SERVICE MANUAL

WITH 660 SUZUKI EFI ENGINE

HAULSTER® POLICE VEHICLE

FOR

MODEL 898487

Part No. 2703285

INDEX

Lincoln, Nebraska • Printed in U.S.A.

25–6–00–CU

SECTION 1

ELECTRONIC FUEL INJECTION THEORY

ELECTRONIC FUEL INJECTION THEORY

MANAGEMENT SYSTEM DESCRIPTION

FOREWORD

This SECTION provides information on the basic operation of the Electronic Fuel Injection engine control system. The text covers what the Electronic Fuel Injection engine control system does and how it works.

Read this SECTION to gain better understanding of the Electronic Fuel Injection engine, which, we are convinced, will help diagnose engine management problems.

ELECTRONIC FUEL INJECTION ENGINE CONTROL

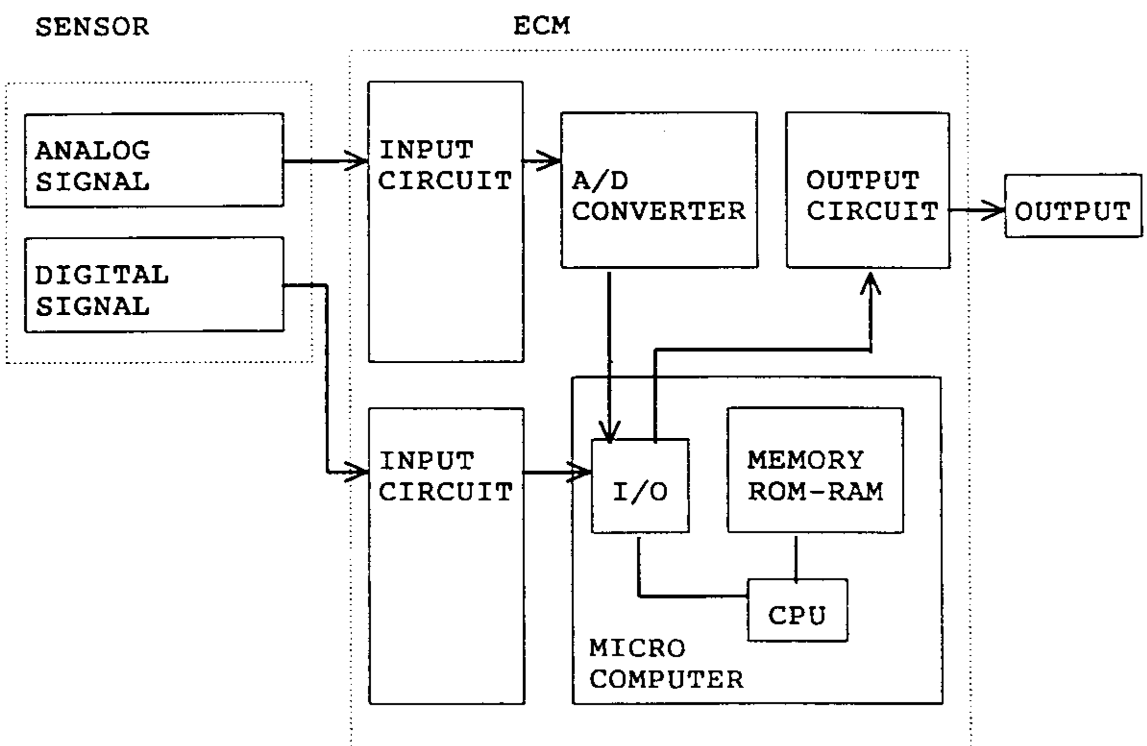
Technical Instruction

1. Performance and configuration of engine control

Engine control system and micro computer

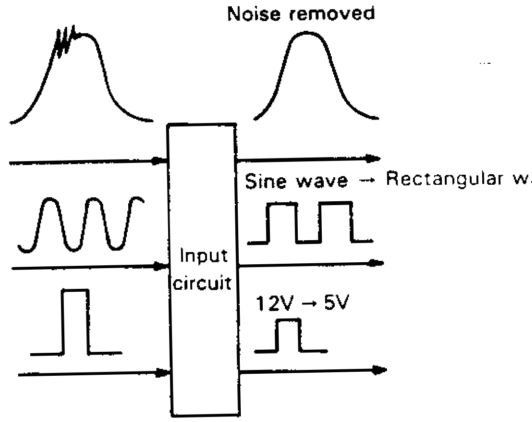
This vehicle uses many different electronic control devices which make use of a microcomputer. Ones equipped in vehicles are: engine control system and automatic transmission control system. Use of a microcomputer makes it possible to handle a large amount of information in such a short time. Computer allow for highly accurate, multifunction system control. Described in this section is the engine controller utilizing a microcomputer.

The controller used in the engine control system is called ECM (Electronic Control Module) also known throughout this manual as engine control module.. Its components, configuration and connection with the actuator are shown in the figure below.
When the input signal from the sensor enters the ECM, it passes through the input circuit first. If it is an analog signal, it is converted into a digital signal by the A/D converter and then inputted to the microcomputer. If it is a digital signal, it is inputted to the microcomputer as it is. The microcomputer processes these input signals and outputs the results through the output circuit to the actuator.



Input circuit

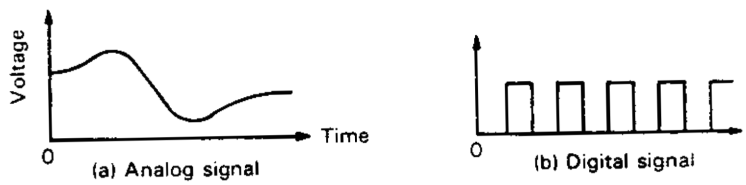
When a signal from each sensor enters ECM, it first passes through the input circuit, where any noise on each signal is removed and a sine wave signal such as a crank angle signal is converted to a pulse signal (rectanglar wave). Another function of the input circuit is to convert the voltage level of the digital signal to such voltage level that can be processed by the microcomputer which operates at a 5V voltage.



Functions of Input Circuit

A/D Converter

The analog signal received by the ECM must be converted into a digital signal for microcomputer processing and this conversion is done by the A/D converter.



Type of input signal from sensor

Microcomputer

The microcomputer accepts signals from the sensors as necessary, processes them by using programs and data written in it and then sends the results to the output circuit as fuel injection signals, ignition signals, etc. Here each of its components is described.

(1) CPU

CPU is the brain of the microcomputer. It processes the input data by using the processing program stored in the ROM. In the CPU, simultaneous processing of a large amount of data is not expected, for the data is processed one by one within each unit time. However, as the processing speed is as high as to handle over one million operations per second, it can process a large amount of data very quickly.

(2) Memory (ROM, RAM)

The ROM (Read–Only Memory) is where programs and data necessary for control are stored. Once stored in it, they are retained as they are, even if power has been turned OFF and no change can be made to them.

The RAM (Random Access Memory) is where input data and processed results are temporarily stored. They will be erased if power is turned OFF.

(3) Input/output interface

The input/output interface controls receiving and sending signals according to the command from CPU. As CPU cannot process a large amount of data simultaneously as described above, inputting/ outputing of signals is executed according to the programmed sequence.

Output circuit

As the output signal from the microcomputer is a digital signal, it cannot operate the actuator. The output circuit has a function to operate the actuator, based on the output signal from the microcomputor.

Basic functions of engine control system

Basic functions of the engine control system include fuel injection control, idle speed control and ignition timing control that are synthetically controlled by ECM which has a built–in microcomputer.

Outline of engine control functions Electronic fuel injection

The electronic fuel injection control system controls injection timing and injection time (amount of injection). As ECM has an operation expression for injection time stored in its memory, it calculates the optimum injection time according to the input signals (amount of intake air, engine speed, cooling water temperature, etc.) from sensors.

Idle speed control (ISC)

ECM has target idle speeds for various engine conditions stored in its memory. When it receives signals (including cooling water temperature, D–range signal of A/T vehicles, etc.) from each sensor, it controls so that the idle speed becomes the target speed.

Electronic spark advance (ESA) control

ECM has optimum ignition timing for various engine conditions stored in its memory. When it receives signals (including engine speed, amount of intake air, cooling water temperature and throttle opening) from each sensor, it controls the ignition timing based on such signals.

Self diagnosis function

The self–diagnosis function is used to diagnose a trouble. When an abnormal signal is fed to ECM, it detects the abnormality, stores that data in its backup RAM and indicates what the trouble is by using code numbers and diagnosis lamp when probed.

Fail–safe function

When an abnormal signal is fed to ECM, the fail–safe function selects the standard value stored in its ROM of ECM to avoid the engine failure. When a critical abnormality has occurred, however, it makes the engine stop.

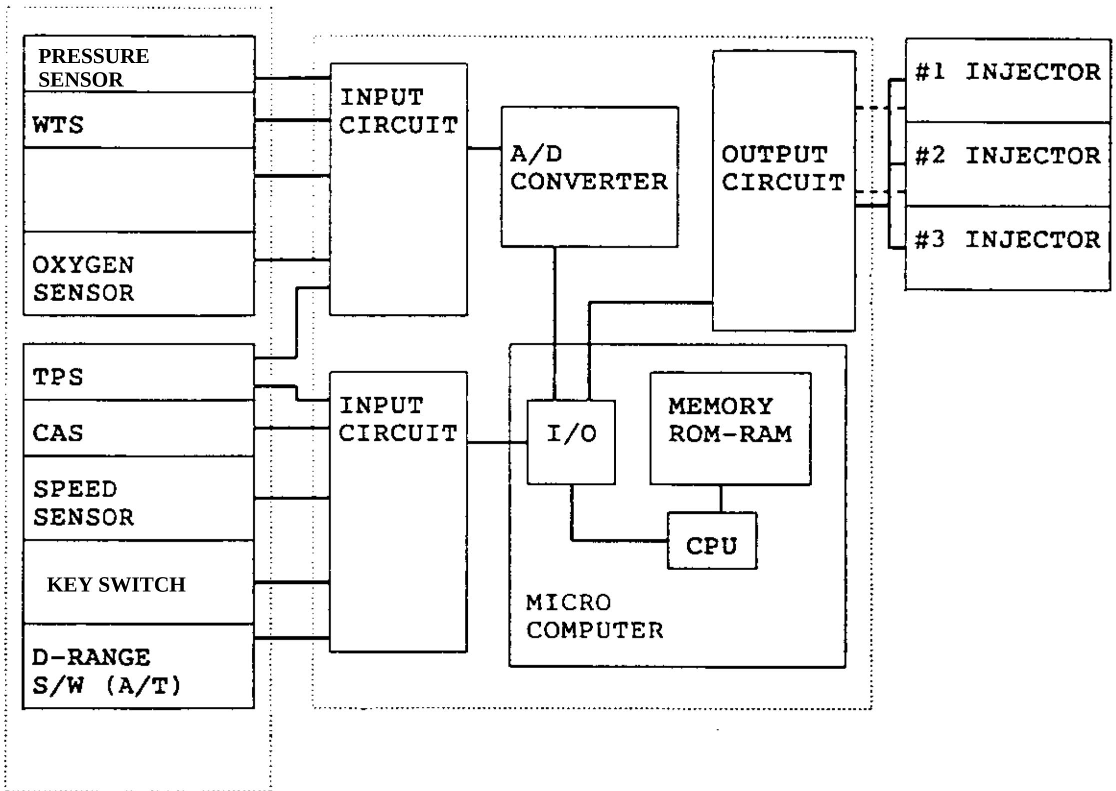
Back–up (failsafe) function

The back–up failsafe function executes a certain fuel injection and ignition control when an abnormality has occurred in the microcomputer in ECM so that driving can be continued long enough to return to the repair facility.

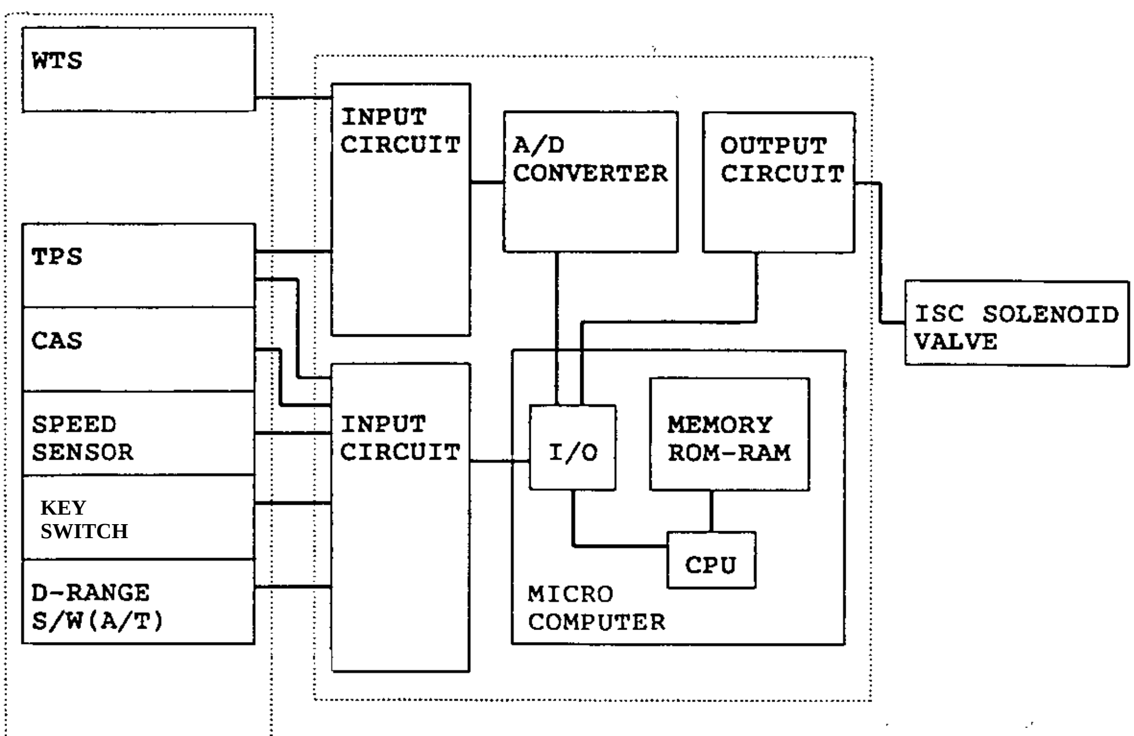
System configuration of each control function

Following block diagrams show configurations of sensors and actuators used for such control systems as fuel injection control, idle speed control, ignition control EGR control and purging control.

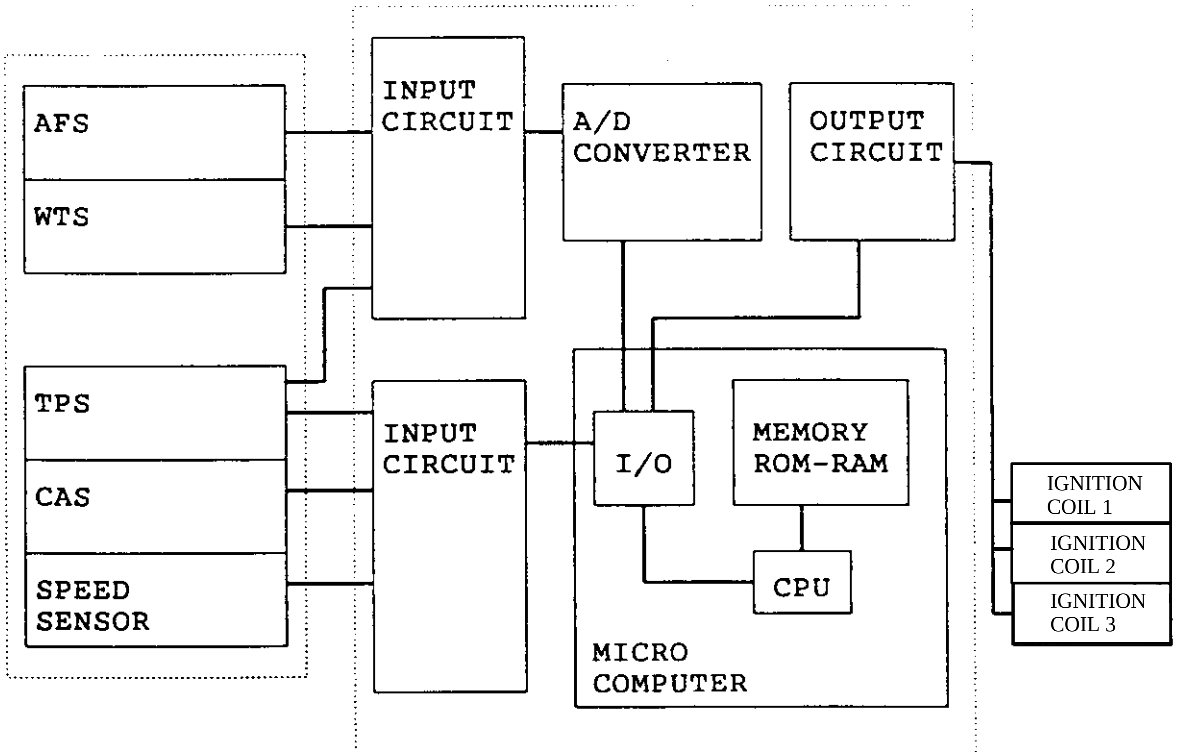
(1) Fuel injection control



(2) Idle speed control



(3) Ingition control sensor



Configuration of Engine Control System

The engine control system consists of the following sub–systems.

Intake air system

This system supplies the air necessary for combustion. The air filtered by the air cleaner flows through the throttle body into the surge tank. Then it is distributed in the intake manifold and drawn into each combustion chamber. This system also includes the air regulator which controls the first idle speed and the ISC solenoid valve which controls the idle speed.

Ignition system

This system consists of ignition coils and ignition plug. It emits sparks to the ignition plug according to the ignition signal. Also, it sends the ignition check signal from the primary circuit of the ignition coil to ECM.

Control system

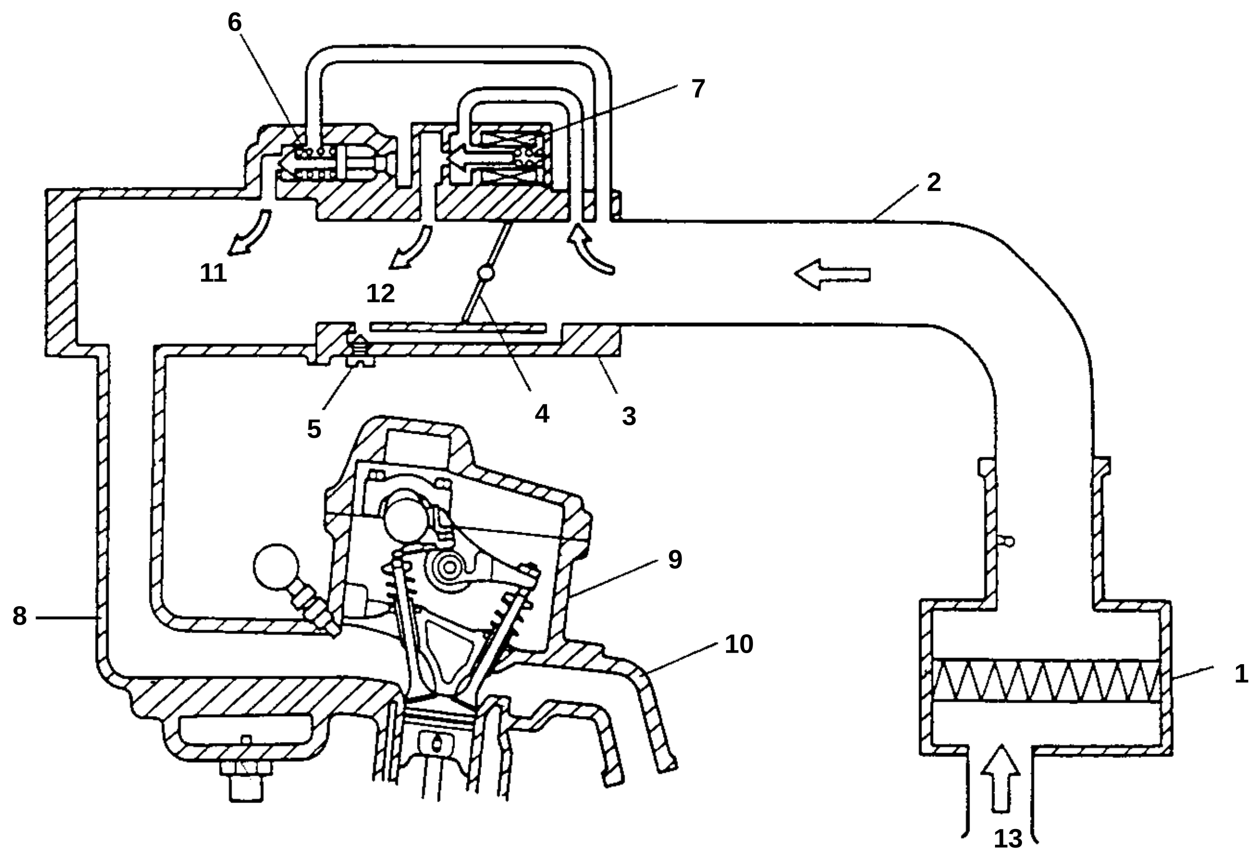
This system consists of the signal system (including sensors and switches), ECM, actuator system (including an injecter, ISC solenoid valve and igniter) and power source to control fuel injection, idle speed and ignition timing.

Air intake system

The main components of the air intake system are air cleaner, air flow meter, air intake pipe, throttle body, air valve, ISC solenoid valve and intake manifold.

The air (by the amount corresponding to the throttle valve opening and engine speed) is filtered by the air cleaner, passes through the throttle body, is distributed by the intake manifold and finally drawn into each combustion chamber.

When the engine is idling, when it is cold or when the ISC solenoid valve is opened according to the signal from ECM, the air bypasses the throttle valve through bypass passage which varies in each case and is finally drawn into the intake manifold.



1. AIR CLEANER
2. AIR INTAKE PIPE
3. THROTTLE BODY
4. THROTTLE VALVE
5. IDLE SPEED ADJUSTING SCREW
6. AIR VALVE
7. ISC SOLENDOID VALVE
8. INTAKE MANIFOLD
9. CYLINDER HEAD
10. EXHAUST MANIFOLD
11. AIR FLOW WHEN ENGINE COLD
12. AIR FLOW WHEN ISC SOLENOID VALVE OPEN
13. FRESH AIR

Description of intake system

The air filtered by the air cleaner flows into the surge tank but only by such amount according to the opening of the throttle in the throttle body as well as the engine speed.

The throttle valve in the throttle body regulates the air amount into the engine by its opening. The air from the throttle body goes into the surge tank and is distributed to the intake manifold of each cylinder to be drawn into the combustion chamber.

When the engine is cold, as the engine cooling water temperature is low, the air regulator opens and the air bypasses the throttle valve and flows into the surge tank. Due to such function, even when the throttle valve is completely closed, the air flows into the surge tank, increasing the idle speed by that amount and warm–up operation is improved.

After the engine has been warmed up, the ISC solenoid valve regulates the air bypassing the throttle valve, thereby stabilizing the idle speed.

Throttle body

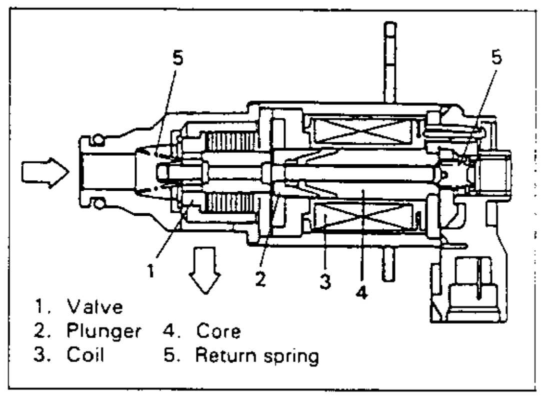
The main components of the throttle body are: a throttle valve which regulates the amount of intake air, a throttle sensor which detects throttle valve opening, a bypass passage to allow a small amount of air during idling and a thermo–wax type air regulator which boosts the engine warm–up at a low temperature.

Idle speed control (ISC)

The idle speed control uses a linear solenoid type ISC solenoid valve to stabilize the idle speed by changing the amount of air flow bypassing the ISC solenoid valve according to the ECM.

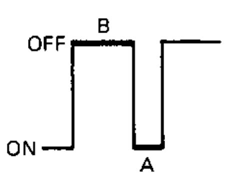
ISC solenoid valve

Shown at the right is this type of ISC solenoid valve.



When electricity flows according to the signal from the ECM, the coil is excited, causing the valve shaft to move. Due to this movement, the clearance between the solenoid valve and the valve body changes to control the idle speed although the fast idle speed is controlled by the air regulator.

The ECM controls ON/OFF of electricity flow to the coil by using the XHz frequency and controls the ISC solenoid valve position by using its duty ratio. That is, the longer the ON time is (or the larger the ISC duty ratio is), the larger the valve opening becomes, resulting in more amount of the bypassing air. This duty ratio can be expressed as follows.



$$\text{Duty ratio} = \frac{A}{A+B} \times 100\ (\%)$$

IDLE SPEED CONTROL (ISC)

The ISC duty ratio is calculated by using the following equation.
ISC duty ratio = (Basic value + Correction at engine start + Electric load compensation + D range compensation

+F/B compensation +Learning compensation +Low speed
compensation) x battery voltage compensation x Water temperature compensation

Described below is how control is done at each time.

(1) When the engine is at a stop

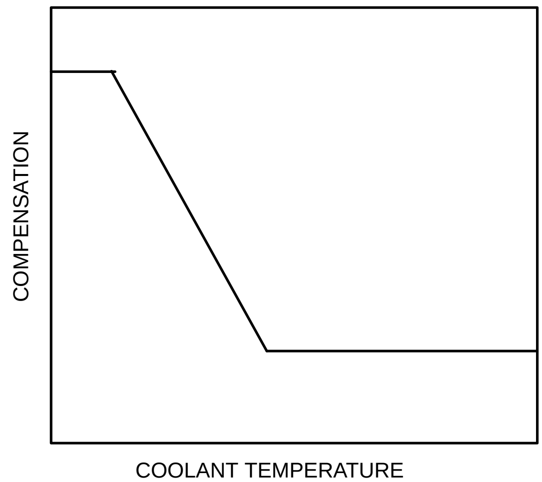
The ISC solenoid valve remains OFF or completely closed.

(2) When the engine is started (correction at engine start)

Once the engine is started, the ISC solenoid valve opens widely to increase the bypassing air for quicker warm–up. At this time, the ISC duty ratio initially set varies depending on the temperature of the cooling water. The lower the temperature is, the higher value it is set to.

(3) During the engine is warmed up (Compensation at engine start) (Basic value)

The ISC duty value set at the engine start as described in (2) attenuates by a constant value to the basic duty value which is determined only by the cooling water temperature.

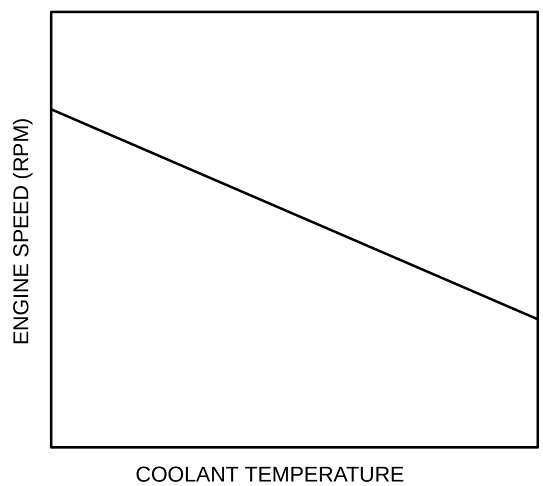


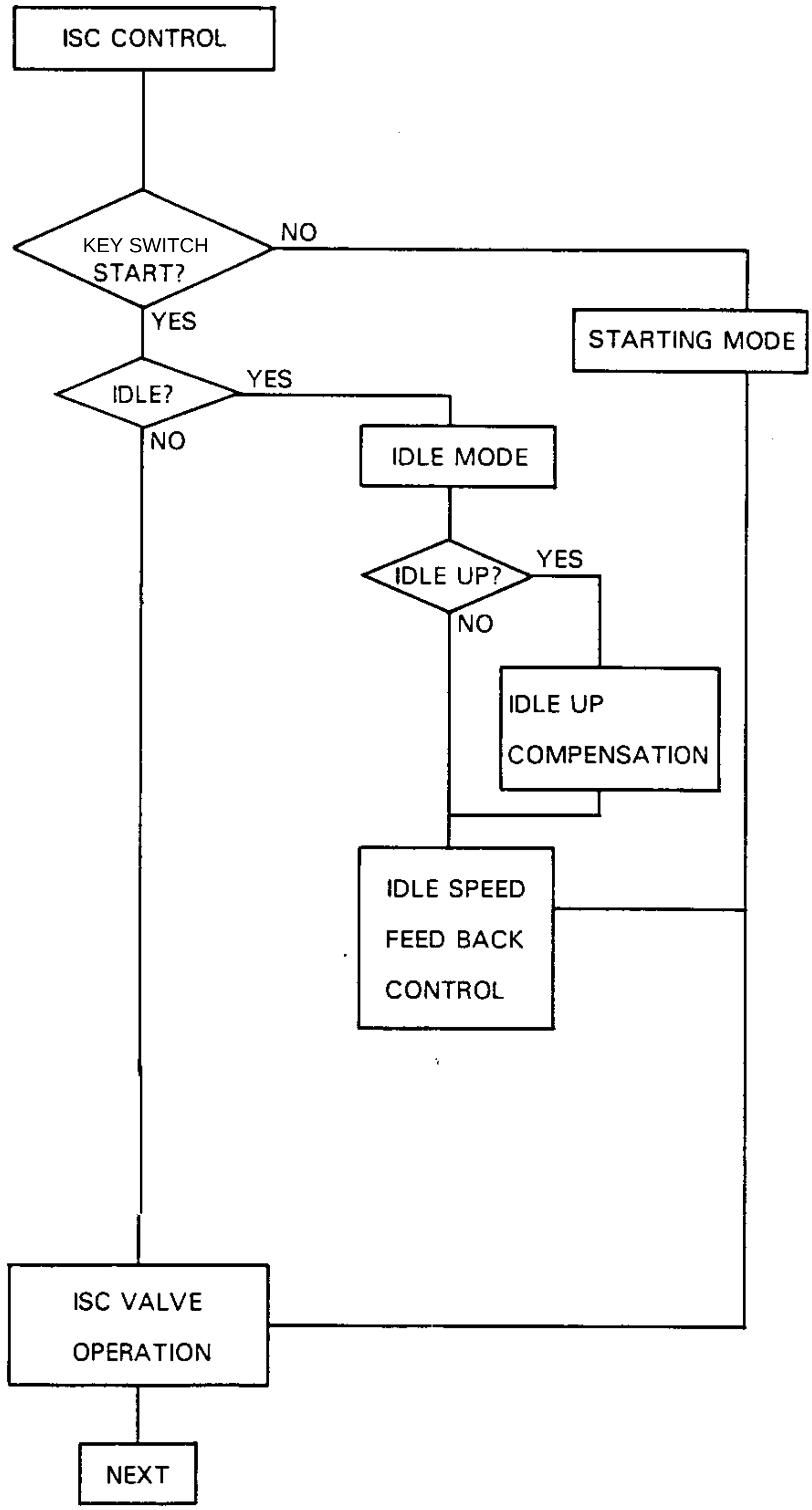
(4) When a load is applied to the engine

When the D range signal (the select lever position, applicable to A/T vehicles only) turns ON, the ISC duty ratio is increased by the amount of value stored in the ECM memory to prevent the idle speed from varying.

(5) Feedback (F/B) compensation

The ECM stores target speeds for different levels of the cooling water temperature in memory. During idling, the duty ratio is varied for compensation so that the engine idle speed remains constantly at this target speed (target idle speed). For example, when the idle speed drops lower than the target speed, the duty ratio is increased by increasing the feedback compensation value. Then the amount of the bypassing air increases and the engine idle speed increases. The target speed varies depending on the shift position (for the A/T vehicles).




ISC CONTROL
KEY SWITCH
START?
NO
YES
STARTING MODE
IDLE?
YES
NO
IDLE MODE
IDLE UP?
YES
NO
IDLE UP
COMPENSATION
IDLE SPEED
FEED BACK
CONTROL
ISC VALVE
OPERATION
NEXT

FUEL SYSTEM

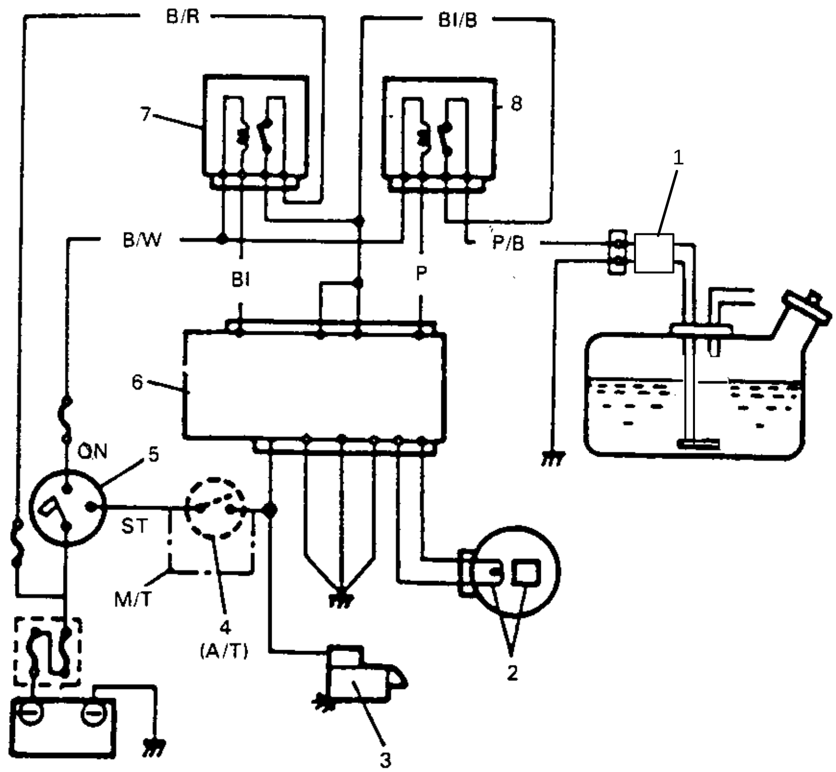
Fuel pump control

The fuel pump of the electronic fuel injection system is controlled so that it operates only when the engine is running. This is a safety device to stop the fuel pump whenever the engine stops even if the ignition switch is ON.

(1) When the ignition switch is turned ON, the main relay turns ON immediately to pass electricity as far as the upper side of the pump relay contact point.

(2) The pump relay under the control of the ECM turns ON when any of the following conditions is met and the fuel pump is activated as long as it is ON.

Conditions	Pump ON time
• After ignition switch On	2 seconds
• When starter signal ON	
• When crank angle sensor signal fed	2 seconds

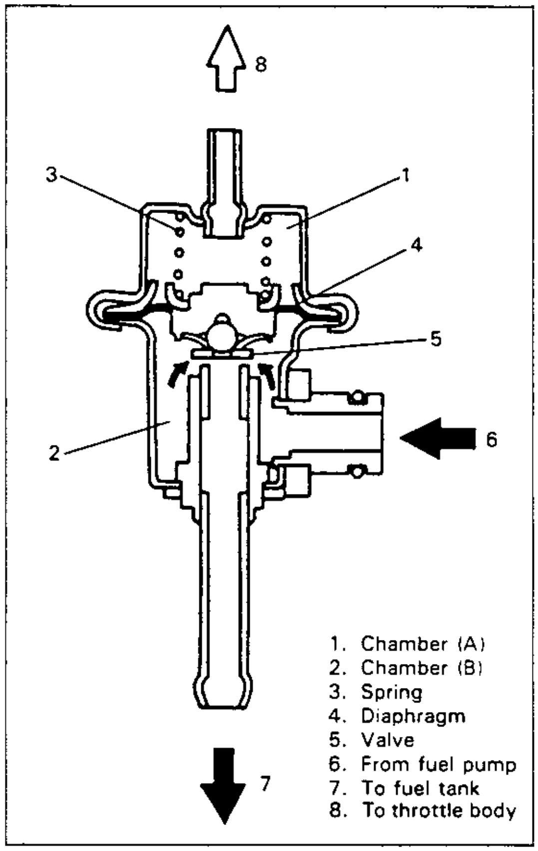


1. Fuel pump
2. CAS
3. Starter
4. Shift switch (A/T)
5. Main switch
6. ECM
7. Main relay
8. Fuel pump relay

Fuel pressure control system

As the amount of injected fuel supply to the engine is controlled according to the injection signal (to determine how long the injector injects fuel) sent to the injector by the ECM, it is also necessary to control the fuel pressure. Otherwise, fuel injection increases when the fuel pressure is high and decreases when it is low even though the fuel injection time is the same.

Furthermore, since fuel injection takes place in the intake manifold, if the fuel pressure is kept constant, the amount of injected fuel supply increases when the manifold vacuum is high and decreases when it is low. Therefore, to keep the air/fuel ratio at a proper level, a pressure regulator is used to control the fuel pressure for more accurate control over the amount of fuel injection.



Pressure Regulator Cross-Section

Pressure regulator

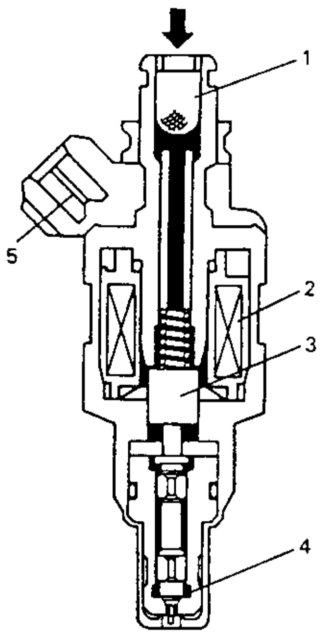
The pressure regulator controls the fuel pressure applied to the injector so that it is kept 2.9kg/cm2 higher than the ambient air pressure. When the fuel pressure rises more than 2.9kg/cm2 higher than the air pressure, the diaphragm is pushed up to send back an excess fuel to the fuel tank through the return pipe so that the fuel pressure is constantly kept 2.9kg/cm2 higher than the air pressure.

Pulsation damper

Although the fuel pressure is controlled by the pressure regulator so that it stays 2.9kg/cm2 higher than the air pressure in the manifold, it varies slightly when fuel is injected by the injector. The pulsation damper absorbs such slight variation by function of spring and diaphragm in it.

Fuel injection control system Injector

A nozzle attached to the intake manifold is an injector. Equipped with an electromagnetic valve, it injects fuel according to the injection time calculated by the ECM.
When electricity flows to the coil, it attracts the plunger and the needle valve, as it is incorporated to the plunger, also moves to its full open position, allowing fuel to inject through the clearance between the needle valve and injector body. How much fuel is injected is determined by how long the needle valve is open, that is, how long the coil is energized, because other conditions such as the needle valve stroke, size of the injection port and fuel pressure against the pressure at the injection point are all fixed.



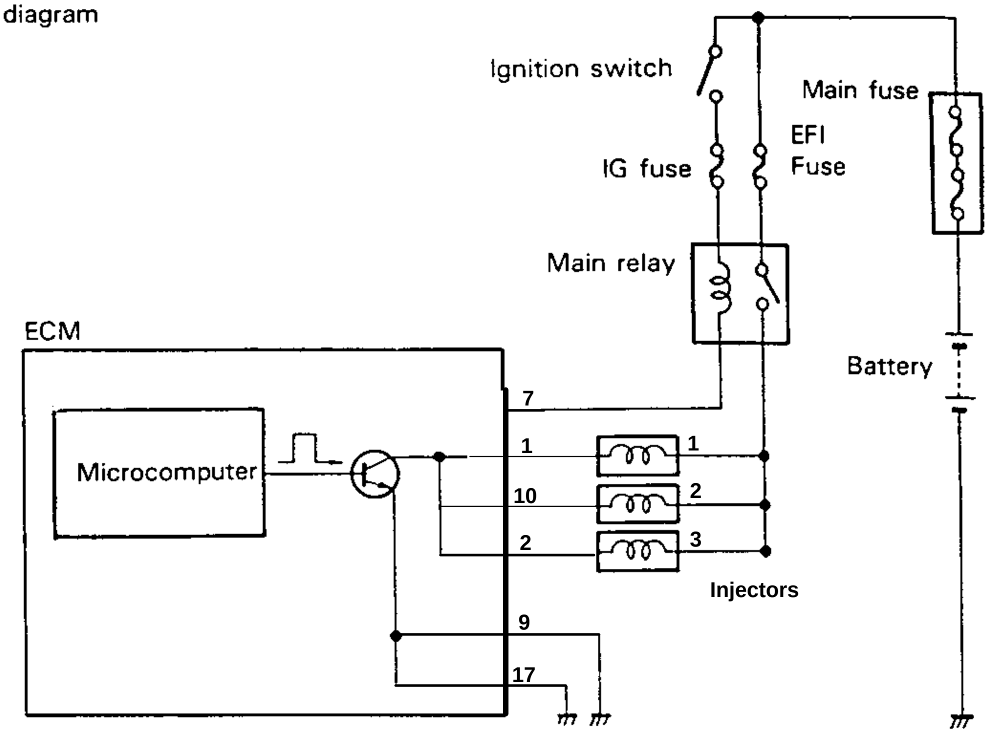
1. Filter
2. Solenoid coil
3. Plunger
4. Needle valve
5. Terminals

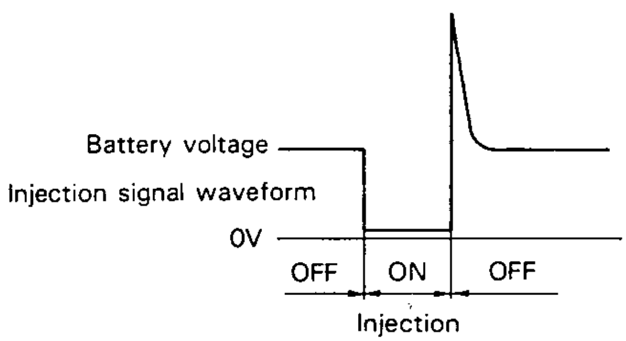
Fuel Injector Cross-Section

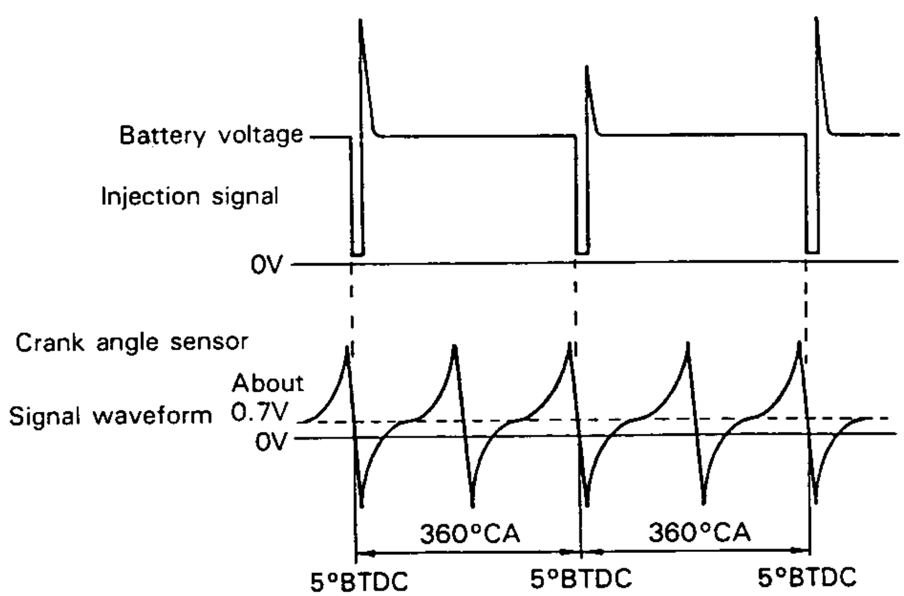
Drive circuit of injector

The type of drive circuit of the injector is a voltage control type and current control type. This type of drive circuit includes battery, Electronic Fuel Injection fuse, main relay, injector and ECM, where the built–in transistor turns ON according to the fuel injection signal fed from the microcomputer, thereby electricity passes to the injector and fuel is injected.

Injector circuit diagram







Fuel injection control

There are three types of fuel injection control for different injection methods: all cylinders synchronous injection, group injection and sequential injection as described below by using examples.

FUEL INJECTION CONTROL SYSTEM

Synchronous injection at start

When the engine is cranking, all three injectors start injecting the fuel simultaneously at every CAS 6 ° signal (ignition signal) or every two CAS 6 signals (ignition signals) depending on the engine cooling water temperature. It occurs several times till the injection time within one ignition cycle becomes as specified (the time is determined according to the signals from sensors).

Synchronous injection while low speed and low load

When the engine speed is lower than 6000 RPM. and the engine is under low load, all three injectors inject fuel simultaneously and synchronously at every four CAS 6° signals, that is, twice every crankshaft turn.

Synchronous injection while high speed or high load

When the engine speed is higher than 6,000 RPM. or the engine is under high load, all three injectors inject fuel simultaneously and synchronously at every two CAS 6° signals, that is, once every crankshaft turn.

Asynchronous injection

When the accelerator pedal is depressed (when the idle switch turns OFF from ON and when the throttle valve opening increases suddenly), three injectors inject fuel simultaneously once to a few times in addition to the synchronous injection and independently of the CAS signal.

Fuel injection control

- Fuel injection control
  - Synchronous injection
    - Injection at engine start
      - Basic injection time at start
      - Air/fuel ratio learning compensation, voltage compensation
    - Injection after engine start
      - Basic injection time
      - Inclusive compensation
        - Increase compensation after engine start
        - Increase compensation during engine warm–up
        - Intake air temperature compensation
        - Increase compensation during acceleration
        - Voltage compensation
        - Air/fuel ratio feedback compensation
        - Air/fuel ratio learning compensation
        - Fuel cut
        - Others
  - Asynchronous injection
    - Injection during acceleration

Synchronous injection .

(1) Injection at engine start

As the intake air is unstable when starting (cranking) the engine, the fuel injection time, if calculated on the basis of the amount of the intake air and the engine speed, has a great variation. Therefore, the injection time at the engine start is calculated by using the basic injection time at the engine start which is determined by the cooling water temperature and the engine speed as well as the inclusive compensation factor.

Definition of engine start: The state with the starter signal ON and engine speed of 500 RPM or lower is judged as the engine start.

Injection time at engine start=

Basic injection time at engine start x inclusive compensation factor x K_1

K_1 : 0 When WOT

1 Other than the above

K_1 is set to use as a remedy if the engine should have failed to start and an ignition plug converage have occurred. Also, when the cooling water temperature is low, the injection time at start is divided for effective spraying to ensure better start. (Divided injection)
Criteria for execution of divided injection: When cooling water temperature is low.
Number of division= Injection time at engine start + constant time

(2) Injection after engine start

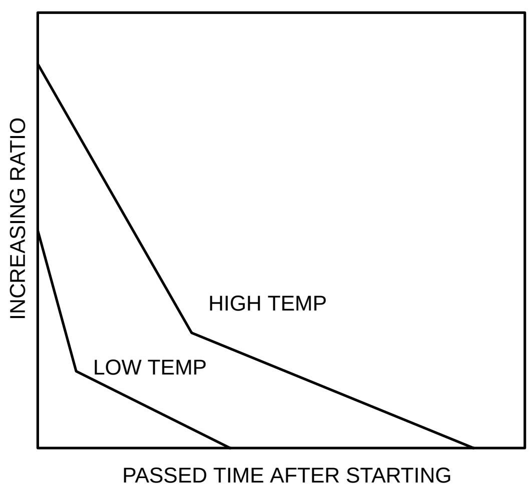
The injection time after engine start is calculated by using the following equation.
Injection time after engine start= Basic injection time x inclusive compensation factor
Given below is explanation of each term.

(1) Basic injection time
The basic injection time is calculated by using the amount of intake air metered by the air flow meter and the engine speed given by the crank angle sensor in the following equation.

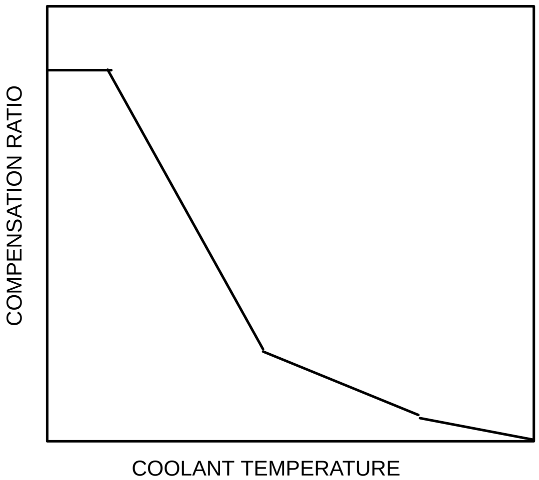
$$\text{Basic injection time} = K \times \frac{\text{Amount of intake air}}{\text{Engine speed}}$$

(2) 2 Inclusive compensation factor
This compensation factor is used to compensate the basic injection time to obtain an optimum air/fuel ratio for each engine condition whether the engine is cold, during acceleration or otherwise. It is obtained by adding and multiplying various compensation factors which are calculated by using signals from sensors.
Inclusive compensation factor= Intake air temperature compensation factor (if available) x (after **start** increase compensation factor + engine warm–up increase compensation + acceleration increase compensation factor)

But the voltage compensation time is not used for compensation of the basic injection time but it is added independently. Here each compensation factor is described.

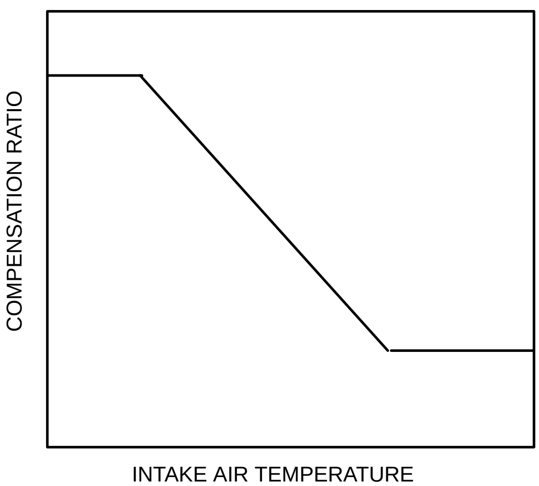


- After start increase compensation
  This increase compensation is executed immediately after the engine start according to the cooling water temperature at the engine start so that the engine speed is stabilized. The initial value of the compensation factor is larger when the cooling water temperature at the engine start, this value reduces quickly to ”0”. When this increase compensation is used, the air/fuel ratio is richer than its optium value.

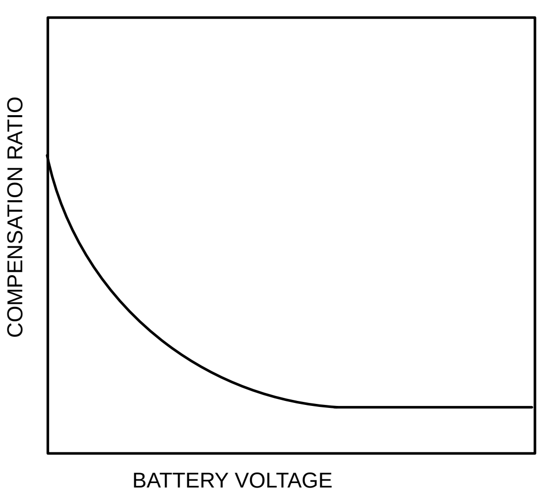


- Warm–up increase compensation
  The fuel injection is increased according to the cooling water temperature and the engine speed to improve operation when the engine is cold. The lower the cooling water temperature, the larger the increase is. When this increase compensation is used, the air/fuel ratio is richer than its optimum value.

- Intake air compensation
  This compensation factor is used to compensate the variation of the air/fuel ratiowhich occurs due to the difference in the intake air density caused by the intake air temperature (air temperature in the manifold). The air/fuel ratio is compensated usual value at 20°C by increasing or decreasing the amount of injection, based on the signal from the intake air temperature sensor which is built in the air flowmeter.



- Acceleration increase compensation
  To improve performance during acceleration, the amount of injection is increased according to the cooling water temperature and the amount of acceleration (varying amount of the intake air) during and after the engine warm–up. The lower the cooling water temperature is and the larger the acceleration is (the larger the amount of the intake air), the more the amount of injection is increased. When this increase compensation is used, the air/fuel ratio is richer than its optimum value.



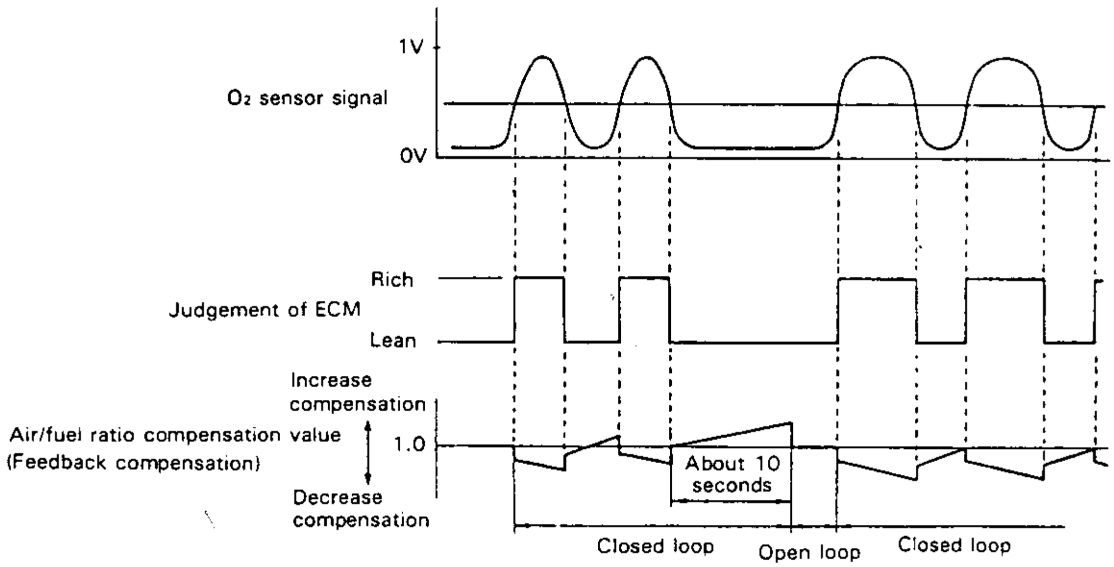
- Voltage compensation
  When the injection signal from the ECM turn ON, there is a delay before the injector opens its valve. This delay is called ”lost injection time”. Such delay is shorter when the battery voltage is higher, and longer when the voltage is lower. It causes variation in the air/fuel ratio. In order to adjust the air/fuel ratio to its optimum value constantly, a voltage compensation time is applied according to the battery voltage. The voltage compensation time is shorter when the battery voltage is higher and longer when the voltage is lower.

- Output increase compensation
  The output range is detected by using signals of the engine speed and the throttle opening and the amount of injection is increased by the value fixed for the basic injection time and the engine speed at that time. The amount of injection is controlled for a ratio which is richer than its optimum value.

- Air/fuel ratio feedback compensation
  SUZUKI uses a rhodium catalytic converter to process C0, HC and NOx contents in the exhaust gas. It oxidize CO and HC and reduces NOx simultaneously into non–toxic CO2 H2O Oz and N2 respectively; although only near the optimum air/fuel ratio range. In other words, when the air/fuel ratio becomes leaner than its optimum value, more NOx is generated and when it becomes richer, more CO and HC are generated. In order to process the exhaust gas by making an effective use of the catalytic converter rhodium, it is necessary to keep the air/fuel ratio accurately to its optimum value. However, as the air/fuel ratio range in which C0, HC and NOx are processed is small, it is impossible to keep it to its optimum value constantly with the open loop control. To make it possible, the air/fuel ratio feedback control (compensation) is executed. When the air/fuel ratio feedback compensation is executed, first, whether the air/fuel ratio is richer or leaner than its optimum value is judged by using the signal from the Oz sensor and the fuel injection is decreased when it is rich and increased when it is lean to keep it to the optimum air/fuel ratio. Such feedback compensation is not executed under following conditions to ensure optimum operation. (This is called ”open loop control”.)

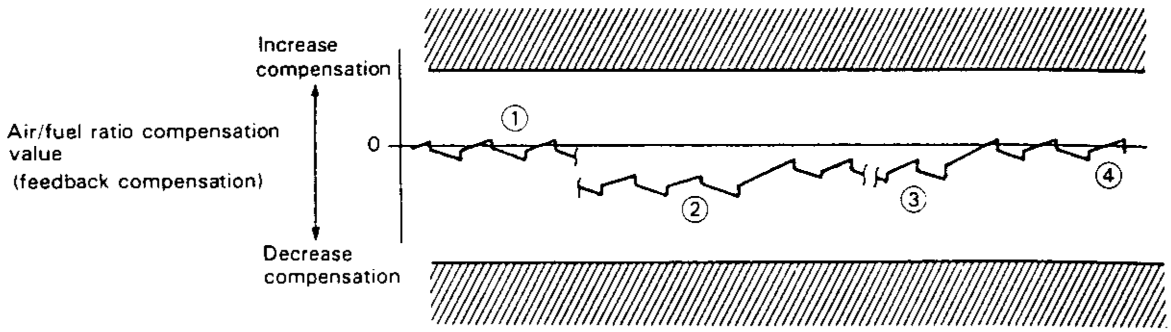
Conditions under which air/fuel ratio feedback control is not executed:

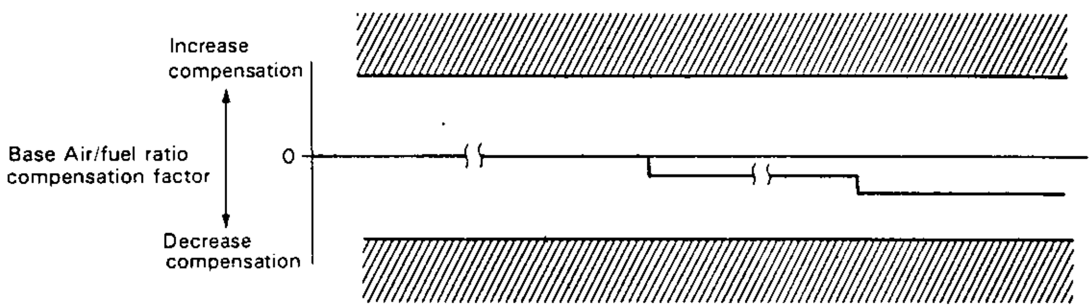
- Cooling water temperature
- During after start increase compensation
- When O2 sensor is judged as inactive
- During output increase compensation
- During fuel cut



The electromotive voltage of the O2 sensor becomes high (about 1 V) when the air/fuel ratio is richer than its optimum value, and becomes low (about V) when it is leaner. The ECM receivers this signal and compares it with the reference value to determine whether it is richer or leaner. When it is richer, the ECM reduces the air/fuel ratio feedback compensation factor (air/fuel ratio compensation value) in steps to reduce the amount of injection (step reduction) and then at a constant rate (skip reduction). When it is leaner, it is increased in steps first and then at a constant rate. (This is called ”closed loop control”.)
There is a limit to the air/fuel ratio feedback compensation factor. It varies within the range between –0.20 to +0.20. Also, when the ECM lean judgement continues about 10 seconds, the ECM judges the O2 sensor inactive and sets the air/fuel ratio feedback compensation factor to ”0”. (This is called ”open loop control”.)

- Base Air/fuel ratio compensation
  This Base Air/fuel ratio compensation is a long–term compensation. While the air fuel ratio feedback compensation is a short–term one. As the engine is subject to change, deviation (as shown by 1 and 2 below) occurs in the air/fuel ratio feedback compensation factor which is used to compensate the air/fuel ratio to its optimum value. However, the range of the air/fuel ratio feedback compensation is limited and compensation beyond this limit is impossible. For this reason, the ECM learns (or sets) the air/fuel ratio feedback compensation factor value so that its central value becomes its optimum value (or sets the air/fuel learning compensation ratio as shown by (~) and (~) below) and also uses it to adjust the fuel injection time. This compensation value is stored in the nonvolatile memory. In this way, it is not erased even when the ignition switch is turned OFF and reflected in the next driving. It remains effective for compensation of the injection time even when the feedback control is stopped. (The Base air/fuel ratio compensation factor is reset to ”0” when the battery is disconnected.)





- Fuel cut
  There are two types: During deceleration fuel cut and high speed fuel cut
  (1) During deceleration fuel cut
  When the engine speed is high and the throttle valve is completely closed (when decelerating) the fuel injection is stopped to prevent the catalyst from getting overheated.
  Conditions for execution of during deceleration fuel cut:
  - The idle switch is ON, and
  - the engine speed exceeds the specified value (which varies depending on the cooling water temperature)

  Conditions for recovery
  - the idle switch is OFF, or
  - the engine speed is below the specified value (which varies depending on the cooling water temperature).

  (2) High speed fuel cut
  To prevent the engine from over–running, the fuel is cut when the engine speed exceeds a certain level and again supplied when it drops below that level.

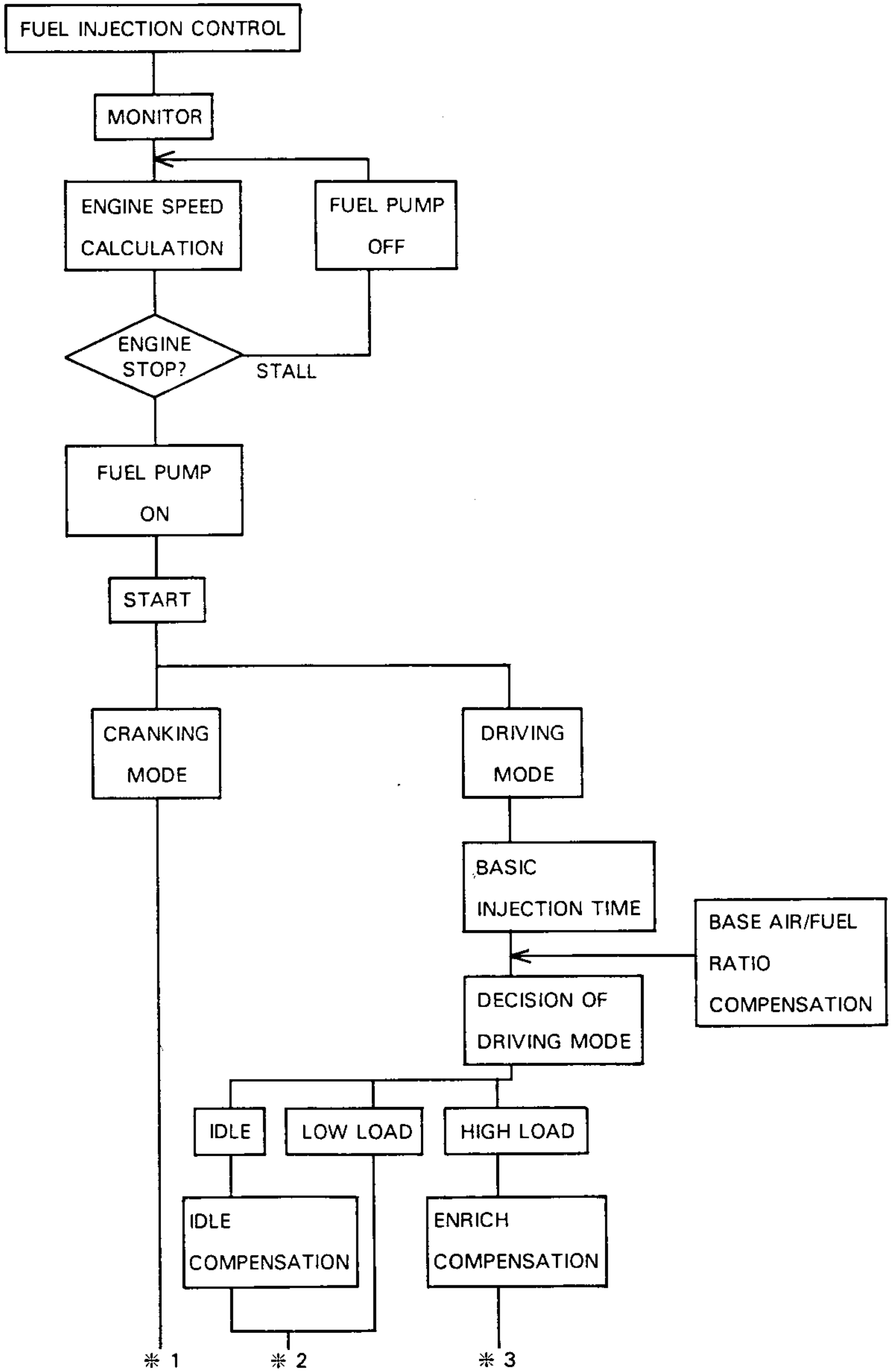
Asynchronous injection

(1) During acceleration injection

When following conditions are met, an injection occurs immediately and asynchronously with the crank angle signal

$\boxed{1}$ When the idle switch is turned OFF.
Conditions for execution: Other than when the engine is started, and the idle switch is turned OFF.

$\boxed{2}$ When the throttle opening variation is large
The fuel is injected by such injection time that is in accordance with the throttle opening variation, the amount of the basic injection and the cooling water temperature.
Condition for execution: Other than when the engine is started, fuel cut is not applied, and the idle switch is OFF.



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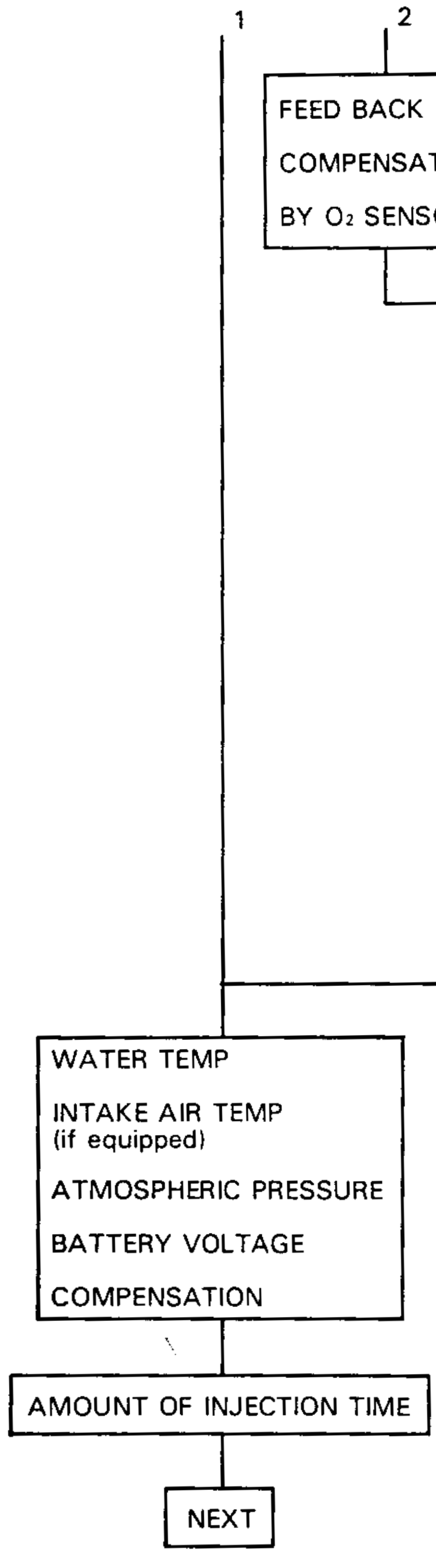
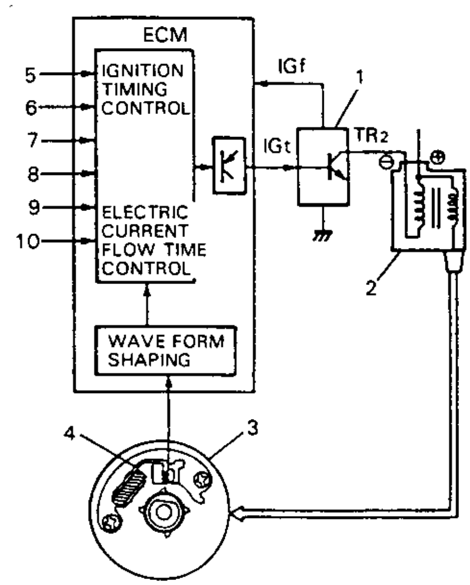

1
2
3
FEED BACK COMPENSATION BY O_2 SENSOR
ACCELERATION?
NO
YES
POWER ENRICHING COMPENSATION
DECELERATION?
NO
YES
FUEL CUT
WATER TEMP
INTAKE AIR TEMP (if equipped)
ATMOSPHERIC PRESSURE
BATTERY VOLTAGE
COMPENSATION
AMOUNT OF INJECTION TIME
NEXT

IGNITION SYSTEM

Ignition signal system

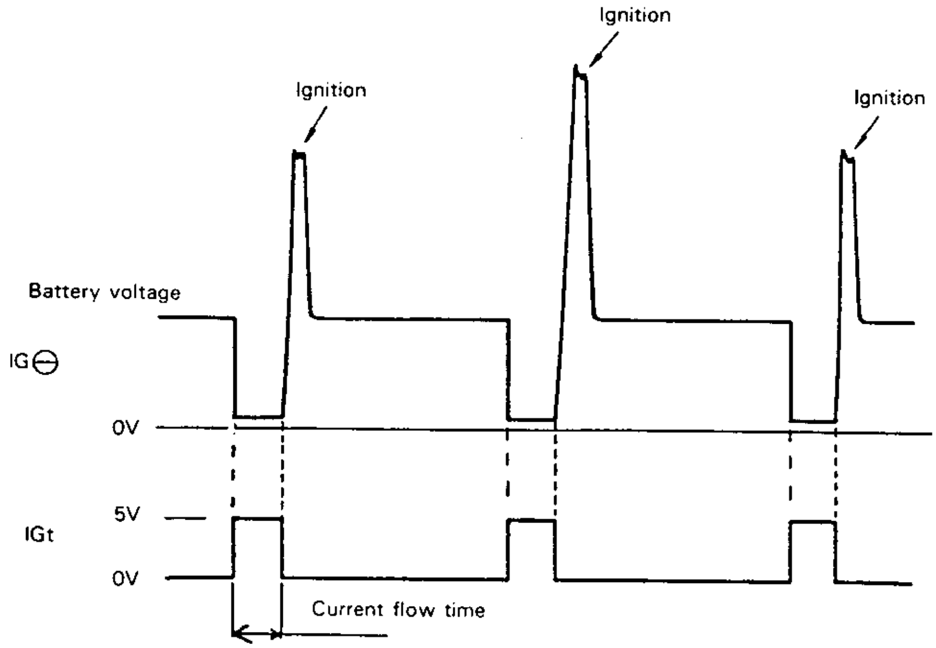
Shown below is the basic ignition signal circuit.



1. Igniter (Power unit)
2. Ignition coil
3. Distributor
4. CAS
5. MAP (Pressure Sensor)
6. TPS
7. WTS
8. Vehicle speed sensor
9. Battery voltage
10. Test switch terminal

The ECM calculates the energizing time and ignition timing based on the signals from sensors. Instructions for the start of passing the electricity to the igniter and for the ignition timing are given by using the IGt signal from the ECM. That is, passing the electricity starts at the rise of the IGt signal and the ignition at its fall.

When the IGt signal rises, the TR2 of the igniter turns ON to cause the primary current to flow into the ignition coil and when it falls, the TR2 turns OFF and the current in the primary coil is shut off, thereby a high voltage is generated in the secondary coil to ignite the spark plug.



Ignition control system

The ignition control system controls the ignition to the optimum timing. There are two types: fixed ignition and soft ignition.

Fixed ignition

When the following conditions are met, the ignition timing is fixed to the initial set position of the crank angle signal.
Condition for execution: Either of the following

- when engine speed is below 5OOrpm
- when microcomputer fails.

Other than the above, the soft ignition is used.

Soft ignition control

The soft ignition control has two phases: ignition timing control (ignition advance control) and current flow time control.

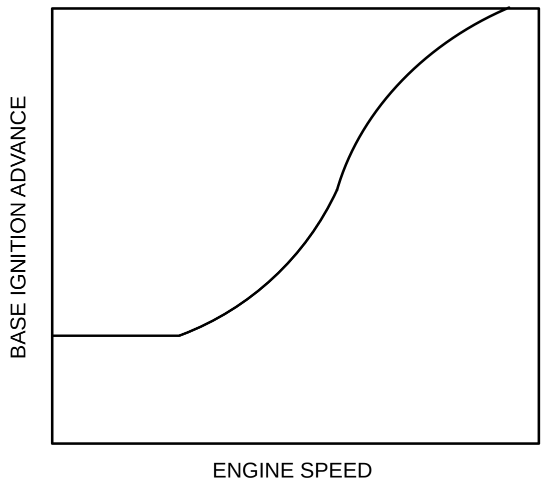
(2) Ignition timing control

The ignition advance is calculated by using the following equation.
Ignition advance=Basic advance + Cooling water temperature compensation advance
+ idle stabilizing compensation advance

Each of the above advances is described below.

1 Basic advance How much the basic advance is controlled depends on the conditions of the idle switch.

- When the idle switch is ON
  The basic advance is set according to the engine speed.



- When the idle switch is OFF
  The optimum basic advance is set according to the engine load (basic injection time) and the engine speed.

Engine speed / Injection time	1000 (rpm)		2000		3000		4000	. . .
1.0 ms								
2.0								
								. . .
3.0								
4.0								
⋮				⋮				

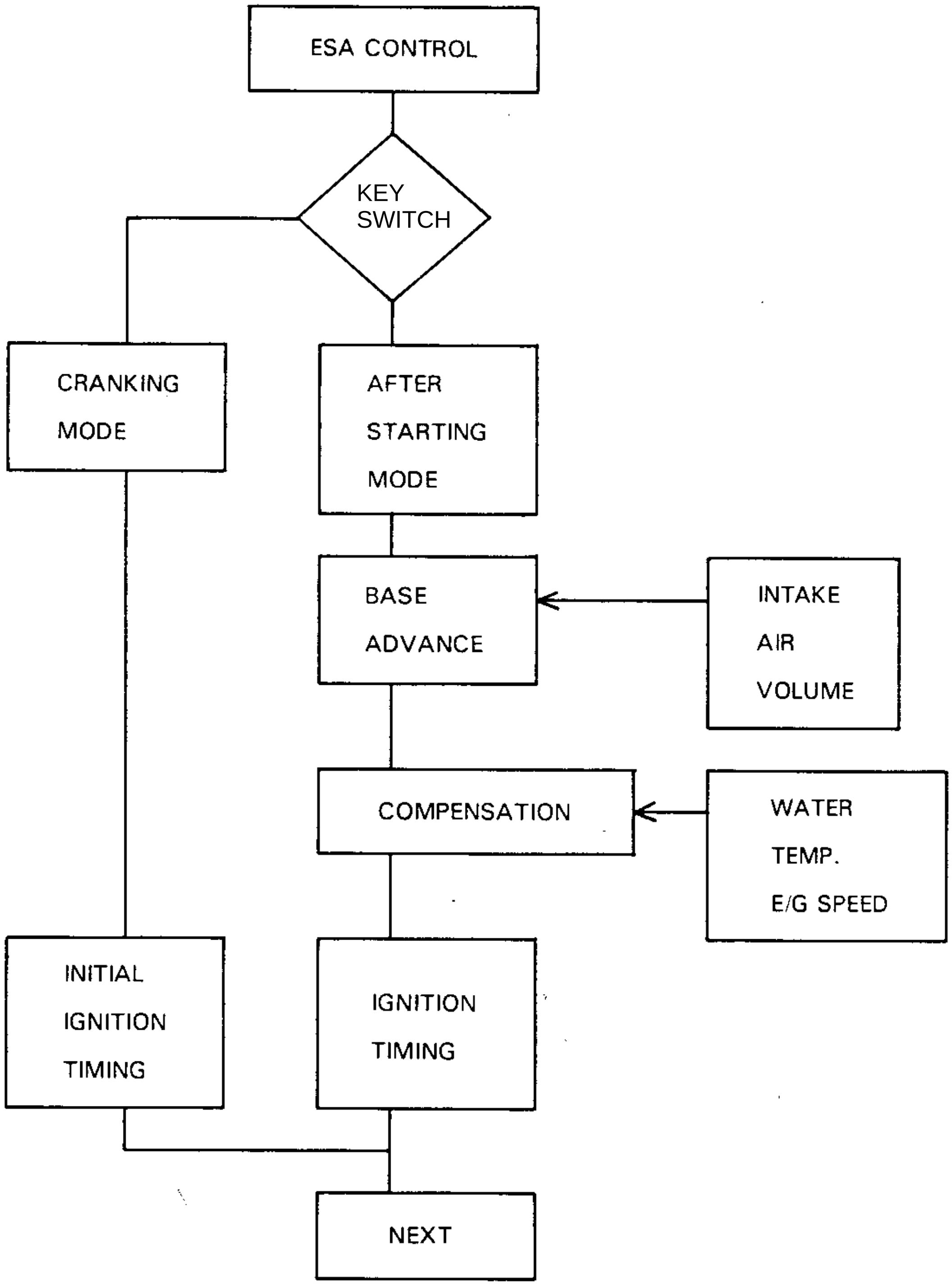
Basic advance °BTD

2 Cooling water temperature compensation advance

- Warm–up compensation advance When the cooling water temperature is low, the ignition is advanced to improve warm–up performance and driveability. The lower the temperature is, the larger the ignition is advanced.
- High temperature compensation advance When the cooling water temperature is higher than 90°C and the engine load is large, the advance angle is decreased.

3 Idle stabilizing compensation advance

When the ISC feedback control is being executed, the advance angle is compensated according to the varying idle speed so that the idle speed is stabilized.


ESA CONTROL
KEY SWITCH
CRANKING MODE
AFTER STARTING MODE
BASE ADVANCE
INTAKE AIR VOLUME
COMPENSATION
WATER TEMP. E/G SPEED
INITIAL IGNITION TIMING
IGNITION TIMING
NEXT

SECTION 2

PERIODIC MAINTENANCE

ALTERNATOR BELT INSPECTION

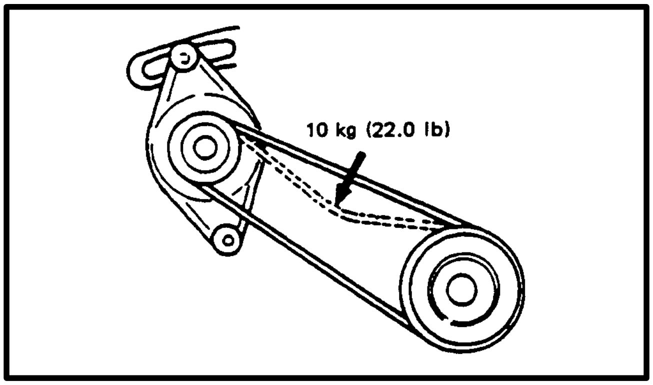
1) Disconnect negative battery lead at battery.

2) Inspect belts for cracks, cuts, deformation, wear and cleanliness. Check belt for tension. The belt is in proper tension if it deflects 11 to 14mm (0.43–0.55in.) under thumb pressure (about 10 kg or 22 lbs.).

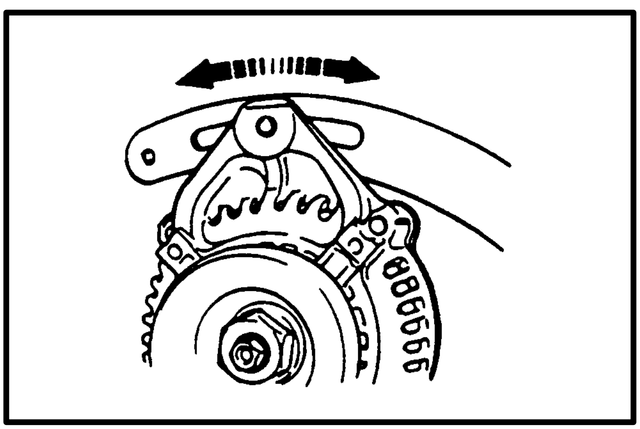
Belt tension specification	11–14 mm (0.43–0.55 in.) as deflection

NOTE:

When replacing belt with a new one, adjust belt tension to 10–12mm (0.40–0.47 in.)



3) If the belt is too tight or too loose, adjust it to specification by adjusting alternator position.



4) Tighten alternator adjusting bolt and pivot bolt.

5) Connect negative battery lead to battery.

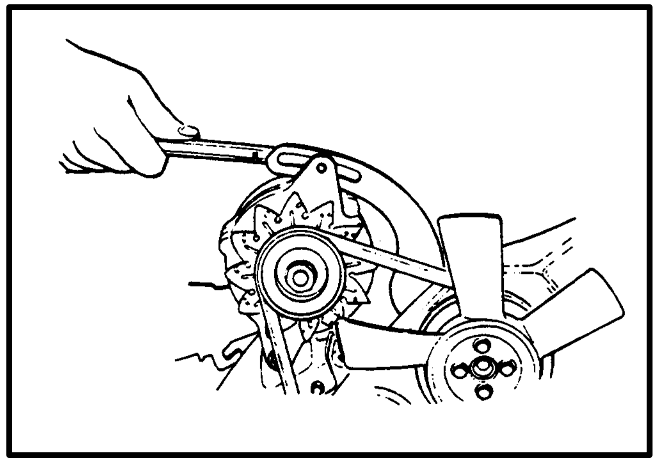
WARNING

All inspections and adjustments noted above are to be performed with ENGINE NOT RUNNING.

Replacement and adjustment

1) Disconnect negative battery lead at battery.

2) Loosen alternator adjusting bolt and pivot bolts, move alternator inward.



3) Replace belt.

4) Move Alternator outward and adjust belt to specified tension.

5) Tighten alternator adjusting bolt and pivot bolts

6) Connect negative battery lead to battery.

WARNING

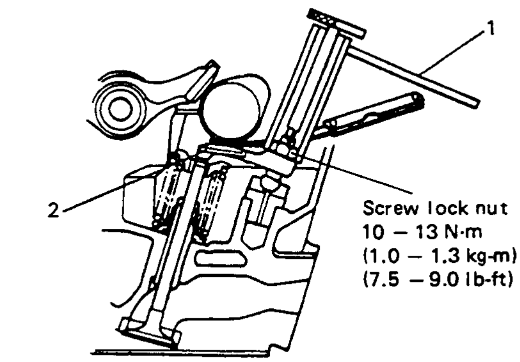
All adjustments noted above are to be performed with ENGINE NOT RUNNING.

VALVE LASH INSPECTION

1) Remove engine valve cover.

2) Inspect intake and exhaust valve lash and adjust as necessary.

		Cold	Hot
Valve Lash Specifications	Intake		
	Exhaust	0.10mm (.0039 in.)	0.12mm (.0047 in.)



1. Tappet adjuster wrench (Special tool 09917-18210)
2. Rocker arm cam-riding face

3) Refer to SECTION 3 for valve lash inspection and adjustment procedures.

4) Install engine valve cover and tighten bolts to specifications.

CAMSHAFT TIMING BELT REPLACEMENT

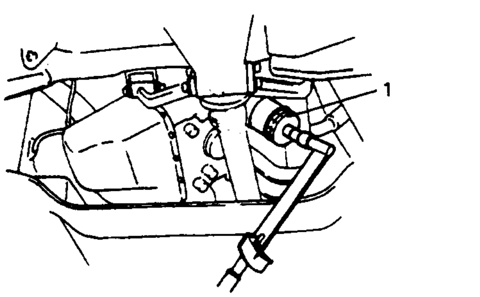
Refer to SECTION 3 for camshaft timing belt removal and installation procedures.

ENGINE OIL FILTER CHANGE

1) Loosen oil filter using an oil filter wrench.

NOTE:

Before installing new oil filter, apply a thin coat of engine oil to the "O" ring filter seal.



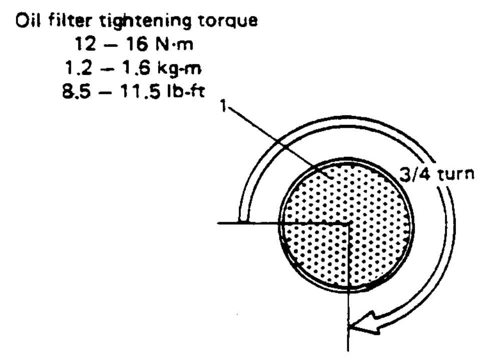
1. Oil filter wrench socket

2) Screw new oil filter on by hand until the filter "O" ring contacts the mounting surface.

CAUTION

To tighten the oil filter properly, it is important to accurately identfy the position at which the filter "O" ring first contacts the mounting surface.

3) Tighten the filter 3/4 turn from the point of contact with the mounting surface using an oil filter wrench.



1. Oil filter

CAUTION

To prevent oil leakage, make sure that the oil filter is tight, but do not overtighten it.

4) After installing oil filter, start engine and check oil filter for leakage.

ENGINE OIL CHANGE

Before draining engine oil, check engine for oil leakage. If any evidence of leakage is found, make sure to correct defective part before proceeding to the following work.

1) Drain engine oil by removing drain plug.

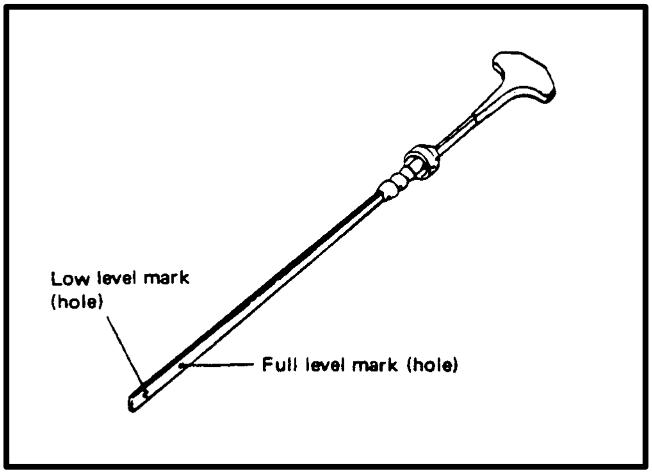
2) After draining oil, wipe drain plug and around drain plug hole clean. Reinstall drain plug, and tighten securely.

Drain Plug	N–m	kg–m	lb–ft.
Torque Specifications	30–40	3.0–4.0	22–28.5

3) Replenish oil until oil level is brought to FULL level mark on dipstick (about 2.9 liter or 6,1/5.1 US/Imp pt.). The filter inlet is located above the engine valve cover.

4) Start the engine and run it for 3 minutes to bring it up to operating temperature. Stop the engine and wait

another 3 minutes before checking the oil level. Add oil as necessary, to bring oil level to FULL level mark on dip stick.

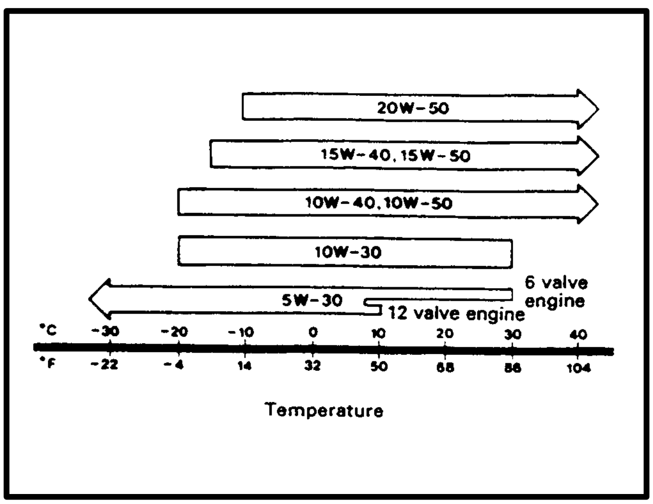


NOTE:

Steps 1–3 outlined above must be performed with ENGINE NOT RUNNING. For step 4), be sure to have adequate ventilation while engine is running.

It is recommended to use engine oil of SF, SG or SH class.

PROPER ENGINE OIL VISCOSITY CHART



ENGINE OIL CAPACITY

Oil pan capacity	2.9 Liters (6.1/5.1 US/Imp pt.)
Oil filter capacity	0.2 liters (0.4/0.3 US/Imp pt.)
Total	3.1 liters (6.6/5.5 US Imp pt.)

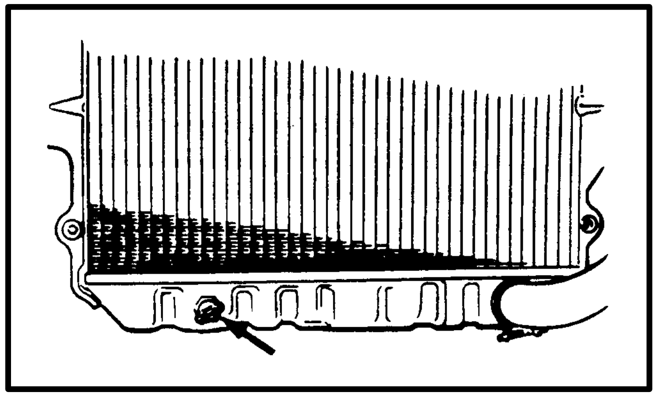
ENGINE COOLANT CHANGE

WARNING

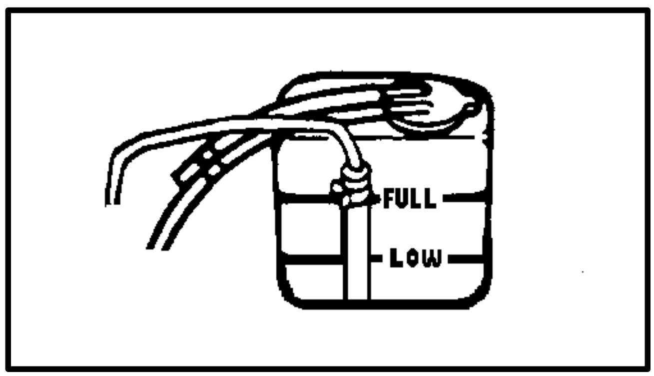
To help avoid danger of being burned, do not remove radiator cap while engine and radiator are still hot. Scalding fluid and steam can escape under pressure if the cap is taken off too soon.

1) Remove radiator cap when engine is cool.

2) Remove radiator drain plug to drain coolant.



3) Remove radiator overflow tank, and drain.



4) Reinstall plug, securing it properly in place.

5) Reinstall overflow tank

6) Fill radiator with specified amount of coolant, and run engine for 2 or 3 minutes at idle. This forces out any air which still may be trapped within the cooling system. STOP ENGINE. Add coolant as necessary until coolant level reaches the filler throat of radiator. Reinstall radiator cap.

7) Add coolant to reservoir tank so that the level aligns with the full mark.

COOLANT CAPACITY	
Engine, radiator and heater	4.2 liters (8.9/7.4 US/Imp pt.)

Reservoir tank	0.5 liters (1.1/0.9 US/Imp pt.)
Total	4.7 liters (10.0/8.3 US/Imp pt.)

CAUTION

When changing engine coolant, use mixture of 50% water and 50% anti–freeze for regions where ambient temperatures fall lower than –16 degrees C (3 degrees F) in winter and mixture of 70% water and 30% anti–freeze for regions where ambient temperatures do not fall lower than –16 degrees C (3 degrees F).

Even in regions where no freezing temperature is anticipated, a mixture of 70% water and 30% anti–freeze should be used for the purpose of corrosion protection and lubrication.

COOLING SYSTEM HOSES AND CONNECTIONS INSPECTIONS

1) Visually inspect cooling system hoses for any evidence of leakage and cracks. Examine them for damage, and check connection clamps for tightness.

2) Replace all hoses which show evidence of leakage, cracks or other damage. Replace all clamps which cannot maintain proper tightness.

EXHAUST PIPES AND MOUNTINGS INSPECTION

WARNING

To avoid danger of being burned, do not touch exhaust system when system is hot. Any service on exhaust system should be performed when system is cool.

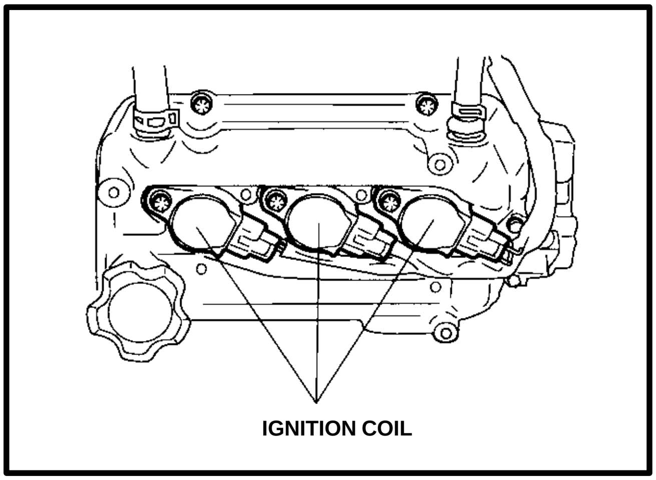
When carrying out periodic maintenance, or the vehicle is raised for other service, check exhaust system as follows:

- Check rubber mountings for damage, deterioration, and out of position.
- Check exhaust system for leakage, loose connections, dents and damages. If nuts or bolts are loose, tighten them to specification. Refer to below chart for torque specifications.
- Check nearby body areas for damaged, missing, or mispositioned parts, open seams, holes, loose connections or other defects which could permit exhaust fumes to seep into the vehicle.
- Any defects should be fixed at once.

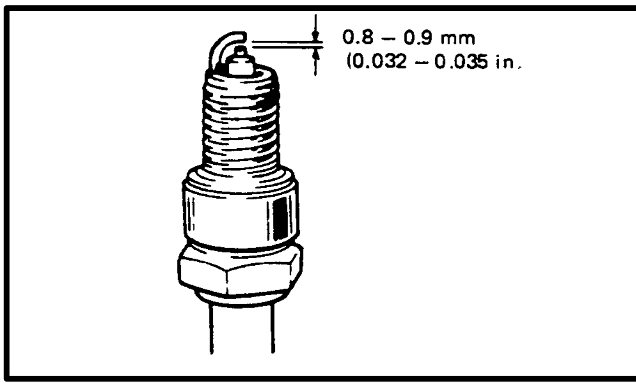
Bolts and nuts	Tightening torque
Exhaust pipe bolts and nuts	40–60 N–m 4.0–6.0 kg–m 29.0–43.0 lb–ft

SPARK PLUGS REPLACEMENT

1) Remove scews holding ignition coils, remove ignition coils.



2) Using a spark plug socket, loosen and remove plugs.



NOTE:

When replacing spark plugs, make sure to use new plugs of specified heat range and size.

SPARK PLUG SPECIFICATIONS

Manufacturer	Heat Range Standard type
NGK	DCPR7E
Nippondenso	XU22EPR–U

3) Install new spark plug. Tighten plugs to specification.

4) Connect ignition coil to spark plugs. Secure with the orginal hardware.

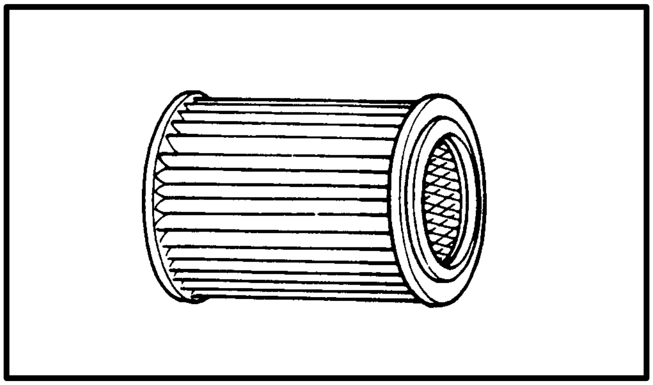
Spark plug tightening torque	25–30 N–m 2.5–3.0 kg–m 18.5–21.5 lb–ft

AIR FILTER ELEMENT CLEANING AND REPLACEMENT

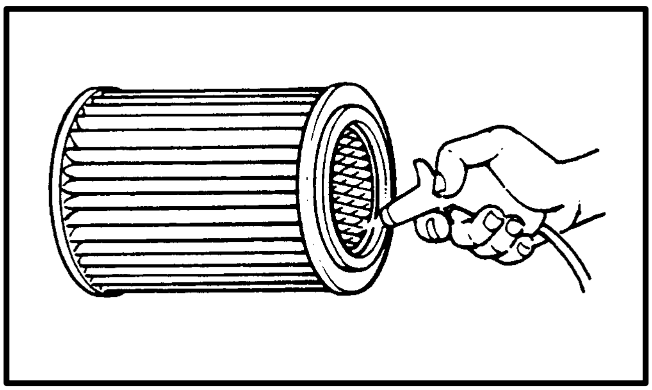
Air filter element

1) Remove air cleaner cap.

2) Take cleaner element out of the air cleaner case.



3) Clean or replace with a new one. To clean element, blow off dust with compressed air from inside of element.



4) Install cleaner element into air cleaner case.

NOTE:

After driving in a dusty area, check element for dust. If found dusty, clean as outlined above.

FUEL TANK CAP, LINES AND CONNECTIONS INSPECTION

1) Visually inspect fuel lines and connections for evidence of fuel leakage, hose cracking and damage. Make sure all clamps and hose connections are secure.

2) Repair leaky joints, imperfect hose connections and clamps, if any.

3) Replace hoses that are suspected of being cracked.

4) Visually inspect fuel tank cap. If it's damaged or deteriorated, replace it with a new one.

ELECTRICAL

WIRING HARNESS AND CONNECTIONS

1) Visually inspect all wires located in engine compartment for evidence of breakage. Inspect the condition of the insulation (cracks). All clips and clamps should have solid connections to wires.

2) Replace any wires in deteriorated or otherwise defective condition.

SECTION 3

TROUBLE SHOOTING

Condition	Possible Cause	Correction
Poor starting (hard starting)	**Starter will not run**	
	1. Main fuse blown	Replace
	2. Contact not closing in main switch, or this switch open–circuited	Repair or replace
	3. Run–down battery	Recharge
	4. Defective magnetic switch to starter	Replace
	5. Loose battery terminal connection	Clean and retighten
	6. Defective brushes in starter	Replace
	7. Loose battery cord connection	Retighten
	8. Open in field or armature circuit of starter	Repair or replace
	No Spark	
	1. Defective spark plug	Adjust gap, or replace
	2. Contact not closing positively in main switch, or this switch open–circuited	Repair or replace
	3. Loose or blown fuse	Replace
	4. Defective ignition coil	Set right or replace
		Replace
	Faulty intake and exhaust systems	
	1. Fuel pump not discharging adequately	Replace
	2. Clogged fuel filter	Clean, or replace
	3. Loose intake manifold	Retighten
	4. Clogged fuel hose or pipe	Clean or replace
	5. Not enough fuel in the tank	Refill
	6. Malfunctioning fuel cut solenoid valve	Check solenoid valve for proper operation and replace if necessary
	Abnormal engine internal condition	
	1. Ruptured cylinder head gasket	Replace
	2. Improper valve clearance	Adjust
	3. Weakened or broken valve spring	Replace
	4. Loose manifold, permitting air to be drawn in	Retighten and, as necessary, replace gasket
	5. Worn pistons, rings or cylinders	Replace worn rings and pistons and rebore as necessary

Condition	Possible cause	Correction
Poor starting (Hard starting)	6. Broken or slipped valve timing belt	Replace
	7. Poor valve seating	Repair or replace
	8. Wrong kind of engine oil	Replace
	9. Burnt valves	Replace
	10. Sticky valve stem	Correct or replace valve and guide
Not enough power	**Inadequate compression**	
	1. Improper valve clearance	Adjust
	2. Valves not seating tightly	Repair
	3. Valve stems tending to seize	Replace
	4. Broken or weakened valve spring	Replace
	5. Piston rings seized in grooves, or broken	Replace
	6. Worn pistons, rings or cylinders	Replace worn parts and rebore as necessary
	7. Leaky cylinder head gasket	Replace
	Improperly timed ignition	
	1. Defective spark plug	Adjust gap or replace
	Fuel system out of order	
	1. Defective fuel pump	Repair or replace
	2. Clogged fuel filter	Replace
	3. Clogged fuel pipe	Clean or replace
	4. Clogged fuel tank outlet	Clean
	5. Loose joint in fuel system	Retighten
	6. Old or dirty fuel	Replace fuel
	Abnormal condition in air intake system	
	1. Air cleaner dirty and clogged	Clean or replace
	Overheating tendency of engine	
	1. (Refer to the section entitled “over–heating.”)	
	Others	
	1. Dragging brakes	Repair or replace
	2. Slipping clutch	Adjust or replace
	3. Slippling automatic transmission	Repair or replace

Condition	Possible cause	Correction
Engine hesitates (Momentary lack of response as the accelerator is depressed. Can occur at all vehicle speeds. **Usually most severe when first trying to make the vehicle move, as from a stop sign.)**	**Abnormal condition in electrical system**	
	1. Defective spark plug	Replace
	2. Deteriorated ignition coil, or crack resulting in spark leakage	Replace
	Abnormal condition in fuel system	
	1. Inadequately discharging fuel pump	Replace
	Abnormal condition in engine	
	1. Loss of compression pressure due to leaky cylinder head gasket	Replace
	2. Compression pressure too low because of worn pistons, rings, cylinders or burnt valves	Replace and rebore as necessary
Surges (Engine power variation under steady throttle or cruise. Feels like the vehicle speeds up and down with no change in the accelerator pedal.)	**Fuel system out of order**	
	1. Clogged fuel filter	Replace
	2. Kinky, leaky or damaged fuel hoses and lines	Check and replace as necessary
	3. Malfunctioning fuel pump	Check and replace as necessary
	4. Leaky manifold	Replace
	Ignition system out of order	
	1. Defective ignition coil	Check and repair or replace
	2. Defective spark plug (excess carbon deposits, improper gap, burned electrodes, etc...)	Check and clean, adjust or replace

Condition	Possible cause	Correction
Erratic idling (Improper engine idling)	**Abnormal condition in ignition system** 1. Defective spark plug 2. Damaged or defective coils **Abnormal condition in fuel system** 1. Incorrect idle adjustment 2. Clogged air cleaner elements **Others** 1. Loose connection or disconnection of vacuum hoses 2. Low compression	 Adjust or replace Connect or replace Adjust Clean or replace Connect Previously outlined
Abnormal detonation	**Abnormal condition in ignition system** 1. Spark plugs tending to overheat 3. Loose connection in high–tension or low tension circuit. Damaged coil wires **Abnormal condition in fuel system** 1. Clogged fuel filter and fuel lines 2. Malfunctioning fuel pump	 Change plug heat value Retighten Replace or clean Replace

Condition	Possible cause	Correction
Abnormal detonation	**Abnormal condition in engine**	
	1. Excessive carbon deposit on piston crowns or cylinder head	Clean
	2. Blown cylinder head gasket, resulting in low compression pressure	Replace
	3. Improper valve clearance	Adjust
	4. Valves tending to seize	Replace
	5. Weakened valve springs	Replace
Overheating	**Abnormal condition in ignition system**	
	1. Wrong heat value of spark plugs	Change heat valve
	Abnormal condition in fuel system	
	3. Loose inlet manifold	Retighten
	Abnormal condition in cooling system	
	1. Not enough coolant	Refill
	2. Loose or broken water pump belt	Adjust or replace
	3. Erratically working thermostat	Replace
	4. Poor water pump performance	Replace
	5. Leaky radiator cores	Repair or replace
	Abnormal condition in lubrication system	
	1. Clogged oil filter	Replace
	2. Clogged oil strainer	Clean
	3. Deteriorated oil pump performance	Replace
	4. Oil leakage from oil pan or pump	Repair
	5. Improper engine oil grade	Replace with proper grade oil
	6. Not enough oil in oil pan	Replenish
	Others	
	1. Dragging brakes	Repair or replace
	2. Slipping clutch	Adjust or replace
	3. Blown cylinder head gasket	Replace

Condition	Possible cause	Correction
Engine noise **Note: Before checking the mechanical noise, make sure that:** • **Specified spark plug is used.** • **Specified fuel is used.**	**Crankshaft noise** 1. Worn–down bearings, resulting in excessively large running clearances 2. Worn connecting–rod bearing 3. Distorted connecting rods 4. Worn crankshaft journals 5. Worn crankpins	 Replace Replace Repair or replace Replace by grinding, or replace crankshaft Repair by grinding, or replace crankshaft
Engine noise **Note: Before checking the mechanical noise, make sure that:** **– Specified spark plug is used.** **– Specified fuel is used.**	**Noise due to piston, rings, pins or cylinders** 1. Abnormally worn cylinder bores 2. Worn pistons, rings or pins 3. Pistons tending to seize 4. Broken piston rings **Others** 1. Excessively large camshaft thrust play 2. Excessively large crankshaft thrust cleaner 3. Valve clearance too large 4. Not enough engine oil	 Rebore to next over size or replace Replace Replace Replace Replace Adjust as prescribed Adjust as prescribed Replenish

Condition	Possible cause	Correction
High fuel consumption	**Abnormal condition ignition system**	
	1. Leak or loose connection of high tension cord	Repair or replace
	2. Defective spark plug (improper gap, heavy deposits, burned electrodes, etc...)	Check and repair or replace
	Abnormal condition in fuel system	Clean or replace
	1. Clogged air cleaner element	
	Abnormal condition in engine	Previously outlined
	1. Low compression	Repair or replace
	2. Poor valve seating	Adjust
	3. Improper valve seating	
	Others	Repair or replace
	1. Dragging breaks	Adjust or replace
	2. Slipping clutch	Adjust
	3. Improper tire pressure	
Excessive engine oil consumption	**Oil leakage**	
	1. Loose oil drain plug	Tighten
	2. Loose oil pan securing bolts	Tighten
	3. Deteriorated or broken oil pan sealant	Replace sealant
	4. Leaky oil seals	Replace
	5. Blown cylinder head gasket	Replace
	6. Improper tightening of oil filter	Tighten
	7. Loose oil pressure switch	Tighten

Condition	Possible cause	Correction
Excessive engine oil consumption	**“ Oil pumping “ (Oil finding its way into combustion chambers.)**	
	1. Sticky piston ring	Remove carbon and replace rings
	2. Worn piston ring groove and ring	Replace piston and ring
	3. Improper location of piston ring gap	Reposition ring gap
	4. Worn piston or cylinders	Replace pistons and rebore as necessary
	Oil leakage along valve stems	
	1. Defective valve stem oil seals	Replace
	2. Badly worn valves or valve guide bushes	Replace

STARTING MOTOR

Condition	Possible cause	Correction
Starter runs but pinion will not mesh into ring gear.	1. Worn pinion of starter clutch 2. Defective splines, resulting in sticky pinion plunging motion 3. Worn bushing 4. Worn teeth of ring gear	Replace Repair or replace Replace Replace
Starter will not run at all, or runs but runs too slow to crank with full force.	**Battery trouble** 1. Poor contact in battery terminal connection 2. Loose ground cable connection 3. Battery run down 4. Battery voltage too low due to battery deterioration **Ignition switch trouble** 1. Poor contacting action 2. Lead wire socket loose in place 3. Open–circuit between ignition switch and magnet switch	 Repair or retighten Retighten Recharge Replace Replace Retighten Repair
Starter will not run at all, or runs but runs too slow to crank with full force.	**Magnet switch trouble** 1. Lead wire socket loose in place 2. Burnt contact plate, or poor contacting action 3. Open–circuit in pull–in coil 4. Open–circuit in holding coil **Starter proper trouble** 1. Brushes seating poorly or worn down 2. Burnt commutator 3. Open–circuit in armature winding 4. Worn–down starter	 Retighten Replace, or repair Replace Replace Repair or replace Repair or replace Replace Replace
Starter does not stop running	1. Fused contact points of magnet–switch contact plate 2. Short–circuit between turns of magnet switch coil (Layer short–circuit) 3. Failure of returning action in ignition switch	Repair or replace Replace Replace

ALTERNATOR

Condition	Possible cause	Correction
Battery quickly becomes over discharged.	1. Loose or broken “V” belt 2. Battery cables loose, corroded or worn 3. Improper acid concentration or low level of battery electrolyte 4. Defective battery cell plates 5. Insufficient contact in battery terminal connection. 6. Excessive electrical load 7. IC regulator or alternator faulty	Adjust or replace Repair or replace Replace, or replenish Replace the battery Clean and retighten Check charging system Replace

Charge light does not light with ignition ON and engine off	1. Fuse blown 2. Light burned out 3. Loose wiring connection 4. IC regulator	Check fuse Replace light Tighten loose connections Replace
Alternator noise	1. Worn. loose or otherwise defective bearings	Replace

SECTION 4

ENGINE MECHANICS

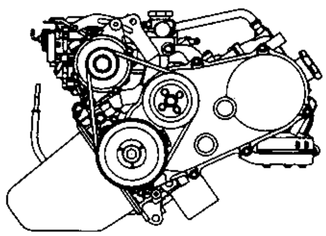
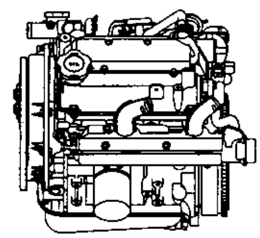
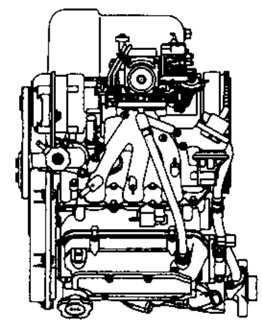
SUMMARY

The type F6A engine (in–line 3–cylinder, total displacement 657 cc) offers an engine having a sleeveless compact structure through the use of a high–rigidity cast iron block.

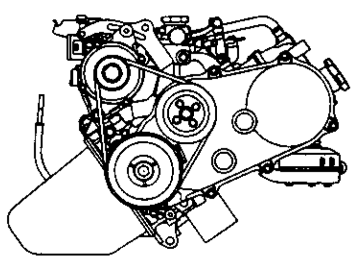
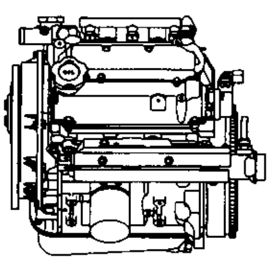
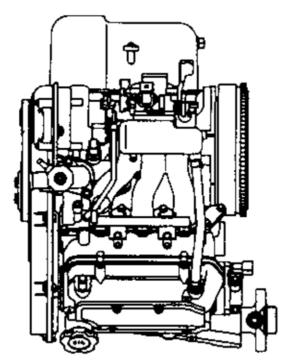
The cylinder head is made of aluminum alloy, with a 4–valve SOHC design.

The cylinder head of the 4–valve SOHC type as the compact structure in which the intake–side rocker arms are a seesaw type, and the exhaust–side rocker arms are a cantilever type. Also, the intake–side rocker arms are made of aluminum alloy and have reduced friction.

The model F6A engine is a belt system which is extremely quiet for driving the cam shaft.

Carburetor type

EFI type

ENGINE SPECIFICATIONS

Model			
Type		Carburetor	EFI
No. and arrangement of cylinders		In–line three–cylinder w traverse	
Form of combustion chamber		Pentroof form	
Valve mechanism		SOHC4 valve/drive	
Total displacement (cc)		657	
Bore y stroke (mm)		65.0×66.0	
Compression ratio		10.5	
Maximum output (PS/rpm)		42/5500 (net)	50/6000 (net)
Maximum torque (kg • m/rpm)		5.8/3000 (net)	6.2/35 00 (net)
Ignition sequence		1–3–2	
Oil used (normal/frigid region)		10W–30 (SH) 5W–30 (SG)/5W–30 (SG)	
Oil capacity (L)	when oil changed	3.2	
	when filter changed also	3.4	

ENGINE BODY

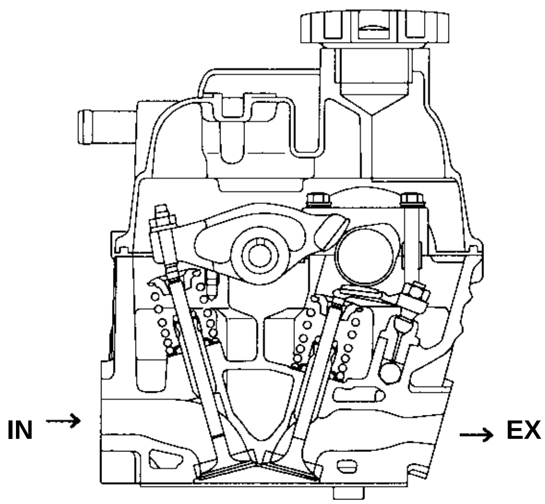
CYLINDER HEAD/VALVE TRAIN

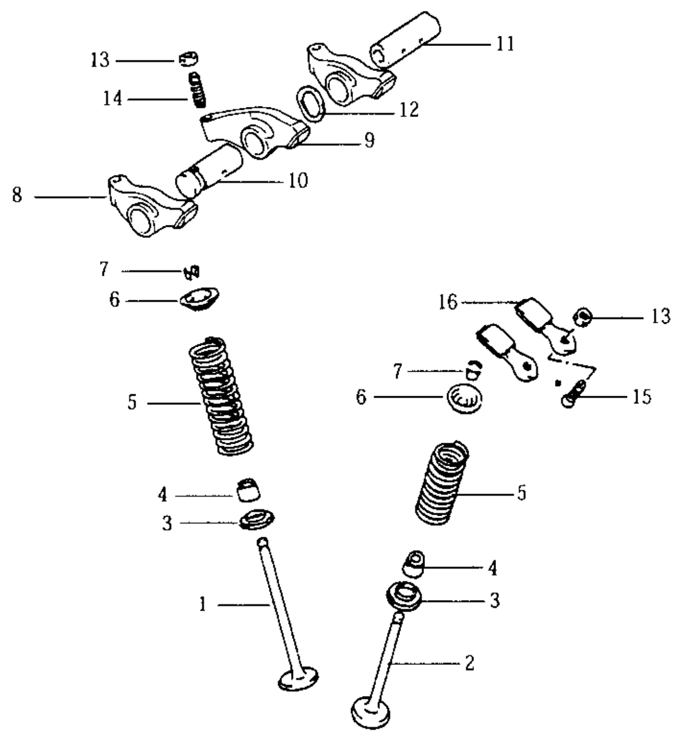
4–VALVE

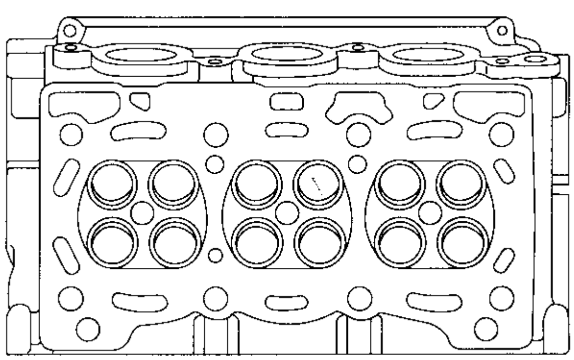
The cylinder head is made of an aluminum alloy that is lightweight and has excellent heat radiating properties and uses a cross–flow system in the layout of the air intake valves. The combustion chambers have improved combustion efficiency by using a center–plug type pentroof form.

The valve driving system is a rocker arm system using a seesaw type for the intake side and a cantilever type for the exhaust side.

Valve clearance is adjusted by adjusting screw on both intake and exhaust.



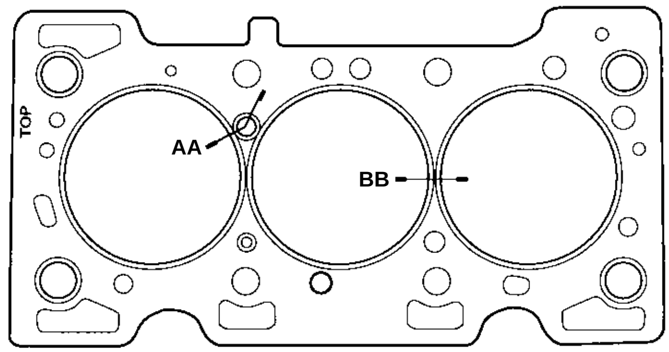




1. Intake valve
2. Exhaust valve
3. Valve spring sheet
4. Valve spring
5. Valve stem seal
6. Valve spring retainer
7. Valve cotter
8. Intake valve rocker arm No. 1
9. Intake valve rocker arm No. 2
10. Rocker arm shaft No. 1
11. Rocker arm shaft No. 2
12. Web washer
13. Lock nut
14. Adjusting screw
15. Exhaust valve adjusting screw
16. Exhaust valve rocker arm

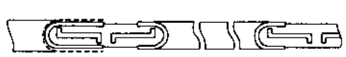
CYLINDER HEAD GASKET

The head gasket uses carbon graphite as a parent material and the bore areas are made of stainless steel and given improved durability.

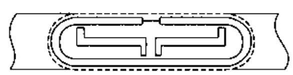


	Material
Parent material	carbon graphite
Bore sections	stainless steel
Oil holes	copper

A–A' section

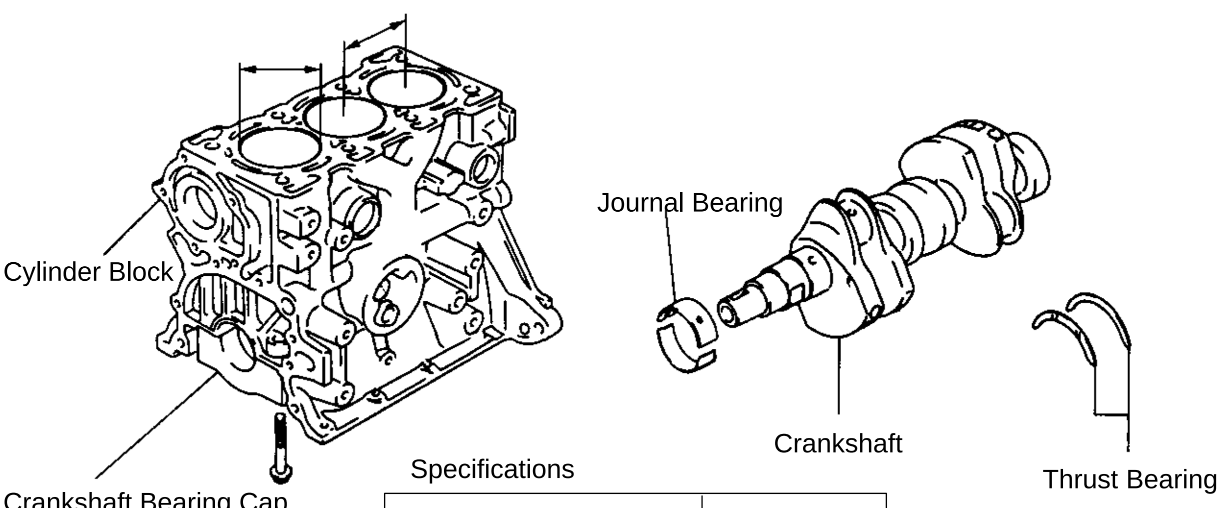


B–B' section



CYLINDER BLOCK

The cylinder block is made of a special cast iron and has a compact structure with no sleeves and a bore pitch of 72 mm.

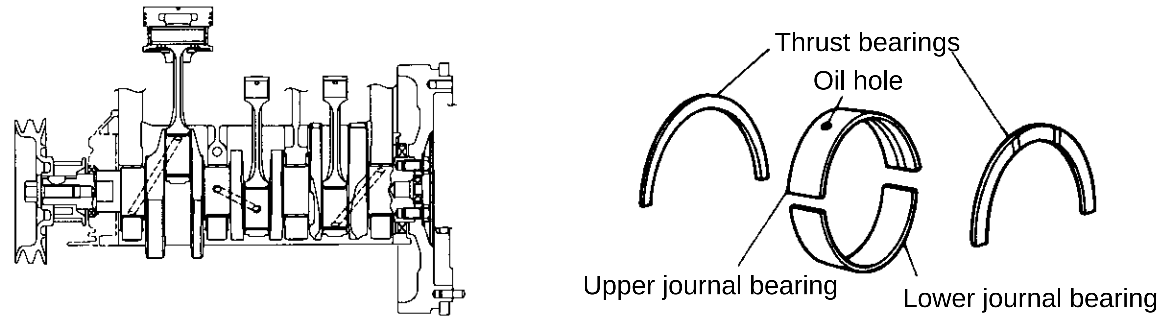


Specifications

Bore diameter (mm): d	65.0
Stroke (mm)	66.0
Pitch (mm): p	72.0
Number of cylinders	3
Number of bearings	4

CRANKSHAFT

The crankshaft is a 4–bearing type made of cast iron, and has reduced vibration and noise by providing balance or which offset the No. 1 ranking No. 3 crank.

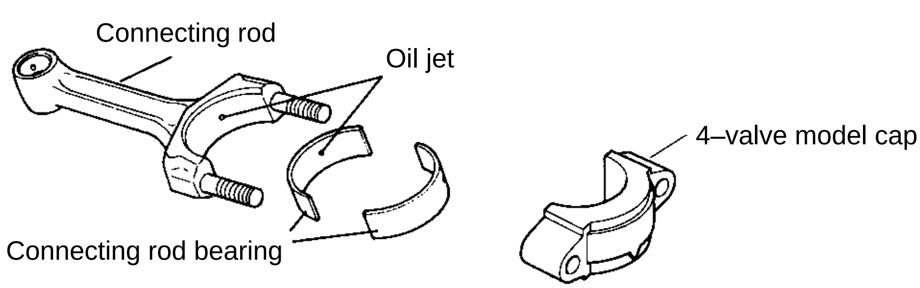


SPECIFICATIONS

Crankshaft	Journal diameter (mm)	ϕ44 (ϕ43.982~ϕ44.000)		
	Pin diameter (mm)	ϕ36 (ϕ35.982~ϕ36.000)		
	Crank radius (mm)	ϕ33		
	Total length (mm)	ϕ341		
Journal bearings	Material: aluminum alloy (back plate steel) Center thickness: standard 2.0 mm U/S 2.125 mm	Supply part (mm)	Standard 1 type 1.986~1.990	U/S 1 type 2.105~2.115
Thrust bearings	Material: aluminum alloy (back plate steel) Center thickness: standard 2.5 mm O/S 2.563 mm	Supply part (mm)	Standard 1 type 2.470 ~2.520	O/S 1 type 2.533 ~2.583

CONNECTING RODS

The connecting rod is made of cast iron for the 4–valve vehicles, and uses an H–shaped form. The larger end is divided vertically and is connected with a special retainer bolt. Also, an oil jet is provided on the larger end, which lubricates the small end, pistons, and cylinder wall face. Aluminum alloy construction is adopted for the connecting rod bearings.

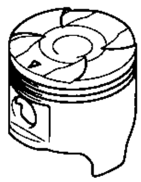


SPECIFICATIONS

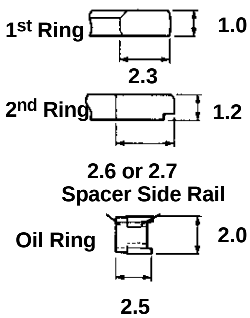
Connecting rod	Large end part (mm)	ϕ39 (ϕ39.000~ϕ39.018)		
	Small end part (mm)	4–valve models: ϕ16 (ϕ16.003~ϕ16.011)		
	Center gap distance (mm)	109.8		
Connecting rod bearing	Material: aluminum alloy (back plate steel) Center thickness: standard 1.5 mm U/S 1.625 mm	Supply part (mm)	Standard 1 type 1.486~1.502	U/S 1 type 1.605~1.615

PISTONS/PISTON RINGS/PISTON PINS

Pistons are made of aluminum alloy and have a slipper skirt, with a valve recess provided at the top of the piston. The first ring increases initial conformity having a barrel face form, and the second ring increases oil run–off properties with a tapered undercut form. The first ring is provided with chrome plating and has increased durability on the outer circumference of the oil ring and on the outer circumference of the second ring in turbo models. A full floating type piston pin is used, reducing friction.



Model



Piston Specifications

	Model
Top part volume (cc) undercut	1.4
Outer diameter (mm)	ϕ64.965~ϕ64.985
Height from boss center to top (mm)	25.5
Internal diameter of pin (mm)	ϕ16.006~ϕ16.014

Piston Pin Specifications

	Model
Pin outer diameter (mm)	ϕ15.995 ~ϕ16.005
Pin length (mm)	49.5

Piston Ring Specifications

	Model		
	1st	2nd	Oil
Width (mm)	1.0	1.2	2.0
Thickness (mm)	2.3	2.6 or 2/7	2.5
Form	Barrel face type	Tapered undercut type	Assembly type
Peripheral area plating	Yes	No	Yes

TIMING BELT/TIMING PULLEY/TIMING BELT TENSIONER

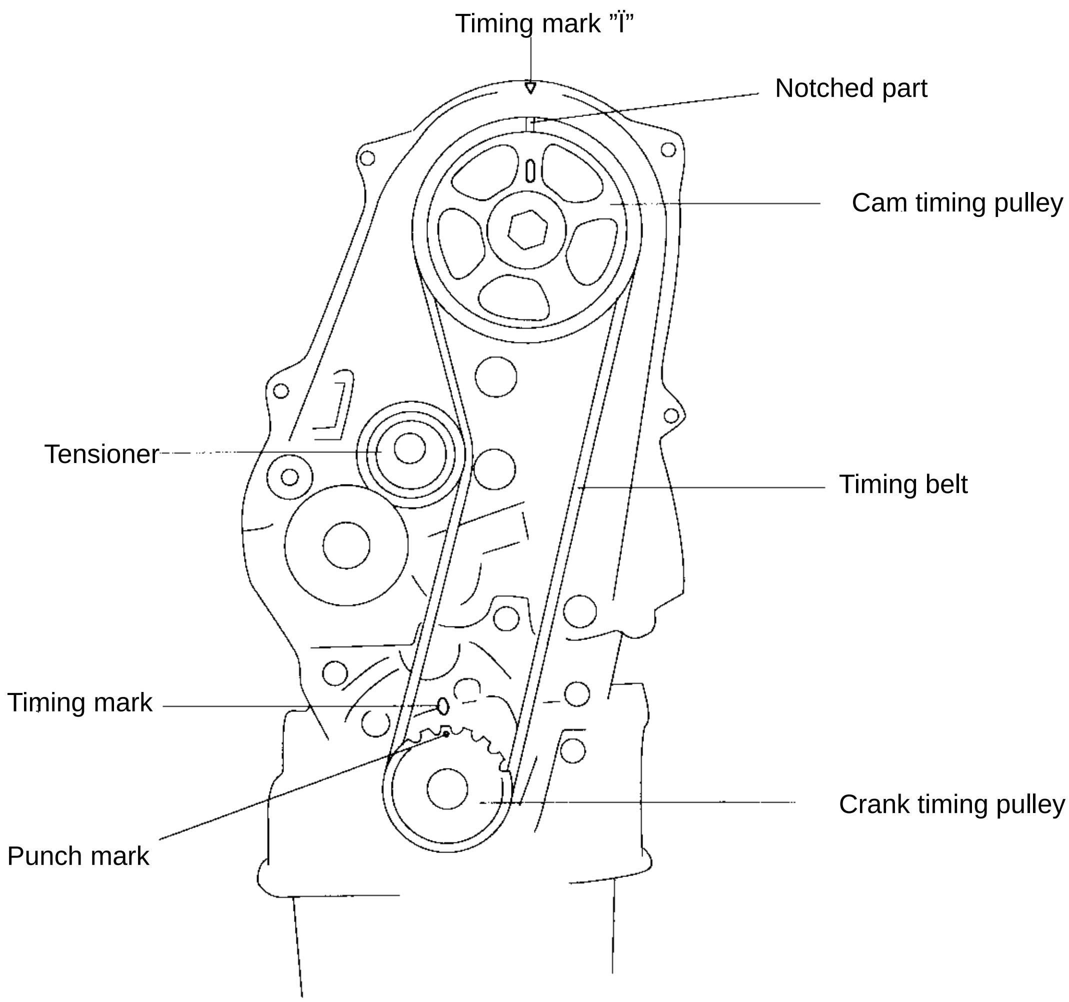
The timing drive system uses a quiet belt system.

The rotation of the crankshaft is transmitted via the crankshaft timing pulley to the camshaft timing pulley by means of the timing belt.

Since timing marks are engraved or cast in the timing pulley, timing belt inside cover, and oil pump case, when attached, adjustment is performed by matching each timing mark.

The timing belt is provided with a timing belt tensioner on the slack side.

The timing belt tensioner uses a sealed lubricant bearing system and is fixed by means of the bolt after the initial tension of the timing belt has been fixed using a special tool.



TIMING BELT SPECIFICATIONS

	4–valve models
Gear tooth form	YU
No. of teeth	103
Pitch	8.0 mm

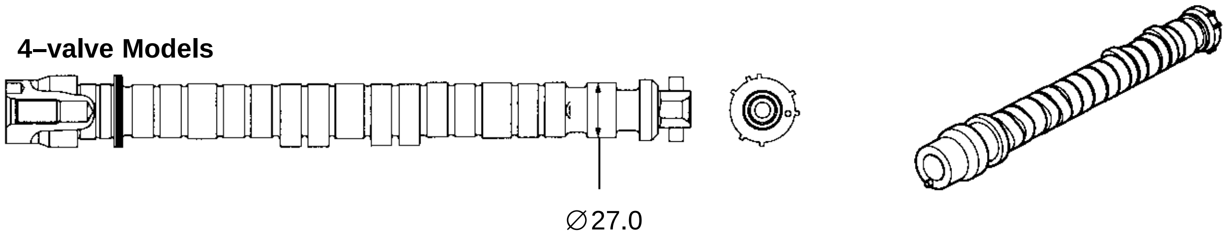
TIMING PULLEY SPECIFICATIONS

	Camshaft timing
No. of teeth	44

CAMSHAFT

The camshaft is made of cast iron and is designed for high rigidity as a solid structure. The rear portion is formed as a single body by pressure–insertion of the signal rotor.

4–valve Models



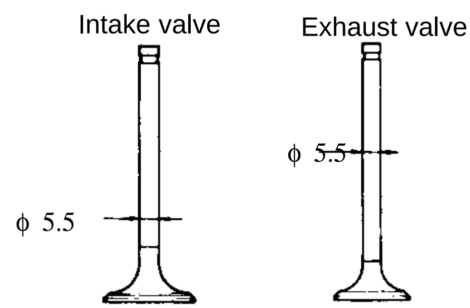
Cam height (mm)	IN	EX	IN	EX
	35.984	35.986	31.147	29.550

VALVES/VALVE SPRINGS

Valves are subjected to Tuffride treatment on the entire surface, increasing wear resistance. The valve springs use single springs have unequal pitch, increasing the conformity of the valves and preventing jumping. The valve springs are used in common on both the intake side and the exhaust side. The valve guides are used in common both on the intake side and exhaust side, and are pressed into the cylinder head. The valve sheets are made of a special annealed alloy having excellent durability and are pressed into the cylinder head.

VALVE SPECIFICATION INTAKE VALVE EXHAUST VALVE

	4–valve models	
Total length (mm)	IN	EX
Stem diameter (mm)	92.07	80.51
	ϕ5.5	
Umbrella diameter (mm)	ϕ25.6	ϕ22.4

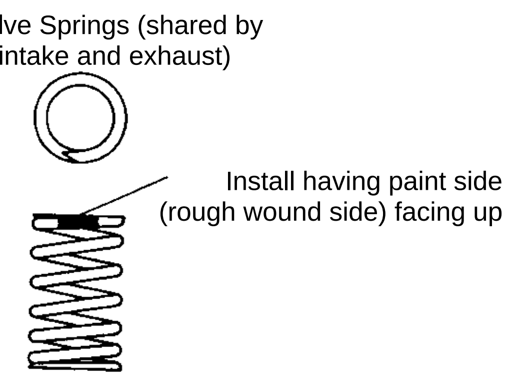


VALVE SPRING SPECIFICATION

Line diameter (mm)	ϕ3.3
Total wind No.	7.20
Free length (mm)	37.09

VALVE SPRING SPECIFICATION

Angle	IN(°)	flat 15° sheet face 45°
	EX(°)	flat 15° sheet face 45°
Contact width (mm)	4–valve models: IN 1.2 EX 1.2	



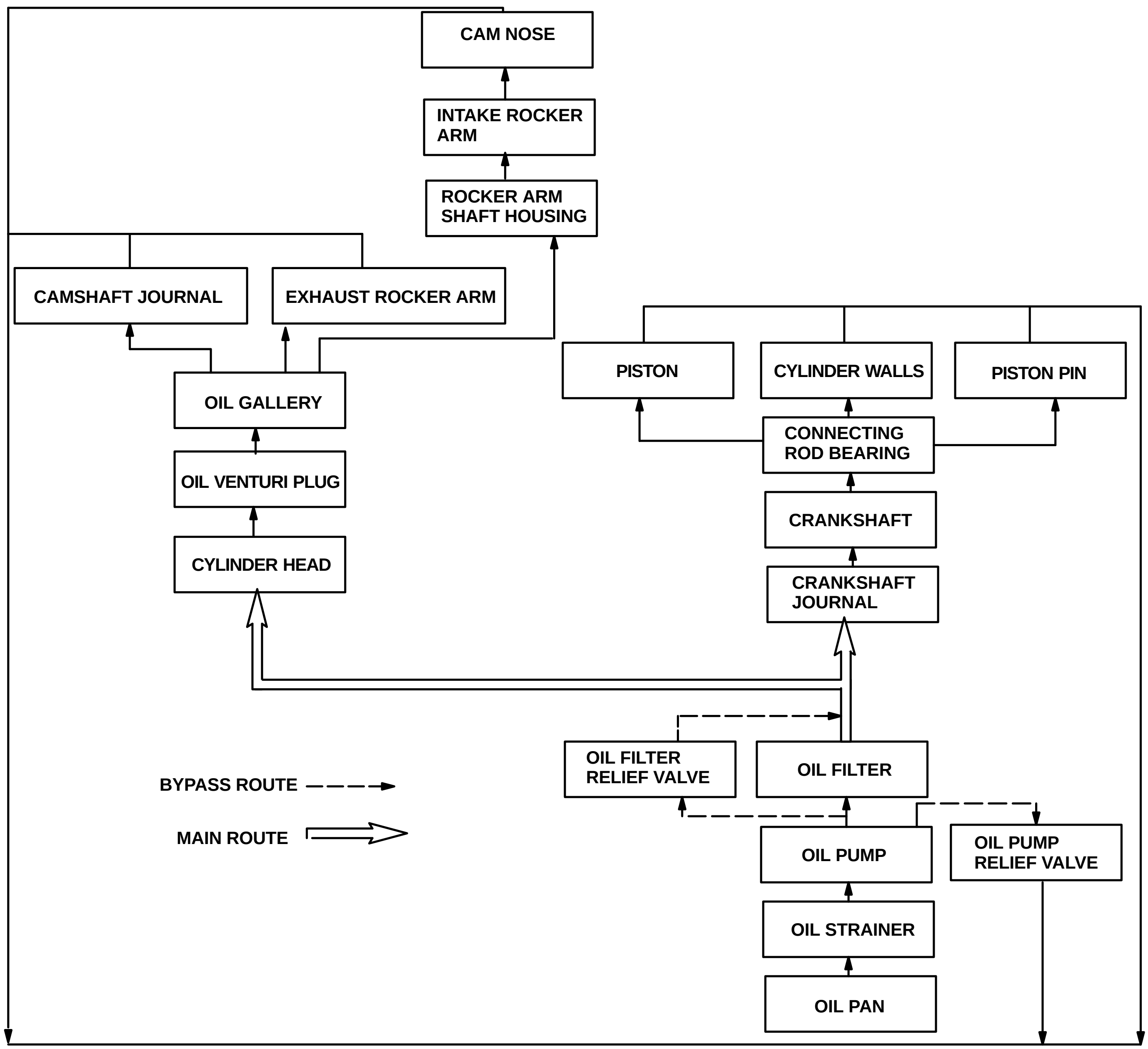
LUBRICATION SYSTEM

The engine lubrication uses a wet sump system, which is full–flow filtration force–feed system that force–feeds the oil using a pump that is driven by the driveshaft. The oil is drawn up from the oil pump strainer, and passes through the oil filter before flowing into the main channel.

The oil flowing out of the main channel lubricates each crank journal, passes through the oil passage inside the crankshaft, flows into the connecting rod bearings, and is sprayed from the oil jets which are at the larger end of the connecting rods, lubricating the pistons, piston pins, and cylinder walls.

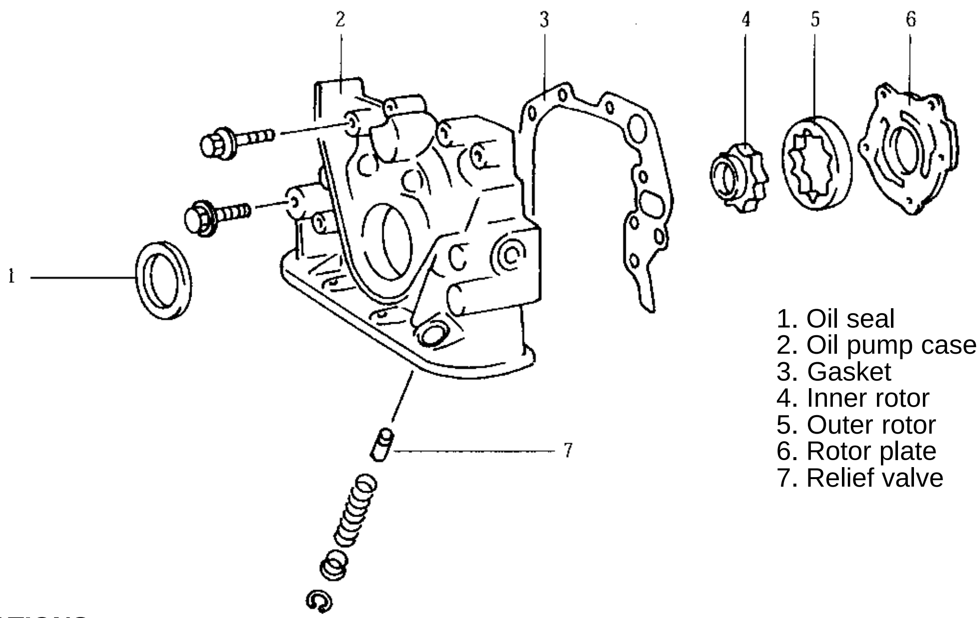
Also, a passage leads from crank journal No. 2 to the oil pressure switch and cylinder head.

In the 4–valve models, the oil flowing into the cylinder head passes through the oil venturi plug and flows into the oil gallery of the cylinder head. From the oil gallery of the cylinder head the oil flows into each camshaft journal and each exhaust rocker arm and pivot part. From the oil gallery of the cylinder head, also, oil flows to the rocker arm shaft housing No. 5, passing inside the rocker arm shaft and along the outer periphery of the sparkplug hole pipe, and lubricates the cam nose from the oil jet of the rocker arm.



OIL PUMP

The oil pump uses a trochoid system, and is driven directly by engagement with the width across the flat of the crankshaft and the inner rotor.

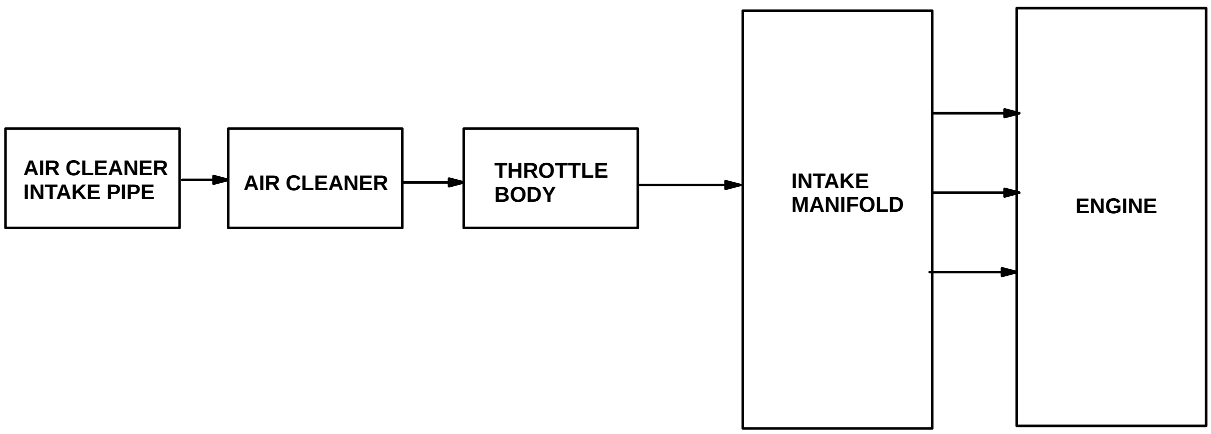


1. Oil seal
2. Oil pump case
3. Gasket
4. Inner rotor
5. Outer rotor
6. Rotor plate
7. Relief valve

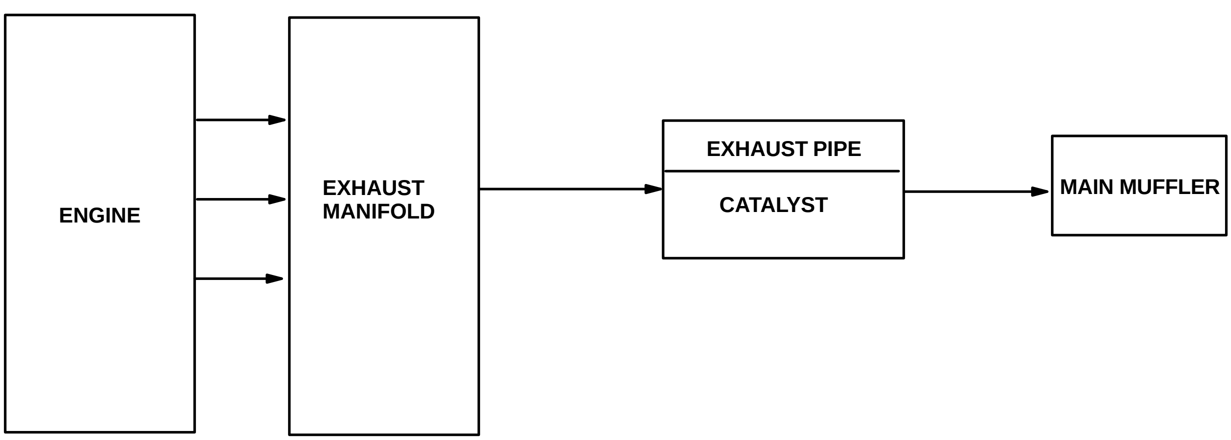
SPECIFICATIONS

Discharge pressure, discharge amount (pump rotation speed 4000 rpm)	When 270 kPa {2.8 kgf/cm^2} 14 L/min
Relief valve open pressure	290~370 kPa {2.8~3.6 kgf/cm^2}

INTAKE SYSTEM



EXHAUST SYSTEM



SECTION 5

ENGINE REPAIR

GENERAL DESCRIPTION

ENGINE

1. The engine is a water cooled, in–line, 3 cylinder, 4–stroke gasoline unit with its S.O.H.C. (single overhead camshaft) valve mechanism arranged for “V”–type configuration with12 valves (2 intake and 2 exhaust valves per cylinder).

The single overhead camshaft is mounted over the cylinder head; it is driven from the crankshaft through the timing belt. Unlike conventional overhead valve (O.H.V..) engines, this engine has no push rods. Thus, drive for valves is more direct and enables the valves to follow the crankshaft without any delay.

2. The distinctive features of the engine may be summarized as follows:

- Because of inlet and exhaust ports arranged for cross–flow pattern, with valves located in “V”–type configuration, both volumetric and scavenging efficiencies are very high.
- The combustion chamber formed between piston crown and cylinder head is of a pent roof type. This feature is calculated to make available greater horsepower from a lesser amount of fuel.
- The supports for camshaft and rocker shafts are integral with the cylinder head, so that the valve mechanism noise is markedly reduced by the structural rigidity and, moreover, that the number of valve mechanism parts is reduced, let alone a more compact size of the engine.
- The timing belt for driving the camshaft runs quiet and is light in weight.
- A high–grade cast iron is used for the material of the cylinder block. The block is shaped to present deep skirts and retain greater rigidity.
- The crankshaft is a one–piece forging, and is supported by four bearings for vibration free running.
- Heating by hot water is employed for the inlet manifold in order to facilitate fuel carburation and insure that uniform distribution of the mixture. The higher combustion efficiency of this engine is largely explained by the inlet manifold feature.

ENGINE LUBRICATION

The oil pump is of a trochoid type, and mounted on the crankshaft at crankshaft pulley side.

Oil is drawn up through oil pump strainer and passed through pump to oil filter.

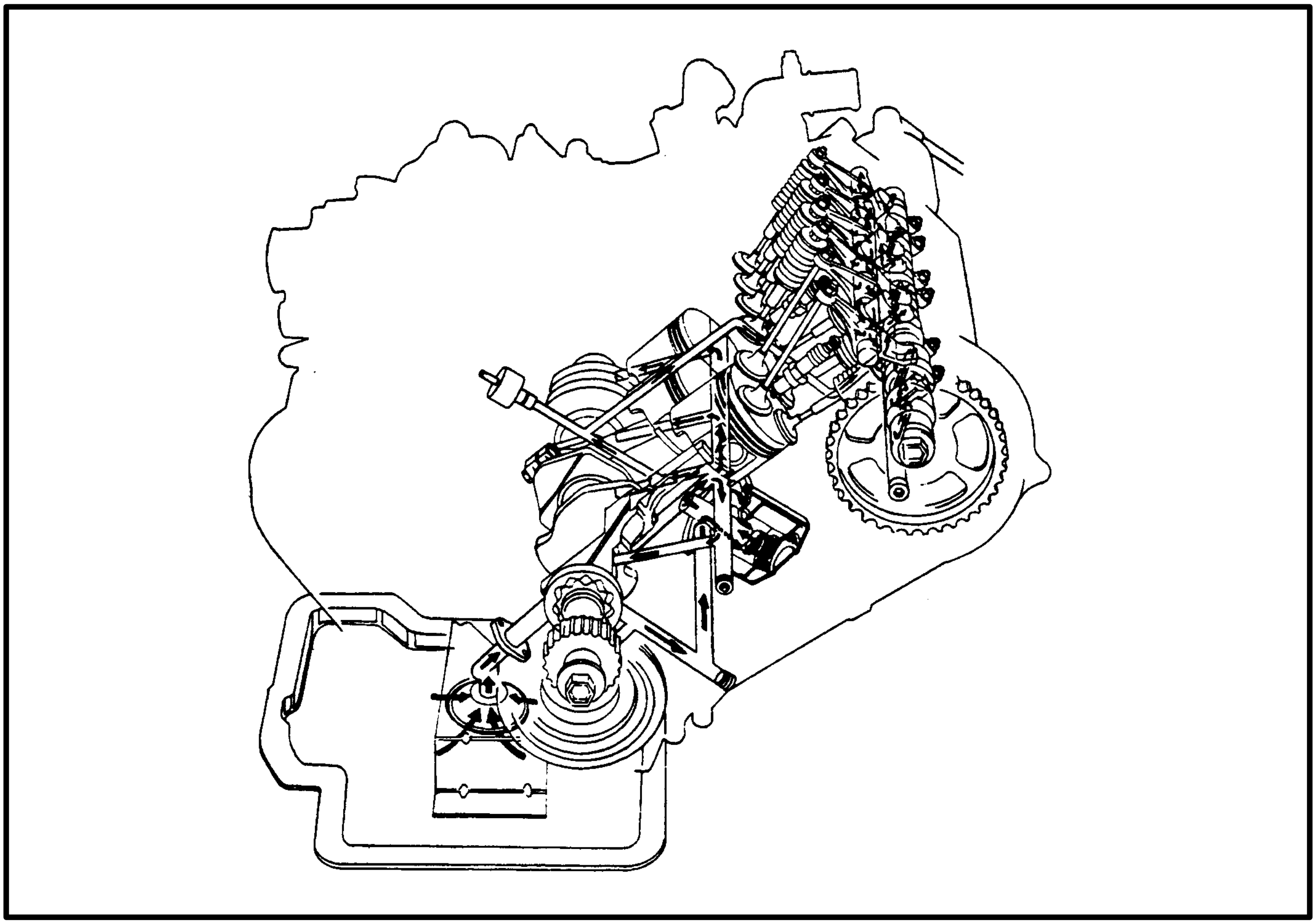
The filtered oil flows into two paths in cylinder block.

In one path, oil reaches crankshaft journal bearings.

Oil from crankshaft journal bearings is supplied to connecting rod bearings by means of intersecting passages drilled in crankshaft, and then injected from a small hole provided on big end of connecting rod to lubricate piston, rings, and cylinder wall.

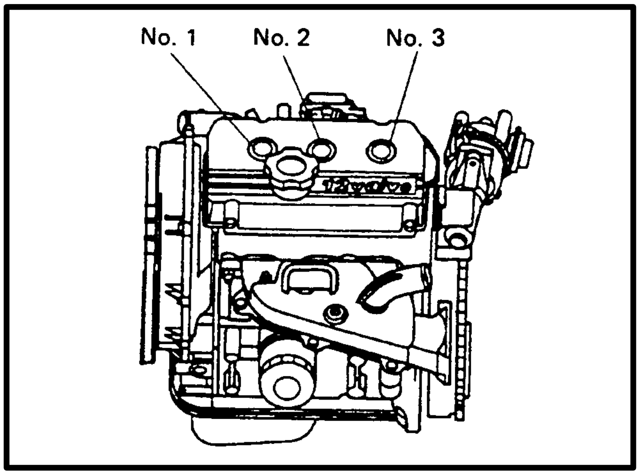
In another path, oil goes up to cylinder head and lubricates camshaft journals, racker arm, camshaft, etc., passing through oil gallery in rocker arm shaft.

An oil relief valve is provided on oil pump. This valve starts relieving oil pressure when the pressure comes over about 3.4 kg/cm2 (48.4 psi, 340 kPa). Relieved oil drains back to oil pan.



NOTE:

Throughout this MANUAL, the three cylinders of the engine are identified by numbers: No. 1, No. 2 and No. 3 as counted from front end.

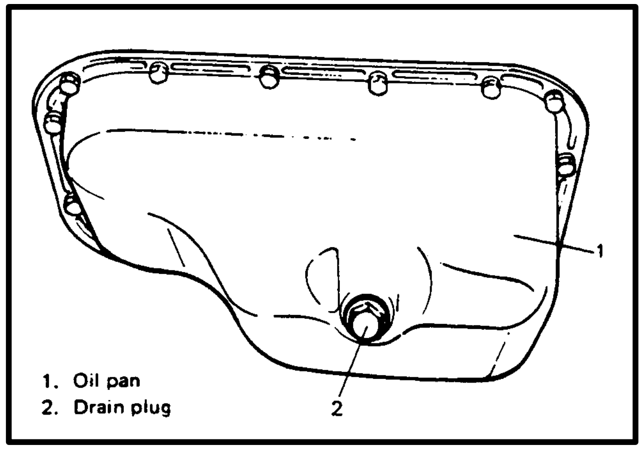


NOTE:

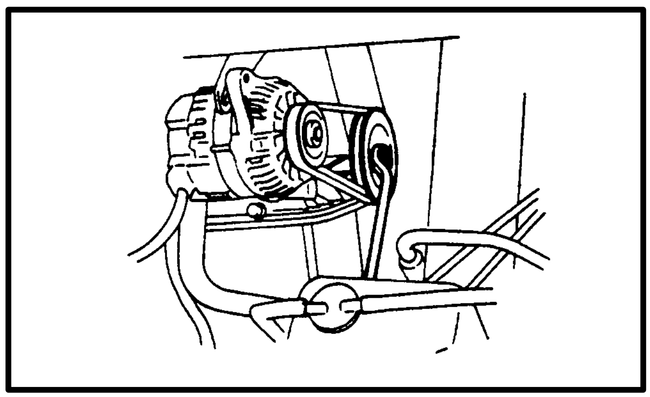
> **Observe critically before starting to remove a component or part by loosening bolts, nuts and the like. What you may find before and during disassembly is valuable information necessary for successful reassembly.**
>
> **Be careful in handling aluminum–alloy parts. They are softer than steel and cast–iron parts and their finished surfaces more easily take scratch marks.**
>
> **Have trays and pans ready for setting aside the disassembled parts in an orderly manner. Place the parts in the trays and pans in such a way that they can be readily identified. Put match marks or tags on them, as necessary, so that they will go back to where they came from.**

Carry out engine disassembly in the following sequence.

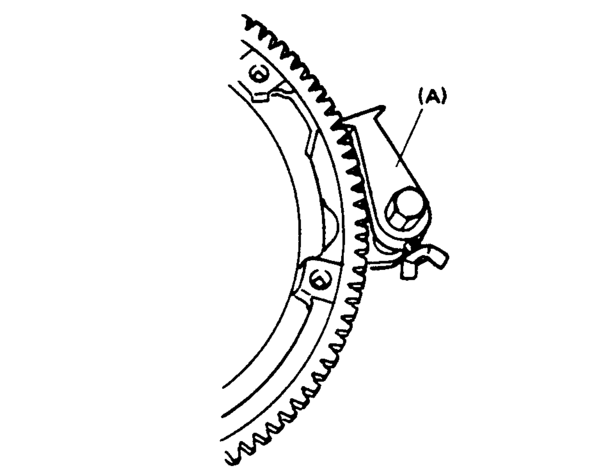
1) Loosen drain plug and drain out engine oil.



2) Remove alternator and alternator mounting brackets.



3) Remove crankshaft pulley similarly, with special tool attached to flywheel so that crankshaft will not turn.

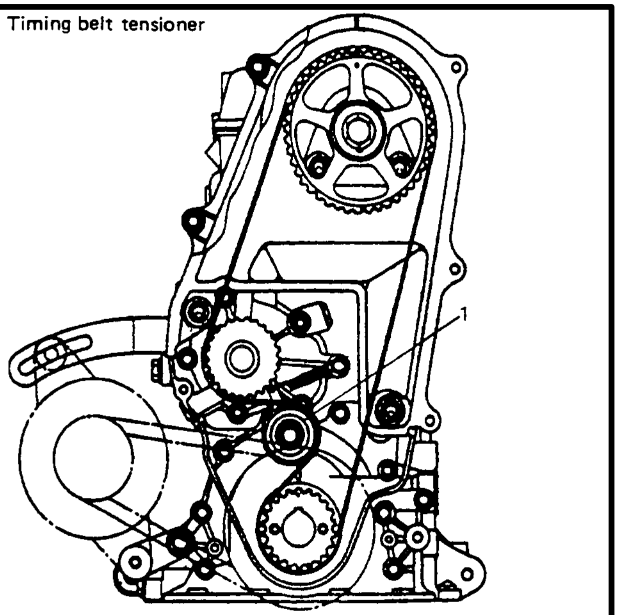


(A): Flywheel holder (Special tool 09924-17810)

4) Remove timing belt outside cover.

5) Remove timing belt tensioner after removing a part of the tensioner spring.

1. Timing belt tensioner



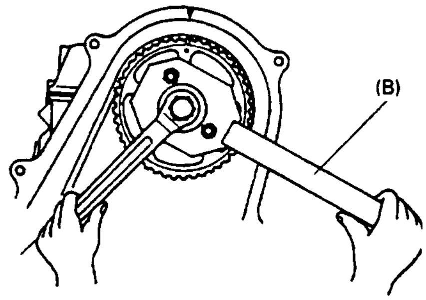
6) Remove timing belt.

CAUTION

When timing belt has been removed, never turn crankshaft or camshaft.

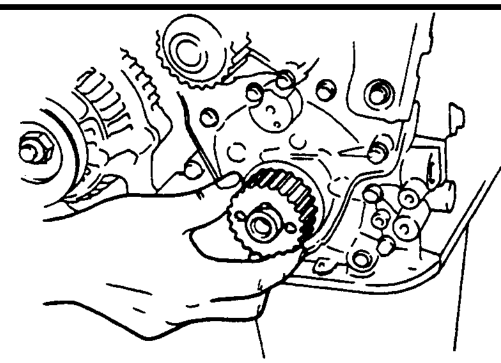
If camshaft must be turned, turn by crankshaft so that timing mark is deviated by 30° or more.

7) Remove camshaft timing belt pulley and key with special tool attached, as shown, to lock camshaft.



(B): Camshaft lock holder (Special tool 09917-68220) or the like

8) Remove crankshaft timing belt pulley, and key.



9) Remove timing belt inside cover.

10) Remove water pump.

11) Remove exhaust manifold cover.

12) Take off exhaust manifold.

13) Remove exhaust manifold gasket.

14) Using an oil filter wrench, remove oil filter.

NOTE:

Be careful not to spill the oil when removing the filter.

15) Disconnect PCV (Positive crankcase ventilation valve) hose or crankcase ventilation hose from cylinder head cover.

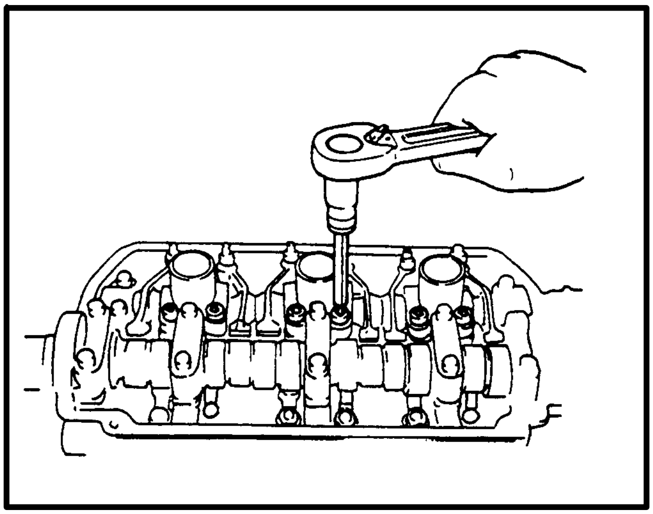
16) Remove intake manifold with throttle body.

17) Remove water inlet pipe.

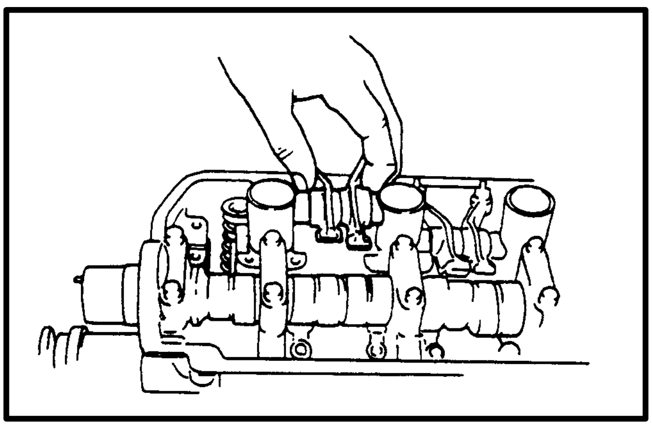
18) Take off valve cover.

19) Loosen all valves adjusting screws fully. Leave screws in place.

20) Remove rocker arm shaft caps.

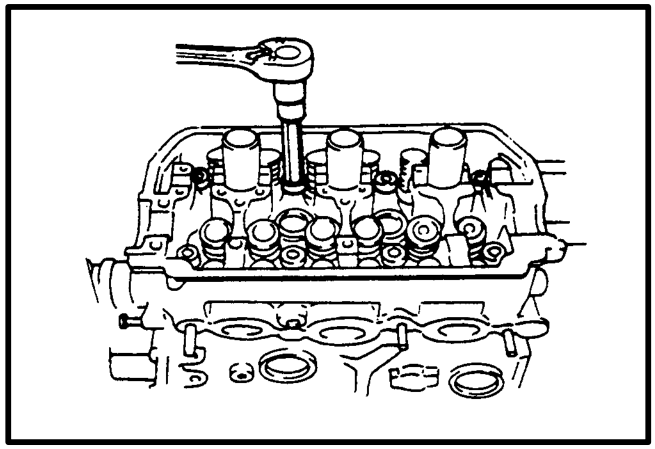


21) Remove intake rocker arm shaft.

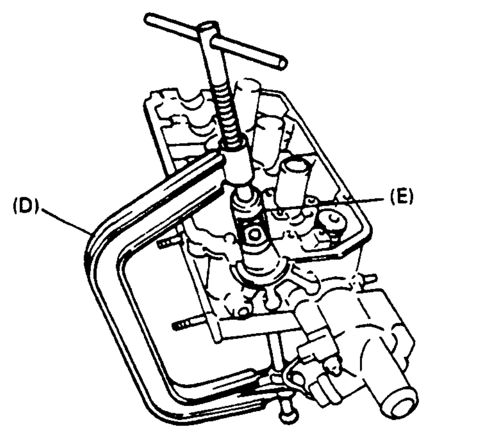


22) Remove camshaft caps, camshaft and exhaust rocker arms.

23) Remove cylinder head.



a) Use valve lifter and attachment to compress valve spring in order to free valve retainer pieces for removal. In this way, remove valve spring and valves.

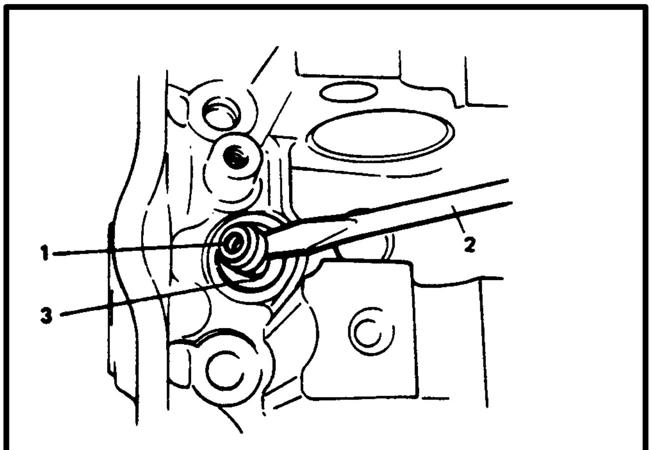


(D): Valve lifter (Special tool 09916-14510)
(E): Valve lifter attachment (Special tool 09916-14910)

b) Remove valve stem oil seal from guide, and then valve spring seat.

NOTE:

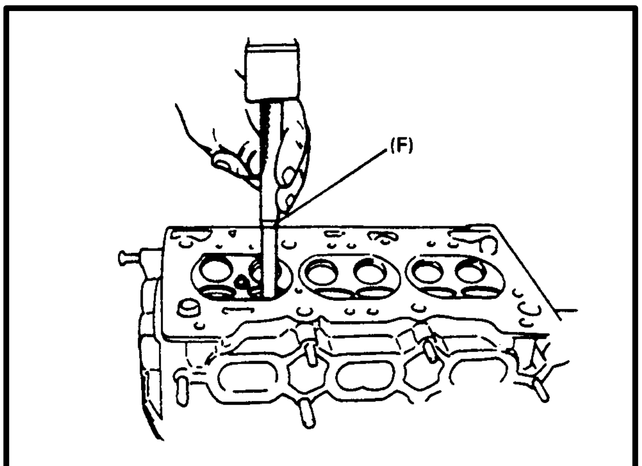
Do not reuse oil seal once disassembled. Be sure to use new oil seal when assembling.



c) Using special tool, drive valve guide out from combustion chamber side to valve spring side.

NOTE:

Do not reuse valve guide once disassembled. Be sure to use new valve guide (Oversize) when assembling.

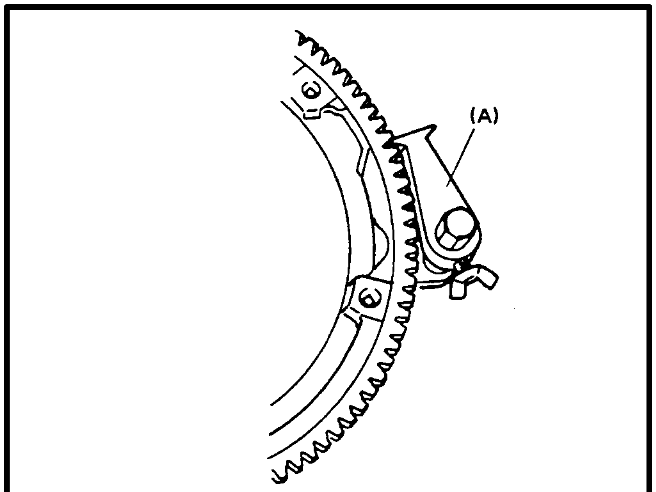


(F): Valve guide remover (Special tool 09916-44310)

NOTE:

Place disassembled parts except valve stem oil seal and guide in order, so that they can be installed in their original positions.

24) Remove flywheel; using special tool as shown.



(A): Flywheel holder (Special tool 09924-17810)

25) Remove alternator bracket.

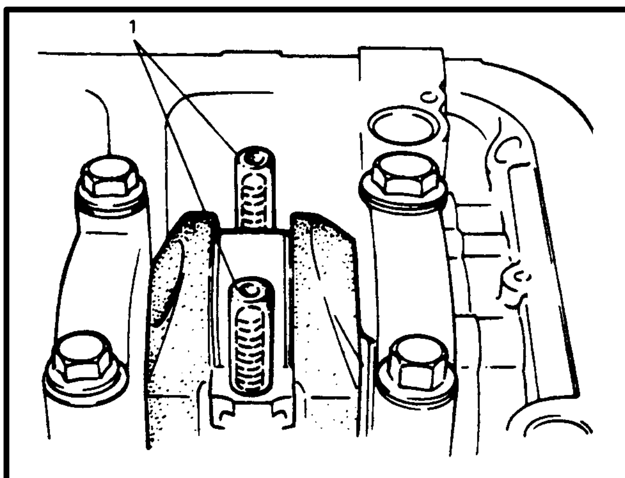
26) Remove engine mounting brackets from cylinder block.

27) Remove oil pan.

28) Remove oil pump strainer.

29) Remove connecting rod bearing caps.

30) Install guide hose over threads of rod bolts. This is to prevent damage to bearing journal and cylinder wall when removing connecting rods.



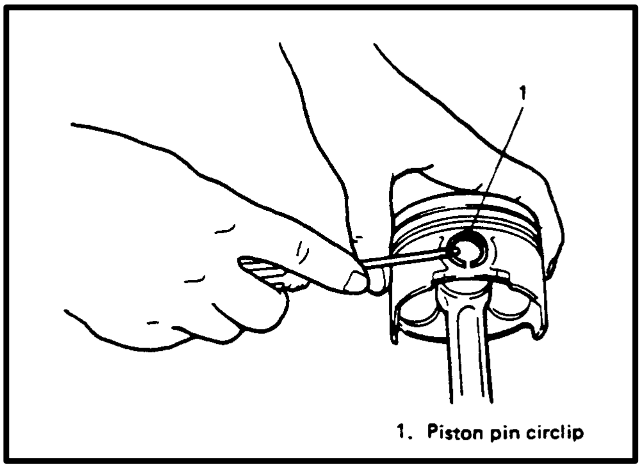
31) Decarbon top of cylinder bore, before removing piston from cylinder.

32) Push piston and connecting rod assembly out through the top of cylinder bore.

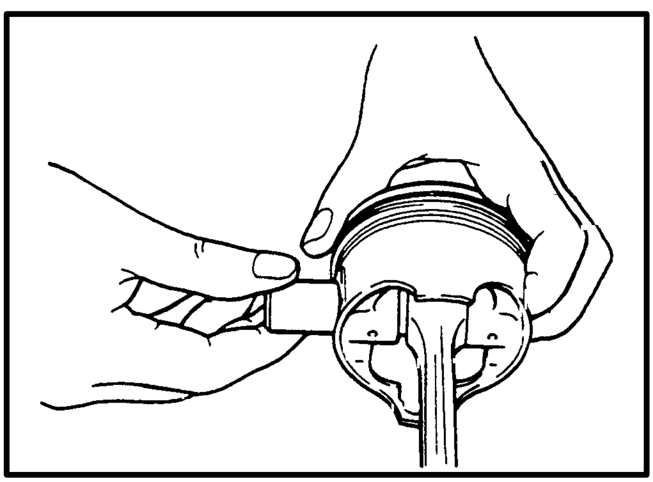
CAUTION

> **Before pushing the piston out, scribe the cylinder number on its crown.**
>
> **Be sure to identify each piston, piston pin, connecting rod and bearing cap by using the cylinder number.**

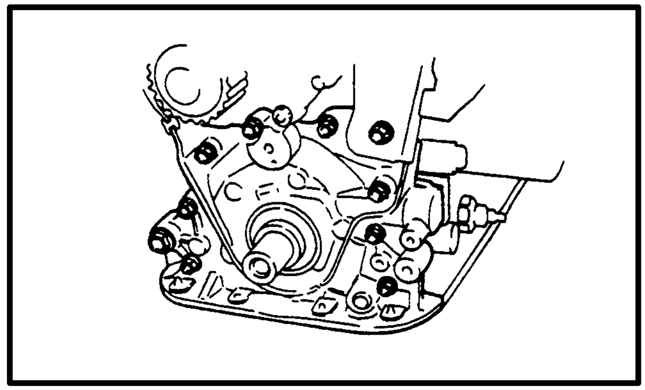
a) From each piston, ease out piston pin circlips, as shown.



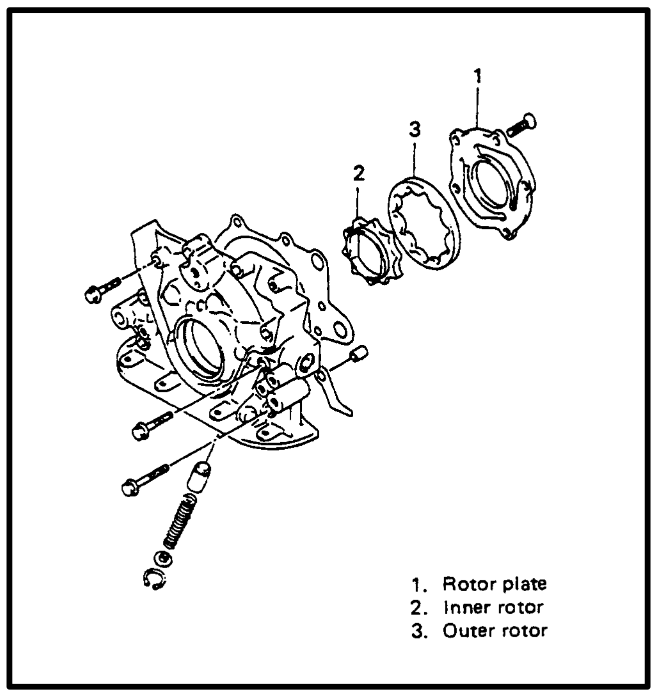
b) Force piston pin out.



33) Remove oil pump case.



a) Remove oil pump rotor plate.



b) Take out inner and outer rotor.

34) Remove oil seal housing.

35) Remove crankshaft bearing caps, and take out crankshaft.

INSPECTION OF ENGINE COMPONENTS

NOTE:

- During and immediately after disassembly, inspect cylinder block and head for evidence of water leakage or damage and, after washing them clean, inspect more closely.

- Wash all disassembled parts clean, removing, grease, carbon and scales, before inspecting them to determine whether repair is necessary or not.
- Descale water jackets
- Used compressed air to clear internal oil holes and passages.
- Do not disturb set combinations of valves, bearings, bearing caps, etc. Have the sets segregated and identified.

Cylinder Head

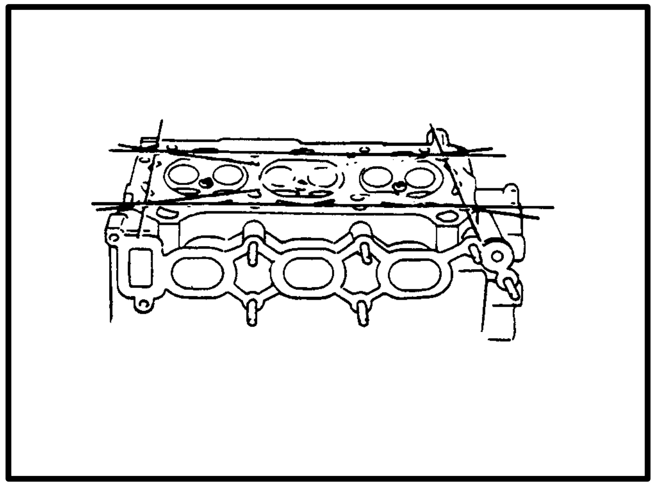
- Remove all carbon from combustion chambers.

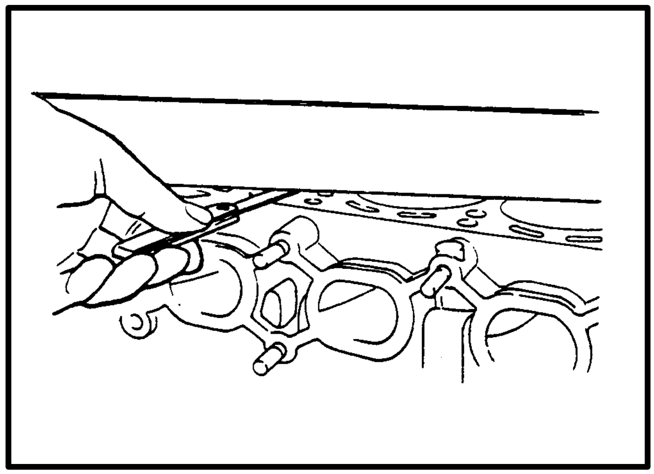
NOTE:

Do not use any sharp–edged tool to scrape off the carbon. Be careful not to scuff or nick metal surfaces when de–carboning. This applies to valves and valve seats, too.

- Check cylinder head for cracks in intake and exhaust ports, combustion chambers and head surface.
- Flatness of gasketed surface:
  Using a straightedge and thickness gauge, check the flatness at a total of 6 locations. If the limit, stated below, is exceeded, correct gasketed surface with a surface plate and abrasive paper of about #400 (water proof silicon carbide abrasive paper): place paler on and over surface plate, and rub gasketed surface against paper to grind off high spots. Should this fail to reduce thickness gauge readings to within the limit, replace cylinder head.
- Leakage of combustion gases from this gasketed joint is often due to a warped gasketed surface; such leakage results in reduced power output and hence an increased amount of fuel expense.

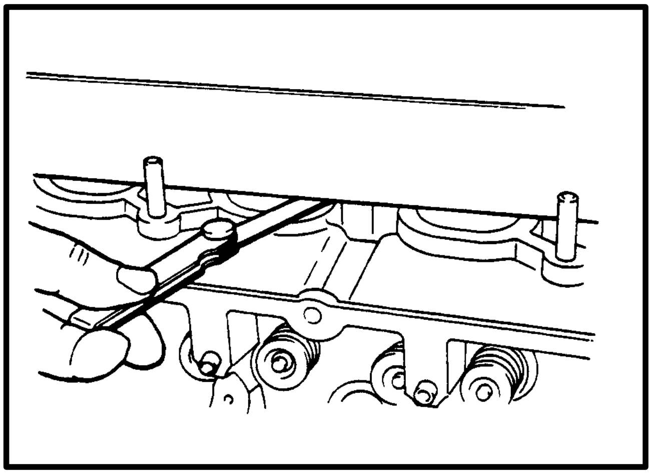
Limit of distortion	0.05 mm (0.002 in.)



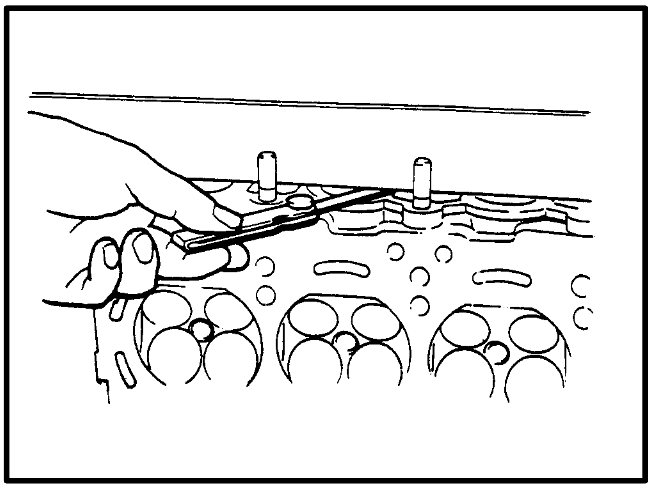


- Distortion of manifold seating faces: Check the seating faces of cylinder head for manifolds, using a straightedge and thickness gauge, in order to determine whether these faces should be corrected or the cylinder head replaced.

Limit of distortion	0.10 mm (0.004 in.)



Measuring Surface of Intake Manifold Seating Face



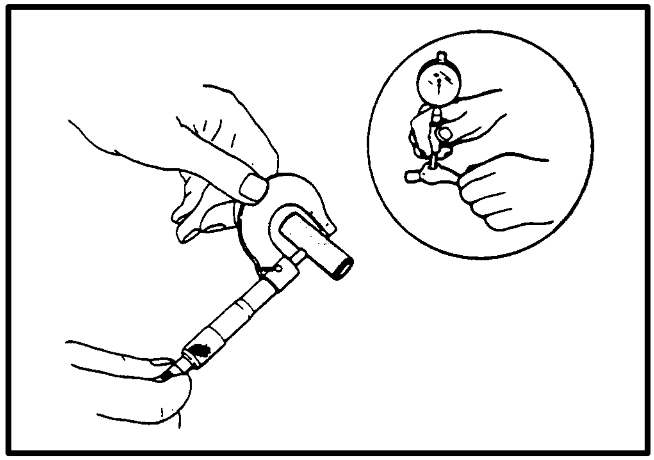
Measuring surface of Exhaust Manifold Seating Face

Rocker–Arm Shaft and Rocker Arms

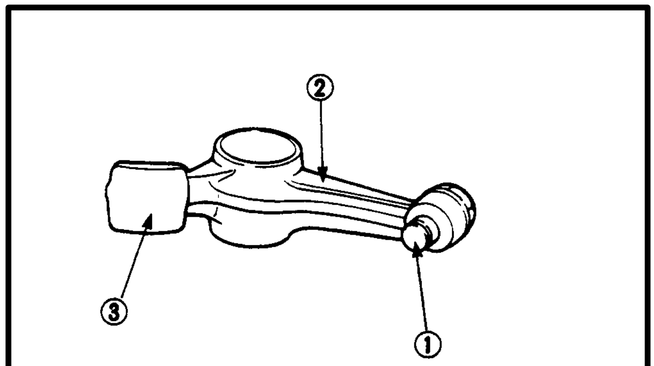
- Shaft–to–arm clearance (IN & EX): Using a micrometer and a bore gauge, measure rocker shaft dia. and rocker arm I.D..

- The difference between two readings is the arm–to–shaft clearance on which limit is specified. if the limit is exceeded, replace shaft or arm, or both.

Item		Standard	Limit
Arm–to shaft clear-ance	**Intake & Exhaust**	0.005 – 0.040 mm (0.0002–0.0016 in.)	0.06 mm (0.0024 in.)



- Wear of rocker–arm and adjusting screw: If the tip (1) of adjusting screw is badly worn, replace screw. Arm; must be replaced if its cam–riding face (3) is badly worn.



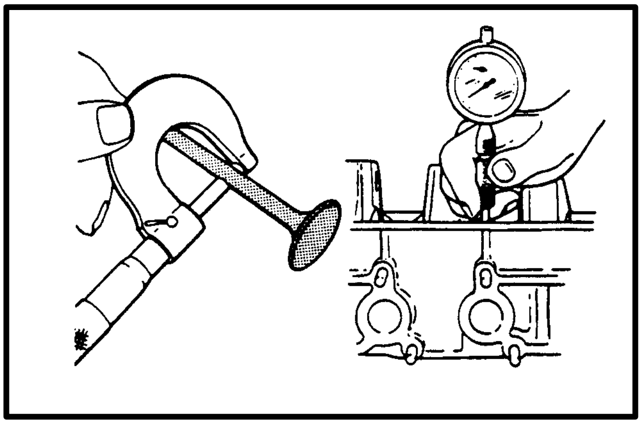
- Visually examine each rocker–arm wave washer for evidence of breakage or weakening. Be sure to replace washers found in bad condition.

Valve Guides

Using a micrometer and bore gauge, take diameter readings on valve stems and guides to determine stem clearance in guide. Be sure to take a reading at more than one place along the length of each stem and guide.

Item		Standard	Limit
Valve stem diameter	**Int**	4.965–4.980 mm (0.1955–0.1960 in.)	————
	Exh	4.950–4.965 mm (0.1949–0.1954 in.)	————
Valve guide I.D.	**Int**	5.000–5.012 mm (0.1969–0.1973 in.)	————
	Exh	5.000–5.012 mm (0.1969–0.1973 in.)	————

Stem–to–guide clearance	Int	0.020–0.047 mm (0.0008–0.0018 in.)	0.07 mm (0.0035 in.)
	Exh	0.035–0.062 mm (0.0014–0.0024 in.)	0.09 mm (0.0035 in.)

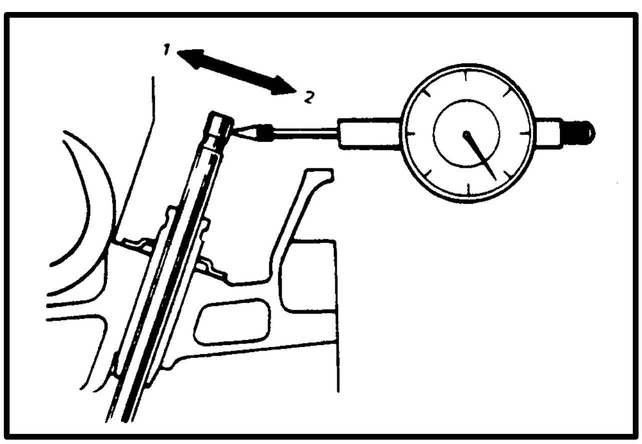


If bore gauge is not available, check end deflection of the valve stem in place with a rigid dial gauge.

Move stem end in the directions (1) and (2) to measure end deflection.

If deflection exceeds its limit, replace valve stem and valve guide.

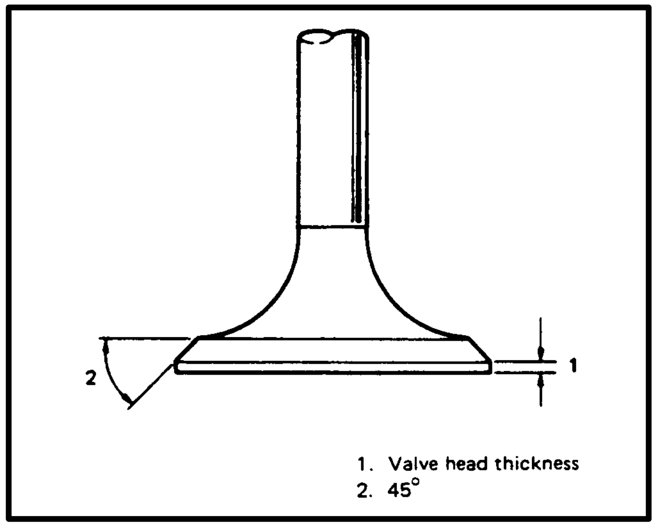
Valve stem end deflection limit	Intake	0.14 mm (0.0055 in.)
	Exhaust	0.18 mm (0.0070 in.)



Valves

- Remove all carbon from valves.
- Inspect each valve for wear, burn or distortion at its face and stem and replace as necessary.
- Measure thickness of valve head. If measured thickness exceeds its limit specified below, replace valve.

Valve head thickness		
Standard	**Limit**	
1.0 mm (0.039 in.)	**Intake**	0.6 mm (0.0236 in.)
	Exhaust	0.7 mm (0.0275 in.)

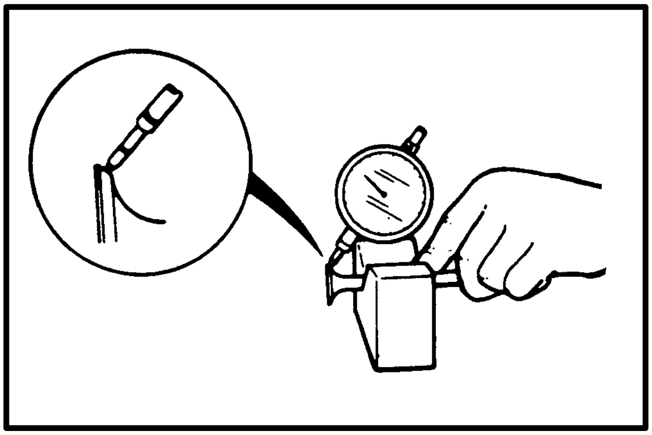


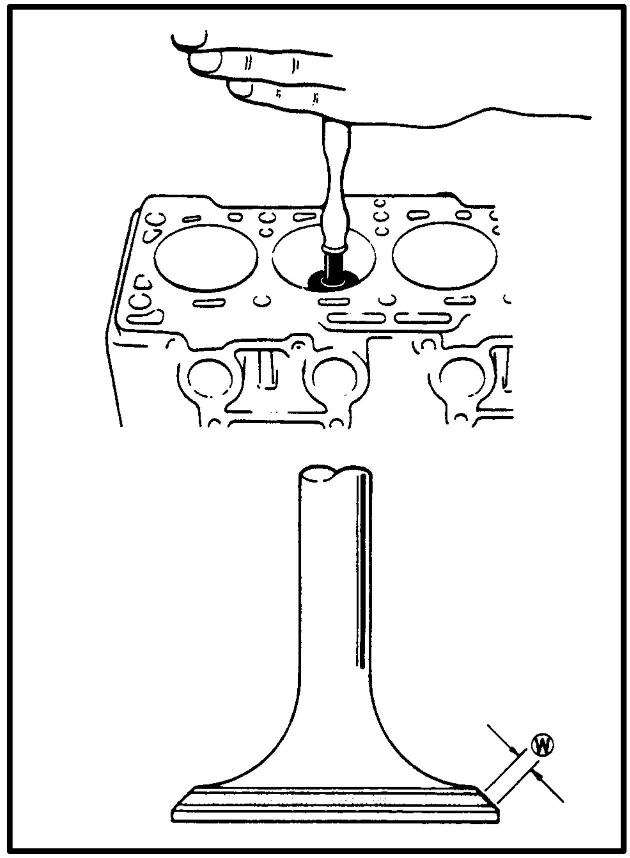
- Check end face of each valve stem for wear. This face meets rocker arm intermittently in operation, and might become concave or otherwise irregular. As necessary, smoothen the end face with an oil stone and, if this grinding removes the end stock by as much as 0.5 mm (0.0196 in.) (as measured from the original face), replace the valve.

Limit on stock allowance of valve stem end face	0.5 mm (0.0196 in.)

- check each valve for radial runout with a dial gauge and "V" block. To check runout, rotate valve slowly. If runout exceeds limit, replace valve.

Limit on valve head radial runout	0.08mm (0.003 in.)





Valve Seats

CAUTION

Valves to be checked and serviced for seating width and contact pattern must be those found satisfactory in regard to stem clearance in the guide and also requirements stated on preceding page under VALVES.

- **Seating contact width:** Produce a contact pattern on each valve in the usual manner, namely, by giving a uniform coat of marking compound (red–lead paste) to valve seat and by rotatingly tapping seat with valve head. Valve lapper tool (tool used in valve lapping) must be used.

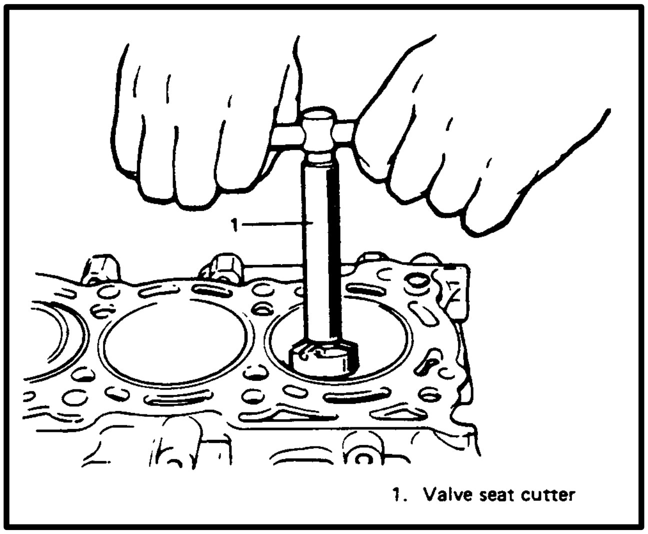
- The pattern produced on seating face of valve must be a continuous ring without any break, and width (W) of pattern must be within stated range as follows.

Standard seating width (W) revealed by contact pattern on valve face	Intake	1.1 – 1.3 mm (0.0434 – 0.0511 in.)
	Exhaust	

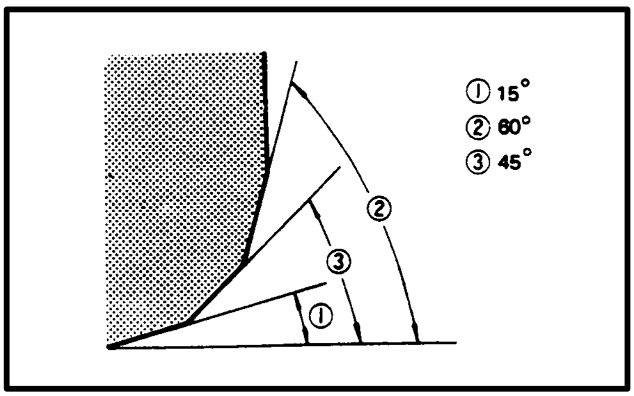
- Valve seat repair: Valve seat not producing uniform contact with its valve or showing a width (W) of seating contact that is off the specified range must be repaired by re–grinding or by cutting and regrinding and finished by lapping.

- 1) EXHAUST VALVE SEAT: Use a valve seat cutter to make three cuts as shown below figure. Three cutters must be used: The first for making 15° angle, the second for making 60° angle and the last for making 45° seat angle. The third cut must be made to produce the desired seat width (W).

Seat width (W) for exhaust valve seat	1.1 –1.3 mm (0.0434 – 0.0511 in.)



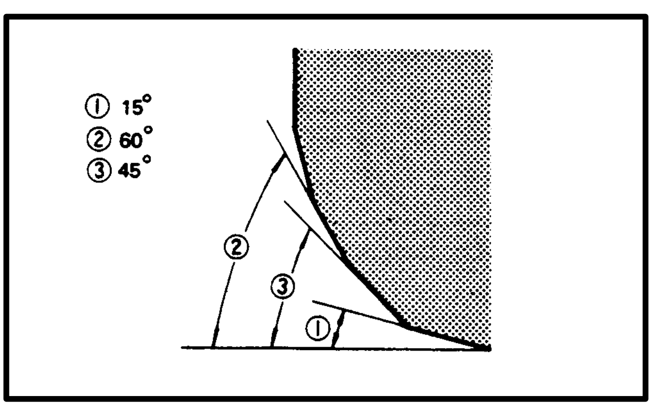
Valve seat cutting



Valve seat angles for exhaust valve seat

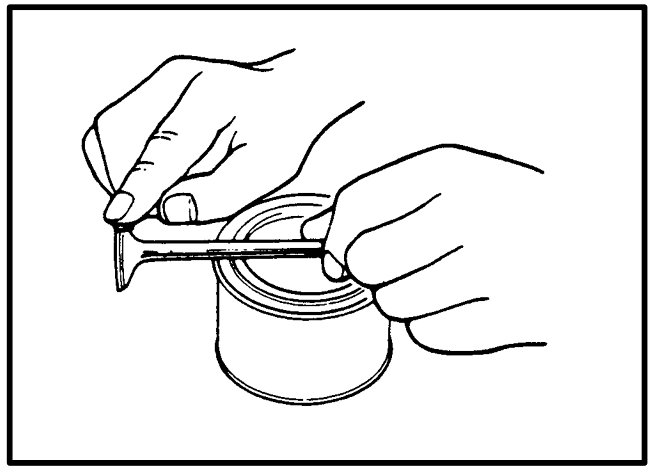
2) INTAKE VALVE SEAT: Cutting sequence is the same as for exhaust valve seats but the second angle differs, as will be noted in below figure.

Seat width (W) for intake valve seat	1.1 – 1.3 mm (0.0434 – 0.0511 in.)



Valve seat angles for intake valve seat

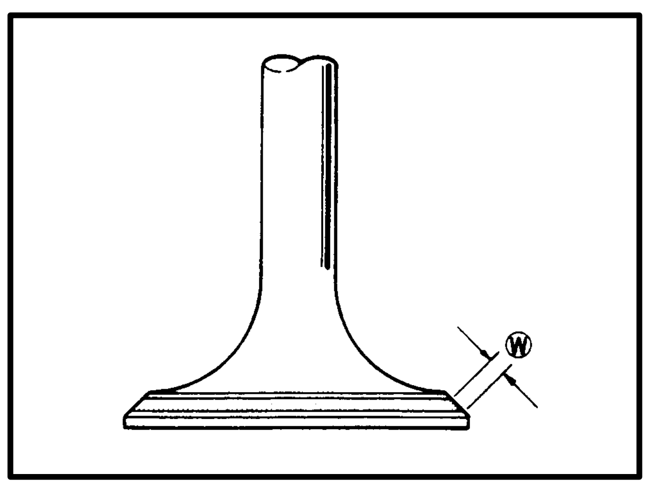
3) VALVE LAPPING: Lap valve on seat in two steps, first with coarse–grit lapping compound applied to its face and the second with a fine–grit compound, each time using a valve lapper according to usual lapping method.



Applying lapping compound to valve face

NOTE:

> **After lapping, wipe compound off valve face and seat, and produce contact pattern with marking compound (red–lead paste). Check to be sure that contact is centered widthwise on valve seat and that there is no break in contact pattern ring.**
>
> **Be sure to check and, as necessary, adjust valve clearance after reinstalling cylinder head and valve mechanism.**

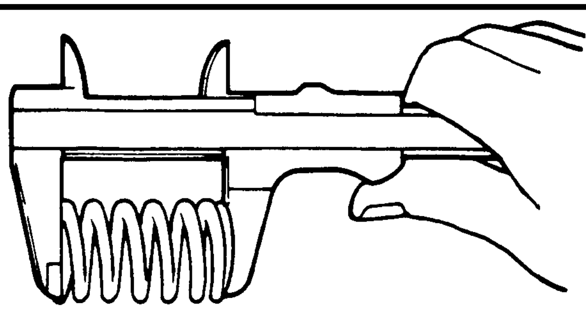


Valve Springs

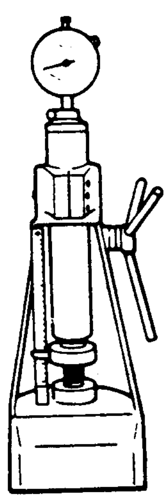
- Referring to the criterion–data given below, check to be sure that each spring is in sound condition, free of any evidence of breakage or weakening. Remember, weakened valve springs can be the cause of chatter, not to mention the possibility of reducing power output due to gas leakage caused by decreased seating pressure.

Item	Standard
Valve spring free length	37.09 mm

Valve springs for this engine are single springs of unequal pitch. The same valve spring is used for both intake and exhaust valves.

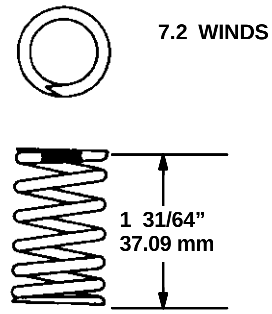


Measuring free length of spring



Checking spring preload

Valve spring squareness limit	2.0 mm (0.079 in.)

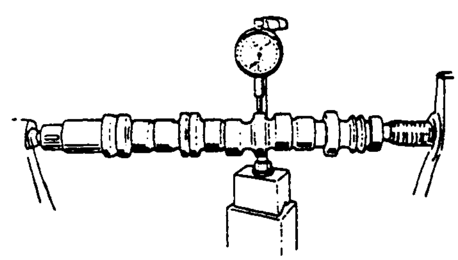


Make sure when installing valve springs that the painted side (rough wound) faces up.

Camshaft

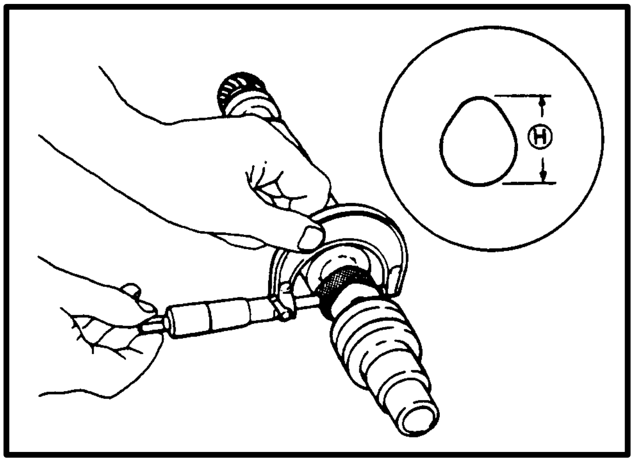
- Runout of camshaft:
  Hold camshaft between two “V” blocks, and measure runout by using a dial gauge.
  If runout exceeds its limit, replace camshaft.

Runout limit	0.10 mm (0.0039 in.)



- Cam wear:
  Using a micrometer, measure height (H) of cam lobe. If measured height is less than respective limits, replace camshaft.

Camheight (H)	Standard
Intake cam	31.147 mm (1.2459 in.)
Exhaust cam	29.550 mm (1.1820 in.)

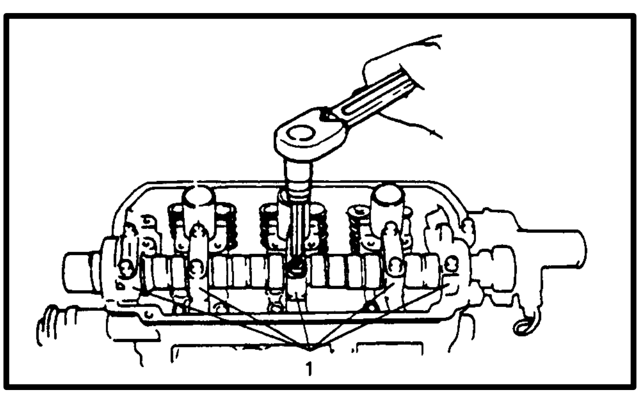


- Journal wear:
  Check camshaft journals and camshaft housings for pitting, scratches, wear or damage.
  If any malcondition is found,replace camshaft or cylinder head with housing. Never replace cylinder head without replacing housings.
  Check clearance by using gaging plastic. The procedure is as follows.
  1) Clean housings and camshaft journals.
  2) Make sure that all valve lash adjusters are removed and install camshaft to cylinder head.
  3) Place a piece of gaging plastic the full width of journal of camshaft (parallel to camshaft).
  4) Install housings and evenly torque housing bolts to specified torque. Housings MUST be torqued to specification in order to assure proper reading of camshaft journal clearance.

NOTE:

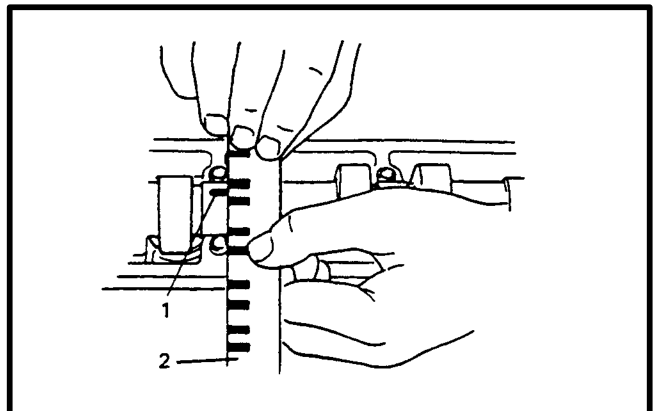
Do not rotate camshaft while gaging plastic is installed.

Tightening torque for journal bolts	9 – 12 N–m (0.9 – 1.2 kg–m) (7.0 – 8.5 lb–ft)



5) Remove housing, and using scale on gaging plastic envelope, measure gaging plastic width at its widest point.

	Standard	Limit
Journal clearance	0.045 – 0.087 mm (0.0018 – 0.0034 in.)	0.12 mm (0.0047 in.)

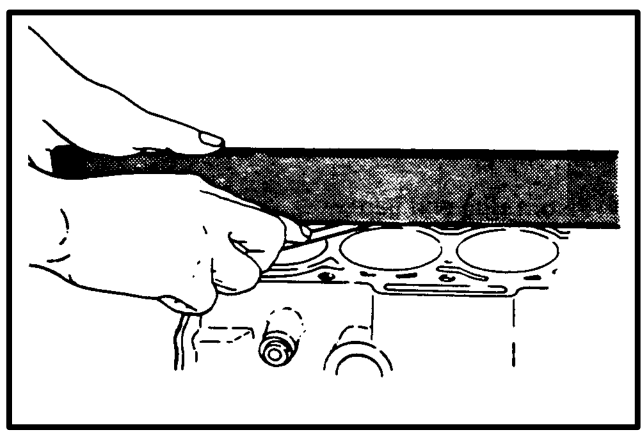


1. Gaging plastic
2. Scale

Cylinder Block

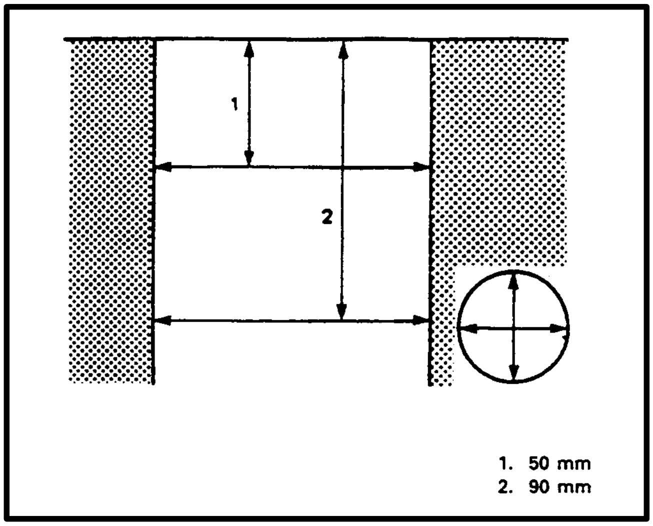
- Distortion of gasketed surface:
  Using a straightedge and a thickness gauge, check gasketed surface for distortion and, if result exceeds specified limit, correct it.

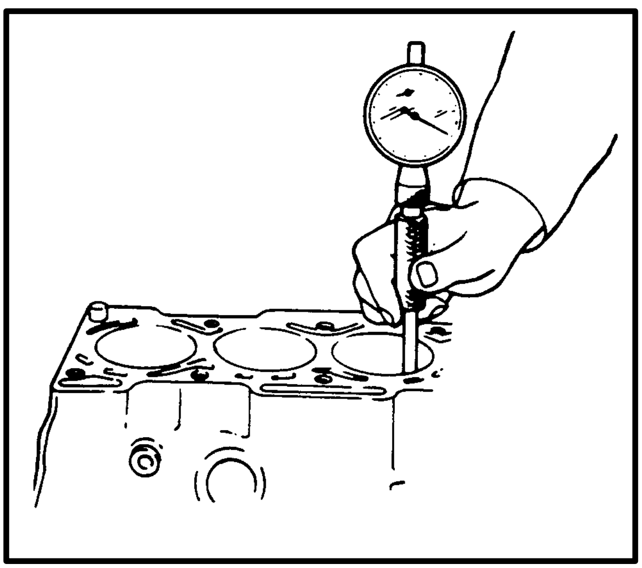
Limit of distortion	0.05 mm (0.0020 in.)



- Cylinder bore:
  Using a cylinder gauge, measure cylinder bore in thrust and axial directions at two positions.
  If any of the following conditions is noted, rebore cylinder.
  1) Cylinder bore diameter exceeds limit.
  2) Difference of measurements at two positions exceeds taper limit.
  3) Difference between thrust and axial measurements exceeds out–of–round limit.

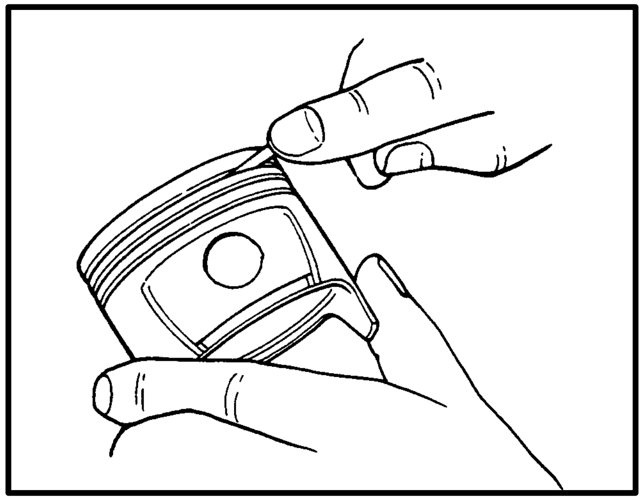
Cylinder bore dia. limit	65.070 mm (2.5618 in.)
Taper and out–of–round limit	0.10 mm (0.0039 in.)





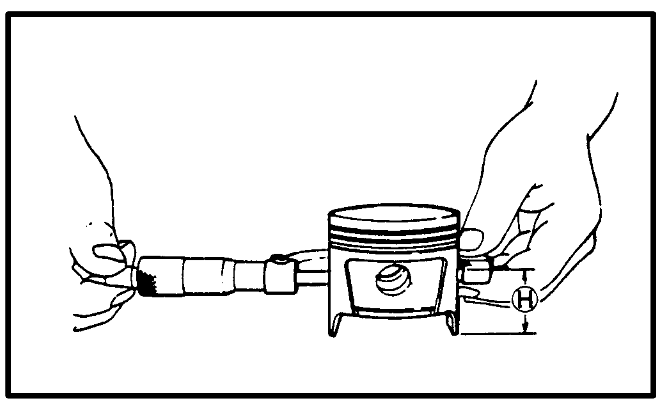
Piston and piston rings

- Inspect the outer surface of each piston for evidence of burn and for scratch or groove marks. Minor flaws can be removed by sanding with fine grain sandpaper.
- De–carbon the piston crown and ring grooves, using a soft metal scraping tool.



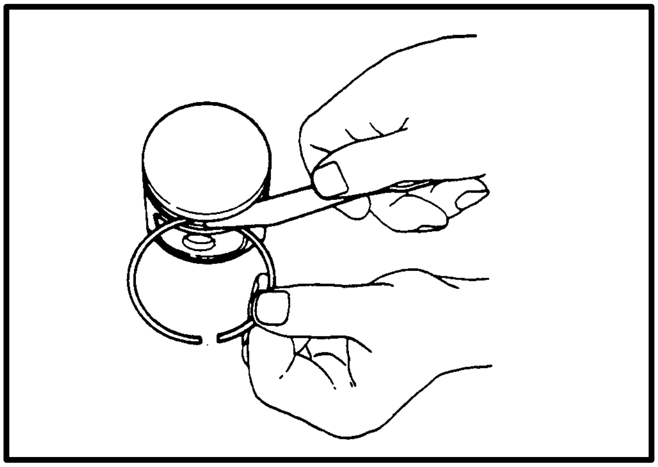
- Piston Diameter:
  Piston to cylinder clearance, mentioned above, is equal to the bore diameter minus the piston diameter, which is to be measured by measuring at the level of the piston in the direction transverse to piston pin axis, as shown if figure below. This level (H) for the skirt end is 15.0 mm (0.59 in.) high.

Piston Diameter	**Standard**	64.965 – 64.985mm 2.5577 – 2.5584 in.)
	Oversize 0.25 mm (0.0098 in.)	65.215 – 65.235 mm (2.5676 – 2.5683 in.)
	Oversize 0.50 mm (0.0196 in.)	65.465 – 65.485 mm (2.5774 – 2.5781 in.)



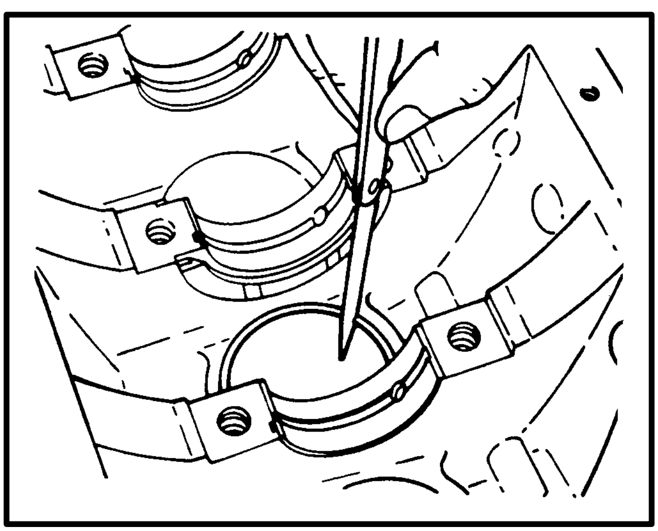
- Ring clearance in the groove:
  Using a thickness gauge, check each piston ring in its groove for side clearance and if the limit stated below is exceeded, measure the groove width and ring width to determine whether the piston or the ring or both have to be replaced.

Item		Standard	Limit
Ring clearance in the groove	Top Ring	0.03–0.07 mm (0.0012–0.0027 in.)	0.12 mm (0.0047 in.)
	2nd Ring	0.02–0.06 mm (0.0008–0.0023 in.)	0.10 mm (0.0039 in.)



- Piston ring end gap:
  To measure the end gap, insert the piston ring into the cylinder bore, locating it at the lowest part of the bore and holding it true and square; then use a thickness gauge to measure the gap. If the gap measured exceeds the limit replace the ring.

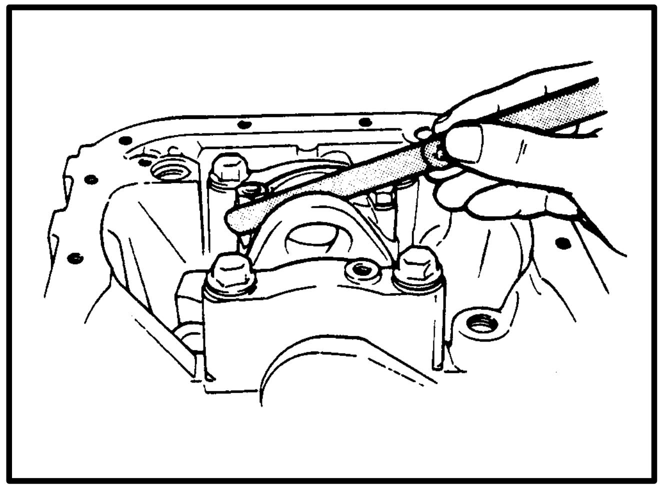
Item		Standard	Limit
Piston ring end gap	Top Ring	0.12–0.27 mm (0.0047–0.0106 in.)	0.7 mm (0.0275 in.)
	2nd Ring	0.12–0.27 mm (0.0047–0.0106 in.)	0.7 mm (0.0275 in.)
	Oil Ring	0.20–0.70 mm (0.0079–0.0275 in.)	1.8 mm (0.0708 in.)



Connecting Rods

- Big–end thrust clearance:
  Check the big end of each connecting rod for thrust clearance, with the rod fitted and connected to its crank pin in the normal manner. If the clearance measured is found to exceed the limit, the connecting rod or the crankshaft, whichever is responsible for the excessive clearance, must be replaced.

Item	Standard	Limit
Big–end thrust clearance	0.010–0.31 mm (0.0039–0.0122 in.)	0.35 mm (0.0178 in.)



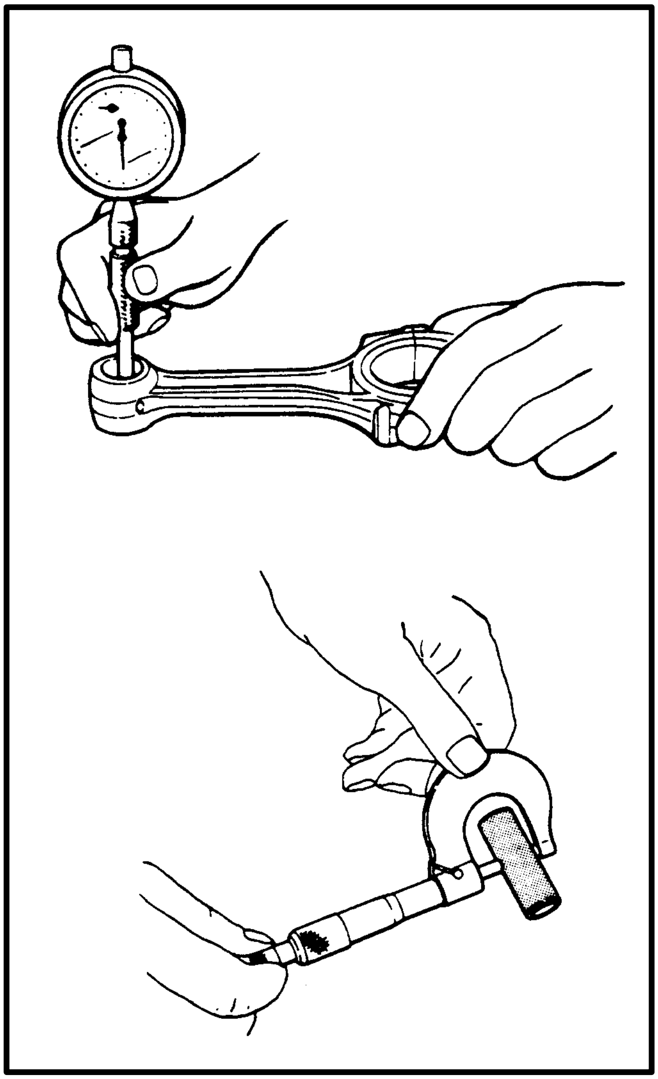
- Connecting rod alignment:
  Mount connecting rod on aligner to check it for bow or twist. If either limit is exceeded, replace it.

Limit on bow	0.05 mm (0.0020 in.)
Limit on twist	0.10 mm (0.0039 in.)

- Inspect small end of each connecting rod for wear and evidence of cracks or any other damage, paying particular attention to the condition of its bush. Check piston pin clearance in small end. Replace connecting rod if its small end is badly worn or damaged or if the clearance check exceeds the limit.

Item	Standard	Limit
Pin clearance in small end	0.003–0.016 mm (0.0001–0.0006 in.)	0.05mm (0.0020 in.)

Small–end I.D.	16.006–16.014 mm (0.6401–0.6406 in.)
Piston pin dia.	15.995–16.005 mm (0.6297–0.6402 in.)



Connecting–rod Big End Bearings

- Inspect bearings for signs of fusion, pitting, burn or flaking and observe the contact pattern. Bearings found in defective condition through this inspection must be replaced.

⚠ CAUTION

Bearings are not meant to be repaired by scraping or sanding with sandpaper or by any machining. The remedy is to replace them.

- Crankpin to bearing clearance:
  Check this clearance by using gaging plastic (Plastigage). Here's how to use gaging plastic:
  1) Prepare by cutting, a length of gaging plastic roughly equal to bearing width a place it axially on crankpin, avoiding the oil hole.
  2) Make up the big end in the normal manner, with bearings in place and by tightening the cap to the specification.

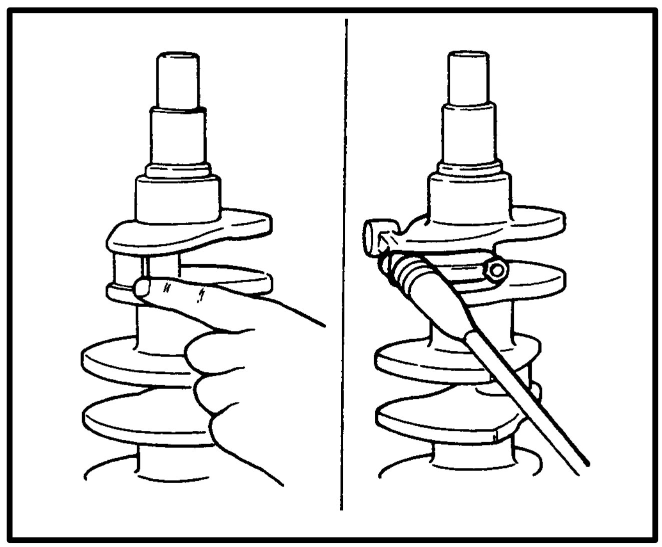
NOTE:

Never rotate crankshaft or turn rod when a piece of gaging plastic (Plastigage) is in the radial clearance.

Bearing cap tightening torque	31–35 N–m 3.1–3.5 kg–m 22.5–25.0 lb–ft

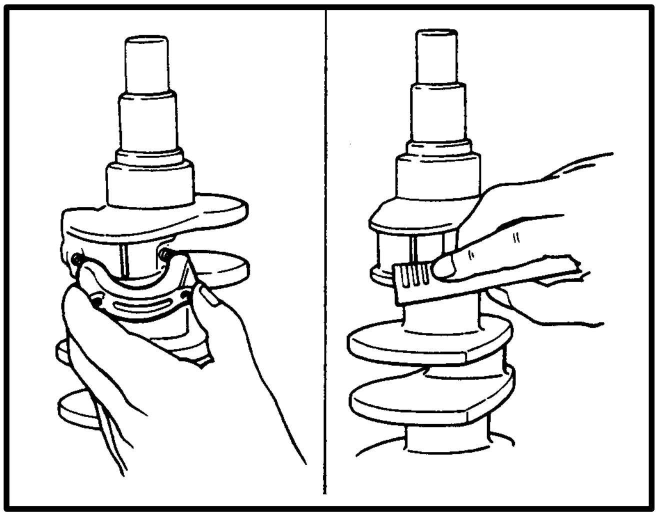
NOTE:

When fitting bearing cap to crankpin, be sure to discriminate between its two ends.



3) Remove the cap and measure the width of flattened gaging plastic piece with the gaging plastic envelope scale. This measurement must be taken at the widest part.

Item	Standard	Limit
Crankpin–to–bearing clearance	0.020–0.040 mm (0.0008–0.0016 in.)	0.065 mm (0.0025 in.)



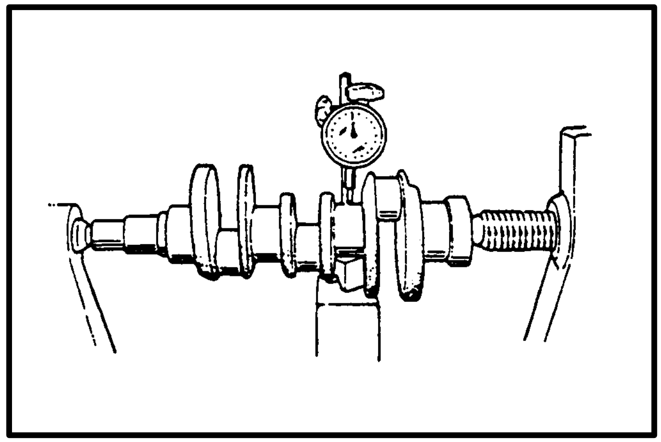
4) If the limit, indicated above, is exceeded, re–grind the crankpin to the undersize and use of the undersize bearing, both of which are stated below:

Bearing size	Crankpin diameter
Standard	35.982–36.000 mm (1.4167–1.4173 in.)
0.25 mm (0.0098 in.) undersize	35.732–35.750 mm (1.4068–1.4074 in.)
0.50 mm (0.0196 in.) undersize	35.482–35.500 mm (1.3970–1.3976 in.)

Crankshaft

- Runout:
  Using a dial gauge, measure runout at center journal. Rotate crankshaft slowly, if runout exceeds limit, replace crankshaft.

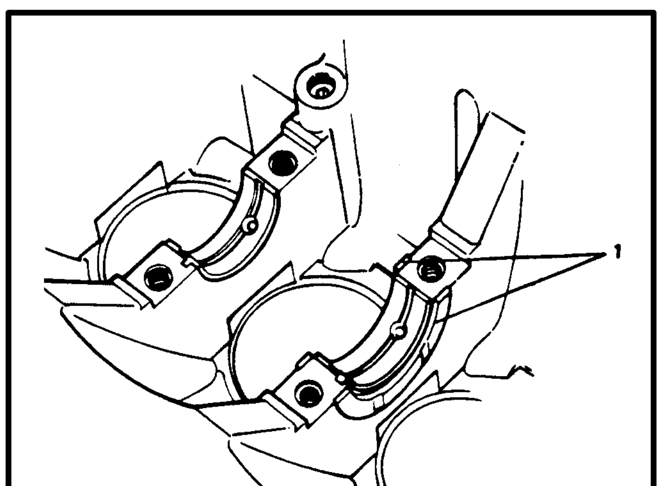
Limit on crankshaft runout	0.03 mm (0.0011 in.)



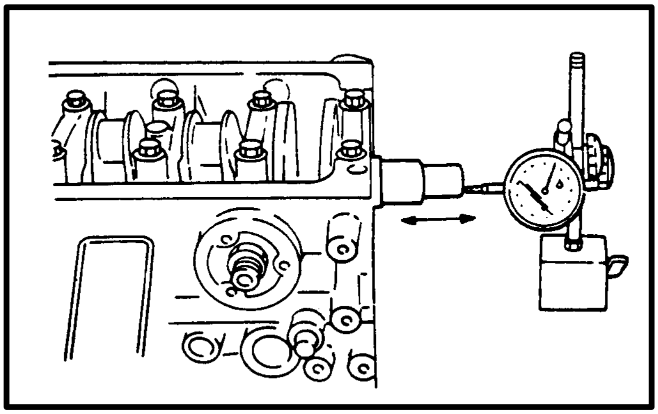
- Crankshaft thrust play:
  Measure this play with crankshaft set in cylinder block in the normal manner, that is, with thrust bearing caps installed. Tighten bearing cap bolts to specified torque.
  Use a dial gauge to read displacement in axial (thrust) direction of crankshaft.
  If the limit is exceeded, replace thrust bearing with new standard one or oversize one to obtain standard thrust play.

Item	Standard	Limit
Crank-shaft thrust play	0.11–0.31 mm (0.0044–0.0122 in.)	0.35 mm (0.0138 in.)

Tightening torque for cap bolts	55–60 N–m 5.5–6.0 kg–m 40.0–43.0 lb–ft



1. Thrust bearing

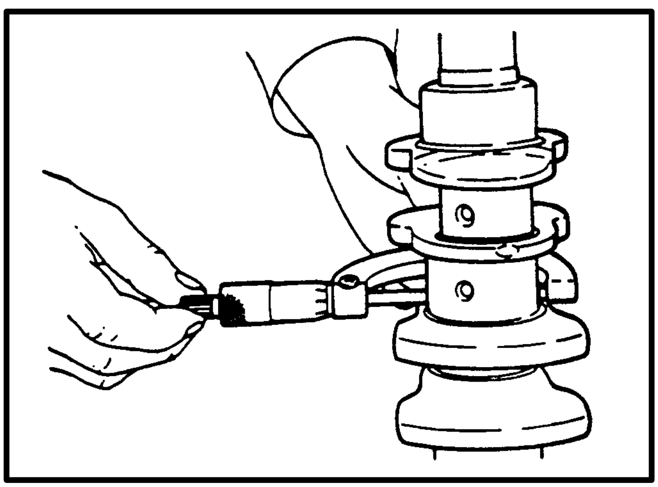


- Out of round and taper (uneven wear):
  An unevenly worn crankshaft journal or crankpin shows up as difference in diameter at a cross section or along its length (or both). This difference, if any, is to be determined from micrometer readings taken as shown in figure below.
  If any of the journals or crankpins is badly damaged or if the amount of uneven wear in the sense explained above exceeds the limit, repair (by re–grinding) or replace the crankshaft.

Limit or uneven wear	0.01 mm (0.0004 in.)

NOTE:

Where journal or crankpin re–grinding is necessary, finish the diameter to the size necessary for the undersize bearing.



Crankshaft Journal Bearings

- Inspect the bearings for signs of fusion, pitting, burn or flaking and observe the contact pattern. Defective bearings must be replaced.

CAUTION

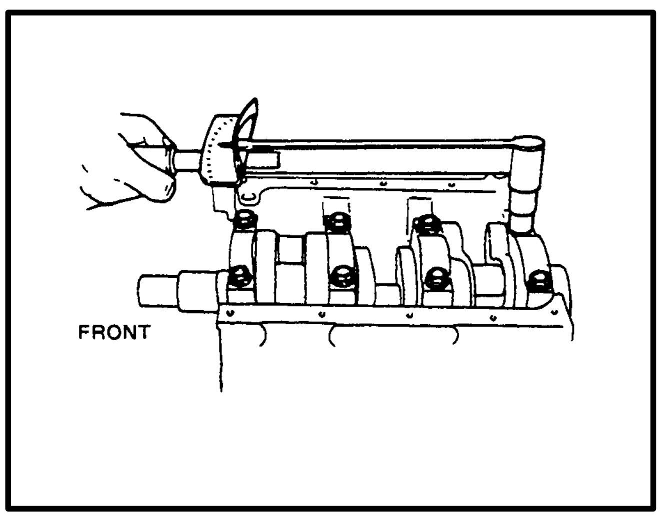
As in the case of connecting rod bearings, the journal bearings are not meant to be repaired by scraping or sanding with sandpaper or by any other machining.

- Journal to bearing clearance:
  Check this clearance by using gaging plastic (Plastigage). The following method is based on the use of gaging plastic:
  1) Cut the gaging plastic stock to the required length (equal to the width of the bearing), and place it axially on the journal, avoiding the oil hole.
  2) Mount the crankshaft in usual manner, tightening the bearing caps to the specified torque value. (It is assumed that a gaging plastic piece is pinched at each journal.) Do not rotate the crankshaft when gaging plastic is in,

Tightening torque for cap bolts	55–60 N–m 5.5–6.0 kg–m 40.0–43.0 lb–ft

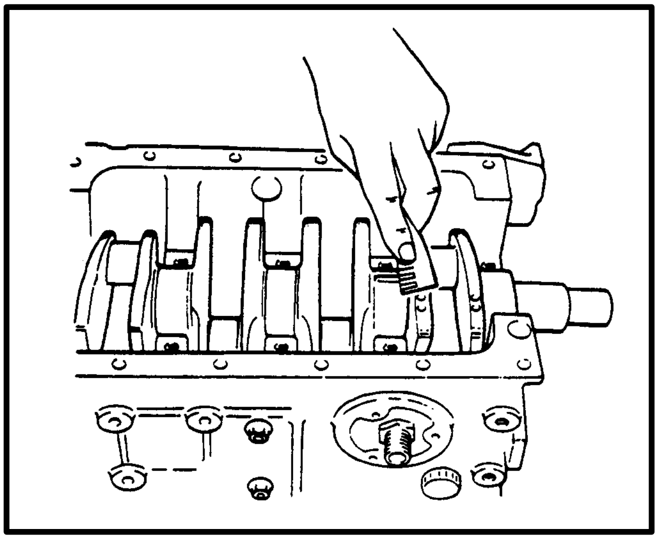
CAUTION

Each of the four bearing caps has an arrow marked on it. Be sure to position each cap with its arrow pointing to front end and to match it (by the cylinder number) to its journal. Remember, the three cylinders are numbered, 1, 2, and 3, as counted from the front of engine.



3) Remove the caps. By referring to the envelope scale, measure the width of the widest part of the piece, and determine whether the radial clearance checked (obtain from the gaging plastic piece) is within the limit.

Item	Standard	Limit
Journal–to–bearing clearance	0.020–0.040 mm (0.0008–0.0016 in.)	0.065 mm (0.0026 in.)

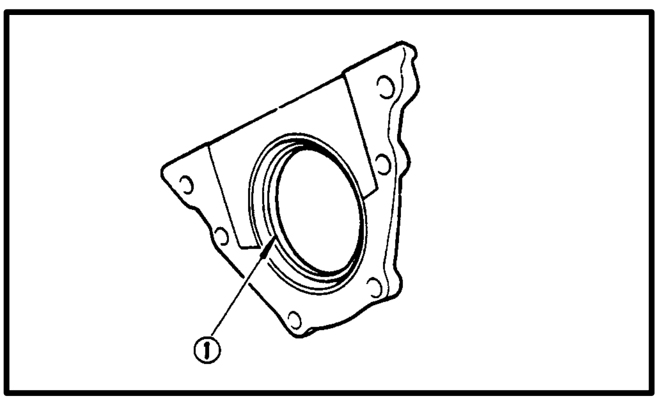


4) If the limit is exceeded, re–grind the journals to the undersize and use the undersize bearing.

Bearing size	Journal diameter
Standard	43.982–44.00 mm (1.7316–1.7322 in.)
0.25 mm undersize (0.0098 in.)	43.732–43.750 mm (1.7218–1.7224 in.)
0.50 mm undersize (0.0196 in.)	43.482–43.500 mm (1.7119–1.7125 in.)

Oil Seals

Carefully inspect the oil seals removed in disassembly, examining the lip portion (1) of each oil seal for wear and damage. Use of new oil seals in reassembly is recommended.



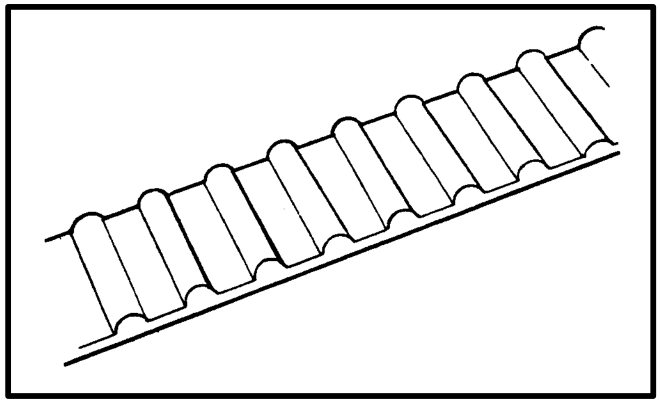
Timing Belt and Timing Pulleys

Inspect the belt and pulleys for wear, cracks and signs of failure. Replace them as necessary.

CAUTION

Do not bend the belt. Keep away oil and water from the belt. The belt must be kept clean.

The pulleys and belt tensioner, too, must be kept clean and free of oil and water.



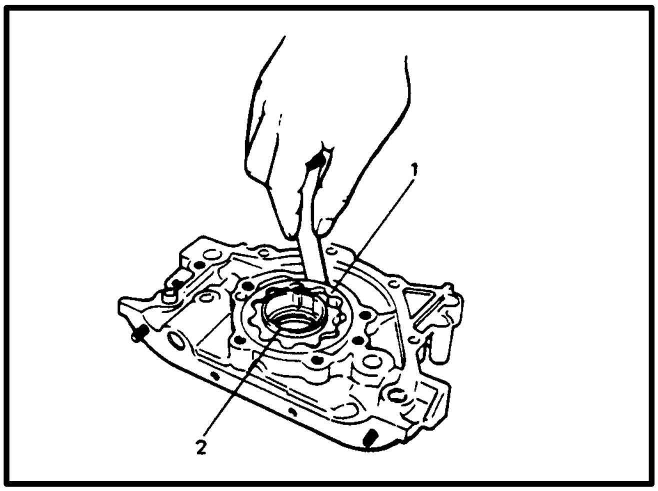
Oil Pump

1) Inspect oil seal lip for fault or other damage. Replace as necessary.

2) Inspect outer and inner gears, gear plate, and oil pump case for excessive wear or damage.

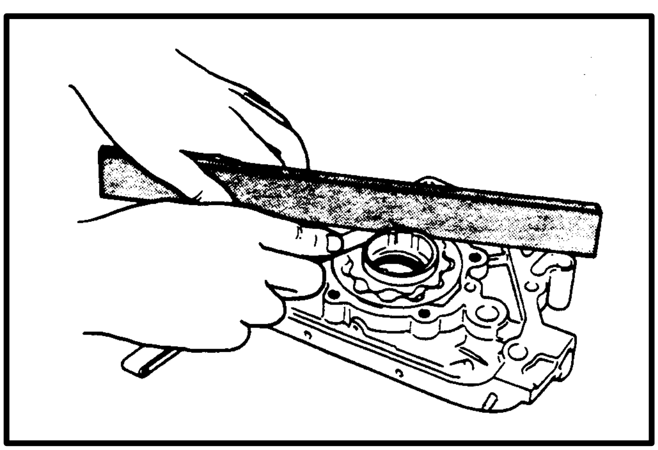
- Radial clearance:
  Check radial clearance between outer rotor and case, using thickness gauge.
  If clearance exceeds its limit, replace outer rotor or case.

Item	Standard	Limit
Radial clearance between outer rotor and case	0.10–0.17 mm (0.0040–0.0067 in.)	0.31 mm (0.0122 in.)



- Side clearance:
  Using straightedge and thickness gauge, measure side clearance.

Item	Standard	Limit
Side clearance of inner and outer rotors	0.065–0.115 mm (0.0026–0.0045 in.)	0.15 mm (0.0059 in.)



ENGINE REASSEMBLY

NOTE:

All parts to be used in reassembly must be perfectly clean.

Oil sliding and rubbing surfaces of engine parts with engine oil just before using them in reassembly.

Have liquid packing ready for use. Bond No.1215 is specified for it. Use it wherever its use is specified in order to ensure leak–free (oil and water) workmanship of reassembly.

There are many running clearances. During the course of engine reassembly, be sure to check these clearances, one after another, as they form.

Gaskets, "O" rings and similar sealing components must be in perfect condition. For these components, use replacement parts stock.

Tightening torque is specified for important fasteners (mainly nuts and bolts) of the engine and other components. Use torque wrenches and constantly refer to the specified values given.

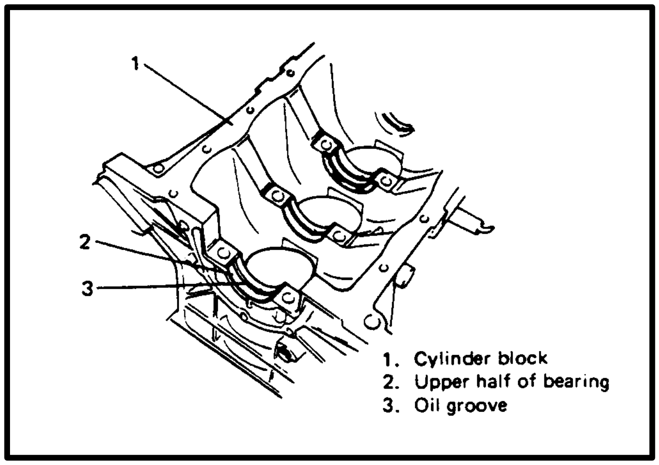
Do not disregard match marks provided on parts. Some of them are those given at the time of disassembly.

There are many sets of parts. Crankshaft bearings, connecting rods, pistons, etc., are in combination sets. Do not disturb such combinations and make sure that each part goes back to where it came from.

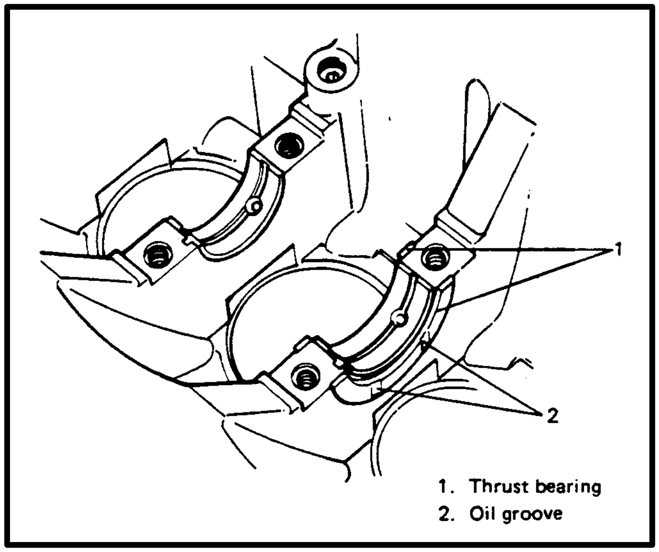
Engine reassembly is the reverse of engine disassembly as far as sequence is concerned, but there are many reassembling steps that involve measures necessary for restoring engine as close to factory assembled condition as possible. Only those steps will be dealt with here.

Crankshaft

1) Install main bearings and be sure to oil them as shown.



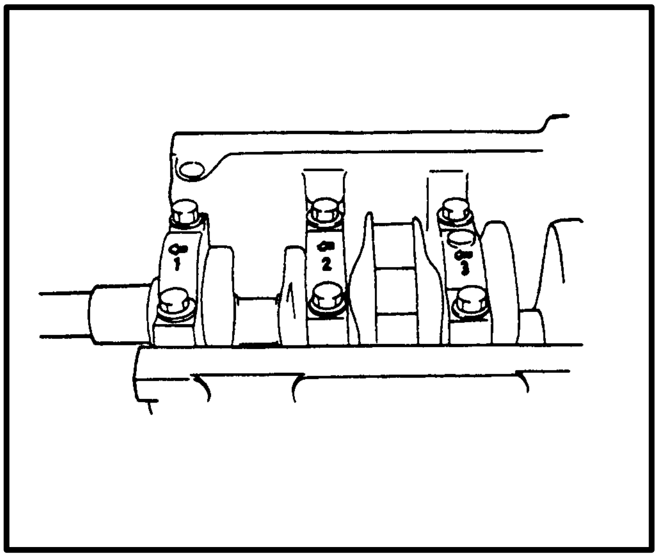
2) Install thrust bearings to cylinder block between NO. 2 and No. 3 cylinders. Face oil grooves side to crank webs.



3) Install crankshaft to cylinder block.

4) Oil crankshaft journals.

5) When fitting crankshaft bearing caps to journals after setting crankshaft in place, be sure to point the arrow mark (on each cap) to front side. Fit the sequentially in the ascending order, 1, 2, 3 and 4, starting from front (pulley) side.

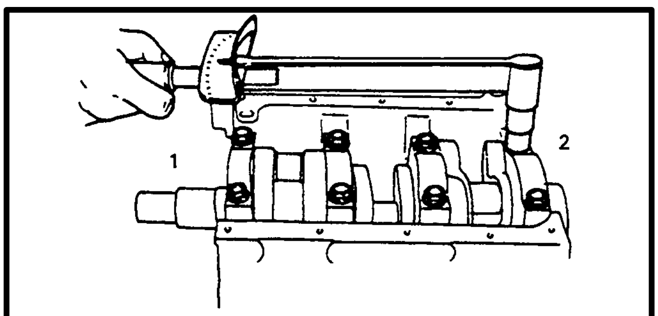


Tightening torque for bearing cap bolts	55–60 N–m 5.5–6.0 kg–m 40.0–43.0 lb–ft

Gradual and uniform tightening is important for bearing cap bolts. Make sure that the four caps become tight equally and uniformly to the specified torque.

NOTE:

After tightening cap bolts, check to be sure that crankshaft rotates smoothly when turned by hand.



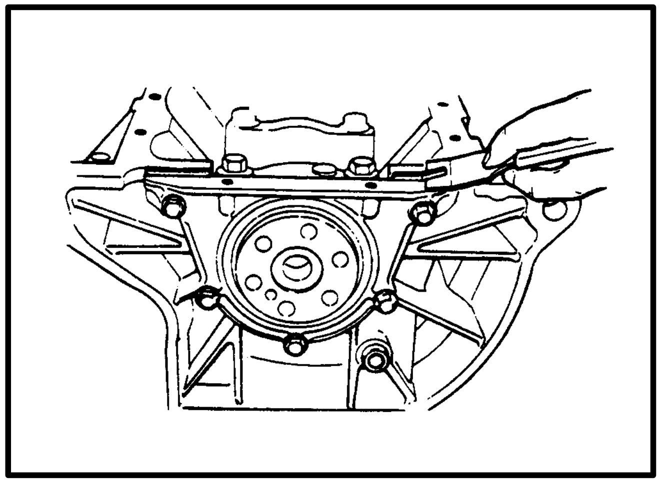
1. Crankshaft pulley side
2. Clutch side

Oil Seal Housing

Install oil seal housing and its gasket. This housing demands a new gasket: do not reuse the gasket removed in disassembly. After bolting the housing to the block, the gasket edges might bulge out; if so, cut off the edges to make the joint seam flat and smooth: use a sharp knife.

NOTE:

Just before mounting the housing, oil the lip portion of the oil seal.



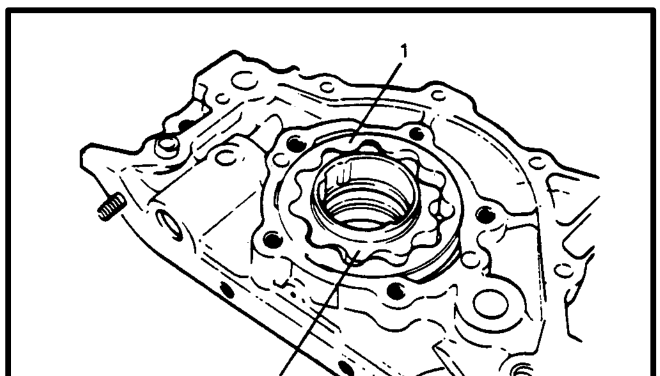
Oil Pump

Reassemble components of oil pump assembly according to following procedure, if disassembled.

a) wash, clean and then dry all disassembled parts.

b) Apply thin coat of engine oil to inner and outer rotors, oil seal lip portion, and inside surfaces of oil pump case and plate.

c) Install outer and inner rotors to pump case.



1. Outer rotor
2. Inner rotor

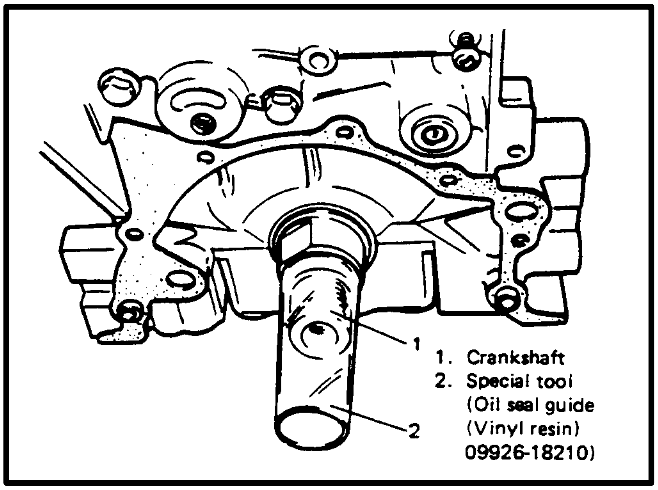
d) Install rotor plate.

e) After installing plate, check to be sure that gears turn smoothly by hand.

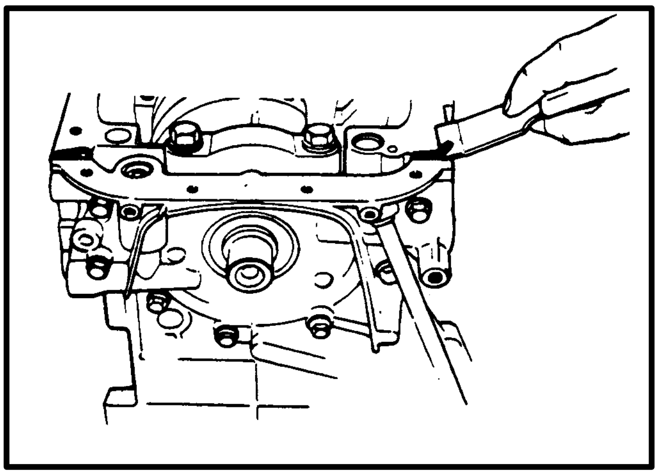
1) Install two oil pump pins and oil pump gasket to cylinder block. Use new gasket.

2) Install oil pump to crankshaft and cylinder block.

To prevent oil lip seal from being damaged or upturned when installing oil pump to crankshaft, fit special tool (Oil seal guide) to crankshaft, and apply engine oil to special tool.



3) Edge of oil pump gasket might bulge out: if it does, cut bulge off with sharp knife, making edge smooth and flush with end faces of the pump case and cylinder block.



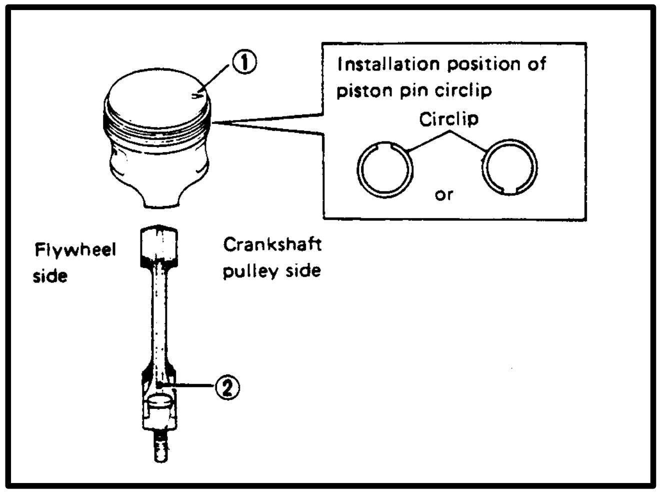
Piston, Piston Rings and Connecting Rod

1) Install connecting rod to piston.

POSITION OF PISTON RELATIVE TO CONNECTING ROD: The arrow (1) on the crown points to front (pulley) side, and the oil hole (2) comes on inlet port side. See figure below.

NOTE:

Before pinning piston to connecting rod, oil the small end and pin holes.



2) Install piston rings to piston.

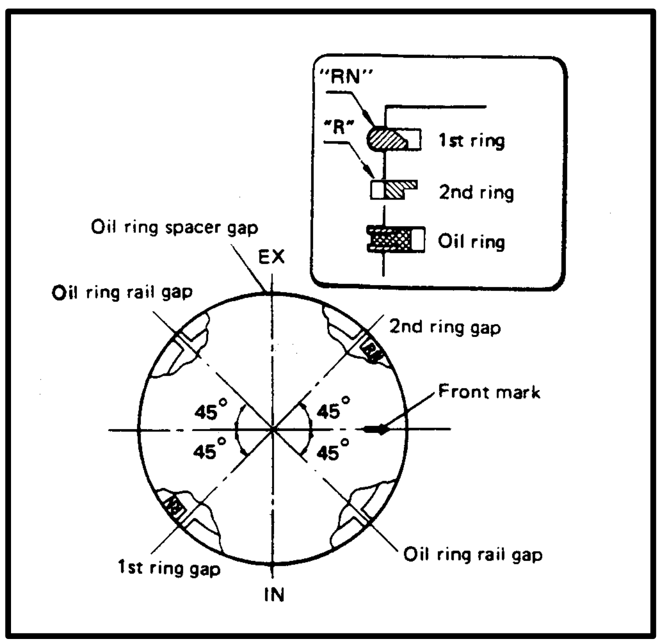
a) 1st and 2nd rings have "RN" mark. When installing these piston rings to piston, direct marked side of each ring toward top of piston.

b) 1st ring differs from 2nd ring by referring to figure below.

c) When installing oil ring, install spacer first and then two rails.

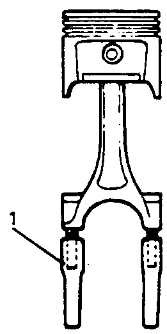
NOTE:

- After installing three rings (1st, 2nd and oil rings), distribute their end gaps as shown in figure.
- After fitting the rings, oil them in the grooves.



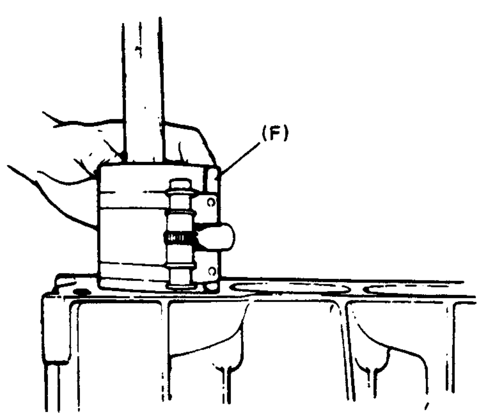
3) Install piston and connecting rod assembly into cylinder bore.

- Apply engine oil to pistons, rings, cylinder walls, connecting rod bearings and crank pins.
- Put guide hoses over connecting rod bolts as shown. These guide hoses protect crankpin and thread of rod bolt from damage during installation of connecting rod and piston assembly.



1. Guide hose

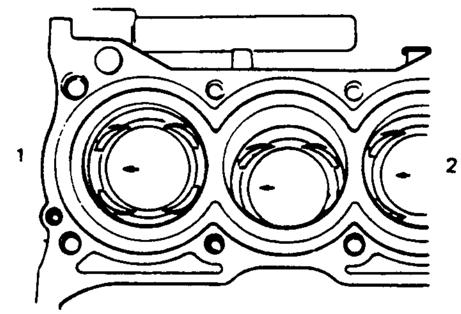
- When installing piston and connecting rod assembly into cylinder bore, point arrow mark on each piston head to crankshaft pulley side.
- Use piston ring compressor (Special tool) to compress rings. Guide connecting rod into place on the crankshaft.
- Using a hammer handle, tap piston head to install piston into bore. Hold ring compressor firmly against cylinder block until all piston rings have entered cylinder bore.



(F): Piston ring compressor (Special tool 09916-77310)

NOTE:

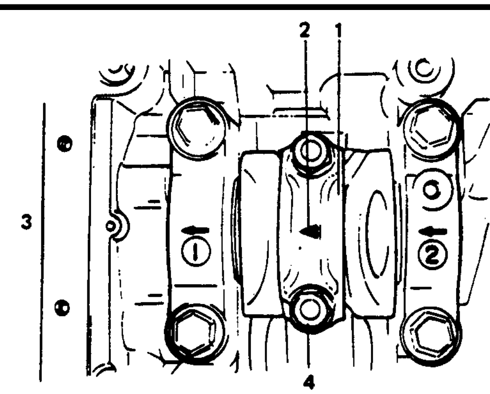
After installing piston and connecting rods, double–check to be sure that the arrows on piston crowns are all pointing to pulley (front) side.



1. Crankshaft pulley side
2. Flywheel side

- Apply engine oil to crankpins.

4) Install connecting rod bearing cap.
When installing cap to rod, point arrow mark on cap to crankshaft pulley side.



1. Bearing cap
2. Arrow mark
3. Crankshaft pulley side
4. Cap nut

Tighten cap nuts to specification
After fitting all three big–end bearing caps, start tightening them uniformly, being sure to equalize tightness between right and left on each cap. The sequence here is similar to that for crankshaft bearing caps.

Tightening torque for big–end caps	31–35 N–m 3.1–3.5 kg–m 22.5–25.0 lb–ft

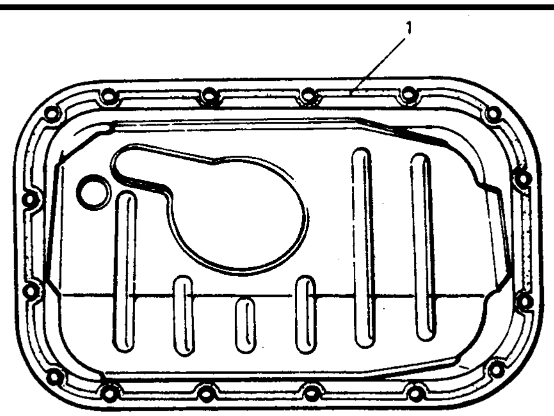
Oil Pump Strainer

Install oil pump strainer to oil pump.
Bearing in mind that "O" ring is often forgotten and left out in reassembly. Absence of this ring defeats the purpose served by the strainer.

Oil Pan

1) Clean mating surfaces of oil pan and cylinder block. Remove oil, old sealant, and dusts from mating surfaces.

After cleaning, apply silicon type sealant to oil pan mating surface continuously.



1. Sealant (99000-31150)

2) After fitting oil pan to block, run in securing bolts and start tightening at the center: move wrench outward, tightening one bolt at a time. Tighten bolts to specified torque.

Tightening torque for oil pan bolt	9–12 N–m 0.9–1.2 kg–m 7.0–8.5 lb–ft

Cylinder Head

NOTE:

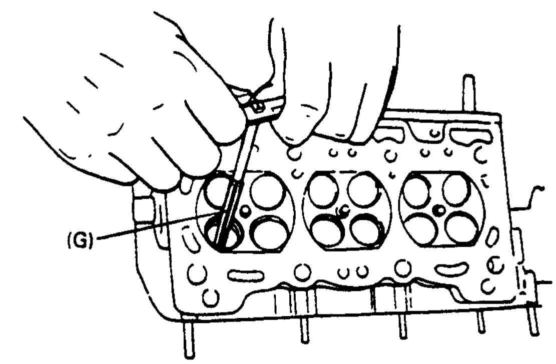
- Do not reuse valve guide once disassembled. Install new (oversize) valve guide.
- Intake and exhaust valve guides are identical.

Valve guide oversize	0.03 mm (0.0012 in.)
Valve guide protrusion (Intake and exhaust)	13 mm (0.51 in.)

1) Install new valve guide into cylinder head.

a) Before installing new valve guide into cylinder head, ream guide hole with 10.5 mm reamer (Special tool) to remove burrs, making sure that guide hole diameter after reaming comes within specified range.

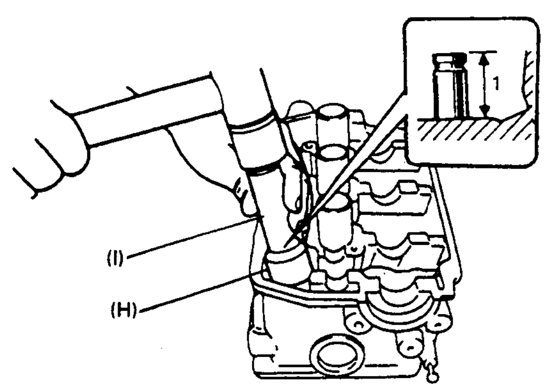
Valve guide hole diameter (Intake & Exhaust)	10.530–10.545 mm (0.4146–0.4151 in.)



(G): 10.5 mm reamer (Special tool 09916-37320)

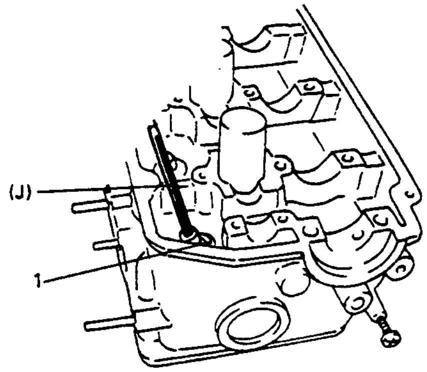
b) Install valve guide to cylinder head.
Heat cylinder head uniformly at temperature of 80 to 100° C (176 to 212° F), using care not to distort head, and drive new valve guide into hole with special tools.

Drive in new valve guide until valve guide installer (Special tool) contacts cylinder head. After Installation, make sure that valve guide protrudes by 13 mm from cylinder head.



1. Valve guide protrusion (13 mm)
(H): Valve guide installer (Special tool 09916-57340)
(I) : Valve guide installer handle (Special tool 09916-57330)

c) Ream valve guide bore with 5 mm reamer (Special tool). After reaming, clean bore.



1. Valve guide
(J) : 5 mm reamer (Special tool 09916-34570)

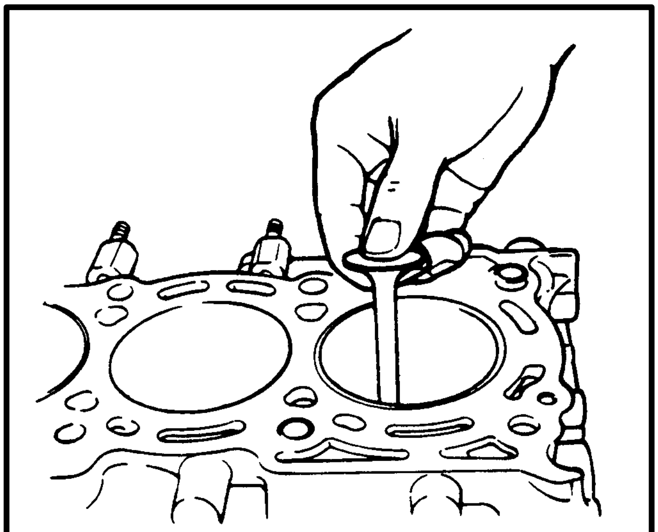
2) Install valve spring seat to cylinder head.

3) Install new valve stem seal to valve guide. After applying engine oil to seal and the install seal to valve guide. After installation, check to be sure that seal is properly fixed to valve guide.

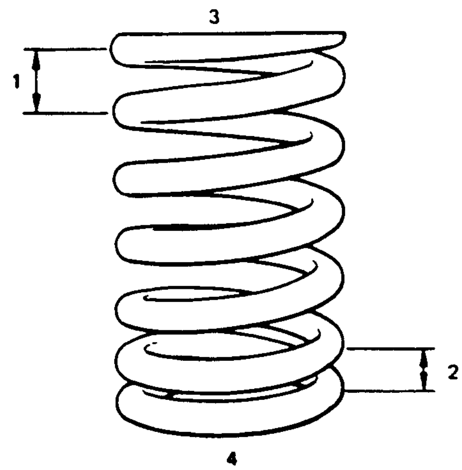
Do not reuse oil seal from disassembly. Be sure to install new oil seal.

When installing, never tap or hit with hammer or anything else. Tapping or hitting with hammer may cause damage to seal.

4) Install valve to valve guide.
Before installing valve to valve guide, apply engine oil to stem seal, valve guide bore, and valve stem.



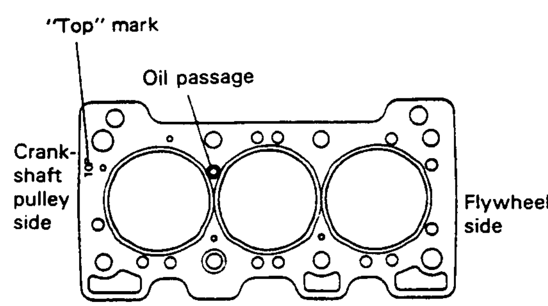
5) Install valve spring and spring retainer.
each valve spring has top end (large–pitch end) and bottom end (small–pitch end). Be sure to position spring in place with painted side up.



1. Large-pitch
2. Small-pitch
3. Valve spring retainer side
4. Valve spring seat side

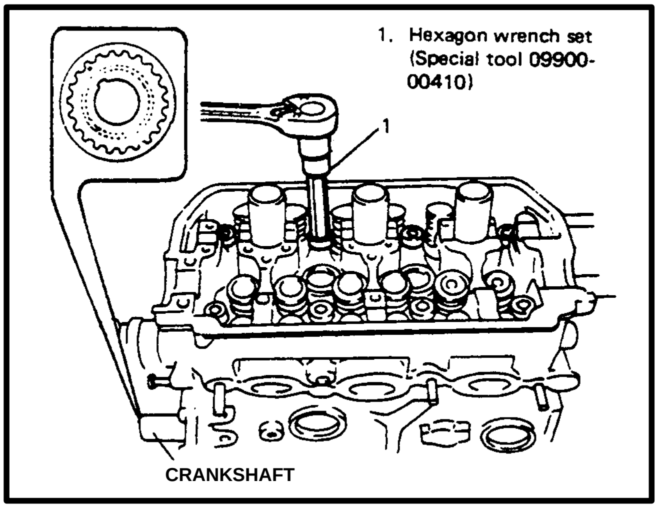
6) Using special tool (Valve lifter), compress valve spring and fit two valve retainers to groove provided in valve stem.

7) Install new head gasket as shown in figure below in such a way that "TOP" mark provided on the gasket comes on top side (toward cylinder head) and on crankshaft pulley side.



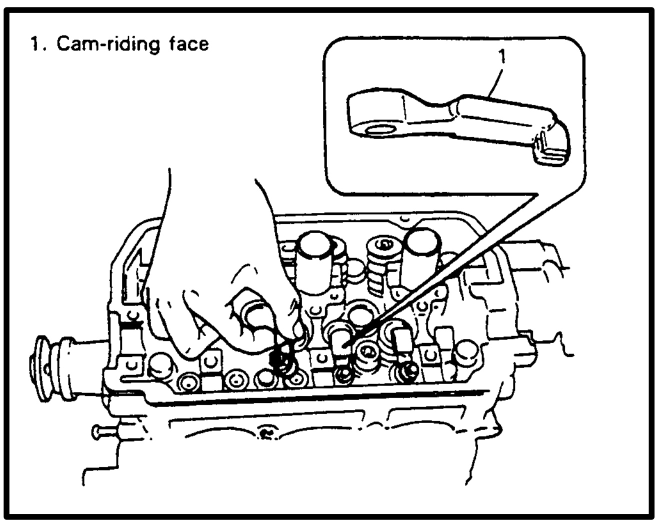
8) With key position of crankshaft pulley set about 30 degrees away from matching mark on cylinder block, place cylinder head on cylinder. Then using special tool, tighten cylinder head bolts to specified torque, starting with center bolt and toward outside.

Tightening torque for cylinder head bolt	60–65 N–m (6.0–6.5 kg–m) 43.5–47.0 lb–ft)



Camshaft & Rocker–arm Shaft

1) Apply engine oil to exhaust rocker arm at its cam–riding face and install it to valve stem end face and rocker–arm adjust screw.

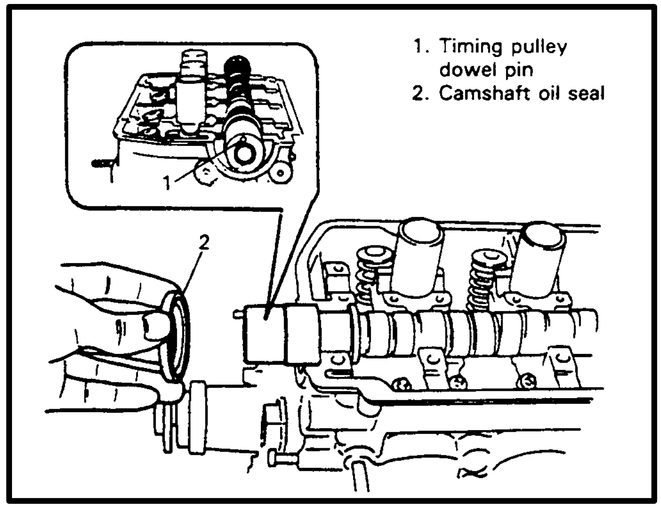


2) Place camshaft on camshaft journal of cylinder head at such angle that No. 1 piston is at top dead center of exhaust stroke (timing pulley dowel pin is at the top). Then install camshaft oil seal from timing belt pulley side of engine.

NOTE:

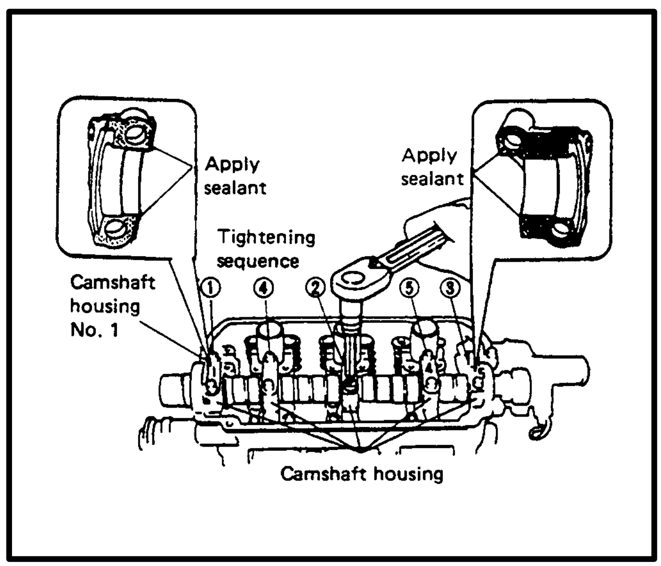
When placing camshaft on camshaft journal, use care so that exhaust rocker arm will not come off,

After applying engine oil to oil seal lip, press fit camshaft oil seal till oil seal surface becomes flush with housing surface.

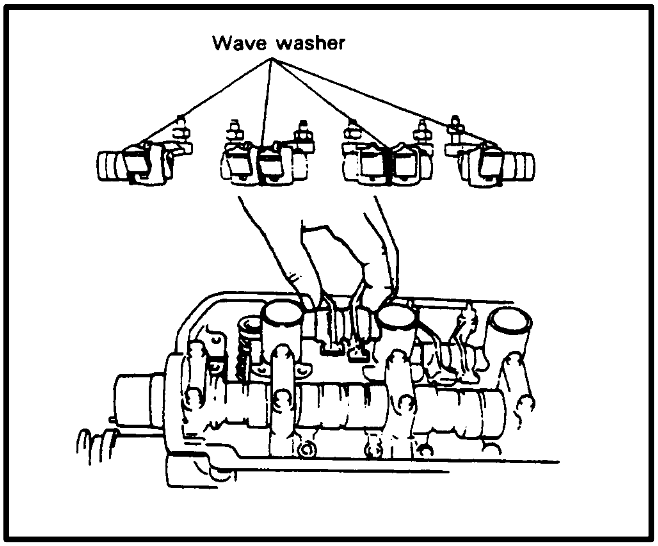


3) After removing oil thoroughly from mating surfaces of camshaft housing No.1 and No. 5 and cylinder head, apply sealant (Suzuki Bond No. 1215) (99000–31110). Then tighten to specified torque.

Tightening torque for camshaft housing bolt	9–12 N–m (0.9–1.2 kg–m) (7.0–8.5 lb–ft)



4) Install rocker arm, wave washer and rocker arm shaft as a set to cylinder had and then install rocker arm shaft housing. (Align curved surfaces of rocker arm shaft and spark plug hole.)



NOTE:

Valve clearance is adjusted after all parts are assembled. So it is not adjusted at this point. Leave rocker arm adjusting screw as loose as possible.

Intake Manifold and Carburetor

1) Install intake manifold gasket to cylinder head. Use new gasket.

NOTE:

Clean cylinder head mating surface with gasket before installation.

2) Install intake manifold with carburetor to cylinder head.

3) Tighten manifold bolts and nuts to specified torque.

Tightening torque for manifold bolts and nuts	18–28 N–m 1.8–2.8 kg–m 13.5–20.0. lb–ft

Water Pump

1) Install water pump gasket to cylinder block. Use new gasket.

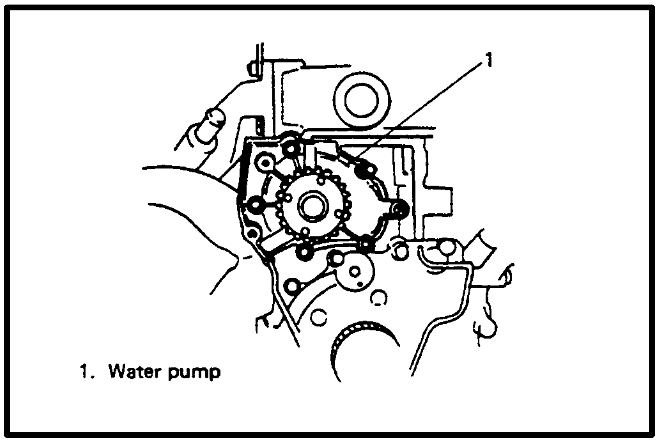
NOTE:

Clean cylinder block mating surface with gasket before installation.

2) Install water pump to cylinder block.

3) Tighten bolts and nuts to specified torque.

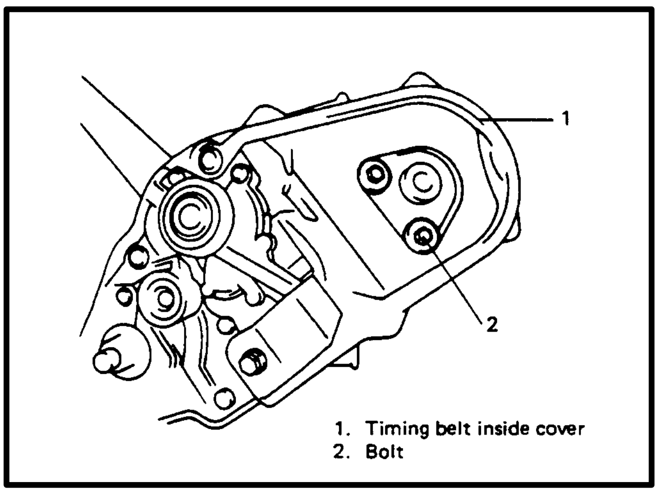
Tightening torque for water pump bolts and nuts	9–12 N–m 0.9–1.2 kg–m 7.0–8.5 lb–ft



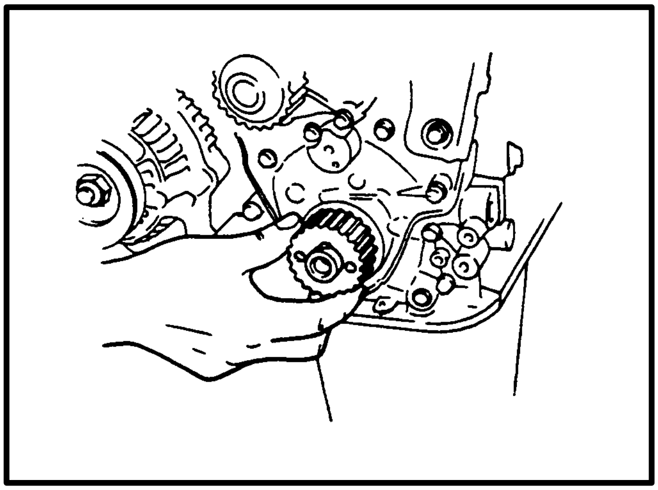
Timing Belt Inside Cover, Belt Pulleys, Tensioner, Timing Belt and Outside Cover

1) Install timing belt inside cover.

Tightening torque for timing belt inside cover bolt	9–12 N–m 0.9–1.2 kg–m 7.0–8.5 lb–ft

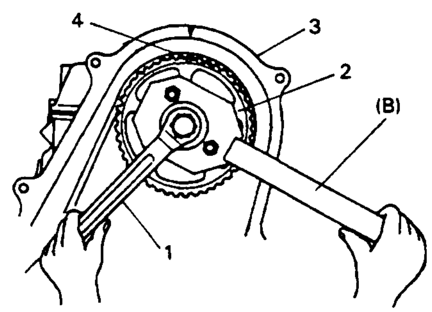


2) Install crankshaft timing belt, key and pulley. Refer to figure below for proper installation of timing belt pulley.



3) Install key and camshaft timing belt pulley. When installing pulley, direct its timing marked side to timing belt outside cover side. Tighten pulley bolt to specified torque with special tool applied as shown in figure below.

Tightening torque for pulley bolt	50–60 N–m 5.0–6.0 kg–m 36.5–43.0 lb–ft



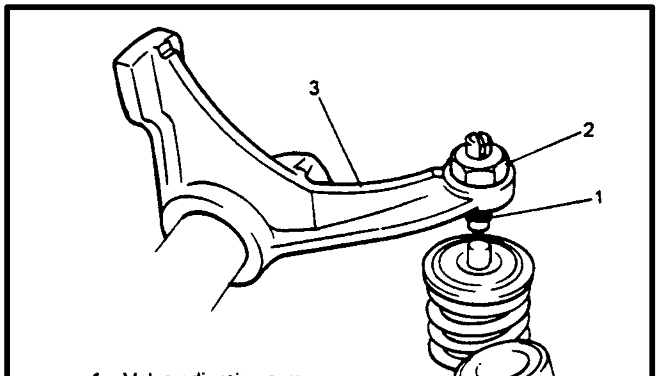
1. Wrench
2. Camshaft timing belt pulley
3. Timing belt inside cover
4. Timing mark

(B) : Camshaft lock holder (Special tool 09917-68220)

4) Put tensioner and spring together. Tighten the bolt to the extent that the tensioner can be moved easily by hand.

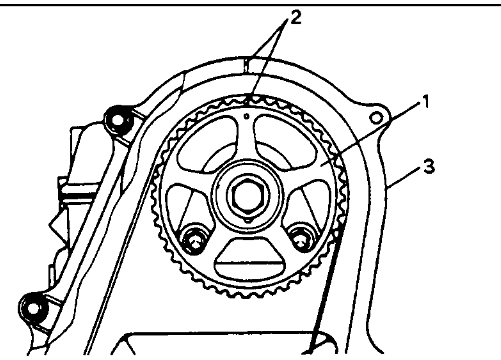
5) Before installing timing belt to camshaft pulley and crankshaft timing belt pulley, loosen all valve adjusting screws of intake and exhaust rocker arms fully, or check to ensure they are loose.

This is to permit free rotation of camshaft for the following reason; when installing timing belt to both pulleys, belt should be correctly tensed by tensioner spring force. If camshaft does not rotate freely, belt will not be correctly tensed by the tensioner,



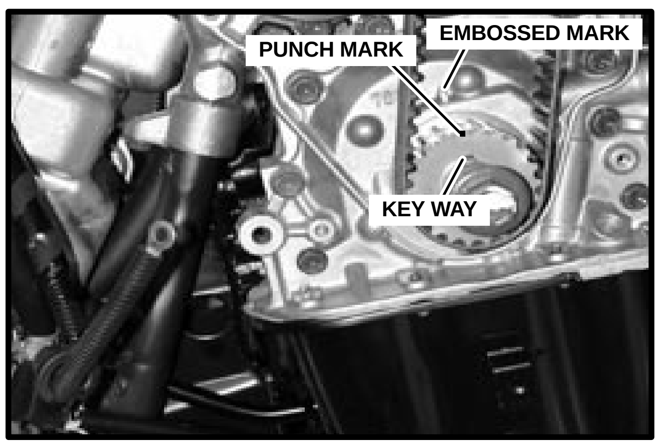
1. Valve adjusting screw
2. Lock nut
3. Rocker arm

6) Inside timing cover, align timing marks (1) on camshaft pulley with"V" mark (2) on timing belt.



1. Camshaft timing pulley
2. Timing mark
3. Timing belt inside cover

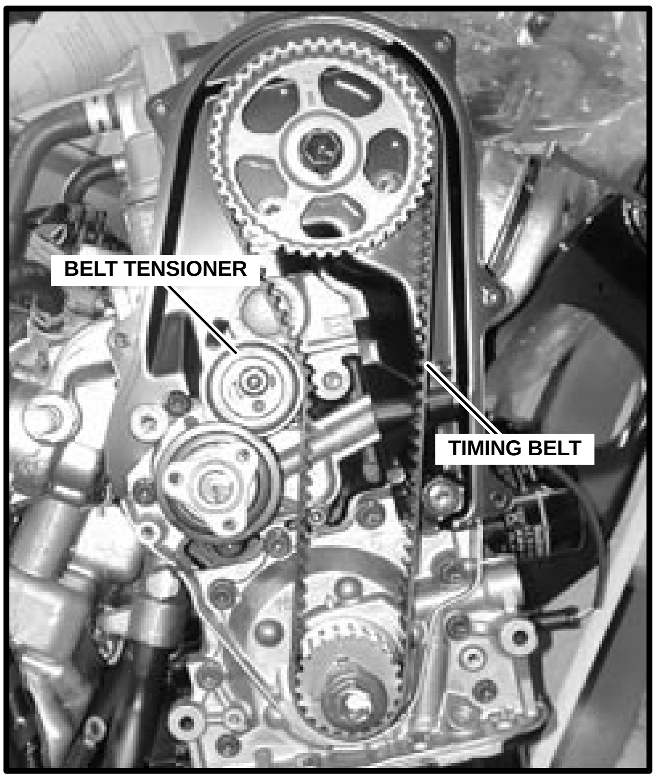
7) Turn crankshaft clockwise and align punchmark (3) (key way) on crankshaft timing belt pulley with embossed mark (4) on timing belt inside cover.



8) You now have the two pulleys correctly related to each other in angular sense. Under this condition, put on timing belt in such a way that portion of belt indicated as (6) (drive side of belt) is free of any slack.

NOTE:

> **When installing timing belt, match arrow mark on timing belt with rotating direction of crankshaft.**
>
> **In this state, No. 1 piston is at top dead center of compression stroke.**



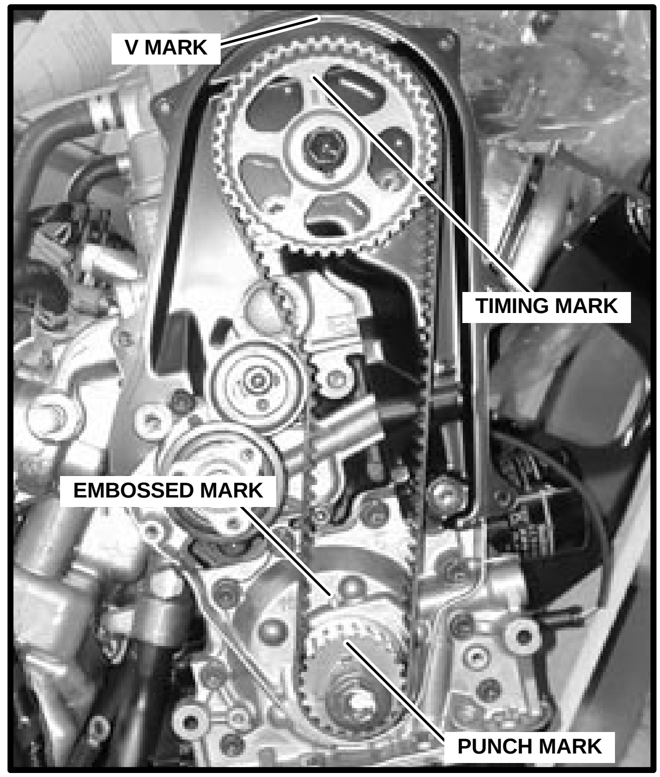
9) After putting on belt, adjust belt tensioner as shown in figure above. The belt tensioner is spring loaded. Remove excess slack from timing belt and tighten socket head screw. Torque belt tensioner screw to specification shown in chart below.

Rotate crankshaft clockwise fully twice and recheck torrque.

Tightening torque for tensioner bolts	15–23 N–m 1.5–2.3 kg–m 11.0–16.5 lb–ft

CAUTION

After setting belt tensioner, turn crankshaft two rotations in clockwise direction to see if marks (1) (2) (3) and (4) locate themselves on the same straight line. If they do not line up straight, the foregoing procedure must be repeated to satisfy this requirement.



10) Install timing belt outside cover. Make sure to install clip as shown below before installing water pump pulley.

Tightening torque for outside cover bolt	9–12 N–m 0.9–1.2 kg–m 7.0–8.5 lb–ft

11) Install crankshaft pulley and water pump pulley.

Oil Filter

Install oil filter.

CAUTION

For oil filter installation refer to SECTION 1 of this manual.

Exhaust Manifold and Cover

1) Install exhaust manifold gasket to cylinder head. Use new gasket.

NOTE:

Clean cylinder head mating surface with gasket before installation.

2) Install exhaust manifold to cylinder head.

3) Tighten bolts and nuts to specified torque.

Tightening torque for bolts and nuts	18–20 N–m 1.8–2.0 kg–m 13.5–14.0 lb–ft

4) Install exhaust manifold cover.

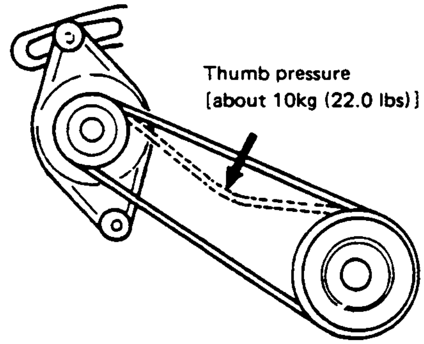
Crankshaft Pulley and Alternator

1) Install crankshaft pulley.
Fit keyway on pulley, and tighten bolt to specification, with flywheel holder (Special tool) hitched to flywheel so that crankshaft will not turn.

Tightening torque for pulley bolt	80–90 N–m 8.0–9.0 kg–m 58.0–65.0 lb–ft

2) Install alternator assembly and drive belt.
The drive belt must be tensioned to the specification after the alternator is installed. Check the tension at the middle point of the belt between crank pulley and alternator pulley. To vary the tension for adjustment, adjust the alternator.

Belt tension specification	11–14 mm (0.43–0.55 in.) as deflection



NOTE:

when replacing belt with a new one, adjust belt tension to 10–12 mm (0.40–0.47 in.).

Valve Lash (Clearance) Adjustment

Adjust valve lash of all intake and exhaust valves to specification, referring to description of valve lash of ENGINE MAINTENANCE SERVICE.

Valve Cover

Install cover to cylinder head and tighten bolts to specified torque.

Tightening torque for valve cover bolts	9–12 N–m 0.9–1.2 kg–m 7.0–8.5 lb–ft

ENGINE MAINTENANCE SERVICE

Fan belt

Adjust belt tension as outlined in SECTION 1 Periodic Maintenance.

Ignition Timing

Refer to SECTION 8, Ignition System.

Valve Lash (Clearance)

Valve lash specification:

When checking valve clearance, insert thickness gauge between camshaft and cam–riding face of rocker arm.

Cold engine	**IN**	0.08 mm (0.0031 in.)
	EX	0.10 mm (0.0039 in.)

Warm engine	**IN**	0.12 mm (0.0047 in.)
	EX	0.12 mm (0.0047 in.)

CAUTION

When using specification for warm engine, warm up engine until engine cooling fan starts running and take measurement or make adjustment within 20 to 30 minutes after engine is stopped.

Checking and adjusting procedures:

NOTE:

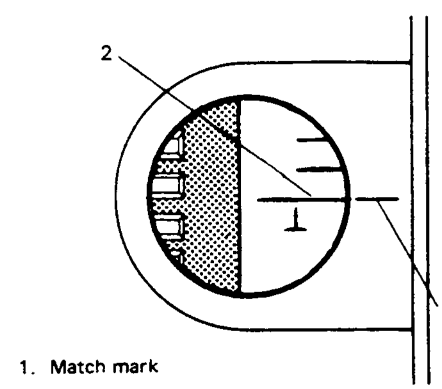
Refer to the beginning of this SECTION for cylinder numbers (No. 1, No. 2, and No. 3) mentioned in this section.

1) Remove negative battery cable.

2) Remove valve cover.

3) Remove ignition timing check rubber plug from housing of transmission case.

4) Turn crankshaft clockwise (viewing from crankshaft pulley side) to the extent that line (2) above "T" mark punched on flywheel is aligned with match mark (1) on transmission case as shown below, i.e. No. 1 cylinder piston reaches TDC position.



1. Match mark
2. "T" (TDC) mark

5) Remove distributor cap and check that rotor is positioned properly. If rotor is out of place, turn the crankshaft clockwise once (360°). In this state, check valve clearance according to table below and adjust if necessary

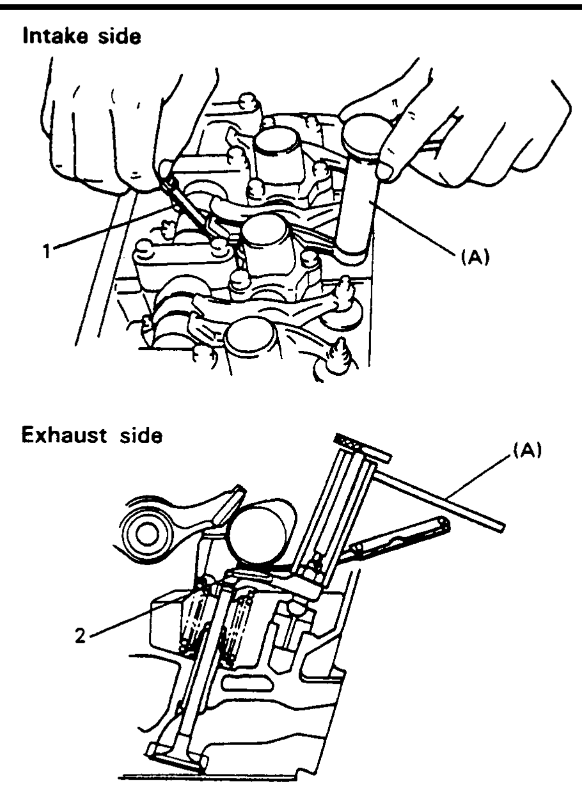
Cylinder Number		1	2	3
No. 1 cylinder TDC of compression stroke	**IN**	X	X	
	EX	X		X
No. 1 cylinder TDC of exhaust stroke	**IN**			X
	EX		X	

Valve clearance as marked with "X" in above table can be measured.

NOTE:

When adjustment becomes necessary in step 5, loosen adjusting screw lock nut and then make adjustment by turning adjusting screw. After adjustment, tighten lock nut to specified torque while holding adjusting screw stationary and then make sure again that clearance is within specification.

Adjusting screw lock nut tightening torque	10–13 N–m 1.0–1.3 kg–m 7.5–9.0 lb–ft



(A): Tappet adjuster wrench

1. Thickness gauge
2. Rocker arm cam-riding face

6) Upon completion of check and adjustment, install cylinder valve cover and torque bolts to specification.

Tightening torque for cylinder head cover bolts	9–12 N–m 0.9–1.2 kg–m 7.0–8.5 lb–ft

Engine OIl

Refer to SECTION 1 of this manual.

Engine Oil Filter

For removal and installation of filter, refer to SECTION 1 of this manual.

Engine Coolant

This subject is covered in SECTION 7, Engine Cooling System.

Exhaust System

Inspect each exhaust pipe connection for tightness, and examine muffler and other parts for evidence of breakage and leakage of gases. Repair or replace defective parts, if any.

Compression Pressure Measurement

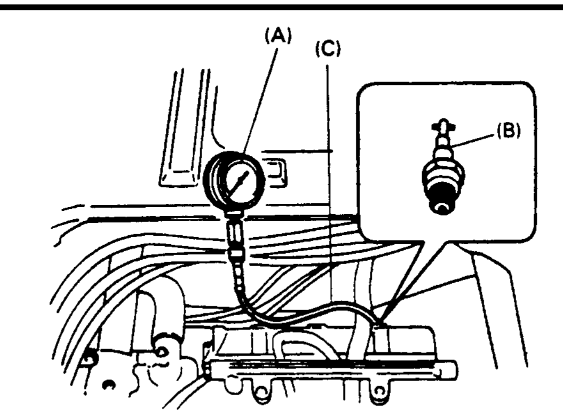
Check compressin pressure on all three cylinders as follows:

1) Warm up engine.

2) Stop engine after warming up.

3) Remove all spark plugs and disconnect high tension coil wire from ignition coil.

4) Install compression gauge (special tool) into spark plug hole.



(A): Compression gauge
(B): Compression gauge attachment
(C): Compression gauge hose

5) Depress accelerator pedal all the way to make throttle open fully.

6) Crank engine with fully charged battery, and read the highest pressure on compression gauge.

	Compression pressure
Standard	12.5 kg/cm2 (177.8 psi)/ 400 RPM
Limit	9.5 kg/cm2 (135.1 psi)/ 400 RPM
Max. difference between any two cylinders	1.0 kg/cm2 (14.2 psi)/ 400 RPM

7) Carry out steps 4) through 6) on each cylinder to obtain readings.

NOTE:

Compression pressure value is measured by using compression gauge (Special tool).

Oil Pump Discharge Pressure Measurement

NOTE:

Prior to checking oil pressure, check the following.

Oil level in oil pan.
If level is low, add oil to Full level line on oil dip stick.

Oil quality.
If oil is discolored, or deteriorated, change oil. For particular oil to be used , refer to table in SECTION 1.

Oil leak.
If oil leak is found, repair it.

1) Disconnect lead wire from oil pressure switch.

2) Remove oil pressure switch from cylinder block.

3) Install oil pressure gauge (special tool) in vacated threaded hole.

4) Start engine and warm it up to normal operating temperature.

5) After warming up, raise engine speed to 4,000 RPM and measure oil pressure.

Oil pressure specification	2.7–3.7 kg/cm2 38.4–52.6 psi at 4,000 RPM

6) After checking oil pressure, stop engine and remove oil pressure gauge.

7) Before reinstalling oil pressure switch, be sure to wrap its screw threads with sealing tape and tighten switch to specified torque.

Tightening torque for oil pressure switch	12–15 N–m 1.2–1.5 kg–m 9.0–10.5 lb–ft

NOTE:

If sealing tape edge is bulged out from screw threads of switch, cut off edge.

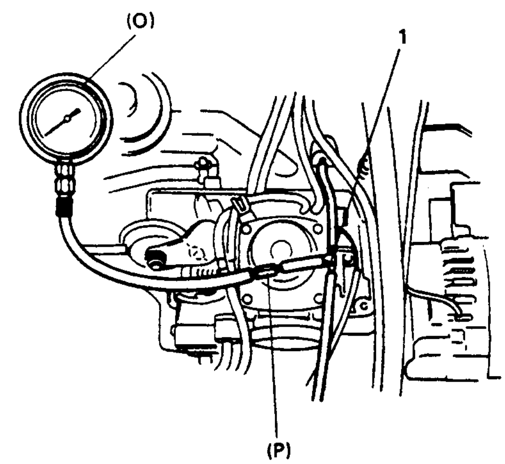
8) After installing oil pressure switch, start engine and check switch for oil leakage.

Vacuum Measurement

Engine vacuum that develops in intake line is a good indicator of engine condition. Vacuum checking procedure is as follows:

1) Warm up engine to normal operating temperature.

2) Install vacuum gauge (O) to pressure sensor hose, as shown in figure below. Install engine tachometer.



1. Hose joint (T type)
(O): Vacuum gauge
(P) : Hose joint

3) Run engine at specified idling speed and under this running condition, read vacuum gauge. Vacuum should be between 40cmHg (15.8 in.Hg) and 48 cmHg (18.8 in.Hg).

A low vacuum reading means that any combination of the following malconditions is the cause, which must be corrected before releasing machine to customer.

a) Leaky cylinder head gasket

b) Leaky intake manifold gasket

c) Leaky valves

d) Weakend valve springs

e) Maladjusted valve clearance

f) Valve timing out of adjustment

NOTE:

Should indicating hand of the vacuum gauge oscillate violently, turn adjusting nut (A) to steady it.

Standard vacuum (Sea level)	40–48 cmHg (15.8–18.8 in.Hg) at specified idling speed.

4) After checking, remove vacuum gauge.

5) Before reinstalling vacuum checking switch, be sure to wrap its screw threads with sealing tape and tighten switch.

RECOMMENDED TORQUE SPECIFICATIONS

Fastening parts	Tightening torque		
	N·m	kg-m	lb-ft
1. Cylinder head bolt	58–62	5.8–6.2	42.0–44.5
2. Cylinder head cover bolt	9–12	0.9–1.2	7.0–8.5
3. Spark plug	10–20	1.0–2.0	7.5–14.0
5. Valve adjusting screw lock nut	10–13	1.0–1.3	7.5–9.0
6. Crankshaft main bearing cap bolt	55–60	5.5–6.0	40.0–43.0
7. Oil filter stand	20–25	2.0–2.5	14.5–18.0
8. Oil filter ass'y	12–16	1.2–1.6	9.0–11.5
9. Oil pressure switch	12–15	1.2–1.5	9.0–10.5
10. Oil drain plug	30–40	3.0–4.0	22.0–28.5
11. Oil pan bolt	9–12	0.9–1.2	7.0–8.5
12. Water pump bolt	9–12	0.9–1.2	7.0–8.5
13. Flywheel bolt	40–45	4.0–4.5	29.0–32.5
14. Oil seal housing bolt	9–12	0.9–1.2	7.0–8.5
15. Connecting rod bearing cap nut	31–35	3.1–3.5	22.5–25.0
16. Crankshaft pulley bolt	80–90	8.0–9.0	58.0–65.0
17. Exhaust center pipe nut	40–60	4.0–6.0	29.0–43.0
18. Timing belt inside cover bolt asnd nut	9–12	0.9–1.2	7.0–8.5
19. Camshaft timing pulley bolt	50–60	5.0–6.0	36.5–43.0
20. Timing belt tensioner bolt	15–23	1.5–2.3	11.0–16.5
21. Camshaft housing bolt	9–12	0.9–1.2	7.0–8.5
22. Oil pump case bolt	9–12	0.9–1.2	7.0–8.5
23. Oil pump rotor plate screw	9–12	0.9–1.2	7.0–8.5
24. Intake & exhaust manifold bolt and nut	18–28	1.8–2.8	13.5–20.0
25. Timing belt outside cover bolt	9–12	0.9–1.2	7.0–8.5
26. Engine mounting member bolt	45–60	4.5–6.0	22.0–28.5
27. Engine mounting bracket nut	35–45	3.5–4.5	25.5–32.5
28. Exhaust center pipe bolt	40–60	4.0–6.0	29.0–43.0

SECTION 6

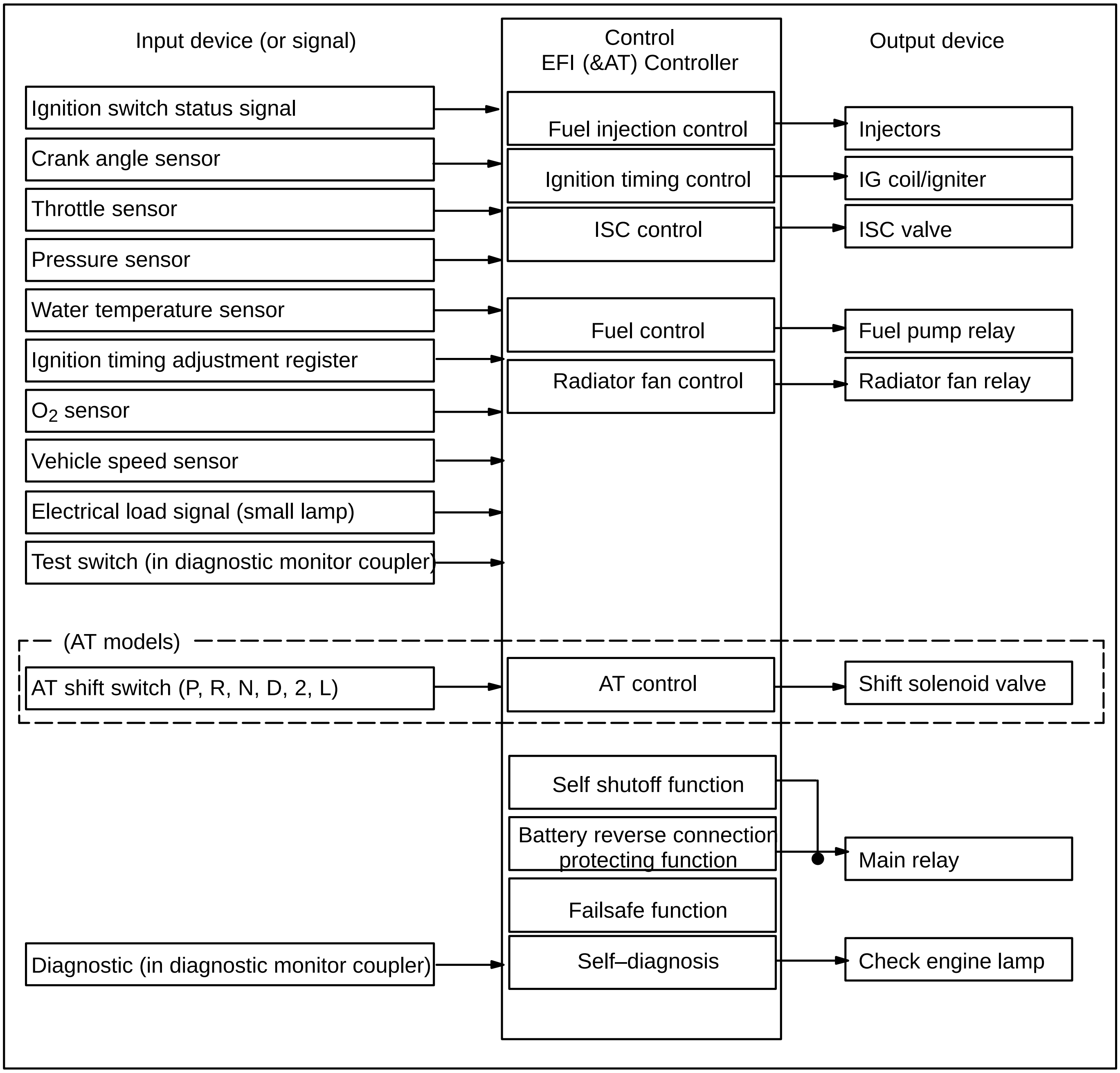
ENGINE CONTROL SYSTEM

SUMMARY

MPI (Multi–Point Injection) type EFI (Electronic Fuel Injection) is used in engine control, achieving optimal air–fuel ratio control. Additionally, by combining (integrating) the AT controller with the ECM (Engine Control Module), space saving is achieved and maintenance qualities are improved. The main characteristics are as follows.

- A speed density system which determines the fuel injection amount according to the engine rpm and intake manifold pressure is used.
- A sequential (separate injection by cylinder) system is used for the fuel injection system.
- A full–transistor type direct ignition system is used for ignition control.
- By means of the self–diagnosis function, when abnormality is detected in the ECM input signal, minimal driving performance is secured by means of the failsafe function in the unlikely event of a malfunction.

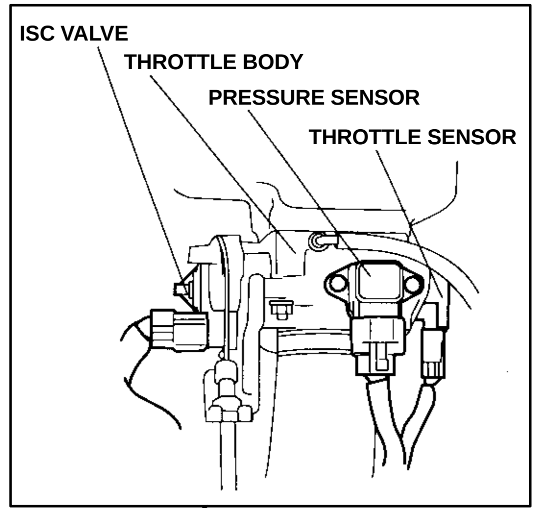
The following diagram shows the input/output and control items for the EFI (&AT)(&A/C) controller.

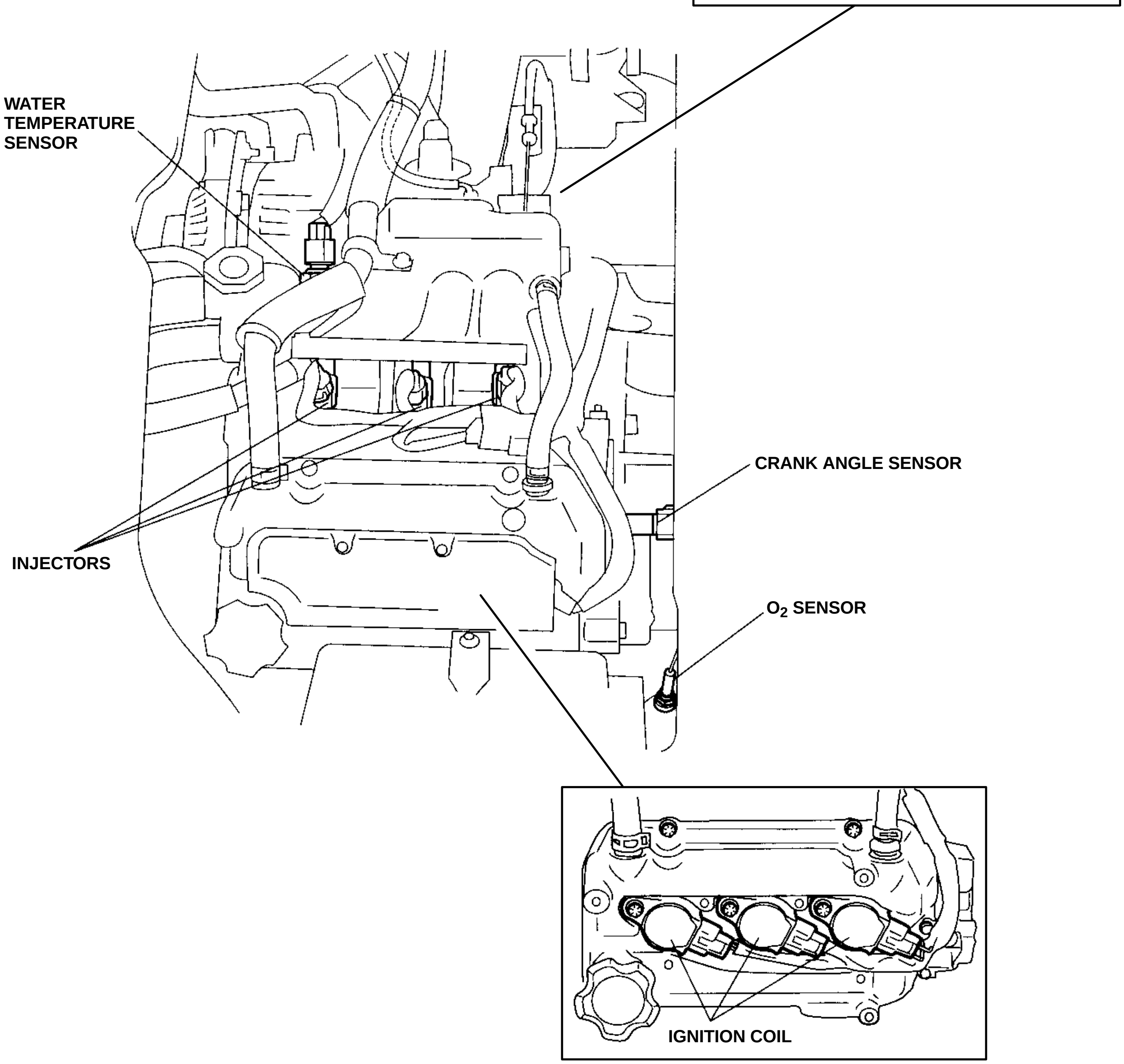


Note: Internal circuit diagrams of the controller, etc., described in this section are shown as a conceptual drawing in order to explain operation and may differ in part from actual configuration.

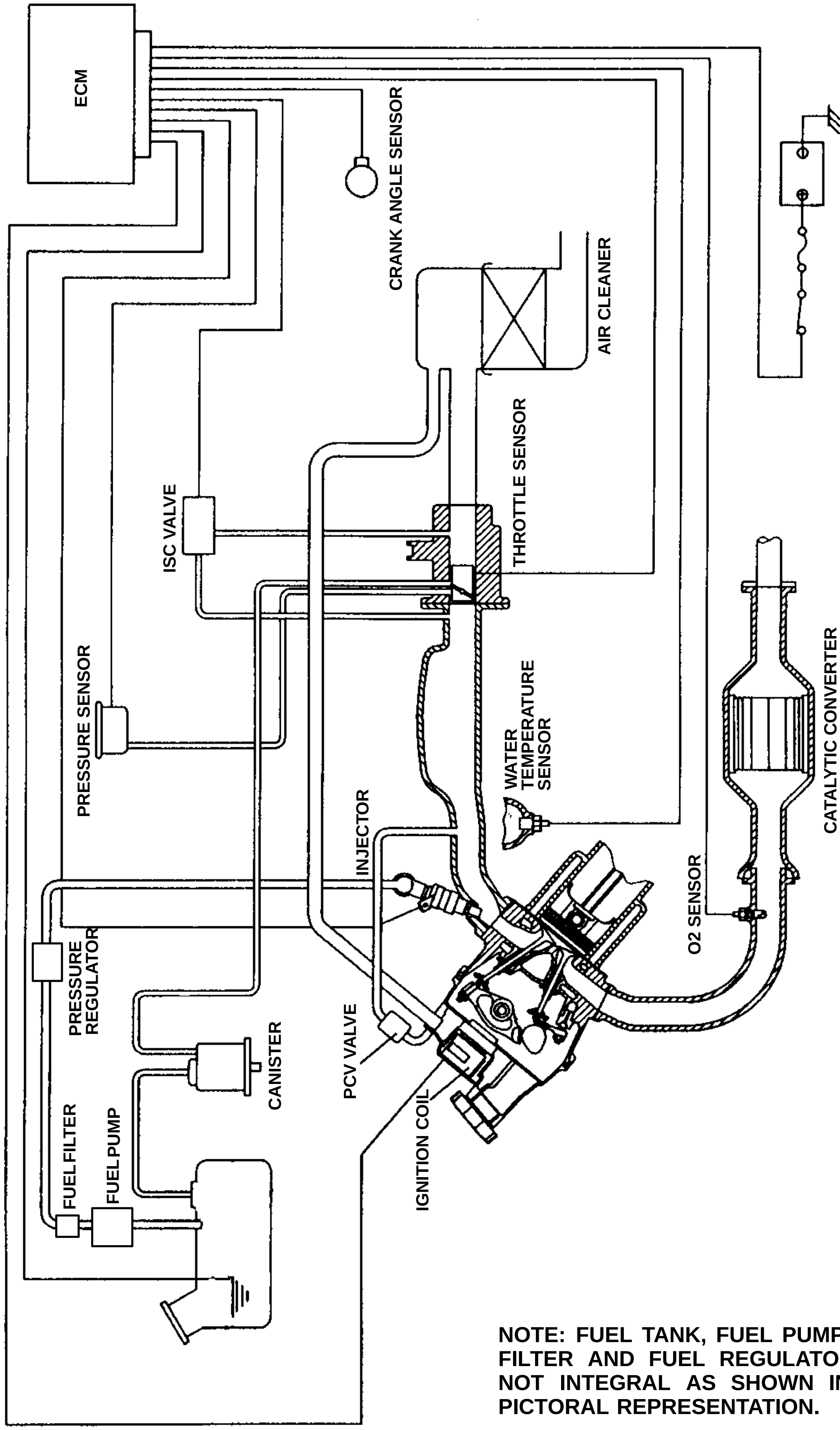
CONTROL SYSTEM PARTS LAYOUT DIAGRAM

The control system is composed of sensors, which send data concerning the engine and driving status to the ECM, the ECM, which controls actuators according to the signals from sensors, and the actuators.



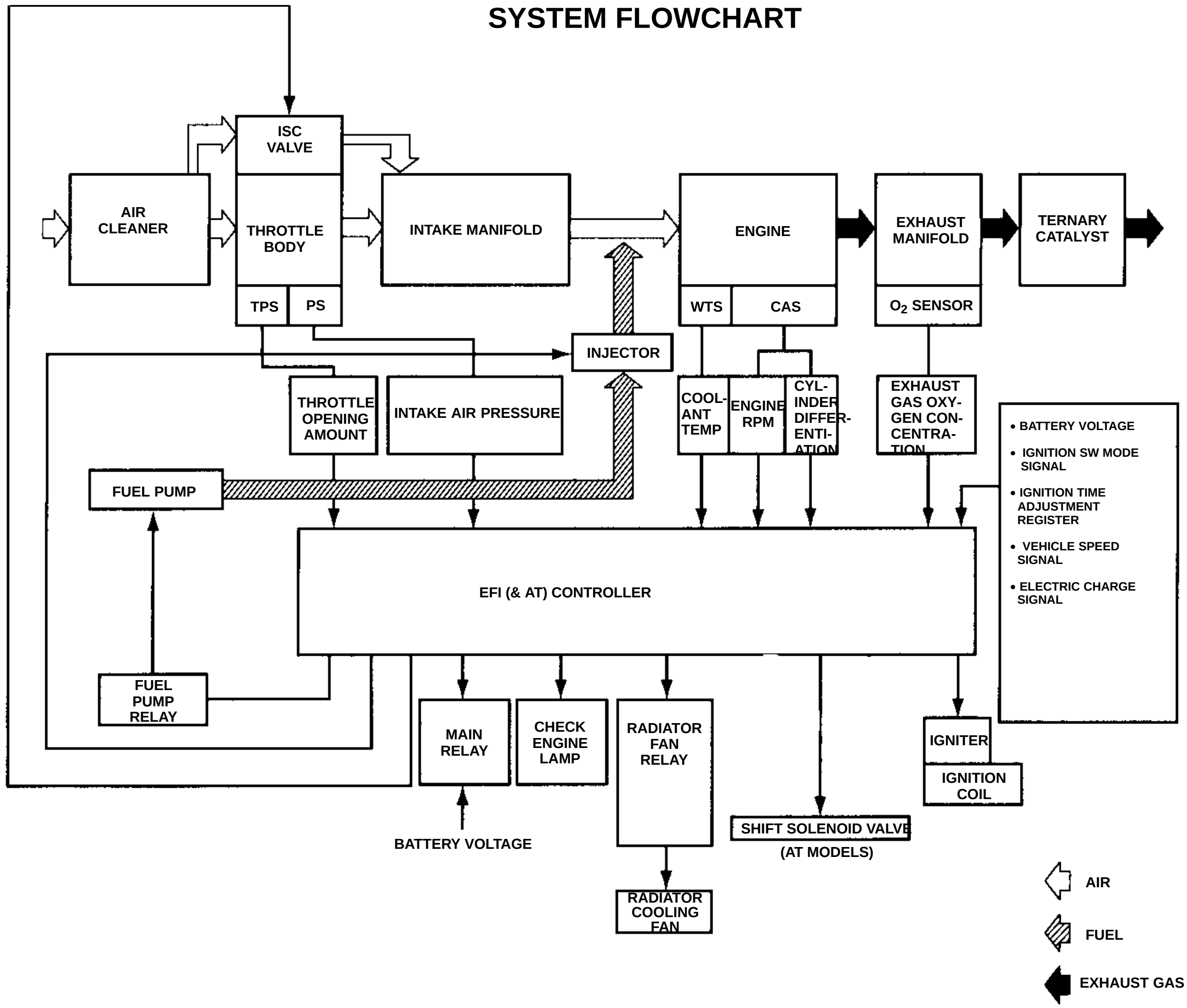


SYSTEM CONFIGURATION DRAWING

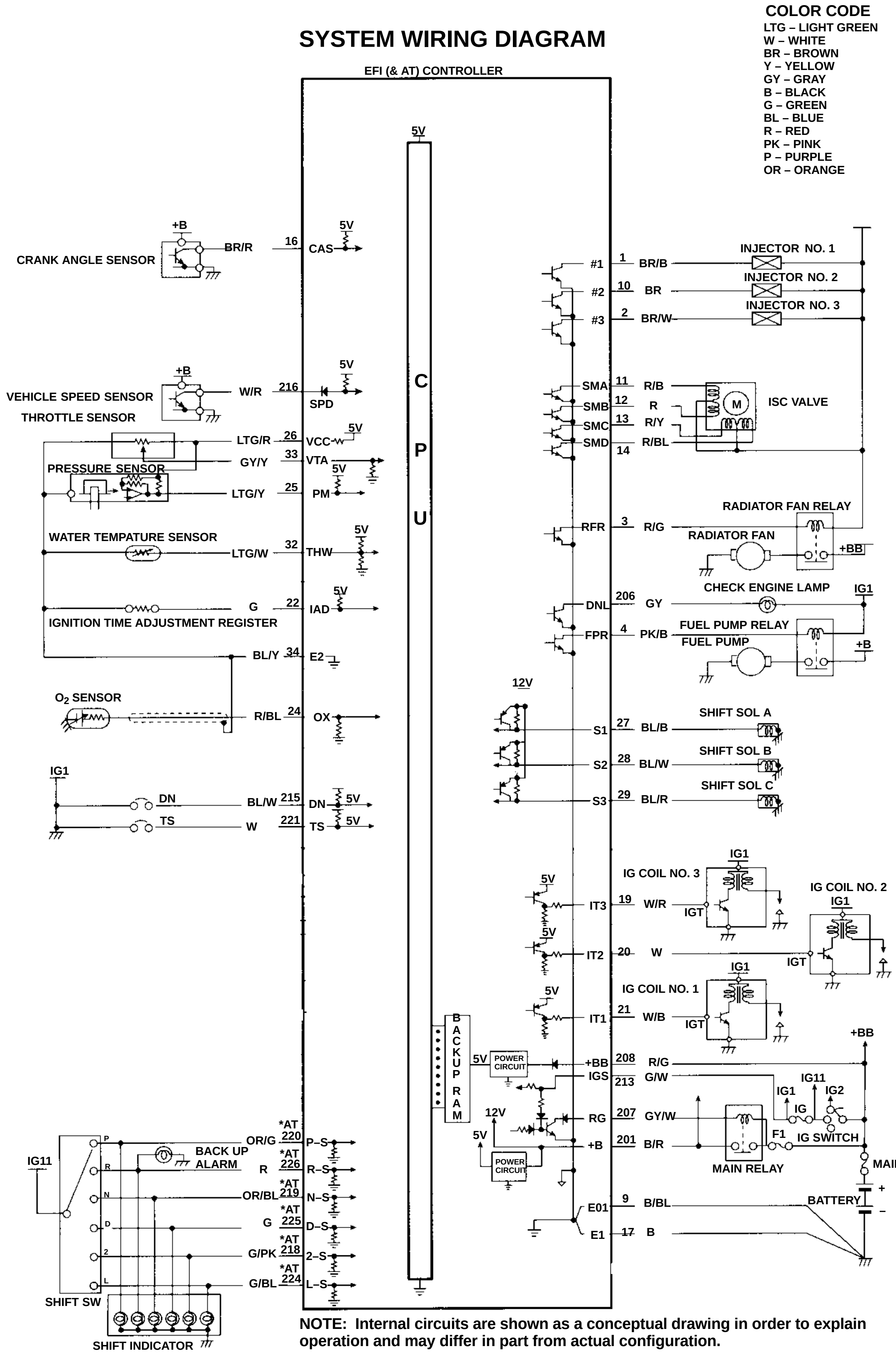


NOTE: FUEL TANK, FUEL PUMP, FUEL FILTER AND FUEL REGULATOR ARE NOT INTEGRAL AS SHOWN IN THIS PICTORAL REPRESENTATION.

SYSTEM FLOWCHART



SYSTEM WIRING DIAGRAM



NOTE: Internal circuits are shown as a conceptual drawing in order to explain operation and may differ in part from actual configuration.

FUEL SYSTEM

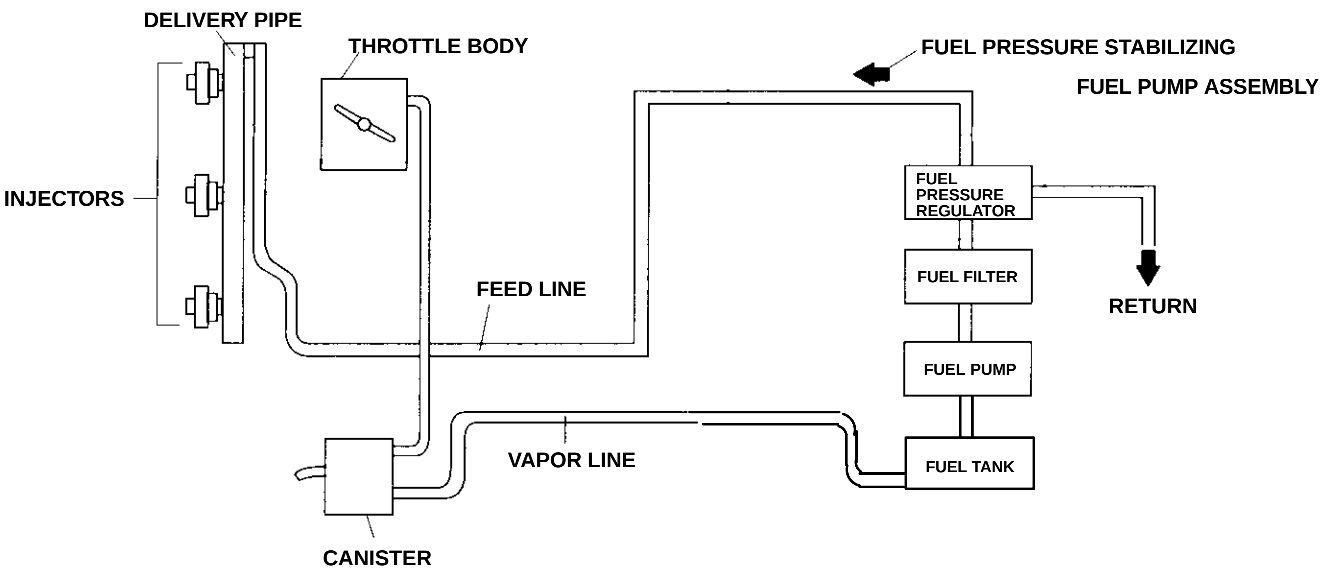
The fuel system comprises of the fuel tank, fuel pump, fuel filter, fuel pressure regulator, delivery pipe, injectors and fuel feed line.

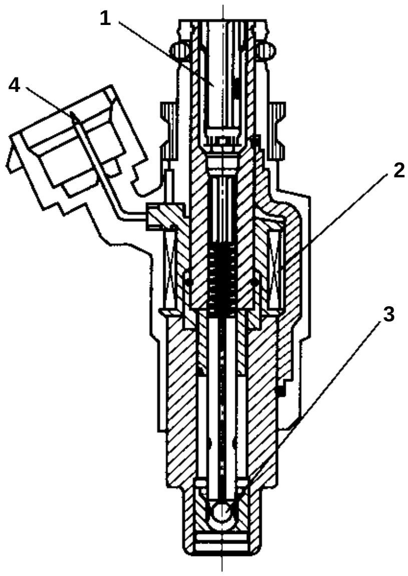
The fuel in the fuel tank is drawn up by the fuel pump, filtered by the fuel filter, transported to the delivery pipe, and injected by the injectors.

The fuel is filtered and subjected to pressure adjustment before being sent to the delivery pipe.

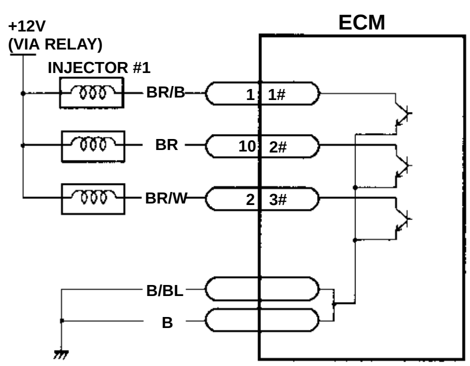
Excess fuel created by fuel pressure adjustment by the fuel pressure regulator is returned to the fuel tank.

Fuel vapor produced from the fuel tank passes through the fuel vapor line and is introduced into a charcoal canister.





1. FILTER
2. SOLENOID COIL
3. BALL VALVE
4. INJECTOR TERMINAL



COLOR CODE
B – BLACK
BR – BROWN
W – WHITE
BL – BLUE

Injectors

The injector is a device which injects fuel in the delivery pipe into the intake manifold under control of the ECM, and uses an MPI (multi–point injection) system, whereby fuel is injected into the manifold of each cylinder. In the injector operation, the injector valve opens when the coil is electrified, and closes when power is cut off.
Since the lift amount and fuel pressure in the delivery pipe when the valve is open are always fixed, the injected fuel amount is determined by the valve opening time, that is, the duty time of the injectors.
One of the injector terminals is always supplied with battery voltage from the main relay when the ignition switch is ON, and the other is connected to the ECM separately for each injector from #1 through #3.
Since fuel injection controlled uses a sequential system, each inductor operates separately, and when the injector terminal of the corresponding ECM is grounded, fuel is injected.
The voltage of each injector terminal of the ECM is approximately 0 V during fuel injection and at other times is the battery voltage.

Injector coil resistance: 14.5 Ω (20°C)

Fuel Filler Cap

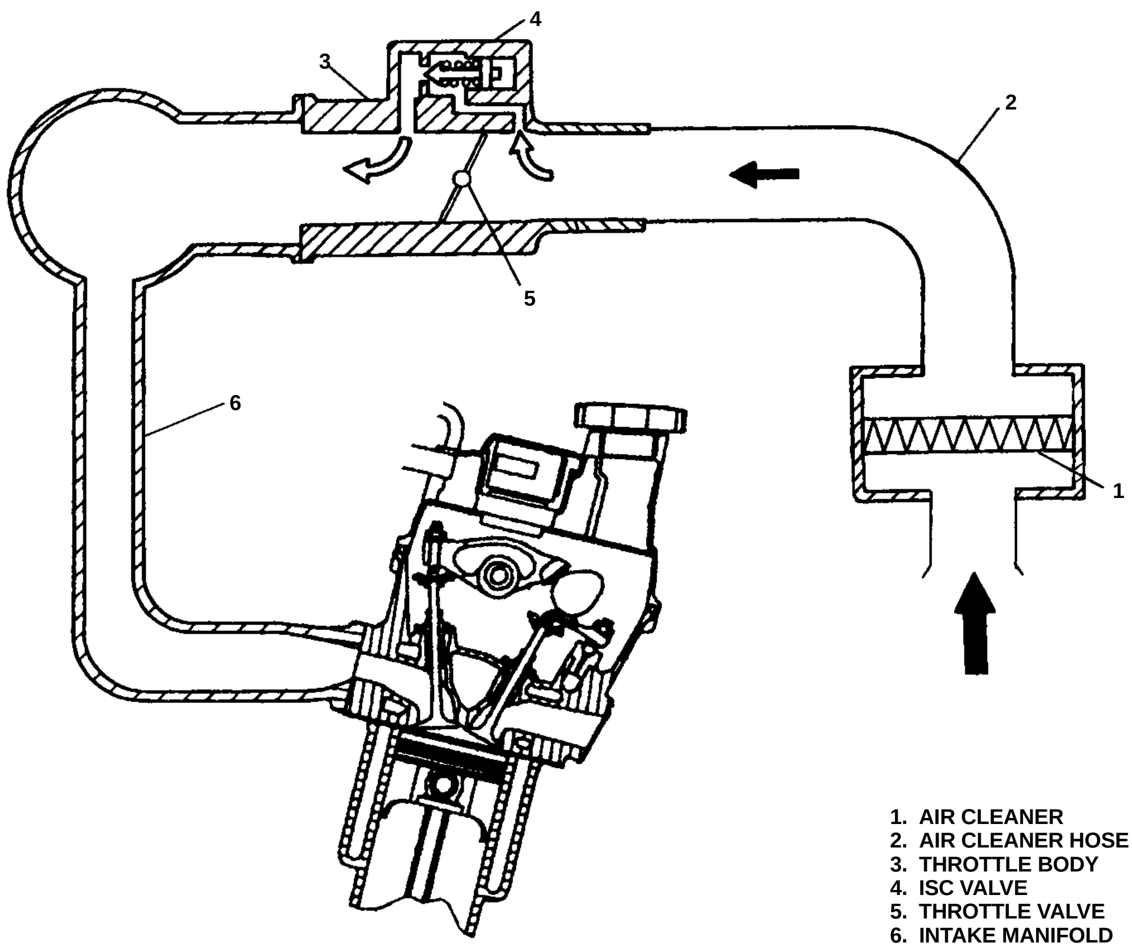
The fuel filler cap is a threaded type used to prevent fuel spray–out.
A ratchet is provided on the screw part, and when the cap is attached by turning clockwise, the ratchet makes a loud clicking noise. At this time, the gasket of the cap is pressed against the filler neck flange, and the fuel intake opening is sealed. By this means, the fuel tank is sealed against the leakage of fuel vapor.

AIR INTAKE SYSTEM

Air that has been filtered by the air cleaner passes through the throttle body and is distributed to the intake manifold of each cylinder. The intake air amount is indirectly measured by measuring the intake air pressure using the pressure sensor.

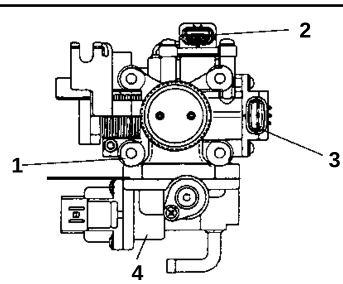
When the throttle valve is fully closed, air necessary for idling rpm is supplied to the intake manifold through the ISC valve.

The ISC valves uses a stepper motor type ISC valve, which changes the opening of the bypass passage under control of the ECM so that the idling rpm remains constant. When the cooling water temperature is low, the idling speed is raised by opening the bypass passage using the ISC valve.



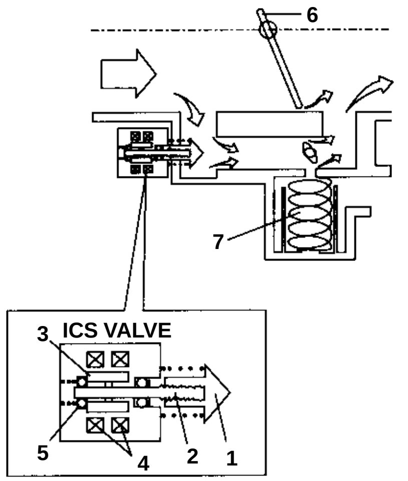
1. AIR CLEANER
2. AIR CLEANER HOSE
3. THROTTLE BODY
4. ISC VALVE
5. THROTTLE VALVE
6. INTAKE MANIFOLD

⬅ : INTAKE AIR
⇦ : BYPASS AIR

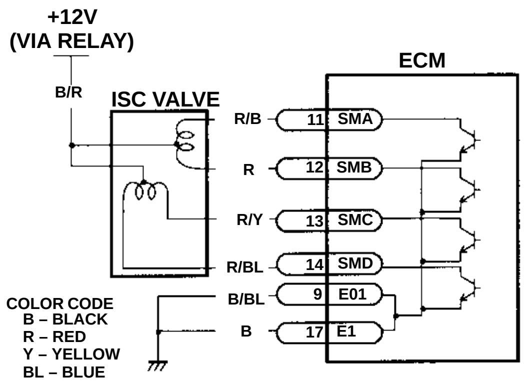


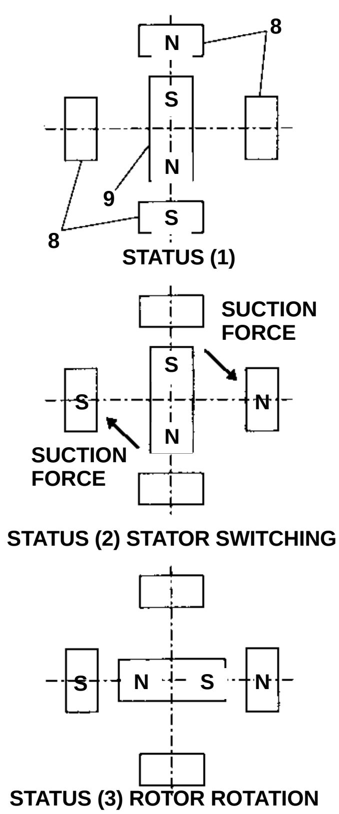
1. THROTTLE BODY
2. PRESSURE SENSOR
3. THROTTLE SENSOR
4. ISC VALVE

Throttle Body
The throttle body adjusts the intake air amount using a throttle valve, which is linked with the accelerator pedal, and is composed of the throttle sensor, which detects the throttle valve opening, a pressure sensor, which indirectly measures the intake air pressure, and an ISC valve, which stabilizes the idling by adjusting the bypass air amount.



1. VALVE PINTLE
2. SCREW SHAFT
3. MAGNET (ROTOR)
4. COIL
5. BEARING
6. THROTTLE VALVE
7. BIMETAL TYPE LIMITER VALVE





8. STATOR
9. ROTOR

ISC Valve

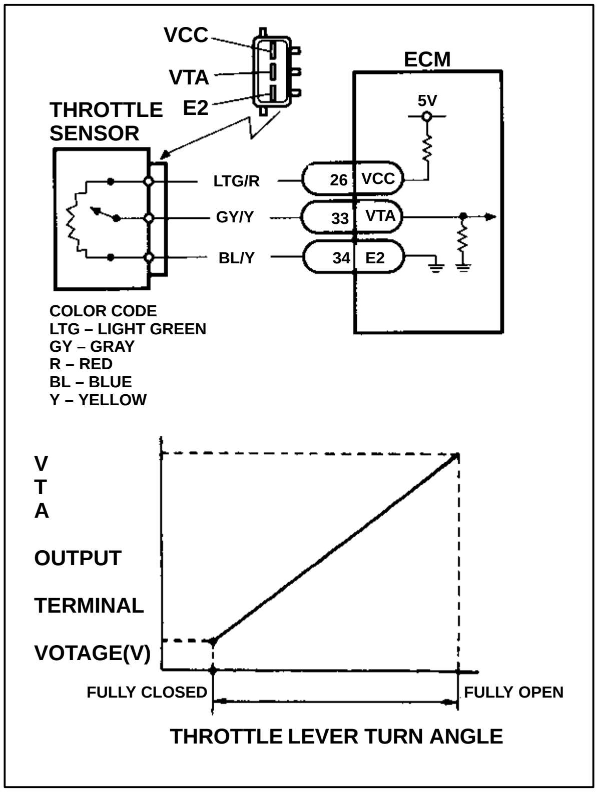
The ISC valve controls the bypass air amount and stabilizes the idling rpm.
The ISC valve is installed on the throttle body and uses a stepper motor system.
The transistor for driving the ISC valve in the ECM receives an instruction from the CPU and switches ON or OFF, the step motor in the ISC valve rotates a number of steps proportional to the instruction, driving the valve, thereby the bypass passage is opened or closed, and the engine is controlled to the target idling rpm. The stepper motor rotates using the magnetic attraction of a stator and rotor. When the excitation of the stator is switched from the state (1) in the figure to the left, becoming state (2), torque in the magnetic rotational direction is produced in the rotor, and a stable position is achieved in state (3) by the rotation of the rotor. (The figure to the left shows the operating principle of the stator rotor and may be different from that actually used. The actual system uses two–phase excitation.) By repeating this, the rotor turns in a number of steps according to the instruction of the ECM, the rotation is converted to torque (extension–contraction) via a screw shaft, and the ISC flow amount is changed by the stroke of the valve pintle.
A battery voltage is fed to the center terminal of the two coils from the main relay when the ignition switch is ON, and the two end terminals are each connected to the ”SMA~D” terminals of the ECM. The voltage of the ”SMA~D” terminals of the ECM is under 1 V when connected, and otherwise is the battery voltage.

THROTTLE POSITION SENSOR (VTA)

The throttle position sensor is installed on the throttle body and detects the throttle opening in linkage with the throttle shaft.

The throttle position sensor comprises of a potentiometer which is linked with the throttle shaft. One end of the resistor of the potentiometer that is linked to the throttle shaft is supplied sensor power supply voltage (about 5 V) from the ”VCC” terminal of the ECM, any other end is grounded from the ”E2” terminal.

When the slider slides along the resistor, the output voltage of the ”VTA” terminal of the ECM changes, and the throttle opening is thereby linearly detected.



WATER TEMPERATURE SENSOR (THW)

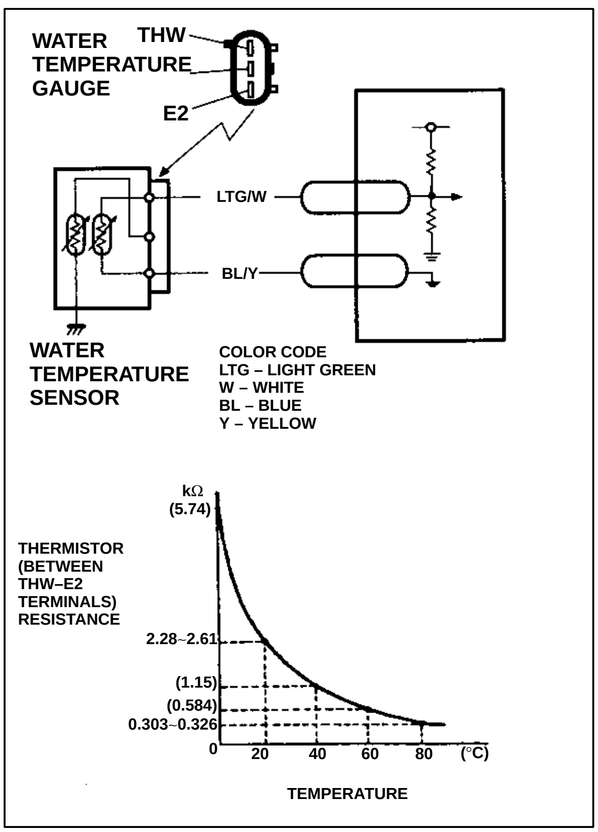
The water temperature sensor is installed at the intake manifold and is a thermistor in which the resistance changes in accordance with the temperature of the cooling water.

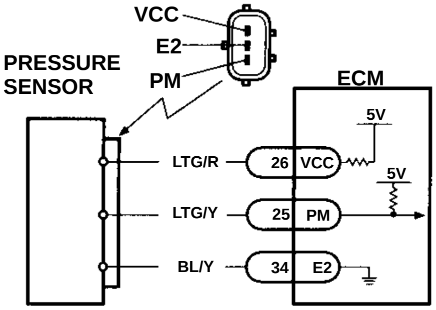
One end of the thermistor of the water temperature sensor is connected to the ”THW” terminal of the ECM, and the other end is connected to the ”E2” terminal (sensor earth).

When the ambient temperature of the water temperature sensor changes, the resistance of the thermistor changes, and the voltage applied to the ”THW” terminal also changes.

The ECM detects the voltage of the ”THW” terminal as the cooling water temperature.

Since the resistance of the thermistor decreases as the temperature increases, the voltage at the ”THW” terminal becomes lower as the temperature is raised.



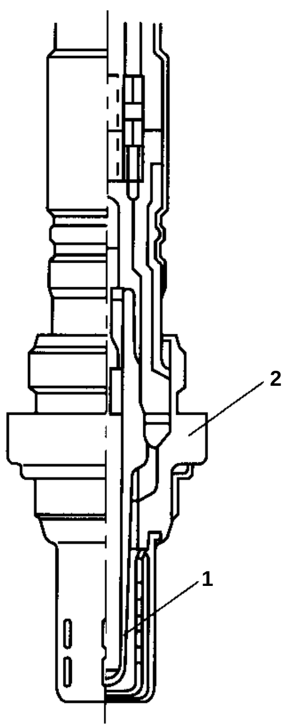


PRESSURE SENSOR (PM)

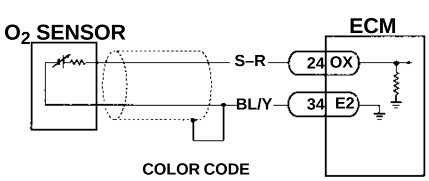
The pressure sensor is a sensor that is installed on the throttle body, detects changes in the intake manifold pressure.

One terminal of the pressure sensor is connected to the ”VCC” terminal of the ECM, sensor voltage (approx. 5 V) is supplied from the ECM, and one of the remaining two terminals is connected to the ”E2” terminal (sensor earth).

The other terminal is connected to the ”PM” terminal of the ECM, and the voltage changes in conjunction with changes in the intake manifold pressure (0~5 V). The ECM detects the changing voltage level of the ”PM” terminal as intake manifold pressure changes. The voltage of the ”PM” terminal is low when the pressure is low, and high when the pressure is high.



1. ZIRCONIA ELEMENT
2. HOUSING



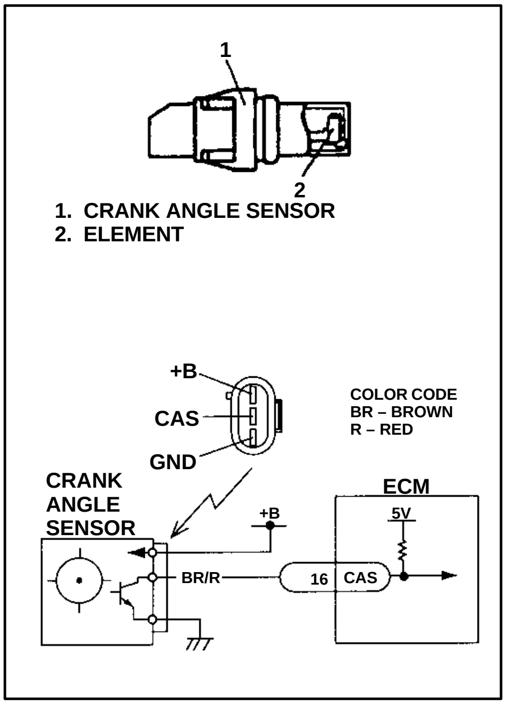
COLOR CODE
R – RED
BL – BLUE
Y – YELLOW

O_2 SENSOR (OX)

The O_2 sensor is a sensor that is installed on the exhaust manifold and detects changes in the oxygen concentration in the exhaust gas by means of a zirconia element (platina–coated) that changes its output voltage according to the oxygen concentration. The sensor is connected to the ”OX” terminal of the ECM and the main body is grounded to the engine.

When the oxygen concentration in the exhaust gas changes, the voltage of the ”OX” element changes (0~1 V), and the detector detects this voltage level as the oxygen concentration. A voltage of the ”OX” terminal becomes lower when the oxygen concentration increases (approx. 0 V), and becomes higher (approx. 1 V) when the amount of oxygen decreases.

Note: The O_2 sensor is not activated unless the temperature of the main body reaches 300°C or above.

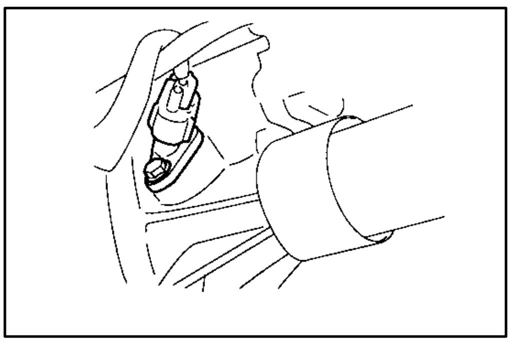


Crank Angle Sensor (CAS)

The crank angle sensor is installed on the sensor case and houses an element which converts magnetic changes into voltage.

Magnetic changes produced by the rotation of a signal rotor installed on the camshaft are converted into voltage signals by the element.

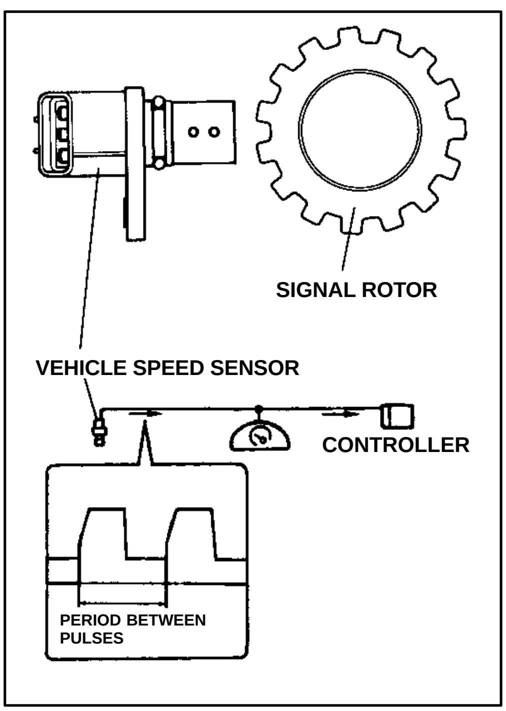
This voltage signal is sent to the ECM, where it becomes a basic signal for distinguishing cylinders and for determining engine rpm.



Vehicle Speed Sensor (SPD)

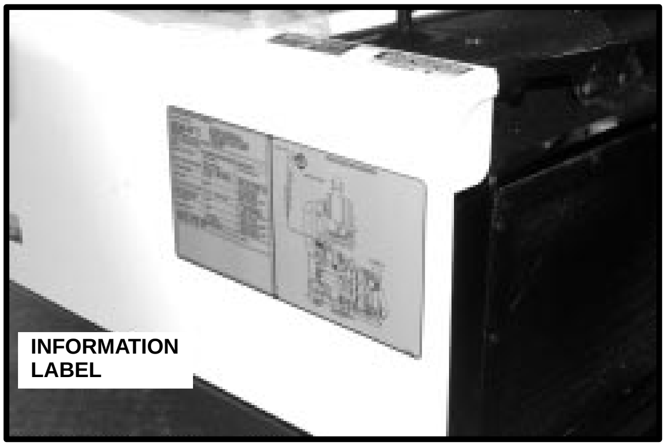
The vehicle speed sensor is installed on the transmission and is a sensor which converts magnetic changes produced by the rotation of the signal rotor into voltage signals.

The vehicle speed sensor performs frequency division so that 4 pulses are output for 1 signal rotor rotation, and the output is connected to the speedometer, ECM and speed limit module.



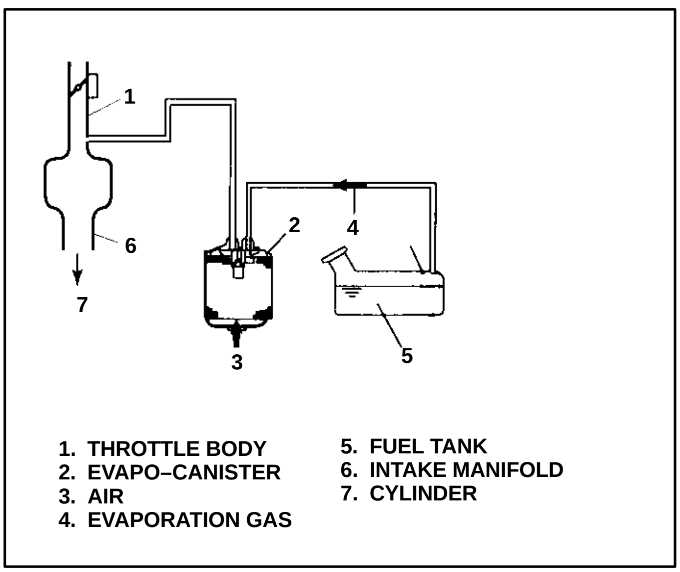
EMISSION SYSTEM

The emission system is composed of a fuel vapor gas emission prevention device, blow–by gas recovery device, and ternary catalyst device.



Information Decal

The information decal is located on the vehicle engine cover.

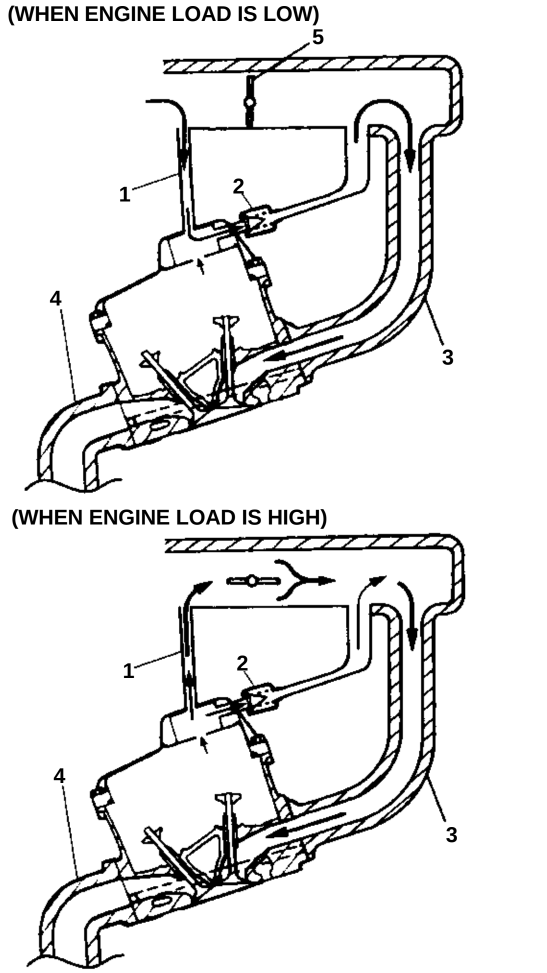


Fuel Vapor Gas Emission Prevention Device

The fuel vapor gas emission prevention device is provided in order to prevent the escape of fuel vapor gas.

When the fuel vapor inside the fuel tank reaches a certain pressure, and the vapor is drawn into the canister.

The gas that has been drawn into the canister is drawn out by the negative pressure produced in the intake manifold during engine operation, and undergoes combustion together with the fuel–air mixture that has been drawn in.



1. BREATHER HOSE
2. PCV VALVE
3. INTAKE MANIFOLD
4. EXHAUST MANIFOLD
5. THROTTLE VALVE

Blow–by Gas Recovery Device

The blow–by gas recovery device is provided in order to return unconsumed gas (consisting mainly of HC) that has escaped into the crank case from gaps between the pistons and cylinders to the combustion chamber, where it undergoes combustion, and uses a closed type consisting of a cylinder head cover, PCV valve, breather hose, and throttle valve.

[Under low engine load]

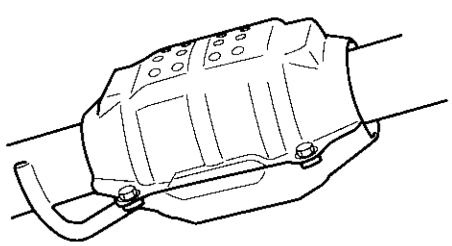
Since the opening of the throttle valve is slight, air that has been drawn in from the air cleaner passes through the breather hose and is sent to the cylinder head cover. At the same time, since large negative pressure is produced in the intake manifold, the PCV valve is opened.

Thus, blow–by gas that has passed through the oil trap and collected in the cylinder head cover is swept into the combustion chamber by the air passing through the breather hose.

[Under high engine load]

Since the opening of the throttle valve is large, the pressure in the upstream and downstream of the throttle valve is roughly equal, but the downstream side of the air cleaner assumes a negative pressure to the extent of the resistance of the air cleaner.

Thus, the blow–by gas is swept into the combustion chamber from both the breather hose and PCV valve.



Ternary Catalyst Device

The ternary catalyst is provided in order to oxidize and lower the amount of CO and HC, which are the harmful constituents of exhaust gas, and uses a monolith type having an integrated structure.

In order to make the catalyst function at an efficiency closest to the theoretical air–fuel ratio, the air–fuel ratio is adjusted by the ECM.

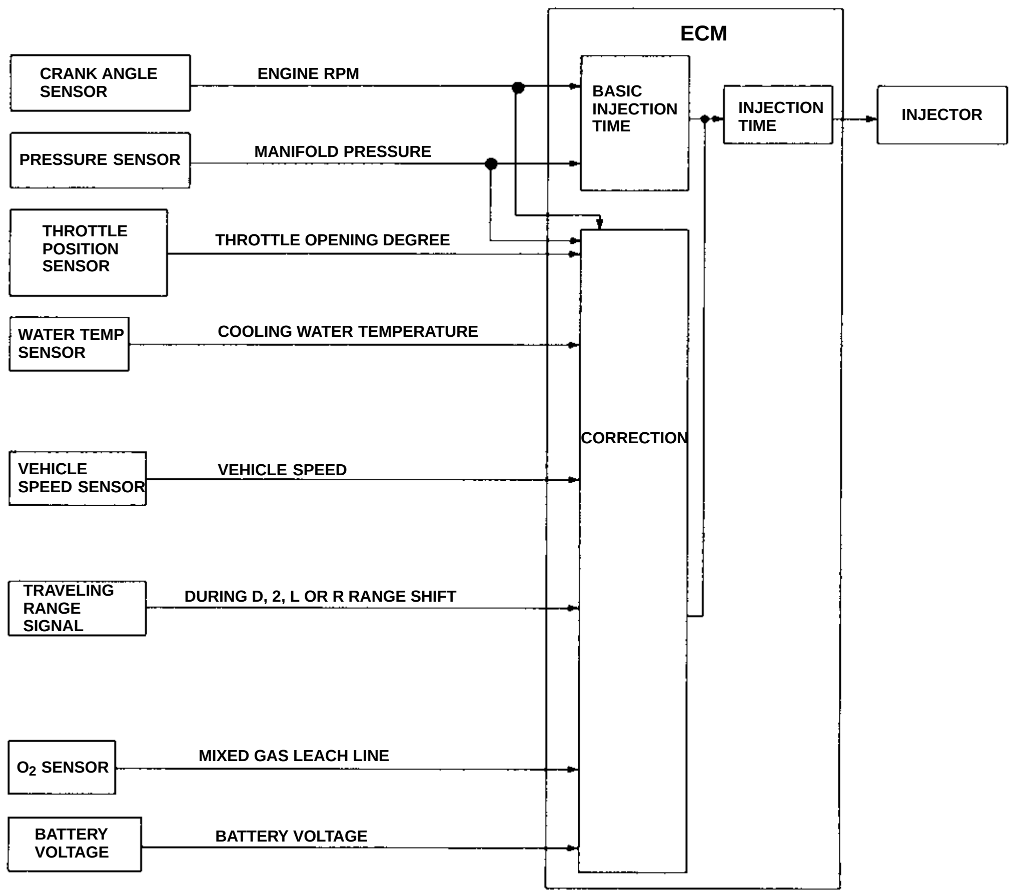
CONTROL SYSTEM

The ECM (Engine Control Module) is incorporated into the EFI(&AT) controller housed behind the engine compartment under the center panel of the storage compartment. The ECM performs optimal actuator control during driving by processing data input from the sensors.
The following are the principal control items.

Control Items	Description
Fuel injection control	Controls the injection timing and injection amount of fuel injected by the injectors so that the optimal amount of fuel is injected in the correct timing.
Ignition timing control	Controls ignition of sparkplugs to optimal timing according to driving status.
ISC control	Stabilizes the idling rpm by controlling the opening of the ISC valve according to the warm up status and air conditioner load, etc.
Fuel pump relay control	Controls the fuel pump by controlling fuel pump relay.
(Radiator fan relay control)	Controls radiator fan relay, which controls the radiator cooling fan.
(AT control)	Controls solenoid valve according to vehicle speed, throttle opening, shift position, etc.
Self–diagnosis	Illuminates check engine lamp when abnormalities detected in ECM input signal, stores diagnosis result, and displays problem area by flashing of check engine lamp.

FUEL INJECTION CONTROL

A speed density method is used whereby ECM calculates the air intake amount according to the engine rpm (crank angle sensor) and intake manifold pressure (pressure sensor), and determines the basic injection time. The fuel injection method (timing) and fuel injection amount (time) are controlled as follows using a start mode that is used when starting the engine and a feedback mode that is used during normal driving.



STOP MODE:

• Engine speed under 50 rpm (when input of crank angle sensor signal is 0.8 sec or more)

START MODE:

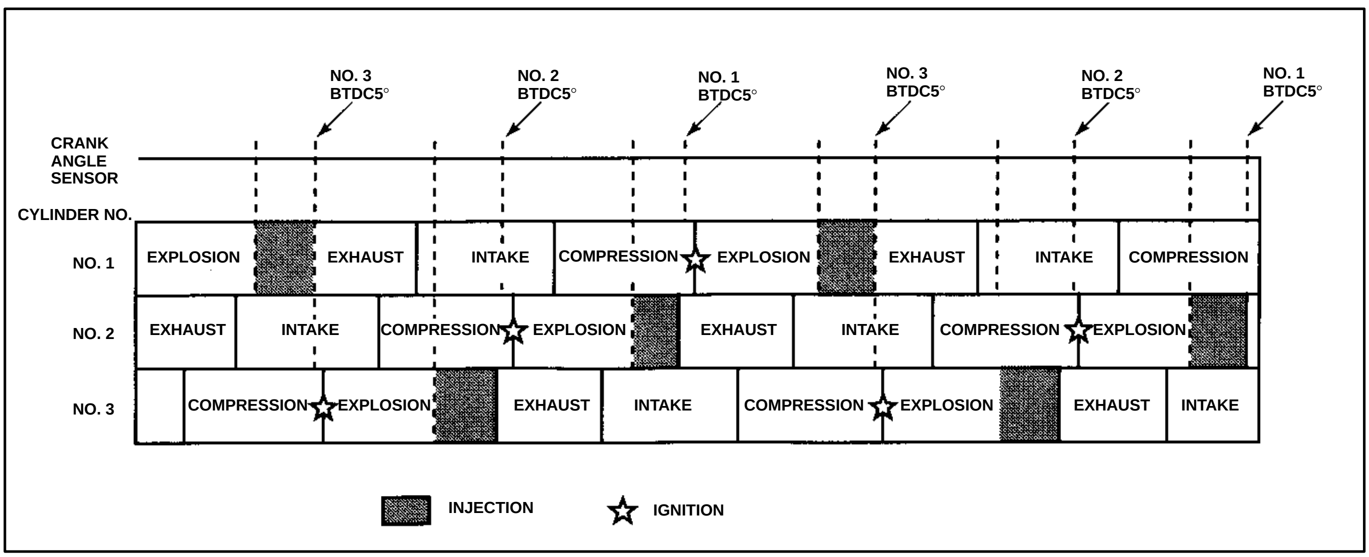
In the fuel injection mode used outside of stop mode, when the engine speed is 600 rpm or lower, injection is performed simultaneously for all cylinders upon each crank angle sensor signal input. However, when the temperature is extremely low, multi–division injection is used. Fuel injection amount determined by adding a correction for ineffective injection time to the following starting injection time.

- Starting injection time: Time determined according to cooling water temperature. As the injection time is extended the lower the cooling water temperature becomes, and starting ability is increased.
- Ineffective injection time: in order to correct for delay in the injection time due to low battery voltage, the charging time to the injectors is extended according to the degree of reduction in battery voltage.

FEEDBACK MODE:

During normal driving, sequential control, which performs injection in the order 1–3–2 for each cylinder, is used. Injection is performed in the exhaust sequence of each cylinder. The fuel injection amount is calculated by adding following correction to the basic fuel injection time, which is determined according to the engine rpm and air intake amount.

- Volume efficiency correction: The fuel injection time is adjusted according to the engine rpm and intake air pressure.
- Feedback correction: The air–fuel ratio is corrected from the oxygen concentration in the exhaust gas according to the O_2 sensor to the theoretical air–fuel ratio.
- Amount increase correction immediately after starting: The fuel injection time is corrected according to cooling water temperature when starting. The correction amount is gradually reduced after starting.
- Idle A/F learning function correction: The fuel injection time is corrected during idling. If the basic air–fuel ratio to which the air–fuel ratio feedback correction is added is significantly deviated from the theoretical air–fuel ratio due to the passage of years, etc., problems occur in driving which prevent feedback correction from being performed when the engine is cold, etc. For this reason, a learning function is added to the ECM, and the changing basic air–fuel ratio can be maintained close to the theoretical air–fuel ratio.
- A/F correction: Corrects for deviation in air–fuel ratio in all driving regions.
- Atmospheric pressure correction: Predicts atmospheric pressure from engine running status and corrects for deviation in air–fuel ratio occurring due to changes in atmospheric pressure.
- Acceleration amount increase correction: Detects acceleration status from changes in air intake pressure amount, cooling water temperature, and engine rpm, and extends fuel injection time.
- Deceleration amount increase correction: Detects acceleration status from changes in air intake pressure amount, cooling water temperature, and engine rpm, and extends fuel injection time.
- Acceleration asynchronous injection control: Detects changes in throttle sensor amount as acceleration status, causes fuel injection in an injection timing determined according to cooling water temperature outside of the aforementioned injection timing.



FUEL CUT MODE:

Under the following conditions, fuel injection is stopped.

- Fuel cut at high engine rpm: In order to prevent the engine from running at excessively high rpm, fuel injection is halted when the engine speed reaches 7800 rpm or above.
- Fuel cut upon deceleration:

  When the throttle valve opening is small and engine rpm is high, injection is halted in order to prevent emission of HC.

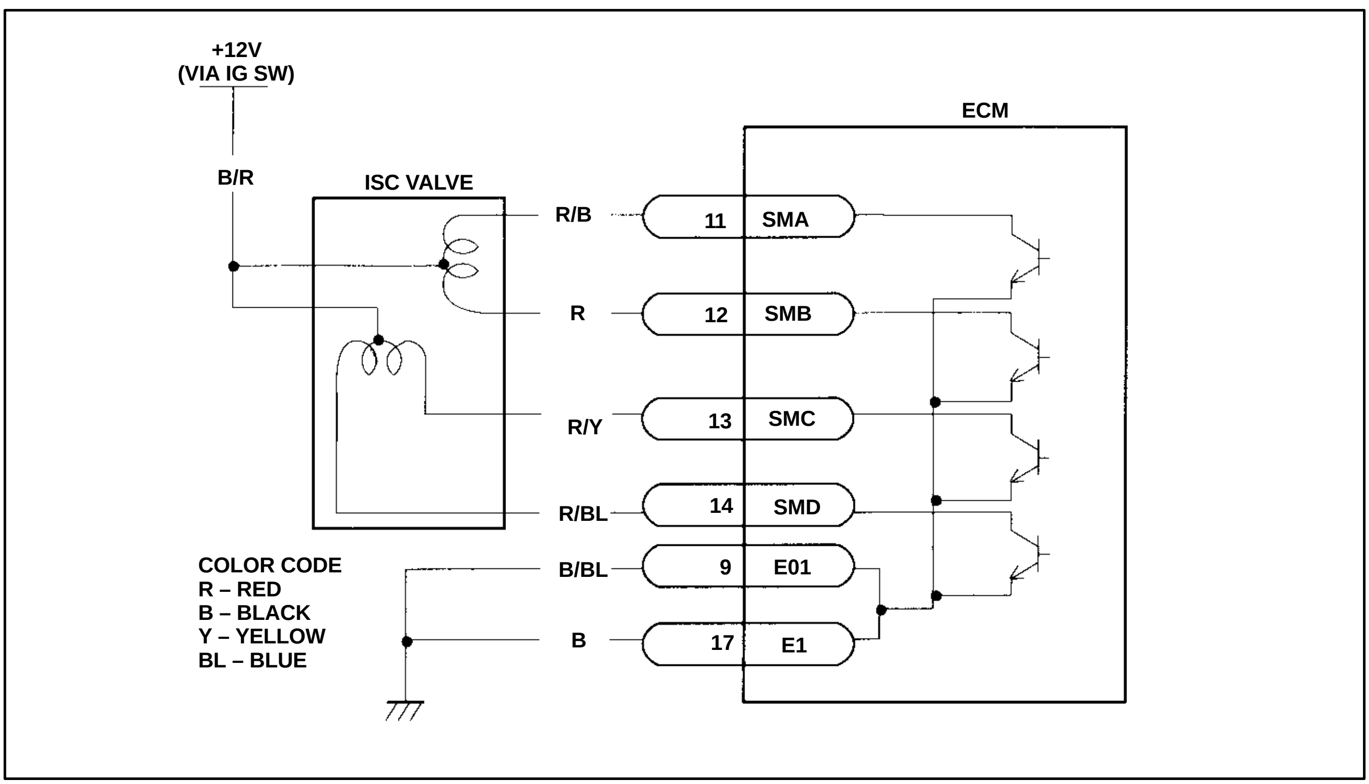
  When the engine rpm falls below a specified level, the fuel cut is released.

  The specified rpm for fuel cut upon deceleration is determined based on the cooling water temperature.

ISC STEPPER MOTOR CONTROL

The ISC stepper motor is controlled in the following modes according to various conditions.

- Operation shutdown: When the battery voltage is less than 9.0 V, operation of the ISC is halted.
- Initialization: When the ignition key is switched from ON to OFF, initializing is performed, and ISC is placed in standby imposition of step 80.
- Stop mode: When the engine speed is 50 rpm or less, fixed at step 80.
- Start mode: When engine is at low rpm (cranking), fixed at bypass air amount when starting.
- Normal mode: Normally, bypass air amount is determined by adding the following correction to the basic bypass air amount which changes according to the cooling water temperature.
- Correction immediately after starting: The bypass air amount is determined according to the cooling water temperature after starting, and a correction amount is gradually decreased according to the engine warm–up status.
- RPM feedback correction: The bypass air amount is corrected according to the difference between the present idle rpm and the target idle rpm.
- Electrical load idle–up correction: When the headlights are on, the bypass air amount is increased by a specified amount.
- Dash pot correction: When the idle switch is ON and the engine rpm has changed from a high region to a certain level or below, the bypass air amount is increased, and the emission of HC is prevented.
- Atmospheric pressure correction: The bypass air amount is corrected according to the atmospheric pressure.
- Radiator fan idle–up correction: When the radiator fan is operating, the bypass air amount is increased by a specified amount.
- D range idle–up correction: The bypass air amount is increased by a specified amount according to the shift lever operating status (R, D, 2, L).
- Correction when load changes: When shifting to no–correction status in the idle–up status described above, the correction amount is gradually decreased.



MAIN RELAY CONTROL

The main relay supplies battery voltage to the ECM according to the ON/OFF status of the ignition switch.

When the ignition switch is turned ON, the coil of the relay is ground, and thereby the relay switch circuit is closed.

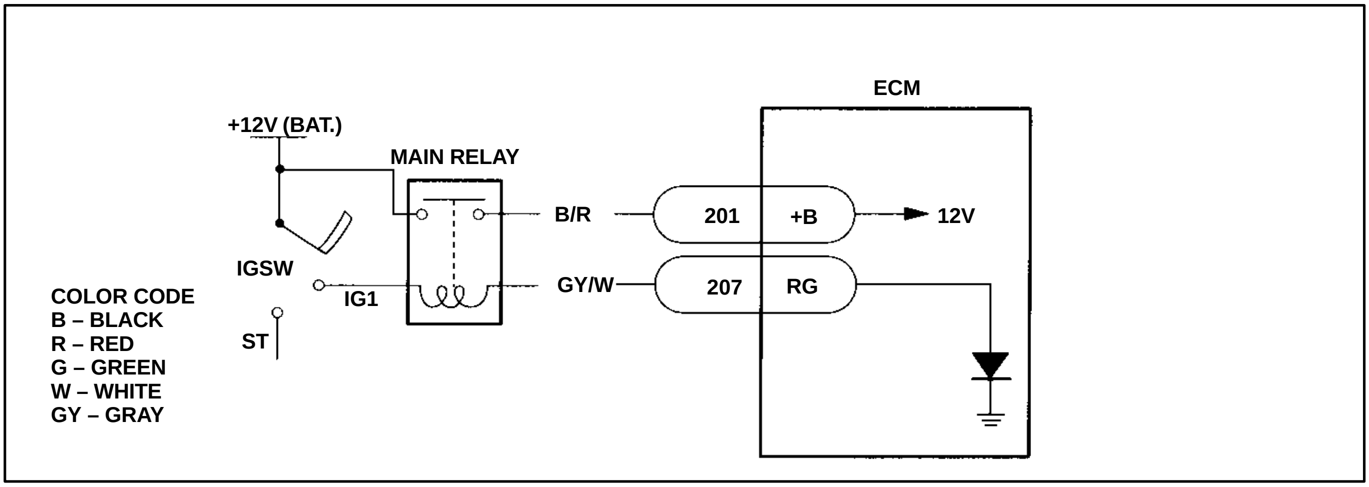
By this means, battery voltage is applied to the "+B" terminal, and the EFI system is activated.

Further, the output circuit of the relay supplies battery voltage to the following actuators and sensors.

Actuators and servers using the main relay as a power source

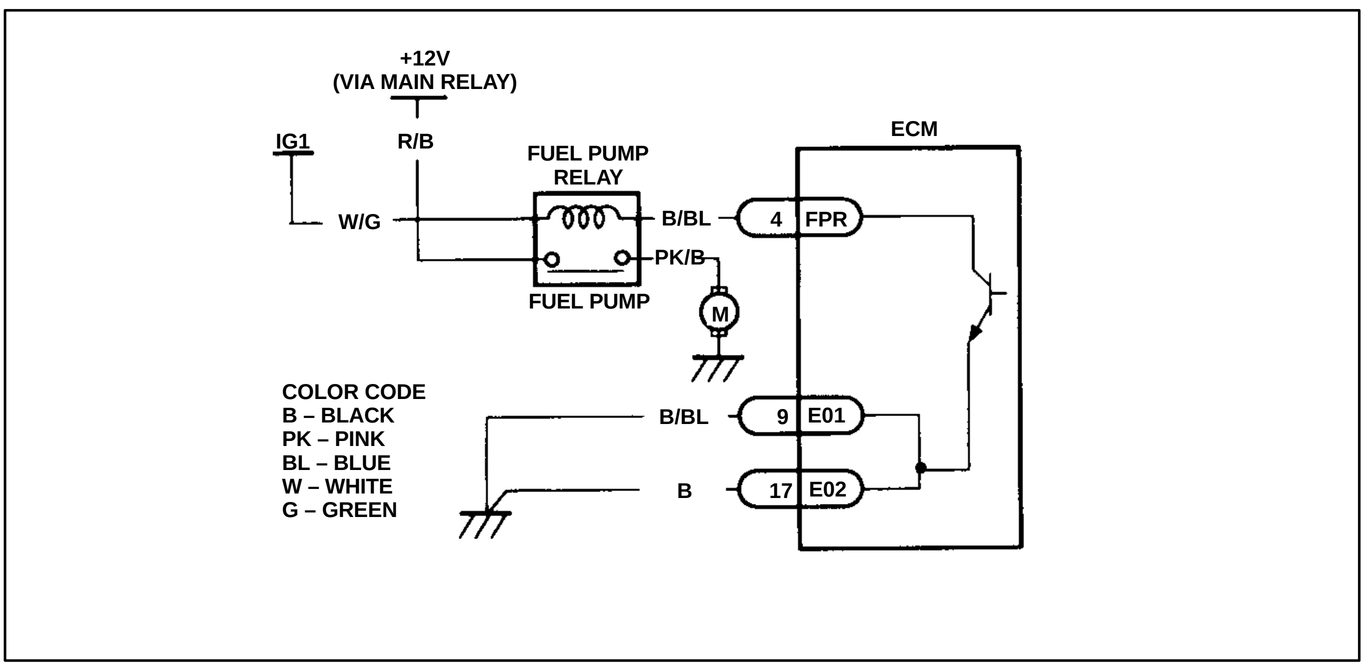
- Injectors
- ISC valves
- Crank angle sensor
- Vehicle speed sensor
- Radiator fan relay (coil side)
- Fuel Pump

The circuit of the relay coil is connected to a ground via a diode in the ECM, and prevents current from running through the coil in the unlikely event of reverse connection of the battery.



FUEL PUMP RELAY CONTROL

The ON/OFF control of the fuel pump is performed by the ECM controlling the fuel pump relay (controlling current flowing to the relay coil part). When the relay is ON, battery voltage is applied to the fuel pump, and the pump is operated. The fuel pump operates under the following conditions.

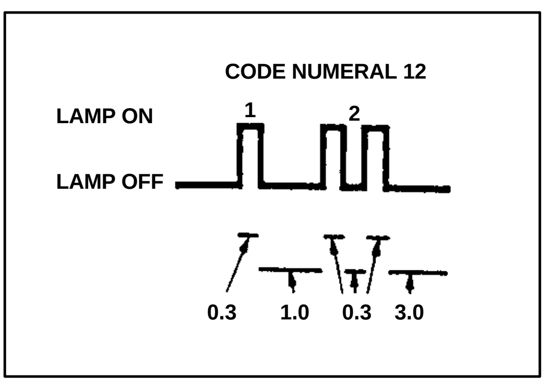


DIAGNOSIS (SELF–DIAGNOSIS) FUNCTION

The ECM is provided with a self–diagnosis function, whereby it illuminates the check engine lamp in the combination meter when there is an abnormality in an input signal, providing notification of the occurrence of an abnormal condition. Further, when control is performed based on this abnormal signal, there is a possibility that engine trouble may occur and driving may not be possible, so the failsafe function is provided which secures minimal driving performance using a standard signal in the ECM, ignoring this signal.

CODE DISPLAY/DIFFERENTIATION METHOD

- Insert diagnostic jumper (P.N. 2700920) and differentiation is achieved by the blinking frequency of the check engine lamp in the combination meter.



- Code differentiation is performed in the regions shown to the left.

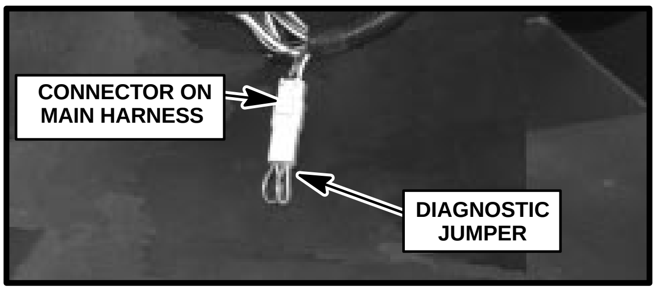
Note: The codes are displayed three at a time in order of priority.

CODE RETRIEVAL PROCEDURE

NOTE: • When there are multiple failure locations, all of the codes are displayed 3 times each in order of priority of code.
• See Section 2B for AT system diagnosis codes.

NOTE: The jumper will perform diagnostic checks on various electrical components.

3. Place the gear selector into **park,** apply the park brake and turn the ignition switch to the **off** position.
4. Open the right lid in the storage compartment located behind the cab. Locate the plug-in connector coming from the small section of wire-harness.
5. Plug the diagnostic jumper into the plug-in connector with the blue/white wire and the black wire.



6. Turn the ignition switch to the **on** position and note the brake fluid level warning light at the lower left corner of the instrument panel.
7. The light will flash a code to let you know that everything is normal (Code 12) **or** to let you know which specific component needs attention.
8. The light will first flash to correspond to the first digit of the code, then flash again to correspond with the second digit of the code.
9. A Code 14 would turn the light on for 0.3 seconds then off for one second (long pause), then on-off, on-off, on-off, on-off (the last four flashes will be short quick flashes).
10. If a Code 43 were present the light would - flash then pause,... flash then pause,... flash then pause,... flash then pause, ***then*** flash, flash, flash (four long pauses followed by three quick flashes).
11. The code will continue to repeat itself until the ignition switch is turned off.

NOTE: If there are multiple faults, each code will be displayed three (3) times starting with the lowest numbered code.

12. Turn the ignition key to the **off** position, then back to the **on** position each time you want to take a reading.

The following list shows which code number corresponds to which component and lists possible causes for each fault:

CODE

11 **Pressure Sensor** – Voltage at pin 25 (green/yellow wire) of the 34 pin ECU connector is either higher than 4.5 V or lower than 0.19V. **Failsafe Mode:** Fixed to specified pressure valve

12 **Normal** – System operating normally

13 **Throttle Sensor** – Voltage at pin 33 (gray/yellow wire) of the 34 pin ECU connector is either higher than 4.73V or lower than 0.25V.

14 **O2 Sensor** – No signal for a length of time at pin 24 of the 34 pin ECU connector.

15 **Crank Angle Sensor** – While in starting mode, no signal is seen at pin 16 (brown/red wire) of the 34 pin ECU connector.

16 Vehicle Speed Sensor – No signal for a length of time at pin 16 (orange wire) of the 26 pin ECU connector.

19 Water Temperature Sensor – Voltage at pin 32 (green/white wire) of the 34 pin ECU connector is either higher than 4.85V or lower than 0.15V. **Failsafe Mode:** Control system sot that cooling termperature is 83°C (continous running of radiator fan).

41 Shift Solenoid No. 1 – Open or short circuit at pin 27 (blue/black wire) of the 34 pin ECU connector, should be “on” if gear selector is in “L” (“on” meaning there should be 12 volts going through this wire).

42 Shift Solenoid No. 2 – Open or short circuit at pin 28 (blue/white wire) of the 34 pin ECU connector, should be on if gear selector is in “L” or “2” (“on” meaning there should be 12 volts going through this wire).

43 Shift Solenoid No. 3 – Open or short circuit at pin 29 (blue/red wire) of the 34 pin ECU connector.

46 Shift Switch – No signal at pin 18 (green/pink wire) of the 26 pin ECU connector, **and** no signal at pin 19 (orange/blue wire) of the 26 pin ECU connector, **and** no signal at pin 20 (orange/green wire) of the 26 pin ECU connector, and no signal at pin 24 (green/blue wire) of the 26 pin ECU connector, **and** no signal at pin 25 (green wire) of the 26 pin ECU connector, **and** no signal at pin 26 (red wire) of the 26 pin ECU connector.
or
signal present at more than one of pins 18, 19, 20, 24, 25 and 26 of the 26 pin ECU connector.

SECTION 7

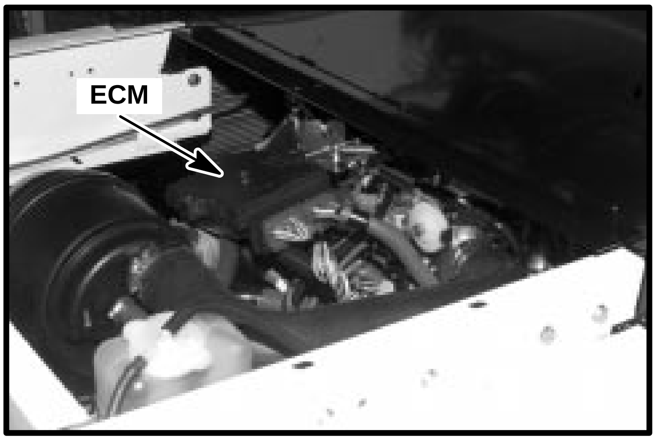
ENGINE REMOVAL

ENGINE REMOVAL

This section covers the removal of the Suzuki 660 engine from the Model 898487 On–road Cushman Police Vehicle. The engine and transmission are to be removed from the vehicle as an assembly.

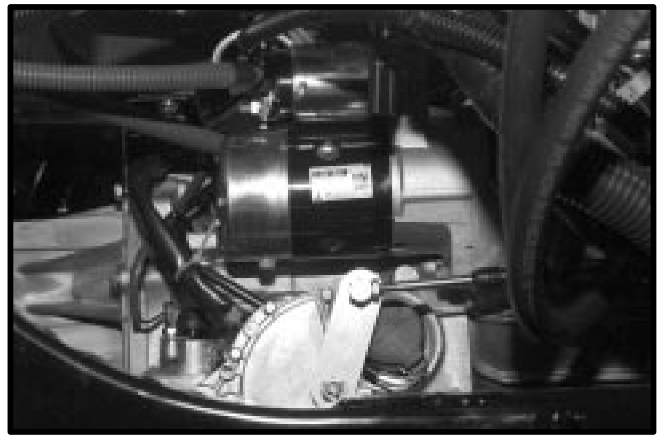
Procedure

1. Disconnect negative (–) and positive cables from battery terminals.



2. Remove transmission access cover.
3. Remove ECM cover located underneath middle section of storage compartment. Disconnect ECM plugs.

4. Remove engine cover with seat and left hand side panel.

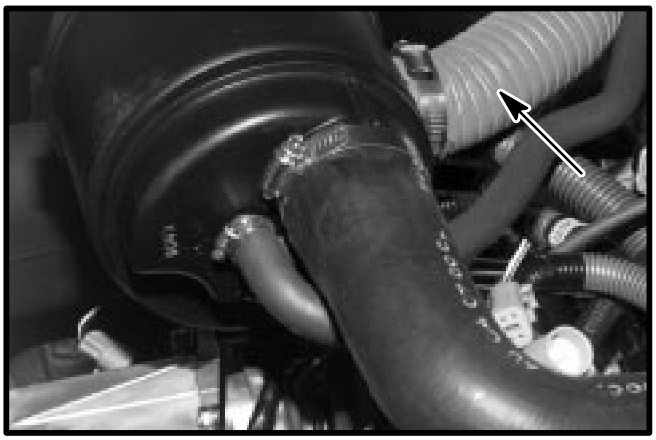


5. Disconnect lead wires and positive (+) battery cable from starting motor.

6. Disconnect negative (–) battery cable and wiring harness ground wires from transmission.

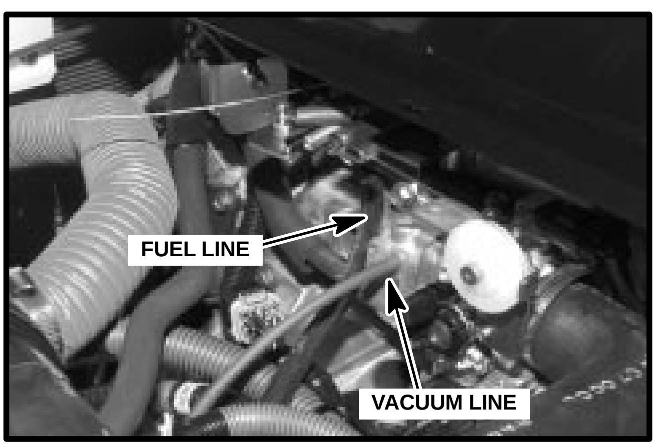
7. Disconnect all wiring harness electrical quick disconnects from transmission.

8. Disconnect lead wires from water temperature sender.

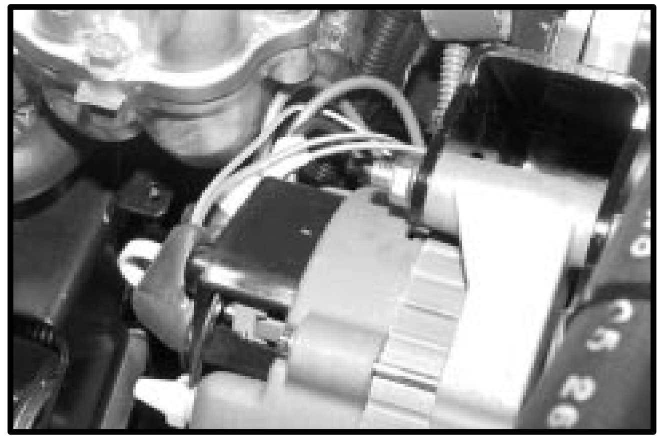


9. Remove air cleaner hose.

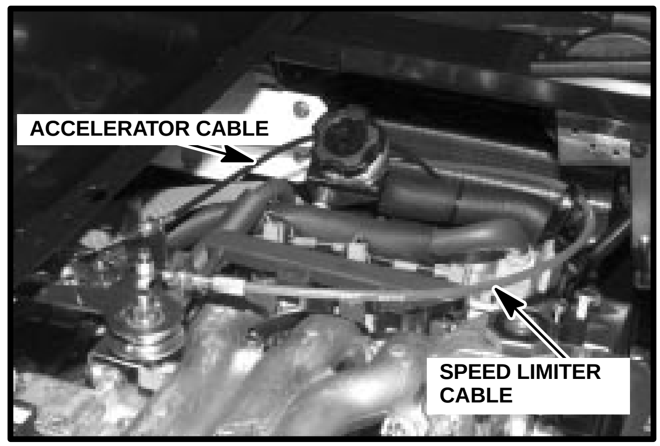
10. Remove fuel tank cap to release fuel vapor pressure in fuel tank and then reinstall it.



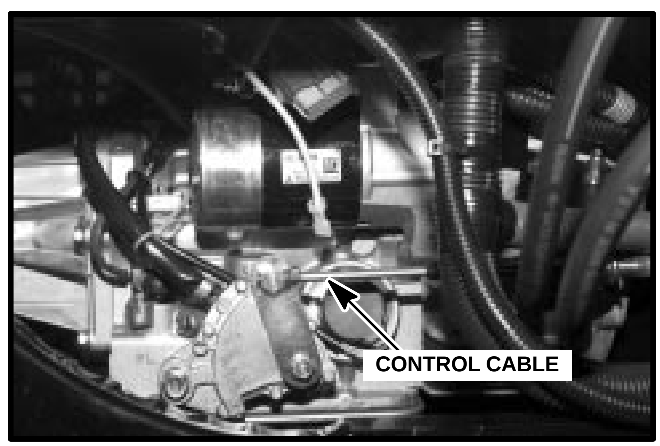
11. Disconnect vacuum and fuel lines.



12. Disconnect lead wires from alternator terminals.

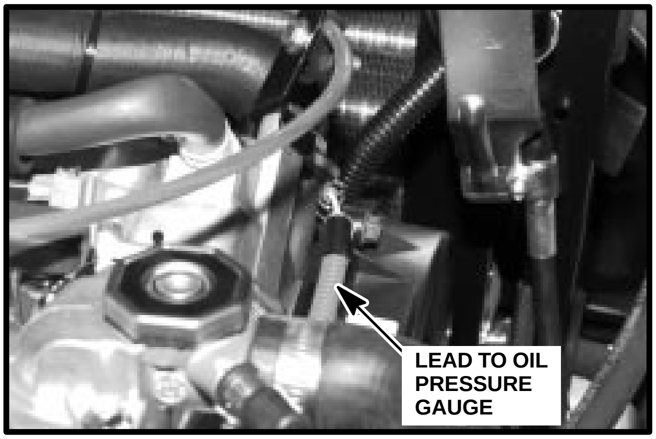


13. Disconnect accelerator cable and speed limiter cable.



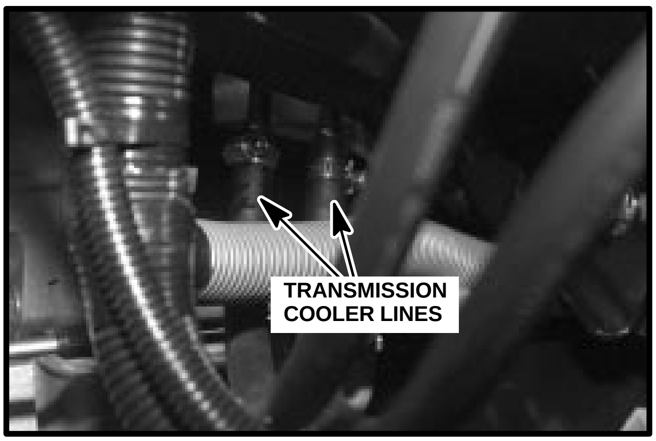
14. Disconnect gear shift control cable from transmission.

15. Raise the vehicle. Refer to the chassis service manual for jacking procedures.



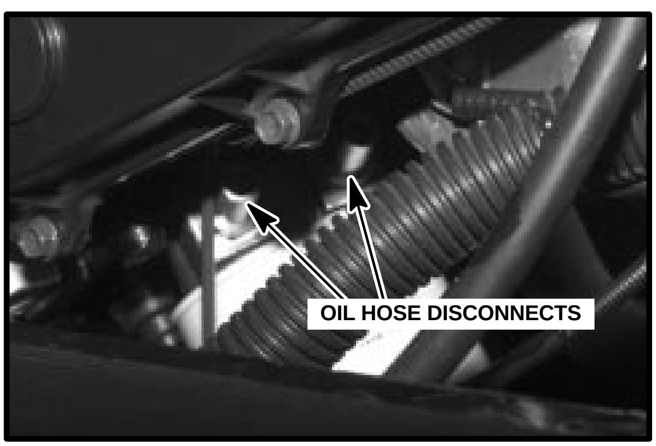
16. Disconnect lead wire from oil pressure gauge.

17. Drain radiator of coolant.



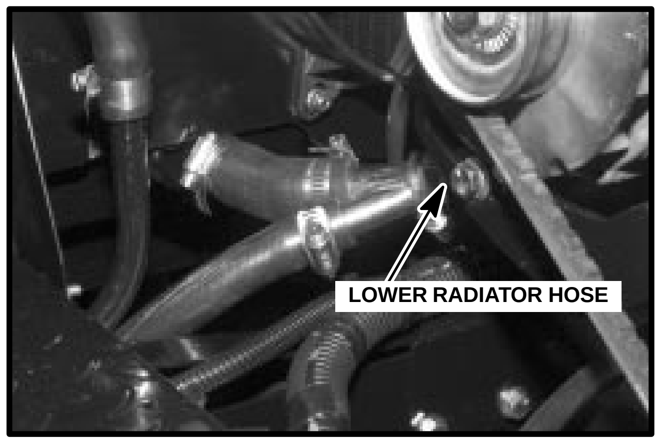
18. Disconnect and drain transmission cooling lines.

19. Remove drive shaft.

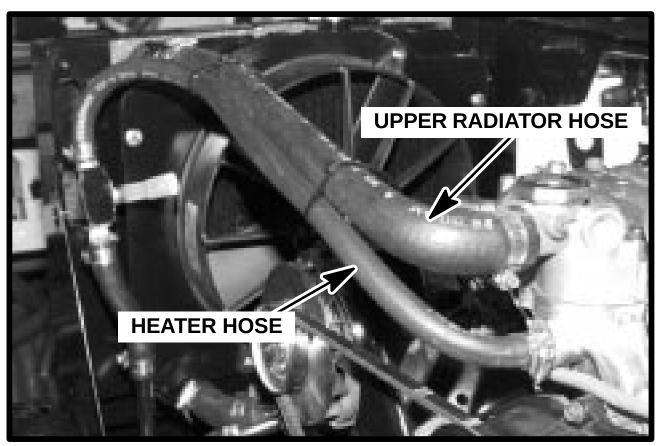


20. Disconnect oil hose from oil filter.

21. Disconnect catalytic converter from exhaust manifold.



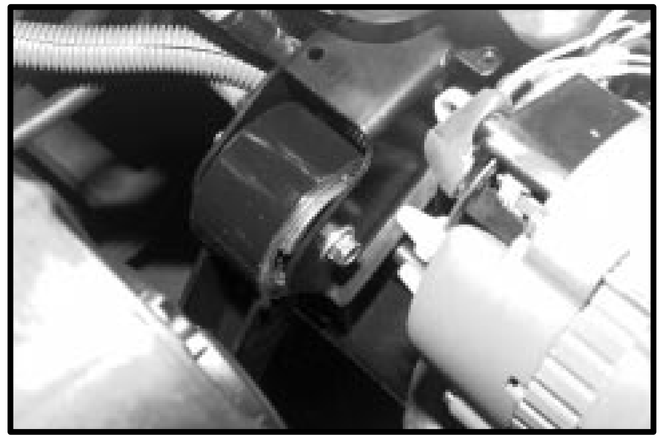
22. Disconnect heater inlet and outlet hose from Y connector.

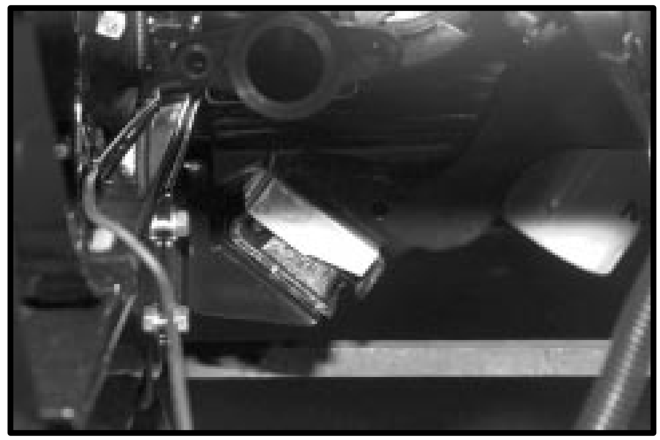


23. Remove radiator inlet hose from radiator to engine and heater hose to engine.

24. Place transmission or floor jack under “engine with transmission”. Place wood blocks between transmission and jack so that engine with transmission is held horizontally even when motor mount bolts are removed.

25. Place engine hoist lift arm through right hand door, and attach with lift chain to engine. (You may want to remove the steering wheel to give you more room for the hoist and engine. Refer to your chassis service manual for proper removal of steering wheel).



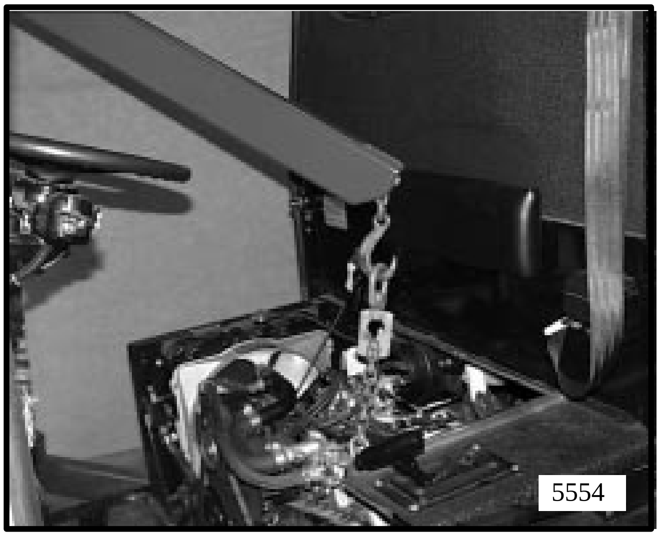


26. Remove motor mount bolts.

27. Remove transmission mounting bracket bolts.

CAUTION

Before starting to lift the engine, check once again to be sure that their is no connection left undone!



28. Carefully remove engine with transmission.

SECTION 8

IGNITION SYSTEM

GENERAL DESCRIPTION

IGNITION SYSTEM

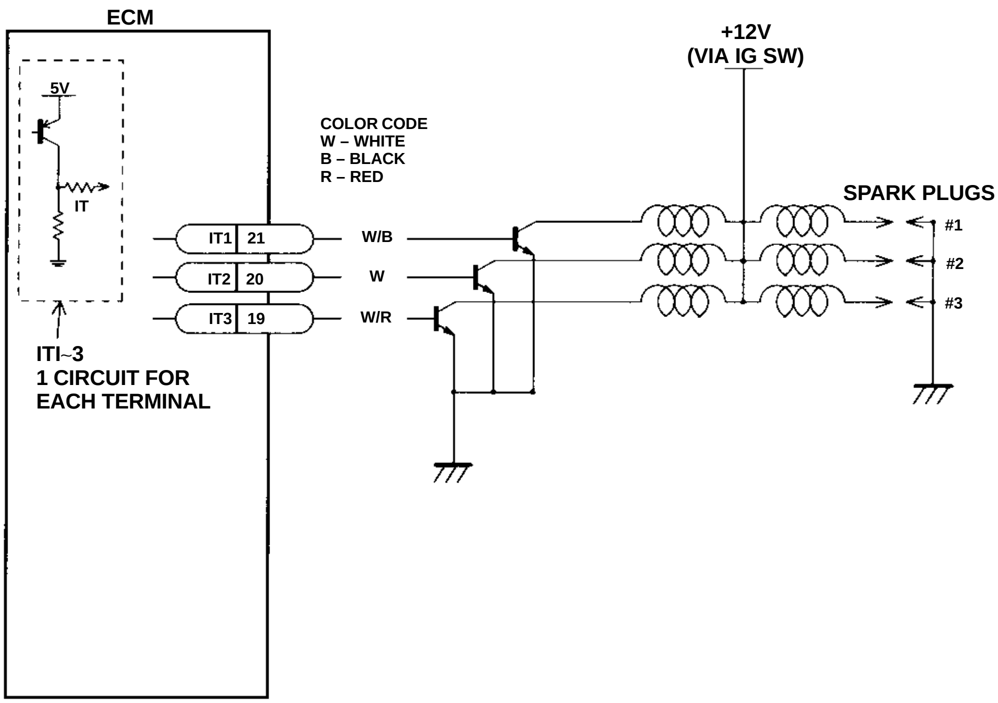
This vehicle uses a full–transistor type, direct–ignition system, comprising of (3) ignition coils, (3) spark plugs and the Engine Control Module or ECM. The ECM also has the function of controlling the automatic transmission shift points, if vehicle is so equipped.

In this direct ignition systems, the ECM has the function of the distributor. Because the ECM is solid state, there is no moving parts (such as in a distributor) and wear items are eliminated, simplifying tune up procedures.

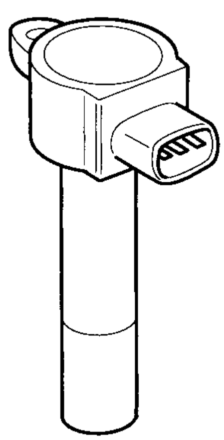
Each of the three ignition coils are placed directly on a spark plug, thereby eliminating the high–tension cables (spark plug wires). Both distributor and plug wires are eliminated with this direct ignition system.

The ECM has a self–diagnostic mode to detect abnormal input signals as a means of component fault detection. By reviewing abnormal (out of normal range) ECM inputs, the diagnostic mode usually indicates which component has failed and speeds the repair time.

The ECM also has a fail-safe (limp home) mode which allows minimal engine function in the unlikely event of ECM failure.



IGNITION COIL

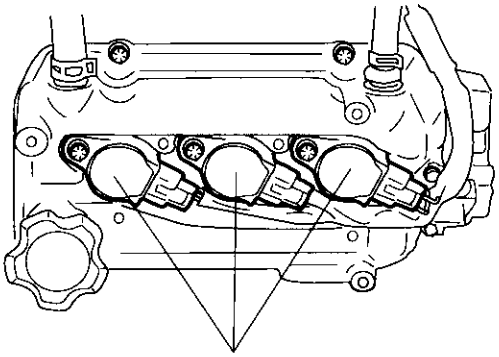


The ignition coils provide the high voltage necessary for ignition. They function similar to a normal (single coil) system with the difference of each coil being individually placed over a spark plug. The coil windings are protected by a molded plastic housing with weather–resistant wiring connections.

Each coil also contains power transistors which provide current switching and amplification.

When the ECM (Engine Control Module) allows the base current (IT signal) to flow to a transistor, the collector currrent flows and passes through the ignition coil primary circuit side.

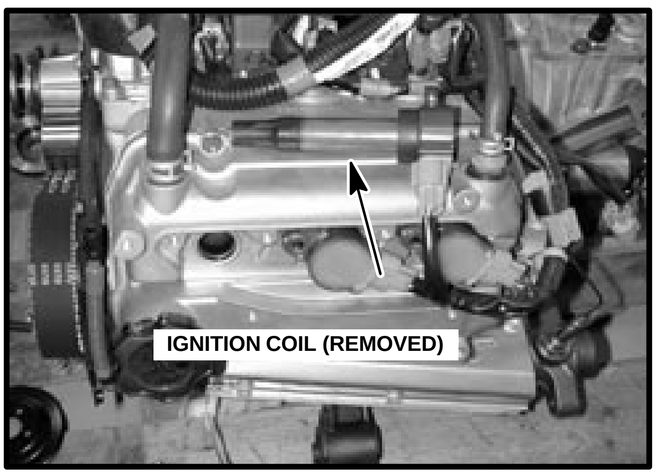
When the IT signal is switched off while current is passing through the primary coil, (current is abruptly shut off), a self–induction condition occurs and reverse electomagnetic force is generated. In conjection, mutual induction action operates and high voltage is generated by the secondary coil, producing current to the spark plug.



IGNITION COIL TEST

Ignition coil resistance (cold)	Primary	1.08–1.32 Ω
	Secondary	22.1–29.2 k/Ω

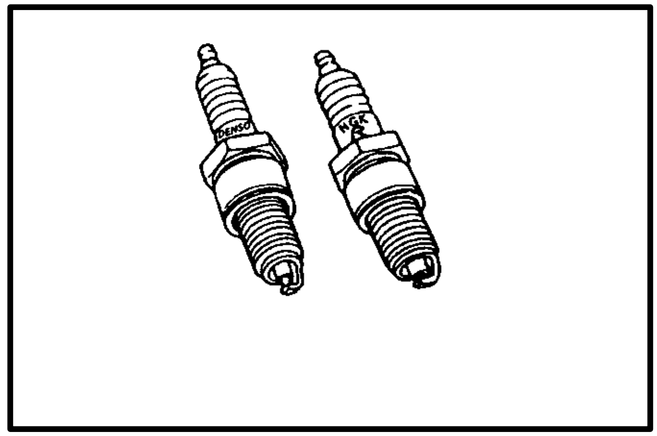
Measure primary and secondary coil resistances (at 20° C or 68° F). If the resistance is out of range in either the primary or secondary circuit, replace the ignition coil with a new one.



Using insulated pliers and current resistant work gloves, remove the suspect ignition coil. Use a new spark plug or one that is known to be a good spark plug. Insert the plug into the ignition coil (with ignition wiring still attached to the coil). Using gloves and insulated pliers, ground the plug against a convenient unpainted surface on the engine block.

Make absolutely certain that you are completely out of the way of hot or moving parts and nothing will fall into the engine when it starts. Have an assistant crank the engine or use a remote starting switch while closely observing the spark plug electrode. There should be a fat blue spark at each ignition sequence. If no spark or a weak yellow spark, replace the coil and try again.

SPARK PLUGS

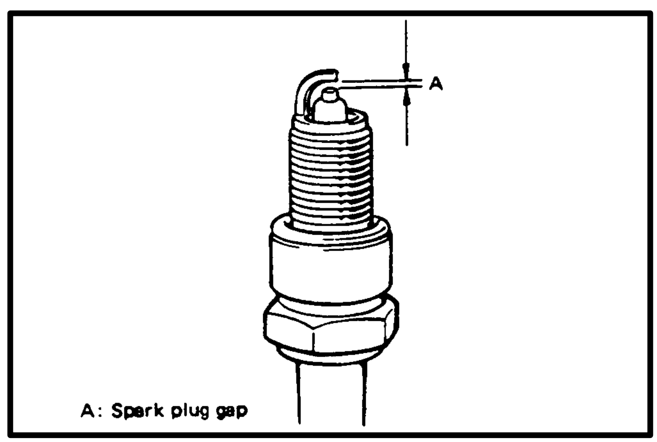


Manufacturer	Model	Plug gap (mm)
NGK	DCPR7E	0.8~0.9
Denso	XU22EPR–U	

To check spark plugs, remove ignition coils, then remove the spark plugs. Inspect the plugs for:

- Electrode wear
- Carbon deposits
- Insulator damage
- Spark plug gap

Remove any unusual deposits, adjust the plug gap , clean the plug with a spark plug cleaner or replace the plugs with new. In the event of insulation damage or sev-erly burned electrodes, oily deposits or other abnormal condition, replace the spark plugs.



Install spark plugs and torque them to specifications shown below

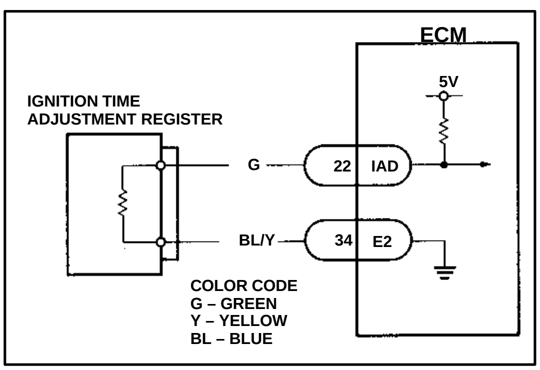
Spark plug torque	N–m	kg–m
	25–30	2.5–3.0

Condition	Possible Cause	Correction
Engine cranks, but will not start or hard to start	**No Spark** • Blown fuse for ignition coil • Loose connection or disconnection of lead wires • Faulty spark plug(s)	 Replace Connect securely Adjust, clean or replace
Poor fuel economy or engine performance	• Faulty spark plug(s)	Adjust, clean or replace

IGNITION TIMING ADJUSTMENT REGISTER

Ignition timing adjustment is performed by means of a register. The resistance is classified into a total of twelve types, and twelve stages of adjustment are possible.

Mark	1	2	3	4	5	6	7	8	9	10	11
Resistance	Low										High
Ignition timing	Delay										Advance



One end of the ignition timing adjustment register coupler is connected to the ”IAD” terminal connected to the 5 V power supply via a pull–up resistor inside the ECM, and the other end is grounded at the ”E2” terminal.

Depending upon the resistance of the register plugged into the register coupler, the ”IAD” terminal voltage of the ECM changes, and accordingly, the ECM determines which register has been plugged in, and performs fine adjustment of the ignition timing.

When advancing the ignition timing, adjustment is performed by replacement with a register having higher resistance, and when delaying the ignition timing, by replacement with a register having lower resistance.

IGNITION TIMING CONTROL

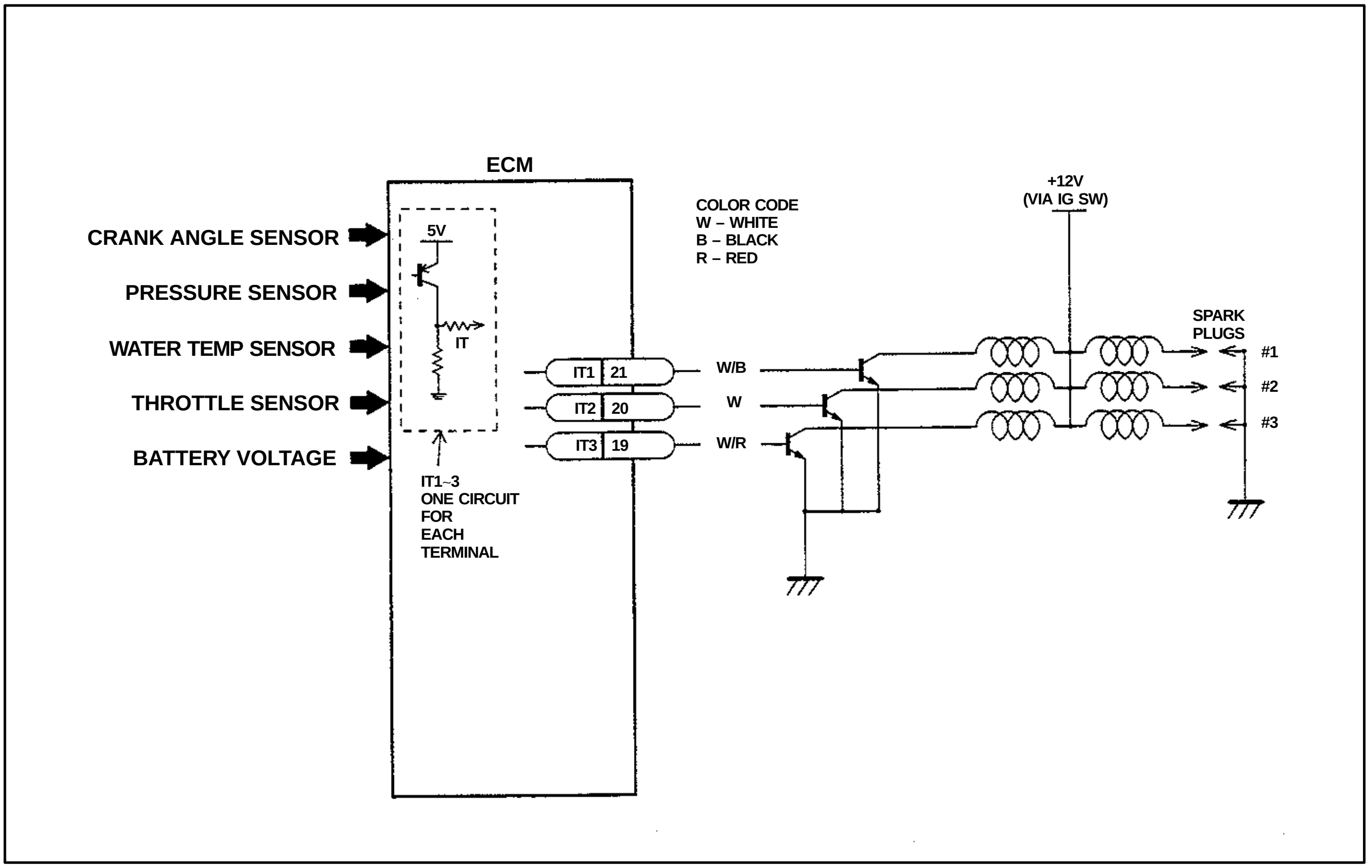
Low rpm (starting) mode: When the engine speed is 600 rpm or lower, ignition is adjusted to BTDC5°.

Connection occurs in the interval from 75° BTDC to 5° BTDC.

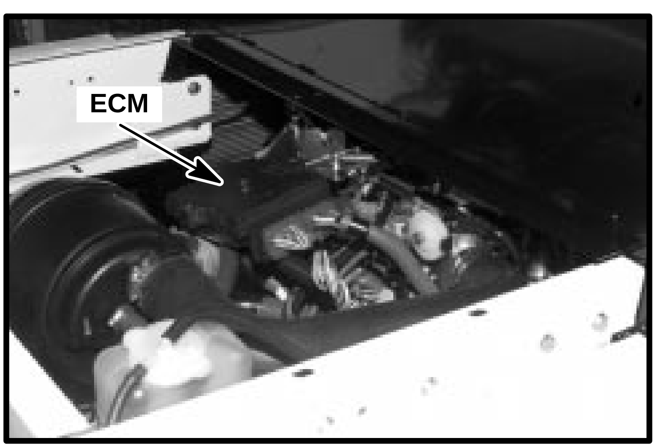
Ignition timing adjustment mode: When diagnositc jumper (P.N. 2700920) in place, the ignition timing is fixed at 5° BTDC.

Normal control mode: In normal ignition timing, the angle is danced or delayed by adding the following correction to the basic ignition timing, which is determined according to the engine rpm and intake air amount. However, these are controlled at 50° BTDC~10° ATDC (corresponding to the crank angle axis).

- Water temperature correction angle: Corrected according to the cooling water temperature. The angle is delayed when the cooling water temperature is high.
- Idle stabilization correction angle: Corrected according to rpm fluctuations during idling.



ENGINE CONTROL MODULE (ECM)



SECTION 9

FUEL SYSTEM

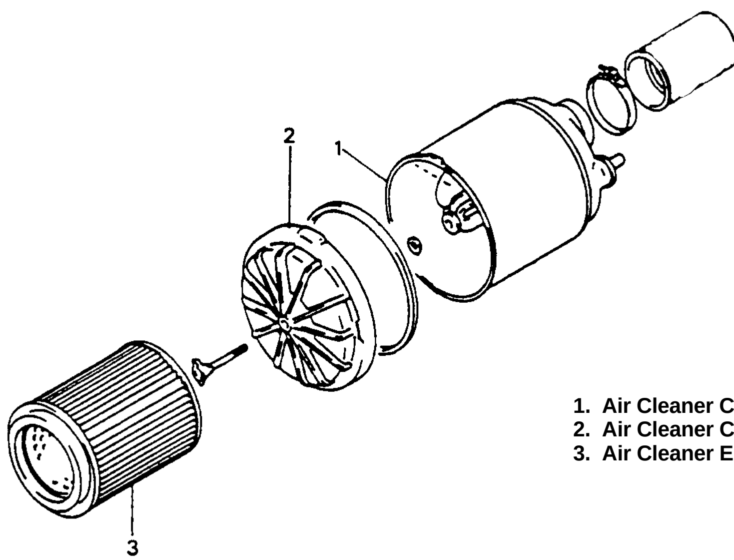
AIR CLEANER

GENERAL DESCRIPTION

In the air cleaner case, a dry–type air cleaner element is provided for filtering out dirt and dust from air being drawn into the engine for combustion.

A damaged element must be replaced with a new one, since it allows dust particles to enter the engine if used as it is. Such dust particles could cause wear to the engine inner parts and this further results in decreased power.

The filter element must be cleaned periodically. Dusty and dirty element causes decrease in power and increase in fuel consumption. A dusty element even after cleaning should be replaced with a new one.



1. Air Cleaner Case
2. Air Cleaner Case Cap
3. Air Cleaner Element

MAINTENANCE SERVICES

Air Cleaner Element

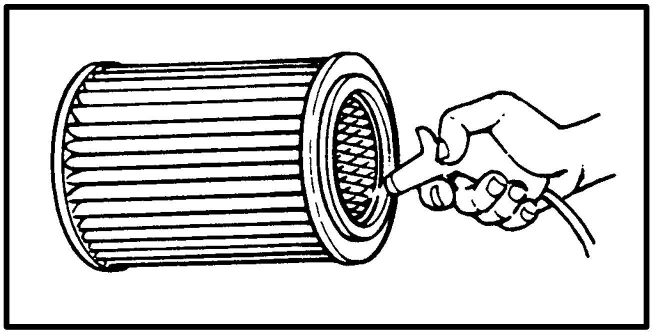
Air cleaner element should be cleaned or replaced periodically according to following method.

Cleaning

1) Remove engine access cover.

2) Remove air cleaner case cap.

3) Take out air cleaner element from air cleaner case and blow off dust with compressed air from inside of element.



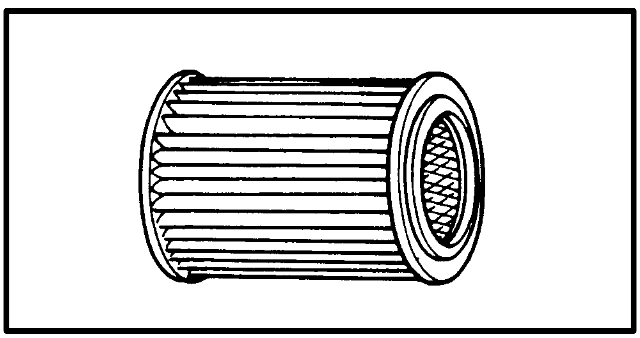
4) Install element and end cap.

Replacement

1) Remove engine access cover.

2) Remove air cleaner case cap.

3) Replace air cleaner element with a new one.



4) Install cap.

5) Check all hose connections to verify they are tight.

FUEL PUMP, FILTER AND LINES

GENERAL DESCRIPTION

The main components of the fuel system are fuel tank, fuel pump, fuel regulator and fuel filter; and it includes two lines; fuel feed and fuel vapor.

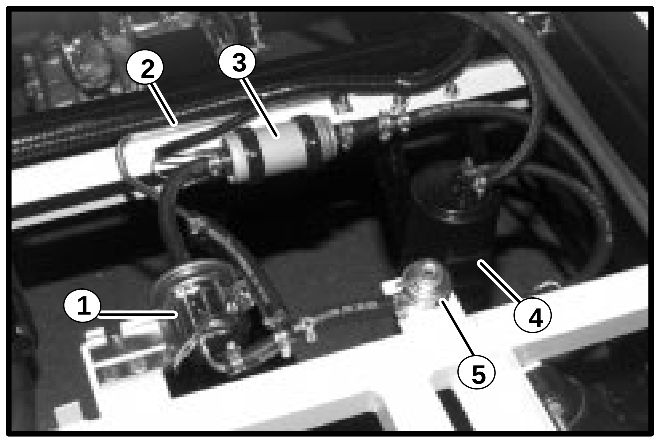
Fuel Pump

An electric fuel pump is mounted in the body cavity above and to the rear of the differential ; forward of the fuel tank.

Its operation is as follows:

When the ignition switch is turned “on”, electric current flows to the coil through the contactor and magnetizes it. As the magnetized coil attracts the plunger, rod and diaphragm, the fuel is drawn into the chamber through the inlet valve. When the rod is pulled up, the contactor cuts the electrical current, thereby the plunger rod and diaphragm are pushed down by the spring force. Then the fuel in the chamber pushes the outlet valve to open and is discharged through the outlet pipe.

By repeating the above operation, a constant amount of fuel is discharged at all times, regardless of driving conditions.



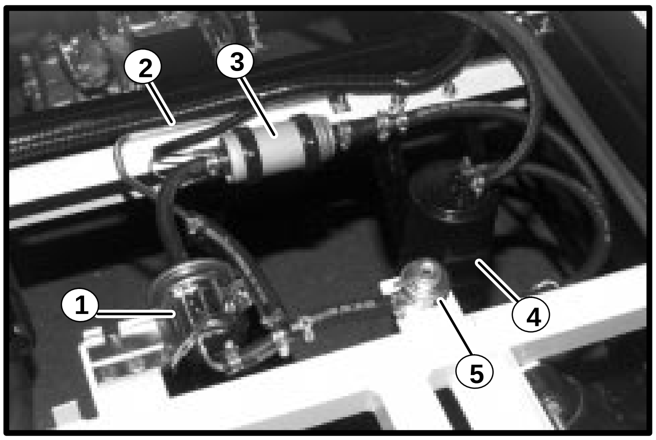
1. **Fuel Filter**
2. **Fuel Line**
3. **Fuel Pump**
4. **Carbon Canister**
5. **Regulator**

NOTE: Operating fuel line presure is 42 PSI.

Fuel Filter

Fuel filter is mounted on the chassis above the differential.

Fuel enters the filter through its inlet hole and after passing through the filtering element, comes out of its outlet hole connected to the fuel pump. This filter is not meant to be disassembled. It is of a cartridge type, consisting of a filtering element in a metal case.



1. **Fuel Filter**
2. **Fuel Line**
3. **Fuel Pump**
4. **Carbon Canister**
5. **Regulator**

WARNING

Before attempting service of any type on fuel system, the following cautions should be always observed.

Disconnect negative battery cable at battery.

DO NOT smoke, and place "NO SMOKING" signs near your work area.

Be sure to have a CO2 fire extinguisher on hand.

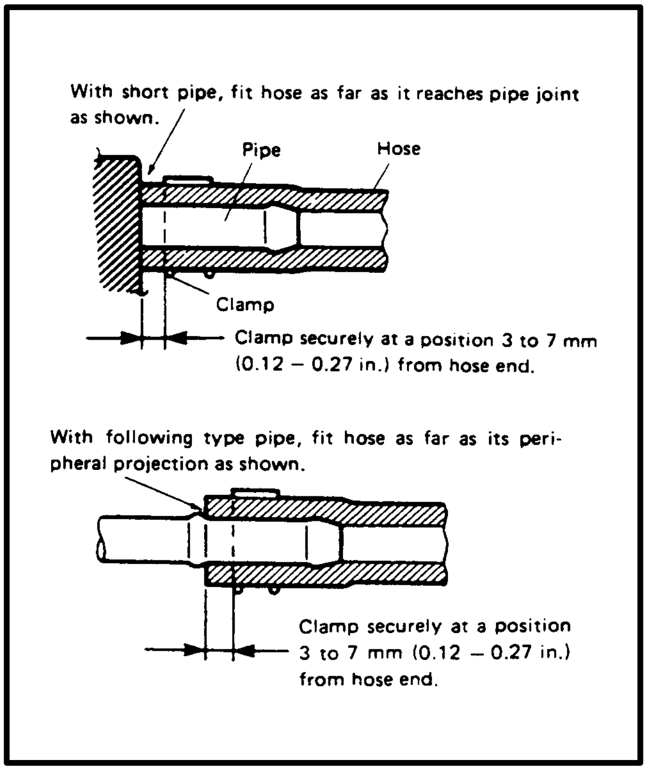
Be sure to perform work in a well ventilated area and away from any open flames (such as gas water heaters).

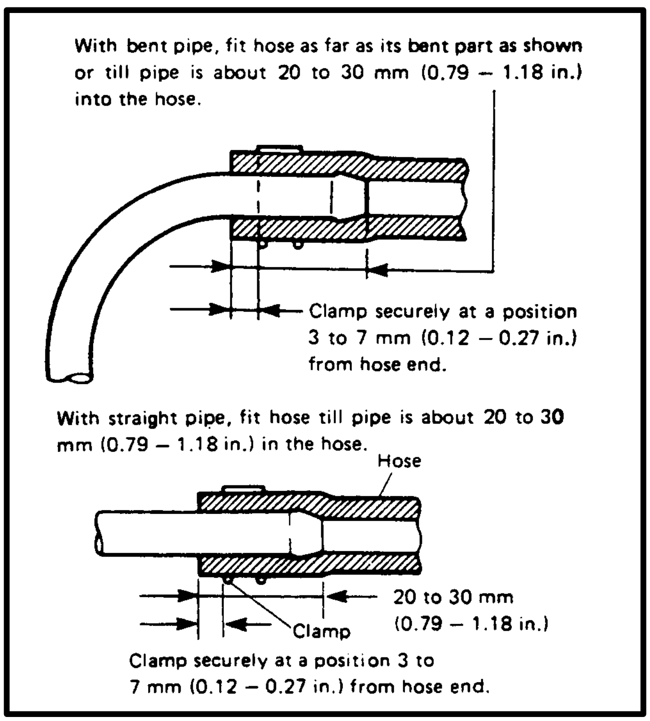
Wear safety glasses.

To relieve fuel vapor pressure in fuel tank, remove fuel filler cap from filler neck and then reinstall it.

A small amount of fuel may be released after the fuel line is disconnected. In order to reduce the chance of personal injury, cover the fitting to be disconnected with a shop cloth. Be sure to put that cloth in an approved container when disconnection is completed.

Note that fuel hose connection varies with each type of pipe. Be sure to connect and clamp each hose correctly referring to the following.





Fuel Pump

Removal

1) Disconnect negative battery cable.

2) Remove fuel filler can to release fuel vapor pressure in the fuel tank. After releasing, reinstall the cap.

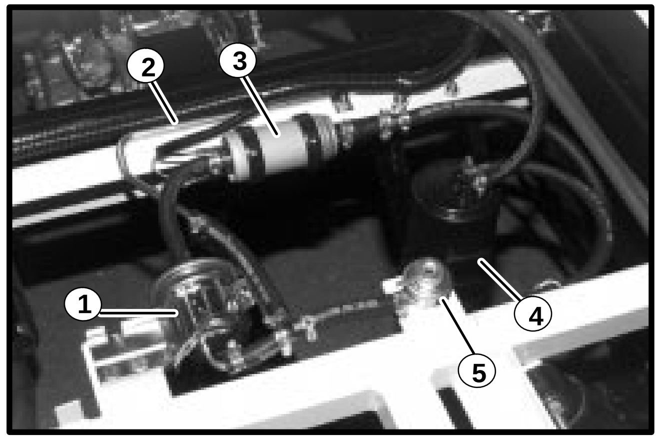
3) Disconnect fuel pump lead wires at the fuel pump.

NOTE:

There is a positive (+) and negative (–) wire, and a (+) positive indicator on the fuel pump.

4)Disconnect fuel inlet and outlet hose from fuel pump.

5) Remove fuel pump.



1. **Fuel Filter**
2. **Fuel Line**
3. **Fuel Pump**
4. **Carbon Canister**
5. **Regulator**

Installation

Reverse removal procedure for installation using care for the following.

- Make sure of proper hose connection

Fuel Filter

Removal

1) Remove negative battery cable.

2) Remove fuel filler cap from fuel filler neck to release fuel vapor pressure in fuel tank. After releasing, reinstall cap.

3) Hoist vehicle.

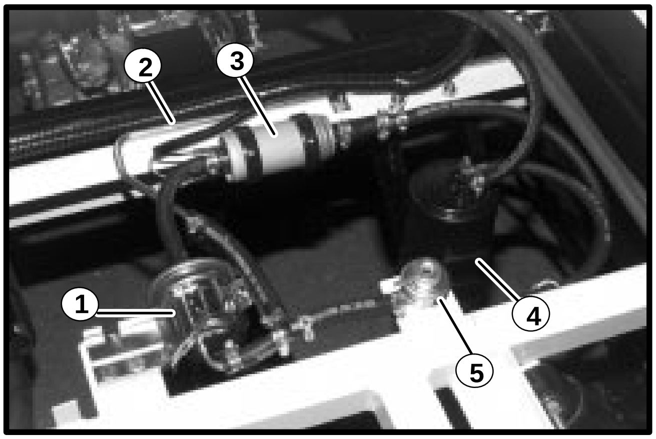
4) Place fuel container under fuel filter.

5) Disconnect inlet and outlet pipes from fuel filter by using two wrenches.

6) Remove fuel filter from body.

Installation

1) Install filter and clamp, and connect inlet and outlet hoses to fuel filter.



1. **Fuel Filter**
2. **Fuel Line**
3. **Fuel Pump**
4. **Carbon Canister**
5. **Regulator**

2) Connect negative cable to battery.

3) After installation, start engine and check system for leaks.

Fuel Tank

Removal

1) Disconnect negative battery cable from battery.

2) To release the pressure in fuel tank, remove fuel filler cap and then reinstall it.

3) Raise vehicle (refer to jacking instructions for safe procedures).

4) Disconnect fuel gauge electrical wiring.

5) As fuel tank has no drain plug, drain fuel by pumping fuel out through fuel filler neck. Use hand operated pump device to remove fuel.

6) Disconnect fuel return hose.

7) Disconnect fuel vapor hose.

NOTE:

Before finally removing fuel tank, recheck to ascertain all hoses and electric wires are disconnected and free.

8) Remove fuel tank.

Installation

Reverse removal procedure for installation using care for the following:

Refer to general description of this item for piping and clamp positions.

- Make sure for correct hose to pipe connection
- Clamp hoses securely.
- Upon completion of installation, start engine and check hose joints for leaks.

SECTION 10

COOLING SYSTEM

ENGINE COOLING SYSTEM

Radiator Cap

A pressure–vent cap is used on the radiator. The cap contains a pressure valve and vacuum valve. The pressure valve is held against its seat by a spring of pre–determined strength which protects the cooling system by relieving the pressure if the pressure in the cooling system rises above 0.9 kg/cm. (12.8 psi, 90 kPa). 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.

The cap has its face marked 0.9, which means that its pressure valve opens at 0.9 kg/cm. (12.8 psi, 90 kPa).

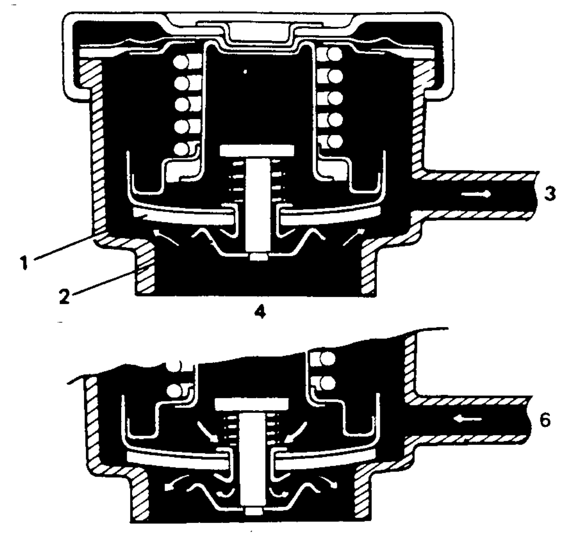
NOTE:

Do not remove radiator cap to check engine coolant level; check coolant visually with the see through coolant reservoir/overflow tank.

Coolant should be added only to reservoir tank as necessary.

WARNING

As long as there is pressure in the cooling system, the temperature can be considerably higher that 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 pressure is high will cause the solution to boil instantaneously and possibly with explosive force, spewing the solution over engine, vehicle and person removing cap.



1. Pressure valve
2. Vacuum valve
3. To water reservoir tank
4. Pressure relief
5. Vacuum relief
6. From water reservoir tank

Water Reservoir Tank

A "see through" plastic reservoir tank is connected to the radiator by a hose. As the vehicle is driven, the coolant is heated and expands. The portion of the coolant displaced by this expansion flows from the radiator into the reservoir tank. When the vehicle is stopped and the coolant cools and contracts, the displaced coolant is drawn back into the radiator by vacuum.

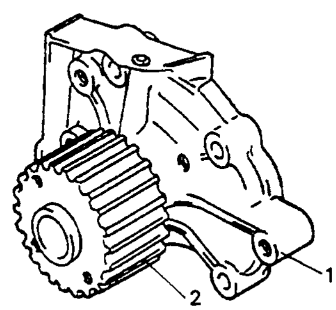
Thus, the radiator is kept filled with coolant to desired level at all times, resulting in increasing cool efficiency.

Coolant level should be between "FULL" and "LOW" marks on the reservoir tank.

Coolant should be added only to the reservoir tank as necessary.

Water Pump

The centrifugal type water pump is used in the cooling system. The pump impeller is supported by a totally sealed bearing. The water pump can not be disassembled.



1. Water pump
2. Water pump pulley

Thermostat

A wax pellet type thermostat is used in the coolant outlet passage to control the flow of engine coolant, to provide fast engine warm up and to regulate coolant temperatures.

A wax pellet element is hermetically contained in a metal case, and expands when heated and contracts when cooled.

When the pellet is heated and expands, the metal case pushes down the valve to open it.

As the pellet is cooled, the contraction allows a spring to close the valve.

Thus, the valve remains closed while the coolant is cold, preventing circulation of coolant through the radiator.

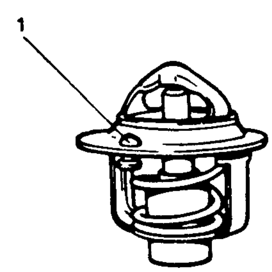
At this point, coolant is allowed to circulate only throughout the engine to warm is quickly and evenly.

As the engine warms, the pellet expands and the thermostat valve opens, permitting coolant to flow through the radiator.

In the top portion of the thermostat, and air bleed valve is provided; this valve is for venting out the gas or air, if any, that is accumulated in the circuit.

There are two types of thermostats, A and B, as given below. Either one is used depending on vehicle specifications. The temperature at which the valve begins to open is stamped of each thermostat. Be sure to note this stamped temperature for replacement.

Thermostat Functional Specifications		
	Thermostat "A"	**Thermostat "B"**
Temp. at which valve begins to open	82° C (179° F)	88° C (190° F)
Temp. at which valve becomes fully open	95° C (203° F)	100° C (212° F)
Valve Lift	More than 8 mm at 95° C	More than 8 mm at 100° C



1. Air bleed valve

COMPONENT REMOVAL

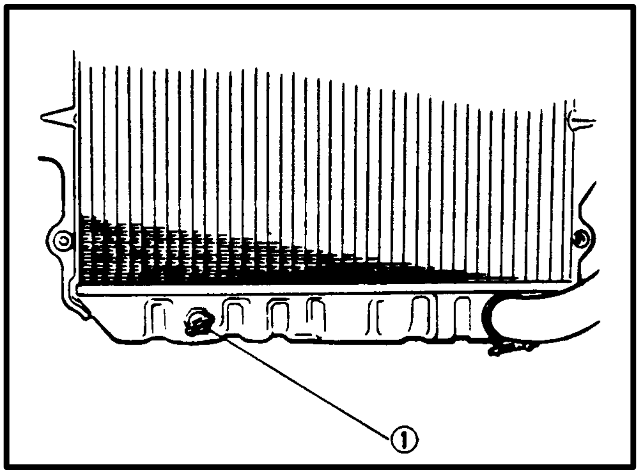
WARNING

- **Check to make sure that cooling water temperature is cold before removing any cooling system components.**
- **Make sure to disconnect the negative battery cable from the negative terminal of the battery before removing any parts.**

Coolant Draining

1) Remove radiator cap.

2)Loosen drain plug (1) on radiator to drain coolant.



Removal of Radiator Hoses

1) Drain cooling system

2) To remove the hoses, loosen the screw on each hose clamp and pull hose end off.

Alternator Belt

1) Loosen alternator drive belt tension

2) Remove alternator belt

Radiator Removal

1) Drain cooling system.

2) Disconnect engine cooling fan motor lead wire at coupler.

3) Disconnect radiator outlet hose from radiator.

4) Disconnect radiator inlet hose from radiator.

5) Remove radiator shroud securing bolts.

6) Remove cooling fan/motor and radiator shroud.

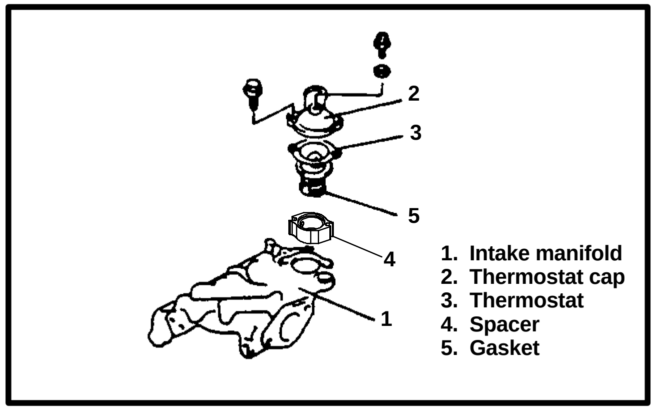
7) Remove radiator.

Thermostat Removal

1) Drain cooling system.

2) Disconnect thermostat cap from intake manifold.

3) Remove thermostat.



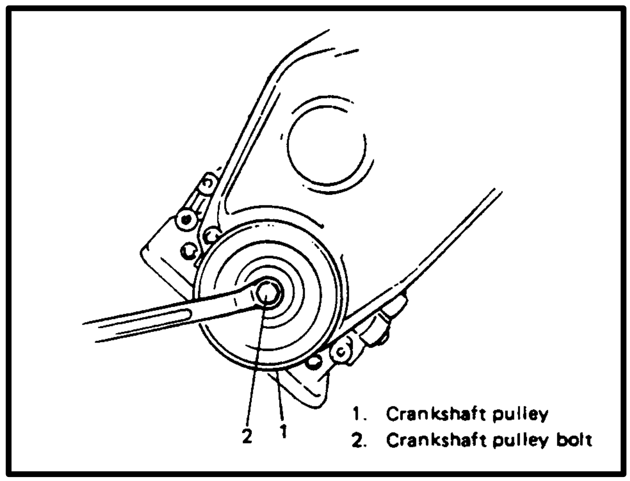
Water Pump Removal

1) Drain cooling system Refer to “Coolant Draining” on previous page.

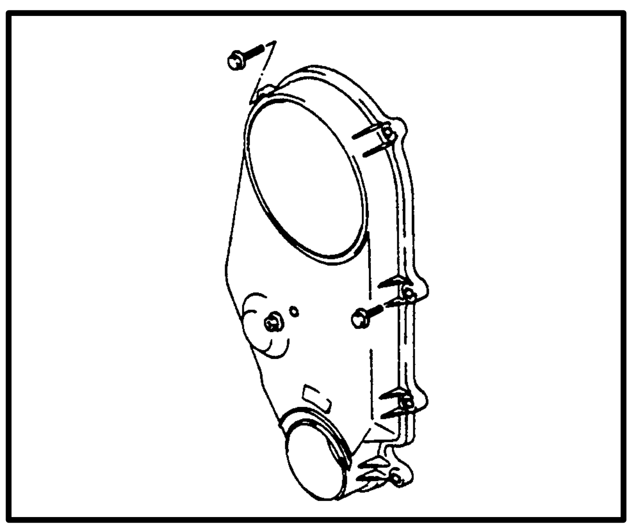
2) Disconnect negative battery cable from battery terminal.

3) Loosen water pump drive belt tension. Then remove water pump pulley and pump drive belt.

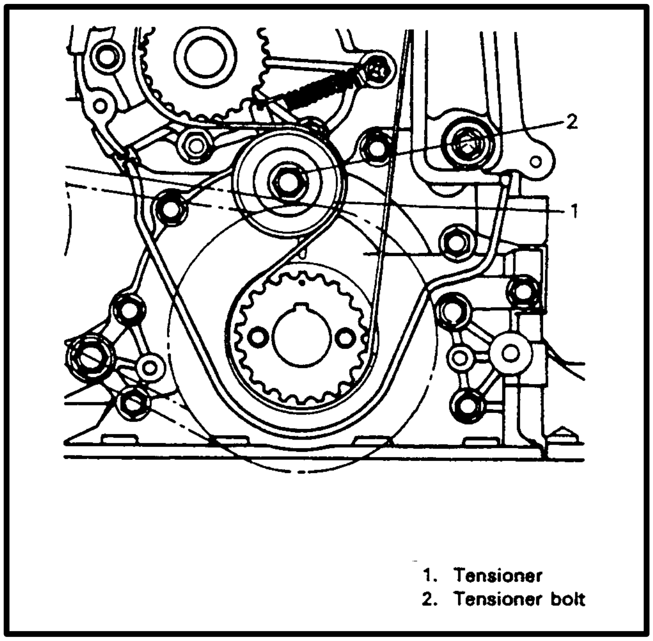
4) Remove crankshaft pulley.



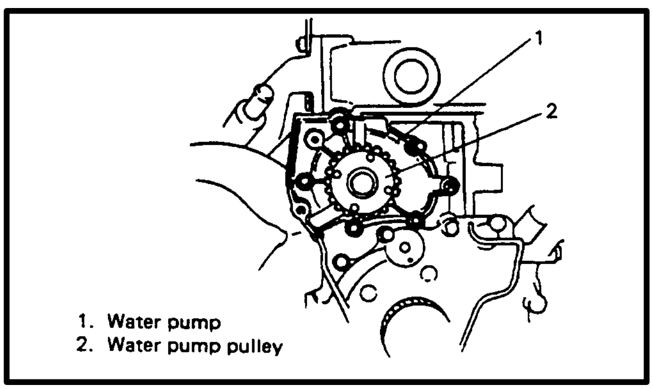
5) Remove timing belt outside cover.



6) Remove tensioner and timing belt.



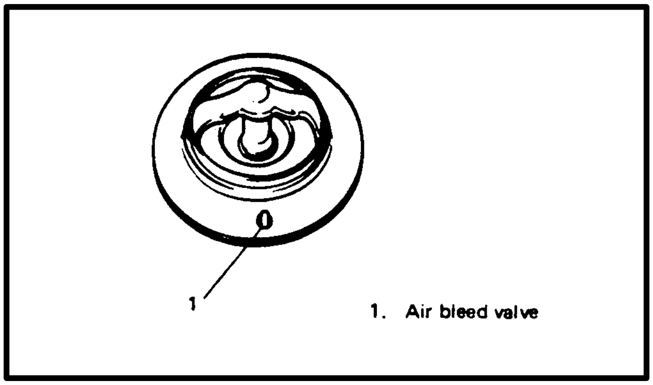
7) Remove water pump.



INSPECTION OF COMPONENTS

Thermostat

1) Make sure that the air bleed valve of thermostat is clear. Should this valve be clogged, engine would tend to overheat.



2) Check valve seat for some foreign objects being stuck which might prevent valve from seating tight.

NOTE:

Check interference between water tempature sensor and thermostat.

3) Check thermostatic movement of wax pellet as follows:

- **Immerse thermostat in water, and heat water gradually.**
- **Check the the valve starts to open at specified temperature.**
- **If valve starts to open at a temperature substantially below or above specification, thermostat unit should be replaced with a new one. such a unit, if re–used, will bring about overcooling or overheating tendency.**

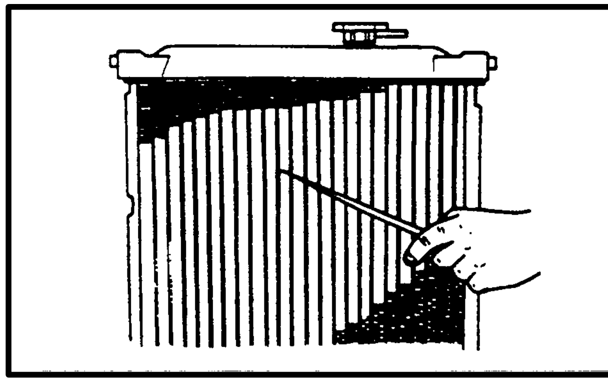
Radiator

If water side of the radiator is found excessively rusted or covered with scales, clean it by flushing with radiator cleaner compound. This flushing should be carried out at regular intervals due to scale or rust formation advancing with time.

Inspect radiator cores and straighten any flattened or bent fins. Clean cores, removing dirt and any debris.

Excessive rust or scale formation inside of radiator lowers cooling efficiency. Flattened or bent fins obstruct flow of air through the core to impede heat dissipation.

Radiator Flushing Interval	Two years (recommended)



Water Pump

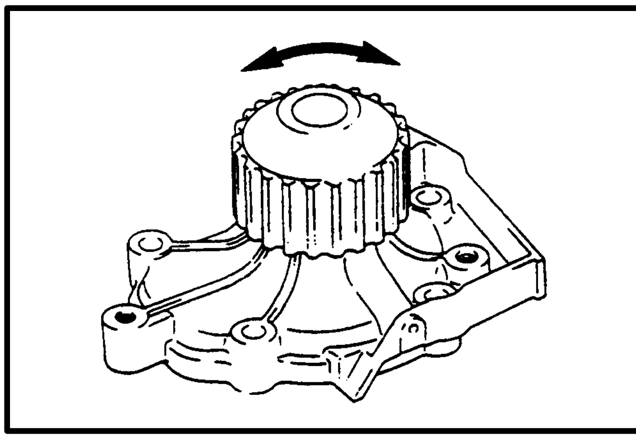
NOTE:

Do not disassemble water pump.

If any repair is required on pump, replace it as an assembly.

- **Rotate water pump by hand to check for smooth operation.**

If pump does not rotate smoothly or makes an abnormal noise, replace it.



IMPORTANT STEPS FOR REINSTALLATION

Water Pump

1) Install new pump gasket to cylinder block.

2) Install water pump to cylinder block.

Tightening torque for nuts and bolts	9–12 n–m 0.9–1.2 kg–m 7.0–8.5 lb–ft.

3) Remove cylinder head cover and loosen all valve adjusting screws of intake and exhaust rocker arms fully.

4) Install belt tensioner, tensioner spring, timing belt and outside cover.

NOTE:

- **Special care must be used when installing belt tensioner and timing belt. Be sure to refer to SECTION 3 of this manual.**
- **Torque each bolt and nut to specification.**

5) Install crankshaft pulley and pump drive belt.

6)Adjust intake and exhaust valve lashes. (For adjustment and related data, refer to SECTION 3 of this manual.

7) Adjust alternator belt tension. (Refer to SECTION 10 of this manual).

8) connect negative Θ cable at battery.

9) Fill cooling system

Thermostat

1) When positioning thermostat on intake manifold, be sure to bring its air bleed valve to front side of engine.

2) Install new gasket and thermostat cap to intake manifold

3) Fill cooling system.

Radiator

Install or connect radiator by reversing removal procedure, noting the following.

1) Tighten bolts securely for proper installation.

2) Install radiator shroud and cooling fan.

3) Tighten shroud bolts and fan nut.

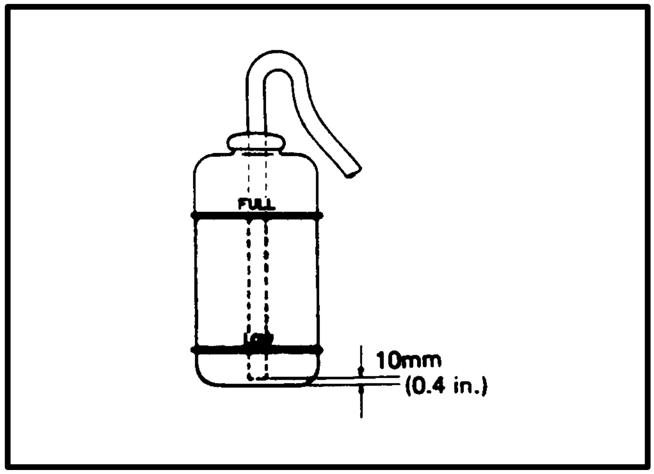
4) Connect radiator inlet and outlet hoses and fix joints of 2 hoses with clamps.

5) Adjust alternator belt tension.

6) Fill with specified amount of coolant.

NOTE:

Check to ensure that there is a clearance of 10 mm (0.40 in.) between the end of the rubber hose in the reservoir and the bottom of the reservoir.



Alternator Belt

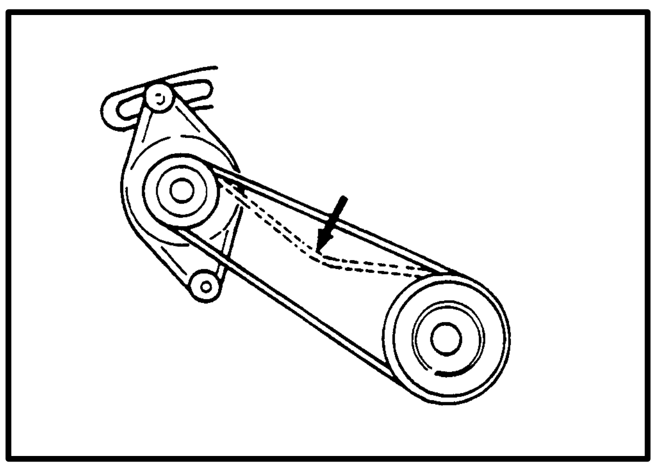
1) Inspect belts for cracks, cuts, deformation, wear and cleanliness. If necessary, replace the belt.

2) Check belt for tension. The belt is in proper tension if it deflects 11 to 14 mm (0.43–0.55 in.) under thumb pressure (about 10 kg or 22 lbs.).

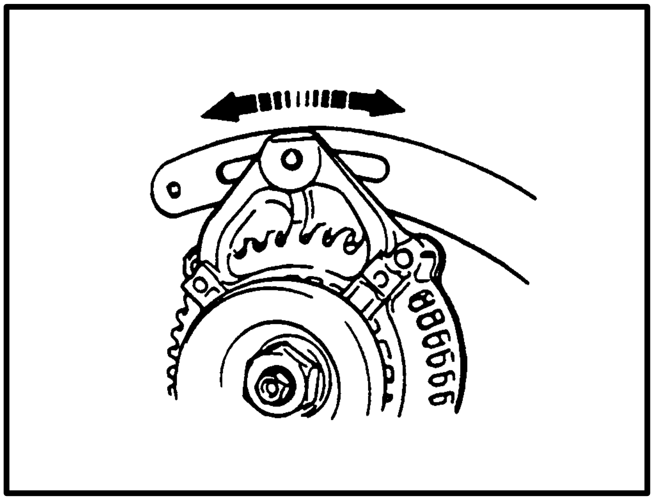
Belt tension specification	11–14 mm (0.43–0.55 in.) as deflection

NOTE:

When replacing the belt with a new one, adjust belt tension to 10–12 mm (0.28–0.47 in.).



2) If belt is too tight or too loose, adjust it to proper tension by adjusting alternator.



3) Tighten alternator adjusting bolt and pivot bolts.

4) If it is necessary to replace belt, refer to SECTION 10 for procedure.

WARNING

All adjustments described above are to be performed with ENGINE NOT RUNNING.

Coolant

The coolant recovery system is standard. The coolant in the radiator expands with heat, and the overflow is collected in the reservoir tank.

When the system cools down, the coolant is drawn back into the radiator.

The cooling system has been filled at the factory with a quality coolant that is a 50/50 mixture of water and \ethylene glycol antifreeze.

This 50/50 mixture coolant solution provides freezing protection to –36°C (–33°F)

- **Maintain cooling system freeze protection at –36°C (–33°F) to ensure protection against corrosion and loss of coolant from boiling. This should be done even if freezing temperatures are not expected.**

- **Add ethylene glycol base coolant when coolant has to be added because of coolant loss or to proved added protection against freezing at temperatures lower than –36°C (–33°F).**

ANTI–FREEZE PROPORTIONING CHART

Freezing Temperature	**°C**	**–16**	**–36**
	°F	**3**	**–33**
Antifreeze/ coolant concentration	**%**	**30**	**50**

COOLANT CAPACITY	
Engine, radiator and heater	4.2 liters (8.9/7.4 US/Imp pt.)
Reservoir tank	0.5 liters (1.1/0.9 US/Imp pt.)
Total	4.7 liters (10.0/8.3 US/Imp pt.)

NOTE:

- **Alcohol or methanol base coolants or plain water alone should not be used in cooling system at any time, as damage to to cooling system could occur.**

- **Even in an area where no freezing temperatures is anticipated, mixture of 70% water and 30% ethylene glycol antifreeze (Anti–freeze/Anticorrosion coolant) should be used for the purpose of corrosion protection and lubrication.**

Coolant Level

To check level, remove seat and look at “see through” water reservoir tank.

WARNING

To help avoid danger of being burned:

- **do not remove reservoir tank cap while coolant is “boiling”.**
- **do not remove radiator cap while engine and radiator are still hot.**

Scalding fluid and steam can be blown out under pressure if either cap is taken off too soon.

When engine is cool, check coolant level in reservoir tank. Abnormal coolant level should be between “FULL” and “LOW” marks on reservoir tank.

If coolant level is below “low mark, remove reservoir tank cap and add proper coolant to tank to bring coolant level up to “FULL” mark. Then, reinstall cap.

NOTE:

If proper quality antifreeze is used, there is no need to add extra inhibitors or additives that claim to improve system. They may be harmful to proper operation of system, and are unnecessary expense.

Cooling System Service

Cooling system should be serviced as follows:

1) Check cooling system for leaks or damage.

2) Wash radiator cap and filler neck with clean water by removing radiator cap when engine is cold.

3) Check coolant for proper level and freeze protection.

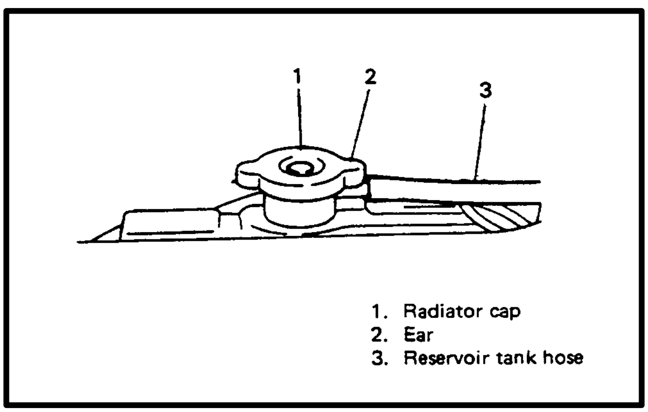
4) Using a pressure tester, check system and radiator cap for proper pressure holding capacity 0.9 kg/cm2 (12.8 psi, 90 kPa). If replacement of cap is required, use proper cap specified for this vehicle.

5) Tighten hose clamps and inspect all hoses. replace hoses whenever cracked, swollen or otherwise deteriorated.

6) Clean frontal area of radiator core.

NOTE:

After installing radiator cap to radiator, make sure that its ear is aligned with reservoir tank hose as shown in figure. If not, turn cap more to align its ear with hose.



Installation of radiator cap

Cooling System, Flush and Refill

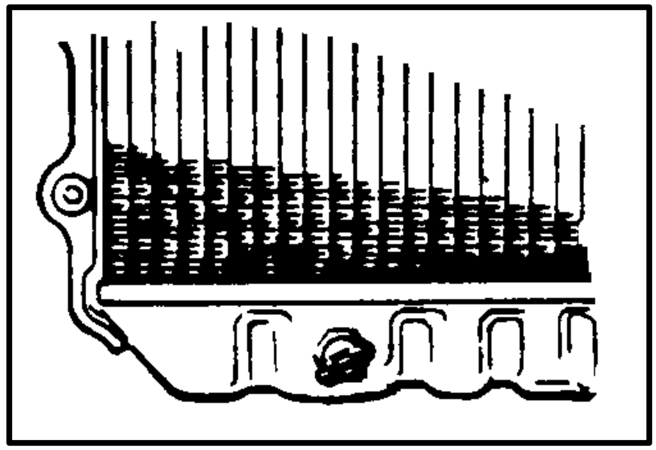
1) Remove radiator cap when engine is cool:

WARNING

To help avoid danger of being burned, do not remove radiator cap while engine and radiator are still hot. Scalding fluid and steam can be blown out under pressure if cap is taken off too soon.

2) With radiator cap removed, run engine until upper radiator hose is hot (this shows that the thermostat is open and coolant is flowing through system).

3) Stop engine and open radiator drain plug to drain coolant.



Radiator Drain Plug

4) Close drain plug. Add water until system is filled and run engine until upper radiator hose is hot again.

5) Repeat steps 3) and 4) several times until drained liquid is nearly colorless.

6) Drain system and the close radiator drain plug tightly.

7) Disconnect hose from water reservoir tank. Remove tank and pour out any fluid. Scrub and clean inside of tank with soap and water. Flush it well with clean water and drain. Reinstall tank and hose.

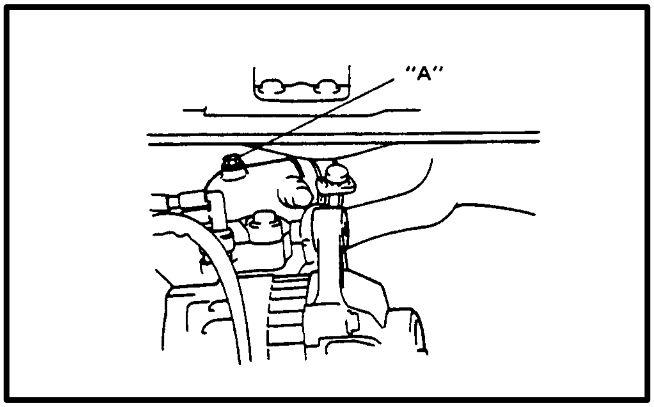
8) Add proper mixture coolant (refer to page) of good quality ethylene glycol anti–freeze and water to radiator and tank. Fill radiator to the base of radiator filler neck and reservoir tank to "FULL" level mark. Reinstall reservoir tank cap.

9) Loosen air bleeding bolt "A" on engine side and after making sure that coolant has come out through the air bleeding hole of bolt "A", tighten bolt "A". (Radiator should be always kept full of coolant).

CAUTION

Be sure to replace old gasket used for bolt "A" with new one.

Tightening torque for bolt "A"	2–4 N–m 0.2–0.4 kg–m 1.5–2.5 lb–ft.



10) Run engine, with radiator cap removed, until radiator upper hose is hot.

11) With engine idling, add coolant to radiator until level reaches the bottom of filler neck. Install radiator cap, making sure that its ear lines up with reservoir tank hose.

SECTION 11

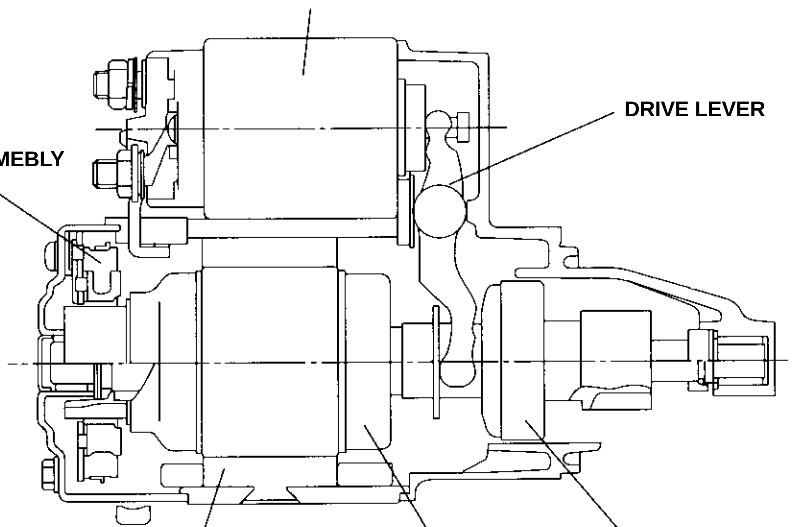
CRANKING SYSTEM

CRANKING SYSTEM

The cranking system is mainly composed of the battery, starting motor, ignition switch, and inhibitor switch (AT models).

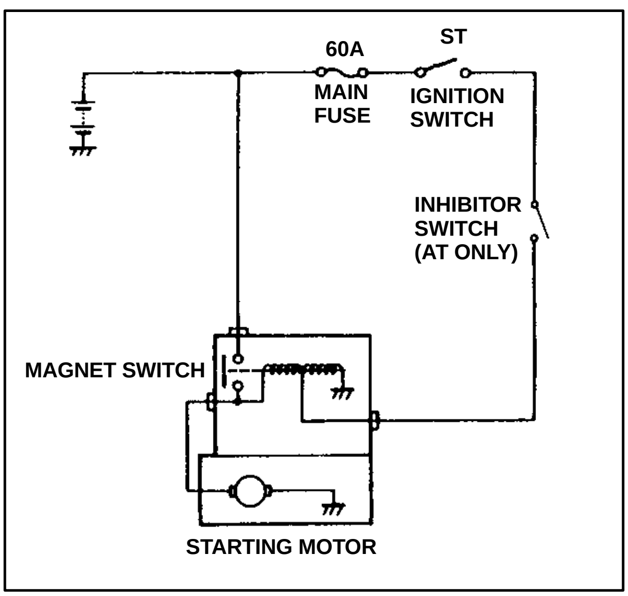
Starting Motor

The starting motor uses a solenoid shift type.



Specifications

	MT Models	AT Models
Maker	Mitsubishi Electric Motor	
Type	Solenoid shift type	
Output (kW)	0.6	0.8



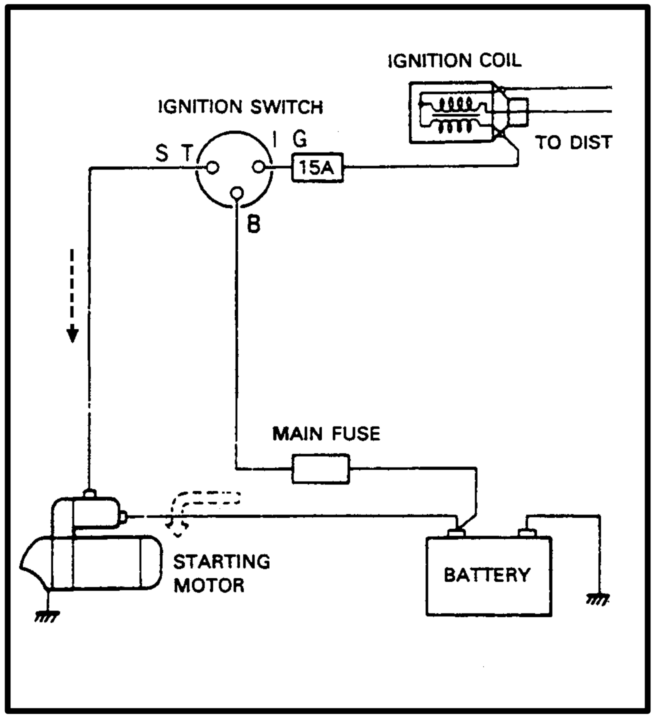
Operation

When the ignition switch is in the ST (start) position (in AT models, inverter SW also is ON), the coil of the magnetic switch is magnetized, the plunger and drive lever move, and the pinion engages with the flywheel gear of the engine. At this time, the magnet switch is also in an ON state, and the engine starts. When the engine is started, while the ignition switch is in the ST position, the pinion one–way clutch prevents the speed of the armature from increasing excessively, and when the switch is removed from the ST position, the plunger is returned by a return spring inside the magnet switch, and engagement with the pinion is released.

CRANKING CIRCUIT

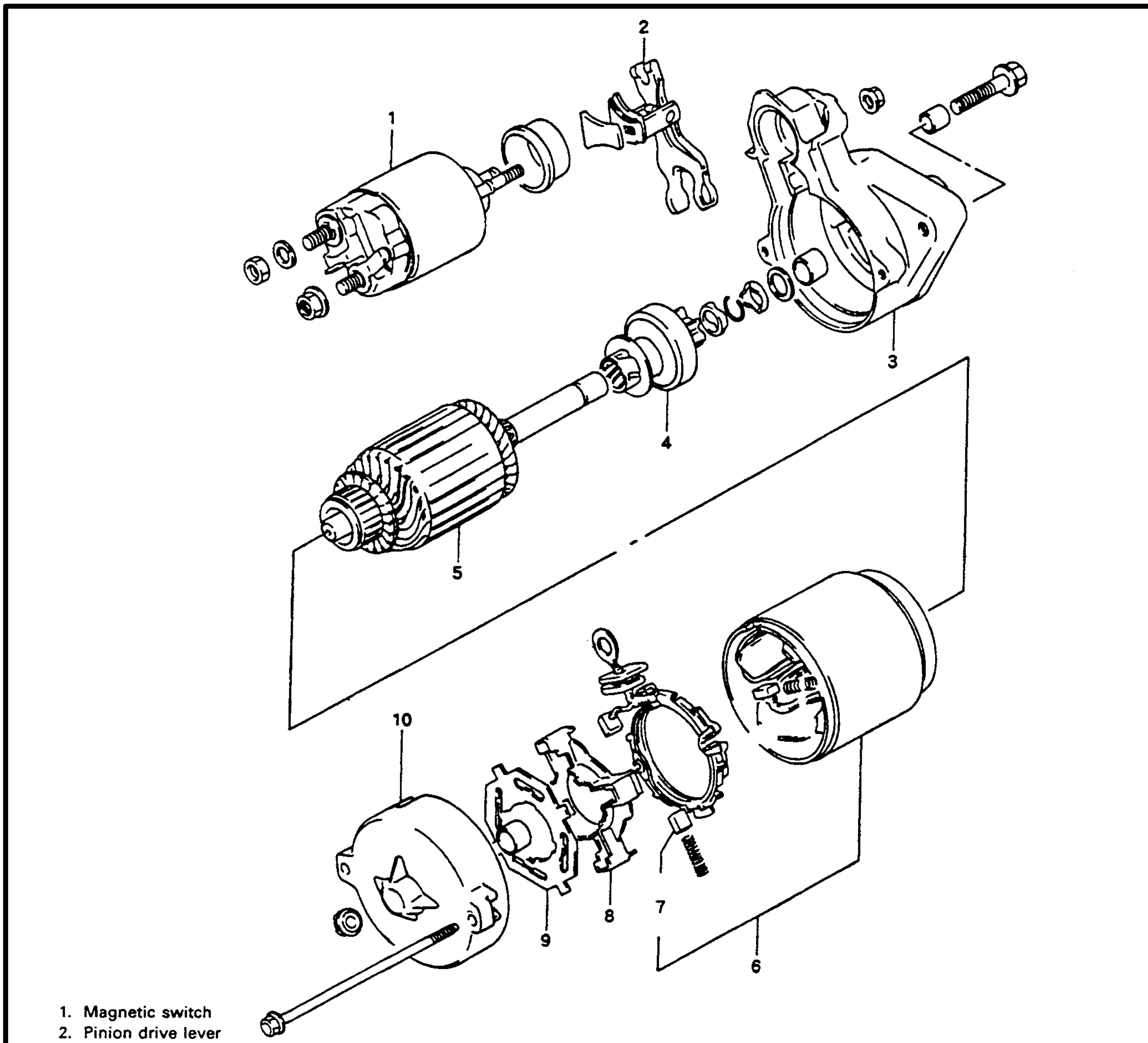
The cranking circuit consists of the battery, starting motor, ignition switch, and related, electrical wiring. These components are connected electrically as shown in the figure. Only the starting motor will be covered in this section.

MANUFACTURER	NIPPONDENSO
OUTPUT	0.6 kW



STARTING MOTOR

The starting motor consists of parts shown below and has permanent magnets mounted in the starter motor yoke (housing). The magnetic switch assembly and parts in the starting motor are enclosed in the housing so that they will be protected against possible dirt and water exposure. In the circuit shown in figure on page , the magnetic (motor) switch coils are magnetized when the ignition switch is closed. The resulting plunger and pinion drive lever movement causes the pinion to engage the flywheel gear and the magnetic switch main contacts to close, and cranking takes place. When the engine starts the pinion over–running clutch protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage.



1. Magnetic switch
2. Pinion drive lever
3. Drive housing assembly
4. Overrunning clutch assembly
5. Armature
6. Yoke assembly
7. Brush holder assembly
8. Brush holder
9. Insulator
10. Commutator end housing assembly

Possible symptoms do to starting system trouble would be as follows:

- Starting motor does not run (or runs slowly)
- Starting motor runs but fails to crank engine
- Abnormal noise is heard

Proper diagnosis must be made To determine exactly where the cause of each trouble lies, in battery, wiring harness, (including ignition switch), starter motor or engine. Check the following items and narrow down scope of possible causes.

- Condition of trouble
- Tightness of battery terminals (including ground cable connection on engine side) and starter motor terminals
- Discharge of battery

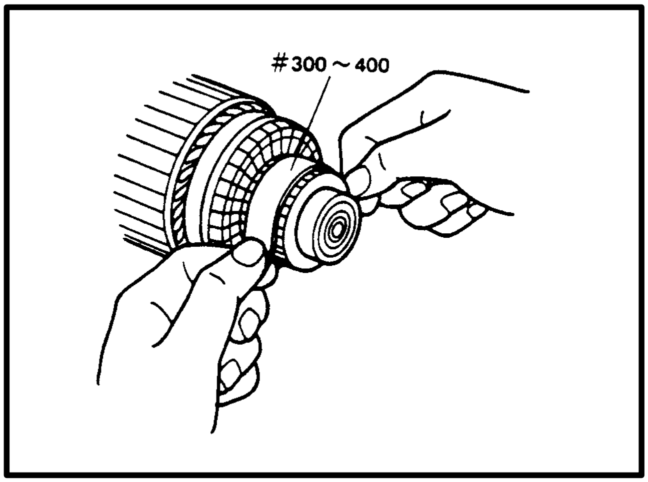
Condition	Possible Cause	Correction
Motor Not Running	**No operating sound of magnetic switch**	
	1. Dead battery	Recharge Battery
	2. Battery voltage too low due to battery deterioration	Replace battery
	3. Poor contact in battery terminal connection	Retighten or replace
	4. Loose grounding cable connection	Retighten
	5. Fuse loose or blown	Tighten or replace
	6. Poor contacting action of ignition switch	Replace
	7. Lead wire coupler loose in place	Retighten
	8. Open–circuit between ignition switch and magnetic switch	Repair
	9. Open–circuit in pull–in coil	Replace magnetic switch
	10. Poor sliding of plunger	Replace
Motor Not Running	**Operating sound of magnetic switch heard**	
	1. Dead Battery	Recharge battery
	2. Battery voltage too low due to battery deterioration	Replace battery
	3. Loose battery cable connections	Retighten
	4. Burnt main contact point, or poor contacting action of magnetic switch	Replace magnetic switch
	5. Brushes not seated properly or worn out	Repair or replace
	6. Weakened brush spring	Replace
	7. Burnt commutator	Replace
	8. Poor grounding of field coil	Repair
	9. Layer short–circuit of armature	Replace
	10. Crankshaft rotation obstructed	Repair

Condition	Possible Cause	Correction
Starter motor running too slow (low torque)	**If battery and wiring are satisfactory, inspect starter motor**	
	1. Insufficient contact of magnetic switch main contacts	Replace
	2. Layer short–circuit of armature	Replace
	3. Disconnected, burnt or worn commutator	Repair or replace
	4. Poor grounding of field coil	Repair
	5. Worn brushes	Replace
	6. Weakened brush springs	Replace spring
	7. Burnt or abnormally worn end bushings	Replace
Starter motor runs, but does not crank engine	1. Worn pinion tip	Replace starter drive
	2. Poor sliding of starter drive	Replace
	3. Starter drive slipping	Replace
	4. Worn teeth on ring gear	Replace flywheel
Noise	1. Abnormally worn bushings	Replace
	2. Worn pinion or ring gear	Replace pinion or flywheel
	3. Poor sliding of pinion (failure in return movement)	Repair or replace
Starter motor does not stop running	1. Fused contact points of magnetic switch	Replace
	2. Short–circuit between turns of magnetic switch coil (layer short–circuit)	Replace
	3. Failure of returning action in ignition switch	Replace

STARTER MOTOR INSPECTION

INSPECT ARMATURE

Inspect commutator for dirt or burn. Correct with emery cloth or lathe, if necessary.

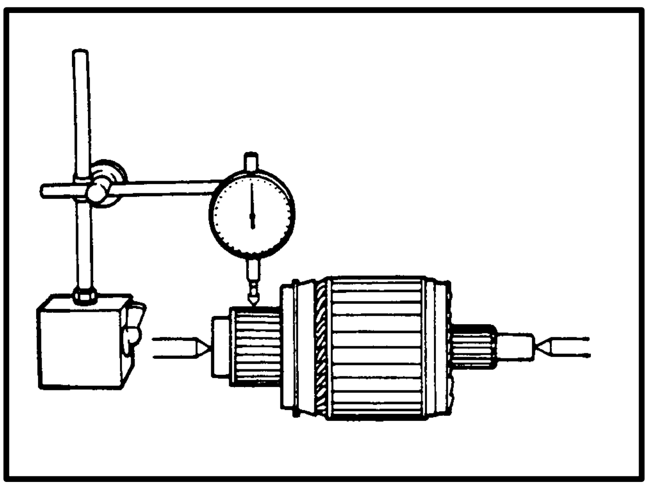


Check commutator for uneven wear. If deflection of dial gauge pointer exceeds limit, repair or replace.

NOTE:

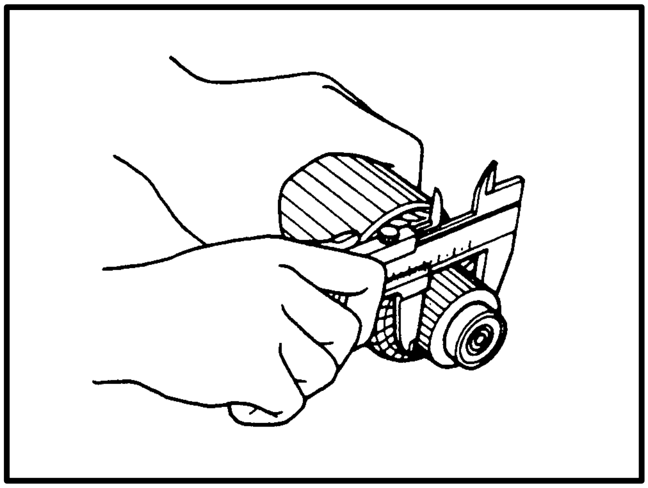
Below specification presupposes that armature is free from bend. Bent shaft must be replaced.

	Standard	Limit
Commutator out of round	0.05 mm (0.0019 in.) or less	0.4 mm (0.015in.)



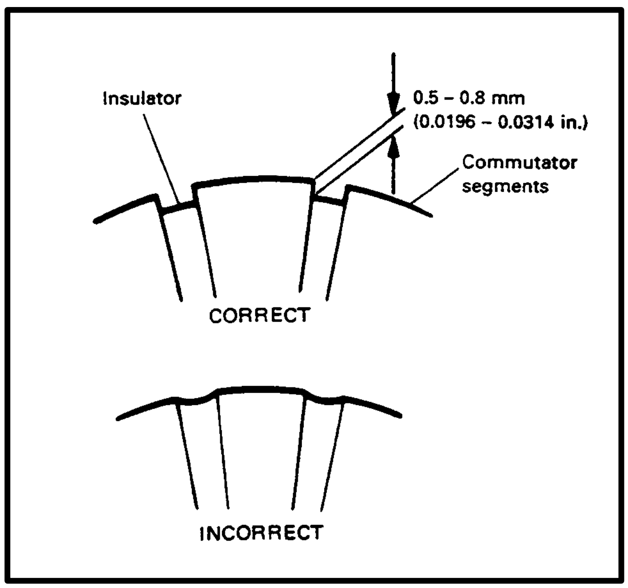
Inspect commutator for wear. If below the limit, replace armature.

	Standard	Limit
Commutator outside diameter	29.4 mm (1.16 in.)	28.8 mm (1.14 in.)



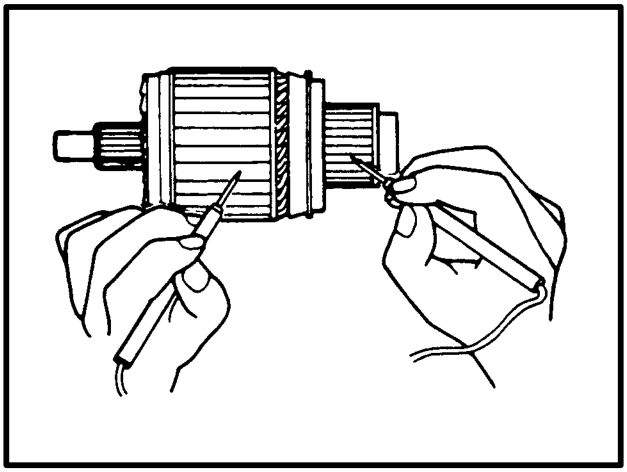
Inspect commutator for mica depth. correct or replace if below the limit.

	Standard	Limit
Commutator mica depth	0.5–0.8 mm (0.0196–0.0314 in.)	0.2 mm (0.0078 in.)



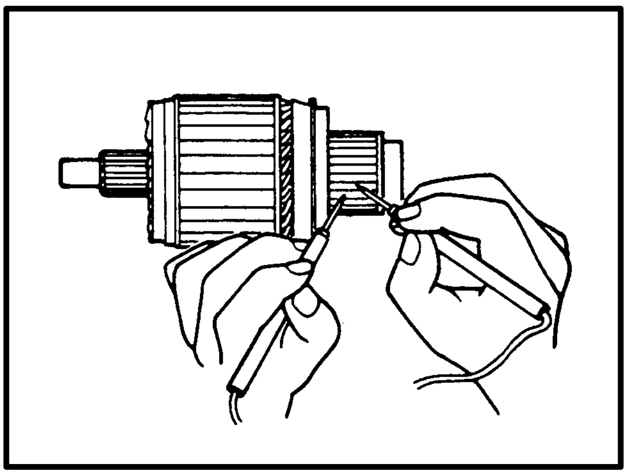
Ground Test

Check commutator and armature core. If there is continuity, armature is grounded and must be replaced.



Open Circuit Test

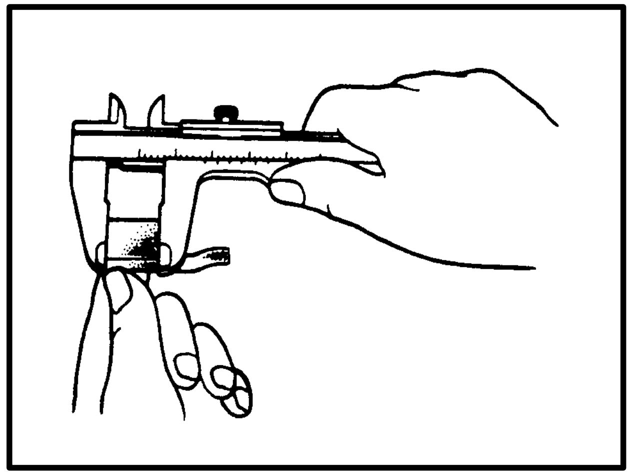
Check for continuity between segments, If there is no continuity at any test point, there is an open circuit and armature must be replaced.



INSPECT BRUSHES

- Check brushes for wear. If below the limit, replace the brush.

Maker	Standard	Limit
Nippondenso	17.5 mm (0.69 in.)	12 mm (0.48 in.)



- Install brushes to each brush holder and check for smooth movement.

PERFORMANCE TEST

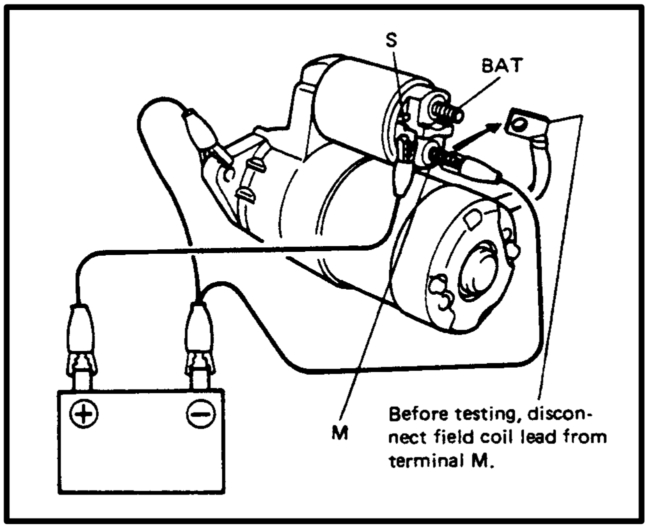
 **CAUTION**

These tests must be performed within 3–5 seconds to avoid burning out coil.

Pull–in Test

Connect battery to magnetic switch as shown. Check that plunger moves outward.

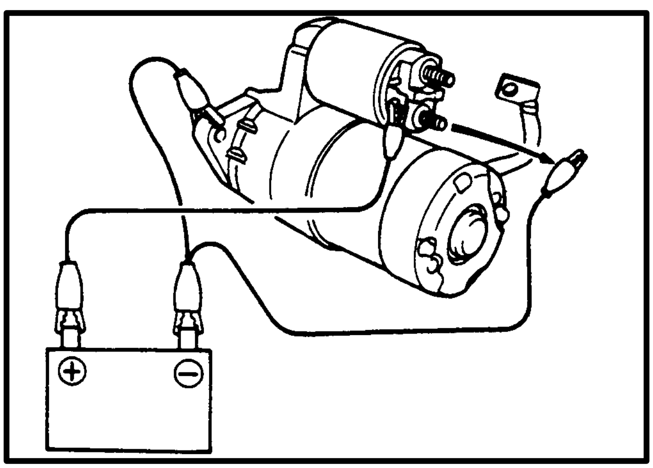
If plunger does not move, replace the starter solenoid.



Hold–In test

While connected as above with plunger out, disconnect negative lead from terminal “M”. check that plunger remains out.

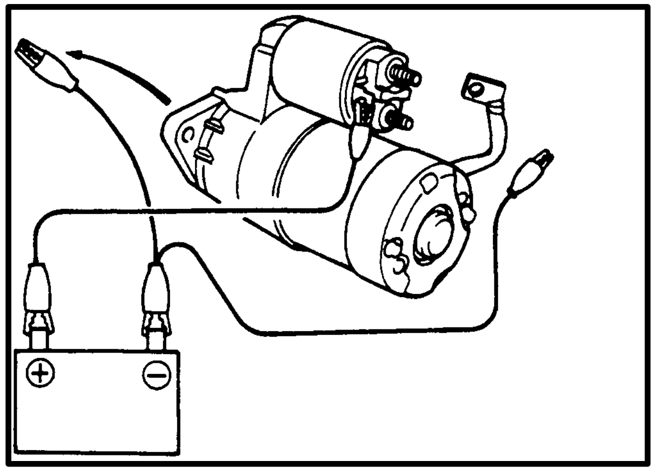
If plunger returns inward, replace the solenoid.



Check Plunger Return

Disconnect negative lead from switch body. Check that plunger returns inward.

If plunger does not return, replace the solenoid.

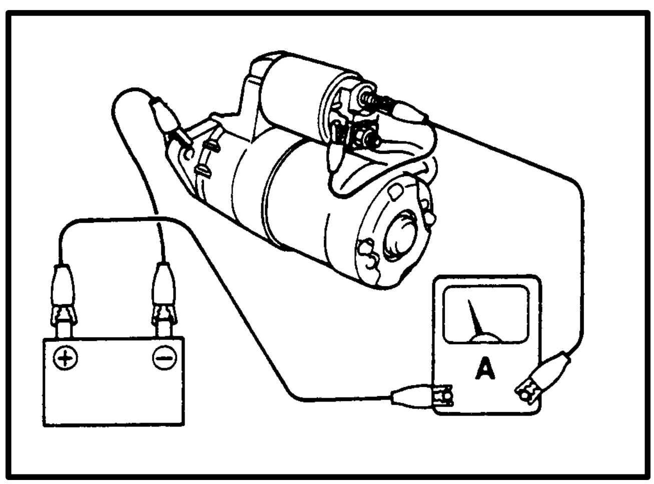


NO–LOAD PERFORMANCE TEST

a) Connect battery with ammeter to starter as shown.

b) Check that starter rotates smoothly and steadily with pinion moving out. check that ammeter reads the specified current.

Specified Current
Less than 50 A at 11V (Nippondenso)



SECTION 12

CHARGING SYSTEM

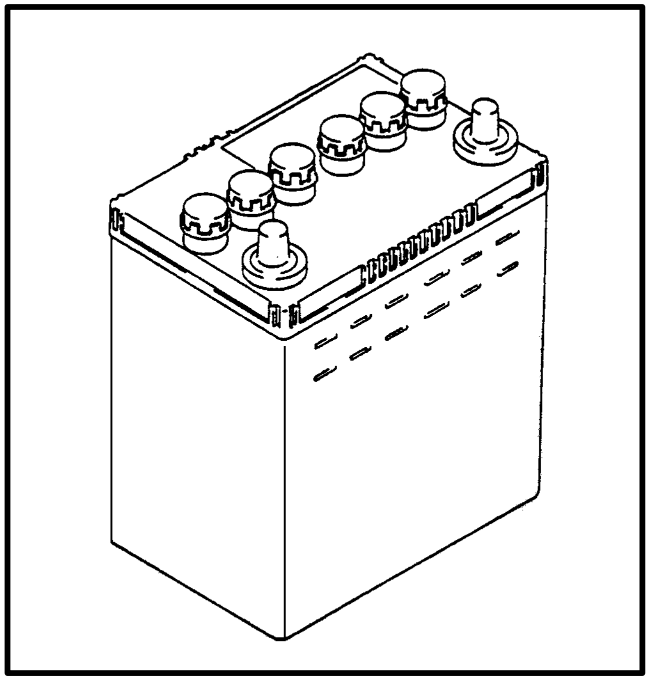
ALTERNATOR DESCRIPTION

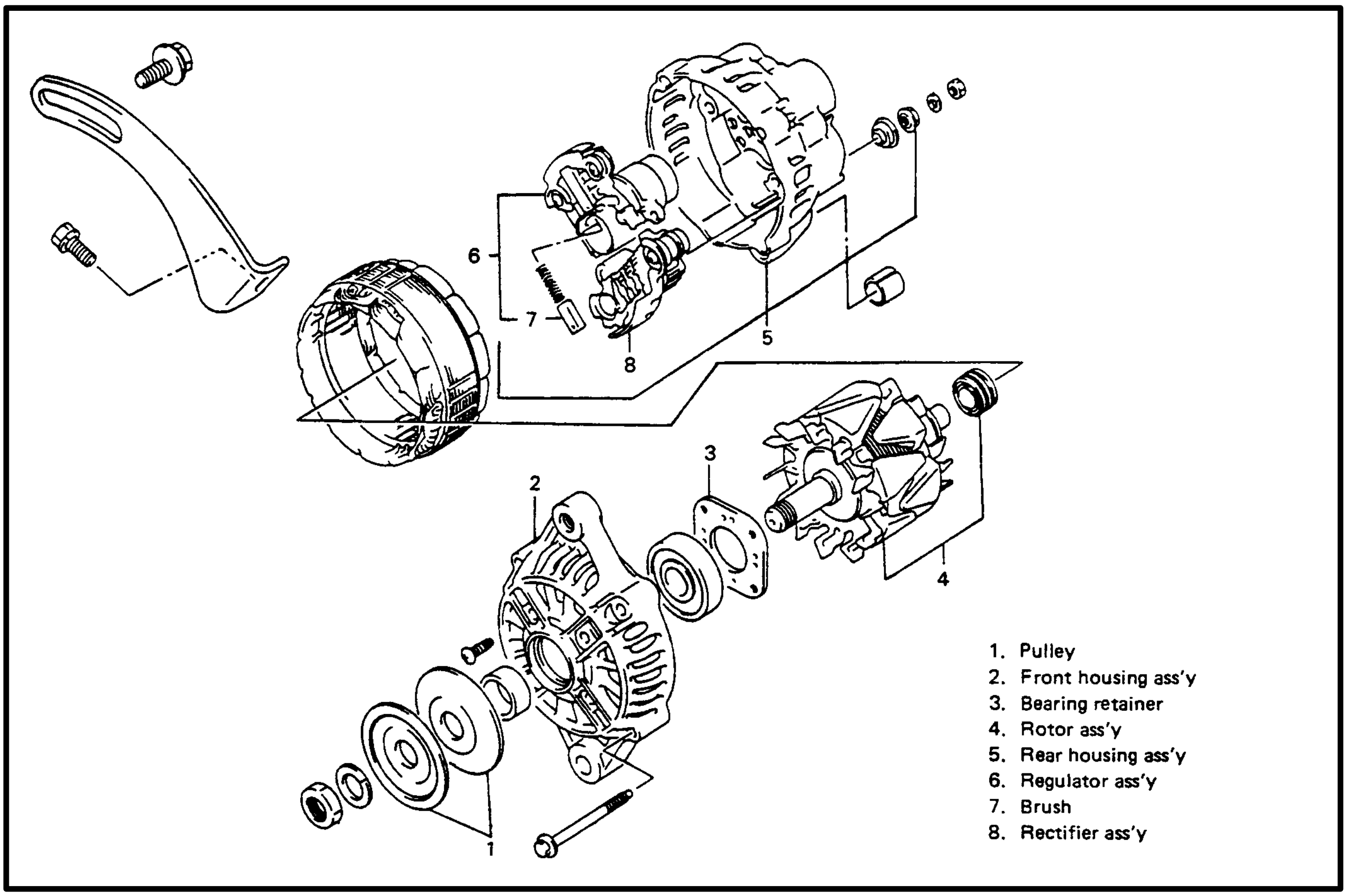
MAX. ALTERNATOR OUTPUT	45A

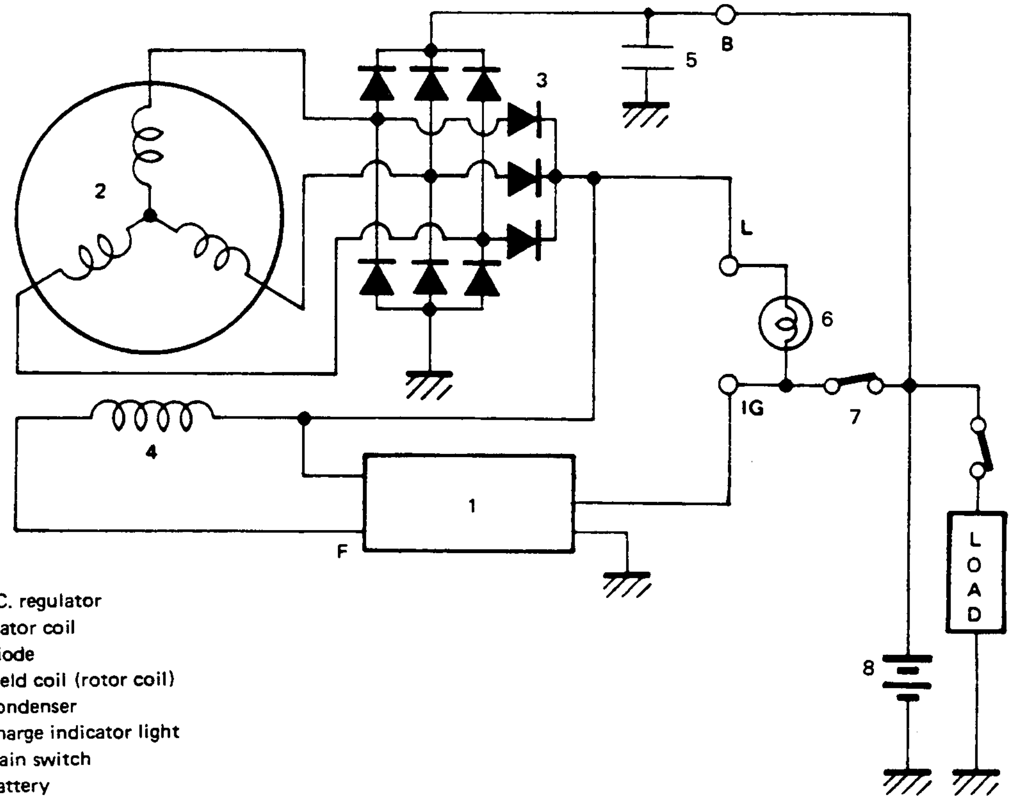
BATTERY

The basic charging system is the IC integral regulator charging system. The internal components are connected electrically as shown in the following schematic diagram battery.

The battery has three major functions in the electrical system. First , it is a source of electrical 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 exceeds the output of the alternator.







1. I.C. regulator
2. Stator coil
3. Diode
4. Field coil (rotor coil)
5. Condenser
6. Charge indicator light
7. Main switch
8. Battery

CARRIER AND HOLDDOWN

The battery carrier and hold–down clamp should be clean and free from corrosion before installing the battery. The carrier should be in good condition so it will support the battery securely and keep it level. Make certain there are no parts in carrier before installing the battery. To prevent the battery from shaking in its carrier, the hold–down bolts should be tight but not over–tightened.

VISUAL INSPECTION

Check for obvious damage, such as a cracked or broken case, that could permit loss of electrolyte. If obvious damage is noted, replace battery. Determine cause of damage and correct as needed.

JUMP STARTING

Both booster and discharged battery should be treated carefully when using jumper cables. Follow procedure outlined below, being careful not to cause sparks.

WARNING

- **Departure from these conditions or procedures described below could result in:**

1) Serious personal injury (particularly to eyes) or property damage from such causes as battery explosion, battery acid or electrical burns. 2) Damage to electronic components of either vehicle.

- **Never expose battery to open flame or electric spark. Batteries generate gases which are flammable and explosive.**
- **Remove rings, watches , and other jewelry. Wear approved eye protection.**
- **Do not allow battery fluid to contact eyes, skin, fabrics, or painted surfaces, as fluid is a corrosive acid. Flush any contacted area with water immediately and thoroughly.**
- **Be careful that metal tools or jumper cables do not contact positive terminal (or metal in contact with it) and any other metal in vehicle, because a short circuit could occur.**
- **Batteries should always be kept out of reach of children.**

1) Set parking brake and place automatic transmission in PARK. Turn off ignition, turn off lights and all other electrical loads.

2) Check electrolyte level. If it is below low level line, add distilled water to return electrolyte to its correct level.

CAUTION

When jump starting engine with charging equipment, be sure equipment used is 12– volt and negative ground. Do not use 24– volt charging equipment. Using such equipment can cause serious damage to electrical system or electronic parts.

3) Attach end of one jumper cable to positive terminal of booster battery and the other end of the same cable to positive terminal of discharged battery. (Use 12–volt battery only to jump start engine).

4) Attach one end of the remaining negative cable to negative terminal of booster battery, and the other end to a solid engine ground (such as exhaust manifold) at least 50 cm. (20 inches) away from battery of vehicle being started.

WARNING

Do not connect negative cable directly to negative terminal of dead battery.

5) Start engine of vehicle that is providing jump start and turn off electrical accessories. Then start engine of the vehicle with discharged battery.

6) Reverse connecting procedure exactly when disconnecting jumper cables. Negative cable must be disconnected from engine that was jump started first.

REMOVE AND REPLACE

When handling battery, the following safety precautions should be followed:

- Hydrogen gas is produced by batteries. A flame or spark near battery may cause the gas to ignite
- Battery fluid is highly acidic. Avoid spilling on clothing or other fabric. Any spilled electrolyte should be flushed with large quantities of water and cleaned immediately. To remove or replace battery, always disconnect negative cable first, then positive cable.

ALTERNATOR BELT TENSION

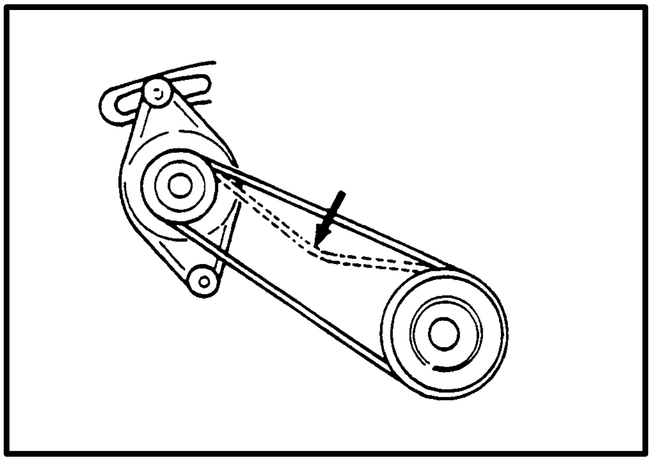
WARNING

Disconnect negative cable at battery before checking and adjusting belt tension.

1) Inspect belts for cracks, cuts, deformation, wear and cleanliness. If necessary, replace the belt.

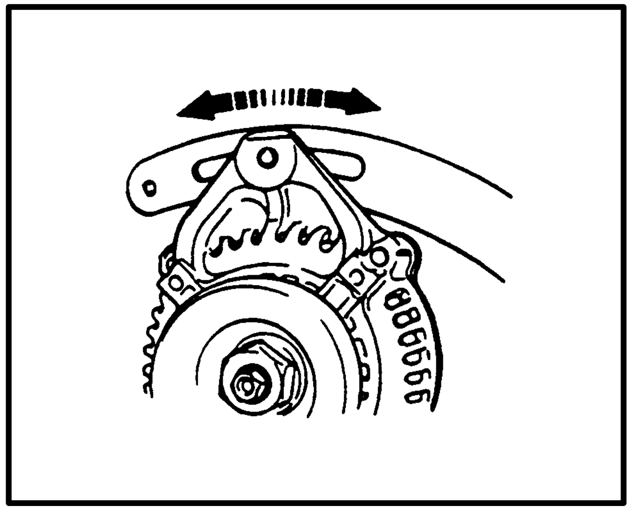
2) Check belt for tension. The belt is in proper tension if it deflects 11 to 14 mm (.43–.55 in.) under thumb pressure (about 10 kg or 22 lbs.).

Belt tension specification	11–14 mm (0.43–0.55 in.) as deflection



NOTE:

When replacing belt with new one, adjust belt tension to 10–12 mm (0.40–0.47 in.)



3) If the belt is too tight or too loose, adjust it to specification by adjusting alternator position.

4) Tighten alternator adjusting bolt and pivot bolt.

5) Connect negative battery lead to battery.

FAULTY INDICATOR LIGHT OPERATION

Symptom	Possible Cause	Correction
Charge light does not light with ignition ON and engine off	• Fuse blown • Light burned out • Wiring connection loose • IC regulator faulty	Check fuse Replace light Tighten loose connections Replace IC regulator
Charge light does not go out with engine running (battery requires frequent recharging)	• Drive belt loose or worn • Battery cables loose, corroded or worn • IC regulator faulty • Wiring faulty	Adjust or replace drive belt Repair or replace cables Check charging system Repair wiring

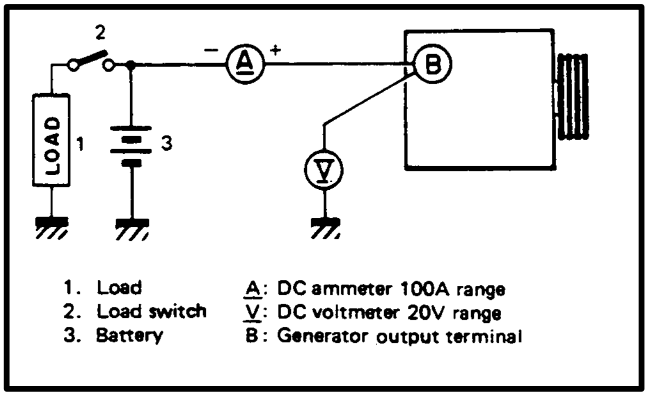
UNDERCHARGED BATTERY

This conditions, as evidenced by slow cranking or indicator clear with red dot can be caused by one or more of the following conditions even though indicator light may be operating normally. Following procedure also applies to vehicle with voltmeter and ammeter.

1) Connect voltmeter and ammeter as shown below.

NOTE:

Discharged battery will not work for this test. Before testing, make sure that battery is fully charged.



2) Run engine from idling up to 3,000 RPM and read meters.

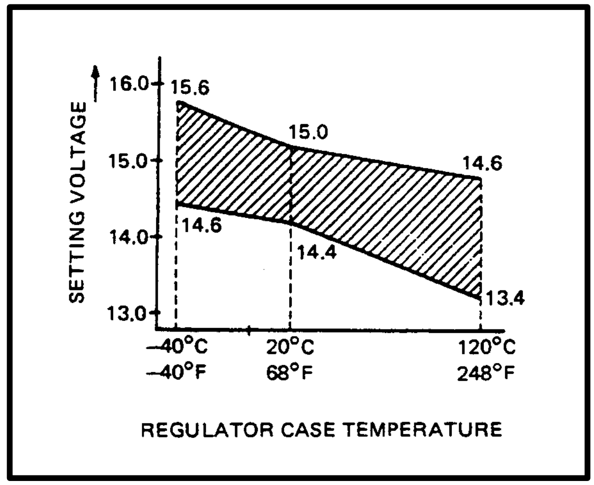
CAUTION

All electrical loads except ignition are switched off.

Standard Current	10 A maximum
Standard voltage	14.4–15.0 V at 20° C, 68° F

NOTE:

Consideration should be taken that voltage differs somewhat with regulator case temperature.



3) When voltage is higher than standard voltage range, check ground of brush. If no faulty condition is found, replace IC regulator.

4) When voltage is lower than standard voltage range, run engine at 3,000 RPM and turn off headlights. Measure electric current. If measured value is larger than that under no load condition, it is normal.

SECTION 13

SPEED LIMITER

SYSTEM OPERATION

Trombetta's P613–K1 throttle control solenoid kit consists of a "three wire," dual coil solenoid, electromechanical control module and stainless steel sheathed pull cable. The sheathed pull cable allows the solenoid to be mounted away from hostile environments, such as engine vibration and high temperature.

The throttle solenoid is activated automatically for "on demand" to bring the idle speed to a pre–set position.

The control module allows the solenoid to operate as a continuous duty device. When the module is wired as recommended, applying 12 VDC to the white/black wire applies voltage to the hold–in and pull–in coil of the solenoid. After 0.5 seconds to 0.75 seconds, power is automatically removed from the pull–in coil. Power will remain at the hold–in coil until the 12 VDC signal is removed from the white/black wire.

TROUBLESHOOTING HINTS

If the solenoid will not engage, check the following:

1. Check the stranded pull cable for damage (e.g., melted or crimped sheath).
2. Check the stranded pull cable for binding.
3. Check system voltage at the green/yellow and white/black wires.
4. Check module terminals for proper voltage and operation. If the module does not meet these specifications, replace it.
5. Check solenoid resistance (remove wires from module). If resistance is not within specifications listed below, replace the solenoid.

12VDC System
0.17 ohms White to Black wire
0.13 ohms Red to Black wire

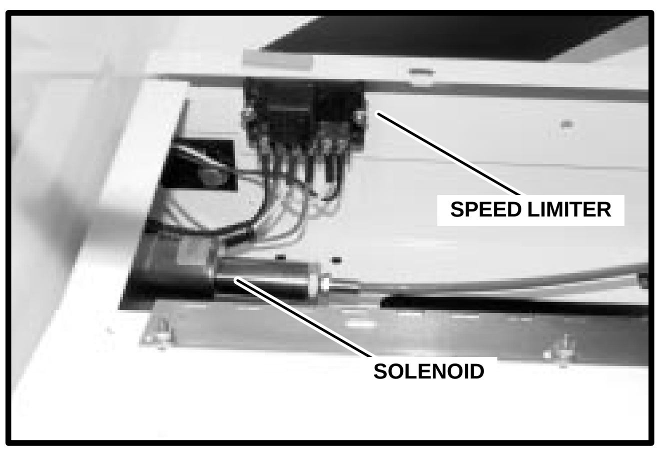
6. Be sure cable is not bent beyond guidelines.
7. Check for proper adjustments.
8. Contact the factory if you are unable to resolve the problem.

CONTROL MODULE VOLTAGE MEASUREMENTS

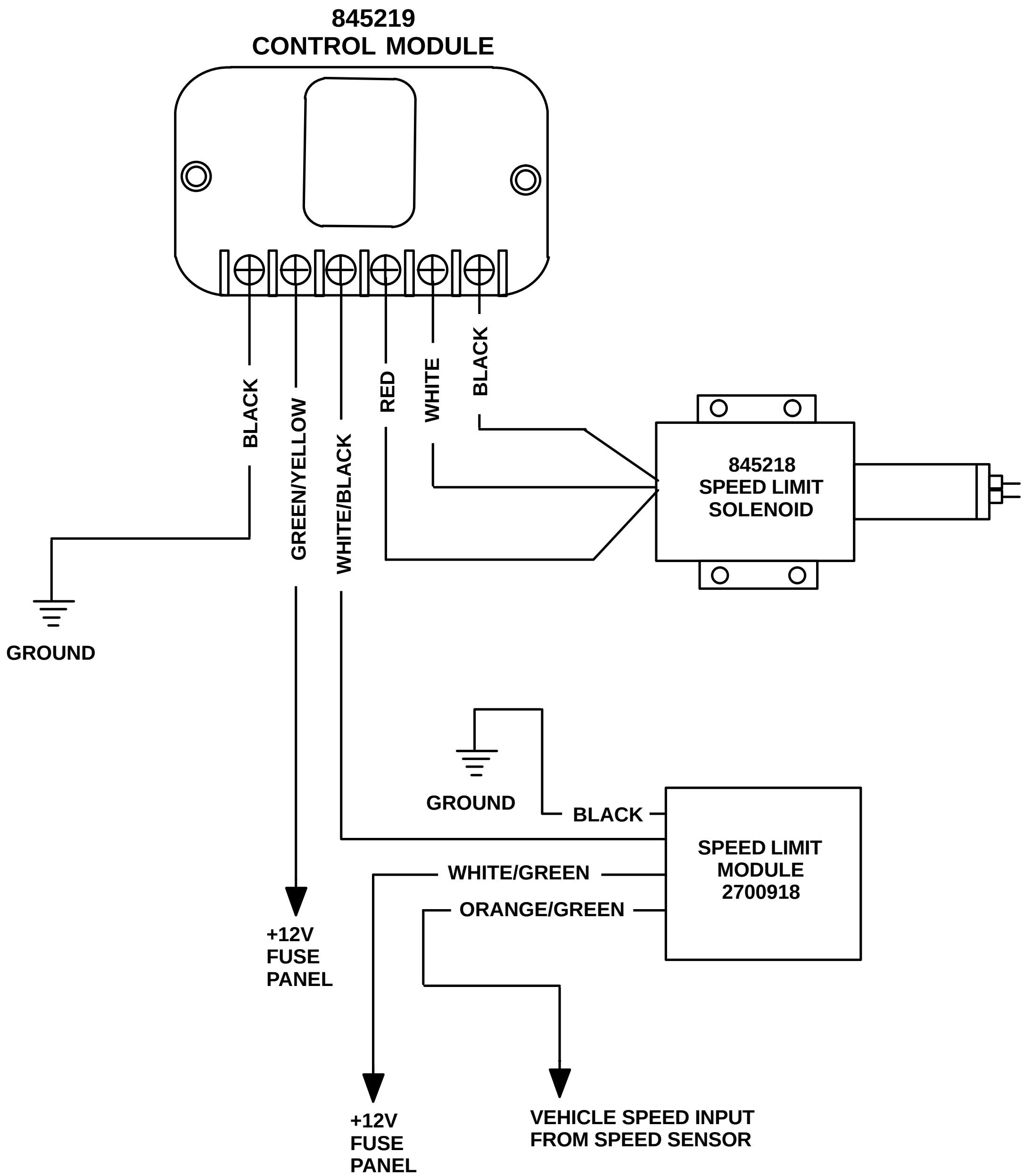
Wire Color	Voltage
Black	Chassis Ground
Green/Yellow	12 VDC when key ON
White/Black	12 VDC when vehicle speed is below 41 MPH ± 3MPH (33 MPH ± 3 MPH for 53749 NYC Mod.)
Red	12 VDC when 12 VDC is present at white/black wire
White	12 VDC for 0.5 to 0.75 seconds after 12 VDC at white/black wire
Black	Common for solenoid

SPEED LIMIT MODULE

Wire Color	Voltage
Black	Chassis Ground
White/Green	12 VDC when key ON
White/Black	Output to Control Module
Orange/Green	Input from Speed Sensor (Same signal that operates the speedometer on the instrument panel. So if the speedometer is working, this signal is working as well.)



SPEED LIMITING CIRCUIT



SECTION 14

CHASSIS

STORAGE

Before storing the vehicle or battery for an extended period, the battey should be thoroughly cleaned, fully charged and the electrolyte brought up to the proper level.

During storage, batteries should be periodically recharged. Charging interval depends on the average temperature at which the batteries are stored.

40° – 60°F (4° – 15°C) . . . . . . Charge every 2 months

Above 60°F (4° – 15°C) . . . . . Charge every 2 months

Clean, inspect and test the batteries before putting them back into service.

JACKS, JACKING LOCATIONS AND USING A HOIST

When it is necessary to raise the vehicle for any repair or service, use jackstands to provide adequate support. Do not rely on hydraulic or mechanical jacks.

To avoid unexpected vehicle movement, always set the parking brake and make sure the direction selector is in “neutral”.

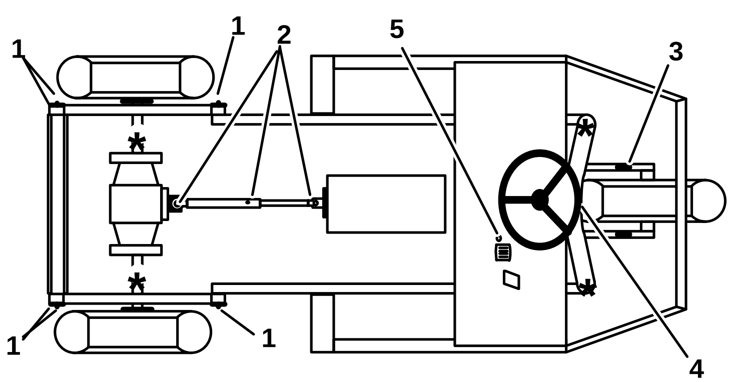
A scissors type jack with a 1 1/2 ton (minimum) capacity, that can be lowered to 3 3/8” (86 mm) height is required.

Position the jack under the differential axle tube to raise the rear wheel, or under the frame near the front wheel to raise the front wheel (the jacking locations are shown on the chassis lubrication chart illustration on page). These are the ONLY jacking locations to be used. Raise the vehicle ONLY enough to perform maintenance required.

NOTICE

- To prevent damage to the vehicle or attached accessory, NEVER use a hoist to raise one corner of the vehicle. ALWAYS raise BOTH front or rear corners equally.

CHASSIS LUBRICATION CHART



CHASSIS LUBRICATION GUIDE

Perform every 100 hours or 1000 miles

LUBRICATION AREA	NUMBER OF FITTINGS*
1. Rear spring shackles	6
2. Drive shaft	3
3. Leading link bushings	2
4. Lower fork pivot bearing	1
5. Brake bellcrank (pivot bushing)	1

* Use a lithium base pressure gun grease on all grease fittings.

NOTE

- Too much lubricant can damage the seals on item 2.

IMPORTANT!
JACKING LOCATIONS ARE INDICATED BY *

FIGURE 4

⚠ WARNING

- **Jackstands should ALWAYS be used to provide adequate support. NEVER rely on hydraulic or mechanical jacks for support.**

SERVICE AND MAINTENANCE

⚠ WARNING

- **NEVER attempt to perform service or maintenance functions on this vehicle if you are UNTRAINED or UNAUTHORIZED. Improper maintenance can cause hazardous conditions.**

See your authorized CUSHMAN dealer for necessary maintenance and service.

- **When replacement parts are required, use genuine CUSHMAN parts or parts with equivalent characteristics including type, strength and material. Failure to do so may result in product malfunction and possible injury to the operator and/or bystanders.**
- **Immediately replace any warning decal that becomes hard to read.**

MAINTENANCE GUIDE

The guide is set up for average use on clean, paved surfaces. Vehicles used in dusty areas, for winter driving or in wet, snowy or muddy conditions require more frequent service.

AS REQUIRED

Check tire pressure
Check self adjusting brakes

EVERY 200 HOURS OF OPERATION

Perform previous Services
Lubricate all grease fittings *
Check differential oil level **

EVERY 1000 HOURS OR YEARLY

Perform previous Services
Change differential oil **
Clean and repack front wheel bearings

* Refer to the lubrication chart.

** The differential oil must be changed after the FIRST 100 hours or 1000 miles of service.

BRAKE FLUID

Use type .... Dot (3)

Access to the master cylinder is through the opening in the floorboard in front of the operators seat.

LUBRICATING BRAKE PEDAL BUSHING

The brake pedal pivot bushing lubrication fitting is located just below the hole in the floorboard, near the brake pedal. See Figure 5.

Pedal Lubrication Access Hole
FIGURE 5

BRAKE SHOE REPLACEMENT

1. Remove the front wheel and hub assembly.
2. Disconnect both return springs from shoe assembly and brake lever. Remove shoe retainers. Remove brake lever and adjuster. Care must be taken not to disturb the hydraulic wheel cylinder. Remove the brake shoes from the backing plate. See Figure 6.

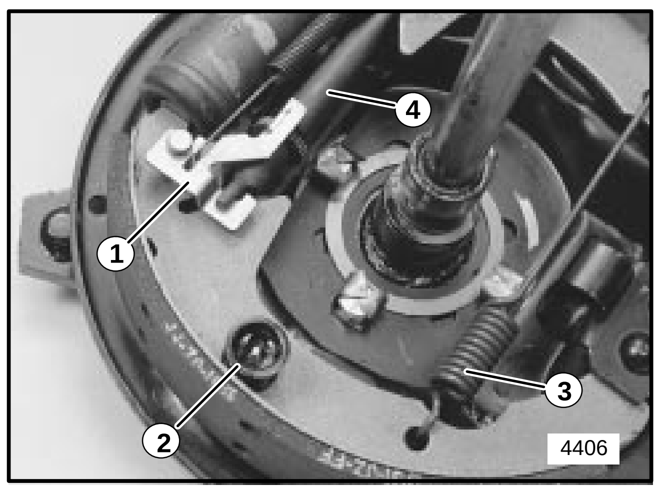


FIGURE 6

1. Brake Lever	**3. Return Springs**
2. Shoe Retainers	**4. Brake Adjuster**

NOTICE

- DO NOT press the brake pedal while the brake is disassembled.
- Examine the wheel cylinder for leaks before reassembly by carefully pulling back each rubber boot on

the wheel cylinder. Fluid present in the boot area indicates a leaking wheel cylinder. Refer to Figure 7.

3. Clean the brake backing plate.

Reassembly

4. Apply a thin layer of high temperature lubricant to the brake backing plate where the brake shoes make contact (6 places) and brake adjuster. See Figure 7.

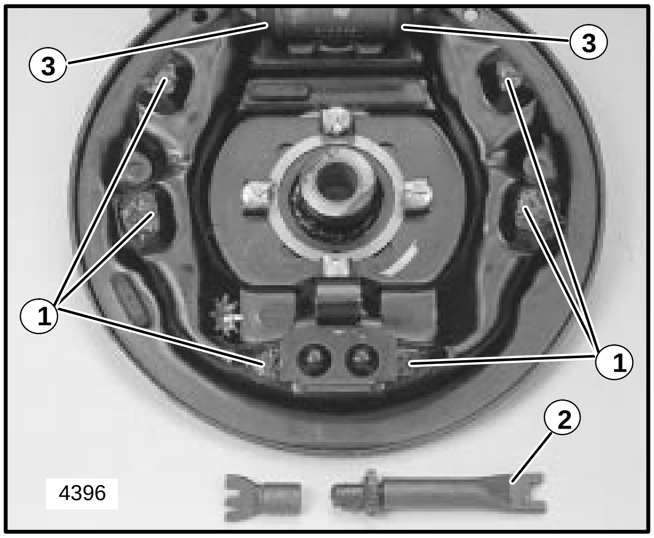


FIGURE 7

1. Brake Shoe Contact Pads (6)

2. Brake Adjuster

3. Wheel Cylinder Rubber Boots

5. Install brake shoes and brake adjuster. See Figure 8.

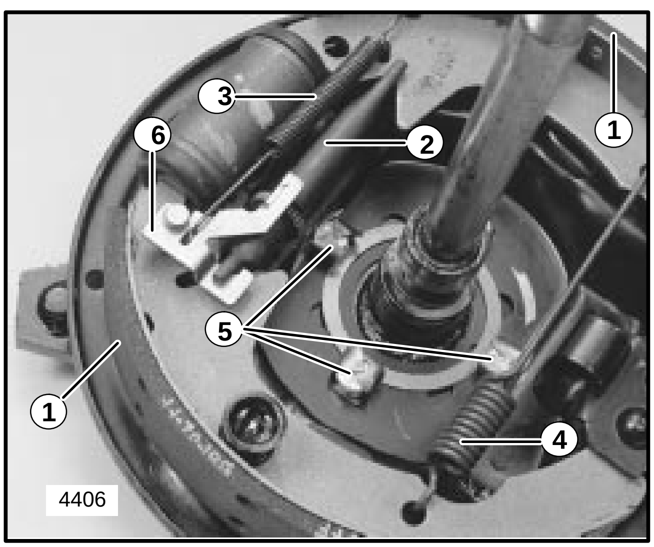


FIGURE 8

1. Brake Shoe	**4. Large Retainer Spring**
2. Brake Adjuster	**5. Brake Retainers**
3. Small Retainer Spring	**6. Brake Lever**

6. Install brake retainers, brake lever and small retainer spring. Install larger retainer spring. See Figure 8 on page 16.

NOTICE

- Note position of brake lever and small retainer spring. See Figure 8 on page 16.

7. Install new seals, clean and repack wheel bearings with a lithium based lubricant. Install wheel bearings then install wheel assembly onto vehicle. Refer to front wheel bearing section for correct procedure.

FRONT BRAKE ADJUSTMENT

NOTICE

- This brake is self adjusting and needs adjustment only on initial installation.

1. Raise the vehicle off the ground.

⚠ WARNING

- **Support the vehicle on approved jackstands, to prevent it from falling and causing injury. DO NOT rely on hydraulic or mechanical jacks to support the vehicle while working on or under it.**

2. Remove adjusting hole cover from brake dust shield. See Figure 9.

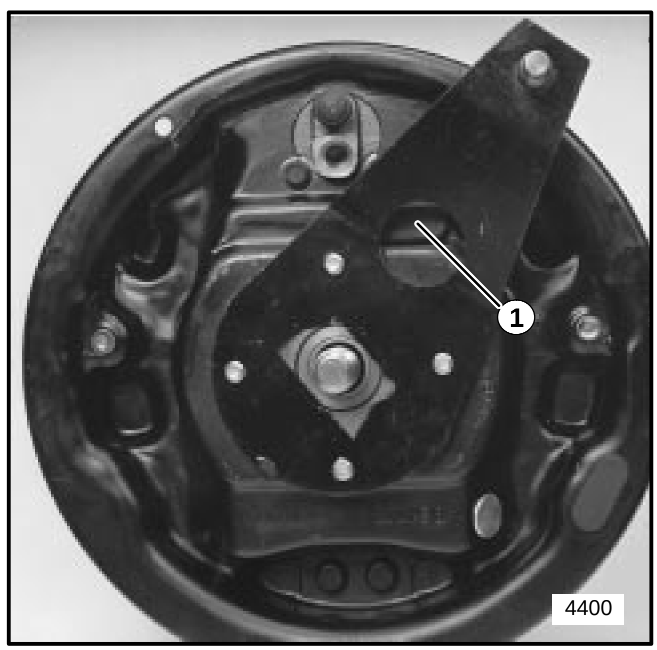


FIGURE 9
1. Adjusting Hole Cover

3. Using a flat blade screwdriver, turn the adjusting wheel up (screwdriver handle down) to adjust brake

shoes until a slight drag is felt while turning front wheel assembly.

4. Reinstall the adjusting hole cover.

REAR BRAKE ADJUSTMENT

NOTICE

- This brake is self adjusting and needs adjustment only on initial installation.

1. Raise the vehicle off the ground.

WARNING

- **Support the vehicle on approved jackstands, to prevent it from falling and causing injury. DO NOT rely on hydraulic or mechanical jacks to support the vehicle while working on or under it.**

2. Remove rear wheel.

3. Turn drum until hole is in approximate position shown. See Figure 10.

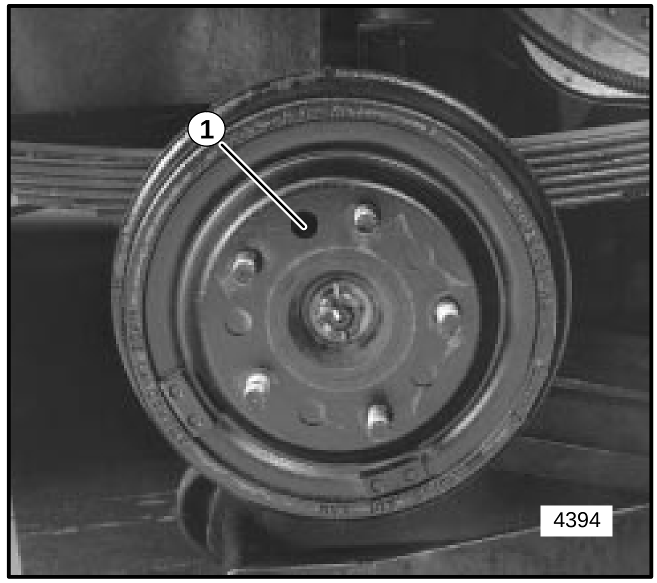
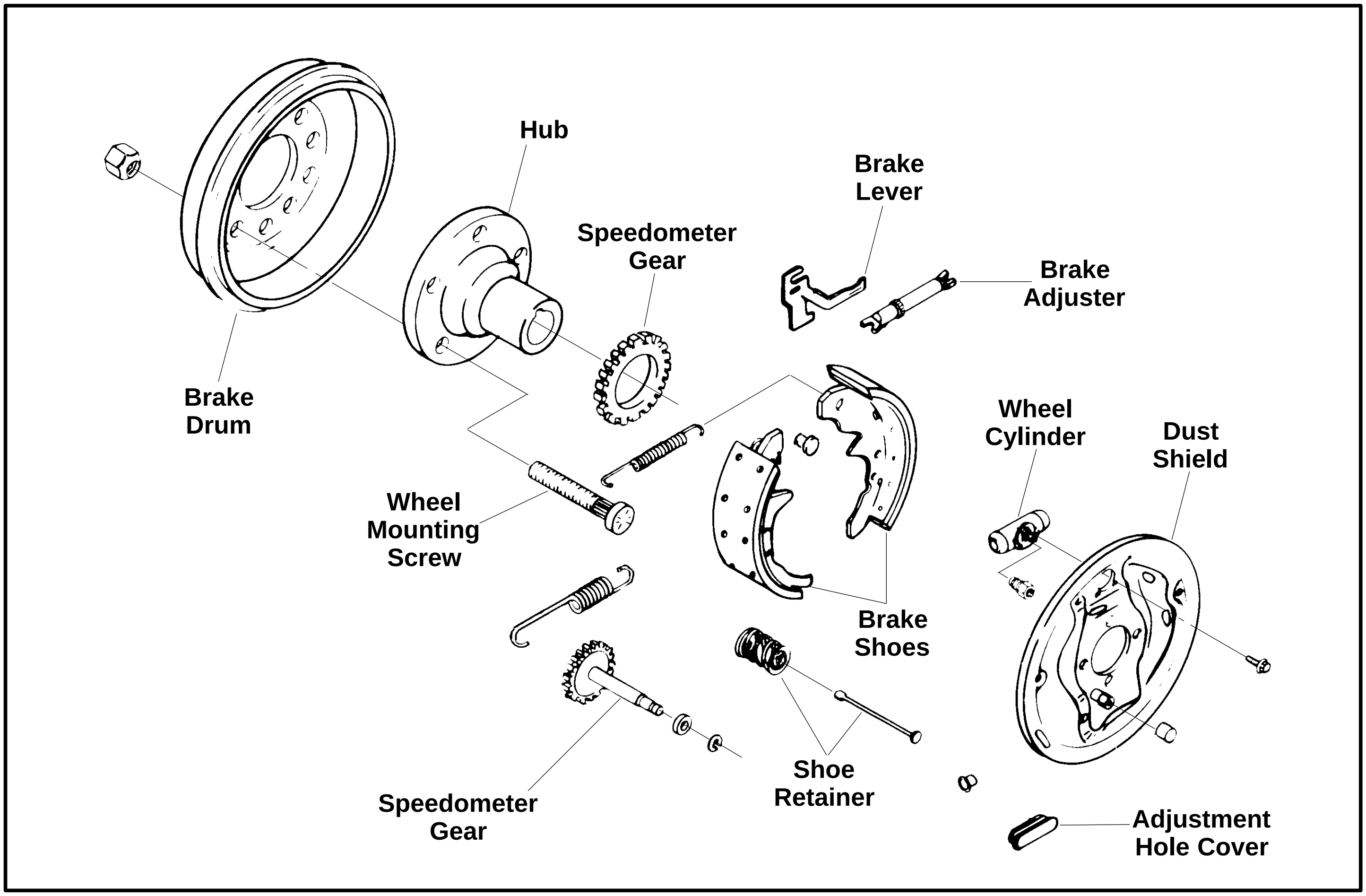


FIGURE 10

1. Position Hole Here

4. Using a flat blade screwdriver, turn the adjusting wheel down (screwdriver handle up) to adjust brake shoes until a slight drag is felt while turning the rear wheel assembly.

5. Reinstall the rear wheel. Tighten lug nuts to 70 to 100 ft.–lbs. (95 to 140 N·m) torque. Make sure the valve stem is located toward the outside of the vehicle.



(Typical) Rear Brake Assembly

FIGURE 11

MASTER CYLINDER

Master cylinder failures may usually be recognized by repeated loss of brake fluid or by brake pedal fading gradually while brakes are applied. Check master cylinder and immediate area for signs of leaking fluid. If leakage is found on the end of cylinder where brake lines are attached, check for loose or broken lines or loose brass "U" fitting. Repair as necessary. If leak is found on opposite end around the boot, it is necessary to replace or repair the master cylinder. If pedal fades while brakes are applied and there is no air in the lines or leakage at the wheel cylinders, the master cylinder must be replaced or rebuilt.

⚠ WARNING

- **Pedal fading may be experienced with no loss of fluid, due to defective internal parts in the master cylinder.**

To remove master cylinder, remove fitting screw holding brass fitting to master cylinder. **Note:** Brake lines DO NOT need to be removed from brass fitting. Remove two cylinder mounting screws and remove cylinder by pulling away from master cylinder push rod.

Replace cylinder in reverse manner. Fill cylinder with fluid and bleed the brake system.

BRAKE PEDAL FREE TRAVEL

Free travel of the brake pedal can be checked by removing the master cylinder filler plug. Press the brake pedal slowly by hand while watching the surface of the fluid for bubbles or slight turbulence which indicates adequate free travel.

No disturbance on the fluid surface indicates insufficient free travel and the linkage between the pedal and master cylinder must be adjusted.

Loosen the locknut between the pushrod and brake rod and turn the pushrod into the brake rod to shorten the length. See Figure 12, page 19. Check for disturbance again and adjust as needed to obtain proper free travel.

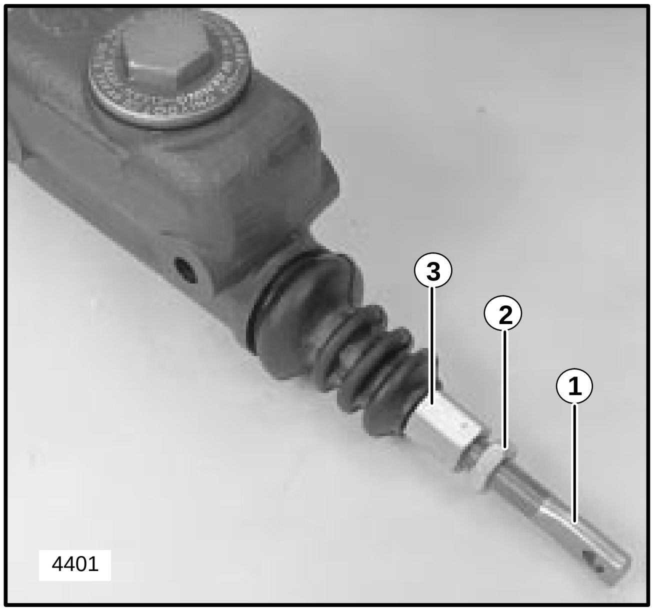


FIGURE 12

1. Brake Rod
2. Locknut
3. Push Rod

Rebuild Procedure For Master Cylinder

If cylinder is to be rebuilt, remove from vehicle and proceed as follows:

1. Remove filler cup and gasket and pour fluid from reservoir. (Do not reuse fluid).
2. Remove boot from cylinder.
3. Remove lock ring, washer, pistons, primary cup, spring, valve and valve seat from cylinder.
4. Clean cylinder and filler cup thoroughly in alcohol. (Do not use gasoline or kerosene).
5. Inspect walls of master cylinder barrel for rust or score marks; if necessary recondition by honing. Brake cylinder hones are available from automotive supply distributors. Hone only enough to clean up the wall. Clean cylinder again with alcohol, dry with compressed air.
6. Reassemble in reverse order. Dip all internal parts in brake fluid prior to assembly.
7. Install the master cylinder in the vehicle, fill with fluid and bleed the brake system. Check for leaks prior to returning vehicle to service.

NOTICE

- Severe pitting, scoring, and/or rust requires replacement with a new or rebuilt master cylinder.

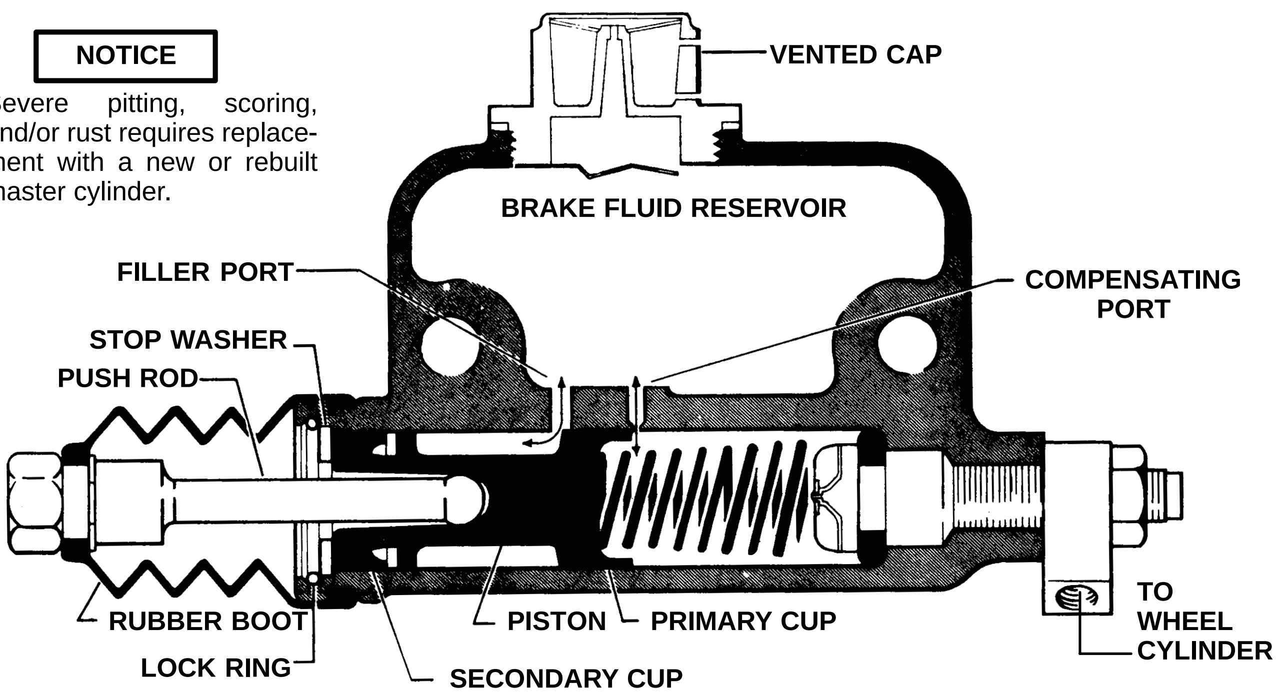


FIGURE 13

REBUILD PROCEDURE FOR 1” WHEEL CYLINDERS

Disconnect brake line and brake shoes and remove the wheel cylinder. Remove the boot from each end of the cylinder, push the pistons, rubber cups and spring from the cylinder. Wash cylinder in alcohol. Examine walls for rust or score and hone if necessary. Dip cups and pistons in brake fluid and reassemble parts into the cylinder. Install the wheel cylinder on the vehicle and connect the brake line. Bleed the entire brake system. Check for leaks prior to returning vehicle to service.

NOTICE

- Severe pitting, scoring and/or rust requires replacement of unusable wheel cylinders with new cylinders.

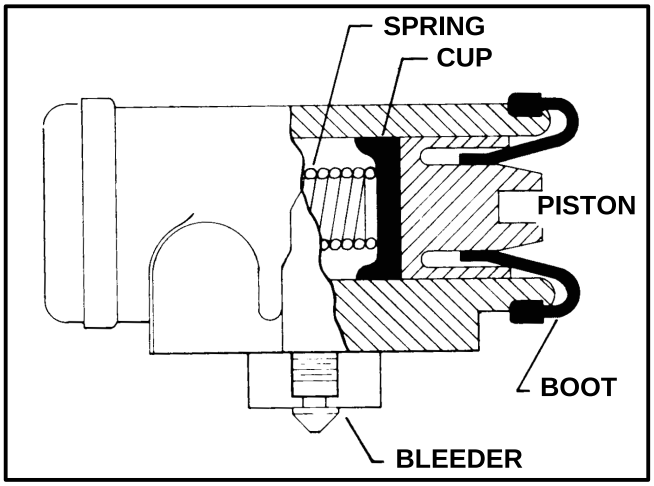


FIGURE 14

BLEEDING THE BRAKES

- Start the bleeding procedure with the wheel cylinder located the farthest distance from the master cylinder.

Fill the master cylinder with brake fluid (replace master cylinder cap to avoid splashing of fluid).

Attach small clear tube to the bleeding nipple. This nipple is on the back side of the wheel cylinder and protrudes through a hole in the top of the brake dust shield (do not mistake it for a lubrication fitting). The nipple is threaded and must be turned to the left slightly to allow air trapped in the brake line to escape. Place the free end of the bleeder tube in a container, making sure there is enough brake fluid in the container to seal the end of the tube.

Pump brake pedal slowly until fluid coming from the bleeder fitting is clear and free of air bubbles. (By using clear tubing you can see when only brake fluid is passing through the tubing and when the fluid clears). When all the air is out of brake line, tighten the bleeding nipple while holding the brake pedal in the down position. Repeat the above operation for each brake line. After a brake line is bled, refill the master cylinder, making sure it is full before starting the bleeding operation of each brake line.

When all brake lines are full of fluid, and are completely free of any air, the next step is to adjust the brake shoes for proper clearance.

TROUBLESHOOTING BRAKE SYSTEM

Brakes Drag

1. Improper brake shoe adjustment.
2. Improper adjustment of master cylinder.
3. Improper axle end play.
4. Corrosion between parking brake, cable and cable housing.
5. Broken brake lever spring.
6. Loose wheel bearings.
7. Wheel cylinders stuck.

Brakes Grab

1. Leaking wheel cylinder.
2. Brake drum scored.
3. Grease or oil on lining.
4. Air in lines.
5. Wheel cylinder stuck.
6. Lining loose on shoe.

Spongy Brake Pedal

1. Air in hydraulic line.

Excessive Pedal Travel

1. Brake shoe adjustment needed.
2. Fluid low in master cylinder.
3. Faulty or misadjusted master cylinder.

⚠ WARNING

- **If brake pedal travels closer than one inch (25 mm) to vehicle floorboard, the brakes must be adjusted or repaired. Failure to adjust or repair as needed may cause loss of brakes.**

STEERING GEAR

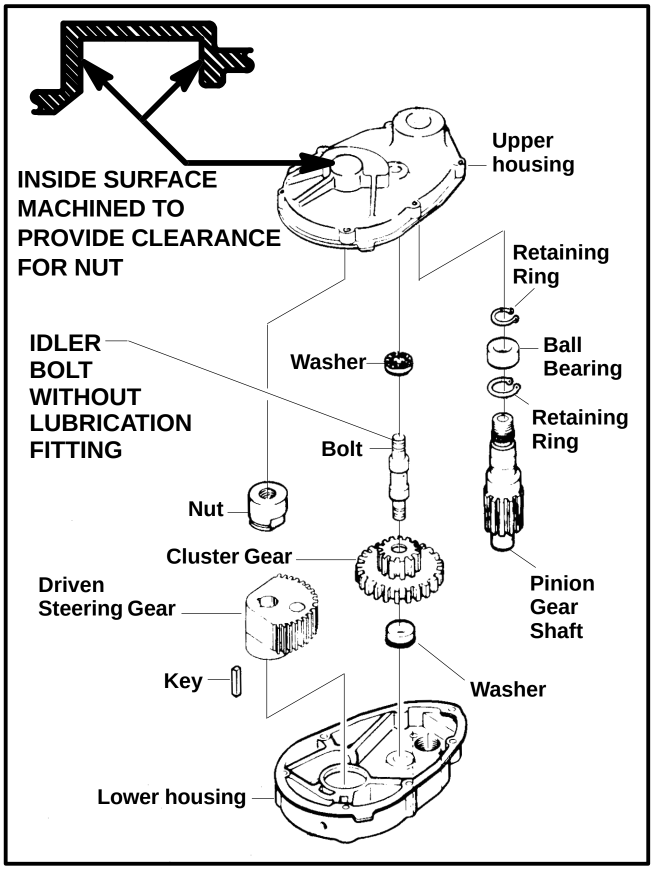


FIGURE 15

Disassembly

With the horn wire disconnected, remove the horn button and lift wire from the pinion shaft.

Remove the steering wheel retaining nut and lift the wheel from the shaft.

Remove the top idler bolt nut and washer and the gear case retaining screws. The case may now be lifted off.

Remove the driven gear nut. The gear may now be removed by the use of a 1/2–20 knock–off (obtainable through your Cushman dealer).

Remove the lower idler bolt nut and washer and lift the cluster gear and idler bolt from the lower case.

CAUTION

- **Inspect all gears and splines for wear or damage. If the wear or damage is excessive, replace with new parts. Also inspect the pinion shaft for wear.**

Reassembly

Place a locating washer, with the knurled side down, over the hole for the idler adjustment bolt. Insert the adjustment bolt, add another locating washer on the outside of the lower housing with the knurled side against the housing. Secure with a nut and tighten finger tight. See Figure 15.

Place a liberal amount of lubrication in recess of idler adjusting bolt and place the cluster gear over the idler adjusting bolt.

Determine the correct keyway in the driven gear (see Figure 16 below) and install gear. Torque the steering bushing nut to 40–50 ft.–lbs. (54 –70 N·m). Apply a liberal amount of lithium based lubricant to the gear teeth and all bearing surfaces.

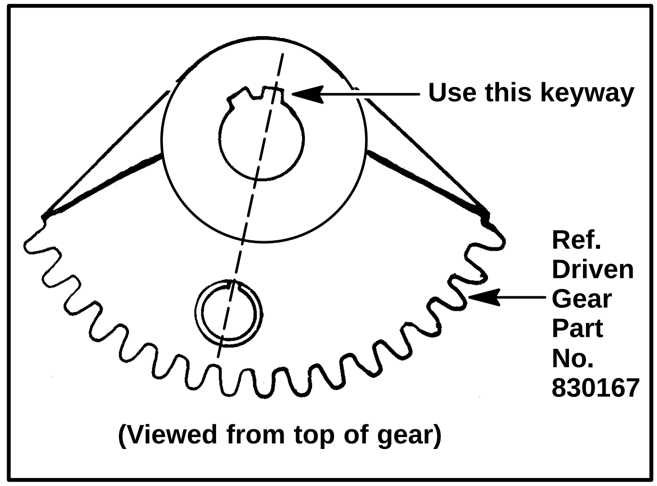


FIGURE 16

Adjust the height of the lower housing as shown in Figure 17 (page 22). Tighten the support mounting screws.

Tighten the five lower housing and support bracket screws to 20–25 ft.–lbs. (27–34 N·m).

Place one locating washer, knurled side up, over the idler adjustment bolt. Assemble upper housing to lower housing. Place another locating washer over the adjustment bolt with the knurled side against the upper housing. Secure with a nut and tighten finger tight. Tighten housing attaching screws to 8–10 ft.–lbs. (11–14 N·m).

Backlash Adjustment

The weight of the vehicle must be on the wheels or hold the front wheel to prevent the fork from turning. Loosen the upper and lower idler bolt adjusting nuts, turn the steering wheel counterclockwise and hold with light pressure. Snug the lower idler adjusting nut and then the upper adjusting nut. Use a socket wrench and at least a 4" (101.6 mm) extension. Care MUST be exercised to avoid cocking the idler bolt. With slight pressure on the steering wheel in counterclockwise direction, tighten lower nut 40–50 ft.–lbs. (54–70 N·m). Check backlash for a maximum of 1/4" (6.4 mm) travel of the steering wheel rim, then tighten upper adjusting nut 40–50 ft.–lbs. (54–70 N·m). Check operation of the steering for free operation. A slight amount of roughness is permitted after the front fork and wheel has been rotated either direction 15°. It is better to have the allowable roughness than the maximum permitted backlash. If it is necessary to readjust the idler bolt, the locating washers (Part No. 816449) must be rotated to prevent the serrations from falling into the same marks.

Tighten the nut securing the steering wheel to the steering shaft before the vehicle is placed into service. The correct torque is 40 ft.–lbs. (54 N·m).

WARNING

- **Failure to tighten the steering nut to the torque specified may allow the steering wheel to become disengaged from the shaft which will result in a loss of steering control.**

Install the horn wire assembly and related parts. Connect the wire to the brown wire coming from the front main wiring harness.

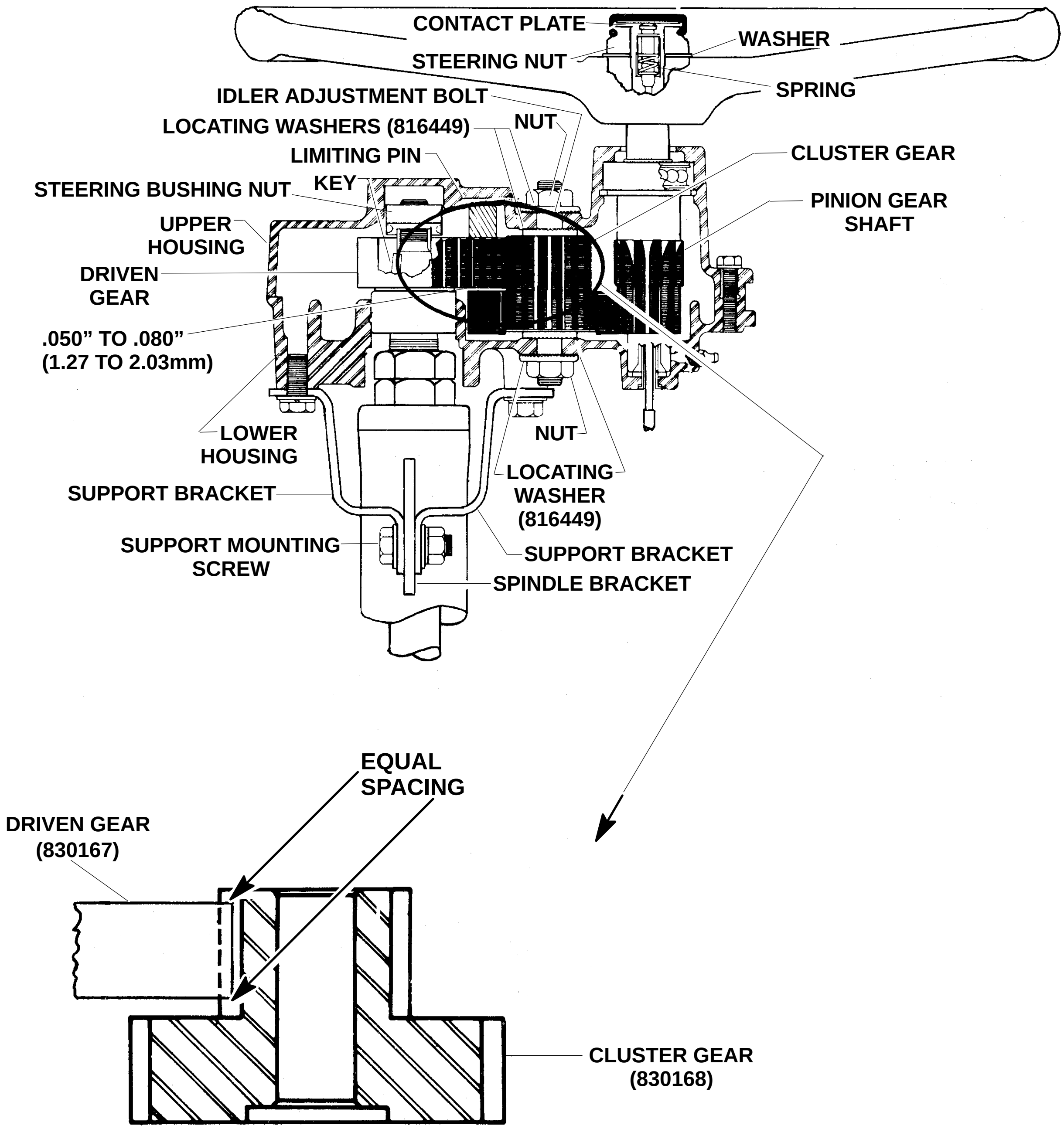


FIGURE 17

FRONT FORK

Disassembly

1. Raise vehicle high enough to provide room for the fork to be removed from from bottom of vehicle.

WARNING

- **When it is necessary to raise the vehicle for any repair or service, use jackstands to provide adequate support. DO NOT rely on hydraulic or mechanical jacks for support.**

2. Disassemble the steering gear assembly.
3. Remove front wheel assembly and related parts.
4. Remove top jam nut on fork.
5. Remove second jam nut securing fork in frame and carefully lower fork assembly.

NOTICE

- Care must be used in removing the fork. There are (28) loose ball bearings in the bottom and (20) loose ball bearings on the top end of fork tube in the frame. Refer to Figure 18 for proper parts stack–up.

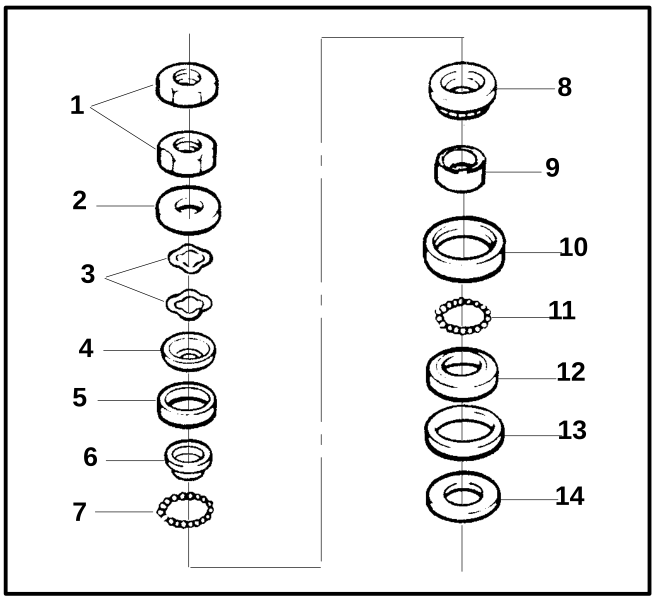


FIGURE 18

1. Jam Nut	**8. Upper Bearing Cup**
2. Dust Seal Cover	**9. Upper Fork Bushing**
3. Wave Washer	**10. Lower Bearing Cup**
4. Washer	**11. 1/4” Ball**
5. Dust Seal	**12. Lower Bearing Cone**
6. Upper Bearing Cone	**13. Felt Dust Shield**
7. 3/16” Ball	**14. Large Washer**

6. Clean and inspect all parts for wear and damage. If parts are worn or damaged, replace with new parts.

Reassembly

7. Place 1/4” (6.4 mm) ball bearings in lower bearing cone. Apply a liberal amount of wheel bearing lubricant. Place felt dust shield around bearings to hold them in place. See Figure 19.

8. Place 3/16” (4.7 mm) ball bearing in upper bearing cup. Apply liberal amount of wheel bearing lubricant. Place dust shield around bearings to hold them in place. See Figure 19.

FIGURE 19

1. Bottom ball, cone and dust seal

2. Top ball, cone and dust seal

9. Place large washer onto fork. See Figure 18 for proper location of parts.

10. Place bearing cone with 1/4” (6.4 mm) balls, cup and dust seal in place onto fork. Install fork into frame.

11. Install upper fork bushing with bearing cup, 3/16” (4.7 mm) balls, cone, dust seal, washer, two wave washers, dust seal and cover. Refer to Figure 18 for proper location of parts.

12. Secure parts in place by installing the lower jam nut to fork threads. Snug nuts tight enough to hold fork assembly into frame tube securely.

13. Install front wheel assembly.

14. Refer to following fork bearing adjustment.

FORK BEARING ADJUSTMENT

1. Raise the front of the vehicle off the floor.

WARNING

- **When it is necessary to raise the vehicle for any repair or service, use jackstands to provide adequate support. DO NOT rely on hydraulic or mechanical jacks.**

NOTICE

- The complete steering gear must be removed to adjust fork pivot bearings. Refer to the steering gear overhaul section for proper parts positioning, assembly sequence and torque specifications during assembly.

2. Tighten the jam nut to 15 ft.–lbs. (20 N·m) torque. Hold this nut to keep it from turning and tighten the locking nut to 91 ft.–lbs. (120 N·m) minimum, 109 ft.–lbs. maximum torque. Refer to Figure 20.

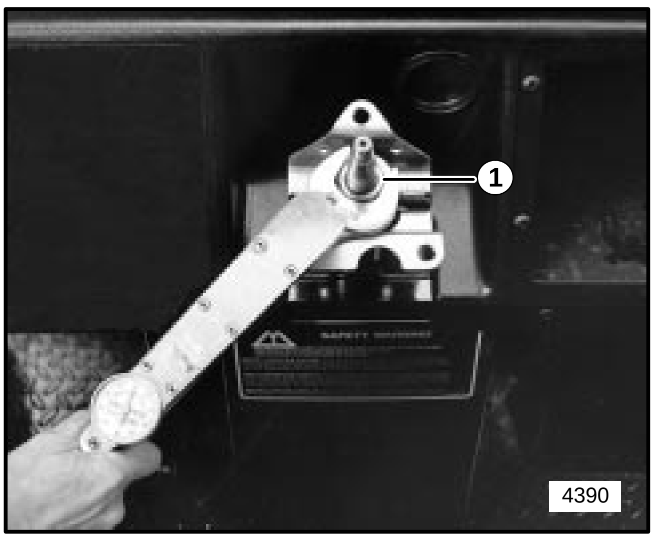


FIGURE 20

1. Jam Nut

NOTICE

- The adjustments shown will depress the wave washers and provide the proper preload on the bearings. The fork must turn freely side to side.

3. Lubricate fork tube lubrication fitting. See Figure 21 for location of fork tube fitting.

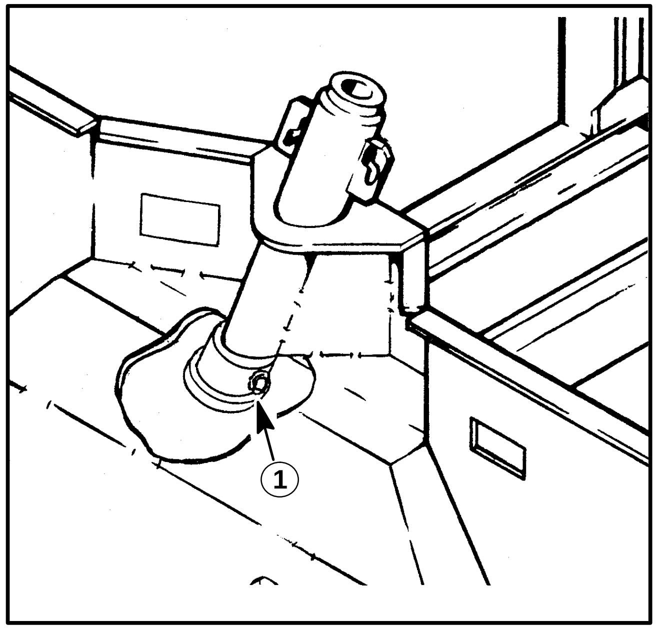


FIGURE 21

1. Fork Tube Lubrication Fitting

FRONT WHEEL BEARINGS

NOTICE

- The front wheel is mounted on taper roller bearings that must be checked periodically to insure proper operation and durability.

- The bearings should be repacked yearly with a lithium based lubricant.

1. Raise the front of the vehicle off the floor.

WARNING

- **When it is necessary to raise the vehicle for any repair or service, use jackstands to provide adequate support. DO NOT rely on hydraulic or mechanical jacks for support.**

2. Remove the front wheel and hub assembly by removing the axle nut, lockwasher and by rotating the axle lock to allow the axle assembly to slide from the fork sidearm assembly. Refer to Figure 22 on page 25.

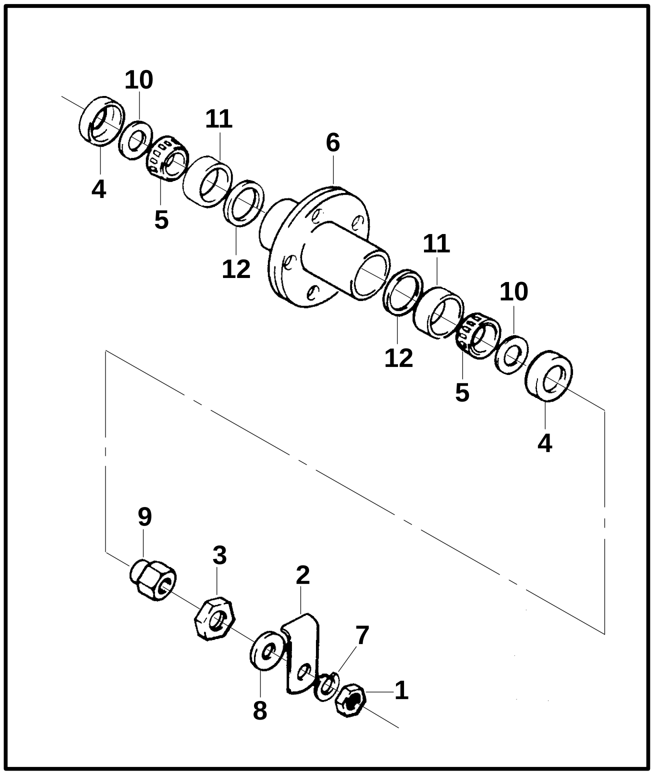


FIGURE 22

1. Axle Nut	**8. Special Washer**
2. Axle Lock	**9. Bearing Adjusting Nut**
3. Jam Nut	**10. Oil Slinger**
4. Lubrication Seals	**11. Bearing Cup**
5. Bearing Cone	**12. Bearing Backing Ring**
6. Hub	
7. Lockwasher	

3. Remove special washer, jam nut and bearing adjusting nut.

4. Remove lubrication seals, oil slinger and bearings.

5. Clean and inspect all parts for wear and damage. If there is any sign of wear, replace with new parts.

6. If the roller bearing cup was removed, replace with new parts. BE SURE backing ring is installed first.

7. Pack bearings with wheel bearing lubricant.

8. Install bearings and new lubrication seals into wheel hub.

NOTICE

- DO NOT reuse grease seals after they have been removed. Replace with new parts to prevent damage to bearings and other components.

9. Install hub onto axle. Tighten the bearing adjustment nut 7 to 13 ft.–lbs. (10 to 17 N·m) torque while rotating the hub by hand. Back off nut 1/6 turn. This will allow the hub to rotate freely without drag. A slight amount of end play is allowed. Refer to Figure 23 for part locations.

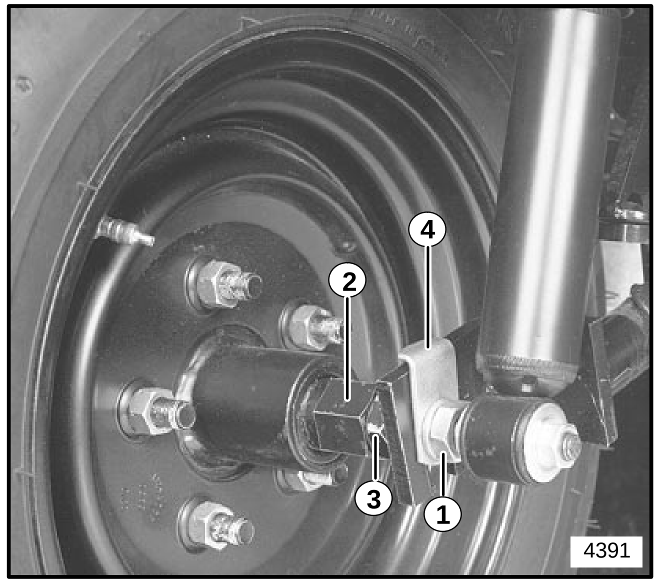


FIGURE 23

1. Axle Lock Nut

2. Bearing Adjustment Nut

3. Bearing Jam Nut

4. Axle Lock

10. Tighten bearing jam nut. See Figure 23.

REAR TIRE AND WHEEL REMOVAL

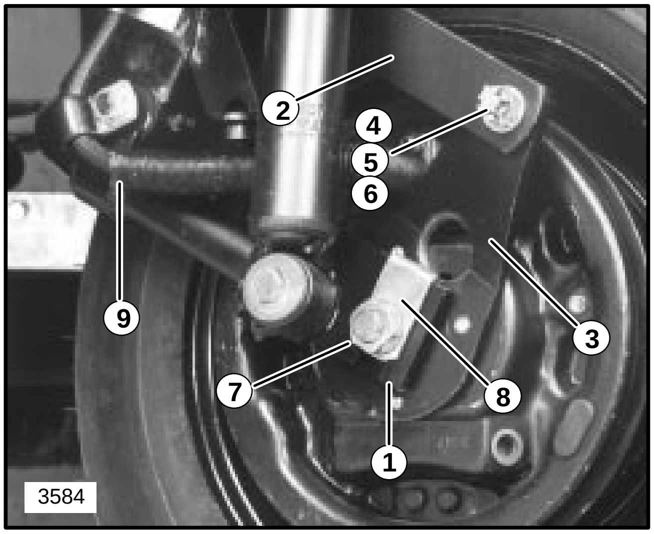
Remove and reinstall as follows:

- Remove the wheel retaining nuts and remove wheel assembly from hub.
- When reinstalling the tire and wheel make sure the valve stem faces the outside and tighten the wheel retaining nuts to 70 to 100 ft.-lbs. (95 to 140 N·m) torque.

FRONT TIRE REMOVAL

IMPORTANT!

READ THIS SECTION COMPLETELY BEFORE ATTEMPTING TIRE/WHEEL REMOVAL OR FRONT WHEEL INSTALLATION.



Front Wheel (Brake Side)

FIGURE 24

1. **Front Fork Side Arm**
2. **Brake Anchor Link**
3. **Brake Arm**
4. **Cotter Pin**
5. **Castle Nut**
6. **Washer**
7. **Axle Nut & Lockwasher**
8. **Axle Lock**
9. **Brake Hose and Protector**

Brake Link Bushings (not shown, refer to SAFETY WARNING regarding Brake Link Bushings at the bottom of page 26, column 2).
Large Flat Washer (not shown, refer to reinstallation procedure).

Remove the hub, brake and axle as follows:

- DO NOT disconnect the brake hose.
- Remove the cotter pins, washers and castle nuts attaching the brake anchor link to the front fork and brake arm. Discard the cotter pins.
- Pull the link straight off the mounting studs. Retain the bushing located in the hole at each end of the brake anchor link.
- Disassemble the LEFT shock absorber attaching hardware and the lower end of the shock absorber. Note position of all parts.
- Loosen the axle nuts and lower the entire hub, brake and axle assembly from the front fork. Remove the wheel retaining nuts.
- Position and support the brake hose and protector to avoid damage while the wheel, hub and axle are being assembled.

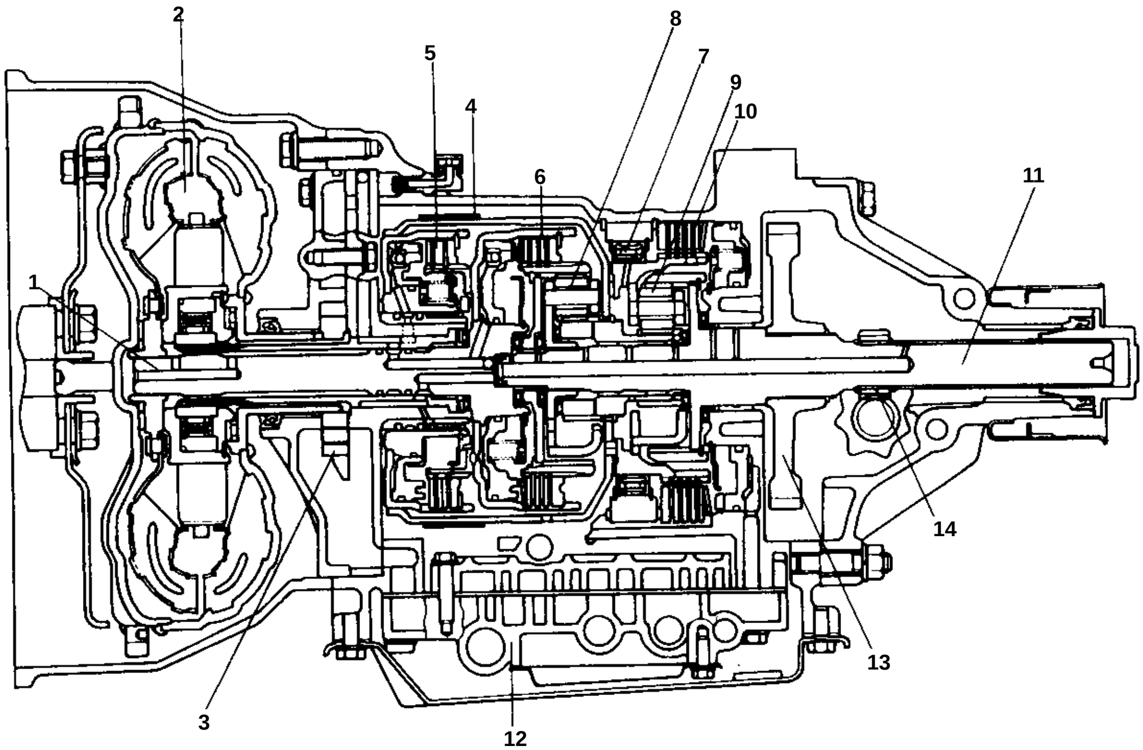
SECTION 15

TRANSMISSION
AUTOMATIC

SUMMARY

The three–speed automatic transmission uses an A–type manufactured by Aishin.

The AT controller is integrated with the EPI controller.



1. INPUT SHAFT
2. TORQUE CONVERTER
3. OIL PUMP
4. SECOND BRAKE
5. DIRECT CLUTCH
6. FORWARD CLUTCH
7. ONE–WAY CLUTCH
8. FRONT PLANETARY GEAR
9. REAR PLANETARY GEAR
10. FIRST REVERSE BRAKE
11. OUTPUT SHAFT
12. VALVE BODY
13. PARKING LOCK GEAR
14. SPEEDOMETER DRIVE GEAR

MODEL A172 SPECIFICATIONS

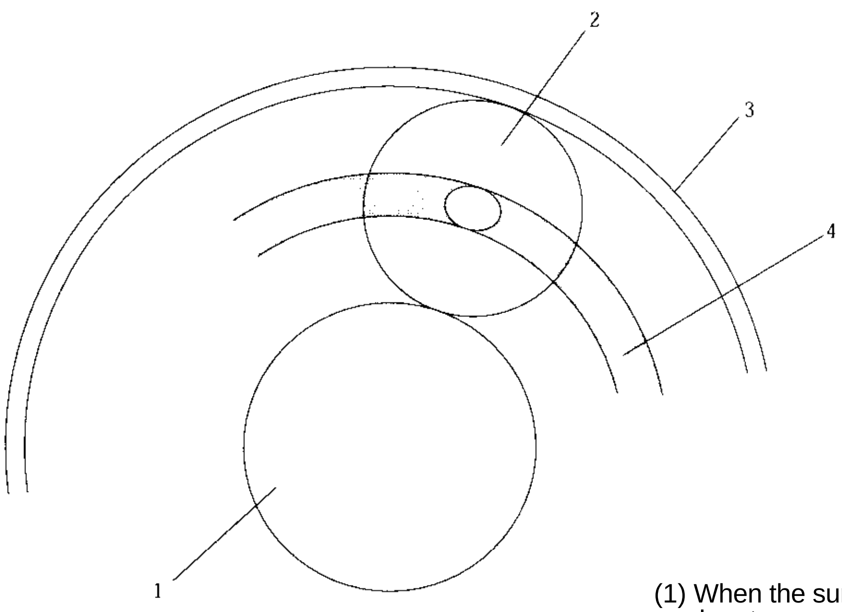
<table>
<tr><td colspan="3">Items</td><td colspan="2">Specifications</td></tr>
<tr><td colspan="3">Engine</td><td colspan="2">F6A</td></tr>
<tr><td>Con-
verter
torque</td><td colspan="2">Type</td><td colspan="2">3–element 1–stage 2–phase</td></tr>
<tr><td></td><td colspan="2">Stall torque ratio</td><td colspan="2">2.07</td></tr>
<tr><td>Pump
oil</td><td colspan="2">Type</td><td colspan="2">Trochoid oil pump</td></tr>
<tr><td></td><td colspan="2">Drive method</td><td colspan="2">Engine drive</td></tr>
<tr><td></td><td colspan="2">Type</td><td colspan="2">Forward 3–stage, reverse 1 stage planetary gear train</td></tr>
<tr><td></td><td colspan="2">Shift position</td><td colspan="2">P range: change gear neutral, output axle fixed, engine start
R range: reverse
N range: change gear neutral, engine start
D range: fwd 1st gear :2nd gear : 3rd gear
2 range: fwd 1st gear :2nd gear : 3rd gear
L range: fwd 1st gear :2nd gear : 3rd gear</td></tr>
<tr><td></td><td>Gear
ratio</td><td>1st gear</td><td>2.727</td><td>Front sun gear tooth number 37
Rear sun gear tooth number 27
Front pinion gear tooth number 16
Rear pinion gear tooth number 17
Front internal gear tooth number 69
Rear internal gear tooth number 60</td></tr>
<tr><td></td><td></td><td>2nd gear</td><td>1.536</td><td></td></tr>
<tr><td></td><td></td><td>3rd gear</td><td>1.000</td><td></td></tr>
<tr><td></td><td></td><td>Reverse</td><td>2.222</td><td></td></tr>
<tr><td></td><td colspan="2">Control elements</td><td colspan="2">Wet multi–disk clutch 2 sets
Band type brake 1 set
Wet multi–disk brake 1 set
One–way clutch 1 set</td></tr>
<tr><td></td><td colspan="2">Lubrication method</td><td colspan="2">Force–feed by oil pump</td></tr>
<tr><td></td><td colspan="2">Cooling method</td><td colspan="2">Radiator–assisted cooling: water cooling</td></tr>
<tr><td colspan="3">Oil used</td><td colspan="2">Mercon/Dexron II</td></tr>
</table>

POWER TRANSMISSION MECHANISM

PLANETARY GEAR UNIT

This unit is used for shifting during driving, and switching between forward, reverse, and neutral.

Unit is composed of a sun gear, planetary gear, and internal gear. This unit is provided on the front rear and by combination of connections is able to perform forward, reverse, and shifting.



1. Sun gear
2. Planetary gear
3. Internal gear
4. Planetary carrier

(1) When the sun gear is fixed, the number of rotations of the planetary carrier is less than that of internal gear.
(2) When the planetary gear is fixed, the number of rotations of the sun gear is more than that of internal gear, and both turn in reverse.
(3) When the internal gear is fixed, the number of rotations of the sun gear is more than that of the planetary gear.

CLUTCH AND BRAKE

These connect and fix the constituent parts of the front and rear in order to perform shifting by the planetary gear unit.

The clutch, excluding the one–way clutch, and brake operate by hydraulic pressure which is switched by means of a valve body, shift valve, or solenoid valve.

Operation overview

	Forward clutch	2nd brake band	Direct clutch	1st reverse brake	One–way clutch
Shift position					
P					
R			±	±	
N					
3rd gear	±		±		
2nd gear	±	±			
1st gear (D, 2 range)	±				±*
1st gear (L range)	±			±	

*Operates only during acceleration

ONE–WAY CLUTCH

This clutch connects the input shaft and front internal gear. In the driving range excluding reverse, direct line pressure is applied from the manual valve, and gear is always connected.

DIRECT CLUTCH

This clutch connects the input shaft and sun gear. Operates in 3rd gear and reverse. This is called a direct clutch since the gear ratio is 1:1 in 3rd gear.

FIRST REVERSE CLUTCH

This clutch fixes the rear carrier. It operates during 1st gear in the L range and during reverse. In the L range it has the function of acting as in engine brake.

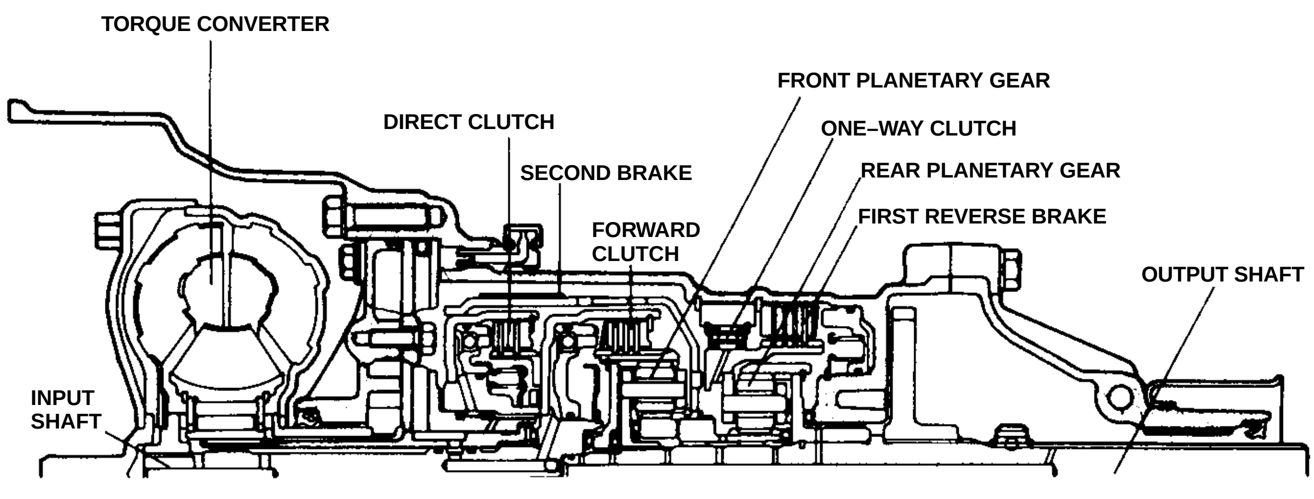
SECOND BRAKE BAND AND BRAKE SERVO

This brake fixes the sun gear. It operates in 2nd gear.
Operation is by the second brake servo, and line pressure is applied to the tightening side and release side.
When line pressure is applied to the tightening side, the brake operates.
Even if line pressure is applied to the tightening side, when line pressure is applied to the release side, the second brake will not operate.

THE PISTON OPERATION TIMING AND SPEED OF THE SECOND BRAKE ARE CONTROLLED BY THE NO. 3 SOLENOID.

One–way clutch

This clutch prevents the reverse rotation of the rear gear, and operates mechanically, not by hydraulic pressure. Since the rear gear is able to turn in a forward direction during engine braking, the engine braking is not effective.



POWER TRANSMISSION PATH

1st gear (L range)

OPERATING CLUTCH

Forward clutch: connects input shaft and front internal gear
First reverse brake: fixes rear gear

INPUT/OUTPUT

Input front internal gear
Output: rear internal gear

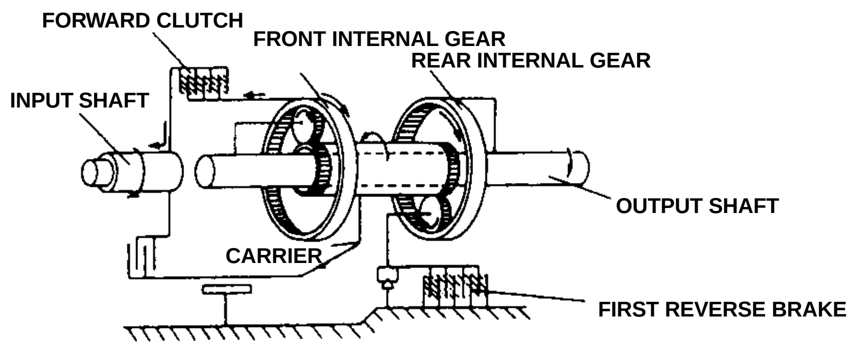
Rotating status of each gear		Front	Rear
Input rpm $N_i$rpm	Internal gear	Forward ($N_i$rpm)	Forward ($n_i$rpm)
Output rpm $n_i$rpm	Carrier	Forward ($N_c$rpm)	Stop
$N_i > N_c = n_i$	Sun gear	Reverse	

Since $N_i > n_i$, the output rpm is slowed in relation the input rpm.
Since the clutch and brake are in a connected state, engine braking is effective.

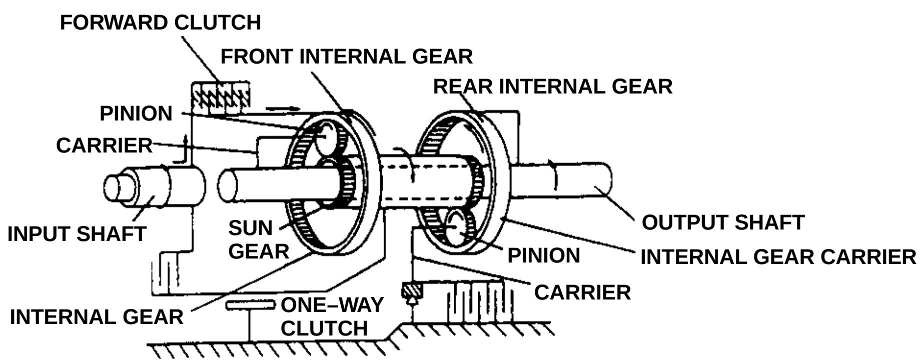
1ST GEAR (D, 2 RANGE)

The operating clutch, input/output, gear, and carrier rotating status are nearly the same as when in the L range, but the carrier is not fixed, only the reverse direction is fixed by the one–way clutch, and allowing rotation in the forward direction.
When the engine braking is used, a force turning in the forward direction is applied to the rear gear, it is able to turn. Thus engine braking is ineffective.

[L] RANGE



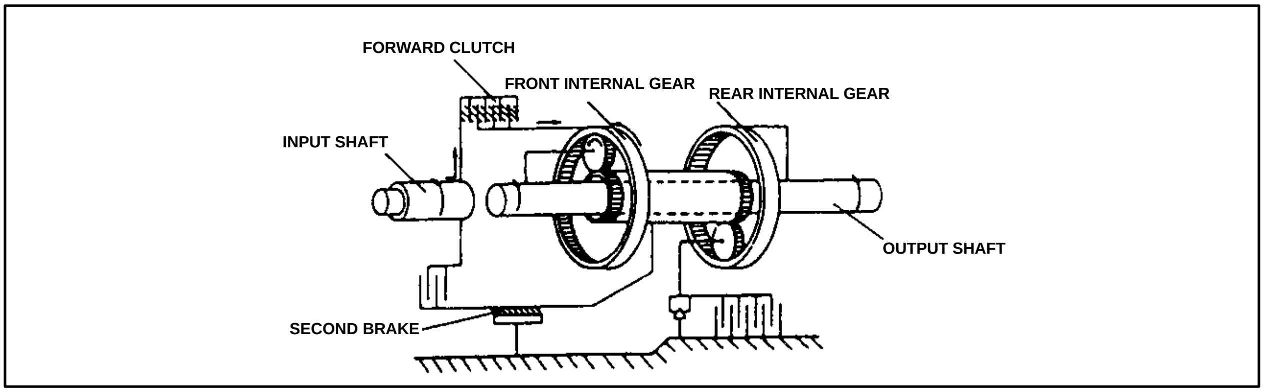
[D] • [2] RANGE



2ND GEAR

Since $N_i > n_i$, the output rpm is slowed in relation to the input rpm.
Since the rotation of the sun gear was reverse in 1st gear, the front carrier was slowed to that extent, but in 2nd gear the sun gear is fixed, so the slowing of the front gear is less than that in 1st gear. Accordingly, the output rpm is higher than in 1st gear.

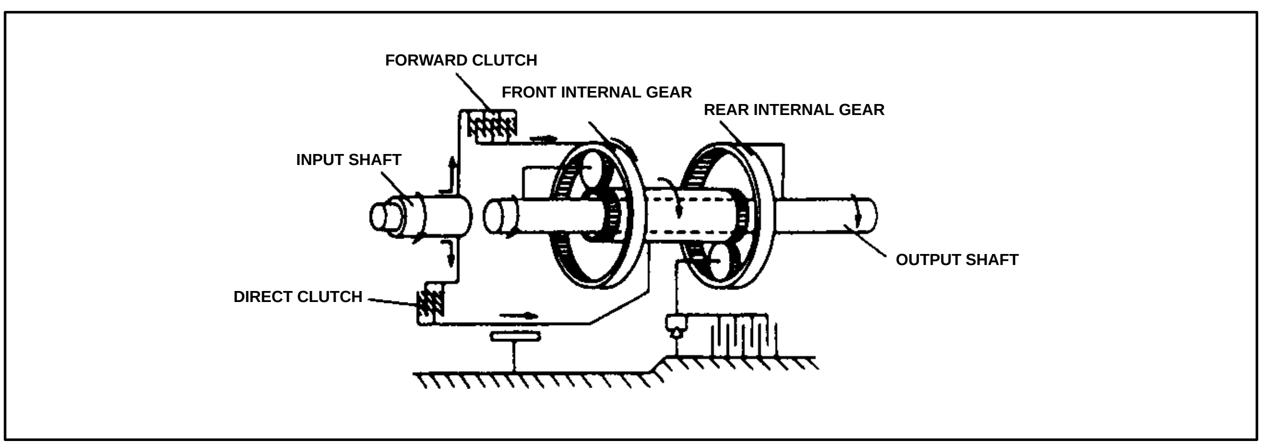
Operating brake, clutch		Front	Rear	Input: front internal gear
Forward clutch: connects input shaft and front internal gear 2nd brake band: fixes sun gear	Internal gear	Fwd ($N_i$rpm)	Fwd ($n_i$rpm)	Output: front carrier
	Carrier	Fwd ($N_c$rpm)	Stop	Input rpm $N_i$rpm
	Sun gear	Reverse		Output rpm $n_c$rpm



3RD GEAR

Since the output rpm of the front internal gear and the sun gear are the same, the front planetary unit rotates at one body so that $N_i = N_c$, and the output shaft and input shaft are in a state direct connection.

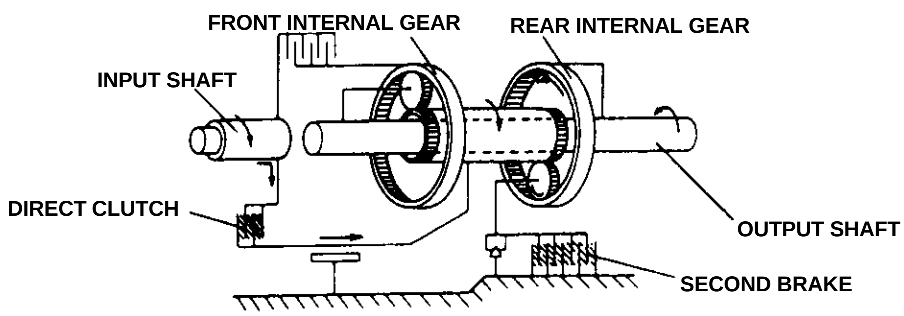
Operating brake, clutch Forward clutch: connects input shaft and front internal gear Direct clutch: connects input shaft and sun gear		Front	Rear	Input: front internal gear Output: front carrier Input rpm $N_i$rpm Output rpm $n_c$rpm $N_i = N_S = N_c$
	Internal gear	Fwd ($N_i$rpm)	Fwd ($n_i$rpm)	
	Carrier	Fwd ($N_c$rpm)	Fwd ($n_c$rpm)	
	Sun gear	Fwd ($N_S$rpm)		



REVERSE

The rear carrier is fixed, and the sun gear rotates turns in a forward direciton, so the rear internal gear turns in a reverse direction. Thus the output shaft rotation is reversed, and the vehicle moves backward.

Operating brake, clutch Direct clutch: connects input shaft and sun gear 1st reverse brake: fixes rear gear		Front	Rear	Input: front internal gear Output: front carrier Input rpm N_S Output rpm n_i $N_S > n_i$ $0 > n_I$
	Internal gear	Rvse ($N_i$rpm)	Rvse ($n_i$rpm)	
	Carrier	Rvse ($N_i$rpm)	Fixed	
	Sun gear	Fwd ($N_S$rpm)		



HYDRAULIC MECHANISM

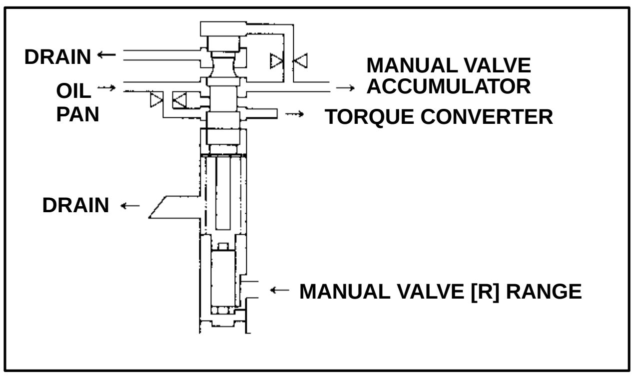
VALVE BODY

The valve body distributes the hydraulic pressure generated by the oil pump to the clutch and brake.

Internally, is comprised of a manifold valve, which distributes the basic hydraulic pressure, shift valves, which switch hydraulic pressure to the clutch and brake, pressure regulator valve, which adjusts the line pressure, accumulator, which absorbs the shift shock, etc.

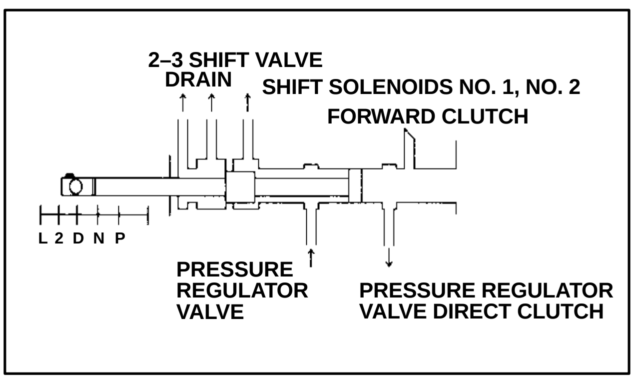
The oil pathway is provided on the main body, and the shift pumps are operated by means of shift solenoid valves.

Valve name	Function
Pressure regulator valve	Regulates line pressure according to running status
Locust modulator valve	Regulates line pressure applied to 1st reverse brake
Manual valve	Distributes line pressure according to position of selector lever
1–2 shift valve	Performs shifting from 1st to 2nd gear
2–3 shift valve	Performs shifting from 2nd to 3rd gear
Shift solenoid valve No. 1 (direct clutch solenoid)	Opens and closes drain port by solenoid, switches line pressure to 1–2 shift valve
Shift solenoid valve No. 2 (direct clutch solenoid)	Opens and closes drain port by solenoid, switches line pressure to 2–3 shift valve
Shift solenoid valve No. 3 (direct clutch solenoid)	Acts as a damper when second brake band servo is operating



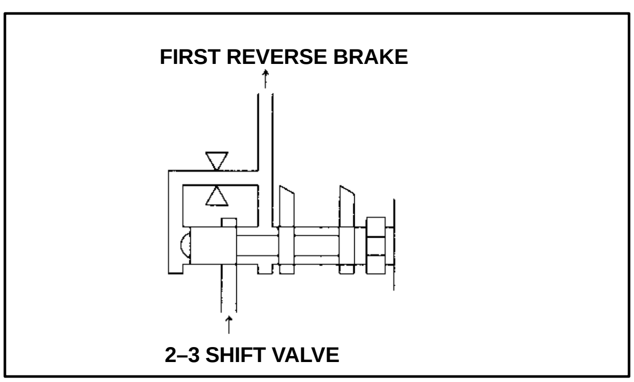
VALVES AND SOLENOIDS
PRESSURE REGULATOR VALVE

This valve adjusts the hydraulic pressure generated by the oil pump to a designated pressure (line pressure). The hydraulic pressure changes according to the running range.



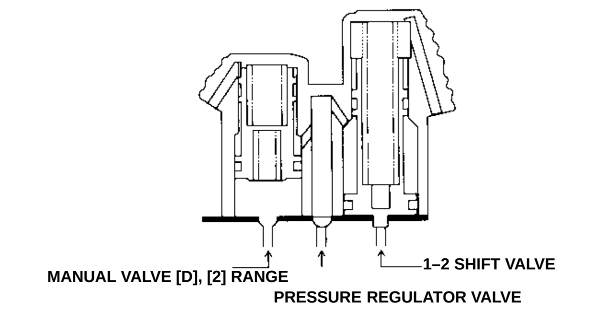
MANUAL VALVE

This valve switches the direct line pressure according to the selector lever.



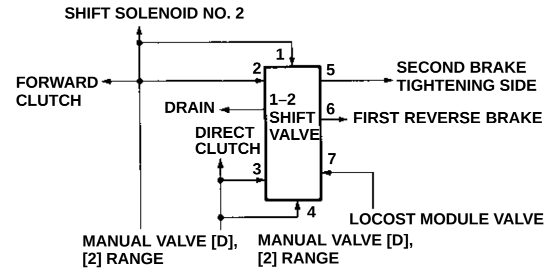
LOCOST MODULATOR VALVE

This valve absorbs shock so that the increase in oil pressure is dampened when line pressure is applied to the first reverse brake in the L range and R range.



ACCUMULATORS NO. 1 AND NO. 2

These valves dampen the increase in hydraulic pressure applied to the tightening side of the 2nd brake band servo and hydraulic pressure applied to the forward clutch.

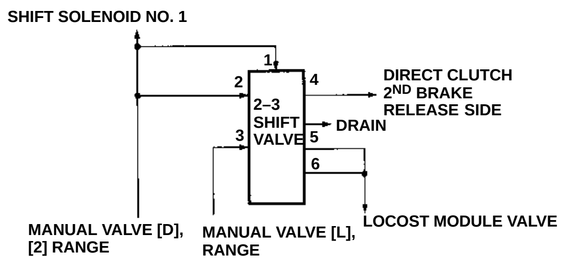


1–2 SHIFT VALVE

This valve shifts up or down between 1st gear and 2nd gear and is operated by the shift solenoid No. 2.

Shifts to 1st gear when line pressure is applied only to 1 on the shift valve.

In 1st gear, the 6–7 passage is open, 2 and 3 are closed. 5 is drained. In 2nd and 3rd gears and in reverse, the 2–5 and 3–6 passages are open, and 7 is closed.



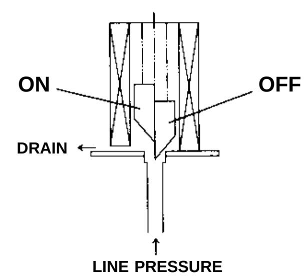
2–3 SHIFT VALVE

This valve shifts up or down between 2nd gear and 3rd gear and is operated by the shift solenoid No. 1.

Shifts to 3rd gear when line pressure is applied to 1 on the shift valve.

In 1st and 2nd gears and reverse, 3–6 passage is open, and 2 is closed. 4 is drained.

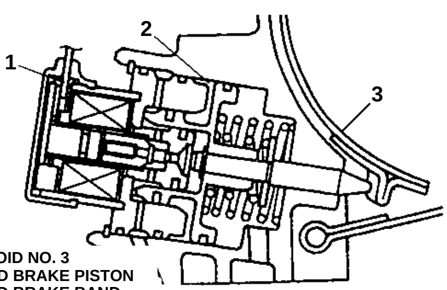
In 3rd gear, the 2–4 passage is open, and 3 is closed. 5 is drained.



SHIFT SOLENOIDS NO. 1 (DIRECT CLUTCH SOLENOID) AND NO. 2 (2ND BRAKE SOLENOID)

These solenoid valves control the pilot pressure that operates the shift valves.

When ON, the drain port on the valve operation side is open, and when OFF it is closed.



1. SOLENOID NO. 3
2. SECOND BRAKE PISTON
3. SECOND BRAKE BAND

SOLENOID VALVE NO. 3 (2ND BRAKE SERVO SET)

This valve restricts abrupt operation when the 2nd brake band servo is operated, and is not directly related to shifting.

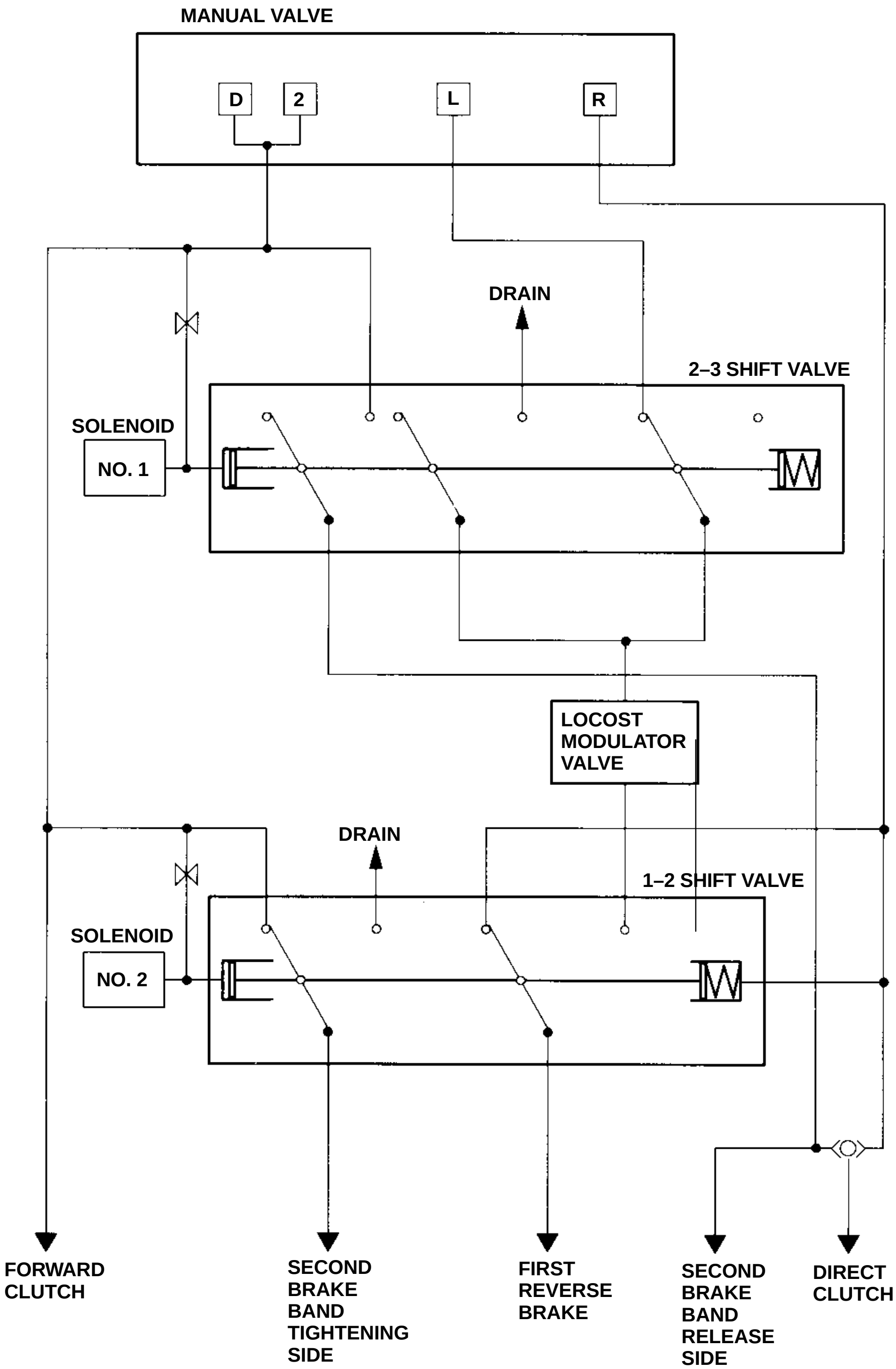
HYDRAULIC CIRCUIT

The hydraulic pressure for gear shifting operation is the line pressure.

The line pressure is a hydraulic pressure which operates the clutch and brake, and is switched by the manual valve, 1–2 shift valve, and 2–3 shift valve.

The line pressure changes by adjusting the pressure using the pressure regulator valve and locust modulator valve, according to the position of the selector lever.

Refer to pressure regulator valve, manual valve, and locost modulator valve of valves and solenoids with respect to control details.



	Shift solenoid	
	No. 1	No. 2
1st gear	O	X
2nd gear	O	O
3rd gear	X	O

O .... **ON**
X .... **OFF**

1ST GEAR (L RANGE)

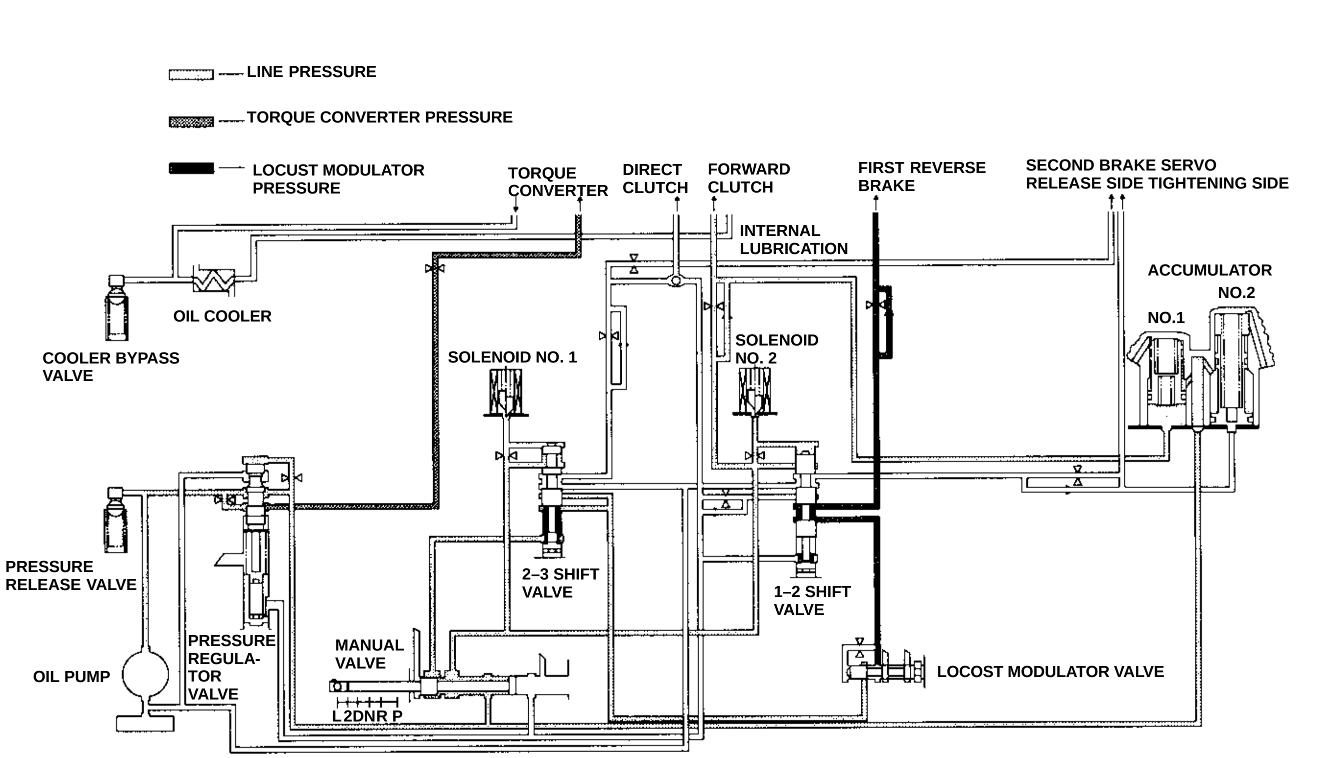
Line Pressure

Pressure regulator valve → manual valve → forward clutch

manual valve ↓ 2–3 shift valve → locost modulator valve → first reverse brake

Since the shift solenoid valve No. 1 is ON, the 2–3 shift valve is not operate, and the line pressure passing through the port of the L range of the manual valve passes through the 2–3 shift valve and the locost modulator and operates the first reverse brake.

The shift solenoid valve No. 2 is OFF, the 1–2 shift valve is operated, the line pressure operates only the forward clutch.



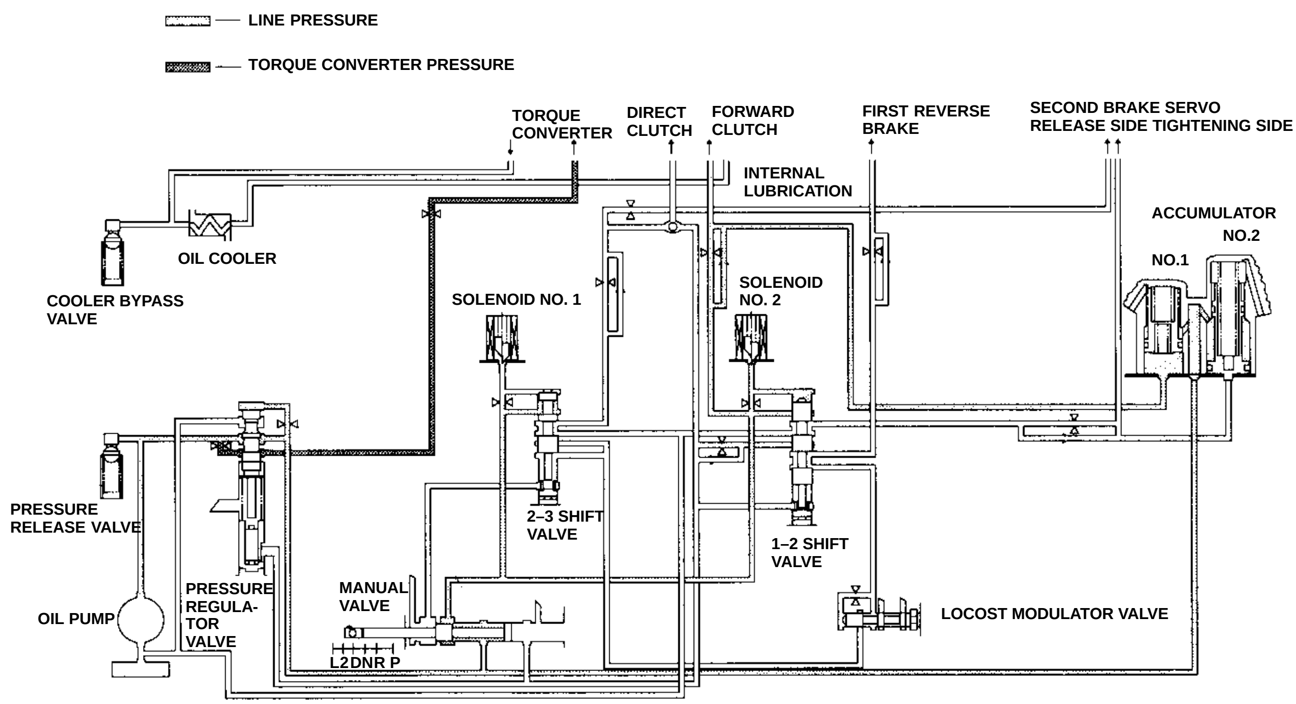
1ST GEAR (D, 2 RANGE)

Line Pressure

Pressure regulator valve → manual valve → $\boxed{\text{forward clutch}}$

Since solenoid valve No. 1 is ON, the 2–3 shift valve is not operated, the line pressure is halted at the 2–3 shift valve.

Shift solenoid valve No. 2 is OFF, the 1–2 shift valve is operated, and the line pressure operates only on the forward clutch.



2ND GEAR

Line Pressure

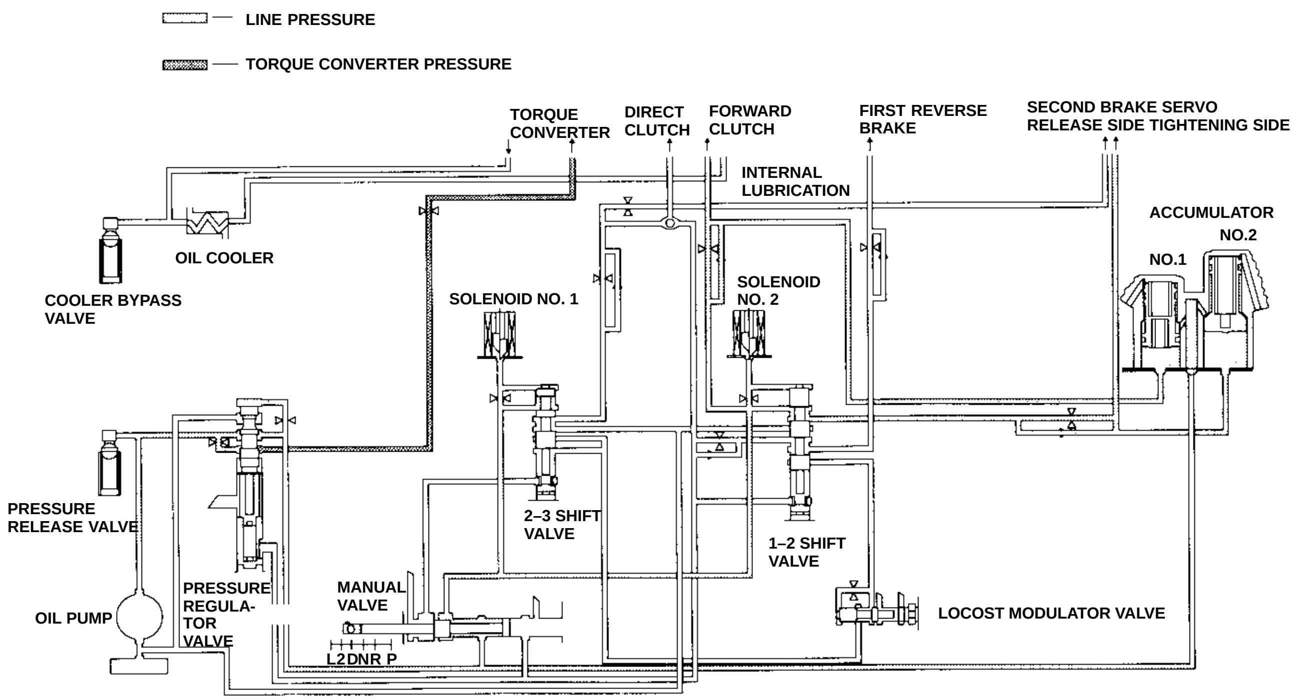
Pressure regulator valve ⟶ manual valve ⟶ forward clutch

manual valve ⟶ 1–2 shift valve ⟶ 2nd brake servo tightening side

Since shift solenoid valve No. 1 is ON, the pilot pressure is drained, and the 2–3 shift valve does not operate.

Since shift solenoid valve No. 2 is ON, the line pressure is stopped, and the 1–2 shift valve does not operate.

The line pressure operates the forward clutch, and the line pressure passing through the 1–2 shift valve is applied to the 2nd brake servo tightening side, so the 2nd brake is operated.



3RD GEAR

Line Pressure

Pressure regulator valve → manual valve → forward clutch

manual valve → 1–2 shift valve → 2nd brake servo tightening side

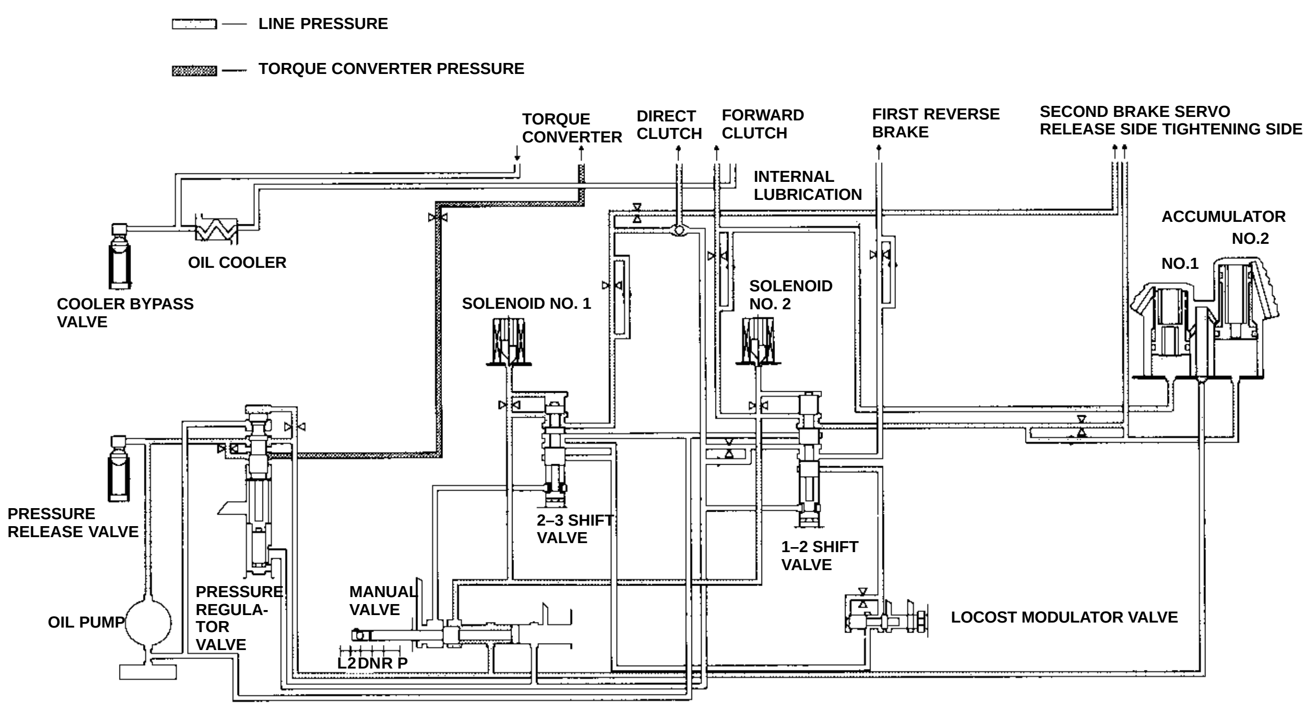
1–2 shift valve → 2–3 shift valve → 2nd brake servo tightening side

2–3 shift valve → Direct clutch

Since shift solenoid valve No. 1 is OFF, the 2–3 shift valve operates.

The line pressure operates the forward clutch via the manual valve, and the line pressure operating on the 1–2 shift valve is applied to the 2nd brake servo tightening side and the 2–3 shift valve.

Since the shift solenoid No. 2 is ON, the 1–2 shift valve does not operate, and line pressure is applied to the 2nd brake release side and direct clutch.



REVERSE

Line Pressure

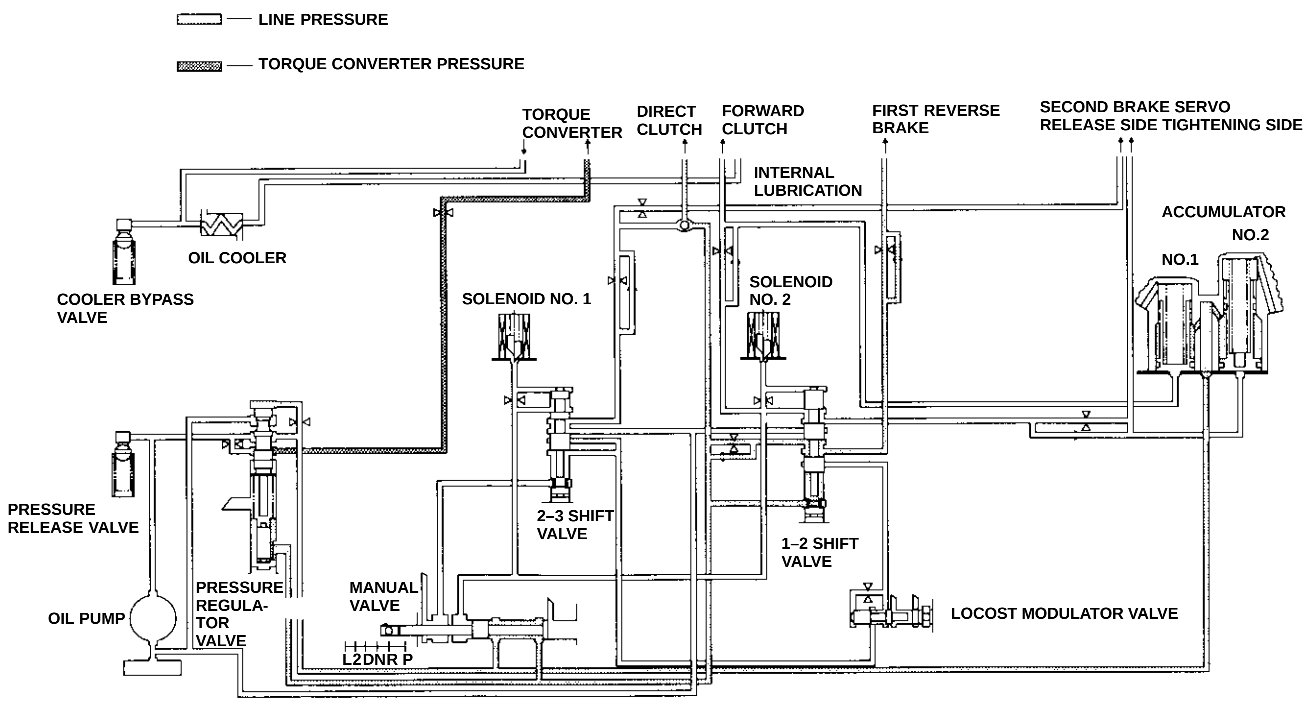
Pressure regulator valve → manual valve → 1–2 shift valve → $\boxed{\text{1st reverse brake}}$

manual valve → $\boxed{\text{direct clutch}}$ → Pressure regulator valve

Line pressure passes through the 1–2 shift valve and directly operates the first reverse brake and direct clutch.

Although the shift solenoid valves No. 1 and No. 2 are OFF, since the line pressure is closed off by the manual valve, shifting is unaffected.

Additionally, line pressure is applied to the pressure regulator valve, and the line pressure is held at a high level the normal.



CONTROL MECHANISM

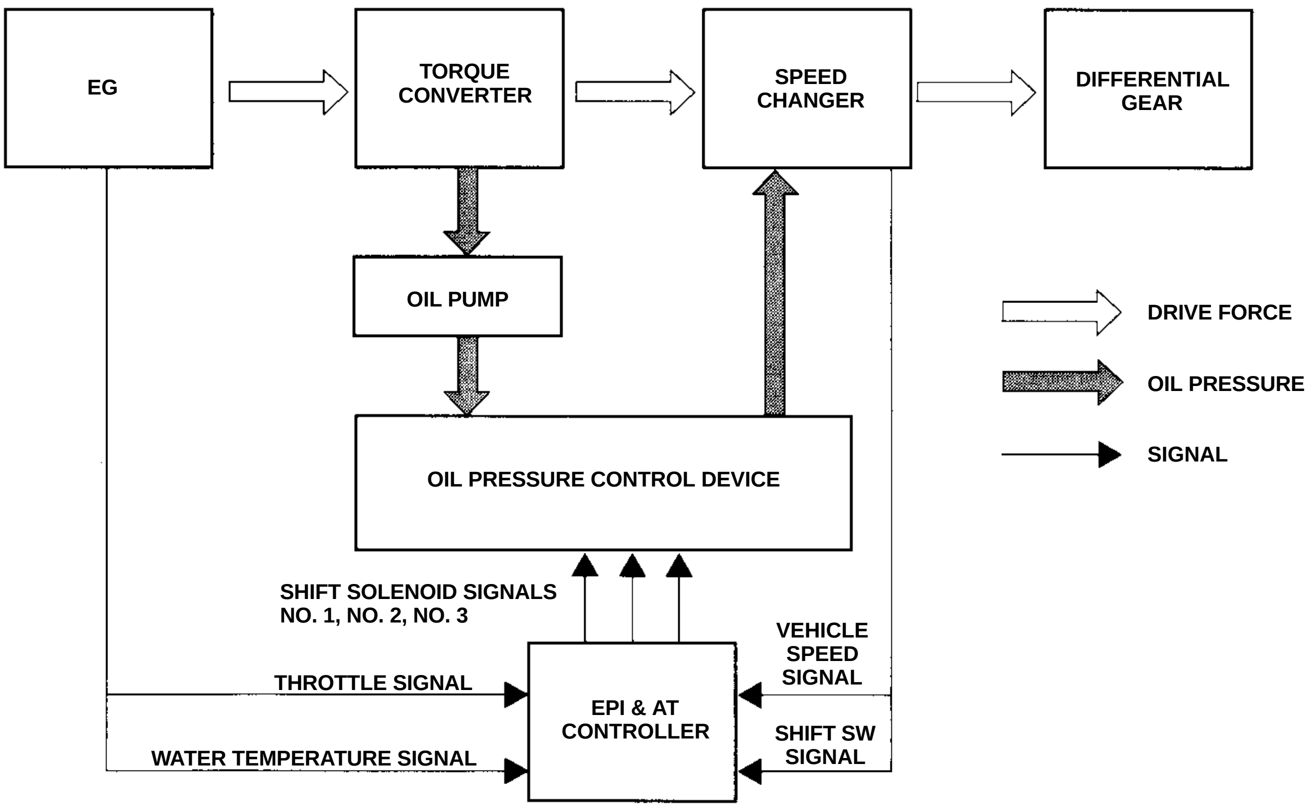
GEARSHIFT CONTROL

Shifting in the EPI models is performed using shift solenoid valves No. 1 and No. 2, which are controlled by the AT controller that is integrated with the EPI controller, and in manual valve that is controlled by the selector lever.

When the selector lever is in neutral at P or N, or reverse in R, mechanical shifting is performed by the manual valve and line pressure.

In other ranges, shifting up and shifting down into or from 1st, 2nd or 3rd gear is performed by the shift solenoid valves No. 1 and No. 2.

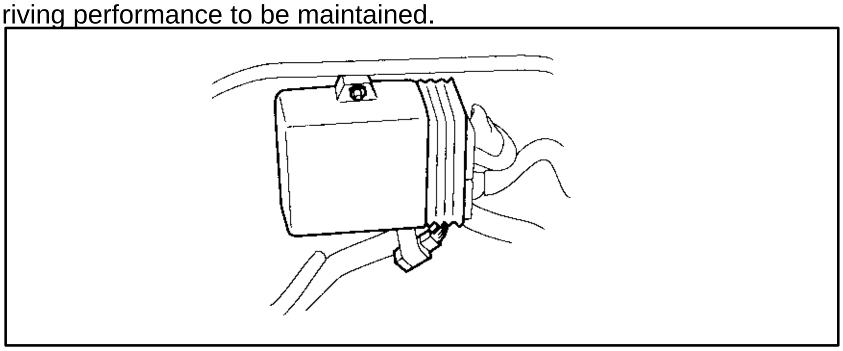
Please refer to the preceding pages for the power transmission path and hydraulic circuit for each change of gears.

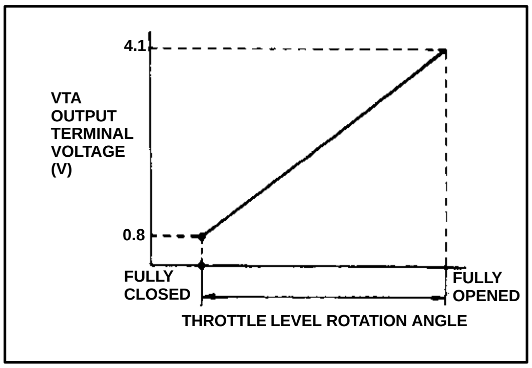


AT CONTROLLER

The controller is installed behind the engine compartment under the storage compartment center section, and is integrated with the EPI controller. The output signals of the shift solenoids No. 1, No. 2, and No. 3 are transmitted according to the input signals from each sensor and perform shifting between 1st gear, 2nd gear, and 3rd gear.

A diagnosis function is provided for detecting abnormalities in the controller unit and input and output signals. When a system error occurs, a failsafe function operates, allowing the minimal driving performance to be maintained.



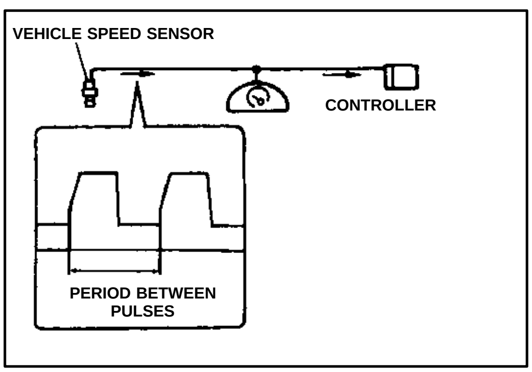


INPUT SIGNAL

Throttle signal

Voltage changes in the throttle sensor are read as signals, and input as the throttle opening.

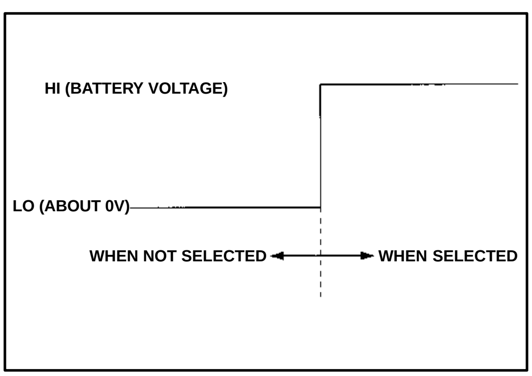
These are used as a reference for changing gears together with the vehicle speed signal.



VEHICLE SPEED SIGNAL

Changes in the rpm of the output pulse of the vehicle speed sensor are read as vehicle speed signal and are input as vehicle speed.

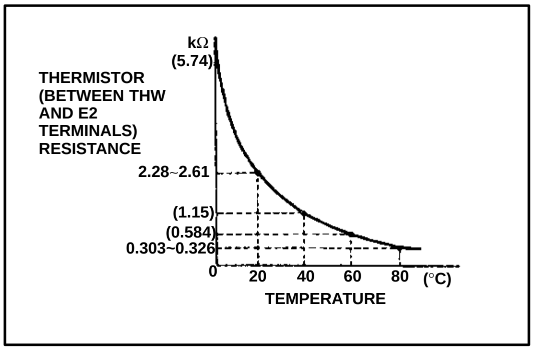
These are used as a reference for changing gears together with the throttle signal.



SHIFT POSITION SIGNAL

According to output for the shift lever switch, the present selector lever position and manual valve position are detected.

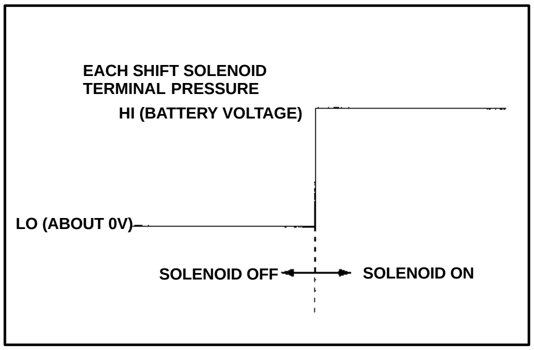
These are used as a reference for determining the driving gear for a vehicle speed.



WATER TEMPERATURE SIGNAL

Changes in the resistance of the water temperature sensor are read as changes in voltage, and are input as the cooling water temperature.

The gearshift point changes according to the temperature.

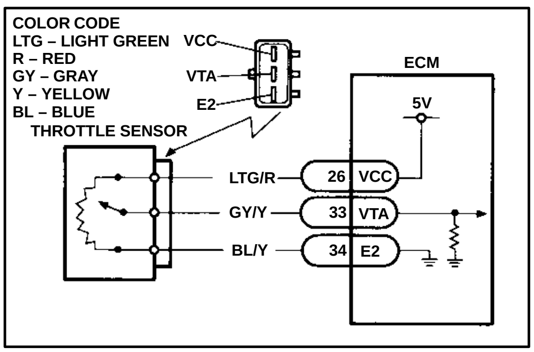


OUTPUT SIGNALS

Shift solenoid No. 1 (direct clutch solenoid) and No. 2 (2nd brake solenoid) signals

These are signals which, based on the input signals, operate the shift solenoids No. 1 and No. 2.

	1st	2nd	3rd
Shift Solenoid No. 1	ON	ON	OFF
Shift Solenoid No. 2	OFF	ON	ON

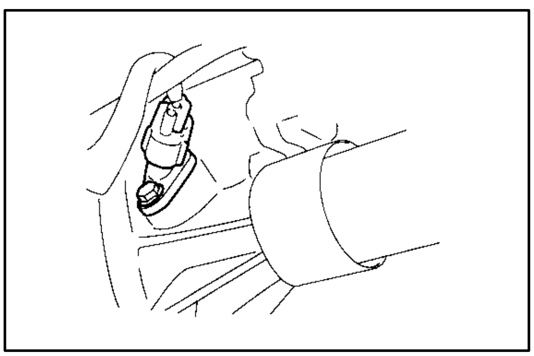


SENSOR SWITCHES

Throttle sensor

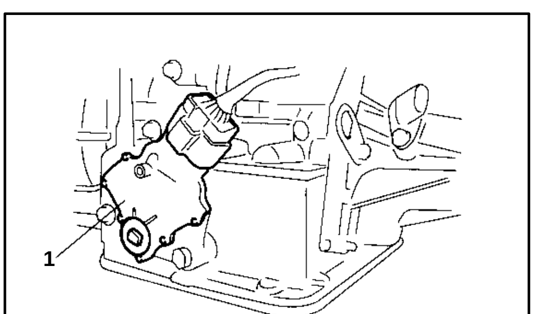
Installed on the throttle shaft, detects throttle opening.

See section 1C for details.



VEHICLE SPEED SENSOR

In the AT case, and picks up the signal rotor number of the output shaft by sensor.



1. SHIFT SWITCH

SHIFT SWITCH

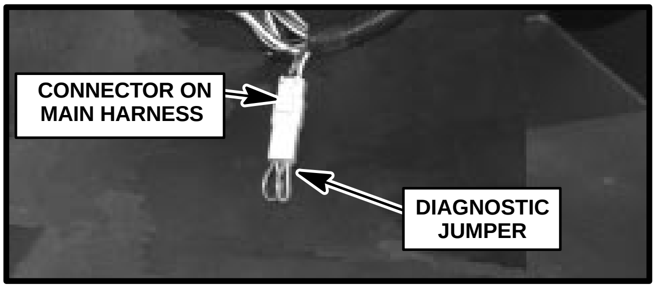
Installed on the manual shift shaft, and by applying battery voltage to the controller according to the position of the selector lever, detects the present positions of the selector lever and manual valve.

DIAGNOSIS (WITH FAILSAFE FUNCTION)

The controller is provided with a diagnosis function, which detects and displays abnormalities in the input/output signals and controller main unit**.**

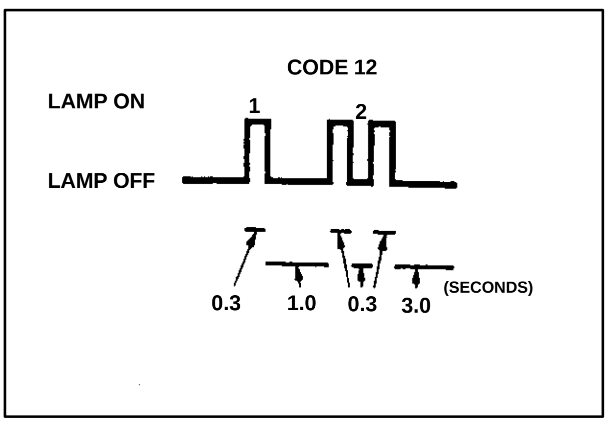
However, abnormalities in mechanical parts such as the power transmission system and hydraulic system cannot be detected.

When abnormality occurs, by connecting to diagnostic coupler in the engine compartment relay box, a code is display by blinking the engine check lamp.



DIAGNOSTIC CODE TABLE

Error code	Diagnosis item	Diagnosis content	Failsafe control	
12	Normal			
41	Shift solenoid No. 1 (direct clutch solenoid)	Open circuit	Performs normal control	Shifts between 2^{nd} and 3^{rd} gear, does not enter 1^{st} gear
		Short	Solenoid OFF	
42	Shift solenoid No. 2 (2nd brake solenoid)	Open circuit	Performs normal control	Shifts between 1^{st} and 3^{rd} gear, does not enter 2^{nd} gear
		Short	Solenoid OFF	
43	Shift solenoid No. 3	Open circuit	Solenoid OFF	
		Short	Performs normal control	
16	Vehicle speed sensor	No signal or signal ceased while driving	D range à 3^{rd} gear fixed 2 range à 2^{nd} gear fixed L range à 1^{st} gear fixed	
13	Throttle sensor	Over (≥ 4.73 V)	Throttle opening considered completely closed (AT only)	
		Under (≤ 2.25 V)		
46	Shift switch	No signal	Maintained shift position immediately before failure evaluation value	
		2 or more signals input simultaneously	Determined shift position in the following order of priority: D > 2 > L > R > N > P	



- Code discrimination is performed as shown to the laugh.

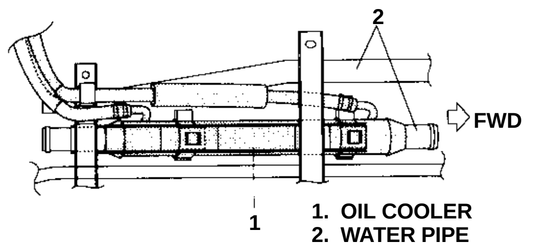
Note: the codes are displayed 3 at a time in order of smallness.

OTHER MECHANISMS

OIL PUMP

A trochoid type oil pump is installed on the AT case input shaft side.

It is driven by means of a torque converter shell case. Thus, when the engine stops, lubrication is not performed in the AT.



OIL COOLER

A pipe type oil cooler is installed on the radiator outlet pipe.

	P	● Parking position • Output shaft of the mission is mechanically locked. • Engine can start. • Key interlock mechanism of ignition Key is released. • When ignition key is ON, when button is pushed while brake pedal is depressed, shift to other range is possible.
⬆⬇		
	R	● Reverse position • Can be used when car is backed up.
⬆⇩		
	N	● Neutral position • Engine can be started.
⇧⇩		
	D	● Normal drive position • Shifts automatically according to vehicle speed and accelerator opening among $1^{st} \Leftrightarrow 2^{nd} \Leftrightarrow 3^{rd} \Leftrightarrow 4^{th}$ gears. (However, up to 3rd gear when 0/D OFF.)
⇧⇩		
	2	● Position used when engine brake is applied, or fixing at 2nd gear • Automatically shifts between $1^{st} \Leftrightarrow 2^{nd}$.
⇧⬇		
	L	● 1st gear position • Used when ascending steep slopes or when strong engine brake is required for descending.

SELECTOR LEVER

Floor shift models have a selector lever in the center console area.

N D 2 can be selected freely, but PàR, NàR, and 2àL cannot be selected unless the button is pressed.

In order to prevent operational error, a key interlock mechanism and shift locked mechanism are used, and a reverse warning device is used, which notifies the driver that the transmission is in the R region by sounding a warning tone when the vehicle is in reverse.

⬆operate by pushing button

⇧operated without pushing button