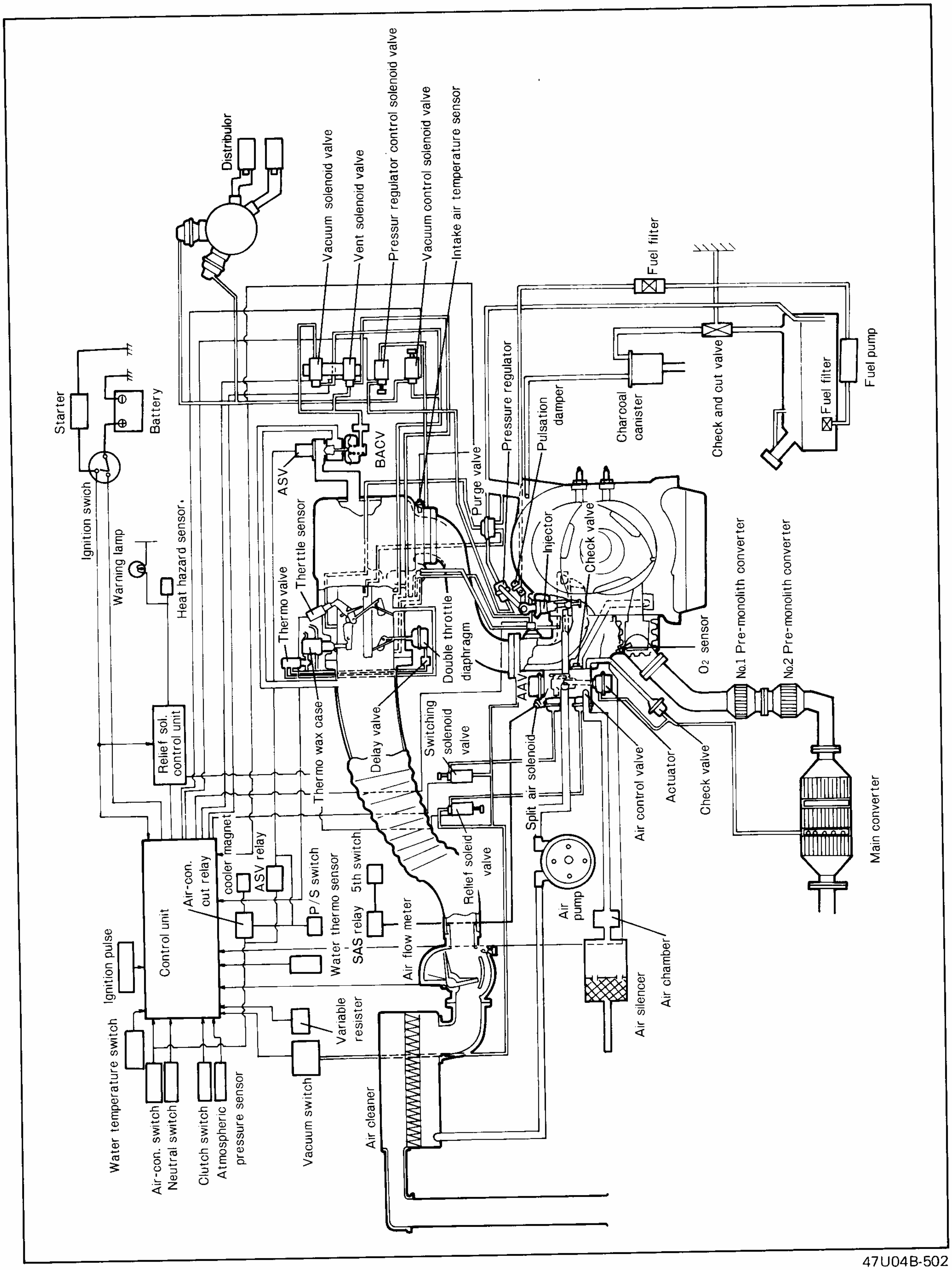
FUEL, INTAKE, EXHAUST AND EMISSION CONTROL SYSTEM (13B ENGINE)

SYSTEM DIAGRAM



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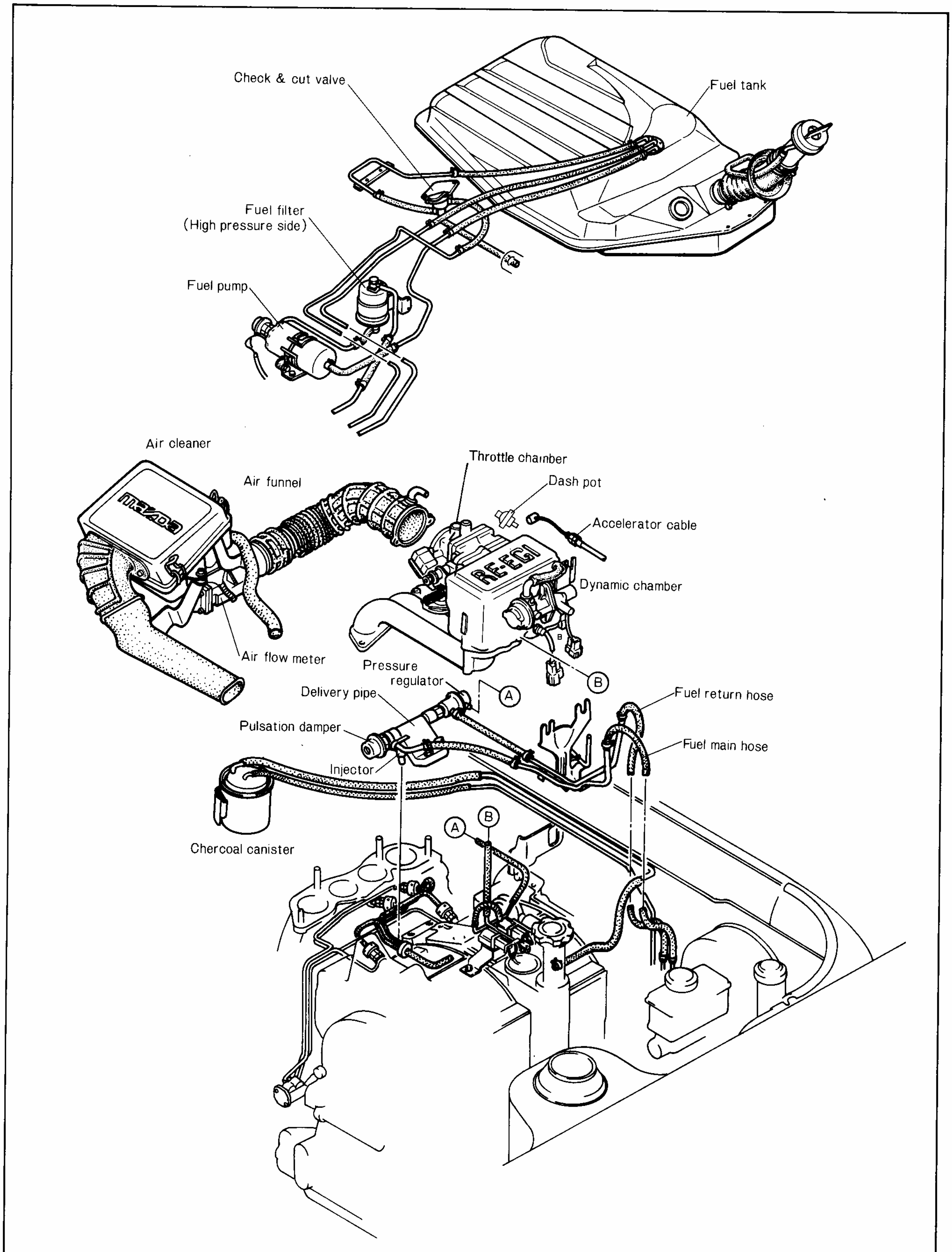
EMISSION CONTROL SCHEMATIC DIAGRAM



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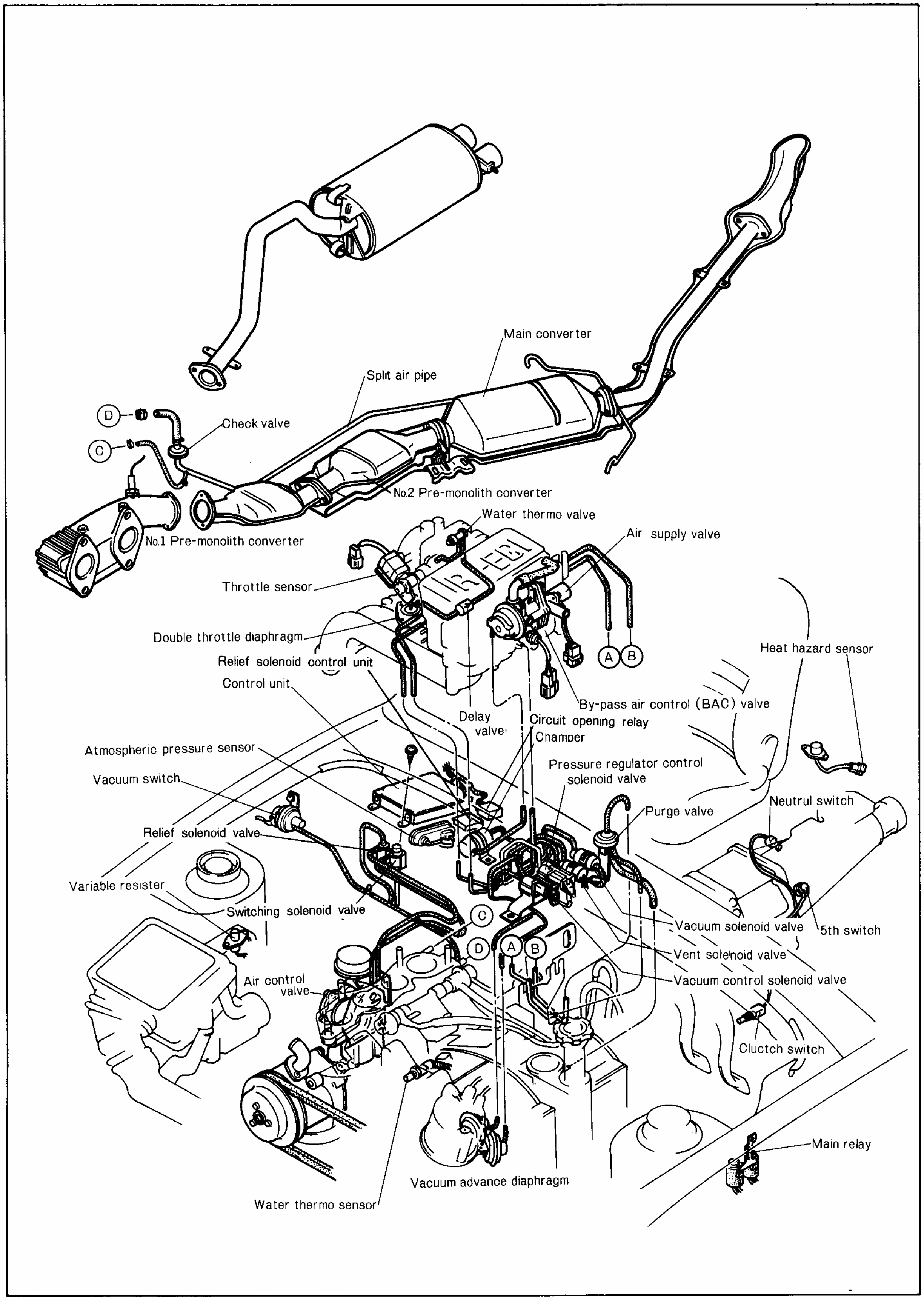

Main converter
Split air pipe
D
C
Check valve
No.2 Pre-monolith converter
Water thermo valve
No.1 Pre-monolith converter
Air supply valve
Throttle sensor
Double throttle diaphragm
A
B
Relief solenoid control unit
Heat hazard sensor
Control unit
By-pass air control (BAC) valve
Delay valve
Circuit opening relay
Chamber
Atmospheric pressure sensor
Pressure regulator control solenoid valve
Vacuum switch
Neutrul switch
Purge valve
Relief solenoid valve
Variable resister
Switching solenoid valve
Vacuum solenoid valve
5th switch
Vent solenoid valve
Vacuum control solenoid valve
Air control valve
Cluctch switch
Main relay
Vacuum advance diaphragm
Water thermo sensor

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COMPONENT DESCRIPTIONS

Component	Function	Remarks
1. Air Cleaner	Filters air into throttle chamber	
2. Air Control Valve (ACV)	Directs air to one of three locations; exhaust port, 3-bed catalyst or back to the relief air silencer	Consists of 3 valves: Air Relief Valve Air Switching Valve Anti-afterburn Valve
3. Air Flow Meter	Detects amount of intake air; sends signal to control unit	
4. Air Pump	Supplies secondary air to ACV	
5. Air Supply Valve	Supplies by-pass air into dynamic chamber	During air-con. operation During P/S operation
6. Anti-Afterburn Valve	Supplies fresh air into rear port during deceleration	Included in ACV; vacuum operated
7. Atmospheric Pressure Sensor	Detects atmospheric pressure; sends to control unit	
8. By-pass Air Control (BAC) Valve	Controls amount of by-pass air to maintain idling speed, etc.	Controlled by vent solenoid valve and vacuum solenoid valve
9. Canister	Stores gas tank fumes when engine stops	Vented to atmosphere through charcoal and filter
10. Check and Cut Valve	Releases excessive pressure or vacuum in fuel tank to atmosphere Prevents fuel loss if vehicle overturns	

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COMPONENT DESCRIPTIONS

Component	Function	Remarks
11. Clutch Switch and Neutral Switch	Detect in-gear condition; sends signal to control unit	Closes when clutch pedal is depressed; opens when clutch pedal is released Closes in neutral; opens in all other ranges
12. Control Unit	Detects the following: 1. Engine speed 2. Radiator coolant temperature 3. Engine coolant temperature 4. Throttle opening 5. Intake manifold vacuum 6. O_2 concentration 7. In-gear condition 8. Idle mixture 9. Floor temperature 10. Intake air temperature 11. Cranking signal 12. Atmospheric pressure 13. Air conditioner ON/OFF condition 14. Amount of intake air Controls operation of the following: 1. Vacuum control solenoid valve 2. Switching solenoid valve 3. Relief solenoid valve 4. BAC valve (vent solenoid valve and vacuum solenoid valve) 5. Pressure regulator control solenoid valve 6. Fuel injection system	1. Ignition coil − terminal 2. Water temperature switch 3. Water thermo sensor 4. Throttle sensor 5. Vacuum switch 6. O_2 sensor 7. Clutch switch and neutral switch 8. Variable resistor 9. Heat hazard sensor 10. Intake air temperature sensor 11. Starter switch 12. Atmospheric pressure sensor 13. Air con. switch 14. Air flow meter
13. Dash Pot	Gradually closes throttle during deceleration	Contacts at 2,350 ~ 2,650 rpm (in neutral)
14. Heat Hazard Sensor	Detects floor temperature; sends signal to relief solenoid valve control unit	Closes above 130°C (266°F) when heat hazard sensor is closed; relieves secondary air

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Component	Function	Remarks
15. Intake Air Temperature Sensor	Detects intake air temperature; controls pressure control valve and BAC valve through control unit	Thermistor
16. No. 1 Pre-Monolith Converter	Reduce HC, CO	Oxidizing catalyst
17. No. 2 Pre-Monolith Converter	Reduce HC, CO and NOx	3 way catalyst
18. Over Drive Switch	Controls ACV solenoid	5th gear: open Others: closed
19. O_2 Sensor	Detects exhaust manifold O_2 concentration; sends signal to control unit	
20. Pressure Regulator Control Solenoid Valve	Shuts vacuum passage between dynamic chamber and pressure regulator (to prevent engine stopping)	Operates when: Intake air temperature is above 50°C (122°F) During cranking After cranking
21. Purge Valve	Carries evaporative fumes from gas tank and canister to intake manifold	During open throttle
22. Relief Solenoid Valve	Relieves secondary air to air cleaner when unnecessary	Blue
23. Split Air Solenoid Valve	Controls amount of split air; increase split air when ACV solenoid operates	Operates when overdrive switch is open

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Component	Function	Remarks
24. Split Air Injection Pipe	Secondary air injected between center monolith and rear monolith (main converter) above 1,100 rpm with open throttle	
25. Switching Solenoid Valve	Switches secondary air to exhaust port or rear catalyst	Gray
26. Throttle Sensor	Detects throttle opening angle	
27. Vacuum Advance Diaphragm	Controlled by solenoid valve	
28. Vacuum Control Solenoid Valve	Cut vacuum to distributor during deceleration, etc.	Green
29. Vacuum Switch	Detects intake manifold vacuum; sends signal to control unit	Opens when intake manifold vacuum is 0 ~ 100 mmHg
30. Vent Solenoid Valve and Vacuum Solenoid Valve	Controls BAC valve	Controlled by control unit
31. Water Temperature Switch	Detects radiator coolant temperature; sends signal to control unit	Above 15°C (59°F): ON
32. Water Thermo Sensor	Detects engine coolant temperature; sends signal to control unit	Thermistor
33. 3-bed Monolith Converter	Further reduces HC, CO and NOx	3 way catalyst (Main converter)

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OUTLINE OF CONSTRUCTION

AIR INDUCTION SYSTEM

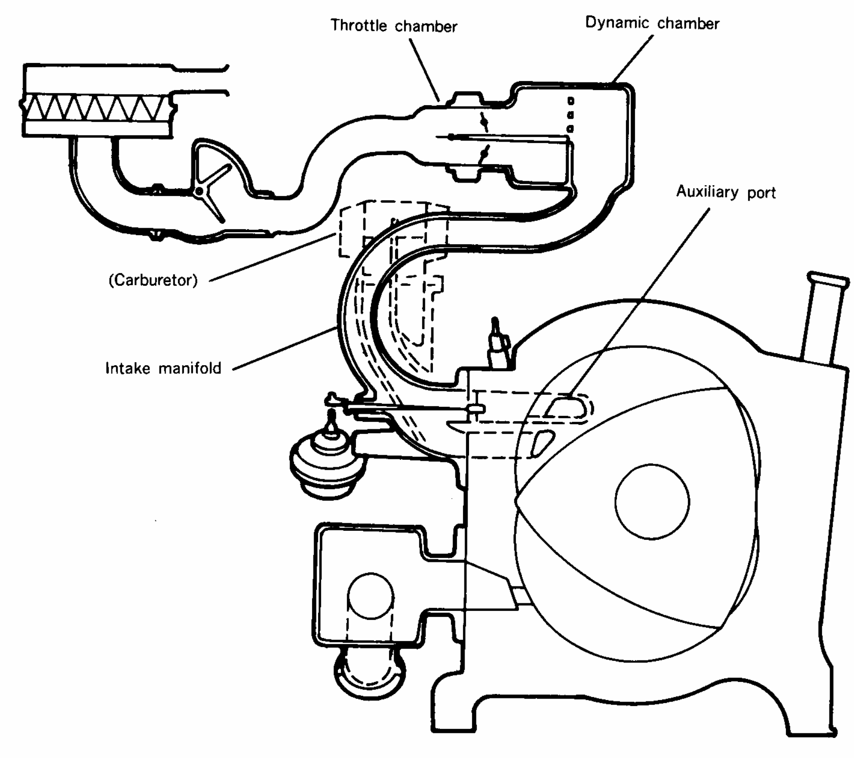
1. DYNAMIC SUPERCHARGE SYSTEM

The dynamic chamber is completely separated in to primary and secondary chambers. Each chamber is connected to the intake ports for each rotor by two intake manifolds, totalling four in the twin-rotor engine.

The dynamic chamber inlet is provided with a two-stage throttle valve. An electronic gasoline injection (EGI) system is used, which makes possible the use of the long intake manifolds.

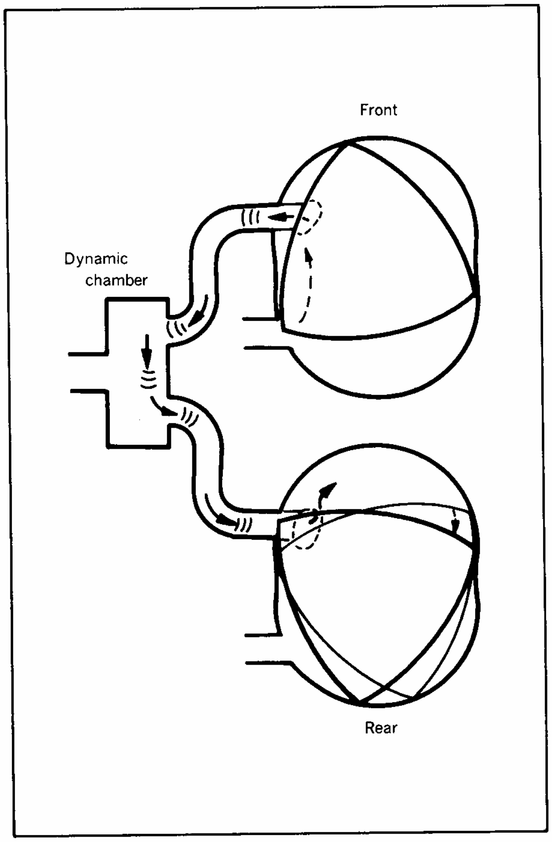
(1) Objective

To take advantage of pressure changes in the intake path in order to improve intake air efficiency.



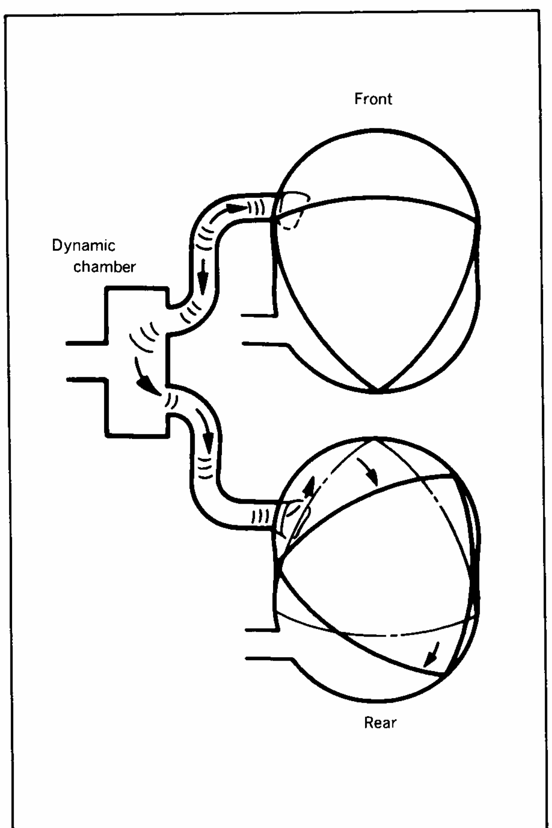
Reference notes:

- When the EGI is used, the air and fuel can be thought of as individual components. Consequently, there is much more freedom regarding the shape, diameter and length of the intake manifold than when a carburetor is used.
- When a carburetor is used, a triple venturi arrangement is used in order to improve vaporization of the gasoline. But, because the inner diameter of the intake manifold is correspondingly smaller, charging efficiency is poor in the high-speed range, and there is a sharp loss of power.
- The dynamic supercharge system is designed for high intake air efficiency from low speed to high speed by using the multiplication effect of the 6-port induction (6PI) system.



(2) Effects of the dynamic supercharge system
Intake air efficiency is improved by the combination of the following two effects.

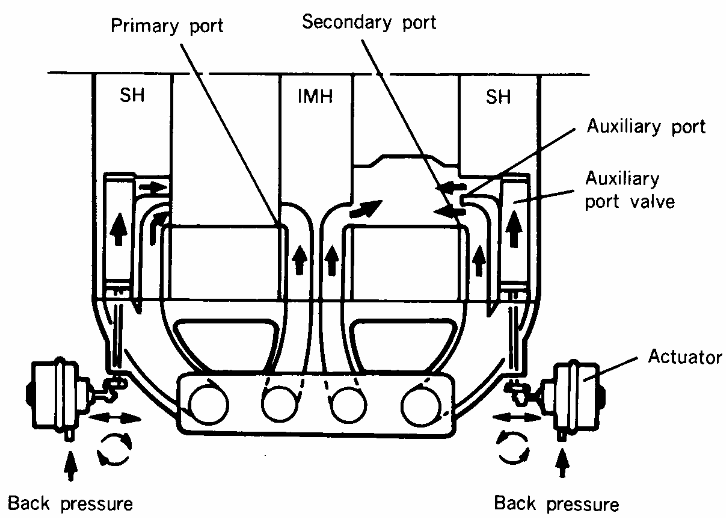
Exhaust obstruction effect
When the front intake port begins to open, because there is an overlap, there is pressure in the dynamic chamber caused by exhaust pressure within the cylinder. At that time, the rear rotor enters the compression cycle, the cylinder pressure begins to become higher than the pressure of the intake manifold, but, because of the effect of the pressure return from the front, supercharging of the air is possible until immediately before the rear intake port closes.



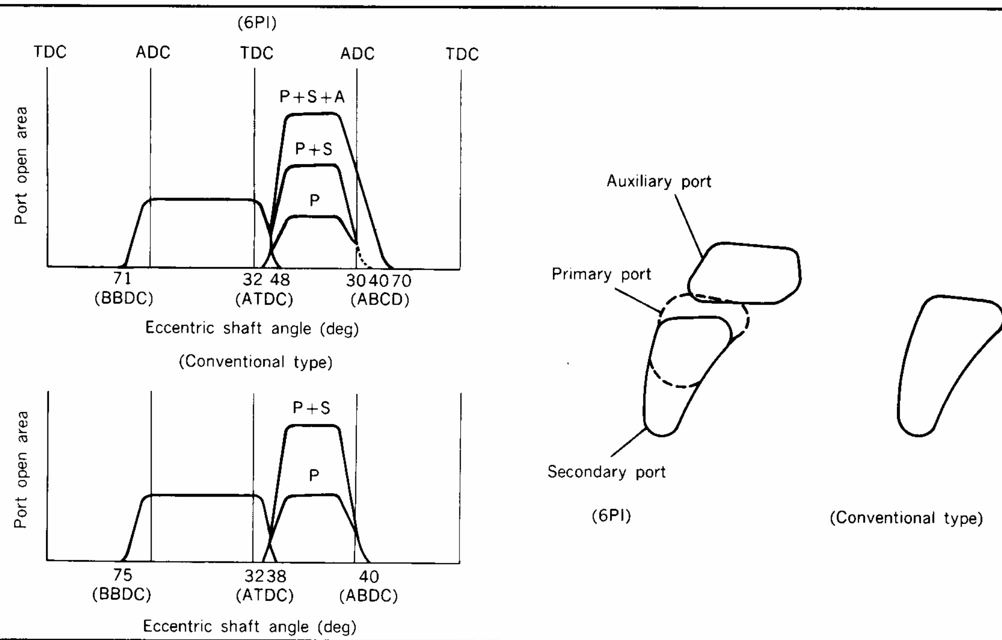
Intake inertia effect
Intake inertia is caused by the closing of the front intake port. A compression wave occurs, and the pressure within the manifold is changed from negative pressure to positive pressure.
This compression wave passes through the dynamic chamber and accelerates (supercharges) the intake of the rear cylinder.

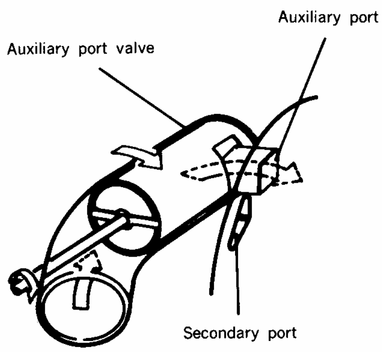
2. 6PI (6-PORT INDUCTION) SYSTEM

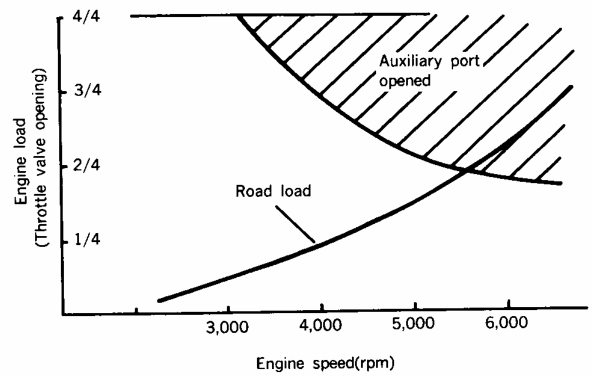
The 6PI system is composed of three intake ports per rotor: a primary, a secondary, and a secondary-auxiliary port. There is a total of six ports in a twin-rotor engine.



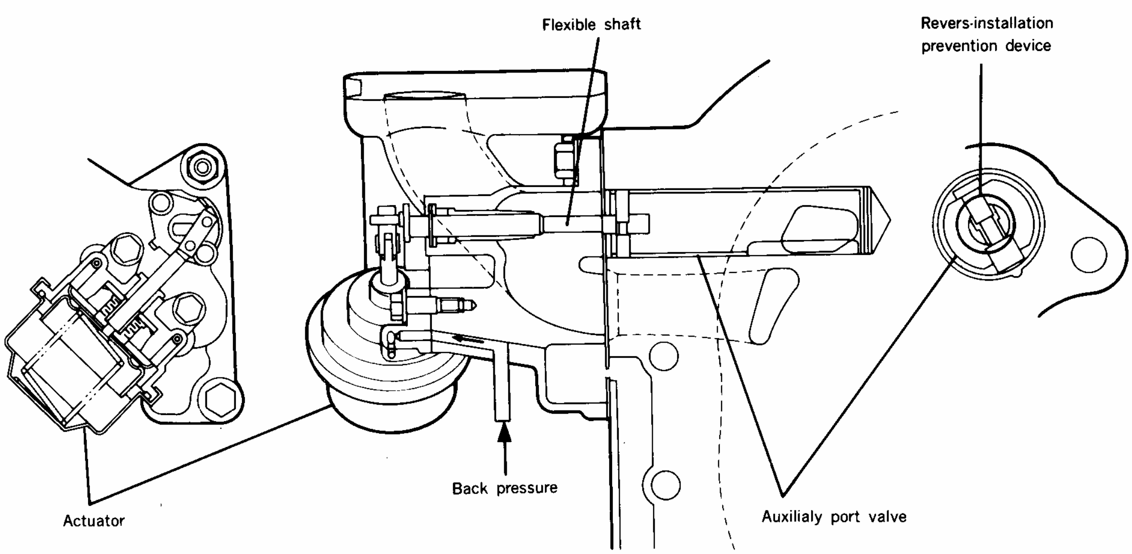
To prevent mixture blowback into the intake manifold at low speeds, the IC (intake port close) timing of the primary and secondary main ports are relatively advanced to suit the low-speed requirement. IC timing of the auxiliary port is optimized for high-speed performance. The auxiliary port is equipped with a rotating valve (auxiliary port valve), controlled by exhaust pressure which is virtually proportional to the power.
This rotating valve closes at low speeds, and opens or closes at high speeds depending on demand.





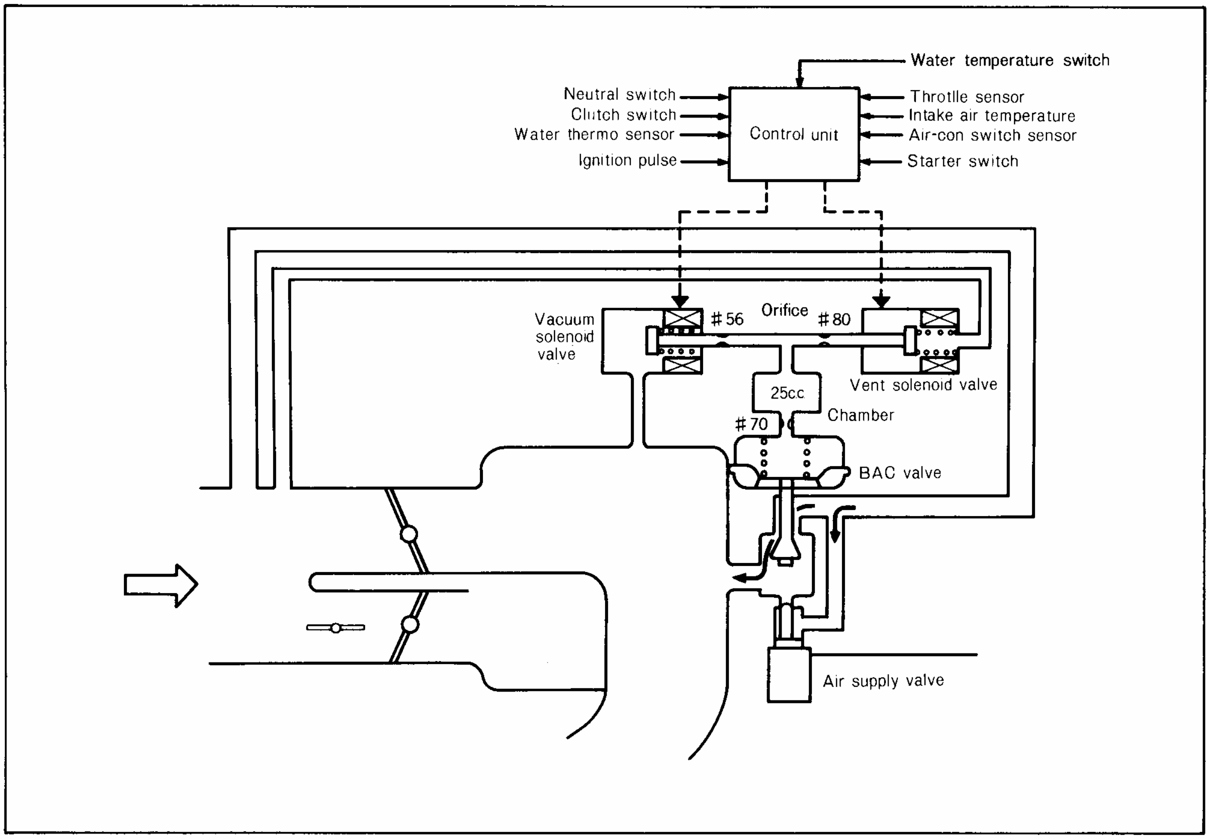


The auxiliary port valve and actuator are two separate parts. In addition, a flexible shaft is provided at the middle of the driveshaft in order to absorb dimensional variations, and a reverse-installation prevention device is fitted at the valve coupling.



BAC (BY-PASS AIR CONTROL) SYSTEM

This system consists of the BAC valve, chamber, vent solenoid, vacuum solenoid, ASV (Air Supply Valve) and control unit.
Except during AWS (accelerated warming-up system) operation and warming-up (when the fast-idle mechanism operates and the primary throttle valve is forced open), the BAC valve operates, by commands from the control unit, to maintain 800 rpm during idling.



OPERATION

1 Operation under ordinary conditions

(1) The vacuum and vent solenoids operate little by little as on off duty signals are received from the control unit, making a pressure adjustment of the amount of vacuum applied to the diaphragm chamber of the BAC valve.

(2) The vacuum is led once to a chamber (25 cc), where pressure pulsations are alleviated (surge prevention).

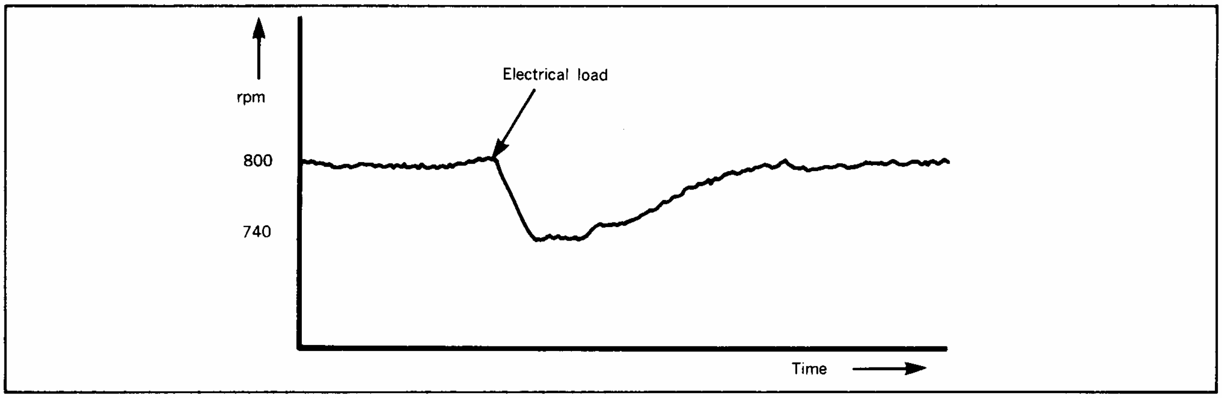
(3) Depending upon the volume of vacuum applied to the diaphragm chamber, the valve moves up and down, thereby controlling the amount of by-pass air.

(4) When the amount of by-pass air is increased and the engine speed (idling) increases, rpm signals are sent to the control unit, so the control unit once again emits commands to each solenoid to maintain the engine speed at 800 rpm, the vacuum applied to the diaphragm chamber becomes large, and the amount of by-pass air decreases.

(5) If engine speed decreases too much, operation is the same as described above: the vacuum applied to the diaphragm becomes small, and the amount of by-pass air increases.

2 Electrical load

When, during idling, a small load (electrical load) is applied, such as for example when the headlights are turned on, the engine speed drops to 730 ~ 740 rpm.
It takes a little time (a few seconds), because of the effect of the vacuum tube diameter, and the capacity of the diaphragm chamber, the air chamber and the orifice, for the idling speed to return to 800 rpm by the correction made by the BAC valve.

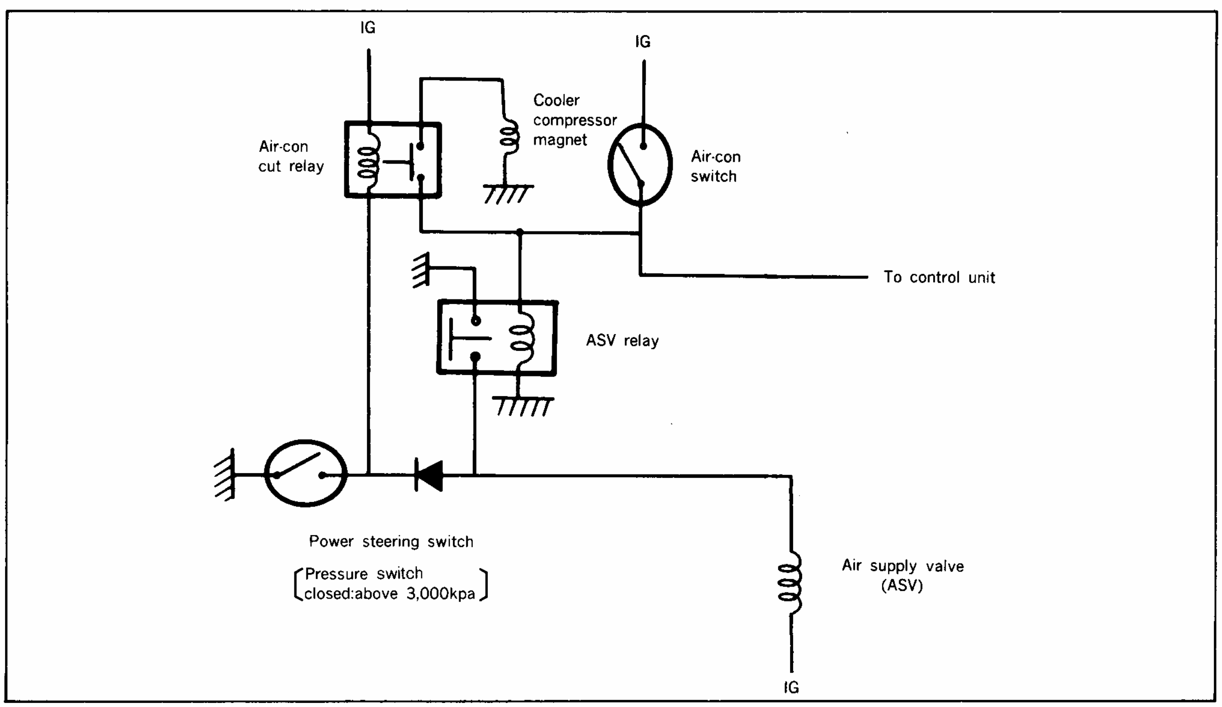


3 Air-conditioning and power steering load

If, during idling, the air-conditioner or the power steering is switched on:

Note
The power-steering is switched on when the steering wheel is turned all the way in either direction.

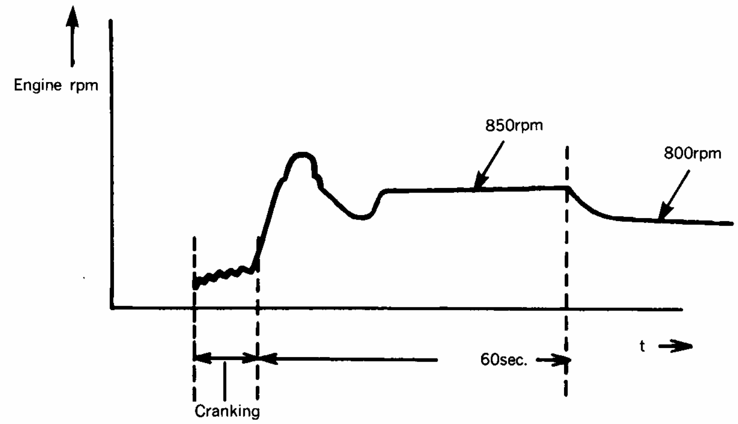
- When the air-conditioner load or power steering load is applied, in order to maintain a steady idling speed, the ASV (air supply valve) supplies a certain amount of by-pass air, and then the BAC valve functions to correct the idling speed to 800 rpm.
- If the power steering is switched on while the air-conditioner is operating, power to the air-conditioner magnetic clutch is switched off, stopping the compressor operation without stopping the blower motor.



4 Restarting the engine while hot

In order to improve engine idling stability when the engine is restarted while hot (when the intake air temperature is 50°C or higher), the BAC valve is regulated for 60 seconds after starting so that the idling speed is maintained at 850 rpm.

- Fuel pressure control (the pressure regulator control solenoid valve in the fuel system) is synchronized. See page 4B—28.

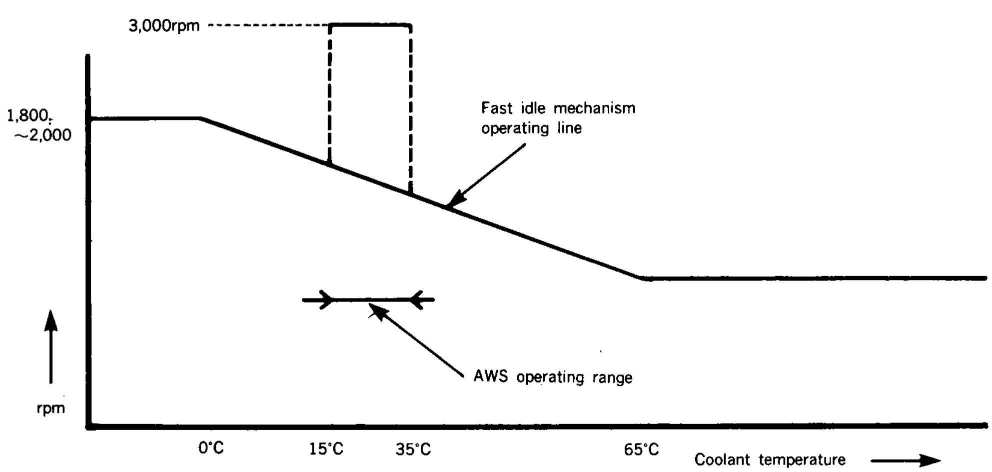


5 During operation of accelerated warming-up system (AWS)

When all of the conditions below are satisfied, the engine speed is held at about 3,000 rpm for 13 seconds after the engine is started.

(1) Engine coolant temperature 15 ~ 35°C (59 ~ 95° F) . . . water thermo sensor
(2) Clutch pedal is depressed . . . clutch switch
(3) Transmission in neutral . . . neutral switch
(4) Starter signal switches from on to off . . . starter switch

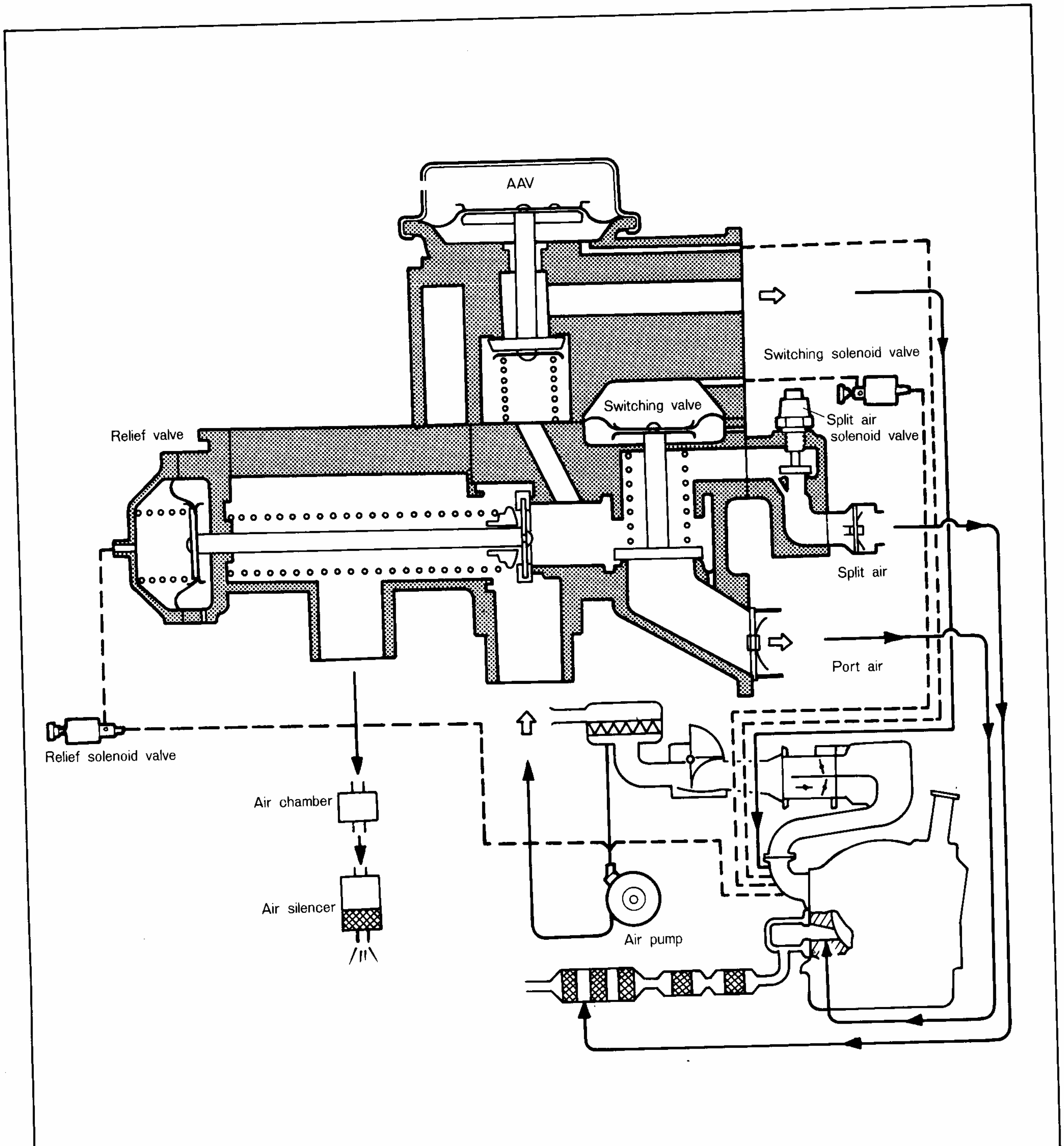
- AWS when all conditions are satisfied.



EMISSION CONTROL SYSTEM

1. SECONDARY AIR CONTROL SYSTEM

The switching valve and relief valve operate by commands from the control unit, depending upon the engine coolant temperature, the engine speed, the throttle opening, the vacuum switch, the timer, the speed sensor and the radiator coolant temperature, thus expediting the purification of the CO, HC and NOx within the catalyst converter and preventing overheating of the converter.

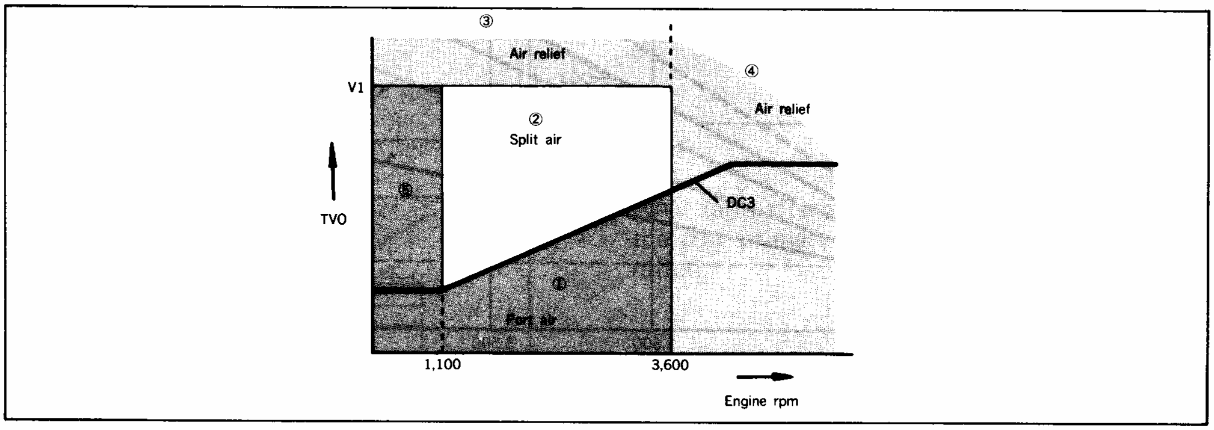


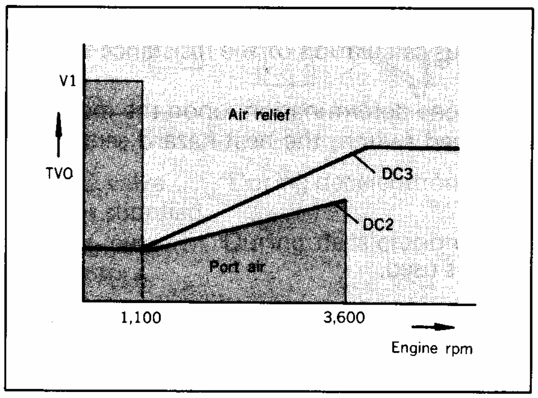
Operation after engine warm-up

(1) During idling and during deceleration, port air is supplied, and CO and HC are oxidized.
(2) During normal conditions of 1100 ~ 3600 rpm and during acceleration (at or above the DC3 line, described on page 4B—18), split air is supplied, NOx is reduced, and CO and HC are oxidized.
- Note that 120 seconds after the switchover from port air to split air, secondary air will be relieved.

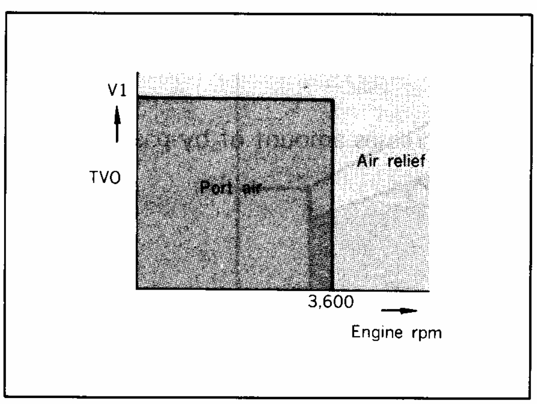
(3) When engine speed is 3600 rpm or less, there is air relief (V1 vacuum switch OFF) if the intake manifold vacuum becomes −100 mmHg or less.
(4) Secondary air will be relieved at 3600 rpm or higher.
(5) When the throttle opening is large at 1100 rpm or less, port air changes to split air 8 seconds later.

Note
Secondary air will be relieved when the heat-hazard sensor (floor sensor) is ON.





When radiator coolant temperature is 15°C or lower
- The operation will be as shown in the illustration at the left.
  Note that operation will occur with the DC2 line as the border.
  There is no relationship to engine coolant temperature.

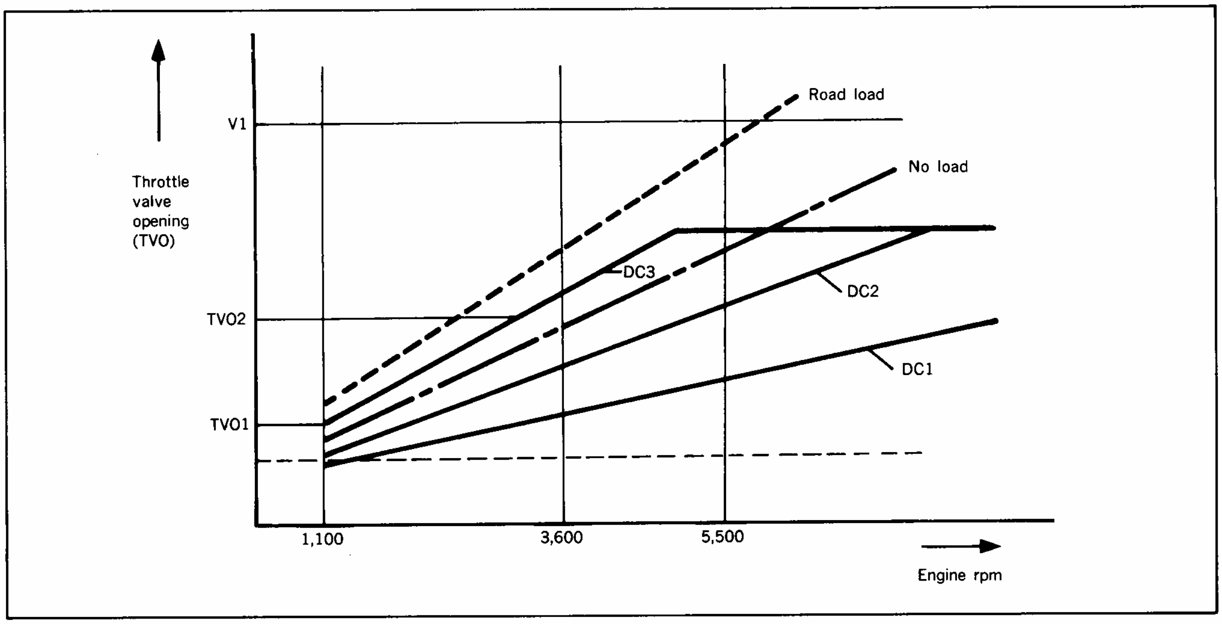


When radiator coolant temperature is 15°C or higher and engine coolant temperature is 50°C or lower
- Port air is supplied until 3600 rpm. At that time, fuel volume is increased (warm-up volume increase), and the catalyst temperature is quickly increased.

REFERENCE NOTE

About the DC lines

The relationship between the load of the engine and rpm is shown in the illustration below.
The DC lines are memorized lines. The relationship between the resistance value of the throttle sensor and engine rpm changes is constantly being input to the microcomputer within the control unit.



Whether actual running conditions (acceleration, cruising, deceleration) are at a position above the DC line or are at a position below it is determined by instantaneous calculation of the resistance value of the throttle sensor and the engine rpm (input signals).
The activation of each device also depends, in addition to the zone determination, upon the individual conditions of the coolant temperature switch, the vehicle speed switch, the heat-hazard sensor, the clutch switch, the neutral switch, etc.

1 DC1 line

This is a line that effects fuel cut; the zone below the DC1 line is used.

- Zone below DC1 line:
  Throttle opening . . . very small
  Engine rpm . . . high
  (Conditions similar to full deceleration by engine braking)

2 DC2 line

At or above the DC2 line . . .

- Vacuum advance of distributor is activated.

At or above DC1 line and at or below DC2 line . . .

- One-side fuel cut (front cut) and operation of BAC valve. (Increases amount of by-pass air during deceleration.)

3 DC3 line

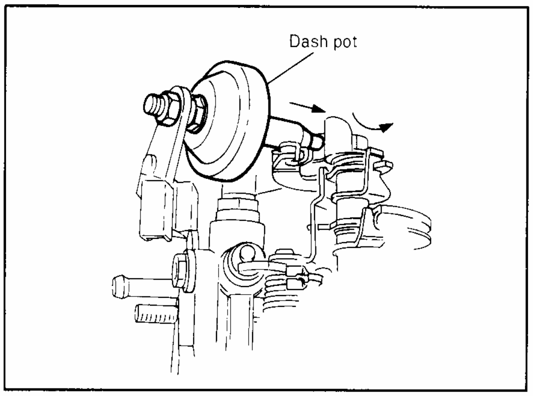
At or above DC3 line . . .

- Switching valve is activated: port air → split air

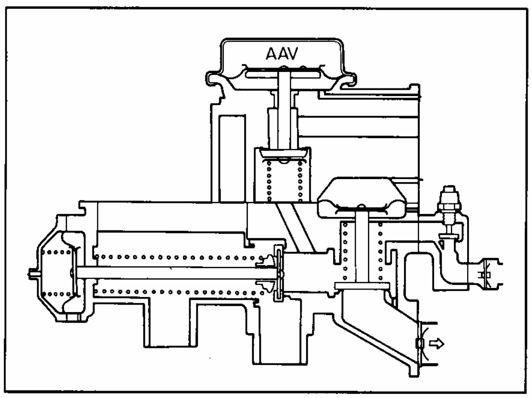
Because it is at a position above the no-load line, the area at and above the DC3 line is the no-load area, and can't be reached even if the engine speed is increased. Note, however, that it can be reached momentarily when there is a change from idling to rapid acceleration, but a test of the operation of the device cannot be made.

2. DECELERATION SYSTEM

When there is a change from acceleration to deceleration, the air/fuel mixture deteriorates sharply (becomes rich), and, because misfiring occurs, CO and HC increase. These problems are resolved by the systems described below.



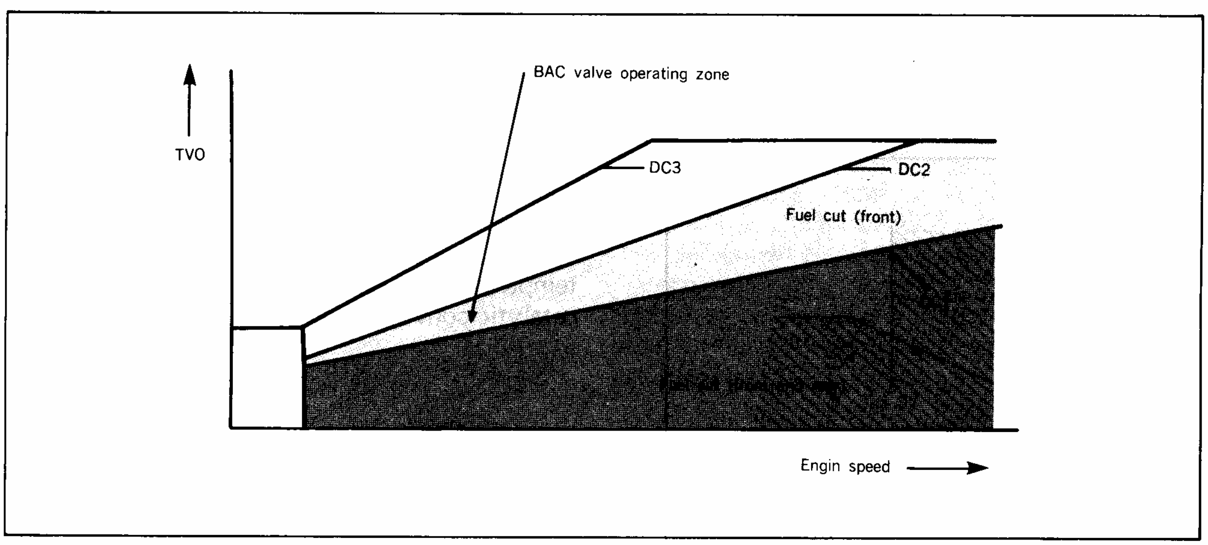
(1) Dash pot . . . During deceleration, the throttle valve is gradually closed, thus preventing a sharp deterioration of the air/fuel mixture.



(2) AAV (anti-afterburn valve) . . . Air is supplied to the rear primary port immediately after deceleration.

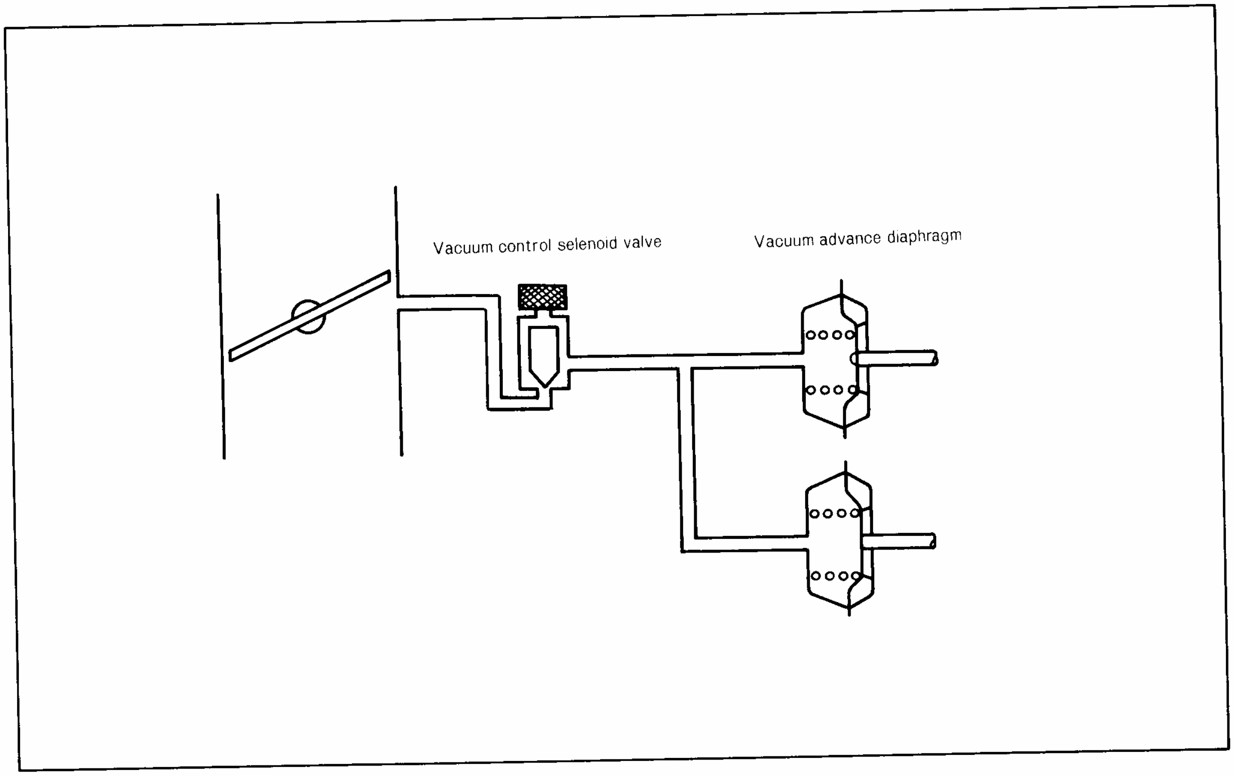
(3) BAC valve . . . During deceleration (semi-reduction of speed), the BAC valve operates, and by-pass air is supplied.

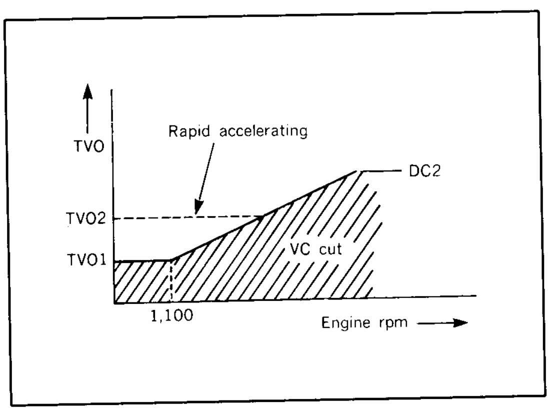
(4) Fuel cut . . . During deceleration above a certain engine speed, fuel is not supplied from the injectors.



3. IGNITION CONTROL SYSTEM

The leading and trailing vacuum advance is controlled by commands from the control unit.

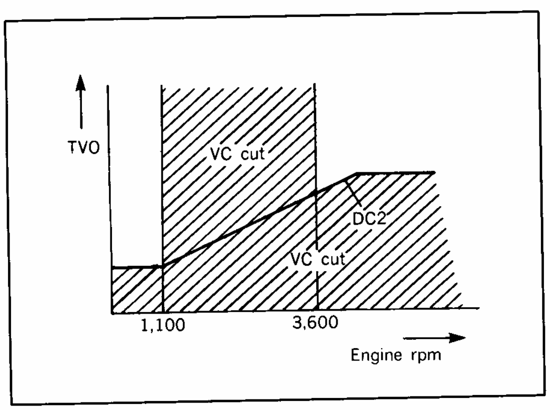




Operation after engine warm-up

- VC at and above DC2 line
- VC cut at and below DC2 line
- When there is sudden acceleration from a position at or above TV02 (broken line), VC is cut for 3 seconds (to prevent "knocking").
  *TVO change rate 20% or more/0.13 sec.

Reference
VC. . . .Vacuum from intake manifold to vacuum advance diaphragm.



When radiator coolant temperature is 15°C or higher and engine coolant temperature is 50°C or lower.

- During 1100 ~ 3600 rpm for 120 seconds after engine is started, VC is cut, and exhaust gas temperature becomes high to warm up the catalytic converter quickly.

EGI (ELECTRONIC GASOLINE INJECTION) SYSTEM

This system consists of various types of sensors, which detect engine conditions, and a control unit which controls the injection amount based upon the detected signals. It is designed to always maintain the most suitable air/fuel ratio depending upon driving conditions.

FEATURES OF THE EGI SYSTEM

The EGI system has the following advantages over the carburetor system.

1. A good driving "feeling"
   (1) Because there is no venturi restriction such as there is with a carburetor, there is little intake resistance, so engine output is large.
   (2) Because the amount of fuel injected near the combustion chamber corresponds with changes of the amount of intake air, engine response in relation to axle operation is good during acceleration.
   (3) Because the air/fuel ratio can be automatically corrected to the optimum value by the computer, the "feeling" is excellent from cold starting to high-speed driving.
   (4) Because a fuel reduction is possible during deceleration, the "feeling" of deceleration is good and fuel consumption is improved.
2. Exhaust gas countermeasures can be more easily made.
   (1) Because the amount of fuel injection can be set most appropriately and the air/fuel ratio of each combustion chamber can be made uniform, there is little variation of CO and HC and, moreover, because the absolute volume can be reduced, exhaust gas countermeasures can be more easily taken.

OUTLINE OF THE EGI SYSTEM

The EGI system can be roughly divided into the following 3 parts:

1. Intake Air System

The necessary amount of air for combustion is supplied.

2. Fuel System

The necessary amount of fuel (gasoline) for combustion is supplied at a fixed pressure to the injector. The injector measures and injects the fuel within the intermediate housing air-intake port according to injection signals from the control unit.

3. Control System

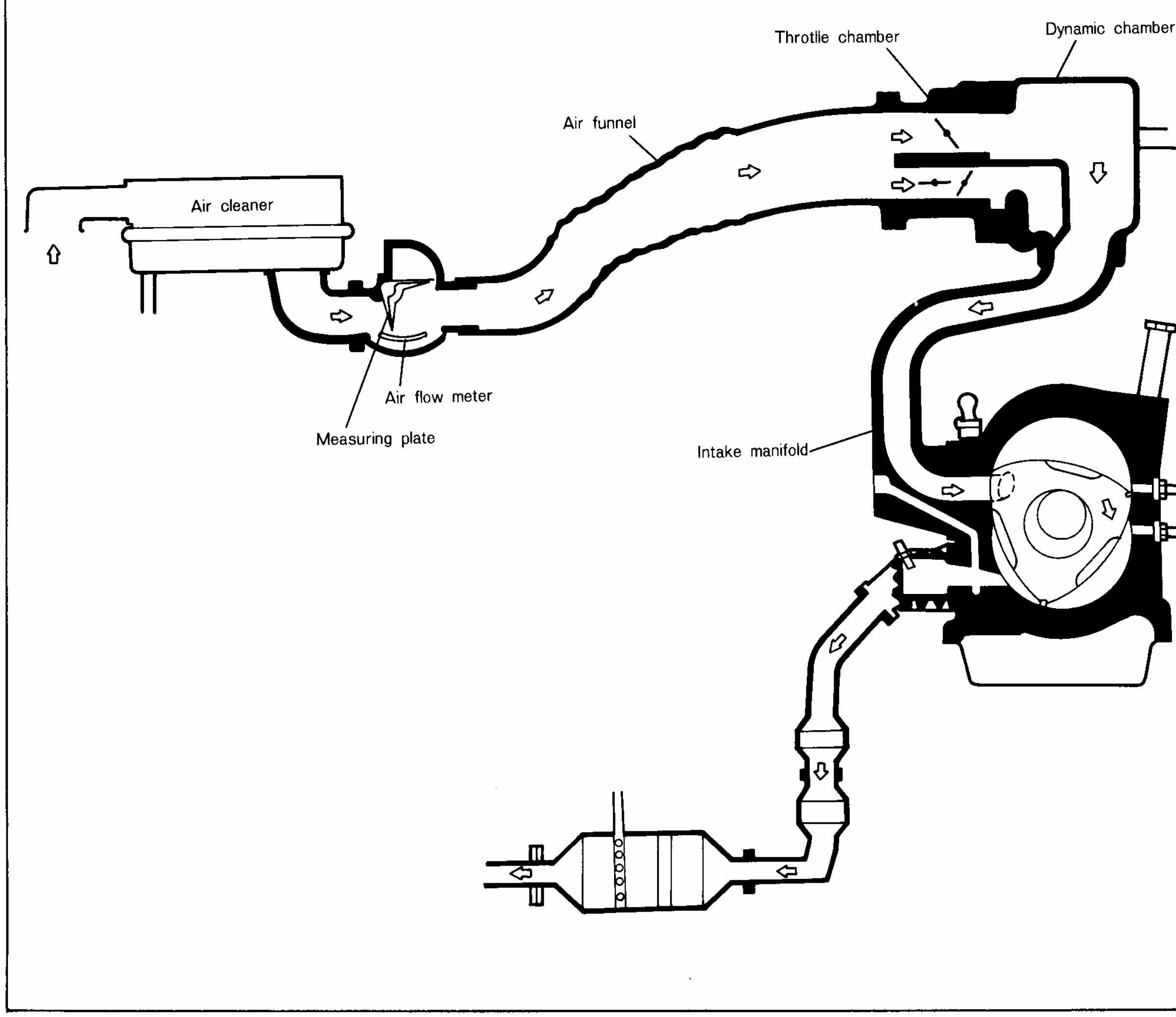
The various sensors detect conditions such as the amount of intake air, engine speed, coolant temperature, intake air temperature, acceleration or deceleration conditions, oxygen concentration in the exhaust pipe, atmospheric pressure, etc. Then the injection time is determined by the control unit based on these signals. There are two types of injection control: injection control of injection signals sent to the injector, and fuel pump control of the on/off operation of the fuel pump.

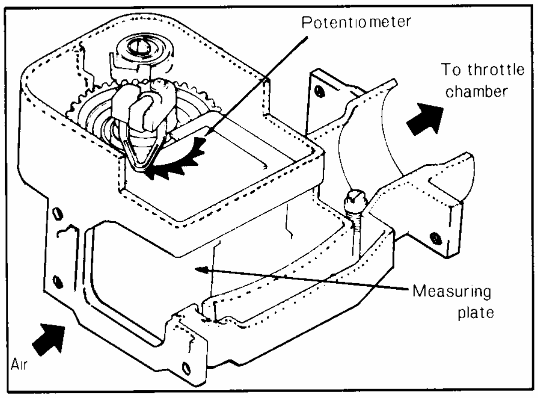
1. INTAKE AIR SYSTEM

The intake air system is the system which supplies the amount of air necessary for the mixture, and also measures the quantity of air flow.

Operation

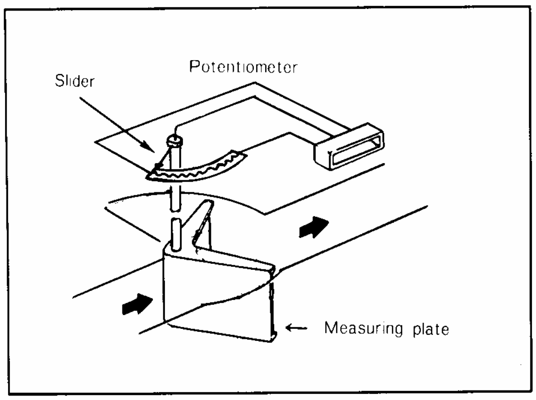
The amount of intake air flow, changed by the throttle opening and engine speed, is measured by the opening angle of the measuring plate in the air-flow meter, and electric signals are sent to the control unit.
Meanwhile, the amount of fuel is controlled to the most appropriate amount, according to the amount of intake air, by the control unit, and is injected by the injector.



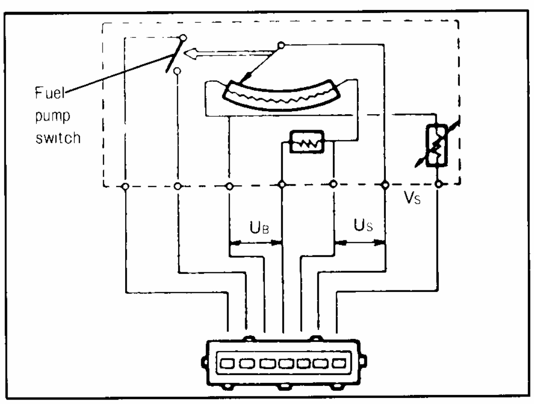


Air-flow Meter

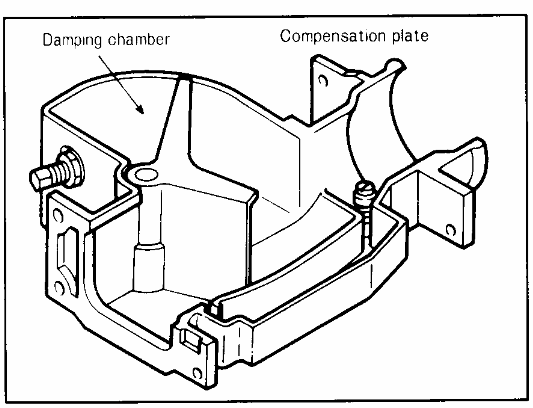
- The air-flow meter detects the amount of intake air as voltage changes of the potentiometer, and the control unit determines the basic fuel injection amount according to these signals.



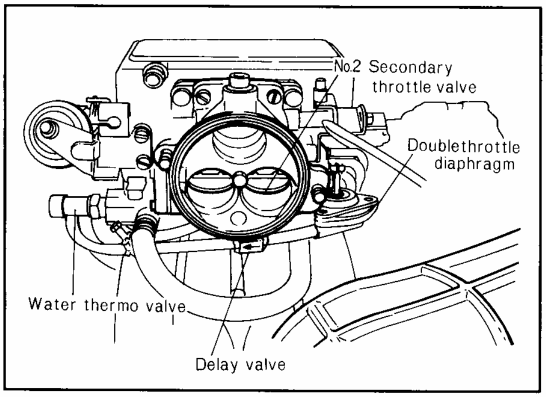
- When the air from the air cleaner passes through the air-flow meter, the measuring plate opens the return spring to the balance angle as a result of the force created by air flow. At this time, the amount of intake air is detected as a voltage ratio by the potentiometer, which is connected to the same shaft as the measuring plate. The resulting signal is sent to the control unit.



- The voltage which detects the changes of the measuring plate opening is called **Vs** voltage; this voltage becomes higher as the plate opening becomes larger, and becomes lower as the plate opening becomes smaller.
  The potentiometer detects the amounts of intake air as voltage ratios **Us** and **UB**.



- The damping chamber applies reverse torque to the compensation plate when there is a sudden reduction in the amount of intake air (when the throttle valve is suddenly closed) in order to prevent over-response of the air-flow meter, and also absorbs pulsations within the intake air pipe so that the amount of intake air is stably measured.



Throttle Chamber

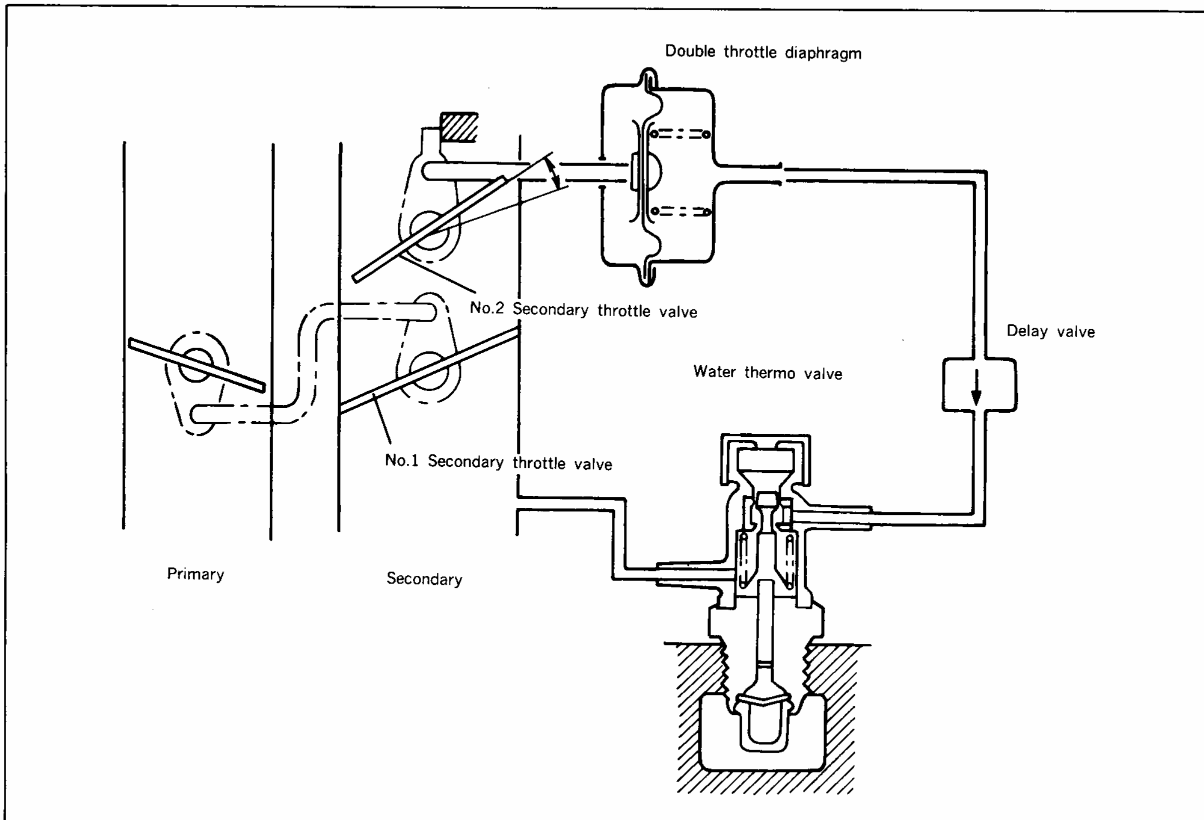
- A 2-stage, 3-barrel type throttle chamber is used.
- It is composed of a throttle valve to control the amount of intake air, a by-pass system used during idling, a fast-idle mechanism and throttle sensor to detect the throttle valve opening, and a dash pot.
- The primary valve and secondary valve are connected by a link arrangement, and, when the degree of opening of the primary valve becomes 15 degrees or more, the interlocked secondary valve begins to open.

Double-throttle System

The double-throttle system is composed of the No. 2 secondary throttle valve, a double-throttle diaphragm, a delay valve, and a thermo valve. It functions to prevent full throttle operation when the engine is cold.

Operation

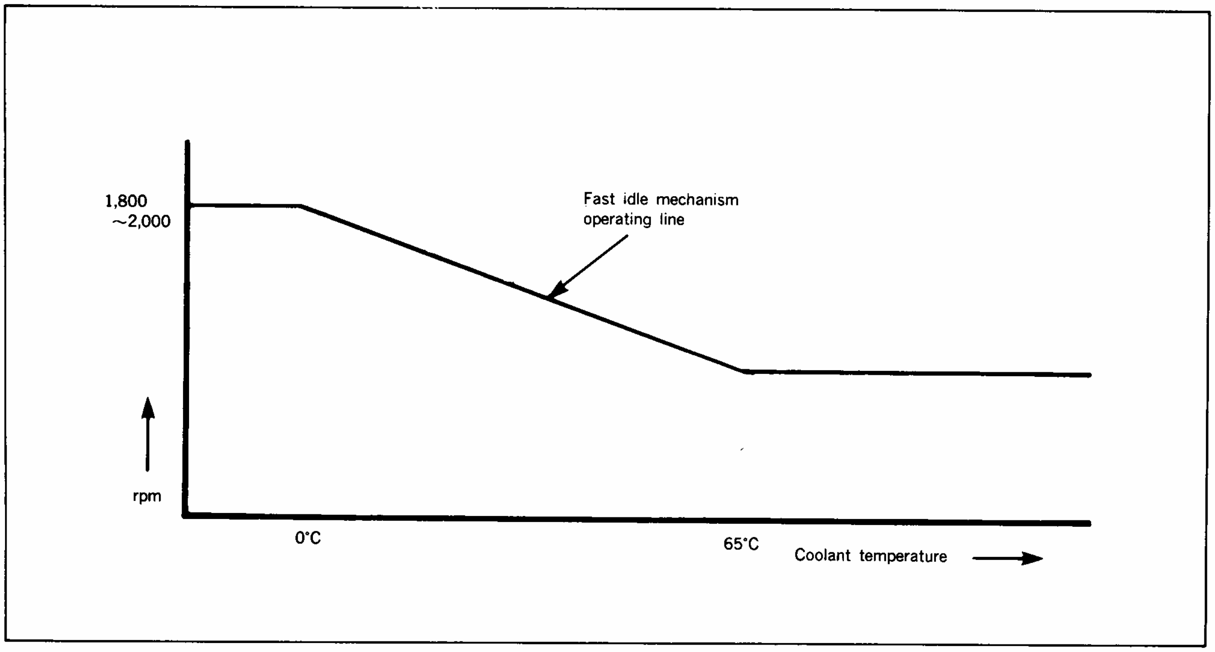
When the engine is cold (60°C (140°F) or less), the vacuum passage of the thermo valve opens, and the No. 2 secondary throttle valve is closed by the double-throttle diaphragm.
When the throttle valve is fully open, the intake manifold vacuum becomes nearly equivalent to atmospheric pressure, but, because the vacuum in the diaphragm chamber is gradually reduced by the action of the delay valve, the No. 2 secondary throttle valve does not open quickly.
When the temperature of the coolant exceeds 60°C (140°F), the vacuum passage of the thermo valve is closed, and, because the atmospheric air passage opens, the No. 2 secondary throttle valve becomes fully open.

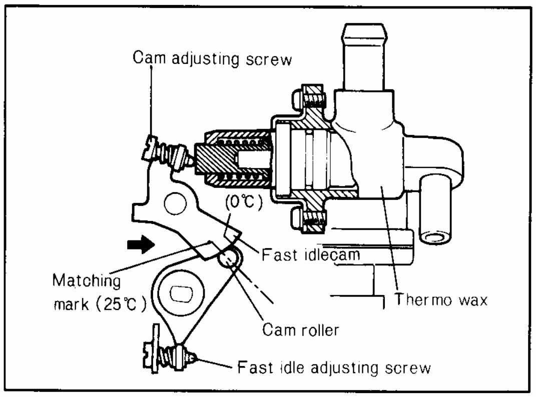


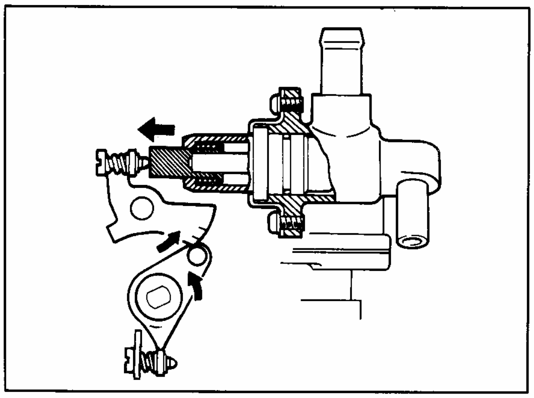
Fast-idle Mechanism

With a function equivalent to the choke of a carburetor, it performs this function by the degree of opening, by thermo wax, of the throttle valve, and by the amount of fuel increase. The thermo wax case is located on the throttle chamber.

Engine coolant is led into the wax case, the wax rod extends as the coolant temperature becomes higher, this turns the fast-idle cam, and the throttle valve is thus gradually closed.







Operation of the throttle valve

(1) Before starting, the accelerator pedal is first depressed once, bringing the fast-idle cam over the roller.

(2) After starting, the degree of opening is maintained according to the coolant temperature at that time by the fast-idle cam.

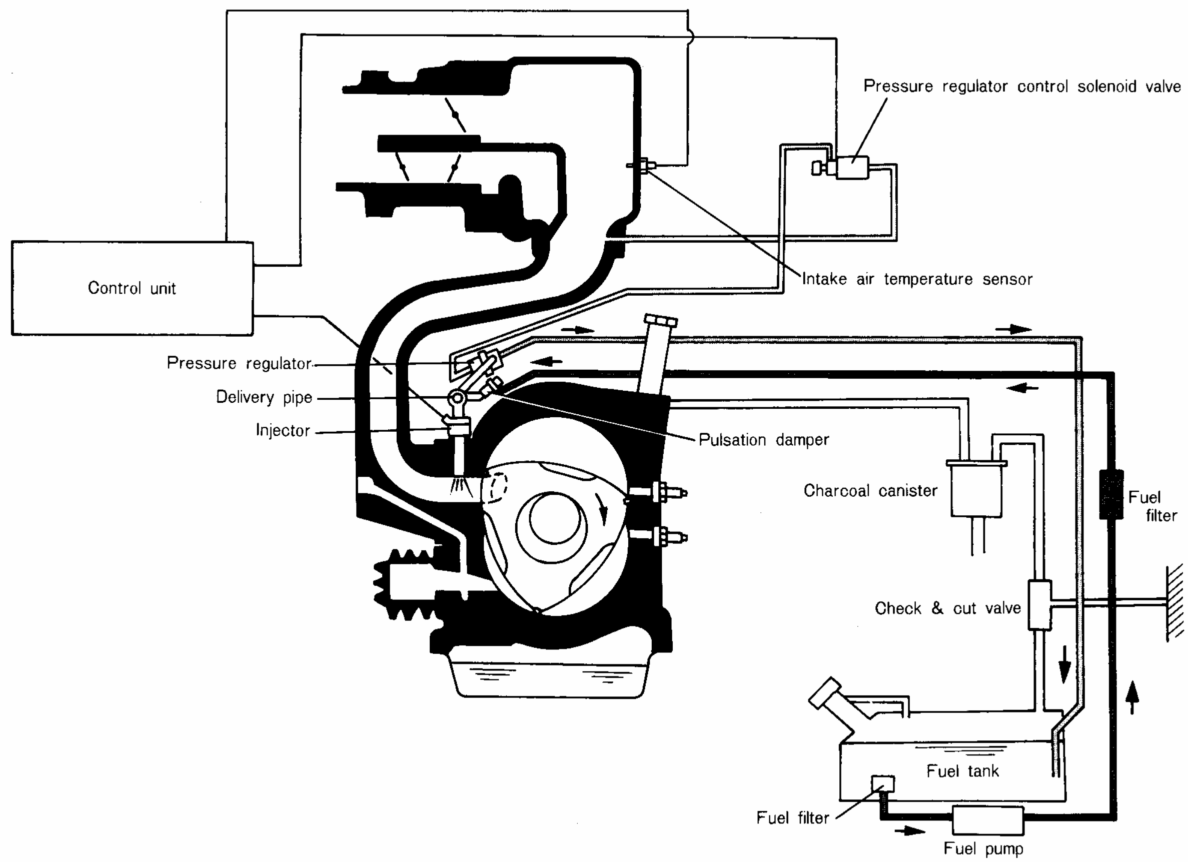
(3) As warm-up progresses, the thermo wax rod extends, the fast-idle cam turns, and the throttle valve begins to close.

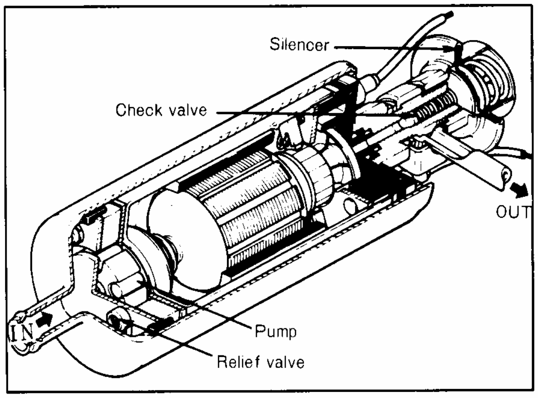
(4) When the engine is completely warmed up, the fast-idle cam moves away from the roller, and the throttle valve opening changes to the prescribed (usual) idle opening.

2. FUEL SYSTEM

The fuel system sends the fuel necessary for combustion at a fixed pressure to the injectors, and then measures and injects the fuel according to injection signals from the control unit.

- The fuel pump sends the fuel in the fuel tank under pressure to each injector via the fuel filter (low-pressure side), the pressure line (high-pressure side), the fuel filter (high-pressure side), and the delivery pipe.
- Each injector opens the solenoid valve within the injector according to the injection signal from the control unit, and fuel is injected to the intermediate housing intake port.
- The pressure regulator adjusts the fuel pressure applied to the injectors. Extra fuel is returned to the fuel tank through the return pipe.



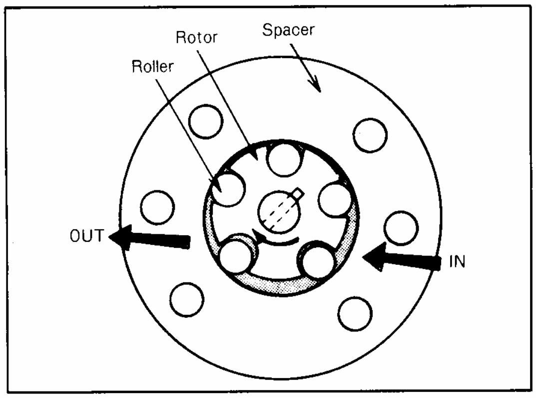


Fuel Pump

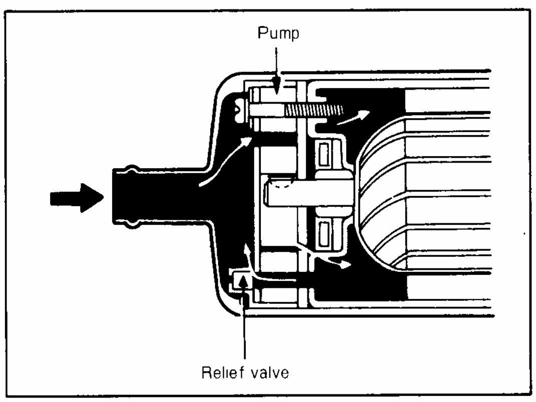
The fuel pump used is the motor type. In addition to the main body, the pump includes a silencer, a check valve to maintain residual pressure, and a relief valve.

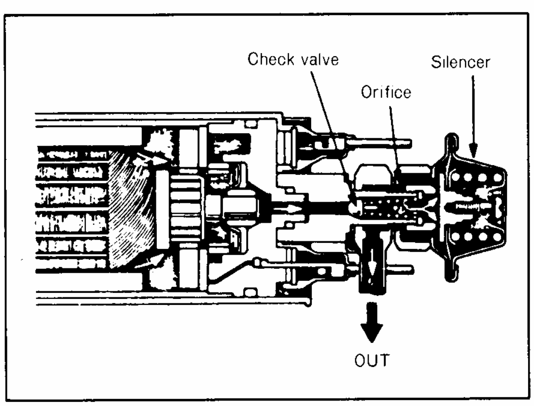
Specifications

Discharge (discharge pressure: 200 kPa) Voltage 12V, current 5.0A or less	100 ℓ/h or more
Outlet pressure	350 ~ 500 kPa (49.8 ~ 71.1 lb/in²)



- The main body of the pump itself consists of a pump spacer which is the outer circumference of the motor-driven rotor pump, and a roller which functions as the seal between the rotor and pump spacer.
  When the rotor turns, the roller is pressed against the inner wall of the pump spacer by centrifugal force, and it then turns together with the rotor, acting as a seal as it turns. The volume of the chamber enclosed by these three parts changes as the rotor turns, fuel is sucked in at the intake side, and pressure is applied to the fuel at the discharge side.
- If, because of some abnormality at the discharge side, fuel could not be discharged, the fuel pressure would become high. When the pressure reaches 350 ~ 500 kPa, the relief valve opens, and the fuel at the high- and low-pressure sides in the pump circulates, thus preventing the pressure from exceeding the specified pressure.





Silencer

The pump discharges fuel five times for each turn of the rotor. The pressure within the fuel pipe changes each time fuel is discharged, resulting in pulsations. The silencer functions to absorb these pulsations of the fuel pressure, absorbing them by movements of the diaphragm and the orifice.

Check Valve

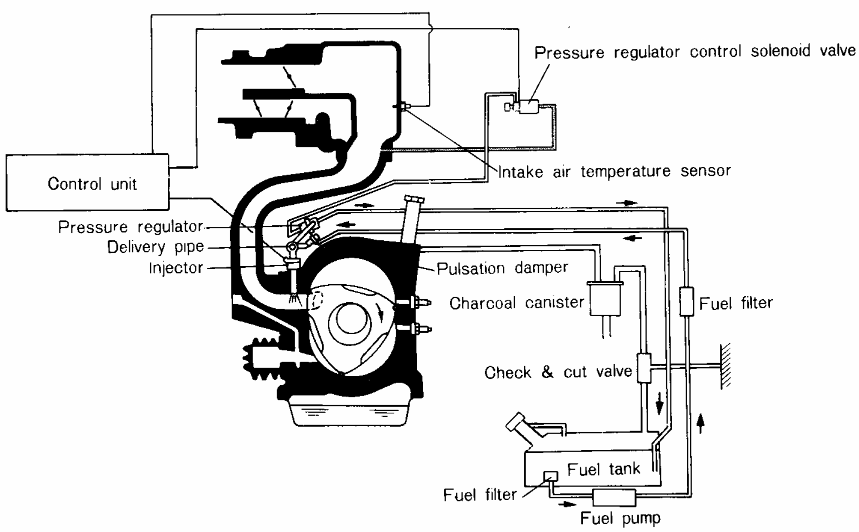
After the pump stops, the check valve is closed by spring force, thus maintaining the residual pressure within the fuel pipe. This residual pressure not only prevents vapor locking when the temperature is high, but also functions to make engine starting easy.

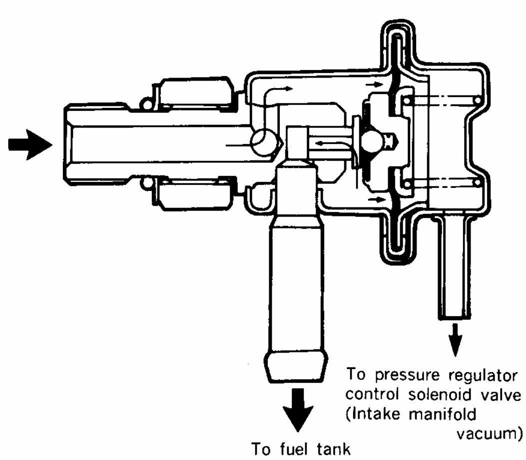
Hot Start Assist System

This system is composed of a pressure-regulator-control solenoid valve, pressure regulator, control unit and intake air temperature sensor attached to the dynamic chamber.
The hot start assist system has been developed for easier starting during hot under-hood conditions, and to maintain the proper idling speed once the vehicle has been started.

Operation

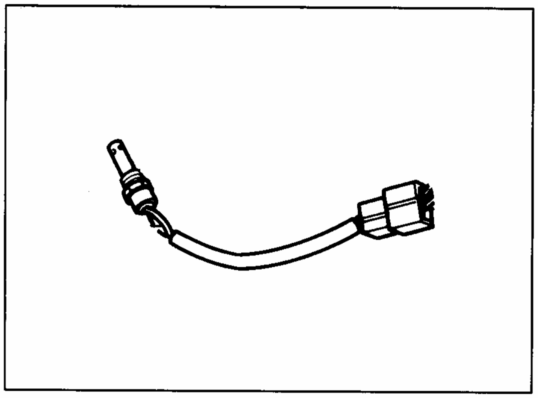
When the temperature within the engine compartment becomes 50°C (122°F) or more, the resistance of the intake air temperature sensor is measured. The control unit activates the pressure-control valve, and, for 60 seconds after the engine is started, the vacuum passage between the dynamic chamber and the pressure regulator is closed.
As a result of this, the diaphragm chamber of the pressure regulator maintains atmospheric pressure as it is, and fuel is injected from the injector at a pressure of 260 kPa (37.0 psi). In order to synchronize with the BAC system during this time the idling speed becomes approximately 850 rpm. When the 60 seconds have passed, the fuel pressure during idling becomes about 200 kPa (28.4 psi) because the vacuum is led to the diaphragm chamber of the pressure regulator.





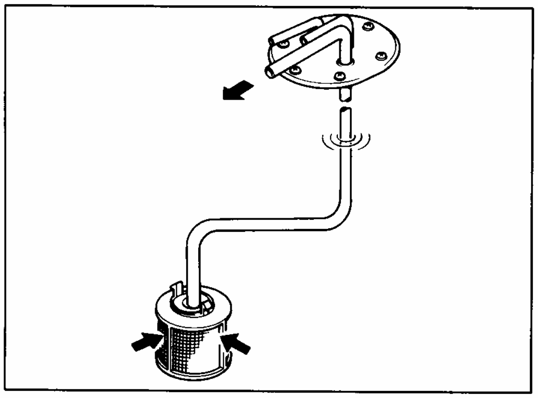
Pressure Regulator

The pressure regulator adjusts the fuel pressure applied to the injector.
Because the amount of fuel injected is regulated by the time the injector is activated, it is necessary that the fuel pressure applied to the injector always be constant. If, however, the fuel pressure is kept constant, the amount of fuel injected will change slightly when the intake manifold vacuum changes, even if the activation times (operation times) to the injectors are the same. Thus, the manifold vacuum is led to the spring chamber of the pressure regulator, and the fuel pressure is always maintained at a high pressure of 260 kPa (37.0 psi) relative to the manifold vacuum, thereby making possible fine adjustments of the fuel injection amount. When the fuel pressure becomes 260 kPa (37.0 psi) or higher relative to the intake manifold vacuum, the diaphragm is pressed, the valve opens, and the excess fuel is returned to the fuel tank through the return pipe.



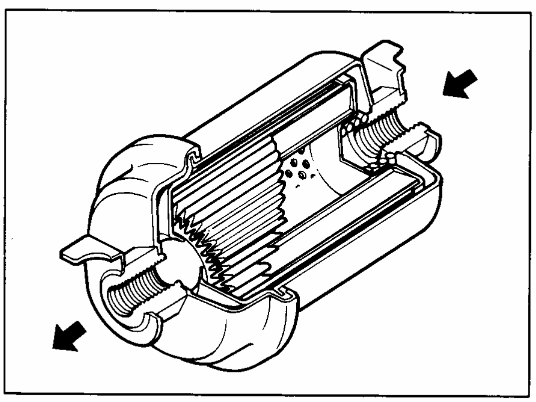
Intake Air Temperature Sensor

This is a sensor to detect the temperature of the intake air.
The intake air temperature sensor is a thermistor; its resistance value changes according to changes of the temperature of the intake air.
These changes are replaced by voltage so that signals are sent to the control unit.



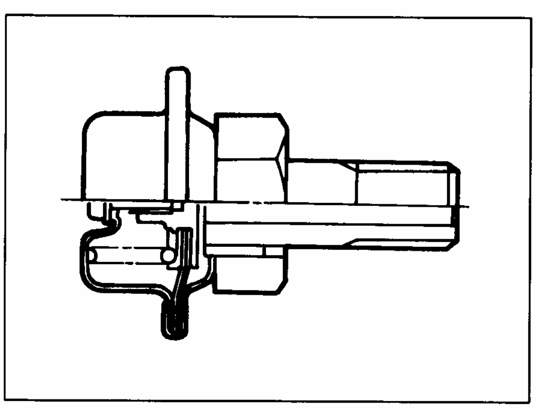
Fuel Filter (low-pressure side)

This fuel filter removes dirt and other foreign materials from the fuel brought up from the fuel tank.
This filter is built into the fuel tank.



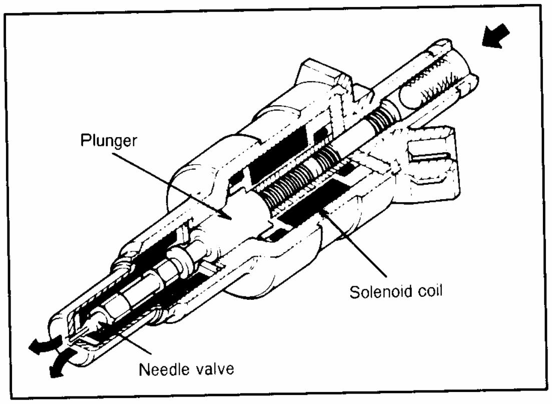
Fuel Filter (high-pressure side)

This fuel filter removes dirt and other foreign materials from fuel passing through the fuel pump.

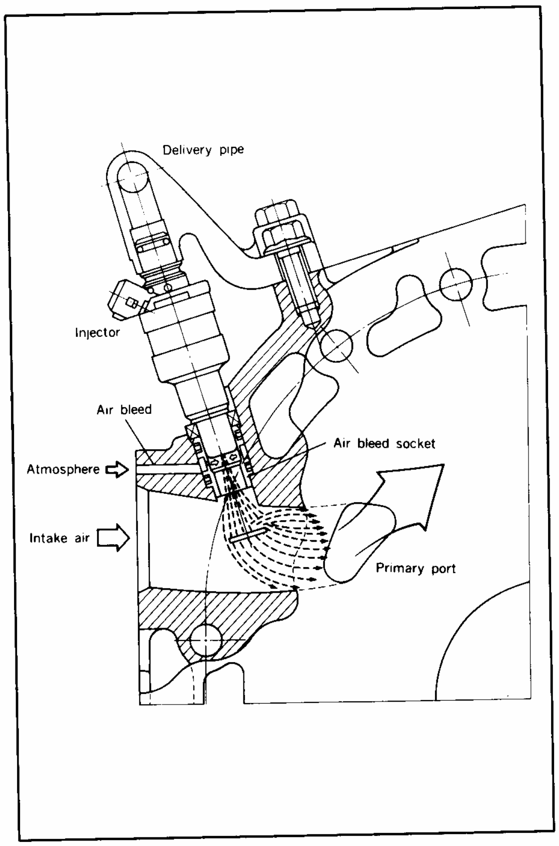


Pulsation Damper

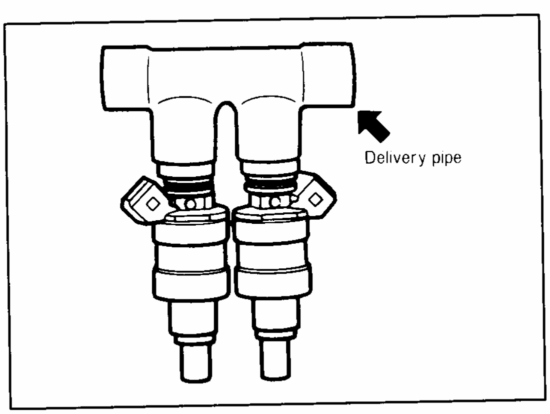
This pulsation damper absorbs pulsation sounds caused by operation of the injectors and sounds of the operation of the injectors themselves.



Injector
The injector injects the fuel based upon the injection signals calculated by the control unit. When these injection signals are applied to the solenoid coil, the plunger is attracted to the coil. Because the needle valve is unified with the plunger, the valve is pulled toward the inner side and fuel is injected. Because the stroke of the needle valve is constant, the amount of the injection is regulated by the time the needle valve is open, or, in other words, by the activation time of the solenoid coil.



Semi-direct Injection Mechanism
One injector is located at the front and at the rear of the intake air port of the intermediate housing.
There is, on the nozzle, an air bleed which functions to vaporize the fuel during idling, when the flow of air is slow, and when the load is light.
In addition, in order to improve the mixture of fuel and air, there is an air bleed socket which prevents mis-flow of the fuel and also further heightens the fuel injection performance.

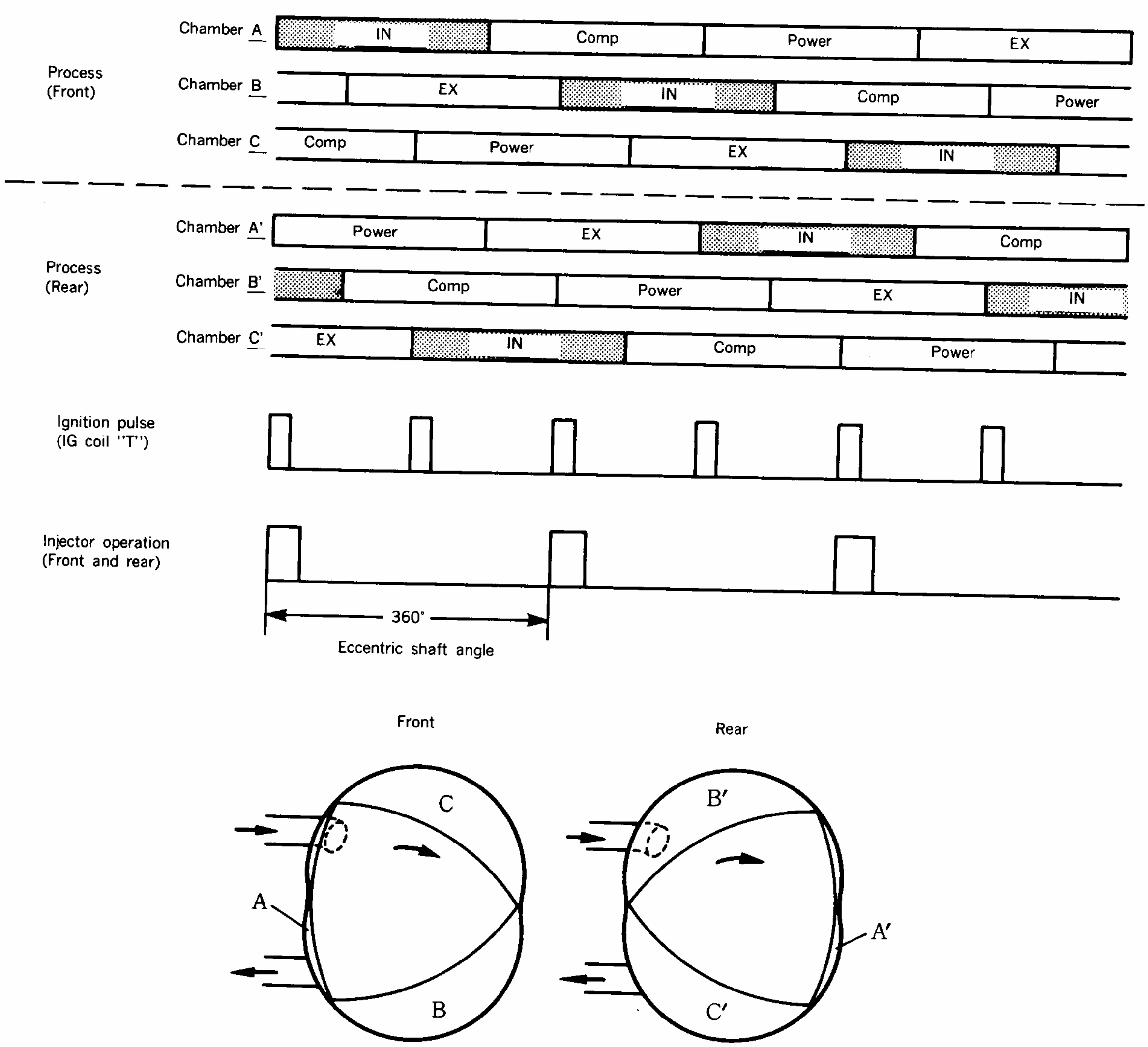


Delivery Pipe
The delivery pipe functions to distribute the high-pressure fuel to each injector.

3. CONTROL SYSTEM

The basic amount of fuel injection is calculated by multiplying the ratio (Q/N) of the intake air amount (Q) and engine rpm (N) by a constant coefficient. There is one injection during the intake process.

1. Number of Injections and Injection Timing

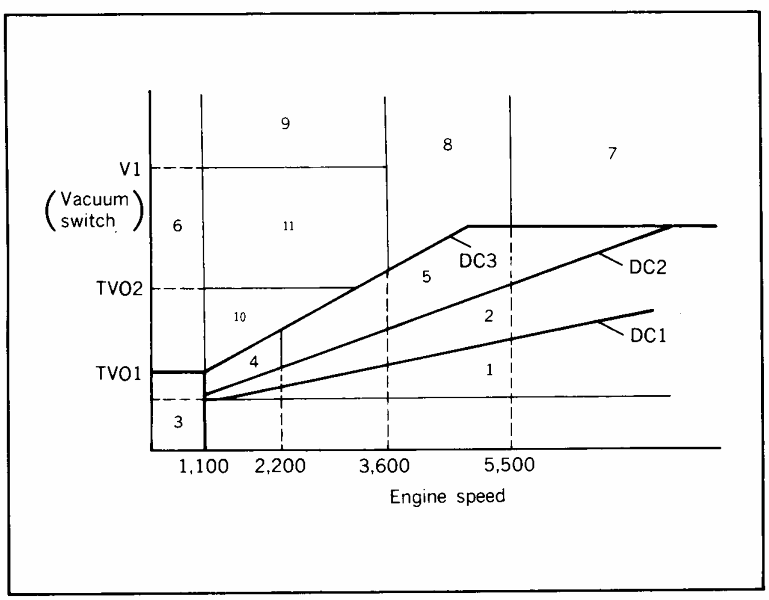


2. Correction of Basic Injection Amount

The correction of the basic injection amount is made by changing the time the solenoid coil of the injector is energized.

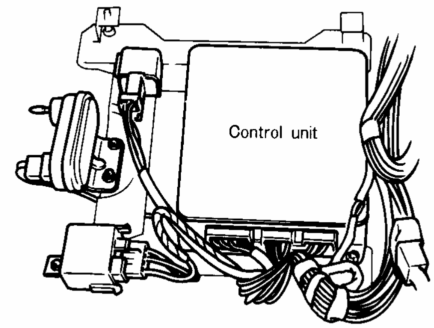
Correction of air/fuel ratio

Correction	Input sensor	Reason
Air concentration correction	Intake-air temperature sensor (with built-in air-flow meter)	To correct any deviation of the air/fuel mixture caused by changes of the air concentration
Battery voltage correction	Battery voltage	To prevent fluctuations of needle valve-open time
Feedback correction	O_2 sensor	To cope with exhaust gas
Volume increase immediately after starting	Coolant temperature sensor Key switch	To prevent stalling immediately after starting
Warm-up volume increase	Water thermo sensor	To improve driveability during cold
Deceleration volume decrease	Throttle sensor Ignition pulse	To improve fuel consumption To improve driveability during deceleration
Output volume increase	Vacuum switch Ignition pulse	To improve driveability under heavy load
Acceleration volume increase	Throttle sensor Ignition pulse	To improve response during acceleration
High speed volume increase	Throttle sensor Ignition pulse	To reduce exhaust gas temperature
Air/fuel ratio volume increase	Throttle sensor Ignition pulse Variable resistor	To improve idling stability
Light load volume increase	Throttle sensor Ignition pulse	To improve driveability
High-altitude correction	Atmospheric pressure sensor	To reduce fuel consumption at high altitude



Air/fuel ratio correction range (after warm-up)

1. Deceleration decrease (both sides cut)
2. Deceleration decrease (front side cut)
3. Idling increase. . . . manual adjustment of air/fuel ratio
4. Light load, low speed increase . . .30%
5. Light load, high speed increase. . .20%
6. Low speed increase 25%
7. High speed increase 26%
8. High speed increase 20%
9. Output increase. 15%
10. Feedback correction
11. Feedback correction



Control Unit (EGI)

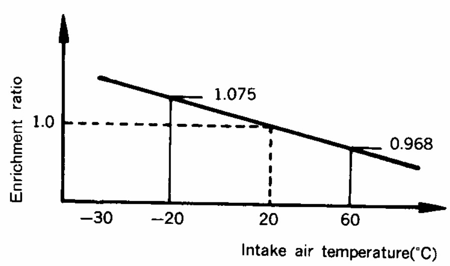
The control unit calculates the intake air signal from the air-flow meter and the basic injection signal from the engine speed, then adds to this corrections made according to signals from each sensor, and then determines the final injection time (fuel injection amount). In addition, it also calculates the injection timing from the engine speed, and the injector is controlled by the injection signals determined by this timing.

$$\text{Injection Time}(T) = K \frac{\text{Air Flow Rate}(Q)}{\text{Engin Speed}(N)}$$

K ; a coefficient

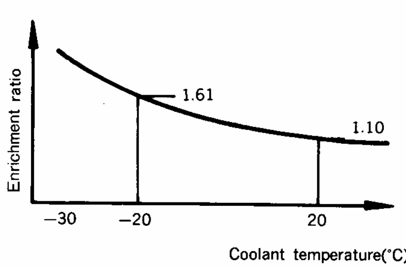
Basic Injection Characteristics

The most fundamental injection characteristics are those calculated from the intake air amount, detected by the air-flow meter, and the engine speed, detected from the ignition pulse.
The relationship between the injection amount and the amount of intake air and engine speed is shown in the figure at the right.



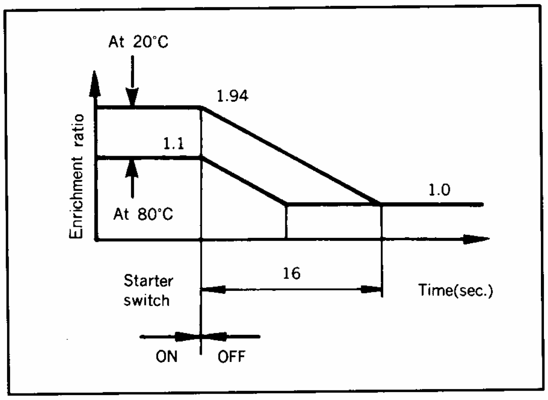
Intake Air Temperature Correction Characteristics

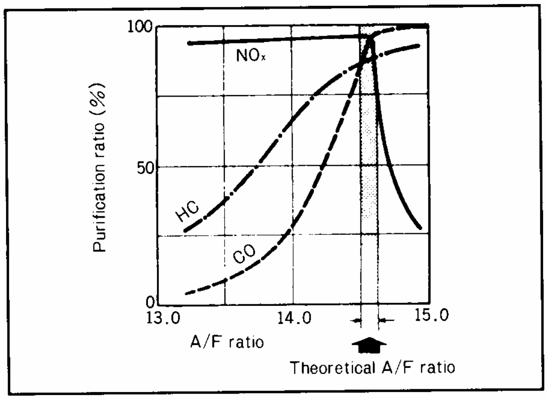
This is a correction made in order to prevent deviations of the air/fuel ratio as a result of differences of intake air concentration caused by differences of intake air temperature.
Intake air temperature is sensed by the intake-air temperature sensor in the air-flow meter. With an intake air temperature of 20°C (68°F) as the standard, there is an injection increase at any temperature below the standard, and a decrease at any temperature above the standard.

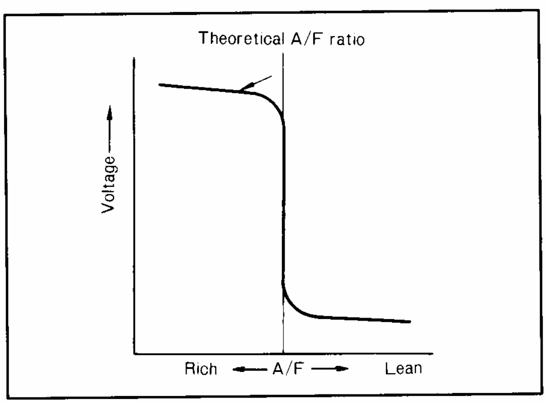


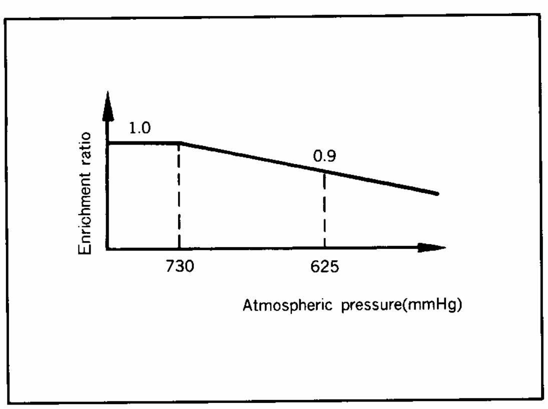
Warm-up Injection-increase Characteristics

In order to maintain good driveability during cold weather, the injection amount is increased as a result of signals from the water thermo sensor when the coolant temperature is low.
With a coolant temperature of 80°C (176°F) as the standard, there is an injection increase when the temperature is below that standard; at 80°C (176°G) or higher, there is a return to the basic injection amount.









Starting Injection-increase Characteristic

Starting performance is improved by an injection increase for a fixed time period after the engine is started (after the starter is disengaged), and also by an injection increase during engine starting (while starter is engaged). The ratio of increase is maximum during starting, thereafter decreasing as time passes after the engine is started. The increase ratio and the length of time the increase continues vary depending upon the coolant temperature.

Air/fuel Ratio Correction Characteristic (feedback correction characteristic)

Increases and decreases of the fuel injection amount repeatedly occur as a result of signals from the O_2 sensor. The air/fuel ratio is regulated within a narrow range near the high theoretical air/fuel ratio (of the purification performance of the 3-way catalyst).

In order to maintain good starting and driving performance, there is no feedback control under the following conditions:

- During starting (when the starter is operated)
- When coolant temperature is 50°C (122°F) or lower
- When there is an increased amount of injection (idling, light load, output, acceleration)
- When the fuel amount is cut (deceleration)

When, as a result of the characteristics mentioned above, the air/fuel ratio is richer than the theoretical air/fuel ratio, the O_2 sensor sends a high electromotive force signal to the control unit, and, when the air/fuel ratio is leaner than the theoretical ratio, it sends a low signal to the control unit.

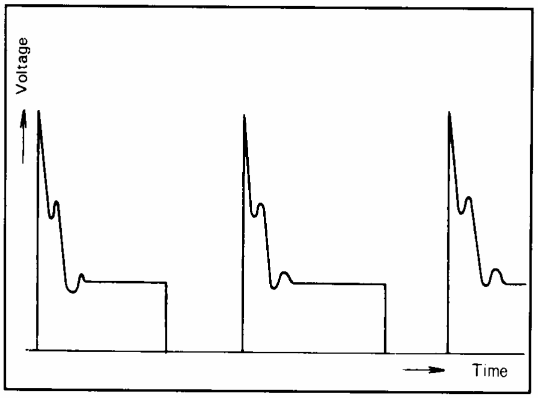
The control unit compares this signal to a certain fixed standard voltage, and, if it is higher than the standard voltage, the control unit judges that the air/fuel ratio is richer than the theoretical air/fuel ratio, and so reduces the amount of fuel; if, on the contrary, the signal is lower than the standard voltage, it judges that the actual air/fuel ratio is leaner than the theoretical ratio, and so increases the amount of fuel. In this way, the purification performance of the 3-way catalyst is regulated so as to be near the high theoretical air/fuel ratio.

High-altitude Correction Characteristics

Because air density is low at high altitude, the usual amount of injection would result in an air/fuel ratio which is too rich, which would impair driving performance.

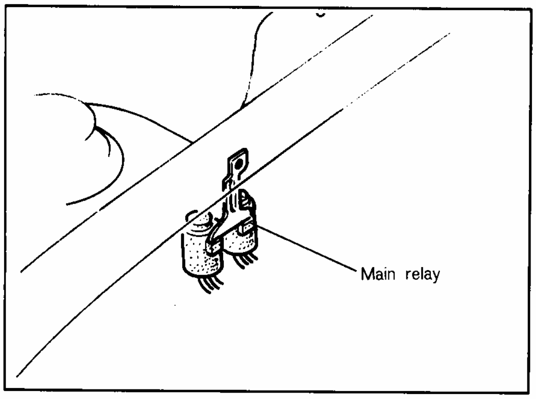
In order to compensate for this, the amount of fuel injection is reduced by signals from the atmospheric pressure sensor.

With an atmospheric pressure of 730 mmHg (28.7 inHg) as the standard, there is a reduction of the fuel injection amount at any atmospheric pressure below that standard.



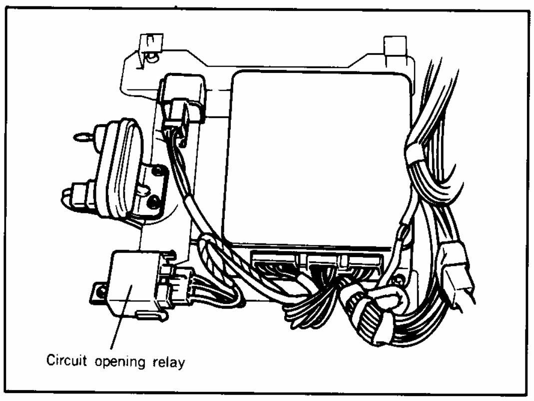
Ignition Pulse

This signal detects the engine speed from the counter electromotive force (300V ~ 400V) which occurs when the primary current of the ignition coil is switched ON/OFF.
The engine speed signals become, together with the potentiometer signals of intake amount, the fundamental signals for determination of the length of time of the injection.



Main Relay

There are 2-contact relays which switch the power supply which regulates the injector and the control unit.
They are located in front of the clutch master cylinder.

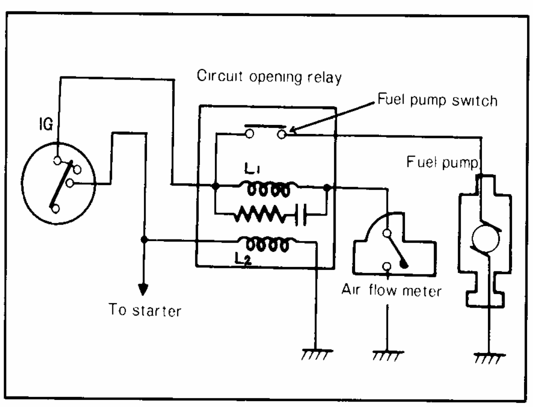


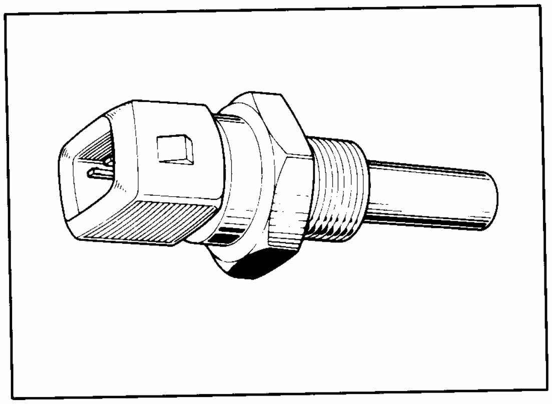
Circuit Opening Relay

This relay regulates signals to the fuel pump.
It cuts off the power supply so that the fuel pump won't operate if the engine is not running, even though the ignition switch may be ON.

Operation

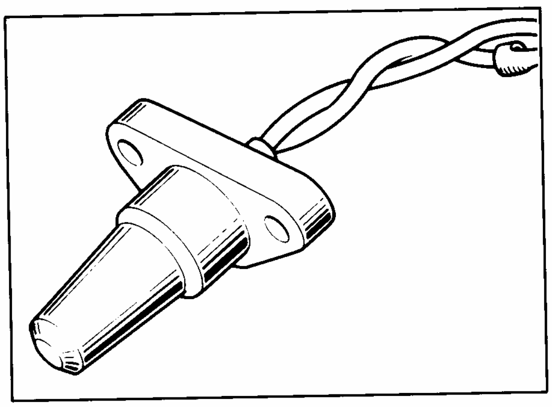
1. When the starter is turned, current flows to the coil (L2), the points close, and current flows to the fuel pump.
2. When the engine starts, current no longer flows to the coil (L2).
3. The fuel pump switch built into the air-flow meter is switched ON.
4. Current flows to the coil (L1).
5. When the engine is stopped, the fuel pump switch is switched OFF.
   (The pump stops even if the ignition switch is ON.)





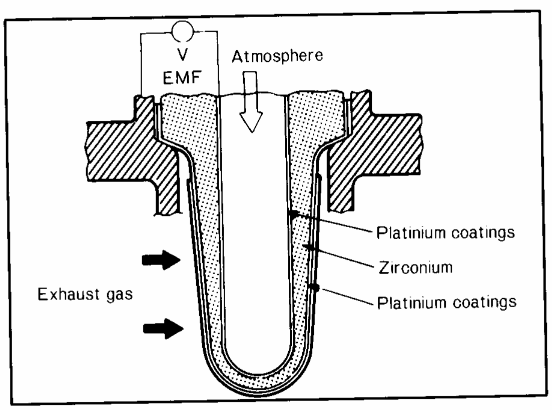
Water Thermo Sensor

This is a sensor which detects the coolant temperature, and has a built-in thermistor which changes according to changes in the temperature. The change in the temperature of the coolant is detected as a change in the resistance value of the thermistor, this is converted to voltage. This signal is sent to the control unit. Acting on this signal, the control unit increases the amount of fuel in accordance with the temperature of the coolant, thus improving driving performance when the engine is cold.



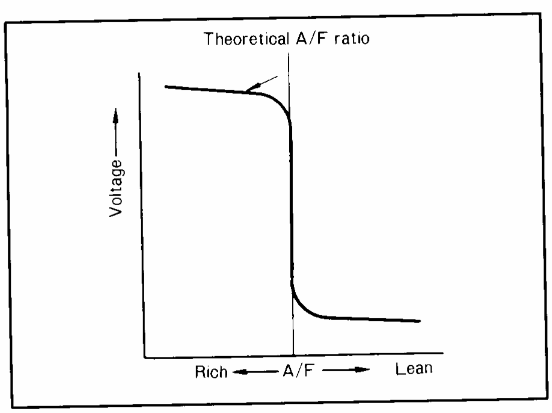
Intake Air Temperature Sensor

This sensor detects the temperature of the intake air, and is located within the air-flow meter.
Changes in the temperature of the intake air are detected as a change in the resistance value of the thermistor inside the intake-air temperature sensor. This is converted to voltage, and a signal is sent to the control unit. The control unit increases or decreases the amount of fuel injection according to the rise and fall (resistance high or low) of the temperature of the intake air.



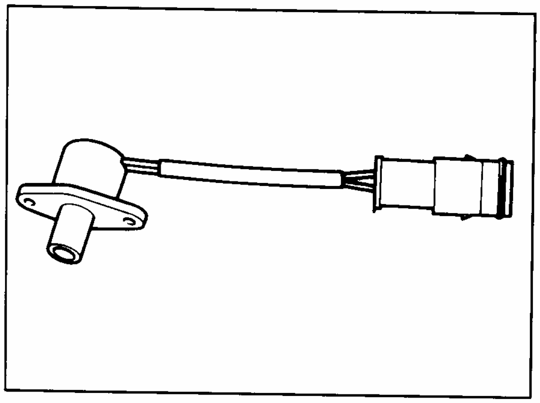
O_2 Sensor

This is a sensor which detects the oxygen concentration (air/fuel ratio) of the exhaust gas. Acting on its signal, the control unit decides upon fuel increases or decreases.
The O_2 sensor is located within the exhaust pipe. Exhaust gas is directed to its external surface and outside air to its internal surface. When the concentration of oxygen is different for the two surfaces, the zirconia element generates an electromotive force. When the temperature becomes high, the electromotive force (EMF) is suddenly changed to the boundary of the theoretical air/fuel ratio as a result of the catalytic action of the platinum coated on the surface.

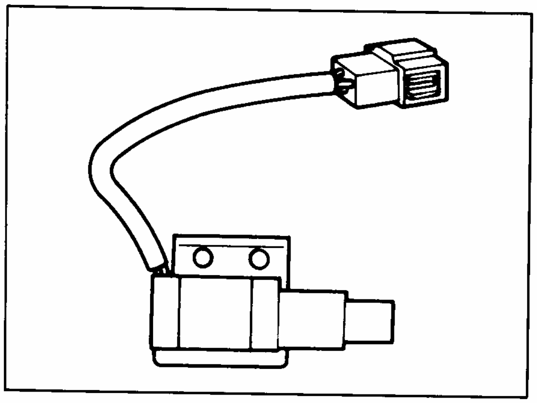


O_2 sensor characteristics

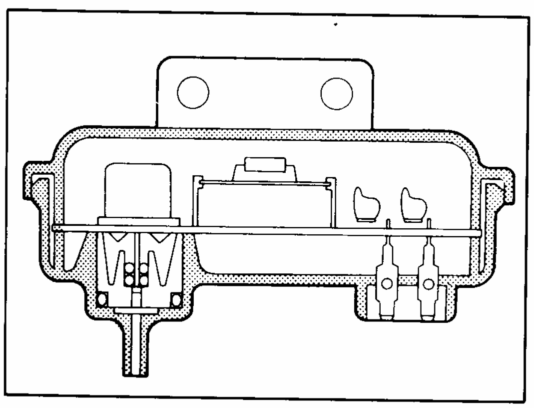
Actual air/fuel ratio < theoretical ratio (rich)	Large EMF
Actual air/fuel ratio > theoretical ratio (lean)	Small EMF



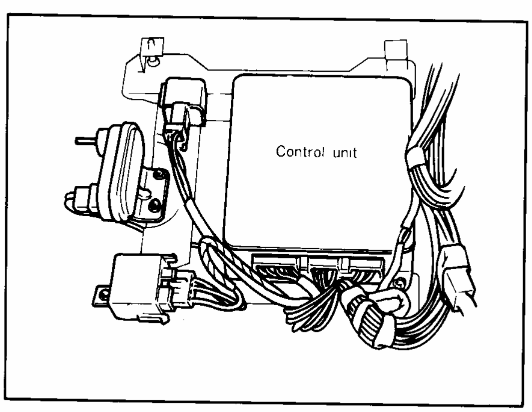
Variable Resistor
The variable resistor is used to adjust the air/fuel ratio at the factory only (tamper-proof).



Throttle Sensor
The throttle sensor detects the degree of throttle valve opening, by detecting the output voltage resulting from the change of the resistance value caused by the change of the degree of throttle opening.



Atmospheric Pressure Sensor
The atmospheric pressure sensor detects the pressure of the atmosphere and converts this to electric signals. These output signals are used in order to make compensation adjustments for high altitude.



EMISSION CONTROL UNIT

Various conditions such as engine temperature, load, rpm, vehicle driving conditions, etc. are input to the emissions control unit as input signals.
These input signals are electrically processed within the emissions control unit. Then output signals which match input conditions are output to the various devices, and, together with controlling emissions, control signals (fuel-increase signals and fuel-cut signals) which match the engine operating range are sent to the injector.