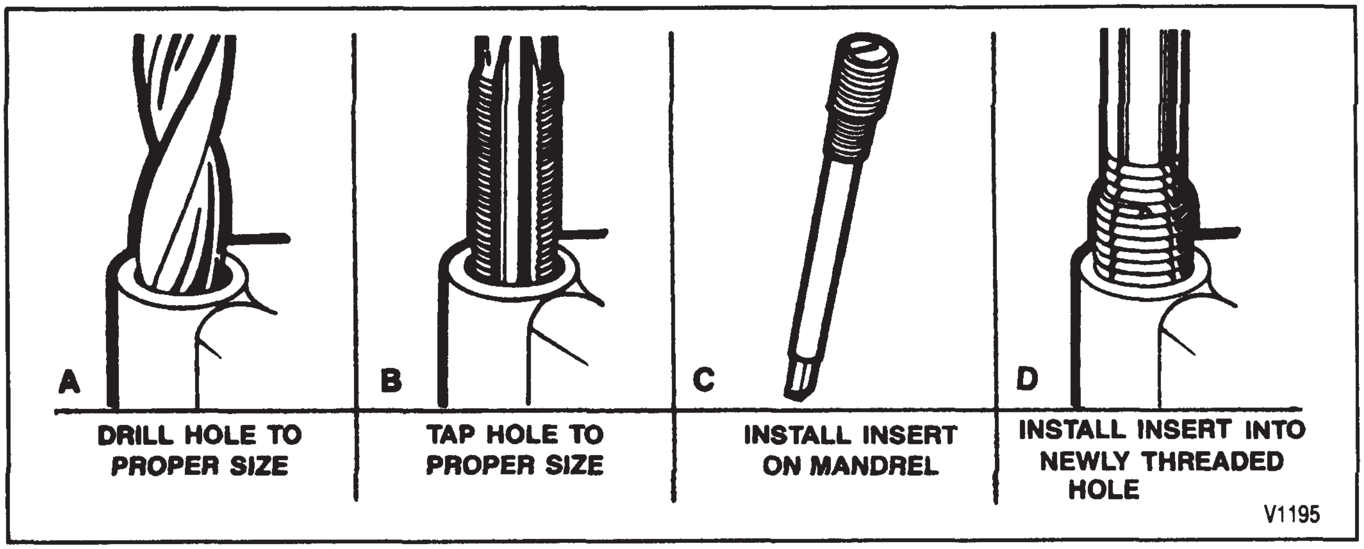

Figure 55—Repairing Thread Holes

4. Thread the thread insert onto the mandrel of the installer (figure 55). Engage the tang of the insert onto the end of the mandrel.
5. Lubricate the insert with light engine oil (except when installing in aluminum) and install.

Important

- When correctly installed, the insert should be flush to one turn below the surface.

6. If the tang of the insert does not break off when backing out the installer, break the tang off with a drift.

SPECIFICATIONS

ENGINE SPECIFICATIONS (4.3L)

All Specifications are in INCHES unless otherwise noted.

<table>
<tr><td colspan="6">GENERAL DATA:</td></tr>
<tr><td colspan="4">Type</td><td colspan="2">V6</td></tr>
<tr><td colspan="4">Displacement</td><td colspan="2">4.3L (262 Cu. In.)</td></tr>
<tr><td colspan="4">RPO (VIN Code)</td><td>LB4 (Z)</td><td>L35 (W)</td></tr>
<tr><td colspan="4">Bore</td><td colspan="2">4.00</td></tr>
<tr><td colspan="4">Stroke</td><td colspan="2">3.48</td></tr>
<tr><td colspan="4">Compression Ratio</td><td>9.3:1</td><td>9.05:1</td></tr>
<tr><td colspan="4">Firing Order</td><td colspan="2">1-6-5-4-3-2</td></tr>
<tr><td colspan="4">Oil Pressure (Minimum)</td><td colspan="2">6 psi @ 1000 RPM; 18 psi @ 2000 RPM; 24 psi @ 4000 RPM</td></tr>
<tr><td colspan="6">CYLINDER BORE:</td></tr>
<tr><td colspan="4">Diameter</td><td colspan="2">4.0007-4.0017</td></tr>
<tr><td rowspan="2">Out Of Round</td><td colspan="3">Production</td><td colspan="2">0.001 (Maximum)</td></tr>
<tr><td colspan="3">Service</td><td colspan="2">0.002 (Maximum)</td></tr>
<tr><td rowspan="3">Taper</td><td rowspan="2" colspan="2">Production</td><td>Thrust Side</td><td colspan="2">0.0005 (Maximum)</td></tr>
<tr><td>Relief Side</td><td colspan="2">0.001 (Maximum)</td></tr>
<tr><td colspan="3">Service</td><td colspan="2">0.001 (Maximum)</td></tr>
<tr><td colspan="6">PISTON:</td></tr>
<tr><td rowspan="2">Clearance</td><td colspan="3">Production</td><td colspan="2">0.0007-0.0017</td></tr>
<tr><td colspan="3">Service Limit</td><td colspan="2">0.0027 (Maximum)</td></tr>
<tr><td colspan="6">PISTON RING:</td></tr>
<tr><td rowspan="6">COMPRESSION</td><td rowspan="3">Groove Clearance</td><td rowspan="2">Production</td><td>Top</td><td rowspan="2">0.0012-0.0032</td><td rowspan="2">0.0014-0.0032</td></tr>
<tr><td>2nd</td></tr>
<tr><td colspan="2">Service Limit</td><td colspan="2">0.0042 (Maximum)</td></tr>
<tr><td rowspan="3">Gap</td><td rowspan="2">Production</td><td>Top</td><td colspan="2">0.010-0.020</td></tr>
<tr><td>2nd</td><td>0.010-0.025</td><td>0.018-0.026</td></tr>
<tr><td colspan="2">Service Limit</td><td colspan="2">0.0035 (Maximum)</td></tr>
<tr><td rowspan="4">OIL</td><td rowspan="2">Groove Clearance</td><td colspan="2">Production</td><td>0.002-0.007</td><td>0.0014-0.032</td></tr>
<tr><td colspan="2">Service Limit</td><td colspan="2">0.008 (Maximum)</td></tr>
<tr><td rowspan="2">Gap</td><td colspan="2">Production</td><td colspan="2">0.015-0.055</td></tr>
<tr><td colspan="2">Service Limit</td><td colspan="2">0.065</td></tr>
<tr><td colspan="6">PISTON PIN:</td></tr>
<tr><td colspan="4">Diameter</td><td>0.9270-0.9273</td><td>0.9270-0.9271</td></tr>
<tr><td rowspan="2" colspan="2">Clearance In Piston</td><td colspan="2">Production</td><td>0.0002-0.0007</td><td>0.0004-0.0008</td></tr>
<tr><td colspan="2">Service Lmit</td><td colspan="2">0.001 (Maximum)</td></tr>
<tr><td colspan="4">Fit In Rod</td><td>0.0008-0.0016 Interference</td><td>0.0013-0.0019 Interference</td></tr>
<tr><td colspan="6">EXHAUST MANIFOLD:</td></tr>
<tr><td colspan="4">Surface Flatness</td><td colspan="2">0.010 (Maximum)</td></tr>
<tr><td colspan="6">INLET MANIFOLD:</td></tr>
<tr><td colspan="4">Surface Flatness</td><td colspan="2">0.010 (Maximum)</td></tr>
<tr><td colspan="6">CYLINDER HEAD:</td></tr>
<tr><td colspan="4">Surface Flatness</td><td colspan="2">0.004 (Overall)</td></tr>
<tr><td colspan="6">BALANCE SHAFT:</td></tr>
<tr><td colspan="4">Front Bearing Journal Diameter</td><td>—</td><td>1.1812-1.1815</td></tr>
<tr><td colspan="4">Rear Bearing Journal Diameter</td><td>—</td><td>1.4209-1.4215</td></tr>
</table>

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SPECIFICATIONS

ENGINE SPECIFICATIONS (4.3L) (CONT.)

All Specifications are in INCHES unless otherwise noted.

DISPLACEMENT:			4.3L (LB4, VIN Z)	4.3L (L35, VIN W)
CRANKSHAFT:				
Main Journal	Diameter	#1	2.4484-2.4493	2.448-2.4495
		#2, #3	2.4481-2.4490	2.4485-2.4494
		#4	2.4479-2.4488	2.4480-2.4489
	Taper	Production	0.0002 (Maximum)	
		Service Limit	0.001 (Maximum)	
	Out Of Round	Production	0.0002 (Maximum)	
		Service Limit	0.001 (Maximum)	
Main Bearing Clearance	Production	#1	0.0008-0.0020	
		#2, #3	0.0011-0.0023	
		#4	0.0017-0.0032	
	Service Limit	#1	0.0010-0.0015	
		#2, #3	.0010-0.0025	
		#4	0.0025-0.0035	
Crankshaft End Play			0.002-0.006	0.002-0.007
Crankshaft Runout			0.001 (Maximum)	
Crankpin	Diameter		2.2487-2.2497	
	Taper	Production	0.0005	
		Service Limit	0.001 (Maximum)	
	Out Of Round	Production	0.0005	
		Service Limit	0.001 (Maximum)	
Rod Bearing Clearance	Production		0.0013-0.0035	
	Service Limit		0.0030	
Rod Side Clearance			0.006-0.014	
CAMSHAFT:				
Lobe Lift ± 0.002	Intake		0.234	0.288
	Exhaust		0.257	0.294
Journal Diameter			1.8682-1.8692	
			0.004-0.012	0.001-0.009
VALVE SYSTEM:				
Lifter			Hydraulic	
Rocker Arm Ratio			1.50:1	
Valve Lash		Intake	One Turn Down from Zero Lash	Torque Rocker Arm Nut to 27 N·m (20 ft. lbs.)
		Exhaust		
Face Angle (Intake & Exhaust)			45°	
Seat Angle (Intake & Exhaust)			46°	
Seat Runout (Intake & Exhaust)			0.002 (Maximum)	
Seat Width		Intake	0.035-0.060	
		Exhaust	0.062-0.093	
Stem Clearance	Production	Intake	0.0010-0.0027	0.0011-0.0027
		Exhaust	0.0010-0.0027	0.0011-0.0027
	Service	Intake	High Limit Production +0.001	
		Exhaust	High Limit Production +0.002	
Valve Spring (Outer)	Free Length		2.03	
	Pressure lbs. @ in.	Closed	76-84 lbs. @ 1.70-in.	
		Open	194-206 lbs. @ 1.25-in.	
	Installed Height ± 1/32"		1.690-1.710	
Valve Spring Damper	Free Length		1.86	
	Approx # of Coils		4	
Valve Lift	Intake		—	0.432
	Exhaust		—	0.441

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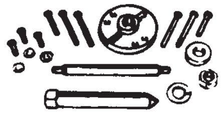
SPECIFICATIONS (CONT.)

FASTENER TIGHTENING SPECIFICATIONS

Item	N·m	Ft. Lbs.	In. Lbs.
Rocker Arm Cover Bolts	10	—	90
Intake Manifold Bolts	48	35	—
Exhaust Manifold Bolts			
Center Two Bolts	36	26	—
All Others	28	20	—
Cylinder Head Bolts	90	65	—
Torsional Damper Bolt	95	70	—
Front Cover Bolts	14	—	124
Oil Pan Nuts	23	17	—
Oil Pan Bolts	11	—	97
Oil Pump Bolt	90	65	—
Rear Crankshaft Oil Seal Retainer Screws and Nuts	15	—	133
Camshaft Sprocket Bolts	28	21	—
Connecting Rod Cap Nuts (Torque Plus 60°)	27	20	—
Oil Filter Adapter Bolts	20	15	—
Main Bearing Cap Bolts	110	75	—
Oil Pump Cover Bolts	9	—	80
Flywheel Bolts	100	75	—
Spark Plugs	30	22	—
Coolant Outlet Bolts	28	21	—
Coolant Pump Bolts	40	30	—
Flywheel Housing Bolts	44	32	—
Hydraulic Lifter Restrictor Retainer Bolts	16	12	—
Oil Pan Studs to Oil Seal Retainer or Crankcase	2	—	18
Camshaft Thrust Plate	12	—	106
EGR Valve Stud	15	11	—
EGR Valve Nut	23	17	—
EGR Valve Bolt	23	17	—
Oil Pan Drain Plug	25	18	—
Balance Shaft Retainer Bolts (L35 V6)	14	—	120
Balance Shaft Driven Gear Bolt (L35 V6) (Torque Plus 35°)	20	15	—
Lower Intake Manifold (L35 V6)	48	35	—
Upper Intake Manifold (L35 V6)	14	—	124
Rocker Arm Nut (L35 V6)	27	20	—
Rocker Arm Stud to Cylinder Head (L35 V6)	47	35	—
Balance Shaft Drive Gear LRetaining Stud (L35 V6)	16	12	—
Camshaft Sprocket Nut (L35 V6)	28	21	—

T2522

SPECIAL TOOLS

1.  J 23523-E

2.  J 5892-C

3.  J 23590

4.  J 35468

5.  J 8080

6.  J 8037

7.  J 5239

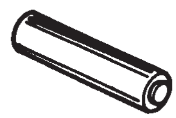
8.  J 23738-A

9.  J 5802-01

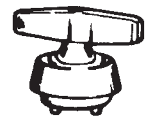
10.  J 5715
11. J 6036

12.  J 6880

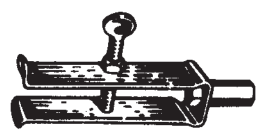
13.  J 5825-A

14.  J 5590

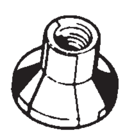
15.  J 8520

16.  J 35621

17.  J 38834

18.  J 26941

19.  J 8092

20.  J 36996

1. TORSIONAL DAMPER REMOVER AND INSTALLER
2. VALVE SPRING COMPRESSOR
3. AIR ADAPTER
4. CRANKSHAFT SEAL INSTALLER AND CENTERING TOOL
5. MAIN BEARING REPLACER
6. PISTON RING COMPRESSOR
7. GUIDE SET
8. VACUUM PUMP
9. STUD REMOVER
10. REAMER (0.003-INCH OVERSIZE)
11. REAMER (0.013-INCH OVERSIZE)
12. STUD INSTALLER
13. CRANKSHAFT GEAR PULLER
14. CRANKSHAFT GEAR INSTALLER
15. DIAL INDICATOR ADAPTER
16. CRANKSHAFT REAR SEAL INSTALLER
17. BALANCE SHAFT BEARING SERVICE KIT
18. NEEDLE BEARING REMOVER
19. DRIVER HANDLE
20. BALANCE SHAFT INSTALLER

F8796

SECTION 6B1

ENGINE COOLING

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

COOLING SYSTEM

These vehicles have a pressure type engine cooling system with thermostatic control of the coolant circulation. The cooling system is sealed by a pressure type radiator cap that causes the system to operate at higher than atmospheric pressure. The high pressure operation raises the boiling point of the coolant, thereby increasing the cooling efficiency of the radiator. The 105kPa (15 psi) pressure cap raises the boiling point of the coolant to about 125°C (257°F) at sea level.

The pressure-vacuum valve radiator cap allows the coolant to expand through the pressure valve in the center of the cap without building unnecessary pressure. The expanding coolant flows into the coolant reservoir. The vent valve closes due to expansion and coolant flow. The nominal 105kPa (15 psi) pressure will not be reached until the system is working at maximum capacity. Any air or vapor in the cooling system will be forced to the coolant reservoir and out through the vent tube at the top of the reservoir. As the system cools, the extra coolant in the reservoir will be drawn back to the radiator through the vent valve. In this manner, the radiator will keep itself full at all times.

COOLANT RECOVERY TANK

A "see-through" plastic reservoir, similar to the familiar windshield washer jar, is connected to the radiator by a hose. As the vehicle is driven, the coolant is heated and expands. The portion of the fluid displaced by this expansion flows from the radiator into the recovery bottle. When the vehicle is stopped and the coolant cools and contracts, vacuum draws the displaced coolant back into the radiator. Thus, the radiator is kept filled with coolant to the desired level at all times, resulting in increased cooling efficiency. Keep the coolant level between "ADD" and "FULL" marks on the recovery bottle. These marks are about one liter (one quart) apart. Use a 44/56 (50/50 in Canada) mixture of ethylene glycol anti-freeze and water to keep the system at the "FULL" mark when hot.

COOLANT PUMP

2.5L ENGINE

The coolant pump is of the centrifugal impeller type with six impellers. The engine fan is coupled with the coolant pump and the pump body is mounted to the front cover. The coolant pump has enclosed type ball bearings and is sealed with balance type mechanical seals for maximum durability.

2.8L AND 4.3L ENGINES

The die cast pump is of the centrifugal vane impeller type. The impeller turns on a steel shaft that rotates in a permanently lubricated ball bearing.

The pump inlet is connected to the bottom of the radiator by means of a rubber hose. From the pump, coolant passes through the engine front cover into the coolant passages in the block to pick up excess engine heat.

THERMOSTAT

A pellet-type thermostat in the coolant outlet passage controls the flow of engine coolant to provide fast engine warm- up and to regulate coolant temperatures. A wax pellet element in the thermostat expands when heated and contracts when cooled. The pellet is connected through a piston to a valve. When the pellet is heated, pressure is exerted against a rubber diaphragm which forces the valve to open. As the pellet cools, the contraction allows a spring to close a valve. Thus, a valve remains closed while the coolant is cold, preventing circulation of coolant through the radiator. At this point, coolant circulates throughout the engine to warm it quickly and evenly.

As the engine warms, the pellet expands and the thermostat valve opens, permitting coolant to flow through the radiator where heat is passed through the radiator walls. This opening and closing of the thermostat permits enough coolant to enter the radiator to keep the engine within operating limits.

DIAGNOSIS OF ENGINE COOLING

SYSTEM CHECKS

DRIVE BELT

Check the drive belt for looseness, wear, cracks, and damage. If the belt is loose, check the belt tensioner for proper operation. Check that the belt is within the proper operating range on the belt tensioner scale (figures 25 and 26). If the belt is out of the acceptable range, replace it with the correct size belt. The belt tensioner is not adjustable. If the belt tensioner is not working properly, it must be replaced.

If the belt is worn or damaged, replace it with the correct size belt.

EXHAUST LEAKS

To check for exhaust leaking into the cooling system, drain the system until the coolant level stands just above the top of the cylinder heads(s), then disconnect the radiator upper hose and remove the thermostat and belt. Start the engine and accelerate several times. At the same time, note any appreciable coolant rise or the appearance of bubbles which may indicate that exhaust gases are leaking into the cooling system.

NOTICE: A worn head gasket may allow exhaust gases to leak into the cooling system. This can damage the cooling system as the gases combine with the water to form acids which are harmful to the radiator and engine.

COOLANT PUMP

Check coolant pump operation by running the engine while squeezing the upper radiator hose. When the engine warms, a pressure surge should be felt. Check for a plugged vent hole in the pump.

RADIATOR

Test for restrictions in the radiator by warming the engine up and then turning the engine off and feeling the radiator. The radiator should be hot along the left side and warm along the right side, with an even temperature rise from right to left. Cold spots in the radiator indicate clogged sections.

THERMOSTAT

Make an operational check of the thermostat by hanging the thermostat on a hook in a 33 percent glycol solution, -12° (10°F) below the temperature indicated on the valve. With the valve submerged and the coolant agitated, the valve should close.

OVERHEAT AND/OR NOISE

Restrictions in the cooling system can cause engine overheating and/or cooling system noise.

Components prone to this condition are the cylinder head, coolant pump, block, thermostat housing, and inlet manifold. Symptoms are:

- Engine may make snapping/cracking noises.
- Heater core may gurgle or surge.
- Radiator hoses may collapse and expand.
- Heater hoses may vibrate and thump.
- Overheat light may or may not come on.

Symptoms are caused by coolant boiling at some localized area and may be noticed after extended idling and/or while driving. Determine which side of the engine is involved and whether it is at the front or rear of the engine.

Diagnosis/Inspection

1. Isolate the area by probing the engine with a sounding bar (large screwdriver).

CAUTION: The radiator cap should be removed from a cool engine only. If the radiator cap is removed from a hot cooling system, serious personal injury may result.

2. With the radiator cap removed, observe the coolant being circulated in the radiator. Feel the front area of the radiator for cold spots which indicate blockage. Blocked radiators generally occur on units that have accrued miles and not on new vehicles.
3. Inspect the thermostat to see if it opens.
4. Inspect the thermostat housing to make sure it is free of obstructions.
5. Remove the coolant pump from the vehicle and remove the back cover on the pump. Inspect all internal passages using a flashlight.
6. Inspect the crossover at the front of the inlet manifold. This entire passage can be seen only with the thermostat removed.
7. Remove the heads and check the block with a pen light flashlight. Never replace a block unless the restricted area can be seen.
8. Inspect the heads if the problem is not found. Heads with blocked coolant passages generally have more than one area that is blocked. Look for signs of overheat discoloration (a dark blue or black area). If none are found, look in the coolant passages for blockage and probe all accessible passages. The head is intricate, and all the passages cannot be reached. Use a substantial wire to go through or around a partially blocked area. If nothing is found by visual inspection and probing, inspect the passages for a rough, ragged appearance. The roughest internal passages are probably the ones that are blocked. Replace a blocked or suspect head and inspect the replacement head before installation.

FAN CLUTCH DIAGNOSIS

NOISE

Fan noise is sometimes evident under the following normal conditions.

- When the clutch is engaged for maximum cooling.
- During the first few minutes after start-up until the clutch can re-distribute the silicone fluid back to its normal disengaged operating condition (after overnight settling).

Fan noise or an excessive roar will occur continuously. If the fan cannot be rotated by hand or there is a rough grating feel as the fan is turned, replace the clutch.

LOOSENESS

Check a loose fan assembly for wear and replace as necessary. Under various temperature conditions, there is a visible lateral movement at the tip of the fan blade. Approximately 6.5 mm (1/4 in.) maximum lateral movement measured at the fan tip is allowable. This is not cause for replacement.

SILICONE FLUID LEAKS

The fan clutch operation is not affected by small fluid leaks which may occur in the area around the bearing assembly. If leakage appears excessive, replace the fan clutch.

ENGINE OVERHEATING

If the fan and clutch assembly free-wheels with no drag (revolves more than five times when spun by hand), replace the clutch.

THERMOSTAT DIAGNOSIS

Refer to the thermostat diagnosis chart for detailed thermostat diagnostic procedures (figure 1).

COOLANT DIAGNOSIS

HYDROMETER

Due to changes in commercially available antifreeze, the use of a hydrometer may give an incorrect reading. The hydrometer should be used to test ethylene glycol base antifreeze only. Ethylene glycol base antifreeze is recommended for year round use.

COOLANT TESTER

Coolant testers J 26568 (Centigrade Scale) and J 23688 (Fahrenheit Scale) can be used to check the anti-freeze protection of the coolant. Make sure the hydrometer readings are correct. Unless J 26568 or J 23688 has a provision for temperature correction, test the temperature at which J 26568 or J 23688 is calibrated. If the coolant is warmer or cooler, the reading may be incorrect. Follow the manufacturers directions for using J 26568 or J 23688.

Cleaning

- Before each use, swing back the plastic cover at the slanted end of J 26568 or J 23688, exposing the measuring window and the bottom of the plastic cover (figure 2).
- Wipe dry with tissue or clean soft cloth.
- Close the plastic cover.

Testing

Tools Required:
J 26568 or J 23688 Coolant Tester

- Do not remove the clear plastic pump from the tester.
- Release the tip of the pump from J 26568 or J 23688.

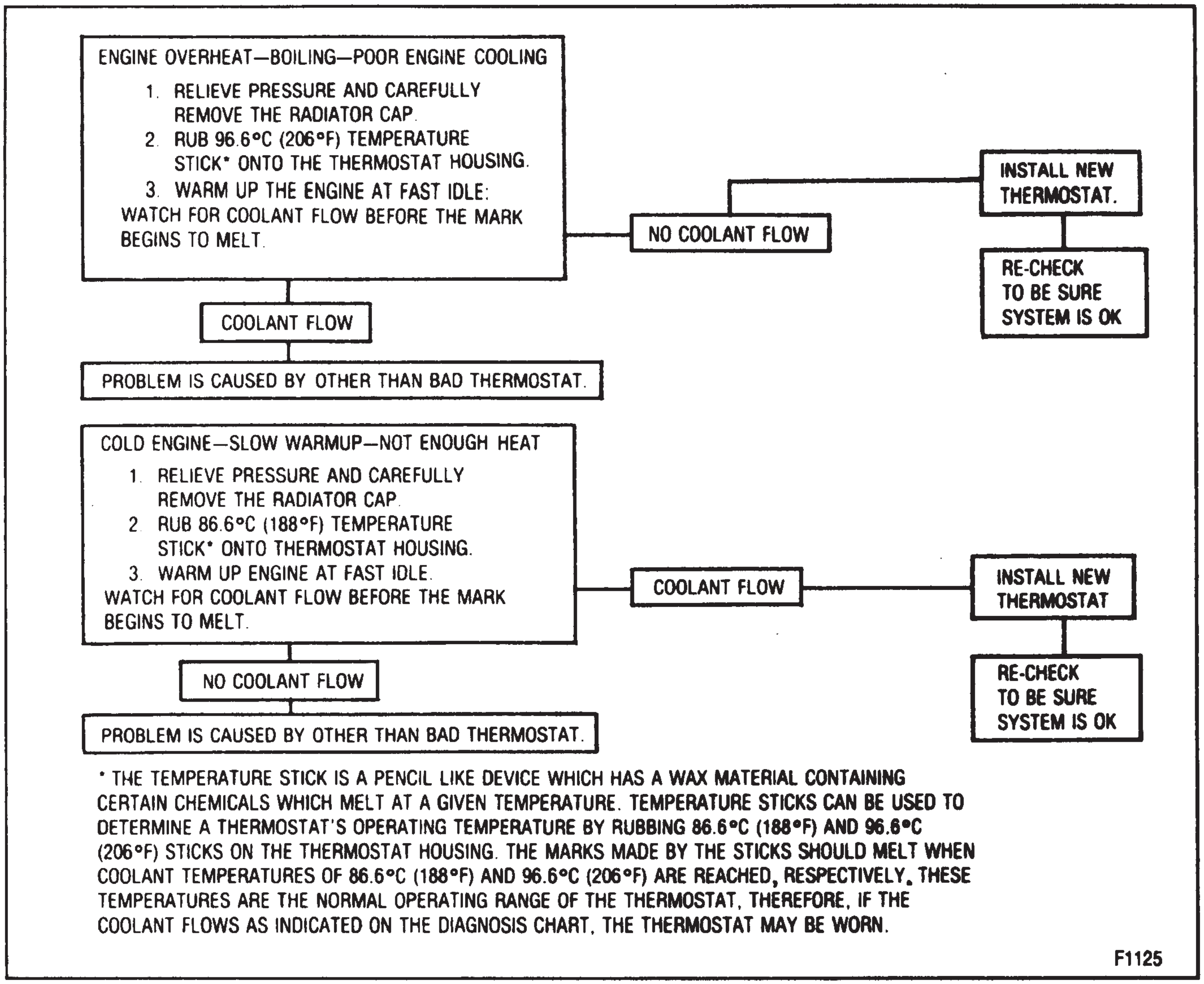


Figure 1—Thermostat Diagnosis

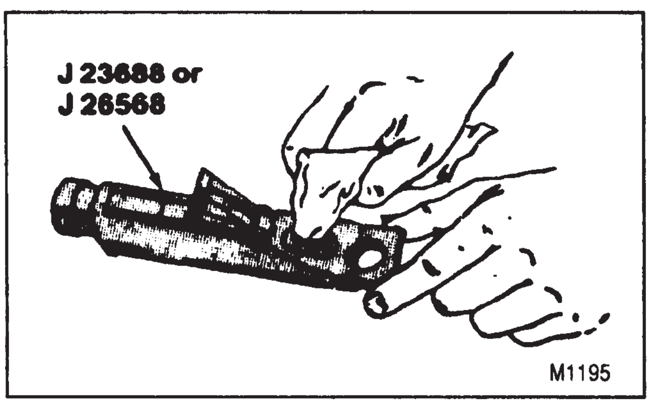


Figure 2—Cleaning the Coolant Tester

- Insert the tip of the pump into the radiator filler neck (figure 3).
  - Make sure the tip of the pump is below the level of the coolant.
  - Press and release the bulb to draw a sample.
  - Insert the tip of the pump into the cover plate opening.

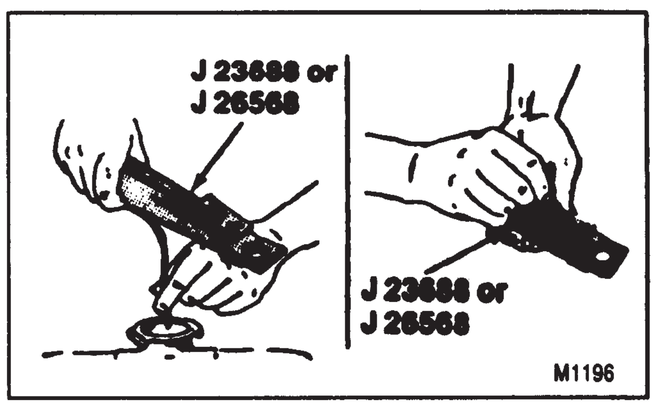


Figure 3—Collecting the Coolant

- Press the bulb and inject a few drops of coolant onto the measuring surface.
- Do not open the plastic cover when taking readings because water evaporation can change the reading.

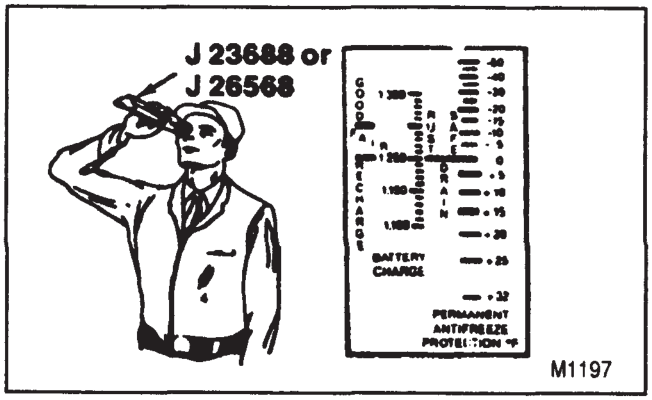


Figure 4—Reading the Coolant Tester

Reading

- Point J 26568 or J 23688 toward any light source and look into the eyepiece (figure 4).
  - Coolant protection reading is at the point where the dividing line between light and dark crosses the scale (anti-freeze protection is the scale on the right).
  - Temperature scale is reversed from a standard thermometer scale.
  - Below zero readings are on upper half of the scale.
  - Readings on the lower half of the scale indicate solutions without enough anti-freeze concentration to provide adequate rust protection.
  - If the readings are not clear, the measuring surfaces were not cleaned and dried properly. Wipe dry and make a new test.

COOLING SYSTEM DIAGNOSIS

Refer to the cooling system diagnosis chart for detailed cooling system diagnostic procedures (figures 5, 6, and 7).

UNCOMMON COOLING SYSTEM PROBLEMS

Problems Not Requiring Disassembly of the Cooling System

1. Remove large obstructions blocking the radiator or condenser.
   - Auxiliary oil cooler.
   - License plates.
   - Spare tires.
   - Ice, mud, or snow obstructing the grille.
2. Engine oil is overfilled.
3. Incorrect radiator for the application.
   - Check the part number.
4. Loose, damaged, or missing air seals.
5. Missing or damaged lower air baffle.
6. Incorrect ignition timing.

Problems Requiring Disassembly of the Cooling System

1. Incorrect or damaged fan.
2. Worn or damaged emission system components.
   - Could cause overheating at idle.
   - Damaged positive crankcase ventilation (PCV) valve, thermal vacuum switch (TVS), or coolant temperature switch (CTS).
3. Pressure check the cooling system with the pressure cap installed.
   - Shows if the pressure cap leaks because of radiator filler neck damage.
4. Worn or damaged coolant pump.
   - Impeller vanes eroded or broken.
   - Worn or damaged bearing and/or seal. Check for shaft or bearing play.
5. Plugged radiator tubes.
   - Perform a flow check.
6. Internal system leaks.
   - Head gasket.
   - Cracked block.
   - Timing chain cover.
   - Intake manifold gasket.
7. Plugged coolant passages in the cylinder heads.
   - Visual check.

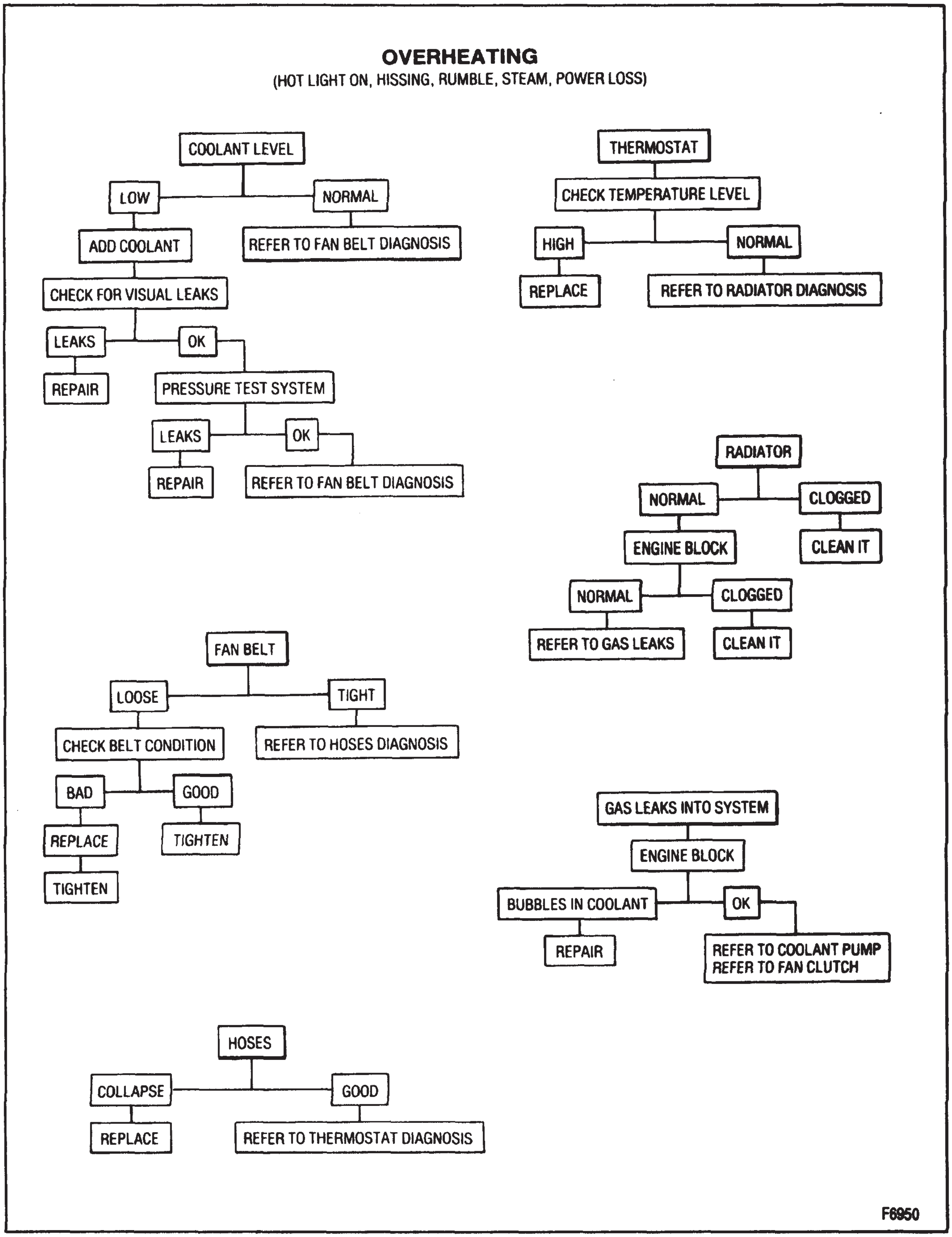


Figure 5—Overheating Diagnosis

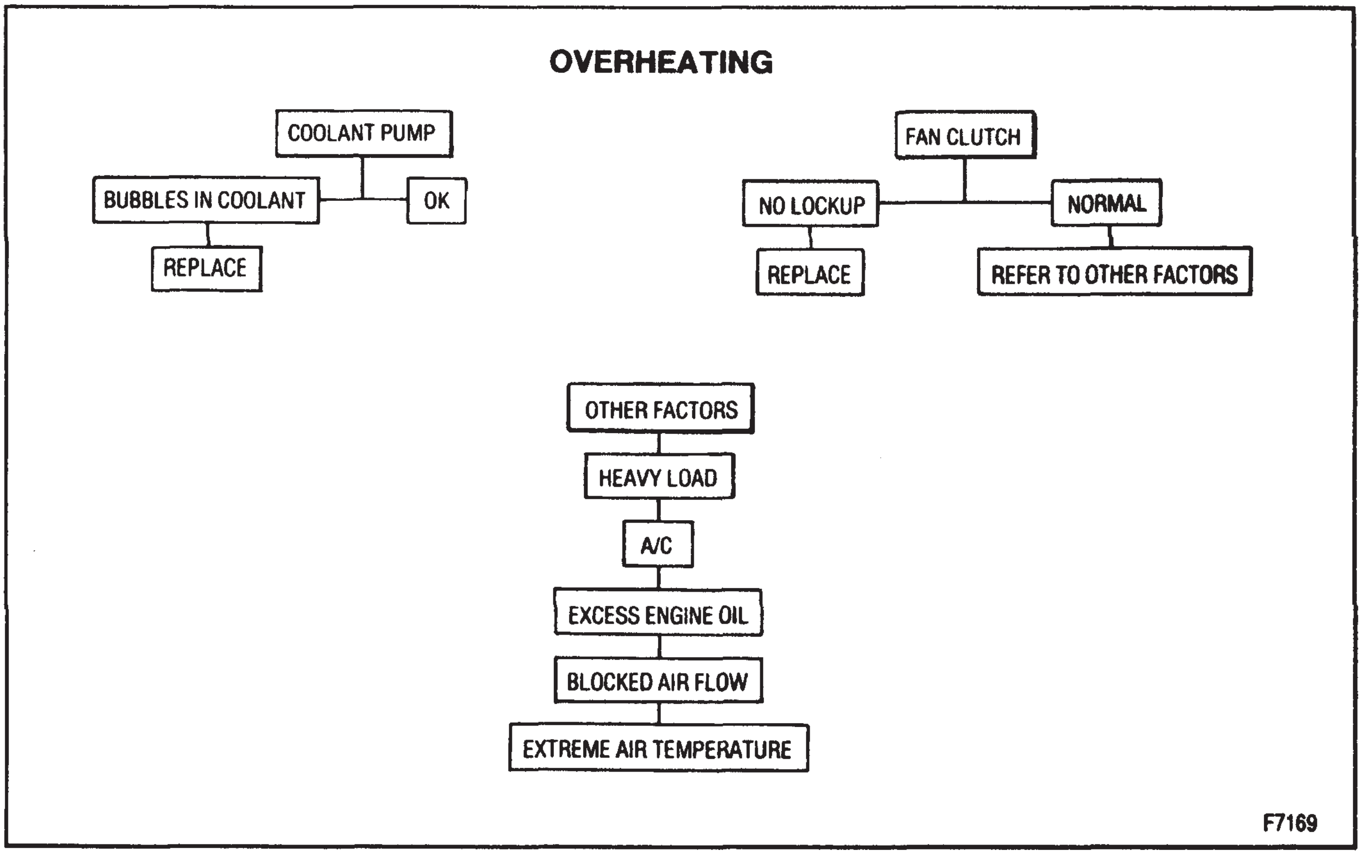


Figure 6—Overheating Diagnosis

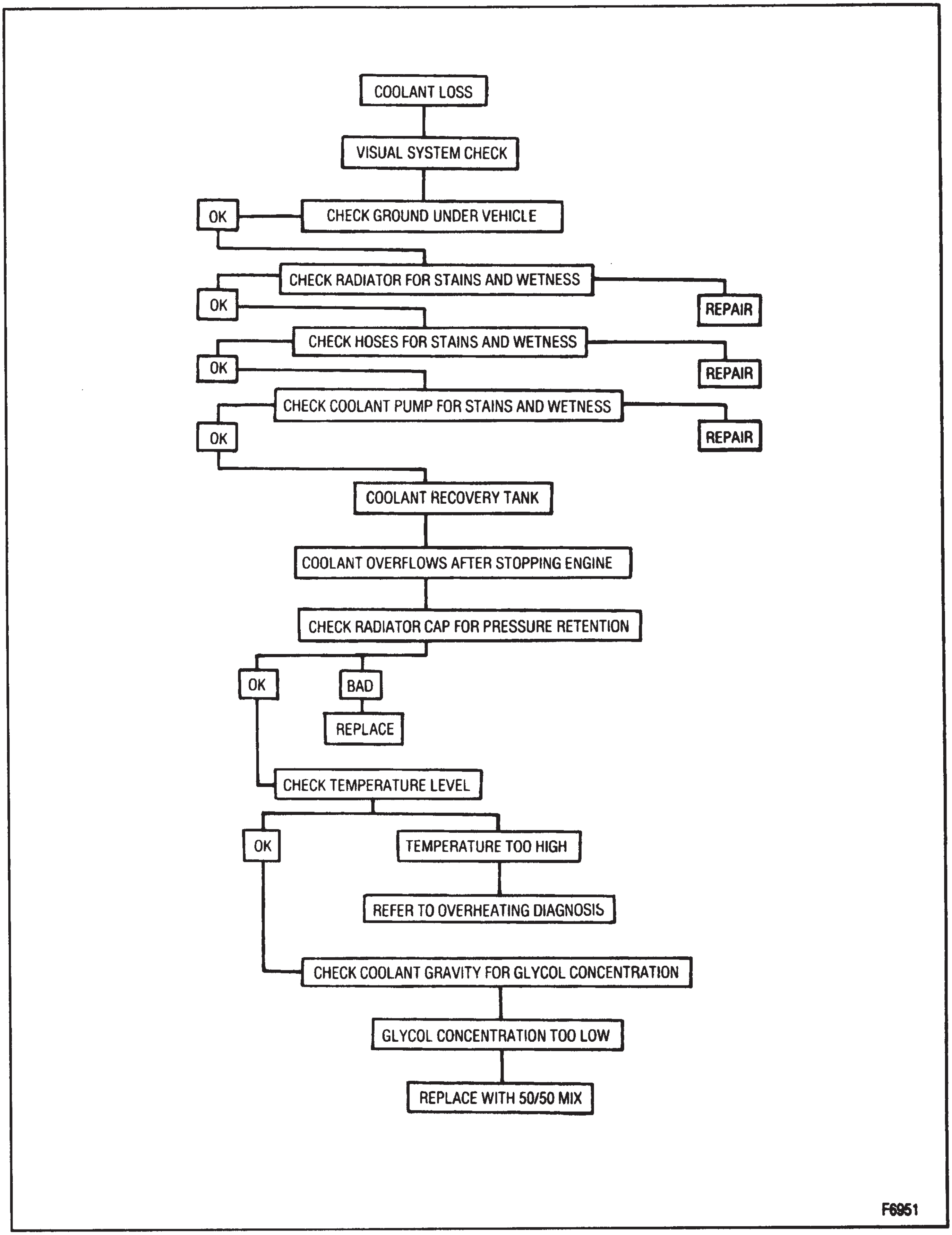


Figure 7—Coolant Loss Diagnosis

ON-VEHICLE SERVICE

DRAINING AND FILLING THE COOLING SYSTEM

Draining

1. Place a drain pan under the radiator drain cock.
2. Install a tube on the drain cock.
3. Place the end of the tube in the pail or pan.
4. Be sure the cooling system is cool, then remove the radiator cap.
5. Open the drain cock completely.
6. Lift the cooling system drain until the flow stops.
7. Place a drain pan under the engine.
8. Remove the drain plug in the engine block.
9. Let the engine block drain until the flow stops. There may be some more drainage from the radiator at this time.
10. Replace the engine block drain plug.
11. Close the radiator drain cock.

Filling

1. Check the radiator drain cock to be sure that it is closed.
2. Check the engine drain plug to be sure that it is tight.
3. Premix the antifreeze, with clear water on a 44/56 (50/50 in Canada) ratio.
   - If the old coolant is being used, check it for 44/56 glycol/water mix (50/50 in Canada) and make sure that it is clean and clear.
4. Place a large top funnel in the radiator fill hole.
5. Slowly pour in the coolant. The amount needed for the vehicle should be known. The filling may be slowed because of the thermostat being closed.
6. After the cooling system is filled to 1/2 inch below the fill hole, start the engine and let the cooling system warm up. When the thermostat opens, the coolant level may drop. If the level drops, add coolant until the level is up to the fill hole.
7. Replace the radiator cap.
8. Check the coolant level in the recovery tank. Add coolant if needed.

FLUSHING THE COOLING SYSTEM

Various methods and equipment can be used to flush the cooling system. If special equipment such as a back flusher is used, follow the equipment manufacturer's instructions.

Important

- Remove the thermostat before flushing the cooling system.

COOLANT RECOVERY TANK REPLACEMENT

Remove or Disconnect (Figure 8)

1. Hose from the coolant reservoir tank (10).
2. Bolt (14).
3. Coolant reservoir tank (10).
4. Coolant from the reservoir tank.

Install or Connect (Figure 8)

1. Coolant reservoir tank (10) to the vehicle.

NOTICE: See "Notice" on page 6B1-1.

2. Bolt (14).

Tighten

- Bolt (14) to 10 N·m (86 in. lbs.).

3. Hose to the coolant reservoir tank (10).
   - Fill the reservoir tank to the proper level with 44/56 (50/50 in Canada) mixture of ethylene glycol coolant and water in accordance with GM 6038-M.

RADIATOR HOSE REPLACEMENT

Remove or Disconnect (Figures 9, 10, and 11)

1. Negative battery cable.
2. Coolant from the radiator so the level of the coolant is below the hose being removed.
3. Clamps (118).
4. Radiator inlet hose (119) from the radiator (120) and coolant outlet.
5. Radiator outlet hose (121) from the radiator (120) and coolant pump.

Install or Connect (Figures 9, 10, and 11)

1. Radiator outlet hose (121) to the radiator (120) and coolant pump.
2. Radiator inlet hose (119) to the radiator (120) and coolant outlet.
   - The inlet hose (119) used with the 4.3L (VIN Z) engine must be routed as shown in figure 10.
   - The inlet hose (119) used with the 4.3L (VIN W) engine must be routed as shown in figure 11.

NOTICE: See "Notice" on page 6B1-1.

3. Clamps (118).

Tighten

- Clamps (118) to 2.5 N·m (22 in. lbs.).

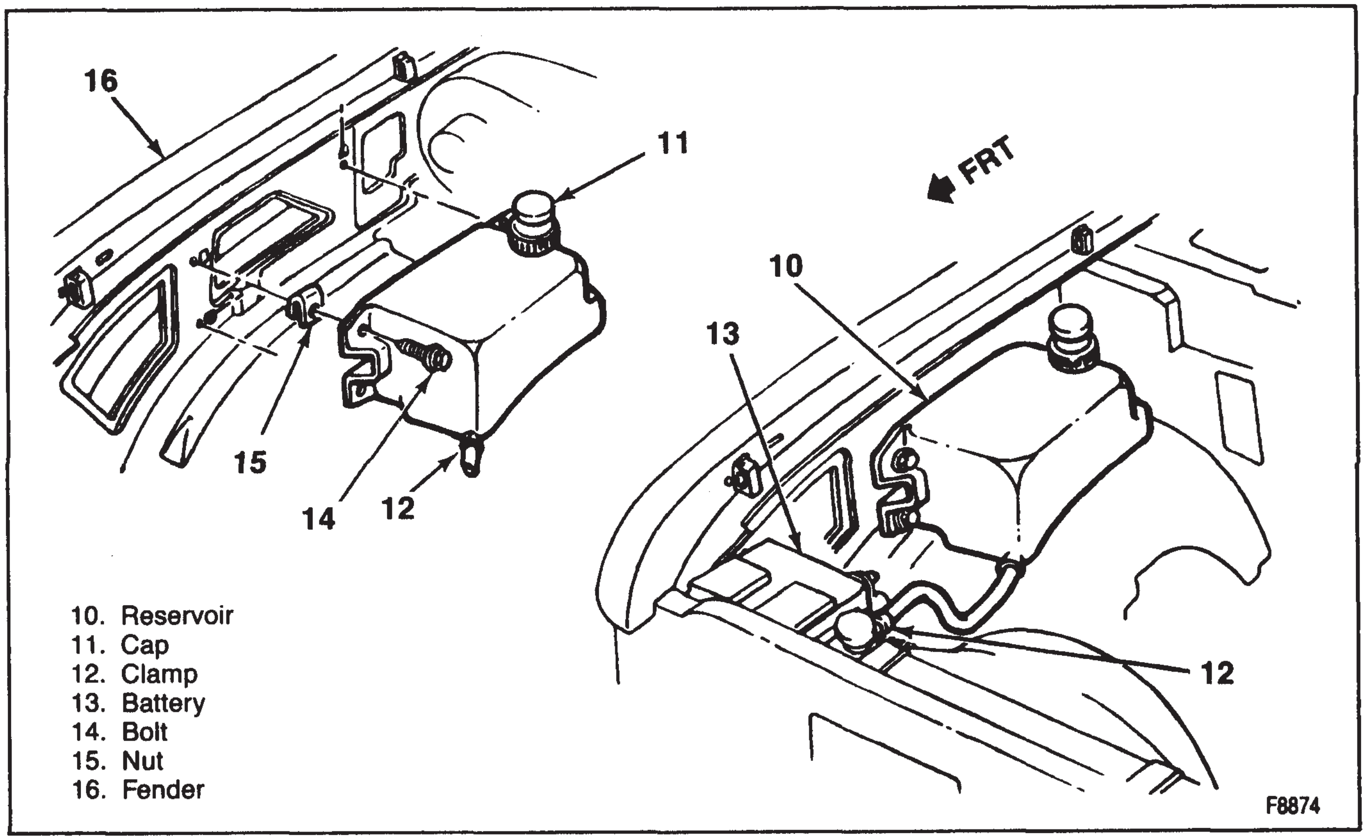


Figure 8—Coolant Recovery System (2.5L, 2.8L, and 4.3L Engines)

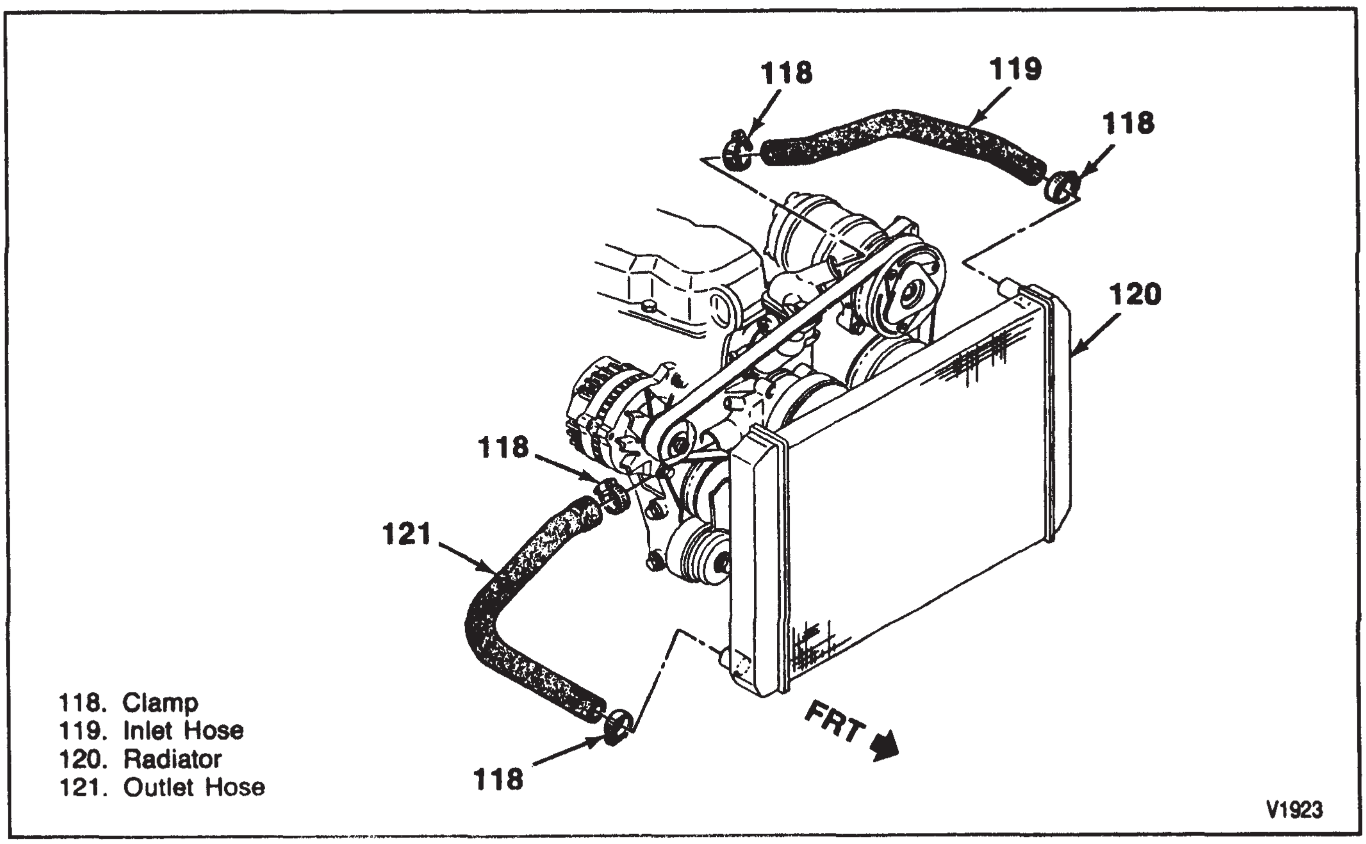


Figure 9—Radiator and Hoses (2.5L Engine, VIN A)

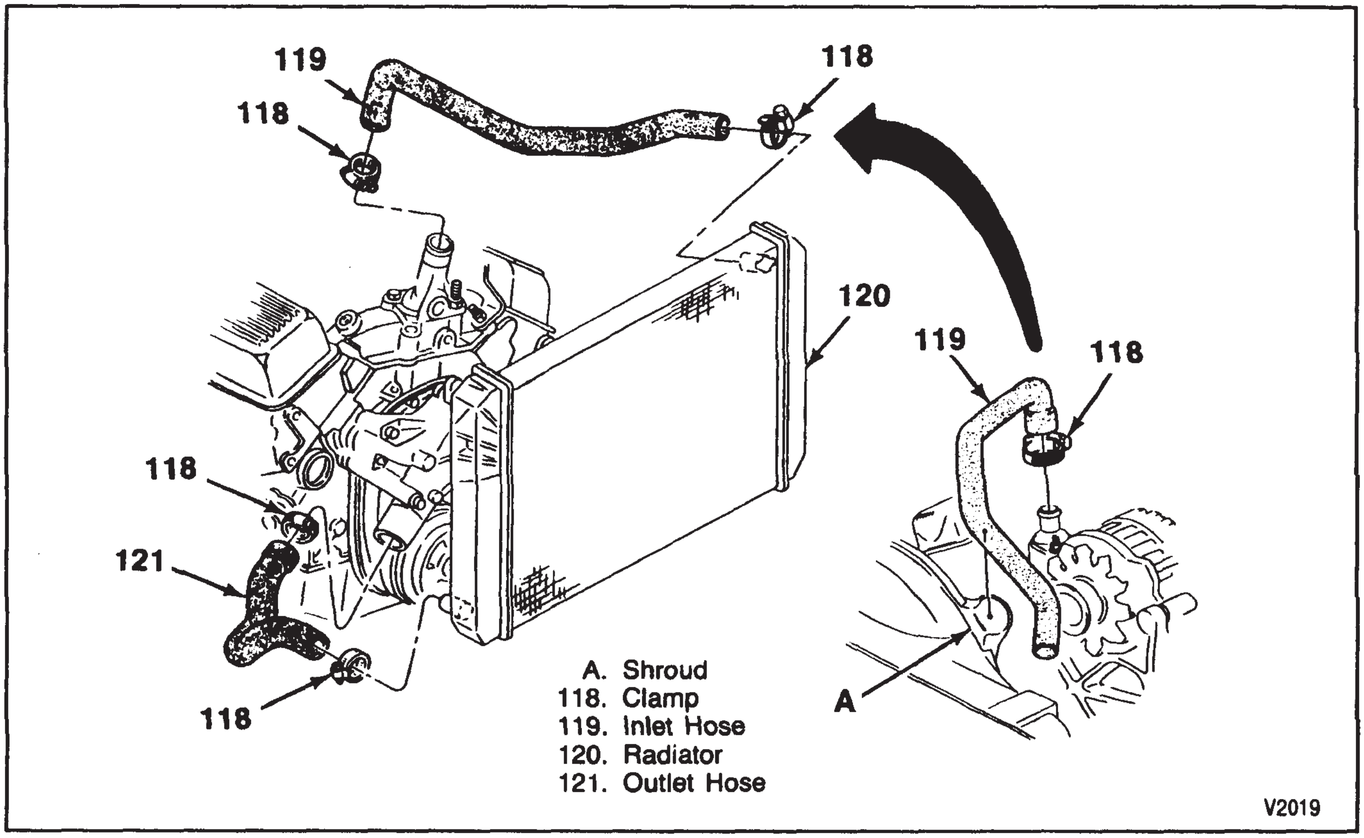


Figure 10—Radiator and Hoses (4.3L Engine, VIN Z)

4. Coolant to the proper level. Refer to "Draining and Filling the Cooling System."
5. Negative battery cable.
   - Check the system for leaks.

FAN/FAN CLUTCH REPLACEMENT

Remove or Disconnect (Figures 12 through 15)

1. Upper fan shroud.
2. Nuts (7 and 9).
3. Fan (2) and clutch (6) assembly.
4. Fan (2) from the clutch (6).

CAUTION: Do not use or repair a damaged fan assembly. An unbalanced fan assembly could fly apart and cause personal injury and/or property damage. Replace damaged assemblies with new assemblies.

Install or Connect (Figures 12 through 15)

NOTICE: For steps 1 and 4, see "Notice" on page 6B1-1.

1. Fan (2) using bolts (4 and 8), to the clutch (6).

Tighten

- Bolts (4 and 8) to 13 N.m (9 ft. lbs.), 2.5L and 2.8L engines.
- Bolts (4) to 35 N.m (25 ft. lbs.), 4.3L engines.

2. Fan and clutch (7) to the pulley.
3. Nuts (7 and 9).

Tighten

- Nuts to 24 N.m (17 ft. lbs.).

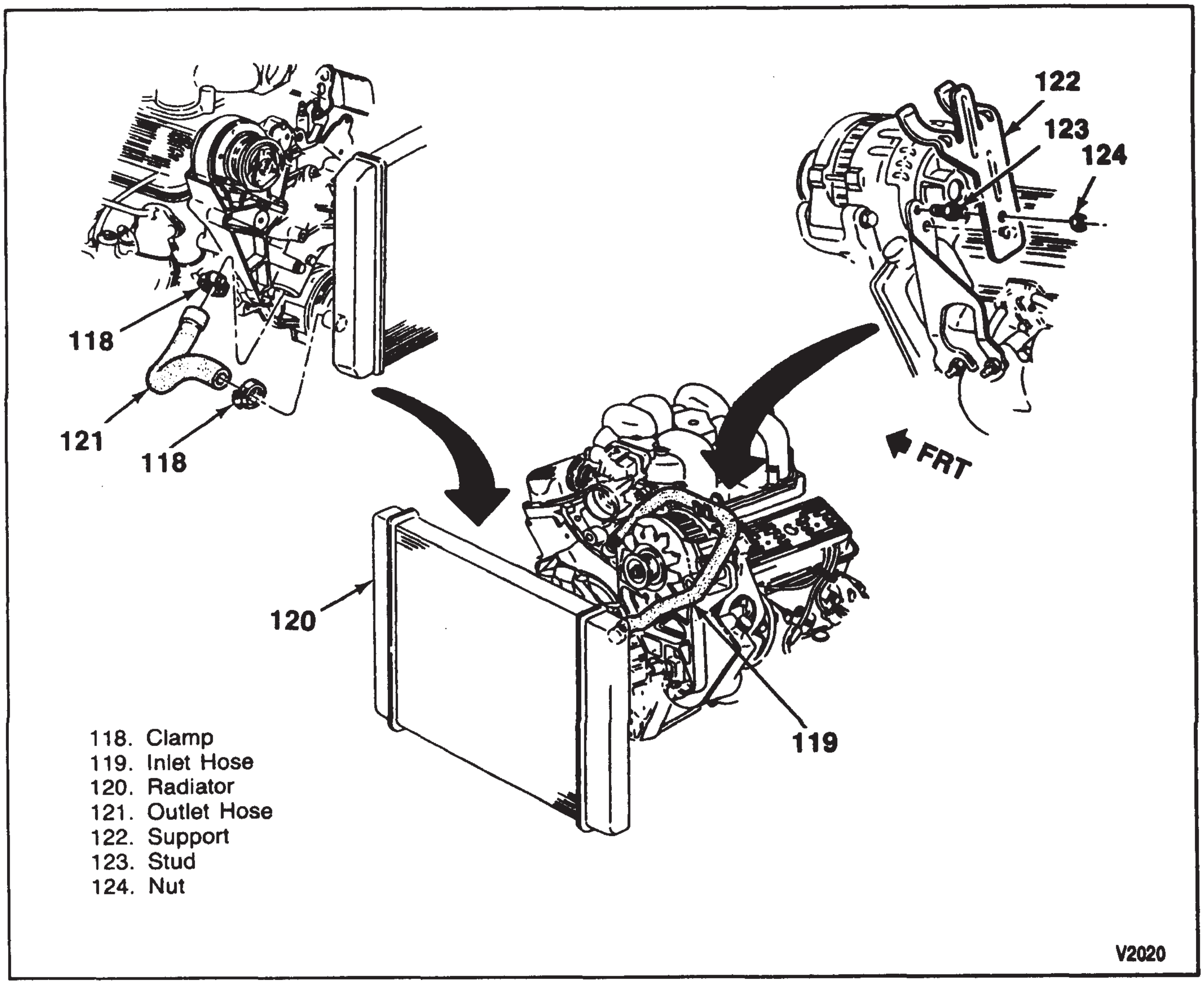


Figure 11—Radiator and Hoses (4.3L Engine, VIN W)

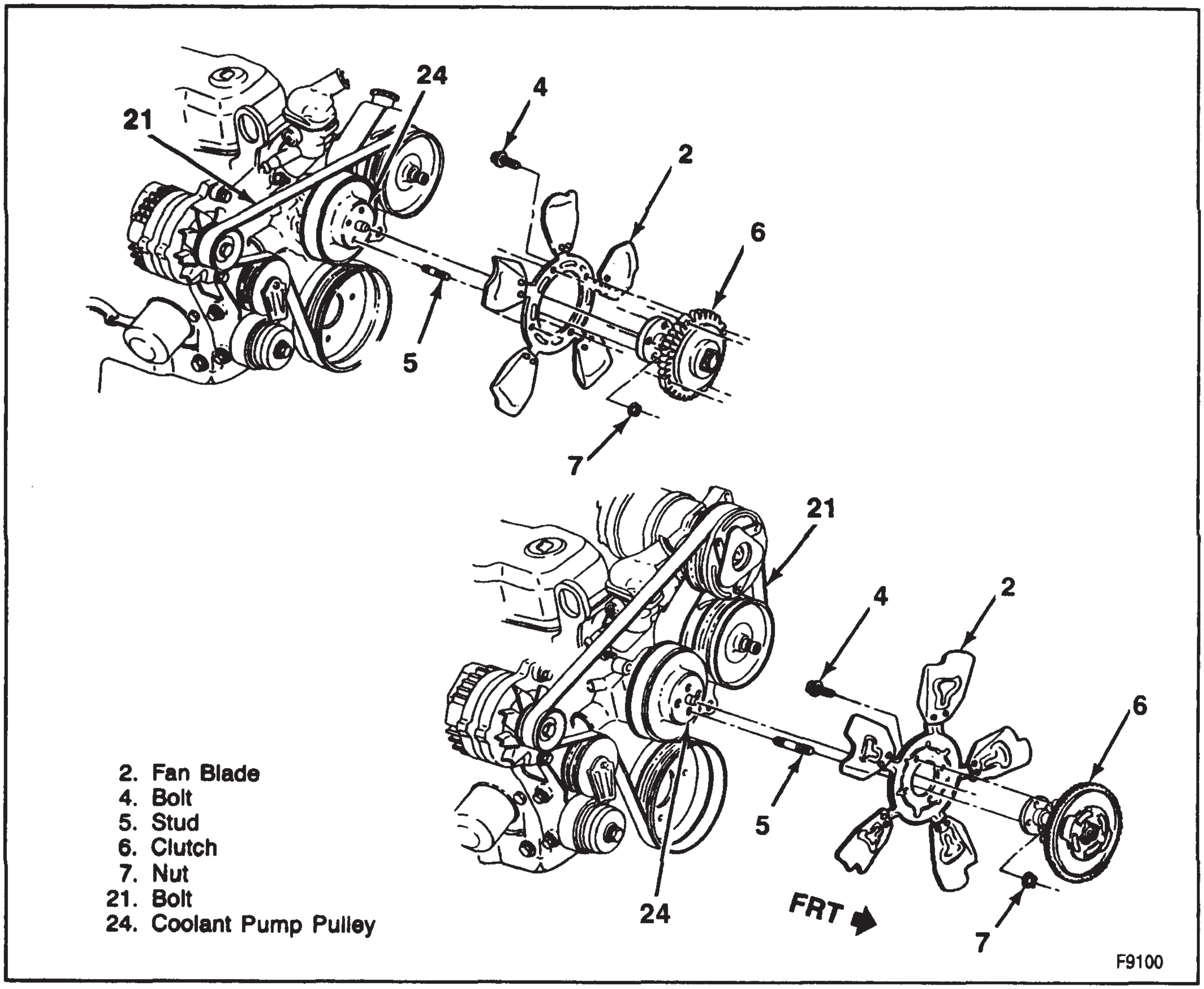


Figure 12—Fan/Fan Clutch (2.5L Engine)

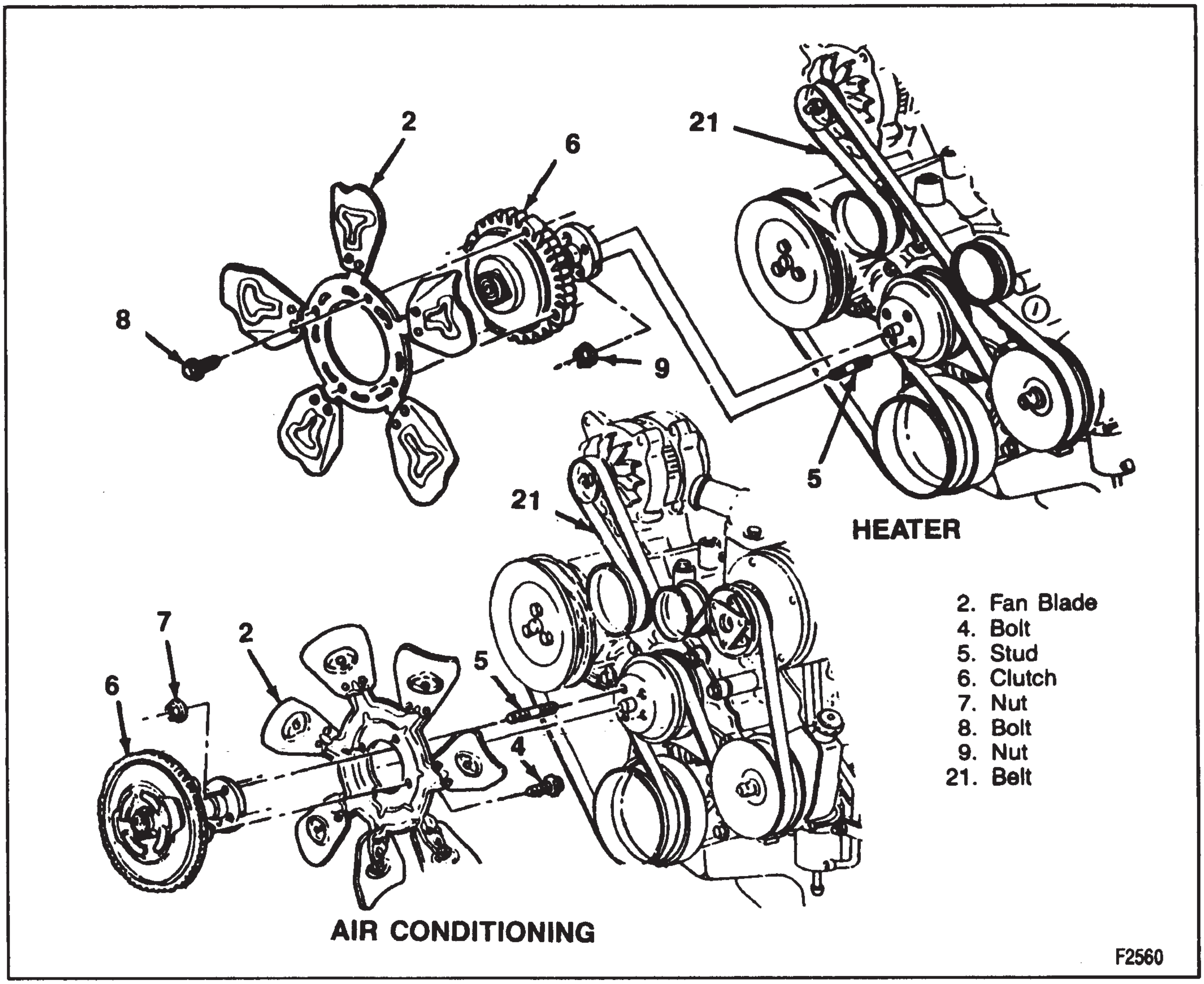


Figure 13—Fan/Fan Clutch (2.8L Engine)

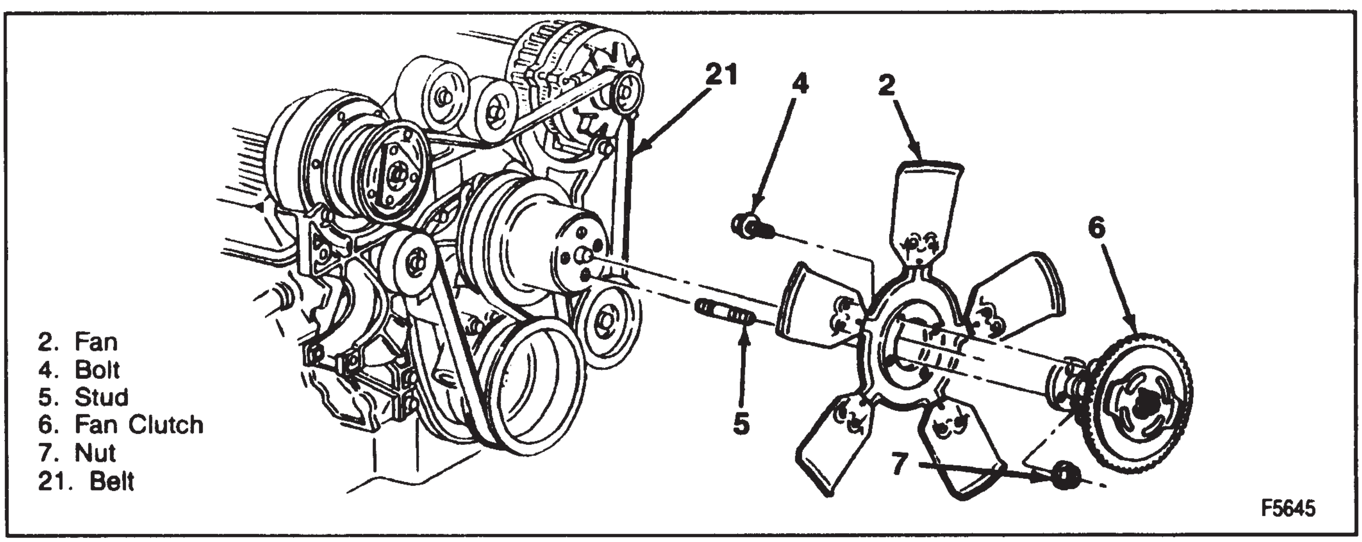


Figure 14—Fan/Fan Clutch (4.3L Engine W/Air Conditioning)

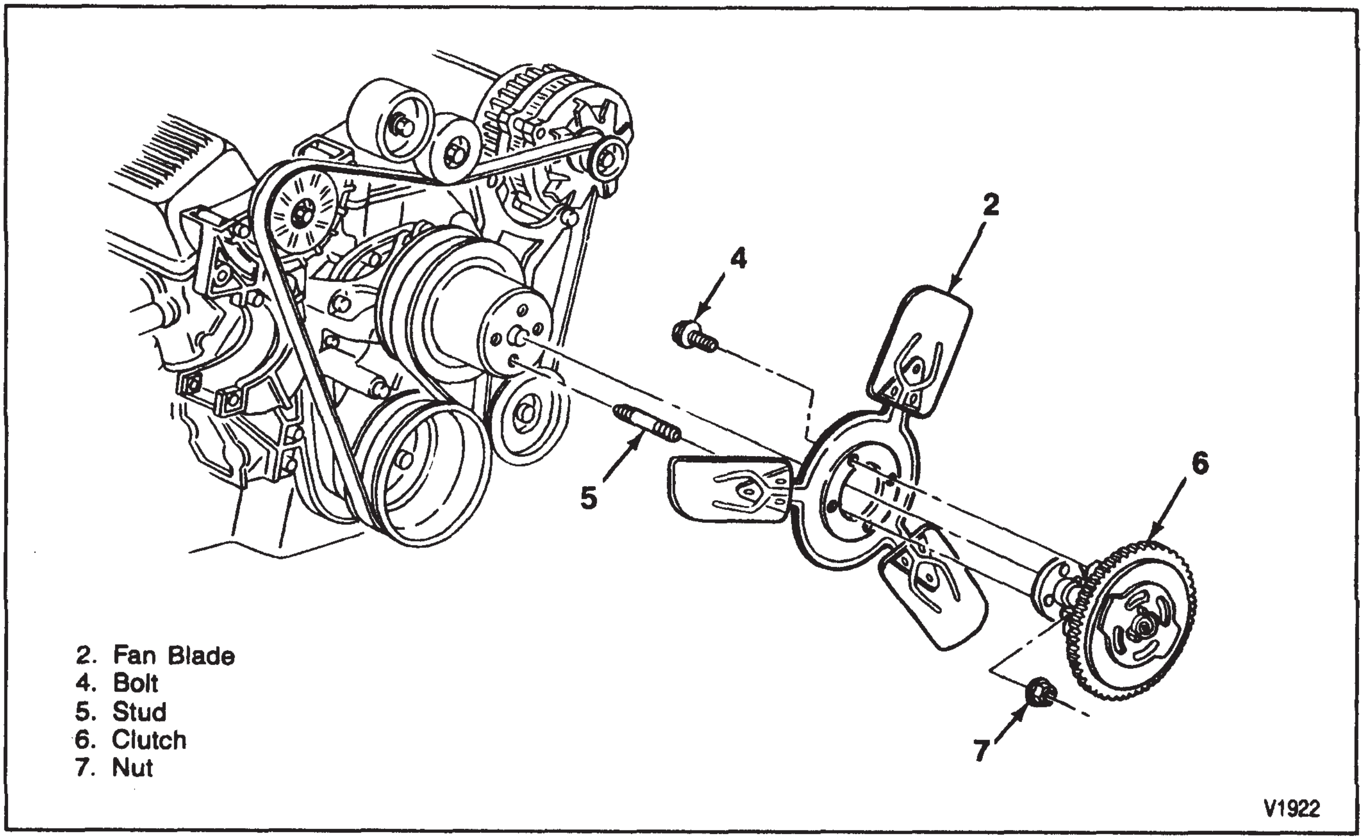


Figure 15—Fan/Fan Clutch (4.3L Engine W/O Air Conditioning)

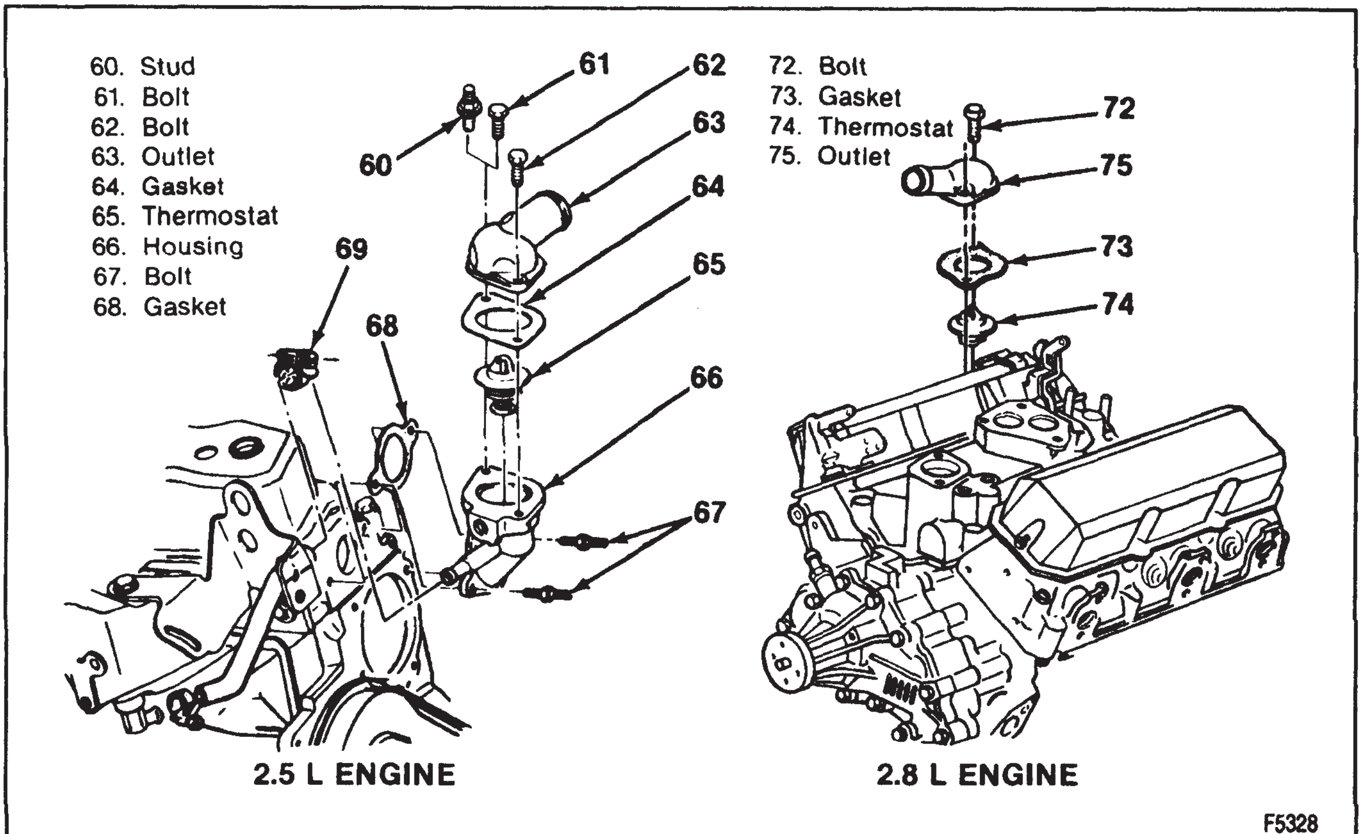


Figure 16—Thermostat and Components (2.5L and 2.8L Engines)

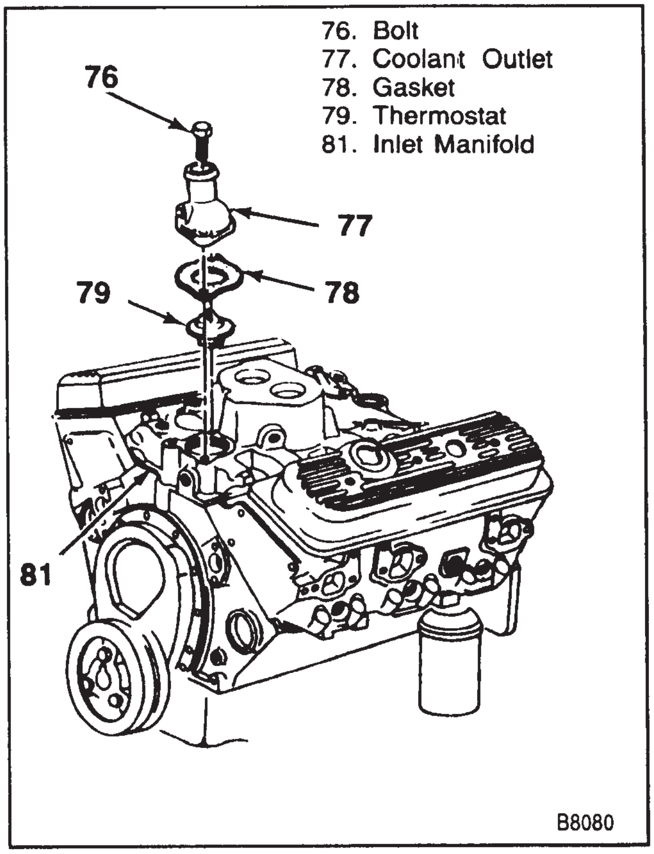


Figure 17—Thermostat and Components (4.3L Engine, VIN Z)

THERMOSTAT REPLACEMENT

Remove or Disconnect (Figures 16 through 18)

1. Coolant from the radiator.
2. Bolt (61, 62, 72, 76).
3. Stud (60) (2.5L engine).
4. Outlet (63, 75, 77).
5. Gasket (64, 73, 78).
6. Thermostat (65, 74, 79).

Clean

- All parts and sealing surfaces.

Install or Connect (Figures 16 through 18)

NOTICE: For steps 5 and 6, see "Notice" on page 6B1-1.

1. 3 mm (1/8 inch) bead of RTV sealer 1052289 or equivalent to the groove on the water outlet sealing surface.
2. Thermostat (65, 74, 79).
3. New gasket (64, 73, 78).
4. Outlet (63, 75, 77).
5. Bolt (61, 62, 72, 76).
6. Stud (60) (2.5L engine).

Tighten

- Bolt (61, 62, 72, 76) and stud (60) to 28 N.m (21 ft. lbs.).
- Bolt (76) 4.3L VIN W engine only, to 19 N.m (14 ft. lbs.).

7. Coolant to the radiator.

Inspect

- For leaks at the sealing surface after starting the engine.

COOLANT PUMP REPLACEMENT

Remove or Disconnect (Figures 19 and 20)

1. Coolant from the radiator.
2. Multiple ribbed drive belt.
3. Upper fan shroud.
4. Fan and fan clutch assembly.
5. Coolant pump pulley.
6. Radiator outlet hose clamp and hose.
7. Bolts (44) and nut (43).
8. Coolant pump (41).
9. Gasket(s) (42).

Inspect

- All parts and replace as necessary.

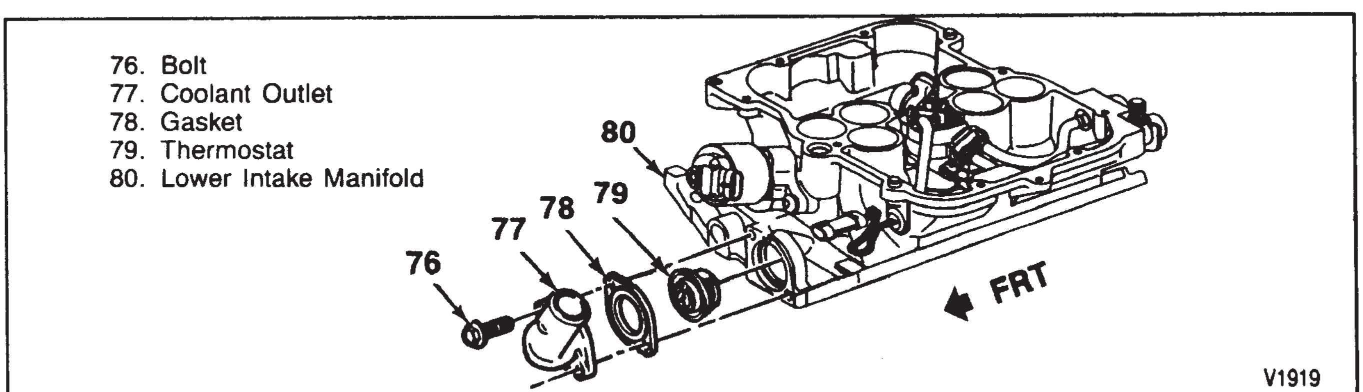


Figure 18—Thermostat and Components (4.3L Engine, VIN W)

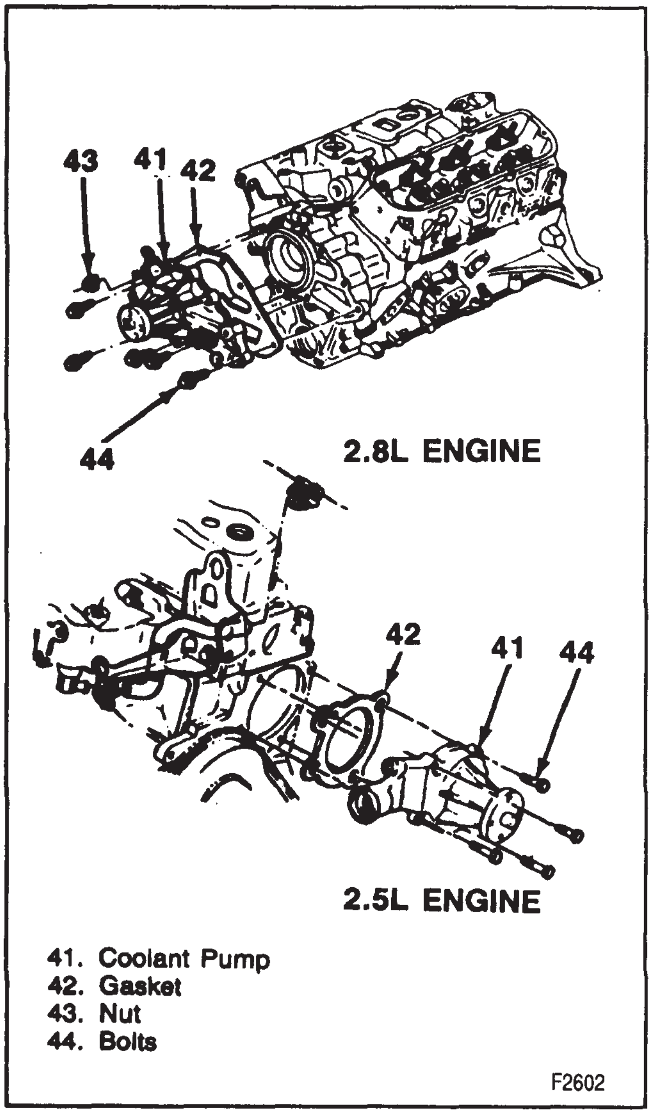


Figure 19—Coolant Pump and Components (2.5L and 2.8L Engines)

Important

- Be sure all mating surfaces are free of burrs or other imperfections.

Install or Connect (Figures 19 and 20)

1. Gasket(s) (42) in place.
2. Coolant pump (41).

NOTICE: See "Notice" on page 6B1-1.

3. Bolts (44) and nut (43).
   - Sealant (GM part number 1052080) or equivalent is to be applied to the bolt threads.

Tighten

- Bolts to 30 N.m (22 ft. lbs.).
- Nut to 30 N.m (22 ft. lbs.).

4. Radiator outlet hose and clamp.
5. Coolant pump pulley.
6. Fan and fan clutch assembly.
7. Multiple ribbed drive belt.
8. Upper fan shroud.
9. Coolant to the radiator.

Important

- Start the engine and check for leaks.

BELT TENSIONER REPLACEMENT

Remove or Disconnect (Figures 21 through 26)

1. Negative battery cable.
2. Multiple ribbed drive belt. Refer to "Multiple Ribbed Drive Belt Replacement."
3. Bolt (53).
4. Tensioner (26).

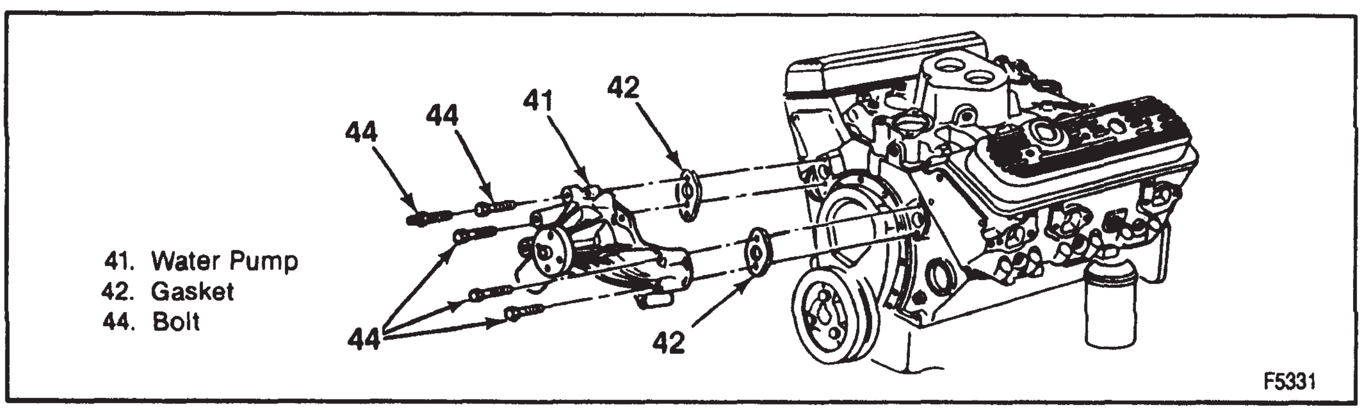


Figure 20—Coolant Pump and Components (4.3L Engine)

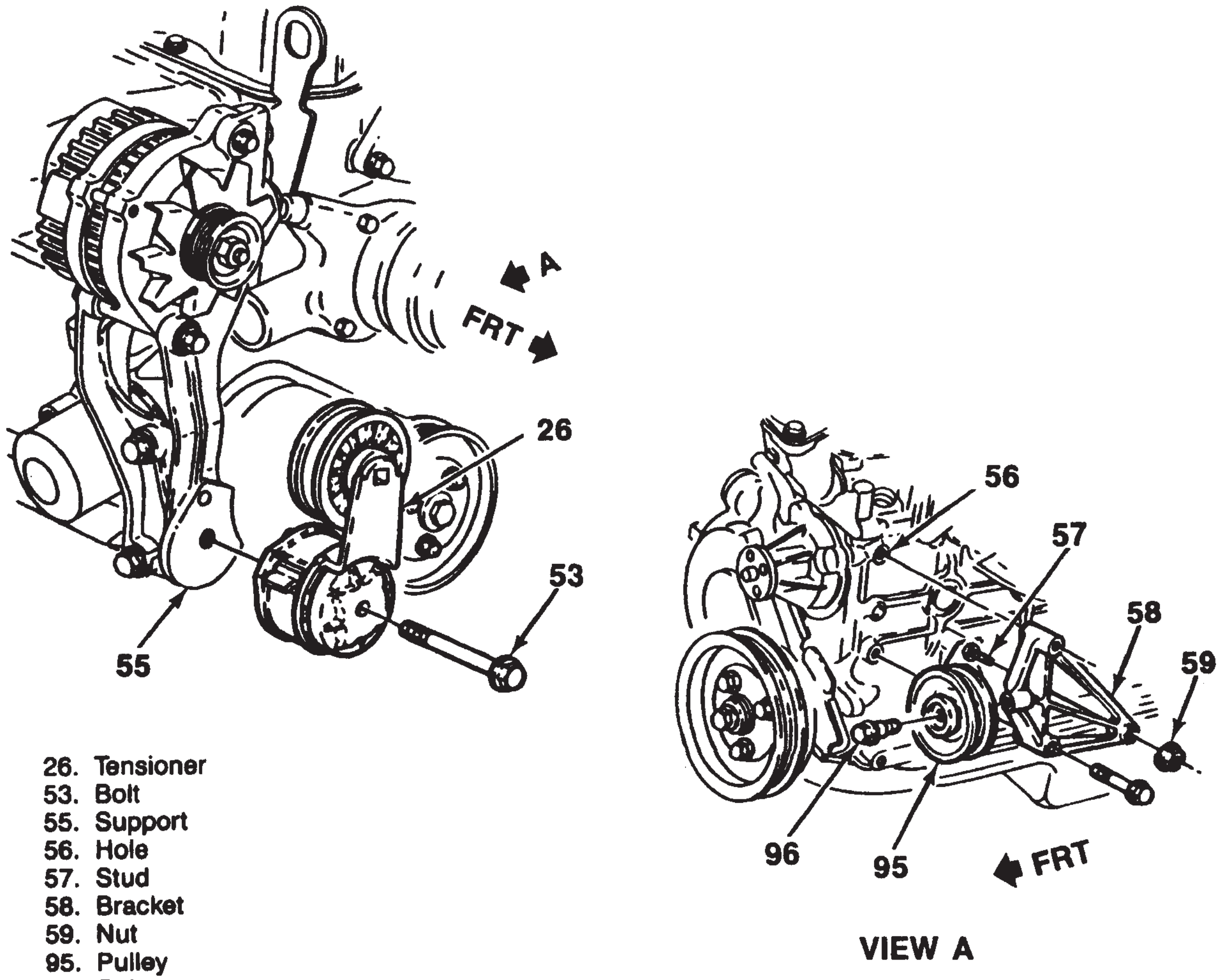


Figure 21—Belt Tensioner and Idler Pulley (2.5L Engine)

Install or Connect (Figures 21 through 26)

1. Tensioner (26) to mounting bracket.

NOTICE: See "Notice" on page 6B1-1.

2. Bolt (53).

Tighten

- Bolt (53) to 85 N·m (63 ft. lbs.).

3. Multiple ribbed drive belt. Refer to "Multiple Ribbed Drive Belt Replacement."
4. Negative battery cable.

MULTIPLE RIBBED DRIVE BELT REPLACEMENT

Maintaining the multiple ribbed drive belt and pulleys can extend the normal life of a drive belt.

PULLEY INSPECTION

Examine the pulleys for chips, nicks, tool marks, cracks, bent sidewalls, corrosion, or other damage.

1. Place a straightedge or position a cord across the two pulleys so they touch at all points.
2. Turn each pulley one half revolution and recheck with a straightedge or cord. *Full* contact at *all* points must be made. If contact is not made at all points, the pulley may be warped or its shaft could be bent. Replace any parts found to be damaged.
3. If the belt becomes loose and squeals or the belt comes off the engine drive pulleys. This condition may be caused by a worn idler pulley or worn belt tensioner pulley (plastic).

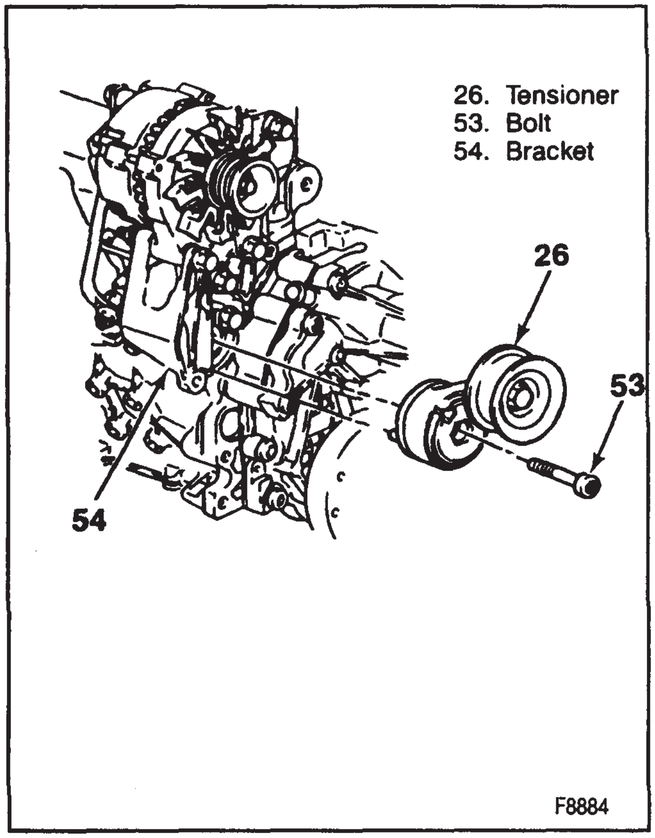


Figure 22—Belt Tensioner Assembly (2.8L Engine)

DRIVE BELT INSPECTION

Replace a frayed or cracked belt. Do not use drive belt dressings to extend belt life.

BELT INSTALLATION

Install a multiple ribbed belt following the belt routing (figures 27 and 28). The grooves in the belt must match the grooves in the pulleys.

The tensioner is spring loaded. After removing the belt, the tensioner will return the tension position (figures 21 through 26).

DRIVE BELT REPLACEMENT

Remove or Disconnect (Figures 27 and 28)

1. Use a 1/2-inch breaker bar with a 16-mm (5/8-inch) socket placed on the tensioner pulley axis bolt and rotate the tensioner to the left (counterclockwise).
2. Belt.

Install or Connect (Figures 27 and 28)

1. Route belt over all the pulleys except the belt tensioner.
2. Use a 1/2-inch breaker bar with a 16-mm (5/8-inch) socket placed on the tensioner pulley axis bolt and rotate the tensioner to the left (counterclockwise).
3. Belt over the belt tensioner pulley.
4. Check the belt for correct "V" groove tracking around each pulley.

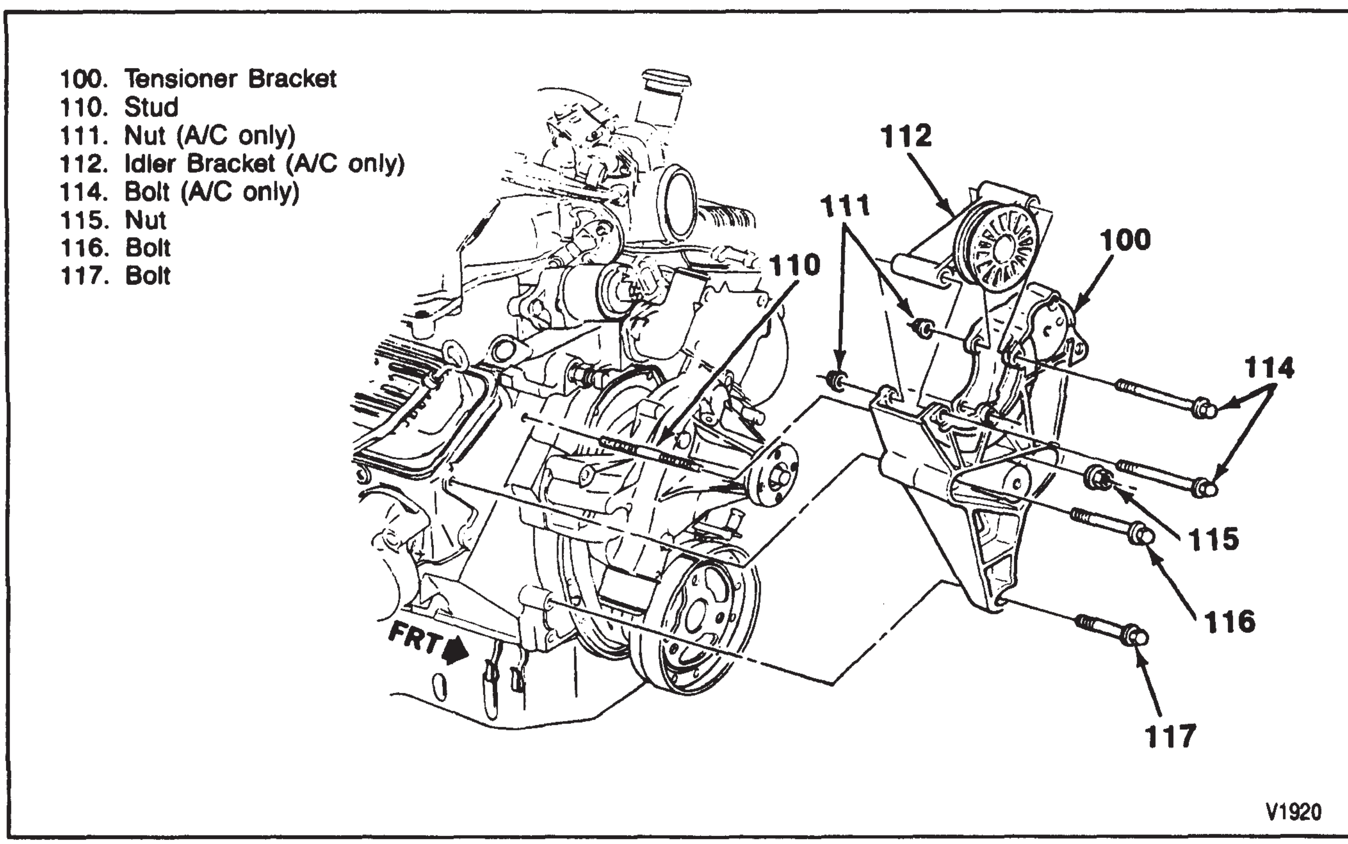


Figure 23—Idler Pulley and Bracket (4.3L Engine)

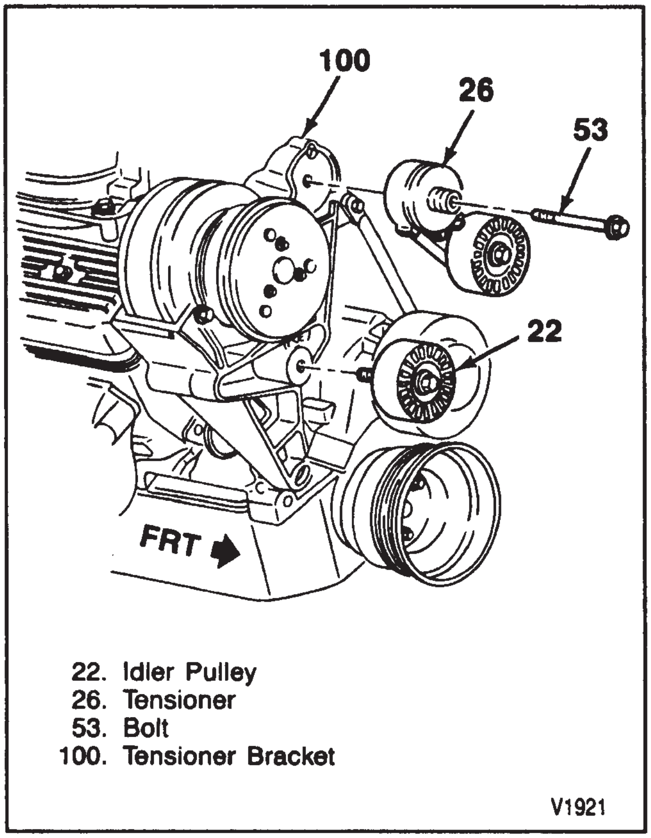


Figure 24—Belt Tensioner and Idler Pulley (4.3L Engine)

ENGINE OIL COOLER LINE REPLACEMENT

TWO-WHEEL DRIVE

Remove or Disconnect (Figures 29 and 30)

1. Lines (92) from radiator (87).
2. Lines (92) from oil filter adapter (94).
3. Bracket (86).
4. Engine oil cooler lines (92) from vehicle.

Install or Connect

1. Oil cooler lines (92) to vehicle
2. Limes to oil filter adapter (94).
3. Lines (92) to radiator oil cooler.
4. Bracket (86).

FOUR-WHEEL DRIVE

Remove or Disconnect

1. Lines (92) from remote oil filter adapter (91) to radiator.
2. Seals (93) from adapter (91) and radiator (87).
3. Lines (92) from remote oil filter adapter (91) to engine mounted adapter (94).
4. Seals (93) from remote (91) and engine mounted adapters (94).

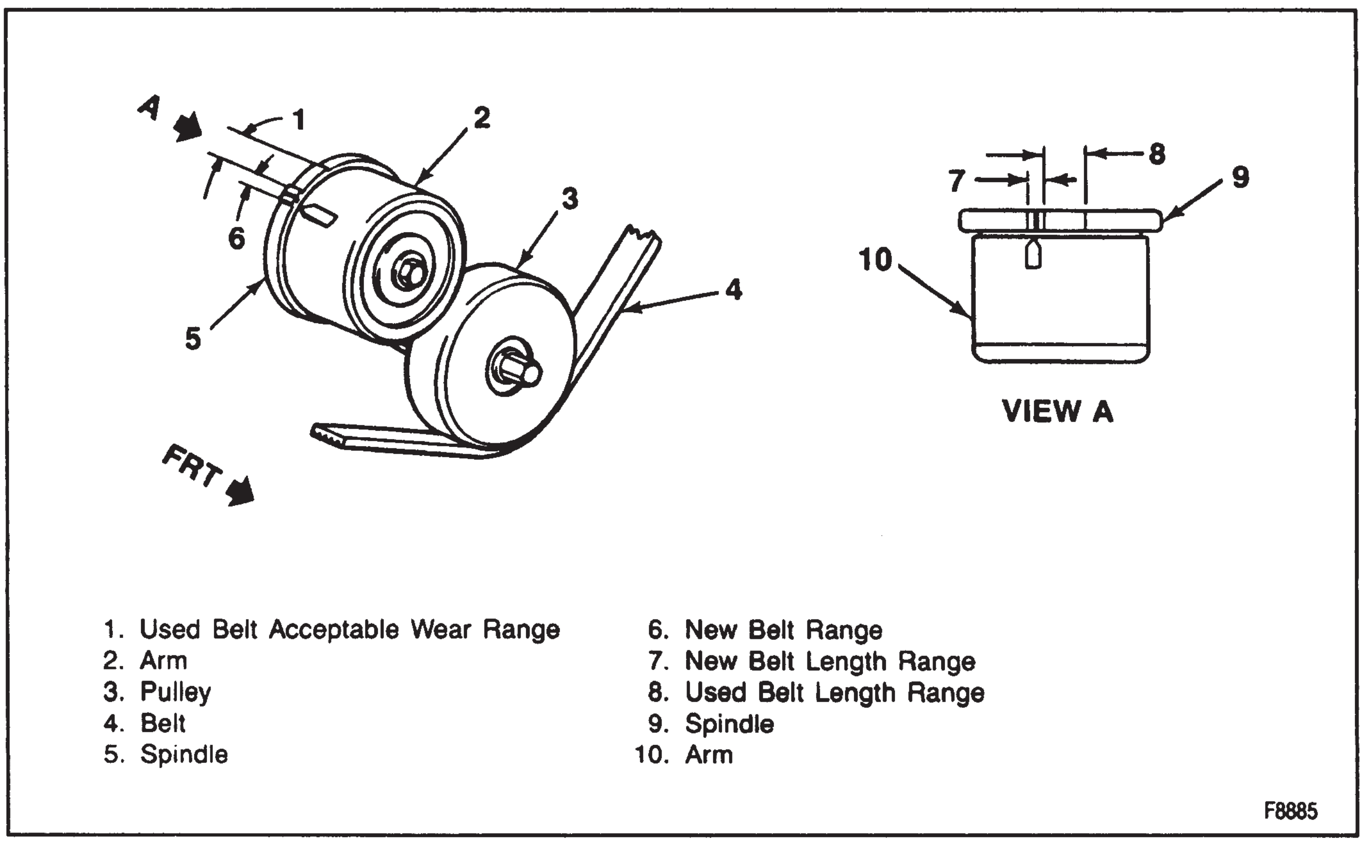
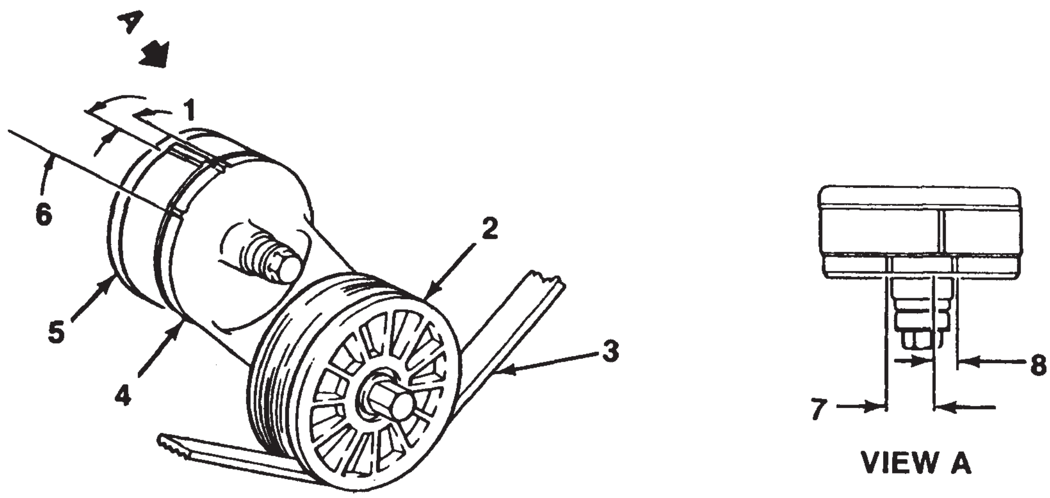


Figure 25—Automatic Belt Tensioner and Belt Length Scale (4.3L Engine)



1. New Belt Range
2. Pulley
3. Belt
4. Arm
5. Spindle
6. Used Belt Acceptable Wear Range
7. Used Belt Length Range
8. New Belt Length Range

F8886

Figure 26—Automatic Belt Tensioner and Belt Length Scale (4.3L Engine)

Install or Connect

1. New seals (93) to remote (91) and engine mounted adapters (94).
2. Lines (92) to remote oil filter (91) and engine mounted adapter (94).
3. New seals (93) to radiator (87) and remote oil filter adapter (91).
4. Lines (92) to remote oil filter adapter (91) and radiator.

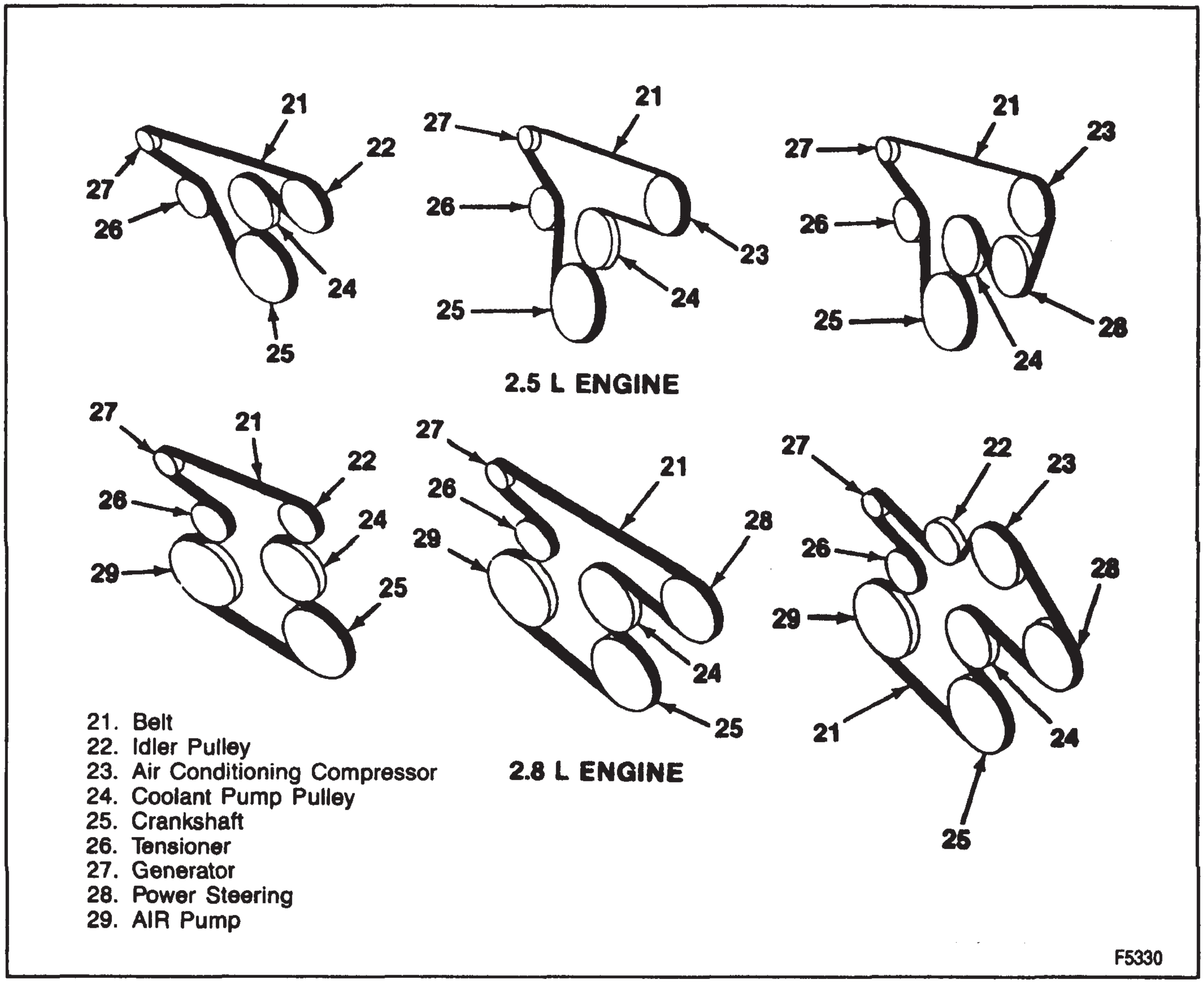
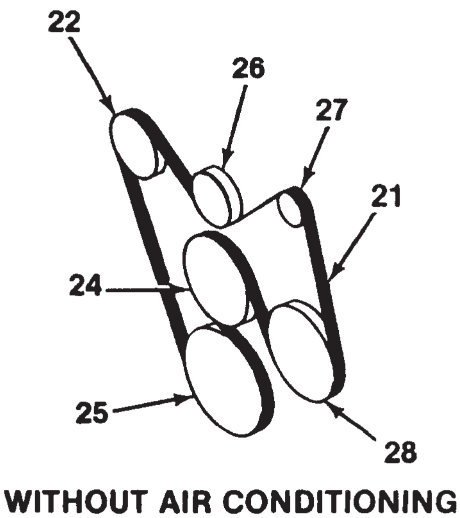
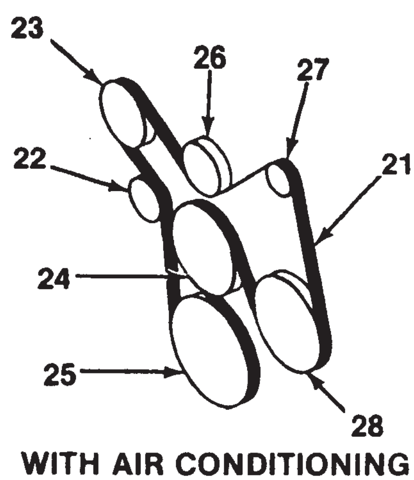


Figure 27—Multiple Rib Drive Belt Routing (2.5L and 2.8L Engines)

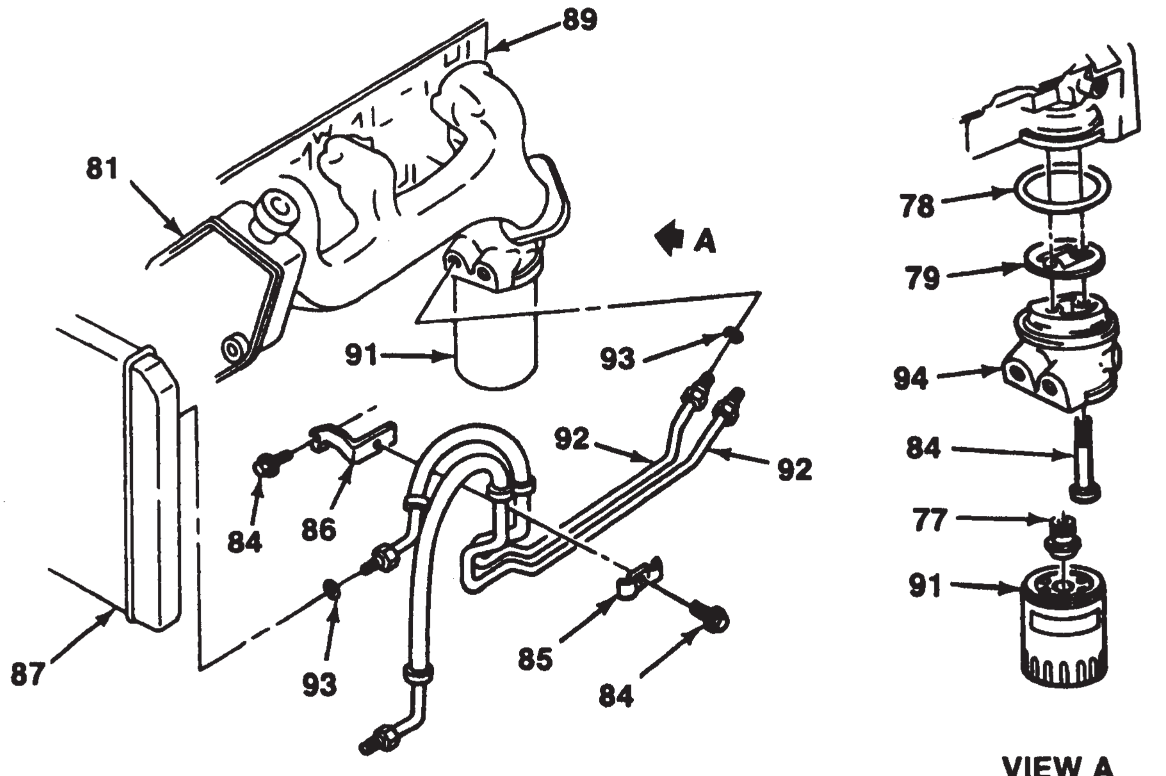




21. Belt
22. Idler Pulley
23. Air Conditioning Compressor
24. Water Pump
25. Crankshaft
26. Tensioner
27. Generator
28. Power Steering
29. AIR Pump

F5329

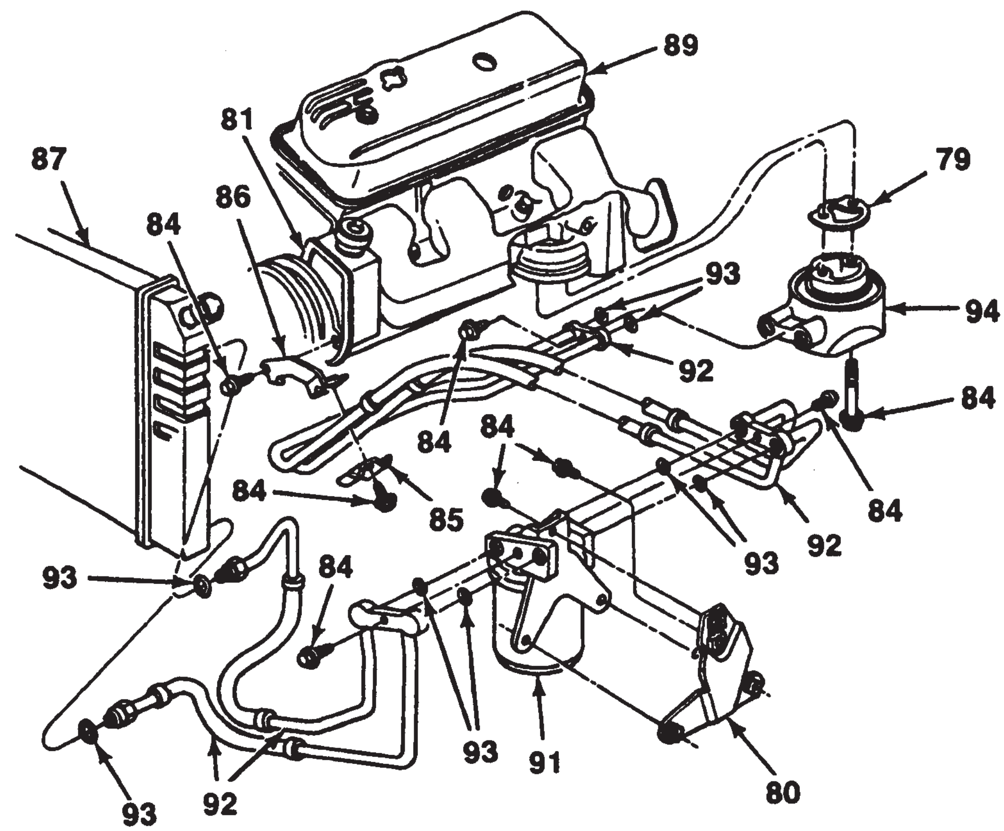
Figure 28—Multiple Rib Drive Belt Routing (4.3L Engine)



77. Fitting
78. Seal
79. Gasket
81. Power Steering Pump
84. Bolt
85. Clamp
86. Bracket
87. Radiator
89. Engine
91. Oil Filter
92. Oil Cooler Lines
93. Seals

F9094

Figure 29—Engine Oil Cooler Lines (Two-Wheel Drive)



79. Gasket
80. Bracket
81. Power Steering Pump
84. Bolt
85. Clamp
86. Bracket
87. Radiator
89. Engine
91. Oil Filter
92. Oil Cooler Lines
93. Seals
94. Adapter

F9082

Figure 30—Engine Oil Cooler and Lines (Four-Wheel Drive)

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

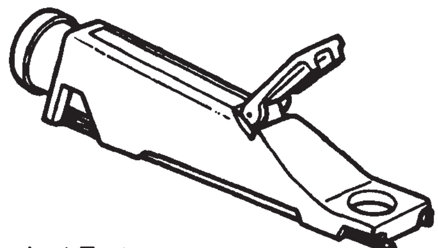
	N·m	Ft. Lbs.
Coolant Tank Screw	9	7*
Fan To Clutch Assembly Bolt - 2.5L Engine With Air	35	26
Coolant Pump Hub Stud - 2.5L Engine With Air	8	6*
Nut - Coolant Pump Pulley and Clutch - 2.5L Engine With Air	29	18
Coolant Pump Hub Stud - 2.8L Engine	8	6*
Fan to Clutch - 2.8L Engine	35	26
Fan and Clutch Assembly to Pulley Nut - 2.8L Engine	29	18
Thermostat Outlet Housing Bolt - 2.5L and 2.8L Engines	28	21
Thermostat Outlet Housing Stud - 2.5L Engine	28	21
Coolant Pump to Engine Block Bolt - 2.5L Engine	23	17
Coolant Pump to Engine Block Bolt - 2.8L Engine	30	22
Coolant Pump to Engine Block Stud - 2.8L Engine	30	22
Thermostat Outlet Housing Bolts - 4.3L Engine (VIN Z)	28	21
Thermostat Outlet Housing Bolts - 4.3L (VIN W)	40	30
Belt Tensioner Bolt	19	14
Coolant Pump Bolts - 4.3L Engine	85	63
Fan Clutch Nuts - 4.3L Engine	35	26

*Inch Pounds

T2029

SPECIAL TOOLS

1



J-23688 (Farenheit Scale)
J-26568 (Centigrade Scale)

1. Coolant Tester

F2603

SECTION 6B2

RADIATOR

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

RADIATOR

The radiator is a crossflow, tube, and center type, utilizing an aluminum core with plastic side tanks. The core and side tanks can be replaced separately. Core repair is easily made with the hot melt adhesive method. Refer to figures 1, 2, and 3.

All radiators are fitted with a shroud designed to assist the fan in directing air flow through the radiator core and also serve as a fan guard. Provision for coolant expansion is achieved with a coolant recovery tank. This retards coolant overflow and reduces frequent refills.

Pressure is maintained in the radiator and system by a pressure cap. The pressure cap has two valves; one relieves pressure and the other compensates for coolant contraction when the engine is stopped. Radiator caps are provided in 103 kPa (15 psi) rating.

Radiators used with automatic transmissions have transmission oil coolers built into the right hand tank, with inlet and outlet fittings for transmission fluid circulation. Manual transmission vehicles use radiators without transmission oil coolers. Vehicles equipped with air conditioning use a radiator with extra cooling capacity for greater cooling demands. There is an optional engine oil cooler available that is built into the left hand tank, with inlet and outlet fittings for engine oil circulation.

RADIATOR CAP

A pressure-vent cap allows a build-up of 103 kPa (15 psi) in the cooling system. This pressure raises the boiling point of the coolant to about 125°C (257°F) at sea level. Do not remove the radiator cap to check the engine coolant level; check the coolant visually at the see-through coolant reservoir. Add coolant to the reservoir when the system cools.

CAUTION: As long as there is pressure in the cooling system, the temperature can be considerably higher than the boiling temperature of the solution in the radiator, without causing the solution to boil. Removal of the radiator cap while the engine is hot and the pressure is high will cause the solution to boil instantaneously and possibly with explosive force, spewing the solution over the engine, fenders, and person removing the cap. If the solution contains flammable anti-freeze such as alcohol (not recommended for use at any time), there is also the possibility of causing a serious fire.

The pressure-type radiator filler cap contains a blow off or pressure valve and a vacuum or atmospheric valve. The pressure valve is held against its seat by a

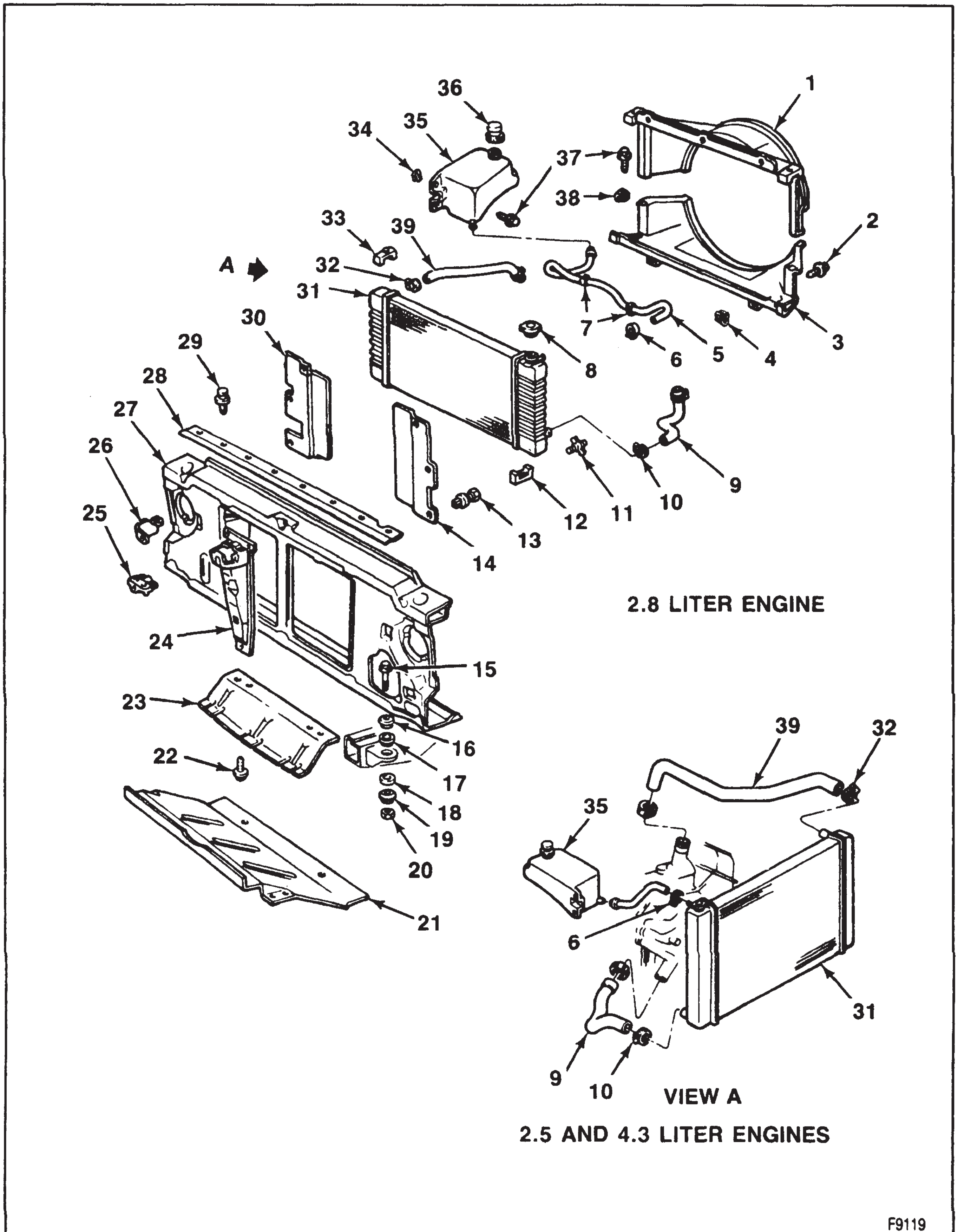


Figure 1—Radiator Mounting and Related Parts

1. Upper Fan Shroud
2. Hex Bolt
3. Lower Fan Shroud
4. U-Nut
5. Coolant Reservoir Hose
6. Clamp
7. Plastic Retainer
8. Radiator Fill Cap
9. Radiator Outlet Hose
10. Clamp
11. Drain Cock
12. Insulator
13. Retainer
14. Left Support Baffle
15. Bolt
16. Spacer
17. Cushion
18. Frame Support Insulator
19. Retainer
20. Hex Nut
21. Shield
22. Hex Bolt
23. Radiator Support Lower Baffle
24. Support
25. Hood Latch Catch
26. Hood Stop
27. Radiator Support
28. Hood Seal
29. Hood Seal Retainer
30. Right Support Baffle
31. Radiator
32. Clamp
33. Insulator
34. Spring Nut
35. Reservoir
36. Reservoir Cap
37. Hex Bolt
38. U-Nut
39. Radiator Inlet Hose
40. Upper Radiator Hose
41. Lower Radiator Hose

F9120

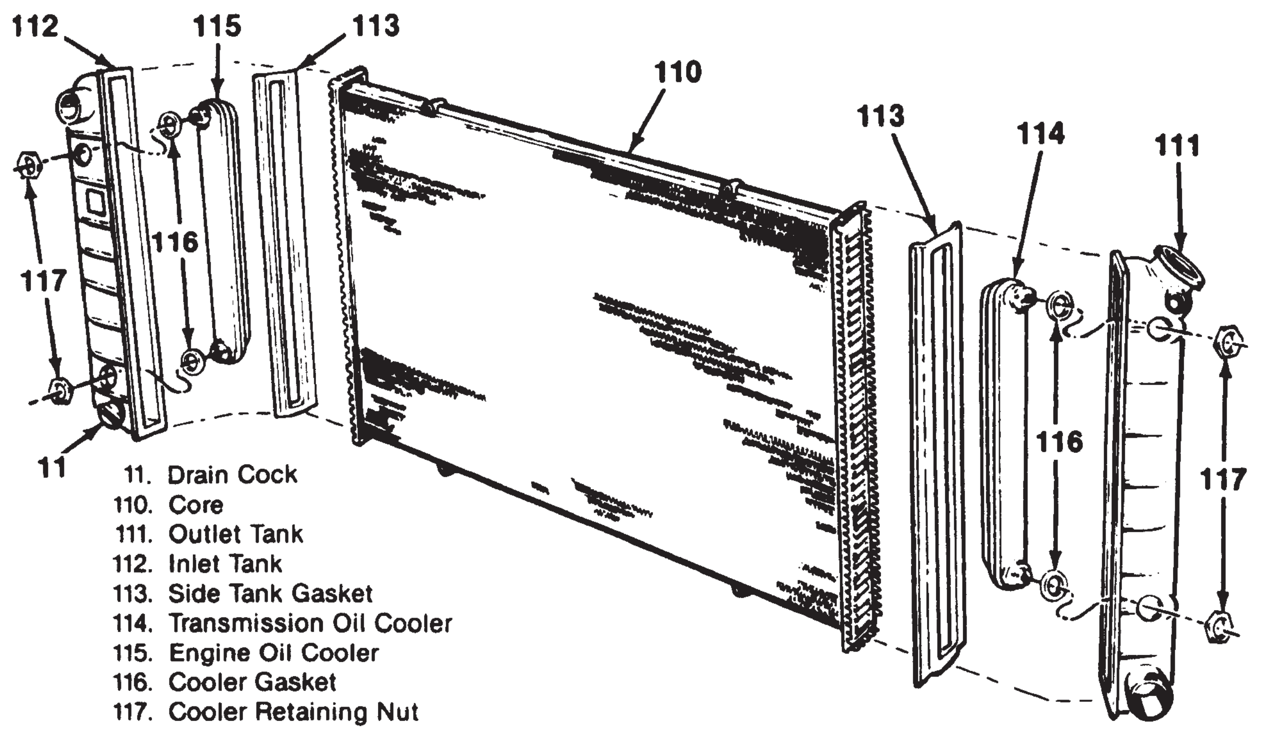
Figure 2—Radiator Mounting and Related Parts

spring of pre-determined strength, which protects the radiator by relieving internal pressure when it exceeds cooling system design limits. The vacuum valve is held against its seat by a light spring which permits opening of the valve to relieve vacuum created in the system when it cools off and which otherwise might cause the radiator to collapse (figure 4).

The radiator cap is designed to discourage inadvertent removal. To safely remove the cap, rotate the cap slowly counterclockwise (do not press down) to detent. Allow any pressure to relieve. Next, press down on the cap and continue to rotate cap counterclockwise and lift off the cap.

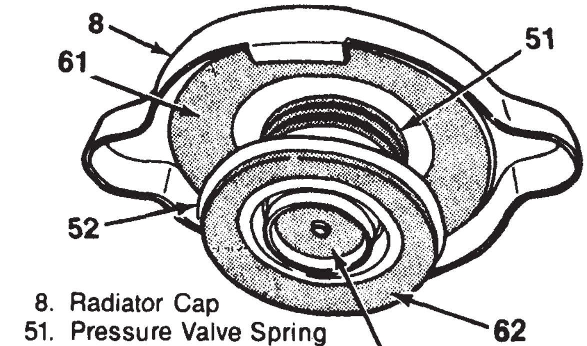
Under the diaphragm spring at the top of the cap is a rubber asbestos gasket. Embossed on the cap is a caution against its being opened and arrows indicating the proper closed position (figure 5).

The seal of the filler cap and the operation of the pressure relief valve can be checked using a conventional cooling system testing kit (figure 6).



F9121

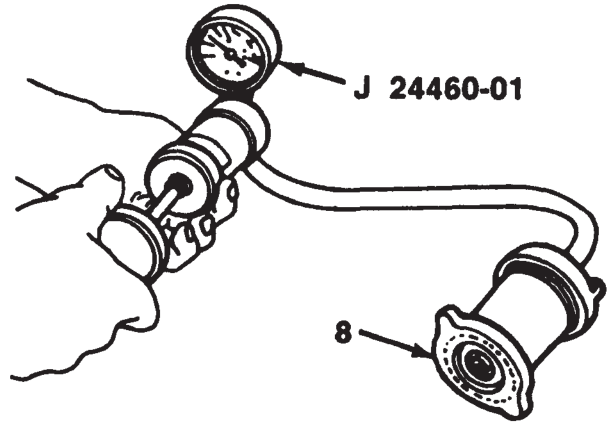
Figure 3—Radiator Components



8. Radiator Cap
51. Pressure Valve Spring
52. Pressure Relief Valve
53. Vacuum Valve
61. Radiator Cap Seal
62. Pressure Valve Seal

F9122

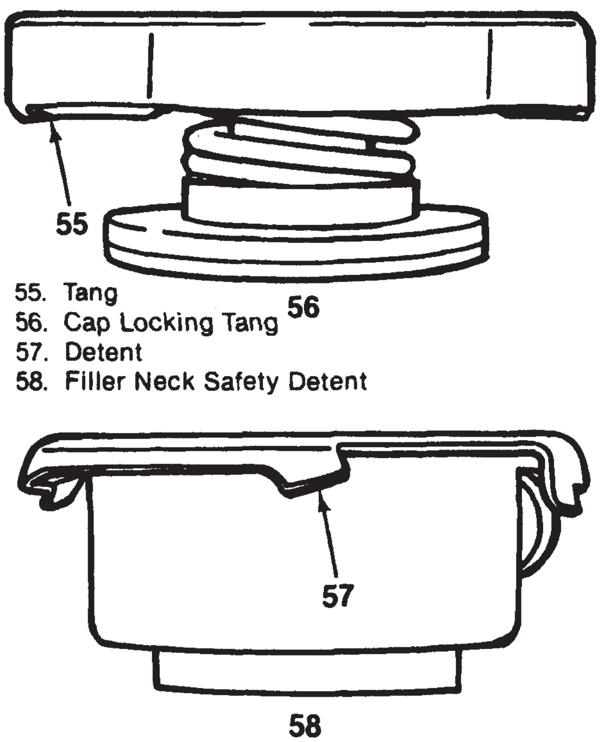
Figure 4—Radiator Cap Pressure and Vacuum Valves



8. Radiator Cap

F9123

Figure 6—Testing the Radiator Pressure Cap



55. Tang
56. Cap Locking Tang
57. Detent
58. Filler Neck Safety Detent

B8671

Figure 5—Radiator Cap and Filler Neck

DIAGNOSIS OF RADIATOR

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine Overheats	1. Cooling area obstructed. 2. Radiator fins plugged. 3. Leaking radiator. 4. Bent fins.	1. Remove or relocate added on parts that may block air to the radiator. 2. Remove any debris (bugs, leaves, etc.) from the radiator fins. 3. Repair leaks or replace seals. 4. Repair or replace.
Radiator Loose	1. Loose screws. 2. Missing insulators.	1. Tighten screws. 2. Replace insulators.
		D0133

MAINTENANCE RECOMMENDATIONS

Check the outside of the radiator for bent fins or signs of leakage. Repair leaking radiator cores.

Do not seal temporarily with a sealer type antifreeze or coolant additive. Remove any stones between the fins. Clean loose debris and road film from the radiator core with a quality grease solvent and compressed air. Direct the stream of solvent at the front of the core for more efficient cleaning.

Remove the grille, fan guard, and fan shroud, to ensure a thorough cleaning.

Remove the radiator cap and look for plugging and scale on the inside of the tank. Replace a badly plugged radiator. Test the radiator and system as described in ENGINE COOLING (SECTION 6B1).

1. Check the coolant level. If low, add recommended coolant as required.
2. Check the hose conditions and tighten the clamps if leakage is evident. Replace cracked, stripped, or corroded clamps.
3. Check the coolant hoses for spongy or cracked appearance. Replace deteriorated hoses or bursting could occur, which would result in coolant loss and extensive damage due to overheating.
4. Check the radiator core for leaks and for accumulation of dirt which may obstruct the air passages and reduce heat transfer.
5. Check the surge tank or recovery tank for leaks. Plastic bottles may develop cracks from being damaged by flying objects. Metal tanks should be checked at weld seams.
6. Inspect the radiator rubber mountings and bumpers for deterioration and replace as necessary. Check the mounting bolts, supports, braces, tie rods, and stabilizer rods. Components should be securely fastened in place if mounting bolts are missing, loose, or stripped. Also check for damage to core, side flanges, and supporting components.
7. Check for clearance between the fan blades, core, and shroud. Check the fan attaching bolts for tightness and that none are missing. Replace the fan if any blade is bent. The distance between the blades and shroud should be equal around the entire perimeter of the shroud. Adjust as necessary after any adjustment has been made to the fan or the fan mounting bracket and hub.
8. Inspect the filler cap seal for evidence of cracking, separation, or deterioration. Replace as required.
9. To assist in maintaining efficient heat dissipation, an occasional external flushing with water will remove the majority of dirt accumulation and foreign matter from between the core fins. Direct water under moderate pressure from behind the core to force debris out in the opposite direction of its entry. Direct the water stream in line with the fins to reduce the possibility of bending fins.

RADIATOR INTERNAL DEPOSITS

A radiator with a dirty, obstructed, or leaking core will cause the engine to overheat. A scale deposit inside the radiator is a result of using hard, high mineral content water in the cooling system. The effect of heat on the minerals in the water causes the formation of scale, or hard coating, on metal surfaces within the radiator, thereby reducing the transfer of heat. Some hard water will produce a silt-like deposit which restricts the flow of water. Replace a radiator that is plugged or has a heavy scale on the core.

SCALE REMOVAL

To remove the hardened scale, a direct chemical action is necessary. A flushing compound at the specified rate of 30 grams per liter (4 oz. per gallon) of radiator capacity, should be added to the coolant water in the form of a dissolved solution while the engine is running. Operate the engine for 15 minutes, then drain and flush the system with clean water.

There are various types of flushing compounds commercially available, but they should be obtained from a reliable source. Most compounds attack metals and should not remain in the engine for more than a few minutes. A neutralizer should be used in the cooling system immediately after a descaling solvent is used.

For extremely hard, stubborn coatings, such as lime scale, use a stronger solution. The corrosive action of a stronger solution will affect the thin metals of the radiator, thereby reducing its operating life. A complete flushing and rinsing is mandatory and must be accomplished skillfully.

After the solvent and neutralizer have been used and the cooling system is flushed, drain the entire system and fill it with clean, soft water plus a rust inhibitor or high boiling type antifreeze. After filling the cooling system, check for radiator, hose, and engine coolant leaks.

ON-VEHICLE SERVICE

RADIATOR REPLACEMENT

Remove or Disconnect (Figures 1, 2, and 7 through 11)

1. Coolant from the radiator.
2. Coolant reservoir hose (17).
3. Upper fan shroud (1).
4. Hoses (8 and 21).
5. Transmission fluid cooler pipes (41 and 42).
6. Engine oil cooler pipes (48).
7. Radiator (31).

Inspect

- All parts and connections for leaks and wear. Replace if necessary.

Install or Connect (Figures 1, 2, and 7 through 11)

1. Radiator (31).
2. Engine oil cooler line fittings (48).

Tighten

- Fittings to 35 N·m (25 ft. lbs.).

3. Transmission fluid cooler line fittings (41 and 42).

Tighten

- Fittings to 27 N·m (20 ft. lbs.).

4. Hoses (8 and 21).
5. Upper fan shroud (1).
6. Coolant reservoir hose (17).
7. Coolant to the radiator.

DRAIN COCK REPLACEMENT

Remove or Disconnect (Figure 12)

1. Drain cock (118).
2. Seal (131).
3. Body (132).

Inspect

- Drain cock (118), seal (131), and body (132) for cracks or damage.

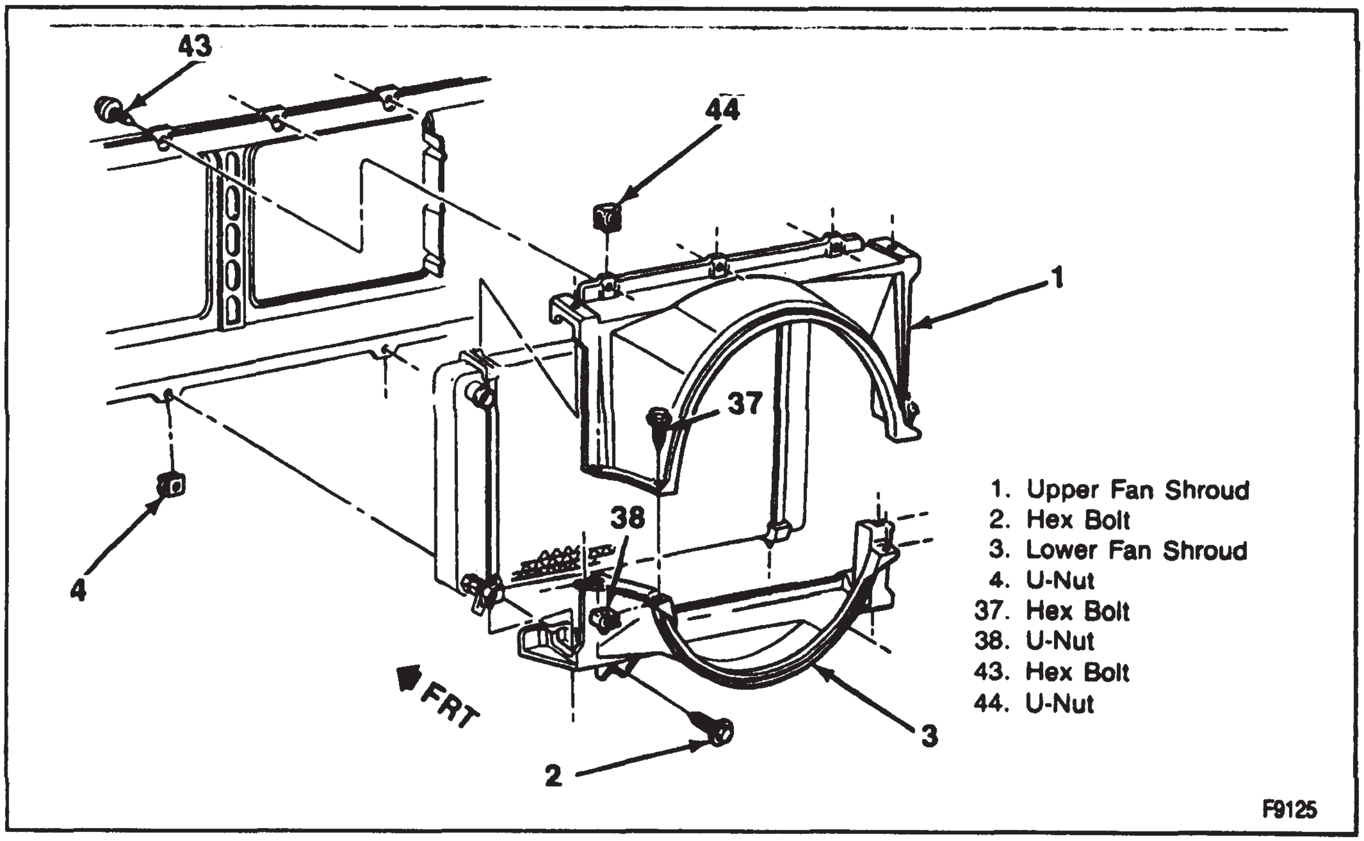


Figure 7—Fan Shroud (2.5L and 2.8L Engines)

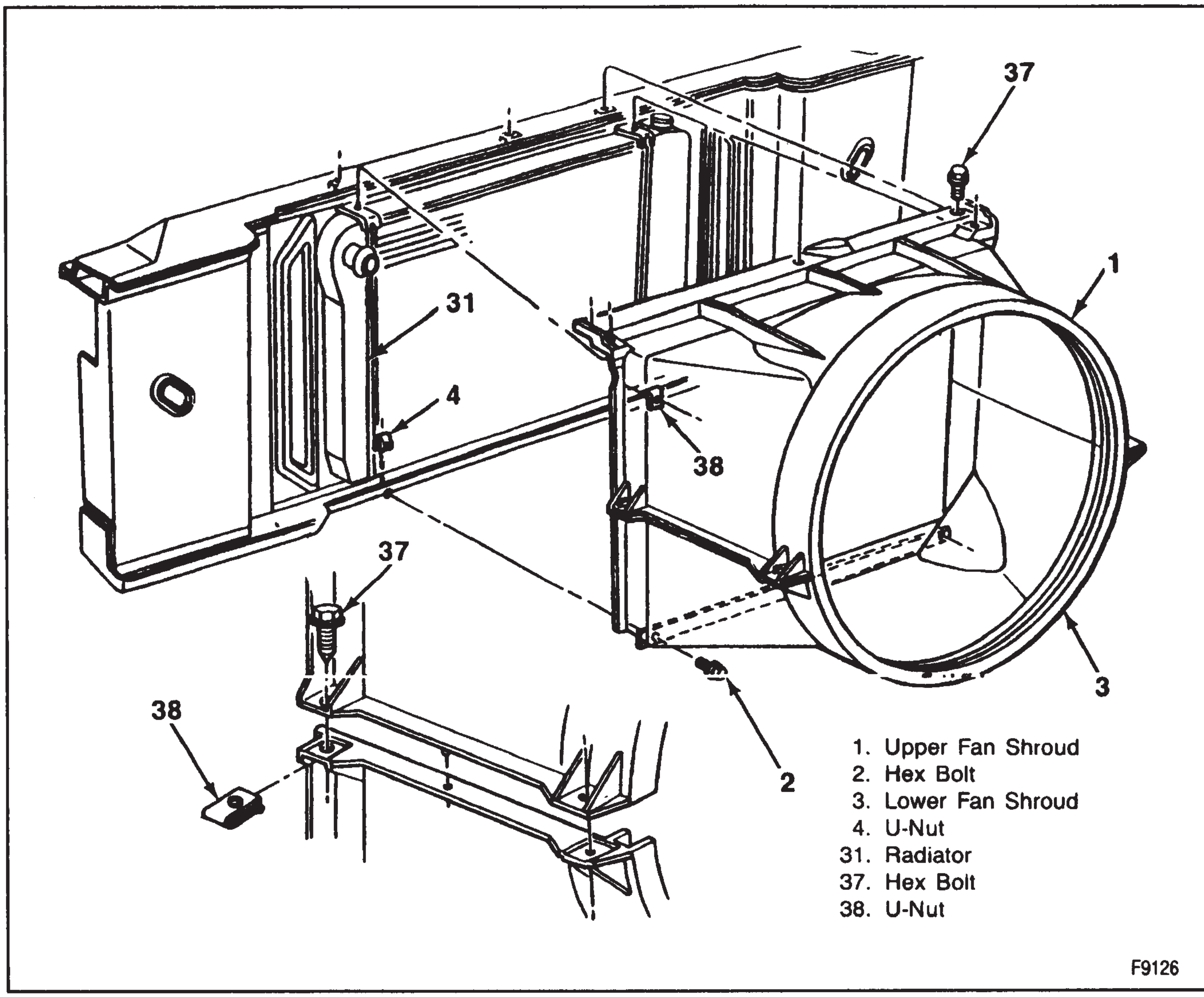


Figure 8—Fan Shroud (4.3L Engine)

Install or Connect (Figure 12)

1. Body (132).
2. Seal (131).
3. Drain cock (118).

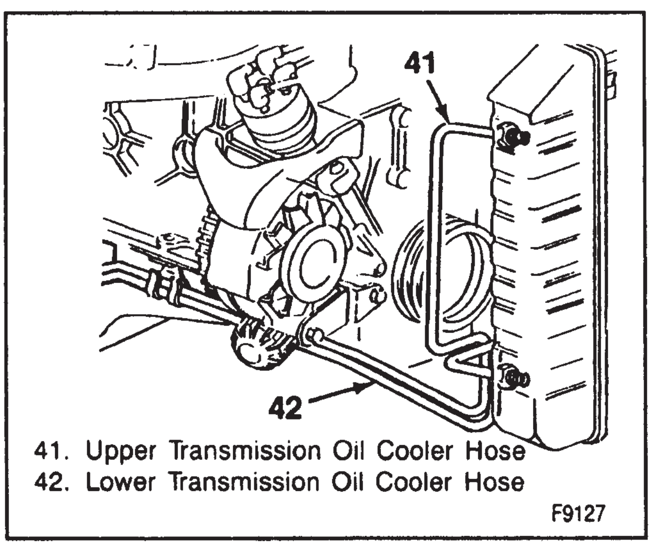


Figure 9—Transmission Fluid Cooler Pipes

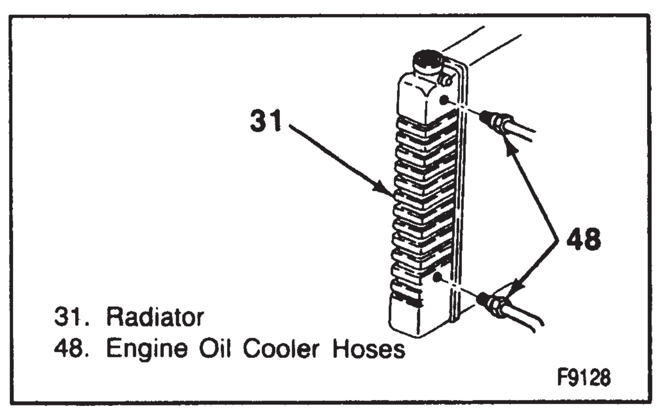


Figure 10—Engine Oil Cooler Lines

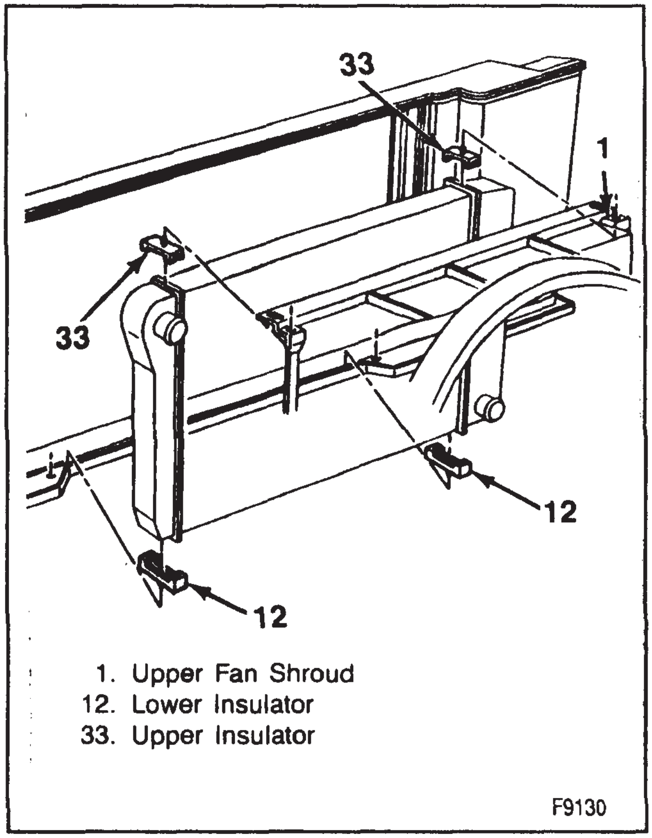


Figure 11—Radiator Replacement (2.5L, 2.8L, 4.3L Engines)

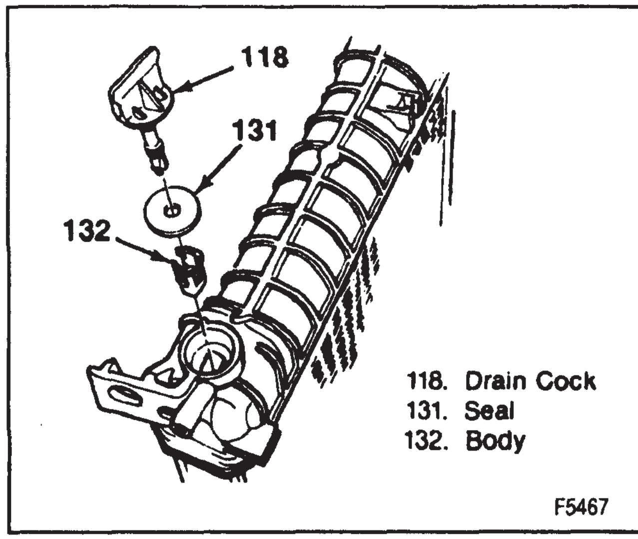


Figure 12—Drain Cock

ALUMINUM RADIATOR SERVICE

TESTING PROCEDURES

LEAK TESTING

Some core leaks can be detected by adding water to the radiator. Clean the core so that the damaged area can be found.

1. Remove dirt and insects from the fins with a common water hose without a nozzle. Excessive water pressure could damage the fins.
2. Scrub the core with a soft-bristle brush using clean, hot water, or hot water with a mild detergent.

ON-VEHICLE PRESSURE TESTING

You can pressure-test the aluminum-plastic radiator with J 24460-01 Cooling System Tester (figure 14). With the system at a cool temperature, remove the radiator cap, connect the gage, and apply normal system operating pressure. Do not exceed 138 kPa (20psi). Watch the gage needle for an indication of a leak, and examine the radiator and other cooling system parts for escaping coolant.

Repair hose and hose connections as required. Check the radiator cap to ensure that it will maintain the correct pressure.

If the radiator leaks during the pressure test, mark the leak area.

OFF-VEHICLE LEAK TESTING

NOTICE: Do not use boil-out tanks, vats, or other tanks that have been used for copper and brass radiators. The flux, acid, and caustic cleaners remaining in these tanks will attack the aluminum and cause radiator failure. Use a separate test tank containing clean water for servicing aluminum/plastic radiators.

1. Install test fittings or rubber test caps in the inlet and outlet necks and seal the oil cooler fittings with metal plugs to protect the cooler and keep the fluid from running out (figure 15).
2. Attach the pressure tester and gradually apply air pressure until 138 kPa (20 psi) is attained. Do not exceed 138 kPa (20 psi). Check the pressure gage to see if there is a pressure loss. To ensure that there are no small leaks, run water over the repair area and look for bubbles. (A mild detergent is helpful.) If a large water tank is available, submerge the radiator and check for air bubbles.

REPAIRABLE LEAKS

There are two types of leaks that can be repaired on the aluminum-plastic radiator: core leaks and gasket or seal leaks. Leaks in the plastic tanks cannot be repaired (figure 16).

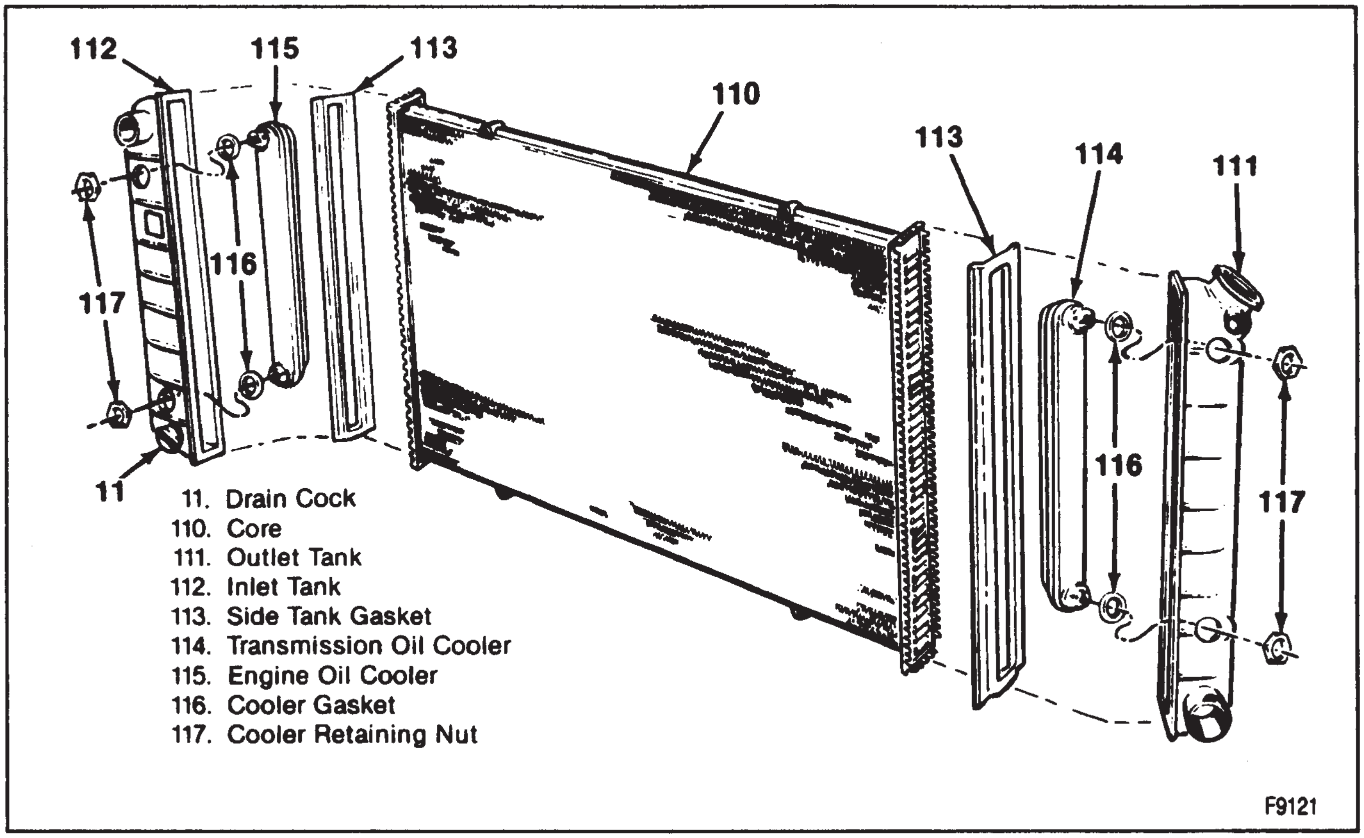


Figure 13—Radiator Components

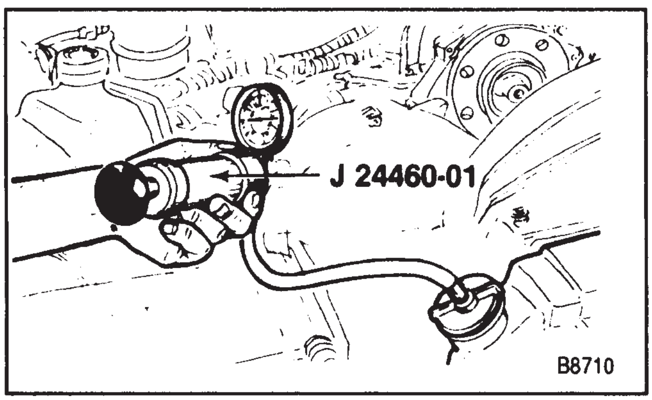


Figure 14—Pressure Testing

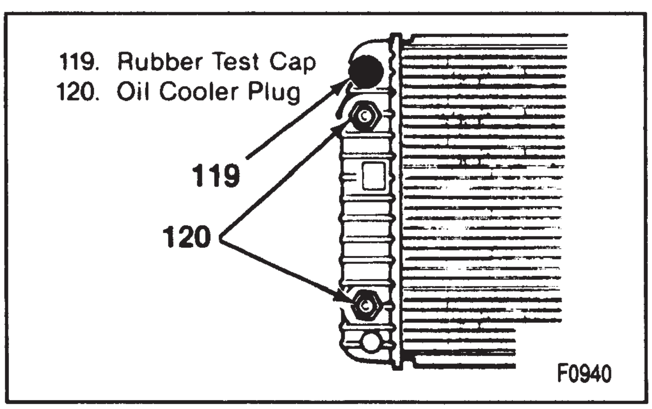


Figure 15—Oil Cooler Plugs

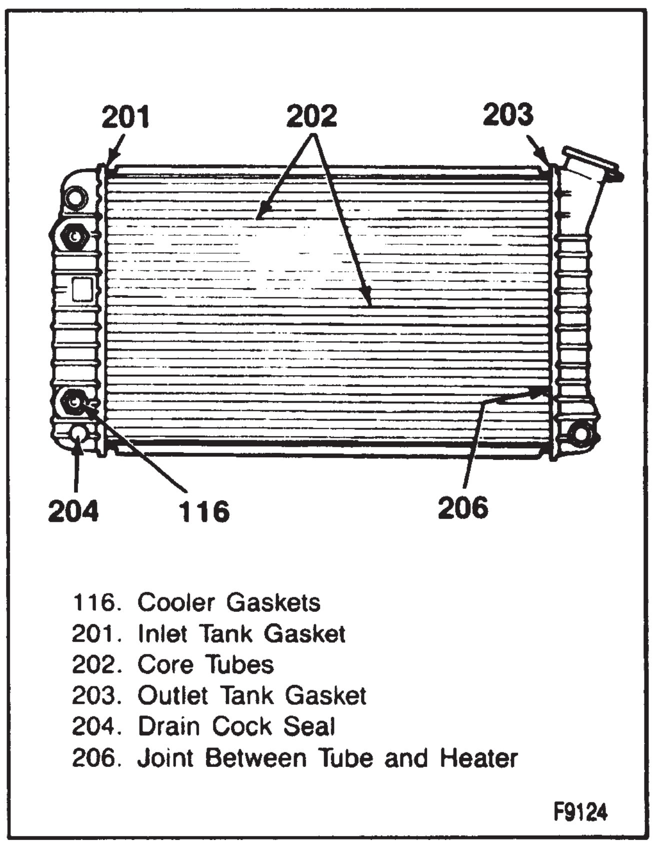


Figure 16—Possible Leak Areas

Core leaks can occur in a tube or in the joints between the tubes and headers. Gasket leaks can occur in the joints between the plastic tanks and the headers or in the joints between the oil cooler fittings and the tank. Some leaks can be repaired while the radiator is on the vehicle; however, it is usually best to remove the radiator.

REPAIR METHODS

There are several methods that can be used to repair the radiator core, but the hot melt adhesive method repair kit is the most simple and effective.

The kit contains adhesive sticks, cotton swabs, a wire brush and the primer. The adhesive stick is reusable, has an indefinite shelf life, and is waste-free. Store the sticks in a sealed container to keep them dry (figure 17).

RADIATOR REPAIR PROCEDURES

The aluminum-plastic radiator can be repaired. The following components can be replaced:

- Core
- Tanks and gaskets
- Oil coolers and gaskets
- Drain cock and gasket

The tanks cannot be repaired if broken or cracked. The radiator core can be replaced and the new core used with the original tanks and oil cooler.

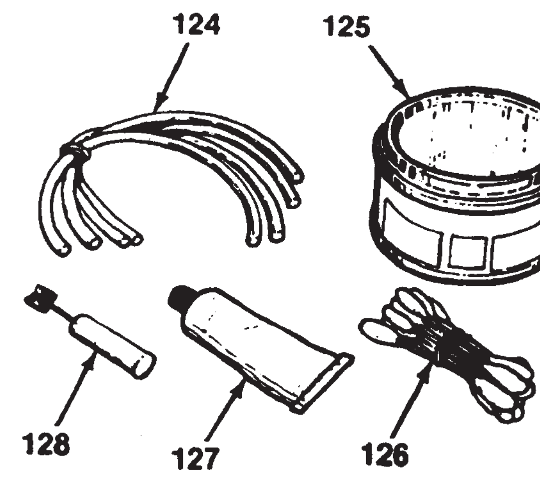
PRECAUTIONS

As with all cooling system service, take measures to prevent personal injury and damage to the system.

CAUTION: To help avoid being burned, do not remove the radiator cap while the engine and radiator are hot. Scalding fluid and steam can be blown out under pressure if the cap is taken off too soon.

NOTICE: DO NOT USE "BOIL OUT" TANKS OR VATS. Common service methods may destroy an aluminum radiator. Do not use caustic or lye cleaning solutions for aluminum radiators. USE CLEAN WATER WHEN SERVICING ALUMINUM RADIATORS.

- Do not open the hood if you can see or hear steam or coolant escaping from the engine compartment.
- Do not remove the radiator cap if the radiator feels warm.
- Do not remove the radiator cap or coolant recovery cap if the coolant in the recovery tank looks like it is boiling.
- Wear eye protection.
- Wear gloves to protect your hands against excessive heat of the effects of chemicals on your skin.
- Prevent dirt and water from entering the transmission oil cooler.
- Do not use boil-out vats or other tanks that have been used for copper and brass radiators. The flux, acid, and caustic cleaners in these tanks will attack the aluminum and cause radiator failure. Use a separate test tank containing clean water for servicing aluminum/plastic radiators.



124. Adhesive Sticks
125. Kit Container
126. Cotton Swabs
127. Primer
128. Wire Brush

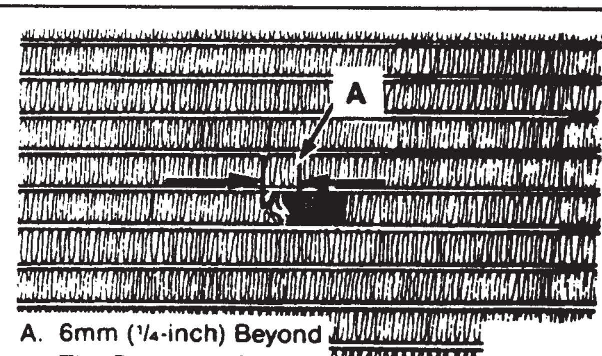
F0942

Figure 17—Hot Melt Repair Kit

NOTICE: Never use shop air to pressure test radiators that is not regulated at 138 kPa (20 psi). Pressures over 138 kPa (20 psi) will damage the radiator.

SPECIAL PREPARATION

For damaged areas between the cooling fins, it may be necessary to remove some of the fins. Do not remove more fins than necessary. Usually 6 mm (1/4 inch) beyond the leak or damaged area is enough to make an effective repair (figure 18).



A. 6mm (1/4-inch) Beyond The Damaged Area

F0946

Figure 18—Fins Removed from the Damaged Area

TUBE BLOCKING

If a tube is severely damaged, it can be blocked off (figure 19).

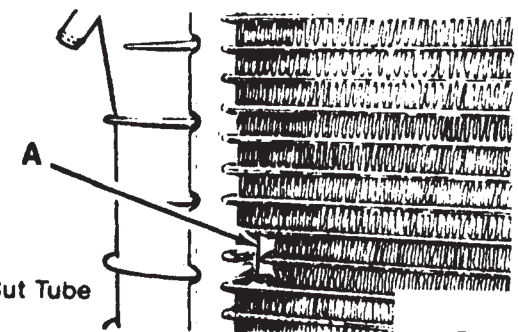
NOTICE: Do not block off more than two tubes in a radiator. Blocking off more than two tubes will reduce the cooling capacity of the system.

Cut the tube off 6 mm (1/4 inch) from the header and pinch shut before it is cleaned and sealed. Refer to "General Core Repair."

HEADER REPAIR

If the header or a tube near the header requires a repair, the side tank does not have to be removed. A wet cloth can be placed against the side tank where the repair has to be made (figure 20). The side tank can also be submerged in a tank of water up to the header (figure 21).

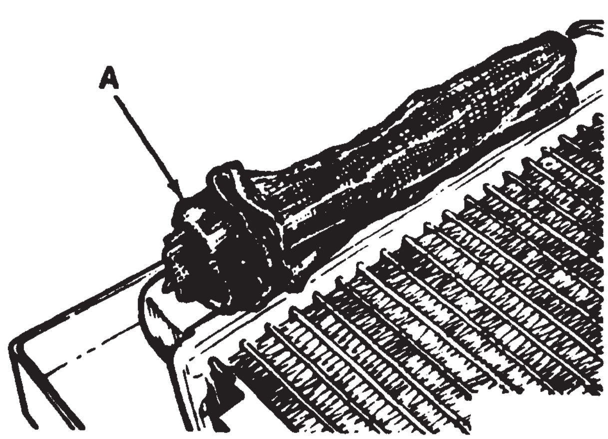
NOTICE: One of these procedures have to be used when repairs are made on or near the header to prevent damage to the tank or gasket.



A. Cut Tube

F0947

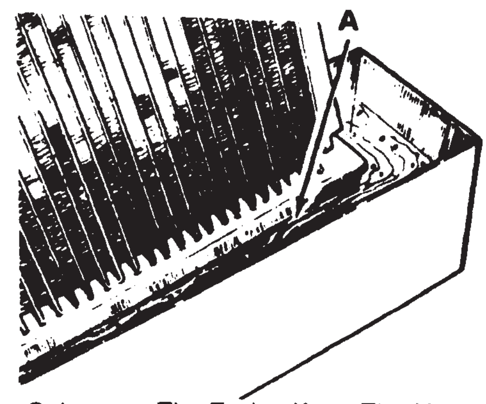
Figure 19—Tube Blocking



A. Apply A Wet Cloth

B9016

Figure 20—Using a Wet Cloth on a Side Tank



A. Submerge The Tank—Keep The Header Above The Water Line

F0949

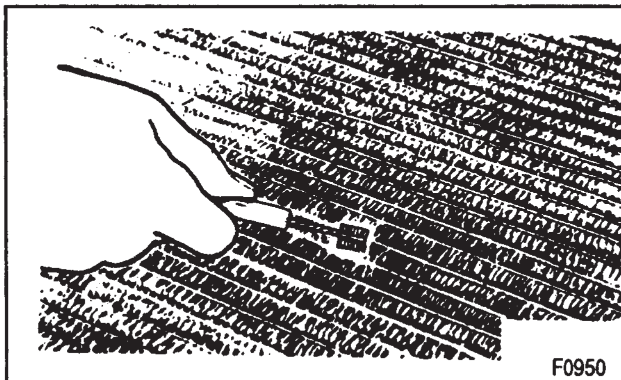
Figure 21—Submerging the Side Tank

GENERAL CORE REPAIR

Preparation of the repair area surface cannot be over-emphasized. If the leak area surface is not clean, the repair materials will not stick to the surface.

1. Position the core so the repair is accessible.
2. Apply a wet cloth if you are working near the plastic tanks or the joints between the core tubes and header (figure 20), or submerge the tank in water (figure 21).
3. Heat the repair area slightly with a small torch or heat gun to be sure it is dry. Do not use a blow torch.
4. Brush the area to be repaired with the small steel brush that is supplied in the kit and blow dust away from the repair area (figure 22).
5. Open the tube of primer, using the spurred cap or a pin, and apply primer to the repair area only. Use of the primer produces a stronger repair. Do not heat the primer.

CAUTION: The primer contains trichlorethane. It could be harmful or fatal if swallowed. If swallowed, get medical attention. Use with adequate ventilation. In case of eye contact, flush with water and get medical attention. In case of body contact, wash with soap and water. Do not mix the primer with water.



F0950

Figure 22—Cleaning the Area with a Steel Brush

6. Scrub the repair area with a cotton swab until a fresh swab stays clean. The clear, yellow-brown coating does not have to be removed (figure 23).
7. Heat the repair area with a heat gun or by moving the torch in a circular pattern (figure 24). Use a soft, small, blue flame (like a gas stove flame).
8. Withdraw the torch and rub the adhesive stick on the repair area (figure 25). The adhesive will flow at a temperature of approximately 260°C (500°F). If the stick doesn't melt, remove it and reapply the heat. Do not heat the stick with a flame. High heat will burn and char the adhesive.
9. Continue heating until the adhesive flows and wets the entire repair area and fills the joint. If a hole is in the center of a tube, heat the tube and let the hot surface melt and pull in the adhesive. The force of the flame or heat gun will also tend to guide the adhesive toward the hole. For leaks between a tube and header, flow the adhesive around the tube and header joint with the tank installed.
10. Heat the repair area until the adhesive is bubble-free and smooth, with a light yellow color. Curing is not required.
11. Test the radiator for leaks when cool. If the repair area still leaks, reheat it gently to dry it. Heat and reflow the adhesive or apply more as necessary to repair the leak.

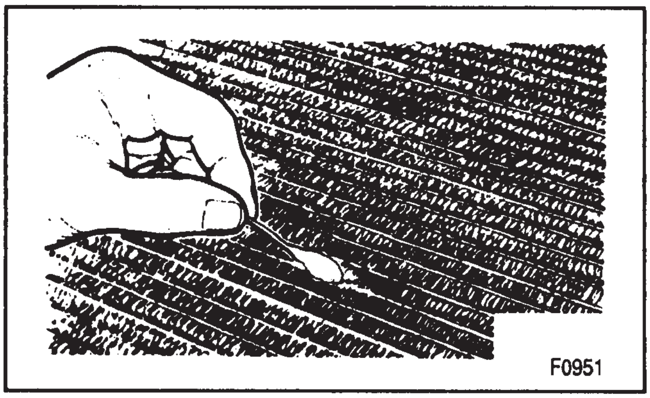


Figure 23—Scrubbing the Area with a Cotton Swab

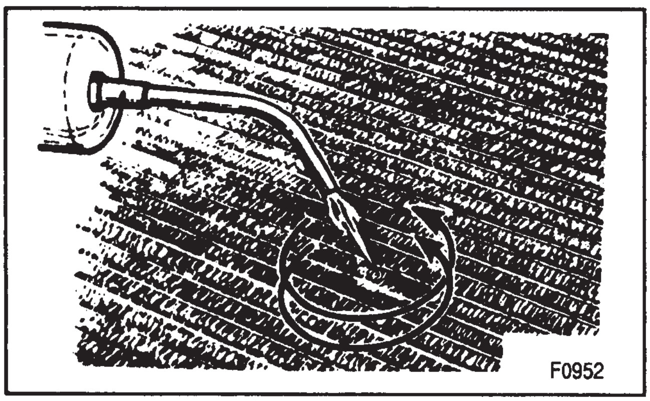


Figure 24—Heating the Repair Area

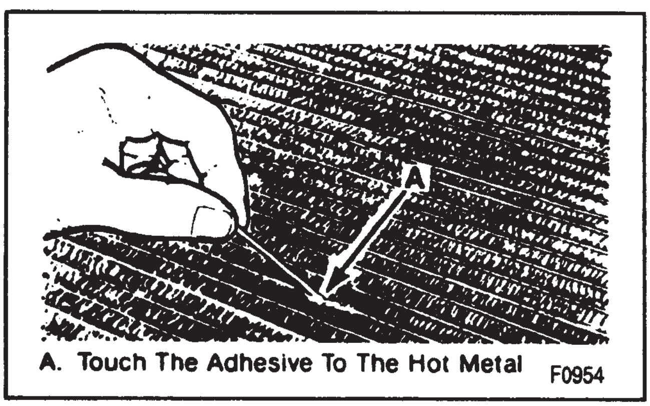


Figure 25—Applying the Hot Melt Adhesive to the Repair Area

TANK GASKET LEAK REPAIR

Tank gasket leaks can be mistaken for tank or header leaks. If a plastic tank leaks from the header joint gasket, tighten the clinch tabs with locking-type pliers (figure 26). If this method doesn't seal the leak, remove the tank for further inspection.

1. Pry open the clinch tabs, except those under the inlet, outlet, and filler necks, using BT 8260 Radiator Core Remover/ Installer or a screwdriver (figure 27). Lift the tabs only enough to allow removal.

NOTICE: Do not overbend the tabs. Overbending could result in breakage. If there are more than three tabs broken on one side of the header, or more than two adjacent tabs together, replace the core.

2. Lift the tank and slide it out from under the remaining clinched tab. You may have to have to tap the tank with your hand to dislodge the gasket. Lift the remaining tab(s) with pliers.

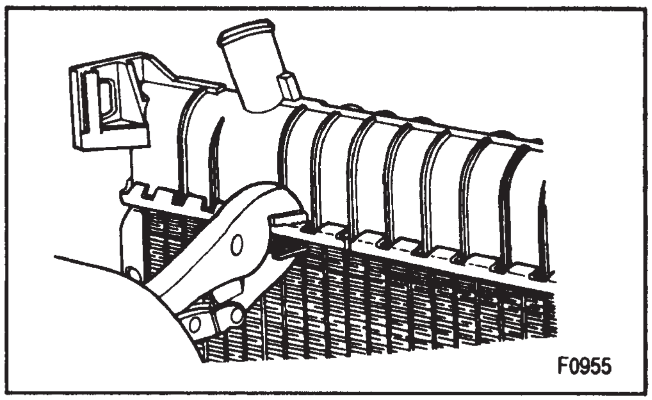


Figure 26—Tightening the Clinch Tabs

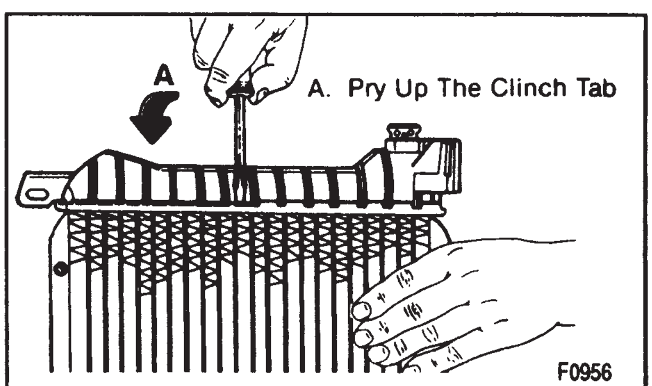


Figure 27—Opening the Clinch Tabs

3. Remove the gasket.
4. Clean the header and gasket groove of all dirt and old rubber.
5. Clean the sealing edge of the plastic tank.
6. Examine the header gasket and surface and tank flange for evidence of leakage. Clean or repair the surface to remove dirt, burrs, and bumps.
7. Remove the oil cooler, if equipped, and install it in the new tank.
8. Dip or coat the new tank gasket in engine coolant and position it on the header surface. The coolant helps hold the gasket in place.
9. Position the tank and gasket to the header. Clamp it in place and secure it by bending four clinch tabs as shown in figure 28.
10. Clamp the remaining clinch tabs around the header using the clinching tool or pliers following the clinching sequence in figure 29.

Important

- Tighten the clinch tabs starting at the center and working out to the ends.

11. Replace the core if there are more than three tabs broken on one side or two adjacent tabs broken.
12. Install the drain cock, if removed.
13. Test the radiator.

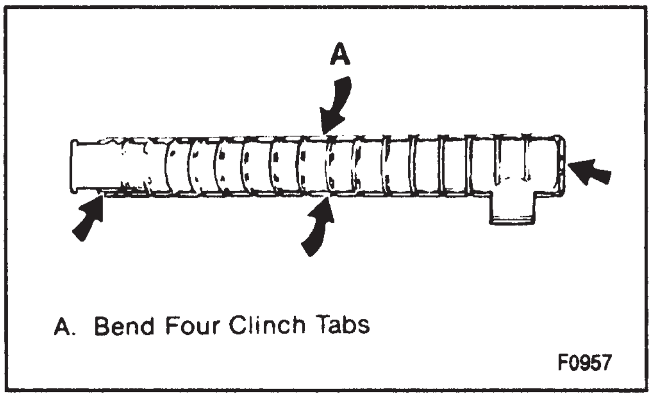


Figure 28—Seating the Tank to the Radiator Tank

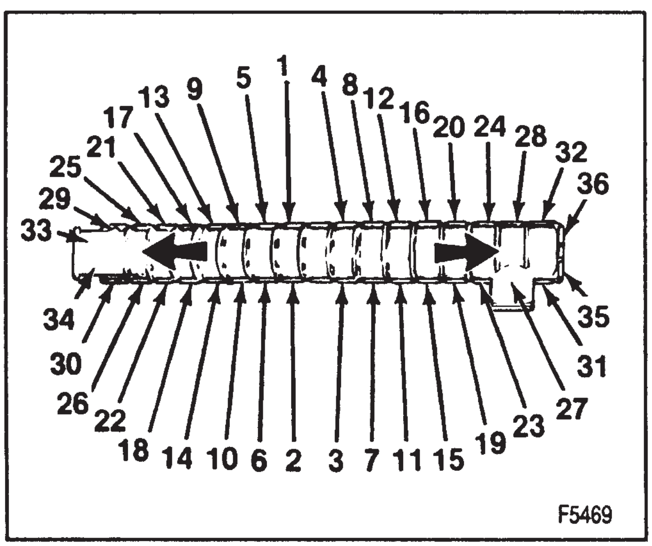


Figure 29—Clinching Sequence

OIL COOLER GASKET REPLACEMENT

Remove the outlet tank to replace the oil cooler. The oil cooler gaskets can be replaced without removing the tank.

Remove or Disconnect (Figure 30)

1. Radiator and lay it on a flat surface.
2. Bottom oil cooler nut and loosen the top nut.
3. Press the oil cooler into the hole and remove the gasket using a small hook (figure 30).
4. Blow-dry all surfaces on the tank and oil cooler.

Install or Connect (Figure 30)

1. New gasket without lubrication.
   - Be sure it is seated properly inside the tip of the fitting.
   - Reach into the oil cooler and push it into position against the tank.
2. Loosely assemble the oil cooler nut.
3. Replace the other gasket by following the same procedure.

NOTICE: See "Notice" on page 6B2-1.

4. Install the oil cooler nuts.

Tighten

- Engine oil cooler nuts to 20 N·m (15 ft. lbs.).
- Transmission oil cooler nuts to 27 N·m (20 ft. lbs.).
- Do not overtighten.

5. Leak test.

OIL COOLER REPLACEMENT

Remove or Disconnect (Figure 13)

1. Side tank (111) or (112) from the radiator.
2. Nuts from the oil cooler fitting (117).
3. Oil cooler (114) or (115) and gaskets (116).

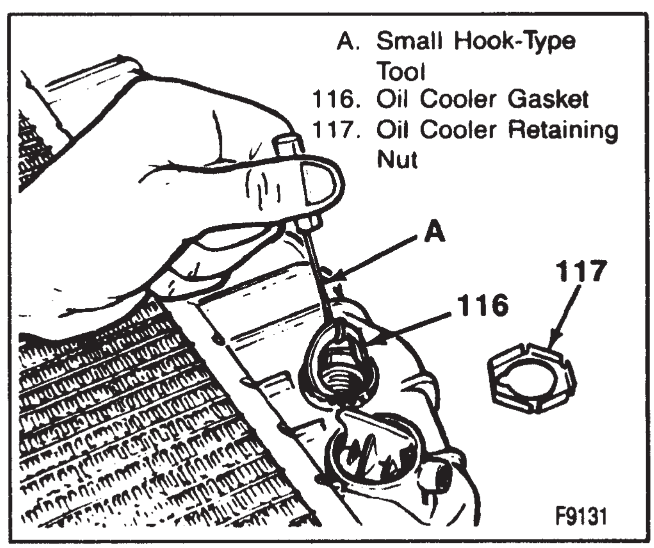


Figure 30—Removing the Oil Cooler Gasket

4. Rubber gaskets (116) from the oil cooler (114) or (115).

Clean

- Oil cooler gasket areas.

Install or Connect (Figure 13)

1. Rubber gaskets (116) to the oil cooler (114) or (115).
2. Oil cooler (114) or (115) to the side tank (111) or (112).
   - Do not loosen or misalign the gaskets.

NOTICE: See "Notice" on page 6B2-1.

3. Retaining nuts (117).

Tighten

- Transmission oil cooler nuts to 27 N.m (20 ft. lbs.).
- Engine oil cooler nuts (117) to 20 N.m (15 ft. lbs.).

4. Side tank (111) or (112) to the radiator.
5. Leak test.

RECORE

If the radiator core is damaged beyond repair and the other parts are serviceable, install the original inlet and outlet tanks, oil cooler, radiator cap, and drain valve, along with the new core and new gaskets.

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Item	N·m	Ft. Lbs.
Shroud and Radiator Screws	10	8*
Oil Cooler Line Fittings	35	25
Transmission Cooler Line Fittings	27	20
Oil Cooler Retainer Nuts	27	20
Transmission Cooler Retainer Nuts	27	20

*Inch-pounds

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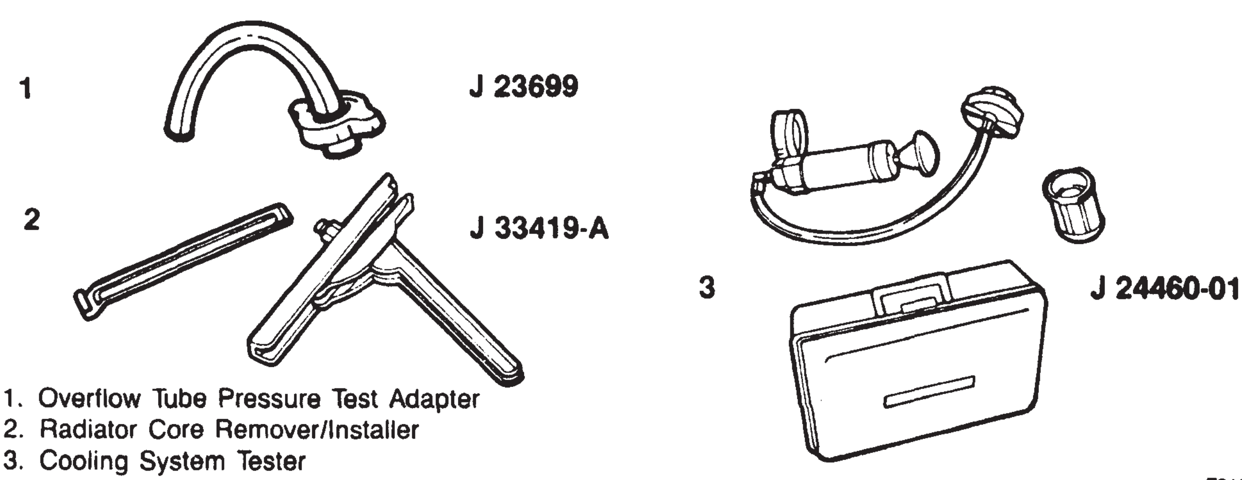
SPECIAL TOOLS



1. Overflow Tube Pressure Test Adapter
2. Radiator Core Remover/Installer
3. Cooling System Tester

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SECTION 6C

FUEL SYSTEM

The engines used in this vehicle use a Throttle Body Injection (TBI) or a Central Port Injection (CPI) unit in the fuel system. All fuel system information pertaining to the TBI and CPI units, fuel filters, fuel pumps, fuel tanks, and accelerator controls can be found in the 1992 Light Duty Fuel and Emissions Manual if you are using X-9229 or to the Fuel and Emissions section at the rear of this manual if you are using ST-369-92.

SECTION 6D

ENGINE ELECTRICAL

CONTENTS

ELECTRICAL SYSTEM

Engine electrical system diagnosis includes the battery, charging system (generator and related wiring), cranking system, and ignition system (distributor, spark plugs and wiring).

Each vehicle is equipped with an electronic computer command control system. There is a "Service Engine Soon" lamp on the instrument panel. For a detailed description of the lamp's operation and use as a diagnostic indicator, refer to the Fuel and Emissions Section or Service Manual. If you are using ST 369-92, refer to the Fuel and Emissions section at the back of the service manual. If you are using X-9229, refer to the separate Fuel and Emissions Service Manual.

SECTION 6D1

BATTERY

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

BATTERY

GENERAL DESCRIPTION

The battery has three major functions in the electrical systems: first, it provides a source of energy for cranking the engine; second, it acts as a voltage stabilizer for the electrical system; and third, it can, for a limited time, provide energy when the electrical load used exceeds the output of the generator.

The battery specification label contains information pertinent to the servicing of the battery such as test ratings and recommended replacement part numbers. This information is also included in the specifications at the end of this section. The label also includes safety warnings (figure 1).

The sealed battery as shown in figure 2 is standard. Refer to "Specifications" at the end of this section for specific application.

Water never needs to be added to the sealed battery. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents allow what small amount of gasses that are produced in the battery to escape. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages.

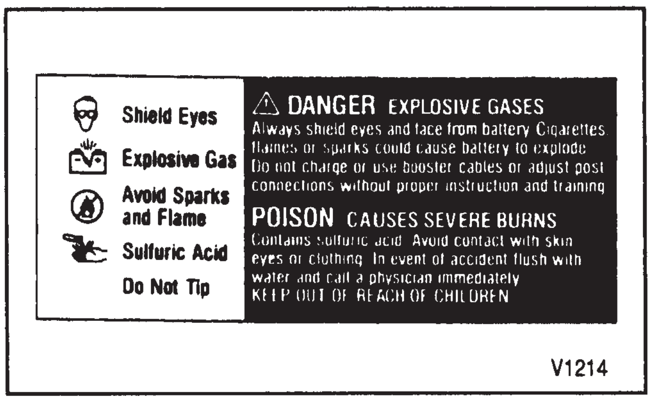

Figure 1—Safety Precautions

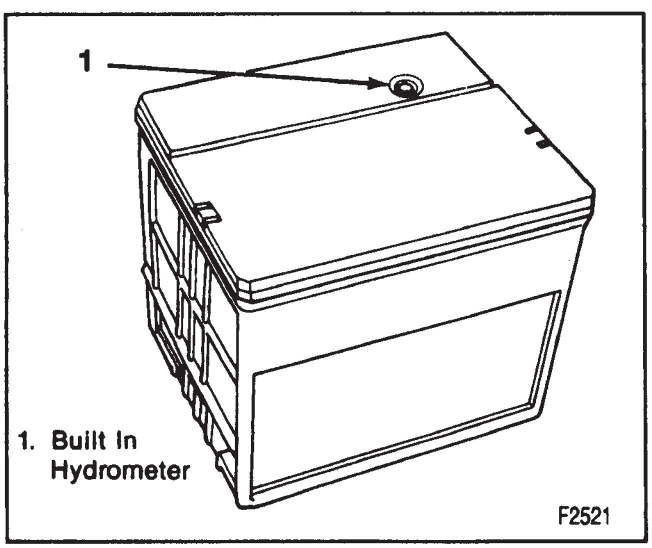

Figure 2—Sealed Battery with Side Terminals

Besides reducing gassing, the special chemistry greatly reduces the possibility of overcharge damage.

Keep the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45 degree angle in any direction can allow a small amount of electrolyte to leak out the vent hole.

Do not exceed this 45 degree angle when carrying or installing the battery.

Evidence of electrolyte leakage does not always mean the battery is defective.

RATINGS

Batteries are rated according to their reserve capacity in minutes and their cold cranking power in amperes. Both methods involve measuring the battery terminal voltage after a specified time period and discharge current.

The "reserve capacity" is defined as the maximum length of time it is possible to travel at night with minimum electrical load and no generator output. Expressed in minutes, it is the time required for a fully charged 12-volt battery, at a temperature of 27°C (80°F), being discharged at a constant current of 25 amperes, to reach a terminal voltage of 10.5 volts.

The "cold cranking ampere" (CCA) test measures the amperage delivered by the battery at -18°C (0°F) for 30 seconds.

Refer to the "Specifications" at the end of this section for battery ratings.

BUILT-IN HYDROMETER

The sealed battery has a special temperature compensated hydrometer built into the cover to show at a glance the battery's state-of-charge. The hydrometer has a green ball within a cage which is attached to a clear plastic rod. The green ball will float at a predetermined specific gravity of the electrolyte. When the green ball floats, it rises within the cage and positions itself under the rod. Visually a green dot then shows in the center of the hydrometer (figure 3). The built-in hydrometer provides a guide for battery testing and charging.

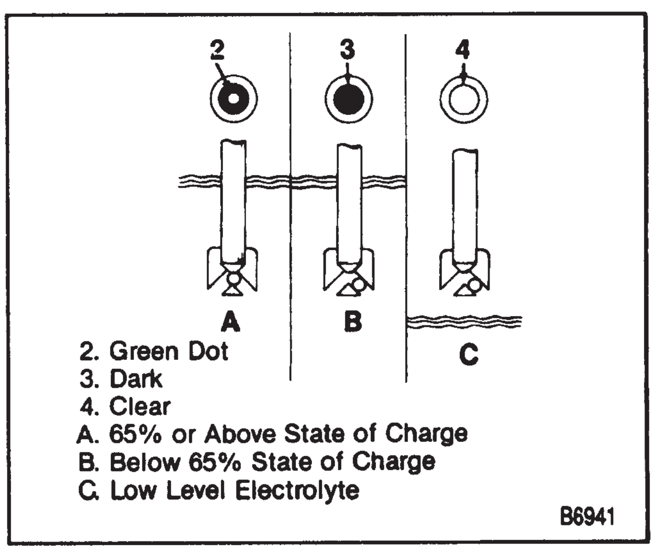

Figure 3—Built-In Hydrometer

When looking at the hydrometer, make sure that the battery has a clean top. A lamp may be needed in some poorly-lit areas.

1. GREEN DOT VISIBLE: The state of charge is 65 percent or more of the full charge.
2. DARK: GREEN DOT NOT VISIBLE: The state of charge is below 65 percent. Charge the battery until the green dot appears. (Shake the battery slightly to make the green dot appear after charging).
3. CLEAR OR LIGHT YELLOW: The fluid level has dropped below the bottom of the hydrometer. This can be caused by a broken case, tipping of the battery, normal wearout, or overcharging because of a problem in the electrical system. Check the system and replace the battery.

GENERAL INFORMATION

COMMON CAUSES OF MALFUNCTION

If testing shows the battery to be in good condition but the battery doesn't perform satisfactorily, check for the following:

1. Vehicle accessories left on overnight.
2. Extended slow-speed driving with many accessories turned on.
3. The vehicle electrical load is more than the generator output, particularly with the addition of aftermarket equipment.
4. Problems in the charging system such as shorts, slipping fan belt, or worn generator or regulator parts.
5. Loose or poor battery cable-to-post connections, previous improper charging of a rundown battery, or loose hold-downs.
6. High-resistance connections in the cranking system.
7. Electronic devices draining the battery when the vehicle is parked for along period of time. Disconnect the negative cable if the vehicle will be stored for more than 30 days.

Electrolyte Freezing

The freezing point of electrolyte depends on its specific gravity. Since freezing may ruin a battery, protect it against freezing by keeping it in a charge condition.

Carrier And Hold-Down

The carrier and hold-down should be clean and free from corrosion before battery installation.

The carrier should be in a sound mechanical condition so that it will support the battery securely and keep it level. Make certain there are no foreign objects in the carrier before installation.

To prevent the battery from shaking in its carrier, tighten the hold-down bolts. However, do not tighten the bolts to where the battery case or cover is placed under a severe strain.

BATTERY STORAGE

If the vehicle is going to be stored for up to 30 days, both battery cables should be disconnected. Check the battery state of charge and recharge if necessary. Check the battery at regular intervals and bring it to full charge to prevent deterioration. In cold climates this is necessary to prevent freezing.

If the vehicle is going to be stored for longer than 30 days, remove the battery and store it in a cool dry place. Periodically check the charge and recharge as necessary to prevent deterioration of the battery.

DIAGNOSIS OF BATTERY

VISUAL INSPECTION

Check for obvious damage such as a cracked or broken case or cover that could permit loss of electrolyte. If damage, replace the battery. Determine the cause of the damage and correct.

HYDROMETER TEST

GREEN DOT VISIBLE: If the hydrometer has a GREEN DOT visible, the battery is ready for testing. Proceed to "Load Test."

DARK; GREEN DOT NOT VISIBLE: Charge the battery as outlined under the heading "Battery Charging Procedure" later in this section.

LIGHT OR BRIGHT INDICATOR: Do not charge, test, or jump start the battery. Replace the battery.

LOAD TEST

If the battery is in the vehicle, make sure the ignition switch is off. If there is more than one battery, check each separately.

1. Disconnect the battery cables from the terminals.
2. Install adapter AC-Delco ST 1201 or equivalent (figure 4).
3. If adapters are not available, use a 3/8-inch 16 UNC bolt and stainless steel nut (figure 5). Finger tighten. Contact must be made through the lead pads at the face of the terminals, not through the threads of the bolt.
4. Install a voltmeter and battery load tester to the adapters.
5. Remove the surface charge from recently charged batteries by applying a 300-ampere load across the adapters for 15 seconds.
6. Do not remove the surface charge from batteries which have been in storage.
7. Turn the load off and wait 15 seconds for the battery to recover.
8. Apply the specified load selected from the chart in "Specifications." Observe the battery voltage after 15 seconds with the load connected, then turn off the load.

9. If the battery voltage does not drop below the minimum voltage as shown in the following "Voltage and Temperature Chart", the battery is good and should be returned to service. (The battery temperature must be estimated by feel and by the temperature the battery has been exposed to for the preceding few hours.) If the battery voltage drops below the minimum voltage listed, replace the battery.

Voltage And Temperature Chart

TEMPERATURE	MINIMUM VOLTAGE
21° C (70° F & Above)	9.6
10° C (50° F)	9.4
-1° C (30° F)	9.1
-10° C (15° F)	8.8
-18° C (0° F)	8.5

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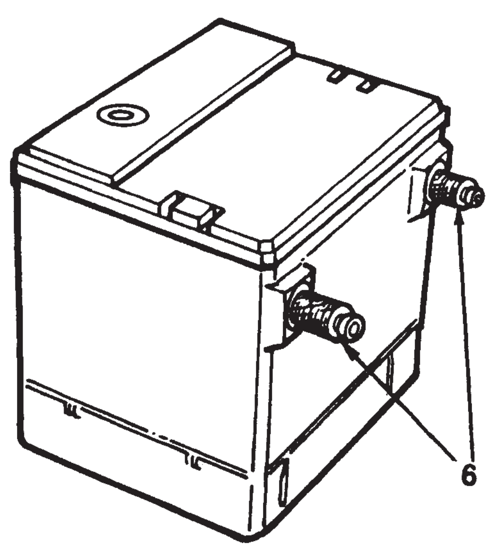
PARASITIC CURRENT DRAIN TEST

If a battery needs recharging and no cause is evident, check the vehicle for excessive parasitic current drain.

One or more on-board solid state control modules, such as the ECM, may, at some time, exhibit a failure mode that causes a high parasitic drain on the vehicle's battery. When the battery is disconnected to install an ammeter, etc., the excessive current drain may not occur once circuit continuity is restored. Even though cycling the ignition key to the RUN and then to the OFF position may at times cause such a drain to recur, there may be drains that will not recur unless the vehicle systems are reactivated in a road test. Since the key switch should not be rotated to the ACCESSORY, RUN, or START position with an ammeter installed between the battery terminal and the battery cable, a current drain test tool or suitable jumper wire must be used as described in the following procedures.

Two test procedures are given below. The first requires the use of the current drain test tool J 38758. If the tool is not available, use the second test procedure. However, certain types of parasitic drains cannot be identified using the second test procedure because the vehicle systems cannot be road tested.

Before starting either procedure, make sure the ignition switch is in the "Lock" position and that all electrical accessories are turned off and the doors closed.



6. Adapter charging tool attached to terminals.

F6505

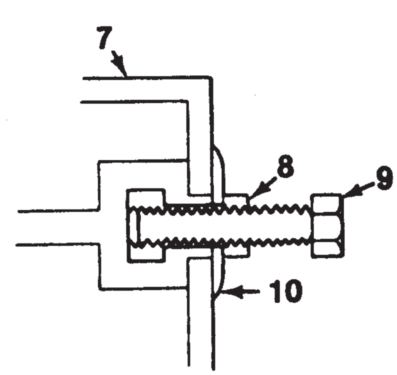
Figure 4—Testing and Charging Terminal Adapter

CURRENT DRAIN TEST USING J 38758

Tools Required:
J 38758 Current Drain Tool

NOTICE: The current drain tool should never be turned to the "Off" position with the engine running or damage could occur to the attached ammeter or the vehicle electrical system.

1. Remove the negative battery cable.
2. Install the male end of J 38758 to the negative battery terminal (figure 6).
3. Turn the knob of the tool to the "Off" position.
4. Install the negative battery cable to the female end of the test tool.
5. Turn the test tool to the "On" position.
6. Road test the vehicle while activating all accessories, such as the radio and air conditioning.
7. Turn the ignition switch to the "Off" position and remove the key.



7. Case
8. 3/8-inch 16 UNC Nut
9. 3/8-inch 16 UNC Bolt
10. Electrical Contact

B9715

Figure 5—Testing and Charging Using Bolt and Nut

Important

- From this point on, electrical continuity must be maintained in the ground circuit to the main battery, either through the current drain test tool (in the "On" position) or through the ammeter.

8. Set an ammeter or multimeter to the 10 amp scale and connect it to the terminals on the drain test tool. Be sure the meter used has at least 10 amp, preferably 20 amp measurement capability.
9. Turn the drain test tool to the "Off" position to allow current to flow through the meter.
10. Wait at least 60 seconds. Check the current reading. If the current reading is at or below two amps, close the test tool (to maintain continuity in the electrical system) and switch down to the two amp scale for a more accurate reading when the test tool is reopened.
11. Take the reading in milliamps if possible.
12. Find the reserve capacity of the battery in "Specifications" at the end of this section. Divide this number by 4. Compare this to the multimeter reading. The current drain reading should not exceed this number. (Example: If a battery has a reserve capacity of 100 minutes, the current drain should not exceed 25 milliamps).

NOTICE: Always turn the test tool knob to the "On" position before removing each fuse to maintain continuity in the electrical system and to avoid damaging the meter due to accidental overloading, such as opening a door to change a fuse.

13. If current draw is too high, remove system fuses one fuse at a time until the current draw returns to a value less than or equal to the specifications. Start with fuses that are hot at all times. Refer to the Electrical Diagrams and Diagnosis Manual. Perform steps 8 through 10 above each time a fuse is removed.
14. Removing the ECM fuse should cause a drop of less than 10 milliamps.
    - If the drop is more than 10 milliamps, check the orange wires for a short to ground. Also check the components connected to the orange wires. Refer to the Electrical Diagrams and Diagnosis Manual.
    - If there is no drop in the milliamp reading, the ECM is not drawing current. Replace the ECM.
15. Repeat the parasitic current drain procedure after any repair has been completed.
16. When the cause of excessive current draw has been located and repaired, remove the test tool and connect the negative battery cable to the negative battery terminal.

Tighten

- Negative battery cable bolt to 15 N·m (11 ft. lbs.).

CURRENT DRAIN TEST WITHOUT J 38758

Before starting this procedure, make sure the ignition switch is in the "Lock" position and that all electrical accessories are turned off and the doors closed.

Tools Required:

ST-1201 Battery Terminal Adapter

1. Remove the negative battery cable.
2. Install the battery terminal adapter ST-1201 to the negative battery terminal and tighten to 15 N.m (11 ft. lbs).
3. If adapters are not available, use a 3/8-inch 16 UNC bolt and stainless steel nut as described earlier in this section. Finger tighten. Contact must be made through the lead pads at the face of the terminals, not through the threads of the bolt.
4. Install a 3 mm^2 (12 gage) jumper wire with an alligator clip on each end between the end of the negative battery cable and the side terminal adapter (figure 7).

CAUTION: Do not rotate the ignition switch to the "Start" position. Doing so will cause the jumper wire to become extremely hot and may result in personal injury and vehicle fire.

12. Battery
13. Multimeter
14. Meter Leads
19. Negative Battery Cable

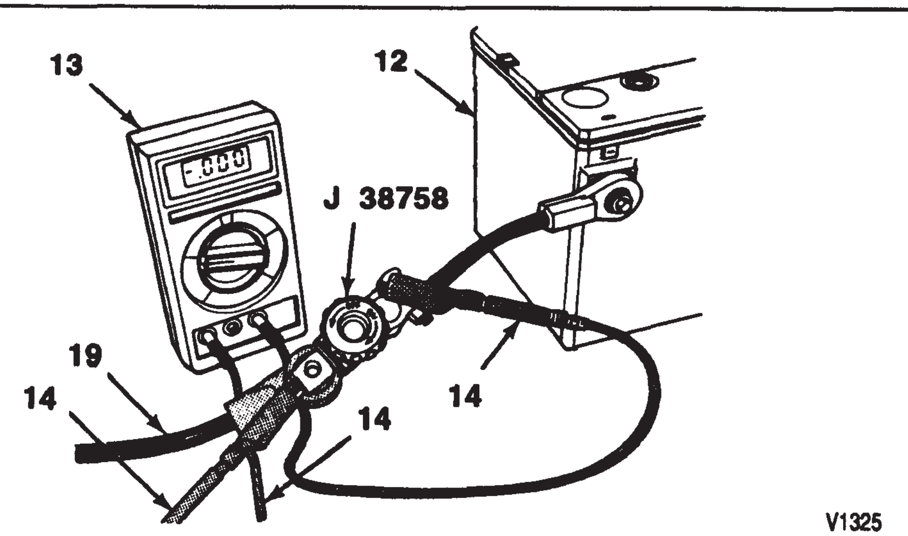
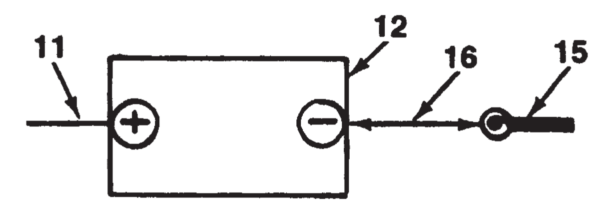


Figure 6—Current Drain Tool Installed



11. Positive Battery Cable Connector
12. Battery
15. End of Negative Battery Cable
16. Jumper Wire

F9826

Figure 7—Jumper Wire Position

5. Turn the ignition switch to the "Run" position. This is done to reset the solid state ECM which shuts off when the battery is disconnected. The ECM may be causing a high current drain, which might not show up if an ammeter is used before reactivating the ECM.
6. Turn the ignition switch to the "Lock" position and remove the key from the switch.

Important

- Make sure the ignition and all accessories are off.
- Make sure that circuit continuity between the negative battery cable and the side terminal battery adapter is not interrupted during the next step.

7. Install a digital multimeter or ammeter capable of measuring 20 amperes between the negative battery cable and and the terminal adapter.

Important

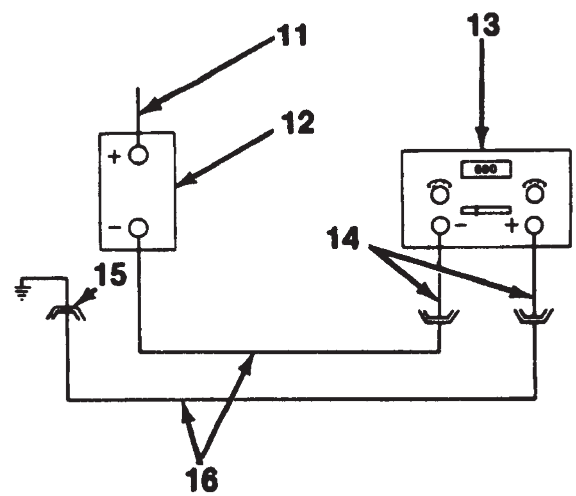
- Be sure the multimeter is in parallel to the 3 mm^2 (12 gage) jumper wire and set to the highest DC scale.

8. Remove the 3 mm^2 (12 gage) jumper wire. The multimeter will now be wired as shown in figure 8.

Adjust

- The ammeter scale to the lowest DC scale possible without going out of range and note the reading in milliamps.

9. Find the reserve capacity of the battery in "Specifications" at the end of this section. Divide this number by four. Compare this to the multimeter reading. The current drain reading should not exceed this number. (Example: If a battery has a reserve capacity of 100 minutes, the current drain should not exceed 25 milliamps).



11. Positive Battery Cable Connected
12. Battery
13. Multimeter J-34029-A or Equivalent Set on DC, MA and 2000 Scale
14. Meter Test Leads
15. End of Negative Battery Cable
16. Jumper Wires

F2756

Figure 8—Battery Drain Test

10. If current draw is too high, check the system for causes such as a shorted wire or a compartment lamp that does not shut off when it should.
11. Repeat the parasitic current drain procedure after any repair has been completed.
12. When the cause of excessive current draw has been located and repaired, remove the test tool and connect the negative battery cable to the negative battery terminal.

Tighten

- Negative battery cable bolt to 15 N.m (11 ft. lbs.).

BATTERY ON-VEHICLE SERVICE

BATTERY CHARGING PROCEDURES

The following basic rules apply to any sealed battery charging situation:

1. Do not charge a battery if the hydrometer is clear or light yellow—replace the battery.
2. Charge rates between 3 and 50 amperes are satisfactory as long as spewing of electrolyte does not occur or the battery does not feel over 52°C (125°F). If spewing occurs or temperature exceeds 52°C (125°F), the charging rate must be reduced or temporarily halted to permit cooling.

   Estimate battery temperature by touching or feeling the battery case.
3. Some charges feature polarity protection circuitry which prevents charging unless the charger leads are connected to the battery terminals correctly. A

completely discharged battery may not have enough voltage to activate this circuitry, even though leads are connected properly, making it appear that the battery will not accept charging current. Therefore, follow the specific charger manufacturer's instruction telling how to bypass or override the circuitry so that the charger will turn on and charge a low-voltage battery.

4. The battery is sufficiently charged when the green dot in the built-in hydrometer is visible. No further charging is required. Tap the hydrometer lightly at hourly intervals during charging to see if the green dot appears.
5. Battery charging consists of a charge current in amperes for a period of time in hours. Thus a 25-ampere charging rate for 2 hours would be 50 ampere-hour charge to the battery. In most cases, batteries whose load test values are less than 200 amperes will have the green dot visible after at least a 50 ampere-hour charge. Most batteries whose load test values are greater than 200 amperes will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear after this amount of charging, continue charging for another 50 or 75 ampere-hours. If the green dot still does not appear, replace the battery.
6. The time required for a charge will vary according to:

   a. Size of battery—Example: A discharged large heavy-duty battery requires more than twice the recharging as a discharged small passenger car battery.
   b. Temperature—Example: A longer time will be needed to charge any battery at -18°C (0°F) than at 17°C (80°F).When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then, as the battery warms, it will accept a higher rate.
   c. State-of-charge—Example: A discharged battery requires more than twice as much charge as a half-charged battery. Because the electrolyte is nearly pure water and therefore a poor conductor, the current accepted is low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.
   d. Charge Capacity—Example: A charge which can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

EMERGENCY STARTING DUE TO A DISCHARGED BATTERY

If the vehicle will not start due to a discharged battery, it can be started by using energy from another battery—a procedure called "jump starting."

NOTICE: Do not push or tow the vehicle to start it. Under some conditions this may damage the catalytic converter or other parts of the vehicle. Also, since this vehicle has a 12-volt battery, be sure the vehicle or equipment used to jump start the engine is also 12 volt. Use of any other type system may damage the vehicle's electrical components.

JUMP STARTING INSTRUCTIONS

CAUTION: Batteries produce explosive gasses, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:

- **Always shield your eyes and avoid leaning over the battery whenever possible.**
- **Do not expose the battery to open flames or sparks.**
- **Do not allow battery acid to contact the eyes or skin. Flush any contacted areas with water immediately and thoroughly, and get medical help.**
- **Follow each step in the jump starting instructions.**

1. Position the vehicle with the good (charged) battery so that the booster (jumper) cables will reach, but never let the vehicles touch. Also be sure booster cables do not have loose or missing insulation.
2. In both vehicles:
   - Turn off the ignition and all lamps and accessories except the hazard flasher or any lamps needed for the work area.
   - Apply the parking brake firmly, and shift the automatic transmission to Park (or manual transmission to Neutral).
3. Making sure the cable clamps do not touch any other metal parts, clamp one end of the first booster cable to the positive (+) terminal on one battery, and the other end to the positive terminal on the other battery (figure 9). Never connect (+) to (-).

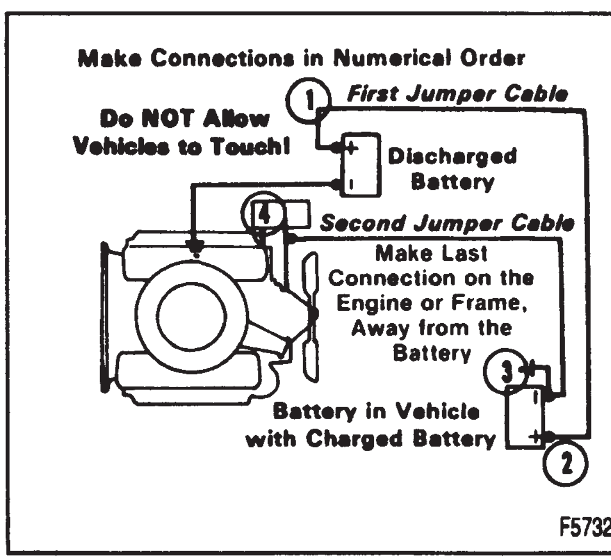


Figure 9—Jump Starting Connection

4. Clamp one end of the second cable to the negative (-) terminal of the good (charged) battery and make the final connection to a heavy metal bracket such as the mounting bracket of the generator or air conditioner compressor (if so equipped) on the engine about 450 millimeters (18 inches) from the discharged battery. Make sure the cables are not on or near pulleys, fans, or other parts that will move when the engine is started.
5. Start the engine of the vehicle with the good (charged) battery and run the engine at a moderate speed for several minutes. Then, start the engine of the vehicle that has the discharged battery.
6. Remove the booster cables by reversing the above installation sequence exactly. While removing each clamp, take care it does not touch any other metal while the other end remains attached.

BATTERY CABLES

Excessive resistance caused by poor terminal connections and partial short circuits through defective cable insulation will result in an abnormal voltage drop in the starter cable. Low voltage at the starter will prevent normal starter operation and cause hard starting.

CAUTION: To prevent possible personal injury from a moving vehicle or operating engine do the following before performing the checks:
1. Engage the parking brakes and block the wheels.
2. Place the manual transmission in the neutral position or the automatic transmission in park.
3. Disconnect the battery feed at the distributor.

1. Check the voltage drop between ground (negative battery terminal) and the vehicle frame. Place one prod of the test voltmeter on the grounded battery post (not on the cable clamp) and the other on the frame. Operate the starter and note the voltage reading.
2. Check the voltage drop between the positive battery terminal and starter terminal stud with starter operating.
3. Check the voltage drop between the starter housing and frame with the starter operating.
4. If the voltage drop in any of the above is more than 1.0 volt, there is excessive resistance in the circuit. To eliminate resistance, the cables should be disconnected and connections cleaned. If cables are frayed or the clamps corroded, the cables should be replaced. When selecting new cables, be sure they are at least as large as the ones being replaced.

Battery cable routing is shown in figures 10 through 13.

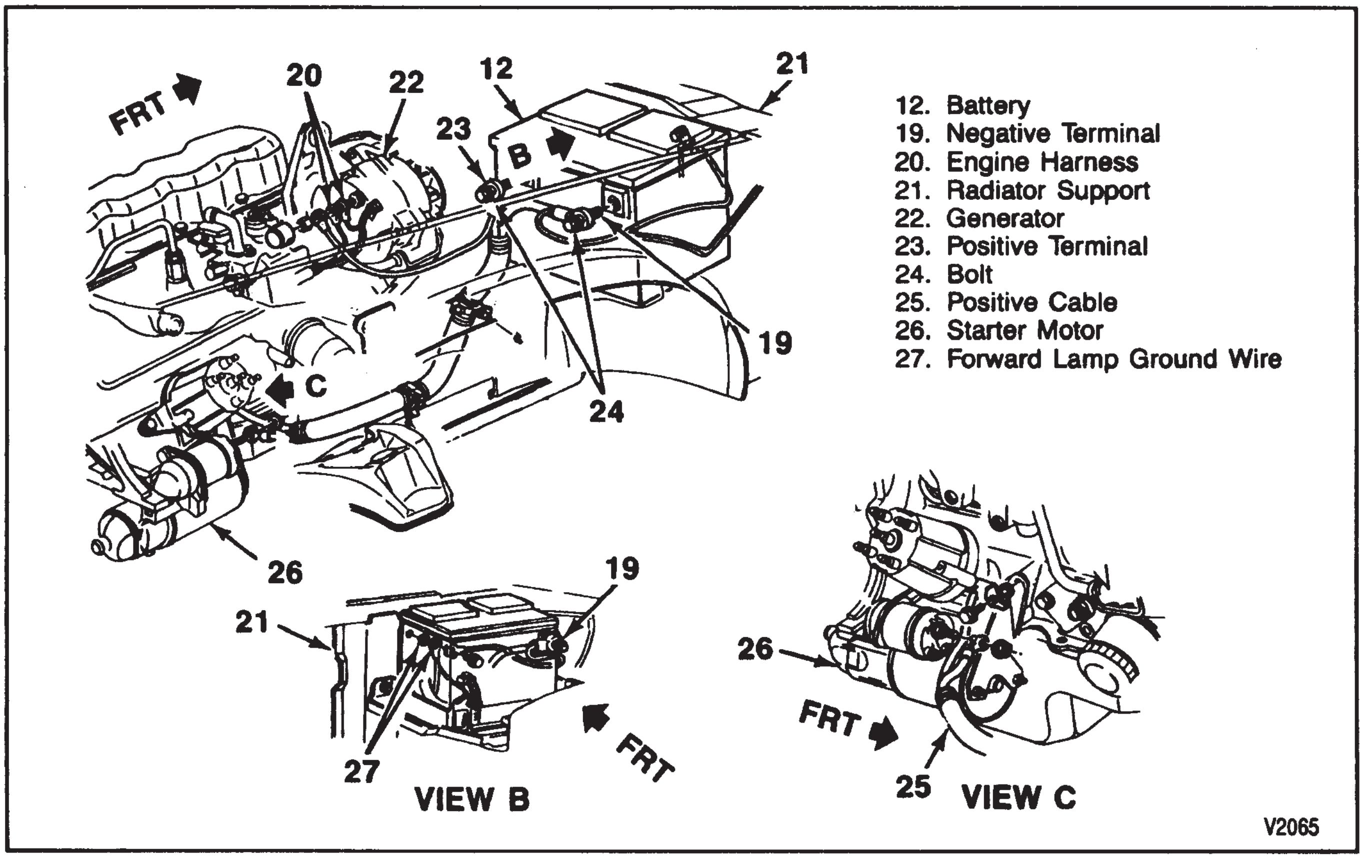


Figure 10—Battery Cable Routing for the 2.5L (L38) Engine - Pickup Truck

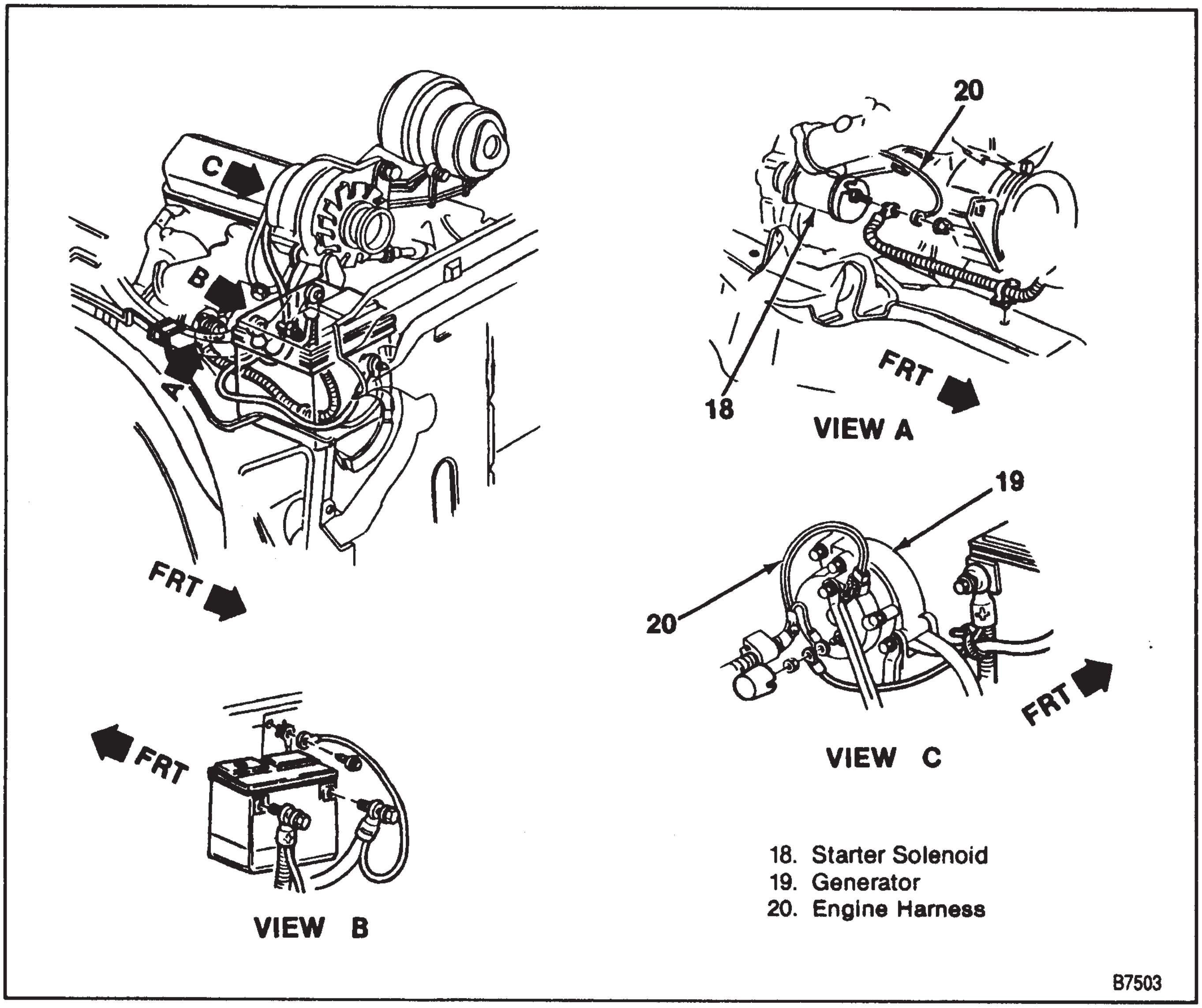


Figure 11—Battery Cable Routing for the 2.8L Engine

BATTERY REPLACEMENT

When handling a battery, observe the following safety precautions.

1. Hydrogen gas is produced by the battery. A frame or spark near the battery may cause the gas to ignite.
2. Battery fluid is highly acidic. Avoid spilling on clothing or skin. Any spilled electrolyte should be flushed with large quantities of water and cleaned immediately.

Remove or Disconnect (Figure 14)

1. Negative cable from the negative battery terminal.
2. Positive cable from the positive battery terminal.
3. Battery retainer and nut.
4. Battery.

Inspect

1. Battery for damage.
2. Cables and connectors.
3. Carrier for damage or foreign objects.
   - If damage is noted, find and correct the cause.

Install or Connect

NOTICE: For steps 2, 3, and 4, refer to "Notice" on page 6D1-1.

1. Battery into cleaned carrier.
2. Retainer and nut.

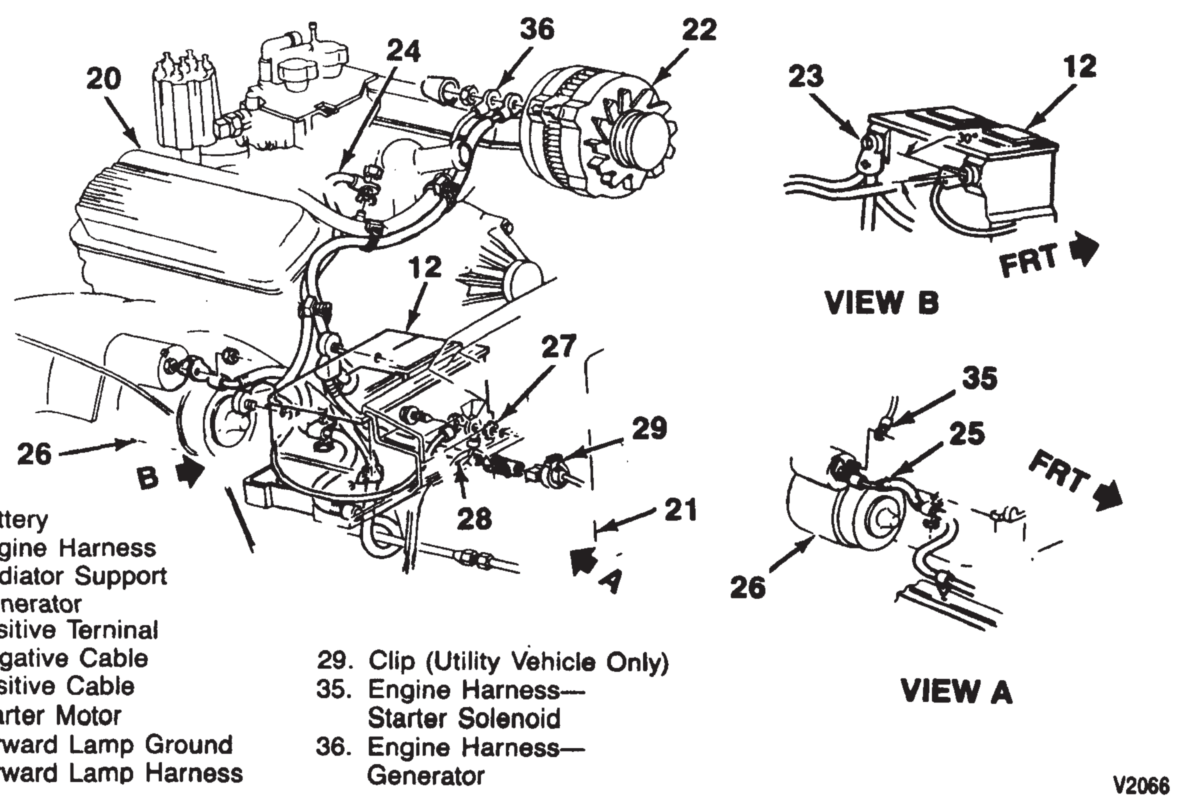
Tighten

- Retainer nut to 17 N·m (13 ft. lbs.).

3. Positive cable to the positive terminal.
4. Negative cable to the negative terminal.

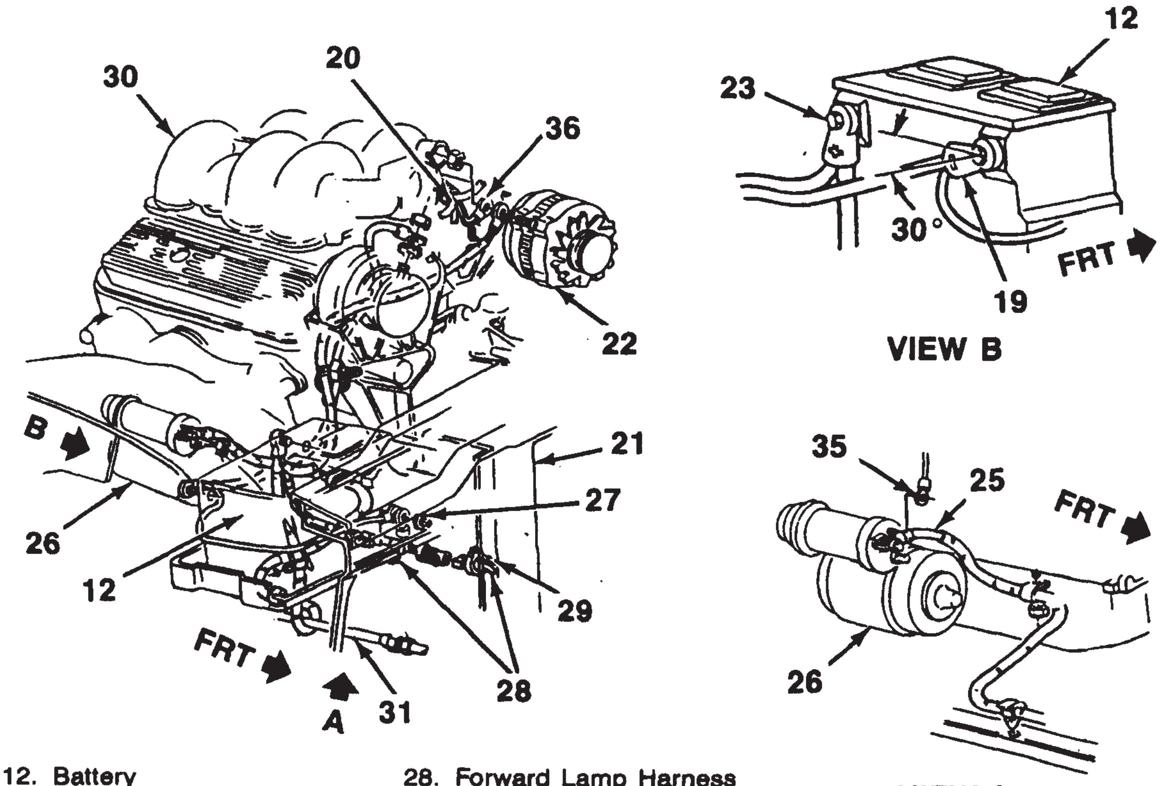
Tighten

- Battery terminals to 15 N·m (11 ft. lbs.).



12. Battery
20. Engine Harness
21. Radiator Support
22. Generator
23. Positive Terminal
24. Negative Cable
25. Positive Cable
26. Starter Motor
27. Forward Lamp Ground
28. Forward Lamp Harness
29. Clip (Utility Vehicle Only)
35. Engine Harness—Starter Solenoid
36. Engine Harness—Generator

Figure 12—Battery Cable Routing for the 4.3L (LB4) Engine - Pickup and Utility Vehicles



12. Battery
19. Negative Terminal
20. Engine Harness
21. Radiator Support
22. Generator
23. Positive Terminal
25. Positive Cable
26. Starter Motor
28. Forward Lamp Harness
29. Clip (Utility Vehicle Only)
30. Engine Harness Ground
31. A/C Evaporator Tube
35. Engine Harness—Starter Solenoid
36. Engine Harness—Generator

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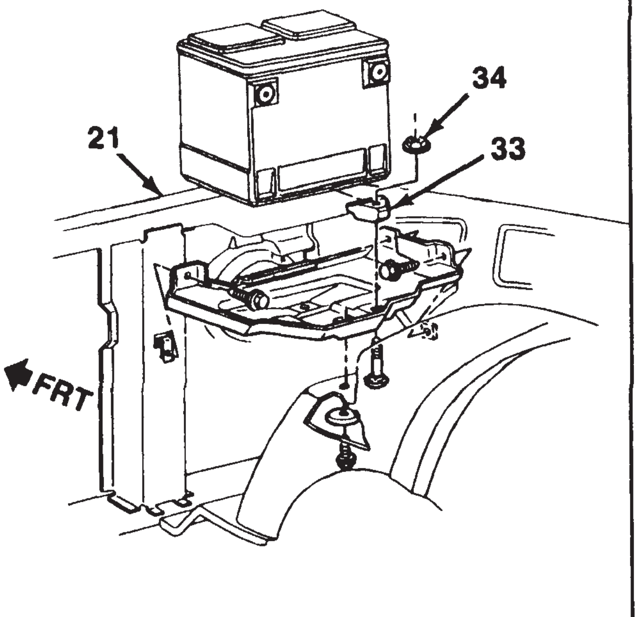
Figure 13—Battery Cable Routing for the 4.3L H.P.Engine (L35) - Pickup and Utility Vehicle



21. Radiator Support
33. Retainer
34. Retainer Nut

Figure 14—Battery Tray

SPECIFICATIONS

BATTERY SPECIFICATIONS

Part No.	Description	Replacement Cat. No.	Volts	Cold Cranking Amperes Rating at -18°C (0°F)	Reserve Capacity (Minutes at 25 Amps)	Load Test (Amperes)
1981730	Delco 730	75-60	12	525	90	260
1981734*	Delco 734	78A-72	12	630	115	310

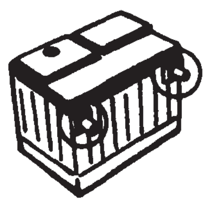
*Heavy Duty Usage

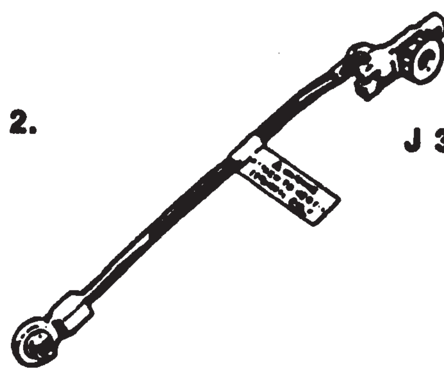
FASTENERS

	N·m	Ft. Lbs.
Battery Retainer Nut	17	13
Battery Terminals	15	11

T2031

SPECIAL TOOLS

1.  ST 1201

2.  J 38758

1. Battery Terminal Adapters—PN 12303040.
   Available by ordering through AC Delco distributors.
2. Current Drain Tool

V1331

SECTION 6D2

CRANKING SYSTEM

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

DESCRIPTION

CRANKING CIRCUIT

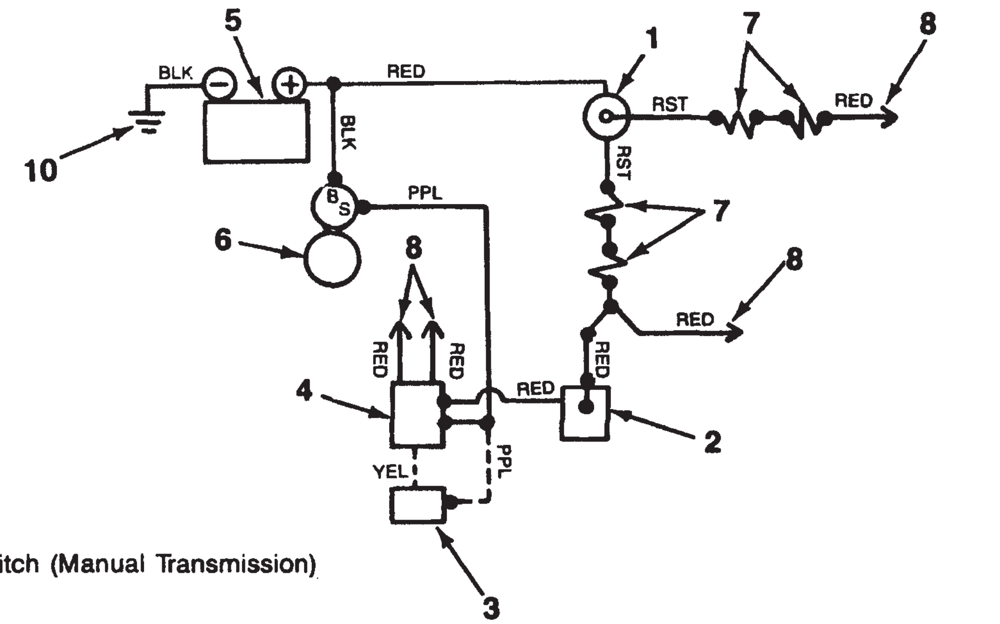
The basic cranking circuit consists of the battery, starter motor, ignition switch, neutral start switch (manual transmission) and related electrical wiring (figure 1). There is a fusible link between the starter solenoid and the junction block (2.8L engine only). For a schematic of the complete circuit, refer to the Electrical Diagrams and Diagnosis Manual for this model.

STARTER MOTOR

Two types of starter motors are used on these engines.

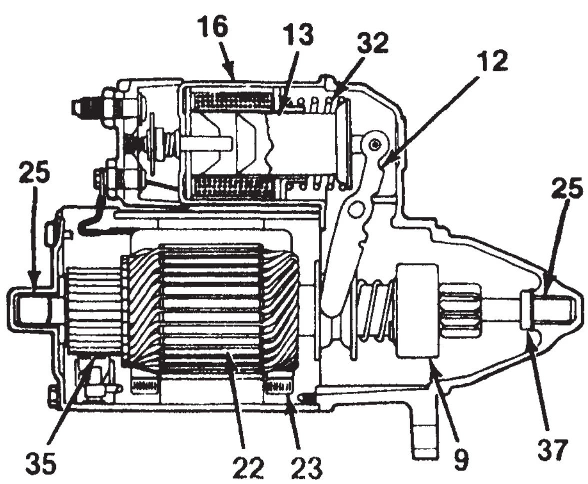
The SD-200 and the SD-260 are straight drive starters with the pinion driven directly by the armature shaft. They have pole pieces arranged around the armature that are energized by wound field coils (figure 2). Both have the shift lever mechanism and the solenoid plunger enclosed in the drive housing to protect them from exposure to dirt, icing conditions, and splash.

In the basic circuit (figure 1) the solenoid windings are energized when the ignition switch is closed (in the "Start" position). The resulting plunger and shift lever movement causes the pinion to mesh with the engine flywheel ring gear and the solenoid main contacts to close, and engine cranking takes place. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage. To prevent excessive overrun, open the ignition switch (release from the "Start" position) immediately when the engine starts.



1. Generator
2. Junction Block
3. Neutral Start Switch (Manual Transmission)
4. Ignition Switch
5. Battery
6. Starter Motor
7. Fusible Link
8. To Bulkhead Connector
10. Chassis Ground

Figure 1—Cranking Circuit



9. Clutch
12. Shift Lever
13. Plunger
16. Solenoid
22. Armature
23. Field Coil
25. Bushing
32. Return Spring
35. Brush
37. Pinion Stop

Figure 2—SD-200 and SD-260 Starter Motor

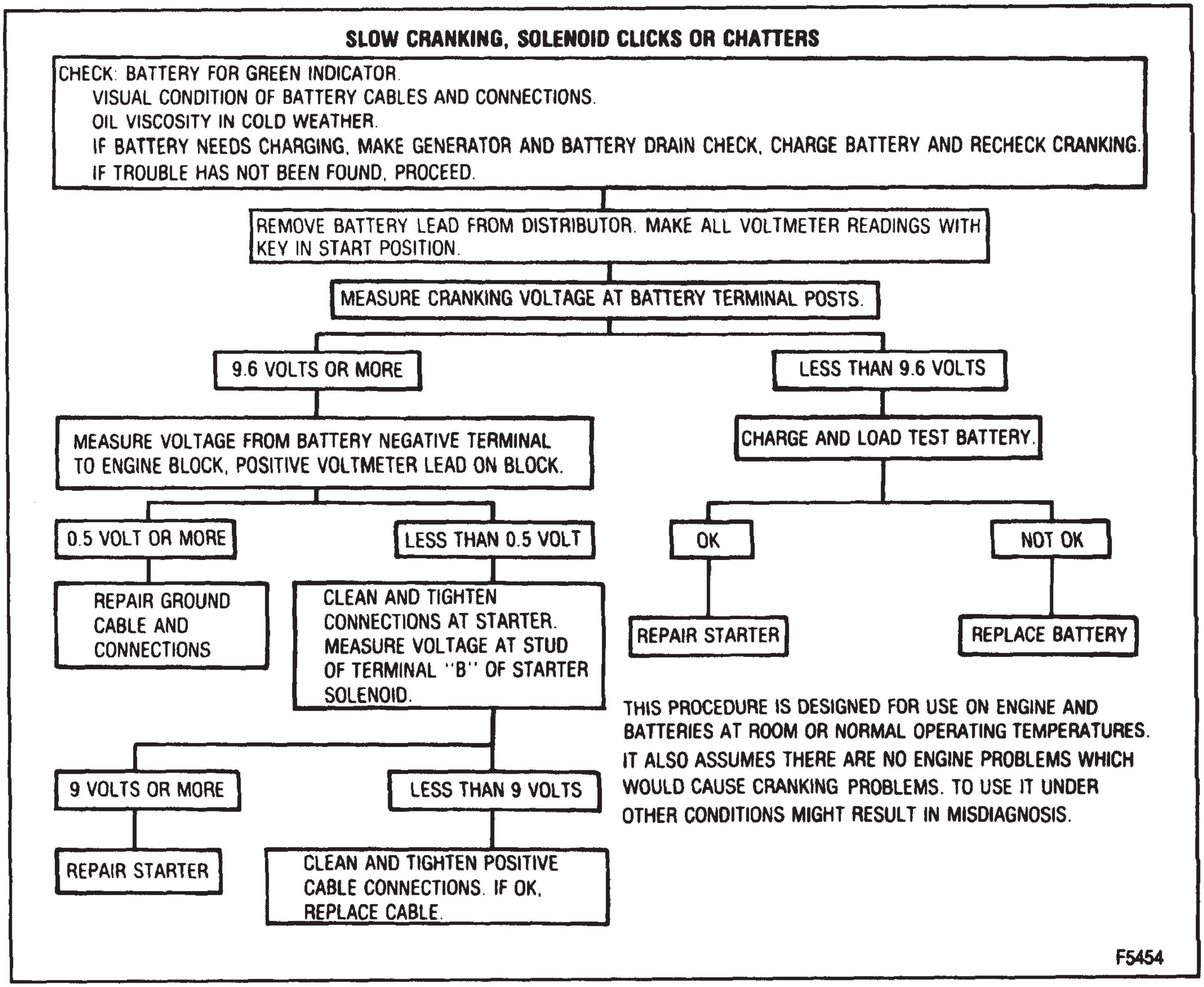


Figure 3—Cranking System Diagnosis

DIAGNOSIS OF CRANKING SYSTEM

Refer to figures 3, 4, and 5 for a diagnosis of the cranking system. Before removing any unit in the system for repair, make the following checks.

CRANKING CIRCUIT

BATTERY

Determine the condition of the battery. Refer to BATTERY (SECTION 6D1) for battery diagnosis and testing.

WIRING

Inspect the circuit wiring for damage. Inspect all connections to the starter motor, solenoid, ignition switch, and battery, including all ground connections. Clean and tighten all connections as required. Check the fusible link.

SOLENOID AND CONTROL SWITCHES

Check all switches to determine their condition.

A vehicle equipped with a manual transmission has a neutral start switch attached to the clutch which closes when the clutch is depressed. A vehicle with an automatic transmission has a mechanical interlock in the steering column which does not allow the ignition switch to be turned to the start position unless the transmission is in the park or neutral position.

STARTER MOTOR NOISE

Refer to the starter noise diagnostic chart.

Shims are available for the 2.8L and 4.3L engines to adjust the pinion clearance.

PINION CLEARANCE

1. Remove the lower flywheel housing cover.
2. Inspect the flywheel for signs of unusual wear such as chipped or missing gear teeth or the flywheel being bent. If the flywheel needs replacing, refer to the appropriate engine section in SECTION 6 in this manual.

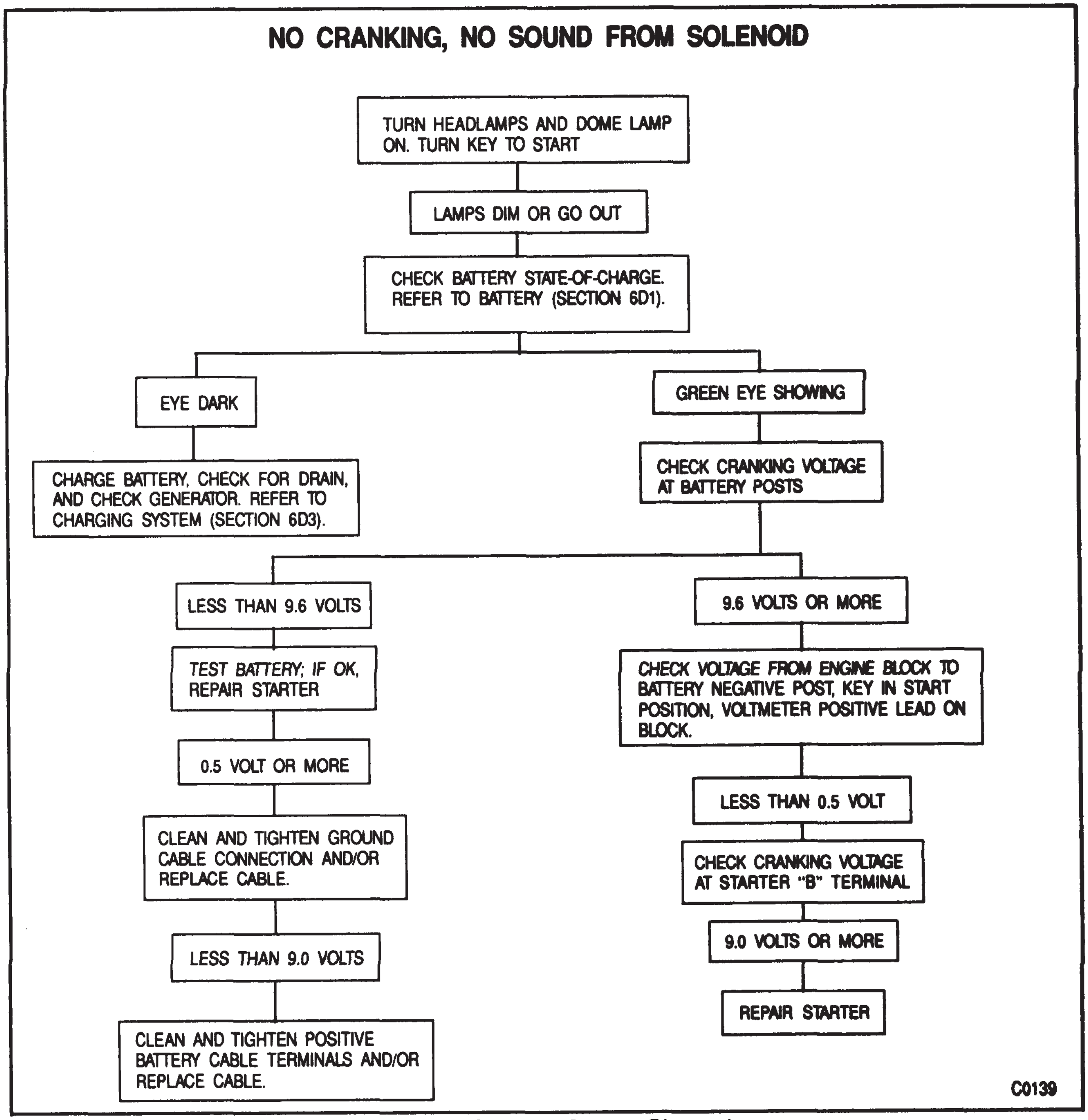


Figure 4—Cranking System Diagnosis

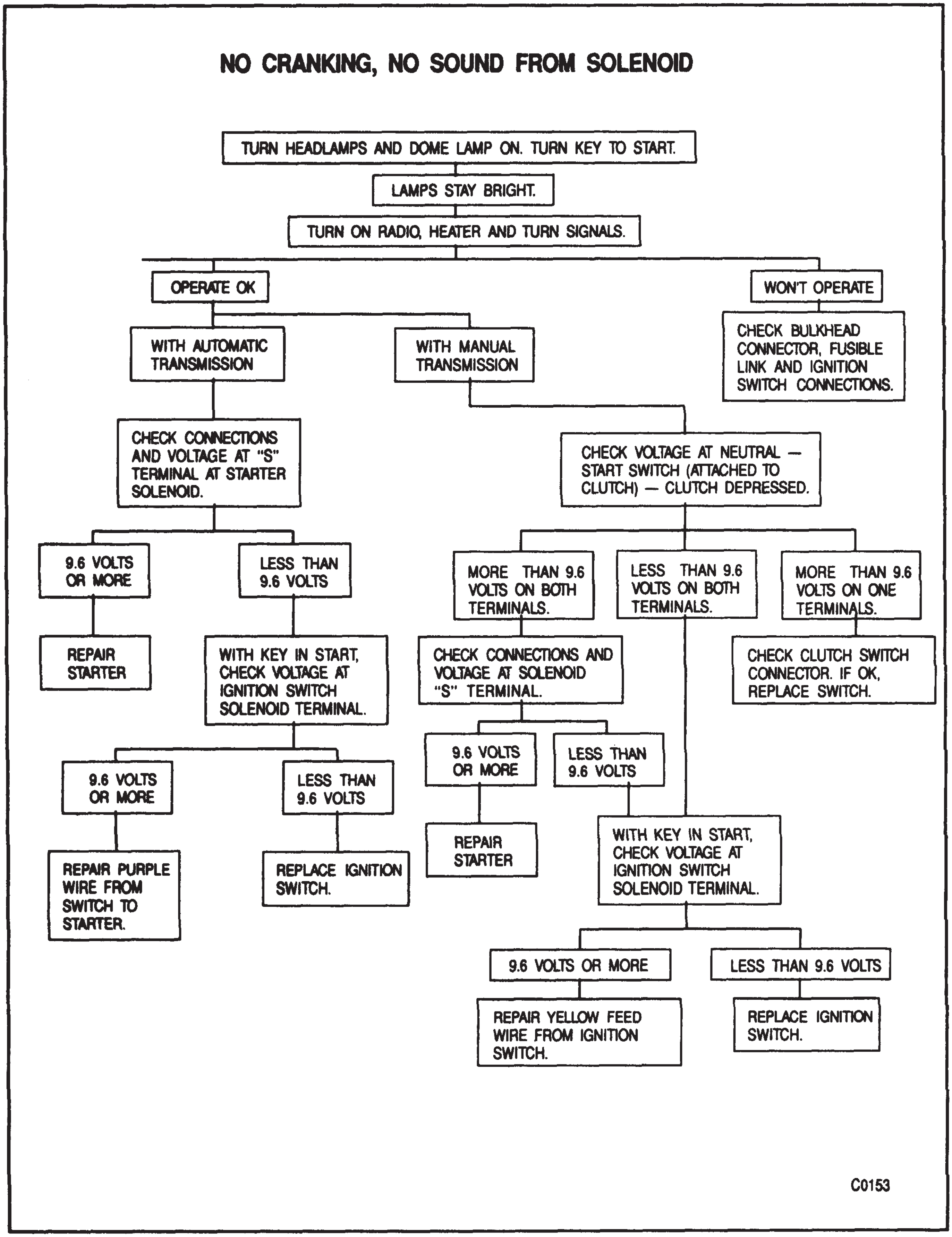
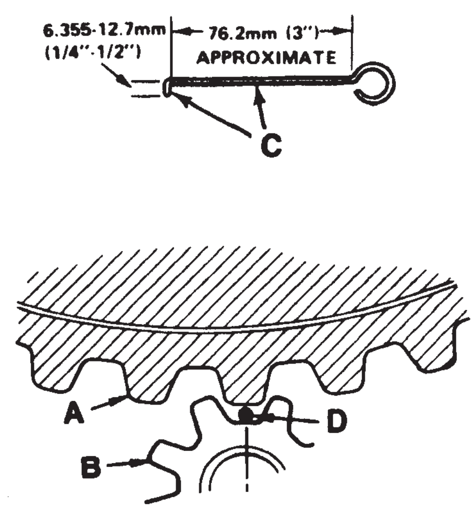


Figure 5—Cranking System Diagnosis



A. Flywheel
B. Pinion
C. Wire Gage
D. Insert 0.5mm (0.020 inch) diameter tip of wire gage here

F6159

Figure 6—Flywheel to Pinion Clearance

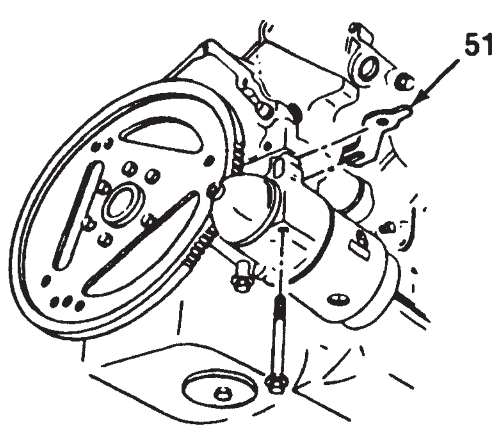
3. Start the engine and gently touch the outside diameter of the rotating flywheel ring gear with chalk or crayon to show the high point of tooth runout after the engine is turned off. Turn the engine off and rotate the flywheel so that the marked teeth are in the area of the starter pinion gear.
4. Disconnect the negative battery cable to prevent accidental cranking of the engine.
5. Measure the clearance between the top of the ring gear tooth and bottom of the pinion tooth using the width of the wire gage (figure 6). Normal clearance is 0.5 to 1.5 mm (0.01 to 0.06 inch).
6. If the clearance is less than 0.5 mm (0.02 inch) and the starter whines after firing, shim the starter away from the flywheel (figures 7 and 8). Add 1.0-mm (0.04-inch) shims, one at a time, between the starter mounting pads and the engine until the noise problem is corrected. Do not use more than two shims on the 4.3L engine or four shims on the 2.8L engine.
7. If the pinion clearance is more than 1.5 mm (0.06 inch) and the starter whines during cranking, shim the starter toward the flywheel.
   On the 4.3L engine, add 0.33-mm (0.013-inch) shims between the outboard starter mounting pad and engine mount until the noise stops. Do not add more than four shims total.

NOTICE: Refer to "Notice" on page 6D2-1.

8. When shimming is done, torque the mounting bolts.

Tighten

- Bolts to 45 N·m (33 ft. lbs.).



51. Shim = 1.0 mm (0.04-inch)

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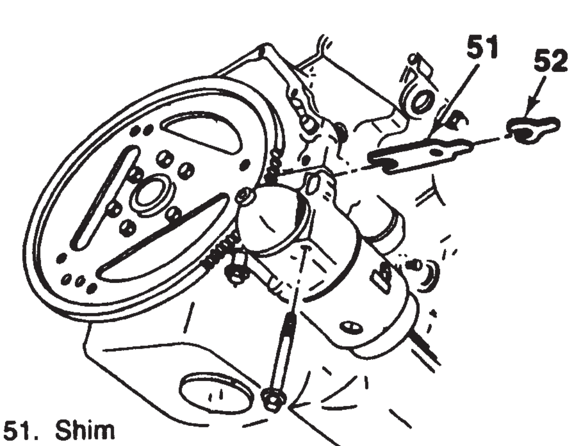
Figure 7—Shimming the Starter Motor on the 2.8L Engine



51. Shim
52. Shim

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Figure 8—Shimming the Starter Motor on the 4.3L Engine

DIAGNOSIS OF STARTER MOTOR NOISE

PROBLEM	POSSIBLE CAUSE	CORRECTION
High-pitched whine during cranking (before engine fires) but engine cranks and fires normally.	Distance too great between the starter pinion and the flywheel.	Remove shims at the starter mount. Refer to "Starter Motor Noise".
High-pitched whine after the engine fires as key is being released. The engine cranks and fires normally. This complaint is often diagnosed as "starter hang-in" or "solenoid weak".	Distance too small between the starter pinion and the flywheel. Flywheel runout contributes to the intermittent nature of the problem.	Add shims at the starter mount. Refer to "Starter Motor Noise".
A loud "whoop" after the engine fires but while the starter is still held engaged. Sounds like a siren if the engine is revved while the starter is engaged.	Usually due to a worn starter motor clutch.	Remove the starter motor and check the clutch. Refer to the Light Duty Truck Unit Repair Manual.
A "rumble," "growl," or (in severe cases) a "knock" as the starter is coasting down to a stop after starting the engine.	Usually due to a bent or unbalanced starter armature.	Remove the starter motor and check the armature. Refer to the Light Duty Truck Unit Repair Manual.
		D0134

CRANKING SYSTEM ON-VEHICLE SERVICE

MAINTENANCE

Keep starter terminals and other terminals in the electrical system clean and tight. A loose or corroded connection or terminal will cause excessive resistance in the system which will result in hard starting.

At regular intervals, inspect the cranking system to locate and correct potential causes of trouble before the system performance is affected.

Starter motors do not require lubrication except during overhaul.

STARTER MOTOR

If the battery, wiring, and switches are in satisfactory condition and the engine is functioning properly but cranking problems persist, remove the motor and refer to the Light Duty Truck Unit Repair Manual.

Never operate the starter motor more than 30 seconds at a time without pausing to allow it to cool for at least two minutes. Overheating, caused by excessive cranking, will damage the motor.

STARTER MOTOR REPLACEMENT

Remove or Disconnect (Figures 7, 9, and 10)

- Place the vehicle on a hoist.

1. Negative battery cable.
2. Brush end mounting bracket on the 2.5L engine starter motor (figure 9).
3. Solenoid wiring.
   * On the 4.3L, raise the vehicle halfway on the hoist, and reach through the right wheel well.

- Raise the vehicle.

4-wheel drive vehicles:

4. Four bolts on the skid plate (if equipped).
5. Skid plate (if equipped).
6. Bolts and the two brackets holding the brake line to the crossmember.
7. Crossmember (three bolts on each side).
8. Bracket holding the transmission fluid cooler lines to the flywheel housing, brace rod to the flywheel

housing and/or the lower flywheel housing if necessary.

All models:

9. Two bolts holding the starter to the engine.
10. Starter and the shim (if present).

Install or Connect (Figures 7, 9, and 10)

NOTICE: For steps 1 and 9, refer to "Notice" on page 6D2-1.

1. Starter and shim (if present) to the engine with bolts.

Tighten

- Bolts on the 2.5L engine to 43 N·m (31 ft. lbs.).
- Bolts on the 2.8L and 4.3L engines to 45 N·m (33 ft. lbs.).

4-wheel drive vehicles:

2. Lower flywheel housing (if removed).
3. Transmission lines bracket to the housing (if present).
4. Brace rod to the housing (if equipped).
5. Crossmember to the frame end with six bolts.
6. Two brake line brackets to the crossmember with bolts.
7. Skid plate (if equipped).

4.3L engine:

- Lower the hoist halfway.

8. Solenoid wiring by reaching through the right wheel well.

All vehicles:

- Lower the vehicle.

9. Brush end mounting bracket and wiring (2.5L).

Tighten

- Mounting bracket nuts to 8 N·m (75 in. lbs.).

10. Wires to the solenoid terminals.
11. Negative battery cable.

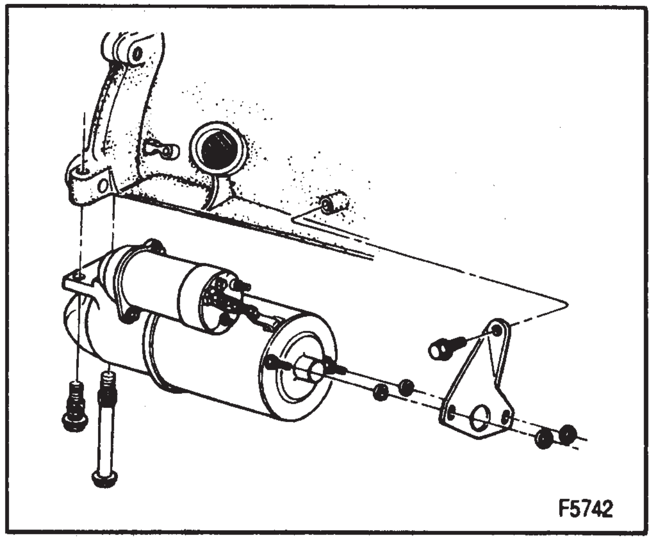


Figure 9—Starter Motor Mounting on the 2.5L Engine

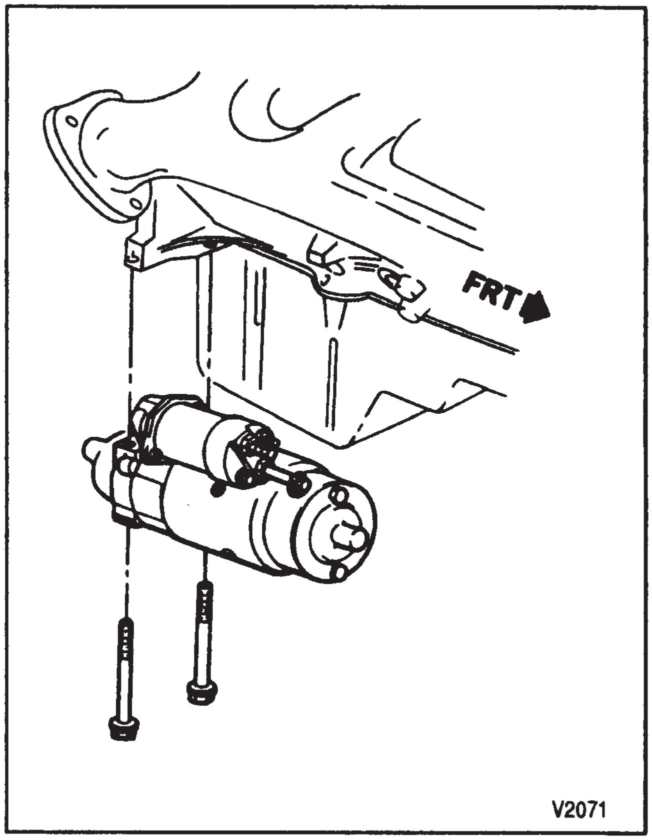


Figure 10—Starter Motor Mounting on the 4.3L Engine

SPECIFICATIONS

STARTER SPECIFICATIONS

Engine Application	Starter		Rotation	No Load Test at 10 Volts				Solenoid
				AMPS		RPM		
	Part No.	Series		Minimum	Maximum	Minimum	Maximum	
2.8L	10455016	SD-200	CW	50	75	6000	11,900	1114530
2.5L	10455018	SD-200	CW	50	75	6000	11,900	1114530
4.3L	10455013	SD-260	CW	50	62	8500	10,700	10469039

STARTER SHIMS

Engine Application	Part No.	mm	Inch
2.8L	14057992	2.0	0.08
2.8L	14057993	1.0	0.04
4.3L	14036090	1.0	0.04
4.3L	1246249	0.33	0.013

FASTENER TIGHTENING SPECIFICATIONS

	N.m	Ft. Lbs.	In. Lbs.
STARTER			
2.5L Engine			
Mounting Bolts	43	31	—
Brush End Nuts	8	—	75
2.8L and 4.3L Engine			
Mounting Bolts	45	33	—

T2033

SECTION 6D3

CHARGING SYSTEM

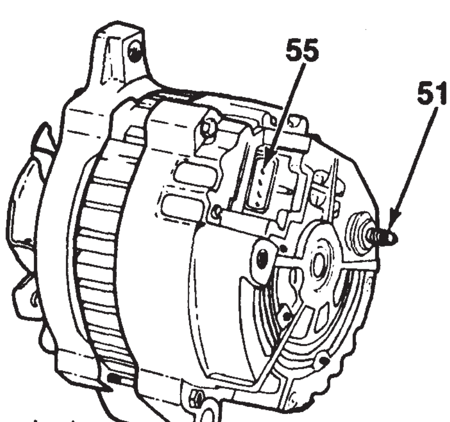
***NOTICE:** When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.*

CONTENTS

GENERAL DESCRIPTION

CHARGING SYSTEM

The charging system consists of the battery, the generator, the regulator, and the charging system indicator lamp circuitry. On the 2.5L and 4.3L engines, the generator has a fusible link in two of the three wires at the BAT terminal. The generator supplies electrical power for charging the battery and operating accessories.



51. BAT Terminal
55. Terminals P, L, I, S

F2516

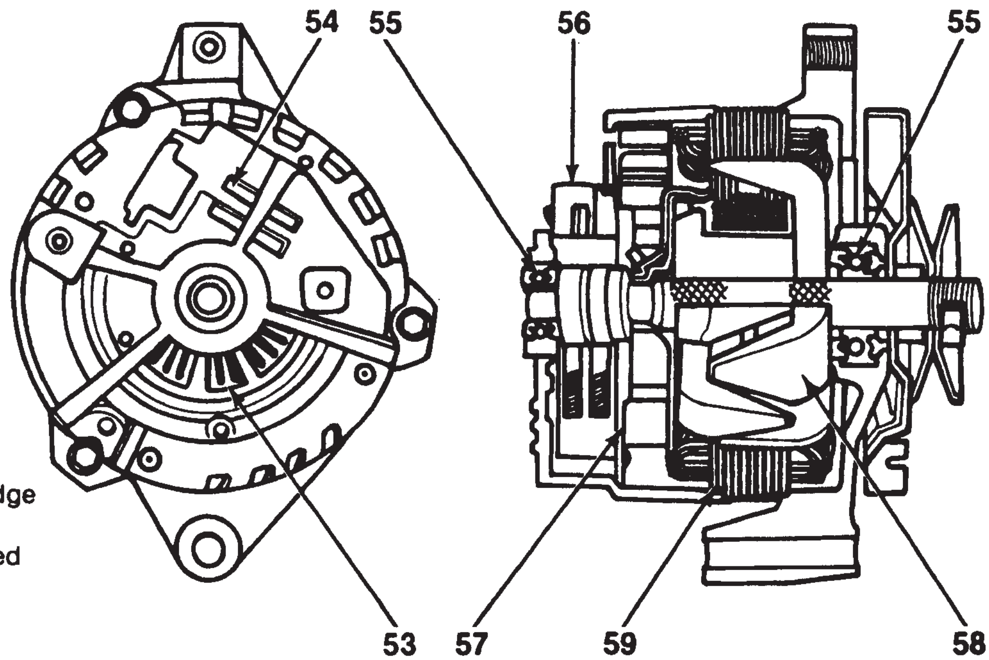
Figure 1—CS-130 Generator

The CS-130 (figures 1 and 2) is a generator featuring a high ampere output per pound of weight. The CS stands for charging system and 130 is the measurement in millimeters of the outside diameter of the stator laminations.

This generator with integral regulator does not have a diode trio. The delta stator, rectifier bridge, and rotor with slip rings and brushes are electrically similar to other generators. A conventional fan and pulley are used, and an internal fan cools the slip rings, end frame, rectifier bridge, and regulator.

The charge indicator, which appears on the instrument panel as a battery symbol (except on the right-hand drive vehicle), lights when the engine control switch is closed and goes out when the engine is running. If the charge indicator is on with the engine running, a charging system problem is indicated. This indicator will glow at full brilliance, not half lit, if any charging problem occurs or if the system voltage is too high or too low.

The regulator voltage setting varies with temperature, and limits system voltage by controlling rotor field current. It switches rotor field current on and off at a fixed frequency of about 400 cycles per second. By varying the on-off time, correct average field current for proper system voltage control is obtained. At high speeds, the on-time may be 10 percent and the off-time 90 percent. At low speeds, with high electrical loads, on-off time may be 90 percent and 10 percent respectively.



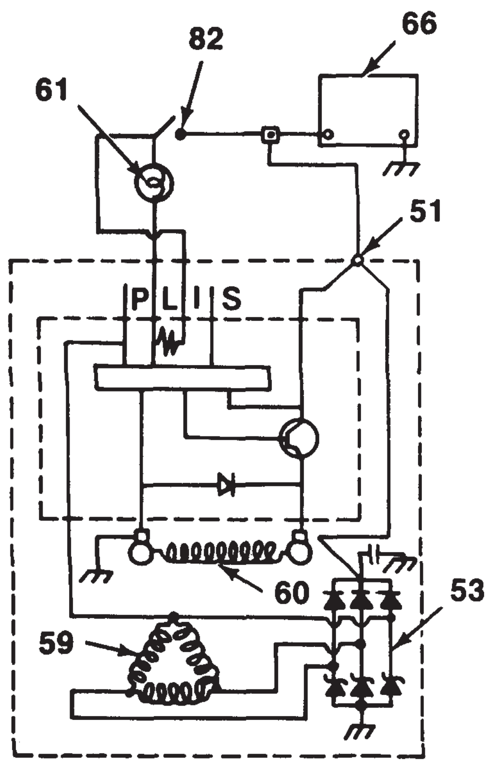
53. Rectifier Bridge
54. Regulator
55. Double Sealed Ball Bearing
56. Terminals
57. Internal Fan
58. Rotor
59. Stator

B9568

Figure 2—Generator Components

The regulator has four terminals, "P," "L," "I," and "S" (figure 3). The use of the "P," "L," and "S" terminals is optional. The "P" terminal is connected to the stator, and may be wired to a tachometer or other device. The "S" terminal may be wired to the battery to sense voltage to be controlled. The "L" and "I" terminals serve to turn on the regulator and allow field current to flow when the switch is closed. The "I" terminal may be connected directly to the switch, or through a resistor. The "I" circuit may be used with or without the "L" circuit; that is, with or without anything connected to the "L" circuit. Refer to the Electrical Diagrams and Diagnosis Manual for the S/T truck for specific application.

The generator is not serviceable, and no periodic maintenance is required. It should not be disassembled for any reason.



51. BAT Terminal
53. Rectifier Bridge
59. Stator
60. Field
61. Indicator Lamp
66. Battery
82. Switch

F8806

Figure 3—CS Generator Schematic

DIAGNOSIS OF THE CHARGING SYSTEM

NOISY GENERATOR

Noise from a generator may be caused by a loose drive pulley, loose mounting bolts, worn or dirty bearings, or a worn stator. If the pulley and mounting bolts are snug and the noise continues, replace the generator. Refer to "Generator Replacement" later in this section.

Do not disassemble the generator. Even separating the two end frames will cause damage to the slip ring end bearing. This generator cannot be serviced. It must be replaced.

ELECTRICAL TESTS

Before performing the diagnosis procedures on the vehicle, be certain that the system wiring is good and generator belts are not slipping. Also, the battery must be fully charged for a valid test of the charging system.

NOTICE: To avoid damage to the vehicle electrical system, observe the following precautions:

- ***Do not polarize the generator.***
- ***Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.***
- ***NEVER operate the generator with the output terminal open-circuited.***
- ***Make sure the generator and battery have the same ground polarity.***
- ***When connecting a charger or booster battery to the vehicle battery, connect negative to negative and positive to positive.***

CIRCUIT DIAGNOSIS

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

- Abnormal indicator lamp operation.
- An undercharged battery as evidenced by slow cranking or dark hydrometer.
- An overcharged battery as evidenced by excessive spewing of electrolyte from the vents.

A basic wiring diagram for the charging system is shown in figure 3. When the system is operating normally, the indicator lamp will come on when the engine control switch is turned on and go out when the engine starts. If the lamp operates abnormally, or if an undercharged or overcharged battery condition occurs, the following procedure may be used to diagnose the charging system. Remember that an undercharged battery is often caused by accessories being left on overnight, or by a switch stuck closed which allows a lamp, such an instrument panel compartment lamp, to stay on.

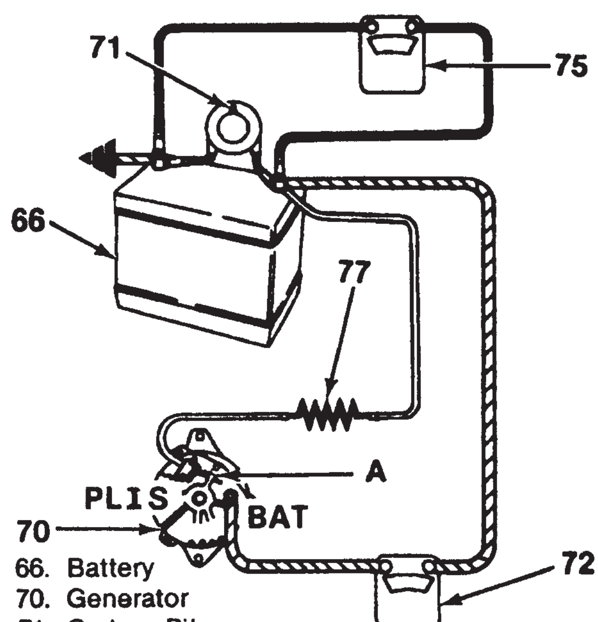
This generator does not have a test hole.

DIAGNOSTIC TEST FOR CS-130

1. Check belt for wear and tension. Check wiring.
2. Go to Step 5 for vehicles without a charge indicator lamp.
3. With the engine control switch on and the engine stopped, the lamp should be on. If not, detach the wiring harness at the generator and use a fused (5 amp) jumper to ground the "L" terminal lead.
   - If the lamp lights, replace the generator.
   - If the lamp does not light, locate the open circuit between the grounding lead and the engine control switch. The lamp may be open.
4. With the switch on, and the engine running at moderate speed, the lamp should be off. If not, detach the wiring harness at the generator.
   - If the lamp goes out, replace the generator.
   - If the lamp stays on, check for a grounded "L" terminal wire in the harness.
5. If the battery is undercharged or overcharged:
   - Detach the wiring harness connector from the generator.
   - With the switch on and the engine not running, connect a voltmeter from ground to the "L" terminal in the wiring harness, and to the "I" terminal, if used. The wiring harness may connect to either "I" or to both.
   - A zero reading indicates an open circuit between the terminal and the battery. Correct as required.
   - Connect the harness connector to the generator and run the engine at moderate speed with accessories off.
   - Measure the voltage across the battery. If above 16 volts, replace the generator.
   - Connect an ammeter at the generator output terminal, connect a voltmeter across the generator, turn on the accessories and load the battery with a carbon pile to obtain maximum amperage. Maintain voltage at 13 volts or above.
     - If the output in amperes is within 15 amperes of the rated output, the generator is OK. (Refer to "Specifications" at the end of this section.)
     - If the output is not within 15 amperes of the rated output, replace the generator.

GENERATOR BENCH CHECK

1. Make connections as shown in figure 4, except leave the carbon pile disconnected. The ground polarity of the generator and battery must be the same. The battery must be fully charged. Use a 30 to 500 ohm resistor between the battery and the "L" terminal.
2. Slowly increase generator speed and observe the voltage.
3. If the voltage is uncontrolled and increases above 16 volts, the rotor field is shorted, the regulator is not working properly, or both. A shorted rotor field coil can cause problems in the regulator.
4. If the voltage is below 16 volts, increase speed and adjust the carbon pile to obtain maximum amperage output. Maintain the voltage above 13 volts.
5. If the output is within 15 amperes of the rated output, the generator is good.
6. If the output is not within 15 amperes of the rated output, replace the generator.



66. Battery
70. Generator
71. Carbon Pile
72. Ammeter
75. Voltmeter
77. Resistor
A. Connect Resistor to "L" Terminal

F2514

Figure 4—Connections for Generator Output Test

ON-VEHICLE SERVICE

GENERATOR REPLACEMENT

The removal and installation instructions serve only as a guide. Additional operations may be required on some vehicles to remove other equipment to gain access to the generator, drive belts and brackets.

CAUTION: Failure to observe Step 1 in this procedure may result in an injury from the hot battery lead at the generator.

Remove or Disconnect (Figures 5, 6, and 7)

1. Negative battery cable at the battery.
2. Terminal plug and battery lead from the back of the generator.
3. Drive belt.
4. Bolt at the back of the generator.
5. Two mounting bolts.
6. Generator from the mounting bracket.

Install or Connect (Figures 5, 6, and 7)

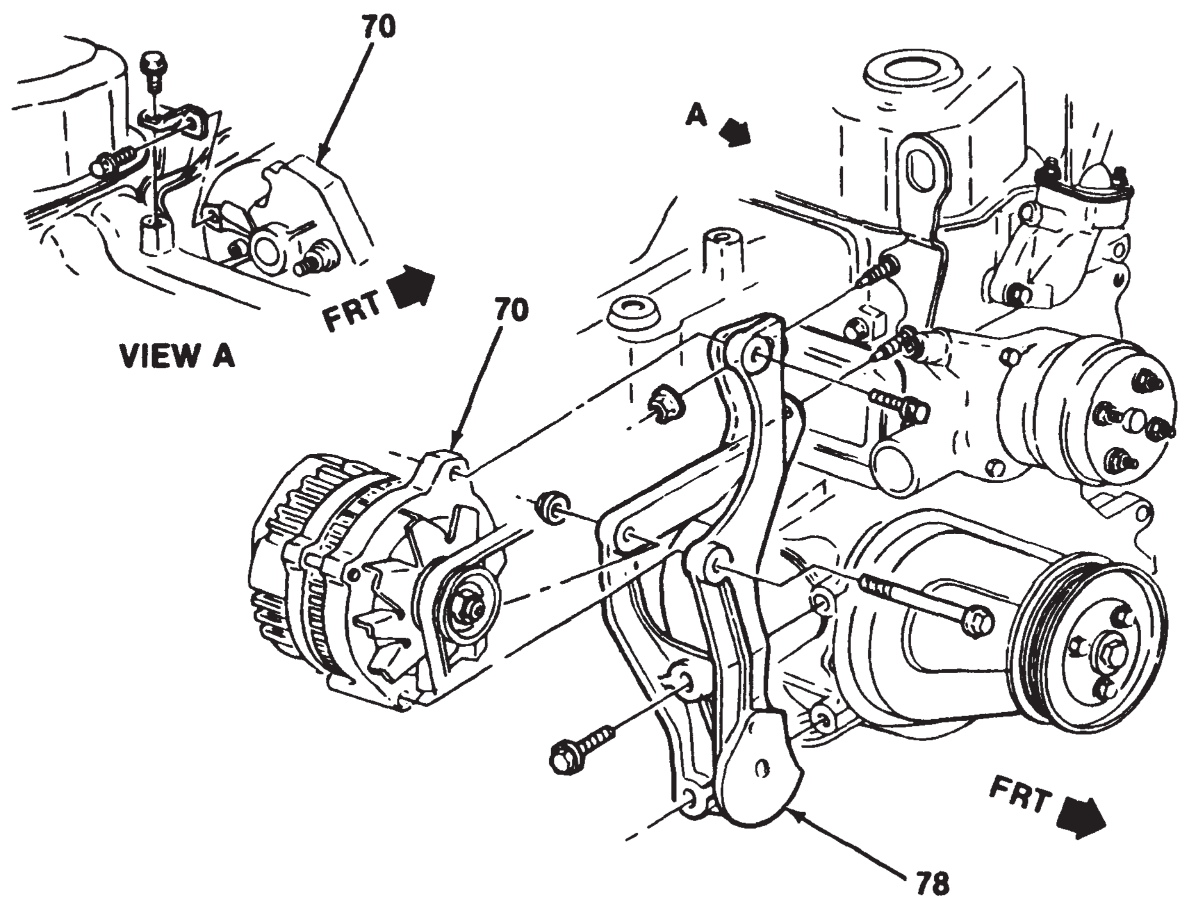
1. Generator to the mounting bracket with two bolts.
2. Bolt to the back of the generator.
3. Drive belt.

NOTICE: Refer to "Notice" on page 6D3-1.

Tighten

2.5L Engine
- Nut on the lower mounting bolt to 50 N.m (37 ft. lbs.).
- Upper mounting bolt to 34 N.m (25 ft. lbs.).
- Rear bolt to 27 N.m (20 ft. lbs.).

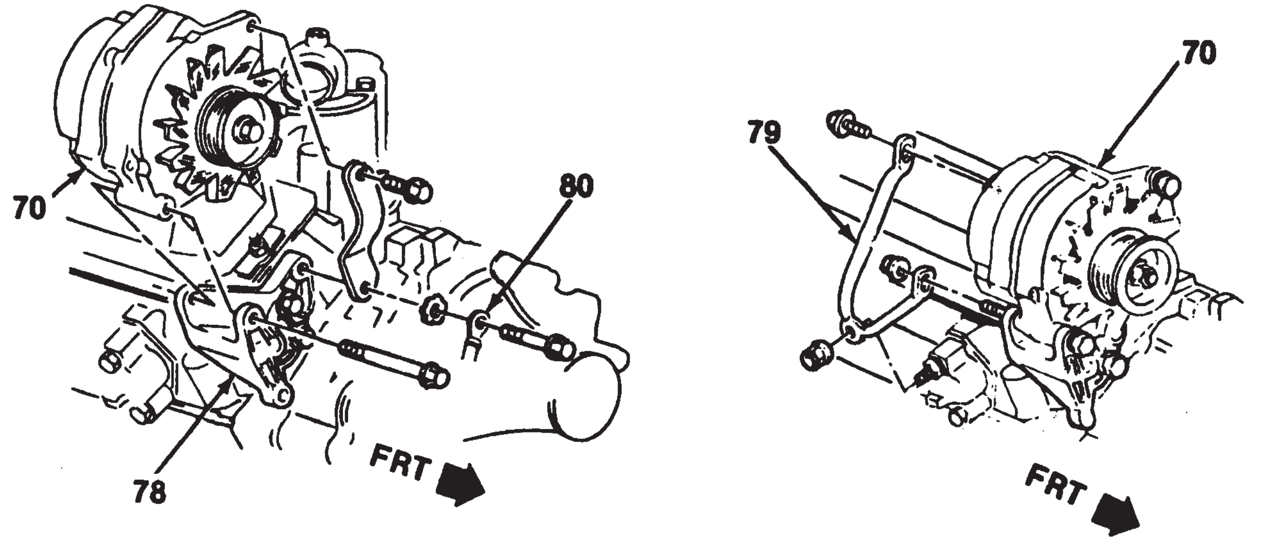
2.8L Engine
- Lower mounting bolt to 50 N.m (25 ft. lbs.).
- Upper mounting bolt to 25 N.m (18 ft. lbs.).
- AIR pump bracket bolt and stud nut to 25 N.m (18 ft. lbs.).



70. Generator
78. Mounting Bracket

B-07631
B7631

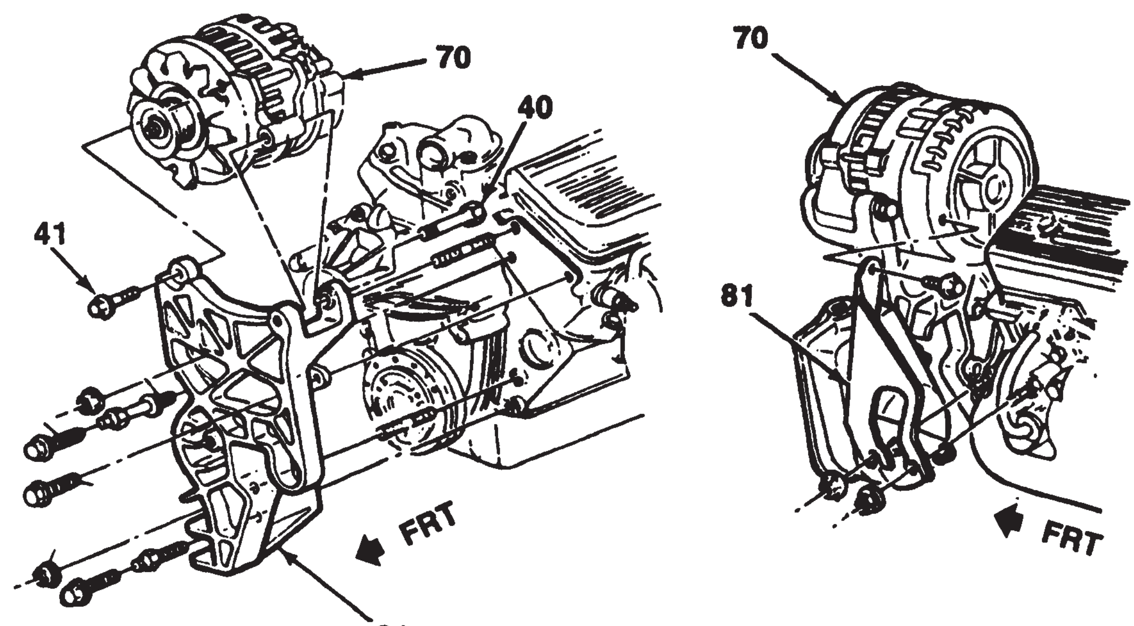
Figure 5—Generator Mounting for the 2.5L Engine



70. Generator
78. Mounting Bracket
79. A.I.R. Pump Bracket
80. Negative Battery Cable

B7632

Figure 6—Generator Mounting for the 2.8L Engine



40. Left Mounting Bolt
41. Right Mounting Bolt
70. Generator
81. Brace

F6520

Figure 7—Generator Mounting for the 4.3L Engine

4.3L Engine

- Left mounting bolt to 50 N·m (37 ft. lbs.).
- Right mounting bolt to 25 N·m (18 ft. lbs.).
- Bolt at brace: 25 N·m (18 ft. lbs.).

4. Terminal connector and battery lead to the back of the generator.
5. Negative battery cable.

SPECIFICATIONS

GENERATOR SPECIFICATIONS

Engine	Part Number				Field Current (80°F)		Cold Output		Rated Hot Output	
		Series	Type	Rotation	Amps	Volts	Amps	RPM	Amps	RPM
2.5L	1101618	CS 130	100	CW	5.7-7.5	12	26	1200	96	6500
2.8L	1101259	CS 130	100	CW	4.8-5.7	12	30	1600	85	6500
4.3L	10479801	CS 130	100	CW	4.8-5.7	12	30	1600	85	6500

FASTENERS

	N·m	Ft. Lbs.
2.5L Engine		
Lower Mounting Nut	50	37
Rear Bolt	27	20
Upper Mounting Bolt	34	25
2.8L Engine		
Lower Mounting Bolt	50	37
Upper Mounting Bolt	25	18
AIR Pump Bracket Bolt and Stud Nut	25	18
Bottom Bracket Nut	50	37
4.3L Engine		
Left Mounting Bolt	50	37
Right Mounting Bolt	25	18
Bolt at Brace	25	18

T2032

SECTION 6D4

IGNITION SYSTEM

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

IGNITION SYSTEM

All ignition systems includes a battery, a distributor, an ignition (engine control) switch, spark plugs, and the primary and secondary wiring. Information on the battery is located in BATTERY (SECTION 6D1).

DISTRIBUTOR

A distributor with a separate coil is used on these engines (figure 1). The coil connects to the rotor through a high tension wire.

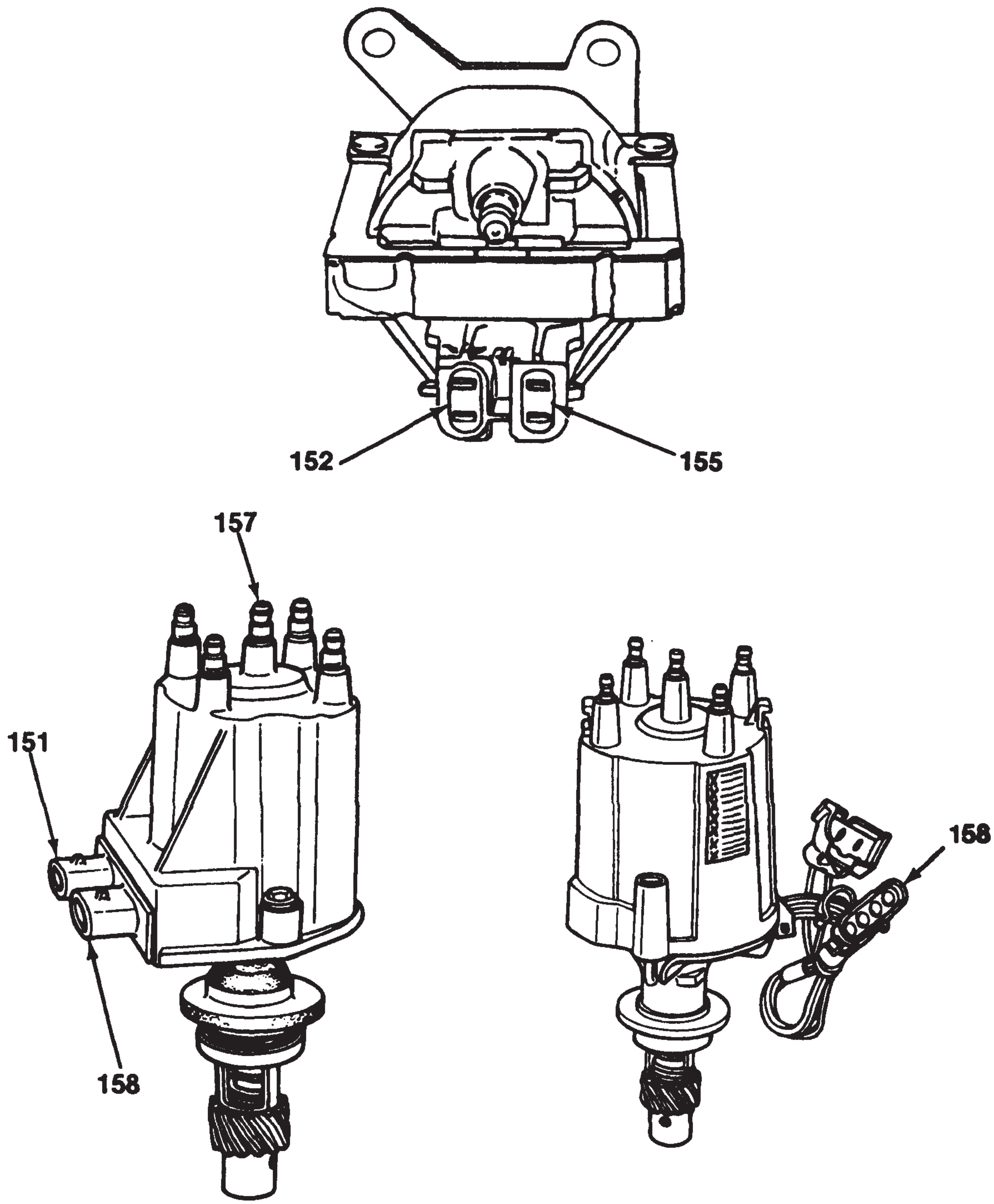
The distributor uses a magnetic pickup assembly located inside the distributor which contains a permanent magnet, a pole piece with internal teeth, and pickup coil. When the teeth of the timer core rotating inside the pole piece line up with the teeth of the pole piece, an induced voltage in the pickup coil signals the electronic module to trigger the coil primary circuit. The primary current decreases and a high voltage of up to 35,000 volts is induced in the ignition coil secondary winding which is directed through the rotor and secondary leads to fire the spark plugs. The capacitor in the distributor is for radio noise suppression.

The distributor also features a longer spark duration, made possible by the higher amount of energy stored in the coil primary. This is desirable for firing lean mixtures.

No periodic lubrication is required. Engine oil lubricates the lower bushing and an oil-filled reservoir provides lubrication for the upper bushing.

EST (ELECTRONIC SPARK TIMING) SYSTEM

EST is a part of most computer command control systems. The computer, called an ECM (Electronic Control Module), monitors information from various



151. Ignition Coil Connector Terminals
152. Terminal for Distributor Module Connector
155. Teminal for Ignition Switch
Connector and Tach Connector
157. Coil Lead
158. Four Terminal Connector

F8865

Figure 1—EST Distributor with Separate Coil

engine sensors, computes the desirable spark timing, and signals the distributor to change the timing.

The distributor does not contain centrifugal advance weights, springs, or a vacuum advance unit.

For information on the Electronic Spark Timing system, system components and their locations, and diagnostic charts, refer to the Fuel and Emissions Service Manual. If you are using ST 369-92, the manual is at the back of the service manual. If you are using X-9229, the manual is under separate cover.

ELECTRONIC SPARK CONTROL (ESC)

The 2.8L and 4.3L engines are equipped with electronic spark control (figures 2, 3 and 4). A knock sensor is mounted in the engine block. It is connected by a blue wire to the ESC module, mounted on the cowl in the engine compartment. The sensor, in response to engine knock, sends a signal to the module. This sends a signal to the ECM, located in the passenger compartment. The ECM sends a signal to the distributor to retard spark timing.

Information and diagnostic material on ESC are located in the Fuel and Emissions Manual. If you are using ST 369-92, the manual is at the back of the service manual. If you are using X-9229, the manual is under separate cover.

IGNITION TIMING

Timing specifications for each engine are listed on the Vehicle Emissions Control Information label on the radiator support. Always follow Vehicle Emissions Control Information label procedures when adjusting timing. When using a timing light, connect an adapter between the No. 1 spark plug and the No. 1 spark plug wire, or use an inductive type pickup. Do not pierce the plug lead. Once the insulation of the spark plug cable has been broken, voltage will jump to the nearest ground, and the spark plug will not fire properly.

Some engines incorporate a magnetic timing probe hole for use with special electronic timing equipment. Consult manufacturer's instructions for use of this equipment.

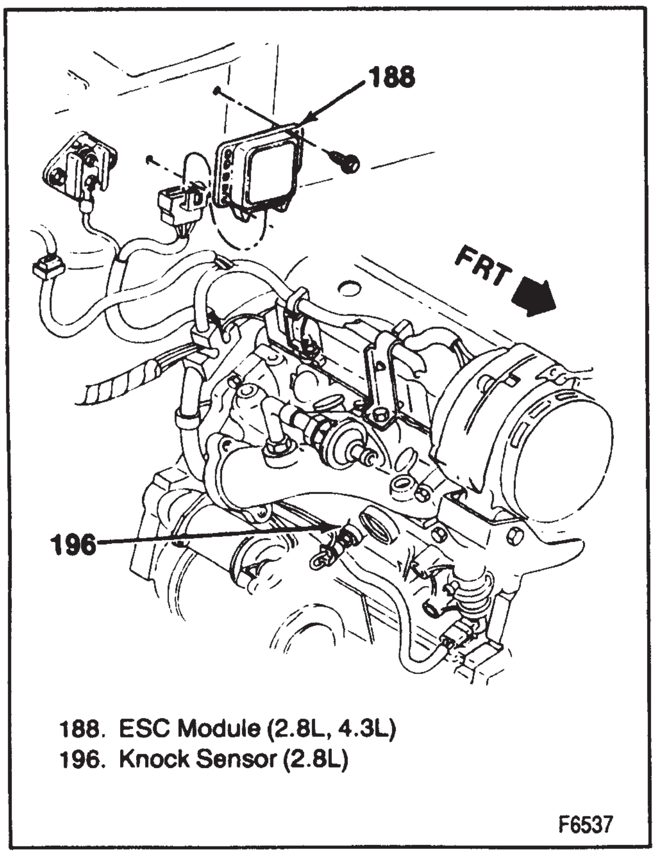


Figure 2—Electronic Spark Control

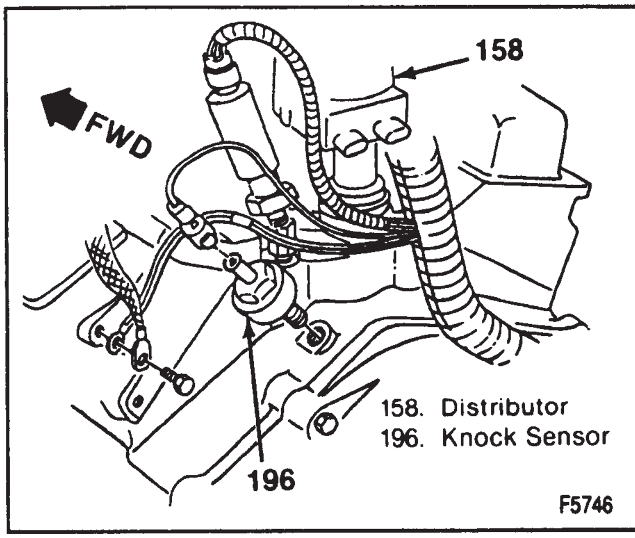


Figure 3—Knock Sensor (4.3L LB4 Engine)

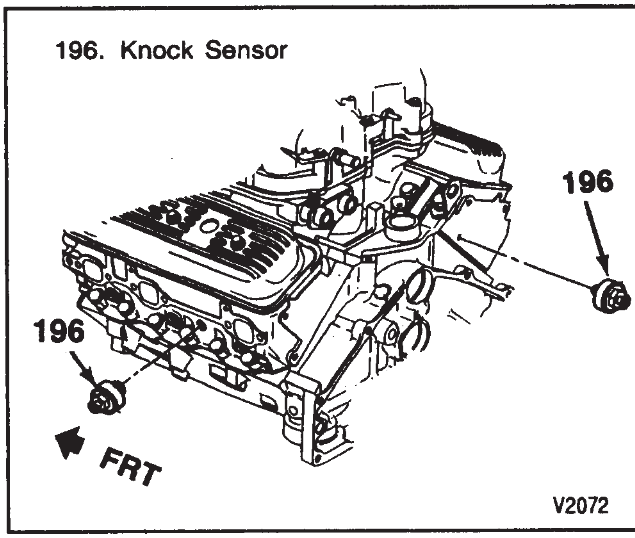


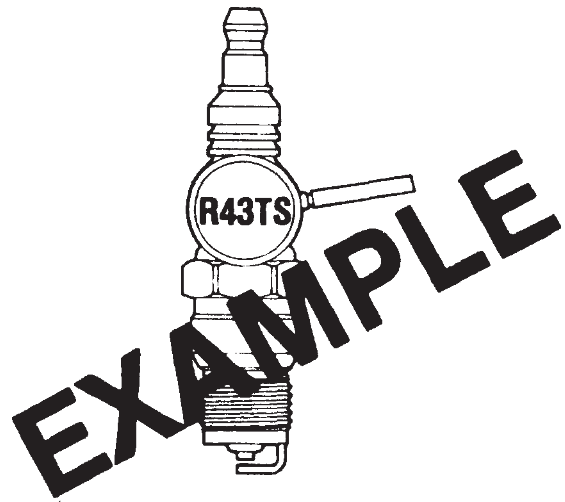
Figure 4—Knock Sensor (4.3L L35 Engine)

SPARK PLUG WIRES

The 7 mm wire used on the 2.5L and 2.8L engines and the 8 mm wire used on the 4.3L engine has an outer layer of silicone. The silicone spark plug boots form a tight seal on the plugs. Refer to "Spark Plug Wiring and Boots" later in this section for service precautions.

SPARK PLUGS

Resistor-type, tapered-seat spark plugs are used on all engines. No gasket is used on these tapered seat plugs. Refer to figures 5 and 6 for an explanation of letter coding on spark plugs. A dot before the spark



R = Resistor
4 = 14mm Thread
3 = Heat Range
T = Taper Seat
S = Extended Tip

F8866

Figure 5—Spark Plug Coding

Numbers relate to thread size as follows:
1st number denotes THREAD SIZE

4 = 14 mm	2 = ½-inch taper
8 = 18 mm	5 = ½-inch
10 = 10 mm	6 = ¾-inch
12 = 12 mm	7 = ⅞-inch

2nd number denotes HEAT RANGE

0-1-2-3-4-5-6-7-8-9
COLD ———— HOT

F2496

Figure 6—Spark Plug Coding Chart

letter coding on spark plugs. A dot before the spark plug code or the letter "C" after the number in the code indicates the plug has a copper core. Refer to the Specifications at the end of this section for information on spark plugs or to the Vehicle Emissions Control Information label on the radiator support for correct gap information.

Normal or average service is assumed to be a mixture of idling, slow speed, and high speed operation with some of each making up the daily total driving. Occasional or intermittent high-speed driving is essential to good spark plug performance as it provides increased and sustained combustion heat that burns away any excess deposits of carbon or oxide that may have accumulated from frequent idling or continual stop-and-go or slow-speed driving. Spark plugs are protected by an insulating boot made of special heat-resistant material which covers the spark plug terminal and extends downward over a portion of the plug insulator. These boots prevent flash-over with resultant missing of the engine, even though a film is allowed to accumulate on the exposed portion of plug porcelains.

Do not mistake corona discharge for flash-over or a shorted insulator. Corona is a steady blue light appearing around the insulator, just above the shell crimp. It is the visible evidence of a high-tension field, and has no effect on ignition performance. Usually it can be detected only in darkness. This discharge may repel dust particles, leaving a clear ring on the insulator just above the shell. This ring is sometimes mistakenly regarded as evidence that combustion gases have blown out between shell and insulator.

DIAGNOSIS OF IGNITION SYSTEM

ELECTRONIC SPARK TIMING SYSTEM

The Fuel and Emissions Service Manual covers this system, including the diagnostic use of the "Service Engine Soon" lamp. If you are using ST 369-92, the manual is at the back of the service manual. If you are using X-9229, the manual is under separate cover.

Refer to the Light Duty Truck Unit Repair Manual for distributor component checks.

DIAGNOSIS OF SPARK PLUGS

PROBLEM	POSSIBLE CAUSE	CORRECTION
Brown to grayish-tan deposits and slight electrode wear.	Normal wear.	Clean, regap, reinstall.
Dry, fluffy black carbon deposits.	Poor ignition output.	Check distributor to coil connections. Refer to the Fuel and Emissions Service Manual.
Wet, oily deposits with very little electrode wear.	1. "Break-in" of new or recently overhauled engine. 2. Excessive valve stem guide clearances. 3. Worn intake valve seals.	1. Degrease, clean and reinstall the plugs. 2. Refer to ENGINE (SECTION 6A). 3. Replace the seals.
Red, brown, yellow and white colored coatings on insulator. Engine misses intermittently under severe operating conditions.	By-products of combustion.	Clean, regap, and reinstall. If heavily coated, replace.
Colored coatings heavily deposited on the portion of the plug projecting into the chamber and on the side facing the intake valve.	Leaking seals if condition is found in only one or two cylinders.	Check the seals. Replace if necessary. Clean, regap, and reinstall the plugs.
Shiny yellow glaze coating on insulator.	Melted by-products of combustion.	Avoid sudden acceleration with wide-open throttle after long periods of low speed driving. Replace the plugs.
Burned or blistered insulator tips and badly eroded electrodes.	Overheating.	1. Check the cooling system. 2. Check for sticking heat riser valves. Refer to ENGINE (SECTION 6A). 3. Lean air-fuel mixture. Refer to the Fuel and Emissions Service Manual. 4. Check the heat range of the plugs. May be too hot. 5. Check ignition timing. May be over-advanced. 6. Check the torque value of the plugs to ensure good plug-engine seat contact.
Broken or cracked insulator tips.	Heat shock from sudden rise in tip temperature under severe operating conditions. Improper gapping of plugs.	Replace the plugs. Gap correctly.

D0071

IGNITION SYSTEM ON-VEHICLE SERVICE

SERVICE PRECAUTIONS

Some service tachometers and electronic diagnostic equipment may NOT be compatible with this ignition system. Consult your representative of such equipment.

1. When making compression checks, disconnect the engine control switch feed wire at the distributor. When disconnecting this connector, release the locking tab while pulling downward on the connector body; do not use a screwdriver or tool to release the locking tab as it may break the tab.
2. No periodic lubrication of the distributor is required. Engine oil lubricates the lower bushing and an oil-filled reservoir provides lubrication for the upper bushing.
3. The tachometer (TACH) terminal is next to the engine control switch (BAT) connector on the distributor cap.

NOTICE: The tachometer terminal must NEVER be allowed to touch ground, because damage to the module inside the distributor and/or ignition coil can result.

4. There is no manual dwell adjustment.
5. The material used to construct the spark plug wires is very pliable and soft. This wire will withstand more heat and carry a higher voltage. Due to the more pliable wire, scuffing and cutting become easier. It is therefore extremely important that the spark plug wires be routed correctly to prevent chafing or cutting. When removing a spark plug wire from a spark plug, twist the boot on the spark plug and **pull on the boot** to remove the wire.

IGNITION COIL CHECK

1. Disconnect the distributor lead and wiring from the coil.
2. Connect an ohmmeter as shown in figure 7, step 1. Use the high scale. The reading should be infinite. If not, replace the coil.
3. Connect the ohmmeter as shown in step 2 (figure 7). Use the low scale. The reading should be very low or zero. If not, replace the coil.
4. Connect the ohmmeter as shown in step 3. Use the high scale. The meter should not read infinite. If it does, replace the coil.
5. Reconnect the distributor lead and wiring to the coil.

PICKUP COIL CHECK

1. Disconnect the negative battery cable.
2. Remove the distributor cap.
3. Disconnect the pickup coil connector from the module.
4. Check the resistance of the coil with an ohmmeter.
   - Connect an ohmmeter to either pickup coil lead and the housing as shown in figure 8, step 1. The reading should be infinite. If not, replace the coil.
   - Connect an ohmmeter to both pickup coil leads as shown in figure 8, step 2. Flex the leads by hand at the coil and the connector to locate any intermittent opens. The ohmmeter should read a constant unchanging value in the 500 to 1500 ohm range. If not, replace the coil.
- To replace the coil, remove the distributor. Refer to the Light Duty Truck Unit Repair Manual for distributor disassembly.

DISTRIBUTOR AND COIL REPLACEMENT

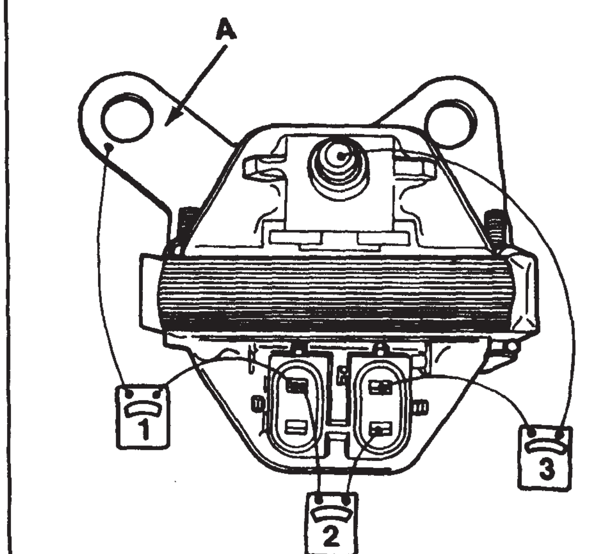
Replacement distributors are not available already assembled. Replacement kits contain all the components to assemble a new distributor.

The distributor has a separate coil which is mounted on the right side of the engine.

DISTRIBUTOR

Remove or Disconnect

1. Negative battery cable.
2. Air cleaner and hoses.
3. Wiring harness connectors at the side of the distributor cap.
4. Two screws on the sides of the distributor cap.
5. Coil wire and spark plug wires on either the left or right side of the distributor.



A. Scrape clean metal ground.

F2117

Figure 7—Testing the Ignition Coil

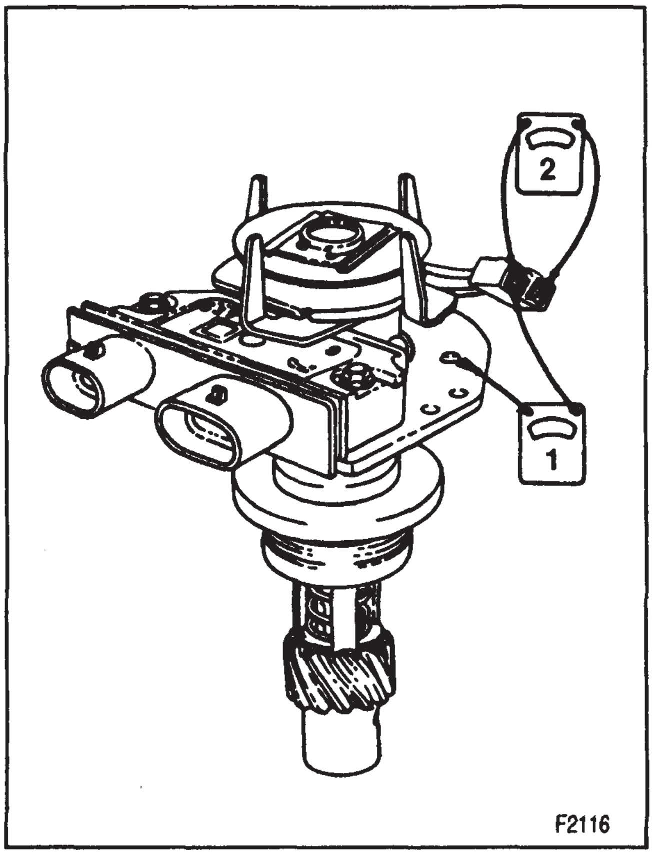


Figure 8—Testing the Pickup Coil

6. Distributor cap and move it aside.
   - Scribe a mark on the distributor shaft in line with the rotor.
   - Scribe a mark on the engine in line with the rotor.
   - Note the position of the distributor housing in relation to the engine.
7. Distributor, bolt, and hold-down clamp.
8. Distributor and gasket, when present.

Install or Connect

- To ensure correct timing of the distributor it must be installed with the rotor correctly positioned as noted in step 6 of the removal procedure. Line up the rotor, the mark on the distributor shaft, and the mark on the engine.
- If the distributor shaft won't drop into the engine, insert a screwdriver into the hole for the distributor and turn the oil pump driveshaft.

1. Distributor and gasket, where present.

NOTICE: Refer to "Notice" on page 6D4-1.

2. Hold-down clamp and bolt.

Tighten

- Bolt on the 2.5L to 17 N·m (13 ft. lbs.).
- Bolt on the 2.8L to 35 N·m (26 ft. lbs.).
- Bolt on the 4.3L to 27 N·m (20 ft. lbs.).

3. Distributor cap.
4. Wiring harness connectors at the side of the distributor.
5. Spark plug wires and coil wire.
6. Air cleaner and hoses.
7. Negative battery cable.
   - Check the engine timing.

IGNITION COIL

Remove or Disconnect

1. Negative battery cable.
2. Wiring connectors at the side of the coil.
3. Coil wire.
4. Nuts or screws holding the coil bracket and coil to the engine bracket or manifold.
5. Coil bracket and coil.
   - Drill and punch out the two rivets holding the coil to the bracket.
6. Coil from the bracket.

Install or Connect

A replacement coil kit comes with two screws to attach the coil to the bracket.

1. Coil to the bracket with two screws.
2. Coil bracket to the engine bracket or manifold with studs and nuts.
3. *Coil wire.*
4. Wiring connectors.
5. Negative battery cable.

IGNITION TIMING

CAUTION: To prevent possible personal injury from a moving vehicle or operating engine do the following before performing the checks:

1. **Engage the parking brake and block the wheels.**
2. **Place the automatic transmission in park or the manual transmission in neutral.**

1. Refer to the Vehicle Emissions Control Information label located on the radiator support panel. Follow all instructions on the label.
2. Refer to the Fuel and Emissions Manual at the back of the service manual or under separate cover for information on the bypass timing mode and directions for setting the timing.
3. With the engine control switch off, connect the pickup lead of the timing light to the number one spark plug. Use a jumper lead between the wire and plug or an inductive type pick up.

   DO NOT pierce the wire or attempt to insert a wire between the boot and the wire. Connect the timing light power leads according to manufacturer's instructions.
4. Follow all instructions on the Vehicle Emission Control Information label. Start the engine, and aim the timing light at the timing mark (figure 9). The line on the balancer or pulley will line up at the timing mark. If a change is necessary, loosen the distributor hold-down clamp bolt at the base of

the distributor. While observing the mark with the timing light, slightly rotate the distributor until the line indicates the correct timing. Tighten the hold-down bolt, and recheck the timing.

5. Turn off the engine and remove the timing light. Reconnect the number one spark plug wire, if removed.

SPARK PLUG REPLACEMENT

Remove or Disconnect

1. Negative battery cable.
2. Spark plug wires and boots.
   - Turn each boot one half turn before removing it.
   - Label the plug wires.

NOTICE: These spark plugs have a ceramic insulator which is about 1/8-inch longer than earlier model plugs. Be sure to use a spark plug socket which is deep enough for this longer length plug. Failure to do so could cause cracking of the insulator and arcing inside the plug, resulting in engine miss.

3. Spark plugs.

Inspect

- Each plug for wear and gap. Refer to "Specifications" at the end of this section for gap information.

Install or Connect

NOTICE: Refer to "Notice" on page 6D4-1.

1. Spark plugs.

Tighten

- Plugs to 15 N·m (11 ft. lbs.).

2. Wire and boot assemblies. Refer to "Spark Plug Wiring and Boots" below for precautions.
3. Negative battery cable.

SPARK PLUG WIRING AND BOOTS

PRECAUTIONS

1. Twist boots one-half turn before removing.
2. When removing the boot, do not use pliers or other tools that could tear the boot.

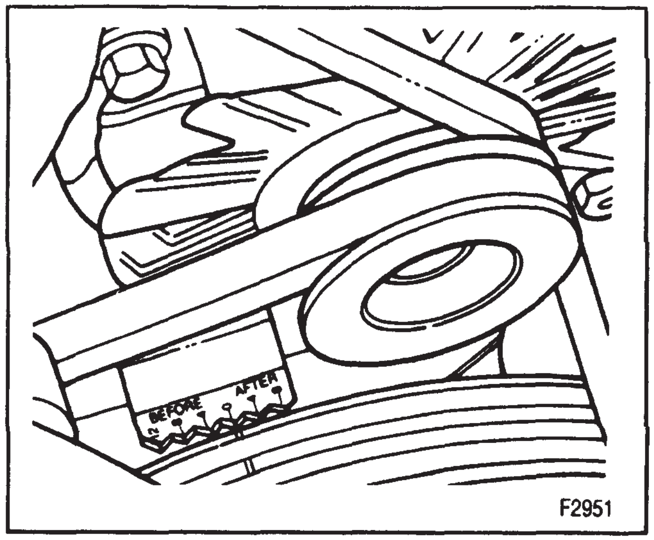


Figure 9—Typical Timing Mark

3. Do not force anything between the wire and the boot, or through the silicone jacket of the wiring.
4. Do not pull on the wires to remove the boot. Pull on the boot, or use a tool designed for this purpose.
5. Special care should be exercised when installing spark plug boots to assure that the metal terminal within the boot is fully seated on the spark plug terminal and that the boot has not moved on the wire. If boot to wire movement has occurred, the boot will give a false visual impression of being fully seated. A good check to assure that boots have been properly assembled is to push sideways on the installed boots. If they have been correctly installed, a stiff boot with only slight looseness will be noted. If the terminal has not been properly seated on the spark plug, only the resistance of the boot will be felt when pushing sideways.

SPARK PLUG WIRE REPLACEMENT

Wire routings must be kept intact during service and followed exactly when wires have been disconnected or when replacement of the wires is necessary. Failure to route the wires properly can lead to radio ignition noise and crossfiring of the plugs, or shorting of the leads to ground. The correct routing for each engine is shown in figures 10 through 15.

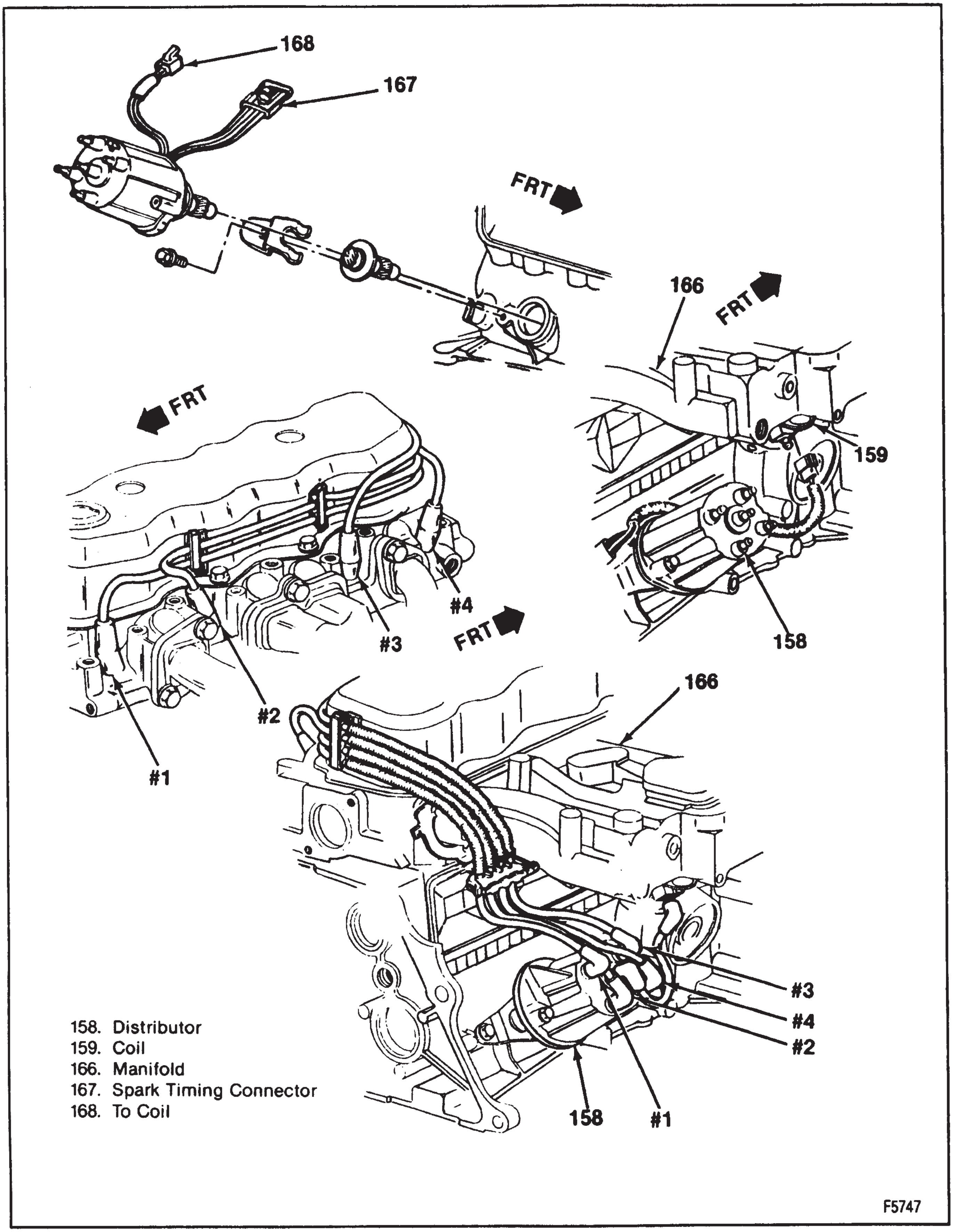


Figure 10—Spark Plug Wire Routing for the 2.5L Engine

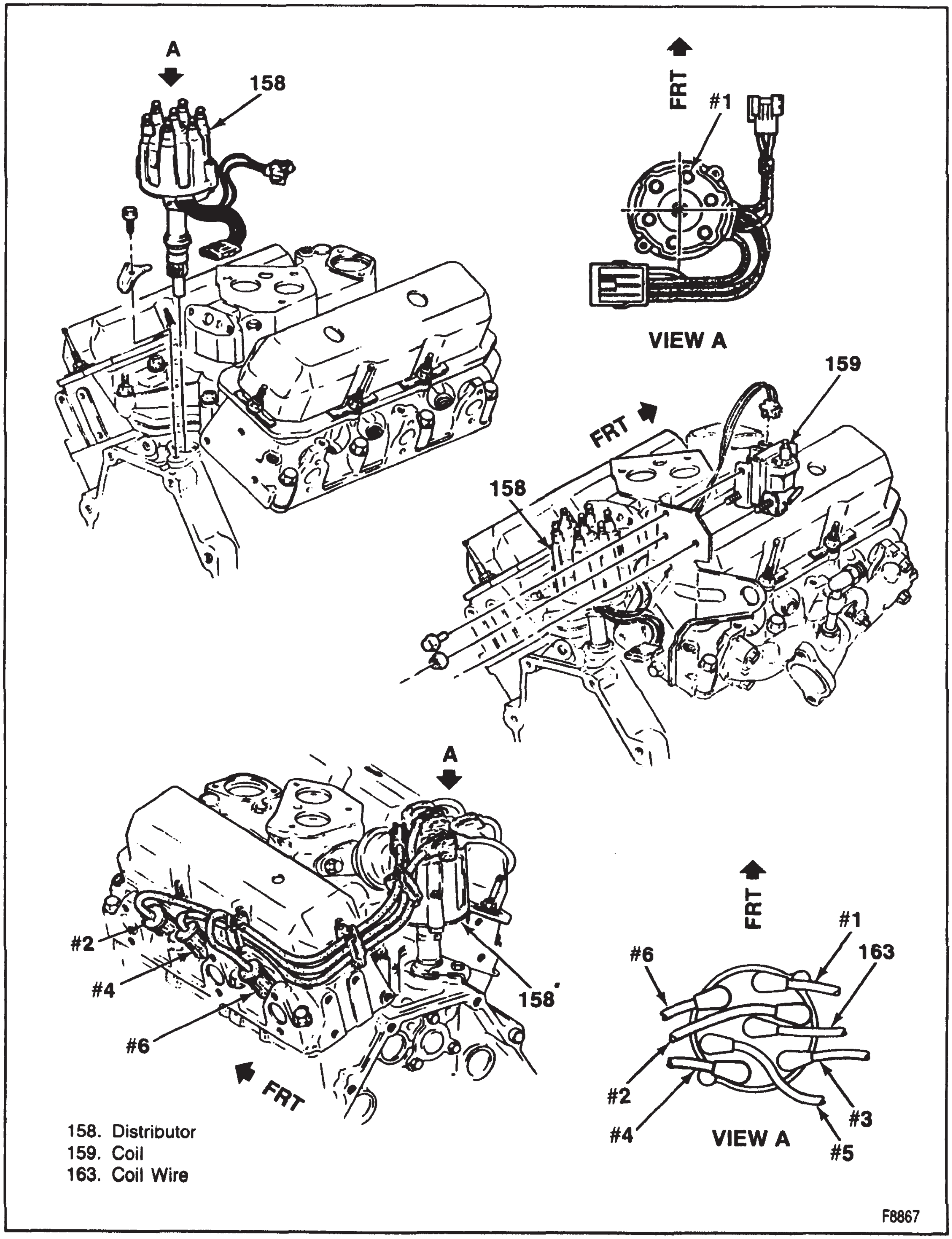


Figure 11—Distributor, Coil, and Spark Plug Wiring for the 2.8L Engine

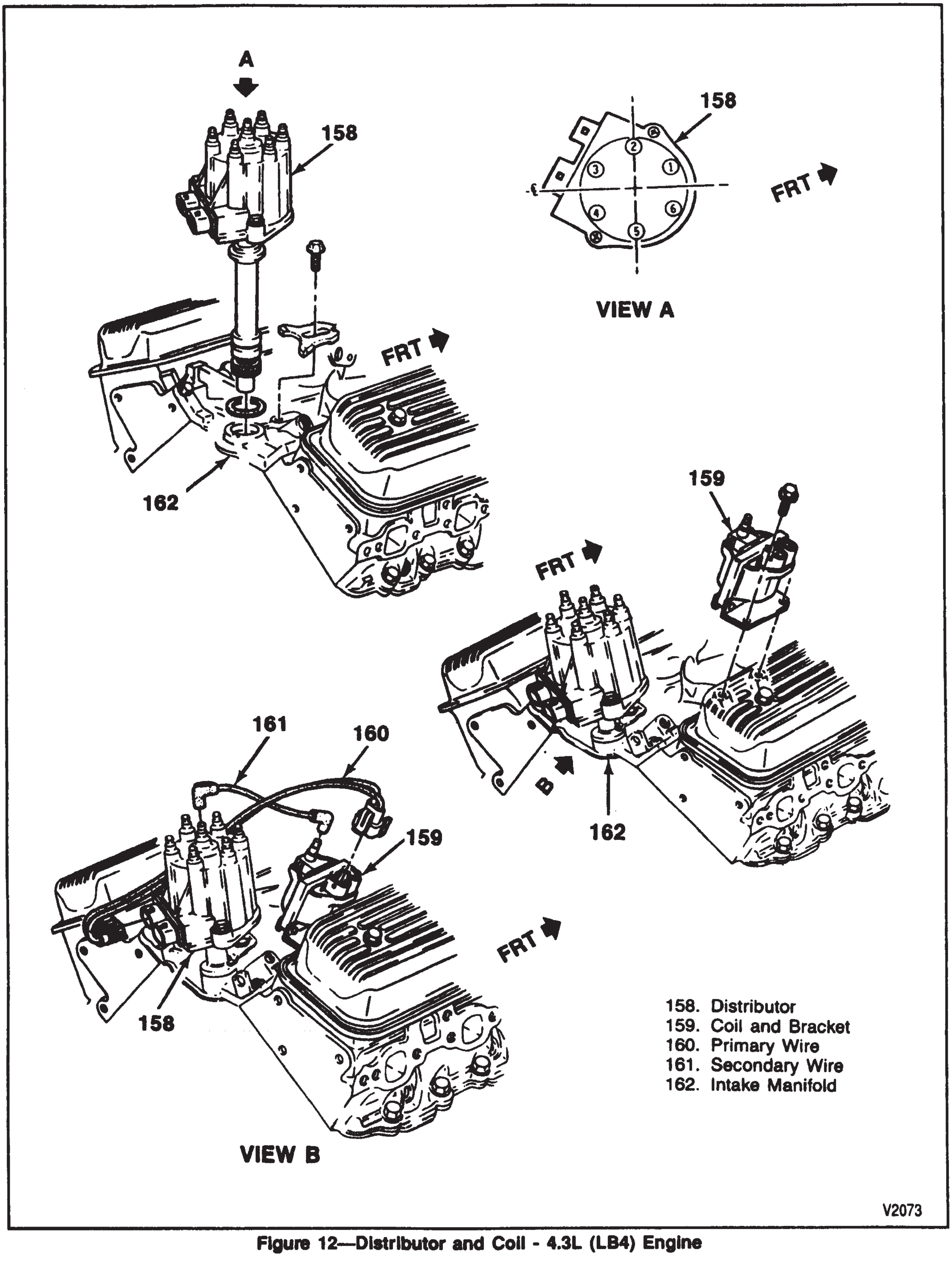
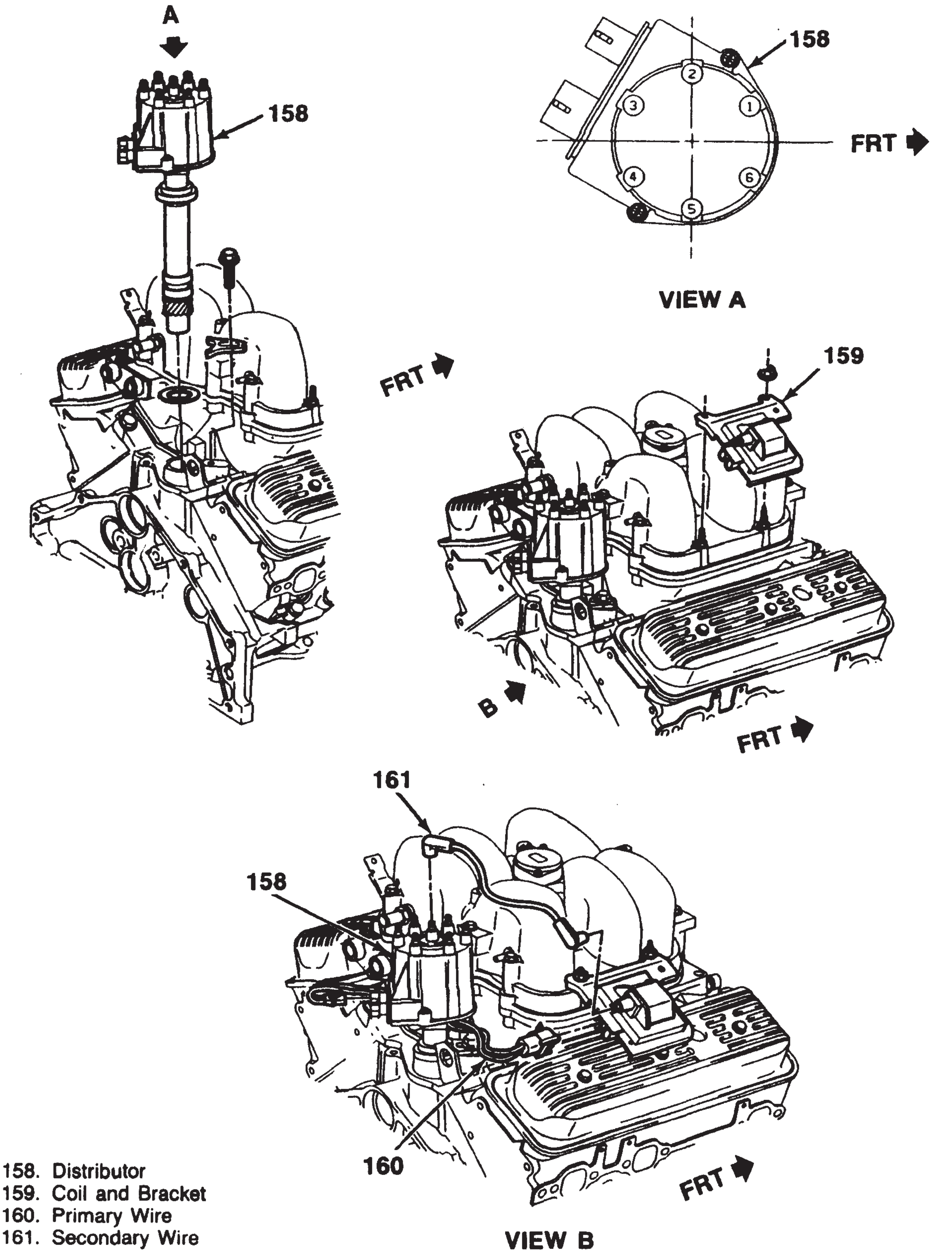


Figure 12—Distributor and Coil - 4.3L (LB4) Engine



158. Distributor
159. Coil and Bracket
160. Primary Wire
161. Secondary Wire

Figure 13—Distributor and Coil - 4.3L (L35) Engine

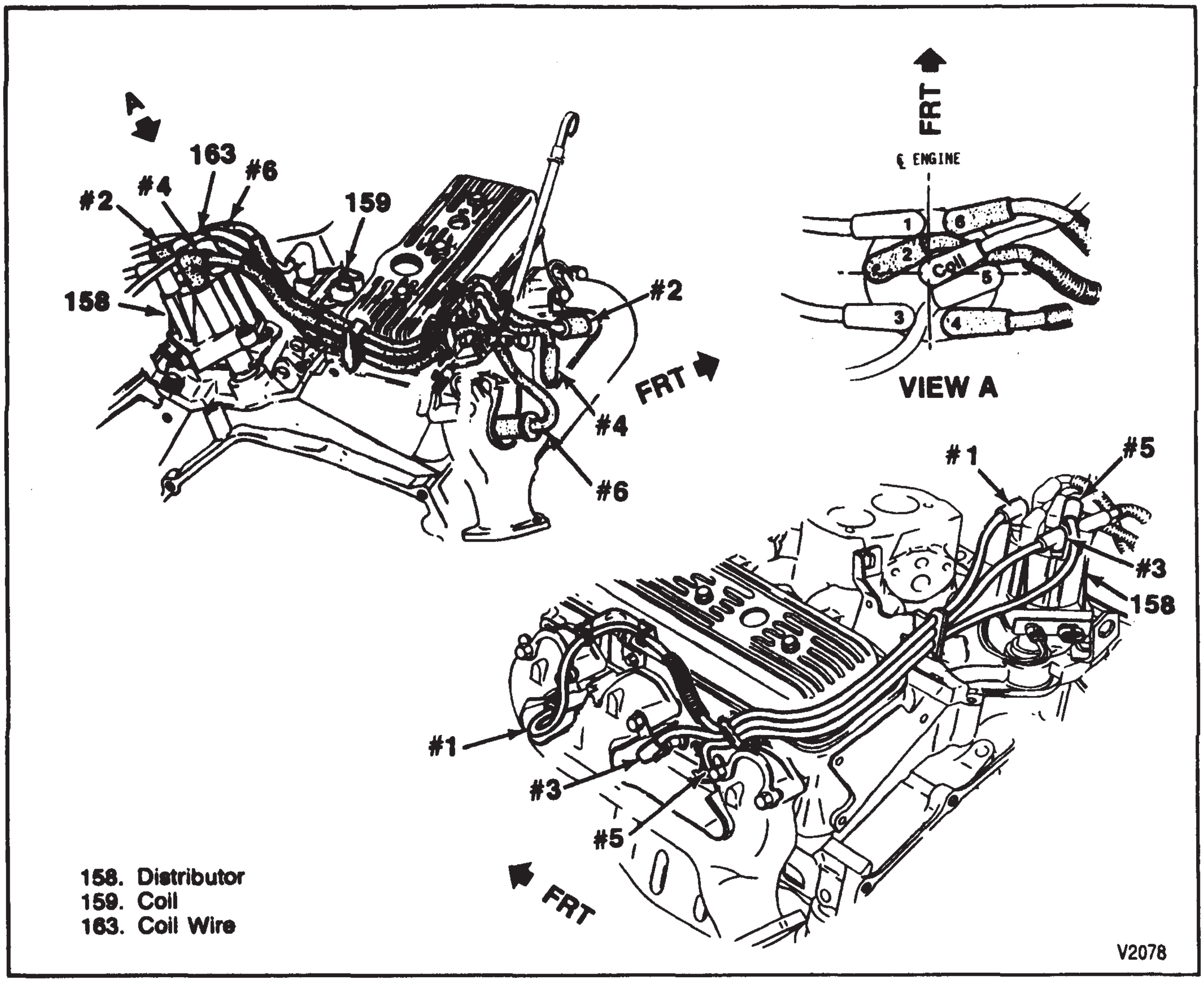
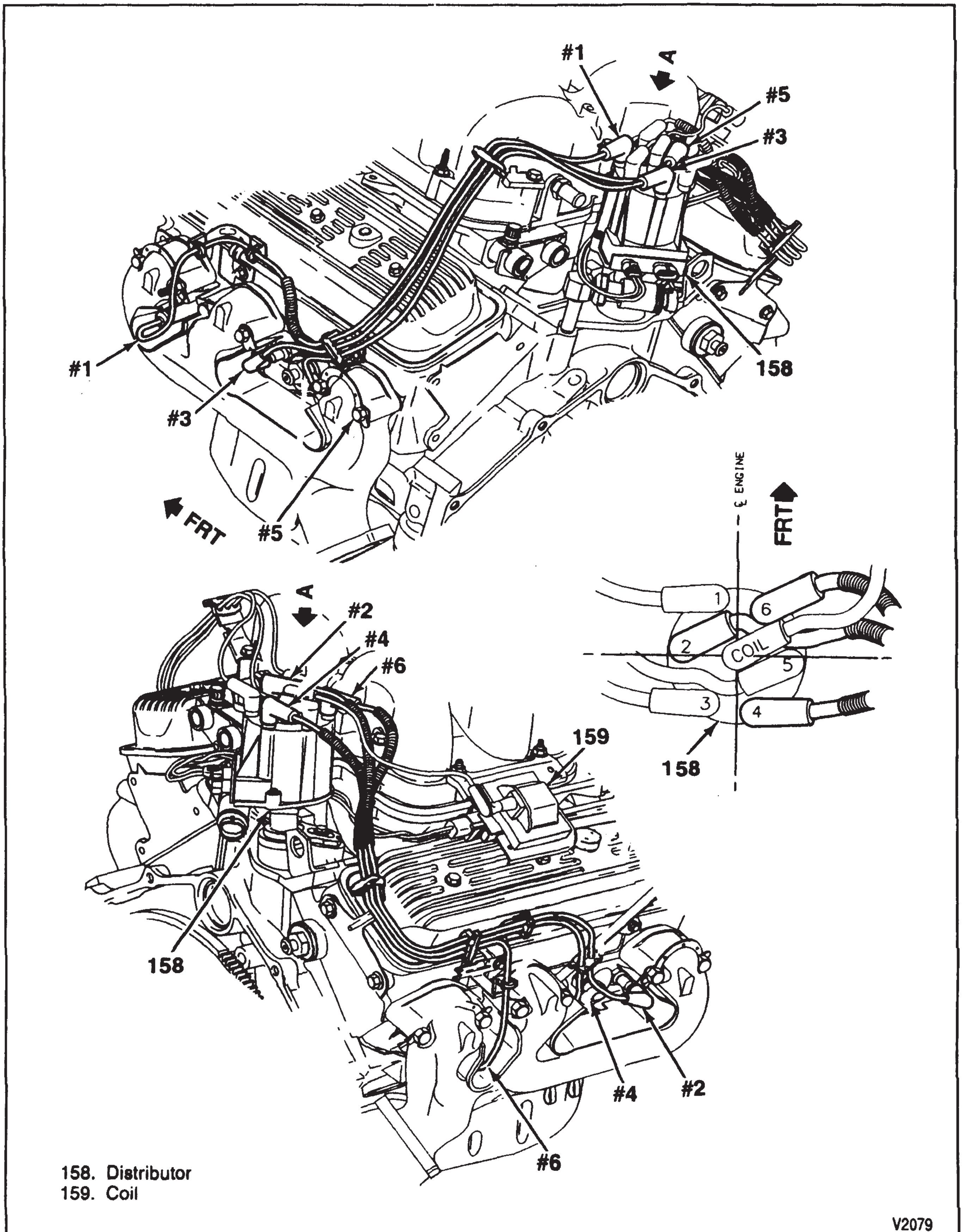


Figure 14—Spark Plug Wire Routing for the 4.3L (LB4) Engine



158. Distributor
159. Coil

Figure 15—Spark Plug Wire Routing for the 4.3L (L35) Engine

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Item	N·m	Ft. Lbs.
Distributor Hold-Down Bolt (2.5L Engine)	17	13
Distributor Hold-Down Bolt (2.8L Engine)	35	26
Distributor Hold-Down Bolt (4.3L Engine)	27	20

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SPARK PLUGS

Engine	Plug	Gap (Inch)	Torque	
			N·m	Ft. Lbs.
2.5L	•R43TS6	0.060	15	11
2.8L	•R43TSK	0.045	15	11
4.3L (L35)*	•CR43TS	0.045	15	11
4.3L (LB4)**	•CR43TS	0.035	15	11

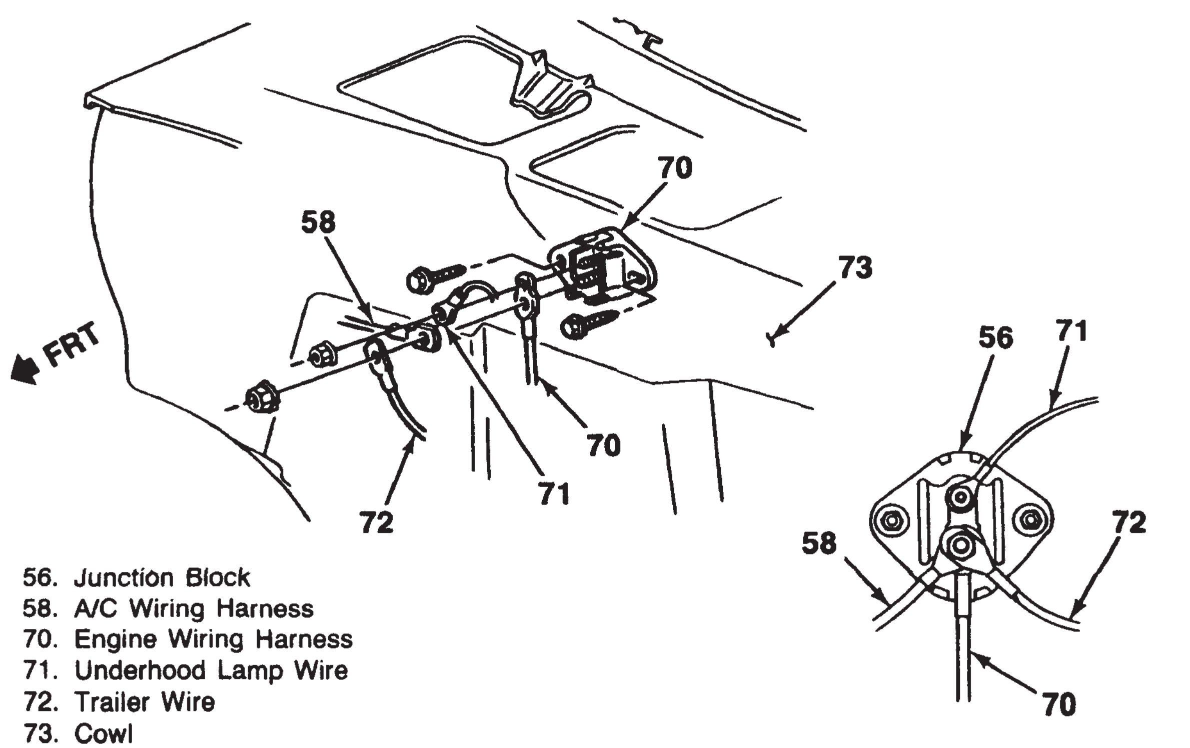
*AC part number for L35 plugs is 25132383.
**AC part number for LB4 plugs is 25107381.

T2343

SECTION 6D7

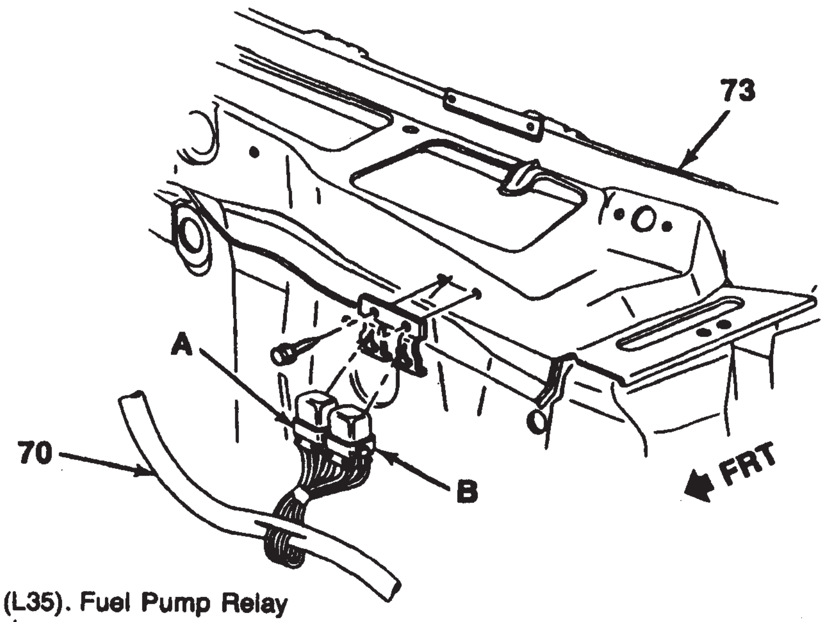
ENGINE WIRING

When it is necessary to move any of the wiring, whether to lift wires away from their harnesses or move harnesses to reach some component, take care that all wiring is replaced in its original position and all harnesses routed correctly. If clips or retainers break, replace them. Electrical problems can result from wiring or harnesses becoming loose and moving from their original positions or from being rerouted. Refer to figures 1 through 14 for correct routing of engine wiring.



56. Junction Block
58. A/C Wiring Harness
70. Engine Wiring Harness
71. Underhood Lamp Wire
72. Trailer Wire
73. Cowl

Figure 1—Battery Junction Block



A. VTC Relay with 4.3L (L35). Fuel Pump Relay Location for other Engines
B. Fuel Pump Relay for 4.3L Engines. A/C Relay for Other Engines
70. Engine Wiring Harness
73. Cowl

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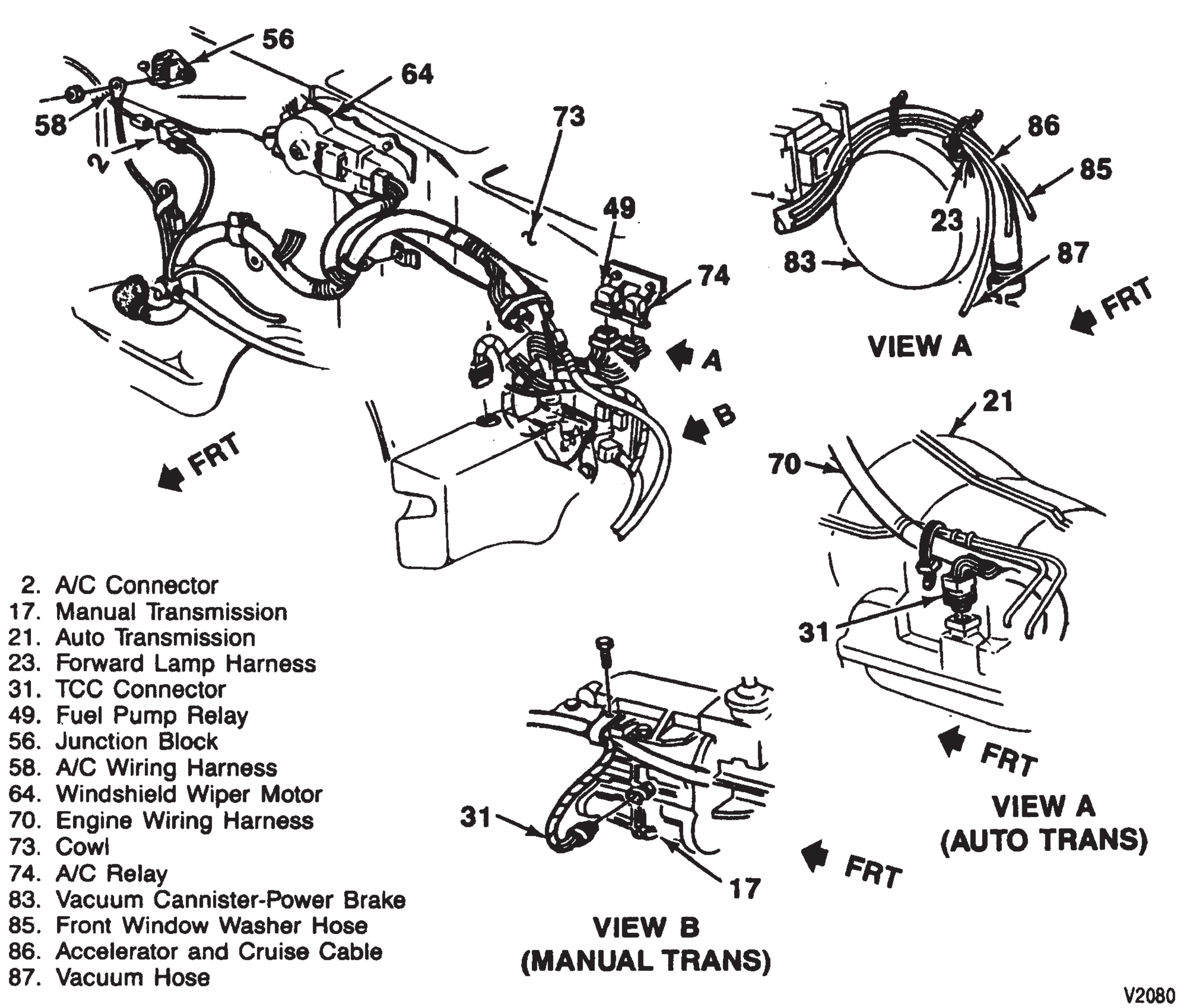
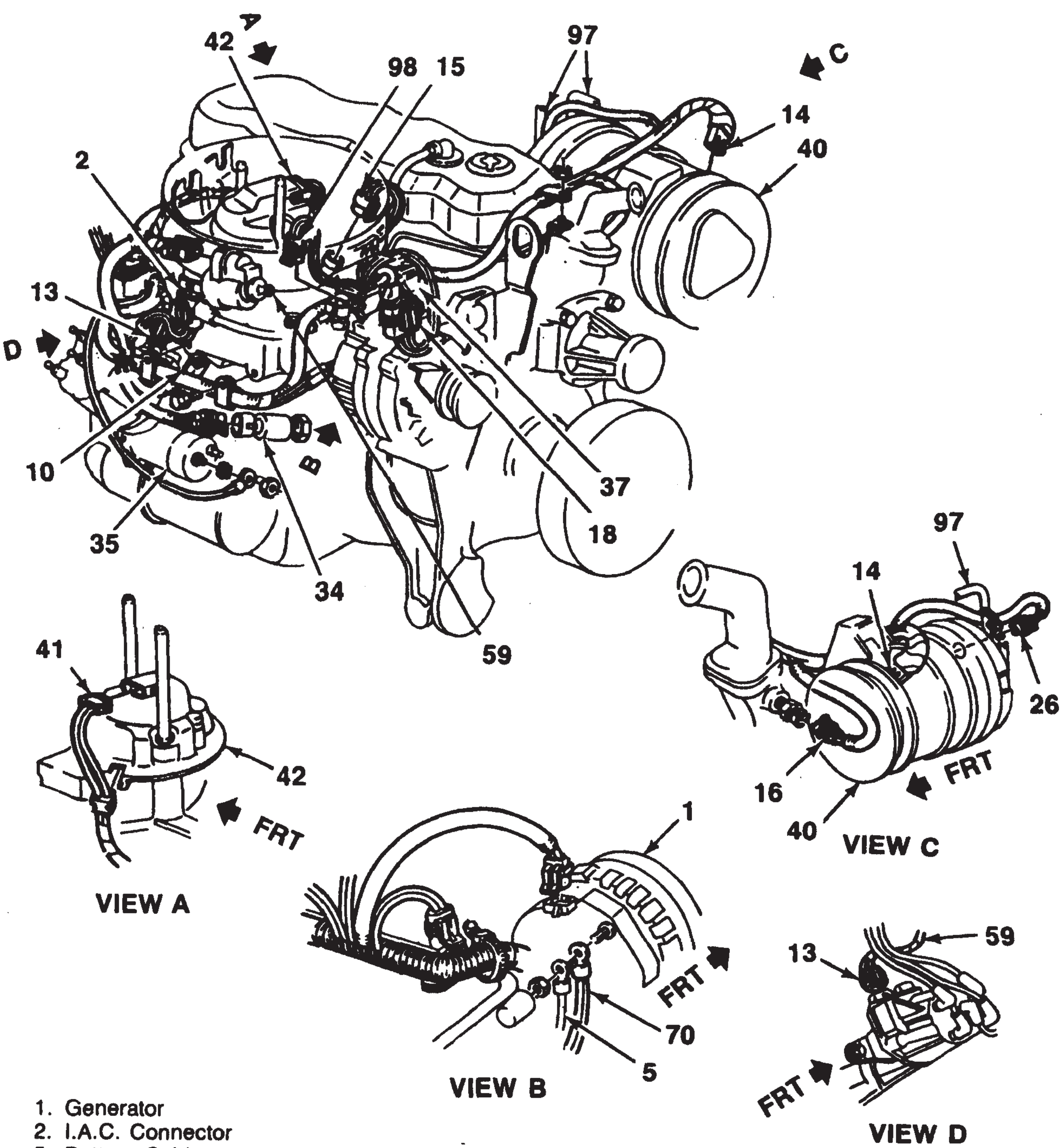
Figure 2—Relay Bracket



2. A/C Connector
17. Manual Transmission
21. Auto Transmission
23. Forward Lamp Harness
31. TCC Connector
49. Fuel Pump Relay
56. Junction Block
58. A/C Wiring Harness
64. Windshield Wiper Motor
70. Engine Wiring Harness
73. Cowl
74. A/C Relay
83. Vacuum Cannister-Power Brake
85. Front Window Washer Hose
86. Accelerator and Cruise Cable
87. Vacuum Hose

Figure 3—Engine Wiring at the Cowl - 2.5L (L38) Engine



1. Generator
2. I.A.C. Connector
5. Battery Cable
10. Coil Connector
13. Distributor Connector
14. A/C Compressor Clutch Connector
15. TPS Connector
16. Coolant Temp. Sensor Connector
18. MAP Sensor Connector
26. A/C Low Pressure Switch Connector
34. Oil Pressure Switch
35. Starter Motor
37. MAP Sensor
40. A/C Compressor
41. Fuel Injector Connector
42. TBI Unit
59. EGR Solenoid
70. Engine Wiring Harness
97. A/C Compressor and Condenser Hose Assembly
98. M.A.T. Connector

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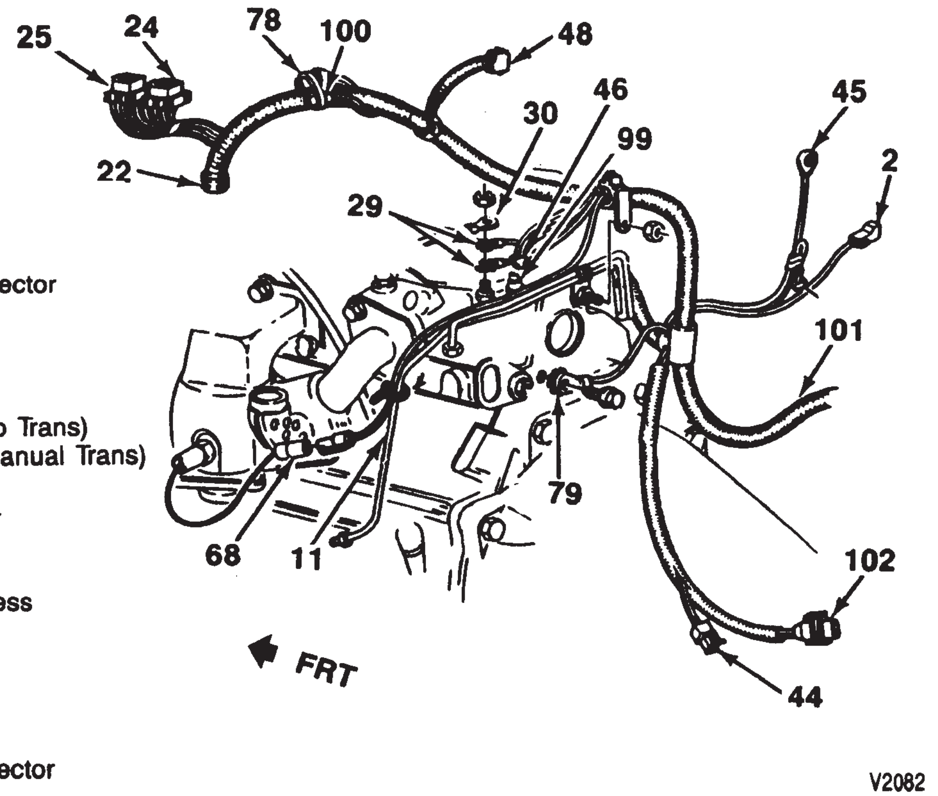
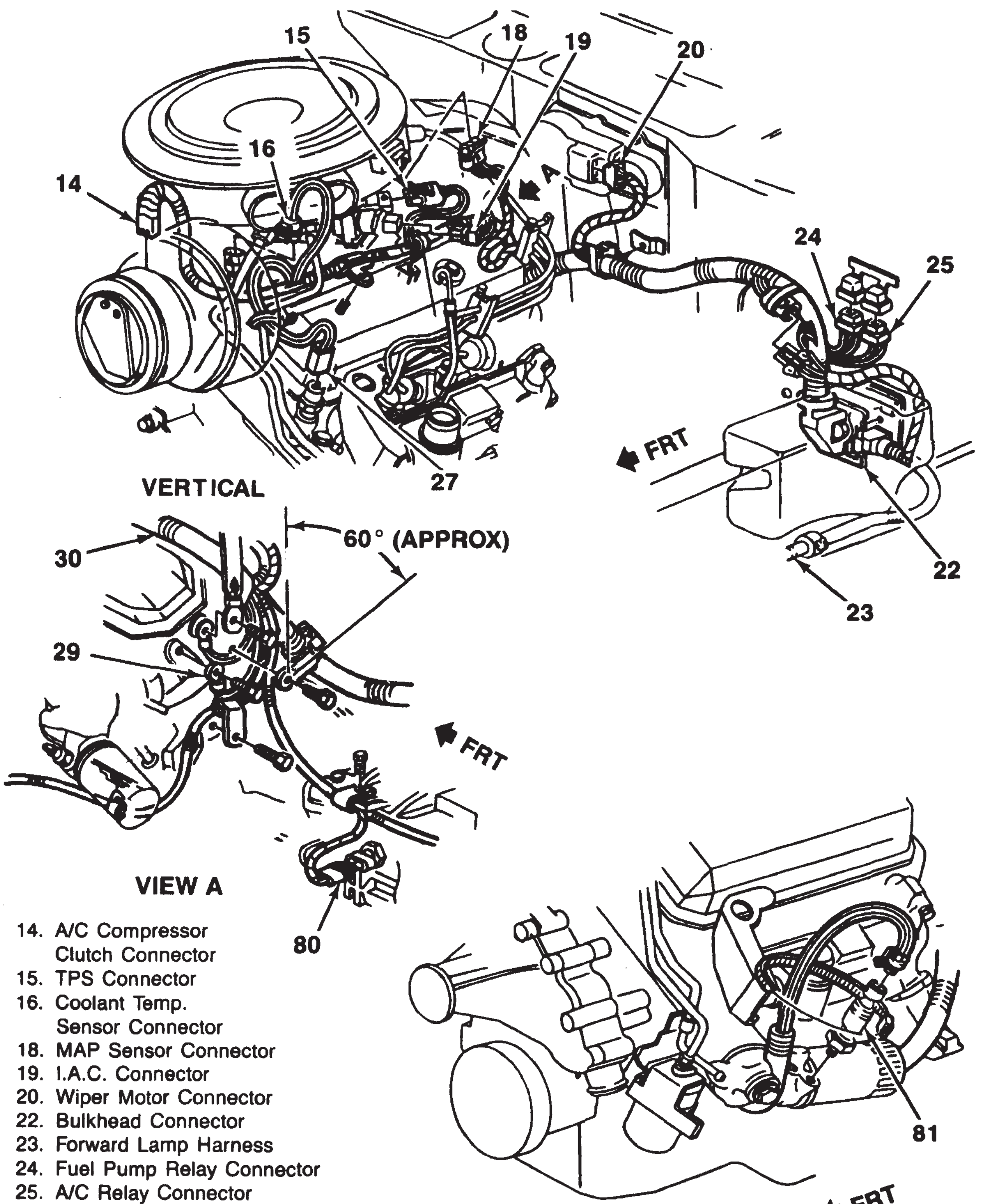
Figure 4—Engine Wiring - Right Front - 2.5L (L38) Engine



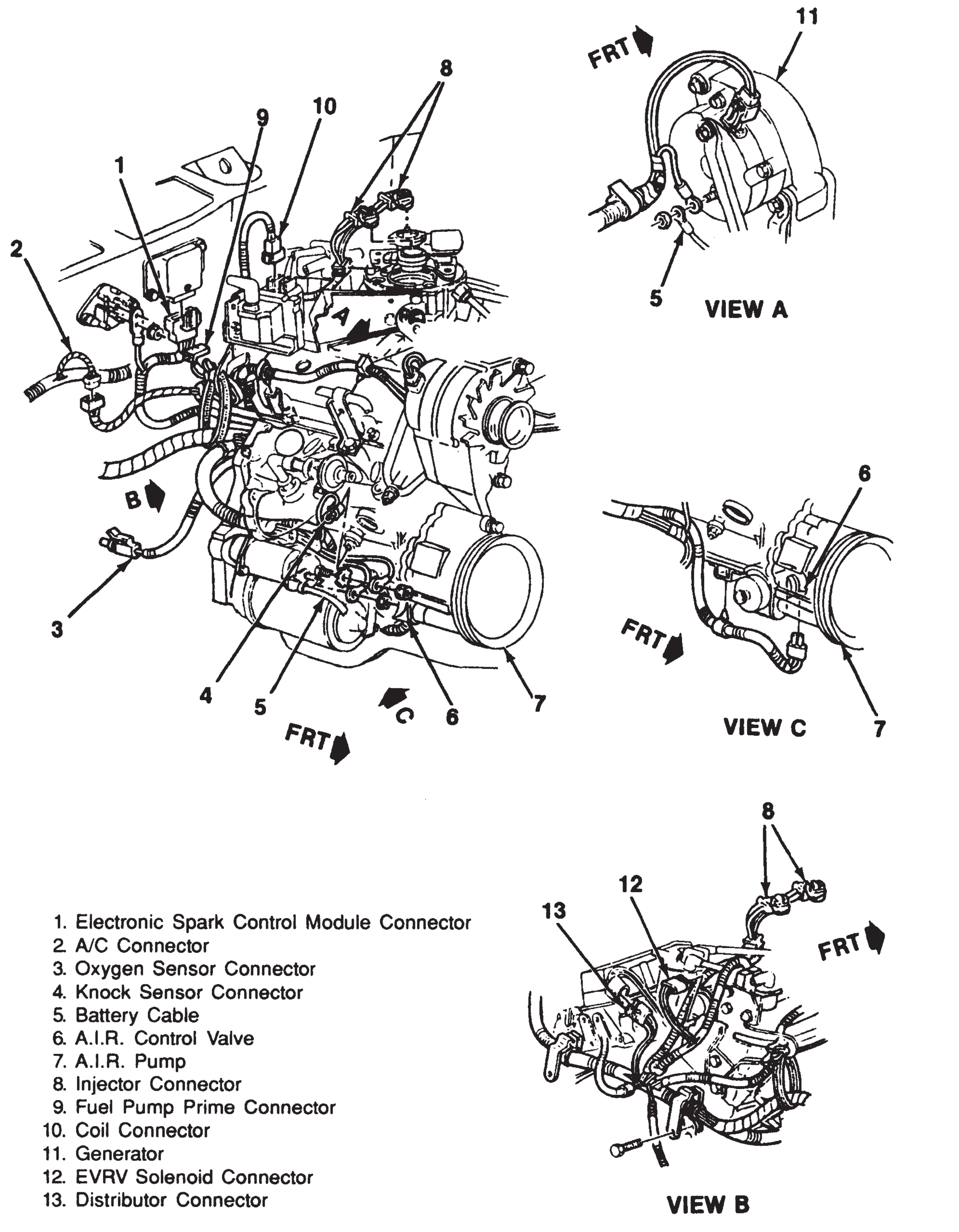
2. To A/C Connector
11. Return Fuel Pipe
22. To Bulkhead Connector
24. Fuel Pump Relay Connector
25. To A/C Relay
29. Oxygen Sensor and System Ground
30. Engine Ground Strap
44. To TCC Connector (Auto Trans) or to Backup Switch (Manual Trans)
45. To Junction Block
46. Temperature Transducer
48. To Wiper Motor
68. Oxygen Sensor
78. To Forward Lamp Harness
79. Redundant Ground
99. Engine Coolant Switch
100. To Power Steering Anticipate Switch
101. To ECM Grommet
102. To Speed Sensor Connector

Figure 5—Engine Wiring - Left Rear - 2.5L (L38) Engine



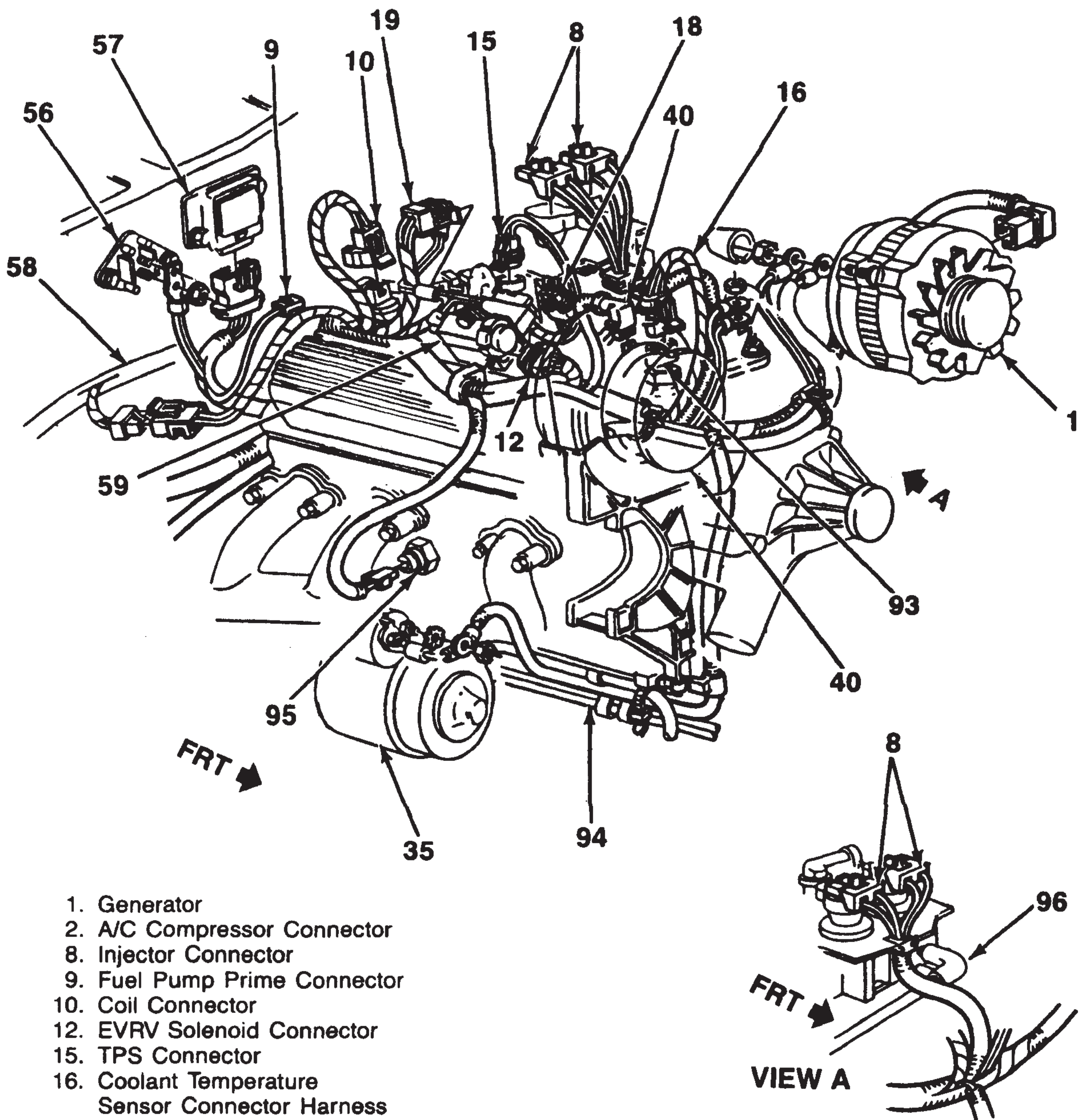
14. A/C Compressor Clutch Connector
15. TPS Connector
16. Coolant Temp. Sensor Connector
18. MAP Sensor Connector
19. I.A.C. Connector
20. Wiper Motor Connector
22. Bulkhead Connector
23. Forward Lamp Harness
24. Fuel Pump Relay Connector
25. A/C Relay Connector
27. Water Temp. Switch/Sensor Connector
29. Oxygen Sensor System Ground
30. Engine Ground Strap
80. Backup Lamp Harness Connector
81. Fuel Pump Switch and Oil Pressure Gage Sensor

Figure 6—Engine Wiring - Left Side - 2.8L Engine



1. Electronic Spark Control Module Connector
2. A/C Connector
3. Oxygen Sensor Connector
4. Knock Sensor Connector
5. Battery Cable
6. A.I.R. Control Valve
7. A.I.R. Pump
8. Injector Connector
9. Fuel Pump Prime Connector
10. Coil Connector
11. Generator
12. EVRV Solenoid Connector
13. Distributor Connector

Figure 7—Engine Wiring - Right Side - 2.8L Engine



1. Generator
2. A/C Compressor Connector
8. Injector Connector
9. Fuel Pump Prime Connector
10. Coil Connector
12. EVRV Solenoid Connector
15. TPS Connector
16. Coolant Temperature Sensor Connector Harness
18. MAP Sensor Connector
19. I.A.C. Connector
35. Starter Motor
40. A/C Compressor
56. Junction Block
57. ESC Module
58. A/C Wiring Harness
59. EVRV Solenoid
93. Coolant Sensor
94. Transmision Oil Cooler Lines
95. Engine Coolant Temperature Indicator Switch Assembly
96. PCV Line

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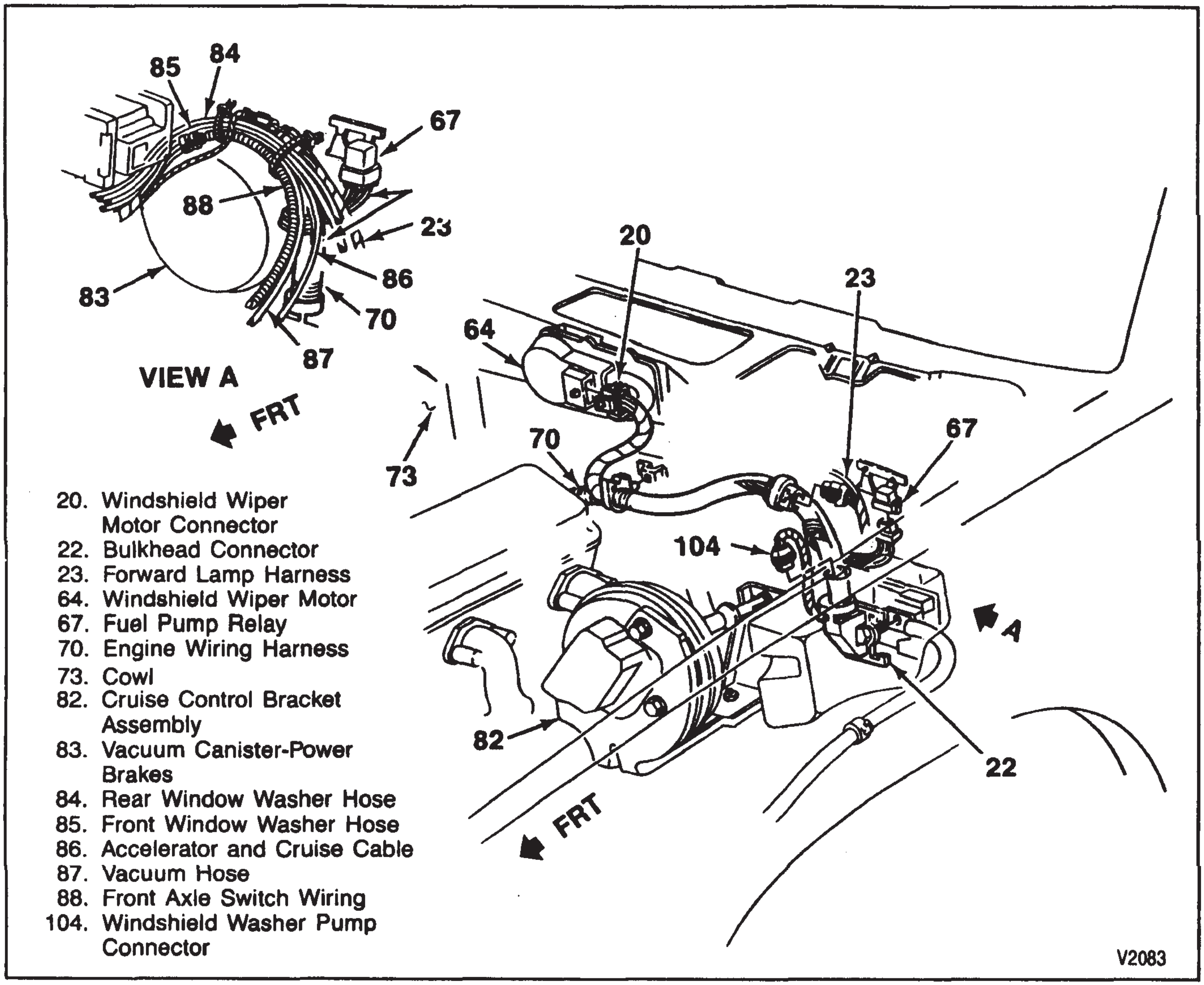
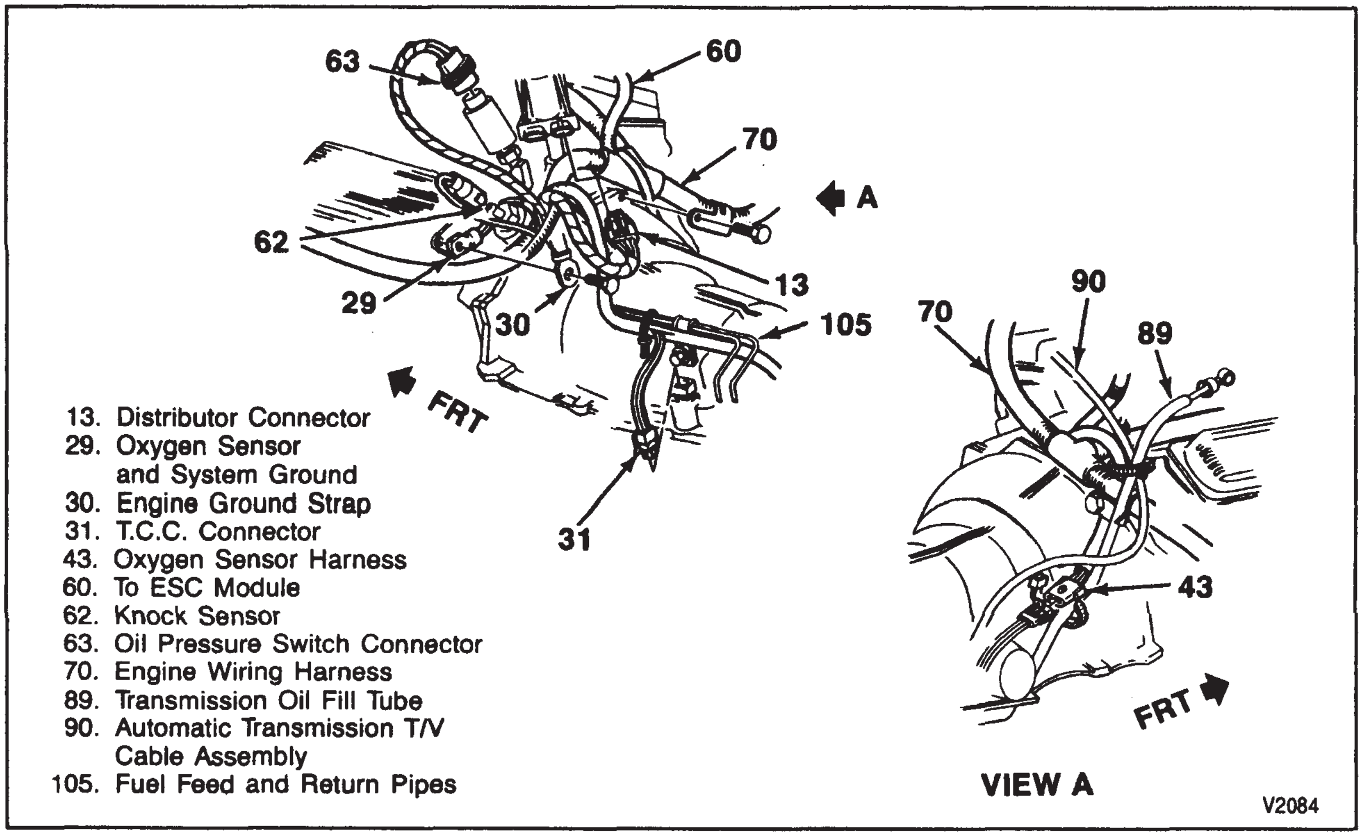
Figure 8—Engine Wiring - Right Front - 4.3L (LB4) Engine



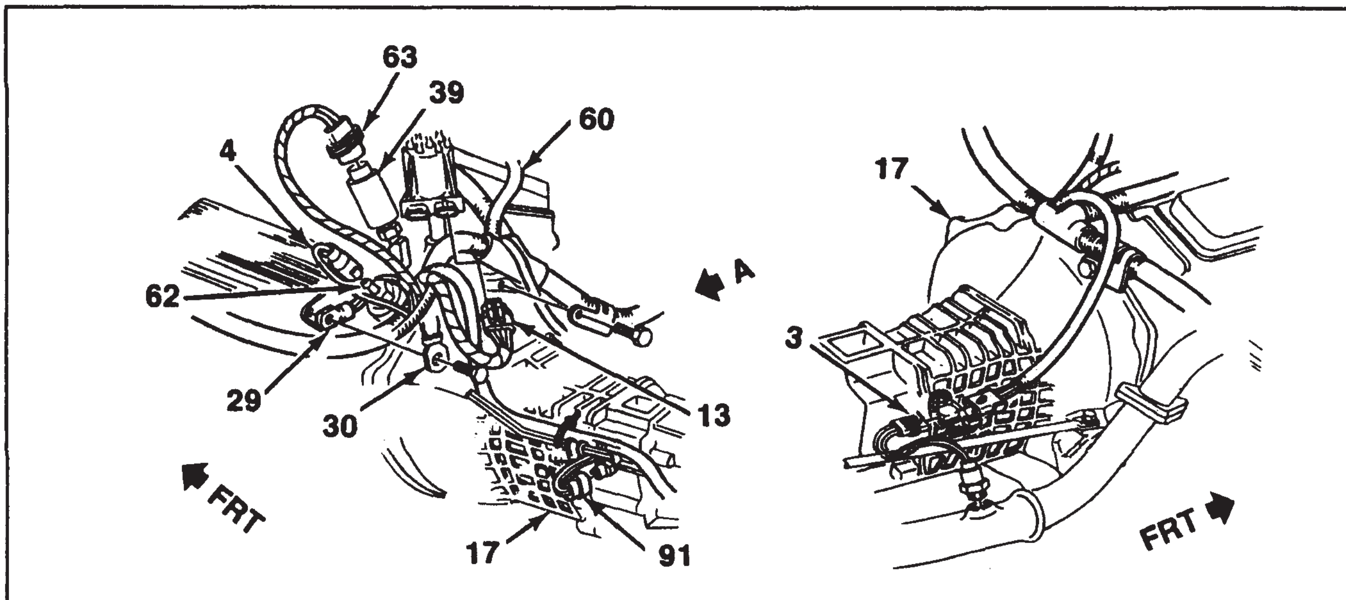
20. Windshield Wiper Motor Connector
22. Bulkhead Connector
23. Forward Lamp Harness
64. Windshield Wiper Motor
67. Fuel Pump Relay
70. Engine Wiring Harness
73. Cowl
82. Cruise Control Bracket Assembly
83. Vacuum Canister-Power Brakes
84. Rear Window Washer Hose
85. Front Window Washer Hose
86. Accelerator and Cruise Cable
87. Vacuum Hose
88. Front Axle Switch Wiring
104. Windshield Washer Pump Connector

Figure 9—Engine Wiring - Left Front - 4.3L (LB4) Engine



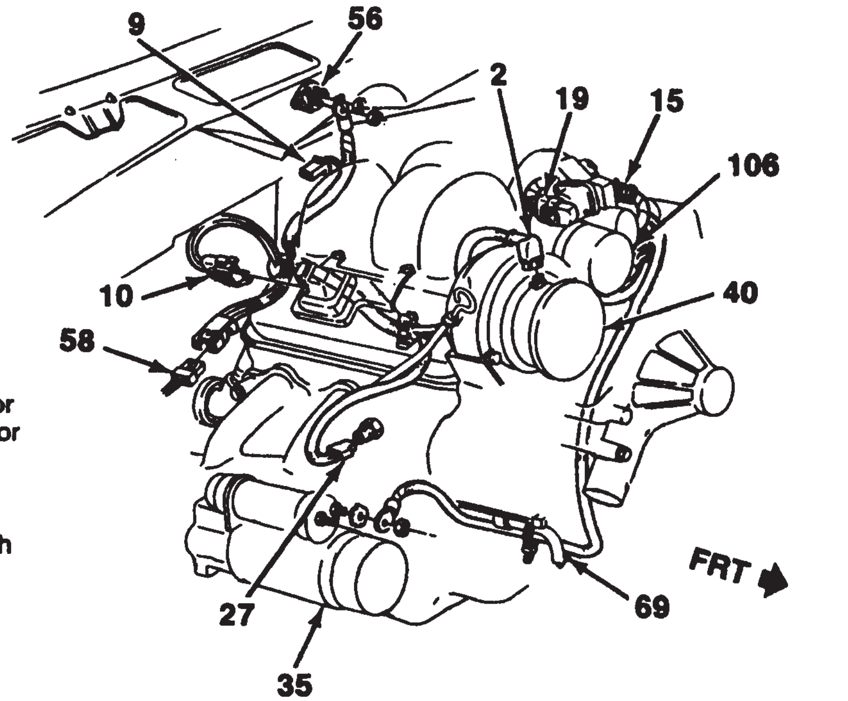
13. Distributor Connector
29. Oxygen Sensor and System Ground
30. Engine Ground Strap
31. T.C.C. Connector
43. Oxygen Sensor Harness
60. To ESC Module
62. Knock Sensor
63. Oil Pressure Switch Connector
70. Engine Wiring Harness
89. Transmission Oil Fill Tube
90. Automatic Transmission T/V Cable Assembly
105. Fuel Feed and Return Pipes

Figure 10—Engine Wiring - Rear - 4.3L (LB4) Engine with 4-Speed Automatic Transmission



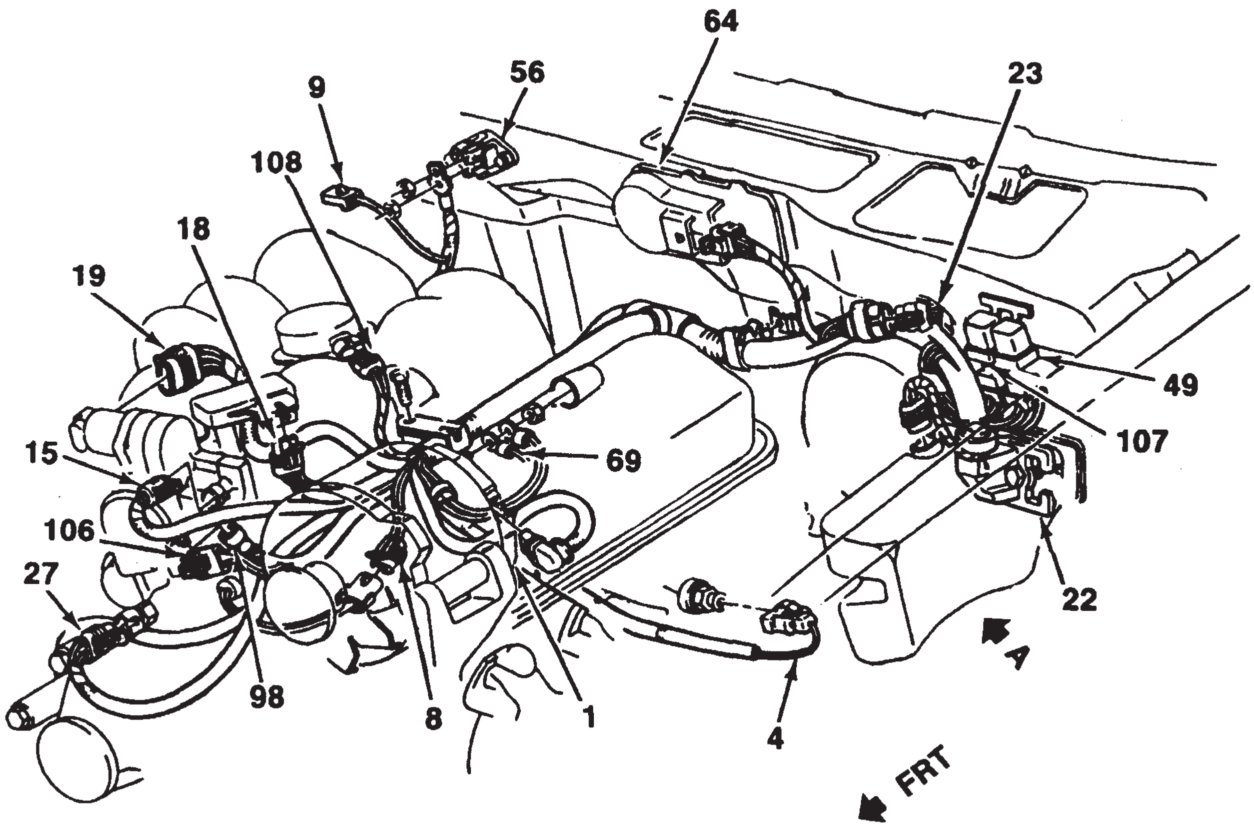
3. Oxygen Sensor Connector
4. Knock Sensor Connector
13. Distributor Connector
17. Manual Transmission
29. Oxygen Sensor and System Ground
30. Ground Strap
39. Oil Pressure Switch and Sensor
60. To ESC Module
63. Oil Pressure Switch Connector
91. Backup Lamp Switch Connector

Figure 11—Engine Wiring - Rear - 4.3L (LB4) Engine with 5-Speed Manual Transmission



2. A/C Compressor Connector
9. Fuel Pump Prime Connector
10. Distributor Coil Connector
15. TPS Connector
19. I.A.C. Connector
27. Coolant Temperature Switch Connector
35. Starter Motor
40. A/C Compressor
56. Junction Block
58. A/C Wiring Harness
69. Positive Battery Cable
106. EGR Connector

Figure 12—Engine Wiring - Right Front - 4.3L (L35) Engine



1. Generator
4. Knock Sensor Connector
8. Injector Connector
9. Fuel Pump Prime Connector
15. TPS Connector
18. MAP Sensor Connector
19. IAC Connector
22. Bulkhead Connector
23. Forward Lamp Harness
27. Coolant Temperature Switch Connector
49. Fuel Pump Relay
56. Junction Block
64. Windshield Wiper Motor
69. Positive Battery Cable
83. Vacuum Cannister - Power Brake
84. Rear Window Washer Hose
85. Front Window Washer Hose
87. Vacuum Hose
88. Front Axle Switch Wiring
98. MAT Sensor Connector
106. EGR Connector
107. VTC Relay Connector
108. VTC Harness Connector

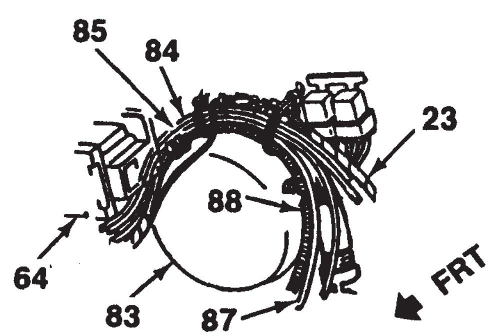


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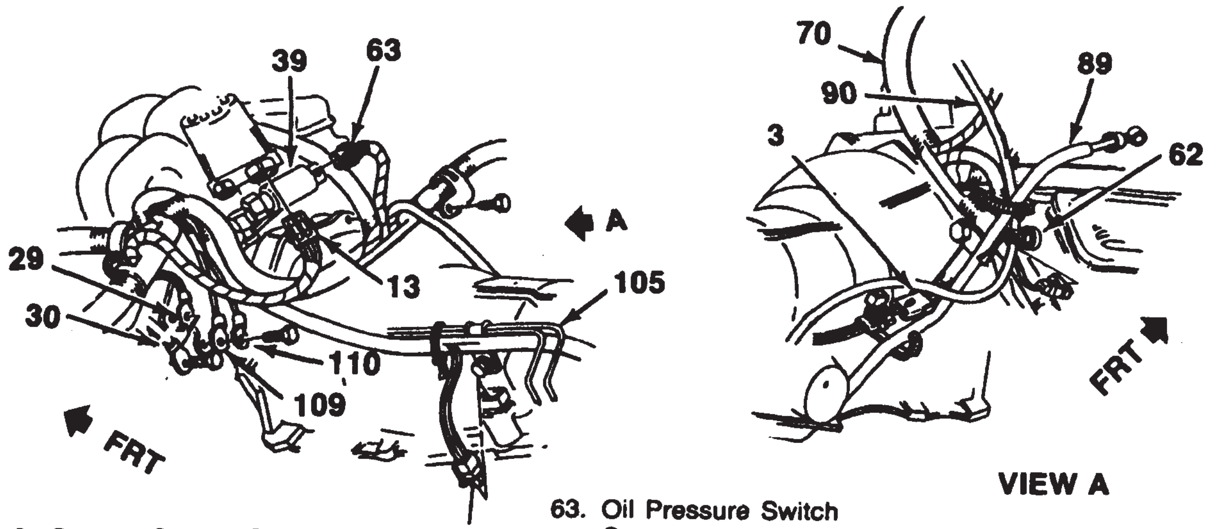
Figure 13—Engine Wiring - Left Front - 4.3L (L35) Engine



3. Oxygen Sensor Connector
13. Distributor Connector
29. Oxygen Sensor and System Ground
30. Ground Strap
31. TCC Connector
39. Oil Pressure Switch and Sensor
62. Knock Sensor
63. Oil Pressure Switch Connector
70. Engine Wiring Harness
89. Transmission Oil Fill Tube
90. Automatic Transmission T.V. Cable Assembly
105. Fuel Feed and Return Pipe Assembly
109. System Ground
110. Ground

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Figure 14—Engine Wiring - Rear - 4.3L (L35) Engine with 4-Speed Automatic Transmission

SECTION 6E

EMISSIONS

The engines used in this vehicle use a Throttle Body Injection (TBI) or a Central Port Injection (CPI) unit. For information about Throttle Body Injection (TBI) or Central Port Injection (CPI) engine emission systems including Computer Command Control, Exhaust Gas Recirculation (EGR), Fuel Control, Evaporative Emission Control, and Ignition Systems, refer to the 1992 Light Duty Fuel and Emissions Manual if you are using X-9229 or to the Fuel and Emissions section at the rear of this manual if you are using ST-369-92.

SECTION 6F

EXHAUST SYSTEM

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number for the application. If the correct part number is unavailable, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or systems damage could result.

CONTENTS

GENERAL DESCRIPTION

Exhaust system designs will vary according to model designation and intended use of the vehicle.

The exhaust system uses a flange and seal joint coupling to secure the exhaust pipe to the engine manifold. The other connections use a slip joint coupling design with a clamp and U-bolt.

The exhaust system is suspended by hangers attached to the frame members. This will permit some movement of the exhaust system, but should not permit the transfer of noise and vibration into the vehicle.

Heat shields are used to protect both the vehicle and the environment from the high temperatures developed from the exhaust system, especially the catalytic converter.

The catalytic converter is an emission control device added to the gasoline engine exhaust system to reduce hydrocarbon and carbon monoxide pollutants from the exhaust gas. The converter contains beads which are coated with a catalytic material containing platinum, palladium, and rhodium to reduce the level of nitrogen oxides. The catalyst in the converter is not serviceable.

NOTICE: The catalytic converter requires the use of unleaded fuel only. Using leaded fuel will damage the catalytic converter and other emission system components.

Exhaust system performance complaints, such as excessive back pressure, are noticeable by their effect on engine performance. However, other malfunctioning vehicle components have similar effects on engine performance and are characterized by the same symptoms or complaints. Therefore, it is necessary to refer to the engine diagnosis procedure when attempting to diagnose this type of problem.

DIAGNOSIS OF THE EXHAUST SYSTEM

Exhaust system performance complaints, such as excessive back pressure, are noticeable by their effect on engine performance. However, other malfunctioning vehicle components have similar effects on engine performance and are characterized by the same symptoms or complaints. Therefore, it is necessary to refer to the engine diagnosis procedure when attempting to diagnose this type of problem.

NOTICE: Replacement of exhaust system parts MUST be OEM standard.

PROBLEM	POSSIBLE CAUSE	CORRECTION
Vibrating or Rattling From Exhaust System	Loose and/or misaligned components.	Align, then tighten connections. Check for damaged hanger or mounting brackets and clamps.
Restricted Exhaust System	1. "Kinked" exhaust tubing. 2. Restriction within the muffler. Refer to "Restricted Exhaust System Check" in the Fuel And Emissions Manual*. 3. End of tail pipe obstruction. 4. Plugged catalytic converter (may result from serious engine malfunction). Refer to "Restricted Exhaust System Check" in the Fuel And Emissions Manual*.	1. If possible, repair the damaged condition; otherwise, replace the component. 2. If restriction is suspected, remove the muffler and visually check it. Replace muffler if condition is doubtful. 3. Remove the obstruction, or if end is crimped, straighten outlet. 4. Replace the catalytic converter.
Exhaust Leakage and/or Noise	1. Leakage at exhaust component joints and couplings. 2. Improperly installed or misaligned. 3. Exhaust manifold cracked or broken. 4. Leak between exhaust manifold and cylinder head. 5. Damaged or worn seals or packing. 6. Burned or rusted out exhaust pipe heat tube extension. 7. Burned or rusted out exhaust pipe. 8. Burned or blown out muffler. 9. Broken or loose clamps and/or brackets.	1. Tighten clamps or couplings to specified torque. 2. Align, then tighten connections. 3. Replace the manifold. 4. Tighten the manifold to cylinder head nuts and bolts to specifications. 5. Replace the seals or packing as necessary. 6. Replace the heat tube extensions as required. 7. Replace the exhaust pipe. 8. Replace the muffler assembly. 9. Repair or replace as necessary.

*In the 1992 Light Duty Fuel and Emissions Manual if you are using X-9229 and in the "Fuel and Emissions" section at the rear of this manual if you are using ST-369-92.

D0107

ON-VEHICLE SERVICE

INSPECTION

Inspect exhaust pipes, seals, catalytic converters, mufflers, and tailpipes for cracked joints, broken welds, and corrosion damage that would result in a leaking exhaust system. Inspect the clamps, brackets, and insulators for cracks and stripped or corroded bolt threads.

The exhaust system, including heat shields, must be free of leaks, binding, grounding, and excessive vibration. These conditions are usually caused by damaged or loose flange bolts, seals, heat shields, brackets, or pipes. If any of these conditions exist, check the exhaust system components and alignment. Align and replace as necessary.

REMOVING EXHAUST PARTS

CAUTION: Always wear protective goggles and gloves when removing exhaust parts as falling rust and sharp edges from worn exhaust components could result in serious personal injury.

When removing exhaust components, an accumulation of dirt and corrosion can make the work difficult. Using a penetrating oil on the threads of U-bolts can assist in the removal of these components.

INSTALLING EXHAUST PARTS

NOTICE: Replacement of exhaust system parts MUST be OEM standard to ensure that the vehicle operates as designed.

When installing a new exhaust pipe or muffler and tailpipe, on any model, check for proper alignment. Rattles and noise vibrations in the exhaust system are usually caused by misaligned of parts. When aligning the system, leave all bolts or nuts loose until all parts are properly aligned then tighten, working from the front to the rear.

Exhaust system hangers, hanger brackets, and clamps which are damaged should be replaced to maintain exhaust system alignment.

Important

- When jacking or lifting the vehicle from the frame side rails, be certain lift pads do not contact the catalytic converter as damage to the converter will result.
- When servicing of the exhaust system requires removing and replacing the oxygen sensor, Refer to "Oxygen Sensor Service" in the 1992 Light Duty Fuel and Emissions Manual if you are using X-9229 and in the "Fuel and Emissions" section at the rear of this manual if you are using ST-369-92.
- Sealer 9985020 or equivalent is to be applied to all slip joint connections.
- When replacing a muffler, the tailpipe should also be replaced.
- When installing the exhaust pipe to the engine manifold, always use new nuts. Clean the engine manifold stud threads with a wire brush before installing the new nuts.

Refer to figures 1 through 16 for component replacement of the engine exhaust system.

CATALYTIC CONVERTER REPLACEMENT

Remove or Disconnect

- Raise the vehicle on a hoist.

1. Clamps at the front and rear of the converter.
2. Converter from the muffler.
3. Converter from the front exhaust pipe.

Install or Connect

- Apply sealer 9985020 or equivalent at the slip joint connections.

1. New catalytic converter into the exhaust pipe.
2. Muffler to catalytic converter.

NOTICE: See "Notice" on page 6F-1.

3. New U-bolts and clamps at the front and rear of the converter.

- Check for clearance and alignment.

Tighten

- Clamps to support 37 N·m (27 ft. lbs.).

- Lower the vehicle.

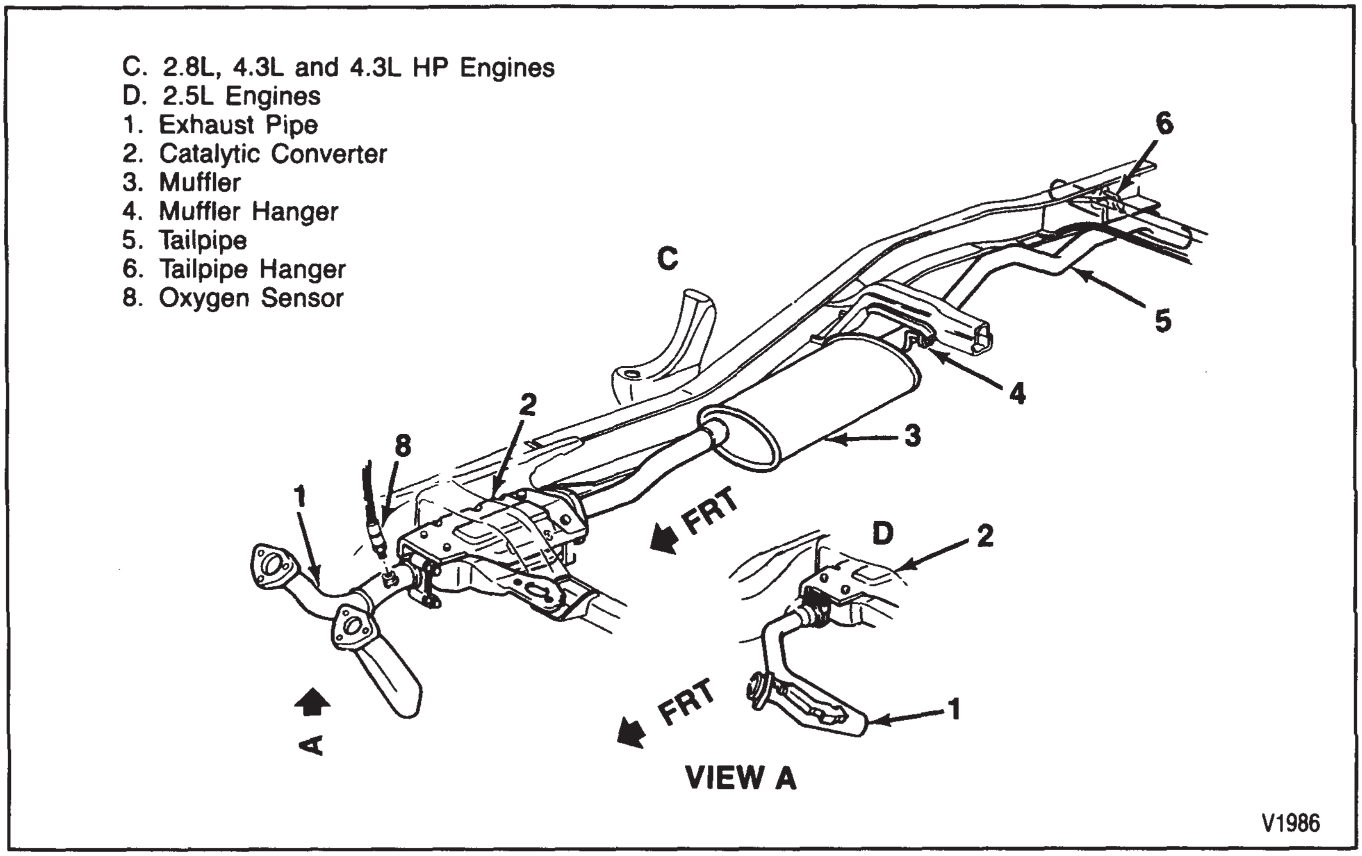


Figure 1—Exhaust Layout—2WD, Regular Cab, 73.1-inch Box, Pickup

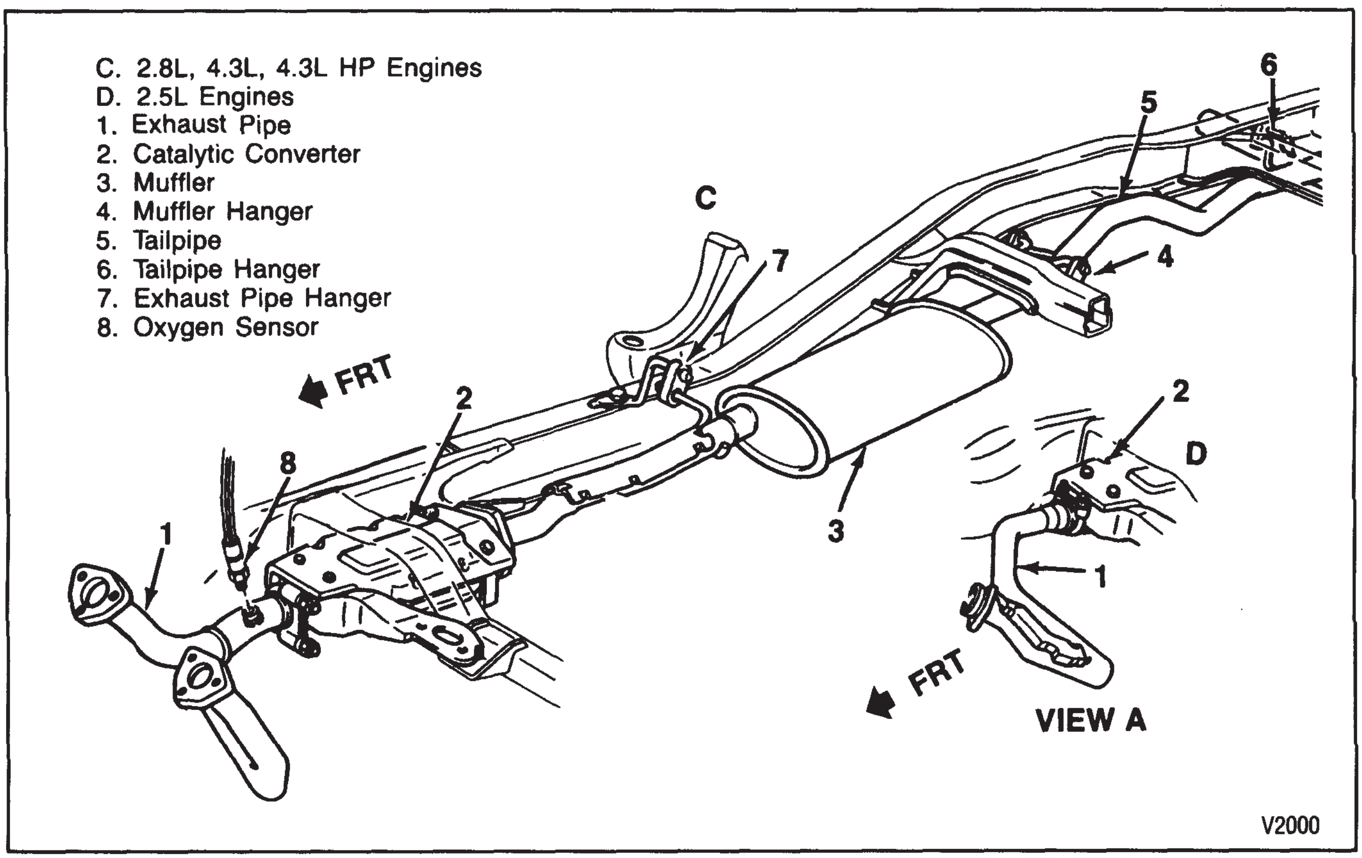


Figure 2—Exhaust Layout—2WD, Regular Cab, 89-inch Box, and 2WD, Extended Cab, Pickup

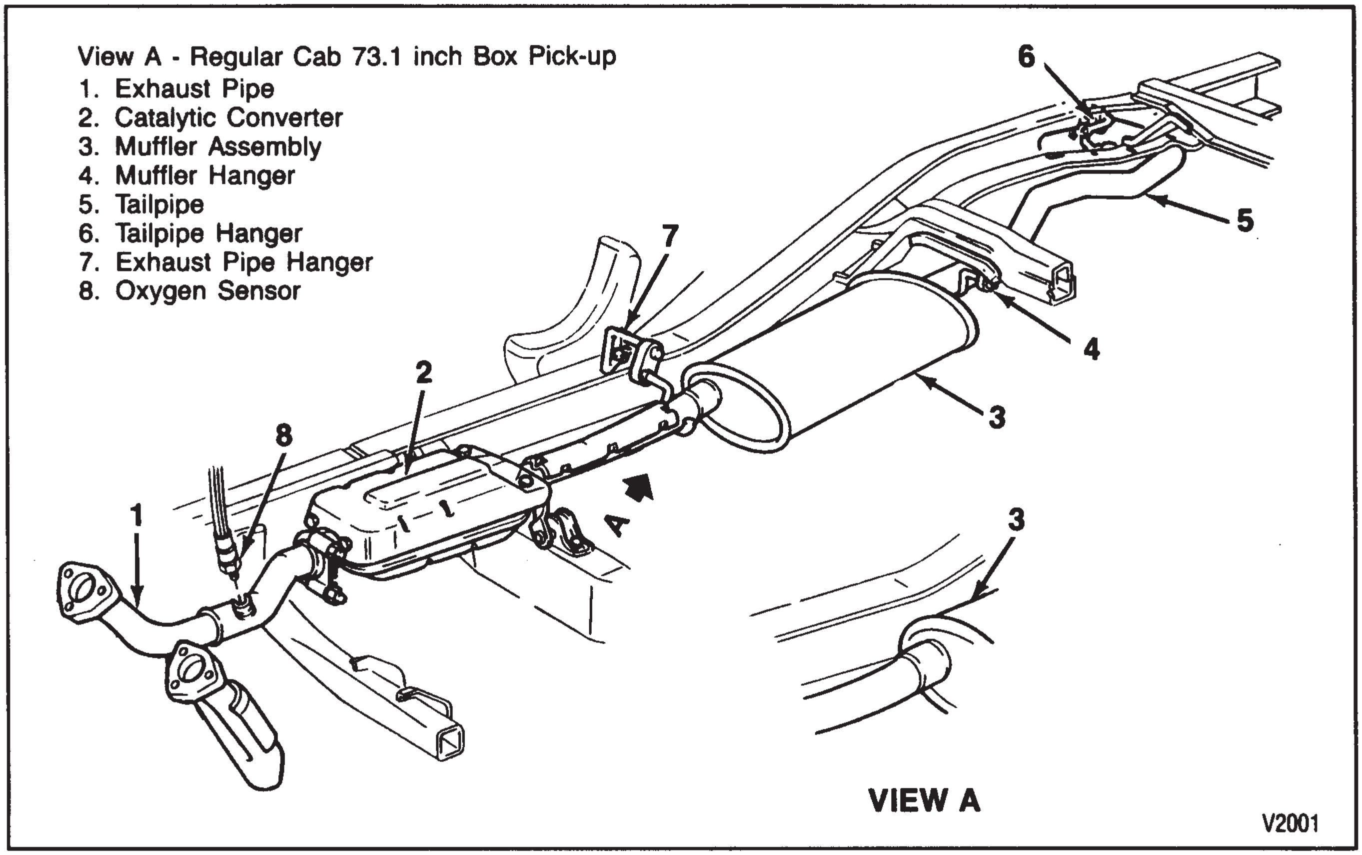


Figure 3—Exhaust Layout—All 4WD Pickup Models

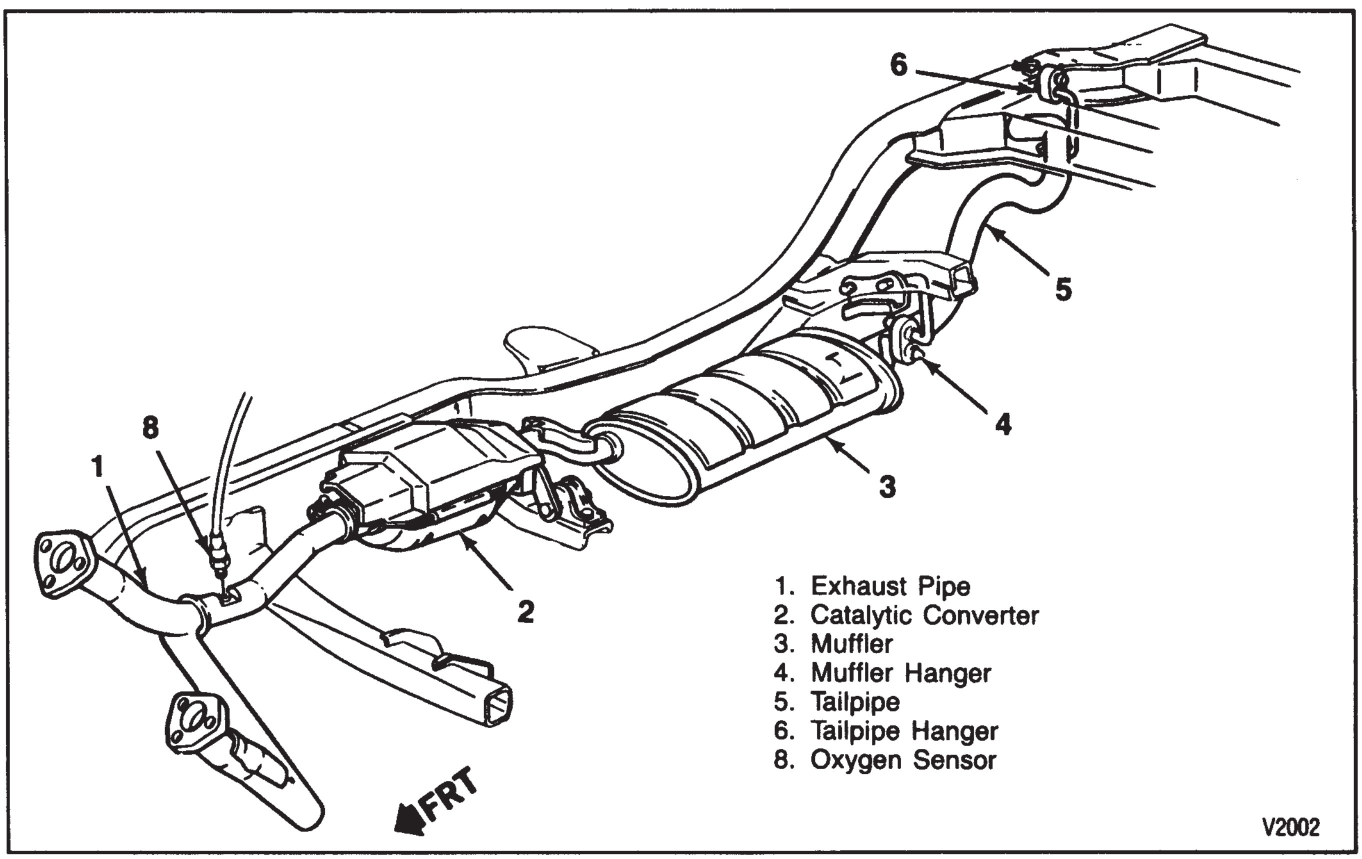


Figure 4—Exhaust Layout—2WD and 4WD Utility Models

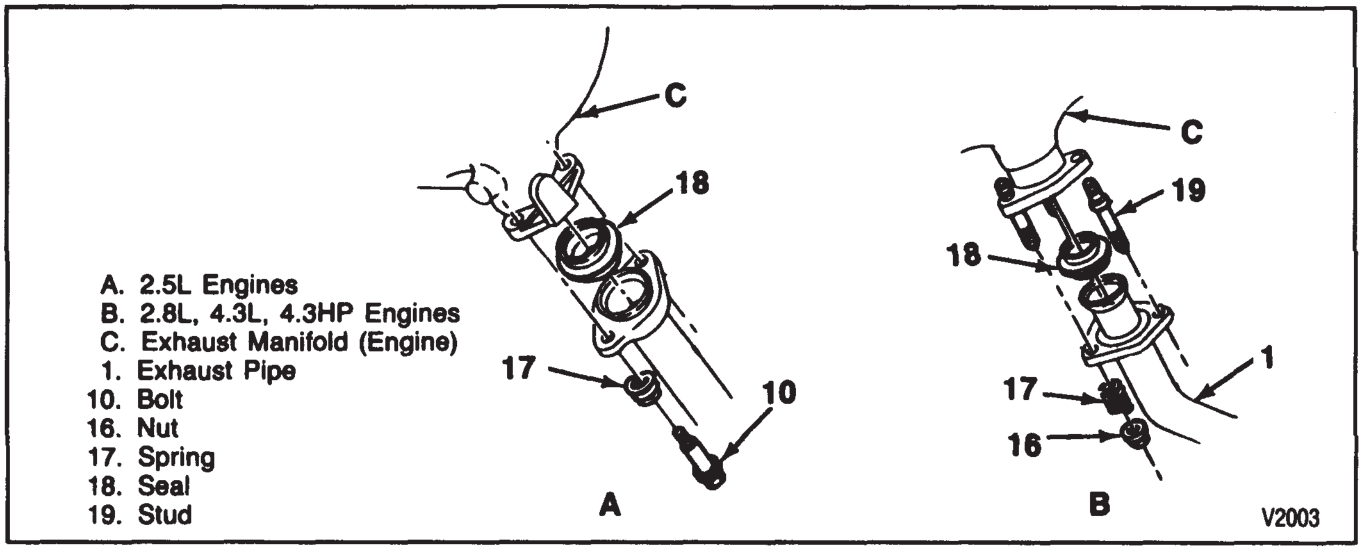


Figure 5—Exhaust Pipe to Engine Connections, All 2WD and 4WD Models

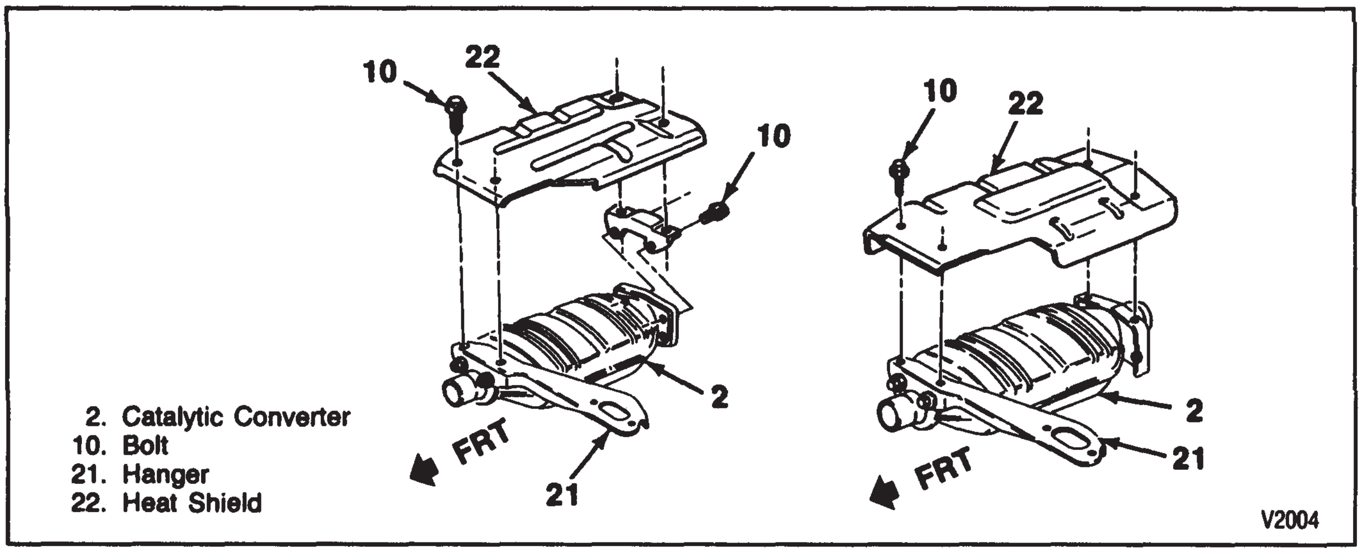
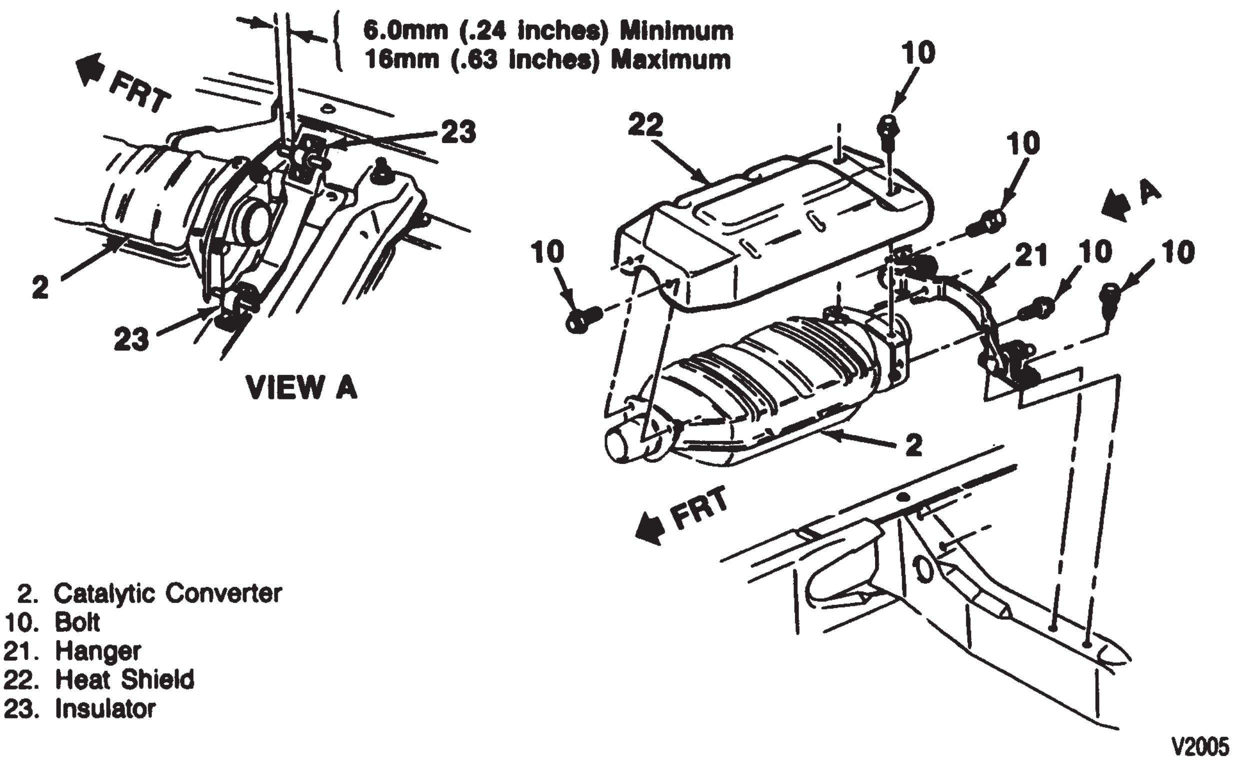
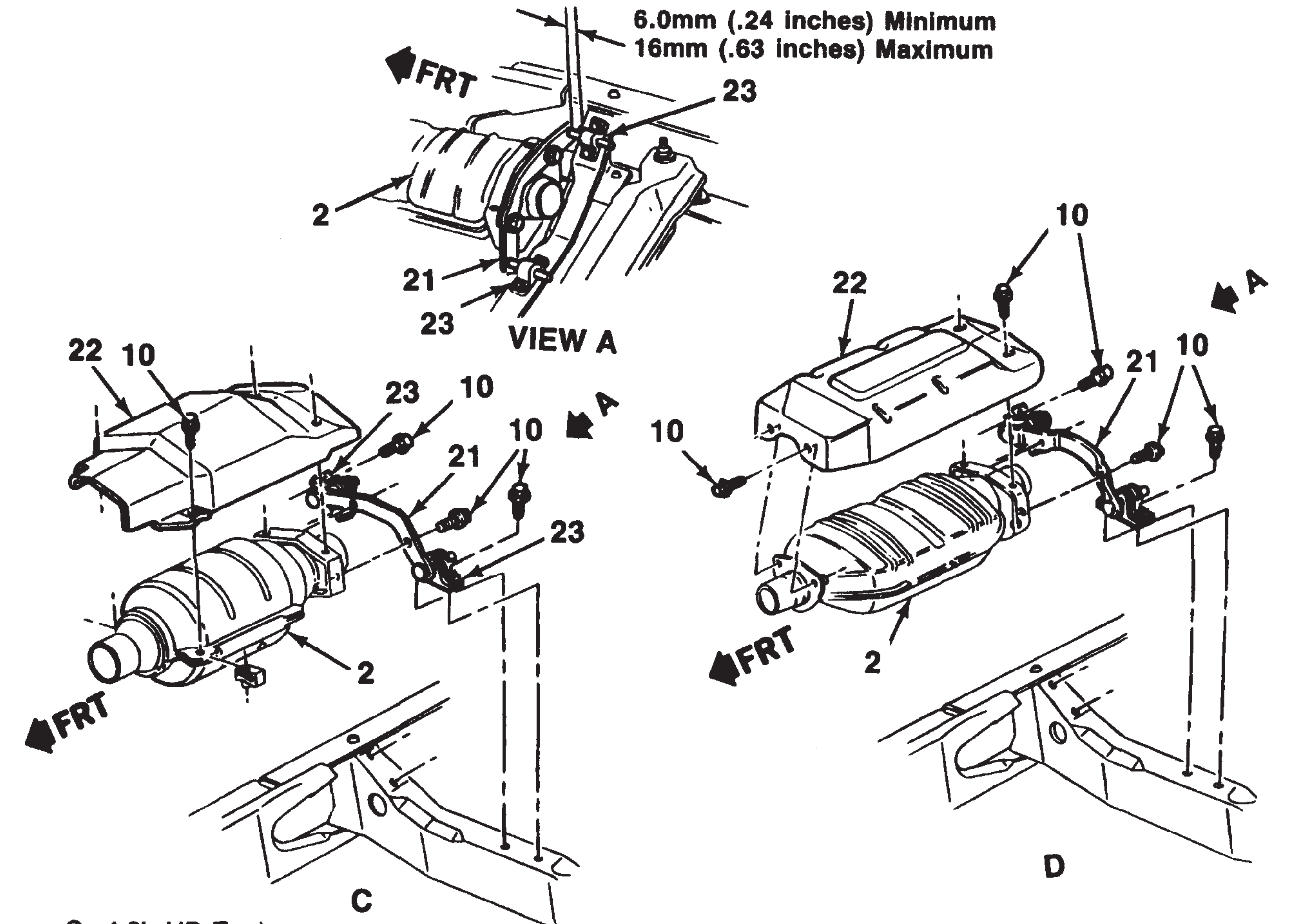


Figure 6—Catalytic Converter Heat Shield—2WD Pickup



2. Catalytic Converter
10. Bolt
21. Hanger
22. Heat Shield
23. Insulator

Figure 7—Catalytic Converter Heat Shield—4WD Pickup



C. 4.3L HP Engine
D. 4.3L Engine
2. Catalytic Converter
10. Bolt
21. Hanger
22. Heat Shield
23. Insulator

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Figure 8—Catalytic Converter Heat Shield and Hanger—2WD and 4WD, 4 Door Utility and 4WD, 2 Door Utility

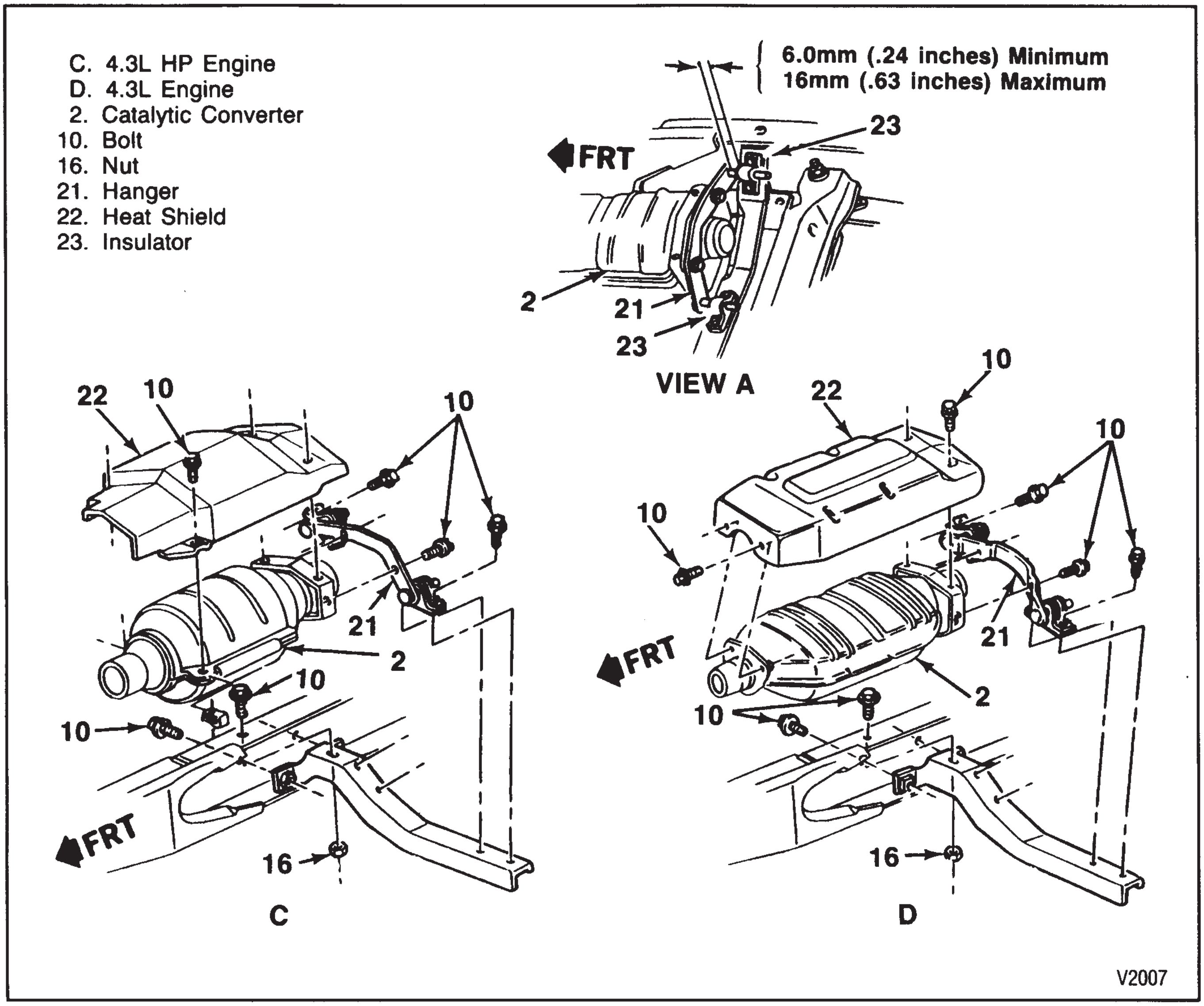


Figure 9—Catalytic Converter Heat Shield and Hanger—2WD, 2 Door Utility

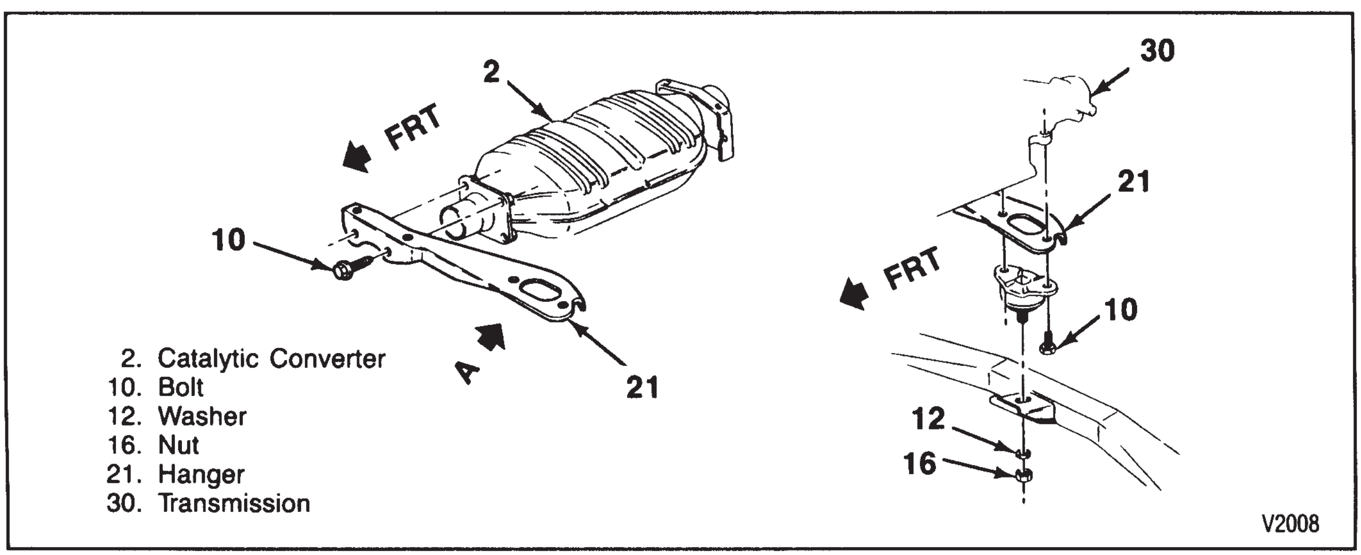


Figure 10—Catalytic Converter Hanger—2WD Pickup

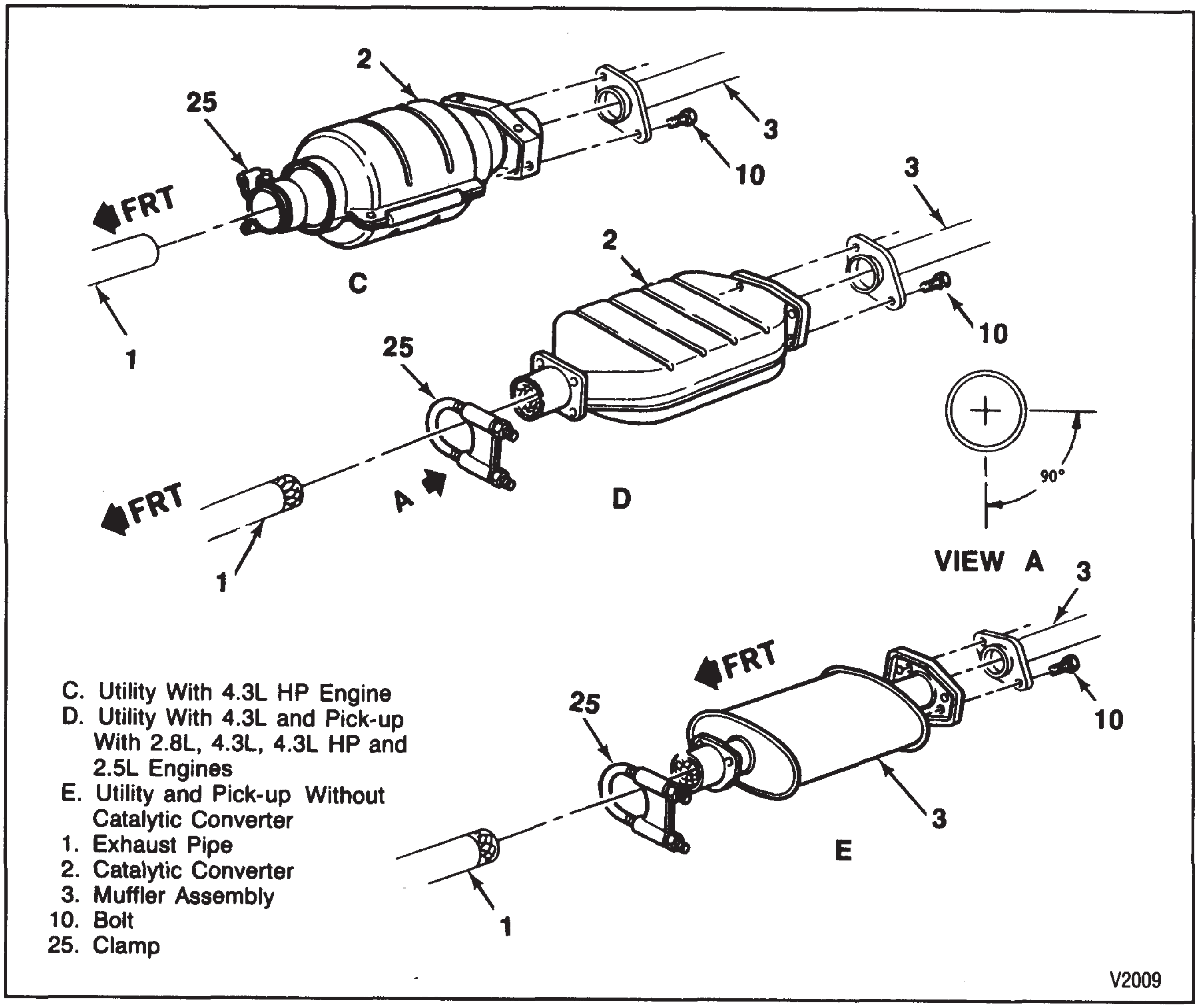


Figure 11—Catalytic Converter Attachment

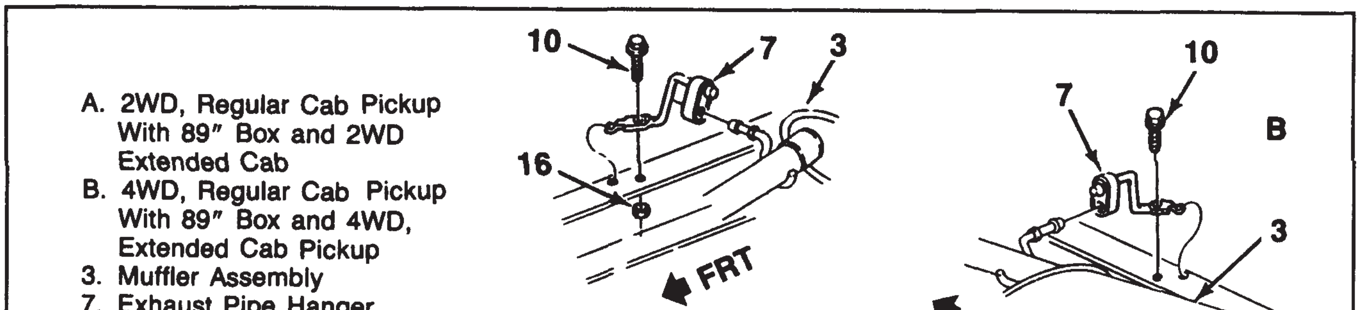
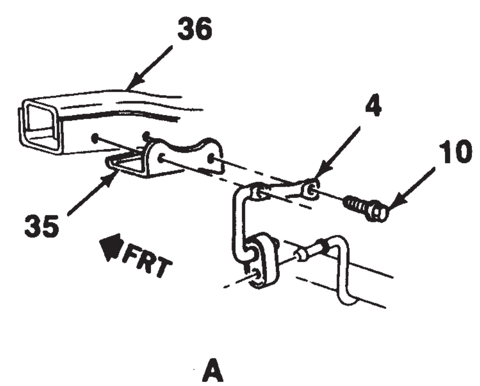
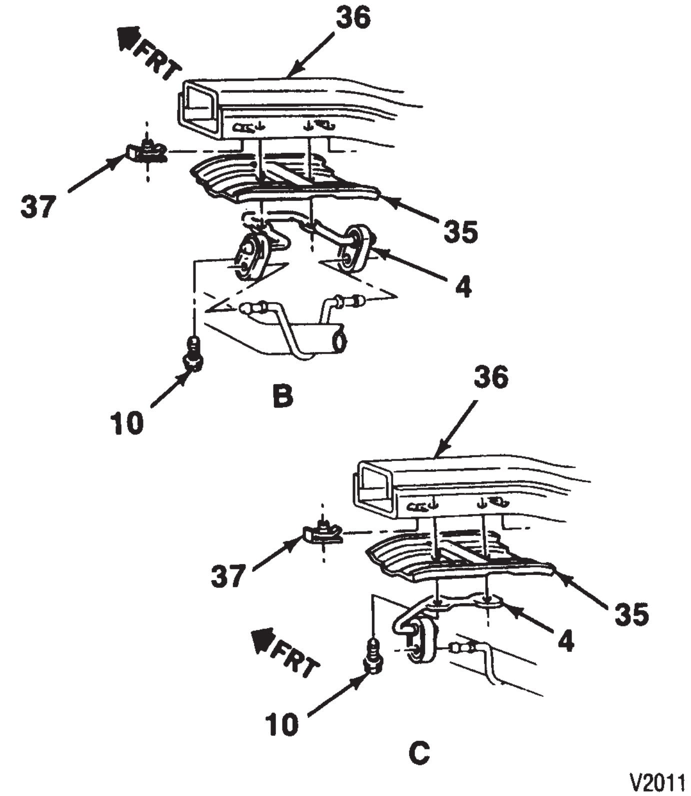


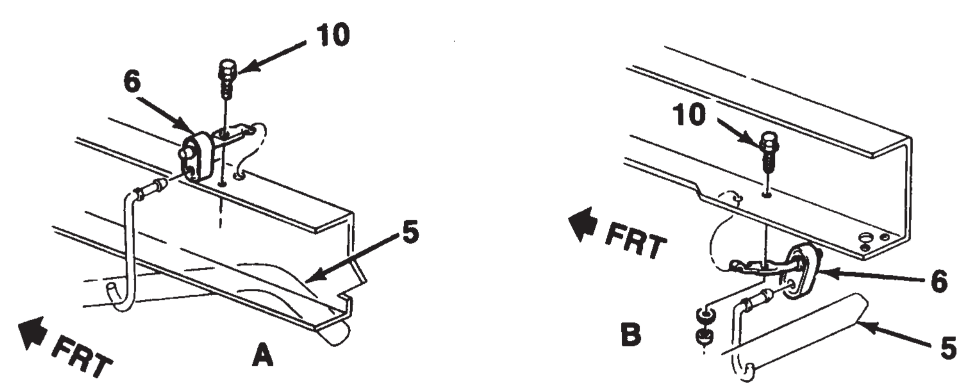
Figure 12—Exhaust Pipe Hangers—Pickup





A. Utility Vehicles
B. 2WD, Regular Cab Pick-up w/89 inch Box and 2WD Extended Cab
C. 2WD, Regular Cab Pick-up w/73.1 inch Box and 4WD Pick-up (All)
4. Muffler Hanger
10. Bolt
35. Shield
36. Crossmember
37. Nut

Figure 13—Muffler Assembly Hangers



A. Utility Vehicles
B. 2WD Pickup
C. 4WD Pickup
5. Tailpipe
6. Tailpipe Hanger
10. Bolt

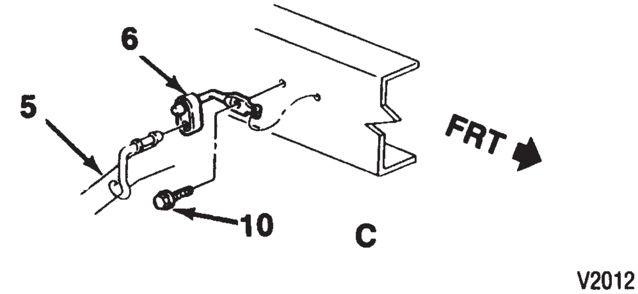


Figure 14—Tailpipe Hangers

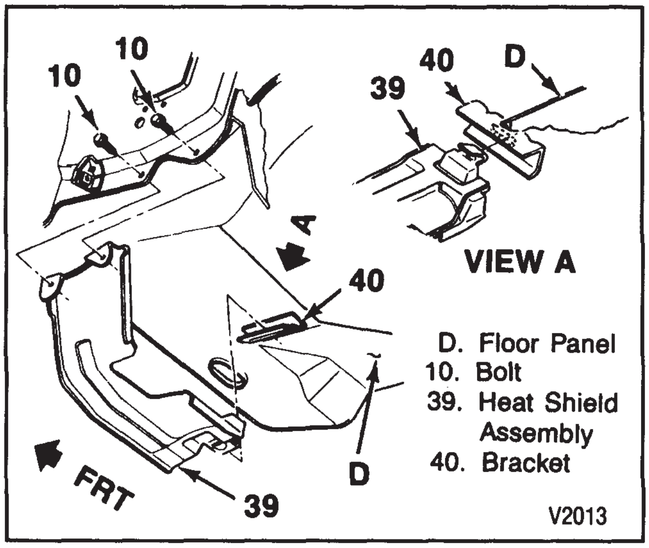


Figure 15—Exhaust Pipe Heat Shield Assembly —2WD Pickup with 4.3L and 4.3L HP Engines

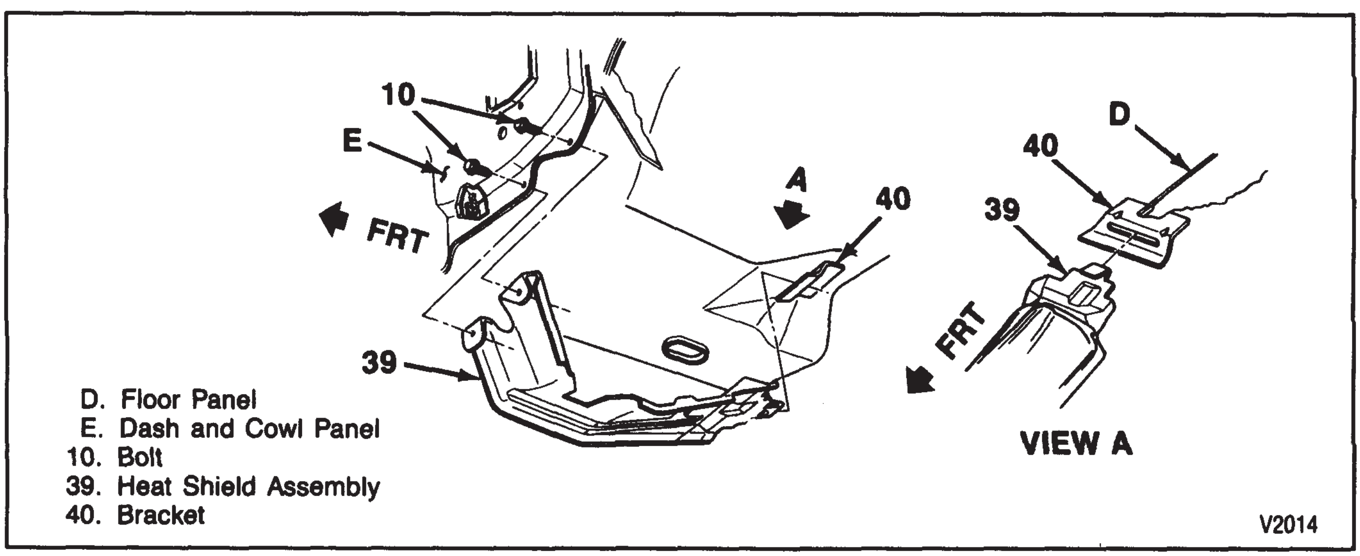


Figure 16—Exhaust Pipe Heat Shield Assembly—2WD, 2 Door and 4 Door Utility and 4WD, Utility and Pickup, (All) with 4.3L and 4.3L HP Engines

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Item	N·m	Ft. Lbs.	In. Lbs.
Converter Clamp Utility with 4.3L HP	54	40	—
Converter Hanger Bolts 2WD Pick-up	34	25	—
Conver Hanger to Frame Bolt 4WD Pick-up	17	13	—
Converter Hanger to Frame Bolt 2 WD and 4WD, 2 and 4 Door Utility and 4WD, 2 Door Utility with 4.3L and 4.3L HP	17	13	—
Converter Heat Shield Bolt (Top) 2WD Pick-up	13	—	115
Converter Heat Shield Bolt (Rear) 2WD Pick-up	10	—	89
Converter Heat Shield Bolt (Top) 4 WD Pick-up	13	—	115
Converter Heat Shield Bolt (Front) 4WD Pick-up	34	25	—
Converter Heat Shield Bolt (Rear) 4WD Pick-up	31	24	—
Converter Heat Shield Bolt (Top) 2WD and 4WD, 2 and 4 Door Utility and 4WD, 2 Door Utility with 4.3L and 4.3L HP	10	—	89
Converter Heat Shield Bolt (Front and Rear) 2WD and 4WD, 2 and 4 Door Utility and 4WD, 2 Door Utility with 4.3L and 4.3L HP	32	24	—
Exhaust Pipe to Converter Clamp Nuts Pick-up	47	35	—
Exhaust Pipe to Muffler Clamp Nuts	47	35	—
Exhaust Pipe to Exhaust Manifold (Engine) Bolts 2.5L	20	15	—
Exhaust Pipe to Exhaust Manifold (Engine) Bolts 2.8L, 4.3L, 4.3L HP Nut to Stud	21	15	—
Exhaust Pipe Hanger 2WD Pick-up Nut to Bolt	46	34	—
Exhaust Pipe Hanger 4 WD Pick-up Bolt	17	13	—
Exhaust Manifold Heat Shield Bolt	2	—	18
Muffler and Tailpipe Hanger Bolt Utility	17	13	—
Muffler and Tailpipe Hanger Bolt 2WD and 4WD Pick-ups	25	18	—
Tailpipe Hanger Bolt Utility and 4WD Pick-up	17	13	—
Tailpipe Hanger Bolt 2WD Pick-up	46	34	—

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SECTION 7

TRANSMISSION

CONTENTS

SECTION 7A

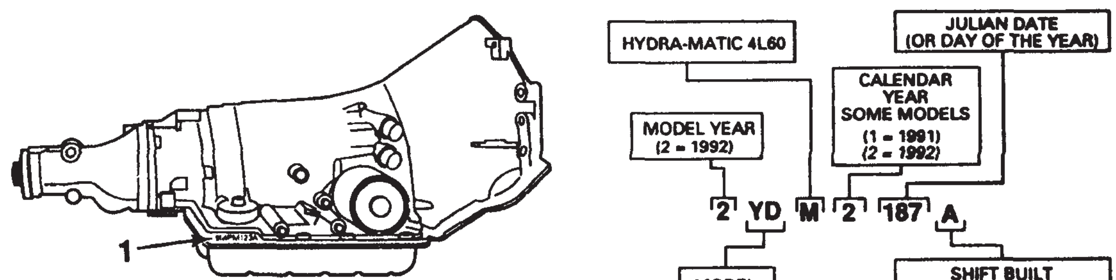
AUTOMATIC TRANSMISSION

CONTENTS

TRANSMISSION IDENTIFICATION INFORMATION

The 4L60 transmission has the identification information stamped into the case pan rail (figure 1). This information will assist in the servicing and determination of replacement parts when ordered through a GM parts catalog.

Additional transmission identification is provided on the service parts identification label (figure 2). This label contains information on the regular production options (RPO) as well as standard and mandatory



HYDRA-MATIC 4L60 TRANSMISSION IDENTIFICATION INFORMATION

1. Transmission I.D. Location

V1378

Figure 1—Transmission Identification Information 4L60

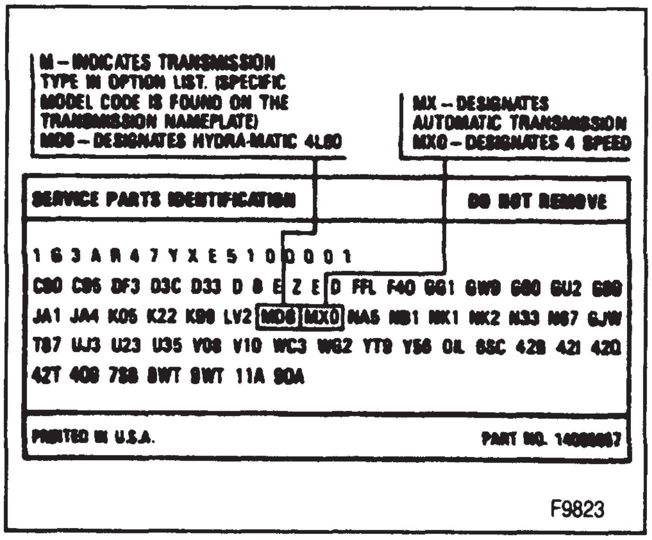


Figure 2—Service Parts Identification Label

options. This label is affixed to the inside of each vehicle at the assembly plant. Refer to GENERAL INFORMATION (SECTION 0A) for label location and additional information.

TRANSMISSION DEFINITIONS

The following definitions are being provided to establish a common language and assist the user in describing transmission related conditions. Some of these terms or conditions are used in 4L60 (SECTION 7A1).

THROTTLE POSITIONS

- Minimum Throttle—the least amount of throttle opening required for an upshift.
- Light Throttle—approximately 1/4 of the accelerator pedal travel.
- Medium Throttle—approximately 1/2 of the accelerator pedal travel.
- Heavy Throttle—approximately 3/4 of the accelerator pedal travel.
- Wide Open Throttle (WOT)—full travel of the accelerator pedal.
- Full Throttle Detent Downshift—a quick application of the accelerator pedal to its full travel, forcing a downshift.
- Zero Throttle Coastdown—a full release of the accelerator pedal while the vehicle is in motion and in drive range.
- Engine Braking—a condition where the engine is used to slow the vehicle by manually downshifting during a zero throttle coastdown.

SHIFT CONDITIONS

- Bump—a sudden and forceful application of a clutch or band.
- Chuggle—a bucking or jerking condition that may be engine related. It may be most noticeable when the converter clutch is engaged. It is similar to the feel of towing a trailer.
- Delayed—a condition where a shift is expected but does not occur for a period of time. Samples of the condition could be described as clutch or band engagement which does not occur as quickly as expected during a part throttle or wide open throttle application of the accelerator or when manually downshifting to a lower range. Also defined as "LATE" or "EXTENDED."
- Double Bump ("Double Feel")—too sudden and forceful application of a clutch or band.
- Early—a condition where the shift occurs before the vehicle has reached a proper speed and tends to labor the engine after the upshift.
- End Bump—a firmer feel at the end of a shift as compared to the feel at the start of the shift. Also defined as "END FEEL" or "SLIP BUMP."
- Firm—a noticeable quick application of a clutch or band that is considered normal with a medium to heavy throttle shift. Should not be confused with "HARSH" or "ROUGH."
- Flare—a quick increase in engine rpm accompanied by a momentary loss of torque. This most generally occurs during a shift. Also defined as "SLIPPING."
- Harsh ("Rough")—a more noticeable application of a clutch or band as compared to "FIRM." This condition is considered undesirable at any throttle position.
- Hunting—a repeating quick series of upshifts and downshifts that cause a noticeable change in engine rpm. An example could be described as a 4-3-4 shift pattern. Also defined as "BUSYNESS."
- Initial Feel—a distinctly firmer feel at the start of a shift as compared to the finish of the shift.
- Late—a shift that occurs when the engine is at a higher than normal rpm for a given amount of throttle.
- Shudder—a repeating jerking sensation similar to "CHUGGLE" but more severe and rapid in nature. This condition may be most noticeable during certain ranges of vehicle speed. May also be used to define the condition after converter clutch engagement.
- Slipping—a noticeable increase in engine rpm without a vehicle speed increase. A slip usually occurs during or after initial clutch or band engagement.
- Soft—a slow, almost unnoticeable clutch application with very little shift feel.
- Surge—a repeating engine related feeling of acceleration and deceleration that is less intense than "CHUGGLE."
- Tie-Up—a condition where two opposing clutches are attempting to apply at the same time, causing the engine to labor with a noticeable loss of engine rpm.

NOISE CONDITIONS

- Gear Noise—a whine, most noticeable in first gear and reverse that is related to vehicle speed. A gear noise condition may become less noticeable or go away after an upshift.
- Pump Noise—a high pitched whine that increases in intensity with engine rpm. This condition may also be noticeable in "PARK" and "NEUTRAL" operating ranges with the vehicle stationary.

PRELIMINARY CHECKING PROCEDURE

The condition of an automatic transmission not operating properly may be influenced by one or a combination of the following items:

- Fluid level high/low.
- Engine performance. Refer to the 1992 Light Duty Fuel and Emissions Manual if you are using X-9229 and to the Fuel and Emissions section at the rear of this manual if you are using ST-369-92.
- TV cable adjustment.
- Manual linkage adjustment.
- Internal fluid leaks. Refer to 4L60 (SECTION 7A1).
- Electrical system 4L60. Refer to ELECTRICAL (SECTION 8) or the Electrical Diagrams and Diagnosis manual for this model. ED&D if you are using X-9229 use X-9243 and if you are using ST-369-92 use ST-369-92-EDD.
- Transmission or other mechanical component. Refer to 4L60 (SECTION 7A1).

NOISE AND VIBRATION ANALYSIS

A noise or vibration that is noticeable when the vehicle is in motion MAY NOT be the result of the transmission.

If noise or vibration is noticeable in "Park" (P) and "Neutral" (N) with engine at idle, but is less noticeable as rpm increases, the cause may be from poor engine performance.

Inspect

1. Tires for:
   - Uneven wear
   - Imbalance
   - Mixed sizes
   - Mixed radial and bias ply. Refer to TIRES AND WHEELS (SECTION 3E).
2. Suspension components for:
   - Alignment and wear
   - Loose fasteners
3. *Engine/transmission mounts for:*
   - Damage
   - Loose bolts
4. Transmission case mounting holes for:
   - Missing bolts, nuts, studs
   - Stripped threads
   - Cracks
5. Flywheel for:
   - Missing or loose bolts
   - Cracks
   - Imbalance. Refer to ENGINE (SECTION 6).
6. Torque converter for:
   - Missing or loose bolts or lugs
   - Missing or loose balance weights
   - Imbalance

TRANSMISSION FLUID LEVEL INFORMATION

Checking fluid level, color, and condition at regular intervals will provide early diagnosis information about the transmission. This information may then be used to correct a condition that, if not detected early, could result in major transmission repairs.

When adding or changing fluid, use only DEXRON®-IIE. Refer to MAINTENANCE AND LUBRICATION (SECTION OB) for maintenance information and servicing intervals.

NOTICE: Do not overfill. Overfilling will cause foaming, loss of fluid, and possible damage to the transmission.

- Fluid level should be checked when it reaches normal operating temperatures of 88 - 90°C (190 - 200°F). This temperature is reached after approximately 15 miles (24 km) of highway driving.
- Fluid color will be red when new. The red dye is added so the assembly plant can identify it as transmission fluid and distinguish it from engine oil or anti-freeze. The red dye is not an indicator of the quality and is not permanent. As the vehicle is driven, the transmission fluid will begin to look darker in color. The color may eventually appear light brown.
- Inaccurate fluid level readings will result if checked immediately after the vehicle has been operated under any of the following conditions.
  - In high ambient temperatures above 32°C (90°F).
  - At sustained high speeds.
  - In heavy city traffic during hot weather.
  - As a towing vehicle.
  - In commercial service (taxi or police use).

TRANSMISSION FLUID CHECKING PROCEDURE

Inspect (Figure 3)

NOTICE: The automatic transmission fluid level must be checked with the vehicle at normal operating temperature 82-93°C (180-200°F). Temperature will greatly affect transmission fluid level. If the vehicle is not at normal operating temperature and the proper checking procedures are not followed, the result could be a false reading of the fluid level indicator and an incorrect adjustment of the fluid level.

1. Start engine and operate vehicle for 15 minutes or until normal operating temperature is reached.
2. Park vehicle on level ground.
3. Apply parking brake and block wheels.
4. Move gear selector through all gear positions.
5. Move gear selector to "Park" (P).
6. Let vehicle idle for 3 minutes with accessories off.
7. Check fluid level, color, and condition.

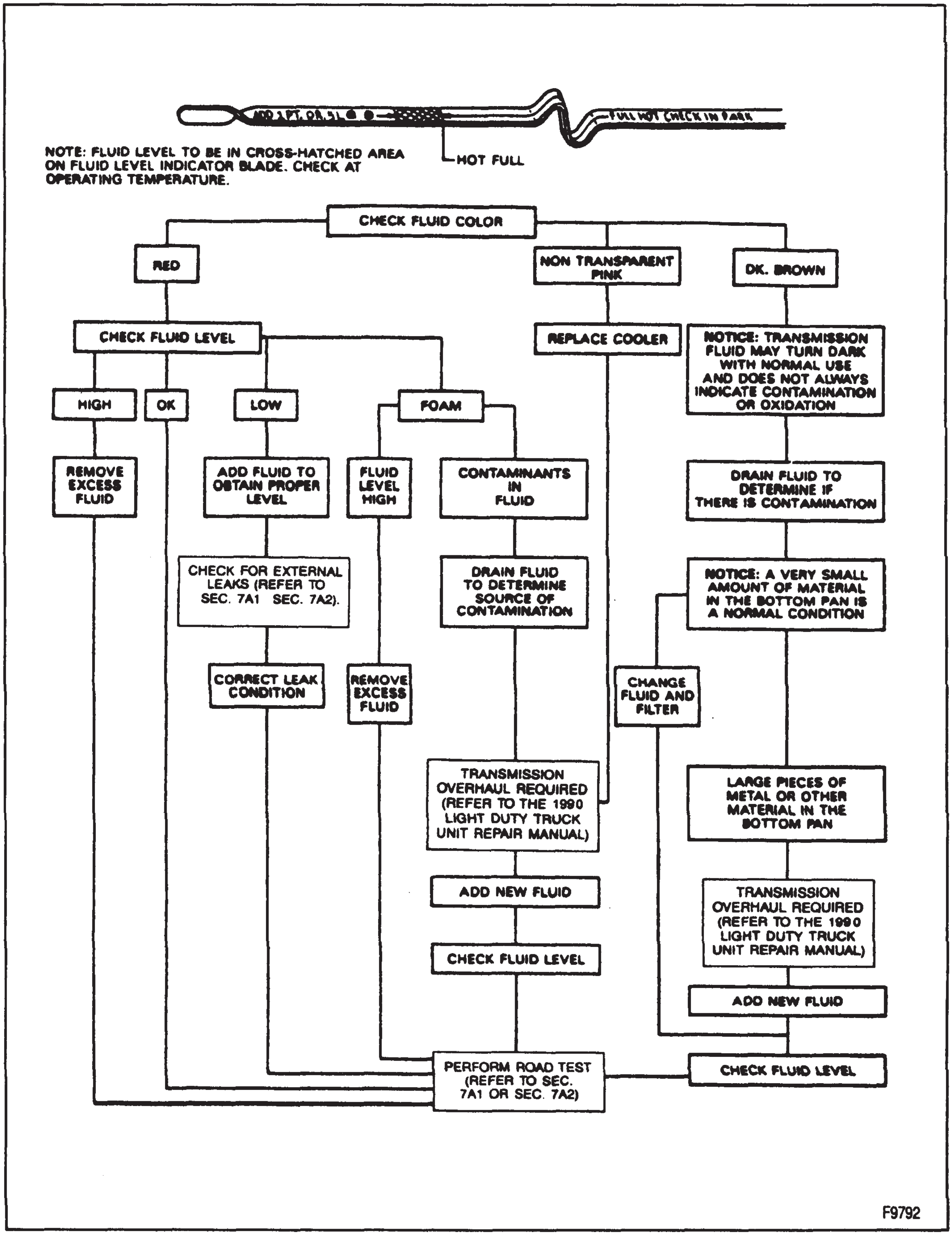


Figure 3—Checking Fluid Color, Level, and Condition

SECTION 7A1

4L60 AUTOMATIC TRANSMISSION

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number for the application. If the correct part number is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

SECTION/HYDRA-MATIC 4L60

AUTOMATIC TRANSMISSION DIAGNOSIS

RPO MD8

GENERAL DESCRIPTION

Figure 1

The HYDRA-MATIC 4L60 is a fully automatic transmission for rear wheel drive vehicles which provides four forward gear ranges and a reverse.

The major components of this transmission are:

- Torque Converter Clutch Asm.
- Vane Type Pump
- 2-4 Band Asm.
- Five Multiple Disc Clutches
- Two Planetary Gear Sets
- One Sprag Clutch
- One Roller Clutch
- Valve Body Asm.

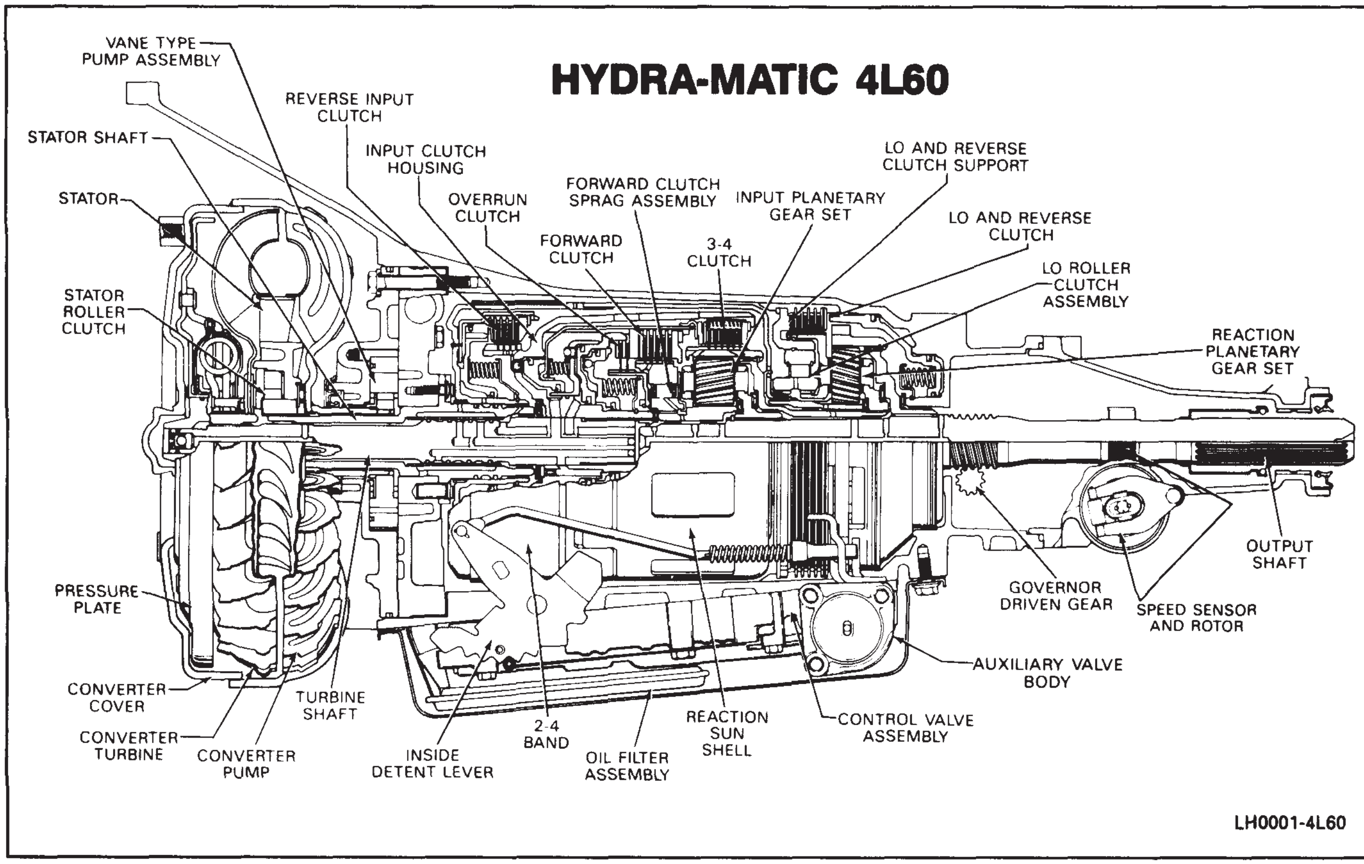


Figure 1 HYDRA-MATIC 4L60 Transmission

The oil pressure and shift points are controlled by throttle opening via a throttle valve cable. (See Section 7A1 for T.V. cable information).

The transmission can be operated in any one of the following seven modes:

P – Park position prevents the vehicle from rolling either forward or backward. (For safety reasons the parking brake should be used in addition to the park position).

R – Reverse allows the vehicle to be operated in a rearward direction.

N – Neutral allows the engine to be started and operated without driving the vehicle. If necessary this position may be selected if the engine must be restarted with the vehicle moving.

Ⓓ – Overdrive is used for all normal driving conditions. It provides four gear ratios plus converter clutch operation. Downshifts are available for safe passing by depressing the accelerator.

D – Drive position is used for city traffic, hilly terrain, and trailer towing. It provides three gear ranges. Again, downshifts are available by depressing the accelerator.

2 – Manual second is used to provide acceleration and engine braking. This range may be selected at any vehicle speed.

1 – Manual Lo is used to provide maximum engine braking. This range may also be selected at any vehicle speed.

DIAGNOSIS INFORMATION

ROAD TEST PROCEDURE

- Perform the road test following the sequence given
- Km/h (mph) shift points will vary with actual throttle position and driver habits
- Not all possible throttle positions and corresponding mph shift point information have been provided.
- Compare the results of the test with shift speed chart information. Use these results with the diagnosis information contained in this Automatic Transmission Diagnosis Section to evaluate the transmission.
- This test should only be performed when traffic and road conditions permit
- Observe all traffic safety regulations

Drive and Reverse Engagement Shift Check

1. Start engine
2. Depress brake pedal
3. Move gear selector:
   - "Park" (P) to "Reverse" (R)
   - "Reverse" (R) to "Neutral" (N) to "Drive" (D)
   - Drive and/or Reverse engagement, may take from 1-2 seconds at normal operating temperatures (80° to 90°C/180° to 200°F). Engagement should not be harsh.

Upshifts and Torque Converter Clutch (TCC) Apply

Figure 2

With gear selector in "Overdrive" Ⓓ

1. Accelerate using a steady increasing throttle pressure
2. Note the shift speed point gear engagements for:
   - 2nd gear
   - 3rd gear
   - Overdrive
3. Note the speed shift point for TCC apply. This should occur while in third gear or overdrive. If the apply is not noticed, refer to the Torque Converter Clutch Diagnosis information contained in this section of the Service Manual.

Important

The torque converter clutch will not engage if engine coolant has not reached a minimum operating temperature of approximately 54°C (130°F).

Part Throttle Downshift

At vehicle speeds of 64 to 88 km/h (40 to 55 mph) quickly depress the accelerator to a half open position and observe:

- TCC release
- Transmission downshift to 3rd gear immediately

Full Throttle (Detent) Downshift

At vehicle speeds of 77 to 88 km/h (48 to 55 mph) quickly depress the accelerator to a wide open position and observe:

- TCC release
- Transmission downshift to 2nd gear immediately

Manual Downshift

1. At vehicle speeds of 64 to 88 km/h (40 to 55 mph) release the accelerator pedal while moving the gear selector to "Third" (D) gear and observe:
   - TCC release
   - Transmission downshift to 3rd gear should be immediate
   - Engine should slow vehicle down
2. Move gear selector to "Overdrive" Ⓓ and accelerate to 64 to 72 km/h (40 to 45 mph). Release the accelerator pedal while moving the gear selector to "Second" (2) gear and observe.
   - TCC release
   - Downshift to second gear should be immediate
   - Engine should slow vehicle down

1992 HYDRA-MATIC 4L60 SHIFT SPEED CHART

MODEL	1-2 MIN THROTTLE	2-3 MIN THROTTLE	3-4 MIN THROTTLE	1-2 W.O.T.	4-3 COAST DOWN	3-2 COAST DOWN	2-1 COAST DOWN
AAM	13-17	26-32	37-51	30-41	28-33	16-24	7-10
ACM	13-17	25-32	41-51	28-40	25-36	17-24	10-12
ADM, AKM	13-17	26-32	37-52	30-41	28-33	16-24	7-10
BBM	14-18	26-33	40-52	31-46	25-30	14-25	9-11
BCM	14-18	25-32	42-53	31-45	27-34	14-24	9-11
BFM	13-16	24-28	38-52	27-42	25-29	14-21	8-10
BWM	13-17	26-31	39-52	31-45	25-30	14-24	9-11
CAM, CBM, KMM	14-17	22-28	46-52	28-39	34-44	14-22	10-12
CCM, CFM, KHM, WBM	13-16	21-26	42-48	27-39	31-39	12-20	10-12
CHM, CJM, KJM, WCM	15-18	23-30	48-56	31-44	36-47	16-23	11-13
DDM	16-19	26-32	35-47	33-55	24-31	15-23	10-13
FBM	14-18	26-34	43-53	37-51	28-35	16-24	10-12
FTM	12-15	21-26	39-50	28-41	31-39	13-22	10-12
FUM	12-15	22-26	38-47	25-41	24-30	14-20	9-11
FZM	13-16	2332	44-52	36-46	35-40	10-19	10-12
LAM, LBM, LCM, LDM, LFM	11-13	21-24	39-45	24-33	28-38	14-21	7-9
LHM	12-14	21-26	48-53	23-33	35-47	13-21	8-10
MJM, MNM, WAM	13-17	22-28	46-52	28-39	34-44	14-22	10-12
MMM	12-15	24-28	39-47	29-48	29-35	15-26	9-11
MSM	12-15	24-28	38-47	22-36	27-36	12-19	7-8
SAM	12-15	18-24	47-53	24-37	37-47	10-18	9-12
SFM	10-12	18-23	43-52	25-37	36-45	13-19	8-10
SHM, TLM	14-17	24-31	49-56	30-42	37-48	15-24	11-13
TAM, TBM	15-18	28-34	48-53	31-52	32-39	17-28	10-12
TWM	12-17	23-27	32-38	25-33	26-30	15-22	9-11
YDM	13-17	22-28	38-51	29-53	21-27	13-19	9-11

NOTES: 1. ALL SPEEDS INDICATED ARE IN MILES PER HOUR. CONVERSION TO km/h = MPH x 1.609.
2. SHIFT POINTS WILL VARY SLIGHTLY DUE TO ENGINE LOADS AND VEHICLE OPTIONS.
3. SPEEDS LISTED WITH + EXCEED 65 MPH.
4. SPEEDS ARE BASED ON TPS OF 10 TO 20. USE A SCAN TOOL TO MEASURE CORRECT TPS.

NH0002-4L60

Figure 2 Shift Speed Chart

3. Move gear selector to "Overdrive" (D) and accelerate to 40 km/h (25 mph). Release the accelerator pedal while moving the gear selector to "First" (1) gear and observe:
   - TCC release
   - Transmission downshift to 1st gear should be immediate
   - Engine should slow vehicle down

Coastdown Downshift

1. With the gear selector in "Overdrive" (D) accelerate to 4th gear and TCC apply.
2. Release the accelerator pedal and lightly apply the brakes to observe:
   - TCC release
   - Shift points for downshifts

Manual Gear Range Selection

Manual Third (D)

1. With vehicle stopped, place gear selector in "Third" (D) and accelerate to observe:
   - The first to second gear shift point
   - The second to third gear shift point

Manual Second (2)

1. With vehicle stopped, place gear selector in "Second" (2) and accelerate to observe:
   - The first to second gear shift point
2. Accelerate to 40 km/h (25 mph) and observe:
   - That a second to third gear shift does not occur
   - That TCC does not engage

Manual First (1)

1. With vehicle stopped, place gear selector in "First" (1) and accelerate to 24 km/h (15 mph) and observe:
   - That no upshift occurs
   - That TCC does not engage

Reverse

1. With vehicle stopped, place gear selector in "Reverse" (R) and slowly accelerate to observe reverse gear operation.

TORQUE CONVERTER CLUTCH (TCC) DIAGNOSIS

The Torque Converter Clutch is applied by fluid pressure which is controlled by a solenoid located inside the Automatic Transmission assembly. The solenoid is energized by completing an electrical circuit through a combination of switches and sensors.

Functional Check Procedure

Inspect

1. Install a tachometer or scan tool.
2. Drive the vehicle until proper transmission operating temperature is reached.
3. Drive the vehicle at 80 to 88 km/h (50 to 55 mph) with light throttle (road load).
4. Maintaining throttle, lightly touch the brake pedal and check for release of the TCC and a slight increase in engine rpm.
5. Release the brake, slowly accelerate and check for a re-apply of the TCC and a slight decrease in engine rpm.

To properly diagnose the Torque Converter Clutch (TCC) system, perform all electrical testing first and then test the hydraulic system.

- For diagnosis of electrical or emission control related components of the TCC, refer to the specific vehicle section in Section 6E2-C8, Driveability and Emissions.
- For diagnosis of TCC hydraulic controls, refer to the Fluid Flow and Circuit Description, and Wiring Diagrams provided in this section.
- Section 8A, Electrical Diagnosis, shows vehicle wiring diagrams if additional information is necessary.

  NOTICE: Use only high impedence type ohmmeters for electrical testing on the TCC circuit. If another type of ohmmeter is used, damage to the TCC solenoid may occur.

  NOTICE: Do not bench test the TCC solenoid using an automotive type battery. Accidentally crossed wires will damage the internal diode of the solenoid.

- A completed circuit does not indicate that the solenoid will actually apply.

LINE PRESSURE CHECK

Figure 3

The next step in diagnosing the Automatic Transmission is to do a line pressure check. This is a valuable tool in diagnosis since line pressure controls the hydraulic functions of the transmission.

Refer to figure 3 for the Line Pressure Check Procedure and line pressure chart.

TORQUE CONVERTER EVALUATION

The torque converter should be replaced under any of the following conditions:

- External leaks in the hub weld area
- Converter hub is scored or damaged.
- Converter pilot is broken, damaged or fits poorly into crankshaft.
- Steel particles are found after flushing the cooler and cooler lines.
- Pump is damaged or steel particles are found in the converter.
- Vehicle has TCC shudder and/or no TCC apply. Replace only after all hydraulic and electrical diagnoses has been made. (Converter clutch material may be glazed.)
- Converter has an imbalance which cannot be corrected. (Refer to Converter Vibration Test Procedure in the Transmission Unit Repair Section.)
- Converter is contaminated with engine coolant containing antifreeze.
- Internal failure of stator roller clutch
- Excess end play
- Heavy clutch debris due to overheating (blue converter)
- Steel particles or clutch lining material found in fluid filter or on magnet when no internal parts in unit are worn or damaged — indicates that lining material came from converter.

Noise

Torque converter whine is usually noticed when the vehicle is stopped and the transmission is in "Drive" or "Reverse". The noise will increase when engine rpm is increased. The noise will stop when the vehicle is moving or when the torque converter clutch is applied because both halves of the converter are turning at the same speed.

Perform a stall test to make sure the noise is actually coming from the converter:

1. Place foot on brake.
2. Put gear selector in "Drive".
3. Depress accelerator to approximately 1200 rpm for no more than six seconds.

NOTICE: If the accelerator is depressed for more than six seconds, damage to the transmission may occur.

A torque converter noise will increase under this load.

Important

- This noise should not be confused with pump whine noise which is usually noticeable in "Park", "Neutral" and all other gear ranges. Pump whine will vary with pressure ranges.

Torque Converter Stator

The torque converter stator roller clutch can malfunction in two different ways. It can either remain locked up at all times or freewheel in both directions.

If the stator is freewheeling at all times, the vehicle tends to have poor acceleration from the standstill. The car may act normal at speeds above 50 to 55 km/h (30 to 35 mph). If poor acceleration is noted, it should first be determined that the exhaust system is not blocked, the engine timing is correct, and the transmission is in "First" (1) gear when starting out.

If the engine accelerates freely to high rpm in "Neutral" (N), it can be assumed that the engine and exhaust system are normal. Checking for poor performance in "Drive" (D) and "Reverse" (R) will help determine if the stator is freewheeling at all times.

If the stator is locked up at all times, performance from a standstill appears normal. Engine rpm and acceleration is restricted or limited, however, at high speeds. The engine may overheat with this condition. Visual examination of the converter may reveal a blue color from overheating.

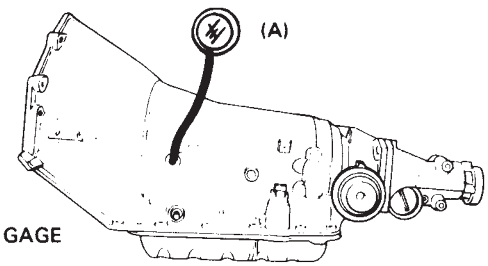
If the torque converter has been removed from the vehicle, the stator roller clutch can be checked by inserting a finger into the splined inner race of the roller clutch and trying to turn the race in both directions. The inner race should turn freely clockwise, but not turn or be very difficult to turn counterclockwise.

The Torque Converter should not be replaced if:

- The oil has an odor, is discolored, and there is no evidence of metal or clutch facing particles.
- The threads in one or more of the converter bolt holes are damaged.
  - Correct with thread insert. (Refer to Section 6A.)
- Transmission failure did not display evidence of damaged or worn internal parts, steel particles or clutch plate lining material in unit and inside the fluid filter.
- Vehicle has been exposed to high mileage (only). The exception may be where the torque converter clutch dampener plate lining has seen excess wear by vehicles operated in heavy and/or constant traffic, such as taxi, delivery or police use.

LINE PRESSURE CHECK PROCEDURE

- **CHECK TRANSMISSION FLUID LEVEL**
- **CHECK AND ADJUST T.V. CABLE**
- **CHECK OUTSIDE MANUAL LINKAGE AND CORRECT**
- **CHECK ENGINE TUNE**
- **INSTALL PRESSURE GAGE**
- **CONNECT TACHOMETER TO ENGINE**
- **CHECK PRESSURE AS FOLLOWS:**



(A) ATTACH PRESSURE GAGE

Minimum T.V. Line Pressure Check

Set the T.V. cable to specification; and with the brakes applied, take the line pressure readings in the ranges and at the engine R.P.M. indicated in the chart below.

Full T.V. Line Pressure Check

Full T.V. line pressure readings are obtained by tying or holding the T.V. cable to the full extent of its travel; and with the brakes applied, take the line pressure readings in the ranges and at the engine R.P.M. indicated in the chart below.

***NOTICE:** Total running time combination not to exceed 2 minutes.

CAUTION: Brakes must be applied at all times.

1992 HYDRA-MATIC 4L60 TRANSMISSION PRESSURES

RANGE	MODEL	NORMAL PRESSURE AT MINIMUM T.V.		NORMAL PRESSURE AT FULL T.V.	
		kPa	PSI	kPa	PSI
PARK, NEUTRAL, OVERDRIVE & MANUAL 3RD @ 1000 RPM	AAM	518-587	75-85	866-1063	126-154
	ACM	451-515	65-75	823-1020	119-148
	ADM, AKM, APM	518-587	75-85	1097-1381	159-200
	BFM, BJM, FUM, YDM	451-515	65-75	1116-1430	1162-208
	BHM, BWM, CAM, CBM, DBM, KAM, KMM, MJM, MNM, WAM	451-515	65-75	851-1063	123-154
	CCM, CFM, KHM, KLM, TMM, WBM	451-515	85-75	947-1185	137-172
	CHM, CJM, KJM, RAM, TNM, WCM	451-515	65-75	914-1149	133-167
	DDM	518-587	75-85	981-1221	142-177
	FBM	451-515	65-75	918-1146	133-166
	FTM, FZM	451-515	65-75	1073-1354	155-196
	FUM	518-587	75-85	1350-1732	195-251
	LAM, LBM, LCM, LDM, LFM	451-515	65-75	871-1091	126-158
	LHM	518-587	75-85	1332-1766	193-256
	MMM, MSM	518-587	75-85	935-1173	135-170
	SAM, SFM	451-515	65-75	845-1068	123-155
	SHM, SPM, TLM	451-515	65-75	969-1231	141-179
	TAM, TBM	451-515	65-75	914-1188	132-172
	TWM	451-515	65-75	1002-1267	145-183
REVERSE @ 1000 RPM	AAM	738-836	107-121	1234-1515	197-220
	ACM, BCM, DAM	742-847	108-123	1354-1677	197-244
	ADM, AKM, APM	738-836	107-121	1563-1967	226-285
	BFM, BJM, YDM	742-847	108-123	1834-2351	266-341
	BHM, BWM, CAM, CBM, DBM, KAM, KMM, MJM, MNM, WAM	742-847	108-123	1400-1747	203-253
	CCM, CFM, KHM, KLM, TMM, WBM	742-847	108-123	1556-1948	226-283
	CHM, CJM, KJM, RAM, TNM, WCM	742-847	108-123	1503-1889	218-274
	DDM	738-836	108-123	1397-1739	202-252
	FBM	580-662	84-96	1180-1472	171-214
	FTM, FZM	742-847	108-123	1763-2225	256-323
	FUM	665-754	97-109	1734-2225	251-322
	LAM, LBM, LCM, LDM, LFM	741-845	107-123	1429-1790	207-260
	LHM	665-754	97-109	1710-2268	248-329
	MMM, MSM	738-836	108-123	1331-1671	193-242
	SAM, SFM	580-662	84-96	1085-1372	157-199
	SHM, SPM, TLM	742-847	108-123	1593-2023	231-293
	TAM, TBM	741-845	107-123	1503-1952	218-283
	TWM	741-845	107-123	1646-2082	238-301
MANUAL 2ND & MANUAL LO @ 1000 RPM	AAM, ADM, AKM, APM, BBM, DDM, MMM, MSM	1121-1269	163-184	1121-1269	163-180
	ACM, BCM, BFM, BHM, BJM, BWM, CAM, CBM, CCM, CFM CHM,CJM, DAM, DBM, FBM, FTM, FZM, KAM, KHM, KJM, KMM, MJM, MNM, RAM, SAM, SFM, SHM, SPM, TAM, TBM, TLM, TMM, TNM, TWM, WAM, WBM, WCM, YDM	1127-1286	163-186	1127-1286	163-186
	LAM, LBM, LCM, LDM, LFM	1191-1359	173-197	1191-1359	173-197
	FUM, LHM	1293-1465	188-223	1293-1465	188-213

Line pressure is basically controlled by pump output and the pressure regulator valve. In addition, line pressure is boosted in Reverse, Second and Lo by the reverse boost valve.

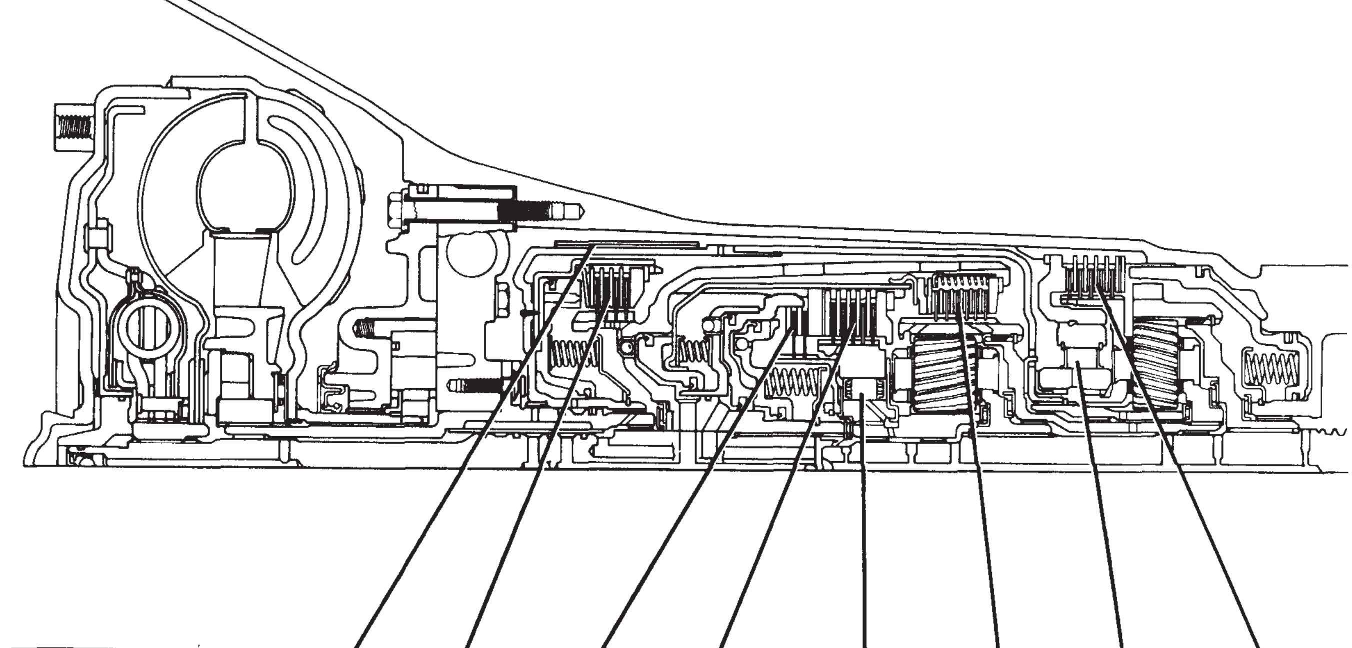
Also, in the Neutral, Drive, Intermediate and Reverse positions of the selector lever, the line pressure should increase with throttle opening because of the T.V. system. The pressure is controlled by the T.V. cable, the throttle lever and bracket assembly and the T.V. link, as well as the control valve assembly.

The main line pressure tap plug is located on the left side of the transmission above the outside manual lever. NH0003-4L60

Figure 3 Line Pressure Check Procedure

HYDRA-MATIC 4L60 - GEAR RATIOS

FIRST	3.06		FOURTH	.70
SECOND	1.62		REVERSE	2.29
THIRD	1.00			



RANGE	GEAR	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV. CLUTCH
P-N									
D	1st				APPLIED	HOLDING		HOLDING	
	2nd	APPLIED			APPLIED	HOLDING			
	3rd				APPLIED	HOLDING	APPLIED		
	4th	APPLIED			APPLIED		APPLIED		
D	1st			APPLIED	APPLIED	HOLDING		HOLDING	
	2nd	APPLIED		APPLIED	APPLIED	HOLDING			
	3rd			APPLIED	APPLIED	HOLDING	APPLIED		
2	1st			APPLIED	APPLIED	HOLDING		HOLDING	
	2nd	APPLIED		APPLIED	APPLIED	HOLDING			
1	1st			APPLIED	APPLIED	HOLDING		HOLDING	APPLIED
R	REVERSE		APPLIED						APPLIED

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Figure 4 Clutch Application Chart

CONDITION	INSPECT COMPONENT	FOR CAUSE
OIL PRESSURE HIGH OR LOW (Verify With Gage—Refer To Line Pressure Check Procedure)	• Oil Pump Assembly (7)	— Pressure regulator valve (218) stuck. — Pressure regulator valve spring (219) damaged. — Rotor guide (213) omitted or mis-assembled. — Rotor (214) cracked or broken. — T.V. boost valve (222), reverse boost valve (220) or sleeve (221) stuck, damaged or incorrectly assembled. — Orifice hole in pressure regulator valve (218) plugged. — Sticking slide (206) or excessive rotor clearance. — Pressure relief ball (231) not seated or damaged. — Porosity in pump cover or body. — Wrong pump cover. — Pump faces not flat. — Excessive rotor clearance.
	• Oil Filter (71)	— Intake pipe restricted by casting flash. — Cracks in filter body or intake pipe. — "O" ring seal (70) missing, cut or damaged. — Wrong grease used on rebuild.
	• T.V. Exhaust Ball (91)	— Stuck or damaged.
	• Throttle Lever & Bracket Assembly (65)	— Misassembled, binding or damaged.
	• Throttle Link (64)	— Misassembled, binding or damaged.
	• Valve Body (67)	— Manual valve (340) scored or damaged. — Spacer plate (56) or gaskets (88 & 89) incorrect, misassembled or damaged. — Face not flat. — Throttle valve (326) sticking. — T.V. limit valve (332) sticking. — Modulated downshift valve (301) stuck. — Line bias valve (336) stuck. — 2-3 Shift valve (316) stuck. — Checkballs omitted or misassembled.
	• Case (10)	— Case to valve body face not flat.
HIGH OR LOW SHIFT POINTS	• T.V. Cable	— Binding or not correctly adjusted.
	• T.V. Exhaust Ball (91)	— Stuck or damaged.
	• Throttle Lever & Bracket Assembly (65)	— Misassembled, binding or damaged.

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Figure 5 Diagnosis Chart A

CONDITION	INSPECT COMPONENT	FOR CAUSE
HIGH OR LOW SHIFT POINTS (Continued)	• Oil Pump Assembly (7)	— Stuck pressure regulator valve (218) or T.V. boost valve (222). — Sticking pump slide (206).
	• Valve Body Assembly (67)	— Sticking throttle valve (326) or plunger (324). — Modulated T.V. up or down valves (301 & 303) sticking. — T.V. limit valve (332) sticking. — Spacer plate (56) or gaskets (88 & 89) misassembled, damaged or incorrect. — Line bias valve (336) sticking.
	• Case (10)	— Porous or damaged valve body pad. — Governor filter (47A) restricted or damaged. — 2-4 Servo Assembly (13-31) a. 2-4 accumulator porosity. b. Damaged servo piston seals. c. Apply pin damaged or improper length. — 2-4 Band Assembly (602) a. Burned. b. Anchor pin not engaged.
1ST GEAR RANGE ONLY — NO UPSHIFT	• Governor Assembly (45)	— Governor valve (107) sticking. — Governor driven gear (83) loose or damaged: a. Wear on bottom of gear indicates pin is not pressed in deep enough. b. Wear of corner of gear indicates pin is missing. c. Wear resembles an apple core if wrong gear is used, or there is a burr on the output shaft, or output shaft to input carrier snap ring (661) is missing. d. Wear on one side of gear indicates the governor has seized in the bore. — Governor driven gear retaining pin (82) missing. — Nicks or burrs on output shaft (687). — Nicks or burrs on governor sleeve (106) or case bore. — Governor support pin in case too long or short. — Governor weights (108 & 109) or springs (110 & 111) missing, binding or damaged.
	• Valve Body (67)	— 1-2 Shift valve (322) sticking. — Spacer plate (56) or gaskets (88 & 89) mispositioned or damaged.
	• Case (10)	— Case to valve body face not flat or damaged. — Governor filter (47A) restricted or damaged.

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Figure 6 Diagnosis Chart B

CONDITION	INSPECT COMPONENT	FOR CAUSE
1ST GEAR RANGE ONLY — NO UPSHIFTS (Continued)	• 2-4 Servo Assembly (13-31)	— Restricted or blocked apply passages in case. — Nicks or burrs on servo pin (29) or pin bore in case. — 4th Servo piston (16) in backwards.
	• 2-4 Band Assembly (602)	— 2-4 Band (602) worn or damaged. — Band anchor pin not engaged.
SLIPS IN 1ST GEAR	• Forward Clutch Assembly	— Clutch plates (649) worn. — Porosity or damage in forward clutch piston (630). — Forward clutch piston inner and outer seals (629) missing, cut or damaged. — Input housing to forward clutch housing "O" ring seal (622) missing, cut or damaged. — Damaged forward clutch housing (628). — Forward clutch housing retainer and ball assembly (627) not sealing or damaged.
	• Forward Clutch Accumulator	— Piston seal (369) missing, cut or damaged. — Piston (367) out of its bore. — Porosity in the piston or auxiliary valve body (377). — Stuck abuse valve (360).
	• Oil Pump (7)	— Auxiliary accumulator valve tube (96) leaks, not seated in pump cover or missing.
	• Input Housing & Shaft Assembly (621)	— Turbine shaft seals (619) missing, cut or damaged.
	• Valve Body (67)	— 1-2 Accumulator valve (333) stuck. — Face not flat, damaged lands or interconnected passages. — Spacer plate (56) or gaskets (88 & 89) incorrect, mispositioned or damaged.
	• T.V. Cable	— Binding or broken.
	• Low Roller Clutch (678)	— Damage to lugs or inner ramps. — Rollers not free moving. — Inadequate spring tension — Damage to inner splines. — Lube passage plugged.
	• Torque Converter (1)	— Stator roller clutch not holding.

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Figure 7 Diagnosis Chart C

CONDITION	INSPECT COMPONENT	FOR CAUSE
SLIPS IN 1ST GEAR (Continued)	• 1-2 Accumulator Assembly (59-63)	— Porosity in piston (61) or 1-2 accumulator cover and pin assembly (62). — Damaged ring grooves on piston. — Piston seal (60) missing, cut or damaged. — Valve body to spacer plate gasket (89) at 1-2 Accumulator cover, missing or damaged. — Leak between piston and pin. — Broken 1-2 accumulator spring (59).
	• Oil Pressure	— (See Causes of High or Low Oil Pressure.)
	• 2-4 Servo Assembly (13-31)	— 4th Servo piston (16) in backwards.
1-2 SHIFT SPEED — HIGH OR LOW	• T.V. Cable	— Binding or broken. — Not correctly adjusted.
	• Governor Assembly (45)	— (See 1st Gear Range Only — No Upshift.)
	• Throttle Lever & Bracket Assembly (65)	— Misassembled, binding or damaged. — T.V. link missing, binding or damaged.
	• Valve Body (67)	— T.V. exhaust checkball (91) stuck. — T.V. plunger (324) sticking. — Face not flat.
	• Oil Pump Assembly (71) or Case (10)	— Face not flat.
SLIPPING OR ROUGH 1-2 SHIFT	• Throttle Lever & Bracket Assembly (65)	— Incorrectly installed or damaged. — T.V. cable broken or binding.
	• Valve Body Assembly (67)	— Throttle valve (326) sticking. — 1-2 Shift valve train (317-322) stuck. — Gaskets (88 & 89) or spacer plate (56) incorrect, mispositioned or damaged. — Line bias valve (336) stuck. — 1-2 Accumulator valve (333) stuck. — T.V. limit valve (332) stuck. — Face not flat.
	• 2-4 Servo Assembly (13-31)	— Apply pin (29) too long or too short. — 2nd servo apply piston seal missing, cut or damaged. — Restricted or missing oil passages. — Servo bore in case damaged.
	• 2nd Accumulator (59-63)	— Porosity in 1-2 accumulator housing (62) or piston (61). — Piston seal or groove damaged. — Nicks or burrs in 1-2 accumulator housing. — Missing or restricted oil passage.

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Figure 8 Diagnosis Chart D

CONDITION	INSPECT COMPONENT	FOR CAUSE
SLIPPING OR ROUGH 1-2 SHIFT (Continued)	• 2-4 Band (602)	— Worn or mispositioned.
	• Oil Pump Assembly (7) or Case (10)	— Faces not flat.
NO 2-3 SHIFT OR 2-3 SHIFT SLIPPING, ROUGH OR HUNTING	• Converter (1)	— Internal damage.
	• Governor Assembly (45)	— Valve (107) stuck. — Drive gear retaining pin (82) missing or loose. — Governor weights (108 & 109) binding. — Governor driven gear (83) damaged. — Governor support pin in case too long or too short.
	• Oil Pump (7)	— Stator shaft (216) sleeve scored or off location.
	• Valve Body (67)	— 2-3 Valve train (313-316) stuck. — Accumulator valve (333) stuck. — Spacer plate (56) or gaskets (88 & 89) incorrect, mispositioned or damaged. — Throttle valve (326) stuck. — T.V. limit valve (332) stuck.
	• Input Housing Assembly (621)	— Clutch plates worn [3-4 (654) or forward (649)]. — Excessive clutch plate travel. — Cut or damaged piston seals [3-4 (624) or forward (629)]. — Porosity in input clutch housing (621) or piston (623). — 3-4 Piston checkball (620) stuck, damaged or not sealing. — Restricted apply passages. — Forward clutch piston retainer and ball assembly (627) not seating. — Sealing balls loose or missing.
	• Case (10)	— 3rd Accumulator retainer and ball assembly (80) not seating.
	• 2-4 Servo Assembly (13-31)	— 2nd Apply piston seals (23 & 24) missing, cut or damaged.
NO 3-4 SHIFT/SLIPPING OR ROUGH 3-4 SHIFT	• Governor (45)	— Governor weights (108 & 109) binding. — Governor valve (107) stuck. — Governor driven gear retaining pin (82) missing or loose. — Governor driven gear (83) damaged. — Governor support pin in case too long or too short.

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Figure 9 Diagnosis Chart E

CONDITION	INSPECT COMPONENT	FOR CAUSE
NO 3-4 SHIFT/SLIPPING OR ROUGH 3-4 SHIFT (Continued)	• Oil Pump Assembly (7)	Faces not flat. — Pump cover retainer and ball assembly omitted or damaged.
	• Valve Body Assembly (67)	— Valves stuck. • 2-3 Shift valve (313-316) train. • Accumulator valve (333). • Throttle valve (326). • T.V. limit valve (332). • 1-2 Shift valve train (317-322). • 3-2 Control valve (339). — Manual valve link (64) bent or damaged. — Spacer plate (56) or gaskets (88 & 89) incorrect, mispositioned or damaged.
	• 2-4 Servo Assembly (13-31)	— Incorrect band apply pin (29). — Missing or damaged servo seals (14 & 17). — Porosity in pistons, cover or case. — Damaged piston seal grooves. — Plugged or missing orifice cup plug (86).
	• Case (10)	— 3rd Accumulator retainer and ball assembly (80) leaking. — Porosity in 3-4 accumulator piston (52) or bore. — 3-4 Accumulator piston seal (53) or seal grooves damaged. — Plugged or missing orifice cup plug (81). — Restricted oil passage.
	• Input Housing Assembly (621)	— Refer to Slipping 2-3 Shift.
	• 2-4 Band Assembly (602)	— Worn or misassembled.
NO REVERSE OR SLIPS IN REVERSE	• Input Housing Assembly (621)	— 3-4 Apply ring (625) stuck in applied position. — Forward clutch not releasing. — Turbine shaft seals (619) missing, cut or damaged.
	• Manual Valve Link (705)	— Disconnected.
	• Oil Pump Assembly (7)	— Retainer and ball assembly missing or damaged. — Stator shaft seal rings (233) or ring grooves damaged. — Stator shaft sleeve scored or damaged. — Reverse boost valve (220) stuck, damaged or misassembled. — Cup plug missing. — Restricted oil passage. — Faces not flat. — Converter clutch valve (227) stuck.

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Figure 10 Diagnosis Chart F

CONDITION	INSPECT COMPONENT	FOR CAUSE
NO REVERSE OR SLIPS IN REVERSE (Continued)	• Valve Body Assembly (67)	— 2-3 Shift valve (316) stuck. — Manual linkage (64) not adjusted. — Spacer plate (56) and gaskets (88 & 89) incorrect, mispositioned or damaged.
	• Reverse Input Clutch Assembly (605)	— Clutch plate (612) worn. — Reverse input housing and drum assembly (605) cracked at weld. — Clutch plate retaining ring out of groove. — Return spring assembly retaining ring (610) out of groove. — Seals (608) cut or damaged. — Restricted apply passage. — Porosity in piston (607). — Belleville plate (611) installed incorrectly. — Excessive clutch plate travel. — Oversized housing.
	• Auxiliary Valve Body (377)	— Lo overrun valve (364) stuck. — Orificed cup plug (359) restricted, missing or damaged.
	• Lo And Reverse Clutch	— Clutch plates (682) worn. — Porosity in piston (695). — Seals (696) damaged. — Return spring assembly retaining ring (693) mispositioned. — Restricted apply passage.
NO PART THROTTLE OR DELAYED DOWNSHIFTS	• T.V. Cable	— Loose or incorrectly installed.
	• T.V. Bracket Assembly (65)	— Bent.
	• 2-4 Servo Assembly (13-31)	— Servo cover retaining ring (13) omitted or misassembled. — 4th Apply piston (16) damaged or misassembled. — Servo inner housing (22) damaged or misassembled.
	• Governor Assembly (45)	— Governor weights (108 & 109) binding. — Governor valve (107) stuck.
	• Valve Body Assembly (67)	— Valves stuck. • Throttle valve (326) • 3-2 Control valve (339) • T.V. modulated downshift (301) — 4-3 Sequence valve body channel blocked.
HARSH GARAGE SHIFT	• Auxiliary Valve Body (377)	— Orifice cup plug (359) missing. — Check ball (55) missing.

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Figure 11 Diagnosis Chart G

CONDITION	INSPECT COMPONENT	FOR CAUSE
NO OVERRUN BRAKING — MANUAL 3-2-1	• External Linkage	— Not adjusted properly.
	• Valve Body Assembly (67)	— Valves stuck. • 4-3 Sequence valve (329) • Throttle valve (326) — Checkball #3 mispositioned. — Spacer plate (56) and gaskets (88 & 89) incorrect, damaged or mispositioned.
	• Input Clutch Assembly (621)	— Turbine shaft oil passages plugged or not drilled. — Turbine shaft seal rings (619) damaged. — Turbine shaft sealing balls loose or missing. — Porosity in forward (630) or overrun clutch piston (632). — Overrun piston seals (631) cut or damaged. — Overrun piston checkball (633) not sealing.
NO CONVERTER CLUTCH APPLY	• Electrical	— 12 Volts not supplied to transmission. — Outside electrical connector damaged. — Inside electrical connector, wiring harness or solenoid damaged. — Electrical short (pinched solenoid wire). — Solenoid not grounded. — Incorrect or damaged pressure switches. — Temperature switch damaged.
	• Converter (1)	— Internal damage.
	• Oil Pump Assembly (7)	— Converter clutch valve (227) stuck or assembled backwards. — Converter clutch valve retaining ring (225) mispositioned. — Pump to case gasket (9) mispositioned. — Orifice cup plug (240) restricted or damaged. — Solenoid "O" ring seal (49) cut or damaged. — High or uneven bolt torque (pump body to cover).
	• Input Housing and Shaft (621)	— Turbine shaft "O" ring seal (618) cut or damaged. — Turbine shaft retainer and ball assembly (617) restricted or damaged.
	• Valve Body Assembly (67)	— TCC shift valve stuck. — TCC apply valve stuck. — Solenoid o-ring leaking.
	• Solenoid Screen (47B)	— Blocked.

ALL ILLUSTRATION NUMBERS REFERENCE HYDRA-MATIC 4L60 UNIT REPAIR SECTION

LH0012-4L60-R1

Figure 12 Diagnosis Chart H

CONDITION	INSPECT COMPONENT	FOR CAUSE
CONVERTER SHUDDER	• Torque Converter Assembly (1)	— Internal damage.
	• Oil Pump Assembly (7)	— Converter clutch valve (227) stuck. — Restricted oil passage.
	• Oil Filter (71)	— Crack in filter body. — Flash restricting filter neck. — "O" ring seal (70) cut or damaged.
	• Miscellaneous	— Low oil pressure. — Engine not tuned properly.
	• Input Housing and Shaft Assembly (621)	— Turbine shaft "O" ring (618) cut or damaged. — Turbine shaft retainer and ball assembly (617) restricted or damaged.
NO CONVERTER CLUTCH RELEASE	• Solenoid	— External ground. — Clogged exhaust orifice.
	• Converter (1)	— Internal damage.
	• Valve Body Assembly (67)	— Converter clutch apply valve stuck in apply position.
	• Oil Pump Assembly (7)	— Converter clutch valve (227) stuck.
	• ECM	— External ground.
DRIVES IN NEUTRAL	• Forward Clutch	— Not releasing.
	• Manual Valve Link (705)	— Disconnected.
	• Case (10)	— Face not flat. — Internal leakage.
2ND GEAR START (DRIVE RANGE)	• Governor Assembly (45)	— Valve (107) stuck. — Governor support pin too long or missing.
	• Forward Clutch Sprag Assembly (642)	— Sprag assembly installed backwards.
NO PARK	• Parking Linkage (701-715)	— Actuator rod assembly (701) bent or damaged. — Actuator rod spring binding or improperly crimped. — Actuator rod not attached to inside detent lever (703). — Parking lock bracket (710) damaged or not torqued properly.

ALL ILLUSTRATION NUMBERS REFERENCE HYDRA-MATIC 4L60 UNIT REPAIR SECTION

LH0013-4L60-R1

Figure 13 Diagnosis Chart I

CONDITION	INSPECT COMPONENT	FOR CAUSE
NO PARK (Continued)	• Parking Linkage (Cont.)	— Inside detent lever (703) not torqued properly. — Detent roller and spring assembly (709) mispositioned or not torqued properly. — Parking pawl (711) binding or damaged.
RATCHETING NOISE	• Parking Pawl (711)	— Parking pawl return spring (714) weak, damaged or misassembled.
OIL OUT THE VENT	• Oil Pump (7) • Valve Body (67) • Miscellaneous	— Chamfer in pump body rotor pocket too large. — T.V. limit valve (332) stuck. — Fluid level - overfilled.
VIBRATION IN REVERSE AND WHINING NOISE IN PARK	• Oil Pump (7)	— Broken vane rings (212).
NO DRIVE IN ALL RANGES	• Torque Converter (1)	— Converter to flex plate bolts missing.
NO DRIVE IN DRIVE RANGE	• Torque Converter (1)	— Stator roller clutch not holding. — Converter not bolted to flex plate.
FRONT OIL LEAK	• Torque Converter (1) • Torque Converter Seal (2)	— Welded seam leaking. — Damaged converter hub. — Damaged seal assembly. — Missing garter spring.
DELAY IN DRIVE AND REVERSE	• Torque Converter (1)	— Converter drainback.

ALL ILLUSTRATION NUMBERS REFERENCE HYDRA-MATIC 4L60 UNIT REPAIR SECTION

LH0014-4L60-R1

Figure 14 Diagnosis Chart J

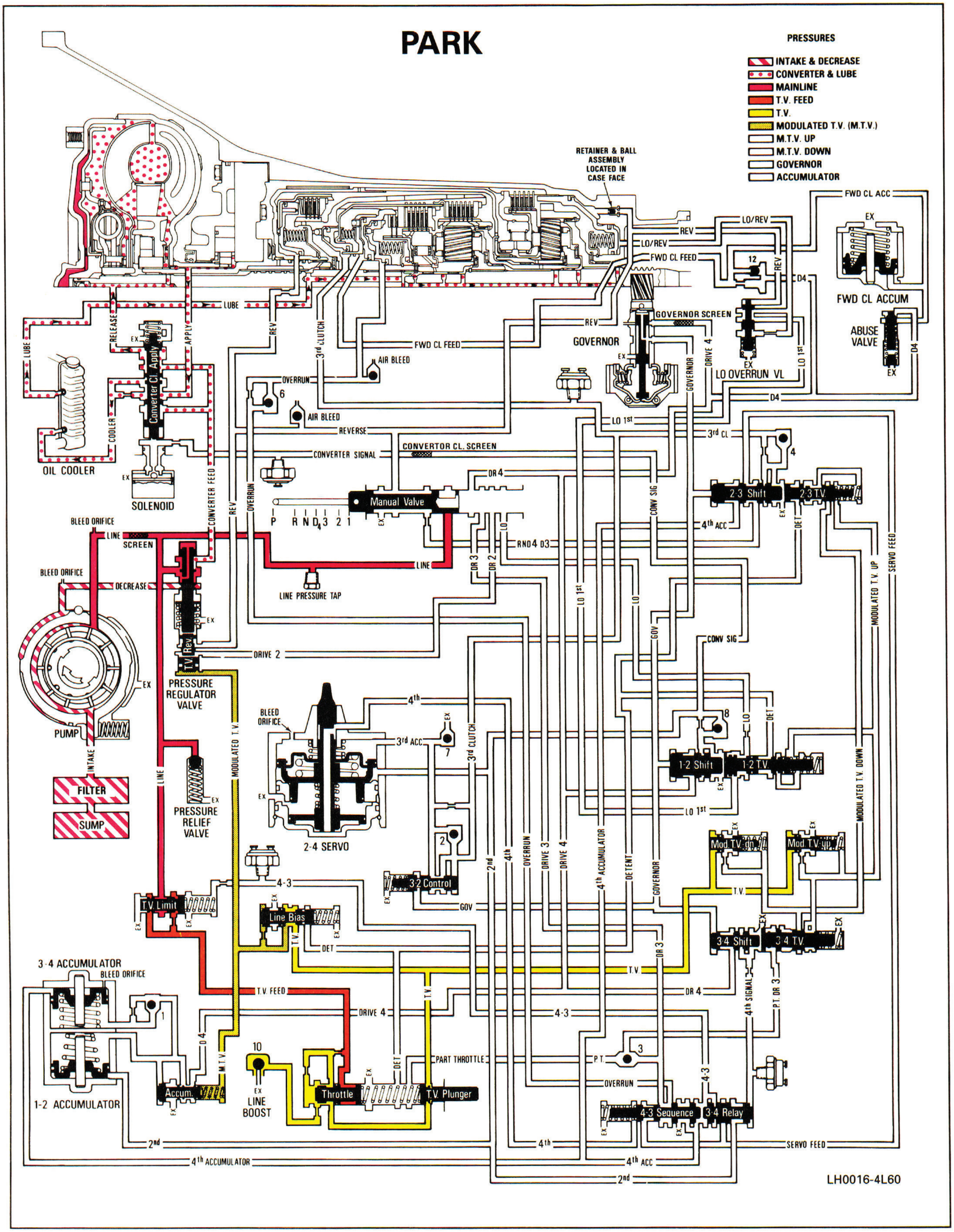


Figure 15 Park — Engine Running

PARK—ENGINE RUNNING

CONVERTER CLUTCH – RELEASED	3-4 CLUTCH – RELEASED	2-4 BAND – RELEASED
REVERSE INPUT CLUTCH – RELEASED	LO AND REVERSE CLUTCH – RELEASED	OVERRUN CLUTCH – RELEASED
FORWARD CLUTCH – RELEASED	LO ROLLER CLUTCH – NOT HOLDING	FORWARD SPRAG CLUTCH – NOT HOLDING

With the selector lever in the Park (P) position, oil from the pump is directed to the following:

1. Pressure Regulator Valve
2. Release Side of the Converter and the Lubrication System
3. Decrease Side of the Pump Slide
4. Manual Valve
5. T.V. System (Limit Valve, Throttle Valve, Line Bias Valve, M.T.V. Up Valve and M.T.V. Down Valve)
6. Pressure Relief Valve
7. Line Pressure Tap

Oil flows from the pump to the pressure regulator valve which regulates the pump pressure. When the pump output exceeds the demand of line pressure, oil from the pressure regulator valve is directed to the converter clutch apply valve. The converter clutch apply valve directs oil to the release side of the converter clutch. Converter return oil is directed to the transmission cooler by the converter clutch apply valve. Oil from the cooler is directed to the transmission lubrication system.

Oil is also directed from the pressure regulator valve to the pump slide to decrease pump output in relation to the combined pressure of M.T.V. oil and regulator valve spring force. Line pressure acts on the pressure relief valve which will exhaust any oil above 2,240 to 2,520 kPa (320 to 360 psi).

Line pressure at the manual valve is available for use in other drive ranges.

Line pressure at the T.V. limit valve is limited to 620 kPa (90 psi). This limited pressure is directed to the throttle valve where it is regulated to a variable pressure called throttle valve (T.V.) pressure. T.V. pressure increases with carburetor opening and is directed to the line bias, M.T.V. up and M.T.V. down valves.

At the line bias valve, T.V. pressure is modulated to M.T.V. pressure. M.T.V. pressure helps to control line pressure at the pressure regulator valve and accumulator pressure at the accumulator valve.

T.V. pressure at the M.T.V. up valve and M.T.V. down valve is available for use when accelerating in other ranges.

SUMMARY

The converter is filled from the release side; all clutches and the band are released. The manual linkage has the parking pawl engaged in the reaction internal gear lugs. At idle, there is not sufficient T.V. pressure to open the M.T.V. up or M.T.V. down valves.

LH0017-4L60

Figure 16 Park — Engine Running — Legend

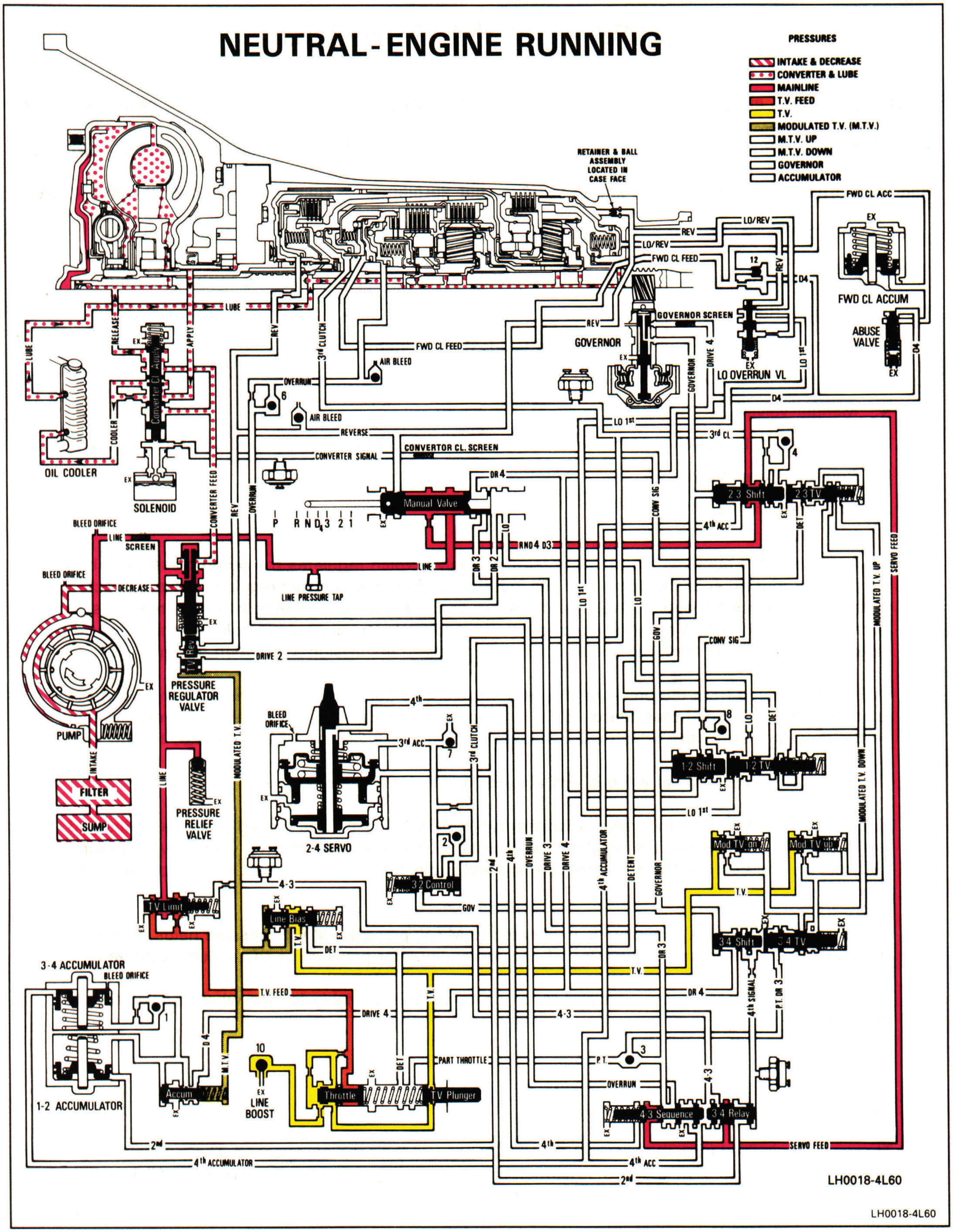


Figure 17 Neutral — Engine Running

NEUTRAL—ENGINE RUNNING

CONVERTER CLUTCH – RELEASED

3-4 CLUTCH – RELEASED

2-4 BAND – RELEASED

REVERSE INPUT CLUTCH – RELEASED

LO AND REVERSE CLUTCH – RELEASED

OVERRUN CLUTCH – RELEASED

FORWARD CLUTCH – RELEASED

LO ROLLER CLUTCH – NOT HOLDING

FORWARD SPRAG CLUTCH – NOT HOLDING

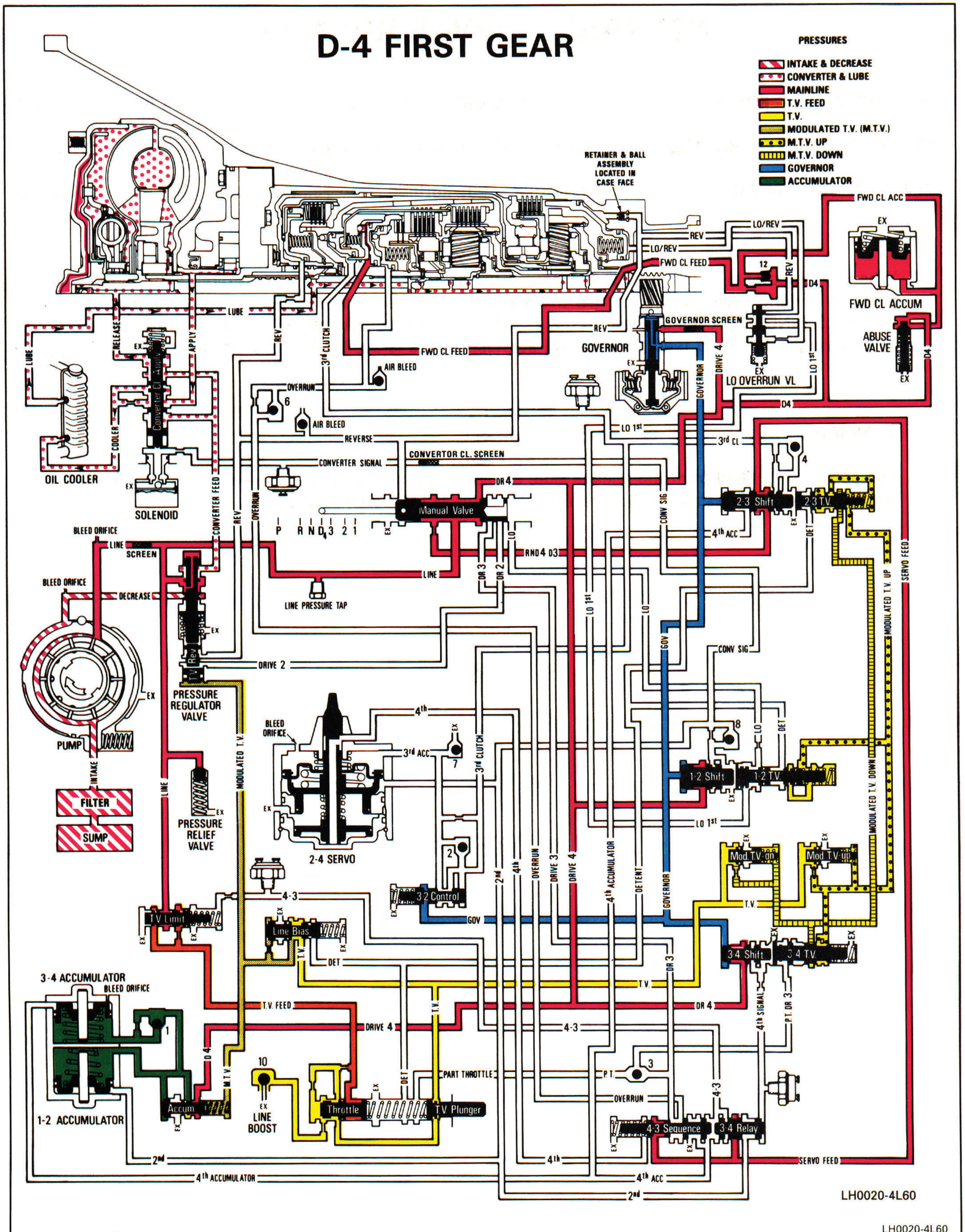
When the selector lever is moved to the Neutral (N) position, the line pressure is directed to the same areas as in Park, except in Neutral (N) the manual valve directs oil into the Reverse, Neutral, Drive 4, Drive 3 (RND4D3) oil is directed to the 2-3 shift valve which directs RND4D3 oil to the 3-4 relay valve through the servo feed passage. Oil at these valves is available for use in other ranges.

SUMMARY

The converter is filled from the release side; all clutches and the band are released. At idle, there is not sufficient T.V. pressure to open the M.T.V. up or M.T.V. down valves.

LH0019-4L60

Figure 18 Neutral — Engine Running — Legend



LH0020-4L60

Figure 19 D4 — First Gear

D-4—FIRST GEAR

FORWARD CLUTCH – APPLIED **LO ROLLER CLUTCH – HOLDING** **FORWARD SPRAG CLUTCH – HOLDING**

When the selector lever is moved to the Drive (D) position, the manual valve is repositioned to allow line pressure to enter the Drive 4 (D4) passage. Drive 4 oil then flows to the following:

1. Forward Clutch Accumulator, Forward Clutch and Abuse Valve
2. Governor Valve
3. 1-2 Shift Valve
4. Accumulator Valve
5. 3-4 Shift Valve

BASIC CONTROL

Drive 4 oil is directed to the forward clutch accumulator where the #12 checkball seats, routing forward clutch feed through an orifice. This combines with the forward clutch accumulator to cushion the forward clutch apply.

During "Rock Cycle" conditions (stuck in mud or snow and "Rocking" out), an abuse valve routes D4 oil to forward clutch feed oil to quicken the apply of the forward clutch.

Drive 4 oil is directed to the 1-2 and 3-4 shift valves. Drive 4 oil is directed to the accumulator valve and is regulated to a pressure called accumulator pressure; this pressure is directed to the 1-2 and 3-4 accumulator pistons to act as a cushion for the band apply in second gear and overdrive.

Drive 4 oil is orificed into the governor passage, and is regulated to a variable pressure called governor pressure. Governor pressure increases with vehicle speed and acts against the 1-2, 2-3, 3-4, and the 3-2 control valve springs.

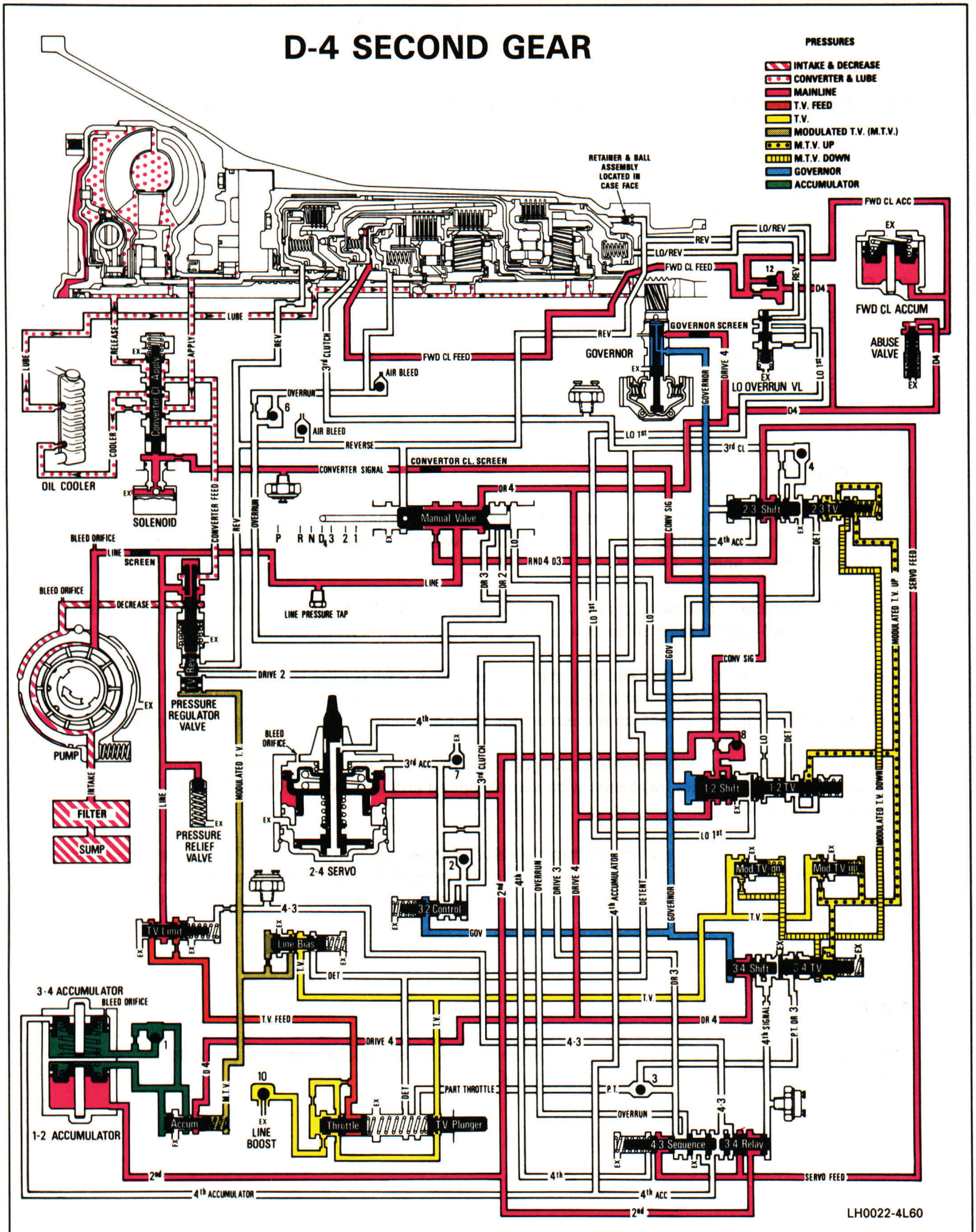
In first gear, there could be sufficient throttle valve plunger travel to increase T.V. pressure enough to open the M.T.V. up and the M.T.V. down valves. In first gear, M.T.V. up exerts pressure against governor pressure at the 1-2, 2-3, and 3-4 valves. M.T.V. down pressure is stopped by a land at the 2-3 and 3-4 throttle valves.

SUMMARY

The converter clutch is released, the forward sprag clutch is holding, the forward clutch is applied; the transmission is in Drive (D) Range — First Gear.

LHO021-4L60

Figure 20 D4 — First Gear — Legend



LH0022-4L60

Figure 21 D4 — Second Gear

D-4—SECOND GEAR

2-4 BAND – APPLIED **FORWARD SPRAG CLUTCH – HOLDING** **FORWARD CLUTCH – APPLIED**

As both vehicle speed and governor pressure increase, the force of the governor oil acting on the 1-2 shift valve overcomes the pressure of M.T.V. up oil and the force of the 1-2 throttle valve spring. This allows the 1-2 shift valve to open and Drive 4 (D4) oil to enter the second (2nd) oil passage. This oil is called second (2nd) oil. Second oil from the 1-2 shift valve is directed to the following:

1. 1-2 Shift Checkball (8)
2. 2-4 Servo
3. 1-2 Accumulator Piston
4. Solenoid Assembly (Converter Clutch)
5. 3-4 Relay Valve

BASIC CONTROL

Second oil from the 1-2 shift valve will seat the 1-2 shift checkball (8) forcing 2nd oil through an orifice. Second oil is then directed to the 2-4 servo to apply the 2-4 band. At the same time, 2nd oil moves the 1-2 accumulator piston against accumulator pressure and the accumulator spring to maintain a controlled build-up of pressure on the servo during the 1-2 shift for a smooth band apply. 2nd oil at the 3-4 relay valve is available for use in other ranges.

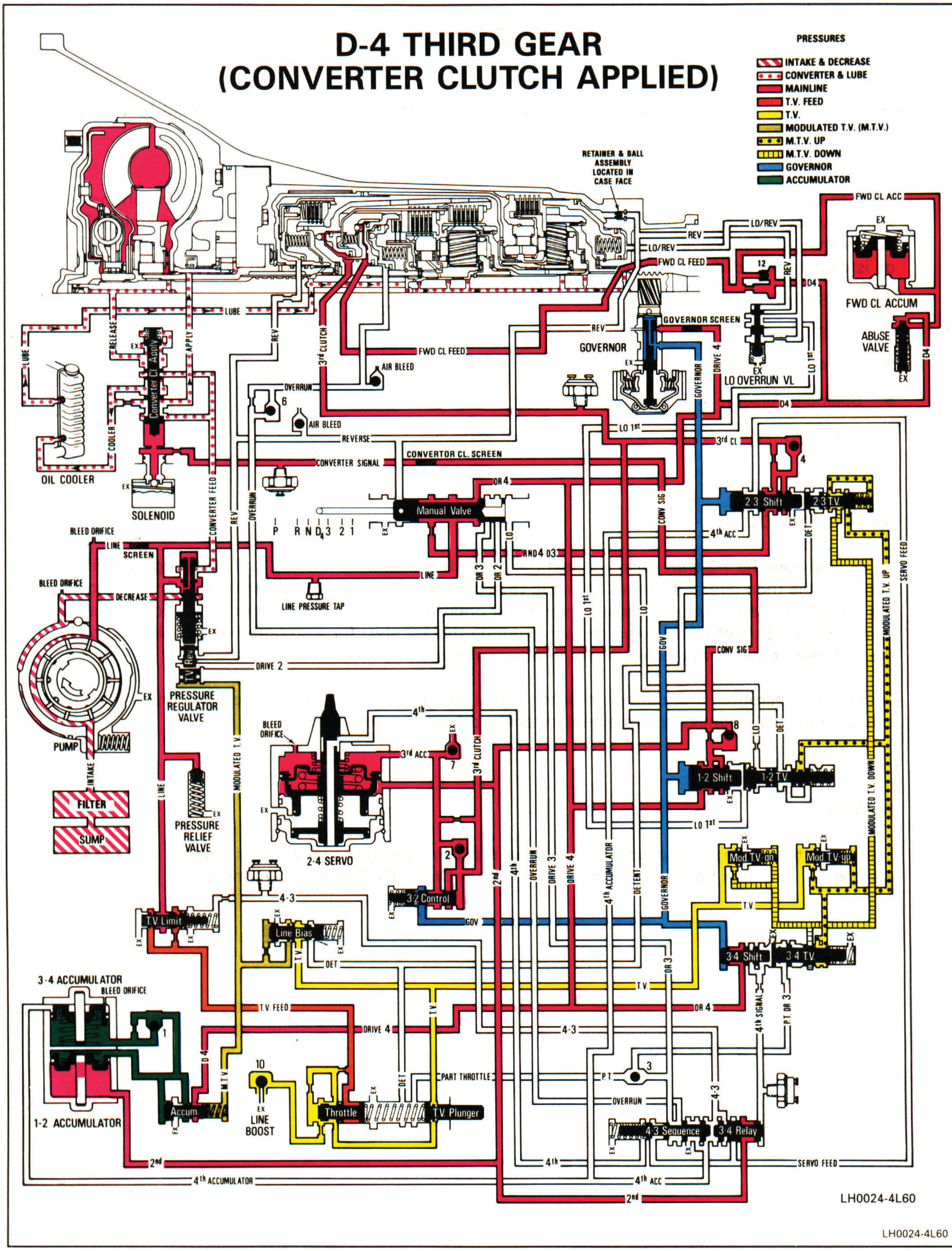
Second oil is rerouted into converter clutch signal oil above the 1-2 shift valve. Converter signal oil exhausts at this solenoid until a signal is received from the vehicles E.C.M.

SUMMARY

The converter clutch is released, the 2-4 band is applied, the forward clutch is applied, and the forward sprag clutch is holding; the transmission is in Drive (D) Range — Second Gear.

LH0023-4L60

Figure 22 D4 — Second Gear — Legend



LH0024-4L60

Figure 23 D4 — Third Gear — Converter Clutch Applied

D-4—THIRD GEAR

(Converter Clutch Applied)

CONVERTER CLUTCH – APPLIED

FORWARD CLUTCH – APPLIED

FORWARD SPRAG CLUTCH – HOLDING

3-4 CLUTCH – APPLIED

As both vehicle speed and governor pressure increase, the force of governor oil acting on the 2-3 shift valve overcomes the force of the 2-3 T.V. spring and M.T.V. up oil. This allows the 2-3 shift valve to open and allows RND4D3 oil to enter the 3rd clutch passage.

Third clutch oil from the 2-3 shift valve is directed to the following:

1. 3-2 Exhaust Checkball (4)
2. 3-4 Clutch Piston
3. Third Clutch Accumulator Checkball (2)
4. Third Accumulator Exhaust Checkball (7)
5. 2-4 Servo (Release Side)
6. 3-2 Control Valve

BASIC CONTROL

Third clutch oil from the 2-3 shift valve flows past the 3-2 exhaust checkball (4), to the 3-4 clutch piston. At the same time, third clutch oil is directed past the third clutch accumulator checkball (2), seats the third accumulator exhaust check ball (7), and then into the release side of the 2-4 servo. This third clutch accumulator pressure combined with the servo cushion spring, moves the second apply piston, in the 2-4 servo, against second oil and acts as an accumulator for a smooth 2-4 band release and 3-4 clutch apply.

Third clutch oil is present at the 3-2 control valve in preparation of a third gear to second gear shift.

Once the solenoid receives a signal from the vehicles controls and solenoid is on, converter clutch signal oil will shift the converter clutch apply valve, and redirect converter feed oil into the apply passage. The apply oil flows between the stator shaft and converter hub to charge the converter with oil and push the converter pressure plate against the converter cover, causing a mechanical link between the engine and the turbine shaft. The rate of apply is controlled by the orifice checkball capsule in the end of the turbine shaft.

At the same time the converter clutch apply valve will direct converter feed oil through an orifice to the transmission cooler. Cooler oil is directed to the transmission lubrication system.

SUMMARY

The converter clutch is applied*, the forward clutch is applied, the forward sprag clutch is holding, the 3-4 clutch is applied and the 2-4 band is released; the transmission is in Drive (D) Range — Third Gear (direct drive).

*The converter clutch may or may not be applied, depending on shift calibration and solenoid operation.

LH0025-4L60

Figure 24 D4 — Third Gear — Converter Clutch Applied — Legend

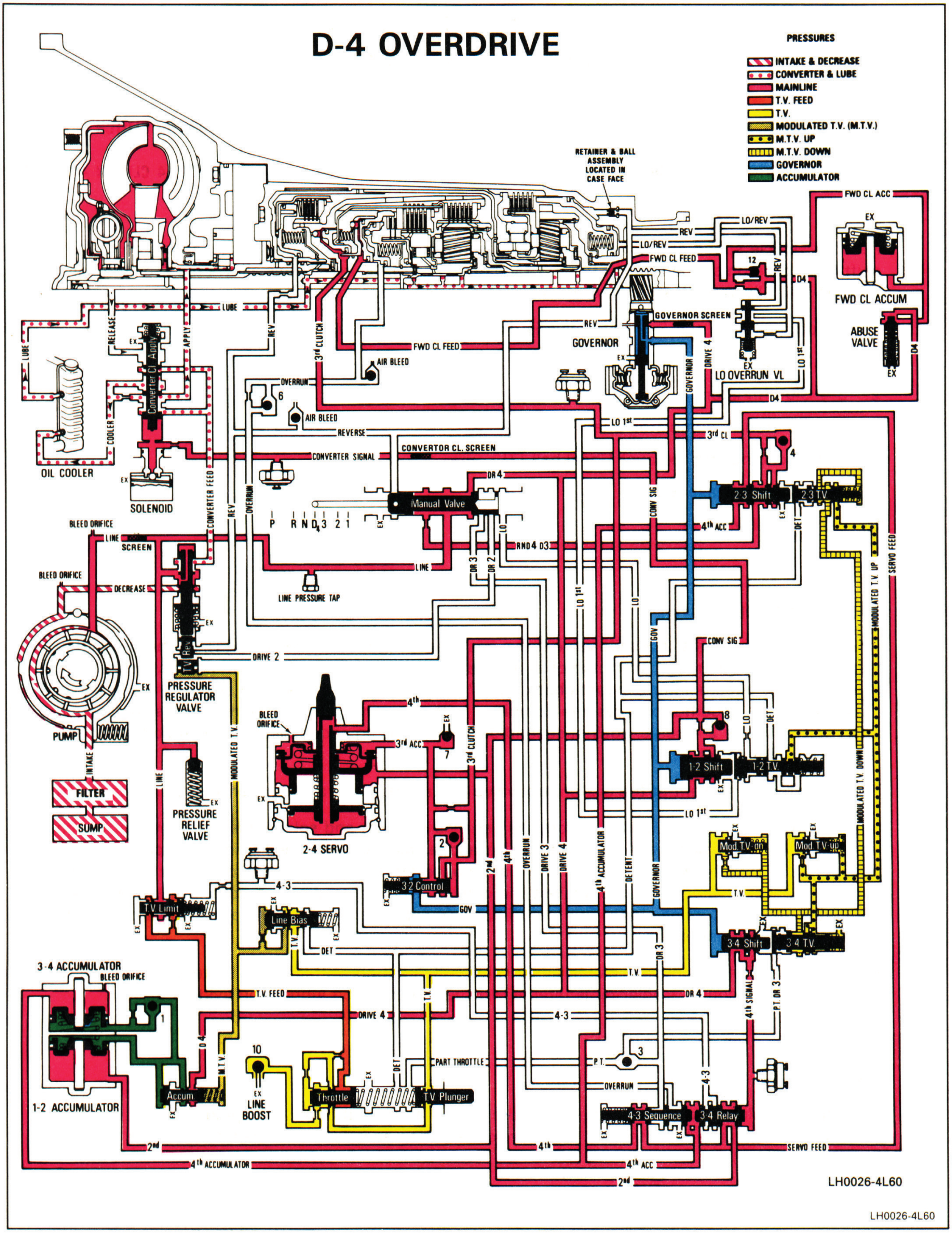


Figure 25 D4 — Overdrive

D-4—OVERDRIVE

CONVERTER CLUTCH – APPLIED **3-4 CLUTCH – APPLIED** **2-4 BAND – APPLIED**
FORWARD CLUTCH – APPLIED **FORWARD SPRAG CLUTCH – NOT HOLDING**

As both vehicle speed and governor pressure increase, the force of governor oil acting on the 3-4 shift valve overcomes the force of the 3-4 T.V. spring and M.T.V. up oil. This opens the 3-4 shift valve sending Drive 4 (D4) into the fourth signal passage. Fourth signal oil will overcome the 4-3 sequence valve spring and open the 3-4 relay and the 4-3 sequence valves, allowing second oil to enter the servo feed passage.

Servo feed oil is directed to the following:

1. 2-3 Shift Valve
   a. Which directs oil to the:
      1) 3-4 Accumulator
      2) 4-3 Sequence Valve
2. 4-3 Sequence Valve
   a. Which directs oil to the:
      1) 4th Apply Piston (in the 2-4 servo)

BASIC CONTROL

Servo feed oil passes through the 4-3 sequence valve and becomes fourth oil. Fourth oil then enters the 2-4 servo, applies pressure on the fourth apply piston, and applies the 2-4 band.

SUMMARY

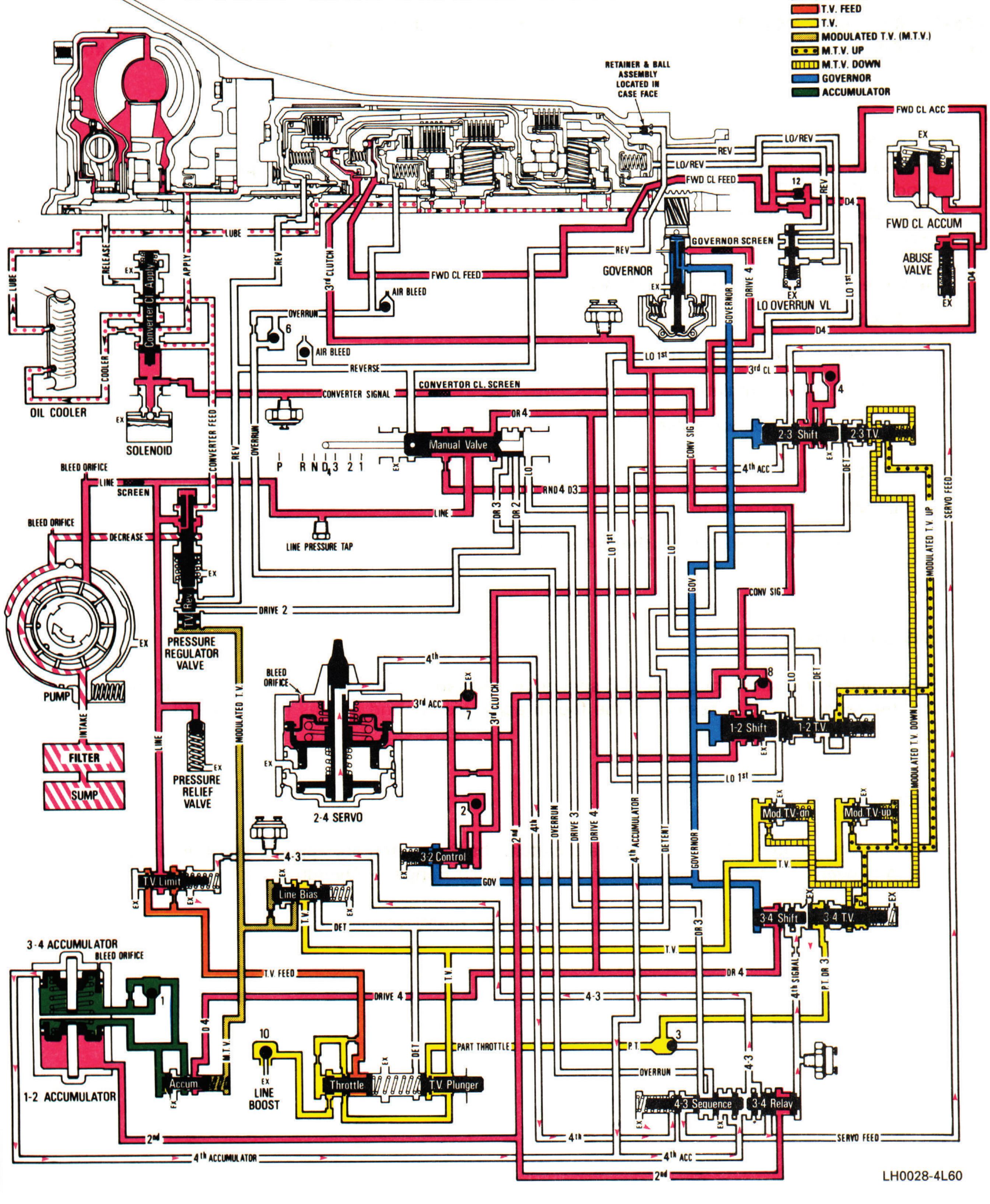
The converter clutch*, 2-4 band, forward clutch, the 3-4 clutch are applied, and the forward sprag clutch is overrunning; the transmission is in Drive (D) Range — Overdrive.

*The converter clutch may or may not be applied, depending on solenoid operation.

LH0027-4L60

Figure 26 D4 — Overdrive — Legend

PART THROTTLE 4-3 AND MODULATED DOWNSHIFTS



LH0028-4L60

Figure 27 Part Throttle 4-3 and Modulated Downshifts

PART THROTTLE 4-3 AND MODULATED DOWNSHIFTS

(Valves In Third Gear Position)

CONVERTER CLUTCH – APPLIED*
FORWARD SPRAG CLUTCH – HOLDING

FORWARD CLUTCH – APPLIED
3-4 CLUTCH – APPLIED

A part throttle 4-3 downshift can be accomplished by depressing the accelerator pedal far enough to move the throttle valve (T.V.) plunger to allow the T.V. oil to enter the part throttle (P.T.) passage. This oil, called part throttle (P.T.) oil, is then routed to the 3-4 throttle valve.

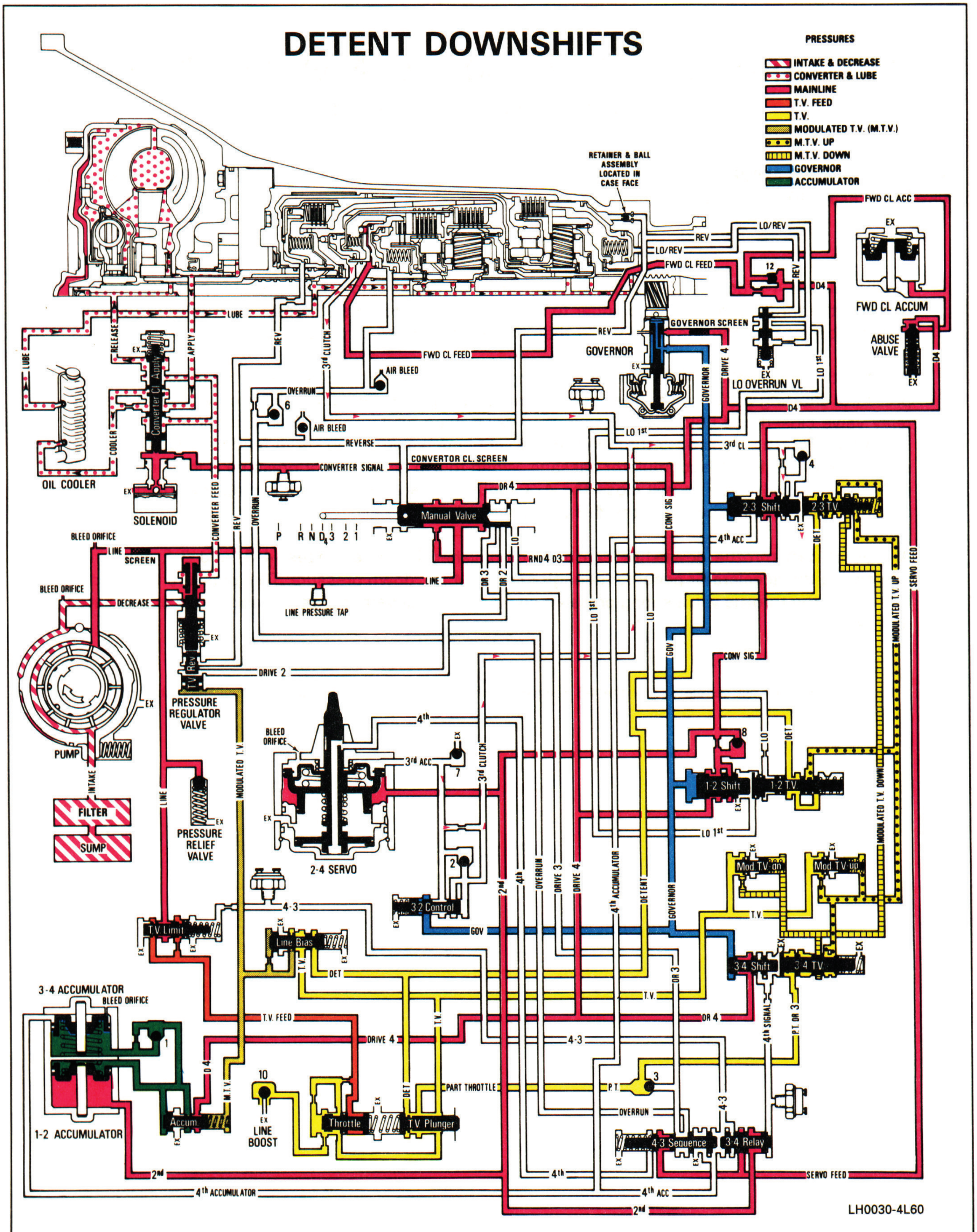
Part throttle oil and the 3-4 throttle valve spring force will close the 3-4 shift valve against governor pressure, shutting off D4 oil to the fourth signal passage. Fourth accumulator oil will push the 3-4 relay valve closed and hold the 4-3 sequence valve open while it exhausts at an orifice at the T.V. limit valve. Fourth oil will pass through the 4-3 sequence valve to the servo feed passage to the 2-3 shift valve to the fourth accumulator passage. When fourth accumulator pressure is low enough, the 4-3 sequence valve spring will close the 4-3 sequence valve and the remaining fourth and fourth accumulator oil will exhaust at the 4-3 sequence valve.

A type of part throttle downshift can be accomplished in some ranges (4-3, and 3-2, shifts) by depressing the accelerator pedal far enough to raise M.T.V. down pressure. This pressure when combined with the throttle valve spring pressure can overcome governor pressure and cause a modulated downshift.

*The converter clutch will be released for the 4-3 downshift and may or may not be reapplied depending on shift calibration and solenoid operation.

LHOO29-4L60

Figure 28 Part Throttle 4-3 and Modulated Downshifts — Legend



LH0030-4L60

Figure 29 Detent Downshifts

DETENT DOWNSHIFTS

(Valves In Second Gear Position)

CONVERTER CLUTCH – RELEASED

2-4 BAND – APPLIED

FORWARD CLUTCH – APPLIED

FORWARD SPRAG CLUTCH – HOLDING

While operating at speeds below approximately 60 mph (96 km/h), a forced or detent 3-2 downshift is possible by depressing the accelerator pedal fully. This will position the throttle valve (T.V.) plunger to allow T.V. oil to enter the detent passage. This oil, called detent oil, is then routed to the following:

1. Line Bias Valve
2. 2-3 Throttle Valve
3. 1-2 Throttle Valve
4. Converter Clutch Throttle Valve (Non E.C.M. Controlled Vehicles Only)

Detent oil from the T.V. plunger flows to the line bias valve to boost modulated T.V. (M.T.V.) pressure. M.T.V. oil acting on the T.V. boost valve will boost line pressure approximately 70 kPa (10 psi).

The E.C.M. will discontinue the signal provided to the solenoid to release the converter clutch.

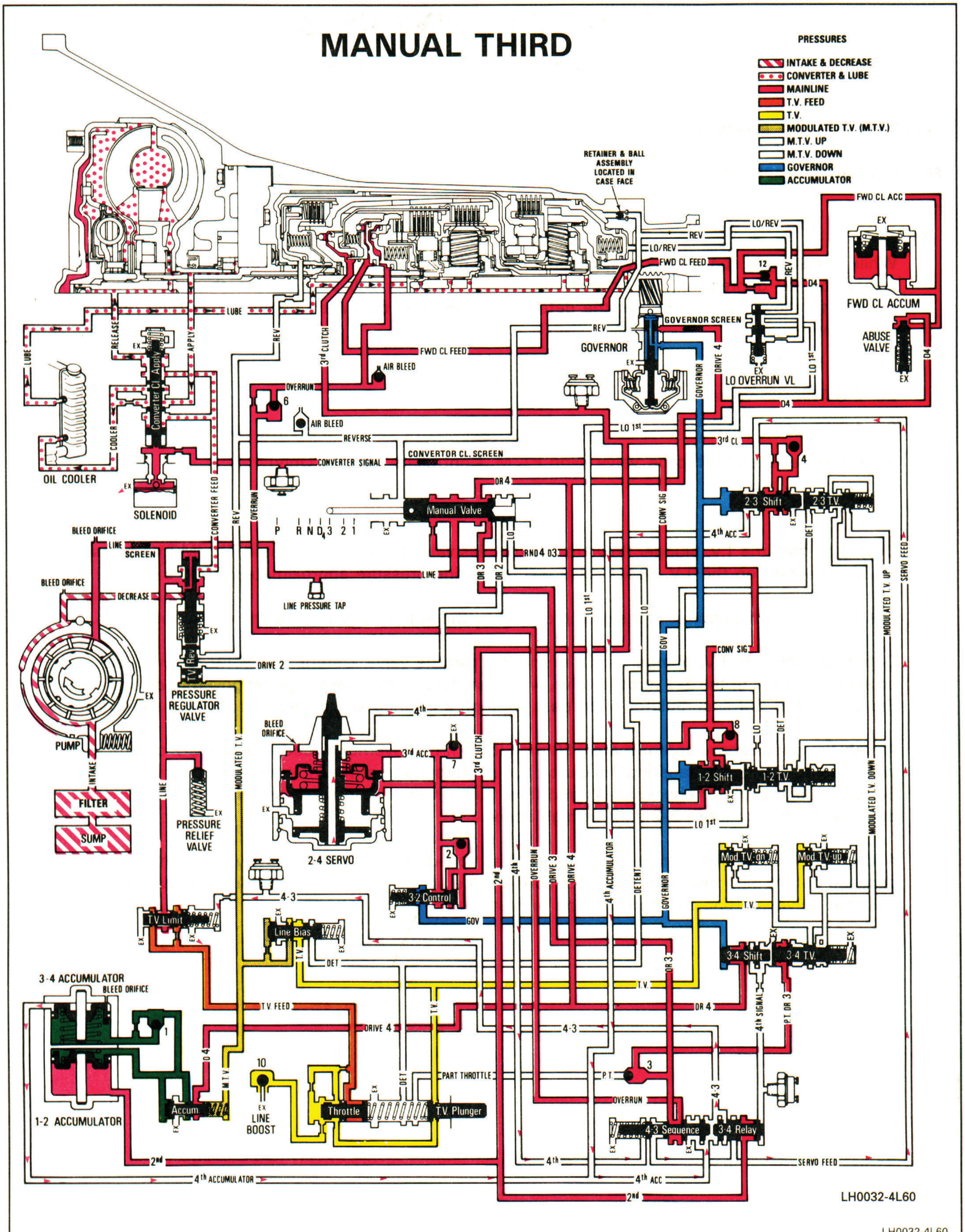
Detent oil from the T.V. plunger flows to the 2-3 throttle valve. Detent and M.T.V. down oil, acting on separate areas of the 2-3 throttle valve, will close the 2-3 shift valve against governor oil and allow 3rd clutch and 3rd accumulator oil to pass through an orifice and exhaust at the 2-3 shift valve.

At vehicle speeds above approximately 50 mph (80 km/h), governor oil acting on the 3-2 control valve will close it. Now the exhausting 3rd clutch accumulator oil from the intermediate servo will seat the 3rd clutch accumulator checkball (2) and flow through another orifice controlling the intermediate band apply for a smooth 3-2 shift at high speed.

A detent 2-1 downshift can be accomplished at speeds below approximately 30 mph (48 km/h), because detent oil pressure and the 1-2 spring force acting on the 1-2 throttle valve will close the 1-2 shift valve, shifting the transmission to first gear.

LH0031-4L60

Figure 30 Detent Downshifts – Legend



LH0032-4L60

Figure 31 Manual Third

MANUAL THIRD

CONVERTER CLUTCH – RELEASED*

OVERRUN CLUTCH – APPLIED

FORWARD CLUTCH – APPLIED

3-4 CLUTCH – APPLIED

A forced 4-3 downshift can be accomplished by moving the selector lever from Drive (D) Range to Third (3rd) Gear. When the selector lever is moved to the Third (3rd) Gear position, D3 oil from the manual valve is directed to the following:

1. 4-3 Sequence Valve
2. Part Throttle and Drive 3 (D3) Checkball (3)
3. 3-4 Shift Valve

D3 oil will close the 3-4 shift valve and allow the 4th signal oil to exhaust.

D3 oil combined with the 4-3 sequence valve spring force will close the 4-3 sequence valve to allow the fourth and fourth accumulator oil to exhaust and release the band. D3 oil then flows into the overrun clutch passage where it applies the overrun clutch to keep the forward sprag clutch from overrunning when engine braking is needed.

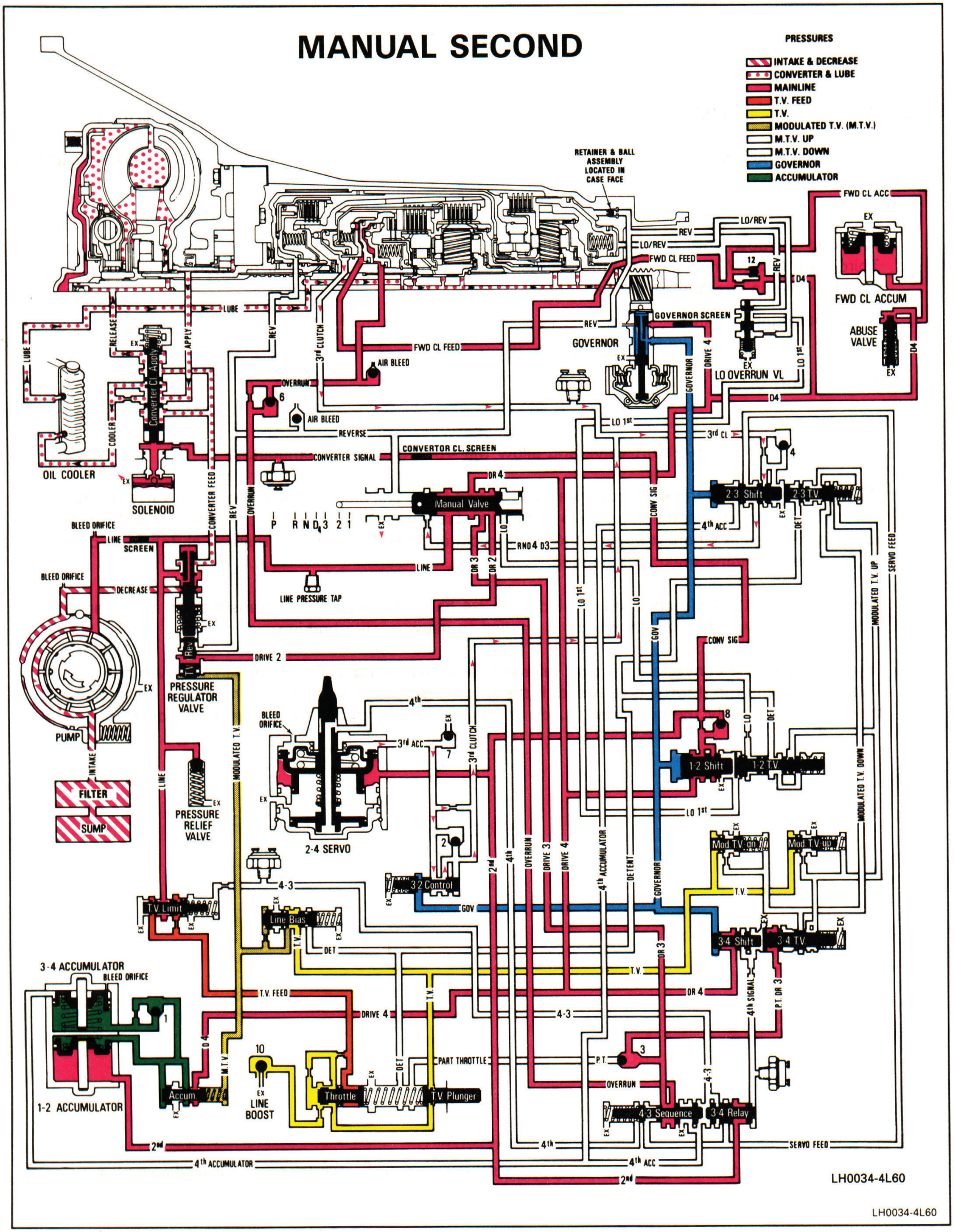
The forward and 3-4 clutches are applied. The 2-4 band is released. The transmission is in Manual Third, direct drive. The overrun clutch is applied to allow engine braking.

In manual 3rd, the converter is shown released, and there is no M.T.V. up or M.T.V. down pressure. This is assuming the throttle is released. If the throttle is opened sufficiently, the E.C.M. could signal the solenoid to apply the converter clutch and the M.T.V. up and M.T.V. down valves could open.

*The converter clutch may or may not be applied, depending on shift calibration and solenoid operation.

LH0033-4L60

Figure 32 Manual Third – Legend



LH0034-4L60

Figure 33 Manual Second

MANUAL SECOND

CONVERTER CLUTCH – RELEASED*

OVERRUN CLUTCH – APPLIED

2-4 BAND – APPLIED

FORWARD CLUTCH – APPLIED

A forced 3-2 downshift can be accomplished by moving the selector lever from Third (3rd) Gear to Second (2nd) Gear position.

When the selector lever is moved to the Second (2nd) Gear position, RND4D3, 3rd clutch, and 3rd accumulator oil will exhaust at the manual valve. With no pressure to apply the 3-4 clutch, or release the 2-4 band, the transmission will shift to second gear.

The manual valve will also direct line pressure into the D2 passage. Drive 2 (D2) oil will act on the reverse boost valve to boost line pressure to 1206 kPa (175 psi) which is required to prevent the 2-4 band and forward clutch from slipping.

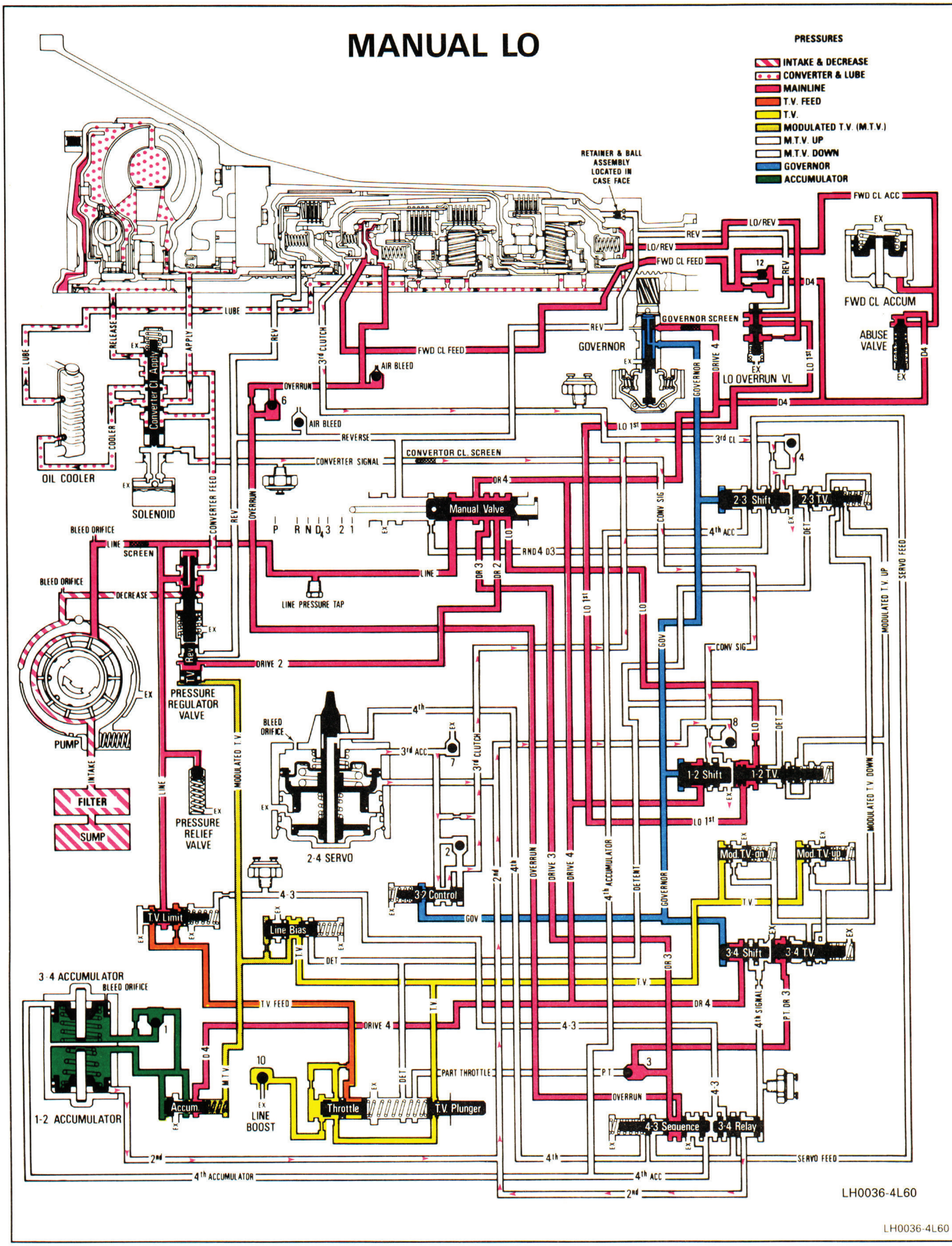
SUMMARY

The forward clutch and 2-4 band are applied. The transmission is in second gear. Also, the overrun clutch is still applied to allow engine braking when needed.

*The converter clutch may or may not be applied, depending on shift calibration and solenoid operation.

LH0035-4L60

Figure 34 Manual Second — Legend



LH0036-4L60

Figure 35 Manual Lo

MANUAL LO

CONVERTER CLUTCH – RELEASED

OVERRUN CLUTCH – APPLIED

FORWARD CLUTCH – APPLIED

LO ROLLER CLUTCH – APPLIED

Maximum downhill braking can be obtained at speeds below 30 mph (48 km/h) with the selector in Lo (1st) range. Lo/1st oil pressure, which is 1206 kPa (175 psi), is the same as second (2nd) oil pressure because second (D2) oil is still present.

Lo oil from the manual valve is directed to the following:

1. 1-2 Shift Valve Train
2. Lo and Reverse Clutch
3. Lo Overrun Valve

Lo oil at the 1-2 T.V. valve combined with the 1-2 throttle valve spring force will close the 1-2 shift valve at speeds approximately 35 mph (56 km/h) or below. This allows 2nd oil to exhaust, releasing the 2-4 band, and lo oil to apply the lo and reverse clutch.

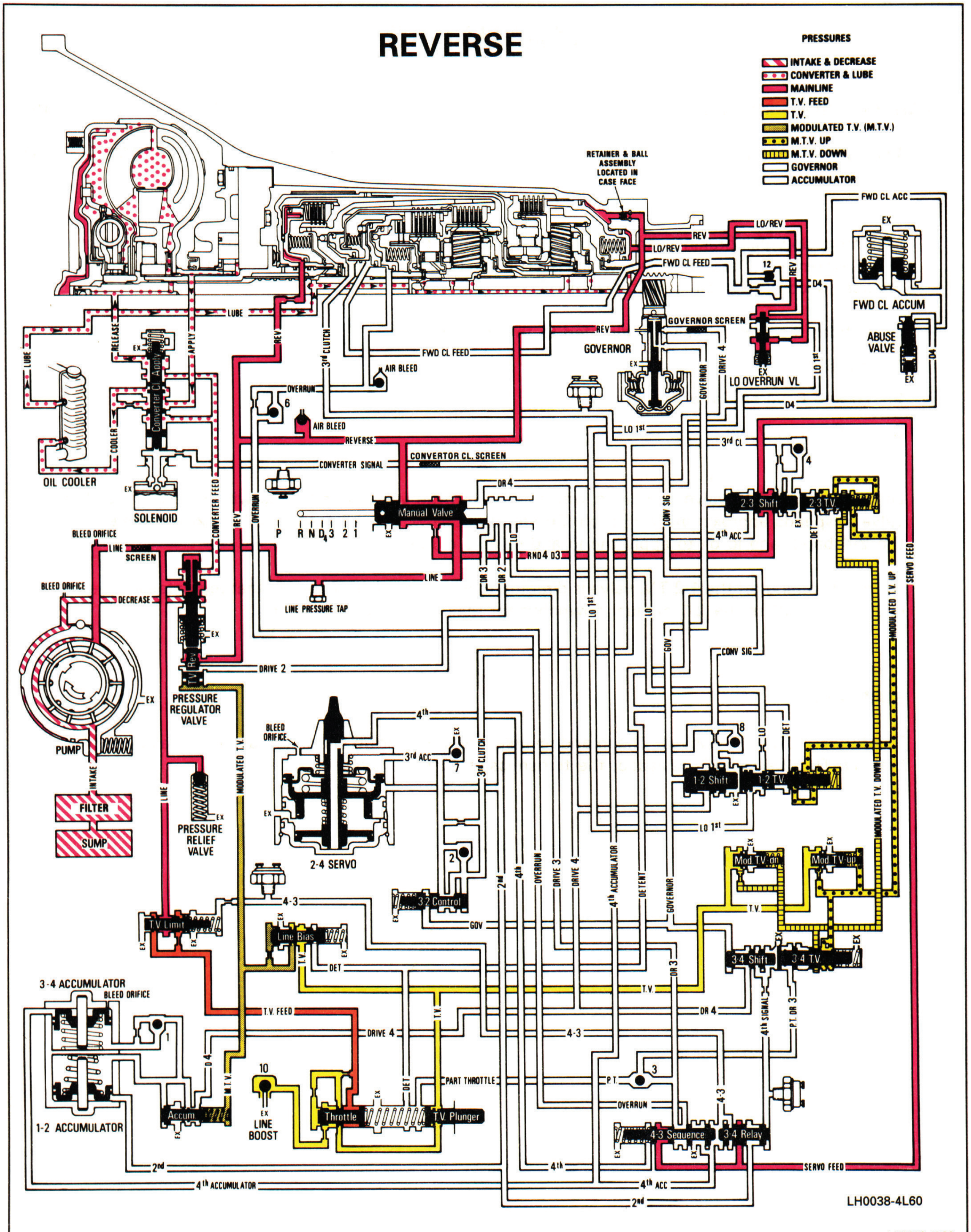
Lo/1st oil coming off the 1-2 T.V. valve is directed toward the lo overrun valve that regulates lo/reverse oil. This smoothes the 2-1 manual downshift for maximum engine braking.

SUMMARY

The forward clutch is applied. The lo and reverse, and the overrun clutch are applied to allow engine braking. The 2-4 band is released, the transmission is in Lo Range — First Gear.

LH0037-4L60

Figure 36 Manual Lo — Legend



LH0038-4L60

Figure 37 Reverse

REVERSE

REVERSE INPUT CLUTCH – APPLIED

LO AND REVERSE CLUTCH – APPLIED

When the selector lever is moved to the Reverse (R) position, the manual valve is repositioned to allow line pressure to enter the reverse passage which directs oil to the following:

1. Lo and Reverse Clutch
2. Reverse Input Clutch
3. Reverse Boost Valve
4. Lo Overrun Valve

Reverse oil is orificed at the retainer and ball assembly, and regulated at the lo overrun valve to apply the lo and reverse clutch.

Reverse oil is orificed into the reverse input clutch and orificed out of the reverse input piston for a smooth apply of the reverse input clutch during the shift.

Reverse oil acting on the reverse boost valve in the pressure regulator will boost line pressure to approximately 670 kPa (100 psi). M.T.V. oil from the line bias valve acting on the T.V. boost valve, in the pressure regulator, will further boost line pressure from 670 kPa (100 psi) at idle to 1690 kPa (245 psi) at full throttle.

SUMMARY

The reverse input clutch is applied. The lo and reverse clutch is applied. The transmission is in Reverse (R).

LH0039-4L60

Figure 38 Reverse – Legend

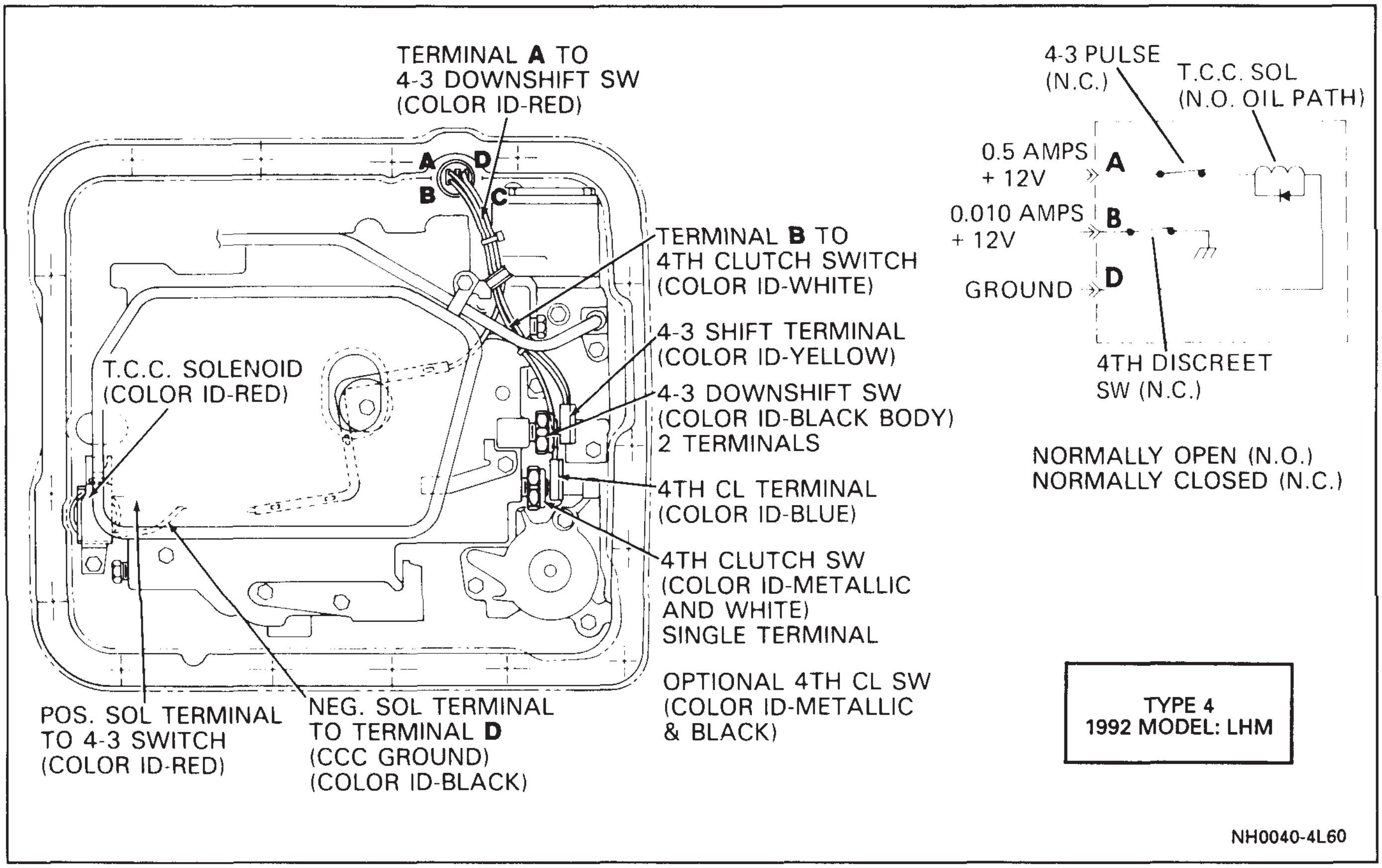


Figure 39 Wiring Diagram — Type 4

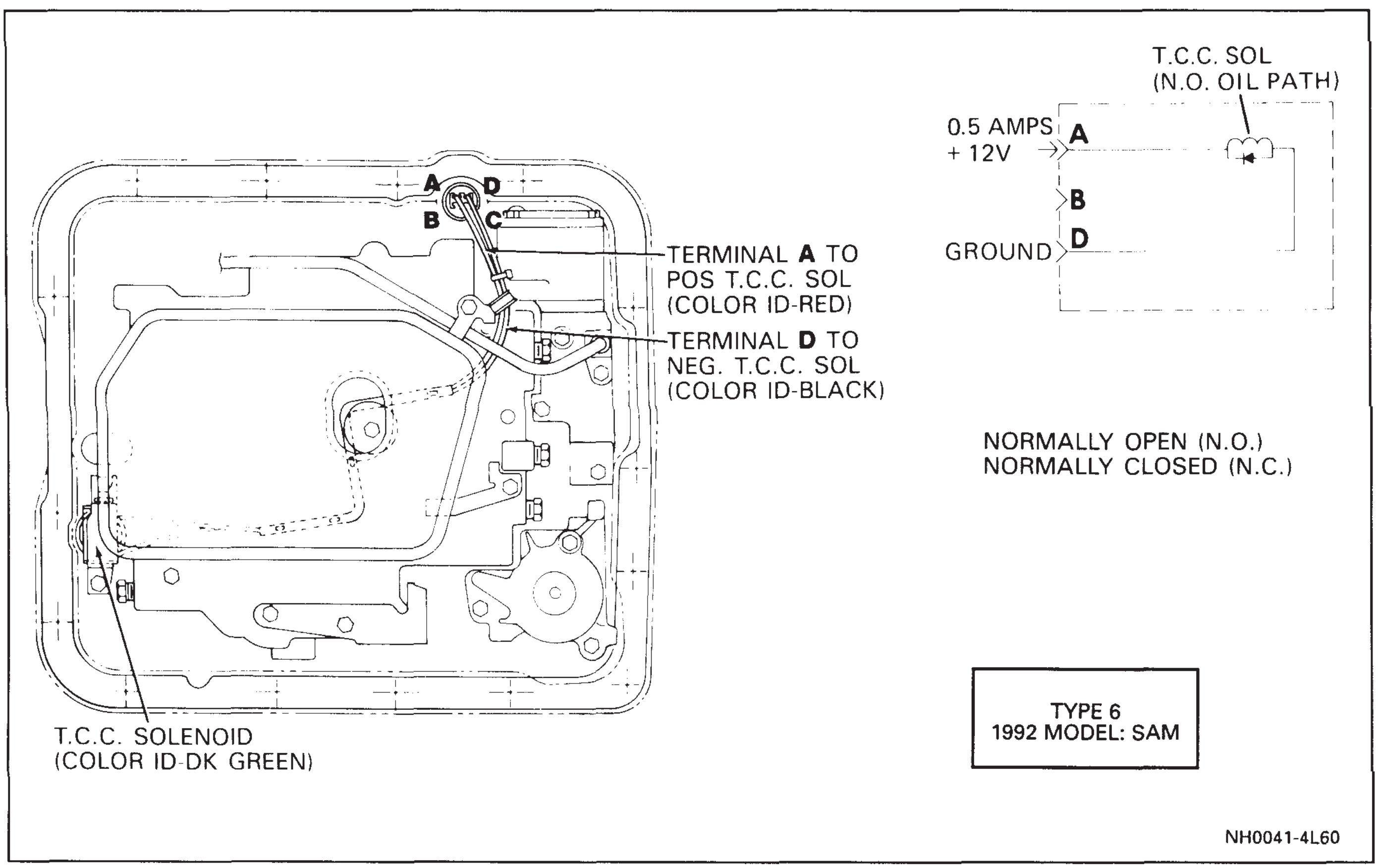


Figure 40 Wiring Diagram — Type 6

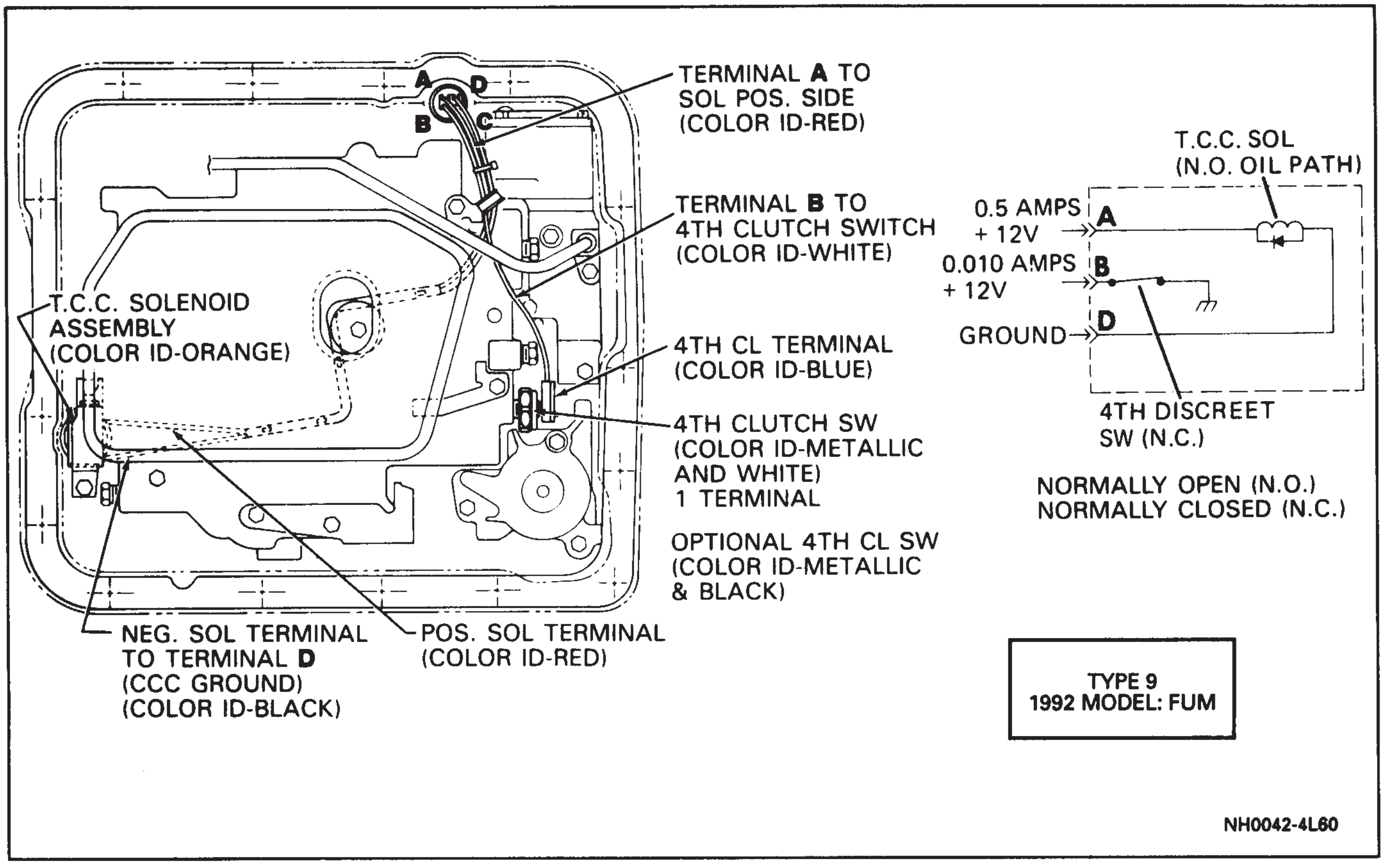


Figure 41 Wiring Diagram — Type 9

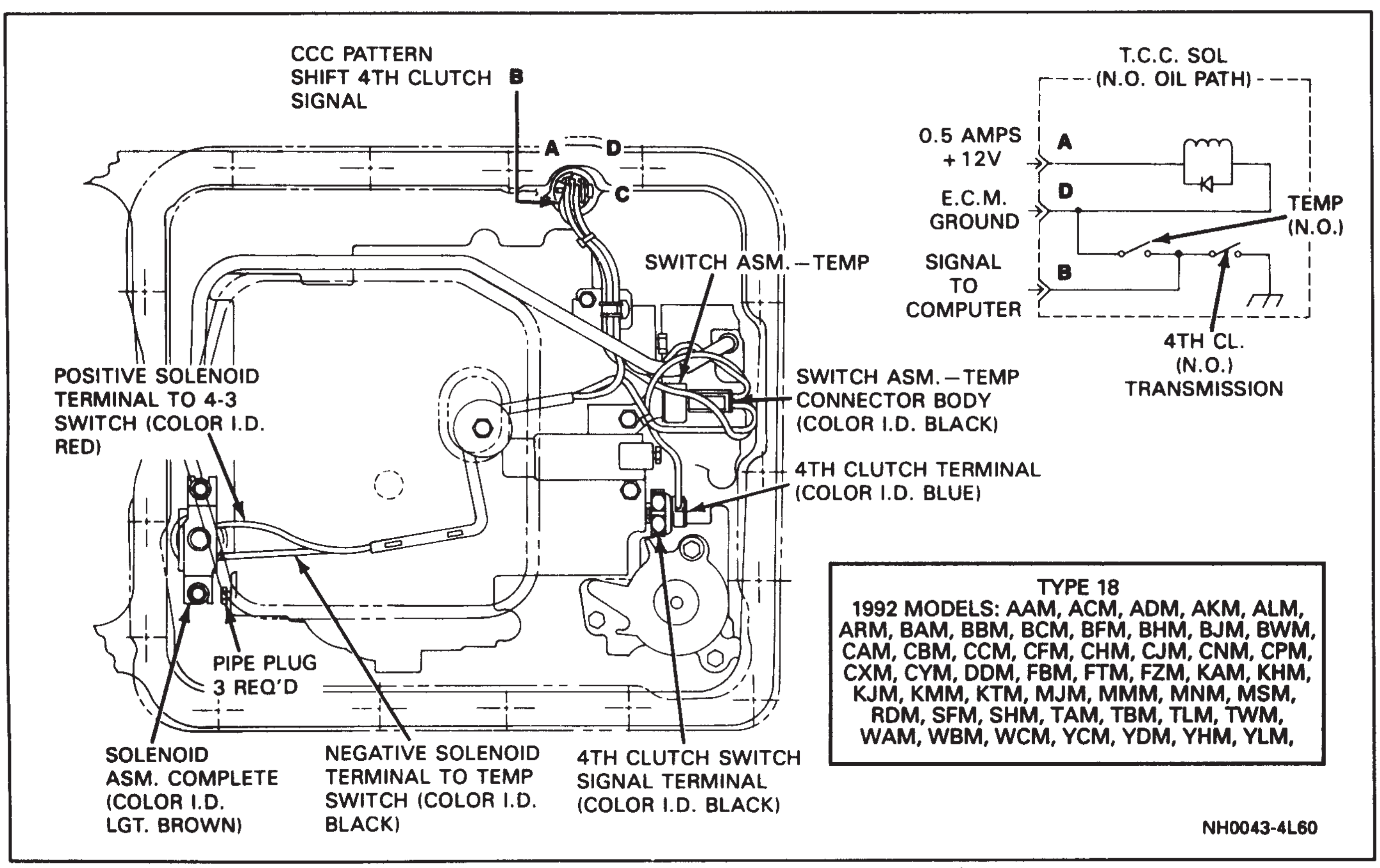


Figure 42 Wiring Diagram — Type 18

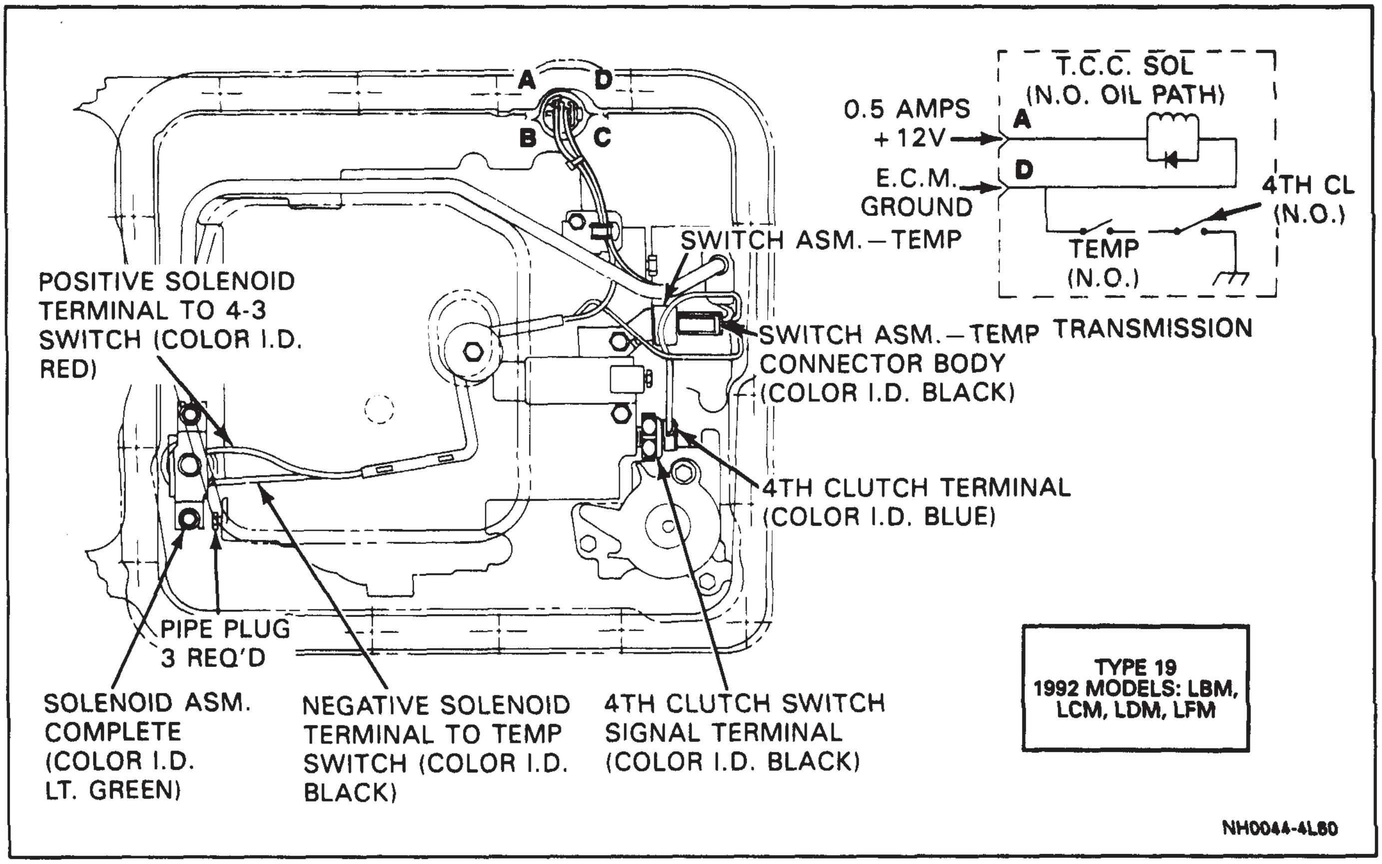


Figure 43 Wiring Diagram — Type 19

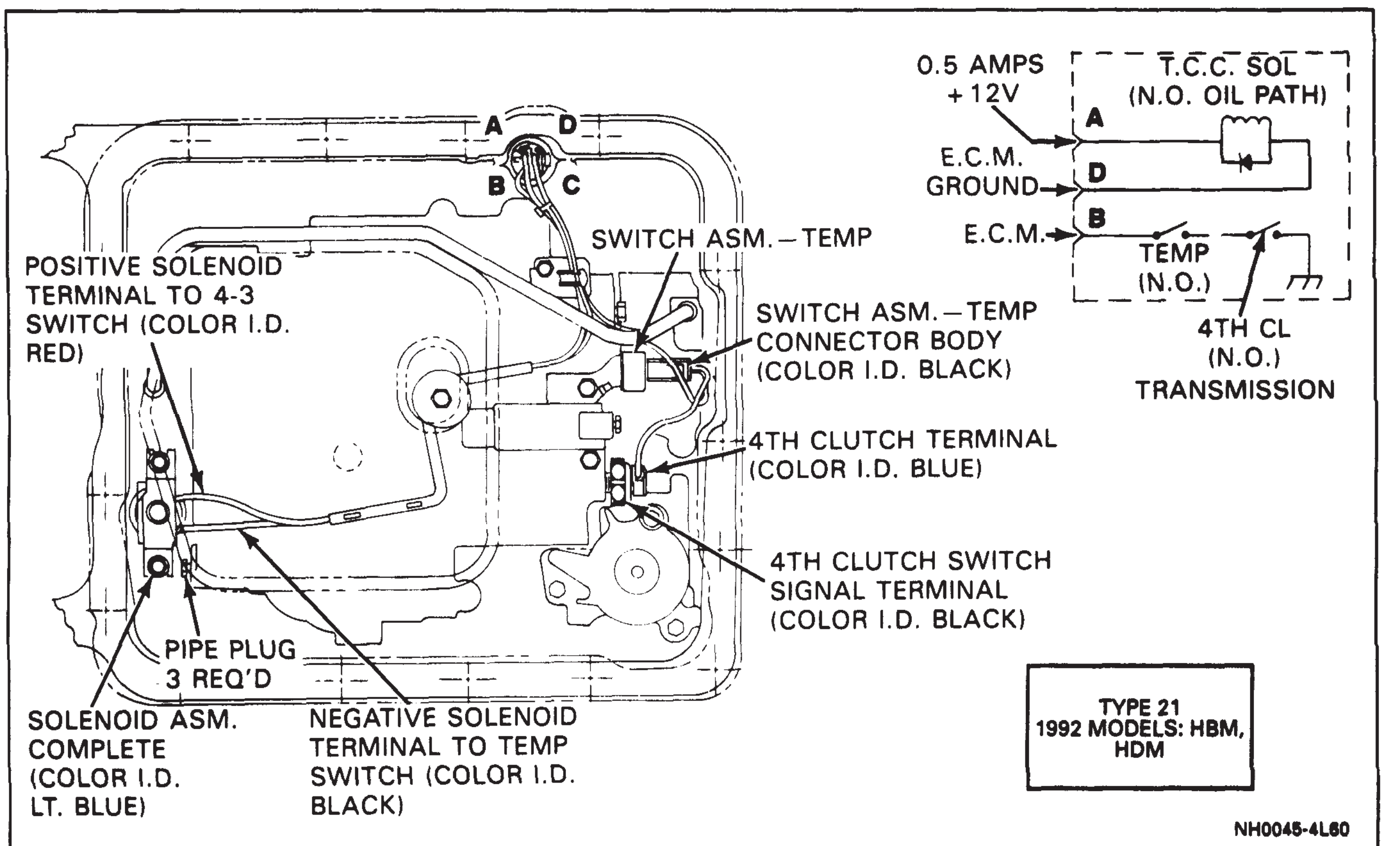
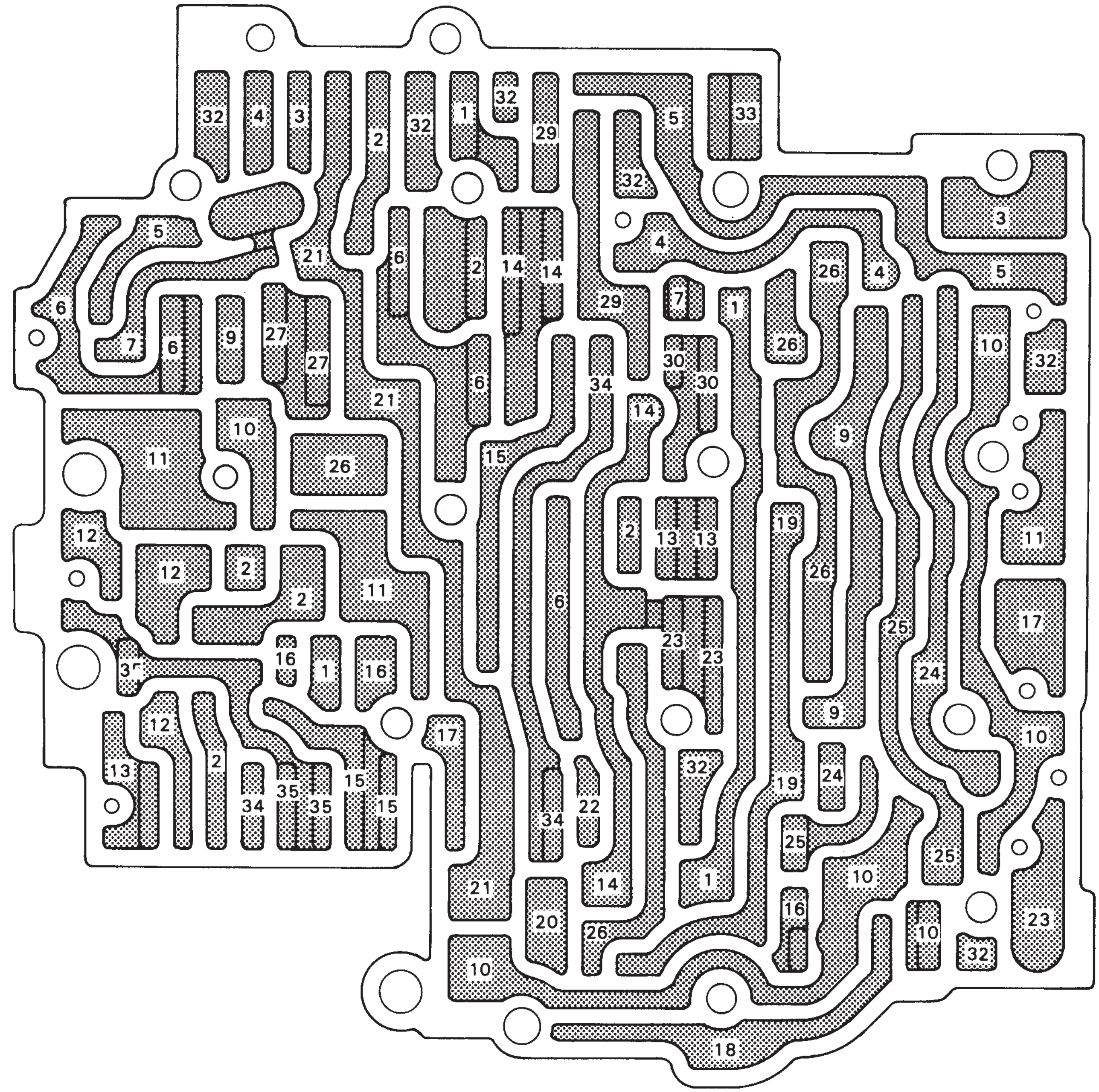


Figure 44 Wiring Diagram — Type 21



ILL. NO.	DESCRIPTION	ILL. NO.	DESCRIPTION	ILL. NO.	DESCRIPTION
1	LINE	16	T.V.F.	31	IDENTIFICATION
2	D4	17	OVERRUN CLUTCH	32	VOID
3	D2	18	T.V. EX.	33	EXHAUST
4	LO	19	D3/PART THROTTLE	34	SF
5	REVERSE	20	PART THROTTLE	35	4-3
6	GOVERNOR	21	D3	42	D4 ABUSE
7	LO - 1ST FEED	22	4TH CLUTCH	43	3RD FEED
9	3RD ACCUMULATOR	23	C.C. SIG.	44	3-2 HIGH SPEED
10	T.V.	24	MOD. UP	45	2ND FEED
11	M.T.V.	25	MOD. DOWN	46	3RD CL. EXHAUST
12	ACCUMULATOR	26	DETENT	47	4TH FEED
13	4TH SIGNAL	27	3-4 CLUTCH	48	1-2 ACCUMULATOR
14	2ND CLUTCH	29	RND4-3		
15	3-4 ACCUMULATOR	30	3RD CLUTCH		

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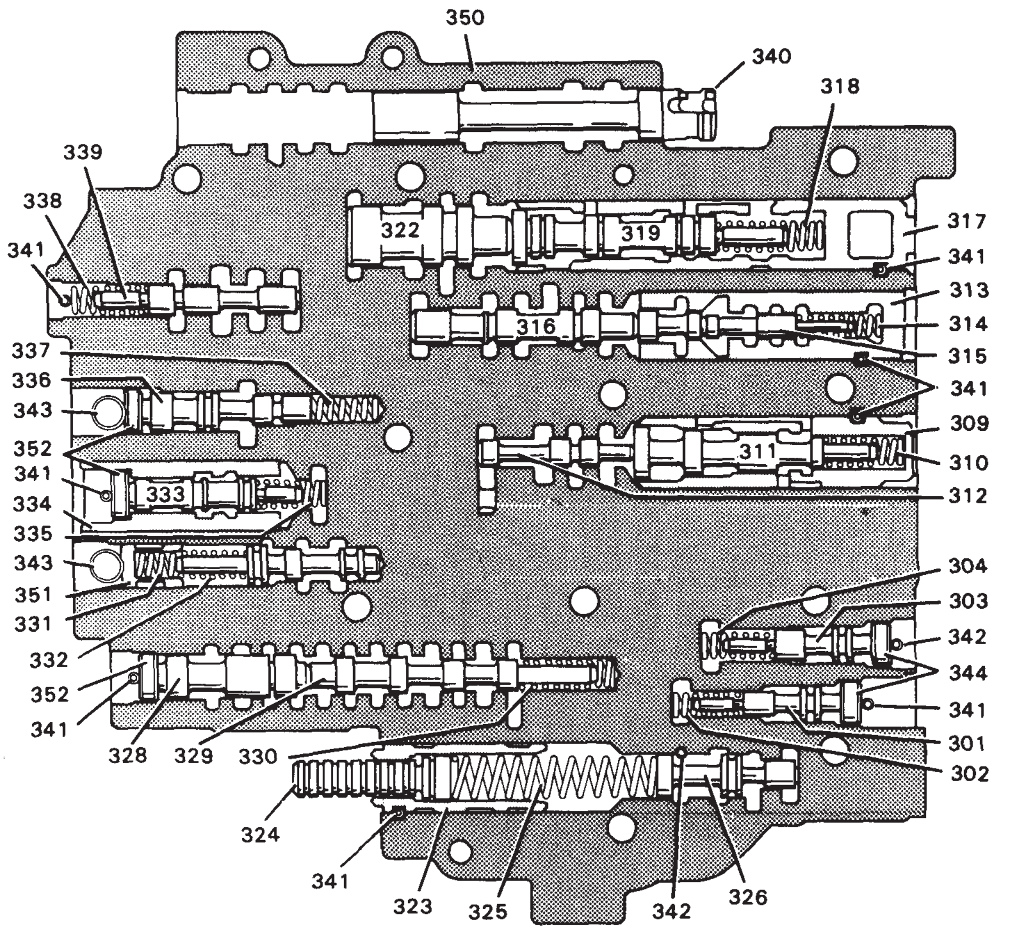
Figure 45 Valve Body Passages

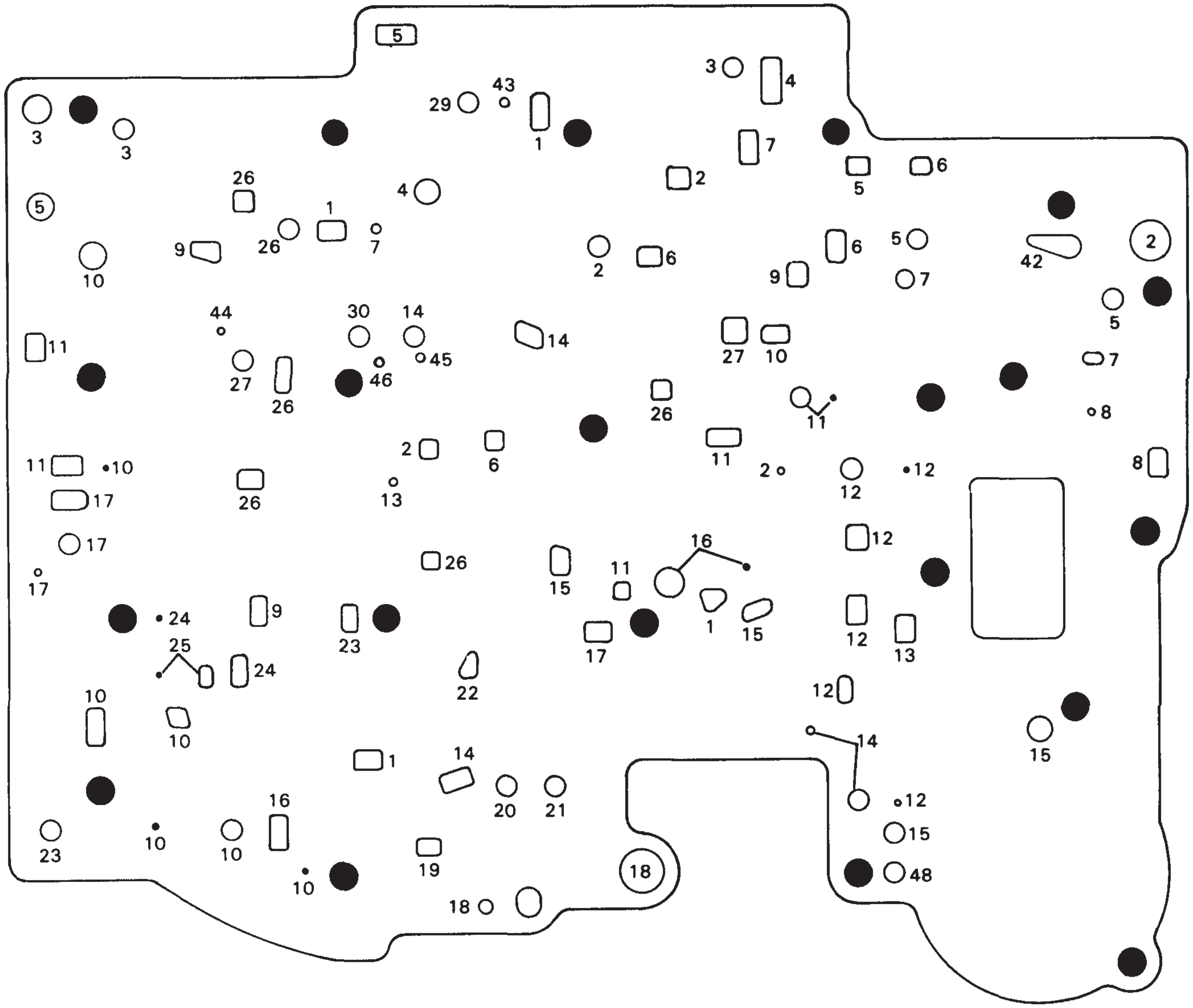


ILL. NO.	DESCRIPTION
301	VALVE, T.V. MODULATOR DOWNSHIFT
302	SPRING, T.V. MODULATOR DOWNSHIFT VALVE
303	VALVE, T.V. MODULATOR UPSHIFT
304	SPRING, T.V. MODULATOR UPSHIFT VALVE
309	SLEEVE, 3-4 THROTTLE VALVE
310	SPRING, 3-4 THROTTLE VALVE
311	VALVE, 3-4 THROTTLE
312	VALVE, 3-4 SHIFT
313	SLEEVE, 2-3 THROTTLE VALVE
314	SPRING, 2-3 THROTTLE VALVE
315	VALVE, 2-3 THROTTLE
316	VALVE, 2-3 SHIFT
317	SLEEVE, 1-2 THROTTLE VALVE
318	SPRING, 1-2 THROTTLE VALVE
319	VALVE, 1-2 THROTTLE
322	VALVE, 1-2 SHIFT
323	SLEEVE, THROTTLE VALVE PLUNGER
324	PLUNGER, THROTTLE VALVE
325	SPRING, THROTTLE VALVE
326	VALVE, THROTTLE
328	VALVE, 3-4 RELAY
329	VALVE, 4-3 SEQUENCE

ILL. NO.	DESCRIPTION
330	SPRING, 4-3 SEQUENCE VALVE
331	SPRING, T.V. LIMIT VALVE
332	VALVE, T.V. LIMIT
333	VALVE, 1-2 ACCUMULATOR
334	SLEEVE, 1-2 ACCUMULATOR VALVE
335	SPRING, 1-2 ACCUMULATOR VALVE
336	VALVE, LINE BIAS
337	SPRING, LINE BIAS VALVE
338	SPRING, 3-2 CONTROL
339	VALVE, 3-2 CONTROL
340	VALVE, MANUAL
341	PIN, COILED SPRING
342	PIN, COILED SPRING
343	RETAINER, SPRING (SLEEVE)
344	PLUG, VALVE BORE
350	BODY, CONTROL VALVE
351	PLUG, T.V. LIMIT
352	PLUG, VALVE BORE (12.5 - O.D.)

LH0047-4L60

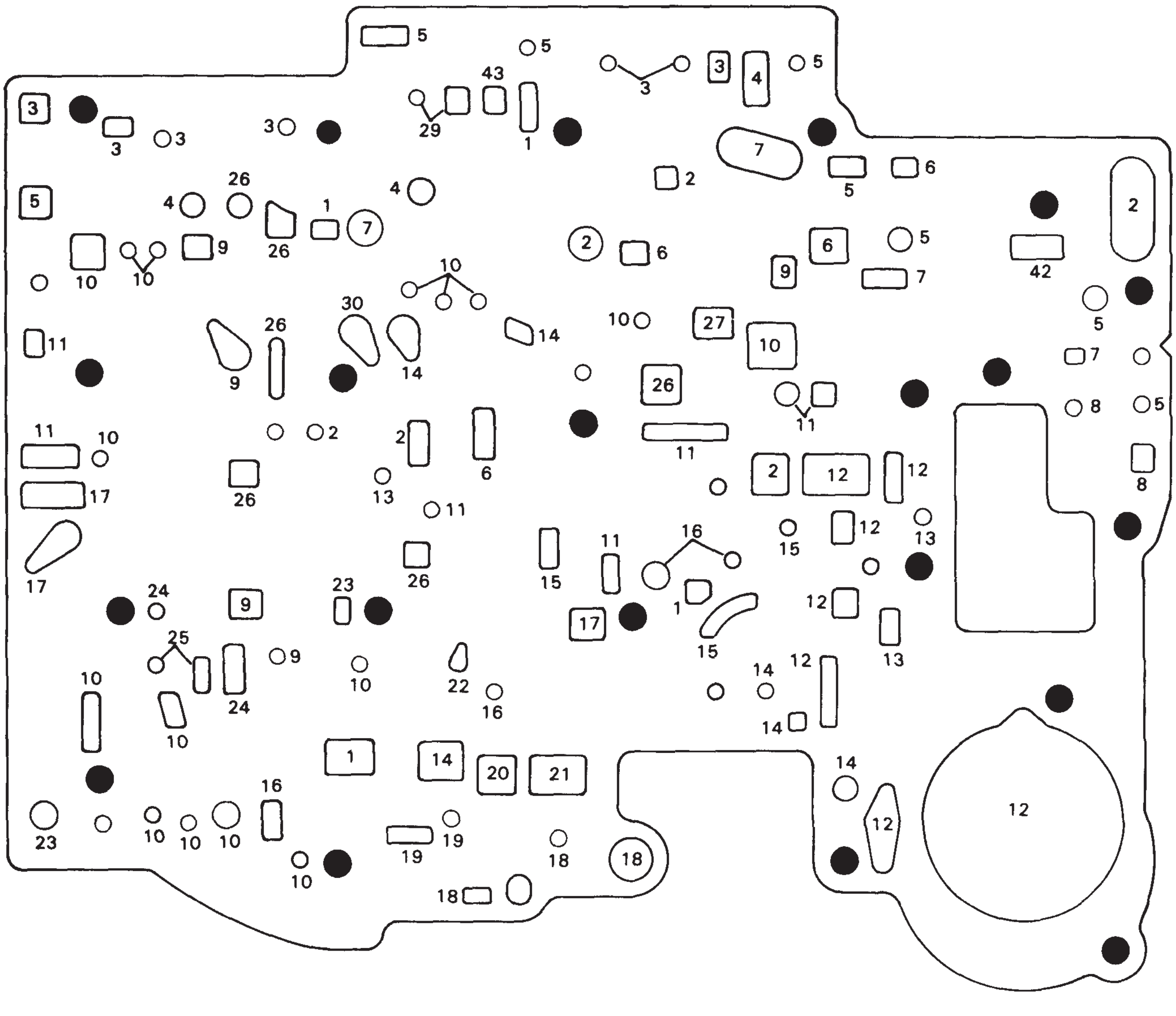
Figure 46 Valve Trains



ILL. NO.	DESCRIPTION	ILL. NO.	DESCRIPTION	ILL. NO.	DESCRIPTION
1	LINE	14	2ND CLUTCH	27	3-4 CLUTCH
2	D4	15	3-4 ACCUMULATOR	29	RND4-3
3	D2	16	T.V.F.	30	3RD CLUTCH
4	LO	17	OVERRUN CLUTCH	31	IDENTIFICATION
5	REVERSE	18	T.V. EX.	42	D4 ABUSE
6	GOVERNOR	19	D3/PART THROTTLE	43	3RD FEED
7	LO - 1ST FEED	20	PART THROTTLE	44	3-2 HIGH SPEED
8	LO/REVERSE	21	D3	45	2ND FEED
9	3RD ACCUMULATOR	22	4TH CLUTCH	46	3RD CL. EXHAUST
10	T.V.	23	C.C. SIG.	47	4TH FEED
11	M.T.V.	24	MOD. UP	48	1-2 ACCUMULATOR
12	ACCUMULATOR	25	MOD. DOWN		
13	*4TH SIGNAL*	*26*	*DETENT*		

LH0048-4L60

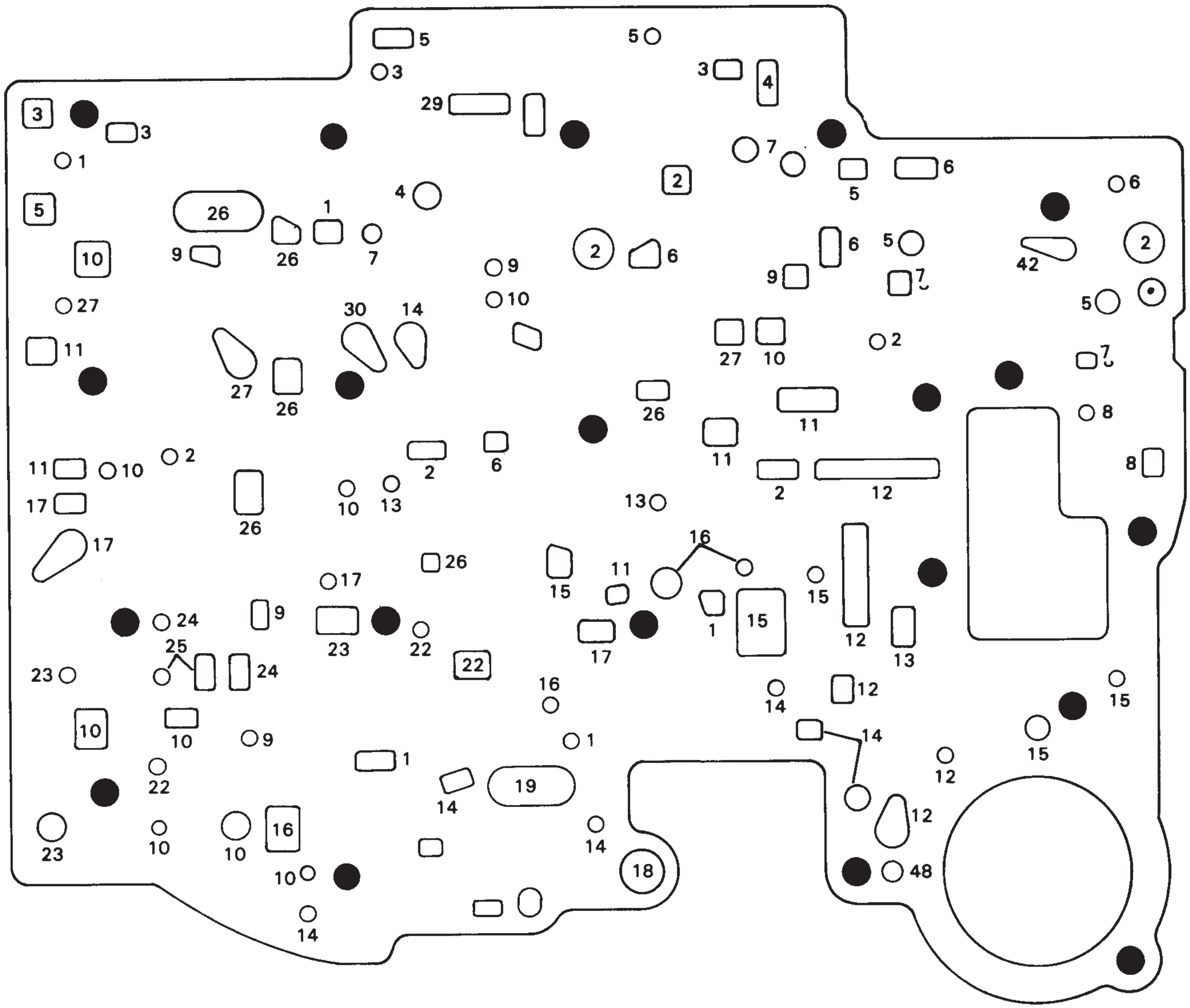
Figure 47 Typical Spacer Plate



ILL. NO.	DESCRIPTION
1	LINE
2	D4
3	D2
4	LO
5	REVERSE
6	GOVERNOR
7	LO - 1ST FEED
8	LO/REVERSE
9	3RD ACCUMULATOR
10	T.V.
11	M.T.V.
12	ACCUMULATOR
13	4TH SIGNAL
14	2ND CLUTCH
15	3-4 ACCUMULATOR
16	T.V.F.
17	OVERRUN CLUTCH
18	T.V. EX.
19	D3/PART THROTTLE
20	PART THROTTLE
21	D3
22	4TH CLUTCH
23	C.C. SIG.
24	MOD. UP
25	MOD. DOWN
26	DETENT
27	3-4 CLUTCH
29	RND4-3
30	3RD CLUTCH
31	IDENTIFICATION
42	D4 ABUSE
43	3RD FEED
44	3-2 HIGH SPEED
45	2ND FEED
46	3RD CL. EXHAUST
47	4TH FEED
48	1-2 ACCUMULATOR

LH0049-4L60

Figure 48 Spacer Plate to Valve Body Gasket



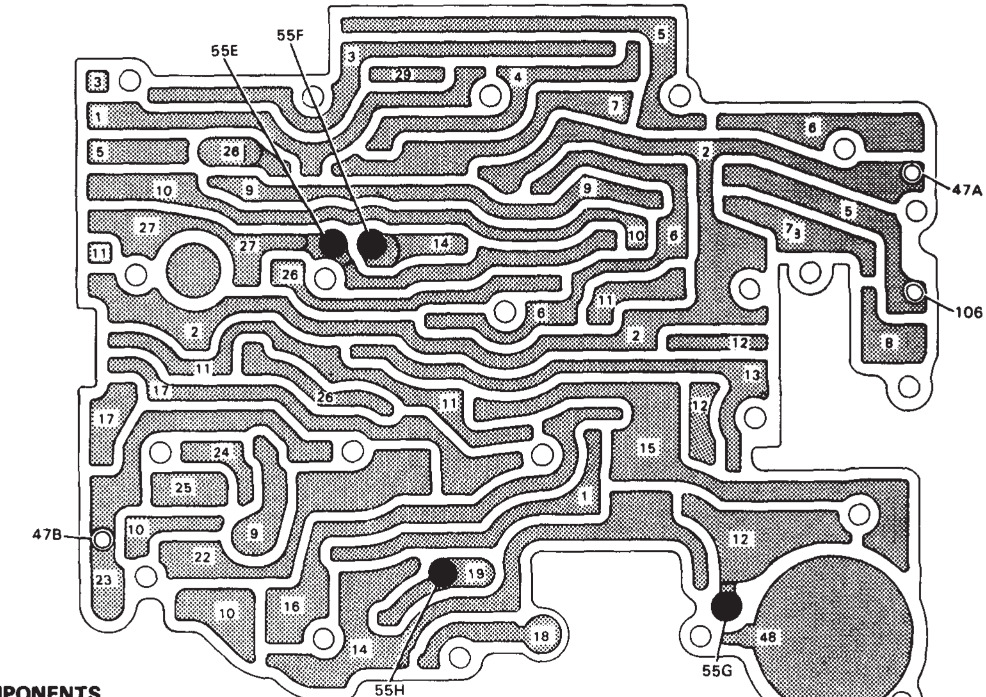
ILL. NO.	DESCRIPTION
1	LINE
2	D4
3	D2
4	LO
5	REVERSE
6	GOVERNOR
7	LO - 1ST FEED
8	LO/REVERSE
9	3RD ACCUMULATOR
10	T.V.
11	M.T.V.
12	ACCUMULATOR
13	4TH SIGNAL
14	2ND CLUTCH
15	3-4 ACCUMULATOR
16	T.V.F.
17	OVERRUN CLUTCH
18	T.V. EX.
19	D3/PART THROTTLE
20	PART THROTTLE
21	D3
22	4TH CLUTCH
23	C.C. SIG.
24	MOD. UP
25	MOD. DOWN
26	DETENT
27	3-4 CLUTCH
29	RND4-3
30	3RD CLUTCH
31	IDENTIFICATION
42	D4 ABUSE
43	3RD FEED
44	3-2 HIGH SPEED
45	2ND FEED
46	3RD CL. EXHAUST
47	4TH FEED
48	1-2 ACCUMULATOR

LH0050-4L60

Figure 49 Spacer Plate to Case Gasket

PASSAGES

1 LINE
2 D4
3 D2
4 LO
5 REVERSE
6 GOVERNOR
7 LO - 1ST FEED
8 LO/REVERSE
9 3RD ACCUMULATOR
10 T.V.
11 M.T.V.
12 ACCUMULATOR (4TH)
13 4TH SIGNAL
14 2ND CLUTCH
15 3-4 ACCUMULATOR
16 T.V.F.
17 OVERRUN CLUTCH
18 T.V. EX.
19 D3/PART THROTTLE
20 PART THROTTLE
21 D3
22 4TH CLUTCH
23 C.C. SIG.
24 MOD. UP
25 MOD. DOWN
26 DETENT
27 3-4 CLUTCH (3-2 EX)
29 RND4-3
42 D4 ABUSE
43 3RD FEED
44 3-2 HIGH SPEED
45 2ND FEED
46 3RD CL. EXHAUST
47 4TH FEED
48 1-2 ACCUMULATOR

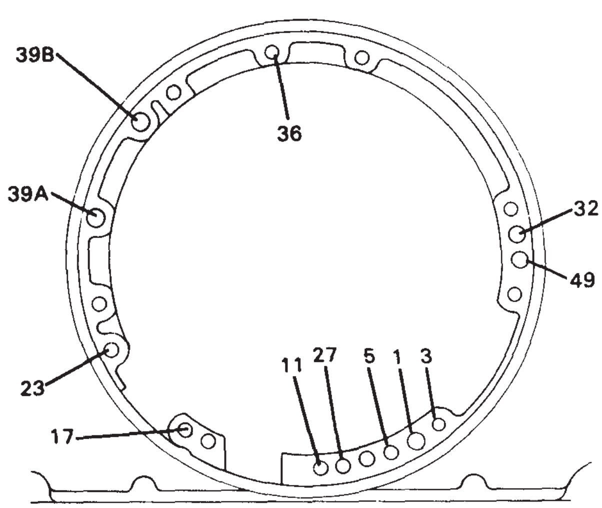


COMPONENTS

47A GOVERNOR FILTER LOCATION
47B CONVERTER CLUTCH FILTER LOCATION
55E #4 CHECK BALL (3-4 CLUTCH/3-2 EX.)
55F #8 CHECK BALL (2ND/1-2)
55G #1 CHECK BALL (4TH ACCUMULATOR)
55H #3 CHECK BALL (PART THROTTLE/DRIVE 3)
106 RETAINER & BALL ASM. (DOUBLE-ORIFICE)

LH0051-4L60

Figure 50 Case Passages and Checkball Locations

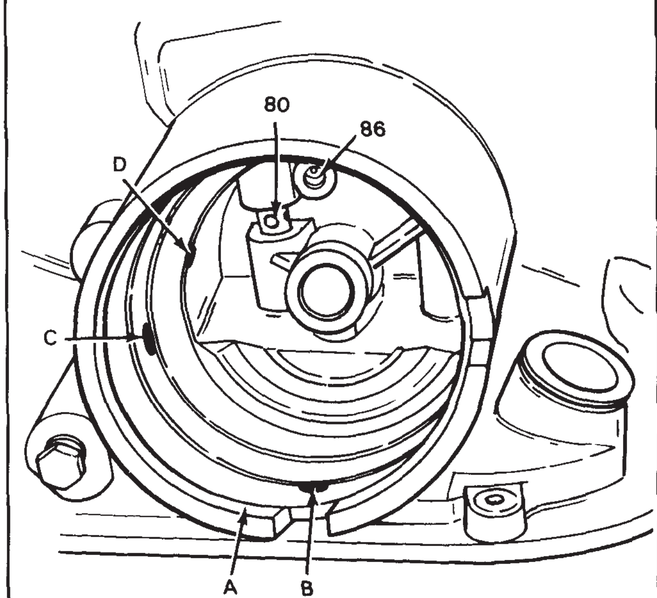


CASE OIL PASSAGES

1 LINE
3 DR-2
5 REVERSE
11 M.T.V.
17 O.R. CLUTCH
23 CONV. CL. SIG.
27 3-4 CLUTCH
32 VOID
36 VENT
39(a) LUBE TO COOLER
39(b) LUBE FROM COOLER
49 PRESSURE TAP

LH0052-4L60

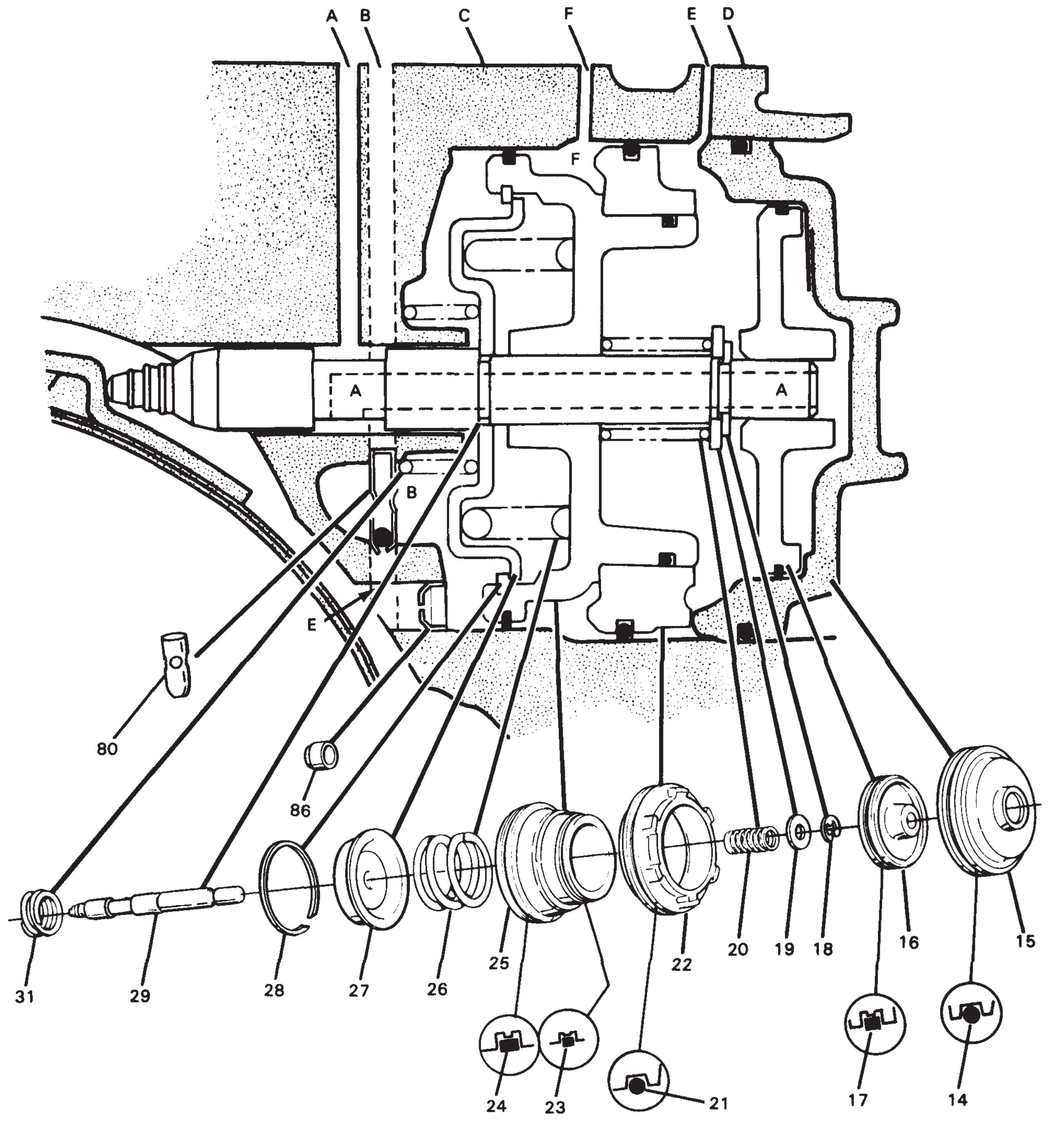
Figure 51 Pump to Case Passages



A 2-4 SERVO BORE
B SERVO EXHAUST HOLE
C 2ND & 4TH BAND APPLY PASSAGE
D 3RD ACCUM. PRESSURE TAP PASSAGE
80 RETAINER & BALL ASSEMBLY, 3RD ACCUM.
86 PLUG, CASE SERVO

LH0053-4L60

Figure 52 Servo Passages



A 4TH OIL
B 3RD ACCUMULATOR OIL
C VALVE BODY FACE
D OIL PAN FLANGE
E EXHAUST
F 2ND OIL
14 SEAL, "O" RING (2-4 SERVO COVER)
15 COVER, 2-4 SERVO
16 PISTON, 4TH APPLY
17 RING, OIL SEAL (4TH APPLY PISTON) (OUTER)
18 RING, RETAINER (APPLY PIN)
19 WASHER, SERVO APPLY PIN
20 SPRING, SERVO APPLY PIN
21 SEAL, "O" RING
22 HOUSING, SERVO PISTON (INNER)
23 RING, OIL SEAL (2ND APPLY PISTON) (INNER)
24 RING, OIL SEAL (2ND APPLY PISTON) (OUTER)
25 PISTON, 2ND APPLY
26 SPRING, SERVO CUSHION
27 RETAINER, SERVO CUSHION SPRING
28 RING, RETAINER (2ND APPLY PISTON)
29 PIN, 2ND APPLY PISTON
31 SPRING, SERVO RETURN
80 RETAINER & BALL ASSEMBLY, 3RD ACCUM.
86 PLUG, CASE SERVO

LH0054-4L60

Figure 53 Servo Assembly

1 LINE
3 D2
5 REVERSE
11 MODULATED T.V.
17 OVERRUN CLUTCH
23 CONVERTER CLUTCH SIGNAL
23(a) CONVERTER CLUTCH SIGNAL (ORIFICE CUP PLUG)
27 3-4 CLUTCH
32 VOID
33 EXHAUST
33(a) EXHAUST (T.C.C. RELEASE)
33(b) EXHAUST (PRESS. REG.)
36 VENT
37 DECREASE
37(a) DECREASE AIR BLEED (ORIFICE CUP PLUG)
38 SEAL DRAIN
39 LUBE
39(a) LUBE TO COOLER
39(b) LUBE FROM COOLER
40 CONVERTER CLUTCH RELEASE
41 CONVERTER CLUTCH FEED
41(a) CONVERTER CLUTCH FEED TO COOLER (ORIFICE CUP PLUG)

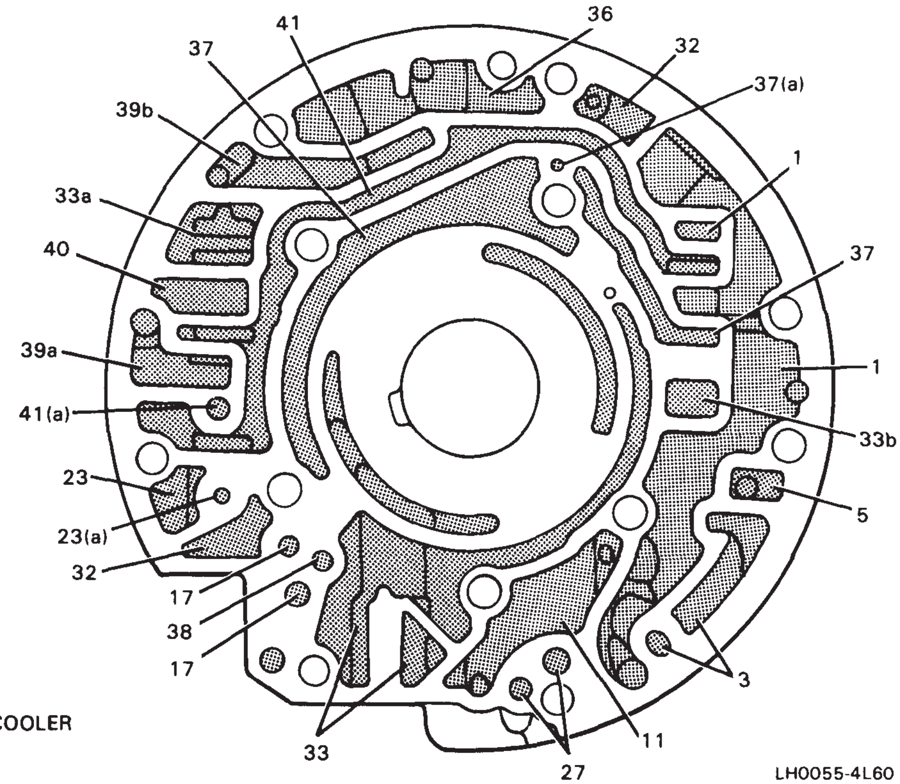


Figure 54 Pump Cover Passages

1 LINE
3 D2
5 REVERSE
11 MODULATED T.V.
17 OVERRUN CLUTCH
23 CONVERTER CLUTCH SIGNAL
27 3-4 CLUTCH
32 VOID
33 EXHAUST
33(a) EXHAUST (T.C.C. RELEASE)
33(b) EXHAUST (PRESS. REG.)
36 VENT
37 DECREASE
38 SEAL DRAIN
39 LUBE
39(a) LUBE TO COOLER
39(b) LUBE FROM COOLER
40 CONVERTER CLUTCH RELEASE
41 CONVERTER CLUTCH FEED

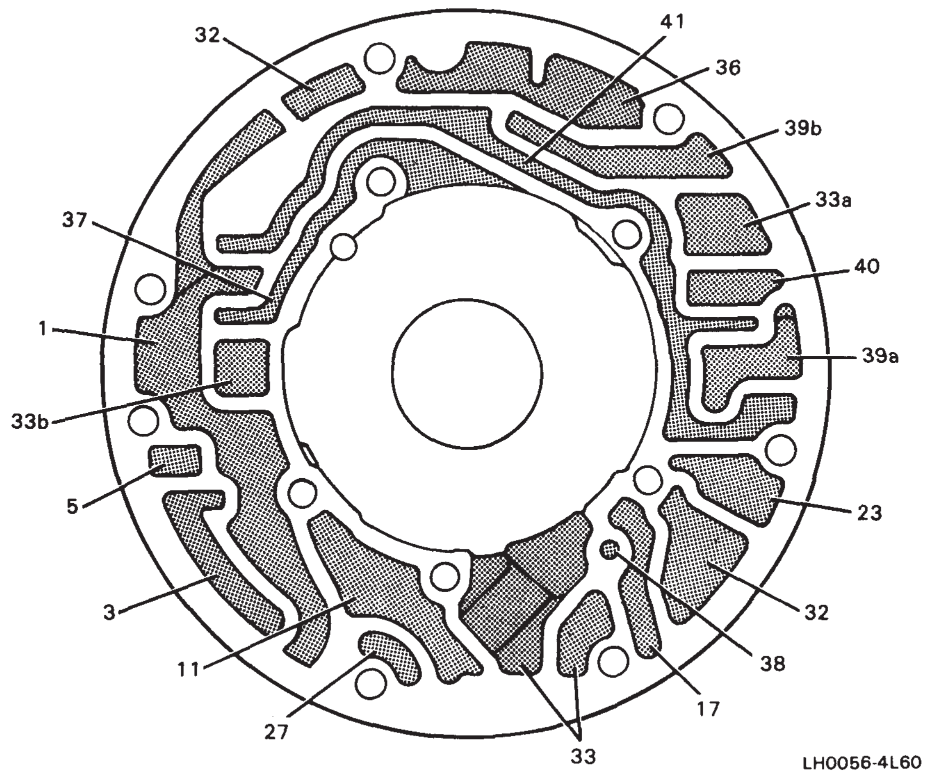


Figure 55 Pump Body Passages

ON-VEHICLE SERVICE

PARTS CLEANING, INSPECTION, AND REPLACEMENT

- Use appropriate safety equipment such as:
  - — Safety glasses.
  - — Safety shoes.
  - — Gloves.
- Keep the work area and tools clean.
- Clean the exterior of the transmission before removing any parts.
- Do not use wipe cloths or rags.
- *Do not use solvents on rubber seals or Teflon* or plastic thrust washers.
- Blow out all passages with compressed air.
- Clean small passages with fine wire.
- Handle parts carefully to prevent damage.
- Lubricate all internal parts with transmission fluid during assembly.
- When installing screws, bolts, or studs into aluminum, always dip the threads in transmission fluid.
- Always use a torque wrench for the proper torque.
- Recondition damaged or stripped aluminum threads with thread inserts.
- Replace all gaskets and O-ring seals.
  - — Do not use gasket cement or sealers.
- Replace Teflon or plastic seal and install using the proper seal protector.

Inspect

- Manual linkage for wear at the pivoting points, bent or broken links, and rods.
- All seals gaskets, O-rings, and mating surfaces for nicks, cuts, or other damage.
- Snap rings for expansion or compression, distortion, nicks, and proper ring to groove fit.
- Bearings and thrust surfaces for wear, scoring, and pitting.

FLYWHEEL AND TORQUE CONVERTER VIBRATION TEST

1. Start the engine.
2. With the engine at idle speed and the transmission in Park or Neutral, observe vibration.
3. Shut the engine off.

NOTICE: Some engine/transmission combinations cannot be balanced in this manner due to limited clearances between the torque converter bolts and engine. Be sure bolts do not bottom out in lug nuts or the torque converter cover could be dented and cause internal damage.

Remove or Disconnect

1. Converter cover attaching bolts.
2. Flywheel to torque converter attaching bolts.
   - Rotate the torque converter 1/3 turn.

Install or Connect

NOTICE: See "Notice" on page 7A1-1 for steps 1 and 2.

1. Flywheel to torque converter attaching bolts.

   Tighten

   - Bolts to 62 N.m (45 ft. lbs.).
2. Converter cover bolts.

   Tighten

   - Bolts to 10 N.m (89 in. lbs.).
3. Start the engine and check for vibration. Repeat the procedure until the best possible balance is obtained.

FLUID LEAK DIAGNOSIS AND REPAIR

The cause of most external leaks can generally be located and repaired with the transmission in the vehicle.

METHODS FOR LOCATING LEAKS

General Method

1. Verify that the leak is transmission fluid.
2. Thoroughly clean the suspected leak area.
3. Operate the vehicle for about 15 miles or until normal operating temperatures are reached.
4. Park the vehicle over clean paper or cardboard.
5. Shut the engine off and look for fluid spots on the paper.
6. Make necessary repairs.

Powder Method.

1. Thoroughly clean the suspected leak area with solvent.
2. Apply an aerosol type powder (foot powder) to the suspected leak area.
3. Operate the vehicle for about 15 miles or until normal operating temperatures are reached.
4. Shut the engine off.
5. Inspect the suspected leak area and trace the leak path through the powder to find the source.
6. Make necessary repairs.

Dye and Black Light Method.

1. Follow the manufacturer's recommendation for the amount of dye to be used.
2. Find the leak with a black light.
3. Make necessary repairs.

REPAIRING THE LEAK

Once the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must be repaired also. Before attempting to repair a leak, check to be sure that the following conditions are correct as they may cause a leak.

Gaskets.

- Fluid level/pressure is too high.
- Plugged vent or drain-back holes.
- Improperly torqued fasteners or dirty/damaged threads.
- Warped flanges or sealing surface.
- Scratches, burrs, or other damage to the sealing surface.
- Damaged or worn gasket.
- Cracking or porosity of the component.
- Improper sealant used (where applicable).

Seals.

- Fluid level pressure is too high.
- Plugged vent or drain-back holes.
- Damaged seal bore (scratched, burred, or nicked).
- Damaged or worn seal.
- Improper installation.
- Cracks in component.
- Manual or output shaft surface scratched, nicked, or missing.
- Loose or worn bearing causing excess seal wear.

POSSIBLE POINTS OF OIL LEAKS

1. Transmission and transmission oil pan:
   - Attaching bolts not torqued correctly.
   - Improperly installed or damaged gasket.
   - Oil pan or mounting face not flat.
2. Case leak:
   - Filler tube multi-lip seal damaged or missing.
   - Filler tube bracket misaligned.
   - TV cable multi-lip seal missing, damaged or improperly installed.
   - Governor cover or O-ring damaged or missing.
   - Speedometer driven gear/speed sensor seal damaged.
   - Manual shaft seal damaged.
   - Oil cooler connector fittings loose or damaged.
   - Propeller shaft oil seal worn or damaged.
   - Governor cover.
   - Line pressure pipe plug loose.
   - Porous casting.
3. Leak at converter end:
   - Converter seal damaged.
     - — Seal lip cut (check converter hub for damage).
     - — Bushing moved forward and damaged.
     - — Garter spring missing from seal.
   - Converter leak in weld area.
   - Porous casting (case of pump).
4. Fluid comes out vent pipe or fill tube.
   - Overfilled.
   - Water or coolant in fluid (fluid will appear milky).
   - Porous case.
   - Incorrect fluid level indicator.
   - Plugged vent.
   - Drain back holes plugged.
   - The alignment of the oil pump to case gasket (if equipped).

CASE POROSITY REPAIR

1. Clean the leak area with solvent and air dry.

CAUTION: Epoxy adhesive may cause skin irritations and eye damage. Read and follow all information on the container label as provided by the manufacturer.

2. Mix a sufficient amount of epoxy adhesive (GM Part No. 1052533 or equivalent) following the manufacturer's recommendations.
3. While the transmission case is hot, apply epoxy adhesive with a clean, dry, soldering acid brush.
4. Allow the epoxy adhesive to cure for three hours before starting the engine.
5. Repeat fluid leak diagnosis procedures.

TORQUE CONVERTER CLUTCH ELECTRICAL CONTROLS

The Torque Converter Clutch (TCC) system uses controls that are internal as well as external to the transmission. For internal control components of the TCC system, refer to the Hydraulic Diagnosis Chart for wiring diagrams and switch locations.

The external control components of the TCC system include:

- Brake Release Switch—To avoid stalling the engine when braking, the converter clutch is released any time the brakes are applied.
- Electronic Control Module—Receives input signals and grounds TCC solenoid to apply clutch when the proper operating conditions are met.
- Throttle Position Sensor—Sends throttle position information to the Electronic Control Module.
- Vacuum Sensor—Sends engine vacuum (load) information to the Electronic Control Module.
- Vehicle Speed Sensor—Sends vehicle speed information to the Electronic Control Module.
- Coolant Temperature Sensor—Sends engine coolant temperature information to the Electronic Control Module.

TORQUE CONVERTER CLUTCH DIAGNOSIS

To properly diagnose the torque converter clutch system, perform all electrical testing before the hydraulic testing. For additional testing of the torque converter clutch system. Refer to the Fuel and Emissions Manual if you are using X-9229. Refer to the Fuel and Emissions Section at the rear of this manual if you are using ST 369-92.

SHIFT LINKAGE

Remove or Disconnect (Figure 55)

- Note the position of any washers, spacers, and insulators removed.
- Apply the parking brake.

1. Retaining pin (226).
2. Rod (231) from the column lever (228).
   - Note the positions of the washers (227), spacer (229) and insulator (227).
3. Bolt (234) and washer (233) from the swivel (232).
4. Rod (231) from the vehicle.
5. Retaining pin (235) from the transmission control lever (236).

Clean

- Metal parts using solvent. Wipe dry using a clean, dry rag.
- Rubber or nylon parts using soapy water. Wipe dry using a clean, dry rag.

Install or Connect (Figure 55)

1. Transmission control lever (236).
   - Place the end of the lever in the holes in the transmission shift lever (237).
2. New retaining pin (235).
   - Nut (232) to 15 N·m (11 ft. lbs.).
3. Rod (231) to the transmission control lever (236).

NOTICE: See "Notice" on page 7A1-1.

4. Spring washer (233) and bolt (234).

Tighten

- Bolt (234) to 25 N·m (18 ft. lbs.).

5. Rod (231) to the column lever (228).
   - Install the washer (227), insulator (229), and spacer (230).
6. New retaining pin (226).

Tighten

- Adjust the linkage. Refer to "Shift Linkage Adjustment" in this section.

SHIFT LINKAGE ADJUSTMENT

Remove or Disconnect

- Apply the parking brake.

1. Loosen the screw (234).
2. Put the column selector lever in the "N" (Neutral) position.
   - Put the lever in the neutral gate; do not use the indicator to find the neutral position.
3. Put the transmission in neutral.
   - Move the shift lever (231) (figure 55) to the forward position, then back to the second detent (figure 56).
4. Hold the rod (231) tightly in the swivel (232).

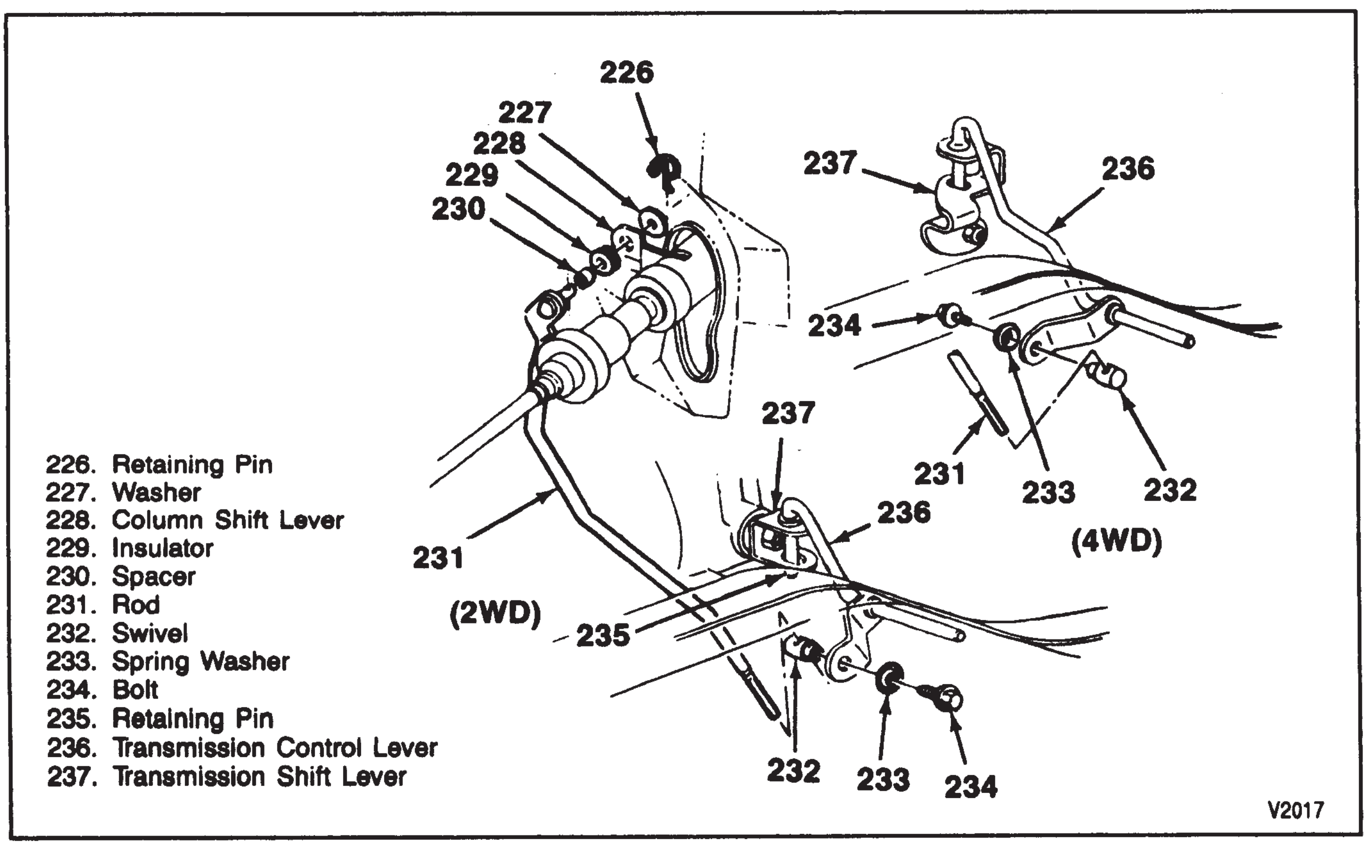


Figure 55—Shift Linkage

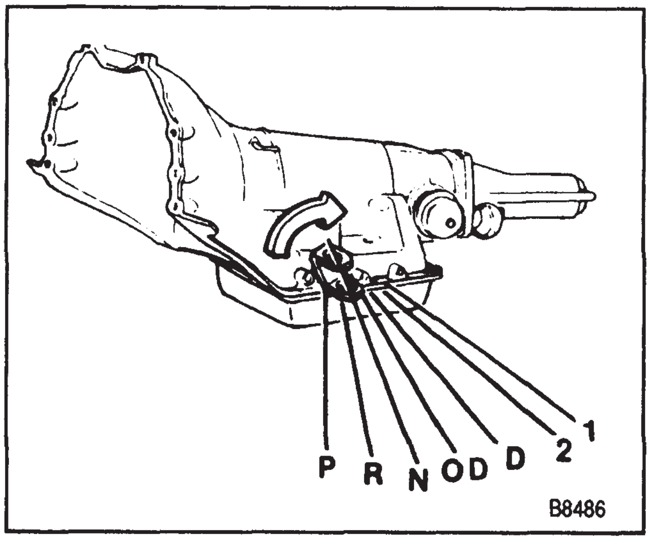


Figure 56—Shift Positions

Tighten

- Bolt (234) to 25 N.m (18 ft. lbs.).

Inspect

5. Put the column selector lever in the "P" (Park) position.
6. Check the adjustment.
   - The column selector lever must go into all positions.
   - The engine must start in the "P" (Park) or "N" (Neutral) positions only. Adjust if needed, refer to "Neutral Start Switch" in this section.

CAUTION: With the selector lever in the "Park" position, the parking pawl should freely engage within the rear (reaction) internal gear lugs or output ring gear lugs and prevent the vehicle from rolling, which could cause personal injury.

7. Align the indicator, if needed.
8. Release the parking brake.

THROTTLE VALVE (TV) CABLE

The TV Cable used with the 4L60 transmission should not be thought of as an automatic downshift cable. The TV cable used on the 4L60 controls line pressure, shift points, shift feel, part throttle downshifts, and detent downshifts. The function of the cable is similar to the combined functions of a vacuum modulator and a detent cable.

The TV cable operates the TV link (144) and bracket in the transmission (figure 57).

The TV bracket assembly serves two (2) basic functions:

1. The primary function of the assembly is to transfer the TBI throttle plate movement to the TV plunger in the control valve assembly, as related by the TV cable and linkage. This causes TV pressure and line pressure to increase according to engine throttle opening and also controls part throttle and detent downshifts. The proper adjustment of the TV cable is based on the TV plunger being fully depressed and flush with the TV bushing at engine wide open throttle.
2. The second function of the assembly involves a TV exhaust ball. The function of this system is to prevent the transmission from operating at low (idle position) pressures, if the TV cable should become broken or disconnected. If the cable is disconnected or broken, the TV lifter rod will not move from its normal spring loaded-up position which holds the TV exhaust check ball off its seat. The TV lifter rod will drop down to allow the TV exhaust ball to seat only if the cable is broken, disconnected, or extremely out of adjustment. With the transmission pan removed, it should be possible to pull down on the TV exhaust valve lifter rod and let the springs return the rod to its normal up position. If the throttle lever and bracket assembly or lifter rod binds or sticks so that the TV lifter rod cannot lift the exhaust ball off its seat, high line pressures and delayed shifts will result.

Remove or Disconnect (Figure 57)

1. Air cleaner.
2. Cable terminal (255) from the throttle lever (140).
3. Cable housing (141) from the bracket while compressing locking tangs (A).
4. Routing clips or straps.
5. Screw (252) and the washer.
6. Cable (142) from the transmission link (144).
   - Pull up on cable cover at the transmission until the cable is visible.
7. Seal (254).

Install or Connect (Figure 57)

1. New seal (254) into the transmission case hole.
2. Cable (142) to the transmission link.

NOTICE: See "Notice" on page 7A1-1.

3. Screw (252) and the flat washer.

Tighten

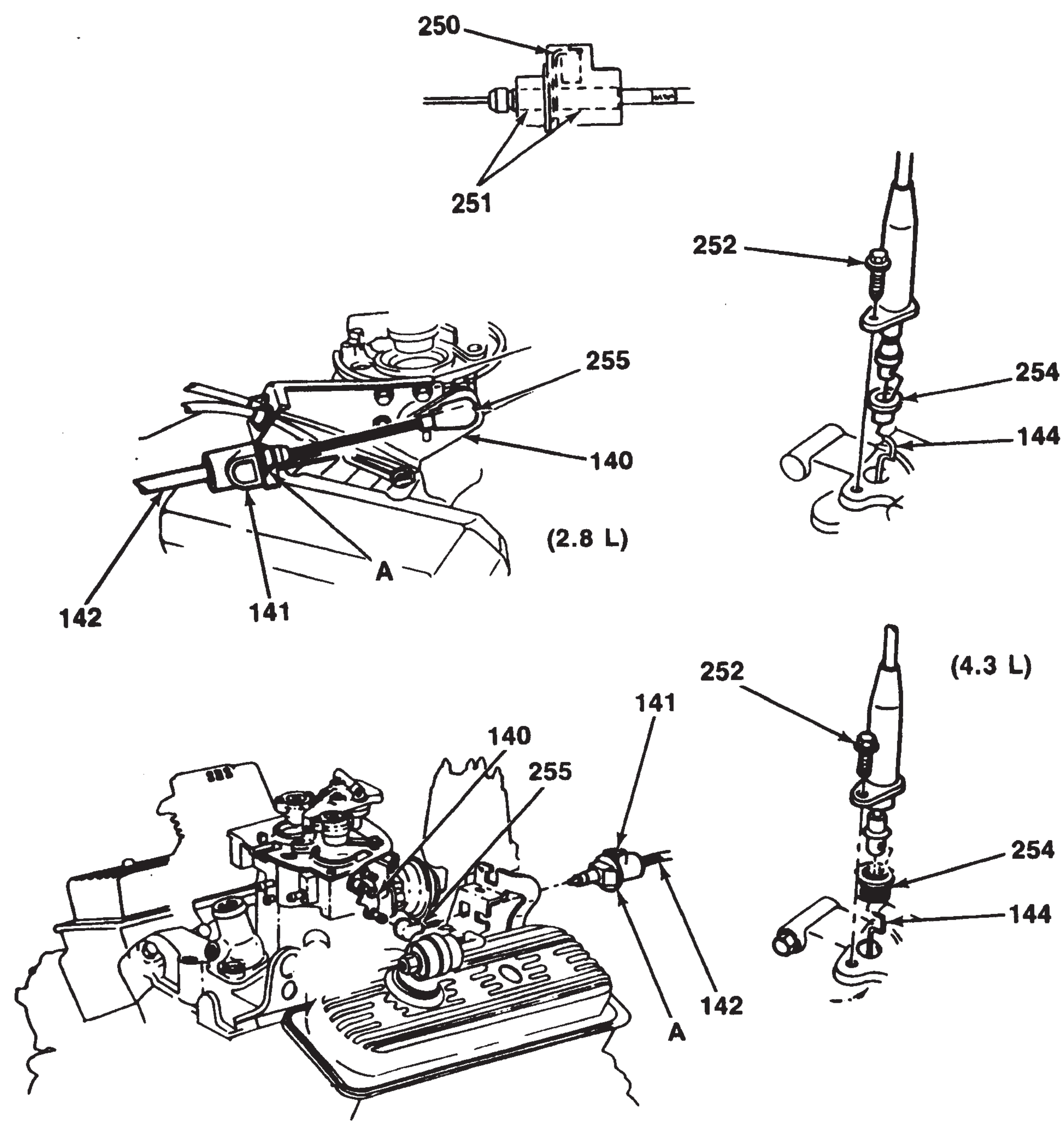
- Screw (252) to 10 N.m (88 in. lbs.).

4. Cable routing clips or straps.
5. Cable (142) through the engine bracket and engage locking tangs (B) of the cable on the bracket.

Important

- Avoid damaging or kinking the cable.

6. Cable terminal (255) from the throttle lever (140).
   - Pull on upper end of cable. It should travel a short distance with light resistance caused by the small return spring on the TV lever. When releasing the upper end of the TV cable, it should return to the zero TV position.
7. Adjust the TV cable. Refer to "Throttle Valve (TV) Cable Adjustment" in this section.



A. Locking Tangs
140. Throttle Lever
141. Throttle Lever
142. Cable
144. Link
250. Re-Adjust Tab
251. Slider
252. Screw
254. Seal
255. Terminal

F6965

Figure 57—TV Cable Replacement

THROTTLE VALVE (TV) CABLE ADJUSTMENT

Adjustment of the TV cable must be made by rotating the throttle lever at the throttle body. Do not use the accelerator pedal to rotate the throttle lever.

Adjust (Figure 57)

1. Depress and hold down the metal re-adjust tab (250) at the engine end of the TV cable (142).
2. Move the slider (251) until it stops against the fitting.
3. Release the readjustment tab (250).
4. Rotate the throttle lever (140) to its "full travel position."
5. The slider (251) must move (ratchet) toward the lever when the lever is rotated to its full travel position.
   - Check that cable moves freely. The cable may appear to function properly with the engine stopped and cold. Recheck after the engine is hot.
6. Road test the vehicle.

CHANGING THE FLUID AND FILTER

Remove or Disconnect (Figure 58)

- Raise the vehicle and support it using suitable safety stands.
- Place a drain pan under transmission oil pan.

1. Oil pan screws (74) from the front and sides only.
   - Loosen the rear oil pan screws approximately 4 turns.

NOTICE: Do not damage the transmission case or oil pan sealing surfaces.

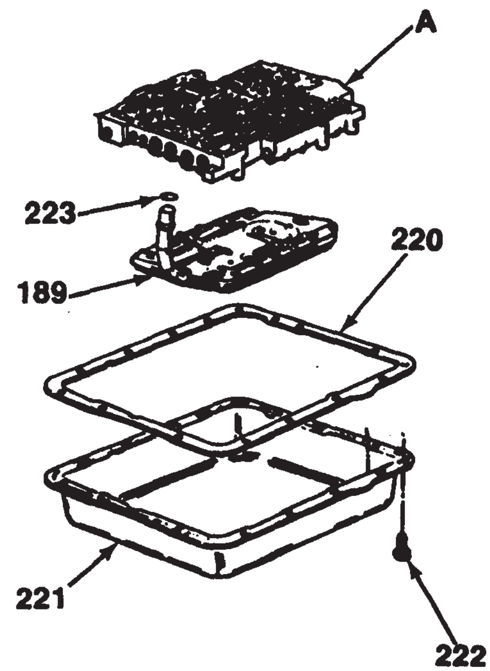
2. Lightly tap the oil pan (73) with a rubber mallet or pry down to allow the fluid to drain.
   - Inspect the fluid color, refer to AUTOMATIC TRANSMISSION (SECTION 7A).
3. Remaining oil pan screws (74), oil pan and the gasket (72).
4. Oil filter (71) and the seal (70).
   - The seal may be stuck in the case.

Clean

- Transmission case and oil pan gasket surfaces with solvent and air dry.
  — All traces of old gasket material must be removed.

Install or Connect (Figure 58)

- Coat a new seal (70) with a small amount of TRANSJEL® J 36850 or equivalent.



A. Valve Body
189. Filter
220. Gasket
221. Oil Pan
222. Bolts
223. Seal

F6968

Figure 58-Transmission Fluid Replacement

1. New seal (70) onto a new filter (71).
2. New filter into the case.
3. Oil pan and a new gasket.

NOTICE: See "Notice" on page 7A1-1.

4. Screws.

Tighten

- Screws (74) to 20 N·m (15 ft. lbs.).

5. New transmission fluid.
   - Lower the vehicle.
   - Fill the transmission to the proper level with DEXRON®-IIE fluid. Refer to "Checking and Adding Fluid" in this section.

Important

- Do not overfill.

6. Check the oil pan gasket for leaks.

GOVERNOR

Remove or Disconnect (Figure 59)

- Raise the vehicle.
- Lower the transmission if needed for clearance, refer to "Transmission Replacement" in this section.

1. Governor cover (46) and the seal or gasket as used.
   - Tap around the cover (46) flange with a punch.

Important

- Do not damage the governor cover. If the cover is damaged it must be replaced.

2. Governor (45).

Clean

- Governor using solvent. Air dry and blow out all passages using dry compressed air.

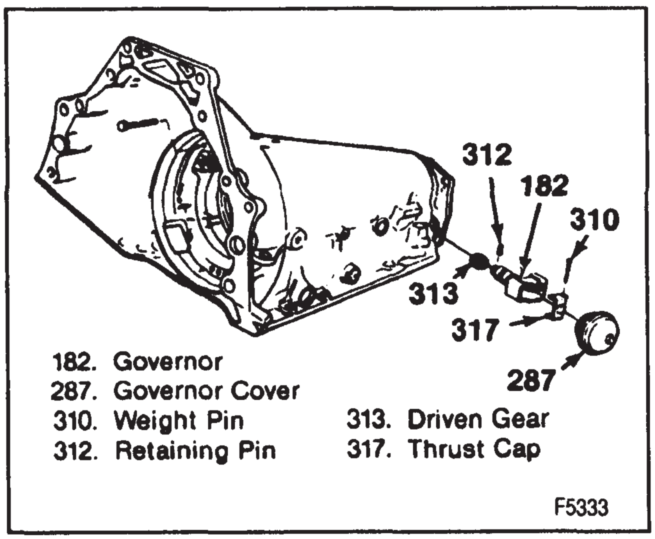


Figure 59—Governor

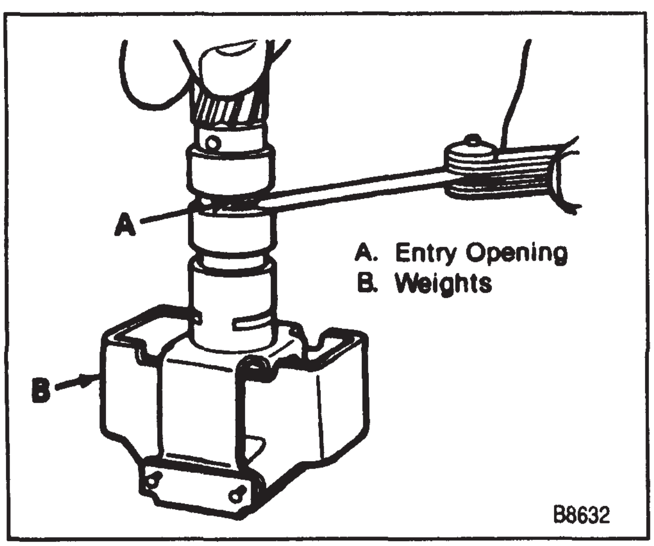


Figure 60—Measuring the Governor Valve Entry Opening

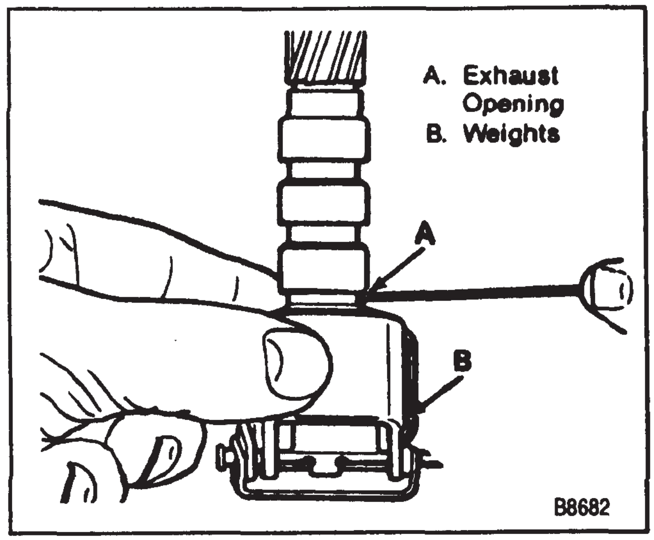


Figure 61—Measuring the Governor Valve Exhaust Opening

Inspect

- All parts for nicks, burrs, scoring, and galling.
- Governor sleeve for binding.
- Governor valve for binding.
- Vehicle speed sensor for loose fit.
- Weight springs for kinks or damage.
- Weights for binding.
- Valve entry opening. With the weights held all the way outward, the opening should be 5.1 mm (0.020 in.) (figure 60).
- Valve exhaust opening. With the weights held all the way inward, the opening should be 5.1 mm (0.020 in.) (figure 61).
- If the weights, sleeve, or valve do not operate freely, disassemble and clean the governor.

Disassemble (Figures 62 and 63)

1. The governor weight pins (84).
   - Cut off one end of each pin to remove them.
2. The thrust cap (85), the weights (108 and 109) and the springs (110 and 111).
3. The valve (107) from the sleeve.
4. The vehicle speed sensor if needed. Refer to "Vehicle Speed Sensor" in this section.
5. Clean the governor parts and inspect for damage.

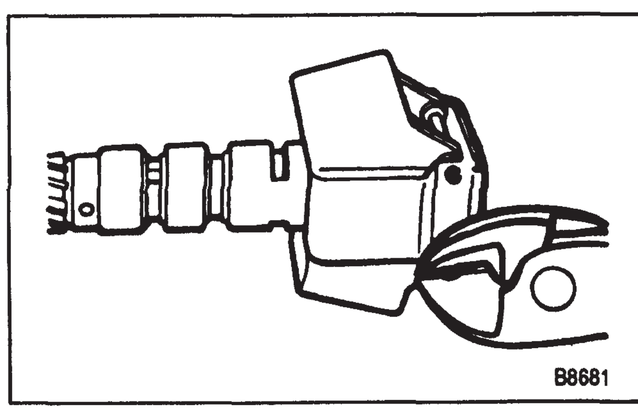
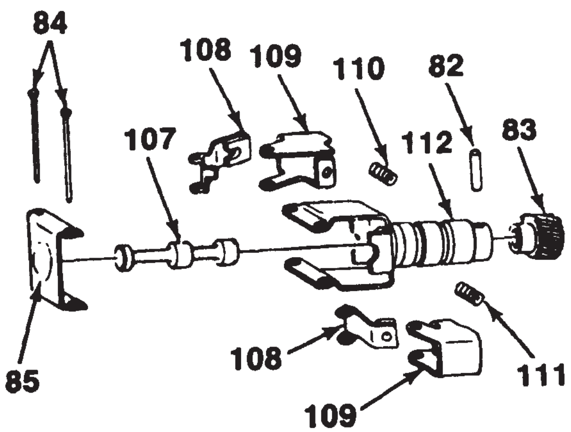


Figure 62—Removing the Governor Weight Pins



82. Governor Gear Retainer Pin
83. Governor Drive Gear
84. Governor Weight Pin
85. Governor Thrust Cap
107. Governor Valve
108. Governor Secondary Weight
109. Governor Primary Weight
110. Governor Primary Weight Spring
111. Governor Secondary Weight Spring
112. Sleeve and Carrier Assembly

F9657

Figure 63—Governor Components

Assemble (Figures 62 and 63)

1. Install vehicle speed sensor, if needed. Refer to "Vehicle Speed Sensor Replacement" in this section.
2. Valve (107) into the sleeve.
3. Springs (110), the weights (108 and 109) and the thrust cap (85) onto the governor, aligning the pin holes.
4. New weight pins (84) and crimp both ends of each pin.

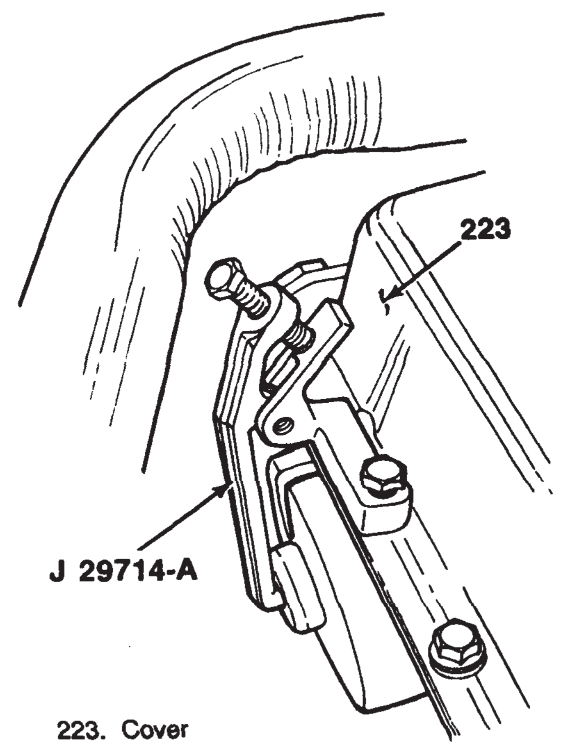
Install or Connect (Figure 59)

1. Governor (45)
2. Governor cover (46) and a new seal or gasket as used.
   - Put a thin coat of Loctite Cup Plug Sealant #11 or equivalent, on the cover (46) flange before installation.
   - Tap the cover into place using a brass drift.
- Raise the transmission if, it was lowered. Refer to "Transmission Replacement" in this section.
- Lower the vehicle.
3. Transmission fluid if needed. Refer to AUTOMATIC TRANSMISSION (SECTION 7A).

2-4 SERVO

Remove or Disconnect (Figures 64 and 65)

Tool Required:
J 29714-A Servo Cover Compressor.



223. Cover

F6996

Figure 64—Removing The Servo Cover

- Raise the vehicle.
- Lower the transmission if needed for clearance. Refer to "Transmission Replacement" in this section.
1. Retaining ring and the cover (15) using J 29714-A.
2. Seal from the cover.
3. 4th apply piston (16).
4. 2nd apply piston assembly (18).
5. Spring (31).

Disassemble (Figures 66 and 67)

Tool Required:
J 22269-01 Piston Compressor.

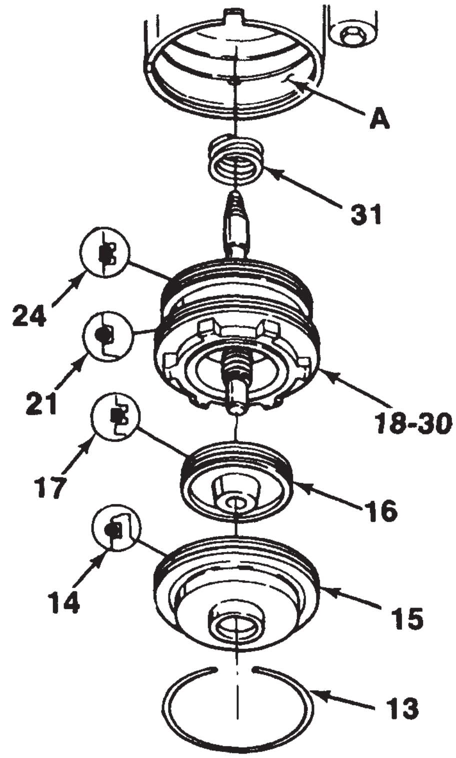
1. Housing (22) from the piston (25).
   - Seal from the housing.
2. Retainer ring from the pin (29).
   - Washer and the spring.
3. Pin (29).
   - Seals from the pin.
4. Retainer ring from the piston (25) using J 22269-01.
   - Retainer and the spring.
   - Seals from the piston.

Clean

- All parts using solvent. Air dry.

Inspect

- Pistons for porosity and damage.
- Seal grooves for damage.
- Cover for porosity and damage.



A. Case Servo Bore
13. Servo Cover Retaining Ring
14. O-Ring Seal (2-4 Servo Cover)
15. 2-4 Servo Cover
16. 4th Apply Piston
17. Oil Ring Seal (4th Apply Piston Outer)
18-30. 2nd Apply Piston Assembly
21. O-Ring Seal
24. Oil Ring Seal (2nd Apply Piston Outer)
31. Servo Spring Return

F9654

Figure 65—2-4 Servo

- Seals for nicks and cuts and binding in the seal grooves.
  — If damage is found, check for the cause of the damage.
- Springs for kinks and bending.
- Pin for wear and burrs.

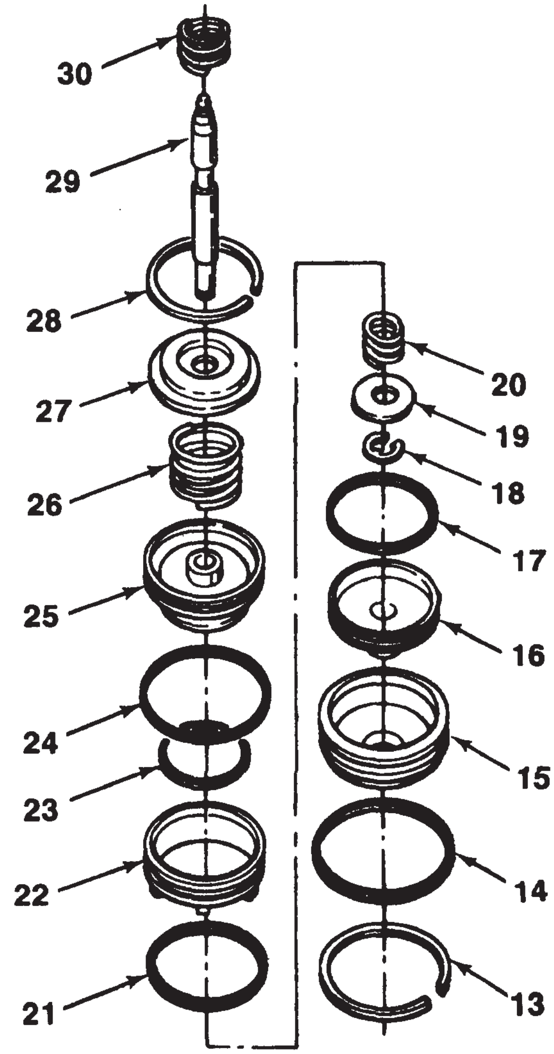
Important

- Check the case servo bore for damage and sharp edges.

Measure (Figures 68 and 69)

Tool Required:
J 33037 Band Apply Pin Tool Vernier calipers or micrometer

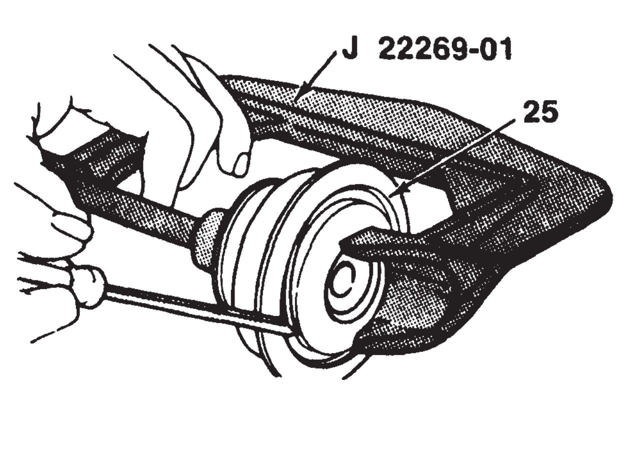
1. Servo pin length (figure 68).
   A. Install pin and J 33037 as shown.
   B. Apply 11.0 N·m (97 in. lbs.) torque and check the gage slot (A).
      — If the white line is seen in the slot, the pin is correct.
      — If the white line is not seen in the slot, replace the pin using the chart (Figure 68).



13. Servo Cover Retaining Ring
14. O-Ring Seal (2-4 Servo Cover)
15. 2-4 Servo Cover
16. 4th Apply Piston
17. Oil Ring Seal (4th Apply Piston Outer)
18. Retainer Ring (Apply Pin)
19. Servo Washer (Apply Pin)
20. Servo Spring (Apply Pin)
21. O-Ring Seal
22. Servo Piston Housing (Inner)
23. Oil Ring Seal (2nd Apply Piston Inner)
24. Oil Ring Seal (2nd Apply Piston Outer)
25. 2nd Apply Piston
26. Servo Spring Cushion
27. Servo Cushion Spring Retainer
28. Retainer Ring (2nd Apply Piston)
29. 2nd Apply Piston Pin
31. Servo Spring Return

F9655

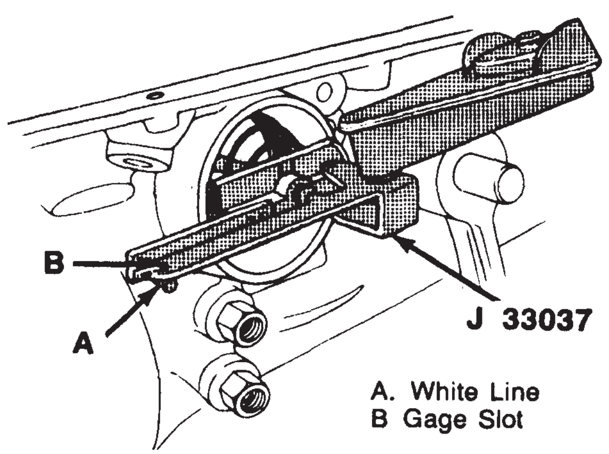
Figure 66—Apply Piston Assembly



25. Second Apply Piston Assembly

F9656

Figure 67—Removing the Retainer Pin



A. White Line
B Gage Slot

Pin is Preset at Factory and Must Not be Readjusted.

2-4 SERVO PIN SELECTION		
PIN LENGTH		PIN I.D.
mm	INCH	
66.37 - 66.67	2.61 - 2.62	2 RINGS
67.74 - 68.04	2.67 - 2.68	3 RINGS
69.11 - 69.41	2.72 - 2.73	WIDE BAND

F9653

Figure 68—Measuring the Servo Pin Length

C. Remove the pin and J 33037.

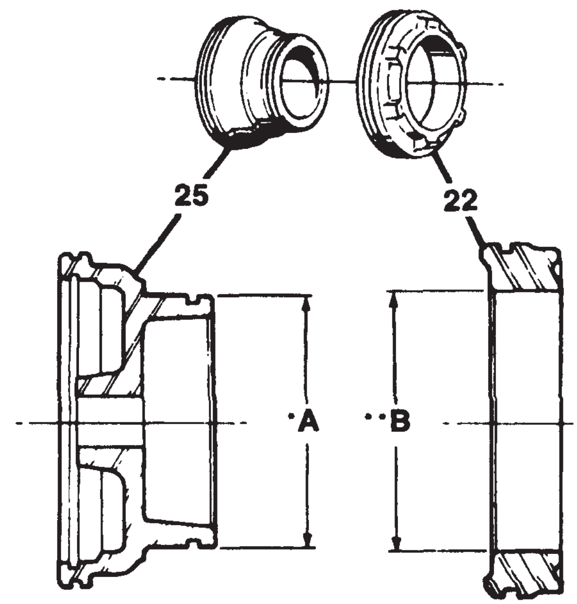
2. Piston and housing dimension (figure 69).
   - Measure the piston dimension (C).
   - Measure the housing dimension (D).
   - Check the chart for the proper dimensions.

Assemble (Figures 66 and 67)

Tool Required:
J 22269-01 Piston Compressor

1. Retainer and the spring in the piston (25).

2ND APPLY PISTON & HOUSING APPLICATION		
MODEL	PISTON DIMENSION *A	HOUSING DIMENSION **B
YDM.	44.64 mm (1.78")	45.54 mm (1.79")
FKM, FXM, MFM, MPM, MWM, MZM, PAM, PBM, PCM, TNM, TUM, TXM, YMM, YUM, YZM	57.85 mm (2.28")	58.74 mm (2.31")
FMM, HBM, HDM, MAM, MCM, MDM, MFM, MKM, MLM, MRM, MTM, MXM, PRM, THM, TJM, TKM, TLM, YNM, YPM, YTM, YXM	63.10 mm (2.48")	64.00 mm (2.52")



22. Inner Servo Piston Housing
25. 2nd Apply Piston

F9658

Figure 69—2nd Apply Piston and Housing Dimensions

- New seals on the piston.
- Retainer ring using J 22269-01.

2. Pin (29).
   - New seals on the pin.
3. Retainer ring on the pin.
   - Spring and the washer.
4. Housing (22) on the piston (25).
   - New seal on the housing.

Important

- Be sure the seals are correctly positioned (figure 66).

Install or Connect (Figures 66 and 67)

Tool Required:
J 29714-A Servo Cover Compressor

1. Spring (31).
2. 2nd apply piston assembly (18).
3. 4th apply piston (16).
4. New seal on the cover.

5. Cover (15) and the retaining ring using J 29714-A.
   • Raise the transmission if needed. Refer to "Transmission Replacement" in this section.
   • Lower the vehicle.
6. Transmission fluid if needed. Refer to AUTOMATIC TRANSMISSIONS (SECTION 7A).

FILLER TUBE REPLACEMENT

Remove or Disconnect (Figure 70)

1. Negative (-) battery cable.
2. Transmission dipstick (101).
3. Air cleaner.
4. Bolt (102) from the tube bracket (103).
   • *Raise the vehicle.*
5. Filler tube (104) from the transmission.
   • Pull filler tube (104) up from the transmission.
6. Filler tube seal (105) from the filler tube (104).

Clean

• Metal parts using solvent. Do not allow solvent to enter the transmission. Air dry.

Install or Connect (Figure 70)

1. New filler tube seal (105) into the transmission case (106).
2. Filler tube (104) into the filler tube seal (105).

NOTICE: See "Notice" on page 7A1-1.

3. Tube bracket bolt (102).

Tighten

• Bolt (102) to 32 N.m (23 lbs. ft.).
• Lower the vehicle.

4. Air cleaner.
5. Transmission dipstick (101).
6. Negative (-) battery cable.

AUXILIARY VALVE BODY

Remove or Disconnect (Figure 71)

1. Negative (-) battery cable.
   • *Raise vehicle and suitably support.*
   • Place drain pan under transmission oil pan.
2. Oil pan bolts from the front and sides only.
   • Loosen rear bolts approximately four turns.

NOTICE: Do not damage transmission case or oil pan sealing surfaces while removing.

• Lightly tap oil pan with rubber mallet or pry to allow fluid to drain.

3. Remaining oil pan bolts, oil pan, and gasket.
4. Oil filter and O-ring.
   • O-ring may be stuck in case.
5. Tube clamp (97).
6. Tube (96).

101. Transmission Dipstick
102. Bolt
103. Tube Bracket
104. Filler Tube
105. Filler Tube Seal
106. Transmission Case

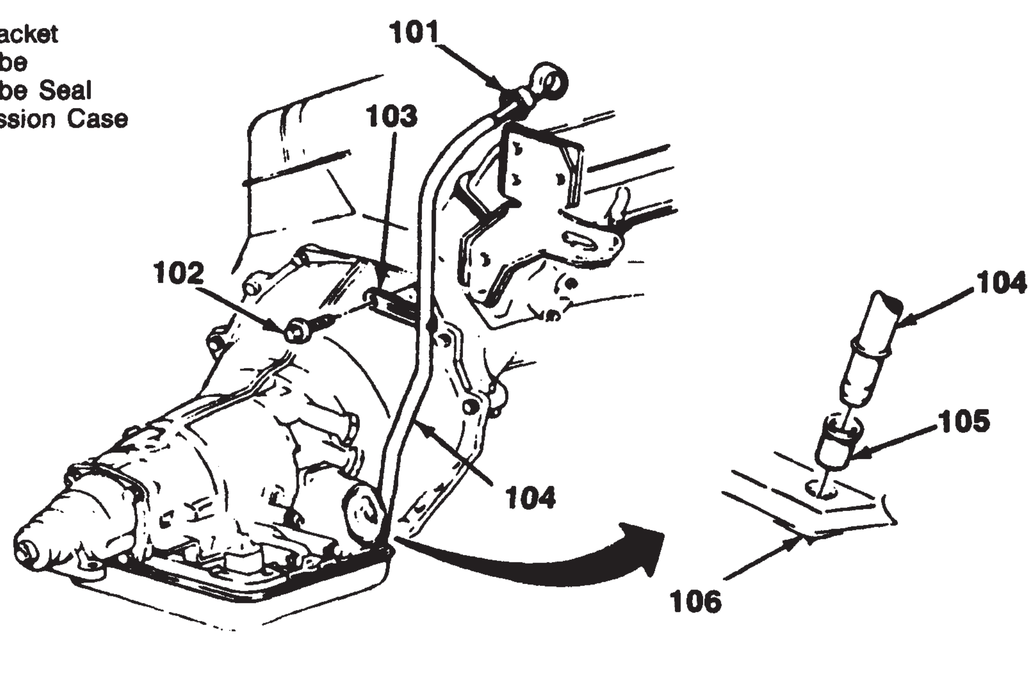


Figure 70—Filler Tube Replacement

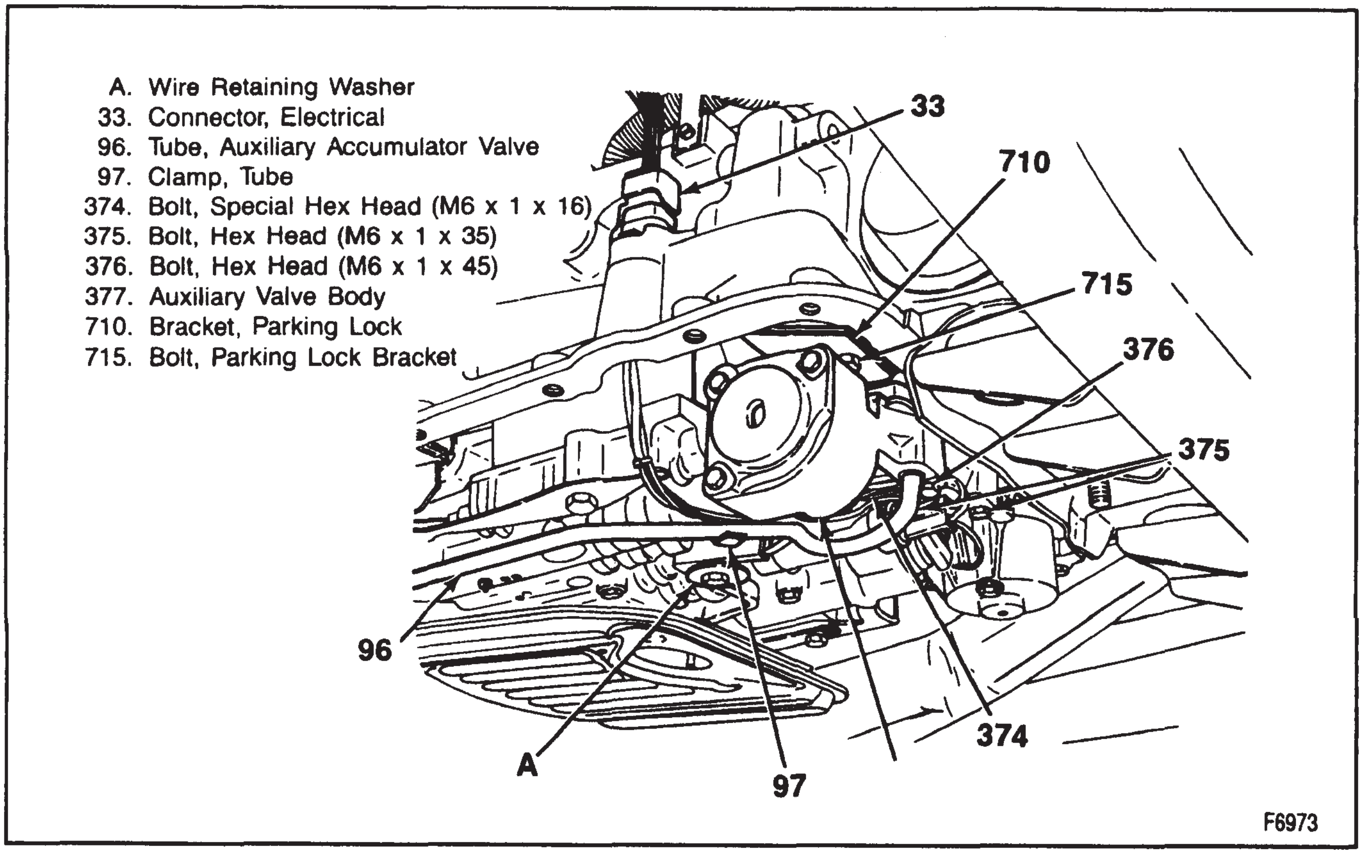


Figure 71—Auxiliary Valve Body

7. Bolts (374 thru 376), auxiliary valve body (377), and check ball.

Inspect

- Refer to the Light Duty Truck Unit Repair Manual for disassembly and inspection procedures.

Install or Connect

NOTICE: For steps 2 and 7, see "Notice" on page 7A1-1.

1. Check ball in valve body.
   - If necessary, use TRANSJEL® J 36850 or equivalent jelly to hold in place.
2. Auxiliary valve body to valve body with bolts (374 thru 376).

Tighten

- Bolts to 11 N·m (97 in. lbs.).

3. Tube (96).
4. Clamp (97).
5. New oil filter and O-ring.
   - Coat O-ring with TRANSJEL® J 36850 or equivalent jelly.
6. Oil pan with new gasket.
   - All traces of old gasket material must be removed from case and pan.
7. Oil pan bolts (74).

Tighten

- Bolts (74) to 20 N·m (15 ft. lbs.).
- Lower vehicle.

8. Negative (-) battery cable.

Adjust

- Fluid level, see Section 7A.
  - DEXRON®-IIE Automatic Transmission Fluid.
  - Inspect for leaks.

VALVE BODY

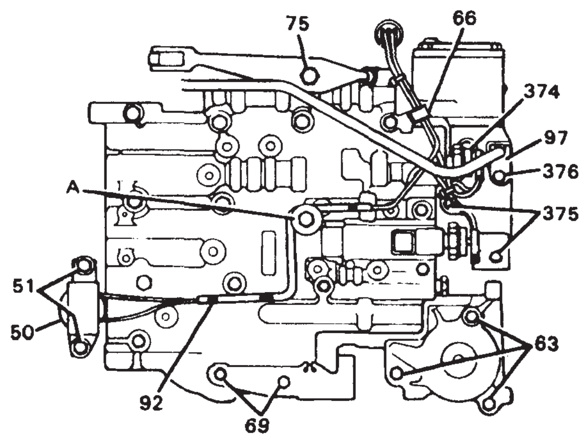
Remove or Disconnect (Figures 72 and 73)

1. Negative (-) battery cable.
2. TV cable at throttle lever.
   - Raise vehicle and support with suitable safety stands.
   - Place drain pan under transmission oil pan.
3. Oil pan bolts from the front and sides.
   - Loosen rear oil pan bolts approximately 4 turns.

Important

- Do not damage transmission case or oil pan seating surfaces.
- Lightly tap oil pan with rubber mallet or pry to allow fluid to drain.

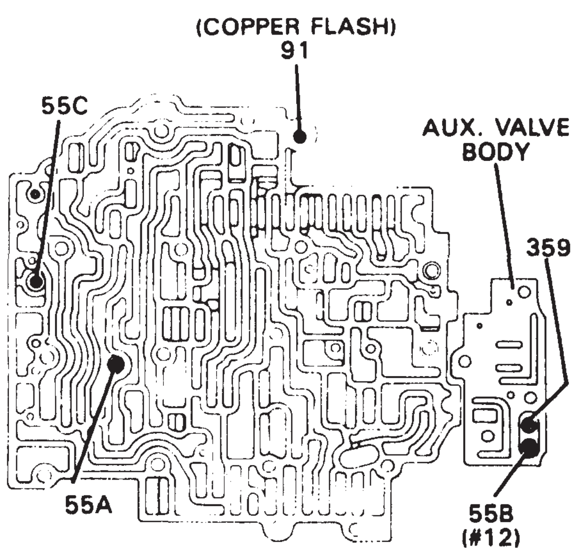
4. Remaining oil pan bolts, oil pan and gasket.
5. Oil filter and O-ring.
   - O-ring may be stuck in case.



A WASHER WIRE RETAINER
50 SOLENOID ASSEMBLY
51 BOLT, HEX WASHER HEAD (SOLENOID)
63 BOLT, ACCUMULATOR COVER
66 CLIP, ELECTRICAL WIRE
69 BOLT, VALVE BODY
75 BOLT, MANUAL DETENT SPRING
92 CONDUIT, SOLENOID WIRE
97 CLAMP, AUXILIARY TUBE
374 BOLT, SPEC. HEX WASHER HEAD (M6 X 1 X 18)
375 BOLT, HEX HEAD (M6 X 1 X 35)
376 BOLT, HEX HEAD (M6 X 1 X 45)

F7174

Figure 72—Valve Body Bolt Locations



55A #2 CHECKBALL (3RD CLUTCH ACCUM.)
55B #12 CHECKBALL (FORWARD CLUTCH)
55C #6 CHECKBALL (DRIVE 3)
91 #10 CHECKBALL (T.V. EXHAUST)
359 CUP PLUG – ORIFICE

F7184

Figure 73—Valve Body Checkball Locations

6. Valve body bolts.
   - Manual control valve link from range selector inner lever.
   - Throttle lever bracket from TV link.
   - Spacer plate and check balls.

Clean

- Oil pan and case of gasket material.
- Valve body components.

Inspect

- Refer to the Light Duty Truck Unit Repair Manual for disassembly and inspection procedures.

Install or Connect

1. Valve body, spacer, check balls, and bolts as outlined in the Light Duty Truck Unit Repair Manual.
2. New O-ring seal and oil filter.
   - Coat O-ring seal with TRANSJEL® J 36850 or equivalent.

NOTICE: See "Notice" on page 7A1-1.

3. New gasket (72), oil pan (73), and bolts (74).

Tighten

- Bolts (74) to 11 N.m (97 in. lbs.).

4. Lower vehicle.
5. Negative (-) battery cable.

Adjust

- Fluid level, Refer to (SECTION 7A).
  - DEXRON®-IIE Automatic Transmission Fluid.
  - Inspect for leaks.

VALVE BODY PRESSURE SWITCH REPLACEMENT

Remove or Disconnect (Figure 74)

1. Negative (-) battery cable.
   - Raise vehicle and suitably support.
2. Transmission oil pan (73).
3. Transmission oil filter (71) and O-ring seal(70).

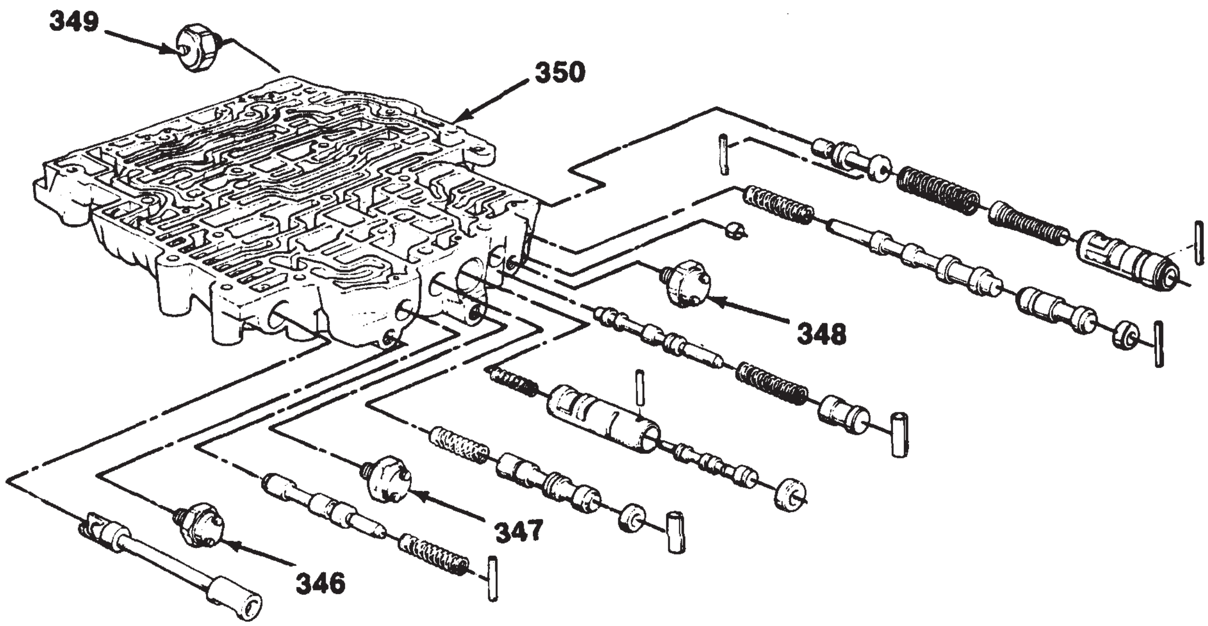
Clean

- Gasket material from oil pan and case.
- Valve body components.

4. Pressure switch (346, 347, 348, or 349).

Install or Connect (Figure 74)

1. New pressure switch (346, 347, 348, or 349).
2. New transmission oil filter (71) and O-ring seal (70).
3. Transmission oil pan (73).



346. Switch Asm., Pressure (3rd Clutch)
347. Switch Asm., Pressure (4-3 Pulse)
348. Switch Asm., Pressure (4th Clutch)
349. Switch Asm., Pressure (T.C.C. Signal)
350. Valve Body

F7183

Figure 74—Pressure Switch Location

NOTICE: See "Notice" on page 7A1-1.

4. Transmission oil pan bolts (74).

Tighten

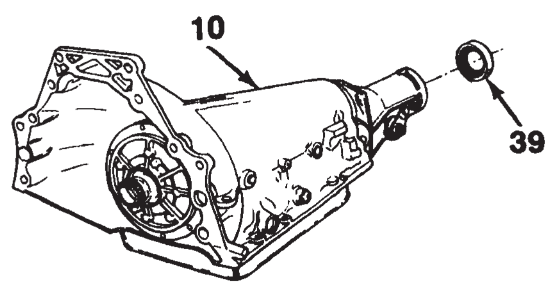
- Bolts (74) to 11 N·m (97 in. lbs.).

5. Transmission fluid. Refer to "Specifications" for the proper amount.
6. Lower the vehicle.
7. Negative (-) battery cable.

REAR EXTENSION OIL SEAL

Remove or Disconnect (Figure 75)

- Raise the vehicle and support with suitable safety stands.
  1. Skid plate, if used.
  2. Transmission fluid.
  3. Propeller shaft. Refer to PROPELLER SHAFT (SECTION 4A).
  4. Seal (39).



10. Transmission Case
39. Case Extension Oil Seal Assembly

F9663

Figure 75—Rear Oil Extension Seal

Install or Connect (Figure 75)

Tool Required:
J 21426 Extension Housing Oil Seal Installer.

1. New seal using J 21426.
   - Coat the outer edge of the seal case with a non-hardening sealer.

2. Propeller shaft. Refer to PROPELLER SHAFT (SECTION 4A).
   • Lower the vehicle.
3. New transmission fluid. Refer to "Specifications" for the proper amount.
4. Skid plate, if used.

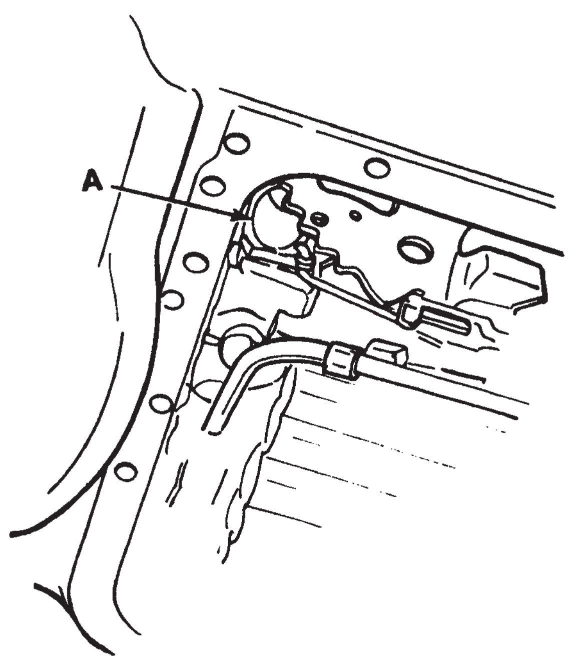
PRESSURE REGULATOR VALVE

Remove or Disconnect (Figures 76 and 77)

1. Negative (-) battery cable.
   • Raise vehicle and suitably support.
   • Drain transmission oil pan.
2. Oil pan and screen.
   • Compress pressure regulator valve with small screwdriver.
3. Retaining ring and slowly release spring tension.
4. Pressure regulator bore plug, valve, spring, and guide. Refer to the Light Duty Truck Unit Repair Manual for inspection procedures.

Install or Connect

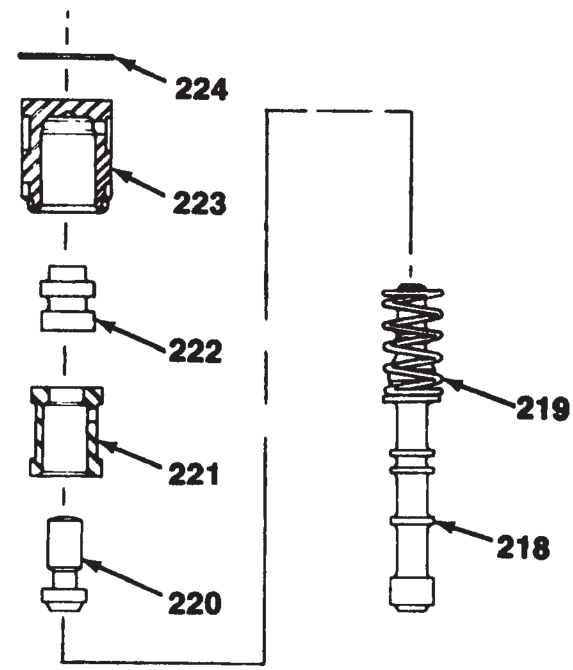
1. Pressure regulator valve assembly.
   • Compress valve and insert retaining ring.
2. Oil pan and screen, using a new gasket.
   • Lower vehicle.
3. Negative (-) battery cable.



A. Pressure Regulator Valve Access Hole

F7141

Figure 76—Pressure Regulator Valve Location



218. Pressure Regulator Valve
219. Pressure Regulator Valve Spring
220. Reverse Boot Valve
221. Reverse Boot Valve Sleeve
222. T.V. Boost Valve
223. T.V. Boost Bushing
224. Oil Pump Reverse Boot Valve Retaining Ring

F7181

Figure 77—Pressure Regulator Valve and Components

Adjust

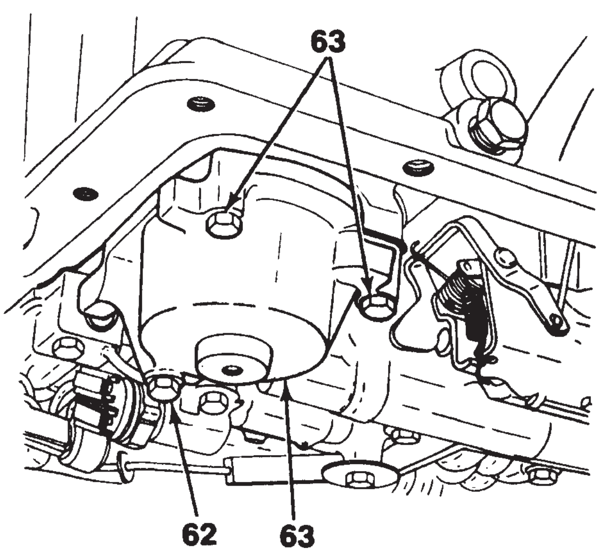
• Fluid level, Refer to Automatic Transmission (SECTION 7A).
   • DEXRON®-IIE Automatic Transmission Fluid.
   • Inspect for leaks.

ACCUMULATOR ASSEMBLY

Remove or Disconnect (Figures 78, 79, 80)

• Raise the vehicle and support it using suitable safety stands.
• Place a drain pan under transmission oil pan.

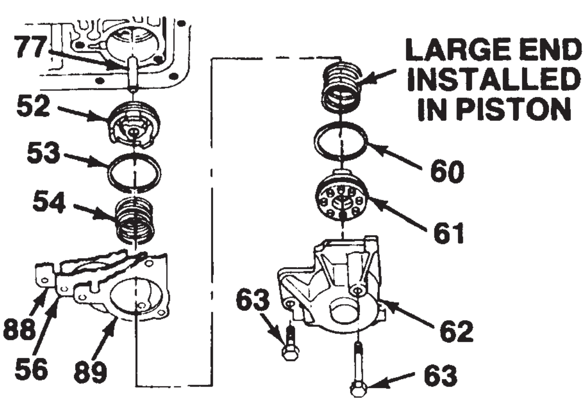
1. Transmission oil pan.
2. Accumulator cover bolts (63).
3. Cover (62).
4. 1-2 accumulator piston (61).
5. Oil seal ring (60).
6. 1-2 accumulator spring (59).
7. Spacer plate from valve body gasket (89).



62. Accumulator Cover
63. Accumulator Cover Bolts

F7176

Figure 78—Accumulator Cover Location



52. Piston, 3-4 Accumulator
53. Ring, Oil Seal (3-4 Accumulator Piston)
54. Spring, 3-4 Accumulator
56. Plate, Valve Body Spacer
59. Spring, 1-2 Accumulator (Conical)
60. Ring, Oil Seal (1-2 Accum. Piston)
61. Piston 1-2 Accumulator
62. Cover & Pin Assembly, 1-2 Accum.
63. Bolt, Accumulator Cover
77. Pin, Accumulator Piston
88. Gasket, Spacer Plate to Case
89. Gasket, Spacer Plate to Valve Body

F7177

Figure 79—1-2 and 3-4 Accumulator Assembly

MODELS	1-2 ACCUMULATOR SPRING COLOR	3-4 ACCUMULATOR SPRING COLOR
MHM, MPM, MWM, MZM, PAM, PBM, PCM, TNM, TUM, TXM	ORANGE	VIOLET
FMM, MAM, MRM, MXM	ORANGE	DK. GREEN
MDM, MKM, MLM, TJM, TKM	ORANGE	RED
FKM, FXM, YDM, YMM, TUM	YELLOW	YELLOW
MCM, PRM, YPM THM, TLM	YELLOW DK. GREEN	RED LT. BLUE
YTM, YZM	YELLOW	VIOLET
HBM	VIOLET	YELLOW
HDM	DK. GREEN	DK. GREEN
YNM	DK. GREEN	YELLOW
YXM	DK. GREEN	DK.GREEN

F7178

Figure 80—Accumulator Spring Chart

8. Valve body spacer plate (56).
9. Spacer plate case gasket (88).
10. 3-4 accumulator spring (54).
11. Oil seal ring (53).
12. 3-4 accumulator piston (52).
13. Accumulator piston pin (77).

Inspect

- The 1-2 accumulator cover (62) for:
  - — Porosity or damage.
  - — Scored piston wall.
  - — Plugged oil passage.
- The 1-2 accumulator piston (61) and the 3-4 accumulator piston (52) for:
  - — Porosity
  - — Ring groove damage.
  - — Pin hole damage.
- 1-2 accumulator spring (59) and 3-4 accumulator spring (54) for distortion or damage.
- Spacer plate (56) and gaskets (88 and 89) for damage.

Install or Connect (Figures 78, 79, and 80)

NOTICE: For Steps 12 and 15 see "Notice" on page 7A1-1.

1. Accumulator piston pin (77).
2. 3-4 accumulator piston (52).
3. Oil seal ring (53).
4. 3-4 accumulator spring (54).
5. Spacer plate to case gasket (99).
6. Valve body spacer plate (56).
7. Spacer plate to valve body gasket (90).
8. 1-2 accumulator spring (59).
9. Oil seal ring (60).
10. 1-2 accumulator piston (61).
11. Cover (62).
12. Accumulator cover bolts (63).

Tighten

- Bolts (63) to 11 N.m (97 in. lbs.).

13. Transmission oil pan (73).
14. Transmission pan gasket (72).
15. Transmission oil pan to case bolts (74).

Tighten

- Bolts (63) 11 N.m (97 in. lbs.).
- Lower the vehicle.

16. New transmission fluid. Refer to "Specifications" for the proper amount.

VEHICLE SPEED SENSOR REPLACEMENT

Remove or Disconnect (Figure 81)

Tool Required:
J 38417 Speed Sensor Remover and Installer.

1. Harness connector (101).
2. Bolt (100).
3. Vehicle speed sensor (99) using J 38417.
   - Have a suitable container to catch the fluid.
4. O-ring seal (42).

Install or Connect

Tool Required:
J 38417 Speed Sensor Remover and Installer

1. New speed sensor (99) and O-ring seal (42) using J 38417.
   - Coat the seal with a thin film of transmission fluid.

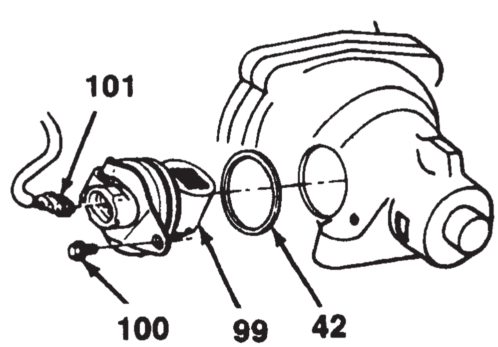
NOTICE: See "Notice" on page 7A1-1.

2. Bolt (100).

Tighten

- Bolt to 11 N.m (97 in. lbs.).

3. Harness connector (101).
   - Refill fluid as required.



42. O-ring Seal
99. Vehicle Speed Sensor (VSS)
100. Bolt
101. Harness Connector

F9542

Figure 81—Vehicle Speed Sensor

TRANSMISSION REPLACEMENT

If the transmission is being lowered for clearance, perform steps 1-9 only.

Remove or Disconnect (Figure 82)

Tool Required:
J 21366 Converter Holding Strap

1. Negative (-) battery cable.
2. Air cleaner, and the TV cable from the throttle linkage, if the transmission is being removed.
   - Raise the vehicle on a hoist.
3. Transmission fluid.
4. Shift linkage.
5. Relieve fuel system pressure and remove fuel lines. Refer to the 1992 Light Duty Fuel and Emissions Manual if are using X-9229 and to the Fuel and Emissions section at the rear of this manual if your are using ST 369-92.
6. Propeller shaft. Refer to PROPELLER SHAFT (SECTION 4A).
   - Front propeller shaft, if used, from the transfer case.
7. The support bracket at the catalytic converter.
   - Any other components as needed for clearance.
   - Support the transmission, and the transfer case, if used, with a transmission jack.
8. Transmission crossmember.

Important

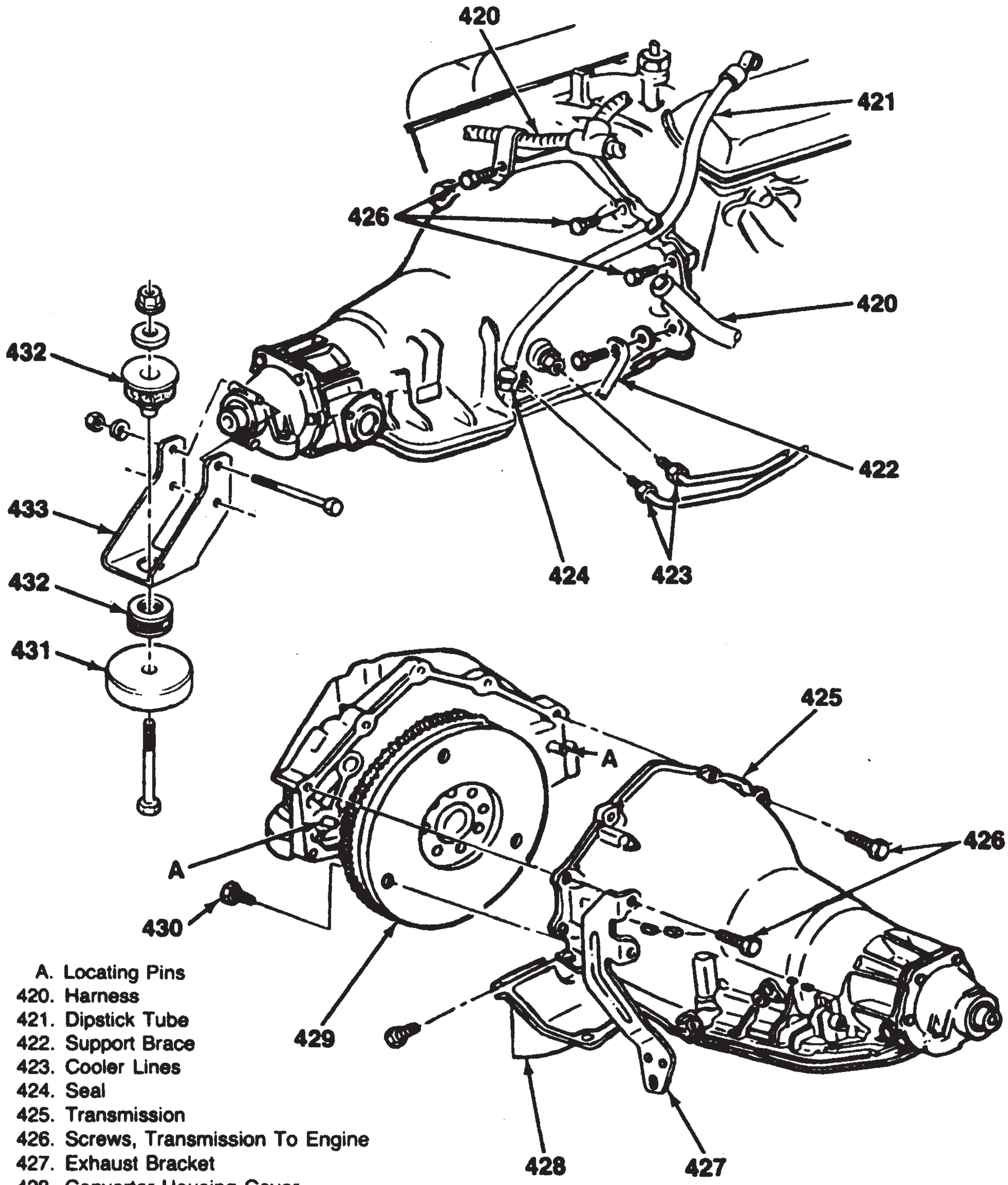
- Do not stretch or damage any cables, wires, or other components when lowering the transmission.

9. Transmission and lower far enough for clearance to reach other components.
10. Dipstick tube (421) and the seal.
    - Cover the opening in the transmission.
11. Speedometer harness connector
12. Vacuum modulator line, if used.
13. Electrical connectors from the transmission.
14. Cooler lines (423).
    - Cap all openings in the transmission and the lines.
15. Transfer case shifter and move it aside, refer to TRANSFER CASE (SECTION 7D).
16. Transmission support braces (422).
    - Note the location of the braces, they must be installed in the same positions.
17. Converter housing cover (428).
    - Mark the flywheel and the torque converter alignment.
18. Screws (430).

Important

- Support the engine with a jack stand before disconnecting the transmission.

19. Screws (426).
    - Note the location of any brackets or clips and move them aside.
    - Slide the transmission straight back of the locating pins (A) and install J 21366.



A. Locating Pins
420. Harness
421. Dipstick Tube
422. Support Brace
423. Cooler Lines
424. Seal
425. Transmission
426. Screws, Transmission To Engine
427. Exhaust Bracket
428. Converter Housing Cover
429. Flywheel
430. Screw, Flywheel To Torque Converter
431. Dampener
432. Insulator
433. Support

Figure 82—Transmission and Components

20. Transmission (425) from the vehicle.

Clean

- Transmission case using a solvent dampened cloth. Do not allow solvent to enter the transmission. Air dry.
- All hardware and flywheel cover using solvent. Air dry.

Inspect

- All parts for wear and damage.
- All seals and fittings for signs of leakage.
- Torque converter for stripped or broken weld nuts or screw holes.
- Transmission case for porosity.

Install or Connect (Figure 82)

NOTICE: For steps 2 and 3 see "Notice" on page 7A1-1.

- If the transmission was lowered for clearance only, perform steps 13-20.

  Tool Required:

  J 21366 Converter Holding Strap

1. Transmission (425).
   - Be sure the torque converter is seated properly and that J 21366 is in place.
   - Support the transmission, and the transfer case if used, with a transmission jack.
   - Raise the transmission into place and remove J 21366.
   - Slide the transmission straight onto the locating pins (A) while lining up the marks on the flywheel and the torque converter.

Important

   - The torque converter must be flush onto the flywheel and rotate freely by hand.
2. Screws (426).
   - All brackets, clips, and harnesses must be positioned as they were when removed.
   - Do not install the dipstick tube or the transmission support brace screws.
3. Screws (430).

Tighten

   - Screws finger tight to insure proper converter seating.
   - Screws (430) to 68 N.m (50 ft. lbs.).
   - Remove the engine hoist or jack.
4. Converter housing cover (428).
   - Hook the cover under the lip of the engine oil pan.
5. Transmission support braces (422).
   - The braces must be installed in the positions form which they were removed.
6. Transfer case, shifter, refer to TRANSFER CASE (SECTION 7D).
7. Cooler lines (423).
   - Uncover the openings.
   - Do not twist or bend the lines.
8. Vacuum modulator line, if used.
9. Speedometer harness connector.
10. Electrical connectors to the transmission.
11. Dipstick tube (421) with a new seal.
    - Uncover the opening and install the seal first.

NOTICE: See "Notice" on page 7A1-1.

    - Install screw (426).

Tighten

    - 32 N.m (23 ft. lbs.).
12. Transmission in place.

Important

    - Do not pinch or damage any cables, wires or other components when raising the transmission.
13. Transmission crossmember and the transmission mount.
    - Any components that were removed for clearance.
    - Remove the transmission jack.
14. The support bracket at the catalytic converter.
15. Propeller shaft, refer to PROPELLER SHAFT (SECTION 4A).
    - Front propeller shaft to the transfer case, if used.
16. Fuel lines. Refer to the 1992 Light Duty Fuel and Emissions Manual if are using X-9229 and to the Fuel and Emissions section at the rear of this manual if your are using ST 369-92.
17. Shift linkage.
    - Lower the vehicle.
18. New transmission fluid.
19. Air cleaner, and the TV cable, if removed.
20. Negative (-) battery cable.

TRANSMISSION COOLER FLUSHING

Transmission oil cooler flushing must be performed whenever a transmission is removed for service. It is essential to flush the oil cooler after transmission installation, after a major overhaul, if fluid contamination is suspected, or in any case of pump or torque converter replacement.

The recommended procedure to flush the transmission cooler after the overhauled or replacement assembly has been installed in the vehicle is as follows.

Tools Required:

J 35944 Cooler Flushing Tool

J 35944-20 or J 35044-CSE Biodegradable Flushing Solution

Preparation

1. After overhauled or service replacement transmission is reinstalled in vehicle, do not reconnect oil cooler pipes.

2. Remove fill cap on J 35944 and fill can with 0.6 liter (20-21 ounces) of flushing solution. Do not overfill, or tool will need to be recharged with air before backflush. Follow manufacturer's suggested procedures for proper handling of solution.

NOTICE: Do not substitute with any other solution. The flushing tool is deigned to use only this concentrate. Use of any solution can result in damage to the tool, cooler components, or improper flushing of the cooler.

3. Secure fill cap and pressurize the flusher can with shop air to 550-700 kPa (80-100 psi).

CAUTION: Shop air supply must be equipped with a water/oil filter and not exceed 825 kPa (120 psi), or personal injury may result.

4. Connect the discharge hose to the transmission end of the oil cooler pipe that goes to the top fitting at the radiator.
5. Clip discharge hose onto the oil drain container.
6. Mount the flushing tool to undercarriage of vehicle with the hook provided and connect the hose from the flushing tool to the remaining oil cooler pipe.
7. With the water valve on the tool in the off position, connect the water hose from the water supply to the tool.
8. Turn on the water supply at the faucet.

Initial Flush

9. Switch the water valve on the tool to the on position. Allow the water to flow through the oil cooler for 10 seconds to remove the supply of transmission fluid in the system.

CAUTION: If water does not flow through the oil cooler (system is completely plugged), do not continue flushing procedure. Turn the water off immediately and inspect the pipes and cooler for restrictions and repair, or personal injury could result.

10. Switch the water valve on the tool to the off position and clip the discharge hose onto a five gallon pail with a lid, or position a shop towel over the end of the discharge hose to prevent splash. Discharge will foam vigorously when solution is introduced into water stream.
11. Switch the water valve on the tool to the on position and depress the trigger to mix flushing solution into the water flow. Use the bale clip provided on the handle to hold the trigger down.
12. Flush oil cooler with water and solution for two minutes. During this flush, attach the air supply to the air valve located on plumbing of tool for 3 to 5 seconds at the end of every 15-20 second interval to create a surging action.

CAUTION: Shop air supply must be equipped with a water/oil filter and not exceed 825 kPa (120 psi), or personal injury could result.

13. Release the trigger and switch the water valve on the tool to the off position.
14. Disconnect both hoses form the oil cooler pipes.

Backflush

15. Connect hoses to the oil cooler pipes opposite from the initial flush procedures to perform a backflush.
16. Repeat steps 11 and 12.
17. Release the trigger and allow water only to rinse the oil cooler for one minute.
18. Switch the water valve on the tool to the oil position and turn the water supply off at the faucet.
19. Attach air supply to the air valve located on plumbing of tool and dry the system out with air for at least two minutes. If moisture is visible exiting from the oil cooler line discharge hose. Use an air chuck clip, if available, to secure the air chuck onto the air valve for ease of operation.

NOTICE: Excessive residual moisture can cause corrosion in the oil cooler or cooler pipes and can damage the transmission. If steps 20 through 23 cannot be completed at this time, rinse the oil cooler and cooler pipes with transmission fluid. Complete steps 20 through 23 after reinstallation of transmission.

20. Connect the cooler feed pipe to the transmission bottom connector.
21. If not already connected, attach the discharge hose to the cooler return pipe (top connector) and place into an appropriate drain container.
22. After filling the transmission with automatic transmission fluid, start the engine and run for 30 seconds. This will remove any residual moisture from the oil cooler and cooler pipes, protect all components from corrosion and check flow rate through the cooler. A minimum of two (2) quarts must be obtained during this 30 second run. If fluid flow is insufficient, check the fluid flow out of the transmission by disconnecting the oil cooler feed line at the radiator and restarting the engine.

Do the following according to flow rate:

- Insufficient Feed Flow: Inspect the transmission for cause.
- Sufficient Feed Flow: Inspect oil cooler pipes and fittings for restrictions or leaks and repeat the oil cooler flushing procedure. Repeat the check of fluid flow out the return line and if flow is still inhibited, replace the oil cooler.

23. Remove discharge hose, reconnect cooler return pipe to transmission and refill unit to proper fluid level.

Tool Cleaning - Every Third Use

24. Disconnect the water supply hose from the tool.
25. Bleed air pressure from the can, remove fill cap, return any unused solution to container, and rinse the can out with water. Do not store tool with solution in tank.

Tool Cleaning - Every Third Use

26. Loosen large coupling nut and remove plumbing from tank.
27. Remove screen from plumbing and wash with water.

28. Use the cleaning pin to remove any material in the solution orifice. Orifice is located in plumbing below screen.
29. Reconnect the plumbing and fill can half with water, secure the fill cap, and pressurize the can to 550-700 kPa (80-100 psi).
30. Aim tool into the five gallon pail or floor drain and depress the trigger to allow water from the can to flow through the solution orifice for 30 seconds to ensure proper cleaning.
31. Bleed air pressure from can, remove the fill cap, and empty the can.
32. Reconnect fill cap flushing tool.

SHIFT INDICATOR REPLACEMENT

Remove or Disconnect (Figure 83)

1. Indicator needle cable (2) from the steering column (4).
2. Shift indicator (1).

Install or Connect (Figure 83)

1. New shift indicator (1)
2. Indicator needle cable (2) to steering column (4).
3. Adjust as necessary. Refer to "Shift Indicator Adjustment" in this section.

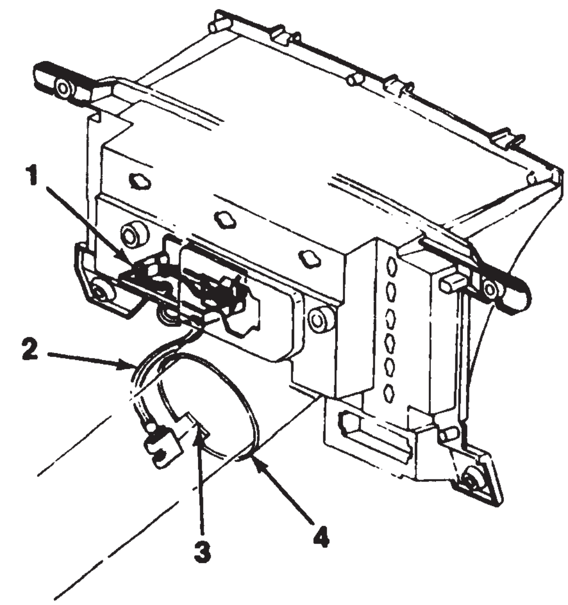
SHIFT INDICATOR ADJUSTMENT

Important

- Care must be taken to assure that the cable rests on the shift bowl and not on the column jacket.
- The wheels must be chocked if the vehicle is on the ground.

Install or Connect (Figure 83)

1. Steering column attachment should be completed.



1. Shift Indicator
2. Indicator Needle Cable
3. Shift Bowl Notch
4. Steering Column

Figure 83—Shift Indicator

2. Attach the indicator needle cable (2) to shift bowl notch (3).
3. When the transmission is shifted into neutral, check for the proper operation of the indicator pointer. The indicator pointer should be centrally located on "N" (NEUTRAL).
4. If indicator pointer is not centered go back to steps 2 and 3.

SPECIFICATIONS

FASTENER TORQUE

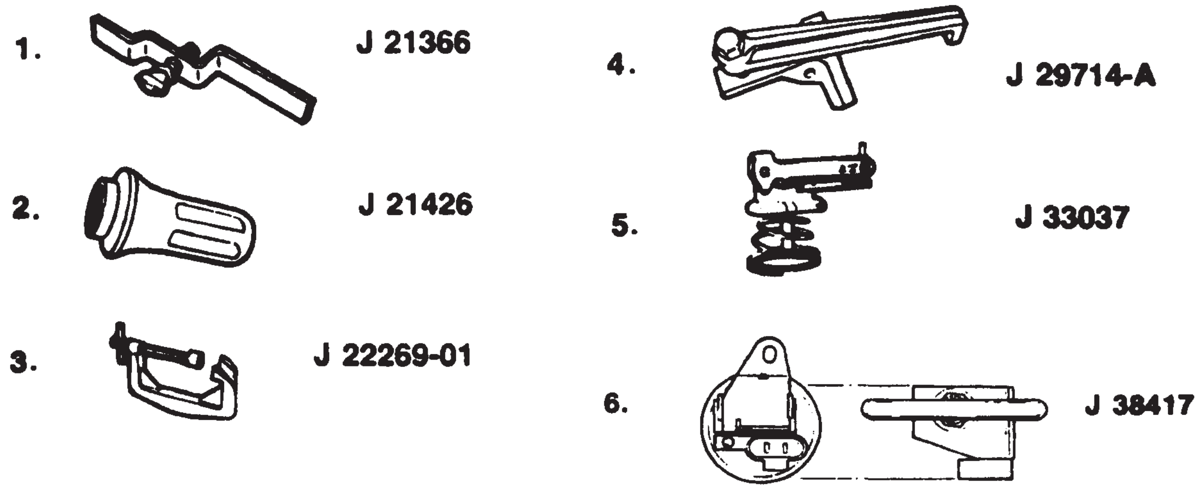
	N·m	Ft. Lbs.	In. Lbs.
Shift Linkage	39	30	—
Swivel to Equalizer Lever	39	30	—
Shift Lever to Transmission	27	20	—
Bracket to Frame	23	17	—
TV Cable	9	—	80
Cooler Lines to Transmission	24	18	—
Cooler Lines to Radiator	24	18	—
Transmission Support Braces	60	44	—
Converter Housing Cover	10	—	88
Transmission to Engine	32	23	—
Dipstick Tube To Engine	32	23	—
Converter to Flywheel	63	46	—
Crossmember to Frame	35	25	—
Transmission Rear Mount to Crossmember	52	38	—
Accumulator Cover to Case (M6-1.0 x 35.0)	11	—	97
Detent Spring to Valve Body	22	16	—
Valve Body to Case	11	—	97
Oil Passage Cover to Case	11	—	97
Solenoid Assembly to Pump	11	—	97
Transmission Oil Pan to Case	11	—	97
Pressure Switches	11	—	97
Auxiliary Valve Body to Case	11	—	97
Case Extension to Case	34	25	—
Manual Shaft to Inside Detent Lever	31	23	—
Pressure Plugs (1/8-27)	11	—	97
Pressure Plugs (1/4-18)	24	18	—
Connector Cooler Pipe	38	28	—

LUBRICATION

Capacity		
—Pan Removal		
4L60	4.7 L	5 qts.
—Overhaul		
4L60	10.6 L	11 qts.
Type Recommended DEXRON®II E		

T2755

SPECIAL TOOLS



1. Converter Holding Strap
2. Extension Housing Oil Seal Installer
3. Piston Compressor
4. Servo Cover Compressor
5. Band Apply Pin Tool
6. Plastic Speed Sensor Removal and Installation Tool

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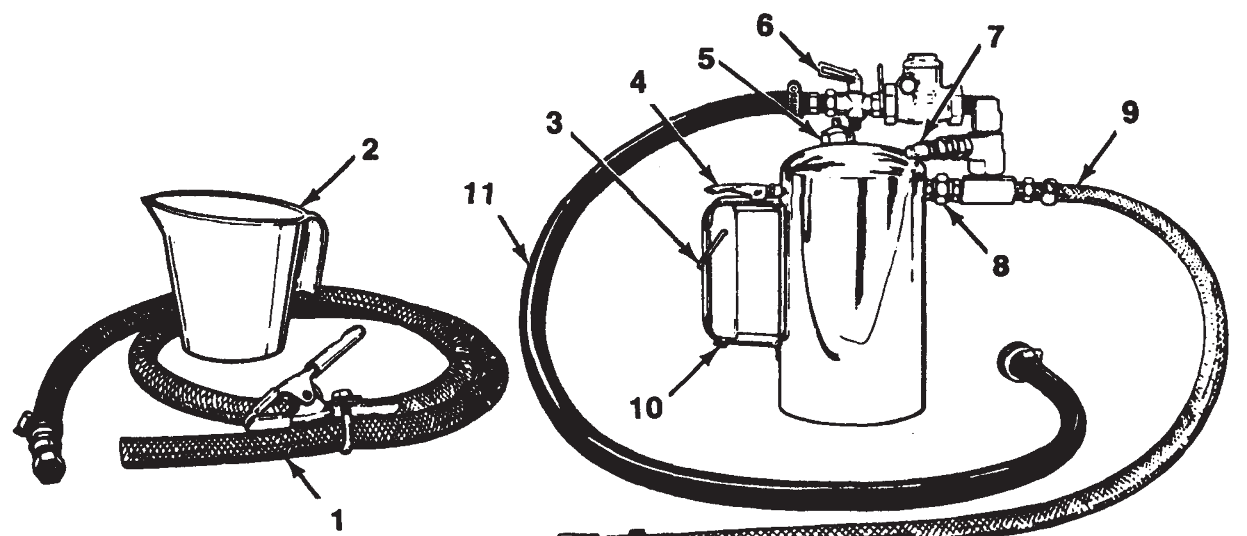

J 35944 Cooler Flushing Tool

1. Discharge Hose
2. Measuring Cup
3. Bale Clip
4. Trigger to Introduce Solution
5. Fill Cap and Tank
6. Water Valve (On-Off)
7. Air Valve to Surge Lines
8. Large Coulping Nut
9. Water and Solution Feed Hose
10. Cleaning Pin
11. Water Supply Hose

F9771

SECTION 7B

MANUAL TRANSMISSION

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

The MW1 transmission is the only manual transmission available for the 2.5L (VIN A) engine. The MY2 transmission is available for the 4.3L (VIN Z) engine.

Manual transmissions are identified by the number of forward gears, and the measured distance between centerlines of the mainshaft and the countergear.

The five-speed 77 mm transmission is a fully synchronized unit with blocker ring synchronizers and a sliding mesh reverse gear. First and second gears have three-piece synchronizer rings, consisting of steel inner and outer cones and a tapered metal ring that is lined on both sides with friction material similar to automatic transmission friction plates. The cones are independent of the gears and can be replaced separately. Third and fourth gear blocker rings are more conventional in appearance, but also are lined with friction material. The fifth gear blocker ring is brass.

The mainshaft and countershaft are supported on tapered roller bearings and must be shimmed for proper end play. First through fourth speed mainshaft gears ride on caged roller bearings. An aluminum transmission case houses the various gears and bearings. The gearshift lever assembly is mounted on top of the extension housing. The shift mechanism does not require adjustment and can be serviced independently of the transmission.

DIAGNOSIS

Before repairing the transmission, check the clutch and shifting linkages to be sure the problem is in the transmission.

TRANSMISSION MOUNT

1. Raise the vehicle and try to move the extension housing up and down.
2. If the plate is loose on the crossmember, tighten the screws.
3. If the rubber is split or spongy, replace the mount.

CLUTCH SPIN DOWN TIME

1. Run the engine at a normal idle with the transmission in neutral and the clutch engaged.
2. Disengage the clutch, wait five seconds and shift the transmission into reverse.
3. If a grinding noise is heard, check the clutch for the problem. Refer to CLUTCH (SECTION 7C).

DIAGNOSIS OF MANUAL TRANSMISSION

PROBLEM	POSSIBLE CAUSE	CORRECTION
Transmission Shifts Hard	1. Shift rail binding 2. Internal bind in the transmission caused by shift forks, selector plates, or synchronizer assemblies. 3. Incorrect lubricant.	1. Check for mispositioned selector arm roll pin, loose cover bolts, worn shift rail bores, worn shift rail, distorted oil seal, or extension housing not aligned with the case. Repair as necessary. 2. Remove, disassemble and inspect the transmission. Replace worn or damaged components as necessary. 3. Drain and refill the transmission.
Gear Clash When Shifting From One Gear To Another	1. Lubricant level low or incorrect lubricant. 2. Gearshift components, or synchronizer assemblies worn or damaged.	1. Drain and refill the transmission and check for lubricant leaks if the level was low. Repair as necessary. 2. Remove, disassemble and inspect the transmission. Replace worn or damaged components as necessary.
Transmission Noisy	1. Lubricant level low or incorrect lubricant. 2. Clutch housing-to-engine, or transmission-to-clutch housing bolts loose. 3. Gearshift mechanism, transmission gears, or bearing components worn or damaged.	1. Drain and refill the transmission. If lubricant level was low, check for leaks and repair as necessary. 2. Check and correct bolt torque as necessary. 3. Remove, disassemble and inspect transmission. Replace worn or damaged components as necessary.
Jumps Out Of Gear	1. Offset lever nylon insert worn or lever loose. 2. Gearshift mechanism, shift forks, selector plates, interlock plate, selector arm, shift rail, springs or shift cover worn or damaged. 3. Gear teeth worn or tapered, synchronizer assemblies worn or damaged, excessive end play caused by worn thrust washers or output shaft gears.	1. Remove the gearshift lever and check for loose offset lever or worn insert. Repair or replace as necessary. 2. Remove, disassemble and inspect the transmission cover assembly. Replace worn or damaged components as necessary. 3. Remove, disassemble and inspect the transmission. Replace worn or damaged components as necessary.
Will Not Shift Into One Gear	1. Gearshift selector plates, interlock plate, or selector arm, worn, damaged, or incorrectly assembled. 2. Synchronizer sleeves or hubs, damaged or worn.	1. Remove, disassemble and inspect the transmission cover assembly. Repair or replace components as necessary. 2. Remove, disassemble and inspect the transmission. Replace worn or damaged components.
Locked In One Gear–Cannot Be Shifted Out	1. Shift rail(s) worn or broken, shifter fork bent or worn. 2. Gearshift lever worn, shift mechanism in the cover incorrectly assembled or broken, worn or damaged gear train components.	1. Inspect and replace worn or damaged parts. 2. Disassemble the transmission. Replace damaged parts or assemble correctly.

D0073

ON-VEHICLE SERVICE

DRAIN AND FILL

Remove or Disconnect (Figures 1 and 2)

1. Filler plug.
2. Drain plug.
3. Transmission oil.
   - Catch the oil in a pan.

Install or Connect (Figures 1 and 2)

1. Drain plug.
2. New transmission oil.
   - Fill to the level of the filler plug hole. Refer to "*Specifications*" *at the end of this section.*
3. Filler plug.

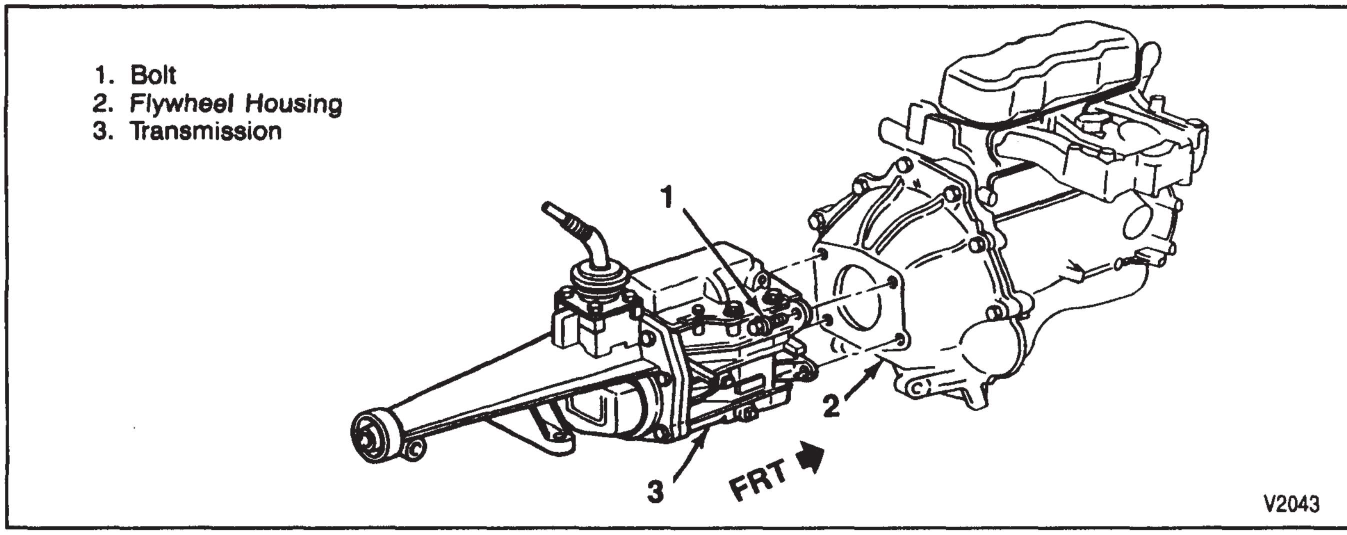

Figure 1—Transmission Installation (Borg-Warner T-5 Models)

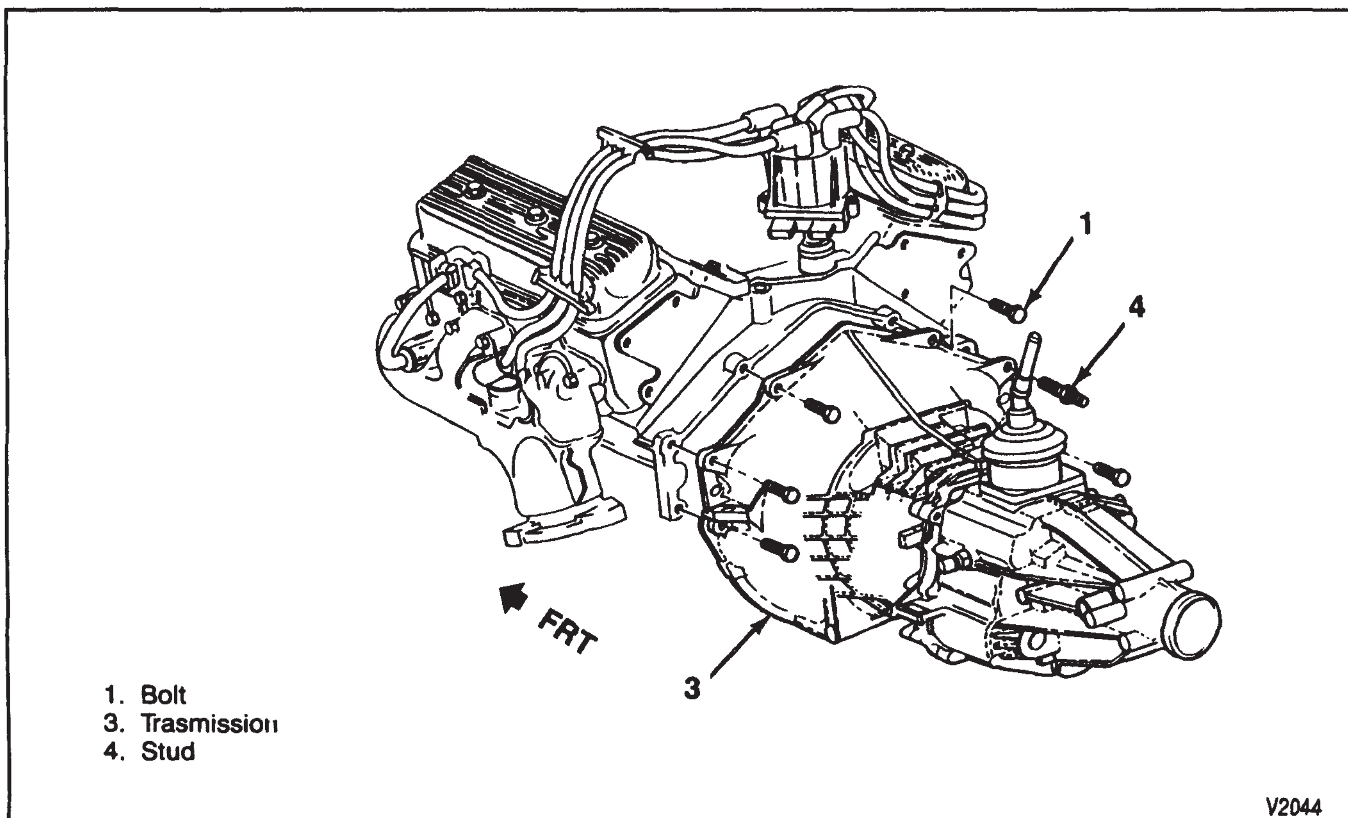

Figure 2—Transmission Installation (New Venture Gear 5LM60 Models)

SHIFT CONTROL LEVER REPLACEMENT

Remove or Disconnect (Figure 3)

1. Shift knob (5) and nut (6).
2. Screws (9) and retainer (10), if used.
3. Boot (8).
4. Shift lever (7) and nut (11).
   - Hold the nut and unscrew the lever using the wrench slots (A).

Install or Connect (Figure 3)

NOTICE: For steps 1, 4, and 5, refer to "Notice" on page 7B-1 of this section.

1. Nut (11).
   - Turn the nut all the way on. Do not tighten.
2. Shift lever (7).
   - Screw the nut (11) up against the lever.
   - Hold the lever using the wrench slots (A).

Tighten

- Nut (11) to 47 N·m (35 ft. lb.).

3. Boot (8).
4. Retainer (10) and screws (9), as used.
5. Nut (6).
   - Screw the nut all the way on. Do not tighten.
6. Shift knob (5).
   - Screw the knob against the nut.
   - Back the knob off to align the shift pattern.
   - Tighten the nut against the knob.

VEHICLE SPEED SENSOR REPLACEMENT

Remove or Disconnect (Figure 4)

1. Harness connector (12).
2. Bolt, if used.
3. Vehicle speed sensor (13).
   - Have a suitable container to catch the fluid.
4. O-ring seal.

Install or Connect (Figure 4)

1. New O-ring seal.
   - Coat the seal with a thin film of transmission fluid.
2. Vehicle speed sensor (13).

NOTICE: See "Notice" on page 7B-1 of this section.

3. Bolt, if used.
4. Harness connector (12).

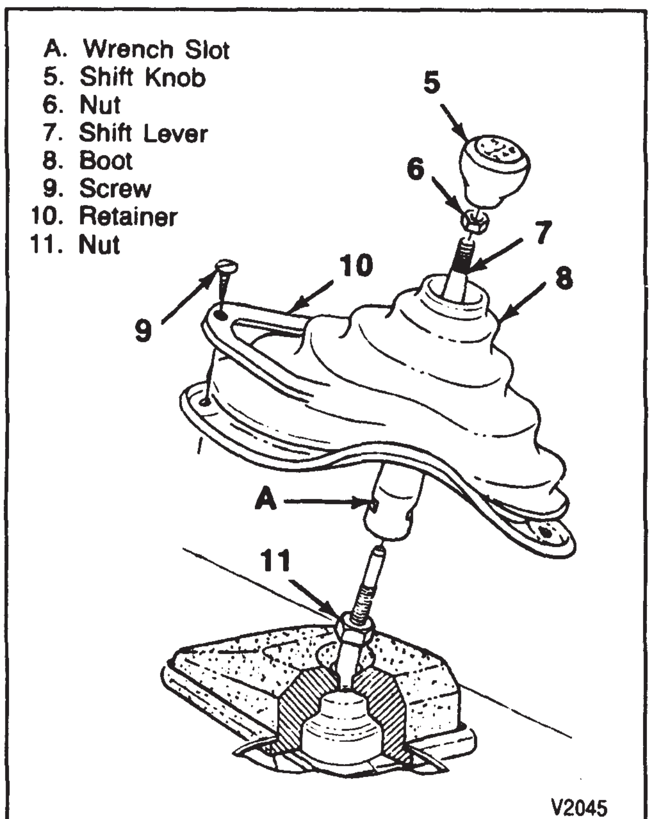

Figure 3—Shift Lever and Boot

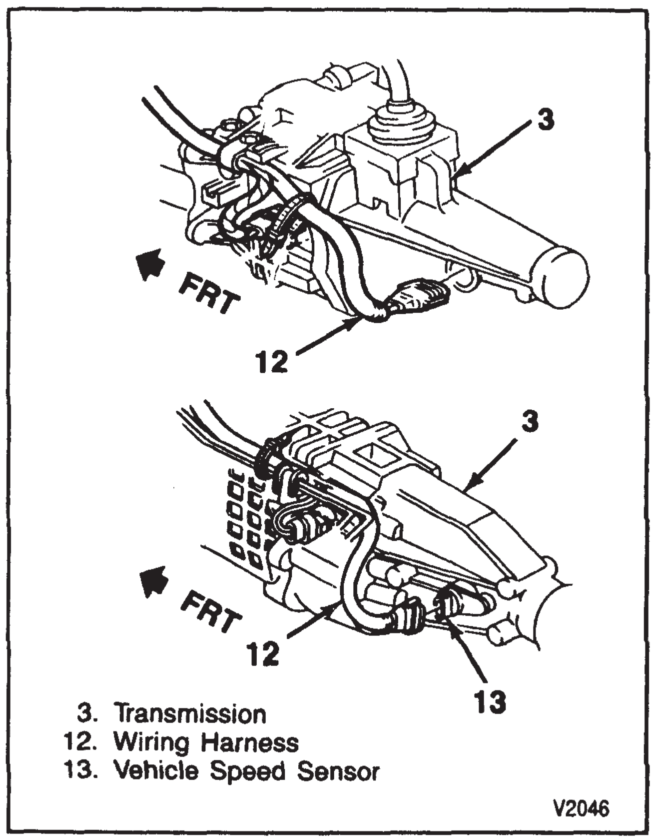

Figure 4—Vehicle Speed Sensor

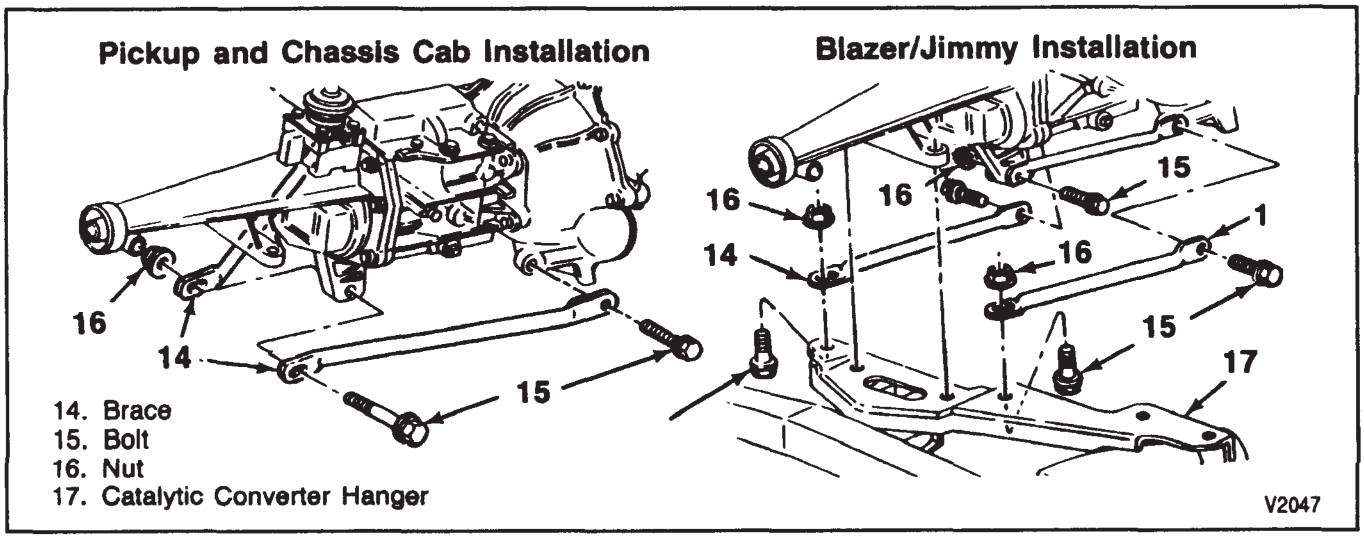

Figure 5—Clutch Housing and Catalytic Hanger

TRANSMISSION REPLACEMENT

Remove or Disconnect (Figures 1, 2, 5, 6, 7, and 8)

- Shift the transmission into neutral.

1. Shift lever. Refer to "Shift Control Lever Replacement" in this section.
   - Raise the vehicle and support it with suitable safety stands.
2. Parking brake cable for clearance. Refer to BRAKES (SECTION 5).
3. Propeller shaft. Refer to PROPELLER SHAFT (SECTION 4A).
4. Skid plate, if used. Refer to TRANSFER CASE (SECTION 7D).
5. Transfer case and shift lever, if used. Refer to TRANSFER CASE (SECTION 7D).
6. Wiring harnesses, as needed.
7. Fuel lines at manifold (4.3L models).
   - Purge fuel system. Refer to Light Duty Fuel and Emission Manual if you are using X-9229 and to the Fuel and Emissions section at the rear of this manual if you are using ST-369-92.
8. Exhaust pipes. Refer to EXHAUST (SECTION 6F).
9. Slave cylinder from the transmission. Refer to CLUTCH (SECTION 7D).
10. Transmission mounting bolts, as necessary.
    - Support the transmission with a jack.
11. Catalytic converter hanger (17) (figure 5).
12. Support braces, as needed (figures 5, 6, 7, and 8).
13. Crossmember, if necessary.
14. Bolts (1) (figures 1 and 2).
    - Support the clutch release bearing.

Important

- Do not let the transmission hang from the clutch.
- Pull the transmission straight back on the clutch hub splines.
- Rotate transmission counter-clockwise and then pull back on clutch hub splines (4.3L models).

15. Transmission (3).

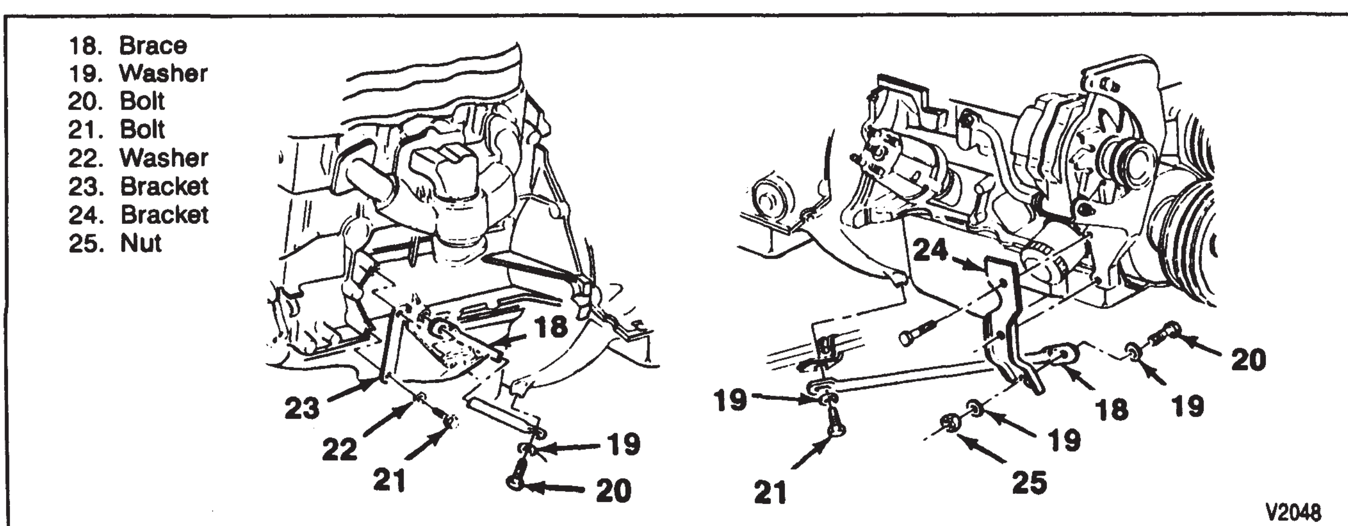

Figure 6—Brace Removal—2.5L (VIN A) Engine

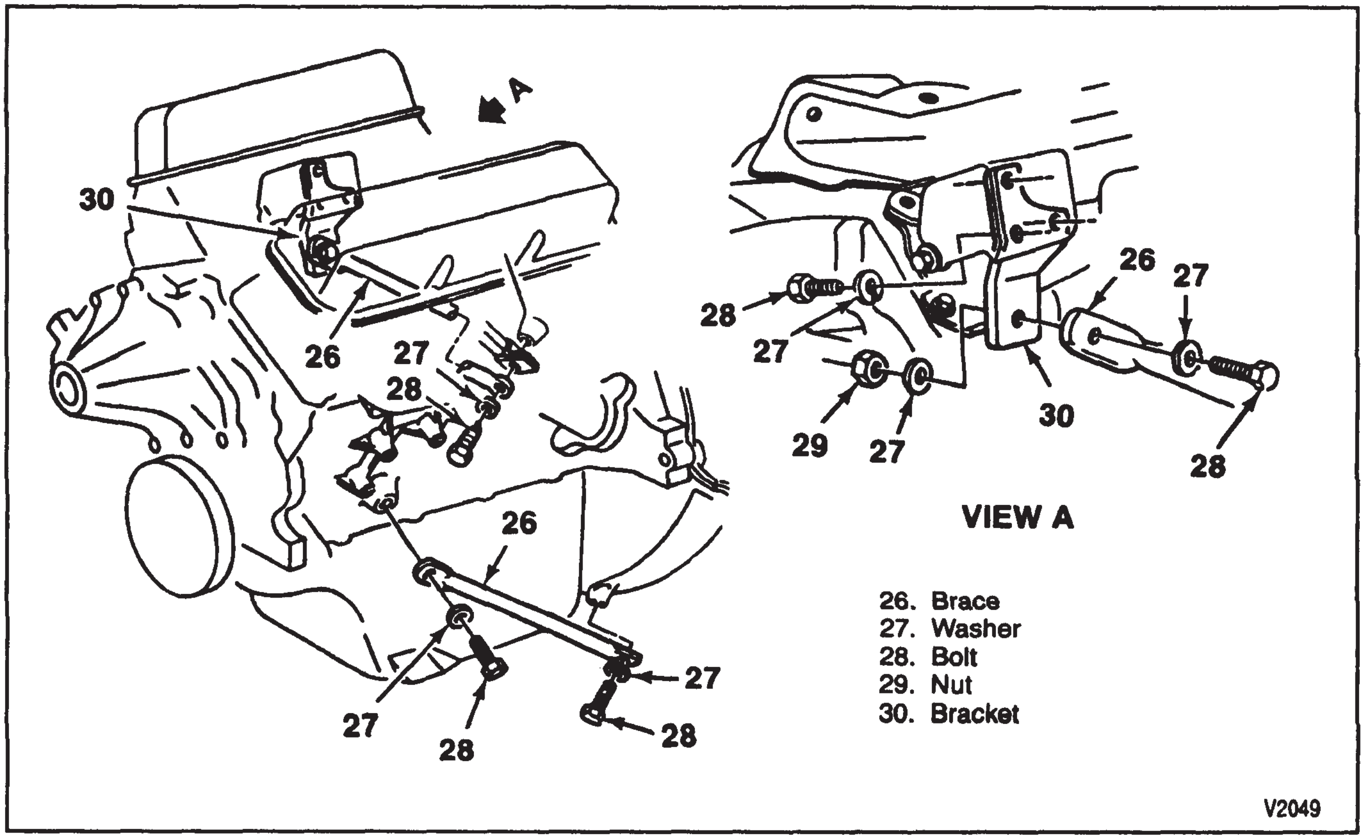

Figure 7—Brace Removal—2.8L (VIN R) Engine

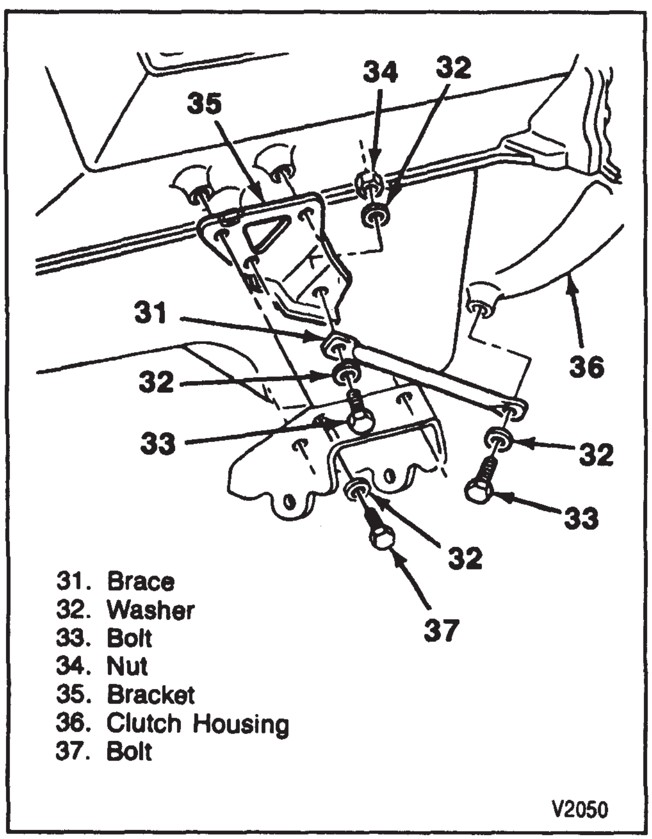

Figure 8—Brace Removal—4.3L (VIN Z and W) Engine

Install or Connect (Figures 1, 2, 5, 6, 7 and 8)

Important

- Do not force the transmission into the clutch.

1. Transmission (3).
   - Put a thin coat of high temperature grease on the main drive gear splines.
   - Shift the transmission into high gear before installing.

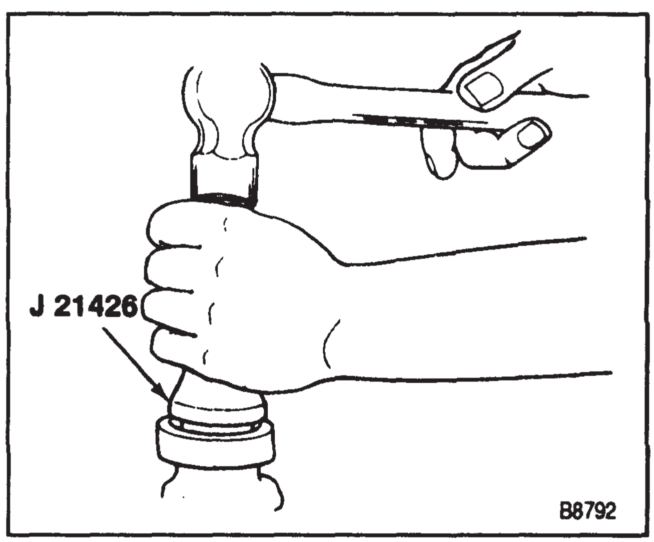

Figure 9—Installing the Rear Extension Seal

- Leave the jack under the transmission to support it.
- Rotate transmission clockwise onto clutch hub splines (4.3L models).

NOTICE: For steps 2 and 6, refer to "Notice" on page 7B-1 of this section.

2. Bolts (1) (figures 1 and 2).

Tighten

- Bolts (1) to 75 N.m (55 ft. lb.) (Borg-Warner).
- Bolts (1) to 47 N.m (35 ft. lb.) (New Venture Gear).

3. Crossmember, if necessary.
   - Remove the jack.
4. Support braces, as needed (figures 5, 6, 7 and 8).

Tighten

- Support brace nuts to 47 N.m (35 ft. lb.).

5. Catalytic converter hanger (17) (figure 5).
6. Transmission mounting bolts, as necessary.

Tighten

- Transmission mounting bolts to 50 N.m (37 ft. lb.).

7. *Slave cylinder to the transmission. Refer to* CLUTCH (SECTION 7C).
8. Exhaust pipes. Refer to EXHAUST (SECTION 6F).
9. Fuel lines to manifold (4.3L models).
10. Wiring harnesses, as needed.
11. Transfer case and the shift lever, if used. Refer to TRANSFER CASE (SECTION 7D).
12. *Skid plate, if used. Refer to TRANSFER CASE* (SECTION 7D).
13. Propeller shaft. Refer to PROPELLER SHAFT (SECTION 4A).
14. Parking brake cable. Refer to BRAKES (SECTION 5).
    - Lower the vehicle.
15. Shift lever. Refer to "Shift Control Lever Replacement" in this section.
    - Shift the transmission into neutral.

EXTENSION HOUSING OIL SEAL REPLACEMENT

Remove or Disconnect (Figures 1, 2, and 9)

- Raise the vehicle and support it with suitable safety stands.

1. Propeller shaft. Refer to PROPELLER SHAFT *(SECTION 4A).*
2. Pry the seal out of the extension housing.

Install or Connect (Figures 1. 2, and 9)

Tool Required:
J 21426 Extension Housing Seal Installer

1. Locking compound on the outside of a new seal.
2. New seal, using J 21426.
   - Fill between the seal lips with chassis grease.
3. Propeller shaft. Refer to PROPELLER SHAFT (SECTION 4A).
4. Check the transmission oil level and add if needed. *Refer to "Specifications" at the end of this* section.

- Lower the vehicle.

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

ITEM	N·m	Ft. Lbs.
Oil Fill Plug	60	46
Oil Drain Plug	60	46
Shift Lever Nut	47	35
Transmission-to-Clutch Housing Bolt	75	55
Transmission-to-Mount Bolt	50	37
Crossmember-to-Mount Bolt	35	26
Crossmember-to-Frame Bolt	35	26

LUBRICATION SPECIFICATIONS

Borg-Warner T-5 Manual Transmission

Capacity .... 2.0L (2.2 Qts.)
Type Recommended .... Dexron® II-E Automatic Transmission Fluid

New Venture Gear 5LM60 Manual Transmission

Capacity .... 1.98L (2.0 Qts.)
Type Recommended .... Synchromesh Transmission Fluid

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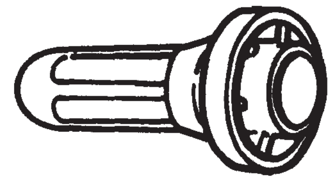
SPECIAL TOOLS

1. Rear Extension Seal Installer

1.  J-21426

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SECTION 7C

CLUTCH

CAUTION: When servicing clutch parts, do not create dust by grinding or sanding clutch disc or by cleaning parts with a dry brush or with compressed air. A water dampened cloth—NOT SOAKED—should be used. The clutch disc contains asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm.

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

The principal parts of the clutch system are the driving members, the driven members and the operating members. The clutch housing is part of the manual transmission assembly.

DRIVING MEMBERS

The driving members consist of two flat surfaces machined to a smooth finish. One of these is the rear face of the engine flywheel, and the other is the front face of the clutch cover assembly.

DRIVEN MEMBERS

The driven member is the clutch disc with a splined hub which is free to slide lengthwise along the splines of the input shaft, and drives the input shaft through these same splines.

The driving and driven members are held in contact by spring pressure. This pressure is exerted by a diaphragm spring in the clutch cover assembly.

OPERATING MEMBERS

Hydraulic Clutch

The clutch release system consists of a clutch master cylinder with a reservoir and an actuator cylinder connected to the master cylinder by hydraulic tubing. The clutch master cylinder is mounted on the cowl panel and the actuator is mounted on the clutch housing. The clutch master cylinder is operated directly off the clutch pedal by a pushrod.

When the clutch pedal is pressed down, hydraulic fluid under pressure from the clutch master cylinder flows into the actuator cylinder. As hydraulic force is applied to the actuator cylinder, the pushrod movement rotates the clutch fork to force the release bearing into the diaphragm spring and release the clutch.

The hydraulic clutch system provides automatic clutch adjustment, so no adjustment of clutch linkage or pedal position is required.

Hydraulic Clutch Fluid

When adding fluid to or refilling the system after service operations use GM Delco Supreme No. II® Brake Fluid or an equivalent fluid that meets DOT 3 specifications.

NOTICE: Do not use mineral or parafin base oil in the clutch hydraulic system. These fluids will damage the rubber parts in the cylinders.

DIAGNOSIS

PRELIMINARY CHECKS

Before attempting to repair the clutch, transmission or related components for any reason other than an obvious failure, the problem and probable cause should be identified. A large percentage of clutch and manual transmission problems are revealed by shifting difficulties such as high shift effort, gear clash or grinding. When any of these problems occur, a careful analysis of these difficulties should be made. Use the "Diagnosis of Clutch" and "Diagnosis of Hydraulic Clutch" charts to assist in roper diagnosis of clutch problems.

Before removal of the clutch hydraulic system, verify the malfunction by measuring the travel of the clutch actuator cylinder pushrod. With the clutch pedal pushed fully to the floor stop, the actuator cylinder pushrod should move 21.3 mm (0.75 inch) minimum against the clutch release lever. Do not replace the hydraulic system if pushrod travel exceeds this distance.

If the actuator cylinder does not meet the travel requirements, check the reservoir fluid level. The actuator cylinder must be in place when checking the fluid level. The proper level is indicated by a step on the reservoir. Fill to the specified level with GM Delco Supreme No. II® Brake Fluid; Hydraulic Clutch Fluid or equivalent that meets DOT 3 specifications. Do not overfill the system.

NOTICE: Carefully clean the top and sides of the reservoir before opening to prevent contamination of the system with dirt, water, or other foreign material. Remove the reservoir diaphragm before adding fluid. Carefully replace the diaphragm, cover gasket, and cover after filling.

If the reservoir requires any fluid, check the hydraulic system components for leakage. Remove the rubber boots from the cylinder and check for leakage past the pistons. A slight wetting of the surfaces is acceptable. Replace the system if excessive leakage is evident.

CLUTCH SPIN DOWN TIME

1. Run the engine at a normal idle with the transmission in neutral and the clutch engaged.
2. Disengage the clutch, wait nine seconds and shift the transmission into reverse.
3. If a grinding noise is heard, refer to the "Diagnosis Of Clutch" chart in this section.

DIAGNOSIS OF CLUTCH

PROBLEM	POSSIBLE CAUSE	CORRECTION
Will Not Disengage (Pedal to the floor and hard to shift into reverse).	1. Air in the hydraulic system. 2. Master or secondary hydraulic cylinder seals worn. 3. Not enough pedal travel. 4. Release bearing worn or damaged. 5. Driven plate worn or damaged. 6. Clutch fork off the ball stud. 7. Driven plate binding. 8. Driven plate warped. Run-out more than 5.08 mm (0.20 in.).	1. Bleed and check for damage. 2. Repair. 3. Adjust the linkage or trim the pedal bumper. 4. Replace. 5. Replace. 6. Install correctly and lubricate. 7. Repair or replace the plate or clutch gear. 8. Replace.
Slipping.	1. Driven plate friction pads worn or oil soaked. 2. Pressure plate or flywheel warped. 3. Diaphragm spring weak. 4. Driven plate overheated or not seated.	1. Replace. Check for leaks as needed. 2. Replace as needed. 3. Replace. 4. Allow to cool and make 30-40 normal starts - DO NOT OVERHEAT.

DIAGNOSIS OF CLUTCH (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Grabbing (Chattering).	1. Engine mounts loose or damaged. 2. Driven plate friction pads oil soaked. 3. Pressure plate or flywheel warped. 4. Driven plate friction pad material burned or smeared onto the pressure plate or flywheel. 5. Clutch gear worn.	1. Tighten or replace. 2. Replace and check for leaks. 3. Replace as necessary. 4. Clean off or replace as needed. 5. Repair the transmission.
Rattling (Transmission Click).	1. Diaphragm spring weak. 2. Clutch fork loose or off the ball stud. 3. Driven plate springs weak or oil in the damper.	1. Replace the pressure plate. 2. Replace the retaining spring or install the fork correctly. 3. Replace and check for leaks as needed.
Release Bearing Noisy With The Clutch Engaged.	1. Release bearing binding. 2. Clutch fork off the ball stud or loose spring tension. 3. Linkage return springs weak.	1. Clean, or replace if damaged, and lubricate. 2. Install, and lubricate. 3. Replace.
Noisy.	1. Release bearing worn or damaged. 2. Clutch fork off the ball stud. 3. Pilot bearing loose.	1. Replace. 2. Install correctly and lubricate. 3. Replace.
Pedal Stays On The Floor When Disengaged.	1. Release bearing binding. 2. Diaphragm spring weak.	1. Free up, or replace, and lubricate. 2. Replace the pressure plate.
Pedal Is Hard To Push.	1. Hydraulic line blocked or crimped. 2. Master or secondary cylinders binding. 3. Drive plate worn.	1. Clean out or replace. 2. Repair or replace as needed. 3. Replace.

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DIAGNOSIS OF HYDRAULIC CLUTCH

PROBLEM	POSSIBLE CAUSE	CORRECTION
Pedal Travels To Floor. No Pressure Or Very Little Resistance.	Master or actuator cylinder faulty. Hose/pipe burst or leaking. Connections leaking. No fluid in reservoir.	Check components and replace, then bleed system.
Pedal Travels To Floor. No Pressure Or Very Little Resistance. Fluid In Master Cylinder Dust Cover.	Rear seal failure in master cylinder.	Service or replace unit, then bleed system.
Pedal Travels To Floor. No Pressure Or Very Little Resistance. Fluid Level In Reservoir Rises As Pedal Is Depressed.	Master cylinder center valve seal faulty	Service or replace unit, then bleed system.
Fluid In Area Of Master Cylinder Dust Cover And On Pedal	Rear seal failure in master cylinder.	Service or replace unit, then bleed system.

DIAGNOSIS OF HYDRAULIC CLUTCH (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Fluid In Actuator Cylinder And On Cylinder Body	Actuator cylinder plunger seal faulty.	Service or replace unit, then bleed system.
Pedal Feels "Spongy" When Depressed	Air in system.	Check fluid level, bleed system. Check and replace parts if symptom recurs.
Pedal Effort High With Long Pedal Travel	Incorrect size master or actuator cylinder fitted.	Check and fit correct unit, then bleed system.
Unable To Select Gears. Pedal Effort And Travel Normal.	Clutch mechanism faulty. Transaxle faulty.	Check and replace clutch or transaxle components.
Clutch Slip	Clutch plate worn. Master and/or actuator cylinder seal worn or damaged. Overfilled reservoir.	Check and replace. Clean and service or replace units. Remove excess fluid.
Difficulty In Selecting Gears. Pedal Effort And Travel Normal.	Clutch or transaxle Imechanism faulty. Wear in clevis linkages.	Check and replace faulty or worn components.
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ON-VEHICLE SERVICE

CLUTCH PEDAL REPLACEMENT

Remove or Disconnect (Figure 1)

1. Lower filler panel. Refer to INTERIOR TRIM (SECTION 10A4).
2. Lower left side air conditioning duct, if needed. Refer to AIR CONDITIONING (SECTION 1B).
3. Clutch start switch. Refer to "Clutch Start Switch Replacement" in this section.
4. Retainer (110) and washer (109).
5. Push rod (108) and washer (107).
6. Nut (102).
7. Bolt (112) and braces (103).
8. Pedal (106) and spring (111).
   - Slide a long screw or rod into the bracket while removing the bolt.
9. Bushings (104) and spacer (105).
10. Bumper (114), if it is worn or damaged.

Install or Connect (Figure 1)

1. New bumper (114), if needed.
2. New spacer (105) and new bushings (104).
   - Coat with grease before installing.
3. Spring (111) and pedal (106).

NOTICE: For steps 4 and 5, refer to "Notice" on page 7C-1 of this section.

4. Bolt (112) and braces (103).

Important

- The bolt (112) must be installed in the direction shown.
- Remove the long screw or rod while installing the bolt (112).

5. Nut (102).

Tighten

- Nut (102) to 35 N·m (26 ft. lb.).

6. Washer (107) and push rod (108).
   - The washer (107) must stand off the pedal as shown.
7. Washer (109) and retainer (110).
8. Clutch start switch. Refer to "Clutch Start Switch Replacement" in this section.
9. Lower left side air conditioning duct, if needed. Refer to AIR CONDITIONING (SECTION 1B).
10. Lower filler panel. Refer to INTERIOR TRIM (SECTION 10A4).
    - Lubricate the clutch pedal with chassis grease.

MASTER CYLINDER AND RESERVOIR REPLACEMENT

Remove or Disconnect (Figure 2)

1. Lower filler panel. Refer to INTERIOR TRIM (SECTION 10A4).
2. Lower left side air conditioning duct, if needed. Refer to AIR CONDITIONING (SECTION 1B).

100. Bracket
101. Bolt
102. Nut
103. Brace
104. Bushing
105. Spacer
106. Pedal
107. Wave Washer
108. Push Rod
109. Washer
110. Retainer
111. Spring
112. Bolt
113. Nut
114. Bumper

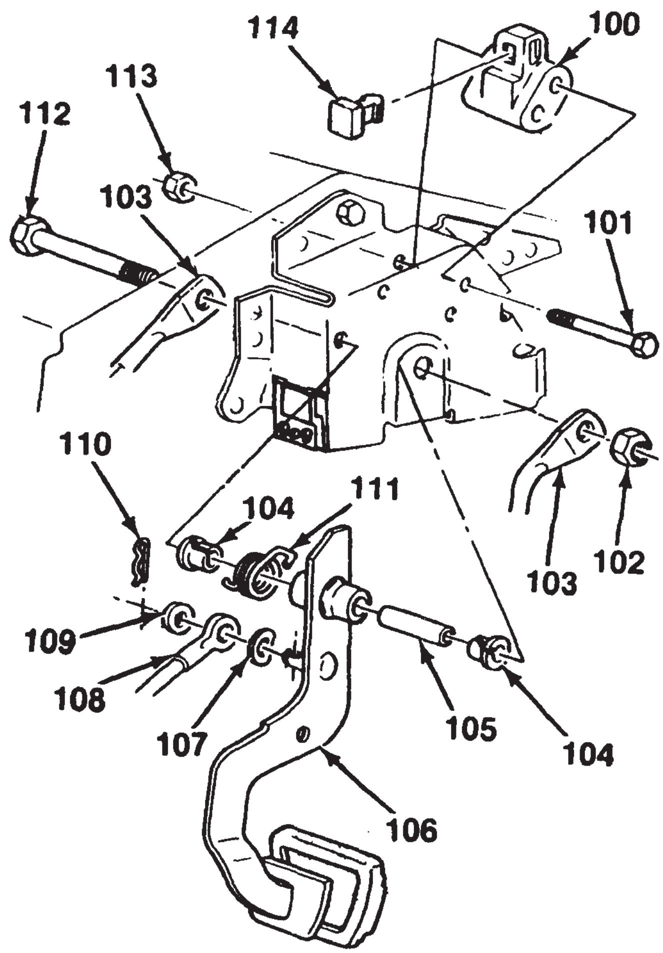

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Figure 1—Clutch Pedal Assembly

3. Retainer (110) and washer (109).
4. Push rod (108) and washer (107).
5. Reservoir hose (121).
6. Secondary cylinder hydraulic line (122) from the master cylinder (123).
7. Nuts (120) and master cylinder (123).
8. Gasket (124).
   - Scrape all gasket material from the master cylinder and the cowl.
9. Bolts (125) and reservoir (126).

Disassemble (Figure 3)

1. Remove adapter (131) and seal (130).
2. Pull dust cover (138) back and remove snap ring (137).
3. Shake push rod (108) and plunger (134) out.
4. Remove seal (136). Remove spring (139), support (132), seal (135) and shim (133).

Clean (Figure 3)

- All parts with clean brake fluid.

Inspect (Figure 3)

- The cylinder bore and the plunger for scratches, ridges, and pitting.
- The dust cover for wear and cracking.

Assemble (Figure 3)

- Lubricate all seals with clean brake fluid.

1. Install the shim (133) and a new seal (135) with the flat against the shim (133). Install the support (132) and the spring (139).
2. Install a new seal (136).
3. Coat the cylinder bore with clean brake fluid and slide the plunger (134) and push rod (108) in.
4. Push the push rod (108) in and install snap ring (137). Coat the inside of the dust cover (138) with grease and slide it into place.
5. Install a new seal (130) and adapter (131).

Install or Connect (Figure 2)

NOTICE: For steps 1 and 3, refer to "Notice" on page 7C-1 of this section.

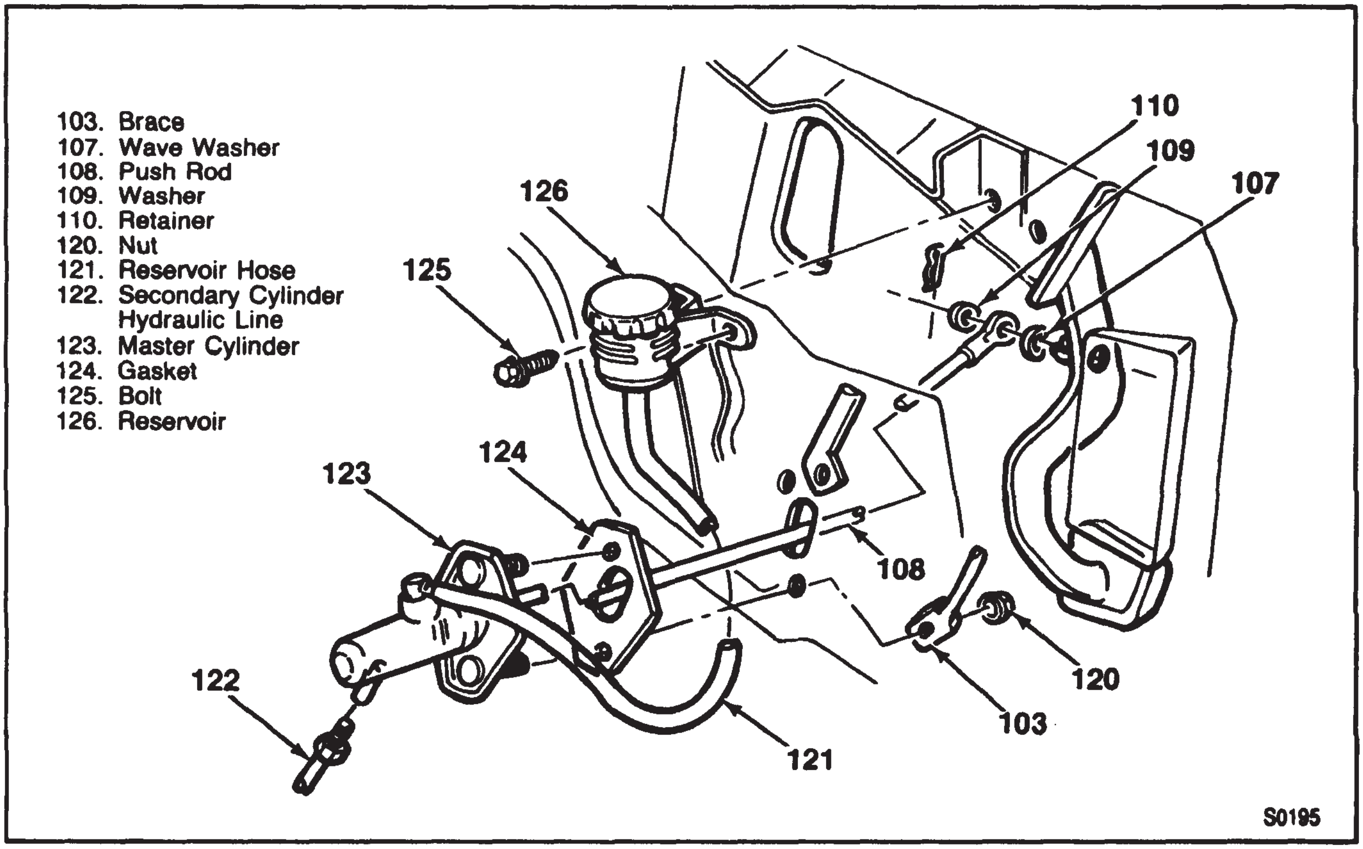


Figure 2—Master Cylinder and Reservoir

1. Reservoir (126) and the bolts (125).

Tighten

- Bolts (125) to 2.8 N·m (25 in. lb.).

2. New gasket (124).
3. Master cylinder (123) and the nuts (120).

Tighten

- Nuts (120) to 18 N·m (13 ft. lb.).

4. Secondary cylinder hydraulic line (122) to the master cylinder (123).
5. Reservoir hose (121).
6. Washer (107) and push rod (108).
7. Washer (109) and retainer (110).
8. Lower left side air conditioning duct, if needed. Refer to AIR CONDITIONING (SECTION 1B).
9. Lower filler panel. Refer to INTERIOR TRIM (SECTION 10A4).
   - Fill the reservoir. Refer to "Specifications" at the end of this section.
   - Bleed the clutch system. Refer to "Hydraulic Clutch Bleeding" in this section.

SECONDARY (SLAVE) CYLINDER AND HYDRAULIC LINE REPLACEMENT

Remove or Disconnect (Figure 4)

- Raise the vehicle and support it with suitable safety stands.

1. Secondary cylinder hydraulic line (122) from the secondary cylinder (142).
2. Nuts (140) and secondary cylinder (142).
3. Secondary cylinder hydraulic line (122).
   - Secondary cylinder hydraulic line (122) from the master cylinder (123).
   - Stud (145) and secondary cylinder hydraulic line (122).
   - Install the stud (145).

Important

- Cover all hydraulic line openings to keep dirt and moisture out of the components.

Disassemble (Figure 5)

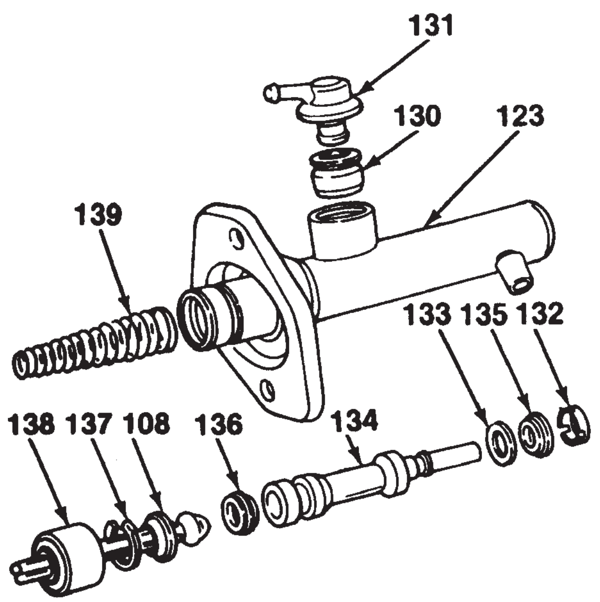
1. Remove the push rod (151) and dust cover (150).
2. Remove the snap ring (148) and shake out the plunger (149).
3. Remove the spring (152) and seal (147).

Clean (Figure 5)

- All parts with clean brake fluid.

Inspect (Figure 5)

- The cylinder bore and the plunger for scratches, ridges and pitting.
- The dust cover for wear and cracking.



108. Push Rod
123. Master Cylinder
130. Seal
131. Adapter
132. Support
133. Shim
134. Plunger
135. Seal
136. Seal
137. Snap Ring
138. Dust Cover
139. Spring

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Figure 3—Master Cylinder Components

Assemble (Figure 5)

1. Coat a new seal (147) with clean brake fluid and slide it into place and install the spring (152).
2. Coat the cylinder bore with clean brake fluid and slide in the plunger (149).
3. Push the plunger (149) in and install a new snap ring (148).
4. Coat the inside of the dust cover (150) with grease and slide it into place. Install the push rod (151).

Install or Connect (Figure 4)

- Uncover the hydraulic line openings.

1. Secondary cylinder hydraulic line (122).
   - Remove the stud (145).
   - Secondary cylinder hydraulic line (122) and the stud (145).

Important

- The hydraulic line must be installed as shown.

NOTICE: See "Notice" on page 7C-1 of this section.

2. Secondary cylinder (142) and nuts (140).

Tighten

- Nuts (140) to 18 N·m (13 ft. lb.).

3. Secondary cylinder hydraulic line (122) onto the secondary cylinder (142).
   - Lower the vehicle.
   - Bleed the clutch system. Refer to "Hydraulic Clutch Bleeding" in this section.

HYDRAULIC CLUTCH BLEEDING

1. Fill the reservoir (126) with new DOT 3 brake fluid to the level of the diaphragm (figures 2 and 4).

Important

- Never use fluid which has been bled from a system to fill the reservoir, as it may be aerated, have too much moisture content and possibly be contaminated.

2. Remove the secondary (slave) cylinder (142) and tip it so the bleeder screw (141) is up.
3. Hold the clutch pedal down, open the bleeder screw (141) to let air and fluid escape, and close the bleeder screw (141). Let up the clutch pedal.
4. Repeat step 3 until all air is out of the system.
   - Check and refill the reservoir as needed while bleeding so that air is not drawn into the system.
5. Install the secondary (slave) cylinder (142) and refill the reservoir (126) if needed.

CLUTCH START SWITCH REPLACEMENT

Remove or Disconnect (Figure 6)

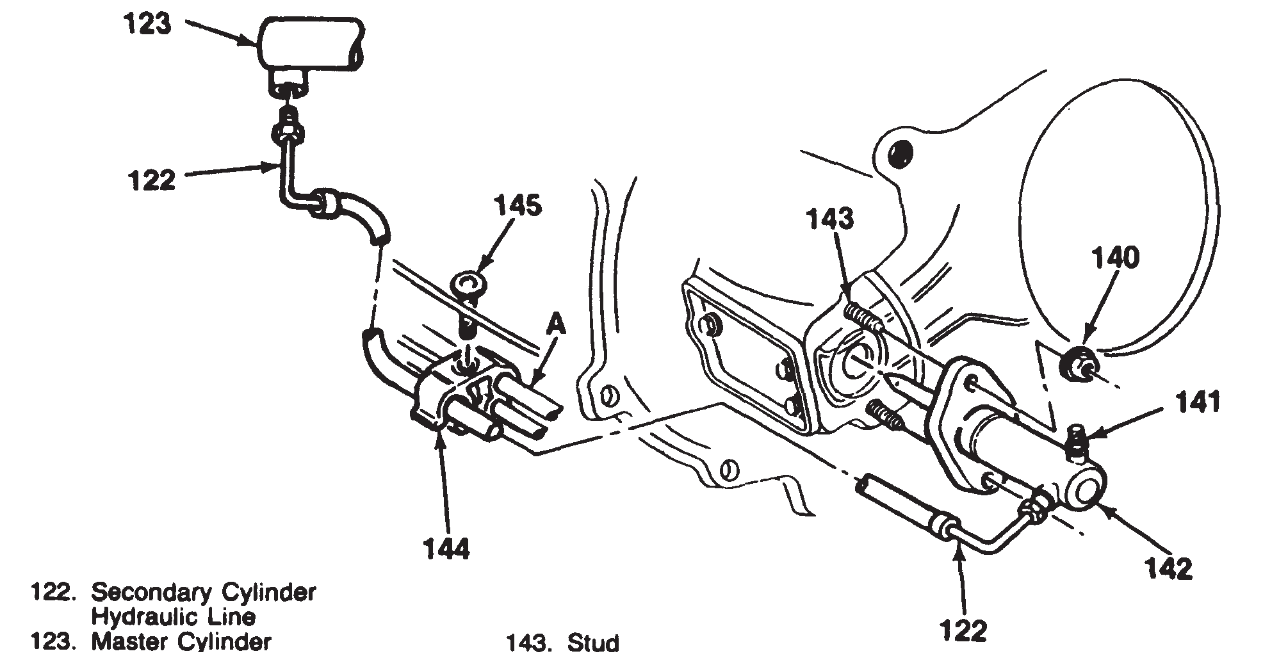
1. Lower filler panel. Refer to INTERIOR TRIM (SECTION 10A4).
2. Connector (155).
3. Clutch start switch (156) from the clutch pedal (106).

Install or Connect (Figure 6)

1. Clutch start switch (156) to the clutch pedal (106).
2. Connector (155).
3. Lower filler panel. Refer to INTERIOR TRIM (SECTION 10A4).

CLUTCH ASSEMBLY AND PILOT BEARING REPLACEMENT

CAUTION: When servicing clutch parts, do not create dust by grinding or sanding clutch disc or by cleaning parts with a dry brush or with compressed air. (A water dampened cloth—NOT SOAKED—should be used). The clutch disc contains asbestos fibers which can become airborne if dust is created during servicing. Breathing dust containing asbestos fibers may cause serious bodily harm.



122. Secondary Cylinder Hydraulic Line
123. Master Cylinder
140. Nut
141. Bleeder Screw
142. Secondary (Slave) Cylinder
143. Stud
144. Clamp
145. Stud
A. Speedometer Cable

Figure 4—Secondary Cylinder and Hydraulic Line

Remove or Disconnect (Figures 7, 8, and 9)

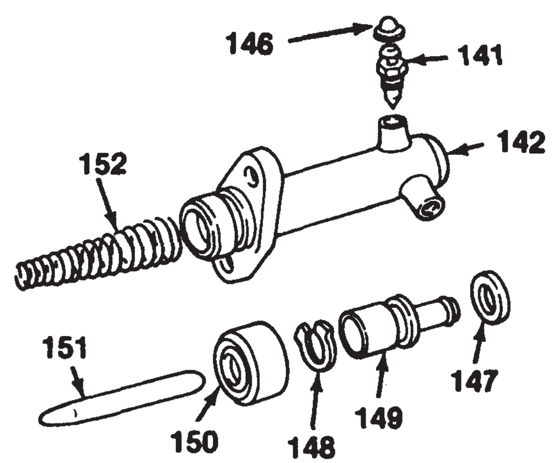
Tools Required:
J 33169 Clutch Alignment Tool
J 23907 Clutch Pilot Bearing Remover

1. Transmission. Refer to MANUAL TRANSMISSION (SECTION 7B).
2. Secondary cylinder (142).
3. Bolts (173) and cover (172).
4. Bolts (165) and flywheel housing (164).
5. The clutch fork (167) and release bearing (162).
   - Pry the clutch fork off the ball stud (163).
   - Pry the retainer (166) out of the clutch fork if it is worn or damaged.
6. Ball stud (163).

Important

- Install J 33169 clutch alignment tool or a used clutch drive gear to support the clutch (figure 8).
- Mark the flywheel, clutch cover and a pressure plate lug for alignment when installing.

7. Bolts (161) and washers (160).
8. Pressure plate (168) and the driven plate (169).
   - Remove the clutch alignment tool.
9. Pilot bearing (170) if it is worn or damaged.
   - Flywheel (171), if removed. Refer to "Flywheel Replacement" in this section.
   - Pilot bearing using J 23907 (figure 9).



141. Bleeder Screw
142. Secondary (Slave) Cylinder
146. Cap
147. Seal
148. Snap Ring
149. Plunger
150. Dust Cover
151. Push Rod
152. Spring

Figure 5—Secondary Cylinder Components

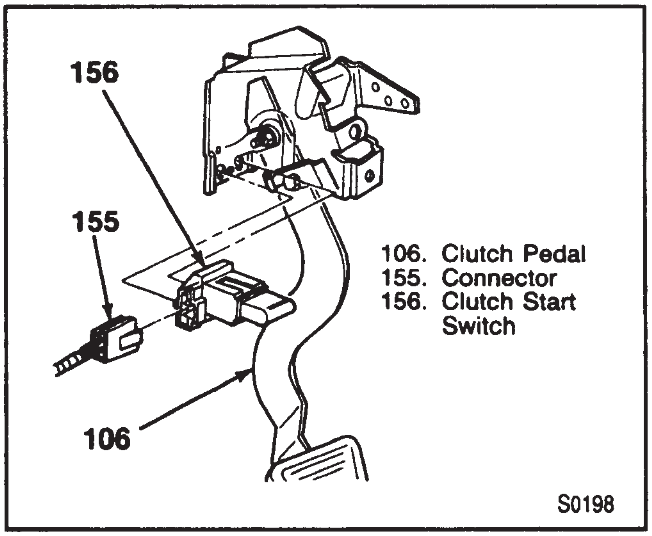


Figure 6—Clutch Start Switch

Clean (Figure 7)

1. All parts with a clean, water dampened cloth to remove any asbestos fibers.
2. Clutch fork (167), flywheel housing (164) and ball stud (163) with solvent. Wipe dry.

NOTICE: The release bearing is permanently packed with lubricant and should not be soaked in cleaning solvent as this will dissolve the lubricant.

Inspect (Figure 7)

- All parts for wear and damage.
- Contact surfaces for scoring and flatness with a straight edge. Driven plate run-out must not be more than 5.08 mm (0.20 inch).
- Friction pads for scoring, gouges, and loose rivets. Check to see if they are oil soaked.
- All splines for nicks, burrs and sliding fit.
- Pressure plate spring for bending and breaks.

Install or Connect (Figures 7, 8, 10, and 11)

Tools Required:
J 33169 Clutch Alignment Tool
J 1522 Pilot Bearing Driver

1. New pilot bearing (170) if needed. Use J 1522 to drive the bearing in until the tool bottoms out (figure 11).
   - Lubricate the bearing with a few drops of machine oil.
2. Flywheel (171), if removed. Refer to "Flywheel Replacement" in this section.
3. Driven plate (169) and cover (172).

Important

- Install J 33169 clutch alignment tool or a used clutch drive gear to support the clutch (figure 8).

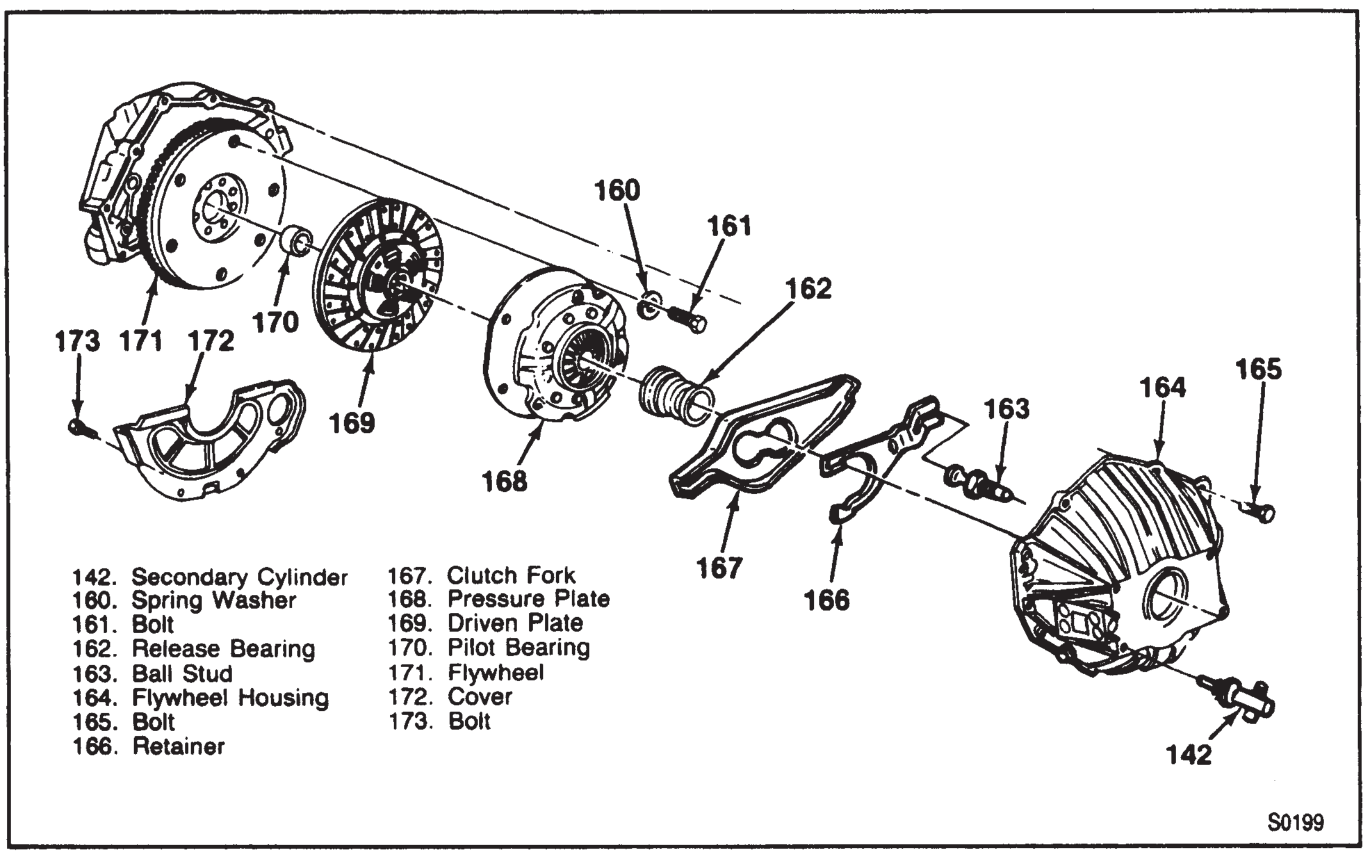


Figure 7—Clutch Assembly and Pilot Bearing

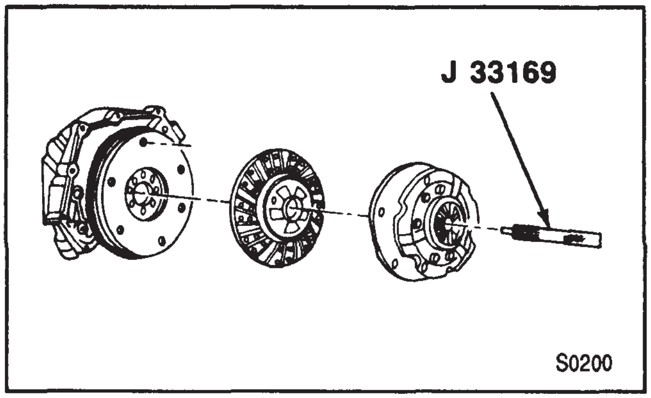


Figure 8—Installing Clutch Alignment Tool

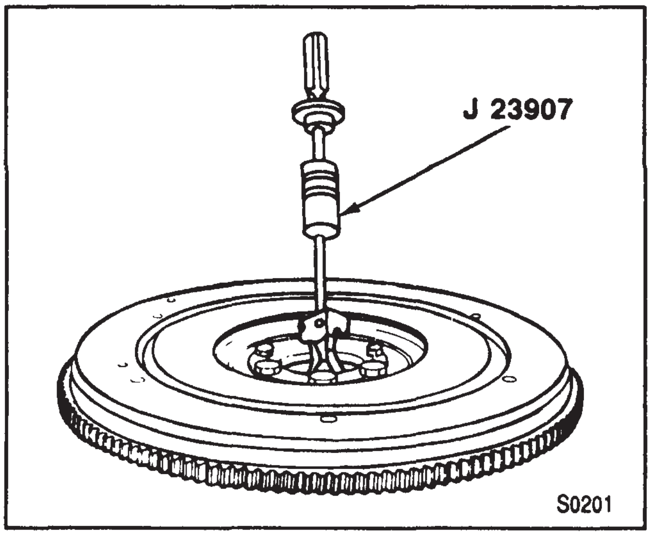


Figure 9—Removing the Pilot Bearing

- Align the marks made during removal or, if new, align the manufacturer's marks.

NOTICE: For steps 4, 8, and 9, refer to "Notice" on page 7C-1 of this section.

4. Washers (160) and bolts (161).
   - Remove the clutch alignment tool.

Important

- Tighten each screw one turn at a time to avoid warping the clutch cover.

NOTICE: Be careful not to use too much lubricant. Excessive lubricant may get on clutch fingers and cause slippage or damage may result to the clutch.

5. Ball stud (163).
   - Pack the seat and coat the rounded end of the ball stud with high temperature (wheel-bearing) grease.
6. New retainer (166), if needed.
   - The retainer must be installed so the fingers and tabs fit into the release bearing groove and the retainer wraps around the flat side of the ball stud head.

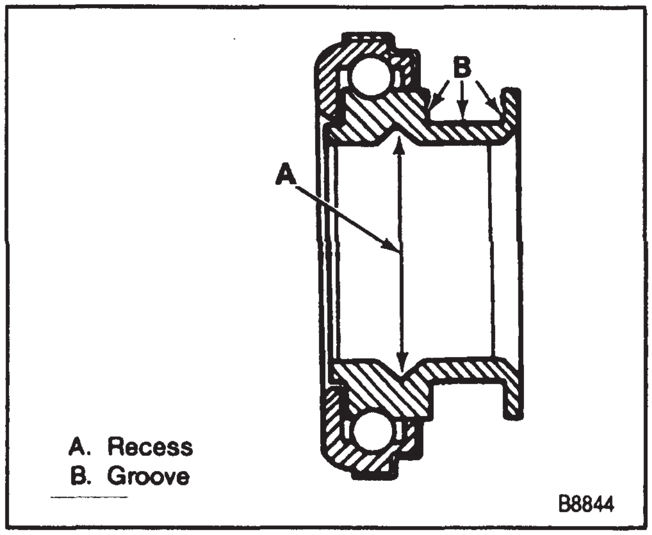


Figure 10—Release Bearing

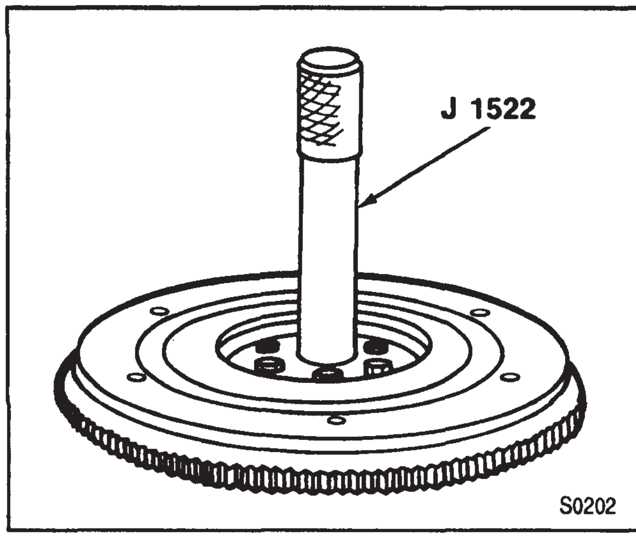


Figure 11—Installing the Pilot Bearing

7. Release bearing (162) and clutch fork (167).
   - Pack the inside recess (A) and coat the outside groove (B) of the release bearing with high temperature (wheel-bearing) grease (figure 10).
8. Flywheel housing (164) and bolts (165).

Tighten

- Bolts (165) to 75 N·m (55 ft. lb.).

9. Cover (172) and bolts (173).
10. Secondary cylinder (142).
11. Transmission. Refer to MANUAL TRANSMISSION (SECTION 7B).

FLYWHEEL REPLACEMENT

For flywheel replacement procedures, refer to ENGINE (SECTION 6).

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

ITEM	N·m	Ft. Lbs.
Clutch Pedal Nut	35	26
Master Cylinder Mounting Nut	18	13
Secondary (Slave) Cylinder Mounting Nut	18	13
Pressure Plate Mounting Bolt	41	30
Flywheel Housing Mounting Bolt	75	55

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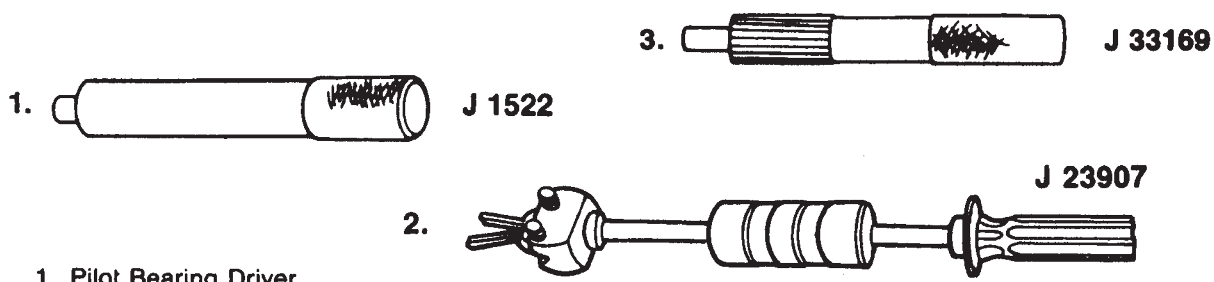
SPECIAL TOOLS



1. Pilot Bearing Driver
2. Clutch Pilot Bearing Remover
3. Clutch Alignment Tool

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SECTION 7D

TRANSFER CASE

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL DESCRIPTION

The transfer case is used to provide power flow to the front axle. The transfer case also provides a means of disconnecting the front axle, providing better fuel economy and quieter operation when the vehicle is driven on improved roads where four-wheel drive is not required. In addition, the transfer case provides an additional gear reduction when placed in low range, which is useful when difficult off-road conditions are encountered.

New Process Models 231 and 233 transfer cases are used on all vehicles covered by this manual.

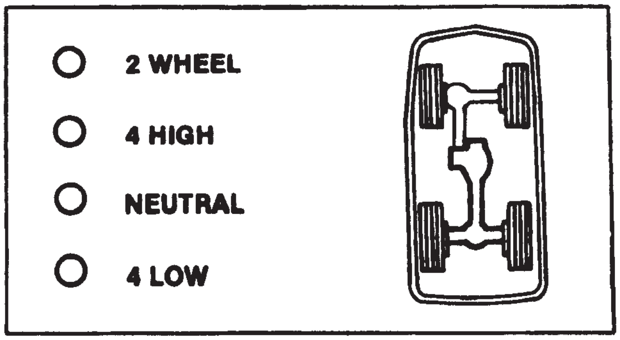
MODEL 231

The Model 231 is an aluminum case, chain-driven unit with four modes of operations: neutral, two-wheel drive high range, four-wheel drive high range, and four-wheel drive low range. Gear reduction for low range is provided by a planetary gear set.

A floor-mounted shift lever is used to select the operating range. The shift pattern is shown in (figure 1). Indicator lights on the floor console show the current mode of operation. When four-wheel drive has been selected, the four-wheel drive indicator light is designed to come on when the front axle has engaged. A slight delay for the front axle indicator light to come on is normal.

MODEL 233

The Model 233 is an electronic shift transfer case, that has three modes of operation: two-wheel drive range, four-wheel drive high range and four-wheel drive low range. Gear reduction for low range is provided by a planetary gear set. The floor-mounted shifter has been eliminated on vehicles equipped with the 233 transfer case. The switch located on the upper left side



TRANSFER CASE SHIFTING PROCEDURE
FOUR-WHEEL DRIVE

TO SHIFT TRANSFER CASE FROM	TO	PROCEDURE
"2 WHEEL" (Rear Wheel Drive)	"4 HIGH" (Four Wheel Drive). Used for low tractions road surfaces only. Do not use on dry pavement).	1. May be made while the vehicle is moving.* 2. Move transfer case shift lever into position. 3. Front axle locks automatically.
"2 WHEEL" or "4 HIGH" (High Range) (Do not use on dry pavement).	"4 LOW" (Low Range) (Used on low traction road surface only. Do not use on dry pavement).	1. Stop vehicle, place transmission in "N" (Neutral). 2. Press shift lever button, move transfer case shift lever with one continuous motion. Do not pause in Neutral as this could result in gear clash. 3. Axle locks automatically.
"4 LOW" (Low Range) (Do not use on dry pavement).	"2 WHEEL" or "4 HIGH" (High Range) (Use 4 High on low traction road surfaces only. Do not use on dry pavement).	1. Stop vehicle, place transmission in "N". 2. Press shift lever button, move transfer case shift lever with one continuous motion. Do not pause in Neutral as this could result in gear clash.
"4 HIGH" (Four Wheel Drive) (Do not use on dry pavement).	"2 WHEEL" (Rear Wheel Drive)	1. May be made while the vehicle is moving. 2. Move transfer case shift lever into position.

* In extreme cold weather, if difficulty is encountered in shifting from "2 WHEEL" to "4 HIGH" while vehicle is moving, it may be necessary to reduce speed or stop the vehicle.

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Figure 1—Shift Pattern and Procedure

of the instrument panel is used to select the operating range. Indicator lights on the switch show the current mode of operation (figure 2).

When four-wheel drive has been selected, the four-wheel drive indicator light on the switch is designed to come on when the front axle has engaged. The light will blink while the front axle is engaging, this is normal.

Follow the procedures listed below for shifting into from Two-Wheel drive to Four-Wheel drive:

2WD to 4HI:

1. May be made at any speed.
2. Press and release the 4HI switch.
3. Front axle locks automatically.
4. Green light blinks and then stays lit.

4HI to 2WD:

1. May be made at any speed.
2. Press and release the 4HI switch.
3. Front axle unlocks automatically.
4. All lights off.

2WD to 4LO:

1. Stop vehicle, place transmission in neutral or depress clutch pedal.
2. Press and release the 4LO switch .

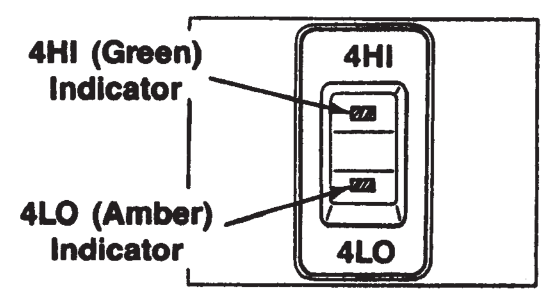

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Figure 2—Electronic Shift Transfer Case Switch and Indicator Lights

3. Wait for 4LO indicator light to stop flashing and stay lit, before shifting the transmission into gear or releasing the clutch pedal.
4. Amber light stays lit.

Important

- If the 4LO switch is pressed when the vehicle is in gear and/or moving, the 4LO (amber) indicator light will flash and not complete the shift until the vehicle speed is under 3 mph and the transmission is in neutral or the clutch pedal is depressed.

4HI to 4LO:

1. Stop vehicle, place transmission in neutral or depress clutch pedal.
2. Press and release the 4LO switch .
3. Wait for 4LO indicator light to stop flashing and stay lit, before shifting the transmission into gear or releasing the clutch pedal.
4. Amber light stays lit.

Important

- If the 4LO switch is pressed when the vehicle is in gear and/or moving, the 4LO (amber) indicator light will flash and not complete the shift until the vehicle speed is under 3 mph and the transmission is in neutral or the clutch pedal is depressed.

4LO to 4HI:

1. Stop vehicle, place transmission in neutral or depress clutch pedal.
2. Press and release the 4HI switch .
3. Wait for the 4LO indicator light to stop flashing and stay lit, before shifting the transmission into gear or releasing the clutch pedal.
4. Green light stays lit.

OPERATION

TWO-WHEEL-DRIVE OPERATION

When the transfer case is in 2WD range, torque flows from the input gear to the range shift hub and mainshaft, through the propeller shaft, to the rear axle. A switch in the shifter mechanism causes the 2WD indicator light to turn on.

FOUR-WHEEL-DRIVE HIGH RANGE OPERATION

Shifting into 4HI range causes the following to happen:

1. A switch in the shifter mechanism causes the 2WD indicator light to turn off and the 4HI indicator light to turn on. The front axle indicator light does not come on immediately.
2. Torque flows from the input gear to the mainshaft the same as in 2WD position. The shift linkage moves the mode synchronizer sleeve into engagement with the clutch teeth of the drive sprocket. This locks the drive sprocket to the mainshaft through the synchronizer sleeve.
3. Torque is transmitted through the drive sprocket and drive chain to the driven sprocket and output shaft. Torque then flows through the front propeller shaft to the front axle.
4. The shift mechanism in the transfer case triggers a vacuum switch (figure 3). Engine vacuum is then applied to a vacuum actuator, mounted on the right fender well, after a delay of about three seconds. Thu delay is provided by a restrictor orifice. The delay allows the system to synchronize properly.
5. The vacuum actuator pulls a cable, which pulls the shift fork in the front axle. This connects the right axle output shaft to the front axle differential. Torque now is available at the front wheels.
6. The front axle shift mechanism, when fully engaged, closes a switch, causing the front axle indicator light to come on. For more information on the front axle shift mechanism and vacuum actuator, refer to FRONT AXLE (SECTION 4C).
7. If the shift lever is moved back to 2WD position, the operation in the preceding steps is reversed. In addition, when the transfer case switch turns the vacuum to the vacuum actuator off, it connects the vacuum actuator hose to atmosphere through a vent hose. The actuator can then return to the two-wheel drive position.

FOUR-WHEEL-DRIVE LOW RANGE OPERATION

1. When the transfer case is shifted into 4LO position, torque flow and operation is similar to 4HI range, except that the range shift hub engages the planetary carrier. The planetary gear set then provides a gear reduction of 2.72:1 to both the front and rear axles.
2. A switch in the shifter mechanism causes the 4HI indicator light to turn off and the 4 LO indicator light to turn on.

TRANSFER CASE CONTROL MODULE (TCCM) AND MOTOR

The (TCCM) transfer case control module controls the motor on the transfer case per the request of the vehicle operator. It is mounted on the back of the ECM housing. The transfer case motor, when energized by pushing the switch, rotates the sector shaft of the transfer case, causing it to change between 2HI, 4HI, and 4LO.

IDENTIFICATION

An identification tag is attached to the rear case half (figure 4). The tag provides the transfer case model number, low range reduction ratio and assembly part number.

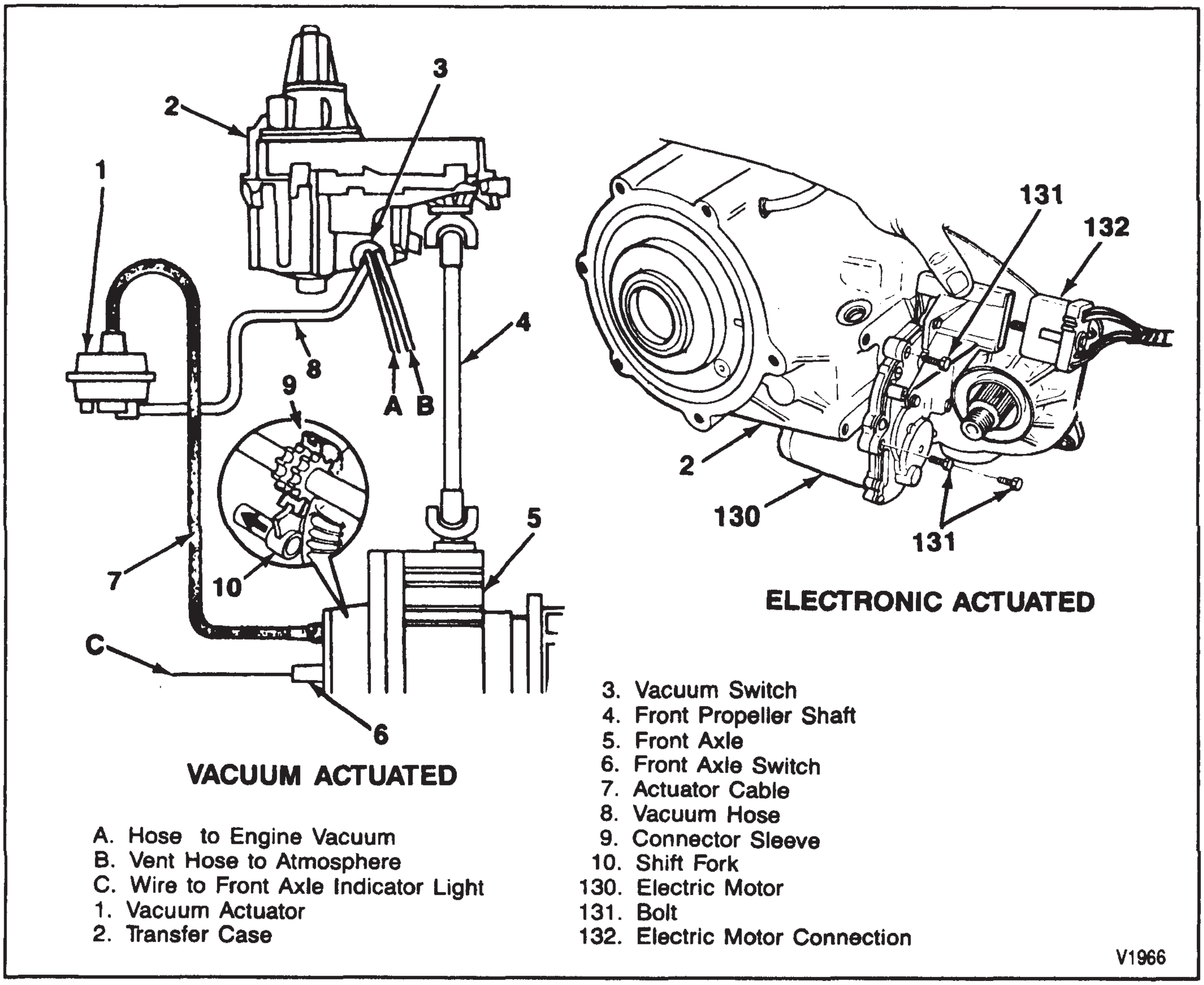

Figure 3—Vacuum and Electronic Actuation System

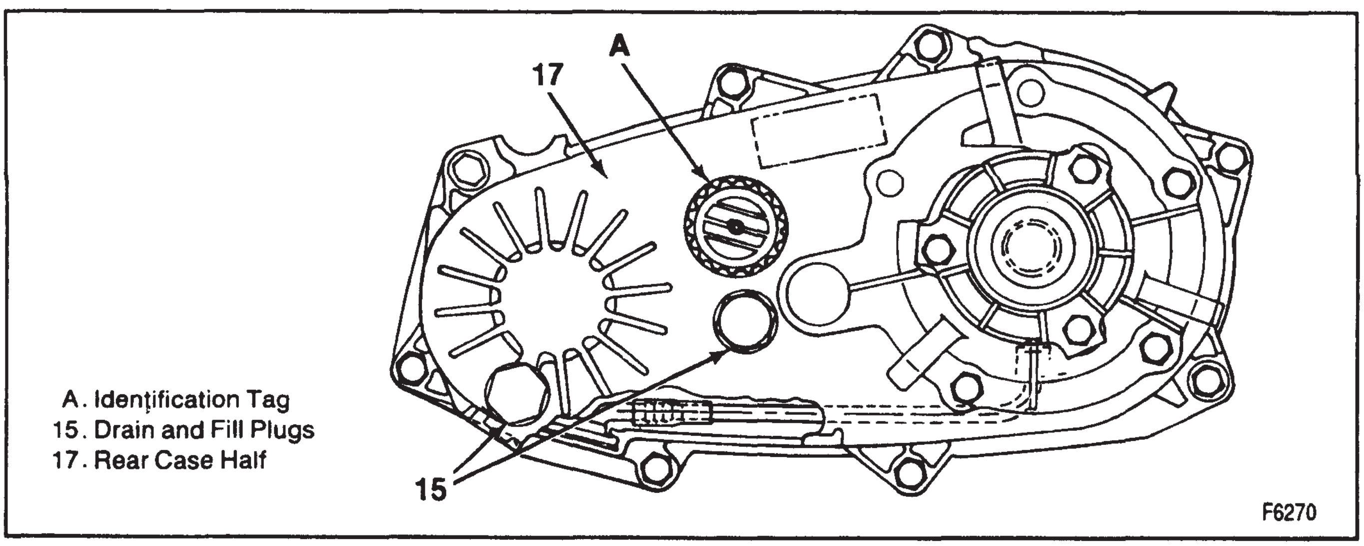

Figure 4—Transfer Case Identification

DIAGNOSIS OF THE TRANSFER CASE (INCLUDING ELECTRONIC SHIFT)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Four Wheel Drive Does Not Engage	1. Vacuum hoses kinked, disconnected, or broken. 2. Engine vacuum insufficient to activate vacuum actuator. At least -40 kPa (12 in. hg.) of vacuum is required at the actuator for proper operation. 3. Actuator cable kinked, misrouted, or disconnected. 4. Faulty vacuum actuator. Check for holes in diaphragm or other damage. 5. Faulty transfer case vacuum switch. 6. Faulty 4WD indicator light, switch, or wiring (4WD engaging but indicator light not coming on). 7. Transfer case linkage improperly adjusted or disconnected. 8. Faulty transfer case: Drive chain broken, range selector ring broken, etc. 9. Faulty front axle. 10. Blown fuse. 11. Bad connection at switch or motor. 12. Faulty motor. 13. Faulty module. 14. Faulty switch.	1. Check routing of hoses. Repair or replace as needed. 2. Repair or tune engine as required. 3. Repair or replace as needed. 4. Replace if necessary. 5. Replace. 6. Repair as needed. 7. Adjust or repair. 8. Repair. Refer to the proper Unit Repair Manual. 9. Refer to FRONT AXLE (SEC. 4C). 10. Replace fuse. 11. Check and repair connections 12. Replace motor. 13. Replace module. 14. Replace switch.
Four Wheel Drive Will Not Disengage	1. Faulty wiring or front axle switch (4WD disengaging but indicator light staying on). 2. Transfer case vacuum switch vent hose or vacuum actuator hose kinked or plugged. 3. Transfer case vent filter plugged. 4. Actuator cable kinked or damaged. 5. Faulty transfer case vacuum switch. 6. Transfer case linkage binding or improperly adjusted. 7. Faulty front axle shift mechanism. 8. Faulty switch. 9. Faulty motor. 10. Faulty module.	1. Repair or replace wiring. 2. Repair or replace. 3. Repair or replace. 4. Replace. 5. Replace. 6. Transfer case linkage binding or improperly adjusted. 7. Repair. 8. Replace switch. 9. Replace motor. 10. Replace module.
Four Wheel Drive Disengages Under Load	1. Insufficient vacuum at vacuum actuator due to vacuum leak, poorly tuned engine, or kinked vacuum hose. -40 kPa (12 in. hg.) of vacuum is required at the actuator for proper operation. 2. Vacuum system not venting properly due to kinked hose, plugged vent, or faulty transfer case vacuum switch. 3. Faulty transfer case or front axle shift mechanism. Refer to the Light Duty Unit Repair Manual.	1. Tune engine or repair vacuum hoses. 2. Repair. 3. Repair.

DIAGNOSIS OF THE TRANSFER CASE (INCLUDING ELECTRONIC SHIFT) (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Transfer Case Shift Lever Is Difficult To Shift Or Will Not Shift Into 4 LOW or NEUTRAL (Vehicle Moving)	1. In extremely cold weather, it may be necessary to reduce vehicle speed or stop before shifting from 2 Wheel to 4 High. 2. If the vehicle was operated for extended period in 4 HIGH mode on dry pavement, difficult shifting may result due to driveline torque load. Stop the vehicle, shift transmissino to neutral and shift transfer case into desired mode. 3. Transfer case external shift linkage binding. 4. Low transfer case lube level, or improper lubricant used. 5. Internal transfer case problem.	1. None required. 2. Operate the vehicle in 2 WHEEL mode on dry pavement. 3. Adjust or repair. 4. Fill with proper lubricant. 5. Repair.
Transfer Case Noisy In All Modes	1. Low transfer case lube level, or improper lubricant used. 2. Internal transfer case problem.	1. Fill with proper lubricant. 2. Repair.
Noisy In Or Jumps Out Of 4 LOW Range	1. Transfer case is not completely engaged in 4 LOW range. Stop vehicle, shift into NEUTRAL, then back to 4 LOW. 2. Shift linkage loose or binding. 3. Transfer case internal shift mechanism faulty.	1. None required. 2. Repair. 3. Repair.
Lubricant Leaking From Transfer Case Vent	1. Transfer case overfilled.	1. Drain lubricant to correct level.
Lubricant Leak At Output shaft Seals	1. Transfer case overfilled. 2. Vent hose plugged or kinked. 3. Output shaft seals damaged or incorreclty installed.	1. Drain lubricant to correct level. 2. Repair. 3. Replace.
Abnormal Front Tire Wear, While In Four Wheel Drive	1. Front end needs alignment. 2. Extended operation on hard, dry sufaces in 4 HIGH mode.	1. Align to specifications. 2. Operate vehicle in 2 WHEEL mode on hard dry surfaces.
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FOUR-WHEEL DRIVE INDICATOR LIGHT DIAGNOSIS

Refer to figures 5 and 6.

VACUUM HOSE ROUTING AND SCHEMATIC

Refer to figure 7.

SYMPTOM TABLE

SYMPTOM	FOR DIAGNOSIS
One or more Indicator Assembly Lamps do not function.	Do Tests A and B
Indicator Assembly Front and Rear Axle Display does not function.	Do TEST C check WHT (150) wire, WHT (156) wire, and BLK (150) wire for an open
No Indicator Assembly Lamps function.	Do TEST A Check BRN/WHT (141) wire and BLK (150) wire for an open

TEST B: INDICATOR ASSEMBLY TEST

Check for: VOLTAGE
At: INDICATOR ASSEMBLY (Connected)
Condition: Selector Quadrant Switch Disconnected

Measure Between	Correct Result	Repair
1 (C2) and Ground	Test lamp lights	*
2 (C2) and Ground	Test lamp lights	*
3 (C2) and Ground	Test lamp lights	*
4 (C2) and Ground	Test lamp lights	*
5 (C2) and Ground	Test lamp lights	*
1 (C1) and Ground	Test lamp lights	*
5 (C1) and Ground	Test lamp lights	*

*If voltage is present at 2 (C1) and test lamp does not light, replace Indicator Assembly.

TEST A: SELECTOR QUADRANT SWITCH TEST

Measure: CONTINUITY
At: SELECTOR QUADRANT SWITCH (Switch Disconnected)

Measure Between	Correct Result	Repair
● Selctor Quadrant Switch; 2 WHEEL		
1 and 5	Continuity	*
● Selctor Quadrant Switch: 4 HIGH		
2 and 5	Continuity	*
● Selector Quadrant Switch: NEUTRAL		
3 and 5	Continuity	*
● Selector Quadrant Switch: 4 LOW		
4 and 5	Continuity	*

- If all results are correct, refer to the Symptom Table.

* If continuity does not exist at any or all terminals, replace the Selector Quadrant Switch.

TEST C: FRONT AXLE SWITCH TEST

Check for: VOLTAGE
At: C190
Condition: Front Axle Switch Connected Selector Quadrant in detent position 2 or 4

Measure Between	Correct Result	Repair
A and Ground	Test lamp lights	*
B and Ground	Test lamp lights	*

- If all results are correct, refer to the Symptom Table.

*Check WHT (150) wire or WHT (156) wire for an open.

**Replace Front Axle Switch.

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Figure 5—Indicator Light Diagnosis

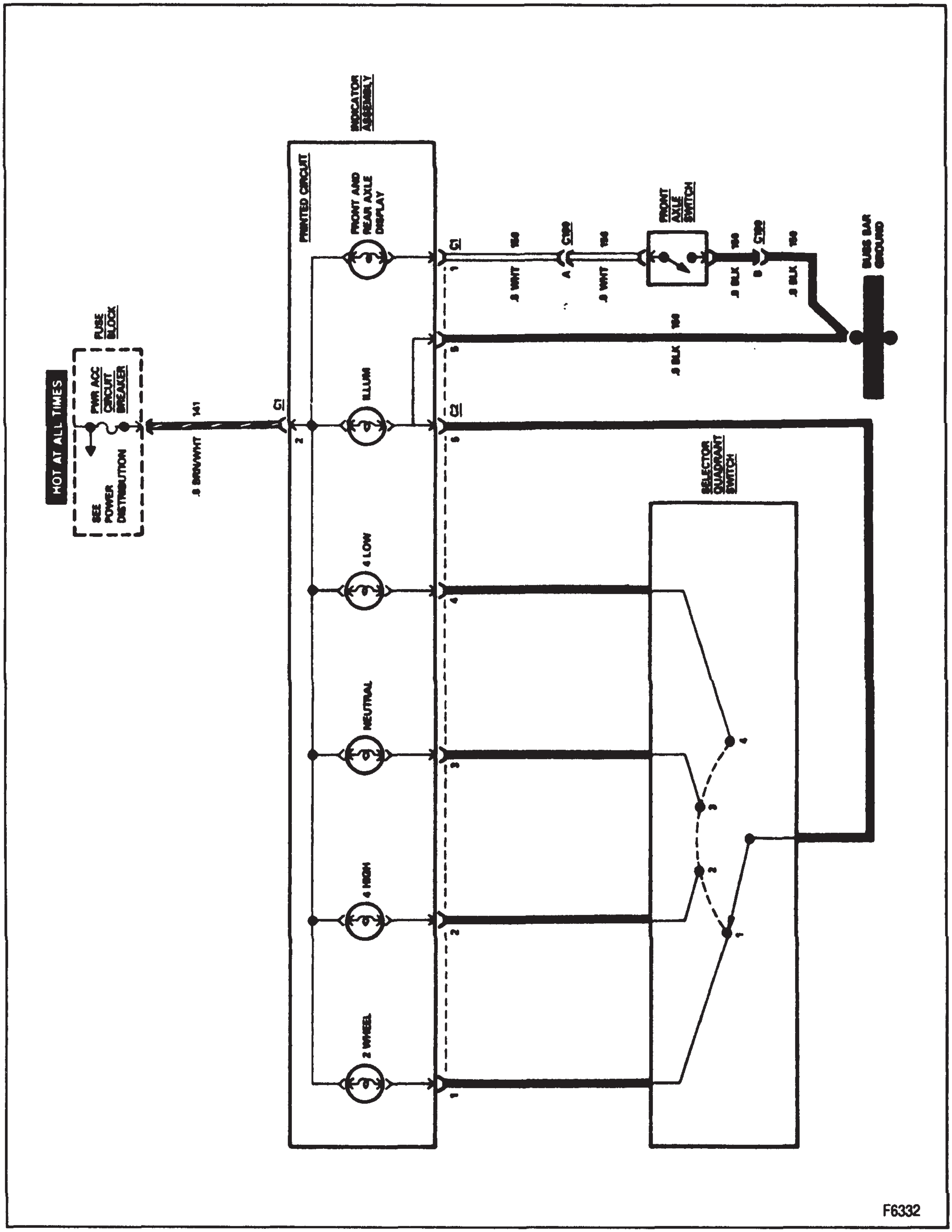


Figure 6—Indicator Light Wiring Schematic

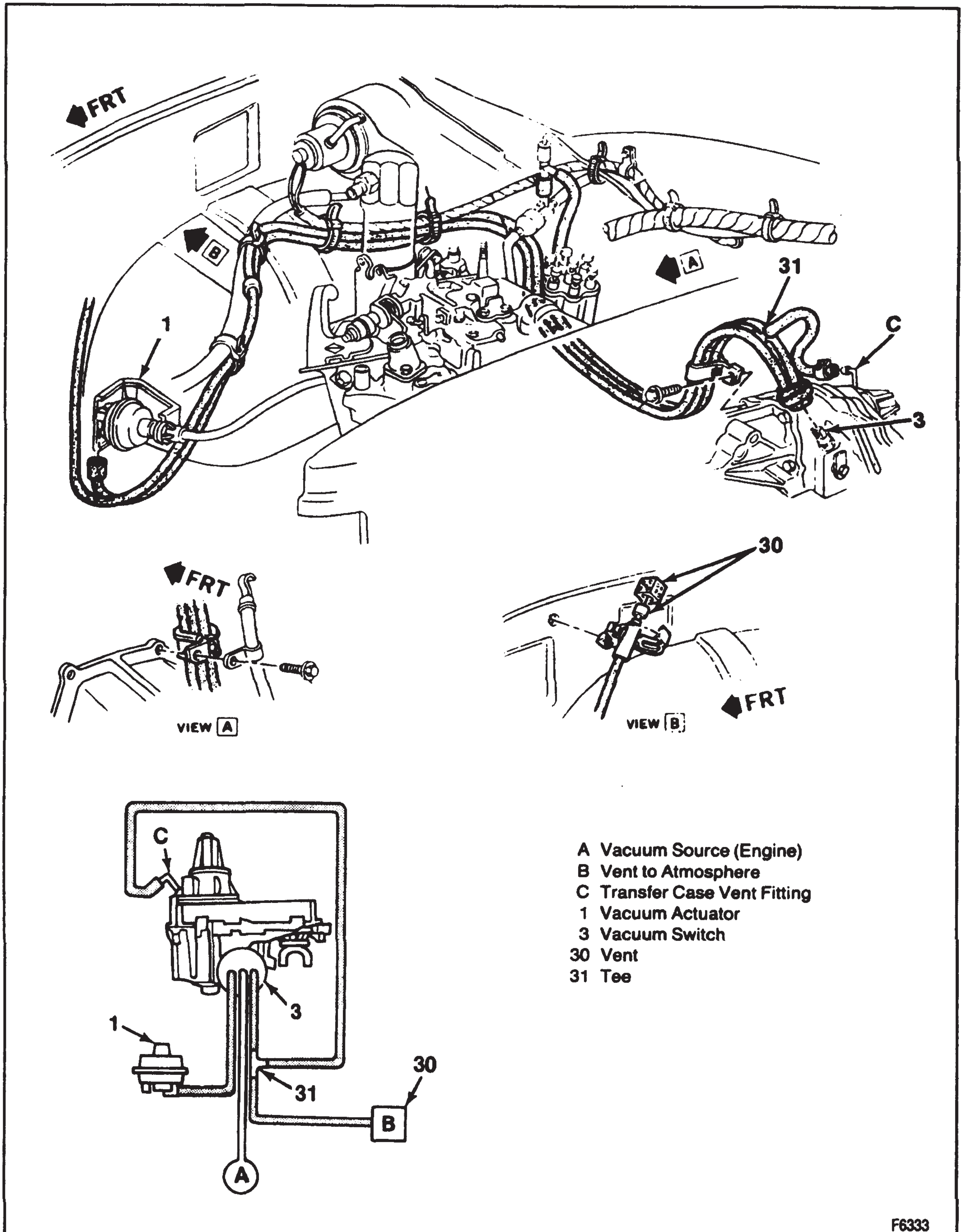


Figure 7—Vacuum Line Routing and Schematic

ON-VEHICLE SERVICE

TRANSFER CASE OIL CHANGE

Remove or Disconnect (Figures 4 and 8)

- Raise the vehicle. Support with suitable safety stands.

1. Skid plate (39) (if equipped).

- Place a drain pan under the drain plug (figure 3).

2. Drain plug (15). Allow the oil to drain.
3. Fill plug (15).

Install or Connect (Figures 4 and 8)

1. Drain plug (15).

Tighten

- Drain plug (15) to 25 N·m (18 ft. lbs.).

2. Oil as described in MAINTENANCE AND LUBRICATION (SECTION 0B) in this manual. Fill the transfer case until the oil level is at the bottom of the filler plug hole.
3. Filler plug (15).

Tighten

- Fill plug (15) to 25 N·m (18 ft.lbs.).

4. Skid plate (39) (if equipped).

- Lower the vehicle.

SKID PLATE REPLACEMENT

Remove or Disconnect (Figure 8)

1. Bolts (42) and washers (40 and 41).
2. Skid plate (39).

Install or Connect (Figure 7)

1. Skid plate (39).

NOTICE: See "Notice" on page 7D-1 of this section.

2. Bolts (42) and washers (40 and 41).

Tighten

- Bolts (42) to 28 N·m (20 ft. lbs.).

TRANSFER CASE LINKAGE ADJUSTMENT

Adjust (Figure 9)

1. Remove the console (48).
2. Raise the shift lever boot up the shift lever.
3. Loosen bolt (44).
4. Loosen bolt (47).
5. Place the shift lever (40) in 4HI position.
6. Install a suitable bolt (A) at the shift lever on the transfer case as shown. This will lock the transfer case in 4HI.
7. Insert an 8 mm (5/16-inch) diameter gage pin or drill bit through the hole in the shift lever into the upper corner of the switch detent bracket (49). This aligns the switch assembly in the 4HI position.

NOTICE: See "Notice" on page 7D-1 of this section.

8. Tighten bolt (47) to 102 N·m (75 ft.lbs.).
9. Tighten bolt (44) to 40 N·m (30 ft.lbs.).
10. Remove the lock bolt (A) and gage pin or drill bit (B).
11. Install the console and boot.

SHIFT LEVER REPLACEMENT

Remove or Disconnect (Figure 10)

1. Negative battery cable.
2. Console (60).
3. Boot (61). Slide the boot up the shift lever.
4. Nut (71).
5. Upper lever (69).
6. Selector quadrant switch (66) and switch detent bracket (67).

- Raise the vehicle. Support with suitable safety stands.

7. Rod (42) at the lower lever (72).
8. Bolt (47), wave washer (46) and flat washer (45).
9. Lower lever (72).

Install or Connect (Figure 10)

1. Lower lever (72).

NOTICE: For steps 2 and 5 see "Notice" on page 7D-1 of this section.

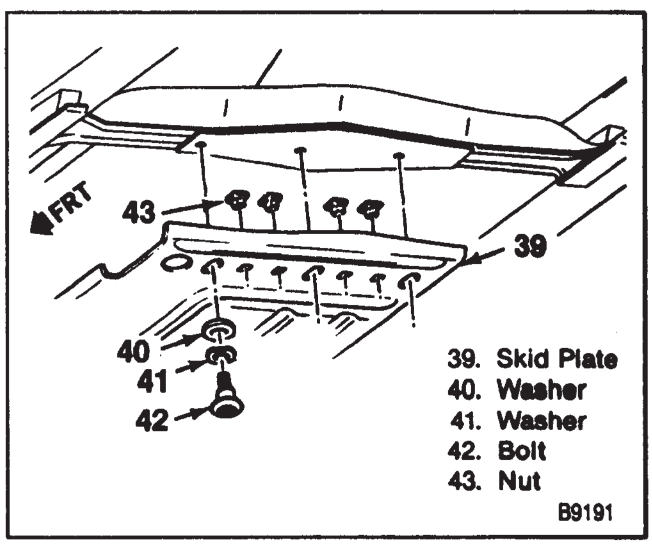
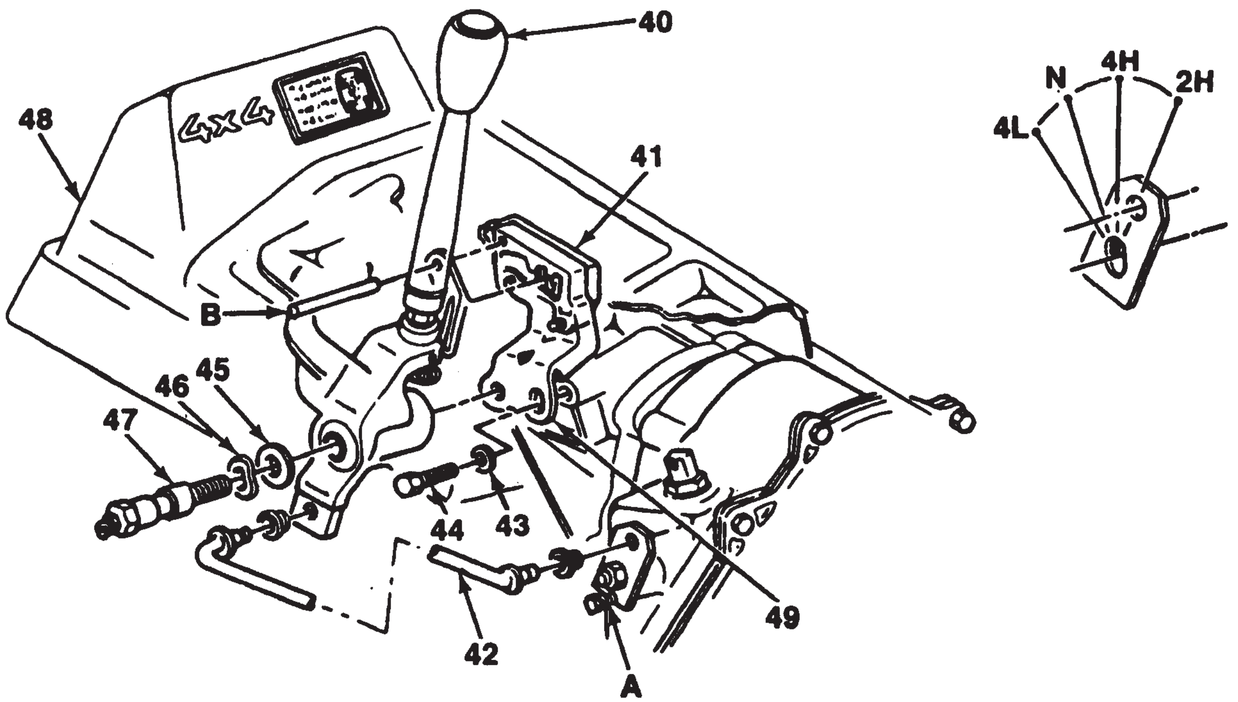


Figure 8—Skid Plate Installation



A. Lock Bolt
B. Gage Pin
40. Shift Lever Assembly
41. Switch Detent Bracket
42. Rod
43. Flat Washer
44. Bolt
45. Flat Washer
46. Wave Washer
47. Bolt
48. Console
49. Bracket

F6334

Figure 9—Shift Linkage Adjustment

2. Bolt (47), wave washer (46), and flat washer (45). Leave finger tight.
3. Rod (42) to the lower lever (72).

- Lower the vehicle.

4. Selector quadrant switch (66) and switch detent bracket (67). Leave the bolts finger tight.
5. Upper lever (69) and nut (71).
   - Screw the upper lever (69) in until the detent pawl (73) clears the switch detent bracket (67). Then screw in 1-1/2 additional turns. Tighten nut (71) to 24 N.m (18 ft. lbs.).

Adjust

- Transfer case linkage, as outline previously.

6. Boot (61).
7. Console (60).
8. Negative battery cable.

SELECTOR QUADRANT SWITCH REPLACEMENT

Remove or Disconnect (Figures 10 and 11)

1. Negative battery cable.
2. Console (60) and boot (61). Slide the boot up the shift lever.
3. Switch harness at the indicator assembly (64) and clip (82).
4. Clip (65).
5. Screws (80).
6. Switch (66).

Install or Connect (Figures 10 and 11)

1. Switch (66) to the bracket (67).
   - Make sure the detent pawl (73) engages the switch contact carrier.
   - Route the harness under the clip (82).

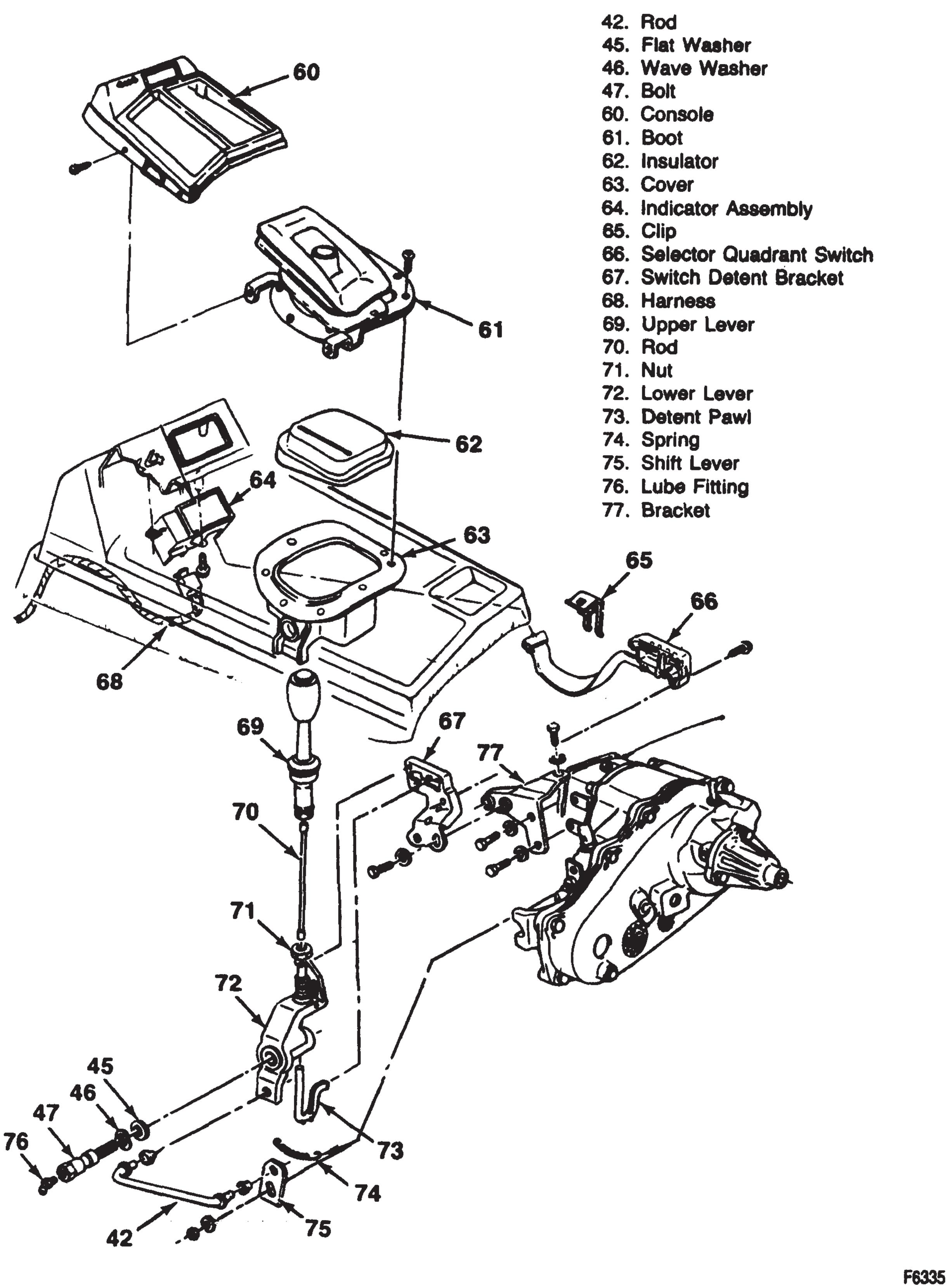


Figure 10—Shift Lever and Components

NOTICE: See "Notice" on page 7D-1 of this section.

2. Screws (80).
3. Clip (65).
4. Switch harness to the indicator assembly (64).
5. Console (60) and boot (61).
6. Negative battery cable.

VACUUM SWITCH REPLACEMENT

Remove or Disconnect (Figure 12)

- Raise the vehicle. Support with suitable safety stands.

1. Vacuum lines (135) from the switch (3).
2. Switch (3).

Install or Connect (Figure 12)

1. Switch (3). Coat the threads with thread sealant.
2. Vacuum lines (135).

- Lower the vehicle.

TRANSFER CASE OUTPUT SHAFT SEAL REPLACEMENT

Remove or Disconnect (Figures (12 and 13)

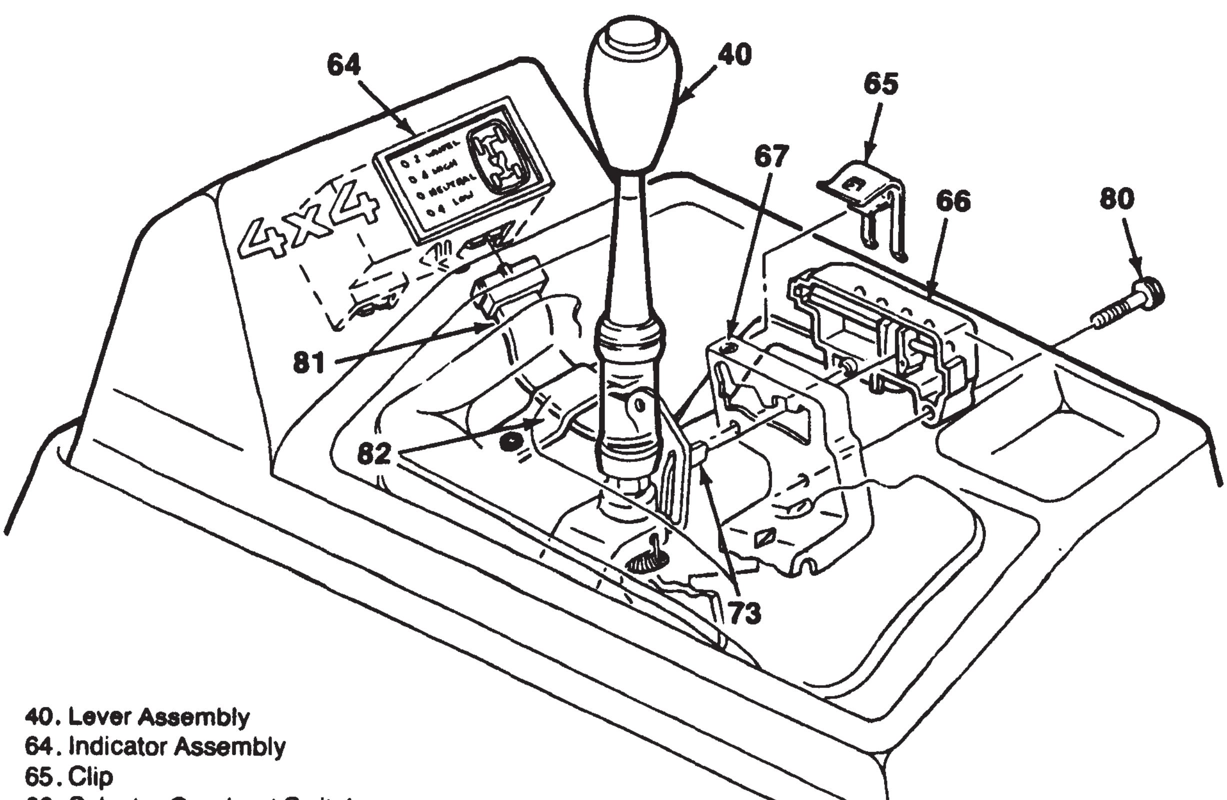
- Raise the vehicle. Support with suitable safety stands.

1. Front or rear propeller shaft, Refer to PROPELLER SHAFT (SECTION 4A).
2. Propeller shaft yoke nut (100) and washers (101).
3. Yoke (102) and shield (103).
4. Seal (104 or 109). Pry out with a screwdriver. Take care not to damage the seal bore.

Install or Connect (Figures 12 and 13)

Tools Required:
J 33834 Front Output Shaft Seal Installer
J 33843 Rear Output Shaft Seal Installer

1. Seal (104 or 109).
   - Lubricate the seal lips with ATF or petroleum jelly.



40. Lever Assembly
64. Indicator Assembly
65. Clip
66. Selector Quadrant Switch
67. Switch Detent Bracket
73. Detent Pawl
80. Screw
81. Harness Connector
82. Clip

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Figure 11—Selector Quadrant Switch

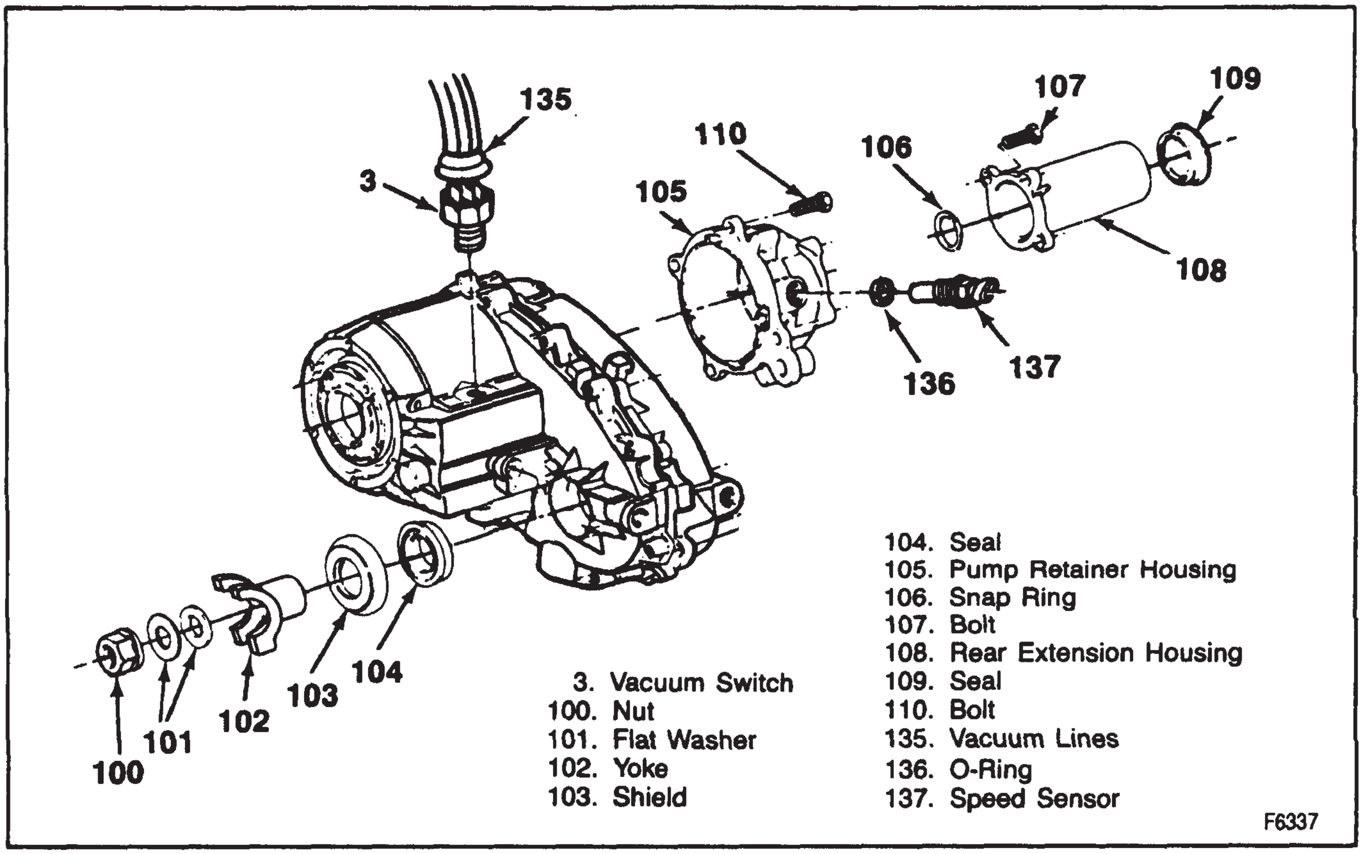


Figure 12—Transfer Case Components

- Install using J 33834 (front seal) or J 33843 (rear seal) (figure 12).

2. Shield (103) and propeller shaft yoke (102).

NOTICE: See "Notice" on page 7D-1 of this section.

3. Washers (101) and yoke nut (100).

Tighten

- Yoke nut to 149 N·m (110 ft. lbs.).

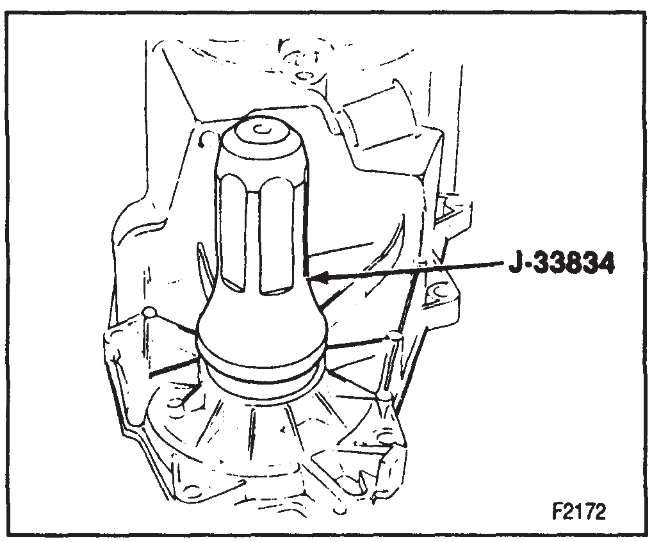


Figure 13—Installing the Output Shaft Seal (Front Seal Shown)

4. Propeller shaft.
- Lower the vehicle.

REAR EXTENSION HOUSING REPLACEMENT AND PUMP RETAINER HOUSING REPLACEMENT

Remove or Disconnect (Figure 12)

- Raise the vehicle. Support with suitable safety stands.

1. Rear propeller shaft, Refer to PROPELLER SHAFT (SECTION 4A).
2. Bolts (107), and rear extension housing (108).
3. Snap ring (106).
4. Vehicle speed sensor (137) and O-ring (136) .
5. Bolts (110).
6. Pump retainer housing (105).
7. Seal (109). Pry out with a screwdriver. Take care not to damage the seal bore.

Clean

- Gasket surfaces with a suitable solvent.

Install or Connect (Figure 12)

Tool Required:
J 33843 Rear Output Shaft Seal Installer

1. Pump retainer housing (105).

- Make sure the gasket surfaces are clean and free of grease and oil.
- Apply RTV sealer to the pump retainer housing sealing surfaces.

NOTICE: For steps 2, 3, and 5 see "Notice" on page 7D-1 of this section.

2. Bolts (110).
   - Apply Loctite 242 (GM part number 1052279) or equivalent to the threads of the bolts (110).

Tighten

- Bolts (110) to 40 N·m (30 ft.lbs.).

3. Snap ring (106).
4. Rear extension housing (108) to the transfer case.
   - Make sure the gasket surfaces are clean and free of grease and oil.
   - Apply RTV sealer to the rear extension housing sealing surfaces.
5. Bolts (107).
   - Apply Loctite 242 or equivalent to the threads of the bolts (107).

Tighten

- Bolts (107) to 31 N·m (23 ft.lbs.).

6. Seal (109).
   - Lubricate the seal lips with ATF or petroleum jelly.
   - Install using J 33843 (figure 12).
7. Vehicle speed sensor.
8. Rear propeller shaft.

- Fill the transfer case with the proper lubricant. Refer to MAINTENANCE AND LUBRICATION (SECTION 0B).
- Lower the vehicle.

ELECTRONIC SHIFT MOTOR REPLACEMENT

Remove or Disconnect (Figures 3, 8, and 12)

1. Negative battery cable.
   - Raise vehicle support with suitable safety stands.
2. Motor electrical connection (132).
3. Front propeller shaft.
4. Front output shaft yoke (102), as outlined previously.
5. Bolts (131).
6. Motor (130).

Install or Connect (Figures 2, 8, and 12)

1. Motor (130).

NOTICE: See "Notice" on page 7D-1 of this section.

2. Bolts (131).

Tighten

- Bolts (131) to 18 N·m (13 ft. lbs.).

3. Front output shaft yoke (102) as previously outlined.
4. Front propeller shaft Refer to PROPELLER SHAFT (SECTION 4A).
5. Motor electrical connection (132).
6. Negative battery cable.
   - Lower vehicle.

TRANSFER CASE REPLACEMENT (231 and 233)

Remove or Disconnect (Figures 3, 7, 8, 9, 10, and 14)

1. Negative battery cable.
   - Shift the transfer case into 4HI.
   - Raise the vehicle. Support with suitable safety stands.
2. Skid plate (if equipped).
   - Drain the oil from the transfer case.
3. Front and rear propeller shafts.
4. Vacuum lines (8) and electrical connections (132), (if equipped).
5. Transfer case shift rod (42) at the transfer case.
6. Bolts (125).
   - Support the transfer case with a suitable jack.
   - Slide the transfer case off the transmission output shaft.
   - Lower the transfer case.
7. Transfer case.
8. Gasket (123 or 125).

Install or Connect (Figures 3, 7, 8, 9, 10, and 14)

1. New gasket (123 or 125) to the transmission. Use gasket sealer to hold it in place.
2. Transfer case to the vehicle.

NOTICE: See "Notice" on page 7D-1 of this section.

3. Bolts (125).

Tighten

- Bolts (125) to 33 N·m (24 ft. lbs.).
- Remove the jack from the transfer case.

4. Shift rod (42) (if equipped).
5. Vacuum lines (8) and electrical connections (132) (if equipped).
6. Front and rear propeller shafts.
7. Skid plate (if equipped).
8. Fill the transfer case with the proper lubricant. Refer to MAINTENANCE AND LUBRICATION (SECTION 0B).
   - Lower the vehicle.
9. Negative battery cable.

TRANSFER CASE ADAPTER REPLACEMENT (AUTOMATIC TRANSMISSION)

Remove or Disconnect (Figure 14)

1. Transfer case, as outlined previously.
2. Bolts (123) and seals (122).
3. Adapter (121).
4. Gasket (120).

Install or Connect (Figure 14)

1. Gasket (120). Make sure the gasket tab faces as shown.
2. Adapter (121).

NOTICE: See "Notice" on page 7D-1 of this section.

3. Bolts (123) and seals (122).

Tighten

- Bolts (123) to 33 N·m (24 ft. lbs.).

4. Transfer case, as outlined previously.

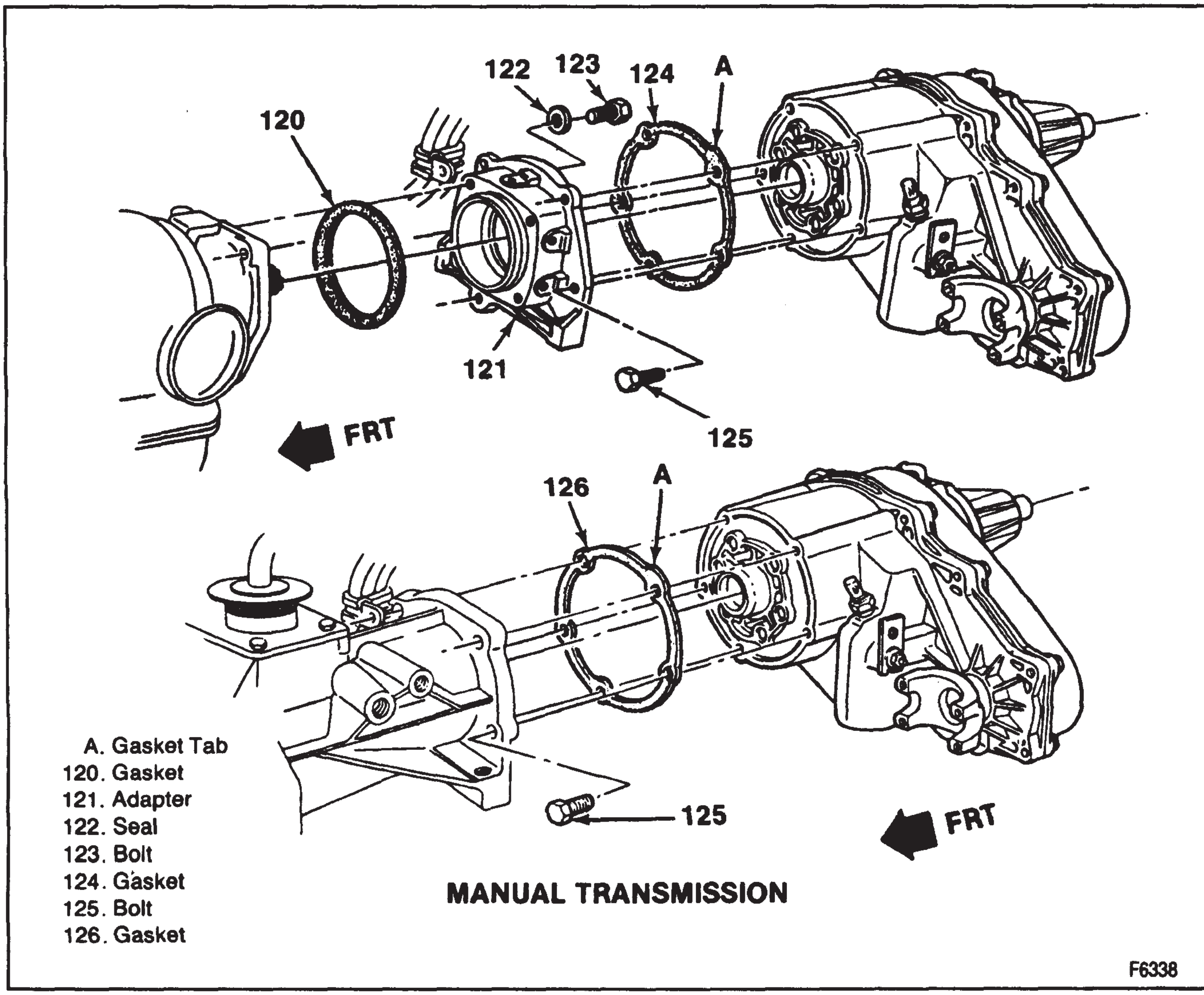
TRANSFER CASE MODULE REPLACEMENT

Remove or Disconnect (Figure 15)

1. Negative battery cable.
2. ECM (engine control module) (200).
3. Electrical connection (202).
4. Module (203).

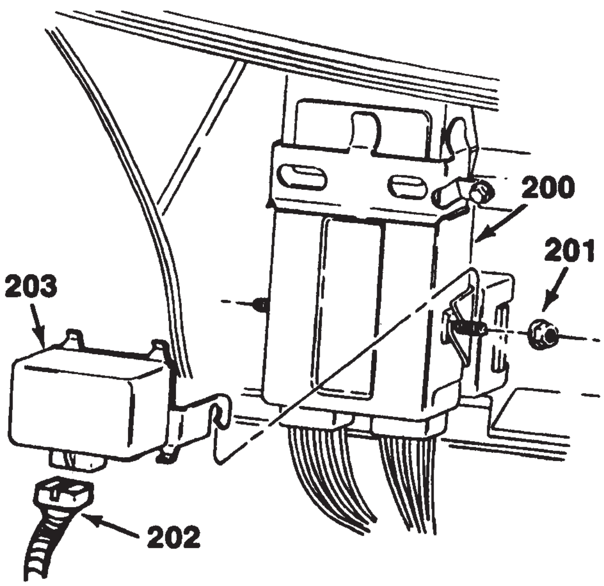
Install or Connect (Figure 15)

1. Module (203).
2. Electrical connection (202).
3. ECM (engine control module) (200).
4. Negative battery cable.



A. Gasket Tab
120. Gasket
121. Adapter
122. Seal
123. Bolt
124. Gasket
125. Bolt
126. Gasket

Figure 14—Transfer Case Installation



200. ECM
201. Nut
202. Electrical Connection
203. Module

V1968

Figure 15—Module Replacement

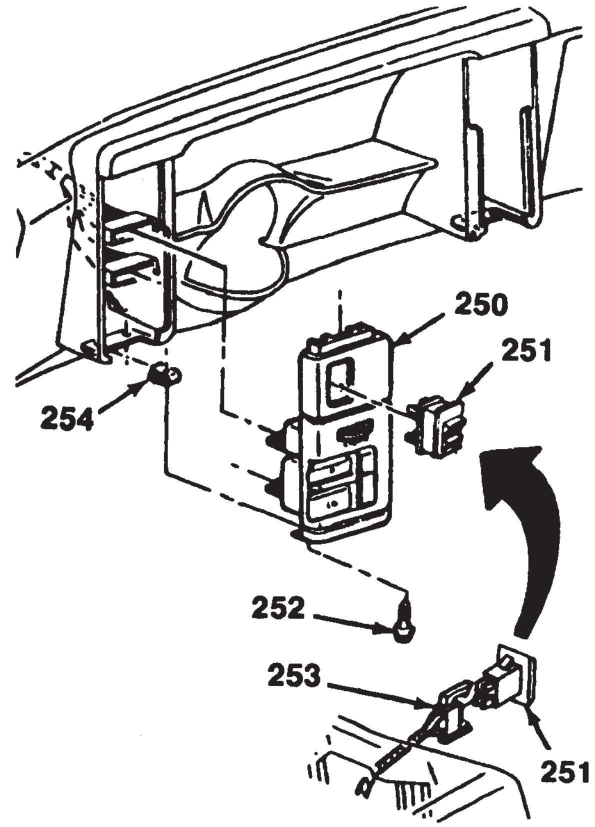
TRANSFER CASE SWITCH REPLACEMENT

Remove or Disconnect (Figure 16)

1. Negative battery cable.
2. Trim plate screws (252).
3. Trim plate (250).
4. Electrical connection (253).
5. Switch (251).

Install or Connect (Figure 16)

1. Switch (251).
2. Electrical connection (253).



250. Trim Plate
251. Transfer Case Switch
252. Screw
253. Electrical Connector
254. Nut

V1969

Figure 16—Transfer Case Switch Replacement

3. Trim plate (250).

NOTICE: See "Notice" on page 7D-1 of this section.

4. Trim plate screws (252).
5. Negative battery cable.

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Item	N·m	Ft. Lbs.
Adapter to Transmission Bolts (Auto. Trans.)	33	24
Adapter to Transfer Case Bolts (Auto. Trans.)	33	24
Mounting to Transfer Case Bolts (Auto. Trans.)	47	35
Transfer Case to Transmission Bolts (Man. Trans.)	33	24
Front Propeller Shaft Yoke Nut	149	110
Drain and Fill Plugs	25	18
Pump Retainer Housing Bolts	40	30
Extension Housing Bolts	31	23
Skid Plate Bolts	28	20
Electronic Motor Connector	4.5	40*
Electronic Shift Motor	18	13
Shift Lever Nut	24	18
Shift Lever Pivot Bolt	102	75
Shift Detent Bracket Bolts	40	30
Detent Retainer Bolts	31	23

*Inch Lbs.

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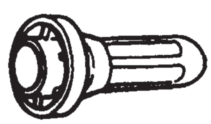
SPECIAL TOOLS

1

2



J 33834

J 33843

1. Front Output Shaft Seal Installer
2. Rear Output Shaft Seal Installer

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