# 2002 LEGACY SERVICE MANUAL

## QUICK REFERENCE INDEX

## NEW CAR INFORMATION SECTION

## FOREWORD

This manual has been prepared to provide information for the construction, operation and other technical details of SUBARU vehicles.
Read this manual thoroughly and make the most of it to give better service to your customers and improve your knowledge of vehicle maintenance.

All information, illustration and specifications contained in this manual are based on the latest product information available at the time of publication approval.

**FUJI HEAVY INDUSTRIES LTD.**



W2290GE

# FOREWORD

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# FOREWORD

# SPECIFICATIONS SPC

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# 1. Legacy

## A: DIMENSIONS

| Model | | | Sedan | Wagon |
|---|---|---|---|---|
| | | | AWD | |
| Overall length | | mm (in) | 4,605 (181.3) | 4,680 (184.3) |
| Overall width | | mm (in) | 1,695 (66.7) | 1,695 (66.7) |
| Overall height (at CW) | | mm (in) | 1,415 (55.7) | 1,515 (59.6) |
| Compartment | Length | mm (in) | 1,965 (77.4) | 1,925 (75.8) |
| | Width | mm (in) | 1,440 (56.7), 1,420 (55.9)*1 | 1,440 (56.7), 1,420 (55.9)*1 |
| | Height | mm (in) | 1,155 (45.5) | 1,190 (46.9), 1,175 (46.3)*2 |
| Wheelbase | | mm (in) | 2,650 (104.3) | 2,650 (104.3) |
| Tread | Front | mm (in) | 1,460 (57.5) | 1,460 (57.5) |
| | Rear | mm (in) | 1,460 (57.5) | 1,455 (57.3) |
| Minimum road clearance | Without catalytic converter | mm (in) | 160 (6.3) | 165 (6.5) |
| | With catalytic converter | mm (in) | 155 (6.1) | 155 (6.1) |
| | Australia | mm (in) | 155 (6.1) | 155 (6.1) |

*1: With leather seat
*2: With sunroof

## B: ENGINE

| Model | | Sedan/Wagon | |
|---|---|---|---|
| | | AWD | |
| | | 2.0 L | 2.5 L |
| Engine type | | Horizontally opposed, liquid cooled, 4-cylinder, 4-stroke gasoline engine | |
| Valve arrangement | | Overhead camshaft type | |
| Bore × Stroke | mm (in) | 92 × 75 (3.62 × 2.95) | 99.5 × 79.0 (3.917 × 3.110) |
| Displacement | $cm^3$ (cu in) | 1,994 (121.67) | 2,457(149.9) |
| Compression ratio | | 10.0 | |
| Firing order | | 1 — 3 — 2 — 4 | |
| Idle speed at Park/Neutral position | rpm | 700±100 | |
| Maximum output | kW (HP)/rpm | 92 (123)/5,600 | 115 (154)/5,600 |
| Maximum torque | N·m (kgf-m, ft-lb)/rpm | 184 (18.8, 136.0)/3,600 | 223 (22.7, 164.2)/3,600 |

## C: ELECTRICAL

| Model | | | Sedan/Wagon | |
|---|---|---|---|---|
| | | | AWD | |
| | | | 2.0 L | 2.5 L |
| Ignition timing at idling speed | | BTDC/rpm | 10°±10°/700 | |
| Spark plug | Type and manufacturer | Without OBD | NGK: BKR6E (without catalyst)<br>CHAMPION: RC10YC4 (with catalyst)<br>NGK: BKR5E-11 (with catalyst) | |
| | | With OBD | RC10YC4 .......... CHAMPION | |
| | | | Alternate | RC8YC4 .......... CHAMPION<br>BKR6E-11 .......... NGK<br>K20PR-U11 .......... NIPPONDENSO |
| Generator | | | 12V — 90A | |
| Battery | Type and capacity (5HR) | For Europe and South America | MT: 12V — 48AH (55D23L)<br>AT: 12V — 52AH (65D23L) | MT: 12V — 48AH (55D23L)<br>AT: 12V — 52AH (75D23L) |
| | | Others | 12V — 27AH (34B19L) | |

## D: TRANSMISSION

| Model | | | Sedan/Wagon | | | |
|---|---|---|---|---|---|---|
| | | | AWD | | | |
| | | | 2.0 L | | 2.5 L | |
| Transmission type | | | 5MT | 4AT | 5MT | 4AT |
| Clutch type | | | DSPD | TCC | DSPD | TCC |
| Gear ratio | | 1st | 3.454 | 2.785 | 3.454 | 2.785 |
| | | 2nd | 2.062 | 1.545 | 2.062 | 1.545 |
| | | 3rd | 1.448 | 1.000 | 1.448 | 1.000 |
| | | 4th | 1.088 | 0.694 | 1.088 | 0.694 |
| | | 5th | 0.825 | — | 0.825*1, 0.780*2 | — |
| | | Reverse | 3.333 | 2.272 | 3.333 | 2.272 |
| Auxiliary transmission gear ratio | | High | 1.000 | — | 1.000 | — |
| | | Low | 1.447 | — | 1.196 | — |
| Reduction gear (Front drive) | 1st reduction | Type of gear | — | Helical | — | Helical |
| | | Gear ratio | — | 1.000 | — | 1.000 |
| | Final reduction | Type of gear | Hypoid | Hypoid | Hypoid | Hypoid |
| | | Gear ratio | 3.900 | 4.111 | 3.700*1, 4.111*2 | 4.111 |
| Reduction gear (Rear drive) | Transfer reduction | Type of gear | Helical | — | Helical | — |
| | | Gear ratio | 1.000 | — | 1.000 | — |
| | Final reduction | Type of gear | Hypoid | Hypoid | Hypoid | Hypoid |
| | | Gear ratio | 3.900 | 4.111 | 3.700*1, 4.111*2 | 4.111 |

5MT: 5-forward speeds with synchromesh and 1-reverse
4AT: Electronically controlled fully-automatic, 4-forward speeds and 1-reverse
DSPD: Dry Single Plate Diaphragm
TCC: Torque Converter Clutch
*1: Except Australia spec. vehicles
*2: Australia spec. vehicles

## E: STEERING

| Model | | Models with 185/70R14 tires | Models with 195/60R15 tires | Models with 205/50R16 tires |
|---|---|---|---|---|
| Type | | Rack and Pinion | | |
| Turns, lock to lock | | 3.1 | | |
| Minimum turning circle | m (ft) | Curb to curb: 10.8±1.0 (35.4±3.3)<br>Wall to wall: 11.5±1.0 (37.7±3.3) | | |

## F: SUSPENSION

| Model | Conventional suspension |
|---|---|
| Front | Macpherson strut type, Independent, Coil spring |
| Rear | Multi-link type, Independent, Coil spring |

## G: BRAKE

| | |
|---|---|
| Service brake system | Dual circuit hydraulic with vacuum suspended power unit |
| Front | Ventilated disc brake |
| Rear | Disc brake |
| Parking brake | Mechanical on rear brakes |

## H: TIRE

| | | | |
|---|---|---|---|
| Rim size | 14 × 5½JJ | 15 × 6JJ | 16 × 6½JJ |
| Tire size | 185/70R14 | 195/60R15 | 205/50R16 |
| Type | Steel belted radial, Tubeless | | |

## I: CAPACITY

| Model | | | Sedan/Wagon | | | |
|---|---|---|---|---|---|---|
| | | | AWD | | | |
| | | | 2.0 L | | 2.5 L | |
| | | | 5MT | 4AT | 5MT | 4AT |
| Fuel tank | | ℓ (US gal, Imp gal) | 64 (16.9, 14.1) | | | |
| Engine oil | Total capacity | ℓ (US qt, Imp qt) | 4.0 (4.2, 3.5) | | | |
| | Engine oil amount for refill | ℓ (US qt, Imp qt) | Approx. 4.0 (4.2, 3.5) | | | |
| Transmission gear oil | | ℓ (US qt, Imp qt) | 3.5 (3.7, 3.1) | — | 3.5 (3.7, 3.1) | — |
| Automatic transmission fluid | | ℓ (US qt, Imp qt) | — | 8.4 – 8.7 (8.9 – 9.2, 7.4 – 7.7) | — | 9.3 – 9.6 (9.8 – 10.1, 8.2 – 8.4) |
| AT differential gear oil | | ℓ (US qt, Imp qt) | — | 1.1 – 1.3 (1.2 – 1.4, 1.0 – 1.1) | — | 1.1 – 1.3 (1.2 – 1.4, 1.0 – 1.1) |
| AWD rear differential gear oil | | ℓ (US qt, Imp qt) | 0.8 (0.8, 0.6) | | | |
| Power steering fluid | | ℓ (US qt, Imp qt) | 0.7 (0.7, 0.6) | | | |
| Engine coolant | | ℓ (US qt, Imp qt) | 7.0 (7.4, 6.2) | 6.9 (7.3, 6.1) | 6.8 (7.2, 6.0) | 6.7 (7.1, 5.9) |

# J: WEIGHT

## 1. SEDAN

### ● LHD Vehicle

| Option code *1 | | | EC | | K4 | | KO, KS | |
|---|---|---|---|---|---|---|---|---|
| Model | | | 2.0 L | | | | | |
| | | | 4WD | | | | | |
| | | | GL | | | | | |
| | | | 5MT | 4AT | 5MT | 4AT | 5MT | 4AT |
| Curb weight (C.W.) | Front | kg (lb) | 785 (1,730) | 810 (1,785) | 775 (1,710) | 800 (1,765) | 790 (1,740) | 815 (1,795) |
| | Rear | kg (lb) | 605 (1,335) | 605 (1,335) | 610 (1,345) | 610 (1,345) | 610 (1,345) | 610 (1,345) |
| | Total | kg (lb) | 1,390 (3,065) | 1,415 (3,120) | 1,385 (3,055) | 1,410 (3,110) | 1,400 (3,085) | 1,425 (3,140) |
| Maximum permissible axle weight (M.P.A.W.) | Front | kg (lb) | 970 (2,140) | 970 (2,140) | 970 (2,140) | 970 (2,140) | 970 (2,140) | 970 (2,140) |
| | Rear | kg (lb) | 975 (2,150) | 975 (2,150) | 975 (2,150) | 975 (2,150) | 975 (2,150) | 975 (2,150) |
| Maximum permissible weight (M.P.W.) | Total | kg (lb) | 1,870 (4,125) | 1,870 (4,125) | 1,870 (4,125) | 1,870 (4,125) | 1,870 (4,125) | 1,870 (4,125) |
| Option | Side airbag | | ○ | ○ | — | — | — | — |
| | Air conditioner | | — | — | — | — | ○ | ○ |
| | Audio | | — | — | — | — | ○ | ○ |
| | Cruise control | | — | — | — | — | — | — |
| | Cold weather pack | | — | — | — | — | — | — |

| Option code *1 | | | EC | | K4 | | KO, KS | |
|---|---|---|---|---|---|---|---|---|
| Model | | | 2.5 L | | | | | |
| | | | 4WD | | | | | |
| | | | GX | | | | | |
| | | | 5MT | 4AT | 5MT | 4AT | 5MT | 4AT |
| Curb weight (C.W.) | Front | kg (lb) | 805 (1,775) | 830 (1,830) | 795 (1,755) | 820 (1,810) | 785 (1,730) | 810 (1,785) |
| | Rear | kg (lb) | 605 (1,335) | 610 (1,345) | 610 (1,345) | 615 (1,355) | 610 (1,345) | 615 (1,355) |
| | Total | kg (lb) | 1,410 (3,110) | 1,440 (3,175) | 1,405 (3,110) | 1,435 (3,165) | 1,395 (3,075) | 1,425 (3,140) |
| Maximum permissible axle weight (M.P.A.W.) | Front | kg (lb) | 985 (2,170) | 985 (2,170) | 985 (2,170) | 985 (2,170) | 985 (2,170) | 985 (2,170) |
| | Rear | kg (lb) | 1,000 (2,205) | 1,000 (2,205) | 1,000 (2,205) | 1,000 (2,205) | 1,000 (2,205) | 1,000 (2,205) |
| Maximum permissible weight (M.P.W.) | Total | kg (lb) | 1,910 (4,210) | 1,910 (4,210) | 1,910 (4,210) | 1,910 (4,210) | 1,910 (4,210) | 1,910 (4,210) |
| Option | Side airbag | | ○ | ○ | — | — | — | — |
| | Air conditioner | | ○ | ○ | ○ | ○ | — | — |
| | Audio | | — | — | — | — | ○ | ○ |
| | Cruise control | | — | — | ○ | ○ | — | — |
| | Cold weather pack | | — | — | — | — | — | — |

*1: For option code, refer to ID section. <Ref. to ID-5, MODEL NUMBER PLATE, IDENTIFICATION, Identification.>

## ● RHD Vehicle

| Option code *1 | | | K1 | EK | | | |
|---|---|---|---|---|---|---|---|
| Model | | | 2.0 L | | | 2.5 L | |
| | | | 4WD | | | | |
| | | | GL | | | GX | |
| | | | 4AT | 5MT | 4AT | 5MT | 4AT |
| Curb weight (C.W.) | Front | kg (lb) | 800 (1,765) | 785 (1,730) | 810 (1,785) | 795 (1,755) | 820 (1,810) |
| | Rear | kg (lb) | 605 (1,335) | 605 (1,335) | 605 (1,335) | 605 (1,335) | 610 (1,345) |
| | Total | kg (lb) | 1,405 (3,100) | 1,390 (3,065) | 1,415 (3,120) | 1,400 (3,085) | 1,430 (3,155) |
| Maximum permissible axle weight (M.P.A.W.) | Front | kg (lb) | 970 (2,140) | 970 (2,140) | 970 (2,140) | 985 (2,170) | 985 (2,170) |
| | Rear | kg (lb) | 975 (2,150) | 975 (2,150) | 975 (2,150) | 1,000 (2,205) | 1,000 (2,205) |
| Maximum permissible weight (M.P.W.) | Total | kg (lb) | 1,870 (4,125) | 1,870 (4,125) | 1,870 (4,125) | 1,910 (4,210) | 1,910 (4,210) |
| Option | Side airbag | | — | ○ | ○ | ○ | ○ |
| | Air conditioner | | — | — | — | — | — |
| | Audio | | ○ | ○ | ○ | ○ | ○ |
| | Cruise control | | — | — | — | — | — |
| | Cold weather pack | | — | — | — | — | — |

| Option code *1 | | | KA | | | |
|---|---|---|---|---|---|---|
| Model | | | 2.0 L | | 2.5 L | |
| | | | 4WD | | | |
| | | | GL (GX) | | GX (RX) | |
| | | | 5MT | 4AT | 5MT | 4AT |
| Unladen mass (U.M.) | Front | kg (lb) | 780 (1,720) | 775 (1,710) | 775 (1,710) | 785 (1,730) |
| | Rear | kg (lb) | 585 (1,290) | 585 (1,290) | 595 (1,310) | 595 (1,310) |
| | Total | kg (lb) | 1,365 (3,010) | 1,360 (3,000) | 1,370 (3,020) | 1,380 (3,045) |
| Gross vehicle mass (G.V.M.) | Front | kg (lb) | 930 (2,050) | 930 (2,050) | 940 (2,075) | 940 (2,075) |
| | Rear | kg (lb) | 970 (2,140) | 970 (2,140) | 980 (2,160) | 980 (2,160) |
| | Total | kg (lb) | 1,900 (4,190) | 1,900 (4,190) | 1,920 (4,235) | 1,920 (4,235) |
| Option | Side airbag | | — | — | — | — |
| | Air conditioner | | ○ | — | — | — |
| | Audio | | ○ | ○ | ○ | ○ |
| | Cruise control | | ○ | — | — | — |
| | Cold weather pack | | — | — | — | — |

*1: For option code, refer to ID section. <Ref. to ID-5, MODEL NUMBER PLATE, IDENTIFICATION, Identification.>

## 2. WAGON

### ● LHD Vehicle

| Option code *1 | | EC | | K4 | | KO, KS | |
|---|---|---|---|---|---|---|---|
| Model | | 2.0 L | | | | | |
| | | 4WD | | | | | |
| | | GL | | | | | |
| | | 5MT | 4AT | 5MT | 4AT | 5MT | 4AT |
| Curb weight (C.W.) | Front kg (lb) | 780 (1,720) | 800 (1,765) | 775 (1,710) | 790 (1,740) | 790 (1,740) | 805 (1,775) |
| | Rear kg (lb) | 650 (1,435) | 650 (1,435) | 655 (1,445) | 655 (1,445) | 655 (1,445) | 655 (1,445) |
| | Total kg (lb) | 1,430 (3,155) | 1,450 (3,195) | 1,430 (3,155) | 1,445 (3,185) | 1,445 (3,185) | 1,460 (3,220) |
| Maximum permissible axle weight (M.P.A.W.) | Front kg (lb) | 960 (2,115) | 960 (2,115) | 960 (2,115) | 960 (2,115) | 960 (2,115) | 960 (2,115) |
| | Rear kg (lb) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) |
| Maximum permissible weight (M.P.W.) | Total kg (lb) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) |
| Option | Side airbag | — | ○ | — | — | — | — |
| | Air conditioner | — | — | — | — | ○ | ○ |
| | Audio | — | — | — | — | ○ | ○ |
| | Cruise control | — | — | — | — | — | — |
| | Cold weather pack | — | — | — | — | — | — |

| Option code *1 | | EC | | K4 | | KO, KS | |
|---|---|---|---|---|---|---|---|
| Model | | 2.5 L | | | | | |
| | | 4WD | | | | | |
| | | GX | | | | | |
| | | 5MT | 4AT | 5MT | 4AT | 5MT | 4AT |
| Curb weight (C.W.) | Front kg (lb) | 790 (1,740) | 820 (1,810) | 775 (1,710) | 790 (1,740) | 790 (1,740) | 805 (1,775) |
| | Rear kg (lb) | 655 (1,445) | 655 (1,445) | 655 (1,445) | 655 (1,445) | 655 (1,445) | 655 (1,445) |
| | Total kg (lb) | 1,445 (3,185) | 1,475 (3,250) | 1,430 (3,155) | 1,445 (3,185) | 1,445 (3,185) | 1,460 (3,220) |
| Maximum permissible axle weight (M.P.A.W.) | Front kg (lb) | 995 (2,195) | 995 (2,195) | 960 (2,115) | 960 (2,115) | 960 (2,115) | 960 (2,115) |
| | Rear kg (lb) | 1,050 (2,315) | 1,050 (2,315) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) |
| Maximum permissible weight (M.P.W.) | Total kg (lb) | 1,980 (4,365) | 1,980 (4,365) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) |
| Option | Side airbag | ○ | ○ | — | — | — | — |
| | Air conditioner | — | ○ | — | — | ○ | ○ |
| | Audio | — | — | — | — | ○ | ○ |
| | Cruise control | — | ○ | — | — | — | — |
| | Cold weather pack | — | ○ | — | — | — | — |

*1: For option code, refer to ID section. <Ref. to ID-5, MODEL NUMBER PLATE, IDENTIFICATION, Identification.>

## ● RHD Vehicle

| Option code *1 | | | K1 | EK | | | | |
|---|---|---|---|---|---|---|---|---|
| Model | | | 2.0 L | | | | 2.5 L | |
| | | | 4WD | | | | | |
| | | | GL | | | | GX | |
| | | | 5MT | 4AT | 5MT | 4AT | 5MT | 4AT |
| Curb weight (C.W.) | Front | kg (lb) | 775 (1,710) | 790 (1,740) | 785 (1,731) | 800 (1,765) | 790 (1,740) | 805 (1,775) |
| | Rear | kg (lb) | 655 (1,445) | 655 (1,445) | 650 (1,435) | 650 (1,435) | 655 (1,445) | 655 (1,445) |
| | Total | kg (lb) | 1,430 (3,155) | 1,445 (3,185) | 1,435 (3,165) | 1,450 (3,195) | 1,445 (3,185) | 1,460 (3,220) |
| Maximum permissible axle weight (M.P.A.W.) | Front | kg (lb) | 960 (2,115) | 960 (2,115) | 960 (2,115) | 960 (2,115) | 995 (2,195) | 995 (2,195) |
| | Rear | kg (lb) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) | 1,030 (2,270) | 1,050 (2,315) | 1,050 (2,315) |
| Maximum permissible weight (M.P.W.) | Total | kg (lb) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) | 1,920 (4,235) | 1,980 (4,365) | 1,980 (4,365) |
| Option | Side airbag | | — | — | ○ | ○ | ○ | ○ |
| | Air conditioner | | — | — | — | — | — | — |
| | Audio | | ○ | ○ | ○ | ○ | ○ | ○ |
| | Cruise control | | — | — | — | — | — | — |
| | Cold weather pack | | — | — | — | — | — | — |

| Option code *1 | | | KA | | | |
|---|---|---|---|---|---|---|
| Model | | | 2.0 L | | 2.5 L | |
| | | | 4WD | | | |
| | | | GL (GX) | | GX (RX) | |
| | | | 5MT | 4AT | 5MT | 4AT |
| Unladen mass (U.M.) | Front | kg (lb) | 775 (1,710) | 775 (1,710) | 765 (1,685) | 780 (1,720) |
| | Rear | kg (lb) | 635 (1,400) | 635 (1,400) | 645 (1,420) | 645 (1,420) |
| | Total | kg (lb) | 1,410 (3,110) | 1,410 (3,110) | 1,410 (3,110) | 1,425 (3,140) |
| Gross vehicle mass (G.V.M.) | Front | kg (lb) | 930 (2,050) | 930 (2,050) | 950 (2,095) | 950 (2,095) |
| | Rear | kg (lb) | 1,010 (2,225) | 1,010 (2,225) | 1,040 (2,295) | 1,040 (2,295) |
| | Total | kg (lb) | 1,940 (4,280) | 1,940 (4,280) | 1,990 (4,390) | 1,990 (4,390) |
| Option | Side airbag | | — | — | — | — |
| | Air conditioner | | ○ | — | — | — |
| | Audio | | ○ | ○ | ○ | ○ |
| | Cruise control | | ○ | — | — | — |
| | Cold weather pack | | — | — | — | — |

*1: For option code, refer to ID section. <Ref. to ID-5, MODEL NUMBER PLATE, IDENTIFICATION, Identification.>

NOTE:
When any of the following optional parts are installed, add the weight to the curb weight.

| Weight of optional parts | | VDC | Cruise control | Air conditioner | Sunroof | Leather interior | SRS Airbag (Side) |
|---|---|---|---|---|---|---|---|
| Front | kg (lb) | 6.5 (14.33) | 2.1 (4.6) | 13.9 (30.6) | 10.9 (24.0) | 1.8 (4.0) | 2.9 (6.4) |
| Rear | kg (lb) | 0.1 (0.22) | 0.3 (0.7) | –0.1 (–0.2) | 16.4 (36.2) | 3.1 (6.8) | 3.0 (6.6) |
| Total | kg (lb) | 6.6 (14.55) | 2.4 (5.3) | 13.8 (30.4) | 27.3 (60.2) | 4.9 (10.8) | 5.9 (13.0) |

| Weight of optional parts | | Cold weather pack | Audio | Rear spoiler | Sports package | Self-leveling rear suspension |
|---|---|---|---|---|---|---|
| Front | kg (lb) | 0.2 (0.44) | 1.8 (4.0) | –0.7 (–1.54) | –1.4 (–3.09) | 0.2 (0.4) |
| Rear | kg (lb) | 0.2 (0.44) | 0.7 (1.5) | 3.2 (7.06) | –3.8 (–8.38) | 4.2 (9.3) |
| Total | kg (lb) | 0.4 (0.88) | 2.5 (5.5) | 2.5 (5.51) | –5.2 (–11.47) | 4.4 (9.7) |

# 2. OUTBACK

## A: DIMENSIONS

| Model | | | OUTBACK |
|---|---|---|---|
| | | | AWD |
| Overall length | | mm (in) | 4,720 (185.8) |
| Overall width | | mm (in) | 1,745 (68.7) |
| Overall height (at CW) | | mm (in) | 1,580 (62.2), 1,590 (62.6)*3 |
| Compartment | Length | mm (in) | 1,925 (75.8) |
| | Width | mm (in) | 1,440 (56.7), 1,420 (55.9)*1 |
| | Height | mm (in) | 1,190 (46.9), 1,175 (46.3)*2 |
| Wheelbase | | mm (in) | 2,650 (104.3) |
| Tread | Front | mm (in) | 1,470 (57.9) |
| | Rear | mm (in) | 1,460 (57.5)*3, 1,465 (57.7) |
| Minimum road clearance | Without catalytic converter | mm (in) | 195 (7.7) |
| | With catalytic converter | mm (in) | 190 (7.5) |
| | Australia | mm (in) | 200 (7.9) |

*1: With leather seat
*2: With sunroof
*3: Australia spec. vehicles

## B: ENGINE

| Model | | OUTBACK | |
|---|---|---|---|
| | | AWD | |
| | | 2.5 L | 3.0 L |
| Engine type | | Horizontally opposed, liquid cooled, 4-cylinder, 4-stroke gasoline engine | Horizontally opposed, liquid cooled, 6-cylinder, 4-stroke gasoline engine |
| Valve arrangement | | Overhead camshaft type | Double overhead camshaft type |
| Bore × Stroke | mm (in) | 99.5 × 79.0 (3.917 × 3.110) | 89.2 × 80.0 (3.512 × 3.150) |
| Displacement | $cm^3$ (cu in) | 2,457 (149.9) | 3,000 (183.06) |
| Compression ratio | | 10.0 | 10.7 |
| Firing order | | 1 — 3 — 2 — 4 | 1 — 6 — 3 — 2 — 5 — 4 |
| Idle speed at Park/Neutral position | rpm | 700±100 | 600±100 |
| Maximum output | kW (HP)/rpm | 115 (154)/5,600 | 154 (206)/6,000 |
| Maximum torque | N·m (kgf-m, ft-lb)/rpm | 223 (22.7, 164.2)/3,600 | 282 (28.8, 208)/4,400 |

## C: ELECTRICAL

| Model | | | | OUTBACK | |
|---|---|---|---|---|---|
| | | | | AWD | |
| | | | | 2.5 L | 3.0 L |
| Ignition timing at idling speed | | BTDC/rpm | 10°±10°/700 | | 10°±8°/600 |
| Spark plug | Type and manufacturer | | RC10YC4 ....... CHAMPION | | PLFR6A ....... NGK |
| | | | Alternate | RC8YC4 ....... CHAMPION<br>BKR6E-11 ....... NGK<br>K20PR-U11 ....... NIPPONDENSO | |
| Generator | | | 12V — 90A | | 12V — 100A |
| Battery | Type and capacity (5HR) | | For Europe and South America | MT: 12V — 48AH (55D23L)<br>AT: 12V — 52AH (75D23L) | 12V — 52AH (75D23L) |
| | | | Others | 12V — 27AH (34B19L) | 12V — 48H (55D23L) |

## D: TRANSMISSION

| Model | | | OUTBACK | | |
|---|---|---|---|---|---|
| | | | AWD | | |
| | | | 2.5 L | | 3.0 L |
| Transmission type | | | 5MT | 4AT | 4AT |
| Clutch type | | | DSPD | TCC | TCC |
| Gear ratio | | 1st | 3.454 | 2.785 | |
| | | 2nd | 2.062 | 1.545 | |
| | | 3rd | 1.448 | 1.000 | |
| | | 4th | 1.088 | 0.694 | |
| | | 5th | 0.825 | — | |
| | | Reverse | 3.333 | 2.272 | |
| Auxiliary transmission gear ratio | | High | 1.000 | — | |
| | | Low | 1.196 | — | |
| Reduction gear (Front drive) | 1st reduction | Type of gear | — | Helical | |
| | | Gear ratio | — | 1.000 | |
| | Final reduction | Type of gear | Hypoid | Hypoid | |
| | | Gear ratio | 3.900*1, 4.111*2 | 4.444 | 4.111 |
| Reduction gear (Rear drive) | Transfer reduction | Type of gear | Helical | — | |
| | | Gear ratio | 1.000 | — | |
| | Final reduction | Type of gear | Hypoid | Hypoid | |
| | | Gear ratio | 3.900*1, 4.111*2 | 4.444 | 4.111 |

5MT: 5 × 2 forward speeds with synchromesh and 1-reverse
4AT: Electronically controlled fully-automatic, 4-forward speeds and 1-reverse
DSPD: Dry Single Plate Diaphragm
TCC: Torque Converter Clutch
*1: Except Australia spec. vehicles
*2: Australia spec. vehicles

## E: STEERING

| Model | | OUTBACK |
|---|---|---|
| Type | | Rack and Pinion |
| Turns, lock to lock | | 3.0 |
| Minimum turning circle | m (ft) | Curb to curb: 11.2±1.0 (36.7±3.3)<br>Wall to wall: 12.0±1.0 (39.4±3.3) |

## F: SUSPENSION

| Model | OUTBACK |
|---|---|
| Front | Macpherson strut type, Independent, Coil spring |
| Rear | Multi-link type, Independent, Coil spring |

## G: BRAKE

| Model | OUTBACK |
|---|---|
| Service brake system | Dual circuit hydraulic with vacuum suspended power unit |
| Front | Ventilated disc brake |
| Rear | Disc brake |
| Parking brake | Mechanical on rear brakes |

## H: TIRE

| Model | OUTBACK |
|---|---|
| Rim size | 16 × 6½JJ |
| Tire size | 215/60R16 |
| Type | Steel belted radial, Tubeless |

## I: CAPACITY

| Model | | | OUTBACK | | |
|---|---|---|---|---|---|
| | | | AWD | | |
| | | | 2.5 L | | 3.0 L |
| | | | 5MT | 4AT | |
| Fuel tank | | ℓ (US gal, Imp gal) | 64 (16.9, 14.1) | | |
| Engine oil | Total capacity | ℓ (US qt, Imp qt) | 4.0 (4.2, 3.5) | | 6.8 (7.2, 6.0) |
| | Engine oil amount for refill | ℓ (US qt, Imp qt) | Approx. 4.0 (4.2, 3.5) | | Approx. 5.8 (6.1, 5.1) |
| Transmission gear oil | | ℓ (US qt, Imp qt) | 4.0 (4.2, 3.5) | — | |
| Automatic transmission fluid | | ℓ (US qt, Imp qt) | — | 9.3 – 9.6 (9.8 – 10.1, 8.2 – 8.4) | |
| AT differential gear oil | | ℓ (US qt, Imp qt) | — | 1.1 – 1.3 (1.2 – 1.4, 1.0 – 1.1) | |
| AWD rear differential gear oil | | ℓ (US qt, Imp qt) | 0.8 (0.8, 0.7) | | |
| Power steering fluid | | ℓ (US qt, Imp qt) | 0.7 (0.7, 0.6) | | |
| Engine coolant | | ℓ (US qt, Imp qt) | 6.8 (7.2, 6.0) | 6.7 (7.1, 5.9) | 7.7 (8.1, 6.8) |

# J: WEIGHT

## 1. OUTBACK

### ● LHD Vehicle

| Option code *1 | | | K4 | | KS | | KO |
|---|---|---|---|---|---|---|---|
| Model | | | 2.5 L | | | | |
| | | | 4WD | | | | |
| | | | 5MT | 4AT | 5MT | 4AT | |
| Curb weight (C.W.) | Front | kg (lb) | 810 (1,785) | 825 (1,820) | 815 (1,795) | 830 (1,830) | 785 (1,730) |
| | Rear | kg (lb) | 670 (1,475) | 670 (1,475) | 670 (1,475) | 670 (1,475) | 650 (1,435) |
| | Total | kg (lb) | 1,480 (3,265) | 1,495 (3,295) | 1,485 (3,275) | 1,500 (3,310) | 1,435 (3,165) |
| Maximum permissible axle weight (M.P.A.W.) | Front | kg (lb) | 995 (2,195) | 995 (2,195) | 995 (2,195) | 995 (2,195) | 960 (2,115) |
| | Rear | kg (lb) | 1,050 (2,315) | 1,050 (2,315) | 1,050 (2,315) | 1,050 (2,315) | 1,030 (2,270) |
| Maximum permissible weight (M.P.W.) | Total | kg (lb) | 2,000 (4,410) | 2,000 (4,410) | 2,000 (4,410) | 2,000 (4,410) | 1,920 (4,235) |
| Option | Side airbag | | — | — | — | — | — |
| | Air conditioner | | ○ | ○ | ○ | ○ | ○ |
| | Audio | | — | — | ○ | ○ | ○ |
| | Cruise control | | ○ | ○ | ○ | ○ | ○ |
| | Cold weather pack | | — | — | — | — | — |
| | Leather interior | | — | — | — | — | ○ |
| | Sunroof | | — | — | — | — | ○ |

| Option code *1 | | | EC | | |
|---|---|---|---|---|---|
| Model | | | 2.5 L | | 3.0 L |
| | | | 4WD | | |
| | | | 5MT | 4AT | |
| Curb weight (C.W.) | Front | kg (lb) | 815 (1,795) | 830 (1,830) | 915 (2,020) |
| | Rear | kg (lb) | 675 (1,490) | 675 (1,490) | 695 (1,530) |
| | Total | kg (lb) | 1,490 (3,285) | 1,505 (3,320) | 1,610 (3,550) |
| Maximum permissible axle weight (M.P.A.W.) | Front | kg (lb) | 1,010 (2,225) | 1,010 (2,225) | 1,040 (2,295) |
| | Rear | kg (lb) | 1,060 (2,335) | 1,060 (2,335) | 1,060 (2,335) |
| Maximum permissible weight (M.P.W.) | Total | kg (lb) | 2,015 (4,445) | 2,015 (4,445) | 2,085 (4,595) |
| Option | Side airbag | | ○ | ○ | ○ |
| | Air conditioner | | ○ | ○ | ○ |
| | Audio | | — | — | ○ |
| | Cruise control | | — | — | ○ |
| | Cold weather pack | | — | — | ○ |
| | Leather interior | | — | — | ○ |
| | Sunroof | | — | — | ○ |

*1: For option code, refer to ID section. <Ref. to ID-5, MODEL NUMBER PLATE, IDENTIFICATION, Identification.>

## ● RHD Vehicle

| Option code *1 | | | EK | | |
|---|---|---|---|---|---|
| Model | | | 2.5 L | | 3.0 L |
| | | | 4WD | | |
| | | | 5MT | 4AT | |
| Curb weight (C.W.) | Front | kg (lb) | 800 (1,765) | 815 (1,795) | 915 (2,020) |
| | Rear | kg (lb) | 670 (1,475) | 670 (1,475) | 695 (1,530) |
| | Total | kg (lb) | 1,470 (3,240) | 1,485 (3,275) | 1,610 (3,550) |
| Maximum permissible axle weight (M.P.A.W.) | Front | kg (lb) | 1,010 (2,225) | 1,010 (2,225) | 1,040 (2,295) |
| | Rear | kg (lb) | 1,060 (2,335) | 1,060 (2,335) | 1,060 (2,335) |
| Maximum permissible weight (M.P.W.) | Total | kg (lb) | 2,015 (4,445) | 2,015 (4,445) | 2,085 (4,595) |
| Option | Side airbag | | — | — | ○ |
| | Air conditioner | | — | — | ○ |
| | Audio | | ○ | ○ | ○ |
| | Cruise control | | — | — | ○ |
| | Cold weather pack | | — | — | ○ |
| | Leather interior | | — | — | ○ |
| | Sunroof | | — | — | ○ |

| Option code *1 | | | KA | | |
|---|---|---|---|---|---|
| Model | | | 2.5 L | | 3.0 L |
| | | | 4WD | | |
| | | | 5MT | 4AT | |
| Unladen mass (U.M.) | Front | kg (lb) | 790 (1,740) | 800 (1,765) | 900 (1,985) |
| | Rear | kg (lb) | 650 (1,435) | 650 (1,435) | 690 (1,520) |
| | Total | kg (lb) | 1,440 (3,175) | 1,410 (3,110) | 1,590 (3,505) |
| Gross vehicle mass (G.V.M.) | Front | kg (lb) | 970 (2,140) | 970 (2,140) | 1,035 (2,280) |
| | Rear | kg (lb) | 1,050 (2,315) | 1,050 (2,315) | 1,050 (2,315) |
| | Total | kg (lb) | 2,020 (4,455) | 2,020 (4,455) | 2,085 (4,595) |
| Option | Side airbag | | — | — | ○ |
| | Air conditioner | | — | — | ○ |
| | Audio | | ○ | ○ | ○ |
| | Cruise control | | — | — | ○ |
| | Cold weather pack | | — | — | ○ |

*1: For option code, refer to ID section. <Ref. to ID-5, MODEL NUMBER PLATE, IDENTIFICATION, Identification.>

NOTE:
When any of the following optional parts are installed, add the weight to the curb weight.

| Weight of optional parts | | Cruise control | Self levelizer | Air conditioner | Sunroof | Leather interior |
|---|---|---|---|---|---|---|
| Front | kg (lb) | 2.1 (4.6) | 0.2 (0.4) | 13.9 (30.6) | 10.9 (24.0) | 1.8 (4.0) |
| Rear | kg (lb) | 0.3 (0.7) | 4.2 (9.3) | –0.1 (–0.2) | 16.4 (36.2) | 3.1 (6.8) |
| Total | kg (lb) | 2.4 (5.3) | 4.4 (9.7) | 13.8 (30.4) | 27.3 (60.2) | 4.9 (10.8) |

| Weight of optional parts | | SRS Airbag (Side) | Cold weather pack | Audio | Rear spoiler | Sports package |
|---|---|---|---|---|---|---|
| Front | kg (lb) | 2.9 (6.4) | 0.2 (0.44) | 1.8 (4.0) | –0.7 (–1.54) | –1.4 (–3.09) |
| Rear | kg (lb) | 3.0 (6.6) | 0.2 (0.44) | 0.7 (1.5) | 3.2 (7.06) | –3.8 (–8.38) |
| Total | kg (lb) | 5.9 (13.0) | 0.4 (0.88) | 2.5 (5.5) | 2.5 (5.51) | –5.2 (–11.47) |

## MEMO

# FUEL INJECTION (FUEL SYSTEM) FU

Page

# 1. General

- The Multipoint Fuel Injection (MFI) system supplies optimum air-fuel mixture under every engine operating condition through the use of the latest electronic control technology.

This system pressurizes the fuel to a constant pressure and injects it into each intake air port in the cylinder head. The injection quantity of fuel is controlled by an intermittent injection system where an electro-magnetic injection valve or injector opens for a short period that is precisely controlled depending on the quantity of air appropriate for each condition of operation. In actual control, an optimum fuel injection quantity is achieved by varying the duration of an electric pulse applied to the injector. This way of control enables simple, yet highly precise metering of the fuel.

- The engine control module (ECM) that controls the fuel injection system corrects the fuel injection amount depending on the vehicle speed, throttle opening, coolant temperature and other vehicle-operation-related information. The ECM receives the information in the form of electric signals from the corresponding sensors and switches.

The MFI system also has the following features:

- Reduced exhaust emissions
- Reduced fuel consumption
- Increased engine output
- Quick response to accelerator and brake pedal operation
- Superior startability and warm-up performance in cold weather due to corrective controls made according to coolant and intake air temperatures

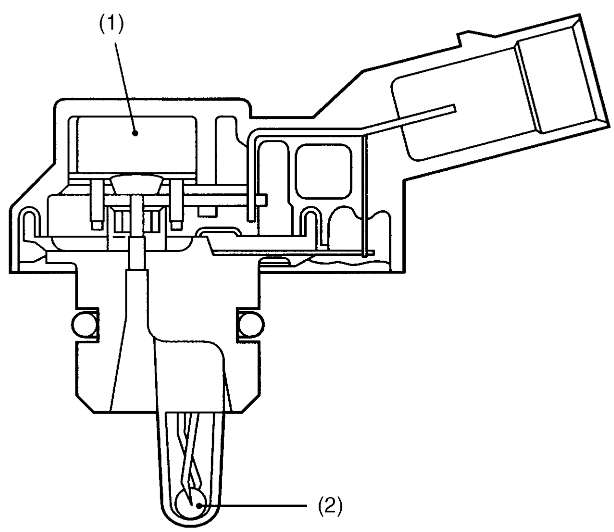
# 2. Air Line

## A: GENERAL

The air filtered by the air cleaner enters the throttle body where it is regulated in the volume by the throttle valve and then enters the intake manifold. It is then distributed to each cylinder where the air is mixed with fuel injected by the injector. During idling operation, air flows into the cylinder through the idle air control solenoid valve, bypassing the throttle valve. This enables controlling the engine idling speed properly.

## B: INTAKE MANIFOLD PRESSURE AND AIR TEMPERATURE SENSORS

The intake manifold pressure sensor and the intake air temperature sensor are integrated into a single unit. The unit is mounted on the intake manifold and measures the absolute air pressure in the intake manifold as well as the temperature of the intake air.
The measured pressure and temperature are converted into electrical signals and sent to the ECM. The ECM uses these signals to control injection and ignition timing as well as the fuel injection amount.

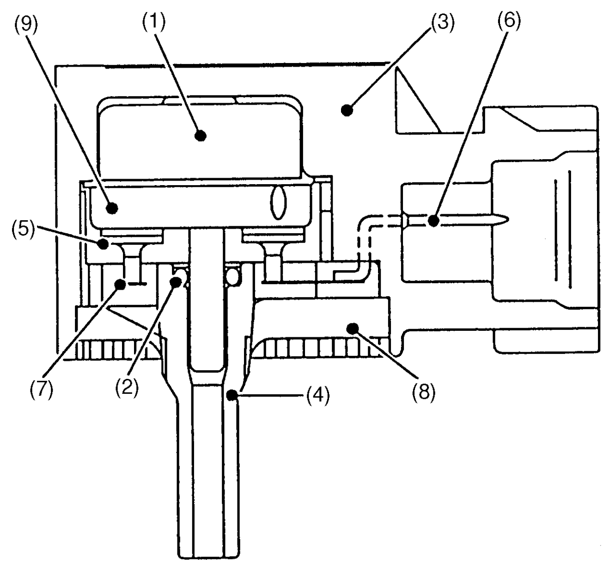



H2H2825B

(1) Pressure sensor
(2) Intake air temperature sensor

## C: ATMOSPHERIC PRESSURE SENSOR

The atmospheric pressure sensor converts pressure values into electric signals, and sends the signals to the ECM.




H2H1869B

(1) Sensor unit
(2) O-ring
(3) Case
(4) Pipe
(5) Through capacity
(6) Terminal
(7) Inner lead
(8) Resin
(9) Metal lid

## D: THROTTLE BODY

In response to operation of the accelerator pedal, the throttle valve in the throttle body opens/closes to regulate the volume of the air drawn into the combustion chamber.

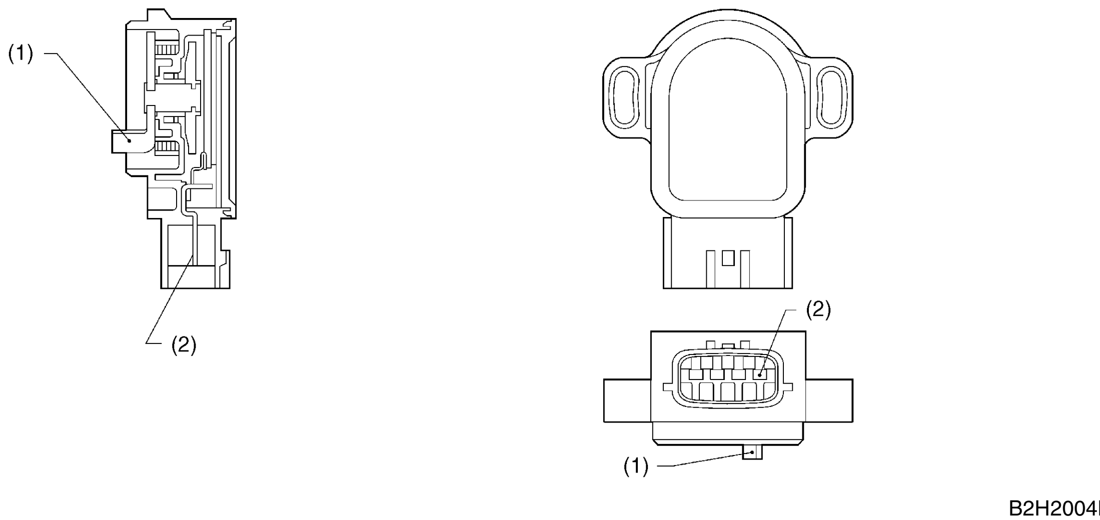
During idling, the throttle valve is almost fully closed and the volume of air passing through the throttle body is less than that passing through the idle air control solenoid valve.

More than half of the air necessary for idling is supplied to the intake manifold via the idle air control solenoid valve which controls properly the engine idling speed, so the idling speed needs not be adjusted.

## E: THROTTLE POSITION SENSOR

- The throttle position sensor is mounted in the throttle body and linked to the throttle valve.

- The throttle position sensor sends the ECM voltage signal corresponding to the opening of the throttle valve. When the sensor's output voltage exceeds a predetermined level, the ECM interprets it as complete closure of the throttle valve. When the output voltage is at another predetermined level, the ECM recognizes that the throttle valve is at a wide open position. Since the output characteristics of the sensor change over years, the ECM is provided with a learning function to be able to interpret signals into throttle valve angles always correctly.




(1) Lever
(2) Terminal

## F: IDLE AIR CONTROL SOLENOID VALVE

● The idle air control solenoid valve is located in the throttle body and regulates the amount of intake air that flows bypassing the throttle valve into the intake manifold during engine idling. It is activated by a signal from the ECM in order to maintain the engine idling speed at a target speed.

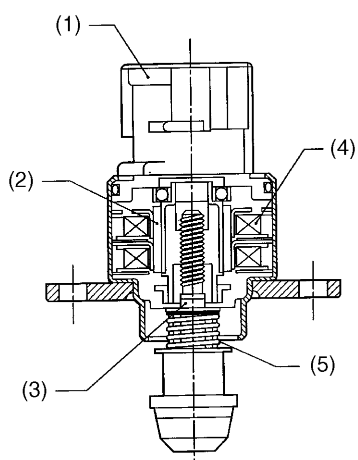
● The idle air control solenoid valve is a stepping motor type solenoid-actuated valve which consists of coils, a shaft, a permanent magnet, a spring and a housing. The housing is an integral part of the throttle body.

● The stepping motor consists of two paired coils, the coils of each pair being arranged face to face with a shaft in between.

● The shaft has a screw at the end around which the permanent magnets are arranged.

● As current flows in the form of pulses through the paired coils sequentially while alternating the polarity, the N and S poles of the permanent magnets around the shaft are repelled by the same poles of the magnetism generated by the coils. This causes a nut externally fixed to the magnets and internally engaging with the screw of the shaft to turn.
The shaft then goes upward or downward.

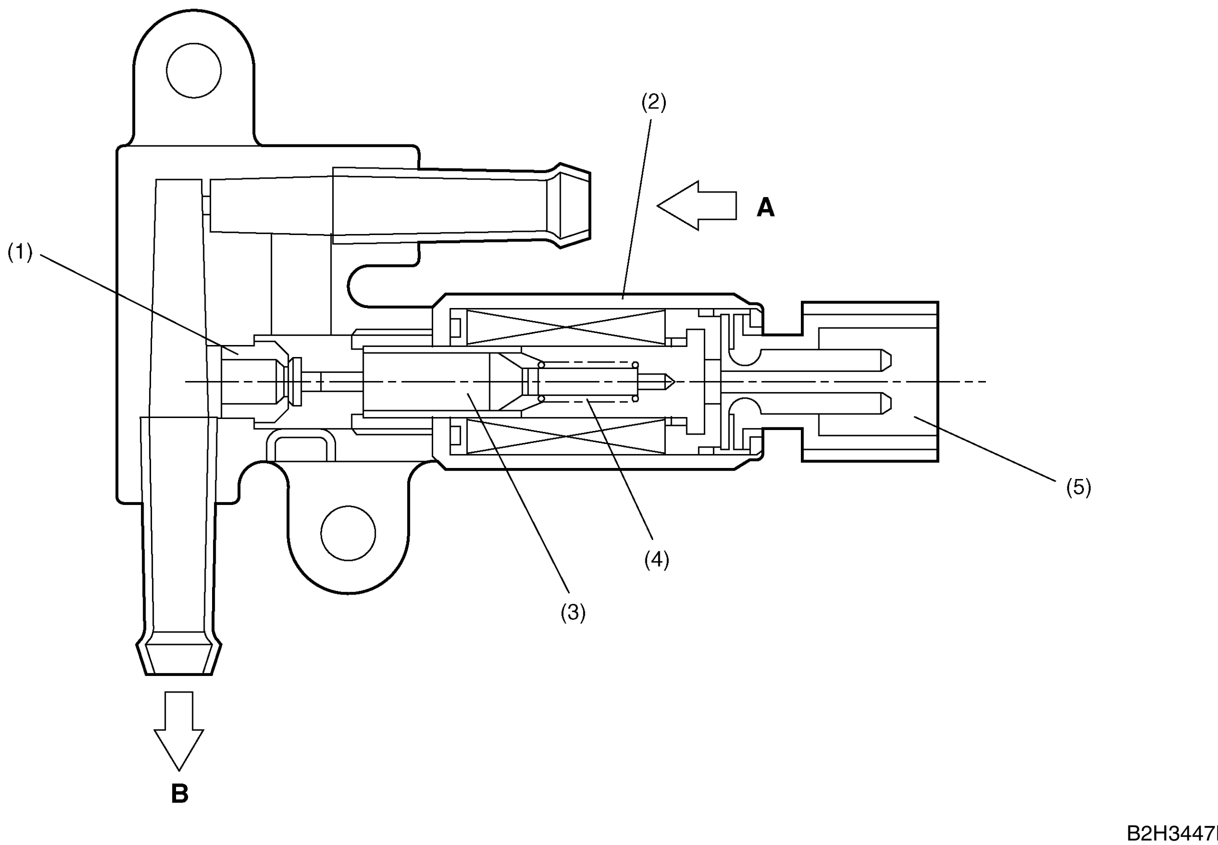
● This upward and downward motions of the shaft open or close the valve port, adjusting the amount of bypass air.




(1) Connector
(2) Permanent magnet
(3) Shaft
(4) Coil
(5) Spring

## G: AIR ASSIST INJECTOR SOLENOID VALVE

The air assist injector solenoid valve is located in the piping between the throttle body and the injector and secured to the intake manifold.
This solenoid valve is opened or closed by the signals from the ECM, adjusting the flow rate of air supplied to the injector.




(1) Valve seat
(2) Solenoid
(3) Plunger and valve
(4) Spring
(5) Connector

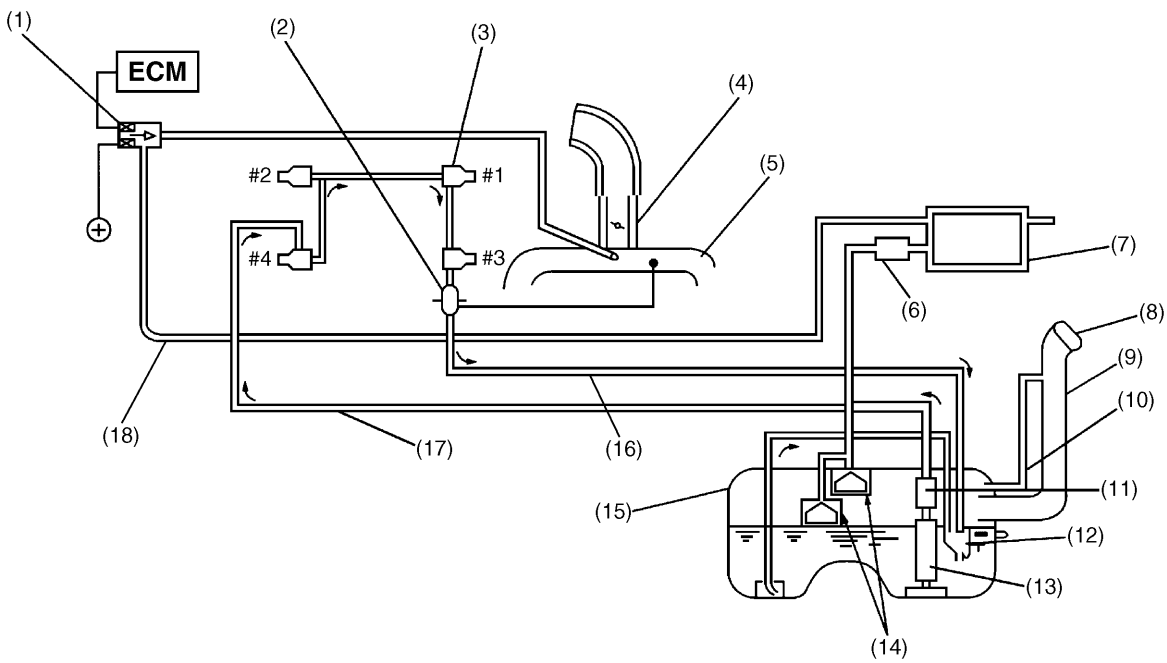
**A:** From idle air control solenoid valve
**B:** To injector

# 3. Fuel Line

## A: GENERAL

- The fuel pressurized by the fuel tank inside pump is delivered to each fuel injector by way of the fuel pipe and fuel filter. Fuel injection pressure is regulated to an optimum level by the pressure regulator.
- Each injector injects fuel into the intake port of the corresponding cylinder where the fuel is mixed with air. The mixture then enters the cylinder.

Fuel injection amount and timing are regulated by the ECM.

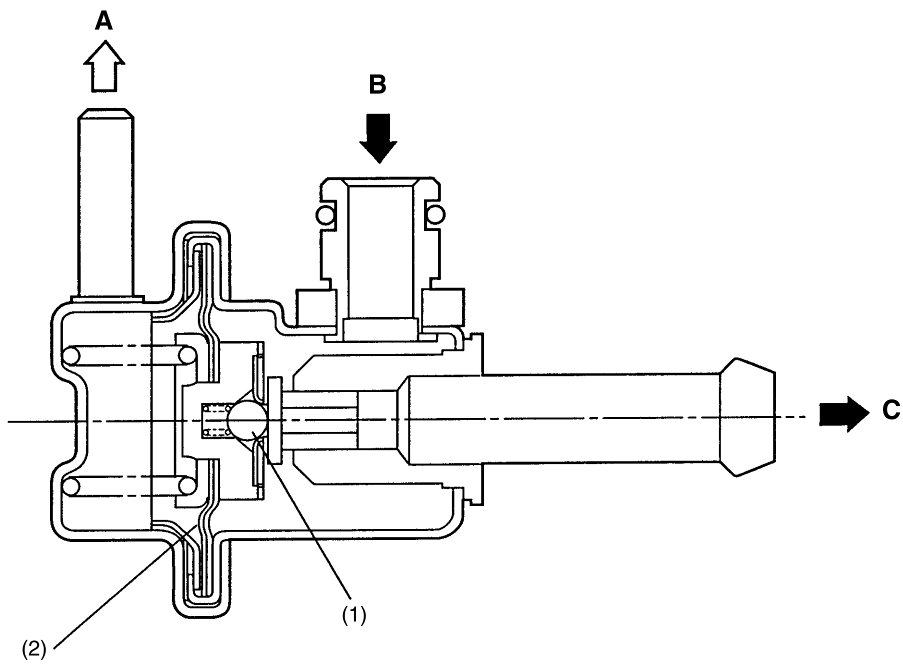



B2H2907B

| | | | |
|---|---|---|---|
| (1) | Purge control solenoid valve | (10) | Air vent pipe |
| (2) | Pressure regulator | (11) | Fuel filter |
| (3) | Fuel injector | (12) | Jet pump |
| (4) | Throttle body | (13) | Fuel pump |
| (5) | Intake manifold | (14) | Fuel cut valve |
| (6) | Two-way valve | (15) | Fuel tank |
| (7) | Canister | (16) | Fuel return line |
| (8) | Filler cap | (17) | Fuel delivery line |
| (9) | Filler pipe | (18) | Fuel evaporation line |

## B: PRESSURE REGULATOR

The pressure regulator is installed at the injector end of the fuel supply line. It has a fuel chamber and spring chamber separated by a diaphragm. Fuel chamber is connected to the fuel supply line and the spring chamber is connected to the intake manifold. Fuel chamber also has a relief valve connected to the fuel return line through which fuel returns to the fuel tank. When the intake manifold vacuum increases, the diaphragm is pulled and the relief valve opens to decrease the fuel supply line pressure (or fuel injection pressure). When the intake manifold vacuum decreases, the diaphragm is pushed by the spring to increase the fuel supply line pressure. Thus, the difference between the fuel injection pressure and the intake manifold vacuum is kept at a constant level of 294 kPa (3.00 kgf/cm$^2$, 43.0 psi) for MT vehicles or 299.1 kPa (3.05 kgf/cm$^2$, 43.4 psi) for AT vehicles to precisely control the amount of injected fuel.




S2H0623C

(1) Relief valve
(2) Diaphragm

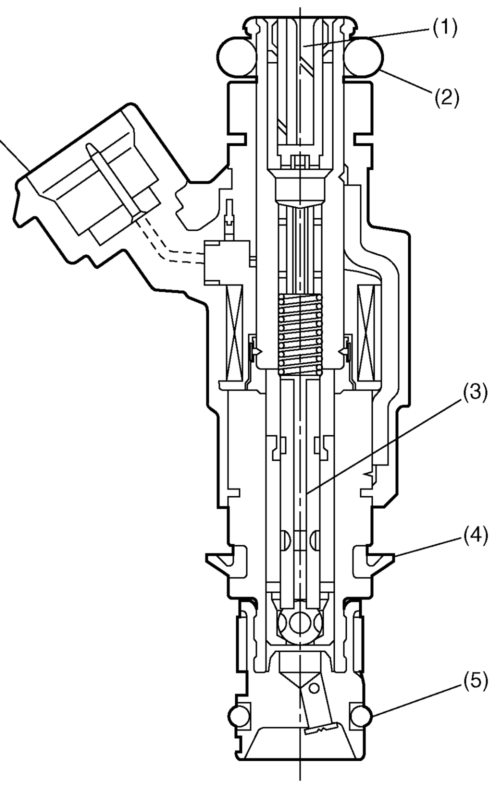
**A:** To intake manifold
**B:** Fuel IN
**C:** Fuel OUT

## C: FUEL INJECTORS

- The MFI system employs top feed type fuel injectors with an air assist feature.
- Each injector is installed in the fuel pipe in such a way that the injector is cooled by fuel.
- The features of this type of fuel injector are as follows:

1) High heat resistance
2) Low driving noise
3) Easy to service
4) Small size

- The injector injects fuel according to the valve open signal from the ECM. The needle valve is lifted by the solenoid which is energized on arrival of the valve open signal.
- Since the injector's nozzle hole area, the lift of valve and the fuel pressure are kept constant, the amount of fuel injected is controlled only by varying the duration of the valve open signal from the ECM.
- Fuel atomization is enhanced using assist air supplied from the idle air control solenoid valve passing through the passage formed in the intake manifold at the area in which each injector is installed. This contributes not only to higher combustion efficiency and higher output but also to cleaner exhaust emissions.

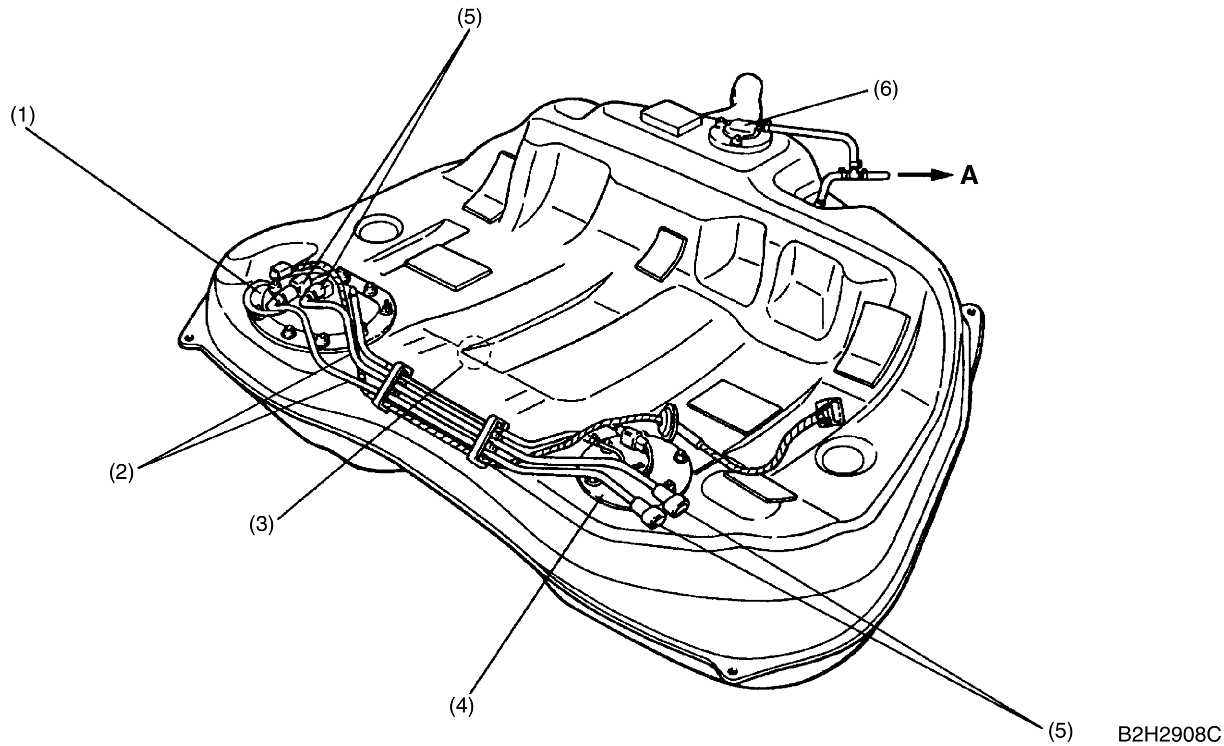



S2H1943A

| | | | |
|---|---|---|---|
| (1) | Filter | (4) | Seal |
| (2) | O-ring | (5) | O-ring |
| (3) | Plunger | (6) | Connector |

## D: FUEL TANK

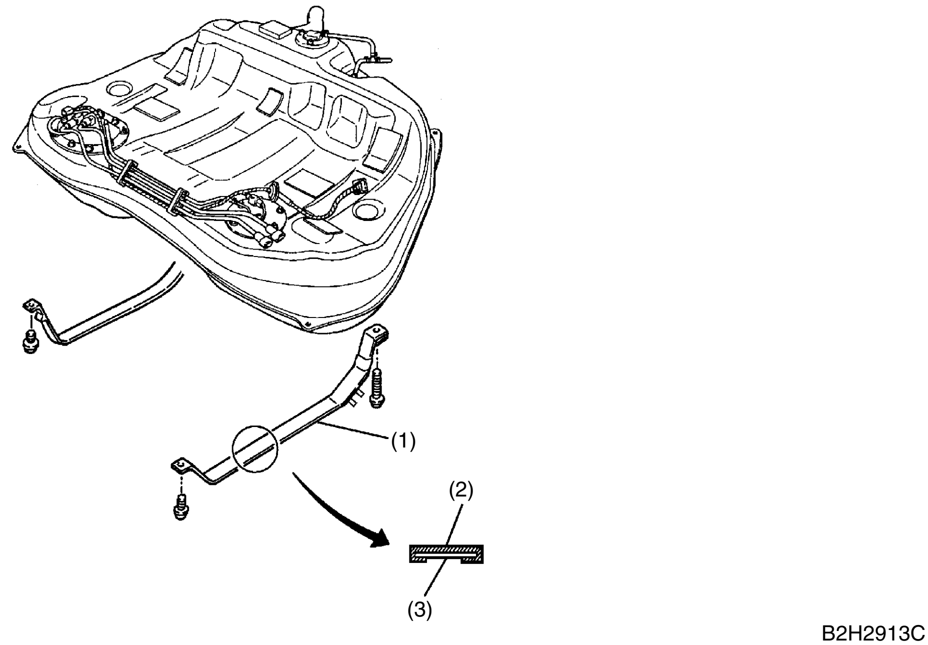
The fuel tank utilizes a two-compartment design to ensure sufficient capacity without interfering with the rear differential. It is provided with a suction jet pump (included in the fuel pump and fuel level sensor assembly) which transfers fuel from one compartment to the other. Each compartment has an individual fuel level sensor.




(1) Fuel pump and fuel level sensor assembly
(2) Nylon tube
(3) Fuel cut valve (Sub-compartment)
(4) Fuel level sensor (Sub-compartment)
(5) Quick connector
(6) Fuel cut valve (Main compartment)

**A:** To two way valve

The fuel tank is located under the rear seat and secured with hold-down bands.

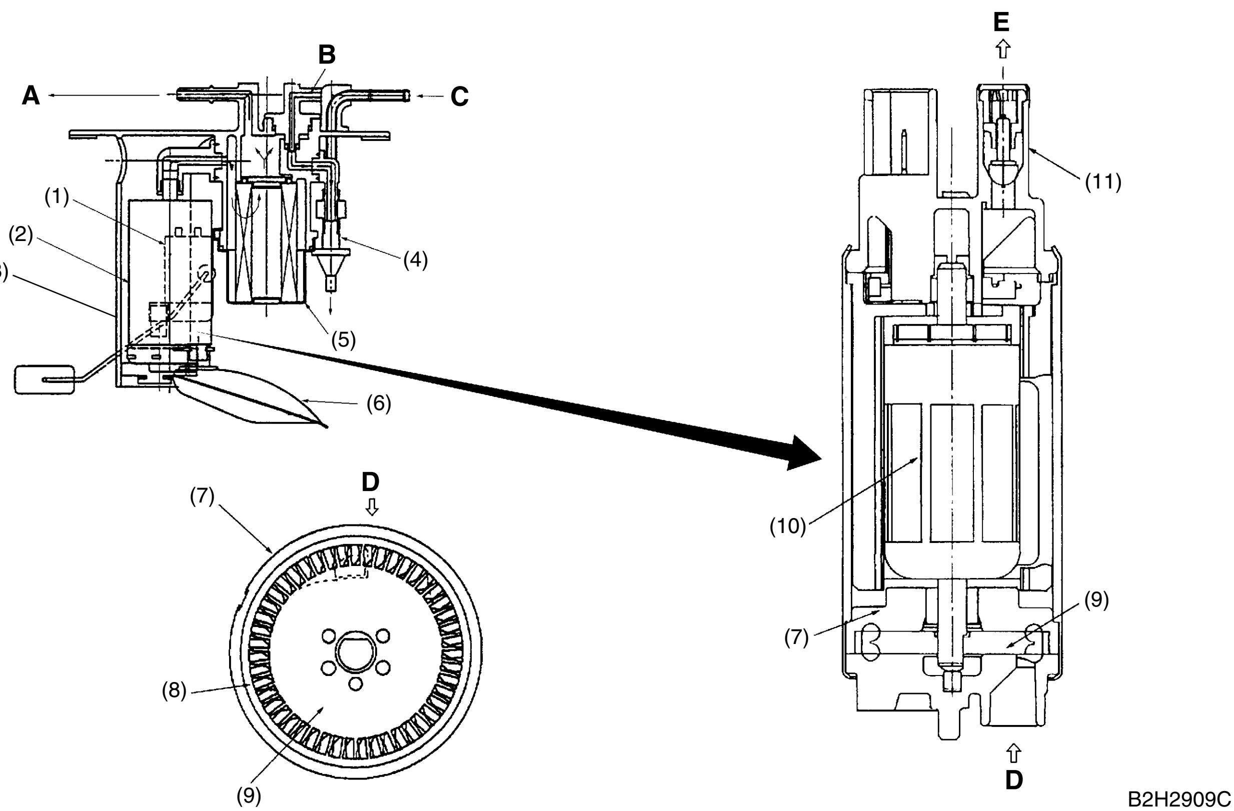



(1) Band
(2) Cushion
(3) Steel

## E: FUEL PUMP AND FUEL LEVEL SENSOR ASSEMBLY

### 1. FUEL PUMP

The fuel pump consists of a motor, impeller, pump casing, pump cover, check valve and filter. It is located in the fuel tank and combined with the fuel level sensor into a single unit. The operation of this impeller type pump is very quiet.

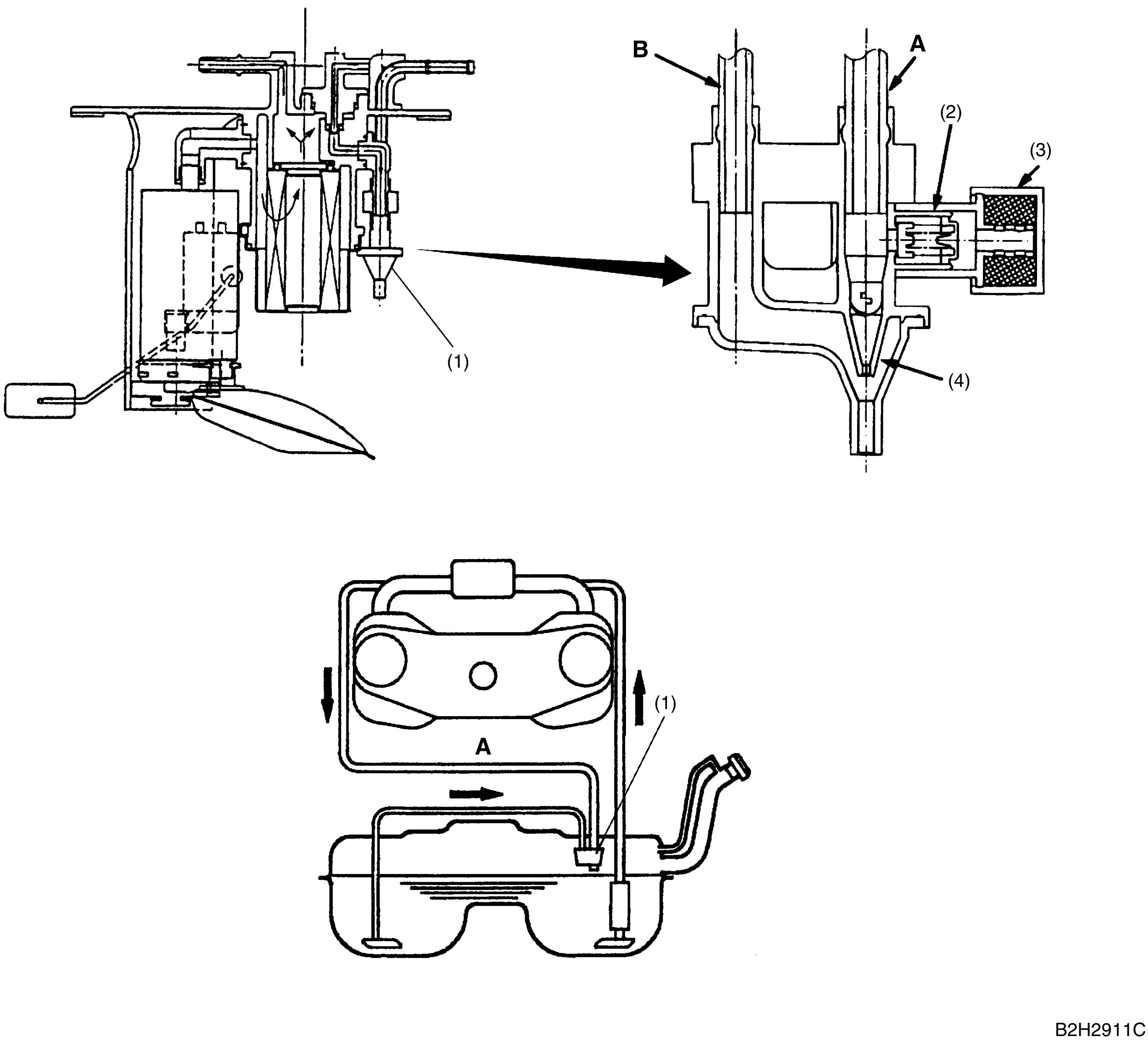



| | | |
|---|---|---|
| (1) Fuel level sensor | (7) Pump casing | **A:** To engine (delivery line) |
| (2) Fuel pump | (8) Fuel passage | **B:** From engine (return line) |
| (3) Pump cover | (9) Impeller | **C:** From sub tank |
| (4) Jet pump | (10) Motor armature | **D:** Suction |
| (5) Cartridge filter | (11) Check valve | **E:** Discharge |
| (6) Mesh filter | | |

- When the ignition switch is turned ON, fuel pump relay is activated. Then the motor operates to rotate the impeller.
- As the impeller rotates, fuel in a vane groove of the impeller flows along the fuel passage into the next vane groove by centrifugal force. When fuel flows from one groove to the next, a pressure difference occurs due to friction. This creates a pumping effect.
- The fuel pushed up by rotation of the impeller then passes through the clearance between the armature and the magnet of the motor and is discharged through the check valve.
- When the fuel discharge pressure reaches the specified level, the relief valve opens and excess fuel is released into the fuel tank. In this manner, the relief valve prevents an abnormal increase in fuel pressure.
- When the engine and the fuel pump stop, spring force acts on the check valve to close the discharge port, so that the fuel pressure in the fuel delivery line is retained.

## 2. JET PUMP

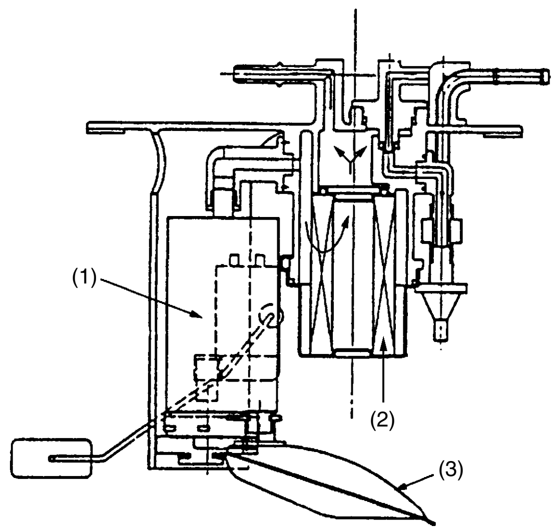
- The jet pump utilizes the velocity of fuel returning from the engine to produce negative pressure in it.
- Using the pumping effect produced by the negative pressure, the jet pump transfers fuel from the sub-compartment to the main compartment of the fuel tank.
- When the return line nozzle is clogged, the fuel sent back through the return line flows back into the fuel tank via the relief valve.




| | | | |
|---|---|---|---|
| (1) | Jet pump | **A:** | Return line |
| (2) | Relief valve | **B:** | From sub tank compartment |
| (3) | Silencer | | |
| (4) | Nozzle | | |

## 3. FUEL FILTERS

There are two different types of fuel filters inside fuel tank, forming integral part of the fuel pump. The filter at the inlet of the fuel pump is a mesh type which removes relatively large particles in the fuel before it enters the pump. The filter at the outlet of the pump is a pressure resistant cartridge type whose inside filtering element can remove small particles in the pressurized fuel.

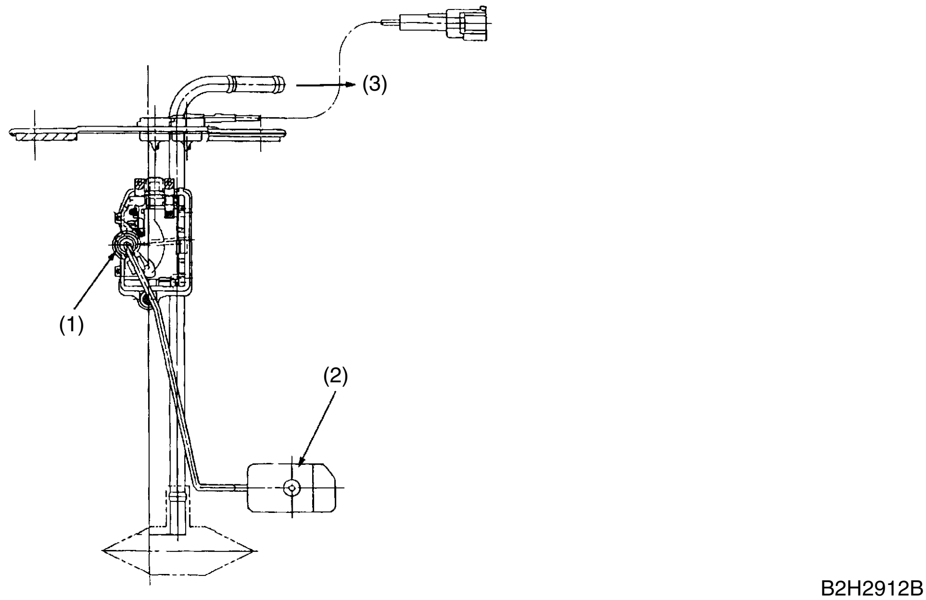



B2H2910D

(1) Fuel pump
(2) Cartridge filter
(3) Mesh filter

## F: SUB-COMPARTMENT FUEL LEVEL SENSOR

This sensor detects the level of the fuel in the sub-compartment (the compartment in which the fuel pump is not located) and acts as part of the fuel transfer line when the jet pump is in operation to maintain the fuel in both compartments at the same level.

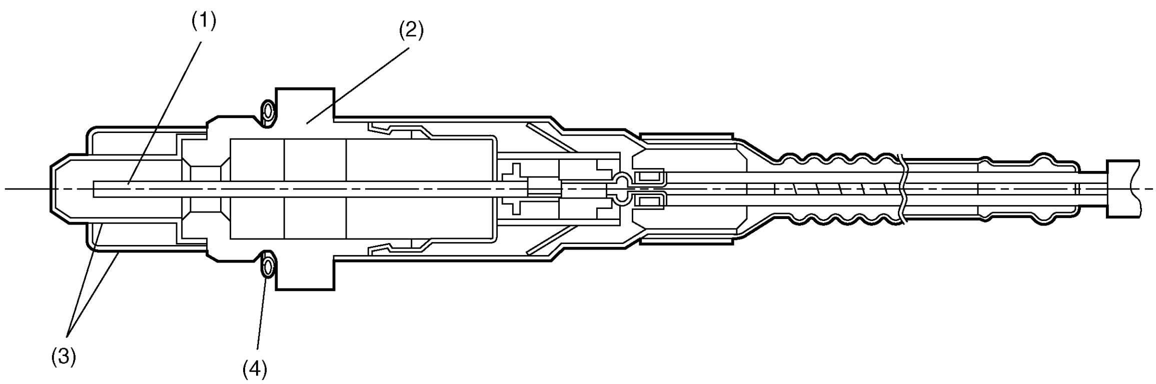



(1) Fuel level sensor (Sub)
(2) Float
(3) To jet pump

# 4. Sensors and Switches

## A: FRONT OXYGEN (A/F) SENSOR

- The front oxygen sensor uses zirconium oxide ($ZrO_2$) which is a solid electrolyte, at portions exposed to exhaust gas.
- The zirconium oxide has the property of generating electromotive force when its both sides are exposed to oxygen ions of different concentration and the magnitude of this electromotive force depends on how much the difference is.
- The front oxygen sensor detects the amount of oxygen in exhaust gases by making use of this property of the zirconium oxide material.
- The zirconium oxide material is formed into a closed end tube and its external surface is exposed to exhaust gases with smaller oxygen ion concentration, whereas its internal surface is exposed to atmospheric air. The external surface has a porous platinum coating. The sensor housing is grounded to the exhaust pipe and the inside is connected to the ECM through the harness to be able to use the current output from the sensor.
- The sensor incorporates a ceramic heater to improve its performance at low temperatures.



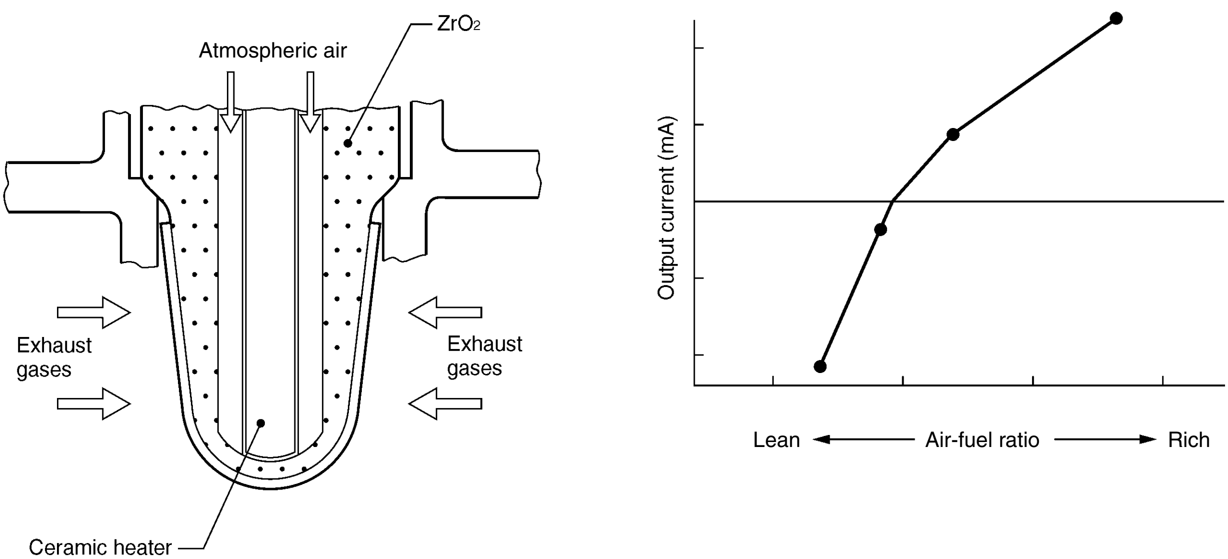

S2H1791B

(1) Sensor element
(2) Sensor housing
(3) Protection tube
(4) Gasket

● When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases is almost completely used in the catalytic reaction by the platinum coating on the external surface of the zirconia tube. This results in a very large difference in the oxygen ion concentration between the inside and outside of the tube, and the electromotive force generated is large.

● When a lean air-fuel mixture is burnt in the cylinder, relatively large amount of oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen ion concentration between the tube’s internal and external surfaces. The electromotive force in this case is very small.

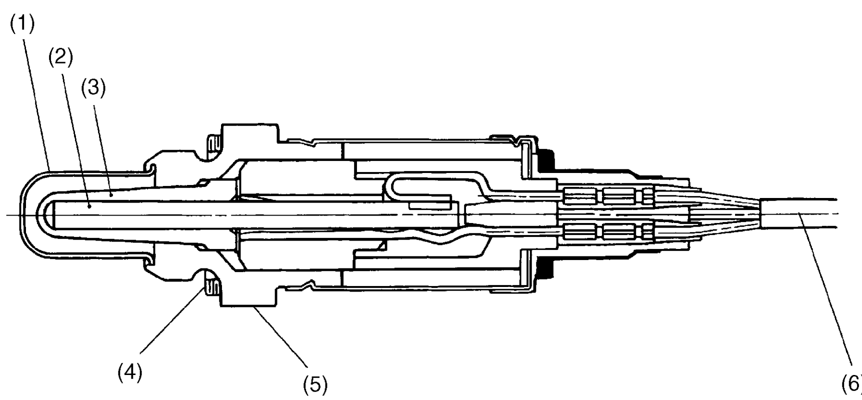
● The difference in oxygen concentration changes drastically in the vicinity of the stoichiometric air-fuel ratio, and hence the change in the electromotive force is also large. By using this information, the ECM can determine the air-fuel ratio of the supplied mixture easily. The front oxygen sensor does not generate much electromotive force when the temperature is low. The output characteristics of the sensor stabilize at a temperature of approximately 700°C (1,292°F).




B2H2006B

## B: REAR OXYGEN SENSOR

- The rear oxygen sensor is used to sense oxygen concentration in the exhaust gas. If the air-fuel ratio is leaner than the stoichiometric ratio in the mixture (i.e., excessive amount of air), the exhaust gas contains more oxygen. To the contrary, if the fuel ratio is richer than the stoichiometric ratio, the exhaust gas contains almost no oxygen.
- Detecting the oxygen concentration in exhaust gas using the oxygen sensor makes it possible to determine whether the air-fuel ratio is leaner or richer than the stoichiometry.
- The rear oxygen sensor has a zirconia tube (ceramic) which generates voltage if there is a difference in oxygen ion concentration between the inside and outside of the tube. Platinum is coated on the inside and outside of the zirconia tube as a catalysis and electrode material. The sensor housing is grounded to the exhaust pipe and the inside is connected to the ECM through the harness.
- A ceramic heater is employed to improve performance at low temperatures.



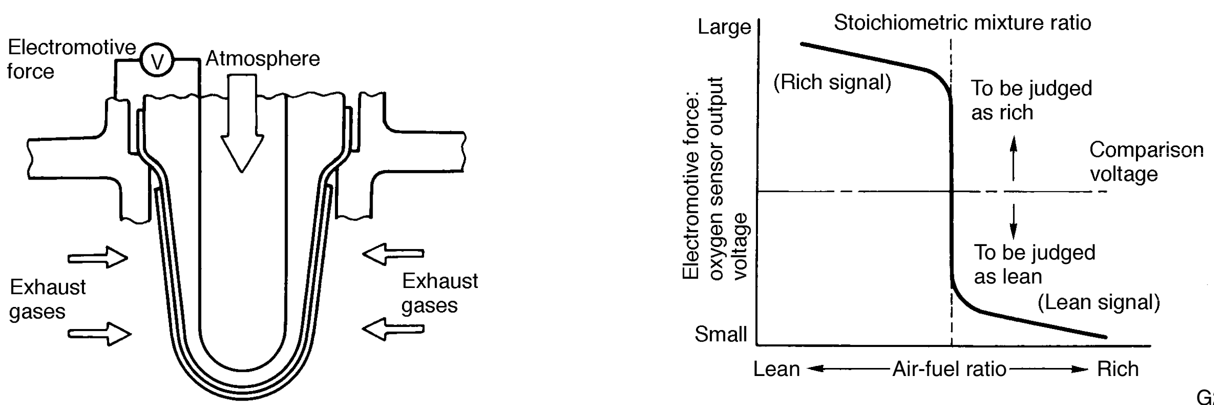

B2H3810C

| | | | |
|---|---|---|---|
| (1) | Protection tube | (4) | Gasket |
| (2) | Ceramic heater | (5) | Sensor housing |
| (3) | Zirconia tube | (6) | Harness |

● When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases is almost completely used in the catalytic reaction by the platinum coating on the external surface of the zirconia tube. This results in a very large difference in the oxygen ion concentration between the inside and outside of the tube, and the electromotive force generated is large.

● When a lean air-fuel mixture is burnt in the cylinder, relatively large amount of oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen ion concentration between the tube's internal and external surfaces. The electromotive force in this case is very small.

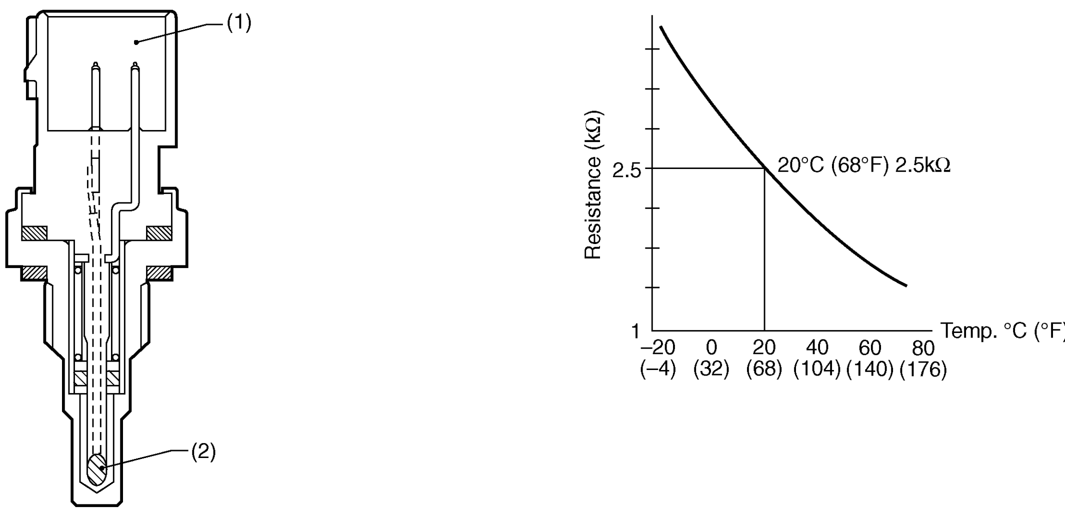
● The difference in oxygen concentration changes drastically in the vicinity of the stoichiometric air-fuel ratio, and hence the change in the electromotive force is also large. By using this information, the ECM can determine the air-fuel ratio of the supplied mixture easily. The rear oxygen sensor does not generate much electromotive force when the temperature is low. The output characteristics of the sensor stabilize at a temperature of approximately 300 to 400°C (572 to 752°F).




G2H0038B

## C: ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant temperature sensor is located on the engine coolant pipe. The sensor uses a thermistor whose resistance changes inversely with temperature. Resistance signals as engine coolant temperature information are transmitted to the ECM to make fuel injection, ignition timing, purge control solenoid valve and other controls.



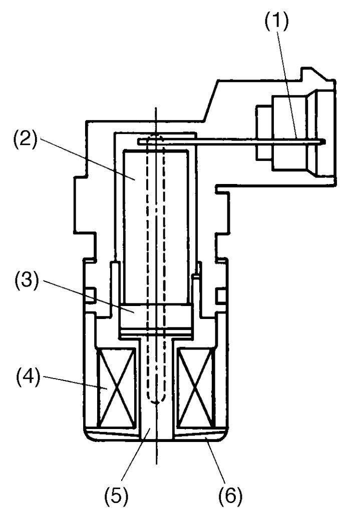

S2H1113B

(1) Connector
(2) Thermistor element

## D: CRANKSHAFT POSITION SENSOR

● The crankshaft position sensor is installed on the oil pump which is located in the front center portion of the cylinder block. The sensor generates a pulse when one of the teeth on the perimeter of the crankshaft sprocket (rotating together with the crankshaft) passes in front of it. The ECM determines the crankshaft angular position by counting the number of pulses.

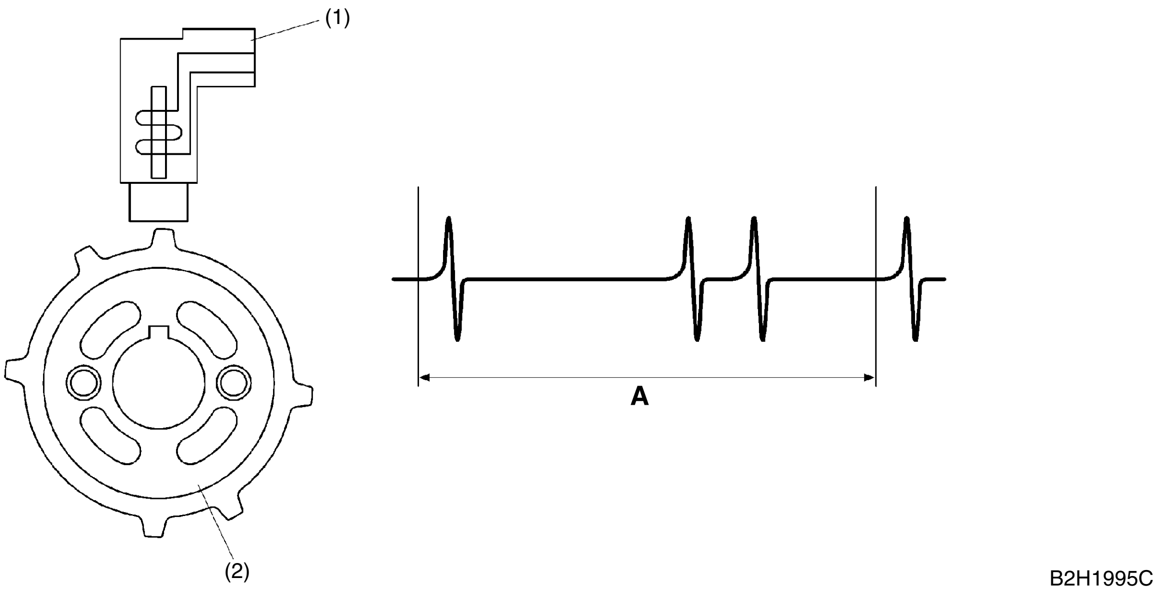
● The crankshaft position sensor is a molded type which consists of a magnet, core, coil, terminals and other components as illustrated below.




B2H0407B

| | |
|---|---|
| (1) Terminal | (4) Coil |
| (2) Yoke core | (5) Core |
| (3) Magnet | (6) Cover |

- As the crankshaft rotates, each tooth aligns with the crankshaft position sensor. At that time, the magnetic flux in the sensor's coil changes since the air gap between the sensor pickup and the sprocket changes. This change in magnetic flux induces a voltage pulse in the sensor and the pulse is transmitted to the ECM.



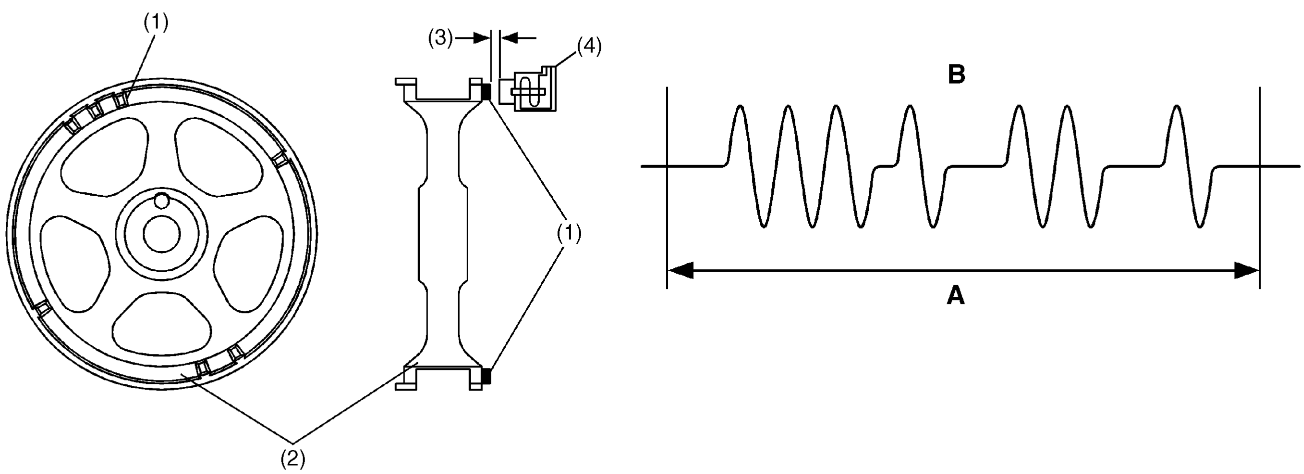

(1) Crankshaft position sensor
(2) Crankshaft sprocket

**A:** Crankshaft half rotation

## E: CAMSHAFT POSITION SENSOR

● The camshaft position sensor is located on the left-hand camshaft support. It detects the combustion cylinder at any given moment.

● The sensor generates a pulse when one of the bosses on the back of the left-hand camshaft drive sprocket passes in front of the sensor. The ECM determines the camshaft angular position by counting the number of pulses.
Internal construction and the basic operating principle of the camshaft position sensor are similar to those of the crankshaft position sensor. A total of seven bosses are arranged at equally spaced four locations (one each at two locations, two at one location, and three at one location) of the sprocket as shown below.



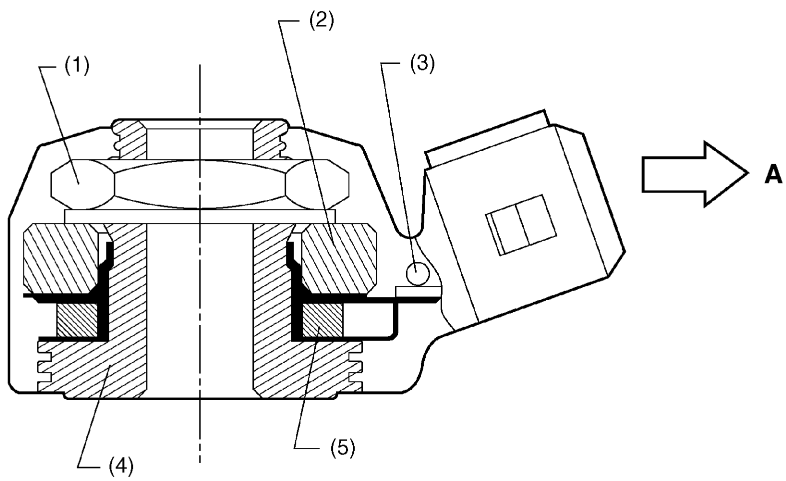

B2H3812C

(1) Boss
(2) Camshaft sprocket
(3) Air gap
(4) Camshaft position sensor

**A:** Camshaft one rotation (Crankshaft two rotations)
**B:** Cylinder identification signal

## F: KNOCK SENSOR

- The knock sensor is installed on the cylinder block, and senses knocking that occurs in the engine.
- The sensor is a piezo-electric type which converts vibration resulting from knocking into electric signals.
- In addition to a piezo-electric element, the sensor has a weight and case as its components. If knocking occurs in the engine, the weight in the case moves causing the piezo-electric element to generate a voltage.
- The knock sensor harness is connected to the bulkhead harness.




B2H1998B

(1) Nut
(2) Weight
(3) Resistor
(4) Housing
(5) Piezo-electric element

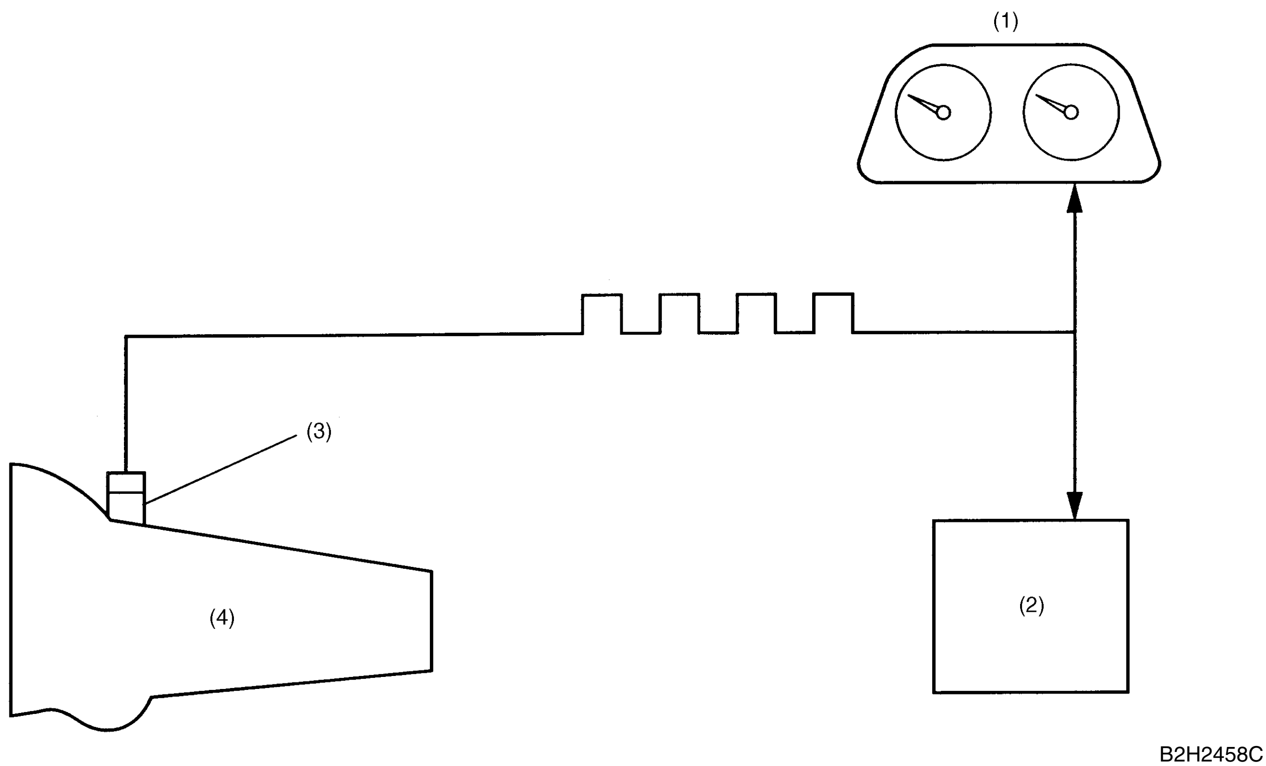
**A:** To knock sensor harness

## G: VEHICLE SPEED SENSOR

### 1. MT VEHICLES

● The vehicle speed sensor is mounted on the transmission.

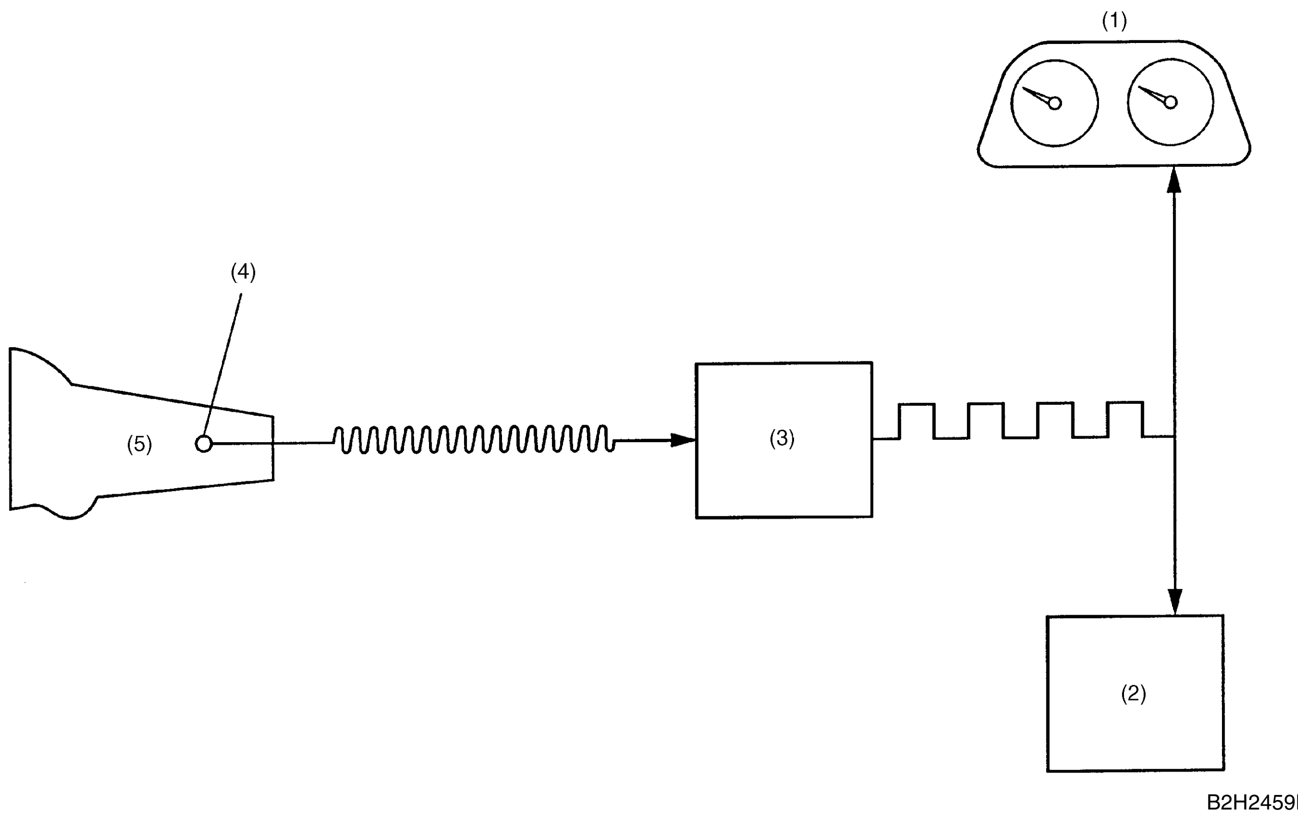
● The vehicle speed sensor generates a 4-pulse signal for every rotation of the front differential and send it to the ECM and the combination meter.




(1) Combination meter
(2) ECM
(3) Vehicle speed sensor
(4) Transmission

## 2. AT VEHICLES

- The vehicle speed sensor is mounted on the transmission.
- The vehicle speed sensor generates a 16-pulse signal for every rotation of the front differential and send it to the transmission control module (TCM). The signal sent to the TCM is converted there into a 4-pulse signal, and then sent to the ECM and the combination meter.




(1) Combination meter
(2) ECM
(3) TCM
(4) Vehicle speed sensor
(5) Transmission

# 5. Control System

## A: GENERAL

The ECM receives signals from various sensors, switches, and other control modules. Using these signals, it determines the engine operating conditions and if necessary, emits signals to one or more systems to control them for optimum operation.

Major control items of the ECM are as follow:

- Fuel injection control
- Ignition system control
- Idle air control
- Canister purge control*1
- Radiator fan control*2
- Fuel pump control
- On-board diagnosis function

*1: Canister purge control is described under “EC – Emission Control (Aux. Emission Control Devices) Evaporative Emission Control System”.

*2: Radiator fan control is described under “CO – Cooling”.

## B: INPUT AND OUTPUT SIGNALS

| Signal | Unit | Function |
|---|---|---|
| Input signals | Intake air temperature and pressure sensor | Detects the temperature of intake and amount of intake air (Measures the absolute pressure). |
| | Atmospheric pressure sensor | Detects the amount of intake air (Measure the atmospheric pressure). |
| | Throttle position sensor | Detects the throttle valve position. |
| | Front oxygen (A/F) sensor | Detects the density of oxygen in exhaust gases at the upstream of the front catalytic converter. |
| | Rear oxygen sensor | Detects the density of oxygen in exhaust gases at the downstream of the front catalytic converter. |
| | Crankshaft position sensor | Detects the crankshaft angular position. |
| | Camshaft position sensor | Detects the combustion cylinder. |
| | Engine coolant temperature sensor | Detects the engine coolant temperature. |
| | Knock sensor | Detects engine knocking. |
| | Vehicle speed sensor | Detects the vehicle speed. |
| | Ignition switch | Detects operation of the ignition switch. |
| | Starter switch | Detects the condition of engine cranking. |
| | Neutral position switch (MT) | Detects that the gear is in neutral. |
| | Park/Neutral position switch (AT) | Detects shift positions. |
| | Torque control signal (AT) | Controls engine torque. |
| | Heater circuit of front and rear oxygen sensor | Detects abnormality in the heater circuit of the front and rear oxygen sensors. |
| | Fuel level sensor | Detects the level of the fuel in the fuel tank. |
| | Diagnostics of AT-ECU | Detects the self-diagnostics of the AT-ECU. |
| | A/C switch | Detects ON-OFF operation of the A/C switch. |
| | Small light switch | Detects ON-OFF operation of the small light switch. |
| | Blower fan switch | Detects ON-OFF operation of the blower fan switch. |
| | Rear defogger switch | Detects ON-OFF operation of the rear defogger switch. |
| Output signals | Fuel Injector | Activates an injector. |
| | Ignition signal | Turns the primary ignition current ON or OFF. |
| | Fuel pump relay | Turns the fuel pump relay ON or OFF. |
| | A/C control relay | Turns the A/C control relay ON or OFF. |
| | Radiator fan control relay | Turns the radiator fan control relay ON or OFF. |
| | Idle air control solenoid valve | Adjusts the amount of air flowing through the bypass line in the throttle body. |
| | Malfunction indicator lamp | Indicates existence of abnormality. |
| | Purge control solenoid valve | Controls purge of evaporative gas absorbed by the canister. |
| | Power supply | Control ON/OFF of the main power supply relay. |

## C: FUEL INJECTION COTROL

● The ECM receives signals from various sensors and based on them, it determines the amount of fuel injected and the fuel injection timing. It performs the sequential fuel injection control over the entire engine operating range except during start-up of the engine.

● The amount of fuel injected depends upon the length of time the injector stays open. The fuel injection duration is determined according to varying operating condition of the engine. For the purpose of achieving highly responsive and accurate fuel injection duration control, the ECM performs a new feedback control that incorporates a learning feature as detailed later.

● The sequential fuel injection control is performed such that fuel is injected accurately at the time when the maximum air intake efficiency can be achieved for each cylinder (i.e., fuel injection is completed just before the intake valve begins to open).

### 1. FUEL INJECTION DURATION

Fuel injection duration is basically determined as indicated below:

● During engine start-up:
The duration defined below is used.

- ● Duration of fuel injection during engine start-up ..... Determined according to the engine coolant temperature detected by the engine coolant temperature sensor.

● During normal operation:
The duration is determined as follows:

Basic duration of fuel injection x Correction factors + Voltage correction time

- ● Basic duration of fuel injection ..... The basic length of time fuel is injected. This is determined by two factors – the amount of intake air detected by the manifold pressure sensor and the engine speed monitored by the crankshaft position sensor.
- ● Correction factors ..... See the next section.
- ● Voltage correction time ..... This is added to compensate for the time lag before operation of injector that results from variation in the battery voltage.

## 2. CORRECTION FACTORS

The following factors are used to correct the basic duration of fuel injection in order to make the air-fuel ratio meet the requirements of varying engine operating conditions:

- Air-fuel ratio feedback factor:

This factor is used to correct the basic duration of fuel injection in relation to the actual engine speed. (See the next section for more detail.)

- Start increment factor:

This factor is used to increase the fuel injection duration only while the engine is being cranked to improve its startability.

- Coolant-temperature-dependent increment factor:

This factor is used to increase the fuel injection duration depending on engine coolant temperature signals to facilitate cold starting. The lower the coolant temperature, the greater the increment.

- After-start increment factor:
  - This factor is used to increase the fuel injection duration for a certain period immediately after start of the engine to stabilize engine operation.
  - The increment depends on the coolant temperature at the start of the engine.

- Wide-open-throttle increment factor:

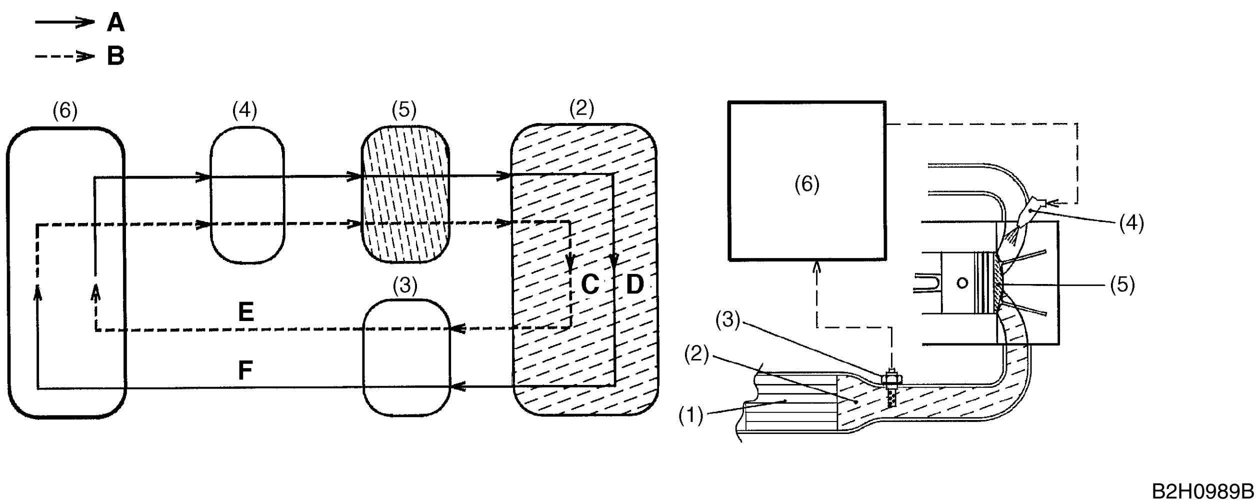
This factor is used to increase the fuel injection duration depending on the relationship between the throttle position sensor signal and manifold pressure sensor signal.

- Acceleration increment factor:

This factor is used to increase the fuel injection duration to compensate for a time lag between air flow measurement and fuel injection control for better engine response to driver's pedal operation during acceleration.

### 3. AIR-FUEL RATIO FEEDBACK FACTOR

The ECM creates this factor utilizing the front oxygen sensor signal. When the signal voltage is low, the air-fuel ratio is richer than the stoichiometric ratio. The ECM then makes the fuel injection duration shorter by modifying the factor. When the voltage is high showing that the mixture is lean, the ECM modifies the factor to make the injection duration longer. In this way, the air-fuel ratio is maintained at a level close to the stoichiometric ratio at which the three-way catalyst acts most effectively.




| | | | |
|---|---|---|---|
| (1) | Front catalyst | A: | Injection duration increment signal |
| (2) | Exhaust gas | B: | Injection duration decrement signal |
| (3) | Front oxygen (A/F) sensor | C: | High oxygen density |
| (4) | Fuel injector | D: | Low oxygen density |
| (5) | Combustion chamber | E: | Lean signal |
| (6) | ECM | F: | Rich signal |

### 4. LEARNING FEATURE

The air-fuel ratio feedback control includes a learning feature which contributes to more accurate and responsive control.

● In the air-fuel ratio feedback control, the ECM calculates the necessary amount of correction based on data from the oxygen sensor and adds the result to the basic duration (which is stored in the ECM's memory for each condition defined by the engine speed and various loads.)

● Without a learning feature, the ECM carries out the above-mentioned process every time. This means that if the amount of necessary correction is large, the air-fuel ratio feedback control becomes less responsive and less accurate.

● The learning feature enables the ECM to store the amount of correction into memory and add it to the basic fuel injection duration to create a new reference fuel injection duration. Using the reference duration as the basic duration for the injection a few times later, the ECM can reduce the amount of correction and thus make its feedback control more accurate and responsive to changes in the air-fuel ratio due to difference in driving condition and sensor/actuator characteristics that may result from unit-to-unit variation or aging over time.

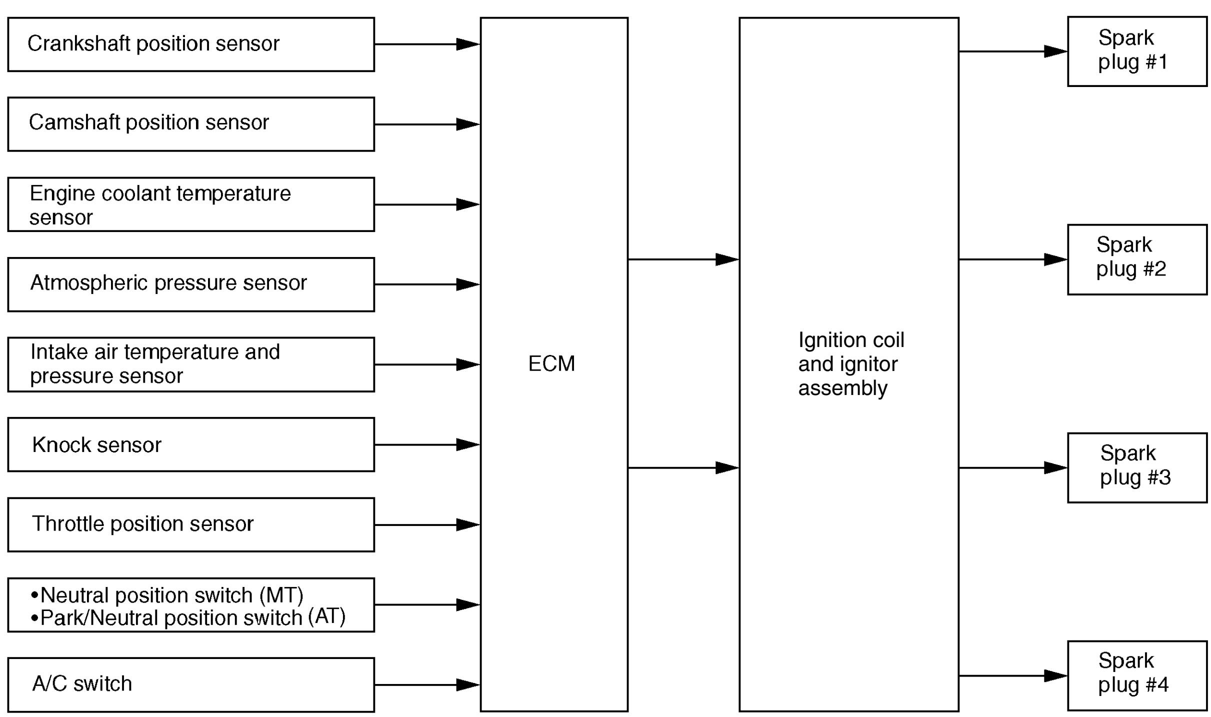
## D: IGNITION SYSTEM CONTROL

● The ECM determines operating condition of the engine based on signals from the pressure sensor, engine coolant temperature sensor, intake air temperature sensor, crankshaft position sensor and other sources. It then selects the ignition timing most appropriate for the condition thus determined from those stored in its memory and outputs at that timing a primary current OFF signal to the ignitor to initiate ignition.

● This control uses a quick-to-response learning feature by which the data stored in the ECM memory is processed in comparison with information from various sensors and switches.

● Thus, the ECM can always perform optimum ignition timing taking into account the output, fuel consumption, exhaust gas, and other factors for every engine operating condition.

● Ignition control during start-up
Engine speed fluctuates during start of the engine, so the ECM cannot control the ignition timing. During that period, the ignition timing is fixed at 10° BTDC by using the 10° signal from the crankshaft position sensor.

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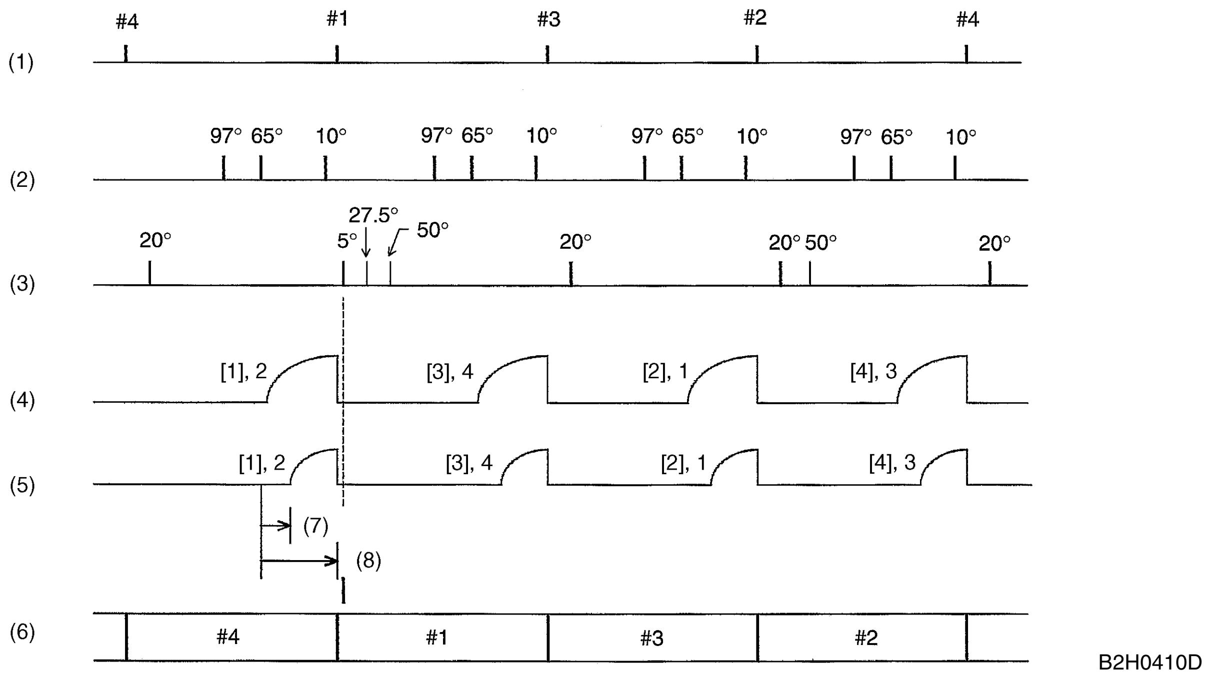
- Ignition control after start of engine

Between the 97° and 65° crank angle signal, the ECM measures the engine speed, and by using this data it decides the dwell set timing and ignition timing according to the engine condition.



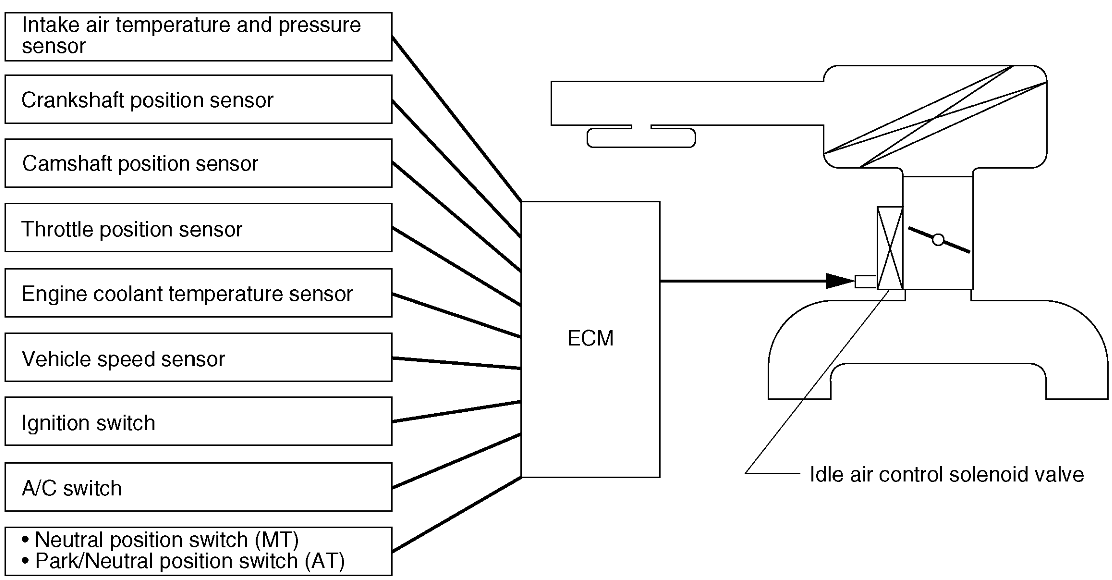

(1) Cylinder number
(2) Crank angle pulse (BTDC)
(3) Cam angle pulse (ATDC)
(4) Ignition timing at starting
(5) Ignition timing at normal condition
(6) Burning cylinder
(7) Dwell set
(8) Ignite

## E: IDLE AIR CONTROL

● The ECM activates the idle air control solenoid valve to control the bypass air flowing through the bypass passage in the throttle body depending on signals from the crankshaft position sensor, engine coolant temperature sensor, pressure sensor and A/C switch so that the proper idle speed for each engine load is achieved.

● The idle air control solenoid valve uses a duty-ratio-controlled solenoid which can continuously vary the opening area of the rotary valve. As the ECM increases the duty ratio, opening of the rotary valve increases so that the bypass air flow increases, and the engine idling speed becomes higher as a result.

● The bypass air control is necessary for:
  - Increasing idling speed when the air conditioning system and/or electrical loads are turned on.
  - Increasing idling speed during early stage of warm up period.
  - Obtaining dashpot function when the throttle valve is quickly closed.
  - Prevention of engine speed variation during idling.




B2H3450C

## F: FUEL PUMP CONTROL

Using the signal from the crankshaft position sensor, the ECM controls operation of the fuel pump by turning its relay ON or OFF. To improve safety, the fuel pump is stopped if the engine stalls with the ignition switch ON.

| Ignition switch ON | Fuel pump relay | Fuel pump |
|---|---|---|
| A certain period of time after ignition switch is turned ON | ON | Operates |
| While cranking the engine | ON | Operates |
| While engine is operating | ON | Operates |
| When engine stops | OFF | Does not operate |

# 6. On-board Diagnosis System

## A: GENERAL

● The on-board diagnosis system detects and indicates a fault by generating a code corresponding to each fault location. The malfunction indicator lamp (CHECK ENGINE light) on the combination meter indicates occurrence of a fault or abnormality.

● When the malfunction indicator lamp comes on as a result of detection of a fault by the ECM, the corresponding diagnostic trouble code (DTC) and freeze frame engine condition are stored in the ECM.

● On the OBD-II conformable car, it is necessary to connect the Subaru Select Monitor (SSM) or General Scan Tool (GST) to the data link connector in order to check the DTC.

● The SSM and GST can read and erase DTCs. They can also read freeze frame data in addition to other pieces of engine data.

● If there is a failure involving sensors which may affect drive control of the vehicle, the fail-safe function ensures minimum level of driveability.

## B: FAIL-SAFE FUNCTION

For a sensor or switch which has been judged faulty in the on-board diagnosis, the ECM, if appropriate, generates an associated pseudo signal to keep the vehicle operational. (The control becomes degraded.)

# FUEL INJECTION (FUEL SYSTEM)

# FU (w/o OBD)

Page

# 1. General

● The Multipoint Fuel Injection (MFI) system supplies optimum air-fuel mixture under every engine operating condition through the use of the latest electronic control technology.

This system pressurizes the fuel to a constant pressure and injects it into each intake air port in the cylinder head. The injection quantity of fuel is controlled by an intermittent injection system where an electro-magnetic injection valve or injector opens for a short period that is precisely controlled depending on the quantity of air appropriate for each condition of operation. In actual control, an optimum fuel injection quantity is achieved by varying the duration of an electric pulse applied to the injector. This way of control enables simple, yet highly precise metering of the fuel.

● The engine control module (ECM) that controls the fuel injection system corrects the fuel injection amount depending on the vehicle speed, throttle opening, coolant temperature and other vehicle-operation-related information. The ECM receives the information in the form of electric signals from the corresponding sensors and switches.

The MFI system also has the following features:

● Reduced exhaust emissions

● Reduced fuel consumption

● Increased engine output

● Quick response to accelerator and brake pedal operation

● Superior startability and warm-up performance in cold weather due to corrective controls made according to coolant and intake air temperatures

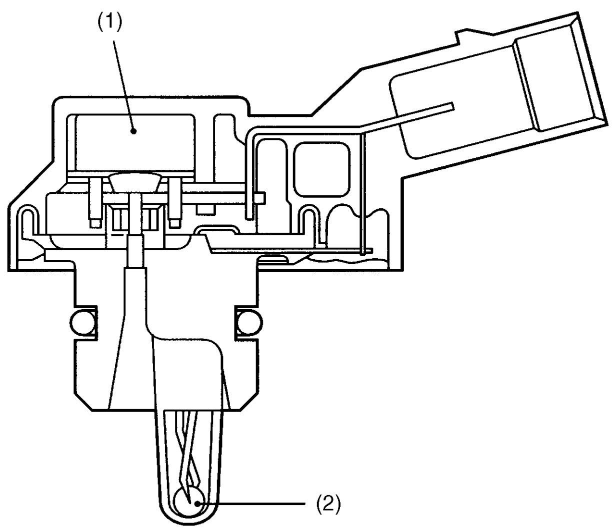
# 2. Air Line

## A: GENERAL

The air filtered by the air cleaner enters the throttle body where it is regulated in the volume by the throttle valve and then enters the intake manifold. It is then distributed to each cylinder where the air is mixed with fuel injected by the injector. During idling operation, air flows into the cylinder through the idle air control solenoid valve, bypassing the throttle valve. This enables controlling the engine idling speed properly.

## B: INTAKE MANIFOLD PRESSURE AND AIR TEMPERATURE SENSORS

The intake manifold pressure sensor and the intake air temperature sensor are integrated into a single unit. The unit is mounted on the intake manifold and measures the absolute air pressure in the intake manifold as well as the temperature of the intake air.
The measured pressure and temperature are converted into electrical signals and sent to the ECM. The ECM uses these signals to control injection and ignition timing as well as the fuel injection amount.




(1) Pressure sensor
(2) Intake air temperature sensor

## C: THROTTLE BODY

In response to operation of the accelerator pedal, the throttle valve in the throttle body opens/closes to regulate the volume of the air drawn into the combustion chamber.

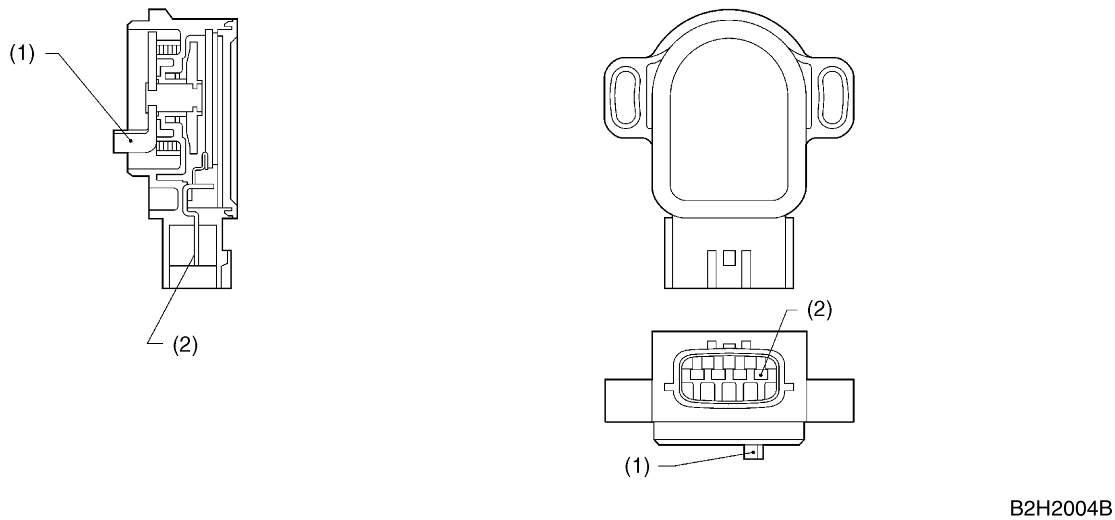
During idling, the throttle valve is almost fully closed and the volume of air passing through the throttle body is less than that passing through the idle air control solenoid valve.

More than half of the air necessary for idling is supplied to the intake manifold via the idle air control solenoid valve which controls properly the engine idling speed, so the idling speed needs not be adjusted.

## D: THROTTLE POSITION SENSOR

- The throttle position sensor is mounted in the throttle body and linked to the throttle valve.

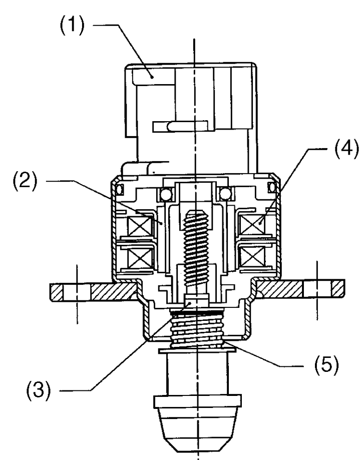
- The throttle position sensor sends the ECM voltage signal corresponding to the opening of the throttle valve. When the sensor's output voltage exceeds a predetermined level, the ECM interprets it as complete closure of the throttle valve. When the output voltage is at another predetermined level, the ECM recognizes that the throttle valve is at a wide open position. Since the output characteristics of the sensor change over years, the ECM is provided with a learning function to be able to interpret signals into throttle valve angles always correctly.




(1) Lever
(2) Terminal

## E: IDLE AIR CONTROL SOLENOID VALVE

- The idle air control solenoid valve is located in the throttle body and regulates the amount of intake air that flows bypassing the throttle valve into the intake manifold during engine idling. It is activated by a signal from the ECM in order to maintain the engine idling speed at a target speed.
- The idle air control solenoid valve is a stepping motor type solenoid-actuated valve which consists of coils, a shaft, a permanent magnet, a spring and a housing. The housing is an integral part of the throttle body.
- The stepping motor consists of two paired coils, the coils of each pair being arranged face to face with a shaft in between.
- The shaft has a screw at the end around which the permanent magnets are arranged.
- As current flows in the form of pulses through the paired coils sequentially while alternating the polarity, the N and S poles of the permanent magnets around the shaft are repelled by the same poles of the magnetism generated by the coils. This causes a nut externally fixed to the magnets and internally engaging with the screw of the shaft to turn.
The shaft then goes upward or downward.
- This upward and downward motions of the shaft open or close the valve port, adjusting the amount of bypass air.




B2H2005B

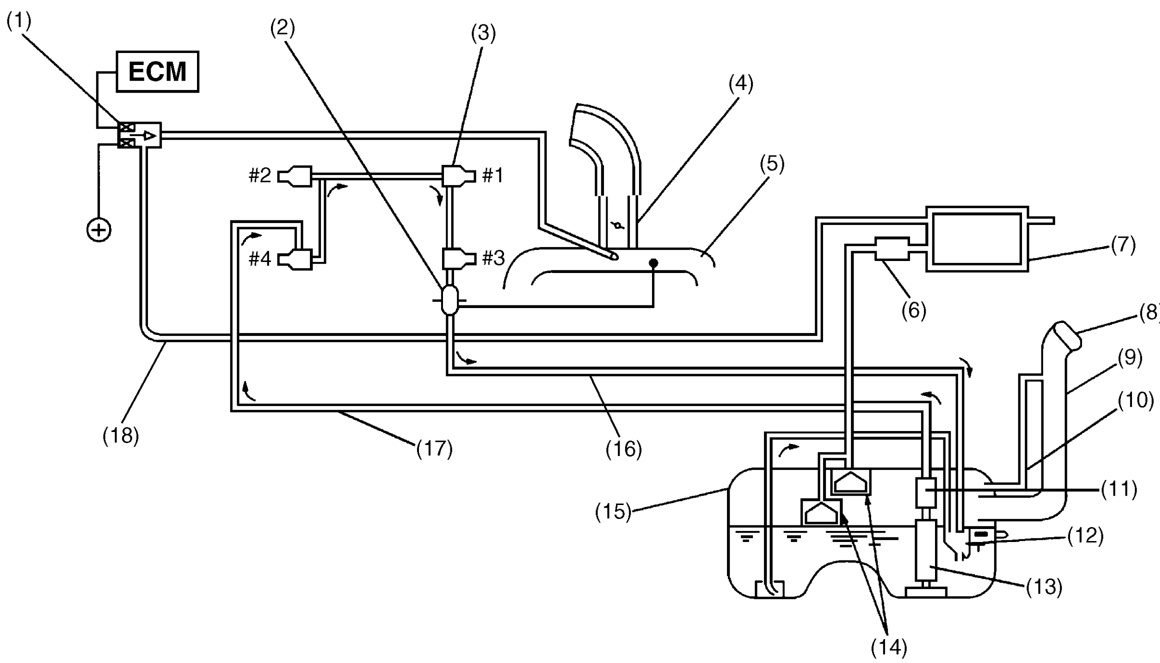
(1) Connector
(2) Permanent magnet
(3) Shaft
(4) Coil
(5) Spring

# 3. Fuel Line

## A: GENERAL

- The fuel pressurized by the fuel tank inside pump is delivered to each fuel injector by way of the fuel pipe and fuel filter. Fuel injection pressure is regulated to an optimum level by the pressure regulator.
- Each injector injects fuel into the intake port of the corresponding cylinder where the fuel is mixed with air. The mixture then enters the cylinder.

Fuel injection amount and timing are regulated by the ECM.

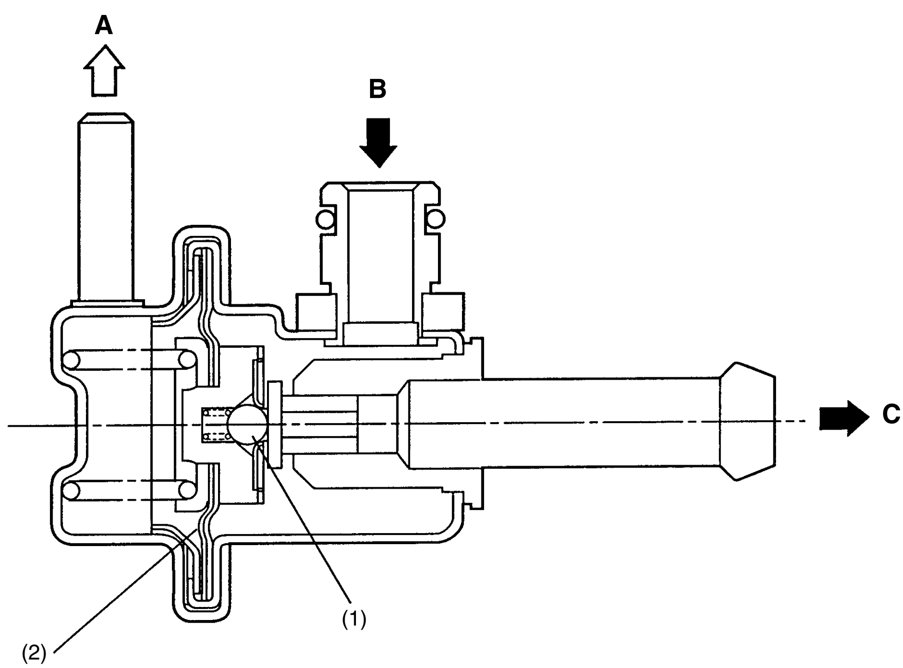



B2H2907B

| | |
|---|---|
| (1) Purge control solenoid valve | (10) Air vent pipe |
| (2) Pressure regulator | (11) Fuel filter |
| (3) Fuel injector | (12) Jet pump |
| (4) Throttle body | (13) Fuel pump |
| (5) Intake manifold | (14) Fuel cut valve |
| (6) Two-way valve | (15) Fuel tank |
| (7) Canister | (16) Fuel return line |
| (8) Filler cap | (17) Fuel delivery line |
| (9) Filler pipe | (18) Fuel evaporation line |

## B: PRESSURE REGULATOR

The pressure regulator is installed at the injector end of the fuel supply line. It has a fuel chamber and spring chamber separated by a diaphragm. Fuel chamber is connected to the fuel supply line and the spring chamber is connected to the intake manifold. Fuel chamber also has a relief valve connected to the fuel return line through which fuel returns to the fuel tank. When the intake manifold vacuum increases, the diaphragm is pulled and the relief valve opens to decrease the fuel supply line pressure (or fuel injection pressure). When the intake manifold vacuum decreases, the diaphragm is pushed by the spring to increase the fuel supply line pressure. Thus, the difference between the fuel injection pressure and the intake manifold vacuum is kept at a constant level of 294 kPa (3.00 kgf/cm$^2$, 43.0 psi) for MT vehicles or 299.1 kPa (3.05 kgf/cm$^2$, 43.4 psi) for AT vehicles to precisely control the amount of injected fuel.




(1) Relief valve
(2) Diaphragm

**A:** To intake manifold
**B:** Fuel IN
**C:** Fuel OUT

## C: FUEL INJECTORS

● The MFI system employs top feed type fuel injectors with an air assist feature.

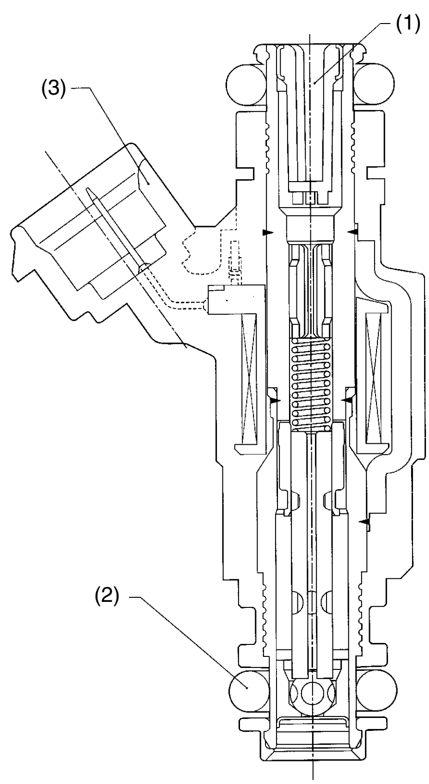
● Each injector is installed in the fuel pipe in such a way that the injector is cooled by fuel.

● The features of this type of fuel injector are as follows:

1) High heat resistance
2) Low driving noise
3) Easy to service
4) Small size

● The injector injects fuel according to the valve open signal from the ECM. The needle valve is lifted by the solenoid which is energized on arrival of the valve open signal.

● Since the injector's nozzle hole area, the lift of valve and the fuel pressure are kept constant, the amount of fuel injected is controlled only by varying the duration of the valve open signal from the ECM.

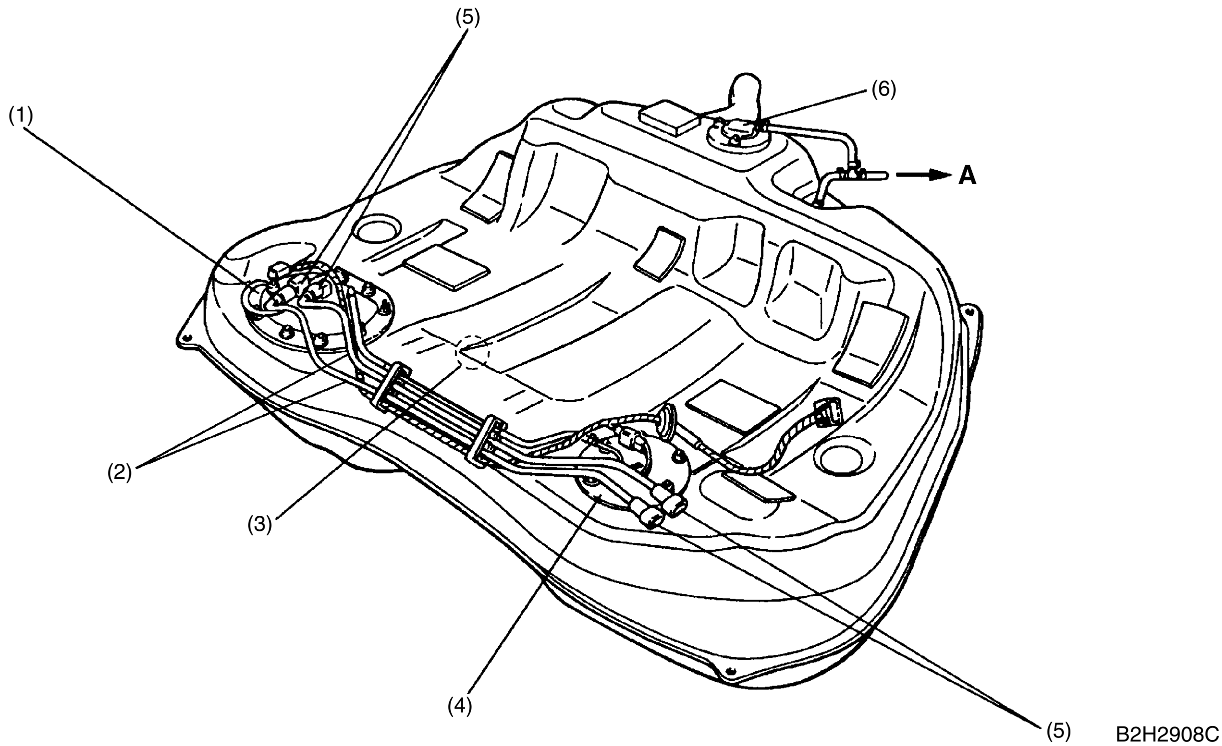



B2H1991B

(1) Filter
(2) O-ring
(3) Connector

## D: FUEL TANK

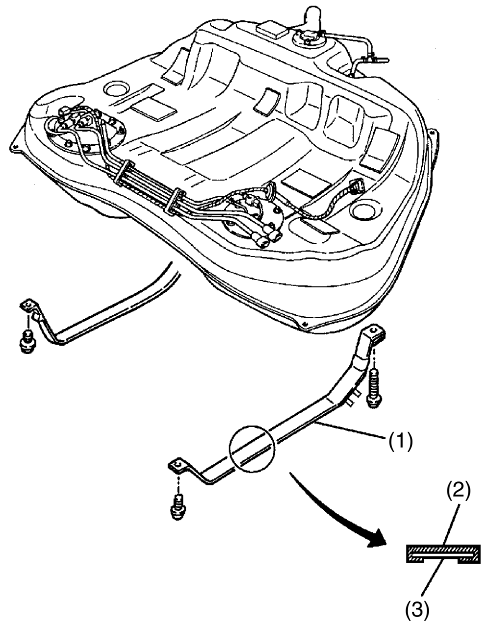
The fuel tank utilizes a two-compartment design to ensure sufficient capacity without interfering with the rear differential. It is provided with a suction jet pump (included in the fuel pump and fuel level sensor assembly) which transfers fuel from one compartment to the other. Each compartment has an individual fuel level sensor.




(1) Fuel pump and fuel level sensor assembly
(2) Nylon tube
(3) Fuel cut valve (Sub-compartment)
(4) Fuel level sensor (Sub-compartment)
(5) Quick connector
(6) Fuel cut valve (Main compartment)

**A:** To two way valve

The fuel tank is located under the rear seat and secured with hold-down bands.



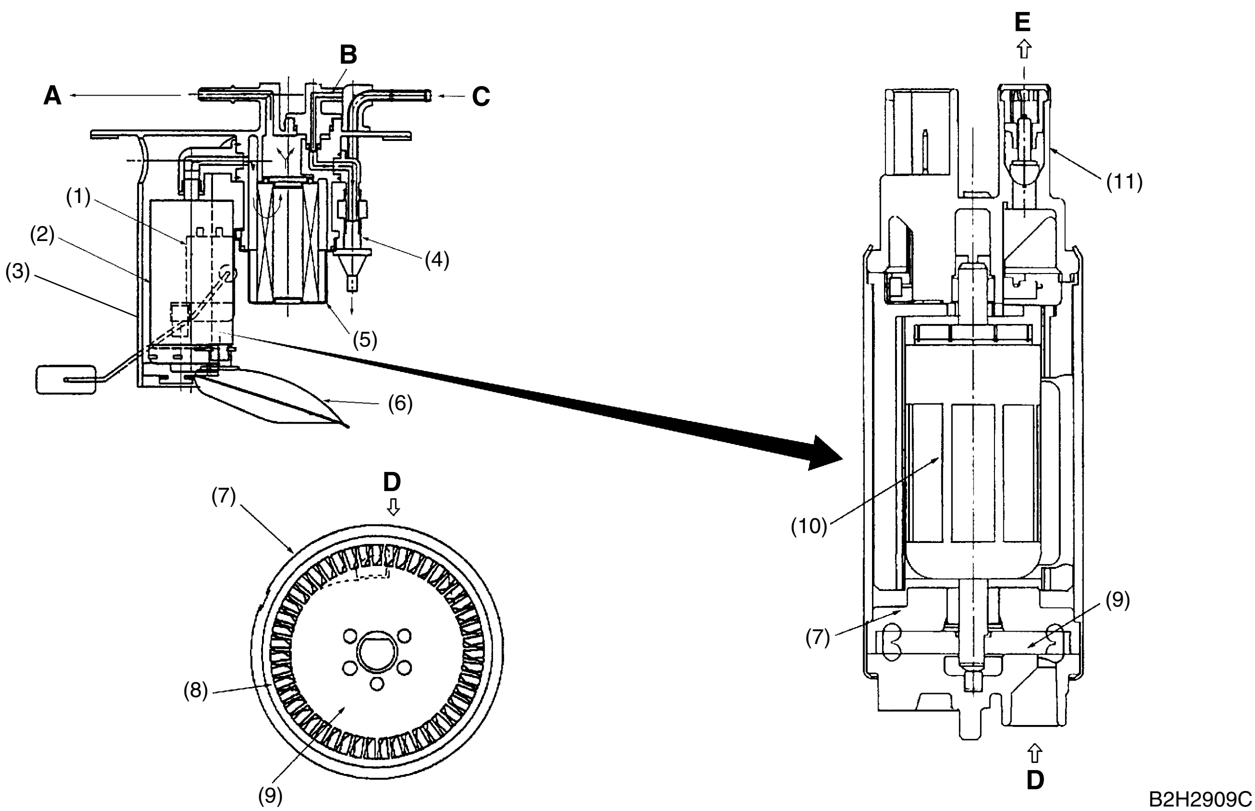

B2H2913C

(1) Band
(2) Cushion
(3) Steel

## E: FUEL PUMP AND FUEL LEVEL SENSOR ASSEMBLY

### 1. FUEL PUMP

The fuel pump consists of a motor, impeller, pump casing, pump cover, check valve and filter. It is located in the fuel tank and combined with the fuel level sensor into a single unit. The operation of this impeller type pump is very quiet.

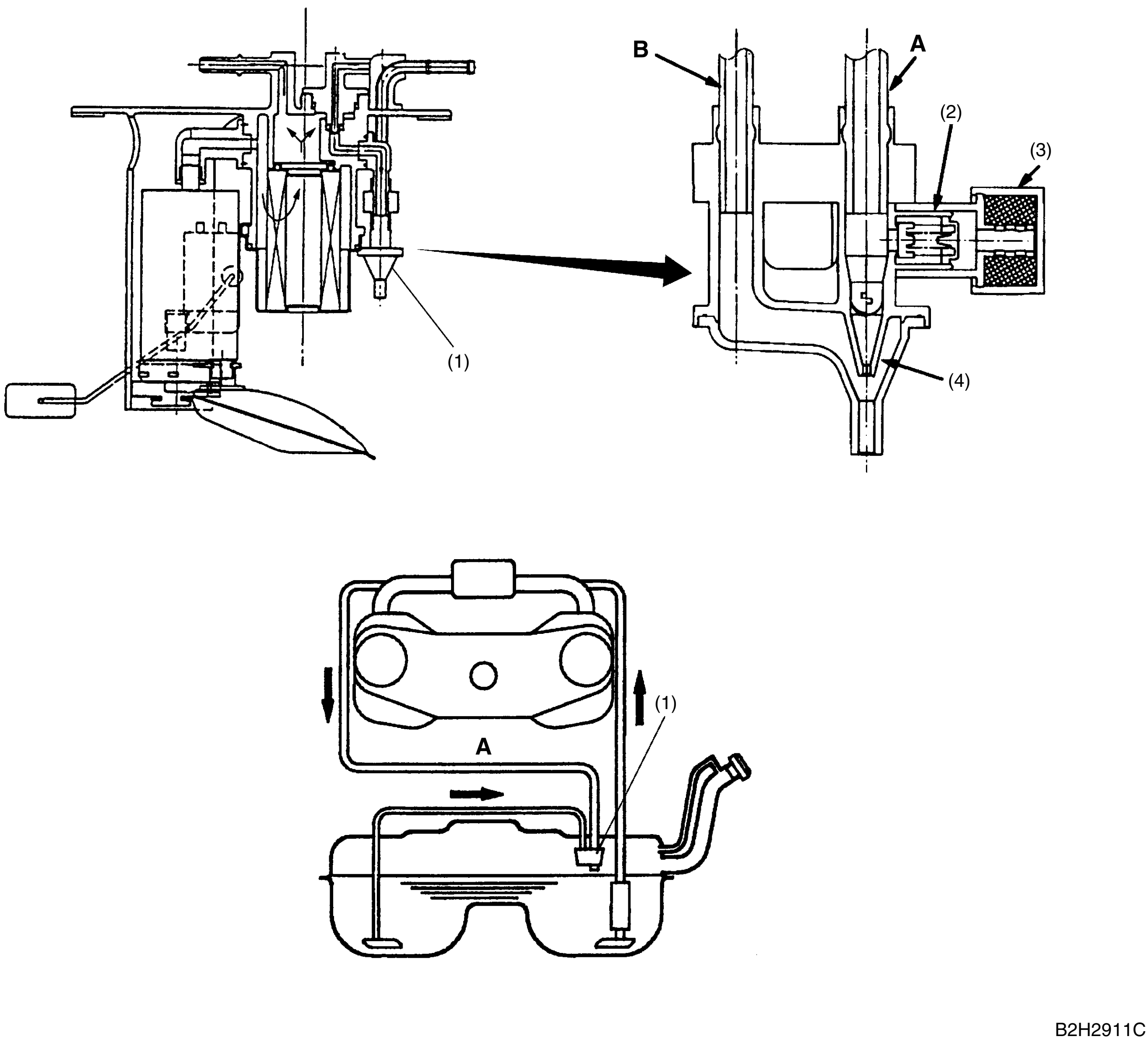



| | | | | | |
|---|---|---|---|---|---|
| (1) | Fuel level sensor | (7) | Pump casing | **A:** | To engine (delivery line) |
| (2) | Fuel pump | (8) | Fuel passage | **B:** | From engine (return line) |
| (3) | Pump cover | (9) | Impeller | **C:** | From sub tank |
| (4) | Jet pump | (10) | Motor armature | **D:** | Suction |
| (5) | Cartridge filter | (11) | Check valve | **E:** | Discharge |
| (6) | Mesh filter | | | | |

- When the ignition switch is turned ON, fuel pump relay is activated. Then the motor operates to rotate the impeller.
- As the impeller rotates, fuel in a vane groove of the impeller flows along the fuel passage into the next vane groove by centrifugal force. When fuel flows from one groove to the next, a pressure difference occurs due to friction. This creates a pumping effect.
- The fuel pushed up by rotation of the impeller then passes through the clearance between the armature and the magnet of the motor and is discharged through the check valve.
- When the fuel discharge pressure reaches the specified level, the relief valve opens and excess fuel is released into the fuel tank. In this manner, the relief valve prevents an abnormal increase in fuel pressure.
- When the engine and the fuel pump stop, spring force acts on the check valve to close the discharge port, so that the fuel pressure in the fuel delivery line is retained.

## 2. JET PUMP

- The jet pump utilizes the velocity of fuel returning from the engine to produce negative pressure in it.
- Using the pumping effect produced by the negative pressure, the jet pump transfers fuel from the sub-compartment to the main compartment of the fuel tank.
- When the return line nozzle is clogged, the fuel sent back through the return line flows back into the fuel tank via the relief valve.

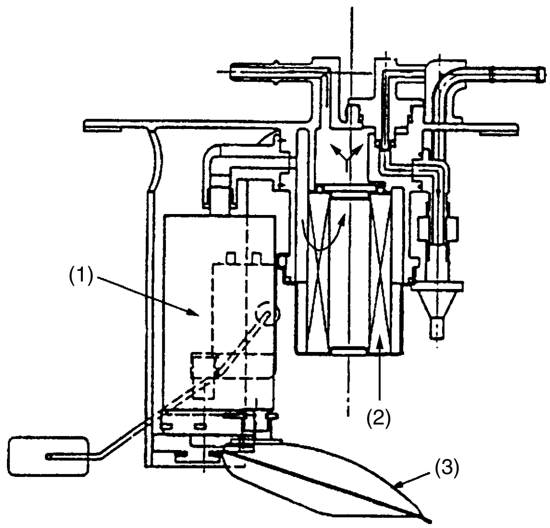



(1) Jet pump
(2) Relief valve
(3) Silencer
(4) Nozzle

**A:** Return line
**B:** From sub tank compartment

## 3. FUEL FILTERS

There are two different types of fuel filters inside fuel tank, forming integral part of the fuel pump. The filter at the inlet of the fuel pump is a mesh type which removes relatively large particles in the fuel before it enters the pump. The filter at the outlet of the pump is a pressure resistant cartridge type whose inside filtering element can remove small particles in the pressurized fuel.

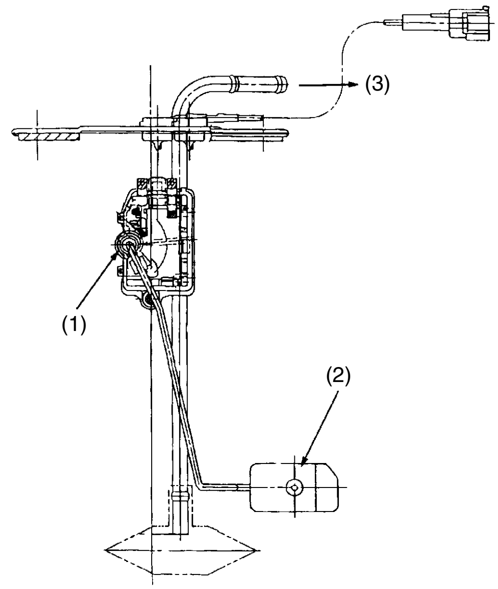



B2H2910D

(1) Fuel pump
(2) Cartridge filter
(3) Mesh filter

## F: SUB-COMPARTMENT FUEL LEVEL SENSOR

This sensor detects the level of the fuel in the sub-compartment (the compartment in which the fuel pump is not located) and acts as part of the fuel transfer line when the jet pump is in operation to maintain the fuel in both compartments at the same level.




(1) Fuel level sensor (Sub)
(2) Float
(3) To jet pump

# 4. Sensors and Switches

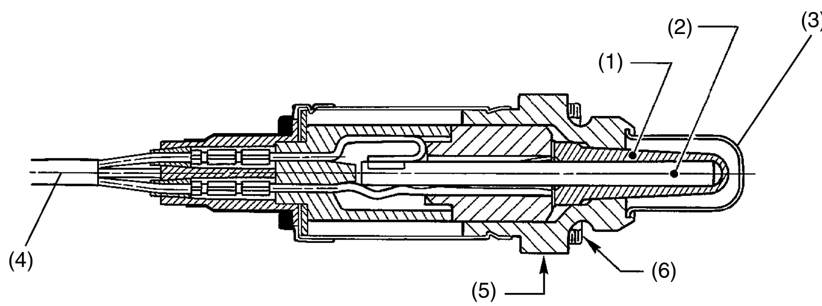
## A: OXYGEN SENSOR (WITH CATALYTIC CONVERTER )

● The oxygen sensor is used to sense oxygen concentration in the exhaust gas. If the air-fuel ratio is leaner than the stoichiometric ratio in the mixture (i.e., excessive amount of air), the exhaust gas contains more oxygen. To the contrary, if the fuel ratio is richer than the stoichiometric ratio, the exhaust gas contains almost no oxygen.

● Detecting the oxygen concentration in exhaust gas using the oxygen sensor makes it possible to determine whether the air-fuel ratio is leaner or richer than the stoichiometry.

● The oxygen sensor has a zirconia tube (ceramic) which generates voltage if there is a difference in oxygen ion concentration between the inside and outside of the tube. Platinum is coated on the inside and outside of the zirconia tube as a catalysis and electrode material. The sensor housing is grounded to the exhaust pipe and the inside is connected to the ECM through the harness.

● A ceramic heater is employed to improve performance at low temperatures.



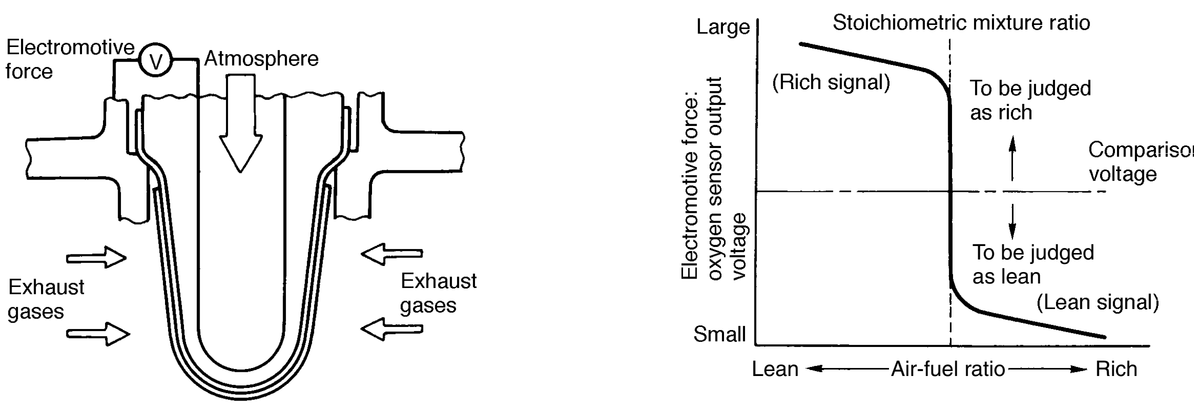

H2H1224D

| | |
|---|---|
| (1) | Zirconia tube |
| (2) | Ceramic heater |
| (3) | Protection tube |
| (4) | Harness |
| (5) | Sensor housing |
| (6) | Gasket |

● When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases is almost completely used in the catalytic reaction by the platinum coating on the external surface of the zirconia tube. This results in a very large difference in the oxygen ion concentration between the inside and outside of the tube, and the electromotive force generated is large.

● When a lean air-fuel mixture is burnt in the cylinder, relatively large amount of oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen ion concentration between the tube's internal and external surfaces. The electromotive force in this case is very small.

● The difference in oxygen concentration changes drastically in the vicinity of the stoichiometric air-fuel ratio, and hence the change in the electromotive force is also large. By using this information, the ECM can determine the air-fuel ratio of the supplied mixture easily. The rear oxygen sensor does not generate much electromotive force when the temperature is low. The output characteristics of the sensor stabilize at a temperature of approximately 300 to 400°C (572 to 752°F).

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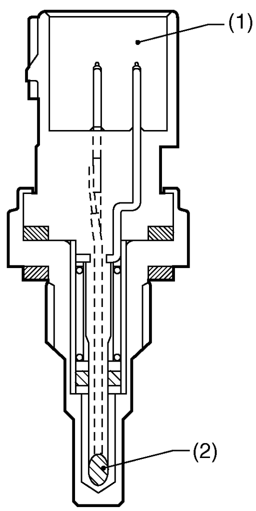
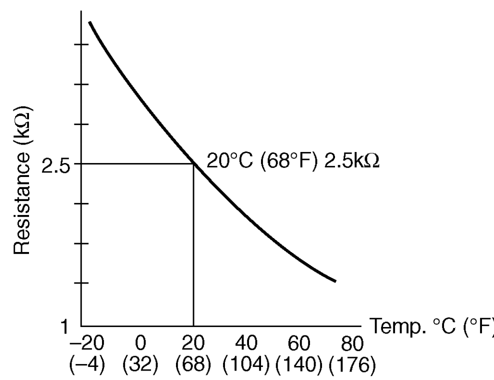
## B: ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant temperature sensor is located on the engine coolant pipe. The sensor uses a thermistor whose resistance changes inversely with temperature. Resistance signals as engine coolant temperature information are transmitted to the ECM to make fuel injection, ignition timing, purge control solenoid valve and other controls.



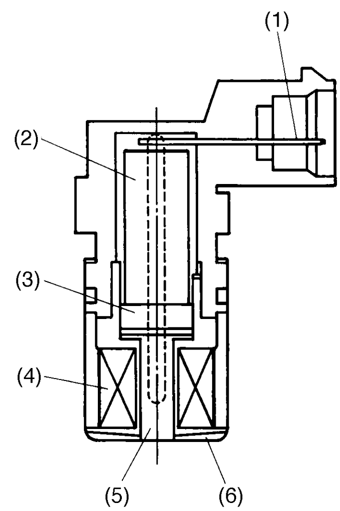




S2H1113B

(1) Connector
(2) Thermistor element

## C: CRANKSHAFT POSITION SENSOR

- The crankshaft position sensor is installed on the oil pump which is located in the front center portion of the cylinder block. The sensor generates a pulse when one of the teeth on the perimeter of the crankshaft sprocket (rotating together with the crankshaft) passes in front of it. The ECM determines the crankshaft angular position by counting the number of pulses.
- The crankshaft position sensor is a molded type which consists of a magnet, core, coil, terminals and other components as illustrated below.

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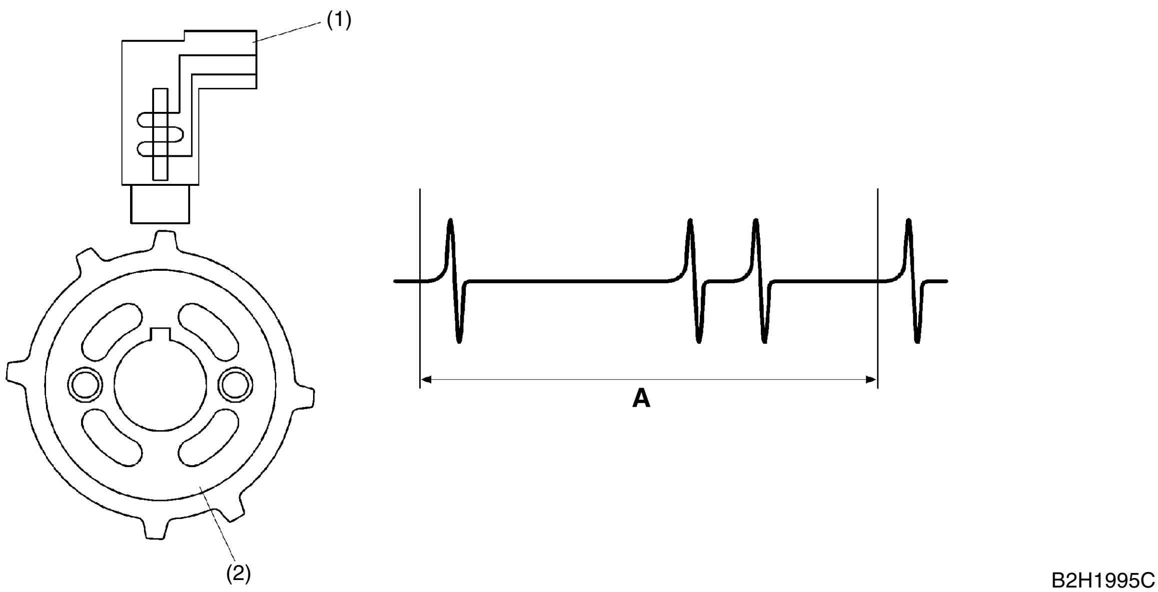
| | | | |
|---|---|---|---|
| (1) | Terminal | (4) | Coil |
| (2) | Yoke core | (5) | Core |
| (3) | Magnet | (6) | Cover |

● As the crankshaft rotates, each tooth aligns with the crankshaft position sensor. At that time, the magnetic flux in the sensor's coil changes since the air gap between the sensor pickup and the sprocket changes. This change in magnetic flux induces a voltage pulse in the sensor and the pulse is transmitted to the ECM.



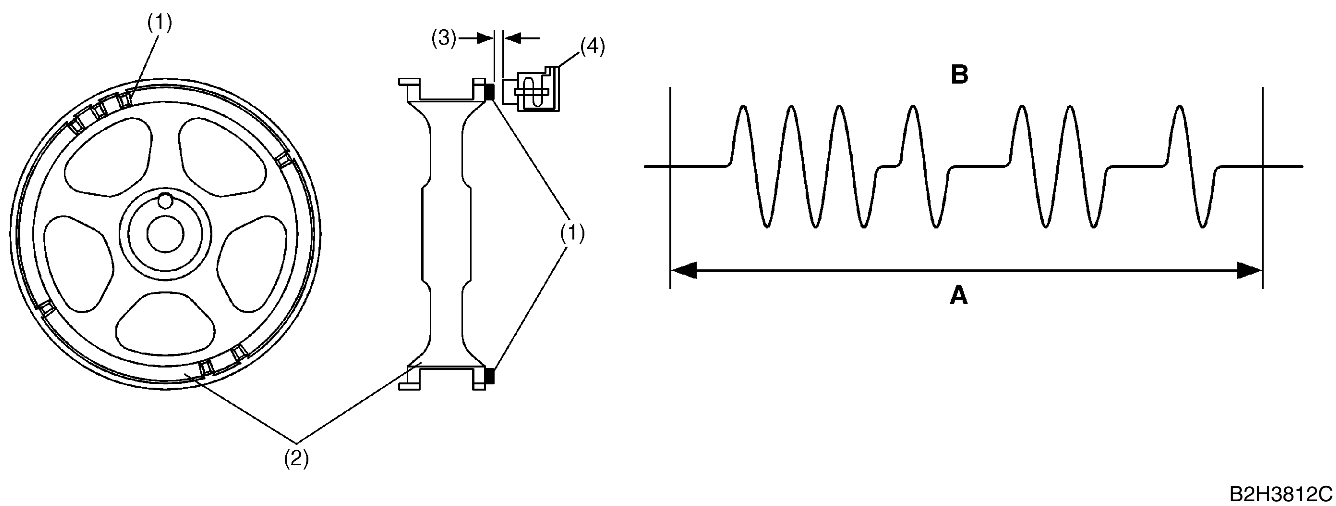

(1) Crankshaft position sensor
(2) Crankshaft sprocket

**A:** Crankshaft half rotation

## D: CAMSHAFT POSITION SENSOR

- The camshaft position sensor is located on the left-hand camshaft support. It detects the combustion cylinder at any given moment.
- The sensor generates a pulse when one of the bosses on the back of the left-hand camshaft drive sprocket passes in front of the sensor. The ECM determines the camshaft angular position by counting the number of pulses.

Internal construction and the basic operating principle of the camshaft position sensor are similar to those of the crankshaft position sensor. A total of seven bosses are arranged at equally spaced four locations (one each at two locations, two at one location, and three at one location) of the sprocket as shown below.

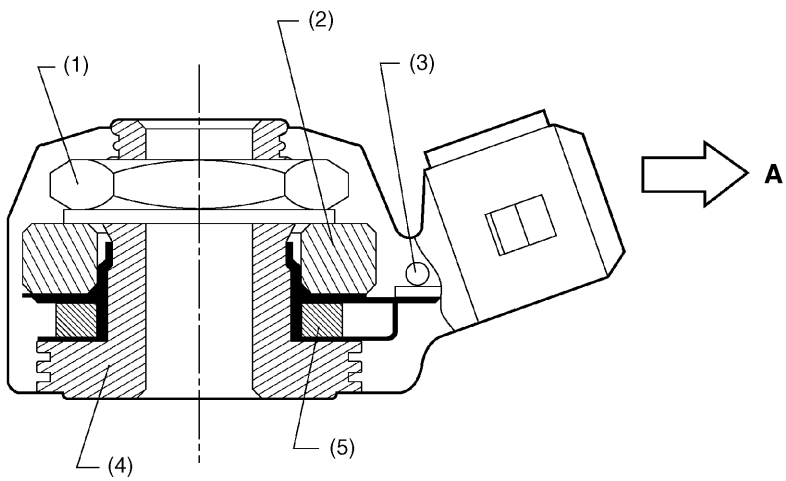



(1) Boss
(2) Camshaft sprocket
(3) Air gap
(4) Camshaft position sensor

**A:** Camshaft one rotation (Crankshaft two rotations)
**B:** Cylinder identification signal

## E: KNOCK SENSOR

- The knock sensor is installed on the cylinder block, and senses knocking that occurs in the engine.
- The sensor is a piezo-electric type which converts vibration resulting from knocking into electric signals.
- In addition to a piezo-electric element, the sensor has a weight and case as its components. If knocking occurs in the engine, the weight in the case moves causing the piezo-electric element to generate a voltage.
- The knock sensor harness is connected to the bulkhead harness.

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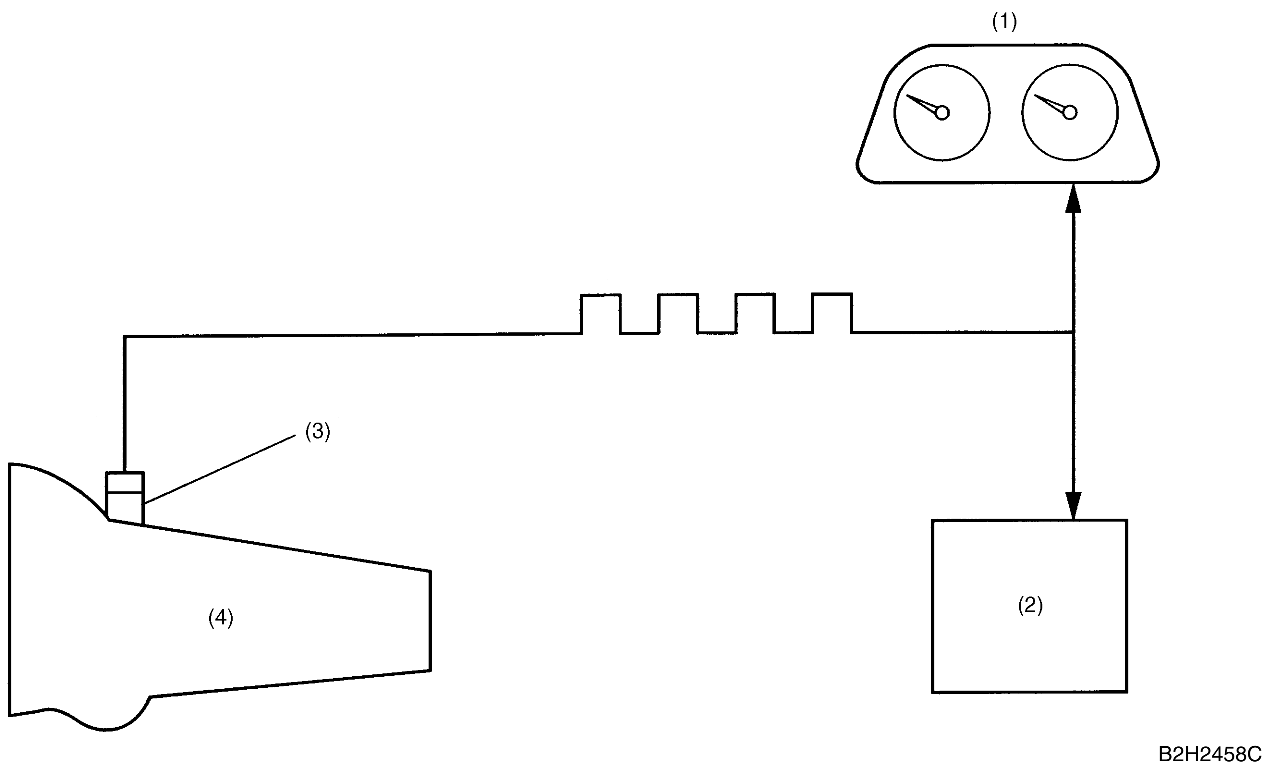
(1) Nut
(2) Weight
(3) Resistor
(4) Housing
(5) Piezo-electric element

A: To knock sensor harness

## F: VEHICLE SPEED SENSOR

### 1. MT VEHICLES

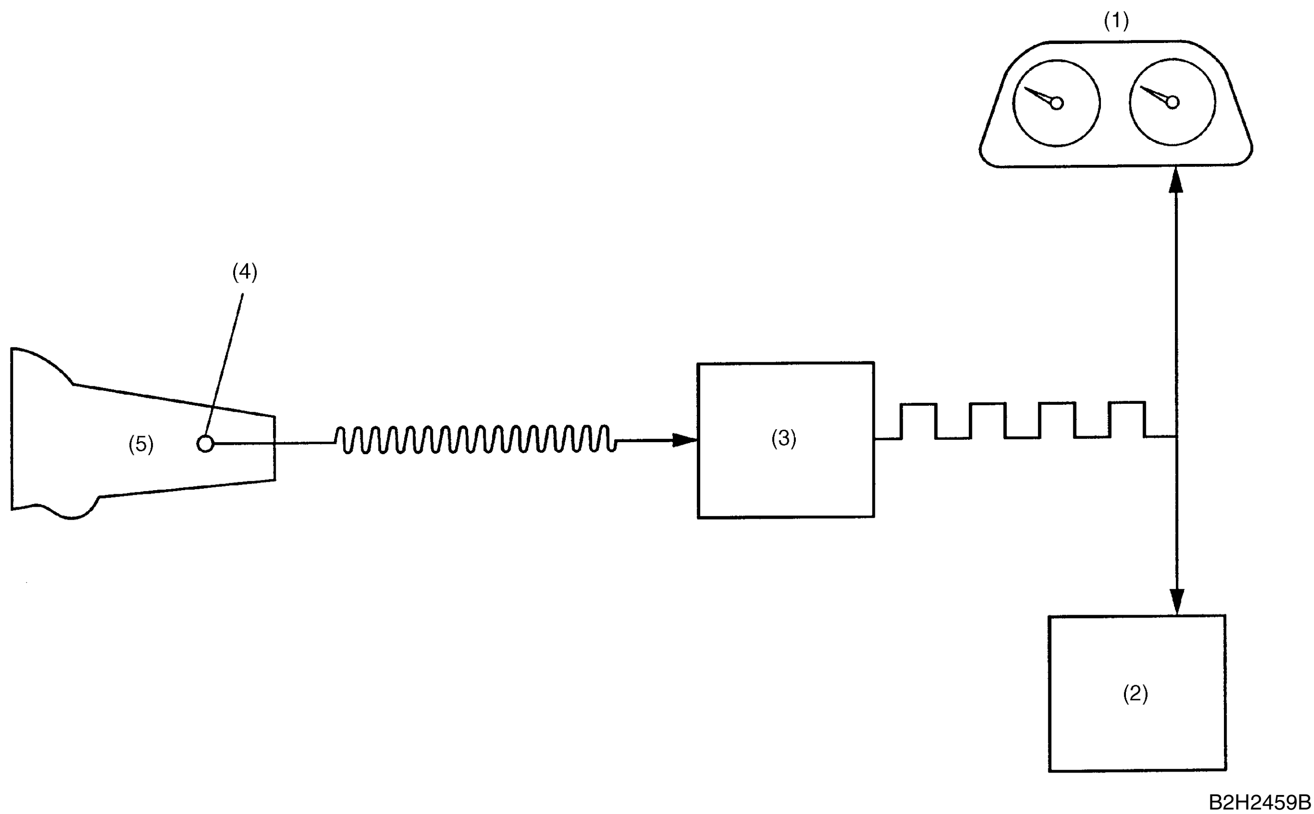
- The vehicle speed sensor is mounted on the transmission.
- The vehicle speed sensor generates a 4-pulse signal for every rotation of the front differential and send it to the ECM and the combination meter.




(1) Combination meter
(2) ECM
(3) Vehicle speed sensor
(4) Transmission

## 2. AT VEHICLES

- The vehicle speed sensor is mounted on the transmission.
- The vehicle speed sensor generates a 16-pulse signal for every rotation of the front differential and send it to the transmission control module (TCM). The signal sent to the TCM is converted there into a 4-pulse signal, and then sent to the ECM and the combination meter.




(1) Combination meter
(2) ECM
(3) TCM
(4) Vehicle speed sensor
(5) Transmission

# 5. Control System

## A: GENERAL

The ECM receives signals from various sensors, switches, and other control modules. Using these signals, it determines the engine operating conditions and if necessary, emits signals to one or more systems to control them for optimum operation.

Major control items of the ECM are as follow:

- Fuel injection control
- Ignition system control
- Idle air control
- Canister purge control*1
- Radiator fan control*2
- Fuel pump control
- On-board diagnosis function

*1: Canister purge control is described under “EC (w/o OBD) – Emission Control (Aux. Emission Control Devices) Evaporative Emission Control System”.

*2: Radiator fan control is described under “CO – Cooling”.

## B: INPUT AND OUTPUT SIGNALS

| Signal | Unit | Function |
|---|---|---|
| Input signals | Intake air temperature and pressure sensor | Detects the temperature of intake and amount of intake air (Measures the absolute pressure). |
| | Throttle position sensor | Detects the throttle valve position. |
| | Oxygen sensor* | Detects the density of oxygen in exhaust gases at the upstream of the front catalytic converter. |
| | Crankshaft position sensor | Detects the crankshaft angular position. |
| | Camshaft position sensor | Detects the combustion cylinder. |
| | Engine coolant temperature sensor | Detects the engine coolant temperature. |
| | Knock sensor | Detects engine knocking. |
| | Vehicle speed sensor | Detects the vehicle speed. |
| | Ignition switch | Detects operation of the ignition switch. |
| | Starter switch | Detects the condition of engine cranking. |
| | Neutral position switch (MT) | Detects that the gear is in neutral. |
| | Park/Neutral position switch (AT) | Detects shift positions. |
| | Torque control signal (AT) | Controls engine torque. |
| | Heater circuit of oxygen sensor* | Detects abnormality in the heater circuit of the oxygen sensors. |
| | Diagnostics of AT-ECU | Detects the self-diagnostics of the AT-ECU. |
| | A/C switch | Detects ON-OFF operation of the A/C switch. |
| | Small light switch | Detects ON-OFF operation of the small light switch. |
| | Blower fan switch | Detects ON-OFF operation of the blower fan switch. |
| | Rear defogger switch | Detects ON-OFF operation of the rear defogger switch. |
| Output signals | Fuel Injector | Activates an injector. |
| | Ignition signal | Turns the primary ignition current ON or OFF. |
| | Fuel pump relay | Turns the fuel pump relay ON or OFF. |
| | A/C control relay | Turns the A/C control relay ON or OFF. |
| | Radiator fan control relay | Turns the radiator fan control relay ON or OFF. |
| | Idle air control solenoid valve | Adjusts the amount of air flowing through the bypass line in the throttle body. |
| | Malfunction indicator lamp | Indicates existence of abnormality. |
| | Purge control solenoid valve | Controls purge of evaporative gas absorbed by the canister. |
| | Power supply | Control ON/OFF of the main power supply relay. |

*: With catalytic converter

## C: FUEL INJECTION COTROL

- The ECM receives signals from various sensors and based on them, it determines the amount of fuel injected and the fuel injection timing. It performs the sequential fuel injection control over the entire engine operating range except during start-up of the engine.
- The amount of fuel injected depends upon the length of time the injector stays open. The fuel injection duration is determined according to varying operating condition of the engine. For the purpose of achieving highly responsive and accurate fuel injection duration control, the ECM performs a new feedback control that incorporates a learning feature as detailed later.
- The sequential fuel injection control is performed such that fuel is injected accurately at the time when the maximum air intake efficiency can be achieved for each cylinder (i.e., fuel injection is completed just before the intake valve begins to open).

### 1. FUEL INJECTION DURATION

Fuel injection duration is basically determined as indicated below:

- During engine start-up:

The duration defined below is used.

  - Duration of fuel injection during engine start-up ..... Determined according to the engine coolant temperature detected by the engine coolant temperature sensor.

- During normal operation:

The duration is determined as follows:

Basic duration of fuel injection x Correction factors + Voltage correction time

  - Basic duration of fuel injection ..... The basic length of time fuel is injected. This is determined by two factors – the amount of intake air detected by the manifold pressure sensor and the engine speed monitored by the crankshaft position sensor.
  - Correction factors ..... See the next section.
  - Voltage correction time ..... This is added to compensate for the time lag before operation of injector that results from variation in the battery voltage.

## 2. CORRECTION FACTORS

The following factors are used to correct the basic duration of fuel injection in order to make the air-fuel ratio meet the requirements of varying engine operating conditions:

- Air-fuel ratio feedback factor:

This factor is used to correct the basic duration of fuel injection in relation to the actual engine speed. (See the next section for more detail.)

- Start increment factor:

This factor is used to increase the fuel injection duration only while the engine is being cranked to improve its startability.

- Coolant-temperature-dependent increment factor:

This factor is used to increase the fuel injection duration depending on engine coolant temperature signals to facilitate cold starting. The lower the coolant temperature, the greater the increment.

- After-start increment factor:
  - This factor is used to increase the fuel injection duration for a certain period immediately after start of the engine to stabilize engine operation.
  - The increment depends on the coolant temperature at the start of the engine.

- Wide-open-throttle increment factor:

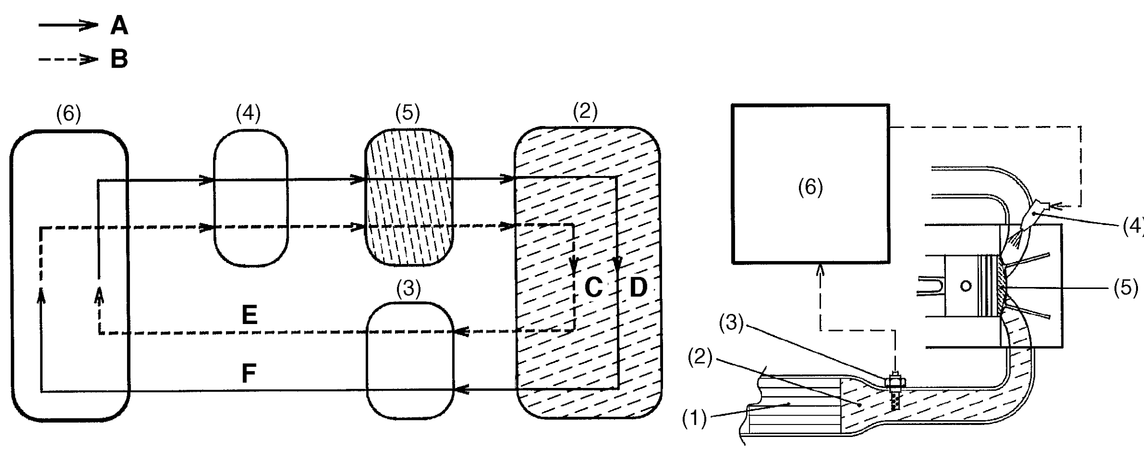
This factor is used to increase the fuel injection duration depending on the relationship between the throttle position sensor signal and manifold pressure sensor signal.

- Acceleration increment factor:

This factor is used to increase the fuel injection duration to compensate for a time lag between air flow measurement and fuel injection control for better engine response to driver’s pedal operation during acceleration.

## 3. AIR-FUEL RATIO FEEDBACK FACTOR (WITH CATALYTIC CONVERTER)

The ECM creates this factor utilizing the oxygen sensor signal. When the signal voltage is low, the air-fuel ratio is richer than the stoichiometric ratio. The ECM then makes the fuel injection duration shorter by modifying the factor. When the voltage is high showing that the mixture is lean, the ECM modifies the factor to make the injection duration longer. In this way, the air-fuel ratio is maintained at a level close to the stoichiometric ratio at which the three-way catalyst acts most effectively.

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| | | | |
|---|---|---|---|
| (1) | Front catalyst | **A:** | Injection duration increment signal |
| (2) | Exhaust gas | **B:** | Injection duration decrement signal |
| (3) | Oxygen sensor | **C:** | High oxygen density |
| (4) | Fuel injector | **D:** | Low oxygen density |
| (5) | Combustion chamber | **E:** | Lean signal |
| (6) | ECM | **F:** | Rich signal |

## 4. LEARNING FEATURE (WITH CATALYTIC CONVERTER)

The air-fuel ratio feedback control includes a learning feature which contributes to more accurate and responsive control.

● In the air-fuel ratio feedback control, the ECM calculates the necessary amount of correction based on data from the oxygen sensor and adds the result to the basic duration (which is stored in the ECM's memory for each condition defined by the engine speed and various loads.)

● Without a learning feature, the ECM carries out the above-mentioned process every time. This means that if the amount of necessary correction is large, the air-fuel ratio feedback control becomes less responsive and less accurate.

● The learning feature enables the ECM to store the amount of correction into memory and add it to the basic fuel injection duration to create a new reference fuel injection duration. Using the reference duration as the basic duration for the injection a few times later, the ECM can reduce the amount of correction and thus make its feedback control more accurate and responsive to changes in the air-fuel ratio due to difference in driving condition and sensor/actuator characteristics that may result from unit-to-unit variation or aging over time.

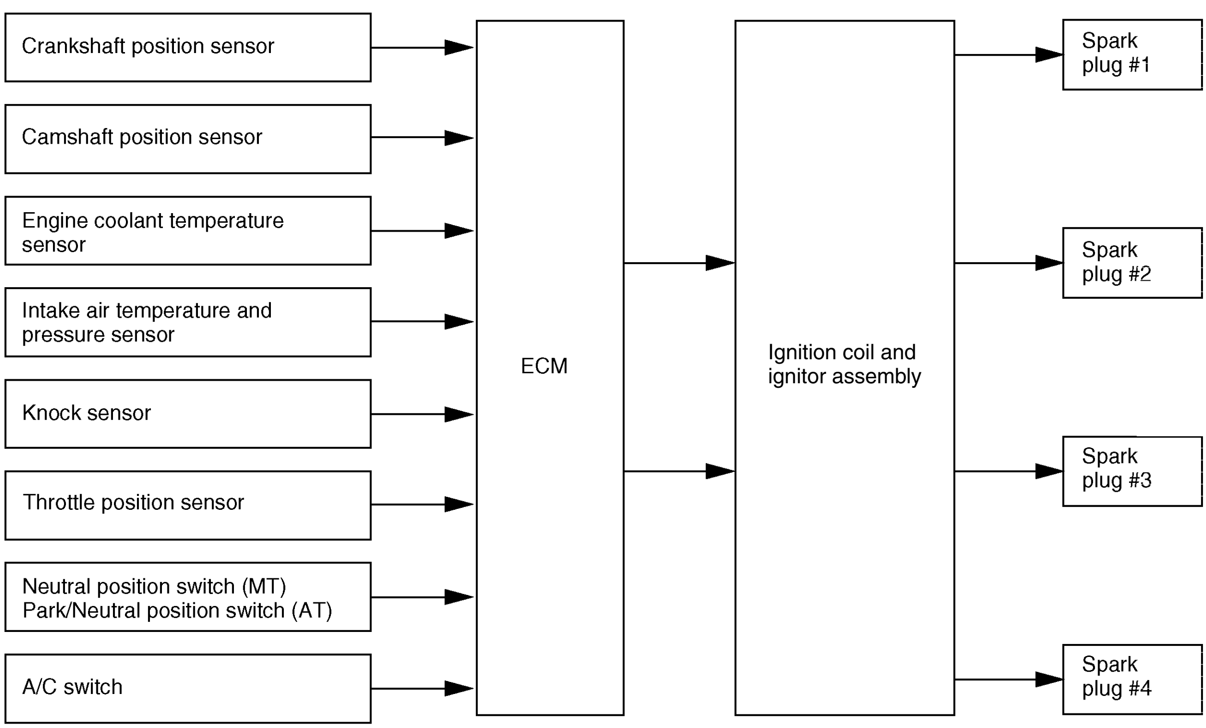
## D: IGNITION SYSTEM CONTROL

● The ECM determines operating condition of the engine based on signals from the pressure sensor, engine coolant temperature sensor, intake air temperature sensor, crankshaft position sensor and other sources. It then selects the ignition timing most appropriate for the condition thus determined from those stored in its memory and outputs at that timing a primary current OFF signal to the ignitor to initiate ignition.

● This control uses a quick-to-response learning feature by which the data stored in the ECM memory is processed in comparison with information from various sensors and switches.

● Thus, the ECM can always perform optimum ignition timing taking into account the output, fuel consumption, exhaust gas, and other factors for every engine operating condition.

● Ignition control during start-up
Engine speed fluctuates during start of the engine, so the ECM cannot control the ignition timing. During that period, the ignition timing is fixed at 10° BTDC by using the 10° signal from the crankshaft position sensor.

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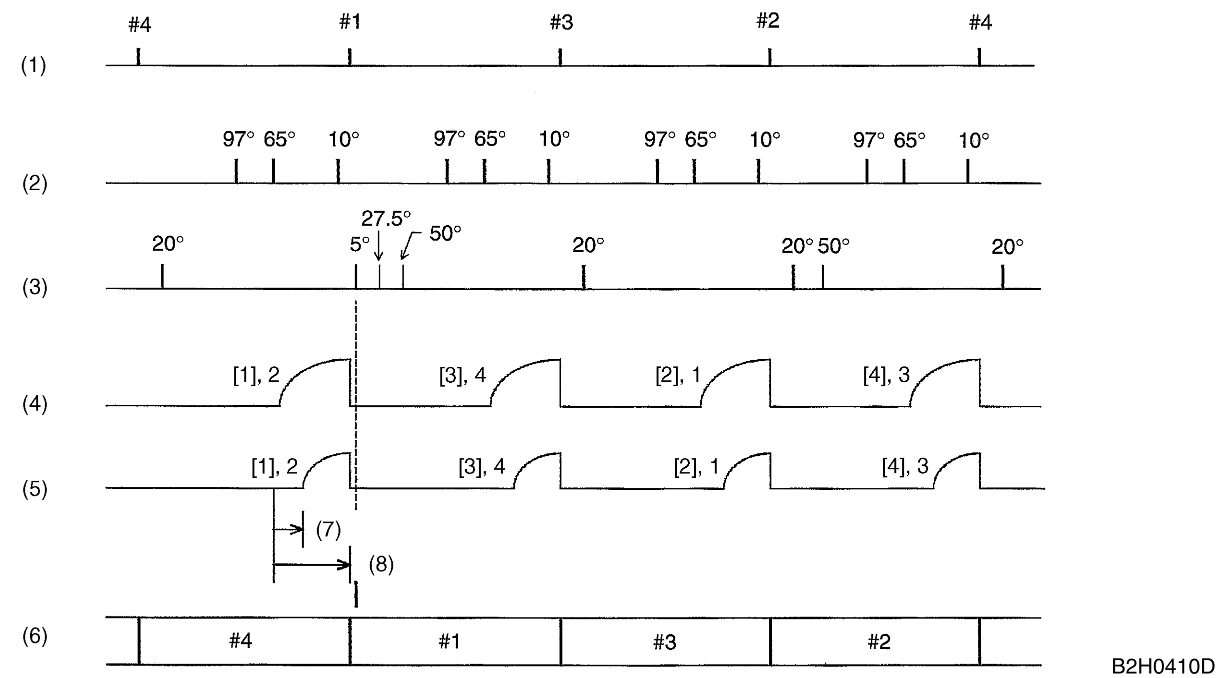
● Ignition control after start of engine

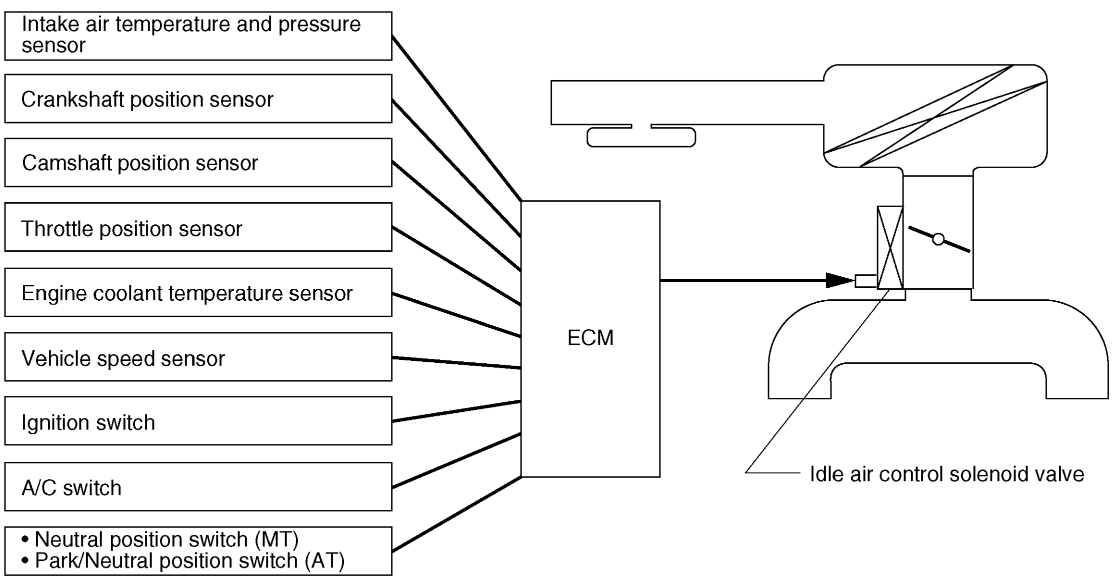
Between the 97° and 65° crank angle signal, the ECM measures the engine speed, and by using this data it decides the dwell set timing and ignition timing according to the engine condition.




| | | | |
|---|---|---|---|
| (1) | Cylinder number | (5) | Ignition timing at normal condition |
| (2) | Crank angle pulse (BTDC) | (6) | Burning cylinder |
| (3) | Cam angle pulse (ATDC) | (7) | Dwell set |
| (4) | Ignition timing at starting | (8) | Ignite |

## E: IDLE AIR CONTROL

- The ECM activates the idle air control solenoid valve to control the bypass air flowing through the bypass passage in the throttle body depending on signals from the crankshaft position sensor, engine coolant temperature sensor, pressure sensor and A/C switch so that the proper idle speed for each engine load is achieved.
- The idle air control solenoid valve uses a duty-ratio-controlled solenoid which can continuously vary the opening area of the rotary valve. As the ECM increases the duty ratio, opening of the rotary valve increases so that the bypass air flow increases, and the engine idling speed becomes higher as a result.
- The bypass air control is necessary for:
  - Increasing idling speed when the air conditioning system and/or electrical loads are turned on.
  - Increasing idling speed during early stage of warm up period.
  - Obtaining dashpot function when the throttle valve is quickly closed.
  - Prevention of engine speed variation during idling.

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## F: FUEL PUMP CONTROL

Using the signal from the crankshaft position sensor, the ECM controls operation of the fuel pump by turning its relay ON or OFF. To improve safety, the fuel pump is stopped if the engine stalls with the ignition switch ON.

| Ignition switch ON | Fuel pump relay | Fuel pump |
|---|---|---|
| A certain period of time after ignition switch is turned ON | ON | Operates |
| While cranking the engine | ON | Operates |
| While engine is operating | ON | Operates |
| When engine stops | OFF | Does not operate |

# 6. On-board Diagnosis System

## A: GENERAL

- The on-board diagnosis system detects and indicates a fault by generating a code corresponding to each fault location. The malfunction indicator lamp (CHECK ENGINE light) on the combination meter indicates occurrence of a fault or abnormality.
- When the malfunction indicator lamp comes on as a result of detection of a fault by the ECM, the corresponding diagnostic trouble code (DTC) and freeze frame engine condition are stored in the ECM.
- The Subaru Select Monitor (SSM) can read and erase DTCs. It can also read freeze frame data in addition to other pieces of engine data.
- If there is a failure involving sensors which may affect drive control of the vehicle, the fail-safe function ensures minimum level of driveability.

## B: FAIL-SAFE FUNCTION

For a sensor or switch which has been judged faulty in the on-board diagnosis, the ECM, if appropriate, generates an associated pseudo signal to keep the vehicle operational. (The control becomes degraded.)

**MEMO**

# EMISSION CONTROL (AUX. EMISSION CONTROL DEVICES)

# EC

Page

# 1. System Overview

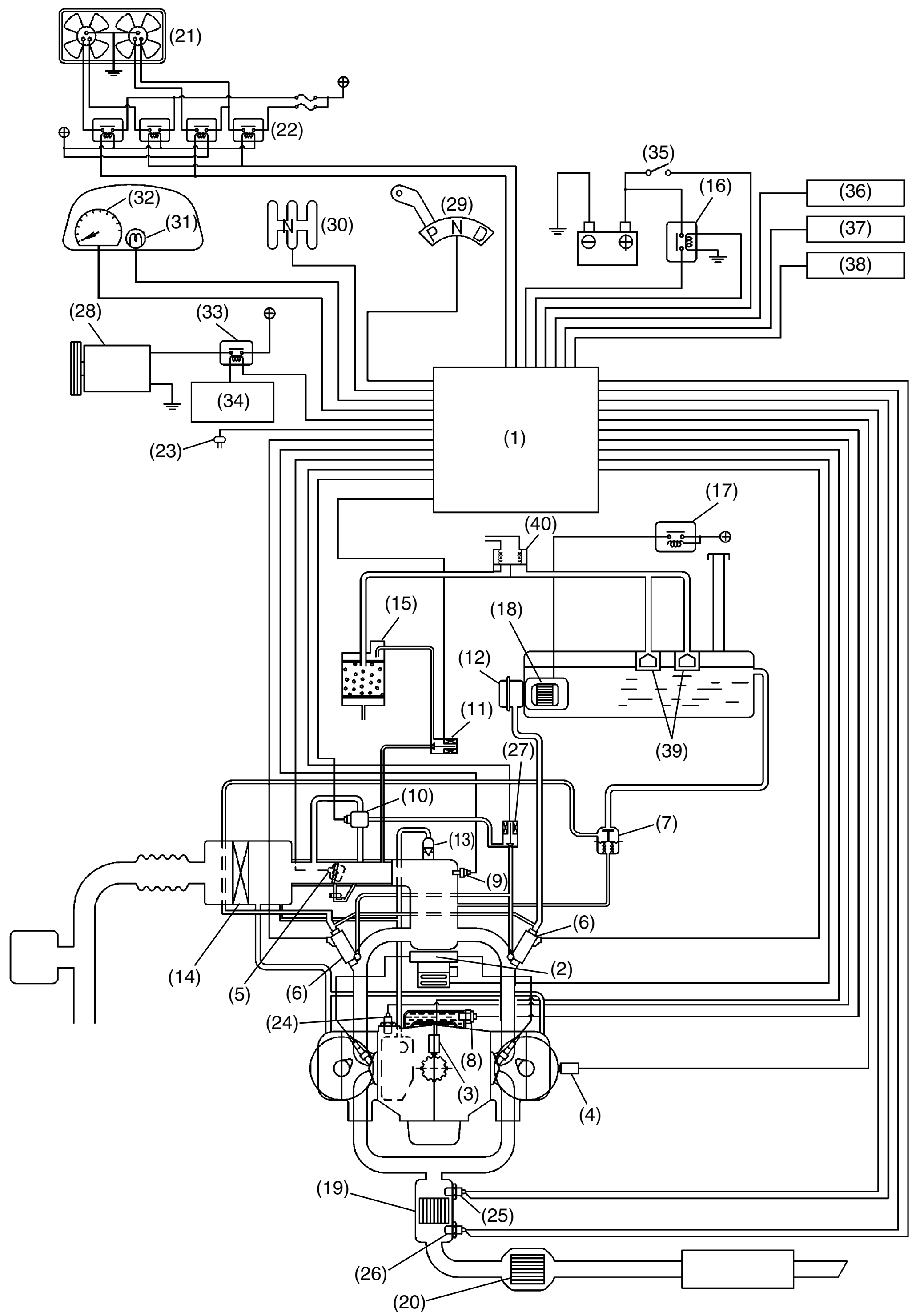
There are three emission control systems which are as follows:

- Crankcase emission control system
- Exhaust emission control system
  - Three-way catalyst system
  - Air/fuel (A/F) control system
  - Ignition control system
- Evaporative emission control system

| Item | | | Main components | Function |
|---|---|---|---|---|
| Crankcase emission control system | | | Positive crankcase ventilation (PCV) valve | Draws blow-by gas into intake manifold from crankcase and burns it together with air-fuel mixture. Amount of blow-by gas to be drawn in is controlled by intake manifold pressure. |
| Exhaust emission control system | Catalyst system | Front | Three-way catalyst | Oxidizes HC and CO contained in exhaust gases as well as reducing NOx. |
| | | Rear | | |
| | A/F control system | | Engine control module (ECM) | Receives input signals from various sensors, compares signals with stored data, and emits a signal for optimal control of air-fuel mixture ratio. |
| | | | Front oxygen (A/F) sensor | Detects quantity of oxygen contained exhaust gases. |
| | | | Rear oxygen sensor | Detects density of oxygen contained exhaust gases. |
| | | | Throttle position sensor | Detects throttle position. |
| | | | Intake air temperature and pressure sensor | Detects absolute pressure of intake manifold. |
| | | | | Detects intake air temperature of intake manifold. |
| | Ignition control system | | ECM | Receives various signals, compares signals with basic data stored in memory, and emits a signal for optimal control of ignition timing. |
| | | | Crankshaft position sensor | Detects engine speed (Revolution). |
| | | | Camshaft position sensor | Detects reference signal for combustion cylinder discrimination. |
| | | | Engine coolant temperature sensor | Detects coolant temperature. |
| | | | Knock sensor | Detects engine knocking. |
| Evaporative emission control system | | | Canister | Absorbs evaporative gas which occurs in fuel tank when engine stops, and releases it to combustion chambers for a complete burn when engine is started. This prevents HC from being discharged into atmosphere. |
| | | | Purge control solenoid valve | Receives a signal from ECM and controls purge of evaporative gas absorbed by canister. |

**MEMO**

# 2. Schematic Diagrams

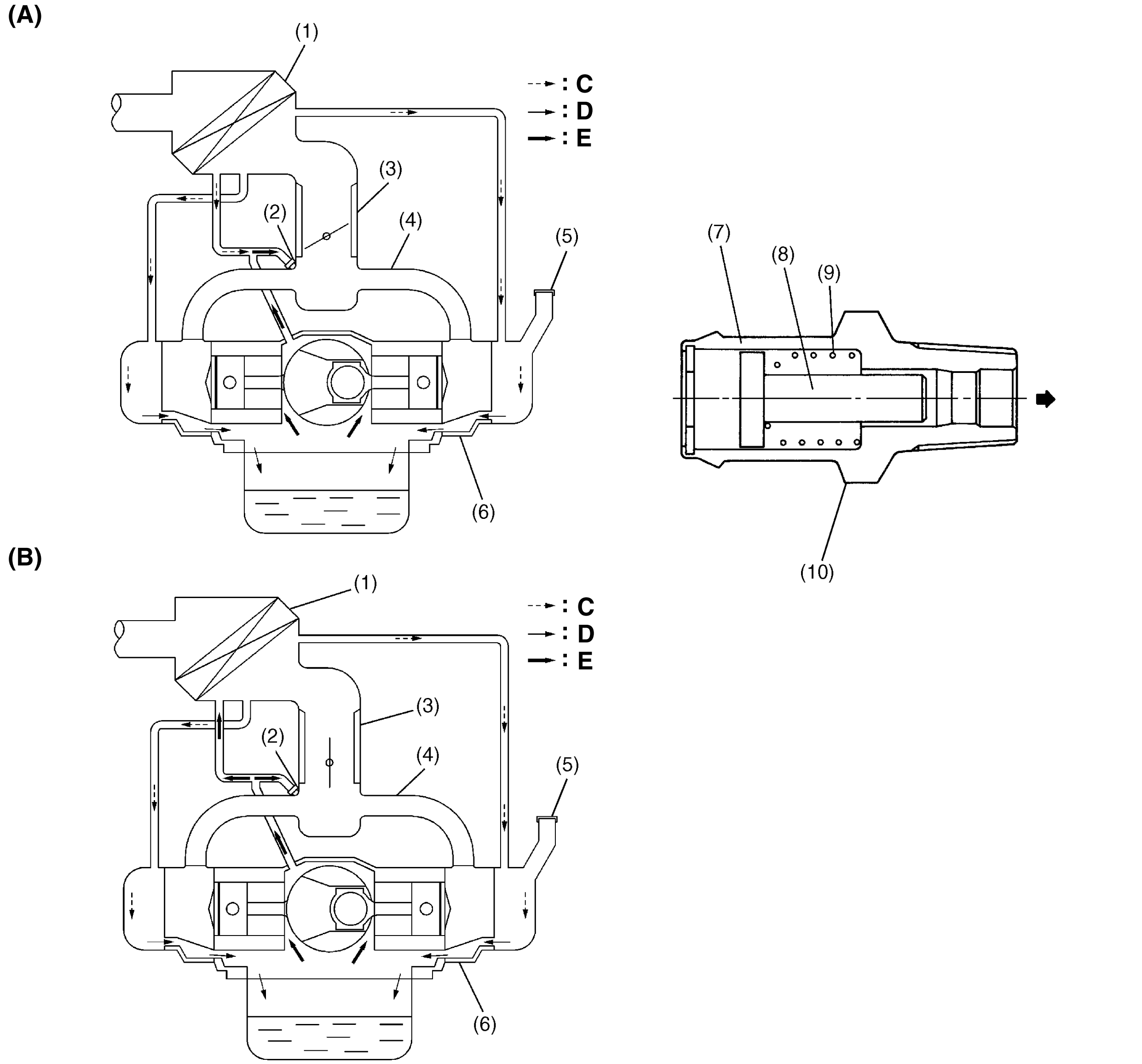



B2H3982A

(1) Engine control module (ECM)
(2) Ignition coil and ignitor assembly
(3) Crankshaft position sensor
(4) Camshaft position sensor
(5) Throttle position sensor
(6) Fuel injectors
(7) Pressure regulator
(8) Engine coolant temperature sensor
(9) Intake air temperature and pressure sensor
(10) Idle air control solenoid valve
(11) Purge control solenoid valve
(12) Fuel pump
(13) PCV valve
(14) Air cleaner element
(15) Canister
(16) Main relay
(17) Fuel pump relay
(18) Fuel filter
(19) Front catalytic converter
(20) Rear catalytic converter
(21) Radiator fan
(22) Radiator fan relay
(23) Atmospheric pressure sensor
(24) Knock sensor
(25) Front oxygen (A/F) sensor
(26) Rear oxygen sensor
(27) Air assist injector solenoid valve
(28) A/C compressor
(29) Inhibitor switch
(30) Neutral switch
(31) CHECK ENGINE malfunction indicator lamp (MIL)
(32) Tachometer
(33) A/C relay
(34) A/C control module
(35) Ignition switch
(36) Transmission control module (TCM)
(37) Vehicle speed sensor
(38) Data link connector
(39) Fuel cut valve
(40) Two-way valve

# 3. Crankcase Emission Control System

- The positive crankcase ventilation (PCV) system prevents air pollution which will be caused by blow-by gas being emitted from the crankcase.
The system consists of a sealed oil filler cap, rocker covers with fresh air inlet, connecting hoses, a PCV valve and an air intake duct.
- In a part-throttle condition, the blow-by gas in the crankcase flows into the intake manifold through the connecting hose of crankcase and PCV valve by the strong vacuum created in the intake manifold. Under this condition, fresh air is introduced into the crankcase through the connecting hose of the rocker cover.
- In a wide-open-throttle condition, a part of blow-by gas flows into the air intake duct through the connecting hose and is drawn into the throttle chamber, because under this is condition, the intake manifold vacuum is not strong enough to introduce through the PCV valve all blow-by gases that increase in the amount with engine speed.

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| | | |
|---|---|---|
| (1) Air cleaner case | (6) Crankcase | **(A)** Part-throttle condition |
| (2) PCV valve | (7) Case | **(B)** Wide-open-throttle condition |
| (3) Throttle body | (8) Valve | **C:** Fresh air |
| (4) Intake manifold | (9) Spring | **D:** Mixture of air and blow-by gas |
| (5) Oil filler cap | (10) PCV valve | **E:** Blow-by gas |

## 4. Three-way Catalyst

- The basic material of three-way catalyst is platinum (Pt), rhodium (Rh) and palladium (Pd), and a thin coat of their mixture is applied onto honeycomb or porous ceramics of an oval shape (carrier). To avoid damaging the catalyst, only unleaded gasoline should be used.
- The catalyst reduces HC, CO and NOx in exhaust gases through chemical reactions (oxidation and reduction). These harmful components are reduced most efficiently when their concentrations are in a certain balance. These concentrations vary with the air-fuel ratio. The ideal air-fuel ratio for reduction of these components is the stoichiometric ratio.
- Therefore, the air-fuel ratio needs to be controlled to around the stoichiometric ratio to purify the exhaust gases most efficiently.

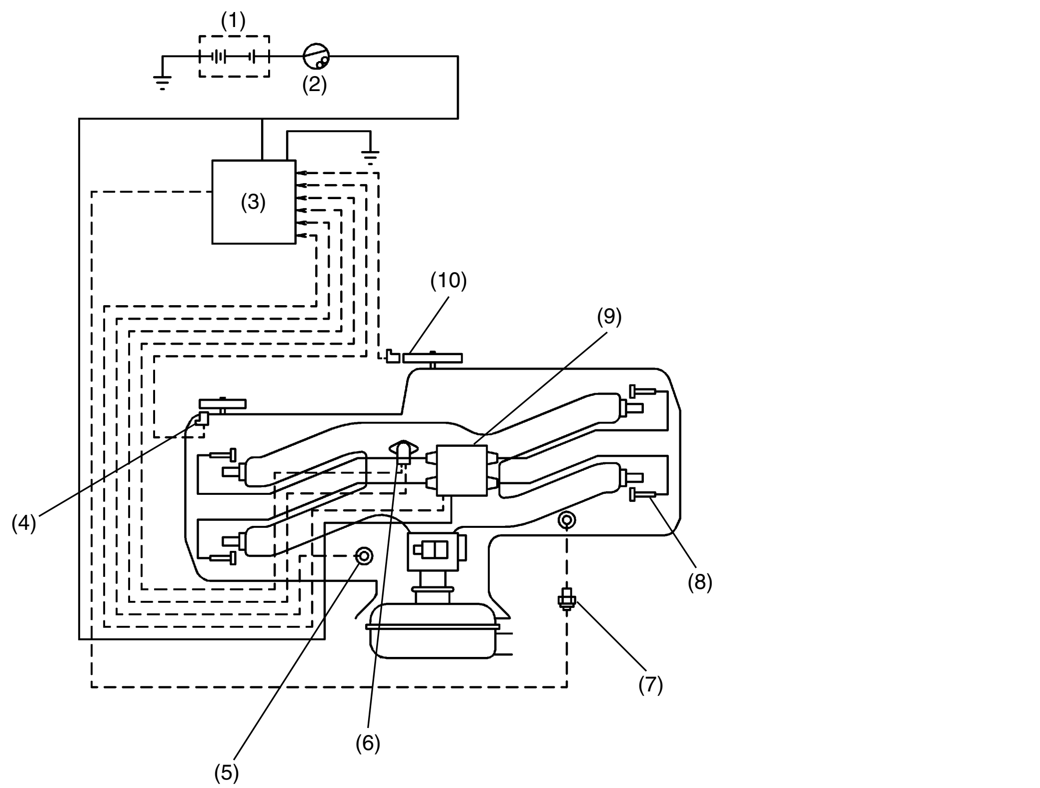
## 5. A/F Control System

- The air/fuel (A/F) control system makes a correction to the basic fuel injection duration in accordance with the signal from the front oxygen sensor so that the stoichiometric ratio is maintained, thus ensuring most effective exhaust gas purification by the three-way catalyst. Different basic fuel injection durations are preset for various engine speeds and loads, as well as the amount of intake air.
- This system also has a “learning” control function which stores the corrected data in relation to the basic fuel injection in the memory map. This allows an appropriate air-fuel ratio correction to be added automatically in quick response to any situation that requires such an effect. Thus, the air-fuel ratio is optimally maintained under various conditions while purifying exhaust gases most effectively, improving driving performance and compensating for changes in sensors’ performance over time.

# 6. Ignition Control System

● The ignition system is controlled by the ECM.
The ECM monitors the operating condition of the engine using the signals from the sensors and switches shown below and determines the ignition timing most appropriate for each engine operating condition. Then it sends a signal to the ignitor, commanding generation of a spark at that timing.

● The ECM uses a preprogrammed map for a “closed-loop” control which provides its ignition timing control with excellent transient characteristics, i.e., highly responsive ignition timing control.

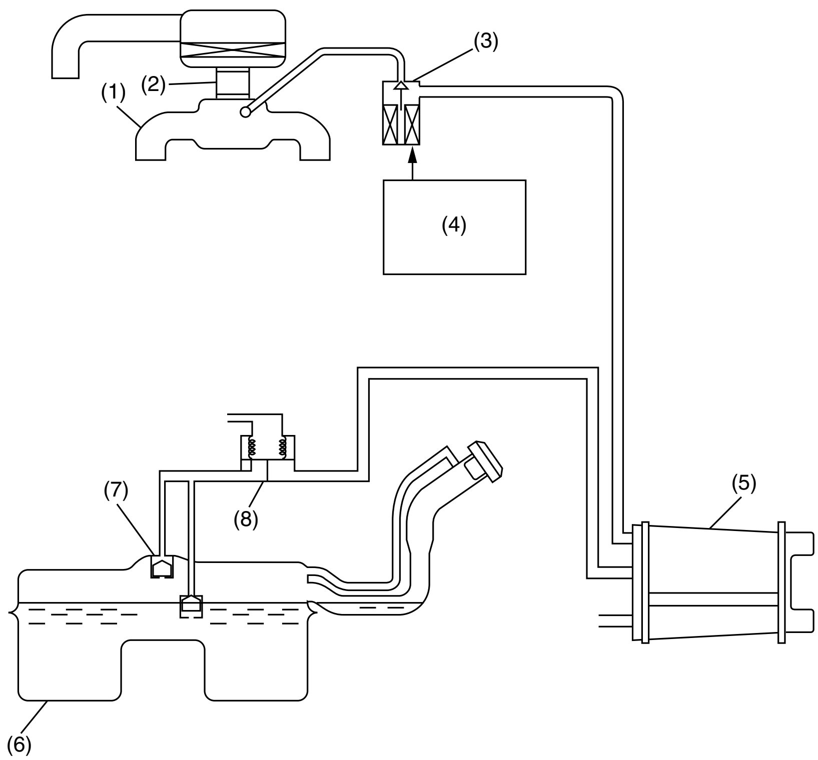



| | | | |
|---|---|---|---|
| (1) | Battery | (6) | Intake air temperature and pressure sensor |
| (2) | Ignition switch | (7) | Engine coolant temperature sensor |
| (3) | ECM | (8) | Spark plug |
| (4) | Camshaft position sensor | (9) | Ignition coil and ignitor assembly |
| (5) | Knock sensor | (10) | Crankshaft position sensor |

# 7. Evaporative Emission Control System

## A: GENERAL

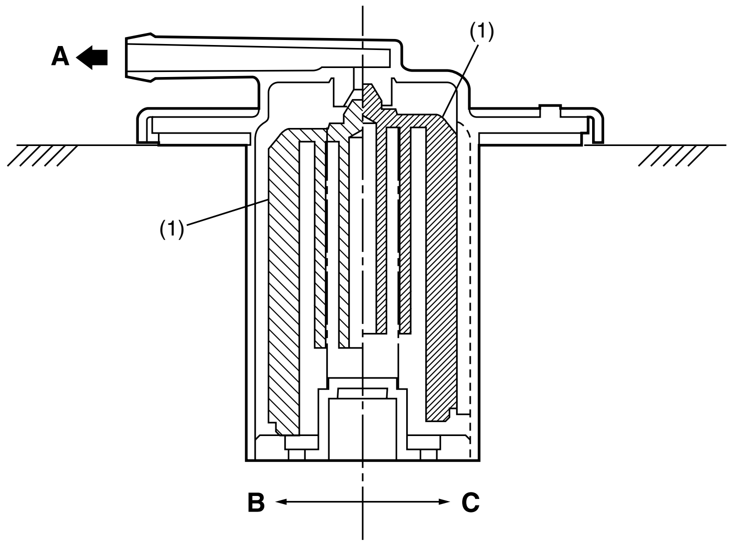
● The evaporative emission control system prevents fuel vapors from escaping into atmosphere. This system includes a canister, purge control solenoid valve, fuel cut valve, and the lines connecting them.
● Fuel vapors in the fuel tank is introduced into the canister through the evaporation line, and are absorbed by activated carbon in it. The fuel cut valve is also incorporated in the fuel tank line.
● The purge control solenoid valve is controlled optimally by the ECM according to the engine condition.




(1) Intake manifold
(2) Throttle body
(3) Purge control solenoid valve
(4) Engine control module (ECM)
(5) Canister
(6) Fuel tank
(7) Fuel cut valve
(8) Two-way valve

## B: FUEL CUT VALVE

The fuel cut valve is built onto the evaporation pipe of the fuel tank cap. The rising level of the fuel in the fuel tank causes the float to move up and close the cap hole so that no fuel can enter the evaporation line.

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(1) Float

**A:** To canister

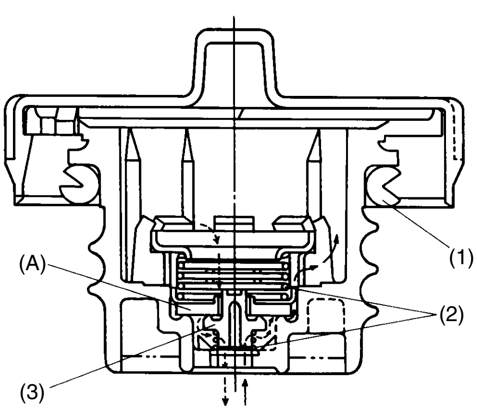
**B:** Valve open

**C:** Valve closed

## C: FUEL TANK CAP

The fuel tank cap has a relief valve which prevents development of vacuum in the fuel tank in the event of a problem with the fuel vapor line.

When there is no problem with the fuel vapor line, the filler pipe is sealed at the portion (A) and by the seal pressed against the filler pipe end. If vacuum develops in the fuel tank, the atmospheric pressure forces the spring down to open the valve; consequently outside air flows into the fuel tank, thus controlling the inside pressure.




B2H0395C

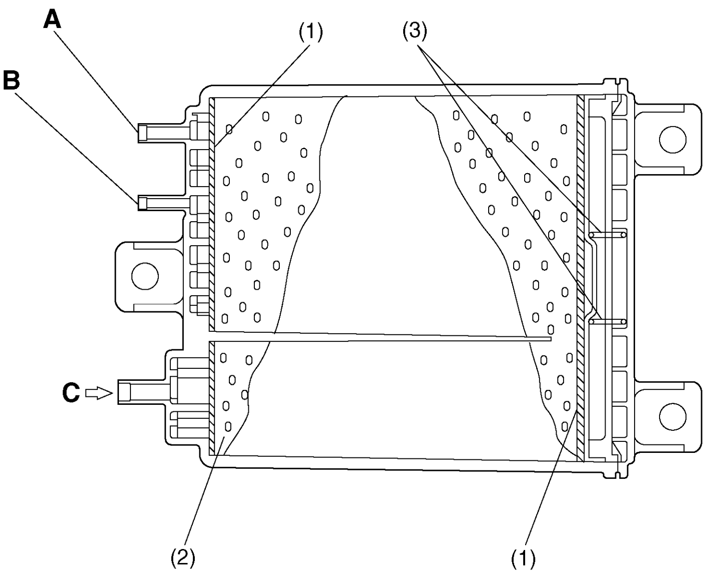
(1) Seal

(2) Spring

(3) Valve

## D: CANISTER

The charcoal filled in the canister temporarily stores fuel vapors. When the purge control solenoid valve is opened by a signal from the ECM, the external fresh air entering the canister carries the fuel vapors into the collector chamber.

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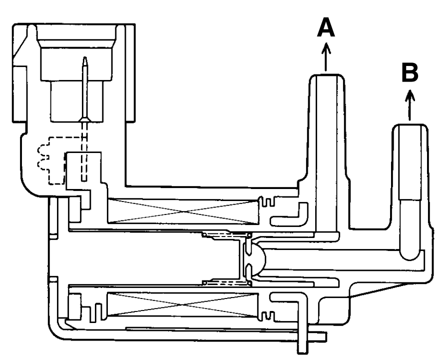
(1) Filter
(2) Activated charcoal
(3) Spring

**A:** To purge control solenoid valve
**B:** From fuel tank
**C:** Air

## E: PURGE CONTROL SOLENOID VALVE

The purge control solenoid valve is on the evaporation line between the canister and intake manifold. It is installed at the underside of intake manifold.

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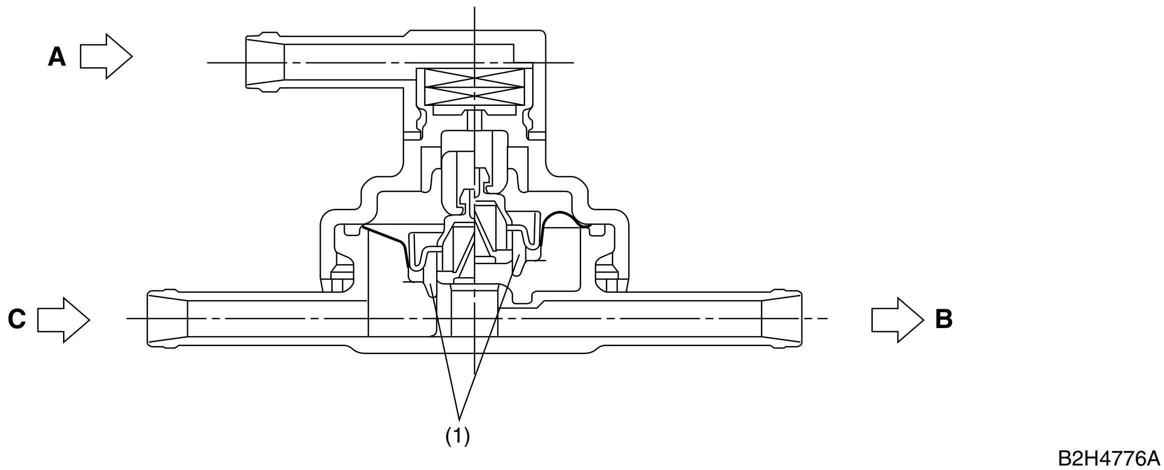
**A:** To canister
**B:** To intake manifold

## F: TWO-WAY VALVE

The two-way valve is located in the evaporation line between the fuel tank and the canister.
When the tank inside pressure becomes higher than the atmospheric pressure, the valve is opened allowing fuel vapors to be introduced into the canister.
On the other hand, when the tank inside pressure becomes lower than the atmospheric pressure, external air is taken from the canister.

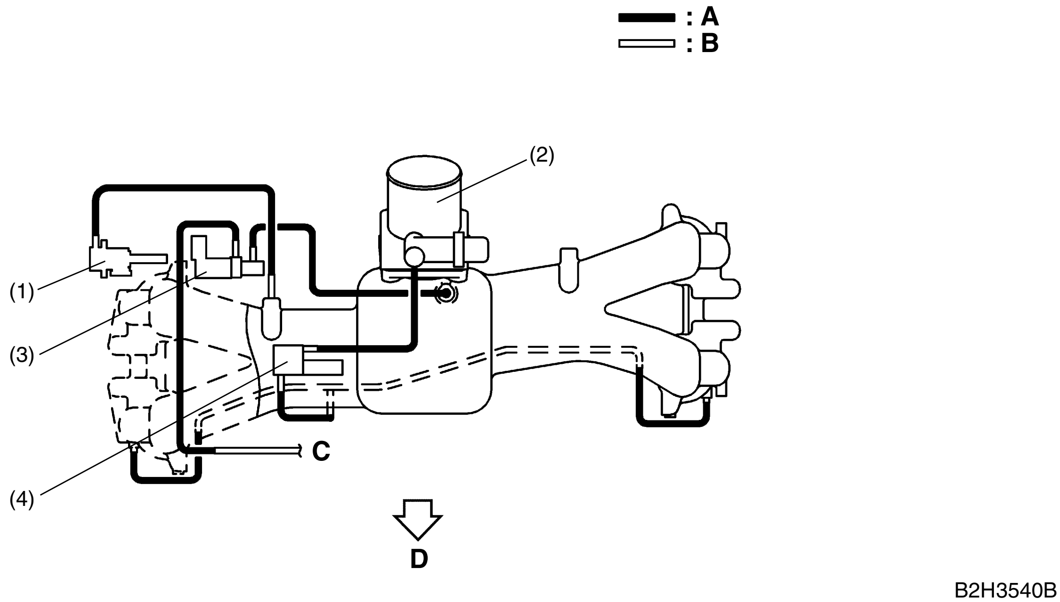



(1) Valve

**A:** Atmospheric pressure
**B:** To canister
**C:** From fuel tank

# 8. Vacuum Connections

The hose and pipe connections of the intake manifold, throttle body and other related parts are as shown in the illustration.




(1) Pressure regulator
(2) Throttle body
(3) Purge control solenoid valve
(4) Air assist injector solenoid valve

**A:** Hose
**B:** Pipe
**C:** To canister
**D:** Front of vehicle

## MEMO

# EMISSION CONTROL (AUX. EMISSION CONTROL DEVICES)

# EC (w/o OBD)

Page

# 1. System Overview

There are three emission control systems which are as follows:

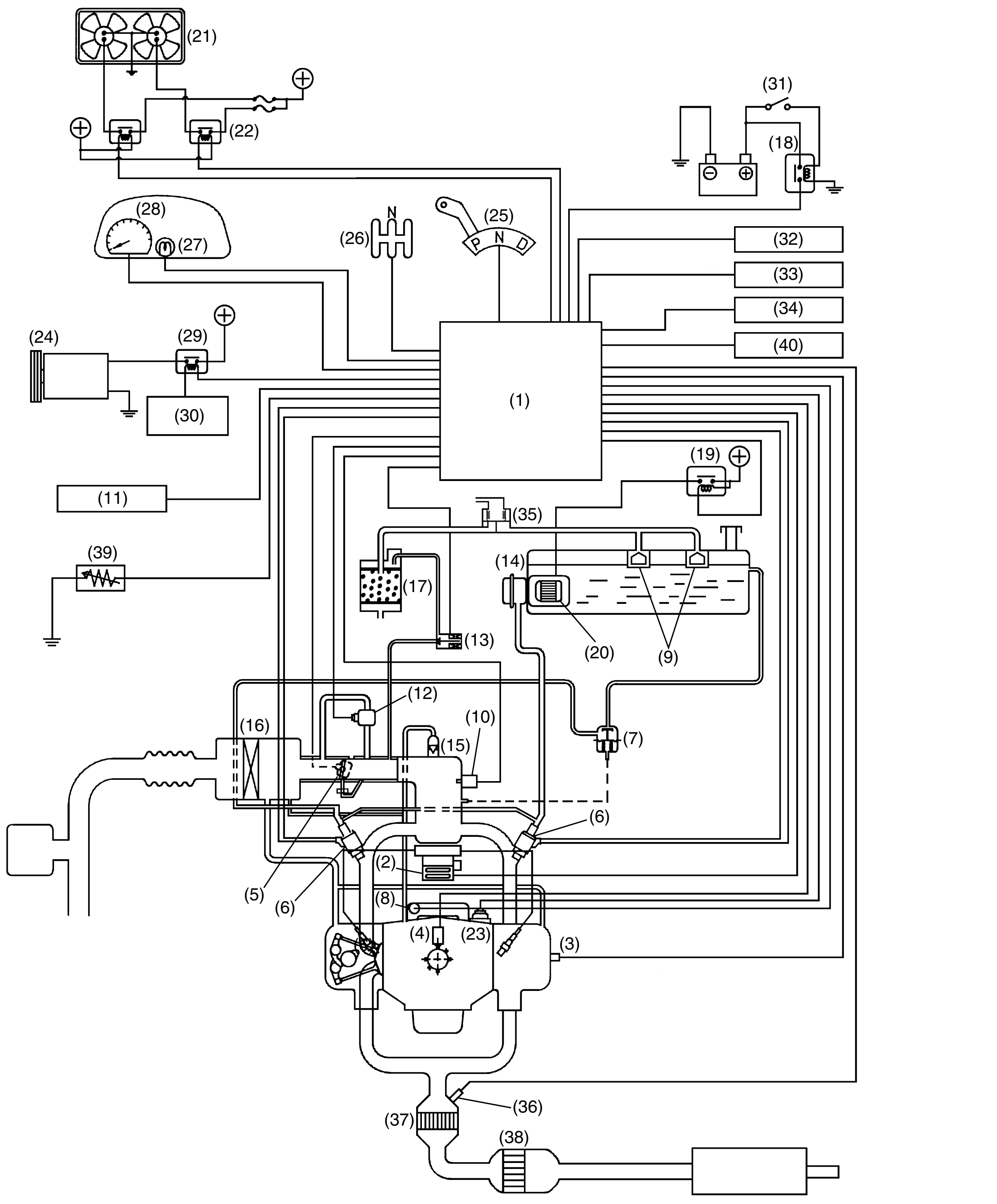
- Crankcase emission control system
- Exhaust emission control system
  - Three-way catalyst system
  - Air/fuel (A/F) control system
  - Ignition control system
- Evaporative emission control system

| Item | | | Main components | Function |
|---|---|---|---|---|
| Crankcase emission control system | | | Positive crankcase ventilation (PCV) valve | Draws blow-by gas into intake manifold from crankcase and burns it together with air-fuel mixture. Amount of blow-by gas to be drawn in is controlled by intake manifold pressure. |
| Exhaust emission control system | Catalyst system*1 | Front<br>Rear*2 | Three-way catalyst | Oxidizes HC and CO contained in exhaust gases as well as reducing NOx. |
| | A/F control system | | Engine control module (ECM) | Receives input signals from various sensors, compares signals with stored data, and emits a signal for optimal control of air-fuel mixture ratio. |
| | | | Oxygen sensor*1 | Detects density of oxygen contained exhaust gases. |
| | | | Throttle position sensor | Detects throttle position. |
| | | | Intake air temperature and pressure sensor | Detects absolute pressure of intake manifold. |
| | | | | Detects intake air temperature of intake manifold. |
| | Ignition control system | | ECM | Receives various signals, compares signals with basic data stored in memory, and emits a signal for optimal control of ignition timing. |
| | | | Crankshaft position sensor | Detects engine speed (Revolution). |
| | | | Camshaft position sensor | Detects reference signal for combustion cylinder discrimination. |
| | | | Engine coolant temperature sensor | Detects coolant temperature. |
| | | | Knock sensor | Detects engine knocking. |
| Evaporative emission control system | | | Canister | Absorbs evaporative gas which occurs in fuel tank when engine stops, and releases it to combustion chambers for a complete burn when engine is started. This prevents HC from being discharged into atmosphere. |
| | | | Purge control solenoid valve | Receives a signal from ECM and controls purge of evaporative gas absorbed by canister. |

*1: With catalyst model
*2: Except Australia outback model

**MEMO**

# 2. Schematic Diagrams



(1) Engine control module (ECM)
(2) Ignition coil and ignitor assembly
(3) Camshaft position sensor
(4) Crankshaft position sensor
(5) Throttle position sensor
(6) Fuel injectors
(7) Pressure regulator
(8) Engine coolant temperature sensor
(9) Fuel cut valve
(10) Intake air temperature and pressure sensor
(11) Power steering pressure switch
(12) Idle air control solenoid valve
(13) Purge control solenoid valve
(14) Fuel pump
(15) PCV valve
(16) Air cleaner element
(17) Canister
(18) Main relay
(19) Fuel pump relay
(20) Fuel filter
(21) Radiator fan
(22) Radiator fan relay
(23) Knock sensor
(24) A/C compressor
(25) Inhibitor switch (AT vehicle only)
(26) Neutral switch (MT vehicle only)
(27) CHECK ENGINE malfunction indicator lamp (MIL)
(28) Tachometer
(29) A/C relay
(30) A/C control module
(31) Ignition switch
(32) Vehicle speed sensor
(33) Data link connector
(34) Power steering fluid pressure switch
(35) Two-way valve
(36) Oxygen sensor *1
(37) Front catalytic converter *1
(38) Rear catalytic converter *1, *2
(39) CO resister (General spec. vehicles only)
(40) Transmission control module (TCM) (AT vehicle only)

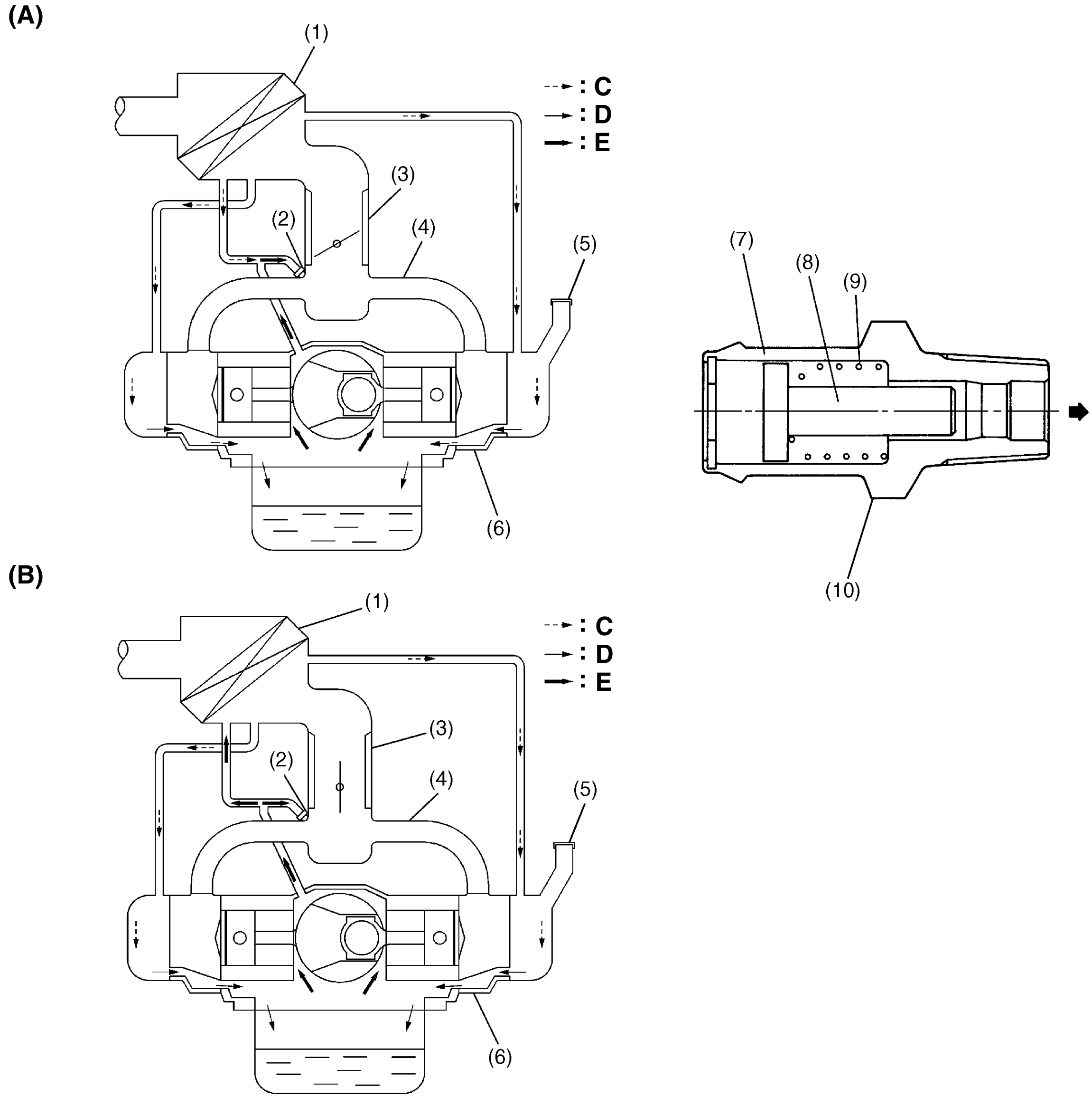
*1: With catalyst model
*2: Except Australia outback model

# 3. Crankcase Emission Control System

● The positive crankcase ventilation (PCV) system prevents air pollution which will be caused by blow-by gas being emitted from the crankcase.
The system consists of a sealed oil filler cap, rocker covers with fresh air inlet, connecting hoses, a PCV valve and an air intake duct.

● In a part-throttle condition, the blow-by gas in the crankcase flows into the intake manifold through the connecting hose of crankcase and PCV valve by the strong vacuum created in the intake manifold. Under this condition, fresh air is introduced into the crankcase through the connecting hose of the rocker cover.

● In a wide-open-throttle condition, a part of blow-by gas flows into the air intake duct through the connecting hose and is drawn into the throttle chamber, because under this is condition, the intake manifold vacuum is not strong enough to introduce through the PCV valve all blow-by gases that increase in the amount with engine speed.

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| | | | | | |
|---|---|---|---|---|---|
| (1) | Air cleaner case | (6) | Crankcase | **(A)** | Part-throttle condition |
| (2) | PCV valve | (7) | Case | **(B)** | Wide-open-throttle condition |
| (3) | Throttle body | (8) | Valve | **C:** | Fresh air |
| (4) | Intake manifold | (9) | Spring | **D:** | Mixture of air and blow-by gas |
| (5) | Oil filler cap | (10) | PCV valve | **E:** | Blow-by gas |

# 4. Three-way Catalyst (with Catalyst Model)

- The basic material of three-way catalyst is platinum (Pt), rhodium (Rh) and palladium (Pd), and a thin coat of their mixture is applied onto honeycomb or porous ceramics of an oval shape (carrier). To avoid damaging the catalyst, only unleaded gasoline should be used.
- The catalyst reduces HC, CO and NOx in exhaust gases through chemical reactions (oxidation and reduction). These harmful components are reduced most efficiently when their concentrations are in a certain balance. These concentrations vary with the air-fuel ratio. The ideal air-fuel ratio for reduction of these components is the stoichiometric ratio.
- Therefore, the air-fuel ratio needs to be controlled to around the stoichiometric ratio to purify the exhaust gases most efficiently.

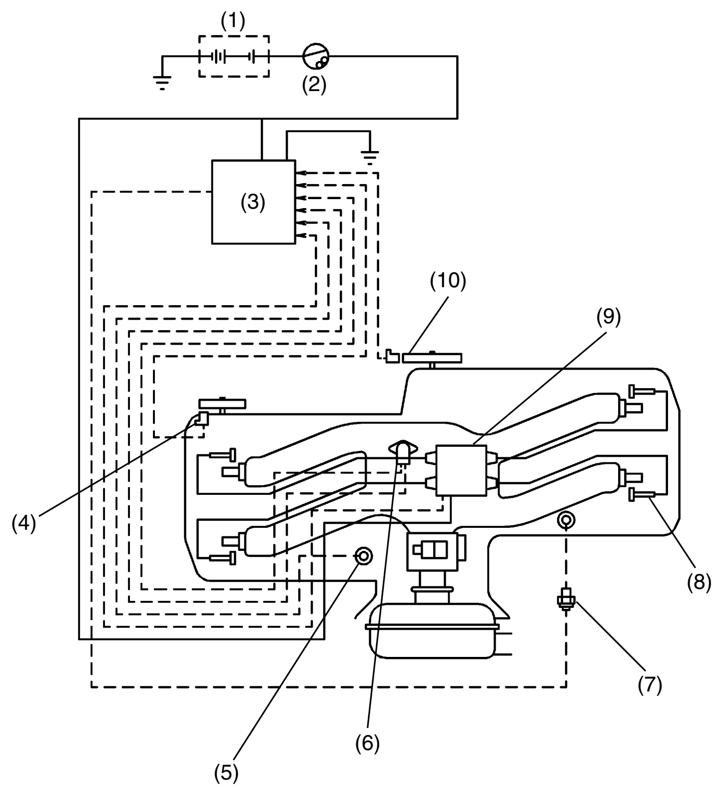
## 5. A/F Control System (with Catalyst Model)

- The air/fuel (A/F) control system makes a correction to the basic fuel injection duration in accordance with the signal from the front oxygen sensor so that the stoichiometric ratio is maintained, thus ensuring most effective exhaust gas purification by the three-way catalyst. Different basic fuel injection durations are preset for various engine speeds and loads, as well as the amount of intake air.
- This system also has a “learning” control function which stores the corrected data in relation to the basic fuel injection in the memory map. This allows an appropriate air-fuel ratio correction to be added automatically in quick response to any situation that requires such an effect. Thus, the air-fuel ratio is optimally maintained under various conditions while purifying exhaust gases most effectively, improving driving performance and compensating for changes in sensors’ performance over time.

# 6. Ignition Control System

● The ignition system is controlled by the ECM.
The ECM monitors the operating condition of the engine using the signals from the sensors and switches shown below and determines the ignition timing most appropriate for each engine operating condition. Then it sends a signal to the ignitor, commanding generation of a spark at that timing.

● The ECM uses a preprogrammed map for a “closed-loop” control which provides its ignition timing control with excellent transient characteristics, i.e., highly responsive ignition timing control.

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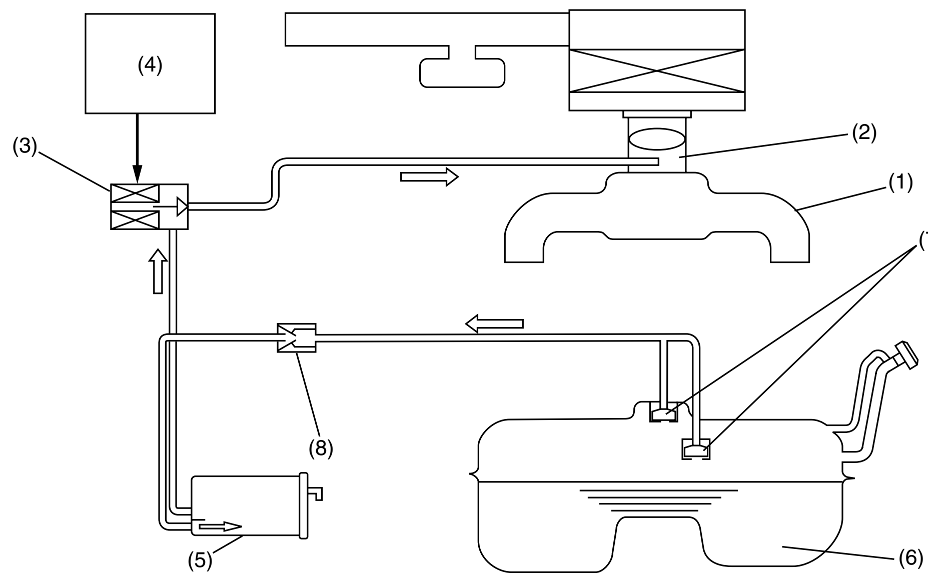
| | | | |
|---|---|---|---|
| (1) | Battery | (6) | Intake air temperature and pressure sensor |
| (2) | Ignition switch | (7) | Engine coolant temperature sensor |
| (3) | ECM | (8) | Spark plug |
| (4) | Camshaft position sensor | (9) | Ignition coil and ignitor assembly |
| (5) | Knock sensor | (10) | Crankshaft position sensor |

# 7. Evaporative Emission Control System

## A: GENERAL

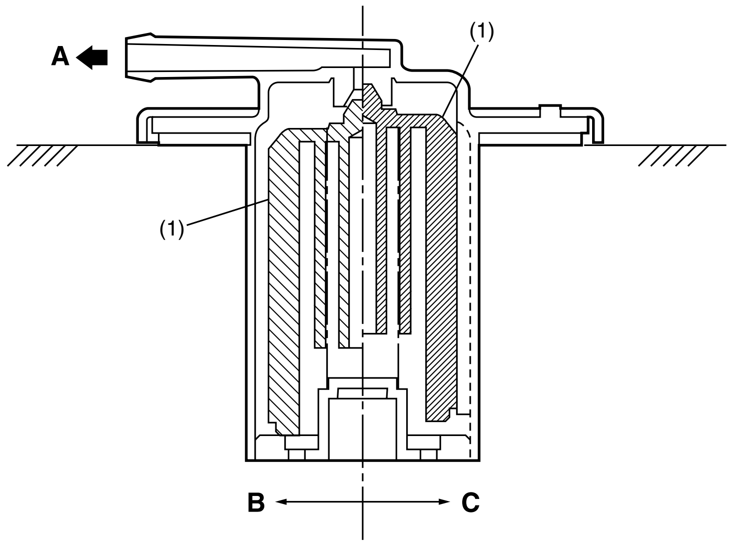
● The evaporative emission control system prevents fuel vapors from escaping into atmosphere. This system includes a canister, purge control solenoid valve, fuel cut valve, and the lines connecting them.
● Fuel vapors in the fuel tank is introduced into the canister through the evaporation line, and are absorbed by activated carbon in it. The fuel cut valve is also incorporated in the fuel tank line.
● The purge control solenoid valve is controlled optimally by the ECM according to the engine condition.




(1) Intake manifold
(2) Throttle body
(3) Purge control solenoid valve
(4) Engine control module (ECM)
(5) Canister
(6) Fuel tank
(7) Fuel cut valve
(8) Two-way valve

## B: FUEL CUT VALVE

The fuel cut valve is built onto the evaporation pipe of the fuel tank cap. The rising level of the fuel in the fuel tank causes the float to move up and close the cap hole so that no fuel can enter the evaporation line.




B2H3342D

(1) Float

**A:** To canister

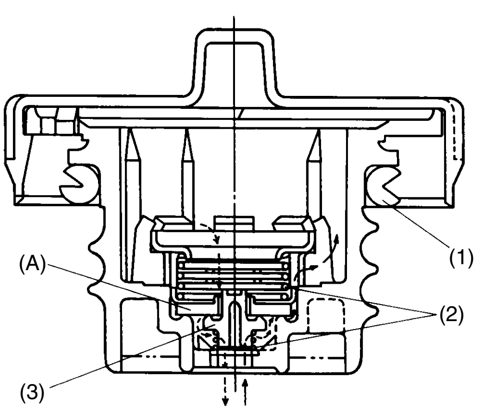
**B:** Valve open

**C:** Valve closed

## C: FUEL TANK CAP

The fuel tank cap has a relief valve which prevents development of vacuum in the fuel tank in the event of a problem with the fuel vapor line.

When there is no problem with the fuel vapor line, the filler pipe is sealed at the portion (A) and by the seal pressed against the filler pipe end. If vacuum develops in the fuel tank, the atmospheric pressure forces the spring down to open the valve; consequently outside air flows into the fuel tank, thus controlling the inside pressure.




B2H0395C

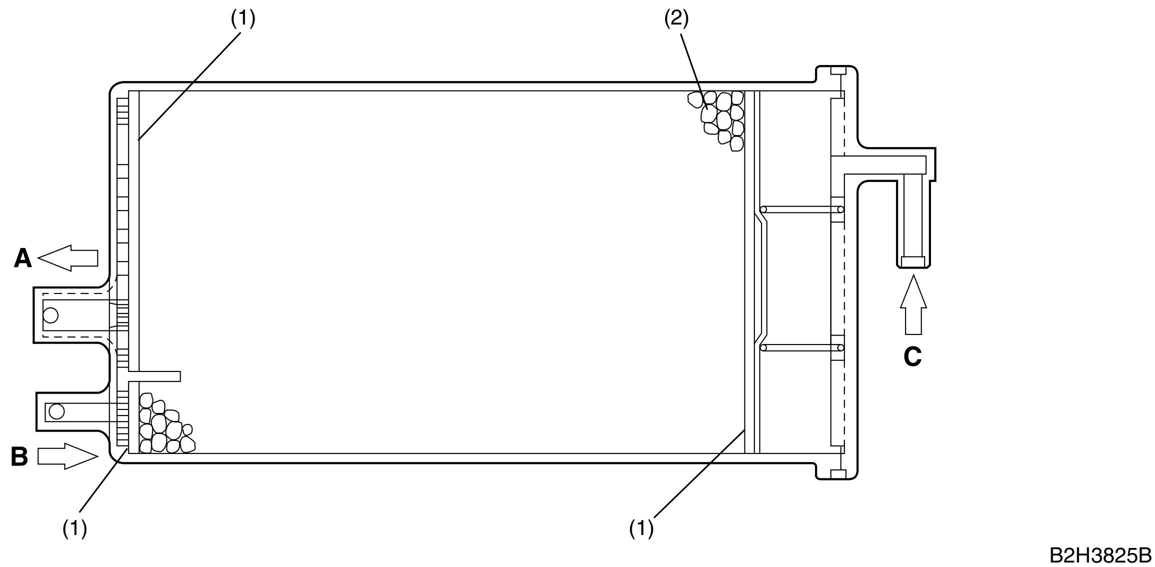
(1) Seal

(2) Spring

(3) Valve

## D: CANISTER

The charcoal filled in the canister temporarily stores fuel vapors. When the purge control solenoid valve is opened by a signal from the ECM, the external fresh air entering the canister carries the fuel vapors into the collector chamber.

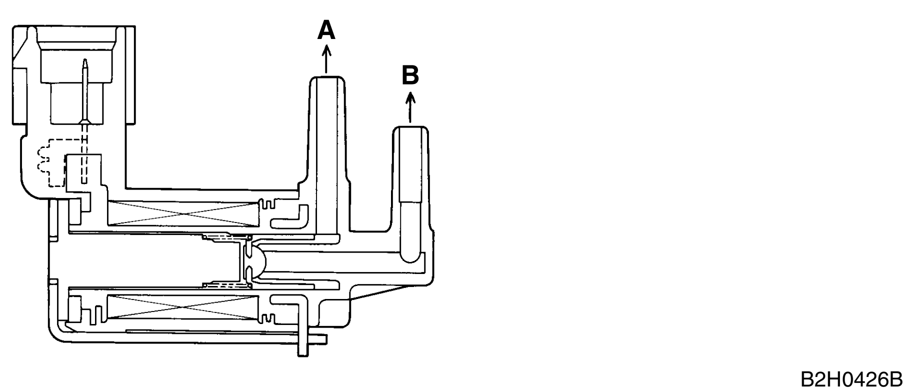



(1) Filter
(2) Activated charcoal

**A:** To purge control solenoid valve
**B:** From fuel tank
**C:** Air

## E: PURGE CONTROL SOLENOID VALVE

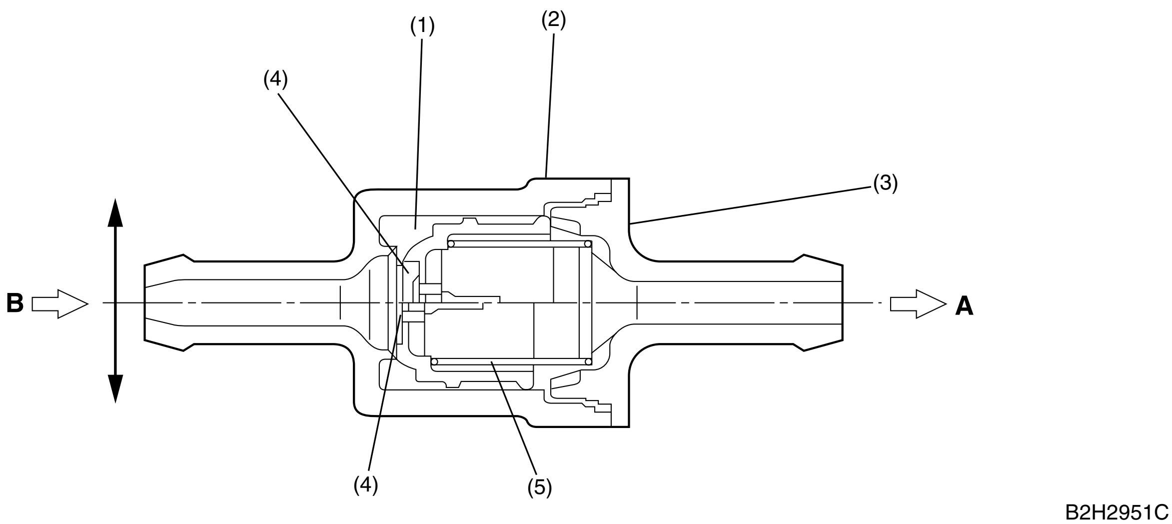
The purge control solenoid valve is on the evaporation line between the canister and throttle body. It is installed at the underside of intake manifold.




**A:** To canister
**B:** To throttle body

## F: TWO-WAY VALVE

The two-way valve is located in the evaporation line between the fuel tank and the canister.
When the tank inside pressure becomes higher than the atmospheric pressure, the valve is opened allowing fuel vapors to be introduced into the canister.
On the other hand, when the tank inside pressure becomes lower than the atmospheric pressure, external air is taken from the canister.

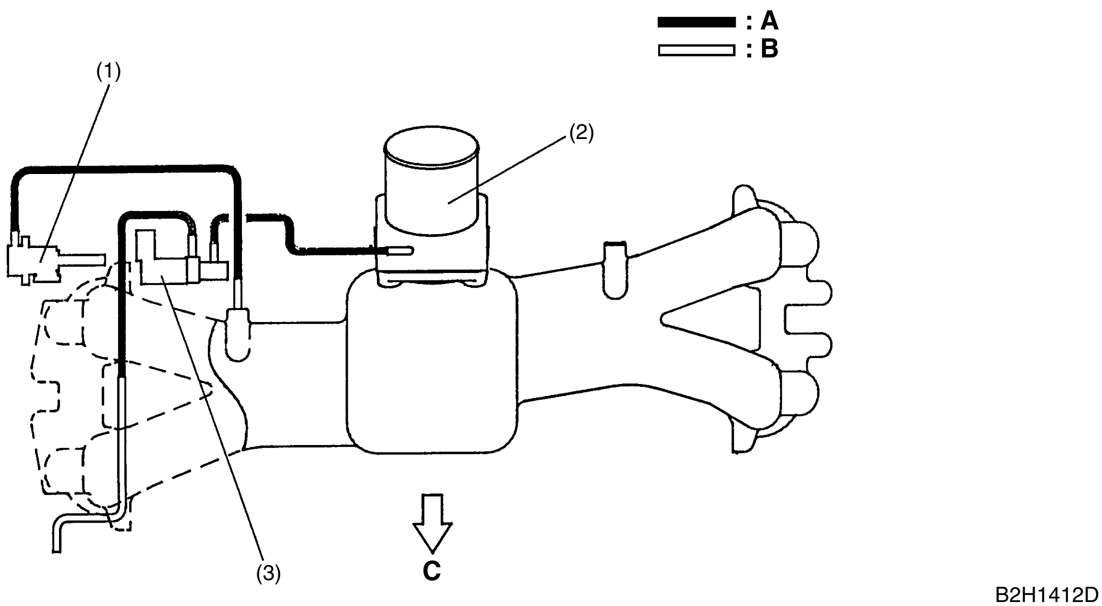



(1) Valve
(2) Body
(3) Cap
(4) Pressure valve
(5) Spring

**A:** To canister
**B:** From fuel tank

# 8. Vacuum Connections

The hose and pipe connections of the intake manifold, throttle body and other related parts are as shown in the illustration.




(1) Pressure regulator
(2) Throttle body
(3) Purge control solenoid valve

**A:** Hose
**B:** Pipe
**C:** Front of vehicle

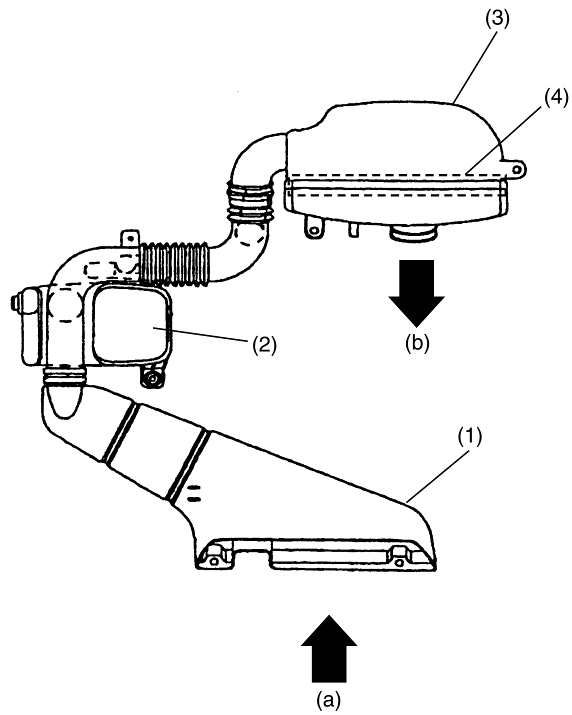
## MEMO

# INTAKE (INDUCTION) IN

**Page**

# 1. General

The intake system consists of an air intake duct, a resonator chamber, and an air cleaner element housed in its case. The resonator, located upstream of the air cleaner case, effectively reduces the intake noise level.




B2H3977A

| | | | |
|---|---|---|---|
| (1) | Air intake duct | (a) | Fresh air |
| (2) | Resonator chamber | (b) | To throttle body |
| (3) | Air cleaner case | | |
| (4) | Air cleaner element | | |

# MECHANICAL ME

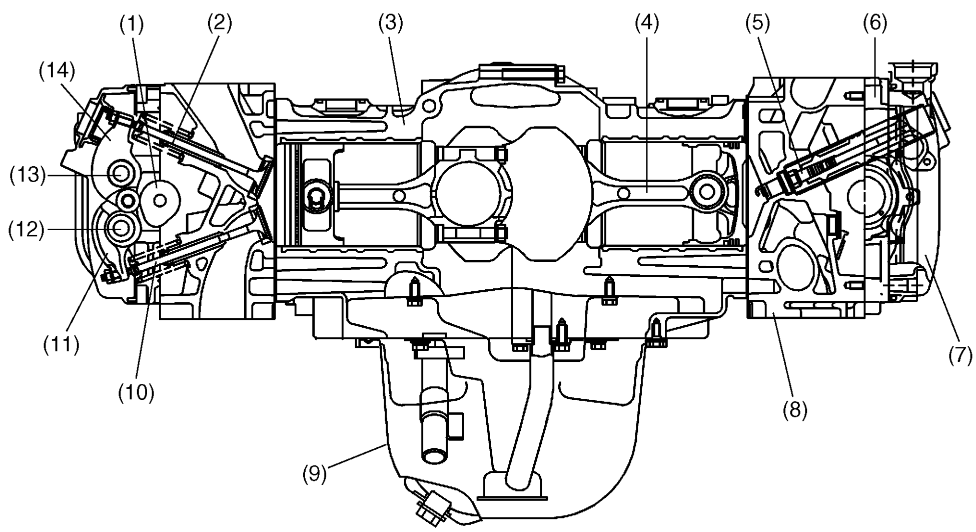
Page

# 1. General

The engine used in this vehicle is of a horizontally opposed, four-cylinder design. This four-stroke-cycle, water-cooled, SOHC engine uses a total of 16 valves and its main components are made of aluminum alloy. It is fueled by a multiple fuel injection system.

The engine's major structural and functional features are as follows:

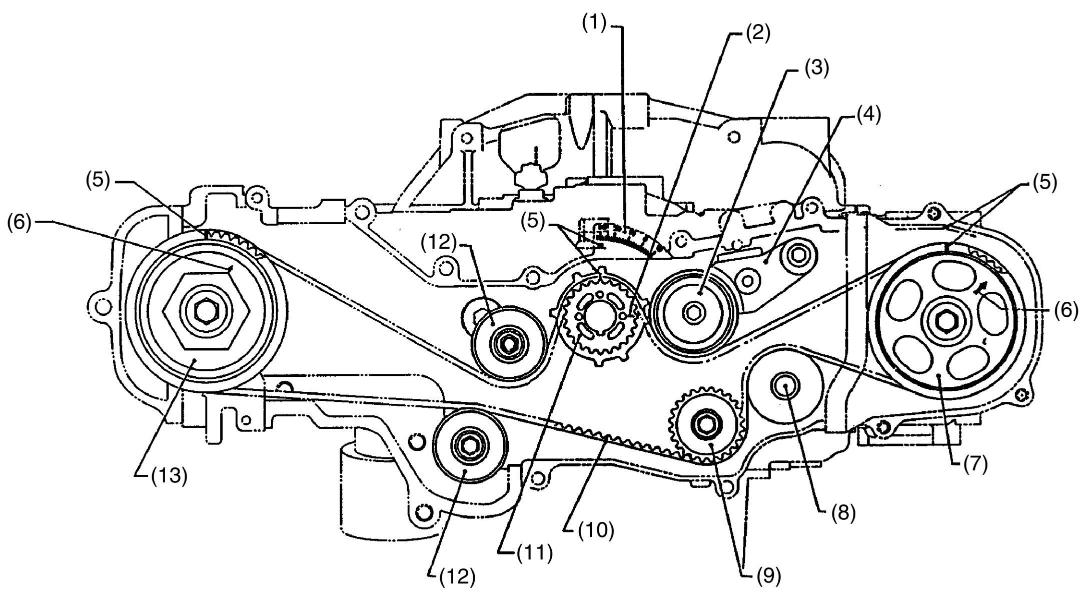
- The cylinder head forms pentroof combustion chambers, each having a spark plug located at its center and two each of intake and exhaust valves (four valves per cylinder). The intake and exhaust ports are located in a cross-flow arrangement.
- There are a screw and nut at the valve end of each rocker arm. They are used for adjusting the valve clearance.
- A single timing belt drives two camshafts on the left and right banks and the engine coolant pump on the left bank. Belt tension is automatically adjusted by a belt tension adjuster, eliminating need for a manual adjustment.
- The crankshaft is supported by five bearings with high rigidity and strength.
- The cylinder block is an aluminum die casting fitted with iron die-cast cylinder liners.




| | | | | | |
|---|---|---|---|---|---|
| (1) | Camshaft | (6) | Camshaft cap | (11) | Exhaust rocker arm |
| (2) | Intake valve | (7) | Valve rocker cover | (12) | Exhaust rocker shaft |
| (3) | Cylinder block | (8) | Cylinder head | (13) | Intake rocker shaft |
| (4) | Connecting rod | (9) | Oil pan | (14) | Intake rocker arm |
| (5) | Spark plug | (10) | Exhaust valve | | |

## 2. Timing Belt

- A single timing belt drives two camshafts (one in the left bank and one in the right bank). The belt also drives the water pump by its non-toothed side.
- The timing belt teeth have a specially designed round profile which contributes to quiet operation. The timing belt is made of strong and inflexible core cords, wear-resistant canvas and heat-resistant rubber material.
- A hydraulic automatic belt tension adjuster always keeps the belt taut to the specified tension. Any manual belt tension adjustment is unnecessary.




NF0040

| | | | |
|---|---|---|---|
| (1) | Timing indicator (For timing mark of crankshaft pulley) | (8) | Water pump pulley |
| (2) | *Piston position mark | (9) | Idler No.2 |
| (3) | Belt tension pulley | (10) | Timing belt |
| (4) | Automatic belt tension adjuster | (11) | Crankshaft sprocket |
| (5) | Alignment mark | (12) | Idler |
| (6) | **Piston position mark | (13) | Camshaft sprocket RH |
| (7) | Camshaft sprocker LH | | |

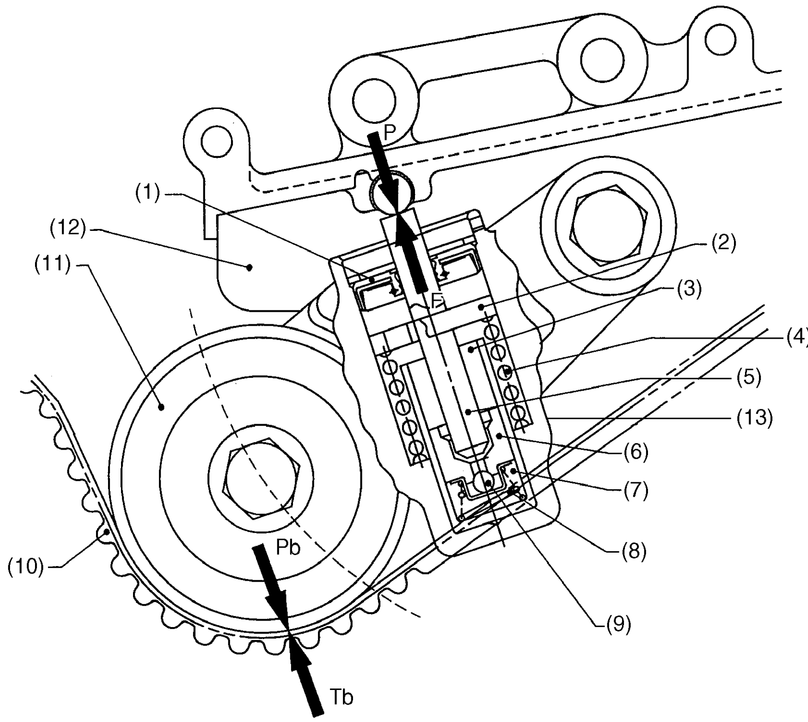
NOTE:

*: The #1 piston is at TDC when the piston position mark on the crankshaft sprocket is aligned with the timing mark on the cylinder block.

**: The #1 piston is at TDC on the compression stroke when the piston position mark on the camshaft sprocket is aligned with the timing mark on the belt cover.

# 3. Automatic Belt Tension Adjuster

The automatic belt tension adjuster consists of a tensioner unit and a bracket. It maintains the timing belt tension automatically at a specified level to enable the belt to transmit power correctly, reduce operating noise and increase the life of the belt.
The cylinder of the tensioner unit incorporates an adjuster rod, wear ring, plunger spring, return spring, check ball and silicone oil.
The automatic belt tension adjuster gives tension to the belt by a levering action which is produced by the push force of the tensioner unit's adjuster rod. It operates in the process detailed below.




NF0368

(1) Oil seal
(2) Wear ring
(3) Oil reservoir chamber
(4) Return spring
(5) Adjuster rod
(6) Plunger
(7) Oil pressure chamber
(8) Plunger spring
(9) Check ball
(10) Timing belt
(11) Belt tension pulley
(12) Tensioner bracket
(13) Cylinder

- Timing belt tensioning action

When the belt becomes slack, the adjuster rod is pushed upward by the return spring. The oil in the reservoir chamber, which is pressurized by the plunger spring to a certain level, pushes open the check ball and flows into the oil pressure chamber to keep the pressure constant.
The thrust force F resulting from extension of the adjuster rod applies a counterclockwise torque to the tensioner bracket, which causes the belt tension pulley at its end to turn in the same direction. This applies tensioning pressure Pb to the timing belt.

- Timing belt tension balancing action

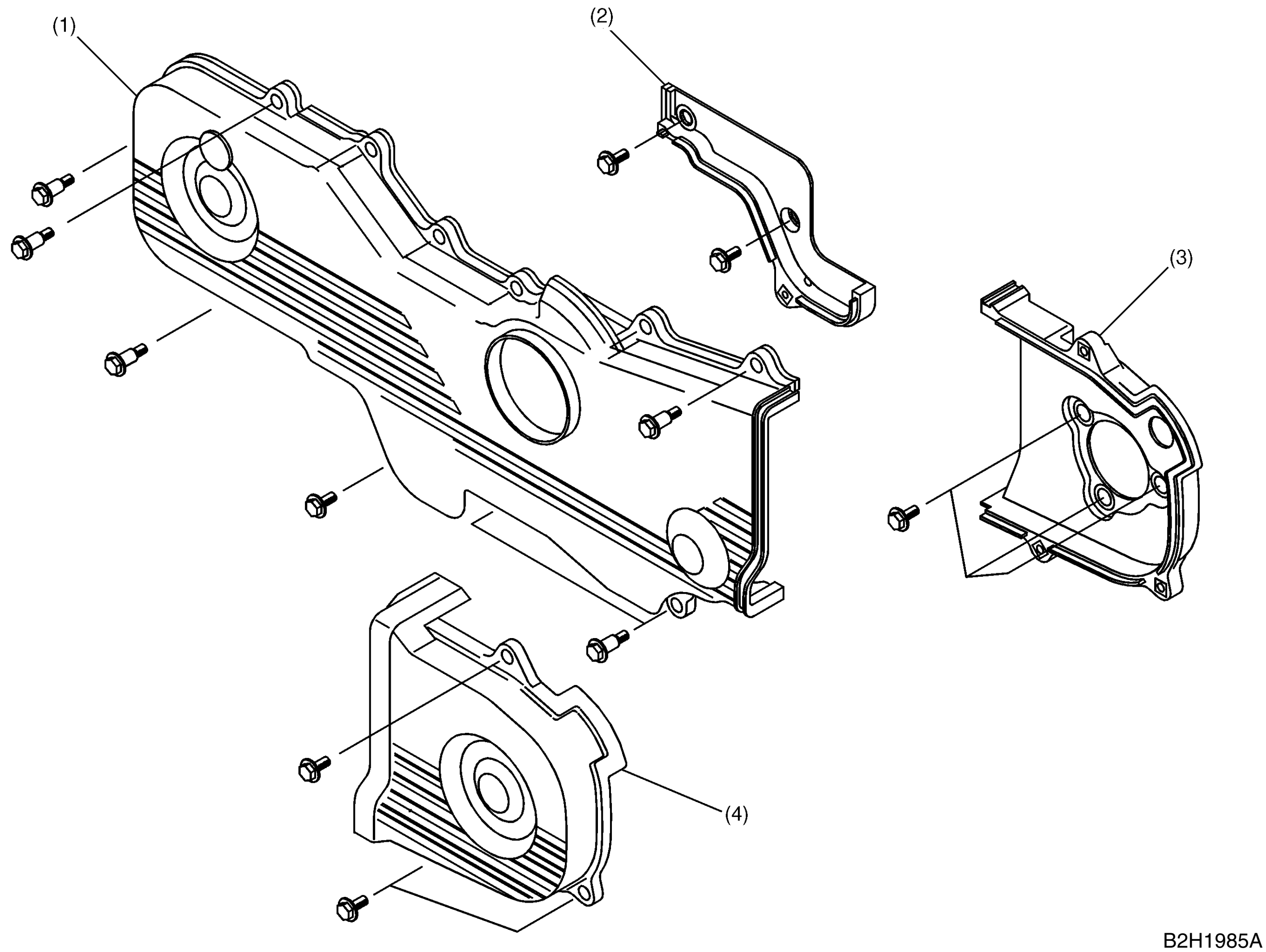
When the belt tension pulley is pushed against the timing belt with pressure Pb, reaction force Tb of the timing belt generates the reaction force P at the point on which the adjustor rod force is acting.
This force P pushes the adjuster rod until it balances with the sum of the thrust force F and the pressure of the oil in the oil pressure chamber. Therefore, the timing belt tension is kept constant.

- Overtension correction action

If the tension of the timing belt increases excessively, the force P becomes larger than the thrust force F and silicone oil is returned from the oil pressure chamber to the reservoir chamber little by little until the force P balances again with the thrust force F. Thus the timing belt tension is maintained at the specified level at all times.

# 4. Belt Cover

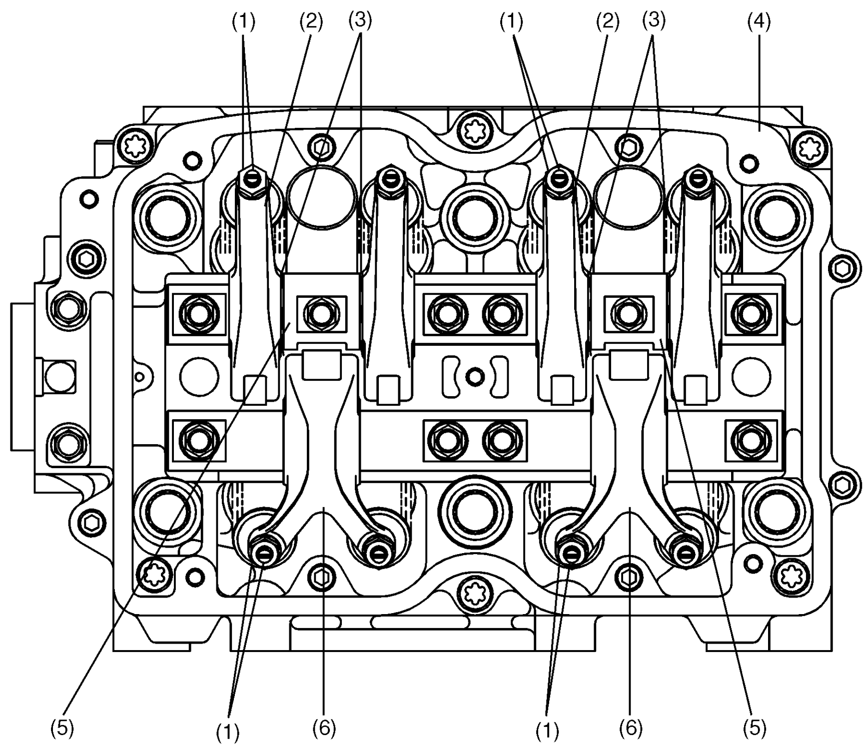
- The belt cover is made of lightweight, heat resistant synthetic resin molding. It constitutes a totally enclosed housing with its cylinder block mating edges sealed with rubber gaskets. This effectively protects the inside components from dust and liquid.
- Rubber seals used between the cylinder block and the belt cover effectively reduces transmission of noise and vibration.
- The front belt cover has a line mark for ignition-timing checking.




(1) Front belt cover
(2) Belt cover No. 2 (RH)
(3) Belt cover No. 2 (LH)
(4) Belt cover (LH)

# 5. Valve Rocker Assembly

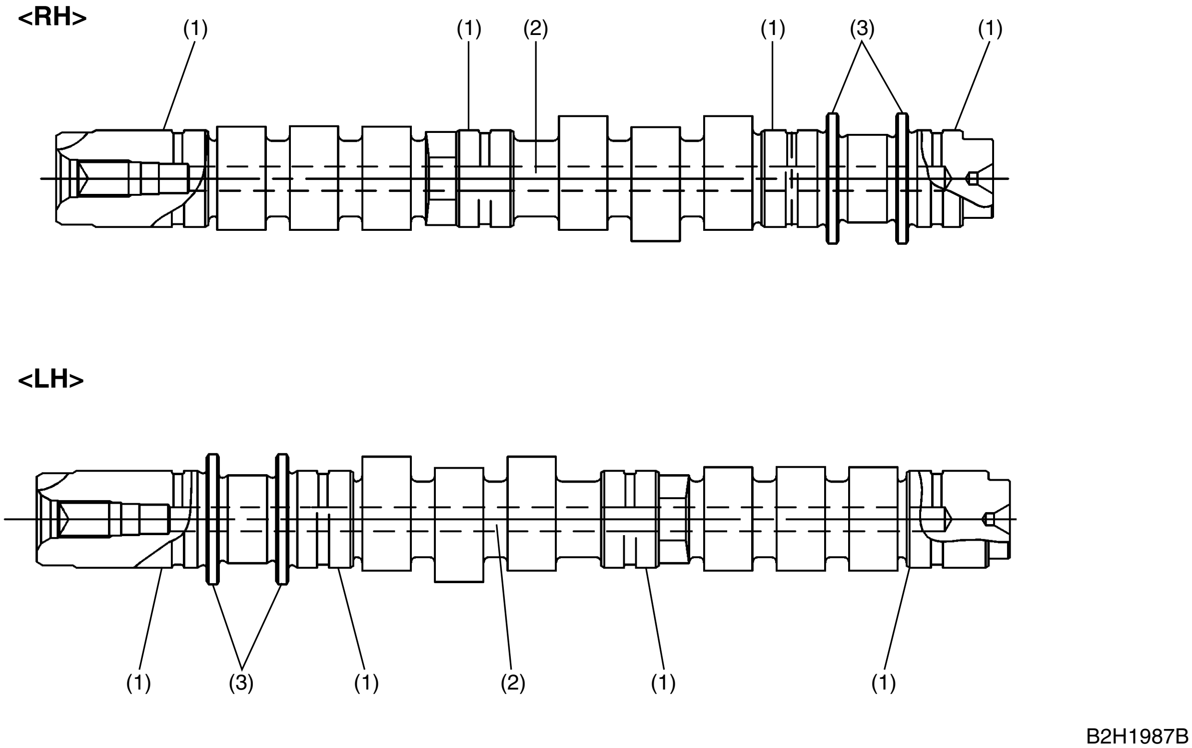
- The intake valve rocker arms and the exhaust valve rocker arms are installed on their own rocker shafts both of which are retained by the camshaft caps.
- The valve end of each rocker arm is provided with valve rocker adjusting screw and nut. Turning of this screw adjusts the valve clearance.
- The exhaust valve rocker arms are Y-shaped, and each arm operates two exhaust valves simultaneously.
- Each rocker shaft has an oil passage in it.




| | | | |
|---|---|---|---|
| (1) | Valve rocker adjusting screw and nut | (4) | Camshaft cap |
| (2) | Intake valve rocker arm | (5) | Supporter |
| (3) | Wave washer | (6) | Exhaust valve rocker arm |

# 6. Camshaft

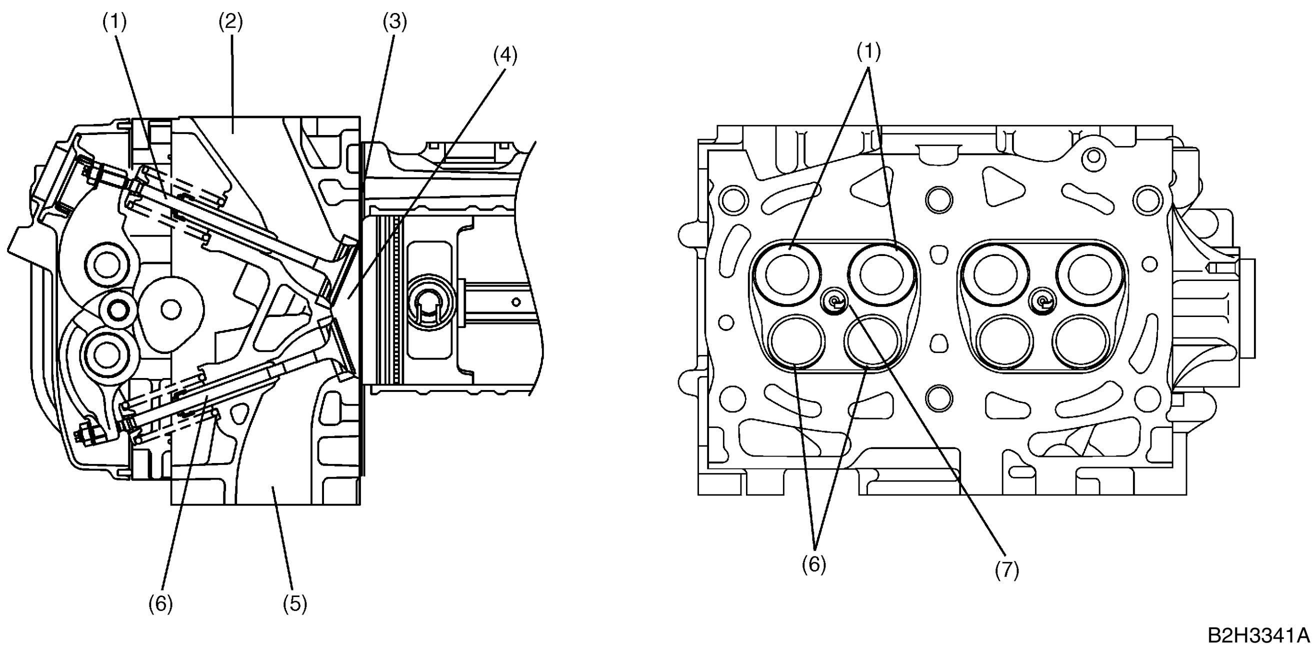
- The camshaft is supported inside the cylinder head at four journals.
- The two flanges on each camshaft supports thrust forces to limit the end play of the camshaft within the tolerance.
- Each camshaft has an oil passage in it.




(1) Journal
(2) Oil passage
(3) Shaft flange

# 7. Cylinder Head

- The cylinder head is made of aluminium die casting.
- Each combustion chamber in the cylinder head is a compact, pentroof design. The spark plug is located at the center of the combustion chamber, which contributes to creation of a wide “squish area” for increased combustion efficiency.
- The two intake and two exhaust valves are arranged on opposite sides for a cross-flow feature.
- The cylinder head gasket is a metallic gasket consisting of three layers of the stainless steel sheets. It is highly resistant to heat and maintains high level of sealing performance for a long period.




(1) Intake valve
(2) Intake port
(3) Squish area
(4) Combustion chamber
(5) Exhaust port
(6) Exhaust valve
(7) Spark plug

# 8. Cylinder Block

● The cylinder block is made of aluminum die casting. Its open-deck design provides it with such advantageous features as relatively small weight, high rigidity and excellent cooling efficiency.

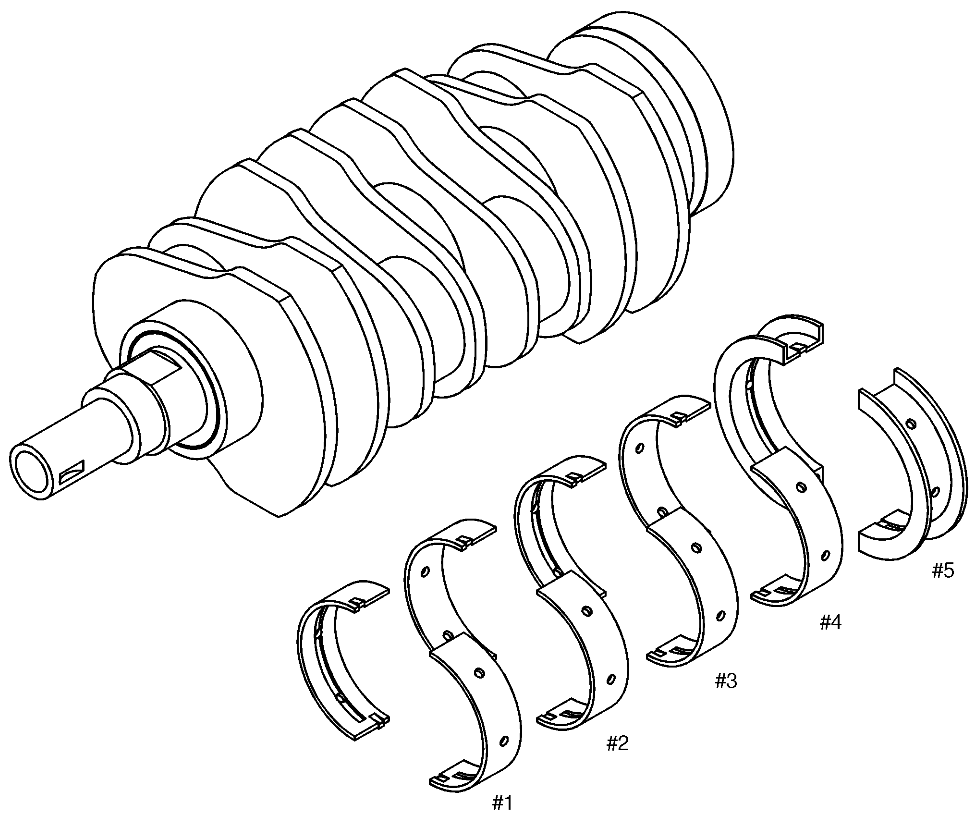
● The cylinder liners are made of cast iron. They are dry type which means their outer surfaces are entirely in contact with the cylinder block.

● The cylinder block supports the crankshaft at its five journals. The journal supporting portions are designed such that sufficient stiffness and quiet operation are ensured.

● The oil pump is located in the front center of the cylinder block and the engine coolant pump is located at the front of the left-cylinder bank. At the rear of the right-cylinder bank is an oil separator which removes oil mist contained in blow-by gas.

# 9. Crankshaft

The crankshaft is supported in the cylinder block by five bearings. Each corner formed by a journal or pin and a web is finished by fillet-rolling method which increases strength of that area. The five crankshaft bearings are made of aluminum alloy and the No. 5 bearing is provided with a flanged metal to support thrust forces.




B2H1978A

# 10.Piston

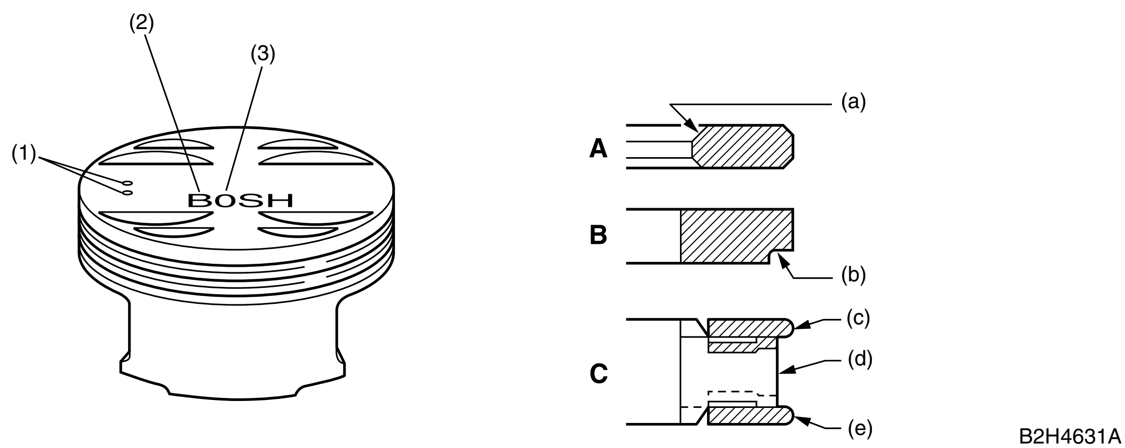
● The pistons are of a slipper skirt design for reduced weight and friction. The oil control ring groove utilizes a thermal design.

● The piston pin is offset either downward (Nos. 1 and 3 pistons) or upward (Nos. 2 and 4 pistons).

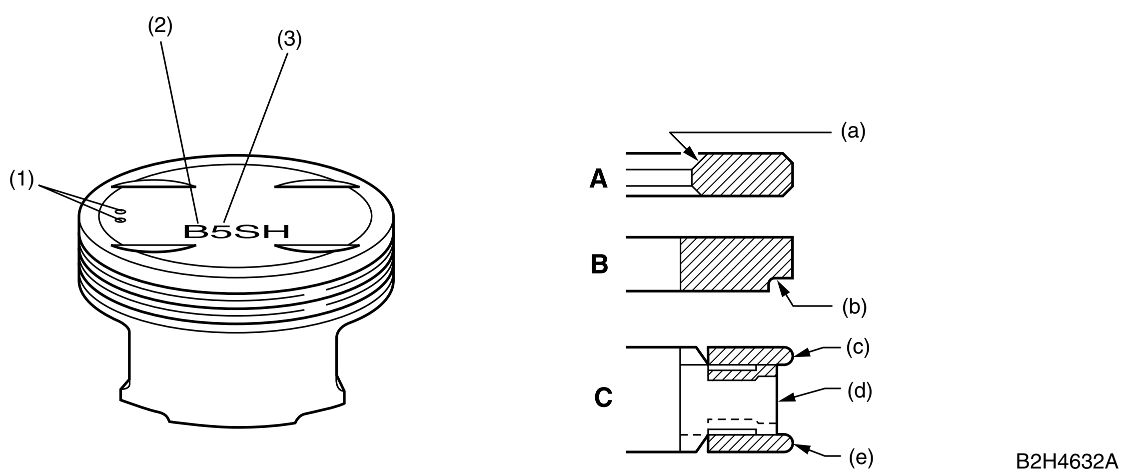
● The piston head has recesses to prevent interference with the intake and exhaust valves. It also has engraved marks to identify the piston size and the direction of installation. All the pistons are common in their design.

● Three piston rings are used for each piston – two compression rings and one oil control ring. The top piston ring has inner bevels and the second piston ring has an interrupt (cut) on the bottom outside to reduce oil consumption.

**2000 cc model**




**2500 cc model**



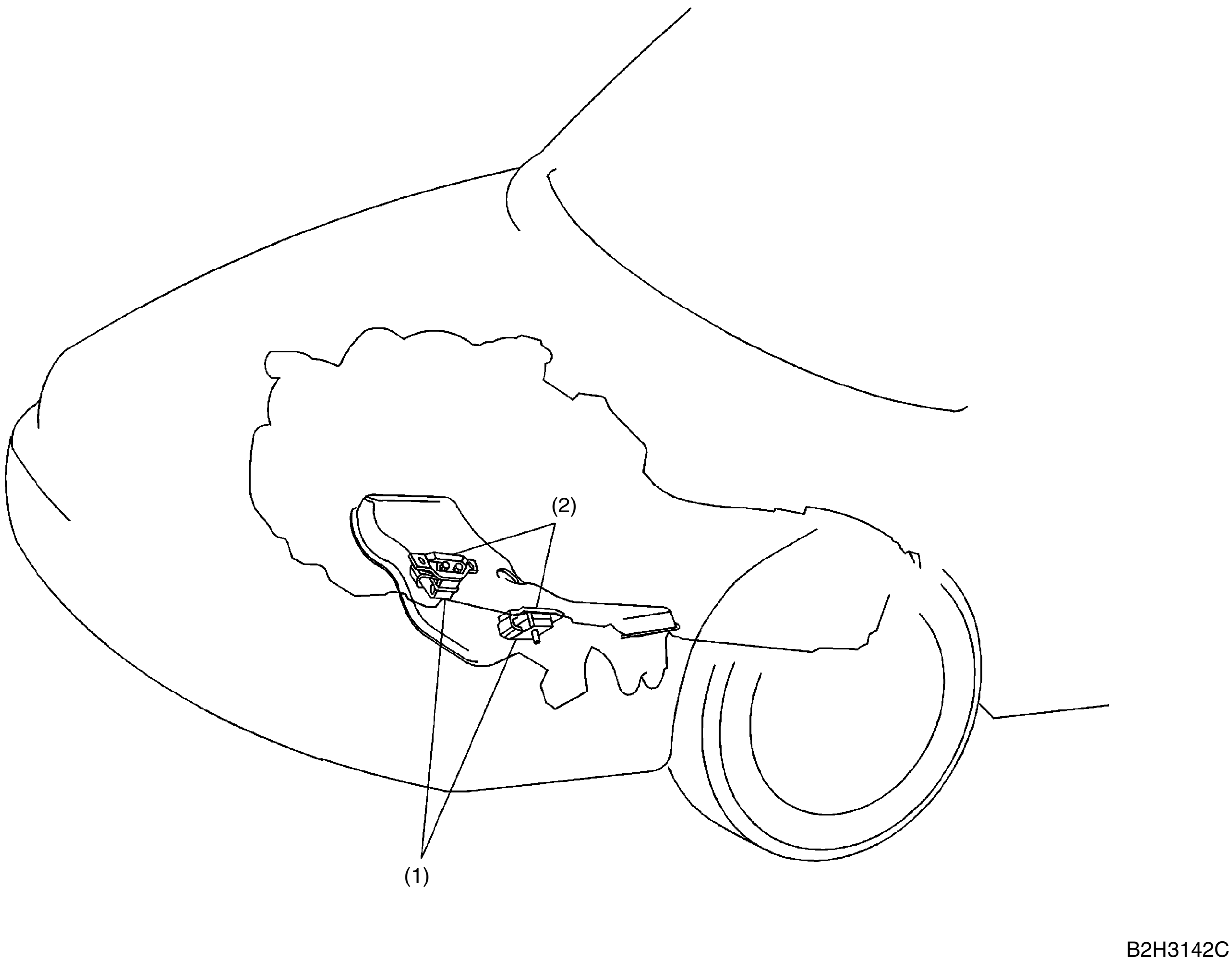

(1) Location mark (Engine front side)
(2) Identification mark (Piston size)
(3) Engine capacity

**A:** Top ring
**B:** Second ring
**C:** Oil ring

(a) Inner-bevel
(b) Interrupt (cut)
(c) Upper rail
(d) Expander
(e) Lower rail

# 11.Engine Mounting

## A: 2000 cc MODEL




(1) Cushion rubber
(2) Bracket

## B: 2500 cc MODEL


(1) Cushion rubber

# EXHAUST EX

**Page**

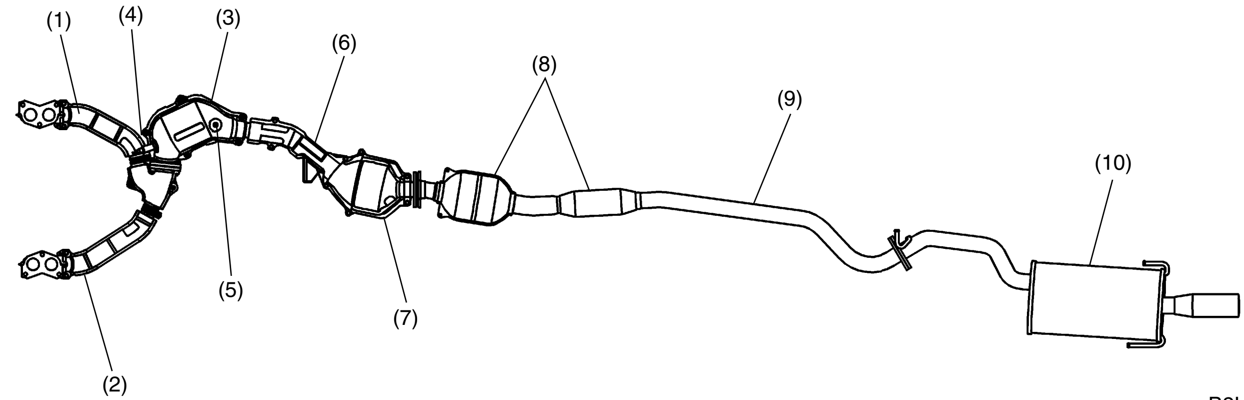
# 1. General

The exhaust system consists of front exhaust pipes, catalytic converters, a center exhaust pipe, a rear exhaust pipe and a muffler. The front catalytic converter is located immediately behind the front exhaust pipe, and the rear catalytic converter is incorporated in the center exhaust pipe.

The exhaust system features an improved sound suppression design; the two branches of the front exhaust pipe join at a point almost equal in distance from the engine's exhaust ports and the rear exhaust pipe has resonance chambers in addition to a muffler of 16 liters (976.4 cu in) capacity. Further, the 2500 cc model has a resonance chamber provided on each front exhaust pipe branch.

# 2. Composition

## 2000 cc Models

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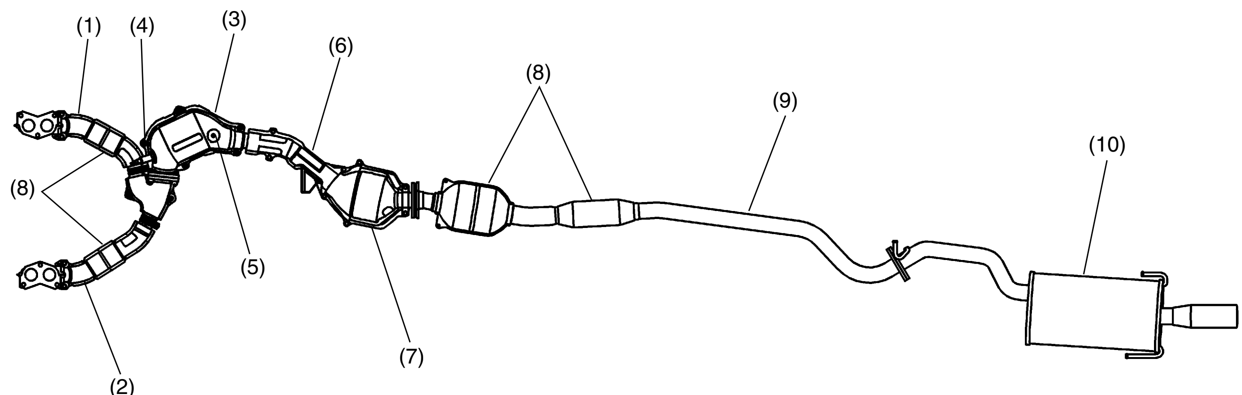
## 2500 cc Models




B2H4627A

(1) Front exhaust pipe RH
(2) Front exhaust pipe LH
(3) Front catalytic converter
(4) Front oxygen (A/F) sensor
(5) Rear oxygen sensor
(6) Center exhaust pipe
(7) Rear catalytic converter
(8) Resonance chamber
(9) Rear exhaust pipe
(10) Muffler

## MEMO

# EXHAUST EX (w/o OBD)

Page

# 1. General

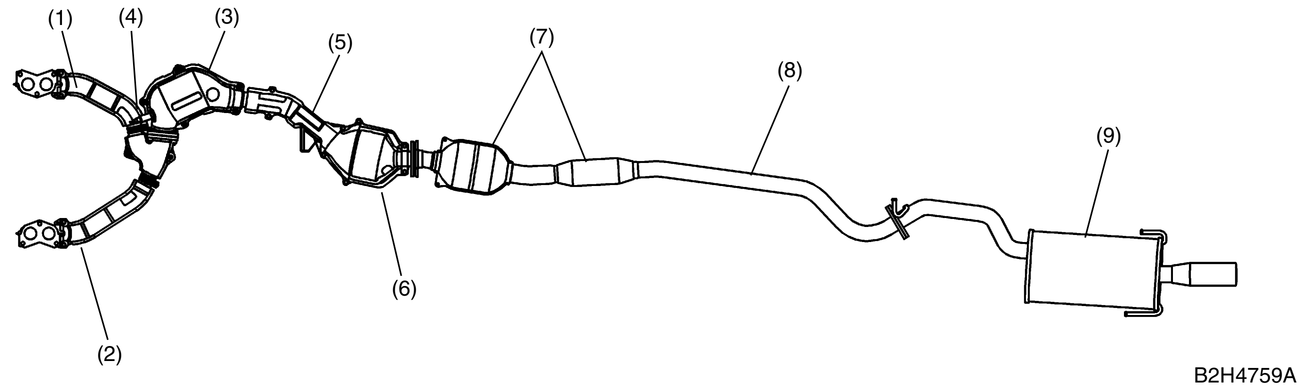
The exhaust system consists of front exhaust pipes, catalytic converters, a center exhaust pipe, a rear exhaust pipe and a muffler. The front catalytic converter is located immediately behind the front exhaust pipe, and the rear catalytic converter is incorporated in the center exhaust pipe.

The exhaust system features an improved sound suppression design; the two branches of the front exhaust pipe join at a point almost equal in distance from the engine's exhaust ports and the rear exhaust pipe has resonance chambers in addition to a muffler of 16 liters (976.4 cu in) capacity. Further, the 2500 cc model has a resonance chamber provided on each front exhaust pipe branch.

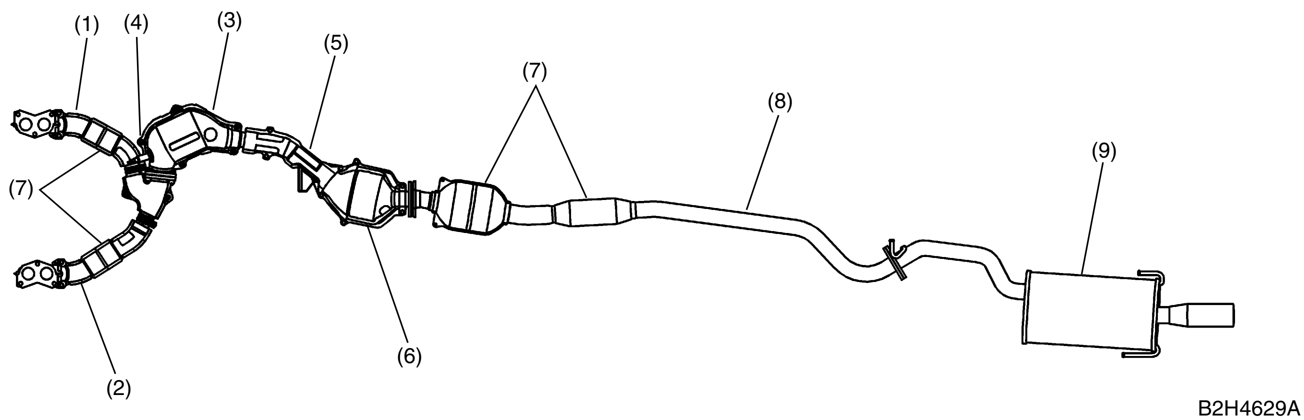
# 2. Composition

## A: WITH CATALYTIC CONVERTER (EXCEPT AUSTRALIA OUTBACK MODELS)

### 2000 cc Models

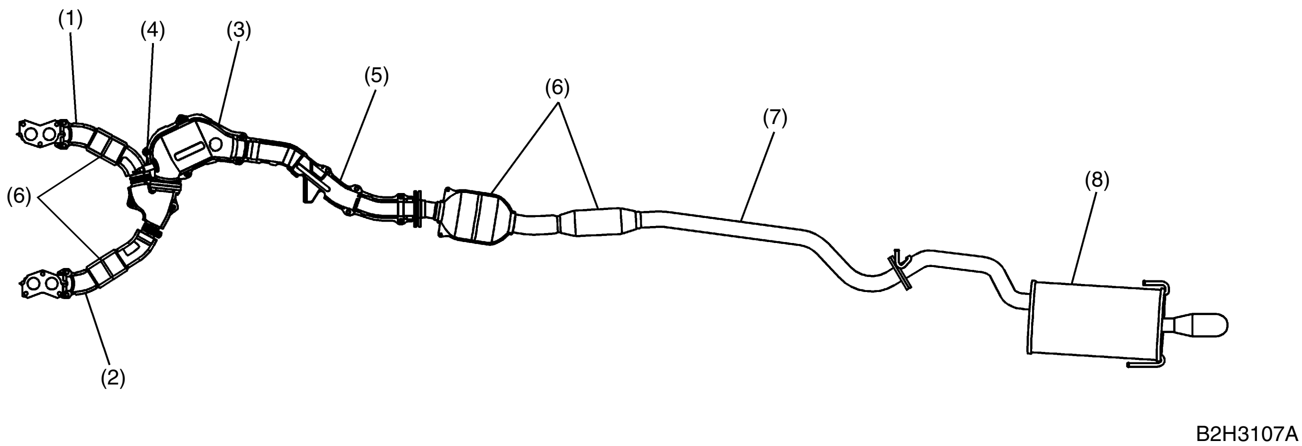



### 2500 cc Models




(1) Front exhaust pipe RH
(2) Front exhaust pipe LH
(3) Front catalytic converter
(4) Oxygen sensor
(5) Center exhaust pipe
(6) Rear catalytic converter
(7) Resonance chamber
(8) Rear exhaust pipe
(9) Muffler

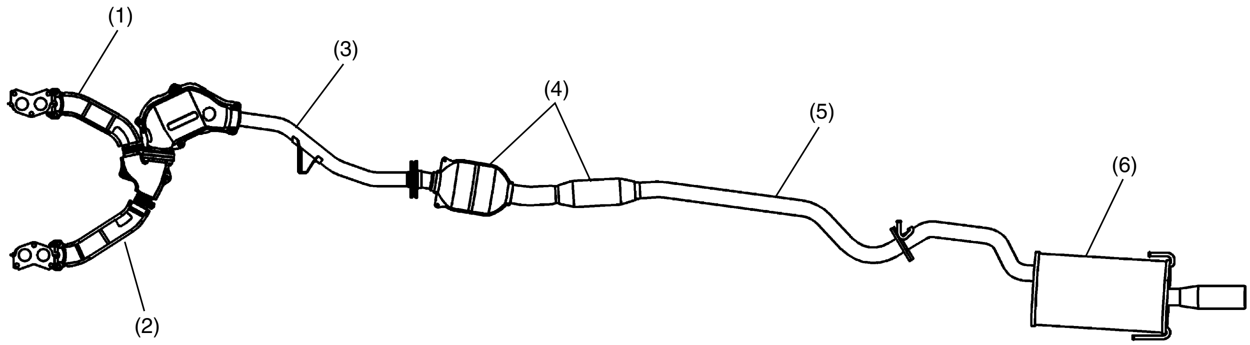
## B: AUSTRALIA OUTBACK MODELS




| | |
|---|---|
| (1) Front exhaust pipe RH | (5) Center exhaust pipe |
| (2) Front exhaust pipe LH | (6) Resonance chamber |
| (3) Front catalytic converter | (7) Rear exhaust pipe |
| (4) Oxygen sensor | (8) Muffler |

## C: WITHOUT CATALYTIC CONVERTER

### 2000 cc Models

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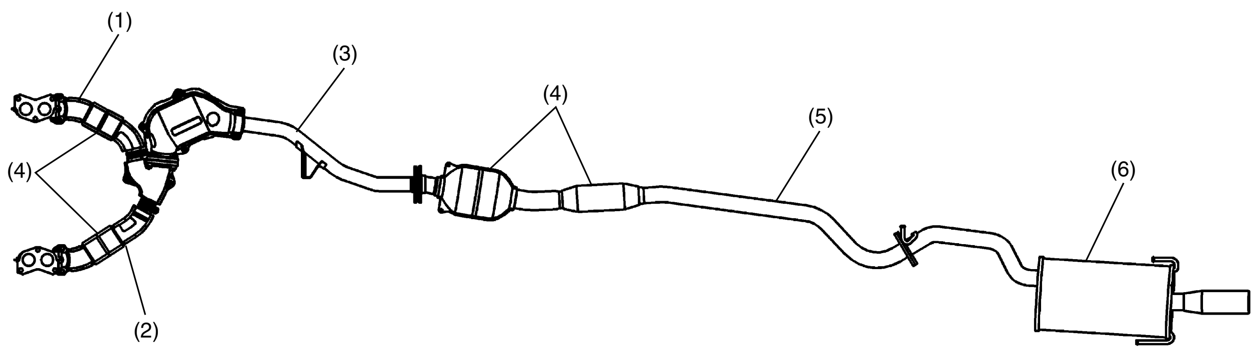
### 2500 cc Models




B2H4630A

| | | | |
|---|---|---|---|
| (1) | Front exhaust pipe RH | (4) | Resonance chamber |
| (2) | Front exhaust pipe LH | (5) | Rear exhaust pipe |
| (3) | Center exhaust pipe | (6) | Muffler |

**MEMO**

# COOLING CO

Page

# 1. General

- The engine cooling system consists of a down-flow radiator which features high heat-dissipation performance, an electric-motor-driven fan, a water pump, a thermostat, and an engine coolant temperature sensor.
- The reservoir tank is designed to eliminate the need for replenishing coolant.
- The ECM controls the operation of the radiator main fan and subfan depending on the signals from the engine coolant temperature sensor, vehicle speed sensor and A/C switch.

## 2. Cooling Circuits

The cooling system operates in three different phases depending on the temperature of the engine coolant.

- 1st phase (thermostat closed)

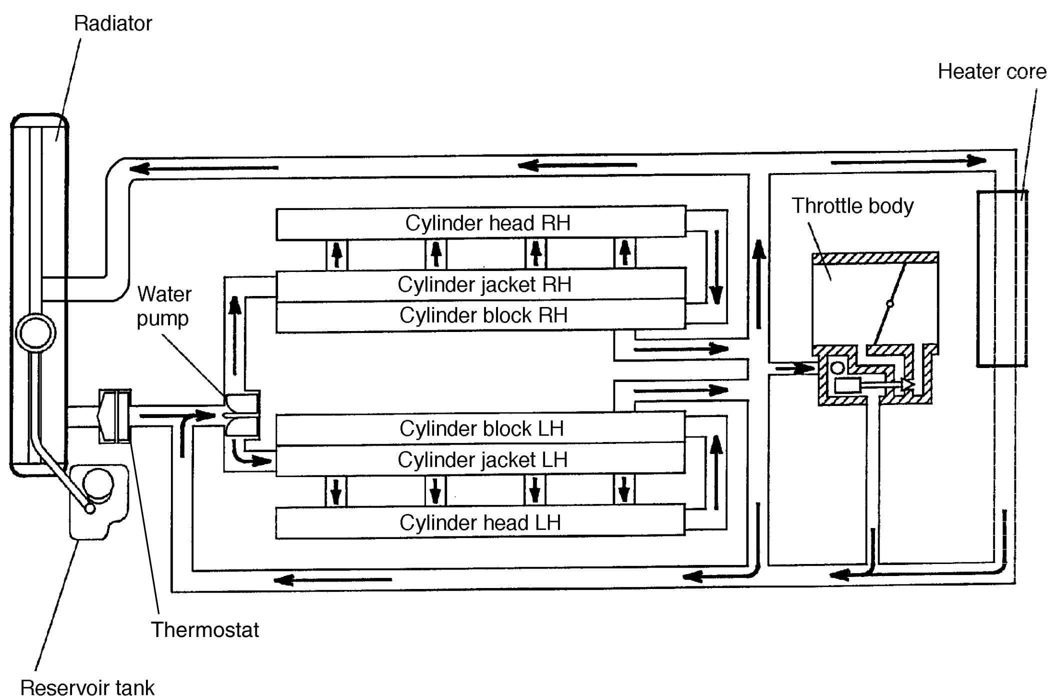
When the engine coolant temperature is below 76°C (169°F), the thermostat remains closed. The coolant flows through the bypass and heater circuits.
This permits the engine to warm up quickly.

- 2nd phase (thermostat open)

When the engine coolant temperature is above 76 – 80°C (169 – 176°F), the thermostat opens. The coolant flows through the radiator where it is cooled.

- 3rd phase (thermostat open and radiator fan operating)

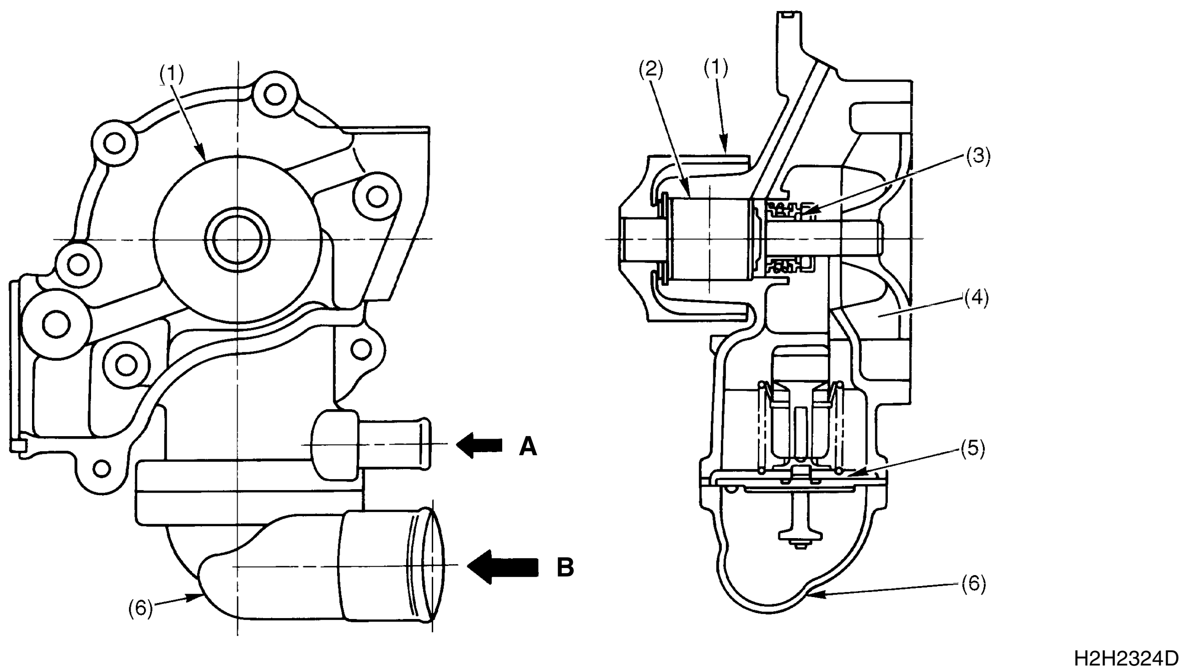
When the engine coolant temperature sensor sends a signal indicating a temperature above 95°C (203°F) to the ECM, it causes the radiator fan (or fans) to operate.




B2H2915B

# 3. Water Pump

The water pump is located in the front portion of the left bank cylinder block and is driven by the engine through the timing belt. The thermostat is fitted into the coolant inlet at the bottom of the water pump. When the pump's impeller rotates, the coolant is drawn into the pump from the lower pipe (which is connected to the radiator hose) via the thermostat. It then flows along the perimeter of the impeller and then is discharged for circulation through a circuit depending on the coolant temperature.

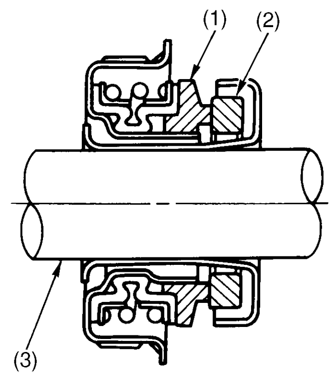



(1) Pulley
(2) Ball bearing
(3) Mechanical seal
(4) Impeller
(5) Thermostat
(6) Thermostat case

**A:** From bypass and/or heater circuit
**B:** From radiator (when thermostat is open)

# 4. Mechanical Seal

The mechanical seal has its seat tightly fitted on the water pump shaft. Since it is a hermetic seal forming an integral part of the water pump, the water pump cannot be disassembled.

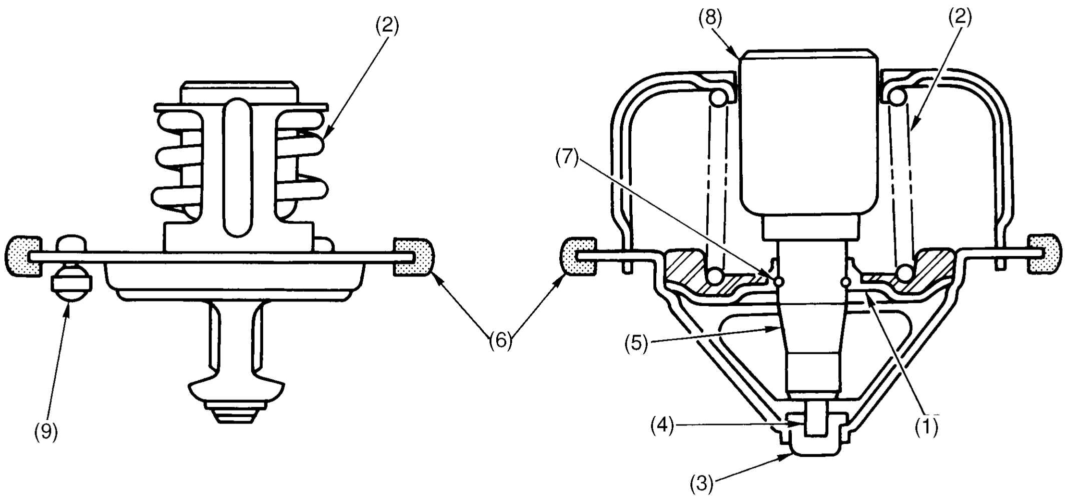



H2H2325

(1) Carbon seal
(2) Ceramics seat
(3) Water pump shaft

# 5. Thermostat

The thermostat has a totally-enclosed wax pellet which expands as the coolant temperature increases. It opens and closes accurately at the preset temperatures and features high durability.

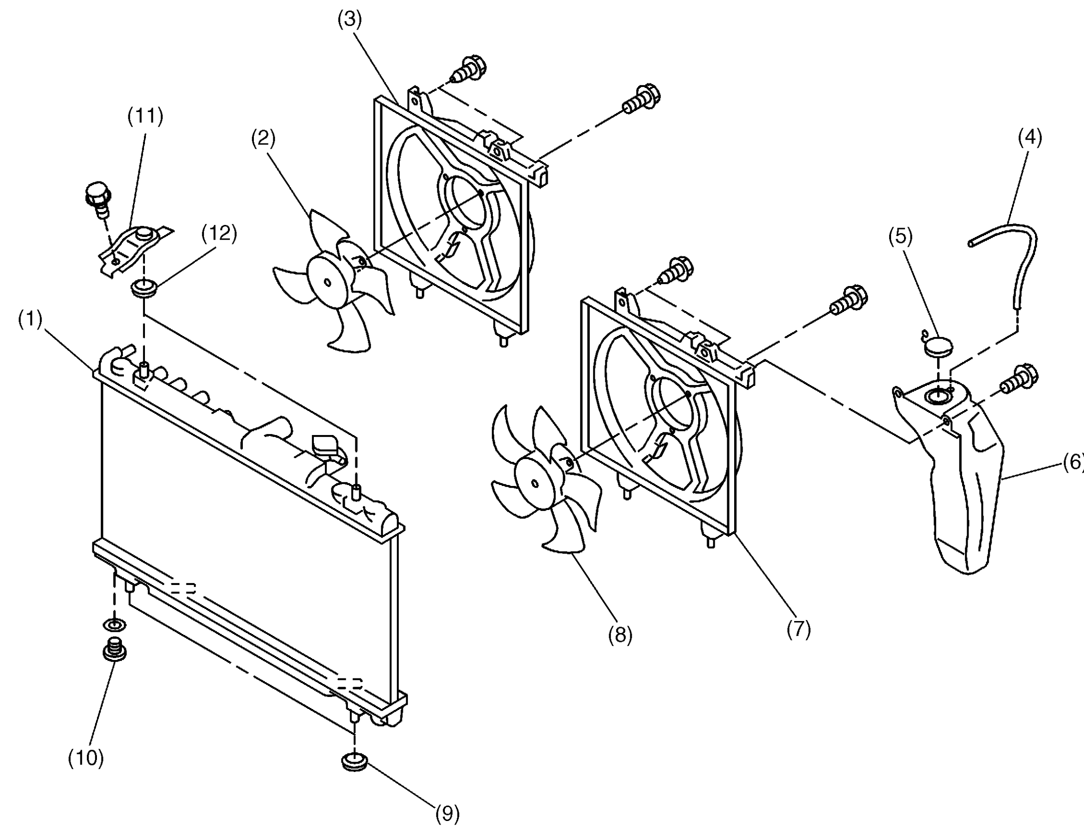



| | | |
|---|---|---|
| (1) Valve | (4) Piston | (7) Stop ring |
| (2) Spring | (5) Guide | (8) Wax element |
| (3) Stopper | (6) Rubber packing | (9) Jiggle valve |

# 6. Radiator Fan

## A: DESCRIPTION

Each radiator fan is made of plastic. It is driven by an electric motor which is retained on a shroud.




B2H2916A

| | | | |
|---|---|---|---|
| (1) | Radiator | (8) | Radiator main fan and fan motor assembly |
| (2) | Radiator subfan and subfun motor assembly (model with A/C) | (9) | Lower cushion |
| (3) | Radiator subfan shroud (model with A/C) | (10) | Drain plug |
| (4) | Overflow hose | (11) | Upper bracket |
| (5) | Reservoir tank cap | (12) | Upper cushion |
| (6) | Reservoir tank | | |
| (7) | Radiator main fan shroud | A/C: | Air conditioning system |

## B: FUNCTION

The operation of the radiator fan is controlled by the ECM. In a model equipped with an air conditioning system (A/C), the ECM uses for the control the signals from the engine coolant temperature sensor, vehicle speed sensor and A/C switch. The ECM on a model without an A/C performs the control based on the signal from the engine coolant temperature and vehicle speed sensors.

### 1. MODEL WITH A/C

| Vehicle speed | A/C compressor | Engine coolant temperature | | | | | |
|---|---|---|---|---|---|---|---|
| | | Lower than 95°C (203°F) | | Between 95 and 99°C (203 and 210°F) | | Higher than 100°C (212°F) | |
| | | Operation of radiator fans | | Operation of radiator fans | | Operation of radiator fans | |
| | | Main fan | Subfan | Main fan | Subfan | Main fan | Subfan |
| Lower than 19 km/h (12 MPH) | OFF | OFF | OFF | ON | OFF | ON | ON |
| | ON | ON | ON | ON | ON | ON | ON |
| Between 20 and 69 km/h (12 and 43 MPH) | OFF | OFF | OFF | ON | OFF | ON | ON |
| | ON | ON | ON | ON | ON | ON | ON |
| Between 70 and 89 km/h (43 and 55 MPH) | OFF | OFF | OFF | OFF | OFF | ON | ON |
| | ON | ON | OFF | ON | ON | ON | ON |
| Higher than 90 km/h (56 MPH) | OFF | OFF | OFF | OFF | OFF | ON | ON |
| | ON | OFF | OFF | ON | OFF | ON | ON |

### 2. MODEL WITHOUT A/C

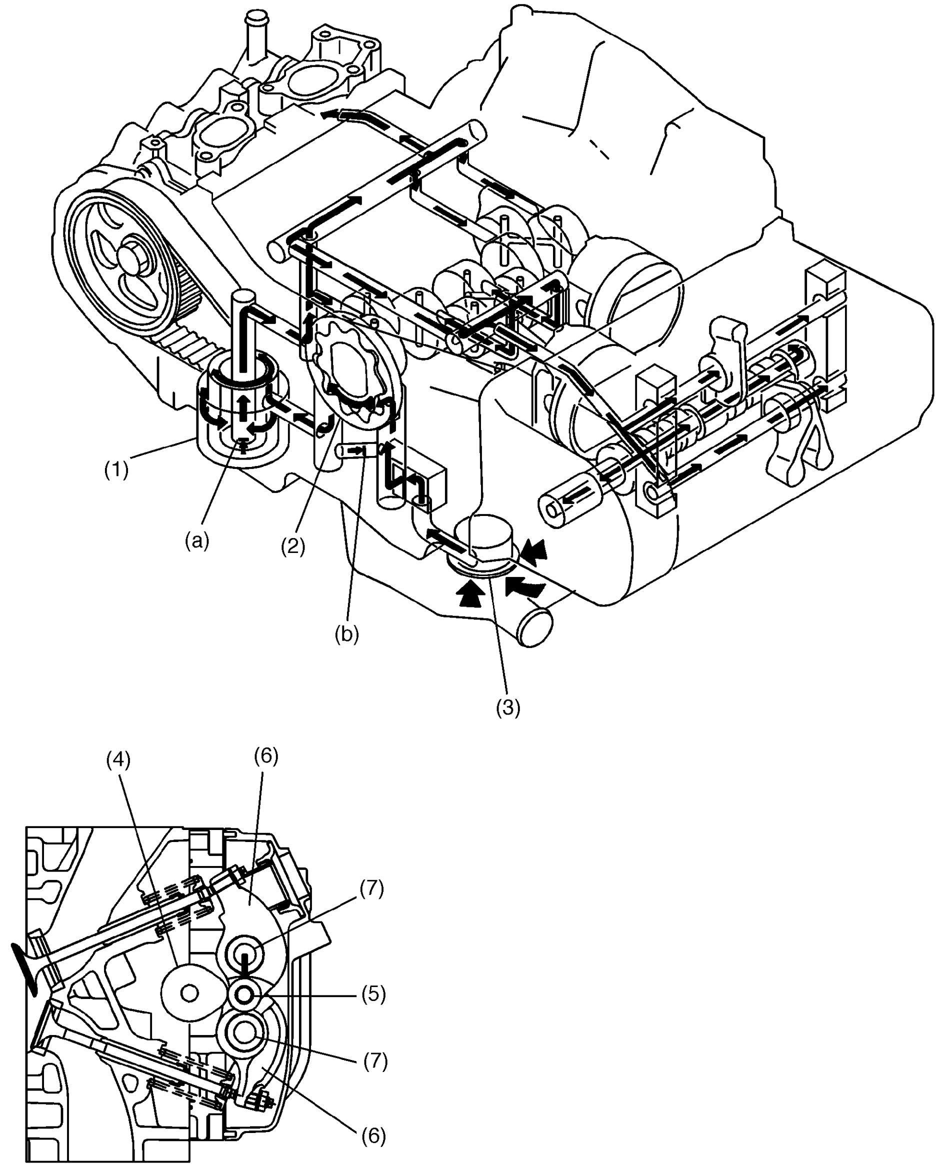
| Vehicle speed | Engine coolant temperature | | |
|---|---|---|---|
| | Lower than 95°C (203°F) | Between 95 and 99°C (203 and 210°F) | Higher than 100°C (212°F) |
| | Operation of radiator main fan | Operation of radiator main fan | Operation of radiator main fan |
| Lower than 19 km/h (12 MPH) | OFF | ON | ON |
| Between 20 and 69 km/h (12 and 43 MPH) | OFF | ON | ON |
| Between 70 and 89 km/h (43 and 55 MPH) | OFF | OFF | ON |
| Higher than 90 km/h (56 MPH) | OFF | OFF | ON |

# LUBRICATION LU

Page

# 1. General

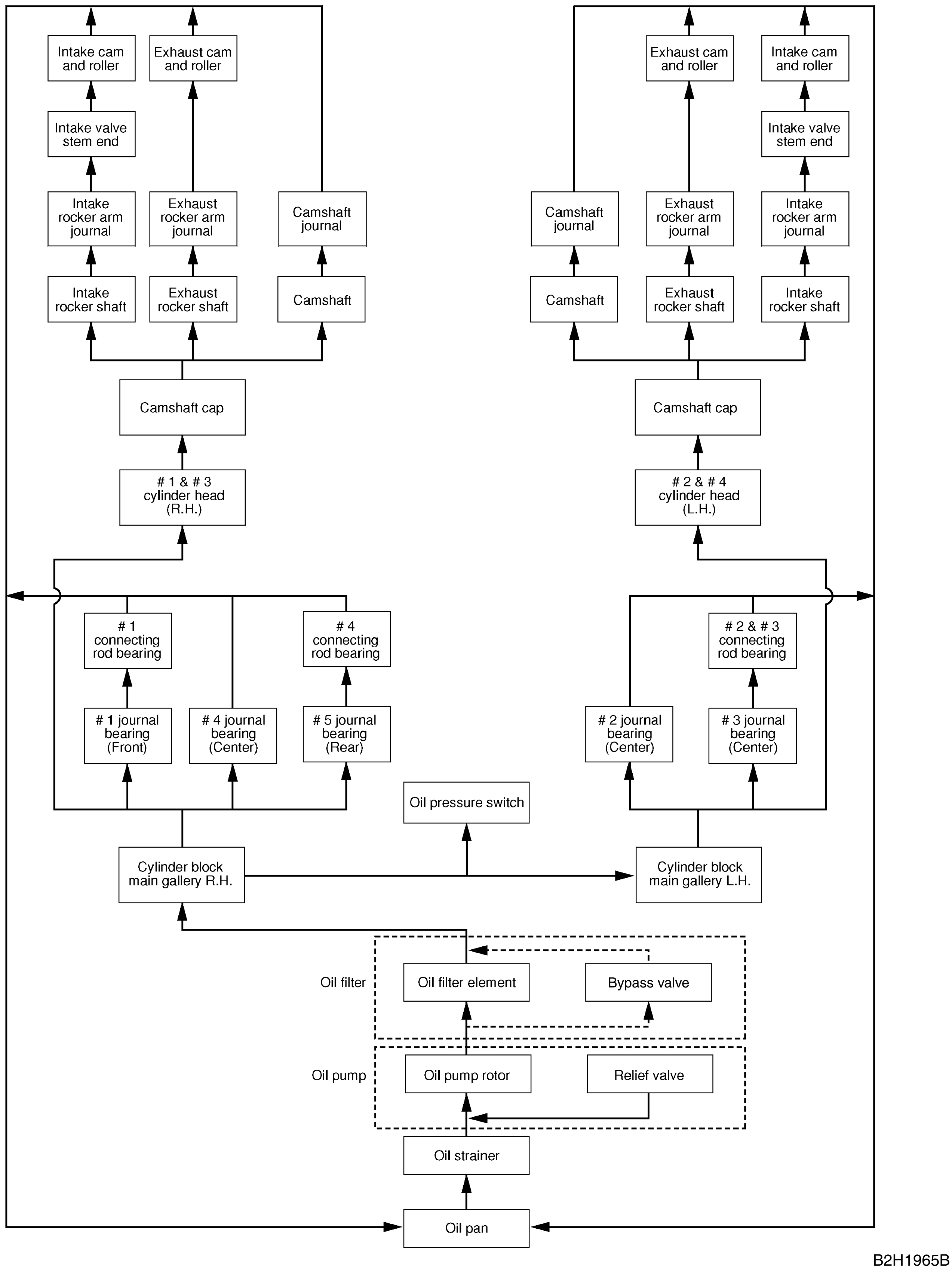
- The lubrication system force-circulates engine oil throughout the engine using an oil pump. The oil pressure is regulated by the relief valve built into the oil pump.
- The oil pump is a thin, large-diameter trochoid rotor type which can accommodate the engine's high output. The pump is directly driven by the crankshaft.
- The engine oil is cleaned by a full-flow, paper element type oil filter. The filter has a bypass valve which allows the engine oil to flow bypassing the filter if it is clogged.
- The inside of the oil pan is fitted with a baffle plate which reduces changes in the oil level due to movement of the vehicle, thus ensuring uninterrupted suction of oil.
- The engine oil discharged from the oil pump is delivered to the journal bearings, connecting rod bearings, and other parts requiring lubrication and cooling via the vertical passage in the right bank of the cylinder block, the oil filter, and the oil galleries in the right and left banks of the cylinder block.
- The engine oil is also distributed to each cylinder head valve mechanism at a proper flow rate achieved by metering by the orifice provided in each oil gallery.




(1) Oil filter
(2) Oil pump
(3) Oil strainer
(4) Camshaft
(5) Roller
(6) Rocker arm
(7) Rocker shaft

(a) Bypass valve opening pressure: 157 kPa (1.6 kgf/cm$^2$, 23 psi)
(b) Relief valve opening pressure: 490 kPa (5.0 kgf/cm$^2$, 71 psi)

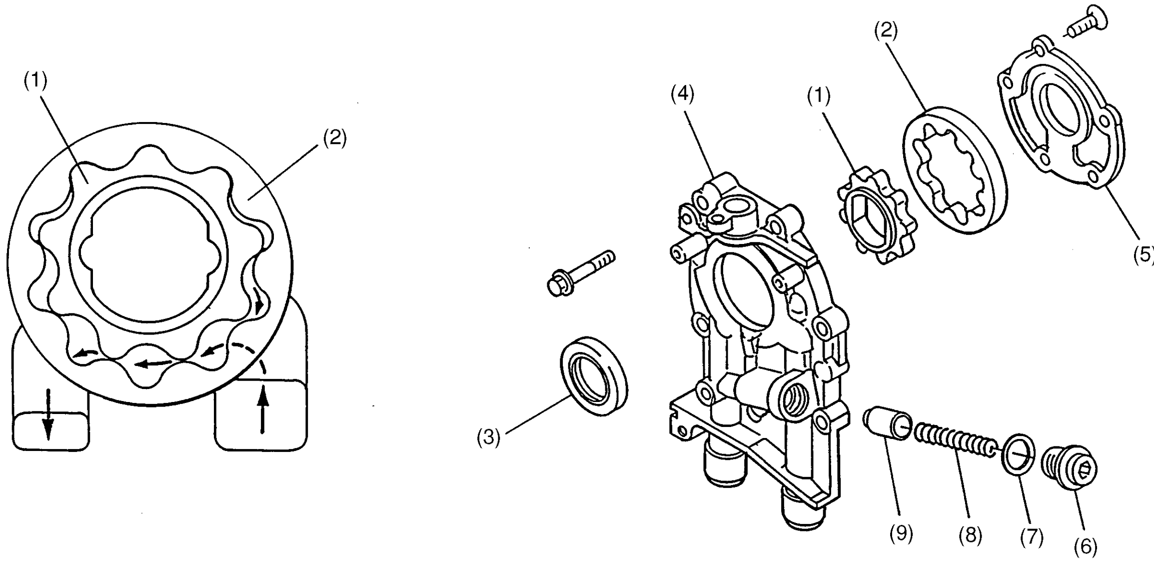
# 2. Engine Oil Flow



# 3. Oil Pump

● The oil pump is a trochoid rotor type consisting of an inner rotor and outer rotor assembled with each other in a pump body. When the inner rotor is driven by the crankshaft, the outer rotor is rotated, changing the space between it and the inner rotor. The change in the space occurs because of the difference in the number of teeth between the rotors.

● Engine oil is drawn into the large space created near the inlet of the pump. It is then carried to the discharge port. As the pump rotates, the space carrying the oil becomes smaller, thus the oil is pressurized and discharged from the outlet port. Oil pressure is regulated by the relief valve built into the pump. Excess oil is directly returned to the inlet port.

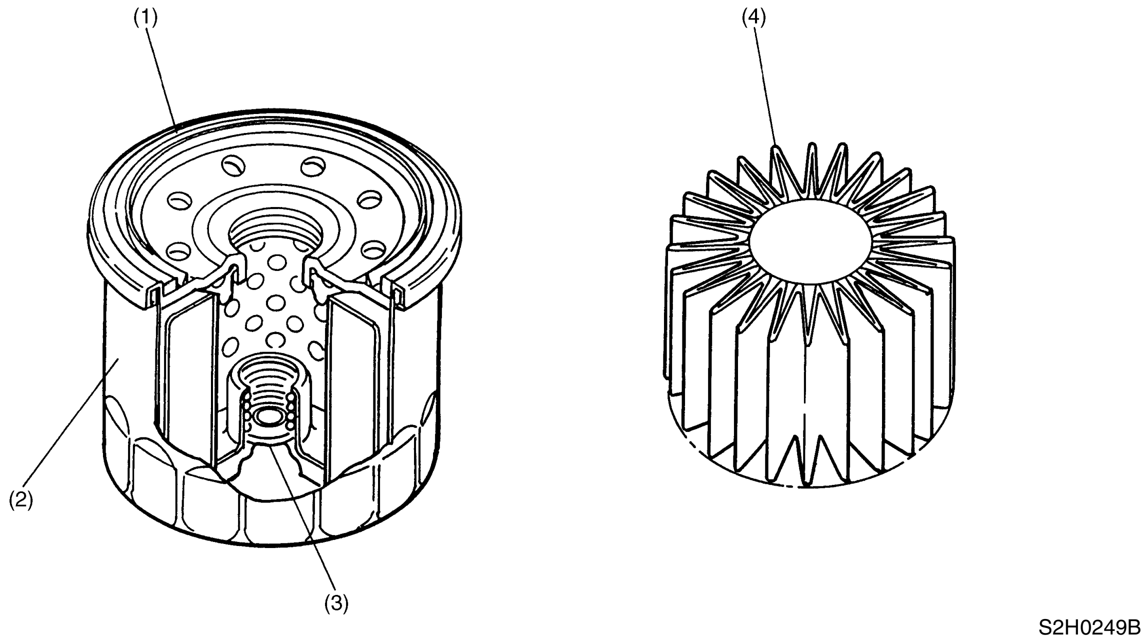



S2H0851A

(1) Inner rotor
(2) Outer rotor
(3) Oil seal
(4) Oil pump case
(5) Oil pump cover
(6) Plug
(7) Gasket
(8) Relief valve spring
(9) Relief valve

# 4. Oil Filter

The oil filter is a full-flow filtering, cartridge type that utilizes a paper element. It also has a built-in bypass valve. The filter element has a special pleat design to increase the effective filtering area.

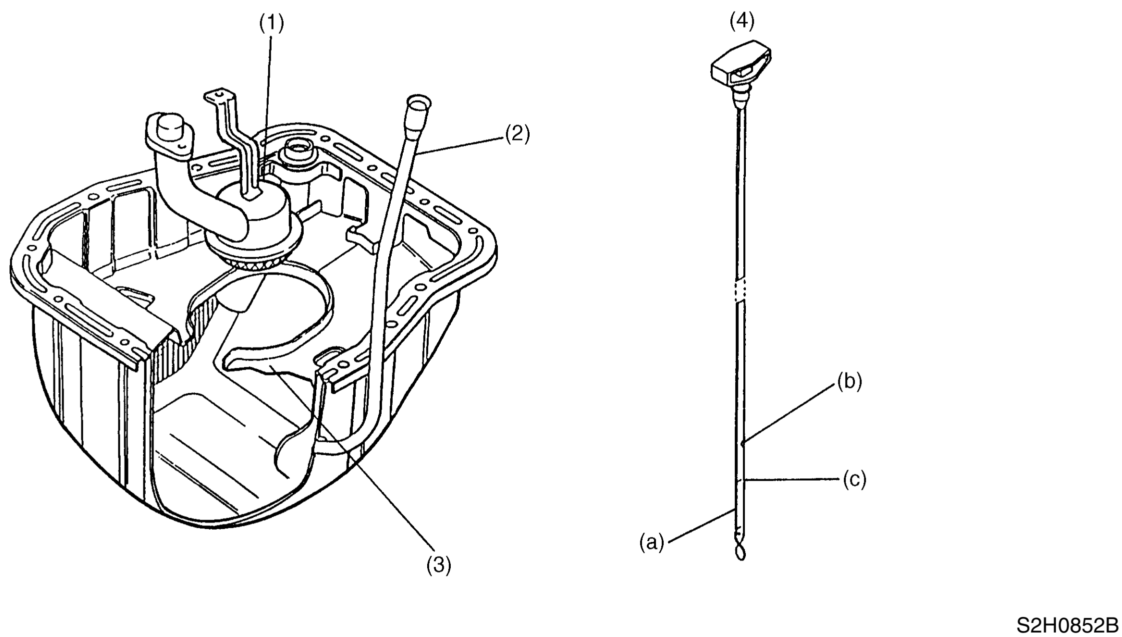



(1) Oil seal
(2) Filter body
(3) Bypass valve
(4) Pleated element

# 5. Oil Pan and Oil Strainer

● The oil pan is attached to the cylinder block using liquid gasket for sealing. The oil strainer is a metal net type and removes large foreign particles from the engine oil. It is located in the middle of the oil pan. The pipe from the strainer is connected to the suction port of the oil pump in the left bank of the cylinder block.

● There is a baffle plate in the oil pan, near the bottom of the cylinder block. It stabilizes the oil level and reinforces the oil pan.

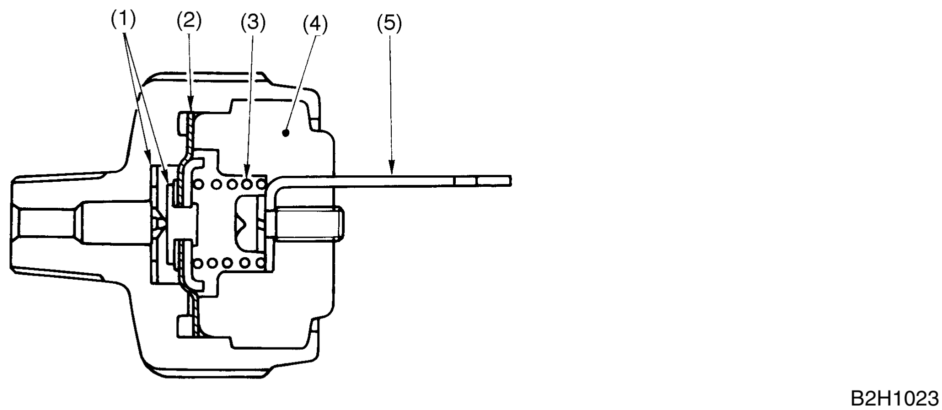



(1) Oil strainer
(2) Level gauge guide
(3) Baffle plate
(4) Oil level gauge

(a) LOW level
(b) FULL level (Engine HOT condition)
(c) FULL level (Engine COLD condition)

# 6. Oil Pressure Switch

The oil pressure switch is located in the front upper portion of the right cylinder block bank. The purpose of this switch is to monitor the operation of the oil pump as well as the lubricating oil pressure when the engine is running.




(1) Contact point
(2) Diaphragm
(3) Spring
(4) Molded portion
(5) Terminal

1) When oil pressure does not build up (immediately after ignition switch is turned ON):
The diaphragm is pushed toward the cylinder block by the spring force (a force equivalent to the specified oil pressure). This closes the contact points, causing the oil pressure warning light in the combination meter to illuminate.

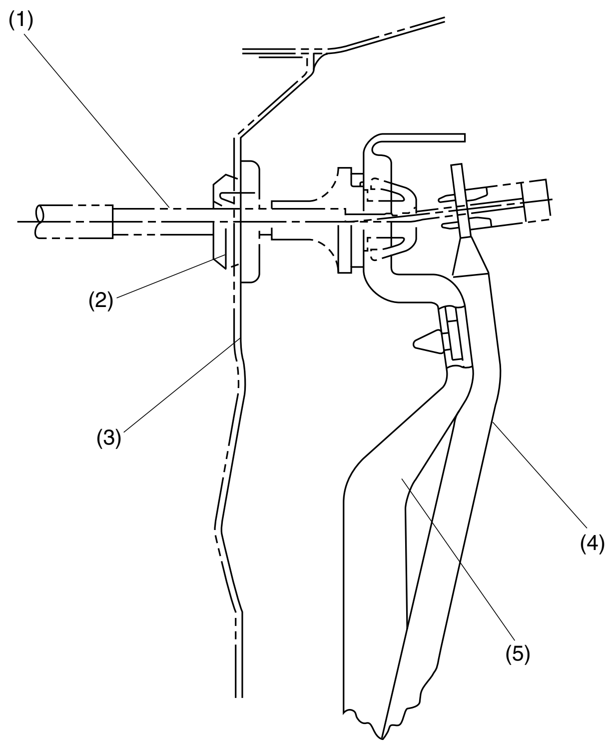
2) When oil pressure reaches the specified value (after engine starts):
After reaching the specified value of 14.7 kPa (0.15 kgf/cm$^2$, 2.1 psi), the oil pressure pushes the diaphragm overcoming the spring force. This opens the contact points and the oil pressure warning light goes out.

# SPEED CONTROL SYSTEM SP

Page

# 1. General

The accelerator outer cable is secured to the accelerator pedal bracket rather than to the toeboard. Securing the outer cable in this way has a merit of making the ratio of throttle valve movement to cable stroke less variable. This arrangement is also effective to prevent unsmooth cable return movement that may result from deformation of the toeboard or improper installation of the accelerator pedal and, therefore, to improve safety.



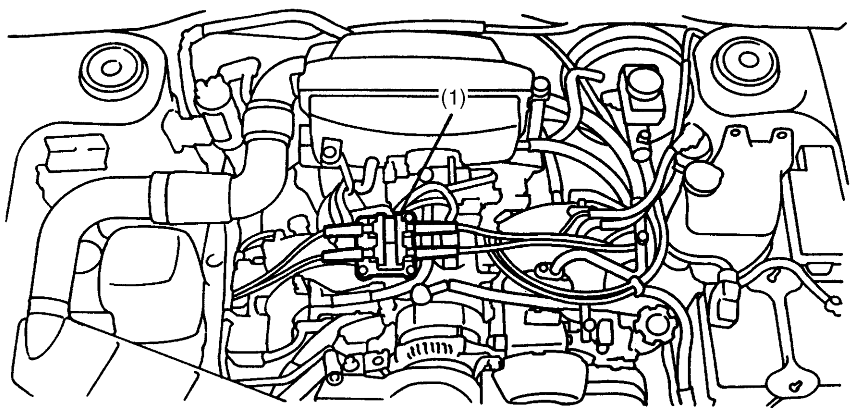

(1) Accelerator cable
(2) Grommet
(3) Toeboard
(4) Accelerator pedal
(5) Bracket

# IGNITION IG

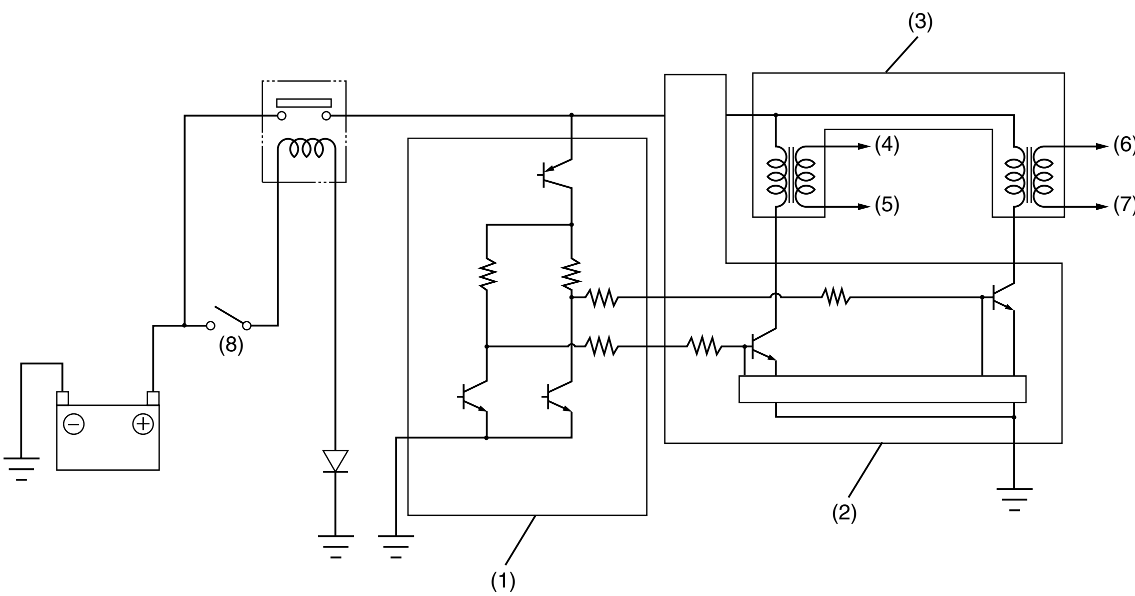
# 1. Ignition Coil

Ignition coils are made integral with an ignitor.

The ignition system is of a dual-ignition-coil design, each coil causing two plugs to generate sparks simultaneously. In response to the signal from the ECM, the ignitor supplies current to an ignition coil and the ignition coil supplies high-voltage current to a pair of spark plugs (#1 and #2 or #3 and #4) simultaneously.



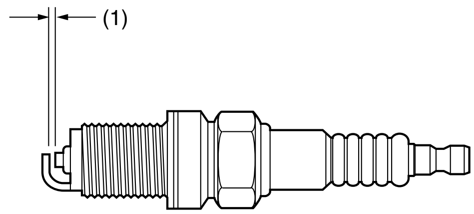

(1) Ignition coil and ignitor assembly




| | | | |
|---|---|---|---|
| (1) | ECM | (5) | Spark plug #2 |
| (2) | Ignitor | (6) | Spark plug #3 |
| (3) | Ignition coil | (7) | Spark plug #4 |
| (4) | Spark plug #1 | (8) | Ignition switch |

## 2. Spark Plug

The spark plug's thread diameter is 14 mm (0.551 in) and the gap is controlled to a value between 1.0 and 1.1 mm (0.039 and 0.043 in).

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(1) Gap : 1.0 – 1.1 mm (0.039 – 0.043 in)

## MEMO

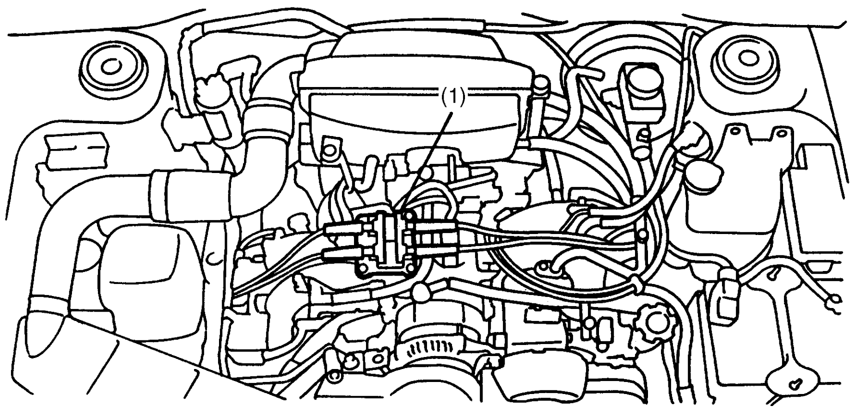
# IGNITION IG (w/o OBD)

Page

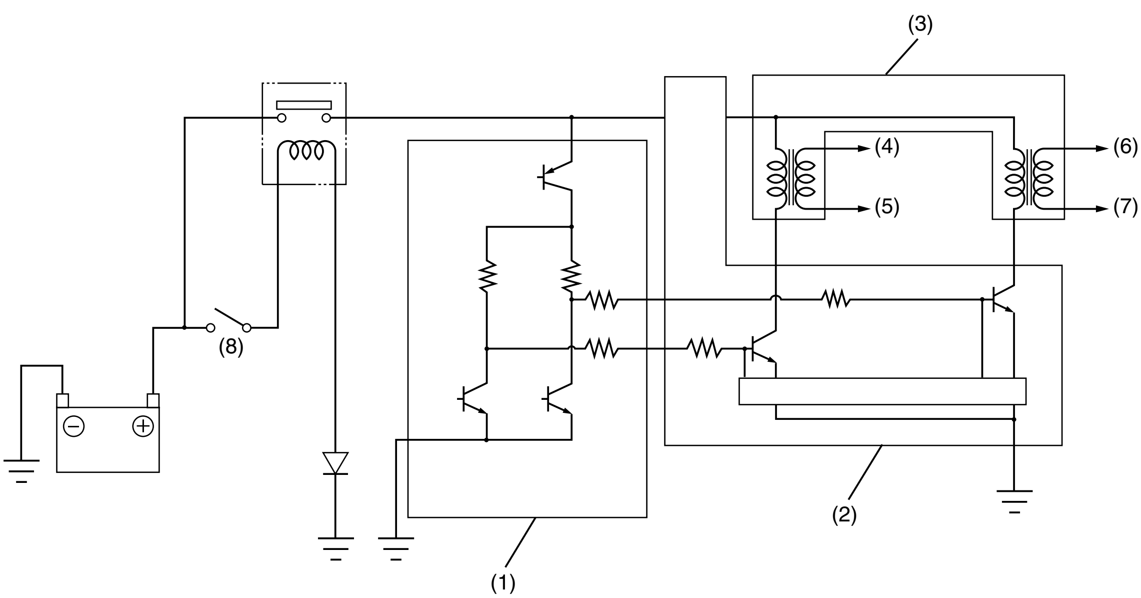
# 1. Ignition Coil

Ignition coils are made integral with an ignitor.

The ignition system is of a dual-ignition-coil design, each coil causing two plugs to generate sparks simultaneously. In response to the signal from the ECM, the ignitor supplies current to an ignition coil and the ignition coil supplies high-voltage current to a pair of spark plugs (#1 and #2 or #3 and #4) simultaneously.



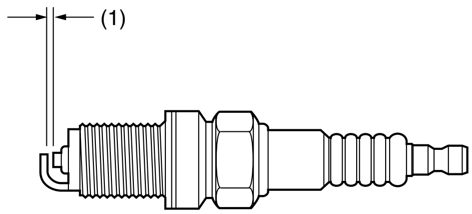

(1) Ignition coil and ignitor assembly




(1) ECM
(2) Ignitor
(3) Ignition coil
(4) Spark plug #1
(5) Spark plug #2
(6) Spark plug #3
(7) Spark plug #4
(8) Ignition switch

# 2. Spark Plug

The spark plug's thread diameter is 14 mm (0.551 in) and the gap is controlled to either of the dimensions shown below.




B2H4152C

| | | | | |
|---|---|---|---|---|
| (1) | Gap : | 1.0 – 1.1 mm (0.039 – 0.043 in) *1 | *1: | With catalytic converter |
| | | 0.7 – 0.8 mm (0.028 – 0.031 in) *2 | *2: | Without catalytic converter |

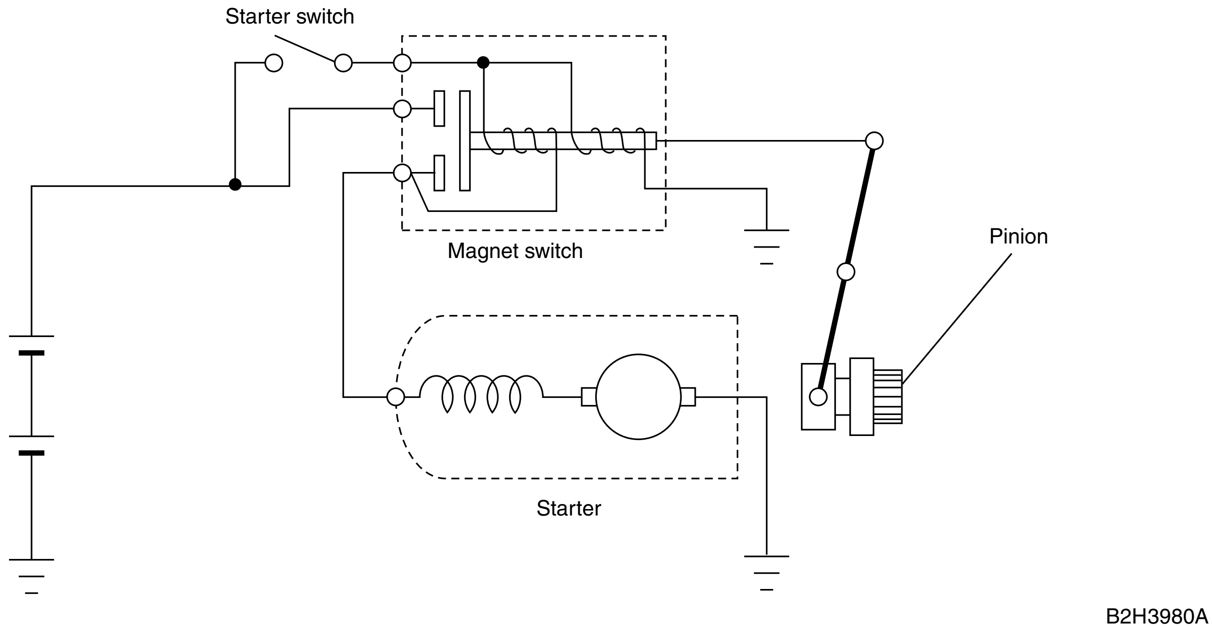
## MEMO

# STARTING/CHARGING SC

Page

# 1. Starter

The starter is of a reduction type. Its output is 1.0 kW on the MT model and 1.4 kW on the AT model.



## 2. Generator

The generator has a built-in regulator which provides diagnostic functions in addition to a voltage regulating function as follows:

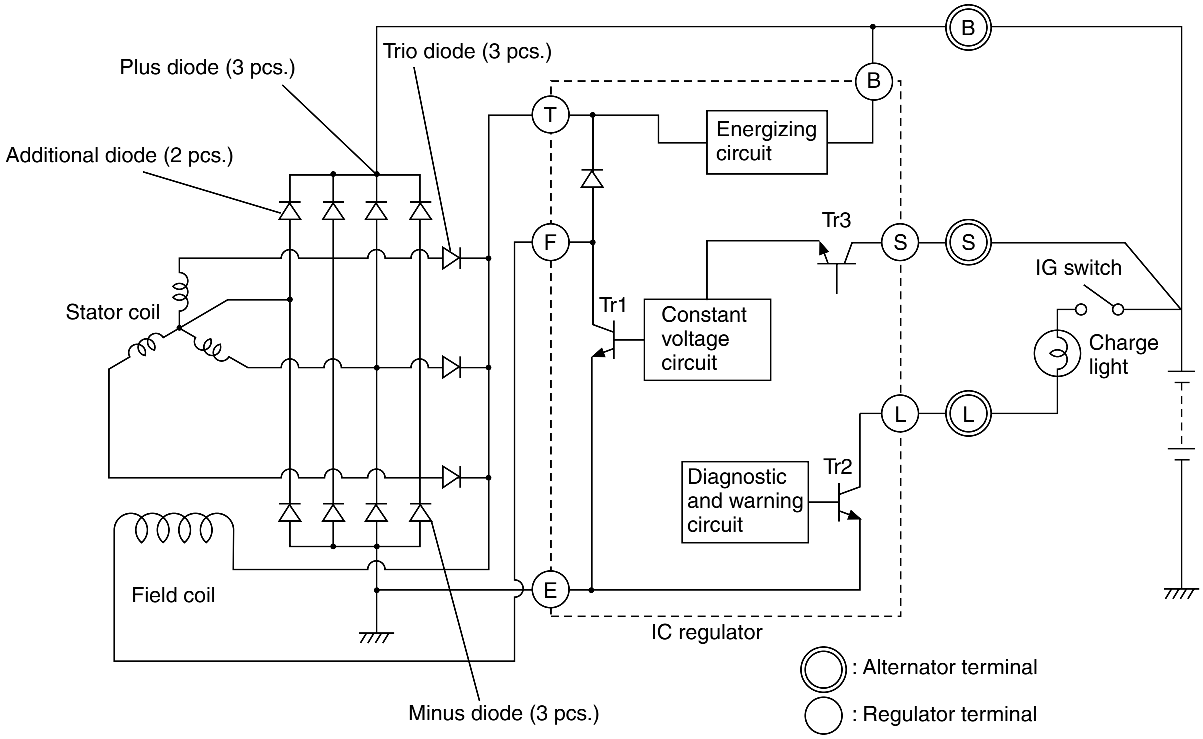
1) Voltage regulation

The on-off operation of transistor $Tr_1$ connects and disconnects the field current circuit, providing a constant level of output voltage.

2) Diagnosis warning

When any of the following problems occur, the charge lamp illuminates.

a. No voltage generation
Brush wear exceeds specified wear limits, field coil circuit is broken, etc.
b. Excessive output
Output voltage is greater than 16 volts (approx.)
c. Terminal B disconnection
Harness is disconnected from alternator terminal B.
d. Terminal S disconnection
Harness is disconnected from alternator terminal S. In this case, voltage is slightly greater than specified regulated voltage; however, voltage regulation is still controlled and the battery is prevented from becoming overcharged.

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# 3. Battery

The battery is located in the left front part of the engine compartment. It is held on a tray by the battery holder.

# FUEL INJECTION (FUEL SYSTEM) FU (H6)

Page

# 1. General

- The Multipoint Fuel Injection (MFI) system supplies optimum air-fuel mixture under every engine operating condition through the use of the latest electronic control technology.

This system pressurizes the fuel to a constant pressure and injects it into each intake air port in the cylinder head. The injection quantity of fuel is controlled by an intermittent injection system where an electro-magnetic injection valve or injector opens for a short period that is precisely controlled depending on the quantity of air appropriate for each condition of operation. In actual control, an optimum fuel injection quantity is achieved by varying the duration of an electric pulse applied to the injector. This way of control enables simple, yet highly precise metering of the fuel.

- The engine control module (ECM) that controls the fuel injection system corrects the fuel injection amount depending on the vehicle speed, throttle opening, coolant temperature and other vehicle-operation-related information. The ECM receives the information in the form of electric signals from the corresponding sensors and switches.

The MFI system also has the following features:

- Reduced exhaust emissions
- Reduced fuel consumption
- Increased engine output
- Quick response to accelerator and brake pedal operation
- Superior startability and warm-up performance in cold weather due to corrective controls made according to coolant and intake air temperatures

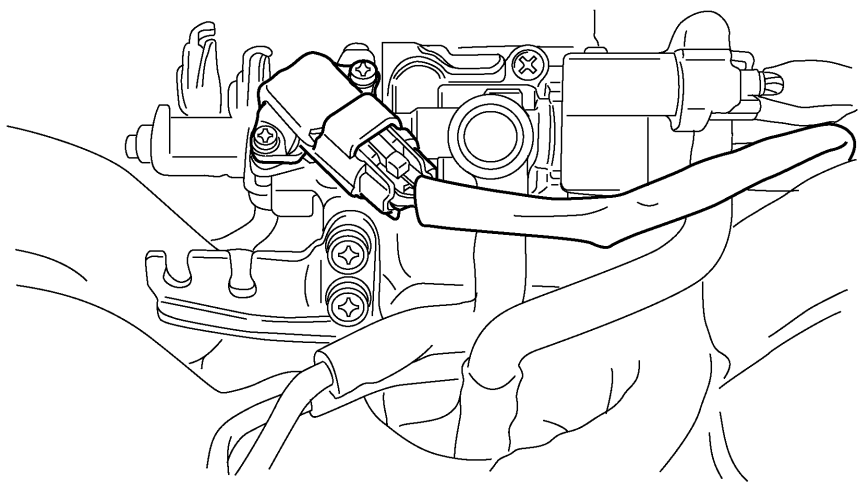
# 2. Air Line

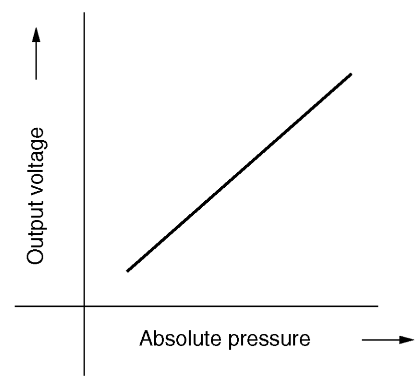
## A: GENERAL

The air filtered by the air cleaner enters the throttle body where it is regulated in the volume by the throttle valve and then enters the intake manifold. It is then distributed to each cylinder where the air is mixed with fuel injected by the injector. During idling operation, air flows into the cylinder through the idle air control solenoid valve, bypassing the throttle valve. This enables controlling the engine idling speed properly.

## B: INTAKE MANIFOLD PRESSURE SENSOR

The intake manifold pressure sensor is attached to the top of the throttle body, and continuously sends to the engine control module (ECM) voltage signals that are proportional to intake manifold absolute pressures. The ECM controls the fuel injection and ignition timing based on the intake manifold absolute pressure signals in addition to other signals from many sensors and other control modules.



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## C: THROTTLE BODY

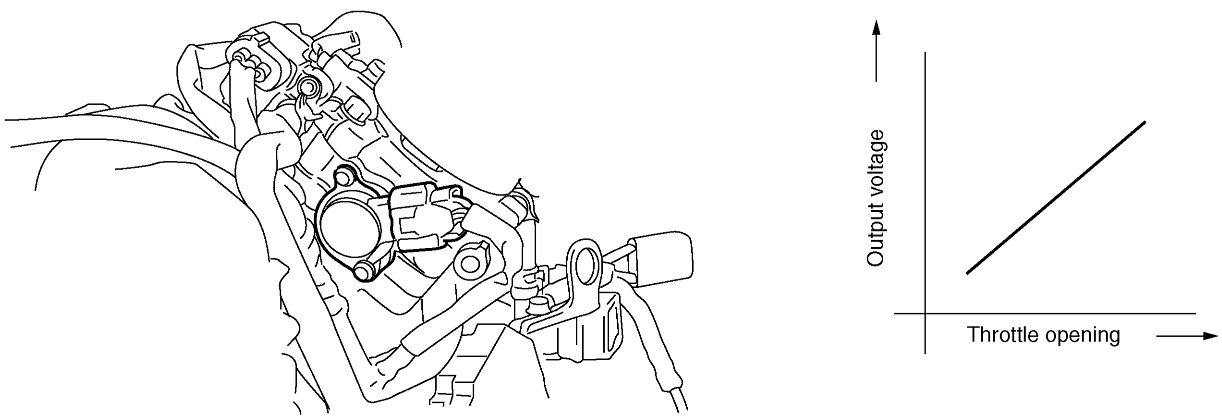
In response to operation of the accelerator pedal, the throttle valve in the throttle body opens/closes to regulate the volume of the air drawn into the combustion chamber.

During idling, the throttle valve is almost fully closed and the volume of air passing through the throttle body is less than that passing through the idle air control solenoid valve.

More than half of the air necessary for idling is supplied to the intake manifold via the idle air control solenoid valve which controls properly the engine idling speed, so the idling speed needs not be adjusted.

## D: THROTTLE POSITION SENSOR

- The throttle position sensor is mounted in the throttle body and linked to the throttle valve.
- The throttle position sensor sends the ECM voltage signal corresponding to the opening of the throttle valve. When the sensor's output voltage exceeds a predetermined level, the ECM interprets it as complete closure of the throttle valve. When the output voltage is at another predetermined level, the ECM recognizes that the throttle valve is at a wide open position. Since the output characteristics of the sensor change over years, the ECM is provided with a learning function to be able to interpret signals into throttle valve angles always correctly.

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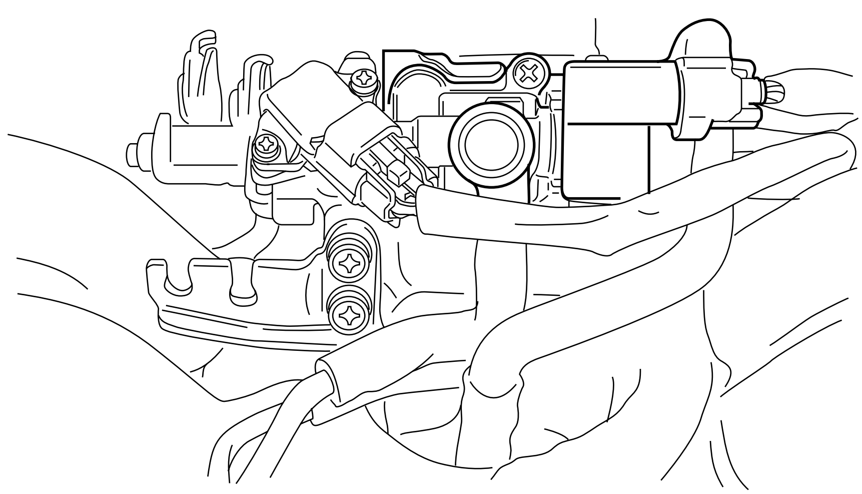
## E: IDLE AIR CONTROL SOLENOID VALVE

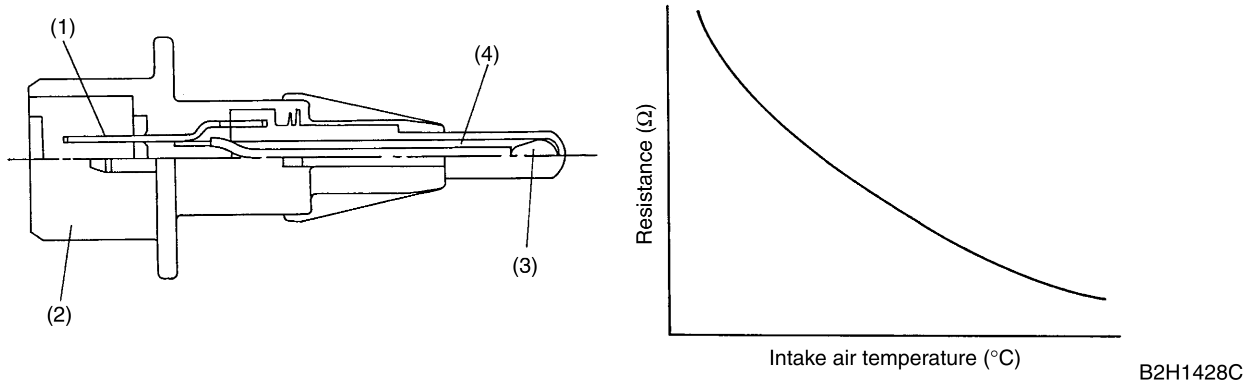
- The idle air control solenoid valve is located in the throttle body and regulates the amount of intake air that flows bypassing the throttle valve into the intake manifold during engine idling. It is activated by a signal from the ECM in order to maintain the engine idling speed at a target speed.
- The idle air control solenoid valve is a solenoid-actuated rotary valve consisting of a coil, rotary valve, spring and housing. The housing is an integral part of the throttle body and provided with a bypass air port whose opening area is changed by the rotary valve.



B2H3907

## F: INTAKE AIR TEMPERATURE SENSOR

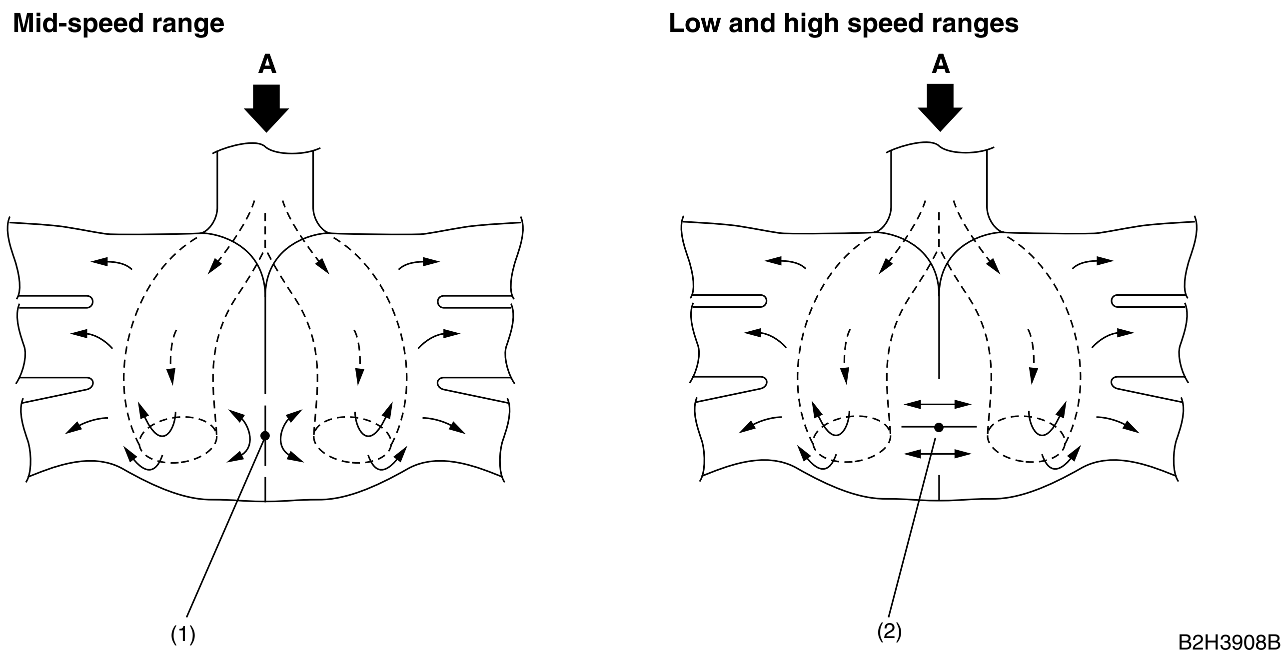
The intake air temperature sensor is located in the air cleaner case and detects the temperature of the intake air introduced through the air intake duct. The ECM uses the resistance signal from the sensor to correct the fuel injection amount.




(1) Terminal
(2) Connector
(3) Thermistor
(4) Housing

## G: INDUCTION CONTROL SYSTEM

There is a butterfly valve on the partition between the intake manifold's right bank and left bank chambers. This valve is operated by the induction valve actuator installed on the intake manifold. During operation of the engine, pressure waves are generated in the intake manifold. The pressure waves have an effect of improving air intake efficiency. To make the most of this effect, the direction of the pressure wave is changed by opening and closing the induction valve in accordance with the engine speed so that increased engine output torque is obtained in all speed ranges.



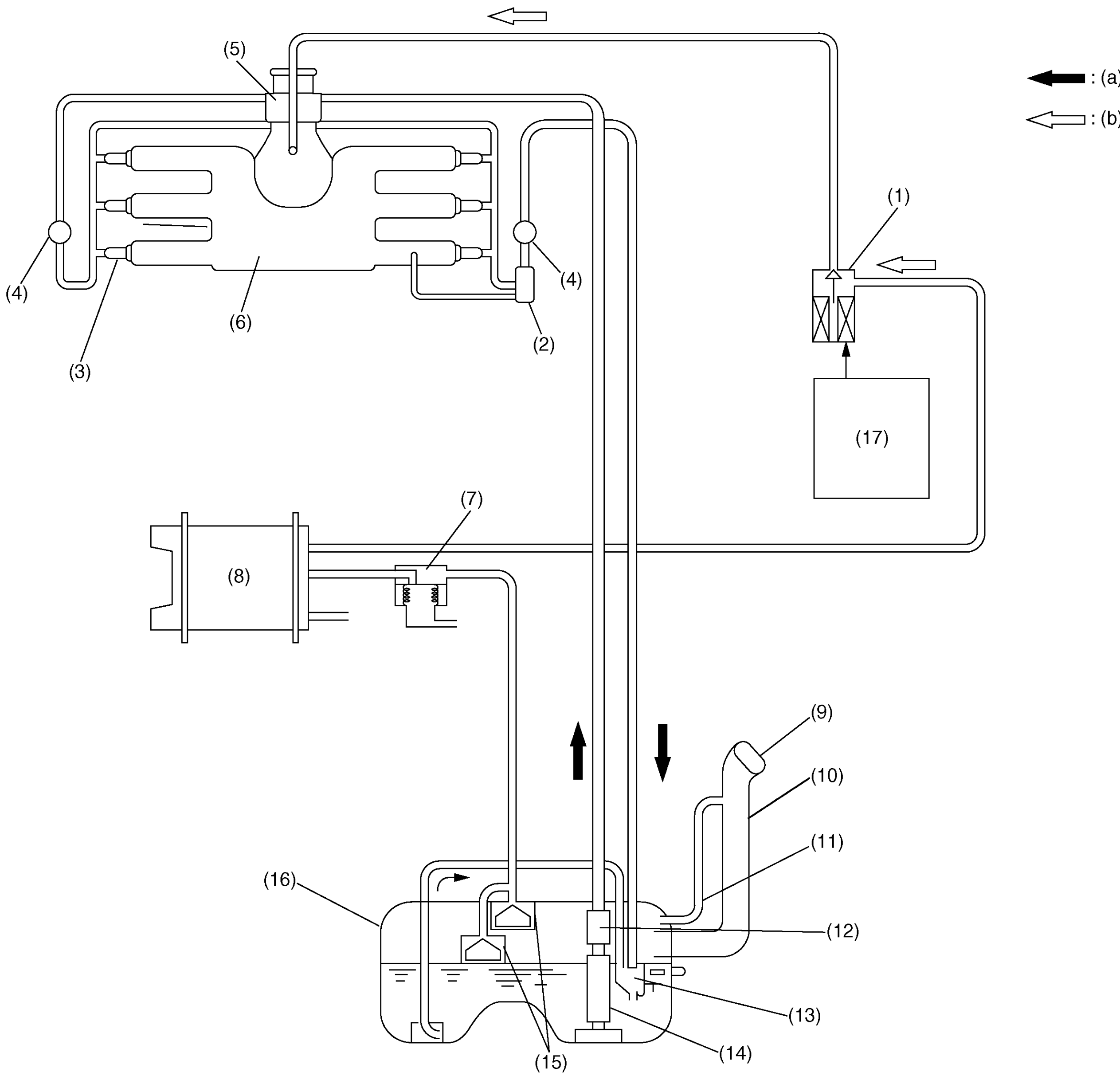

(1) Induction valve (closed)
(2) Induction valve (open)
**A:** From air cleaner

# 3. Fuel Line

## A: GENERAL

- The fuel pressurized by the fuel tank inside pump is delivered to each fuel injector by way of the fuel pipe and fuel filter. Fuel injection pressure is regulated to an optimum level by the pressure regulator.
- Each injector injects fuel into the intake port of the corresponding cylinder where the fuel is mixed with air. The mixture then enters the cylinder.

Fuel injection amount and timing are regulated by the ECM.

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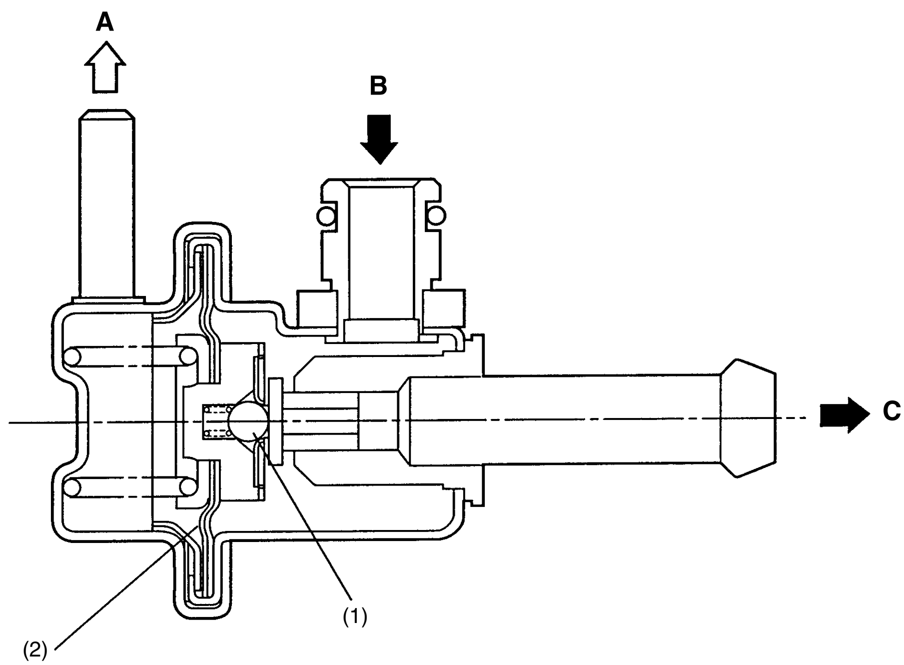
| | | | |
|---|---|---|---|
| (1) | Purge control solenoid valve | (11) | Air vent pipe |
| (2) | Pressure regulator | (12) | Fuel filter |
| (3) | Fuel injector | (13) | Jet pump |
| (4) | Pressure damper | (14) | Fuel pump |
| (5) | Throttle body | (15) | Fuel cut valve |
| (6) | Intake manifold | (16) | Fuel tank |
| (7) | Two-way valve | (17) | ECM |
| (8) | Canister | | |
| (9) | Filler cap | (a): | Fuel line |
| (10) | Filler pipe | (b): | Evaporation line |

## B: PRESSURE REGULATOR

The pressure regulator is installed at the injector end of the fuel supply line. It has a fuel chamber and spring chamber separated by a diaphragm. Fuel chamber is connected to the fuel supply line and the spring chamber is connected to the intake manifold. Fuel chamber also has a relief valve connected to the fuel return line through which fuel returns to the fuel tank. When the intake manifold vacuum increases, the diaphragm is pulled and the relief valve opens to decrease the fuel supply line pressure (or fuel injection pressure). When the intake manifold vacuum decreases, the diaphragm is pushed by the spring to increase the fuel supply line pressure. Thus, the difference between the fuel injection pressure and the intake manifold vacuum is kept at a constant level of 299.1 kPa (3.05 kgf/cm$^2$, 43.4 psi) to precisely control the amount of injected fuel.




S2H0623C

(1) Relief valve
(2) Diaphragm

**A:** To intake manifold
**B:** Fuel IN
**C:** Fuel OUT

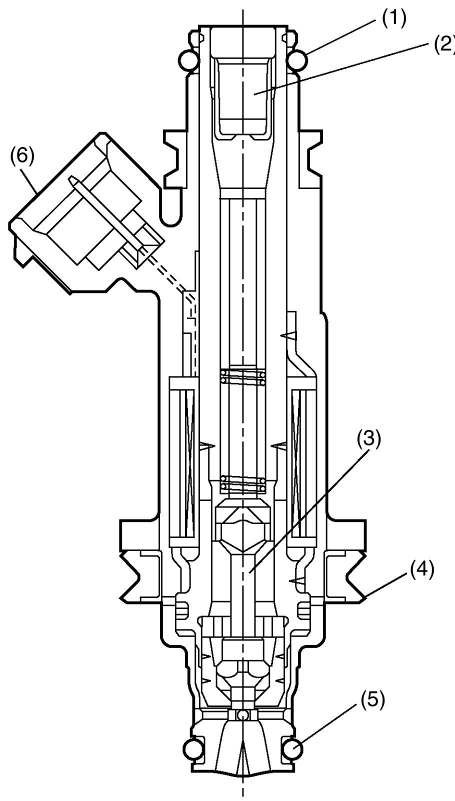
## MEMO

## C: FUEL INJECTORS

- The MFI system employs top feed type fuel injectors with an air assist feature.
- Each injector is installed in the fuel pipe in such a way that the injector is cooled by fuel.
- The features of this type of fuel injector are as follows:

1) High heat resistance
2) Low driving noise
3) Easy to service
4) Small size

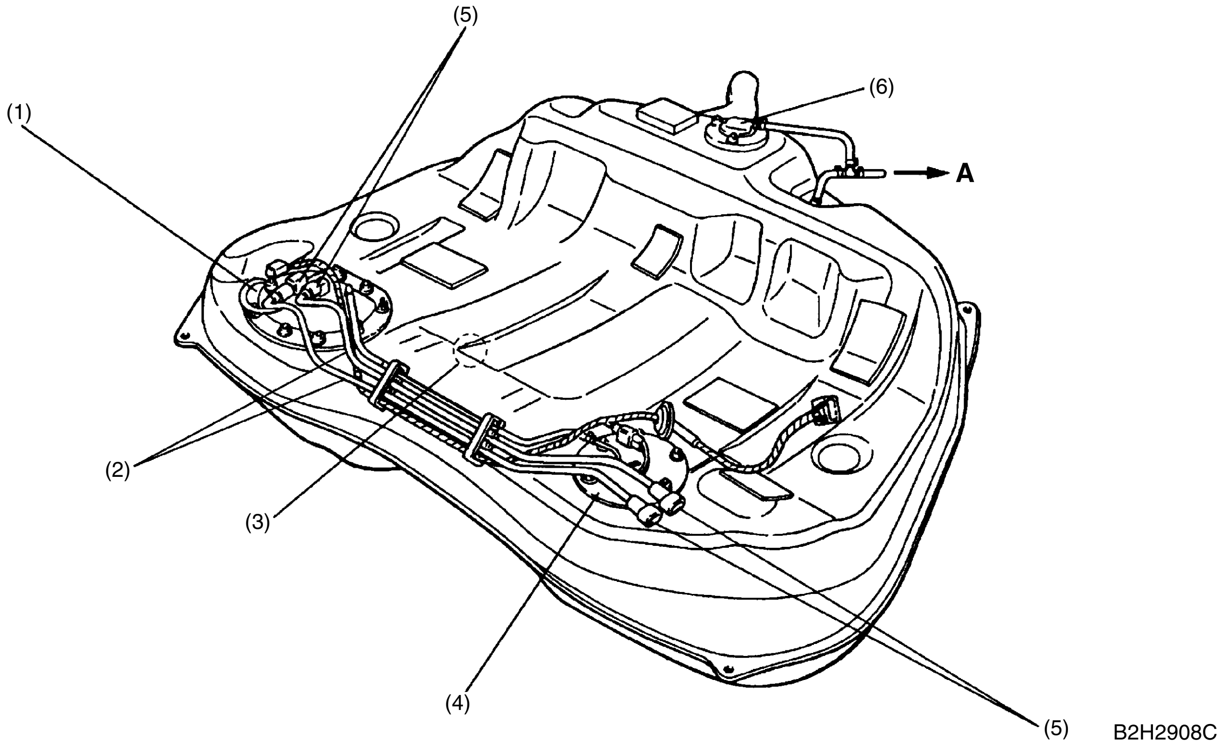
- The injector injects fuel according to the valve open signal from the ECM. The needle valve is lifted by the solenoid which is energized on arrival of the valve open signal.
- Since the injector's nozzle hole area, the lift of valve and the fuel pressure are kept constant, the amount of fuel injected is controlled only by varying the duration of the valve open signal from the ECM.
- Fuel atomization is enhanced using assist air supplied from the idle air control solenoid valve passing through the passage formed in the intake manifold at the area in which each injector is installed. This contributes not only to higher combustion efficiency and higher output but also to cleaner exhaust emissions.




| | | | |
|---|---|---|---|
| (1) | O-ring | (4) | Seal |
| (2) | Filter | (5) | O-ring |
| (3) | Plunger | (6) | Connector |

## D: FUEL TANK

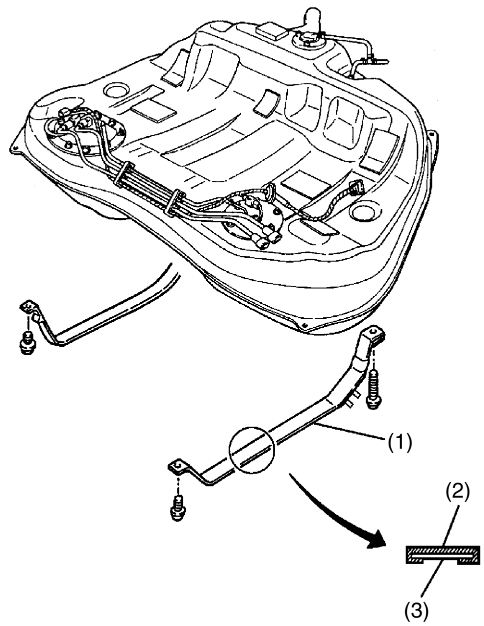
The fuel tank utilizes a two-compartment design to ensure sufficient capacity without interfering with the rear differential. It is provided with a suction jet pump (included in the fuel pump and fuel level sensor assembly) which transfers fuel from one compartment to the other. Each compartment has an individual fuel level sensor.




(1) Fuel pump and fuel level sensor assembly
(2) Nylon tube
(3) Fuel cut valve (Sub-compartment)
(4) Fuel level sensor (Sub-compartment)
(5) Quick connector
(6) Fuel cut valve (Main compartment)

**A:** To two way valve

The fuel tank is located under the rear seat and secured with hold-down bands.

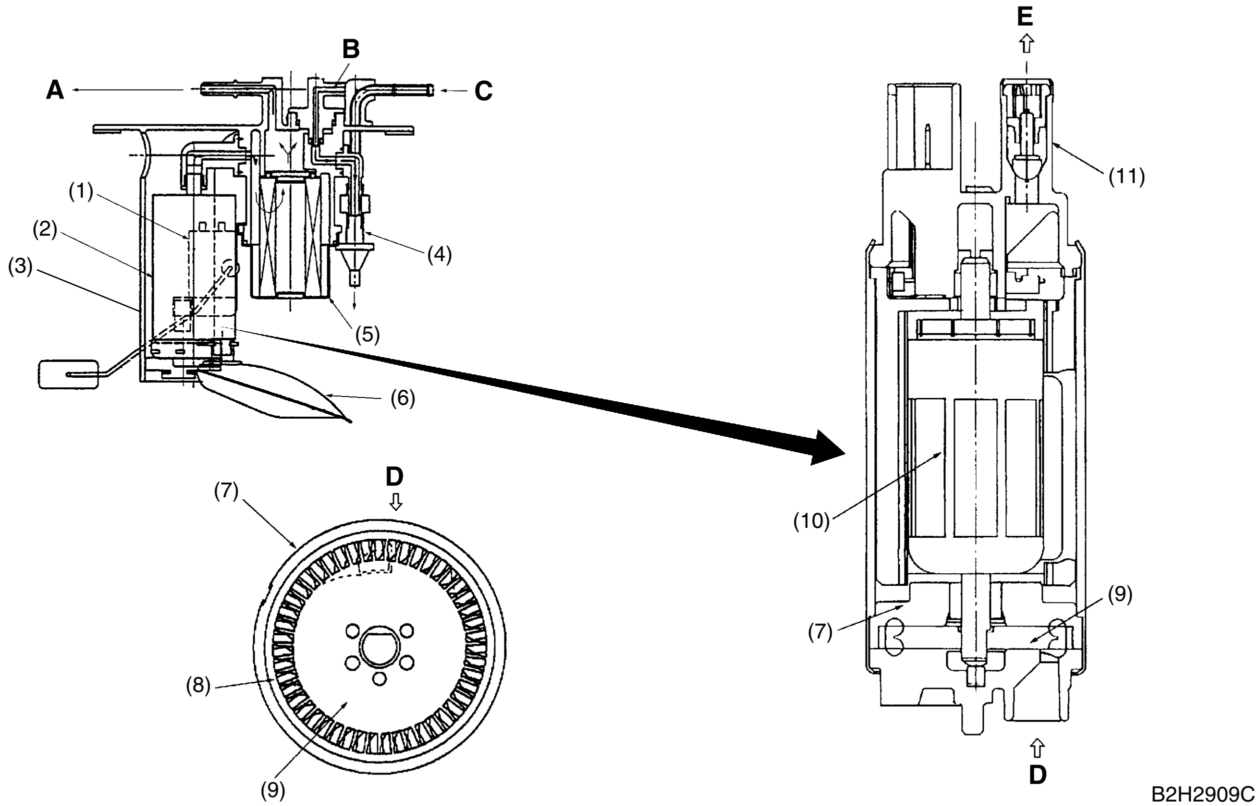



(1) Band
(2) Cushion
(3) Steel

## E: FUEL PUMP AND FUEL LEVEL SENSOR ASSEMBLY

### 1. FUEL PUMP

The fuel pump consists of a motor, impeller, pump casing, pump cover, check valve and filter. It is located in the fuel tank and combined with the fuel level sensor into a single unit. The operation of this impeller type pump is very quiet.

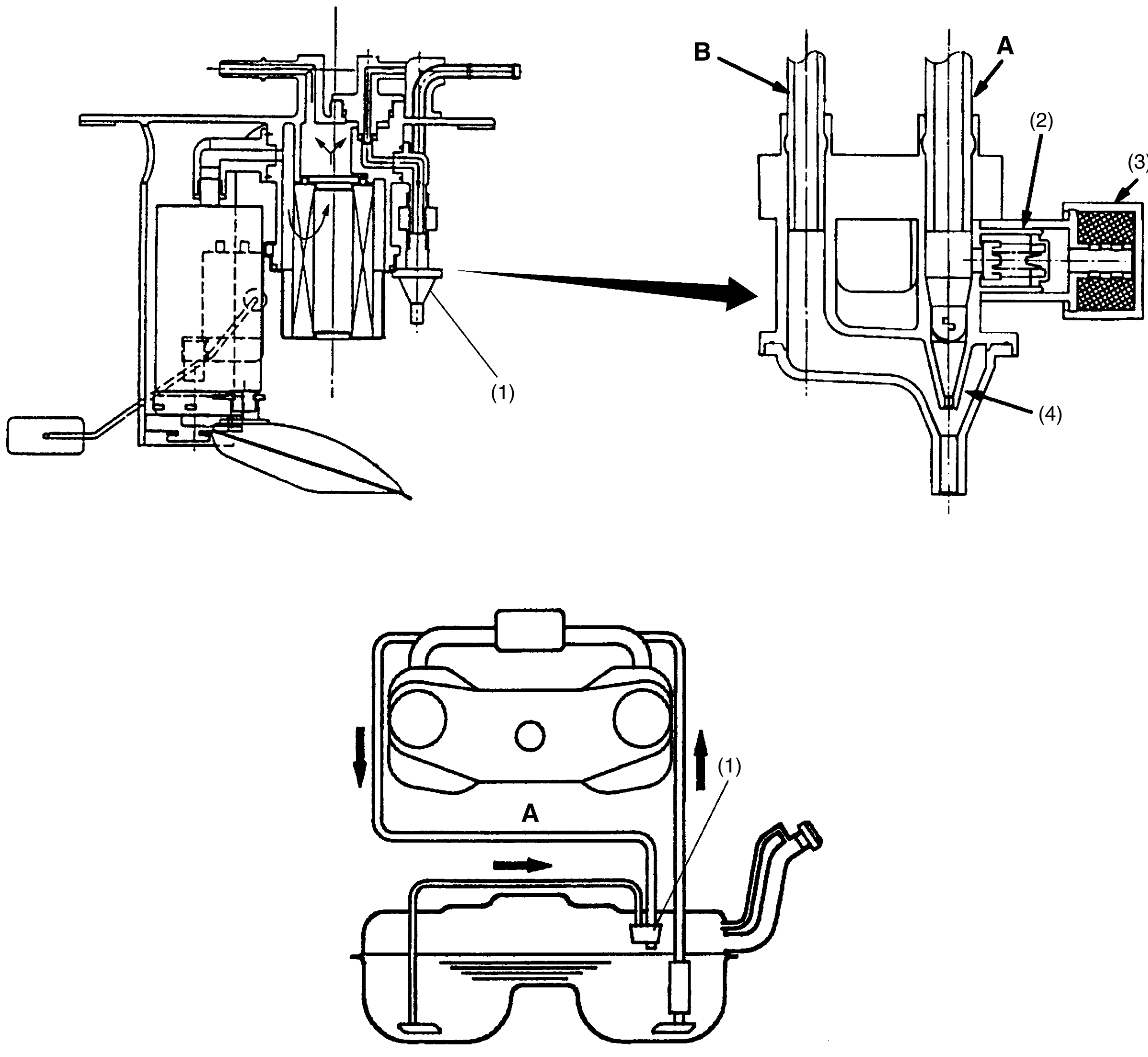



| | | | | | |
|---|---|---|---|---|---|
| (1) | Fuel level sensor | (7) | Pump casing | **A:** | To engine (delivery line) |
| (2) | Fuel pump | (8) | Fuel passage | **B:** | From engine (return line) |
| (3) | Pump cover | (9) | Impeller | **C:** | From sub tank |
| (4) | Jet pump | (10) | Motor armature | **D:** | Suction |
| (5) | Cartridge filter | (11) | Check valve | **E:** | Discharge |
| (6) | Mesh filter | | | | |

- When the ignition switch is turned ON, fuel pump relay is activated. Then the motor operates to rotate the impeller.
- As the impeller rotates, fuel in a vane groove of the impeller flows along the fuel passage into the next vane groove by centrifugal force. When fuel flows from one groove to the next, a pressure difference occurs due to friction. This creates a pumping effect.
- The fuel pushed up by rotation of the impeller then passes through the clearance between the armature and the magnet of the motor and is discharged through the check valve.
- When the fuel discharge pressure reaches the specified level, the relief valve opens and excess fuel is released into the fuel tank. In this manner, the relief valve prevents an abnormal increase in fuel pressure.
- When the engine and the fuel pump stop, spring force acts on the check valve to close the discharge port, so that the fuel pressure in the fuel delivery line is retained.

## 2. JET PUMP

- The jet pump utilizes the velocity of fuel returning from the engine to produce negative pressure in it.
- Using the pumping effect produced by the negative pressure, the jet pump transfers fuel from the sub-compartment to the main compartment of the fuel tank.
- When the return line nozzle is clogged, the fuel sent back through the return line flows back into the fuel tank via the relief valve.



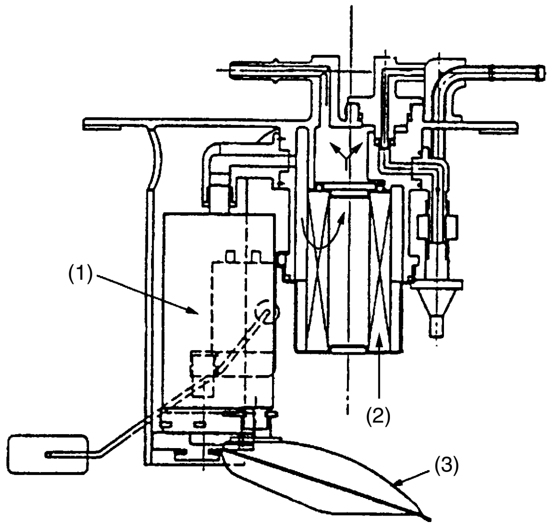

B2H2911C

(1) Jet pump
(2) Relief valve
(3) Silencer
(4) Nozzle

A: Return line
B: From sub tank compartment

## 3. FUEL FILTERS

There are two different types of fuel filters inside fuel tank, forming integral part of the fuel pump. The filter at the inlet of the fuel pump is a mesh type which removes relatively large particles in the fuel before it enters the pump. The filter at the outlet of the pump is a pressure resistant cartridge type whose inside filtering element can remove small particles in the pressurized fuel.



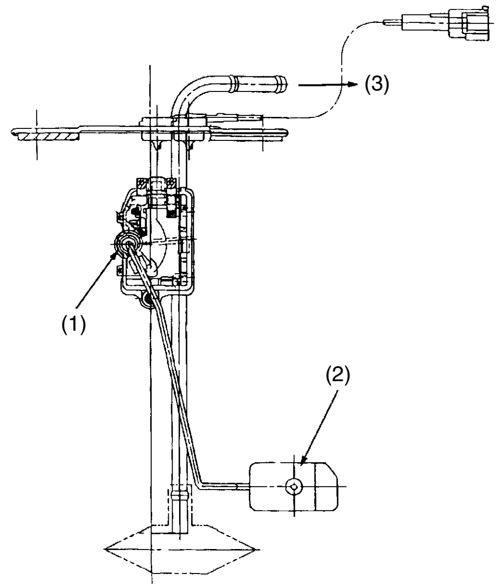

(1) Fuel pump

(2) Cartridge filter

(3) Mesh filter

## F: SUB-COMPARTMENT FUEL LEVEL SENSOR

This sensor detects the level of the fuel in the sub-compartment (the compartment in which the fuel pump is not located) and acts as part of the fuel transfer line when the jet pump is in operation to maintain the fuel in both compartments at the same level.




B2H2912B

(1) Fuel level sensor (Sub)
(2) Float
(3) To jet pump

# 4. Sensors and Switches

## A: FRONT OXYGEN (A/F) SENSOR

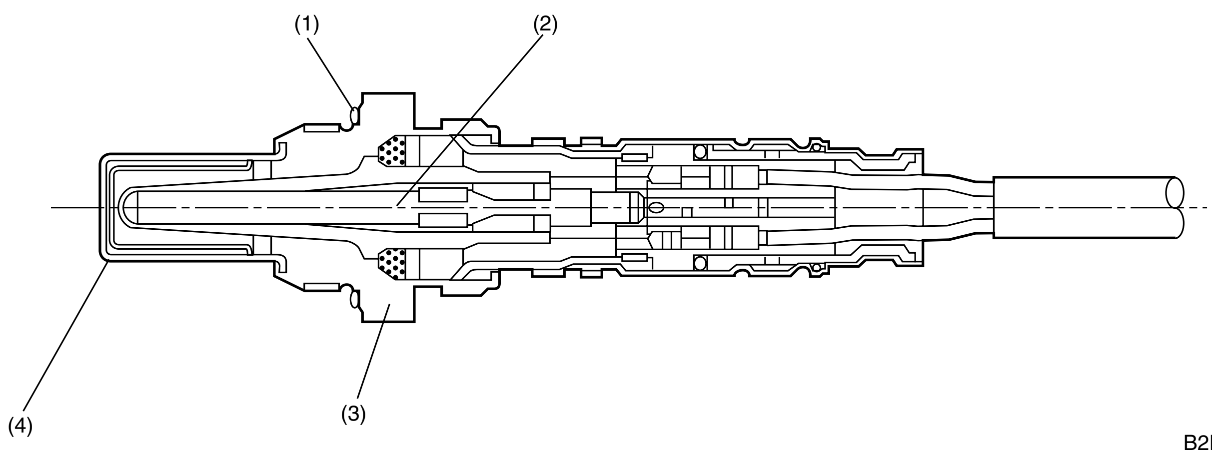
● The front oxygen sensor uses zirconium oxide ($ZrO_2$) which is a solid electrolyte, at portions exposed to exhaust gas.

● The zirconium oxide has the property of generating electromotive force when its both sides are exposed to oxygen ions of different concentration and the magnitude of this electromotive force depends on how much the difference is.

● The front oxygen sensor detects the amount of oxygen in exhaust gases by making use of this property of the zirconium oxide material.

● The zirconium oxide material is formed into a closed end tube and its external surface is exposed to exhaust gases with smaller oxygen ion concentration, whereas its internal surface is exposed to atmospheric air. The external surface has a porous platinum coating. The sensor housing is grounded to the exhaust pipe and the inside is connected to the ECM through the harness to be able to use the current output from the sensor.

● The sensor incorporates a ceramic heater to improve its performance at low temperatures.



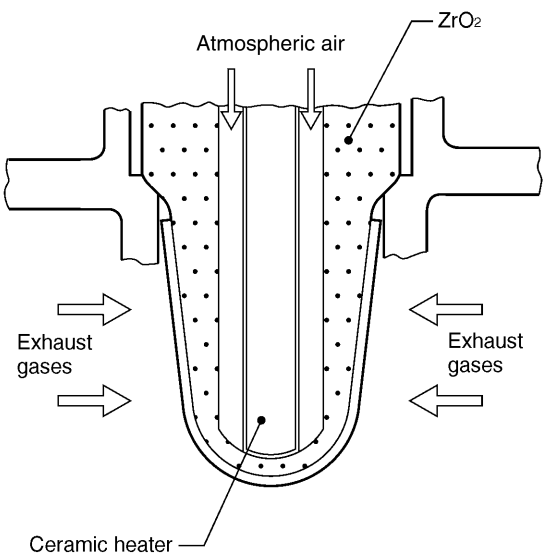

B2H3910B

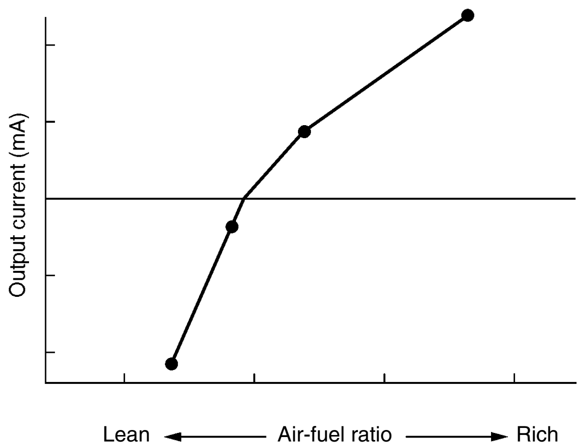
(1) Gasket
(2) Ceramic heater
(3) Sensor housing
(4) Protection tube

● When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases is almost completely used in the catalytic reaction by the platinum coating on the external surface of the zirconia tube. This results in a very large difference in the oxygen ion concentration between the inside and outside of the tube, and the electromotive force generated is large.

● When a lean air-fuel mixture is burnt in the cylinder, relatively large amount of oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen ion concentration between the tube's internal and external surfaces. The electromotive force in this case is very small.

● The difference in oxygen concentration changes drastically in the vicinity of the stoichiometric air-fuel ratio, and hence the change in the electromotive force is also large. By using this information, the ECM can determine the air-fuel ratio of the supplied mixture easily. The front oxygen sensor does not generate much electromotive force when the temperature is low. The output characteristics of the sensor stabilize at a temperature of approximately 700°C (1,292°F).

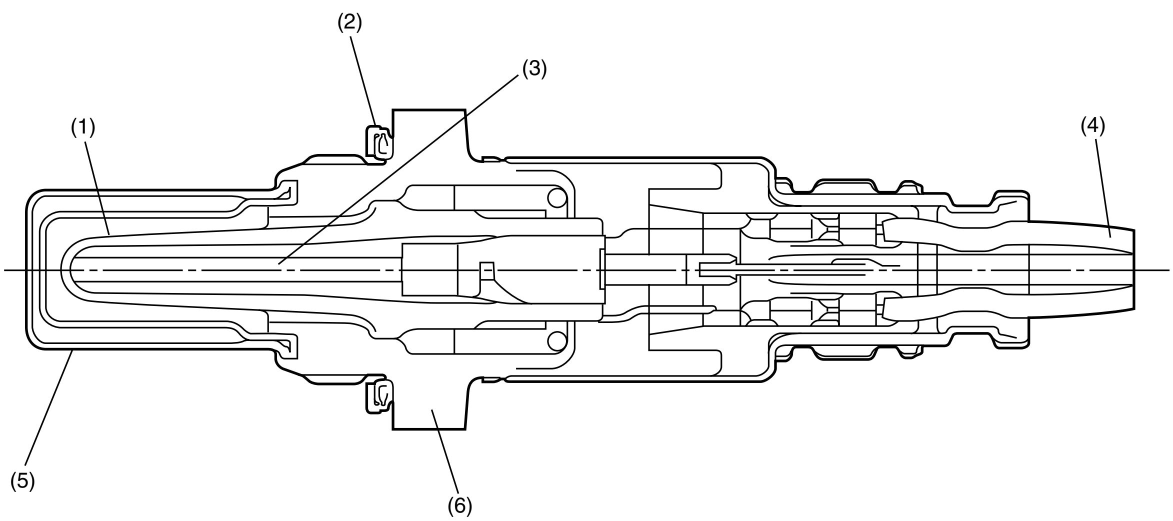



B2H2006B

## B: REAR OXYGEN SENSOR

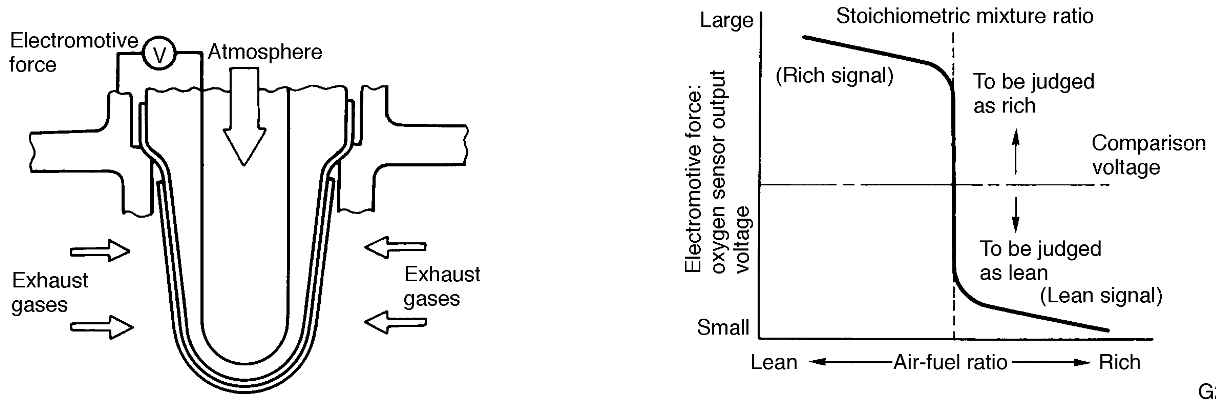
- The rear oxygen sensor is used to sense oxygen concentration in the exhaust gas. If the air-fuel ratio is leaner than the stoichiometric ratio in the mixture (i.e., excessive amount of air), the exhaust gas contains more oxygen. To the contrary, if the fuel ratio is richer than the stoichiometric ratio, the exhaust gas contains almost no oxygen.
- Detecting the oxygen concentration in exhaust gas using the oxygen sensor makes it possible to determine whether the air-fuel ratio is leaner or richer than the stoichiometry.
- The rear oxygen sensor has a zirconia tube (ceramic) which generates voltage if there is a difference in oxygen ion concentration between the inside and outside of the tube. Platinum is coated on the inside and outside of the zirconia tube as a catalysis and electrode material. The sensor housing is grounded to the exhaust pipe and the inside is connected to the ECM through the harness.
- A ceramic heater is employed to improve performance at low temperatures.




B2H4156B

| | |
|---|---|
| (1) Zirconia tube | (4) Harness |
| (2) Gasket | (5) Protection tube |
| (3) Ceramic heater | (6) Sensor housing |

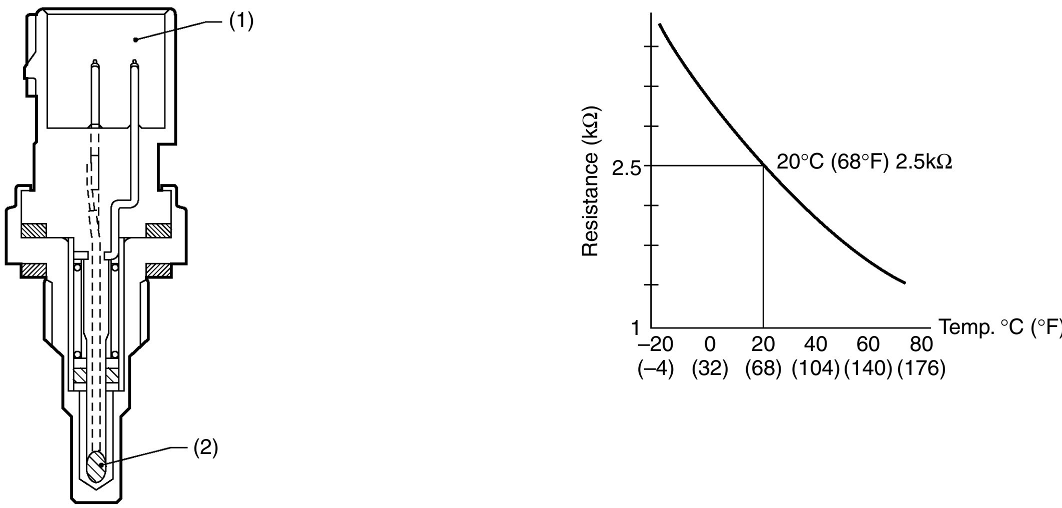
- When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases is almost completely used in the catalytic reaction by the platinum coating on the external surface of the zirconia tube. This results in a very large difference in the oxygen ion concentration between the inside and outside of the tube, and the electromotive force generated is large.
- When a lean air-fuel mixture is burnt in the cylinder, relatively large amount of oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen ion concentration between the tube's internal and external surfaces. The electromotive force in this case is very small.
- The difference in oxygen concentration changes drastically in the vicinity of the stoichiometric air-fuel ratio, and hence the change in the electromotive force is also large. By using this information, the ECM can determine the air-fuel ratio of the supplied mixture easily. The rear oxygen sensor does not generate much electromotive force when the temperature is low. The output characteristics of the sensor stabilize at a temperature of approximately 300 to 400°C (572 to 752°F).




G2H0038B

## C: ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant temperature sensor is located on the engine coolant pipe. The sensor uses a thermistor whose resistance changes inversely with temperature. Resistance signals as engine coolant temperature information are transmitted to the ECM to make fuel injection, ignition timing, purge control solenoid valve and other controls.



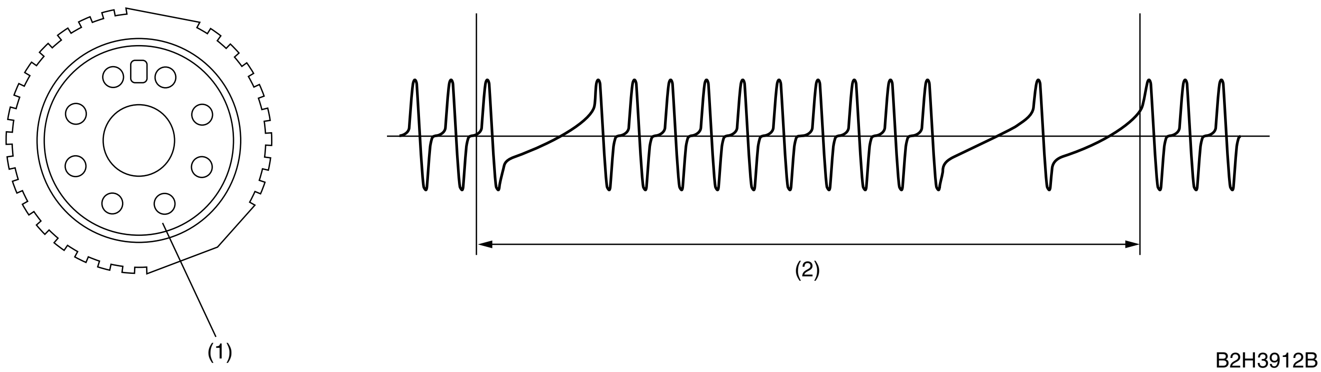

S2H1113B

(1) Connector

(2) Thermistor element

## D: CRANKSHAFT POSITION SENSOR

- The crankshaft position sensor is installed on the rear end of the cylinder block. The sensor generates a pulse when one of the teeth on the perimeter of the crankshaft plate (rotating together with the crankshaft) passes in front of it. The ECM determines the crankshaft angular position by counting the number of pulses.
- As the crankshaft rotates, each tooth of the crankshaft plate aligns with the crankshaft position sensor so that the magnetic flux in the sensor's coil changes since the air gap between the sensor pickup and the crankshaft plate changes. This change in magnetic flux induces a voltage pulse in the sensor and the pulse is transmitted to the ECM.

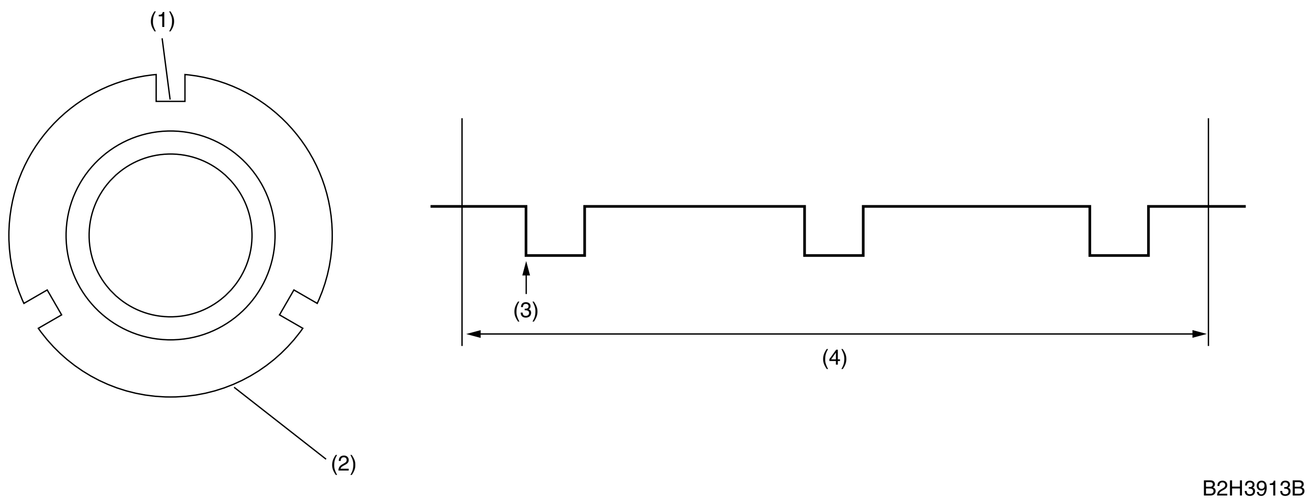



(1) Crankshaft plate
(2) Crankshaft half rotation

## E: CAMSHAFT POSITION SENSOR

● The camshaft position sensor is located on the right-hand cylinder head. It detects the combustion cylinder at any given moment.

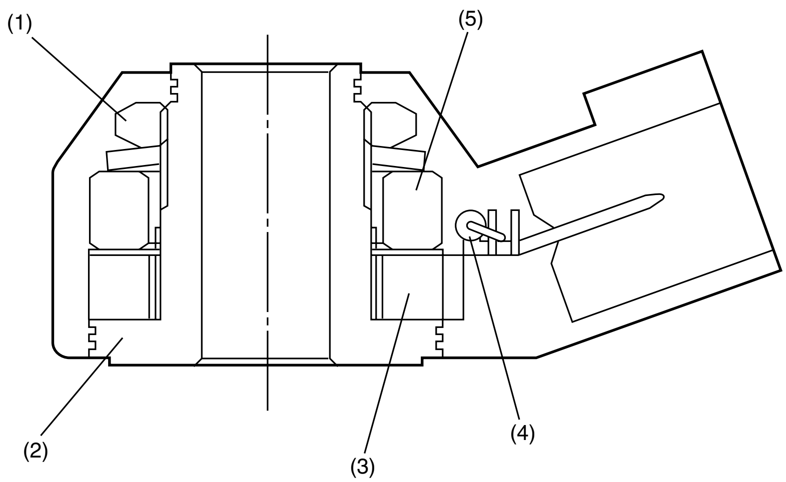
● The sensor generates a pulse when one of the slots on the back of the right-hand camshaft plate passes in front of the sensor. The ECM detects the camshaft position by measuring the pulse. Three slots are provided on the plate as shown below.




(1) Slot
(2) Camshaft plate
(3) Detection point
(4) Camshaft one rotation (Crankshaft two rotations)

## F: KNOCK SENSOR

- The knock sensor is installed on the cylinder block, and senses knocking that occurs in the engine.
- The sensor is a piezo-electric type which converts vibration resulting from knocking into electric signals.
- In addition to a piezo-electric element, the sensor has a weight and case as its components. If knocking occurs in the engine, the weight in the case moves causing the piezo-electric element to generate a voltage.
- The knock sensor harness is connected to the bulkhead harness.

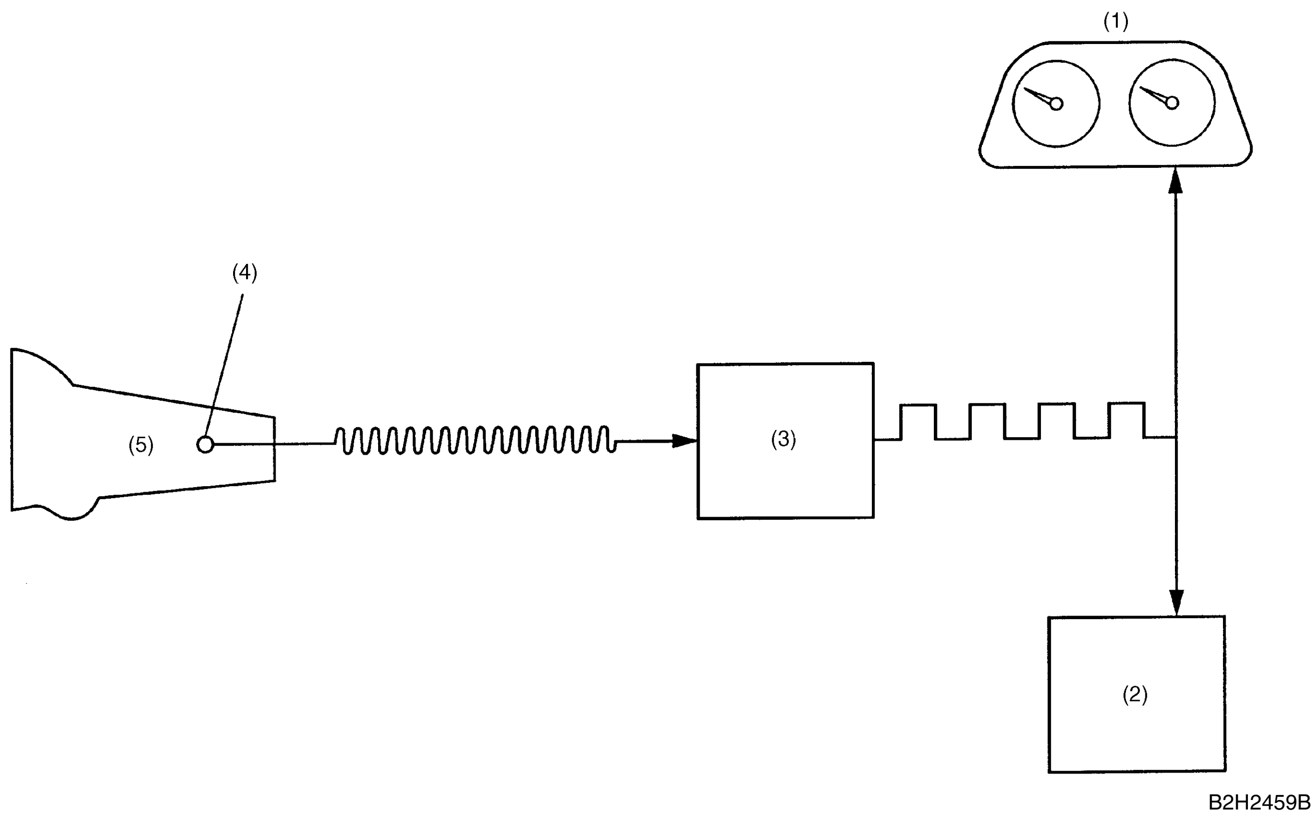



(1) Nut
(2) Housing
(3) Piezo-electric element
(4) Resistor
(5) Weight

## G: VEHICLE SPEED SENSOR

● The vehicle speed sensor is mounted on the transmission.

● The vehicle speed sensor generates a 16-pulse signal for every rotation of the front differential and send it to the transmission control module (TCM). The signal sent to the TCM is converted there into a 4-pulse signal, and then sent to the ECM and the combination meter.




(1) Combination meter
(2) ECM
(3) TCM
(4) Vehicle speed sensor
(5) Transmission

# 5. Control System

## A: GENERAL

The ECM receives signals from various sensors, switches, and other control modules. Using these signals, it determines the engine operating conditions and if necessary, emits signals to one or more systems to control them for optimum operation.

Major control items of the ECM are as follow:

- Fuel injection control
- Ignition system control
- Idle air control
- Canister purge control*1
- Radiator fan control*2
- Fuel pump control
- On-board diagnosis function

*1: Canister purge control is described under “EC (H6) – Emission Control (Aux. Emission Control Devices) Evaporative Emission Control System”.

*2: Radiator fan control is described under “CO (H6) – Cooling”.

## B: INPUT AND OUTPUT SIGNALS

| Signal | Unit | Function |
|---|---|---|
| Input signals | Intake manifold pressure sensor | Detects the amount of intake air (Measures the absolute pressure). |
| | Intake air temperature sensor | Detects the temperature of intake air. |
| | Throttle position sensor | Detects the throttle valve position. |
| | Front oxygen (A/F) sensor | Detects the density of oxygen in exhaust gases at the upstream of the front catalytic converter. |
| | Rear oxygen sensor | Detects the density of oxygen in exhaust gases at the downstream of the rear catalytic converter. |
| | Crankshaft position sensor | Detects the crankshaft angular position. |
| | Camshaft position sensor | Detects the combustion cylinder. |
| | Engine coolant temperature sensor | Detects the engine coolant temperature. |
| | Knock sensor | Detects engine knocking. |
| | Front vehicle speed sensor | Detects the vehicle speed. |
| | Ignition switch | Detects operation of the ignition switch. |
| | Starter switch | Detects the condition of engine cranking. |
| | Park/Neutral position switch | Detects shift positions. |
| | Diagnostic of AT | Detects the self-diagnostics of AT |
| | Heater circuit of front and rear oxygen sensor | Detects the abnormality in heater circuit of front and rear oxygen sensor. |
| | A/C switch | Detects ON-OFF operation of the A/C switch. |
| | Fuel level sensor | Detects the level of the fuel in the fuel tank. |
| | Small light switch | Detects ON-OFF operation of the small light switch. |
| | Blower fan switch | Detects ON-OFF operation of the blower fan switch. |
| | Rear defogger switch | Detects ON-OFF operation of the rear defogger switch. |
| Output signals | Fuel Injector | Activates an injector. |
| | Ignition signal | Turns the primary ignition current ON or OFF. |
| | Fuel pump relay | Turns the fuel pump relay ON or OFF. |
| | A/C control relay | Turns the A/C control relay ON or OFF. |
| | Radiator fan control relay | Turns the radiator fan control relay ON or OFF. |
| | Idle air control solenoid valve | Adjusts the amount of air flowing through the bypass line in the throttle body. |
| | Induction control solenoid valve | Controls induction control valve. |
| | EGR solenoid valve | Controls EGR valve. |
| | Malfunction indicator lamp | Indicates existence of abnormality. |
| | Purge control solenoid valve | Controls purge of evaporative gas absorbed by the canister. |
| | Power supply | Controls ON/OFF of the main power supply relay. |

## C: FUEL INJECTION CONTROL

● The ECM receives signals from various sensors and based on them, it determines the amount of fuel injected and the fuel injection timing. It performs the sequential fuel injection control over the entire engine operating range except during start-up of the engine.

● The amount of fuel injected depends upon the length of time the injector stays open. The fuel injection duration is determined according to varying operating condition of the engine. For the purpose of achieving highly responsive and accurate fuel injection duration control, the ECM performs a new feedback control that incorporates a learning feature as detailed later.

● The sequential fuel injection control is performed such that fuel is injected accurately at the time when the maximum air intake efficiency can be achieved for each cylinder (i.e., fuel injection is completed just before the intake valve begins to open).

### 1. FUEL INJECTION DURATION

Fuel injection duration is basically determined as indicated below:

● During engine start-up:
The duration defined below is used.

- ● Duration of fuel injection during engine start-up ..... Determined according to the engine coolant temperature detected by the engine coolant temperature sensor.

● During normal operation:
The duration is determined as follows:

Basic duration of fuel injection x Correction factors + Voltage correction time

- ● Basic duration of fuel injection ..... The basic length of time fuel is injected. This is determined by two factors – the amount of intake air detected by the manifold pressure sensor and the engine speed monitored by the crankshaft position sensor.
- ● Correction factors ..... See the next section.
- ● Voltage correction time ..... This is added to compensate for the time lag before operation of injector that results from variation in the battery voltage.

## 2. CORRECTION FACTORS

The following factors are used to correct the basic duration of fuel injection in order to make the air-fuel ratio meet the requirements of varying engine operating conditions:

- Air-fuel ratio feedback factor:

This factor is used to correct the basic duration of fuel injection in relation to the actual engine speed. (See the next section for more detail.)

- Start increment factor:

This factor is used to increase the fuel injection duration only while the engine is being cranked to improve its startability.

- Coolant-temperature-dependent increment factor:

This factor is used to increase the fuel injection duration depending on engine coolant temperature signals to facilitate cold starting. The lower the coolant temperature, the greater the increment.

- After-start increment factor:
  - This factor is used to increase the fuel injection duration for a certain period immediately after start of the engine to stabilize engine operation.
  - The increment depends on the coolant temperature at the start of the engine.

- Wide-open-throttle increment factor:

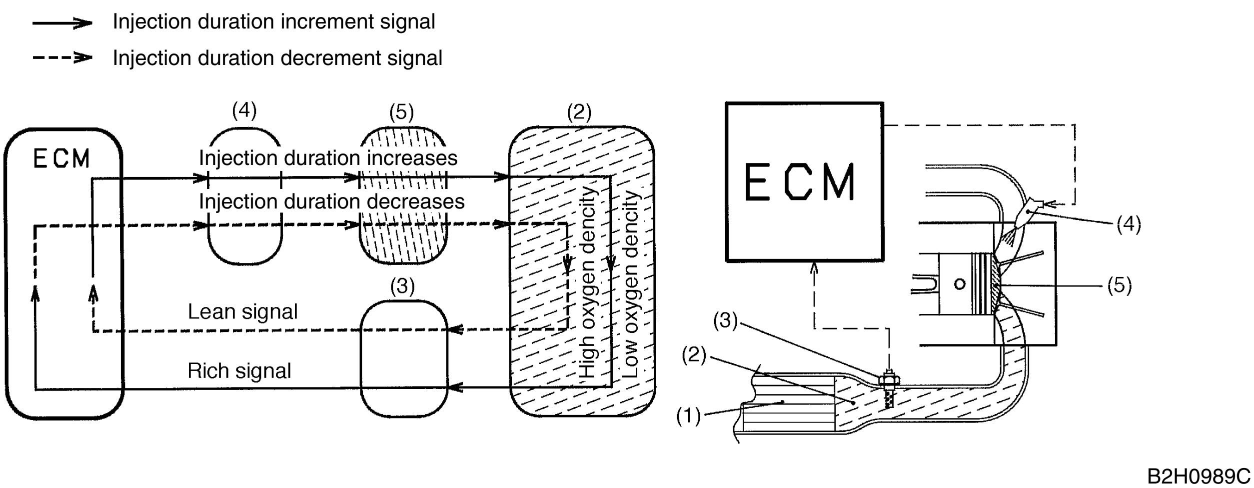
This factor is used to increase the fuel injection duration depending on the relationship between the throttle position sensor signal and manifold pressure sensor signal.

- Acceleration increment factor:

This factor is used to increase the fuel injection duration to compensate for a time lag between air flow measurement and fuel injection control for better engine response to driver's pedal operation during acceleration.

## 3. AIR-FUEL RATIO FEEDBACK FACTOR

The ECM creates this factor utilizing the front oxygen sensor signal. When the signal voltage is low, the air-fuel ratio is richer than the stoichiometric ratio. The ECM then makes the fuel injection duration shorter by modifying the factor. When the voltage is high showing that the mixture is lean, the ECM modifies the factor to make the injection duration longer. In this way, the air-fuel ratio is maintained at a level close to the stoichiometric ratio at which the three-way catalyst acts most effectively.




(1) Front catalyst
(2) Exhaust gas
(3) Front oxygen (A/F) sensor
(4) Fuel injector
(5) Combustion chamber

## 4. LEARNING FEATURE

The air-fuel ratio feedback control includes a learning feature which contributes to more accurate and responsive control.

- In the air-fuel ratio feedback control, the ECM calculates the necessary amount of correction based on data from the oxygen sensor and adds the result to the basic duration (which is stored in the ECM's memory for each condition defined by the engine speed and various loads.)
- Without a learning feature, the ECM carries out the above-mentioned process every time. This means that if the amount of necessary correction is large, the air-fuel ratio feedback control becomes less responsive and less accurate.
- The learning feature enables the ECM to store the amount of correction into memory and add it to the basic fuel injection duration to create a new reference fuel injection duration. Using the reference duration as the basic duration for the injection a few times later, the ECM can reduce the amount of correction and thus make its feedback control more accurate and responsive to changes in the air-fuel ratio due to difference in driving condition and sensor/actuator characteristics that may result from unit-to-unit variation or aging over time.

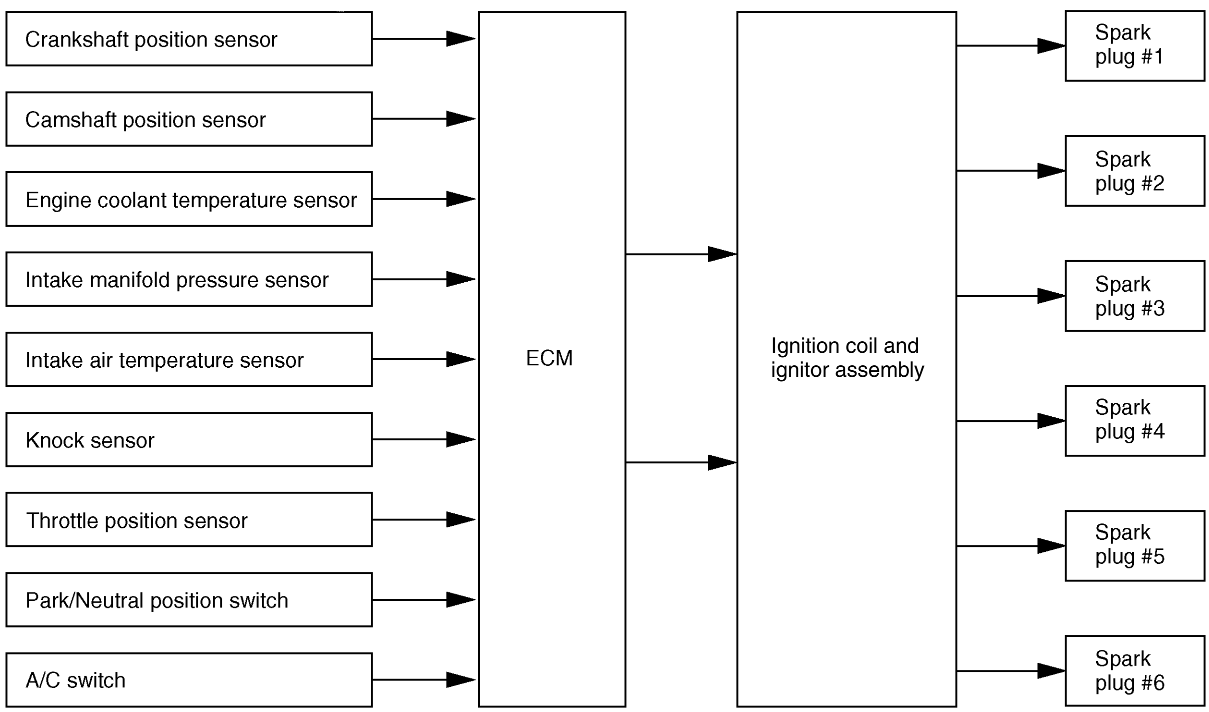
## D: IGNITION SYSTEM CONTROL

● The ECM determines operating condition of the engine based on signals from the pressure sensor, engine coolant temperature sensor, intake air temperature sensor, crankshaft position sensor and other sources. It then selects the ignition timing most appropriate for the condition thus determined from those stored in its memory and outputs at that timing a primary current OFF signal to the ignitor to initiate ignition.

● This control uses a quick-to-response learning feature by which the data stored in the ECM memory is processed in comparison with information from various sensors and switches.

● Thus, the ECM can always perform optimum ignition timing taking into account the output, fuel consumption, exhaust gas, and other factors for every engine operating condition.

● Ignition control during start-up
Engine speed fluctuates during start of the engine, so the ECM cannot control the ignition timing. During that period, the ignition timing is fixed at 10° BTDC by using the 10° signal from the crankshaft position sensor.

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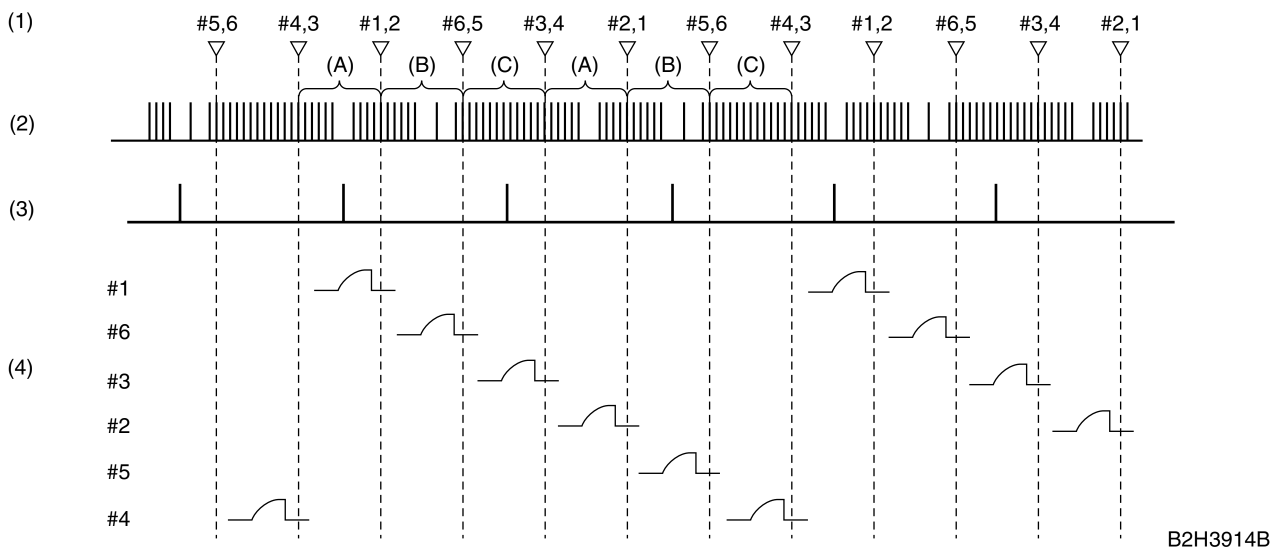
- The ECM receives two types of crank angle signal pulse; one is generated every 10° of crankshaft rotation and the other, every 30° of crankshaft rotation. Using these two types of signal pulse, the ECM determines the position of each piston as follows:

The ECM interprets the pulses of range (A) shown below as the No. 1 and No. 2 cylinder pistons being at TDC, the pulses of range (B) as the No. 5 and No. 6 cylinder pistons being at TDC, and the pulses of range (C) as the No. 3 and No. 4 cylinder pistons being at TDC.

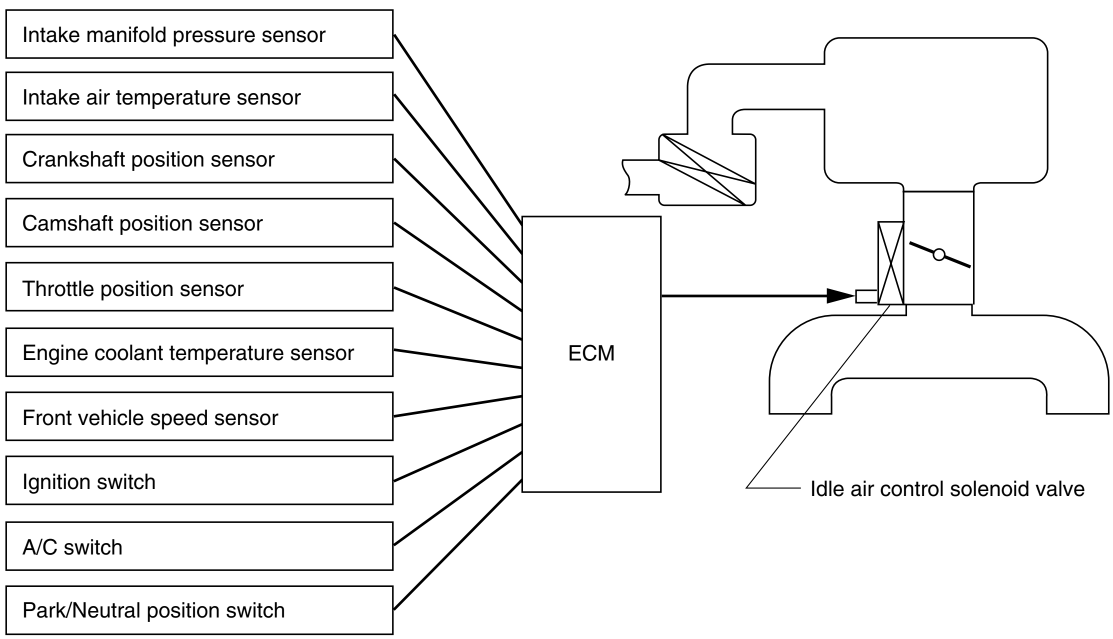
- The ECM outputs an ignition signal for the No. 1, No. 3 or No. 5 cylinder when it receives a camshaft angle pulse before a TDC signal and for the No. 2, No. 4 or No. 6 cylinder when it receives no camshaft angle pulse before a TDC signal.




(1) Cylinder number (TDC)
(2) Crank angle pulse
(3) Cam angle pulse
(4) Ignition timing

## E: IDLE AIR CONTROL

- The ECM activates the idle air control solenoid valve to control the bypass air flowing through the bypass passage in the throttle body depending on signals from the crankshaft position sensor, engine coolant temperature sensor, pressure sensor and A/C switch so that the proper idle speed for each engine load is achieved.
- The idle air control solenoid valve uses a duty-ratio-controlled solenoid which can continuously vary the opening area of the rotary valve. As the ECM increases the duty ratio, opening of the rotary valve increases so that the bypass air flow increases, and the engine idling speed becomes higher as a result.
- The bypass air control is necessary for:
  - Increasing idling speed when the air conditioning system and/or electrical loads are turned on.
  - Increasing idling speed during early stage of warm up period.
  - Obtaining dashpot function when the throttle valve is quickly closed.
  - Prevention of engine speed variation during idling.

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## F: FUEL PUMP CONTROL

Using the signal from the crankshaft position sensor, the ECM controls operation of the fuel pump by turning its relay ON or OFF. To improve safety, the fuel pump is stopped if the engine stalls with the ignition switch ON.

| Ignition switch ON | Fuel pump relay | Fuel pump |
|---|---|---|
| A certain period of time after ignition switch is turned ON | ON | Operates |
| While cranking the engine | ON | Operates |
| While engine is operating | ON | Operates |
| When engine stops | OFF | Does not operate |

# 6. On-board Diagnosis System

## A: GENERAL

- The on-board diagnosis system detects and indicates a fault by generating a code corresponding to each fault location. The malfunction indicator lamp (CHECK ENGINE light) on the combination meter indicates occurrence of a fault or abnormality.
- When the malfunction indicator lamp comes on as a result of detection of a fault by the ECM, the corresponding diagnostic trouble code (DTC) and freeze frame engine condition are stored in the ECM.
- On the OBD-II conformable car, it is necessary to connect the Subaru Select Monitor (SSM) or General Scan Tool (GST) to the data link connector in order to check the DTC.
- The SSM and GST can read and erase DTCs. They can also read freeze frame data in addition to other pieces of engine data.
- If there is a failure involving sensors which may affect drive control of the vehicle, the fail-safe function ensures minimum level of driveability.

## B: FAIL-SAFE FUNCTION

For a sensor or switch which has been judged faulty in the on-board diagnosis, the ECM, if appropriate, generates an associated pseudo signal to keep the vehicle operational. (The control becomes degraded.)

# EMISSION CONTROL (AUX. EMISSION CONTROL DEVICES) EC (H6)

Page

# 1. System Overview

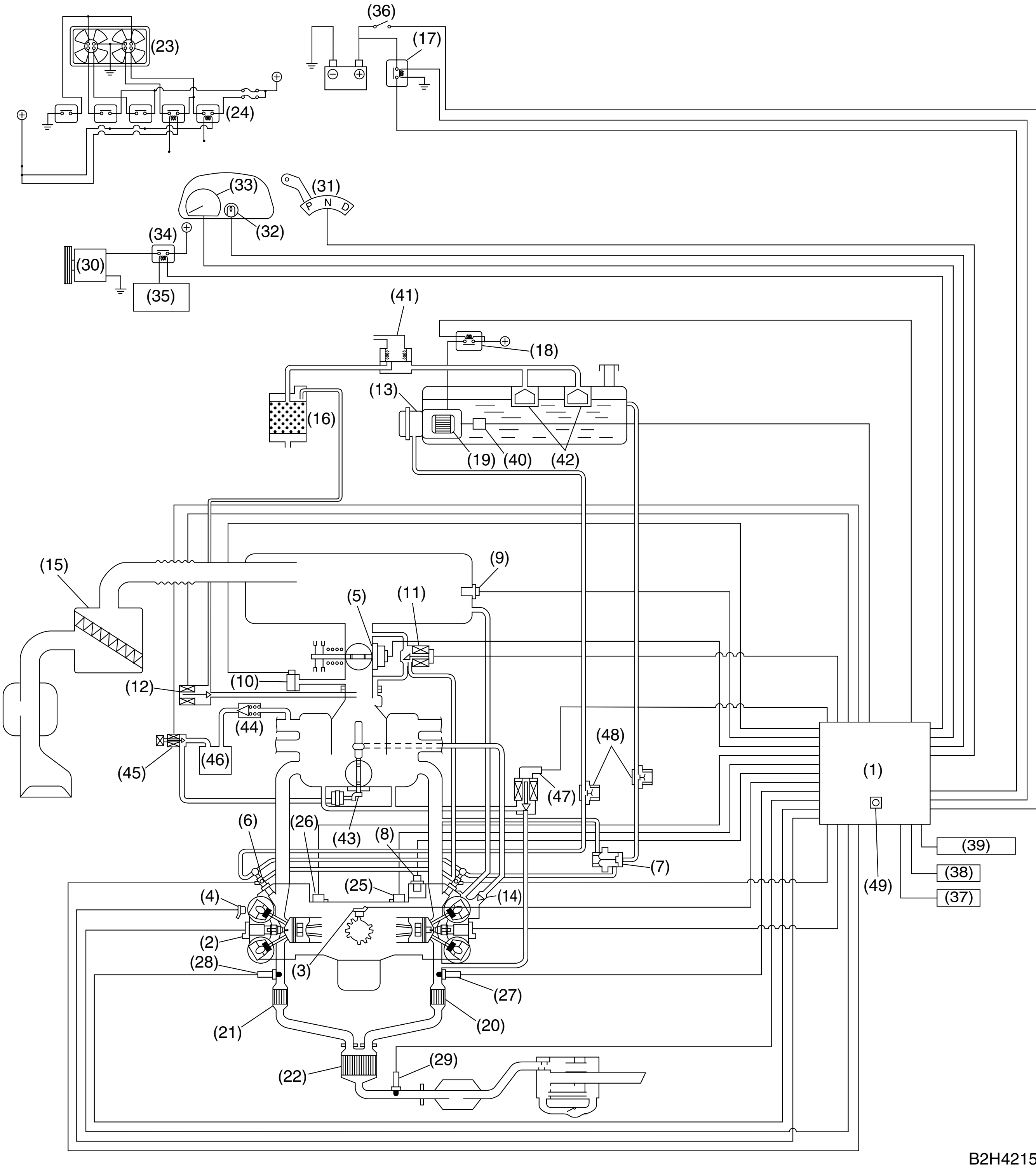
There are three emission control systems which are as follows:

- Crankcase emission control system
- Exhaust emission control system
  - Three-way catalyst system
  - Air/fuel (A/F) control system
  - Ignition control system
- Evaporative emission control system

| Item | | | Main components | Function |
|---|---|---|---|---|
| Crankcase emission control system | | | Positive crankcase ventilation (PCV) valve | Draws blow-by gas into intake manifold from crankcase and burns it together with air-fuel mixture. Amount of blow-by gas to be drawn in is controlled by intake manifold pressure. |
| Exhaust emission control system | Catalyst system | Front | Three-way catalyst | Oxidizes HC and CO contained in exhaust gases as well as reducing NOx. |
| | | Rear | | |
| | A/F control system | | Engine control module (ECM) | Receives input signals from various sensors, compares signals with stored data, and emits a signal for optimal control of air-fuel mixture ratio. |
| | | | Front oxygen (A/F) sensor | Detects quantity of oxygen contained exhaust gases. |
| | | | Rear oxygen sensor | Detects density of oxygen contained exhaust gases. |
| | | | Throttle position sensor | Detects throttle position. |
| | | | Intake manifold pressure sensor | Detects absolute pressure of intake manifold. |
| | | | Intake air temperature sensor | Detects intake air temperature of air cleaner case. |
| | Ignition control system | | ECM | Receives various signals, compares signals with basic data stored in memory, and emits a signal for optimal control of ignition timing. |
| | | | Crankshaft position sensor | Detects engine speed (Revolution). |
| | | | Camshaft position sensor | Detects reference signal for combustion cylinder discrimination. |
| | | | Engine coolant temperature sensor | Detects coolant temperature. |
| | | | Knock sensor | Detects engine knocking. |
| Evaporative emission control system | | | Canister | Absorbs evaporative gas which occurs in fuel tank when engine stops, and releases it to combustion chambers for a complete burn when engine is started. This prevents HC from being discharged into atmosphere. |
| | | | Purge control solenoid valve | Receives a signal from ECM and controls purge of evaporative gas absorbed by canister. |

**MEMO**

# 2. Schematic Diagrams

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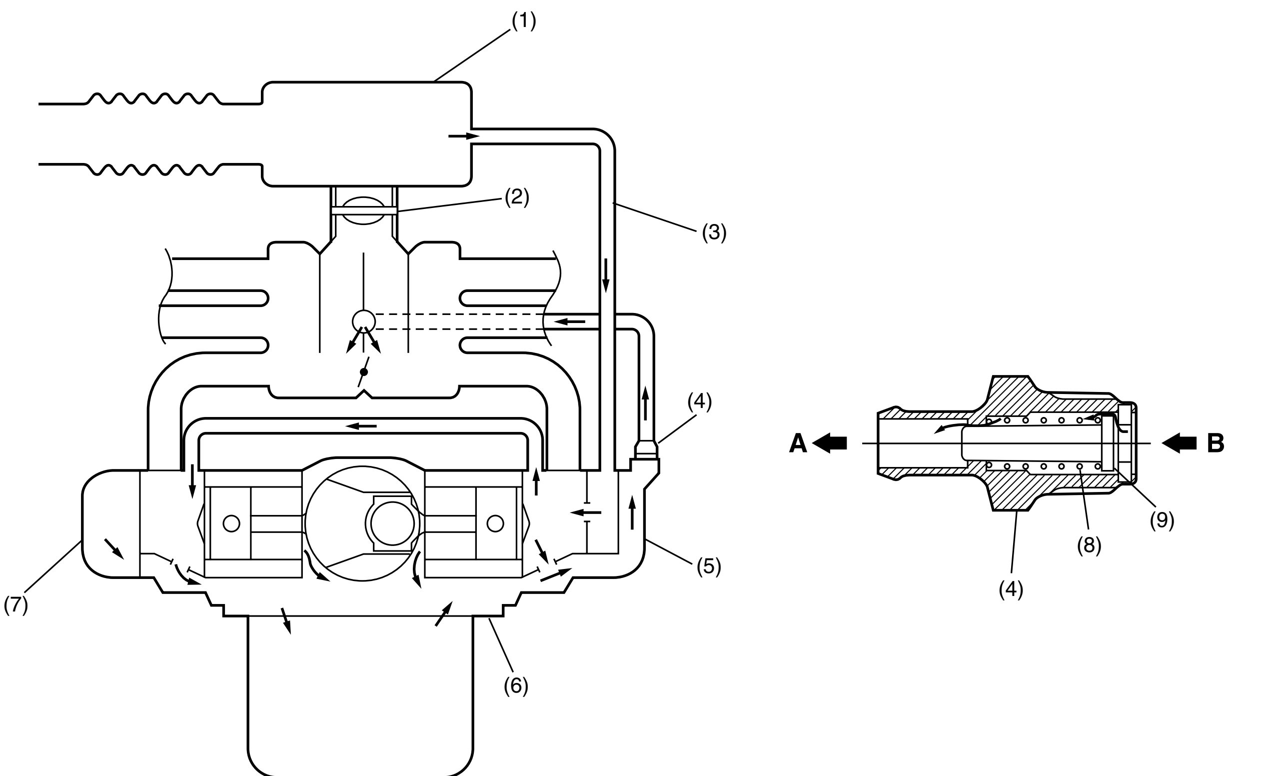
(1) Engine control module (ECM)
(2) Ignition coil and ignitor assembly
(3) Crankshaft position sensor
(4) Camshaft position sensor
(5) Throttle position sensor
(6) Fuel injectors
(7) Pressure regulator
(8) Engine coolant temperature sensor
(9) Intake air temperature sensor
(10) Intake manifold pressure sensor
(11) Idle air control solenoid valve
(12) Purge control solenoid valve
(13) Fuel pump
(14) PCV valve
(15) Air cleaner element
(16) Canister
(17) Main relay
(18) Fuel pump relay
(19) Fuel filter
(20) Front catalytic converter LH
(21) Front catalytic converter RH
(22) Rear catalytic converter
(23) Radiator fan
(24) Radiator fan relay
(25) Knock sensor LH
(26) Knock sensor RH
(27) Front oxygen (A/F) sensor LH
(28) Front oxygen (A/F) sensor RH
(29) Rear oxygen sensor
(30) A/C compressor
(31) Inhibitor switch
(32) CHECK ENGINE malfunction indicator lamp (MIL)
(33) Tachometer
(34) A/C relay
(35) A/C control module
(36) Ignition switch
(37) Vehicle speed sensor
(38) Data link connector
(39) Transmission control module (TCM)
(40) Fuel level sensor
(41) Two-way valve
(42) Fuel cut valve
(43) Induction valve
(44) Check valve
(45) Induction valve control solenoid
(46) Vacuum tank
(47) EGR valve
(48) Fuel damper
(49) Atmospheric pressure sensor

# 3. Crankcase Emission Control System

The positive crankcase ventilation (PCV) system prevents air pollution which will be caused by blow-by gas being emitted from the crankcase.
The system consists of rocker covers with fresh air inlet, connecting hoses, a PCV valve and a chamber.




| | | |
|---|---|---|
| (1) Chamber | (6) Crankcase | **A:** To intake manifold |
| (2) Throttle body | (7) Rocker cover LH | **B:** Blow-by gas |
| (3) Connecting hose | (8) Spring | |
| (4) PCV valve | (9) Valve | |
| (5) Rocker cover RH | | |

## 4. Three-way Catalyst

- The basic material of three-way catalyst is platinum (Pt), rhodium (Rh) and palladium (Pd), and a thin coat of their mixture is applied onto honeycomb or porous ceramics of an oval shape (carrier). To avoid damaging the catalyst, only unleaded gasoline should be used.
- The catalyst reduces HC, CO and NOx in exhaust gases through chemical reactions (oxidation and reduction). These harmful components are reduced most efficiently when their concentrations are in a certain balance. These concentrations vary with the air-fuel ratio. The ideal air-fuel ratio for reduction of these components is the stoichiometric ratio.
- Therefore, the air-fuel ratio needs to be controlled to around the stoichiometric ratio to purify the exhaust gases most efficiently.

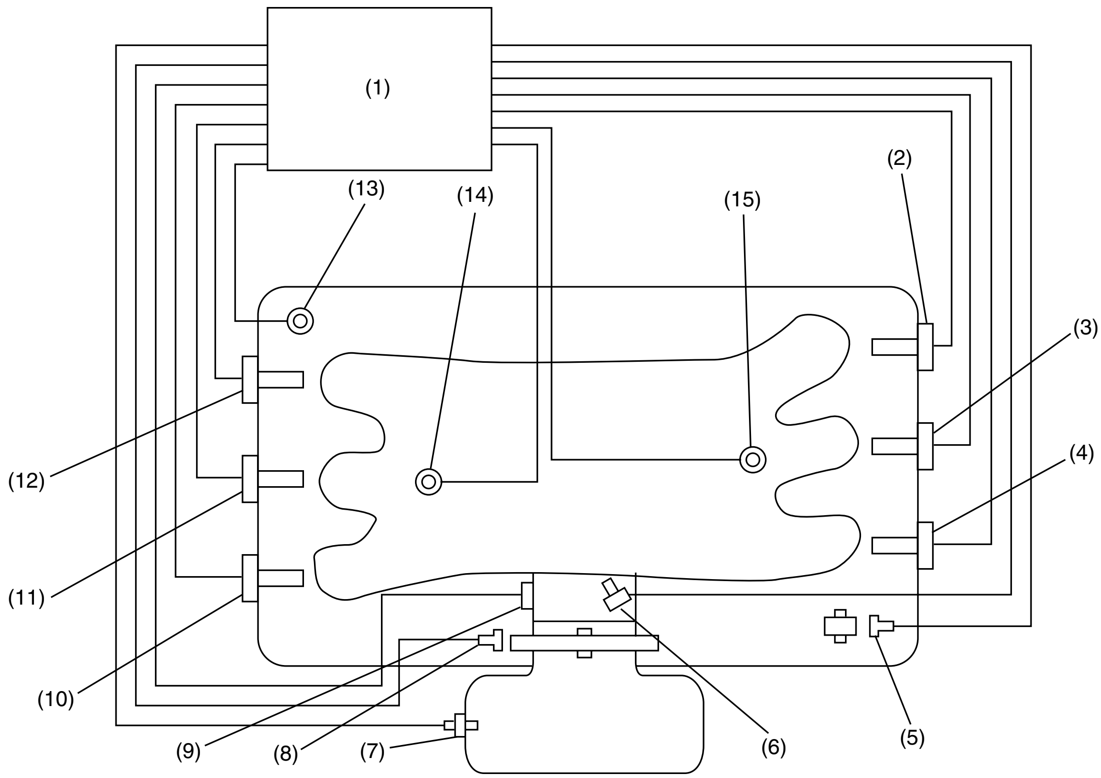
## 5. A/F Control System

- The air/fuel (A/F) control system makes a correction to the basic fuel injection duration in accordance with the signal from the front oxygen sensor so that the stoichiometric ratio is maintained, thus ensuring most effective exhaust gas purification by the three-way catalyst. Different basic fuel injection durations are preset for various engine speeds and loads, as well as the amount of intake air.
- This system also has a "learning" control function which stores the corrected data in relation to the basic fuel injection in the memory map. This allows an appropriate air-fuel ratio correction to be added automatically in quick response to any situation that requires such an effect. Thus, the air-fuel ratio is optimally maintained under various conditions while purifying exhaust gases most effectively, improving driving performance and compensating for changes in sensors' performance over time.

# 6. Ignition Control System

● The ignition system is controlled by the ECM.
The ECM monitors the operating condition of the engine using the signals from the sensors and switches shown below and determines the ignition timing most appropriate for each engine operating condition. Then it sends a signal to the ignitor, commanding generation of a spark at that timing.

● The ECM uses a preprogrammed map for a “closed-loop” control which provides its ignition timing control with excellent transient characteristics, i.e., highly responsive ignition timing control.



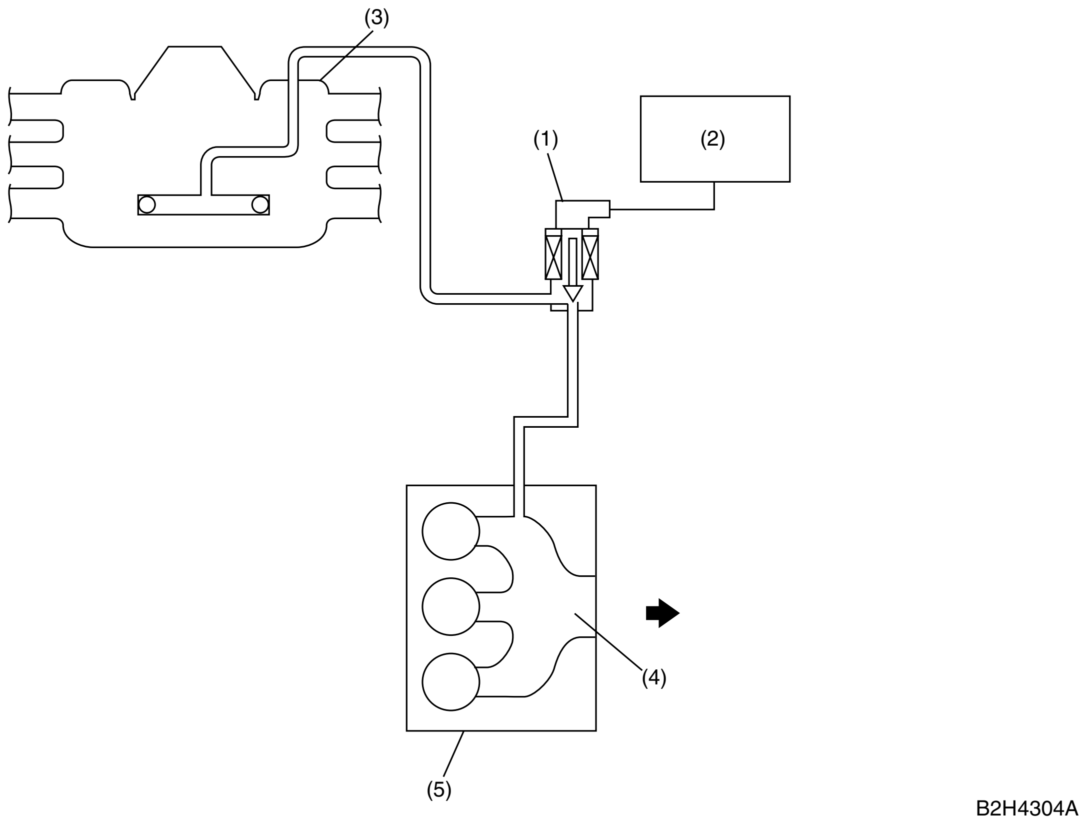

B2H3970A

(1) ECM
(2) #1 Ignition coil
(3) #3 Ignition coil
(4) #5 Ignition coil
(5) Camshaft position sensor
(6) Pressure sensor
(7) Intake air temperature sensor
(8) Crankshaft position sensor
(9) Throttle position sensor
(10) #6 Ignition coil
(11) #4 Ignition coil
(12) #2 Ignition coil
(13) Engine coolant temperature sensor
(14) Knock sensor LH
(15) Knock sensor RH

# 7. Exhaust Gas Recirculation (EGR) System

## A: GENERAL

- The EGR system aims at reduction of NOx by lowering the combustion temperature through recirculation of a part of exhaust gas into cylinders via the intake manifold.
- The EGR valve is controlled by the ECM according to the engine operating condition.

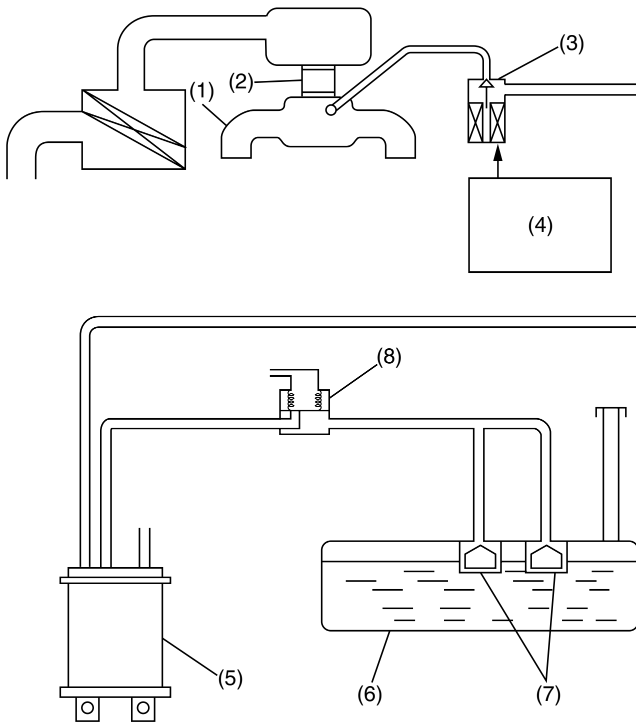



(1) EGR valve
(2) ECM
(3) Intake manifold
(4) Exhaust port
(5) LH cylinder head

# 8. Evaporative Emission Control System

## A: GENERAL

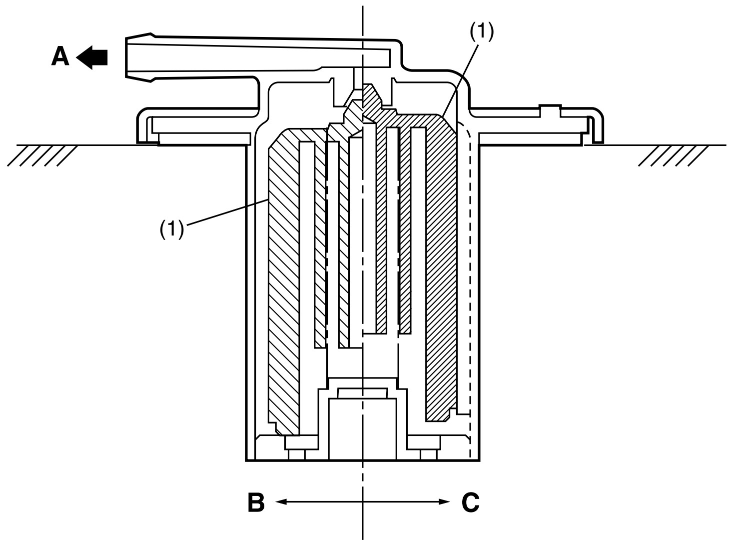
● The evaporative emission control system prevents fuel vapors from escaping into atmosphere. This system includes a canister, purge control solenoid valve, fuel cut valve, and the lines connecting them.
● Fuel vapors in the fuel tank is introduced into the canister through the evaporation line, and are absorbed by activated carbon in it. The fuel cut valve is also incorporated in the fuel tank line.
● The purge control solenoid valve is controlled optimally by the ECM according to the engine condition.




| | |
|---|---|
| (1) Intake manifold | (5) Canister |
| (2) Throttle body | (6) Fuel tank |
| (3) Purge control solenoid valve | (7) Fuel cut valve |
| (4) Engine control module (ECM) | (8) Two-way valve |

## B: FUEL CUT VALVE

The fuel cut valve is built onto the evaporation pipe of the fuel tank cap. The rising level of the fuel in the fuel tank causes the float to move up and close the cap hole so that no fuel can enter the evaporation line.



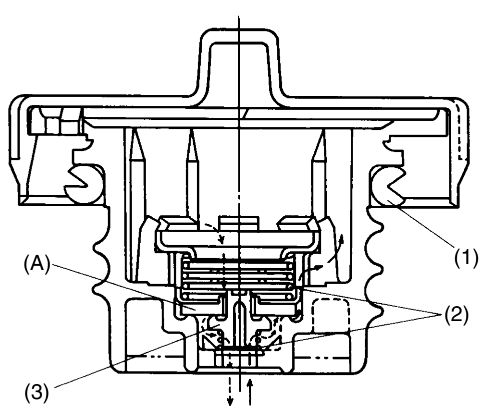

(1) Float

**A:** To canister
**B:** Valve open
**C:** Valve closed

## C: FUEL TANK CAP

The fuel tank cap has a relief valve which prevents development of vacuum in the fuel tank in the event of a problem with the fuel vapor line.

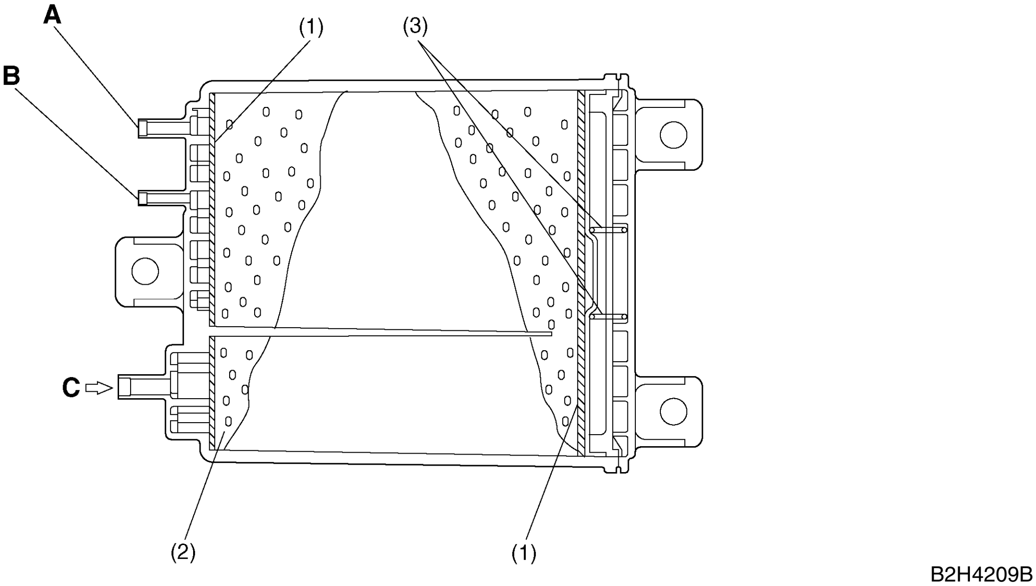
When there is no problem with the fuel vapor line, the filler pipe is sealed at the portion (A) and by the seal pressed against the filler pipe end. If vacuum develops in the fuel tank, the atmospheric pressure forces the spring down to open the valve; consequently outside air flows into the fuel tank, thus controlling the inside pressure.




(1) Seal
(2) Spring
(3) Valve

## D: CANISTER

The charcoal filled in the canister temporarily stores fuel vapors. When the purge control solenoid valve is opened by a signal from the ECM, the external fresh air entering the canister carries the fuel vapors into the collector chamber.

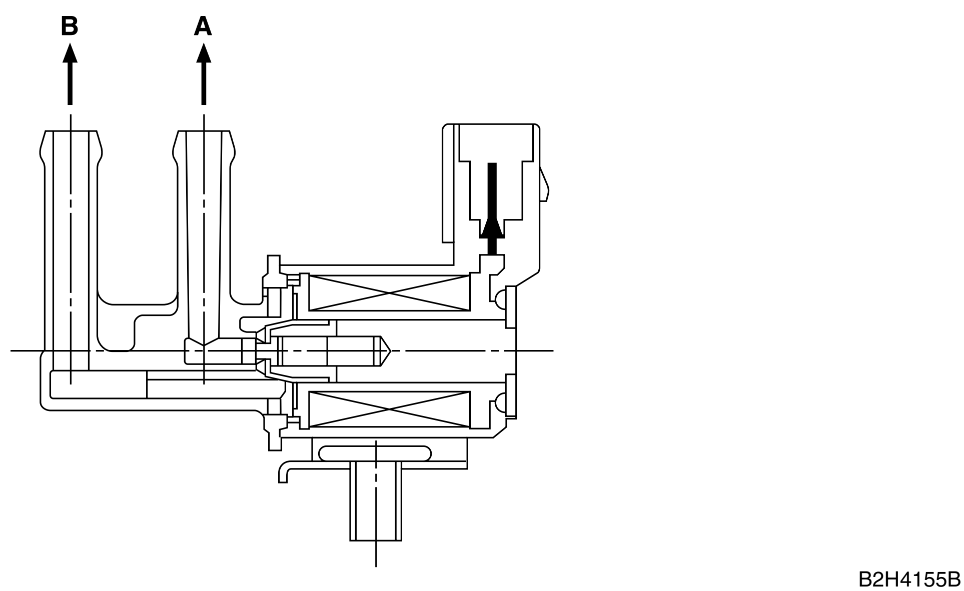



(1) Filter
(2) Activated charcoal
(3) Spring

**A:** To purge control solenoid valve
**B:** From fuel tank
**C:** Air

## E: PURGE CONTROL SOLENOID VALVE

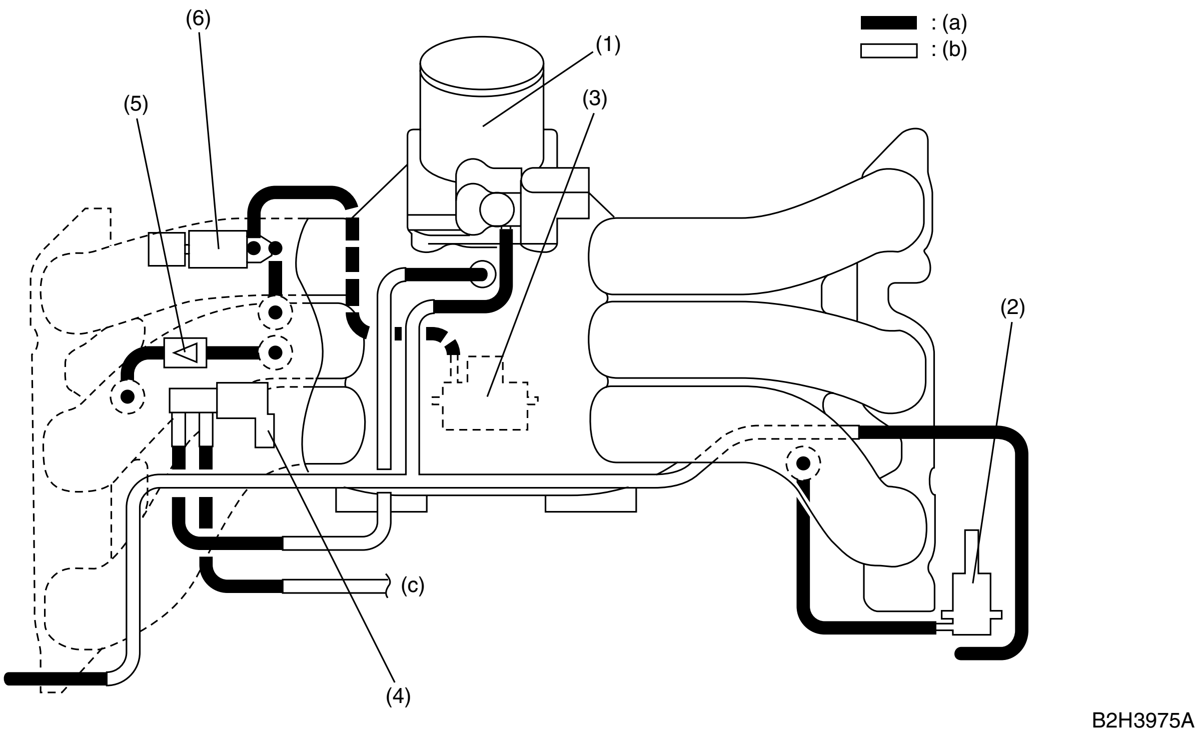
The purge control solenoid valve is on the evaporation line between the canister and throttle body. It is installed at the underside of intake manifold.




**A:** To canister
**B:** To throttle body

# 9. Vacuum Connections

The hose and pipe connections of the intake manifold, throttle body and other related parts are as shown in the illustration.




(1) Throttle body
(2) Pressure regulator
(3) Induction valve
(4) Purge control solenoid valve
(5) Check valve
(6) Induction valve control solenoid

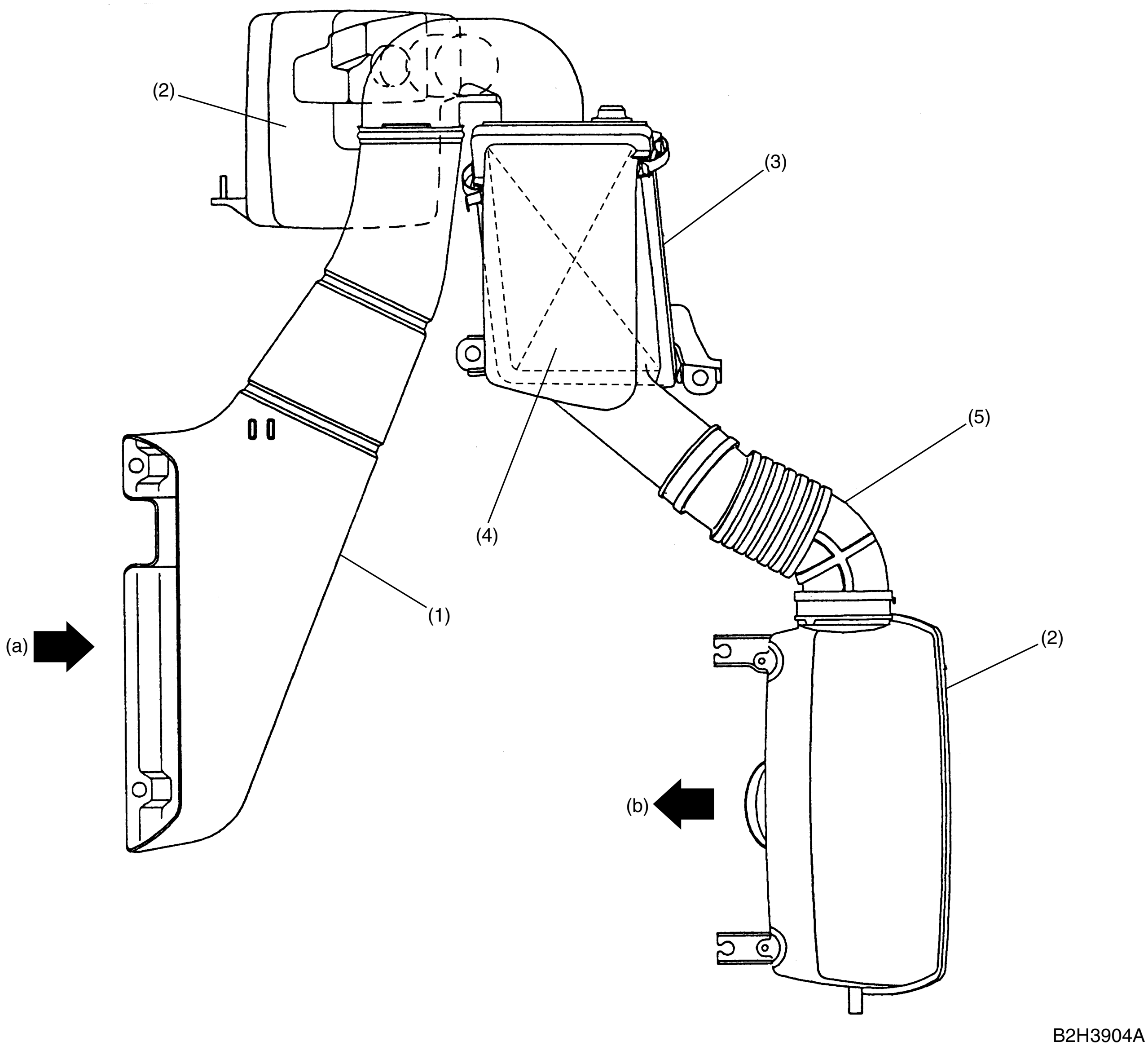
(a): Hose
(b): Pipe
(c): To fuel tank

# INTAKE (INDUCTION) *IN (H6)*

**Page**

# 1. General

The intake system consists of an air intake duct, two resonator chambers, an air cleaner case, and a duct. The resonator chambers (one is located upstream of the air cleaner and the other downstream of the air cleaner) effectively reduce the intake noise level.




(1) Air intake duct
(2) Resonator chamber
(3) Air cleaner case
(4) Air cleaner element
(5) Duct

(a) Fresh air
(b) To throttle body

# MECHANICAL ME (H6)

Page

# 1. General

The H6 engine used in this vehicle is of a horizontally opposed, six-cylinder design. This four-stroke-cycle, water-cooled, DOHC engine uses a total of 24 valves and its main components are made of aluminum alloy. It is fueled by a multiple fuel injection system.

The engine's major structural and functional features are as follows:

● A maintenance-free, chain-and-sprocket type camshaft drive mechanism is used which also contributes to reduction in the overall length of the engine.

● The cylinder block is an aluminum die casting fitted with iron die-cast cylinder liners.

● Lightweight and compact design

The cylinder bore pitch is 98.4 mm (3.874 in), which is much shorter than 113 mm (4.45 in) of the H4 engine.

The cylinder bore and piston stroke dimensions have been selected optimally for sufficient output and reduced size of the engine; they are 89.2 mm (3.512 in) and 80.0 mm (3.15 in) in contrast to 92.0 mm (3.62 in) and 75.0 mm (2.95 in) of the H4 2000 cc engine.

The cylinder block is of a "triple siamese cylinder" design with the three cylinders of each bank cast without coolant passages between cylinders, while ensuring adequate cooling by employing an open-deck design.

The right bank camshafts and the left bank camshafts are driven by different timing chains, whereas the accessories are driven through their own pulleys by a single serpentine belt (two belts were used in the previous model's engine).

● Quiet operation

Unlike V6 engines, horizontally opposed six-cylinder engines do not generate secondary vibration (which is caused by primary operational vibration in a V6 engine and has a frequency twice as large as that of the primary vibration) although V6 engines have space saving merit. In addition to this inherent quietness provided by complete dynamic balance, the H6 engine incorporates the following quietly operating considerations:

The crankshaft is supported by seven bearings and has a diameter of 64.0 mm (2.52 in), which is 4.0 mm (0.157 in) larger than with the previous model's engine.

The chains driving the camshafts are provided with hydraulic tension adjusters and covered by a chain cover at the front of the engine.

An aluminum die-cast upper oil pan reinforces the joint of the right and left cylinder block banks, while giving additional rigidity to the crankshaft bearing areas.

The engine is connected to the transmission more rigidity than with the previous model by using 11 bolts (eight bolts in the previous model).

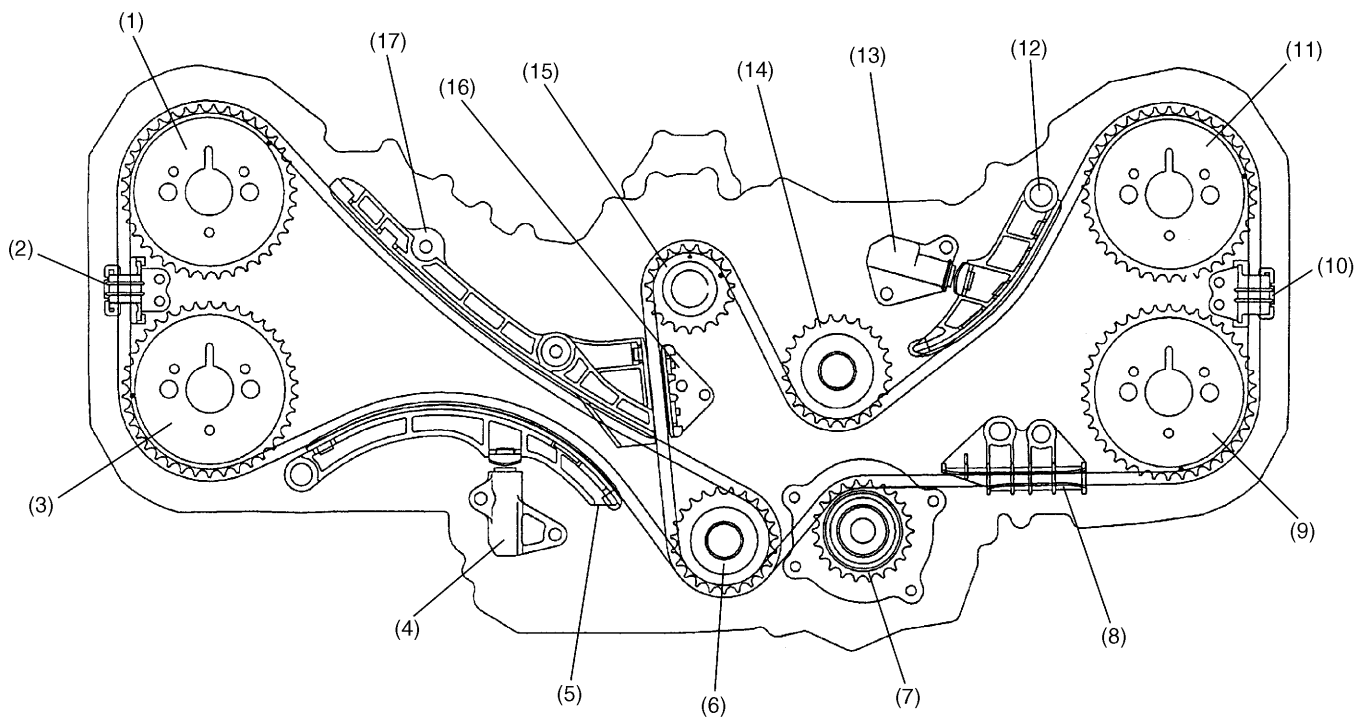
● Clean exhaust gas and high power

The H6 engine has enabled the Legacy to achieve cleaner exhaust emissions without sacrificing output power by adopting, among others, tumble flow generating intake ports and a variable length intake manifold that creates a resonance ramcharging effect.

## 2. Timing Chains

● Two timing chains are used to drive the camshafts, one each for driving the two camshafts on each bank. Every camshaft is fitted with a sprocket through which it is driven by the corresponding timing chain. The left bank timing chain transmits the power from the crankshaft sprocket directly to the left bank camshaft sprockets, whereas the right bank timing chain transmits the crankshaft power via the lower idler sprocket which is driven by the left bank timing chain. (The lower idler gear has two tooth rows; the left bank timing chain engages with the inner row teeth and the right bank chain engages with the outer row teeth.) By this way, the right and left bank camshafts rotate in synchronization with each other.
The left bank timing chain also drives the water pump.

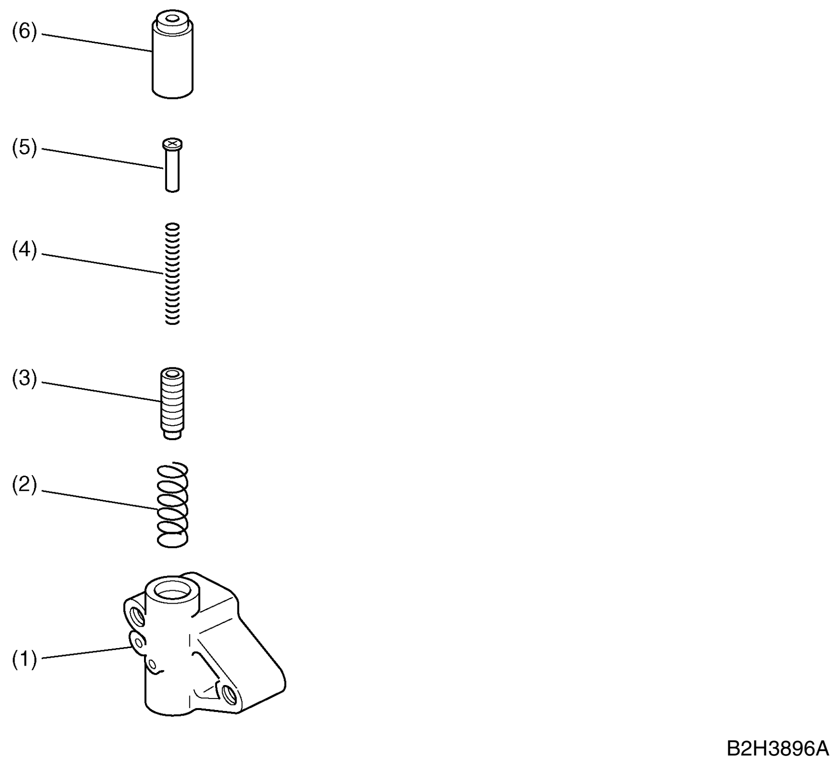
● The hydromechanical automatic chain tension adjuster provided for each chain constantly maintains the specified chain tension necessary to properly drive the camshafts, as well as to provide this chain and sprocket camshaft drive mechanism with a "maintenance-free" feature.




| | | | | | |
|---|---|---|---|---|---|
| (1) | Intake camshaft sprocket RH | (7) | Water pump sprocket | (13) | Tension adjuster LH |
| (2) | Chain guide RH No.1 | (8) | Chain guide LH No.2 | (14) | Upper idler sprocket |
| (3) | Exhaust camshaft sprocket RH | (9) | Exhaust camshaft sprocket LH | (15) | Crankshaft sprocket |
| (4) | Chain tension adjuster RH | (10) | Chain guide LH No.1 | (16) | Center chain guide |
| (5) | Chain tension adjuster lever RH | (11) | Intake camshaft sprocket LH | (17) | Chain guide RH No.2 |
| (6) | Lower idler sprocket | (12) | Tension adjuster lever LH | | |

# 3. Automatic Chain Tension Adjuster

The right and left bank timing chains are provided with their own tensioners. The tensioners are of a hydromechanical type that utilizes the engine oil pressure and can automatically keep the tension of the chains at a proper level without need for manual adjustments.
The tensioner case has an oil port that aligns with the oil port in the cylinder block when it is installed in position. The inside of the tensioner case is a high-pressure hydraulic chamber with a check ball. The pressure of the oil in the camber is adjusted by the relief valve. Featuring a plunger with external screw threads, the tensioner can keep the chain taut constantly even when the engine is stationary.



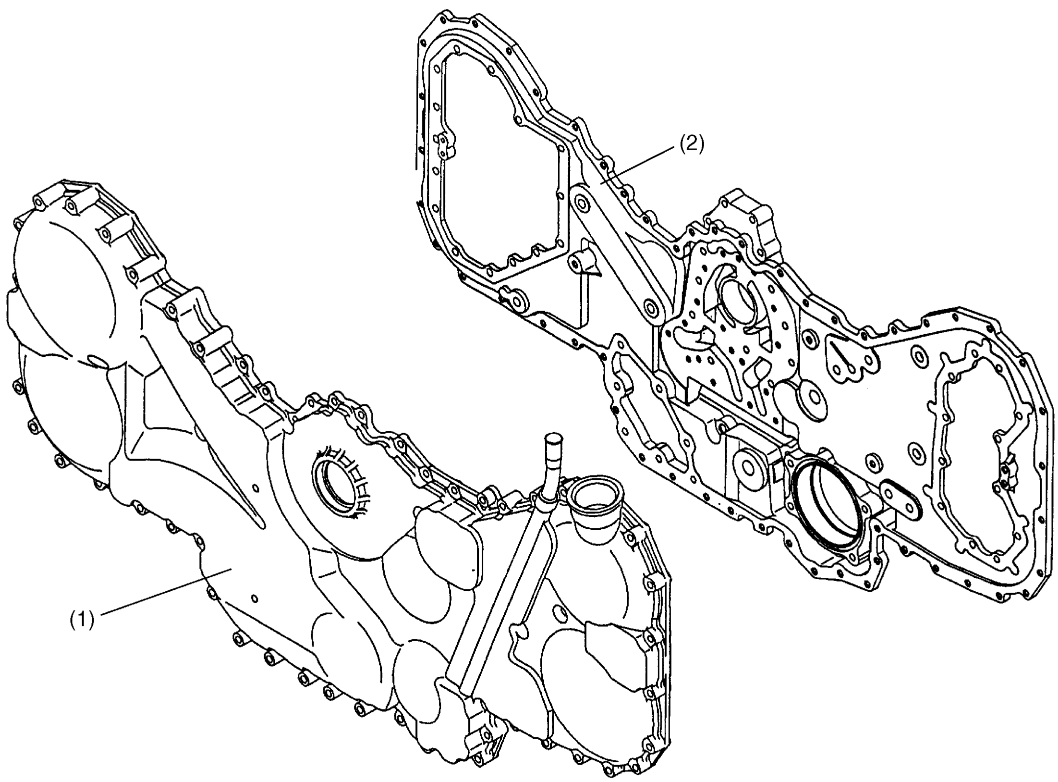

| | | | |
|---|---|---|---|
| (1) | Tensioner case | (4) | Spring |
| (2) | Spring | (5) | Adjuster rod |
| (3) | Plunger | (6) | Plunger case |

# 4. Timing Chain Case

● The timing chain case is formed by the front chain cover and rear chain cover, both made of aluminum die casting. This two-piece chain case design helps reduce noise.

● Sealing materials used between the engine block and rear chain cover are an O-ring, metal gasket, and liquid gasket. Between the front and rear chain covers, liquid gasket is used to prevent oil from leaking out.

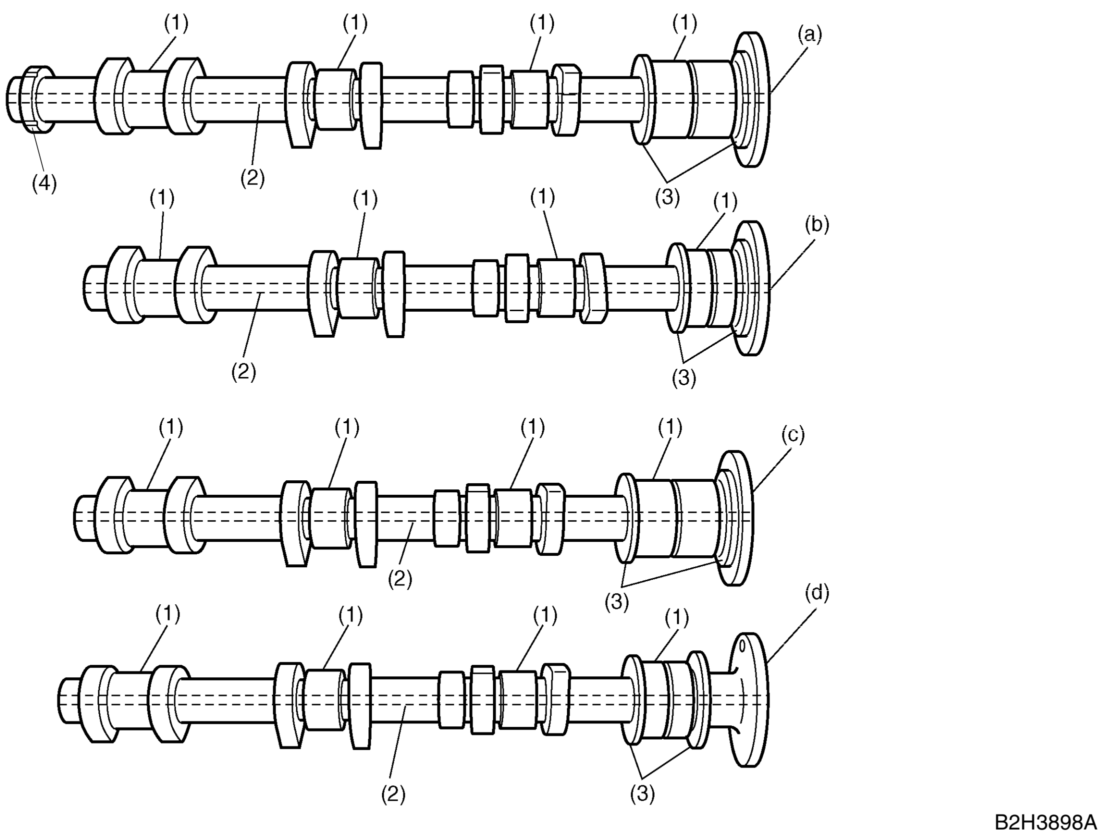
● A fluorocarbon resin oil seal is used at the crankshaft opening in the front chain cover.




(1) Front chain cover
(2) Rear chain cover

# 5. Camshaft

- The camshafts are of a composite material type using sintered steel for cam lobes and carbon steel for pipe part (first in Subaru).
The sintered steel cams are very high in the resistance to wear, which enables the cam lift to be increased. In addition, use of the sintered steel cams contributes to reduction in weight.
- Each camshaft is supported at its four journals by the corresponding bearings. The front-most bearing has flanges on its both ends to receive thrust loads that are generated during movement of the camshaft.
- The bearings are lubricated by the oil that enters the passage in each camshaft from the port at the front-end journal and flows out through the hole in each journal.
- The right intake camshaft has at its rear end a flange which is used as an angle sensing wheel by the camshaft position sensor.




| | | | |
|---|---|---|---|
| (1) | Journal | (a) | RH intake camshaft |
| (2) | Oil passage | (b) | RH exhaust camshaft |
| (3) | Shaft flange | (c) | LH intake camshaft |
| (4) | Camshaft position sensor flange | (d) | LH exhaust camshaft |

# 6. Cylinder Head

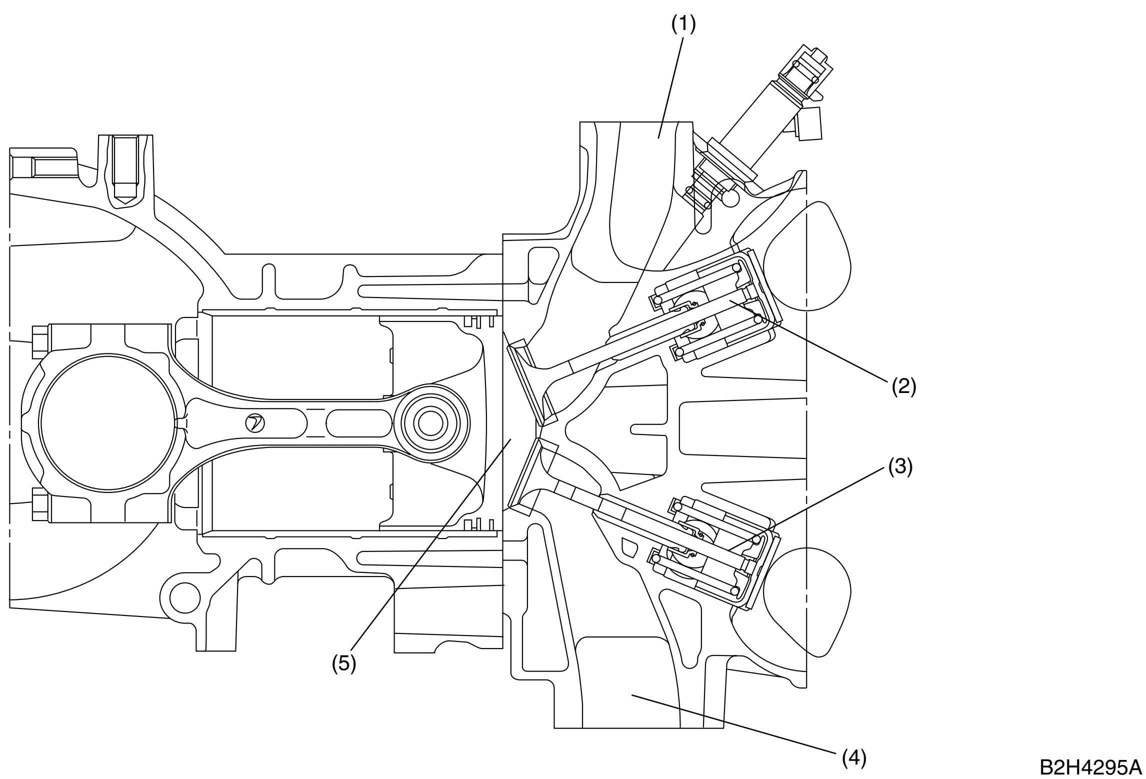
● The cylinder heads are made of aluminum alloy which features light weight and high cooling efficiency.

● Each cylinder head incorporates a DOHC mechanism which is adapted to the “four valves per cylinder” arrangement. The two intake ports are designed to create tumble flow in the cylinder, whereas the two exhaust ports join each other in the cylinder head to form a single oval port. These design features contribute together to cleaner exhaust emissions and higher output.

● The combustion chamber is of a compact pentroof design with the spark plug located at its top center. In combination with the tumble promoting intake ports, a squish area formed between the piston top surface and combustion chamber helps improve mixing of air and fuel and thus combustion efficiency.

● Coolant flows from the rear to the front of the cylinder head of each bank. This serial-flow coolant line arrangement ensures highly efficient cooling of the engine.

● A metal gasket is used between the cylinder head and cylinder block. Tightening the cylinder head bolts by the angle-tightening method ensures invariable sealing performance of this gasket.




(1) Intake port
(2) Intake valve
(3) Exhaust valve
(4) Exhaust port
(5) Combustion chamber

# 7. Cylinder Block

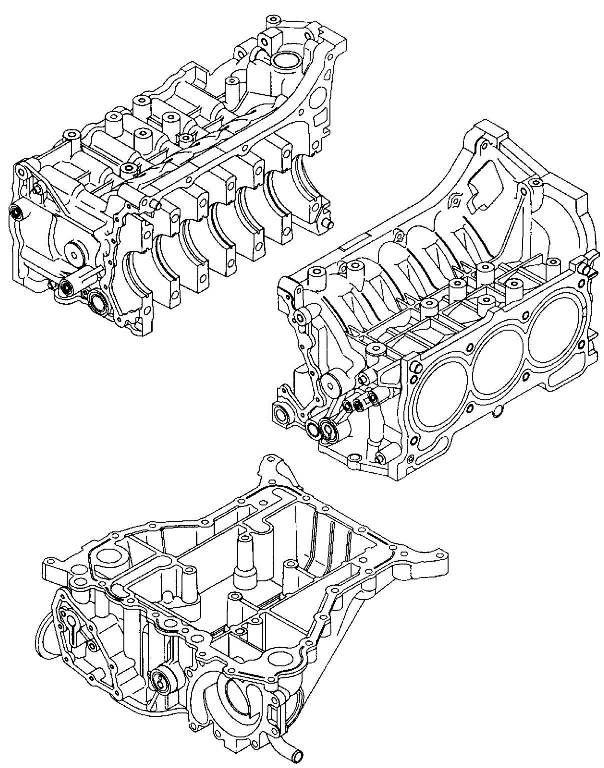
● The cylinder block of this horizontally-opposed-cylinder engine is made of aluminum die casting. It is split into right and left halves at its center where the crankshaft is supported. The cylinder liners are made of cast iron and are embedded as integral part of the cylinder block body during the casting process.

● The coolant passages of the right and left banks are independent of each other (parallel-flow type). The water jackets around the cylinder liners are open at the cylinder head side end of each bank (open-deck design).

● The cylinder block supports the crankshaft's journals through seven main bearings rigidly and quietly. The #7 bearing is a flanged thrust bearing which controls the crankshaft's end play.

● Rigid engine-to-transmission connection is ensured by 11 bolts (three more bolts than with the four-cylinder engine).

● The aluminum die-cast upper oil pan located below the cylinder block reinforces connection between the cylinder block banks and its special form provides a buffle effect to suppress large fluctuation of oil level. In addition, the upper oil pan constitutes part of the oil and cooling circuits as well as the water pump volute chamber and thermostat chamber.



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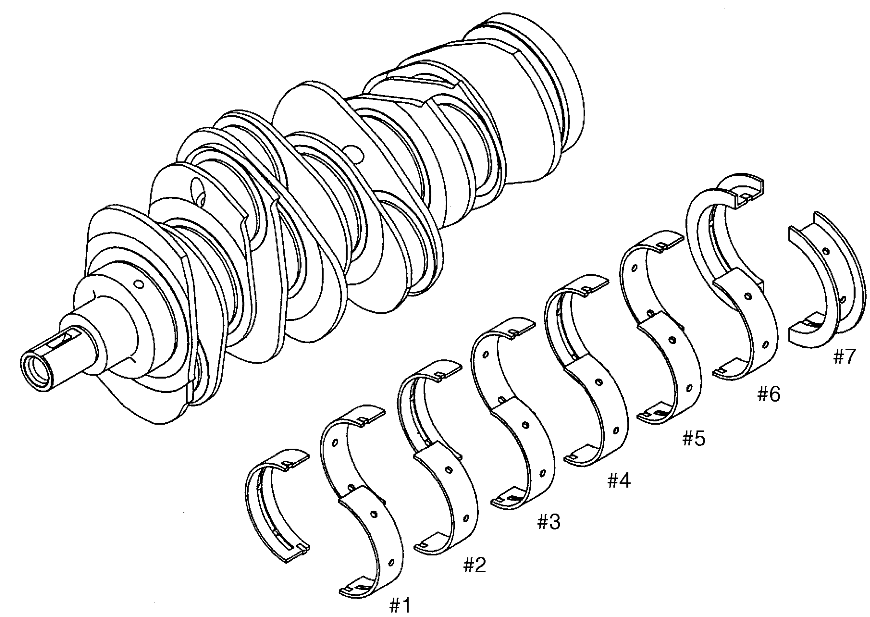
# 8. Crankshaft

The crankshaft is supported in the cylinder block by seven bearings. Each corner formed by a journal or pin and a web is finished by fillet-rolling method which increases strength of that area. The seven crankshaft bearings are made of aluminum alloy and the No. 7 bearing is provided with a flanged metal to support thrust forces.



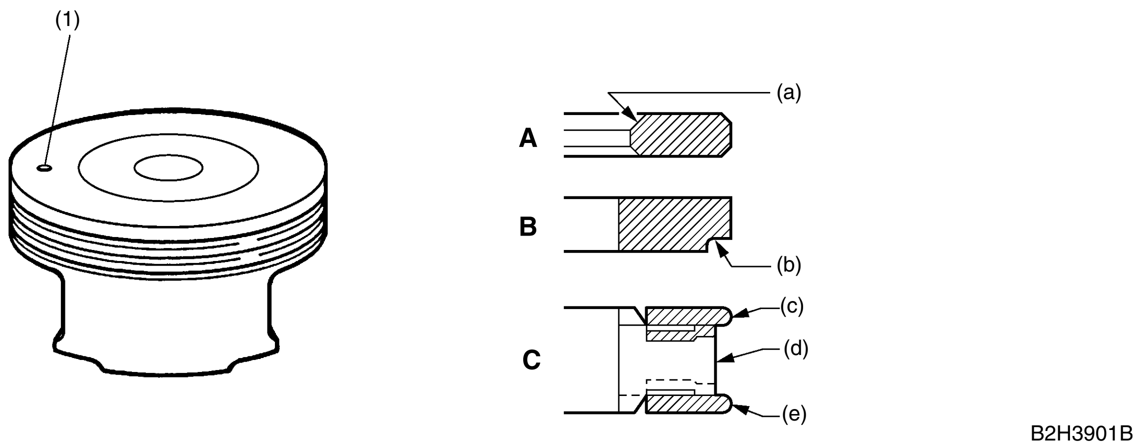
# 9. Piston

● The pistons are of a slipper skirt design for reduced weight and friction. The oil control ring groove utilizes a thermal design.

● The piston pin is offset either downward (Nos. 1, 3 and 5 pistons) or upward (Nos. 2, 4 and 6 pistons).

● The piston crown is spherically concaved and has no recesses for valve head clearance. All the right and left bank pistons are the same in shape. Each piston has a location mark (mark indicating the front of engine) on its top.

● Three piston rings are used for each piston – two compression rings and one oil control ring. The top piston ring has inner bevels and the second piston ring has an interrupt (cut) on the bottom outside to reduce oil consumption.



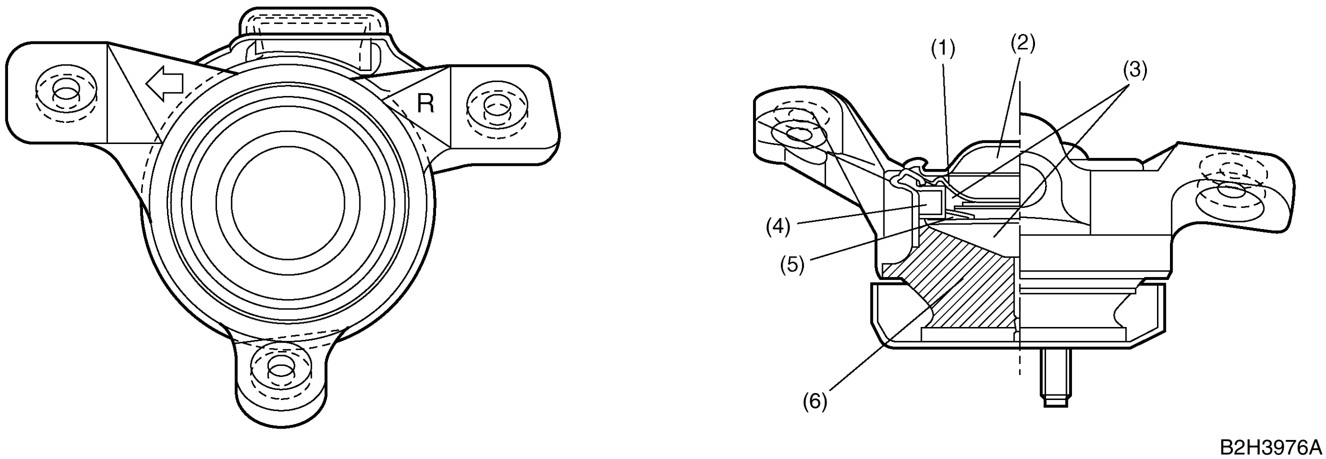

(1) Location mark (Engine front side)

**A:** Top ring
**B:** Second ring
**C:** Oil ring

(a) Inner-bevel
(b) Interrupt (cut)
(c) Upper rail
(d) Expander
(e) Lower rail

# 10.Engine Mounts

The H6 engine is supported by liquid-filled elastic mounts specially developed for use with it. Each mount is rigidly attached to the engine at three points. The mount can effectively reduce vibration and noise thanks to presence of a membrane between the two liquid chambers. The membrane has a function of reducing the spring constant of the mount.




| | | | |
|---|---|---|---|
| (1) | Diaphragm | (4) | Orifice |
| (2) | Air chamber | (5) | Membrane |
| (3) | Liquid chamber | (6) | Rubber piece |

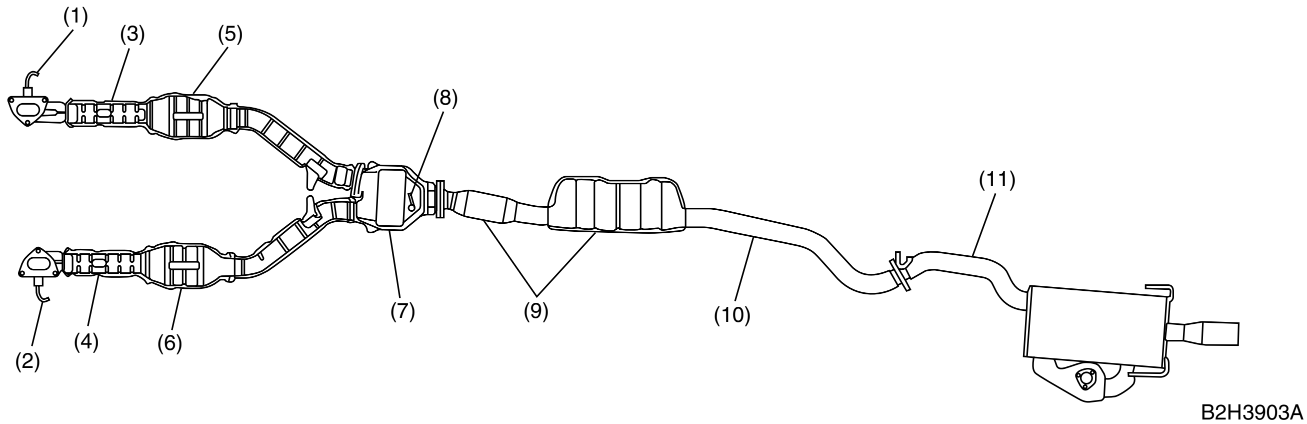
## MEMO

# EXHAUST EX (H6)

Page

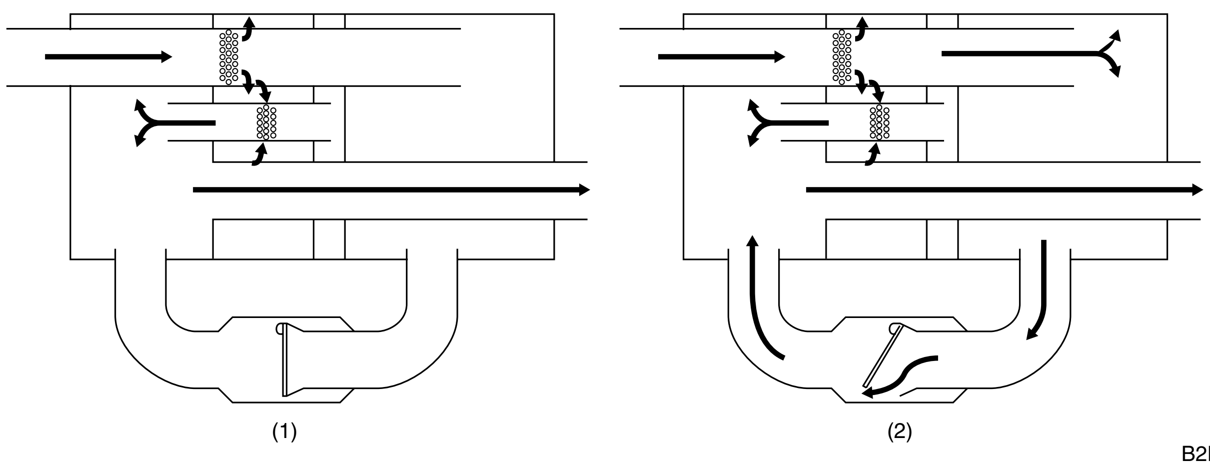
# 1. General

● The exhaust system consists of a front exhaust pipe assembly, a rear exhaust pipe with two resonance chambers, and a variable-flow muffler. The front exhaust pipe assembly consists of right and left exhaust pipes each incorporating a front catalytic converter, and a rear catalytic converter that is located at the joint of the two pipes.




(1) Front oxygen (A/F) sensor RH
(2) Front oxygen (A/F) sensor LH
(3) Front exhaust pipe RH
(4) Front exhaust pipe LH
(5) Front catalytic converter RH
(6) Front catalytic converter LH
(7) Rear catalytic converter
(8) Rear oxygen sensor
(9) Resonance chamber
(10) Rear exhaust pipe
(11) Muffler

● The variable-flow muffler has a valve which opens when the exhaust pressure increases. This helps realize low exhaust noise and high engine output simultaneously.




(1) Low engine speed
(2) High engine speed

# COOLING CO (H6)

**Page**

# 1. General

- The engine cooling system consists of a down-flow radiator which features high heat-dissipation performance, an electric-motor-driven fan, a water pump, a thermostat, and an engine coolant temperature sensor.
- The reservoir tank is designed to eliminate the need for replenishing coolant.
- The ECM controls the operation of the radiator main fan and subfan depending on the signals from the engine coolant temperature sensor, vehicle speed sensor and A/C switch.

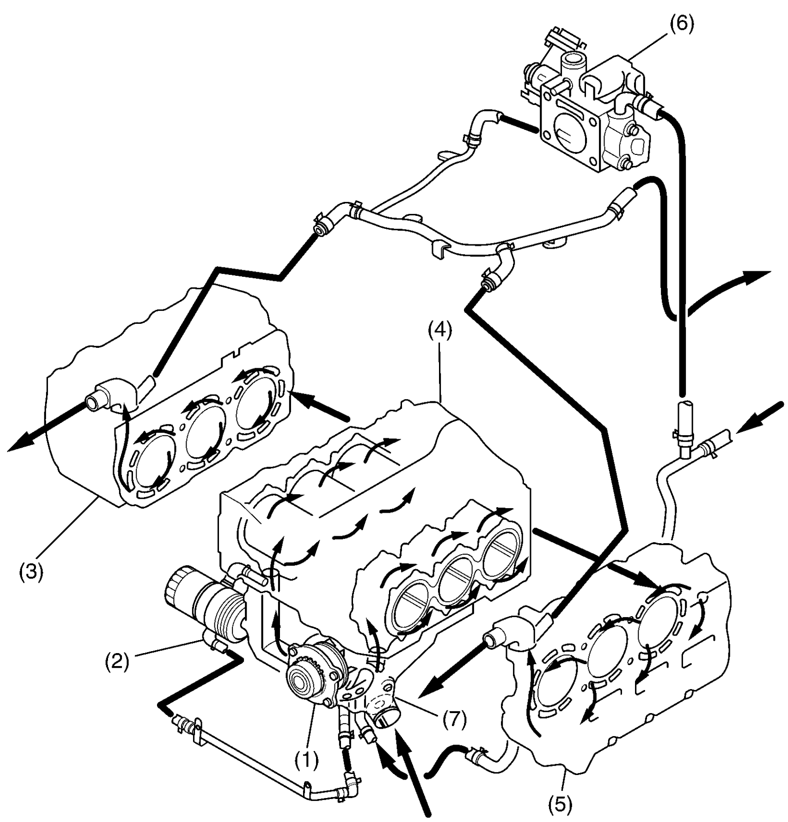
# 2. Cooling Circuits

The cooling system operates in three different phases depending on the temperature of the engine coolant.

● 1st phase (thermostat closed)
When the engine coolant temperature is below 76°C (169°F), the thermostat remains closed. The coolant flows through the bypass and heater circuits.
This permits the engine to warm up quickly.

● 2nd phase (thermostat open)
When the engine coolant temperature is above 76 – 80°C (169 – 176°F), the thermostat opens. The coolant flows through the radiator where it is cooled.

● 3rd phase (thermostat open and radiator fan operating)
When the engine coolant temperature sensor sends a signal indicating a temperature above 91°C (196°F) to the ECM, it causes the radiator fan (or fans) to operate.

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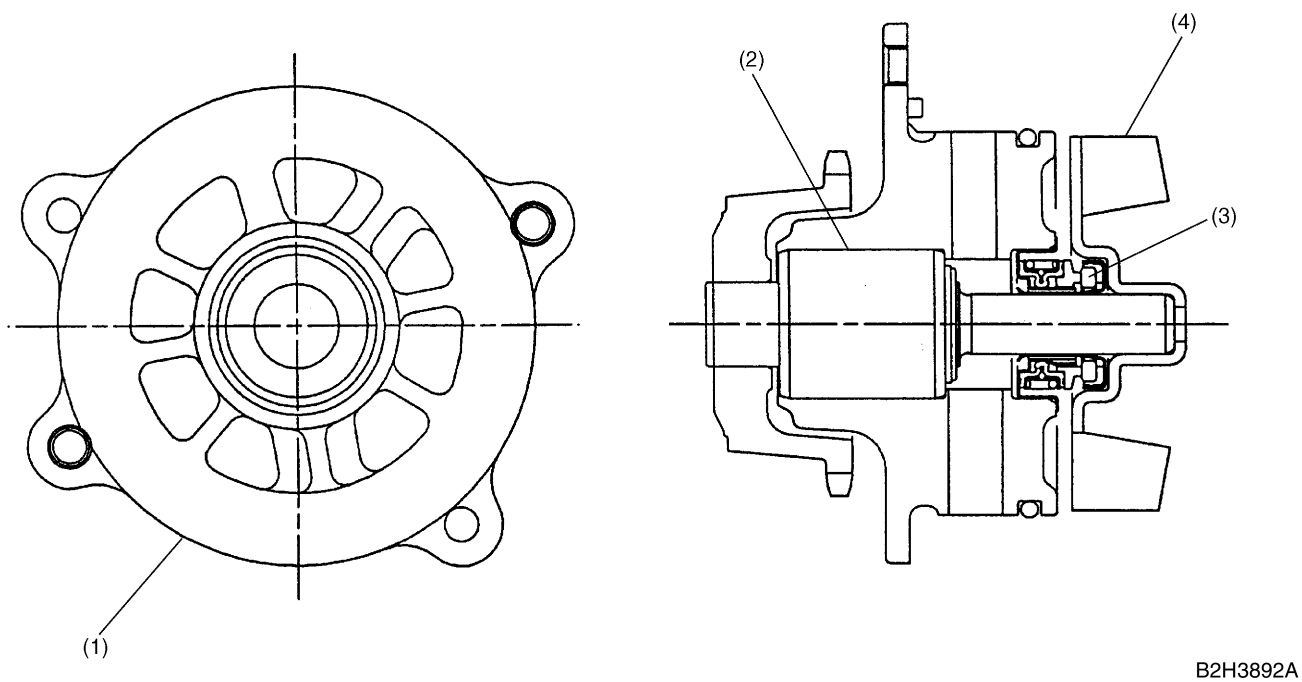
(1) Water pump
(2) Oil cooler
(3) Cylinder head RH
(4) Cylinder block
(5) Cylinder head LH
(6) Throttle body
(7) Thermostat

# 3. Water Pump

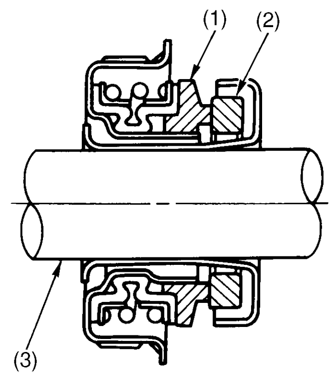
The water pump is fitted in a housing formed in the rear chain cover using an O-ring as a seal between the pump case and the housing. The pump is driven by the timing chain through a sprocket and rotation of the impeller in a volute chamber creates flow of coolant toward the cylinder block. The pump case is made of aluminum die casting and the impeller is made of steel sheet. The impeller shaft is supported by a ball bearing and a roller bearing. Its end exposed to coolant is sealed by a mechanical seal and the other end exposed to engine oil is sealed by an oil seal.
The volute chamber is formed by the rear chain cover and the upper oil pan. A metal gasket is used at the joint between the chain cover and upper oil pan.




(1) Pump case
(2) Ball bearing
(3) Mechanical seal
(4) Impeller
(5) O-ring

# 4. Mechanical Seal

The mechanical seal has its seat tightly fitted on the water pump shaft. Since it is a hermetic seal forming an integral part of the water pump, the water pump cannot be disassembled.

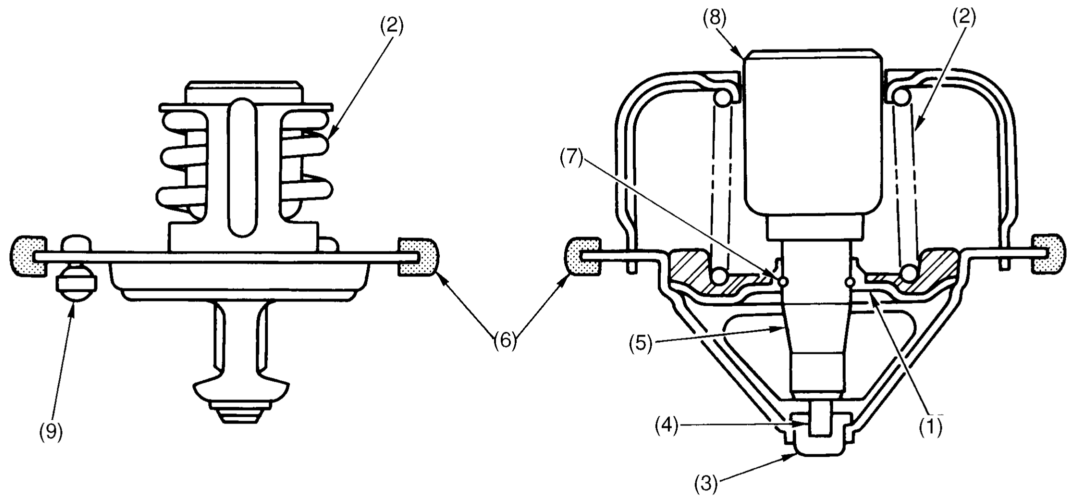



H2H2325

(1) Carbon seal
(2) Ceramics seat
(3) Water pump shaft

# 5. Thermostat

The thermostat has a totally-enclosed wax pellet which expands as the coolant temperature increases. It opens and closes accurately at the preset temperatures and features high durability.

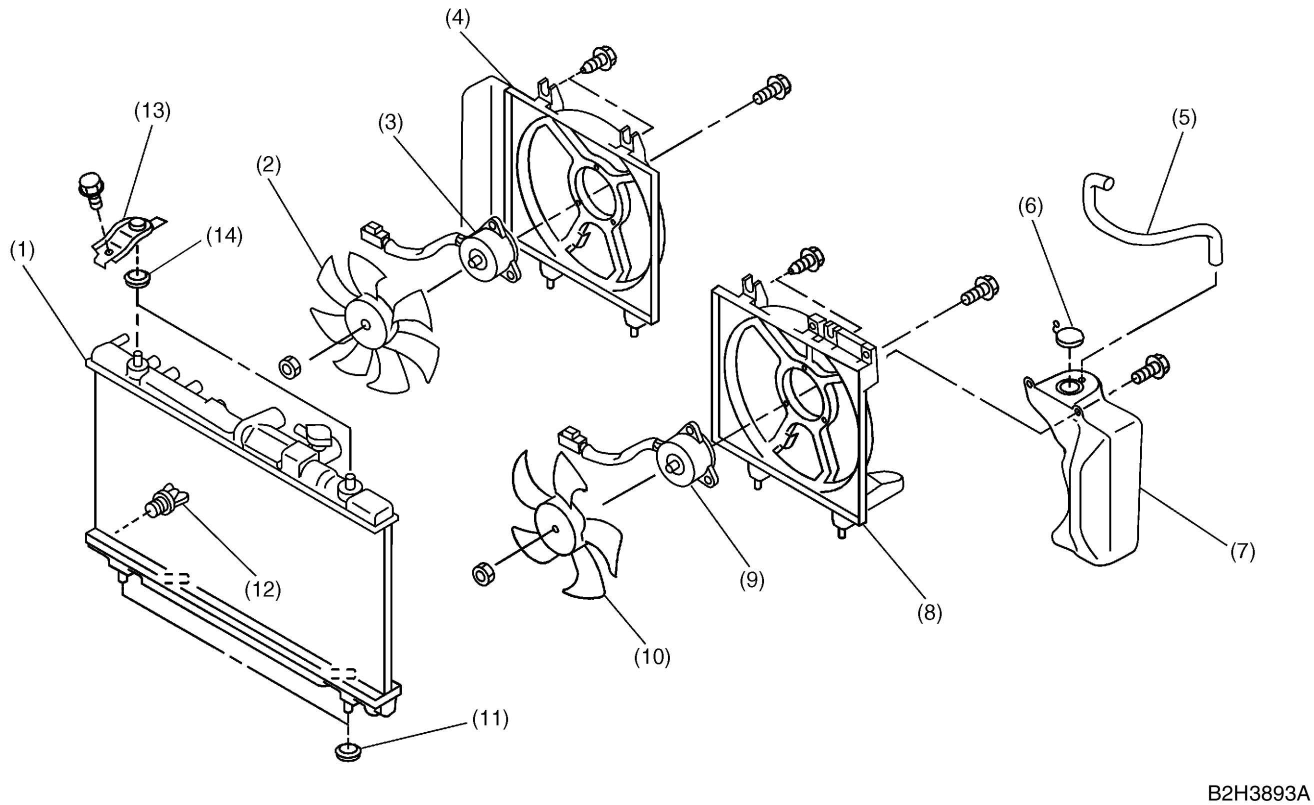



| | | |
|---|---|---|
| (1) Valve | (4) Piston | (7) Stop ring |
| (2) Spring | (5) Guide | (8) Wax element |
| (3) Stopper | (6) Rubber packing | (9) Jiggle valve |

# 6. Radiator Fan

## A: DESCRIPTION

Each radiator fan is made of plastic. It is driven by an electric motor which is retained on a shroud.




| | | | |
|---|---|---|---|
| (1) | Radiator | (8) | Radiator main fan shroud |
| (2) | Radiator subfan | (9) | Radiator main fan motor |
| (3) | Radiator subfan motor | (10) | Radiator main fan |
| (4) | Radiator subfan shroud | (11) | Lower cushion |
| (5) | Overflow hose | (12) | Drain plug |
| (6) | Reservoir tank cap | (13) | Upper bracket |
| (7) | Reservoir tank | (14) | Upper cushion |

## B: FUNCTION

The operation of the radiator fan is controlled by the ECM, depending on the signals from the engine coolant temperature sensor, vehicle speed sensor and A/C switch as shown below.

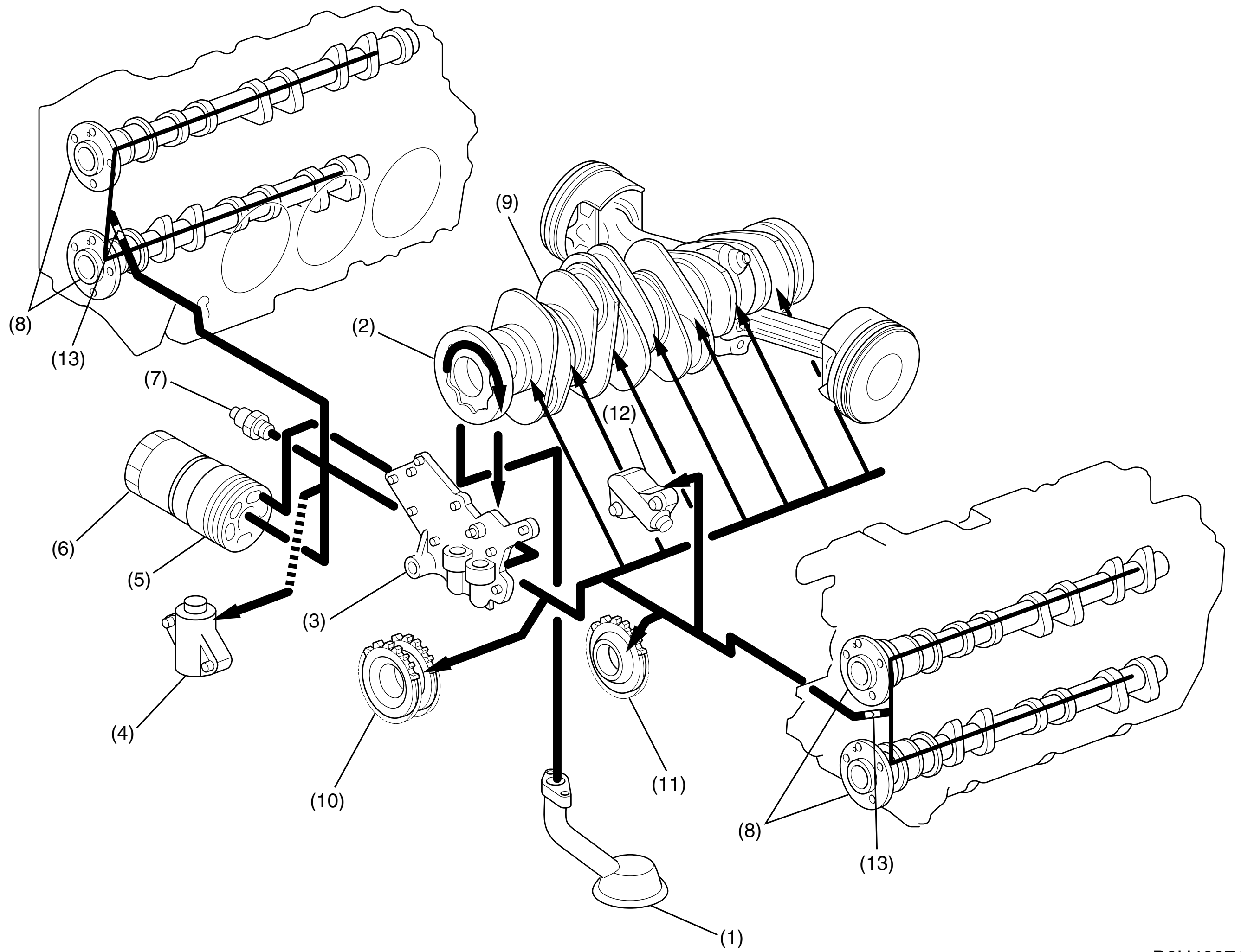
| Vehicle speed | A/C compressor | A/C pressure switch level | Engine coolant temperature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Lower than 95°C (203°F) | | Between 95 and 99°C (203 and 210°F) | | Higher than 100°C (212°F) | |
| | | | Operation of radiator fans | | Operation of radiator fans | | Operation of radiator fans | |
| | | | Main fan | Subfan | Main fan | Subfan | Main fan | Subfan |
| Lower than 19 km/h (12 MPH) | Off | | Off | Off | Low-speed | Low-speed | Mid-speed | Mid-speed |
| | On | Low | Low-speed | Low-speed | Mid-speed | Mid-speed | High-speed | High-speed |
| | | High | Mid-speed | Mid-speed | High-speed | High-speed | High-speed | High-speed |
| Between 20 and 69 km/h (12 and 43 MPH) | Off | | Off | Off | Mid-speed | Mid-speed | High-speed | High-speed |
| | On | Low | High-speed | High-speed | High-speed | High-speed | High-speed | High-speed |
| | | High | High-speed | High-speed | High-speed | High-speed | High-speed | High-speed |
| Between 70 and 105 km/h (43 and 65 MPH) | Off | | Off | Off | Mid-speed | Mid-speed | High-speed | High-speed |
| | On | Low | Mid-speed | Mid-speed | High-speed | High-speed | High-speed | High-speed |
| | | High | High-speed | High-speed | High-speed | High-speed | High-speed | High-speed |
| Higher than 106 km/h (66 MPH) | Off | | Off | Off | Mid-speed | Mid-speed | High-speed | High-speed |
| | On | Low | Off | Off | Mid-speed | Mid-speed | High-speed | High-speed |
| | | High | Mid-speed | Mid-speed | Mid-speed | Mid-speed | High-speed | High-speed |

# LUBRICATION LU (H6)

Page

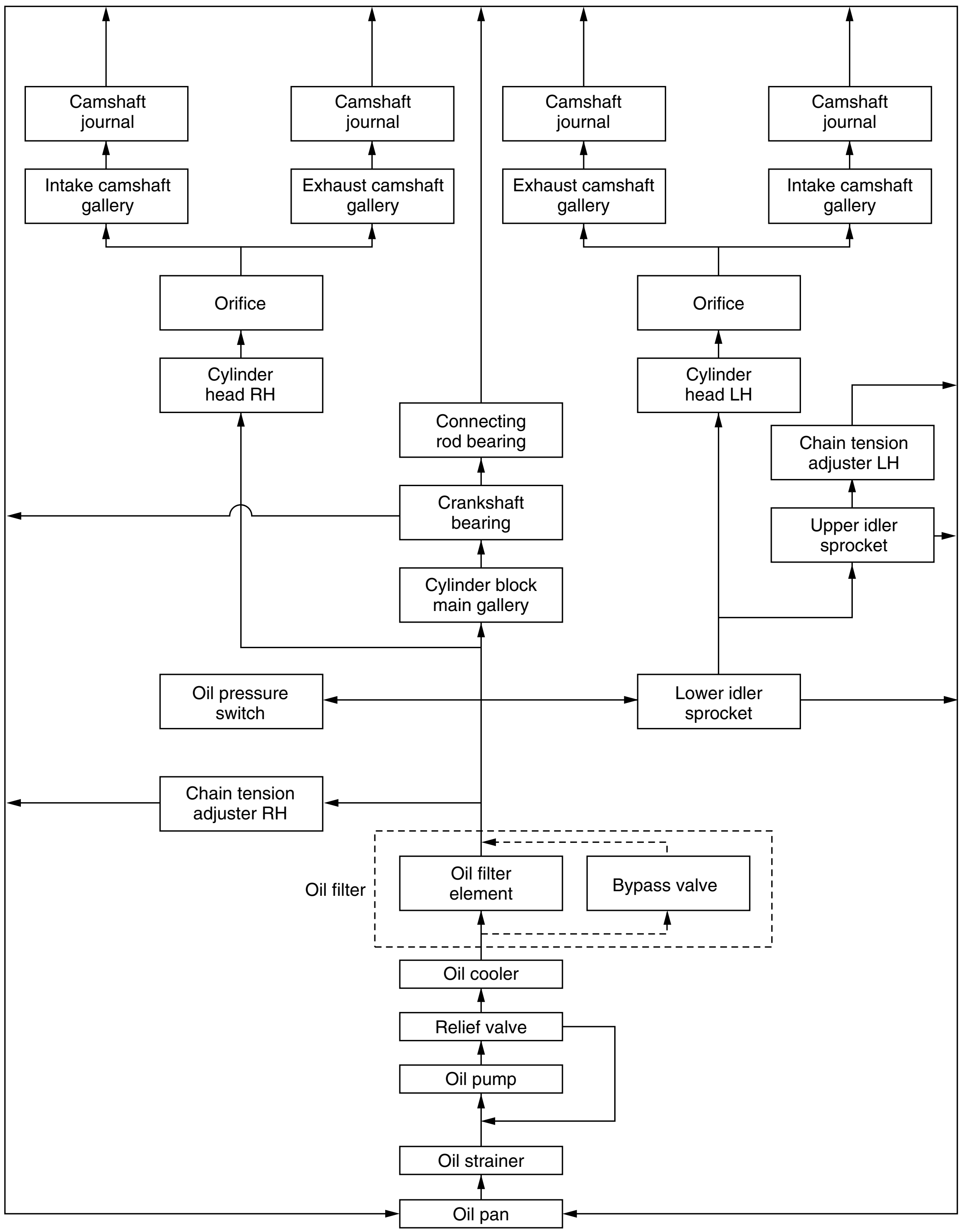
# 1. General

- The lubrication system force-circulates engine oil throughout the engine using an oil pump. The oil pressure is regulated by the relief valve.
- The oil pump is a thin, large-diameter trochoid rotor type which can accommodate the engine's high output. The pump is directly driven by the crankshaft.
- The engine oil is cleaned by a full-flow, paper element type oil filter. The filter has a bypass valve which allows the engine oil to flow bypassing the filter if it is clogged.
- The engine oil discharged from the oil pump is delivered to the journal bearings, connecting rod bearings, and other parts requiring lubrication and cooling via an oil passage, oil filter, and oil galleries.
- The engine oil is also distributed to each cylinder head valve mechanism at a proper flow rate achieved by metering by the orifice provided in each cylinder head oil gallery.




| | | | |
|---|---|---|---|
| (1) | Oil strainer | (8) | Camshaft |
| (2) | Oil pump | (9) | Crankshaft |
| (3) | Relief valve case | (10) | Lower idler sprocket |
| (4) | Chain tension adjuster RH | (11) | Upper idler sprocket |
| (5) | Oil cooler | (12) | Chain tension adjuster LH |
| (6) | Oil filter | (13) | Orifice |
| (7) | Oil pressure switch | | |

# 2. Engine Oil Flow

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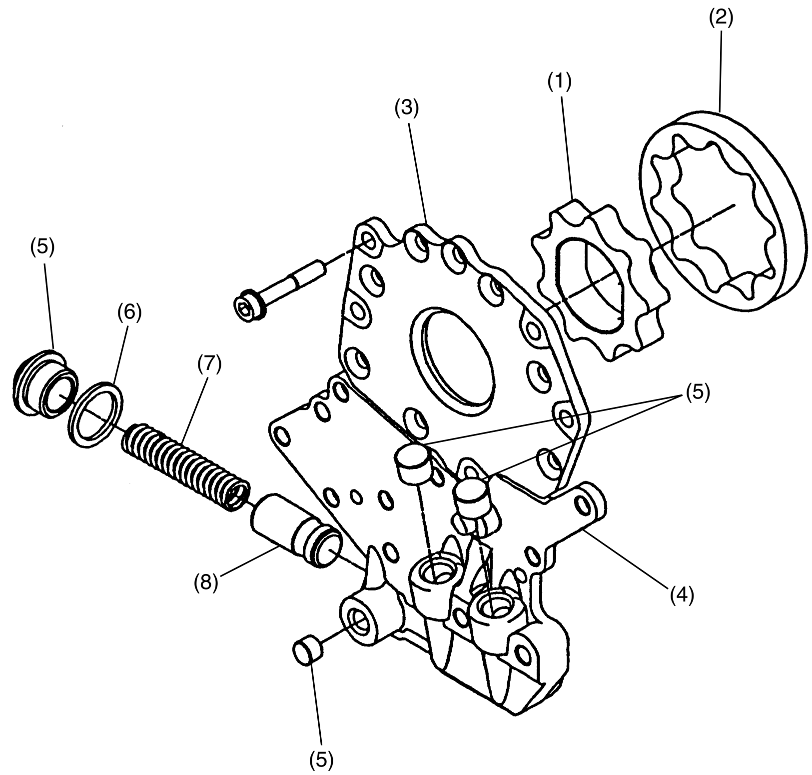
## 3. Oil Pump and Relief Valve

● The oil pump is a thin, large-diameter trochoid roller pump directly driven by the crankshaft. Its outer rotor and inner rotor are assembled with each other inside the rotor housing which is formed in the rear chain cover. The rotor housing is closed by the oil pump cover. The outer rotor, inner rotor and the oil pump cover are made of sintered metal.

● When the pump discharge pressure exceeds a certain level, the relief valve located at the outlet port of the oil pump opens and allows excess oil to return to the inlet of the pump. The relief valve is a single-spool type and housed in an aluminum die-cast case. It is mounted on the rear chain cover with a metal gasket.

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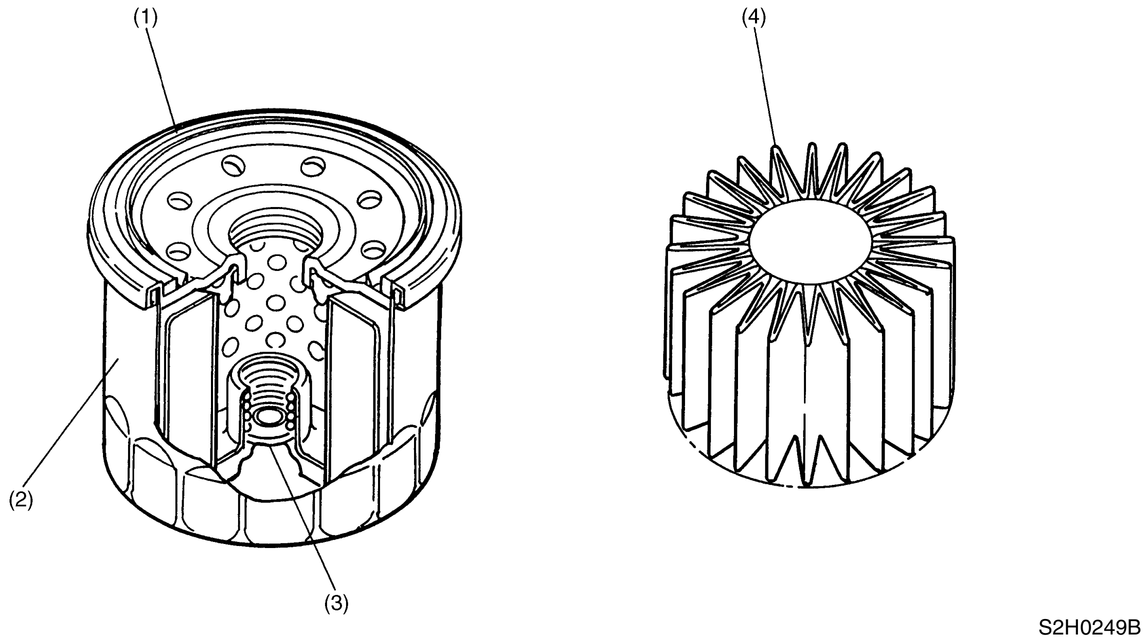
| | |
|---|---|
| (1) Inner rotor | (5) Plug |
| (2) Outer rotor | (6) Gasket |
| (3) Oil pump cover | (7) Relief valve spring |
| (4) Relief valve case | (8) Relief valve |

# 4. Oil Filter

The oil filter is a full-flow filtering, cartridge type that utilizes a paper element. It also has a built-in bypass valve. The filter element has a special pleat design to increase the effective filtering area.

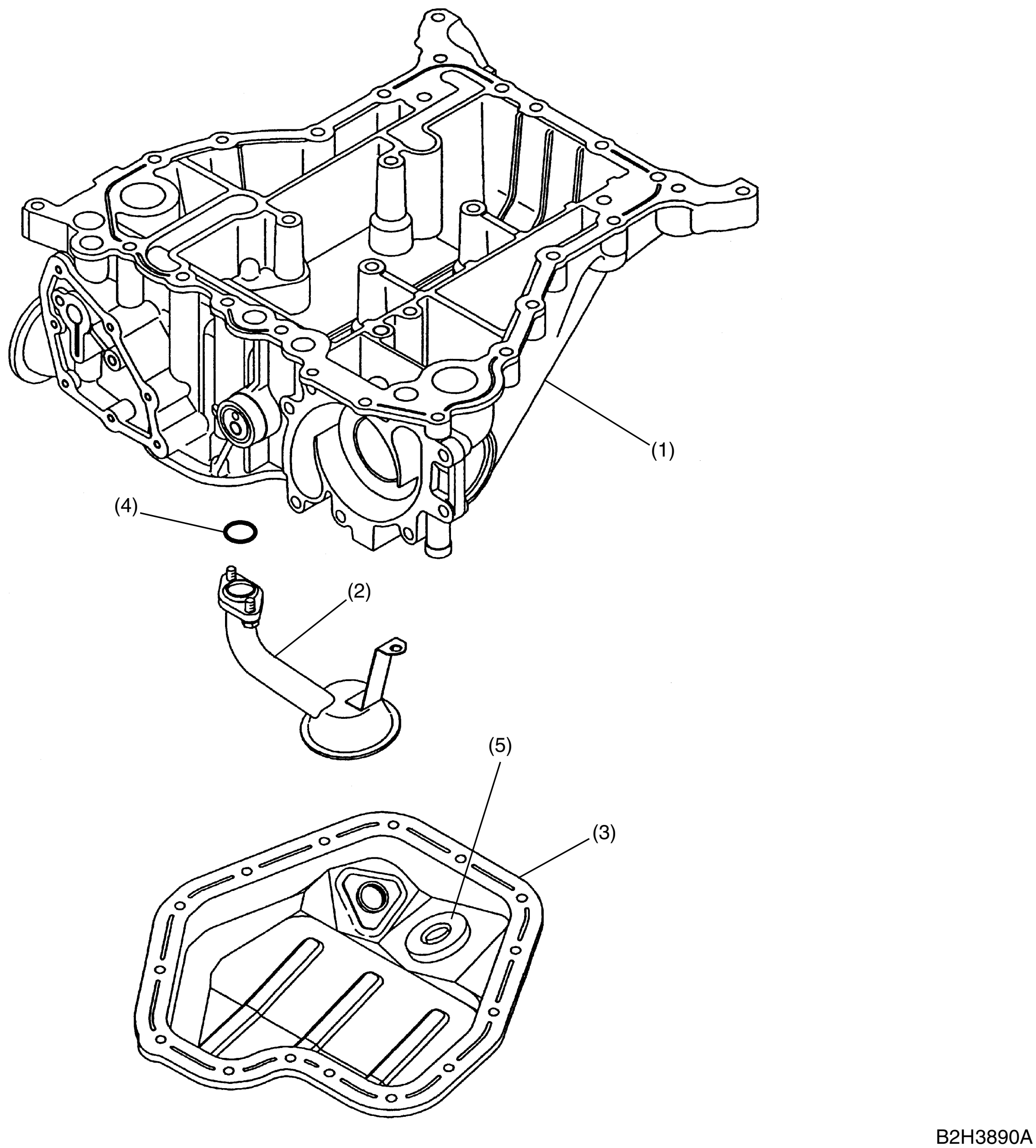



(1) Oil seal
(2) Filter body
(3) Bypass valve
(4) Pleated element

## 5. Oil Pan and Oil Strainer

● The oil pan consists of an upper oil pan (aluminum die-casting) and a lower oil pan (formed steel plate). The upper oil pan has a baffle plate molded in it to improve stability of the oil level.

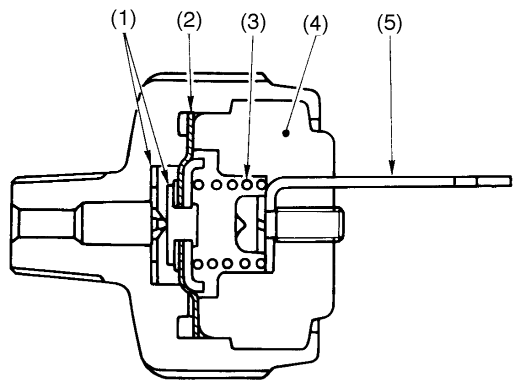
● The oil strainer has a stay whose end is attached to the upper oil pan. The strainer's pipe is connected to the oil pump using an O-ring. The strainer is located close to the bottom at the center of the oil pan where the oil level changes the least.




(1) Upper oil pan
(2) Strainer
(3) Lower oil pan
(4) O-ring
(5) Magnet

# 6. Oil Pressure Switch

The oil pressure switch is located at the right of the upper oil pan. The purpose of this switch is to monitor the operation of the oil pump as well as the lubricating oil pressure when the engine is running.




B2H1023

(1) Contact point
(2) Diaphragm
(3) Spring
(4) Molded portion
(5) Terminal

1) When oil pressure does not build up (immediately after ignition switch is turned ON):
The diaphragm is pushed toward the upper oil pan by the spring force (a force equivalent to the specified oil pressure). This closes the contact points, causing the oil pressure warning light in the combination meter to illuminate.

2) When oil pressure reaches the specified value (after engine starts):
After reaching the specified value of 14.7 kPa (0.15 kgf/cm$^2$, 2.1 psi), the oil pressure pushes the diaphragm overcoming the spring force. This opens the contact points and the oil pressure warning light goes out.

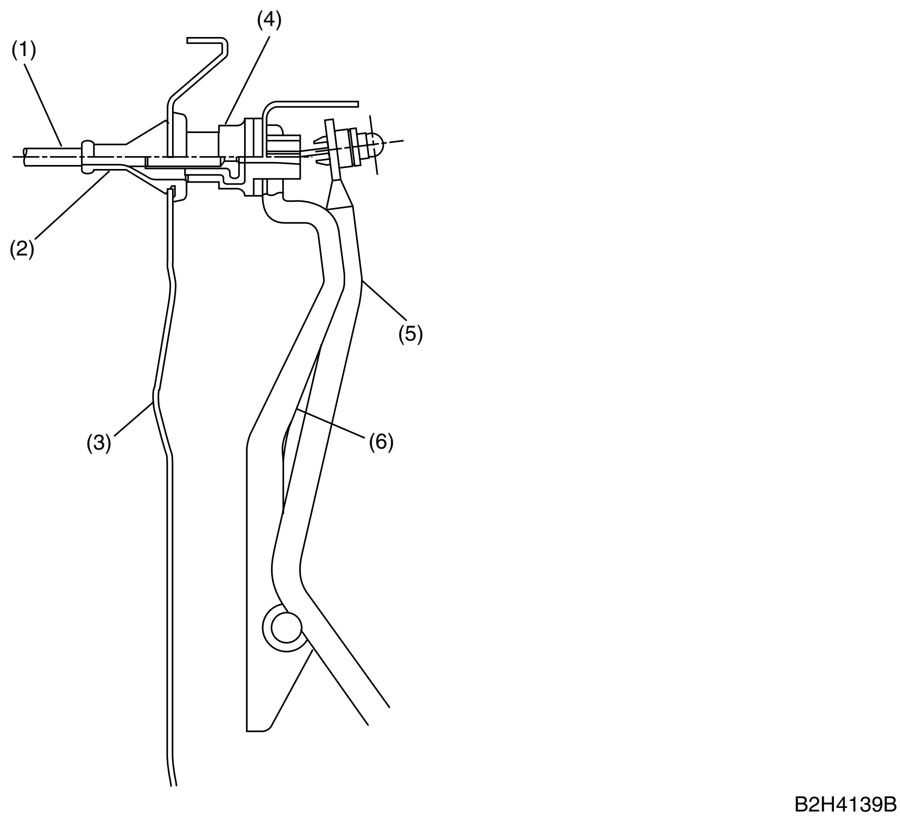
# SPEED CONTROL SYSTEM SP (H6)

Page

# 1. General

The accelerator outer cable is secured to the accelerator pedal bracket rather than to the toeboard. Securing the outer cable in this way has a merit of making the ratio of throttle valve movement to cable stroke less variable. This arrangement is also effective to prevent unsmooth cable return movement that may result from deformation of the toeboard or improper installation of the accelerator pedal and, therefore, to improve safety.

In addition, the floating type casing cap through which the cable is attached to the bracket reduces vibration of the pedal, thus improving quietness.



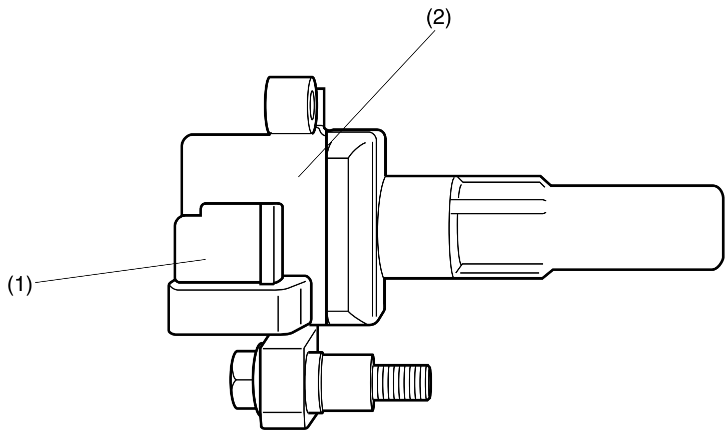

(1) Accelerator cable
(2) Grommet
(3) Toeboard
(4) Casing cap (floating type)
(5) Accelerator pedal
(6) Bracket

# IGNITION IG (H6)

Page

# 1. Ignition Coil

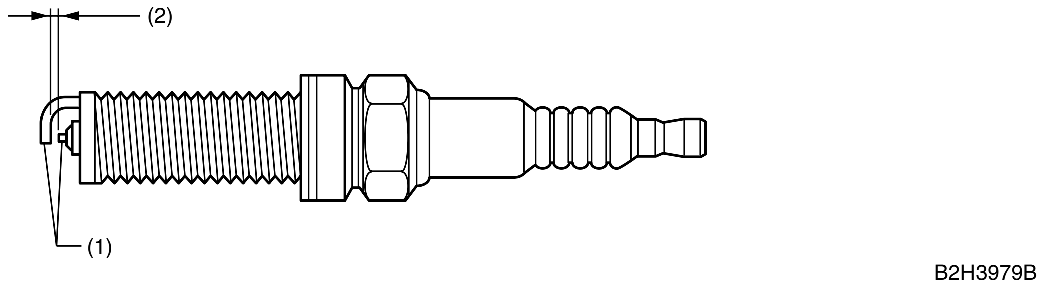
The engine uses a direct ignition system with one ignition coil mounted for each cylinder (or spark plug).
The secondary terminal of the ignition coil is in contact with the spark plug terminal nut.
Since no spark plug cable is used, secondary voltage drop, leaks, or other problems that are inherent in a system using spark plug cables do not occur. The result is high performance and high reliability.




(1) Connector
(2) Ignition coil

## 2. Spark Plug

The spark plug has a platinum tipped electrode. The thread diameter is 14 mm (0.551 in) and the gap is controlled to a value between 1.0 and 1.1 mm (0.039 and 0.043 in).




(1) Platinum tipped electrode

(2) Gap : 1.0 – 1.1 mm (0.039 – 0.043 in)

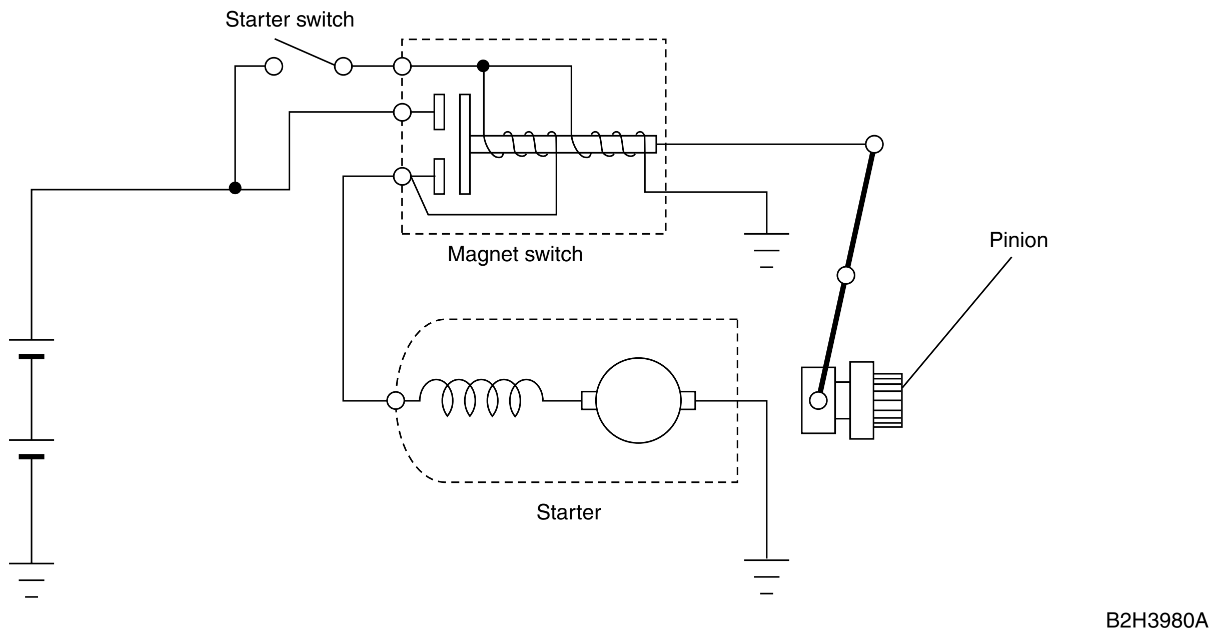
## MEMO

# STARTING/CHARGING SC (H6)

Page

# 1. Starter

The starter is of a reduction type. Its output is 1.4 kW.



## 2. Generator

The generator has a built-in regulator which provides diagnostic functions in addition to a voltage regulating function as follows:

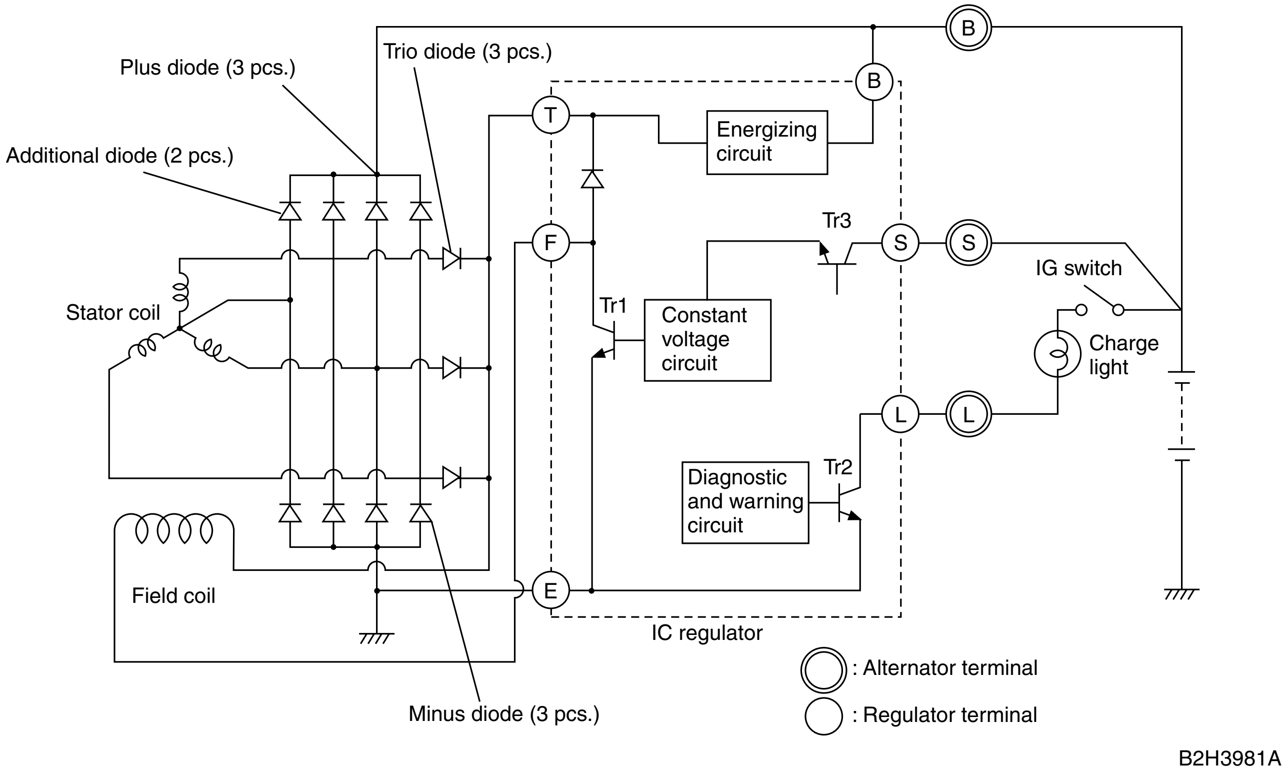
1) Voltage regulation

The on-off operation of transistor $Tr_1$ connects and disconnects the field current circuit, providing a constant level of output voltage.

2) Diagnosis warning

When any of the following problems occur, the charge lamp illuminates.

a. No voltage generation
Brush wear exceeds specified wear limits, field coil circuit is broken, etc.
b. Excessive output
Output voltage is greater than 16 volts (approx.)
c. Terminal B disconnection
Harness is disconnected from alternator terminal B.
d. Terminal S disconnection
Harness is disconnected from alternator terminal S. In this case, voltage is slightly greater than specified regulated voltage; however, voltage regulation is still controlled and the battery is prevented from becoming overcharged.



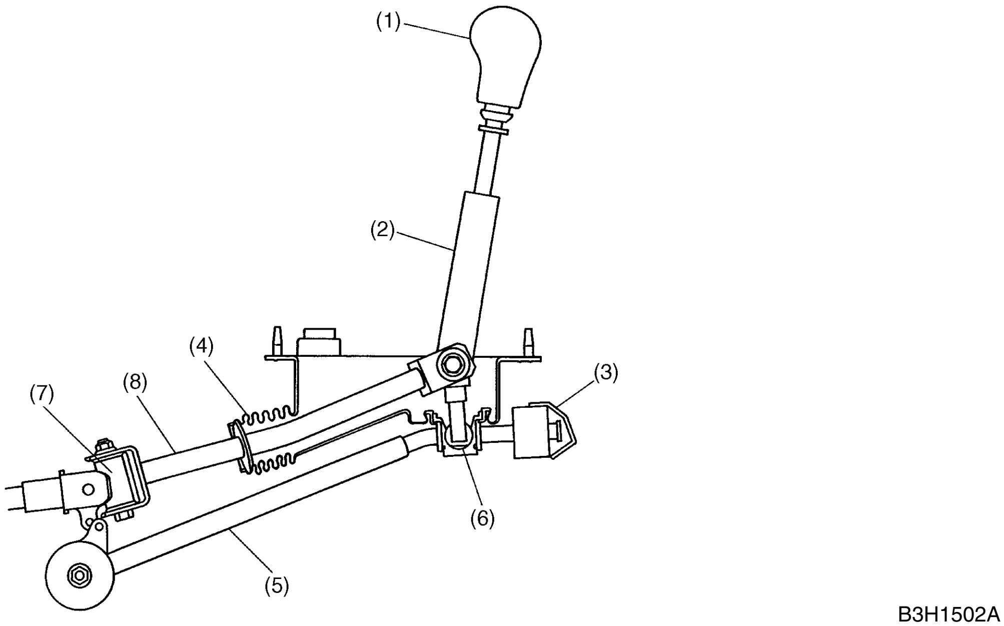
# 3. Battery

The battery is located in the left front part of the engine compartment. It is held on a tray by the battery holder.

# CONTROL SYSTEM CS

# 1. Gear Shift Lever

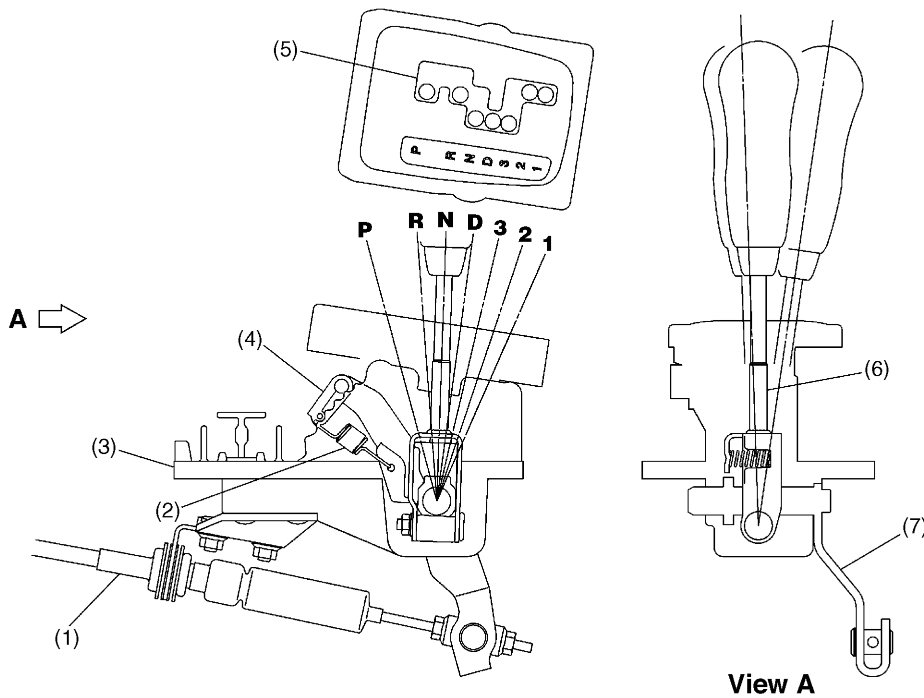
The manual transmission’s gear shift lever system is a parallel link type whose stay is mounted through a cushion rubber.




| | | | |
|---|---|---|---|
| (1) | Knob | (5) | Stay |
| (2) | Lever | (6) | Bush B |
| (3) | Cushion rubber | (7) | Joint |
| (4) | Boot | (8) | Rod |

## 2. Select Lever

- The automatic transmission's select lever moves through seven positions.
- The select lever makes shift direction (longitudinal) movements as well as select direction (lateral) movements. The select lever is guided by a gate to make these movements.
- To transmit movements of the select lever to the transmission, a push-pull cable is used.
- The detent spring is a new addition to the select lever mechanism. It ensures more precise positioning of the select lever.
- A plastic select lever base plate is used.

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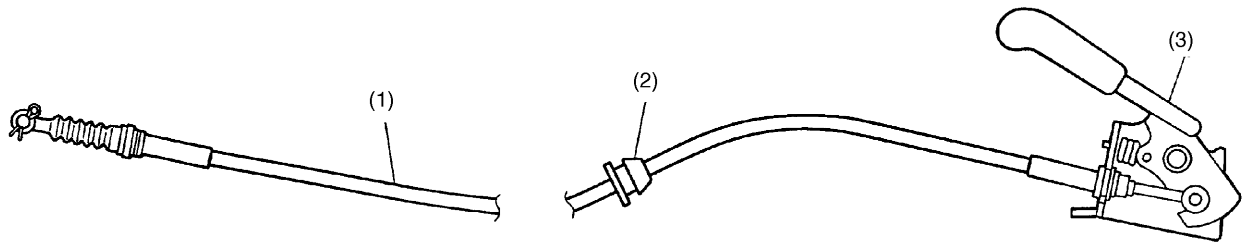
(1) Push-pull cable
(2) Detent spring
(3) Base plate
(4) Detent arm
(5) Gate
(6) Select lever
(7) Arm

# 3. Dual Range Selector Lever

The dual range selector lever is provided behind the transmission shift lever. Moving the range selector lever up and down shifts the Hi-Lo coupling sleeve of the auxiliary transmission gear mechanism via a cable, thereby selecting the low range and high range, respectively.




(1) Cable
(2) Grommet
(3) Dual range selector lever assembly

# AUTOMATIC TRANSMISSION AT

Page

# 1. General

## A: OUTLINE

The automatic transmission comes in two types; one is for the models without a variable torque distribution (VTD) system (called “MPT models” – standing for multi-plate transfer models – in the following description), and the other for the models with a VTD system (called “VTD models” in the following description). Both the types are of a full-time all-wheel drive design, combining the torque converter/clutch section, final reduction section, automatic transmission section, and transfer section into a single unit (see “C: CROSS SECTIONAL VIEW”).

These transmissions are controlled electronically by the transmission control module (TCM). The TCM is a microprocessor-based unit that controls operation of various solenoid valves and other electric devices depending on many variables (throttle opening, vehicle speed, engine speed, selected gear range, etc.) to select the optimum gear and the most appropriate way of power transmission (including engine braking and lock-up clutch engagement) for a particular condition.

The TCM has an additional function of automatically selecting either of the two control patterns (“Base” and “Power”) in accordance with the driving type which it identifies from the rate of movement of the accelerator pedal. It uses the Base pattern typically for cruising on a flat road and the Power pattern during acceleration or up-hill driving.

## 1. MPT MODELS

● The automatic transmission for the MPT models has a transfer hydraulic pressure control unit. This unit is located at the rear of the automatic transmission section and consists of a duty-cycle-controlled solenoid valve which adjusts the hydraulic pressure applied to the wet multi-plate type transfer clutch.

● The TCM has in its memory a set of duty ratio data, each defining at what ratio the transfer clutch should transmit the torque for a particular driving condition. Based on the driving condition information it receives from the corresponding sensors (vehicle speed, throttle opening, gear range, slip of wheels, etc.), the TCM selects an appropriate duty ratio from the memory and uses it to control the solenoid valve. The solenoid valve then regulates the hydraulic pressure to the transfer clutch and the clutch is engaged to a degree determined by the hydraulic pressure.

## 2. VTD MODELS

● Electronically controlled and fully automatic, the four-speed transmission for the VTD models is called “E-4AT”. The center differential of this AWD transmission features the SUBARU drive power distribution system which combines a newly developed compound planetary gear set and an electronically controlled differential action limiting mechanism (limited slip differential or LSD). The system provides the vehicle with easy handling and stable operation features.

● The center differential distributes the drive torque to the front and rear wheels at a ratio of 45.5 : 54.5 through the torque dividing function of the compound planetary gear set. This ratio has been determined with emphasis on maximizing cornering smoothness (that requires optimizing distribution of the cornering forces generated between tires and road surface) rather than maximizing traction performance (that requires optimizing distribution of the dynamic loads). This front-rear torque distribution ratio (and, consequently, the cornering force distribution ratio) is variable due to the function of the electronically controlled differential action limiting mechanism. The range of the variation in the torque distribution ratio is from the ratio originally set for the compound planetary gears to the ratio attained when the differential gear set performs no differential action. This system capable of varying the torque distribution properly according to conditions enables the driver to handle the vehicle easily even in a marginal condition and the vehicle to show improved driveability and stability in all road conditions.

## B: FEATURES

### 1. MPT MODELS

● The transmission uses both structural and control means to reduce gearshift and engagement shocks; a one-way clutch and three accumulators effectively absorb shock loads, while fully electronic gear-shift control (1st through 4th), hydraulic pressure (line pressure) control and lock-up clutch control minimize chances of shock occurring.

● Both power transmission efficiency and fuel economy are improved by the use of a torque converter with hydraulically operated lock-up clutch and a gear train creating four forward and one reverse speeds with two sets of simple planetary gears.

● Apart from a highly rigid transmission case, the use of a push-pull cable for the selector lever mechanism improves quietness as the cable conveys vibration only slightly to the driver's control mechanism.

● The TCM has an on-board diagnosis function to facilitate servicing and a fail-safe control function to ensure minimum level of operation should an important problem occur in the system.

● The degree of engagement of the transfer clutch is accurately controlled by the TCM. This is especially effective to prevent undesirable tight corner braking which would occur when making a sharp turn at a low speed.

● Distribution of torque to the rear wheels is optimally controlled according to the engine output torque and selected gear. This improves fuel efficiency and directional stability.

● When the ABS is in operation, the TCM performs special control for the most effective braking by properly adjusting the degree of engagement of the transfer clutch and fixing the speed to a certain gear.

● The manual range feature enables the driver to hold the transmission in a desired gear. If used properly, it can improve driveability and ride comfort.

### 2. VTD MODELS

● The gearshift feeling is improved by optimally controlling the gearshift timing and the engine torque during gearshifts.

● Both power transmission efficiency and fuel economy are improved by the use of a torque converter with hydraulically operated lock-up clutch and a gear train creating four forward and one reverse speeds with two sets of simple planetary gears.

● The center differential combining compound planetary gears with an electronically controlled and hydraulically operated multi-plate differential action limiting device (limited slip differential) is a vehicle controllability enhancement feature that enables the vehicle to be handled easily even in a marginal condition.

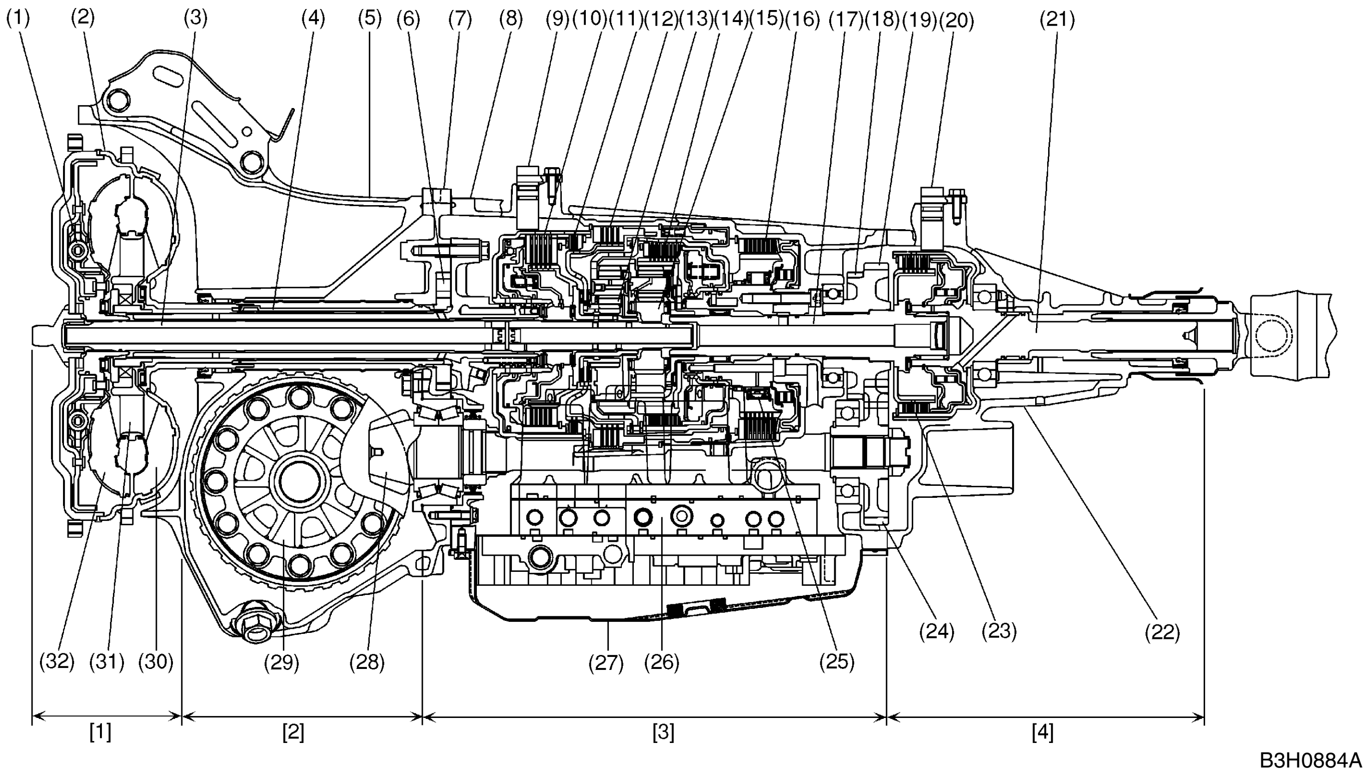
● When the ABS is in operation, the TCM controls the differential action limiting device in such a way that the ABS can be controlled most appropriately in accordance with signals from the ABS system.

● The manual range feature enables the driver to hold the transmission in a desired gear. If used properly, it can improve driveability and ride comfort.

● The TCM has an on-board diagnosis function to facilitate servicing and a fail-safe control function to ensure minimum level of operation should an important problem occur in the system.

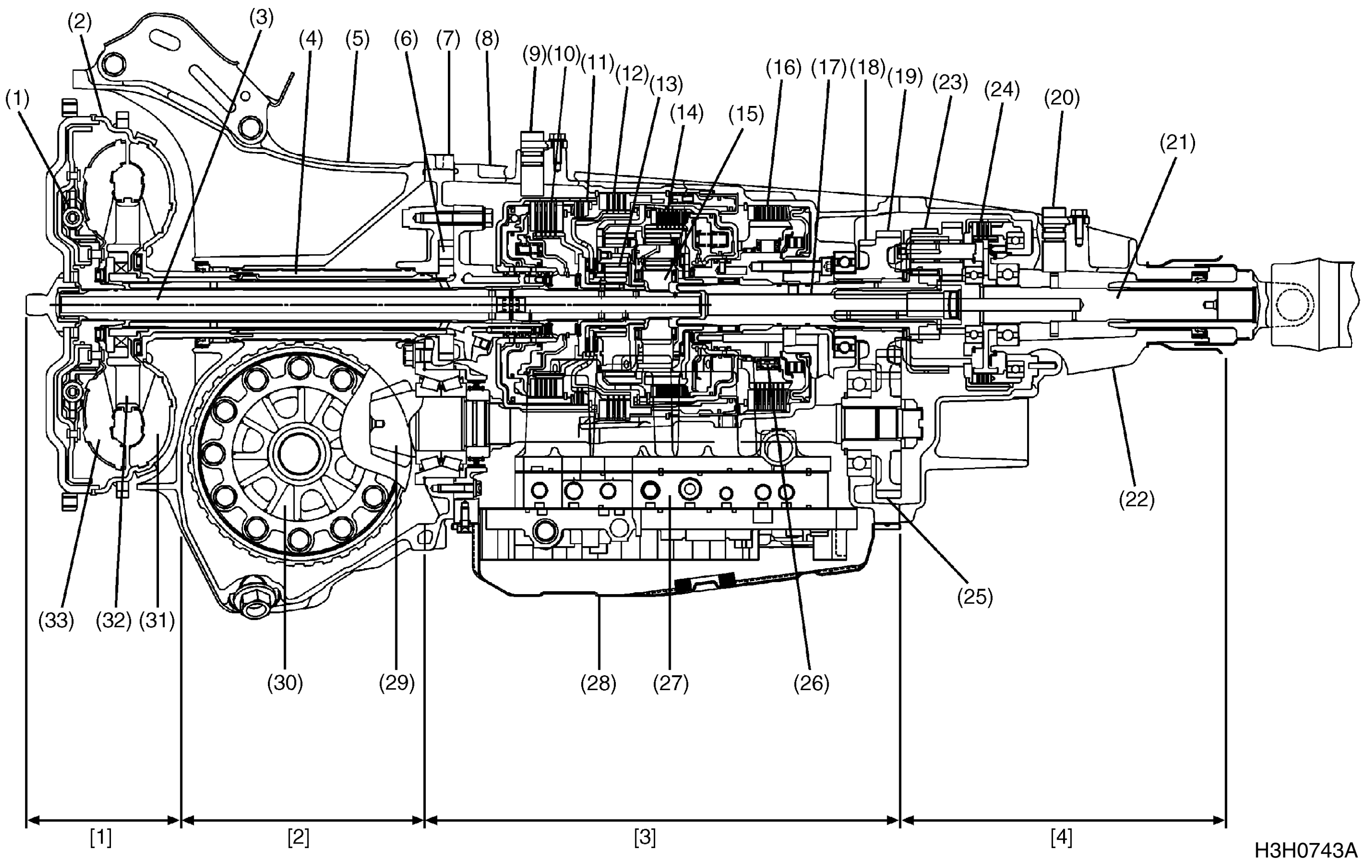
# C: CROSS SECTIONAL VIEW

## 1. MPT MODELS




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (1) | Lock-up damper | (9) | Torque converter turbine speed sensor | (17) | Reduction drive shaft | (25) | One-way clutch | [1] | Torque converter clutch section |
| (2) | Torque converter clutch | (10) | High clutch | (18) | Parking gear | (26) | Hydraulic control valve | | |
| (3) | Input shaft | (11) | Reverse clutch | (19) | Reduction drive gear | (27) | Oil pan | [2] | Final reduction section |
| (4) | Oil pump drive shaft | (12) | 2-4 brake | (20) | Rear vehicle speed sensor | (28) | Drive pinion shaft | | |
| (5) | Torque converter clutch case | (13) | Front planetary gear | (21) | Rear drive shaft | (29) | Hypoid drive gear | [3] | Automatic transmission section |
| (6) | Oil pump | (14) | Low clutch | (22) | Extension case | (30) | Impeller | | |
| (7) | Oil pump housing | (15) | Rear planetary gear | (23) | Transfer clutch | (31) | Stator | [4] | Transfer section |
| (8) | Transmission case | (16) | Low & reverse brake | (24) | Reduction driven gear | (32) | Turbine | | |

## 2. VTD MODELS



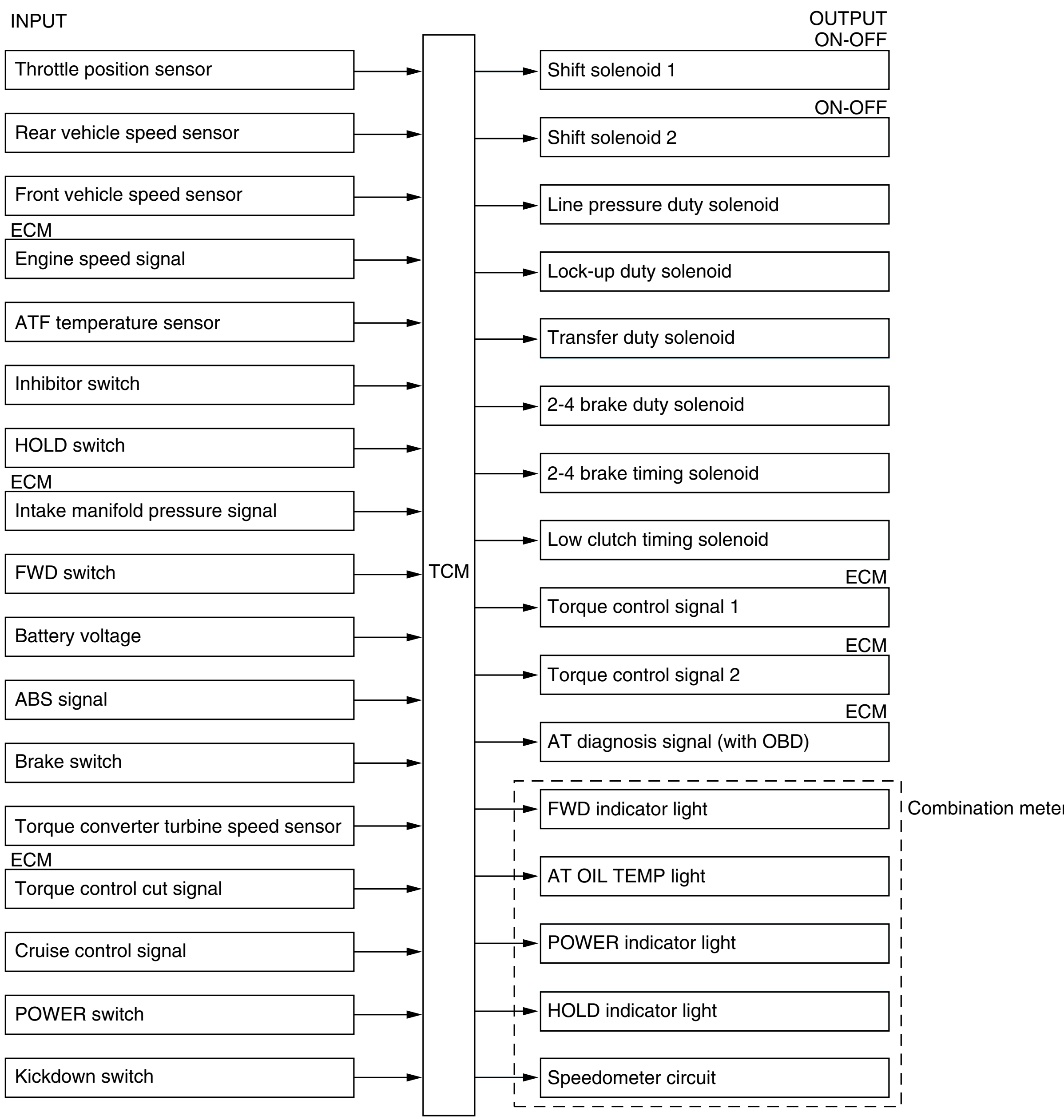

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (1) | Lock-up damper | (10) | High clutch | (19) | Reduction drive gear | (28) | Oil pan | [1] | Torque converter clutch section |
| (2) | Torque converter clutch | (11) | Reverse clutch | (20) | Rear vehicle speed sensor | (29) | Drive pinion shaft | | |
| (3) | Input shaft | (12) | 2-4 brake | (21) | Rear drive shaft | (30) | Hypoid drive gear | [2] | Final reduction section |
| (4) | Oil pump drive shaft | (13) | Front planetary gear | (22) | Extension case | (31) | Impeller | | |
| (5) | Torque converter clutch case | (14) | Low clutch | (23) | Center differential | (32) | Stator | [3] | Automatic transmission section |
| (6) | Oil pump | (15) | Rear planetary gear | (24) | Multi-plate clutch (LSD) | (33) | Turbine | | |
| (7) | Oil pump housing | (16) | Low & reverse brake | (25) | Reduction driven gear | | | [4] | Transfer section |
| (8) | Transmission case | (17) | Intermediate shaft | (26) | One-way clutch | | | | |
| (9) | Torque converter turbine speed sensor | (18) | Parking gear | (27) | Hydraulic control valve | | | | |

# 2. Electrohydraulic Control System

## A: GENERAL

### 1. MPT MODELS

The electrohydraulic control system for the transmission and transfer consists of various sensors and switches, a transmission control module (TCM) and the hydraulic controlling units including solenoid valves. The system controls the automatic transmission operation, including gear shifting, lock-up clutch operation, line pressure, automatic control pattern selection (“Base” and “Power”), and gear-shift timing. It also controls the operation of the transfer clutch. The TCM determines vehicle operating conditions from various input signals and controls a total of eight solenoids (shift solenoids 1 and 2, low clutch timing solenoid, 2-4 brake timing solenoid, line pressure duty solenoid, lock-up duty solenoid, transfer duty solenoid, and 2-4 brake duty solenoid) by sending appropriate signals to them.

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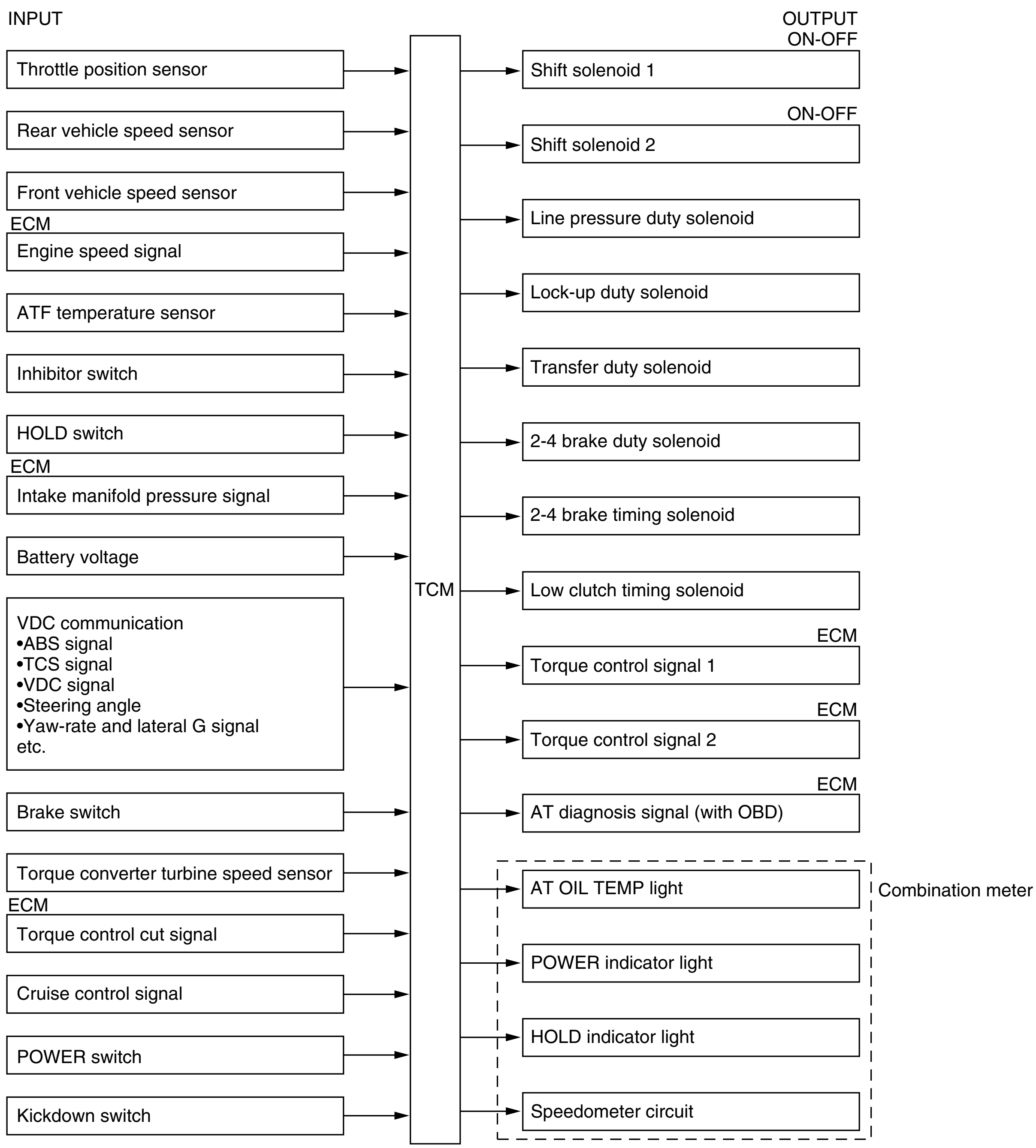
## 2. VTD MODELS

The electrohydraulic control system for the transmission and transfer consists of various sensors and switches, a transmission control module (TCM) and the hydraulic controlling units including solenoid valves. The system controls the automatic transmission operation, including gear shifting, lock-up clutch operation, line pressure, automatic control pattern selection ("Base" and "Power"), and gear-shift timing. It also controls operation of the transfer multi-plate clutch (LSD). The TCM determines vehicle operating conditions from various input signals and controls a total of eight solenoids (shift solenoids 1 and 2, low clutch timing solenoid, 2-4 brake timing solenoid, line pressure duty solenoid, lock-up duty solenoid, transfer duty solenoid, and 2-4 brake duty solenoid) by sending appropriate signals to them.




B3H2262A

## B: INPUT SIGNALS

| Signal name | Major function |
|---|---|
| Throttle position sensor | Indicates the throttle valve position. This signal is used to determine shift point, line pressure, and lock-up engaging vehicle speed, which vary with engine load. |
| Front vehicle speed sensor (located on transmission case) | Indicates the vehicle speed. This signal is used for control of gear shifting, lock-up engaging, line pressure, and transfer clutch operation. |
| Rear vehicle speed sensor (located on extension case) | Used to control transfer clutch, and also as backup signal in case of failure of front vehicle speed sensor. |
| Engine speed signal | Indicates the engine speed. This signal is used for control of lock-up clutch to ensure smooth engagement. |
| Inhibitor switch | Used to determine gears and line pressures in each of ranges “P”, “R”, “N”, “D”, “3”, “2” and “1”. |
| ATF temperature sensor | Indicates the ATF temperature. This signal is used for inhibition of lock-up, release of OD and determination of ATF temperature. |
| FWD switch (MPT models) | Used to change the mode from AWD to FWD. Also used to adapt the vehicle to FWD tester roller. Changeover from AWD to FWD can be made by inserting a fuse into the fuse holder. |
| ABS signal | Used when ABS is operating to optimize ABS control. In this control, transfer clutch torque load capacity is adjusted to eliminate the influence of engine braking and reduce the degree of coupling between front and rear wheels. |
| Cruise control signal | Indicates operation of cruise control system. It is used to expand “4th” operating range. |
| Torque converter turbine speed sensor | Tells the rotation speed of the input shaft. The proportion of this speed to the vehicle speed determines whether shifting should be made or not. |
| Torque control cut signal | Sent from engine control module (ECM) to TCM to inhibit the torque control. |
| Intake manifold pressure signal | Used to determine line pressure of gear shifting. |
| HOLD switch | With this switch “ON”, the vehicle starts in 2nd gear (if the D, 3 or 2 range is selected), which facilitates drive away on a slippery road. |
| POWER switch | With this switch “ON”, the TCM controls gear shifting in the POWER mode which is convenient when rapid acceleration or great power is required. |
| Kickdown switch | Indicates full throttle opening. TCM uses this signal to make kickdown control. |
| TCS signal (VTD models) | Used when TCS is operating to optimize TCS control. In this control, transfer clutch torque is controlled to eliminate the influence of engine braking and reduce the degree of coupling between front and rear wheels. |
| VDC signal (VTD models) | Used when VDC is operating to optimize VDC control. In this control, transfer clutch torque is controlled to eliminate the influence of engine braking and reduce the degree of coupling between front and rear wheels. |
| Steering angle sensor (VTD models) | Used to monitor the vehicle behavior and send signals for transfer control. |
| Yaw-rate and lateral G sensor (VTD models) | Used to monitor the vehicle behavior and send signals for transfer control. |
| Brake switch | If this signal is issued during downhill driving, TCM makes shift down control, causing the vehicle speed to be reduced. |

## C: OUTPUT SIGNALS

| Signal name | Function |
|---|---|
| Shift solenoid 1, 2 | Each of these signals controls shift step by turning the corresponding solenoid ON/OFF. Activating timing is controlled for each solenoid to reduce shift shock. |
| Line pressure duty solenoid | Regulates the line pressure according to driving conditions. |
| Lock-up duty solenoid | Regulates the hydraulic pressure of the lock-up clutch to operate it in three modes (open, smooth and lock-up). |
| Transfer duty solenoid | Regulates the hydraulic pressure of the transfer clutch to control the driving force to the rear drive shaft. |
| AT OIL TEMP light | Causes the light to illuminate when ATF becomes excessively hot (exceeds a set temperature level). |
| 2-4 brake duty solenoid | Regulates 2-4 brake operating pressure to reduce shifting shocks. |
| 2-4 brake timing solenoid | Switches on or off the pressure acting on 2-4 brake timing valve B to control the release timing of the 2-4 brake. |
| Low clutch timing solenoid | Switches on or off the pressure acting on the low clutch timing valve B to control the release timing of the low clutch.<br>Also switches on or off the pressure acting on the reverse inhibit valve to control the reverse inhibit function. |
| Torque control signal 1 | Reduces engine torque during range selection and gear change. |
| Torque control signal 2 | Reduces engine torque during range selection and gear change. |
| POWER indicator light | Indicates whether the shift pattern is “Base” or “Power”. The indicator lights in the POWER mode. This light is also used to display diagnostic trouble codes for the on-board diagnosis function. |
| HOLD indicator light | Indicates whether the shift pattern is “Base” or “Hold”. The indicator lights in the HOLD mode. |

## D: CONTROL ITEMS

### 1. MPT MODELS

| Control item | | | Description of control |
|---|---|---|---|
| Transmission control | Gear shift control | Base shift control<br>● Base pattern<br>● Power pattern | Upshifting and downshifting are set for each range, gear and pattern according to throttle position and vehicle speed. |
| | | ABS-in-operation control | Gear is locked in 3rd when ABS signal enters. |
| | | ATF-low-temperature control | Shifting into 4th gear is prevented when ATF temperature is below the preset value. |
| | | Hold control | With HOLD switch ON, vehicle starts in 2nd gear (if the D, 3 or 2 range is selected). |
| | | Power pattern control (POWER light ON) | Power pattern is selected when POWER switch is ON. |
| | | Base pattern control (POWER light OFF) | Base pattern is selected when POWER switch is OFF. |
| | Lock-up control | Base lock-up control | Lock-up ON is set for D-range 4th gear; ON/OFF is set for all gears (except D-range 4th) and patterns. Lock-up control is performed according to throttle position and vehicle speed. (Basically lock-up is OFF during gear shifting.) |
| | | Smooth control | Smooth lock-up is performed when lock-up is switched on. |
| | Line pressure control | Ordinary control | Line pressure is regulated according to throttle position, vehicle speed and range signals. |
| | | Shifting control | Line pressure is regulated when shifting to lessen shifting shock. |
| | | Starting control | Line pressure is lowered to a minimum so as to reduce engine cranking load. |
| | Shift timing control | Shift step control | ON/OFF timing for shift solenoid is controlled. |
| | | Lock-up control | When shifting, the lock-up clutch is temporarily released. |
| | | Line pressure control | When shifting, line pressure is controlled to the optimum level so as to reduce shifting shock. |
| AWD transfer clutch control | Ordinary transfer control | | Transfer clutch pressure is regulated according to the throttle valve angle and vehicle speed. |
| | 1 range control | | Transfer clutch pressure is increased. |
| | Slip control | | Immediately after detecting a slip, transfer clutch pressure is controlled to the same pressure as 1 range. (This control is canceled if V $\geq$ 60 km/h (37 MPH), or when throttle valve is closed fully.) |
| | Control in turns | | Transfer clutch pressure is reduced after detecting a turn. |
| | ABS-in-operation control | | Transfer clutch pressure is adjusted to a set level immediately after reception of ABS signal. |

## 2. VTD MODELS

| Control item | | | Description of control |
|---|---|---|---|
| Transmission control | Gear shift control | Base shift control<br>● Base pattern<br>● Power pattern | Upshifting and downshifting are set for each range, gear and pattern according to throttle position and vehicle speed. |
| | | ABS-in-operation control | Gear is locked in 3rd when ABS signal enters. |
| | | ATF low temperature control | Shifting into 4th gear is prevented when ATF temperature is below the preset value. |
| | | Hold control | With HOLD switch ON, vehicle starts in 2nd gear (if the D, 3 or 2 range is selected). |
| | | Power pattern control (POWER light ON) | Power pattern is selected when POWER switch is ON. |
| | | Base pattern control (POWER light OFF) | Base pattern is selected when POWER switch is OFF. |
| | Lock-up control | Base lock-up control | Lock-up ON is set for D-range 4th gear; ON/OFF is set for all gears (except D-range 4th) and patterns. Lock-up control is performed according to throttle position and vehicle speed. (Basically lock-up is OFF during gear shifting.) |
| | | Smooth control | Smooth lock-up is performed when lock-up is switched on. |
| | Line pressure control | Ordinary control | Line pressure is regulated according to throttle position, vehicle speed and range signals. |
| | | Shifting control | Line pressure is regulated when shifting to lessen shifting shock. |
| | | Starting control | Line pressure is lowered to a minimum so as to reduce engine cranking load. |
| | Shift timing control | Shift step control | ON/OFF timing for shift solenoid is controlled. |
| | | Lock-up control | When shifting, the lock-up clutch is temporarily released. |
| | | Line pressure control | When shifting, line pressure is controlled to the optimum level so as to reduce shifting shock. |
| AWD mult-plate clutch control (LSD) | Ordinary transfer control | | Multi-plate clutch (LSD) pressure is regulated according to the torque input to the transfer and the driving condition. |
| | Start control | | When starting, the LSD pressure is adjusted proportionately to the throttle value angle. |
| | Control in turns | | When the front and rear wheel speed ratio is less than the set value for a vehicle speed, the LSD pressure is decreased. |
| | Slip control | | When a front or rear wheel starts slipping, the LSD pressure is decreased. |
| | ABS-in-operation control | | The LSD pressure is adjusted to the set level immediately after reception of ABS signal. |
| | Base brake control | | When the brake switch is ON and throttle valve is fully closed, the LSD pressure is lowered. |
| | 1 range control | | The LSD pressure is increased to improve driveability. |

## E: POWER INDICATOR LIGHT

The automatic transmission equipped vehicle is capable of selecting two driving patterns; “Base” pattern for ordinary driving and “Power” pattern for uphill driving or rapid acceleration. The POWER indicator light lights when the Power pattern is selected. See the table below:

| Selector lever position | Change of pattern | POWER indicator light |
|---|---|---|
| “D”, “3”, “2” range | Pattern is changed when power switch is ON. | ● “Base” pattern: OFF<br>● “Power” pattern: ON |

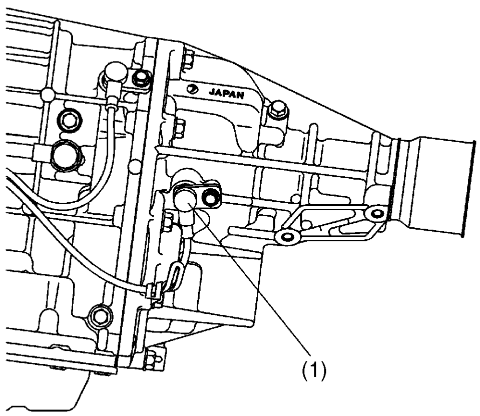
## F: THROTTLE POSITION SENSOR

The throttle position sensor provides electrical signals corresponding to throttle valve positions. The throttle valve angular position and accelerator depressing speed are detected by this throttle position sensor.

## G: REAR VEHICLE SPEED SENSOR

### 1. MPT MODELS

This vehicle speed sensor (output shaft speed sensor) is externally mounted on the extension case. It detects the rear wheel speed in terms of the peripheral speed of the transfer clutch drum and sends sine wave signals (30 pulses per rotation) to the TCM.

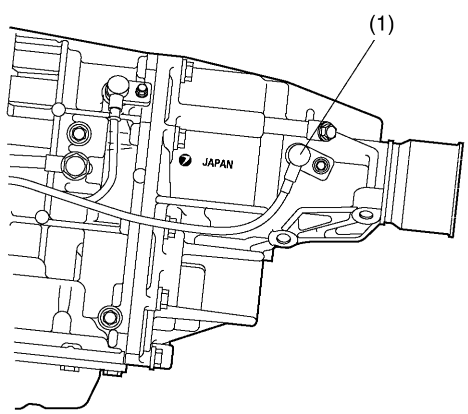



B3H0915C

(1) Rear vehicle speed sensor

### 2. VTD MODELS

This vehicle speed sensor (output shaft speed sensor) is externally mounted on the extension case. It detects the rear wheel speed in terms of the peripheral speed of the rear drive shaft and sends sine wave signals (22 pulses per rotation) to the TCM.




H3H1818C

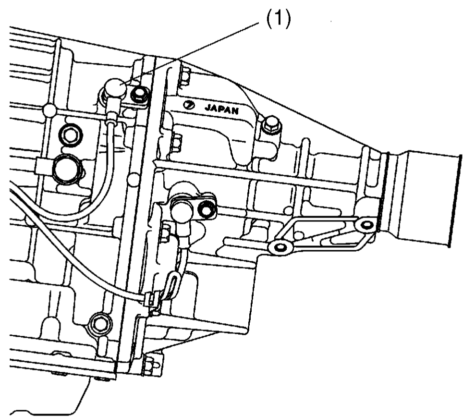
(1) Rear vehicle speed sensor

## H: FRONT VEHICLE SPEED SENSOR

This vehicle speed sensor (output shaft speed sensor) is externally mounted on the transmission case. It detects the front wheel speed and sends sine wave signals (16 pulses per rotation) to the TCM.

The TCM converts the signals into 4-pulse signals and outputs them to both the engine control module (ECM) and the combination meter.

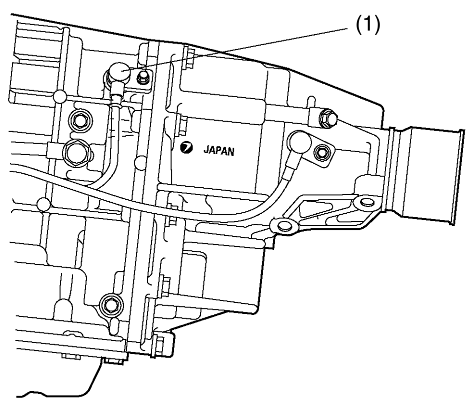
- MPT MODELS




B3H0915D

(1) Front vehicle speed sensor

- VTD MODELS

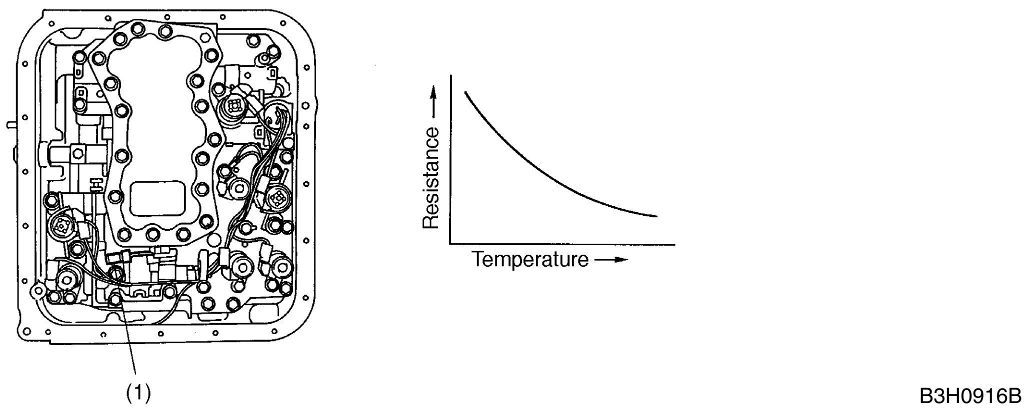



H3H1818D

(1) Front vehicle speed sensor

## I: ATF TEMPERATURE SENSOR

This sensor is located in the hydraulic control valve of the transmission. It detects the temperature of ATF and outputs it as an electrical resistance signal. The output characteristics of the sensor are shown below.

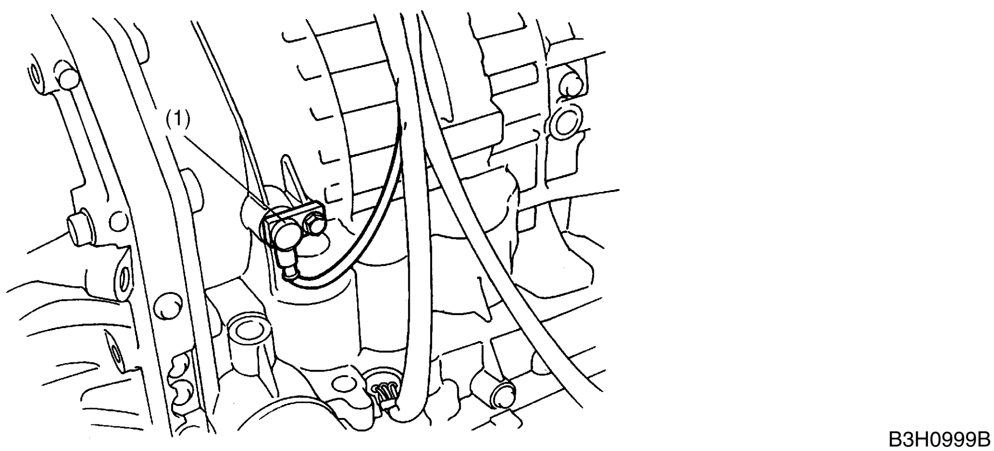



(1) ATF temperature sensor

## J: TORQUE CONVERTER TURBINE SPEED SENSOR

The torque converter turbine speed sensor (output shaft speed sensor) is externally mounted on the transmission case.

The sensor detects the torque converter turbine speed in terms of the rotation speed of the periphery of the high clutch drum coupled to the input shaft, and sends sine wave signals (32 pulses per rotation) to the TCM. The TCM calculates the proportion of the input shaft speed to the vehicle speed and determines whether the shifting is to be made or not.




(1) Torque converter turbine speed sensor

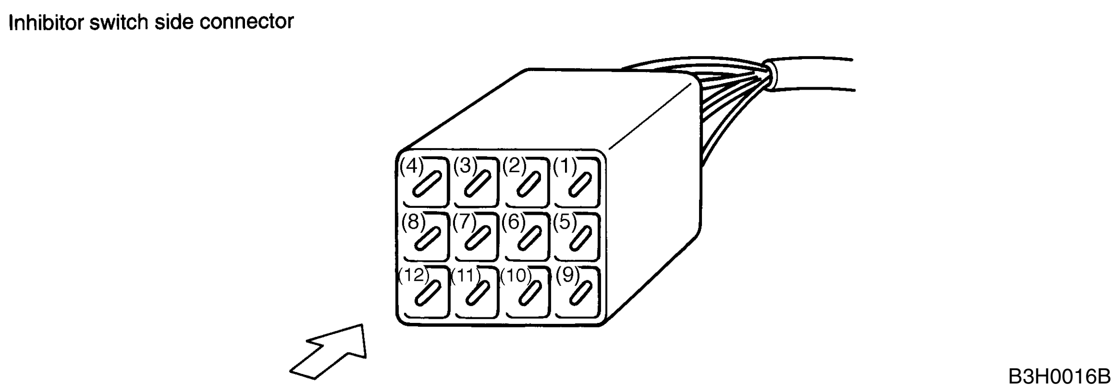
## K: INHIBITOR SWITCH

The inhibitor switch assures safety when starting the engine. This switch is mounted on the right side of the transmission case, and is operated by the selector lever.

When the selector lever is set to P or N, the electrical circuit in the inhibitor switch is closed and the starter circuit is completed for cranking the engine.

When the selector lever is in the R, D, 3, 2 or 1 range, the electrical circuit in the inhibitor switch is open. Hence engine cranking is disabled. In the R range, the backup light circuit is completed in the switch, and the backup lights come on.

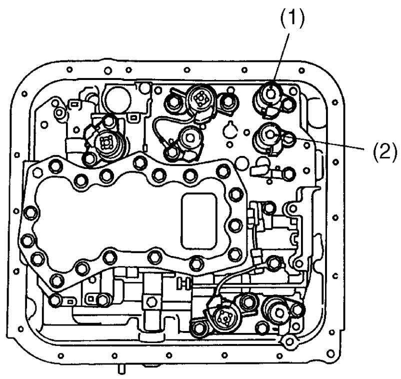
In addition to the above function, the inhibitor switch incorporates a circuit for detecting the selected range position and sending the range signal to the TCM.




| Range position | Pin No. |
|---|---|
| P | (4) – (3)<br>(12) – (11) |
| R | (4) – (2)<br>(10) – (9) |
| N | (4) – (1)<br>(12) – (11) |
| D | (4) – (8) |
| 3 | (4) – (7) |
| 2 | (4) – (6) |
| 1 | (4) – (5) |

## L: SHIFT SOLENOIDS 1 AND 2

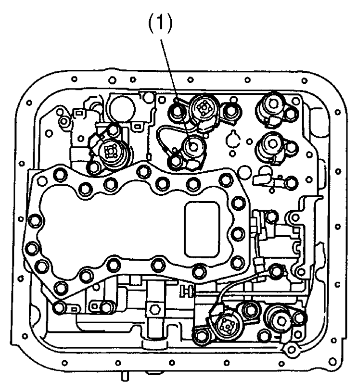
These solenoids are located in the transmission hydraulic control valve. They are turned ON or OFF according to signals from the TCM. The gear positions are changed according to the ON and OFF condition of these solenoids.




(1) Shift solenoid 2
(2) Shift solenoid 1

## M: LOW CLUTCH TIMING SOLENOID

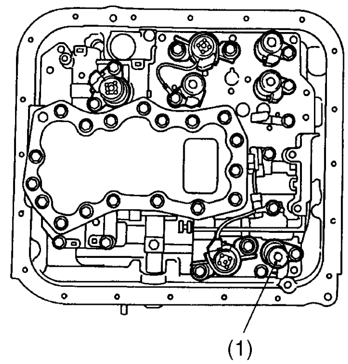
This solenoid is located in the transmission hydraulic control valve. It is turned ON or OFF according to signals from the TCM. It then controls the low clutch timing valve B and reverse inhibitor valve.




(1) Low clutch timing solenoid

## N: 2-4 BRAKE TIMING SOLENOID

This solenoid is located in the transmission hydraulic control valve. It is turned ON or OFF according to signals from the TCM. It then controls the 2-4 brake timing valve B to decrease the change gear shock.

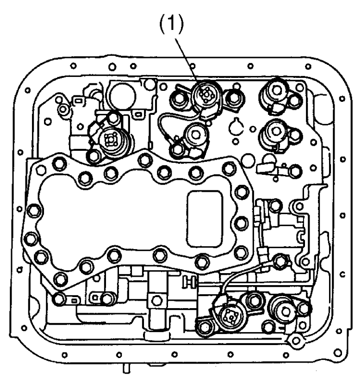



B3H0994L

(1) 2-4 brake timing solenoid

## O: LINE PRESSURE DUTY SOLENOID

This solenoid is located in the transmission hydraulic control valve. Its duty ratio is controlled by signals from the TCM. This solenoid then controls the pressure modifier valve and accumulator control valve A to adjust the line pressure to an optimum pressure level suitable for operating conditions.

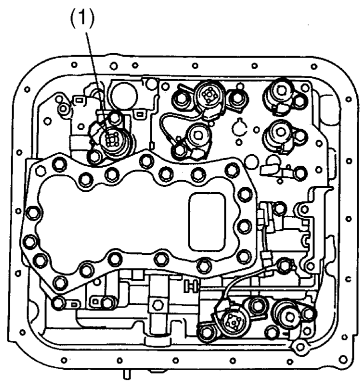



B3H0994M

(1) Line pressure duty solenoid

## P: LOCK-UP DUTY SOLENOID

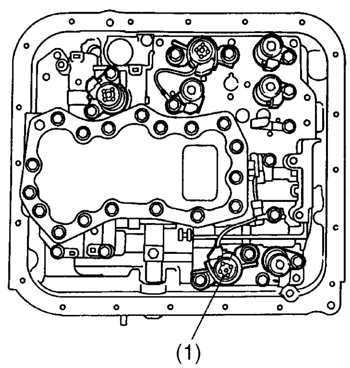
This solenoid is located in the transmission hydraulic control valve. Its duty ratio is controlled by signals from the TCM. It then controls the lock-up control valve to provide smooth engagement and disengagement of the lock-up clutch.




(1) Lock-up duty solenoid

## Q: 2-4 BRAKE DUTY SOLENOID

This solenoid is located in the transmission hydraulic control valve. Its duty ratio is controlled by signals from the TCM. It modulates the 2-4 brake pressure when the 2-4 brake is operated, reducing shifting shocks.

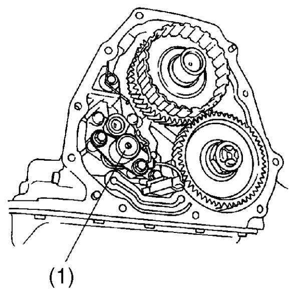



(1) 2-4 brake duty solenoid

## R: TRANSFER DUTY SOLENOID

This solenoid is located in the transfer hydraulic pressure control unit on the rear end of transmission case. Its duty ratio is controlled by signals from the TCM. It then controls the transfer clutch/control valve to control the pressure applied to the transfer clutch.

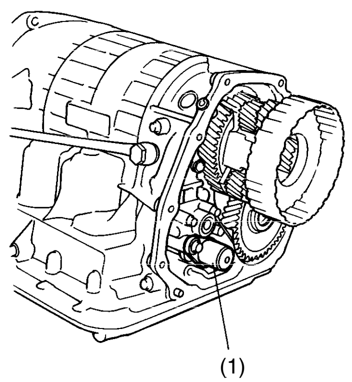
- MPT MODELS




B3H0995C

(1) Transfer duty solenoid

- VTD MODELS




H3H1929C

(1) Transfer duty solenoid

# 3. Transmission Control Module (TCM)

The TCM receives various sensor signals and determines the running conditions of the vehicle. It then sends control signals to each solenoid according to the preset gearshift characteristic data, lock-up operation data, and transfer clutch torque data (duty ratios) / multi-plate clutch (LSD) torque data (duty ratios).

## A: CONTROL SYSTEM

### 1. MPT MODELS

| Control item | | Input signal |
|---|---|---|
| Shift control | Ordinary shift control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Inhibitor switch<br>Power switch<br>Kickdown switch |
| | ABS-in-operation control | ABS signal<br>Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Brake switch |
| | Hydraulic oil temperature control | ATF temperature sensor |
| | Reverse inhibiting control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch |
| | Shift pattern (Base/Power) select control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch<br>Power switch |
| | Hold control | Inhibitor switch<br>Hold switch |
| | Grade control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Brake switch<br>Inhibitor switch<br>Engine speed<br>Intake manifold pressure |
| Lock-up control | Ordinary lock-up control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Inhibitor switch<br>Hold switch<br>Power switch |
| | Smooth control | Throttle position sensor |
| | Hydraulic oil temperature control | ATF temperature sensor |

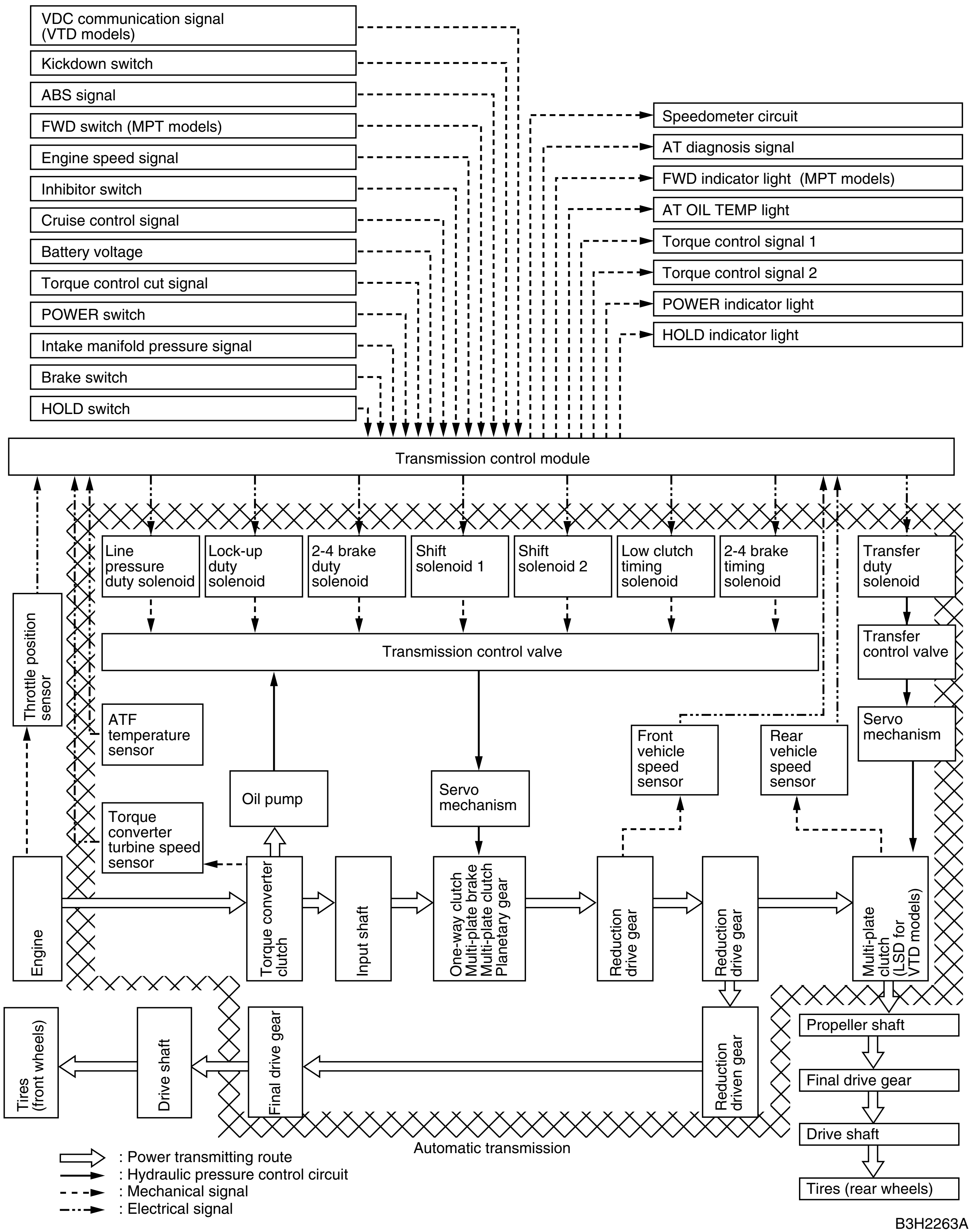
| Control item | | Input signal |
|---|---|---|
| Oil pressure control | Ordinary pressure control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Inhibitor switch<br>ATF temperature sensor |
| | Shifting control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Torque converter turbine speed sensor<br>Inhibitor switch<br>ATF temperature sensor |
| | Starting control | Engine speed<br>ATF temperature sensor<br>Inhibitor switch |
| | Learning control | Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Throttle position sensor<br>Torque converter turbine speed sensor<br>ATF temperature sensor |
| AWD transfer clutch control | Ordinary transfer control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch<br>ATF temperature sensor<br>FWD switch |
| | 1 range control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch<br>Hold switch |
| | Slip detection control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor |
| | Steering control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor |
| | ABS-in-operation control | ABS signal<br>Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Brake switch |

## 2. VTD MODELS

| Control item | | Input signal |
|---|---|---|
| Shift control | Ordinary shift control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Inhibitor switch<br>Power switch |
| | ABS-in-operation control | ABS signal<br>Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Brake switch |
| | Hydraulic oil temperature control | ATF temperature sensor |
| | Reverse inhibiting control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch |
| | Shift pattern (Base/Power) select control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch<br>Power switch |
| | Hold control | Inhibitor switch<br>Hold switch |
| | Grade control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Brake switch<br>Inhibitor switch<br>Engine speed<br>Intake manifold pressure |
| Lock-up control | Ordinary lock-up control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Inhibitor switch<br>Power switch<br>Hold switch |
| | Smooth control | Throttle position sensor |
| | Hydraulic oil temperature control | ATF temperature sensor |

| Control item | | Input signal |
|---|---|---|
| Oil pressure control | Ordinary pressure control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Inhibitor switch<br>ATF temperature sensor |
| | Shifting control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Engine speed<br>Torque converter turbine speed sensor<br>Inhibitor switch<br>ATF temperature sensor |
| | Starting control | Engine speed<br>ATF temperature sensor<br>Inhibitor switch |
| | Learning control | Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Throttle position sensor<br>Torque converter turbine speed sensor<br>ATF temperature sensor |
| AWD multi-plate clutch (LSD) control | Ordinary transfer control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch<br>ATF temperature sensor<br>Steering angle sensor<br>Yaw-rate and lateral G sensor |
| | 1 range control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Inhibitor switch<br>Hold switch |
| | Slip detection control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor |
| | Steering control | Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor |
| | ABS-in-operation control | ABS signal<br>Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor<br>Brake switch |
| | Base brake operating control | Throttle position sensor<br>Front vehicle speed sensor<br>Brake switch |
| | TCS-in-operation control | TCS signal (VDC communication signal)<br>Throttle position sensor<br>Rear vehicle speed sensor<br>Front vehicle speed sensor |
| | VDC-in-operation control | VDC signal (VDC communication signal)<br>Rear vehicle speed sensor<br>Front vehicle speed sensor |

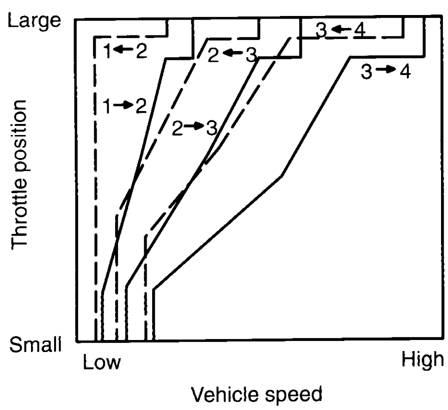
## B: SYSTEM DIAGRAM



## C: SHIFT CONTROL

The TCM performs gear shifting control according to driving conditions by using the shift point characteristic data stored in its memory. Appropriate solenoids are operated at the proper timing corresponding to the shift pattern, throttle position, and vehicle speed for smooth shifting.

NOTE:
When the ATF temperature is below approximately 10°C (50°F), the gear cannot be shifted to the 4th speed.



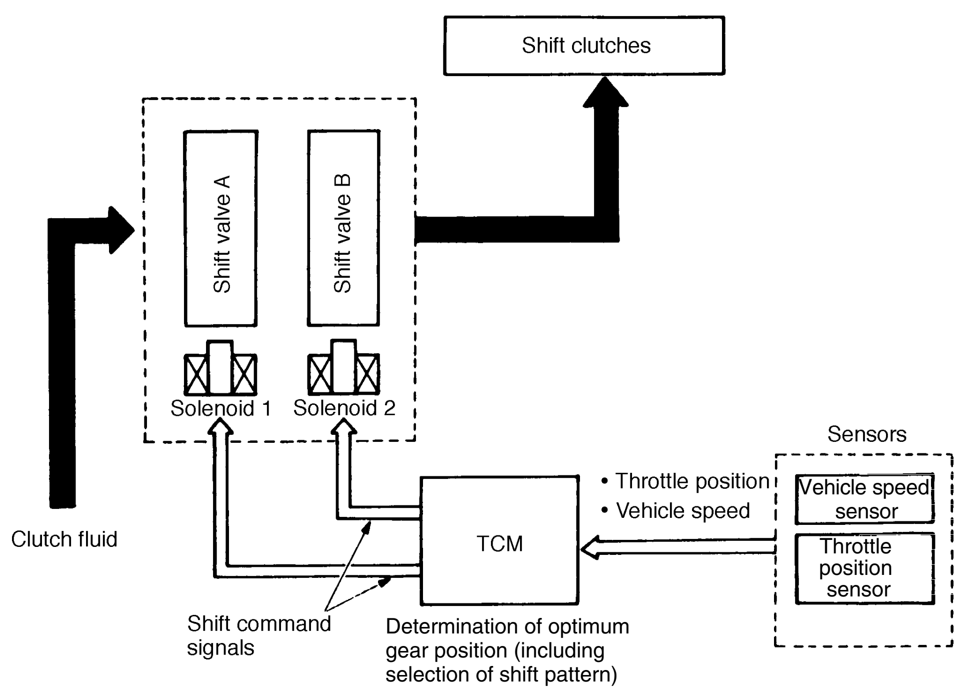

| | Solenoid 1 | Solenoid 2 |
|---|---|---|
| 1st | ON | ON |
| 2nd | OFF | ON |
| 3rd | OFF | OFF |
| 4th | ON | OFF |

G3H0752

● The TCM activates both solenoids 1 and 2 in response to throttle and vehicle speed signals.

● Shift valves move in response to operation of the solenoids, supplying or interrupting the line pressure to each clutch.

● A shift to each gear takes place according to ON-OFF operation of both the solenoids as indicated in the table above.

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## D: LOCK-UP CONTROL

- The TCM has pre-programmed lock-up clutch engagement and disengagement conditions for each gear and shift pattern. In addition, it specifies engagement of the clutch whenever the 4th gear is selected in the D range. The engagement and disengagement conditions are defined in terms of the throttle valve position and vehicle speed.
- The TCM controls the operation of the lock-up clutch by means of the duty solenoid which in turn controls the lock-up control valve as described below:

### 1. NON-LOCK-UP OPERATION

The duty solenoid allows the pilot pressure (supplied from the pilot valve) to be applied to the "disengaging" end of the lock-up control valve spool. The lock-up control valve then opens the clutch disengaging circuit port to allow the lock-up operating pressure (torque converter clutch regular pressure) to build up in the circuit. On the other hand, the valve opens the clutch engaging circuit's port and allows the fluid in the circuit to flow to the ATF cooler, thus lowering the pressure in the circuit. As a result, the lock-up clutch is disengaged due to difference in pressure between both circuits.

This operation is performed for all the speed gears except the 4th gear of the D range.

### 2. LOCK-UP OPERATION

The duty solenoid allows the pilot pressure to be applied to the "engaging" end of the lock-up control valve spool. The lock-up control valve then opens the clutch engaging circuit's port that communicates to the torque converter's impeller chamber, allowing high pressure fluid to flow to the lock-up clutch. The clutch then engages.

- The TCM controls the current to the duty solenoid by gradually changing the duty ratio. As a result, the lock-up control valve also moves gradually, so the clutch engagement pressure increases smoothly. This causes the lock-up clutch to become initially in a half-engaged state and then in a fully engaged state, thus preventing shock during engagement.

This operation is performed for all the speed gears and always when the 4th gear is selected in the D range.

## E: LINE-PRESSURE CONTROL

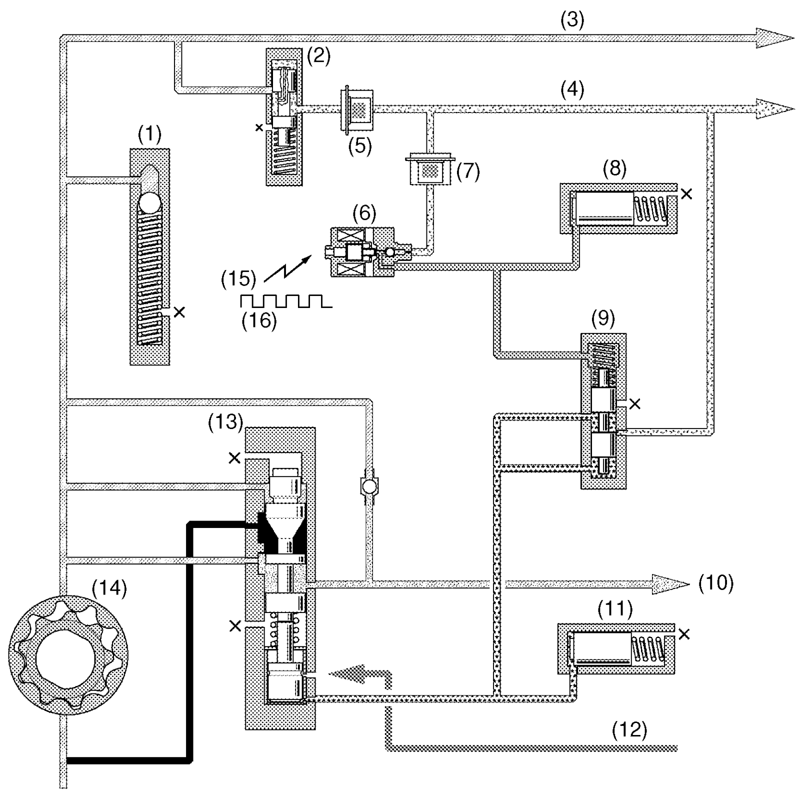
● The oil pump delivery pressure (line pressure) is regulated to a constant pressure by the pilot valve. This pressure is used as the pilot pressure for controlling spool valves.

● The pilot pressure applied to the pressure modifier valve is modulated by the line pressure duty solenoid into the pressure modifier pressure.

● The pressure modifier valve is an auxiliary valve for the pressure regulator valve, and it creates a signal pressure (pressure modifier pressure). The pressure modifier pressure is used to regulate the line pressure to a level optimum for a particular driving condition.

● This pressure modifier pressure is applied to the pressure regulator valve which controls the oil pump delivery pressure.

● The pressure modifier pressure from the pressure modifier valve is cushioned by the pressure modifier accumulator to remove pulsation of the pressure.

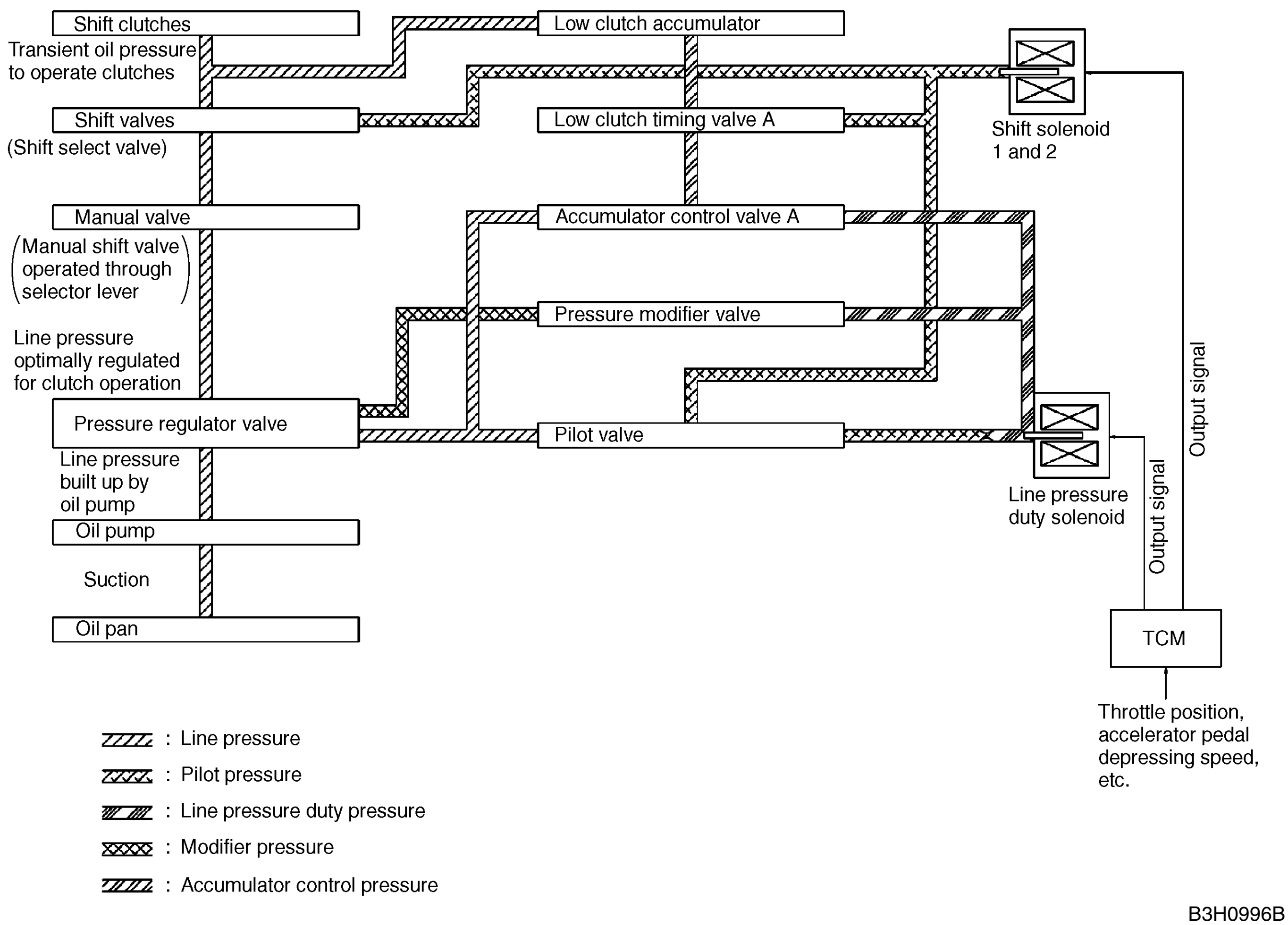



| | | | | | |
|---|---|---|---|---|---|
| (1) | Relief valve | (7) | Filter | (13) | Pressure regulator valve |
| (2) | Pilot valve | (8) | Accumulator | (14) | Oil pump |
| (3) | Line pressure | (9) | Pressure modifier valve | (15) | ON |
| (4) | Pilot pressure | (10) | To ATF cooler circuit | (16) | OFF |
| (5) | Filter | (11) | Accumulator | | |
| (6) | Line pressure duty solenoid | (12) | From R range pressure circuit | | |

## F: LINE-PRESSURE CONTROL DURING SHIFTING

The line pressure which engages shift clutches to create 1st to 4th speeds is controlled by the TCM to meet varying operating conditions.

During gear shifting, the TCM decreases the line pressure to a level that matches the selected gear in order to minimize shifting shock loads.




During gear shifting, the TCM controls the line pressure as follows:

- The TCM receives signals such as throttle position signal and accelerator pedal speed signal. Based on these input signals, it issues a control signal to the line pressure duty solenoid.
- The pressure from the line pressure duty solenoid (line pressure duty pressure) is converted by the pressure modifier valve into a modifier pressure, and the modifier pressure is applied to the pressure regulator valve.
- The pressure regulator valve adjusts the oil-pump-generated line pressure according to the modifier pressure to make the line pressure matched to the driving condition.

## G: SHIFT PATTERN SELECTION CONTROL

### 1. POWER PATTERN CONTROL

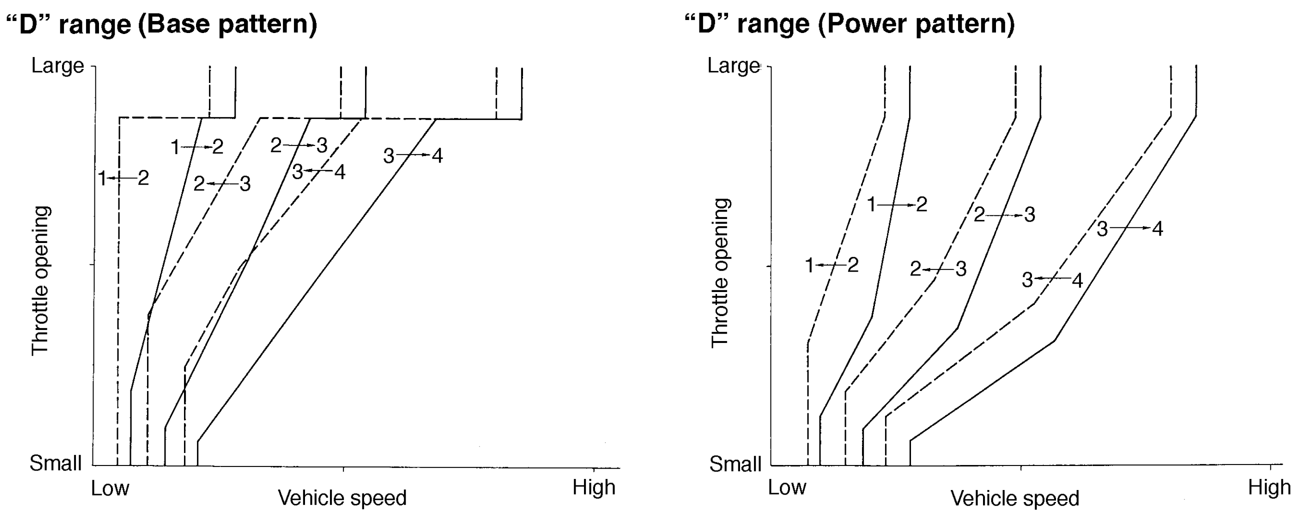
Shift pattern is selectable a base pattern suitable for ordinary economy running and a power pattern suitable for climbing uphill or rapid acceleration.

In the Power pattern, the downshift point and upshift point are set higher than those of the Base pattern.

When the Power pattern is selected, the POWER indicator light in the combination meter lights up.

| Selector lever position | Changeover from Base to Power pattern | Changeover from Power to Base pattern | POWER indicator light |
|---|---|---|---|
| D, 3, and 2 ranges | Occurs when Power switch is ON | Occurs when Power switch is OFF | • Base pattern: OFF<br>• Power pattern: ON |

The Power pattern selection is possible in the D, 3 or 2 range and only when the hold switch is in the OFF position because the hold pattern control takes precedence over the Power pattern control.

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### 2. HOLD PATTERN CONTROL

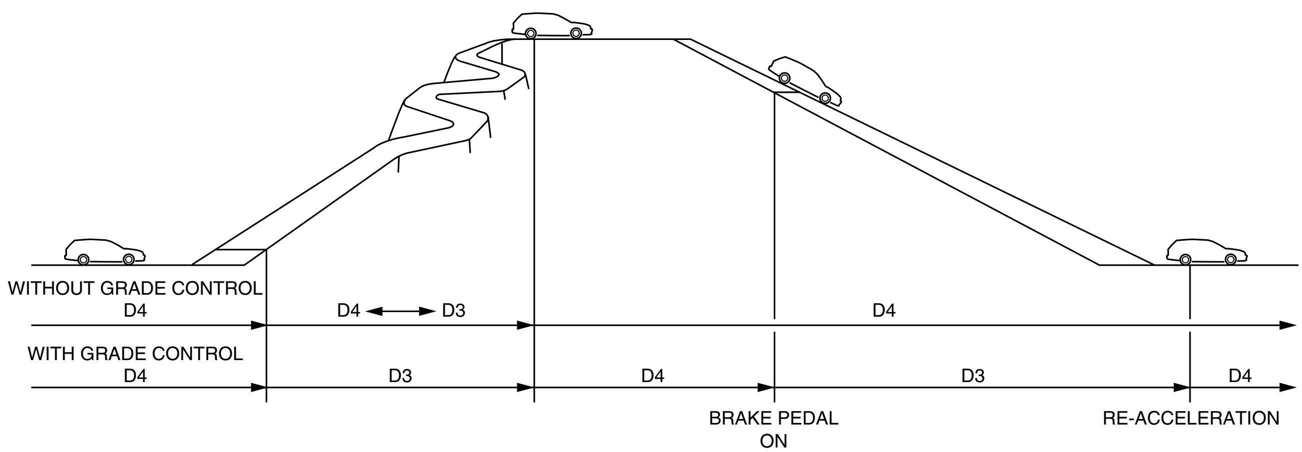
The hold pattern control enables maintaining the transmission in the selected gear (in the 2, 3, and D ranges) or lower when going up or down steep slopes, running on sand, mad or slippery surfaces.

When the hold pattern is selected, the HOLD indicator light in the combination meter lights up.

| Selector position (hold switch ON) | Shift pattern |
|---|---|
| D range | 2nd ⇔ 3rd ⇔ 4th |
| 3 range | 2nd ⇔ 3rd ⇔ 4th |
| 2 range | 2nd ⇔ 3rd ⇔ 4th |

## H: GRADE CONTROL

While the vehicle is driving up a hill, the gear is fixed to the 3rd to avoid repeated gear shift between the 3rd and 4th gears.
When the vehicle is descending a steep slope at a speed of approximately 80 km/hour (50 miles/hour), a 4th to 3rd downshift occurs automatically when the brake pedal is depressed.
This gearshift control is cancelled when the accelerator pedal is depressed.
The TCM performs these controls based mainly on the throttle opening, engine speed and vehicle speed.

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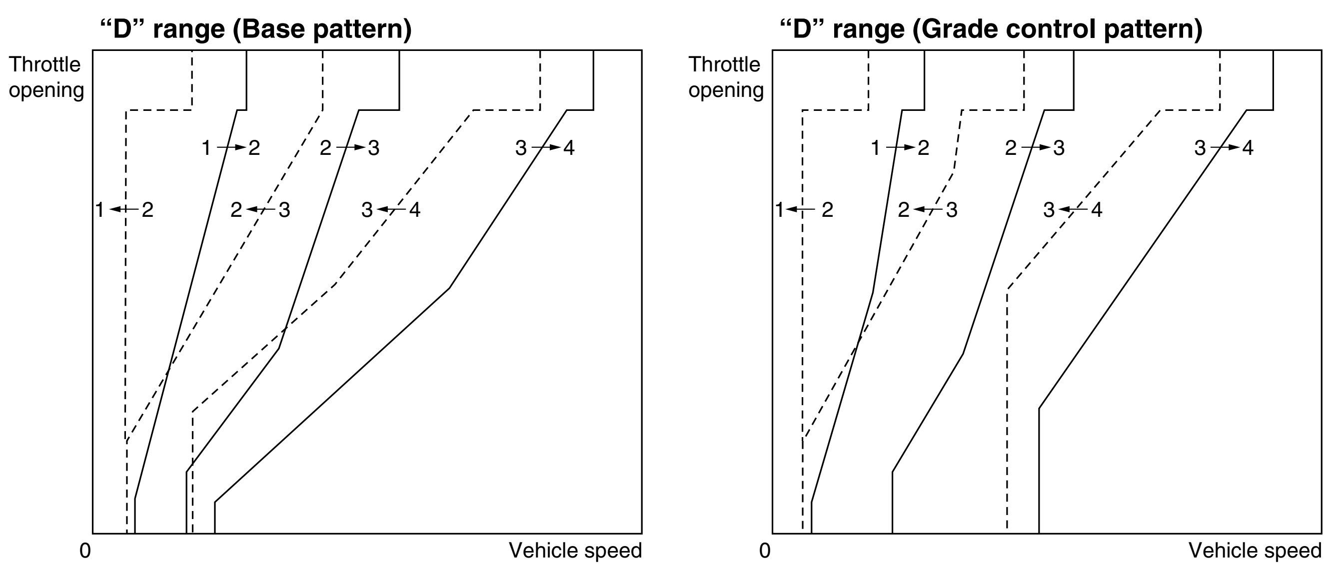


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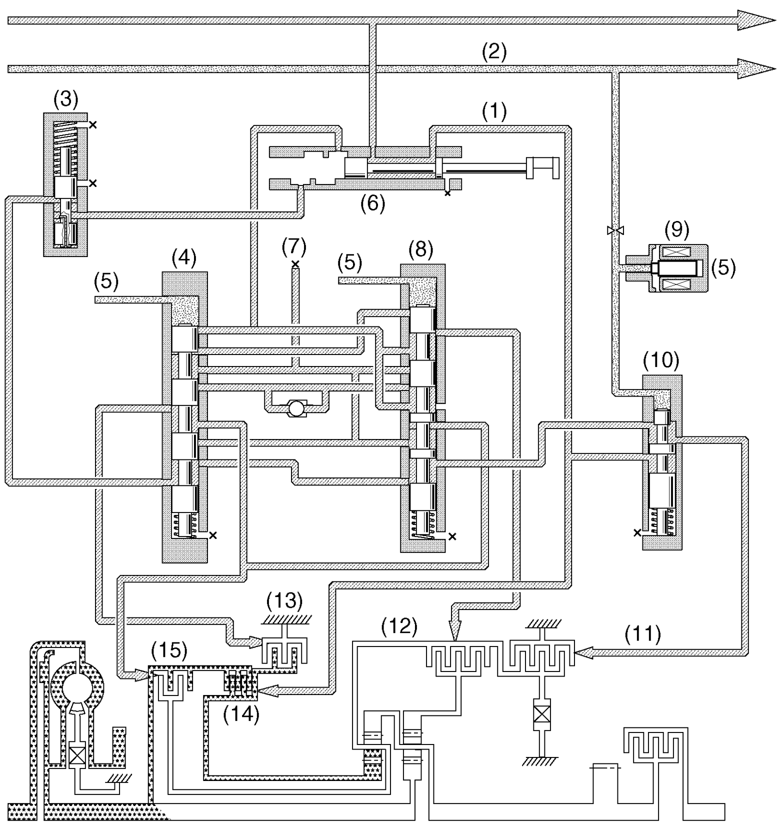
## I: LEARNING CONTROL

The TCM has a learning control function with which it can adapt gear shift timing optimally to the current vehicle conditions by updating correction factors in the memory.
For this reason, gear shift shock may become larger after the power supply is interrupted (disconnection of battery, flat battery, etc.) or immediately after the ATF is replaced.
Larger gear shift shock after power supply interruption occurs because the correction data is reset to those for the new vehicle condition.
The TCM starts learning function again as soon as the power supply is restored. After driving for a while, therefore, the transmission will become able to make gear shifts at the optimum timing.
Larger shift shock immediately after ATF change is caused by change in friction characteristics of the transmission internal parts. Also in this case, the transmission recovers shockless gear shifting after driving for a while.

## J: REVERSE INHIBITION CONTROL

This control prevents the transmission from shifting into the reverse gear when the select lever is accidentally placed in the R position, thus protecting the components such as reverse clutch from being damaged.

If the selector lever is moved to the R position during driving at a speed faster than the predetermined speed, the low clutch timing solenoid is energized. Then, the pilot pressure is supplied to the reverse inhibitor valve. This causes the reverse inhibitor valve to move downward, closing the low & reverse brake port.
In this condition, the low & reverse brake does not engage since the ATF flowing from the manual valve is blocked by the reverse inhibitor valve.
As a result, the transmission is put into the neutral state, and the shifting into the reverse gear is inhibited.

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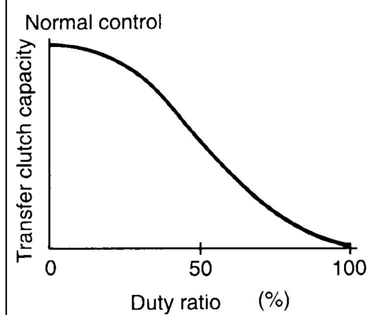
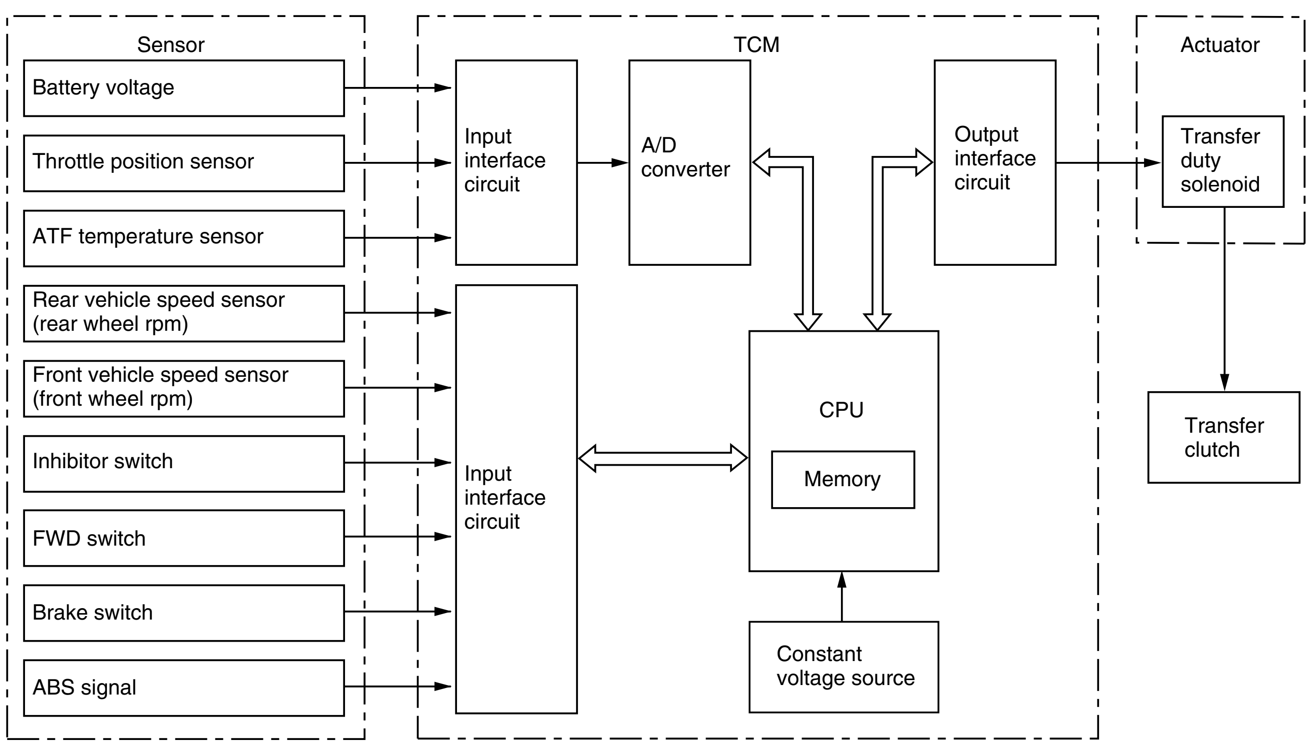
| | | | | | |
|---|---|---|---|---|---|
| (1) | Line pressure | (6) | Manual valve (P range) | (11) | Low & reverse brake (Release) |
| (2) | Pilot pressure | (7) | Drain | (12) | Low clutch |
| (3) | 1st reducing valve | (8) | Shift valve B | (13) | 2-4 brake |
| (4) | Shift valve A | (9) | Low clutch timing solenoid | (14) | Reverse clutch |
| (5) | ON | (10) | Reverse inhibitor valve | (15) | High clutch |

# K: AWD TRANSFER CLUTCH CONTROL (MPT MODELS)

| Control item | | Type of control | Gear position | Remarks |
|---|---|---|---|---|
| 1 | Basic control | Regulates transfer clutch pressure in response to throttle position and vehicle speed. | 1st thru 4th and reverse |  B3H0314 |
| 2 | 1 range control | Increases transfer clutch pressure above basic control pressure | 1st | – |
| 3 | Slip control | Increases transfer clutch pressure to the same level as in the 1 range immediately after a slip is detected. | 1st thru 4th and reverse | Release:<br>When running faster than the set vehicle speed with fully closed throttle |
| 4 | Turning control | Decreases transfer clutch pressure upon detection of a turn. | 1st thru 4th and reverse | – |
| 5 | ABS control | Regulates to the specified transfer clutch pressure quickly when the ABS signal is input. | 1st thru 4th and reverse | – |
| 6 | P and N range control | Regulates to the specified transfer clutch pressure quickly when shifted to the P or N range. | P and N | – |

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## L: AWD CENTER DIFFERENTIAL CONTROL (VTD MODELS)

### 1. CONTROL DESCRIPTION

The TCM controls the engagement of the center differential's multi-plate clutch (LSD) using maps that are pre-programmed based on the throttle opening and engine speed. It selects a map according to driving conditions and use it as the control basis.

### 2. ORDINARY CONTROL

The torque input to the multi-plate clutch is calculated according to various factors such as intake manifold pressure, torque converter turbine speed and selected speed gear. Based on the calculation result, the basic coupling force of the clutch is determined.

The basic coupling force thus obtained is then corrected according to the road slipperiness (which is determined based on steering angle, yaw rate, lateral G signals from the VDC control module) and the feedback correction factor which is used for making the actual yaw rate agree with the yaw-rate estimated from the steering angle sensor signals.

### 3. START CONTROL

When the vehicle speed is 0 km/h (0 MPH), the TCM makes control to generate differential action limiting torque that is proportional to the throttle angle.

This enables the vehicle to start smoothly without swerving even on a slippery road.

### 4. TURNING CONTROL

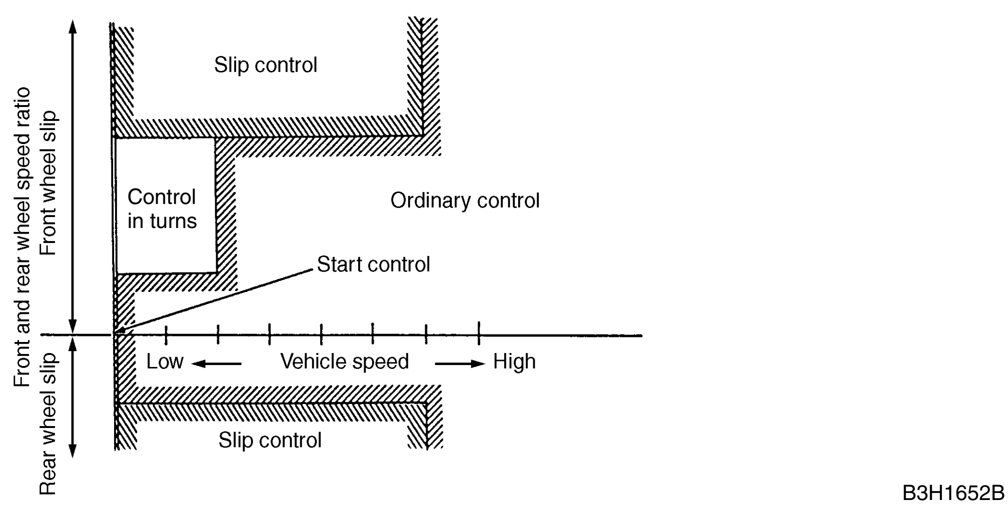
The TCM makes a correction such that the input torque to the multi-plate clutch is reduced as the steering angle increases.

This function is performed to improves turning performance at certain vehicle speed range.

### 5. SLIP CONTROL

When front or rear wheels start slipping with the vehicle running slower than the predetermined speed, the TCM makes control to increase the differential action limiting torque.

This function maintains traction and improves driving stability.



## 6. ABS CONTROL

When the TCM receives an ABS operation signal from the ABS unit, it adjusts the differential action limiting torque to the predetermined level and selects the 3rd gear in which the one-way clutch is freewheeling.

This function improves ABS control.

## 7. BASE BRAKE CONTROL

When the brake switch is ON and the throttle valve is fully closed, the TCM makes control to decrease the differential action limiting torque. The ABS control has priority over this control.

This function improves stability during braking.

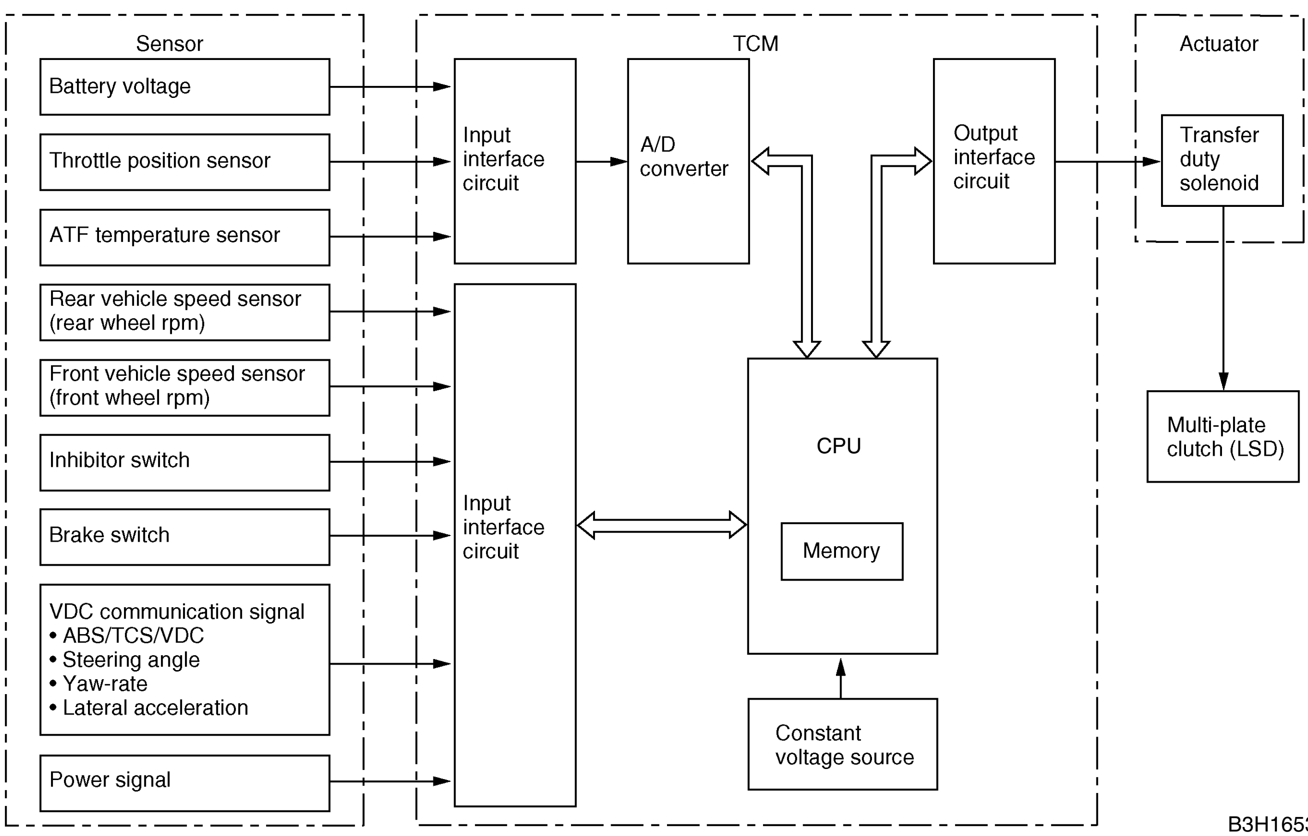
## 8. 1 RANGE CONTROL

When the 1 range is selected, the TCM makes control to increase the differential action limiting torque.

This function improves driving performance and traction.

## 9. CONTROL SYSTEM

The TCM is constantly monitoring the driving conditions of the vehicle using the eleven input signals. Based on the conditions it has determined, the TCM adjusts the duty ratio of current to the transfer duty solenoid thus changing the engagement of the multi-plate clutch. The input signals are used also for automatic transmission control.



## M: TRANSFER CONTROL

### 1. MPT MODELS

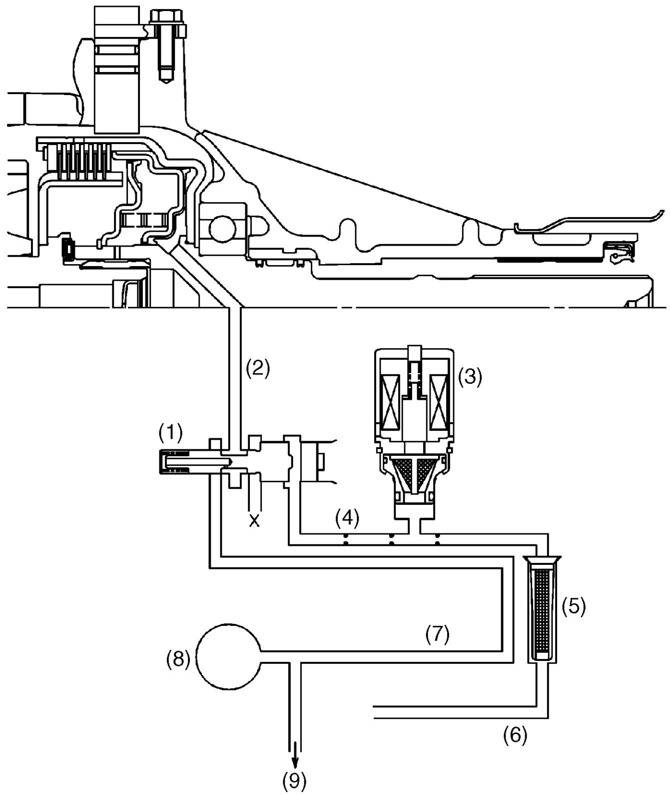
The transfer hydraulic pressure control unit includes a valve body attached to the side of the extension case through a gasket and separator plate.

The pressurized fluids for the transfer hydraulic pressure control (line pressure and pilot pressure) are supplied from the oil pump by way of the passages formed in the transmission case and then the passages in the extension case that lead to the hydraulic circuit in the transfer valve body.

The line pressure is regulated by the transfer control valve whose opening is controlled by the transfer pressure created by the transfer duty solenoid.

- The transfer duty solenoid is controlled by the TCM. The TCM changes the solenoid controlling duty ratio according to the driving conditions.
- The transfer duty solenoid creates the transfer pressure from the pilot pressure. The transfer pressure is applied to the transfer control valve and adjusts the valve's opening.
- The line pressure directly led to the transfer control valve, on the other hand, is regulated by the transfer control valve and becomes the transfer clutch pressure.
- The transfer clutch pressure is applied to the transfer clutch and engages the clutch to a controlled degree.

In this way, the degree of transfer clutch engagement is varied so that optimum torque is distributed to the rear wheels according to vehicle driving conditions.




| | | | | | |
|---|---|---|---|---|---|
| (1) | Transfer control valve | (4) | Transfer pressure | (7) | Line pressure |
| (2) | Transfer clutch pressure | (5) | Filter | (8) | Oil pump |
| (3) | Transfer duty solenoid | (6) | Pilot pressure | (9) | Control valve |

## 2. VTD MODELS

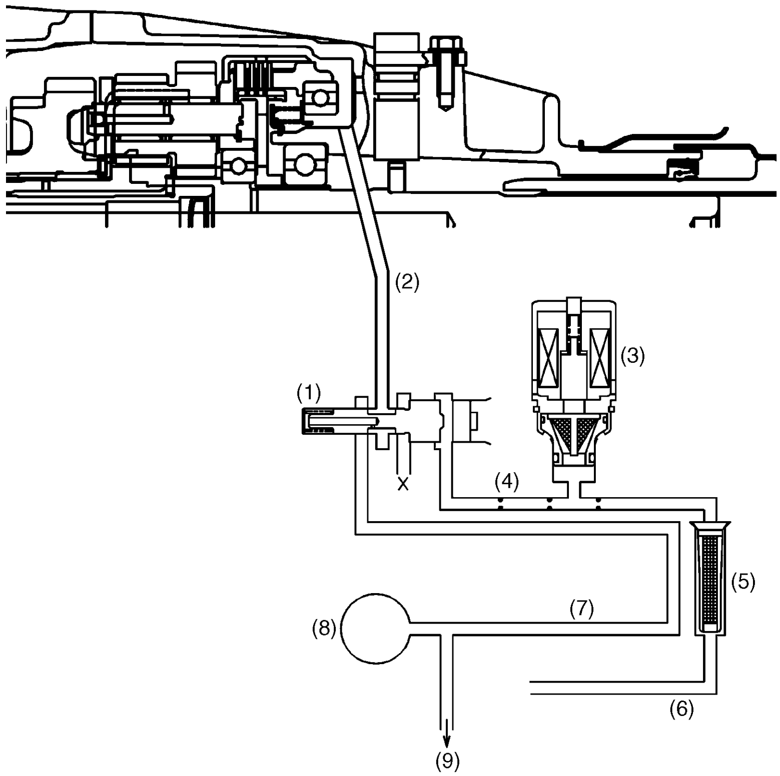
The drive power distribution system includes a valve body attached to the side of the extension case through a gasket and separator plate.

The pressurized fluids for the drive power distribution system (line pressure and pilot pressure) are supplied from the oil pump by way of the passages formed in the transmission case and then the passages in the extension case that lead to the hydraulic circuit in the transfer valve body.

The line pressure is regulated by the transfer control valve whose opening is controlled by the transfer pressure created by the transfer duty solenoid.

- The pilot pressure created by passing through the pilot valve in the transmission's hydraulic control assembly is further regulated into the transfer pressure by the transfer duty solenoid.
- The transfer duty solenoid is controlled by the TCM. The TCM changes the solenoid controlling duty ratio according to driving conditions.
- The transfer pressure thus created is applied to the transfer control valve and adjusts the valve's opening.
- The line pressure directly led to the transfer control valve, on the other hand, is regulated by the transfer control valve and becomes the transfer clutch pressure.
- The transfer clutch pressure is applied to the multi-plate clutch (LSD) and engages the clutch to a controlled degree.

In this way, the degree of multi-plate clutch engagement is varied so that optimum torque is distributed to the rear wheels.




| | | | | | |
|---|---|---|---|---|---|
| (1) | Transfer control valve | (4) | Transfer pressure | (7) | Line pressure |
| (2) | Transfer clutch pressure | (5) | Filter | (8) | Oil pump |
| (3) | Transfer duty solenoid | (6) | Pilot pressure | (9) | Control valve |

# 4. On-board Diagnostics System

## A: FUNCTION

The on-board diagnostics system detects and stores in the form of a code a fault that has occurred in any of the following input and output signal systems.

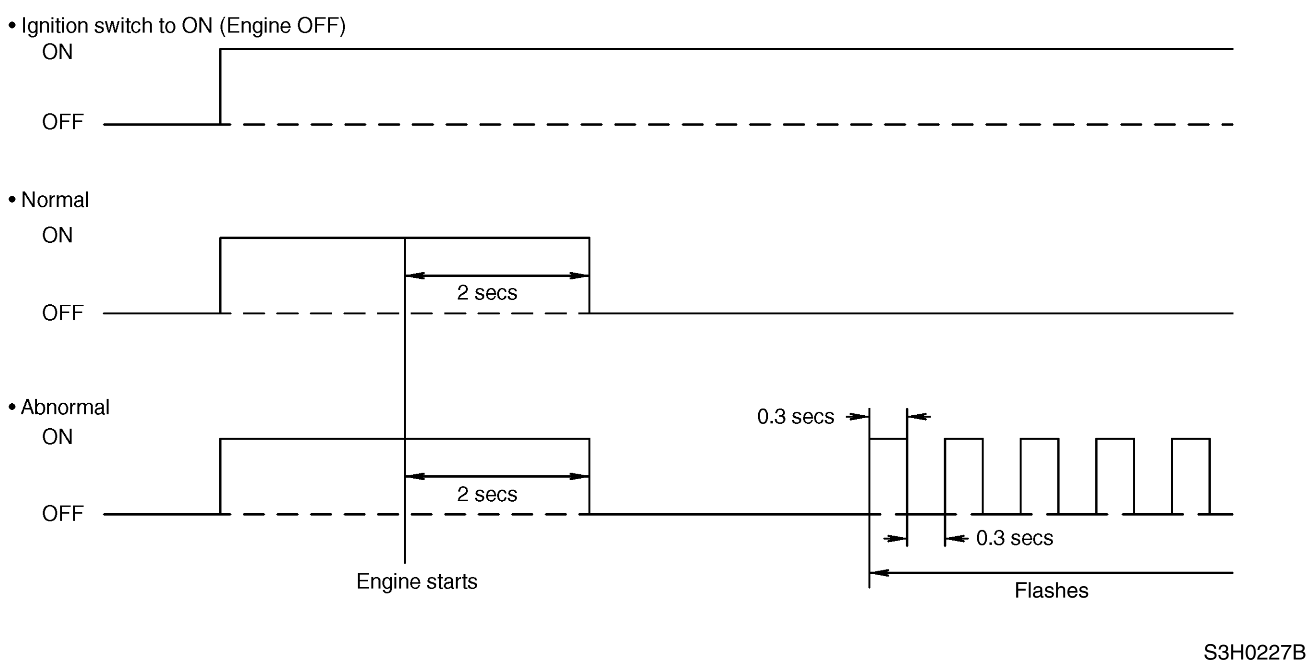
| | | |
|---|---|---|
| Rear vehicle speed sensor | Transfer duty solenoid | Low clutch timing solenoid |
| Front vehicle speed sensor | ATF temperature sensor | Torque converter turbine speed sensor |
| Throttle position sensor | Engine speed signal circuit | – |
| Shift solenoid 1 | Line pressure duty solenoid | – |
| Shift solenoid 2 | AT load signal circuit | – |
| 2-4 brake timing solenoid | Torque control signal circuit | – |
| Lock-up duty solenoid | 2-4 brake duty solenoid | – |

If a fault has been detected, the system tells the fault by causing the POWER indicator light to operate as follows:

- Repeated flashing at 4 Hz frequency ...Errors such as battery trouble
- Repeated flashing at 2 Hz frequency ...No faults in the system
- Flashing at different intervals and frequencies ...Diagnostic trouble codes of corresponding faults
- Continued illumination of light ...Fault in inhibitor switch, idle switch, or wiring

## B: OPERATION OF POWER INDICATOR LIGHT

On starting the engine, the POWER indicator light illuminates and then goes out as shown in the “Normal” diagram below.
If any problem exists, the light continues flashing as shown in the “Abnormal” diagram below.



## C: DIAGNOSTIC TROUBLE CODE

| Code | Faulty component |
|---|---|
| 11 | Engine speed signal circuit |
| 27 | ATF temperature sensor |
| 31 | Throttle position sensor |
| 33 | Front vehicle speed sensor |
| 36 | Torque converter turbine speed sensor |
| 38 | Torque control signal circuit |
| 45 | Intake manifold pressure signal circuit |
| 71 | Shift solenoid 1 |
| 72 | Shift solenoid 2 |
| 73 | Low clutch timing solenoid |
| 74 | 2-4 brake timing solenoid |
| 75 | Line pressure duty solenoid |
| 76 | 2-4 brake duty solenoid |
| 77 | Lock-up duty solenoid |
| 79 | Transfer duty solenoid |
| 86 | VDC communication signal |
| 93 | Rear vehicle speed sensor |

## D: SELECT MONITOR

Various sensor and switch data as well as diagnostic trouble codes for faults that are currently present and occurred in the past can be monitored by connecting the select monitor to the select monitor terminal located under the instrument panel.

# 5. Fail-safe Function

The fail-safe control function ensures minimum level of driveability even if a fault should occur in the vehicle speed sensors, throttle position sensor, inhibitor switch, or any of the solenoids.

- FRONT AND REAR VEHICLE SPEED SENSORS

A dual speed-sensing system is used. The speed signal is taken from the transmission (by the output shaft speed sensor). Even if one sensor system fails, the vehicle can be controlled normally with the other normally operating sensor system.

If both the front and rear vehicle speed sensors become faulty, the vehicle is made to operate only in the 1st and 3rd speeds.

- THROTTLE POSITION SENSOR

If the throttle position sensor becomes faulty, the throttle opening is fixed at the predetermined angle.

- INHIBITOR SWITCH

If the TCM receives different signals simultaneously from a faulty inhibitor switch, it selects a range in the following priority:

D > N (P) > R > 3 > 2 > 1 >

- SHIFT SOLENOID 1 AND 2

If a fault occurs in either of solenoids 1 and 2, both the solenoids are de-energized, and the gear is held in the 3rd.

If both the solenoids should fail, the TCM invariably selects and keeps the 3rd gear.

- LINE PRESSURE DUTY SOLENOID

If the line pressure duty solenoid fails, the solenoid is de-energized and the line pressure is raised to the maximum to enable the vehicle to operate.

In this condition, the usable gears are limited to the 1st and 3rd.

- LOCK-UP DUTY SOLENOID

If the lock-up duty solenoid fails, the solenoid is de-energized and the lock-up clutch is disengaged.

- TRANSFER DUTY SOLENOID

When the transfer duty solenoid becomes faulty, it is de-energized. This causes maximum oil pressure to be applied to the transfer clutch so that the power is always transmitted to the rear axle (direct-coupled AWD condition).

- 2-4 BRAKE DUTY SOLENOID

If a fault occurs in the 2-4 brake duty solenoid, the solenoid is de-energized and the usable gears are limited to the 1st and 3rd.

- LOW-CLUTCH TIMING SOLENOID

If a fault occurs in the low clutch timing solenoid, the solenoid is de-energized and the usable gears are limited to the 1st and 3rd.

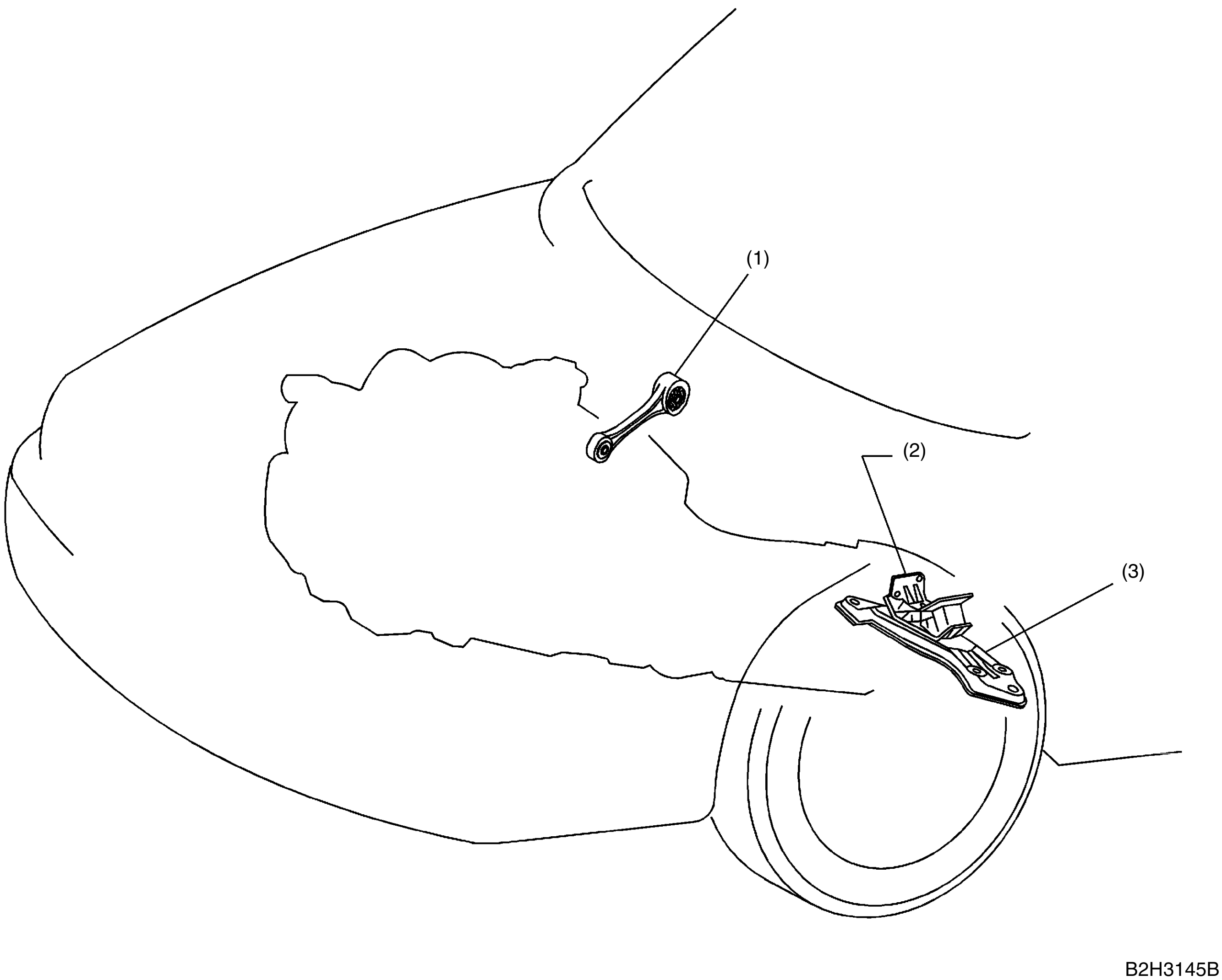
- 2-4 BRAKE TIMING SOLENOID

If a fault occurs in the 2-4 brake timing solenoid, the solenoid is de-energized and the usable gears are limited to the 1st and 3rd.

- TORQUE CONVERTOR TURBINE SPEED SENSOR

If a fault occurs in the torque converter turbine speed sensor, the usable gears are limited to the 1st and 3rd.

# 6. Transmission Mounting




(1) Pitching stopper
(2) Cushion rubber
(3) Cross member

# MANUAL TRANSMISSION AND DIFFERENTIAL

# MT

**Page**

# 1. General

## A: SINGLE-RANGE MODEL

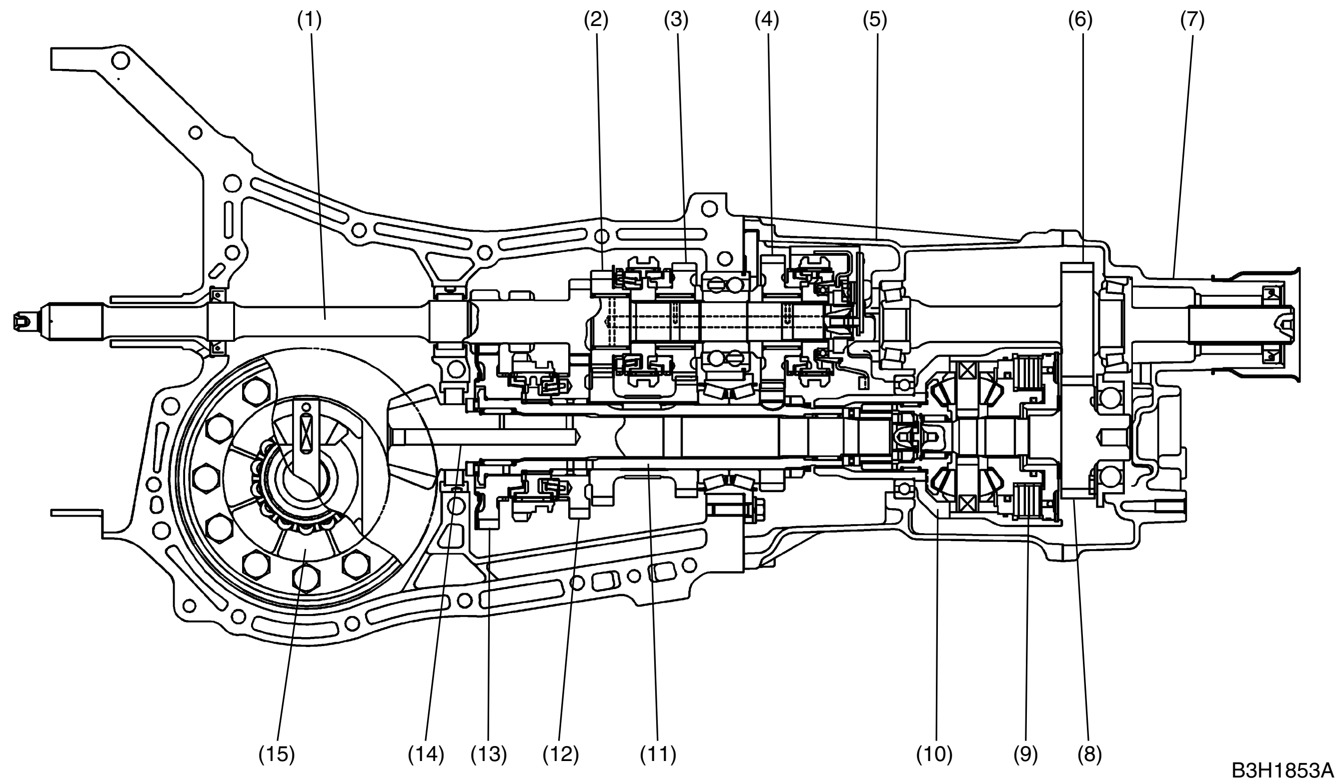
The single-range manual transmission is of a full-time all-wheel-drive design integrating a transmission assembly, front differential, and transfer gear assembly with center differential into a single unit. The transmission creates five forward speeds and one reverse using the corresponding gears all provided with inertia lock-key type synchronizers.

The transmission and front differential are housed in an aluminum case which is split into right and left halves and constitutes also a clutch housing. Located at the rear and joined each other are the transfer case and extension case which house the transfer gears and center differential as well as part of the transmission assembly.

The major features of the transmission are as follows:

- The forward speed gears are helical gears featuring high tooth face strength, large tooth contact areas, and quiet operation.
- Reversing rotation is achieved by making a slidable reverse idler gear engage with both the reverse drive gear on the mainshaft and the reverse driven gear integral with the 1st-2nd synchronizer hub on the drive pinion shaft.

The center differential compensates for the difference in front and rear axle speeds. It consists of a bevel gear set and a viscous coupling located at its rear end which are housed in a single case. The center differential, together with a pair of transfer gears, transmits the power from the transmission to the drive pinion shaft (front wheel drive shaft) and the rear drive shaft. The viscous coupling functions as a differential-action-control element.




(1) Mainshaft
(2) 3rd drive gear
(3) 4th drive gear
(4) 5th drive gear
(5) Transfer case
(6) Transfer driven gear
(7) Extension case
(8) Transfer drive gear
(9) Viscous coupling
(10) Center differential assembly
(11) Driven shaft (countershaft)
(12) 2nd driven gear
(13) 1st driven gear
(14) Drive pinion shaft
(15) Front differential assembly

## B: DUAL-RANGE MODEL

The dual-range manual transmission is of a full-time all-wheel-drive design integrating a transmission assembly, front differential, and transfer gear assembly with center differential into a single unit. The transmission creates five forward speeds and one reverse using the corresponding gears all provided with inertia lock-key type synchronizers.

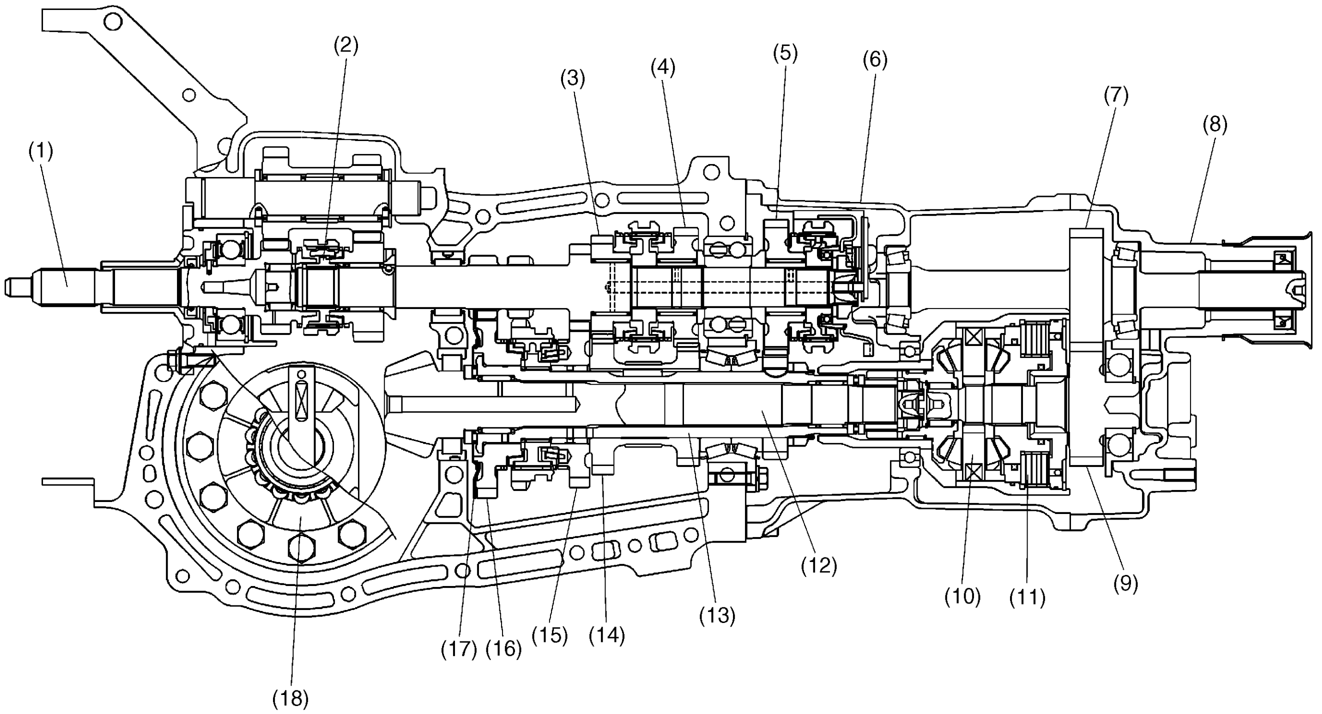
The transmission and front differential are housed in an aluminum case which is split into right and left halves and constitutes also a clutch housing. Located at the rear and joined each other are the transfer case and extension case which house the transfer gears and center differential as well as part of the transmission assembly.

The major features of the transmission are as follows:

- The forward speed gears are helical gears featuring high tooth face strength, large tooth contact areas, and quiet operation.
- Reversing rotation is achieved by making a slidable reverse idler gear engage with both the reverse drive gear on the mainshaft and the reverse driven gear integral with the 1st-2nd synchronizer hub on the drive pinion shaft.
- The 1st driven gear on the drive pinion shaft has a subgear which helps reduce noise during engagement.

The center differential compensates for the difference in front and rear axle speeds. It consists of a bevel gear set and a viscous coupling located at its rear end which are housed in a single case. The center differential, together with a pair of transfer gears, transmits the power from the transmission to the drive pinion shaft (front wheel drive shaft) and the rear drive shaft. The viscous coupling functions as a differential-action-control element.

On the part just above the front differential of the input shaft, there are auxiliary transmission gears of synchromesh design. They provides a dual-range function that allows the driver to select “high” or “low” range as desired. Switching of the range is possible even during driving if the clutch pedal is depressed and then the range selector lever is moved.




| | | | | | |
|---|---|---|---|---|---|
| (1) | Input shaft | (7) | Transfer driven gear | (13) | Driven shaft (countershaft) |
| (2) | Auxiliary transmission gears | (8) | Extension case | (14) | 3rd driven gear |
| (3) | 3rd drive gear | (9) | Transfer drive gear | (15) | 2nd driven gear |
| (4) | 4th drive gear | (10) | Center differential assembly | (16) | 1st driven gear |
| (5) | 5th drive gear | (11) | Viscous coupling | (17) | 1st driven sub-gear |
| (6) | Transfer case | (12) | Drive pinion shaft | (18) | Front differential assembly |

## 2. Auxiliary Transmission Gears

The auxiliary transmission gear mechanism consists of the input high gear (integral part of the input shaft), input low gear, counter gear and Hi-Lo coupling sleeve.

- High range

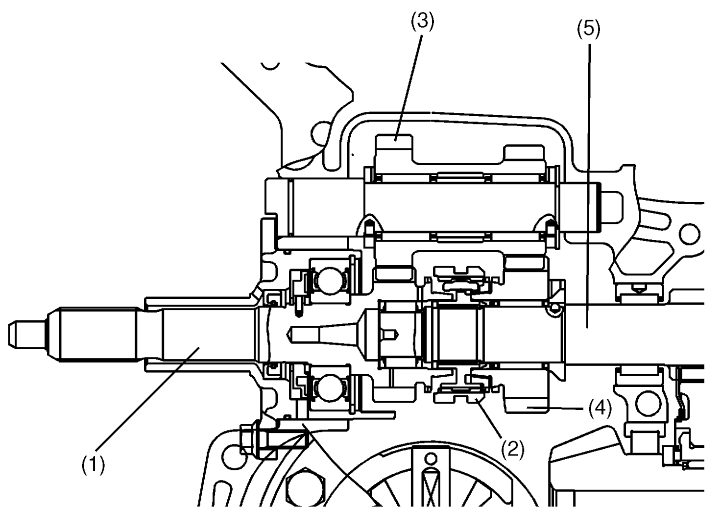
The splines of the Hi-Lo coupling sleeve are in mesh with the splines of the input high gear. The input high gear and the main shaft are directly connected and rotate at the same speed.

The power flow in this range is as follows: input shaft → input high gear → Hi-Lo coupling sleeve → Hi-Lo synchronizer hub → main shaft.

- Low range

The splines on the Hi-Lo coupling sleeve are in mesh with the splines of the input low gear. The input low gear and the main shaft rotate as a unit.

The power flow in this range is as follows: input shaft → counter gear → input low gear → Hi-Lo coupling sleeve and hub → main shaft.




(1) Input shaft (with integrally formed input high gear)
(2) Hi-Lo coupling sleeve
(3) Counter gear
(4) Input low gear
(5) Main shaft

**MEMO**

# 3. Reverse Check Mechanism

Located in the transfer case, the reverse check mechanism prevents a direct 5th-to-reverse shift by using a selector arm and cam combination which allows the gear to be shifted into the reverse only after it has been returned once into the neutral.

## A: CONSTRUCTION

The construction of the reverse check mechanism is as shown in the drawing on the opposing page.

The reverse check sleeve is bolted to the transfer case and houses the mechanism's main components.

The reverse accent shaft is slidable inside the reverse check sleeve and its smaller-diameter end is fitted with the reverse check cam. The cam is rotatable and axially movable on the shaft but its leftward movement is restricted by a step formed on the sleeve's inner wall.

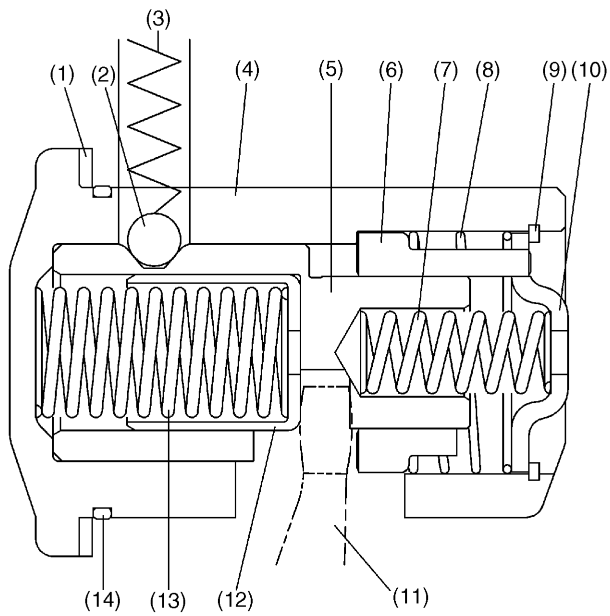
The reverse accent shaft has hollows in both ends. In the left end hollow are the 1st return spring and its cap and in the right end hollow is the reverse return spring which pushes the shaft leftward.

Around the check cam is the reverse check spring whose left end applies simultaneous leftward and rotational forces to the cam.

Both the reverse check spring and reverse return spring are retained at their right ends by the reverse check plate which is held in place by the snap ring.

The reverse accent shaft has a V-groove in which the detent ball is pressed by the reverse accent spring fitted through the hole in the reverse check sleeve.

The reverse check sleeve and reverse accent shaft have a slot and a notch at their bottoms, respectively, and the selector arm is inserted in the notch through the slot.

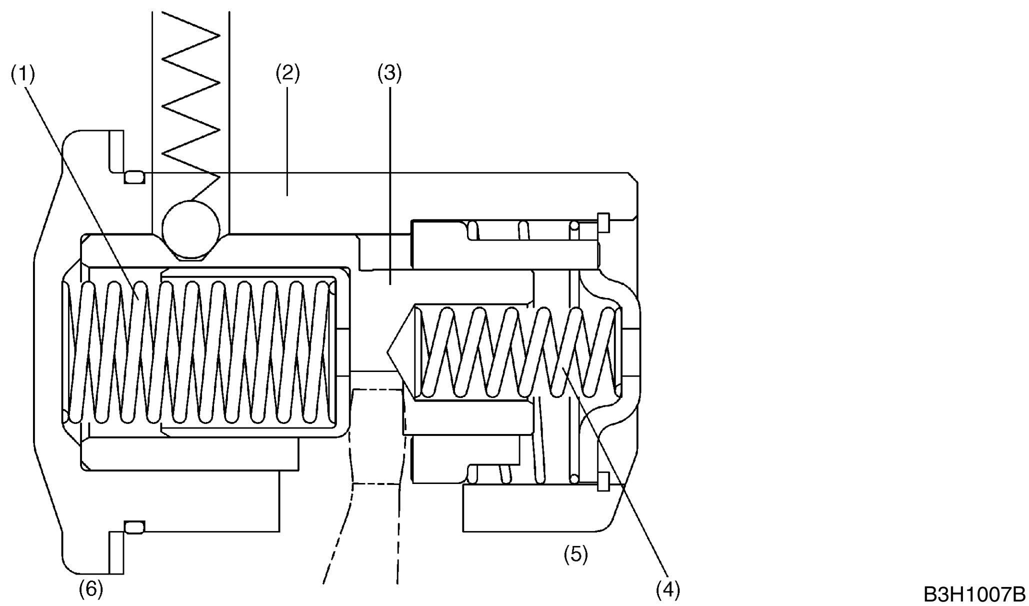



| | | | | | |
|---|---|---|---|---|---|
| (1) | Select adjust shim | (6) | Reverse check cam | (11) | Selector arm |
| (2) | Detent ball | (7) | Reverse return spring | (12) | Spring cap |
| (3) | Reverse accent spring | (8) | Reverse check spring | (13) | 1st return spring |
| (4) | Reverse check sleeve | (9) | Snap ring | (14) | O-ring |
| (5) | Reverse accent shaft | (10) | Reverse check plate | | |

## B: OPERATION

The drawing below shows the state of the reverse check mechanism when the selector arm is in the neutral position. The 1st and 2nd gears will be selected if the selector arm is moved leftward from this point to a stop and then turned in either way. A rightward movement of the arm to a stop will enable selection of the 5th and reverse gears. In the neutral position, the selector arm receives a rightward force (force toward the 5th and reverse gear side) from the 1st return spring and a leftward force (force toward the 1st and 2nd gear side) from the reverse return spring to stay in that position.

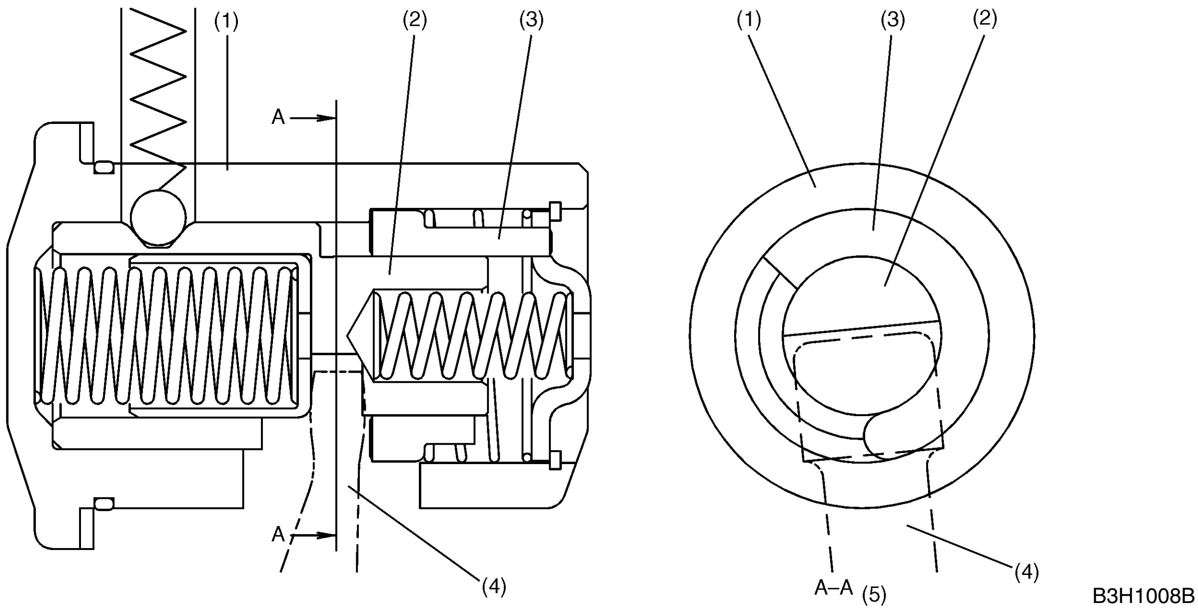
The following explanation describes how the selector arm and reverse check mechanism operate when the driver selects the 5th gear and then selects the reverse gear.




| | | | | | |
|---|---|---|---|---|---|
| (1) | 1st return spring | (3) | Reverse accent shaft | (5) | 5th and reverse gear side |
| (2) | Reverse check sleeve | (4) | Reverse return spring | (6) | 1st and 2nd gear side |

## 1. WHEN SELECTOR ARM IS MOVED TOWARD 5TH AND REVERSE GEAR SIDE

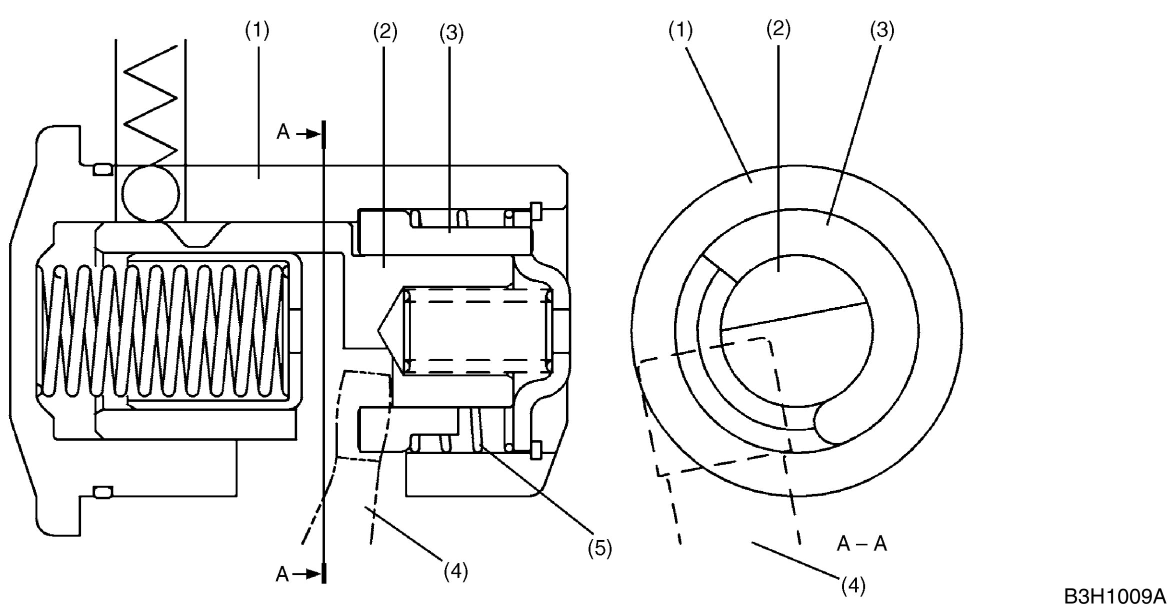
The selector arm moves rightward while pushing both the reverse accent shaft and reverse check cam simultaneously.




| | | |
|---|---|---|
| (1) Reverse check sleeve | (3) Reverse check cam | (5) Neutral position |
| (2) Reverse accent shaft | (4) Selector arm | |

## 2. WHEN SHIFT IS MADE TO 5TH GEAR

The selector arm is turned toward the 5th gear selection direction. When the arm clears the edge of the reverse check cam as it turns, the cam becomes free of the selector arm's pressure and returns to its original position by the force of the reverse check spring.

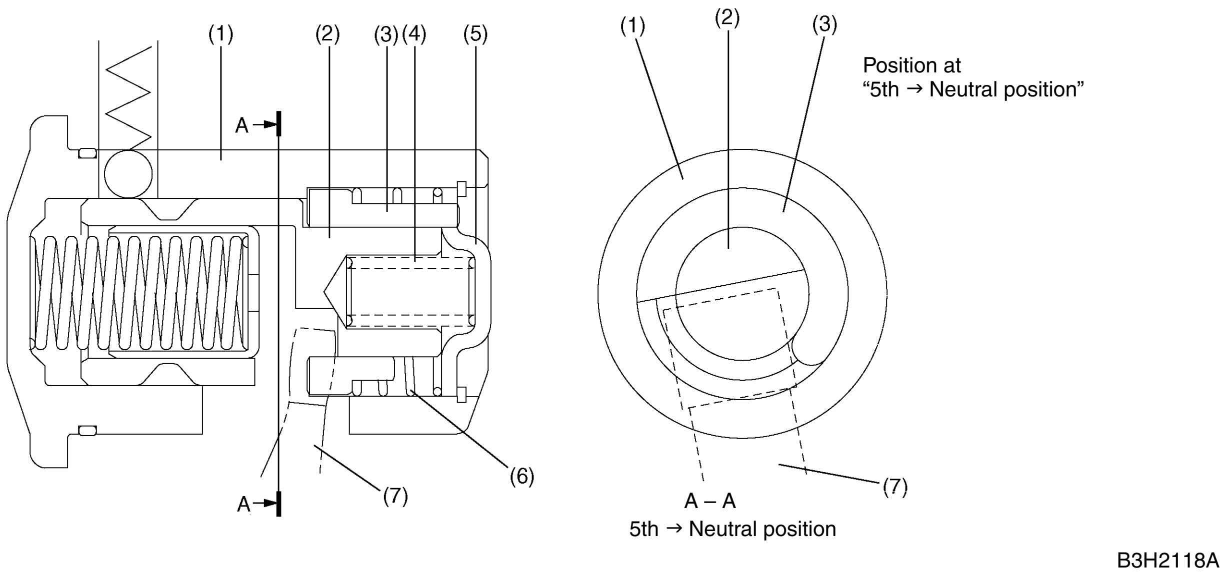



| | | |
|---|---|---|
| (1) Reverse check sleeve | (3) Reverse check cam | (5) Reverse check spring |
| (2) Reverse accent shaft | (4) Selector arm | |

## 3. WHEN A SHIFT FROM 5TH TO REVERSE IS ATTEMPTED

The selector arm turns toward the reverse gear while pushing the reverse accent shaft rightward and the reverse check cam counterclockwise (as viewed in the direction of arrows A).

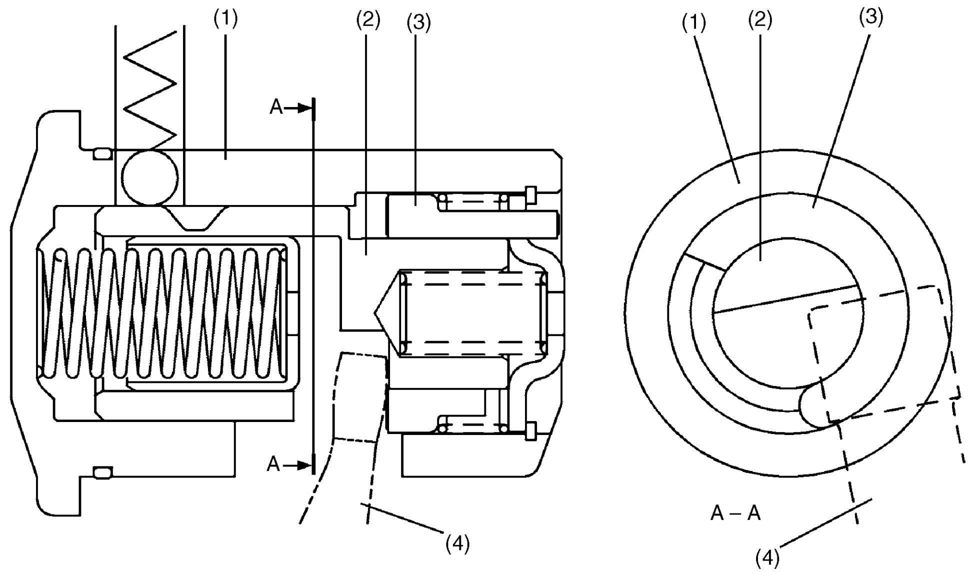
The reverse check cam, however, stops to rotate at a point where its stopper hits against the reverse check plate (this point corresponds to the neutral position in terms of the angle) and prevents the selector arm from moving toward the reverse gear selection direction. The selector arm is then axially pushed to the neutral position by the reverse accent shaft which is given a leftward force by the reverse return spring.




(1) Reverse check sleeve
(2) Reverse accent shaft
(3) Reverse check cam
(4) Reverse return spring
(5) Reverse check plate
(6) Snap ring
(7) Selector arm

## 4. WHEN A SHIFT TO REVERSE IS MADE AFTER RETURN OF SELECTOR ARM TO NEUTRAL

As the ends of the reverse accent shaft and the reverse check cam are on the same plane, the selector arm now can turn toward the reverse gear selection direction after pushing leftward both the shaft and cam simultaneously.




| | |
|---|---|
| (1) Reverse check sleeve | (3) Reverse check cam |
| (2) Reverse accent shaft | (4) Selector arm |

# 4. Center Differential

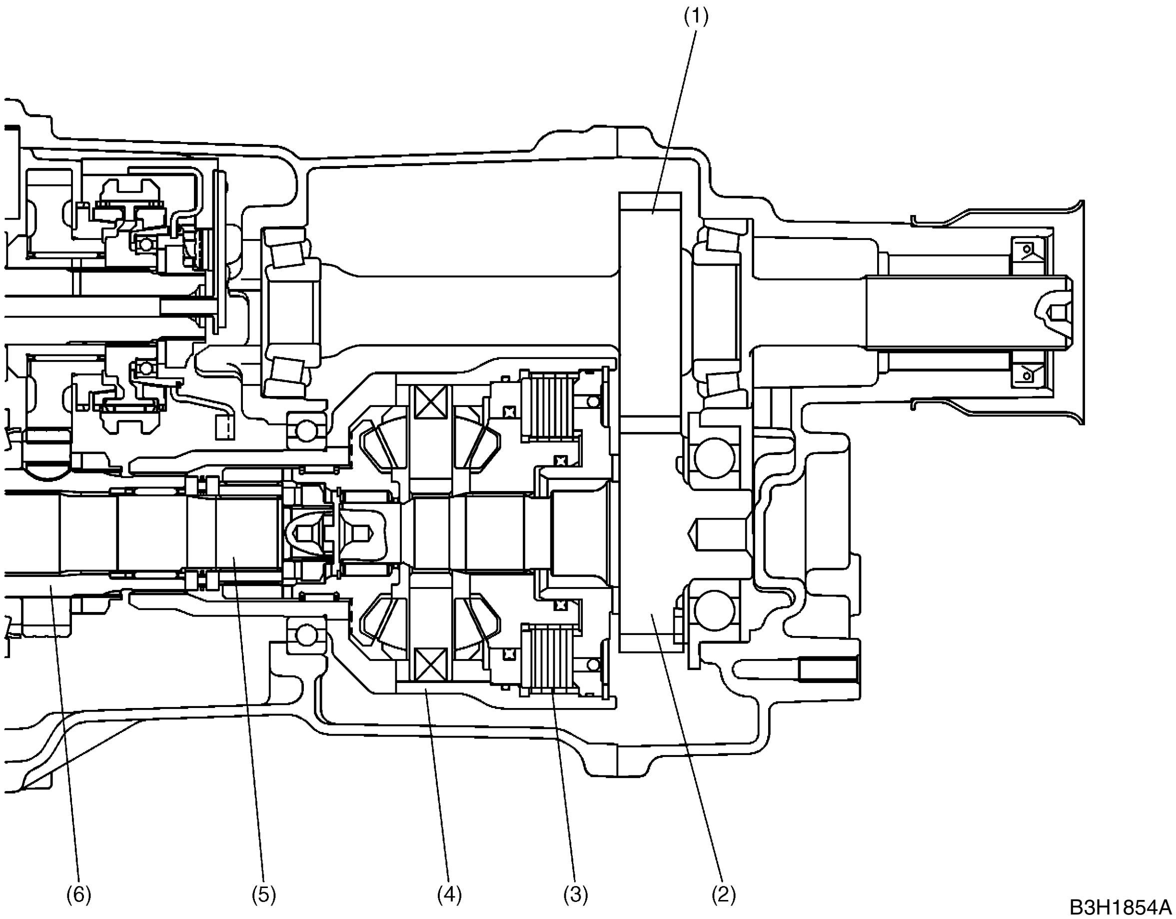
## A: CONSTRUCTION

The center differential consists of a set of bevel gears and a viscous coupling.

The center differential has the following two functions: distributing the engine torque to the front and rear wheel drive shafts and absorbing the difference in rotating speed between the front and rear wheels.

The engine torque enters the center differential case from the transmission's driven shaft. The torque is then distributed through the bevel gear set directly to the drive pinion shaft and via the transfer drive and driven gears to the rear drive shaft.

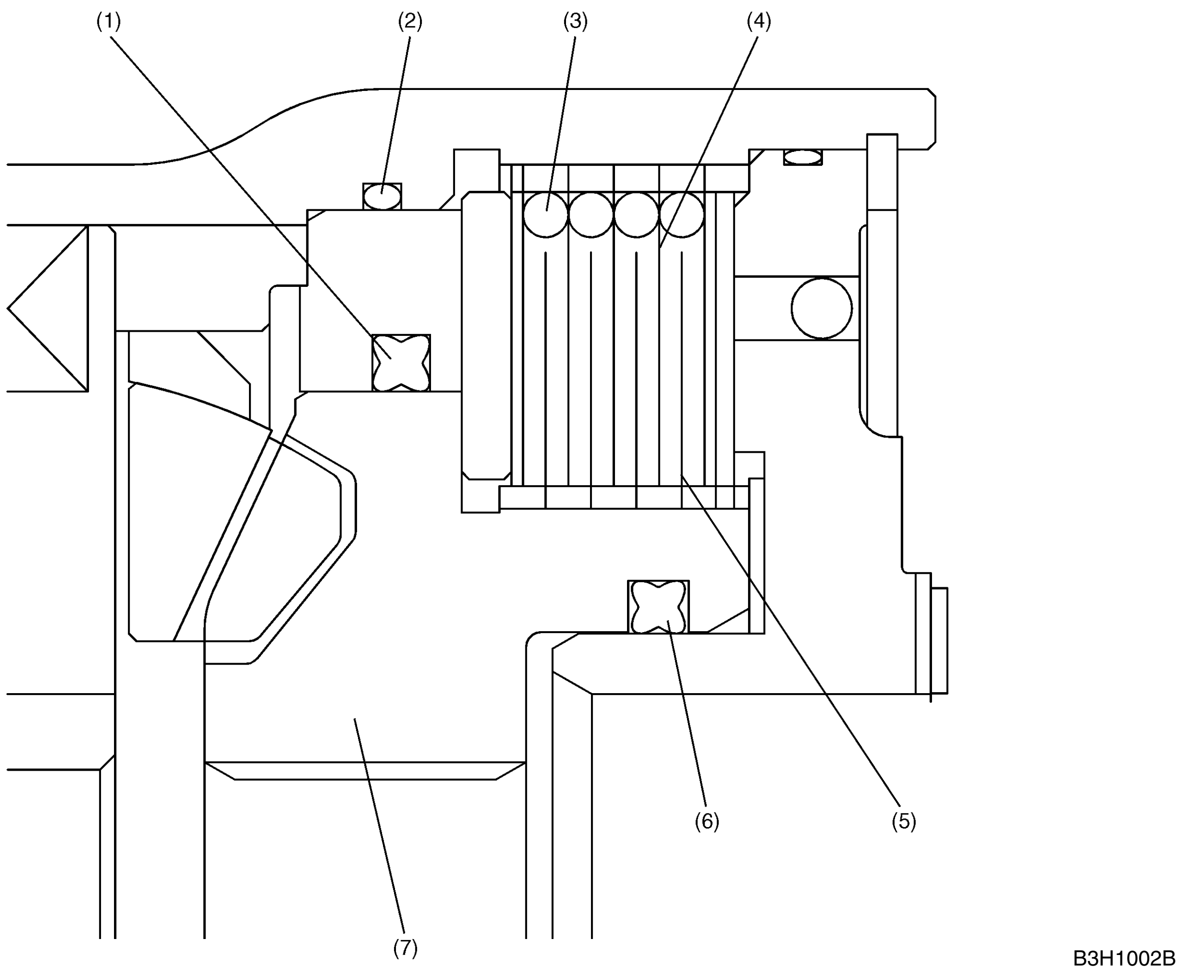
The viscous coupling limits the bevel gear set's differential action when either front or rear wheels spin so that adequate torques are transmitted to the front and rear wheels and proper traction is obtained.




(1) Transfer driven gear
(2) Transfer drive gear
(3) Viscous coupling
(4) Center differential with viscous coupling
(5) Drive pinion shaft
(6) Driven shaft

## B: MECHANISM OF VISCOUS COUPLING

The viscous coupling consists of a number of alternately arranged inner and outer plates and air-and-silicone oil mixture filled into a sealed space that is formed by the center differential case and the rear side gear of the differential gear set. The inner plates have their inner perimeters splined to the side gear and the outer plates have their outer perimeters splined to the center differential case. The outer plates are held apart by spacer rings. There are no spacer rings between the inner rings, so the inner rings are movable slightly in axial directions. X-section rings are used to prevent leakage of silicone oil which would otherwise occur if the oil is pressurized due to large difference in front and rear axle speeds.

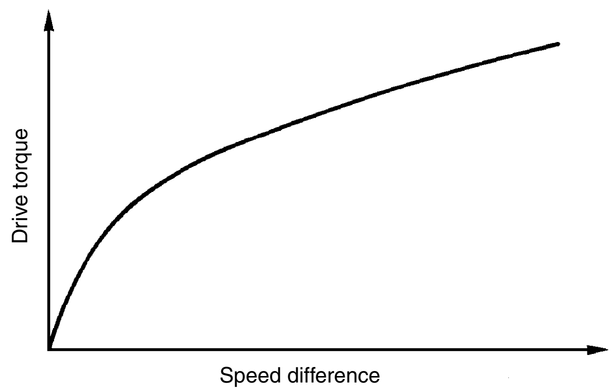



(1) X-section ring
(2) O-ring
(3) Spacer ring
(4) Outer plate
(5) Inner plate
(6) X-section ring
(7) Side gear (rear)

## 1. TORQUE CHARACTERISTICS

When a speed difference occurs between the center differential case and the rear side gear, a shear force is generated in the silicone oil placed between the outer and inner plates. The torque is then transmitted by the silicone oil between the center differential case and the rear side gear.

The greater the speed difference, the greater the shear force generated in the silicone oil. The relationship between the torque transmission and the speed difference is shown in the figure below. As can be seen from the figure, the smaller the speed difference, the smaller the torque transmission and the differential action.

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## 2. HUMP PHENOMENON

Silicone oil is heated and expanded as differential action continues. This causes the pressure of air inside the viscous coupling to increase and the pressure of oil between plates to decrease. As a result, the inner and outer plates are pushed together. This direct plate-to-plate contact causes a non-viscous operation to occur, and this phenomenon is called “hump”.

The hump eliminates the rotating speed difference between the center differential case and the rear side gear (or locks the differential), so soon after it has occurred, the internal pressure and temperature drop. The viscous coupling then returns to the normal shear torque transmitting operation. (The hump phenomenon does not occur under normal operating conditions.)

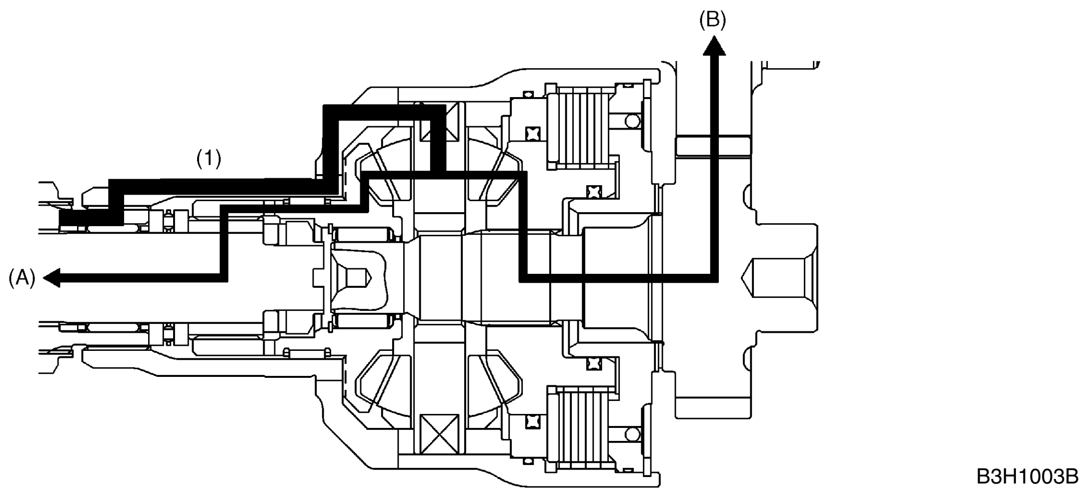
## C: FUNCTION

When there is no speed difference between the front and rear wheels, the center differential delivers the engine torque to the front and rear wheels at a ratio of 50:50.

When a rotating speed difference occurs between the front and rear wheels, the center differential operates to absorb it in a controlled way by the function of the viscous coupling.

### 1. DURING NORMAL DRIVING

During straight-line driving on a flat road at a constant speed, all the four wheels rotate at the same speed. The center differential delivers engine torque evenly to the front and rear drive axles. The viscous coupling does not generate shear torque because there is no relative movements between the inner and outer plates.

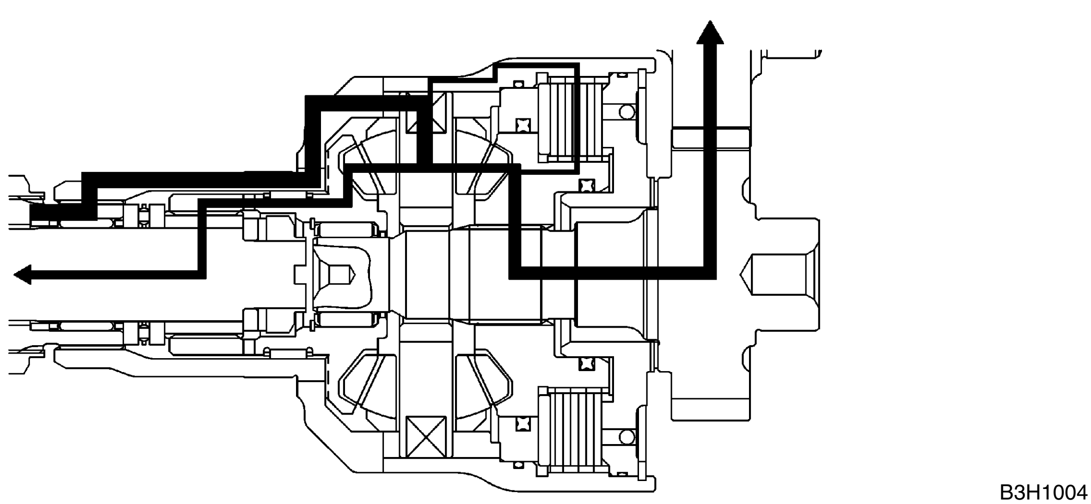



(1) Engine torque (A) To front differential (B) To rear differential

### 2. DURING TURNS AT LOW SPEEDS

During turns at low speeds, rotating speed difference occurs between the front and rear wheels, as well as between the left and right wheels. More particularly, the front wheels rotate faster than the rear wheels. The center differential then acts to absorb the speed difference to enable smooth driving.

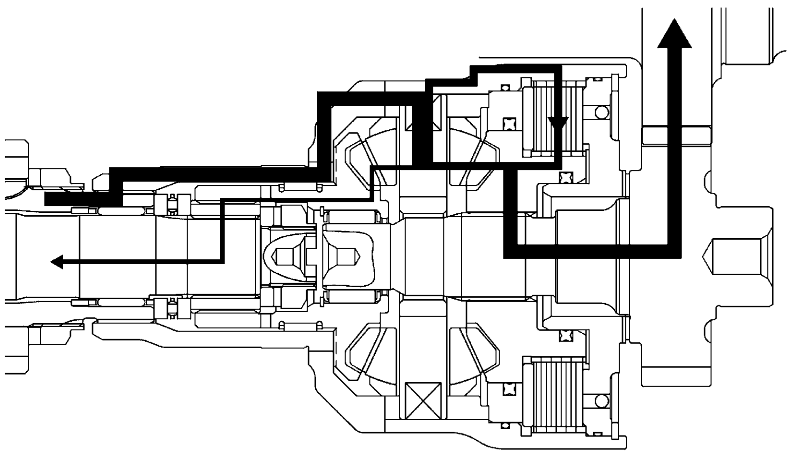
Although the speed difference is small under this condition, operation of the viscous coupling causes more torque to be transmitted to the rear than to the front.



## 3. DRIVING ON ROUGH OR SLIPPERY ROADS

● When front wheels are on a slippery surface

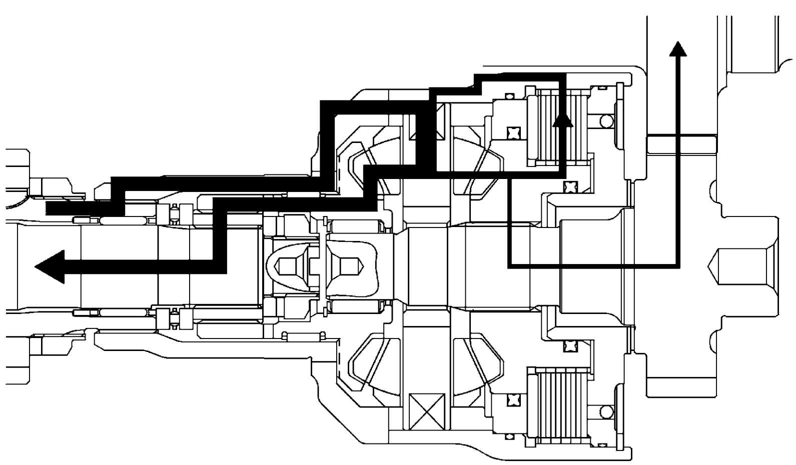
When the front wheels begin to spin, the resulting speed difference between the front and rear drive shafts causes the viscous coupling to generate significant amount of shear torque. As a result, the torque distributed to the rear wheels becomes much larger than that distributed to the spinning front wheels. The traction and driving stability are thus ensured on a rough or slippery road.



B3H1006

● When rear wheels are on a slippery surface

When the vehicle is accelerated quickly from a standing start with the rear wheels on a slippery surface, the distribution of the vehicle weight on the front and rear wheels changes and the rear wheels start spinning. Due to the resulting speed difference between the front and rear drive shafts, the viscous coupling generates a significant amount of shear torque, now in the direction opposite to that generated when the front wheels are on a slippery surface. As a result, the torque distributed to the front wheels becomes much larger than that distributed to the rear wheels.



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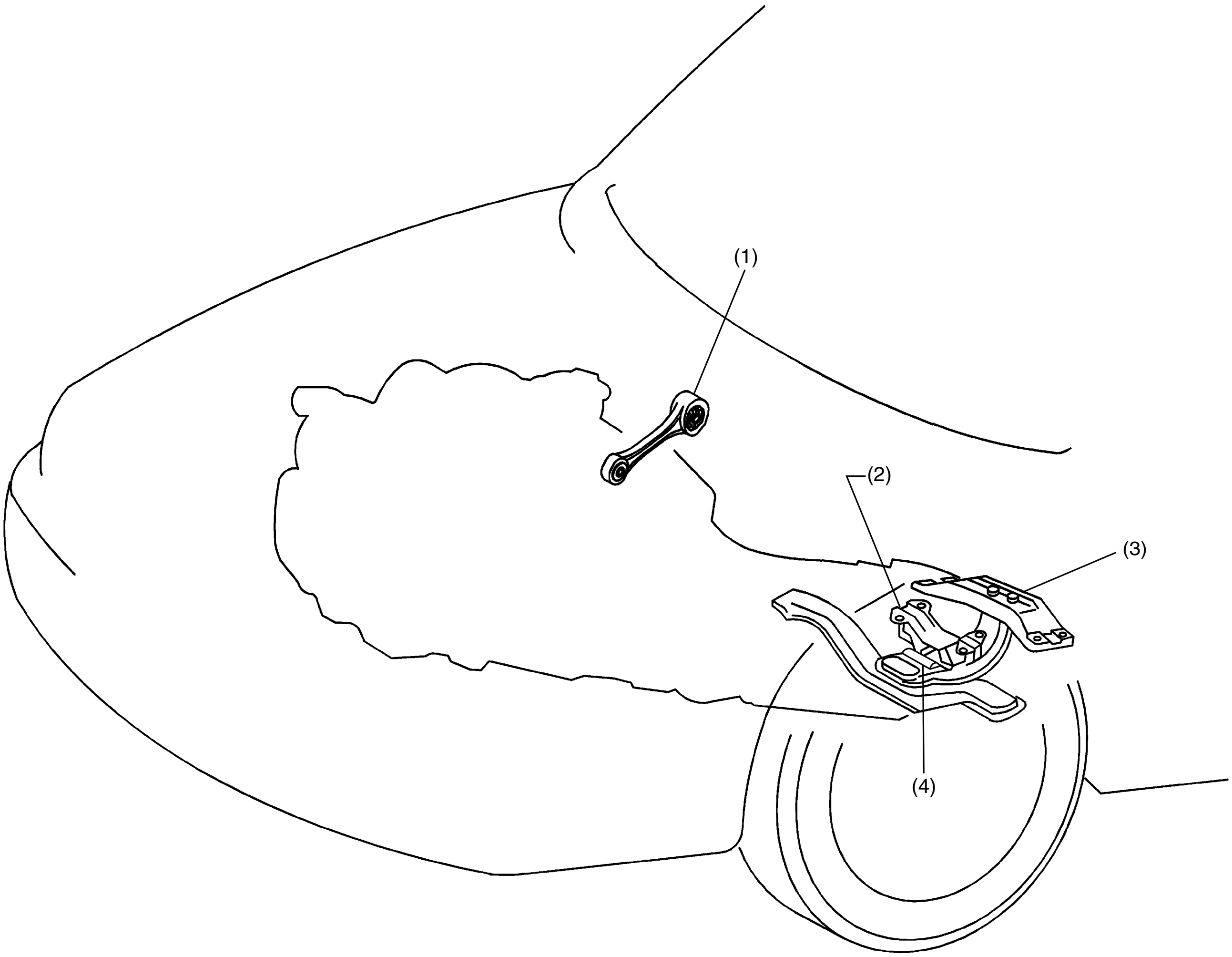
# 5. Transmission Mounting




| | |
|---|---|
| (1) Pitching stopper | (3) Cross member |
| (2) Cushion rubber | (4) Dynamic damper |

## MEMO

# CLUTCH CL

**Page**

# 1. Clutch

## A: OUTLINE

- All the models use a hydraulic clutch control system which is appropriate for increased load to the clutch.
- The hydraulic control system includes a master cylinder which generates a hydraulic pressure as the clutch pedal is depressed and a slave cylinder which receives the hydraulic pressure and activates the clutch release fork to disengage the clutch.
- The clutch mechanism is of a diaphragm spring design which is advantageous in that wear of the clutch disc facing causes only small variation in the push load of the pressure plate.

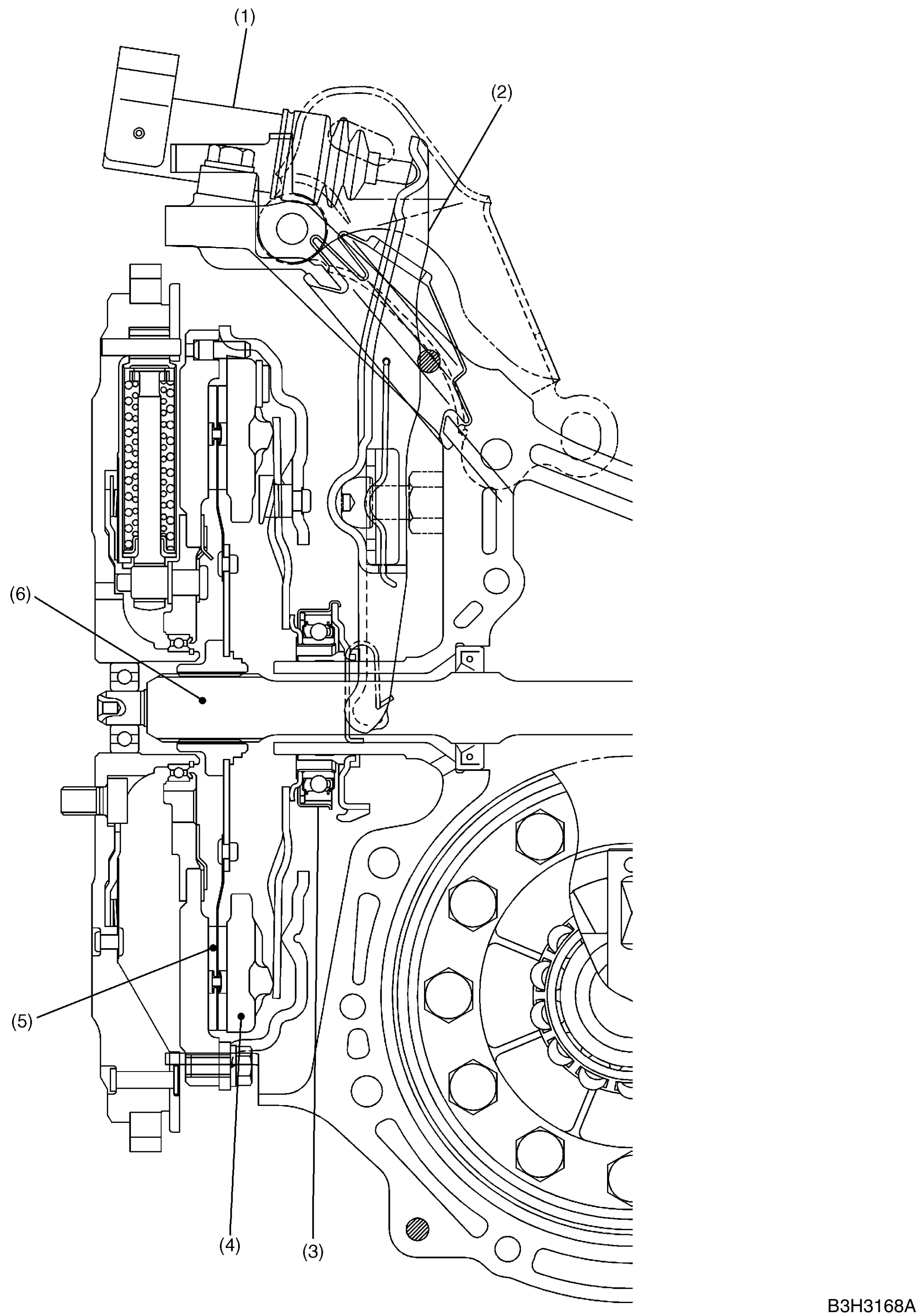
## B: OPERATION

Applying foot pressure to the clutch pedal moves the release lever. This causes the release bearing to slide on the guide, pressing the center of the diaphragm spring. The spring is warped and the force having pressed the pressure plate is lost. As a result, the flywheel, clutch disc and pressure plate are disengaged, disconnecting the driving power.

The push type clutch has the point of action at the tips of the diaphragm spring fingers, through which the pressure plate is pressed to the clutch disc. When the power transmission is to be interrupted, the diaphragm spring is forced to warp using the pivots established on the inward side of the spring finger tips (on the principle of the lever and fulcrum) to disengage the pressure plate from the clutch disc.

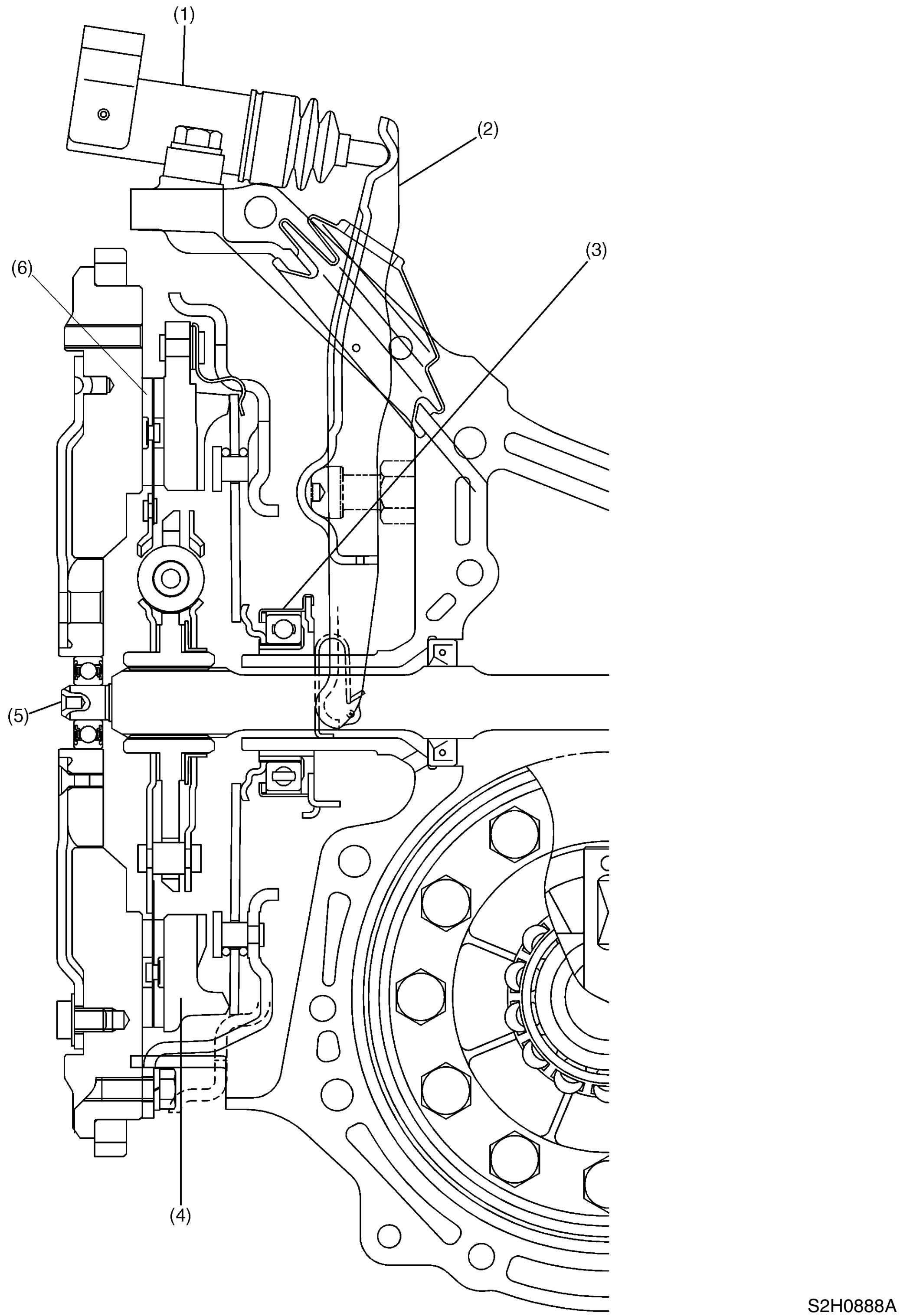
## C: CROSS SECTIONAL VIEW

### 1. EUROPE AND AUSTRALIA MODELS




| | |
|---|---|
| (1) Operating cylinder | (4) Clutch cover |
| (2) Clutch release lever | (5) Clutch disc |
| (3) Clutch release bearing | (6) Transmission main shaft |

## 2. NON-EUROPE AND NON-AUSTRALIA MODELS




| | | | |
|---|---|---|---|
| (1) | Operating cylinder | (4) | Clutch cover |
| (2) | Clutch release lever | (5) | Transmission main shaft |
| (3) | Clutch release bearing | (6) | Clutch disc |

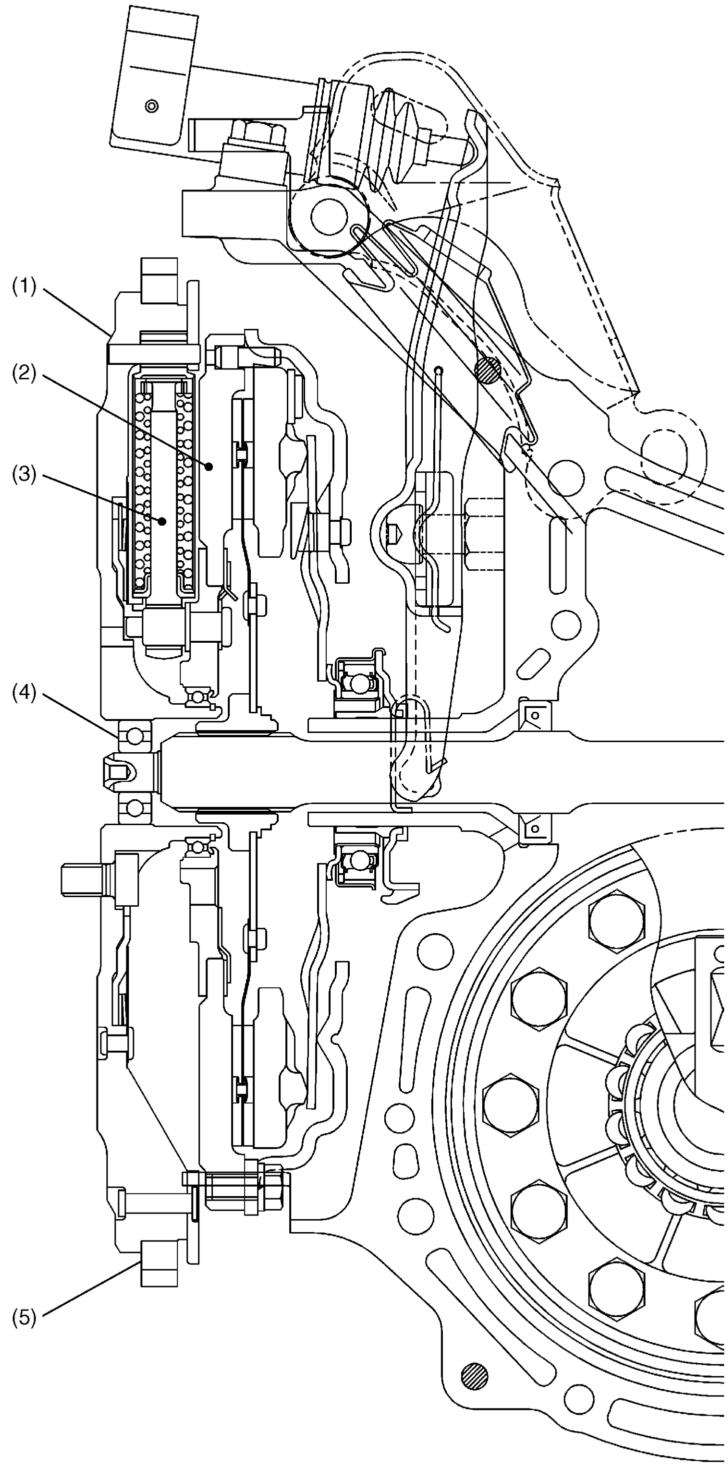
MEMO

# 2. Flywheel

## A: EUROPE AND AUSTRALIA MODELS

The flywheel is of a dual mass type. This flywheel consists of two flywheel masses and a spring box sandwiched between them.

The engine torque from the crankshaft is first transmitted to the primary mass and then to the spring box. The spring box dampens variations in the torque before it transmits the torque to the secondary mass. As a result, a stabler torque is transmitted to the transmission mainshaft through the clutch disc.

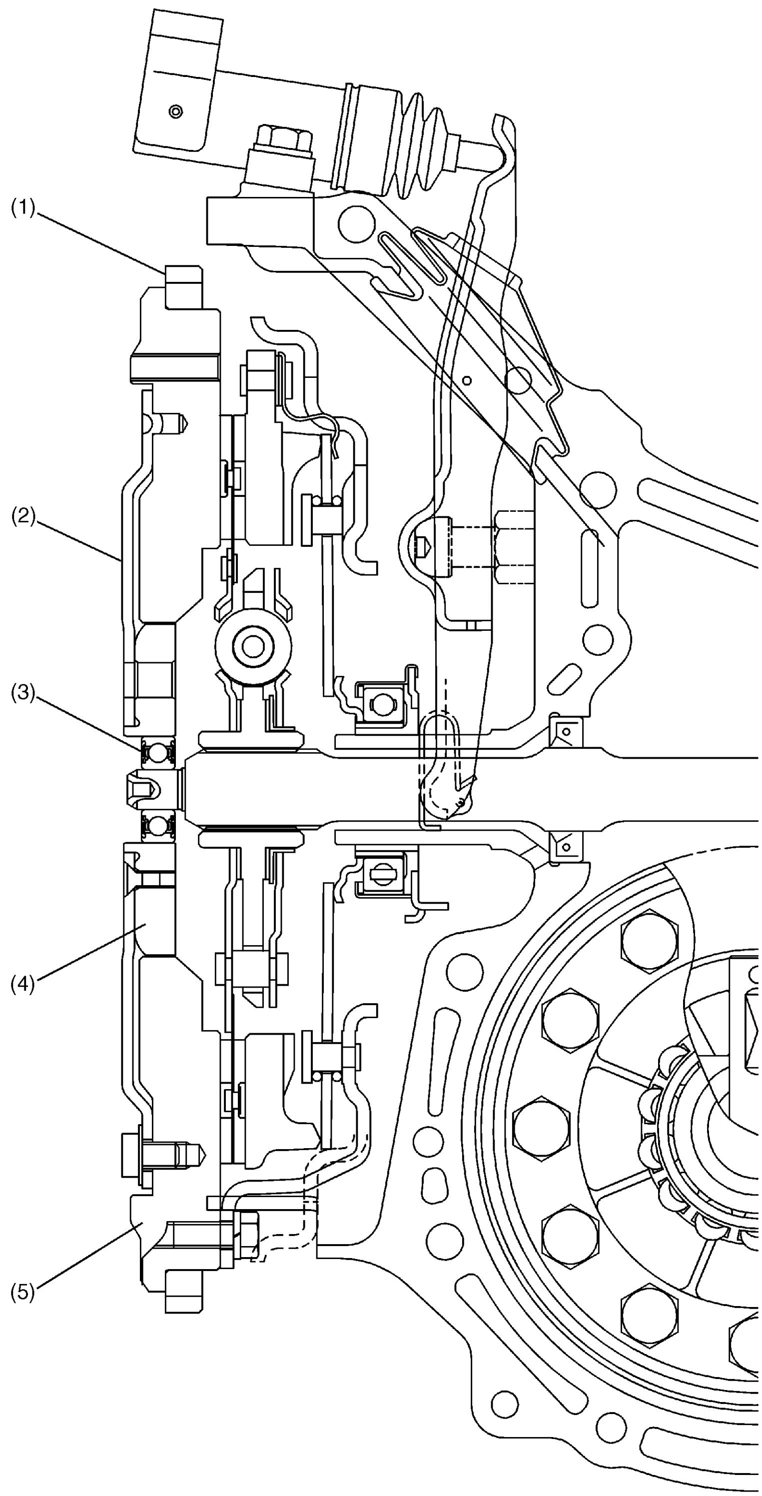



(1) Primary flywheel
(2) Secondly flywheel
(3) Spring boxes
(4) Ball bearing
(5) Ring gear

## B: NON-EUROPE AND NON-AUSTRALIA MODELS

The flywheel is of a flexible type, consisting of a drive plate, reinforcement, and mass flywheel.

This flywheel helps reduce vibration and noise since it transmits the engine power from the crankshaft to the clutch disc through the drive plate and mass flywheel.

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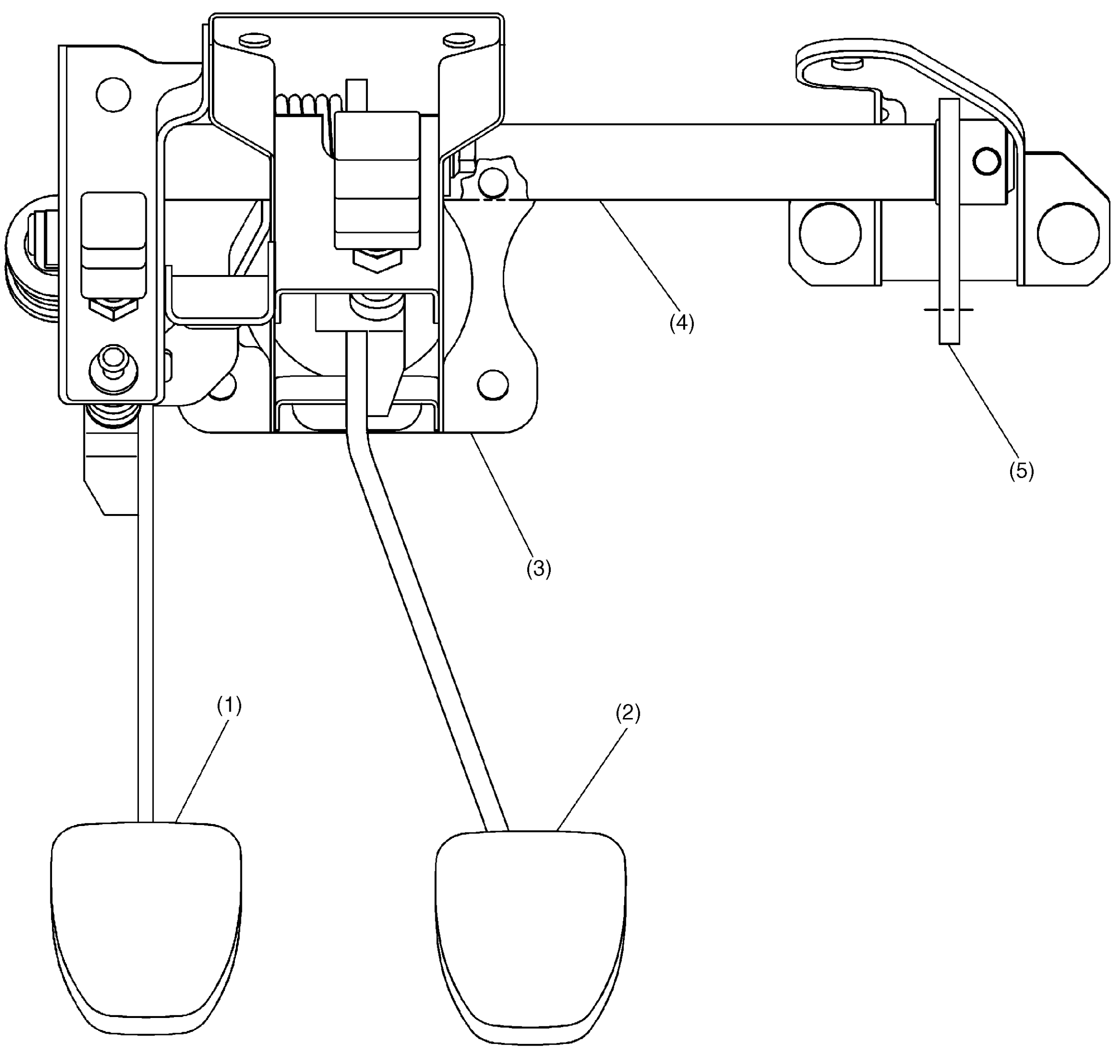
| | | | |
|---|---|---|---|
| (1) | Ring gear | (4) | Reinforcement |
| (2) | Drive plate | (5) | Mass flywheel |
| (3) | Ball bearing | | |

# 3. Hydraulic Clutch Pedal System

## A: CONSTRUCTION

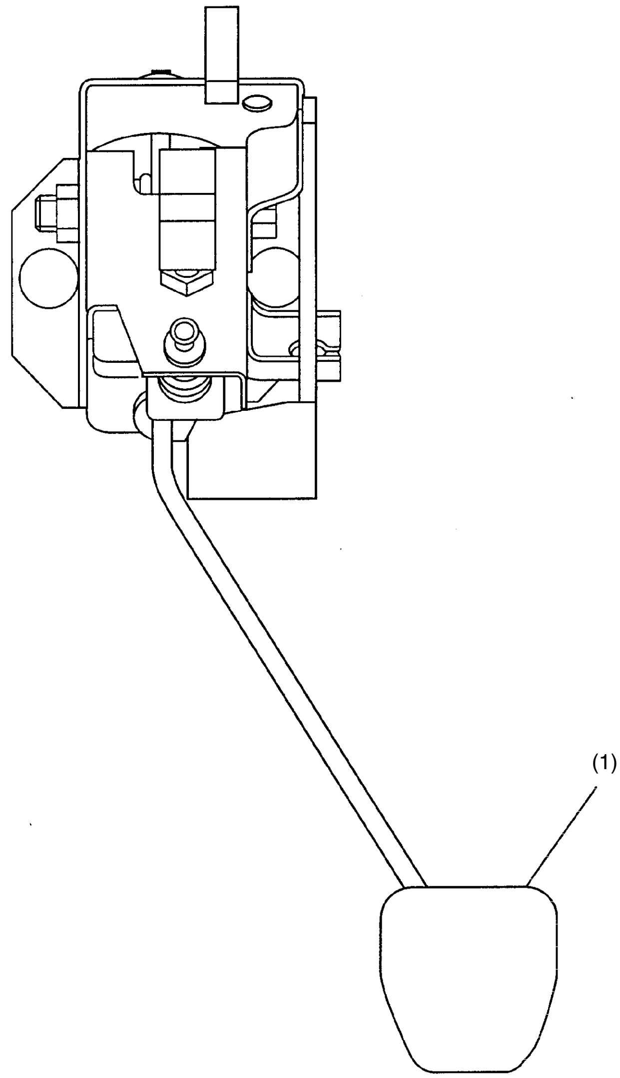
- The hydraulic clutch pedal is connected to the master cylinder via a rod.
- The clutch pedal and brake pedal are mounted on the same bracket (LHD model only).

- **LHD model**



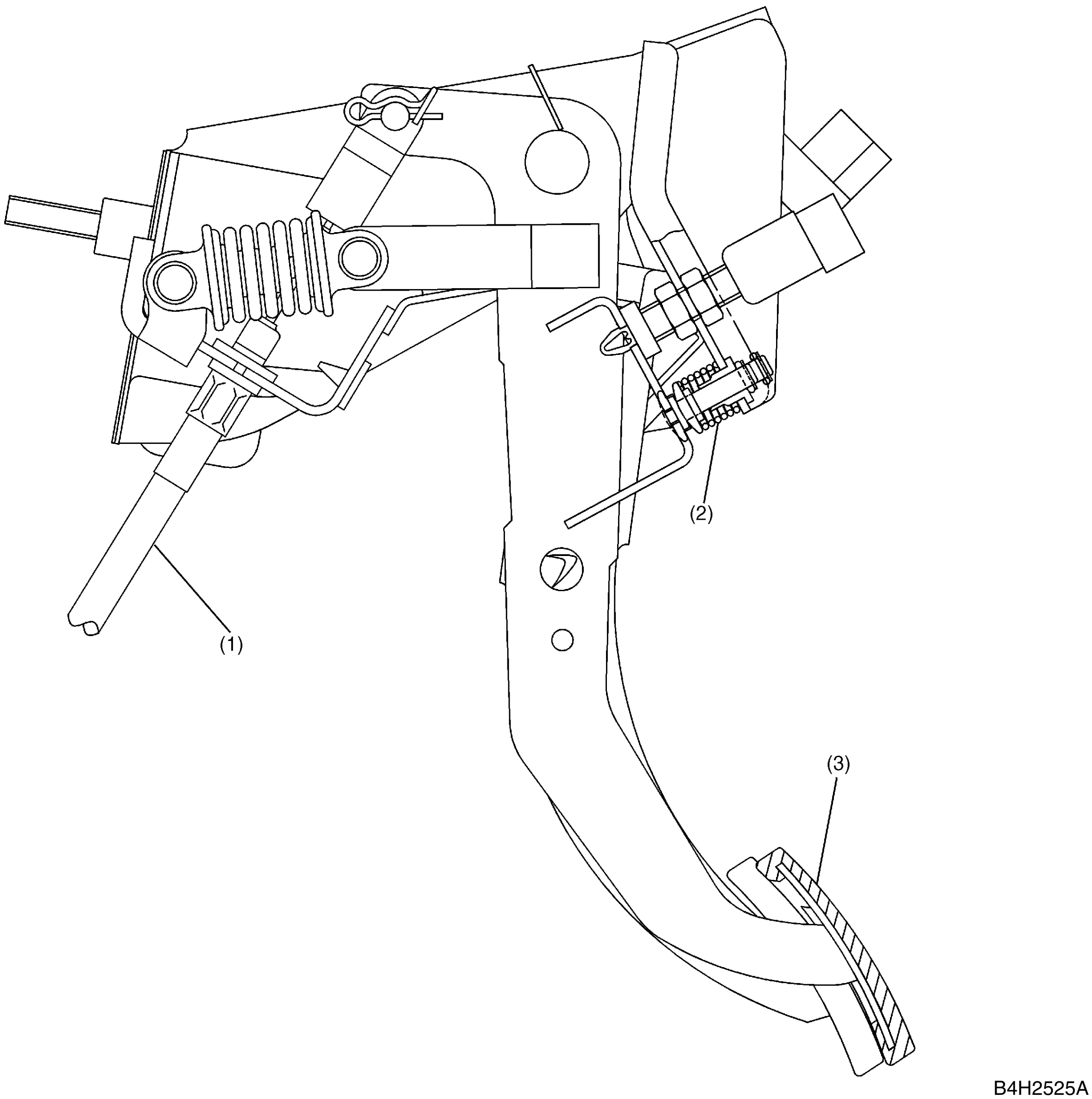

(1) Clutch pedal
(2) Brake pedal
(3) Brake and clutch pedal bracket
(4) Rod
(5) Lever

- **RHD model**




(1) Clutch pedal

- The clutch pedal has a mechanism that reduces the initial force required to depress the clutch pedal.
- A hill holder control cable is connected to the clutch pedal.




(1) PHV cable (Hill holder)
(2) Initial pedal effort reducing mechanism
(3) Clutch pedal

## B: OPERATION

The clutch pedal used with the hydraulic clutch control system is similar to that for a mechanical clutch control system except that it has a spring that returns it to the original position.

# FRONT SUSPENSION FS

Page

# 1. Front Suspension

## A: OUTLINE

The front suspension is a strut-type independent suspension, with cylindrical double-acting, oil-filled dampers and coil springs. The top of each strut assembly is attached to the body through a rubber cushion. Used in combination with other rubber cushions, this rubber cushion effectively insulate vibration and shock and thus improves ride comfort. This type also maintains a wide distance between the upper and lower supporting points and makes adjustment of the caster unnecessary.

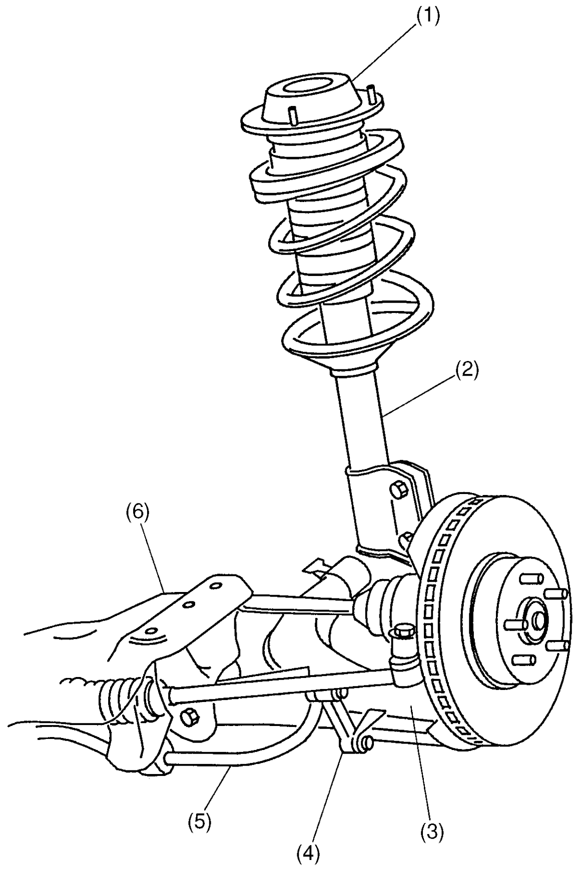
The transverse link is an “L” shaped arm design to increase steering stability and reduce road noise. The transverse link has a maintenance-free ball joint fitted by a castle nut at its outer end. The front of the link’s inner end is fitted to the front crossmember through a rubber cushion and the rear of the inner end is bolted to the vehicle body through a fluid-filled bushing.

The front crossmember is bolted to the vehicle body.

The stabilizer is attached to the front crossmember through rubber cushions and its right and left ends are connected to the stabilizer links through rubber bushings.

The lower end of the stabilizer link is connected to the transverse link through rubber bushings.

A camber angle adjustment mechanism, which uses eccentric bolts, is provided at the joint of the damper strut and axle housing.

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(1) Strut mount
(2) Strut
(3) Transverse link
(4) Stabilizer link
(5) Stabilizer
(6) Front crossmember

## MEMO

# REAR SUSPENSION RS

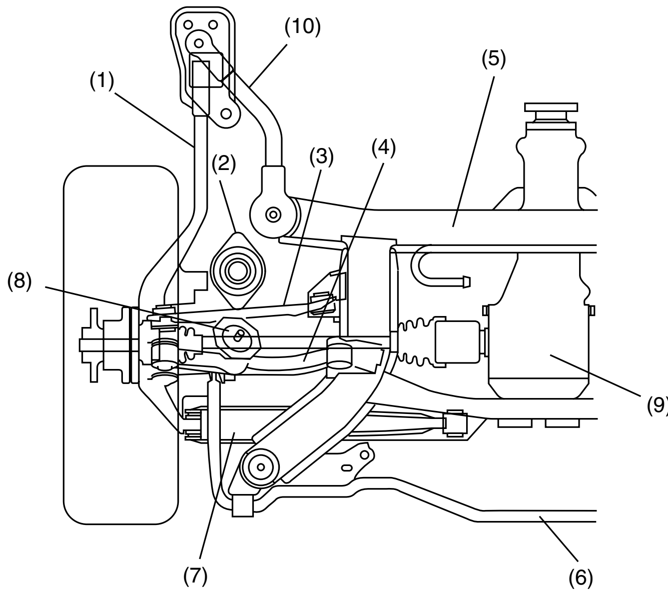
**Page**

# 1. Rear Suspension

## A: OUTLINE

The rear suspension is a multilink type. This type of suspension is characterized by small changes in camber and toe-in against external input of vertical, longitudinal and lateral forces. This enables full use of tire performance and ensures high kinetic performance and stability of the vehicle.

This suspension also features quiet operation because the front link, rear link, upper link and rear differential are all attached to a subframe which in turn is installed to the vehicle body through heavy-duty bushings.




| | | |
|---|---|---|
| (1) Rear arm | (5) Subframe | (9) Rear differential |
| (2) Shock absorber and coil spring | (6) Stabilizer | (10) Support subframe front |
| (3) Front link | (7) Rear link | |
| (4) Upper link | (8) Helper | |

| Component | Key feature | Function |
|---|---|---|
| Rear arm | Made of cast iron for sufficient rigidity. | Supports longitudinal dynamic load. |
| Front link | Made of sheet metal with U-shaped section for sufficient rigidity. | Supports lateral dynamic load. |
| Rear link | Made of sheet metal with U-shaped section for sufficient rigidity. | Supports lateral dynamic load. |
| Upper link | Made of cast iron for sufficient rigidity against impact from helper when suspension is bumped. | Supports lateral dynamic load. |
| Shock absorber and coil spring | Overall length is optimally minimized to eliminate protrusion into the passenger compartment. | Supports and controls vertical dynamic load. |
| Stabilizer | Ball joint type stabilizer link is used to minimize transient rolling of the body. | Controls body rolling. |
| Helper | Attached to the body independently of shock absorber to avoid its protrusion into the passenger compartment. | Combined with upper link to serve as vehicle bump stopper. |
| Subframe | Attached to the body through heavy duty bushings for quiet operation. | Supports front link, rear link, upper link and rear differential. |
| Support subframe front | Made of steel pipe whose ends fixed to the rear arm bracket and subframe. | Improves steerability. |

## MEMO

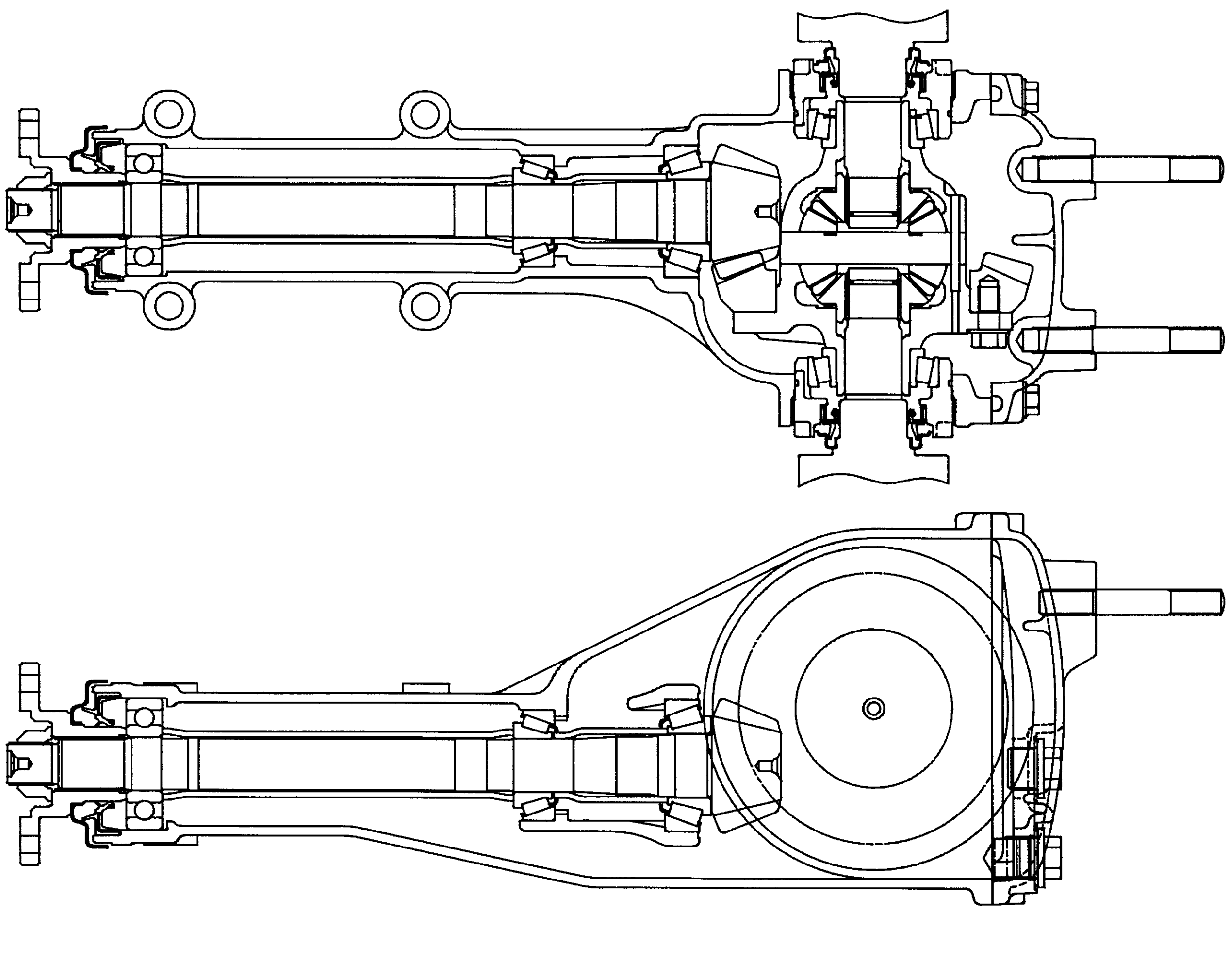
# DIFFERENTIALS DI

Page

# 1. Rear Differential

## A: VA-TYPE

The drive gear is a hypoid gear with nominal diameter of 152 mm (5.98 in). The drive pinion shaft is supported by three bearings. The bearing preload is adjusted by selecting a spacer and washer combination of a proper thickness. The drive pinion height is adjusted by properly selecting the thickness of the washers located at the drive pinion neck using Dummy Shaft and Gauge.



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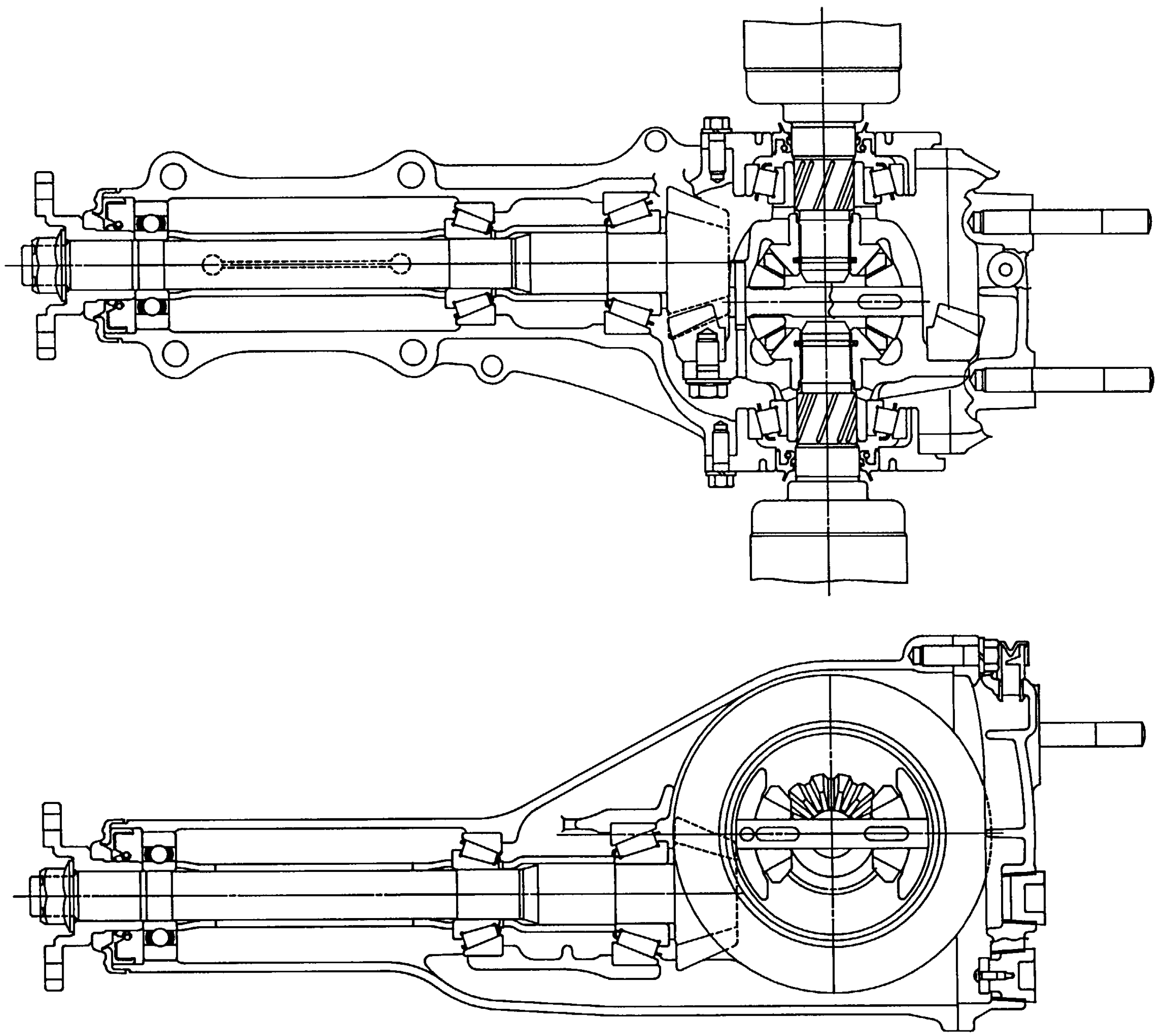
## B: T-TYPE

The drive gear is a hypoid gear with a nominal diameter of 160 mm (6.30 in). The drive pinion shaft is supported by three bearings. The bearing preload is adjusted by selecting a spacer and washer combination of a proper thickness. The drive pinion height is adjusted by properly selecting the thickness of the washers located at the drive pinion neck using Dummy Shaft and Gauge.



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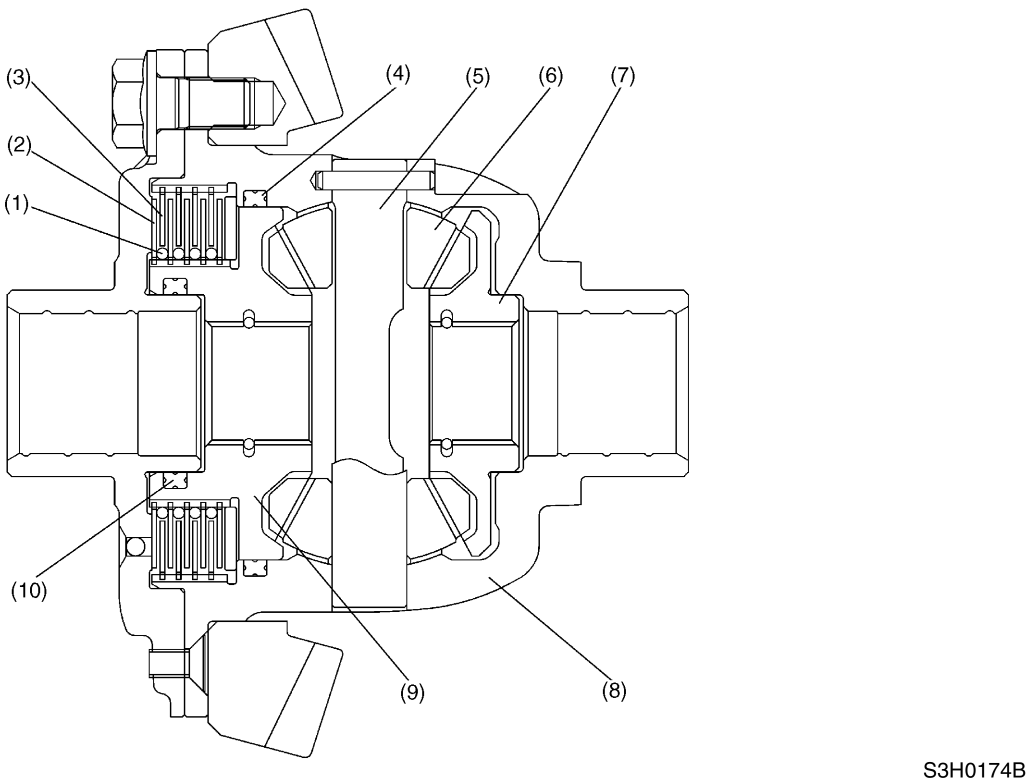
# 2. Limited Slip Differential (LSD)

## A: OUTLINE

The limited slip differential is of a viscous coupling (V/C) type which automatically limits the differential action and distributes torque to the left and right wheels adequately to enhance driving stability when the left and right wheels are rotating at speeds different from each other during driving on a slippery road (muddy, snow-covered or slushy road) or cornering.

## B: STRUCTURE

The V/C type LSD has outer plates and inner plates arranged alternately. Each outer plate is splined to the inside of the differential case at its outer periphery and each inner plate is splined to the outer circumference of the left side gear at its inner periphery.
The inner plates are held in position by spacer rings while the outer rings can slide in the axial direction along the spline teeth.
The space between the differential case and the left side gear is filled with a mixture of high viscosity silicone oil and air and hermetically sealed with X-rings.

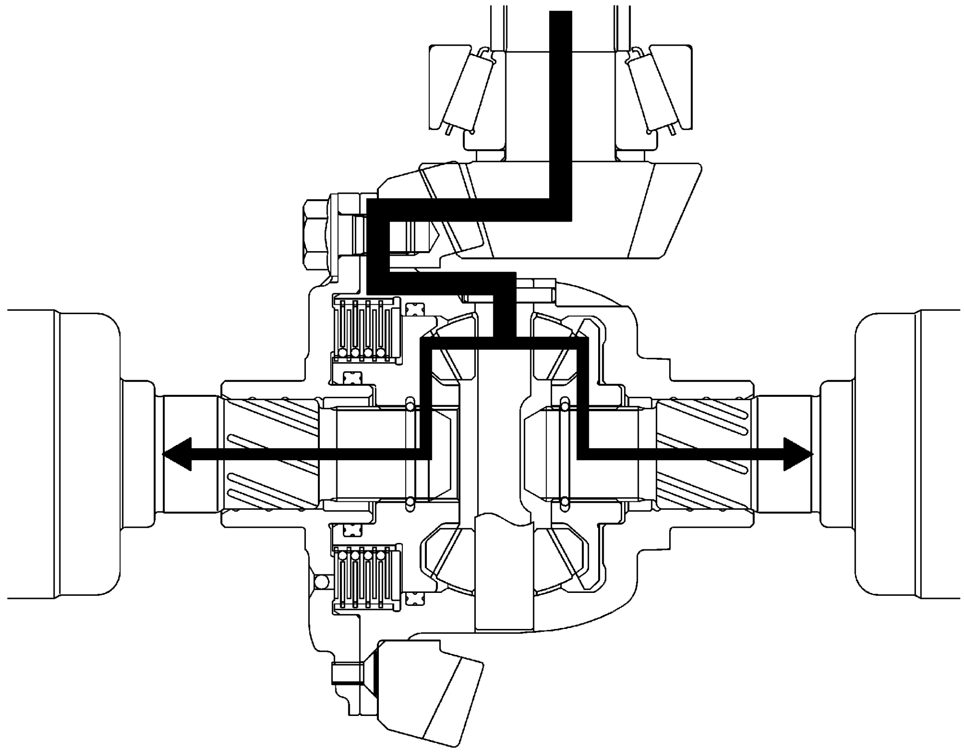



| | | | |
|---|---|---|---|
| (1) | Spacer ring | (6) | Pinion gear |
| (2) | Inner plate | (7) | Side gear (right) |
| (3) | Outer plate | (8) | Differential case |
| (4) | X-ring | (9) | Side gear (left) |
| (5) | Pinion shaft | (10) | X-ring |

## C: OPERATION

### 1. WHEN RIGHT AND LEFT WHEELS ROTATE AT THE SAME SPEED

During normal straight-ahead driving where the right and left wheels rotate at the same speed, the differential case and side gears rotate together, just as in conventional differentials. As a result, driving torque is distributed equally to the right and left side gears.

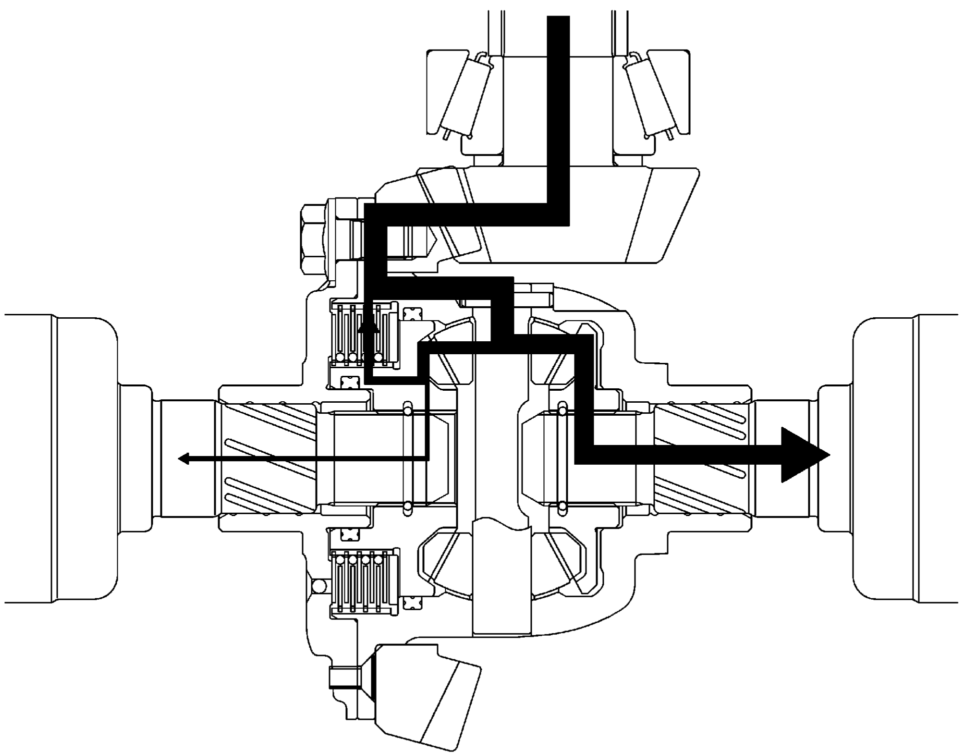


S3H0175

## 2. WHEN RIGHT AND LEFT WHEELS ROTATE AT DIFFERENT SPEEDS

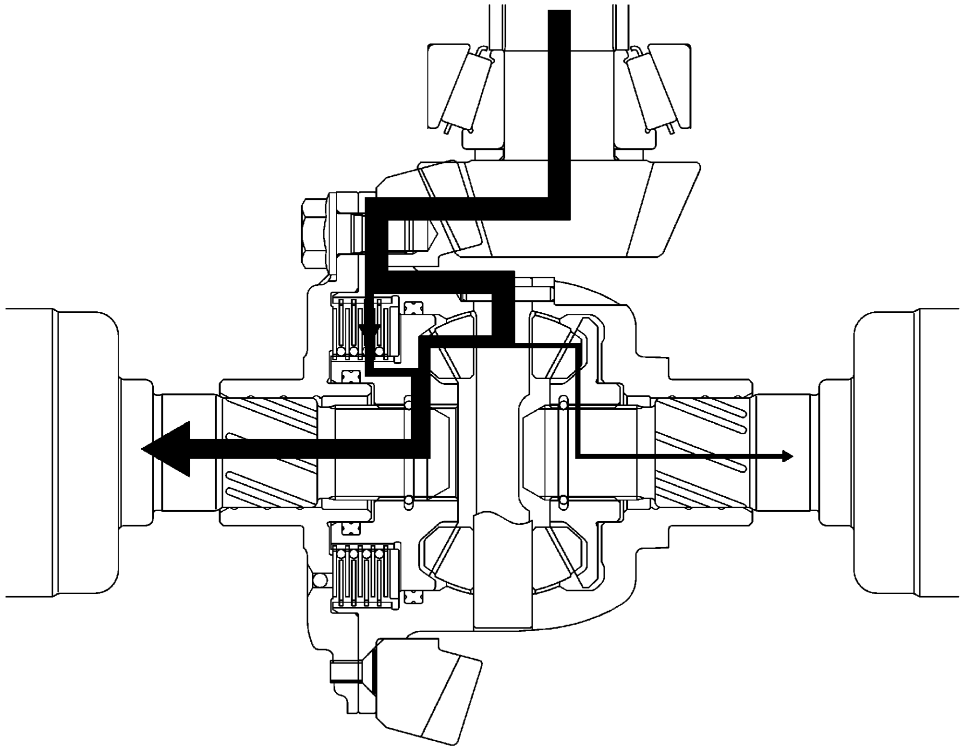
When a speed difference occurs between the right and left wheels, the differential case and the left side gear do not rotate at the same speed any more. The speed difference between them corresponds to that between both the wheels. Because of the shear force caused in the silicone oil, a differential torque is then generated, which limits differential action.
For example, if the left wheel spins due to small road resistance, a speed difference occurs between the right and left wheels. Since there is the V/C between the differential case and left side gear, a differential torque corresponding to the speed difference is generated in the V/C. This differential torque is transferred from the left wheel to the right wheel. As a result, a greater driving torque is distributed to the right wheel which is rotating at a lower speed.
When the right wheel spins, the differential torque is transferred from the right wheel to the left wheel. Also in this case, a torque greater by the differential torque than the torque to the spinning wheel is transmitted to the wheel rotating at the lower speed.

**When left wheel spins**



S3H0176

**When right wheel spins**


S3H0177

## D: SERVICE PROCEDURES FOR LSD

It is not recommended to disassemble the LSD assembly as component parts of LSD assembly are not available individually.

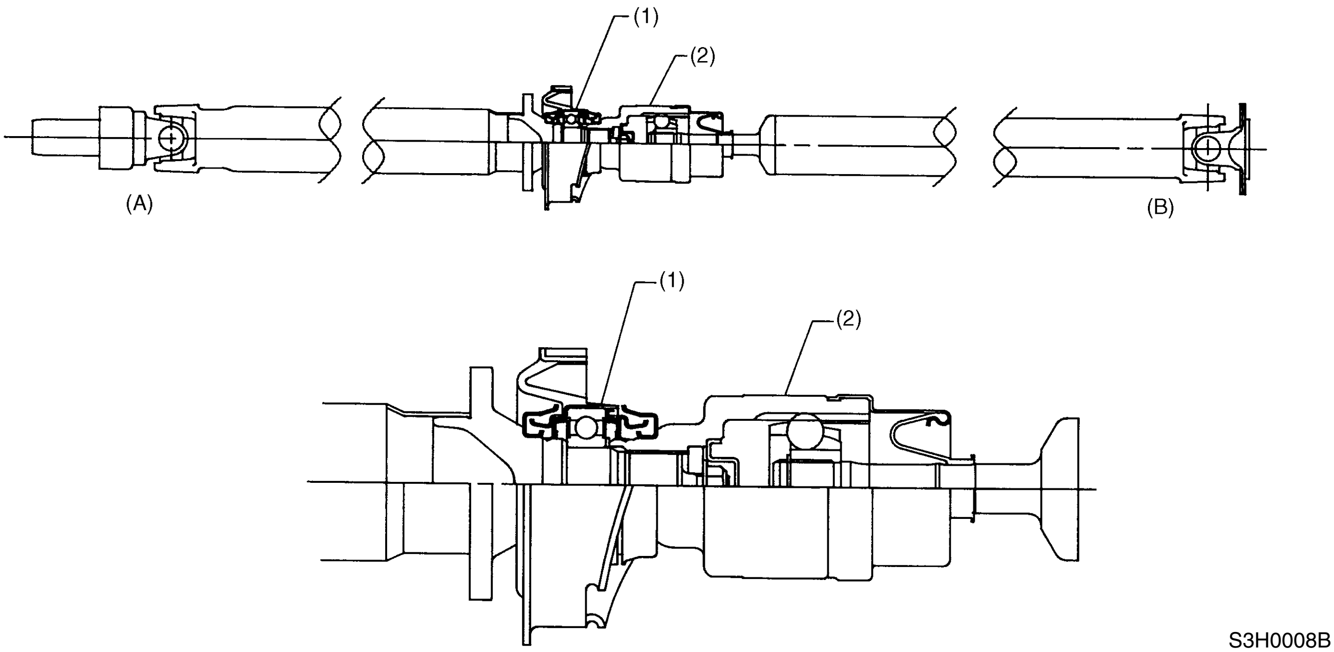
## MEMO

# DRIVE SHAFT SYSTEM DS

Page

# 1. Propeller Shaft

The propeller shaft uses constant velocity joints for quiet operation of the driveline components. The center joint is a double offset joint (DOJ) type which can extend and retract in the axial directions.




(1) Center bearing
(2) Double offset joint (DOJ)
(A) Transmission side
(B) Rear differential side

## MEMO

# 2. Front Axle

## A: GENERAL

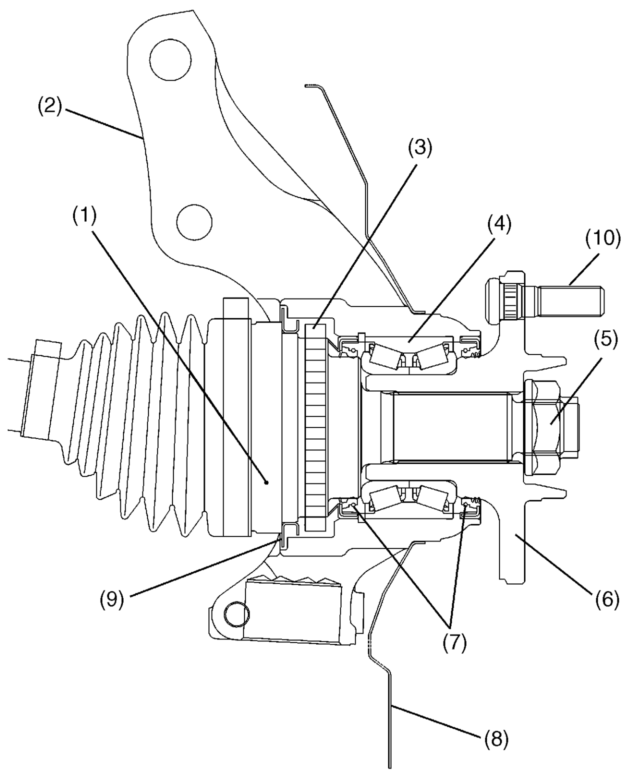
- The inboard end of each axle shaft is connected to the transmission via a constant velocity joint (shudder-less freering tripod joint: SFJ) which is flexible in the axial directions while the outboard end is connected via a bell joint (BJ) to the wheel hub which is supported by a taper roller bearing located inside the axle housing. The BJ features a large operating angle.
Both the constant velocity joints (SFJ and BJ) ensure smooth, regular rotation of the drive wheels with minimum vibration.
- The bearing is a preloaded, non-adjustable tapered roller unit bearing.
Each hub is fitted in the axle housing via the tapered roller bearing.
- The BJ's spindle is splined to the hub and is secured with an axle nut clinched to it.
- The disc rotor is an external mounting type. It is secured to the disc wheel using hub bolts to facilitate maintenance of the disc rotor.
- The axle nuts are given chromate treatment (olive drab treatment).

1) 3.0ℓ ENGINE MODEL

- The hubs are induction-hardened.

2) ALL MODELS EXCEPT 3.0ℓ ENGINE MODEL

- The hubs are same as those used in the previous model.

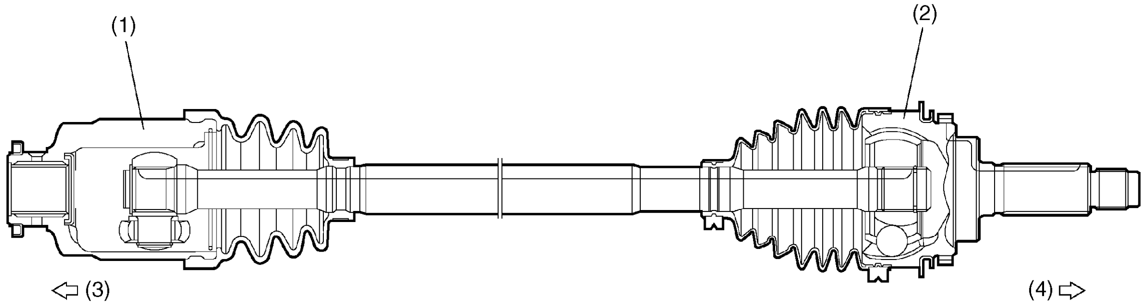



| | | | | | |
|---|---|---|---|---|---|
| (1) | Bell joint (BJ) | (5) | Axle nut | (9) | Baffle plate |
| (2) | Axle housing | (6) | Hub | (10) | Hub bolt |
| (3) | Tone wheel | (7) | Oil seal | | |
| (4) | Bearing | (8) | Brake backing plate | | |

## B: FRONT DRIVE SHAFT

● A shudder-less freering tripod joint (SFJ) is used on the differential side of each front drive shaft. The SFJ can be disassembled for maintenance. It provides a maximum operating angle of 25° and can be moved in the axial directions.

● A bell joint (BJ) is used on the wheel side of each front drive shaft.
The BJ's maximum operating angle is 47.5°.

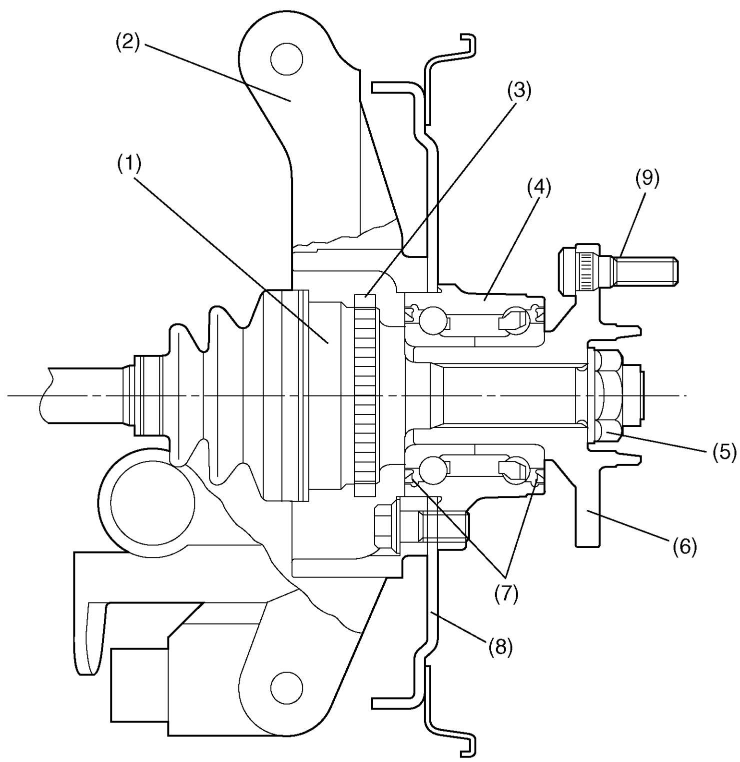



| | | | |
|---|---|---|---|
| (1) | Shudder-less freering tripod joint (SFJ) | (3) | Transmission side |
| (2) | Bell joint (BJ) | (4) | Wheel side |

# 3. Rear Axle

## A: GENERAL

- The inboard end of each axle shaft is connected to the differential via a constant velocity joint (double offset joint: DOJ) which is flexible in the axial directions.
- The axle shaft's outboard end is connected via a bell joint (BJ) to the wheel hub which is supported by the hub unit bearing. The BJ features a large operating angle. Both the constant velocity joints (DOJ and BJ) ensure smooth, regular rotation of the drive wheels with minimum vibration.
- The hub unit bearing's outer race forms integral part of the mounting flange.
The hub unit bearing is bolted to the rear knuckle arm with the brake backing plate in between.
Oil seals are fitted on both sides of the bearing.
The bearing is a preloaded, non-adjustable angular contact ball unit bearing.
- The BJ's spindle is splined to the hub and is secured with an axle nut clinched to it.
- The disc rotor and drum are an external mounting type. It is secured to the disc wheel using hub bolts to facilitate maintenance of the disc rotor and drum.

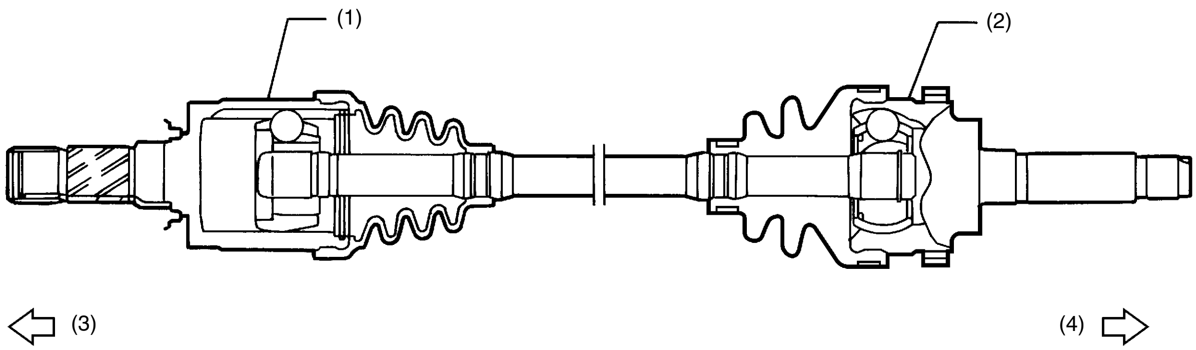



B4H1522B

(1) Bell joint (BJ)
(2) Rear knuckle arm
(3) Tone wheel
(4) Hub unit bearing
(5) Axle nut
(6) Hub
(7) Oil seal
(8) Brake backing plate
(9) Hub bolt

## B: REAR DRIVE SHAFT

- A double offset joint (DOJ) is used on the differential side of each rear drive shaft. The DOJ can be disassembled for maintenance. It provides a maximum operating angle of 23° and can be moved in the axial directions.
- A bell joint (BJ) is used on the wheel side of each rear drive shaft. Its maximum operating angle is 42°.




(1) Double offset joint (DOJ)
(2) Bell joint (BJ)
(3) Differential side
(4) Wheel side

## MEMO

# ABS

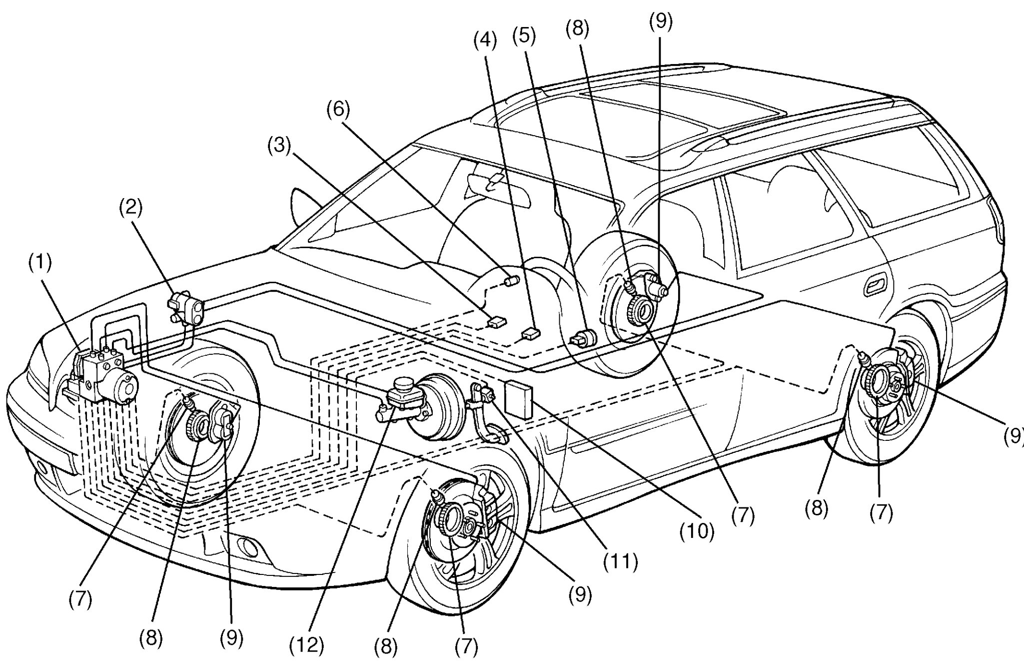
Page

# 1. Anti-lock Brake System (ABS)

## A: FEATURE

- The 5.3i type ABS used in the Legacy has a hydraulic control unit, an ABS control module, a valve relay and a motor relay integrated into a single unit (called “ABSCM & H/U”) for circuit simplicity and reduced weight.
- The ABS electrically controls the brake fluid pressure to each wheel to prevent the wheel from locking during braking on slippery road surfaces, thereby enabling the driver to maintain the directional control.
- If the ABS becomes inoperative, a fail-safe system is activated to ensure same level of braking performance as with a conventional brake system. In that case, the warning light comes on to indicate that the ABS is malfunctioning.
- The ABS is a 4-sensor, 4-channel system; the front wheel system is an independent control design*1, while the rear wheel system is a select-low control design*2.

*1: A system which controls the front wheel brakes individually.
*2: A system which applies the same fluid pressure to both the rear wheels if either wheel starts to lock. The pressure is determined based on the lower of the frictional coefficients of both wheels.

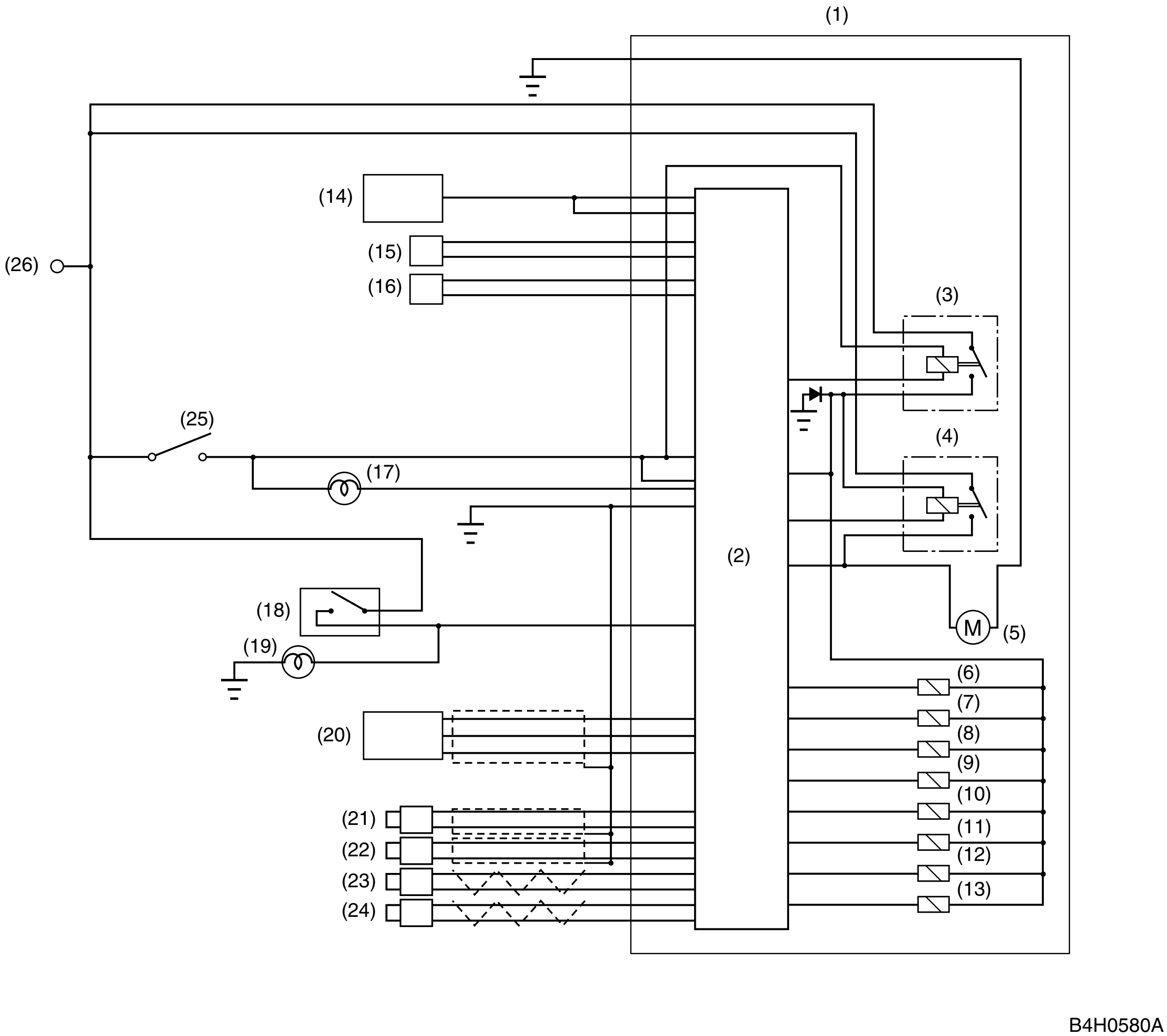



B4H2196A

(1) ABS control module and hydraulic control unit (ABSCM & H/U)
(2) Proportioning valve
(3) Diagnosis connector
(4) Data link connector (for SUBARU select monitor)
(5) G sensor
(6) ABS warning light
(7) Tone wheel
(8) ABS sensor
(9) Wheel cylinder
(10) Automatic transmission control module
(11) Brake switch
(12) Master cylinder

## B: FUNCTIONS OF SENSORS AND ACTUATORS

| Name | | Function |
|---|---|---|
| ABS control module and hydraulic control unit (ABSCM & H/U) | ABSCM section | • It determines the conditions of the wheels and the vehicle body from the wheel speed data and controls the hydraulic unit depending on the result.<br>• When the ABS is active, the ABSCM provides the automatic transmission control module with control signals which are used by the module for co-operative control of the vehicle with the ABSCM.<br>• Whenever the ignition switch is placed at ON, the module performs a self diagnosis sequence. If anything wrong is detected, the module cuts off the system.<br>• It communicates with the SUBARU select monitor. |
| | H/U section | • When the ABS is active, the H/U changes fluid passages to the wheel cylinders in response to commands from the ABSCM.<br>• It constitutes the brake fluid passage from the master cylinder to the wheel cylinders together with the piping. |
| | Valve relay section | It serves as a power switch for the solenoid valves and motor relay coil. It operates in response to a command from the ABSCM. |
| | Motor relay section | It serves as a power switch for the pump motor. It operates in response to a command from the ABSCM. |
| ABS sensors (wheel speed sensors) | | They detect the wheel speed in terms of a change in the density of the magnetic flux passing through them and convert it into an electrical signal. The electrical signal is sent to the ABSCM. |
| Tone wheels | | They give a change in the magnetic flux density by the teeth around themselves to let the ABS sensors generate electrical signals. |
| G sensor | | It detects a change in acceleration in the longitudinal direction of the vehicle and outputs it to the ABSCM as a voltage signal. |
| Stop light switch | | It provides information on whether the brake pedal is depressed or not to the ABSCM. The ABSCM uses it to determine ABS operation. |
| ABS warning light | | It alerts the driver to an ABS fault. When the diagnosis connector and diagnosis terminal are connected, the light flashes to indicate a trouble code stored in the ABSCM. |
| Automatic transmission control module | | It provides gear controls (fixing the speed at 3rd or changing power transmission to front and rear wheels) in response to control signals from the ABSCM. |




| | | | | | |
|---|---|---|---|---|---|
| (1) | ABS control module and hydraulic control unit | (10) | Rear left inlet solenoid valve | (19) | Stop light |
| (2) | ABS control module section | (11) | Rear left outlet solenoid valve | (20) | G sensor |
| (3) | Valve relay | (12) | Rear right inlet solenoidvalve | (21) | Front left ABS sensor |
| (4) | Motor relay | (13) | Rear right outlet solenoid valve | (22) | Front right ABS sensor |
| (5) | Motor | (14) | Automatic transmission control module | (23) | Rear left ABS sensor |
| (6) | Front left inlet solenoid valve | (15) | Diagnosis connector | (24) | Rear right ABS sensor |
| (7) | Front left outlet solenoid valve | (16) | Data link connector | (25) | IGN |
| (8) | Front right inlet solenoid valve | (17) | ABS warning light | (26) | BATTERY |
| (9) | Front right outlet solenoid valve | (18) | Stop light switch | | |

## C: PRINCIPLE OF ABS CONTROL

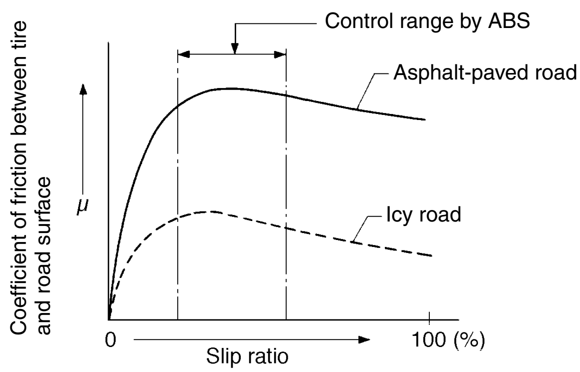
When the brake pedal is depressed during driving, the wheel speed decreases and the vehicle speed does as well. The decrease in the vehicle speed, however, is not always proportional to the decrease in the wheel speed. The non-correspondence between the wheel speed and vehicle speed is called “slip” and the magnitude of the slip is expressed by the “slip ratio” which is defined as follows:

Slip ratio = Vehicle speed – Wheel speed/Vehicle speed x 100%

When the slip ratio is 0%, the vehicle speed corresponds exactly to the wheel speed; when it is 100%, the wheels are completely locking (rotating at a zero speed) while the vehicle is moving.

The braking effectiveness is represented by the “coefficient of friction” between the tire and road surface. The larger the coefficient, the higher the braking effectiveness. The diagram below shows the relationship between the coefficient of friction and the slip ratio for two different road surface conditions (asphalt-paved road and icy road), assuming that the same tires are used for both the conditions and the vehicles are moving forward. Although the braking effectiveness (coefficient of friction) depends on the road surface condition as shown and also on the type of the tire, its peak range generally corresponds to the 8 – 30% range of the slip ratio.

The ABS controls the fluid pressure to each wheel so that a coefficient of friction corresponding to this slip ratio range is maintained.

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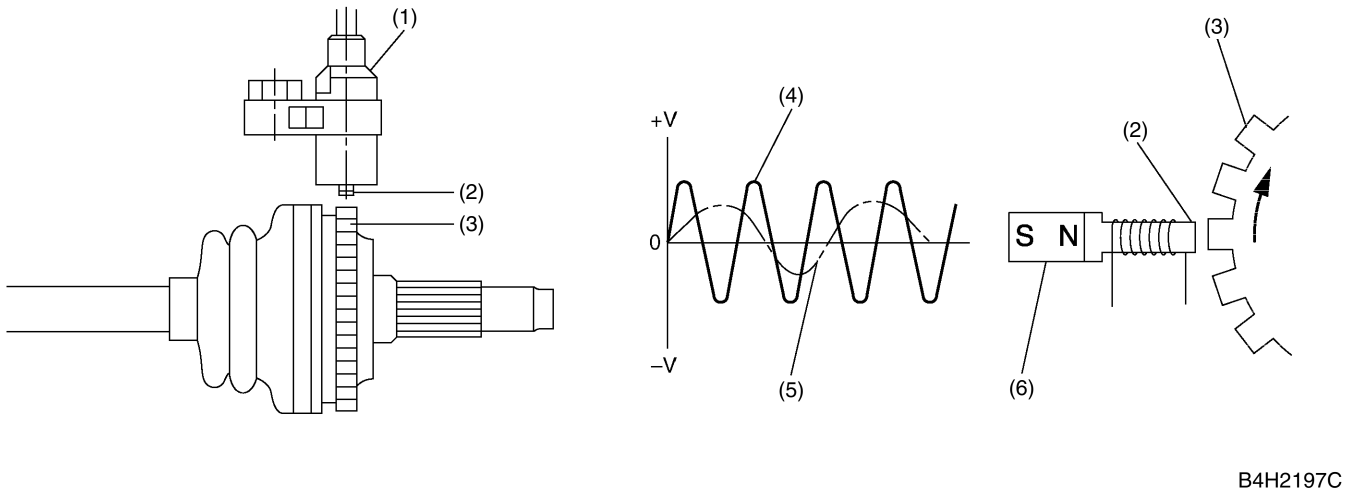
## D: ABS SENSORS

Each of the ABS sensors detects the speed of the corresponding wheel. The sensor consists of a permanent magnet, coil and tone wheel. The magnetic flux produced by the permanent magnet changes as each tooth of the tone wheel (which rotates together with the wheel) passes in front of the magnet's pole piece. The changing magnetic flux induces voltages at a frequency corresponding to the wheel speed.




(1) Sensor body
(2) Pole piece
(3) Tone wheel
(4) Full speed
(5) Low speed
(6) Permanent magnet

## E: ABS CONTROL MODULE AND HYDRAULIC CONTROL UNIT (ABSCM & H/U)

### ● ABS CONTROL MODULE SECTION (ABSCM)

The ABSCM contains two microcontrol modules (MCMs) that complement each other. Both the MCMs process the same program and each MCM monitors the other's outputs. If a mismatch occurs between their outputs, the ABSCM cuts off the system and activate the fail-safe function.

The ABSCM can store a maximum of 3 trouble codes in an EEP ROM. If more than 3 faults have occurred, only the 3 most recent failures are stored and others are erased. Trouble codes remain stored until they are internally or externally erased.
The ABSCM has a test routine (sequence control pattern) which facilitates checking of the hydraulic control unit.

● ABS control
Using primarily the wheel speed data from each ABS sensor and secondarily the vehicle deceleration rate data from the G sensor as parameters, the ABSCM generates a simulated vehicle speed when there is a risk of wheel lock-up. Using the simulated vehicle speed (called "dummy" vehicle speed) as a reference, the ABSCM determines the state of the wheel in terms of the tendency toward lock-up. If the result shows that the wheels are about to lock, the ABSCM issues commands to energize or de-energize the solenoid valves and activate the motor pump of the H/U to modulate the brake fluid pressures that act on the wheel cylinders, thereby preventing the wheels from locking.
The ABSCM controls the right and left front wheel fluid pressures independently and the rear wheel fluid pressures based on the wheel which is the most likely to lock (select-low control).

● Functions available using SUBARU select monitor
When the SUBARU select monitor is connected, the ABSCM allows it
- To read out analog data
- To read out ON/OFF data
- To read out or erase trouble code
- To read out status information in the event of a fault (Freeze frame data)
- To initiate ABS sequence control pattern

● Indication functions
Under the control of the ABSCM, the ABS warning light provides the following three indication function:
- ABS fault alerting
- Trouble code indication (by flashing in the diagnosis mode)
- Valve ON/OFF indication (when sequence control pattern is initiated)

## ● HYDRAULIC CONTROL UNIT SECTION (H/U)

The H/U is a fluid pressure controller consisting of, among others, a motor, solenoid valves, a housing and relays. It also constitutes passage of the two diagonally split brake circuits.

● The pump motor drives an eccentric cam which in turn moves the plunger pump to generate hydraulic pressure.

● The housing accommodates the pump motor, solenoid valve and reservoir. It also constitutes a brake fluid passage.

● The plunger pump, when operated, draws the brake fluid from the reservoir, lets the fluid in a wheel cylinder drain into the reservoir, and/or forces the fluid into the master cylinder.

● The outlet solenoid valve is a 2-position type. It opens or closes the brake fluid passage between a wheel cylinder and the reservoir according to commands from the ABSCM.

● The inlet solenoid valve is duty-controlled to reduce brake fluid pulsation for minimum ABS operation noise.

● The reservoir temporarily stores the brake fluid drained from a wheel cylinder when pressure “decrease” control is performed.

● The damper chamber suppresses brake fluid pulsation which would occur during pressure “decrease” control in the fluid discharged from the plunger pump to minimize kickbacks of the brake pedal.

● The valve relay controls power supply to the solenoid valves and motor relay in response to a command from the ABSCM. In normal (IG ON) condition, the relay is closed to supply power to the solenoid valves and motor relay. When an error occurs in the system, the valve relay is turned OFF to keep the fluid pressure circuit in the normal mode (non-ABS mode).

● The motor relay closes and supplies power to the pump motor in response to a command from the ABSCM during the ABS drive mode operations.

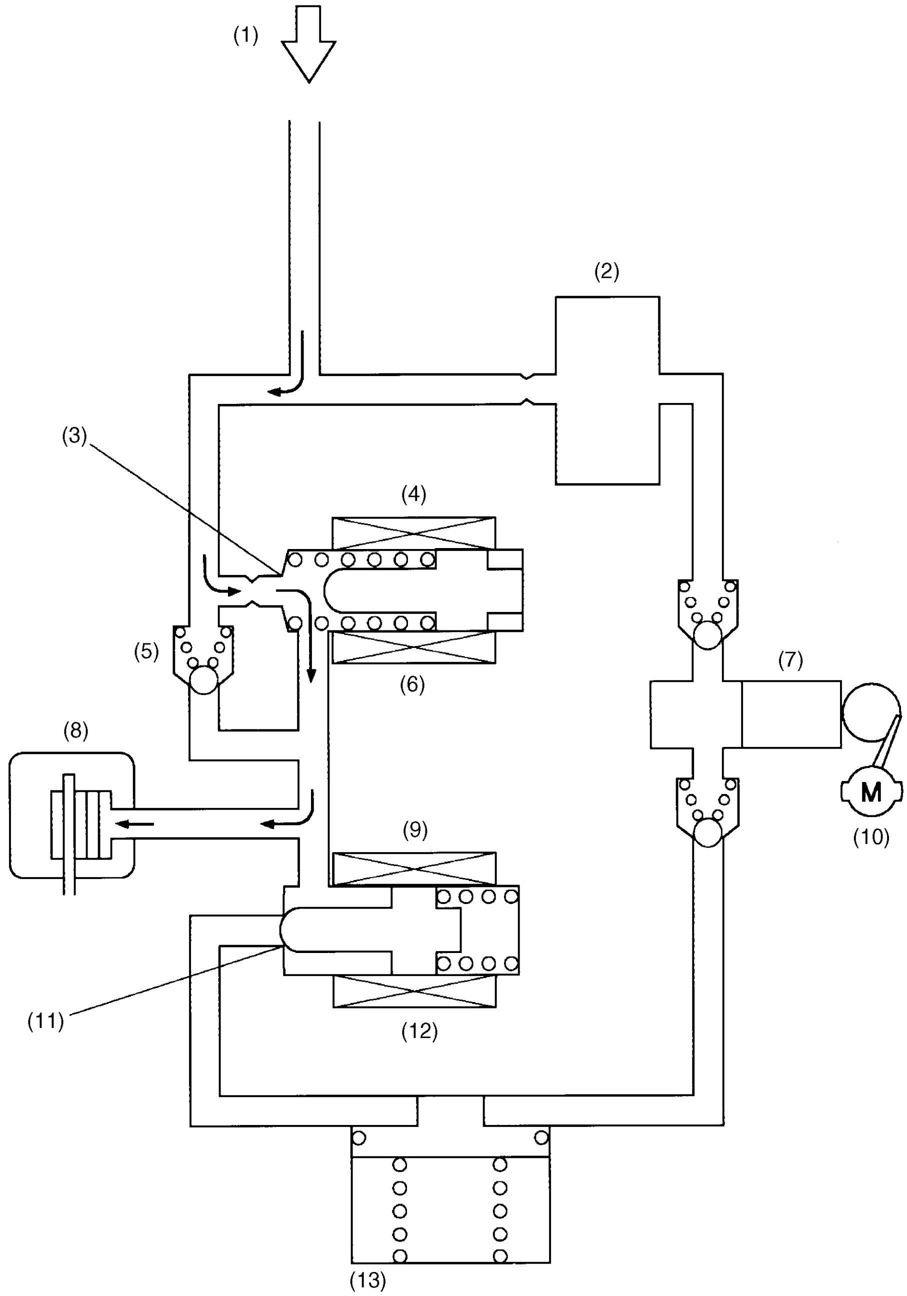
The H/U has four operating modes; normal mode (non-ABS mode), and three ABS active modes, i.e., “increase”, “hold” and “decrease” modes.

**MEMO**

## 1. DURING NORMAL BRAKING (ABS NOT ACTIVE)

Both the inlet and outlet solenoid valves are not energized.
This means that the inlet port of the inlet solenoid valve is open, whereas the outlet port of the outlet solenoid valve is closed. So the fluid pressure generated in the master cylinder is transmitted to the wheel cylinder, producing a brake force.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.

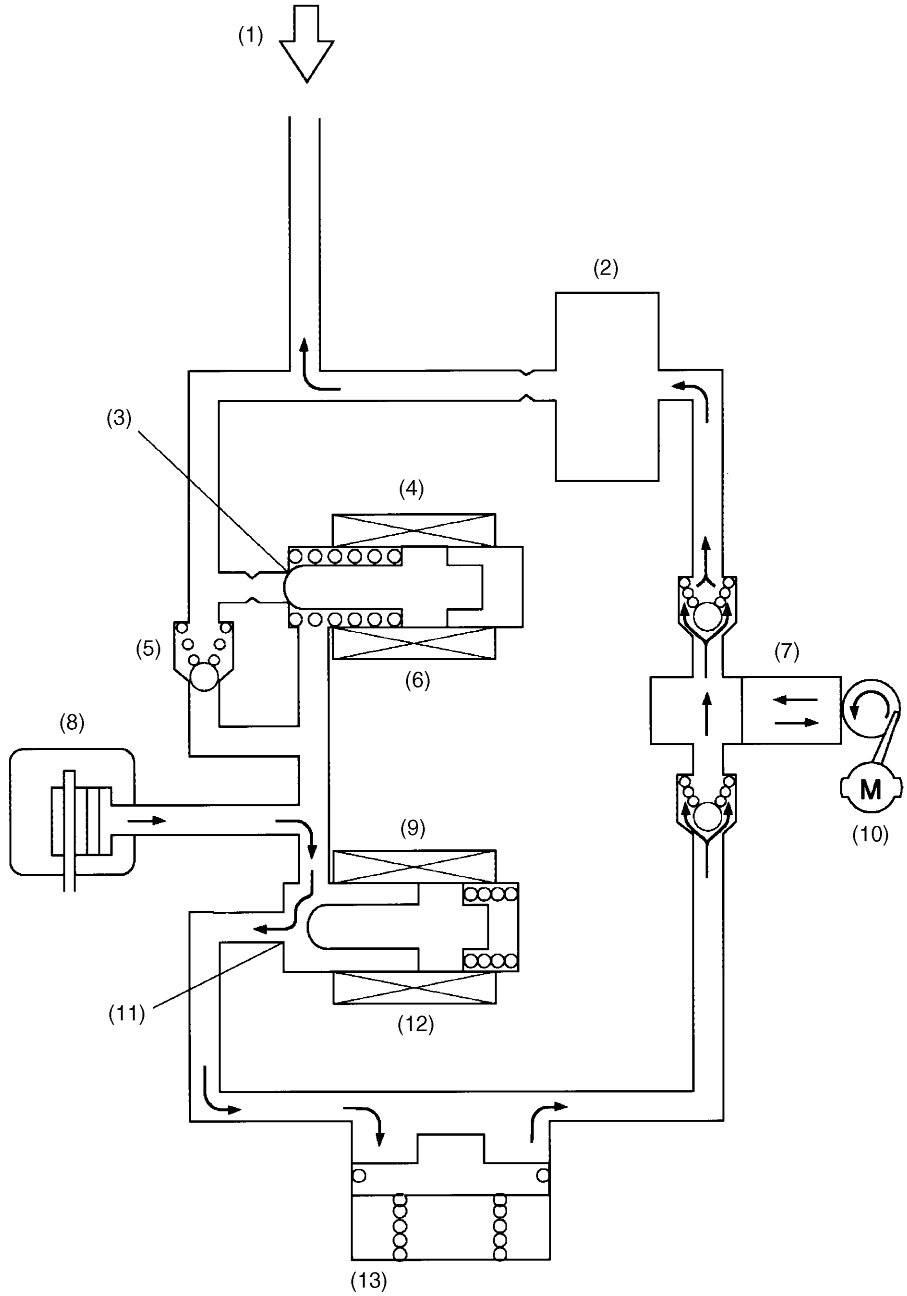



(1) From master cylinder
(2) Damper chamber
(3) Inlet port open
(4) Inlet solenoid valve
(5) Check valve
(6) De-energized
(7) Pump
(8) Wheel cylinder
(9) Outlet solenoid valve
(10) Motor
(11) Outlet port closed
(12) De-energized
(13) Reservoir

## 2. PRESSURE “DECREASE” CONTROL (ABS ACTIVE)

Both the inlet and outlet solenoid valves are energized, which means that the inlet port is closed and the outlet port is open.
In this state, the wheel cylinder is isolated from the master cylinder but open to the reservoir, so the brake fluid in it can be drained into the reservoir, decreasing its pressure and reducing the braking force of the wheel.
The brake fluid collected in the reservoir is forced into the master cylinder by the pump.
During this phase of ABS operation, the pump motor continues operating.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.

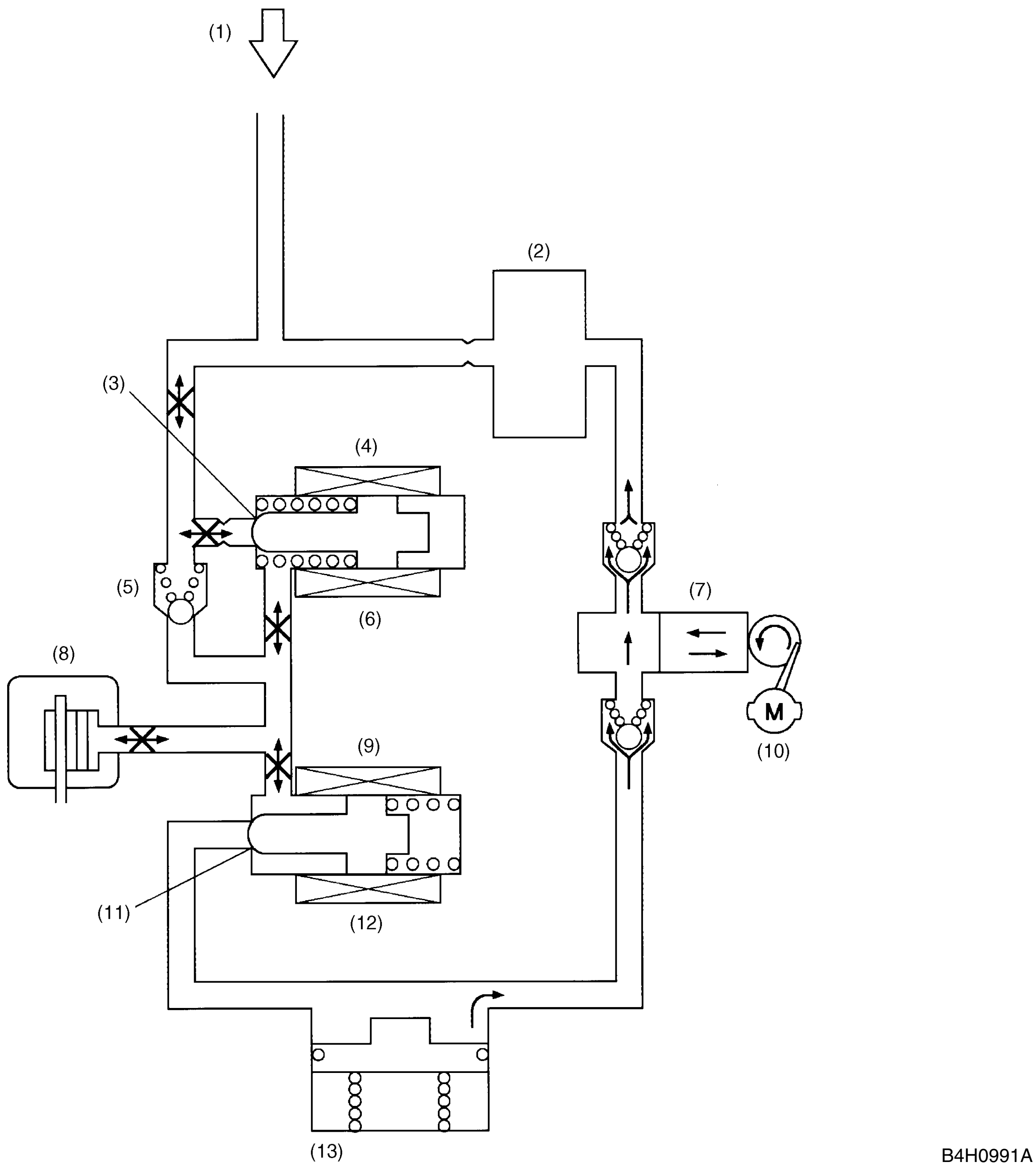



(1) From master cylinder
(2) Damper chamber
(3) Inlet port closed
(4) Inlet solenoid valve
(5) Check valve
(6) Energized
(7) Pump
(8) Wheel cylinder
(9) Outlet solenoid valve
(10) Motor
(11) Outlet port open
(12) Energized
(13) Reservoir

### 3. PRESSURE “HOLD” CONTROL (ABS ACTIVE)

The inlet solenoid valve is energized, so the inlet port is closed.
On the other hand, the outlet solenoid valve is de-energized, so the output port is also closed. In this state, all the passages connecting the wheel cylinder, master cylinder and reservoir are blocked. As a result, the fluid pressure in the wheel cylinder is held unchanged.
During this phase of ABS operation, the pump motor continues operating.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.

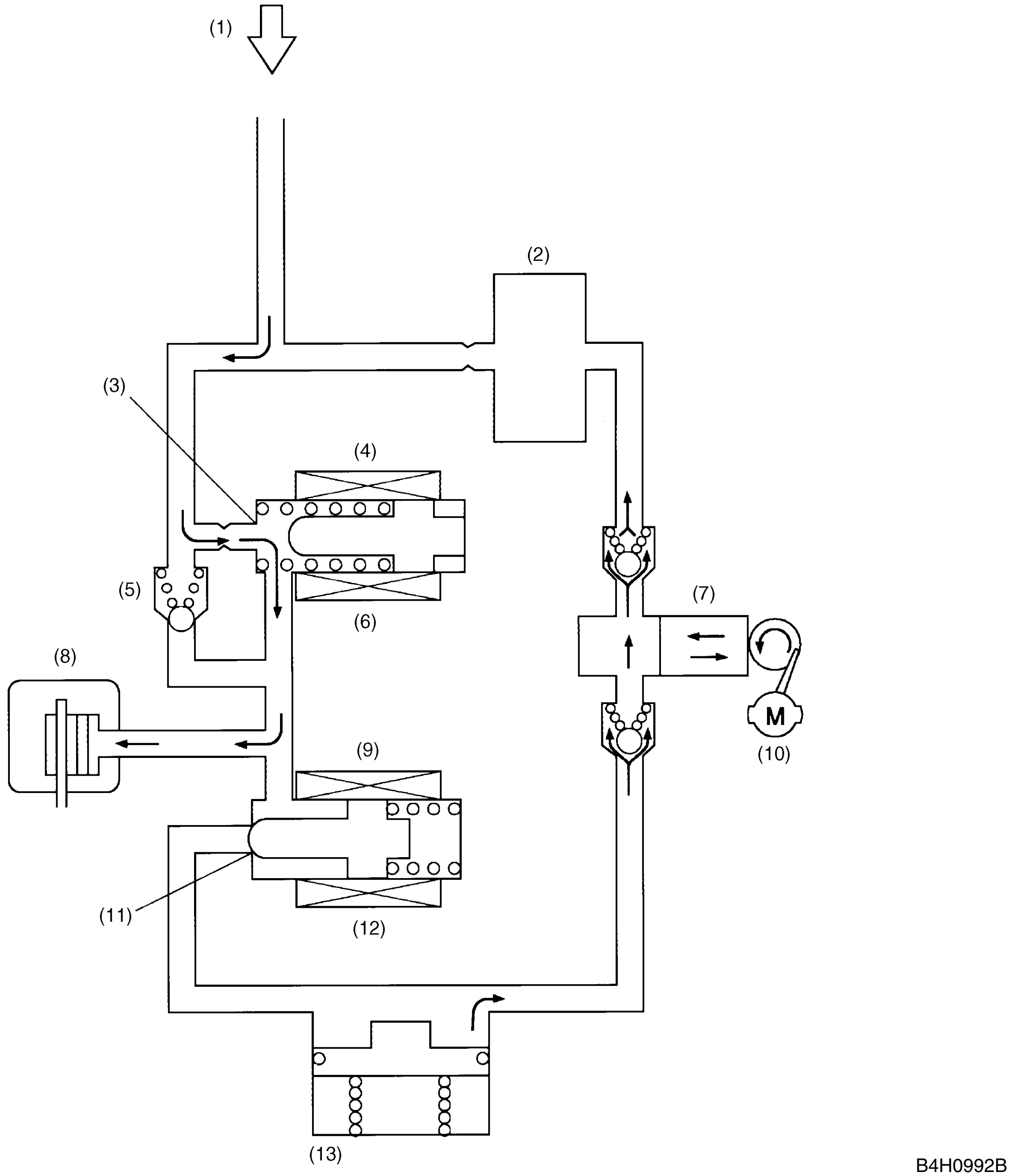



(1) From master cylinder
(2) Damper chamber
(3) Inlet port closed
(4) Inlet solenoid valve
(5) Check valve
(6) Energized
(7) Pump
(8) Wheel cylinder
(9) Outlet solenoid valve
(10) Motor
(11) Outlet port closed
(12) De-energized
(13) Reservoir

## 4. PRESSURE “INCREASE” CONTROL (ABS ACTIVE)

Both the inlet and outlet solenoid valves are de-energized, which means that the inlet port of the inlet solenoid valve is open, whereas the outlet port of the outlet solenoid valve is closed. So the fluid pressure generated in the master cylinder is transmitted to the wheel cylinder and increased fluid pressure in the wheel cylinder applies the brake with a larger force.
During this phase of ABS operation, the pump motor continues operating.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.




| | | | |
|---|---|---|---|
| (1) | From master cylinder | (8) | Wheel cylinder |
| (2) | Damper chamber | (9) | Outlet solenoid valve |
| (3) | Inlet port open | (10) | Motor |
| (4) | Inlet solenoid valve | (11) | Outlet port closed |
| (5) | Check valve | (12) | De-energized |
| (6) | De-energized | (13) | Reservoir |
| (7) | Pump | | |

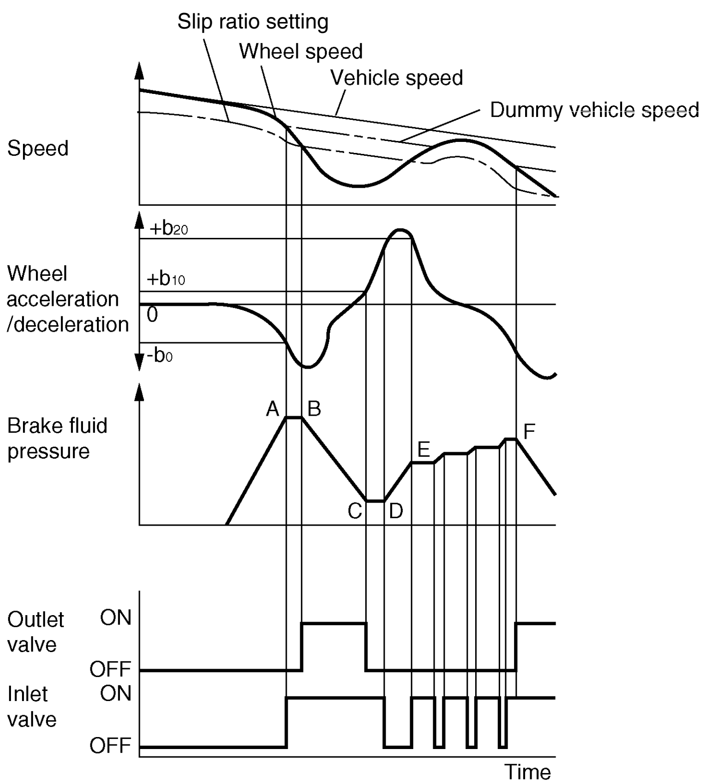
## F: ABS CONTROL CYCLE CURVES

Depressing the brake pedal increases the brake fluid pressure in each wheel cylinder, which in turn decreases the wheel speed (or increases the wheel deceleration rate). When the brake fluid pressure is increased to a level of point “A” of the brake fluid pressure curve in the diagram below (at which the wheel deceleration rate exceeds threshold “$-b_0$”), the ABSCM makes a pressure “hold” control. At the same time, the ABSCM calculates a “dummy” vehicle speed which is a reference speed it uses in the next stage of control.

When the wheel speed then drops below the slip ratio setting, i.e., a speed lower than the “dummy” vehicle speed by the predetermined value (at point “B” of the pressure curve), the ABSCM makes a control to prevent the wheel from locking, or a pressure “decrease” control.

As the wheel cylinder pressure decreases, the wheel speed starts increasing (or the wheel acceleration rate starts rising). When the wheel acceleration rate exceeds threshold “$+b_{10}$” (at point “C” of the pressure curve), the ABSCM makes a pressure “hold” control. When the wheel acceleration rate exceeds threshold “$+b_{20}$” (at point “D” of the pressure curve), the ABSCM recognizes that wheel lock-up will not occur and then makes a pressure “increase” control.

When the wheel acceleration rate drops below threshold “$+b_{20}$”, (at point “E” of the pressure curve), the ABSCM starts pressure “hold” and “increase” control cycles at a given interval.
When the wheel deceleration rate then exceeds threshold “$-b_0$” (at point “F” of the pressure curve), the ABSCM immediately makes a pressure “decrease” control.



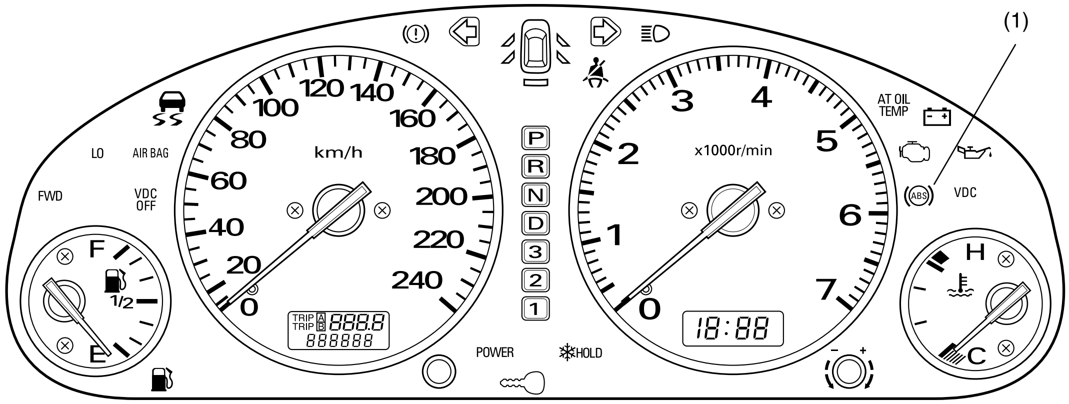

B4H2239B

| Brake fluid Pressure | Inlet valve | Outlet valve |
|---|---|---|
| Increase | OFF | OFF |
| Hold | ON | OFF |
| Decrease | ON | ON |

## G: ABS WARNING LIGHT

When a fault occurs in the signal transmission system or the ABSCM, the ABS warning light in the combination meter comes on. At the same time, the current to the hydraulic control unit is interrupted. The brake system then functions in the same manner as a system without ABS. The warning light utilizes a dual circuit design.

If the warning light comes on, one or more trouble codes should be stored in the control module. They must be identified using the warning light's code indicating function.

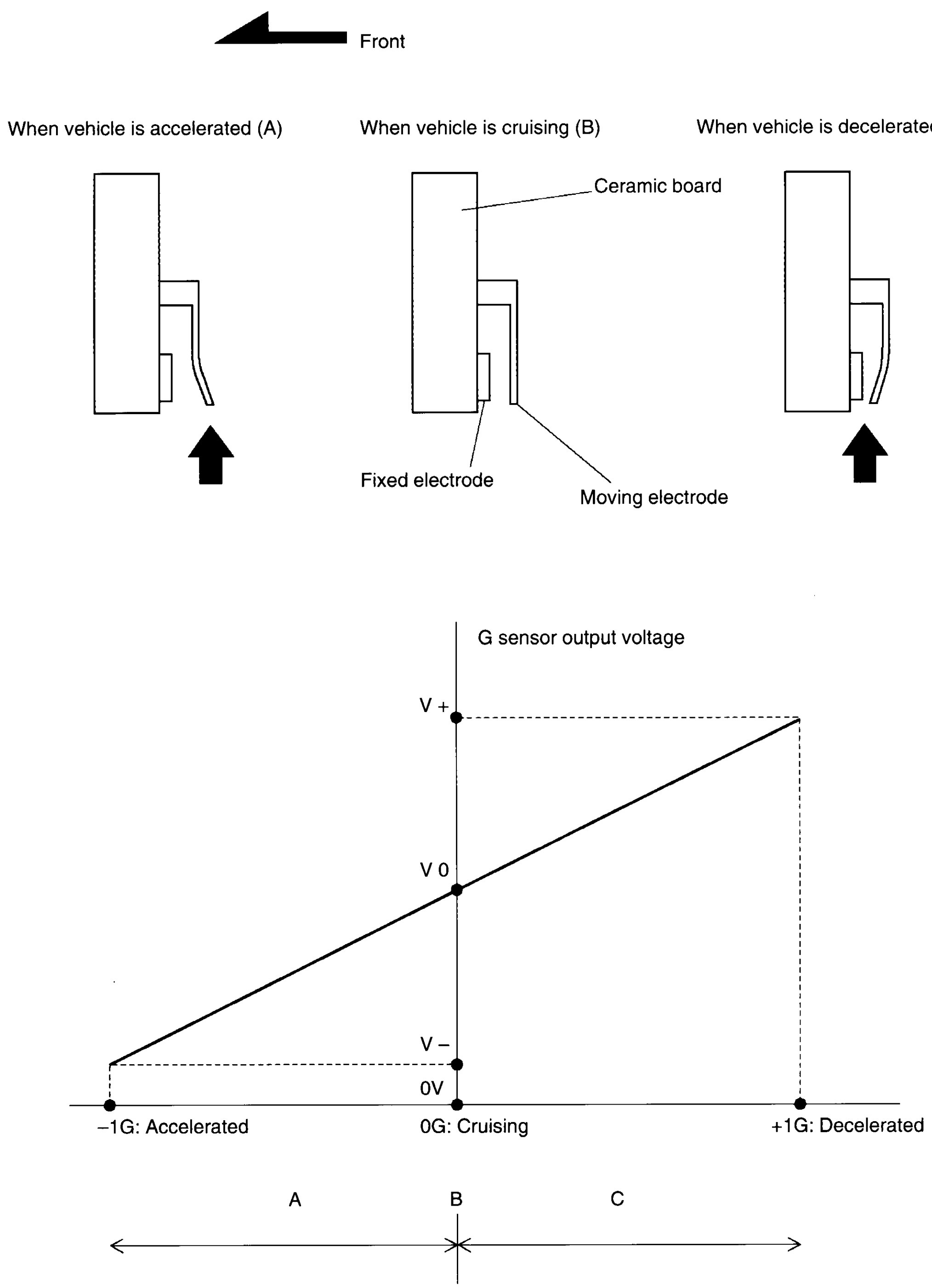



(1) ABS warning light

## H: G SENSOR

The G sensor detects changes in the vehicle's acceleration/deceleration rate in the longitudinal direction.

The moving electrode of a capacitor in the sensor moves away from or close to the fixed electrode as the vehicle accelerates or decelerates and the resulting change in the capacitance of the capacitor is outputs to the ABSCM as a change in the voltage.




G Sensor Output Characteristics

B4H0988

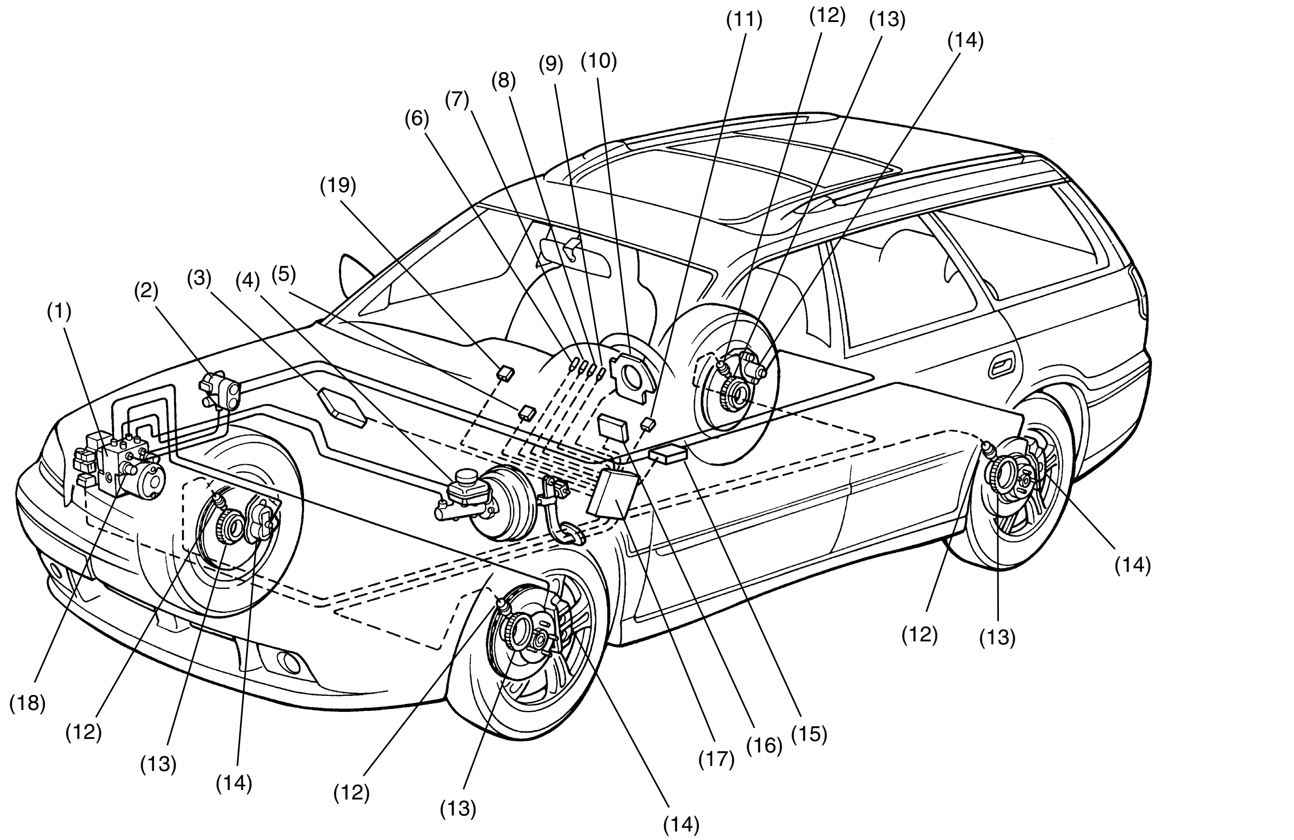
# VDC VDC

Page

# 1. Vehicle Dynamics Control (VDC) System

## A: OUTLINE

The vehicle dynamics control (VDC) system is a driver assist system which enhances vehicle's running stability by utilizing the anti-lock brake system (ABS) and traction control system (TCS) functions in combination with its own function which reduces sudden changes in vehicle behavior that are likely to occur when travelling on a slippery road or quickly avoiding an obstacle on the road.

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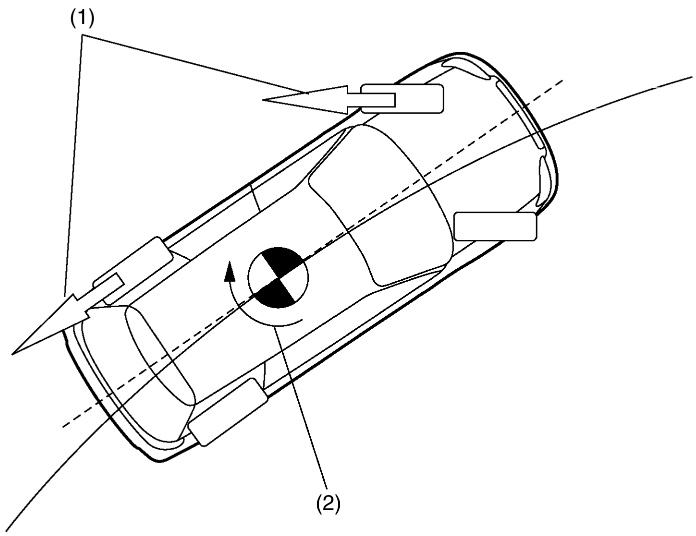
| | | | | | |
|---|---|---|---|---|---|
| (1) | VDC hydraulic control unit | (8) | VDC operating indicator light | (15) | Yaw-rate and lateral G sensor |
| (2) | Proportioning valve | (9) | VDC OFF indicator light | (16) | Automatic transmission control module |
| (3) | Engine control module | (10) | Steering angle sensor | (17) | VDC control module |
| (4) | Master cylinder | (11) | Data link connector (for SUBARU select monitor) | (18) | Pressure sensor |
| (5) | Diagnosis connector | (12) | ABS sensor | (19) | VDC OFF switch |
| (6) | ABS warning light | (13) | Tone wheel | | |
| (7) | VDC warning light | (14) | Wheel cylinder | | |

## B: OPERATION PRINCIPLE OF VDC

### 1. OVERSTEER SUPPRESSION

When the vehicle starts to spin during cornering, the VDC control module (VDCCM) actuates the brakes on the front and rear outer wheels. As a result, a force that counteracts the oversteer-causing yaw moment is generated so that the vehicle's behavior is stabilized.



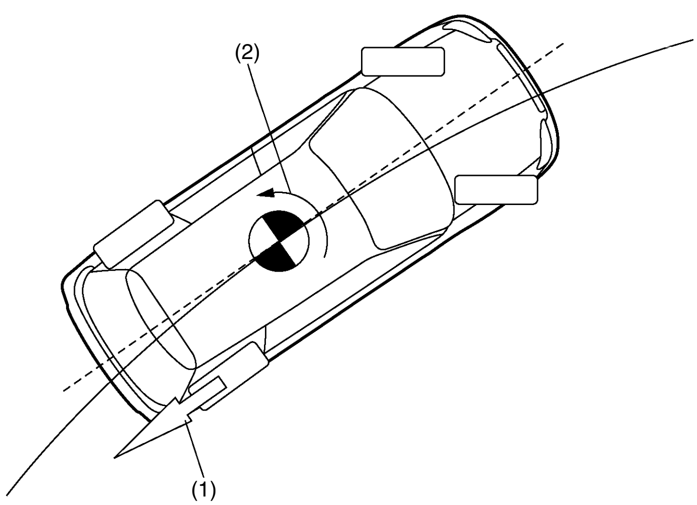

B4H1634B

(1) Braking force

(2) Oversteer-causing yaw moment

### 2. UNDERSTEER SUPPRESSION

When the vehicle starts to drift outward during cornering, the VDCCM causes the rear inner wheel to be braked. As a result, a force that counteracts the understeer-causing yaw moment is generated so that the vehicle's behavior is stabilized.




B4H1635B

(1) Braking force

(2) Understeer-causing yaw moment

## C: FUNCTIONS USED IN VEHICLE’S BEHAVIOR STABILIZATION CONTROL

| | |
|---|---|
| VDC function | The VDC control module (VDCCM) determines the driver’s intention from the data provided by the steering angle sensor, braking pressure sensor, engine-related sensors and other relevant sources and recognizes the result as the target vehicle behavior. At the same time, it determines the vehicle’s actual behavior from the data provided by the yaw-rate sensor, lateral G sensor, ABS sensor and other relevant sources. Then, the module compares the target and actual vehicle behaviors to estimate how the vehicle is running (whether it understeers, oversteers, slips or is in other condition), and based on the result, performs braking control of individual wheels, engine output control and AWD control as necessary to correct the vehicle’s running condition. |
| TCS function | The TCS constantly receives signals from the relevant sensors to monitor the vehicle speed. When the running wheels slip exceeding a certain limit, it performs braking control of individual wheels, engine output control and AWD control as required to maintain optimal traction and adequate side force. |
| ABS function | The ABS constantly receives signals from the relevant sensors to monitor the vehicle speed. When the slip of wheels during braking exceeds a certain limit, it performs braking control of individual wheels and AWD control as required to maintain optimal traction and adequate side force. |

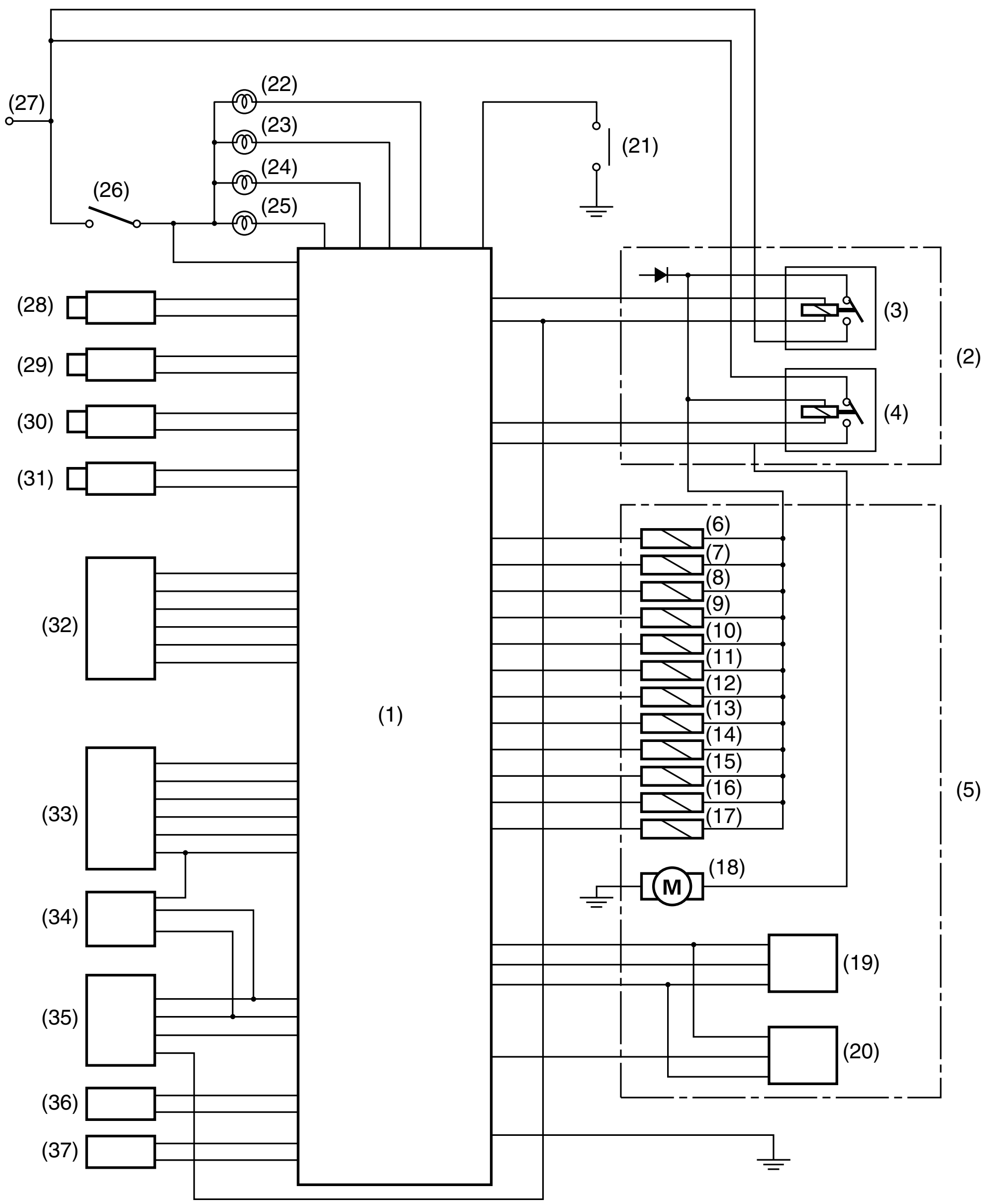
NOTE:

- “Braking control” is effected by the VDCCM as follows:
The VDCCM calculates the required braking force for each wheel and sends signals to the VDC hydraulic unit. The hydraulic unit’s motor pump is then operated to generate the required hydraulic pressure. Further, it controls the hydraulic unit’s solenoid valves to increase, maintain or decrease the hydraulic pressure applied to the brake wheel cylinder as required.
When the brakes are applied by the driver, however, the braking force is controlled by the hydraulic pressure resulting from the driver’s action.
- “Engine output control” is effected by the VDCCM as follows:
The VDCCM calculates the target engine output for each condition, and compares it with the current engine output. Based on the result of comparison, it determines the number of cylinders for which fuel injection is to be stopped and sends a command to the engine control module. The targeted engine output is then achieved.
- “AWD control” is effected by the VDCCM as follows:
When necessary, the VDCCM sends a command to the automatic transmission control module. According to the command, the transmission control module controls the transfer clutch so that the torque is distributed between the front and rear axles optimally.

## D: SYSTEM COMPONENTS AND FUNCTIONS

| | |
|---|---|
| VDCCM | ● Determines the vehicle's running condition from various sensor signals and, based on the result, controls the VDC hydraulic control unit, ABS and TCS as required.<br>● Performs CAN communication with the automatic transmission control module and the steering angle sensor.<br>● Causes the system to stop and the warning light to illuminate if a fault occurs in a circuit of the electrical system. Stores the code that indicates the location of the fault. |
| VDC Hydraulic Control Unit (VDCH/U) | Actuates the pump motor in response to a command from the VDCCM and changes fluid passages using solenoid valves to control the hydraulic pressures applied to the wheel cylinders. |
| Steering angle sensor | Detects the steering direction and angle when the steering wheel is operated by the driver and outputs signals corresponding to them to the VDCCM. |
| Yaw-rate and lateral G sensor | Detects the yaw-rate and lateral G of the vehicle and outputs it to the VDCCM. |
| Pressure sensor | Detects the hydraulic pressure resulting from driver's brake pedal operation and outputs it to the VDCCM. |
| ABS sensor (wheel speed sensor) | Detects the speed of each wheel and outputs it to the VDCCM. |
| Tone wheel | Causes changes in magnetic flux density as its teeth move to enable the ABS sensor to detect the wheel speed. |
| Engine Control Module (ECM) | Controls the engine output in response to commands from the VDCCM. Further, it transmits current engine output and engine speed signals to the VDCCM. |
| Automatic transmission control module | Controls the transfer clutch in response to commands from the VDCCM during VDC control, ABS control or TCS control so that torque is distributed optimally between the front and rear axles. |
| ABS warning light | Alerts the driver to an ABS fault. |
| VDC warning light | Alerts the driver to a VDC or TCS fault. |
| VDC operating indicator light | Blinks when the VDC is operating or lights steadily when the TCS is operating. |
| VDC OFF indicator light | Illuminates to tell the driver that the VDC and TCS are inactive (not due to a system failure). |
| VDC OFF switch | ● Allows the driver to temporarily disengage VDC control.<br>● In "temporarily disengaged" status, the VDC OFF indicator light illuminates. |

NOTE:
CAN (Controller Area Network) communication refers to bidirectional multiplex high-speed communication.




B4H2542A

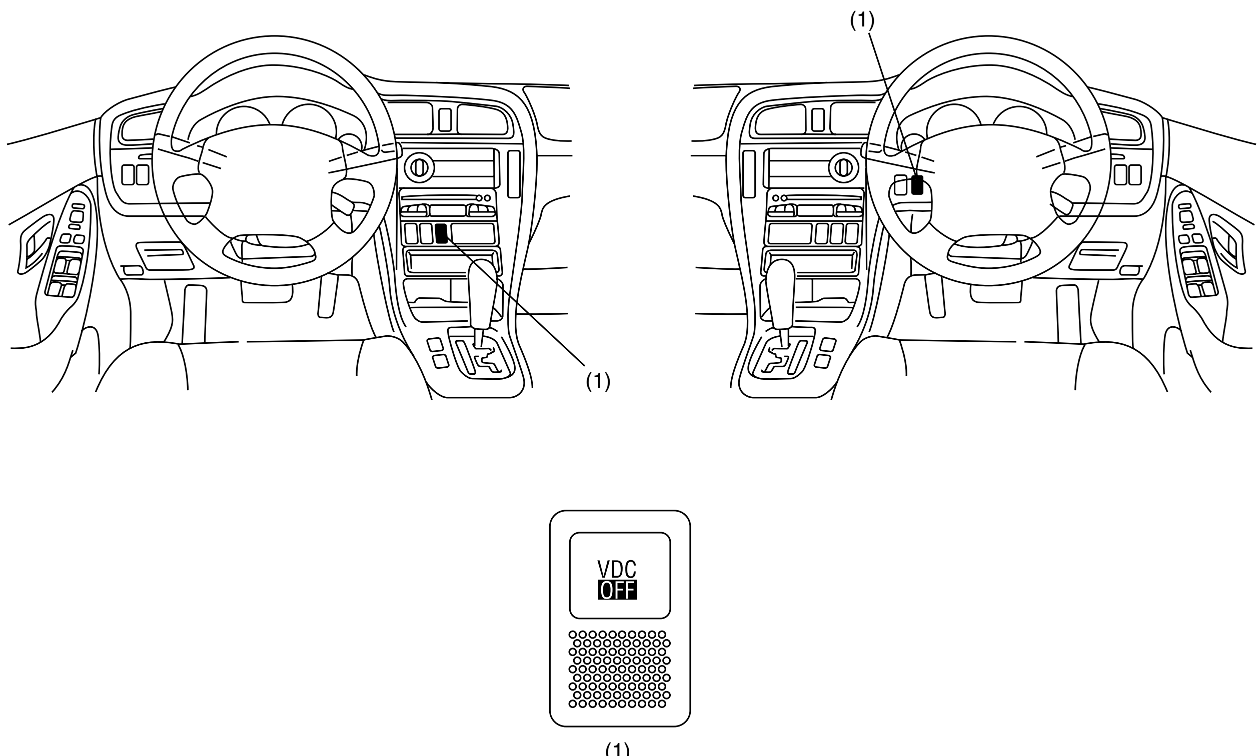
(1) VDC control module
(2) Relay box
(3) Valve relay
(4) Motor relay
(5) Hydraulic control unit
(6) Front left inlet solenoid valve
(7) Front left outlet solenoid valve
(8) Front right inlet solenoid valve
(9) Front right outlet solenoid valve
(10) Rear left inlet solenoid valve
(11) Rear left outlet solenoid valve
(12) Rear right inlet solenoid valve
(13) Rear right outlet solenoid valve
(14) Primary suction solenoid valve
(15) Primary cut solenoid valve
(16) Secondary suction solenoid valve
(17) Secondary cut solenoid valve
(18) Pump motor
(19) Primary pressure sensor
(20) Secondary pressure sensor
(21) VDC OFF switch
(22) ABS warning light
(23) VDC warning light
(24) VDC operating indicator light
(25) VDC OFF indicator light
(26) Ignition relay
(27) BATTERY
(28) Front left ABS sensor
(29) Front right ABS sensor
(30) Rear left ABS sensor
(31) Rear right ABS sensor
(32) Yaw-rate and lateral G sensor
(33) Engine control module
(34) Automatic transmission control module
(35) Steering angle sensor
(36) Diagnosis connector
(37) Data link connector

## E: VDC OFF SWITCH

A switch which allows the driver to temporarily disengage VDC control is added.
In some occasions, better results are obtained by cancelling the VDC to allow the drive wheels to slip for a certain amount:

- When starting the vehicle on icy or unpaved, steep uphill roads.
- When escaping from mud or snow when the wheels are caught in them.

- When the VDC OFF switch is pressed while the engine is running, the VDC OFF indicator light in the combination meter illuminates, and VDC control is temporarily disengaged.
When the VDC OFF switch is pressed again, the VDC OFF indicator light turns off and the system returns to “engaged” status. (“Temporarily disengaged” status and “engaged” status are altered each time the switch is pressed.)
- The VDC control “temporarily disengaged” status automatically returns to “engaged” status when the vehicle speed exceeds 60 km/h (38 MPH). (VDC control cannot be temporarily disengaged at vehicle speeds higher than 60 km/h (38 MPH).
- If the VDC OFF switch is pressed and held for more than 10 seconds, the VDC OFF indicator light in the combination meter turns off. The system will not allow further opereation of the switch until the engine is started for the next time.




B4H0565A

(1) VDC OFF switch

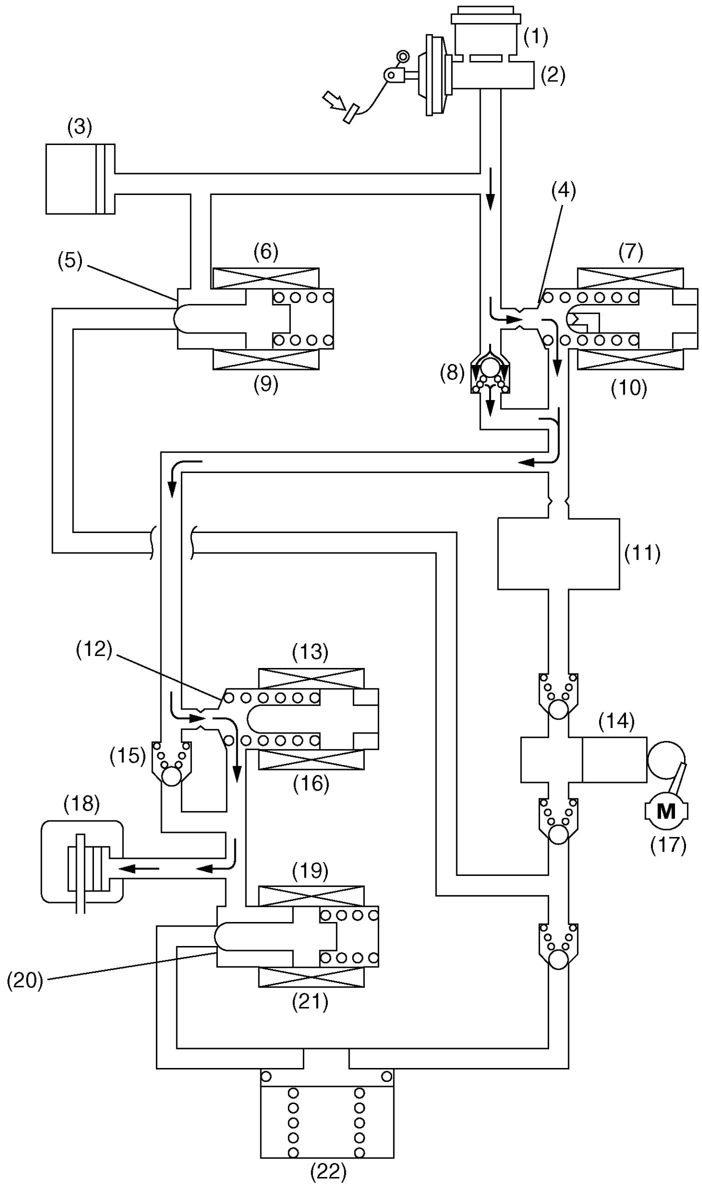
## F: OPERATION OF VDC HYDRAULIC CONTROL UNIT (VDCH/U)

### 1. DURING NORMAL BRAKING

No solenoid valves are energized. The ports of the inlet solenoid valve and cut solenoid valve are open, while the ports of the outlet solenoid valve and suction solenoid valve are closed.

In this state, the fluid pressure generated by the master cylinder can be applied to the wheel cylinder through the open ports of the cut solenoid valve and inlet solenoid valve.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.




B4H1637B

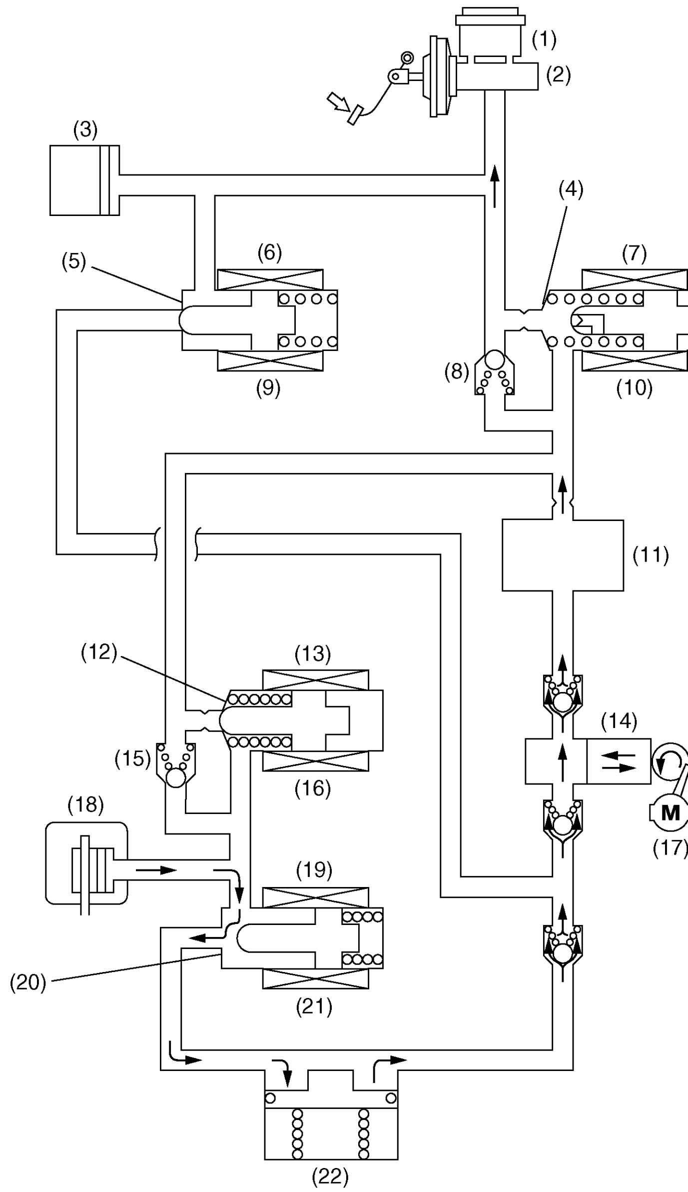
| | | | | | |
|---|---|---|---|---|---|
| (1) | Reservoir tank | (9) | De-energized | (17) | Motor |
| (2) | Master cylinder | (10) | De-energized | (18) | Wheel cylinder |
| (3) | Pressure sensor | (11) | Damper chamber | (19) | Outlet solenoid valve |
| (4) | Port open | (12) | Port open | (20) | Port closed |
| (5) | Port closed | (13) | Inlet solenoid valve | (21) | De-energized |
| (6) | Suction solenoid valve | (14) | Pump | (22) | Reservoir |
| (7) | Cut solenoid valve | (15) | Check valve | | |
| (8) | Check valve | (16) | De-energized | | |

## 2. PRESSURE "DECREASE" CONTROL WITH BRAKE PEDAL DEPRESSED

The inlet solenoid valve and outlet solenoid valve are energized, while the other solenoid valves are not energized. This means that the ports of the inlet solenoid valve and suction solenoid valve are closed, while those of the outlet solenoid valve and cut solenoid valve are open.

Although the fluid pressure generated by the master cylinder can reach the inlet solenoid valve through the open port of the cut solenoid valve, the pressurized fluid cannot go further since the passage is blocked there. On the other hand, since the port of the outlet solenoid valve is open, the brake fluid in the wheel cylinder can flow out into the reservoir. The fluid pressure in the wheel cylinder decreases as a result. The brake fluid in the reservoir is pumped back into the master cylinder.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.




| | | | | | |
|---|---|---|---|---|---|
| (1) | Reservoir tank | (9) | De-energized | (17) | Motor |
| (2) | Master cylinder | (10) | De-energized | (18) | Wheel cylinder |
| (3) | Pressure sensor | (11) | Damper chamber | (19) | Outlet solenoid valve |
| (4) | Port open | (12) | Port closed | (20) | Port open |
| (5) | Port closed | (13) | Inlet solenoid valve | (21) | Energized |
| (6) | Suction solenoid valve | (14) | Pump | (22) | Reservoir |
| (7) | Cut solenoid valve | (15) | Check valve | | |
| (8) | Check valve | (16) | Energized | | |

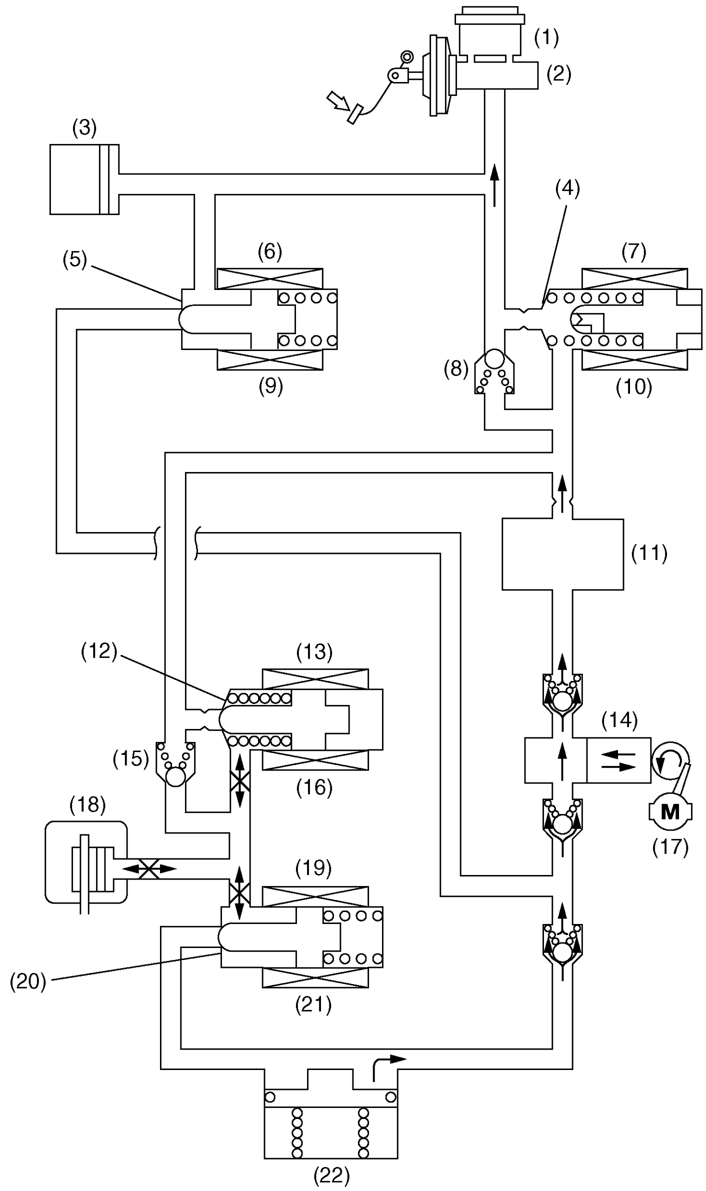
### 3. PRESSURE “HOLD” CONTROL WITH BRAKE PEDAL DEPRESSED

Only the inlet solenoid valve is energized. This means that the ports of the inlet solenoid valve, outlet solenoid valve and suction solenoid valve are all closed except that of the cut solenoid valve.

In this state, the fluid pressure generated by the master cylinder is transmitted through the open port of the cut solenoid valve to the inlet solenoid valve but not beyond the inlet solenoid valve since the passage is blocked there. As the port of the outlet solenoid valve is also closed, the fluid pressure in the wheel cylinder is held unreleased.

The pump is always operated whenever commanded by the VDCCM.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.



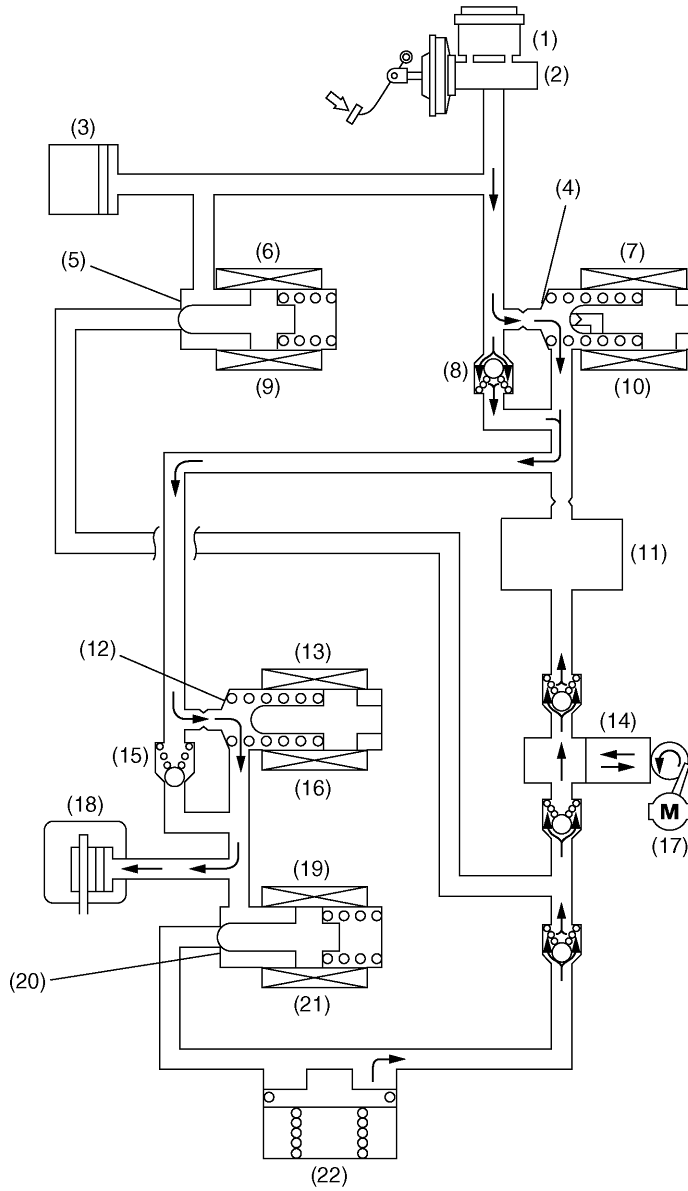

| | | |
|---|---|---|
| (1) Reservoir tank | (9) De-energized | (17) Motor |
| (2) Master cylinder | (10) De-energized | (18) Wheel cylinder |
| (3) Pressure sensor | (11) Damper chamber | (19) Outlet solenoid valve |
| (4) Port open | (12) Port closed | (20) Port closed |
| (5) Port closed | (13) Inlet solenoid valve | (21) De-energized |
| (6) Suction solenoid valve | (14) Pump | (22) Reservoir |
| (7) Cut solenoid valve | (15) Check valve | |
| (8) Check valve | (16) Energized | |

## 4. PRESSURE “INCREASE” CONTROL WITH BRAKE PEDAL DEPRESSED

No solenoid valves are energized. This means that the ports of the inlet solenoid valve and cut solenoid valve are open, while those of the outlet solenoid valve and suction solenoid valve are closed.

In this state, the fluid pressure generated by the master cylinder is transmitted to the wheel cylinder through the open ports of the cut solenoid valve and inlet solenoid valve, applying the brake with an increased force. The pump is always operated whenever commanded by the VDCCM.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.



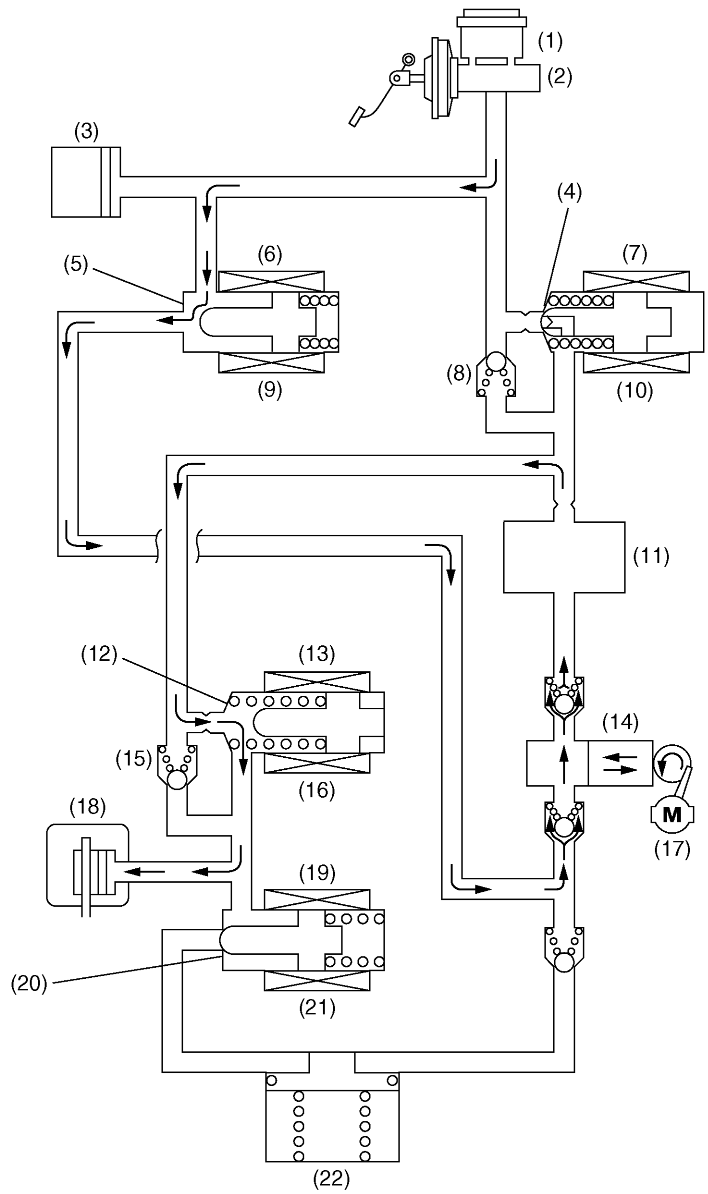

| | | | | | |
|---|---|---|---|---|---|
| (1) | Reservoir tank | (9) | De-energized | (17) | Motor |
| (2) | Master cylinder | (10) | De-energized | (18) | Wheel cylinder |
| (3) | Pressure sensor | (11) | Damper chamber | (19) | Outlet solenoid valve |
| (4) | Port open | (12) | Port open | (20) | Port closed |
| (5) | Port closed | (13) | Inlet solenoid valve | (21) | De-energized |
| (6) | Suction solenoid valve | (14) | Pump | (22) | Reservoir |
| (7) | Cut solenoid valve | (15) | Check valve | | |
| (8) | Check valve | (16) | De-energized | | |

## 5. PRESSURE “INCREASE” CONTROL WITH BRAKE PEDAL NOT DEPRESSED

The cut solenoid valve and suction solenoid valve are energized while the other solenoid valves are not energized. This means that the ports of the cut solenoid valve and outlet solenoid valve are closed, while those of the inlet solenoid valve and suction solenoid valve are open.

In this state, the pump is activated, forcing the brake fluid in the master cylinder reservoir tank into the wheel cylinder through the open port of the suction solenoid valve and then through the open port of the inlet solenoid valve. The brake is then applied with an increased force.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.




B4H1641B

| | | | | | |
|---|---|---|---|---|---|
| (1) | Reservoir tank | (9) | Energized | (17) | Motor |
| (2) | Master cylinder | (10) | Energized | (18) | Wheel cylinder |
| (3) | Pressure sensor | (11) | Damper chamber | (19) | Outlet solenoid valve |
| (4) | Port closed | (12) | Port open | (20) | Port closed |
| (5) | Port open | (13) | Inlet solenoid valve | (21) | De-energized |
| (6) | Suction solenoid valve | (14) | Pump | (22) | Reservoir |
| (7) | Cut solenoid valve | (15) | Check valve | | |
| (8) | Check valve | (16) | De-energized | | |

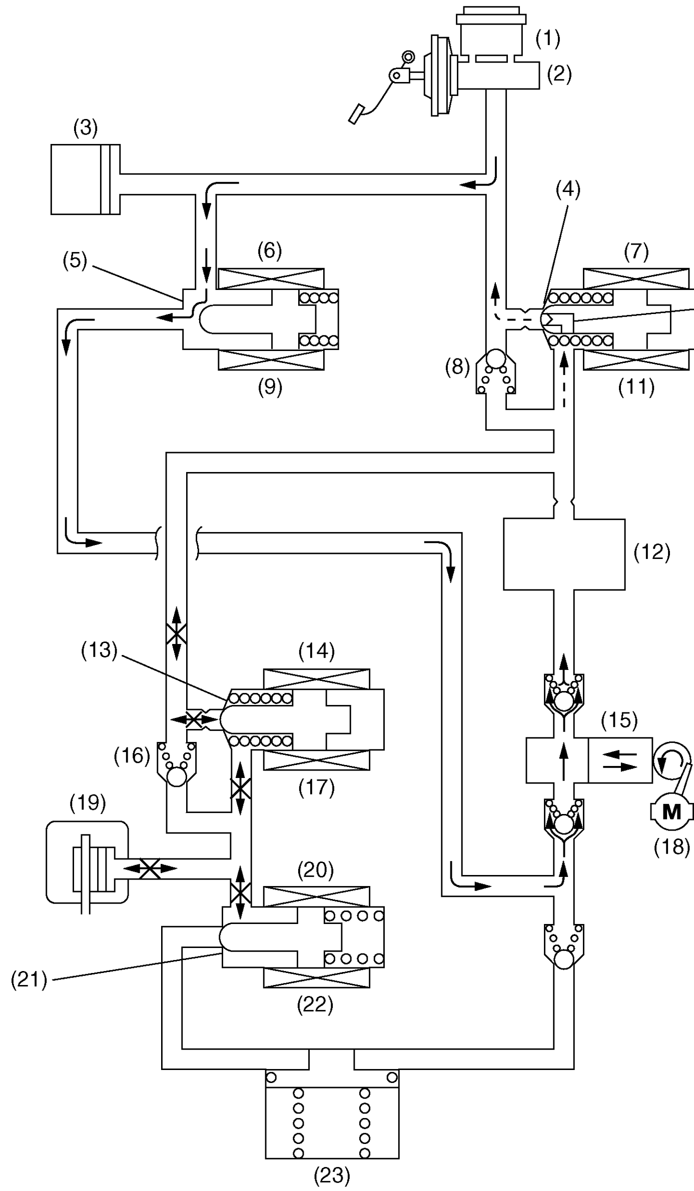
## 6. PRESSURE “HOLD” CONTROL WITH BRAKE PEDAL NOT DEPRESSED

The cut solenoid valve, suction solenoid valve and inlet solenoid valve are all energized, while the outlet solenoid valve is de-energized. This means that the ports of the cut solenoid valve, inlet solenoid valve and outlet solenoid valve are closed, while the port of the suction solenoid valve is open.

In this state, the pump is activated, forcing the brake fluid in the master cylinder reservoir tank through the open port of the suction solenoid valve. The fluid passage is, however, blocked by the closed inlet solenoid valve. Since the port of the outlet solenoid valve is also closed, the fluid pressure in the wheel cylinder is held unreleased.

The fluid pressure generated by the pump becomes higher and higher because the port of the inlet solenoid valve is closed. When it reaches a certain level, the built-in relief valve of the cut solenoid valve opens and allows the brake fluid to return into the master cylinder reservoir tank.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.




B4H1642B

| | | | | | |
|---|---|---|---|---|---|
| (1) | Reservoir tank | (9) | Energized | (17) | Energized |
| (2) | Master cylinder | (10) | Relief valve | (18) | Motor |
| (3) | Pressure sensor | (11) | Energized | (19) | Wheel cylinder |
| (4) | Port closed | (12) | Damper chamber | (20) | Outlet solenoid valve |
| (5) | Port open | (13) | Port closed | (21) | Port closed |
| (6) | Suction solenoid valve | (14) | Inlet solenoid valve | (22) | De-energized |
| (7) | Cut solenoid valve | (15) | Pump | (23) | Reservoir |
| (8) | Check valve | (16) | Check valve | | |

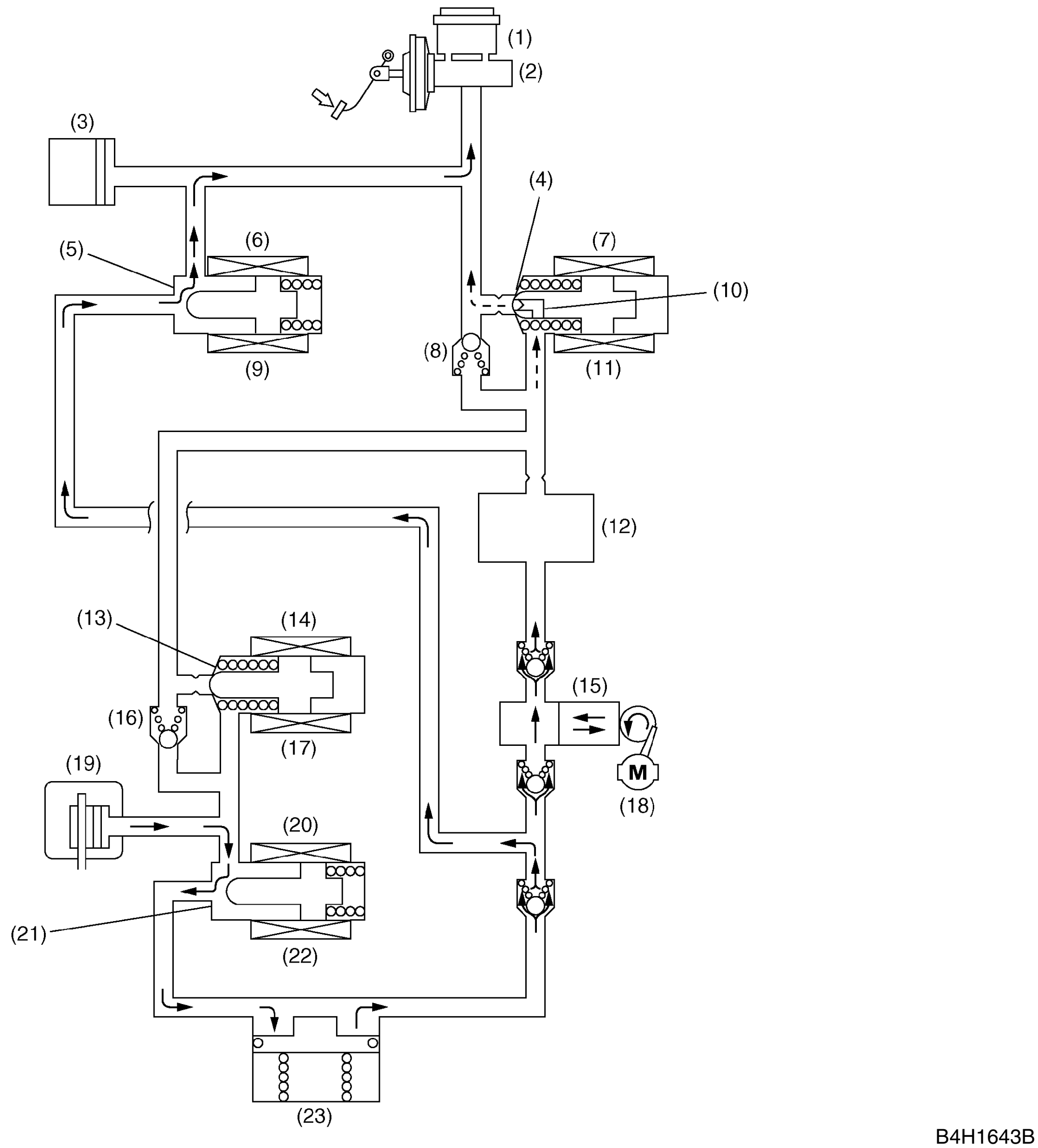
## 7. PRESSURE “DECREASE” CONTROL WITH BRAKE PEDAL NOT DEPRESSED

The cut solenoid valve, suction solenoid valve, inlet solenoid valve and outlet solenoid valve are all energized. This means that the ports of the cut solenoid valve and inlet solenoid valve are closed, while those of the suction and outlet solenoid valves are open.

In this state, the pump is activated drawing the brake fluid from the reservoir and forcing it toward the master cylinder through the open port of the suction solenoid valve. The fluid passage is blocked by the inlet solenoid valve, so the fluid cannot flow toward the wheel cylinder. Since the port of the outlet solenoid valve is open, on the other hand, the brake fluid in the wheel cylinder is allowed to be drawn into the reservoir, so the fluid pressure in the wheel cylinder decreases. The brake fluid drawn into the reservoir is raised from it and forced into the master cylinder reservoir tank through the suction solenoid valve.

The pressure of the fluid in the passage toward the cut solenoid valve becomes higher and higher as the pump operates since the valve is closed. When the pressure reaches a certain level, the build-in relief valve of the cut solenoid valve opens, releasing the brake fluid into the master cylinder reservoir tank.

NOTE:
For simplicity of explanation, operation of the hydraulic control unit is represented by operation of a single wheel circuit.




| | | | | | |
|---|---|---|---|---|---|
| (1) | Reservoir tank | (9) | Energized | (17) | Energized |
| (2) | Master cylinder | (10) | Relief valve | (18) | Motor |
| (3) | Pressure sensor | (11) | Energized | (19) | Wheel cylinder |
| (4) | Port closed | (12) | Damper chamber | (20) | Outlet solenoid valve |
| (5) | Port open | (13) | Port closed | (21) | Port open |
| (6) | Suction solenoid valve | (14) | Inlet solenoid valve | (22) | Energized |
| (7) | Cut solenoid valve | (15) | Pump | (23) | Reservoir |
| (8) | Check valve | (16) | Check valve | | |

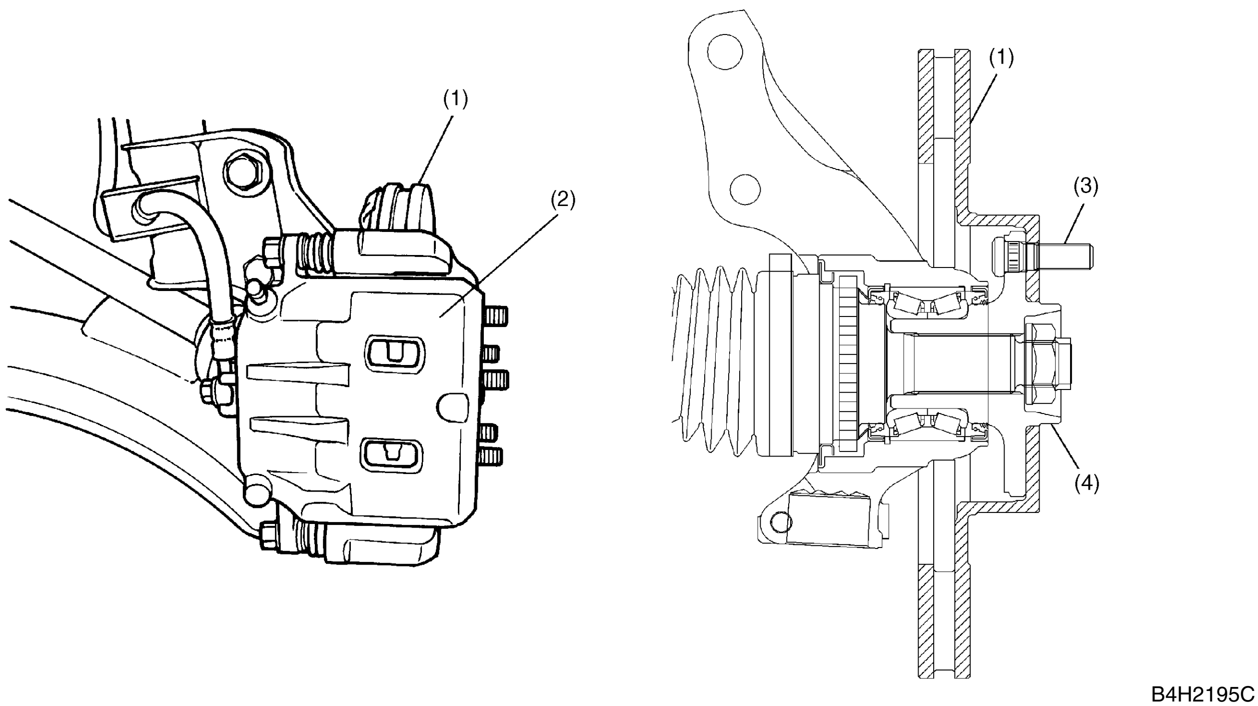
MEMO

# BRAKES BR

Page

# 1. Front and Rear Disc Brakes

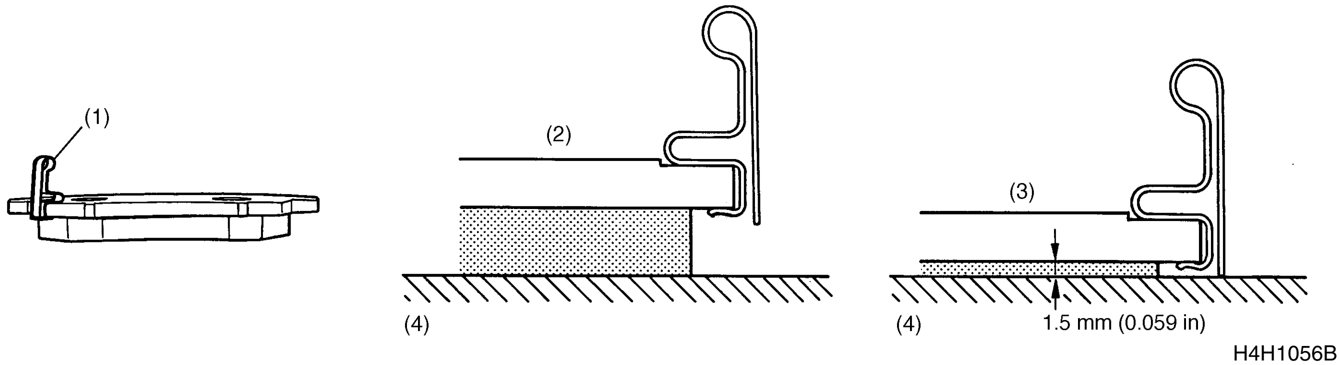
- The front disc brakes are of a ventilated disc type which features high heat dissipation and superb braking stability. In addition, the front brakes quickly restores their original braking performance even when they get wet.
- The rear brakes are disc brakes.
- Each disc rotor, which is fitted on the outside of the hub, is secured together with the wheel using the hub bolts. This facilitates its removal and installation.
- The inner brake pad is provided with a wear indicator.




(1) Disc rotor
(2) Caliper body
(3) Hub bolt
(4) Hub

## A: PAD WEAR INDICATOR

A wear indicator is provided on the inner disc brake pads. When the pad wears down to 1.5 mm (0.059 in) the tip of the wear indicator comes into contact with the disc rotor, and makes a squeaking sound as the wheel rotates. This alerts the driver to the situation.




(1) Wear indicator
(2) New pad
(3) Worn pad
(4) Disc rotor

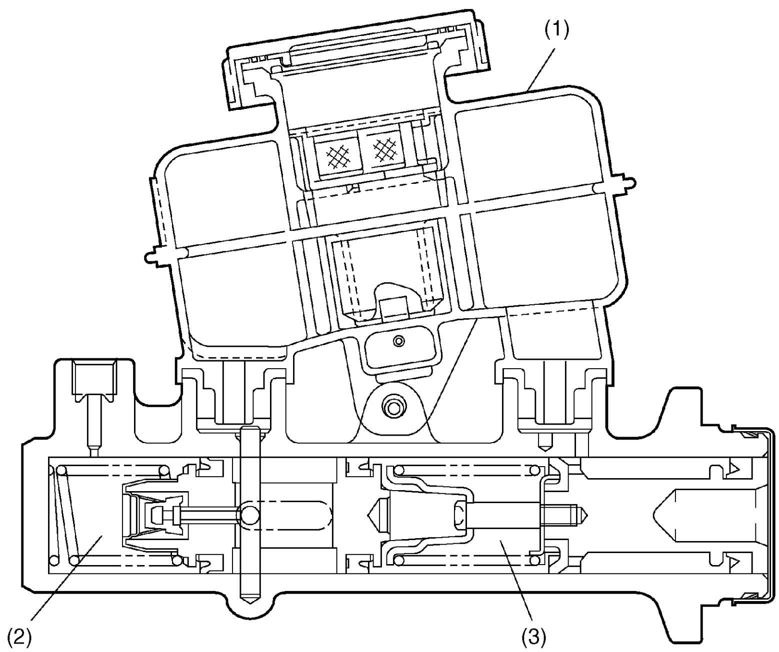
## B: FRICTIONAL MATERIAL OF BRAKE PADS

The brake pads materials do not contain any asbestos which is harmful to human body.

## 2. Master Cylinder

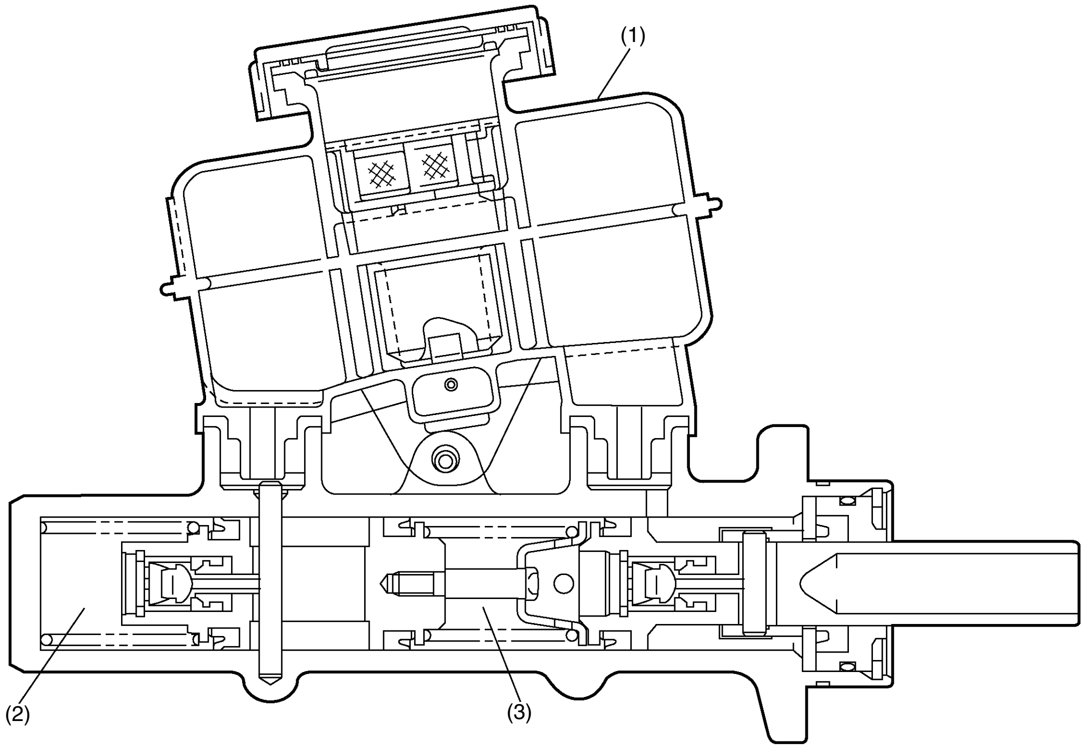
● There is a brake fluid reservoir tank on the master cylinder. The reservoir is completely sealed for extended service life of the brake fluid.

### ABS model




(1) Reservoir tank
(2) Secondary hydraulic chamber (chamber S)
(3) Primary hydraulic chamber (chamber P)

## VDC model

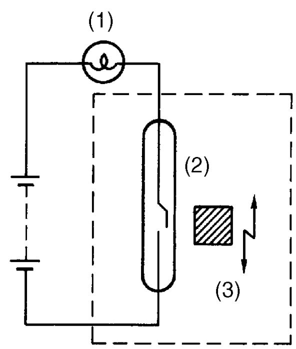



(1) Reservoir tank
(2) Secondary hydraulic chamber (chamber S)
(3) Primary hydraulic chamber (chamber P)

## A: BRAKE FLUID LEVEL SWITCH

The brake fluid level switch is located inside the brake fluid reservoir tank and causes the brake system warning light on the combination meter to come on when the fluid level has dropped below the predetermined level.

The switch assembly consists of a reed switch (normally open) and a permanent magnet that is incorporated in a float.
When the brake fluid level is normal, the float is far above the reed switch, so the force of the magnet is unable to act on the reed switch. The warning light circuit, therefore, remains open.
When the brake fluid level drops to a level approximately 30 mm (1.18 in) below the maximum level and the float lowers accordingly, the magnet aligns with the reed switch, activating the reed switch contact. The warning light then comes on to warn the driver of the situation.
The warning light may, although momentarily, illuminate even when the brake fluid level is normal if the vehicle tilts or swing largely.

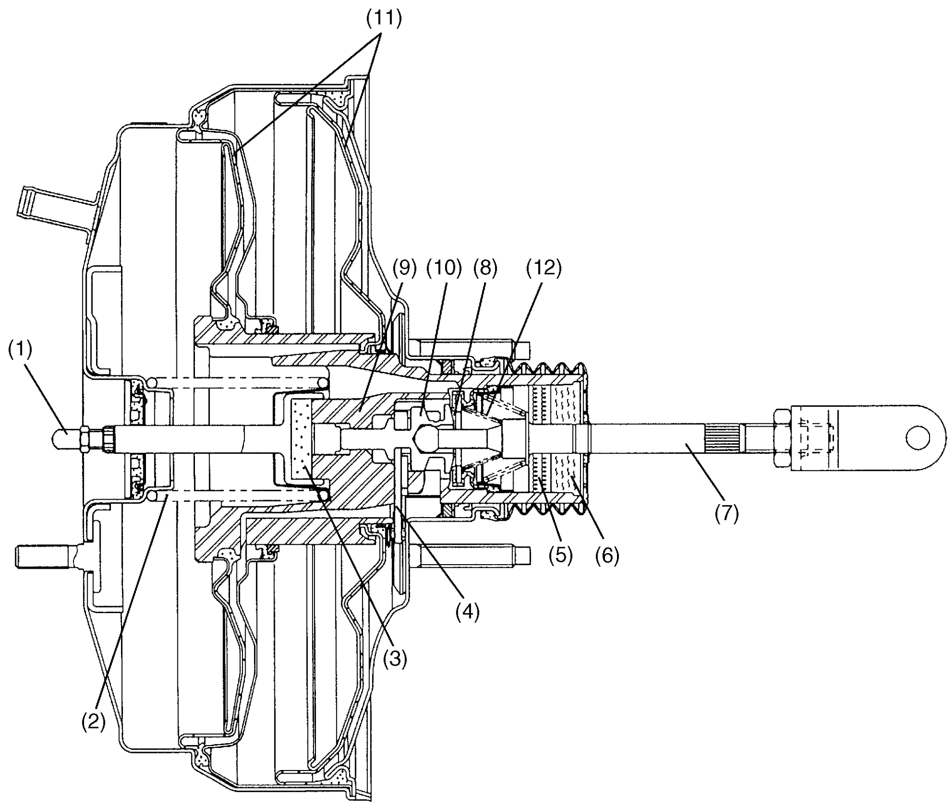



S4H0341A

(1) Warning light (2) Reed switch (3) Permanent magnet

# 3. Brake Booster

- The brake booster is a tandem type that uses two diaphragms. This design provides high brake boosting effects in spite of a reduced diameter.
- All models are equipped with an 8 inch + 9 inch booster.

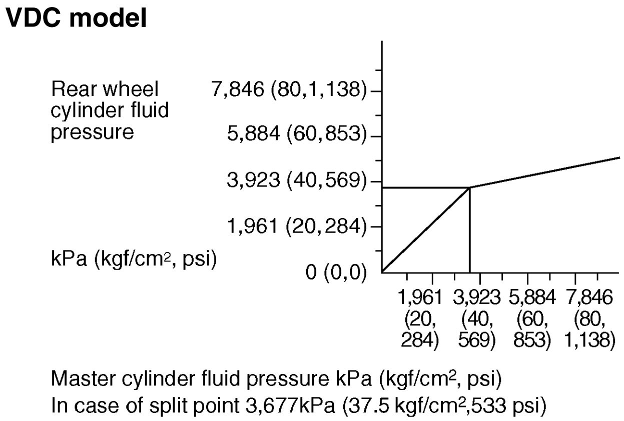



B4H1936A

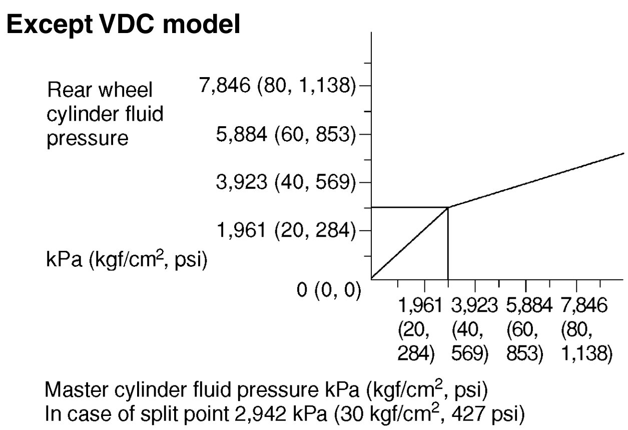
| | | | | | |
|---|---|---|---|---|---|
| (1) | Push rod | (5) | Filter | (9) | Valve body |
| (2) | Return spring | (6) | Silencer | (10) | Plunger valve |
| (3) | Reaction disc | (7) | Operating rod | (11) | Diaphragm plate |
| (4) | Key | (8) | Poppet valve | (12) | Valve return spring |

# 4. Proportioning Valve

The proportioning valve prevents the rear wheels from locking and resultant skidding that would occur during hard braking due to transfer of vehicle weight toward the front wheels. The valve distributes a reduced pressure to the rear wheel brakes as compared with the pressure to the front wheel brakes when a specified master cylinder fluid pressure (called “split point”) is exceeded as shown in the diagrams below.




B4H2221C



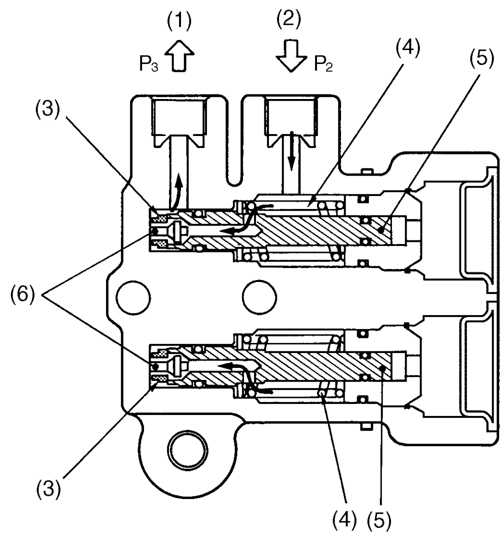

B4H1942B

## A: OPERATION

1) Operation before the split point

The piston is held pressed toward the left by the spring so that the valve is kept away from its seat.

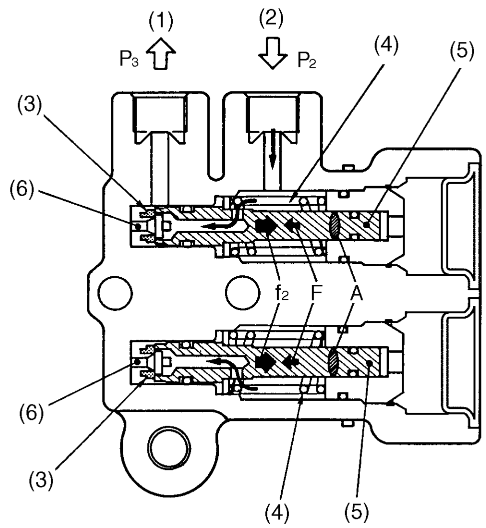
Under this condition, fluid pressure “$P_3$” to the rear wheel cylinders is equal to fluid pressure “$P_2$” from the master cylinder.




| | |
|---|---|
| (1) To rear wheel cylinder | (4) Spring |
| (2) From master cylinder | (5) Piston |
| (3) Seat | (6) Valve |

2) Operation at the split point pressure

When pressure “$P_2$” increases to the split point pressure, force “$f_2$” is generated. (Piston’s cross sectional area “A” has been selected so that the force is generated starting with the split point pressure.) The pressure pushes the piston rightward, overcoming spring force “F”. As a result, the valve seat moves together with the piston rightward and comes in contact with the valve, blocking the passage toward the rear wheel cylinders.




H4H1399B

(1) To rear wheel cylinder
(2) From master cylinder
(3) Seat
(4) Spring
(5) Piston
(6) Valve

3) Operation after reaching the split point pressure

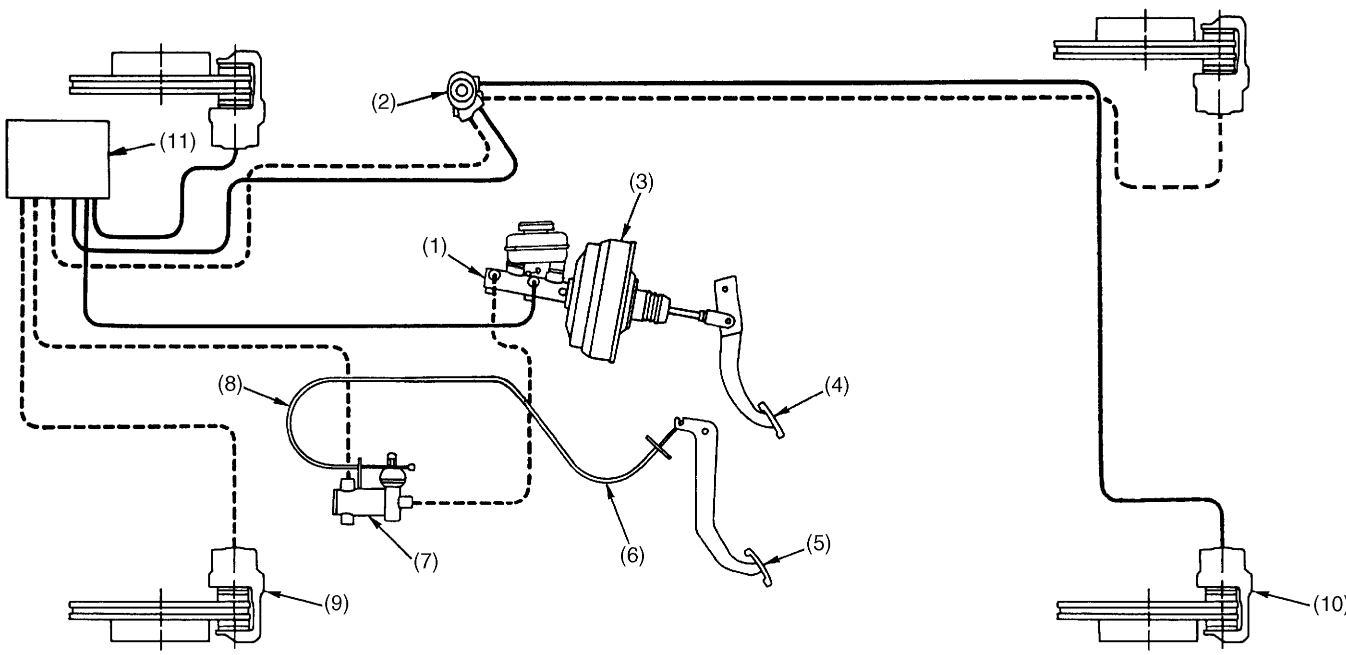
Immediately before the fluid passage toward the rear wheel cylinders is closed, pressure “$P_2$” is slightly higher than pressure “$P_3$”. So the piston can move in the spring force acting direction and the fluid can flow to the wheel cylinders. However, as soon as pressure “$P_2$” becomes equal to “$P_3$”, the valve closes.

This cycle is repeated as long as the pedal is depressed further, but pressure increasing rate of the rear wheel cylinders is smaller than that of the front wheel cylinders.

# 5. Hill Holder

The hill holder is a device that facilitates starting on an uphill road. With the help of this device, even an unexperienced driver can start the vehicle smoothly.

When starting the vehicle on an uphill road, the driver depresses the clutch pedal while keeping the brake pedal depressed and then releases the brake pedal. At this time the hill holder keeps the brakes still applied until the clutch pedal is released. This enables the driver to start the vehicle in a usual manner by depressing the accelerator while releasing the clutch pedal without being troubled by brake pedal operation.

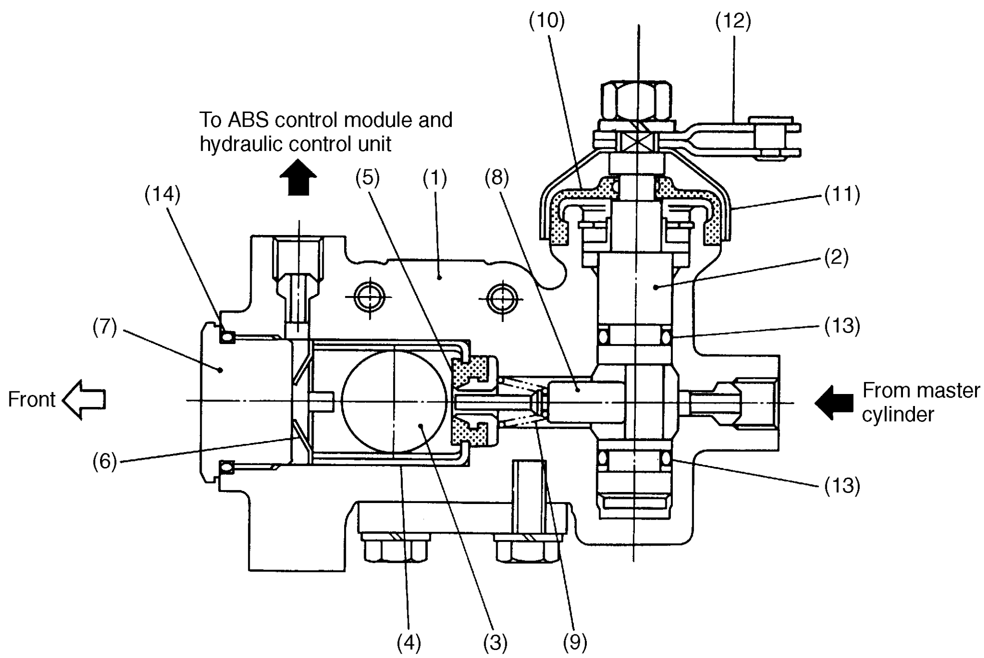



B4H1629A

| | | | | | |
|---|---|---|---|---|---|
| (1) | Master cylinder | (5) | Clutch pedal | (9) | Front brake |
| (2) | Proportioning valve | (6) | Clutch cable | (10) | Rear brake |
| (3) | Brake booster | (7) | Pressure hold valve | (11) | ABS control module/ hydraulic control unit |
| (4) | Brake pedal | (8) | Pressure hold valve (PHV) cable | | |

## A: PRESSURE HOLD VALVE (PHV)

- The PHV is located on the piping that connects the master cylinder and the ABS control module/ hydraulic control unit. It has a camshaft which turns either way by rotation of the lever which is linked to the clutch pedal. The cam of the crankshaft allows the pushrod in the PHV to move rightward (in the drawing below) under the force of a spring when the clutch pedal is depressed and pushes it leftward against the force of the spring when the clutch pedal is released. At the left of the pushrod, there is a ball housed in a chamber which has a seat for the ball. When the vehicle is on a level road, this ball stays at the left (front) of the chamber, but on an uphill road, it tends to move rightward by the gravity. In the latter case, the ball makes contact with the seat unless it is forced to leave the seat by a leftward movement of the pushrod (resulting from release of the clutch pedal).
- When the vehicle is stopped on an uphill road, the driver depresses both the brake and clutch pedals. In this condition, the ball is in the rear (right) position, making contact with its seat and preventing flow of the brake fluid toward the master cylinder. The driver then release the brake pedal while keeping the clutch pedal depressed to restart the vehicle. The brakes, however, remains applied because the pressure in the line to the wheel cylinders is kept unreleased. Then, the driver can release the clutch pedal in the same way as with on a level road while depressing the accelerator pedal since the release of the clutch pedal causes the pushrod to push the ball away from its seat and the brakes are released.

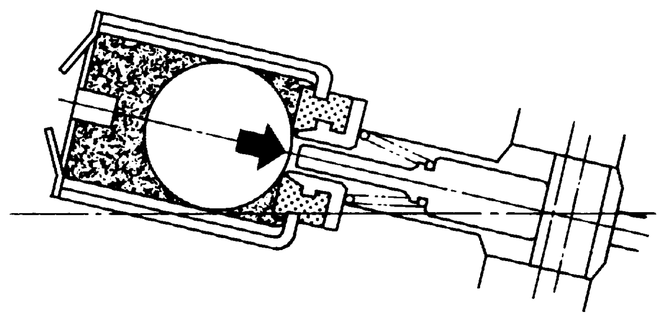



| | | | | | |
|---|---|---|---|---|---|
| (1) | Body | (6) | Plate spring | (11) | Cover |
| (2) | Camshaft | (7) | Cap | (12) | Lever |
| (3) | Ball | (8) | Pushrod | (13) | O-ring |
| (4) | Ball guide | (9) | Spring | (14) | O-ring |
| (5) | Seal | (10) | Boot | | |

## 1. CONDITIONS IN WHICH THE HILL HOLDER OPERATES

The hill holder operates only when the clutch and brake pedals are depressed with the vehicle stopped on an uphill road.

In this condition, the PHV's ball blocks the fluid passage back to the master cylinder and, therefore, the hydraulic pressure in the wheel cylinder circuits is maintained even after the brake pedal has been released as long as the clutch pedal is held depressed.



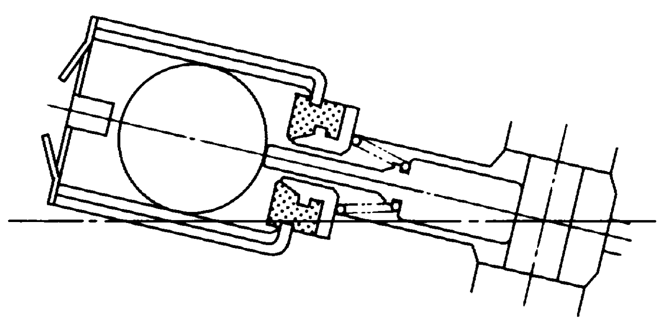
G4H0057

## 2. CONDITIONS IN WHICH THE HILL HOLDER DOES NOT OPERATE

The hill holder does not operate in the following conditions:

● During acceleration and constant speed driving on an uphill road

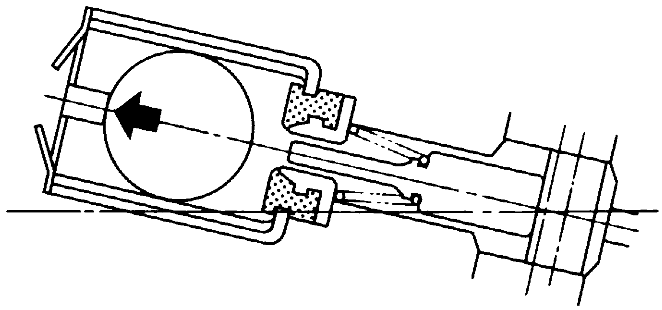
Since driver does not depress the clutch pedal during acceleration or driving at a constant speed, the pushrod keeps the ball away from the seat. The hill holder cannot maintain the pressure in the wheel cylinder circuits when the brake pedal is released.



G4H0058

- During deceleration on an uphill road

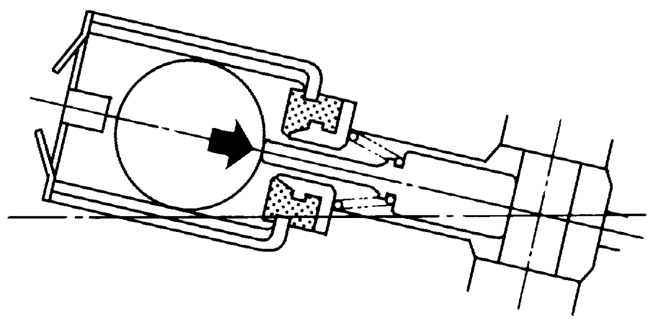
Even if the clutch pedal is depressed during deceleration, the ball is kept away from the seat by the inertia force. So, the hill holder cannot maintain the wheel cylinder circuit pressure.



G4H0059

- When stopping on an uphill road without depressing the clutch pedal

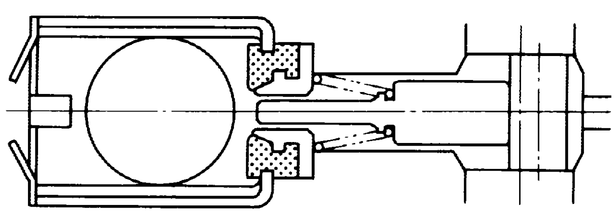
If the driver does not depress the clutch pedal simultaneously with the brake pedal when stopping the vehicle on an uphill road, the hill holder cannot keep the wheel cylinder circuit pressure unreleased when the brake pedal is release.



G4H0060

- On a level road

The ball does not move itself toward its seat except when the vehicle is braked during reversing, so the hill holder does not function during level road driving.



G4H0061

## B: OPERATIONAL PRECAUTIONS

- The hill holder is a device that facilitates starting on an uphill road. When stopping on an uphill road, therefore, the driver must keep the brake pedal depressed or set the parking brake firmly.
- The hill holder may not function on a slope with a small angle of inclination.
- If the brake force is insufficient to hold the vehicle after releasing the brake pedal with the clutch pedal depressed, depress the brake pedal again with a stronger force.
- If the clutch pedal is released halfway and then depressed again (for example, when the driver abandons an attempt of start or changes gear to the low gear from another improperly selected gear), the pressure in the wheel is not retained any more. The driver, therefore, must depress the brake pedal again to use the hill holder function next time.
- Before leaving the vehicle, the driver must apply firmly the parking brake and confirm that the vehicle does not move after releasing the clutch pedal.
- When reversing on a level road, the phenomena listed below may occur. These phenomena are caused by activation of the hill holder and do not mean an abnormality.
    - Braking effect continues when the vehicle is reversed with the clutch and brake pedals depressed and then the brake pedal released.
    - A slight shock occurs in the vehicle when moving the vehicle forward after a reverse movement.

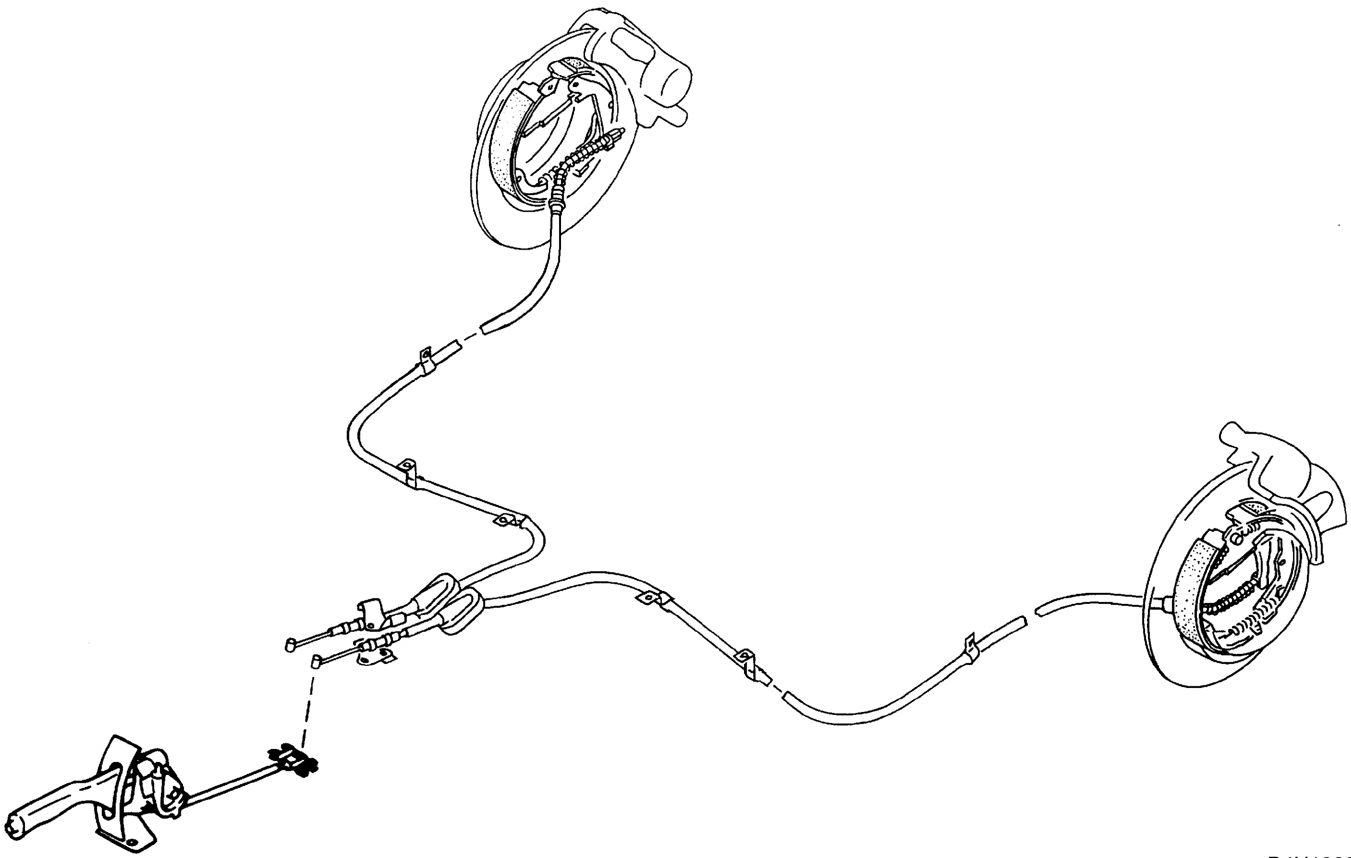
## MEMO

# PARKING BRAKE PB

Page

# 1. Parking Brake

The parking brake uses a drum housed in the disc rotor of each rear disc brake. The shoes are mechanically controlled through linkage and cables.



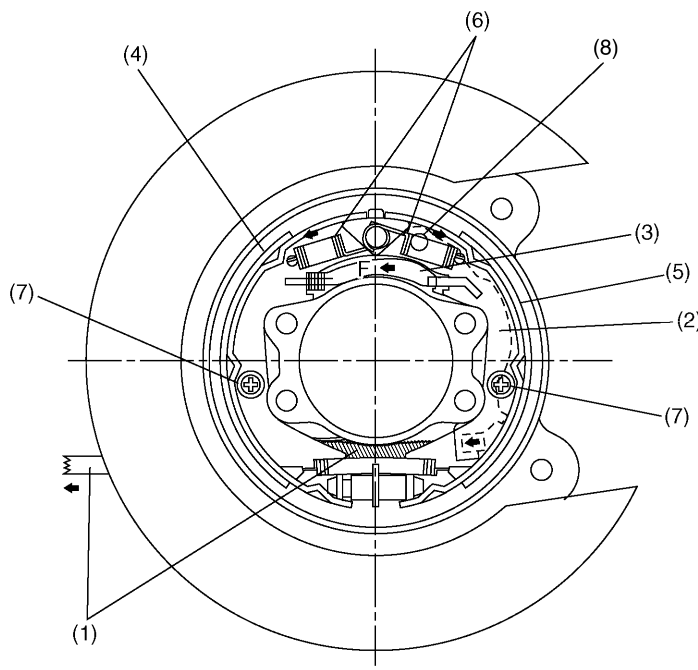
B4H1939

## A: OPERATION

### 1. SETTING

When the parking brake lever is pulled, the shoe actuating lever to which the end of the parking brake cable is connected turns the strut in direction “F” around point “P”.

The strut then presses the brake shoes A and B against the drum. These brake shoes utilize a floating design and are movably supported by hold-down pins. The force applied to brake shoe A and the reaction force “F” applied to the brake shoe B via point “P” press them against the brake drum.

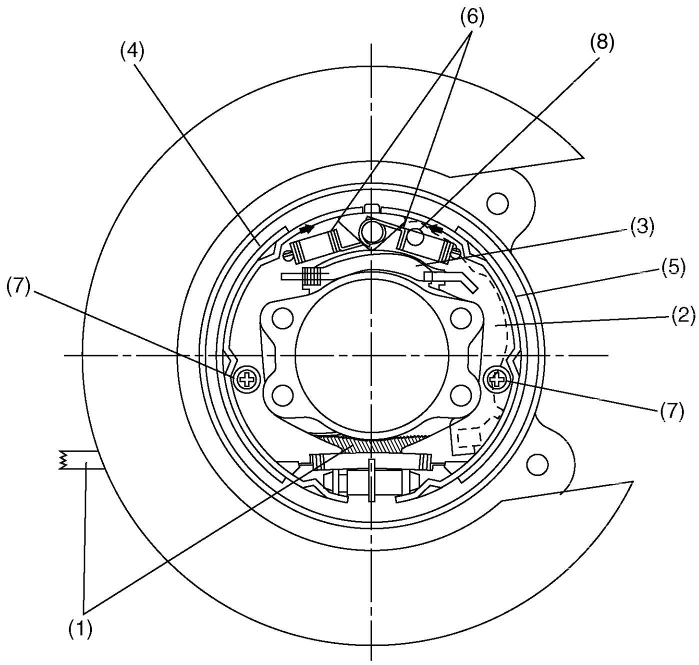



B4H1940B

(1) Parking brake cable
(2) Lever
(3) Strut
(4) Brake shoe A
(5) Brake shoe B
(6) Shoe return spring
(7) Shoe hold down pin
(8) Point “P”

## 2. RELEASING

When the parking brake lever is returned to the release position and the parking brake cables are slackened, the brake shoes A and B are moved back to their original positions by the tension of return springs, so that the parking brake is released.




| | |
|---|---|
| (1) Parking brake cable | (5) Brake shoe B |
| (2) Lever | (6) Shoe return spring |
| (3) Strut | (7) Shoe hold down pin |
| (4) Brake shoe A | (8) Point “P” |

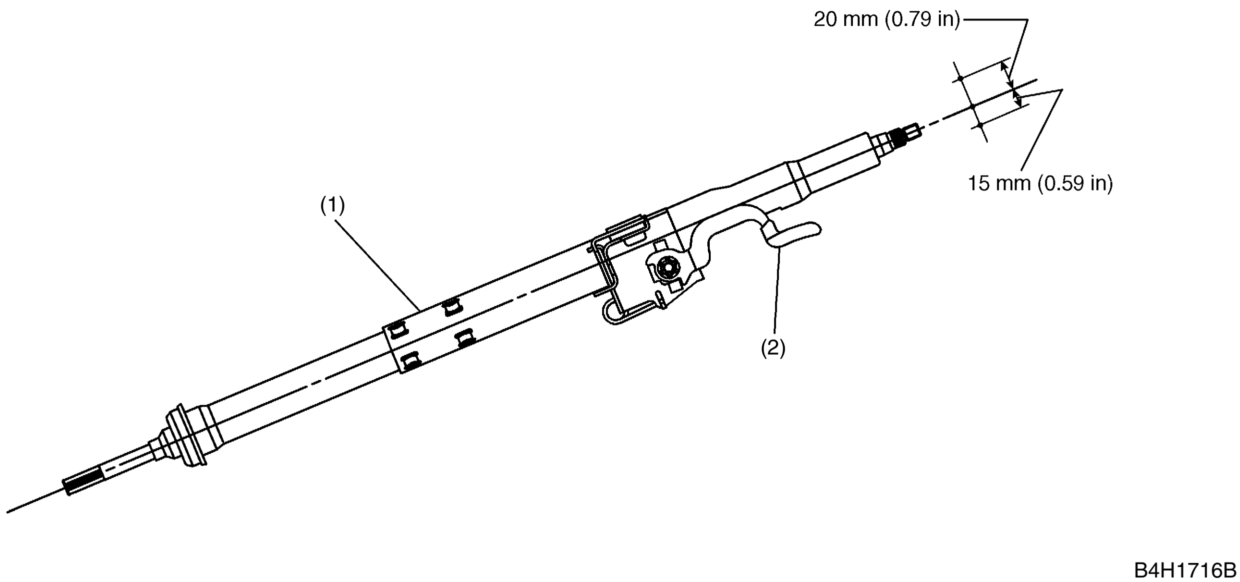
# POWER ASSISTED SYSTEM (POWER STEERING)

# PS

# 1. Tilt Steering Column

## A: TILT MECHANISM

- The steering wheel vertical position can be adjusted within a 35 mm (1.38 in) range by using the tilt lever to unlock the steering column and lock it again at the desired position.



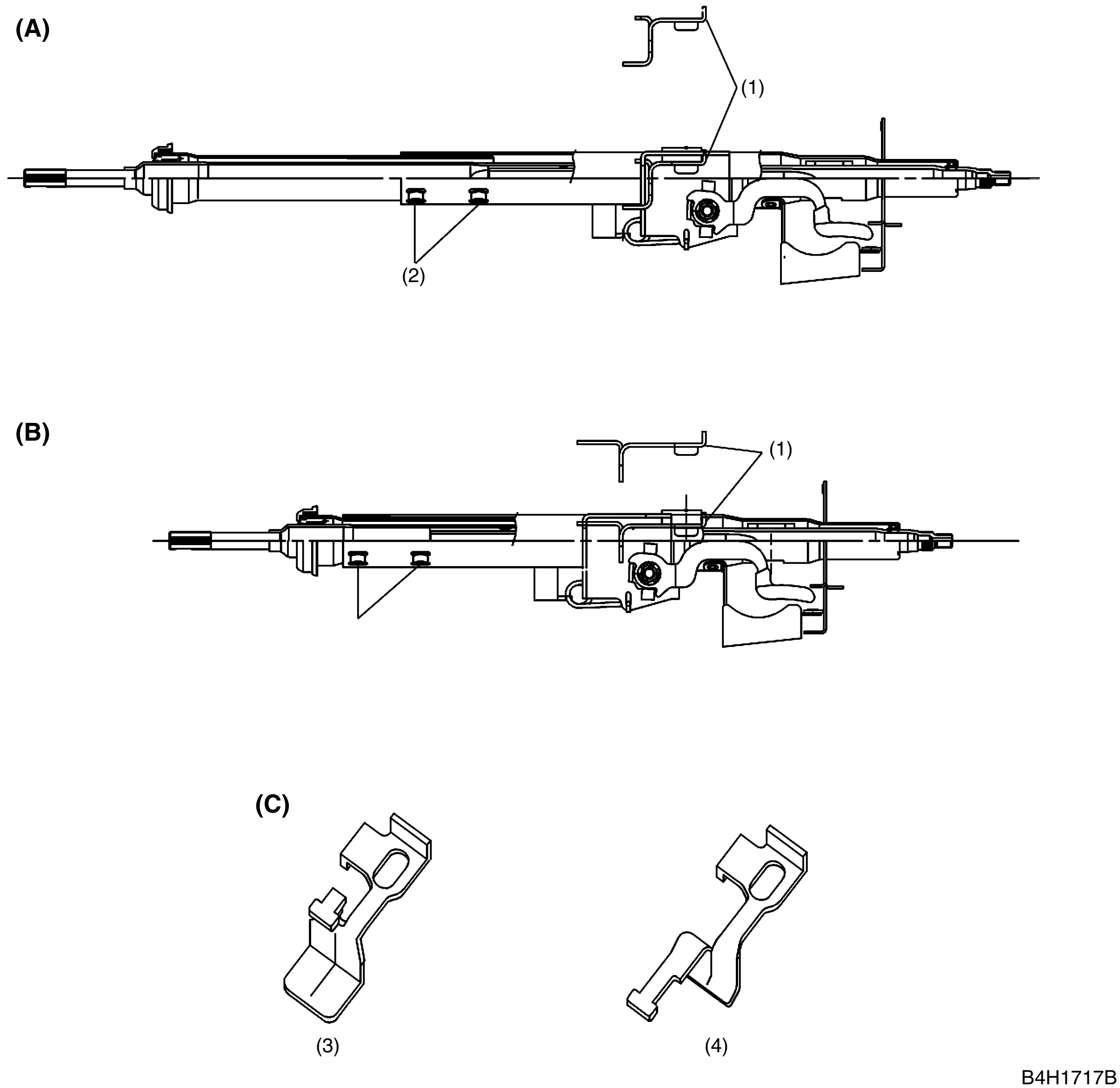

(1) Tilt steering column

(2) Tilt lever

## B: ENERGY-ABSORBING MECHANISM

● To absorb the backward movement energy generated in the engine in the event of a frontal collision, an elliptical fitting type steering column pipe has been adopted. When an impact load exceeding a certain level is applied to the steering column, the elliptical fittings crash and their ends come in contact with each other. The column bending load is supported by the fittings.

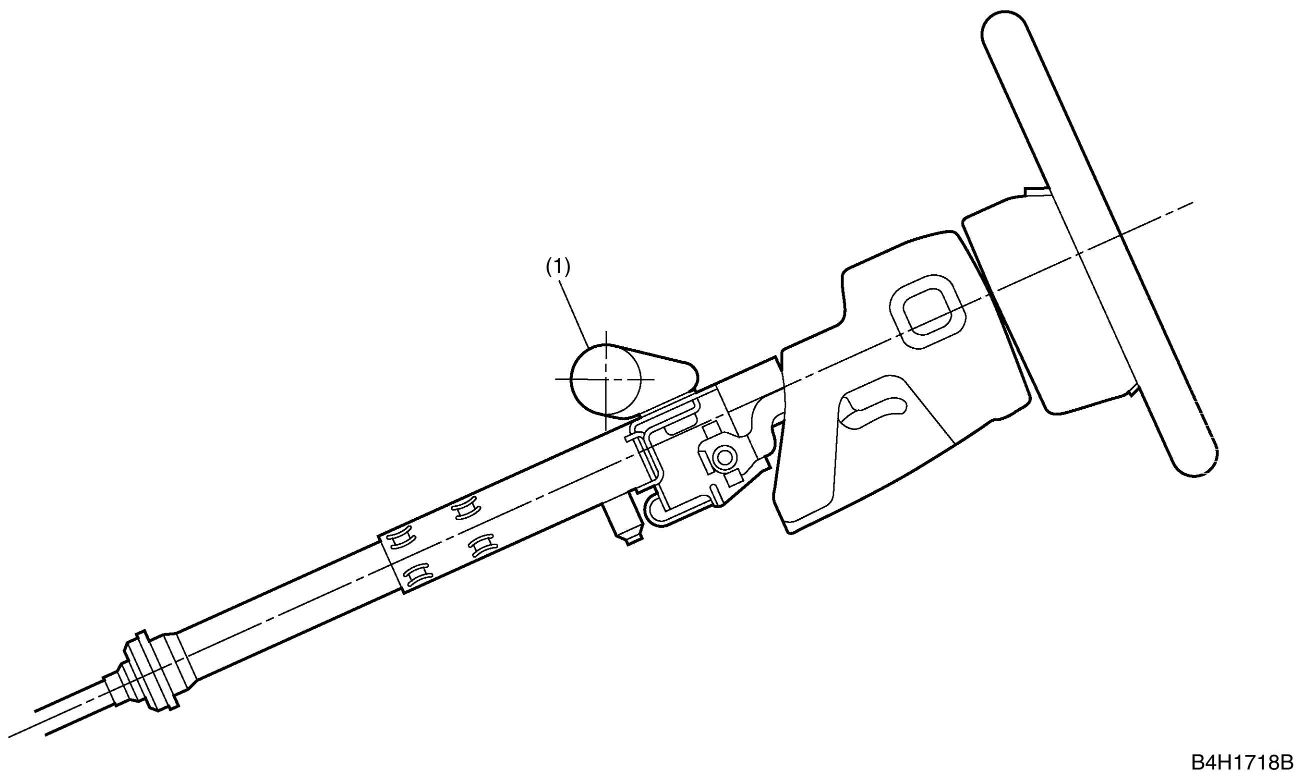
● Another measure to alleviate impact on the driver in the event of a collision is the ripping plate which is located between the steering column and the tilt bracket attached to the steering support beam. When a large impact load is applied to the steering column, the ripping plate is deformed and torn progressively. The impact energy is absorbed during this process.




| | | | |
|---|---|---|---|
| **(A)** | Before absorption of impact energy | (1) | Ripping plate |
| **(B)** | After absorption of impact energy | (2) | Elliptical fitting |
| **(C)** | Ripping plate | (3) | Before ripping |
| | | (4) | After ripping |

## C: STEERING SUPPORT BEAM

The steering column is held in position by a support beam which is installed crosswise in the vehicle body at a level close to the steering wheel to reduce the overhang distance of the steering wheel from the supporting point of the column. The steering shaft upper bearing is also located close to the steering wheel to increase supporting efficiency as well as to minimize vibration of the steering wheel.



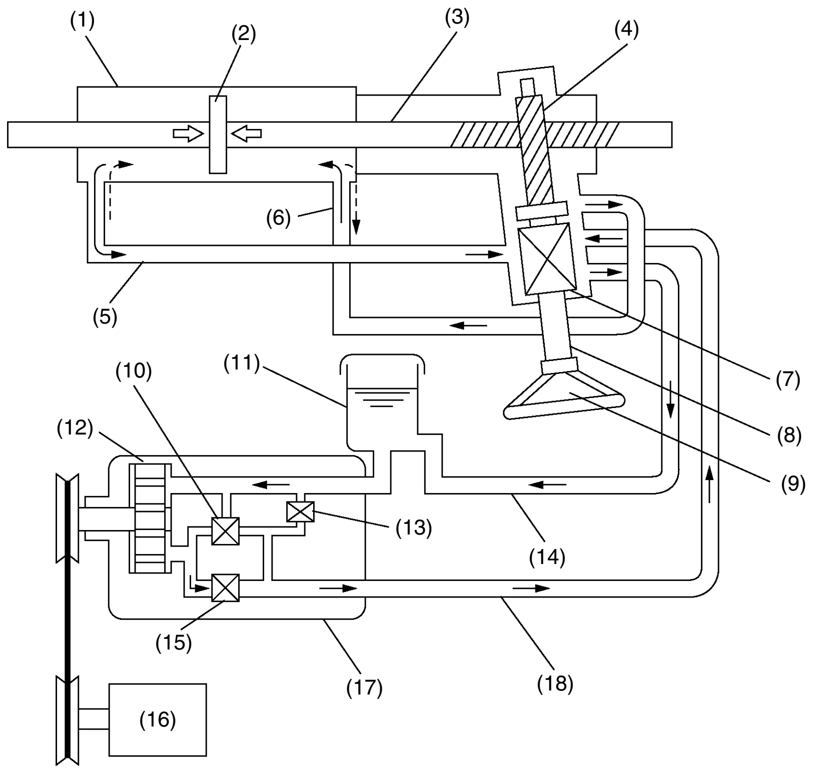

(1) Steering support beam

# 2. Power Steering System

## A: HYDRAULIC SYSTEM

- The fluid pump is directly driven by the engine through a belt.
- When the steering wheel is not being turned, the pressure-sensitive valve in the pump opens to drain the fluid into the fluid reservoir tank.
- The fluid pressure is maintained almost constant regardless of change in the engine speed by the function of the flow control valve. The pressure-regulated fluid is delivered to the control valve via hose A.
- When the steering wheel is turned, the rotary control valve connected to the pinion shaft opens the hydraulic circuit corresponding to the direction in which the steering wheel is turned. The fluid then flows into chamber A or B via pipe A or B.
- The fluid pressure in chamber A or B acts on the rack piston in the same direction as that in which the rack shaft is moved by rotation of the steering wheel. This helps reduce the effort required of the driver to operate the steering wheel.
- Movement of the rack piston causes the fluid in the other chamber to return to the reservoir tank via pipe A or B, control valve, and hose B.
  - As the steering shaft is connected to the pinion shaft mechanically via the rotary control valve, the steering system can operate as a manual system even if the hydraulic system becomes inoperative.
  - To control the maximum fluid pressure, a relief valve is built into the fluid pump to prevent buildup of an excessive fluid pressure.

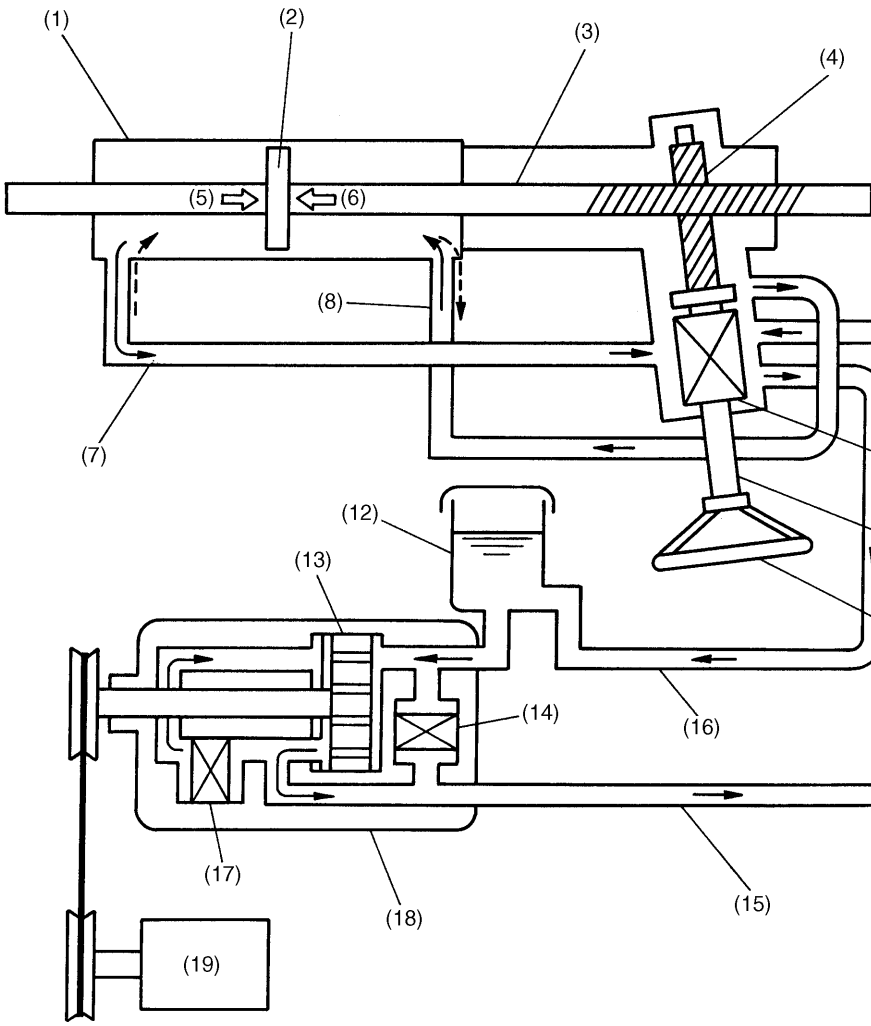
## ALL MODELS EXCEPT 3.0ℓ MODEL




B4H1719B

| | | | | | |
|---|---|---|---|---|---|
| (1) | Power cylinder | (8) | Steering shaft | (15) | Flow control valve |
| (2) | Rack piston | (9) | Steering wheel | (16) | Engine |
| (3) | Rack shaft | (10) | Pressure-sensitive valve | (17) | Fluid pump |
| (4) | Piston shaft | (11) | Tank | (18) | Hose A |
| (5) | Pipe A | (12) | Vane pump | (19) | Chamber A |
| (6) | Pipe B | (13) | Relief valve | (20) | Chamber B |
| (7) | Rotary control valve | (14) | Hose B | | |

## 3.0ℓ MODEL




(1) Power cylinder
(2) Rack piston
(3) Rack shaft
(4) Pinion shaft
(5) Chamber A
(6) Chamber B
(7) Pipe A
(8) Pipe B
(9) Rotary control valve
(10) Steering shaft
(11) Steering wheel
(12) Tank
(13) Vane pump
(14) Relief valve
(15) Hose A
(16) Hose B
(17) Pump control valve
(18) Fluid pump
(19) Engine

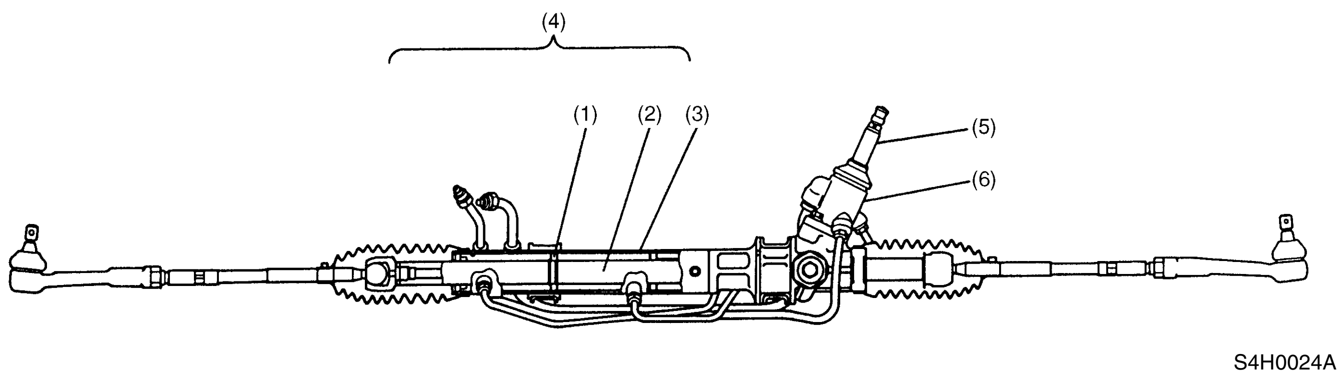
## B: GEARBOX ASSEMBLY

### 1. POWER CYLINDER

The gearbox integrates the control valve and power cylinder into a single unit. The rack shaft serves as a power cylinder piston. The rotary control valve is located around the pinion shaft.

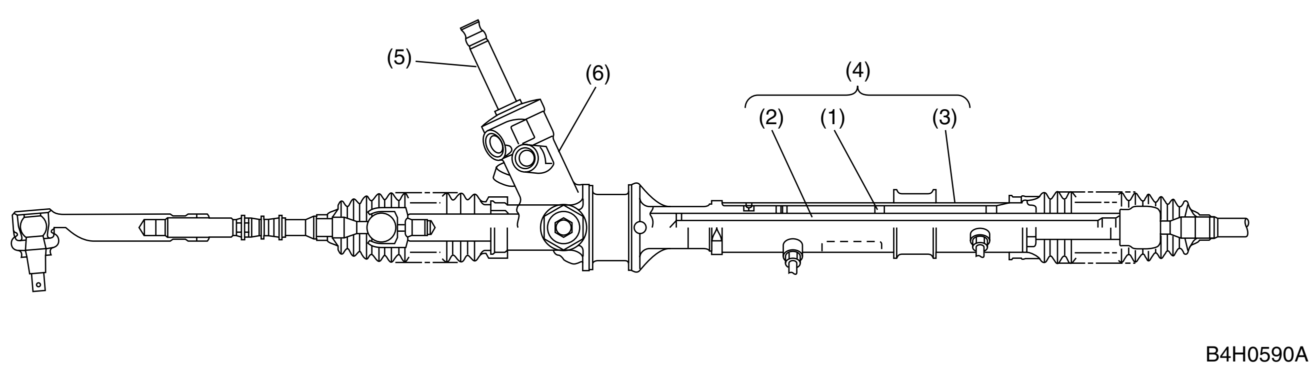
The rotary control valve and power cylinder are connected to each other by two pipes through which hydraulic fluid flows.

#### LHD MODEL




(1) Piston
(2) Rack shaft
(3) Cylinder
(4) Power cylinder
(5) Pinion shaft
(6) Control valve

#### RHD MODEL




(1) Piston
(2) Rack shaft
(3) Cylinder
(4) Power cylinder
(5) Pinion shaft
(6) Control valve

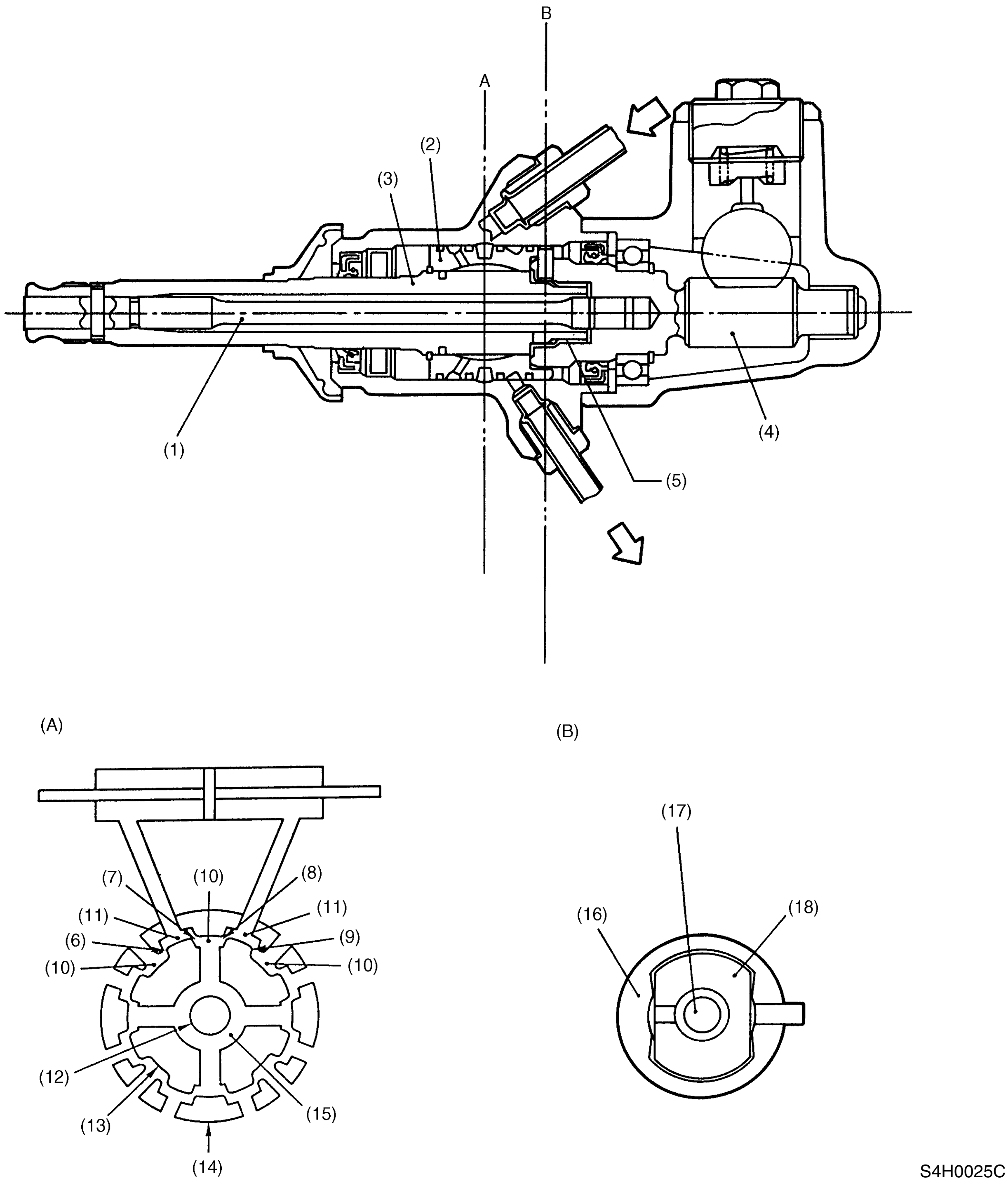
## MEMO

## 2. ROTARY CONTROL VALVE

The rotary control valve consists of a rotor (which rotates together with the steering shaft), a pinion (which is connected to the rotor and torsion bar), and a sleeve (which rotates together with the pinion). The rotor and sleeve have grooves C and D, respectively, which form fluid passages $V_1$ through $V_4$.

The pinion is in mesh with the rotor with adequate clearance, which enable the rack to be moved manually by rotating the steering shaft (fail-safe feature).

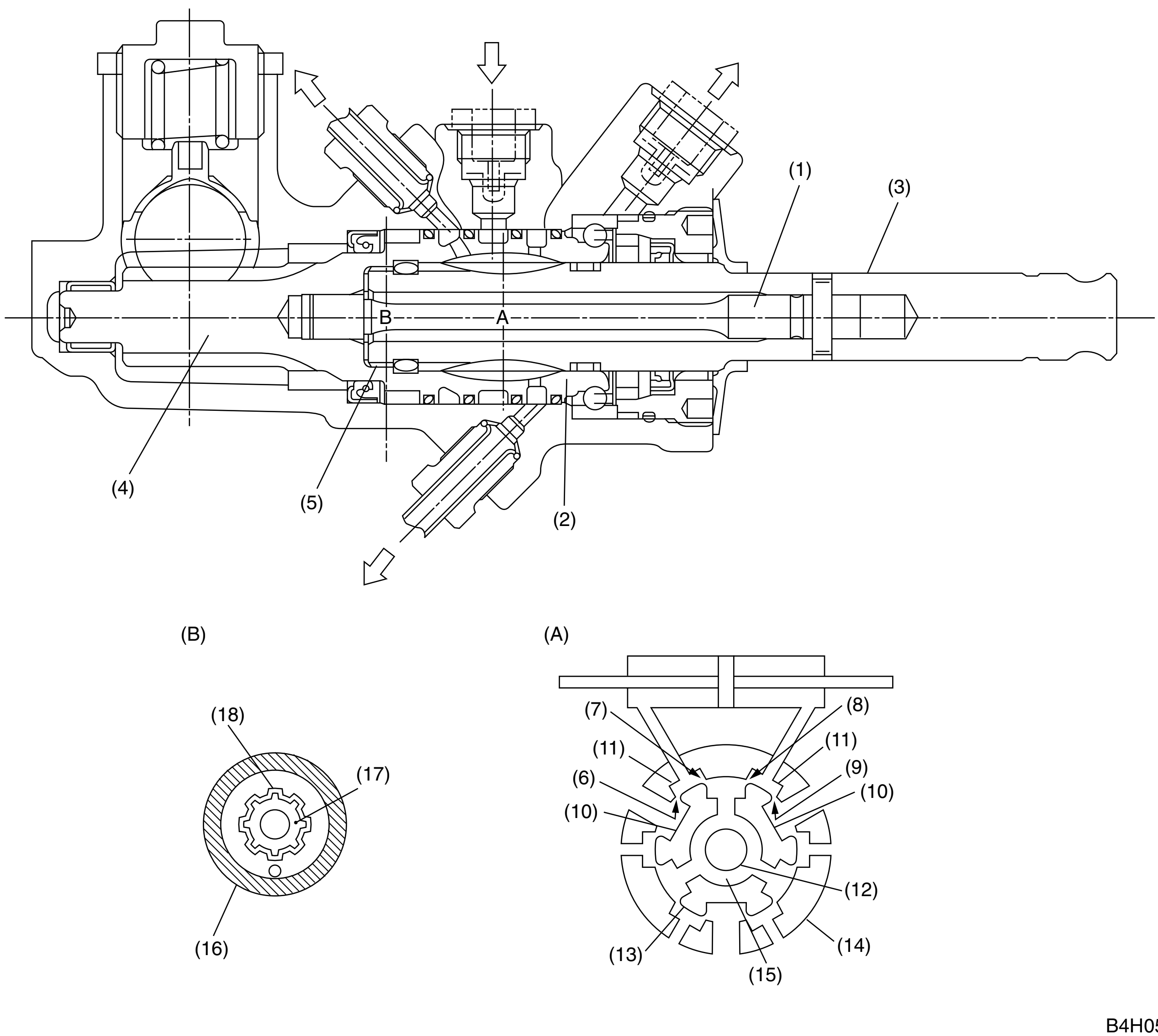
### LHD MODEL



(1) Torsion bar
(2) Sleeve
(3) Rotor
(4) Pinion
(5) Pinion-to-rotor engagement (fail-safe feature)
(6) Fluid passage $V_1$
(7) Fluid passage $V_2$
(8) Fluid passage $V_3$
(9) Fluid passage $V_4$
(10) Groove C
(11) Groove D
(12) Torsion bar
(13) Rotor
(14) Sleeve
(15) Fluid return line (to reservoir tank)
(16) Pinion
(17) Torsion bar
(18) Rotor

(A) Cross-sectional view A (fluid passage switching circuit)
(B) Cross-sectional view B (pinion-to-rotor engagement)

## RHD MODEL



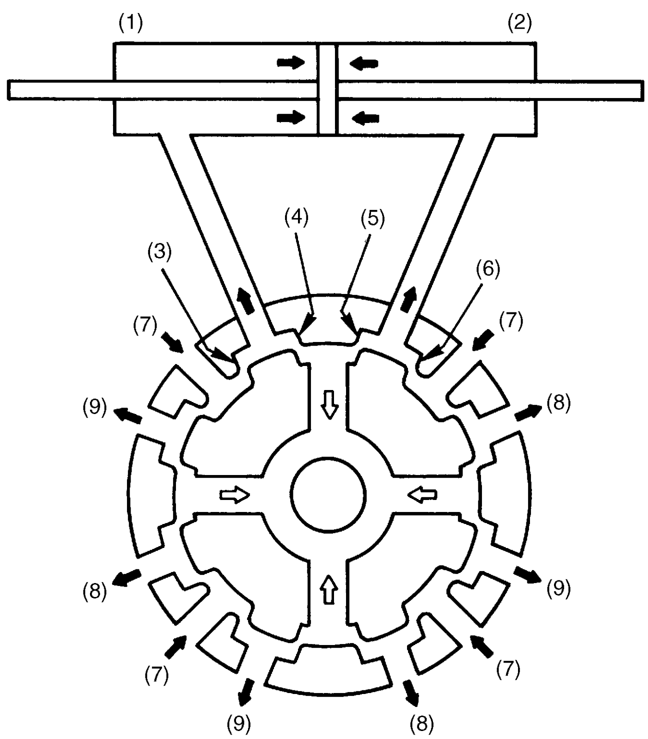

| | | | |
|---|---|---|---|
| (1) | Torsion bar | (12) | Torsion bar |
| (2) | Sleeve | (13) | Rotor |
| (3) | Rotor | (14) | Sleeve |
| (4) | Pinion | (15) | Oil return line (to reservoir) |
| (5) | Pinion-to-rotor engagement (fail-safe feature) | (16) | Valve housing |
| (6) | Fluid passage $V_1$ | (17) | Rotor |
| (7) | Fluid passage $V_2$ | (18) | Pinion |
| (8) | Fluid passage $V_3$ | | |
| (9) | Fluid passage $V_4$ | (A) | Cross-sectional view A (fluid passage switching circuit) |
| (10) | Groove C | (B) | Cross-sectional view B (pinion-to-rotor engagement) |
| (11) | Groove D | | |

- Principle of operation

When the torsion bar is twisted by a rotational force applied to the steering wheel, the relative position between the rotor and sleeve changes. This changes the cross-sectional area of fluid passages $V_1$, $V_2$, $V_3$ and $V_4$. The fluid passages are thus switched and the fluid pressure is controlled in accordance with the operation of the steering wheel.

- When no steering force is applied:
  The rotor and sleeve are held at the neutral position. Fluid passages $V_1$, $V_2$ and $V_3$, which are formed by grooves C and D are open equally. Under this condition, the fluid from the pump returns to the reservoir tank so that neither fluid pressure builds up nor the rack piston moves in the power cylinder.

**LHD MODEL**

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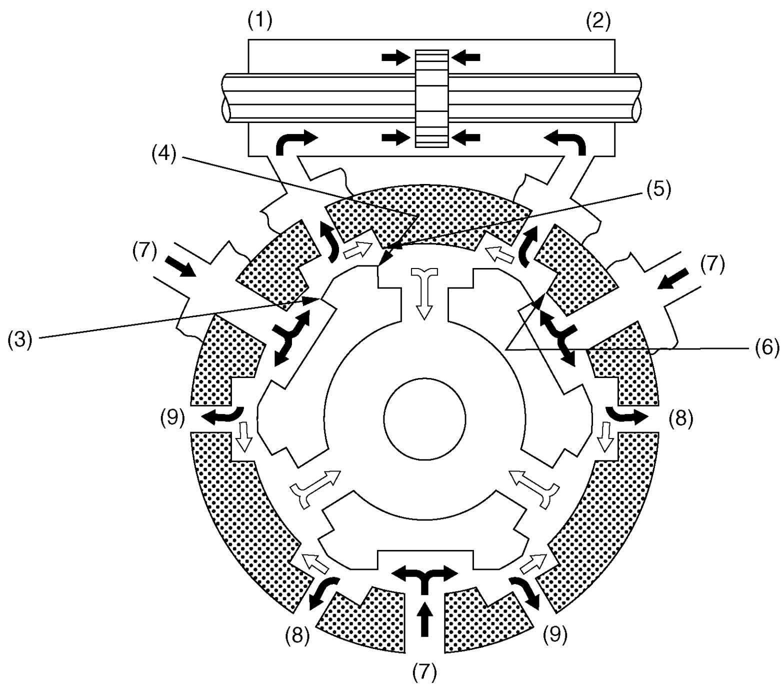
| | | |
|---|---|---|
| (1) Chamber A | (4) $V_2$ | (7) From fluid pump |
| (2) Chamber B | (5) $V_3$ | (8) To A |
| (3) $V_1$ | (6) $V_4$ | (9) To B |

**RHD MODEL**

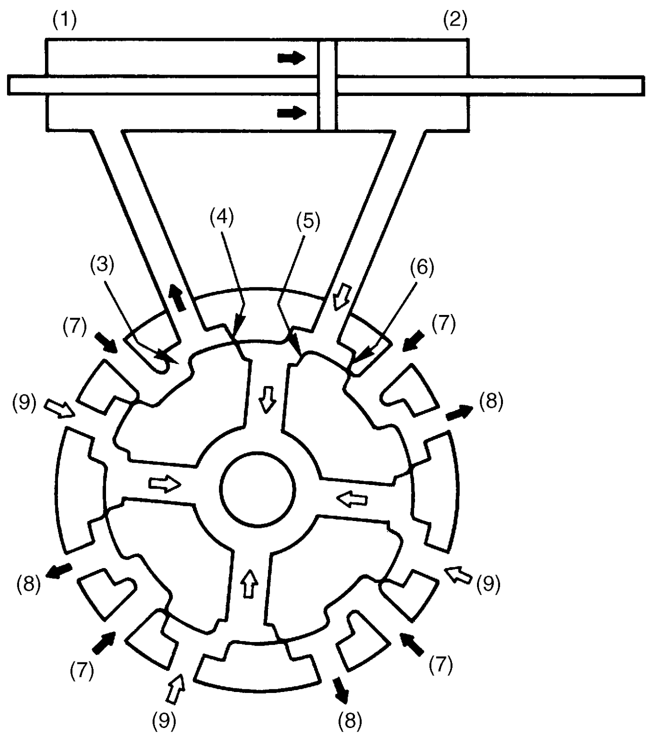



| | | |
|---|---|---|
| (1) Chamber A | (4) $V_2$ | (7) From fluid pump |
| (2) Chamber B | (5) $V_3$ | (8) To A |
| (3) $V_1$ | (6) $V_4$ | (9) To B |

- When steering force is applied:

When the steering wheel is turned to the right, for example, fluid passages $V_1$ and $V_3$ are opened while fluid passages $V_2$ and $V_4$ are nearly closed.
At this point, the fluid pressure in chamber A of the power cylinder increases depending on the degree of closure of fluid passages $V_2$ and $V_4$ so that the rack piston moves to the right. The fluid in chamber B, on the other hand, is drained through fluid passage $V_3$ into the reservoir tank.

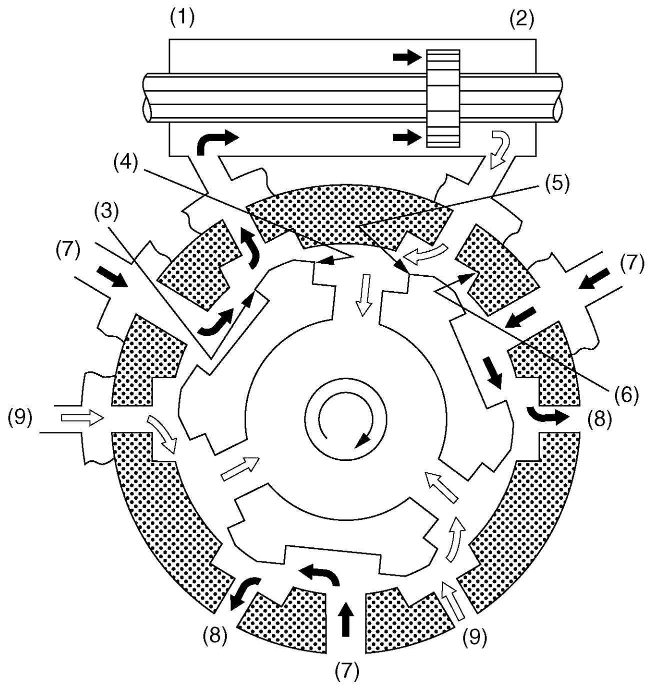
## LHD MODEL




S4H0336A

| | | | | | |
|---|---|---|---|---|---|
| (1) | Chamber A | (4) | $V_2$ | (7) | From fluid pump |
| (2) | Chamber B | (5) | $V_3$ | (8) | To A |
| (3) | $V_1$ | (6) | $V_4$ | (9) | From B |

## RHD MODEL




S4H0337A

| | | |
|---|---|---|
| (1) Chamber A | (4) $V_2$ | (7) From fluid pump |
| (2) Chamber B | (5) $V_3$ | (8) To A |
| (3) $V_1$ | (6) $V_4$ | (9) From B |

- Fail-safe feature

If fluid pressure fails to build up due to, for example, a broken fluid pump drive belt, the steering wheel rotating torque is transmitted from the valve rotor to the pinion through mechanical engagement between them.

## C: FLUID PUMP AND RESERVOIR TANK

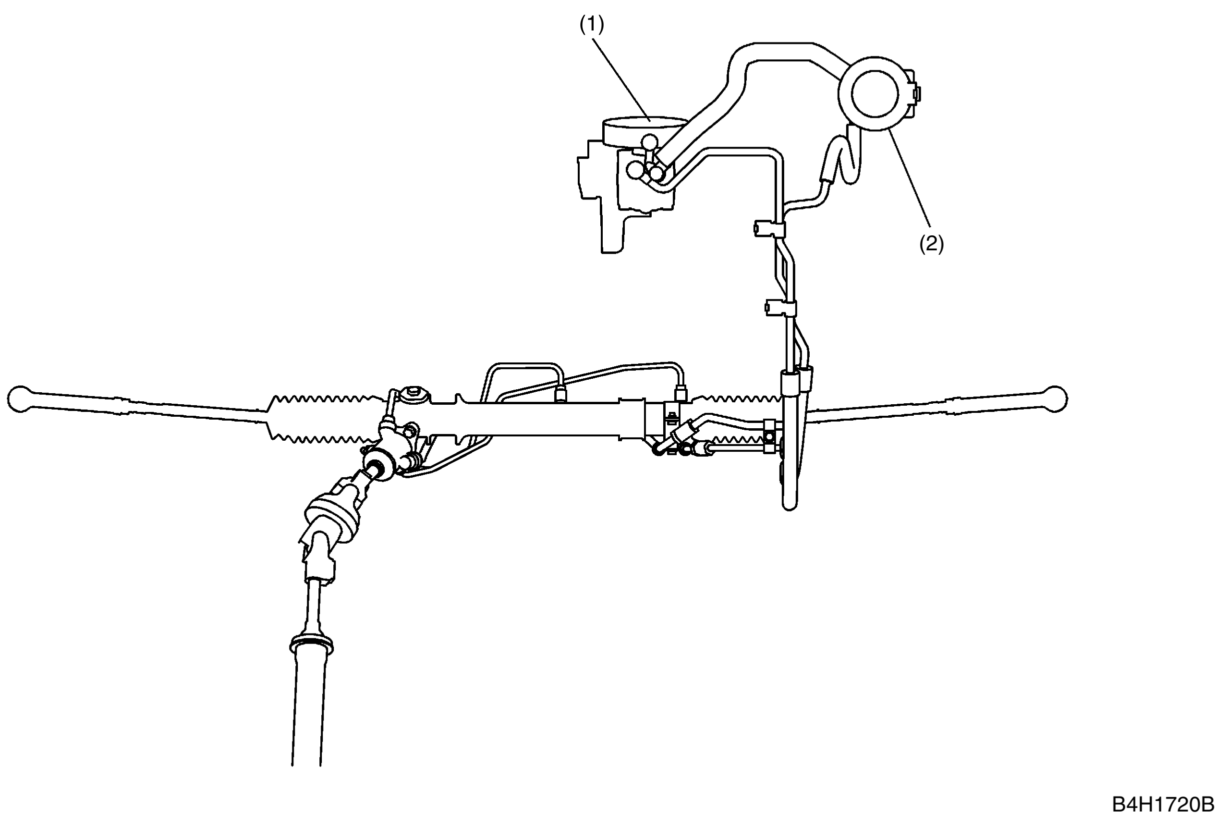
### 1. ALL MODELS EXCEPT 3.0ℓ MODEL

The fluid pump is a vane type driven by the engine via belt.

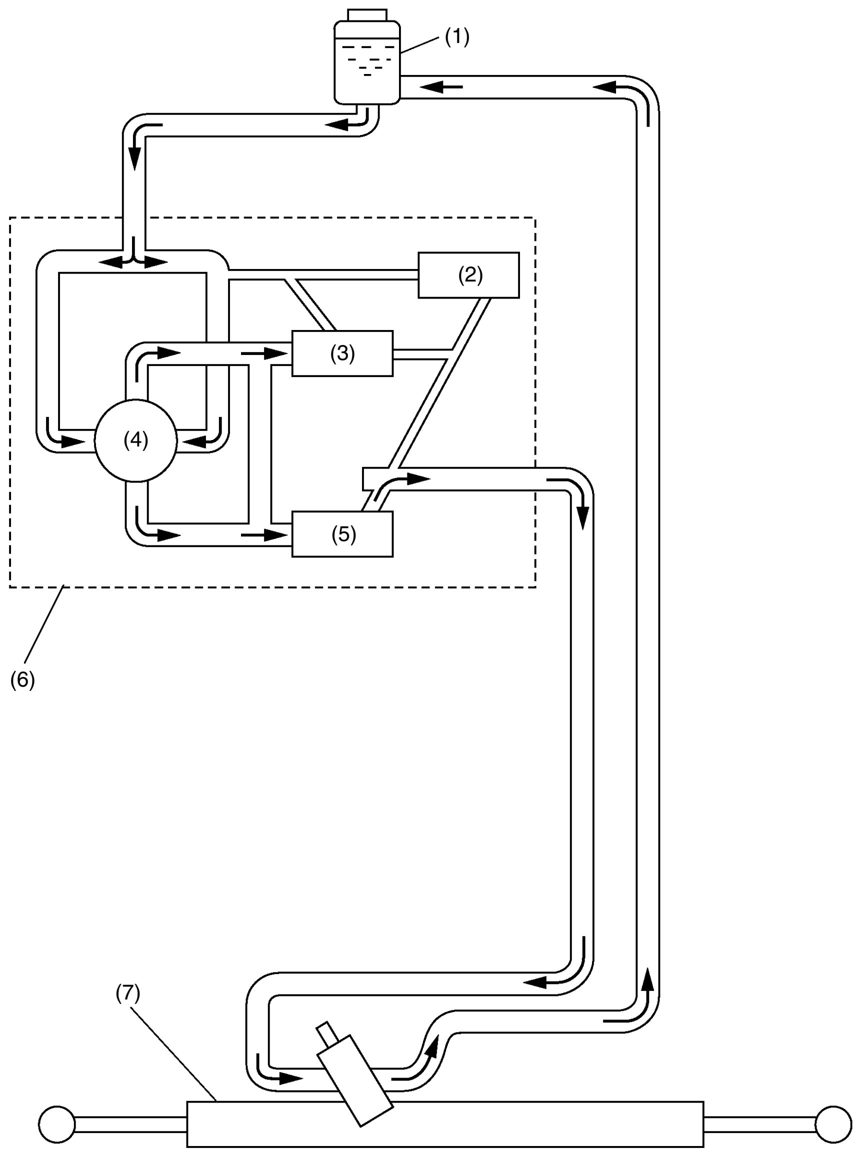
The reservoir tank is mounted on the vehicle body.

The fluid pump incorporates the flow control valve, pressure-sensitive valve, and relief valve, each performing the following functions:

- The flow control valve regulates the flow rate of discharged fluid to a constant level irrespective of the engine speed.
- The pressure-sensitive valve returns the fluid to the reservoir tank when there is no steering input.
- The relief valve protects the system from an excessively high pressure which may occur, for example, when the steering wheel is turned all the way.




(1) Fluid pump
(2) Reservoir tank

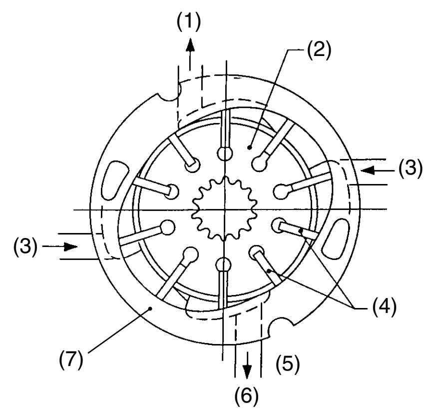



(1) Reservoir tank
(2) Relief valve
(3) Pressure-sensitive valve
(4) Vane pump
(5) Flow control valve
(6) Fluid pump
(7) Steering gearbox

## ● VANE PUMP

The vane pump consists of a rotor, a cam ring, and ten vanes.

When the rotor rotates, the vane movably fitted in each slot of the rotor is radially moved out by centrifugal force and pressed against the inside wall of the cam ring. Since the inside of the cam ring is oval-shaped, the fluid from the suction port is confined and pressurized in the chamber formed between two adjacent vanes as the rotor rotates and is delivered through the discharge port. The pressurized fluid circulates through the hydraulic circuit.

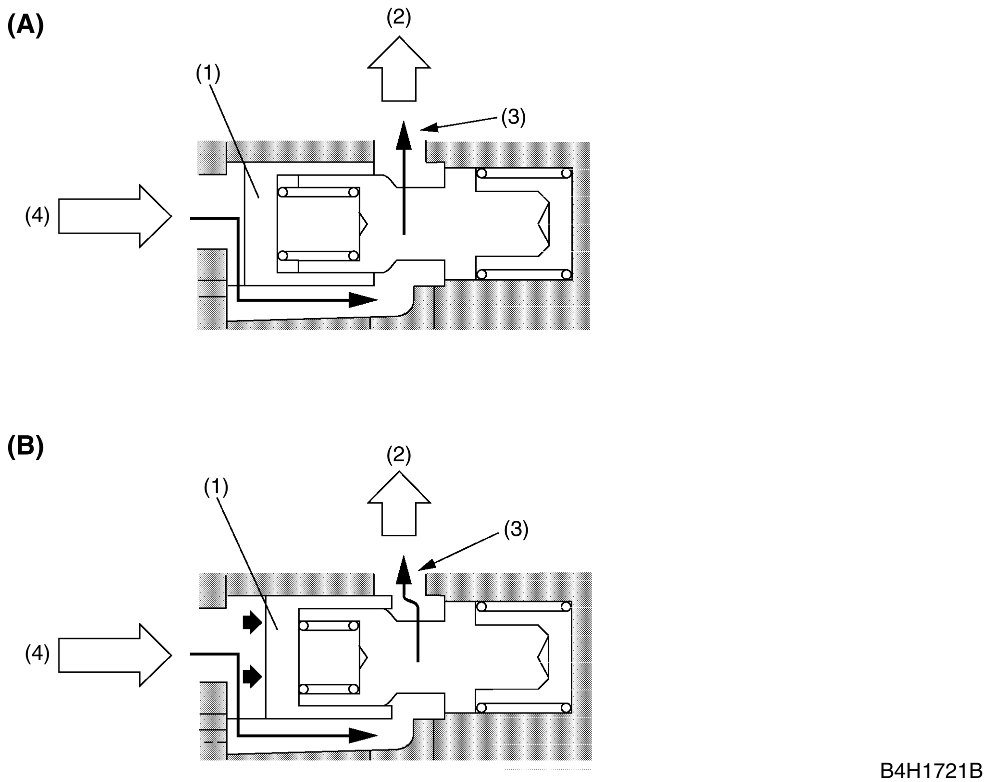



H4H1188C

| | | | |
|---|---|---|---|
| (1) | Discharge | (5) | Vane pump |
| (2) | Rotor | (6) | Discharge |
| (3) | Suction | (7) | Cam ring |
| (4) | Vane | | |

## ● FLOW CONTROL VALVE

The flow control valve consists of a sub-spool which is pushed to the right when the fluid pressure rises as the engine speed increases (and consequently, the pump discharge rate becomes higher). When the sub-spool is shifted to the right, the variable orifice is narrowed, thus the discharge rate is reduced.

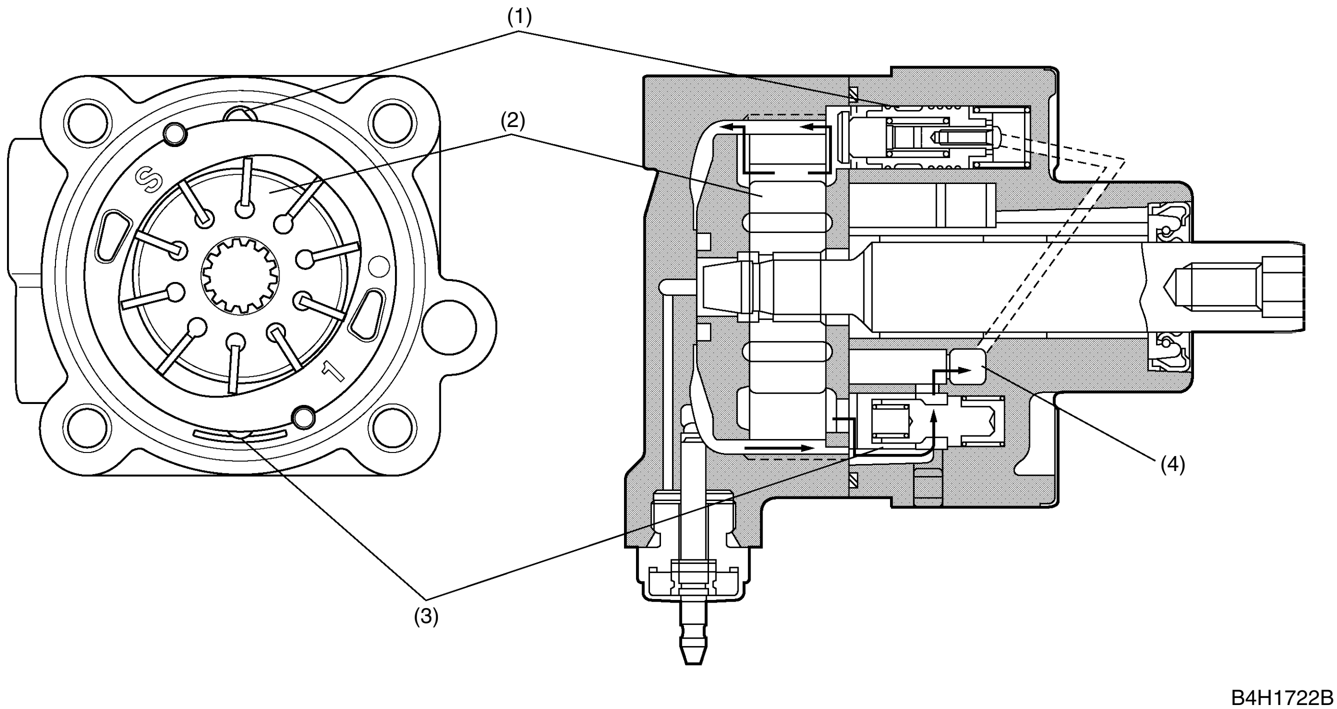



**(A)** Engine speed low
**(B)** Engine speed high

(1) Sub-spool
(2) To steering gearbox
(3) Variable orifice
(4) From vane pump

## ● PRESSURE-SENSITIVE VALVE

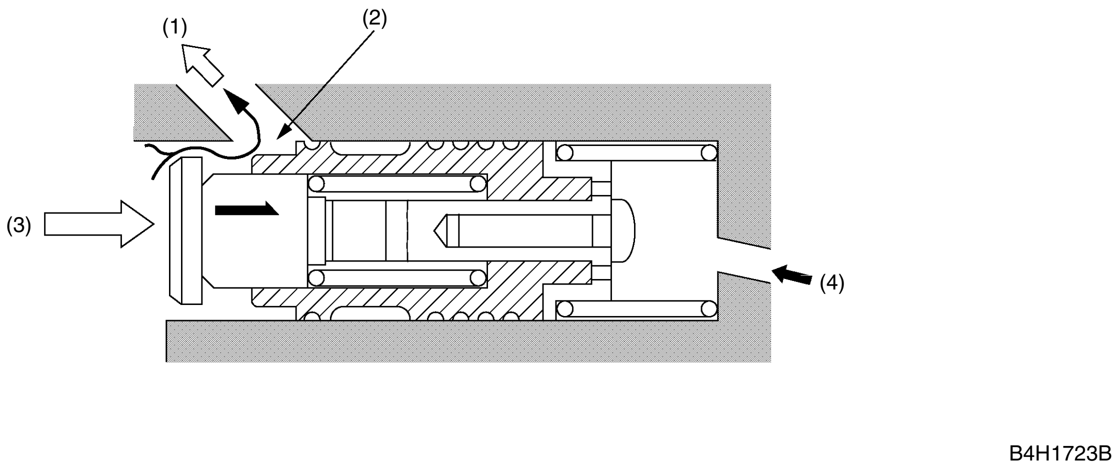
The pressure-sensitive valve's left end is exposed to the fluid pump discharge-pressure and its right end to the flow control valve outlet pressure (the pressure of the fluid being directed to the steering gearbox).




| | |
|---|---|
| (1) Pressure-sensitive valve | (3) Flow control valve |
| (2) Fluid pump | (4) To steering gearbox |

● When the steering wheel is not being turned, the fluid that has passed through the flow control valve is directed to the steering gearbox but it is returned to the reservoir tank without entering the rotary control valve's passages in the gearbox. Therefore, the pressure acting on the valve's right end does not increase.

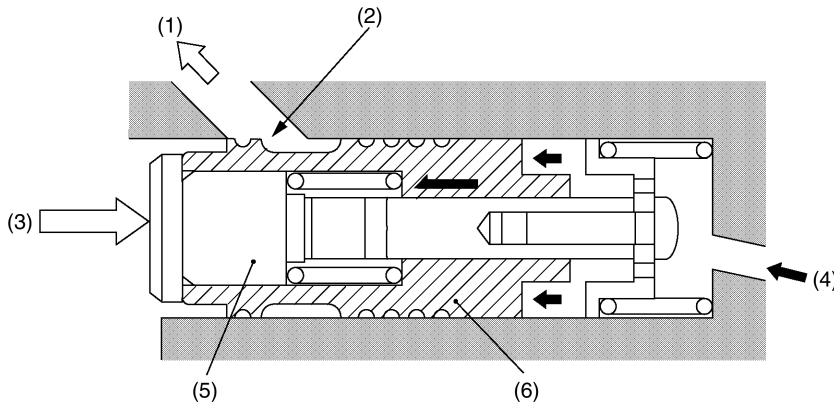
On the other hand, the pressure acting on the left end of valve is the fluid pump-discharge pressure which is higher than the pressure acting on the right end. This causes the pressure-sensitive valve's spool assembly to move to the right. As a result, the drain port which was closed by the outer spool is now opened. The pump discharged fluid then flows to the reservoir tank and the pressure inside the pump is reduced.




(1) To reservoir tank
(2) Drain port open
(3) Pressure from vane pump (high)
(4) Fluid pressure after passing through flow control valve (low)

● When the steering wheel is turned in either direction, the pressure of the fluid that has passed through the flow control valve and directed into the steering gearbox increases as it enters the power cylinder and acts on the rack piston.

The inner spool of the pressure-sensitive valve is kept pressed to the right by the pump-discharge pressure acting on its left end. On the other hand, the fluid pressure acting on the right end of the valve is also high. So, the outer spool is moved to the left, closing the drain port. As a result, the pump internal pressure increases so that the fluid with a high pressure necessary for power assistance is supplied to the gearbox.



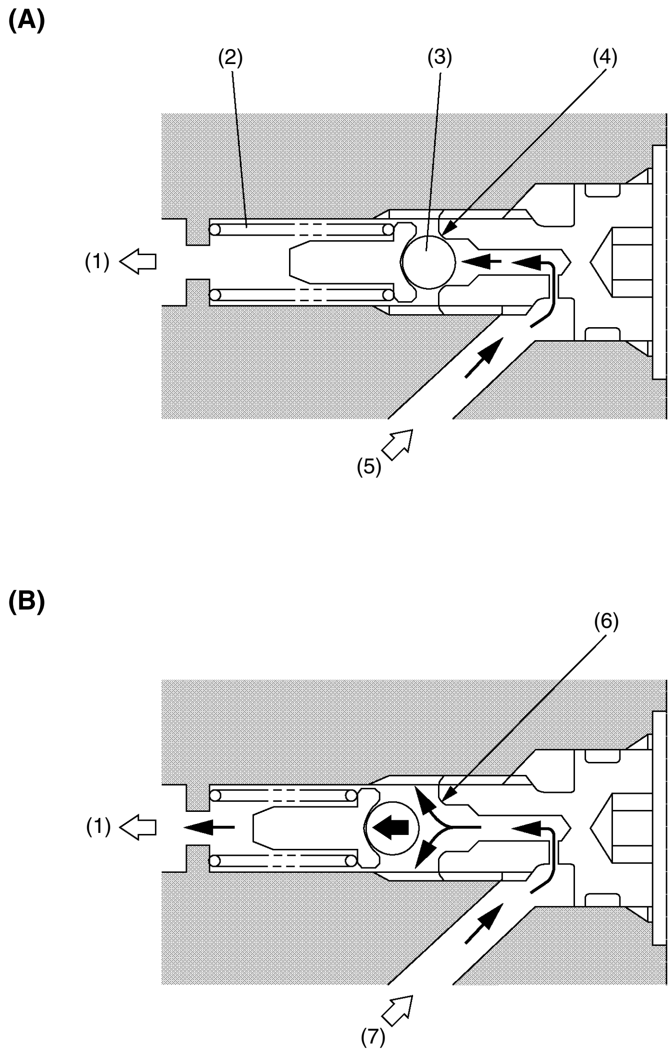

B4H1724B

| | |
|---|---|
| (1) To reservoir tank | (4) Fluid pressure after passing through flow control valve (increased) |
| (2) Drain port closed | (5) Inner spool |
| (3) Pressure from vane pump | (6) Outer spool |

## ● RELIEF VALVE

The relief valve consists of a check ball and a spring. The check ball is exposed to the fluid pressure that is regulated by the flow control valve (branched from the line to the steering gearbox).

If the pressure acting on the check ball is increased abnormally due to, for example, rotation of the steering wheel to a stop and overcomes the spring tension, the ball is pushed to the left, allowing the fluid to be drained into the reservoir tank. Therefore, the pressure to the steering gearbox is prevented from becoming excessively high.




B4H1778B

**(A)** Relief valve not in operation

**(B)** Relief valve in operation

(1) To reservoir tank

(2) Spring

(3) Check ball

(4) Valve closed

(5) Fluid pressure after passing through flow control valve (low)

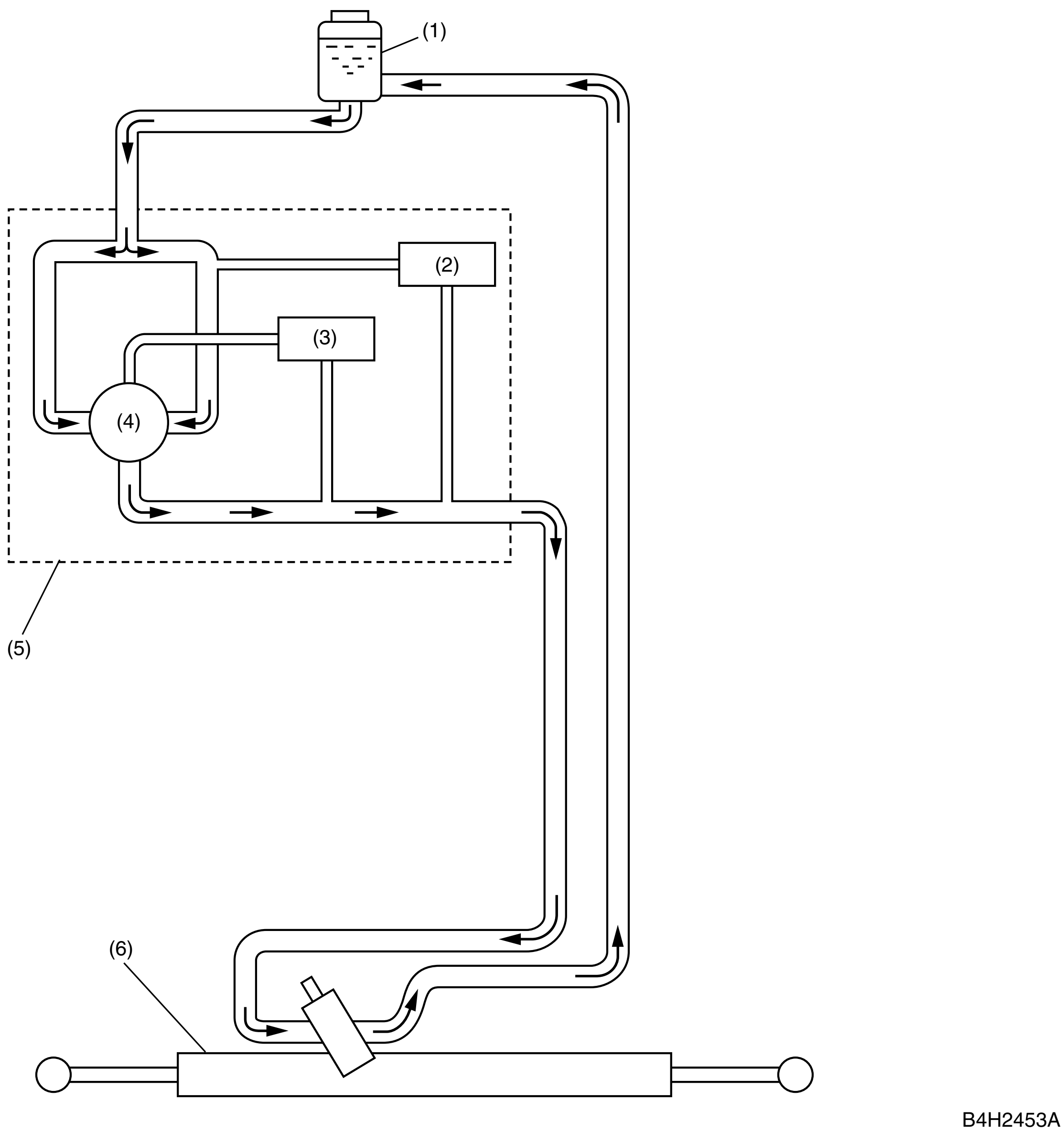
(6) Valve open

(7) Fluid pressure after passing through flow control valve (higher than preset level)

## 2. 3.0ℓ MODEL

● The reservoir tank is mounted on the vehicle body.

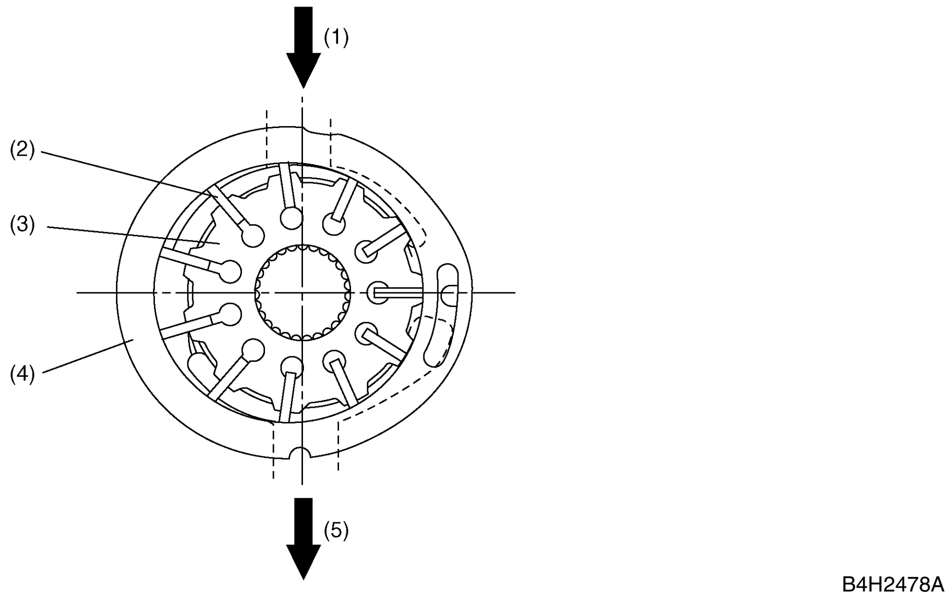
● The fluid pump is belt-driven by the engine. The fluid flow is controlled according to the engine speed so that an adequate steering resistance is given during high-speed operation.
The fluid pump is a variable capacity type vane pump whose delivery rate per rotation decreases as the engine speed increases. The pump is integral with a pump control valve and relief valve.




| | | | |
|---|---|---|---|
| (1) | Reservoir tank | (4) | Vane pump |
| (2) | Relief valve | (5) | Fluid pump assembly |
| (3) | Pump control valve | (6) | Steering gearbox |

- The vane pump consists of a rotor, a cam ring, and eleven vanes.

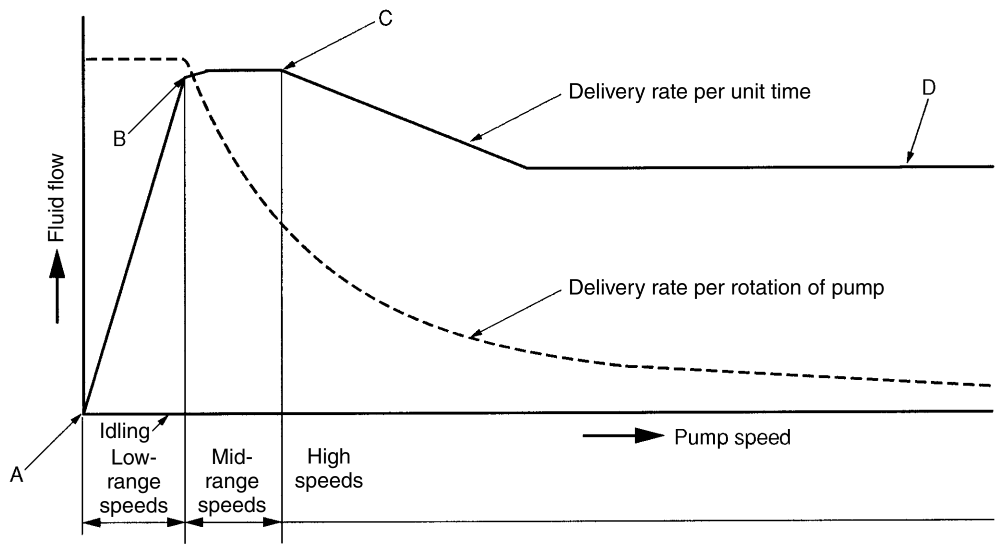
When the rotor rotates, the vane in each slot of the rotor is radially moved out by centrifugal force and pressed against the cam ring. The fluid from the suction port is confined in chambers formed between two adjacent vanes and carried to the discharge port. Since the cam ring is movable in relation to the rotor, the volume of each chamber is variable. This enables the delivery rate per rotation of the pump to be changed.




(1) Suction
(2) Vane
(3) Rotor
(4) Cam ring
(5) Discharge

- **FLOW CONTROL**

The variable capacity pump changes its delivery rate per rotation by changing the degree of eccentricity of the cam ring according to its rotating speed (engine speed).

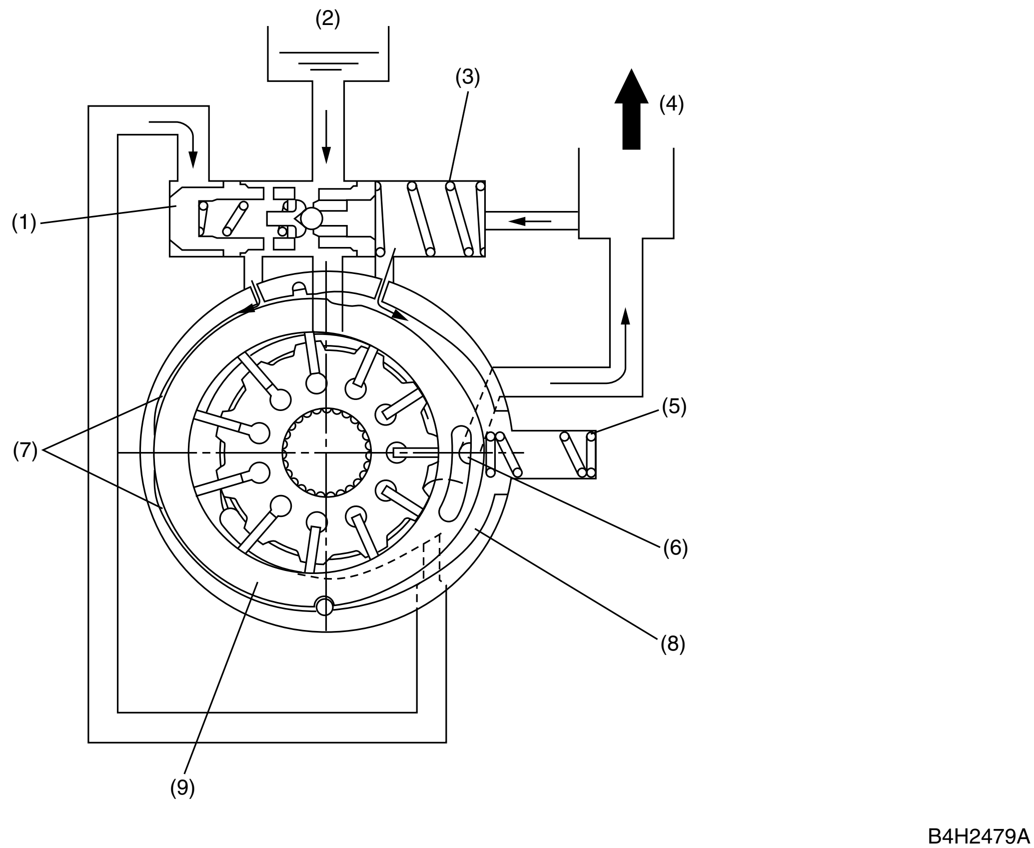



S4H0028B

NOTE:
In the following description, pump speed ranges will be indicated using the speed points A through D shown in the drawing above.

### Low-range-speed operation (A – B range)

In this speed range, as well as in all the other speed ranges, two different pump discharge pressures are always applied to the control valve; one is directly led from the discharge port to the left end of the valve and the other is led through an orifice (variable orifice) to the right end of the valve. Since the orifice has a pressure reducing effect, the latter pressure is lower than the former.
When the pump is operating at a low speed, its discharge pressure is also low, resulting in only small difference between the two pressures. In this condition, the valve stays pushed leftward by the spring, allowing the non-pressurized reservoir tank fluid to enter chamber A. To chamber B, on the other hand, the orifice-reduced discharge pressure is applied, so the cam ring is pushed leftward by the cam ring spring. This makes the eccentricity of the cam ring a maximum and, therefore, the delivery rate per rotation of the pump become a maximum.

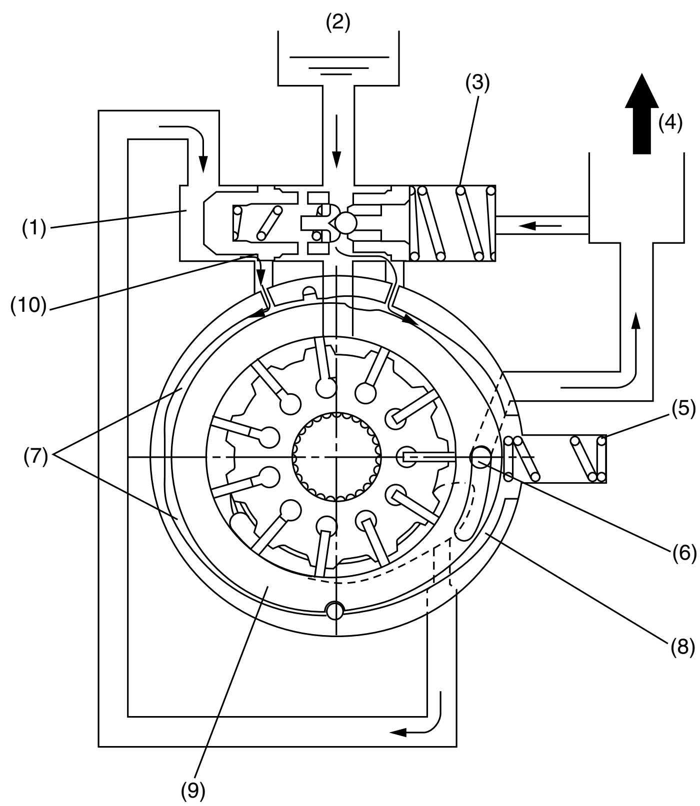



(1) Control valve
(2) Reservoir tank fluid
(3) Control valve spring
(4) Gear box
(5) Cam ring spring
(6) Variable orifice
(7) Pressure chamber A
(8) Pressure chamber B
(9) Cam ring

## Mid-range-speed operation (B – D range)

During mid-range speed operation, the pump increases its delivery rate. Since the pressure before passing through the variable orifice increases, the control valve moves rightward, overcoming the tension of the control valve spring. This movement of the control valve allows the pressure upstream of the variable orifice to be directed to chamber A after being adjusted to a necessary pressure* by the port opening area created by the control valve. On the other hand, chamber B receives the reservoir pressure (suction pressure). This means that the pressure in chamber A is higher than that in chamber B. As a result, the cam ring moves rightward against the tension of the cam spring. This causes the delivery rate per rotation of the pump to be reduced, so that the flow rate of the fluid to the steering gear box decreases accordingly.
The above control is performed when the pump is operating at a speed in the B – D range.

* The "necessary pressure" for chamber A is a pressure required to move the cam ring to the position corresponding to each predetermined flow rate (pump delivery rate). The pressure is obtained by changing the port opening area appropriately through displacement of the control valve. The displacement of the control valve is determined by how much the pressure before the variable orifice is different from that after the orifice.



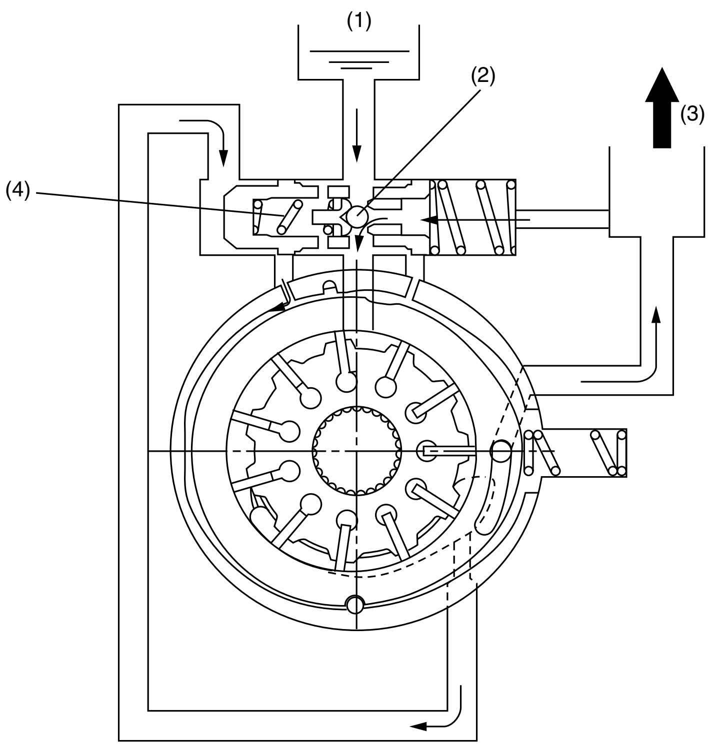

B4H2480A

| | | | |
|---|---|---|---|
| (1) | Control valve | (6) | Variable orifice |
| (2) | Reservoir tank fluid | (7) | Pressure chamber A |
| (3) | Control valve spring | (8) | Pressure chamber B |
| (4) | Gear box | (9) | Cam ring |
| (5) | Cam ring spring | (10) | Opening area |

### Maximum pressure control

When the hydraulic circuit in the steering gear box is closed as a result of a steering action, the pressure in the circuit increases to a very high level. The relief valve prevents the pressure from exceeding a preset safe level in the following way:

If the fluid in the circuit is pressurized to the preset pressure, the fluid pushes the ball of the valve overcoming the tension of the relief spring. Through the opened relief valve, the fluid makes its way to the pump's suction side passage, thus maintaining the circuit pressure at a level lower than the preset pressure.




B4H2481A

(1) Reservoir tank fluid
(2) Relief valve
(3) Gear box
(4) Relief spring

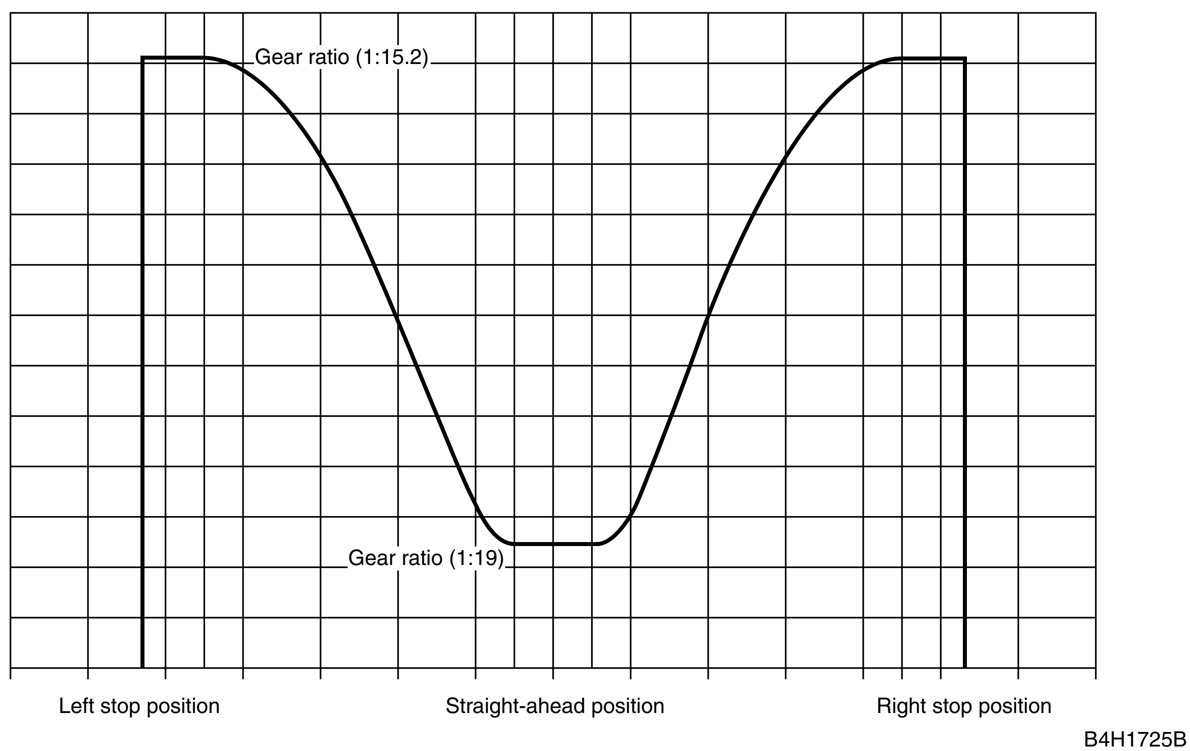
## D: VARIABLE GEAR RATIO (VGR) POWER STEERING

The OUTBACK model is equipped with a VGR power steering system.

The steering gear ratio of this system is 1:19 at around the straight-ahead position for higher stability during high-speed driving.

Near the right and left maximum steering angle positions, the gear ratio is made smaller than that of the straight-ahead position so that the system can respond quickly to steering wheel inputs.

**Gear ratio curve**



## MEMO

# HVAC SYSTEM (HEATER, VENTILATOR AND A/C)

# AC

**Page**

# 1. Heater System

The heater control unit is located in the middle portion of the instrument panel.

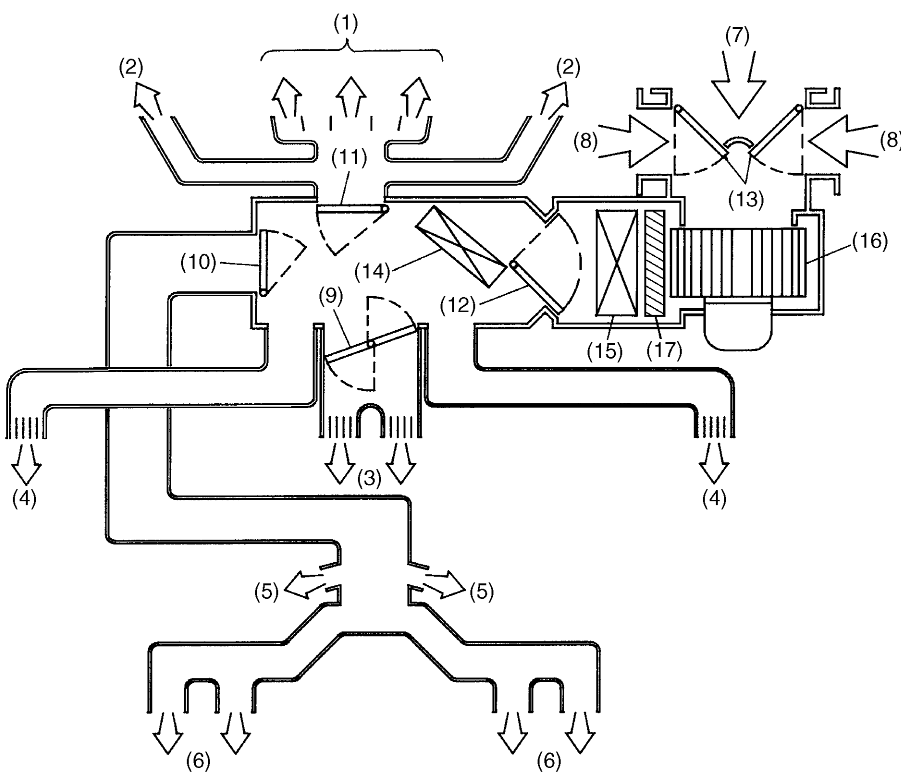
The heater unit has mode doors and an air mix door. The intake unit has an intake door and a blower motor. The heater unit and the intake unit are regulated by their control units.

Fresh outside air is introduced into the cabin through the center and side ventilators when the blower fan is operated.

All models are equipped with front side window defrosters.

An optional filter is provided in front of the evaporator inlet.

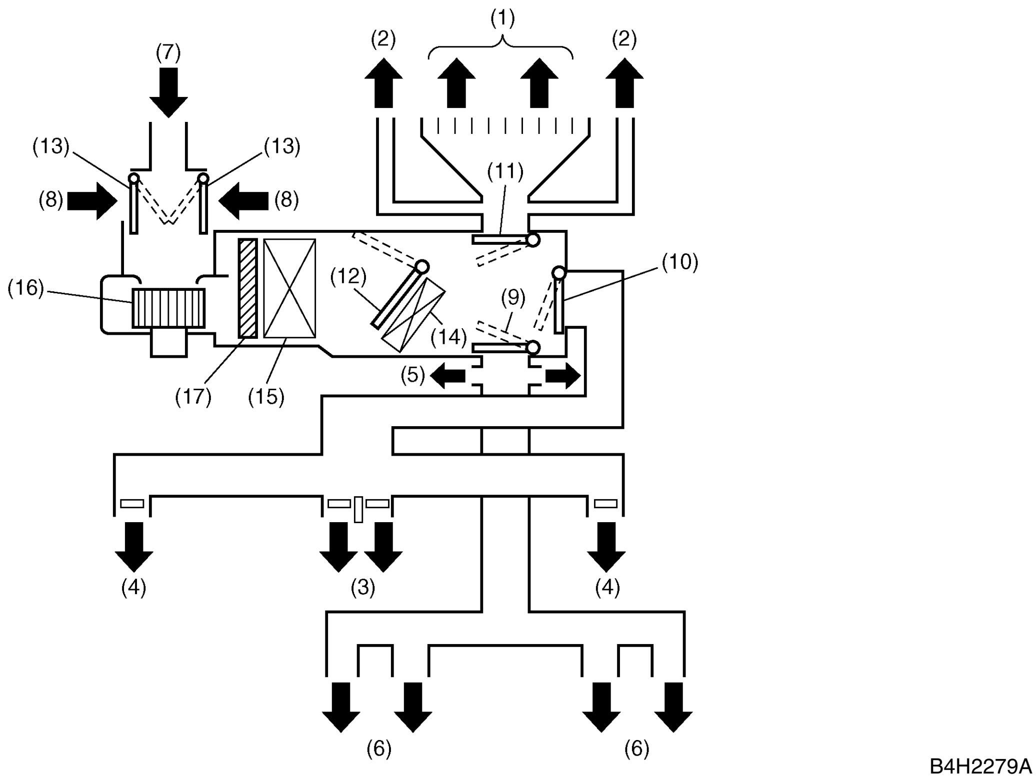
## A: LHD MODEL




B4H2189A

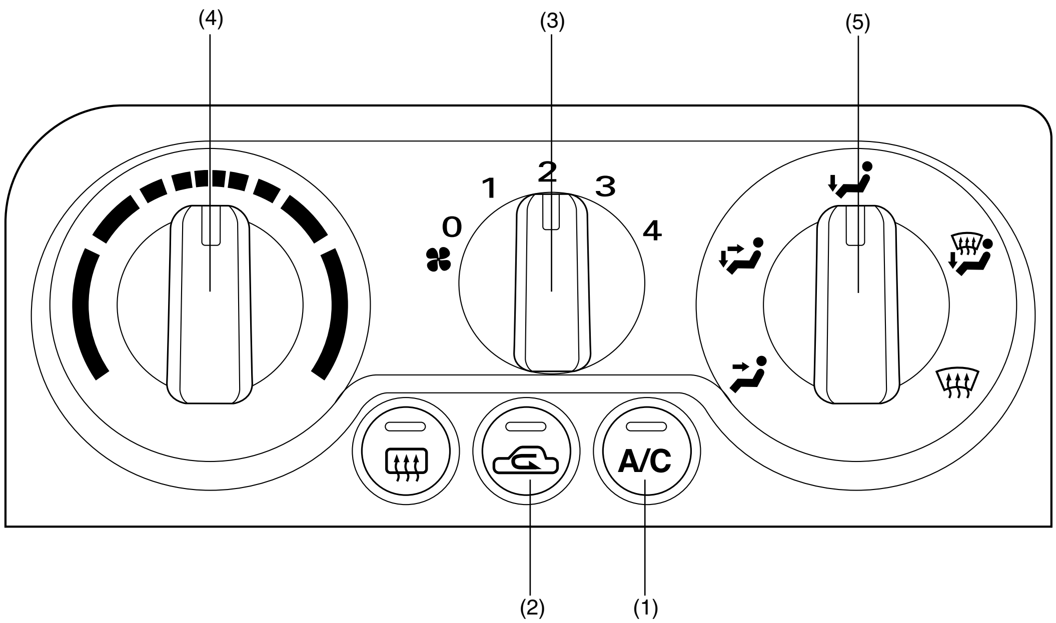
| | | | | | |
|---|---|---|---|---|---|
| (1) | Front defroster outlet | (7) | Fresh air | (13) | Intake door |
| (2) | Side defroster outlet | (8) | Recirculated air | (14) | Heater core |
| (3) | Center ventilator outlet | (9) | Ventilator door | (15) | Evaporator (A/C model) |
| (4) | Side ventilator outlet | (10) | Heater door | (16) | Blower fan |
| (5) | Front heater outlet | (11) | Defroster door | (17) | Filter (Option) |
| (6) | Rear heater outlet | (12) | Air mix door | A/C: | Air conditioner |

## B: RHD MODEL




| | | | | | |
|---|---|---|---|---|---|
| (1) | Front defroster outlet | (7) | Fresh air | (13) | Intake door |
| (2) | Side defroster outlet | (8) | Recirculated air | (14) | Heater core |
| (3) | Center ventilator outlet | (9) | Ventilator door | (15) | Evaporator (A/C model) |
| (4) | Side ventilator outlet | (10) | Heater door | (16) | Blower fan |
| (5) | Front heater outlet | (11) | Defroster door | (17) | Filter (Option) |
| (6) | Rear heater outlet | (12) | Air mix door | A/C: | Air conditioner |

## 2. Switch Functions

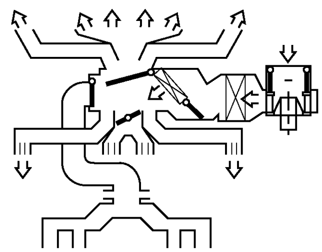
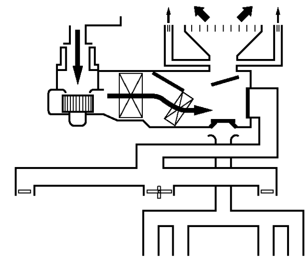
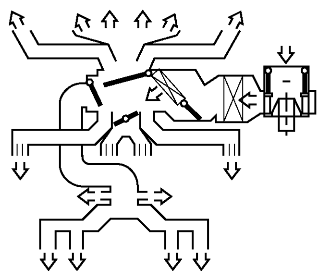
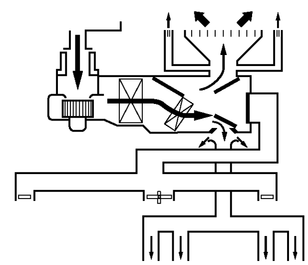
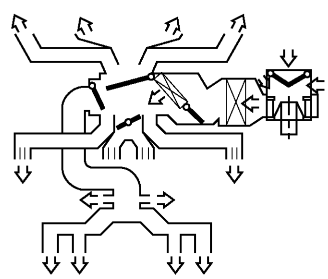
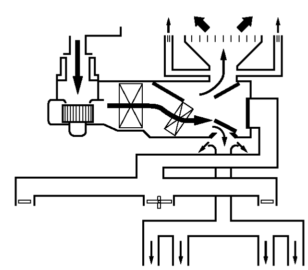
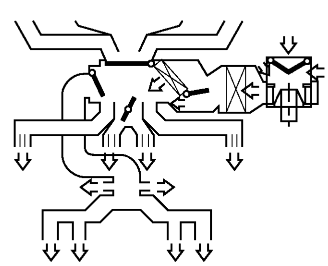
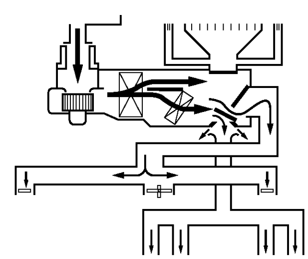
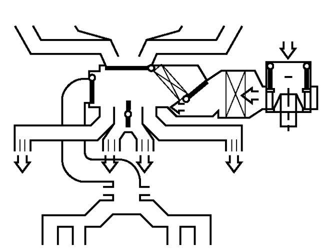
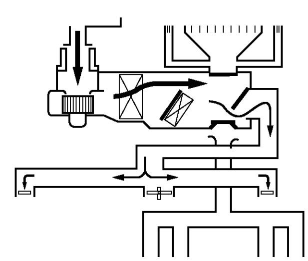



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (1) | Air conditioner switch | Indicator | *ON | | OFF | | |
| | | Compressor | ON | | OFF | | |
| | | *: When the fan switch is turned ON, the indicator compressor also turn ON. | | | | | |
| (2) | Recirculation switch | Indicator | ON | | OFF | | |
| | | Intake door position | Recirc | | Fresh | | |
| (3) | Fan switch | Switch position | 1 | 2 | 3 | 4 | |
| | | Fan speed | 1st (slow) | 2nd | 3rd | 4th (fast) | |
| (4) | Temperature control switch | Any temperature can be selected between COLD and HOT. | | | | | |
| (5) | Mode selector switch | Switch position | | | | | |
| | | Air outlet | Ventilator | Ventilator and heater | Heater | Defroster and heater | Defroster |

B4H2574A

# 3. Mode Selector Switch and Air Flow

## A: AIR FLOW

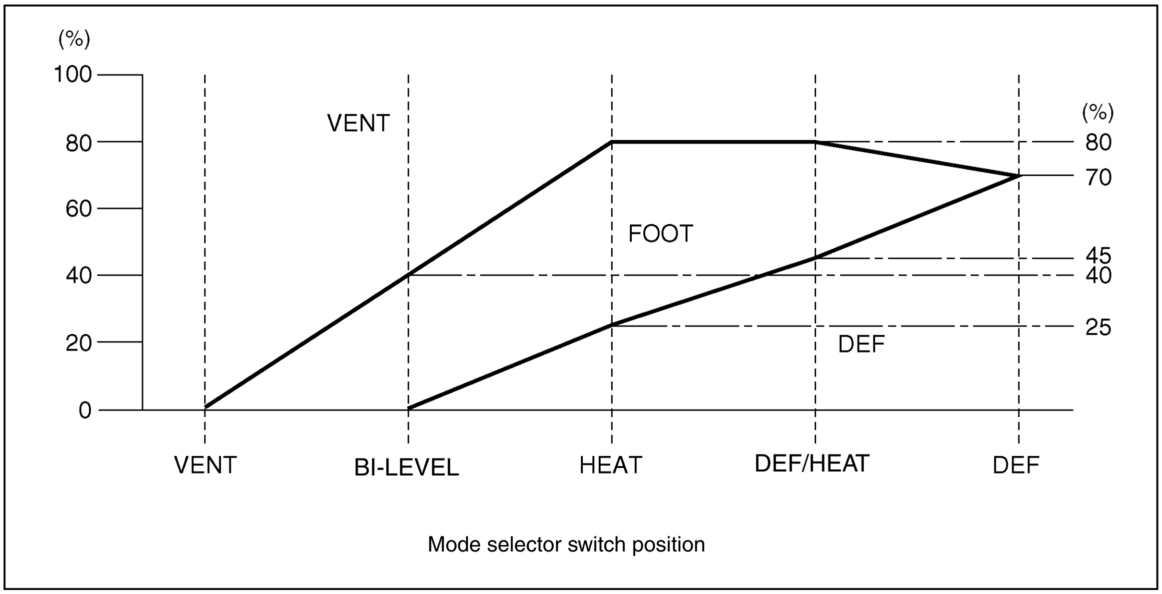
| Mode selector switch position | Air flow | |
|---|---|---|
| | LHD model | RHD model |
|  DEF |  |  |
|  DEF/HEAT |  |  |
|  HEAT |  |  |
|  BI-LEVEL |  |  |
|  VENT |  |  |

B4H1504A

## B: AIR DISTRIBUTION RATIO

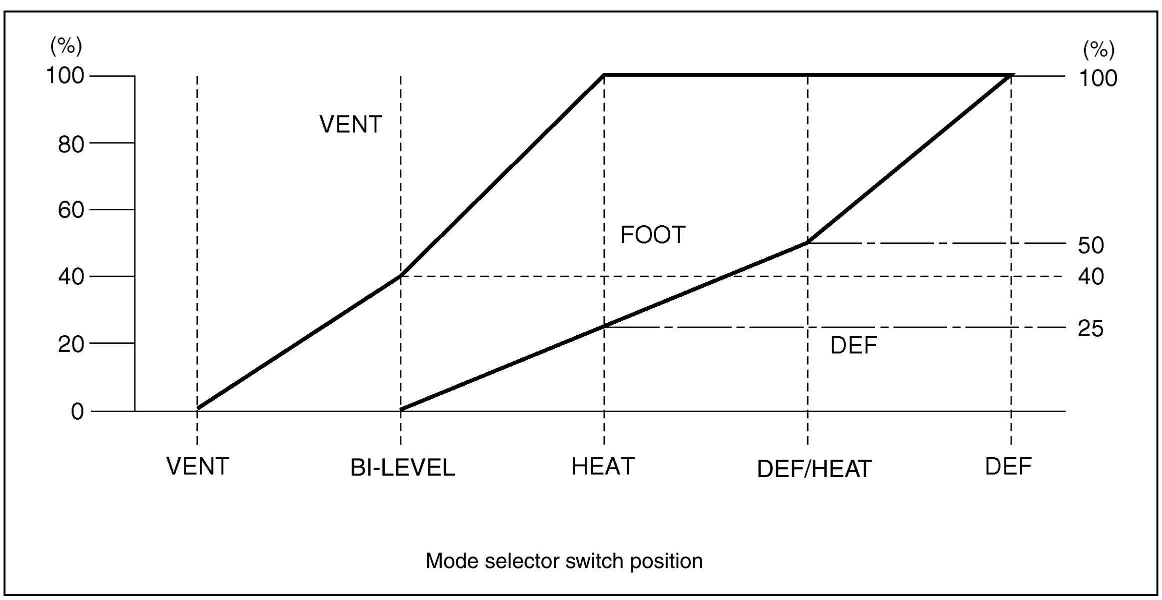
The following diagram shows air distribution for each position of the mode selector switch.

**LHD model**



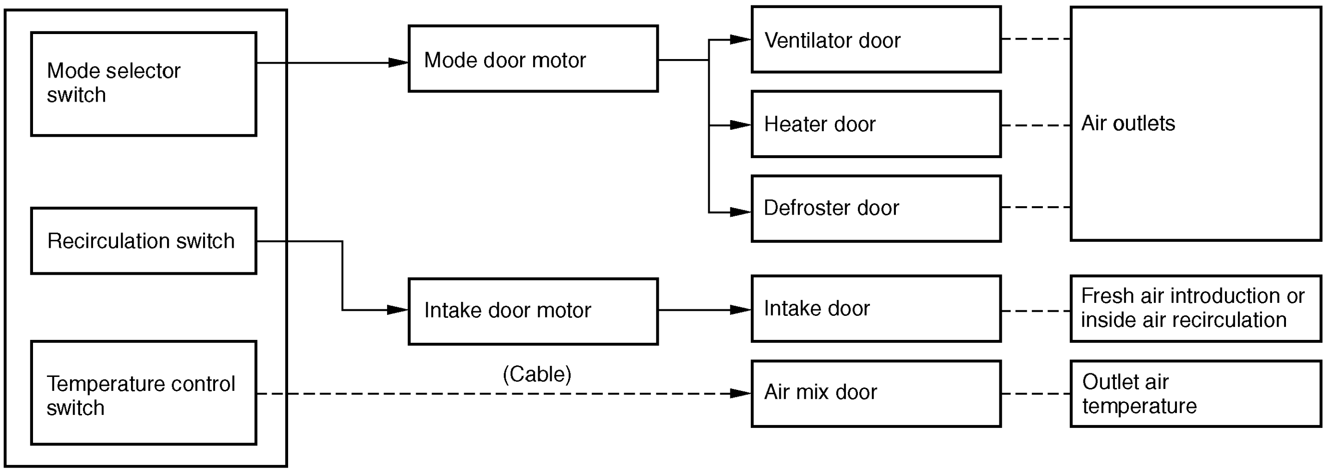

B4H1513C

**RHD model**




B4H1514B

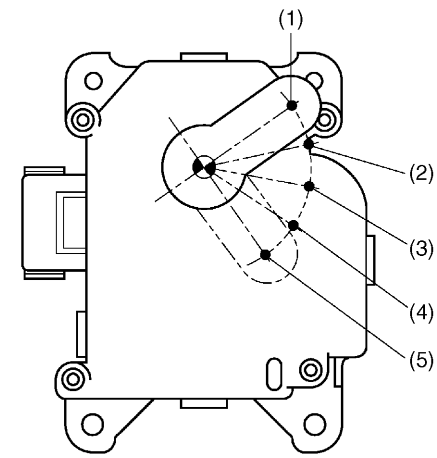
## C: SYSTEM CONTROL FLOW




B4H0046B

# 4. Mode Door Control

The servo motor for driving the mode door is installed on the side facing the driver's seat of the heater unit. Operating the mode selector switch sends a signal to the servo motor. In response to the signal, the motor makes a clockwise or counterclockwise rotation to drive the mode door through a link.

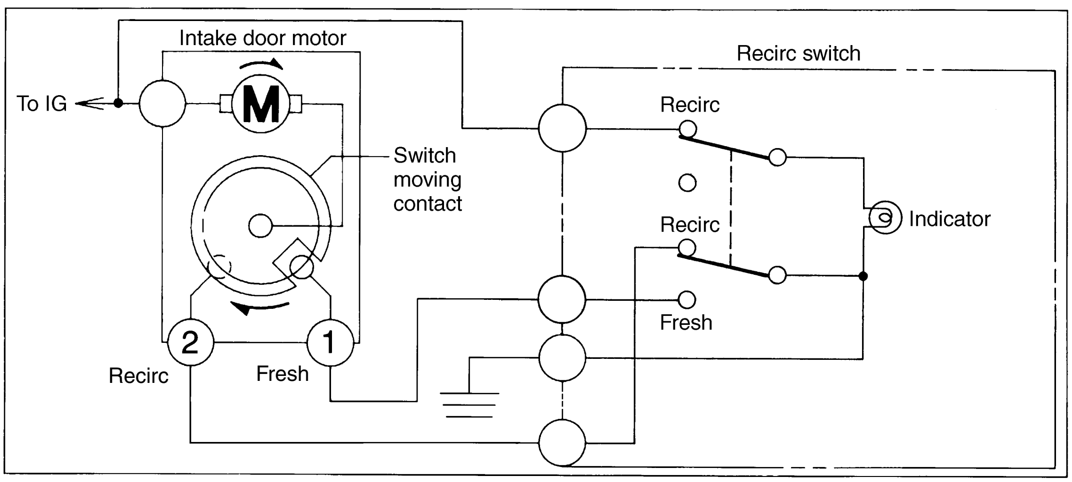



B4H1505A

(1) DEF position
(2) DEF/HEAT position
(3) HEAT position
(4) VENT/HEAT position
(5) VENT position

# 5. Intake Door Control

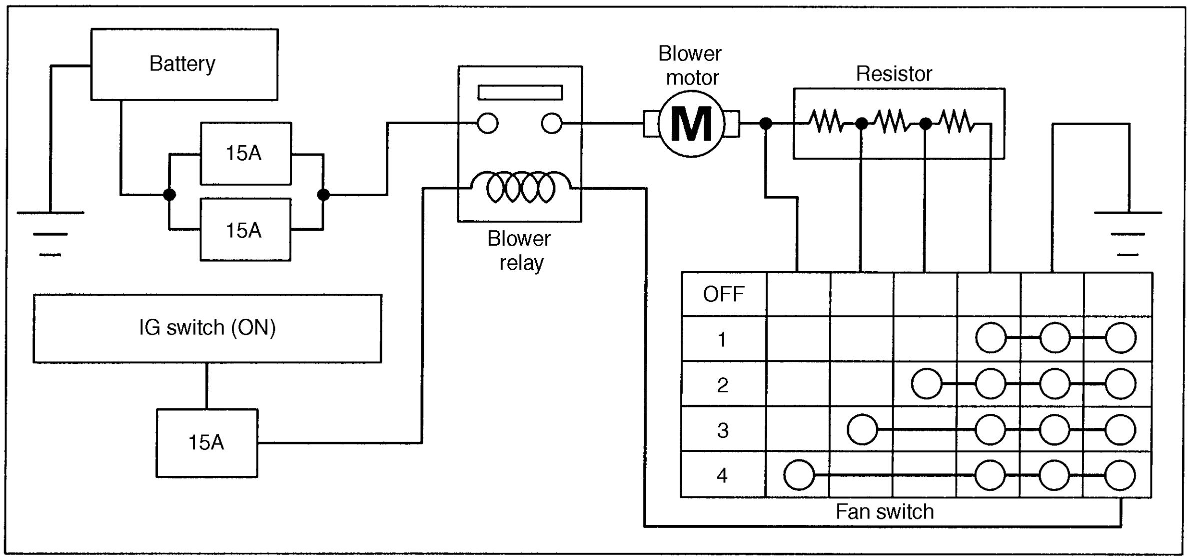
The intake door motor is located on the upper part of the intake unit. It opens and closes the intake doors through a rod and a link. When the recirculation switch is pressed (the indicator comes on), the ground circuit of the intake door motor is formed through terminal 2 of the moving contact instead of through terminal 1. This causes the motor to make a rotation to close the intake doors. Since the moving contact is built into the motor and rotates together with it, the ground circuit of the motor opens when the contact's slot reaches terminal 2. The motor then stops.
When the recirculation switch is pressed again (the indicator goes out), the ground circuit is formed through terminal 1 rather than terminal 2. The motor makes a rotation in the same direction as when the switch is first pressed – but now opening the intake doors – until the moving contact's slot reaches terminal 1.




G4H0741A

# 6. Blower System

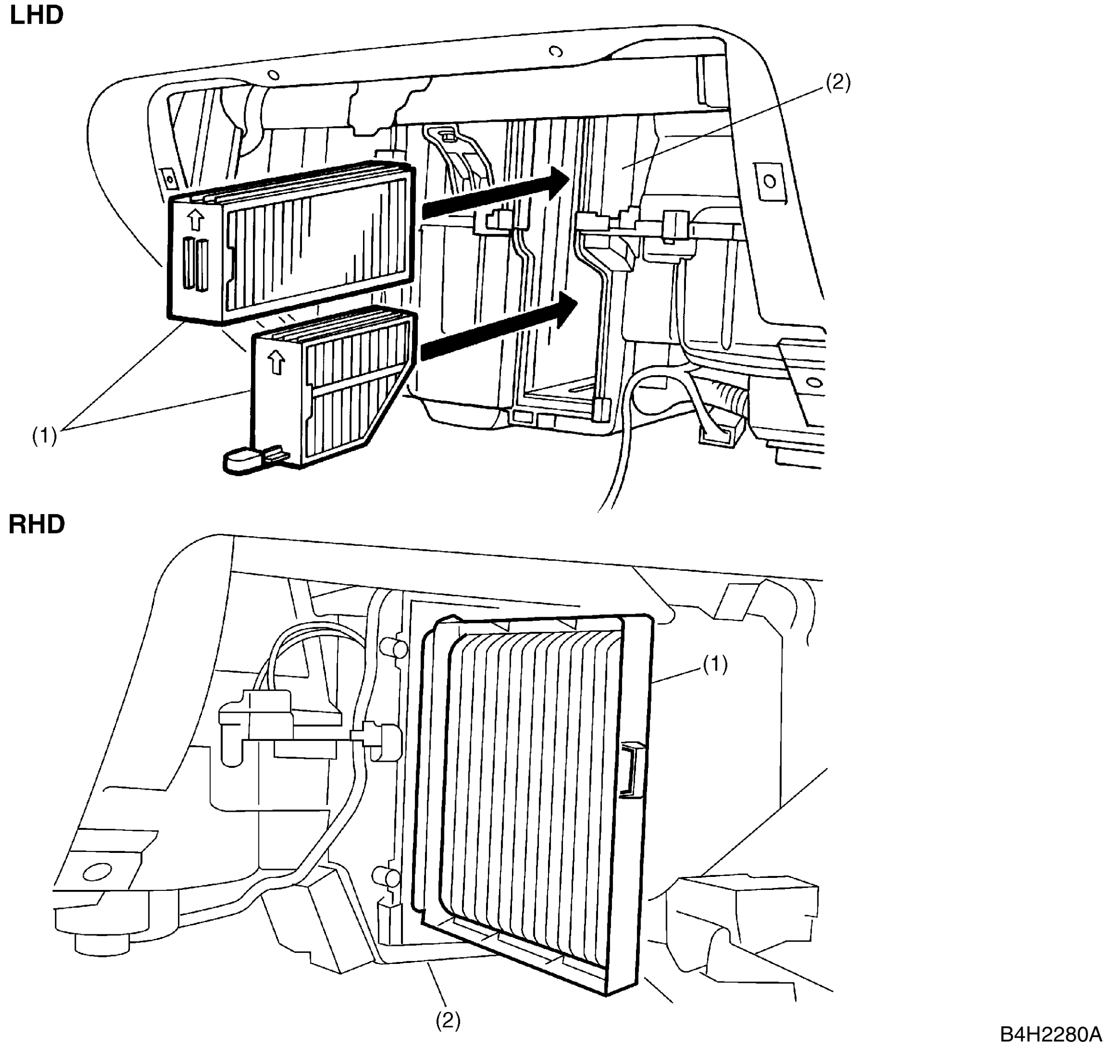
The blower relay is ready to be activated when the ignition switch is in the ON position. With the ignition switch ON, placing the fan switch in any position other than OFF activates the relay, allowing electric current to flow from the battery to the ground through the blower motor, the resistor, and the selected fan switch contacts. The connected resistor(s) vary depending on the selected position of the fan switch and cause the blower motor speed to change.




H4H1097A

# 7. Filter (Option)

The optional filter is located in front of the cooling unit's evaporator inlet.
The air conditioner may fail to exhibit its full performance if the filter is excessively clogged with dust and dirt. It is essential to replace the filter with a new one at the specified interval.




(1) Filter
(2) Cooling unit

# 8. Air Conditioning Cycle

## A: GENERAL

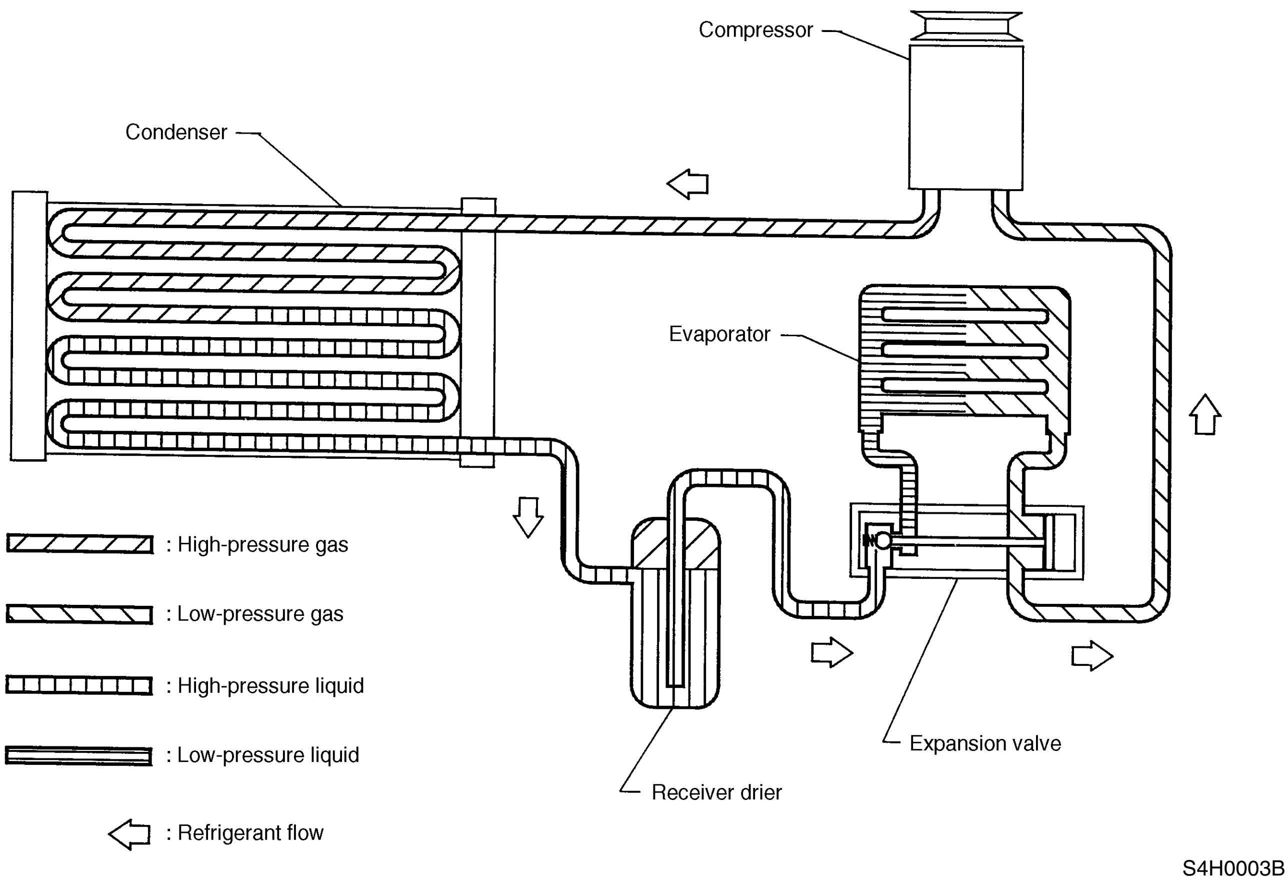
The refrigerant recirculates in the air conditioning system, flowing out of the compressor, passing through the condenser, receiver drier and evaporator, and returning to the compressor.

The flow of refrigerant to the evaporator is controlled by an expansion valve located inside the evaporator.

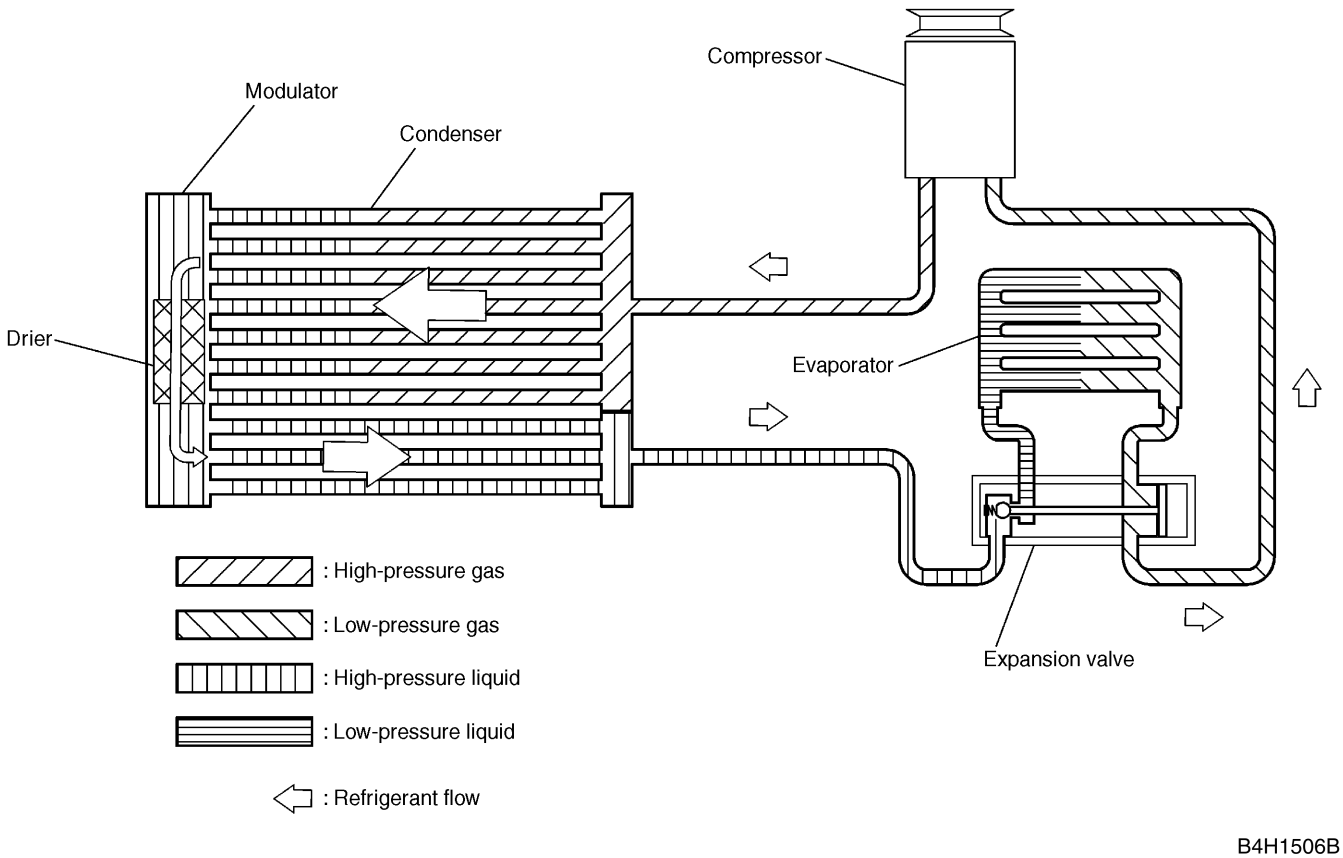
The compressor operates and stops repeatedly to maintain the evaporator temperature within a specified range. When the evaporator temperature falls below the specified temperature, the thermo-control amplifier stops the compressor operation. When the evaporator temperature rises above the specified temperature, the thermo-control amplifier puts back the compressor into operation.

The refrigerant system is protected against excessively high or low pressures by a pressure switch. If the system pressure rises or drops excessively, the pressure switch is activated to prevent the compressor from operating.

**LHD model**



## RHD model

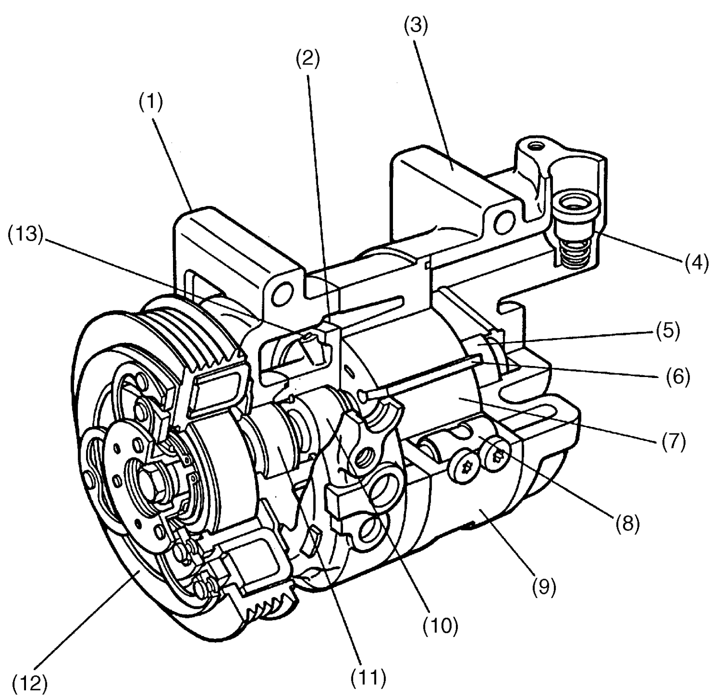

Compressor
Modulator
Condenser
Drier
Evaporator
Expansion valve
: High-pressure gas
: Low-pressure gas
: High-pressure liquid
: Low-pressure liquid
: Refrigerant flow
B4H1506B

# 9. Compressor

## A: LHD MODEL

### 1. GENERAL

The compressor is a rotary type that has a rotor fitted with five radially movable vanes. The rotor rotates together with the vanes in an elliptical cylinder. As the rotor rotates, the volume of each closed space formed between two adjacent vanes (referred to as “cylinder chamber” in the following description) decreases, so that the pressure of the refrigerant gas confined in the cylinder chamber increases. In this way, the rotary compressor performs its function as a pump. The pumping cycle consisting of suction, compression and discharge takes place 10 times during every rotation of the rotor.
On the discharge side of the cylinder, a roll valve is provided that opens at a predetermined high pressure. Air tightness between the rotor shaft and front head is ensured by the shaft seal. The trigger valve incorporated in the front side block provides the function of applying back pressure to the vanes. The compressor contains necessary quantity of compressor oil. The oil is distributed to all the parts requiring lubrication and sealing by utilizing the discharge pressure of the refrigerant.




S4H0307A

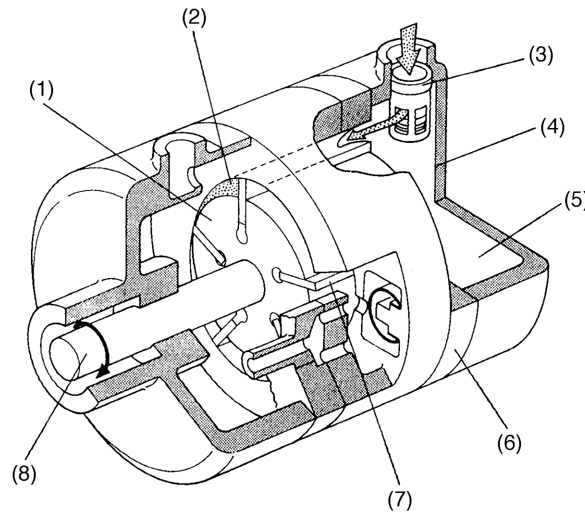
| | | | | | |
|---|---|---|---|---|---|
| (1) | Front head | (6) | Vane | (11) | Shaft seal |
| (2) | Side block | (7) | Rotor | (12) | Magnet clutch |
| (3) | Rear head | (8) | Roll valve | (13) | Trigger valve |
| (4) | Check valve | (9) | Cylinder | | |
| (5) | Rear bearing | (10) | Front bearing | | |

## 2. FUNCTIONS

As the rotor rotates, the volume of each cylinder chamber changes. This creates the compressor's suction, compression and discharge functions as explained in the following:

1) Suction:

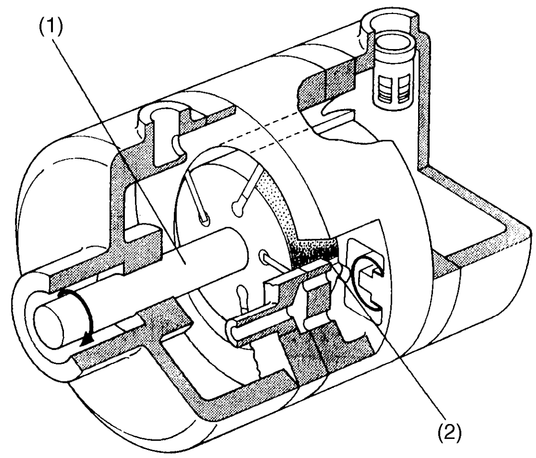
Low-pressure gaseous refrigerant is forced out from the evaporator by rotation of the compressor. It enters the low-pressure chamber in the rear head through the check valve. The refrigerant is then drawn into the cylinder by rotation of the vane-fitted rotor through the two suction ports provided in the rear side block. Air tightness of the cylinder chambers is maintained by the compressor oil.




| | | |
|---|---|---|
| (1) Rotor | (4) Rear head | (7) Vane |
| (2) Refrigerant | (5) Low-pressure chamber | (8) Drive shaft |
| (3) Check valve | (6) Rear side block | |

2) Compression:

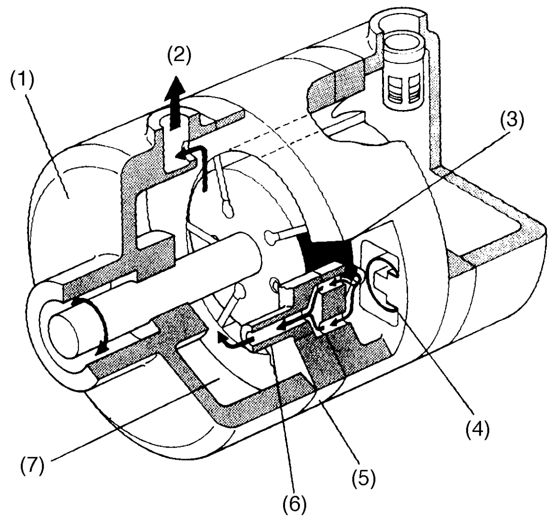
Further rotation of the rotor after suction makes the volume of each cylinder chamber smaller, thus compression occurs.




| | |
|---|---|
| (1) Drive shaft | (2) Refrigerant |

3) Discharge:

When the pressure of refrigerant in the cylinder chamber exceeds a predetermined pressure, the roll valve opens to discharge the refrigerant through a pipe-shaped passage built in the front side block into the high-pressure chamber in the front head. The gaseous refrigerant in the high-pressure chamber is led to a baffle, which separates the compressor oil contained in the refrigerant before it flows into the high-pressure piping.

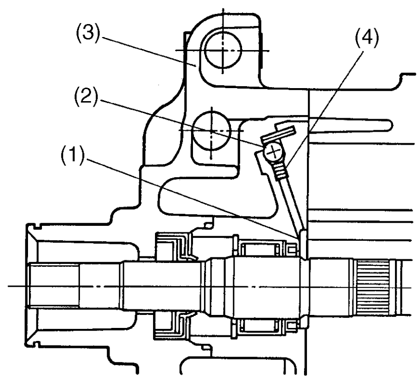



B4H0747A

| | | |
|---|---|---|
| (1) Front head | (4) Roll valve | (7) High-pressure chamber |
| (2) Refrigerant (Discharging) | (5) Front side block | |
| (3) Refrigerant (High-pressure) | (6) Pipe | |

## 3. TRIGGER VALVE

This valve has a function of maintaining a proper level of pressure behind the vanes (vane back pressure) such that they can move easily upon start of the compressor. The trigger valve is incorporated in the front side block and its end opens to a cavity called "K-ditch" that is provided in the rotor side end of the side block. The valve consists of a check ball and a spring.
The vanes are prone to chatter if there is only small difference between the high- and low-pressures. This condition typically occurs when the compressor is started. In such a condition, the spring raises the ball to open the valve and allows the back pressure to act on the vanes, thereby ensuring smooth operation.

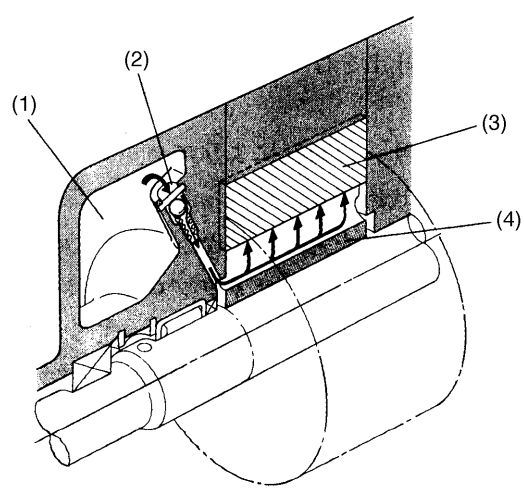



S4H0308A

| | | | |
|---|---|---|---|
| (1) | K-ditch | (3) | Front head |
| (2) | Check ball | (4) | Spring |

1) When compressor starts or when load is low:

When the compressor starts or when the load is low (the high-pressure level is low), the spring can raise the check ball clear of its seat, so the trigger valve is opened. The pressure of the high-pressure chamber then acts on the back end surface of each vane to prevent it from chattering.

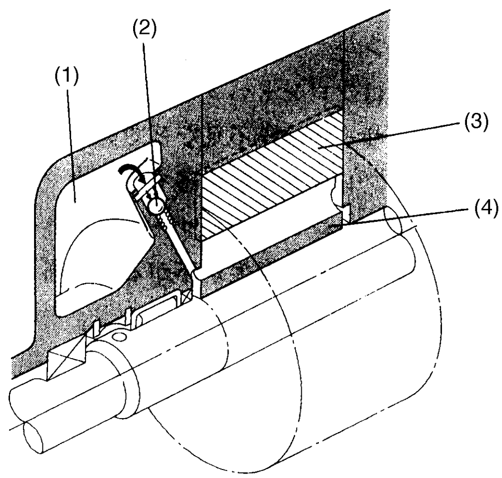



B4H0749A

| | | | |
|---|---|---|---|
| (1) | High-pressure chamber | (3) | Vane |
| (2) | Trigger valve (Open) | (4) | Rotor |

2) When compressor is in regular operation:

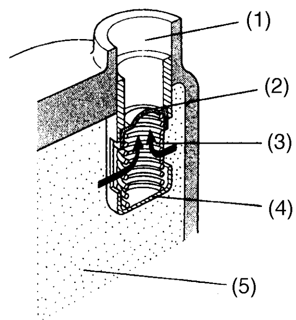
When the pressure in the high-pressure chamber of the compressor increases, the pressure overcomes the spring tension and pushes the check ball against its seat, so the trigger valve closes. The oil port pressure coming through the side block is applied to the end surface of vane to maintain proper back pressure.




(1) High-pressure chamber
(2) Trigger valve (Closed)
(3) Vane
(4) Rotor

## 4. CHECK VALVE

A check valve consisting of a spherical plate and spring is provided at the suction port of the rear head. Immediately after the compressor has stopped, there is large difference between the high- and low-pressures. This would cause reverse rotation of the compressor and consequent reverse flow of refrigerant to the evaporator if no check valve is provided. Immediately after the compressor has stopped, the high-pressure refrigerant forces the check valve plate upward and closes the suction port to prevent flow of refrigerant from the high-pressure side to the low-pressure side.

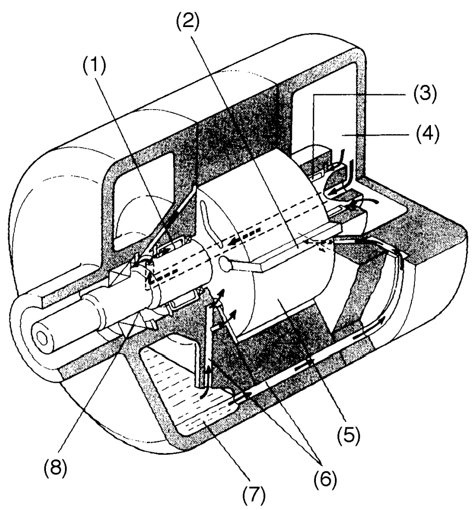



B4H0751A

| | | |
|---|---|---|
| (1) Refrigerant suction port | (3) Spring | (5) Refrigerant |
| (2) Plate | (4) Check valve | |

## 5. LUBRICATION

The lubrication oil is collected at the bottom of the high-pressure chamber. The high-refrigerant pressure in the chamber forces the oil upward through the oil passages in the front side block to lubricate the front end of the rotor. The high-chamber pressure also forces the oil through the passages in the bottom of the cylinder to lubricate the rear end of the rotor. The oil that has lubricated each end of the rotor enters the low-pressure chamber by the internal pressure of the compressor. The oil contained in the gaseous refrigerant from the evaporator passes through the low-pressure chamber and lubricates the rear bearing. The oil also passes through the passage in the drive shaft and lubricates the front bearing and shaft seal before entering the suction port of the cylinder. Since the pressure in the suction port of the cylinder is slightly lower than that in the low-pressure chamber, the oil that has lubricated all the parts enters the suction port and is finally brought by the refrigerant back to the high-pressure chamber.

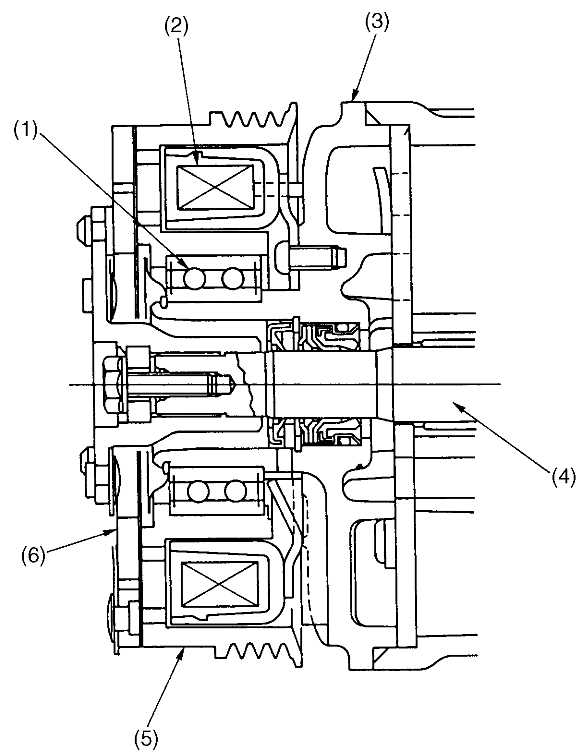



B4H0752A

(1) Front bearing
(2) Vane
(3) Rear bearing
(4) Low-pressure chamber
(5) Rotor
(6) Oil port
(7) High-pressure chamber
(8) Shaft seal

## 6. MAGNET CLUTCH

The magnet clutch serve to transmit engine power to the compressor module. It is built into the compressor shaft. When current flow through the magnet clutch coil, the drive plate is attracted so that the pulley and compressor shaft rotate as a module. When the compressor is not in use, the pulley alone rotates freely.
The compressor used with the six-cylinder engine has a lock sensor. If the sensor detects locking of the compressor resulting from a fault, it causes disengagement of the magnet clutch to protect the engine and the power steering drive.

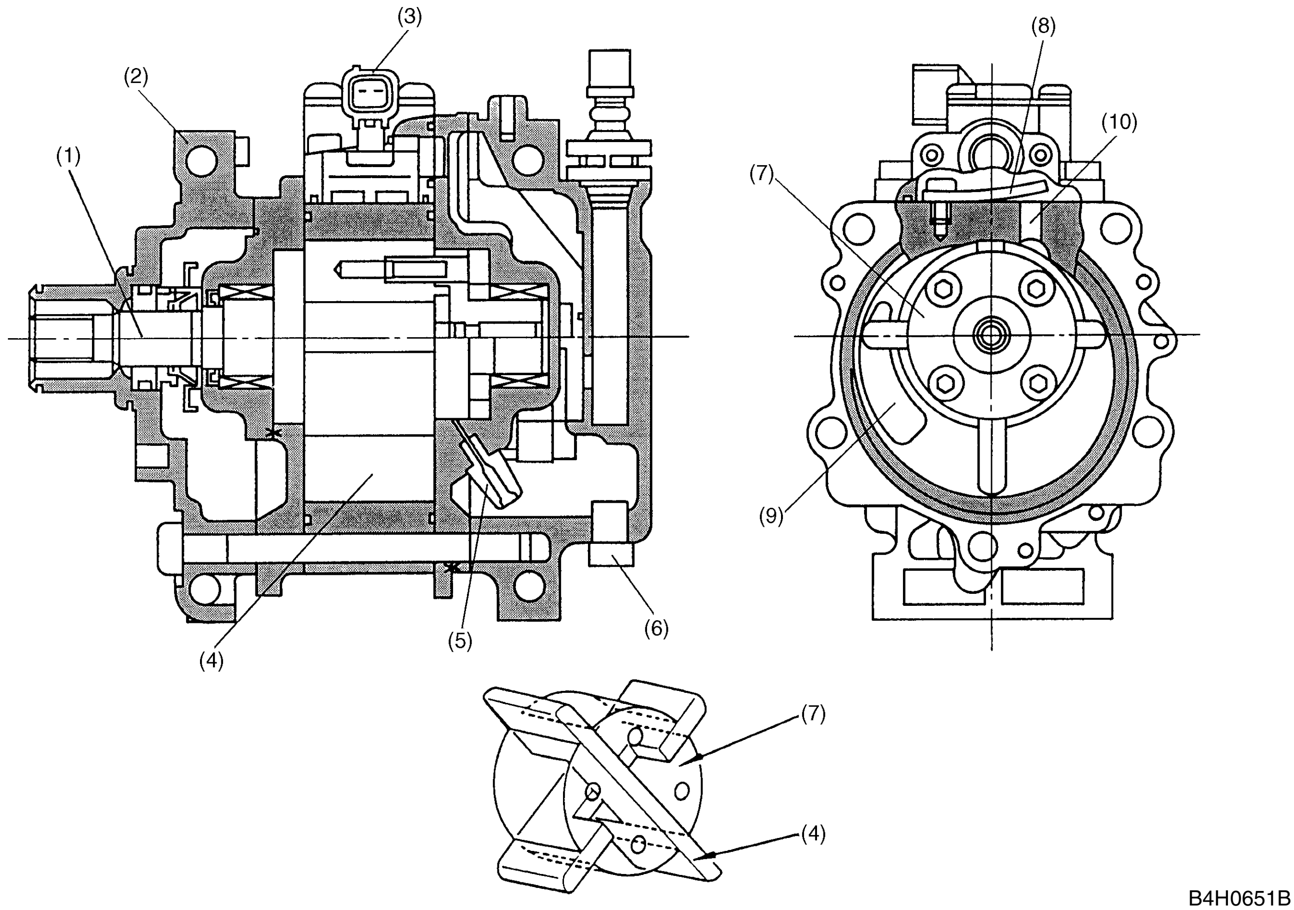



(1) Bearing
(2) Magnet clutch coil
(3) Compressor
(4) Drive shaft
(5) Clutch pulley
(6) Drive plate

## B: RHD MODEL

### 1. GENERAL

The compressor basically consists of a rotor, radially movable vanes on the rotor, and a cylinder two. The rotor is excentrically located in the cylinder and driven by the drive shaft to rotate together with the vanes. Since the gas is compressed by rotation of the vanes, the compressor is called “through vane rotary” type compressor.
The engine torque is transmitted to the drive shaft through a belt and a magnet clutch.
The two vanes intersect with each other at right angles as shown in the following drawing. As the rotor rotates, the vanes’ ends slide along the internal surface of the cylinder, so the vanes make reciprocating motions. During rotation, the volume of each closed space formed between two adjacent vane walls (referred to as “cylinder chamber” in the following description) changes and this provides the compressor with a pumping function consisting of suction, compression and discharge.
The front cylinder head has a discharge port and a discharge valve. When compressed in the cylinder, high-pressure refrigerant gas forces the discharge valve to open and enters the oil separator case where it is separated from oil it has contained. The cylinder head also has a temperature sensor which prevents overheating that would occur if refrigerant gas is short during compressor operation.
The rear cylinder head has an oil return valve which controls the quantity of oil for lubrication of the cylinder chambers, and a sludge valve which, when liquid refrigerant is forced into a cylinder chamber, prevents the liquid compression.




| | | | |
|---|---|---|---|
| (1) | Drive shaft | (6) | Pressure relief valve |
| (2) | Front cylinder head | (7) | Rotor |
| (3) | Temperature sensor connector | (8) | Discharge valve |
| (4) | Vane | (9) | Suction port |
| (5) | Oil return valve | (10) | Discharge port |

## 2. FUNCTION

1) Start of suction — End of suction:

As the compressor rotates, the refrigerant gas from the evaporator moves through the suction hose into the internal low-pressure chamber. Through the suction port provided in the front cylinder head, the refrigerant gas then enters the cylinder chamber (1).

2) Start of compression:

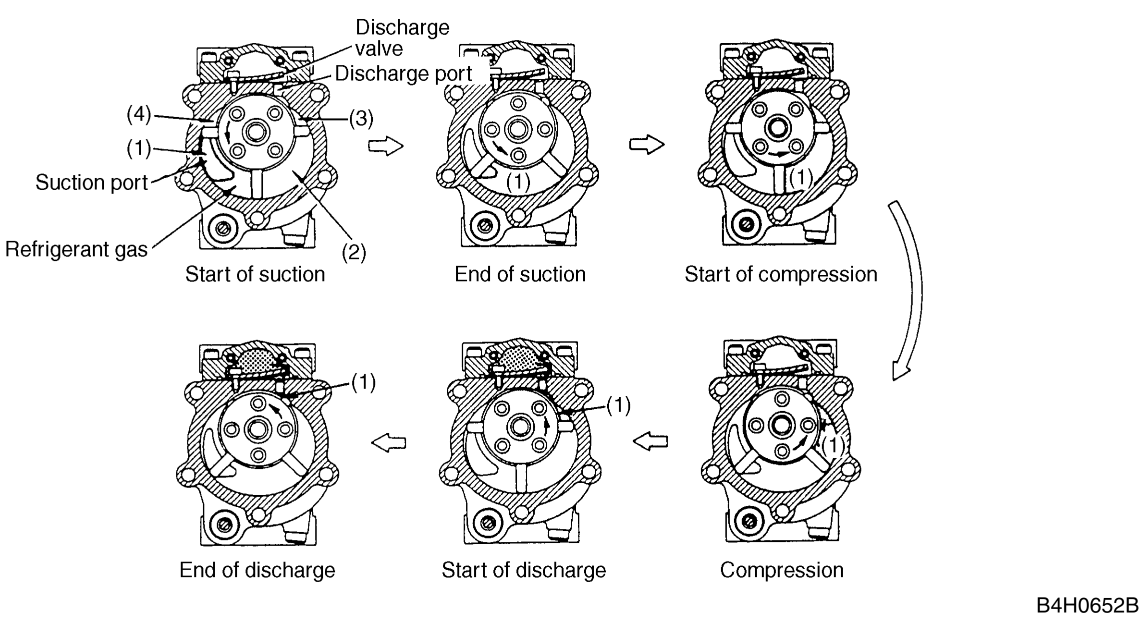
Further rotation of the rotor gradually reduces the volume of the cylinder chamber (1). The refrigerant gas in the cylinder chamber is therefore compressed and its pressure increases.
Air tightness between the cylinder chamber surfaces and the ends of the vanes is maintained by a film of the oil which simultaneously lubricates the cylinder and vanes.

3) Compression — Start of discharge:

The rotor further rotates and the volume of the cylinder chamber (1) further decreases, confining the refrigerant gas in a smaller space. The pressure of the refrigerant gas in the cylinder chamber further increases.
When this pressure becomes higher than the pressure of the high-pressure chamber in the oil separator case, the high pressure refrigerant gas forces the discharge valve to open and enters the high-pressure chamber. The refrigerant is then routed to the condenser.
The pressure of the cylinder chamber (1) may become lower than the pressure of the high-pressure chamber. If this happens, the discharge valve is forced to close by the pressure of the high-pressure chamber, so counterflow of the refrigerant gas from the high-pressure chamber into the cylinder chamber is prevented.

4) End of discharge:

The cylinder chamber (1) has completed compression and discharge of the refrigerant gas. It is ready for starting the above-mentioned cycle again.
The other cylinder chambers (2), (3) and (4) perform the pumping function in exactly the same way as the cylinder chamber (1).

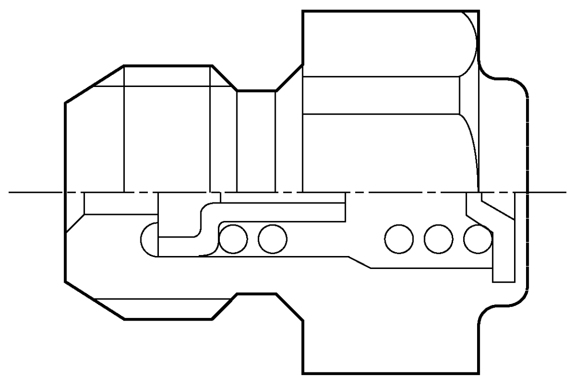


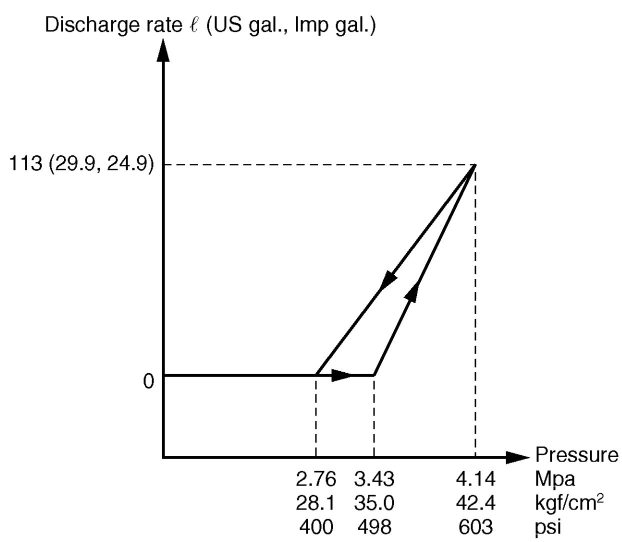
## 3. PRESSURE RELIEF VALVE

When the high pressure exceeds the maximum limit, the pressure relief valve opens and releases the refrigerant into the atmosphere to protect the air conditioning system. This pressure relief valve is designed to minimize the outflow of the refrigerant into the atmosphere.

**CAUTION:**

- **When the pressure relief valve was operated, be sure to perform inspection and remove the cause. Otherwise the problem will recur.**
- **A pressure relief valve that has opened due to an abnormally high pressure must not be reused.**
- **If an abnormal condition occurs, the high- and low-pressure switch usually operates first to stop the compressor. Therefore, the pressure relief valve is not always operated when an abnormally high pressure is generated.**



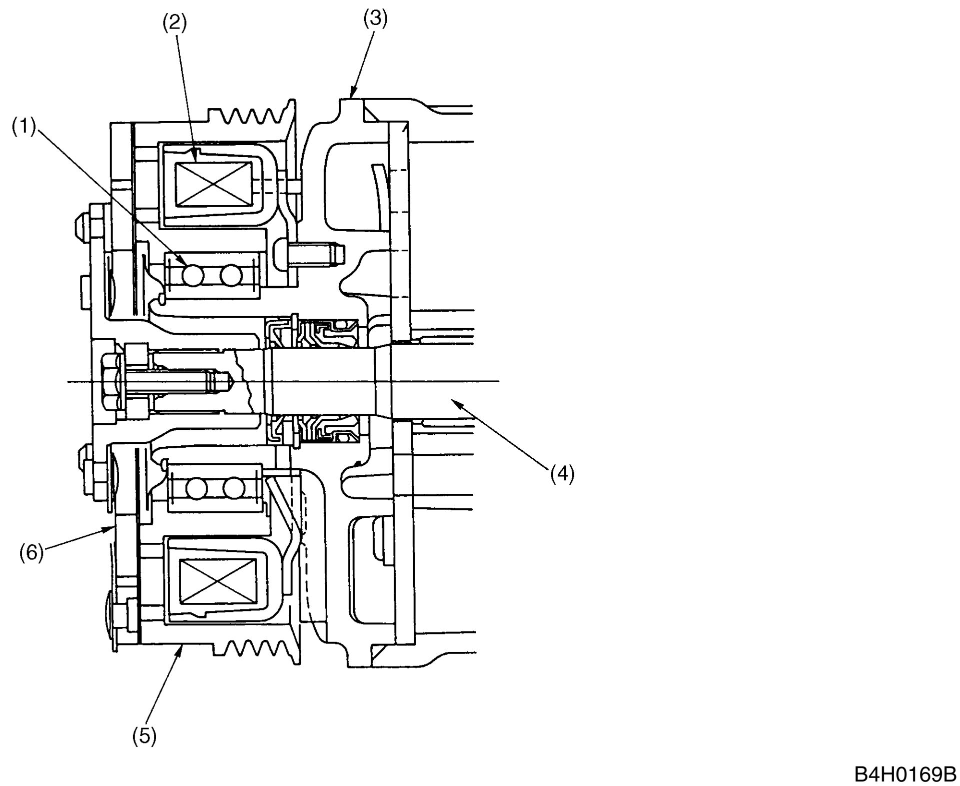



Pressure relief valve operation characteristics

B4H1507B

## 4. MAGNET CLUTCH

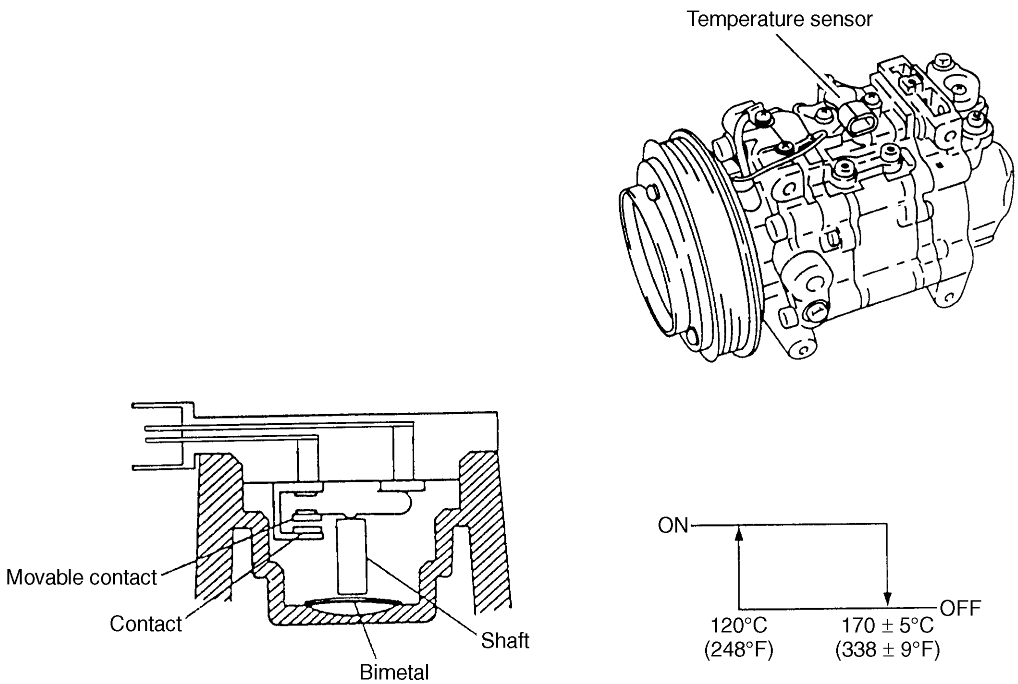
The magnet clutch serve to transmit engine power to the compressor module. It is built into the compressor shaft. When current flow through the magnet clutch coil, the drive plate is attracted so that the pulley and compressor shaft rotate as a module. When the compressor is not in use, the pulley alone rotates freely.
The compressor used with the six-cylinder engine has a lock sensor. If the sensor detects locking of the compressor resulting from a fault, it causes disengagement of the magnet clutch to protect the engine and the power steering drive.




(1) Bearing
(2) Magnet clutch coil
(3) Compressor
(4) Drive shaft
(5) Clutch pulley
(6) Drive plate

## 5. TEMPERATURE SENSOR

The compressor will heat up to an abnormally high temperature if it is operated for long time when incoming refrigerant gas is insufficient.
To prevent overheating of the compressor, a temperature sensor is provided on the compressor.
The sensor has a bimetal which causes the contacts to open when the compressor temperature reaches 170°C (338°F) to stop operation of the compressor.




Temperature sensor internal structure

Temperature characteristics

B4H0654C

# 10.Condenser

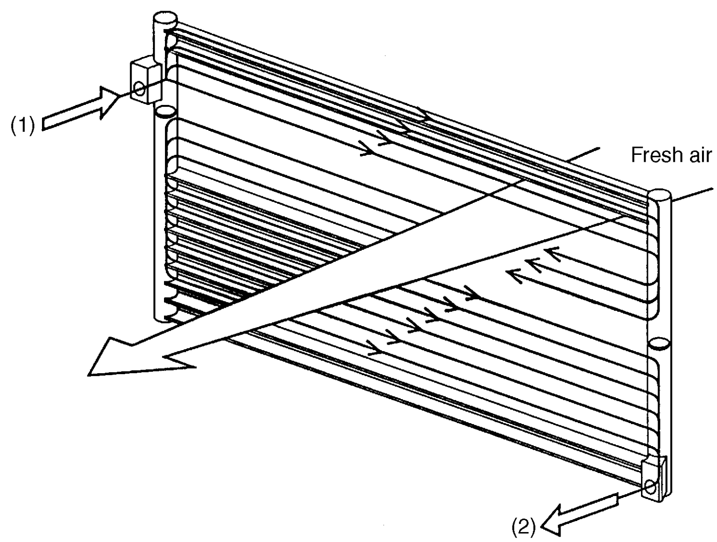
## A: MECHANISM

### 1. LHD MODEL

The high-temperature and high-pressure gaseous refrigerant discharged from the compressor is cooled down and converted into liquid by the condenser.

The condenser consists of tubes and radiating fins.

The heat of the refrigerant flowing through the condenser tubes is released into to the ambient air which is caused to flow across the fins by the cooling fan.



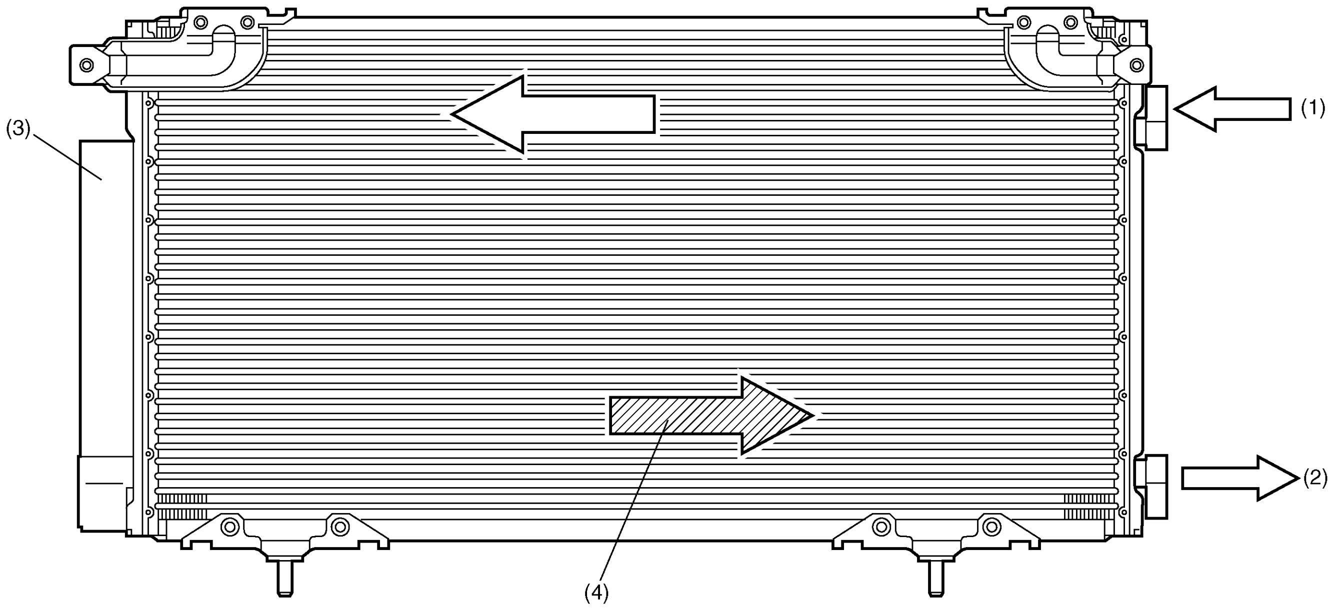

B4H1508A

(1) Refrigerant inlet (High-pressure gaseous refrigerant)

(2) Refrigerant outlet (High-pressure liquid refrigerant)

## 2. RHD MODEL

The condenser is of a multi-flow type with a modulator which incorporates a drier and a filter. Its lower portion forms the sub-cool condenser. The gaseous refrigerant that has entered the condenser flows through the modulator to the sub-cool condenser. Passing through the sub-cool condenser, nearly 100% of the gaseous refrigerant becomes liquid.




(1) Refrigerant inlet (High-pressure gas refrigerant)
(2) Refrigerant outlet (High-pressure liquid refrigerant)
(3) Modulator
(4) Sub-cool condenser portion

# 11.Receiver Drier (LHD Model)

## A: MECHANISM

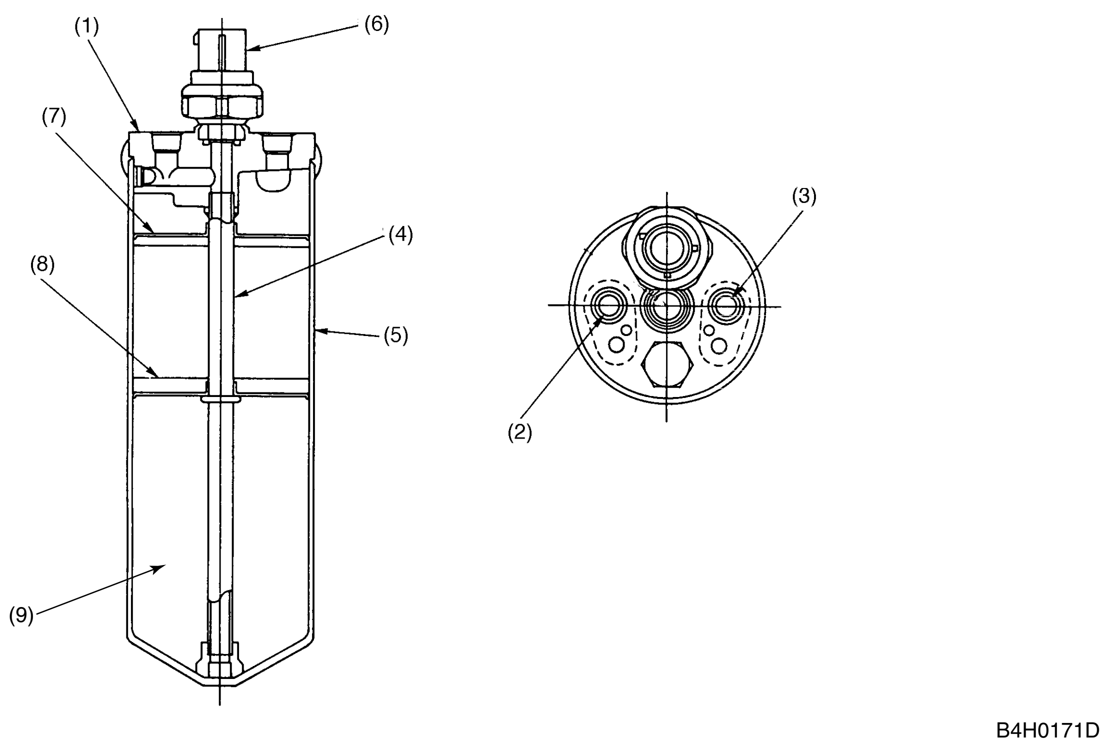
The amount of refrigerant necessary to circulate in the system varies with change in the heat load. The receiver drier stores part of the liquid refrigerant until an increased heat load requires its use again. The receiver drier also has the following functions:

1) It removes bubbles from the liquid refrigerant. (If bubbles are present, the refrigerant passing through the expansion valve varies in quantity, temperature, and pressure, resulting in insufficient cooling.)

2) It removes moisture from the refrigerant.

3) It removes foreign substance from the refrigerant.

The receiver drier contains a strainer to remove foreign substance and desiccant to absorb moisture from refrigerant.




(1) Head block
(2) Inlet
(3) Outlet
(4) Inside pipe
(5) Body
(6) Pressure switch
(7) Strainer
(8) Strainer cushion
(9) Desiccant

# 12.Modulator (RHD Model)

## A: MECHANISM

The modulator incorporates a drier and a filter. It forms an integral part of the condenser.

The amount of circulating refrigerant varies as the heat load changes. The modulator functions as a buffer to enable supply of refrigerant in an amount appropriate for each heat load condition.

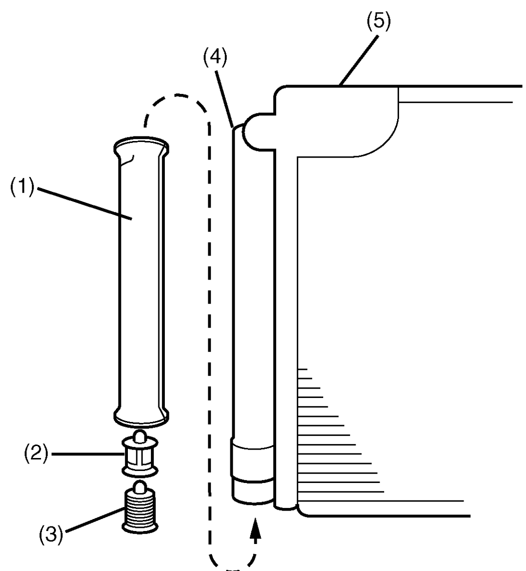
The modulator also has the following functions:

1) It removes bubbles from the liquid refrigerant. (If bubbles are present, the refrigerant passing through the expansion valve varies in quantity, temperature, and pressure, resulting in insufficient cooling.)

2) It removes moisture from the refrigerant.

3) It removes foreign substance from the refrigerant.

The inside filter removes foreign substance and the drier absorbs moisture from the refrigerant.




B4H1510A

(1) Drier

(2) Filter

(3) Cap

(4) Modulator

(5) Condenser

# 13.Pressure Switch

## A: LHD MODEL

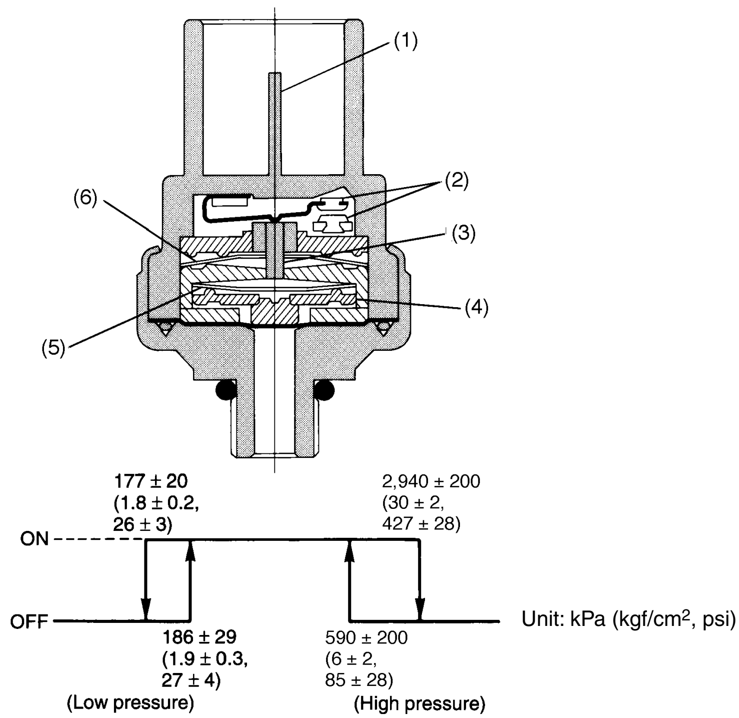
The pressure switch is located on the high-pressure line to the receiver drier. When an abnormally high or low pressure occurs in the high-pressure line, the pressure switch turns OFF to stop operation of the compressor.

- When the pressure is abnormally low [177 kPa (1.8 kgf/cm$^2$, 26 psi) or less]

The pressure switch turns OFF assuming that the refrigerant is lost due to leakage.

- When the pressure is abnormally high [2,940 kPa (30 kgf/cm$^2$, 427 psi) or more]

The pressure switch turns OFF to prevent the system from being damaged.




B4H0172F

(1) Point terminal
(2) Contact point
(3) Guide pin
(4) Pressure guide
(5) High-pressure disc spring
(6) Low-pressure disc spring

## B: RHD MODEL

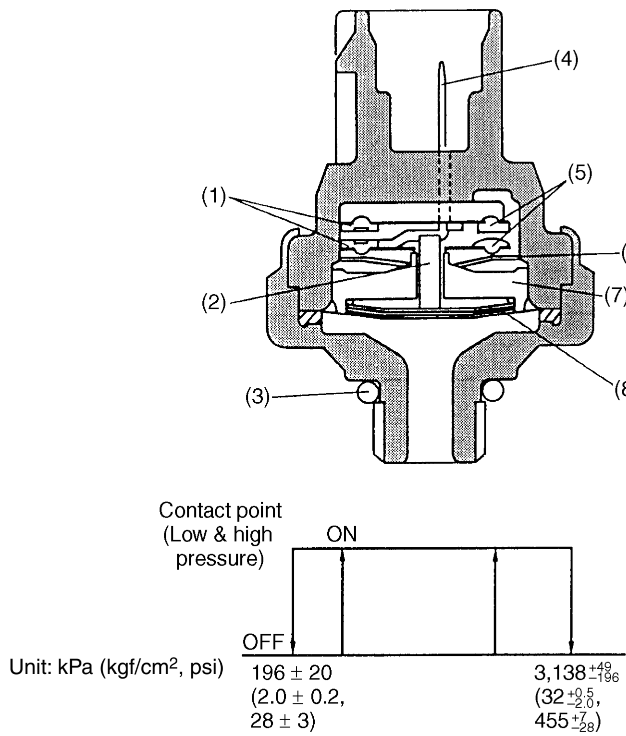
The pressure switch is located on the high-pressure line near the sight glass. When an abnormally high or low pressure occurs in the high-pressure line, the pressure switch turns OFF to stop operation of the compressor.

- When the pressure is abnormally low [196 kPa (2.0 kgf/cm$^2$, 28 psi) or less]

The pressure switch turns OFF assuming that the refrigerant is lost due to leakage.

- When the pressure is abnormally high [3,138 kPa (32 kgf/cm$^2$, 455 psi) or more]

The pressure switch turns OFF to prevent the system from being damaged.




B4H0657C

(1) Rivet
(2) Guide pin
(3) O-ring
(4) Point terminal
(5) Contact point (low and high pressures)
(6) Pressure disc A
(7) Diaphragm
(8) Pressure disc B

# 14.Evaporator

## A: MECHANISM

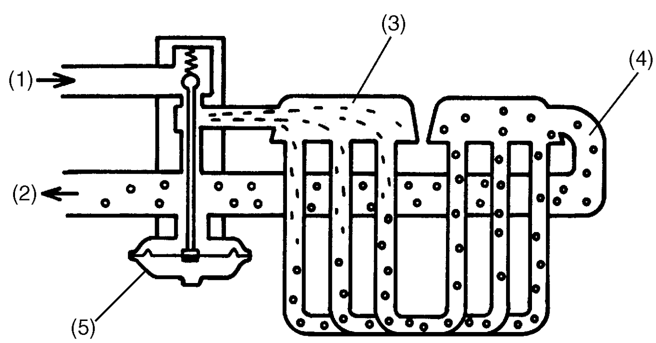
Air pushed by the blower passes through the cooling fins and tubes of the evaporator. Since the air is warmer than the refrigerant, the heat of air moves to the refrigerant through the fins and tubes. As the low-pressure refrigerant moves through the evaporator, heat from the air causes the refrigerant to boil. By the time the refrigerant has passed through the evaporator, it becomes vapor. Moisture in the air condenses to water drops as it moves around the tubes and fins of the evaporator. Water and dirt are then discharged outside the vehicle through a drain hose.

The evaporator is a laminated type and consists of thin, rectangular aluminum plates arranged in multiple layers and fins that are attached between them. During flow through the evaporator, the state of the refrigerant changes as follows:

Misty refrigerant (very close to liquid form) from the expansion valve at a low-pressure, enters the lower tube of the evaporator, where it soaks up heat from the compartment. The refrigerant boils and vaporizes quickly due to the rapid heat exchange. Then the refrigerant is pushed upward by the force of the bubble generated during the heat exchange and enter the upper tube. When it reaches the upper tank, the refrigerant is in a thoroughly vaporized state.

The evaporator has a single tank, and its surface has been given the following treatments.

- Rustproof treatment
- Waterproof treatment
- Moldproof treatment




B4H1511A

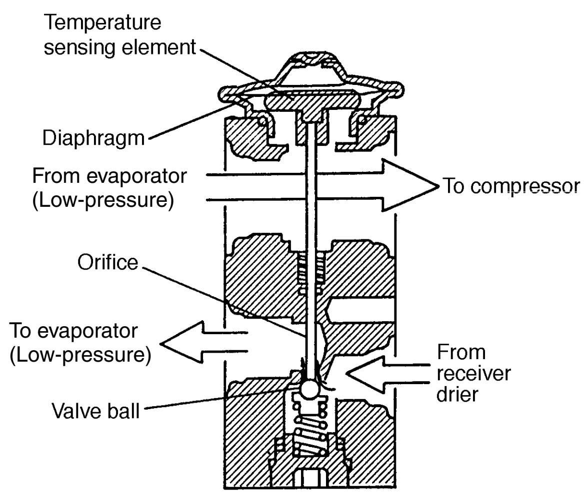
(1) From receiver drier
(2) To compressor
(3) Misty refrigerant
(4) Vapor
(5) Expansion valve

# 15.Expansion Valve

## A: LHD MODEL

### 1. MECHANISM

The expansion valve is connected to both the evaporator inlet and outlet pipes. It converts high-pressure liquid refrigerant which comes from the receiver drier to misty, low-pressure refrigerant which is delivered to the evaporator. Being at low pressure and low temperature, this refrigerant can easily evaporate in the evaporator and remove heat from the cabin air. The valve performs this conversion by automatically controlling the flow rate of refrigerant according to the cooling ability required by the heat load.
The refrigerant temperature is sensed by the temperature sensing element located in the low-pressure refrigerant passage of the expansion valve, and the flow rate of the refrigerant is controlled by changing the lift of the valve ball located in the high-pressure passage.

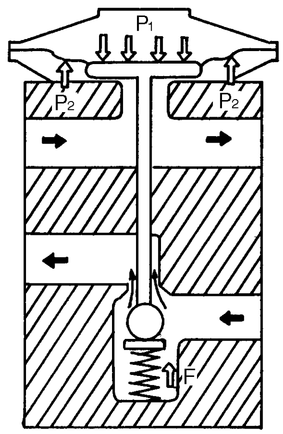



H4H1123C

## 2. FUNCTION

When the heat load to the air conditioning system increases, the refrigerant temperature at the evaporator outlet rises and therefore the pressure $P_1$ around the temperature sensing area increases. As this pressure $P_1$ becomes higher than the sum of the evaporator outlet (low-pressure side) pressure $P_2$ and the spring force F ($P_1 > P_2 + F$), the diaphragm is pressed down, moving the valve ball connected to the diaphragm clear of its seat. This increases the flow of the refrigerant.

When the heat load is small, the action of the valve's inner elements is contrary to the above; the valve ball closes and the flow of the refrigerant decreases.

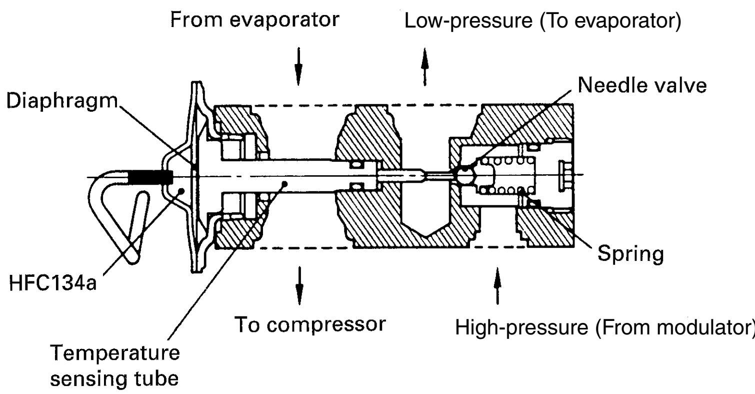



H4H1124

## B: RHD MODEL

### 1. MECHANISM

The expansion valve accomplishes the function of atomizing the high-pressure liquid refrigerant delivered from the modulator by a throttle valve with variable opening, thereby controlling the refrigerant for optimum heat exchange in the evaporator.
It consists of a needle valve (ball), temperature sensing tube, diaphragm, spring, etc. The upper chamber of the diaphragm is filled with freon gas HFC134a.
The temperature sensing tube, provided at the outlet of the refrigerant that has passed through the evaporator, senses the temperature of the gas refrigerant.



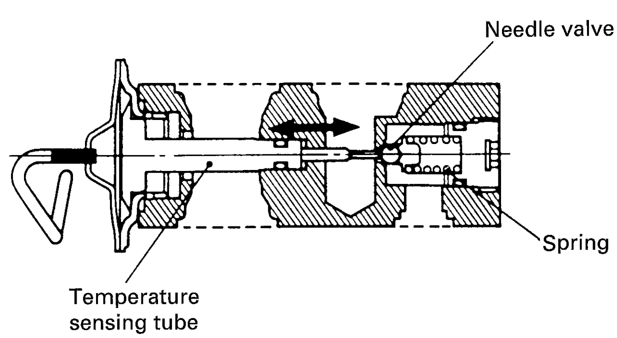

B4H0662B

### 2. FUNCTION

The temperature of the refrigerant that has passed through the evaporator is sensed by the temperature sensing tube, and the volume of freon gas in the diaphragm chamber changes to adjust the opening of the needle valve.

- When the refrigerant temperature is low (when the heat load is small), the volume of freon gas decreases, moving the temperature sensing tube to the left to reduce the opening of the needle valve.

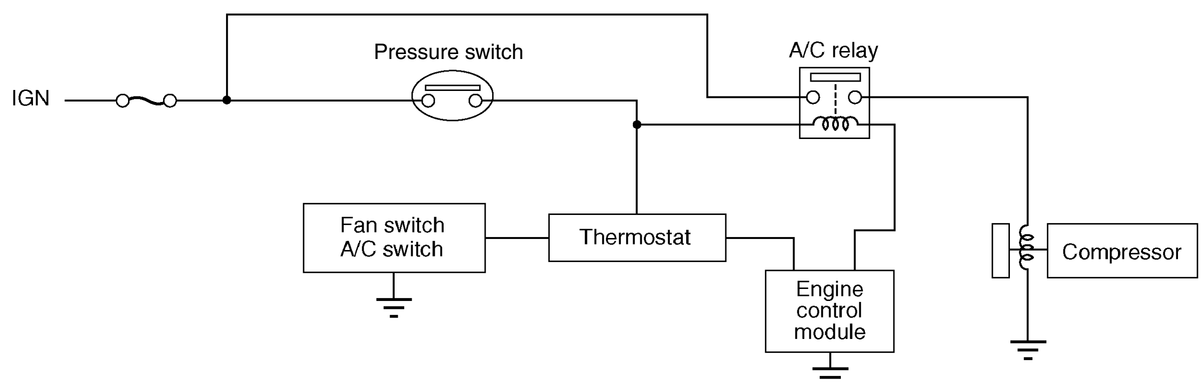
- When the refrigerant temperature is high (when the heat load is large), the volume of freon gas increases, moving the temperature sensing tube to the right to increase the opening of the needle valve.




B4H0663A

# 16.Compressor Clutch “ON” Delay System

When the A/C switch and fan switch are turned ON, a signal is sent to the engine control module. The engine control module then judges whether the engine is in operation. If the engine is operating, the engine control module activates the A/C relay. The maximum clutch “ON” delay times is 0.8 seconds after the A/C relay is activated.




B4H1832B

# 17.Compressor Control System

## A: GENERAL

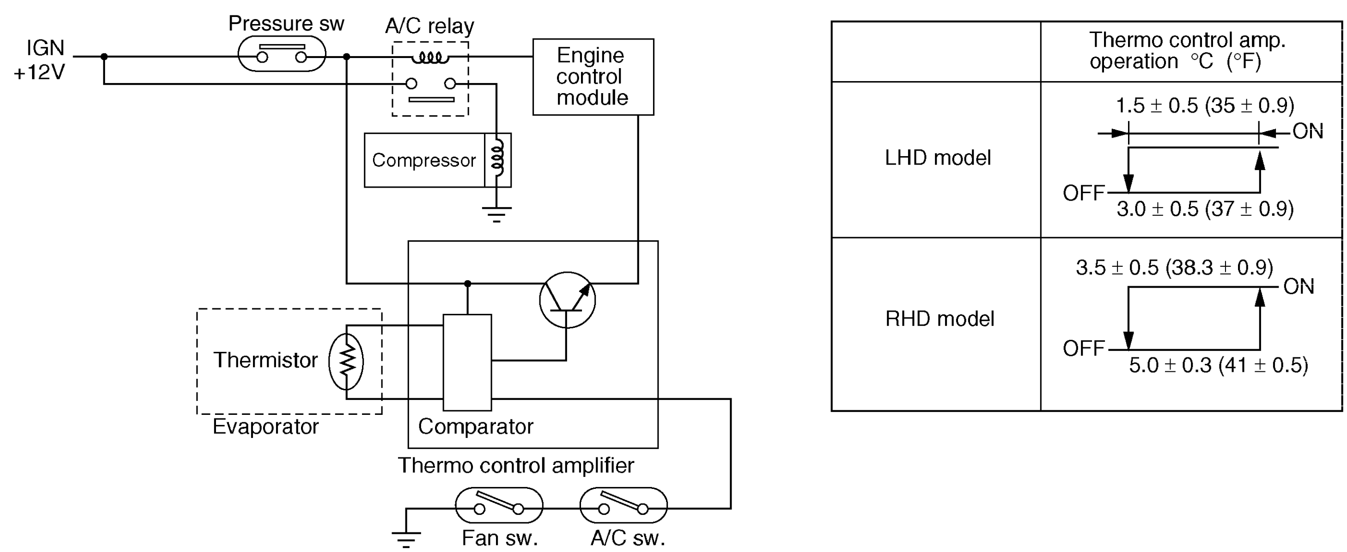
1) When the A/C switch and fan switch are turned ON, the A/C relay is activated. The compressor starts operating, and then the main and sub fans also operate.

2) The thermo control amplifier, when activated, disengages the compressor clutch and the main and sub fans.

3) When the pressure switch turns on, the compressor clutch is disengaged and the main and sub fans also stop.

## B: THERMO CONTROL AMPLIFIER

The thermo control amplifier disconnects the magnet clutch circuit to prevent the evaporator from becoming frosted when the temperature of the evaporator fin drops close to 3°C (37°F). When the limit temperature is reached, the thermistor (located on the evaporator fin) interrupts the base current of the amplifier. This deactivates the A/C relay, which in turn disconnects the magnet clutch circuit.

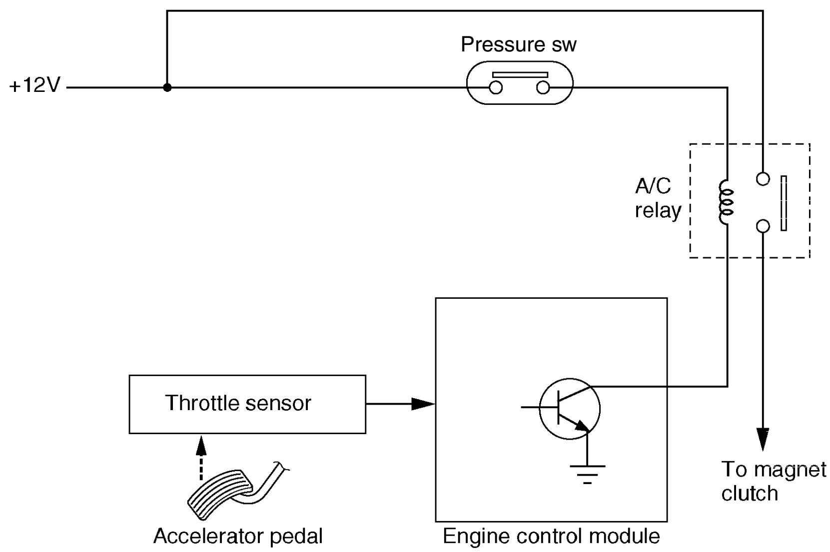



B4H1833B

## C: ACCELERATION CUT SYSTEM

The A/C switch turns the air conditioning system ON and OFF. The on-off signals from the switch are transmitted to the engine control module (ECM).

When the ECM receives a full-throttle signal from the throttle sensor during compressor operation, it deactivates the A/C relay to interrupt electric current to the compressor magnet clutch. This prevents the degradation of acceleration performance. The A/C relay is in the main fuse box located on the left side of the engine compartment.

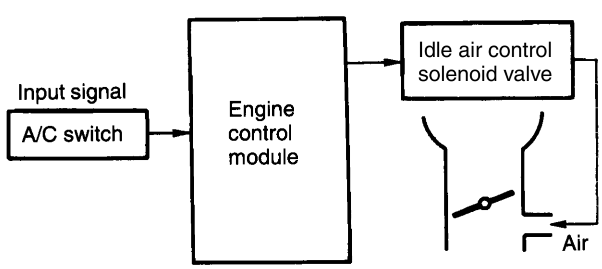



B4H1834B

## D: IDLE SPEED CONTROL

The idle air control solenoid valve increases the engine idling speed when the compressor is in operation.

The engine control module activates the idle air control solenoid valve when it receives an A/C switch ON signal so that necessary by-pass air is introduced into the throttle body to ensure proper idling speed for an increased engine load.




B4H0181A

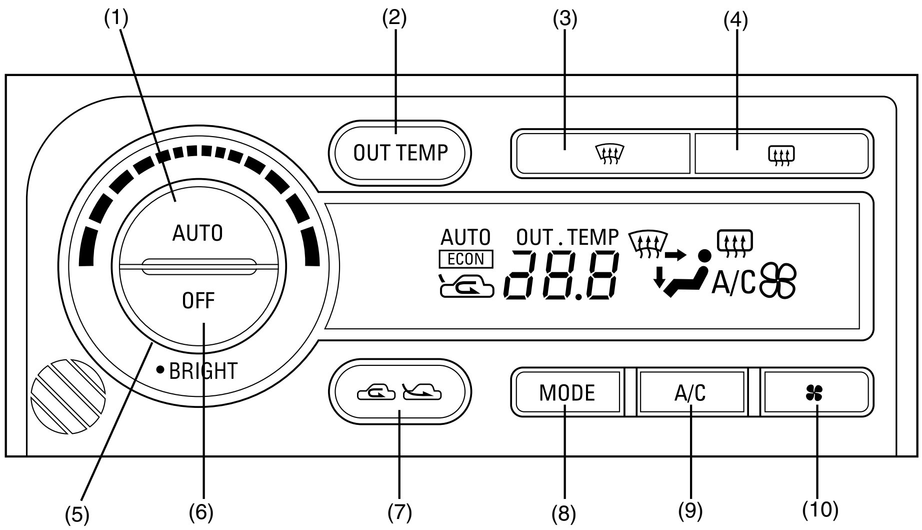
## E: FAN CONTROL

The main fan and sub fan are switched ON and OFF according to the operating modes as shown in the following table.

| Vehicle speed | A/C compressor | Engine coolant temperature | | | | | |
|---|---|---|---|---|---|---|---|
| | | Lower than 95°C (203°F) | | Between 95 and 99°C (203 and 210°F) | | Higher than 100°C (212°F) | |
| | | Operation of radiator fan | | Operation of radiator fan | | Operation of radiator fan | |
| | | Main | Sub | Main | Sub | Main | Sub |
| Lower than 19 km/h (12 MPH) | OFF | OFF | OFF | ON | OFF | ON | ON |
| | ON | ON | ON | ON | ON | ON | ON |
| Between 20 and 69 km/h (12 and 43 MPH) | OFF | OFF | OFF | ON | OFF | ON | ON |
| | ON | ON | ON | ON | ON | ON | ON |
| Between 70 and 105 km/h (43 and 65 MPH) | OFF | OFF | OFF | OFF | OFF | ON | ON |
| | ON | ON | OFF | ON | ON | ON | ON |
| Higher than 106 km/h (66 MPH) | OFF | OFF | OFF | OFF | OFF | ON | ON |
| | ON | OFF | OFF | ON | OFF | ON | ON |

# 18.Automatic Air Conditioning

## A: SWITCH FUNCTIONS




B4H2541A

| | | | |
|---|---|---|---|
| (1) | AUTO switch | (6) | OFF/Bright switch |
| (2) | Ambient temperature display switch | (7) | Fresh/Recirc switch |
| (3) | Defroster switch | (8) | Mode selector switch |
| (4) | Rear deffoger switch | (9) | A/C switch |
| (5) | Temperature set switch | (10) | Blower fan switch |

NOTE:
The beeper for button operation confirmation has been discontinued.

## 1. AUTOMATIC CONTROL OPERATION

● AUTO switch: When this switch is pressed (ON), the air outlet selection, blower fan speed, air temperature, fresh/recirculation switching, and compressor operation are automatically controlled. When the AUTO switch is pressed second time, the compressor operates in the ECON mode. In the ECON mode, the ECM controls compressor operation based on inputs from the intake air temperature sensor. Compressor operating time in the ECON mode is shorter than in the AUTO mode.

● Temperature set switch: A desired cabin temperature can be set in 0.5°C increments.

● OFF/Bright switch: When this switch is pressed, the blower fan and compressor stop and all the indicators go out.
Setting the light switch to the " " or " " position causes the illuminating icons on the display panel to dim. When traveling with the lights on in goomy daylight or in twilight, press the OFF switch for 1 second or longer if you feel it is too hard to identify the icons clearly. The brightness comes back to normal.

## 2. MANUAL CONTROL OPERATION

● A/C switch: The air-conditioner turns on when this switch is pressed first and turns off when it is pressed second time.

● Blower fan switch: Fan speed changes in the order of Lo, M1, M2 and Hi, every time it is pressed.

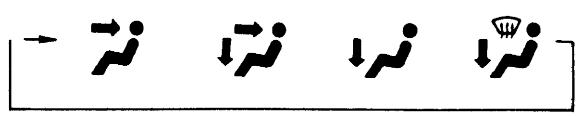
● Ambient temperature display switch: When this switch is pressed momentarily, the ambient temperature is indicated on the display for 5 seconds. When this switch is depressed for more than 1 seconds, the ambient temperature is continuously indicated.

● Defroster switch: Air is directed to the windshield for defrosting when this switch is pressed.

● Rear deffoger switch: Pressing this switch causes the rear deffoger to operate for 15 minutes.

● Fresh/Recirc switch: Every time this switch is pressed, switching takes place between outside air introduction and inside air recirculation alternately.

● Mode selector switch: Pressing this switch changes the outlets to which the air is directed in the order shown below.

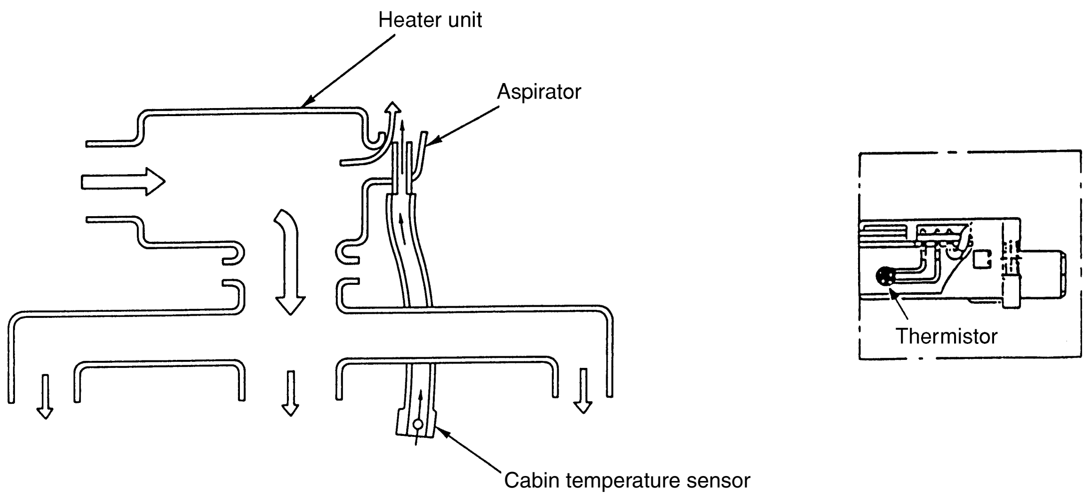


B4H1314B

## B: CABIN TEMPERATURE SENSOR

The cabin temperature sensor sends signals to the ECM.

This sensor consists of an aspirator and a thermistor, the resistance of which changes in inverse proportion to the temperature. The aspirator uses the vacuum created by the heater unit to direct cabin air to the thermistor. (The cabin temperature sensor, therefore, functions only while the blower fan is in operation.)



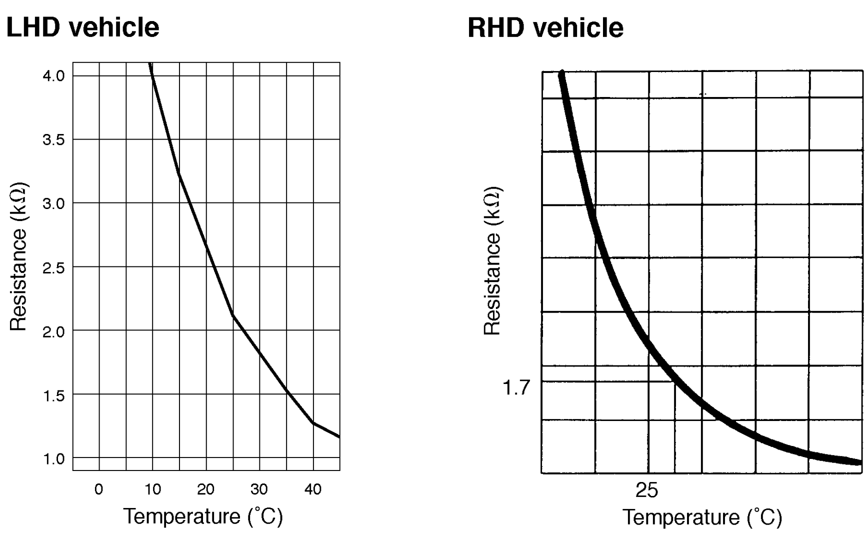

B4H1315B

## C: AMBIENT TEMPERATURE SENSOR

This sensor uses a thermistor to detect the ambient temperature and sends signals the ECM.

The thermistor can detect only an average temperature of the outside air but cannot respond to sharp changes in the temperature because its exterior is made of a plastic to increase the thermal capacity.

The ambient temperature sensor is located on the radiator stay behind the front grille for efficient exposure to the outside air.

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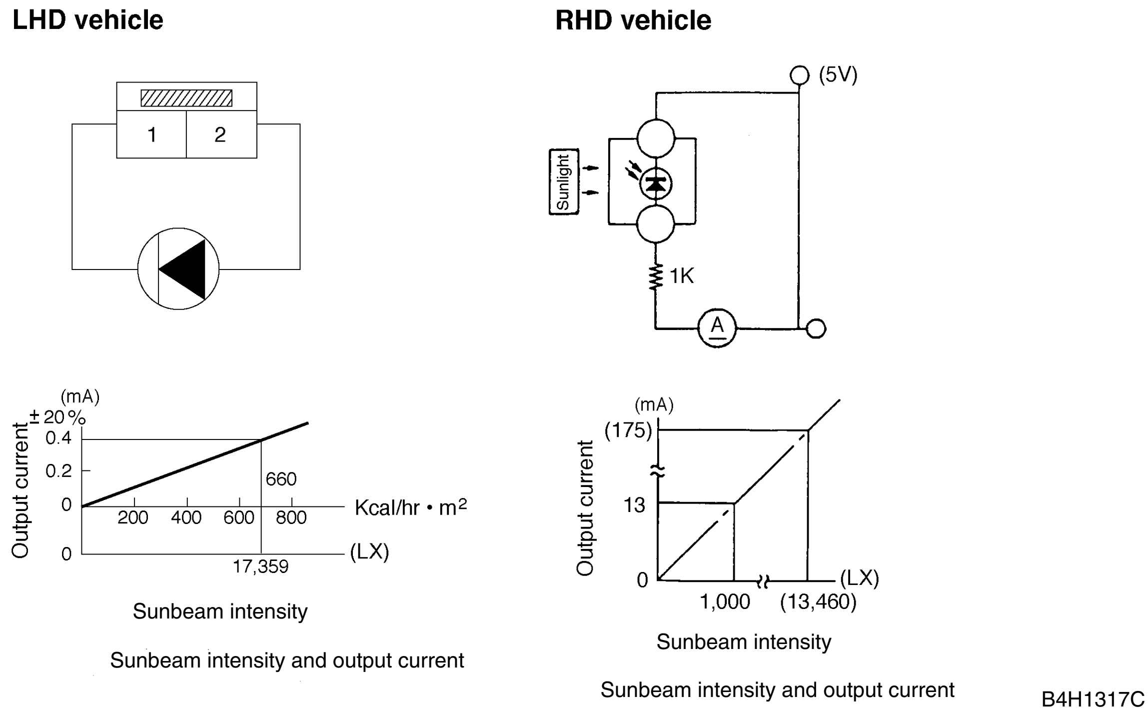
## D: SUNLOAD SENSOR

A photodiode is used in the sunload sensor. The photodiode detects changes in the sunbeam intensity and converts the results into current signals to send to the ECM.

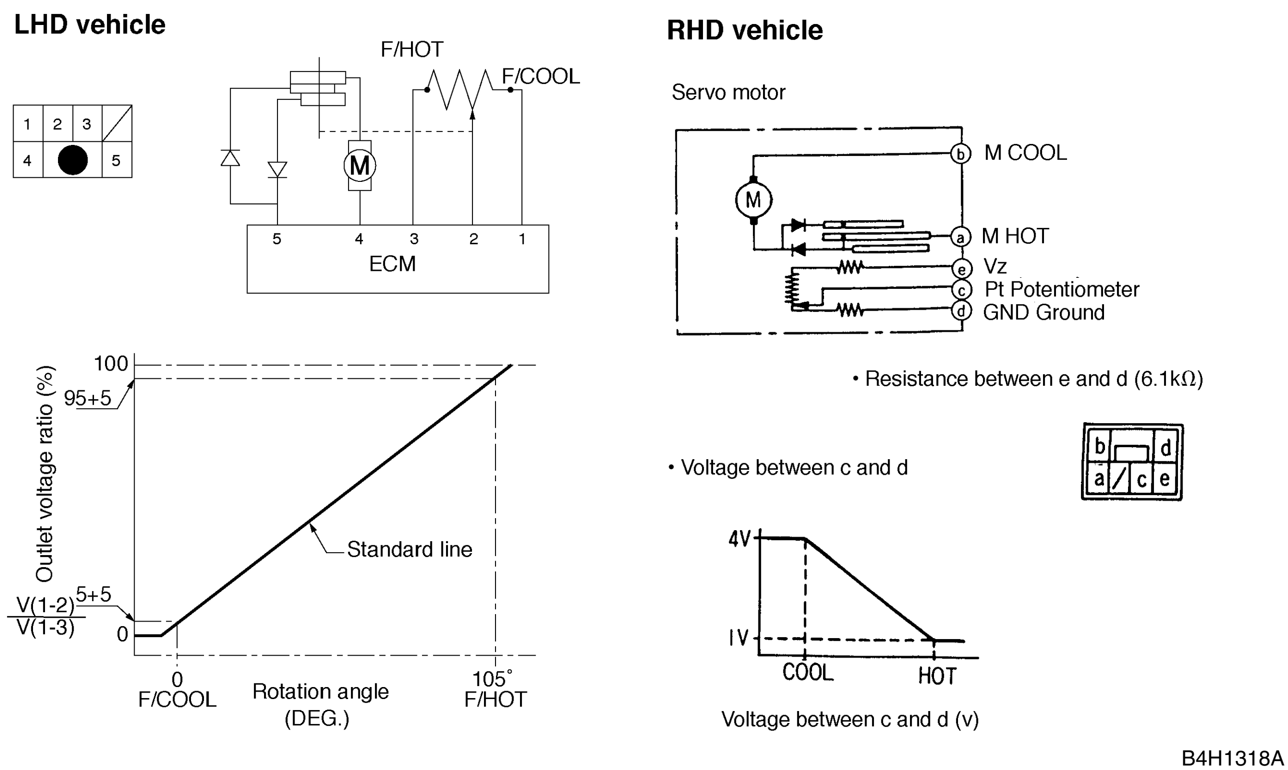
The sunload sensor is built into the front defroster grille.



## E: AIR MIX SERVO MOTOR

According to signals from the ECM, the servo motor forming integral part of the air mix damper rotates in one or the other direction to change the opening of the damper via a link.

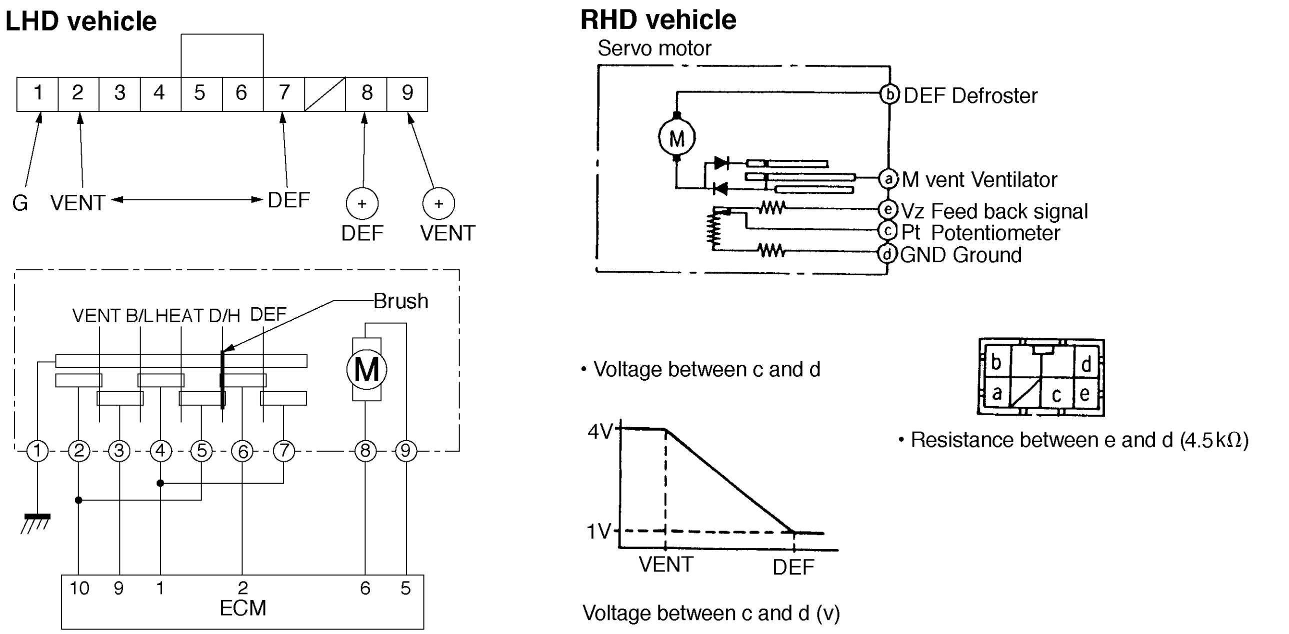
The motor has a built-in potentiometer which detects the opening of the air mix damper and sends the result to the ECM.



## F: AIR OUTLET SWITCHING SERVO MOTORS

According to signals from the ECM, the servo motor incorporated into each air outlet switching damper rotates in one or the other direction to open or close the damper via a link to control the air from the corresponding outlet(s).

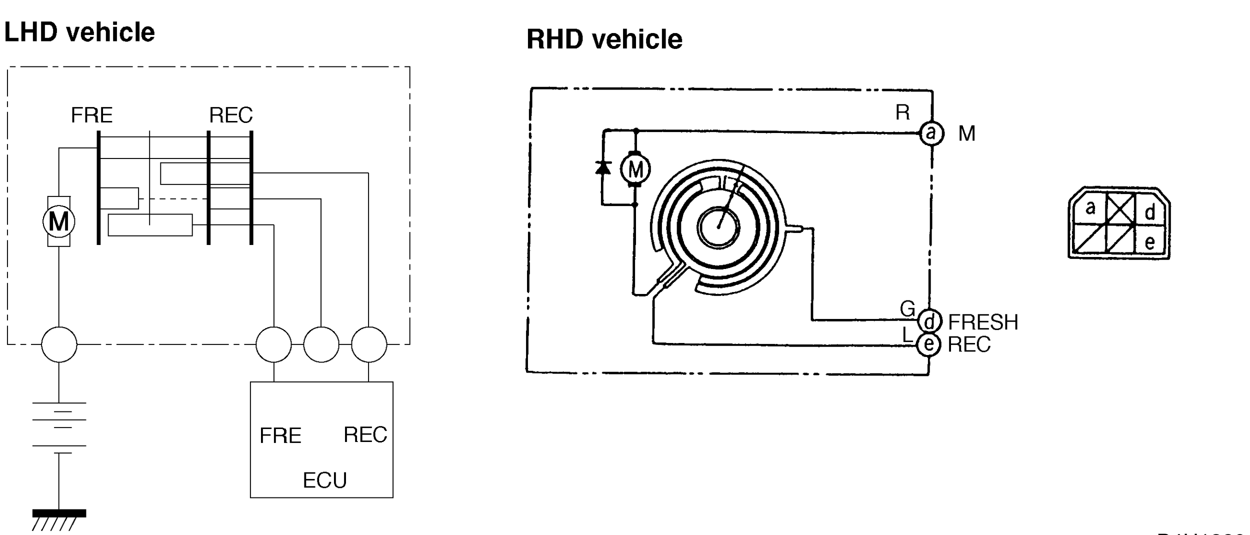
Each motor has a built-in potentiometer which detects the position of its damper and send the result to the ECM.




B4H1319A

## G: FRESH/RECIRC SWITCHING SERVO MOTOR

According to signals from the ECM, the servo motor incorporated into the fresh/recirc switching damper rotates in one or the other direction to perform switching between the outside air introduction and inside air recirculation modes via a link.




B4H1320A

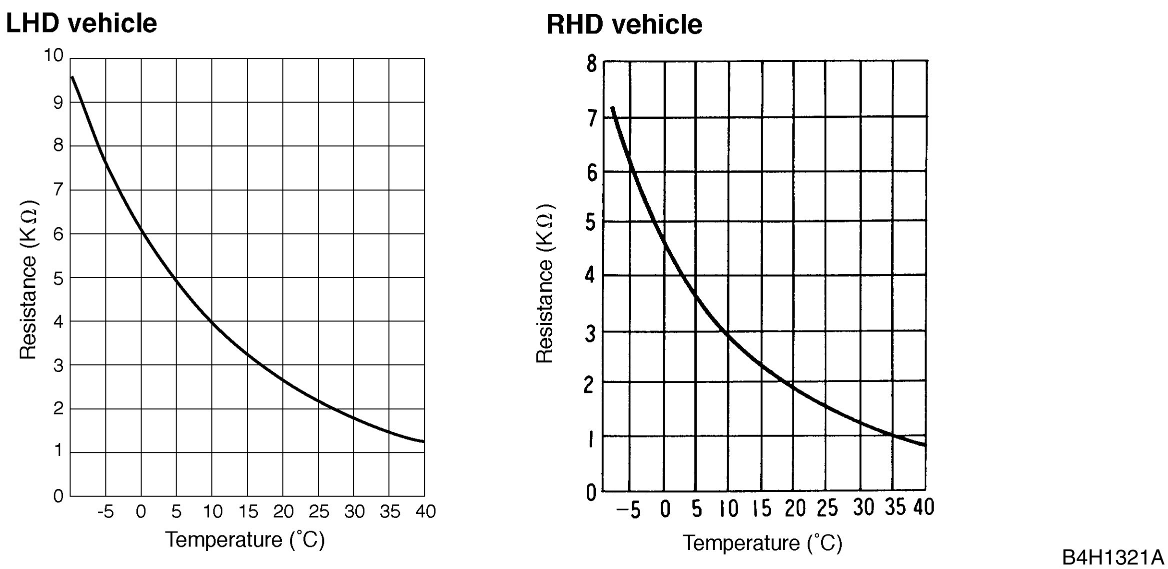
## H: BLOWER SPEED CONTROL POWER TRANSISTOR

The base voltage of the power transistor changes according to blower drive signals from the ECM. The blower speed changes steplessly in accordance with the change in the power transistor's base voltage.

Should an over-current occur, the thermal fuse connected to the circuit (rated to blow at 144°C (291°F)/LHD, 119°C (246°F)/RHD) cuts off the current to the blower.

## I: EVAPORATOR SENSOR

The evaporator sensor detects the temperature at the evaporator outlet and sends the result to the ECM.

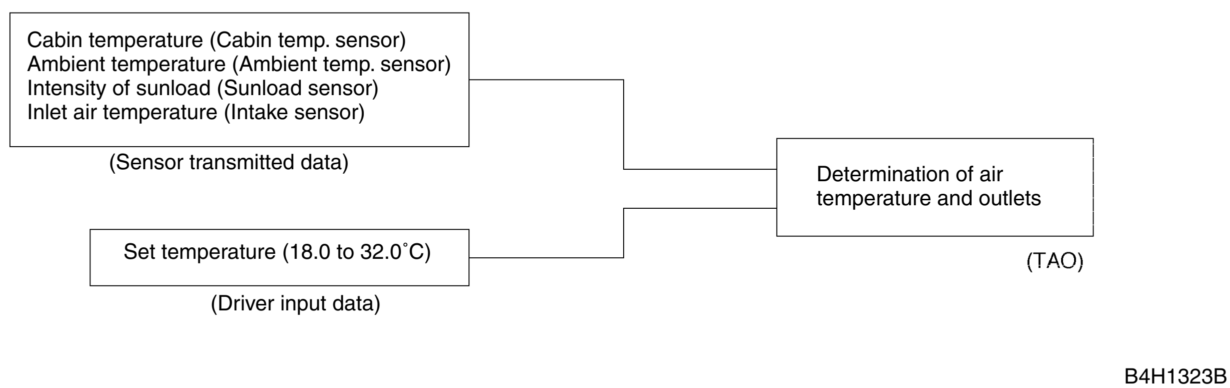


# J: CONTROL SYSTEM

## 1. CALCULATION OF REQUIRED BLOW-OUT AIR TEMPERATURE (TAO)

1) REQUIRED BLOW-OUT AIR TEMPERATURE (TAO):

Upon reception of temperature set switch signals in addition to cabin temperature, ambient temperature and sunload sensor signals, the ECM calculates the TAO first and then, based on the calculated temperature, it determines the outlets from which the air is to be blown out.




2) CALCULATION OF REQUIRED TAO:

● When the set temperature is 18.0°C, the TAO is fixed at the MAX COOL.

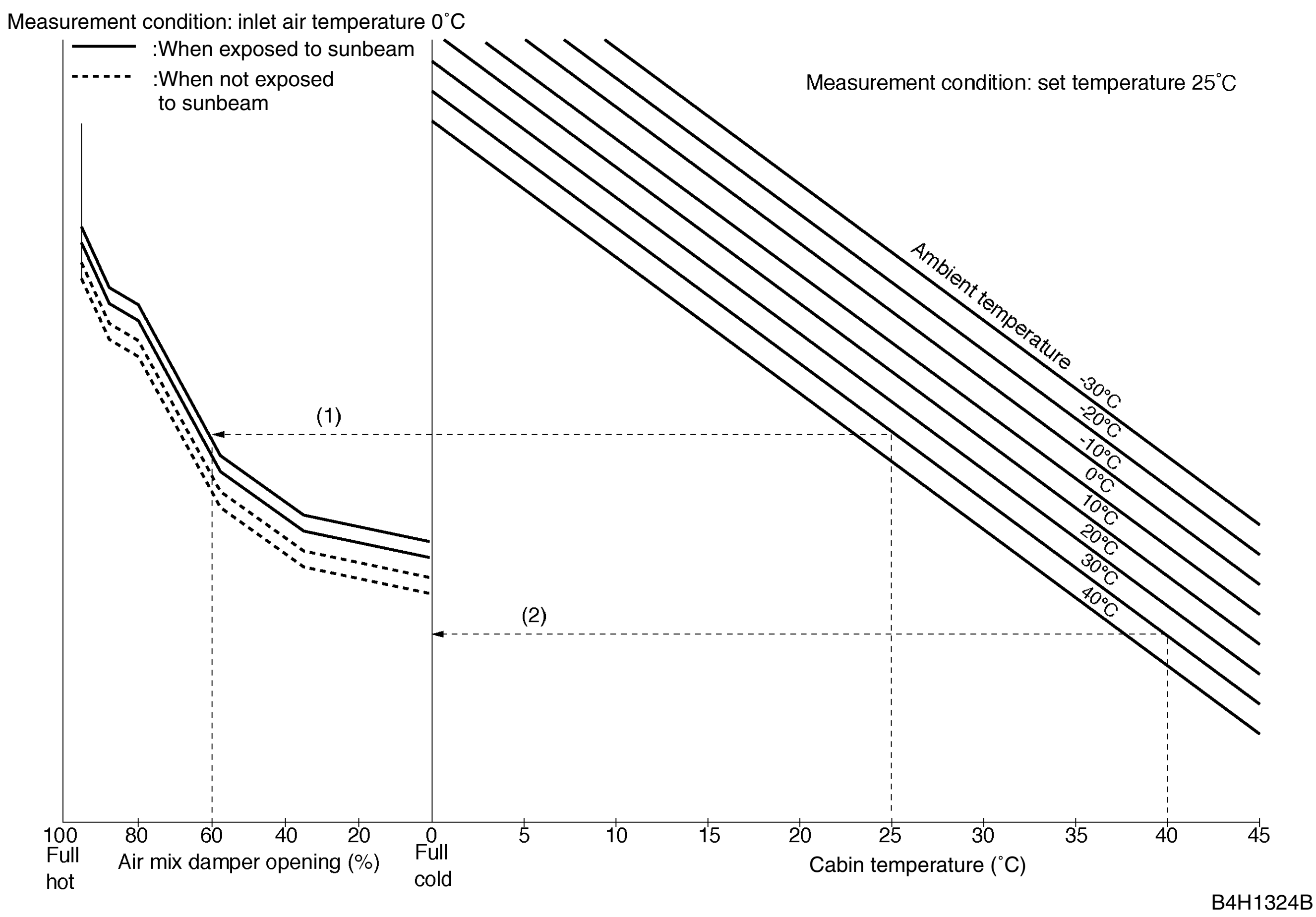
● When the set temperature is 32.0°C, the TAO is fixed at the MAX HOT.

● When the set temperature is 18.5°C to 31.5°C, an optimum TAO is calculated based on the set temperature, as well as the cabin temperature, ambient temperature and sunload data at that time.

## 2. TEMPERATURE CONTROL

1) LHD VEHICLE:

The temperature control is made based on the driver's inputs from the temperature set switch and the data from various temperature sensors; the ECM determines the TAO using these data and operates the air mix motor so that the TAO can be attained.
The ECM compares the air mix damper opening it has received from the air mix damper potentiometer with the target opening it has calculated and, if necessary, operates the motor to move the damper to the HOT or COLD side and hold the damper in an appropriate position.
The target damper opening is corrected using the sunlight intensity data.
The air mix damper is moved fully to the HOT side and held there when the temperature set switch is placed at the FULL HOT position (32°C), while it is moved fully to the COLD side and held there when the switch is placed at the FULL COLD position (18°C).




(1) If the vehicle is exposed to sunbeam, the air mix damper opening is set to 60% when the cabin temperature is 25°C and the ambient temperature is 30°C.

(2) The air mix damper opening is set to 0% (maximum cool position) when the cabin temperature is 40°C and ambient temperature is 30°C.

2) RHD VEHICLE:

- When setting temperature is 18.5°C to 31.5°C:

Blow-out air temperature is controlled by the air mix damper driven by the servo motor. More particularly, the ECM calculates the TAO based on signals from the respective sensors. Next, it determines the cooling capacity using the data from the evaporator sensor (TE) and then calculates the target opening (SW) of the air mix damper based on the TAO and TE. The ECM then activates the servo motor to attain the damper opening. After the damper has been moved to the calculated position, the ECM compares the actual opening (SP) of the air mix damper (detected by the potentiometer incorporated in the servo motor) with the target opening (SW) and, if necessary, causes the motor to move to make the SP exactly correspond to the SW.

- When the switch set temperature is 18.0°C or 32.0°C:

When the switch set temperature is 18.0°C or 32.0°C, input signals from the respective sensors are ignored and the values shown below are invariably used as the TAO (MAX COOL or MAX HOT).

| Switch set temperature (°C) | Control mode | TAO |
|---|---|---|
| 18.0 | MAX COOL | –200 or less |
| 32.0 | MAX HOT | 200 or more |

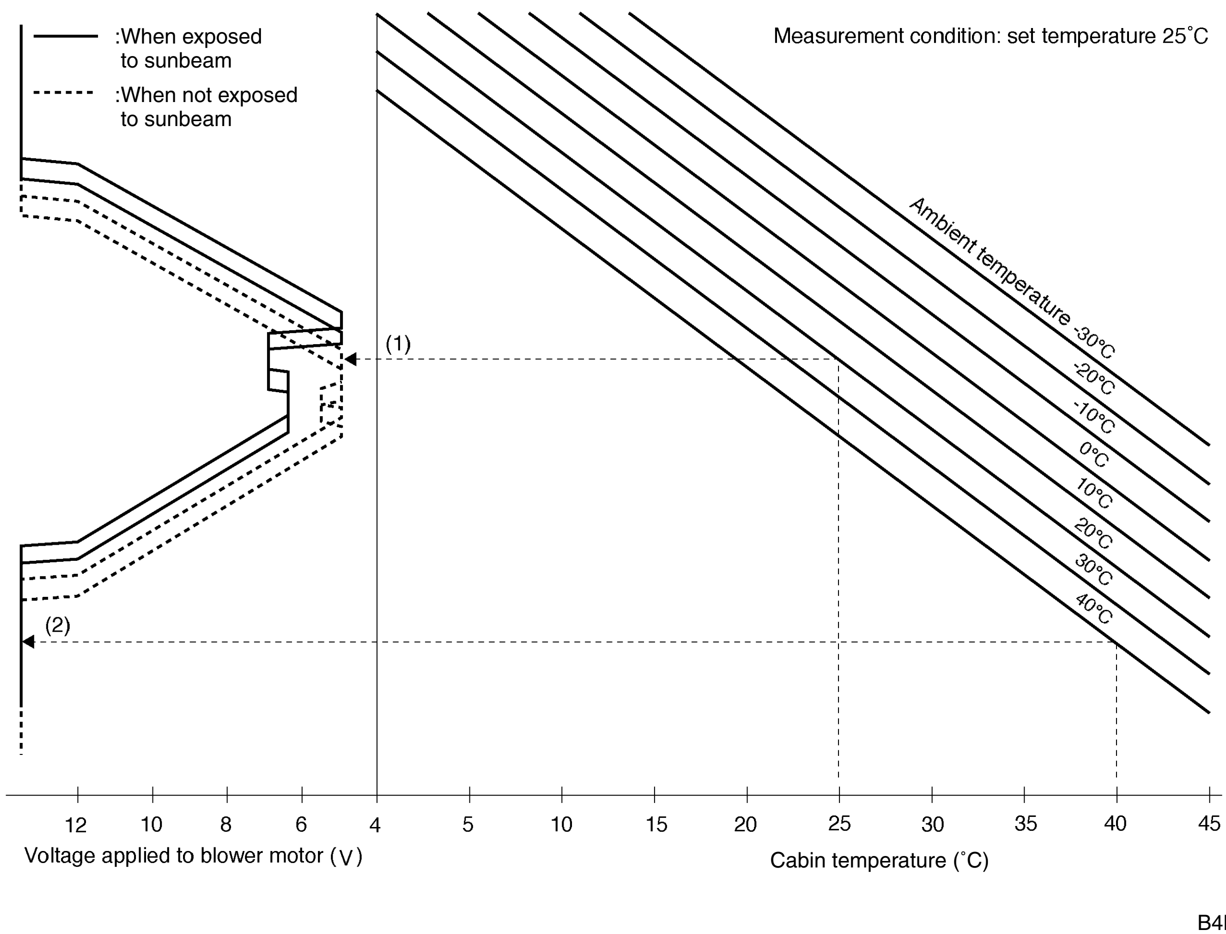
## 3. AIR FLOW CONTROL

1) LHD VEHICLE:

- Normal air flow control:

When the air conditioning system is in the automatic control mode, the air flow is determined based on the TAO calculated by the ECM. The blower fan speed is controlled accordingly.

In the automatic control mode, the minimum air flow is different between DEF mode and the other modes. For the minimum air flow in BI-LEVEL, HEAT and DEF/HEAT modes, a voltage of 5.5V is applied to the blower motor, while for the DEF mode a voltage of 9.0V is applied.
The minimum air flow is corrected by the sunbeam intensity if the VENT or BI-LEVEL mode is selected.




(1) If the vehicle is not exposed to sunbeam, a voltage of approx. 5V is applied to the blower motor when the cabin temperature is 25°C and the ambient temperature is 40°C.

(2) The system (battery) voltage is applied to the blower motor when the cabin temperature is 40°C and the ambient temperature is 40°C.

- Blower fan starting speed control:

When the blower motor is turned ON in the automatic control mode, the fan speed is initially low and then gradually increases (applied voltage increases by 1V every second until an appropriate voltage is reached) to prevent air from blowing out in a gust.

- Blower fan control at low coolant temperatures:

Even when the blower motor is automatically turned ON, the blower fan is kept stopped or allowed to rotate at the minimum speed for a maximum of 150 seconds depending on the cabin temperature and the ambient temperature, if the engine coolant temperature is below 49°C with the air outlets for the VENT or DEF mode selected.

After the conditions for prohibiting blower fan operation or limiting its speed are removed, the voltage applied to the blower motor is increased gradually (by 0.34V every minute) such that a large amount of cold air does not blow out toward the leg area.
Once the coolant temperature exceeds 49°C, the normal blower fan control is performed including the starting speed control.

- Blower fan stop control with compressor ON:

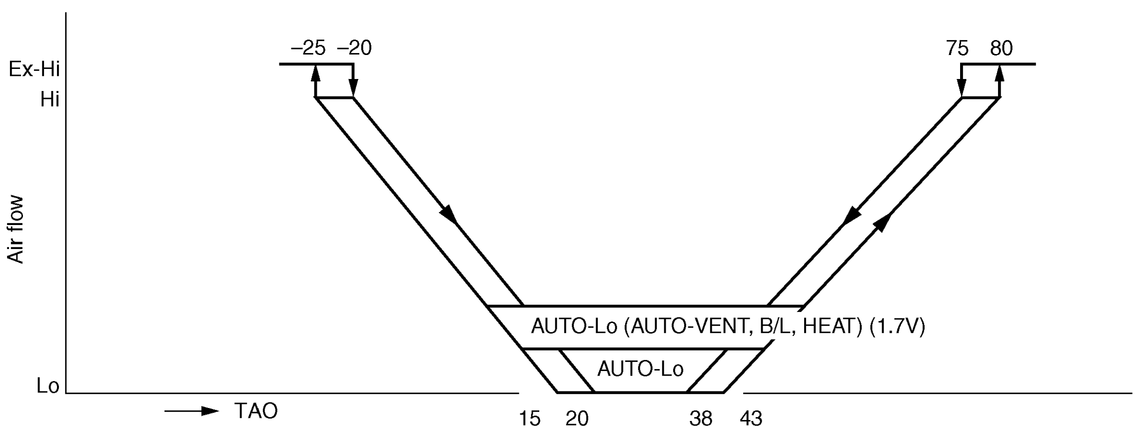
The blower fan is stopped for 3 seconds if the compressor is turned ON with the intake sensor-detected temperature is higher than 35°C.

2) RHD VEHICLE:

In the automatic control mode, the air flow is determined based on the TAO calculated by the ECM. The blower speed is controlled accordingly. When the HEAT, BI-LEVEL (automatic control) or DEF (defroster) is manually selected, the blower speed is controlled in different ways. When the HEAT is selected and the water temperature is still low, the air flow is fixed to the Lo level. When the water temperature rises to or over 49°C, the air flow is determined based on the water temperature (TW) or the TAO, whichever lower. In the DEF mode, the air flow is fixed to the Me.1 level until a certain TAO value is reached, and above that TAO value, the air flow is automatically controlled for an air flow higher than the Me.1 level. When the blower is started, the air flow is varied for 7.5 seconds regardless of the TAO value, and then it is controlled according to the TAO value.

- Air flow control based on TAO:

The blower speed is controlled to any level between the Lo and EX-Hi levels depending on the TAO value.

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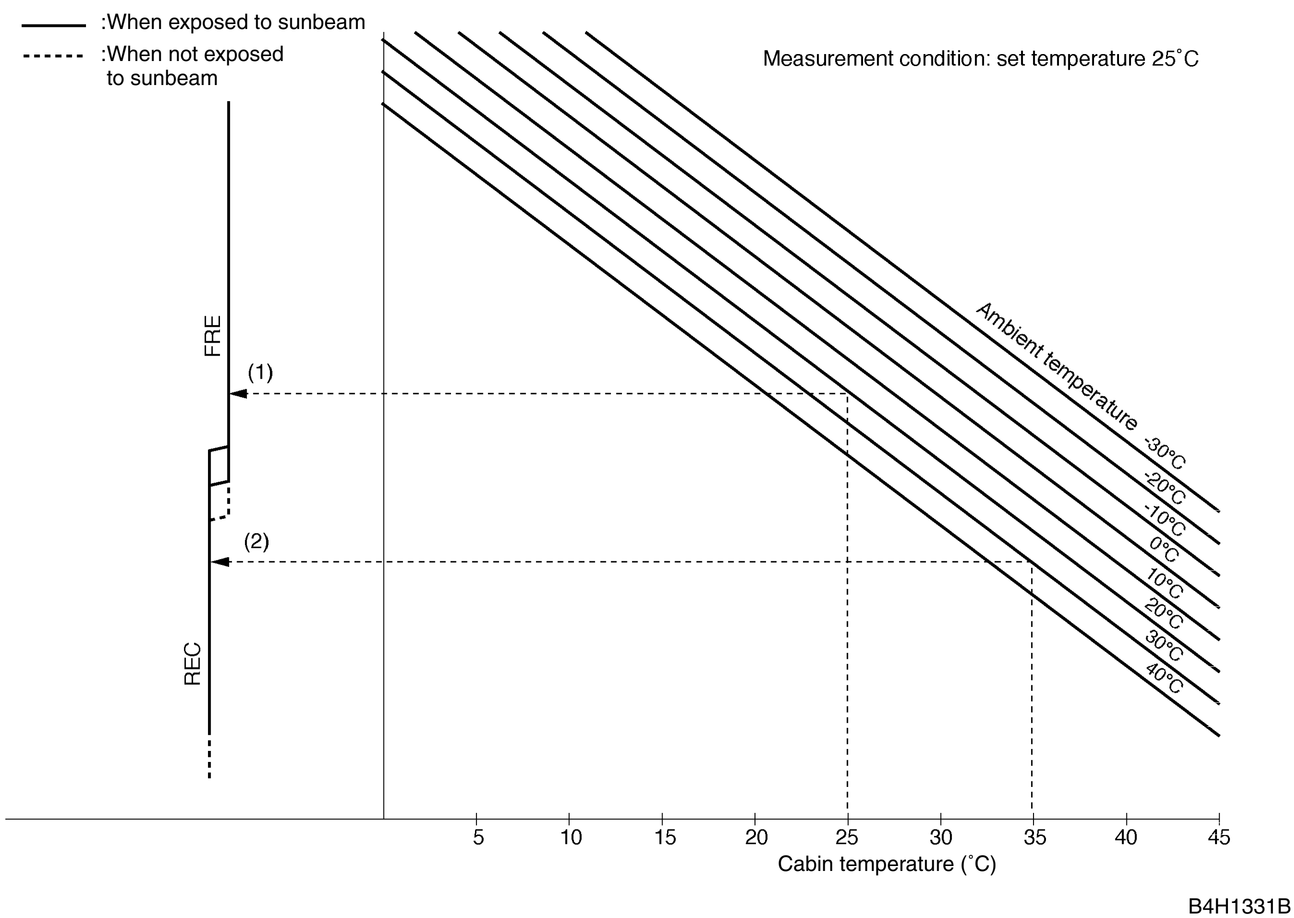
## 4. AIR INLET CONTROL SYSTEM

1) LHD VEHICLE:

The air inlet control system determines whether the air inlet damper is to be opened depending on the TAO calculated by the ECM, thus selecting either inside air recirculation or fresh air introduction.

The damper is generally opened for fresh air introduction when the compressor is turned OFF.

It is also opened generally when the DEF position is selected.




(1) The air inlet damper is opened for fresh air introduction when the cabin temperature is 25°C and the ambient temperature is 20°C.

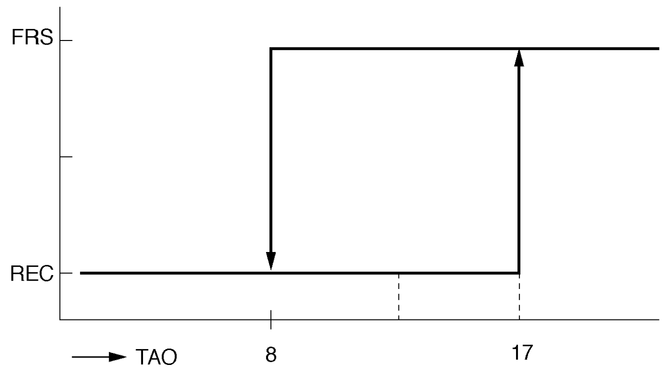
(2) The air inlet damper is closed for inside air recirculation when the cabin temperature is 35°C and the ambient temperature is 30°C.

2) RHD VEHICLE:

- Air inlet control flowchart:

In the automatic air-conditioning mode, the air inlet damper motor is controlled for the FRS (fresh air) position and the REC (air recirculation) position according to the TAO.

- Air inlet control pattern

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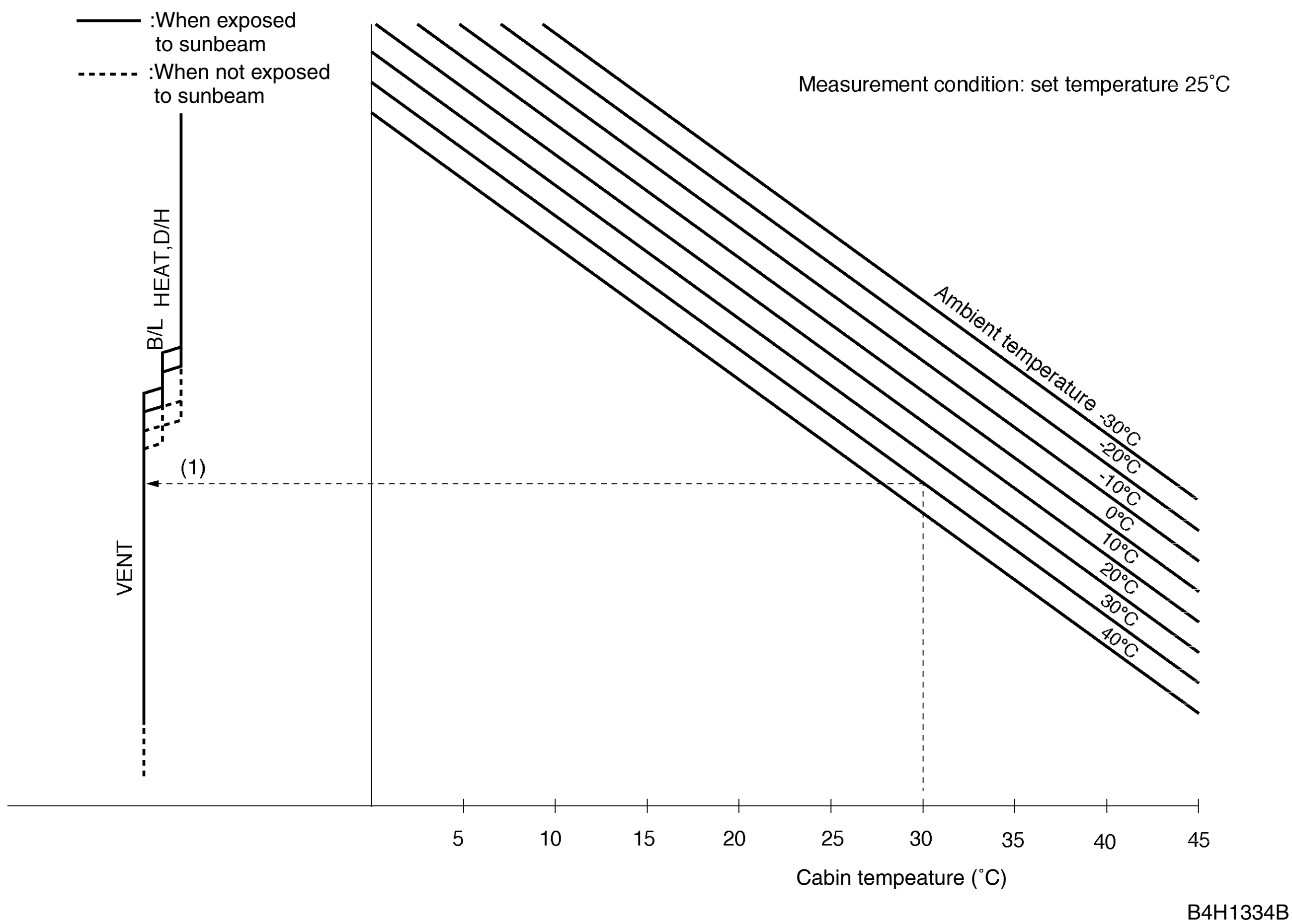
## 5. AIR OUTLET CONTROL SYSTEM

1) LHD VEHICLE:

The air outlet control system automatically selects the most appropriate air outlet combination depending on the ECM-calculated TAO by activating servo-motors for the VENT, BI-LEVEL or HEAT modes.

When the OFF switch is pressed position, the air outlet control system is held in the HEAT mode.




(1) The air outlets for the VENT mode are selected when the cabin temperature is 30°C and the ambient temperature is 30°C.

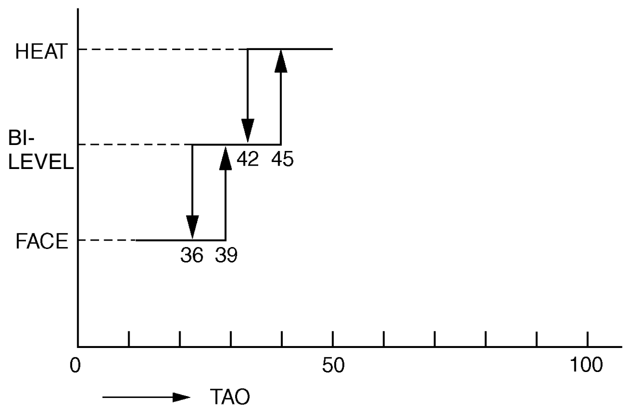
2) RHD VEHICLE:

- Air outlet control:

In the automatic air-conditioning mode, the air outlets are selected based on the TAO and TW and the servo motors for actuating the air outlet switching dampers are controlled to achieve the selected air outlet configuration. After the dampers have been moved, the potentiometer of each servo motor feeds back damper status information to the ECM. If necessary, the ECM actuates the servo motor so that the actual damper position (SPO) corresponds to the target damper position (SWO).

- Air outlet control in automatic air-conditioning mode:

The air outlets are selected based on the TAO for the FACE, BI-LEVEL and HEAT positions.

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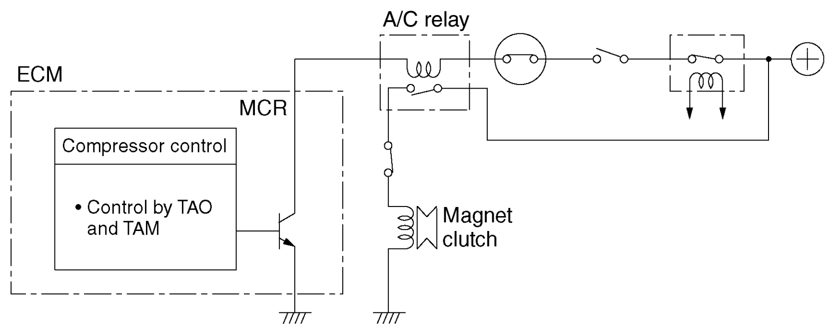
- Air outlet control when HEAT or BI-LEVEL position is automatically selected:

If the air flow calculated based on the TW is at the Lo level, the selected outlets are for the defrosting operation (i.e., the outlet configuration for defrosting is invariably selected when the TW is low).

## 6. COMPRESSOR CONTROL SYSTEM

In the automatic air-conditioning mode, the A/C relay is activated or deactivated depending on the TAO (required blow-out air temperature), TAM (ambient temperature) and T INT (suction air temperature) to operate or stop the compressor.

The compressor operation circuit supplies current to the magnet clutch as the ECM activates the A/C relay by connecting its coil to the ground.

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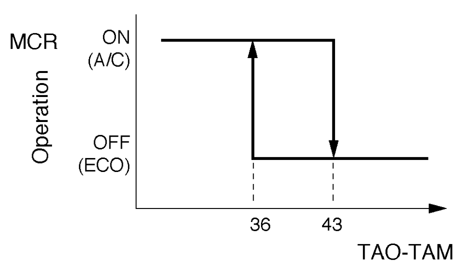
- Control by TAO and TAM (LHD vehicle)

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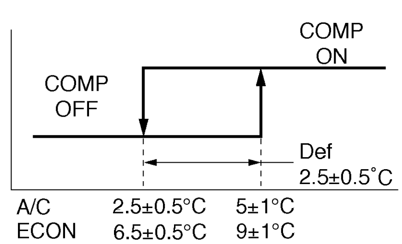
- Control by T INT (LHD vehicle)

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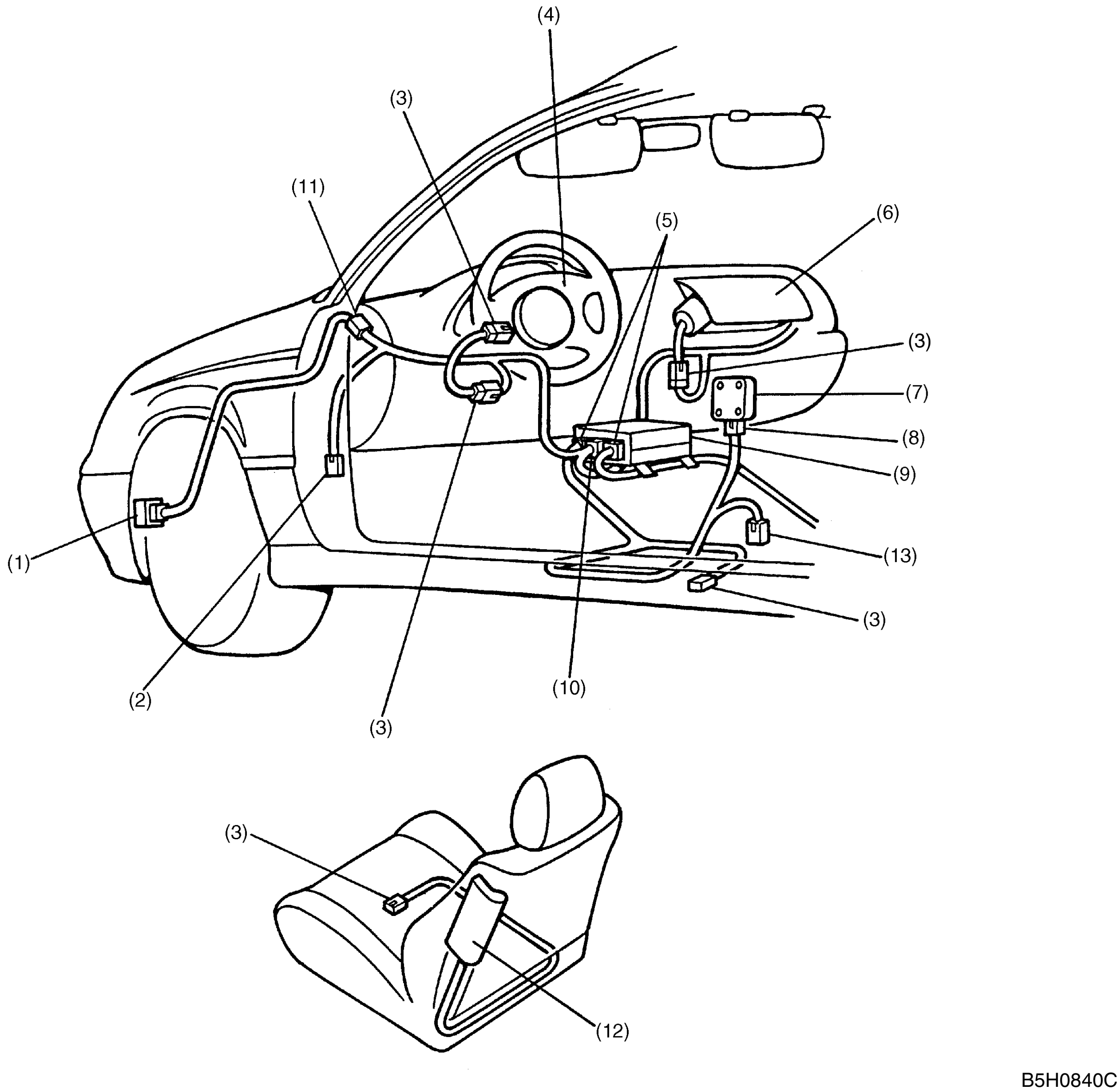
## MEMO

# AIRBAG SYSTEM AB

Page

# 1. Airbag System

## A: INSTALLATION

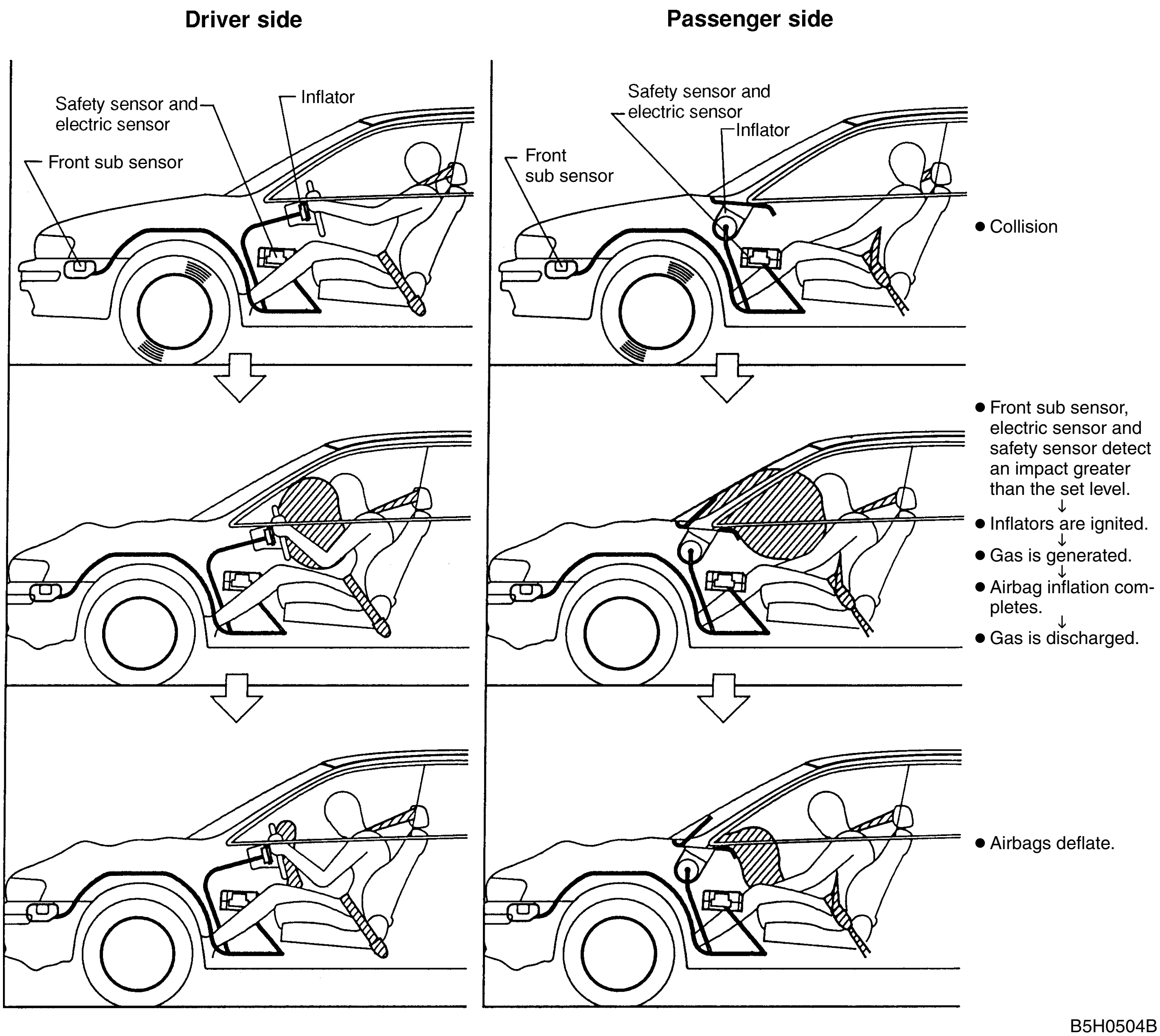



| | | | |
|---|---|---|---|
| (1) | Front sub sensor | (8) | 4-pin connector (Yellow) |
| (2) | 7-pin connector (Yellow) | (9) | Airbag control module |
| (3) | 2-pin connector (Yellow) | (10) | 28-pin connector (Yellow) |
| (4) | Airbag module (Driver) | (11) | 2-pin connector (Blue) |
| (5) | 12-pin connector (Yellow) | (12) | Airbag module (Side) |
| (6) | Airbag module (Passenger) | (13) | 2-pin connector (Yellow) (To seat belt pretensioner) |
| (7) | Side airbag sensor | | |

## B: FUNCTION

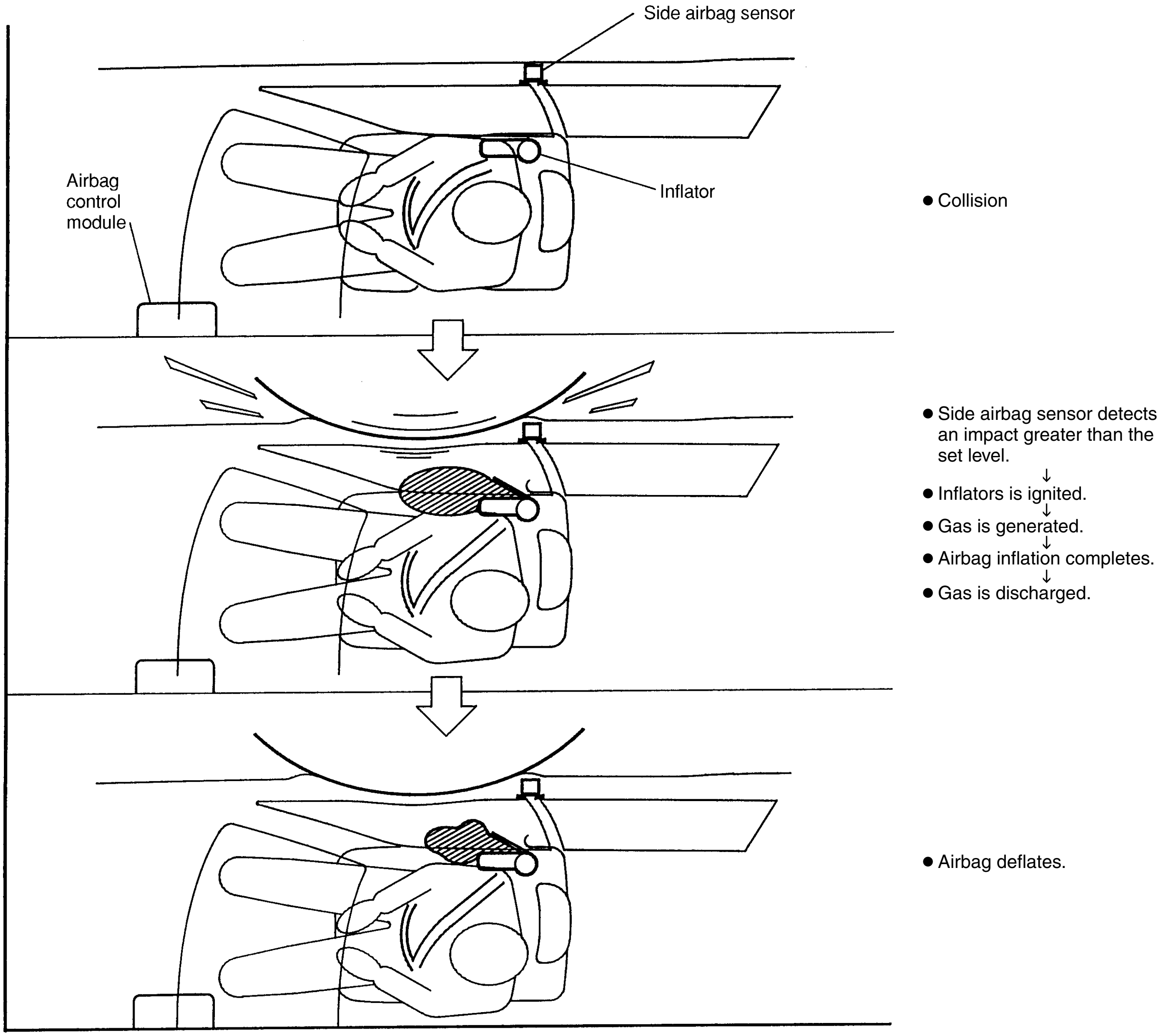
### 1. FRONT AIRBAGS

The airbag system is provided as a driver and front passenger restraint system supplementary to the seat belts. When an impact greater than a set level is applied to the front of the vehicle, the sensors generate an electrical pulse to inflate the airbags in the airbag modules, thus preventing the driver's and passenger's upper bodies from directly hitting against the steering wheel, instrument panel and/or windshield.



## 2. SIDE AIRBAGS

The side airbags provide the driver and front passenger with a restraint supplementary to that by the seat belts in the event of a side-on collision. When an impact greater than the set level is applied to either side of the vehicle, the relevant side airbag sensor sends an ignition signal to the corresponding airbag control module. The side airbag module operates to inflate the airbag, thus reducing the shock inflicted in the outside upper body (chest) of the driver or front passenger.

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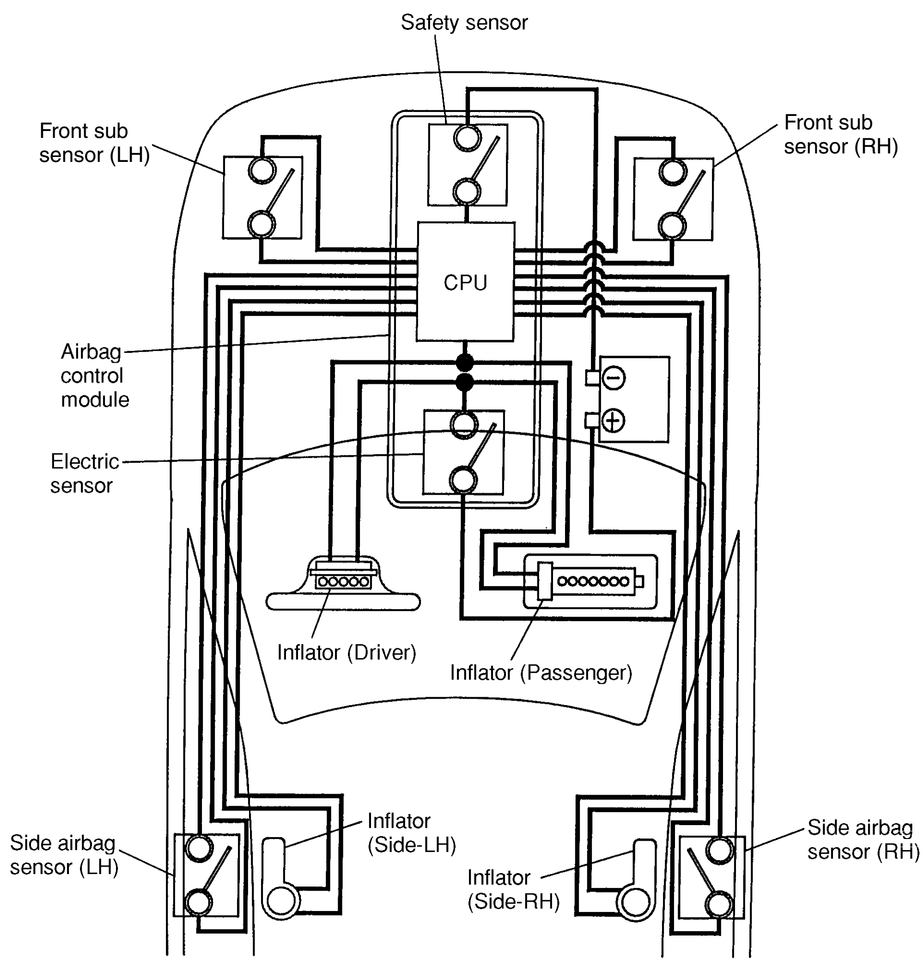
# 2. Construction

## A: GENERAL

● The airbag system consists of an airbag control module, left and right front sub sensors, an electric sensor and safety sensor built into the control module, driver's and passenger's airbag modules each containing an inflator and airbag, and side airbag sensors and modules each containing an inflator and airbag (Side airbag equipped model).

● FRONT AIRBAG SYSTEM:
A frontal impact exceeding the set level causes the safety sensor, electric sensor and one or both front sub sensors to input impact signals to the CPU. The CPU determines whether the airbags should be inflated or not based on these signals.

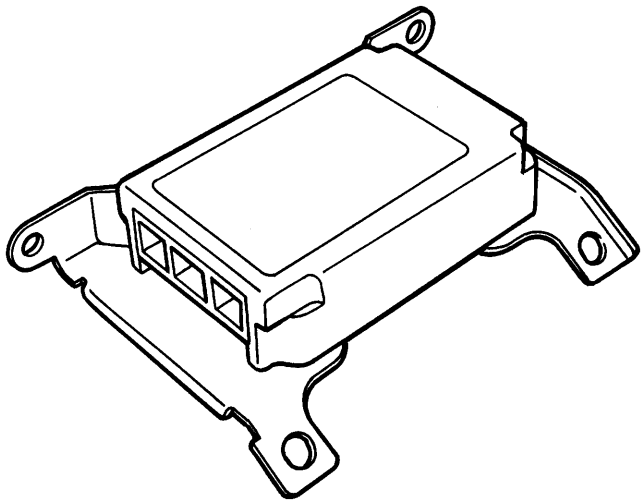
● SIDE AIRBAG SYSTEM:
Input of a side impact signal showing shock energy greater than the set level causes the airbag on the corresponding side to inflate.




B5H0552A

## B: AIRBAG CONTROL MODULE

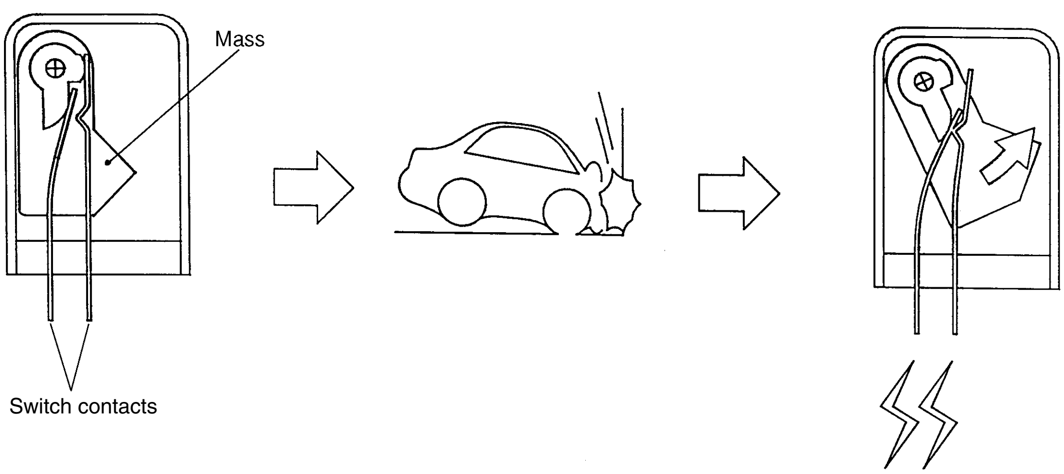
The airbag control module is installed in front of the front floor tunnel. It detects the vehicle's deceleration by receiving electrical signals from its inside safety and electric sensors as well as the front sub sensors and judges whether to inflate the airbags. This control module has a built-in self-diagnosis function. If a fault occurs inside the system, it lights up the airbag warning light in the combination meter. The fault data is stored in the module. A back-up power supply is provided for possible damage to the battery during an accident, and a boosting circuit is built into the module in case of a battery voltage drop.



S5H0010

## C: FRONT SUB SENSOR

One front sub sensor is installed on each side, in front of the front wheel apron wall. The front sub sensor is a pendulum type sensor. If the sensor receives a frontal impact exceeding a certain limit, the mass in the sensor rotates forward to turn the switch ON.



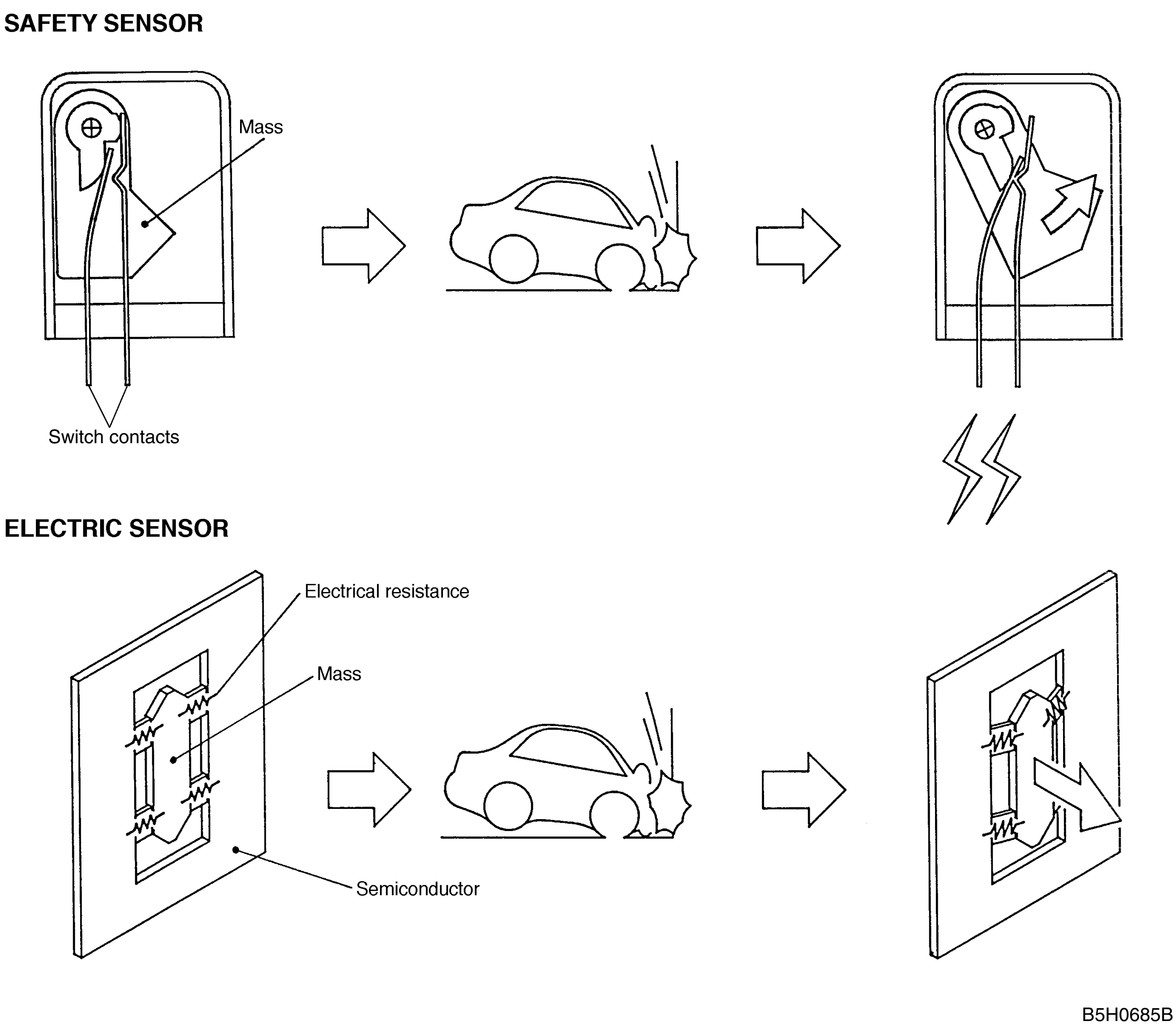

B5H0507B

## D: AIRBAG SENSOR

The safety sensor and electric sensor are incorporated into the airbag control module and the side airbag sensors.

The safety sensor is also a pendulum type sensor. If the sensor receives a frontal or side impact exceeding a certain limit, the mass in the sensor moves in the direction opposite to the impact direction to turn the switch ON.

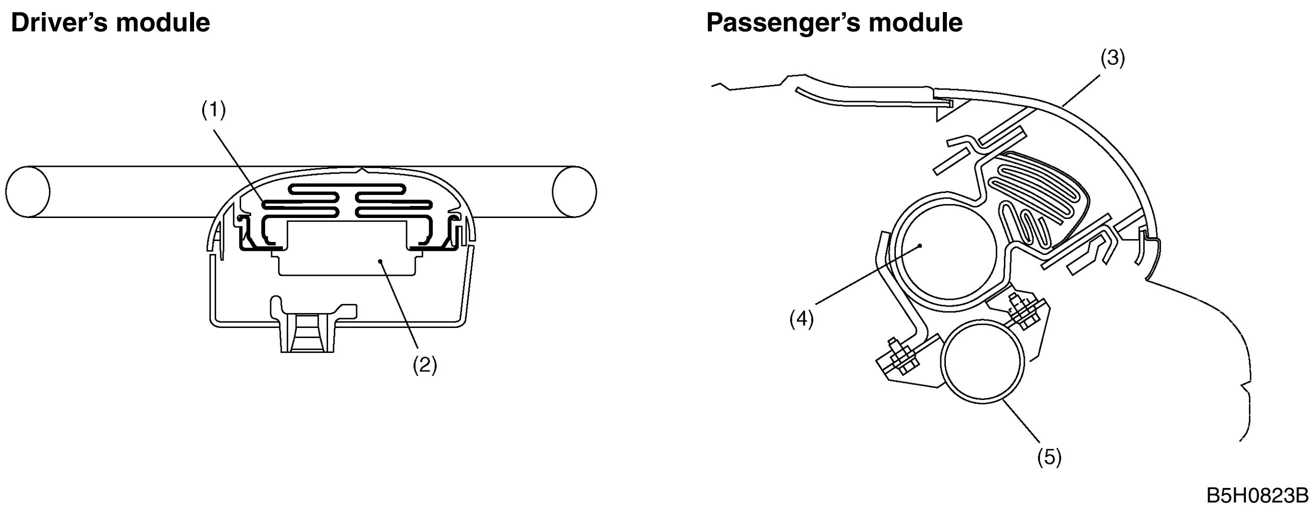
The electric sensor consists of a semiconductor type sensor which senses the deceleration caused by collision in terms of change in the electrical resistance of the impact sensing circuit.



## E: AIRBAG MODULE

### 1. FRONT AIRBAG

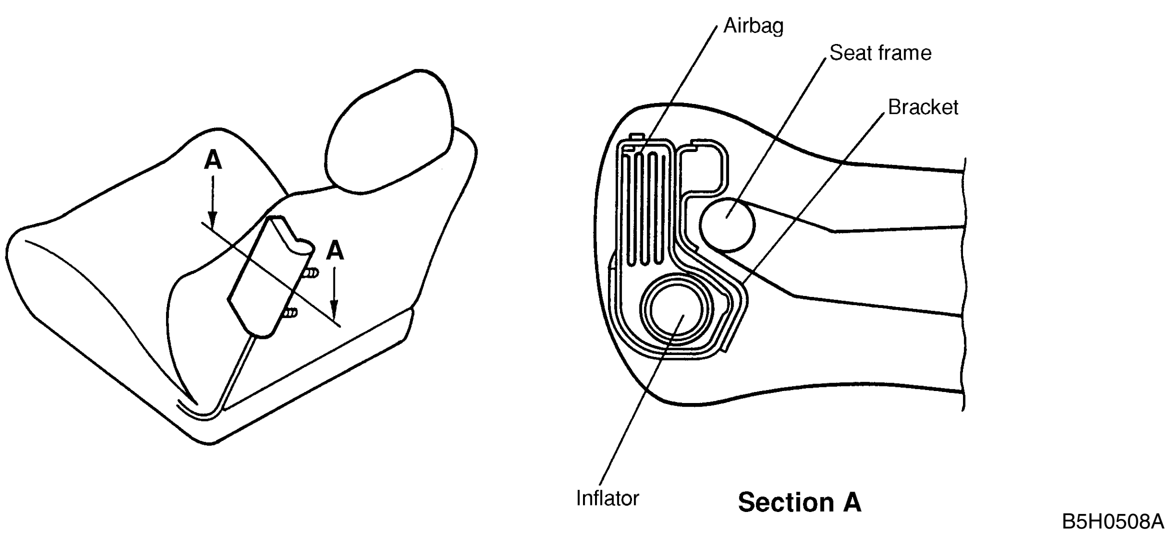
The driver's airbag module is located at the center of the steering wheel and the passenger's airbag module is located at upper portion of instrument panel. Each module contains an airbag and an inflator. If a collision occurs, the inflator produces a large volume of gas to inflate the airbag in a very short time.




(1) Airbag
(2) Inflator (Driver)
(3) Airbag module lid
(4) Inflator (Passenger)
(5) Steering support beam

### 2. SIDE AIRBAG

A side airbag module is located at the outer side of each front seat backrest, and it contains an airbag and an inflator.
If a side-on collision occurs, the inflator produces a large volume of gas to inflate the airbag in a very short time.

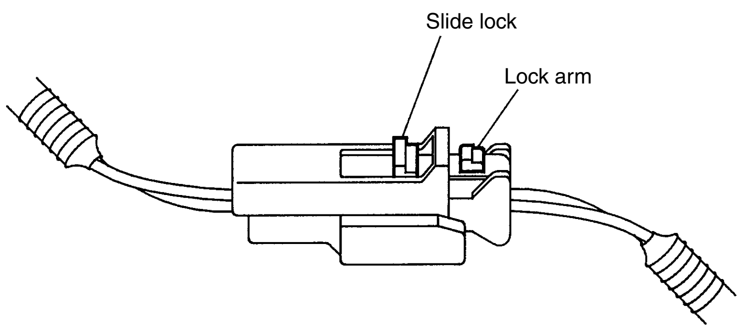


## F: AIRBAG CONNECTORS

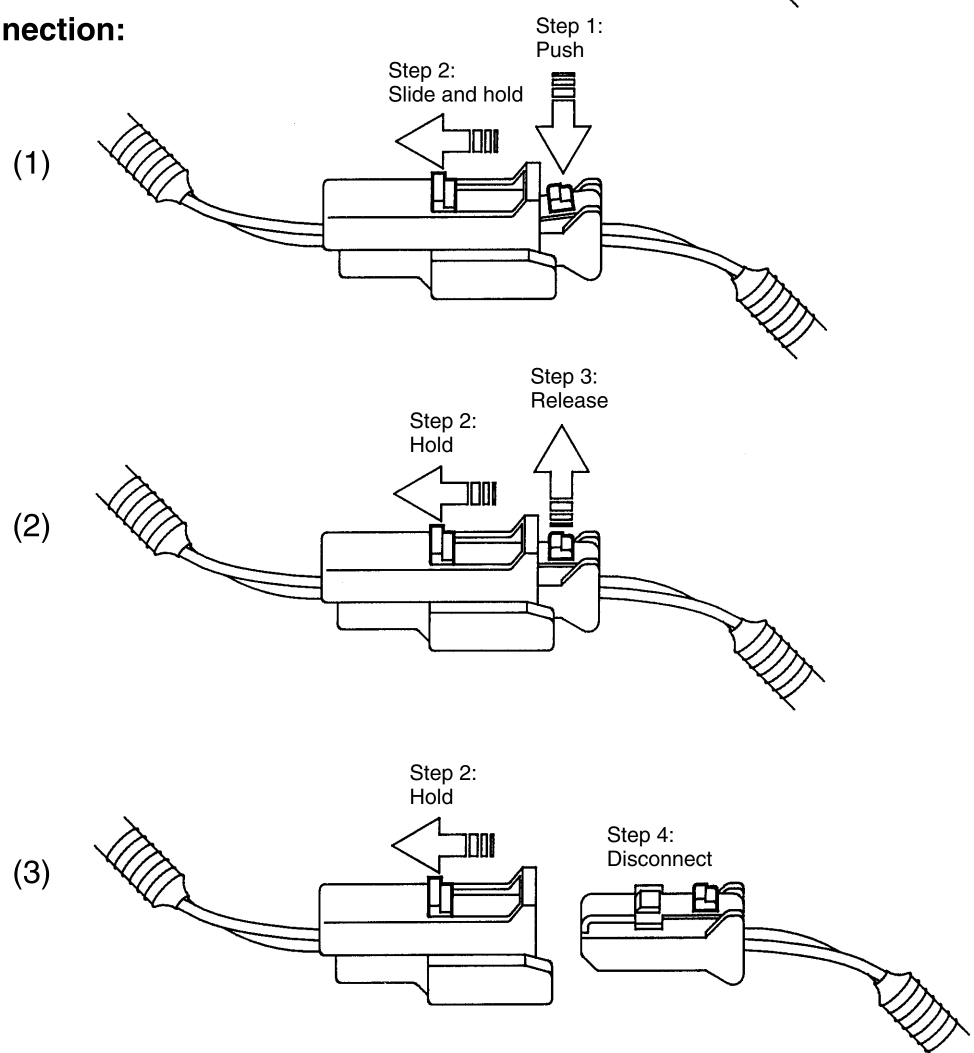
### 1. DESCRIPTION

The airbag system uses connectors with a double lock mechanism and an incomplete coupling detection mechanism for enhanced reliability. If coupling is incomplete, the airbag warning light comes on in the combination meter.

### 2. AIRBAG HARNESS-TO-AIRBAG HARNESS CONNECTOR




**Disconnection:**




**Connection:**
Insert the male side connector half into the other until a “click” is heard.

S5H0012B

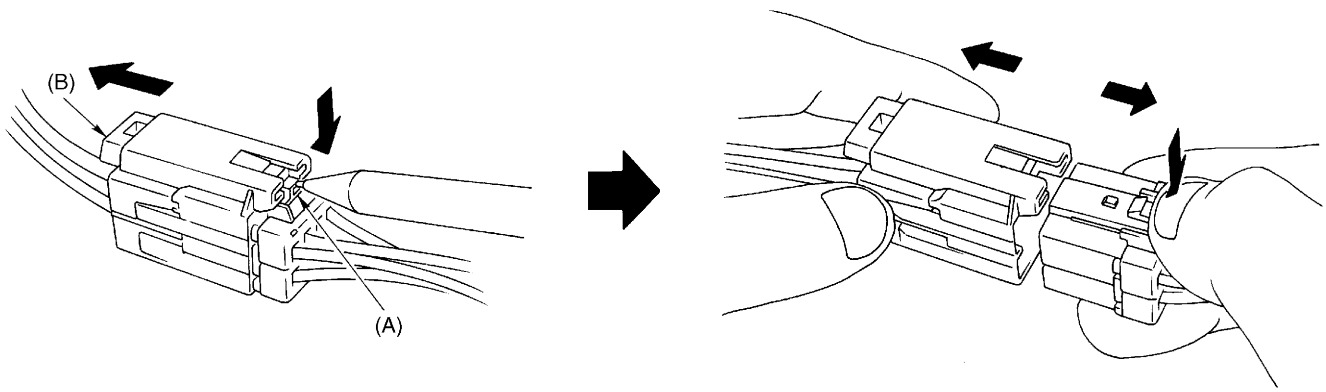
## 3. AIRBAG HARNESS-TO-BODY HARNESS CONNECTOR

**Disconnection:**

Press the lever (A) to let the green lever (B) pop out. This unlocks the double lock mechanism. Then separate the connector halves by pulling them apart while pressing the lever (A).

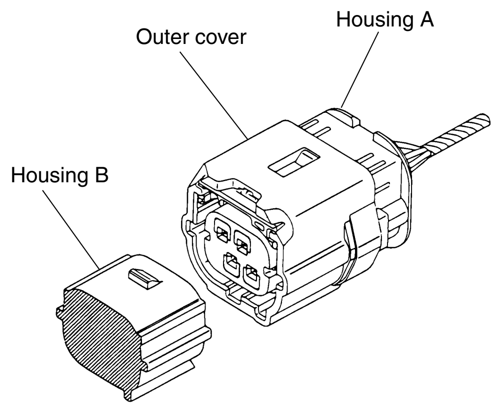
**Connection:**

Insert the male side connector half into the other until a “click” is heard, then push in the green lever (B) until a “click” is heard. This engages the double lock mechanism.



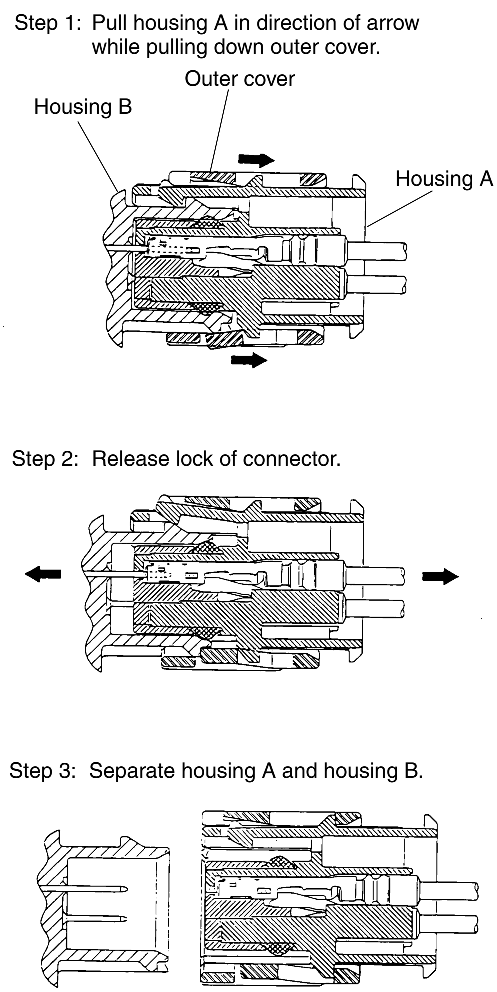

B5H0841A

## 4. FRONT SUB SENSOR AND SIDE AIRBAG SENSOR CONNECTORS




B5H1130A

### Disconnection:



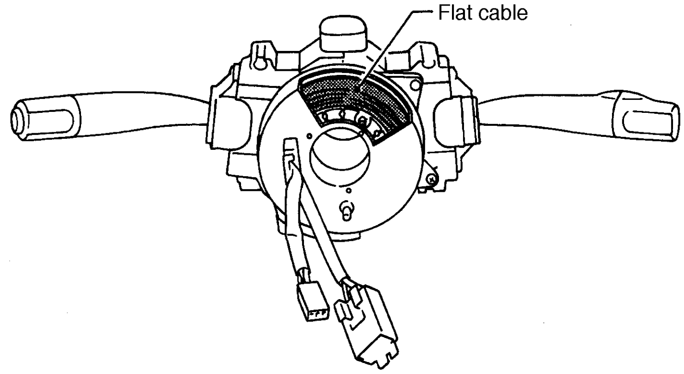

B5H1131A

### Connection:

Insert housing B into housing A until a “click” is heard.

## G: STEERING ROLL CONNECTOR

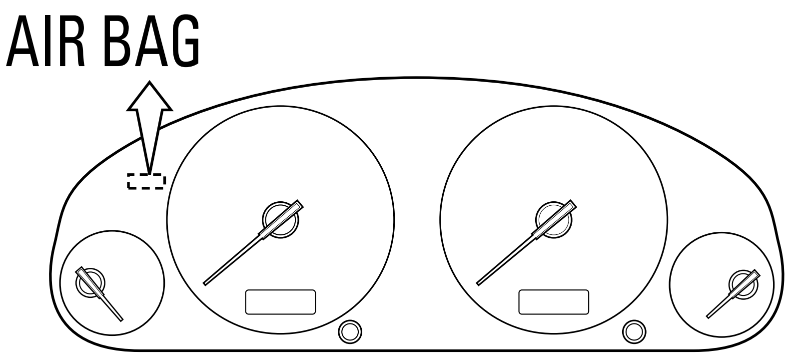
The steering roll connector is located between the steering column and steering wheel. The connector contains a spirally wound flat cable. The cable can follow rotational movements of the steering wheel and ensures connection between the airbag module in the steering wheel and the airbag harness through which electrical signals are transmitted from the airbag control module.




S5H0013A

## H: AIRBAG WARNING LIGHT

The airbag warning light is located inside the combination meter. It illuminates if a poor connection in the airbag circuit occurs, or if the airbag control module detects an abnormal condition. When the airbag system is normal, this light comes on when the ignition switch is turned ON and then goes out about 7 seconds later.

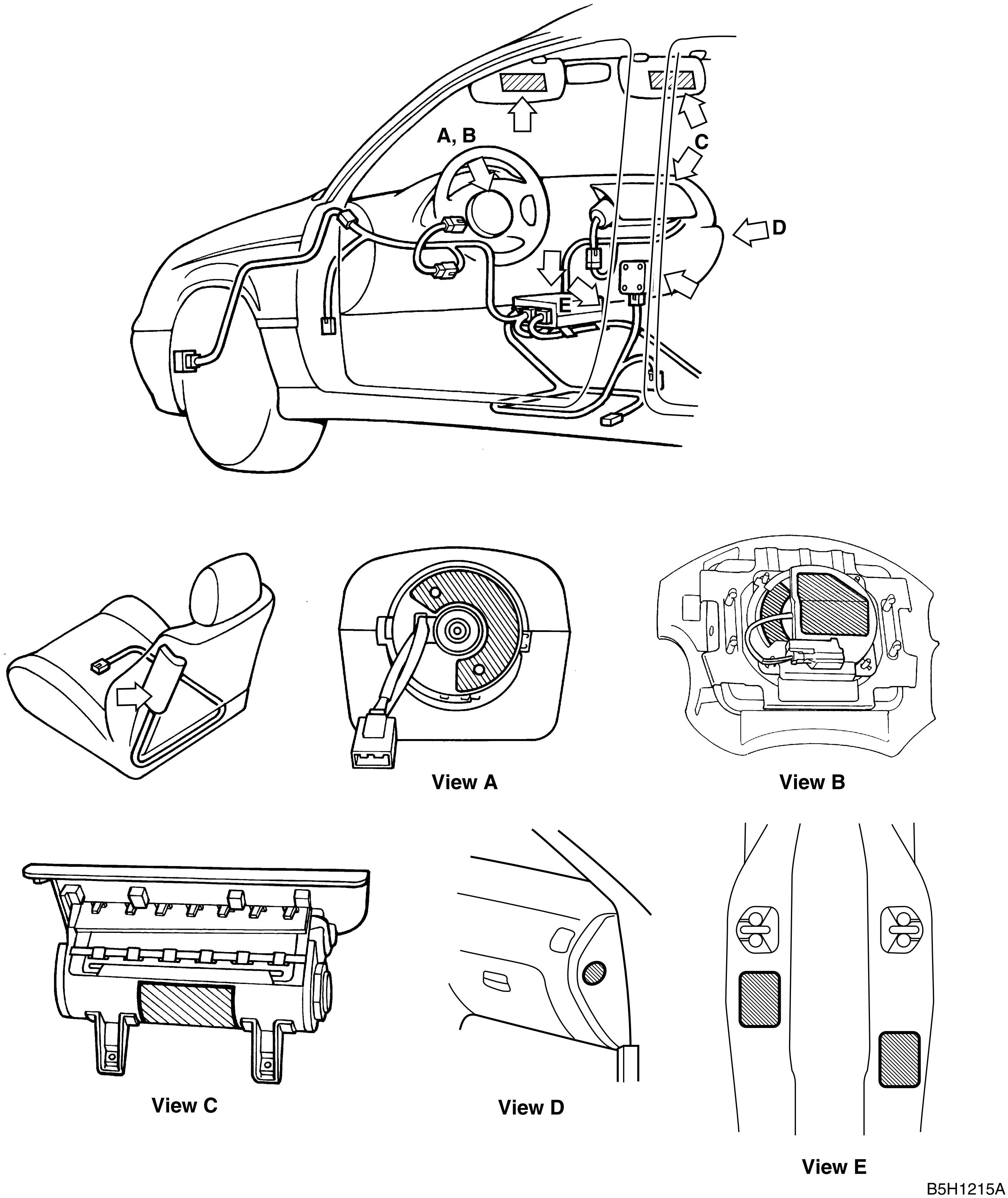



B5H1213

## I: WIRE HARNESS

The wire harness of the airbag is entirely covered with a yellow protective tube, and can easily be distinguished from the other systems' harnesses.

## J: LOCATIONS OF WARNING AND CAUTION LABELS



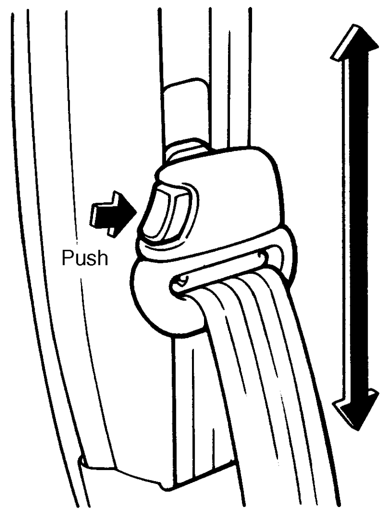
## MEMO

# SEAT BELT SYSTEM SB

# 1. Seat Belt

## A: ADJUSTABLE SHOULDER BELT ANCHOR

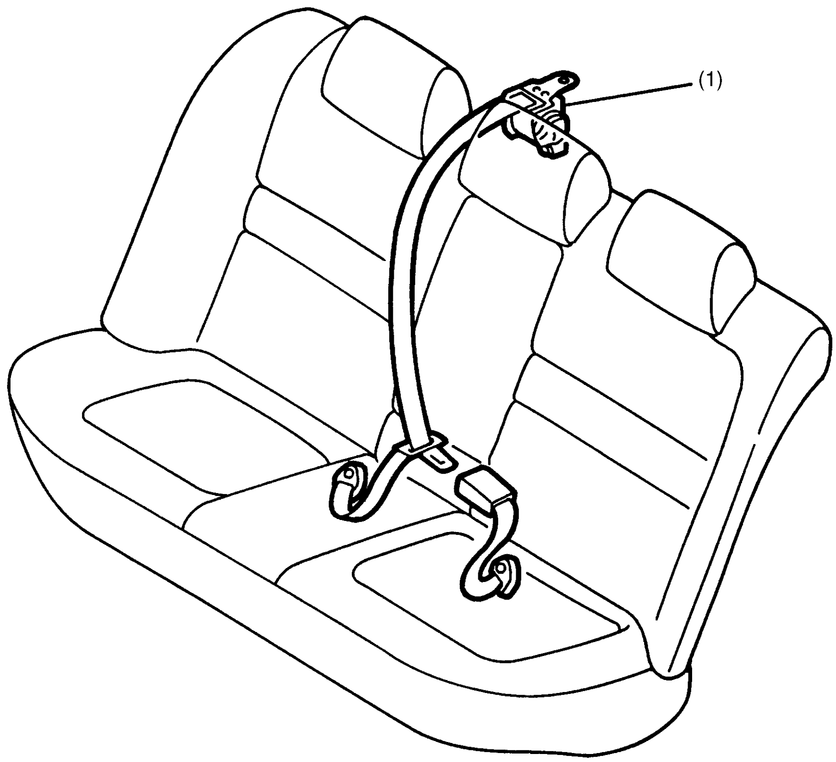
Each front seat belt system has an adjustable shoulder belt anchor which allows the occupant to select the most appropriate anchor height from among the five positions in a 129 mm (5.08 in) range.




B5H0605A

## B: REAR CENTER THREE-POINT TYPE SEAT BELT (SEDAN)

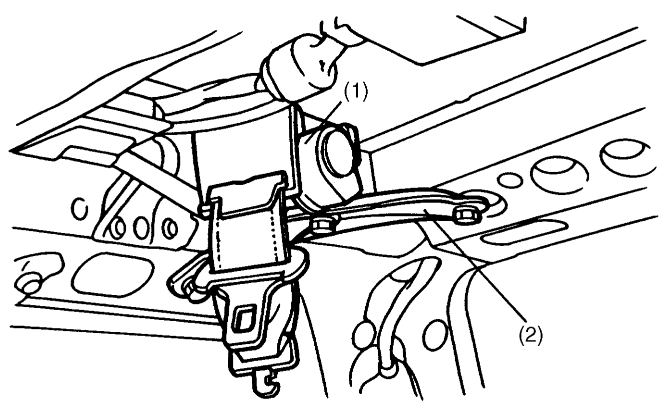
A three-point type seat belt is available for the center seating position of the rear seat.
The retractor for the seat belt is installed on the luggage shelf behind the seating position.




(1) Retractor

## C: REAR CENTER THREE-POINT TYPE SEAT BELT (WAGON)

A three-point type seat belt is available for the center seating position of the rear seat.
The retractor for the seat belt is installed on the ceiling at the rear right of the cabin.

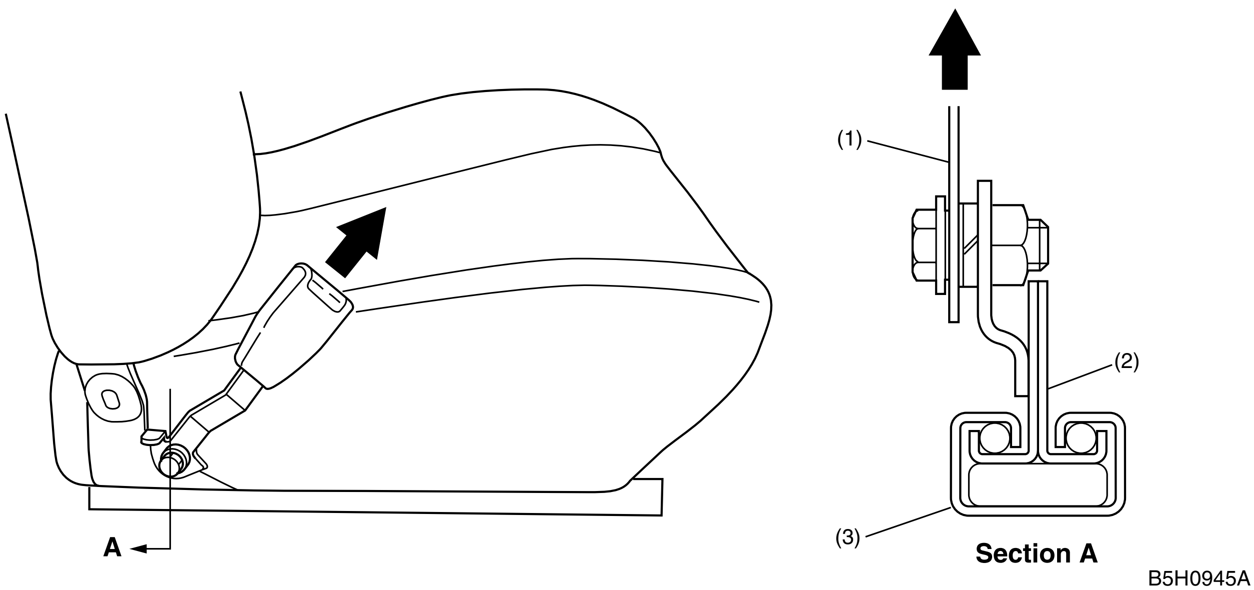



(1) Retractor
(2) Bracket

## D: SEAT ANCHORED INNER BELT

The front inner belt (buckle stalk) is attached to the front seat rather than to the floor. This keeps the position of the occupant relative to the front inner belt always constant even when the front seat is moved for adjustment.

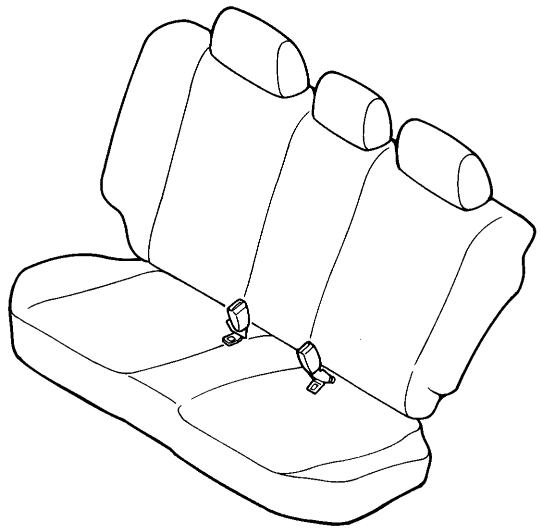
When an impact is applied to the occupant in a collision, the inner belt is pulled together with the upper hook in the direction of the arrow to engage the upper hook with the lower hook. As a result, the impact load is transmitted to the vehicle body and dispersed.




(1) Inner belt
(2) Upper hook
(3) Lower hook

## E: SELF-SUSTAINING TYPE INNER BELT BUCKLE (WAGON)

The rear inner belt buckles are self-sustaining type buckles which rise up by themselves when the seat cushion is folded back to its original position.

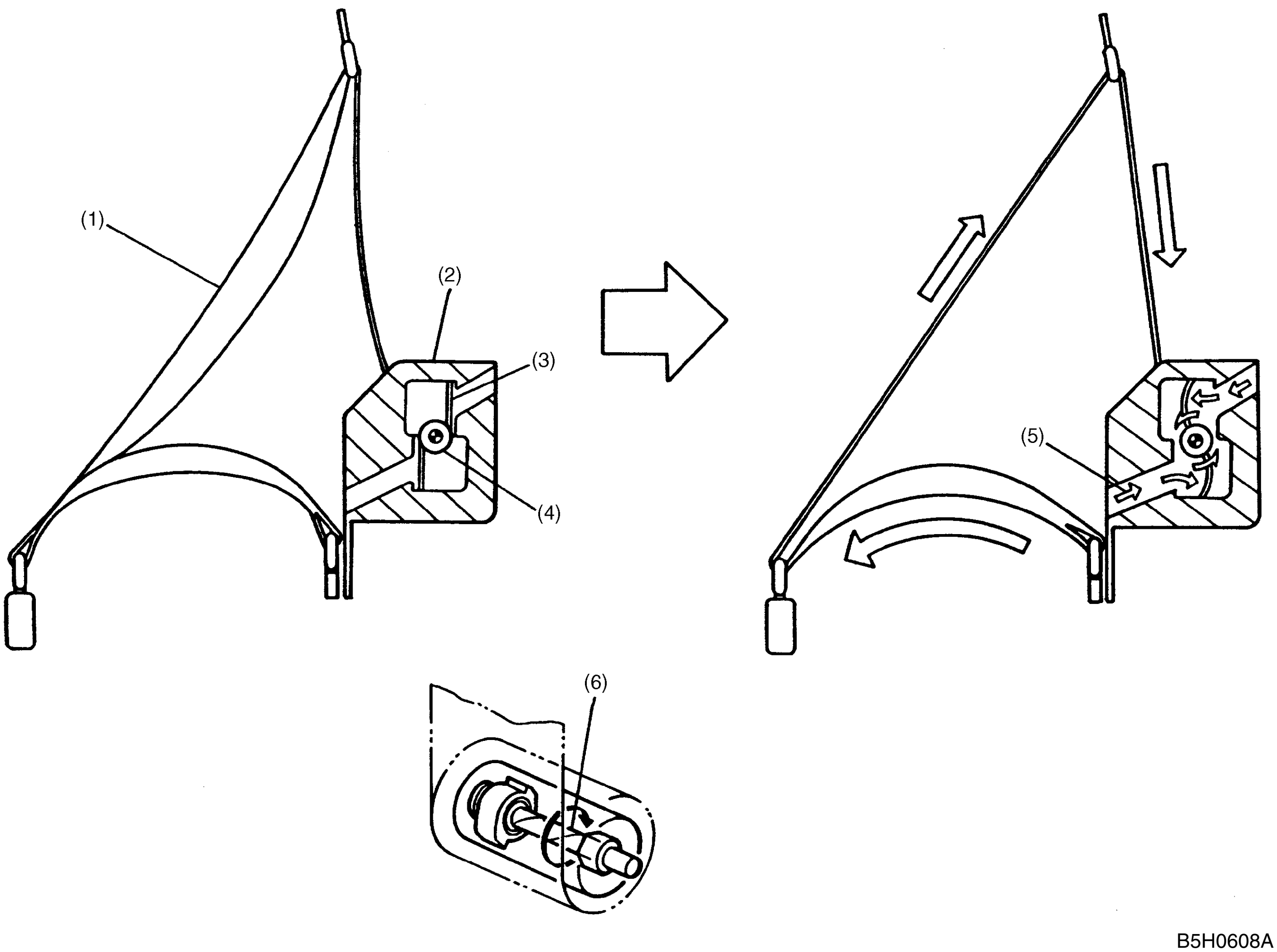


B5H0607

## F: PRETENSIONER

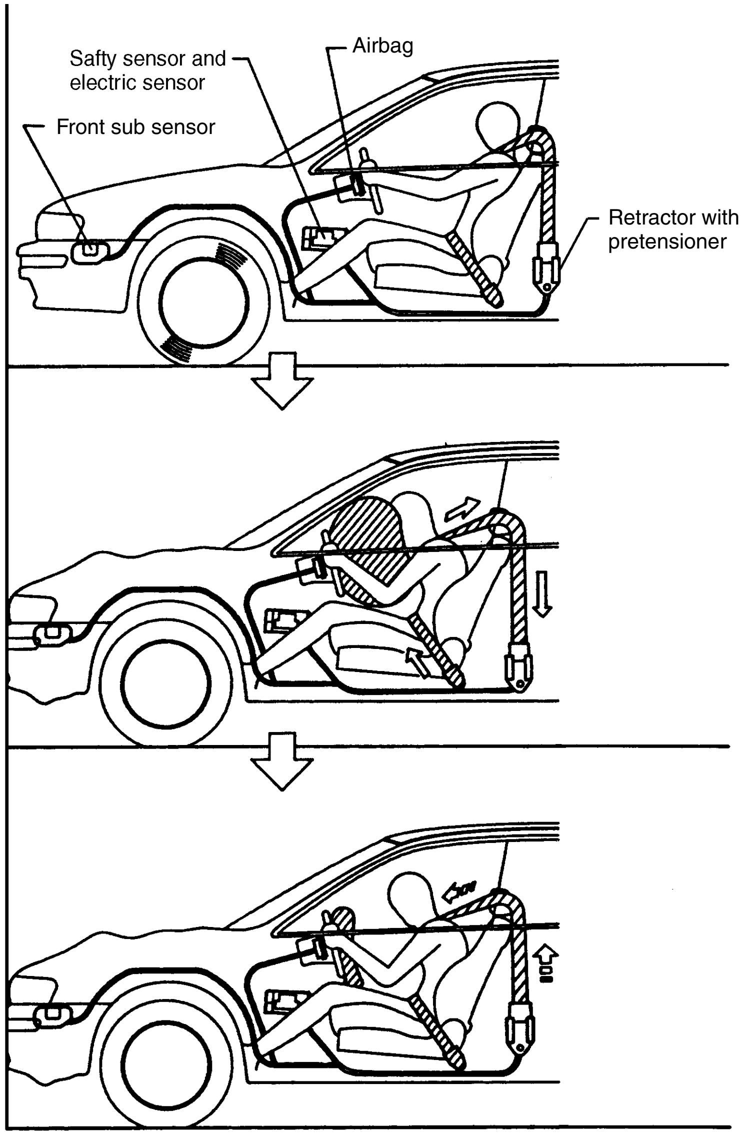
### 1. CONSTRUCTION

The driver's and front passenger's seat belts are equipped with seat belt pretensioners.
The pretensioners use the front sub sensors and the airbag control module inside sensors to control their operation. If the sensors detect an impact exceeding the predetermined level during a frontal or front-angled collision, the front seat belts are quickly rewound by the retractors to take up slacks for maximum restraining of the seat occupants. If the load placed on a seat belt exceeds the predetermined level, the torsion bar twists to allow the belt to be payed out, thus lessening the load imposed on the belt wearer's chest. Once the seat belt pretensioner has been activated, the seat belt retractor remains locked.




(1) Webbing
(2) Retractor
(3) Strip
(4) Shaft
(5) Gas
(6) Torsion bar

## 2. FUNCTION



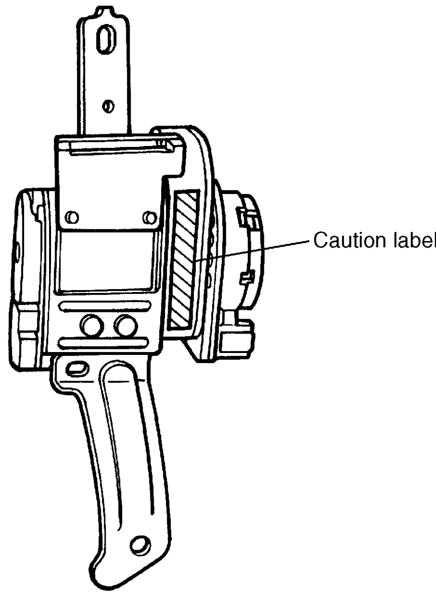

- Collision occurs.

- Front sub sensor, electric sensor and safety sensor detect an impact exceeding predetermined level.
- Pretensioner operates.

- Completion.

B5H0630B

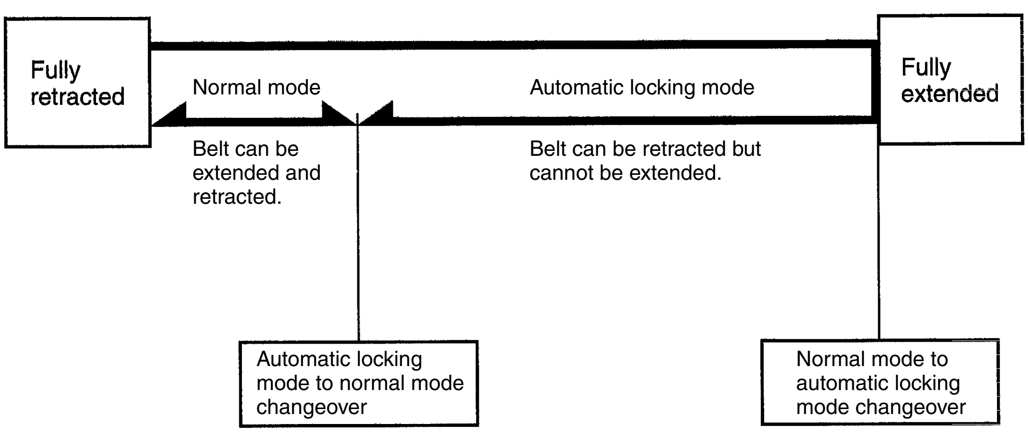
### 3. CAUTION LABEL LOCATION




B5H0937A

## G: AUTOMATIC RETRACTOR

When each of the rear seat belts (for right, left and center seating positions) are drawn out completely, its retractor is placed in the automatic locking mode which is used when installing a child restraint system. In this mode, the belt can be retracted but cannot be extended. When the belt is retracted to a certain length, this mode is cancelled and normal operation is restored.




B5H0328A

# WIPER AND WASHER SYSTEMS

# WW

Page

# 1. Front Wiper and Washer

## A: DESCRIPTION

### 1. FRONT WIPER

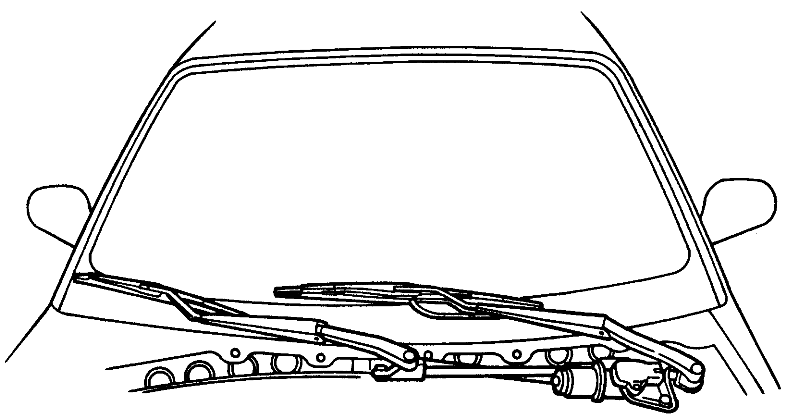
1) The front wiper is of a tandem type featuring wide wiping area. The blade is installed to the arm by means of U-hook joint to improve serviceability.

2) The front wiper operates in the HI and LOW speed modes and the INTERMITTENT mode.

The operation modes can be selected by turning the wiper switch incorporated in the combination switch.

3) In the INTERMITTENT mode, the intermittent unit installed behind the combination switch controls the front wiper operation interval.

4) The front wiper system uses a modular construction in which the wiper motor forms an integral part of the linkage. The motor is installed on the body through rubber mounting.



B6H1164

### 2. FRONT WASHER SYSTEM

1) The washer system consists of a washer tank, a motor and pump unit and a pair of nozzles.

2) The washer tank is installed at the front of the strut mount on the left side of the engine compartment.

3) The washer motor and pump unit is installed at the bottom of the washer tank.

4) The washer nozzles are installed on the hood. Each nozzle is a diffusion nozzle.

5) Each washer nozzle is provided with a check valve which is located just below it.

## 3. SPECIFICATIONS

| | | | | |
|---|---|---|---|---|
| Washer Tank | Capacity | | | 4.0 liters (4.2 US qt, 3.5 Imp qt) |
| Wiper Motor | Rated voltage | | | 12 V |
| | No-load current | | | 4 A or less |
| | Speed [at 2.0 N·m (20 kg-cm, 17 in-lb)] | | HIGH | 72 ± 6 rpm |
| | | | LOW | 47 ± 5 rpm |
| | Locked rotor characteristics | HIGH | Torque | 29.4 N·m (300 kg-cm, 2.2 ft-lb) |
| | | | Current | 36 A or less |
| | | LOW | Torque | 34.3 N·m (350 kg-cm, 2.5 ft-lb) |
| | | | Current | 31.5 A or less |
| Wiper Blade | Length | Driver side | | 550 mm (21.65 in) |
| | | Passenger side | | 500 mm (19.69 in) |

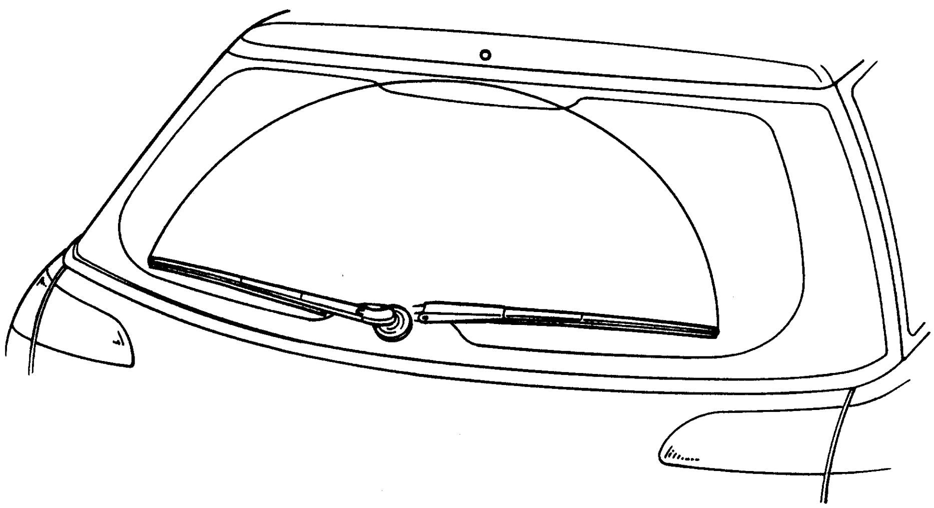
# 2. Rear Wiper and Washer

## A: DESCRIPTION

### 1. REAR WIPER

1) The rear wiper operates intermittently at a 10-second interval.

2) The rear wiper operates over a 168-degree angle.



B6H1165

3) The wiper blade is attached to the arm by means of a U-hook joint in the same way as with the front wipers.

### 2. REAR WASHER SYSTEM

1) The same washer tank is shared by the front and rear washer systems.

2) The washer motor and pump unit is installed at the bottom of the washer tank, adjacent to the front washer's unit.

3) The washer nozzle is installed on the upper portion of rear gate panel. The nozzle has two spray holes.

4) The washer nozzle is provided with a check valve which is located just below it.

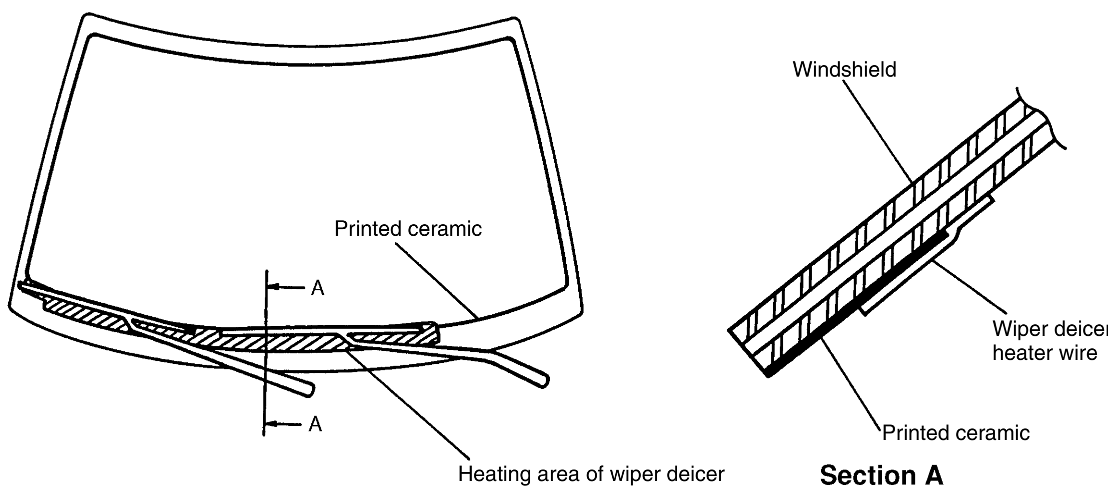
### 3. SPECIFICATIONS

| | | |
|---|---|---|
| Wiper Motor | Rated voltage | 12 V |
| | No-load current | 2 A or less |
| | Speed [at 0.5 N·m (5 kg-cm, 4.3 in-lb)] | 30 ± 5 rpm or more |
| | Locked rotor current | 13 A or less |
| Wiper Blade | Length | 375 mm (14.76 in) |

# 3. Windshield Wiper Deicer

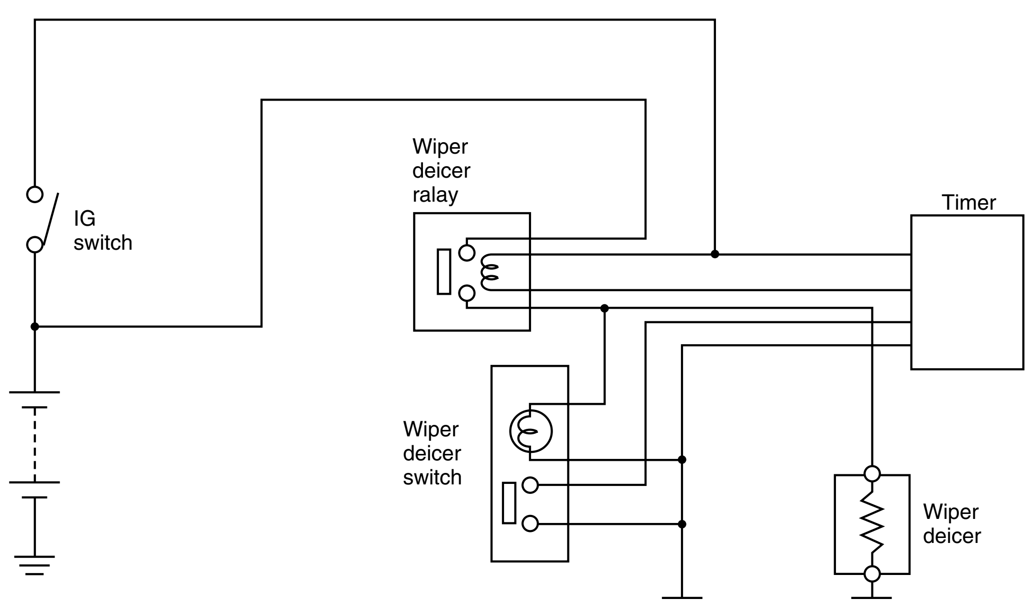
## A: CONSTRUCTION

The wiper deicer system is activated when the wiper deicer switch is pressed with the ignition switch turned ON. It heats the lower part of the windshield with a heater wire to melt the ice that blocks the wiper blades.
The system turns off automatically in 15 minutes after the wiper deicer switch is turned ON.




B6H0857C

## B: CIRCUIT DIAGRAM




B6H0858

## MEMO

# GLASS/WINDOWS/MIRRORS GW

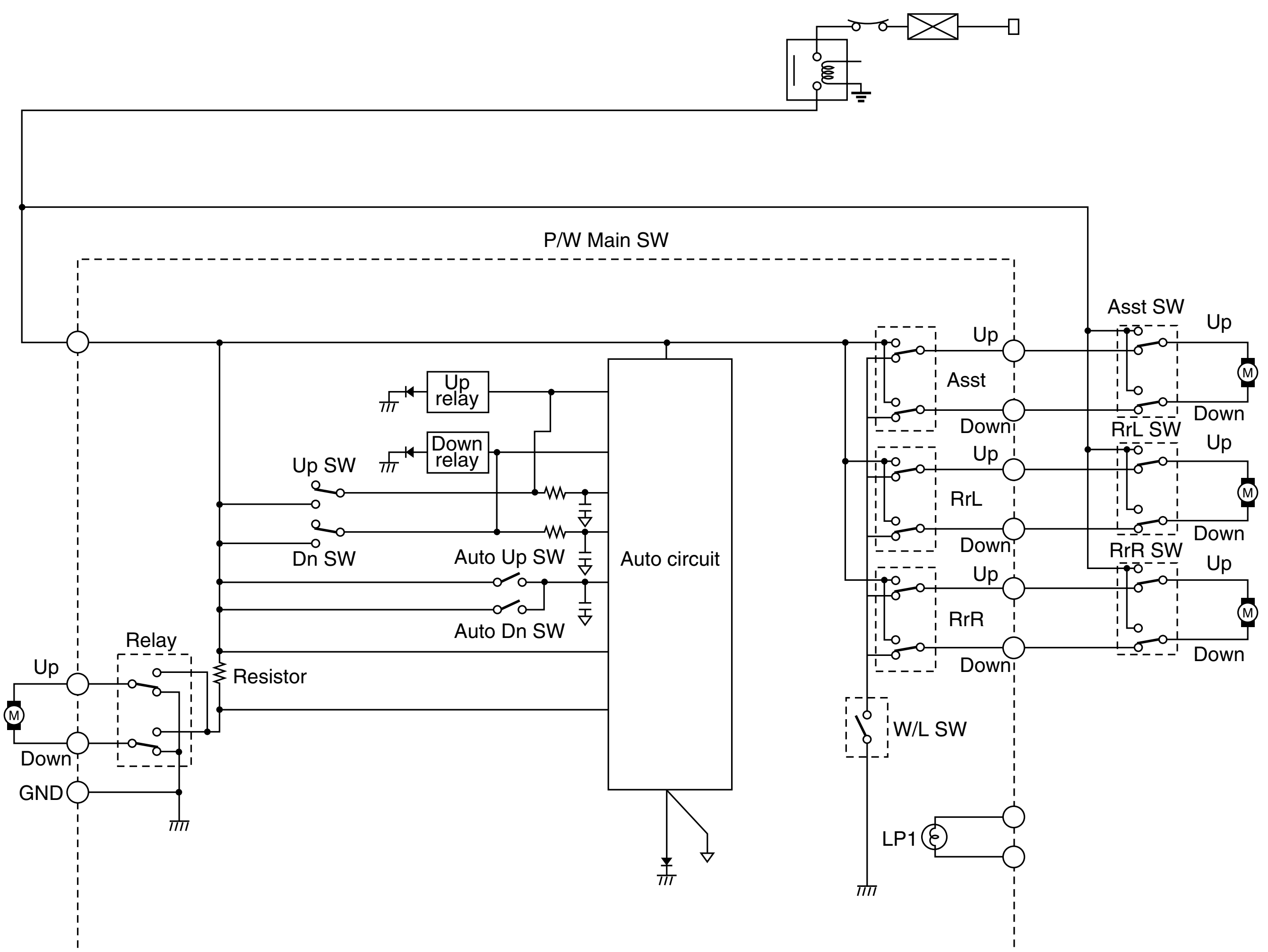
# 1. Power Window

## A: CONSTRUCTION

- The power window system consists of regulator motors and switches for individual doors, relays and a circuit breaker unit.
- Each door window opens/closes by pushing down/pulling up the switch.
- Only the driver's door window switch has a 2-stage mechanism:
  - When the switch is pushed lightly and held in the pushed position, the window continues to lower until the switch is released.
  - When the switch is pushed down fully, the window lowers to the end position automatically.

NOTE:
For the sake of safety, the power window system is designed to operate only when the ignition switch is in the ON position.

## B: CIRCUIT DIAGRAM




B6H1684A

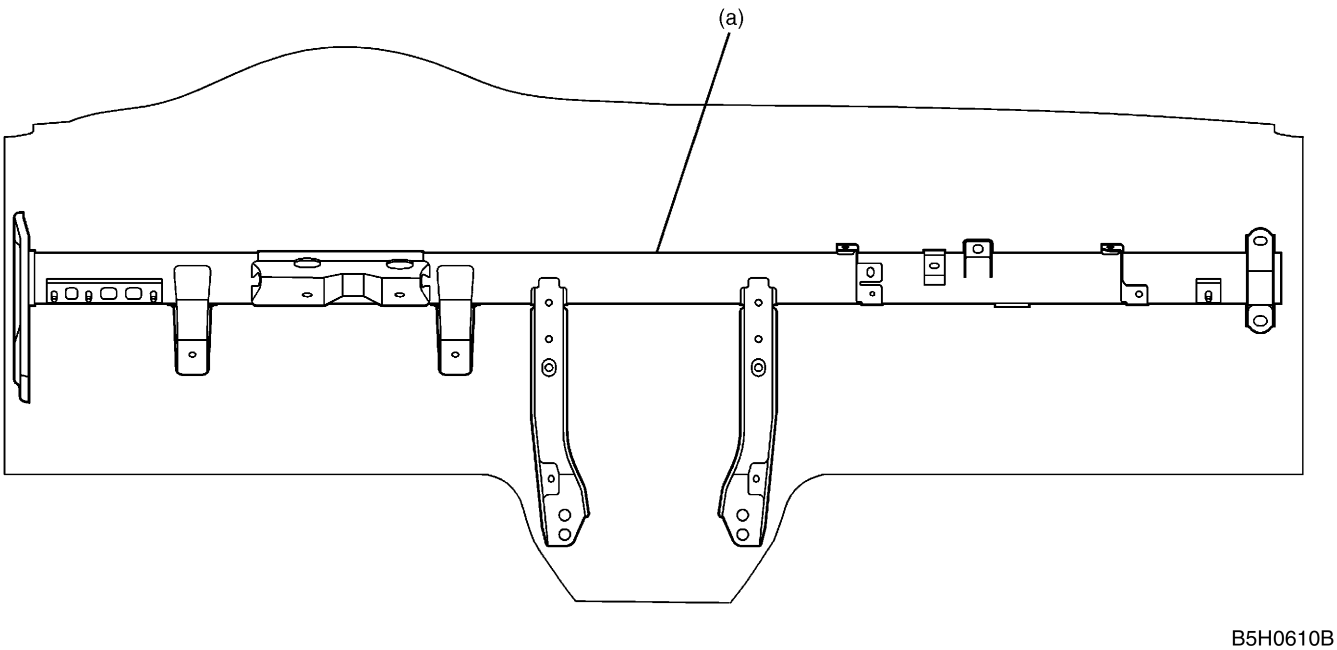
# BODY STRUCTURE BS

# 1. Outline

- The Legacy's body structure is of a semi-monocoque design mainly consisting of press-formed steel sheets welded together.
- A combination of longitudinal frames and annulous frames arranged like a cage forms both a crushable zone that collapses in a controlled manner in the event of a collision (thus absorbing the impact force) and a rigid cabin that is highly resistant to deformation stresses (thus maintaining a survival space for the occupants).

## 2. Steering Support Beam

A steering support beam (a) is provided between the left and right front pillars for reinforced support of the steering column. It also minimizes vibration of the steering column and limits its extension to a minimum in the event of a collision.

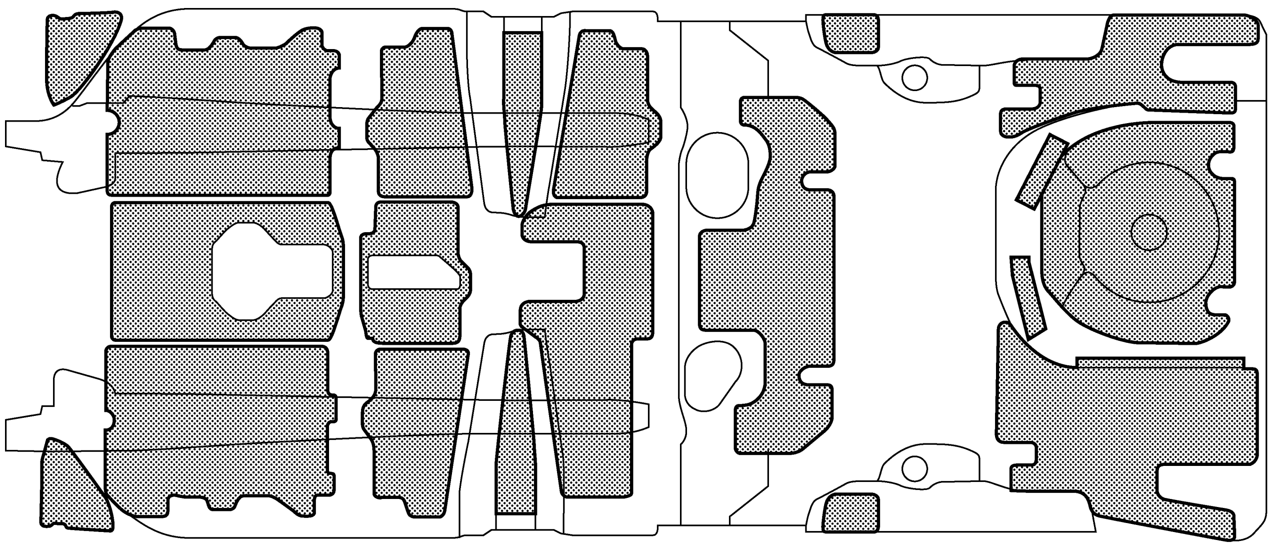


# 3. Quietness

Silencers, dual-wall panels, sound-absorbing materials, etc. are utilized in conjunction with a high-rigidity and vibration/noise-proof body structure in order to ensure quietness of the passenger compartment.

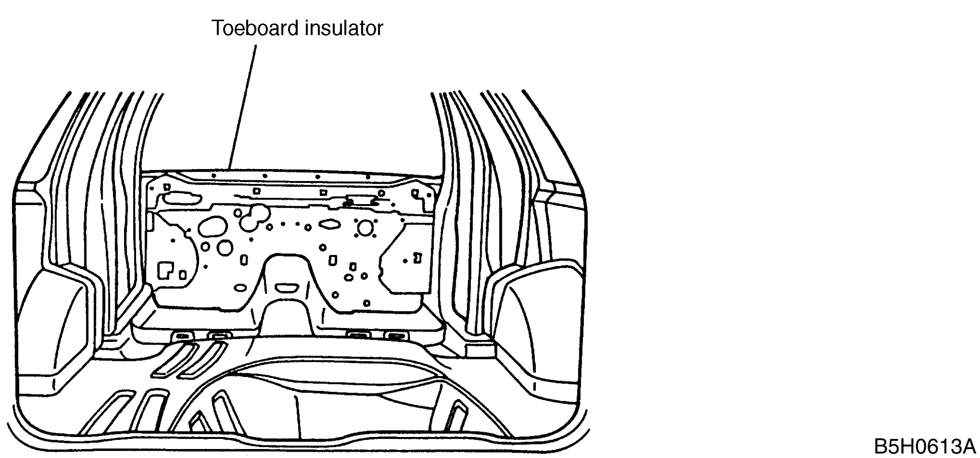
## A: SILENCERS

Silencers (= asphalt sheets) minimize transmission of noise/vibration into the passenger compartment.



## B: DUAL-WALL TOEBOARD

The toeboard is a dual-wall design consisting of an asphalt sheet placed between two steel panels to reduce the transmission of noise and vibration from the engine compartment to the passenger compartment.



# 4. Body Sealing

## A: SEALED PARTS

All gauge holes and other holes used during the body manufacturing process are plugged to prevent entry of water and dust.

Any time the vehicle body has been repaired, the affected holes should be properly plugged with the use of the specified plugs.

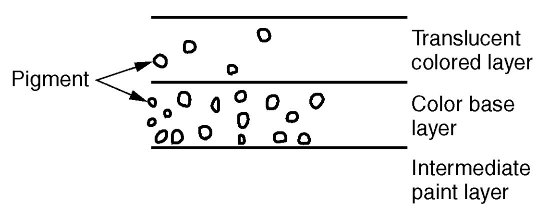
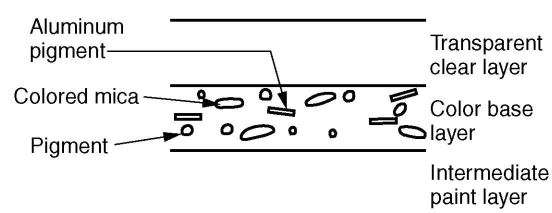
# 5. Painting

## A: SPECIFICATION

| Color name | Color code |
|---|---|
| PURE WHITE | 51E |
| RED MICA (M) | 94H |
| PREMIUM SILVER (M) | 01G |
| DARK GREEN MICA | 16L |
| BLUE MICA (M) | 14L |
| GRAPHITE BLACK MICA | 18L |
| WHITE PEARL MICA | 07C |
| ★ BLUE MICA (M) / GRAY OPAL | 1U3 (14L / 11R) |
| ★ DARK GREEN MICA / DARK GREENISH GRAY (M) | 1U6 (16L / 12R) |
| ★ GREENISH GRAY OPAL / DARK GREENISH GRAY (M) | 1U7 (19Y / 12R) |
| ★ PURE WHITE / GRAY OPAL | 1N1 (51E / 11R) |
| ★ RED MICA (M) / GRAY OPAL | 1U8 (94H / 11R) |

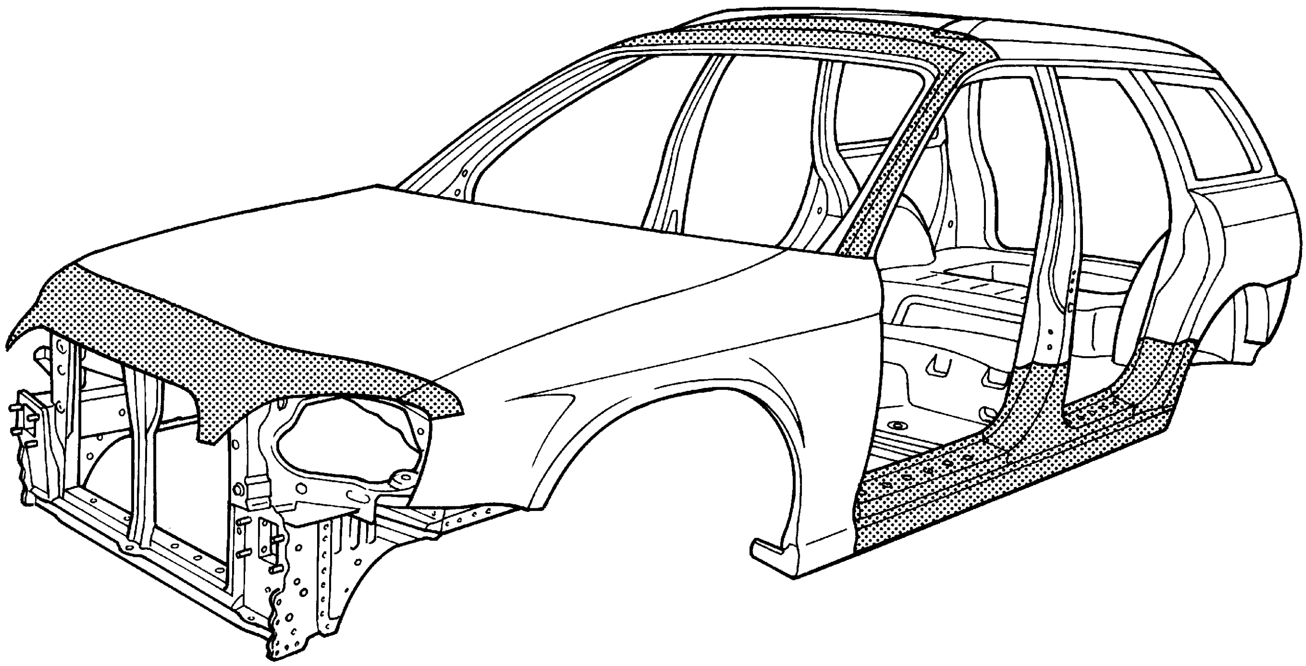
(M): Metallic
★: 2-tone

## B: PAINT FILM STRUCTURE

| Color name | Paint film structure |
|---|---|
| • PURE WHITE<br>• WARM GRAY SOLID |  |
| • DARK GREEN MICA<br>• DEEP BLUE MICA<br>• RED MICA (M)<br>• WARM GRAY OPAL<br>• ROYAL SILVER (M)<br>• GRAY (M)<br>• WHITE PEARL MICA<br>• COOL GRAY OPAL<br>(M): Metalic |  |

B5H0614H

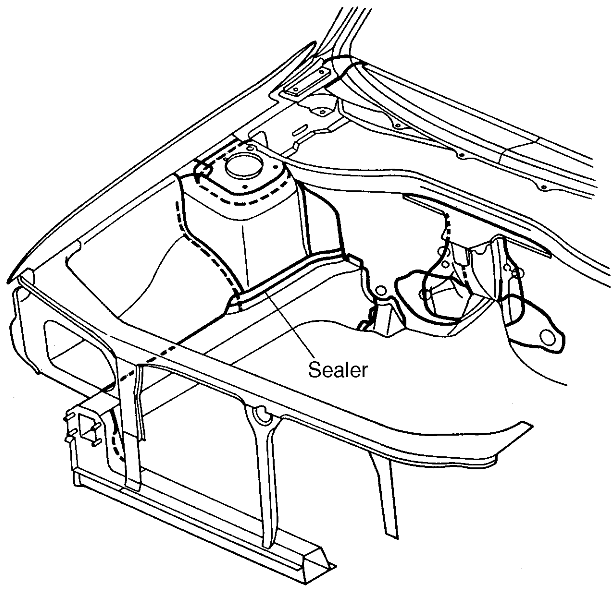
# 6. Anti Chipping Coat (ACC) Application



B5H0831

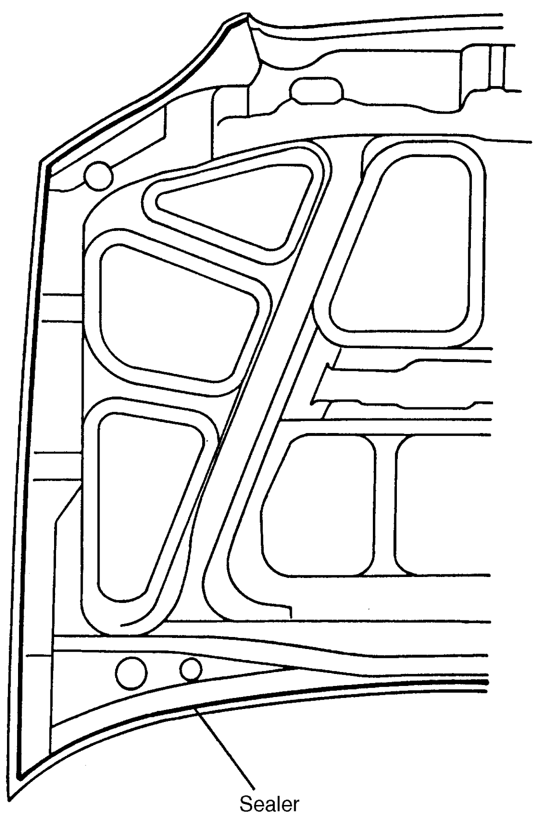
# 7. Sealer Application

## A: ENGINE COMPARTMENT



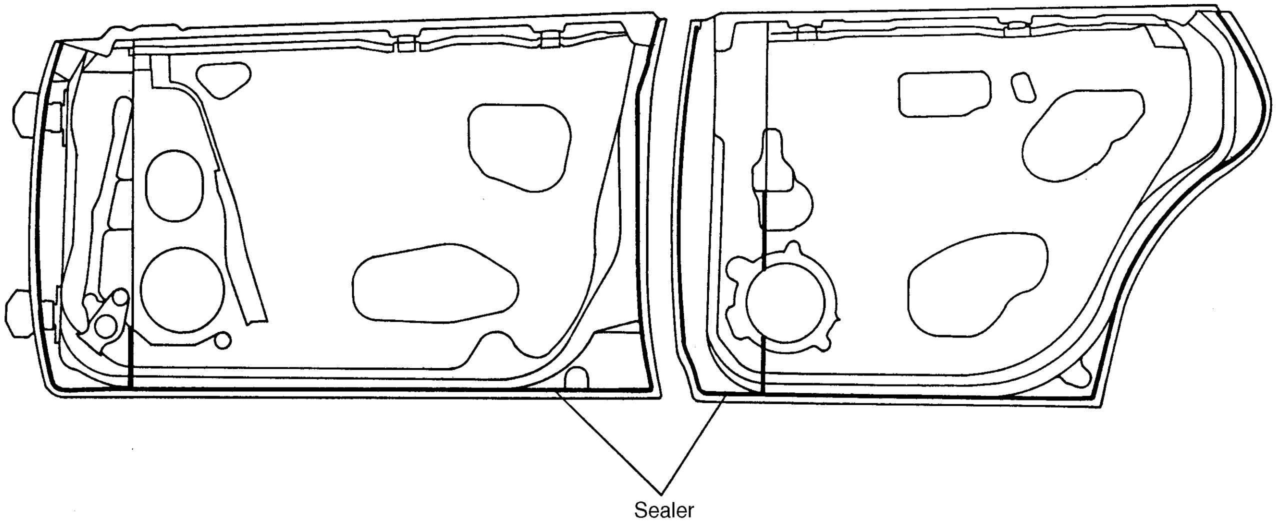

B5H0616A

## B: ENGINE HOOD



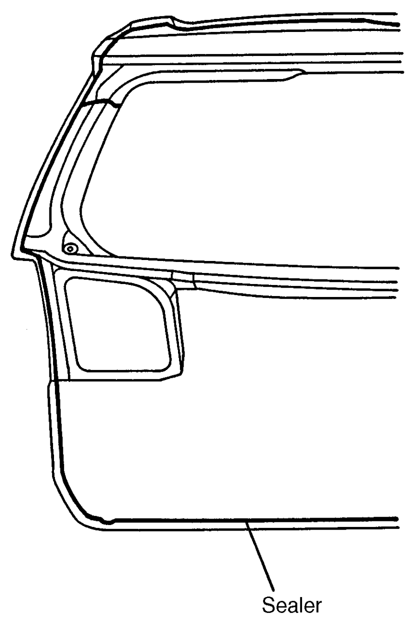

B5H0617A

## C: DOOR



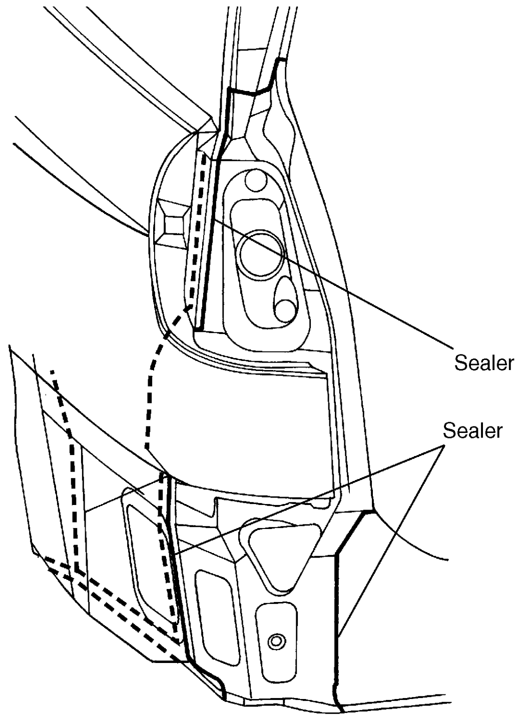

B5H0618A

## D: REAR GATE



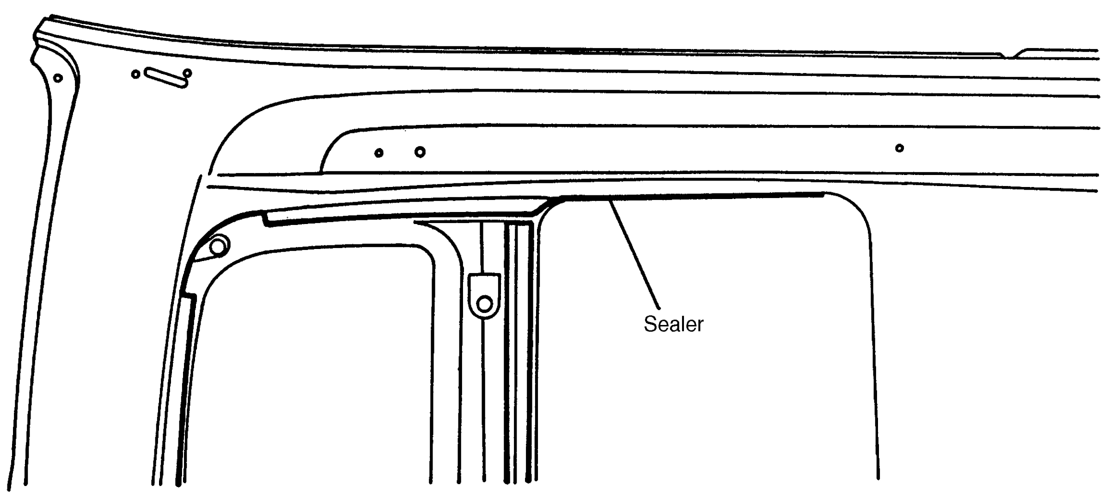

B5H0619A

## E: REAR END (WAGON)



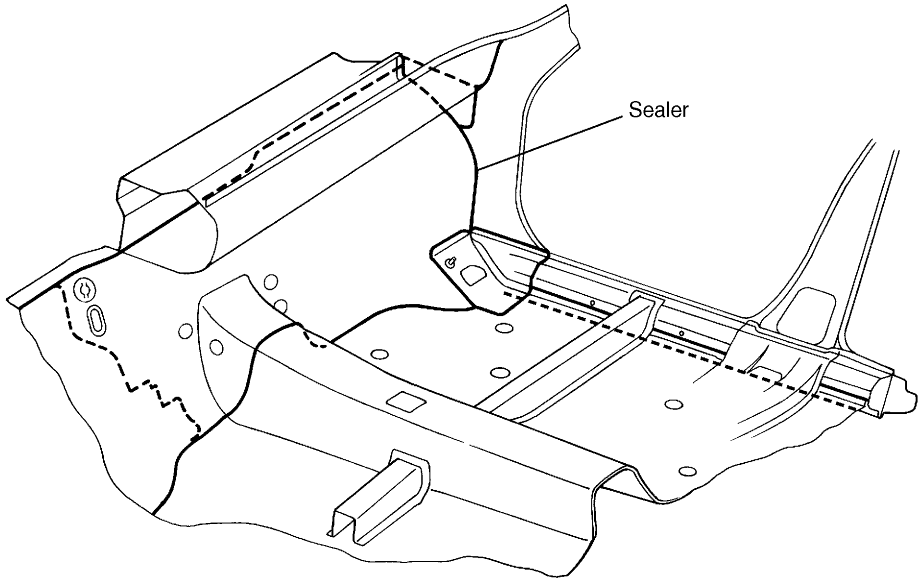

B5H0832A

## F: ROOF PANEL (SUN-ROOFED WAGON)



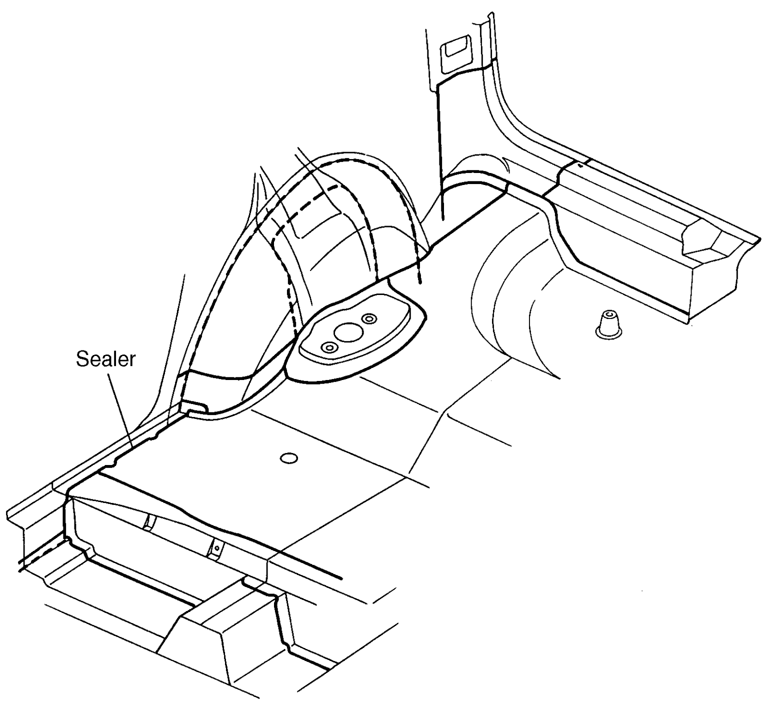

B5H0621A

## G: FRONT FLOOR



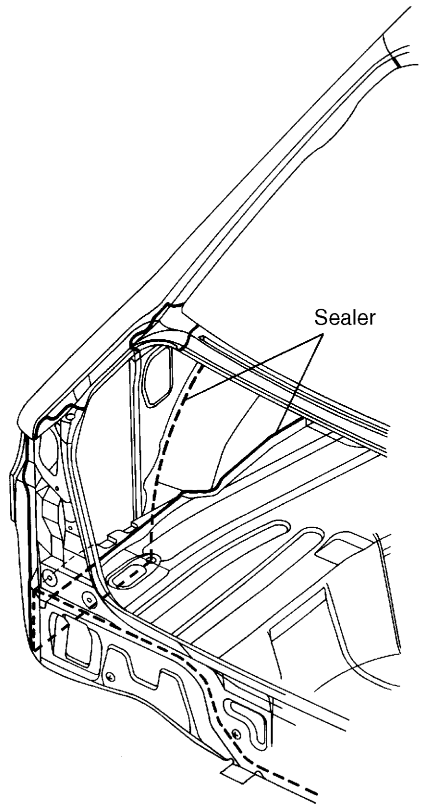

B5H0833A

## H: REAR FLOOR




B5H0623A

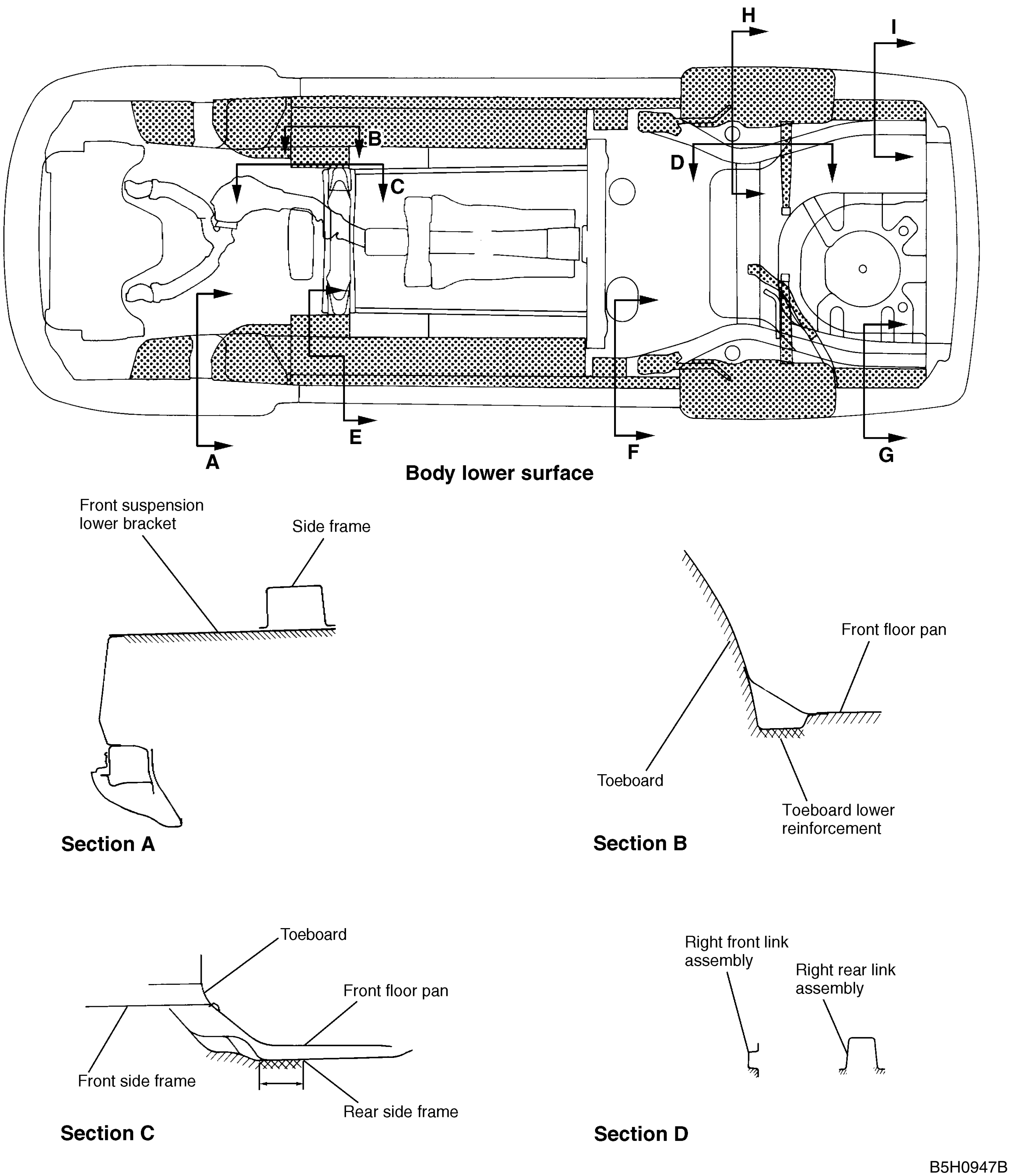
## I: REAR END (SEDAN)

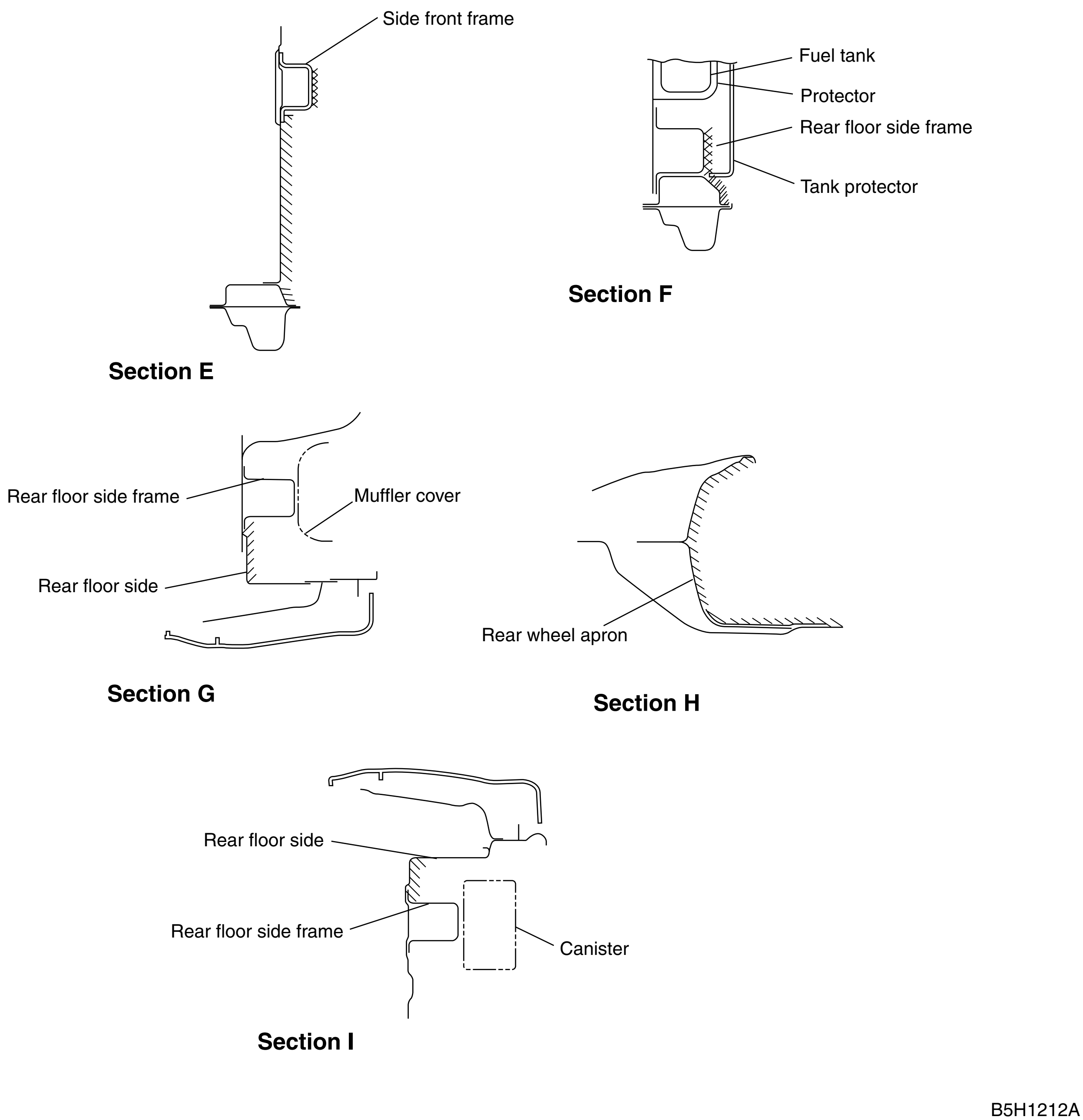



B5H0946A

## MEMO

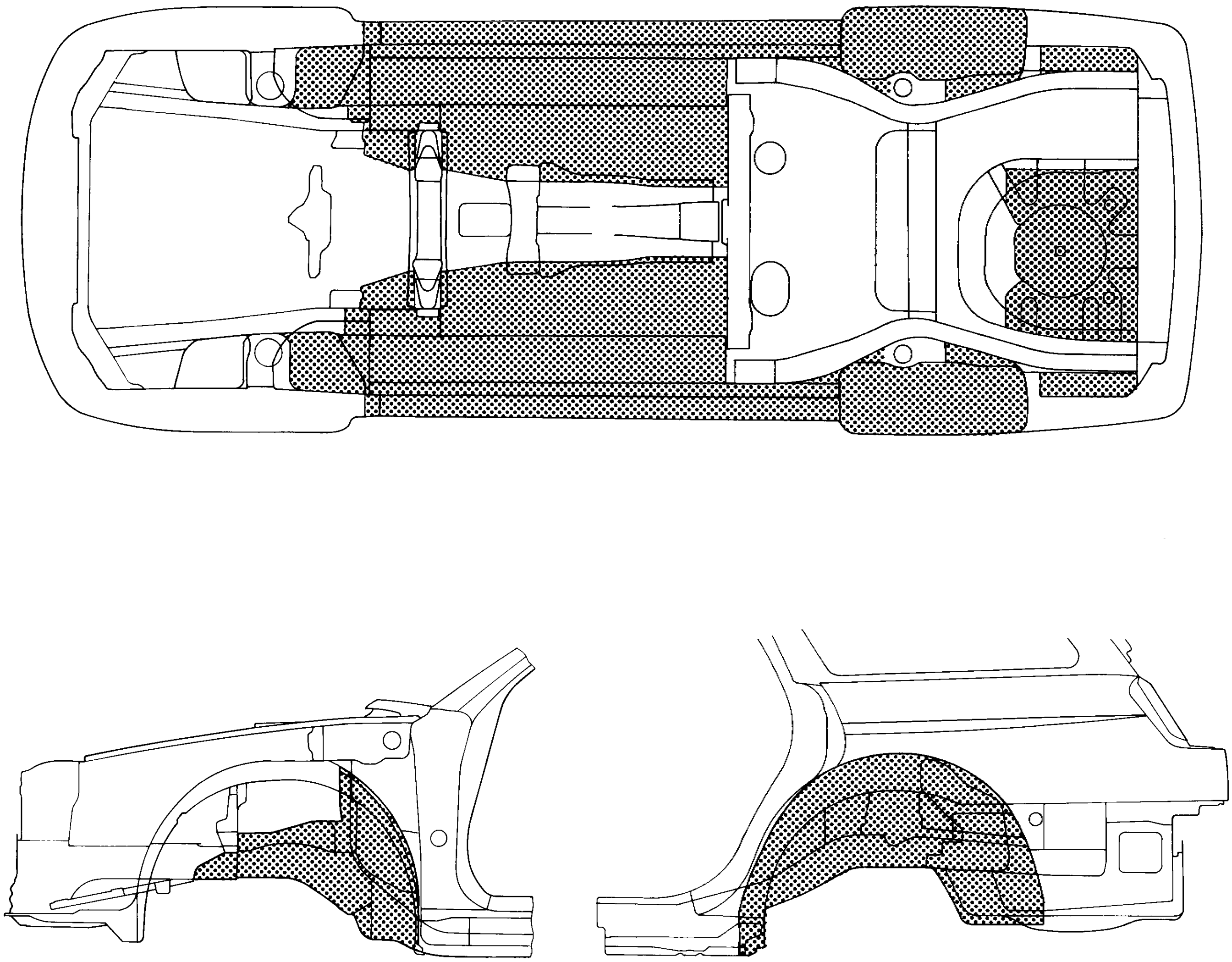
# 8. Anti-rust Wax (Bitumen Wax) Application





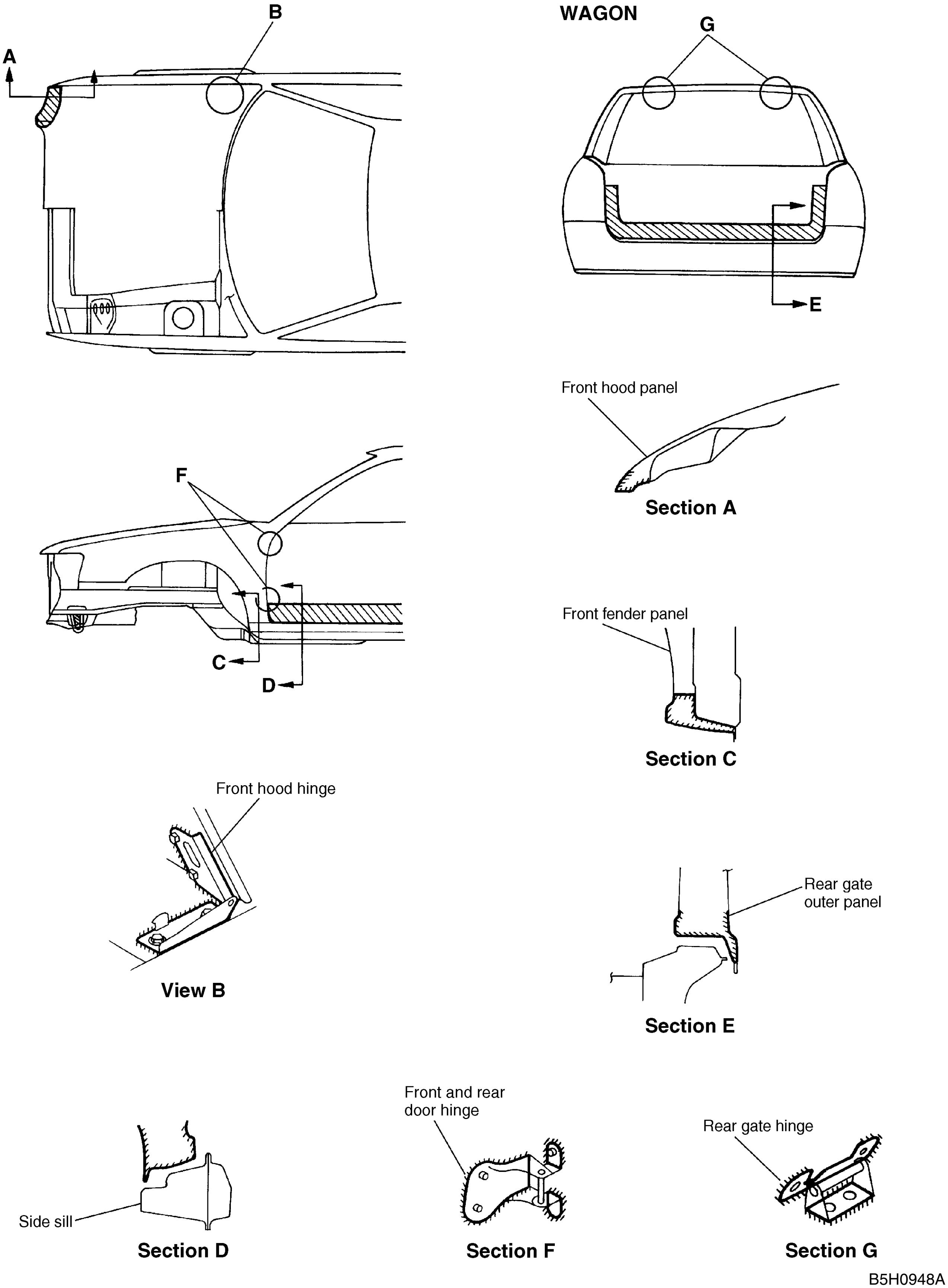
Side front frame
Section E
Fuel tank
Protector
Rear floor side frame
Tank protector
Section F
Rear floor side frame
Muffler cover
Rear floor side
Section G
Rear wheel apron
Section H
Rear floor side
Rear floor side frame
Canister
Section I
B5H1212A

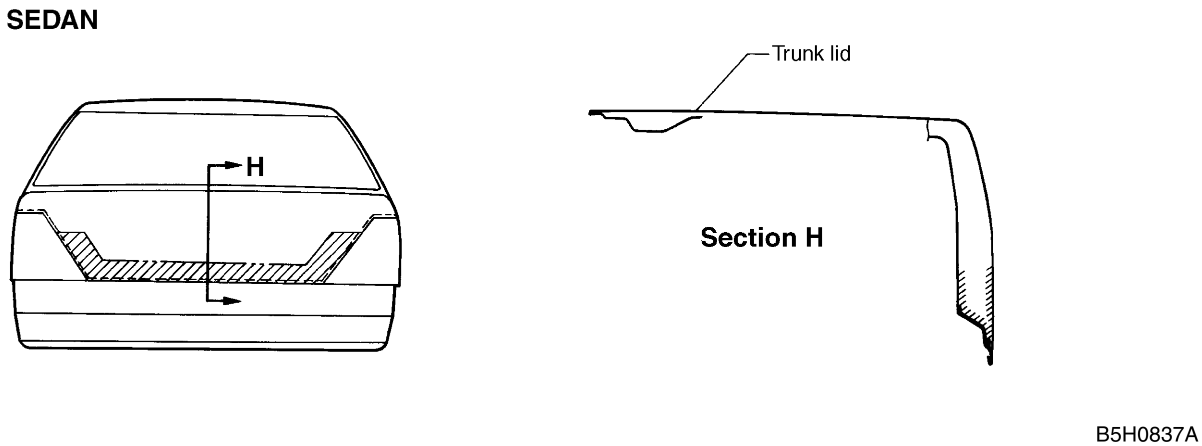
# 9. Polyvinyl Chloride (PVC) Application



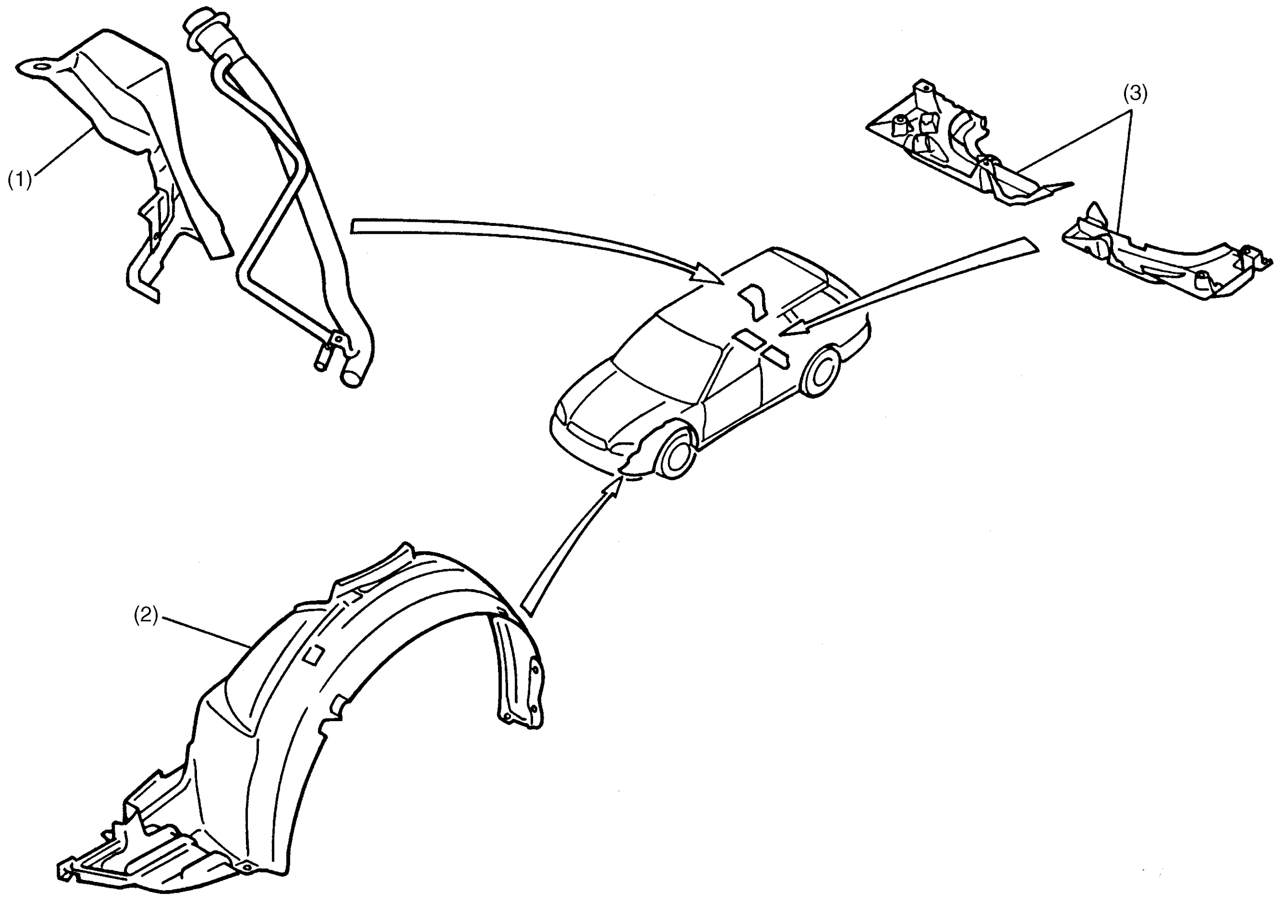
B5H0624

# 10.Hot Wax Application



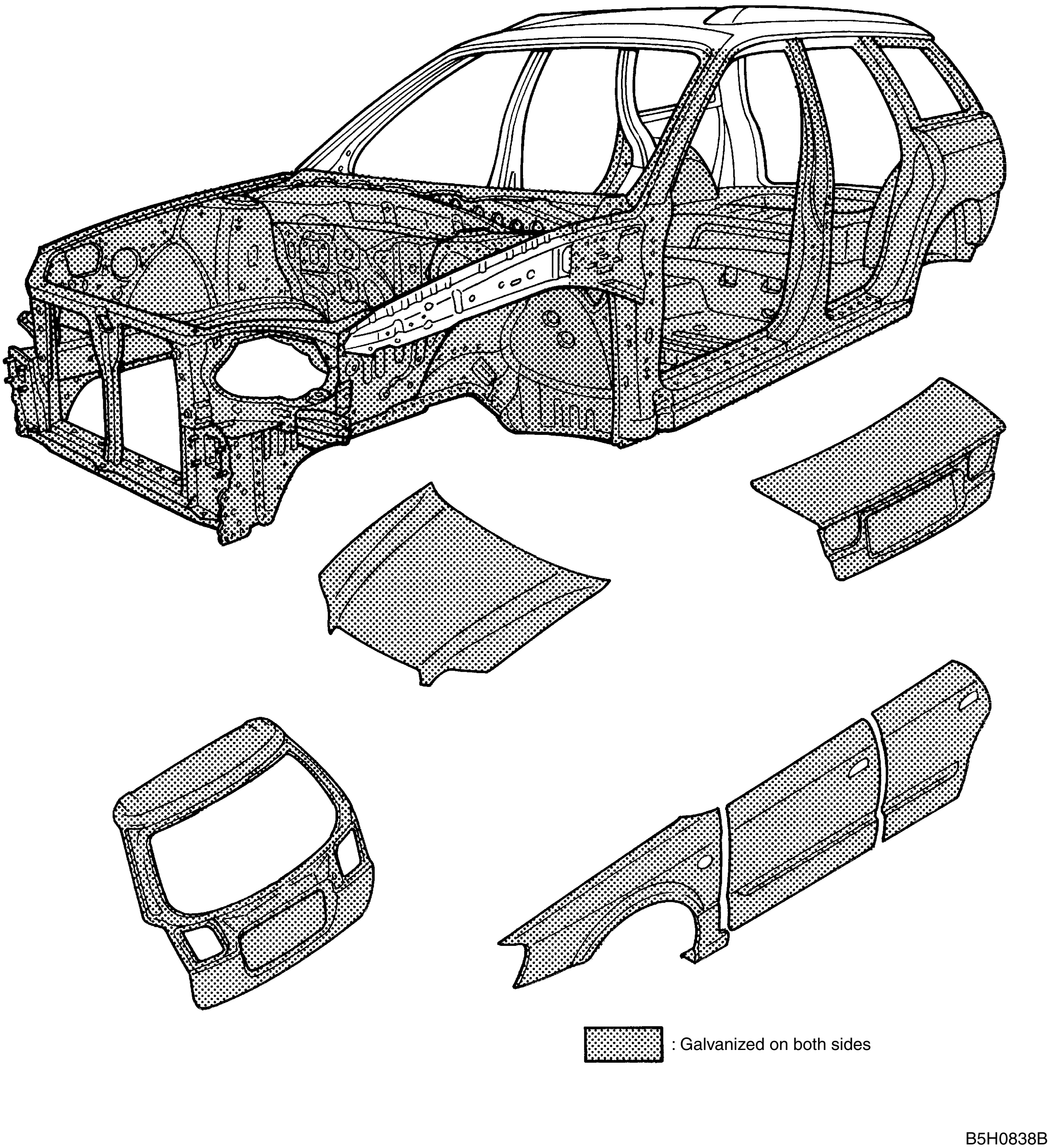

SEDAN
H
Trunk lid
Section H
B5H0837A

# 11.Rustproof Parts



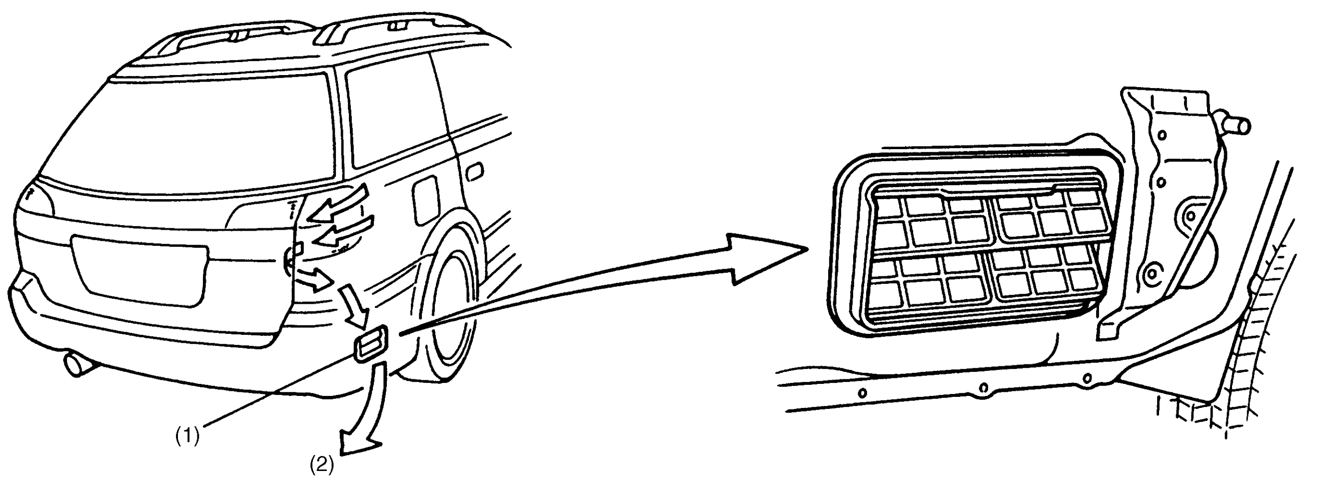

(1) Fuel pipe protector
(2) Front mud guard
(3) Fuel tank protector

# 12.Galvanized Sheet Metal Application



# 13.Ventilation

## A: AIR OUTLET PORT

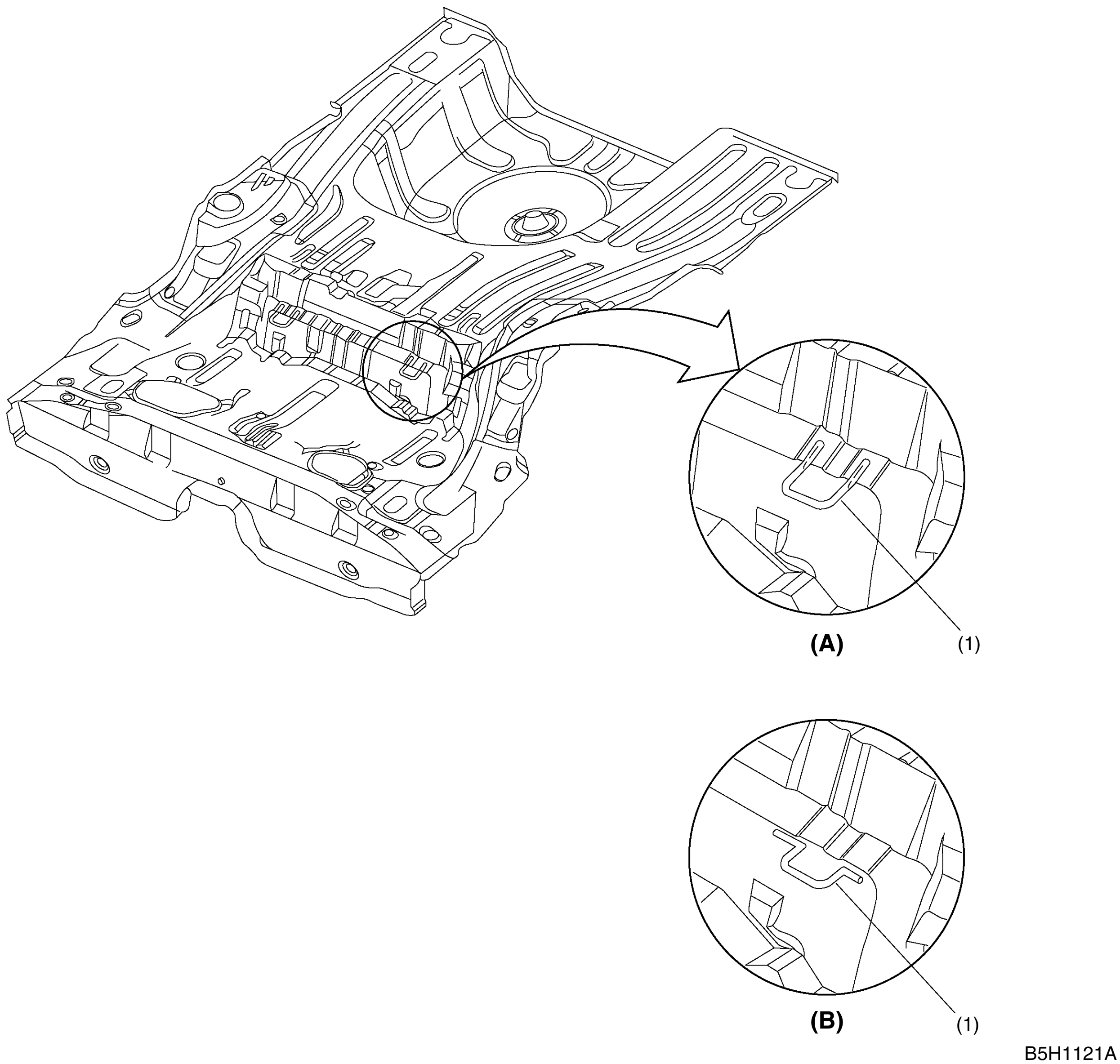



(1) Air outlet port

(2) Air flow

# 14.Child Seat Anchors

Two child seat anchors are added to the rear floor panel below both side seating positions of the rear seat in order to conform with the FMVSS225 (ISO-FIX) requirements for child restraint anchorage systems.




**(A)** WAGON
**(B)** SEDAN
(1) Anchor

# INSTRUMENTATION/DRIVER INFO IDI

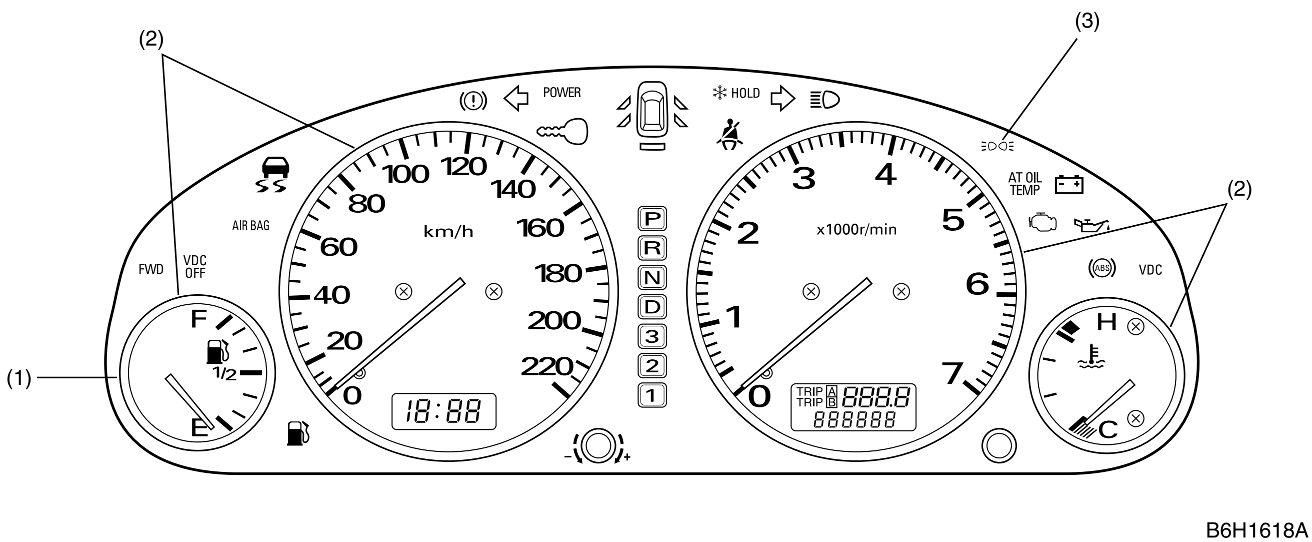
**Page**

# 1. Combination Meter

## A: LUMINESCENT METER

Some models are equipped with a luminescent combination meter with improved visibility and attractive appearance. The luminescent combination meter has the following features:

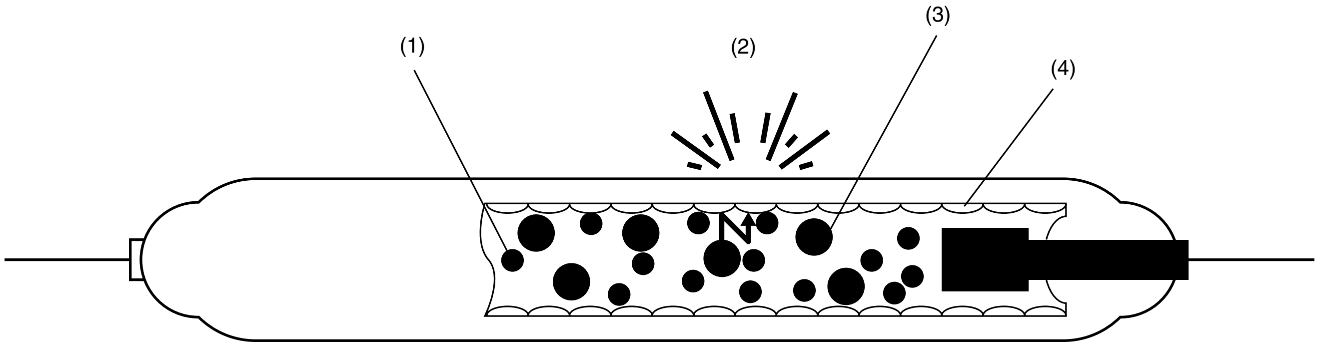
- The intensity of the meter and gauge illumination can be adjusted as desired according to ambient light conditions.
- When the ignition switch is turned to the ON position, the meters and gauges illuminate incrementally: first the rings, then the needles and finally the characters.
- The combination meter panel has a new indicator light which illuminates when the light switch (headlight control knob) is turned to the first position.




(1) Fuel gauge ring (2) Luminescent ring (3) Light switch indicator light

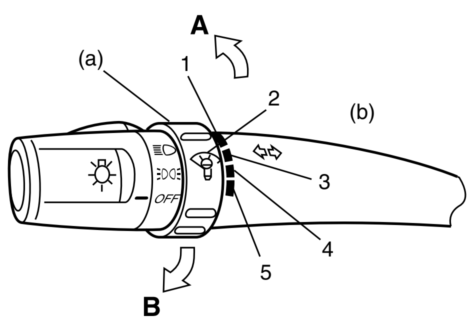
- The rim of the fuel gauge (luminescent ring) starts flashing when the low fuel warning light comes on.
- A cold cathode fluorescent lamp is used for the illumination of the meter and gauge characters.

The cold cathode fluorescent lamp consists of a glass tube, appropriate amounts of mercury vapor and inert gases (argon, neon, etc.) in the glass tube, fluorescer coated on the inner surface of the glass tube, and pole-shaped electrodes at both ends of the tube.
The cold cathode fluorescent lamp operates as follows:
When adequately high voltage is applied between the lamp's electrodes, the anode is bombarded by a few electrons moving in the tube at a high speed toward it. This causes emission of secondary electrons from the anode and an electric discharge then starts. During the electric discharge, mercury molecules in the tube are bombarded by electrons that are moving toward the anode. The electron bombardment is accompanied by radiation of ultraviolet rays. The ultraviolet rays then activate the fluorescer, causing it to emit light.
The cold cathode fluorescent lamp operating in the above-mentioned principle provides the meter and gauge characters with illumination of near sunlight color.




B6H1619A

| | | | |
|---|---|---|---|
| (1) | Mercury molecule | (3) | Ultraviolet rays |
| (2) | Visible light | (4) | Fluorescer |




B6H1620A

| | | | |
|---|---|---|---|
| **(A)** | Brighten | (a) | Brightness control |
| **(B)** | Darken | (b) | Five steps |

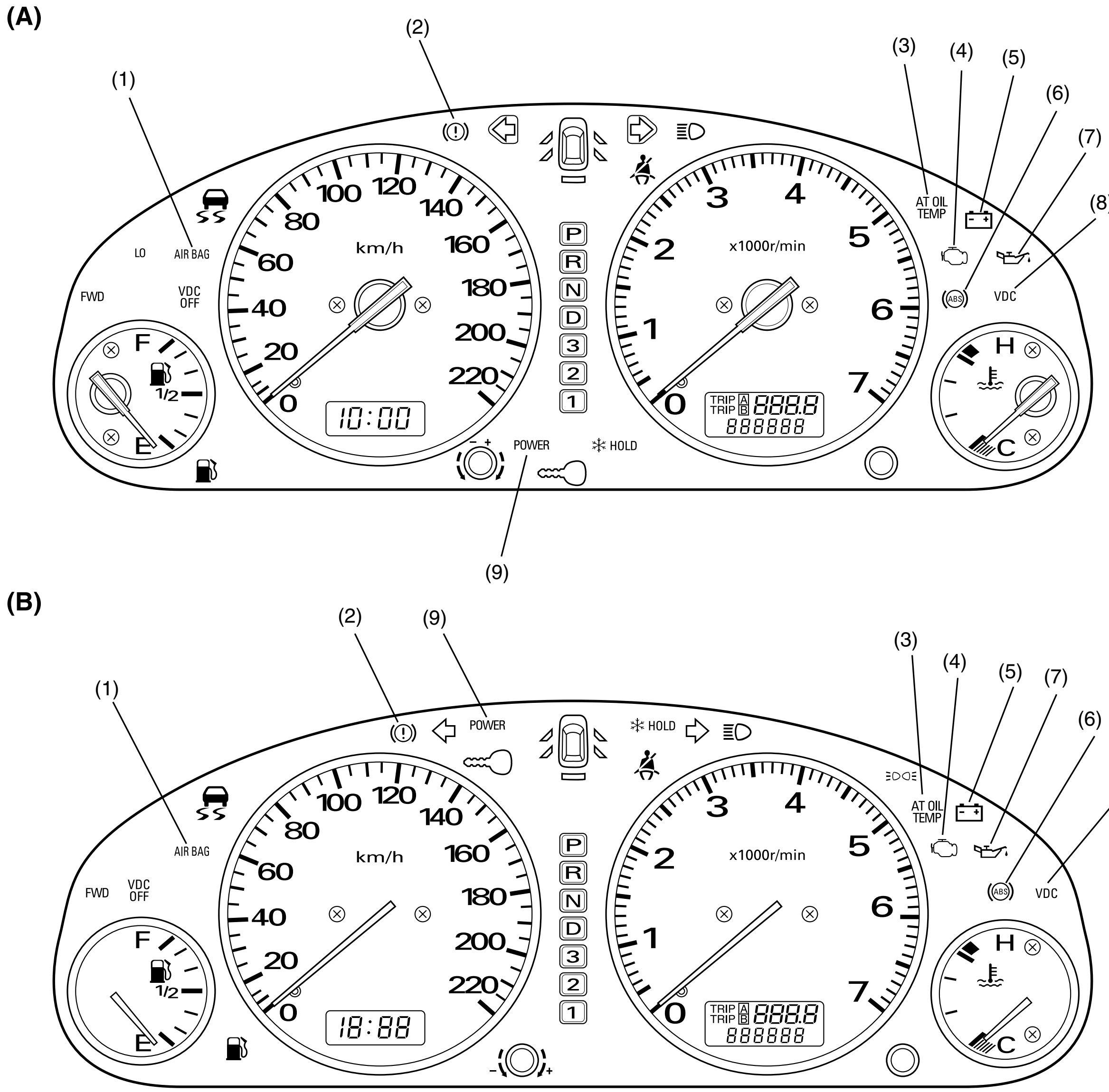
## 1. OPERATION

● The intensity of the meter and gauge illumination can be adjusted in five steps by turning the brightness control to any of the five detent positions (1 – 5).

● Placing the brightness control to the dimming cancellation position (position 1 which is intended for use when the headlights are on) and moving it out of the position result in the following states of the illumination.

- ● Position 1: When the control is placed in this position, the intensity of the illumination becomes the maximum after a delay time of one second.
- ● Other positions: When the control is moved from position 1 to any of the other positions, the illumination dims immediately to the intensity corresponding to the selected position of the illumination variable resistor.

## B: WARNING AND INDICATOR LIGHTS




B6H1621A

**(A)** Normal meter

**(B)** Luminescent meter

(1) AIR BAG system warning light
This light illuminates when a fault occurs in the airbag system.

(2) Brake fluid level warning / parking brake indicator light
This light illuminates when the fluid level in the brake reservoir tank lowers below the specified level and/or when the parking brake is applied.

(3) AT oil temperature warning light
This light illuminates when the ATF temperature exceeds 150°C (302°F).

(4) CHECK ENGINE warning light
This light illuminates when a fault occurs in the MFI (Multiple point Fuel Injection) system.

(5) Charge indicator light
This light illuminates when a fault occurs in the charging system while the engine is running.

(6) ABS warning light
This light illuminates when a fault occurs in any electrical component of the ABS (Anti-lock Brake System).

(7) Oil pressure warning light
This light illuminates when the engine oil pressure decreases below 14.7 kPa (0.15 kgf/cm$^2$, 2.1 psi).

(8) VDC warning light
This light illuminates when a fault occurs in any electrical component of the VDC (Vehicle Dynamics Control).

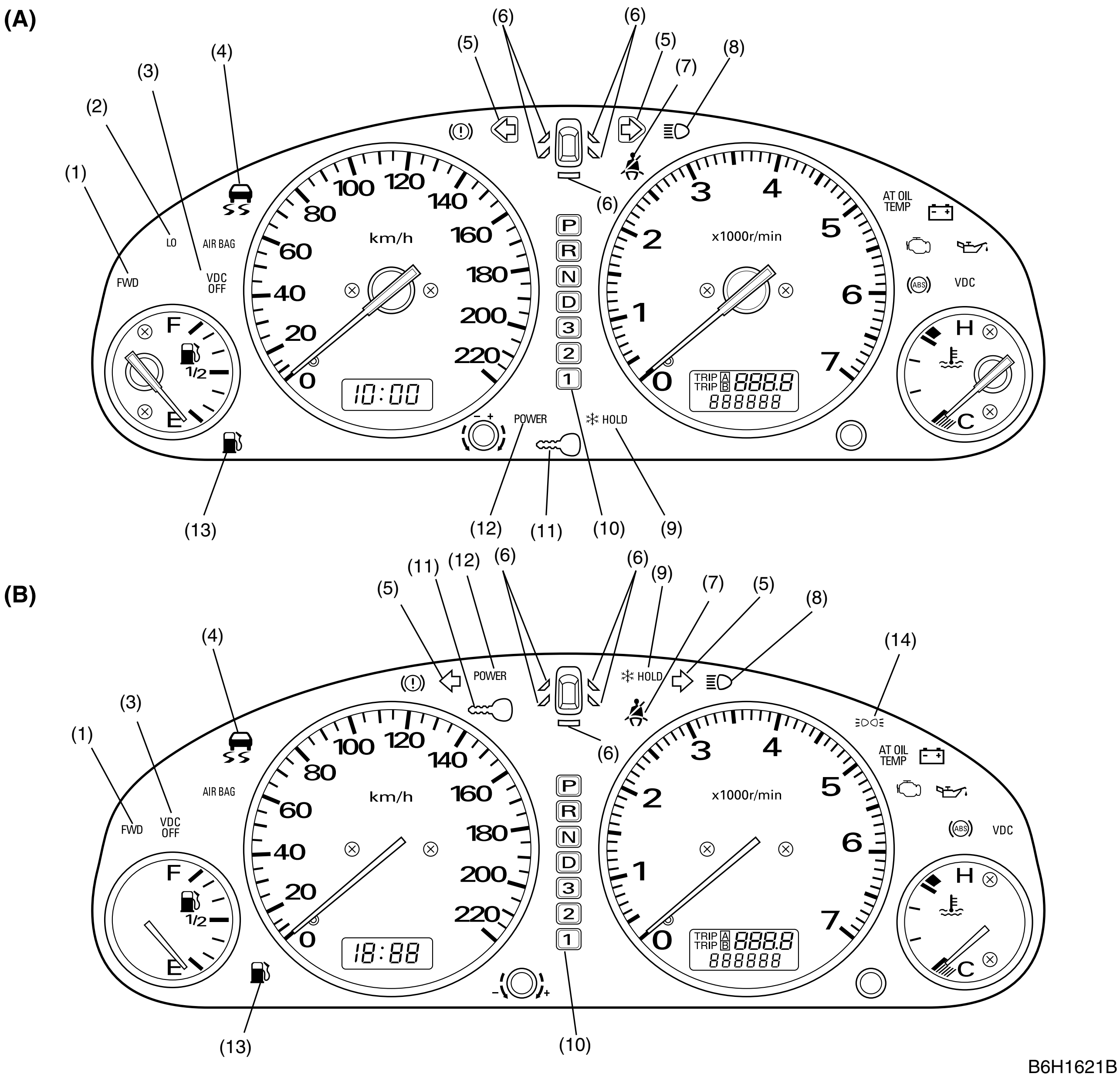
(9) POWER indicator light
This light blinks when a fault occurs in the AT control system.

If everything is normal, the warning and indicator lights should be ON or OFF as shown below according to ignition switch positions.

| Warning/Indicator light | Ignition switch position | | | |
|---|---|---|---|---|
| | LOCK/ACC | ON | ST | While engine is running |
| (1) AIR BAG | OFF | *1 | *1 | *1 |
| (2) Brake fluid level / parking brake | OFF | ON | ON | *3 |
| (3) AT oil temperature | OFF | ON | ON | OFF |
| (4) CHECK ENGINE | OFF | ON | ON | OFF |
| (5) Charge | OFF | ON | ON | OFF |
| (6) ABS | OFF | *2 | *2 | *2 |
| (7) Oil pressure | OFF | ON | ON | OFF |
| (8) VDC | OFF | ON | ON | OFF |
| (9) POWER | OFF | ON | ON | *2 |

*1:This light comes ON for about 6 seconds, and then goes out.
*2:This light comes ON for about 2 seconds, and then goes out.
*3:This light comes ON when the parking brake is applied.

## C: TELLTALE (GRAPHIC MONITOR)



**(A)** Normal meter

**(B)** Luminescent meter

(1) FWD indicator light
This light illuminates when the drive mode is changed from AWD to FWD (with the fuse installed in the FWD switch).

(2) LO indicator light
This light illuminates when the dual-range select lever is in the LO position.

(3) VDC OFF indicator light
This light illuminates when the VDC or TCS is deactivated.

(4) VDC operation indicator light
This light flashes when the VDC system is operating. It also illuminates when the TCS is operating.

(5) Turn signal indicator light
This light blinks in unison with the corresponding turn signal lights when the turn signal switch is operated.

(6) Door open warning light
This light illuminates when one or more doors and/or rear gate are not completely closed.

(7) Seat belt warning light
This light stays illuminated for about 6 seconds after the ignition switch has been turned ON.

(8) Headlight beam indicator light
This light illuminates when the headlights are in the high-beam position.

(9) HOLD indicator light
This light illuminates when the automatic transmission is in the HOLD mode.

(10) AT selector lever position indicator
The light corresponding to the present AT select lever position illuminates when the ignition switch is in any position other than ACC and LOCK.

(11) Immobilizer indicator light
This light illuminates when the immobilizer system is armed.

(12) POWER indicator light
This light illuminates when the automatic transmission is in the POWER mode.

(13) Low fuel warning light
This light illuminates when the quantity of the fuel remaining in the tank has decreased to 10 liters (2.6 US gal, 2.2 Imp gal) or smaller.

(14) Lighting switch indicator light
This light illuminates when the lighting switch is turned to the first position.

If everything is normal, the telltales should be ON, OFF or in other states as shown below according to ignition switch positions.

| Telltale light | | | Ignition switch position | | | |
|---|---|---|---|---|---|---|
| | | | LOCK/ACC | ON | ST | While engine is running |
| (1) | FWD | ● FWD | OFF | ON | ON | ON |
| | | ● AWD | OFF | OFF | OFF | OFF |
| (2) | LO | ● Low range | OFF | ON | ON | ON |
| | | ● High range | OFF | OFF | OFF | OFF |
| (3) | VDC OFF | | OFF | ON | ON | *8 |
| (4) | VDC operation | | OFF | *6 | ON | OFF |
| (5) | Turn signal | | OFF | Blink | Blink | Blink |
| (6) | Door or rear gate open | ● Open | ON | ON | ON | ON |
| | | ● Shut | OFF | OFF | OFF | OFF |
| (7) | Seat belt | | OFF | *3 | *3 | *3 |
| (8) | Headlight beam | ● High beam | OFF | ON | ON | ON |
| | | ● Low beam | OFF | OFF | OFF | OFF |
| (9) | HOLD | | OFF | *2 | *2 | *2 |
| (10) | AT selector lever position | | OFF | ON | ON | ON |
| (11) | Immobilizer | | *5 | OFF | OFF | OFF |
| (12) | POWER | | OFF | ON | *4 | *4 |
| (13) | Low fuel | | OFF | *1 | *1 | *1 |
| (14) | Lighting switch | | OFF | *7 | *7 | *7 |

*1:This light illuminates when quantity of the fuel remaining in the tank has decreased to 10 liters (2.6 US gal, 2.2 Imp gal) or smaller.
*2:This light illuminates when the AT is in the HOLD mode.
*3:This light stays illuminated for about 6 seconds after the ignition switch has been turned ON.
*4:This light illuminates when the AT is in the POWER mode.
*5:This light blinks when the ignition key has been removed from the ignition switch, or when 60 seconds or more time has passed after the ignition key was inserted in the ignition switch and was turned to the LOCK or ACC position.
*6:This light stays ON for about 2 seconds, and then goes out.
*7:This light illuminates when the lighting switch is turned to the first position.
*8:This light stays ON for about 4 seconds, and then goes out.

## D: SPEEDOMETER

### 1. DESCRIPTION

● The speedometer system is an electrical type that uses electric signals from the speed sensor in the MT model or the transmission control module (TCM) in the AT model.

● The vehicle speed sensor is installed on the manual transmission.

● Since the system does not use mechanical components such as rotating cable, there are no opportunities of occurring such problems as meter needle vibration and cable disconnection. Also, it does not constitute any means of mechanical noise transmission.

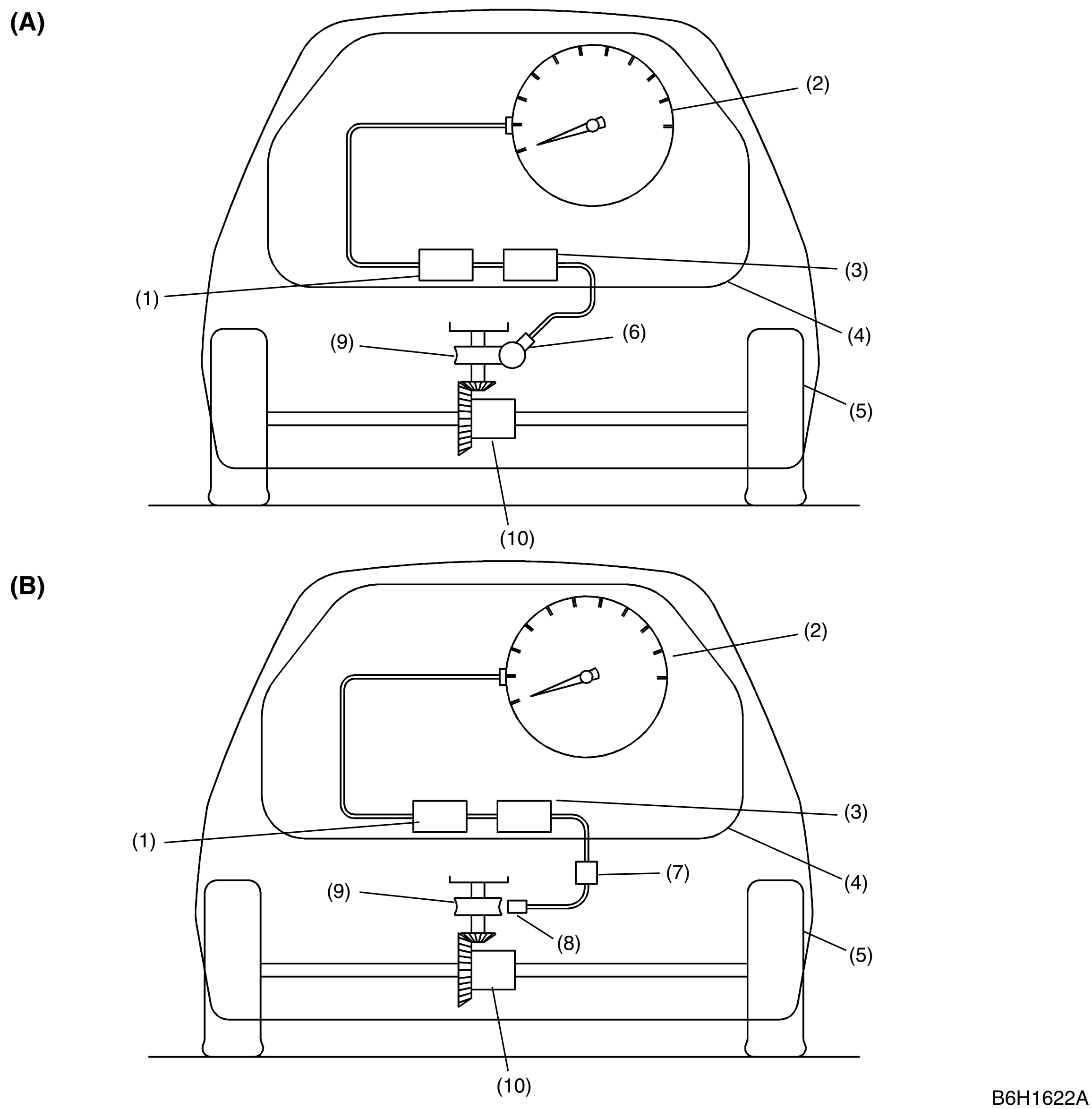
### 2. OPERATION

MT model: The vehicle speed sensor sends vehicle speed signals (4 pulses per rotation of speed sensor's driven shaft) to the speedometer drive circuit in the speedometer.

AT model: The TCM sends vehicle speed signals to the speedometer drive circuit in the speedometer.

NOTE:
Signals from the speed sensor or TCM are also used by the engine control module, automatic transmission control module, etc.

## 3. SYSTEM DIAGRAM




**(A)** MT model
**(B)** AT model

(1) Speedometer movement
(2) Speedometer
(3) Speedometer drive circuit
(4) Combination meter
(5) Front wheel
(6) Speed sensor
(7) TCM
(8) Electromagnetic pick-up
(9) Gear for the speed sensor
(10) Differential

### 4. SPECIFICATIONS

| | | |
|---|---|---|
| Speedometer | Type | Electric pulse type. |
| | Indication | Needle points to 60 km/h (37.3 miles) when 2,548 pulses are input per minute. |

## E: ODOMETER/TRIPMETER

### 1. DESCRIPTION

- The odometer and tripmeter readings appear on a liquid crystal display (LCD).

### 2. OPERATION

MT model: The vehicle speed sensor sends vehicle speed signals (4 pulses per rotation of speed sensor's driven shaft) to the odometer/tripmeter drive circuit in the speedometer (LHD model) or tachometer (RHD model).

AT model: The TCM sends vehicle speed signals to the odometer/tripmeter drive circuit in the speedometer (LHD model) or tachometer (RHD model).

### 3. SPECIFICATIONS

| | | |
|---|---|---|
| Odometer | Type | Pulse count type. |
| | Display | LCD/6 digits; 0 to 999,999 km (mile). |
| | Indication | Counts up 1 km per 2,548 pulses (1 mile per 4,104 pulses). (Count down is impossible.) |
| Tripmeter | Type | Pulse count type. |
| | Display | LCD/4 digits; 0 to 999.9 and 1000 to 9999 km (mile). |
| | Indication | Counts up 1 km per 2,548 pulses (1 mile per 4,104 pulses). (To change the tripmeter from A to B or B to A, push the knob momentarily. To return the tripmeter to zero indication, keep the knob pushed for more than 1 second.) |

## F: VEHICLE SPEED SENSOR

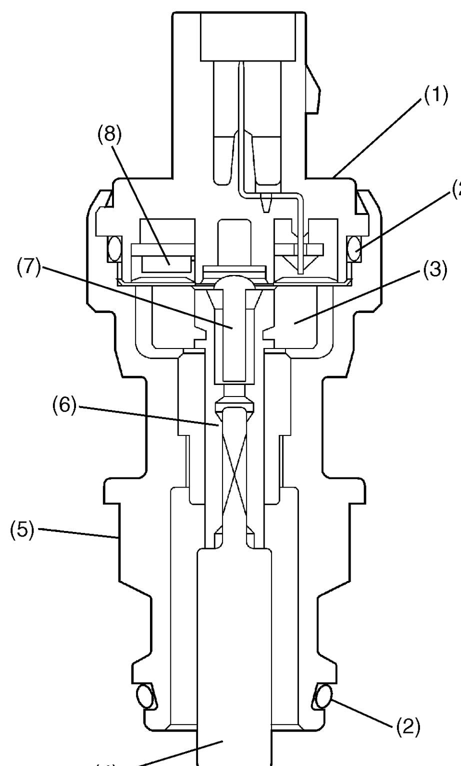
The vehicle speed sensor uses a Hall IC pick-up to generate speed signals. (MT model)

This sensor is installed on the transmission case and detects rotating speed of the transmission output gear.

The sensor generates 4 pulses per rotation of the speed sensor driven shaft and send them to the speedometer.

### 1. CONSTRUCTION

The speed sensor mainly consists of a Hall IC, magnet ring, driven shaft and spring.



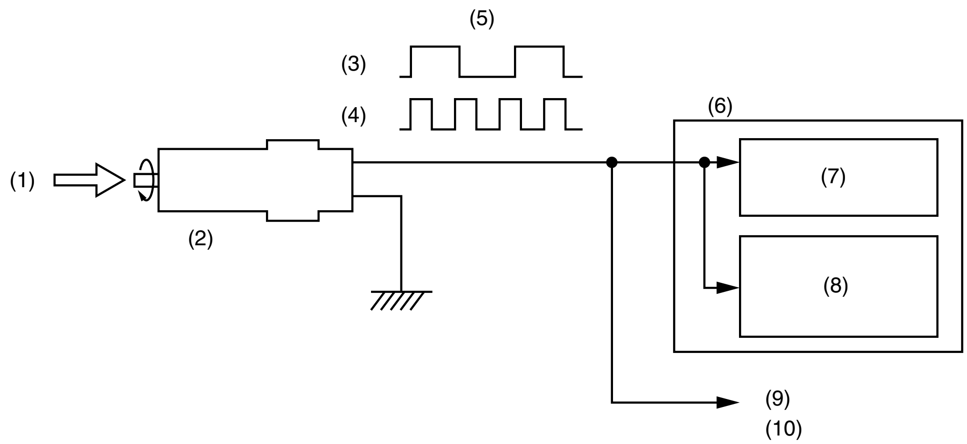

(1) Upper case
(2) O-ring
(3) Magnet ring
(4) Driven key
(5) Lower case
(6) Driven shaft
(7) Rivet
(8) Hall IC

## 2. OPERATION

As the driven key rotates, the magnet turns causing the magnetic field of the Hall IC to change.

The Hall IC generates a signal that corresponds to a change in the magnetic field.

One turn of the driven key in the speed sensor sends 4 pulses to the combination meter, engine control module and cruise control module.




B6H0912E

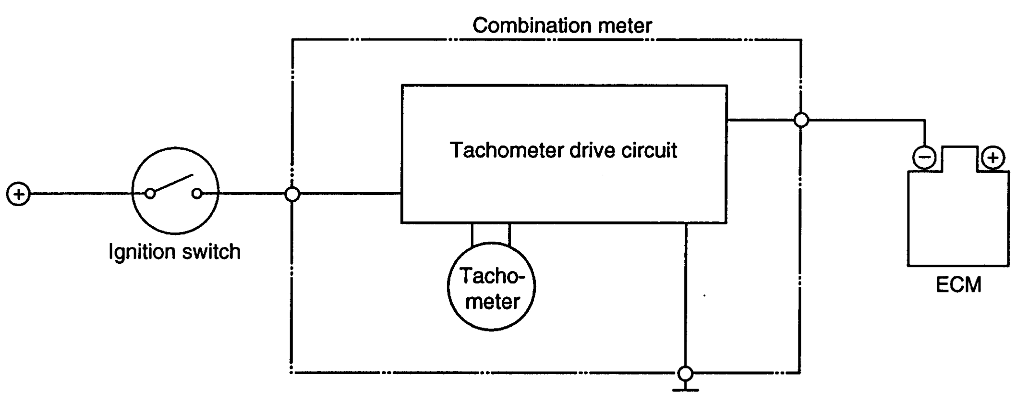
| | | | |
|---|---|---|---|
| (1) | Revolution of transmission output gear | (6) | Combination meter |
| (2) | Vehicle speed sensor | (7) | Speedometer drive circuit |
| (3) | Low speed | (8) | Odometer and tripmeter drive circuit |
| (4) | High speed | (9) | Engine control module |
| (5) | Signal (4 pulses per revolution) | (10) | Cruise control module |

# G: TACHOMETER

The tachometer drive circuit is connected to the engine speed sensing circuit in the engine control module.

When the engine speed increases or decreases, the voltage of the circuit also increases or decreases, changing the magnetic force of the tachometer drive coil.

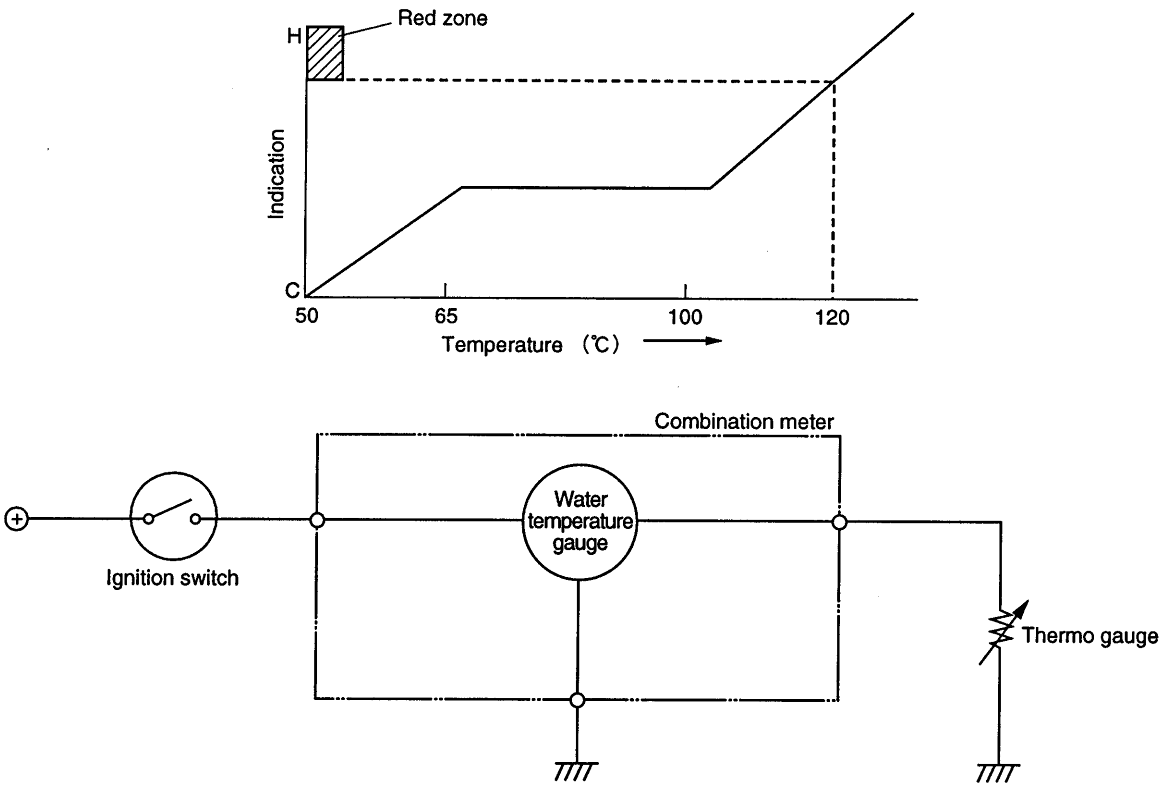
The tachometer needle then moves in accordance with change in the engine speed.




H6H0419

## H: WATER TEMPERATURE GAUGE

- The water temperature gauge is a cross-coil type.
- The water temperature signal is sent from the thermo gauge located on the engine.
- The resistance of the thermo gauge changes according to the engine coolant temperature. Therefore, the current sent to the water temperature gauge also changes according to the engine coolant temperature. As the change in current causes the magnetic force of the coil to change, the gauge's needle moves according to the engine coolant temperature.
- When the coolant is at a normal operating temperature of approx. 70 to 100 °C (158 to 212 °F), the gauge's needle stays in the middle of the indication range as shown below.



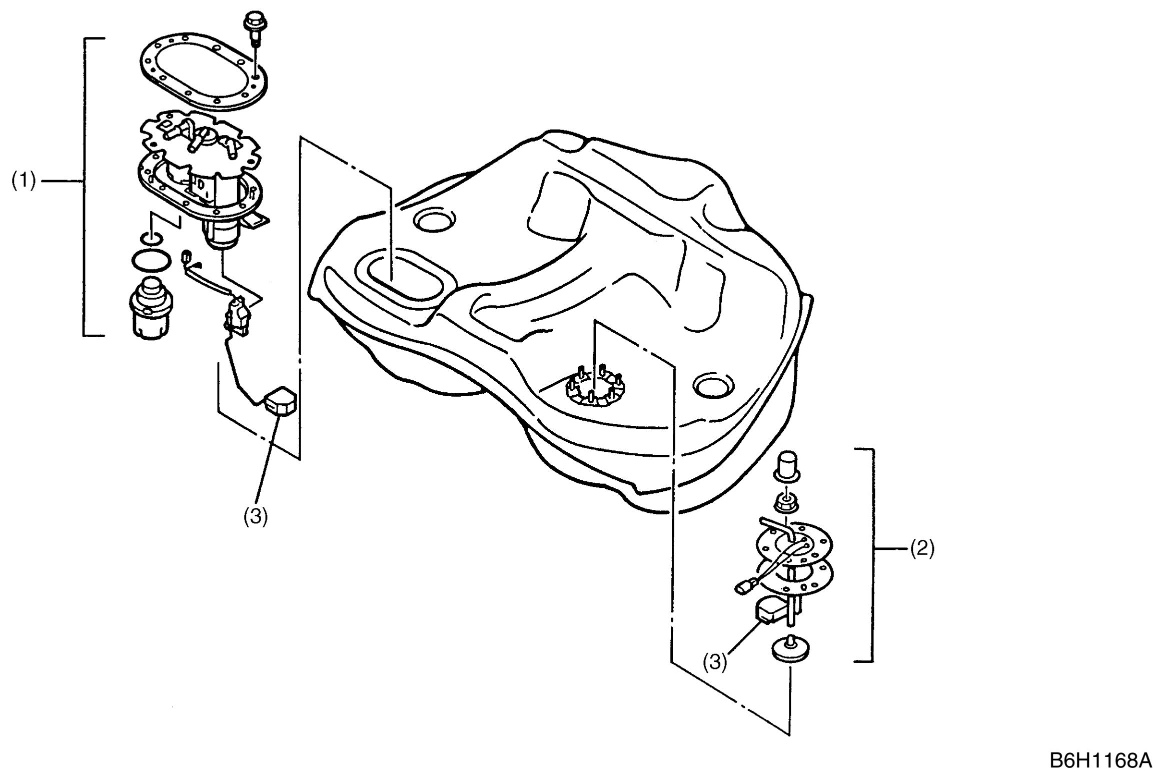

H6H0420

# I: FUEL GAUGE

## 1. GENERAL

● The fuel gauge unit consists of a float and a potentiometer whose resistance varies depending on movement of the float. It is located inside the fuel tank and forms an integral part of the fuel pump. The fuel gauge indicates the fuel level in the tank even when the ignition switch is in the LOCK position.

● All models are equipped with two fuel level sensors. These sensors are installed in the fuel tank, one on the right side and the other on the left side. Two sensors are necessary because the fuel tank is divided into main and sub tank compartments.



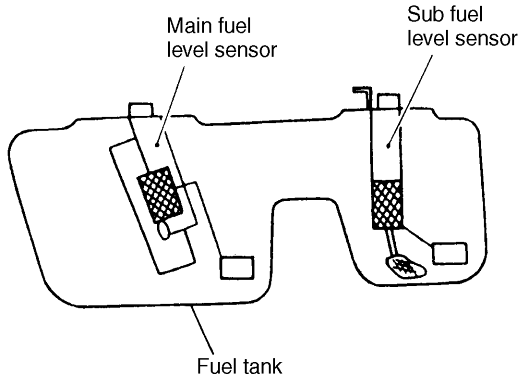

(1) Main fuel level sensor
(2) Sub fuel level sensor
(3) Float

## 2. OPERATION

The low fuel warning light operates as follows:

The combination meter CPU continually monitors the resistance signal from the fuel level sensor. It turns on the low fuel warning light in the combination meter if a resistance value corresponding to the critical fuel level (approx. 76 Ω) is detected successively for about 10 minutes or the period spent for driving a distance of 10 km.

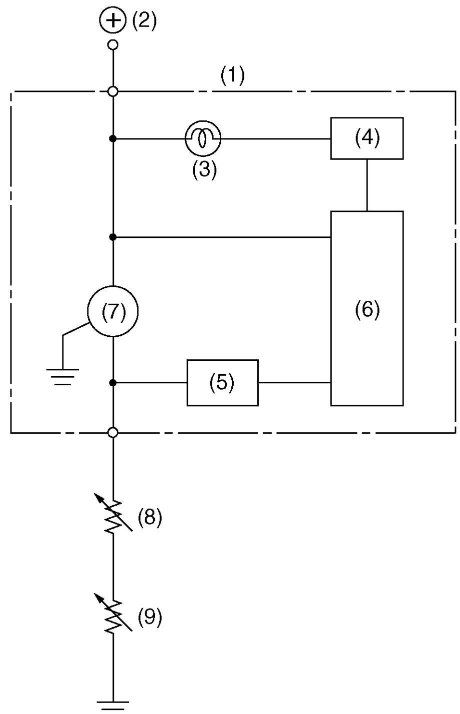
This monitoring time has been decided to avoid false operation of the warning light which may happen when a large part of remaining fuel is collected temporarily in the sub tank compartment.




## 3. SPECIFICATIONS

| | Fuel amount | Resistance |
|---|---|---|
| Main fuel level sensor | FULL | 0.5–2.5 Ω |
| | 1/2 | 18.5–22.5 Ω |
| | EMPTY | 52.5–54.5 Ω |
| Sub fuel level sensor | FULL | 0.5–2.5 Ω |
| | 1/2 | 23.6–27.6 Ω |
| | EMPTY | 39.5–41.5 Ω |

## 4. CIRCUIT DIAGRAM



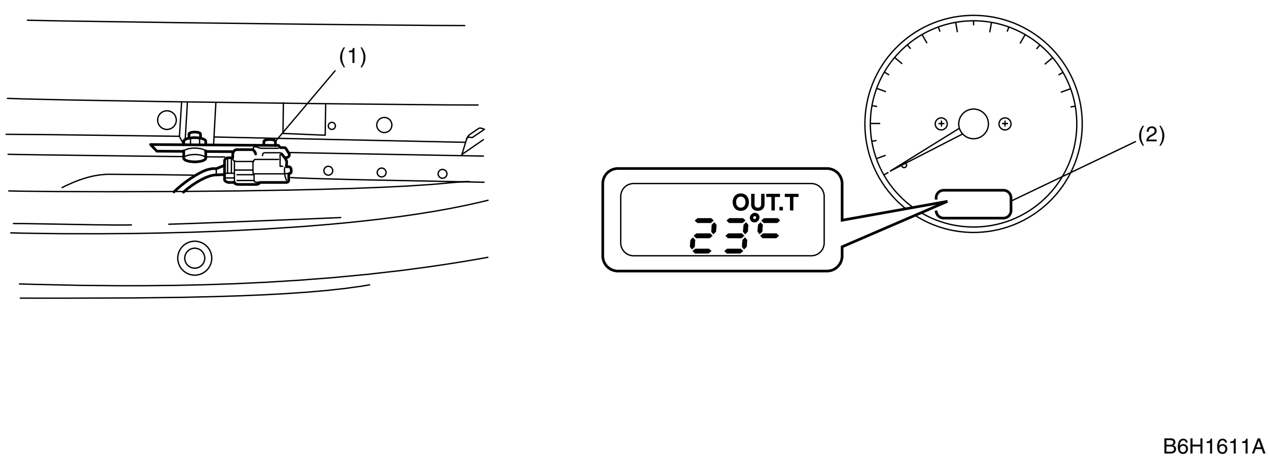

S6H0575A

(1) Combination meter
(2) Ignition switch
(3) Low fuel warning light
(4) Driver
(5) Interface
(6) CUSTOM CPU
(7) Fuel gauge
(8) Sub fuel level sensor
(9) Main fuel level sensor

# 2. Outside Air Temperature Display

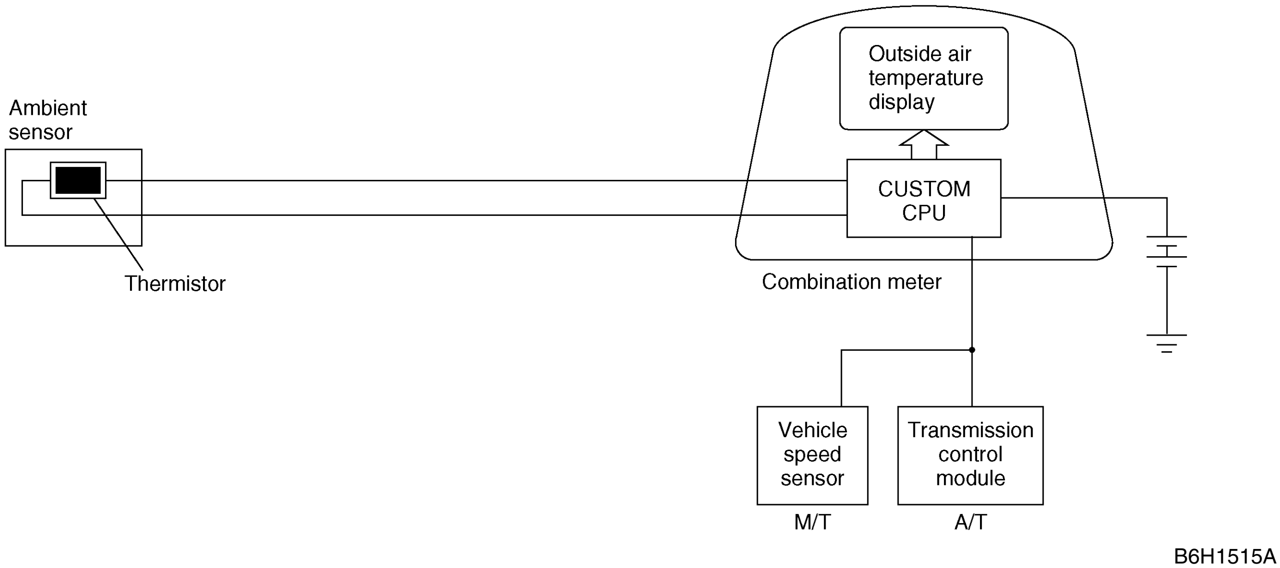
## A: CONSTRUCTION

The outside air temperature display system consists of an ambient sensor (a), the CUSTOM CPU and a liquid crystal display installed in the combination meter. The ambient sensor detects the outside air temperature using the built-in thermistor which varies its resistance according to change in ambient temperature, and sends signals to the CUSTOM CPU.
As soon as the ignition switch is turned ON, the CUSTOM CPU compares the temperature data sent from the ambient sensor with the one that was stored in its memory when the ignition switch was turned OFF last time and it causes the lower of the temperatures to be displayed. However, if 60 minutes or more time has passed between the last turning OFF and the next turning ON of the ignition switch, the temperature that is displayed is a sensor-provided temperature.
When the vehicle is running slowly, the heat released from the engine compartment raises the temperature of the air around the ambient sensor and this affects the temperature data the sensor sends to the CUSTOM CPU. The CPU then makes a special control using the vehicle speed data, i.e., when the vehicle is running at a speed slower than 10 km/h, the CPU uses the temperature that was detected during the most recent vehicle's movement at a speed exceeding 10 km/h rather than a temperature currently being provided by the ambient sensor.




(1) Ambient sensor
(2) Outside air temperature display

## B: CIRCUIT DIAGRAM



## MEMO

# SEATS SE

**Page**

# 1. Front Seat

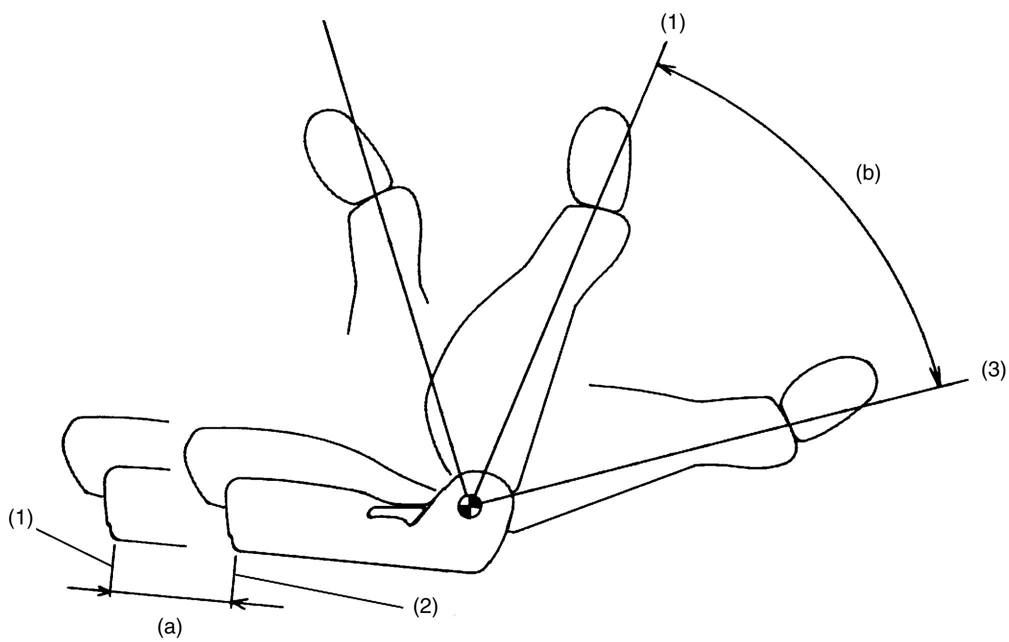
## A: ADJUSTMENT

### 1. STANDARD SEAT

● The height of each headrest is adjustable to any of the 4 positions available at 18 mm (0.71 in) steps.

● The angle of each backrest is adjustable to any of the 33 positions available at 2° steps.

● The front seat can be slid back and forth to one of the 18 positions available at 13.5 mm (0.53 in) steps.




B5H0824E

| | | | |
|---|---|---|---|
| (1) | 1st position | (a) | 18 x 13.5 mm (0.53 in) |
| (2) | 19th position | (b) | 33 x 2° |
| (3) | 34th position | | |

## 2. POWER SEAT

● The driver's power seat has a function of automatically adjusting its fore-aft position, cushion's front and rear portion heights, backrest forward and backward angles, and headrest height in response to operation of the corresponding switches.

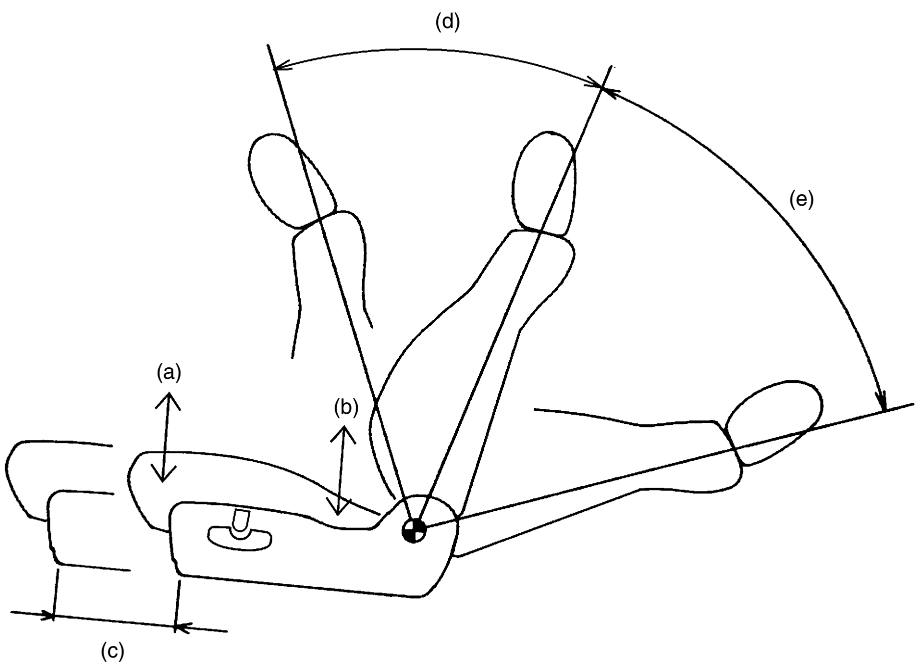
● The height of the headrest is adjustable to any of the 4 positions available at 18 mm (0.71 in) steps.

● The angle of the backrest is adjustable steplessly within a 18° range forward and a 58° range backward.

● The front seat can be slid back and forth steplessly within a 229.5 mm (9.04 in) range.

● The front portion height of the seat cushion can be adjusted steplessly within a 35 mm (1.38 in) range.

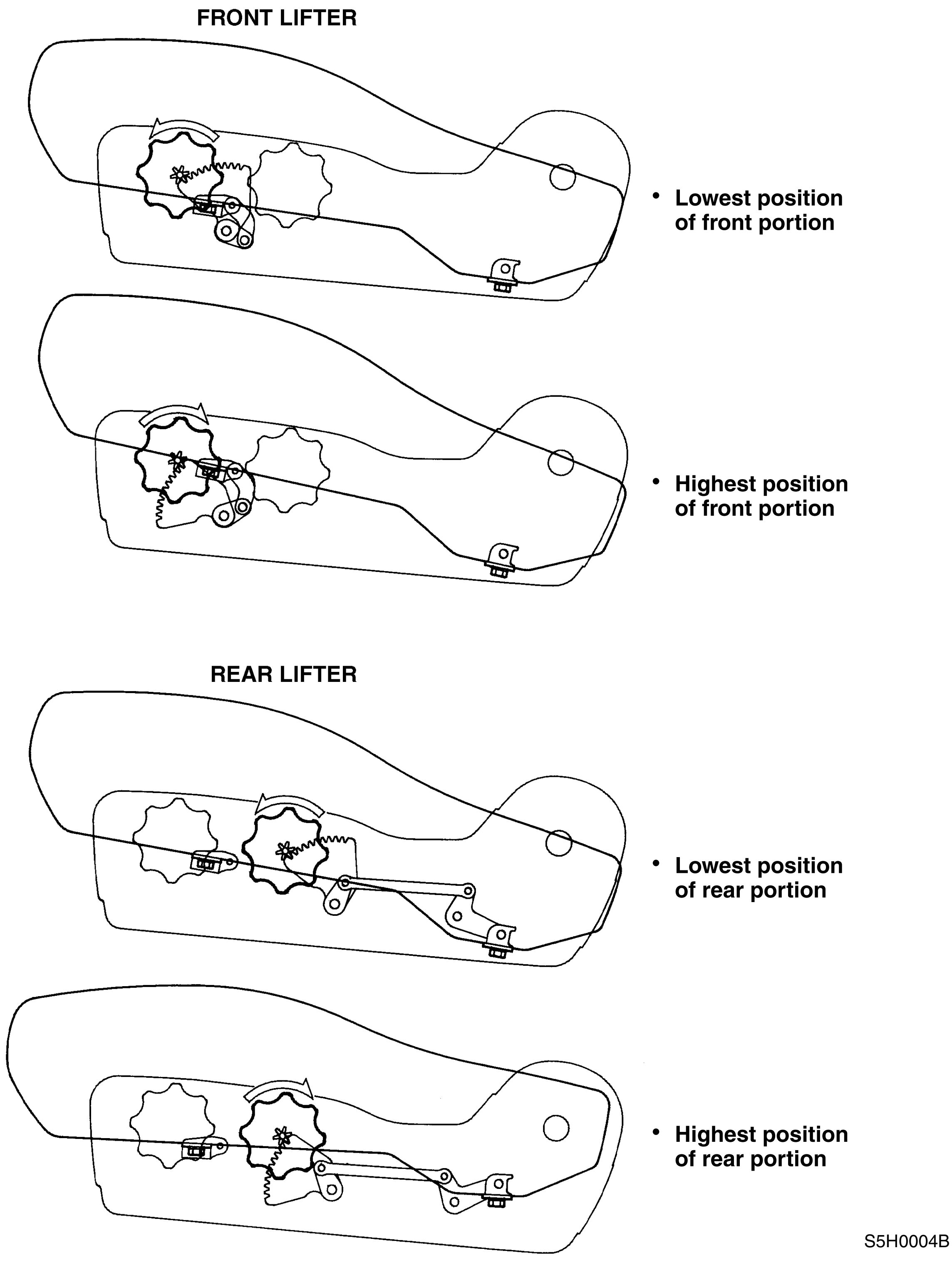
● The rear portion height of the seat cushion can be adjusted steplessly within a 25 mm (0.98 in) range.




(a) 35 mm (1.38 in)
(b) 25 mm (0.98 in)
(c) 229.5 mm (9.04 in)
(d) 18°
(e) 58°

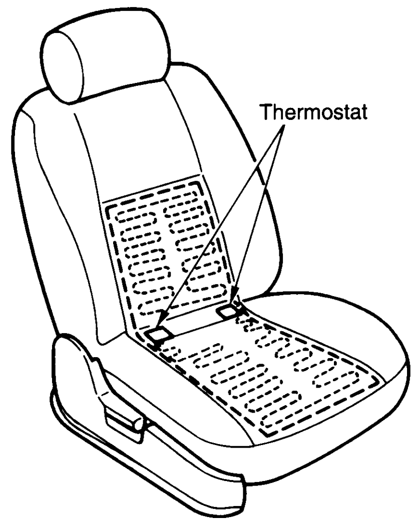
## B: SEAT LIFTERS

- Rotating the front knob forward or backward causes the front lifter to lower or raise the front portion of seat cushion.
- Rotating the rear knob forward or backward causes the rear lifter to lower or raise the rear portion of seat cushion.



## C: SEAT HEATER

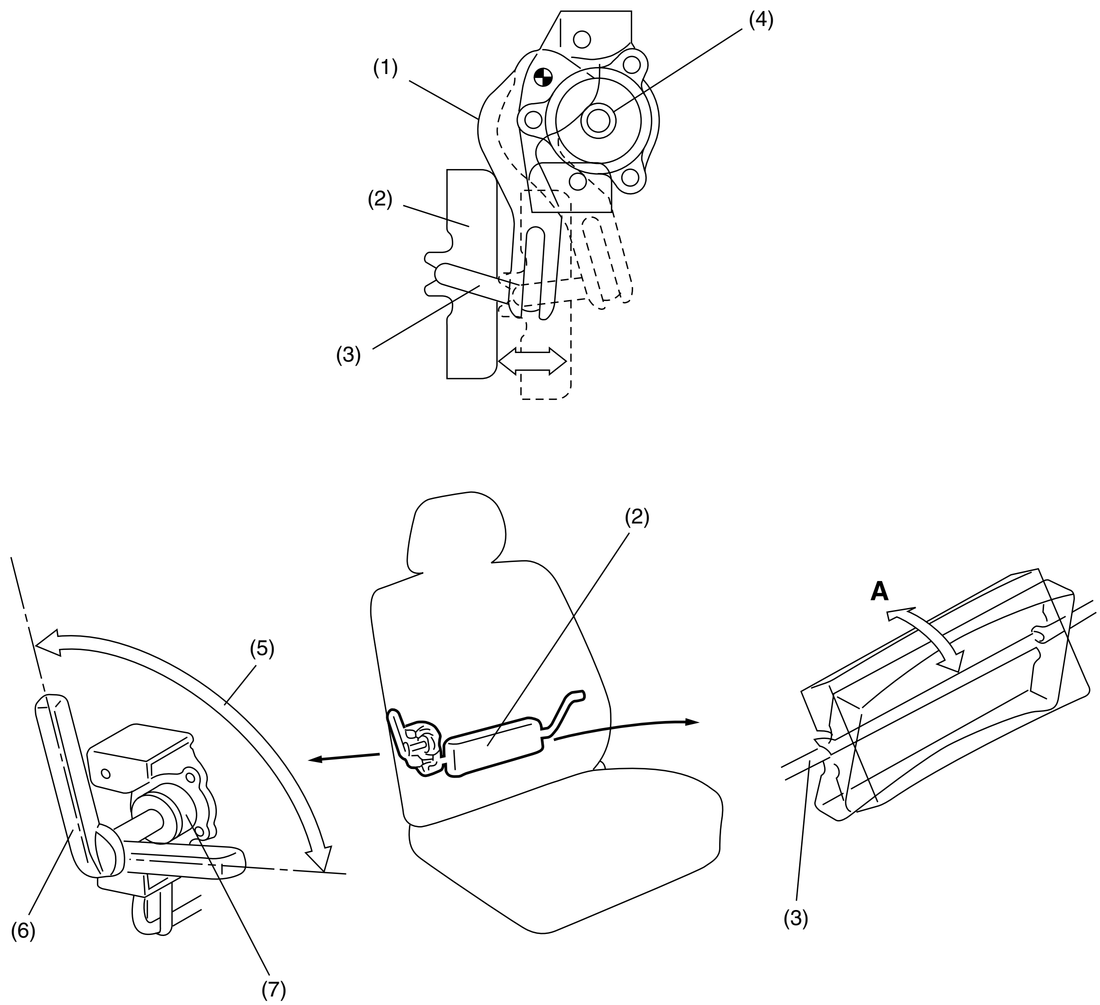
The electric seat heater consists of wire heating elements embedded in the seat cushion and backrest under the seat covering. Heating temperature can be selected between two settings: high-temperature setting for quick warming and low-temperature setting for continuous warming. Two thermostats are used to maintain a selected temperature and ensure safety.




G5H0503

## D: LUMBAR SUPPORT

The position of the lumbar support plate in the backrest changes as the lumbar support adjustment lever is operated to adjust the force of support to the occupant's lower back.
The lumbar support mechanism has been modified to feature stepless adjustment. The material of the support plate is also changed to plastic for a better fit with the occupant's back.

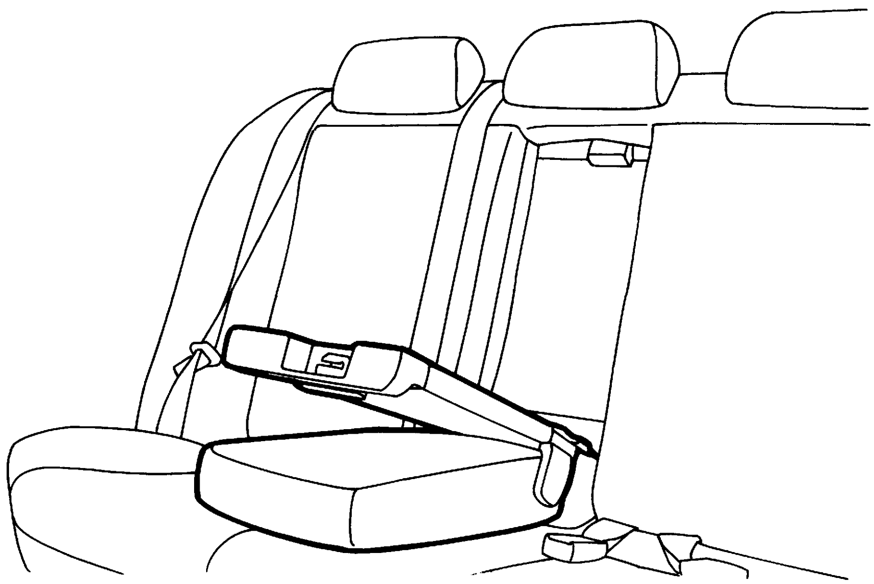



| | | |
|---|---|---|
| (1) Driven gear plate | (5) Stepless adjustable range | **A:** Rotate |
| (2) Lumbar support plate | (6) Lumbar support lever | |
| (3) Torsion bar | (7) Bearing with built-in pinion gear | |
| (4) Pinion gear | | |

## 2. Rear Seat

### SEDAN

A trunk-through hatch is provided behind the armrest. It is accessed by folding down the central portion of backrest which also serves as an armrest in its down position.



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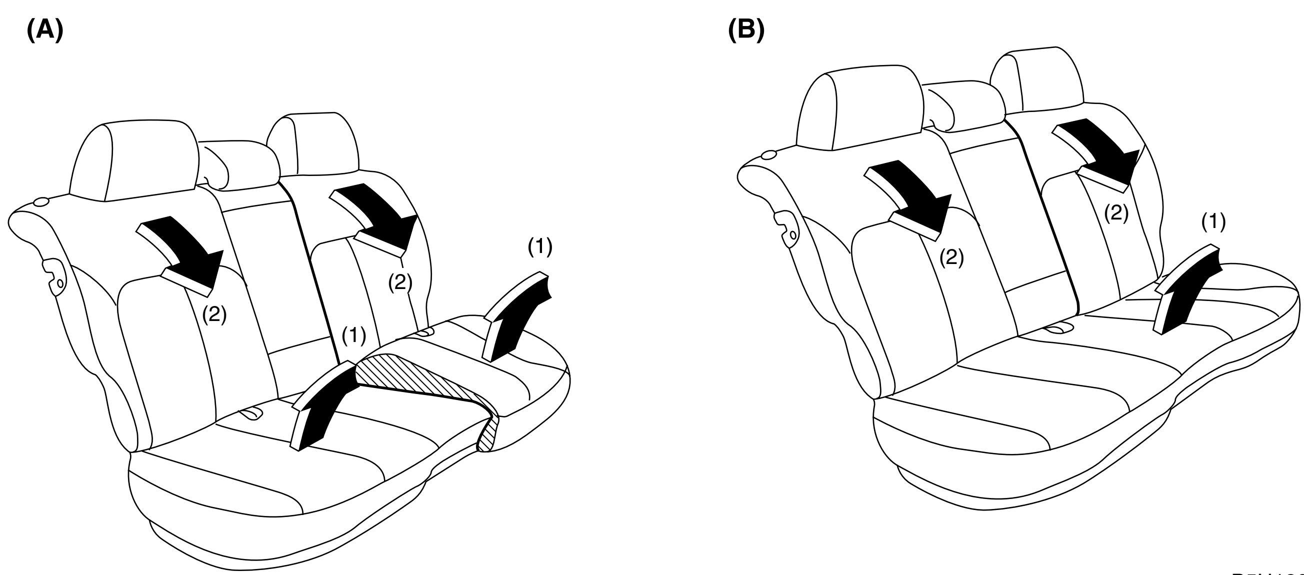
### WAGON

The rear seat is foldable by following the illustrated steps.

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**(A)** Type A
**(B)** Type B
(1) Step 1
(2) Step 2

## MEMO

# SECURITY AND LOCKS SL

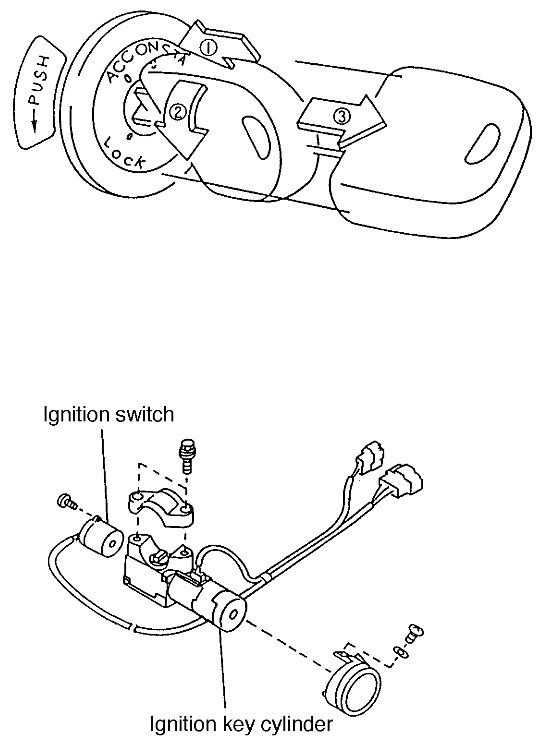
**Page**

# 1. Ignition Switch

## A: DESCRIPTION

### 1. IGNITION SWITCH

When turning the ignition key from “ACC” to “LOCK”, it is necessary to push the key at the “ACC” position (arrow 1 in the illustration) and then turn it to the “LOCK” position (arrow 2).




S6H0146A

### 2. KEY REMINDER CHIME

The key reminder chime sounds when the driver’s door opens and the ignition key is in the “LOCK” or “ACC” position. The chime stops when the key is removed from the ignition switch.

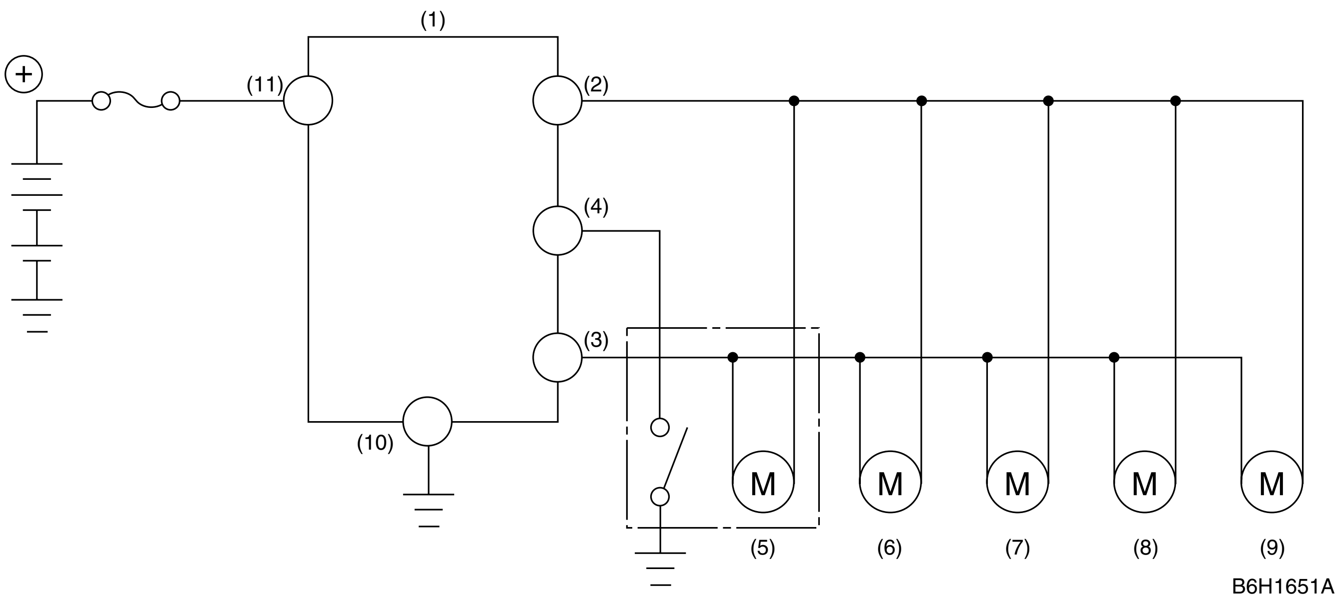
# 2. Power Door Lock

## A: CONSTRUCTION

● The power door lock system consists of a keyless entry control module, a driver's door lock switch (actuator), a front passenger's door lock actuator, rear door lock actuators, and a rear gate lock actuator.

● When the driver locks or unlocks the driver's door using the inside lock knob, the other doors and the rear gate are also locked or unlocked automatically.

## B: CIRCUIT DIAGRAM




(1) Keyless entry control module
(2) Lock output
(3) Unlock output
(4) Door lock switch
(5) Driver's door lock actuator
(6) Front passenger's door lock actuator
(7) Rear LH door lock actuator
(8) Rear RH door lock actuator
(9) Rear gate lock actuator
(10) Ground
(11) Battery

# 3. Keyless Entry System

## A: CONSTRUCTION

- The keyless entry system consists of a transmitter, keyless entry control module (with a built-in antenna), door lock actuators, door switches, hazard warning lights and interior light.
- The keyless entry system operates on a radio frequency, so its transmitter can be used in almost all directions relative to the vehicle.

## B: FUNCTION

### 1. DOOR LOCKING

1) Push the transmitter's LOCK button once.
2) All doors are locked.
3) Check that the hazard warning lights flash once.

### 2. DOOR UNLOCKING

1) Push the transmitter's UNLOCK button once.
2) All doors are unlocked, the ignition switch illumination turns ON and the interior light turns ON (when the interior light switch is set at the middle position).

NOTE:
The interior light and ignition switch illumination illuminates for 15 seconds, then gradually dim and go out in 5 seconds.

If the key is inserted in the ignition switch before the interior light and ignition switch illumination go out, these lights will dim gradually and go out in 5 seconds.

If any door is opened and then closed during the 15-second period, these lights will illuminate for 3 seconds, then dim gradually and go out in 5 seconds.
If the transmitter's LOCK button is pushed during the 15-second period, these lights will go out immediately.

3) Check that the hazard warning lights flash twice.

# 4. Immobilizer System

## A: CONSTRUCTION

The immobilizer system consists of the following components: an indicator light in the combination meter, an immobilizer control module (IMM ECM), an engine control module (ECM), a transponder inside the ignition key, and an antenna fitted to the key cylinder.

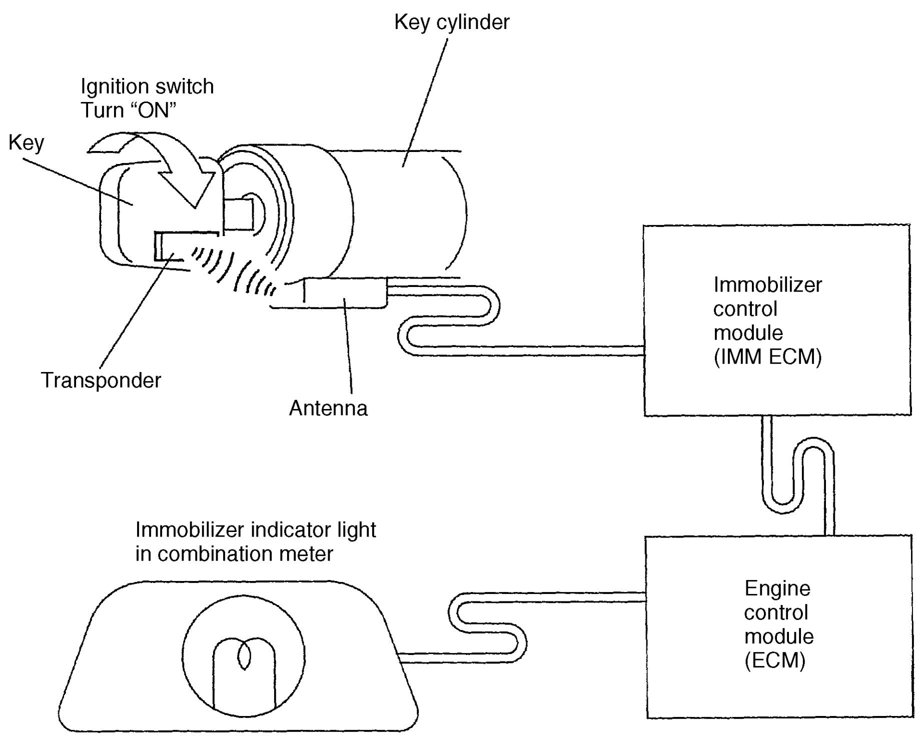
The antenna receives a vehicle ID code emitted from the transponder when the key is inserted into the key cylinder.

The ID code is transmitted to the IMM ECM. The IMM ECM compares the code with a one that has been registered in it. If these ID codes match with each other, the system allows the engine to be started. If they do not match but the key fits in, turning the key may be able to start the engine. The engine, however, will automatically stop after a few seconds.

The immobilizer function is activated automatically when the key is removed from the key cylinder and when 60 seconds have passed after the ignition switch was turned to the “ACC” or “OFF” position. When the function is activated, the indicator light flashes at intervals of 0.2-second ON and 2.8-second OFF.

This indicator light flashing indicates that the system is ready to function if an action of theft is attempted.

In the event that the immobilizer system develops a fault, the immobilizer indicator light illuminates when the ignition switch is turned to the “ON” position.




NF0278

## B: TEACHING OPERATION

The teaching operation is a procedure that must be carried out when an additional key is purchased, the IMM ECM is replaced, or the keys are replaced. The procedure includes initialization of the system and re-registration of the ID code. Once initialized, the system loses the ID code it has retained so far and has no code until a new code is registered. An ID code can be registered with an IMM ECM for up to four keys (transponders).

Any set of keys (four maximum) can be registered only with one IMM ECM. So, if an IMM ECU is replaced with a new one, the keys having been used with the old IMM ECU cannot be used with the new IMM ECU. Therefore, the keys must be replaced simultaneously with the IMM ECU.

The teaching operation is carried out using a select monitor and a special program by an authorized person. Access to the program is strictly controlled for reasons of security.

# SUNROOF/T-TOP/ CONVERTIBLE TOP

# SR

**Page**

# 1. Sunroof

## A: SEDAN

### 1. DESCRIPTION

The sunroof has both tilting and sliding mechanisms. The tilting mechanism raises or lowers the rear of the glass lid when the tilt switch is operated; the sliding mechanism moves the lid backward to open or forward to close when the OPEN/CLOSE switch is operated.

The sunroof has the following features:

- Reduced thickness of the sunroof provides extra overhead clearance in the passenger compartment.
- Extensive use of aluminium die castings for sunroof components contributes to reduction in weight.

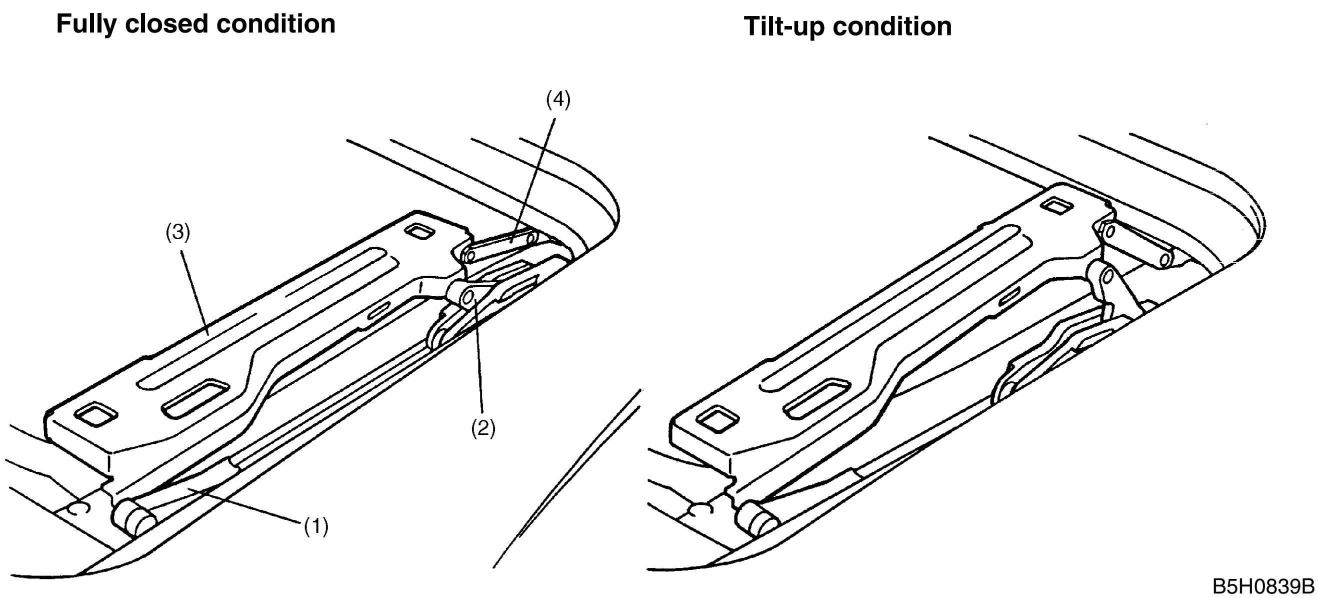
### 2. FUNCTION

- **SUNROOF TILTING AND SLIDING OPERATION**
  - With the sunroof fully closed, pushing the rear side of the tilt switch causes the rear end of the sunroof lid to rise by 50 mm (1.97 in). Pushing then the front side of the switch causes the lid to lower to the original position.
  - Pushing the OPEN/CLOSE switch rearward causes the sunroof lid to slide rearward and open. Pushing the switch forward causes the glass lid to move forward and stop at a point 150 mm (5.91 in) before the fully closed position. Pushing the switch again closes the lid completely.
- **SUN SHADE OPERATION**
  - The sun shade can be opened or closed manually when the sunroof is closed.
  - The sun shade, if closed, moves rearward together with the glass lid when the open side of the OPEN/CLOSE switch is pushed.

## 3. SLIDING AND TILTING MECHANISMS

The motor installed at the front of the sunroof frame rotates a pinion gear to move the drive wire.

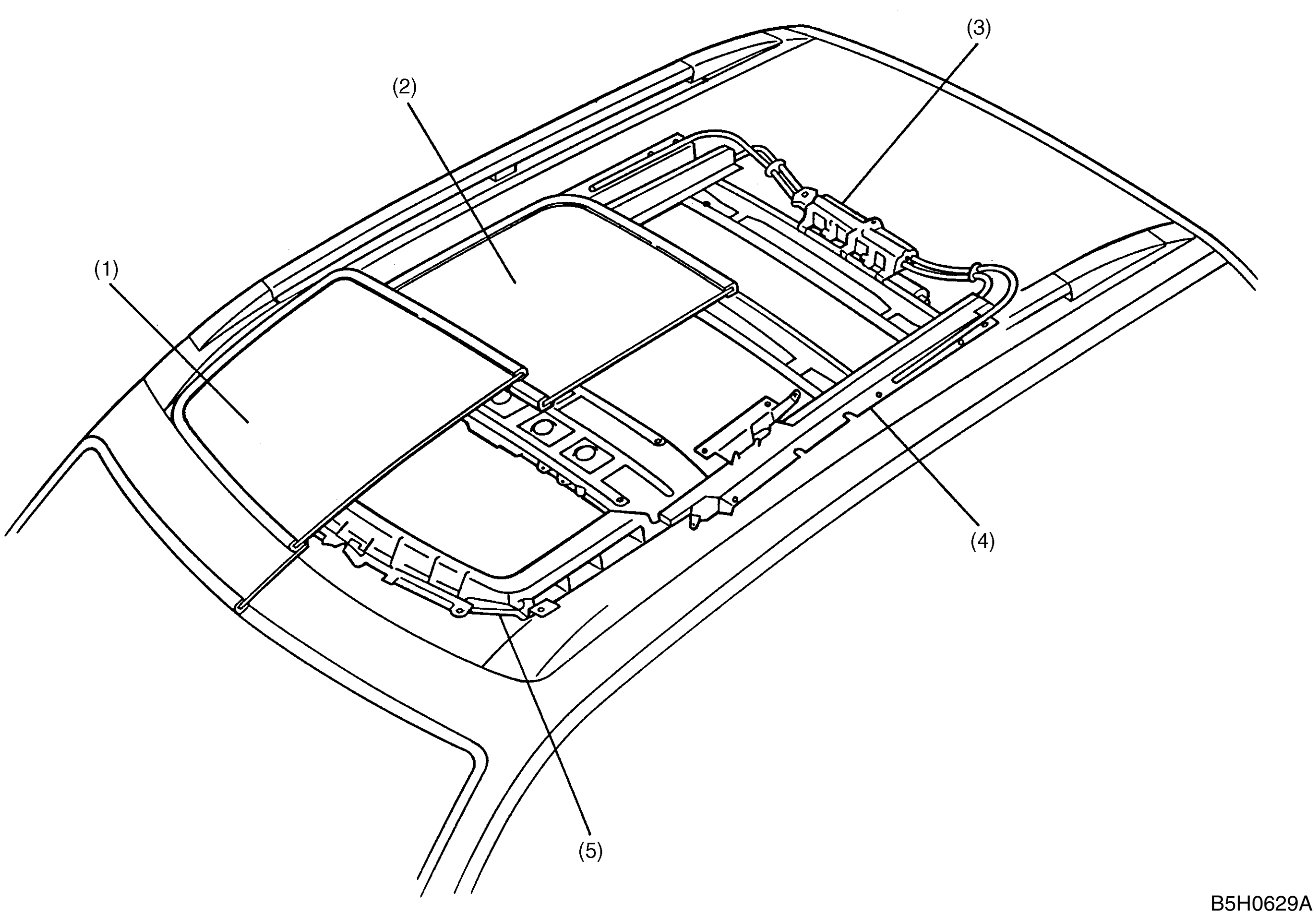
This opens, closes, tilts up or tilts down the glass lid by way of the rear guide connected to the drive wire.




(1) Front guide
(2) Rear guide
(3) Lid bracket
(4) Link

## B: WAGON

### 1. DESCRIPTION




(1) Front glass lid
(2) Rear glass lid
(3) Motor
(4) Rear frame
(5) Front frame

● The front sunroof is a tilting type. The rear end of the glass lid can rise by 50 mm (1.97 in).

● The rear sunroof is a sliding type. When the sunroof is fully opened, the opening area is 340 mm (13.39 in) long and 632 mm (24.88 in) wide.

● Each sunroof uses a 4 mm (0.16 in) thick glass lid and a sunshade.

## 2. FUNCTION

### ● OPEN AND CLOSE OPERATIONS

● With the front sunroof fully lowered, holding the OPEN side of the sunroof switch pressed causes the rear end of the front glass lid to tilt up by 50 mm (1.97 in) and then come to a stop. If the switch is released and its OPEN side pressed again, the rear glass lid now opens, sliding rearward by 200 mm (7.87 in) and stops there. The glass lid further goes to the fully open position if the OPEN side of the sunroof switch is pressed again.

● With the rear sunroof fully open, holding the CLOSE side of the sunroof switch pressed causes the glass lid to move forward until its front edge reaches a point 150 mm (5.91 in) away from the fully closed position. The rear glass lid moves to the fully closed position if the CLOSE side of the sunroof switch is released and then pressed again.
Pressing the same side of the switch after complete closure of the rear sunroof causes the front glass lid to tilt down completely.

### ● SUNSHADE OPERATION

● The front sunshade can be manually opened or closed regardless of the position of the front glass lid.

● The rear sunshade is automatically opened or closed together with the glass lid. In addition, when the glass lid is fully closed, the sunshade can be opened or closed manually.

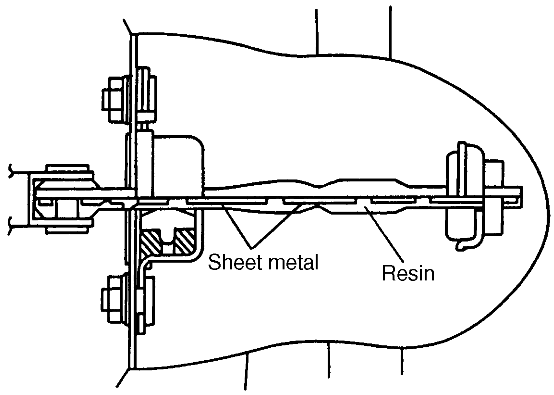
## MEMO

# EXTERIOR BODY PANELS EB

# 1. Door

## A: DOOR CHECKER

The door checkers are of a new type that uses a molded resin part.

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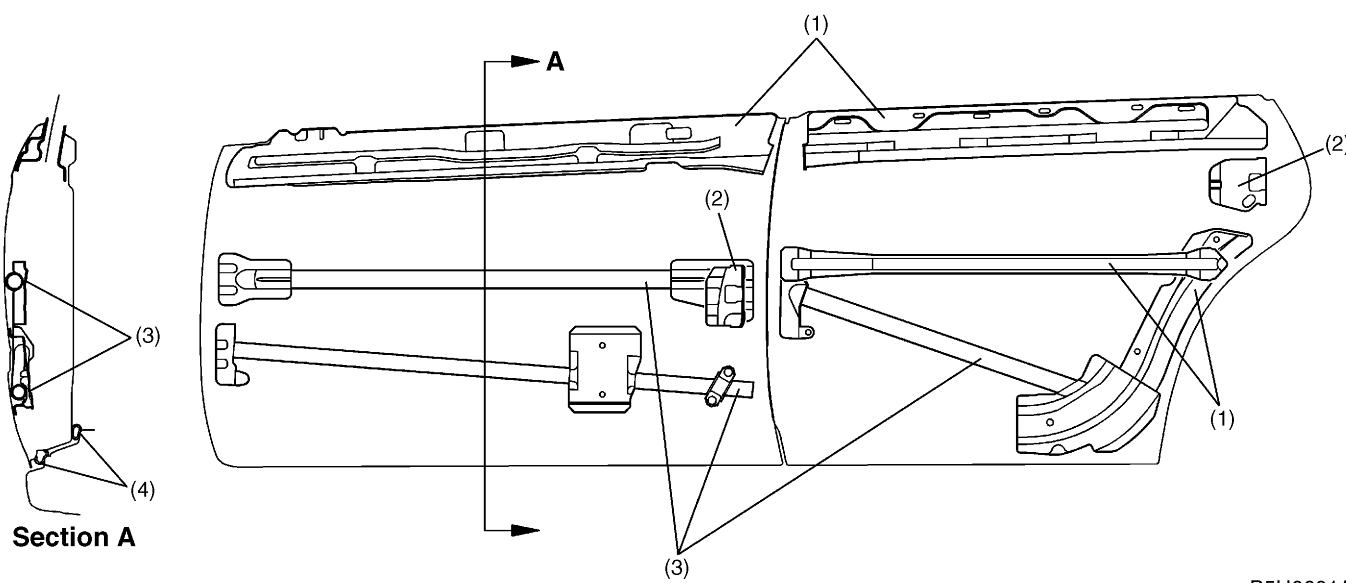
## B: DOOR CONSTRUCTION

- All the front and rear doors have in their inside side door beams, inner reinforcements and reinforcement latches.
- Tight closure at the bottom of each door is ensured by dual sealing.

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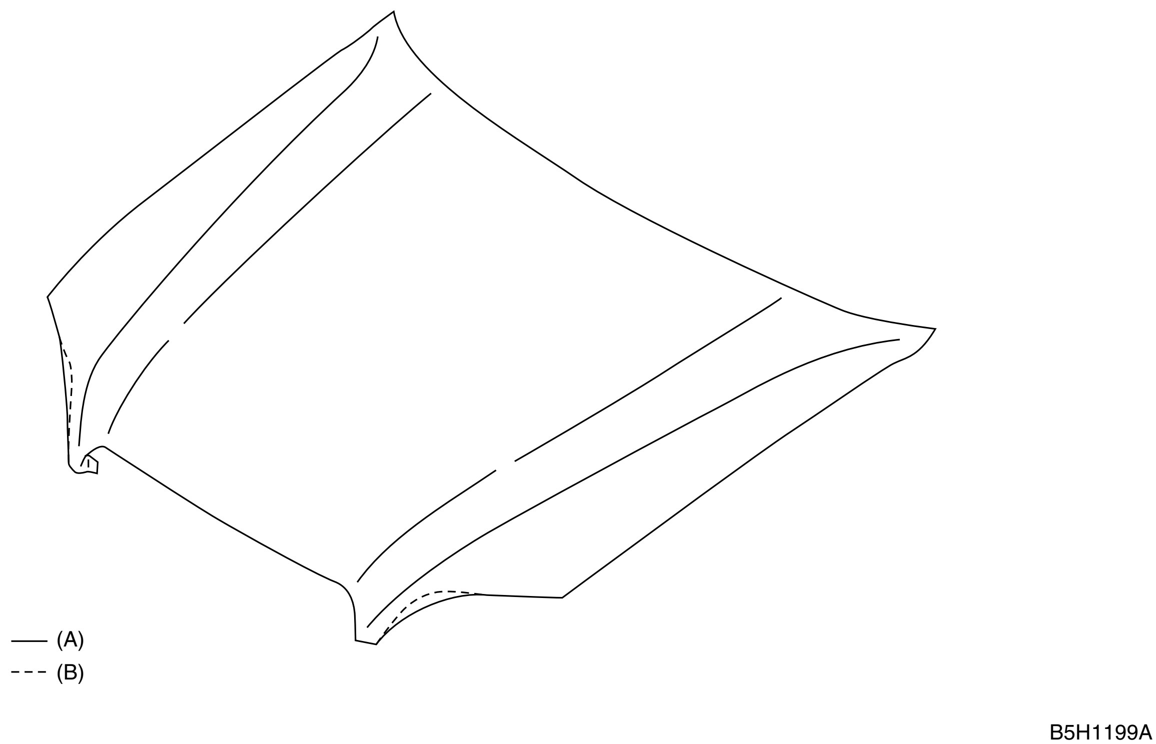
| | | | |
|---|---|---|---|
| (1) | Inner reinforcement | (3) | Side door beam |
| (2) | Reinforcement latch | (4) | Dual sealing |

## 2. Front Hood

Due to the redesigned front section, the contour of the front hood is modified. The material is also changed from steel to aluminum to reduce weight.




(A) New design

(B) Earlier design

## MEMO

# CRUISE CONTROL SYSTEM CC

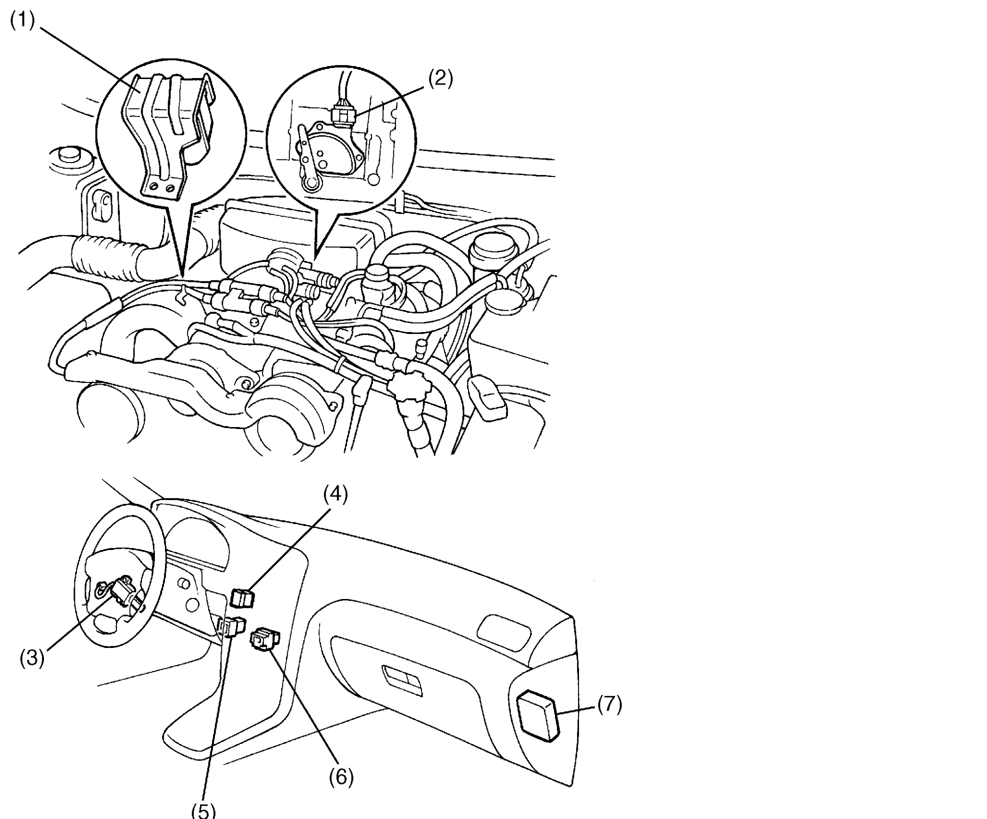
**Page**

# 1. Cruise Control

## A: OPERATION

- The cruise control system automatically controls the vehicle speed. It allows the vehicle to run at a constant speed without need for the driver to keep the accelerator pedal depressed.
- When the driver has activated the system and made a desired speed setting, the cruise control module compares the actual vehicle speed detected by the speed sensor (MT) or transmission control module (AT) with the preset speed in the memory, then generates a signal according to the difference between the two speeds.
This signal is transmitted to the actuator located in the engine compartment.
The actuator operates the throttle cam as necessary to keep the preset vehicle speed.

## B: COMPONENT LOCATION



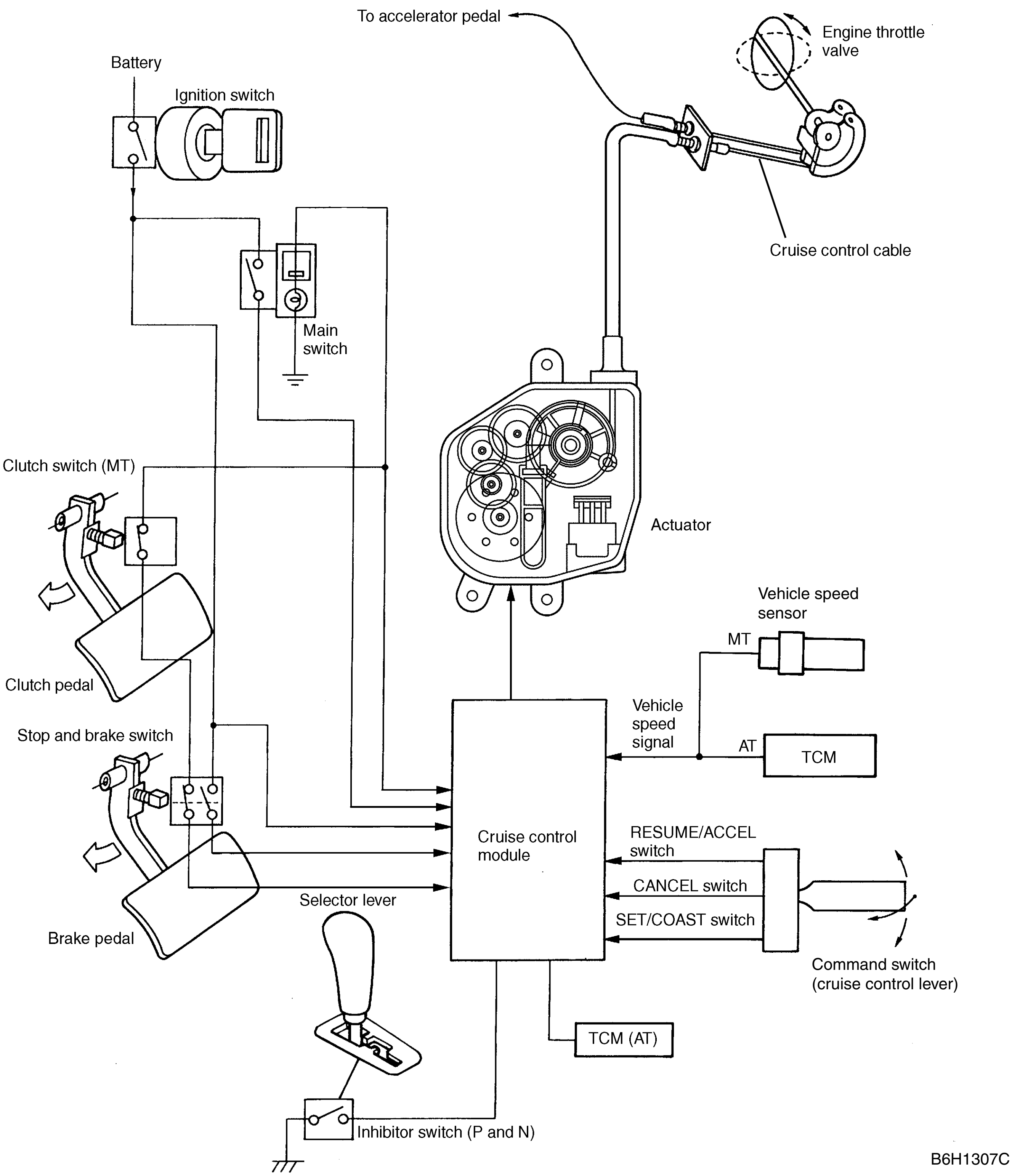

(1) Actuator
(2) Inhibitor switch (AT)
(3) Command switch (cruise control lever)
(4) Main switch
(5) Clutch switch (MT)
(6) Stop and brake switch
(7) Control module

The electrical component locations are for LHD vehicles. The cruise control actuator and the cruise control module locations for RHD vehicles are symmetrically opposite.

## C: CONTROL AND OPERATION

| | |
|---|---|
| Constant speed control | When actual vehicle speed is higher than the “set” speed, the motor in the actuator operates to move the throttle valve in the closing direction by the amount corresponding to the difference between the two speeds. When actual driving speed is lower than “set” speed, the motor operates to move the throttle valve in the opening enabling direction according to the difference in speed. |
| Speed setting control | When SET/COAST switch is pressed with main switch ON while the vehicle is being driven at a speed greater than 40 km/h (25 MPH), current flows to the actuator. This causes the clutch in the actuator to engage, enabling the motor to operate. The motor moves the throttle valve to the position corresponding to the accelerator pedal position. The vehicle is driven at the set speed. |
| Deceleration control | When SET/COAST switch is turned ON while the vehicle is cruising at a constant speed, the motor in the actuator rotates to move the throttle valve in the closing direction. This causes the vehicle to decelerate by a certain amount. When the switch is turned OFF, the vehicle speed is stored in memory and the vehicle maintains that speed thereafter. |
| Acceleration control | When RESUME/ACCEL switch is turned ON while the vehicle is cruising at a constant speed, the motor in the actuator rotates to move the throttle valve in the opening direction. This causes the vehicle to accelerate by a certain amount. When the switch is turned OFF, the vehicle speed is stored in memory and the vehicle maintains that speed thereafter. |
| Resume control | When RESUME/ACCEL switch is turned ON after the cruise control is temporarily cancelled, vehicle speed returns to that speed which was stored in memory just before the cruise control is cancelled. This occurs only when the vehicle is running at a speed greater than 32 km/h (20 MPH).<br>In the following cases, however, the set vehicle speed is completely cleared. Therefore, no resume control is performed.<br>(1) Ignition switch is turned OFF<br>(2) Main switch is turned OFF |
| Manual cancel control | When any of the following signals is entered into the clutch control module, the clutch is disengaged and the cruise control is deactivated.<br>(1) Stop light switch ON signal (Brake pedal depressed) (2) Brake switch OFF signal (Brake pedal depressed) (3) Clutch switch OFF signal (Clutch pedal depressed – MT) (4) Inhibitor switch ON signal (Selector lever set to “N” – AT) (5) CANCEL switch ON signal (Command switch cruise control lever pulled) (6) Ignition switch OFF signal (7) Main switch OFF signal |
| Low speed limit control | When the vehicle speed drops below 32 km/h (20 MPH), the cruise control is automatically cancelled. Cruise control at any speed lower than 40 km/h (25 MPH) cannot be effected. |
| Motor control | When the vehicle speed becomes 10 km/h (6 MPH) or more higher than the memorized speed while vehicle is running utilizing the cruise control (in a downgrade, for example), the actuator’s clutch is turned OFF so that the vehicle decelerates. When the vehicle’s speed decreases by 8 km/h (5.0 MPH) or more from the memorized speed, the clutch is turned ON again so that the cruise control resumes. |

## D: SCHEMATIC


To accelerator pedal
Engine throttle valve
Battery
Ignition switch
Cruise control cable
Main switch
Clutch switch (MT)
Actuator
Vehicle speed sensor
MT
Clutch pedal
Vehicle speed signal
Stop and brake switch
AT
TCM
RESUME/ACCEL switch
Cruise control module
CANCEL switch
Selector lever
SET/COAST switch
Brake pedal
Command switch (cruise control lever)
TCM (AT)
Inhibitor switch (P and N)
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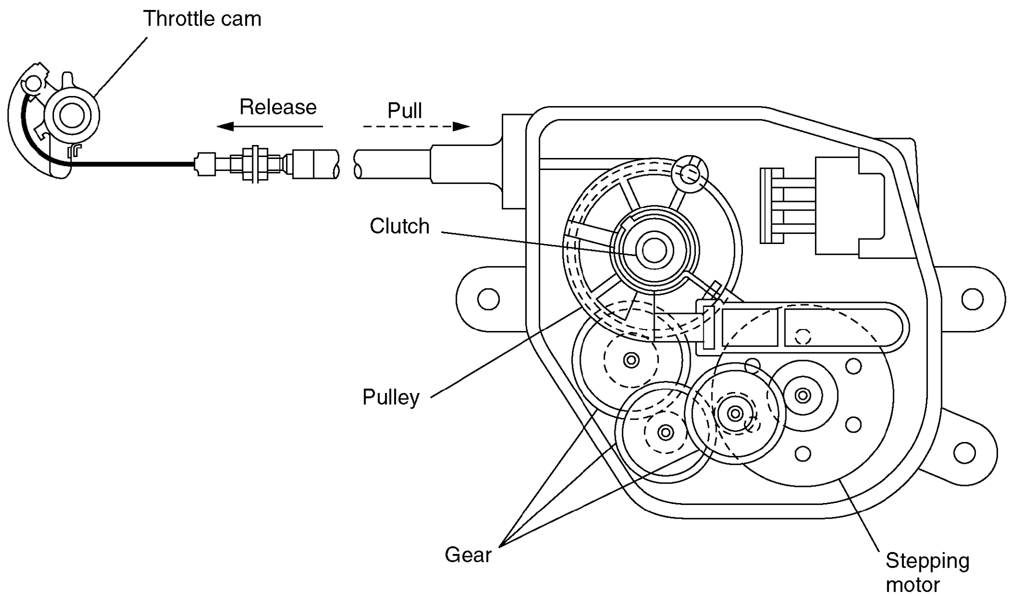
## E: ACTUATOR

In response to a signal from the cruise control module, the clutch in the actuator is turned ON. This causes the stepping motor to operate, pulling the throttle cam for speed control.

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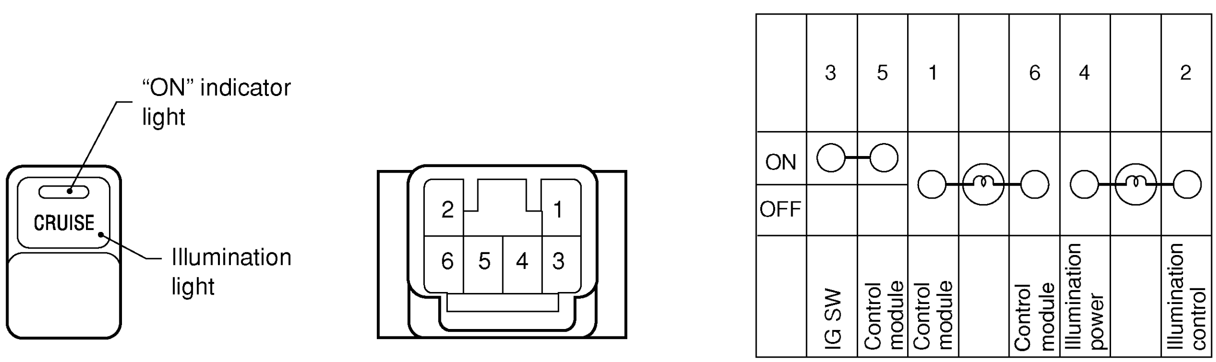
## F: MAIN SWITCH

● The main switch is the main power supply switch of the cruise control module. It has a built-in power indicator and night illumination light.

● When the ignition switch is placed in the OFF position with the main switch ON, the main switch is also turned OFF. Even if the ignition switch is turned ON again, the main switch will stay in the OFF state.

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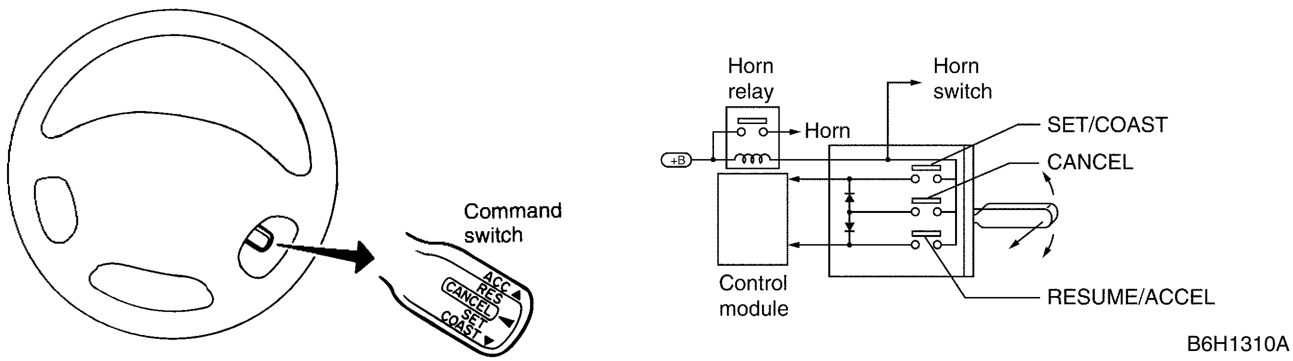
## G: COMMAND SWITCH (CRUISE CONTROL LEVER)

● When the vehicle is driven with the cruise control activated, the command switch controls its operation. It inputs SET/COAST signal, ACCEL/RESUME signal or CANCEL signal to the cruise control module.




● The command switch is located on the right side of the steering wheel, so the driver can operate it without releasing hands from the steering wheel.

● The command switch is a self-returning lever type.

### 1. RESUME/ACCEL AND SET/COAST SWITCH

Each switch contact is held closed as long as the lever is kept pressed in the relevant direction and resulting current is applied as a signal to the control module.

### 2. CANCEL SWITCH

All the switch contacts are closed as long as the lever is pulled toward the CANCEL position (toward the driver). This causes the RESUME/ACCEL and SET/COAST ON signals to be sent to the control module simultaneously.

## H: CANCEL SIGNALS

The cancel signal deactivates the cruise control function. Operating any of the following switches results in generation of the cancel signal. On receiving the signal, the cruise control module cancels the cruise control function.

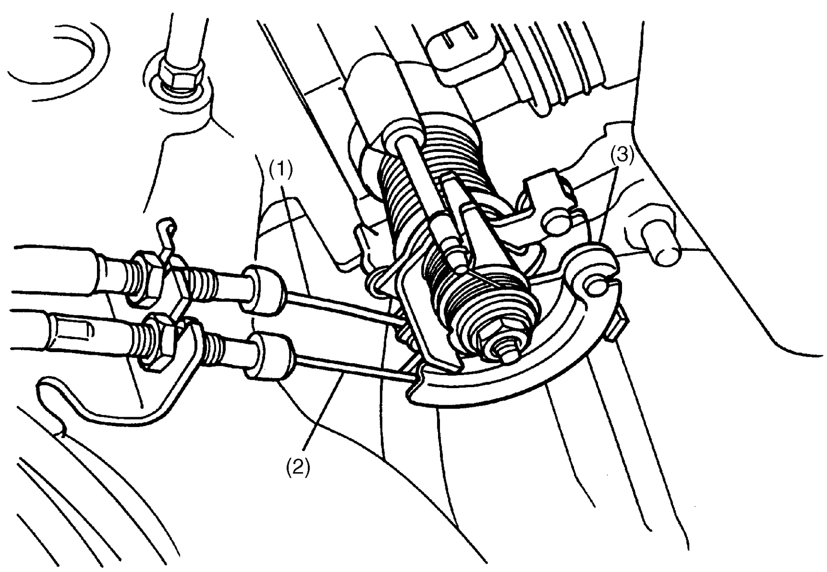
- Stop light switch
- Brake switch
- Clutch switch (MT model)
- Inhibitor switch (AT model)
- Main switch
- Command switch (CANCEL position)

## I: VEHICLE SPEED SENSOR

Vehicle speed sensor is installed on the transmission, and sends signal to the cruise control module which uses it in controlling the cruise control function (MT model).

## J: ENGINE THROTTLE

- The throttle body is equipped with two throttle cams. One is used during acceleration and the other during cruising in order to open or close the throttle valve.
- These cams operate independently of each other. In other words, when one cam operates, the other may not.

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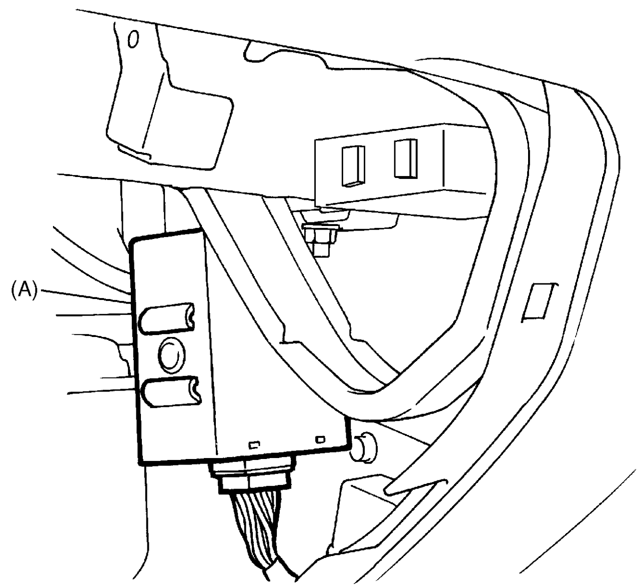
(1) Accelerator cable
(2) Cruise control cable
(3) Throttle cam

## K: CONTROL MODULE

- Based on signals from the related switches and sensors, the cruise control module controls all the following control functions:
Constant speed control; speed setting control; deceleration control; acceleration control; resume control; manual cancel control; low speed limit control; stepping motor control; clutch control
- The control module (A) is located inside of the front pillar lower portion (passenger side).

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## L: FAIL-SAFE FUNCTION

The cruise control system has a fail-safe function that cancels the cruise control operation when any of the following conditions occurs.

### 1. CONFLICT BETWEEN CRUISE CONTROL SWITCHES AND CANCELLATION SIGNAL GENERATING SWITCHES

1) The cruise control system is deactivated if any of the cruise control switches (SET/COAST, RESUME/ACCEL, and CANCEL switches) is turned ON while any of the cancellation signal generating switches (brake, stop lamp, clutch, and inhibitor switches) is being operated. The system is re-activated when the cruise control switch is turned OFF and then turn ON again after the cancellation signal generating switch has been returned to its released position.

2) The cruise control system becomes deactivated if the main switch is turned ON with any of the cruise control switches in the ON position. The system deactivating function is retained until the main switch is turned OFF.

### 2. ABNORMALITIES IN ELECTRIC CIRCUITS

The cruise control system is deactivated and the set speed is also canceled if any of the following abnormalities occurs in the system's electric circuits.

The system deactivation function is retained until the ignition switch or the main switch is turned OFF.

1) The stepping motor terminal is grounded or disconnected; or the stepping motor drive circuit is broken due to a short-circuit.

2) The stepping motor clutch drive circuit is shorted.

3) Vehicle speed variation in a 350 ms period exceeds ±10km/h.

4) Fusion has occurred in an internal relay and is detected while the vehicle is running with the cruise control deactivated.

5) The cruise control module becomes inoperative or its operation is faulty.

6) There is discrepancy between the values stored in the two RAMs of the control module.

7) An abnormality is detected as a result of the self-diagnosis performed after turning ON of the ignition switch.

### 3. ABNORMALITIES IN STEPPING MOTOR

The cruise control system is deactivated if either of the following abnormalities occurs in the stepping motor.

1) The stepping motor does not operate properly.

2) The stepping motor is energized for unduly long period and too frequently.
When the system is deactivated by any of these causes, it cannot be reactivated for 2 – 20 minutes after detection of the abnormal condition.

**MEMO**

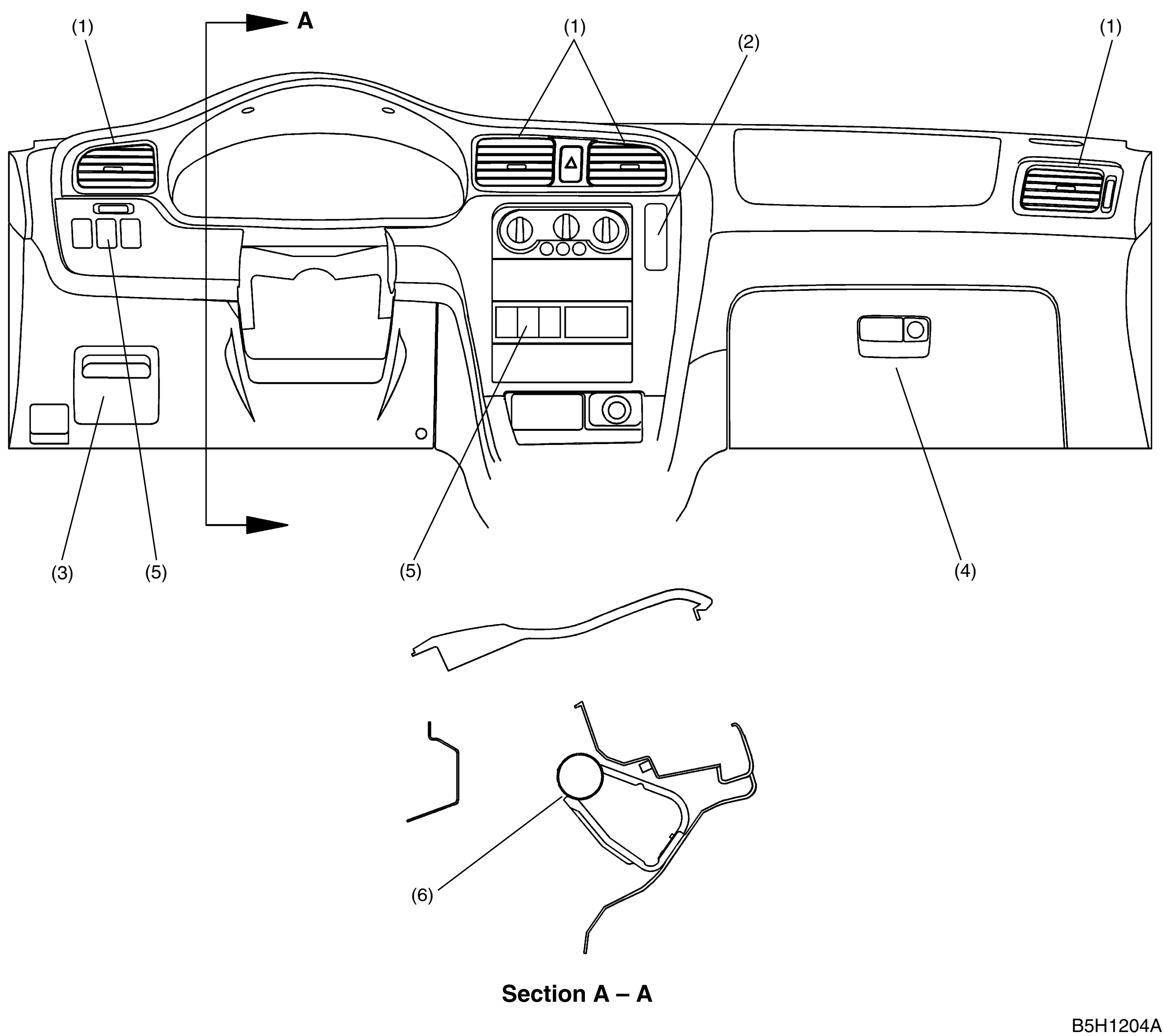
# EXTERIOR/INTERIOR TRIM

# EI

**Page**

# 1. Instrument Panel

- A cup holder is provided on the dashboard.
- The glove compartment has a lockable lid.
- The vent grills are barrel type.
- The dashboard lower cover is fitted with a knee cover.
- The steering support beam connecting the left and right pillars is located behind the instrument panel. The instrument panel is mounted on the support beam.




| | | | |
|---|---|---|---|
| (1) | Barrel type vent grill | (4) | Glove compartment |
| (2) | Cup holder | (5) | Optional accessory switches |
| (3) | Lid | (6) | Steering support beam |

# 2. Trailer Lights Connector

## A: DESCRIPTION

The lights of a trailer (e.g., camping car) can be supplied with power through this connector.

| | | | | |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| (6) | (7) | (8) | (9) | (10) |

B6H1434A

(1) Tail light
(2) Tail light
(3) Stop light
(4) Turn signal LH
(5) Turn signal RH
(6) Rear fog light
(7) Ground
(8) Ground
(9) Empty
(10) Battery +B

**MEMO**